Effects of resolution in an RCM: From 50 to 12 km

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Simulations in 3 different resolutions with the Danish regional climate model HIRHAM has been performed and results showing the effect of resolution on the distribtution of precipitation are presented.

The HIRHAM model has been run in a rotated latitude-longitude system with 0.44, 0.22, and 0.11 degrees resolution, roughly corresponding to 50km, 25km, and 12km grid distance, for a domain covering all of Europe. The experiments were run for 2x30 years, a control period (1961-1990) and a scenario period (2071-2100) in accordance to the SRES emission scenario A2.

The boundary conditions consisted of atmospheric fields and sea-surface temperatures from time slice simulations with the high-resolution atmospheric global model HadAM3H from the British Hadley Centre in 1.875x1.25 degrees resolution from the PRUDENCE project (boundary values available at 3.75x2.5 degrees). These time slices receive SSTs from either observations (1961-1990) or in the scenario experiment observations plus an anomaly calculated with the coupled global model HadCM3.

Average precipitation in general, and the effects of orography in particular for a transect through the Alps are compared to the observational data set collected at the ETH in figure 1 and 2.

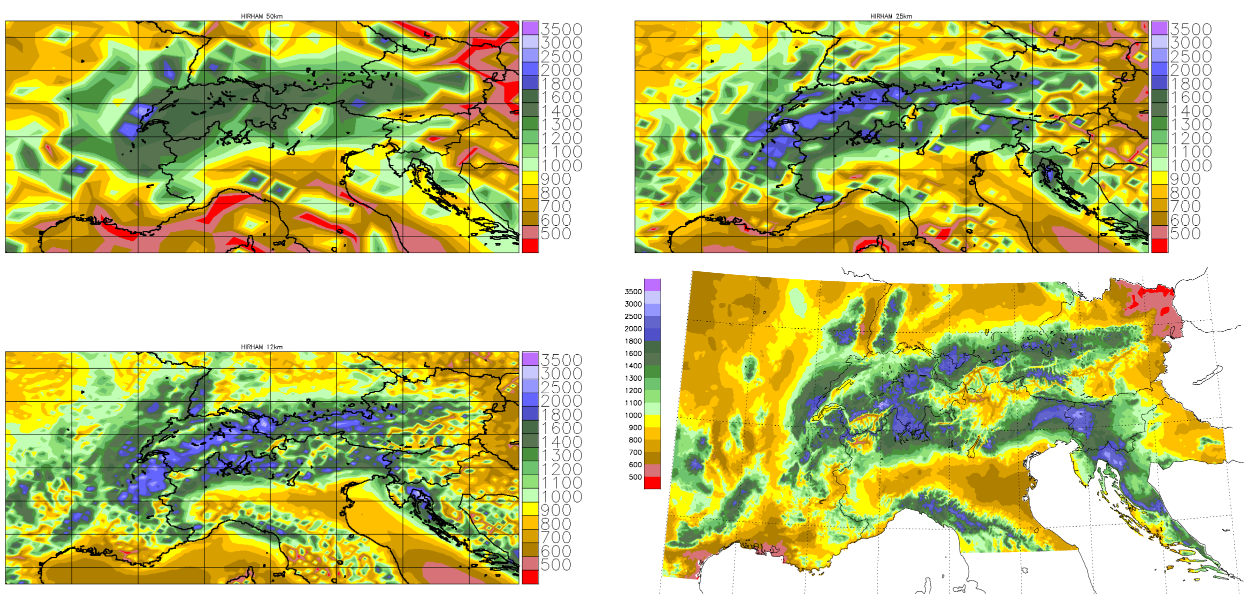

Figure 1. Long-time average of precipitation in the Alps as simulated by HIRHAM in 50 km (upper left figure), 25 km (upper right) and 12 km (lower left) resolution compared to observed climatology (lower right). (Unit: mm/year)

A higher resolution in regional climate simulations is seen to dramatically improve the distribution of precipitation in complex terrain. The very narrow boundary relaxation zone used in these simulations and the absence of a retuning of the physical parameterization does not decrease the quality of large-scale climate features.

Precipitation connected with land-sea contrast has a tendency to fall over water in lower resolution, but moves realistically further inland in higher resolution; see the coast of Croatia in the maps of average precipitation.

In the Alpine transect shown in figure 2, the experiments in 25 and 12 km resolution both show a realistic pattern with maxima in precipitation on the slopes and local minima on the mountain tops; in contrast to this, the 50km experiment shows one broad precipitation maximum, coinciding with mountain tops. For the length scales of this particular mountain chain the important change in realism occurs between 50 and 25 km resolution. For other, smaller orographic features like the Rhône valley or the Apennines there seems to be a transition between 25 and 12 km.

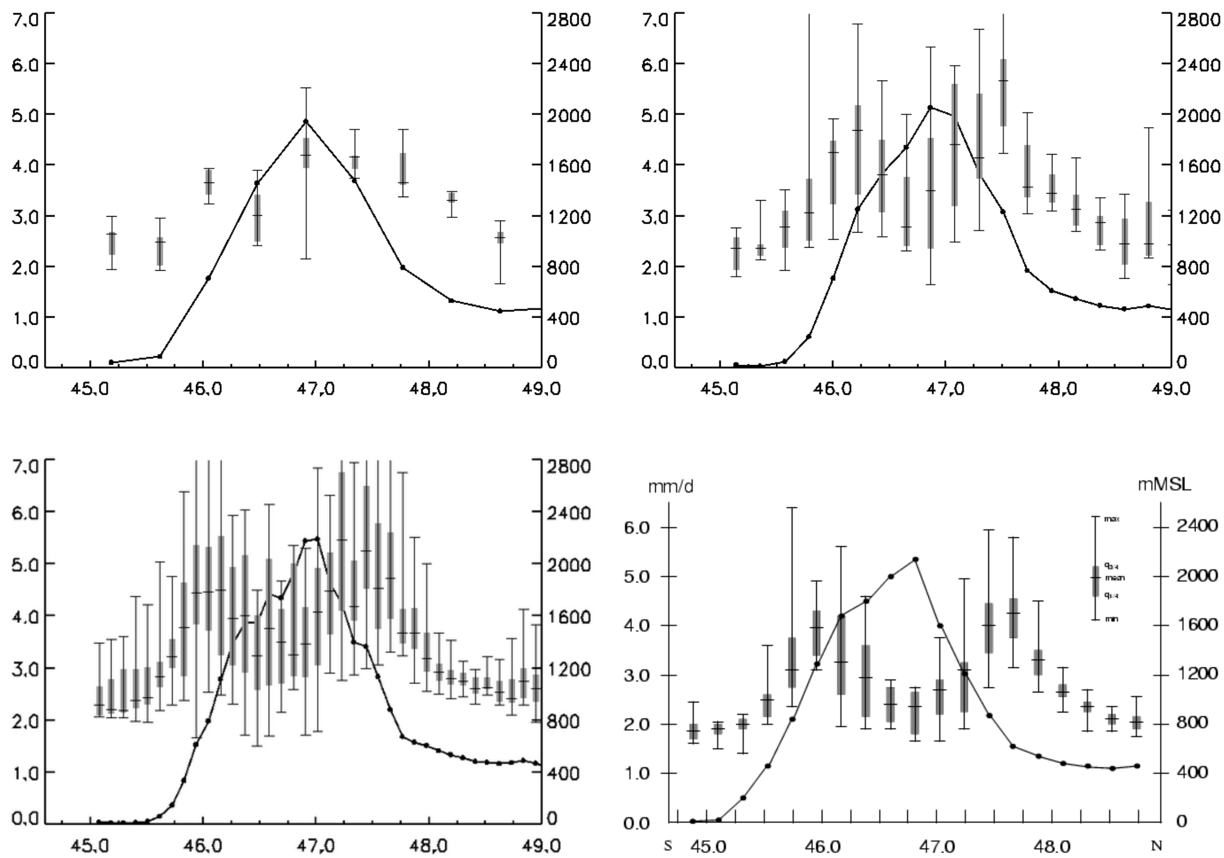

Figure 2. Annual precipitation as a function of latitude for transects through the Alps between 45 and 49 degrees north and 11 and 13.5 degrees east s simulated by HIRHAM in 50 km (upper left figure), 25 km (upper right) and 12 km (lower left) resolution. Thick error bars mark quartiles and thin bars mark extremes across each (model) latitude. The lower figure from Frei and Schär (Int. J. Climatol., 18, 873-900, 1998) shows station data and quantiles from these and are hence not directly comparable to the model results. (Unit: left axis: mm/day, right axis: m above sea level)

Preliminary analysis of the simulations indicate that climate change signals do not show a lot of resolution influence when relative changes are studied. However, this means that absolute precipitation changes are quite different between the different resolutions. This has the consequence that investigations of climate effects on the hydrological cycle in mountain areas like the Alps and in coastal areas are greatly improved by a higher resolution. Examining the intense winter precipitation we again see very little resolution influence on the relative change. Again, this of course means that absolute values will be much more realistically described in a high-resolution experiment. Comparing the relative change in average and the more intense precipitation for the 50km experiment it is seen that the intensity distribution generally just scales, i.e., the change in occurrence of intense precipitation follows what should be expected from the change in average precipitation; there is no general change in the number of wet days or in the shape of the intensity distribution. Further analysis of these experiments will be performed.