Downscaling of precipitation - need and use of observational data

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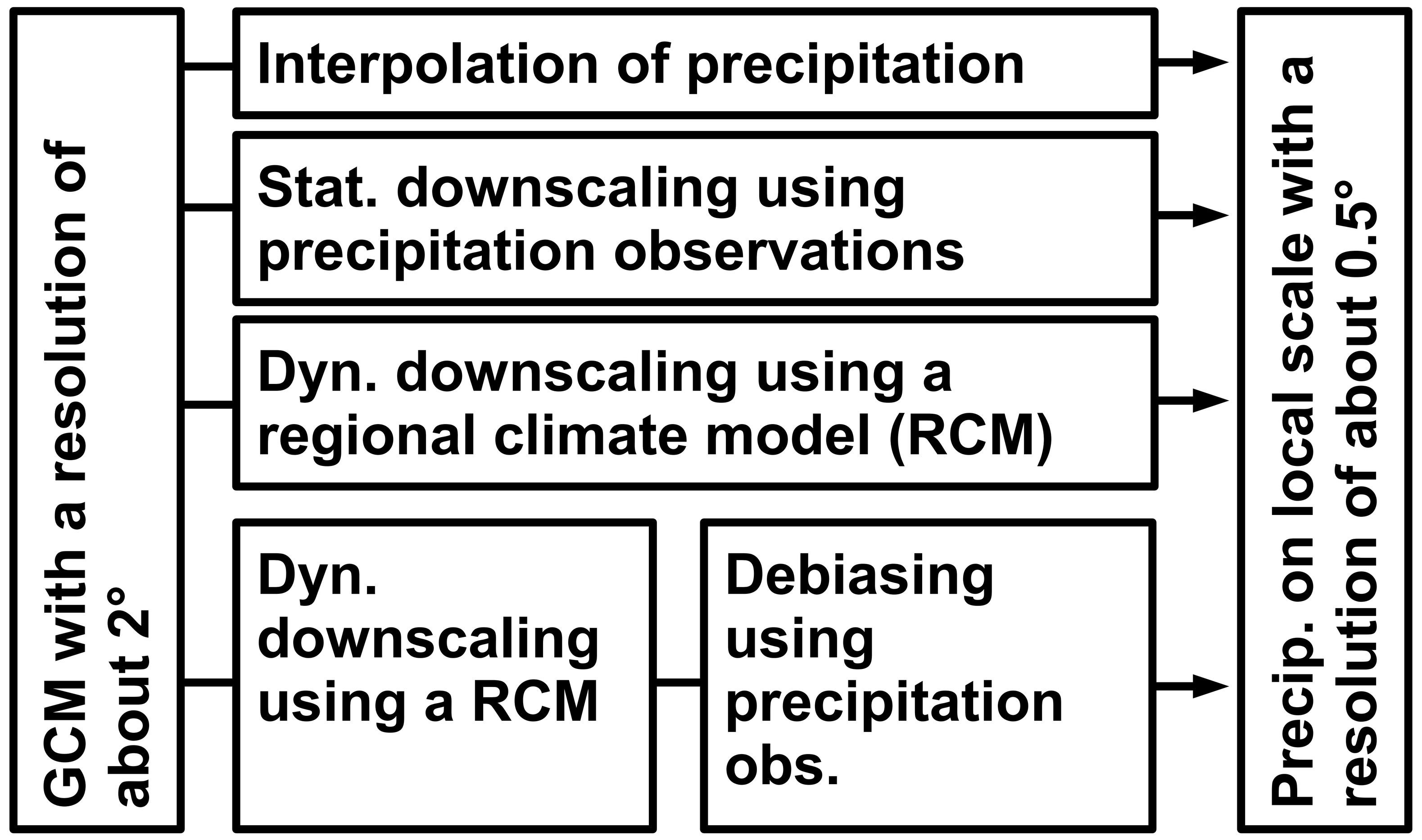
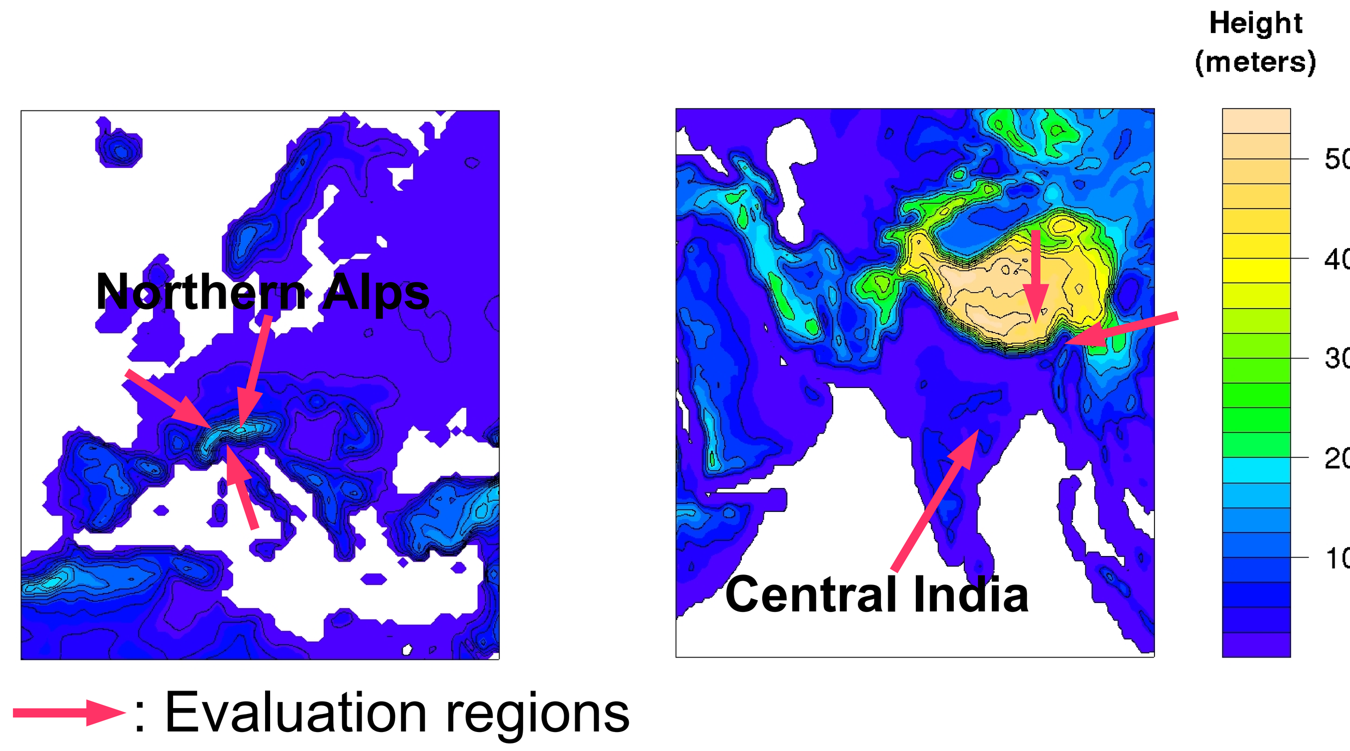
Introduction

Climate projections with global circulation models (GCMs) do not allow regional examinations of water balance or trends of extreme precipitation due to their coarse grid resolution. Therefore, a downscaling of the global simulations to the regional scale is necessary. For a simple statistical downscaling with precipitation of the global model as predictor, observations are needed, whereas pure dynamical downscaling doesn't use any observational data at all. However, observations can be used to remove biases from model predictions involved in the downscaling process. In this presentation we discuss different downscaling methods: Statistical downscaling, dynamical downscaling and downscaling methods involving debiasing on varying grid resolutions.

Different downscaling approaches



RCM domains *Europe* and *Asia*



Data

- GCM: ERA40 reanalysis data with 1.25° resolution
- RCM: CLM simulation data with 0.44° resolution
- Obs.: Gridded daily precipitation datasets with 0.5° resolution
  - *Europe:* Frei & Schär v4.1 daily precip. dataset
  - *Asia:* East Asia Daily Precipitation Analysis dataset.
- Training periods: *Europe* '71-'85, *Asia* '78-'88
- Evaluation periods: *Europe* '86-'99, *Asia* '89-'98

Methods for statistical downscaling of GCM and debiasing of RCM precipitation

A) Local intensity scaling (Schmidli et al., 2006)

1) Observation wet-day threshold WDT^O= 1mm

-> Determine GCM or RCM WDT from the model precipitation (P^m) and the observed precipitation (P^O) in the training period such that $\left|\{P^m | P^m \geq WDT^m\}\right| = \left|\{P^o | P^o \geq WDT^o\}\right|$

2) Estimate scaling factor $s = \dfrac{\overline{\{P^o | P^o \geq WDT^o\}} - WDT^o}{\overline{\{P^m | P^m \geq WDT^m\}} - WDT^m}$

3) Resulting precipitation: $\hat{P} = max\left(0, WDT^o + s\left(P^m - WDT^m\right)\right)$

B) Mapping to gamma distribution (e.g., Ines et al., 2006)

1) same as 1) above

2) Maximum likelihood estimation for shape & scale parameters of gamma distributions for obs. training, model training and model evaluation period $\hat{\alpha}_t^o, \hat{\beta}_t^o, \hat{\alpha}_t^m, \hat{\beta}_t^m, \hat{\alpha}_e^m, \hat{\beta}_e^m$

3) Map model daily precipitation of evaluation period to artificial gamma distribution with shape & scale parameter $\hat{\alpha} = \hat{\alpha}_e^m \cdot \hat{\alpha}_t^o / \hat{\alpha}_t^m, \hat{\beta} = \hat{\beta}_e^m \cdot \hat{\beta}_t^o / \hat{\beta}_t^m$

Results

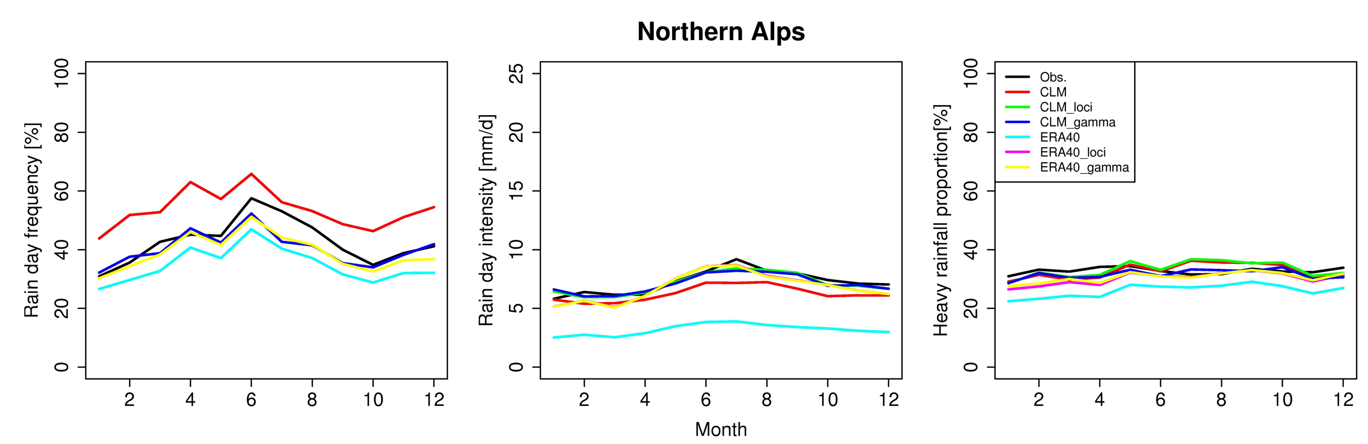


Fig 1: Rain day frequency, intensity and heavy rainfall proportion for different downscaling approaches in Northern Alps. The statistical methods improve both GCM and RCM model data.

Results (continued)

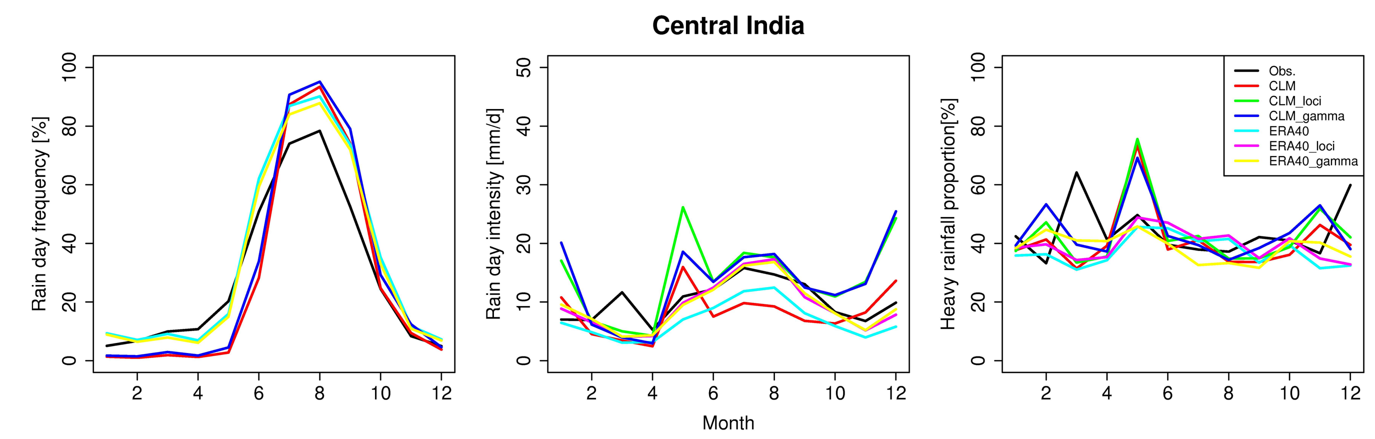


Fig 2: Same as figure 1 but for Central India. Whereas the statistical methods improve the GCM data, the debiased RCM precipitation is in some months (e.g., Nov. & Dec.) less accurate than the originally simulated precipitation.

For the other evaluation regions, the statistical methods deliver similar results to *Northern Alps* with somewhat better results for the European regions (not shown).

Discussion & Conclusion

The two statistical methods yield similar results. Downscaling of GCM precipitation works well, where RCM debiasing fails in *Central India.* Table 1 shows he optimal, monthly calculated and the actually used WDT and s for RCM debiasing in *Central India* and *Northern Alps.*

	Optimal monthly values												Actual
	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug	Sep	Oct	Nov	Dec	value
N. Alps WDT	2.5	2.6	1.9	2.5	2.1	1.8	1.3	1.6	1.8	2.2	0.6	0.7	2.3
C. India WDT	0	0	0	0	0	0	2.6	3.5	3.5	1.1	0.3	0	0.7
N. Alps s	1	1.3	1.2	1.1	1.1	1.1	1.3	1.1	1.2	1.2	1.2	1.2	1.1
C. India s	44	172.8	142.8	133.2	27.6	3.6	1.8	2	2.4	1.4	0.8	0.9	2

Table 1: Seasonal variability of optimal WDT and s for RCM debiasing in Central India and Northern Alps.

Due to the strong seasonality the debiasing fails in *Central India.* Note for instance that the optimal monthly scaling factor for the months November and December would be smaller but the actual value is bigger than one. Seasonal or monthly based estimation of WDT and s may solve this problem but holds the risk of overfitting. Any statistical method used either for downscaling or debiasing must be applied very carefully.The results highly depend on the quality of the input model data.

References:

Schmidli, J., C. Frei, P. L. Vidale, 2006: Downscaling from GCM precipitation: A benchmark for dynamical and statistical downscaling methods. *Int. J. Climatol.*, **26,** 679-689.

Ines, A. V. M., J. W. Hansen, 2006: Bias correction of daily GCM rainfall for crop simulation studies. *Agric. Forest Meteorol.*, **138**, 44-53.

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