# Analysis of submicron aerosol number size distribution in Seoul using the cyclostationary empirical orthogonal functions

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## INTRODUCTION

Aerosols are known to play an important role in climate change directly by scattering or absorbing solar radiation and indirectly by acting as cloud condensation nuclei (CCN) and thus altering cloud radiative properties. The aerosol indirect effect on climate not only has magnitude large enough to countervail the greenhouse effect but also has large uncertainty about it.

Whether aerosols can act as CCN or not depends on the size and chemical composition of aerosol particles. Aerosol number size distribution varies with time and especially when a new particle formation (NPF) event occurs, we can witness the growth of the particles. Since this is a major mechanism that can produce CCN active particles, understanding NPF mechanism is crucially important.

To enhance our knowledge of the effects of aerosols on climate, the importance of aerosol observation all over the world cannot be overemphasized. In this study, we report long-term (2004–2012) aerosol number size distributions and NPF events in Seoul, a densely populated urban city.

## METHODS

Here we analyze the scanning mobility particle sizer (SMPS) data measured during 2004-2012 at the Yonsei University campus (37.6$^{o}$N, 127.0$^{o}$E) located near the center of Seoul, a highly urban Capital city of South Korea. The mobility diameter range was 10-450 nm and the measurement was almost continuous except when the instrument was deployed for field measurements or not operational due to repair.

For cyclostationary processes such as the diurnal variation of the aerosol size distribution, cyclostationary empirical orthogonal function (CSEOF) method (Kim et al., 1996; Kim et al., 2013) is useful for identifying dominant patterns and therefore this method is employed here.

## RESULTS AND DISCUSSION

Figure 1 shows the cyclostationary loading vectors (CSLVs) of the first CSEOF mode of aerosol number size distribution in Seoul, which accounts for 39% of the total variance, the most important pattern of aerosol number size distribution. The CSLVs of the first CSEOF mode shows a distinct peak at 20-70 nm between 0800 and 1000.

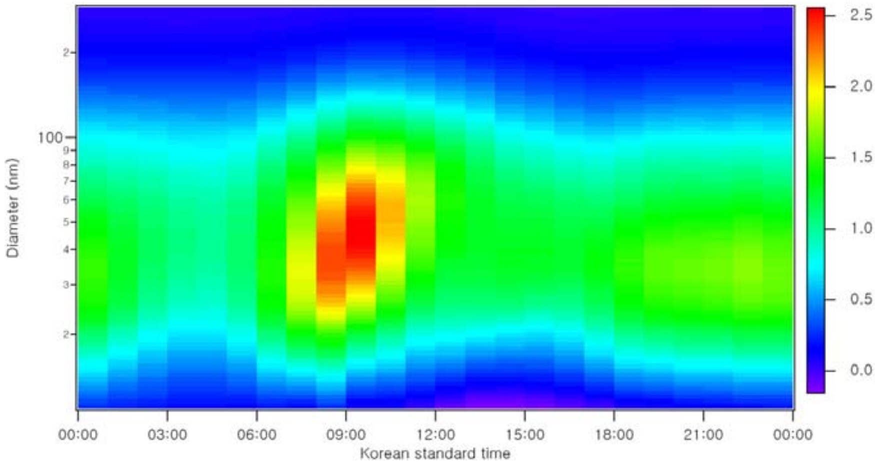


Figure 1. CSLVs of the first CSEOF mode for the Seoul aerosol number size distributions.

Figure 2 shows the variation of the monthly mean principal component (PC) values in the first CSEOF mode. PC values in the first CSEOF mode in winter show very high positive values. A high PC value means that the patterns presented in the CSLVs strongly appear at that time. Since most CSLVs of the first CSEOF mode were positive, the total aerosol number concentration was generally high in winter.

These clear seasonal and diurnal variations of aerosol number concentration and size distribution are found to be due to seasonal monsoon and traffic emission. In Korea, the continental air mass is dominant in winter. Polluted air masses from China seem to contribute to the high aerosol number concentration in this season. In addition, the annual temperature range is very broad. Since the emission amount of each vehicle increases with decreasing temperature, cold air masses in the winter influenced the seasonal variation of aerosol number concentration and size distribution (Ripamonti et al., 2013).

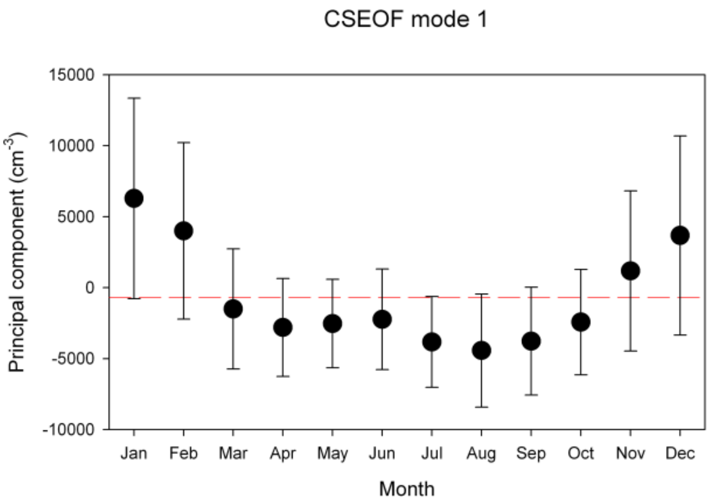


Figure 2. Monthly mean values of the principal component in the first CSEOF mode. Red dashed line indicates the averaged value.

Overall the relative frequency of NPF events is the highest in spring and the average for the whole year is 12.3%. Figure 8 shows the CSLVs of the second CSEOF mode. Since a distinct change in the CSLVs of the second CSEOF mode appears at ~1100 for small size particles, and subsequently, the peak of the CSLVs gradually increases along with particle growth, the second CSEOF mode has a connection with NPF events. Based on the PC time series of the second CSEOF mode, we classify NPF and non-NPF days. NPF event identification by the CSEOF method generally worked well, with some exceptions, such as identifying NPF events that occurred before the sunrise. When NPF events occur, relative humidity and condensation sink are generally lower than the average values. This may suggest that high relative humidity and condensation sink suppress NPF in Seoul.

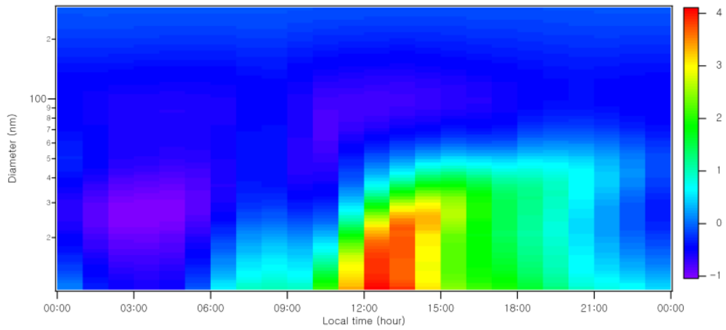

Figure 3. CSLVs of the second CSEOF mode for the Seoul aerosol number size distribution.

More comprehensive analysis of aerosol distribution and NPF characteristics will be discussed at the conference.


## Acknowledgements

The authors would like to thank Prof. Kwang-Yul Kim and Dr. Yumi Kim of Seoul National University for discussion and suggestion, and Seoul city website (http://traffic.seoul.go.kr) for traffic data used in this publication.

This research was supported by the "Advanced Research on Applied Meteorology" of the National Institute of Meteorological Research (NIMR) of the Korea Meteorological Administration (KMA)


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