COMPARISON OF A HIGH-RESOLUTION REGIONAL SIMULATION AND THE ERA40 REANALYSIS OVER THE ALPINE REGION

Kerstin Prömmel, Beate Müller, Martin Widmann, Julie Jones

GKSS Research Centre, Max-Planck-Str. 1, 21502 Geesthacht, Germany
E-mail: *kerstin.proemmel@gkss.de*

Abstract: Within the EU project ALP-IMP a high-resolution regional simulation driven by the ERA40 reanalysis has been performed for the Greater Alpine Region (GAR) for the period 1958 to the present. A comparison of the high-resolution simulation and the ERA40 reanalysis regridded to 1 deg resolution with four different monthly mean temperature datasets for the GAR shows for both very high correlations of around 0.9, and in general slightly higher correlations for the regional simulation. Correlations of the regional simulation and the reanalysis with observations increase with spacial scale. The separation of the GAR into six subregions identifies the Po plain as a region where the high-resolution simulation as well as ERA40 have problems in reproducing the instrumental measurements.

***Keywords** - ALP-IMP, high-resolution regional modelling, REMO, ERA40 reanalysis*

1. INTRODUCTION

The numerical simulation of weather and climate over the Alpine region is a challenge because of the complex topography. To include a realistic topography in a climate model a very high resolution is needed. The comparison of the skill of a high-resolution simulation driven by the ERA40 reanalysis with the reanalysis itself allows to analyze whether the higher resolution leads to an added value. The high-resolution simulation described in this study covers the period from 1958 to the present with multi-variable hourly output.

2. MODEL

The high-resolution regional simulation has been performed with REMO (REgional MOdel, Jacob and Podzun, 1997). The dynamical core of REMO is based on the numerical weather prediction model EM of the German Weather Service (DWD) and the parameterisations are taken from the ECHAM4 climate model of the Max-Planck-Institute for Meteorology in Hamburg.

The REMO simulation discussed here has a very high horizontal resolution of 1/6 degree on 20 vertical levels in the troposphere and lower stratosphere. It is driven by the approximately 1.12 degree resolution ERA40 reanalysis through prescribing the values at the lateral boundaries and through forcing the large-scale wind field within the model domain by the spectral nudging technique (von Storch et al., 2000).

3. COMPARISON WITH INSTRUMENTAL DATASETS

Both the REMO simulation and the ERA40 reanalysis (regridded to 1 degree resolution) are compared with different monthly mean temperature datasets for the GAR. One is the gridded temperature dataset of the Climate Research Unit (CRU TS 2.0, Mitchell et al., 2003) with a resolution of 1/2 degree. The others are the recently completed HISTALP datasets, which contain one station dataset consisting of 131 long temperature series back to a maximum of 1760 and two

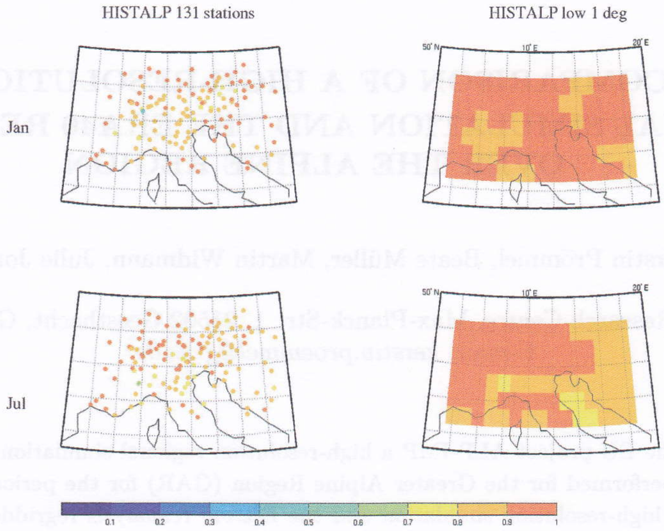

Figure 1: Correlations of monthly mean temperatures between the REMO simulation and the HISTALP station dataset and REMO and the HISTALP gridded dataset from low-elevation stations for January and July.

Table 1: Definition of the subregions

No.	Definition
1	West (Maritime)
2	East (Continental)
3	South (Adriatic)
4	Po Plain
5	Central Alpine Low Level
6	High Level (>1400 m a.s.l.)

gridded temperature anomaly datasets of 1 degree resolution derived from the station series, one from low- (HISTALP low) and one from high-elevation stations (HISTALP high). The comparison between REMO (ERA40) and the three gridded datasets is done for the resolutions of 1/6 deg, 1/2 deg, 1 deg, 2 deg and 3 deg (1/2 deg, 1 deg, 2 deg and 3 deg).

The correlation between REMO and the datasets and ERA40 and the datasets is calculated monthly for the period from 1958 to the present for each gridpoint. As an example for the correlation maps obtained, the correlations between REMO and the HISTALP station dataset and REMO and HISTALP low are shown for January and July in Fig. 1. To discuss the results the correlations are averaged over the whole Alpine area ranging from 3.5 deg to 18.5 deg west and 42.5 deg to 49.5 deg north and additionally over six subregions (Table 1) defined by Böhm et al. (2001).

3.1. REMO

The seasonal cycle of the Alpine area mean correlations is nearly identical for all datasets and resolutions and therefore represents a basic property of the REMO simulation. There are two peaks in the seasonal cycle, one around March and one in September with values around 0.95. The two minima occur in August and November with values around 0.88. The comparison of the correlations of REMO with the different datasets shows that the lowest correlations occur between REMO and the HISTALP station dataset almost during the whole year and the highest

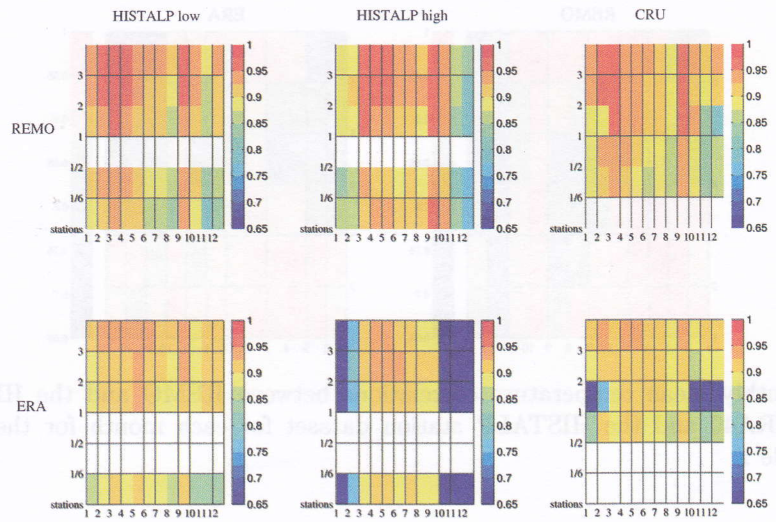

Figure 2: Monthly mean temperature correlations between REMO and the three gridded datasets and ERA40 and the datasets for each month for the five different resolutions and the HISTALP stations averaged over the Alpine area. The datasets are the HISTALP dataset from low-elevation stations (HISTALP low), the HISTALP dataset from high-elevation stations (HISTALP high) and the CRU dataset (CRU), the resolutions are 1/6 deg, 1/2 deg, 1 deg, 2 deg and 3 deg and the stations are those on which the HISTALP low and HISTALP high datasets are based, respectively.

correlations occur between REMO and HISTALP low. All correlations between REMO and the datasets increase with resolution (Fig. 2).

The Alpine area mean bias shows that the REMO simulation is too warm during the whole year (not shown). From May to October the bias amounts to more than 1 K with the highest values in July and August. In winter the bias is around 0 K. For all resolutions the bias has similar values.

The correlations averaged over the six different subregions are lowest for subregion 4, the Po Plain (Fig. 3). The highest correlations are found either for subregion 1, 2 or 6, i.e. West (Maritime), East (Continental) or High Level.

3.2. ERA40

For all resolutions and datasets except for the HISTALP gridded dataset from high-elevation stations the seasonal cycles of the Alpine area mean correlations are similar among each other but not very pronounced. The highest correlations occur in September and from February to May (around 0.92), the lowest in August and from October to January (around 0.88). In comparison to the correlations between ERA40 and the gridded datasets the correlation between ERA40 and the HISTALP station dataset is lowest of all datasets during the whole year and, as for REMO, the correlations increase with resolution (Fig. 2). The correlations of the HISTALP gridded datasets from high-elevation stations have for all resolutions a very clear seasonal cycle with highest values from March to September und very low values from October to February.

The Alpine area mean bias is negative from April to September with the most negative values around -1.5 K from May to July (not shown). During the remaining year the bias is around 0 K. The bias does not differ much for the different resolutions.

The separation into the six subregions shows that the area mean correlations are lowest for subregions 4 and 5, the Po Plain and the Central Alpine Low Level and from October to February for subregion 6, High Level. The highest correlations occur for the subregions 1 and 2, West

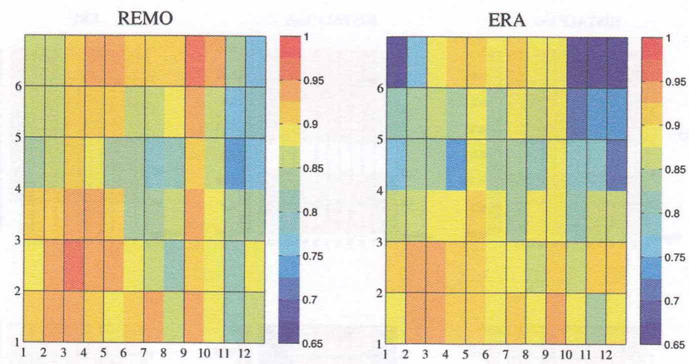

Figure 3: Monthly mean temperature correlations between REMO and the HISTALP station dataset and ERA40 and the HISTALP station dataset for each month for the six subregions defined in Table 1.

(Maritime) and East (Continental) (Fig. 3).

4. CONCLUSIONS

For all four different datasets (CRU, HISTALP stations, HISTALP gridded from low- and from high-elevation stations) and all resolutions the REMO simulation has slightly higher monthly mean temperature correlations than the ERA40 reanalysis nearly during the whole year. For both REMO and ERA40 it is evident that the Alpine area mean correlation increases continuously with spatial scale.

By separating the GAR into six subregions the Po plain can be identified as a region of which the temperature is difficult to reproduce, especially during summer and winter. In summer, instabilities are very frequent in this region which cause convection and showers which lead to a cooling. In winter, heavy fog occurs frequently. Those weather phenomena are apparently difficult to simulate, even with a regional model.

As future work it is planned to calculate the correlations from daily values and to compare simulated precipitation with observational datasets in the GAR.

REFERENCES

Böhm, R., I. Auer, M. Brunetti, M. Maugeri, T. Nanni, W. Schöner, 2001: Regional Temperature Variability in the European Alps: 1760-1998 from Homogenized Instrumental Time Series, *International Journal of Climatology*, **21**, 1779-1801.

Jacob, D. and R. Podzun, 1997: Sensitivity Studies with the Regional Climate Model REMO, *Meteorology and Atmospheric Physics*, **63**, 119-129.

Mitchell, T.D., T.R. Carter, P.D. Jones, M. Hulme, M. New, 2003: A Comprehensive Set of High-resolution Grids of Monthly Climate for Europe and the Globe: the Observed Record (1901-2000) and 16 Scenarios (2001-2100). *Journal of Climate*: submitted.

von Storch, H., H. Langenberg, F. Feser, 2000: A Spectral Nudging Technique for Dynamical Downscaling Purposes, *Monthly Weather Review*, **128**, 3664-3673.