



# Cassini Composite Infrared Spectrometer (CIRS) Observations of Titan 2004–2017

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## Abstract

From 2004 to 2017, the *Cassini* spacecraft orbited Saturn, completing 127 close flybys of its largest moon, Titan. *Cassini*'s Composite Infrared Spectrometer (CIRS), one of 12 instruments carried on board, profiled Titan in the thermal infrared (7–1000  $\mu\text{m}$ ) throughout the entire 13 yr mission. CIRS observed on both targeted encounters (flybys) and more distant opportunities, collecting 8.4 million spectra from 837 individual Titan observations over 3633 hr. Observations of multiple types were made throughout the mission, building up a vast mosaic picture of Titan's atmospheric state across spatial and temporal domains. This paper provides a guide to these observations, describing each type and chronicling its occurrences and global-seasonal coverage. The purpose is to provide a resource for future users of the CIRS data set, as well as those seeking to put existing CIRS publications into the overall context of the mission, and to facilitate future intercomparison of CIRS results with those of other *Cassini* instruments and ground-based observations.

**Key words:** infrared: planetary systems – instrumentation: interferometers – planets and satellites: atmospheres – planets and satellites: individual (Titan) – space vehicles: instruments – techniques: spectroscopic

**Supporting material:** machine-readable tables

## 1. Introduction

Titan is the largest moon of Saturn—5150 km in diameter—and the only moon in the solar system to possess a substantial atmosphere. Titan was discovered by Christiaan Huygens in 1655, and proof of its atmosphere was provided by Kuiper (1944) through observations of methane absorption in its spectrum. The first up-close encounter was made by the *Voyager 1* spacecraft on 1980 November 12 (Stone & Miner 1981), which used the technique of radio occultation to penetrate the atmosphere and determine the surface radius (Tyler et al. 1981), hitherto unknown. *Voyager 1* made many important findings about Titan using its onboard suite of instruments, but was unable to penetrate the thick haze to observe the surface (Smith et al. 1981).

In 2004, the *Cassini* spacecraft arrived at the Saturn system, beginning a planned 4 yr investigation of the planet, its rings, and its moons (Matson 2002). Ultimately the mission was extended twice, and the spacecraft was retired only in 2017 September after all fuel reserves had been expended, at which time it was plunged into Saturn's atmosphere, making a final

set of unique measurements. Titan was a major focus of the mission, and during its 13 yr in orbit, *Cassini* made 127 targeted encounters with Titan at ranges <100,000 km, as well as numerous additional observations from greater distances. During its third flyby, *Cassini* released the *Huygens* probe built by the European Space Agency (ESA), which descended to Titan's surface under parachute (Lebreton et al. 2005). *Huygens* delivered the first close-up pictures of Titan's surface (Tomasko et al. 2005) and made the first in situ measurements of the local atmospheric conditions (Bird et al. 2005; Fulchignoni et al. 2005; Israël et al. 2005; Niemann et al. 2005; Zarnecki et al. 2005).

Each Titan encounter was different, occurring with a unique combination of approach and departure direction, velocity, minimum approach distance, local time, Kronian season, and other characteristics. Every flyby was also therefore different in science potential, and a unique emphasis was developed for each one: RADAR versus mass spectrometry at closest approach, inbound mapping in reflected light (daylit inbound encounters) versus thermal infrared (nighttime inbound encounters), spacecraft orientation optimized for remote sensing platform versus particles and fields, and so on.

*Cassini*'s TOST group (Titan Orbiter Science Team; Steadman et al. 2010), with representation from each of the 12 instrument teams plus major spacecraft subsystems, was tasked with developing the exact science timeline for each Titan encounter. TOST worked by dividing the 24–48 hr encounter segment into

<sup>11</sup> Contributions to the project during internship at NASA GSFC.



smaller periods, each assigned to a “prime” instrument that would dictate spacecraft pointing, as well as any number of “rider” instruments that would passively collect data without determining their direction of pointing.<sup>12</sup> This strategy was effective because similar instruments were typically “co-boresighted,” i.e., pointing in the same direction. In particular, this was the case for the “ORS group” (Optical Remote Sensing), which consisted of four remote sensing spectrometers and cameras: the Ultraviolet Imaging Spectrometer (UVIS; Esposito et al. 2004), the Imaging Science Subsystem (ISS; Porco et al. 2004), the Visual and Infrared Mapping Spectrometer (VIMS; Brown et al. 2004), and the Composite Infrared Spectrometer (CIRS) described hereafter.

CIRS (Kunde et al. 1996; Flasar et al. 2004; Jennings et al. 2017) was designed and built by NASA’s Goddard Space Flight Center (GSFC) in partnership with more than a dozen other institutions, including hardware contributions from the UK, France, and Germany. CIRS was the successor to *Voyager*’s IRIS instrument (Infrared Radiometer and Spectrometer; Hanel et al. 1980), built on the same principle of Fourier Transform Spectroscopy (FTS) in the mid- and far-infrared but with significant upgrades to its spectral range, spectral resolution, sensitivity, and number of detector pixels. CIRS continued to operate at full capacity during the entire 13 yr mission and was ultimately allocated the most Titan observation time as the “prime” instrument of any *Cassini* instrument, by virtue of its ability to observe both Titan’s day and night sides, and to conduct high-value science over the entire range of spacecraft distances.

This paper covers two main topics: (i) the main types of CIRS observations of Titan and (ii) the spatial and temporal coverage of Titan achieved for each type. The objective is to provide a complete and comprehensive description of the CIRS observations of Titan—the science goals, observation implementation, and spatial and temporal coverage. This is anticipated to be of value to multiple groups: members of other *Cassini* instrument teams in their ongoing data analysis efforts, future users of CIRS data accessible through the Planetary Data System (PDS; McMahon 1996; see Appendix A), ground-based observers analyzing complementary data sets such as the ALMA archive (Stoehr et al. 2014), and perhaps also science planners of future Titan instruments and missions. Concluding remarks are given in Section 8.

## 2. Cassini Mission and CIRS Instrument Overview

### 2.1. Cassini Mission Implications for Titan Science

Saturn has an obliquity of  $26.7^\circ$  and an orbital period of 29.5 Earth yr, so it has seasons that are approximately 7.4 terrestrial yr in length. Titan orbits in Saturn’s equatorial plane with a negligible axial tilt relative to its orbit, so has seasons of the same length as Saturn. When *Cassini* arrived at Saturn in 2004 July, the season was northern winter. *Cassini* was originally planned to have a prime mission (PM) from 2004–2008; eventually, this was extended to 2010, which encompassed Saturn’s equinox in 2009. A second and final extension then continued the mission through 2017, thereby reaching Saturn’s northern summer solstice that year (Figure 1). Finally, on 2017 September 15, the spacecraft exhausted all its fuel and was destroyed by a planned entry into Saturn to prevent the

possibility of a later, uncontrolled impact with a moon. The long duration of this 13 yr mission thus enabled *Cassini* to experience almost two full seasons on Saturn and Titan, which has proved crucial for understanding the seasonal and even interannual change (by comparison to other data sets such as *Voyager*) in their atmospheres (Lockwood & Thompson 2009; Coustenis et al. 2013).

During the mission, the spacecraft changed its orbital inclination relative to the Saturn ring plane (equatorial plane) continuously (Figure 2), so as to have equal opportunities to rendezvous with the moons (requiring low inclination) and to view the rings (requiring high inclination). Flybys of Titan were used as gravity-assist maneuvers, changing the spacecraft inclination while minimizing fuel expenditure. The effect on Titan observations was twofold: (i) frequent flyby opportunities and (ii) almost every flyby geometry was different, in terms of encounter range at closest approach and trajectory (subspacecraft track on Titan). This implied that each flyby had to be individually designed for unique science observations/instrument operations, and that the possible atmospheric and surface coverage was dictated by the particular orbital geometry.

Flybys of Titan are divided into two categories: “targeted” encounters ( $r < 100,000$  km) and “untargeted” or distant encounters ( $r > 100,000$  km). All of these encounters may be identified by a *Cassini* orbit number; in addition, the targeted encounters are also given a flyby number in the format  $Tn$ —see data table in Appendix B. For example, the T6 flyby occurred on orbit 13 at a range of 3660 km, while the last encounter of the mission on orbit 292 was at a range of 119,733 km and therefore does not have a “T” number. Several exceptions to the naming convention must be noted. The very first, untargeted Titan encounter at a range of 339,123 km immediately following Saturn orbit insertion (SOI) is given the special designation “T0,” on orbit 0. Immediately following T0, the first several orbits, originally containing T1 and T2, were redesigned to accommodate a more distant flyby for the *Huygens* probe data relay. This entailed adding an additional orbit; therefore, encounters T1 and T2 became TA, TB and TC, with the rest of the planned tour continuing using the already designated numbers from T3 onward.

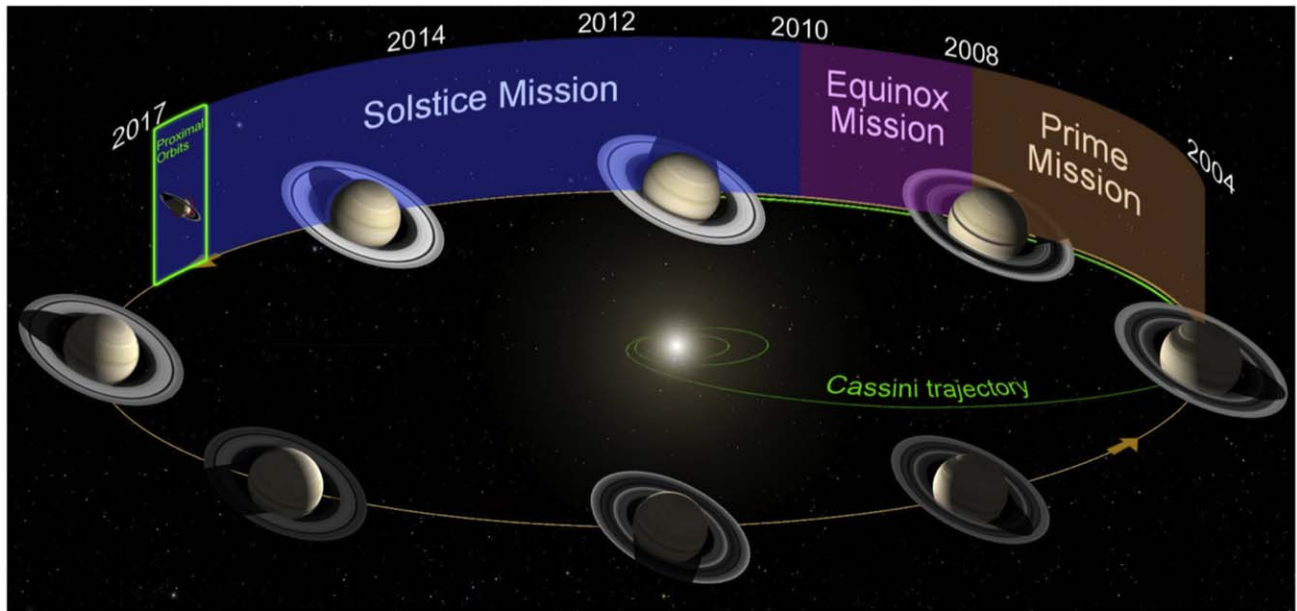
Figure 3 shows a histogram of flyby ranges; approximately one-third of targeted flybys (41/127) were at ranges  $< 1000$  km, and a further one-third (39/127) occurred at ranges 1000–1500 km, still inside the atmosphere defined by the exobase at 1500 km (Yelle et al. 2008; Vuitton et al. 2019). Therefore, on 63% of Titan targeted flybys (those where  $r < 100,000$  km) in situ measurements of the atmosphere were possible, as well as remote sensing on approach and departure. The remaining approximately one-third (47/127) of targeted flybys were at ranges 1500–100,000 km, along with 14 more distant encounters.

### 2.2. CIRS Instrument Overview

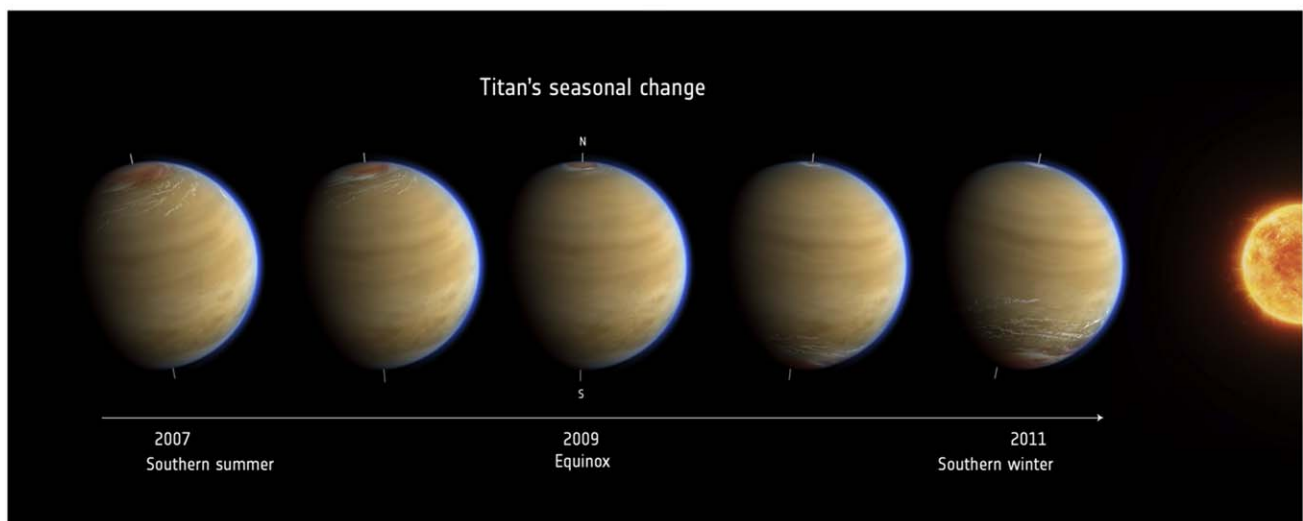
A detailed description of the instrument is given in Jennings et al. (2017), while some key facts are given here that are most relevant to the Titan observation planning. The CIRS instrument was a dual spectrometer, which used a field-splitting beam splitter to direct the incoming light from a 50 cm diameter telescope into mid- and far-infrared spectrometers. These functioned in tandem, sharing a common mirror carriage mechanism that defined the spectral resolution through its distance of travel, from a lowest apodized resolution of  $15.5\text{ cm}^{-1}$  to a highest apodized resolution of  $0.5\text{ cm}^{-1}$ . The

<sup>12</sup> Mostly: some riders were listed as “collaborative” between several instruments, meaning that the prime instrument was required to develop pointing that would also fulfill science goals for important rider observations.

(a)



(b)



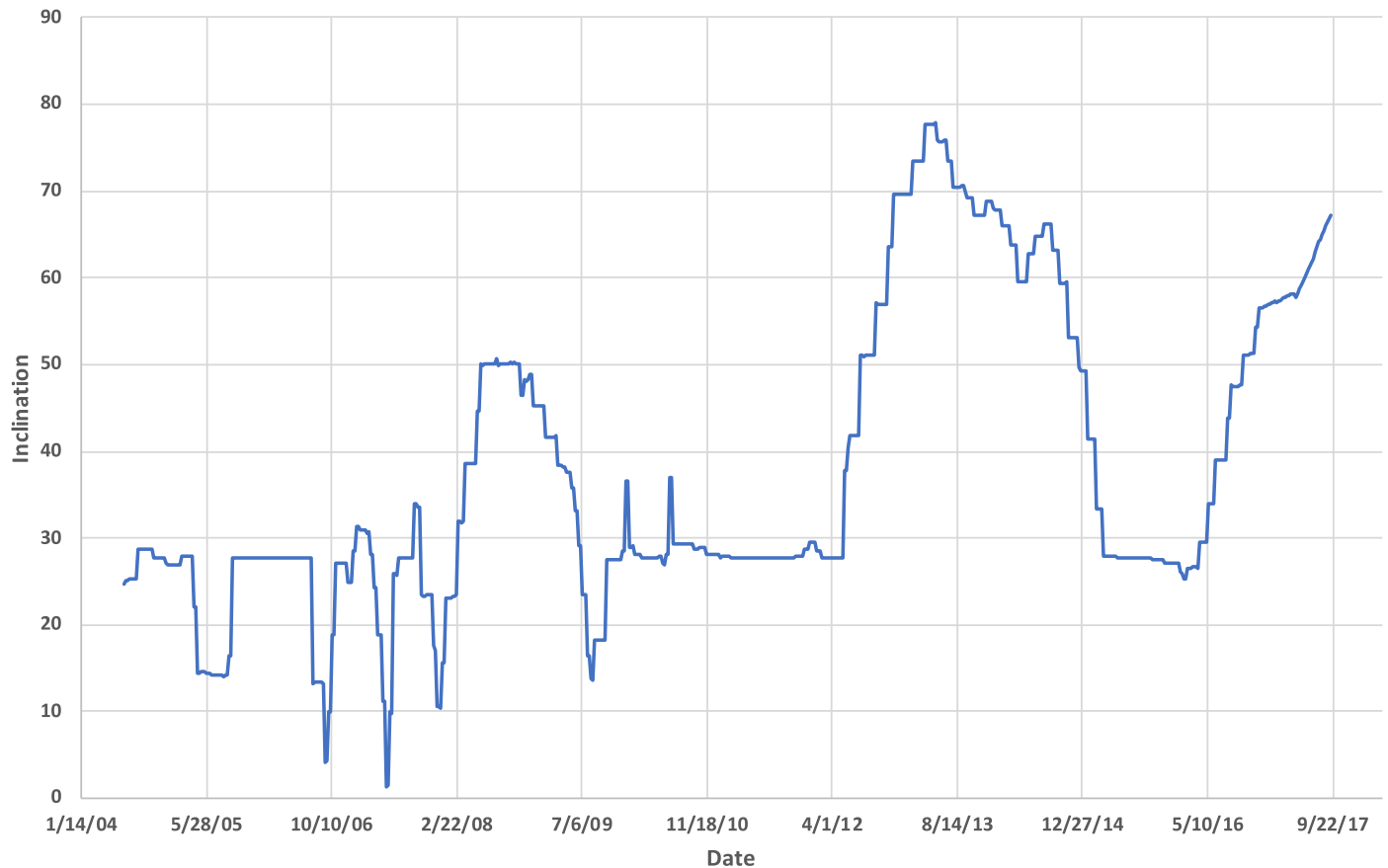
**Figure 1.** (a) Changing seasons on Saturn during the *Cassini* mission timeframe. (JPL/NASA) (b) Seasons on Titan around equinox in 2009. (ESA/AOES).

lowest resolutions required the shortest movements (4.5 s), while the highest resolutions required the longest movements (52 s). Intermediate resolutions were possible, with the most common medium resolution being  $2.75 \text{ cm}^{-1}$  (12 s). This created a trade-off: acquiring many low-resolution spectra was desirable in some circumstances—for example during observations of strong gas emissions such as methane—and enabled rapid repositioning for mapping purposes. High-resolution spectra required longer acquisition times, and therefore a substantial dwell time on source to build up significant a signal-to-noise ratio (S/N). This was desirable when measuring weaker gas emissions of less abundant species that required a higher resolution to isolate.

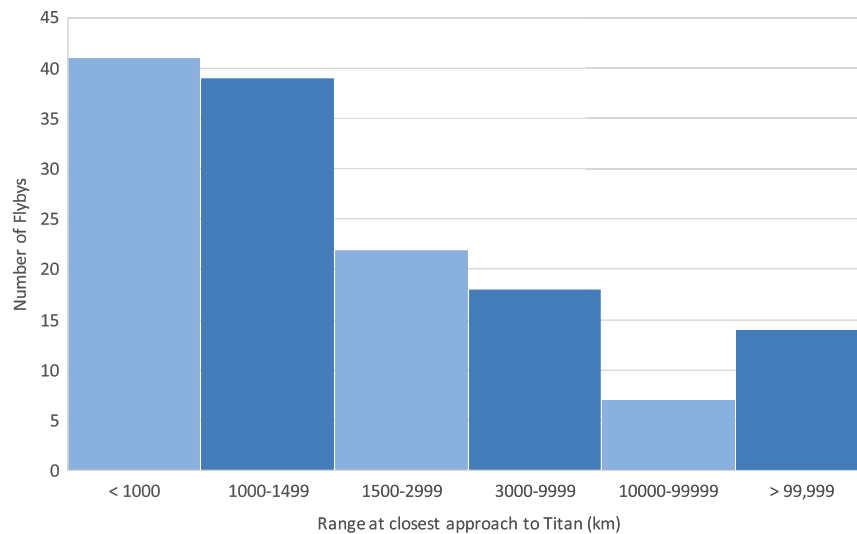
A second important consideration was the number and configuration of the pixels, as shown in Figure 4. The far-infrared focal plane, known as FP1, was a single large pixel similar to *Voyager* IRIS that was optimized for sensitivity to

light from  $10$  to  $600 \text{ cm}^{-1}$  ( $1000\text{--}17 \mu\text{m}$ ).<sup>13</sup> The mid-infrared reception was very different from that of *Voyager* IRIS and used twin  $1 \times 10$  mercury-cadmium-telluride arrays sensitive to  $600\text{--}1100 \text{ cm}^{-1}$  (FP3, photoconductive-type detectors,  $17\text{--}9 \mu\text{m}$ ) and  $1100\text{--}1400 \text{ cm}^{-1}$  (FP4, photovoltaic-type detectors,  $9\text{--}7 \mu\text{m}$ ). The optical boresights were closely aligned with the spacecraft  $-Y$  direction, while the mid-infrared arrays were aligned along the  $Z$  axis, and FP1, FP3, and FP4 were offset in the  $X$  direction (Nixon et al. 2009b). The implication was that the  $-Y$  direction was pointed at Titan for optical measurements, while rotating the spacecraft about the  $Z$  axis swept the mid-infrared arrays across the sky to perform “pushbroom” mapping. Subsequent offsetting in  $X$  permitted multiple, parallel sweeps.

<sup>13</sup> A second detector in the far-infrared, FP2, was descoped before launch.



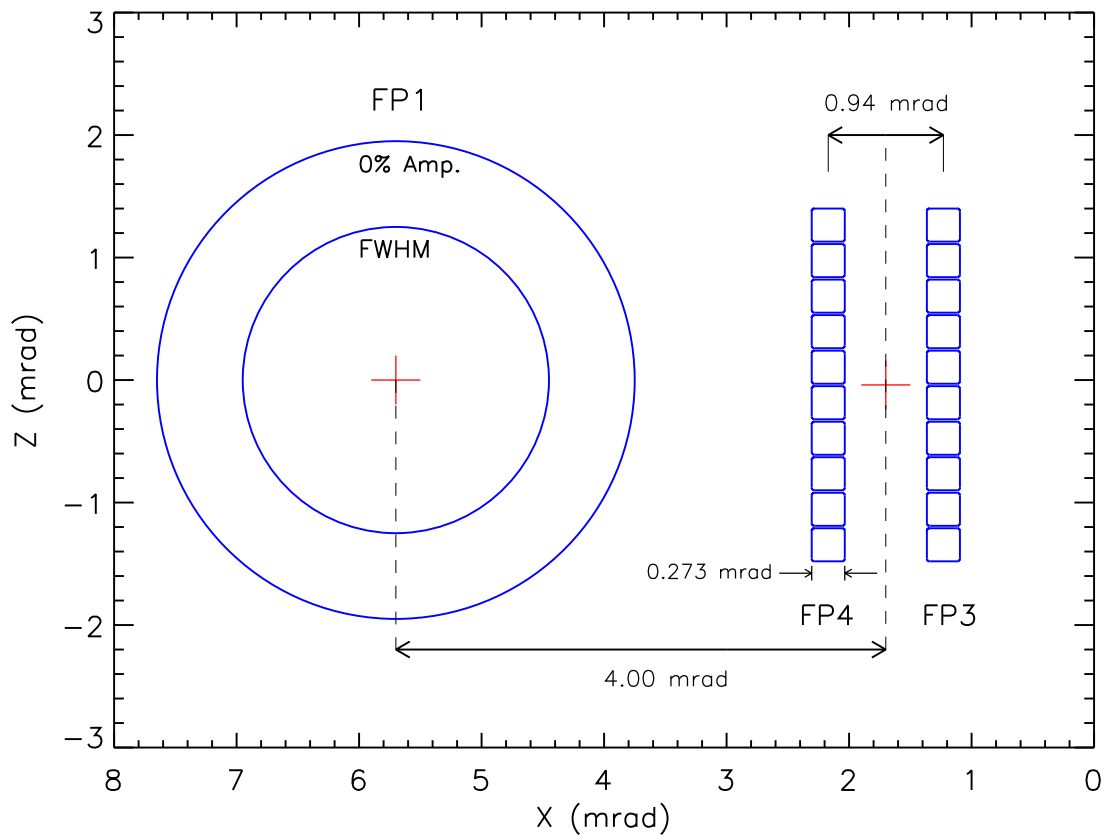
**Figure 2.** Magnitude of inclination of *Cassini*'s orbit over time relative to the Saturn ring plane.



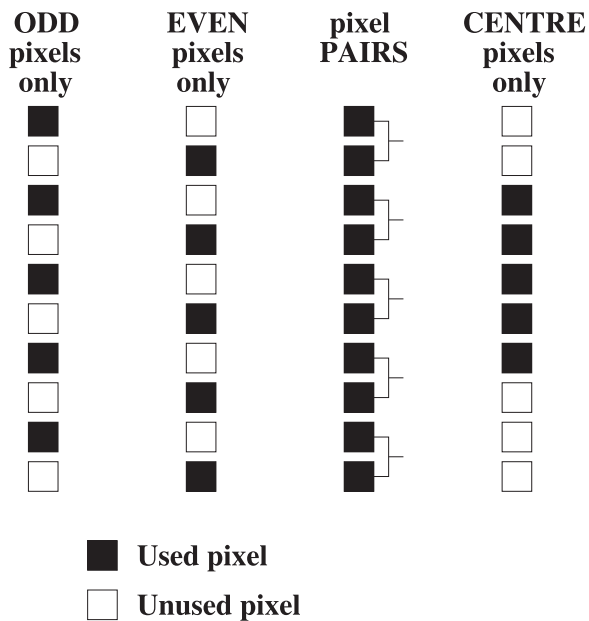
**Figure 3.** Frequency of Titan flybys at different closest approach distances. Close flybys at  $r < 1500$  constituted the majority of targeted flybys ( $r < 100,000$  km), while flybys at 100,000 km and farther were considered untargeted distant encounters.

A further factor in observation design was detector readout. CIRS had 11 simultaneous readout channels: one for FP1, and five each for FP3 and FP4. This meant that typically only half of the mid-infrared detectors could be used at a time. Readout modes for the mid-infrared included odd detectors only (1, 3, 5, 7, 9 on each of FP3 and FP4), even detectors only (2, 4, 6, 8, 10 on each array), or center mode (4–8 on FP3 and 3–7 on FP4). A

typical observation alternated back and forth between the even and odd readout modes on successive scans to allow for the fullest spatial sampling, known as “blink” mode. However, a “pair” mode was also available that utilized all 10 detectors on each array by reading them out in five pairs (1 + 2, 3 + 4, 5 + 6, 7 + 8, 9 + 10). Pair mode effectively created double-size detector pixels that may be harder to model in certain



**Figure 4.** CIRS field of view showing relative sizes and orientations of detectors.



**Figure 5.** CIRS detector readout modes for the mid-infrared arrays: FP3 and FP4.

circumstances, but had the advantage of using the maximum possible amount of incoming flux—a  $\sqrt{2}$  advantage over the other modes that was used to improve the S/N. A graphical summary is shown in Figure 5.

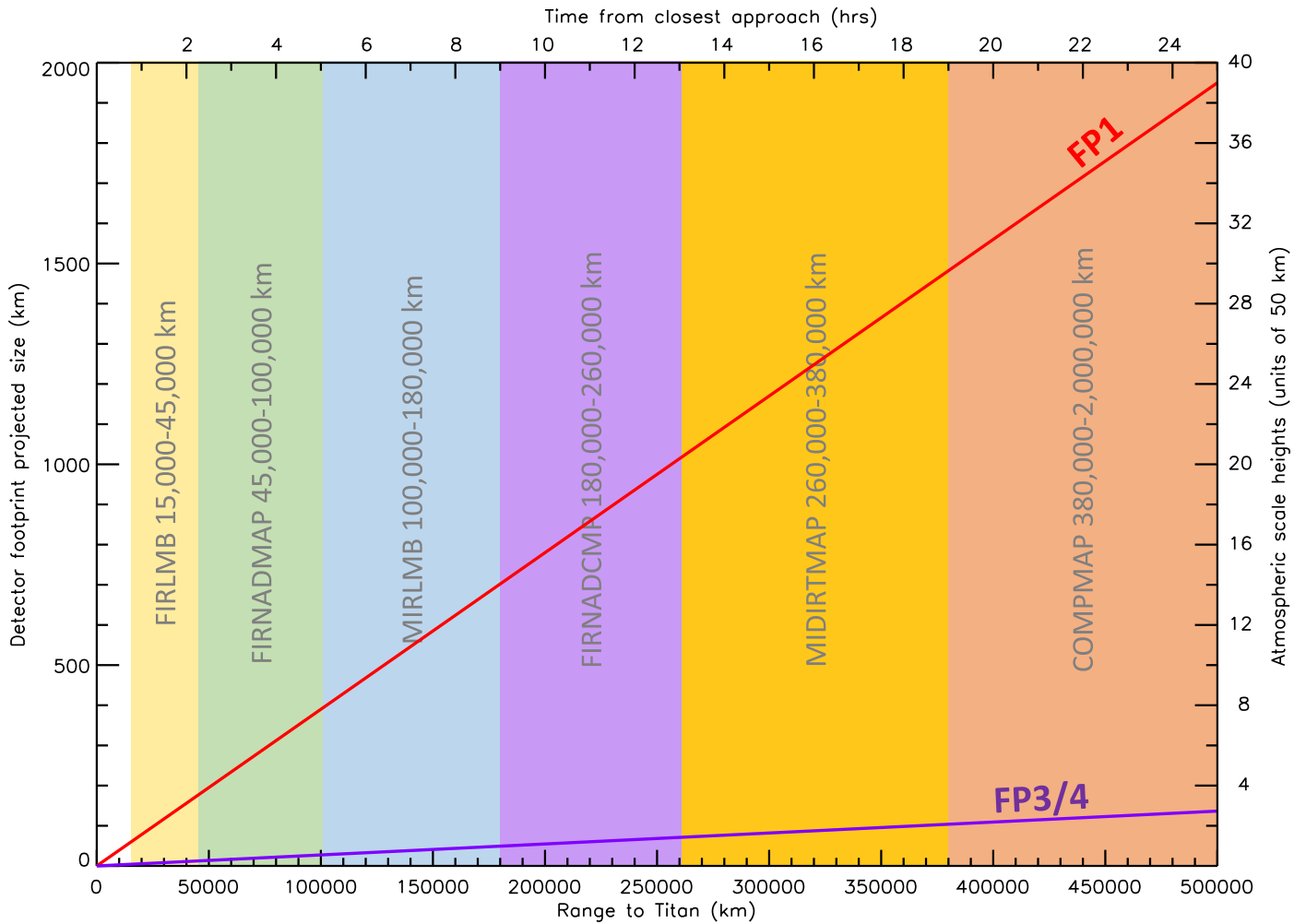
A final note regarding the instrument is that frequent calibration data were required in addition to science observations. Only radiometric (flux) calibration was taken in flight, to

enable the conversion from detector counts to physical radiance units, and comprised two types. The first was “dark sky” or “deep space” observations of the 2.73 K background (sky background avoiding planets, moons, the Sun, IR-bright stars, etc.), equivalent to zero radiance for the purpose of CIRS, and the second was a warm internal target (shutter) that was periodically emplaced into the beam path for the mid-infrared only (FP3 and FP4).<sup>14</sup> These flux calibration observations were made sometimes before, sometimes after, or occasionally interspersed within longer science observations; and sometimes while slewing the spacecraft to reach a target point. Later in the mission, the normal practice became to concentrate the calibration observations in dedicated blocks of time (normally 6–8 hr) during downlink of spacecraft data to Earth when the instrument was usually pointing at empty space, and the previous practice of taking calibration data during science observations diminished. This new paradigm created longer, more homogeneous blocks of calibration data, at the expense of the calibration data being slightly more remote in time from the science observations that they would later be used to calibrate. When using CIRS data, care must be taken to sift out calibration observations from science data. For further details, see Jennings et al. (2017).

### 3. Overview of CIRS Titan Observations

We define two common terms used to distinguish major types of CIRS observations: nadir and limb. A nadir observation was one where the detector field of view intersects

<sup>14</sup> FP1 did not require a shutter, as the detector was thermostated to the temperature of the rest of the instrument optics, providing a virtual reference point.



**Figure 6.** Projected footprint size of the CIRS far-infrared (FP1) and mid-infrared (FP3/4) detectors as a function of range from Titan. Different observation types were performed at different ranges.

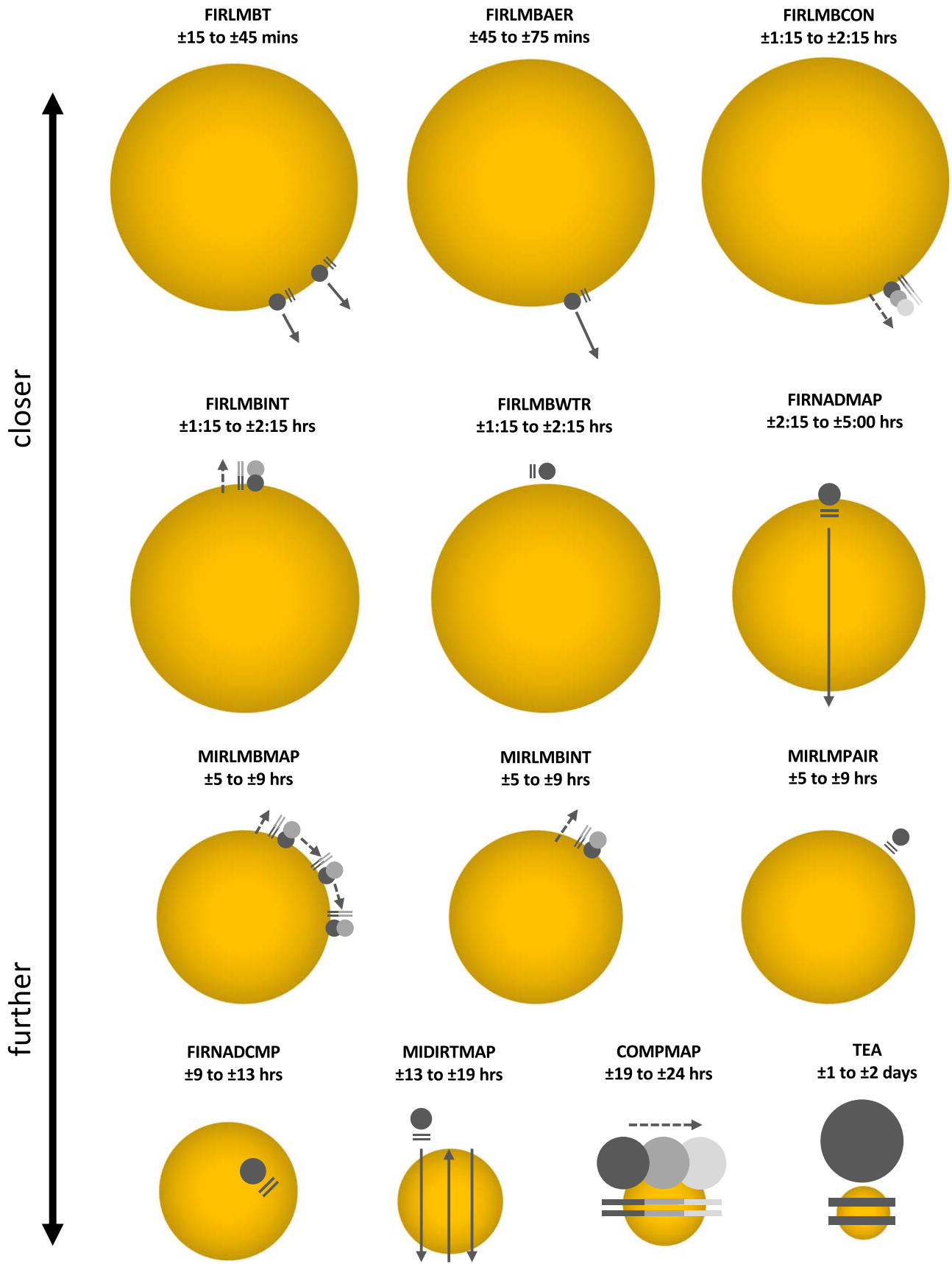
Titan’s surface (not necessarily normal to the surface), whereas a limb observations pointed the detector(s) just outside the disk of Titan’s solid body and measured the atmosphere only, between the surface and the exobase at around 1500 km. To obtain a nadir map in the far- or mid- infrared, the detector(s) was (were) swept up and down in parallel tracks in the Z direction, with offsets in X. A limb profile (vertical cross-section) could be obtained with FP1 by moving the detector in a radial direction, from the surface outward. In the mid-infrared, scanning was not needed as the detectors formed a linear array: a vertical profile could be obtained by placing the arrays perpendicular to the limb and moving upward to a second higher position if required.

The CIRS team developed a suite of different observation types customized for each distance range from Titan. These were divided into two wavelength categories: mid or far-infrared led, and three articulation types: integration, 1D map, or 2D map. The distinction between “far-infrared” and “mid-infrared” observations may initially appear confusing: after all, during all Titan observations, both the far-infrared pixel (FP1) and some subset of the mid-infrared pixels (FP3/4) were read out, as shown in Figure 5. The reason for the dichotomy was due to the vast difference in pixel sizes: 3.9 mrad FWHM for FP1 versus 0.273 mrad for FP3/4, a factor of 14 different. This required that position-step sizes, slewing rates, and other

spacecraft-pointing maneuvers were customized not only according to distance from Titan, but also by detector type (mid-/far-infrared), both of which combined to determine the projected size of the footprint in kilometers, according to the formula  $s = r\Delta\theta$ , where  $s$  is the footprint size,  $r$  is the distance, and  $\Delta\theta$  is the angular size of the detector (Figure 6).

“Integrations,” otherwise known as “sit-and-stare” type observations, consisted of a long dwell at a single target point, either on the disk or “limb” (atmosphere visible on the horizon), often punctuated by periods of offset pointing onto space (“dark sky”) for calibration purposes. One-dimensional maps occurred in several flavors: latitudinal, longitudinal, or vertical. Latitudinal or longitudinal scans consisted of a slow “slew” (spacecraft turning about one inertial axis) so as to move the detectors slowly across Titan’s disk in the north-south (N–S) or east-west (E–W) direction. Vertical scans, on the other hand, were designed to move the arrays in a radial direction—usually away from Titan’s center—to measure a vertical section (or profile) of the atmosphere. Radial scans usually began on Titan’s disk, moving upward (away from center) over the limb and stopping when the atmosphere became too tenuous (optically thin) for any further signal to be recorded.

Because articulating the spacecraft in two dimensions was more difficult and demanding on the spacecraft reaction wheels



**Figure 7.** Schematic showing the types of CIRS Titan observations performed at various times from closest approach. Arrows with solid lines indicate continuous slewing, while arrows with broken lines indicate repositioning. Projected detector footprints are approximate only, because these change with distance.

**Table 1**  
Types of CIRS Titan Observations

| Observation<br>Name                | Time Relative<br>to C/A (HH:MM) |         | Range<br>(10 <sup>3</sup> km) |      | Spectral<br>Resol.<br>(cm <sup>-1</sup> ) | Type        | Maximum<br>Scan Rate<br>(μrad s <sup>-1</sup> ) | Maximum<br>Num. of<br>Positions |
|------------------------------------|---------------------------------|---------|-------------------------------|------|-------------------------------------------|-------------|-------------------------------------------------|---------------------------------|
|                                    | Start                           | End     | Min                           | Max  |                                           |             |                                                 |                                 |
|                                    |                                 |         |                               |      |                                           |             |                                                 |                                 |
| <i>Standard Far-infrared Types</i> |                                 |         |                               |      |                                           |             |                                                 |                                 |
| FIRLMBT                            | ±00:15                          | ±00:45  | 5                             | 15   | 15.0                                      | radial scan | 43                                              | ...                             |
| FIRLMBAR                           | ±00:45                          | ±01:15  | 15                            | 25   | 15.0                                      | radial scan | 55                                              | ...                             |
| FIRLMBINT                          | ±01:15                          | ±02:15  | 25                            | 45   | 0.5                                       | integration | ...                                             | 2                               |
| FIRNADMAP                          | ±02:15                          | ±05:00  | 45                            | 100  | 15.0                                      | 1D map      | 7                                               | ...                             |
| <i>Standard Mid-infrared Types</i> |                                 |         |                               |      |                                           |             |                                                 |                                 |
| MIRLMBINT                          | ±05:00                          | ±09:00  | 100                           | 180  | 0.5                                       | integration | ...                                             | 2                               |
| MIRLMBMAP                          | ±05:00                          | ±09:00  | 100                           | 180  | 15.0                                      | integration | ...                                             | 2 × 18                          |
| FIRNADCMP                          | ±09:00                          | ±13:00  | 180                           | 260  | 0.5                                       | integration | ...                                             | 1                               |
| MIDIRTMAP                          | ±13:00                          | ±19:00  | 260                           | 380  | 3.0                                       | 2D scan     | 4                                               | ...                             |
| COMPMAP                            | ±19:00                          | ±24:00  | 380                           | 2000 | 0.5                                       | integration | ...                                             | 2–5                             |
| <i>Evolved Late-mission Types</i>  |                                 |         |                               |      |                                           |             |                                                 |                                 |
| FIRLMBCON                          | ±01:15                          | ±02:15  | 25                            | 40   | 3.0                                       | integration | ...                                             | 3                               |
| FIRLMBWTR                          | ±01:15                          | ±02:15  | 25                            | 40   | 0.5                                       | integration | ...                                             | 1                               |
| MIRLMPAIR                          | ±05:00                          | ±09:00  | 100                           | 180  | 0.5                                       | integration | ...                                             | 2                               |
| TEA                                | ±40:00                          | ±100:00 | 800                           | 2000 | 0.5                                       | integration | ...                                             | variable                        |

and thrusters than a single axis articulation, 1D scans of any type were usually preceded by a turn about the  $-Y$  direction (optical boresight direction). This would set up the secondary axes ( $X$  and  $Z$ ) in a N–S, E–W, or appropriate direction perpendicular to the limb, so that the 1D scan could then be performed by turning about a single axis only. For example, an N–S scan might be set up by first turning about  $-Y$  so that the  $+X$  axis was aligned with Titan’s north pole; the N–S scan would then proceed by turning about the  $Z$  axis to “comb” the mid-infrared detector arrays downward in an N–S direction. Similarly, a radial scan at  $45^\circ\text{N}$  latitude might be set up by pointing  $+X$  perpendicular to the limb at  $45^\circ\text{N}$  (i.e.,  $Z$  parallel or tangent to the edge of Titan’s disk) and then rotating the spacecraft about the  $Z$  axis to scan the detectors upward (radially away from Titan’s center).

Two-dimensional maps were performed by slewing in two directions,  $X$  and  $Z$ . Typically, the map might proceed by imaging a square box on the sky enclosing Titan; the initial pointing would then be moved to one “corner” of the box and a turn performed around the  $Z$  axis to comb the array down the first side of the box (see Figure 7, MIDIRTMAP). The arrays would then be offset in  $X$ , and the scan repeated in the opposite direction. The amount of  $X$  offset would typically be set to just under one array length of the FP3 detectors to allow for positional overlap (which could be used later for calibration purposes to compensate for any instrument temperature drifts). The angular size of the scan in  $Z$  would be reduced or increased at every iteration to compensate for the changing distance to Titan and its changing angular size on the sky.

With these major goals and categories in mind, nine initial CIRS Titan observation types were constructed prior to SOI in 2004, when planning the PM (2004–2008), as described in Flasar et al. (2004). Experience during the PM led to four new observation types being introduced in the Equinox (2008–2010) and Solstice (2010–2017) Missions; see also Nixon et al. (2012a). A summary of all final observation types is given in Table 1 and shown in Figure 7. Final observation

specifications are described with examples in the following subsections, grouped by observation type.

#### 4. Far-infrared Limb Observations

Far-infrared limb observations constituted the closest observations to Titan, in the window from 15 to 135 minutes from closest approach, or a range of approximately  $(5\text{--}45) \times 10^3$  km. At this close range, the large FP1 detector achieved the best possible resolution on Titan’s limb to obtain vertical profiles of temperature, aerosol opacity, and gas abundances. At  $\sim 45$  minutes from closest approach, FP1 could resolve about 1 pressure scale height on Titan’s limb; by 2 hr from closest approach, the resolution was  $\sim 3$  scale heights (see Figure 6).

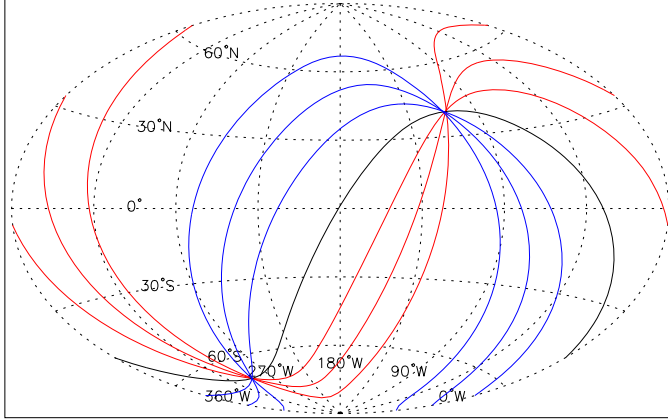
During a flyby, and especially at close range, the horizon circle was constantly changing, either in longitude, latitude, or both. However, there were two points on the horizon, roughly perpendicular to the subspacescraft track projected onto Titan’s surface, where multiple horizon circles (as a function of time) intersected, as seen in Figure 8. These were considered to be “horizon nodes,” or “limb stationary points,” and targeting limb observations at or close to these points was desirable because a more homogeneous atmospheric sample could thus be obtained (see Nixon et al. 2010a for a more detailed discussion of this topic). Figure 9 shows the limb horizon nodes for all flybys in the mission, which were used as a guide when choosing pointing for positioning scans/integrations; additional factors included a preference for covering a wide range of latitudes and not repeating latitudes close together in time.

Descriptions of types of far-infrared limb observations are given below, and a full listing of the far-infrared limb observation dates, times, and pointing locations is given in Appendix C.

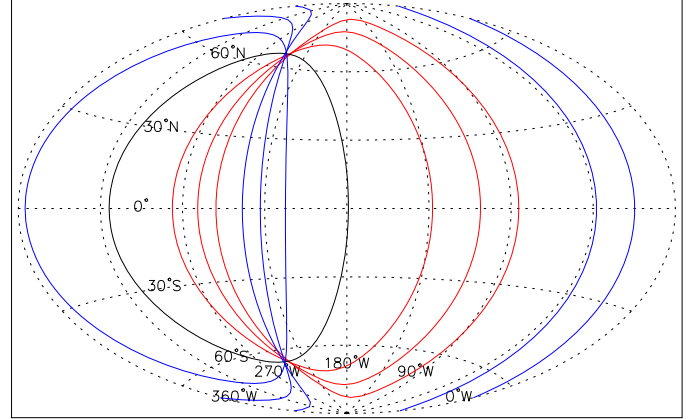
##### 4.1. FIRLMBT

*Science overview:* The far-infrared limb temperature scan (FIRLMBT) observation was the closest observation to Titan,

Tour SM-7: Titan flyby 73  
C/A  $\pm 1^h$ , C/A  $\pm 30^m$ , C/A  $\pm 15^m$ , C/A



Tour SM-7: Titan flyby 74  
C/A  $\pm 1^h$ , C/A  $\pm 30^m$ , C/A  $\pm 15^m$ , C/A



**Figure 8.** Example horizon circles at 0,  $\pm 15$ ,  $\pm 30$ ,  $\pm 60$  minutes for T73 and T74. Red = approaching, Blue = receding, Black = closest approach. Horizon “nodes” were two locations where all circles intersected, indicating limb-viewing locations that were continuously visible and ideal for limb sounding.

occurring at  $(5\text{--}15) \times 10^3$  km (15–45 minutes from closest approach). At 30 minutes from closest approach, FP1 resolved  $\sim 40$  km on Titan’s limb, or about 80% of an atmospheric scale height ( $\sim 50$  km). The observation was designed to allow for several vertical profiles of temperature to be obtained via measurement of  $N_2\text{--}N_2$  collision-induced absorption (CIA) or opacity at  $50\text{--}150\text{ cm}^{-1}$ , focusing on pressure levels of 8–100 mbar in the lower stratosphere and upper troposphere (Flasar et al. 2004; Sylvestre et al. 2018)—see Figure 10.

**Implementation:** The lowest spectral resolution of CIRS was used ( $15.5\text{ cm}^{-1}$ ), which enabled a rapid spectrum acquisition time (5 s). A turn rate of  $\sim 40\text{ }\mu\text{rad s}^{-1}$  meant that the FOV moved by only 0.2 mrad, or 1/20 of a pixel, during a single spectrum. Therefore, at least 10 spectra can be coadded (2 mrad) without loss of spatial resolution, typically considered to be one-half of the detector size (i.e., Nyquist sampling). Each limb scan covered  $\sim 28$  mrad, taking about 11 minutes. Allowing for repositioning at the start and end of the scan, two scans were typically achieved in the nominal 30 minute window. The two scans were notionally positioned  $10^\circ$  apart in latitude, although this was not achievable if the flyby was at high inclination. Due to the customization of each Titan flyby through negotiation with other *Cassini* teams, the FIRLMBT observation was sometimes shorter or longer than 30 minutes, in which case the scan rate was adjusted accordingly (up or down). If the required scan rate exceeded  $50\text{ }\mu\text{rad s}^{-1}$ , only one scan was implemented, and/or the observation was merged with the adjacent FIRLMBAR observation.

#### 4.2. FIRLMBAR

**Science overview:** The far-infrared aerosol scan (FIRLMBAR) was the second-closest observation to Titan, occurring at  $(15\text{--}25) \times 10^3$  km (45–75 minutes from closest approach). Like FIRLMBT, this was also a limb scan observation designed to measure vertical profiles of aerosol opacity in the range  $250\text{--}600\text{ cm}^{-1}$ . Due to the differing spectral dependence of CIA, aerosols, and clouds (condensates), the vertical profile can be isolated and measured (Teauby et al. 2009a; de Kok et al. 2010; Anderson & Samuelson 2011; Anderson et al. 2018). By considering multiple flybys, latitudinal and temporal variations of aerosol and condensates may be inferred (Jennings et al. 2012a, 2012b, 2015). FIRLMBAR data also provide important

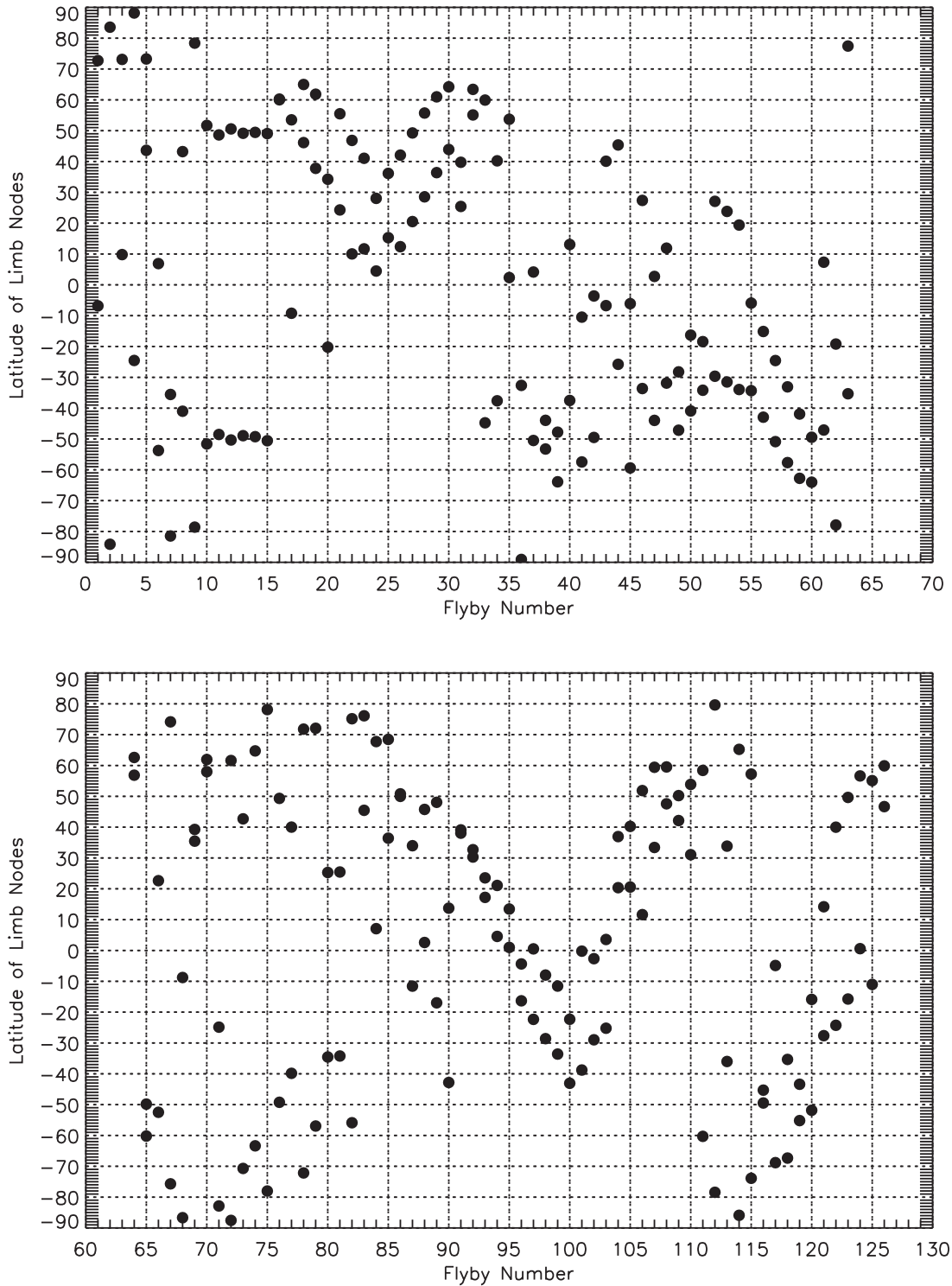
constraints for modeling nadir-viewing observations, where vertical information is more ambiguous.

**Implementation:** From 2004 to 2010, two scans separated by  $5^\circ$  on the horizon were implemented in the 30 minute window, covering a radial distance of 51 mrad, or about 1000 km from  $-100$  to  $+900$  km relative to the surface. The scan required was consequently rapid:  $\sim 55\text{ }\mu\text{rad s}^{-1}$ . From 2010, the observation was redesigned to focus on altitudes  $-100$  to  $+600$  km, because the signal became too weak for detection at higher altitudes. A slower scan rate was also employed ( $\sim 28\text{ }\mu\text{rad s}^{-1}$ ) to increase the S/N. Also, the number of scans was reduced from two to one (Figure 11), as it was found that similar aerosol information could be obtained from the FIRLMBT observations, and therefore, it became desirable to focus on high fidelity rather than greater spatial coverage.

#### 4.3. FIRLMBINT

**Science overview:** The far-infrared limb integration constituted the third type of the original FIRLMB observation group, designed prior to orbit insertion. This observation type was implemented from 75 to 135 minutes from closest approach, or at a range of  $(25\text{--}45) \times 10^3$  km. In contrast to FIRLMBT and FIRLMBAR, the FIRLMBINT was not a scan (slew), but rather a sit-and-stare observation (or integration) at a series of fixed pointings relative to Titan. The objective was to obtain measurements of trace gas concentrations at two altitudes to obtain a basic vertical gradient. In particular, measurements of the gases CO ( $30\text{--}70\text{ cm}^{-1}$ ),  $C_2N_2$  ( $233\text{ cm}^{-1}$ ), and  $H_2O$  ( $\sim 150\text{--}250\text{ cm}^{-1}$ ; de Kok et al. 2007b; Cottini et al. 2012b; Lellouch et al. 2014) were of interest, because they do not have spectral bands detectable by CIRS in the mid-infrared. However,  $C_3H_4$  ( $328\text{ cm}^{-1}$ ) and  $C_4H_2$  ( $228\text{ cm}^{-1}$ ) were also measured (Sylvestre et al. 2018), as well as a weak band of  $HC_3N$  at  $499\text{ cm}^{-1}$ . FIRLMBINTs have also been used to characterize aerosols and condensates (ices; de Kok et al. 2007a, 2010; Samuelson et al. 2007; Anderson et al. 2010, 2014, 2016, 2018; Anderson & Samuelson 2011; Jolly et al. 2015).

**Implementation:** The FIRLMBINT was implemented as two fixed integrations at 125 and 225 km above the limb (later, a third, intermediate point at 175 km was added as a separate observation: see FIRLMBWTR). The highest spectral resolution of CIRS was used,  $0.5\text{ cm}^{-1}$ , requiring 52 s acquisition

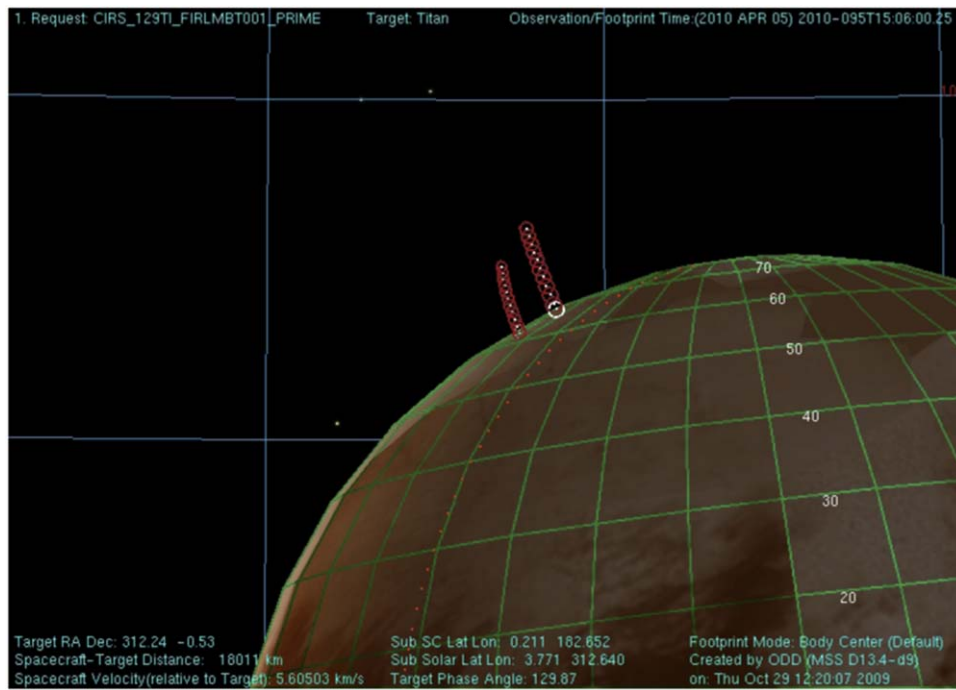


**Figure 9.** Horizon nodes for Titan flybys during the *Cassini* mission. Flybys “1” and “2” are TB and TC, respectively. These indicated desirable pointing positions for far-infrared limb observations (close to Titan) and were used to guide observation design.

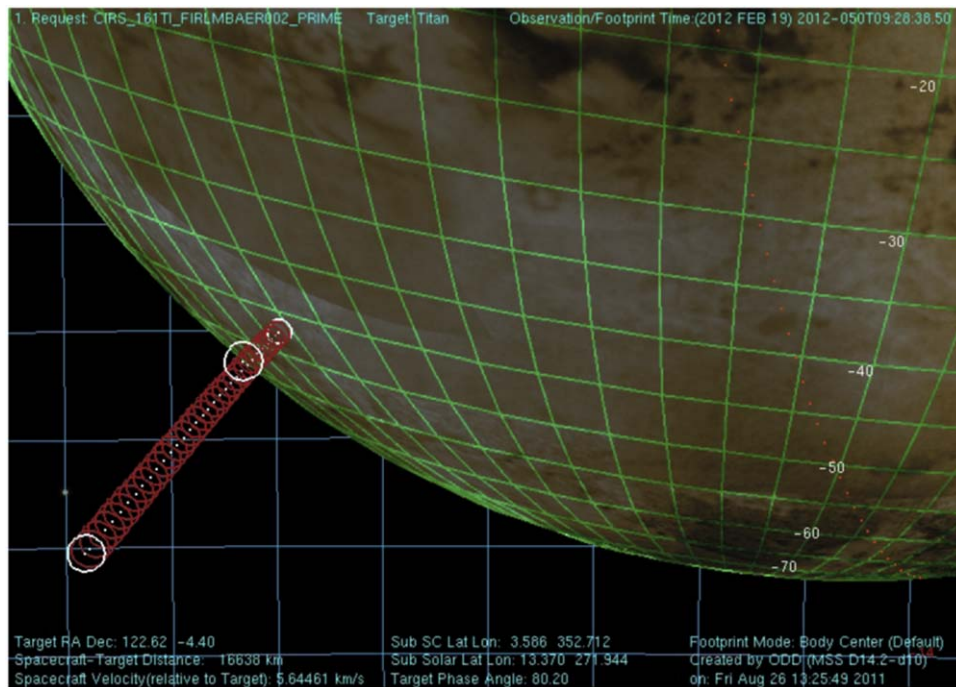
times for a single spectrum. The observation proceeded by pointing for nominally 13 minutes (15 spectra) at 125 km, then 13 minutes at 225 km, followed by a repeat of the two positions. Due to the changing range from Titan, two shorter visits at each altitude (Figure 12) were preferred instead of one longer visit, ensuring that the spatial footprint at each altitude was not too dissimilar.

#### 4.4. FIRLMBCON

*Science overview:* The far-infrared limb condensate integration (FIRLMBCON) was designed to address the gap in resolution between the high spectral resolution integrations (FIRLMBINT,  $0.5 \text{ cm}^{-1}$ ), and the low-resolution scans (FIRLMBT and FIRLMBAER,  $15 \text{ cm}^{-1}$ ). The lower resolution of the aerosol scans was insufficient to resolve condensate (ice)



**Figure 10.** Example of a CIRS far-infrared limb temperature observation (CIRS\_129TI\_FIRLMBT001\_PRIME, 2010 April 5, T67) showing two parallel limb scan tracks with FP1 at around 70° N to measure lower atmosphere temperatures. FP1 FOV projected size  $\sim 70$  km at time of snapshot.



**Figure 11.** Example of a CIRS far-infrared limb aerosol scan (CIRS\_161TI\_FIRLMBT002\_PRIME, 2012 February 19, T82) showing a single slow limb scan with CIRS FP1 to measure aerosols. FP1 FOV projected size  $\sim 65$  km at time of snapshot.

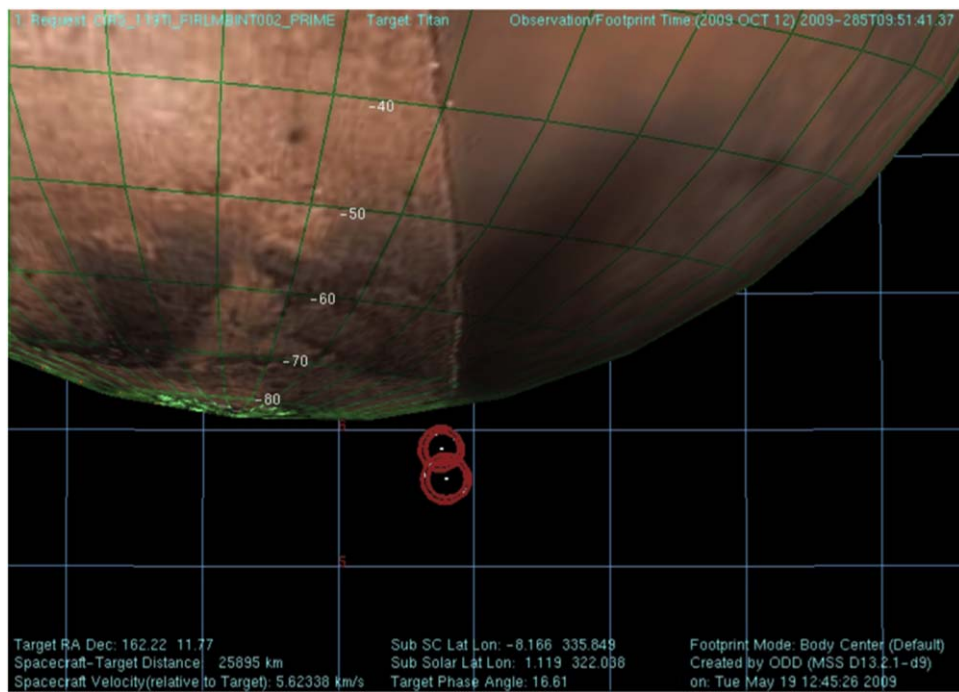
features in the spectrum, such as  $\text{HC}_3\text{N}$  at  $506\text{ cm}^{-1}$ , while the high-resolution integrations had sufficient spectral resolution but an insufficient S/N and altitude information. Data from the FIRLMBCON observation has been used to infer the presence of  $\text{C}_4\text{N}_2$  ice at  $478\text{ cm}^{-1}$  (Anderson et al. 2016, 2018).

*Implementation:* The observation was implemented twice, on T67 and T118 (see Table 5), as a modified FIRLMBINT from 135 to 75 minutes from closest approach on the inbound

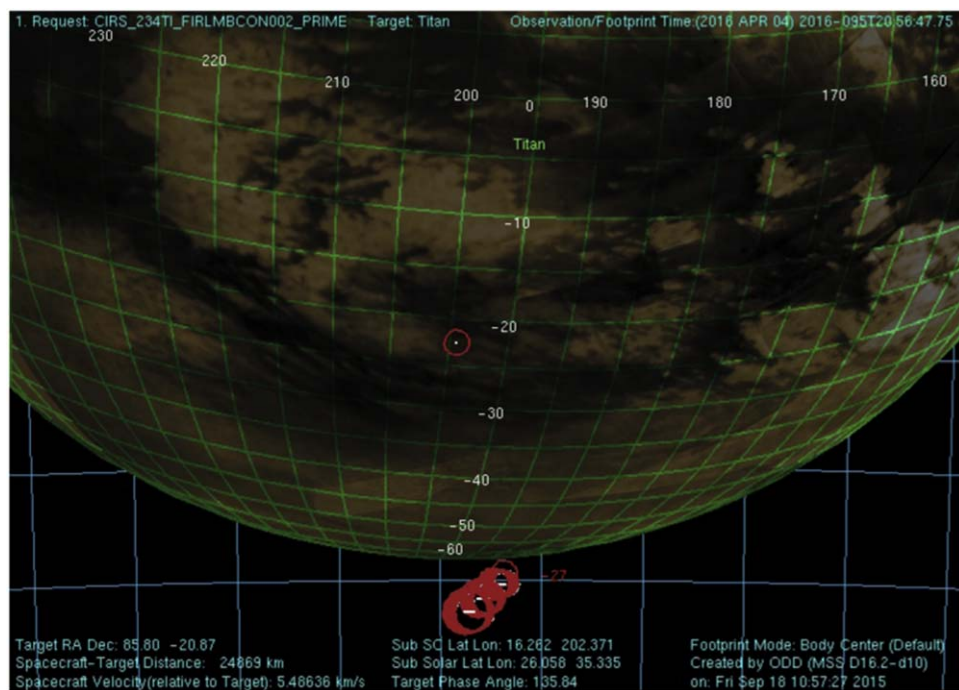
approach of the flyby. The spectral resolution was set to  $3.0\text{ cm}^{-1}$ , with three dwells at 125, 175, and 225 km. See Figure 13.

#### 4.5. FIRLMBWTR

*Science overview:* Water had previously been detected on Titan by the *Infrared Space Observatory* (Coustenis et al. 1998),



**Figure 12.** Example of a CIRS far-infrared limb integration (CIRS\_119TI\_FIRLMBINT002\_PRIME, 2009 October 12, T62) showing integration at two altitudes with CIRS FP1 to measure the vertical gradient of trace gases including  $\text{C}_2\text{N}_2$ ,  $\text{C}_3\text{H}_4$  and  $\text{C}_4\text{H}_2$ . Each altitude was visited twice during a one-hour observation to reduce the difference in size of the projected FOV. FP1 FOV projected size  $\sim 100$  km at time of snapshot.

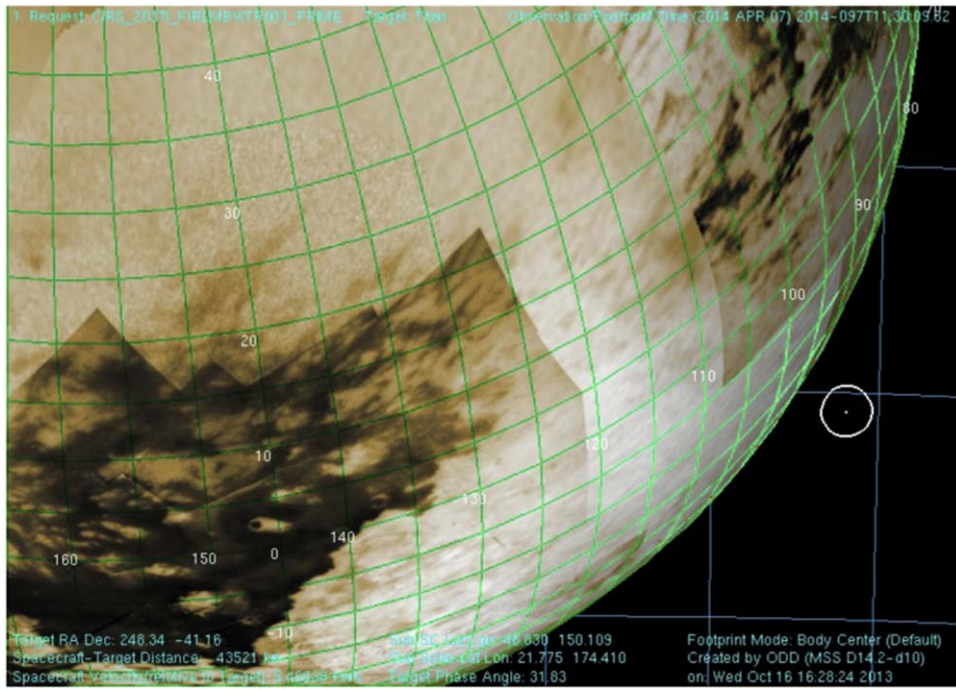


**Figure 13.** Example of a CIRS far-infrared limb condensate observation (CIRS\_234TI\_FIRLMBCON002\_PRIME, 2016 April 4, T118) showing integration at three vertical positions (100, 150, 200 km altitude) to measure concentrations of condensed gas species. FP1 footprints on the disk were due to spacecraft slewing at the start of the observation to arrive at the limb pointing. FP1 FOV projected size  $\sim 97$  km at time of snapshot.

which determined a disk-average abundance. The use of CIRS data, which averaged over multiple FIRLMBINTs to provide a simple vertical profile from abundances retrieved at 125 and 225 km, permitted the first measurement of water on Titan's limb (Cottini et al. 2012b). It was later suggested (S. Hörst 2012, private communication) that a third, intermediate data point at

175 km would help to better distinguish between photochemical model profiles.

*Implementation:* As with the FIRLMBCON, the FIRLMBWTR was performed as a modified FIRLMBINT in the same time/distance window of 75–135 minutes from closest approach. In this case, however, the entire 1 hr period was spent integrating at a



**Figure 14.** Example of a CIRS far-infrared limb water observation (CIRS\_203TI\_FIRLMBWTR001\_PRIME, 2014 April 7, T100) showing a single integration at 175 km with CIRS FP1 to fill in between the 125 and 225 km positions of the FIRLMBINT. FP1 FOV projected size  $\sim 170$  km at time of snapshot.

single altitude of 175 km, intermediate to the usual two FIRLMBINT altitudes, at  $0.5 \text{ cm}^{-1}$  resolution. Due to the very weak water emission, three 1 hr observations at low latitudes were scheduled on T100, T123, and T125 with the intention that these would later be combined to provide a single measurement at 175 km. See Figure 14.

#### 4.6. Spatial and Temporal Coverage of Far-infrared Limb Observations

The coverage of CIRS far-infrared limb observations is shown in Figure 15. Observations (symbols) largely track the limb stationary nodes (points). These provide a huge improvement over the previous limb observations by *Voyager 1* (Coustenis et al. 1991) both in latitude coverage and in time. While the latitude sampling over the entire mission is excellent, different latitudes are mostly sampled at different times, preventing a true global snapshot from being obtained at any one epoch. It is clear from the pattern where the inclined orbits occur (2008–2010 and 2013–2015), where limb viewing is restricted to low latitudes as the flybys took the spacecraft over the polar regions. The consequence is that there are some gaps in spatial and temporal coverage that hinder our attempts to understand the formation and breakup of the polar vortices.

### 5. Mid-infrared Limb Observations

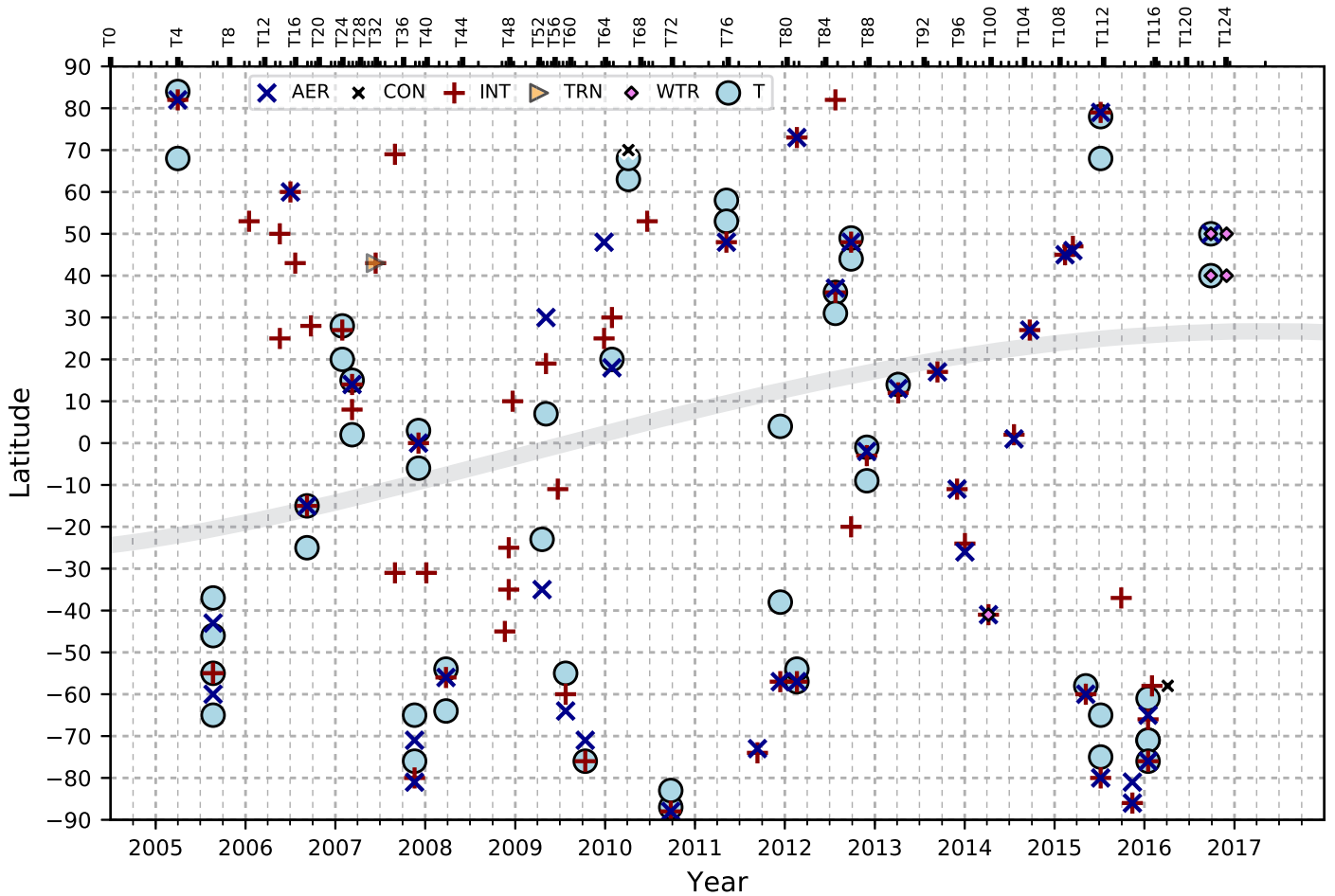
Mid-infrared limb observations were made from 5 to 9 hr from closest approach, or a distance of approximately  $(100\text{--}180) \times 10^3$  km. At the start of the mission, there were two principal types—MIRLMBINT and MIRLMBMAP, which were alternated throughout the mission. Later, an additional type, MIRLMPAIR, was added. Note that unlike FP1, where the single detector was circular and rotations around the detector (approximately equivalent to the  $-Y$  direction of the spacecraft) were unimportant, for CIRS FP3 and FP4 the arrays were linear, and therefore

the array direction (spacecraft secondary axis pointing) was also important. A complete listing of the mid-infrared limb observations is given in Appendix D. Note that the horizon nodes, so crucial for the far-infrared limb observations, were not an important consideration for the mid-infrared limb measurements, as the distance was much greater and therefore the horizon was changing much more slowly.

#### 5.1. MIRLMBMAP

*Science overview:* The mid-infrared limb map (MIRLMBMAP) observation was designed to measure vertical profiles of temperature in Titan’s stratosphere from  $\sim 120\text{--}500$  km, or 5.0 to 0.005 mbar, primarily by modeling/inversion of the  $\nu_4$  band emissions of  $\text{CH}_4$  centered at  $1304 \text{ cm}^{-1}$  (Achterberg et al. 2008a, 2008b, 2011; Teanby et al. 2012, 2017). MIRLMBMAPs have also been used to measure the vertical profile of the most abundant trace gases, such as  $\text{HCN}$ ,  $\text{C}_2\text{H}_2$ , and  $\text{HC}_3\text{N}$  (Teanby et al. 2007), and to observe dynamical redistribution over Titan’s changing seasons (Teanby et al. 2012; Vinatier et al. 2015).

*Implementation:* At 140,000 km range, the mid-infrared arrays 3 mrad in length had a projected size of  $\sim 420$  km. The arrays were positioned perpendicular to Titan’s limb ( $+/-Z$  direction perpendicular to the edge of the disk). Two successive and overlapping pointing altitudes were used with the array centers at 100 km and then 350 km, which also allowed for pointing error by the spacecraft of up to 1 mrad (although in practice pointing accuracy was always better than 0.5 mrad.) If pointing was exact, the arrays covered altitudes  $-120$  to  $+570$  km over both positions. Dwells were performed at each altitude for  $\sim 4$  minutes using the fast acquisition, low spectral resolution mode ( $15 \text{ cm}^{-1}$ ), with the FP3/4 arrays “blinking” between odd and even detector readout on alternate spectra to allow for maximum possible vertical information. The arrays



**Figure 15.** Latitudes and times of CIRS far-infrared limb observations throughout the mission. Different symbols denote different observation types, and the small black points denote horizon-viewing nodes. See text for details. The gray line indicates the subsolar latitude.

were then repositioned to a different limb location. This was notionally an increment of  $5^\circ$  in latitude, although as flyby inclination increased, the horizon circle unavoidably transitioned from latitude (most useful) to longitude (less useful). This may be understood by considering that when viewing Titan from the equatorial plane, the horizon circle includes all latitudes, while from a vantage point above either pole, the horizon circle is the equator, permitting only limb viewing of a single latitude (but multiple longitudes). Altogether, some 15–18 vertical profiles were typically obtained in a 4 hr observation window (see Figure 16).

### 5.2. MIRLMBINT

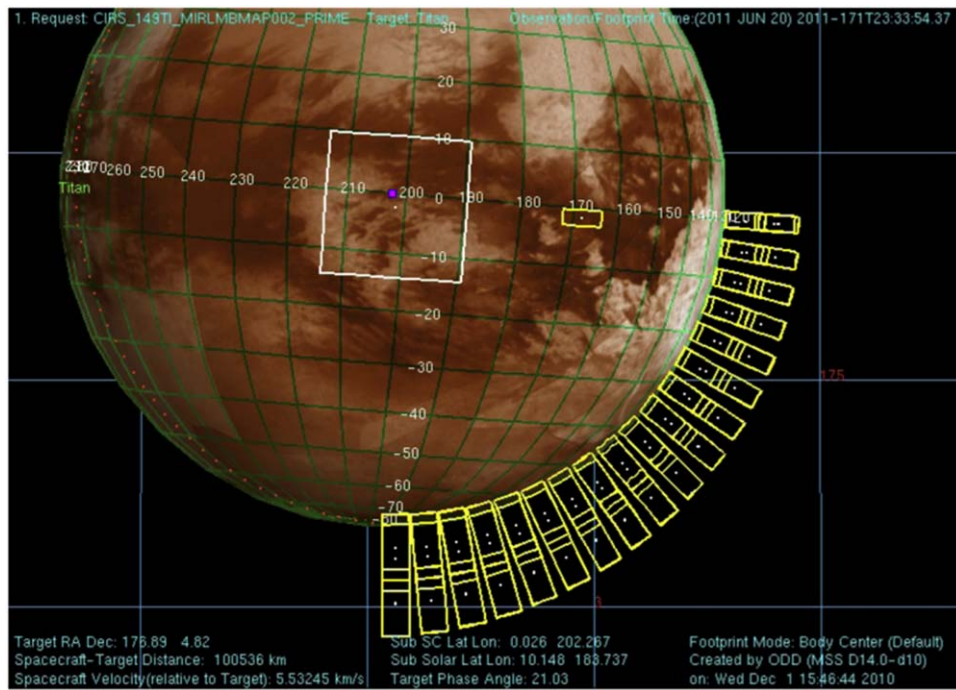
*Science overview:* The mid-infrared limb integrations were designed to measure a single vertical profile of trace gases from  $\sim 100$ – $500$  km, including hydrocarbons, nitriles,  $\text{CO}_2$ , and other species using high spectral resolution ( $0.5 \text{ cm}^{-1}$ ). Many of these were detected on CIRS FP3 ( $600$ – $1100 \text{ cm}^{-1}$ ). FP4 provided vertical temperature information at approximately the same location (although the two arrays were actually side by side, so the locations were not identical). MIRLMBINT data have resulted in numerous publications describing vertical and temporal mapping of trace gases (Teanby et al. 2007, 2008a, 2012, 2017; Vinatier et al. 2007a, 2010b, 2015, 2018; Nixon et al. 2009a; Lombardo et al. 2019b), aerosols (Vinatier et al. 2010a, 2012) and benzene ice (Vinatier et al. 2018). In addition, these data proved invaluable for new detections such

as propene (Nixon et al. 2013a; Lombardo et al. 2019a) and many isotopologues of previously known gas species including  $\text{H}^{13}\text{CN}$  and  $\text{HC}^{15}\text{N}$  (Vinatier et al. 2007b),  $^{13}\text{CH}_4$  and  $^{13}\text{CH}_3\text{D}$  (Bézar et al. 2007; Nixon et al. 2008a, 2012b),  $\text{H}^{13}\text{CCH}$  and  $\text{C}_2\text{HD}$  (Coustenis et al. 2008; Nixon et al. 2008a),  $^{13}\text{CH}_2^{12}\text{CH}_3$  (Nixon et al. 2008a),  $\text{H}^{13}\text{CCCN}$  (Jennings et al. 2008),  $^{13}\text{CO}_2$  and  $\text{CO}^{18}\text{O}$  (Nixon et al. 2008b), and  $\text{H}^{13}\text{CCCCH}$  and  $\text{HC}^{13}\text{CCCH}$  (Jolly et al. 2010).

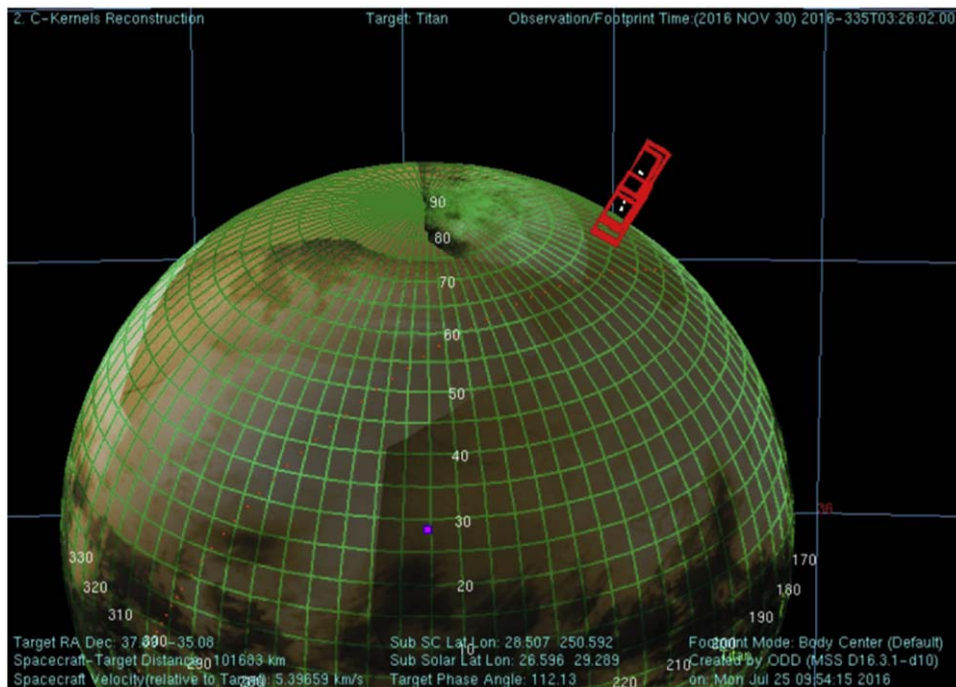
*Implementation:* MIRLMBINT was similar to the MIRLMB-MAP; however, only a single limb location (latitude) was observed, again at two altitudes together covering approximately  $-100$  to  $+600$  km. As with the complementary far-infrared limb integration (FIRLMBINT), the two positions were observed twice for  $\sim 1$  hr each to reduce the difference in projected array size at the two altitudes that would otherwise be incurred due to the spacecraft approaching/receding from Titan. See Figure 17.

### 5.3. MIRLMPAIR

*Science overview:* While the mid-infrared limb integrations were successful in measuring vertical profiles of many known trace gases, CIRS scientists later wished to search more intensively for new, undetected gases and isotopes that may have even weaker signals undetectable in the MIRLMBINTs. As it was impossible to increase spectral resolution beyond the maximum ( $0.5 \text{ cm}^{-1}$ ), the other option was to increase the S/N by acquiring more spectra, including the use of the pair mode (see Section 2.2). Results from modeling of MIRLMBPAIR



**Figure 16.** Example of a CIRS mid-infrared limb temperature map (CIRS\_149TI\_MIRLMBMAP002\_PRIME, 2011 June 20, T77) showing the progressive “stepping” of the mid-infrared detectors around the limb while maintaining a “vertical” (radial) orientation of the arrays. Each yellow rectangle encompasses both FP3 and FP4. Two altitude positions were used at each latitude, with slight vertical overlap to allow for pointing uncertainties. Mid-IR projected array length  $\sim 290$  km at time of snapshot.

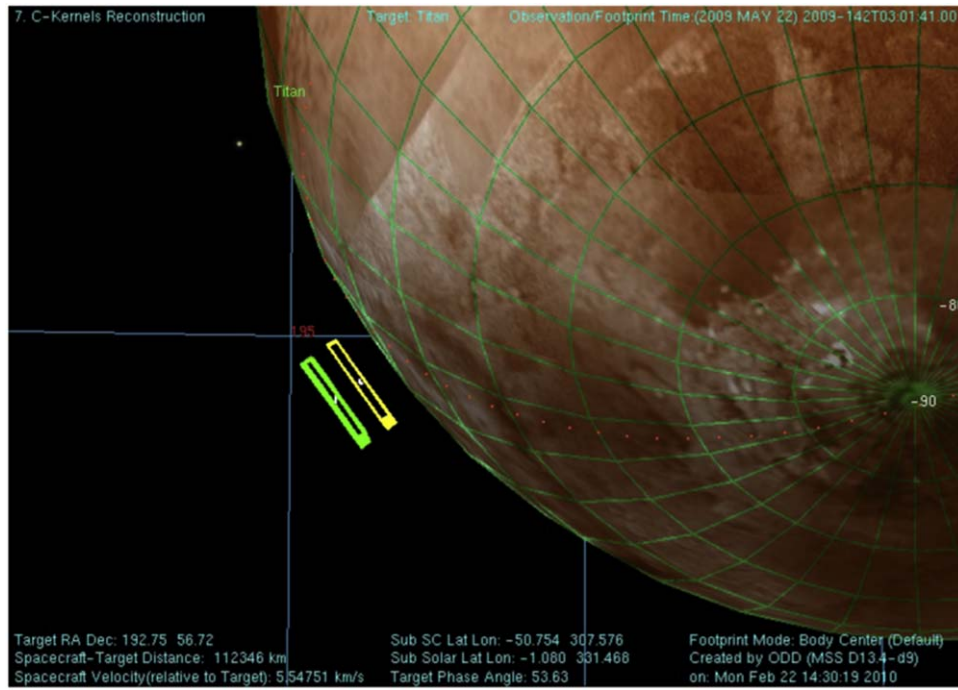


**Figure 17.** Example of a CIRS mid-infrared limb integration (CIRS\_250TI\_MIRLMBINT002\_PRIME, 2016 November 30, T125) showing a limb integration with CIRS FP3/4 to measure the vertical profile of trace gases at a single latitude. Red rectangles indicate the FP3/4 combined footprint, two footprints at lower altitude position, and two at higher altitude position with some overlap. Projected array length  $\sim 295$  km at time of snapshot.

data to search for trace gases and measure isotopes are described in Nixon et al. (2010b, 2012b, 2013b)

*Implementation:* The solution adopted to increase the S/N was to position the arrays parallel to the disk edge, so that all pixels were close to the same altitude (actually, there was a small difference between the pixels at the array ends, which are farther from the horizon, and those at the center). Then all

pixels from either FP3 or FP4 could be coadded into a single spectrum. The spectra were acquired at  $0.5 \text{ cm}^{-1}$  resolution (52 s scans), and the pixels were read out in pair mode, doubling the effective number of spectra compared to the usual odd/even modes that only read out half the pixels at a time. The arrays were maintained at a single position throughout the observation, with the lower array (either FP3 or FP4) at a fixed



**Figure 18.** Example of a CIRS mid-infrared limb “pair” observation (CIRS\_111TL\_MIRLMPAIR002\_PRIME, 2009 May 22, T55) showing integration with the arrays parallel to the limb to allow for coadding of all pixels on each array, used in pair mode. Yellow (lower altitude) array is FP3, and green (upper altitude) array is FP4. Each array spans  $\sim 325$  km in length at the time of the snapshot.

**Table 2**  
MIRLMPAIR Observations

| Altitude         | Latitude |      |
|------------------|----------|------|
|                  | Low      | High |
| FP3 Low/FP4 High | T55      | T64  |
| FP3 High/FP4 Low | T95      | T72  |

altitude; see Figure 18. The observation was repeated on four occasions: twice at low latitude and twice at high latitude. At each latitude, there were two observations: one with FP3 at low altitude (“bottom”) and FP4 above, and a second observation with the reverse configuration (summarized in Table 2).

#### 5.4. Spatial and Temporal Coverage of Mid-infrared Limb Observations

Figure 19 shows the spatial and temporal coverage of the mid-infrared limb observations during the mission. Of principal note is that the limb maps (MIRLMBMAP, blue bars) have a relatively complete coverage in latitude and season. However, as with the far-infrared limb observations, there are some gaps (e.g., late 2008 to early 2009, late 2010, mid 2014) where the highest northern and southern latitudes are not sampled due to the inclined spacecraft orbits. Limb integrations (MIRLMBINT) also exhibit this pattern, although overall there is repeat coverage of low, medium, and high latitudes in each hemisphere during the mission, providing an excellent reference data set for understanding atmospheric circulation and composition.

## 6. Far-infrared Nadir Observations

Far-infrared nadir observations, like the limb observations, are divided into two types: integrations and scans/maps.

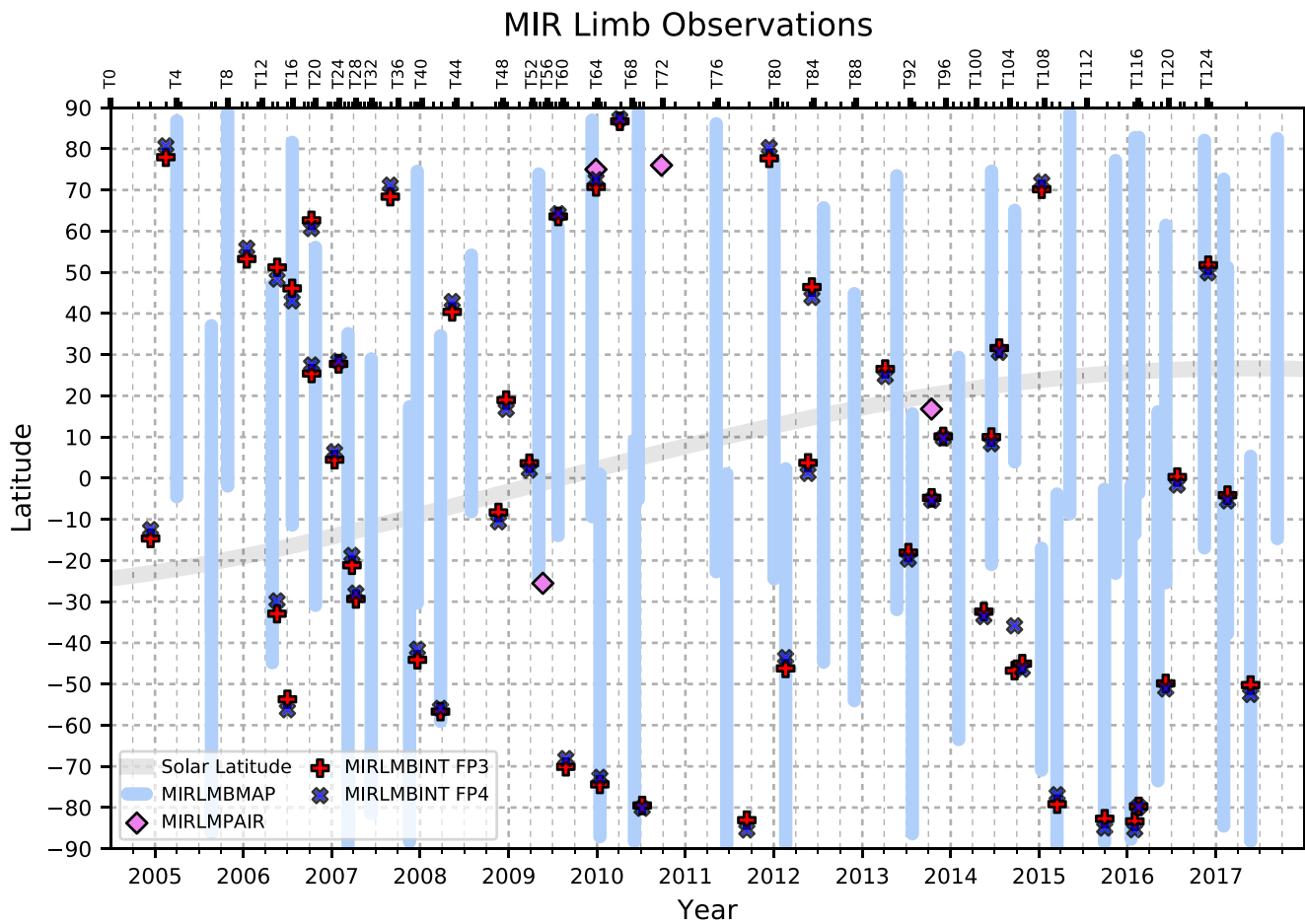
### 6.1. FIRNADMAP (UVIS EUVFUV)

*Science overview:* The far-infrared nadir map observation was designed primarily to measure the temperature of Titan’s surface using a spectral window at  $\sim 530 \text{ cm}^{-1}$  ( $19 \mu\text{m}$ ) where the opacity of both aerosols and collision-induced gas absorption is low (Jennings et al. 2009, 2011, 2016; Cottini et al. 2012a). However, these observations have also been used to measure the spatial variation of condensates (Jennings et al. 2012a, 2015; see also FIRLMBAR). Tropospheric temperatures may also be obtained from the  $\text{N}_2\text{--N}_2$  CIA region at  $50\text{--}150 \text{ cm}^{-1}$  (Lellouch et al. 2014), and the  $\text{N}_2\text{--H}_2$  CIA regions around  $350$  and  $600 \text{ cm}^{-1}$  have been used by Bézard & Vinatier (2019) to infer the  $\text{H}_2$  mole fraction and ortho-to-para ratio in the troposphere.

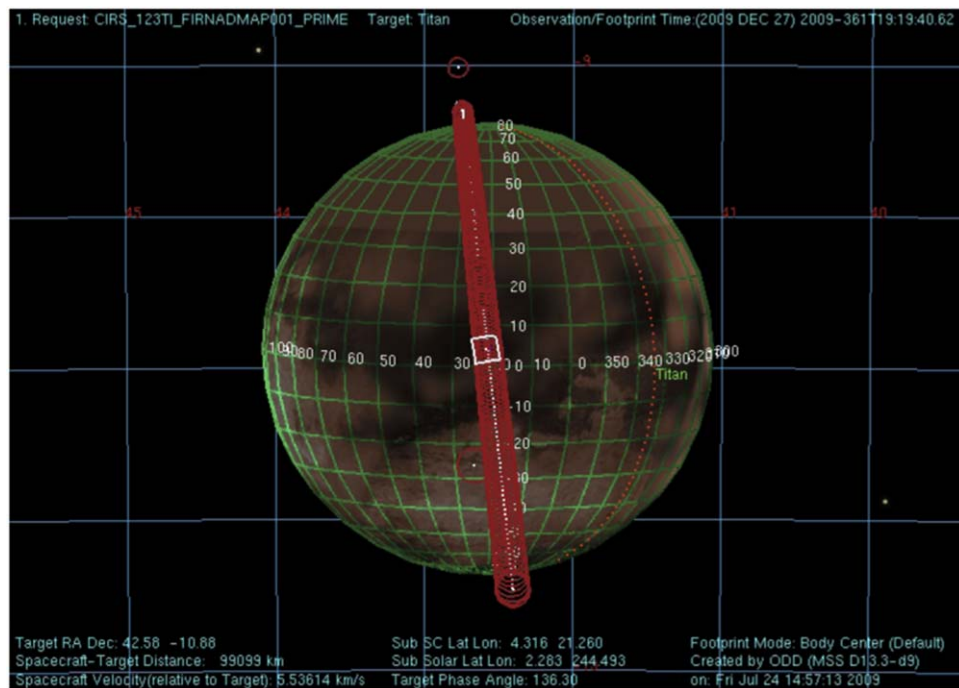
*Implementation:* The observation nominally takes place in the period 02:15 to 05:00 (HH:MM) from closest approach, when the spatial footprint of FP1 is about  $200\text{--}400$  km (see Figure 6). The FP1 detector was typically scanned slowly in a north–south or east–west direction across a diameter of the disk, starting from a position off the limb on dark sky and ending on a dark sky position situated off the disk on the opposite side. The spectral resolution was  $15.0 \text{ cm}^{-1}$ , and the scan speed was  $\sim 7 \mu\text{rad s}^{-1}$ . See Figure 20.

*Variations:* the 2–5 hr time window from Titan closest approach was often requested by other instruments, including RADAR, VIMS, and ISS, resulting in changes to the default template, whereby CIRS might have a shorter time than the nominal 2 hr 45 minutes. In these cases, the scans may have been shortened to cover half a diameter only or to cover a specific part of the visible hemisphere such as Xanadu. Therefore, extracting the exact pointing for the observations from the CIRS archive in the PDS is important.

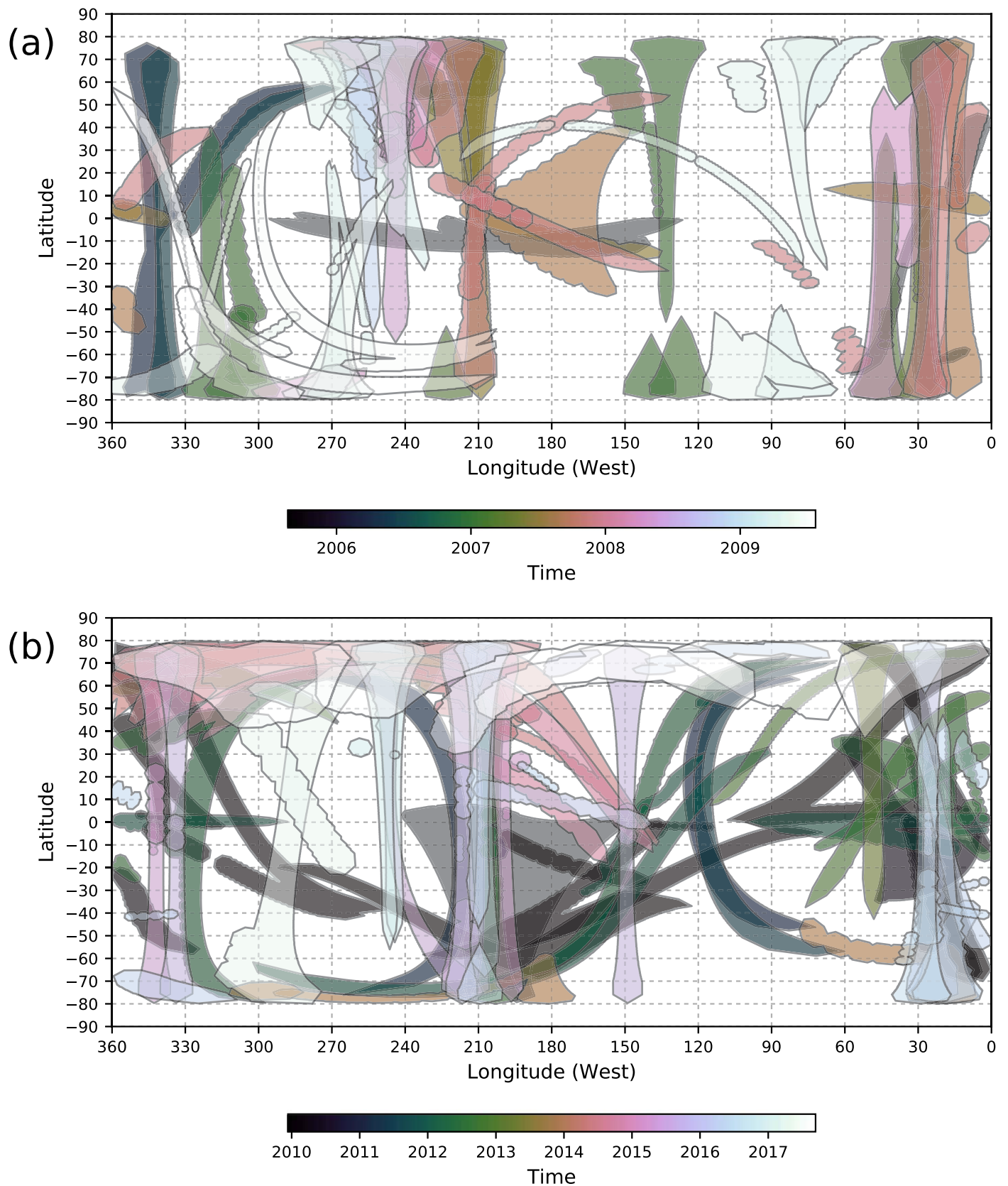
The FIRNADMAP observation was very similar to a UVIS-designed slow scan observation (EUVFUV scan) that took



**Figure 19.** Latitudes and times of CIRS mid-infrared limb observations throughout the mission. Different symbols denote different observation types as described in the text—points are high spectral resolution integrations, while blue bars are low spectral resolution maps. The thick gray line shows the subsolar latitude, indicating advancing seasons.



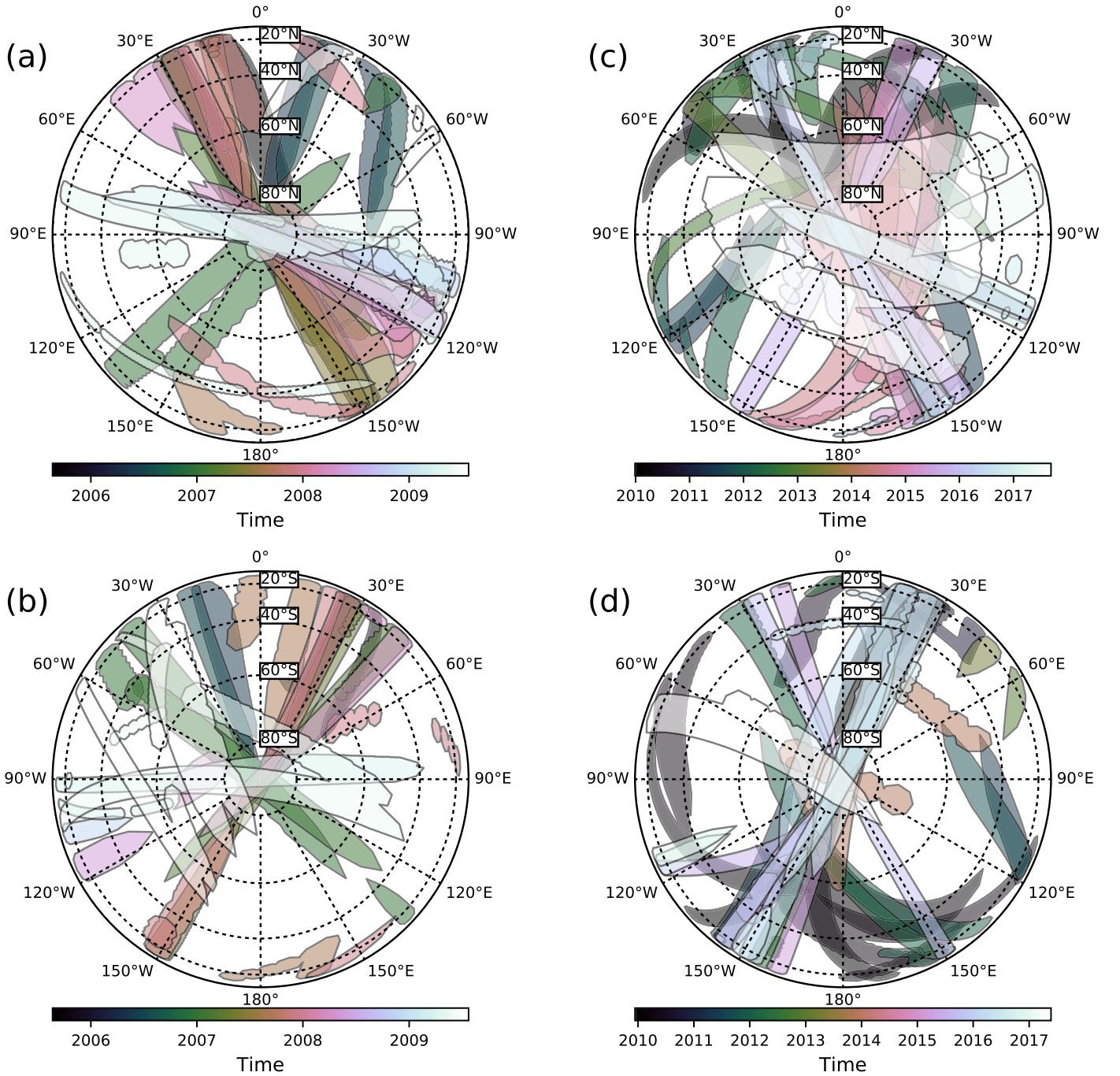
**Figure 20.** Example of a CIRS far-infrared nadir map (CIRS\_123TI\_FIRNADMAP001\_PRIME, 2009 December 27, T64) showing a single slow scan across Titan's disk to measure latitude variation of temperatures of the lower atmosphere and surface. The largest footprint circle (off the south pole) is 386 km in diameter. The white box is the ISS Narrow Angle Camera (NAC) footprint.



**Figure 21.** Coverage maps of CIRS far-infrared nadir-mapping observations (FIRNADMAP) in cylindrical projection for (a) the early mission, 2004–2010, and (b) the late mission, 2010–2017.

place typically 2–7 hr from closest approach to map airglow across an entire hemisphere by sweeping a linear detector array. CIRS acted as a “rider” taking data on these observations, and

they are considered equivalent to the FIRNADMAP for CIRS data analysis purposes. The CIRS ride-along observations with EUVFUV were initially labeled in the form



**Figure 22.** Coverage maps of CIRS far-infrared nadir-mapping observations (FIRNADMAP) in polar projection for the early mission, 2004–2010, northern (a) and southern (b) hemispheres, and the late mission, 2010–2017, northern (c) and southern (d) hemispheres.

CIRS\_nnnFIRNADMAPnnn\_UVIS (where “nnn” are numbers) but later switched to CIRS\_nnnEUVFUVnnn\_UVIS to further distinguish these from the CIRS-designed FIRNADMAPs (see Appendix E).

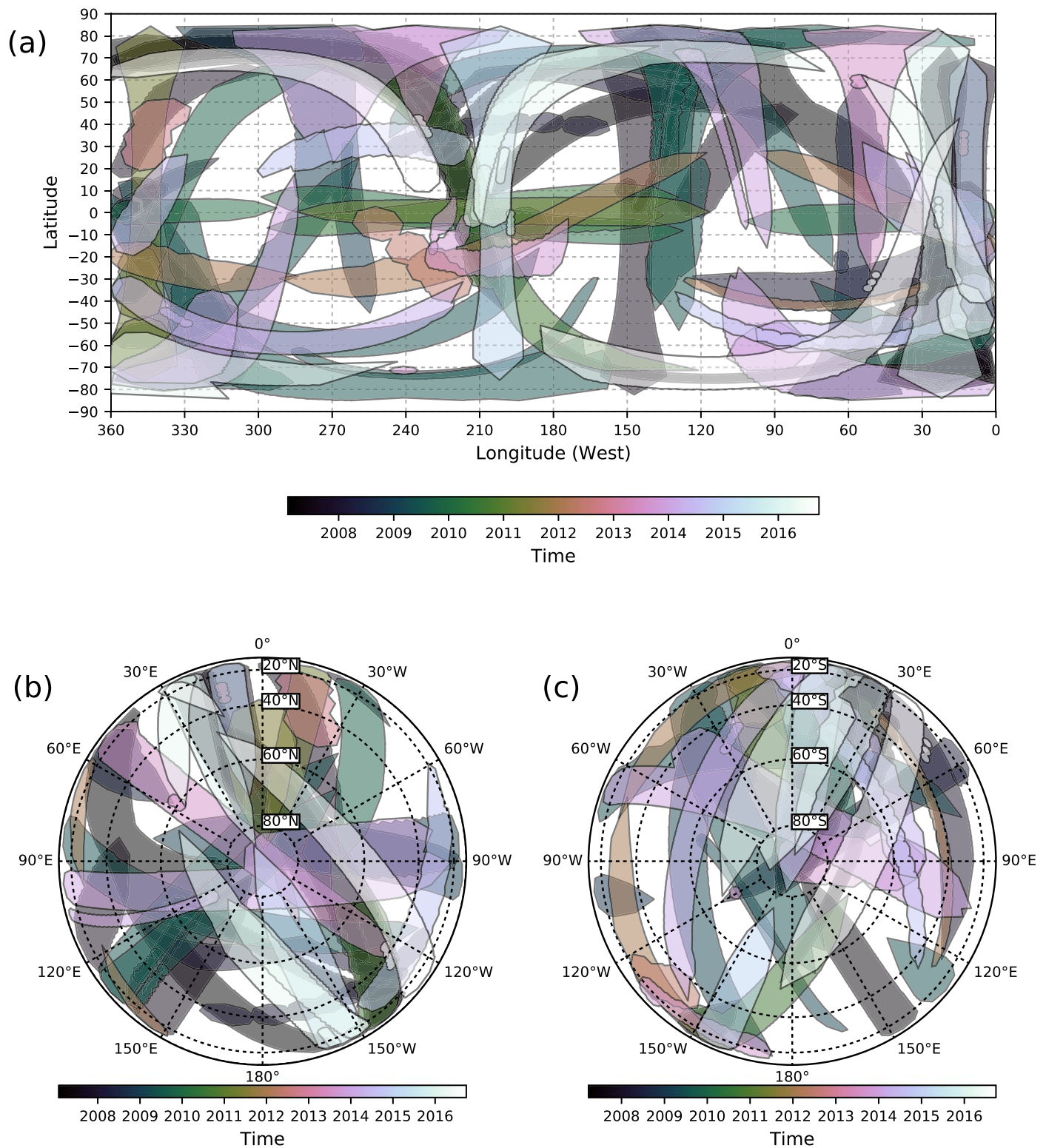
### 6.2. FIRNADMAP: Coverage

Coverage of CIRS FIRNADMAP observations in cylindrical projection is shown in Figure 21, divided into early (2004–2010) and late (2010–2017) mission phases for clarity of viewing. Due in part to the map projection, and also the typically equatorial viewing geometry from the spacecraft, there is substantial “stretching” of the FOV footprint near the

poles. Figure 22 shows the same information but plotted in polar projection, producing less distortion, although the stretching of the FOV footprint at high latitudes is still evident where the spacecraft was viewing from low latitudes. Finally, Figure 23 shows the coverage of the complementary UVIS EUVFUV maps in both rectangular and polar projection for the entire mission.

### 6.3. FIRNADCMP

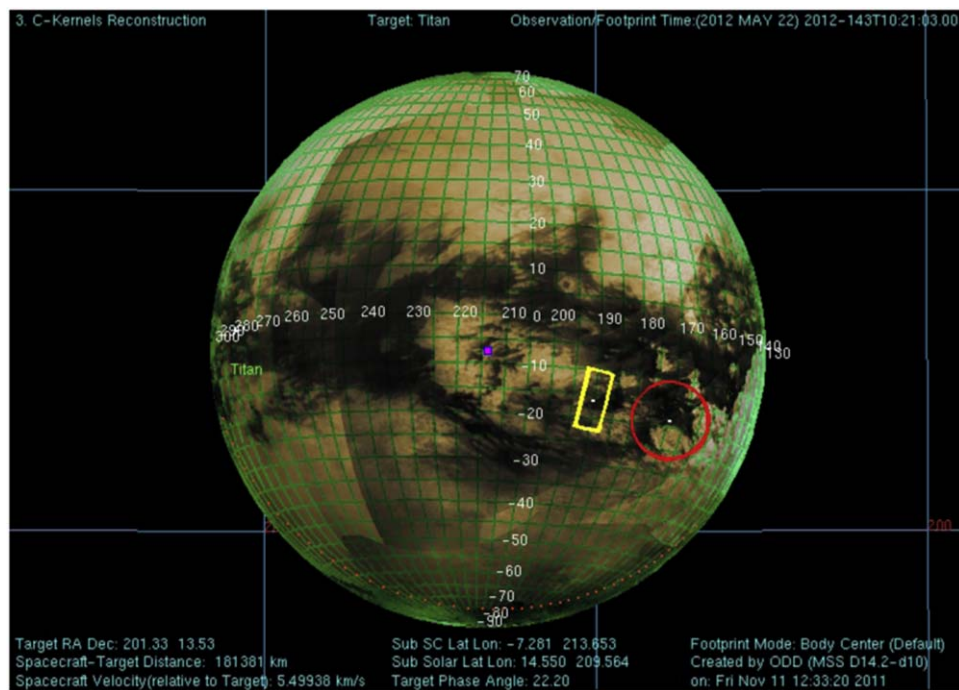
*Science overview:* The far-infrared nadir composition integrations (FIRNADCMP) were designed to complement the far-infrared limb integrations (FIRLMBINT) by providing



**Figure 23.** Coverage maps of UVIS EUV/FUV observations, equivalent to CIRS FIRNADMAP in cylindrical (a) and polar (b), (c) projections.

latitude–longitude spatial coverage with high spectral resolution and S/N, although without vertical resolution. The principal science goals were to measure the abundances of HCN, CO, H<sub>2</sub>O, and CH<sub>4</sub> through their far-infrared rotational lines (de Kok et al. 2007b; Lellouch et al. 2014); hydrocarbons (C<sub>3</sub>H<sub>4</sub>, C<sub>4</sub>H<sub>2</sub>) and nitriles (C<sub>2</sub>N<sub>2</sub>, HC<sub>3</sub>N) can also be measured (de Kok et al. 2008; Teanby et al. 2009b; Sylvestre et al. 2018). Due to the

time and distance from closest approach (nominally 9–13 hr, or  $(180\text{--}260) \times 10^3$  km), these became the most frequent and numerous of all CIRS Titan observations. In addition to the desired FP1 science, large amounts of FP3 and FP4 data were acquired in nadir mode at  $0.5\text{ cm}^{-1}$  resolution. These FP3 and FP4 data were used for many purposes: to map latitude variations of trace gases (e.g., Coustenis et al. 2007, 2010;



**Figure 24.** Example of a CIRS far-infrared nadir composition integration (CIRS\_166TI\_FIRNADCMP001\_PRIME, 2012 May 22, T83) showing a long-duration integration with CIRS FP1 (red circle) on Titan’s disk to measure the abundances of trace gases in the far-infrared. FP1 spans 705 km diameter at the time of the snapshot, while FP3/4 (yellow rectangle) is 525 km in length.

Teanby et al. 2010a; Bampasidis et al. 2012; Coustenis et al. 2013, 2016, 2018; see also MIDIRTMAP), to measure isotopic ratios of hydrocarbons (Nixon et al. 2008a), and to search for new species (Jolly et al. 2015).

*Implementation:* The FP1 detector was positioned at approximately  $45^{\circ}$ – $60^{\circ}$  emission angle, or about two-thirds of the way between the disk center and the disk edge. Where possible, the detector was rotated so that FP3 and FP4 were also on the disk. The instrument then dwelled for typically  $\sim 90$  minutes, bracketed on either side by shorter integrations on deep space, about 1000 km above the limb. Observations of more than 3–4 hr were broken up with an additional one, or in some circumstances by two deep space calibration observations of about 30 minutes between the science time blocks on Titan’s disk. See Figure 24.

#### 6.4. FIRNADCMP: Coverage

Figures 25 and 26 show mission coverage of the far-infrared nadir composition integrations in cylindrical and polar projections, respectively. It is evident that these numerous observations achieved excellent spatial and temporal coverage. See also Appendix F for a complete listing of FIRNADCMP observations.

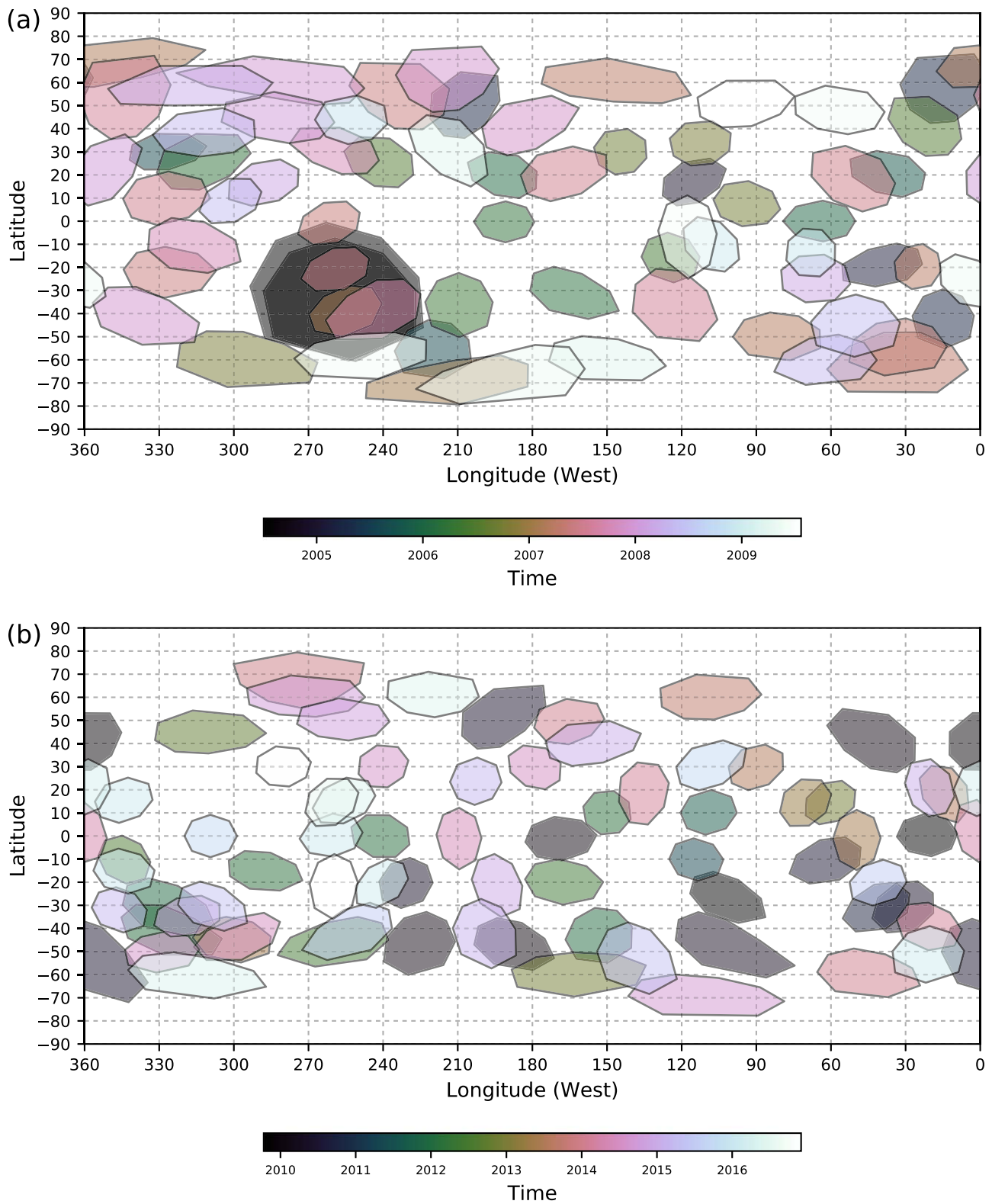
### 7. Mid-infrared Nadir Observations

Mid-infrared nadir observations were the least constrained by detector footprint, because FP3/4 have the smallest projected pixel size. This meant that even at significant distances ( $300$ – $500$ )  $\times 10^3$  km or more from Titan—outside the range in which the limb could be resolved—there was still significant science that could be achieved by mapping the visible disk in nadir mode. Indeed, these proved to be invaluable for monitoring the temperatures and dynamics at a “planetary” scale as the seasons progressed.

#### 7.1. MIDIRTMAP and TEMPMAP

*Science overview:* The mid-infrared temperature map observation was designed as a map of the visible hemisphere at medium spectral resolution ( $3 \text{ cm}^{-1}$ ) primarily to allow temperature retrievals from the  $\nu_4$  band of methane at  $1305 \text{ cm}^{-1}$ . Subsequently, the temperatures retrieved could be converted into wind fields via the thermal wind equation, allowing for Titan’s changing global circulation to be tracked. MIDIRTMAP observations have proved essential for mapping of Titan’s global stratospheric temperature and wind fields; see, for example, Flasar et al. (2005) and Achterberg et al. (2008b, 2011). Due to the excellent spatial coverage and medium spectral resolution, MIDIRTMAP observations have been widely used for not only temperature retrievals, but also for mapping the more abundant trace gases such as  $\text{C}_2\text{H}_2$ , HCN, and  $\text{C}_2\text{H}_6$  (Teanby et al. 2006, 2008b, 2009c, 2010b, 2017, 2019; Coustenis et al. 2007, 2013; Bampasidis et al. 2012), and for measuring Titan’s total emitted power (Li et al. 2011; Li 2015). The combined latitudinal and longitudinal coverage has been used to determine a tilt in the atmospheric rotation axis relative to Titan’s solid body from the temperature field (Achterberg et al. 2008a) and trace gases (Teanby et al. 2010c). In addition, medium spectral resolution FP1 data from the MIDIRTMAPS have been used for retrievals of Titan’s  $\text{H}_2$  abundance from the  $\text{H}_2$ – $\text{N}_2$  dimer at  $\sim 360 \text{ cm}^{-1}$  (Courtin et al. 2012).

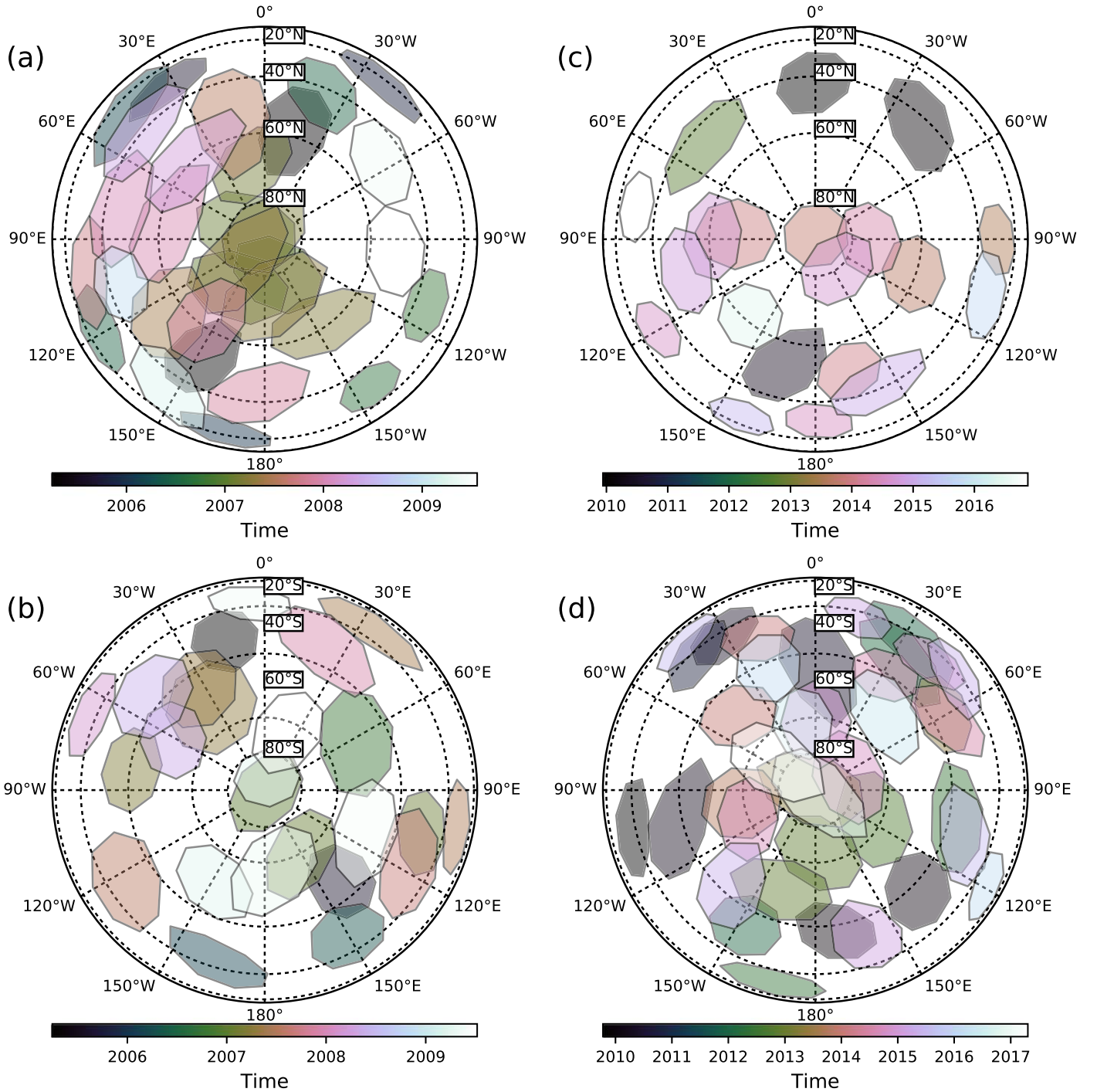
*Implementation:* MIDIRTMAP was a “workhorse” observation for CIRS that was performed on almost every flyby on either the inbound leg of the flyby, the outbound leg, or both. This observation was commonly used because the range at 13–19 hr from C/A ( $(260$ – $480) \times 10^3$  km) was not in high demand for measurements by other instruments, with the exception of cloud monitoring by ISS. The observation was performed using the “pushbroom mapping” method, where the



**Figure 25.** Coverage maps of CIRS far-infrared nadir composition integrations (FIRNADCMP) in cylindrical projection for (a) the early mission, 2004–2010, and (b) the late mission, 2010–2017. Note that the circular FP1 detector is plotted as an octagon, because pointing information is stored for the detector center and eight evenly spaced points around the circumference.

FP3 and 4 arrays were slowly scanned across the visible disk in several (typically four to seven) parallel tracks to map the entire disk. The scan rate was  $\sim 4 \mu\text{rad s}^{-1}$  and tracks overlapped slightly ( $\sim 20\%$ ) to prevent any gaps in coverage. In the early part of the mission, the observations were usually preceded and

followed by a “stare” (integration) on deep space significantly away from the atmosphere. Later, this function was performed instead by dedicated deep space calibration observations (“DSCAL”) by CIRS made during spacecraft downlinks (data relay to Earth), so the “embedded” deep space calibration



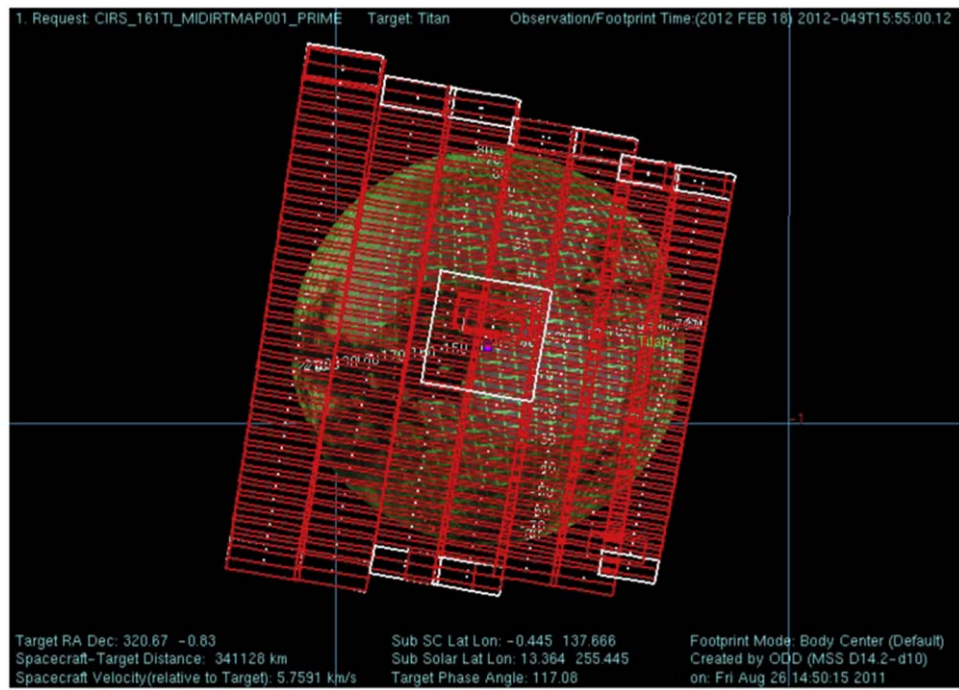
**Figure 26.** Coverage maps of CIRS far-infrared nadir composition integrations (FIRNADCMP) in polar projection for the early mission, 2004–2010, northern (a) and southern (b) hemispheres, and the late mission, 2010–2017, northern (c) and southern (d) hemispheres. Note that the circular FP1 detector is plotted as an octagon, because pointing information is stored for the detector center and eight evenly spaced points around the circumference.

blocks within observations gradually disappeared from usage. See Figure 27.

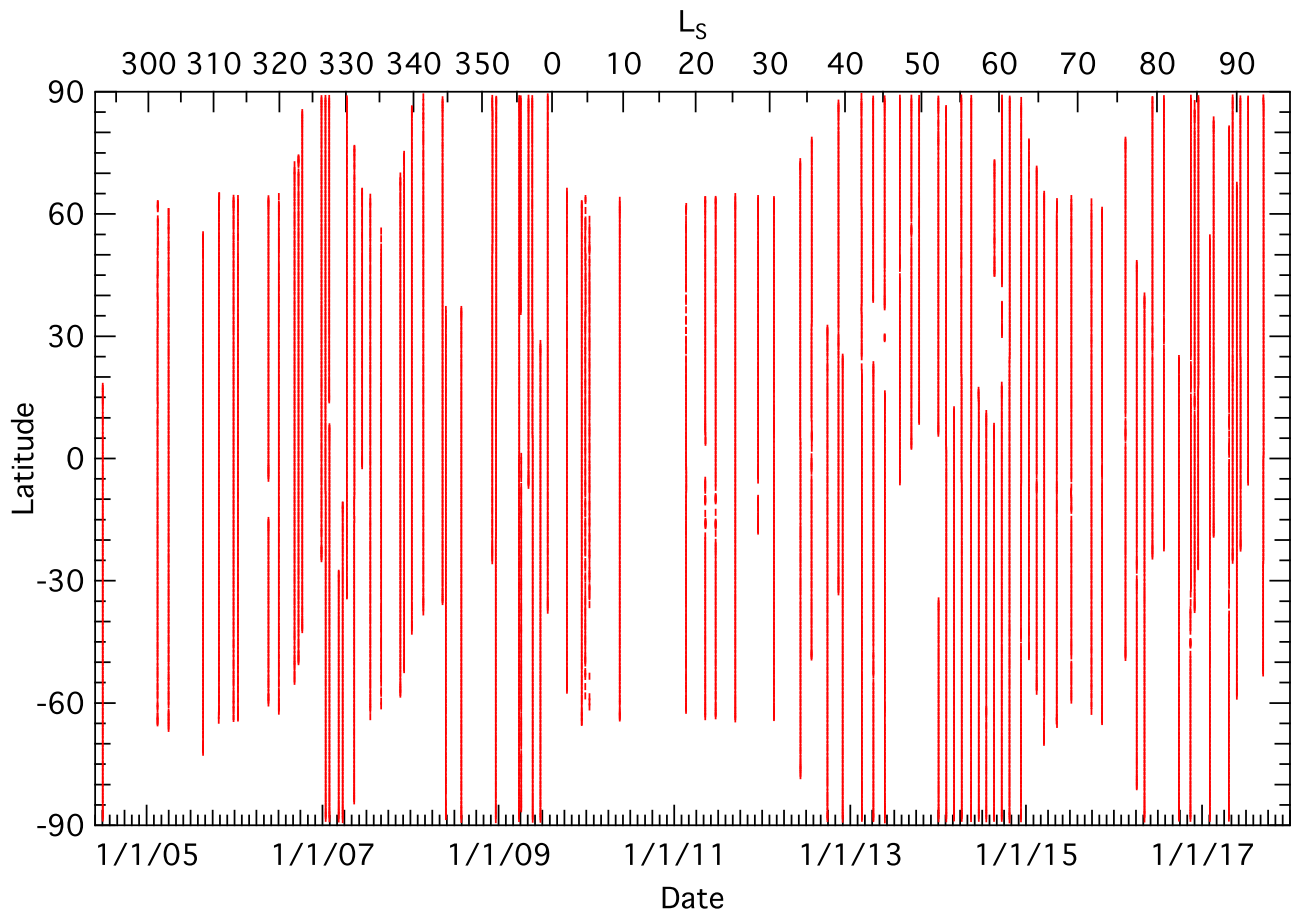
**Variations:** The label “TEMPMAP” was used early in the mission for more distant MIDIRTMAP observations that fell outside of a canonical TOST period—a segment of the *Cassini* timeline designated as a Titan encounter time block. These typically have lower spatial resolution (i.e., larger detector footprints on Titan) than normal MIDIRTMAPs, and correspondingly fewer and shorter angular scans of the arrays to cover the disk, but otherwise accomplish the same mid-infrared

nadir-mapping goal. After the end of the PM, from 2008 onward, the TEMPMAP designation was deprecated, and all observations of this type became MIDIRTMAPs, or the time was used for integrations instead.

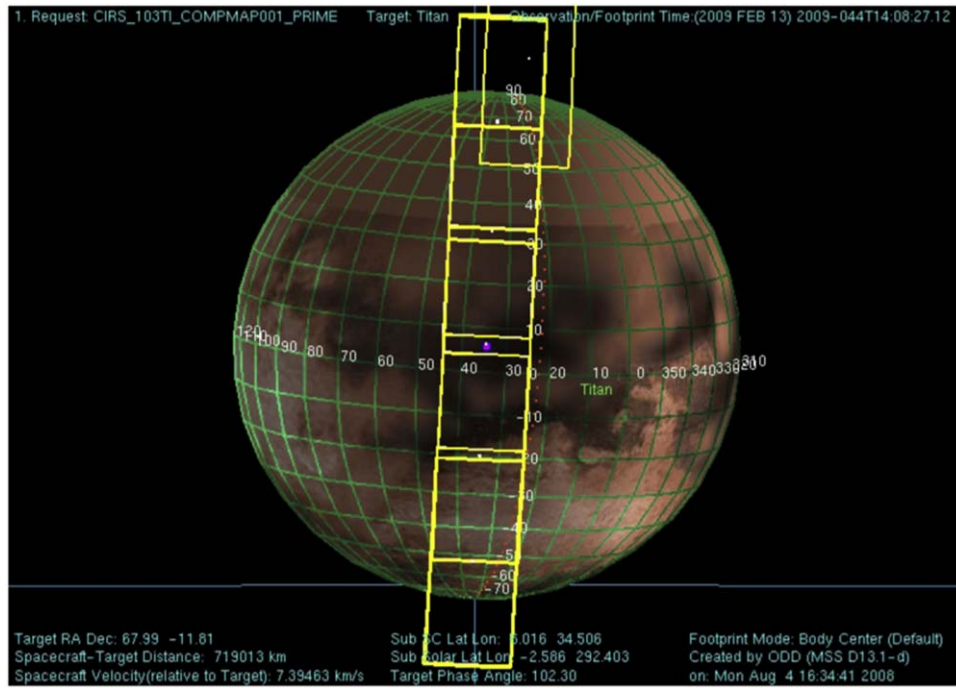
In the late mission, many MIDIRTMAPs were cut short by downlinks that increasingly were moved inward in time, shortening the Titan observation block (a.k.a. the “TOST segment,” after the TOST working group) especially on the unlit (night) side, whether inbound or outbound. In these cases, MIDIRTMAPs that were notionally 6 hr in length were



**Figure 27.** Example of a CIRS mid-infrared temperature map (CIRS\_161TI\_MIDIRTMAP001\_PRIME, 2012 February 18, T82) showing a disk-mapping observation with FP3/4 in “pushbroom” format to measure stratospheric temperatures across the visible disk. Each rectangle is a combined FP3/4 footprint, with the final (largest) footprint spanning 990 km in length. The white box is the ISS Narrow Angle Camera (NAC) footprint.



**Figure 28.** Coverage of CIRS mid-infrared temperature maps in latitude and time during the mission.  $L_s$  indicates the solar longitude, the position angle of the planetary rotation axis relative to the Sun, where  $0^\circ$  is by convention the vernal equinox at the start of northern spring.



**Figure 29.** Example of a CIRS distant composition integration (CIRS\_103TI\_COMPMAP001\_PRIME, 2009 February 13) showing the mid-infrared detector arrays repositioned at several locations to straddle Titan’s disk to obtain a 1D profile of trace gases. Each yellow rectangle is the combined FP3/4 footprint, spanning about 2085 km at time of snapshot.

sometimes cut down to 3–4 hr, resulting in only partial disk maps. In the final months of the mission, during the “F-ring” and “proximal” orbits at high inclination with repeated distant Titan encounters, MIDIRTMAPs were often performed as multiple short blocks, interspersed with ISS “mosaic” observations designed to search for clouds.

### 7.2. MIDIRTMAP: Coverage

Coverage of mid-infrared temperature maps in latitude and time is shown in Figure 28. Aside from a loss of high latitude coverage from 2010 to 2012 due to spacecraft-viewing geometry, overall coverage during the mission is excellent, permitting a wide-ranging survey of Titan’s atmospheric dynamics (winds and circulation). For a full list of these observations, see Appendix G.

### 7.3. COMPMAP and TEA

*Overview:* These were the most distant Titan observations performed by CIRS, occurring at distances  $(0.5\text{--}2.0) \times 10^6$  km. They were very distant integrations at high spectral resolution ( $0.5\text{ cm}^{-1}$ ), usually designed to measure a single section (either N–S or E–W) of trace gas abundances across the disk (Teanby et al. 2006, 2008b, 2010b). The COMPMAP (composition map) name was used when the observation occurred in a regular TOST segment, while in the later mission phases the name TEA was used instead (Titan Exploration at Apoapse) when the observation took place in a non-TOST observation block, and usually at greater range than COMPMAP. See also the observation listing in Appendix H.

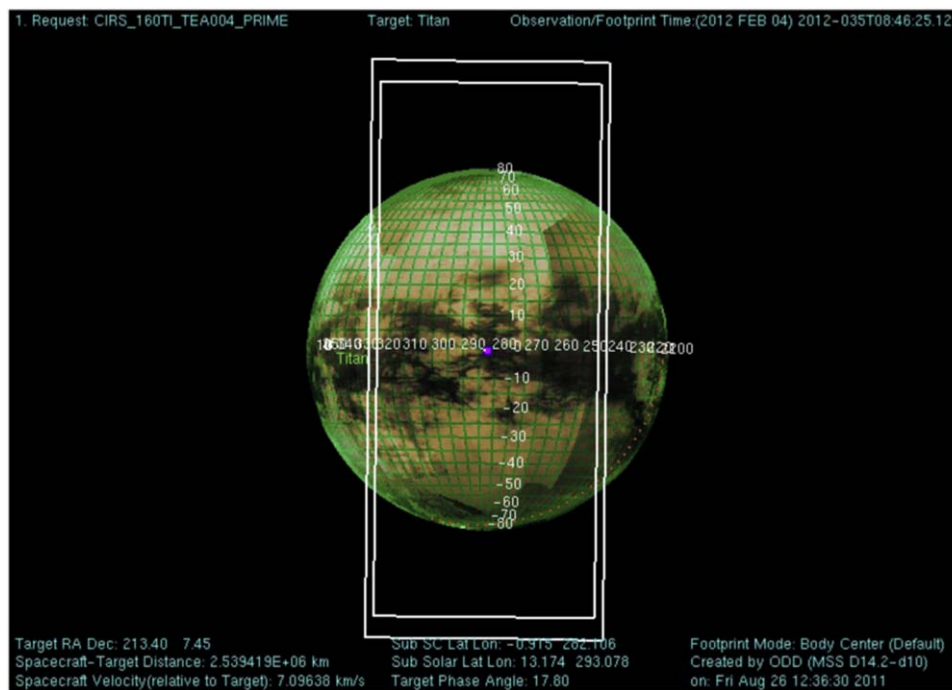
*Implementation:* The FP3/4 arrays were positioned to span Titan’s disk in one to five positions, with long dwells at each position to build up the S/N. COMPMAP varieties tended to be at somewhat closer distances than TEAs and typically had

two or more pointings (Figure 29), whereas the TEAs had only one (Figure 30).

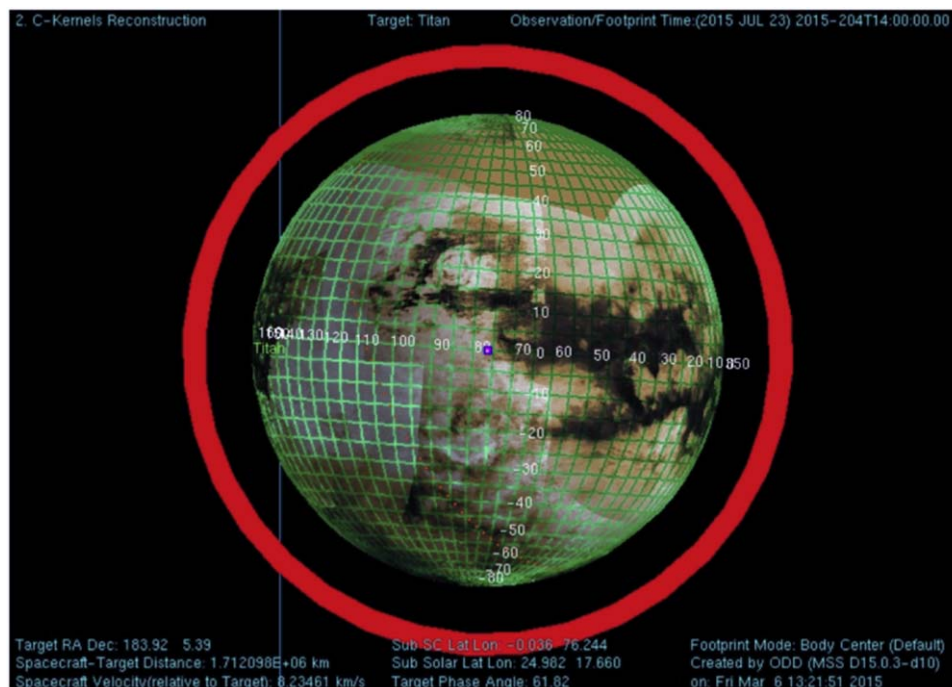
*Variations:* Several very distant TEA observations were specially designed to place Titan entirely within the FP1 pixel for comparison with far-infrared unresolved observations made with *ISO* (Coustenis et al. 1998) and *Herschel* (Moreno et al. 2012), as published in Bauduin et al. (2018; see Figure 31).

## 8. Summary and Conclusions

Table 3 summarizes the number of each type of observation performed, the observation times, numbers of spectra, and data volumes, showing that substantial amounts of data were taken across all observation types. One striking conclusion is that the original nine types of observations (Table 1), planned long before orbit insertion, remained in use throughout the entire 17 yr mission with only minor modifications, a strong testament to the thoughtful forward planning that was put into constructing the standard observation templates. In this process, the *Cassini* CIRS team benefited from many personnel having previous experience with *Voyager* IRIS observations of Titan. The use of these standard observation-type formats greatly facilitated the planning of CIRS observations during 127 flybys of Titan. There is no doubt that designing new and different observations for each flyby would not only have put a much larger burden on the science planning and instrument commanding, but would also have made the data much less useful by complicating the intercomparison of data from observations on different flybys. Though the evolved observation types were used to a much lesser extent, they provided valuable data for some specific science cases and filled in some key gaps left by the standard observation templates. The conclusion is that flexibility and adaptation is important, alongside standardization.



**Figure 30.** Example of a CIRS TEA (“Titan Exploration at Apoapse”) observation (CIRS\_160TI\_TEA004\_PRIME, 2012 February 4) showing the mid-infrared arrays centered across Titan’s disk to obtain a 1D profile of trace gases. The white rectangle shows the combined FP3/4 footprint, about 7340 km in length for the larger footprint.



**Figure 31.** Distant TEA observation CIRS\_219TI\_TEA001\_PRIME (2015 July 23) at a range of 1.7m km designed to place Titan entirely within the FP1 FOV to measure a far-infrared disk-average spectrum for comparison to *ISO* and *Herschel* data. The largest footprint depicted here is 6670 km, about 1500 km larger than Titan’s solid body.

Although the CIRS Titan observing campaign was highly successful, going beyond the expectations and requirements of the mission and instrument design, there were nevertheless restrictions on the science that were imposed by the mission and instrument characteristics. For the purpose of planning successor missions, it is important therefore to consider the limitations of the current data set:

1. *Coverage:* *Cassini* averaged 10 flybys of Titan per Earth calendar year, or about 25 per Titan “month” (1/12 of a Titan year, or 2.5 Earth years). However, due to the different orbital inclinations, flyby distances, and divisions of time between *Cassini* instruments on each flyby, both spatial and temporal coverage remains incomplete. Coverage is more complete for the more distant

**Table 3**  
Summary of Acquired CIRS Titan Data

| Observation Type | PRIME MISSION |            |              |           | EQUINOX MISSION |            |              |           | SOLSTICE MISSION |            |              |           |
|------------------|---------------|------------|--------------|-----------|-----------------|------------|--------------|-----------|------------------|------------|--------------|-----------|
|                  | #             | Total Time | Num. Spectra | Data (MB) | #               | Total Time | Num. Spectra | Data (MB) | #                | Total Time | Num. Spectra | Data (MB) |
| FIRLMBT          | 9             | 05:21:00   | 43212        | 74        | 6               | 03:31:20   | 27648        | 50        | 18               | 11:39:00   | 81996        | 163       |
| FIRLMBABER       | 9             | 05:23:00   | 42765        | 75        | 8               | 04:56:40   | 39735        | 71        | 30               | 18:12:00   | 134807       | 259       |
| FIRLMBINT        | 20            | 17:39:00   | 13638        | 254       | 11              | 11:42:00   | 9581         | 168       | 30               | 29:27:00   | 24193        | 410       |
| FIRLMBCON        | 0             | 00:00:00   | 0            | 0         | 1               | 01:00:00   | 3279         | 14        | 1                | 01:10:00   | 3763         | 15        |
| FIRLMBWTR        | 0             | 00:00:00   | 0            | 0         | 0               | 00:00:00   | 0            | 0         | 3                | 02:53:00   | 2291         | 40        |
| FIRNADMAP        | 25            | 49:52:00   | 342800       | 599       | 15              | 34:35:48   | 230653       | 368       | 35               | 94:46:00   | 625336       | 1095      |
| EUVFUV           | 27            | 111:09:24  | 642448       | 1086      | 15              | 91:41:55   | 383166       | 809       | 26               | 158:35:01  | 840383       | 1620      |
| MIRLMBINT        | 19            | 59:55:00   | 45779        | 834       | 9               | 33:20:00   | 23511        | 422       | 25               | 99:25:40   | 78609        | 1302      |
| MIRLMBMAP        | 15            | 48:19:00   | 312133       | 645       | 6               | 24:08:00   | 179270       | 318       | 26               | 102:15:00  | 774009       | 1345      |
| MIRLMPAIR        | 0             | 00:00:00   | 0            | 0         | 2               | 08:00:00   | 6404         | 115       | 2                | 07:00:00   | 5579         | 100       |
| FIRNADCMP        | 68            | 251:35:00  | 186369       | 3524      | 30              | 111:22:33  | 74083        | 1573      | 74               | 286:25:06  | 222175       | 3916      |
| MIDIRTMAP        | 41            | 226:33:03  | 494729       | 2227      | 23              | 110:06:03  | 228900       | 987       | 88               | 471:10:23  | 1324522      | 5447      |
| COMPMAP          | 34            | 257:51:09  | 193514       | 3656      | 6               | 39:11:00   | 27836        | 451       | 28               | 163:07:00  | 111984       | 2237      |
| TEMPMAP          | 18            | 72:09:00   | 216905       | 945       | 0               | 00:00:00   | 0            | 0         | 0                | 00:00:00   | 0            | 0         |
| TEA              | 0             | 00:00:00   | 0            | 0         | 0               | 00:00:00   | 0            | 0         | 34               | 601:27:00  | 406303       | 7601      |

observations (e.g., MIDIRTMAP) and much more sparse for close-in observations (e.g., FIRLMBINT). Far-infrared limb observations in general fell into a high-demand observation period near closest approach and were therefore more sparsely observed, with the least complete spatial and temporal coverage.

2. *Spatial resolution:* For the far-infrared in particular, observations were frequently limited by the large footprint size of the detector. This meant that observations needed to be made very close to Titan for limb viewing, and even these had a rather large footprint on the limb, never resolving better than a scale height. Similarly, the nadir measurements such as FIRNADMAP were limited to large footprints and were consequently unable to search for phenomena such as temperature anomalies at sub 100 km scales that could be due to differing thermal inertias of lakes, craters, mountains, or any geothermal activity.
3. *S/N:* The FP1 bolometer detector was limited by a lower S/N compared to the mid-infrared detectors, which used a more sensitive technology (photoconductive and photovoltaic band-gap semiconductor for FP3 and FP4 respectively). This became a limiting factor in searching for new gas species and condensates the far-infrared.
4. *Spectral Resolution:* The CIRS highest spectral resolution of  $0.5 \text{ cm}^{-1}$  was a large improvement over *Voyager* IRIS ( $4.3 \text{ cm}^{-1}$ ), but nevertheless the resolution proved limiting in some cases. This was especially true when trying to detect new trace gases with emissions that may be blended with stronger overlying gas bands from molecules such as  $\text{CH}_4$ ,  $\text{C}_2\text{H}_6$ , and  $\text{C}_2\text{H}_2$ . Higher spectral resolution on future instruments may help to tease apart the emission of trace gases and isotopes currently blended with other emissions.

If a future Saturn system mission includes a touring spacecraft (like *Cassini*), with multiple Titan flybys, then low-inclination flybys are clearly preferable scientifically for a CIRS-like instrument. This is because arguably the most important information provided by CIRS is the vertical atmospheric (limb) profiles of temperature and abundance, which can be mapped

across all latitudes only during low-inclination flybys where the horizon circle encompasses all latitudes. On high-inclination flybys, on the other hand, the horizon circle is near-equatorial, limiting the latitudinal information that can be obtained. High-inclination flybys do provide the opportunity for surface temperature mapping of polar regions, although in practice no variation with topography or lakes has yet been measured and only a slow variation with latitude, due to Titan's long days and seasons, and high atmospheric thermal inertia. The closest flyby range implied by CIRS would be set by the FP1 detector resolving one atmospheric scale height ( $\sim 50 \text{ km}$ ), which occurs at a surface-relative altitude of 8600 km, or 3000 km for half scale height resolution (25 km)—similar constraints may apply to other missions.

It is clearly desirable for one type of future mission to Titan to be an orbiter that could have long-term, high-repeat global coverage at uniform spatial resolution. Several have been proposed (e.g., Coustenis et al. 2009; Tobie et al. 2014). A Titan orbiter equipped with a thermal infrared spectrometer (as in the 2007 Titan Explorer mission concept; Lorenz & Waite 2008) and other instruments would permit frequent global “snapshot” measurements of the entire atmospheric state, including temperature, winds, and composition. These, in turn, would enable much tighter constraints to be placed on atmospheric models, such as coupled chemistry and climate 3D Titan global circulation models (GCMs) now under development (Lebonnois et al. 2009, 2012). Future observations and models will both be necessary to fully understand the complex time-dependent interactions between chemistry, dynamics, and meteorology that CIRS and the other *Cassini* instruments have unveiled (Nixon et al. 2018).

The planning, scheduling, execution, and downlink of CIRS Titan observations required the efforts of a large number of people, including the entire *Cassini* mission team at the Jet Propulsion Laboratory (JPL) and international staff at NASA's Deep Space Network (DSN), who uplinked instrument commands and downlinked the science data. Special thanks are due to the *Cassini* Titan Orbiter Science Team (TOST), comprising JPL Science Planning Engineers and representatives from all 12 *Cassini* instrument teams, for collaborative

working to schedule observations. At NASA Goddard Space Flight Center, CIRS instrument operations were supported by a local CIRS Operations Team. Funding for US coauthors was provided by NASA’s *Cassini* Project. N.A.T. received support from the UK Science and Technology Facilities Council (STFC). French coauthors were supported by the Centre National d’Études Spatial (CNES).

## Appendix A CIRS Data in the PDS

The following information is correct at the time of writing; however, the PDS is an evolving internet archive and hence tools and data accessibility may have changed since publication. *Cassini* CIRS data is distributed via two sites: the Atmospheres Node and the Rings Node.

### A.1. Atmospheres Node

The PDS Atmospheres node is the primary delivery point for CIRS data, which can be found here:

[https://pds-atmospheres.nmsu.edu/data\\_and\\_services/atmospheres\\_data/Cassini/inst-cirs.html](https://pds-atmospheres.nmsu.edu/data_and_services/atmospheres_data/Cassini/inst-cirs.html).

Data search tools include the Event Calendar and Master Schedule. Image cubes showing coverage of individual observations are contained in the EXTRAS/CUBE\_OVERVIEW subdirectory of individual data volumes, which are labeled by year and month: e.g., “cocirs\_0401” is the volume for “*Cassini* Orbiter, CIRS, 2004 January.” Data are stored in the DATA/TSDR area of the volumes, while documentation, including a detailed User Guide to the CIRS data set, is included in the DOCUMENT area.

Note: CIRS data at the Rings node is stored in a space-minimizing binary format, with fixed-length records for most ancillary and pointing information, and variable length records for interferogram and spectra. A different format is used at the Rings Node.

### A.2. Rings Node

CIRS data is also stored at the Rings Node:

<https://pds-rings.seti.org/cassini/cirs/>

It is important to note that the data are reformatted by the Rings Node compared to the Atmospheres Node, offering some advantages in readability at the cost of more storage space in bytes. Ancillary data records are stored in ASCII rather than binary format, while the interferograms and spectra are provided as fixed-length (as opposed to variable length) binary records. The remainder of the archive volumes—directories other than DATA—is the same as that at the Atmospheres Node, as delivered by the CIRS team. The data may be browsed, and is also searchable using the OPUS tool: <https://tools.pds-rings.seti.org/opus/#/>.

## Appendix B Ephemerides of *Cassini* Titan Flybys

The dates, times, distances, and other details of *Cassini* targeted and untargeted flybys of Titan are given in Table 4. Note that there are officially 127 targeted flybys: TA, TB, TC (replacing original T1 and T2), and T4-T126. T0 is categorized as untargeted, occurring at a range >100,000 km.

**Table 4**  
Titan Flyby Data

|                                      | Orbit |          |     |          |        | Illum.  | Appr.     | Local     | Closest Appr. |       | Phase  |
|--------------------------------------|-------|----------|-----|----------|--------|---------|-----------|-----------|---------------|-------|--------|
|                                      | #     |          |     | C/A      | Alt    | Inb. or | dir. wrt. | Sol. Time | Lat           | Lon   | at C/A |
| Flyby                                | (Rev) | Date     | DOY | Time     | (km)   | Outb.   | Saturn    | (Dec-Hr)  | (°)           | (°)   | (°)    |
| Saturn Orbit Insertion/Probe Release |       |          |     |          |        |         |           |           |               |       |        |
| T0                                   | 0     | 07/02/04 | 184 | 09:28:53 | 339123 | I/B     | Out       | 4.25      | −64.9         | 332.4 | 66.9   |
| TA                                   | A     | 10/26/04 | 300 | 15:30:05 | 1174   | I/B     | In        | 10.64     | 38.9          | 88.7  | 91.0   |
| TB                                   | B     | 12/13/04 | 348 | 11:38:15 | 1192   | I/B     | In        | 10.52     | 59.2          | 84.7  | 101.5  |
| TC                                   | C     | 01/14/05 | 14  | 11:11:59 | 60007  | I/B     | In        | 10.58     | −0.1          | 251.8 | 92.9   |
| T3                                   | 3     | 02/15/05 | 46  | 06:57:53 | 1579   | I/B     | In        | 10.39     | 30.1          | 69.0  | 98.5   |
| Occultations                         |       |          |     |          |        |         |           |           |               |       |        |
| T4                                   | 5     | 03/31/05 | 90  | 20:05:16 | 2404   | I/B     | Out       | 5.32      | 33.1          | 118.6 | 66.4   |
| T5                                   | 6     | 04/16/05 | 106 | 19:11:46 | 1027   | I/B     | Out       | 5.31      | 74.3          | 271.9 | 127.1  |
| T6                                   | 13    | 08/22/05 | 234 | 08:53:38 | 3660   | I/B     | Out       | 5.00      | −59.6         | 102.1 | 43.6   |
| T7                                   | 14    | 09/07/05 | 250 | 08:11:58 | 1075   | I/B     | Out       | 5.00      | −66.5         | 307.8 | 84.7   |
| Petal Rotations/Magnetotail Passage  |       |          |     |          |        |         |           |           |               |       |        |
| T8                                   | 17    | 10/28/05 | 301 | 04:15:25 | 1353   | I/B     | In        | 9.39      | 1.0           | 246.2 | 104.8  |
| T9                                   | 19    | 12/26/05 | 360 | 18:59:26 | 10411  | I/B     | Out       | 2.97      | −0.4          | 110.4 | 67.1   |
| T10                                  | 20    | 01/15/06 | 15  | 11:41:26 | 2043   | I/B     | In        | 8.56      | −0.1          | 250.9 | 120.5  |
| T11                                  | 21    | 02/27/06 | 58  | 08:25:18 | 1812   | I/B     | Out       | 0.98      | −0.2          | 107.3 | 92.4   |
| T12                                  | 22    | 03/19/06 | 78  | 00:05:55 | 1949   | I/B     | In        | 6.51      | 0.2           | 250.6 | 148.0  |
| T13                                  | 23    | 04/30/06 | 120 | 20:58:14 | 1856   | I/B     | Out       | 22.93     | 0.0           | 106.3 | 120.7  |
| T14                                  | 24    | 05/20/06 | 140 | 12:18:11 | 1879   | O/B     | In        | 4.44      | 0.6           | 249.9 | 163.0  |
| T15                                  | 25    | 07/02/06 | 183 | 09:20:47 | 1906   | I/B     | Out       | 20.88     | −0.4          | 105.5 | 147.8  |
| T16                                  | 26    | 07/22/06 | 203 | 00:25:26 | 950    | O/B     | In        | 2.37      | 85.4          | 318.9 | 105.3  |
| T17                                  | 28    | 09/07/06 | 250 | 20:16:51 | 1000   | O/B     | In        | 2.25      | 22.6          | 56.8  | 44.6   |
| T18                                  | 29    | 09/23/06 | 266 | 18:58:48 | 960    | O/B     | In        | 2.21      | 70.9          | 358.0 | 89.8   |
| T19                                  | 30    | 10/09/06 | 282 | 17:30:07 | 980    | O/B     | In        | 2.16      | 60.8          | 358.1 | 81.0   |
| T20                                  | 31    | 10/25/06 | 298 | 15:58:07 | 1029   | O/B     | In        | 2.11      | 6.2           | 44.2  | 24.7   |

**Table 4**  
(Continued)

| Flyby                                                     | Orbit<br>#<br>(Rev) | Date     | DOY | C/A<br>Time | Alt<br>(km) | Illum.<br>Inb. or<br>Outb. | Appr.<br>dir. wrt.<br>Saturn | Local<br>Sol. Time<br>(Dec-Hr) | Closest Appr. |            | Phase<br>at C/A<br>(°) |
|-----------------------------------------------------------|---------------------|----------|-----|-------------|-------------|----------------------------|------------------------------|--------------------------------|---------------|------------|------------------------|
|                                                           |                     |          |     |             |             |                            |                              |                                | Lat<br>(°)    | Lon<br>(°) |                        |
| T21                                                       | 35                  | 12/12/06 | 346 | 11:41:31    | 1000        | O/B                        | In                           | 1.98                           | 43.5          | 264.6      | 125.2                  |
| <i>Pi-Transfer</i>                                        |                     |          |     |             |             |                            |                              |                                |               |            |                        |
| T22                                                       | 36                  | 12/28/06 | 362 | 10:05:21    | 1297        | O/B                        | In                           | 1.92                           | 40.6          | 357.9      | 61.9                   |
| T23                                                       | 37                  | 01/13/07 | 13  | 08:38:31    | 1000        | O/B                        | In                           | 1.88                           | 30.7          | 358.1      | 53.3                   |
| T24                                                       | 38                  | 01/29/07 | 29  | 07:15:55    | 2631        | O/B                        | In                           | 1.84                           | 32.9          | 330.2      | 71.9                   |
| T25                                                       | 39                  | 02/22/07 | 53  | 03:12:24    | 1000        | O/B                        | Out                          | 13.66                          | 30.4          | 16.1       | 161.3                  |
| T26                                                       | 40                  | 03/10/07 | 69  | 01:49:00    | 981         | O/B                        | Out                          | 13.61                          | 31.7          | 357.7      | 149.5                  |
| T27                                                       | 41                  | 03/26/07 | 85  | 00:23:27    | 1010        | O/B                        | Out                          | 13.57                          | 40.9          | 357.7      | 144.1                  |
| T28                                                       | 42                  | 04/10/07 | 100 | 22:58:00    | 991         | O/B                        | Out                          | 13.53                          | 50.1          | 357.8      | 137.4                  |
| T29                                                       | 43                  | 04/26/07 | 116 | 21:32:58    | 981         | O/B                        | Out                          | 13.49                          | 59.4          | 357.8      | 129.8                  |
| T30                                                       | 44                  | 05/12/07 | 132 | 20:09:58    | 959         | O/B                        | Out                          | 13.44                          | 68.6          | 358.0      | 121.7                  |
| T31                                                       | 45                  | 05/28/07 | 148 | 18:51:55    | 2299        | O/B                        | Out                          | 13.41                          | 76.6          | 358.7      | 114.4                  |
| T32                                                       | 46                  | 06/13/07 | 164 | 17:46:11    | 965         | O/B                        | Out                          | 13.39                          | 84.4          | 358.3      | 107.0                  |
| T33                                                       | 47                  | 06/29/07 | 180 | 16:59:46    | 1933        | O/B                        | Out                          | 13.39                          | 8.4           | 294.9      | 95.6                   |
| <i>Icy Satellites</i>                                     |                     |          |     |             |             |                            |                              |                                |               |            |                        |
| T34                                                       | 48                  | 07/19/07 | 200 | 01:11:20    | 1332        | O/B                        | In                           | 18.46                          | 1.4           | 244.7      | 34.4                   |
| T35                                                       | 49                  | 08/31/07 | 243 | 06:32:36    | 3324        | O/B                        | Out                          | 11.41                          | 63.0          | 111.0      | 86.8                   |
| <i>High Inclination</i>                                   |                     |          |     |             |             |                            |                              |                                |               |            |                        |
| T36                                                       | 50                  | 10/02/07 | 275 | 04:42:43    | 973         | O/B                        | Out                          | 11.39                          | −59.6         | 108.5      | 67.4                   |
| T37                                                       | 52                  | 11/19/07 | 323 | 00:47:25    | 999         | O/B                        | Out                          | 11.29                          | −21.2         | 117.3      | 51.3                   |
| T38                                                       | 53                  | 12/05/07 | 339 | 00:06:50    | 1298        | O/B                        | Out                          | 11.29                          | −79.1         | 173.6      | 69.8                   |
| T39                                                       | 54                  | 12/20/07 | 354 | 22:57:55    | 969         | O/B                        | Out                          | 11.27                          | −70.3         | 175.7      | 61.4                   |
| T40                                                       | 55                  | 01/05/08 | 5   | 21:30:19    | 1014        | O/B                        | Out                          | 11.23                          | −11.5         | 130.3      | 37.6                   |
| T41                                                       | 59                  | 02/22/08 | 53  | 17:32:07    | 1000        | O/B                        | Out                          | 11.12                          | −34.8         | 151.5      | 30.2                   |
| T42                                                       | 62                  | 03/25/08 | 85  | 14:27:48    | 999         | O/B                        | Out                          | 11.02                          | −27.2         | 156.3      | 21.4                   |
| T43                                                       | 67                  | 05/12/08 | 133 | 10:01:58    | 1001        | O/B                        | Out                          | 10.89                          | 18.1          | 137.3      | 35.8                   |
| T44                                                       | 69                  | 05/28/08 | 149 | 08:24:32    | 1400        | O/B                        | Out                          | 10.84                          | 10.4          | 150.3      | 21.0                   |
| <i>High Inclination</i>                                   |                     |          |     |             |             |                            |                              |                                |               |            |                        |
| T45                                                       | 78                  | 07/31/08 | 213 | 02:13:11    | 1614        | I/B                        | Out                          | 10.64                          | −43.5         | 195.2      | 49.1                   |
| T46                                                       | 91                  | 11/03/08 | 308 | 17:35:23    | 1105        | I/B                        | Out                          | 10.39                          | −3.4          | 340.0      | 171.4                  |
| T47                                                       | 93                  | 11/19/08 | 324 | 15:56:28    | 1023        | I/B                        | Out                          | 10.34                          | −21.7         | 177.5      | 28.1                   |
| T48                                                       | 95                  | 12/05/08 | 340 | 14:25:45    | 961         | I/B                        | Out                          | 10.29                          | −10.4         | 178.7      | 25.0                   |
| T49                                                       | 97                  | 12/21/08 | 356 | 12:59:52    | 971         | I/B                        | Out                          | 10.25                          | −44.2         | 236.7      | 82.6                   |
| T50                                                       | 102                 | 02/07/09 | 38  | 08:50:52    | 967         | I/B                        | Out                          | 10.14                          | −33.9         | 306.4      | 136.1                  |
| T51                                                       | 106                 | 03/27/09 | 86  | 04:43:36    | 963         | I/B                        | Out                          | 10.03                          | −30.6         | 234.8      | 84.1                   |
| <i>Saturn Equinox Viewing</i>                             |                     |          |     |             |             |                            |                              |                                |               |            |                        |
| T52                                                       | 108                 | 04/04/09 | 94  | 01:47:46    | 4147        | O/B                        | In                           | 21.87                          | −2.7          | 176.3      | 151.5                  |
| T53                                                       | 109                 | 04/20/09 | 110 | 00:20:45    | 3599        | O/B                        | In                           | 21.83                          | −7.6          | 177.6      | 148.5                  |
| ...                                                       | 109                 | 04/27/09 | 117 | 04:05:52    | 694947      | Both                       | Out                          | 8.50                           | 28.3          | 69.6       | 64.0                   |
| T54                                                       | 110                 | 05/05/09 | 125 | 22:54:15    | 3242        | O/B                        | In                           | 21.79                          | −13.6         | 177.8      | 145.9                  |
| T55                                                       | 111                 | 05/21/09 | 141 | 21:26:41    | 966         | O/B                        | In                           | 21.75                          | −21.9         | 177.9      | 141.5                  |
| T56                                                       | 112                 | 06/06/09 | 157 | 20:00:00    | 968         | O/B                        | In                           | 21.71                          | −31.9         | 178.1      | 135.1                  |
| T57                                                       | 113                 | 06/22/09 | 173 | 18:32:35    | 955         | O/B                        | In                           | 21.67                          | −42.0         | 178.4      | 127.9                  |
| T58                                                       | 114                 | 07/08/09 | 189 | 17:04:03    | 966         | O/B                        | In                           | 21.62                          | −52.1         | 178.8      | 120.2                  |
| T59                                                       | 115                 | 07/24/09 | 205 | 15:34:03    | 956         | O/B                        | In                           | 21.58                          | −62.1         | 179.6      | 112.2                  |
| T60                                                       | 116                 | 08/09/09 | 221 | 14:03:53    | 971         | O/B                        | In                           | 21.53                          | −72.3         | 180.8      | 104.1                  |
| T61                                                       | 117                 | 08/25/09 | 237 | 12:51:37    | 961         | O/B                        | In                           | 21.51                          | −19.2         | 237.1      | 85.9                   |
| <i>Icy Satellite Flybys and Ansa-to-Ansa Occultations</i> |                     |          |     |             |             |                            |                              |                                |               |            |                        |
| T62                                                       | 119                 | 10/12/09 | 285 | 08:36:24    | 1299        | O/B                        | In                           | 21.39                          | −61.8         | 68.9       | 99.4                   |
| T63                                                       | 122                 | 12/12/09 | 346 | 01:03:14    | 4847        | O/B                        | Out                          | 16.61                          | 33.4          | 114.6      | 124.4                  |
| T64                                                       | 123                 | 12/28/09 | 362 | 00:16:58    | 951         | O/b                        | Out                          | 16.61                          | 82.1          | 172.4      | 85.9                   |
| T65                                                       | 124                 | 01/12/10 | 12  | 23:10:36    | 1074        | O/B                        | Out                          | 16.59                          | −82.2         | 359.1      | 95.2                   |
| T66                                                       | 125                 | 01/28/10 | 28  | 22:28:50    | 7486        | O/b                        | Out                          | 16.60                          | −53.0         | 296.7      | 68.6                   |
| T67                                                       | 129                 | 04/05/10 | 95  | 15:50:54    | 7438        | O/B                        | In                           | 20.89                          | 0.4           | 240.4      | 73.0                   |
| <i>High Northern Titan Ground tracks</i>                  |                     |          |     |             |             |                            |                              |                                |               |            |                        |
| T68                                                       | 131                 | 05/20/10 | 140 | 03:24:20    | 1398        | O/B                        | Out                          | 15.75                          | −48.8         | 116.9      | 112.4                  |
| T69                                                       | 132                 | 06/05/10 | 156 | 02:26:27    | 2042        | O/B                        | Out                          | 15.74                          | 87.0          | 6.0        | 87.2                   |
| T70                                                       | 133                 | 06/21/10 | 172 | 01:27:43    | 878         | O/B                        | Out                          | 15.73                          | 83.8          | 172.9      | 82.3                   |

**Table 4**  
(Continued)

| Flyby               | Orbit      | Date     | DOY | C/A<br>Time | Alt<br>(km) | Illum.<br>Inb. or<br>Outb. | Appr.<br>dir. wrt.<br>Saturn | Local<br>Sol. Time<br>(Dec-Hr) | Closest Appr. |            | Phase<br>at C/A<br>(°) |
|---------------------|------------|----------|-----|-------------|-------------|----------------------------|------------------------------|--------------------------------|---------------|------------|------------------------|
|                     | #<br>(Rev) |          |     |             |             |                            |                              |                                | Lat<br>(°)    | Lon<br>(°) |                        |
| <i>Inclined—1</i>   |            |          |     |             |             |                            |                              |                                |               |            |                        |
| T71                 | 134        | 07/07/10 | 188 | 00:22:45    | 1004        | O/B                        | Out                          | 15.71                          | −56.5         | 303.3      | 82.3                   |
| T72                 | 138        | 09/24/10 | 267 | 18:38:41    | 8178        | O/B                        | Out                          | 15.60                          | −14.9         | 290.4      | 59.8                   |
| T73                 | 140        | 11/11/10 | 315 | 13:37:01    | 7926        | O/B                        | Out                          | 15.44                          | −35.3         | 108.4      | 120.9                  |
| <i>Equatorial—1</i> |            |          |     |             |             |                            |                              |                                |               |            |                        |
| T74                 | 145        | 02/18/11 | 49  | 16:04:11    | 3651        | O/B                        | In                           | 20.40                          | 1.0           | 244.5      | 61.6                   |
| T75                 | 147        | 04/19/11 | 109 | 05:00:39    | 10053       | O/B                        | Out                          | 13.69                          | 0.4           | 106.9      | 101.3                  |
| T76                 | 148        | 05/08/11 | 128 | 22:53:44    | 1873        | O/B                        | In                           | 19.58                          | 0.3           | 247.6      | 46.7                   |
| T77                 | 149        | 06/20/11 | 171 | 18:32:00    | 1359        | O/B                        | Out                          | 11.93                          | 0.4           | 106.0      | 73.2                   |
| T78                 | 153        | 09/12/11 | 255 | 02:50:06    | 5821        | O/B                        | In                           | 17.22                          | −0.4          | 60.2       | 159.1                  |
| T79                 | 158        | 12/13/11 | 347 | 20:11:23    | 3583        | O/b                        | Out                          | 12.59                          | 7.4           | 290.9      | 100.1                  |
| T80                 | 159        | 01/02/12 | 2   | 15:13:38    | 29514       | O/B                        | In                           | 18.34                          | −59.5         | 246.9      | 75.8                   |
| T81                 | 160        | 01/30/12 | 30  | 13:39:48    | 31130       | O/B                        | Out                          | 12.33                          | −59.7         | 105.1      | 96.3                   |
| T82                 | 161        | 02/19/12 | 50  | 08:43:17    | 3803        | O/B                        | In                           | 18.08                          | 9.5           | 61.4       | 142.6                  |
| T83                 | 166        | 05/22/12 | 143 | 01:10:11    | 954         | O/B                        | Out                          | 13.40                          | 72.7          | 127.7      | 71.2                   |
| <i>Inclined—2</i>   |            |          |     |             |             |                            |                              |                                |               |            |                        |
| T84                 | 167        | 06/07/12 | 159 | 00:07:21    | 959         | O/B                        | Out                          | 13.38                          | 38.8          | 282.7      | 74.6                   |
| T85                 | 169        | 07/24/12 | 206 | 20:03:07    | 1012        | O/B                        | Out                          | 13.27                          | 62.0          | 149.3      | 58.3                   |
| T86                 | 172        | 09/26/12 | 270 | 14:35:38    | 956         | O/B                        | Out                          | 13.13                          | 62.6          | 200.6      | 46.6                   |
| T87                 | 174        | 11/13/12 | 318 | 10:22:08    | 974         | O/B                        | Out                          | 13.01                          | 11.7          | 124.6      | 68.2                   |
| T88                 | 175        | 11/29/12 | 334 | 08:56:59    | 1015        | O/B                        | Out                          | 12.97                          | 25.9          | 147.9      | 44.1                   |
| T89                 | 181        | 02/17/13 | 48  | 01:56:35    | 1978        | O/B                        | Out                          | 12.78                          | 21.1          | 154.9      | 34.8                   |
| T90                 | 185        | 04/05/13 | 95  | 21:43:30    | 1400        | O/B                        | Out                          | 12.66                          | −16.5         | 129.7      | 68.7                   |
| T91                 | 190        | 05/23/13 | 143 | 17:32:55    | 970         | O/B                        | Out                          | 12.54                          | 46.1          | 239.9      | 50.3                   |
| T92                 | 194        | 07/10/13 | 191 | 13:21:47    | 964         | O/B                        | Out                          | 12.43                          | 37.0          | 234.7      | 45.6                   |
| T93                 | 195        | 07/26/13 | 207 | 11:56:22    | 1399        | O/B                        | Out                          | 12.39                          | 28.1          | 249.2      | 58.0                   |
| T94                 | 197        | 09/12/13 | 255 | 07:43:56    | 1397        | I/B                        | Out                          | 12.27                          | 17.3          | 206.0      | 21.0                   |
| T95                 | 198        | 10/14/13 | 287 | 04:56:27    | 961         | I/B                        | Out                          | 12.19                          | 8.3           | 205.3      | 24.7                   |
| T96                 | 199        | 12/01/13 | 335 | 00:41:19    | 1400        | I/B                        | In                           | 12.07                          | −13.6         | 143.4      | 50.4                   |
| T97                 | 200        | 01/01/14 | 1   | 21:59:41    | 1400        | I/B                        | In                           | 12.00                          | −14.1         | 176.7      | 35.1                   |
| T98                 | 201        | 02/02/14 | 33  | 19:12:38    | 1236        | I/B                        | In                           | 11.92                          | −22.6         | 176.8      | 43.9                   |
| T99                 | 202        | 03/06/14 | 65  | 16:26:47    | 1500        | I/B                        | In                           | 11.84                          | −31.1         | 176.9      | 52.6                   |
| T100                | 203        | 04/07/14 | 97  | 13:41:14    | 963         | I/B                        | In                           | 11.76                          | −36.8         | 187.7      | 59.5                   |
| T101                | 204        | 05/17/14 | 137 | 16:12:15    | 2992        | I/B                        | Out                          | 0.04                           | −37.3         | 161.7      | 157.7                  |
| T102                | 205        | 06/18/14 | 169 | 13:28:25    | 3659        | I/B                        | Out                          | 23.97                          | −36.9         | 178.6      | 165.5                  |
| T103                | 206        | 07/20/14 | 201 | 10:40:58    | 5103        | I/B                        | Out                          | 23.89                          | −31.8         | 178.9      | 170.8                  |
| T104                | 207        | 8/21/14  | 233 | 08:09:09    | 964         | I/B                        | Out                          | 23.82                          | 34.5          | 360.0      | 11.9                   |
| T105                | 208        | 9/22/14  | 265 | 05:23:19    | 1401        | I/B                        | Out                          | 23.75                          | 43.8          | 0.5        | 21.0                   |
| T106                | 209        | 10/24/14 | 297 | 02:40:30    | 1013        | I/B                        | Out                          | 23.67                          | 37.5          | 322.3      | 31.4                   |
| T107                | 210        | 12/10/14 | 344 | 22:26:35    | 980         | I/B                        | Out                          | 23.55                          | 53.8          | 57.4       | 56.0                   |
| T108                | 211        | 1/11/15  | 11  | 19:48:35    | 970         | I/B                        | Out                          | 23.48                          | 69.3          | 1.7        | 45.8                   |
| T109                | 212        | 2/12/15  | 43  | 17:08:04    | 1200        | I/B                        | Out                          | 23.40                          | 78.7          | 4.3        | 55.0                   |
| T110                | 213        | 03/16/15 | 75  | 14:29:48    | 2275        | I/B                        | Out                          | 23.33                          | 74.8          | 95.0       | 70.5                   |
| <i>Equatorial—2</i> |            |          |     |             |             |                            |                              |                                |               |            |                        |
| T111                | 215        | 05/07/15 | 127 | 22:50:23    | 2722        | I/B                        | In                           | 6.00                           | −0.8          | 67.0       | 33.8                   |
| T112                | 218        | 07/07/15 | 188 | 08:09:50    | 10953       | I/B                        | Out                          | 0.77                           | 0.8           | 293.9      | 78.5                   |
| T113                | 222        | 09/28/15 | 271 | 21:37:12    | 1035        | I/B                        | In                           | 6.35                           | −0.8          | 61.4       | 41.9                   |
| T114                | 225        | 11/13/15 | 317 | 05:46:31    | 11297       | I/B                        | Out                          | 2.49                           | −14.4         | 122.4      | 91.8                   |
| <i>Inclined—3</i>   |            |          |     |             |             |                            |                              |                                |               |            |                        |
| T115                | 230        | 01/16/16 | 16  | 02:20:24    | 3548        | I/B                        | Out                          | 2.46                           | −19.0         | 300.2      | 104.0                  |
| T116                | 231        | 02/01/16 | 32  | 01:00:05    | 1398        | I/B                        | Out                          | 2.42                           | −82.7         | 174.8      | 121.2                  |
| T117                | 232        | 02/16/16 | 47  | 23:49:41    | 1018        | I/B                        | Out                          | 2.40                           | −39.1         | 284.0      | 122.4                  |
| T118                | 234        | 04/04/16 | 95  | 19:42:42    | 990         | I/B                        | Out                          | 2.28                           | −62.8         | 243.5      | 138.5                  |
| T119                | 235        | 05/06/16 | 127 | 16:54:37    | 969         | I/B                        | Out                          | 2.20                           | −59.1         | 178.0      | 139.2                  |
| T120                | 236        | 06/07/16 | 159 | 14:06:17    | 974         | I/B                        | Out                          | 2.11                           | −35.8         | 146.8      | 124.6                  |
| T121                | 238        | 07/25/16 | 207 | 09:58:23    | 975         | I/B                        | Out                          | 1.99                           | −6.4          | 129.2      | 101.2                  |
| T122                | 239        | 08/10/16 | 223 | 08:30:53    | 1698        | I/B                        | Out                          | 1.95                           | 12.3          | 123.6      | 88.4                   |
| T123                | 243        | 09/27/16 | 271 | 04:16:59    | 1775        | I/B                        | Out                          | 1.82                           | 22.6          | 124.5      | 86.1                   |
| T124                | 248        | 11/13/16 | 318 | 23:55:56    | 1585        | I/B                        | Out                          | 1.69                           | 37.3          | 120.9      | 78.4                   |

**Table 4**  
(Continued)

| Flyby                         | Orbit<br>#<br>(Rev) | Date     | DOY | C/A<br>Time | Alt<br>(km) | Illum.<br>Inb. or<br>Outb. | Appr.<br>dir. wrt.<br>Saturn | Local<br>Sol. Time<br>(Dec-Hr) | Closest Appr. |            | Phase<br>at C/A<br>(°) |
|-------------------------------|---------------------|----------|-----|-------------|-------------|----------------------------|------------------------------|--------------------------------|---------------|------------|------------------------|
|                               |                     |          |     |             |             |                            |                              |                                | Lat<br>(°)    | Lon<br>(°) |                        |
| T125                          | 250                 | 11/29/16 | 334 | 22:14:32    | 3159        | I/B                        | Out                          | 1.63                           | 42.3          | 127.0      | 80.9                   |
| <i>F Ring/Proximal Orbits</i> |                     |          |     |             |             |                            |                              |                                |               |            |                        |
| ...                           | 253                 | 12/15/16 | 350 | 21:52:44    | 342353      | Both                       | In                           | 1.75                           | 67.9          | 96.0       | 58.4                   |
| ...                           | 255                 | 12/31/16 | 366 | 12:19:04    | 679042      | Both                       | In                           | 1.00                           | 45.2          | 44.6       | 29.1                   |
| ...                           | 259                 | 02/01/17 | 32  | 19:52:54    | 219437      | I/B                        | Out                          | 2.00                           | -30.8         | 312.0      | 90.3                   |
| ...                           | 261                 | 02/17/17 | 48  | 13:10:25    | 186791      | Both                       | Out                          | 1.25                           | 56.6          | 128.3      | 77.6                   |
| ...                           | 264                 | 03/05/17 | 64  | 11:53:50    | 489882      | Both                       | In                           | 1.25                           | 60.0          | 57.4       | 42.4                   |
| T126                          | 270                 | 04/22/17 | 112 | 06:08:07    | 980         | I/B                        | Out                          | 1.03                           | 65.5          | 100.5      | 63.8                   |
| ...                           | 273                 | 05/07/17 | 127 | 20:32:16    | 496014      | Both                       | In                           | 0.75                           | 38.1          | 41.2       | 30.7                   |
| ...                           | 275                 | 05/24/17 | 144 | 00:18:54    | 117956      | I/B                        | Out                          | 0.50                           | -24.1         | 323.1      | 69.0                   |
| ...                           | 278                 | 06/08/17 | 159 | 18:44:46    | 367299      | Both                       | In                           | 0.75                           | 52.6          | 44.0       | 37.9                   |
| ...                           | 283                 | 07/10/17 | 191 | 13:50:51    | 264317      | Both                       | In                           | 0.25                           | 72.2          | 65.8       | 56.3                   |
| ...                           | 285                 | 07/26/17 | 207 | 23:20:01    | 494283      | Both                       | Out                          | 0.75                           | -14.2         | 319.6      | 66.2                   |
| ...                           | 288                 | 08/11/17 | 223 | 05:04:09    | 194991      | O/B                        | In                           | 0.00                           | 70.9          | 131.9      | 77.4                   |
| ...                           | 292                 | 09/11/17 | 254 | 19:04:48    | 119733      | O/B                        | Out                          | 23.50                          | 63.3          | 132.7      | 85.6                   |

(This table is available in machine-readable form.)

### Appendix C

#### Catalog of Far-infrared Limb Observations

A complete listing of dates, times, durations, and latitudes targeted for CIRS far-infrared limb observations (five types) are given in Table 5. See Section 4 for details.

**Table 5**  
CIRS Far-infrared Limb Observations

| Flyby<br>No. | Observation Name            | Date     | Year<br>Day | Start<br>Time | Duration<br>(HR:MN) | Pointing<br>(Latitudes) |
|--------------|-----------------------------|----------|-------------|---------------|---------------------|-------------------------|
| T4           | CIRS_005TI_FIRLMBT002_PRIME | 04/01/05 | 090         | 20:05:16      | 0:45                | 80N, 70N                |
| T4           | CIRS_005TI_FIRLMBT002_PRIME | 04/01/05 | 090         | 20:50:16      | 0:30                | 85N, 75N                |
| T4           | CIRS_005TI_FIRLMBT002_PRIME | 04/01/05 | 090         | 21:20:16      | 0:45                | 85N                     |
| T6           | CIRS_013TI_FIRLMBT002_PRIME | 08/23/05 | 234         | 06:38:37      | 1:00                | 55S                     |
| T6           | CIRS_013TI_FIRLMBT002_PRIME | 08/23/05 | 234         | 07:38:37      | 0:30                | 50S                     |
| T6           | CIRS_013TI_FIRLMBT002_PRIME | 08/23/05 | 234         | 08:08:37      | 0:35                | 50S, 55S                |
| T6           | CIRS_013TI_FIRLMBT003_PRIME | 08/23/05 | 234         | 09:03:37      | 0:35                | 45S, 40S                |
| T6           | CIRS_013TI_FIRLMBT003_PRIME | 08/23/05 | 234         | 09:38:37      | 0:30                | 40S                     |
| T6           | CIRS_013TI_FIRLMBT003_PRIME | 08/23/05 | 234         | 10:08:37      | 1:00                | 45S                     |
| T10          | CIRS_020TI_FIRLMBT003_PRIME | 01/16/06 | 015         | 12:41:27      | 1:00                | 55N                     |
| T14          | CIRS_024TI_FIRLMBT002_PRIME | 05/21/06 | 140         | 09:48:11      | 1:25                | 50N                     |
| T14          | CIRS_024TI_FIRLMBT003_PRIME | 05/21/06 | 140         | 13:45:11      | 0:48                | 50N                     |
| T15          | CIRS_025TI_FIRLMBT003_PRIME | 07/03/06 | 183         | 09:50:47      | 1:00                | 62N                     |
| T15          | CIRS_025TI_FIRLMBT003_PRIME | 07/03/06 | 183         | 10:50:47      | 1:00                | 62N                     |
| T16          | CIRS_026TI_FIRLMBT003_PRIME | 07/23/06 | 203         | 01:40:26      | 1:00                | 45N                     |
| T17          | CIRS_028TI_FIRLMBT002_PRIME | 09/08/06 | 250         | 17:52:51      | 1:00                | 15S                     |
| T17          | CIRS_028TI_FIRLMBT002_PRIME | 09/08/06 | 250         | 18:52:51      | 0:39                | 15S                     |
| T17          | CIRS_028TI_FIRLMBT002_PRIME | 09/08/06 | 250         | 19:31:51      | 0:30                | 15S, 25S                |
| T18          | CIRS_029TI_FIRLMBT003_PRIME | 09/24/06 | 266         | 16:58:49      | 1:15                | 30N                     |
| T24          | CIRS_038TI_FIRLMBT001_PRIME | 01/30/07 | 029         | 05:15:55      | 0:45                | 28N                     |
| T24          | CIRS_038TI_FIRLMBT001_PRIME | 01/30/07 | 029         | 06:00:55      | 0:52                | 28N                     |
| T26          | CIRS_040TI_FIRLMBT001_PRIME | 03/10/07 | 068         | 23:34:00      | 0:51                | 10N                     |
| T26          | CIRS_040TI_FIRLMBT002_PRIME | 03/11/07 | 069         | 02:12:00      | 0:30                | 3N, 17N                 |
| T26          | CIRS_040TI_FIRLMBT002_PRIME | 03/11/07 | 069         | 02:42:00      | 0:30                | 15N                     |
| T26          | CIRS_040TI_FIRLMBT002_PRIME | 03/11/07 | 069         | 03:35:00      | 0:37                | 15N                     |
| T27          | CIRS_041TI_FIRLMBT002_PRIME | 03/27/07 | 085         | 01:56:27      | 0:42                | 44N                     |
| T32          | CIRS_046TI_FIRLMBT003_PRIME | 06/14/07 | 164         | 18:32:11      | 0:16                | 45N                     |
| T35          | CIRS_049TI_FIRLMBT001_PRIME | 09/01/07 | 243         | 04:32:34      | 1:00                | 70N                     |

**Table 5**  
(Continued)

| Flyby No. | Observation Name               | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Latitudes) |
|-----------|--------------------------------|----------|----------|------------|------------------|----------------------|
| T37       | CIRS_052TI_FIRLMBINT001_PRIME  | 11/19/07 | 322      | 22:47:25   | 0:21             | 80S                  |
| T37       | CIRS_052TI_FIRLMBBAER001_PRIME | 11/19/07 | 322      | 23:08:25   | 0:54             | 80S, 70S             |
| T37       | CIRS_052TI_FIRLMBT001_PRIME    | 11/20/07 | 323      | 00:02:25   | 0:30             | 65S, 75S             |
| T38       | CIRS_053TI_FIRLMBINT001_PRIME  | 12/05/07 | 338      | 21:36:50   | 1:15             | 0N                   |
| T38       | CIRS_053TI_FIRLMBBAER001_PRIME | 12/05/07 | 338      | 22:51:50   | 0:25             | 0N                   |
| T38       | CIRS_053TI_FIRLMBT001_PRIME    | 12/05/07 | 338      | 23:16:50   | 0:35             | 5S, 5N               |
| T40       | CIRS_055TI_FIRLMBINT001_PRIME  | 01/06/08 | 005      | 19:30:20   | 0:55             | 30S                  |
| T42       | CIRS_062TI_FIRLMBINT003_PRIME  | 03/26/08 | 085      | 12:28:48   | 0:44             | 55S                  |
| T42       | CIRS_062TI_FIRLMBBAER001_PRIME | 03/26/08 | 085      | 13:12:48   | 0:25             | 55S                  |
| T42       | CIRS_062TI_FIRLMBT001_PRIME    | 03/26/08 | 085      | 13:37:48   | 0:29             | 52S, 62S             |
| T46       | CIRS_091TI_FIRLMBINT001_PRIME  | 11/04/08 | 308      | 15:45:24   | 0:22             | no data              |
| T47       | CIRS_093TI_FIRLMBINT002_PRIME  | 11/20/08 | 324      | 16:58:28   | 1:13             | 45S                  |
| T48       | CIRS_095TI_FIRLMBINT001_PRIME  | 12/06/08 | 340      | 11:25:45   | 1:00             | 35S                  |
| T48       | CIRS_095TI_FIRLMBINT002_PRIME  | 12/06/08 | 340      | 15:20:45   | 1:20             | 25S                  |
| T49       | CIRS_097TI_FIRLMBINT001_PRIME  | 12/22/08 | 356      | 09:59:52   | 1:00             | 10N                  |
| T53       | CIRS_109TI_FIRLMBBAER001_PRIME | 04/20/09 | 109      | 22:45:45   | 0:37             | 8N                   |
| T53       | CIRS_109TI_FIRLMBT001_PRIME    | 04/20/09 | 109      | 23:22:55   | 0:48             | 12S                  |
| T53       | CIRS_109TI_FIRLMBBAER002_PRIME | 04/21/09 | 110      | 00:46:45   | 0:49             | 38S                  |
| T54       | CIRS_110TI_FIRLMBINT001_PRIME  | 05/06/09 | 125      | 20:39:16   | 1:00             | 20N                  |
| T54       | CIRS_110TI_FIRLMBBAER001_PRIME | 05/06/09 | 125      | 21:39:16   | 0:30             | 30N                  |
| T54       | CIRS_110TI_FIRLMBT001_PRIME    | 05/06/09 | 125      | 22:09:16   | 0:35             | 10N, 5N              |
| T57       | CIRS_113TI_FIRLMBINT001_PRIME  | 06/23/09 | 173      | 16:17:35   | 1:05             | 10S                  |
| T59       | CIRS_115TI_FIRLMBT002_PRIME    | 07/25/09 | 205      | 15:49:04   | 0:35             | 50S, 55S             |
| T59       | CIRS_115TI_FIRLMBBAER002_PRIME | 07/25/09 | 205      | 16:24:04   | 0:30             | 60S                  |
| T59       | CIRS_115TI_FIRLMBINT002_PRIME  | 07/25/09 | 205      | 16:54:04   | 0:55             | 60S                  |
| T62       | CIRS_119TI_FIRLMBT001_PRIME    | 10/13/09 | 285      | 07:45:25   | 0:30             | 75S                  |
| T62       | CIRS_119TI_FIRLMBBAER002_PRIME | 10/13/09 | 285      | 09:01:25   | 0:50             | 70S                  |
| T62       | CIRS_119TI_FIRLMBINT002_PRIME  | 10/13/09 | 285      | 09:51:25   | 1:00             | 75S                  |
| T64       | CIRS_123TI_FIRLMBINT001_PRIME  | 12/28/09 | 361      | 22:01:59   | 0:59             | 45N                  |
| T64       | CIRS_123TI_FIRLMBBAER001_PRIME | 12/28/09 | 361      | 23:01:59   | 0:37             | 50N                  |
| T66       | CIRS_125TI_FIRLMBINT001_PRIME  | 01/29/10 | 028      | 19:58:49   | 1:08             | 30N                  |
| T66       | CIRS_125TI_FIRLMBBAER001_PRIME | 01/29/10 | 028      | 21:06:49   | 0:34             | 20N                  |
| T66       | CIRS_125TI_FIRLMBT001_PRIME    | 01/29/10 | 028      | 21:40:19   | 0:34             | 23N, 28N             |
| T67       | CIRS_129TI_FIRLMBCON001_PRIME  | 04/06/10 | 095      | 13:35:39   | 1:00             | 70N                  |
| T67       | CIRS_129TI_FIRLMBBAER001_PRIME | 04/06/10 | 095      | 14:35:39   | 0:30             | 70N                  |
| T67       | CIRS_129TI_FIRLMBT001_PRIME    | 04/06/10 | 095      | 15:05:39   | 0:30             | 70N                  |
| T70       | CIRS_133TI_FIRLMBINT001_PRIME  | 06/21/10 | 171      | 23:12:18   | 1:02             | 55N                  |
| T72       | CIRS_138TI_FIRLMBINT001_PRIME  | 09/25/10 | 267      | 16:23:41   | 1:00             | 87S                  |
| T72       | CIRS_138TI_FIRLMBBAER001_PRIME | 09/25/10 | 267      | 17:23:41   | 0:30             | 87S                  |
| T72       | CIRS_138TI_FIRLMBT001_PRIME    | 09/25/10 | 267      | 17:53:41   | 0:30             | 82S, 87S             |
| T73       | CIRS_140TI_FIRLMBT002_PRIME    | 11/12/10 | 315      | 13:12:01   | 1:10             | Safing event         |
| T73       | CIRS_140TI_FIRLMBBAER002_PRIME | 11/12/10 | 315      | 14:22:01   | 0:30             | Safing event         |
| T73       | CIRS_140TI_FIRLMBINT002_PRIME  | 11/12/10 | 315      | 14:52:01   | 1:00             | Safing event         |
| T76       | CIRS_148TI_FIRLMBINT001_PRIME  | 05/09/11 | 128      | 20:23:45   | 1:00             | 50N                  |
| T76       | CIRS_148TI_FIRLMBBAER001_PRIME | 05/09/11 | 128      | 21:23:45   | 0:45             | 50N                  |
| T76       | CIRS_148TI_FIRLMBT001_PRIME    | 05/09/11 | 128      | 22:08:45   | 0:35             | 55N, 60N             |
| T78       | CIRS_153TI_FIRLMBINT001_PRIME  | 09/13/11 | 255      | 00:35:06   | 1:00             | 73S                  |
| T78       | CIRS_153TI_FIRLMBBAER001_PRIME | 09/13/11 | 255      | 01:35:06   | 0:32             | 73S                  |
| T79       | CIRS_158TI_FIRLMBINT501_PRIME  | 12/14/11 | 347      | 17:56:24   | 1:00             | 57S                  |
| T79       | CIRS_158TI_FIRLMBBAER501_PRIME | 12/14/11 | 347      | 18:56:24   | 0:30             | 57S                  |
| T79       | CIRS_158TI_FIRLMBT501_PRIME    | 12/14/11 | 347      | 19:26:24   | 0:45             | 37S                  |
| T82       | CIRS_161TI_FIRLMBINT001_PRIME  | 02/20/12 | 050      | 06:28:17   | 1:00             | 75N                  |
| T82       | CIRS_161TI_FIRLMBBAER001_PRIME | 02/20/12 | 050      | 07:28:17   | 0:30             | 75N                  |
| T82       | CIRS_161TI_FIRLMBT001_PRIME    | 02/20/12 | 050      | 07:58:17   | 0:45             | 56S                  |
| T82       | CIRS_161TI_FIRLMBT002_PRIME    | 02/20/12 | 050      | 08:43:17   | 0:45             | 56S, 51S             |
| T82       | CIRS_161TI_FIRLMBBAER002_PRIME | 02/20/12 | 050      | 09:28:17   | 0:30             | 56S                  |
| T82       | CIRS_161TI_FIRLMBINT002_PRIME  | 02/20/12 | 050      | 09:58:17   | 1:00             | 56S                  |
| T85       | CIRS_169TI_FIRLMBINT001_PRIME  | 07/25/12 | 206      | 17:33:08   | 1:15             | 37N                  |
| T85       | CIRS_169TI_FIRLMBBAER001_PRIME | 07/25/12 | 206      | 18:48:08   | 0:30             | 37N                  |
| T85       | CIRS_169TI_FIRLMBT001_PRIME    | 07/25/12 | 206      | 19:19:08   | 0:34             | 37N, 32N             |
| T86       | CIRS_172TI_FIRLMBINT001_PRIME  | 09/27/12 | 270      | 12:20:39   | 1:00             | 50N                  |

**Table 5**  
(Continued)

| Flyby No. | Observation Name               | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Latitudes) |
|-----------|--------------------------------|----------|----------|------------|------------------|----------------------|
| T86       | CIRS_172TI_FIRLMB AER001_PRIME | 09/27/12 | 270      | 13:20:39   | 0:25             | 50N                  |
| T86       | CIRS_172TI_FIRLMB T001_PRIME   | 09/27/12 | 270      | 13:46:39   | 0:31             | 50N, 45N             |
| T86       | CIRS_172TI_FIRLMB AER002_PRIME | 09/27/12 | 270      | 15:10:39   | 0:40             | 49N                  |
| T86       | CIRS_172TI_FIRLMB INT002_PRIME | 09/27/12 | 270      | 16:12:39   | 0:38             | 49N                  |
| T88       | CIRS_175TI_FIRLMB INT001_PRIME | 11/30/12 | 334      | 06:41:59   | 1:00             | 2S                   |
| T88       | CIRS_175TI_FIRLMB AER001_PRIME | 11/30/12 | 334      | 07:41:59   | 0:30             | 2S                   |
| T88       | CIRS_175TI_FIRLMB T001_PRIME   | 11/30/12 | 334      | 08:12:59   | 0:29             | 2S                   |
| T90       | CIRS_185TI_FIRLMB INT001_PRIME | 04/06/13 | 095      | 19:28:31   | 1:00             | 14N                  |
| T90       | CIRS_185TI_FIRLMB AER001_PRIME | 04/06/13 | 095      | 20:28:31   | 0:30             | 14N                  |
| T90       | CIRS_185TI_FIRLMB T001_PRIME   | 04/06/13 | 095      | 20:58:31   | 0:30             | 14N                  |
| T94       | CIRS_197TI_FIRLMB AER002_PRIME | 09/13/13 | 255      | 08:23:56   | 0:35             | 19N                  |
| T94       | CIRS_197TI_FIRLMB INT002_PRIME | 09/13/13 | 255      | 08:58:56   | 1:00             | 18N                  |
| T96       | CIRS_199TI_FIRLMB AER002_PRIME | 12/02/13 | 335      | 01:11:19   | 0:45             | 10S                  |
| T96       | CIRS_199TI_FIRLMB INT002_PRIME | 12/02/13 | 335      | 01:56:19   | 1:00             | 10S                  |
| T97       | CIRS_200TI_FIRLMB AER002_PRIME | 01/02/14 | 001      | 22:29:41   | 0:45             | 24S                  |
| T97       | CIRS_200TI_FIRLMB INT002_PRIME | 01/02/14 | 001      | 23:14:41   | 1:00             | 24S                  |
| T100      | CIRS_203TI_FIRLMB WTR001_PRIME | 04/08/14 | 097      | 11:26:14   | 0:53             | 22S                  |
| T100      | CIRS_203TI_FIRLMB AER002_PRIME | 04/08/14 | 097      | 13:50:14   | 1:06             | 40S                  |
| T100      | CIRS_203TI_FIRLMB INT002_PRIME | 04/08/14 | 097      | 15:18:14   | 0:38             | 40S                  |
| T103      | CIRS_206TI_FIRLMB INT005_PRIME | 07/21/14 | 201      | 08:25:58   | 1:00             | 3S                   |
| T103      | CIRS_206TI_FIRLMB AER001_PRIME | 07/21/14 | 201      | 09:25:58   | 0:30             | 3S                   |
| T104      | CIRS_208TI_FIRLMB AER001_PRIME | 09/23/14 | 265      | 05:53:19   | 0:45             | 28N                  |
| T104      | CIRS_208TI_FIRLMB INT002_PRIME | 09/23/14 | 265      | 06:38:19   | 1:00             | 28N                  |
| T109      | CIRS_212TI_FIRLMB AER001_PRIME | 02/13/15 | 043      | 17:38:04   | 0:45             | 47N                  |
| T109      | CIRS_212TI_FIRLMB INT002_PRIME | 02/13/15 | 043      | 18:45:04   | 0:38             | 47N                  |
| T110      | CIRS_213TI_FIRLMB AER002_PRIME | 03/17/15 | 075      | 14:59:49   | 0:45             | 49N                  |
| T110      | CIRS_213TI_FIRLMB INT002_PRIME | 03/17/15 | 075      | 15:44:49   | 1:00             | 49N                  |
| T111      | CIRS_215TI_FIRLMB T002_PRIME   | 05/08/15 | 127      | 23:00:24   | 0:35             | 60S, 55S             |
| T111      | CIRS_215TI_FIRLMB AER003_PRIME | 05/08/15 | 127      | 23:35:24   | 0:30             | 60S                  |
| T111      | CIRS_215TI_FIRLMB INT002_PRIME | 05/09/15 | 128      | 00:05:24   | 1:00             | 60S                  |
| T112      | CIRS_218TI_FIRLMB INT001_PRIME | 07/08/15 | 188      | 05:54:51   | 1:00             | 80S                  |
| T112      | CIRS_218TI_FIRLMB AER001_PRIME | 07/08/15 | 188      | 06:54:51   | 0:30             | 80N                  |
| T112      | CIRS_218TI_FIRLMB T001_PRIME   | 07/08/15 | 188      | 07:24:51   | 0:45             | 80N, 70N             |
| T112      | CIRS_218TI_FIRLMB T002_PRIME   | 07/08/15 | 188      | 08:09:51   | 0:45             | 65S, 75S             |
| T112      | CIRS_218TI_FIRLMB AER002_PRIME | 07/08/15 | 188      | 08:54:51   | 0:30             | 79S                  |
| T112      | CIRS_218TI_FIRLMB INT002_PRIME | 07/08/15 | 188      | 09:24:51   | 1:00             | 79S                  |
| T113      | CIRS_222TI_FIRLMB INT002_PRIME | 09/29/15 | 271      | 23:14:12   | 0:53             | 36S                  |
| T114      | CIRS_225TI_FIRLMB AER002_PRIME | 11/14/15 | 317      | 06:01:31   | 1:10             | 80S, 85S             |
| T114      | CIRS_225TI_FIRLMB INT002_PRIME | 11/14/15 | 317      | 07:11:31   | 0:50             | 85S                  |
| T115      | CIRS_230TI_FIRLMB INT001_PRIME | 01/17/16 | 016      | 00:05:24   | 1:00             | 65S                  |
| T115      | CIRS_230TI_FIRLMB AER004_PRIME | 01/17/16 | 016      | 01:05:24   | 0:30             | 65S                  |
| T115      | CIRS_230TI_FIRLMB T001_PRIME   | 01/17/16 | 016      | 01:35:24   | 0:45             | 60S, 70S             |
| T115      | CIRS_230TI_FIRLMB T002_PRIME   | 01/17/16 | 016      | 02:20:24   | 0:45             | 70S, 75S             |
| T115      | CIRS_230TI_FIRLMB AER005_PRIME | 01/17/16 | 016      | 03:05:24   | 0:30             | 75S                  |
| T115      | CIRS_230TI_FIRLMB INT002_PRIME | 01/17/16 | 016      | 03:35:24   | 1:00             | 75S                  |
| T116      | CIRS_231TI_FIRLMB INT001_PRIME | 02/01/16 | 031      | 22:30:05   | 1:18             | 57S                  |
| T118      | CIRS_234TI_FIRLMB CON002_PRIME | 04/05/16 | 095      | 20:47:42   | 1:10             | 66S                  |
| T119      | CIRS_235TI_FIRLMB INT001_PRIME | 05/07/16 | 127      | 14:37:37   | 1:02             | 54S                  |
| T119      | CIRS_235TI_FIRLMB AER001_PRIME | 05/07/16 | 127      | 15:39:37   | 0:30             | 54S                  |
| T119      | CIRS_235TI_FIRLMB T001_PRIME   | 05/07/16 | 127      | 16:09:37   | 0:30             | 54S x2               |
| T120      | CIRS_236TI_FIRLMB INT001_PRIME | 06/08/16 | 159      | 11:36:17   | 1:15             | 51S                  |
| T120      | CIRS_236TI_FIRLMB AER002_PRIME | 06/08/16 | 159      | 12:52:17   | 0:44             | 51S                  |
| T123      | CIRS_243TI_FIRLMB T002_PRIME   | 09/28/16 | 271      | 04:31:59   | 0:30             | 40N, 50N             |
| T123      | CIRS_243TI_FIRLMB AER002_PRIME | 09/28/16 | 271      | 05:01:59   | 0:30             | 50N                  |
| T123      | CIRS_243TI_FIRLMB WTR001_PRIME | 09/28/16 | 271      | 05:31:59   | 1:00             | 50N                  |
| T125      | CIRS_250TI_FIRLMB T002_PRIME   | 11/30/16 | 334      | 22:29:32   | 0:30             | 10S                  |
| T125      | CIRS_250TI_FIRLMB AER002_PRIME | 11/30/16 | 334      | 22:59:32   | 0:30             | 10S                  |
| T125      | CIRS_250TI_FIRLMB WTR001_PRIME | 11/30/16 | 334      | 23:29:32   | 1:00             | 10S                  |

(This table is available in machine-readable form.)

## Appendix D

### Catalog of Mid-infrared Limb Observations

A complete listing of dates, times, durations, and latitudes targeted for CIRS mid-infrared limb observations (MAPs, INTs, and PAIRs) are given in Table 6. See Section 5 for details.

**Table 6**  
CIRS Mid-infrared Limb Observations

| Flyby No. | Observation Name              | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Latitudes) |
|-----------|-------------------------------|----------|----------|------------|------------------|----------------------|
| TB        | CIRS_00BTI_MIRLMBINT002_PRIME | 12/14/04 | 348      | 16:38:13   | 2:00             | 10S                  |
| T3        | CIRS_003TI_MIRLMBINT002_PRIME | 02/15/05 | 045      | 19:57:53   | 4:00             | 80N                  |
| T4        | CIRS_005TI_MIRLMBMAP002_PRIME | 04/02/05 | 091      | 00:35:16   | 3:30             | 85N–0N               |
| T6        | CIRS_013TI_MIRLMBMAP002_PRIME | 08/23/05 | 234      | 01:23:37   | 2:30             | 25N–35S              |
| T6        | CIRS_013TI_MIRLMBMAP003_PRIME | 08/23/05 | 234      | 13:53:37   | 2:30             | 40S–80S              |
| T8        | CIRS_017TI_MIRLMBMAP003_PRIME | 10/29/05 | 301      | 09:55:25   | 3:20             | 85M–10N              |
| T10       | CIRS_020TI_MIRLMBINT002_PRIME | 01/16/06 | 015      | 02:41:27   | 4:00             | 55N                  |
| T13       | CIRS_023TI_MIRLMBMAP004_PRIME | 05/01/06 | 120      | 11:58:14   | 2:00             | 0N–40S               |
| T13       | CIRS_023TI_MIRLMBMAP006_PRIME | 05/01/06 | 120      | 14:58:14   | 2:00             | 0N–40N               |
| T14       | CIRS_024TI_MIRLMBINT002_PRIME | 05/21/06 | 140      | 03:18:11   | 1:30             | 32S                  |
| T14       | CIRS_024TI_MIRLMBINT003_PRIME | 05/21/06 | 140      | 17:18:11   | 5:00             | 50N                  |
| T15       | CIRS_025TI_MIRLMBINT002_PRIME | 07/03/06 | 183      | 01:20:47   | 2:40             | 55S                  |
| T16       | CIRS_026TI_MIRLMBINT002_PRIME | 07/22/06 | 202      | 15:25:26   | 2:00             | 45N                  |
| T16       | CIRS_026TI_MIRLMBMAP003_PRIME | 07/23/06 | 203      | 05:25:26   | 2:15             | 30N–75N              |
| T19       | CIRS_030TI_MIRLMBINT002_PRIME | 10/10/06 | 282      | 08:30:07   | 3:40             | 60N                  |
| T19       | CIRS_030TI_MIRLMBINT003_PRIME | 10/10/06 | 282      | 22:50:07   | 2:40             | 30N                  |
| T20       | CIRS_031TI_MIRLMBMAP004_PRIME | 10/26/06 | 298      | 20:28:07   | 3:00             | 15S–50N              |
| T21       | CIRS_035TI_MIRLMBINT004_PRIME | 12/13/06 | 346      | 02:41:31   | 1:30             | 15N                  |
| T21       | CIRS_035TI_MIRLMBINT003_PRIME | 12/13/06 | 346      | 18:41:31   | 2:00             | 15N                  |
| T23       | CIRS_037TI_MIRLMBINT001_PRIME | 01/13/07 | 012      | 23:38:31   | 4:00             | 5N                   |
| T24       | CIRS_038TI_MIRLMBINT002_PRIME | 01/30/07 | 029      | 12:15:55   | 4:00             | 30N                  |
| T25       | CIRS_039TI_MIRLMBMAP001_PRIME | 02/22/07 | 052      | 18:12:24   | 3:50             | 25N–30S              |
| T26       | CIRS_040TI_MIRLMBMAP001_PRIME | 03/10/07 | 068      | 16:49:00   | 4:00             | 30N–30S              |
| T27       | CIRS_041TI_MIRLMBINT001_PRIME | 03/26/07 | 084      | 15:23:27   | 4:00             | 20S                  |
| T28       | CIRS_042TI_MIRLMBINT002_PRIME | 04/12/07 | 101      | 02:58:00   | 1:00             | 30S                  |
| T32       | CIRS_046TI_MIRLMBMAP001_PRIME | 06/14/07 | 164      | 08:46:11   | 4:00             | 15N–80S              |
| T35       | CIRS_049TI_MIRLMBINT001_PRIME | 08/31/07 | 242      | 21:32:34   | 4:00             | 70N                  |
| T37       | CIRS_052TI_MIRLMBMAP001_PRIME | 11/19/07 | 322      | 15:47:25   | 4:00             | 60S(R)–20S(L)        |
| T39       | CIRS_054TI_MIRLMBMAP001_PRIME | 12/21/07 | 354      | 13:57:55   | 3:54             | 25S–75N              |
| T39       | CIRS_054TI_MIRLMBINT002_PRIME | 12/22/07 | 355      | 04:02:55   | 3:55             | 45S                  |
| T42       | CIRS_062TI_MIRLMBINT001_PRIME | 03/26/08 | 085      | 05:27:48   | 4:00             | 55S                  |
| T42       | CIRS_062TI_MIRLMBMAP002_PRIME | 03/26/08 | 085      | 19:27:48   | 4:00             | 15S–55S              |
| T43       | CIRS_067TI_MIRLMBINT002_PRIME | 05/13/08 | 133      | 15:01:58   | 4:00             | 40N                  |
| T45       | CIRS_078TI_MIRLMBMAP002_PRIME | 08/01/08 | 213      | 06:58:11   | 3:30             | 0N–45N               |
| T47       | CIRS_093TI_MIRLMBINT002_PRIME | 11/21/08 | 325      | 20:56:28   | 4:00             | 19S                  |
| T49       | CIRS_098TI_MIRLMBINT001_PRIME | 12/22/08 | 356      | 18:29:52   | 3:30             | 15N                  |
| T50       | CIRS_102TI_MIRLMBINT001_PRIME | 02/07/09 | 037      | 23:20:51   | 4:00             | BIU anomaly          |
| T51       | CIRS_107TI_MIRLMBINT002_PRIME | 03/28/09 | 086      | 09:43:36   | 4:00             | 30S                  |
| T54       | CIRS_110TI_MIRLMBMAP001_PRIME | 05/06/09 | 125      | 13:54:16   | 3:50             | 30N–20S              |
| T55       | CIRS_111TI_MIRLMPAIR002_PRIME | 05/23/09 | 142      | 02:26:41   | 4:00             | 25S                  |
| T59       | CIRS_115TI_MIRLMBMAP001_PRIME | 07/25/09 | 205      | 06:34:04   | 4:00             | 0N–60N               |
| T59       | CIRS_115TI_MIRLMBINT002_PRIME | 07/25/09 | 205      | 20:34:04   | 2:00             | 65N                  |
| T61       | CIRS_117TI_MIRLMBINT001_PRIME | 08/26/09 | 237      | 03:51:38   | 3:50             | 60S                  |
| T63       | CIRS_122TI_MIRLMBMAP001_PRIME | 12/12/09 | 345      | 16:03:14   | 4:00             | 85N–0N               |
| T64       | CIRS_123TI_MIRLMPAIR001_PRIME | 12/28/09 | 361      | 15:16:59   | 4:00             | 75N                  |
| T64       | CIRS_123TI_MIRLMBINT002_PRIME | 12/29/09 | 362      | 05:16:59   | 4:00             | 75N                  |
| T65       | CIRS_124TI_MIRLMBINT001_PRIME | 01/13/10 | 012      | 14:10:36   | 4:00             | 75S                  |
| T65       | CIRS_124TI_MIRLMBMAP002_PRIME | 01/14/10 | 013      | 04:10:36   | 4:00             | 85S–0N               |
| T67       | CIRS_129TI_MIRLMBINT001_PRIME | 04/06/10 | 095      | 06:50:39   | 4:00             | 88N                  |
| T69       | CIRS_132TI_MIRLMBMAP001_PRIME | 06/05/10 | 155      | 17:08:27   | 4:18             | 85S–0N               |
| T70       | CIRS_133TI_MIRLMBMAP001_PRIME | 06/21/10 | 171      | 16:27:43   | 4:00             | 5N–85N               |
| T71       | CIRS_134TI_MIRLMBINT001_PRIME | 07/07/10 | 187      | 15:22:45   | 3:00             | 80S                  |
| T72       | CIRS_138TI_MIRLMPAIR001_PRIME | 09/25/10 | 267      | 09:38:41   | 4:00             | 76N                  |

**Table 6**  
(Continued)

| Flyby No. | Observation Name              | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Latitudes) |
|-----------|-------------------------------|----------|----------|------------|------------------|----------------------|
| T73       | CIRS_140TI_MIRMBMAP001_PRIME  | 11/12/10 | 315      | 04:37:01   | 4:00             | Safing event         |
| T76       | CIRS_148TI_MIRLMBMAP001_PRIME | 05/09/11 | 128      | 13:53:45   | 4:00             | 0N–85N               |
| T77       | CIRS_149TI_MIRLMBMAP002_PRIME | 06/21/11 | 171      | 23:32:01   | 4:00             | 0N–85S               |
| T78       | CIRS_153TI_MIRLMBINT001_PRIME | 09/12/11 | 254      | 17:50:06   | 4:00             | 85S                  |
| T79       | CIRS_158TI_MIRLMBINT501_PRIME | 12/14/11 | 347      | 11:11:24   | 4:00             | 80N                  |
| T80       | CIRS_159TI_MIRLMBMAP001_PRIME | 01/03/12 | 002      | 06:13:37   | 4:00             | 75N–10S              |
| T82       | CIRS_161TI_MIRLMBINT001_PRIME | 02/19/12 | 049      | 23:43:17   | 4:00             | 45S                  |
| T82       | CIRS_161TI_MIRLMBMAP002_PRIME | 02/20/12 | 050      | 13:43:17   | 4:00             | 0N–80S               |
| T83       | CIRS_166TI_MIRLMBINT001_PRIME | 05/22/12 | 142      | 16:10:11   | 4:00             | 0N                   |
| T84       | CIRS_167TI_MIRLMBINT001_PRIME | 06/07/12 | 158      | 15:07:21   | 4:00             | 45N                  |
| T85       | CIRS_169TI_MIRLMBMAP002_PRIME | 07/26/12 | 207      | 01:03:07   | 4:00             | 15S–65N              |
| T88       | CIRS_175TI_MIRLMBMAP001_PRIME | 11/29/12 | 333      | 23:56:59   | 4:00             | 50S–30N              |
| T90       | CIRS_185TI_MIRLMBINT001_PRIME | 04/06/13 | 095      | 12:43:31   | 4:00             | 25N                  |
| T91       | CIRS_190TI_MIRLMBMAP001_PRIME | 05/24/13 | 143      | 08:32:55   | 3:00             | 35N–15S              |
| T92       | CIRS_194TI_MIRLMBINT001_PRIME | 07/11/13 | 191      | 04:21:47   | 3:00             | 20S                  |
| T93       | CIRS_195TI_MIRLMBMAP002_PRIME | 07/27/13 | 207      | 15:56:22   | 5:00             | 15N–15S              |
| T95       | CIRS_198TI_MIRLMPAIR001_PRIME | 10/14/13 | 286      | 19:56:27   | 3:00             | 16N                  |
| T95       | CIRS_198TI_MIRLMBINT001_PRIME | 10/15/13 | 287      | 10:56:27   | 3:00             | 2S                   |
| T96       | CIRS_199TI_MIRLMBINT002_PRIME | 12/02/13 | 335      | 05:41:19   | 4:00             | 12N                  |
| T98       | CIRS_201TI_MIRLMBMAP002_PRIME | 02/04/14 | 034      | 01:12:38   | 3:00             | 20N–25N              |
| T101      | CIRS_204TI_MIRLMBINT002_PRIME | 05/18/14 | 137      | 21:12:15   | 4:00             | 35S                  |
| T102      | CIRS_205TI_MIRLMBINT001_PRIME | 06/19/14 | 169      | 04:28:25   | 4:44             | 10N                  |
| T102      | CIRS_205TI_MIRLMBMAP002_PRIME | 06/19/14 | 169      | 18:28:25   | 4:00             | 40N–13S              |
| T103      | CIRS_206TI_MIRLMBINT002_PRIME | 07/21/14 | 201      | 15:40:58   | 4:00             | 30N                  |
| T105      | CIRS_208TI_MIRLMBINT001_PRIME | 09/22/14 | 264      | 20:23:19   | 3:45             | See MIDIRTMAP        |
| T105      | CIRS_208TI_MIRLMBMAP002_PRIME | 09/23/14 | 265      | 12:38:19   | 2:00             | 40N–15N              |
| T106      | CIRS_209TI_MIRLMBINT001_PRIME | 10/24/14 | 296      | 17:40:30   | 4:00             | 45S                  |
| T108      | CIRS_211TI_MIRLMBMAP001_PRIME | 01/12/15 | 011      | 10:48:35   | 4:00             | 30S (R)–55S (L)      |
| T108      | CIRS_211TI_MIRLMBINT002_PRIME | 01/13/15 | 012      | 00:48:35   | 3:00             | 70N                  |
| T110      | CIRS_213TI_MIRLMBMAP001_PRIME | 03/17/15 | 075      | 05:29:49   | 4:00             | 80S (L)–85S –30S (R) |
| T110      | CIRS_213TI_MIRLMBINT002_PRIME | 03/17/15 | 075      | 19:29:49   | 4:00             | 80S                  |
| T111      | CIRS_215TI_MIRLMBMAP002_PRIME | 05/09/15 | 128      | 03:50:24   | 4:00             | 80N (L)–35N (L)      |
| T113      | CIRS_222TI_MIRLMBMAP001_PRIME | 09/29/15 | 271      | 12:37:12   | 4:00             | 20S–85S              |
| T113      | CIRS_222TI_MIRLMBINT002_PRIME | 09/30/15 | 272      | 02:37:12   | 4:00             | 85S                  |
| T114      | CIRS_225TI_MIRLMBMAP001_PRIME | 11/13/15 | 316      | 20:46:31   | 4:00             | 75N–5N               |
| T115      | CIRS_230TI_MIRLMBMAP002_PRIME | 01/17/16 | 016      | 07:20:24   | 4:00             | 85S–25S              |
| T116      | CIRS_231TI_MIRLMBINT001_PRIME | 02/01/16 | 031      | 16:00:05   | 4:00             | 85S                  |
| T116      | CIRS_231TI_MIRLMBMAP002_PRIME | 02/02/16 | 032      | 06:00:05   | 4:00             | 80N–20N              |
| T117      | CIRS_232TI_MIRLMBINT001_PRIME | 02/17/16 | 047      | 14:49:41   | 4:00             | 80S                  |
| T117      | CIRS_232TI_MIRLMBMAP002_PRIME | 02/18/16 | 048      | 04:49:41   | 4:00             | 75N–10N              |
| T119      | CIRS_235TI_MIRLMBMAP001_PRIME | 05/07/16 | 127      | 07:54:37   | 4:00             | 50S–15N              |
| T120      | CIRS_236TI_MIRLMBINT001_PRIME | 06/08/16 | 159      | 05:06:17   | 4:00             | 50S                  |
| T120      | CIRS_236TI_MIRLMBMAP002_PRIME | 06/08/16 | 159      | 19:06:17   | 4:00             | 50N–15S              |
| T121      | CIRS_238TI_MIRLMBINT002_PRIME | 07/26/16 | 207      | 00:15:43   | 4:43             | 0N                   |
| T124      | CIRS_248TI_MIRLMBMAP002_PRIME | 11/15/16 | 319      | 04:55:56   | 4:00             | 10S–50N              |
| T125      | CIRS_250TI_MIRLMBINT002_PRIME | 12/01/16 | 335      | 03:14:32   | 4:00             | 50N                  |
| N/A       | CIRS_259TI_MIRLMBMAP002_PRIME | 02/02/17 | 032      | 20:21:00   | 5:15             | 60S–15N              |
| N/A       | CIRS_261TI_MIRLMBMAP001_PRIME | 02/18/17 | 048      | 08:41:00   | 4:00             | 15N–35S              |
| N/A       | CIRS_261TI_MIRLMBINT001_PRIME | 02/18/17 | 048      | 13:41:00   | 3:00             | 10S                  |
| N/A       | CIRS_275TI_MIRLMBINT001_PRIME | 05/24/17 | 143      | 16:44:00   | 6:34             | 50S                  |
| N/A       | CIRS_275TI_MIRLMBMAP002_PRIME | 05/25/17 | 144      | 06:33:00   | 4:00             | 80S–20S              |

(This table is available in machine-readable form.)

## Appendix E

### Catalog of Far-infrared Nadir Maps

A complete listing of dates, times, durations, and map centroids for CIRS far-infrared nadir maps and CIRS riders on UVIS EUVFUV maps are given in Table 7. See Section 6.1 for details.

**Table 7**  
CIRS Far-infrared Nadir Maps and UVIS EUVFUV

| Flyby No. | Observation Name              | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Center Lat., Lon.) |
|-----------|-------------------------------|----------|----------|------------|------------------|------------------------------|
| TB        | CIRS_00BTI_FIRNADMAP001_UVIS  | 12/14/04 | 348      | 03:38:13   | 4:00             | 6S 159W                      |
| TB        | CIRS_00BTI_FIRNADMAP002_UVIS  | 12/14/04 | 348      | 14:08:13   | 2:30             | 10N 347W                     |
| T3        | CIRS_003TI_FIRNADMAP003_UVIS  | 02/16/05 | 046      | 08:30:53   | 3:27             | 2N 340W                      |
| T5        | CIRS_006TI_FIRNADMAP003_UVIS  | 04/17/05 | 106      | 11:11:46   | 5:00             | 8N 27W                       |
| T6        | CIRS_013TI_FIRNADMAP002_PRIME | 08/23/05 | 234      | 03:53:37   | 2:45             | 3N 32W                       |
| T6        | CIRS_013TI_FIRNADMAP003_PRIME | 08/23/05 | 234      | 11:08:37   | 2:45             | 15S 208W                     |
| T9        | CIRS_019TI_FIRNADMAP005_UVIS  | 12/27/05 | 360      | 21:29:30   | 6:24             | 0N 28W                       |
| T11       | CIRS_021TI_FIRNADMAP003_UVIS  | 02/28/06 | 058      | 13:25:19   | 3:30             | 0N 344W                      |
| T13       | CIRS_023TI_FIRNADMAP003_UVIS  | 05/02/06 | 121      | 02:18:14   | 5:10             | 0N 10W                       |
| T14       | CIRS_024TI_FIRNADMAP002_UVIS  | 05/21/06 | 140      | 04:48:11   | 5:00             | 0N 158W                      |
| T14       | CIRS_024TI_FIRNADMAP003_PRIME | 05/21/06 | 140      | 14:33:11   | 2:45             | 0N 155W                      |
| T15       | CIRS_025TI_FIRNADMAP003_UVIS  | 07/03/06 | 183      | 11:50:47   | 5:30             | 0N 200W                      |
| T16       | CIRS_026TI_FIRNADMAP003_PRIME | 07/23/06 | 203      | 02:40:26   | 2:45             | 6S 339W                      |
| T17       | CIRS_028TI_FIRNADMAP002_UVIS  | 09/08/06 | 250      | 12:46:51   | 4:45             | 10N 149W                     |
| T18       | CIRS_029TI_FIRNADMAP002_UVIS  | 09/24/06 | 266      | 11:28:49   | 4:30             | 14N 141W                     |
| T21       | CIRS_035TI_EUVFUV001_UVIS     | 12/13/06 | 346      | 04:11:31   | 5:00             | 32N 129W                     |
| T22       | CIRS_036TI_FIRNADMAP002_PRIME | 12/29/06 | 362      | 04:35:22   | 3:00             | 41N 133W                     |
| T22       | CIRS_036TI_FIRNADMAP003_PRIME | 12/29/06 | 362      | 13:35:22   | 2:00             | 42S 319W                     |
| T24       | CIRS_038TI_EUVFUV001_UVIS     | 01/29/07 | 028      | 22:15:55   | 6:00             | 59N 116W                     |
| T24       | CIRS_038TI_FIRNADMAP002_PRIME | 01/30/07 | 029      | 11:15:55   | 1:00             | 53S 307W                     |
| T26       | CIRS_040TI_FIRNADMAP001_PRIME | 03/10/07 | 068      | 20:49:00   | 2:45             | 47S 43W                      |
| T26       | CIRS_040TI_FIRNADMAP002_PRIME | 03/11/07 | 069      | 06:04:00   | 0:45             | 46N 228W                     |
| T26       | CIRS_040TI_EUVFUV002_UVIS     | 03/11/07 | 069      | 06:49:00   | 3:00             | ...                          |
| T27       | CIRS_041TI_EUVFUV001_UVIS     | 03/26/07 | 084      | 20:49:27   | 2:23             | 36S 35W                      |
| T27       | CIRS_041TI_FIRNADMAP002_PRIME | 03/27/07 | 085      | 02:38:27   | 0:45             | 32N 218W                     |
| T27       | CIRS_041TI_EUVFUV002_UVIS     | 03/27/07 | 085      | 03:23:27   | 5:00             | 39N 223W                     |
| T29       | CIRS_043TI_FIRNADMAP001_PRIME | 04/27/07 | 116      | 16:32:58   | 2:50             | 27S 28W                      |
| T30       | CIRS_044TI_EUVFUV001_UVIS     | 05/13/07 | 132      | 11:09:58   | 3:50             | ...                          |
| T31       | CIRS_045TI_EUVFUV001_UVIS     | 05/29/07 | 148      | 09:51:55   | 6:00             | 11S 24W                      |
| T31       | CIRS_045TI_FIRNADMAP004_PRIME | 05/29/07 | 148      | 22:51:55   | 1:00             | 13N 212W                     |
| T32       | CIRS_046TI_FIRNADMAP002_UVIS  | 06/14/07 | 164      | 12:46:11   | 2:00             | 7S 24W                       |
| T32       | CIRS_046TI_FIRNADMAP001_UVIS  | 06/14/07 | 164      | 16:12:11   | 0:51             | ...                          |
| T32       | CIRS_046TI_FIRNADMAP002_PRIME | 06/14/07 | 164      | 20:04:11   | 2:42             | 4N 212W                      |
| T33       | CIRS_047TI_EUVFUV001_UVIS     | 06/30/07 | 180      | 11:59:46   | 3:00             | ...                          |
| T33       | CIRS_047TI_FIRNADMAP002_PRIME | 06/30/07 | 180      | 20:59:46   | 1:15             | 0N 209W                      |
| T34       | CIRS_048TI_EUVFUV001_UVIS     | 07/19/07 | 199      | 16:11:20   | 6:00             | ...                          |
| T34       | CIRS_048TI_FIRNADMAP002_PRIME | 07/20/07 | 200      | 05:11:20   | 1:00             | 0N 339W                      |
| T35       | CIRS_049TI_FIRNADMAP001_PRIME | 09/01/07 | 243      | 01:32:34   | 3:00             | 6S 159W                      |
| T35       | CIRS_049TI_FIRNADMAP004_PRIME | 09/01/07 | 243      | 10:32:34   | 1:00             | 10N 347W                     |
| T36       | CIRS_050TI_EUVFUV001_UVIS     | 10/02/07 | 274      | 19:42:43   | 3:49             | ...                          |
| T37       | CIRS_052TI_FIRNADMAP001_PRIME | 11/19/07 | 322      | 19:47:25   | 3:00             | 4S 22W                       |
| T37       | CIRS_052TI_FIRNADMAP002_PRIME | 11/20/07 | 323      | 04:47:25   | 1:00             | 1N 205W                      |
| T38       | CIRS_053TI_FIRNADMAP001_PRIME | 12/05/07 | 338      | 18:36:50   | 3:00             | 8N 27W                       |
| T38       | CIRS_053TI_FIRNADMAP002_PRIME | 12/06/07 | 339      | 04:06:50   | 1:00             | 10N 215W                     |
| T40       | CIRS_055TI_EUVFUV001_UVIS     | 01/06/08 | 005      | 12:30:20   | 4:00             | 21S 32W                      |
| T40       | CIRS_055TI_EUVFUV501_UVIS     | 01/06/08 | 005      | 16:30:20   | 2:00             | ...                          |
| T40       | CIRS_055TI_FIRNADMAP002_PRIME | 01/07/08 | 006      | 01:30:20   | 1:00             | 5S 211W                      |
| T41       | CIRS_059TI_EUVFUV002_UVIS     | 02/23/08 | 053      | 20:02:07   | 2:30             | 25N 227W                     |
| T42       | CIRS_062TI_FIRNADMAP001_PRIME | 03/26/08 | 085      | 09:27:48   | 3:00             | 0N 28W                       |
| T42       | CIRS_062TI_FIRNADMAP002_PRIME | 03/26/08 | 085      | 18:27:48   | 1:00             | 0N 189W                      |
| T43       | CIRS_067TI_FIRNADMAP002_PRIME | 05/13/08 | 133      | 12:11:58   | 2:50             | 0N 344W                      |
| T44       | CIRS_069TI_EUVFUV001_UVIS     | 05/28/08 | 148      | 23:24:32   | 6:00             | BIU anomaly                  |
| T46       | CIRS_091TI_FIRNADMAP001_PRIME | 11/04/08 | 308      | 14:06:23   | 2:01             | BIU anomaly                  |

**Table 7**  
(Continued)

| Flyby No. | Observation Name              | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Center Lat., Lon.) |
|-----------|-------------------------------|----------|----------|------------|------------------|------------------------------|
| T46       | CIRS_091TI_EUVFUV002_UVIS     | 11/04/08 | 308      | 19:27:23   | 7:08             |                              |
| T47       | CIRS_093TI_FIRNADMAP002_PRIME | 11/20/08 | 324      | 18:11:28   | 2:45             | 34N 253W                     |
| T48       | CIRS_095TI_EUVFUV001_UVIS     | 12/06/08 | 340      | 16:40:45   | 6:45             | ...                          |
| T50       | CIRS_102TI_EUVFUV001_UVIS     | 02/08/09 | 038      | 14:50:51   | 3:00             | BIU anomaly                  |
| T51       | CIRS_107TI_FIRNADMAP002_PRIME | 03/28/09 | 086      | 06:32:45   | 3:11             | 54N 266W                     |
| T52       | CIRS_108TI_FIRNADMAP002_PRIME | 04/05/09 | 094      | 03:37:47   | 1:40             | 58S 257W                     |
| T54       | CIRS_110TI_FIRNADMAP001_PRIME | 05/06/09 | 125      | 18:04:16   | 2:35             | 55N 82W*                     |
| T54       | CIRS_110TI_EUVFUV001_UVIS     | 05/07/09 | 126      | 00:54:16   | 7:00             | ...                          |
| T55       | CIRS_111TI_EUVFUV001_UVIS     | 05/22/09 | 141      | 12:26:41   | 6:30             | ...                          |
| T55       | CIRS_111TI_FIRNADMAP002_PRIME | 05/22/09 | 141      | 23:56:41   | 2:30             | 55S 270W*                    |
| T56       | CIRS_112TI_EUVFUV001_UVIS     | 06/07/09 | 157      | 21:41:01   | 7:19             | ...                          |
| T57       | CIRS_113TI_EUVFUV001_UVIS     | 06/23/09 | 173      | 09:32:35   | 6:45             | ...                          |
| T57       | CIRS_113TI_EUVFUV002_UVIS     | 06/24/09 | 174      | 00:02:35   | 3:00             | ...                          |
| T58       | CIRS_114TI_EUVFUV001_UVIS     | 07/09/09 | 189      | 08:04:03   | 6:40             | ...                          |
| T58       | CIRS_114TI_FIRNADMAP002_PRIME | 07/09/09 | 189      | 19:04:03   | 1:30             | 24S 294W*                    |
| T59       | CIRS_115TI_FIRNADMAP002_PRIME | 07/25/09 | 205      | 18:10:09   | 2:23             | 23S 326W                     |
| T60       | CIRS_116TI_EUVFUV001_UVIS     | 08/10/09 | 221      | 05:03:53   | 3:50             | Downlink                     |
| T62       | CIRS_119TI_EUVFUV001_UVIS     | 10/12/09 | 284      | 23:36:25   | 6:51             | ...                          |
| T62       | CIRS_119TI_EUVFUV002_UVIS     | 10/13/09 | 285      | 11:12:30   | 6:24             | ...                          |
| T63       | CIRS_122TI_FIRNADMAP002_PRIME | 12/13/09 | 346      | 03:48:14   | 1:00             | 0N 200W                      |
| T64       | CIRS_123TI_FIRNADMAP001_PRIME | 12/28/09 | 361      | 19:16:59   | 2:45             | 4N 121W                      |
| T65       | CIRS_124TI_FIRNADMAP001_PRIME | 01/13/10 | 012      | 18:10:37   | 2:45             | Angled track                 |
| T65       | CIRS_124TI_FIRNADMAP002_PRIME | 01/14/10 | 013      | 01:10:37   | 3:00             | Angled track                 |
| T66       | CIRS_125TI_EUVFUV001_UVIS     | 01/29/10 | 028      | 13:28:49   | 6:30             | ...                          |
| T66       | CIRS_125TI_EUVFUV002_UVIS     | 01/30/10 | 029      | 00:28:49   | 7:00             | ...                          |
| T67       | CIRS_129TI_FIRNADMAP001_PRIME | 04/06/10 | 095      | 10:50:39   | 2:45             | 25S 130W*                    |
| T67       | CIRS_129TI_FIRNADMAP002_PRIME | 04/06/10 | 095      | 19:50:39   | 1:00             | 10N 310W*                    |
| T69       | CIRS_132TI_EUVFUV001_UVIS     | 06/06/10 | 156      | 04:26:27   | 7:00             | ...                          |
| T70       | CIRS_133TI_FIRNADMAP001_PRIME | 06/21/10 | 171      | 20:27:43   | 2:45             | 0N 9W                        |
| T72       | CIRS_138TI_FIRNADMAP001_PRIME | 09/25/10 | 267      | 13:38:41   | 2:45             | 5S 50W*                      |
| T72       | CIRS_138TI_EUVFUV002_UVIS     | 09/25/10 | 267      | 20:53:41   | 6:45             | ...                          |
| T73       | CIRS_140TI_FIRNADMAP001_PRIME | 11/12/10 | 315      | 08:37:01   | 2:45             | Safing event                 |
| T75       | CIRS_147TI_EUVFUV001_UVIS     | 04/20/11 | 109      | 07:30:39   | 6:30             | ...                          |
| T76       | CIRS_148TI_FIRNADMAP001_PRIME | 05/09/11 | 128      | 17:53:45   | 2:45             | 0N 20W*                      |
| T76       | CIRS_148TI_EUVFUV001_UVIS     | 05/10/11 | 129      | 01:53:45   | 6:00             | ...                          |
| T77       | CIRS_149TI_EUVFUV001_UVIS     | 06/21/11 | 171      | 06:37:00   | 9:25             | ...                          |
| T77       | CIRS_149TI_FIRNADMAP002_PRIME | 06/21/11 | 171      | 21:02:01   | 2:30             | 0N 217W                      |
| T78       | CIRS_153TI_FIRNADMAP001_PRIME | 09/12/11 | 254      | 21:50:06   | 2:45             | 0N 118W*                     |
| T79       | CIRS_158TI_FIRNADMAP501_PRIME | 12/14/11 | 347      | 15:11:24   | 2:45             | 0N 15W                       |
| T80       | CIRS_159TI_FIRNADMAP001_PRIME | 01/03/12 | 002      | 10:13:38   | 2:45             | 25S 138W                     |
| T81       | CIRS_160TI_EUVFUV001_UVIS     | 01/31/12 | 030      | 04:39:47   | 6:45             | ...                          |
| T81       | CIRS_160TI_EUVFUV002_UVIS     | 01/31/12 | 030      | 16:39:47   | 6:00             | ...                          |
| T82       | CIRS_161TI_FIRNADMAP001_PRIME | 02/20/12 | 050      | 03:43:17   | 2:45             | 0N 148W                      |
| T82       | CIRS_161TI_FIRNADMAP002_PRIME | 02/20/12 | 050      | 10:58:17   | 2:45             | 0N 330W*                     |
| T83       | CIRS_166TI_FIRNADMAP001_PRIME | 05/22/12 | 142      | 20:10:11   | 2:33             | 0N 20W                       |
| T84       | CIRS_167TI_FIRNADMAP001_PRIME | 06/07/12 | 158      | 19:07:21   | 2:45             | 22N 18W                      |
| T84       | CIRS_167TI_EUVFUV002_UVIS     | 06/08/12 | 159      | 02:22:21   | 6:45             | ...                          |
| T85       | CIRS_169TI_FIRNADMAP002_PRIME | 07/25/12 | 206      | 22:18:08   | 2:45             | 18S 202W                     |
| T86       | CIRS_172TI_EUVFUV001_UVIS     | 09/27/12 | 270      | 05:35:38   | 6:45             | ...                          |
| T86       | CIRS_172TI_EUVFUV002_UVIS     | 09/27/12 | 270      | 16:50:38   | 6:45             | ...                          |
| T88       | CIRS_175TI_FIRNADMAP001_PRIME | 11/30/12 | 334      | 03:56:59   | 2:45             | 35N 30W                      |
| T90       | CIRS_185TI_FIRNADMAP001_PRIME | 04/06/13 | 095      | 16:43:31   | 2:45             | 42N 48W                      |
| T93       | CIRS_195TI_EUVFUV001_UVIS     | 07/27/13 | 207      | 02:56:19   | 6:45             | ...                          |
| T94       | CIRS_197TI_EUVFUV001_UVIS     | 09/13/13 | 255      | 09:58:56   | 6:45             | ...                          |
| T96       | CIRS_199TI_FIRNADMAP002_PRIME | 12/02/13 | 335      | 02:56:19   | 2:45             | 90S 0W*                      |
| T97       | CIRS_200TI_EUVFUV001_UVIS     | 01/02/14 | 001      | 12:59:41   | 6:45             | ...                          |
| T97       | CIRS_200TI_EUVFUV002_UVIS     | 01/03/14 | 002      | 00:14:41   | 6:45             | ...                          |
| T100      | CIRS_203TI_EUVFUV001_UVIS     | 04/08/14 | 097      | 15:56:14   | 6:45             | ...                          |
| T101      | CIRS_204TI_EUVFUV001_UVIS     | 05/18/14 | 137      | 02:12:15   | 5:15             | ...                          |
| T101      | CIRS_204TI_FIRNADMAP002_PRIME | 05/18/14 | 137      | 18:57:15   | 2:15             | 78N 240W, 72N 313W           |

**Table 7**  
(Continued)

| Flyby No. | Observation Name              | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Center Lat., Lon.) |
|-----------|-------------------------------|----------|----------|------------|------------------|------------------------------|
| T102      | CIRS_205TI_FIRNADMAP002_PRIME | 06/19/14 | 169      | 16:31:25   | 1:57             | 65N 195W*                    |
| T103      | CIRS_206TI_FIRNADMAP002_PRIME | 07/21/14 | 201      | 13:40:58   | 2:00             | 78N 240W                     |
| T105      | CIRS_208TI_EUVFUV001_UVIS     | 09/23/14 | 265      | 02:23:19   | 0:45             | ...                          |
| T105      | CIRS_208TI_EUVFUV002_UVIS     | 09/23/14 | 265      | 11:08:19   | 1:30             | ...                          |
| T105      | CIRS_208TI_FIRNADMAP002_PRIME | 09/23/14 | 265      | 07:38:19   | 3:30             | 57N 200W*                    |
| T109      | CIRS_212TI_EUVFUV001_UVIS     | 02/13/15 | 043      | 08:08:04   | 6:45             | ...                          |
| T109      | CIRS_212TI_EUVFUV002_UVIS     | 02/13/15 | 043      | 19:23:04   | 6:45             | ...                          |
| T110      | CIRS_213TI_FIRNADMAP002_PRIME | 03/17/15 | 075      | 16:44:49   | 2:45             | 6S 200W                      |
| T111      | CIRS_215TI_FIRNADMAP002_PRIME | 05/09/15 | 128      | 01:05:24   | 2:45             | 10S 340W                     |
| T112      | CIRS_218TI_FIRNADMAP002_PRIME | 07/08/15 | 188      | 10:24:51   | 2:45             | 6N 220W                      |
| T113      | CIRS_222TI_FIRNADMAP001_PRIME | 09/29/15 | 271      | 16:37:12   | 3:00             | 0N 150W                      |
| T113      | CIRS_222TI_FIRNADMAP002_PRIME | 09/30/15 | 272      | 00:07:12   | 2:30             | 0N 335W                      |
| T114      | CIRS_225TI_EUVFUV002_UVIS     | 11/14/15 | 317      | 08:01:31   | 6:45             | ...                          |
| T115      | CIRS_230TI_EUVFUV001_UVIS     | 01/16/16 | 015      | 17:20:24   | 6:45             | ...                          |
| T115      | CIRS_230TI_FIRNADMAP002_PRIME | 01/17/16 | 016      | 04:35:24   | 2:45             | 0N 218W                      |
| T116      | CIRS_231TI_EUVFUV001_UVIS     | 02/02/16 | 032      | 04:20:05   | 1:40             | ...                          |
| T116      | CIRS_231TI_FIRNADMAP001_PRIME | 02/01/16 | 031      | 20:00:05   | 2:30             | 5S 24W                       |
| T117      | CIRS_232TI_FIRNADMAP002_PRIME | 02/18/16 | 048      | 02:28:41   | 2:21             | 13N 207W                     |
| T118      | CIRS_234TI_EUVFUV001_UVIS     | 04/05/16 | 095      | 10:42:42   | 6:45             | ...                          |
| T118      | CIRS_234TI_EUVFUV002_UVIS     | 04/05/16 | 095      | 21:57:42   | 6:45             | ...                          |
| T119      | CIRS_235TI_FIRNADMAP001_PRIME | 05/07/16 | 127      | 11:54:37   | 2:42             | 25S 30W*                     |
| T120      | CIRS_236TI_FIRNADMAP001_PRIME | 06/08/16 | 159      | 09:06:17   | 2:30             | 36S 20W                      |
| T120      | CIRS_236TI_FIRNADMAP002_PRIME | 06/08/16 | 159      | 16:21:17   | 2:45             | 38N 207W                     |
| T121      | CIRS_238TI_FIRNADMAP001_PRIME | 07/26/16 | 207      | 04:58:23   | 2:45             | 41S 26W                      |
| T123      | CIRS_243TI_EUVFUV001_UVIS     | 09/27/16 | 270      | 19:16:59   | 6:45             | ...                          |
| T123      | CIRS_243TI_EUVFUV002_UVIS     | 09/28/16 | 271      | 06:31:59   | 6:45             | ...                          |
| T124      | CIRS_248TI_FIRNADMAP002_PRIME | 11/15/16 | 319      | 02:27:56   | 2:28             | 33N 244W                     |
| T125      | CIRS_250TI_FIRNADMAP002_PRIME | 12/01/16 | 335      | 00:29:32   | 2:45             | 31N 246W                     |
| N/A       | CIRS_275TI_FIRNADMAP002_PRIME | 05/25/17 | 144      | 01:18:00   | 4:15             | 20S 305W*                    |
| N/A       | CIRS_292TI_FIRNADMAP001_PRIME | 09/12/17 | 254      | 23:46:00   | 3:00             | N Pole mosaic                |

(This table is available in machine-readable form.)

## Appendix F

### Catalog of Far-infrared Nadir Integrations

A complete listing of dates, times, durations, and pointing positions for CIRS far-infrared nadir integrations are given in Table 8. See Section 6.3 for details.

**Table 8**  
CIRS Far-infrared Nadir Integrations

| Flyby No. | Observation Name              | Date     | DOY | Start Time | Duration (HR:MN) | Pointing (Center Lat., Lon.) |
|-----------|-------------------------------|----------|-----|------------|------------------|------------------------------|
| T0        | CIRS_000TI_FIRNADCMP017_PRIME | 07/04/04 | 185 | 01:00:00   | 2:15             | visible center               |
| T0        | CIRS_000TI_FIRNADCMP001_PRIME | 07/04/04 | 185 | 04:00:00   | 6:00             | visible center               |
| TA        | CIRS_00ATI_FIRNADCMP001_PRIME | 10/27/04 | 300 | 00:00:09   | 4:00             | 30S 200W                     |
| TB        | CIRS_00BTI_FIRNADCMP001_PRIME | 12/13/04 | 347 | 23:38:13   | 4:00             | 10N 120W                     |
| T3        | CIRS_003TI_FIRNADCMP002_PRIME | 02/16/05 | 046 | 14:57:53   | 4:00             | 18S 35W                      |
| T4        | CIRS_005TI_FIRNADCMP002_PRIME | 04/01/05 | 090 | 07:35:16   | 4:00             | 40S 15W                      |
| T4        | CIRS_005TI_FIRNADCMP003_PRIME | 04/02/05 | 091 | 04:05:16   | 4:00             | 47N 210W                     |
| T5        | CIRS_006TI_FIRNADCMP002_PRIME | 04/17/05 | 106 | 07:16:46   | 3:25             | 55N 15W                      |
| T6        | CIRS_013TI_FIRNADCMP003_PRIME | 08/22/05 | 233 | 22:05:37   | 3:18             | 30N 330W                     |
| T6        | CIRS_013TI_FIRNADCMP004_PRIME | 08/23/05 | 234 | 16:23:37   | 4:30             | 60S 220W                     |
| T8        | CIRS_017TI_FIRNADCMP003_PRIME | 10/29/05 | 301 | 13:15:25   | 3:00             | 20N 35W                      |
| T9        | CIRS_019TI_FIRNADCMP002_PRIME | 12/27/05 | 360 | 07:49:30   | 2:10             | 0N 62W                       |
| T10       | CIRS_020TI_FIRNADCMP002_PRIME | 01/15/06 | 014 | 23:41:27   | 2:00             | 20N 190W                     |
| T11       | CIRS_021TI_FIRNADCMP002_PRIME | 02/28/06 | 058 | 16:55:19   | 4:40             | 30S 170W                     |
| T12       | CIRS_022TI_FIRNADCMP003_PRIME | 03/19/06 | 077 | 10:05:57   | 7:00             | 0N 190W                      |

**Table 8**  
(Continued)

| Flyby No. | Observation Name              | Date     | DOY | Start Time | Duration (HR:MN) | Pointing (Center Lat., Lon.) |
|-----------|-------------------------------|----------|-----|------------|------------------|------------------------------|
| T12       | CIRS_022TI_FIRNADCMP008_PRIME | 03/20/06 | 078 | 12:25:57   | 1:41             | 25N 315W                     |
| T13       | CIRS_023TI_FIRNADCMP003_PRIME | 05/01/06 | 120 | 05:34:14   | 6:24             | 25S 320W                     |
| T13       | CIRS_023TI_FIRNADCMP002_PRIME | 05/02/06 | 121 | 07:28:14   | 4:07             | 35S 210W                     |
| T14       | CIRS_024TI_FIRNADCMP003_PRIME | 05/20/06 | 139 | 20:48:11   | 6:30             | 15S 125W                     |
| T15       | CIRS_025TI_FIRNADCMP003_PRIME | 07/02/06 | 182 | 19:50:47   | 3:30             | 15N 230W                     |
| T15       | CIRS_025TI_FIRNADCMP002_PRIME | 07/03/06 | 183 | 18:20:47   | 5:30             | 40N 20W                      |
| T17       | CIRS_028TI_FIRNADCMP003_PRIME | 09/08/06 | 250 | 06:16:51   | 6:00             | 30N 145W                     |
| T18       | CIRS_029TI_FIRNADCMP003_PRIME | 09/24/06 | 266 | 04:58:49   | 5:30             | 10N 95W                      |
| T19       | CIRS_030TI_FIRNADCMP003_PRIME | 10/10/06 | 282 | 03:30:07   | 5:00             | 60S 300W                     |
| T19       | CIRS_030TI_FIRNADCMP002_PRIME | 10/11/06 | 283 | 03:30:07   | 5:51             | 35N 115W                     |
| T21       | CIRS_035TI_FIRNADCMP003_PRIME | 12/12/06 | 345 | 21:11:31   | 5:30             | 65N 130W                     |
| T21       | CIRS_035TI_FIRNADCMP023_PRIME | 12/13/06 | 346 | 22:09:31   | 3:00             | 80S 300W                     |
| T22       | CIRS_036TI_FIRNADCMP003_PRIME | 12/28/06 | 361 | 20:05:22   | 5:30             | 80N 160W                     |
| T22       | CIRS_036TI_FIRNADCMP002_PRIME | 12/29/06 | 362 | 18:35:22   | 2:30             | 90S 320W                     |
| T23       | CIRS_037TI_FIRNADCMP001_PRIME | 01/13/07 | 012 | 19:38:31   | 3:00             | 75N 210W                     |
| T23       | CIRS_037TI_FIRNADCMP002_PRIME | 01/14/07 | 013 | 17:38:31   | 2:00             | 70S 210W                     |
| T24       | CIRS_038TI_FIRNADCMP001_PRIME | 01/29/07 | 028 | 16:15:55   | 5:00             | 85N 290W                     |
| T24       | CIRS_038TI_FIRNADCMP002_PRIME | 01/30/07 | 029 | 16:15:55   | 5:00             | 40S 280W                     |
| T25       | CIRS_039TI_FIRNADCMP001_PRIME | 02/22/07 | 052 | 14:12:24   | 3:00             | 30S 90W                      |
| T25       | CIRS_039TI_FIRNADCMP002_PRIME | 02/23/07 | 053 | 12:12:24   | 2:00             | 70N 350W                     |
| T26       | CIRS_040TI_FIRNADCMP001_PRIME | 03/10/07 | 068 | 12:49:00   | 3:00             | 50S 80W                      |
| T26       | CIRS_040TI_FIRNADCMP002_PRIME | 03/11/07 | 069 | 10:49:00   | 2:00             | 90N 60W                      |
| T27       | CIRS_041TI_FIRNADCMP001_PRIME | 03/26/07 | 084 | 11:23:27   | 3:00             | 70S 20W                      |
| T27       | CIRS_041TI_FIRNADCMP002_PRIME | 03/27/07 | 085 | 09:23:27   | 2:00             | 60N 150W                     |
| T28       | CIRS_042TI_FIRNADCMP001_PRIME | 04/11/07 | 100 | 07:58:00   | 2:00             | 60S 30W                      |
| T28       | CIRS_042TI_FIRNADCMP002_PRIME | 04/12/07 | 101 | 07:58:00   | 5:00             | 70N 180W                     |
| T29       | CIRS_043TI_FIRNADCMP001_PRIME | 04/27/07 | 116 | 06:46:58   | 4:46             | 50S 30W                      |
| T29       | CIRS_043TI_FIRNADCMP002_PRIME | 04/28/07 | 117 | 06:32:58   | 2:00             | 75N 220W                     |
| T30       | CIRS_044TI_FIRNADCMP002_PRIME | 05/14/07 | 133 | 05:09:58   | 2:00             | 0N 260W                      |
| T31       | CIRS_045TI_FIRNADCMP001_PRIME | 05/29/07 | 148 | 04:42:55   | 4:09             | 20S 330W                     |
| T31       | CIRS_045TI_FIRNADCMP002_PRIME | 05/30/07 | 149 | 03:51:55   | 6:14             | 50N 230W                     |
| T32       | CIRS_046TI_FIRNADCMP001_PRIME | 06/14/07 | 164 | 03:39:11   | 1:07             | 20N 50W                      |
| T32       | CIRS_046TI_FIRNADCMP002_PRIME | 06/15/07 | 165 | 02:46:11   | 2:00             | 20S 257W                     |
| T33       | CIRS_047TI_FIRNADCMP001_PRIME | 06/30/07 | 180 | 02:44:46   | 4:15             | 10N 330W                     |
| T33       | CIRS_047TI_FIRNADCMP002_PRIME | 07/01/07 | 181 | 02:14:46   | 4:45             | 20N 170W                     |
| T34       | CIRS_048TI_FIRNADCMP001_PRIME | 07/19/07 | 199 | 10:11:20   | 2:00             | 35S 125W                     |
| T34       | CIRS_048TI_FIRNADCMP002_PRIME | 07/20/07 | 200 | 10:11:20   | 4:49             | 50N 345W                     |
| T35       | CIRS_049TI_FIRNADCMP001_PRIME | 08/31/07 | 242 | 18:17:34   | 2:15             | 10S 40W                      |
| T35       | CIRS_049TI_FIRNADCMP002_PRIME | 09/01/07 | 243 | 15:32:34   | 6:00             | 37S 240W                     |
| T36       | CIRS_050TI_FIRNADCMP001_PRIME | 10/02/07 | 274 | 13:30:43   | 5:12             | 10S 320W                     |
| T36       | CIRS_050TI_FIRNADCMP002_PRIME | 10/03/07 | 275 | 13:42:43   | 2:00             | 30N 255W                     |
| T37       | CIRS_052TI_FIRNADCMP002_PRIME | 11/20/07 | 323 | 09:47:25   | 5:00             | 40N 185W                     |
| T38       | CIRS_053TI_FIRNADCMP001_PRIME | 12/05/07 | 338 | 09:59:50   | 4:07             | 40S 340W                     |
| T38       | CIRS_053TI_FIRNADCMP002_PRIME | 12/06/07 | 339 | 09:06:50   | 2:00             | 60N 215W                     |
| T39       | CIRS_054TI_FIRNADCMP002_PRIME | 12/22/07 | 355 | 07:57:55   | 2:00             | 60N 270W                     |
| T40       | CIRS_055TI_FIRNADCMP001_PRIME | 01/06/08 | 005 | 08:07:20   | 3:23             | 20N 355W                     |
| T40       | CIRS_055TI_FIRNADCMP002_PRIME | 01/07/08 | 006 | 06:30:20   | 5:00             | 45N 280W                     |
| T41       | CIRS_059TI_FIRNADCMP001_PRIME | 02/23/08 | 053 | 04:29:07   | 3:03             | 25S 65W                      |
| T41       | CIRS_059TI_FIRNADCMP002_PRIME | 02/24/08 | 054 | 02:32:07   | 2:00             | 15N 285W                     |
| T42       | CIRS_062TI_FIRNADCMP002_PRIME | 03/26/08 | 085 | 23:27:48   | 2:00             | 60N 310W                     |
| T43       | CIRS_067TI_FIRNADCMP001_PRIME | 05/12/08 | 132 | 23:07:58   | 0:54             | 60S 60W                      |
| T43       | CIRS_067TI_FIRNADCMP002_PRIME | 05/13/08 | 133 | 19:01:58   | 5:00             | 30N 300W                     |
| T44       | CIRS_069TI_FIRNADCMP001_PRIME | 05/28/08 | 148 | 17:24:32   | 2:00             | 45S 50W                      |
| T44       | CIRS_069TI_FIRNADCMP002_PRIME | 05/29/08 | 149 | 17:24:32   | 2:00             | 10N 300W                     |
| T46       | CIRS_091TI_FIRNADCMP001_PRIME | 11/04/08 | 308 | 02:35:24   | 6:00             | BIU anomaly                  |
| T46       | CIRS_091TI_FIRNADCMP002_PRIME | 11/05/08 | 309 | 03:35:24   | 4:38             |                              |
| T47       | CIRS_093TI_FIRNADCMP002_PRIME | 11/21/08 | 325 | 01:56:28   | 3:00             | 45N 255W                     |
| T48       | CIRS_095TI_FIRNADCMP001_PRIME | 12/06/08 | 340 | 01:25:45   | 4:00             | 15S 70W                      |
| T49       | CIRS_097TI_FIRNADCMP001_PRIME | 12/21/08 | 355 | 23:59:52   | 4:00             | 10S 110W                     |
| T50       | CIRS_102TI_FIRNADCMP001_PRIME | 02/07/09 | 037 | 19:50:51   | 3:30             | BIU anomaly                  |
| T51       | CIRS_106TI_FIRNADCMP001_PRIME | 03/27/09 | 085 | 16:43:36   | 3:00             | 60S 150W                     |

**Table 8**  
(Continued)

| Flyby No. | Observation Name              | Date     | DOY | Start Time | Duration (HR:MN) | Pointing (Center Lat., Lon.) |
|-----------|-------------------------------|----------|-----|------------|------------------|------------------------------|
| T51       | CIRS_107TI_FIRNADCMP002_PRIME | 03/28/09 | 086 | 14:43:36   | 3:00             | 35N 215W                     |
| T52       | CIRS_108TI_FIRNADCMP002_PRIME | 04/05/09 | 094 | 10:47:47   | 3:00             | 70S 75W                      |
| T53       | CIRS_109TI_FIRNADCMP001_PRIME | 04/20/09 | 109 | 09:13:42   | 5:07             | Downlink                     |
| T54       | CIRS_110TI_FIRNADCMP001_PRIME | 05/07/09 | 126 | 07:54:16   | 5:00             | 70S 190W                     |
| T55       | CIRS_111TI_FIRNADCMP002_PRIME | 05/23/09 | 142 | 06:26:41   | 3:00             | 25S 5W                       |
| T56       | CIRS_112TI_FIRNADCMP001_PRIME | 06/07/09 | 157 | 06:07:49   | 3:52             | 50N 60W                      |
| T56       | CIRS_112TI_FIRNADCMP002_PRIME | 06/08/09 | 158 | 05:00:01   | 5:00             | 60S 255W                     |
| T57       | CIRS_113TI_FIRNADCMP001_PRIME | 06/23/09 | 173 | 05:05:48   | 3:27             | 15N 75W                      |
| T58       | CIRS_114TI_FIRNADCMP001_PRIME | 07/10/09 | 190 | 02:04:03   | 3:00             | 70S 340W                     |
| T59       | CIRS_115TI_FIRNADCMP001_PRIME | 07/25/09 | 205 | 02:34:04   | 3:00             | 50N 100W                     |
| T60       | CIRS_116TI_FIRNADCMP001_PRIME | 08/10/09 | 221 | 02:01:49   | 2:02             | Downlink                     |
| T62       | CIRS_119TI_FIRNADCMP001_PRIME | 10/12/09 | 284 | 19:36:25   | 3:00             | 25S 105W                     |
| T62       | CIRS_119TI_FIRNADCMP002_PRIME | 10/13/09 | 285 | 17:36:25   | 3:00             | 0N 20W                       |
| T63       | CIRS_122TI_FIRNADCMP001_PRIME | 12/12/09 | 345 | 11:05:56   | 3:57             | 40N 0W                       |
| T64       | CIRS_123TI_FIRNADCMP002_PRIME | 12/29/09 | 362 | 09:16:59   | 3:00             | 45S 190W                     |
| T65       | CIRS_124TI_FIRNADCMP002_PRIME | 01/14/10 | 013 | 08:10:37   | 5:00             | 0N 170W                      |
| T66       | CIRS_125TI_FIRNADCMP001_PRIME | 01/29/10 | 028 | 08:07:18   | 4:22             | 40N 40W                      |
| T66       | CIRS_125TI_FIRNADCMP002_PRIME | 01/30/10 | 029 | 07:28:49   | 5:00             | 45S 225W                     |
| T67       | CIRS_129TI_FIRNADCMP001_PRIME | 04/06/10 | 095 | 03:44:18   | 2:06             | 45S 110W                     |
| T68       | CIRS_131TI_FIRNADCMP001_PRIME | 05/20/10 | 139 | 14:24:20   | 3:00             | 30S 30W                      |
| T68       | CIRS_131TI_FIRNADCMP002_PRIME | 05/21/10 | 140 | 12:24:20   | 4:00             | 20S 230W                     |
| T69       | CIRS_132TI_FIRNADCMP002_PRIME | 06/06/10 | 156 | 11:26:27   | 3:00             | 50N 195W                     |
| T70       | CIRS_133TI_FIRNADCMP001_PRIME | 06/21/10 | 171 | 12:06:01   | 3:21             | 50S 0W                       |
| T71       | CIRS_134TI_FIRNADCMP001_PRIME | 07/07/10 | 187 | 11:07:45   | 4:15             | 10S 60W                      |
| T72       | CIRS_138TI_FIRNADCMP001_PRIME | 09/25/10 | 267 | 06:12:41   | 3:26             | 30S 40W                      |
| T73       | CIRS_140TI_FIRNADCMP001_PRIME | 11/12/10 | 315 | 00:37:01   | 4:00             | Safing event                 |
| T76       | CIRS_148TI_FIRNADCMP001_PRIME | 05/09/11 | 128 | 09:42:00   | 4:12             | 10S 115W                     |
| T78       | CIRS_153TI_FIRNADCMP001_PRIME | 09/12/11 | 254 | 13:50:06   | 4:00             | 10N 110W                     |
| T79       | CIRS_158TI_FIRNADCMP501_PRIME | 12/14/11 | 347 | 04:20:00   | 6:52             | 30S 330W                     |
| T80       | CIRS_159TI_FIRNADCMP001_PRIME | 01/03/12 | 002 | 01:16:59   | 4:57             | 40S 150W                     |
| T81       | CIRS_160TI_FIRNADCMP001_PRIME | 01/30/12 | 029 | 23:36:01   | 5:04             | 40S 330W                     |
| T81       | CIRS_160TI_FIRNADCMP002_PRIME | 01/31/12 | 030 | 22:39:48   | 5:36             | 0N 240W                      |
| T82       | CIRS_161TI_FIRNADCMP001_PRIME | 02/19/12 | 049 | 20:43:17   | 2:00             | 10N 150W                     |
| T82       | CIRS_161TI_FIRNADCMP002_PRIME | 02/20/12 | 050 | 17:43:17   | 2:06             | 15S 290W                     |
| T83       | CIRS_166TI_FIRNADCMP001_PRIME | 05/23/12 | 143 | 10:10:11   | 5:36             | 15S 170W                     |
| T84       | CIRS_167TI_FIRNADCMP002_PRIME | 06/08/12 | 159 | 09:07:21   | 5:00             | 45S 255W                     |
| T85       | CIRS_169TI_FIRNADCMP001_PRIME | 07/25/12 | 206 | 07:03:07   | 4:00             | 10S 345W                     |
| T86       | CIRS_172TI_FIRNADCMP001_PRIME | 09/27/12 | 270 | 01:10:59   | 4:25             | 45N 315W                     |
| T86       | CIRS_172TI_FIRNADCMP002_PRIME | 09/27/12 | 270 | 23:35:38   | 5:00             | 70S 240W                     |
| T87       | CIRS_174TI_FIRNADCMP002_PRIME | 11/14/12 | 318 | 19:22:08   | 5:00             | 72S 185W                     |
| T88       | CIRS_175TI_FIRNADCMP001_PRIME | 11/29/12 | 333 | 21:26:59   | 2:30             | 15N 60W                      |
| T88       | CIRS_175TI_FIRNADCMP002_PRIME | 11/30/12 | 334 | 17:56:59   | 5:00             | 60S 165W                     |
| T90       | CIRS_185TI_FIRNADCMP001_PRIME | 04/06/13 | 095 | 08:43:31   | 4:00             | 15N 70W                      |
| T90       | CIRS_185TI_FIRNADCMP002_PRIME | 04/07/13 | 096 | 06:43:31   | 5:00             | 89S 245W                     |
| T91       | CIRS_190TI_FIRNADCMP001_PRIME | 05/24/13 | 143 | 04:32:55   | 4:00             | 0N 50W                       |
| T91       | CIRS_190TI_FIRNADCMP002_PRIME | 05/25/13 | 144 | 02:32:55   | 5:00             | 45S 300W                     |
| T92       | CIRS_194TI_FIRNADCMP001_PRIME | 07/11/13 | 191 | 01:21:47   | 3:00             | 30N 90W                      |
| T93       | CIRS_195TI_FIRNADCMP001_PRIME | 07/26/13 | 206 | 23:56:22   | 3:00             | 20N 15W                      |
| T94       | CIRS_197TI_FIRNADCMP001_PRIME | 09/12/13 | 254 | 17:43:56   | 5:00             | 60N 110W                     |
| T95       | CIRS_198TI_FIRNADCMP001_PRIME | 10/14/13 | 286 | 16:56:27   | 3:00             | 89N 30W                      |
| T95       | CIRS_198TI_FIRNADCMP002_PRIME | 10/15/13 | 287 | 13:56:27   | 4:53             | 70S 100W                     |
| T96       | CIRS_199TI_FIRNADCMP001_PRIME | 12/01/13 | 334 | 10:41:19   | 5:00             | 90N (FPB)                    |
| T97       | CIRS_200TI_FIRNADCMP001_PRIME | 01/02/14 | 001 | 09:59:41   | 3:00             | 50N 165W                     |
| T97       | CIRS_200TI_FIRNADCMP002_PRIME | 01/03/14 | 002 | 07:21:41   | 4:00             | 60S 45W                      |
| T98       | CIRS_201TI_FIRNADCMP001_PRIME | 02/03/14 | 033 | 05:12:39   | 5:00             | 20N 135W                     |
| T98       | CIRS_201TI_FIRNADCMP002_PRIME | 02/04/14 | 034 | 04:12:39   | 4:00             | 40S 20W                      |
| T100      | CIRS_203TI_FIRNADCMP001_PRIME | 04/08/14 | 097 | 01:41:14   | 3:00             | 75N 90W                      |
| T100      | CIRS_203TI_FIRNADCMP002_PRIME | 04/08/14 | 097 | 22:41:14   | 4:00             | 0N 0W                        |
| T101      | CIRS_204TI_FIRNADCMP002_PRIME | 05/19/14 | 138 | 01:12:15   | 4:00             | 0N 210W                      |
| T102      | CIRS_205TI_FIRNADCMP001_PRIME | 06/19/14 | 169 | 01:28:25   | 3:00             | 45S 300W                     |

**Table 8**  
(Continued)

| Flyby No. | Observation Name              | Date     | DOY | Start Time | Duration (HR:MN) | Pointing (Center Lat., Lon.) |
|-----------|-------------------------------|----------|-----|------------|------------------|------------------------------|
| T102      | CIRS_205TI_FIRNADCMP002_PRIME | 06/19/14 | 169 | 22:28:25   | 3:00             | 30N 180W                     |
| T103      | CIRS_206TI_FIRNADCMP001_PRIME | 07/20/14 | 200 | 22:40:58   | 3:00             | 50S 320W                     |
| T103      | CIRS_206TI_FIRNADCMP002_PRIME | 07/21/14 | 201 | 19:40:58   | 3:00             | 30N 240W                     |
| T104      | CIRS_207TI_FIRNADCMP001_PRIME | 08/21/14 | 232 | 20:09:09   | 3:00             | 70S 110W                     |
| T104      | CIRS_207TI_FIRNADCMP002_PRIME | 08/22/14 | 233 | 17:09:09   | 3:00             | 80N 150W                     |
| T105      | CIRS_208TI_FIRNADCMP001_PRIME | 09/22/14 | 264 | 15:23:19   | 5:00             | 80S 300W                     |
| T105      | CIRS_208TI_FIRNADCMP002_PRIME | 09/23/14 | 265 | 14:38:19   | 2:45             | 60N 270W                     |
| T106      | CIRS_209TI_FIRNADCMP001_PRIME | 10/24/14 | 296 | 14:40:30   | 3:00             | 35S 320W                     |
| T106      | CIRS_209TI_FIRNADCMP002_PRIME | 10/25/14 | 297 | 11:40:30   | 4:00             | 50N 255W                     |
| T107      | CIRS_210TI_FIRNADCMP001_PRIME | 12/11/14 | 344 | 08:26:35   | 5:00             | 70S 0W                       |
| T107      | CIRS_210TI_FIRNADCMP002_PRIME | 12/12/14 | 345 | 07:26:35   | 4:00             | 20S 195W                     |
| T108      | CIRS_211TI_FIRNADCMP001_PRIME | 01/12/15 | 011 | 07:15:35   | 3:33             | 20N 20W                      |
| T108      | CIRS_211TI_FIRNADCMP002_PRIME | 01/13/15 | 012 | 04:48:35   | 4:00             | 40N 160W                     |
| T109      | CIRS_212TI_FIRNADCMP002_PRIME | 02/14/15 | 044 | 02:08:04   | 4:00             | 40S 200W                     |
| T110      | CIRS_213TI_FIRNADCMP001_PRIME | 03/17/15 | 075 | 02:29:49   | 3:00             | 30S 345W                     |
| T110      | CIRS_213TI_FIRNADCMP002_PRIME | 03/17/15 | 075 | 23:29:49   | 4:00             | 25N 205W                     |
| T111      | CIRS_215TI_FIRNADCMP001_PRIME | 05/08/15 | 127 | 09:50:24   | 4:00             | 50S 140W                     |
| T111      | CIRS_215TI_FIRNADCMP002_PRIME | 05/09/15 | 128 | 07:50:24   | 4:00             | 30S 310W                     |
| T112      | CIRS_218TI_FIRNADCMP001_PRIME | 07/07/15 | 187 | 19:09:51   | 4:00             | 20S 40W                      |
| T112      | CIRS_218TI_FIRNADCMP002_PRIME | 07/08/15 | 188 | 17:09:51   | 4:00             | 40S 250W                     |
| T113      | CIRS_222TI_FIRNADCMP001_PRIME | 09/29/15 | 271 | 09:27:12   | 2:10             | 30N 110W                     |
| T113      | CIRS_222TI_FIRNADCMP002_PRIME | 09/30/15 | 272 | 06:37:12   | 4:00             | 0N 310W                      |
| T115      | CIRS_230TI_FIRNADCMP001_PRIME | 01/16/16 | 015 | 12:55:31   | 4:24             | 15S 345W                     |
| T116      | CIRS_231TI_FIRNADCMP001_PRIME | 02/01/16 | 031 | 11:56:59   | 4:03             | 15N 345W                     |
| T116      | CIRS_231TI_FIRNADCMP002_PRIME | 02/02/16 | 032 | 10:00:05   | 4:05             | 0N 260W                      |
| T117      | CIRS_232TI_FIRNADCMP001_PRIME | 02/17/16 | 047 | 10:56:37   | 3:53             | 50S 20W                      |
| T117      | CIRS_232TI_FIRNADCMP002_PRIME | 02/18/16 | 048 | 08:49:41   | 2:00             | 20S 240W                     |
| T118      | CIRS_234TI_FIRNADCMP001_PRIME | 04/05/16 | 095 | 05:42:42   | 5:00             | 20N 0W                       |
| T119      | CIRS_235TI_FIRNADCMP001_PRIME | 05/07/16 | 127 | 04:54:37   | 3:00             | 60S 320W                     |
| T119      | CIRS_235TI_FIRNADCMP002_PRIME | 05/08/16 | 128 | 01:54:37   | 4:00             | 15N 255W                     |
| T120      | CIRS_236TI_FIRNADCMP001_PRIME | 06/08/16 | 159 | 03:33:39   | 1:33             | 70S 10W                      |
| T120      | CIRS_236TI_FIRNADCMP002_PRIME | 06/08/16 | 159 | 23:06:17   | 4:00             | 60N 220W                     |
| T121      | CIRS_238TI_FIRNADCMP002_PRIME | 07/26/16 | 207 | 18:58:23   | 3:30             | 15N 260W                     |
| T124      | CIRS_248TI_FIRNADCMP001_PRIME | 11/14/16 | 318 | 11:55:56   | 3:00             | 89S 50W                      |
| T124      | CIRS_248TI_FIRNADCMP002_PRIME | 11/15/16 | 319 | 08:55:56   | 3:00             | 30N 280W                     |
| T125      | CIRS_250TI_FIRNADCMP002_PRIME | 12/01/16 | 335 | 07:14:32   | 4:00             | 20S 260W                     |
| T126      | CIRS_270TI_FIRNADCMP001_PRIME | 04/22/17 | 111 | 18:08:07   | 3:00             | 75S 55W                      |

(This table is available in machine-readable form.)

## Appendix G

### Catalog of Mid-infrared Nadir Maps

A complete listing of dates, times, and durations for CIRS mid-infrared nadir maps ARE given in Table 9. See Section 7.1 for details.

**Table 9**  
CIRS Mid-infrared Nadir Maps

| Flyby # | Observation Name              | Date     | DOY | Start Time | Duration (HR:MN) |
|---------|-------------------------------|----------|-----|------------|------------------|
| T0      | CIRS_000TI_TEMPMAP101_PRIME   | 07/03/04 | 184 | 03:30:21   | 1:22             |
| T0      | CIRS_000TI_TEMPMAP102_PRIME   | 07/03/04 | 184 | 05:16:21   | 1:24             |
| T0      | CIRS_000TI_TEMPMAP103_PRIME   | 07/03/04 | 184 | 07:04:21   | 1:26             |
| T0      | CIRS_000TI_TEMPMAP104_PRIME   | 07/03/04 | 184 | 10:30:21   | 4:00             |
| T0      | CIRS_000TI_TEMPMAP105_PRIME   | 07/03/04 | 184 | 15:15:21   | 1:45             |
| TA      | CIRS_00ATI_MIDIRTMAP001_PRIME | 10/26/04 | 299 | 17:30:09   | 5:15             |

**Table 9**  
(Continued)

| Flyby # | Observation Name              | Date     | DOY | Start Time | Duration (HR:MN) |
|---------|-------------------------------|----------|-----|------------|------------------|
| TB      | CIRS_00BTI_MIDIRTMAP001_PRIME | 12/13/04 | 347 | 15:13:13   | 8:25             |
| T3      | CIRS_003TI_MIDIRTMAP002_PRIME | 02/15/05 | 045 | 09:57:53   | 9:00             |
| T3      | CIRS_003TI_MIDIRTMAP003_PRIME | 02/16/05 | 046 | 18:57:53   | 4:20             |
| T4      | CIRS_005TI_MIDIRTMAP003_PRIME | 04/02/05 | 091 | 08:05:16   | 6:30             |
| T6      | CIRS_013TI_MIDIRTMAP007_PRIME | 08/23/05 | 234 | 20:53:37   | 7:03             |
| T7      | CIRS_014TI_MIDIRTMAP006_PRIME | 09/07/05 | 249 | 06:00:00   | 5:00             |
| T7      | CIRS_014TI_MIDIRTMAP005_PRIME | 09/08/05 | 250 | 20:11:57   | 6:11             |
| T8      | CIRS_017TI_MIDIRTMAP008_PRIME | 10/28/05 | 300 | 01:24:00   | 7:00             |
| T8      | CIRS_017TI_MIDIRTMAP005_PRIME | 10/29/05 | 301 | 16:15:25   | 7:48             |
| T9      | CIRS_019TI_MIDIRTMAP009_PRIME | 12/28/05 | 361 | 14:04:00   | 13:33            |
| T10     | CIRS_020TI_MIDIRTMAP010_PRIME | 01/15/06 | 014 | 14:23:27   | 9:18             |
| T14     | CIRS_024TI_MIDIRTMAP001_PRIME | 05/22/06 | 141 | 01:18:11   | 2:00             |
| T14     | CIRS_024TI_MIDIRTMAP002_PRIME | 05/22/06 | 141 | 06:18:11   | 2:58             |
| T15     | CIRS_025TI_MIDIRTMAP002_PRIME | 07/03/06 | 183 | 23:50:47   | 7:54             |
| T17     | CIRS_028TI_MIDIRTMAP006_PRIME | 09/07/06 | 249 | 21:56:51   | 7:20             |
| T18     | CIRS_029TI_TEMPMAPO09_PRIME   | 09/23/06 | 265 | 03:30:00   | 7:00             |
| T18     | CIRS_029TI_MIDIRTMAP004_PRIME | 09/23/06 | 265 | 20:58:49   | 7:00             |
| T19     | CIRS_030TI_MIDIRTMAP006_PRIME | 10/09/06 | 281 | 20:16:07   | 6:14             |
| T20     | CIRS_031TI_TEMPMAPO22_PRIME   | 10/25/06 | 297 | 01:26:00   | 7:30             |
| T21     | CIRS_035TI_MIDIRTMAP006_PRIME | 12/12/06 | 345 | 16:08:31   | 4:03             |
| T22     | CIRS_036TI_MIDIRTMAP006_PRIME | 12/28/06 | 361 | 15:04:22   | 5:01             |
| T23     | CIRS_037TI_MIDIRTMAP001_PRIME | 01/13/07 | 012 | 14:23:31   | 2:15             |
| T23     | CIRS_037TI_MIDIRTMAP002_PRIME | 01/13/07 | 012 | 17:38:31   | 2:00             |
| T23     | CIRS_037TI_MIDIRTMAP003_PRIME | 01/14/07 | 013 | 22:38:31   | 3:25             |
| T24     | CIRS_038TI_MIDIRTMAP001_PRIME | 01/29/07 | 028 | 13:00:55   | 2:15             |
| T24     | CIRS_038TI_MIDIRTMAP002_PRIME | 01/30/07 | 029 | 21:15:55   | 5:14             |
| T24     | CIRS_038TI_TEMPMAPO11_PRIME   | 01/31/07 | 030 | 16:37:00   | 6:00             |
| T25     | CIRS_039TI_MIDIRTMAP001_PRIME | 02/22/07 | 052 | 12:12:24   | 2:00             |
| T25     | CIRS_039TI_MIDIRTMAP002_PRIME | 02/23/07 | 053 | 17:12:24   | 7:15             |
| T26     | CIRS_040TI_MIDIRTMAP001_PRIME | 03/10/07 | 068 | 11:08:00   | 1:41             |
| T27     | CIRS_041TI_MIDIRTMAP001_PRIME | 03/26/07 | 084 | 09:07:27   | 2:16             |
| T28     | CIRS_042TI_MIDIRTMAP002_PRIME | 04/12/07 | 101 | 12:58:00   | 7:14             |
| T29     | CIRS_043TI_TEMPMAPO29_PRIME   | 04/29/07 | 118 | 00:15:00   | 3:00             |
| T30     | CIRS_044TI_MIDIRTMAP001_PRIME | 05/13/07 | 132 | 05:45:58   | 1:24             |
| T30     | CIRS_044TI_MIDIRTMAP002_PRIME | 05/14/07 | 133 | 10:09:58   | 1:19             |
| T30     | CIRS_044TI_TEMPMAPO30_PRIME   | 05/14/07 | 133 | 21:43:00   | 3:30             |
| T32     | CIRS_046TI_MIDIRTMAP002_PRIME | 06/15/07 | 165 | 07:46:11   | 2:15             |
| T34     | CIRS_048TI_TEMPMAPO13_PRIME   | 07/18/07 | 198 | 07:40:00   | 3:00             |
| T34     | CIRS_048TI_MIDIRTMAP001_PRIME | 07/19/07 | 199 | 01:48:20   | 7:23             |
| T35     | CIRS_049TI_MIDIRTMAP002_PRIME | 09/01/07 | 243 | 21:32:34   | 6:00             |
| T36     | CIRS_050TI_MIDIRTMAP002_PRIME | 10/03/07 | 275 | 18:42:43   | 8:46             |
| T36     | CIRS_050TI_TEMPMAPO31_PRIME   | 10/04/07 | 276 | 17:30:00   | 6:22             |
| N/A     | CIRS_051TI_TEMPMAPO14_PRIME   | 10/22/07 | 294 | 20:53:00   | 6:10             |
| T37     | CIRS_052TI_TEMPMAPO16_PRIME   | 11/18/07 | 321 | 20:40:00   | 4:00             |
| T37     | CIRS_052TI_MIDIRTMAP002_PRIME | 11/20/07 | 323 | 14:47:25   | 7:00             |
| T38     | CIRS_053TI_MIDIRTMAP002_PRIME | 12/06/07 | 339 | 14:06:50   | 9:37             |
| T40     | CIRS_055TI_TEMPMAPO34_PRIME   | 01/05/08 | 004 | 16:48:00   | 6:23             |
| T40     | CIRS_055TI_MIDIRTMAP002_PRIME | 01/07/08 | 006 | 11:30:20   | 7:00             |
| T41     | CIRS_059TI_MIDIRTMAP002_PRIME | 02/24/08 | 054 | 12:32:07   | 2:53             |
| T41     | CIRS_059TI_TEMPMAPO37_PRIME   | 02/24/08 | 054 | 17:55:07   | 3:25             |
| T41     | CIRS_059TI_TEMPMAPO38_PRIME   | 02/24/08 | 054 | 23:35:07   | 1:52             |
| T43     | CIRS_067TI_MIDIRTMAP002_PRIME | 05/14/08 | 134 | 02:46:58   | 6:30             |
| T44     | CIRS_069TI_MIDIRTMAP001_PRIME | 05/28/08 | 148 | 10:24:32   | 6:00             |
| N/A     | CIRS_072TI_TEMPMAPO18_PRIME   | 06/14/08 | 165 | 05:40:00   | 4:00             |
| T45     | CIRS_078TI_MIDIRTMAP001_PRIME | 07/31/08 | 212 | 08:05:21   | 4:07             |
| T46     | CIRS_091TI_MIDIRTMAP001_PRIME | 11/03/08 | 307 | 20:17:34   | BIU anomaly      |
| T46     | CIRS_091TI_MIDIRTMAP002_PRIME | 11/05/08 | 309 | 07:35:24   | omitted          |
| T47     | CIRS_093TI_MIDIRTMAP002_PRIME | 11/21/08 | 325 | 05:56:28   | 2:00             |

**Table 9**  
(Continued)

| Flyby # | Observation Name              | Date     | DOY | Start Time | Duration (HR:MN) |
|---------|-------------------------------|----------|-----|------------|------------------|
| T48     | CIRS_096TI_MIDIRTMAP001_PRIME | 12/07/08 | 341 | 04:25:45   | 3:06             |
| T49     | CIRS_097TI_MIDIRTMAP001_PRIME | 12/21/08 | 355 | 17:24:32   | 6:35             |
| T49     | CIRS_098TI_MIDIRTMAP002_PRIME | 12/23/08 | 357 | 02:29:52   | 3:30             |
| T50     | CIRS_102TI_MIDIRTMAP002_PRIME | 02/08/09 | 038 | 18:50:51   | BIU anomaly      |
| T50     | CIRS_102TI_MIDIRTMAP003_PRIME | 02/08/09 | 038 | 22:20:51   |                  |
| T51     | CIRS_106TI_MIDIRTMAP001_PRIME | 03/27/09 | 085 | 11:00:31   | 3:43             |
| T51     | CIRS_107TI_MIDIRTMAP002_PRIME | 03/28/09 | 086 | 18:13:36   | 5:12             |
| T52     | CIRS_107TI_MIDIRTMAP001_PRIME | 04/04/09 | 093 | 10:29:34   | 1:48             |
| T52     | CIRS_108TI_MIDIRTMAP002_PRIME | 04/05/09 | 094 | 15:47:47   | 7:37             |
| T53     | CIRS_109TI_MIDIRTMAP002_PRIME | 04/21/09 | 110 | 14:20:45   | Downlink         |
| T54     | CIRS_110TI_MIDIRTMAP001_PRIME | 05/06/09 | 125 | 08:11:47   |                  |
| T55     | CIRS_111TI_MIDIRTMAP001_PRIME | 05/22/09 | 141 | 07:09:49   | 1:17             |
| T55     | CIRS_111TI_MIDIRTMAP002_PRIME | 05/23/09 | 142 | 11:26:41   | 8:00             |
| T57     | CIRS_113TI_MIDIRTMAP002_PRIME | 06/24/09 | 174 | 08:32:35   | 8:00             |
| T59     | CIRS_115TI_MIDIRTMAP001_PRIME | 07/24/09 | 204 | 23:34:04   | 3:00             |
| T62     | CIRS_119TI_MIDIRTMAP001_PRIME | 10/12/09 | 284 | 14:45:21   | 4:21             |
| T63     | CIRS_122TI_MIDIRTMAP002_PRIME | 12/13/09 | 346 | 15:03:14   | 5:00             |
| T64     | CIRS_123TI_MIDIRTMAP001_PRIME | 12/28/09 | 361 | 10:07:24   | 4:10             |
| T65     | CIRS_124TI_MIDIRTMAP002_PRIME | 01/14/10 | 013 | 13:10:37   | 5:21             |
| T68     | CIRS_131TI_MIDIRTMAP001_PRIME | 05/20/10 | 139 | 08:10:04   | 5:44             |
| T68     | CIRS_131TI_MIDIRTMAP002_PRIME | 05/21/10 | 140 | 16:24:20   | 4:40             |
| T73     | CIRS_140TI_MIDIRTMAP001_PRIME | 11/11/10 | 314 | 21:14:00   | Safing event     |
| T74     | CIRS_145TI_MIDIRTMAP001_PRIME | 02/18/11 | 048 | 21:26:11   |                  |
| T74     | CIRS_145TI_MIDIRTMAP002_PRIME | 02/20/11 | 050 | 04:04:11   | 6:31             |
| T76     | CIRS_148TI_MIDIRTMAP002_PRIME | 05/10/11 | 129 | 12:53:45   | 8:13             |
| T77     | CIRS_149TI_MIDIRTMAP002_PRIME | 06/22/11 | 172 | 08:32:01   | 9:45             |
| T78     | CIRS_153TI_MIDIRTMAP001_PRIME | 09/12/11 | 254 | 07:42:00   | 6:08             |
| T79     | CIRS_158TI_MIDIRTMAP002_PRIME | 12/15/11 | 348 | 10:11:24   | 2:29             |
| T82     | CIRS_161TI_MIDIRTMAP001_PRIME | 02/19/12 | 049 | 15:54:00   | 4:49             |
| T84     | CIRS_167TI_MIDIRTMAP001_PRIME | 06/07/12 | 158 | 08:24:00   | 2:43             |
| T84     | CIRS_167TI_MIDIRTMAP002_PRIME | 06/08/12 | 159 | 14:07:21   | 7:12             |
| T85     | CIRS_169TI_MIDIRTMAP001_PRIME | 07/24/12 | 205 | 21:32:59   | 9:30             |
| T86     | CIRS_172TI_MIDIRTMAP002_PRIME | 09/28/12 | 271 | 04:35:39   | 14:45            |
| T87     | CIRS_174TI_MIDIRTMAP001_PRIME | 11/13/12 | 317 | 14:55:59   | 6:26             |
| T87     | CIRS_174TI_MIDIRTMAP002_PRIME | 11/15/12 | 319 | 00:22:08   | 5:14             |
| T88     | CIRS_175TI_MIDIRTMAP002_PRIME | 11/30/12 | 334 | 22:56:59   | 11:43            |
| T89     | CIRS_181TI_MIDIRTMAP001_PRIME | 02/17/13 | 047 | 09:20:59   | 2:30             |
| T89     | CIRS_181TI_MIDIRTMAP002_PRIME | 02/18/13 | 048 | 13:56:36   | 8:19             |
| T90     | CIRS_185TI_MIDIRTMAP001_PRIME | 04/06/13 | 095 | 05:56:00   | 2:48             |
| T90     | CIRS_185TI_MIDIRTMAP002_PRIME | 04/07/13 | 096 | 11:43:31   | 5:52             |
| T91     | CIRS_190TI_MIDIRTMAP001_PRIME | 05/24/13 | 143 | 02:41:00   | 1:52             |
| T91     | CIRS_190TI_MIDIRTMAP002_PRIME | 05/25/13 | 144 | 07:32:55   | 8:03             |
| T93     | CIRS_195TI_MIDIRTMAP001_PRIME | 07/26/13 | 206 | 13:33:59   | 8:22             |
| T94     | CIRS_197TI_MIDIRTMAP001_PRIME | 09/12/13 | 254 | 08:57:59   | 8:46             |
| T95     | CIRS_198TI_MIDIRTMAP001_PRIME | 10/14/13 | 286 | 07:09:59   | 7:46             |
| T96     | CIRS_199TI_MIDIRTMAP001_PRIME | 12/01/13 | 334 | 04:40:00   | 6:01             |
| T97     | CIRS_200TI_MIDIRTMAP001_PRIME | 01/02/14 | 001 | 02:42:59   | 5:17             |
| T97     | CIRS_200TI_MIDIRTMAP002_PRIME | 01/03/14 | 002 | 10:59:41   | 3:23             |
| T98     | CIRS_201TI_MIDIRTMAP001_PRIME | 02/03/14 | 033 | 00:46:59   | 4:26             |
| T98     | CIRS_201TI_MIDIRTMAP002_PRIME | 02/04/14 | 034 | 08:12:39   | 5:59             |
| T99     | CIRS_202TI_MIDIRTMAP002_PRIME | 03/08/14 | 066 | 04:26:47   | 7:19             |
| T100    | CIRS_203TI_MIDIRTMAP001_PRIME | 04/07/14 | 096 | 20:39:59   | 3:01             |
| T100    | CIRS_203TI_MIDIRTMAP002_PRIME | 04/09/14 | 098 | 02:41:14   | 8:24             |
| T101    | CIRS_204TI_MIDIRTMAP001_PRIME | 05/17/14 | 136 | 17:55:59   | 3:46             |
| T101    | CIRS_204TI_MIDIRTMAP002_PRIME | 05/19/14 | 138 | 05:12:15   | 2:54             |
| T102    | CIRS_205TI_MIDIRTMAP001_PRIME | 06/18/14 | 168 | 15:39:00   | 7:49             |
| T102    | CIRS_205TI_MIDIRTMAP002_PRIME | 06/20/14 | 170 | 01:28:25   | 3:06             |
| T103    | CIRS_206TI_MIDIRTMAP001_PRIME | 07/20/14 | 200 | 13:20:59   | 7:20             |

**Table 9**  
(Continued)

| Flyby # | Observation Name              | Date     | DOY | Start Time | Duration (HR:MN) |
|---------|-------------------------------|----------|-----|------------|------------------|
| T104    | CIRS_207TI_MIDIRTMAP001_PRIME | 08/21/14 | 232 | 11:15:59   | 6:53             |
| T104    | CIRS_207TI_MIDIRTMAP002_PRIME | 08/22/14 | 233 | 22:09:09   | 2:17             |
| T105    | CIRS_208TI_MIDIRTMAP001_PRIME | 09/22/14 | 264 | 09:11:59   | 6:11             |
| T105    | CIRS_208TI_MIDIRTMAP002_PRIME | 09/23/14 | 265 | 17:23:19   | 2:44             |
| T106    | CIRS_209TI_MIDIRTMAP001_PRIME | 10/24/14 | 296 | 07:10:00   | 5:31             |
| T106    | CIRS_209TI_MIDIRTMAP002_PRIME | 10/25/14 | 297 | 15:40:30   | 3:10             |
| T107    | CIRS_210TI_MIDIRTMAP001_PRIME | 12/11/14 | 344 | 04:25:00   | 4:02             |
| T107    | CIRS_210TI_MIDIRTMAP002_PRIME | 12/12/14 | 345 | 11:26:35   | 4:38             |
| T108    | CIRS_211TI_MIDIRTMAP001_PRIME | 01/13/15 | 012 | 08:48:35   | 6:03             |
| T109    | CIRS_212TI_MIDIRTMAP002_PRIME | 02/14/15 | 044 | 06:08:04   | 8:17             |
| T110    | CIRS_213TI_MIDIRTMAP001_PRIME | 03/16/15 | 074 | 22:50:00   | 3:39             |
| T110    | CIRS_213TI_MIDIRTMAP002_PRIME | 03/18/15 | 076 | 03:29:49   | 8:31             |
| T111    | CIRS_215TI_MIDIRTMAP001_PRIME | 05/08/15 | 127 | 05:09:59   | 4:41             |
| T111    | CIRS_215TI_MIDIRTMAP002_PRIME | 05/09/15 | 128 | 11:50:24   | 5:29             |
| T112    | CIRS_218TI_MIDIRTMAP001_PRIME | 07/07/15 | 187 | 12:27:00   | 6:42             |
| T112    | CIRS_218TI_MIDIRTMAP002_PRIME | 07/08/15 | 188 | 21:09:51   | 3:54             |
| T113    | CIRS_222TI_MIDIRTMAP002_PRIME | 09/30/15 | 272 | 10:37:12   | 5:45             |
| T114    | CIRS_225TI_MIDIRTMAP001_PRIME | 11/13/15 | 316 | 06:53:59   | 8:53             |
| T117    | CIRS_232TI_MIDIRTMAP002_PRIME | 02/18/16 | 048 | 10:49:41   | 4:00             |
| T118    | CIRS_234TI_MIDIRTMAP001_PRIME | 04/04/16 | 094 | 19:59:00   | 9:44             |
| T119    | CIRS_235TI_MIDIRTMAP001_PRIME | 05/06/16 | 126 | 20:09:00   | 6:46             |
| T119    | CIRS_235TI_MIDIRTMAP002_PRIME | 05/08/16 | 128 | 05:54:37   | 3:24             |
| T120    | CIRS_236TI_MIDIRTMAP002_PRIME | 06/09/16 | 160 | 03:06:17   | 3:52             |
| T121    | CIRS_238TI_MIDIRTMAP002_PRIME | 07/26/16 | 207 | 22:28:23   | 5:04             |
| T123    | CIRS_243TI_MIDIRTMAP001_PRIME | 09/27/16 | 270 | 10:07:58   | 4:09             |
| T124    | CIRS_248TI_MIDIRTMAP001_PRIME | 11/14/16 | 318 | 07:24:00   | 2:32             |
| T124    | CIRS_248TI_MIDIRTMAP002_PRIME | 11/15/16 | 319 | 13:55:56   | 4:53             |
| T125    | CIRS_250TI_MIDIRTMAP002_PRIME | 12/01/16 | 335 | 11:14:32   | 6:33             |
| N/A     | CIRS_253TI_MIDIRTMAP001_PRIME | 12/16/16 | 350 | 10:16:00   | 6:05             |
| N/A     | CIRS_253TI_MIDIRTMAP002_PRIME | 12/16/16 | 350 | 22:21:00   | 4:00             |
| N/A     | CIRS_253TI_MIDIRTMAP003_PRIME | 12/17/16 | 351 | 05:51:00   | 1:30             |
| N/A     | CIRS_253TI_MIDIRTMAP004_PRIME | 12/17/16 | 351 | 08:21:00   | 2:12             |
| N/A     | CIRS_259TI_MIDIRTMAP001_PRIME | 02/02/17 | 032 | 09:19:00   | 3:47             |
| N/A     | CIRS_259TI_MIDIRTMAP002_PRIME | 02/03/17 | 033 | 02:36:00   | 7:00             |
| N/A     | CIRS_261TI_MIDIRTMAP001_PRIME | 02/18/17 | 048 | 02:31:00   | 5:10             |
| N/A     | CIRS_270TI_MIDIRTMAP001_PRIME | 04/22/17 | 111 | 13:24:58   | 2:43             |
| N/A     | CIRS_270TI_MIDIRTMAP002_PRIME | 04/23/17 | 112 | 19:08:07   | 9:53             |
| N/A     | CIRS_273TI_MIDIRTMAP001_PRIME | 05/08/17 | 127 | 19:02:00   | 3:00             |
| N/A     | CIRS_275TI_MIDIRTMAP002_PRIME | 05/25/17 | 144 | 11:33:00   | 4:00             |
| N/A     | CIRS_278TI_MIDIRTMAP001_PRIME | 06/09/17 | 159 | 12:26:00   | 3:00             |
| N/A     | CIRS_278TI_MIDIRTMAP002_PRIME | 06/09/17 | 159 | 16:26:00   | 3:00             |
| N/A     | CIRS_278TI_MIDIRTMAP003_PRIME | 06/09/17 | 159 | 20:26:00   | 2:00             |
| N/A     | CIRS_278TI_MIDIRTMAP004_PRIME | 06/09/17 | 159 | 23:26:00   | 3:00             |
| N/A     | CIRS_278TI_MIDIRTMAP005_PRIME | 06/10/17 | 160 | 03:26:00   | 3:00             |
| N/A     | CIRS_278TI_MIDIRTMAP006_PRIME | 06/10/17 | 160 | 07:26:00   | 2:54             |
| N/A     | CIRS_283TI_MIDIRTMAP001_PRIME | 07/11/17 | 191 | 09:06:00   | 4:15             |
| N/A     | CIRS_283TI_MIDIRTMAP002_PRIME | 07/11/17 | 191 | 14:21:00   | 4:45             |
| N/A     | CIRS_283TI_MIDIRTMAP003_PRIME | 07/11/17 | 191 | 20:36:00   | 3:00             |
| N/A     | CIRS_287TI_MIDIRTMAP001_PRIME | 08/11/17 | 222 | 16:51:00   | 6:40             |
| N/A     | CIRS_292TI_MIDIRTMAP001_PRIME | 09/12/17 | 254 | 06:22:00   | 2:54             |
| N/A     | CIRS_292TI_MIDIRTMAP002_PRIME | 09/13/17 | 255 | 07:46:00   | 5:00             |
| N/A     | CIRS_293TI_MIDIRTMAP003_PRIME | 09/13/17 | 255 | 13:46:00   | 4:30             |

(This table is available in machine-readable form.)

## Appendix H

### Catalog of Distant Titan Observations

A complete listing of dates, times, and durations for distant observations of Titan by CIRS are given in Table 10. See Section 7.3 for details.

**Table 10**  
CIRS Distant Titan Observations

| Observation Name            | Date     | DOY | Time     | Duration (HR:MN) |
|-----------------------------|----------|-----|----------|------------------|
| CIRS_009TI_COMPMAP002_PRIME | 06/07/05 | 157 | 09:30:00 | 06:30:00         |
| CIRS_010TI_COMPMAP003_PRIME | 06/23/05 | 173 | 03:00:00 | 11:00:00         |
| CIRS_015TI_COMPMAP005_PRIME | 09/25/05 | 267 | 19:50:00 | 08:15:00         |
| CIRS_016TI_COMPMAP006_PRIME | 10/10/05 | 282 | 20:27:00 | 11:00:00         |
| CIRS_022TI_COMPMAP002_PRIME | 03/18/06 | 076 | 08:20:00 | 13:59:00         |
| CIRS_030TI_COMPMAP007_PRIME | 10/11/06 | 283 | 19:30:00 | 03:50:00         |
| CIRS_031TI_COMPMAP008_PRIME | 10/24/06 | 296 | 11:26:00 | 14:00:00         |
| CIRS_033TI_COMPMAP009_PRIME | 11/25/06 | 328 | 18:15:00 | 10:45:00         |
| CIRS_035TI_COMPMAP010_PRIME | 12/11/06 | 344 | 19:17:00 | 10:30:00         |
| CIRS_036TI_COMPMAP024_PRIME | 12/27/06 | 360 | 19:49:00 | 09:00:00         |
| CIRS_037TI_COMPMAP026_PRIME | 01/12/07 | 011 | 16:13:00 | 09:51:00         |
| CIRS_037TI_COMPMAP012_PRIME | 01/15/07 | 014 | 14:04:00 | 02:00:00         |
| CIRS_038TI_COMPMAP013_PRIME | 01/27/07 | 026 | 17:51:00 | 09:00:00         |
| CIRS_040TI_COMPMAP026_PRIME | 03/09/07 | 067 | 19:51:00 | 04:00:00         |
| CIRS_041TI_COMPMAP028_PRIME | 03/25/07 | 083 | 16:50:00 | 04:00:00         |
| CIRS_041TI_COMPMAP029_PRIME | 03/28/07 | 086 | 07:42:00 | 15:22:00         |
| CIRS_041TI_COMPMAP030_PRIME | 03/29/07 | 087 | 08:45:00 | 05:30:00         |
| CIRS_043TI_COMPMAP002_PRIME | 04/28/07 | 117 | 11:32:58 | 00:42:00         |
| CIRS_044TI_COMPMAP015_PRIME | 05/15/07 | 134 | 02:43:00 | 08:00:00         |
| CIRS_048TI_COMPMAP013_PRIME | 07/18/07 | 198 | 10:40:00 | 04:00:00         |
| CIRS_051TI_COMPMAP016_PRIME | 10/20/07 | 292 | 20:53:00 | 11:00:00         |
| CIRS_051TI_COMPMAP017_PRIME | 10/21/07 | 293 | 20:23:00 | 03:07:00         |
| CIRS_051TI_COMPMAP018_PRIME | 10/22/07 | 294 | 02:00:00 | 06:23:00         |
| CIRS_052TI_COMPMAP016_PRIME | 11/20/07 | 323 | 21:47:25 | 02:19:09         |
| CIRS_052TI_COMPMAP015_PRIME | 11/21/07 | 324 | 10:27:00 | 07:00:00         |
| CIRS_055TI_COMPMAP001_PRIME | 01/07/08 | 006 | 18:30:20 | 03:14:00         |
| CIRS_057TI_COMPMAP018_PRIME | 01/23/08 | 022 | 14:11:00 | 07:54:00         |
| CIRS_059TI_COMPMAP001_PRIME | 02/22/08 | 052 | 12:06:00 | 06:15:00         |
| CIRS_062TI_COMPMAP019_PRIME | 03/28/08 | 087 | 01:50:00 | 21:30:00         |
| CIRS_066TI_COMPMAP021_PRIME | 04/28/08 | 118 | 07:17:00 | 07:00:00         |
| CIRS_067TI_COMPMAP001_PRIME | 05/14/08 | 134 | 09:16:58 | 03:04:00         |
| CIRS_069TI_COMPMAP001_PRIME | 05/28/08 | 148 | 08:19:32 | 02:05:00         |
| CIRS_072TI_COMPMAP021_PRIME | 06/14/08 | 165 | 09:40:00 | 08:00:00         |
| CIRS_083TI_COMPMAP001_PRIME | 09/01/08 | 244 | 17:04:00 | 07:46:00         |
| CIRS_103TI_COMPMAP001_PRIME | 02/14/09 | 044 | 13:13:00 | 08:17:00         |
| CIRS_122TI_COMPMAP002_PRIME | 12/13/09 | 346 | 20:03:14 | 04:00:00         |
| CIRS_123TI_COMPMAP001_PRIME | 12/30/09 | 363 | 15:32:00 | 08:00:00         |
| CIRS_124TI_COMPMAP002_PRIME | 01/14/10 | 013 | 18:31:36 | 03:39:00         |
| CIRS_128TI_COMPMAP001_PRIME | 03/20/10 | 078 | 03:49:00 | 07:15:00         |
| CIRS_131TI_COMPMAP001_PRIME | 05/22/10 | 141 | 09:40:00 | 08:00:00         |
| CIRS_134TI_COMPMAP001_PRIME | 07/09/10 | 189 | 12:49:00 | 10:10:00         |
| CIRS_139TI_COMPMAP001_PRIME | 10/15/10 | 287 | 04:52:00 | 13:30:00         |
| CIRS_140TI_COMPMAP001_PRIME | 11/13/10 | 316 | 22:00:00 | 08:00:00         |
| CIRS_140TI_COMPMAP002_PRIME | 11/16/10 | 319 | 09:19:00 | 08:00:00         |
| CIRS_143TI_COMPMAP001_PRIME | 01/15/11 | 014 | 17:05:00 | 10:10:00         |
| CIRS_149TI_TEA001_PRIME     | 06/23/11 | 173 | 09:00:00 | 07:30:00         |
| CIRS_149TI_TEA002_PRIME     | 06/24/11 | 174 | 05:42:00 | 21:00:00         |
| CIRS_149TI_TEA003_PRIME     | 06/25/11 | 175 | 11:42:00 | 15:00:00         |
| CIRS_149TI_TEA004_PRIME     | 06/26/11 | 176 | 11:42:00 | 37:29:00         |
| CIRS_154TI_COMPMAP001_PRIME | 09/27/11 | 269 | 22:50:00 | 06:00:00         |
| CIRS_155TI_TEA003_PRIME     | 10/25/11 | 297 | 05:00:00 | 19:00:00         |
| CIRS_155TI_TEA004_PRIME     | 10/26/11 | 298 | 14:32:00 | 13:15:00         |
| CIRS_155TI_TEA005_PRIME     | 10/27/11 | 299 | 14:17:00 | 13:30:00         |
| CIRS_156TI_TEA003_PRIME     | 10/31/11 | 303 | 14:02:00 | 13:30:00         |

**Table 10**  
(Continued)

| Observation Name            | Date     | DOY | Time     | Duration (HR:MN) |
|-----------------------------|----------|-----|----------|------------------|
| CIRS_156TI_TEA004_PRIME     | 11/01/11 | 304 | 14:02:00 | 13:30:00         |
| CIRS_156TI_TEA005_PRIME     | 11/02/11 | 305 | 14:02:00 | 28:45:00         |
| CIRS_156TI_TEA006_PRIME     | 11/04/11 | 307 | 03:47:00 | 15:00:00         |
| CIRS_157TI_COMPMAP001_PRIME | 11/28/11 | 331 | 18:00:00 | 15:34:00         |
| CIRS_158TI_TEA001_PRIME     | 12/17/11 | 350 | 11:20:00 | 15:00:00         |
| CIRS_160TI_TEA002_PRIME     | 02/02/12 | 032 | 15:57:00 | 31:30:00         |
| CIRS_160TI_TEA003_PRIME     | 02/04/12 | 034 | 08:27:00 | 15:00:00         |
| CIRS_160TI_TEA004_PRIME     | 02/05/12 | 035 | 08:27:00 | 20:45:00         |
| CIRS_160TI_TEA005_PRIME     | 02/08/12 | 038 | 17:22:00 | 11:10:00         |
| CIRS_161TI_TEA001_PRIME     | 02/12/12 | 042 | 17:08:00 | 11:10:00         |
| CIRS_181TI_TEA001_PRIME     | 02/19/13 | 049 | 09:46:00 | 25:41:00         |
| CIRS_181TI_TEA002_PRIME     | 02/20/13 | 050 | 21:57:00 | 23:30:00         |
| CIRS_182TI_TEA001_PRIME     | 02/22/13 | 052 | 07:57:00 | 21:00:00         |
| CIRS_182TI_TEA002_PRIME     | 02/23/13 | 053 | 15:52:00 | 11:10:00         |
| CIRS_185TI_TEA001_PRIME     | 04/08/13 | 097 | 07:36:00 | 10:55:00         |
| CIRS_186TI_TEA001_PRIME     | 04/09/13 | 098 | 05:01:00 | 14:45:00         |
| CIRS_186TI_TEA002_PRIME     | 04/10/13 | 099 | 04:46:00 | 15:00:00         |
| CIRS_202TI_TEA001_PRIME     | 03/03/14 | 061 | 21:56:00 | 15:00:00         |
| CIRS_202TI_TEA002_PRIME     | 03/04/14 | 062 | 21:56:00 | 15:00:00         |
| CIRS_202TI_TEA003_PRIME     | 03/05/14 | 063 | 21:56:00 | 13:30:00         |
| CIRS_206TI_TEA001_PRIME     | 07/11/14 | 191 | 00:00:00 | 13:00:00         |
| CIRS_206TI_TEA002_PRIME     | 07/11/14 | 191 | 13:00:00 | 13:27:00         |
| CIRS_206TI_TEA003_PRIME     | 07/12/14 | 192 | 12:57:00 | 37:15:00         |
| CIRS_219TI_TEA001_PRIME     | 07/24/15 | 204 | 13:06:00 | 13:20:00         |
| CIRS_219TI_TEA002_PRIME     | 07/25/15 | 205 | 12:56:00 | 13:30:00         |
| CIRS_233TI_TEA001_PRIME     | 03/07/16 | 066 | 16:00:00 | 08:00:00         |
| CIRS_241TI_TEA002_PRIME     | 08/28/16 | 240 | 11:23:00 | 35:20:00         |
| CIRS_252TI_COMPMAP001_PRIME | 12/16/16 | 350 | 06:16:00 | 04:00:00         |
| CIRS_253TI_COMPMAP001_PRIME | 12/16/16 | 350 | 17:21:00 | 04:00:00         |
| CIRS_253TI_COMPMAP002_PRIME | 12/17/16 | 351 | 03:21:00 | 01:30:00         |
| CIRS_259TI_COMPMAP001_PIE   | 02/02/17 | 032 | 14:06:00 | 05:15:00         |
| CIRS_259TI_COMPMAP002_PRIME | 02/03/17 | 033 | 09:36:00 | 05:45:00         |
| CIRS_268TI_COMPMAP001_PIE   | 04/08/17 | 097 | 02:36:00 | 05:47:00         |
| CIRS_268TI_COMPMAP002_PIE   | 04/08/17 | 097 | 09:23:00 | 05:16:00         |
| CIRS_271TI_COMPMAP001_PRIME | 04/24/17 | 113 | 23:36:00 | 11:36:00         |
| CIRS_278TI_COMPMAP001_PRIME | 06/09/17 | 159 | 08:26:00 | 03:00:00         |
| CIRS_280TI_COMPMAP001_PIE   | 06/26/17 | 176 | 00:28:00 | 04:24:00         |
| CIRS_283TI_COMPMAP001_PRIME | 07/11/17 | 191 | 04:20:00 | 03:46:00         |
| CIRS_283TI_COMPMAP002_PRIME | 07/12/17 | 192 | 00:36:00 | 03:42:00         |
| CIRS_283TI_COMPMAP003_PRIME | 07/12/17 | 192 | 08:04:00 | 01:51:00         |
| CIRS_285TI_COMPMAP001_PRIME | 07/27/17 | 207 | 21:51:00 | 01:30:00         |
| CIRS_287TI_COMPMAP001_PIE   | 08/12/17 | 223 | 00:31:00 | 05:00:00         |
| CIRS_288TI_COMPMAP001_PIE   | 08/12/17 | 223 | 06:31:00 | 05:00:00         |
| CIRS_288TI_COMPMAP002_PIE   | 08/12/17 | 223 | 12:31:00 | 04:30:00         |
| CIRS_288TI_COMPMAP003_PIE   | 08/12/17 | 223 | 18:01:00 | 06:15:00         |
| CIRS_290TI_COMPMAP001_PIE   | 08/29/17 | 240 | 00:19:00 | 04:16:00         |
| CIRS_292TI_COMPMAP001_PRIME | 09/13/17 | 255 | 03:46:00 | 03:00:00         |
| CIRS_293TI_COMPMAP002_PRIME | 09/13/17 | 255 | 18:46:00 | 02:20:00         |

(This table is available in machine-readable form.)

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## References

- Achterberg, R. K., Conrath, B. J., Gierasch, P. J., Flasar, F. M., & Nixon, C. A. 2008a, *Icar*, **197**, 549
- Achterberg, R. K., Conrath, B. J., Gierasch, P. J., Flasar, F. M., & Nixon, C. A. 2008b, *Icar*, **194**, 263
- Achterberg, R. K., Gierasch, P. J., Conrath, B. J., Michael Flasar, F., & Nixon, C. A. 2011, *Icar*, **211**, 686
- Anderson, C. M., Samuelson, R., Achterberg, R., Barnes, J., & Flasar, F. 2014, *Icar*, **243**, 129
- Anderson, C. M., & Samuelson, R. E. 2011, *Icar*, **212**, 762
- Anderson, C. M., Samuelson, R. E., Bjoraker, G. L., & Achterberg, R. K. 2010, *Icar*, **207**, 914
- Anderson, C. M., Samuelson, R. E., & Nna-Mvondo, D. 2018, *SSRv*, **214**, 125
- Anderson, C. M., Samuelson, R. E., Yung, Y. L., & McLain, J. L. 2016, *GeoRL*, **43**, 3088
- Bampasidis, G., Coustenis, A., Achterberg, R. K., et al. 2012, *ApJ*, **760**, 144
- Bauduin, S., Irwin, P., Lellouch, E., et al. 2018, *Icar*, **311**, 288
- Bézar, B., Nixon, C. A., Kleiner, I., & Jennings, D. E. 2007, *Icar*, **191**, 397
- Bézar, B., & Vinatier, S. 2019, *Icar*, in press (doi:10.1016/j.icarus.2019.03.038)
- Bird, M. K., Allison, M., Asmar, S. W., et al. 2005, *Natur*, **438**, 800
- Brown, R. H., Baines, K. H., Bellucci, G., et al. 2004, *SSRv*, **115**, 111
- Cottini, V., Nixon, C. A., Jennings, D. E., et al. 2012a, *P&SS*, **60**, 62
- Cottini, V., Nixon, C. A., Jennings, D. E., et al. 2012b, *Icar*, **220**, 855
- Courtin, R., Sim, C. K., Kim, S. J., & Gautier, D. 2012, *P&SS*, **69**, 89
- Coustenis, A., Achterberg, R. K., Conrath, B. J., et al. 2007, *Icar*, **189**, 35
- Coustenis, A., Atreya, S. K., Balint, T., et al. 2009, *ExA*, **23**, 893
- Coustenis, A., Bampasidis, G., Achterberg, R. K., et al. 2013, *ApJ*, **779**, 177
- Coustenis, A., Bézar, B., Gautier, D., & Marten, A. 1991, *Icar*, **89**, 152
- Coustenis, A., Jennings, D. E., Achterberg, R. K., et al. 2016, *Icar*, **270**, 409
- Coustenis, A., Jennings, D. E., Achterberg, R. K., et al. 2018, *ApJL*, **854**, L30
- Coustenis, A., Jennings, D. E., Jolly, A., et al. 2008, *Icar*, **197**, 539
- Coustenis, A., Jennings, D. E., Nixon, C. A., et al. 2010, *Icar*, **207**, 461
- Coustenis, A., Salama, A., Lellouch, E., et al. 1998, *A&A*, **336**, L85
- de Kok, R., Irwin, P., & Teanby, N. 2010, *Icar*, **209**, 854
- de Kok, R., Irwin, P. G. J., Teanby, N. A., et al. 2007a, *Icar*, **191**, 223
- de Kok, R., Irwin, P. G. J., Teanby, N. A., et al. 2007b, *Icar*, **186**, 354
- de Kok, R., Irwin, P. G. J., & Teanby, N. A. 2008, *Icar*, **197**, 572
- de Kok, R., Irwin, P. G. J., Teanby, N. A., et al. 2010, *Icar*, **207**, 485
- Esposito, L. W., Barth, C. A., Colwell, J. E., et al. 2004, *SSRv*, **115**, 299
- Flasar, F. M., Achterberg, R. K., Conrath, B. J., et al. 2005, *Sci*, **308**, 975
- Flasar, F. M., Kunde, V. G., Abbas, M. M., et al. 2004, *SSRv*, **115**, 169
- Fulchignoni, M., Ferri, F., Angrilli, F., et al. 2005, *Natur*, **438**, 785
- Hanel, R., Crosby, D., Herath, L., et al. 1980, *ApOpt*, **19**, 1391
- Israel, G., Szopa, C., Raulin, F., et al. 2005, *Natur*, **438**, 796
- Jennings, D. E., Achterberg, R. K., Cottini, V., et al. 2015, *ApJL*, **804**, L34
- Jennings, D. E., Anderson, C. M., Samuelson, R. E., et al. 2012a, *ApJL*, **761**, L15
- Jennings, D. E., Anderson, C. M., Samuelson, R. E., et al. 2012b, *ApJL*, **754**, L3
- Jennings, D. E., Cottini, V., Nixon, C. A., et al. 2011, *ApJL*, **737**, L15
- Jennings, D. E., Cottini, V., Nixon, C. A., et al. 2016, *ApJL*, **816**, L17
- Jennings, D. E., Flasar, F. M., Kunde, V. G., et al. 2009, *ApJL*, **691**, L103
- Jennings, D. E., Flasar, F. M., Kunde, V. G., et al. 2017, *ApOpt*, **56**, 5274
- Jennings, D. E., Nixon, C. A., Jolly, A., et al. 2008, *ApJL*, **681**, L109
- Jolly, A., Cottini, V., Fayt, A., et al. 2015, *Icar*, **248**, 340
- Jolly, A., Fayt, A., Benilan, Y., et al. 2010, *ApJ*, **714**, 852
- Kuiper, G. P. 1944, *ApJ*, **100**, 378
- Kunde, V. G., Ade, P. A., Barney, R. D., et al. 1996, *Proc. SPIE*, **2803**, 162
- Lebonnois, S., Burgalat, J., Rannou, P., & Charnay, B. 2012, *Icar*, **218**, 707
- Lebonnois, S., Rannou, P., & Hourdin, F. 2009, *RSPTA*, **367**, 665
- Lebreton, J.-P., Witasse, O., Sollazzo, C., et al. 2005, *Natur*, **438**, 758
- Lellouch, E., Bézar, B., Flasar, F. M., et al. 2014, *Icar*, **231**, 323
- Li, L. 2015, *NatSR*, **5**, 8239
- Li, L., Nixon, C. A., Achterberg, R. K., et al. 2011, *GeoRL*, **38**, 23201
- Lockwood, G., & Thompson, D. 2009, *Icar*, **200**, 616
- Lombardo, N. A., Nixon, C. A., Achterberg, R. K., et al. 2019a, *Icar*, **317**, 454
- Lombardo, N. A., Nixon, C. A., Sylvestre, M., et al. 2019b, *AJ*, **157**, 160
- Lorenz, R. D., & Waite, J. H., Jr. 2008, Titan Explorer Flagship Mission Study, Tech. Rep., Baltimore, MD: Johns Hopkins Univ. Appl. Phys. Lab.
- Matson, D. L. 2002, *SSRv*, **104**, 1
- McMahon, S. K. 1996, *P&SS*, **44**, 3
- Moreno, R., Lellouch, E., Lara, L. M., et al. 2012, *Icar*, **221**, 753
- Niemann, H. B., Atreya, S. K., Bauer, S. J., et al. 2005, *Natur*, **438**, 779
- Nixon, C., Lorenz, R., Achterberg, R., et al. 2018, *P&SS*, **155**, 50
- Nixon, C. A., Achterberg, R. K., & Flasar, F. M. 2010a, in Proc. IEEE Aerospace Conf., ed. K. Profet, D. Woerner, & R. Mattingly (Piscataway, NJ: IEEE), 1174
- Nixon, C. A., Achterberg, R. K., Teanby, N. A., et al. 2010b, *FaDi*, **147**, 65
- Nixon, C. A., Achterberg, R. K., Vinatier, S., et al. 2008a, *Icar*, **195**, 778
- Nixon, C. A., Anstey, T. M., Flasar, F. M., & Achterberg, R. K. 2012a, in Proc. IEEE Aerospace Conf., ed. K. Profet, D. Woerner, & R. Mattingly (Piscataway, NJ: IEEE), 1633
- Nixon, C. A., Jennings, D. E., Bézar, B., et al. 2008b, *ApJL*, **681**, L101
- Nixon, C. A., Jennings, D. E., Bézar, B., et al. 2013a, *ApJL*, **776**, L14
- Nixon, C. A., Jennings, D. E., Flaud, J.-M., et al. 2009a, *P&SS*, **57**, 1573
- Nixon, C. A., Teanby, N. A., Calcutt, S. B., et al. 2009b, *ApOpt*, **48**, 1912
- Nixon, C. A., Teanby, N. A., Irwin, P., & Hörst, S. M. 2013b, *Icar*, **224**, 253
- Nixon, C. A., Temelso, B., Vinatier, S., et al. 2012b, *ApJ*, **749**, 159
- Porco, C. C., West, R. A., Squyres, S., et al. 2004, *SSRv*, **115**, 363
- Samuelson, R. E., Smith, M. D., Achterberg, R. K., & Pearl, J. C. 2007, *Icar*, **189**, 63
- Smith, B. A., Soderblom, L., Beebe, R., et al. 1981, *Sci*, **212**, 163
- Steadman, K., Pitesky, J., Ray, T., Burton, M., & Alonge, N. 2010, Cassini Titan Science Integration: Getting a “Jumpstart” on the Process (Reston, VA: AIAA)
- Stoehr, F., Lacy, M., Leon, S., et al. 2014, *Proc. SPIE*, **9149**, 914902
- Stone, E. C., & Miner, E. D. 1981, *Sci*, **212**, 159
- Sylvestre, M., Teanby, N. A., Vinatier, S., Lebonnois, S., & Irwin, P. G. J. 2018, *A&A*, **609**, A64
- Teanby, N. A., Bézar, B., Vinatier, S., et al. 2017, *NatCo*, **8**, 1586
- Teanby, N. A., de Kok, R., Irwin, P. G. J., et al. 2008a, *JGRE*, **113**, E12003
- Teanby, N. A., de Kok, R., & Irwin, P. G. J. 2009a, *Icar*, **204**, 645
- Teanby, N. A., Irwin, P. G., de Kok, R., et al. 2006, *Icar*, **181**, 243
- Teanby, N. A., Irwin, P. G. J., de Kok, R., et al. 2007, *Icar*, **186**, 364
- Teanby, N. A., Irwin, P. G. J., de Kok, R., et al. 2008b, *Icar*, **193**, 595
- Teanby, N. A., Irwin, P. G. J., de Kok, R., et al. 2009b, *Icar*, **202**, 620
- Teanby, N. A., Irwin, P. G. J., de Kok, R., & Nixon, C. A. 2009c, *RSPTA*, **367**, 697
- Teanby, N. A., Irwin, P. G. J., de Kok, R., & Nixon, C. A. 2010a, *FaDi*, **147**, 51
- Teanby, N. A., Irwin, P. G. J., de Kok, R., & Nixon, C. A. 2010b, *ApJL*, **724**, L84
- Teanby, N. A., Irwin, P. G. J., & de Kok, R. J. 2010c, *P&SS*, **58**, 792
- Teanby, N. A., Irwin, P. G. J., Nixon, C. A., et al. 2012, *Natur*, **491**, 732
- Teanby, N. A., Sylvestre, M., Sharkey, J., et al. 2019, *GeoRL*, **46**, 3079
- Tobie, G., Teanby, N., Coustenis, A., et al. 2014, *P&SS*, **104**, 59
- Tomasko, M. G., Archinal, B., Becker, T., et al. 2005, *Natur*, **438**, 765
- Tyler, G. L., Eshleman, V. R., Anderson, J. D., et al. 1981, *Sci*, **212**, 201
- Vinatier, S., Bézar, B., de Kok, R., et al. 2010a, *Icar*, **210**, 852
- Vinatier, S., Bézar, B., Fouchet, T., et al. 2007a, *Icar*, **188**, 120
- Vinatier, S., Bézar, B., Lebonnois, S., et al. 2015, *Icar*, **250**, 95
- Vinatier, S., Bézar, B., & Nixon, C. A. 2007b, *Icar*, **191**, 712
- Vinatier, S., Bézar, B., Nixon, C. A., et al. 2010b, *Icar*, **205**, 559
- Vinatier, S., Rannou, P., Anderson, C. M., et al. 2012, *Icar*, **219**, 5
- Vinatier, S., Schmitt, B., Bézar, B., et al. 2018, *Icar*, **310**, 89
- Vuitton, V., Yelle, R. V., Klippenstein, S. J., Hörst, S. M., & Lavvas, P. 2019, *Icar*, **324**, 120
- Yelle, R. V., Cui, J., & Müller-Wodarg, I. C. F. 2008, *JGRE*, **113**, E10003
- Zarnecki, J. C., Leese, M. R., Hathi, B., et al. 2005, *Natur*, **438**, 792



# Erratum: “*Cassini* Composite Infrared Spectrometer (CIRS) Observations of Titan 2004–2017” (2019, *ApJS*, 244, 14)

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## 1. Erratum Text

Following release of the published article, it was noticed that one figure, and a set of tables, contained erroneous information, which is now described and corrected.

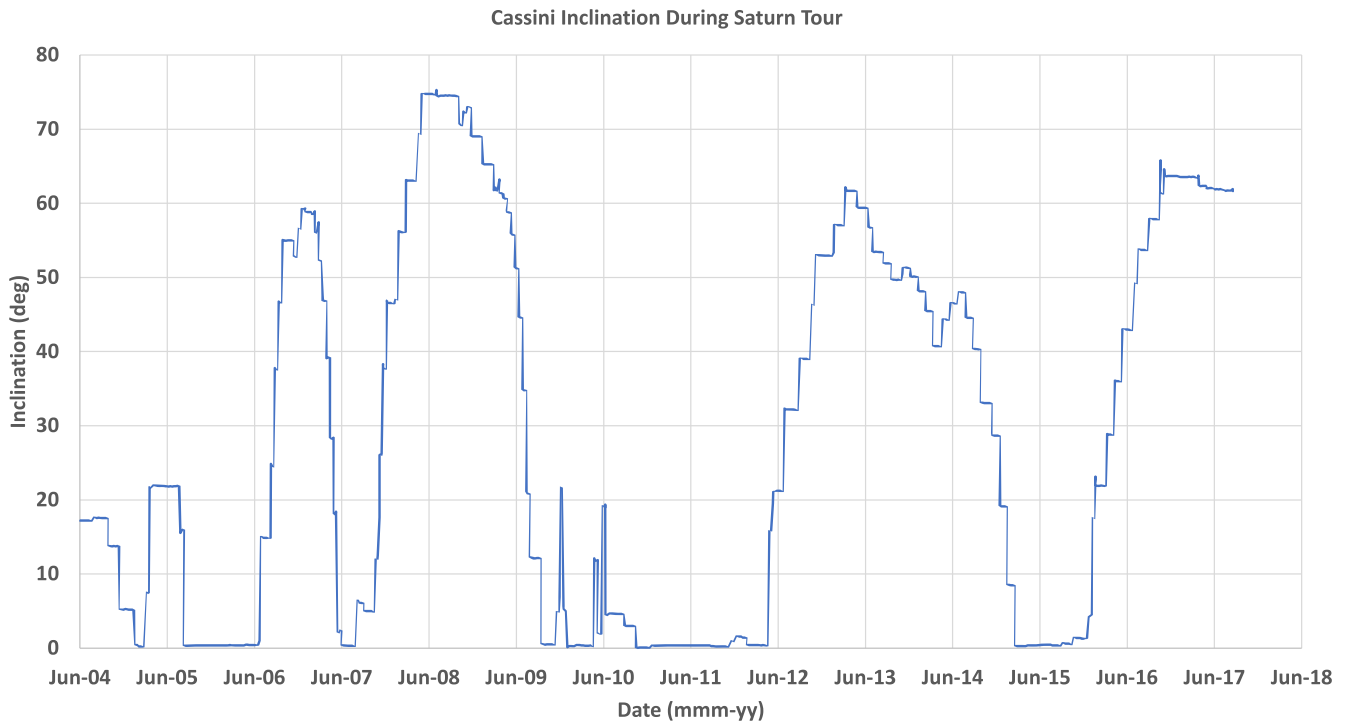
First, in Figure 2 of the published article “Magnitude of inclination of *Cassini*’s orbit over time relative to the Saturn ring plane” the inclination values shown in the figure are in fact with respect to the ecliptic plane, not Saturn’s ring plane. A corrected figure is given in Figure 2 below.

Second, a small but highly significant error occurred in the dates reported for the observations as listed in Tables 5–10 of Appendices C–H. Although the reported “day-of-year” (DOY) number is correct, the date (MM/DD/YY) was advanced by one day due to a conversion error. Hence, for example, the observation CIRS\_200TI\_FIRLMBAER002\_PRIME of Table 5, flyby T97, is reported as DOY 001, but January 2. This applies uniformly to all dates reported in Tables 5–10, while the time of day remains correct. Since no Titan observations are reported on DOY 365 or 366, there is no case where the year is incorrect, although both the month as well as the day of the month may be wrong for dates at the end of months. Table 4 of the published article, giving the dates of flybys, has correct dates and is unaffected.

Replacement tables, with corrected dates are included in Tables 5–10, which replace Tables 5–10 of the published article.

<sup>11</sup> Contributions to the project during internship at NASA GSFC.





**Figure 2.** Magnitude of inclination of Cassini's orbit over time relative to the Saturn ring plane (corrected).

**Table 5**  
CIRS Far-Infrared Limb Observations (Corrected)

| Flyby No. | Observation Name            | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Latitudes) |
|-----------|-----------------------------|----------|----------|------------|------------------|----------------------|
| T4        | CIRS_005TI_FIRLMBT002_PRIME | 03/31/05 | 090      | 20:05:16   | 0:45             | 80N, 70N             |
| T4        | CIRS_005TI_FIRLMBT002_PRIME | 03/31/05 | 090      | 20:50:16   | 0:30             | 85N, 75N             |
| T4        | CIRS_005TI_FIRLMBT002_PRIME | 03/31/05 | 090      | 21:20:16   | 0:45             | 85N                  |
| T6        | CIRS_013TI_FIRLMBT002_PRIME | 08/22/05 | 234      | 06:38:37   | 1:00             | 55S                  |
| T6        | CIRS_013TI_FIRLMBT002_PRIME | 08/22/05 | 234      | 07:38:37   | 0:30             | 50S                  |
| T6        | CIRS_013TI_FIRLMBT002_PRIME | 08/22/05 | 234      | 08:08:37   | 0:35             | 50S, 55S             |
| T6        | CIRS_013TI_FIRLMBT003_PRIME | 08/22/05 | 234      | 09:03:37   | 0:35             | 45S, 40S             |
| T6        | CIRS_013TI_FIRLMBT003_PRIME | 08/22/05 | 234      | 09:38:37   | 0:30             | 40S                  |
| T6        | CIRS_013TI_FIRLMBT003_PRIME | 08/22/05 | 234      | 10:08:37   | 1:00             | 45S                  |
| T10       | CIRS_020TI_FIRLMBT003_PRIME | 01/15/06 | 015      | 12:41:27   | 1:00             | 55N                  |
| T14       | CIRS_024TI_FIRLMBT002_PRIME | 05/20/06 | 140      | 09:48:11   | 1:25             | 50N                  |
| T14       | CIRS_024TI_FIRLMBT003_PRIME | 05/20/06 | 140      | 13:45:11   | 0:48             | 50N                  |
| T15       | CIRS_025TI_FIRLMBT003_PRIME | 07/02/06 | 183      | 09:50:47   | 1:00             | 62N                  |
| T15       | CIRS_025TI_FIRLMBT003_PRIME | 07/02/06 | 183      | 10:50:47   | 1:00             | 62N                  |
| T16       | CIRS_026TI_FIRLMBT003_PRIME | 07/22/06 | 203      | 01:40:26   | 1:00             | 45N                  |
| T17       | CIRS_028TI_FIRLMBT002_PRIME | 09/07/06 | 250      | 17:52:51   | 1:00             | 15S                  |
| T17       | CIRS_028TI_FIRLMBT002_PRIME | 09/07/06 | 250      | 18:52:51   | 0:39             | 15S                  |
| T17       | CIRS_028TI_FIRLMBT002_PRIME | 09/07/06 | 250      | 19:31:51   | 0:30             | 15S, 25S             |
| T18       | CIRS_029TI_FIRLMBT003_PRIME | 09/23/06 | 266      | 16:58:49   | 1:15             | 30N                  |
| T24       | CIRS_038TI_FIRLMBT001_PRIME | 01/29/07 | 029      | 05:15:55   | 0:45             | 28N                  |
| T24       | CIRS_038TI_FIRLMBT001_PRIME | 01/29/07 | 029      | 06:00:55   | 0:52             | 28N                  |
| T26       | CIRS_040TI_FIRLMBT001_PRIME | 03/09/07 | 068      | 23:34:00   | 0:51             | 10N                  |
| T26       | CIRS_040TI_FIRLMBT002_PRIME | 03/10/07 | 069      | 02:12:00   | 0:30             | 3N, 17N              |
| T26       | CIRS_040TI_FIRLMBT002_PRIME | 03/10/07 | 069      | 02:42:00   | 0:30             | 15N                  |
| T26       | CIRS_040TI_FIRLMBT002_PRIME | 03/10/07 | 069      | 03:35:00   | 0:37             | 15N                  |
| T27       | CIRS_041TI_FIRLMBT002_PRIME | 03/26/07 | 085      | 01:56:27   | 0:42             | 44N                  |
| T32       | CIRS_046TI_FIRLMBT003_PRIME | 06/13/07 | 164      | 18:32:11   | 0:16             | 45N                  |
| T35       | CIRS_049TI_FIRLMBT001_PRIME | 08/31/07 | 243      | 04:32:34   | 1:00             | 70N                  |
| T37       | CIRS_052TI_FIRLMBT001_PRIME | 11/18/07 | 322      | 22:47:25   | 0:21             | 80S                  |
| T37       | CIRS_052TI_FIRLMBT001_PRIME | 11/18/07 | 322      | 23:08:25   | 0:54             | 80S, 70S             |

**Table 5**  
(Continued)

| Flyby No. | Observation Name              | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Latitudes) |
|-----------|-------------------------------|----------|----------|------------|------------------|----------------------|
| T37       | CIRS_052TI_FIRLMBT001_PRIME   | 11/19/07 | 323      | 00:02:25   | 0:30             | 65S, 75S             |
| T38       | CIRS_053TI_FIRLMBINT001_PRIME | 12/04/07 | 338      | 21:36:50   | 1:15             | 0N                   |
| T38       | CIRS_053TI_FIRLMBT001_PRIME   | 12/04/07 | 338      | 22:51:50   | 0:25             | 0N                   |
| T38       | CIRS_053TI_FIRLMBT001_PRIME   | 12/04/07 | 338      | 23:16:50   | 0:35             | 5S, 5N               |
| T40       | CIRS_055TI_FIRLMBINT001_PRIME | 01/05/08 | 005      | 19:30:20   | 0:55             | 30S                  |
| T42       | CIRS_062TI_FIRLMBINT003_PRIME | 03/25/08 | 085      | 12:28:48   | 0:44             | 55S                  |
| T42       | CIRS_062TI_FIRLMBT001_PRIME   | 03/25/08 | 085      | 13:12:48   | 0:25             | 55S                  |
| T42       | CIRS_062TI_FIRLMBT001_PRIME   | 03/25/08 | 085      | 13:37:48   | 0:29             | 52S, 62S             |
| T46       | CIRS_091TI_FIRLMBINT001_PRIME | 11/03/08 | 308      | 15:45:24   | 0:22             | no data              |
| T47       | CIRS_093TI_FIRLMBINT002_PRIME | 11/19/08 | 324      | 16:58:28   | 1:13             | 45S                  |
| T48       | CIRS_095TI_FIRLMBINT001_PRIME | 12/05/08 | 340      | 11:25:45   | 1:00             | 35S                  |
| T48       | CIRS_095TI_FIRLMBINT002_PRIME | 12/05/08 | 340      | 15:20:45   | 1:20             | 25S                  |
| T49       | CIRS_097TI_FIRLMBINT001_PRIME | 12/21/08 | 356      | 09:59:52   | 1:00             | 10N                  |
| T53       | CIRS_109TI_FIRLMBT001_PRIME   | 04/19/09 | 109      | 22:45:45   | 0:37             | 8N                   |
| T53       | CIRS_109TI_FIRLMBT001_PRIME   | 04/19/09 | 109      | 23:22:55   | 0:48             | 12S                  |
| T53       | CIRS_109TI_FIRLMBT001_PRIME   | 04/20/09 | 110      | 00:46:45   | 0:49             | 38S                  |
| T54       | CIRS_110TI_FIRLMBT001_PRIME   | 05/05/09 | 125      | 20:39:16   | 1:00             | 20N                  |
| T54       | CIRS_110TI_FIRLMBT001_PRIME   | 05/05/09 | 125      | 21:39:16   | 0:30             | 30N                  |
| T54       | CIRS_110TI_FIRLMBT001_PRIME   | 05/05/09 | 125      | 22:09:16   | 0:35             | 10N, 5N              |
| T57       | CIRS_113TI_FIRLMBT001_PRIME   | 06/22/09 | 173      | 16:17:35   | 1:05             | 10S                  |
| T59       | CIRS_115TI_FIRLMBT002_PRIME   | 07/24/09 | 205      | 15:49:04   | 0:35             | 50S, 55S             |
| T59       | CIRS_115TI_FIRLMBT002_PRIME   | 07/24/09 | 205      | 16:24:04   | 0:30             | 60S                  |
| T59       | CIRS_115TI_FIRLMBT002_PRIME   | 07/24/09 | 205      | 16:54:04   | 0:55             | 60S                  |
| T62       | CIRS_119TI_FIRLMBT001_PRIME   | 10/12/09 | 285      | 07:45:25   | 0:30             | 75S                  |
| T62       | CIRS_119TI_FIRLMBT001_PRIME   | 10/12/09 | 285      | 09:01:25   | 0:50             | 70S                  |
| T62       | CIRS_119TI_FIRLMBT002_PRIME   | 10/12/09 | 285      | 09:51:25   | 1:00             | 75S                  |
| T64       | CIRS_123TI_FIRLMBT001_PRIME   | 12/27/09 | 361      | 22:01:59   | 0:59             | 45N                  |
| T64       | CIRS_123TI_FIRLMBT001_PRIME   | 12/27/09 | 361      | 23:01:59   | 0:37             | 50N                  |
| T66       | CIRS_125TI_FIRLMBT001_PRIME   | 01/28/10 | 028      | 19:58:49   | 1:08             | 30N                  |
| T66       | CIRS_125TI_FIRLMBT001_PRIME   | 01/28/10 | 028      | 21:06:49   | 0:34             | 20N                  |
| T66       | CIRS_125TI_FIRLMBT001_PRIME   | 01/28/10 | 028      | 21:40:19   | 0:34             | 23N, 28N             |
| T67       | CIRS_129TI_FIRLMBT001_PRIME   | 04/05/10 | 095      | 13:35:39   | 1:00             | 70N                  |
| T67       | CIRS_129TI_FIRLMBT001_PRIME   | 04/05/10 | 095      | 14:35:39   | 0:30             | 70N                  |
| T67       | CIRS_129TI_FIRLMBT001_PRIME   | 04/05/10 | 095      | 15:05:39   | 0:30             | 70N                  |
| T70       | CIRS_133TI_FIRLMBT001_PRIME   | 06/20/10 | 171      | 23:12:18   | 1:02             | 55N                  |
| T72       | CIRS_138TI_FIRLMBT001_PRIME   | 09/24/10 | 267      | 16:23:41   | 1:00             | 87S                  |
| T72       | CIRS_138TI_FIRLMBT001_PRIME   | 09/24/10 | 267      | 17:23:41   | 0:30             | 87S                  |
| T72       | CIRS_138TI_FIRLMBT001_PRIME   | 09/24/10 | 267      | 17:53:41   | 0:30             | 82S, 87S             |
| T73       | CIRS_140TI_FIRLMBT002_PRIME   | 11/11/10 | 315      | 13:12:01   | 1:10             | Safing event         |
| T73       | CIRS_140TI_FIRLMBT002_PRIME   | 11/11/10 | 315      | 14:22:01   | 0:30             | Safing event         |
| T73       | CIRS_140TI_FIRLMBT002_PRIME   | 11/11/10 | 315      | 14:52:01   | 1:00             | Safing event         |
| T76       | CIRS_148TI_FIRLMBT001_PRIME   | 05/08/11 | 128      | 20:23:45   | 1:00             | 50N                  |
| T76       | CIRS_148TI_FIRLMBT001_PRIME   | 05/08/11 | 128      | 21:23:45   | 0:45             | 50N                  |
| T76       | CIRS_148TI_FIRLMBT001_PRIME   | 05/08/11 | 128      | 22:08:45   | 0:35             | 55N, 60N             |
| T78       | CIRS_153TI_FIRLMBT001_PRIME   | 09/12/11 | 255      | 00:35:06   | 1:00             | 73S                  |
| T78       | CIRS_153TI_FIRLMBT001_PRIME   | 09/12/11 | 255      | 01:35:06   | 0:32             | 73S                  |
| T79       | CIRS_158TI_FIRLMBT001_PRIME   | 12/13/11 | 347      | 17:56:24   | 1:00             | 57S                  |
| T79       | CIRS_158TI_FIRLMBT001_PRIME   | 12/13/11 | 347      | 18:56:24   | 0:30             | 57S                  |
| T79       | CIRS_158TI_FIRLMBT001_PRIME   | 12/13/11 | 347      | 19:26:24   | 0:45             | 37S                  |
| T82       | CIRS_161TI_FIRLMBT001_PRIME   | 02/19/12 | 050      | 06:28:17   | 1:00             | 75N                  |
| T82       | CIRS_161TI_FIRLMBT001_PRIME   | 02/19/12 | 050      | 07:28:17   | 0:30             | 75N                  |
| T82       | CIRS_161TI_FIRLMBT001_PRIME   | 02/19/12 | 050      | 07:58:17   | 0:45             | 56S                  |
| T82       | CIRS_161TI_FIRLMBT002_PRIME   | 02/19/12 | 050      | 08:43:17   | 0:45             | 56S, 51S             |
| T82       | CIRS_161TI_FIRLMBT002_PRIME   | 02/19/12 | 050      | 09:28:17   | 0:30             | 56S                  |
| T82       | CIRS_161TI_FIRLMBT002_PRIME   | 02/19/12 | 050      | 09:58:17   | 1:00             | 56S                  |
| T85       | CIRS_169TI_FIRLMBT001_PRIME   | 07/24/12 | 206      | 17:33:08   | 1:15             | 37N                  |
| T85       | CIRS_169TI_FIRLMBT001_PRIME   | 07/24/12 | 206      | 18:48:08   | 0:30             | 37N                  |
| T85       | CIRS_169TI_FIRLMBT001_PRIME   | 07/24/12 | 206      | 19:19:08   | 0:34             | 37N, 32N             |
| T86       | CIRS_172TI_FIRLMBT001_PRIME   | 09/26/12 | 270      | 12:20:39   | 1:00             | 50N                  |
| T86       | CIRS_172TI_FIRLMBT001_PRIME   | 09/26/12 | 270      | 13:20:39   | 0:25             | 50N                  |

**Table 5**  
(Continued)

| Flyby No. | Observation Name               | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Latitudes) |
|-----------|--------------------------------|----------|----------|------------|------------------|----------------------|
| T86       | CIRS_172TI_FIRLMBT001_PRIME    | 09/26/12 | 270      | 13:46:39   | 0:31             | 50N, 45N             |
| T86       | CIRS_172TI_FIRLMBBAER002_PRIME | 09/26/12 | 270      | 15:10:39   | 0:40             | 49N                  |
| T86       | CIRS_172TI_FIRLMBINT002_PRIME  | 09/26/12 | 270      | 16:12:39   | 0:38             | 49N                  |
| T88       | CIRS_175TI_FIRLMBINT001_PRIME  | 11/29/12 | 334      | 06:41:59   | 1:00             | 2S                   |
| T88       | CIRS_175TI_FIRLMBBAER001_PRIME | 11/29/12 | 334      | 07:41:59   | 0:30             | 2S                   |
| T88       | CIRS_175TI_FIRLMBT001_PRIME    | 11/29/12 | 334      | 08:12:59   | 0:29             | 2S                   |
| T90       | CIRS_185TI_FIRLMBINT001_PRIME  | 04/05/13 | 095      | 19:28:31   | 1:00             | 14N                  |
| T90       | CIRS_185TI_FIRLMBBAER001_PRIME | 04/05/13 | 095      | 20:28:31   | 0:30             | 14N                  |
| T90       | CIRS_185TI_FIRLMBT001_PRIME    | 04/05/13 | 095      | 20:58:31   | 0:30             | 14N                  |
| T94       | CIRS_197TI_FIRLMBBAER002_PRIME | 09/12/13 | 255      | 08:23:56   | 0:35             | 19N                  |
| T94       | CIRS_197TI_FIRLMBINT002_PRIME  | 09/12/13 | 255      | 08:58:56   | 1:00             | 18N                  |
| T96       | CIRS_199TI_FIRLMBBAER002_PRIME | 12/01/13 | 335      | 01:11:19   | 0:45             | 10S                  |
| T96       | CIRS_199TI_FIRLMBINT002_PRIME  | 12/01/13 | 335      | 01:56:19   | 1:00             | 10S                  |
| T97       | CIRS_200TI_FIRLMBBAER002_PRIME | 01/01/14 | 001      | 22:29:41   | 0:45             | 24S                  |
| T97       | CIRS_200TI_FIRLMBINT002_PRIME  | 01/01/14 | 001      | 23:14:41   | 1:00             | 24S                  |
| T100      | CIRS_203TI_FIRLMBWTR001_PRIME  | 04/07/14 | 097      | 11:26:14   | 0:53             | 22S                  |
| T100      | CIRS_203TI_FIRLMBBAER002_PRIME | 04/07/14 | 097      | 13:50:14   | 1:06             | 40S                  |
| T100      | CIRS_203TI_FIRLMBINT002_PRIME  | 04/07/14 | 097      | 15:18:14   | 0:38             | 40S                  |
| T103      | CIRS_206TI_FIRLMBINT005_PRIME  | 07/20/14 | 201      | 08:25:58   | 1:00             | 3S                   |
| T103      | CIRS_206TI_FIRLMBBAER001_PRIME | 07/20/14 | 201      | 09:25:58   | 0:30             | 3S                   |
| T104      | CIRS_208TI_FIRLMBBAER001_PRIME | 09/22/14 | 265      | 05:53:19   | 0:45             | 28N                  |
| T104      | CIRS_208TI_FIRLMBINT002_PRIME  | 09/22/14 | 265      | 06:38:19   | 1:00             | 28N                  |
| T109      | CIRS_212TI_FIRLMBBAER001_PRIME | 02/12/15 | 043      | 17:38:04   | 0:45             | 47N                  |
| T109      | CIRS_212TI_FIRLMBINT002_PRIME  | 02/12/15 | 043      | 18:45:04   | 0:38             | 47N                  |
| T110      | CIRS_213TI_FIRLMBBAER002_PRIME | 03/16/15 | 075      | 14:59:49   | 0:45             | 49N                  |
| T110      | CIRS_213TI_FIRLMBINT002_PRIME  | 03/16/15 | 075      | 15:44:49   | 1:00             | 49N                  |
| T111      | CIRS_215TI_FIRLMBT002_PRIME    | 05/07/15 | 127      | 23:00:24   | 0:35             | 60S, 55S             |
| T111      | CIRS_215TI_FIRLMBBAER003_PRIME | 05/07/15 | 127      | 23:35:24   | 0:30             | 60S                  |
| T111      | CIRS_215TI_FIRLMBINT002_PRIME  | 05/08/15 | 128      | 00:05:24   | 1:00             | 60S                  |
| T112      | CIRS_218TI_FIRLMBINT001_PRIME  | 07/07/15 | 188      | 05:54:51   | 1:00             | 80S                  |
| T112      | CIRS_218TI_FIRLMBBAER001_PRIME | 07/07/15 | 188      | 06:54:51   | 0:30             | 80N                  |
| T112      | CIRS_218TI_FIRLMBT001_PRIME    | 07/07/15 | 188      | 07:24:51   | 0:45             | 80N, 70N             |
| T112      | CIRS_218TI_FIRLMBT002_PRIME    | 07/07/15 | 188      | 08:09:51   | 0:45             | 65S, 75S             |
| T112      | CIRS_218TI_FIRLMBBAER002_PRIME | 07/07/15 | 188      | 08:54:51   | 0:30             | 79S                  |
| T112      | CIRS_218TI_FIRLMBINT002_PRIME  | 07/07/15 | 188      | 09:24:51   | 1:00             | 79S                  |
| T113      | CIRS_222TI_FIRLMBINT002_PRIME  | 09/28/15 | 271      | 23:14:12   | 0:53             | 36S                  |
| T114      | CIRS_225TI_FIRLMBBAER002_PRIME | 11/13/15 | 317      | 06:01:31   | 1:10             | 80S, 85S             |
| T114      | CIRS_225TI_FIRLMBINT002_PRIME  | 11/13/15 | 317      | 07:11:31   | 0:50             | 85S                  |
| T115      | CIRS_230TI_FIRLMBINT001_PRIME  | 01/16/16 | 016      | 00:05:24   | 1:00             | 65S                  |
| T115      | CIRS_230TI_FIRLMBBAER004_PRIME | 01/16/16 | 016      | 01:05:24   | 0:30             | 65S                  |
| T115      | CIRS_230TI_FIRLMBT001_PRIME    | 01/16/16 | 016      | 01:35:24   | 0:45             | 60S, 70S             |
| T115      | CIRS_230TI_FIRLMBT002_PRIME    | 01/16/16 | 016      | 02:20:24   | 0:45             | 70S, 75S             |
| T115      | CIRS_230TI_FIRLMBBAER005_PRIME | 01/16/16 | 016      | 03:05:24   | 0:30             | 75S                  |
| T115      | CIRS_230TI_FIRLMBINT002_PRIME  | 01/16/16 | 016      | 03:35:24   | 1:00             | 75S                  |
| T116      | CIRS_231TI_FIRLMBINT001_PRIME  | 01/31/16 | 031      | 22:30:05   | 1:18             | 57S                  |
| T118      | CIRS_234TI_FIRLMBCON002_PRIME  | 04/04/16 | 095      | 20:47:42   | 1:10             | 66S                  |
| T119      | CIRS_235TI_FIRLMBINT001_PRIME  | 05/06/16 | 127      | 14:37:37   | 1:02             | 54S                  |
| T119      | CIRS_235TI_FIRLMBBAER001_PRIME | 05/06/16 | 127      | 15:39:37   | 0:30             | 54S                  |
| T119      | CIRS_235TI_FIRLMBT001_PRIME    | 05/06/16 | 127      | 16:09:37   | 0:30             | 54S x2               |
| T120      | CIRS_236TI_FIRLMBINT001_PRIME  | 06/07/16 | 159      | 11:36:17   | 1:15             | 51S                  |
| T120      | CIRS_236TI_FIRLMBBAER002_PRIME | 06/07/16 | 159      | 12:52:17   | 0:44             | 51S                  |
| T123      | CIRS_243TI_FIRLMBT002_PRIME    | 09/27/16 | 271      | 04:31:59   | 0:30             | 40N, 50N             |
| T123      | CIRS_243TI_FIRLMBBAER002_PRIME | 09/27/16 | 271      | 05:01:59   | 0:30             | 50N                  |
| T123      | CIRS_243TI_FIRLMBWTR001_PRIME  | 09/27/16 | 271      | 05:31:59   | 1:00             | 50N                  |
| T125      | CIRS_250TI_FIRLMBT002_PRIME    | 11/29/16 | 334      | 22:29:32   | 0:30             | 10S                  |
| T125      | CIRS_250TI_FIRLMBBAER002_PRIME | 11/29/16 | 334      | 22:59:32   | 0:30             | 10S                  |
| T125      | CIRS_250TI_FIRLMBWTR001_PRIME  | 11/29/16 | 334      | 23:29:32   | 1:00             | 10S                  |

**Table 6**  
CIRS Mid-infrared Limb Observations (Corrected)

| Flyby No. | Observation Name              | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Latitudes) |
|-----------|-------------------------------|----------|----------|------------|------------------|----------------------|
| TB        | CIRS_00BTI_MIRLMBINT002_PRIME | 12/13/04 | 348      | 16:38:13   | 2:00             | 10S                  |
| T3        | CIRS_003TI_MIRLMBINT002_PRIME | 02/14/05 | 045      | 19:57:53   | 4:00             | 80N                  |
| T4        | CIRS_005TI_MIRLMBMAP002_PRIME | 04/01/05 | 091      | 00:35:16   | 3:30             | 85N—0N               |
| T6        | CIRS_013TI_MIRLMBMAP002_PRIME | 08/22/05 | 234      | 01:23:37   | 2:30             | 25N—35S              |
| T6        | CIRS_013TI_MIRLMBMAP003_PRIME | 08/22/05 | 234      | 13:53:37   | 2:30             | 40S—80S              |
| T8        | CIRS_017TI_MIRLMBMAP003_PRIME | 10/28/05 | 301      | 09:55:25   | 3:20             | 85S—10N              |
| T10       | CIRS_020TI_MIRLMBINT002_PRIME | 01/15/06 | 015      | 02:41:27   | 4:00             | 55N                  |
| T13       | CIRS_023TI_MIRLMBMAP004_PRIME | 04/30/06 | 120      | 11:58:14   | 2:00             | 0N—40S               |
| T13       | CIRS_023TI_MIRLMBMAP006_PRIME | 04/30/06 | 120      | 14:58:14   | 2:00             | 0N—40N               |
| T14       | CIRS_024TI_MIRLMBINT002_PRIME | 05/20/06 | 140      | 03:18:11   | 1:30             | 32S                  |
| T14       | CIRS_024TI_MIRLMBINT003_PRIME | 05/20/06 | 140      | 17:18:11   | 5:00             | 50N                  |
| T15       | CIRS_025TI_MIRLMBINT002_PRIME | 07/02/06 | 183      | 01:20:47   | 2:40             | 55S                  |
| T16       | CIRS_026TI_MIRLMBINT002_PRIME | 07/21/06 | 202      | 15:25:26   | 2:00             | 45N                  |
| T16       | CIRS_026TI_MIRLMBMAP003_PRIME | 07/22/06 | 203      | 05:25:26   | 2:15             | 30N—75N              |
| T19       | CIRS_030TI_MIRLMBINT002_PRIME | 10/09/06 | 282      | 08:30:07   | 3:40             | 60N                  |
| T19       | CIRS_030TI_MIRLMBINT003_PRIME | 10/09/06 | 282      | 22:50:07   | 2:40             | 30N                  |
| T20       | CIRS_031TI_MIRLMBMAP004_PRIME | 10/25/06 | 298      | 20:28:07   | 3:00             | 15S—50N              |
| T21       | CIRS_035TI_MIRLMBINT004_PRIME | 12/12/06 | 346      | 02:41:31   | 1:30             | 15N                  |
| T21       | CIRS_035TI_MIRLMBINT003_PRIME | 12/12/06 | 346      | 18:41:31   | 2:00             | 15N                  |
| T23       | CIRS_037TI_MIRLMBINT001_PRIME | 01/12/07 | 012      | 23:38:31   | 4:00             | 5N                   |
| T24       | CIRS_038TI_MIRLMBINT002_PRIME | 01/29/07 | 029      | 12:15:55   | 4:00             | 30N                  |
| T25       | CIRS_039TI_MIRLMBMAP001_PRIME | 02/21/07 | 052      | 18:12:24   | 3:50             | 25N—30S              |
| T26       | CIRS_040TI_MIRLMBMAP001_PRIME | 03/09/07 | 068      | 16:49:00   | 4:00             | 30N—30S              |
| T27       | CIRS_041TI_MIRLMBINT001_PRIME | 03/25/07 | 084      | 15:23:27   | 4:00             | 20S                  |
| T28       | CIRS_042TI_MIRLMBINT002_PRIME | 04/11/07 | 101      | 02:58:00   | 1:00             | 30S                  |
| T32       | CIRS_046TI_MIRLMBMAP001_PRIME | 06/13/07 | 164      | 08:46:11   | 4:00             | 15N—80S              |
| T35       | CIRS_049TI_MIRLMBINT001_PRIME | 08/30/07 | 242      | 21:32:34   | 4:00             | 70N                  |
| T37       | CIRS_052TI_MIRLMBMAP001_PRIME | 11/18/07 | 322      | 15:47:25   | 4:00             | 60S(R)—20S(L)        |
| T39       | CIRS_054TI_MIRLMBMAP001_PRIME | 12/20/07 | 354      | 13:57:55   | 3:54             | 25S—75N              |
| T39       | CIRS_054TI_MIRLMBINT002_PRIME | 12/21/07 | 355      | 04:02:55   | 3:55             | 45S                  |
| T42       | CIRS_062TI_MIRLMBINT001_PRIME | 03/25/08 | 085      | 05:27:48   | 4:00             | 55S                  |
| T42       | CIRS_062TI_MIRLMBMAP002_PRIME | 03/25/08 | 085      | 19:27:48   | 4:00             | 15S—55S              |
| T43       | CIRS_067TI_MIRLMBINT002_PRIME | 05/12/08 | 133      | 15:01:58   | 4:00             | 40N                  |
| T45       | CIRS_078TI_MIRLMBMAP002_PRIME | 07/31/08 | 213      | 06:58:11   | 3:30             | 0N—45N               |
| T47       | CIRS_093TI_MIRLMBMAP002_PRIME | 11/20/08 | 325      | 20:56:28   | 4:00             | 19S                  |
| T49       | CIRS_098TI_MIRLMBINT001_PRIME | 12/21/08 | 356      | 18:29:52   | 3:30             | 15N                  |
| T50       | CIRS_102TI_MIRLMBINT001_PRIME | 02/06/09 | 037      | 23:20:51   | 4:00             | BIU anomaly          |
| T51       | CIRS_107TI_MIRLMBINT002_PRIME | 03/27/09 | 086      | 09:43:36   | 4:00             | 30S                  |
| T54       | CIRS_110TI_MIRLMBMAP001_PRIME | 05/05/09 | 125      | 13:54:16   | 3:50             | 30N—20S              |
| T55       | CIRS_111TI_MIRLMPAIR002_PRIME | 05/22/09 | 142      | 02:26:41   | 4:00             | 25S                  |
| T59       | CIRS_115TI_MIRLMBMAP001_PRIME | 07/24/09 | 205      | 06:34:04   | 4:00             | 0N—60N               |
| T59       | CIRS_115TI_MIRLMBINT002_PRIME | 07/24/09 | 205      | 20:34:04   | 2:00             | 65N                  |
| T61       | CIRS_117TI_MIRLMBINT001_PRIME | 08/25/09 | 237      | 03:51:38   | 3:50             | 60S                  |
| T63       | CIRS_122TI_MIRLMBMAP001_PRIME | 12/11/09 | 345      | 16:03:14   | 4:00             | 85N—0N               |
| T64       | CIRS_123TI_MIRLMPAIR001_PRIME | 12/27/09 | 361      | 15:16:59   | 4:00             | 75N                  |
| T64       | CIRS_123TI_MIRLMBINT002_PRIME | 12/28/09 | 362      | 05:16:59   | 4:00             | 75N                  |
| T65       | CIRS_124TI_MIRLMBINT001_PRIME | 01/12/10 | 012      | 14:10:36   | 4:00             | 75S                  |
| T65       | CIRS_124TI_MIRLMBMAP002_PRIME | 01/13/10 | 013      | 04:10:36   | 4:00             | 85S—0N               |
| T67       | CIRS_129TI_MIRLMBINT001_PRIME | 04/05/10 | 095      | 06:50:39   | 4:00             | 88N                  |
| T69       | CIRS_132TI_MIRLMBMAP001_PRIME | 06/04/10 | 155      | 17:08:27   | 4:18             | 85S—0N               |
| T70       | CIRS_133TI_MIRLMBMAP001_PRIME | 06/20/10 | 171      | 16:27:43   | 4:00             | 5N—85N               |
| T71       | CIRS_134TI_MIRLMBINT001_PRIME | 07/06/10 | 187      | 15:22:45   | 3:00             | 80S                  |
| T72       | CIRS_138TI_MIRLMPAIR001_PRIME | 09/24/10 | 267      | 09:38:41   | 4:00             | 76N                  |
| T73       | CIRS_140TI_MIRMBMAP001_PRIME  | 11/11/10 | 315      | 04:37:01   | 4:00             | Safing event         |
| T76       | CIRS_148TI_MIRLMBMAP001_PRIME | 05/08/11 | 128      | 13:53:45   | 4:00             | 0N—85N               |
| T77       | CIRS_149TI_MIRLMBMAP002_PRIME | 06/20/11 | 171      | 23:32:01   | 4:00             | 0N—85S               |
| T78       | CIRS_153TI_MIRLMBINT001_PRIME | 09/11/11 | 254      | 17:50:06   | 4:00             | 85S                  |
| T79       | CIRS_158TI_MIRLMBINT501_PRIME | 12/13/11 | 347      | 11:11:24   | 4:00             | 80N                  |
| T80       | CIRS_159TI_MIRLMBMAP001_PRIME | 01/02/12 | 002      | 06:13:37   | 4:00             | 75N—10S              |
| T82       | CIRS_161TI_MIRLMBINT001_PRIME | 02/18/12 | 049      | 23:43:17   | 4:00             | 45S                  |

**Table 6**  
(Continued)

| Flyby No. | Observation Name              | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Latitudes) |
|-----------|-------------------------------|----------|----------|------------|------------------|----------------------|
| T82       | CIRS_161TI_MIRLMBMAP002_PRIME | 02/19/12 | 050      | 13:43:17   | 4:00             | 0N—80S               |
| T83       | CIRS_166TI_MIRLMBINT001_PRIME | 05/21/12 | 142      | 16:10:11   | 4:00             | 0N                   |
| T84       | CIRS_167TI_MIRLMBINT001_PRIME | 06/06/12 | 158      | 15:07:21   | 4:00             | 45N                  |
| T85       | CIRS_169TI_MIRLMBMAP002_PRIME | 07/25/12 | 207      | 01:03:07   | 4:00             | 15S—65N              |
| T88       | CIRS_175TI_MIRLMBMAP001_PRIME | 11/28/12 | 333      | 23:56:59   | 4:00             | 50S—30N              |
| T90       | CIRS_185TI_MIRLMBINT001_PRIME | 04/05/13 | 095      | 12:43:31   | 4:00             | 25N                  |
| T91       | CIRS_190TI_MIRLMBMAP001_PRIME | 05/23/13 | 143      | 08:32:55   | 3:00             | 35N—15S              |
| T92       | CIRS_194TI_MIRLMBINT001_PRIME | 07/10/13 | 191      | 04:21:47   | 3:00             | 20S                  |
| T93       | CIRS_195TI_MIRLMBMAP002_PRIME | 07/26/13 | 207      | 15:56:22   | 5:00             | 15N—15S              |
| T95       | CIRS_198TI_MIRLMPAIR001_PRIME | 10/13/13 | 286      | 19:56:27   | 3:00             | 16N                  |
| T95       | CIRS_198TI_MIRLMBINT001_PRIME | 10/14/13 | 287      | 10:56:27   | 3:00             | 2S                   |
| T96       | CIRS_199TI_MIRLMBINT002_PRIME | 12/01/13 | 335      | 05:41:19   | 4:00             | 12N                  |
| T98       | CIRS_201TI_MIRLMBMAP002_PRIME | 02/03/14 | 034      | 01:12:38   | 3:00             | 20N—25N              |
| T101      | CIRS_204TI_MIRLMBINT002_PRIME | 05/17/14 | 137      | 21:12:15   | 4:00             | 35S                  |
| T102      | CIRS_205TI_MIRLMBINT001_PRIME | 06/18/14 | 169      | 04:28:25   | 4:44             | 10N                  |
| T102      | CIRS_205TI_MIRLMBMAP002_PRIME | 06/18/14 | 169      | 18:28:25   | 4:00             | 40N—13S              |
| T103      | CIRS_206TI_MIRLMBINT002_PRIME | 07/20/14 | 201      | 15:40:58   | 4:00             | 30N                  |
| T105      | CIRS_208TI_MIRLMBINT001_PRIME | 09/21/14 | 264      | 20:23:19   | 3:45             | See MIDIRTMAP        |
| T105      | CIRS_208TI_MIRLMBMAP002_PRIME | 09/22/14 | 265      | 12:38:19   | 2:00             | 40N—15N              |
| T106      | CIRS_209TI_MIRLMBINT001_PRIME | 10/23/14 | 296      | 17:40:30   | 4:00             | 45S                  |
| T108      | CIRS_211TI_MIRLMBMAP001_PRIME | 01/11/15 | 011      | 10:48:35   | 4:00             | 30S (R)—55S (L)      |
| T108      | CIRS_211TI_MIRLMBINT002_PRIME | 01/12/15 | 012      | 00:48:35   | 3:00             | 70N                  |
| T110      | CIRS_213TI_MIRLMBMAP001_PRIME | 03/16/15 | 075      | 05:29:49   | 4:00             | 80S (L)—85S—30S (R)  |
| T110      | CIRS_213TI_MIRLMBINT002_PRIME | 03/16/15 | 075      | 19:29:49   | 4:00             | 80S                  |
| T111      | CIRS_215TI_MIRLMBMAP002_PRIME | 05/08/15 | 128      | 03:50:24   | 4:00             | 80N (L)—35N (L)      |
| T113      | CIRS_222TI_MIRLMBMAP001_PRIME | 09/28/15 | 271      | 12:37:12   | 4:00             | 20S—85S              |
| T113      | CIRS_222TI_MIRLMBINT002_PRIME | 09/29/15 | 272      | 02:37:12   | 4:00             | 85S                  |
| T114      | CIRS_225TI_MIRLMBMAP001_PRIME | 11/12/15 | 316      | 20:46:31   | 4:00             | 75N—5N               |
| T115      | CIRS_230TI_MIRLMBMAP002_PRIME | 01/16/16 | 016      | 07:20:24   | 4:00             | 85S—25S              |
| T116      | CIRS_231TI_MIRLMBINT001_PRIME | 01/31/16 | 031      | 16:00:05   | 4:00             | 85S                  |
| T116      | CIRS_231TI_MIRLMBMAP002_PRIME | 02/01/16 | 032      | 06:00:05   | 4:00             | 80N—20N              |
| T117      | CIRS_232TI_MIRLMBINT001_PRIME | 02/16/16 | 047      | 14:49:41   | 4:00             | 80S                  |
| T117      | CIRS_232TI_MIRLMBMAP002_PRIME | 02/17/16 | 048      | 04:49:41   | 4:00             | 75N—10N              |
| T119      | CIRS_235TI_MIRLMBMAP001_PRIME | 05/06/16 | 127      | 07:54:37   | 4:00             | 50S—15N              |
| T120      | CIRS_236TI_MIRLMBINT001_PRIME | 06/07/16 | 159      | 05:06:17   | 4:00             | 50S                  |
| T120      | CIRS_236TI_MIRLMBMAP002_PRIME | 06/07/16 | 159      | 19:06:17   | 4:00             | 50N—15S              |
| T121      | CIRS_238TI_MIRLMBINT002_PRIME | 07/25/16 | 207      | 00:15:43   | 4:43             | 0N                   |
| T124      | CIRS_248TI_MIRLMBMAP002_PRIME | 11/14/16 | 319      | 04:55:56   | 4:00             | 10S—50N              |
| T125      | CIRS_250TI_MIRLMBINT002_PRIME | 11/30/16 | 335      | 03:14:32   | 4:00             | 50N                  |
| N/A       | CIRS_259TI_MIRLMBMAP002_PRIME | 02/01/17 | 032      | 20:21:00   | 5:15             | 60S—15N              |
| N/A       | CIRS_261TI_MIRLMBMAP001_PRIME | 02/17/17 | 048      | 08:41:00   | 4:00             | 15N—35S              |
| N/A       | CIRS_261TI_MIRLMBINT001_PRIME | 02/17/17 | 048      | 13:41:00   | 3:00             | 10S                  |
| N/A       | CIRS_275TI_MIRLMBINT001_PRIME | 05/23/17 | 143      | 16:44:00   | 6:34             | 50S                  |
| N/A       | CIRS_275TI_MIRLMBMAP002_PRIME | 05/24/17 | 144      | 06:33:00   | 4:00             | 80S—20S              |

**Table 7**  
CIRS Far-infrared Nadir Maps and UVIS EUVFUV (Corrected)

| Flyby No. | Observation Name              | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Center Lat., Lon.) |
|-----------|-------------------------------|----------|----------|------------|------------------|------------------------------|
| TB        | CIRS_00BTI_FIRNADMAP001_UVIS  | 12/13/04 | 348      | 03:38:13   | 4:00             | 6S 159W                      |
| TB        | CIRS_00BTI_FIRNADMAP002_UVIS  | 12/13/04 | 348      | 14:08:13   | 2:30             | 10N 347W                     |
| T3        | CIRS_003TI_FIRNADMAP003_UVIS  | 02/15/05 | 046      | 08:30:53   | 3:27             | 2N 340W                      |
| T5        | CIRS_006TI_FIRNADMAP003_UVIS  | 04/16/05 | 106      | 11:11:46   | 5:00             | 8N 27W                       |
| T6        | CIRS_013TI_FIRNADMAP002_PRIME | 08/22/05 | 234      | 03:53:37   | 2:45             | 3N 32W                       |
| T6        | CIRS_013TI_FIRNADMAP003_PRIME | 08/22/05 | 234      | 11:08:37   | 2:45             | 15S 208W                     |
| T9        | CIRS_019TI_FIRNADMAP005_UVIS  | 12/26/05 | 360      | 21:29:30   | 6:24             | 0N 28W                       |
| T11       | CIRS_021TI_FIRNADMAP003_UVIS  | 02/27/06 | 058      | 13:25:19   | 3:30             | 0N 344W                      |
| T13       | CIRS_023TI_FIRNADMAP003_UVIS  | 05/01/06 | 121      | 02:18:14   | 5:10             | 0N 10W                       |
| T14       | CIRS_024TI_FIRNADMAP002_UVIS  | 05/20/06 | 140      | 04:48:11   | 5:00             | 0N 158W                      |
| T14       | CIRS_024TI_FIRNADMAP003_PRIME | 05/20/06 | 140      | 14:33:11   | 2:45             | 0N 155W                      |
| T15       | CIRS_025TI_FIRNADMAP003_UVIS  | 07/02/06 | 183      | 11:50:47   | 5:30             | 0N 200W                      |
| T16       | CIRS_026TI_FIRNADMAP003_PRIME | 07/22/06 | 203      | 02:40:26   | 2:45             | 6S 339W                      |
| T17       | CIRS_028TI_FIRNADMAP002_UVIS  | 09/07/06 | 250      | 12:46:51   | 4:45             | 10N 149W                     |
| T18       | CIRS_029TI_FIRNADMAP002_UVIS  | 09/23/06 | 266      | 11:28:49   | 4:30             | 14N 141W                     |
| T21       | CIRS_035TI_EUVFUV001_UVIS     | 12/12/06 | 346      | 04:11:31   | 5:00             | 32N 129W                     |
| T22       | CIRS_036TI_FIRNADMAP002_PRIME | 12/28/06 | 362      | 04:35:22   | 3:00             | 41N 133W                     |
| T22       | CIRS_036TI_FIRNADMAP003_PRIME | 12/28/06 | 362      | 13:35:22   | 2:00             | 42S 319W                     |
| T24       | CIRS_038TI_EUVFUV001_UVIS     | 01/28/07 | 028      | 22:15:55   | 6:00             | 59N 116W                     |
| T24       | CIRS_038TI_FIRNADMAP002_PRIME | 01/29/07 | 029      | 11:15:55   | 1:00             | 53S 307W                     |
| T26       | CIRS_040TI_FIRNADMAP001_PRIME | 03/09/07 | 068      | 20:49:00   | 2:45             | 47S 43W                      |
| T26       | CIRS_040TI_FIRNADMAP002_PRIME | 03/10/07 | 069      | 06:04:00   | 0:45             | 46N 228W                     |
| T26       | CIRS_040TI_EUVFUV002_UVIS     | 03/10/07 | 069      | 06:49:00   | 3:00             | ...                          |
| T27       | CIRS_041TI_EUVFUV001_UVIS     | 03/25/07 | 084      | 20:49:27   | 2:23             | 36S 35W                      |
| T27       | CIRS_041TI_FIRNADMAP002_PRIME | 03/26/07 | 085      | 02:38:27   | 0:45             | 32N 218W                     |
| T27       | CIRS_041TI_EUVFUV002_UVIS     | 03/26/07 | 085      | 03:23:27   | 5:00             | 39N 223W                     |
| T29       | CIRS_043TI_FIRNADMAP001_PRIME | 04/26/07 | 116      | 16:32:58   | 2:50             | 27S 28W                      |
| T30       | CIRS_044TI_EUVFUV001_UVIS     | 05/12/07 | 132      | 11:09:58   | 3:50             | ...                          |
| T31       | CIRS_045TI_EUVFUV001_UVIS     | 05/28/07 | 148      | 09:51:55   | 6:00             | 11S 24W                      |
| T31       | CIRS_045TI_FIRNADMAP004_PRIME | 05/28/07 | 148      | 22:51:55   | 1:00             | 13N 212W                     |
| T32       | CIRS_046TI_FIRNADMAP002_UVIS  | 06/13/07 | 164      | 12:46:11   | 2:00             | 7S 24W                       |
| T32       | CIRS_046TI_FIRNADMAP001_UVIS  | 06/13/07 | 164      | 16:12:11   | 0:51             | ...                          |
| T32       | CIRS_046TI_FIRNADMAP002_PRIME | 06/13/07 | 164      | 20:04:11   | 2:42             | 4N 212W                      |
| T33       | CIRS_047TI_EUVFUV001_UVIS     | 06/29/07 | 180      | 11:59:46   | 3:00             | ...                          |
| T33       | CIRS_047TI_FIRNADMAP002_PRIME | 06/29/07 | 180      | 20:59:46   | 1:15             | 0N 209W                      |
| T34       | CIRS_048TI_EUVFUV001_UVIS     | 07/18/07 | 199      | 16:11:20   | 6:00             | ...                          |
| T34       | CIRS_048TI_FIRNADMAP002_PRIME | 07/19/07 | 200      | 05:11:20   | 1:00             | 0N 339W                      |
| T35       | CIRS_049TI_FIRNADMAP001_PRIME | 08/31/07 | 243      | 01:32:34   | 3:00             | 6S 159W                      |
| T35       | CIRS_049TI_FIRNADMAP004_PRIME | 08/31/07 | 243      | 10:32:34   | 1:00             | 10N 347W                     |
| T36       | CIRS_050TI_EUVFUV001_UVIS     | 10/01/07 | 274      | 19:42:43   | 3:49             | ...                          |
| T37       | CIRS_052TI_FIRNADMAP001_PRIME | 11/18/07 | 322      | 19:47:25   | 3:00             | 4S 22W                       |
| T37       | CIRS_052TI_FIRNADMAP002_PRIME | 11/19/07 | 323      | 04:47:25   | 1:00             | 1N 205W                      |
| T38       | CIRS_053TI_FIRNADMAP001_PRIME | 12/04/07 | 338      | 18:36:50   | 3:00             | 8N 27W                       |
| T38       | CIRS_053TI_FIRNADMAP002_PRIME | 12/05/07 | 339      | 04:06:50   | 1:00             | 10N 215W                     |
| T40       | CIRS_055TI_EUVFUV001_UVIS     | 01/05/08 | 005      | 12:30:20   | 4:00             | 21S 32W                      |
| T40       | CIRS_055TI_EUVFUV501_UVIS     | 01/05/08 | 005      | 16:30:20   | 2:00             | ...                          |
| T40       | CIRS_055TI_FIRNADMAP002_PRIME | 01/06/08 | 006      | 01:30:20   | 1:00             | 5S 211W                      |
| T41       | CIRS_059TI_EUVFUV002_UVIS     | 02/22/08 | 053      | 20:02:07   | 2:30             | 25N 227W                     |
| T42       | CIRS_062TI_FIRNADMAP001_PRIME | 03/25/08 | 085      | 09:27:48   | 3:00             | 0N 28W                       |
| T42       | CIRS_062TI_FIRNADMAP002_PRIME | 03/25/08 | 085      | 18:27:48   | 1:00             | 0N 189W                      |
| T43       | CIRS_067TI_FIRNADMAP002_PRIME | 05/12/08 | 133      | 12:11:58   | 2:50             | 0N 344W                      |
| T44       | CIRS_069TI_EUVFUV001_UVIS     | 05/27/08 | 148      | 23:24:32   | 6:00             | BIU anomaly                  |
| T46       | CIRS_091TI_FIRNADMAP001_PRIME | 11/03/08 | 308      | 14:06:23   | 2:01             | BIU anomaly                  |
| T46       | CIRS_091TI_EUVFUV002_UVIS     | 11/03/08 | 308      | 19:27:23   | 7:08             |                              |
| T47       | CIRS_093TI_FIRNADMAP002_PRIME | 11/19/08 | 324      | 18:11:28   | 2:45             | 34N 253W                     |
| T48       | CIRS_095TI_EUVFUV001_UVIS     | 12/05/08 | 340      | 16:40:45   | 6:45             | ...                          |
| T50       | CIRS_102TI_EUVFUV001_UVIS     | 02/07/09 | 038      | 14:50:51   | 3:00             | BIU anomaly                  |
| T51       | CIRS_107TI_FIRNADMAP002_PRIME | 03/27/09 | 086      | 06:32:45   | 3:11             | 54N 266W                     |
| T52       | CIRS_108TI_FIRNADMAP002_PRIME | 04/04/09 | 094      | 03:37:47   | 1:40             | 58S 257W                     |
| T54       | CIRS_110TI_FIRNADMAP001_PRIME | 05/05/09 | 125      | 18:04:16   | 2:35             | 55N 82W*                     |

**Table 7**  
(Continued)

| Flyby No. | Observation Name              | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Center Lat., Lon.) |
|-----------|-------------------------------|----------|----------|------------|------------------|------------------------------|
| T54       | CIRS_110TI_EUVFUV001_UVIS     | 05/06/09 | 126      | 00:54:16   | 7:00             | ...                          |
| T55       | CIRS_111TI_EUVFUV001_UVIS     | 05/21/09 | 141      | 12:26:41   | 6:30             | ...                          |
| T55       | CIRS_111TI_FIRNADMAP002_PRIME | 05/21/09 | 141      | 23:56:41   | 2:30             | 55S 270W*                    |
| T56       | CIRS_112TI_EUVFUV001_UVIS     | 06/06/09 | 157      | 21:41:01   | 7:19             | ...                          |
| T57       | CIRS_113TI_EUVFUV001_UVIS     | 06/22/09 | 173      | 09:32:35   | 6:45             | ...                          |
| T57       | CIRS_113TI_EUVFUV002_UVIS     | 06/23/09 | 174      | 00:02:35   | 3:00             | ...                          |
| T58       | CIRS_114TI_EUVFUV001_UVIS     | 07/08/09 | 189      | 08:04:03   | 6:40             | ...                          |
| T58       | CIRS_114TI_FIRNADMAP002_PRIME | 07/08/09 | 189      | 19:04:03   | 1:30             | 24S 294W*                    |
| T59       | CIRS_115TI_FIRNADMAP002_PRIME | 07/24/09 | 205      | 18:10:09   | 2:23             | 23S 326W                     |
| T60       | CIRS_116TI_EUVFUV001_UVIS     | 08/09/09 | 221      | 05:03:53   | 3:50             | Downlink                     |
| T62       | CIRS_119TI_EUVFUV001_UVIS     | 10/11/09 | 284      | 23:36:25   | 6:51             | ...                          |
| T62       | CIRS_119TI_EUVFUV002_UVIS     | 10/12/09 | 285      | 11:12:30   | 6:24             | ...                          |
| T63       | CIRS_122TI_FIRNADMAP002_PRIME | 12/12/09 | 346      | 03:48:14   | 1:00             | 0N 200W                      |
| T64       | CIRS_123TI_FIRNADMAP001_PRIME | 12/27/09 | 361      | 19:16:59   | 2:45             | 4N 121W                      |
| T65       | CIRS_124TI_FIRNADMAP001_PRIME | 01/12/10 | 012      | 18:10:37   | 2:45             | Angled track                 |
| T65       | CIRS_124TI_FIRNADMAP002_PRIME | 01/13/10 | 013      | 01:10:37   | 3:00             | Angled track                 |
| T66       | CIRS_125TI_EUVFUV001_UVIS     | 01/28/10 | 028      | 13:28:49   | 6:30             | ...                          |
| T66       | CIRS_125TI_EUVFUV002_UVIS     | 01/29/10 | 029      | 00:28:49   | 7:00             | ...                          |
| T67       | CIRS_129TI_FIRNADMAP001_PRIME | 04/05/10 | 095      | 10:50:39   | 2:45             | 25S 130W*                    |
| T67       | CIRS_129TI_FIRNADMAP002_PRIME | 04/05/10 | 095      | 19:50:39   | 1:00             | 10N 310W*                    |
| T69       | CIRS_132TI_EUVFUV001_UVIS     | 06/05/10 | 156      | 04:26:27   | 7:00             | ...                          |
| T70       | CIRS_133TI_FIRNADMAP001_PRIME | 06/20/10 | 171      | 20:27:43   | 2:45             | 0N 9W                        |
| T72       | CIRS_138TI_FIRNADMAP001_PRIME | 09/24/10 | 267      | 13:38:41   | 2:45             | 5S 50W*                      |
| T72       | CIRS_138TI_EUVFUV002_UVIS     | 09/24/10 | 267      | 20:53:41   | 6:45             | ...                          |
| T73       | CIRS_140TI_FIRNADMAP001_PRIME | 11/11/10 | 315      | 08:37:01   | 2:45             | Safing event                 |
| T75       | CIRS_147TI_EUVFUV001_UVIS     | 04/19/11 | 109      | 07:30:39   | 6:30             | ...                          |
| T76       | CIRS_148TI_FIRNADMAP001_PRIME | 05/08/11 | 128      | 17:53:45   | 2:45             | 0N 20W*                      |
| T76       | CIRS_148TI_EUVFUV001_UVIS     | 05/09/11 | 129      | 01:53:45   | 6:00             | ...                          |
| T77       | CIRS_149TI_EUVFUV001_UVIS     | 06/20/11 | 171      | 06:37:00   | 9:25             | ...                          |
| T77       | CIRS_149TI_FIRNADMAP002_PRIME | 06/20/11 | 171      | 21:02:01   | 2:30             | 0N 217W                      |
| T78       | CIRS_153TI_FIRNADMAP001_PRIME | 09/11/11 | 254      | 21:50:06   | 2:45             | 0N 118W*                     |
| T79       | CIRS_158TI_FIRNADMAP501_PRIME | 12/13/11 | 347      | 15:11:24   | 2:45             | 0N 15W                       |
| T80       | CIRS_159TI_FIRNADMAP001_PRIME | 01/02/12 | 002      | 10:13:38   | 2:45             | 25S 138W                     |
| T81       | CIRS_160TI_EUVFUV001_UVIS     | 01/30/12 | 030      | 04:39:47   | 6:45             | ...                          |
| T81       | CIRS_160TI_EUVFUV002_UVIS     | 01/30/12 | 030      | 16:39:47   | 6:00             | ...                          |
| T82       | CIRS_161TI_FIRNADMAP001_PRIME | 02/19/12 | 050      | 03:43:17   | 2:45             | 0N 148W                      |
| T82       | CIRS_161TI_FIRNADMAP002_PRIME | 02/19/12 | 050      | 10:58:17   | 2:45             | 0N 330W*                     |
| T83       | CIRS_166TI_FIRNADMAP001_PRIME | 05/21/12 | 142      | 20:10:11   | 2:33             | 0N 20W                       |
| T84       | CIRS_167TI_FIRNADMAP001_PRIME | 06/06/12 | 158      | 19:07:21   | 2:45             | 22N 18W                      |
| T84       | CIRS_167TI_EUVFUV002_UVIS     | 06/07/12 | 159      | 02:22:21   | 6:45             | ...                          |
| T85       | CIRS_169TI_FIRNADMAP002_PRIME | 07/24/12 | 206      | 22:18:08   | 2:45             | 18S 202W                     |
| T86       | CIRS_172TI_EUVFUV001_UVIS     | 09/26/12 | 270      | 05:35:38   | 6:45             | ...                          |
| T86       | CIRS_172TI_EUVFUV002_UVIS     | 09/26/12 | 270      | 16:50:38   | 6:45             | ...                          |
| T88       | CIRS_175TI_FIRNADMAP001_PRIME | 11/29/12 | 334      | 03:56:59   | 2:45             | 35N 30W                      |
| T90       | CIRS_185TI_FIRNADMAP001_PRIME | 04/05/13 | 095      | 16:43:31   | 2:45             | 42N 48W                      |
| T93       | CIRS_195TI_EUVFUV001_UVIS     | 07/26/13 | 207      | 02:56:19   | 6:45             | ...                          |
| T94       | CIRS_197TI_EUVFUV001_UVIS     | 09/12/13 | 255      | 09:58:56   | 6:45             | ...                          |
| T96       | CIRS_199TI_FIRNADMAP002_PRIME | 12/01/13 | 335      | 02:56:19   | 2:45             | 90S 0W*                      |
| T97       | CIRS_200TI_EUVFUV001_UVIS     | 01/01/14 | 001      | 12:59:41   | 6:45             | ...                          |
| T97       | CIRS_200TI_EUVFUV002_UVIS     | 01/02/14 | 002      | 00:14:41   | 6:45             | ...                          |
| T100      | CIRS_203TI_EUVFUV001_UVIS     | 04/07/14 | 097      | 15:56:14   | 6:45             | ...                          |
| T101      | CIRS_204TI_EUVFUV001_UVIS     | 05/17/14 | 137      | 02:12:15   | 5:15             | ...                          |
| T101      | CIRS_204TI_FIRNADMAP002_PRIME | 05/17/14 | 137      | 18:57:15   | 2:15             | 78N 240W, 72N 313W           |
| T102      | CIRS_205TI_FIRNADMAP002_PRIME | 06/18/14 | 169      | 16:31:25   | 1:57             | 65N 195W*                    |
| T103      | CIRS_206TI_FIRNADMAP002_PRIME | 07/20/14 | 201      | 13:40:58   | 2:00             | 78N 240W                     |
| T105      | CIRS_208TI_EUVFUV001_UVIS     | 09/22/14 | 265      | 02:23:19   | 0:45             | ...                          |
| T105      | CIRS_208TI_EUVFUV002_UVIS     | 09/22/14 | 265      | 11:08:19   | 1:30             | ...                          |
| T105      | CIRS_208TI_FIRNADMAP002_PRIME | 09/22/14 | 265      | 07:38:19   | 3:30             | 57N 200W*                    |
| T109      | CIRS_212TI_EUVFUV001_UVIS     | 02/12/15 | 043      | 08:08:04   | 6:45             | ...                          |
| T109      | CIRS_212TI_EUVFUV002_UVIS     | 02/12/15 | 043      | 19:23:04   | 6:45             | ...                          |

**Table 7**  
(Continued)

| Flyby No. | Observation Name              | Date     | Year Day | Start Time | Duration (HR:MN) | Pointing (Center Lat., Lon.) |
|-----------|-------------------------------|----------|----------|------------|------------------|------------------------------|
| T110      | CIRS_213TI_FIRNADMAP002_PRIME | 03/16/15 | 075      | 16:44:49   | 2:45             | 6S 200W                      |
| T111      | CIRS_215TI_FIRNADMAP002_PRIME | 05/08/15 | 128      | 01:05:24   | 2:45             | 10S 340W                     |
| T112      | CIRS_218TI_FIRNADMAP002_PRIME | 07/07/15 | 188      | 10:24:51   | 2:45             | 6N 220W                      |
| T113      | CIRS_222TI_FIRNADMAP001_PRIME | 09/28/15 | 271      | 16:37:12   | 3:00             | 0N 150W                      |
| T113      | CIRS_222TI_FIRNADMAP002_PRIME | 09/29/15 | 272      | 00:07:12   | 2:30             | 0N 335W                      |
| T114      | CIRS_225TI_EUVFUV002_UVIS     | 11/13/15 | 317      | 08:01:31   | 6:45             | ...                          |
| T115      | CIRS_230TI_EUVFUV001_UVIS     | 01/15/16 | 015      | 17:20:24   | 6:45             | ...                          |
| T115      | CIRS_230TI_FIRNADMAP002_PRIME | 01/16/16 | 016      | 04:35:24   | 2:45             | 0N 218W                      |
| T116      | CIRS_231TI_FIRNADMAP001_PRIME | 01/31/16 | 031      | 20:00:05   | 2:30             | 5S 24W                       |
| T116      | CIRS_231TI_EUVFUV001_UVIS     | 02/01/16 | 032      | 04:20:05   | 1:40             | ...                          |
| T117      | CIRS_232TI_FIRNADMAP002_PRIME | 02/17/16 | 048      | 02:28:41   | 2:21             | 13N 207W                     |
| T118      | CIRS_234TI_EUVFUV001_UVIS     | 04/04/16 | 095      | 10:42:42   | 6:45             | ...                          |
| T118      | CIRS_234TI_EUVFUV002_UVIS     | 04/04/16 | 095      | 21:57:42   | 6:45             | ...                          |
| T119      | CIRS_235TI_FIRNADMAP001_PRIME | 05/06/16 | 127      | 11:54:37   | 2:42             | 25S 30W*                     |
| T120      | CIRS_236TI_FIRNADMAP001_PRIME | 06/07/16 | 159      | 09:06:17   | 2:30             | 36S 20W                      |
| T120      | CIRS_236TI_FIRNADMAP002_PRIME | 06/07/16 | 159      | 16:21:17   | 2:45             | 38N 207W                     |
| T121      | CIRS_238TI_FIRNADMAP001_PRIME | 07/25/16 | 207      | 04:58:23   | 2:45             | 41S 26W                      |
| T123      | CIRS_243TI_EUVFUV001_UVIS     | 09/26/16 | 270      | 19:16:59   | 6:45             | ...                          |
| T123      | CIRS_243TI_EUVFUV002_UVIS     | 09/27/16 | 271      | 06:31:59   | 6:45             | ...                          |
| T124      | CIRS_248TI_FIRNADMAP002_PRIME | 11/14/16 | 319      | 02:27:56   | 2:28             | 33N 244W                     |
| T125      | CIRS_250TI_FIRNADMAP002_PRIME | 11/30/16 | 335      | 00:29:32   | 2:45             | 31N 246W                     |
| N/A       | CIRS_275TI_FIRNADMAP002_PRIME | 05/24/17 | 144      | 01:18:00   | 4:15             | 20S 305W*                    |
| N/A       | CIRS_292TI_FIRNADMAP001_PRIME | 09/11/17 | 254      | 23:46:00   | 3:00             | N Pole mosaic                |

**Note.** Where the observation track is offset from the subspaceraft point, the midpoint of the scan is given; these entries are marked with an asterisk.

**Table 8**  
CIRS Far-infrared Nadir Integrations (Corrected)

| Flyby No. | Observation Name              | Date     | DOY | Start Time | Duration (HR:MN) | Pointing (Center Lat., Lon.) |
|-----------|-------------------------------|----------|-----|------------|------------------|------------------------------|
| T0        | CIRS_000TI_FIRNADCMP017_PRIME | 07/03/04 | 185 | 01:00:00   | 2:15             | visible center               |
| T0        | CIRS_000TI_FIRNADCMP001_PRIME | 07/03/04 | 185 | 04:00:00   | 6:00             | visible center               |
| TA        | CIRS_00ATI_FIRNADCMP001_PRIME | 10/26/04 | 300 | 00:00:09   | 4:00             | 30S 200W                     |
| TB        | CIRS_00BTI_FIRNADCMP001_PRIME | 12/12/04 | 347 | 23:38:13   | 4:00             | 10N 120W                     |
| T3        | CIRS_003TI_FIRNADCMP002_PRIME | 02/15/05 | 046 | 14:57:53   | 4:00             | 18S 35W                      |
| T4        | CIRS_005TI_FIRNADCMP002_PRIME | 03/31/05 | 090 | 07:35:16   | 4:00             | 40S 15W                      |
| T4        | CIRS_005TI_FIRNADCMP003_PRIME | 04/01/05 | 091 | 04:05:16   | 4:00             | 47N 210W                     |
| T5        | CIRS_006TI_FIRNADCMP002_PRIME | 04/16/05 | 106 | 07:16:46   | 3:25             | 55N 15W                      |
| T6        | CIRS_013TI_FIRNADCMP003_PRIME | 08/21/05 | 233 | 22:05:37   | 3:18             | 30N 330W                     |
| T6        | CIRS_013TI_FIRNADCMP004_PRIME | 08/22/05 | 234 | 16:23:37   | 4:30             | 60S 220W                     |
| T8        | CIRS_017TI_FIRNADCMP003_PRIME | 10/28/05 | 301 | 13:15:25   | 3:00             | 20N 35W                      |
| T9        | CIRS_019TI_FIRNADCMP002_PRIME | 12/26/05 | 360 | 07:49:30   | 2:10             | 0N 62W                       |
| T10       | CIRS_020TI_FIRNADCMP002_PRIME | 01/14/06 | 014 | 23:41:27   | 2:00             | 20N 190W                     |
| T11       | CIRS_021TI_FIRNADCMP002_PRIME | 02/27/06 | 058 | 16:55:19   | 4:40             | 30S 170W                     |
| T12       | CIRS_022TI_FIRNADCMP003_PRIME | 03/18/06 | 077 | 10:05:57   | 7:00             | 0N 190W                      |
| T12       | CIRS_022TI_FIRNADCMP008_PRIME | 03/19/06 | 078 | 12:25:57   | 1:41             | 25N 315W                     |
| T13       | CIRS_023TI_FIRNADCMP003_PRIME | 04/30/06 | 120 | 05:34:14   | 6:24             | 25S 320W                     |
| T13       | CIRS_023TI_FIRNADCMP002_PRIME | 05/01/06 | 121 | 07:28:14   | 4:07             | 35S 210W                     |
| T14       | CIRS_024TI_FIRNADCMP003_PRIME | 05/19/06 | 139 | 20:48:11   | 6:30             | 15S 125W                     |
| T15       | CIRS_025TI_FIRNADCMP003_PRIME | 07/01/06 | 182 | 19:50:47   | 3:30             | 15N 230W                     |
| T15       | CIRS_025TI_FIRNADCMP002_PRIME | 07/02/06 | 183 | 18:20:47   | 5:30             | 40N 20W                      |
| T17       | CIRS_028TI_FIRNADCMP003_PRIME | 09/07/06 | 250 | 06:16:51   | 6:00             | 30N 145W                     |
| T18       | CIRS_029TI_FIRNADCMP003_PRIME | 09/23/06 | 266 | 04:58:49   | 5:30             | 10N 95W                      |
| T19       | CIRS_030TI_FIRNADCMP003_PRIME | 10/09/06 | 282 | 03:30:07   | 5:00             | 60S 300W                     |
| T19       | CIRS_030TI_FIRNADCMP002_PRIME | 10/10/06 | 283 | 03:30:07   | 5:51             | 35N 115W                     |
| T21       | CIRS_035TI_FIRNADCMP003_PRIME | 12/11/06 | 345 | 21:11:31   | 5:30             | 65N 130W                     |
| T21       | CIRS_035TI_FIRNADCMP023_PRIME | 12/12/06 | 346 | 22:09:31   | 3:00             | 80S 300W                     |
| T22       | CIRS_036TI_FIRNADCMP003_PRIME | 12/27/06 | 361 | 20:05:22   | 5:30             | 80N 160W                     |
| T22       | CIRS_036TI_FIRNADCMP002_PRIME | 12/28/06 | 362 | 18:35:22   | 2:30             | 90S 320W                     |
| T23       | CIRS_037TI_FIRNADCMP001_PRIME | 01/12/07 | 012 | 19:38:31   | 3:00             | 75N 210W                     |
| T23       | CIRS_037TI_FIRNADCMP002_PRIME | 01/13/07 | 013 | 17:38:31   | 2:00             | 70S 210W                     |
| T24       | CIRS_038TI_FIRNADCMP001_PRIME | 01/28/07 | 028 | 16:15:55   | 5:00             | 85N 290W                     |
| T24       | CIRS_038TI_FIRNADCMP002_PRIME | 01/29/07 | 029 | 16:15:55   | 5:00             | 40S 280W                     |
| T25       | CIRS_039TI_FIRNADCMP001_PRIME | 02/21/07 | 052 | 14:12:24   | 3:00             | 30S 90W                      |
| T25       | CIRS_039TI_FIRNADCMP002_PRIME | 02/22/07 | 053 | 12:12:24   | 2:00             | 70N 350W                     |
| T26       | CIRS_040TI_FIRNADCMP001_PRIME | 03/09/07 | 068 | 12:49:00   | 3:00             | 50S 80W                      |
| T26       | CIRS_040TI_FIRNADCMP002_PRIME | 03/10/07 | 069 | 10:49:00   | 2:00             | 90N 60W                      |
| T27       | CIRS_041TI_FIRNADCMP001_PRIME | 03/25/07 | 084 | 11:23:27   | 3:00             | 70S 20W                      |
| T27       | CIRS_041TI_FIRNADCMP002_PRIME | 03/26/07 | 085 | 09:23:27   | 2:00             | 60N 150W                     |
| T28       | CIRS_042TI_FIRNADCMP001_PRIME | 04/10/07 | 100 | 07:58:00   | 2:00             | 60S 30W                      |
| T28       | CIRS_042TI_FIRNADCMP002_PRIME | 04/11/07 | 101 | 07:58:00   | 5:00             | 70N 180W                     |
| T29       | CIRS_043TI_FIRNADCMP001_PRIME | 04/26/07 | 116 | 06:46:58   | 4:46             | 50S 30W                      |
| T29       | CIRS_043TI_FIRNADCMP002_PRIME | 04/27/07 | 117 | 06:32:58   | 2:00             | 75N 220W                     |
| T30       | CIRS_044TI_FIRNADCMP002_PRIME | 05/13/07 | 133 | 05:09:58   | 2:00             | 0N 260W                      |
| T31       | CIRS_045TI_FIRNADCMP001_PRIME | 05/28/07 | 148 | 04:42:55   | 4:09             | 20S 330W                     |
| T31       | CIRS_045TI_FIRNADCMP002_PRIME | 05/29/07 | 149 | 03:51:55   | 6:14             | 50N 230W                     |
| T32       | CIRS_046TI_FIRNADCMP001_PRIME | 06/13/07 | 164 | 03:39:11   | 1:07             | 20N 50W                      |
| T32       | CIRS_046TI_FIRNADCMP002_PRIME | 06/14/07 | 165 | 02:46:11   | 2:00             | 20S 257W                     |
| T33       | CIRS_047TI_FIRNADCMP001_PRIME | 06/29/07 | 180 | 02:44:46   | 4:15             | 10N 330W                     |
| T33       | CIRS_047TI_FIRNADCMP002_PRIME | 06/30/07 | 181 | 02:14:46   | 4:45             | 20N 170W                     |
| T34       | CIRS_048TI_FIRNADCMP001_PRIME | 07/18/07 | 199 | 10:11:20   | 2:00             | 35S 125W                     |
| T34       | CIRS_048TI_FIRNADCMP002_PRIME | 07/19/07 | 200 | 10:11:20   | 4:49             | 50N 345W                     |
| T35       | CIRS_049TI_FIRNADCMP001_PRIME | 08/30/07 | 242 | 18:17:34   | 2:15             | 10S 40W                      |
| T35       | CIRS_049TI_FIRNADCMP002_PRIME | 08/31/07 | 243 | 15:32:34   | 6:00             | 37S 240W                     |
| T36       | CIRS_050TI_FIRNADCMP001_PRIME | 10/01/07 | 274 | 13:30:43   | 5:12             | 10S 320W                     |
| T36       | CIRS_050TI_FIRNADCMP002_PRIME | 10/02/07 | 275 | 13:42:43   | 2:00             | 30N 255W                     |
| T37       | CIRS_052TI_FIRNADCMP002_PRIME | 11/19/07 | 323 | 09:47:25   | 5:00             | 40N 185W                     |
| T38       | CIRS_053TI_FIRNADCMP001_PRIME | 12/04/07 | 338 | 09:59:50   | 4:07             | 40S 340W                     |
| T38       | CIRS_053TI_FIRNADCMP002_PRIME | 12/05/07 | 339 | 09:06:50   | 2:00             | 60N 215W                     |
| T39       | CIRS_054TI_FIRNADCMP002_PRIME | 12/21/07 | 355 | 07:57:55   | 2:00             | 60N 270W                     |

**Table 8**  
(Continued)

| Flyby No. | Observation Name              | Date     | DOY | Start Time | Duration (HR:MN) | Pointing (Center Lat., Lon.) |
|-----------|-------------------------------|----------|-----|------------|------------------|------------------------------|
| T40       | CIRS_055TI_FIRNADCMP001_PRIME | 01/05/08 | 005 | 08:07:20   | 3:23             | 20N 355W                     |
| T40       | CIRS_055TI_FIRNADCMP002_PRIME | 01/06/08 | 006 | 06:30:20   | 5:00             | 45N 280W                     |
| T41       | CIRS_059TI_FIRNADCMP001_PRIME | 02/22/08 | 053 | 04:29:07   | 3:03             | 25S 65W                      |
| T41       | CIRS_059TI_FIRNADCMP002_PRIME | 02/23/08 | 054 | 02:32:07   | 2:00             | 15N 285W                     |
| T42       | CIRS_062TI_FIRNADCMP002_PRIME | 03/25/08 | 085 | 23:27:48   | 2:00             | 60N 310W                     |
| T43       | CIRS_067TI_FIRNADCMP001_PRIME | 05/11/08 | 132 | 23:07:58   | 0:54             | 60S 60W                      |
| T43       | CIRS_067TI_FIRNADCMP002_PRIME | 05/12/08 | 133 | 19:01:58   | 5:00             | 30N 300W                     |
| T44       | CIRS_069TI_FIRNADCMP001_PRIME | 05/27/08 | 148 | 17:24:32   | 2:00             | 45S 50W                      |
| T44       | CIRS_069TI_FIRNADCMP002_PRIME | 05/28/08 | 149 | 17:24:32   | 2:00             | 10N 300W                     |
| T46       | CIRS_091TI_FIRNADCMP001_PRIME | 11/03/08 | 308 | 02:35:24   | 6:00             | BIU anomaly                  |
| T46       | CIRS_091TI_FIRNADCMP002_PRIME | 11/04/08 | 309 | 03:35:24   | 4:38             |                              |
| T47       | CIRS_093TI_FIRNADCMP002_PRIME | 11/20/08 | 325 | 01:56:28   | 3:00             | 45N 255W                     |
| T48       | CIRS_095TI_FIRNADCMP001_PRIME | 12/05/08 | 340 | 01:25:45   | 4:00             | 15S 70W                      |
| T49       | CIRS_097TI_FIRNADCMP001_PRIME | 12/20/08 | 355 | 23:59:52   | 4:00             | 10S 110W                     |
| T50       | CIRS_102TI_FIRNADCMP001_PRIME | 02/06/09 | 037 | 19:50:51   | 3:30             | BIU anomaly                  |
| T51       | CIRS_106TI_FIRNADCMP001_PRIME | 03/26/09 | 085 | 16:43:36   | 3:00             | 60S 150W                     |
| T51       | CIRS_107TI_FIRNADCMP002_PRIME | 03/27/09 | 086 | 14:43:36   | 3:00             | 35N 215W                     |
| T52       | CIRS_108TI_FIRNADCMP002_PRIME | 04/04/09 | 094 | 10:47:47   | 3:00             | 70S 75W                      |
| T53       | CIRS_109TI_FIRNADCMP001_PRIME | 04/19/09 | 109 | 09:13:42   | 5:07             | Downlink                     |
| T54       | CIRS_110TI_FIRNADCMP001_PRIME | 05/06/09 | 126 | 07:54:16   | 5:00             | 70S 190W                     |
| T55       | CIRS_111TI_FIRNADCMP002_PRIME | 05/22/09 | 142 | 06:26:41   | 3:00             | 25S 5W                       |
| T56       | CIRS_112TI_FIRNADCMP001_PRIME | 06/06/09 | 157 | 06:07:49   | 3:52             | 50N 60W                      |
| T56       | CIRS_112TI_FIRNADCMP002_PRIME | 06/07/09 | 158 | 05:00:01   | 5:00             | 60S 255W                     |
| T57       | CIRS_113TI_FIRNADCMP001_PRIME | 06/22/09 | 173 | 05:05:48   | 3:27             | 15N 75W                      |
| T58       | CIRS_114TI_FIRNADCMP001_PRIME | 07/09/09 | 190 | 02:04:03   | 3:00             | 70S 340W                     |
| T59       | CIRS_115TI_FIRNADCMP001_PRIME | 07/24/09 | 205 | 02:34:04   | 3:00             | 50N 100W                     |
| T60       | CIRS_116TI_FIRNADCMP001_PRIME | 08/09/09 | 221 | 02:01:49   | 2:02             | Downlink                     |
| T62       | CIRS_119TI_FIRNADCMP001_PRIME | 10/11/09 | 284 | 19:36:25   | 3:00             | 25S 105W                     |
| T62       | CIRS_119TI_FIRNADCMP002_PRIME | 10/12/09 | 285 | 17:36:25   | 3:00             | 0N 20W                       |
| T63       | CIRS_122TI_FIRNADCMP001_PRIME | 12/11/09 | 345 | 11:05:56   | 3:57             | 40N 0W                       |
| T64       | CIRS_123TI_FIRNADCMP002_PRIME | 12/28/09 | 362 | 09:16:59   | 3:00             | 45S 190W                     |
| T65       | CIRS_124TI_FIRNADCMP002_PRIME | 01/13/10 | 013 | 08:10:37   | 5:00             | 0N 170W                      |
| T66       | CIRS_125TI_FIRNADCMP001_PRIME | 01/28/10 | 028 | 08:07:18   | 4:22             | 40N 40W                      |
| T66       | CIRS_125TI_FIRNADCMP002_PRIME | 01/29/10 | 029 | 07:28:49   | 5:00             | 45S 225W                     |
| T67       | CIRS_129TI_FIRNADCMP001_PRIME | 04/05/10 | 095 | 03:44:18   | 2:06             | 45S 110W                     |
| T68       | CIRS_131TI_FIRNADCMP001_PRIME | 05/19/10 | 139 | 14:24:20   | 3:00             | 30S 30W                      |
| T68       | CIRS_131TI_FIRNADCMP002_PRIME | 05/20/10 | 140 | 12:24:20   | 4:00             | 20S 230W                     |
| T69       | CIRS_132TI_FIRNADCMP002_PRIME | 06/05/10 | 156 | 11:26:27   | 3:00             | 50N 195W                     |
| T70       | CIRS_133TI_FIRNADCMP001_PRIME | 06/20/10 | 171 | 12:06:01   | 3:21             | 50S 0W                       |
| T71       | CIRS_134TI_FIRNADCMP001_PRIME | 07/06/10 | 187 | 11:07:45   | 4:15             | 10S 60W                      |
| T72       | CIRS_138TI_FIRNADCMP001_PRIME | 09/24/10 | 267 | 06:12:41   | 3:26             | 30S 40W                      |
| T73       | CIRS_140TI_FIRNADCMP001_PRIME | 11/11/10 | 315 | 00:37:01   | 4:00             | Safing event                 |
| T76       | CIRS_148TI_FIRNADCMP001_PRIME | 05/08/11 | 128 | 09:42:00   | 4:12             | 10S 115W                     |
| T78       | CIRS_153TI_FIRNADCMP001_PRIME | 09/11/11 | 254 | 13:50:06   | 4:00             | 10N 110W                     |
| T79       | CIRS_158TI_FIRNADCMP501_PRIME | 12/13/11 | 347 | 04:20:00   | 6:52             | 30S 330W                     |
| T80       | CIRS_159TI_FIRNADCMP001_PRIME | 01/02/12 | 002 | 01:16:59   | 4:57             | 40S 150W                     |
| T81       | CIRS_160TI_FIRNADCMP001_PRIME | 01/29/12 | 029 | 23:36:01   | 5:04             | 40S 330W                     |
| T81       | CIRS_160TI_FIRNADCMP002_PRIME | 01/30/12 | 030 | 22:39:48   | 5:36             | 0N 240W                      |
| T82       | CIRS_161TI_FIRNADCMP001_PRIME | 02/18/12 | 049 | 20:43:17   | 2:00             | 10N 150W                     |
| T82       | CIRS_161TI_FIRNADCMP002_PRIME | 02/19/12 | 050 | 17:43:17   | 2:06             | 15S 290W                     |
| T83       | CIRS_166TI_FIRNADCMP001_PRIME | 05/22/12 | 143 | 10:10:11   | 5:36             | 15S 170W                     |
| T84       | CIRS_167TI_FIRNADCMP002_PRIME | 06/07/12 | 159 | 09:07:21   | 5:00             | 45S 255W                     |
| T85       | CIRS_169TI_FIRNADCMP001_PRIME | 07/24/12 | 206 | 07:03:07   | 4:00             | 10S 345W                     |
| T86       | CIRS_172TI_FIRNADCMP001_PRIME | 09/26/12 | 270 | 01:10:59   | 4:25             | 45N 315W                     |
| T86       | CIRS_172TI_FIRNADCMP002_PRIME | 09/26/12 | 270 | 23:35:38   | 5:00             | 70S 240W                     |
| T87       | CIRS_174TI_FIRNADCMP002_PRIME | 11/13/12 | 318 | 19:22:08   | 5:00             | 72S 185W                     |
| T88       | CIRS_175TI_FIRNADCMP001_PRIME | 11/28/12 | 333 | 21:26:59   | 2:30             | 15N 60W                      |
| T88       | CIRS_175TI_FIRNADCMP002_PRIME | 11/29/12 | 334 | 17:56:59   | 5:00             | 60S 165W                     |
| T90       | CIRS_185TI_FIRNADCMP001_PRIME | 04/05/13 | 095 | 08:43:31   | 4:00             | 15N 70W                      |
| T90       | CIRS_185TI_FIRNADCMP002_PRIME | 04/06/13 | 096 | 06:43:31   | 5:00             | 89S 245W                     |

**Table 8**  
(Continued)

| Flyby No. | Observation Name              | Date     | DOY | Start Time | Duration (HR:MN) | Pointing (Center Lat., Lon.) |
|-----------|-------------------------------|----------|-----|------------|------------------|------------------------------|
| T91       | CIRS_190TI_FIRNADCMP001_PRIME | 05/23/13 | 143 | 04:32:55   | 4:00             | 0N 50W                       |
| T91       | CIRS_190TI_FIRNADCMP002_PRIME | 05/24/13 | 144 | 02:32:55   | 5:00             | 45S 300W                     |
| T92       | CIRS_194TI_FIRNADCMP001_PRIME | 07/10/13 | 191 | 01:21:47   | 3:00             | 30N 90W                      |
| T93       | CIRS_195TI_FIRNADCMP001_PRIME | 07/25/13 | 206 | 23:56:22   | 3:00             | 20N 15W                      |
| T94       | CIRS_197TI_FIRNADCMP001_PRIME | 09/11/13 | 254 | 17:43:56   | 5:00             | 60N 110W                     |
| T95       | CIRS_198TI_FIRNADCMP001_PRIME | 10/13/13 | 286 | 16:56:27   | 3:00             | 89N 30W                      |
| T95       | CIRS_198TI_FIRNADCMP002_PRIME | 10/14/13 | 287 | 13:56:27   | 4:53             | 70S 100W                     |
| T96       | CIRS_199TI_FIRNADCMP001_PRIME | 11/30/13 | 334 | 10:41:19   | 5:00             | 90N (FPB)                    |
| T97       | CIRS_200TI_FIRNADCMP001_PRIME | 01/01/14 | 001 | 09:59:41   | 3:00             | 50N 165W                     |
| T97       | CIRS_200TI_FIRNADCMP002_PRIME | 01/02/14 | 002 | 07:21:41   | 4:00             | 60S 45W                      |
| T98       | CIRS_201TI_FIRNADCMP001_PRIME | 02/02/14 | 033 | 05:12:39   | 5:00             | 20N 135W                     |
| T98       | CIRS_201TI_FIRNADCMP002_PRIME | 02/03/14 | 034 | 04:12:39   | 4:00             | 40S 20W                      |
| T100      | CIRS_203TI_FIRNADCMP001_PRIME | 04/07/14 | 097 | 01:41:14   | 3:00             | 75N 90W                      |
| T100      | CIRS_203TI_FIRNADCMP002_PRIME | 04/07/14 | 097 | 22:41:14   | 4:00             | 0N 0W                        |
| T101      | CIRS_204TI_FIRNADCMP002_PRIME | 05/18/14 | 138 | 01:12:15   | 4:00             | 0N 210W                      |
| T102      | CIRS_205TI_FIRNADCMP001_PRIME | 06/18/14 | 169 | 01:28:25   | 3:00             | 45S 300W                     |
| T102      | CIRS_205TI_FIRNADCMP002_PRIME | 06/18/14 | 169 | 22:28:25   | 3:00             | 30N 180W                     |
| T103      | CIRS_206TI_FIRNADCMP001_PRIME | 07/19/14 | 200 | 22:40:58   | 3:00             | 50S 320W                     |
| T103      | CIRS_206TI_FIRNADCMP002_PRIME | 07/20/14 | 201 | 19:40:58   | 3:00             | 30N 240W                     |
| T104      | CIRS_207TI_FIRNADCMP001_PRIME | 08/20/14 | 232 | 20:09:09   | 3:00             | 70S 110W                     |
| T104      | CIRS_207TI_FIRNADCMP002_PRIME | 08/21/14 | 233 | 17:09:09   | 3:00             | 80N 150W                     |
| T105      | CIRS_208TI_FIRNADCMP001_PRIME | 09/21/14 | 264 | 15:23:19   | 5:00             | 80S 300W                     |
| T105      | CIRS_208TI_FIRNADCMP002_PRIME | 09/22/14 | 265 | 14:38:19   | 2:45             | 60N 270W                     |
| T106      | CIRS_209TI_FIRNADCMP001_PRIME | 10/23/14 | 296 | 14:40:30   | 3:00             | 35S 320W                     |
| T106      | CIRS_209TI_FIRNADCMP002_PRIME | 10/24/14 | 297 | 11:40:30   | 4:00             | 50N 255W                     |
| T107      | CIRS_210TI_FIRNADCMP001_PRIME | 12/10/14 | 344 | 08:26:35   | 5:00             | 70S 0W                       |
| T107      | CIRS_210TI_FIRNADCMP002_PRIME | 12/11/14 | 345 | 07:26:35   | 4:00             | 20S 195W                     |
| T108      | CIRS_211TI_FIRNADCMP001_PRIME | 01/11/15 | 011 | 07:15:35   | 3:33             | 20N 20W                      |
| T108      | CIRS_211TI_FIRNADCMP002_PRIME | 01/12/15 | 012 | 04:48:35   | 4:00             | 40N 160W                     |
| T109      | CIRS_212TI_FIRNADCMP002_PRIME | 02/13/15 | 044 | 02:08:04   | 4:00             | 40S 200W                     |
| T110      | CIRS_213TI_FIRNADCMP001_PRIME | 03/16/15 | 075 | 02:29:49   | 3:00             | 30S 345W                     |
| T110      | CIRS_213TI_FIRNADCMP002_PRIME | 03/16/15 | 075 | 23:29:49   | 4:00             | 25N 205W                     |
| T111      | CIRS_215TI_FIRNADCMP001_PRIME | 05/07/15 | 127 | 09:50:24   | 4:00             | 50S 140W                     |
| T111      | CIRS_215TI_FIRNADCMP002_PRIME | 05/08/15 | 128 | 07:50:24   | 4:00             | 30S 310W                     |
| T112      | CIRS_218TI_FIRNADCMP001_PRIME | 07/06/15 | 187 | 19:09:51   | 4:00             | 20S 40W                      |
| T112      | CIRS_218TI_FIRNADCMP002_PRIME | 07/07/15 | 188 | 17:09:51   | 4:00             | 40S 250W                     |
| T113      | CIRS_222TI_FIRNADCMP001_PRIME | 09/28/15 | 271 | 09:27:12   | 2:10             | 30N 110W                     |
| T113      | CIRS_222TI_FIRNADCMP002_PRIME | 09/29/15 | 272 | 06:37:12   | 4:00             | 0N 310W                      |
| T115      | CIRS_230TI_FIRNADCMP001_PRIME | 01/15/16 | 015 | 12:55:31   | 4:24             | 15S 345W                     |
| T116      | CIRS_231TI_FIRNADCMP001_PRIME | 01/31/16 | 031 | 11:56:59   | 4:03             | 15N 345W                     |
| T116      | CIRS_231TI_FIRNADCMP002_PRIME | 02/01/16 | 032 | 10:00:05   | 4:05             | 0N 260W                      |
| T117      | CIRS_232TI_FIRNADCMP001_PRIME | 02/16/16 | 047 | 10:56:37   | 3:53             | 50S 20W                      |
| T117      | CIRS_232TI_FIRNADCMP002_PRIME | 02/17/16 | 048 | 08:49:41   | 2:00             | 20S 240W                     |
| T118      | CIRS_234TI_FIRNADCMP001_PRIME | 04/04/16 | 095 | 05:42:42   | 5:00             | 20N 0W                       |
| T119      | CIRS_235TI_FIRNADCMP001_PRIME | 05/06/16 | 127 | 04:54:37   | 3:00             | 60S 320W                     |
| T119      | CIRS_235TI_FIRNADCMP002_PRIME | 05/07/16 | 128 | 01:54:37   | 4:00             | 15N 255W                     |
| T120      | CIRS_236TI_FIRNADCMP001_PRIME | 06/07/16 | 159 | 03:33:39   | 1:33             | 70S 10W                      |
| T120      | CIRS_236TI_FIRNADCMP002_PRIME | 06/07/16 | 159 | 23:06:17   | 4:00             | 60N 220W                     |
| T121      | CIRS_238TI_FIRNADCMP002_PRIME | 07/25/16 | 207 | 18:58:23   | 3:30             | 15N 260W                     |
| T124      | CIRS_248TI_FIRNADCMP001_PRIME | 11/13/16 | 318 | 11:55:56   | 3:00             | 89S 50W                      |
| T124      | CIRS_248TI_FIRNADCMP002_PRIME | 11/14/16 | 319 | 08:55:56   | 3:00             | 30N 280W                     |
| T125      | CIRS_250TI_FIRNADCMP002_PRIME | 11/30/16 | 335 | 07:14:32   | 4:00             | 20S 260W                     |
| T126      | CIRS_270TI_FIRNADCMP001_PRIME | 04/21/17 | 111 | 18:08:07   | 3:00             | 75S 55W                      |

**Table 9**  
CIRS Mid-infrared Nadir Maps (Corrected)

| Flyby # | Observation Name              | Date     | DOY | Start Time | Duration (HR:MN) |
|---------|-------------------------------|----------|-----|------------|------------------|
| T0      | CIRS_000TI_TEMPMAPI01_PRIME   | 07/02/04 | 184 | 03:30:21   | 1:22             |
| T0      | CIRS_000TI_TEMPMAPI02_PRIME   | 07/02/04 | 184 | 05:16:21   | 1:24             |
| T0      | CIRS_000TI_TEMPMAPI03_PRIME   | 07/02/04 | 184 | 07:04:21   | 1:26             |
| T0      | CIRS_000TI_TEMPMAPI04_PRIME   | 07/02/04 | 184 | 10:30:21   | 4:00             |
| T0      | CIRS_000TI_TEMPMAPI05_PRIME   | 07/02/04 | 184 | 15:15:21   | 1:45             |
| TA      | CIRS_00ATI_MIDIRTMAP001_PRIME | 10/25/04 | 299 | 17:30:09   | 5:15             |
| TB      | CIRS_00BTI_MIDIRTMAP001_PRIME | 12/12/04 | 347 | 15:13:13   | 8:25             |
| T3      | CIRS_003TI_MIDIRTMAP002_PRIME | 02/14/05 | 045 | 09:57:53   | 9:00             |
| T3      | CIRS_003TI_MIDIRTMAP003_PRIME | 02/15/05 | 046 | 18:57:53   | 4:20             |
| T4      | CIRS_005TI_MIDIRTMAP003_PRIME | 04/01/05 | 091 | 08:05:16   | 6:30             |
| T6      | CIRS_013TI_MIDIRTMAP007_PRIME | 08/22/05 | 234 | 20:53:37   | 7:03             |
| T7      | CIRS_014TI_MIDIRTMAP006_PRIME | 09/06/05 | 249 | 06:00:00   | 5:00             |
| T7      | CIRS_014TI_MIDIRTMAP005_PRIME | 09/07/05 | 250 | 20:11:57   | 6:11             |
| T8      | CIRS_017TI_MIDIRTMAP008_PRIME | 10/27/05 | 300 | 01:24:00   | 7:00             |
| T8      | CIRS_017TI_MIDIRTMAP005_PRIME | 10/28/05 | 301 | 16:15:25   | 7:48             |
| T9      | CIRS_019TI_MIDIRTMAP009_PRIME | 12/27/05 | 361 | 14:04:00   | 13:33            |
| T10     | CIRS_020TI_MIDIRTMAP010_PRIME | 01/14/06 | 014 | 14:23:27   | 9:18             |
| T14     | CIRS_024TI_MIDIRTMAP001_PRIME | 05/21/06 | 141 | 01:18:11   | 2:00             |
| T14     | CIRS_024TI_MIDIRTMAP002_PRIME | 05/21/06 | 141 | 06:18:11   | 2:58             |
| T15     | CIRS_025TI_MIDIRTMAP002_PRIME | 07/02/06 | 183 | 23:50:47   | 7:54             |
| T17     | CIRS_028TI_MIDIRTMAP006_PRIME | 09/06/06 | 249 | 21:56:51   | 7:20             |
| T18     | CIRS_029TI_TEMPMAPI09_PRIME   | 09/22/06 | 265 | 03:30:00   | 7:00             |
| T18     | CIRS_029TI_MIDIRTMAP004_PRIME | 09/22/06 | 265 | 20:58:49   | 7:00             |
| T19     | CIRS_030TI_MIDIRTMAP006_PRIME | 10/08/06 | 281 | 20:16:07   | 6:14             |
| T20     | CIRS_031TI_TEMPMAPI22_PRIME   | 10/24/06 | 297 | 01:26:00   | 7:30             |
| T21     | CIRS_035TI_MIDIRTMAP006_PRIME | 12/11/06 | 345 | 16:08:31   | 4:03             |
| T22     | CIRS_036TI_MIDIRTMAP006_PRIME | 12/27/06 | 361 | 15:04:22   | 5:01             |
| T23     | CIRS_037TI_MIDIRTMAP001_PRIME | 01/12/07 | 012 | 14:23:31   | 2:15             |
| T23     | CIRS_037TI_MIDIRTMAP002_PRIME | 01/12/07 | 012 | 17:38:31   | 2:00             |
| T23     | CIRS_037TI_MIDIRTMAP003_PRIME | 01/13/07 | 013 | 22:38:31   | 3:25             |
| T24     | CIRS_038TI_MIDIRTMAP001_PRIME | 01/28/07 | 028 | 13:00:55   | 2:15             |
| T24     | CIRS_038TI_MIDIRTMAP002_PRIME | 01/29/07 | 029 | 21:15:55   | 5:14             |
| T24     | CIRS_038TI_TEMPMAPI11_PRIME   | 01/30/07 | 030 | 16:37:00   | 6:00             |
| T25     | CIRS_039TI_MIDIRTMAP001_PRIME | 02/21/07 | 052 | 12:12:24   | 2:00             |
| T25     | CIRS_039TI_MIDIRTMAP002_PRIME | 02/22/07 | 053 | 17:12:24   | 7:15             |
| T26     | CIRS_040TI_MIDIRTMAP001_PRIME | 03/09/07 | 068 | 11:08:00   | 1:41             |
| T27     | CIRS_041TI_MIDIRTMAP001_PRIME | 03/25/07 | 084 | 09:07:27   | 2:16             |
| T28     | CIRS_042TI_MIDIRTMAP002_PRIME | 04/11/07 | 101 | 12:58:00   | 7:14             |
| T29     | CIRS_043TI_TEMPMAPI29_PRIME   | 04/28/07 | 118 | 00:15:00   | 3:00             |
| T30     | CIRS_044TI_MIDIRTMAP001_PRIME | 05/12/07 | 132 | 05:45:58   | 1:24             |
| T30     | CIRS_044TI_MIDIRTMAP002_PRIME | 05/13/07 | 133 | 10:09:58   | 1:19             |
| T30     | CIRS_044TI_TEMPMAPI30_PRIME   | 05/13/07 | 133 | 21:43:00   | 3:30             |
| T32     | CIRS_046TI_MIDIRTMAP002_PRIME | 06/14/07 | 165 | 07:46:11   | 2:15             |
| T34     | CIRS_048TI_TEMPMAPI13_PRIME   | 07/17/07 | 198 | 07:40:00   | 3:00             |
| T34     | CIRS_048TI_MIDIRTMAP001_PRIME | 07/18/07 | 199 | 01:48:20   | 7:23             |
| T35     | CIRS_049TI_MIDIRTMAP002_PRIME | 08/31/07 | 243 | 21:32:34   | 6:00             |
| T36     | CIRS_050TI_MIDIRTMAP002_PRIME | 10/02/07 | 275 | 18:42:43   | 8:46             |
| T36     | CIRS_050TI_TEMPMAPI31_PRIME   | 10/03/07 | 276 | 17:30:00   | 6:22             |
| N/A     | CIRS_051TI_TEMPMAPI14_PRIME   | 10/21/07 | 294 | 20:53:00   | 6:10             |
| T37     | CIRS_052TI_TEMPMAPI16_PRIME   | 11/17/07 | 321 | 20:40:00   | 4:00             |
| T37     | CIRS_052TI_MIDIRTMAP002_PRIME | 11/19/07 | 323 | 14:47:25   | 7:00             |
| T38     | CIRS_053TI_MIDIRTMAP002_PRIME | 12/05/07 | 339 | 14:06:50   | 9:37             |
| T40     | CIRS_055TI_TEMPMAPI34_PRIME   | 01/04/08 | 004 | 16:48:00   | 6:23             |
| T40     | CIRS_055TI_MIDIRTMAP002_PRIME | 01/06/08 | 006 | 11:30:20   | 7:00             |
| T41     | CIRS_059TI_MIDIRTMAP002_PRIME | 02/23/08 | 054 | 12:32:07   | 2:53             |
| T41     | CIRS_059TI_TEMPMAPI37_PRIME   | 02/23/08 | 054 | 17:55:07   | 3:25             |
| T41     | CIRS_059TI_TEMPMAPI38_PRIME   | 02/23/08 | 054 | 23:35:07   | 1:52             |
| T43     | CIRS_067TI_MIDIRTMAP002_PRIME | 05/13/08 | 134 | 02:46:58   | 6:30             |
| T44     | CIRS_069TI_MIDIRTMAP001_PRIME | 05/27/08 | 148 | 10:24:32   | 6:00             |
| N/A     | CIRS_072TI_TEMPMAPI18_PRIME   | 06/13/08 | 165 | 05:40:00   | 4:00             |

**Table 9**  
(Continued)

| Flyby # | Observation Name              | Date     | DOY | Start Time | Duration (HR:MN)    |
|---------|-------------------------------|----------|-----|------------|---------------------|
| T45     | CIRS_078TI_MIDIRTMAP001_PRIME | 07/30/08 | 212 | 08:05:21   | 4:07                |
| T46     | CIRS_091TI_MIDIRTMAP001_PRIME | 11/02/08 | 307 | 20:17:34   | BIU anomaly omitted |
| T46     | CIRS_091TI_MIDIRTMAP002_PRIME | 11/04/08 | 309 | 07:35:24   |                     |
| T47     | CIRS_093TI_MIDIRTMAP002_PRIME | 11/20/08 | 325 | 05:56:28   | 2:00                |
| T48     | CIRS_096TI_MIDIRTMAP001_PRIME | 12/06/08 | 341 | 04:25:45   | 3:06                |
| T49     | CIRS_097TI_MIDIRTMAP001_PRIME | 12/20/08 | 355 | 17:24:32   | 6:35                |
| T49     | CIRS_098TI_MIDIRTMAP002_PRIME | 12/22/08 | 357 | 02:29:52   | 3:30                |
| T50     | CIRS_102TI_MIDIRTMAP002_PRIME | 02/07/09 | 038 | 18:50:51   | BIU anomaly         |
| T50     | CIRS_102TI_MIDIRTMAP003_PRIME | 02/07/09 | 038 | 22:20:51   |                     |
| T51     | CIRS_106TI_MIDIRTMAP001_PRIME | 03/26/09 | 085 | 11:00:31   | 3:43                |
| T51     | CIRS_107TI_MIDIRTMAP002_PRIME | 03/27/09 | 086 | 18:13:36   | 5:12                |
| T52     | CIRS_107TI_MIDIRTMAP001_PRIME | 04/03/09 | 093 | 10:29:34   | 1:48                |
| T52     | CIRS_108TI_MIDIRTMAP002_PRIME | 04/04/09 | 094 | 15:47:47   | 7:37                |
| T53     | CIRS_109TI_MIDIRTMAP002_PRIME | 04/20/09 | 110 | 14:20:45   | Downlink            |
| T54     | CIRS_110TI_MIDIRTMAP001_PRIME | 05/05/09 | 125 | 08:11:47   |                     |
| T55     | CIRS_111TI_MIDIRTMAP001_PRIME | 05/21/09 | 141 | 07:09:49   | 1:17                |
| T55     | CIRS_111TI_MIDIRTMAP002_PRIME | 05/22/09 | 142 | 11:26:41   | 8:00                |
| T57     | CIRS_113TI_MIDIRTMAP002_PRIME | 06/23/09 | 174 | 08:32:35   | 8:00                |
| T59     | CIRS_115TI_MIDIRTMAP001_PRIME | 07/23/09 | 204 | 23:34:04   | 3:00                |
| T62     | CIRS_119TI_MIDIRTMAP001_PRIME | 10/11/09 | 284 | 14:45:21   | 4:21                |
| T63     | CIRS_122TI_MIDIRTMAP002_PRIME | 12/12/09 | 346 | 15:03:14   | 5:00                |
| T64     | CIRS_123TI_MIDIRTMAP001_PRIME | 12/27/09 | 361 | 10:07:24   | 4:10                |
| T65     | CIRS_124TI_MIDIRTMAP002_PRIME | 01/13/10 | 013 | 13:10:37   | 5:21                |
| T68     | CIRS_131TI_MIDIRTMAP001_PRIME | 05/19/10 | 139 | 08:10:04   | 5:44                |
| T68     | CIRS_131TI_MIDIRTMAP002_PRIME | 05/20/10 | 140 | 16:24:20   | 4:40                |
| T73     | CIRS_140TI_MIDIRTMAP001_PRIME | 11/10/10 | 314 | 21:14:00   | Safing event        |
| T74     | CIRS_145TI_MIDIRTMAP001_PRIME | 02/17/11 | 048 | 21:26:11   |                     |
| T74     | CIRS_145TI_MIDIRTMAP002_PRIME | 02/19/11 | 050 | 04:04:11   | 6:31                |
| T76     | CIRS_148TI_MIDIRTMAP002_PRIME | 05/09/11 | 129 | 12:53:45   | 8:13                |
| T77     | CIRS_149TI_MIDIRTMAP002_PRIME | 06/21/11 | 172 | 08:32:01   | 9:45                |
| T78     | CIRS_153TI_MIDIRTMAP001_PRIME | 09/11/11 | 254 | 07:42:00   | 6:08                |
| T79     | CIRS_158TI_MIDIRTMAP002_PRIME | 12/14/11 | 348 | 10:11:24   | 2:29                |
| T82     | CIRS_161TI_MIDIRTMAP001_PRIME | 02/18/12 | 049 | 15:54:00   | 4:49                |
| T84     | CIRS_167TI_MIDIRTMAP001_PRIME | 06/06/12 | 158 | 08:24:00   | 2:43                |
| T84     | CIRS_167TI_MIDIRTMAP002_PRIME | 06/07/12 | 159 | 14:07:21   | 7:12                |
| T85     | CIRS_169TI_MIDIRTMAP001_PRIME | 07/23/12 | 205 | 21:32:59   | 9:30                |
| T86     | CIRS_172TI_MIDIRTMAP002_PRIME | 09/27/12 | 271 | 04:35:39   | 14:45               |
| T87     | CIRS_174TI_MIDIRTMAP001_PRIME | 11/12/12 | 317 | 14:55:59   | 6:26                |
| T87     | CIRS_174TI_MIDIRTMAP002_PRIME | 11/14/12 | 319 | 00:22:08   | 5:14                |
| T88     | CIRS_175TI_MIDIRTMAP002_PRIME | 11/29/12 | 334 | 22:56:59   | 11:43               |
| T89     | CIRS_181TI_MIDIRTMAP001_PRIME | 02/16/13 | 047 | 09:20:59   | 2:30                |
| T89     | CIRS_181TI_MIDIRTMAP002_PRIME | 02/17/13 | 048 | 13:56:36   | 8:19                |
| T90     | CIRS_185TI_MIDIRTMAP001_PRIME | 04/05/13 | 095 | 05:56:00   | 2:48                |
| T90     | CIRS_185TI_MIDIRTMAP002_PRIME | 04/06/13 | 096 | 11:43:31   | 5:52                |
| T91     | CIRS_190TI_MIDIRTMAP001_PRIME | 05/23/13 | 143 | 02:41:00   | 1:52                |
| T91     | CIRS_190TI_MIDIRTMAP002_PRIME | 05/24/13 | 144 | 07:32:55   | 8:03                |
| T93     | CIRS_195TI_MIDIRTMAP001_PRIME | 07/25/13 | 206 | 13:33:59   | 8:22                |
| T94     | CIRS_197TI_MIDIRTMAP001_PRIME | 09/11/13 | 254 | 08:57:59   | 8:46                |
| T95     | CIRS_198TI_MIDIRTMAP001_PRIME | 10/13/13 | 286 | 07:09:59   | 7:46                |
| T96     | CIRS_199TI_MIDIRTMAP001_PRIME | 11/30/13 | 334 | 04:40:00   | 6:01                |
| T97     | CIRS_200TI_MIDIRTMAP001_PRIME | 01/01/14 | 001 | 02:42:59   | 5:17                |
| T97     | CIRS_200TI_MIDIRTMAP002_PRIME | 01/02/14 | 002 | 10:59:41   | 3:23                |
| T98     | CIRS_201TI_MIDIRTMAP001_PRIME | 02/02/14 | 033 | 00:46:59   | 4:26                |
| T98     | CIRS_201TI_MIDIRTMAP002_PRIME | 02/03/14 | 034 | 08:12:39   | 5:59                |
| T99     | CIRS_202TI_MIDIRTMAP002_PRIME | 03/07/14 | 066 | 04:26:47   | 7:19                |
| T100    | CIRS_203TI_MIDIRTMAP001_PRIME | 04/06/14 | 096 | 20:39:59   | 3:01                |
| T100    | CIRS_203TI_MIDIRTMAP002_PRIME | 04/08/14 | 098 | 02:41:14   | 8:24                |
| T101    | CIRS_204TI_MIDIRTMAP001_PRIME | 05/16/14 | 136 | 17:55:59   | 3:46                |
| T101    | CIRS_204TI_MIDIRTMAP002_PRIME | 05/18/14 | 138 | 05:12:15   | 2:54                |
| T102    | CIRS_205TI_MIDIRTMAP001_PRIME | 06/17/14 | 168 | 15:39:00   | 7:49                |

**Table 9**  
(Continued)

| Flyby # | Observation Name              | Date     | DOY | Start Time | Duration (HR:MN) |
|---------|-------------------------------|----------|-----|------------|------------------|
| T102    | CIRS_205TI_MIDIRTMAP002_PRIME | 06/19/14 | 170 | 01:28:25   | 3:06             |
| T103    | CIRS_206TI_MIDIRTMAP001_PRIME | 07/19/14 | 200 | 13:20:59   | 7:20             |
| T104    | CIRS_207TI_MIDIRTMAP001_PRIME | 08/20/14 | 232 | 11:15:59   | 6:53             |
| T104    | CIRS_207TI_MIDIRTMAP002_PRIME | 08/21/14 | 233 | 22:09:09   | 2:17             |
| T105    | CIRS_208TI_MIDIRTMAP001_PRIME | 09/21/14 | 264 | 09:11:59   | 6:11             |
| T105    | CIRS_208TI_MIDIRTMAP002_PRIME | 09/22/14 | 265 | 17:23:19   | 2:44             |
| T106    | CIRS_209TI_MIDIRTMAP001_PRIME | 10/23/14 | 296 | 07:10:00   | 5:31             |
| T106    | CIRS_209TI_MIDIRTMAP002_PRIME | 10/24/14 | 297 | 15:40:30   | 3:10             |
| T107    | CIRS_210TI_MIDIRTMAP001_PRIME | 12/10/14 | 344 | 04:25:00   | 4:02             |
| T107    | CIRS_210TI_MIDIRTMAP002_PRIME | 12/11/14 | 345 | 11:26:35   | 4:38             |
| T108    | CIRS_211TI_MIDIRTMAP001_PRIME | 01/12/15 | 012 | 08:48:35   | 6:03             |
| T109    | CIRS_212TI_MIDIRTMAP002_PRIME | 02/13/15 | 044 | 06:08:04   | 8:17             |
| T110    | CIRS_213TI_MIDIRTMAP001_PRIME | 03/15/15 | 074 | 22:50:00   | 3:39             |
| T110    | CIRS_213TI_MIDIRTMAP002_PRIME | 03/17/15 | 076 | 03:29:49   | 8:31             |
| T111    | CIRS_215TI_MIDIRTMAP001_PRIME | 05/07/15 | 127 | 05:09:59   | 4:41             |
| T111    | CIRS_215TI_MIDIRTMAP002_PRIME | 05/08/15 | 128 | 11:50:24   | 5:29             |
| T112    | CIRS_218TI_MIDIRTMAP001_PRIME | 07/06/15 | 187 | 12:27:00   | 6:42             |
| T112    | CIRS_218TI_MIDIRTMAP002_PRIME | 07/07/15 | 188 | 21:09:51   | 3:54             |
| T113    | CIRS_222TI_MIDIRTMAP002_PRIME | 09/29/15 | 272 | 10:37:12   | 5:45             |
| T114    | CIRS_225TI_MIDIRTMAP001_PRIME | 11/12/15 | 316 | 06:53:59   | 8:53             |
| T117    | CIRS_232TI_MIDIRTMAP002_PRIME | 02/17/16 | 048 | 10:49:41   | 4:00             |
| T118    | CIRS_234TI_MIDIRTMAP001_PRIME | 04/03/16 | 094 | 19:59:00   | 9:44             |
| T119    | CIRS_235TI_MIDIRTMAP001_PRIME | 05/05/16 | 126 | 20:09:00   | 6:46             |
| T119    | CIRS_235TI_MIDIRTMAP002_PRIME | 05/07/16 | 128 | 05:54:37   | 3:24             |
| T120    | CIRS_236TI_MIDIRTMAP002_PRIME | 06/08/16 | 160 | 03:06:17   | 3:52             |
| T121    | CIRS_238TI_MIDIRTMAP002_PRIME | 07/25/16 | 207 | 22:28:23   | 5:04             |
| T123    | CIRS_243TI_MIDIRTMAP001_PRIME | 09/26/16 | 270 | 10:07:58   | 4:09             |
| T124    | CIRS_248TI_MIDIRTMAP001_PRIME | 11/13/16 | 318 | 07:24:00   | 2:32             |
| T124    | CIRS_248TI_MIDIRTMAP002_PRIME | 11/14/16 | 319 | 13:55:56   | 4:53             |
| T125    | CIRS_250TI_MIDIRTMAP002_PRIME | 11/30/16 | 335 | 11:14:32   | 6:33             |
| N/A     | CIRS_253TI_MIDIRTMAP001_PRIME | 12/15/16 | 350 | 10:16:00   | 6:05             |
| N/A     | CIRS_253TI_MIDIRTMAP002_PRIME | 12/15/16 | 350 | 22:21:00   | 4:00             |
| N/A     | CIRS_253TI_MIDIRTMAP003_PRIME | 12/16/16 | 351 | 05:51:00   | 1:30             |
| N/A     | CIRS_253TI_MIDIRTMAP004_PRIME | 12/16/16 | 351 | 08:21:00   | 2:12             |
| N/A     | CIRS_259TI_MIDIRTMAP001_PRIME | 02/01/17 | 032 | 09:19:00   | 3:47             |
| N/A     | CIRS_259TI_MIDIRTMAP002_PRIME | 02/02/17 | 033 | 02:36:00   | 7:00             |
| N/A     | CIRS_261TI_MIDIRTMAP001_PRIME | 02/17/17 | 048 | 02:31:00   | 5:10             |
| N/A     | CIRS_270TI_MIDIRTMAP001_PRIME | 04/21/17 | 111 | 13:24:58   | 2:43             |
| N/A     | CIRS_270TI_MIDIRTMAP002_PRIME | 04/22/17 | 112 | 19:08:07   | 9:53             |
| N/A     | CIRS_273TI_MIDIRTMAP001_PRIME | 05/07/17 | 127 | 19:02:00   | 3:00             |
| N/A     | CIRS_275TI_MIDIRTMAP002_PRIME | 05/24/17 | 144 | 11:33:00   | 4:00             |
| N/A     | CIRS_278TI_MIDIRTMAP001_PRIME | 06/08/17 | 159 | 12:26:00   | 3:00             |
| N/A     | CIRS_278TI_MIDIRTMAP002_PRIME | 06/08/17 | 159 | 16:26:00   | 3:00             |
| N/A     | CIRS_278TI_MIDIRTMAP003_PRIME | 06/08/17 | 159 | 20:26:00   | 2:00             |
| N/A     | CIRS_278TI_MIDIRTMAP004_PRIME | 06/08/17 | 159 | 23:26:00   | 3:00             |
| N/A     | CIRS_278TI_MIDIRTMAP005_PRIME | 06/09/17 | 160 | 03:26:00   | 3:00             |
| N/A     | CIRS_278TI_MIDIRTMAP006_PRIME | 06/09/17 | 160 | 07:26:00   | 2:54             |
| N/A     | CIRS_283TI_MIDIRTMAP001_PRIME | 07/10/17 | 191 | 09:06:00   | 4:15             |
| N/A     | CIRS_283TI_MIDIRTMAP002_PRIME | 07/10/17 | 191 | 14:21:00   | 4:45             |
| N/A     | CIRS_283TI_MIDIRTMAP003_PRIME | 07/10/17 | 191 | 20:36:00   | 3:00             |
| N/A     | CIRS_287TI_MIDIRTMAP001_PRIME | 08/10/17 | 222 | 16:51:00   | 6:40             |
| N/A     | CIRS_292TI_MIDIRTMAP001_PRIME | 09/11/17 | 254 | 06:22:00   | 2:54             |
| N/A     | CIRS_292TI_MIDIRTMAP002_PRIME | 09/12/17 | 255 | 07:46:00   | 5:00             |
| N/A     | CIRS_293TI_MIDIRTMAP003_PRIME | 09/12/17 | 255 | 13:46:00   | 4:30             |

**Table 10**  
CIRS Distant Titan Observations (Corrected)

| Observation Name            | Date     | DOY | Time     | Duration (HR:MN) |
|-----------------------------|----------|-----|----------|------------------|
| CIRS_009TI_COMPMAP002_PRIME | 06/06/05 | 157 | 09:30:00 | 06:30:00         |
| CIRS_010TI_COMPMAP003_PRIME | 06/22/05 | 173 | 03:00:00 | 11:00:00         |
| CIRS_015TI_COMPMAP005_PRIME | 09/24/05 | 267 | 19:50:00 | 08:15:00         |
| CIRS_016TI_COMPMAP006_PRIME | 10/09/05 | 282 | 20:27:00 | 11:00:00         |
| CIRS_022TI_COMPMAP002_PRIME | 03/17/06 | 076 | 08:20:00 | 13:59:00         |
| CIRS_030TI_COMPMAP007_PRIME | 10/10/06 | 283 | 19:30:00 | 03:50:00         |
| CIRS_031TI_COMPMAP008_PRIME | 10/23/06 | 296 | 11:26:00 | 14:00:00         |
| CIRS_033TI_COMPMAP009_PRIME | 11/24/06 | 328 | 18:15:00 | 10:45:00         |
| CIRS_035TI_COMPMAP010_PRIME | 12/10/06 | 344 | 19:17:00 | 10:30:00         |
| CIRS_036TI_COMPMAP024_PRIME | 12/26/06 | 360 | 19:49:00 | 09:00:00         |
| CIRS_037TI_COMPMAP026_PRIME | 01/11/07 | 011 | 16:13:00 | 09:51:00         |
| CIRS_037TI_COMPMAP012_PRIME | 01/14/07 | 014 | 14:04:00 | 02:00:00         |
| CIRS_038TI_COMPMAP013_PRIME | 01/26/07 | 026 | 17:51:00 | 09:00:00         |
| CIRS_040TI_COMPMAP026_PRIME | 03/08/07 | 067 | 19:51:00 | 04:00:00         |
| CIRS_041TI_COMPMAP028_PRIME | 03/24/07 | 083 | 16:50:00 | 04:00:00         |
| CIRS_041TI_COMPMAP029_PRIME | 03/27/07 | 086 | 07:42:00 | 15:22:00         |
| CIRS_041TI_COMPMAP030_PRIME | 03/28/07 | 087 | 08:45:00 | 05:30:00         |
| CIRS_043TI_COMPMAP002_PRIME | 04/27/07 | 117 | 11:32:58 | 00:42:00         |
| CIRS_044TI_COMPMAP015_PRIME | 05/14/07 | 134 | 02:43:00 | 08:00:00         |
| CIRS_048TI_COMPMAP013_PRIME | 07/17/07 | 198 | 10:40:00 | 04:00:00         |
| CIRS_051TI_COMPMAP016_PRIME | 10/19/07 | 292 | 20:53:00 | 11:00:00         |
| CIRS_051TI_COMPMAP017_PRIME | 10/20/07 | 293 | 20:23:00 | 03:07:00         |
| CIRS_051TI_COMPMAP018_PRIME | 10/21/07 | 294 | 02:00:00 | 06:23:00         |
| CIRS_052TI_COMPMAP016_PRIME | 11/19/07 | 323 | 21:47:25 | 02:19:09         |
| CIRS_052TI_COMPMAP015_PRIME | 11/20/07 | 324 | 10:27:00 | 07:00:00         |
| CIRS_055TI_COMPMAP001_PRIME | 01/06/08 | 006 | 18:30:20 | 03:14:00         |
| CIRS_057TI_COMPMAP018_PRIME | 01/22/08 | 022 | 14:11:00 | 07:54:00         |
| CIRS_059TI_COMPMAP001_PRIME | 02/21/08 | 052 | 12:06:00 | 06:15:00         |
| CIRS_062TI_COMPMAP019_PRIME | 03/27/08 | 087 | 01:50:00 | 21:30:00         |
| CIRS_066TI_COMPMAP021_PRIME | 04/27/08 | 118 | 07:17:00 | 07:00:00         |
| CIRS_067TI_COMPMAP001_PRIME | 05/13/08 | 134 | 09:16:58 | 03:04:00         |
| CIRS_069TI_COMPMAP001_PRIME | 05/27/08 | 148 | 08:19:32 | 02:05:00         |
| CIRS_072TI_COMPMAP021_PRIME | 06/13/08 | 165 | 09:40:00 | 08:00:00         |
| CIRS_083TI_COMPMAP001_PRIME | 08/31/08 | 244 | 17:04:00 | 07:46:00         |
| CIRS_103TI_COMPMAP001_PRIME | 02/13/09 | 044 | 13:13:00 | 08:17:00         |
| CIRS_122TI_COMPMAP002_PRIME | 12/12/09 | 346 | 20:03:14 | 04:00:00         |
| CIRS_123TI_COMPMAP001_PRIME | 12/29/09 | 363 | 15:32:00 | 08:00:00         |
| CIRS_124TI_COMPMAP002_PRIME | 01/13/10 | 013 | 18:31:36 | 03:39:00         |
| CIRS_128TI_COMPMAP001_PRIME | 03/19/10 | 078 | 03:49:00 | 07:15:00         |
| CIRS_131TI_COMPMAP001_PRIME | 05/21/10 | 141 | 09:40:00 | 08:00:00         |
| CIRS_134TI_COMPMAP001_PRIME | 07/08/10 | 189 | 12:49:00 | 10:10:00         |
| CIRS_139TI_COMPMAP001_PRIME | 10/14/10 | 287 | 04:52:00 | 13:30:00         |
| CIRS_140TI_COMPMAP001_PRIME | 11/12/10 | 316 | 22:00:00 | 08:00:00         |
| CIRS_140TI_COMPMAP002_PRIME | 11/15/10 | 319 | 09:19:00 | 08:00:00         |
| CIRS_143TI_COMPMAP001_PRIME | 01/14/11 | 014 | 17:05:00 | 10:10:00         |
| CIRS_149TI_TEA001_PRIME     | 06/22/11 | 173 | 09:00:00 | 07:30:00         |
| CIRS_149TI_TEA002_PRIME     | 06/23/11 | 174 | 05:42:00 | 21:00:00         |
| CIRS_149TI_TEA003_PRIME     | 06/24/11 | 175 | 11:42:00 | 15:00:00         |
| CIRS_149TI_TEA004_PRIME     | 06/25/11 | 176 | 11:42:00 | 37:29:00         |
| CIRS_154TI_COMPMAP001_PRIME | 09/26/11 | 269 | 22:50:00 | 06:00:00         |
| CIRS_155TI_TEA003_PRIME     | 10/24/11 | 297 | 05:00:00 | 19:00:00         |
| CIRS_155TI_TEA004_PRIME     | 10/25/11 | 298 | 14:32:00 | 13:15:00         |
| CIRS_155TI_TEA005_PRIME     | 10/26/11 | 299 | 14:17:00 | 13:30:00         |
| CIRS_156TI_TEA003_PRIME     | 10/30/11 | 303 | 14:02:00 | 13:30:00         |
| CIRS_156TI_TEA004_PRIME     | 10/31/11 | 304 | 14:02:00 | 13:30:00         |
| CIRS_156TI_TEA005_PRIME     | 11/01/11 | 305 | 14:02:00 | 28:45:00         |
| CIRS_156TI_TEA006_PRIME     | 11/03/11 | 307 | 03:47:00 | 15:00:00         |
| CIRS_157TI_COMPMAP001_PRIME | 11/27/11 | 331 | 18:00:00 | 15:34:00         |
| CIRS_158TI_TEA001_PRIME     | 12/16/11 | 350 | 11:20:00 | 15:00:00         |
| CIRS_160TI_TEA002_PRIME     | 02/01/12 | 032 | 15:57:00 | 31:30:00         |
| CIRS_160TI_TEA003_PRIME     | 02/03/12 | 034 | 08:27:00 | 15:00:00         |

**Table 10**  
(Continued)

| Observation Name         | Date     | DOY | Time     | Duration (HR:MN) |
|--------------------------|----------|-----|----------|------------------|
| CIRS_160TI_TEA004_PRIME  | 02/04/12 | 035 | 08:27:00 | 20:45:00         |
| CIRS_160TI_TEA005_PRIME  | 02/07/12 | 038 | 17:22:00 | 11:10:00         |
| CIRS_161TI_TEA001_PRIME  | 02/11/12 | 042 | 17:08:00 | 11:10:00         |
| CIRS_181TI_TEA001_PRIME  | 02/18/13 | 049 | 09:46:00 | 25:41:00         |
| CIRS_181TI_TEA002_PRIME  | 02/19/13 | 050 | 21:57:00 | 23:30:00         |
| CIRS_182TI_TEA001_PRIME  | 02/21/13 | 052 | 07:57:00 | 21:00:00         |
| CIRS_182TI_TEA002_PRIME  | 02/22/13 | 053 | 15:52:00 | 11:10:00         |
| CIRS_185TI_TEA001_PRIME  | 04/07/13 | 097 | 07:36:00 | 10:55:00         |
| CIRS_186TI_TEA001_PRIME  | 04/08/13 | 098 | 05:01:00 | 14:45:00         |
| CIRS_186TI_TEA002_PRIME  | 04/09/13 | 099 | 04:46:00 | 15:00:00         |
| CIRS_202TI_TEA001_PRIME  | 03/02/14 | 061 | 21:56:00 | 15:00:00         |
| CIRS_202TI_TEA002_PRIME  | 03/03/14 | 062 | 21:56:00 | 15:00:00         |
| CIRS_202TI_TEA003_PRIME  | 03/04/14 | 063 | 21:56:00 | 13:30:00         |
| CIRS_206TI_TEA001_PRIME  | 07/10/14 | 191 | 00:00:00 | 13:00:00         |
| CIRS_206TI_TEA002_PRIME  | 07/10/14 | 191 | 13:00:00 | 13:27:00         |
| CIRS_206TI_TEA003_PRIME  | 07/11/14 | 192 | 12:57:00 | 37:15:00         |
| CIRS_219TI_TEA001_PRIME  | 07/23/15 | 204 | 13:06:00 | 13:20:00         |
| CIRS_219TI_TEA002_PRIME  | 07/24/15 | 205 | 12:56:00 | 13:30:00         |
| CIRS_233TI_TEA001_PRIME  | 03/06/16 | 066 | 16:00:00 | 08:00:00         |
| CIRS_241TI_TEA002_PRIME  | 08/27/16 | 240 | 11:23:00 | 35:20:00         |
| CIRS_252TI_COMP001_PRIME | 12/15/16 | 350 | 06:16:00 | 04:00:00         |
| CIRS_253TI_COMP001_PRIME | 12/15/16 | 350 | 17:21:00 | 04:00:00         |
| CIRS_253TI_COMP002_PRIME | 12/16/16 | 351 | 03:21:00 | 01:30:00         |
| CIRS_259TI_COMP001_PIE   | 02/01/17 | 032 | 14:06:00 | 05:15:00         |
| CIRS_259TI_COMP002_PRIME | 02/02/17 | 033 | 09:36:00 | 05:45:00         |
| CIRS_268TI_COMP001_PIE   | 04/07/17 | 097 | 02:36:00 | 05:47:00         |
| CIRS_268TI_COMP002_PIE   | 04/07/17 | 097 | 09:23:00 | 05:16:00         |
| CIRS_271TI_COMP001_PRIME | 04/23/17 | 113 | 23:36:00 | 11:36:00         |
| CIRS_278TI_COMP001_PRIME | 06/08/17 | 159 | 08:26:00 | 03:00:00         |
| CIRS_280TI_COMP001_PIE   | 06/25/17 | 176 | 00:28:00 | 04:24:00         |
| CIRS_283TI_COMP001_PRIME | 07/10/17 | 191 | 04:20:00 | 03:46:00         |
| CIRS_283TI_COMP002_PRIME | 07/11/17 | 192 | 00:36:00 | 03:42:00         |
| CIRS_283TI_COMP003_PRIME | 07/11/17 | 192 | 08:04:00 | 01:51:00         |
| CIRS_285TI_COMP001_PRIME | 07/26/17 | 207 | 21:51:00 | 01:30:00         |
| CIRS_287TI_COMP001_PIE   | 08/11/17 | 223 | 00:31:00 | 05:00:00         |
| CIRS_288TI_COMP001_PIE   | 08/11/17 | 223 | 06:31:00 | 05:00:00         |
| CIRS_288TI_COMP002_PIE   | 08/11/17 | 223 | 12:31:00 | 04:30:00         |
| CIRS_288TI_COMP003_PIE   | 08/11/17 | 223 | 18:01:00 | 06:15:00         |
| CIRS_290TI_COMP001_PIE   | 08/28/17 | 240 | 00:19:00 | 04:16:00         |
| CIRS_292TI_COMP001_PRIME | 09/12/17 | 255 | 03:46:00 | 03:00:00         |
| CIRS_293TI_COMP002_PRIME | 09/12/17 | 255 | 18:46:00 | 02:20:00         |

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