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Effect of typhoon on atmospheric aerosol particle pollutants accumulation over Xiamen, China

Jinpei Yan*, Liqi Chen, Qi Lin, Shuhui Zhao, Miming Zhang

Key Laboratory of Global Change and Marine-Atmospheric Chemistry, Third Institute of Oceanography, SOA, Xiamen 361005, PR China

HIGHLIGHTS

- Aerosol properties during typhoon process were observed in high resolution over Xiamen.
- Two pollutant groups were observed during the whole typhoon periods.
- Seven types of particle clusters were obtained during the observation.
- Ship emissions and stagnant atmosphere dominated the formation of first pollutant group.
- Second pollutant caused by the combined effect of local emissions and long-term transports.

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ABSTRACT

Great influence of typhoon on air quality has been confirmed, however, rare data especially high time resolved aerosol particle data could be used to establish the behavior of typhoon on air pollution. A single particle aerosol spectrometer (SPAMS) was employed to characterize the particles with particle number count in high time resolution for two typhoons of Soulik (2013) and Soudelor (2015) with similar tracks. Three periods with five events were classified during the whole observation time, including pre – typhoon (event 1 and event 2), typhoon (event 3 and event 4) and post – typhoon (event 5) based on the meteorological parameters and particle pollutant properties. First pollutant group appeared during pre-typhoon (event 2) with high relative contributions of V – Ni rich particles. Pollution from the ship emissions and accumulated by local processes with stagnant meteorological atmosphere dominated the formation of the pollutant group before typhoon. The second pollutant group was present during typhoon (event 3), while typhoon began to change the local wind direction and increase wind speed. Particle number count reached up to the maximum value. High relative contributions of V – Ni rich and dust particles with low value of NO_3^-/SO_4^{2-} was observed during this period, indicating that the pollutant group was governed by the combined effect of local pollutant emissions and long-term transports. The analysis of this study sheds a deep insight into understand the relationship between the air pollution and typhoon.

1. Introduction

The importance of aerosol particles has received considerable attention throughout the world because of their impact on air quality, human health (Buonanno et al., 2013; Kanakidou et al., 2005), atmospheric visibility and global climate change (Prather, 2009; Chen and Penner, 2005). Aerosol compositions are necessary for identifying their sources and predicting their effects on atmospheric processes. Studies on aerosol properties in the coastal area of Xiamen including size distribution, source identification (Yan et al., 2015; Zhao et al., 2011) have been present, recently. However, offline filter sampling methods were conducted mostly in these studies, which were limited by low time resolution because of long sampling time (Zhang et al., 2007). It was difficult to clarify the physico – chemical process of aerosol particles in some special atmospheric events using offline filter sampling method, since the physical and chemical characteristics of aerosol particles would change rapidly within a very short time.

Xiamen is an island located in the southeast China with a sub-

* Corresponding author. No.178 Daxue Road, Siming district, Xiamen, Third Institute of Oceanography, SOA, 361005, PR China.
E-mail address: jpyan@tio.org.cn (J. Yan).

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tropical climate under the influence of the Asian monsoon. In cold seasons of winter and spring, a northeasterly wind becomes the most prevailing wind direction. Air masses associated with the winter monsoon usually consist of anthropogenic components and fossil combustion species which affect the air quality in Xiamen through long-range transport (Yan et al., 2015). While in summertime, typhoons and the Pacific high system are the predominant weather conditions under the summer monsoon season. Typhoon generally with strong wind and moisture circulation may cause tremendous damage along the path of the typhoon migration routs (Huang et al., 2009; Fang et al., 2009; Feng et al., 2007; Chuang et al., 2008). However, there were insufficient studies to discuss the relationship between typhoon and air quality in Xiamen over southeast China (Li et al., 2015).

Typhoon has great effect on the chemical composition of aerosol in the atmosphere, since it may carry large quantity of chemical fluxes for major elements due to its associated large water volumes. Some special chemical species were carried to the places where the typhoon passed and some were scavenged (Fang et al., 2009; Sakihama and Tokuyama, 2005). Generally, typhoon moves quickly along the path and the chemical characteristic of aerosol particle changes in a very short time, so a long sampling interval of fine particle is difficult to estimate the effect of the typhoon. However, most of the previous analyses of aerosol particles were based on the results of relatively long sampling time. The impact of aerosol sources could be diluted for long sampling intervals, which made it difficult to identify the sudden short events, such as typhoon. It is hard to estimate the influence of typhoon on the atmospheric aerosol particles based on the offline sampling method. Since online aerosol mass spectrometry has been available to provide size and chemical information of aerosol particles in atmospheric environment (Sullivan et al., 2007; Spencer et al., 2007), they were used to characterize the aerosol chemical composition, aerosol source, mixing state, secondary aerosol formation and other aerosol processes in the atmosphere (Melissa et al., 2007; Fu et al., 2015).

Xiamen is one of the Cleanest Cities of China (http://www.cnemc.cn/), pollutant variations could impact the air quality greatly. In this paper, in order to identify the effect of typhoon process on the chemical characteristics and pollutant sources of aerosol particles, two typhoons (Soulik and Soudelor) with similar tracks were investigated, using a high time-resolved instrument to classify the characteristics of aerosol particles under various weather conditions of typhoon processes in coastal area, Xiamen. We investigated the major chemical components and sources of aerosol particles during typhoon landing period, and compared to those during pre – typhoon and post – typhoon. The backward trajectory results were also given to evaluate pollutant sources along the typhoon migration routs. Three periods with five events were classified during the whole observation time, including pre-typhoon (event 1 and event 2), typhoon (event 3 and event 4) and post-typhoon (event 5) based on the meteorological parameters and particle pollutant properties. The study sheds an insight to understand the effect of typhoon on atmospheric particulates.

2. Experimental methods

2.1. Sampling site and typhoon migration routs

The observations were carried out in a Marine Atmospheric Environment Monitory Station located in the Xiamen (24°16′ N, 118°05′ E), as seen in Fig. 1, which was on the platform of 10th Research Building about 45 m height above the sea level. The observation station is a coastal station on the seaside of southern Xiamen. The immediate area is residential with a heavy traffic expressway nearby the location and a berth approximately 5 km east from the station. The observation station could be a representative of coastal urban district due to the impacts of traffic, seasalt, residential, construction and ship emissions.

Fig. 1 shows the tracks of two typhoon centers of Soulik (2013) and Soudelor (2015) (http://typhoon.nmc.cn). Both of them grew to super typhoons and landed on the southeast coat of China. As a strong typhoon, Soulik, the 7th typhoon of 2013, made landfall late on July 12 in northern Taiwan before degrading to a tropical storm. Briefly emerging over the Taiwan Strait, the typhoon moved onshore for a second making landfall in Fuzhou, southeastern China on July 13. The storm was last noted as a tropical depression early on July 14, as seen in Fig. 1a. Typhoon Soudelor, the 13th typhoon of 2015, stroke Fujian as a strong storm, which made landfall over Hualian, Taiwan, late on August 7 and emerged over in the Taiwan Strait early the next day. The typhoon soon moved to land over Putian, southeastern China and degraded to a tropical depression by August 9, as seen in Fig. 1b. As mentioned above, typhoon Soulik and Soudelor had the similar track and both made landfall in the northern Xiamen and the landing sites of two typhoons were rather close. In this case, the typhoon Soulik and Soudelor could have similar impacts on weather conditions over Xiamen. In this paper, we presented the effect of the two typical typhoons on the atmospheric aerosol particles over Xiamen.

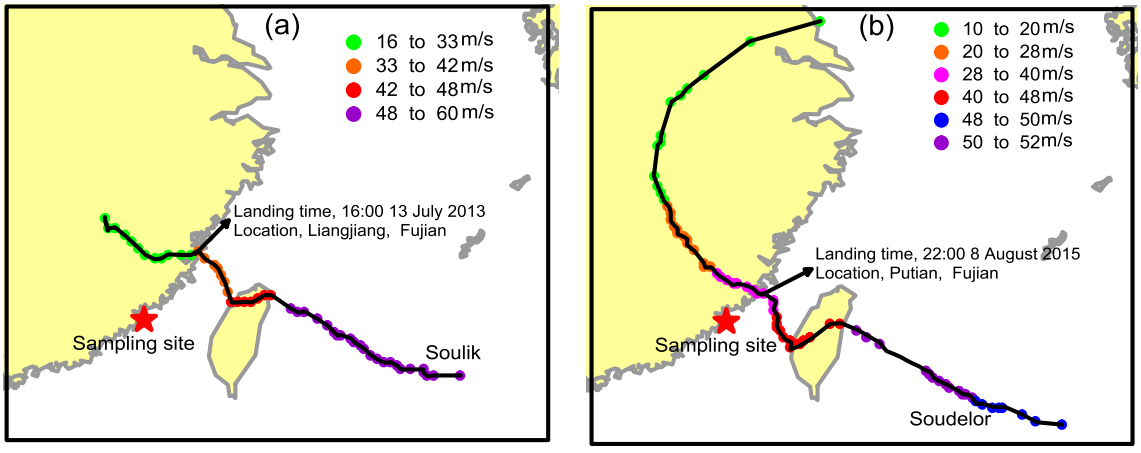

Fig. 1. Tracks of typhoon Soulik and Soudelor and the sampling site in Xiamen (a) typhoon Soulik, July 2013 and (b) typhoon Soudelor, August 2015.