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Scale bridging in atmospheric composition simulation for air quality studies

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The processes determining the atmospheric composition and its evolution cover a wide spectrum of scales, ranging from the global scale (interesting for climate and large scale transport episodes like volcanic eruptions or large forest fires) to the molecular scale (where dissipation of energy takes place along with the basic transformation processes).

Moreover, studying the interaction between climate and anthropogenic activities, specifically those concentrated in megacities/hot spots, require 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).

A complete treatment of these processes implies therefore the ability of connecting their descriptions at the different scales. This connection is already well established in the direction of global-to-regional (or regional-to-local) when the output from coarser models is used to feed boundary conditions into more refined models. This is done routinely, for example, in meteorological applications.

The exchange of information in the reverse sense (i.e. the feed of information from a high resolution model to a coarse resolution model) is higly non-trivial. Such kind of interaction is of high interest expecially for air quality studies. In fact in large scale simulations we expect the largest uncertainties to correspond to the most polluted areas where the highly inhomogeneous distribution of sources together with the intrinsic non-linearity of the processes involved can generate non negligeable departures between coarse and fine scale simulations.

In the work presented here, the nudging approach has been used to force the low resolution chemical composition model using an high resolution run. A numerical experiment simulating the year 2007 is performed to apply the method to the case of the Po Valley hot spot using BOLCHEM, an atmospheric dynamic and composition model in which meteorology and chemistry are coupled online. The results show that in general the forced low resolution model simulation is closer to the high resolution than the non-forced model, and this variation changes with the species and the season. We also observed an influence of the forcing outside of the forcing area and the spread of the effect outside the forcing area is quantified to be at least about 5% over an extension about 9 times larger.