Added value of high resolution for ALADIN Regional Climate Model

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Limited area models have been first designed at 50 km resolution (Giorgi, 1990) and widely used at this horizontal resolution during 15 years (e.g. PRUDENCE European project, http://prudence.dmi.dk, Christensen and Christensen, 2007). Recently international projects target the 25 km resolution (e.g. ENSEMBLES European project, http://www.ensembles-eu.org) or even 10 km resolution (e.g. CECILIA European project, http://www.cecilia-eu.org).

Despite the huge cost of such models when their integration area is large, modelers expect to improve the simulations by getting more realistic surface forcings and by solving the continuous hydrodynamics equations with more accuracy. The result is not always convincing, since the physical parameterizations are generally developed, selected, and sometimes adjusted at lower (and less costly for tests) resolution. Another outcome of a higher resolution is the refinement of the output fields. Some details can appear at high resolution that are absent at coarser resolution. The most obvious example is surface elevation and, as a direct consequence surface temperature. Precipitation may also be improved, provided that the model does not over-simulate mountain forcing and that the model flow has the right direction.

There is a strong demand for regional details by climate impact users. However, given the chaotic behavior of the climate system, there is little chance that an impact simulated with 20 km accuracy by a scenario is a robust feature. From our experience, the agreement between members of ensemble scenarios if found at a much larger scale. However, if we can prove that the details provided by a regional model are in agreement with observation, we demonstrate that the spatial sensitivity of the model is correct. This increases our confidence in its sensitivity to other factors like greenhouse gas concentration.

The difficulty to evaluate the model capacity to resolve 10 km-scale details comes from the lack of high resolution homogeneous climate network. We have a high density of observations in some populated regions, but it hardly covers large areas. At Météo-France, an analysis system, named SAFRAN, has been developed in the 1980s for operational purpose. It has recently been extended back to 1970 and is maintained in real time (Quintana-Seguí et al., 2008). The data cover France on a 8km Lambert grid.

In order to evaluate the added value of using a high resolution model for simulating small spacial scales over France, two ERA40-driven simulations have been carried out with ALADIN. ALADIN is a limited area model used for short-range forecasting by a consortium of European and North-African countries (including Météo-France). It corresponds to a spectral version on a bi-periodicized Lambert grid of the global model ARPEGE (Bubnova et al., 1995). A climate version has been recently developed (Déqué and Somot, 2007). We use here version 4 of the climate model ARPEGE/ALADIN. Two versions on a relatively small domain (as compared with the EU-ENSEMBLES version) covering France have been designed. The first one has a 56 km grid on a Lambert projection centered at 47°N, 2°E with 50 latitudes by 50 longitudes. The second one has a 12 km grid on the same projection and 150 latitudes by 150 longitudes. The free (i.e. not Davies relaxed) part of the two integration domains corresponds to the same area covering France and a 200 km rim around the country. Both versions use exactly the same physical parameterizations (with the same time step, the same diffusion parameters, the same calibration parameters and the same source of soil characteristics). Each model has been integrated over the ERA40 period (1958-2001) and the mean climatology of the 1961-1990 period has been calculated. The two models have very similar systematic errors (somewhat too cold and too rainy), but no detrimental lateral boundary condition effect over France is seen in the precipitation field. One could have feared artificial numerical rainfall near the boarders, due to the small size of the domains.

Table 1 shows the spatial correlation over France of the simulated seasonal climatologies of 2m temperature and precipitation. The model land point data have been interpolated onto the 9304 land points of the SAFRAN grid with triangular interpolation (to minimize smoothing). The large-scale part of a field is obtained by replacing each local value by the spatial average in a 56x56km box centered on the grid point. The small-scale part is then the residual. The correlation is calculated separately for the large-scale and the small-scale parts. If we use raw temperature, ALADIN-12 km will obviously outperform ALADIN-56 km in the small scales because its finer orography. We have therefore used a 6.5 K/km vertical gradient to set the two models and the analysis at the sea level.

As far as the large-scale is concerned, both model have high correlation for temperature, the lower resolution version being slightly better. The precipitation correlation is less, and the higher resolution version is better. As far as the small-scale is concerned, the lower resolution has practically no skill: since the size of the box is the size of its grid mesh, the only small-scale features which remain are the changes in North-South or East-West gradients; these features are created by horizontal interpolation only. For precipitation and, to a lesser extent for temperature (winter and autumn only), the higher resolution version is able to produce relevant information inside the 56x56km boxes.

This result show that going from 56 km to 12 km resolution produces observation-related information. Linear interpolation from a coarser resolution is not equivalent.

		Temperature				Precipitation			
		DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
LS	ALADIN 56 km	0.81	0.91	0.95	0.89	0.66	0.83	0.85	0.64
	ALADIN 12 km	0.79	0.88	0.94	0.86	0.74	0.90	0.92	0.74
SS	ALADIN 56 km	0.11	0.04	0.07	0.12	0.08	0.05	0.07	0.06
	ALADIN 12 km	0.40	0.04	0.06	0.33	0.50	0.54	0.47	0.52

Table 1: Spatial correlation over France for two versions of ALADIN versus SAFRAN analyses for seasonal mean temperature (elevation effects removed) and precipitation. Correlation is calculated separately for large-scale (LS, above 56 km) and small scale (SS, between 12 km and 56 km).

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