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Are atmospheric aerosols able to modify the surface winds? A sensitivity study of the biomass burning aerosols impact on the spatially-distributed wind over Europe

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Atmospheric aerosols affect the Earth's climate through their radiative effects, being one of the most uncertain areas in climate modelling. Aerosols are widely known to affect radiation, temperature, stability, clouds and precipitation through their radiative effects, which depend mainly on the aerosol optical properties. These can be divided into direct and semi-direct effect, produced by the scattering and absorption of radiation; and indirect effect, which influences the aerosols-cloud interactions. In this sense, wind fields affect aerosols levels by several different processes, finally resulting in a wind-dependent emission over land or ocean. Moreover they can disperse the particles leading to a cleaner atmosphere. But, how do aerosol particles affect the wind? Scientific literature about their effects on wind is scarce.

In this sense, the objective of this work is to assess the effects of biomass burning aerosols on spatially-distributed winds over Europe. The methodology carried out consists of three WRF-Chem simulations for Europe during the Russian fires (25 July to 15 August 2010) differing in the inclusion (or not) of aerosol direct and direct+indirect radiative feedbacks. These simulations have been carried out under the umbrella of the EuMetChem COST ES1004 Action. A Euro-CORDEX compliant domain at 0.22º and 23 km resolution has been used. The first simulation does not take into account any aerosol feedbacks (NFB), the second simulation differs from the base case by the inclusion of direct effect (DFB); while the third includes the direct+indirect radiative feedbacks (TFB).

Results depict that the presence of aerosol reduces the wind module over Russian. Aerosol radiative effects imply a decrease of the shortwave downwelling radiation at the bottom of the atmosphere (with maximum values of 50 W m-2 over Russia). As a consequence there is a reduction on the temperature at 2 m up to 1 K. The decrease of the temperature reduces the convective processes and the turbulence, developing a more stable planetary boundary layer with lower heights (around 80 m). This implies a wind speed reduction of 0.4 m s-1 (spatial correlation between planetary boundary layer and wind speed is around 0.4). On the other hand, the decrease of the temperature favours an increase of the surface pressure not only over Russia but also extends towards northern Europe. Opposite, the surface pressure decreases over central Europe where there is an increase of the wind speed up to 0.4 m s-1. The indirect effects of the aerosols also affect wind direction, especially in the North Sea (around 10 degrees). This work evidences the importance of taking into account the aerosol radiative effects in order to improve the representativeness of winds and could help to estimate the wind energy.