Comparison of post-processing techniques for COSMO-CLM precipitation over the Po basin

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Introduction

The ultimate aim of this work is to produce reliable future climate scenarios necessary for impact assessments of climate change. Impacts studies often need climate information on very small scale since hydrogeological risks usually affect localized areas. Moreover hydrological models are sensitive to bias in the forcing data, and post-processing or bias correction methods should therefore be applied to climate data before their use in hydrological models. The two traditional methods generally used to perform the downscaling of climate scenarios, statistical and dynamical, are here used together in order to combine their advantages. In this work we compare results obtained using three different statistical post-processing methods directly applied to the RCM outputs following the Model Output Statistics (MOS) approach. These methods have been tested over the Po river basin, that is an interesting domain to study the impact of climate change on the hydrogeological risk due to its vulnerability and to its complex orography and its climatic variability.

Data and methods

MODEL DATA

The dynamical downscaling is performed using the non-hydrostatic regional climate model COSMO-CLM, with horizontal resolution of 8 km. Three simulations have been considered:

1. **ERA40 driven** simulation for the baseline period 1971-2000
2. **CMCC-MED driven** simulation using the 20C3M control scenario (1971-2000)
3. **CMCC-MED driven** simulation using the RCP4.5 IPCC scenario (focus on 2071-2100)

OBSERVED DATA

The observed data of daily precipitation are provided by ARPA Emilia Romagna over a gridded dataset based on 1128 precipitation stations covering the Po basin over the period 1971-2000 [1,2].

The performances of the MOS methods have been evaluated by means of a leave-one-out-cross-validation. The methods are assessed in terms of spatial similarity of three ETCCDI indices between observed dataset and downscaled fields at seasonal scale.

ETCCDI indices

LABEL	DESCRIPTION	UNITS
1 - PRCPTOT	Total precipitation	mm
2 - R1	Number of days with precipitation over 1 mm/day (i.e. rainy days)	day
3 - RX1DAY	Maximum precipitation in 1day	mm

MOS METHODS

Three different methods of increasing complexity [3]:

1. Linear Scaling (LS) → It consists in correcting the monthly differences between observed and simulated precipitation values

$$P^*(d) = P(d) \cdot \frac{\mu_m(P_{obs}(d))}{\mu_m(P_{rcm}(d))}$$

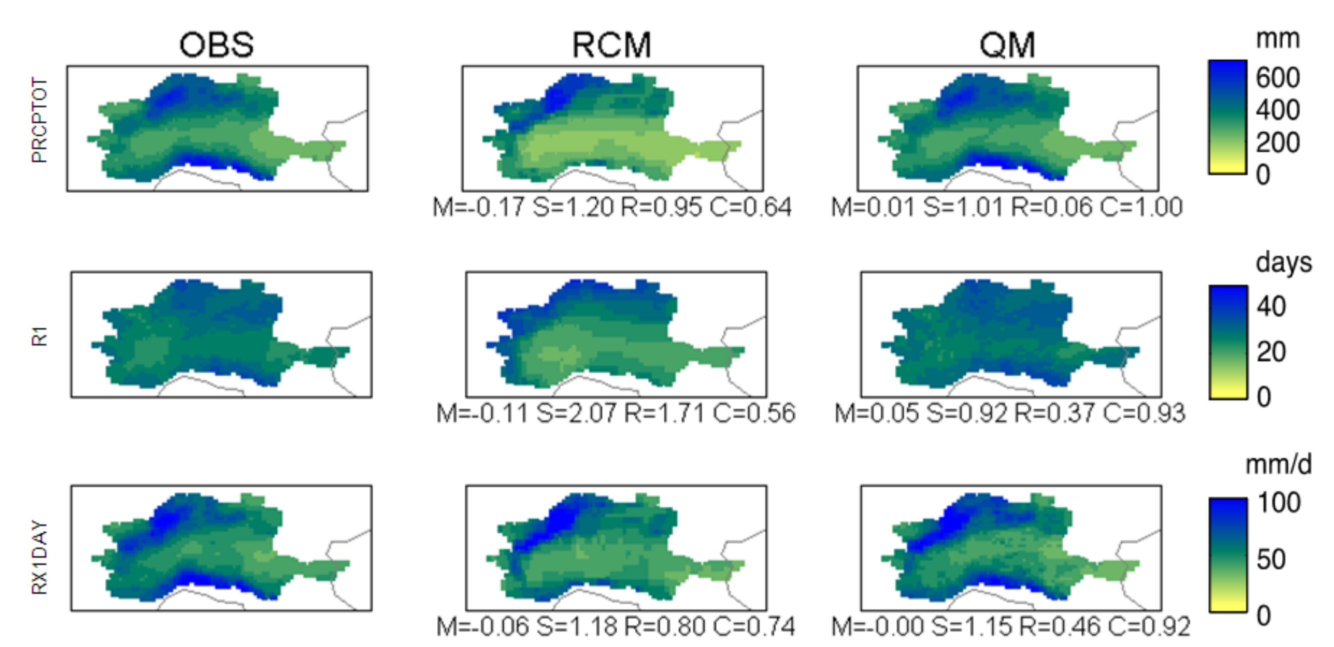
2.Quantile Mapping (QM) → It tries to correct all the statistical moments of the distribution function of the RCM precipitation values

$$P^*(d) = F_{obs}^{-1}(F_{rcm}(P(d)))$$

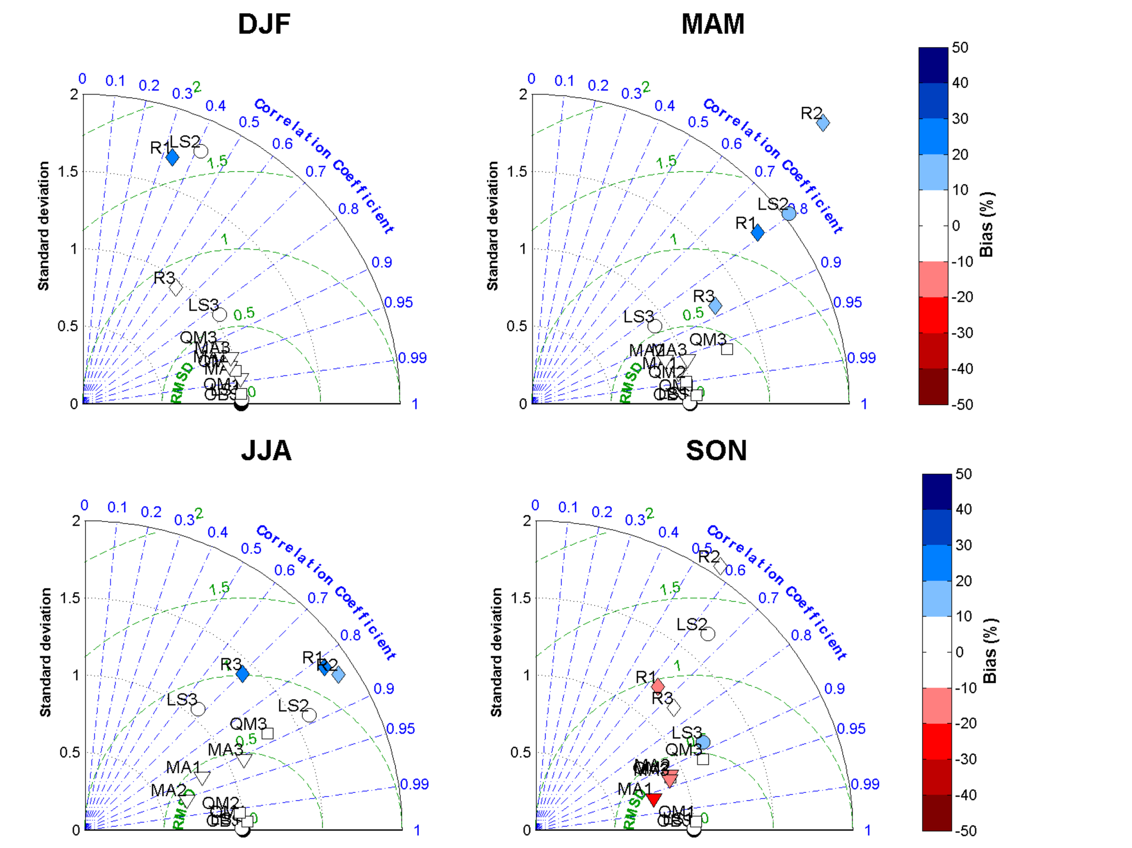
3.MOS Analogs (MA) [4] → It is based on the hypothesis that "analogue" weather patterns should cause "analogue" local effects. It consists in a two steps procedure: for each day to be downscaled in a test period, first the closest historical predictor (the RCM precipitation, i.e. the analog) is found and then the observed local precipitation, correspondent to the analog day, is used as downscaled precipitation.

ERA40 driven simulation

The comparison between the three methods is first performed under "optimal" conditions, that is, considering the ERA40 driven simulation ("perfect" boundary conditions), in order to reduce the influence of the errors relate to the General Circulation Model.



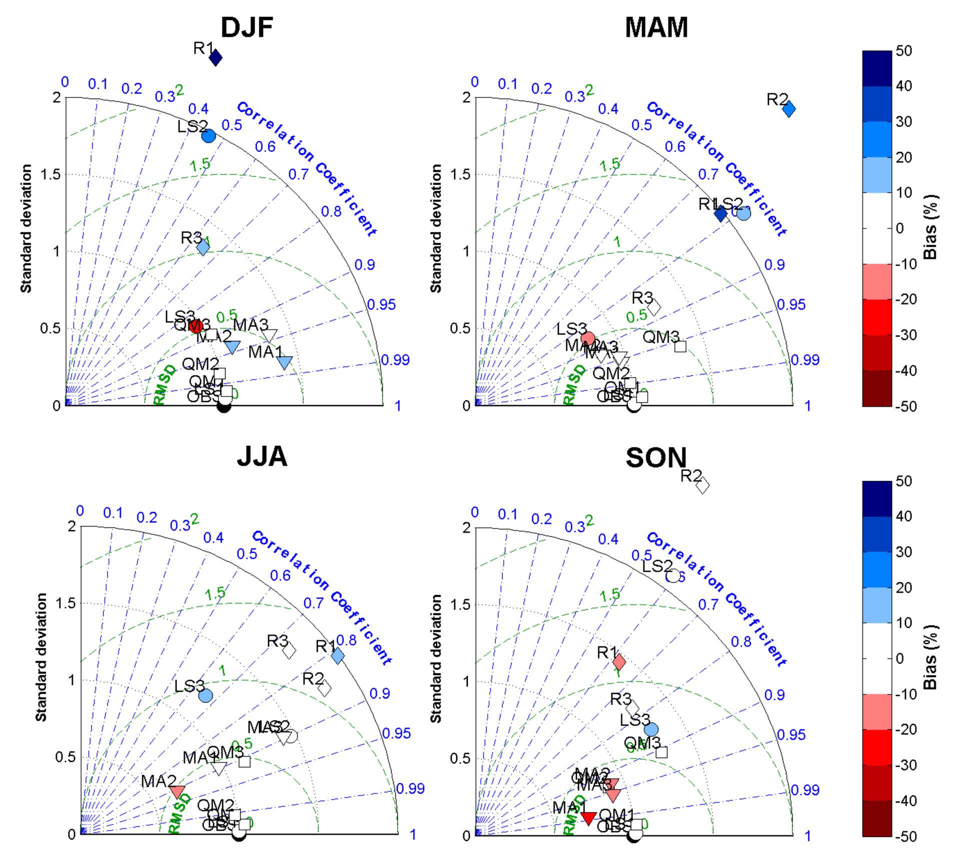
Spatial distribution of the observed (left), COSMO-CLM (central) and QM (right) autumn precipitation values (averaged over the control period 1971-2000) for the three ETCCDI indices considered. The spatial validation scores for the RCM and QM simulated values are given below the corresponding panels: bias (or mean error M), relative standard deviations (S), correlation (C) and centred root-mean-square (R).



Taylor diagrams for the seasonal precipitation climatology. Better results are closer to observation (OBS). The circles with LS are used for the linear-scaling method, the squares with QM for the quantile mapping, the triangles with MA for the MOS analogs method while the diamonds with R for the RCM. The colours indicate the bias (in percentage respect to the observed mean). The numbers correspond to the different indices: 1=PRCPTOT; 2=R1; 3=RX1DAY

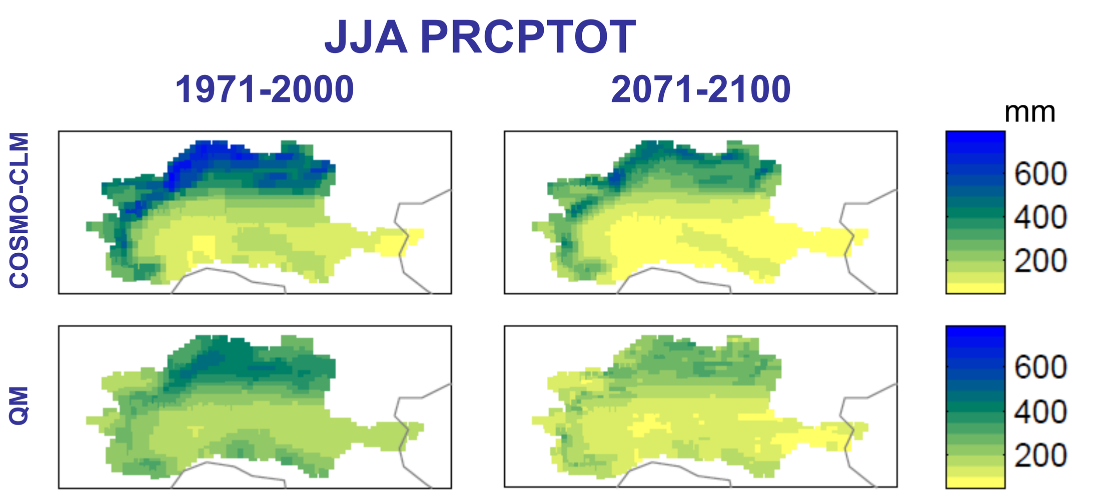
CMCC-MED driven simulation

These methods have subsequently been tested under "suboptimal" conditions, that is, using RCM driven by GCM in current climate.



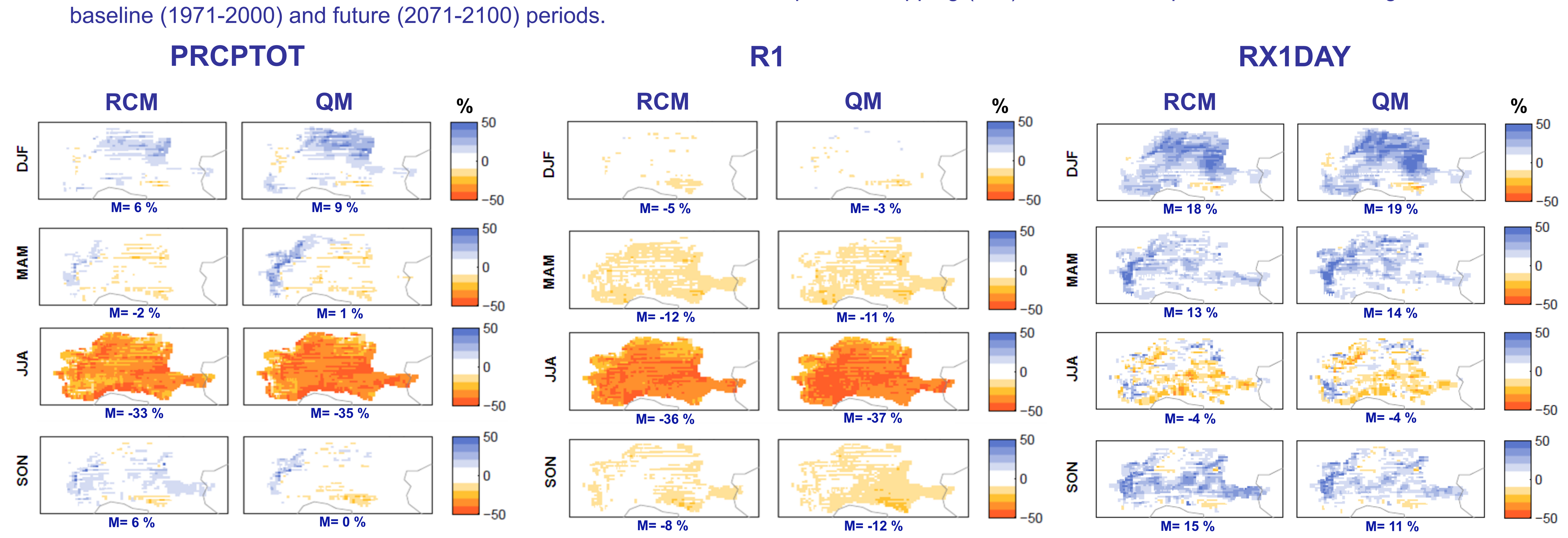
Future scenarios

Maps for summer values of the PRCPTOT index, both for RCM and QM, for past and future periods.



The climate change signal for the PRCPTOT index shows a strong decrease in summer months and a substantial steady (or slight increasing) signal in the other seasons. A decrease in the number of rainy days is projected in all seasons (more pronounced in summer). Finally the scenarios indicate a slight increasing (between 10 and 20%) in the RX1DAY index, in all seasons except in summer where a noisy signal occurs.

Future scenarios for PRCPTOT, R1 and RX1DAY. Values for RCM and quantile mapping (QM) method are expressed in % of change between the baseline (1971-2000) and future (2071-2100) periods.



Conclusions

The GCM-driven RCM presents the same bias features of the reanalysis driven simulation, but with a greater overestimation of PRCPTOT and R1 in winter.
The cross-validation results indicate that the MOS downscaled values generally outperform the uncalibrated RCM outputs, both in "optimal" and in "sub-optimal" conditions:

- The linear scaling method is generally able to improve only the mean values of precipitation
- The quantile mapping has often the best scores as it improves the representation of the mean regimes, the frequency and the extremes of precipitation, regardless of the season
- The MOS analog technique generally outperform the RCM outputs regardless of the index considered, but it has more problems in correcting autumn precipitation (probably due to the seasonal bias of the RCM).

The future scenarios of RCM and MOS methods are similar, indicating that these post-processing techniques are able to preserve the climate change signal of the RCM. The added value of the MOS scenarios lies in their absolute values. Indeed the MOS outputs may be very useful for those users who require high-resolution data as input for impact models.

References

[1] Turco, M., Zollo, A.L., Vezzoli, R., Ronchi, C. and Mercogliano, P. (2013), *Daily precipitation statistics over the Po Basin: observation and post-processed RCM results, submitted to SISC.*
[2] Turco, M., Zollo, A.L., Ronchi, C., de Luigi, C. and Mercogliano, P. (2013), *Assessing gridded observations for daily precipitation extremes in the Alps with a focus on northwest Italy*, Natural Hazards and Earth System Sciences, 13, pp. 1–12.
[3] Turco, M., Zollo, A.L., Rianna, G., Cattaneo, L., Vezzoli, R. and Mercogliano, P. (2013), *Post-processing methods for COSMO-CLM precipitation over Italy*, Technical report, CMCC.
[4] Turco, M., Quintana-Seguì, P., Llasat, M.C., Herrera, S., and Gutiérrez, J.M. (2011), *Testing MOS precipitation downscaling for ENSEMBLES regional climate models over Spain*, Journal of Geophysical Research, No. 116 (D18), pp. 1-14.