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Influence of Climate on $PM_{2.5}$ Concentrations over Europe : a Meteorological Analysis using a 9-year Model Simulation

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In the early 1970s, it has been demonstrated that a large number of deaths and health problems are associated with particulate pollution. As a consequence, several governments have set health-based air quality standards to protect public health. Particulate matter with an aerodynamical diameter of 2.5 $\mu g.m^{-3}$ or less ($PM_{2.5}$) is particularly concerned by these measures. As $PM_{2.5}$ concentrations are strongly dependent on meteorological conditions, it is important to investigate the relationships between $PM_{2.5}$ and meteorological parameters. This will help to understand the processes at play and anticipate the effects of climate change on $PM_{2.5}$ air quality.

Most of the previous work agree that temperature, wind speed, humidity, rain rate and mixing height are the meteorological variables that impact $PM_{2.5}$ concentrations the most. A large number of those studies used Global Circulation Models (GCM) and Chemical Transport Models (CTM) and focus on the USA. They typically predict a diminution of $PM_{2.5}$ concentrations in the future, with some geographical and/or temporal discrepancies, when only the climate evolution is considered. When considering changes in emissions along with climate, no consensus has yet been found. Furthermore, the correlations between $PM_{2.5}$ concentrations and meteorological variables are often low, which prevents a straightforward analysis of their relationships.

In this work, we consider that $PM_{2.5}$ concentrations depend on both large-scale atmospheric circulation and local meteorological variables. We thus investigate the influence of present climate on $PM_{2.5}$ concentrations over Europe by representing it using a weather regimes/types approach. We start by exploring the relationships between classical weather regimes, meteorological variables and $PM_{2.5}$ concentrations over five stations in Europe, using the EMEP air quality database. The pressure at sea level is used in the classification as it effectively describes the atmospheric circulation. We experimentally verify some intuitive results: weather regimes associated with weak (*resp.* high) precipitation, wind and low (*resp.* high) temperatures correspond to higher (*resp.* lower) $PM_{2.5}$ concentrations. We also observe that rain rate is the variable that impacts $PM_{2.5}$ concentrations the most. Next, we search for better relationships by adding this second variable to the classification: we therefore build new weather regimes, called weather types. Because of the low number of the EMEP observations, we compute $PM_{2.5}$ concentrations with the Polyphemus/Polair3D CTM for years between 2000 and 2008 in order to obtain a spatially and temporally complete dataset of $PM_{2.5}$ concentrations and chemical components, which can be used to relate $PM_{2.5}$ concentrations to meteorological regimes and specific variables. By classifying both a large-scale variable and a local variable that influence the $PM_{2.5}$ concentrations and using gridded data of the modeled concentrations of $PM_{2.5}$, we obtain a more robust analysis.

The results of this work will provide the basis to predict the effects of climate change (via the evolution of weather regimes/types frequencies) on $PM_{2.5}$ chemical composition and concentrations.