High-resolution simulation for the Alpine climate since 1958 – validation on monthly and daily timescales

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A high-resolution regional simulation for Europe performed with REMO (REgional MOdel, Jacob and Podzun, 1997) for the period 1958 to 1998 has been analyzed with focus on the Greater Alpine Region (GAR) with its complex topography.

The dynamical core of REMO is based on the numerical weather prediction model EM (Europa Modell) of the German Weather Service and the parameterizations are taken from the ECHAM4 climate model of the Max-Planck-Institute for Meteorology. The simulation discussed here has a very high horizontal resolution of 1/6 deg on 20 vertical levels in the troposphere and lower stratosphere. It is driven by the 1.12 deg 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).

To validate the REMO simulation on different timescales, first, it is compared to the HISTALP monthly mean temperature station dataset for the GAR consisting of 131 long temperature series with a maximum length of nearly 250 years (Auer et al., 2005). Second, the simulation is compared to a daily mean temperature station dataset for Austria and Switzerland. To analyze whether the high resolution of the simulation leads to an added value in comparison to the ERA40 reanalysis, the reanalysis is also compared to both station datasets. The complex topography of the Alps can not be fully captured by REMO and ERA, which leads to large differences in altitude between the stations and the corresponding grid points. Therefore, a mean altitude correction of 0.65K/100m was applied to the model data.

The comparison is done by calculating correlation, bias and root mean squared error between the stations and the corresponding model grid points. The resulting values are averaged over six subregions defined by Böhm et al. (2001), namely West (Maritime), East (Continental), South (Adriatic), Po Plain, Central Alpine Low Level (CALL) and High Level (CAHL) (Fig. 2).

On the monthly timescale the correlations between the simulations and the HISTALP stations are generally high with lowest values in December and January of 0.63 to 0.91 and highest values in spring and autumn of 0.92 to 0.97. For West, East, South and Po Plain ERA has slightly higher monthly mean temperature correlations than REMO during nearly the whole year whereas for CAHL the opposite is true. For subregion CALL ERA and REMO have the same correlations.

The correlations between the simulations and the daily mean temperature dataset, which is limited to subregions West, East, CALL and CAHL (Fig. 4), are generally high with lowest values in winter and highest values in spring and summer. Except for East REMO has higher correlations than ERA during the whole year.

The monthly bias is positive (0 to 3 K) for both simulations and all subregions except CAHL during the whole year. REMO has for all subregions largest bias in late summer and smallest bias in winter and spring except for CAHL where temperature simulated by REMO is too warm in summer and too cold in winter. The ERA bias for West, East, South and Po Plain is in summer smaller and in winter larger than the REMO bias. For CAHL the opposite is true and for CALL the ERA bias is smaller only in autumn. The daily bias shows no differences to the bias on a monthly timescale.

As an indicator of the skill of REMO relative to ERA, the reduction of error has been calculated. Positive values indicate the magnitude of improvement of REMO in comparison to

ERA. On the monthly timescale REMO shows a slight improvement for all subregions except CAHL in winter and early spring (Fig. 1). In CALL this improvement ranges even from November to July. In CAHL REMO shows no improvement in winter due to the larger bias whereas the improvement from April to November is due to the smaller bias. REMO performs worst in East, South and Po Plain in summer.

The reduction of error on the daily timescale shows an improvement of REMO in comparison to ERA for subregions West, CALL and especially CAHL during nearly the whole year which is most pronounced in summer (Fig. 3). For subregion East REMO shows no improvement at all.

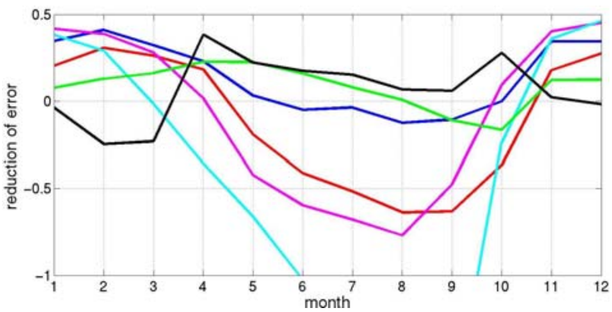

Fig 1: Reduction of error based on monthly mean temperature data averaged over six subregions.

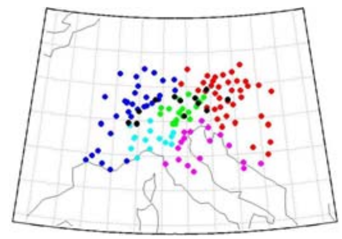

Fig 2: Monthly mean station dataset.

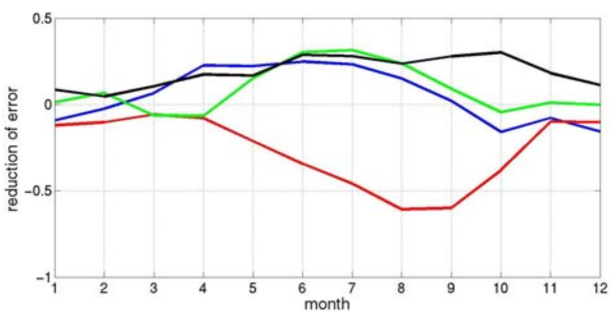

Fig 3: Reduction of error based on daily mean temperature data averaged over four subregions.

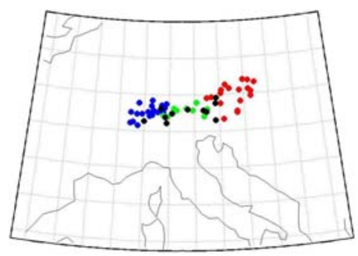

Fig 4: Daily mean station dataset.

To conclude, on the monthly timescale the higher resolution of REMO leads to an added value in comparison to ERA in winter and early spring and for the inner Alpine low and high level stations with more complex topography also in early summer. On the daily timescale REMO performs better than ERA during nearly the whole year for the inner Alpine regions and subregion West. The good performance of ERA can be explained by the fact that the observed temperature is an input variable for the reanalysis whereas REMO has to calculate the temperature.

References:

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