Evaluation of empirical-statistical error correction of daily precipitation from a regional climate model in the Alpine Region

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Introduction

Regional climate models (RCMs) considerably advanced in reproducing the historical state of climate in meso-scale resolution, but are nevertheless still known to feature systematic errors. Particularly, small-scale patterns of daily precipitation are highly dependent on model resolution and parameterization and can frequently not be used directly in climate impact assessment studies.

This study aims to enhance the quality of daily precipitation time series from RCMs and to explore the performance of empirical-statistical RCM post-processing techniques for model error correction. For this purpose the ability of an ensemble of post-processing techniques is tested.

Methods

Four empirical-statistical post-processing methods have been applied to daily RCM precipitation time series. These approaches are

- Local scaling (LS) [3]
- Quantile mapping (QM) [4]
- Multiple linear regression (MLR) [5]
- Multiple linear regression using randomization (MLRandom) [6].

All methodologies are applied point-wise. LS and QM modify climate model precipitation amount. The linear regression approaches calibrate their transfer functions based on various meteorological parameters. The parameter-combinations are derived by objective predictor-selection. For rough pre-selection a stepwise screening procedure is applied. Subsequently, an all subset regression selects the four most determining predictors.

Study Region & Data

Study Region

- Location: Austria
- Characteristics: Diverse/mountainous orography and diverse climate conditions within a few hundred kilometers

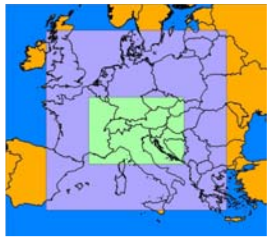
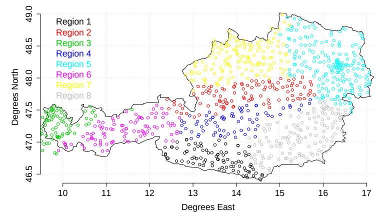


Figure 2: Spatial extend of the regional climate Model (MM5) domain. The green area covers the Greater Alpine region with a grid point distance of 10 km[1].



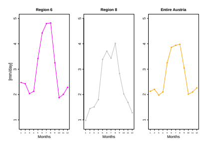


Figure 1: (Upper panel): Observational stations in Austria. The stations are clustered in homogenous precipitation regions. (Left panel): Precipitation climatologies of selected regions 1981-1990/1999.

Observational Station Data

- Parameter: Precipitation
- Temporal resolution: Daily, 1981-1999
- Characteristics: 919 stations (Fig. 1), quality checked, first order homogenized

Climate Model Data

- Parameters: Precipitation, surface air pressure, humidity, temperature, wind, geopotential height on surface and/or 850, 700, 500 hPa
- Temporal resolution: Daily, 1981-1990 and single year 1999
- Spatial resolution: 10 km regular grid, Greater Alpine region (Fig. 2)
- RCM: Mesoscale model MM5 [2]

Results

The methods' performances are evaluated under different climatic conditions around the alpine ridge. For this purpose eight homogenous precipitation sub-regions (Fig. 1) have been defined by clustering the observed daily precipitation time series. Exemplarily, the results are shown for region 6 and 8 as well as for entire Austria. The evaluation is performed within a cross validation framework.
Box and whisker plots display the seasonal and annual differences between model and observed precipitation (Figs. 3-5). Taylor diagrams show the temporal variance and correlation characteristics of the models compared to observational data (Figs. 6-8). The results are color-coded: RCM (black), LS (red), QM (green), MLR (blue), MLR random (light-blue).

- →*QM and LS virtually remove the model bias (bias near zero)*
- →*QM and LS improvement is up to ~ 2.8 mm/day*
- →*QM and LS adapt the model-observation variance ratio to near one*
- →*MLR and MLRandom partially enhance bias characteristics*
- →*MLR underestimates the variance, MLRandom adapts variance ratio to near one*
- →*MLRrandom increases the range of differences due to the noise term*
- →*MLRrandom downgrades RMS and correlation*

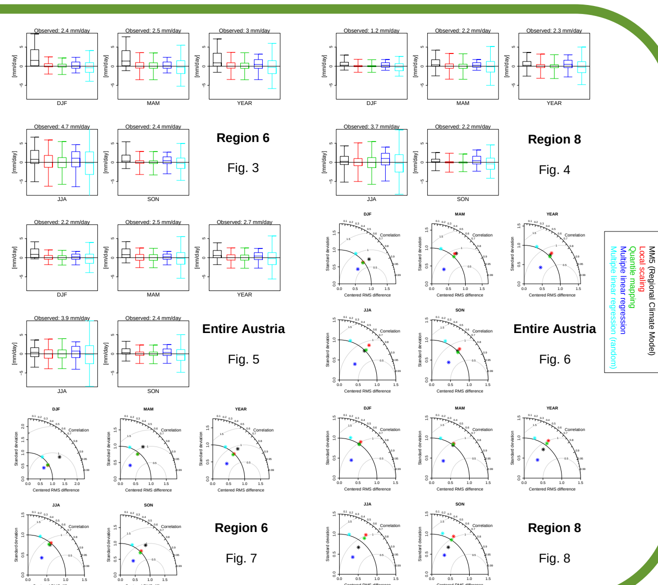


Figure 3-5: Box and whisker plots display the median seasonal and annual differences between model and observation as lines in the middle of 25 and 75 quantile boxes. Additionally "whiskers" show the 10 and 90 quantiles. Observed mean climatologies are given in the header.
Figure 6-8: Taylor diagrams showing the temporal variance and correlation characteristics of the models compared to observational data. The distance to point 1 on the abscissa (grey circle) represents the centred RMS distance to the observation, the radial distance to the zero point represents the variance ratio between model and observation, and the angle between the abscissa and the model vector represents the correlation between model and observation.

Conclusion & Outlook

The results supports the application of climate model post-processing techniques in climate change impact research. Even in summer and in complex terrain, QM and LS drastically enhance the quality (mean and variance) of daily precipitation time series from a regional climate model. Concerning MLR, the linear framework handicaps the modeling of non-normal distributed daily precipitation (remaining biases) and reduces variability. The additional technique of randomization is suitable for adapting variability at the expenses of worse temporal correlation.

Further studies will include the analog method and analyze the shown results according to extremes. Moreover, the construction of climate scenarios and the quantification of impacts of post-processing techniques on these scenarios is planned.

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