Effects of permafrost degradation on alpine grassland in a semi-arid basin on the Qinghai–Tibetan Plateau

To cite this article: Shuhua Yi et al 2011 Environ. Res. Lett. 6 045403

View the article online for updates and enhancements.

Related content
- Response characteristics of vegetation and soil environment to permafrost degradation in the upstream regions of the Shule River Basin
  Shengyun Chen, Wenjie Liu, Xiang Qin et al.
- Responses of alpine grassland on Qinghai–Tibetan plateau to climate warming and permafrost degradation: a modeling perspective
  Shuhua Yi, Xiaoyun Wang, Yu Qin et al.
- Storage, patterns, and control of soil organic carbon and nitrogen in the northeastern margin of the Qinghai–Tibetan Plateau
  Wenjie Liu, Shengyun Chen, Xiang Qin et al.

Recent citations
- The Review of Current Distribution of Vegetation Resources in Yunnan-Guizhou Plateau and the Mechanism Research of Its Effects on Rocky Desertification Process
  \#30591 and
- Variations in Growing-Season NDVI and Its Response to Permafrost Degradation in Northeast China
  Jinting Guo et al
  Yousheng Wang et al
Effects of permafrost degradation on alpine grassland in a semi-arid basin on the Qinghai–Tibetan Plateau

Shuhua Yi, Zhaoye Zhou, Shilong Ren, Ming Xu, Yu Qin, Shengyun Chen and Baisheng Ye

State Key Laboratory of Cryosphere Sciences, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, 320 Donggang West Road, Lanzhou 730000, People’s Republic of China

E-mail: yis@lzb.ac.cn

Received 29 March 2011
Accepted for publication 2 September 2011
Published 25 October 2011
Online at stacks.iop.org/ERL/6/045403

Abstract
Permafrost on the Qinghai–Tibetan Plateau (QTP) has degraded over the last few decades. Its ecological effects have attracted great concern. Previous studies focused mostly at plot scale, and hypothesized that degradation of permafrost would cause lowering of the water table and drying of shallow soil and then degradation of alpine grassland. However, none has been done to test the hypothesis at basin scale. In this study, for the first time, we investigated the relationships between land surface temperature (LST) and fractional vegetation cover (FVC) in different types of permafrost zone to infer the limiting condition (water or energy) of grassland growth on the source region of Shule River Basin, which is located in the north-eastern edge of the QTP. LST was obtained from MODIS Aqua products at 1 km resolution, while FVC was upscaled from quadrat (50 cm) to the same resolution as LST, using 30 m resolution NDVI data of the Chinese HJ satellite. FVC at quadrat scale was estimated by analyzing pictures taken with a multi-spectral camera. Results showed that (1) retrieval of FVC at quadrat scale using a multi-spectral camera was both more accurate and more efficient than conventional methods and (2) the limiting factor of vegetation growth transitioned from energy in the extreme stable permafrost zone to water in the seasonal frost zone. Our study suggested that alpine grassland would respond differently to permafrost degradation in different types of permafrost zone. Future studies should consider overall effects of permafrost degradation, and avoid the shortcomings of existing studies, which focus too much on the adverse effects.

Keywords: fractional vegetation cover, land surface temperature, permafrost degradation, alpine grassland, Qinghai–Tibetan Plateau

1. Introduction
Permafrost has degraded over the last few decades on the Qinghai–Tibetan Plateau (QTP) (Cheng and Wu 2007, Wu and Zhang 2010); its ecological impacts have received great concerns (Yang et al 2010). It was hypothesized that degradation of permafrost will cause lowering of the ground water table and drying of surface soil, and then degradation of alpine grassland (Jin et al 2009). To test this hypothesis, long-term studies should be performed to monitor the changes of soil environments and vegetation characteristics during the process of permafrost degradation. However, few such monitoring sites exist. An alternative way is to select plots in different areas, which represent different stages of permafrost degradation, and compare the soil environments and vegetation characteristics among them. Results from studies of this type on the QTP supported the above hypothesis (e.g. Wang et al 2008). However, due to difficulties of road accessibility and
Figure 1. Source region of Shule River Basin with different types of permafrost. 1–8 denotes different landscapes where two or three remote sensing plots (30 m × 30 m) were set; each plot has nine quadrats (50 cm × 50 cm) evenly distributed.

logistics, the number of plots studied was very limited, and results were usually affected by local factors, e.g. topography and disturbances.

Remote sensing is an important tool to cover a large study area, and is a good complement to traditional field work. Microwave remote sensing is usually used for retrieving surface soil water content. However, its spatial resolution is too low to study the effects of permafrost degradation on surface soil moisture (e.g. resolutions of SMMR and AMSR are 140 and 50 km at 6.6 and 10.7 GHz, respectively). The relationship between land surface temperature (LST) and normalized difference of vegetation index (NDVI)/fractional vegetation cover (FVC) has been used in surface soil moisture studies using AVHRR datasets (8 km) (Carlson 2007). Therefore, this relationship is potentially useful in studies of the effects of permafrost degradation on surface soil moisture.

FVC is one of the most important and intuitive vegetation characteristics of alpine grassland ecosystems, and is studied extensively at different scales. For relatively low spatial resolution remote sensing applications (e.g. 1 and 8 km in MODIS and AVHRR datasets, respectively), FVC was calculated using the NDVI of a specific pixel, NDVI of pure vegetation and soil pixels, and was seldom validated (Li et al 2003). For relatively high spatial resolution remote sensing applications (e.g. 30 m in Landsat TM/ETM + datasets), the relationship between FVC and vegetation indices (usually NDVI) at quadrat scale on the ground was first established, then applied to other pixels (Zha et al 2003, Liu et al 2004). Measurements of vegetation indices in situ might happen at different times, and at much smaller spatial scale than that of remote sensing; direct application of the established relationship to remote sensing pixel might be unreasonable. The means of estimating FVC on ground is also problematic. It is usually estimated visually in situ or from pictures taken in situ (Meusburger et al 2010); or using software to classify vegetation from soil, based on RGB (red, green and blue) or IHS (intensity, hue and saturation) characteristics in pictures (Li et al 2005). However, these methods are arbitrary and/or time consuming.

In this study, we aimed to (1) develop an accurate and time-saving method to estimate FVC at quadrat scale, (2) upscale FVC from quadrat scale to 1 km scale, using a 30 m scale satellite remote sensing dataset, and (3) study the characteristics of FVC and LST, and the relationship between FVC and LST on different types of permafrost over a basin on the QTP.

2. Methodology

2.1. Study area and field work

Shule River Basin is located in the western part of Qilian Mountain, which is in the northeast edge of the QTP, China (figure 1). It is mainly controlled by westerly winds, and seldom affected by the Asian monsoon. Mean annual air temperature ranged from −4.0 to −19.4 °C, and mean annual precipitation ranged from 200 to 400 mm over the period of 1960–2010. The study area is in the source regions of Shule River Basin, where alpine meadow and alpine steppe are the dominant vegetation types. The classification of different permafrost types by Cheng and Wang (1982) was used for this study: extreme stable permafrost (mean annual ground temperature (MAGT, at depth of about 15 m) < −5 °C), stable permafrost (−5 °C < MAGT < −3 °C), substable permafrost (−3 °C < MAGT < −1.5 °C), transition permafrost (−1.5 °C < MAGT < −0.5 °C), unstable permafrost (−0.5 °C < MAGT < 0.5 °C), and seasonal frost (MAGT > 0.5 °C). The area fractions are 16%, 18%, 21%, 23%, 17%, and 5% for the six frost types, respectively. The field work was carried out during the period 25 July–3 August.
used is an Agricultural Digital Camera (ADC, Tetracam Inc., (TM). Iron frames (50 cm
third, and second bands of the Landsat Thematic Mapper
red, and green, which are approximately equal to the fourth,
1536 pixels. The ADC records three bands, i.e. near infrared,
2010. We set up two or three plots (30 m × 30 m) in seven
landscapes (table 1; none of these selected landscapes was
located in the extreme stable or stable permafrost zones due
to problems of road accessibility). There were no grazing
activities on those landscapes. Slopes of all plots are gentle
(less than 4°). In each plot, we set up nine quadrats (50 cm ×
50 cm) evenly (figure 1), and took pictures with a conventional
camera and a multi-spectral camera vertically at a height
of ∼1.4 m over each quadrat. The multi-spectral camera used
is an Agricultural Digital Camera (ADC, Tetracam Inc.,
Chatsworth, CA, USA), with resolution of 2048 pixels ×
1536 pixels. The ADC records three bands, i.e. near infrared,
red, and green, which are approximately equal to the fourth,
third, and second bands of the Landsat Thematic Mapper
(TM). Iron frames (50 cm × 50 cm) were used to confine
quadrats. Only the part inside the iron frame was used for FVC
estimation.

To calibrate and validate the reflectance of the red
and near infrared bands of ADC, we set up extra quadrats
in landscape 1 (permafrost zone with alpine meadow), 7
(permafrost zone with alpine steppe) and 8 (seasonal frost zone
with alpine steppe) to take pictures, and to measure spectral
reflectance using a spectroradiometer (ASD, FieldSpec HH
(300–1000 nm), ASD inc., Boulder, CO, USA).

2.2. Estimations of FVC at quadrat scale

2.2.1. Estimations based on conventional pictures. We
randomly selected 50 quadrats, and had six persons to estimate
FVCs from conventional pictures individually. We also had
four different persons to derive FVCs based on the
classification of the same 50 pictures with WinCAM software
(Regent Instruments Inc. Quebec, Canada). We performed
one-way ANOVA tests for six visual estimations to evaluate
whether there are significant differences among them. Since
we did not know the exact value of FVC for a quadrat, we
assumed that the average of six visual estimations and four
estimations based on WinCAM classification was the ‘true’
FVC of a quadrat. We compared each individual visual
estimation and the averages of combinations of any two, three,
four and five visual estimations with the ‘true’ FVC. The
same tests were done for estimations based on WinCAM
classifications. These tests were performed in R.

2.2.2. Calculations based on multi-spectral pictures. We
sent five multi-spectral pictures to the ADC company with
ASD measured reflectance values of green (G), red (R) and
near infrared (NIR). The ADC company then provided an
updated calibration file. The other multi-spectral pictures
were then processed using this new calibration file in
PixelWrench2 software, which came with the camera, to get
TIFF format pictures. NDVI = (NIR − R)/(NIR + R) were
further derived. To check the validity of NDVI calculated
from multi-spectral pictures, we compared them with the
Corresponding NDVI derived from measurements with ASD.

We used the threshold method to calculate the FVC of a
quadrat based on a multi-spectral picture. For example, if the
NDVI of a pixel is greater than a threshold, then this pixel is
considered as a vegetation pixel; the ratio between the number
of vegetation pixels and number of total pixels is the FVC of
a quadrat. To determine the threshold value, we randomly
selected 10 of the above-mentioned 50 quadrats. We used
‘true’ FVC as the target value, and calculated the threshold
value of NDVI for each multi-spectral picture in the following way:
(1) providing the initial, maximal and minimal value of a
threshold; (2) looping through each pixel in the picture; if the
NDVI of a pixel is greater than the specified threshold, then
this pixel is considered as a vegetation pixel, otherwise a soil
pixel; (3) calculating the overall vegetation pixel fraction; if it
is greater than a target value, then we set the minimal threshold
to be the current threshold, and use the average of the maximal
value and the current threshold value as the new threshold;
vice versa; (4) iterating through (2) to (3), until the difference
between calculated FVC and target FVC is less than a specified
value (0.1% in this study). We used the average of threshold
values from 10 multi-spectral pictures as the threshold. Then
we applied it on the multi-spectral pictures of the other 40
quadrats, and compared the calculated FVCs with the ‘true’
FVCs.

2.3. LSTs and FVCs at 1 km scale

We used eight day composite 1 km MYD11A2 LST products
of MODIS Aqua from 20 July to 27 July directly. We did
not calculate FVCs at 1 km scale based on NDVIs of each
pixel, of bare soil and of fully vegetated pixels. We up-scaled
FVCs using HJ-1 A/B (HJ, 30 m resolution) data. HJ is a new
generation of small Chinese civilian earth-observing optical

Table 1. Overviews of the landscapes in the study area.

<table>
<thead>
<tr>
<th>Landscape</th>
<th>Location (longitude, latitude, altitude)</th>
<th>Vegetation type</th>
<th>Dominant species</th>
<th>Soil frost type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(98°18′28.6″, 38°25′13.0″, 3891)</td>
<td>Alpine meadow</td>
<td>Kobresia capillifolia, Carex moorcroftii</td>
<td>Transition permafrost</td>
</tr>
<tr>
<td>2</td>
<td>(98°16′14.7″, 38°21′16.4″, 4007)</td>
<td>Alpine meadow</td>
<td>Kobresia pygmaea, Kobresia humilis</td>
<td>Sub-stable permafrost</td>
</tr>
<tr>
<td>3</td>
<td>(98°19′26.0″, 38°28′37.7″, 3890)</td>
<td>Alpine meadow</td>
<td>Carex moorcroftii, Stipa purpurea</td>
<td>Unstable permafrost</td>
</tr>
<tr>
<td>4</td>
<td>(98°14′49.0″, 38°32′30.0″, 3943)</td>
<td>Alpine meadow</td>
<td>Stipa purpurea, Artemisia nanschanica</td>
<td>Unstable permafrost</td>
</tr>
<tr>
<td>5</td>
<td>(98°12′20.3″, 38°33′2.4″, 3837)</td>
<td>Alpine steppe</td>
<td>Stipa purpurea, Artemisia minor</td>
<td>Unstable permafrost</td>
</tr>
<tr>
<td>6</td>
<td>(98°06′13.8″, 38°37′54.8″, 3742)</td>
<td>Alpine steppe</td>
<td>Poa pratensis, Stipa basiplumosa</td>
<td>Unstable permafrost</td>
</tr>
<tr>
<td>7</td>
<td>(97°57′30.4″, 38°46′33.8″, 3640)</td>
<td>Alpine steppe</td>
<td>Stipa basiplumosa, Limonium aureum var. dielsianum</td>
<td>Seasonal frost</td>
</tr>
<tr>
<td>8</td>
<td>(97°57′30.4″, 38°46′33.8″, 3640)</td>
<td>Alpine steppe</td>
<td>Stipa basiplumosa, Limonium aureum var. dielsianum</td>
<td>Seasonal frost</td>
</tr>
</tbody>
</table>

Due to road accessibility, we did not set up plots in landscape 3.
satellite, and has the same bands as the first four bands of TM; the overpass date was 25 July 2010.

(1) Based on multi-spectral pictures, we calculated the FVCs of all other quadrats. For each plot, we got mean value of FVC from 9 quadrats.

(2) We assumed that the variability of FVCs was small during our field period. We partitioned plots into two categories, one for establishing the relationship between FVCs on the ground and NDVIs of the corresponding pixels on the HJ remote sensing dataset, and the other for validating the relationship (one plot in each landscape).

(3) The plot scale relationship was then applied on the other pixels to retrieve FVCs of the whole study area.

(4) Finally, the 30 m scale FVCs were aggregated to the 1 km scale of MODIS.

Based on the 1 km scale FVCs and LSTs, we compared the FVCs and LSTs among six different permafrost types described earlier using one-way ANOVA in R, and the relationships between FVCs and LSTs.

3. Results

3.1. Estimations based on conventional pictures

A one-way ANOVA (analysis of variance) test for six visual estimations showed that the FVC estimations were significantly different ($p < 0.01$). The maximum and mean of standard deviations of FVC visual estimations of all quadrats among six visual estimations were 33% and 14%, respectively (figure 2(a)). A one-way ANOVA test for four estimations with WinCAM classification showed that the FVC estimations were significantly different ($p < 0.05$). The maximum and mean of standard deviations of FVC visual estimations of all quadrats among four estimations were 25% and 10%, respectively (figure 2(b)). The averages of FVCs from six visual estimations were not significantly different from the averages of FVCs from four estimations from WinCAM classification ($p > 0.05$). Table 2 shows the comparisons of the averages of combinations of estimations based on visual/WinCAM classification and ‘true’ FVCs. For visual estimations, four out of six individual visual estimations, five out of 15 two-person averages, and three out of 20 three-person averages were significantly different from the ‘true’ FVCs ($p < 0.05$). For estimations of FVCs based on WinCAM classification, only one out of four was significantly different from the ‘true’ FVC ($p < 0.02$).

3.2. Estimations based on multi-spectral pictures

The comparisons of NDVI between measurements from multi-spectral pictures and from an ASD Field spec Handheld showed that the Pearson correlation coefficients (r) were 0.97, 0.97, and 0.94, for landscapes 1, 7, and 8, respectively ($p < 0.01$, sample sizes were 25, 21, and 24, respectively; figure not shown here).

The threshold for NDVI was 0.45. The FVCs derived using this threshold are presented in figure 3. The $r$ between FVCs estimated with NDVI and the ‘true’ FVCs was 0.85 ($p < 0.01$). FVCs derived were not significantly different from the ‘true’ FVCs ($p > 0.05$); 75% were within one standard deviation of the average of FVCs estimated with conventional pictures, while most of the other 25% were greater than the upper limit.

3.3. FVCs and LSTs of different permafrost zones

The relationship between FVC and NDVI at plot scale can be described by a linear equation (figure 4(a)), comparisons
between calculated and observed FVCs were reasonably good (figure 4(b)).

The generated FVC of sub-stable permafrost was the greatest, and its average was significantly different from those of stable and transition permafrost (p < 0.01, figure 5(a)). The FVC of seasonal frost was the smallest, and its average was significantly different from those of unstable and extreme stable permafrost (p < 0.01, figure 5(a)).

LSTs retrieved from MODIS increased from extreme stable permafrost to seasonal permafrost; they had a similar pattern to that of MAGTs (figure 5(b)), which was extrapolated to the whole basin using borehole measurements (Cheng and Wang 1982).

3.4. Relationships between FVC and LST of different permafrost zones

The relationships between FVC and LST changed from positive in the extreme stable and stable permafrost, to relatively weak positive in sub-stable permafrost, and to positive in the transition, unstable permafrost and seasonal frost zones (figure 6).

4. Discussion

4.1. Estimations of FVC at quadrat scale

It usually takes 1–2 min to visually estimate FVC on one conventional picture, and 5–10 min using WinCAM software to classify. While using the threshold method, processing of one multi-spectral picture required less than 1 s. The threshold method is much more efficient. If the averages of all FVC estimations based on conventional pictures were considered as ‘true’ FVCs, there were large differences among different visual estimations. At least three visual estimations were needed to have the mean FVC not significantly different from the ‘true’ value. Similarly, two estimations of FVC were required when using WinCAM classification. FVCs derived from the threshold method using NDVI were not significantly different from the ‘true’ FVCs.

The NDVI threshold we used in this study was 0.45, which is greater than the sum of the average (0.2) and two standard deviations (0.1) of NDVIs of various soils (Montandon and Small 2008). However, we still had higher soil NDVI in those quadrats that FVCs estimated from multi-spectral pictures were higher than ‘true’ FVCs. Most of these quadrats were in landscape 7, which has salinized soil. Using NDVI = 0.45 as threshold, these soil pixels were misclassified as vegetation. There was one quadrat which had much lower estimated FVC based on NDVI threshold. In the conventional picture of this quadrat, there were flowers, which were considered as vegetation in visual estimation; however flowers had much lower NDVI values than NDVI threshold, and were considered as non-vegetation.

4.2. FVCs and NDVIs of various scales

Studies have shown that ground based measurements of NDVI were much higher than those from Landsat TM (30 m);
and multi-scale comparisons of vegetation indices using different sensors were not recommended (Cheng 2006, Théau et al. 2010). Our results showed that NDVIs from ground measurements were higher than those of corresponding remote sensing datasets. Since the value of NDVI is affected by various factors, including solar zenith angle, and the multi-spectral pictures were not taken at the same time as the overpass of the satellite, we did not establish a relationship between the NDVI of the ground and of the satellite; we assumed that the FVC of the study area would not change during our nine day field work period, and established a relationship between the FVC and the NDVI of the satellite. On the QTP, grassland has maximal above-ground biomass between early July and mid-August (Li and Zhou 1998). In source regions of Shule River Basin, NDVI values from MODIS maximized between late July and early August for most of the years 2000–2010 (figures not shown here). Thus the above-mentioned assumption about FVC is valid. Due to the harsh environment of the QTP, we cannot set more plots, and thus the number of plots used for establishing the relationship and validating was small. We actually used an unmanned aerial vehicle to take multi-spectral pictures using the same ADC camera in our field work area at a height of about 1 km. Each picture can cover hundreds of 30 m pixels, which can be used for establishing the equation and validating. These pictures need further processing, and are not presented here. This might be a useful tool in the study of alpine grassland on the QTP in the near future. Alpine grassland types, i.e. alpine meadow, alpine meadow-steppe, and alpine steppe, are different; even for the same grassland type, there are differences among different succession stages. However, it is a common practice to aggregate similar types when a detailed alpine grassland type distribution is not available. It is our next step to survey alpine grassland types in our study area, and develop a specific FVC–NDVI relationship for each type.

4.3. Limiting factors of vegetation growth on different permafrost zones

Relationships between LST and NDVI/FVC were originally used to study soil moisture and evapotranspiration (Sun et al. 2008, Tang et al. 2010). Sun and Kafatos (2007) and Karnieli et al. (2010) found that this relationship should be used with caution, because it does not hold in cold regions. In this study, we applied the relationship in studying the limiting factors of vegetation growth in different permafrost types. In the extreme stable permafrost zone, LST was low and FVC was small, vegetation growth was basically limited by energy; in the seasonal frost zone, LST was high and FVC was small, vegetation growth was basically limited by water. In the sub-stable permafrost zone, FVC was the highest and LST was less than that of the seasonal frost zone, and greater than that of the extreme stable zone; the relationship between FVC and LST was neither negative nor positive. This suggested that a
combination of water and energy was optimal for vegetation growth.

Our results showed that 1 km scale MODIS datasets were suitable for studying the effects of permafrost degradation on surface soil wetness and vegetation. The area fractions of extreme stable and stable permafrost areas are 16% and 18%, respectively, where vegetation growth will benefit from increasing air temperature; however, recent studies focus too much on the negative effects of permafrost degradation (Yang et al. 2010). To properly assess the effects of warming on vegetation on the QTP, the extreme stable and stable permafrost areas should not be neglected.

Although our study was performed for alpine grassland on the QTP, the method we propose should be useful for studying effects of permafrost degradation of other cold region ecosystems, e.g. arctic tundra.

5. Conclusions

In this study, we first developed a new method using multispectral pictures to estimate FVCs of alpine grassland at quadrat scale. This method is both accurate and time saving. We then upscaled quadrat FVCs to 1 km resolution through 30 m resolution HJ satellite data. Finally, we analyzed the relations between upscaled FVCs and measured LSTs of MODIS in different types of permafrost zone of source regions of Shule River Basin. Results showed that the limiting factor of vegetation growth transitioned from energy in the extreme stable permafrost zone to water in the seasonal frost zone, which suggested that permafrost degradation caused drying of surface soil and degradation of alpine grassland. However, warming of permafrost might also be of benefit to growth of alpine grassland in extreme stable and stable permafrost zones. Existing studies focus too much on the adverse effects of permafrost degradation. To objectively project changes of alpine grassland in a warming climate, future studies should consider both adverse and beneficial effects of permafrost degradation.

Acknowledgments

This study was supported through grants provided to Yi as part of the Major State Basic Research Development Programme of China (973 Programme) (No 2007CB411502), the National Basic Research Program (2010CB951402), and the One Hundred People Plan of the Chinese Academy of Sciences. We would like to thank Drs Huakun Zhou, Gouying Zhou, Guangyang Yue, and Mr Zhilong Zhang for estimating vegetation cover visually or using WinCAM software, and Professor Yu Sheng for providing permafrost distribution data.

References

Carlson T N 2007 An overview of the ‘Triangle Method’ for estimating surface evapotranspiration and soil moisture from satellite imagery Sensor \textbf{7} 1612–29


Cheng G and Wu T 2007 Responses of permafrost to climate change and their environmental significance, Qinghai-Tibet Plateau J. Geophys. Res. \textbf{113} F02S03

Cheng Q 2006 Multisensor comparisons for validation of MODIS vegetation indices 

Pedosphere \textbf{16} 362–70


Li W and Zhou X (ed) 1998 Ecosystems of Qinghai-Xizang (Tibetan) Plateau and Approach for their Sustainable Management, Series of Studies on Qinghai-Xizang (Tibetan) Plateau (Guangzhou: Guangdong Science & Technology Press)


Wu Q and Zhang T 2010 Changes in active layer thickness over the Qinghai–Tibetan Plateau from 1995 to 2007 J. Geophys. Res. \textbf{115} D09107
