# Regional Modelling over Complex Terrain

Martin Widmann, Beate Müller, Julie Jones, and Hans von Storch

System Analysis and Modeling, Institute for Coastal Research
GKSS Research Center, Geesthacht Germany

This contribution to the ALP-IMP project will provide a numerical simulation for the weather in the Alpine Region from 1958 to the present with multi-variable hourly output and a horizontal resolution of about 17 km on 20 vertical levels in the troposphere and lower stratosphere. It will be used for the analysis of topographic effects and mesoscale circulation patterns, and as a basis for climate reconstructions.

Numerical atmospheric models can be used for weather forecasts, for simulations of the past and future climate (they are then usually coupled to other components of the climate systems, such as the ocean and the cryosphere), as well as for a physically consistent interpolation of instrumental observations using data assimilation methods. The latter application led to global atmospheric reanalyses, in which global atmospheric models are forced towards surface and upper-air meteorological measurements of about the last 50 years in order to provide comprehensive information on the atmospheric states for the entire troposphere and lower stratosphere. The major reanalyses currently available are the NCEP/NCAR (National Center for Environmental Prediction/National Center for Environmental Research, USA) reanalysis (Kalnay et al.,1997), which has a spatial resolution of about 200 km in midlatitudes and covers the period 1948 to present, and the recently completed ERA40 reanalysis from the European Center for Medium-Range Weather Forecast, which has a spatial resolution of about 100 km in midlatitudes and is available for the period 1958 to present. In both cases the output is available every 6 hours.

Due to their relatively low spatial resolution, which results from limitations in computer power, the global reanalyses do not realistically describe mesoscale features of the weather in the Alpine region, since these are strongly influenced by the complex topography and by processes on spatial scales not resolved by the global models. This problem, which also occurs in numerical weather prediction and in climate simulations, can be overcome by deriving local or regional information from the global model output either by statistical downscaling methods, or by forcing a high-resolution model for a limited area with the global model simulation. The second approach is suitable for ALP-IMP, where high-resolution, four-dimensional, multi-variate atmospheric states for the Alpine region are needed for process analyses and as input for climate reconstructions.

The regional model that will be used for ALP-IMP is REMO (REgional MOdel, Jacob and Podzun, 1997). It is based on the dynamical core of the numerical weather prediction model EM of the German Weather Forecast Service (DWD) and parameterisations for non-resolved processes taken from the ECHAM4 climate model of the Max-Planck-Instititute for Meteorology in Hamburg. In a systematic comparison (Frei et al., 2003) this model compared well with other regional models. It has already been used in two long simulations for Europe, both with a spatial resolution of about 50 km. In the simulation by Jacob and Podzun (2001), which covers the period 1979 to 1993, the model was forced at the lateral boundaries with an earlier version of the global ERA reanalysis (ERA15), whereas the simulation by von Storch et al. (2000), which covers the period 1958 to 1998 additionally applied a spectral nudging technique (see also Waldron et al., 1996) inside the model domain. The second approach keeps the regional simulation close to the global model state on large spatial scales that are realistically simulated by the global model, while regional features may evolve independently from the forcing. Spectral nudging has been shown to have the advantage of reducing unrealistic large-scale ensemble variability in multiple simulations with identical large-scale forcing (Weisse et al., 2003), and, by comparison of regional simulations with satellite observation, of leading to more realistic positions of frontal systems (Keup-Thiel et al., 2003).

Simulations with 50 km resolution are still too coarse to resolve many important aspects of the atmospheric circulation over complex topography. A ten year long REMO simulation with about 17 km resolution, forced by the ERA15 reanalysis, showed substantial improvements over the Alpine area (D. Jacob, pers. com.). Within ALP-IMP we will produce a simulation for the full ERA40 period 1958 to present with about 17 km resolution, driven by the ERA40 reanalysis using spectral nudging. The model will be run at the German Climate Computation Centre (DKRZ), where the currently installed computer power allows a model domain that covers most of Europe (see Fig.1). The resulting state-of-the-art, high-resolution analysis of the European weather since 1958 will have a wide range of potential applications.

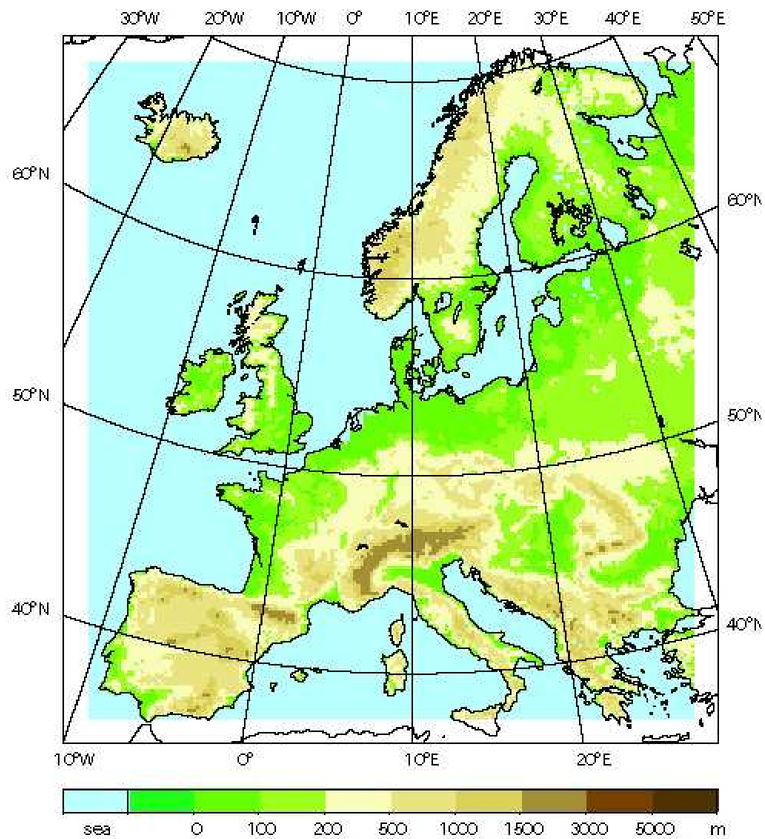


Figure 1: Domain and topography of the regional model that will be used for the ALP-IMP simulations. The boundary region in which the lateral forcing from the ERA40 reanalysis leads to unrealistic boundary effects is not shaded.

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