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To cite this article: Lili Li *et al* 2017 *IOP Conf. Ser.: Earth Environ. Sci.* **74** 012010

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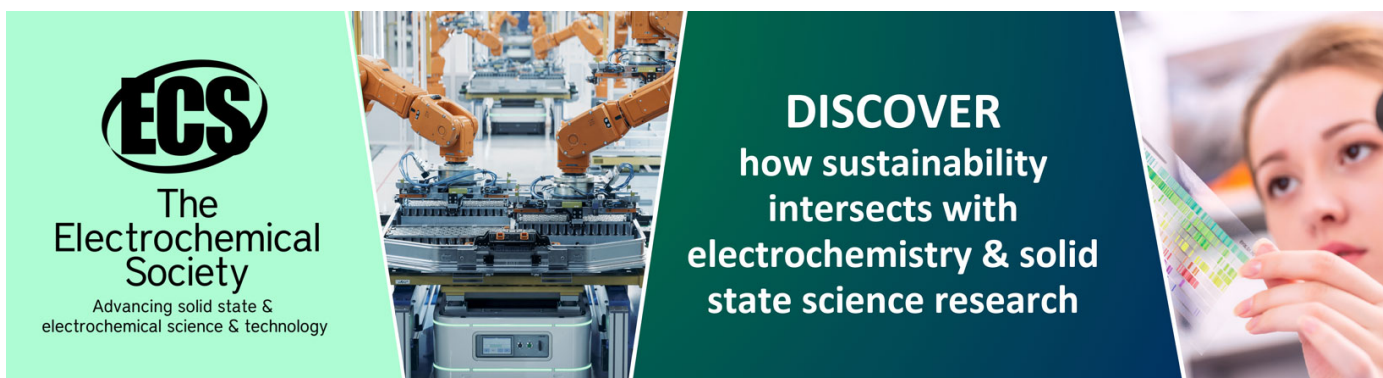
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Monitoring an air pollution episode in Shenzhen by combining MODIS satellite images and the HYSPLIT model

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Abstract. Urban air pollution is influenced not only by local emission sources including industry and vehicles, but also greatly by regional atmospheric pollutant transportation from the surrounding areas, especially in developed city clusters, like the Pearl River Delta (PRD). Taking an air pollution episode in Shenzhen as an example, this paper investigates the occurrence and evolution of the pollution episode and identifies the transport pathways of air pollutants in Shenzhen by combining MODIS satellite images and HYSPLIT back trajectory analysis. Results show that this pollution episode is mainly caused by the local emission of pollutants in PRD and oceanic air masses under specific weather conditions.

1. Introduction

As a coastal city located in south-central Guangdong, China (about 113.7°E -114.6 and 22.4 °N-22.9 °N), Shenzhen is one of areas that boasts fast economic growth and population explosion in the world. Rapid industrial development and heavy traffic pressure caused the increase in haze days and deterioration of air quality, which has drawn widespread attention from the government and public[1-2]. However, air pollution is not only a local but a regional problem, for some pollutants could be transported over hundreds and thousands of kilometres [3]. Owing to its unique topography and meteorology, Shenzhen is sensitive to regional transport of air pollutants from the surrounding areas.

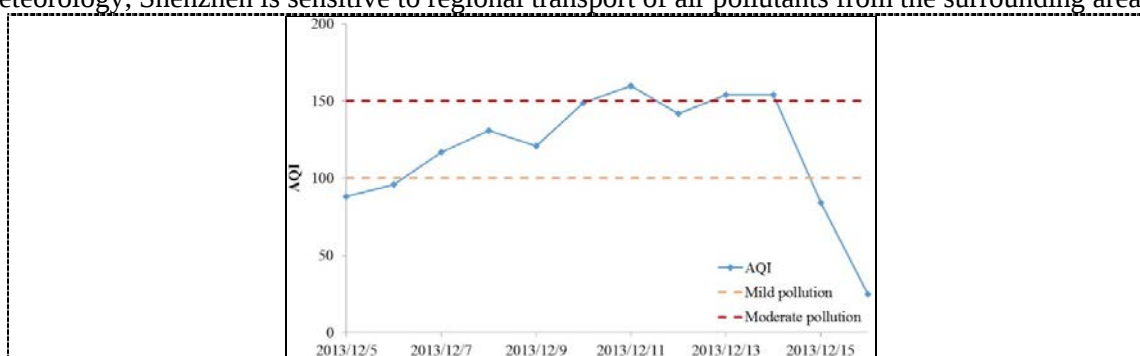


Figure 1. Variation trend of air quality index(AQI) during December 5-16, 2013 in Shenzhen

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During December 5th to 16th, 2013, an air pollution episode occurred in Shenzhen, and the air quality index (AQI) reached the standard of mild pollution from December 7, and then increased into moderate pollution during December 10-14, as is shown in Figure 1. Taking this episode as an example, this study combines MODIS satellite images with the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model to analyse the pollution episode and identify the transport pathways of air pollutants in Shenzhen.

2. Data and Method

2.1. Data

Satellite data used in this study over Shenzhen and its surrounding areas were provided by a Moderate-resolution imaging spectroradiometer (MODIS) (on-board the Terra and Aqua satellite) and downloaded from NASA Level 1 and Atmosphere Archive and Distribution System. They are calibrated L1B data with 500m spatial resolution including visible, near-infrared, and mid-infrared bands. Images during December 6-14, 2013 were acquired, together with monitoring data from 11 air quality stations provided by the Department of Environmental Protection of Guangdong Province, China. The station observations include air quality index, and concentrations of PM₁₀, PM_{2.5}, SO₂, NO₂ and Ozone.

2.2. HYSPLIT model

The Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) transport model, developed by NOAA's Air Resources Laboratory, is a complete system for computing simple air mass trajectories, as well as complex transport, dispersion, chemical transformation, and deposition simulations[4]. The model calculation method is a hybrid between the Lagrangian approach, using a moving frame of reference for the advection and diffusion calculations as the trajectories or air parcels move from their initial location, and the Eulerian methodology, which uses a fixed three-dimensional grid as a frame of reference to compute pollutant air concentrations[5]. The model can be run as a stand-alone application, or interactively on the website (<http://www.ready.noaa.gov/index.php>).

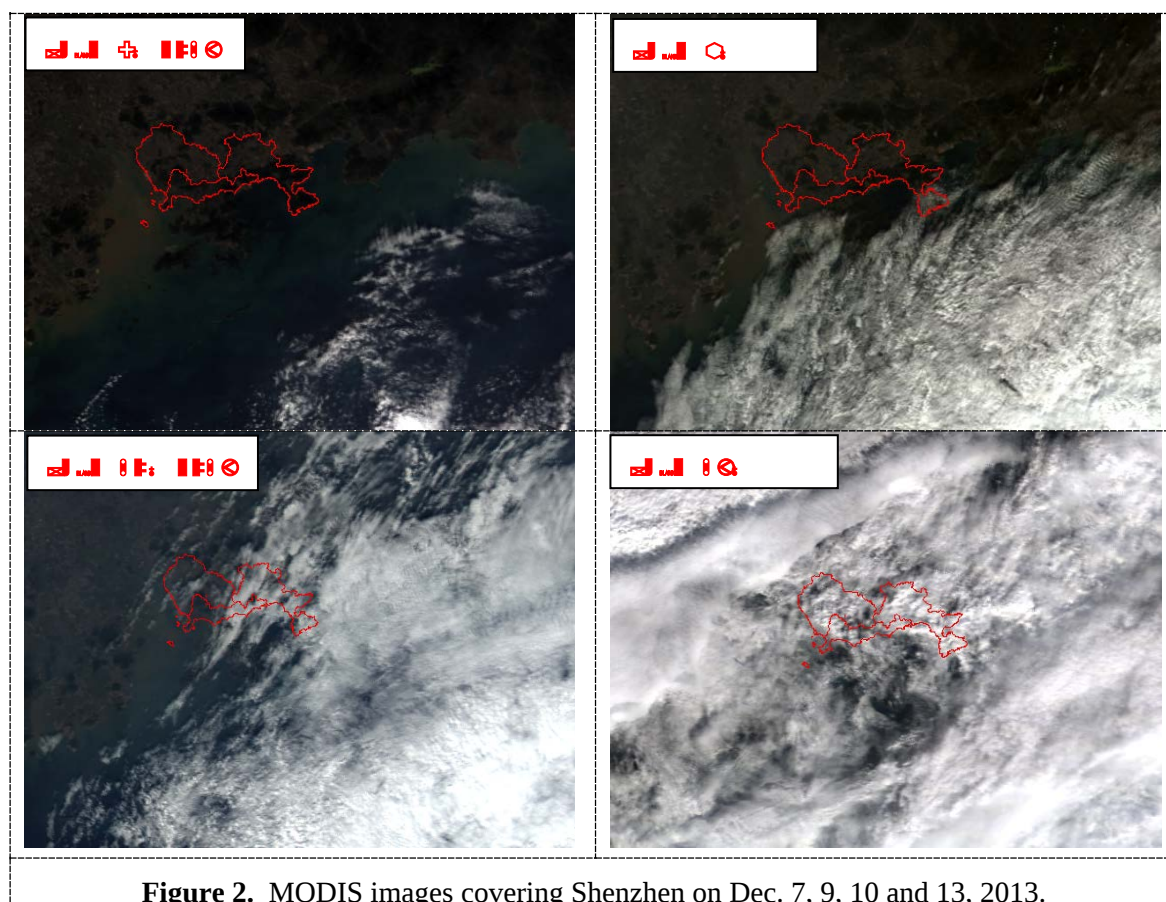
3. Results and discussion

According to the variations of AQI in Figure 1, the air pollution episode is divided into four phases: before the pollution (December 5-6), beginning of the pollution (December 7-9), worsening of the pollution (December 10-14) and disappearance of the pollution (December 15-16). Figure 2 is MODIS images covering Shenzhen (the red polygon) and its surrounding areas on Dec. 7, 9, 10 and 13. Images below clearly show the occurrence and transportation of the air pollution episode. In the satellite image on Dec. 6, ground objects were clear with little cloud cover, indicating that air quality over the region was fine. On Dec. 9, the air pollution episode broke out, and the thick cloud and aerosol layer led to the low visibility of the objects. Oceanic air masses from the east-south moved to Shenzhen, and accelerated the air pollution on Dec. 10. Until December 13, the whole region was covered with thick cloud cover and haze so that nothing could be recognized from the MODIS image, and the air quality turned to be moderate pollution.

Taking Shenzhen(22.5°N, 114°E)(UTC+0800) as the reference point, we used HYSPLIT model to calculate the backward air masses trajectories at the altitude of 50m, 100m and 300m in four periods of this air pollution episode, as Figure 3 shows. The red, blue and green lines represent the path of air masses at 50 meters, 100 meters and 300 meters, respectively. The region was affected by different airflows in the pollution period, as was controlled by the north air masses before and after the pollution Shenzhen, and during the pollution process was controlled by the south air masses.

On December 1, a large-scale haze pollution event broke out in the central and eastern parts of China, and the northerly air from the inland areas blew the polluted air to the southern coastal areas. But due to the weak transportation the north wind, the air quality in Shenzhen was fine. But until December 7th, the south-east air turned to be oceanic air mass from the South China Sea Strait in the east, and

arrived in Shenzhen along the south China coastline. The near-surface airflow mainly originated from the east Taiwan Strait. The weak south-east wind facilitated the accumulation of surrounding pollutants, thus mild air pollution occurred in Shenzhen. During December 10 to 14, the trajectory of the near-surface air in Shenzhen came from the Pearl River Delta, through the South China Sea and the Pearl River Estuary, acting as a loop; air at low altitudes was influenced by the oceanic air mass from the northeast, and reached Shenzhen through the southeast coast, the western Guangdong and the Pearl River estuary. The trajectory of air was above 2000hpa and controlled by high pressure, thus the stable atmospheric structure of troposphere hindered the diffusion of the pollutants and caused moderate pollution in the region. After December 15, the direction of air changed to north-east, and the air quality in Shenzhen gradually improved.

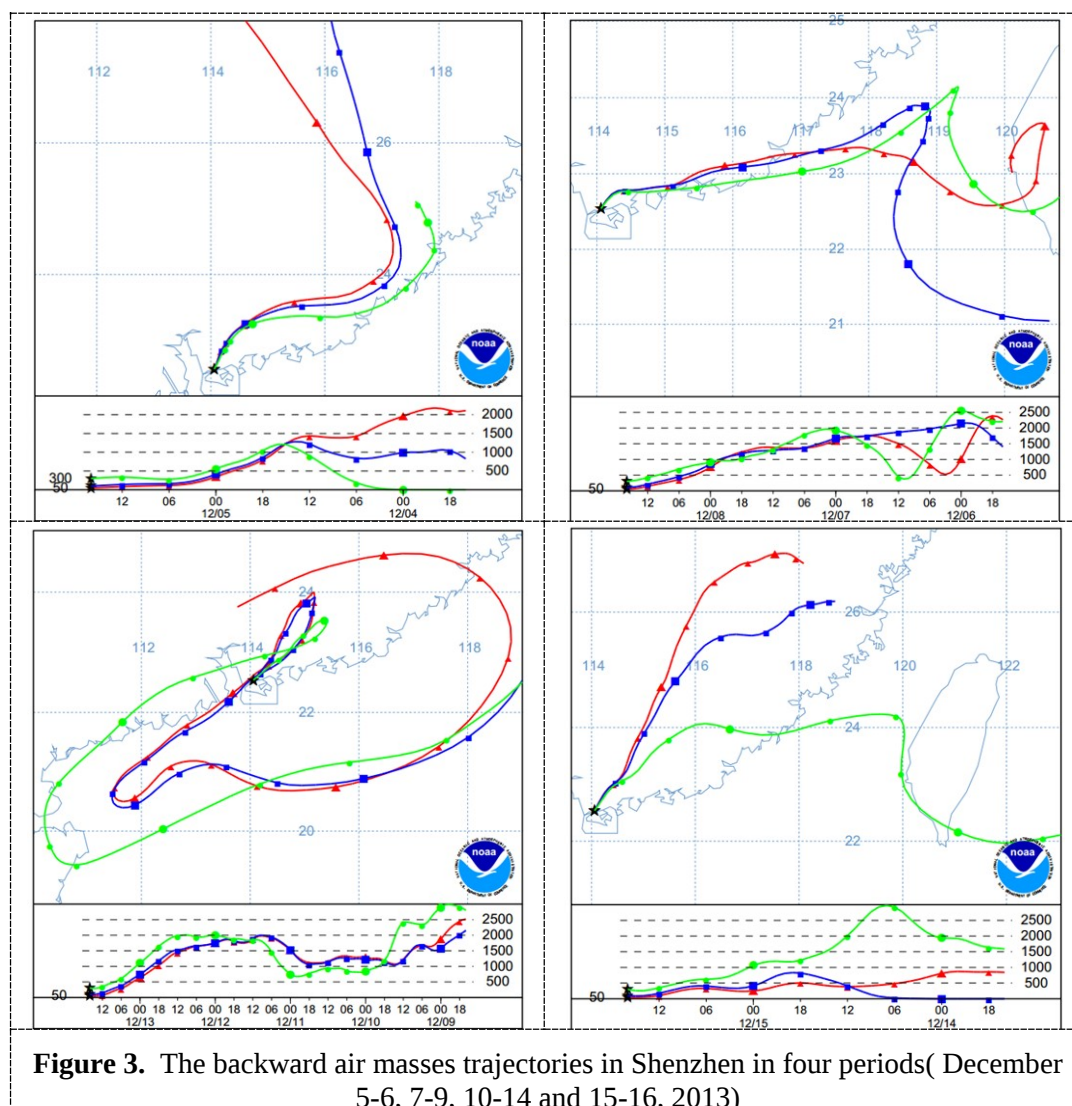


4. Conclusions

Combining MODIS satellite images and back trajectories from HYSPLIT model, this study analysed the four phases of an air pollution episode during December 5-16, 2013 in Shenzhen and identified the transport pathways of air pollutants. The results indicate that weak east-south wind and weak atmospheric vertical movement were the weather conditions during the pollution, while the north airflow and strong air convection after December 15th were conducive to the diffusion of air pollutants. Backward trajectory analysis shows that the pollution episode was mainly caused by the local emission of pollutants in the Pearl River Delta region and oceanic air masses under specific weather conditions.

Acknowledgement

China National 863 Program (2006AA06A306) and State Key Laboratory of Organic Geochemistry Program (SKLOGA201603A) are acknowledged for financial supports.



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