Simulation of seasonal influence on particle diversity and mixing state over Greater Paris

S. Zhu [1], and K.S. Sartelet [1]

[1] CEREA, joint laboratory Ecole des Ponts ParisTech - EDF R&D, Université Paris-Est, Champs-sur-Marne, 77455, France

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Presenting author email:blueingelt@gmail.com

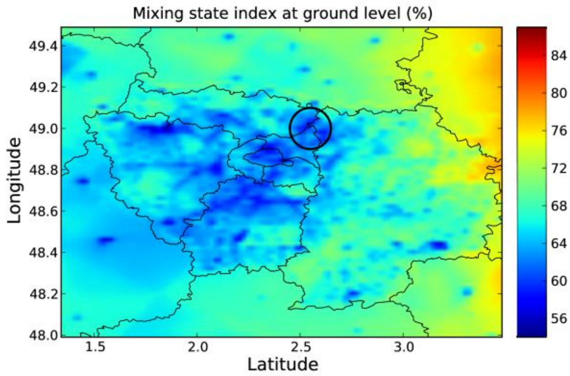
A size-composition resolved aerosol model (SCRAM) (Zhu et al., 2015a) was developed in order to investigate particle mixing states. SCRAM has been coupled to the Polyphemus air quality platform to simulate the evolution of mixing-state resolved particles during both a summer period (June to July 2009) and a winter period (January to February 2010, Zhu et al., 2015b).

Simulation results are first compared with measurements to evaluate the model performance, and both the summer and winter simulation results meet the model performance criterion proposed by Boylan and Russell (2006).

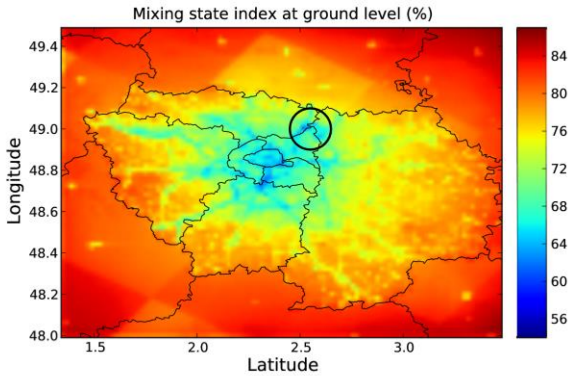
Then a new quantification approach based on information-theoretic entropy (Riemer and West, 2013) is used to derive the single particle diversity and particle mixing-state index from both the summer and winter simulations. The particle mixing-state index describes the diversity of the particle population. A group of particles with heterogeneous compositions has a low mixing-state index, and is considered as barely mixed. On the opposite, a group of particles with a homogeneous composition has a high mixing-state index and is considered as internally mixed.

The seasonal influence on particle diversity and mixing-state is studied. Figures 1 compares the spatial distribution of the averaged particle mixing-state index over Greater Paris for both the summer and winter simulations. In both seasons, particles are found less mixed close to the centre of Paris, and around the busiest roads and the Roissy airport (denoted by the black circle in Figure 1). This is due to high emissions of unmixed particles in those regions. Besides, in winter, PM concentrations are found much more concentrated over the centre of Paris with low mixing-state index, while the countryside is dominated by very aged transported particles with very low concentration, and high mixing-state index. In the summer, the overall mixing state index is lower than in the winter because of higher emissions of biogenic compounds, which lead to numerous barely mixed organic particles.

Besides, aerosols optical properties and their abilities to be activated as cloud condensation nuclei (CCN) are also studied for both simulations. Concerning aerosol optical properties, the average aerosol optical depth (AOD) is higher during the summer period (0.30) than the winter period (0.13), because of higher PM concentrations on average over the simulated domain. By comparing the CCN activation percentage at a constant 1% supersaturation level over the computational domain, a relatively higher CCN activation percentage is found in the summer simulation (77.78%) than in the winter simulation (75.35%). This is because particles contain a higher percentage of hydrophilic species in the summer than in the winter, which makes particles easier to be activated.



(a) Summer



(b) Winter

Figure 1. Comparison of averaged particle mixing-state index between summer and winter simulations.

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