EVALUATION OF RETROSPECTIVE REGIONAL CLIMATE MODEL RUNS WITH VERA WITHIN THE PROJECT RECLIP:MORE

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Abstract: The 3-year project "Research for Climate Protection: Model Run Evaluation" (reclip:more) is a cooperation of five academic institutions in Austria The major aim of the project is to evaluate the capability of dynamical and statistical downscaling methods in the Alpine region to create climate scenarios at mesoscale and microscale resolutions. Two regional circulation models ALADIN and the PSU/NCAR mesoscale model MM5 will be driven by ERA-40 reanalysis data and ECHAM5 global circulation model (GCM) results, representing current (1991-2000) and future (2041-2050) climate to accomplish dynamical downscaling from the coarse GCM resolution (spectral truncation T106, i.e. ~120 km horizontal resolution) to 10-15 km. The evaluation of the 2D surface fields of the retrospective runs are performed with the Vienna Enhanced Resolution Analyses (VERA) scheme. VERA produces model independent 2D analyses of meteorological parameters on a regular grid. The comparison will cover single extreme events, an annual cycle and a ten year period. The results will serve as a criteria to find the best model set up for the prospective runs.

Keywords – *RCM, dynamical downscaling, VERA, model evaluation*

1. INTRODUCTION

A reliable assessment of future climate impacts in Austria makes necessary to provide regional climate model (RCM) runs, and additional tasks to deliver high resolution downscaled datasets for past and future climate targeting the entire eastern alps covering Austria. The project reclip:more (Research for Climate Protection: Model Run Evaluation) is a cooperation of five academic institutions: The Department of Meteorology and Geophysics of Vienna University (IMG), the Institute of Meteorology of Vienna University of Natural Resources and Applied Life Sciences (BOKU-Met), the Institute for Geophysics, Astrophysics and Meteorology of the Graz University (IGAM), the Central Institute for Meteorology and Geodynamics (ZAMG) and ARC systems research GmbH (Environmental Planning Department), which is leading the project.

The major goal of the project is to provide future regional climate model scenarios for Austria at meso- and microscale resolutions by applying regional climate models and statistical downscaling methods and to evaluate the capability of the applied models and methods to create climate scenarios for the Alpine region. The goals besides providing climate scenario data are (1) – quantify the uncertainties of regional climate simulations related to observed climate data, (2) – investigate the sensitivity of regional climate simulations and interpolated climate data to the influence of different model parameters and data processing techniques. To achieve this, data preparations, a set of common model experiments and data evaluations have to be carried out.

Two regional circulation models – the French ALADIN model and the US/Canadian mesoscale model MM5 – will be driven by ERA-40 reanalysis data and by ECHAM5 global circulation model (GCM) results, representing current (1991-2000) and future (2041-2050) climate to accomplish dynamical downscaling from the coarse GCM resolution (spectral truncation T106, i.e. ~120 km horizontal resolution) to 15 km. Further downscaling to 1 km resolution will be accomplished by statistical methods. The model validation tasks will provide a benchmarking of the 2 regional circulation models. For further information on the project reclip:more see Loibl et al., 2004.

This paper focus on the evaluation module of the surface fields of the retrospective model runs with the Vienna Enhanced Resolution Analysis (VERA) scheme. First and preliminary results will be discussed.

2. EVALUATION STRATEGY FOR SURFACE FIELDS

The horizontal resolution of the used RCMs (10 km to 15 km) is still too coarse to compare instantaneous values of surface stations especially over complex terrain with nearby model grid points. In addition, the model analysed fields do not represent an independent source for evaluating a model run since they represent mainly the first guess field in data sparse areas. The analysis tool VERA fits this gap. The method is based on an integral of squared second spatial derivatives, which is minimised. The second derivatives are obtained from overlapping finite elements using a polynomial approach (Steinacker et al. 2000). Furthermore, it includes a sophisticated Bayesian quality control tool. This is one of the fundamentals of this method, as a good data quality is absolutely necessary to obtain meteorologically and physically reliable analyses fields (Häberli et al., 2004). Downscaling of the fields in data sparse areas is performed by using the fingerprint technique, which introduces an physical a priori knowledge of the field distribution over complex terrain (Ratheiser et al., 2005).

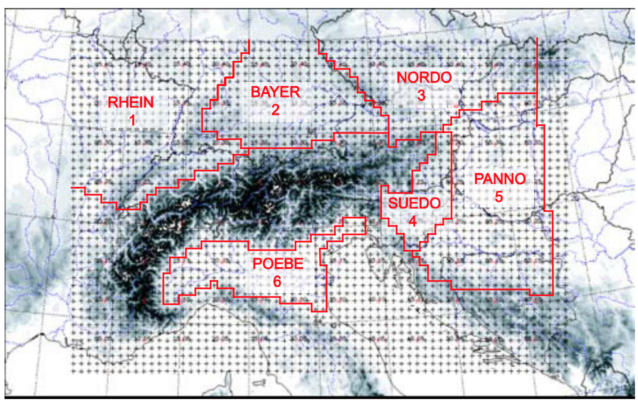

Figure 1. VERA grid (20 km grid distance) and domain. Red marked areas and numbers indicate regions for which the statistical verification measures are determined.

VERA produces surface fields of potential temperature, equivalent potential temperature, mean sea level pressure and 10m wind on a regular basis without using a first guess field. It is therefore best suited to serve as an independent reference for model evaluations. The analysis domain covers the larger Alpine region (see Fig. 1). Since the VERA parameters like potential temperature and equivalent potential temperature are not standard model output parameters, they are calculated from the appropriate model parameters from the model surface or from the lowest model level, respectively. In a second step the model data are interpolated to the VERA grid by using the Cressman approach. In a final step the differences between the VERA topography and the model topography are taken into account by using the standard atmosphere for the vertical interpolation.

The resulting fields (difference fields between model forecasts and VERA analyses) are investigated on a statistical basis. Subdomains according to Fig. 1 are defined to study the behaviour of the RCMs for different climate regions. The comparison will cover single extreme events, an annual cycle (1999, including the MAP-SOP) and a ten year period (1991-2000).

3. RESULTS

In the following some preliminary results of the comparison with the "annual" run of the ALADIN model are discussed. ALADIN is used for dynamical downscaling of the ERA40 data. The model set up consists of a one way nesting in ERA40 fields (T159, ~120 km, 60 levels). ALADIN is initialised on a daily basis (00 UTC) and performs a 30 hour forecast run. The boundaries are updated with ERA40 data every 6 hours. ALADIN is a spectral model with a horizontal resolution of ~12 km and 40 levels. The model domain covers Central Europe (2800 km x 2500 km) with the Alpine region in the centre.

Surface parameters as used in the VERA scheme are not direct model output (DMO) parameters of any RCM. They are determined in a post processing step, e.g. mean sea level pressure (MSLP) or they are calculated by us from DMO parameters, e.g. equivalent potential temperature. However, a modified reduction method for the MSLP field is used in the model to suppress thermal pressure features (heat low, cold high) over complex terrain. This leads to large differences between model field and analyzed field as shown in Fig. 2, left panel for July 1999. The values are higher of up to 5 hPa in the model than in the analysis over the Alpine Region. If the standard reduction formula for the model surface pressure field is applied the differences almost disappear and a very good agreement between model and analysis can be found (Fig. 2, right panel). The latter approach has the advantage that both data sources for the comparison (model surface pressure field and SYNOP pressure observations) are treated with the same method.

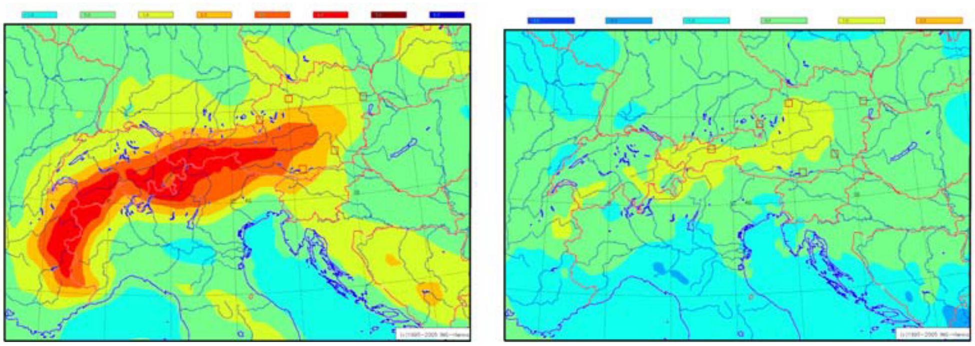

Figure 2. BIAS of mean sea level pressure (ALADIN-VERA) for July 1999. Positive values (red colours): forecasted values are higher than analyzed values; negative values (blue colours) forecasted values are lower than analyzed values. Left panel: BIAS estimated by using pressure reduction formulae as implemented in the model; right panel: BIAS estimated by using standard pressure reduction formulae.

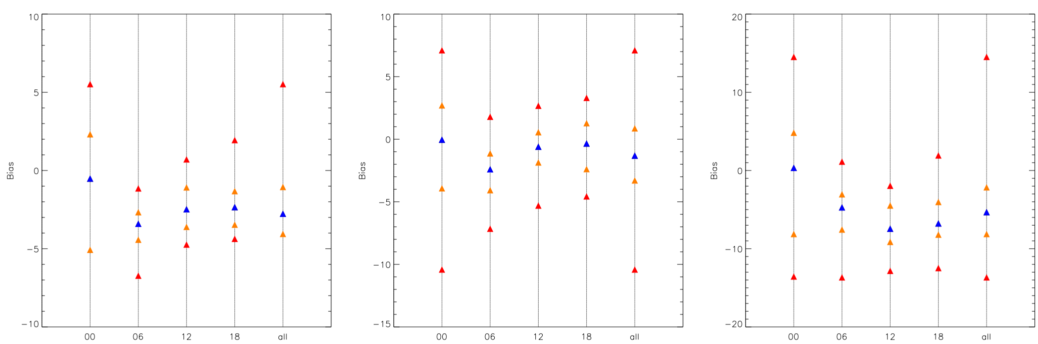

Figure 3. BIAS of equivalent potential temperature (ALADIN-VERA) for July 1999 for the sum of all climate regions (see. Fig. 1, left), for the climate region BAYER (center) and for the climate region POEBE (right) stratified according to 6 hourly intervals (00, 06, 12, 18) and the whole month (all, right column). Blue triangles: median; orange triangles: upper (0.75) and lower (0.25) quartile; red triangles: maximum and minimum.

Fig. 3 shows the BIAS of the equivalent temperature for July 1999 and roughly its diurnal fluctuation on a 6 hour interval. The left panel represents the results for all grid points according to climate regions 1 to 6 (see Fig. 1), the same for the climate region BAYER (north of the Alps) in the centre and for the climate region POEBE (south of the Alps) on the right panel. In all cases the median shows the smallest BIAS around 0 K for 00 UTC. On the other hand upper and lower quartile as well as minimum and maximum values extend over a larger range than for the other times. The BIAS are systematically negative in all cases which indicate that the model forecast is too cold compared to the analysis. The median shows a BIAS between - 3 K and - 4 K for the sum of all climate regions with the lowest value for 06 UTC. The climate region BAYER (centre panel) shows smaller values for the BIAS throughout the day. A pronounced BIAS in the afternoon hours (12 UTC and 18 UTC) of up to – 8 K in the median indicates a severe problem in the model forecast for the climate region POEBE (right panel). The comparison of the potential temperature and mixing ratio fields (not shown) gives some hints that ALADIN has problems to moisten the lowest layers adequately.

4. CONCLUSON AND OUTLOOK

In the first project year of reclip:more the evaluation strategy for surface fields has been worked out and implemented. Since the parameters of the evaluation tool VERA are not direct DMO parameters they are produced by a post processing step of the used ALADIN model. It could be shown that in the case of MSLP this leads to unrealistic features especially over complex terrain. The reason is a modified reduction method used in the model which suppresses the generation of thermal pressure features over the Alpine Region.

The results shown in this paper for July 1999 indicate that ALADIN has some problems in moistening the lowest atmospheric layer over the Po-valley. This leads to a BIAS of – 8 K in the median for the equivalent potential temperature in the afternoon hours. The further evaluation of the RCM runs with VERA is under progress, however, the model independent comparison of surface fields seems to have a large potential to undercover possible model deficiencies.

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