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Bridging the scales in atmospheric composition simulations using a nudging technique

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Studying the interaction between climate and anthropogenic activities, specifically those concentrated in megacities/hot spots, requires the description of processes in a very wide range of scales from local, where anthropogenic emissions are concentrated to global where we are interested to study the impact of these sources.

The description of all the processes at all scales within the same numerical implementation is not feasible because of limited computer resources. Therefore, different phenomena are studied by means of different numerical models that can cover different range of scales.

The exchange of information from small to large scale is highly non-trivial though of high interest. In fact uncertainties in large scale simulations are expected to receive large contribution from the most polluted areas where the highly inhomogeneous distribution of sources connected to the intrinsic non-linearity of the processes involved can generate non negligible departures between coarse and fine scale simulations.

In this work a new method is proposed and investigated in a case study (August 2009) using the BOLCHEM model.

Monthly simulations at coarse (0.5° European domain, run A) and fine (0.1° Central Mediterranean domain, run B) horizontal resolution are performed using the coarse resolution as boundary condition for the fine one. Then another coarse resolution run (run C) is performed, in which the high resolution fields remapped on to the coarse grid are used to nudge the concentrations on the Po Valley area. The nudging is applied to all gas and aerosol species of BOLCHEM.

Averaged concentrations and variances over Po Valley and other selected areas for O3 and PM are computed. It is observed that although the variance of run B is markedly larger than that of run A, the variance of run C is smaller because the remapping procedure removes large portion of variance from run B fields. Mean concentrations show some differences depending on species: in general mean values of run C lie between run A and run B. A propagation of the signal outside the nudging region is observed, and is evaluated in terms of differences between coarse resolution (with and without nudging) and fine resolution simulations.