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Multi-scale chemistry-transport modelling of the 2022 extreme Sahara dust event over Paris

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Mineral dust aerosol, which is mainly composed of soil particles, is one of the most widespread and important aerosols in the atmosphere. It impacts air quality and regulates regional and global radiative forcing. It remains a challenge to portray this impact at urban scale with a spatial zooming of up to a few meters resolution. Towards gaining better insights into the processes affecting the global dust cycle, such as transport, deposition, and life cycle of dust aerosol, multi-scale modelling approach of mineral dust aerosol is used. In this work, we simulate the transport of Sahara dust on the different scales: regional scale (Europe) and urban scale (Paris). At the regional (European) scale, WRF-CHEM model is used to provide more detailed information on the transport of Sahara dust towards Europe. Instead of the typical technique of employing climatology data from the inventories, the initialization and boundary conditions of the gas species and aerosols are established using data from the CAMS reanalysis. In the same manner, ERA-5 reanalysis data are used to feed the meteorology. WRF-CHEM is a regional-scale atmospheric chemistry model which takes into account the physics, chemistry, and morphology of dust aerosol with a finest resolution of 1km around Paris in a 4 step grid nesting system, viz., 27 km^2, 9 km^2, 3 km^2, and 1 km^2. The WRF run is nudged hourly by ERA-5 data and every three hours by CAMS data at the boundary of the parent domain only. The nested grids are initialized by their parent domain, however, there is no nudging for the nested domains.
At the local scale, the general purpose CFD open source solver code_saturne (developed by EDF R&D) is used in order to compute the carrying air and the pollutant dispersion in building areas in the center of Paris. Results of the regional scale modelling by WRF-CHEM are used as initial and boundary conditions for the local scale calculations. One of the main practical difficulties of urban modelling is the lack of open access to complete data about building geometry for any urban area. OpenStreetMaps is one of the most complete sources that can provide needed geometries. In order to use geometry from different sources (like a LiDAR measurements or shape files provided by Institut Géographique National of France) we convert geometry into the point cloud and use it as input for the internal mesh generator implemented on the base of API of code_saturne. This approach allows for generating mesh with 2 meters spatial resolution near the buildings and about 60 meters resolutions on the boarder of the calculation domain. A comparison with measurements taken from the ground reveals qualitative agreement.

Keywords: urban scale modelling, regional scale modelling, WRF-CHEM, code_saturne, CFD

References