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Simulations of aerosol-cloud-radiation feedback with coupled "online" WRF/Chem model over Europe

Paolo Tuccella, Gabriele Curci, and Guido Visconti
CETEMPS, Dept. Physics, University of L'Aquila, Italy

In recent years, aerosols have been important subject of study of the scientific community. Aerosol particles play a key role in climate system acting on the global budget of radiation, both directly by scattering and absorbing the incoming radiation and indirectly by altering cloud properties. The feedback among aerosol-cloud-radiation is one the most uncertain issues in study of climate change.

In this work, we simulate the aerosol-cloud-radiation with fully coupled "online" WRF/Chem model. Two simulations are conducted over Europe: a baseline simulation with no feedbacks, and another in which we activate direct and indirect aerosol effects.

In baseline simulation the model reproduces the meteorological fields with small biases. Hourly and daily maximum ozone is simulated with a correlation of 0.66 and 0.81, respectively, with respect to EMEP ground observations. NO2 is underestimated by about of 0.9 μg/m3 and exhibits a correalation of 0.40. PM2.5 aerosol mass is underestimated of about 30%. This negative bias is due to organic mass, soil dust and unspeciated PM2.5. The magnitude of total mass of inorganic aerosol constituents is well reproduced, but the model overestimates nitrates by about a factor of 1.5 and underpredicts sulphates by 50%.

The model is very sensitive to direct and indirect aerosol forcing. When we add these effectsto the simulation, we find a change in cloud optical depth (COD) of up to $\pm$50% with respect to the baseline simulation. We observe similar spatial structures of those in COD in the difference of other variables. Shortwawe radiation at surface and planetary boundary layer height display differences up to $\pm$15% (or $\pm$50 W/m2 and $\pm$40 m, respectively).We find smaller differences of $\pm$3% ($\pm$0.4 °C) for 2-meter temperature.