Assessing climate change impacts on the water resources in Pune, India, using downscaling and hydrologic modeling

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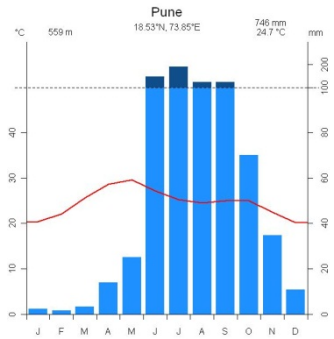
1. Future water shortage in India?

Limited water availability



Increasing water demand

How will climate change affect water resources?

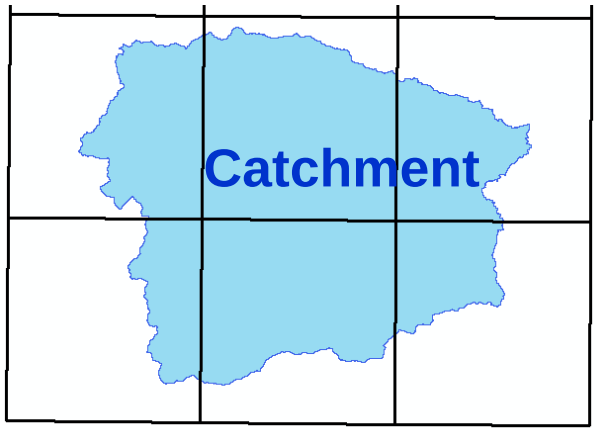
1. Objectives

Develop a downscaling technique that generates consistent weather data.

Assess impacts of climate change on the water resources.

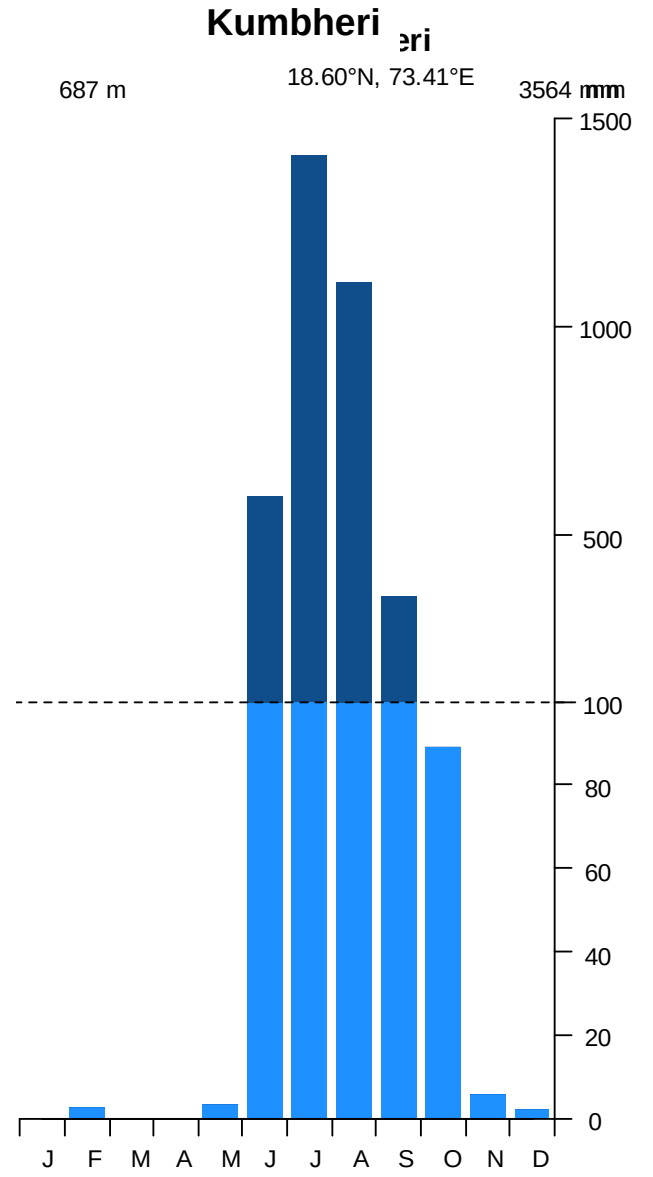
1. Downscaling

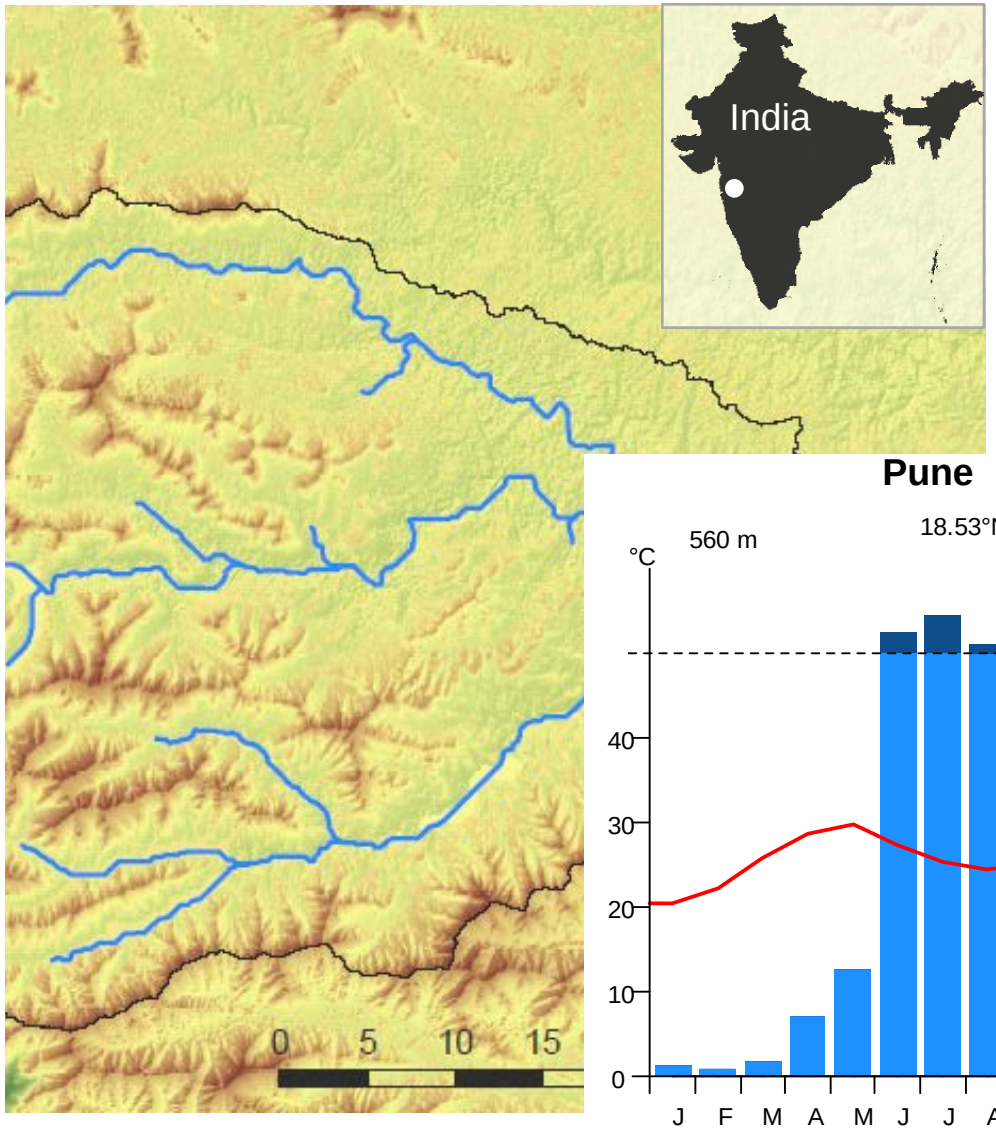
Regional Climate Model (RCM)



2. Evaluate the impact of climate change scenario on the water resources

2. Study area: Rainfall variability

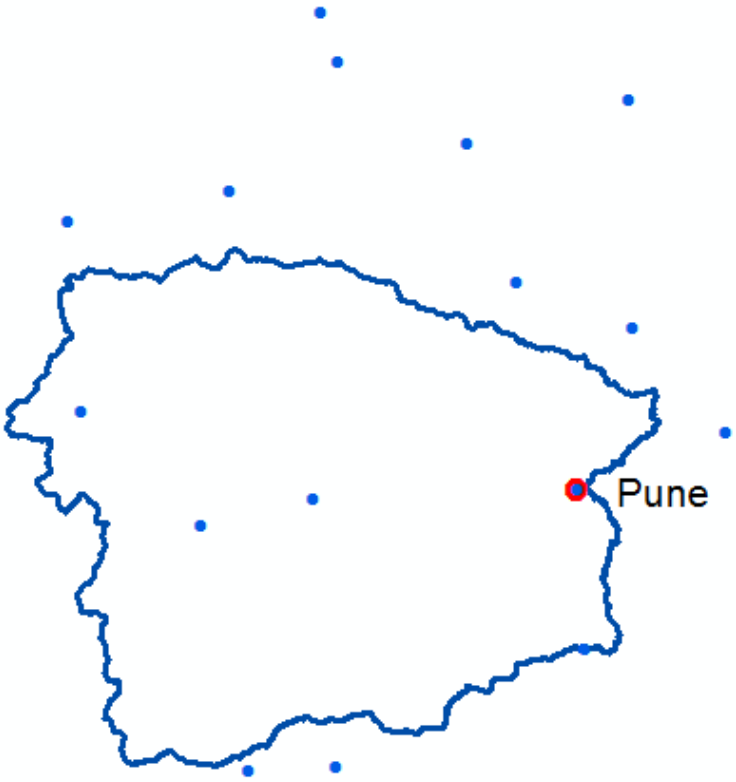




2. Methodology: Data

Measured Climate Data (1988 - 2008)

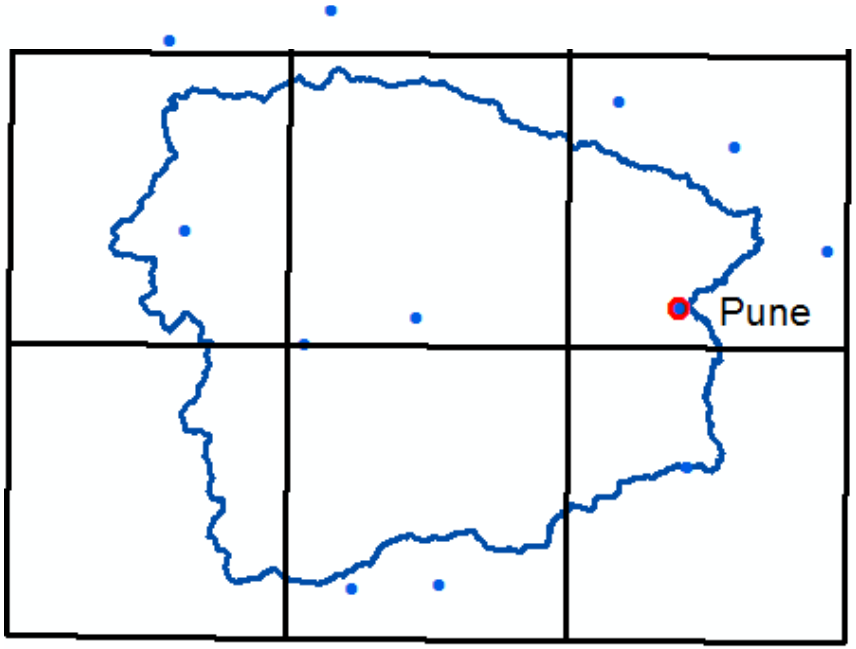
- Temperature data for IMD weather station Pune
- Rainfall data for 16 gauges within and near the study area
  - Interpolated to derive subbasin values



2. Methodology: Data

Regional Climate Model Data (COSMO-CLM)*

- driven by global ocean-atmosphere model ECHAM5/MPIOM
- applying IPCC emission scenario A1B
- Spatial resolution: Six 0.25° grid cells
- Baseline period: 1960-2000
- Scenario period: 2001-2100
- Variables: Temperature and rainfall



*** Kindly provided by Institute for Atmospheric and Environmental Sciences, Goethe-University Frankfurt**

2. Downscaling Methodology

Problems:

1. Coarse RCM data – spatially variable rainfall distirbution
2. Climate variables are interdependent, a derived climate scenario should provide consistent variable values

Solution:

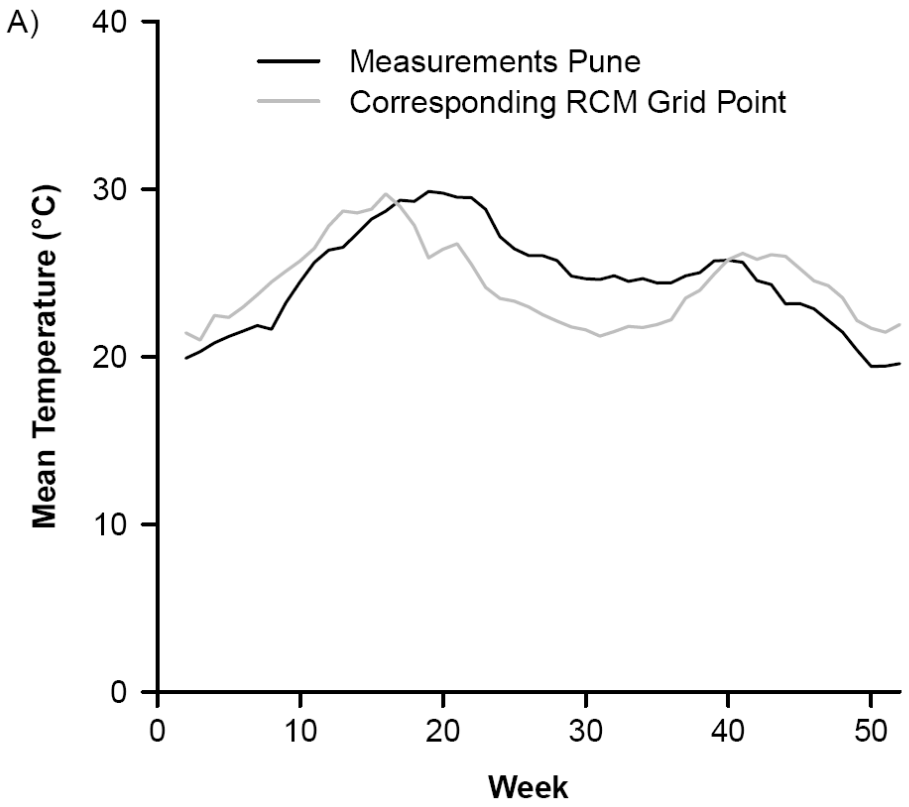
Use measured data and rearrange it with the help of the RCM scenario data

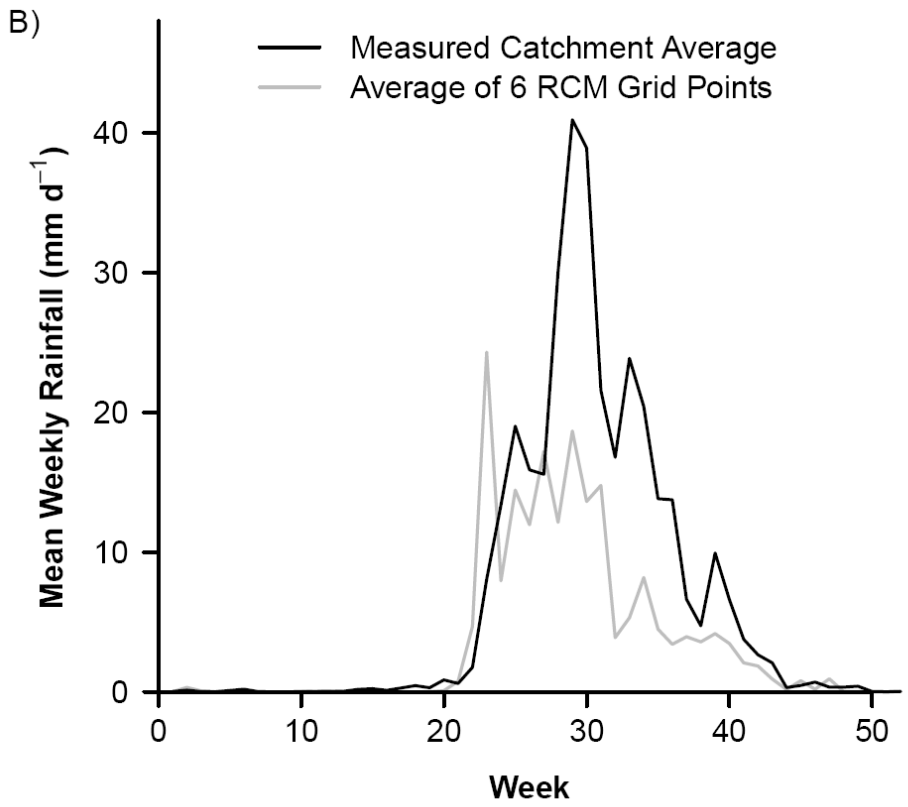
Method:

2.1 Bias Correction of RCM Data
2.2 Identification of similar weeks in RCM baseline period for RCM scenario period
2.3 Rearranging measured data to represent the scenario period using the similarity derived in 2.2

2.1 Bias Correction of RCM Data

Comparison of RCM and measured data for 13 baseline years





Correction by applying a weekly temperature offset

Correction by applying a weekly rainfall factor

2.2 Identification of similar RCM weeks

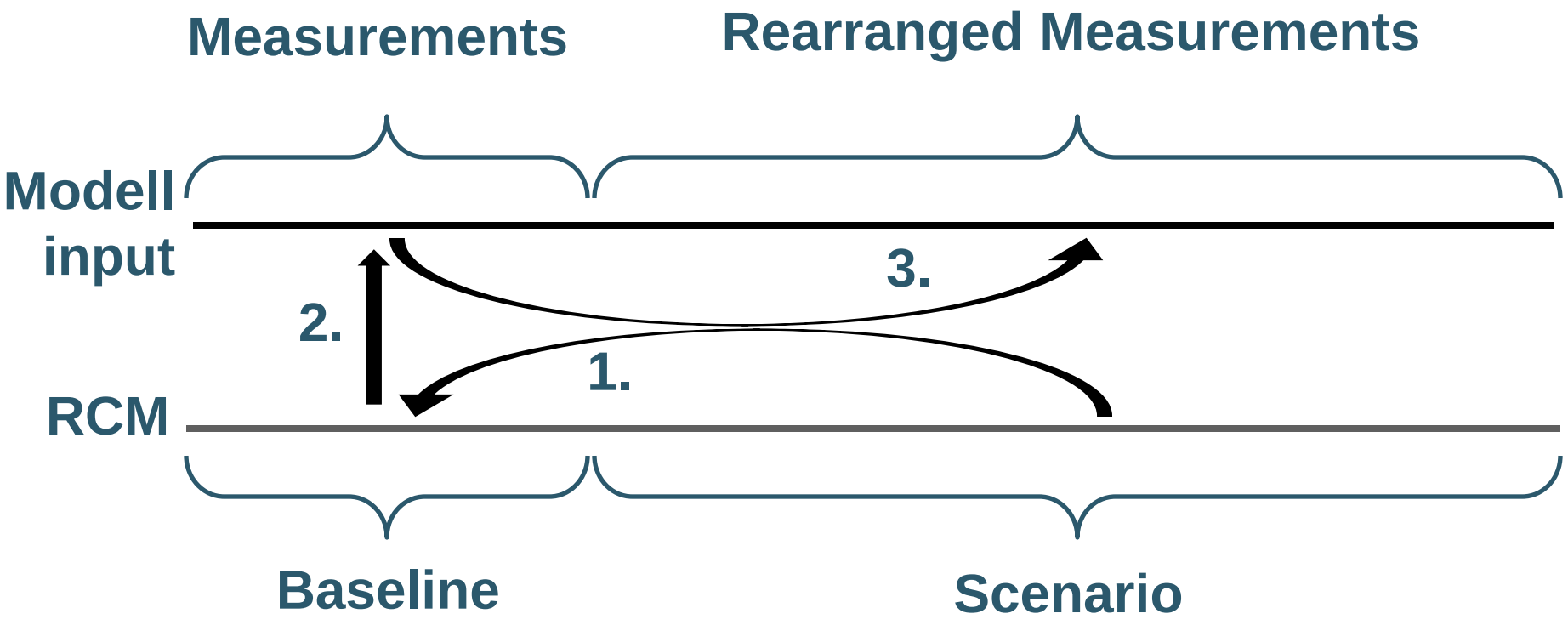
Identification of similar weeks in RCM baseline period for RCM scenario period

Similarity Index

$$I_Z = (zT)^2 + (zP)^2$$

$$zx = \sqrt{\frac{1}{ij}\sum_{i=1}^{7}\sum_{j=1}^{6}\frac{(xb_{ij} - xs_{ij})^2}{\sigma_{xs}^2}}$$

2.3 Rearranging measured data to represent the scenario period



3.1 Validation of the rearranged scenario

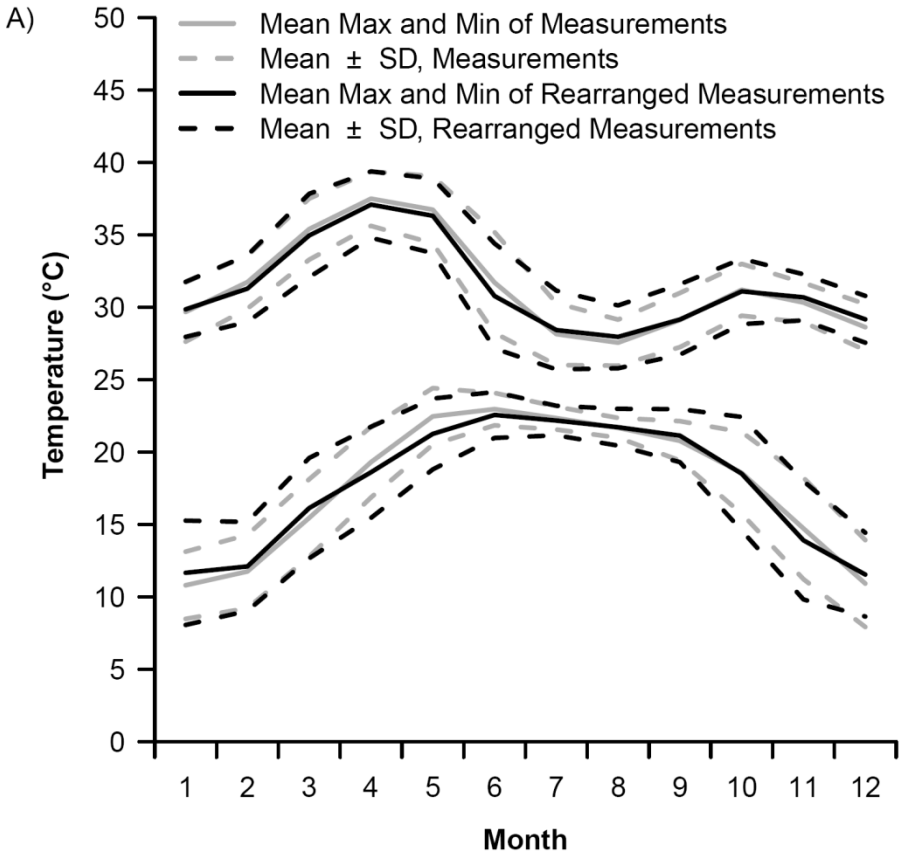
Temperature:

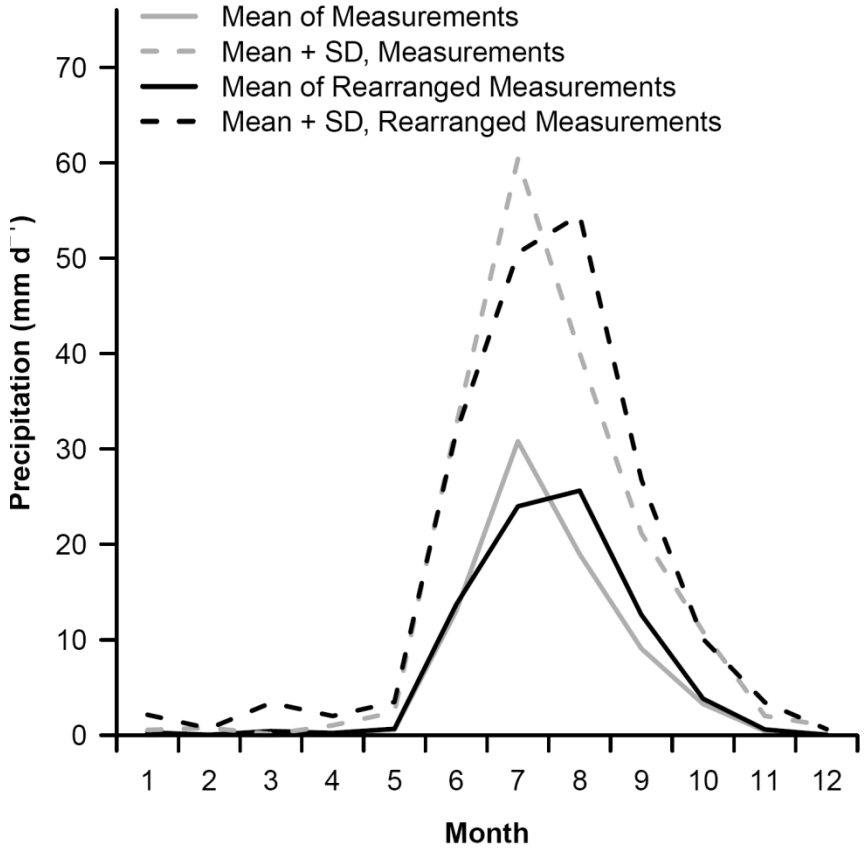
1. **Representation of the mean monthly values of the baseline period**
2. **Representation of the temperature trend for the scenario period**

Rainfall:

1. **Representation of the mean monthly values of the baseline period**
2. **No trend for the scenario period**

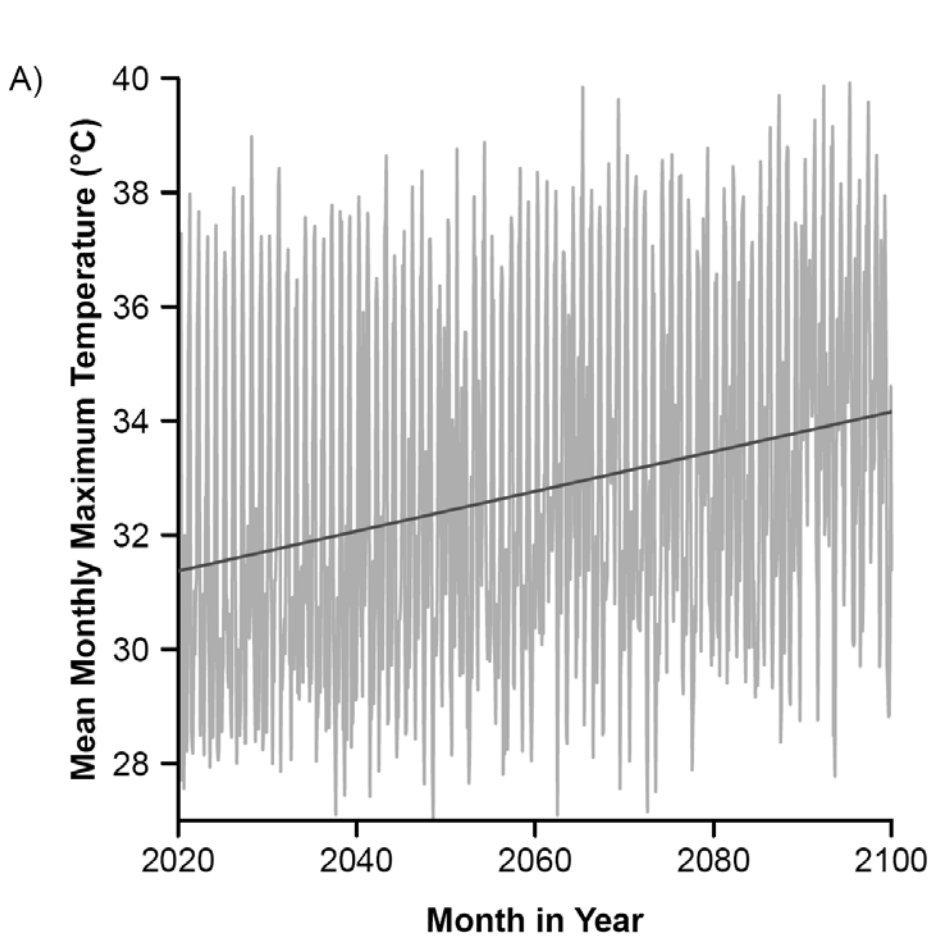
3.1.1 Assessment of the derived climatology

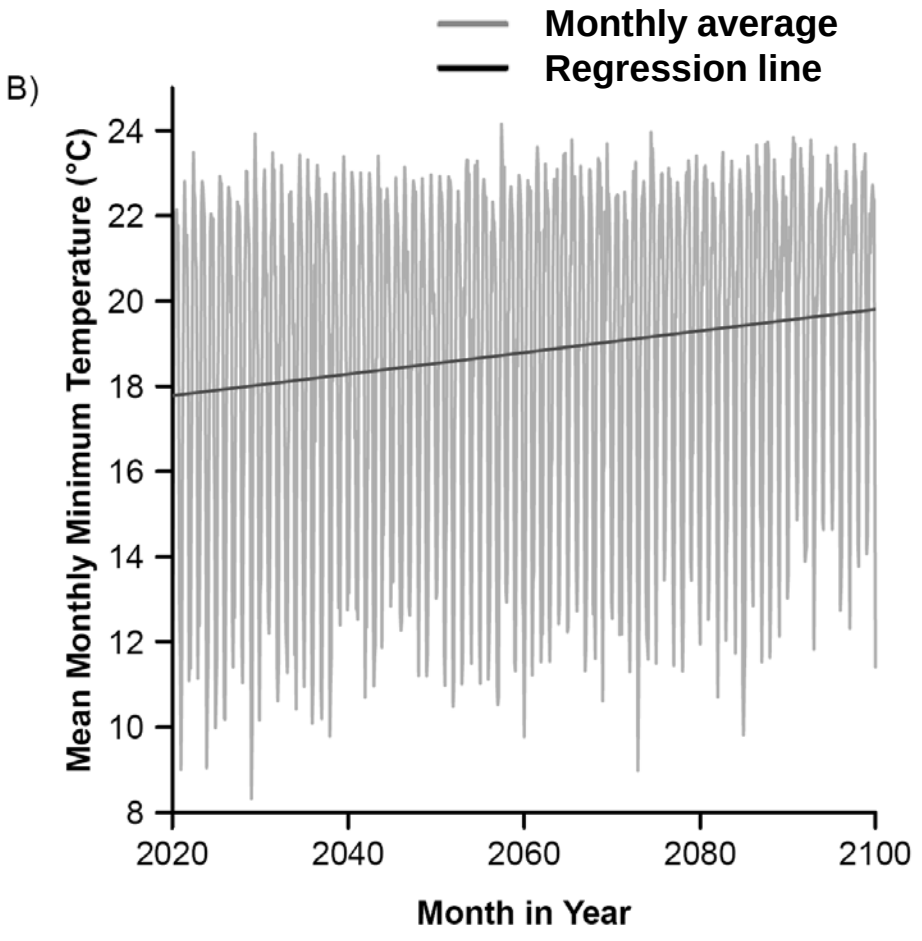




Comparison of original and rearranged measured data for the baseline period (13 years)

3.1.2 Scenario temperatures

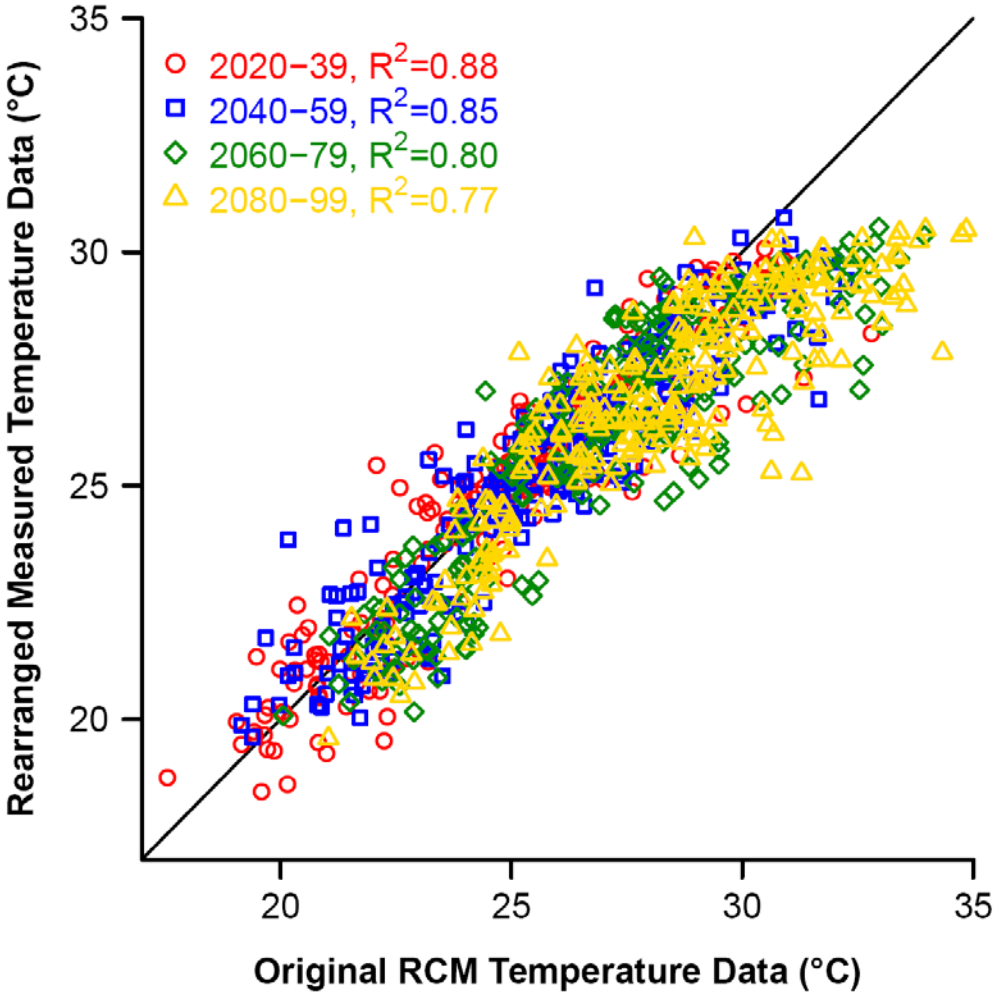




Maximum temperature

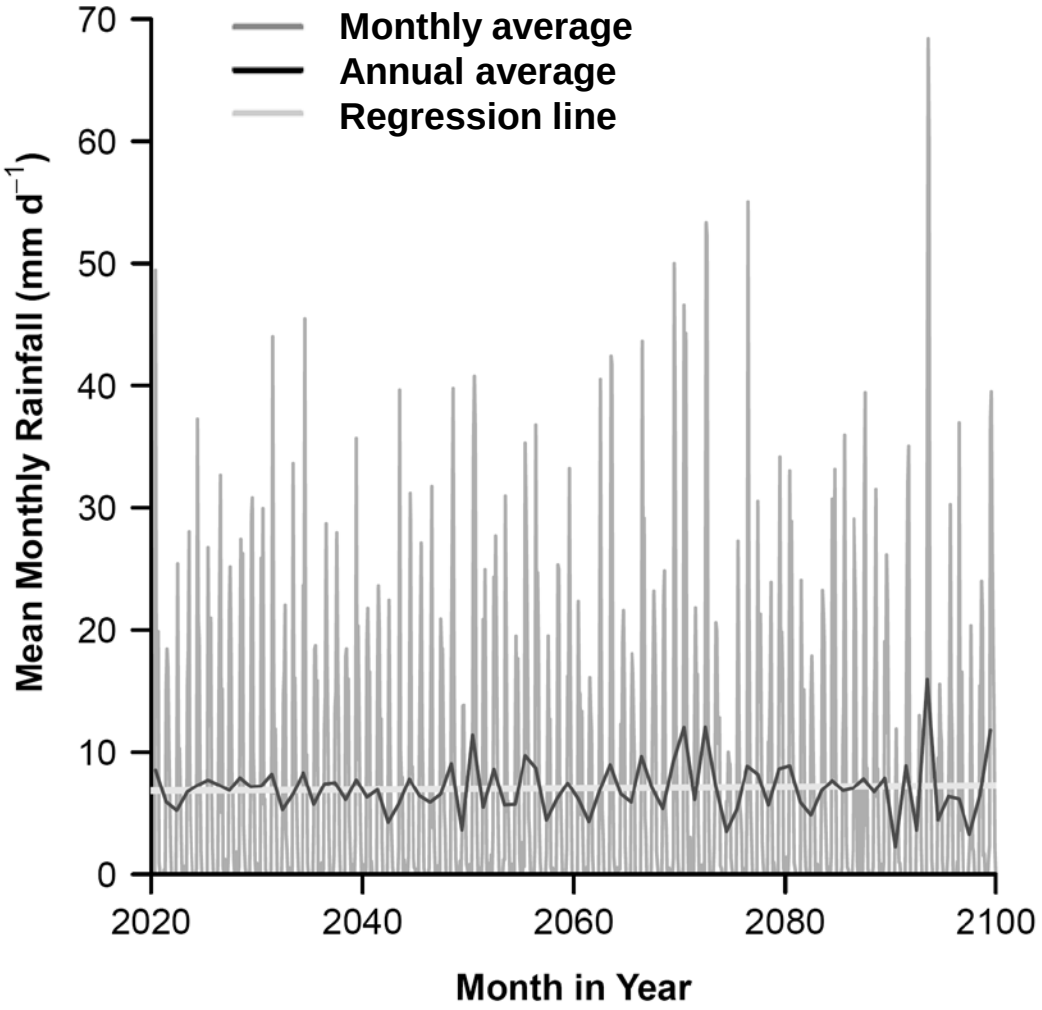
Minimum temperature

3.1.2 Representation of the temperature trend



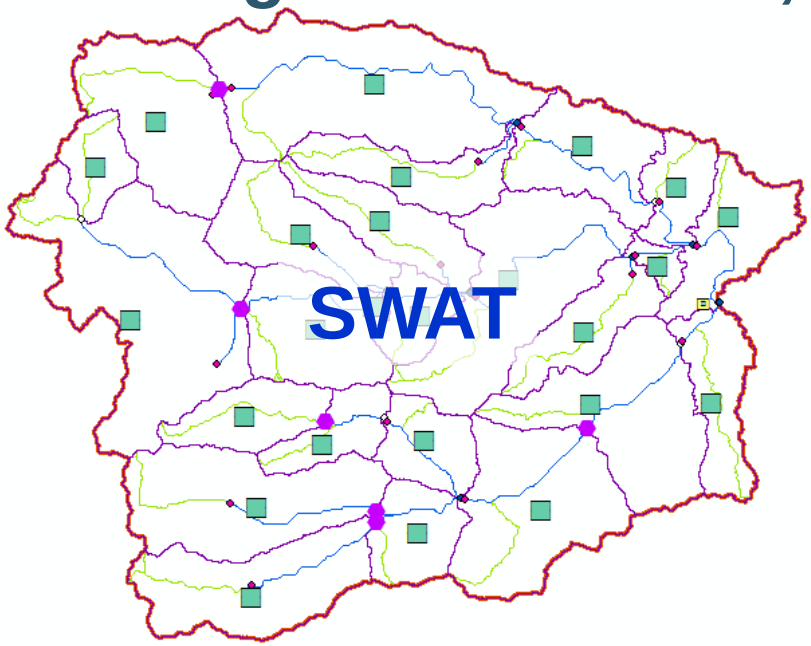
Underestimation of the RCM temperature trend in the periods 2060-79 and 2080-99

3.1.3 Scenario rainfall



3.2 Impact on the water balance

Assessment by using a hydrologic model setup for the catchment using the Soil and Water Assessment Tool (SWAT) (see Wagner et al. 2011, Wagner et al. 2012)



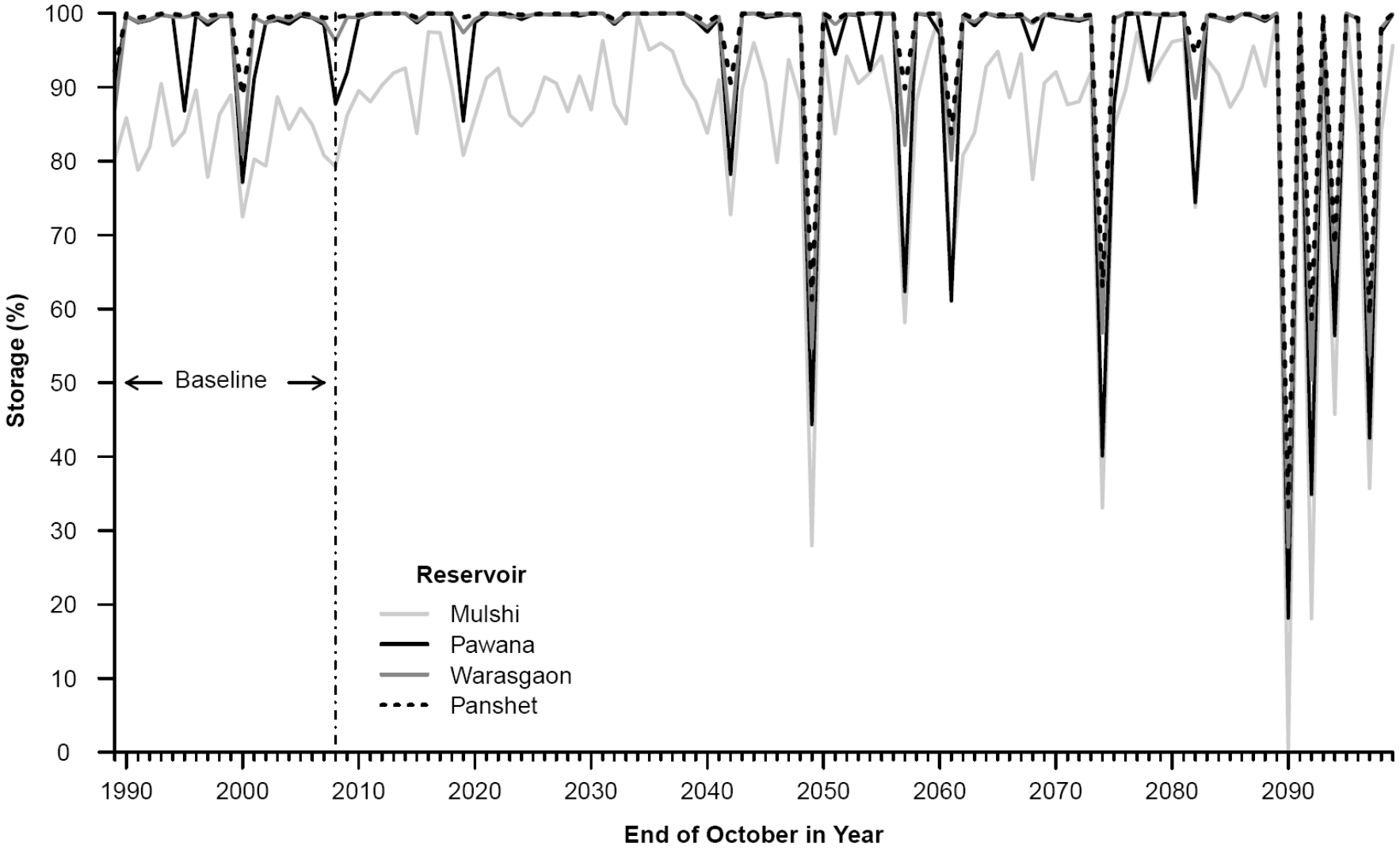
Impact on:

1. **Reservoir storage**
2. **Runoff**
3. **Annual ET**
4. **Monthly ET**

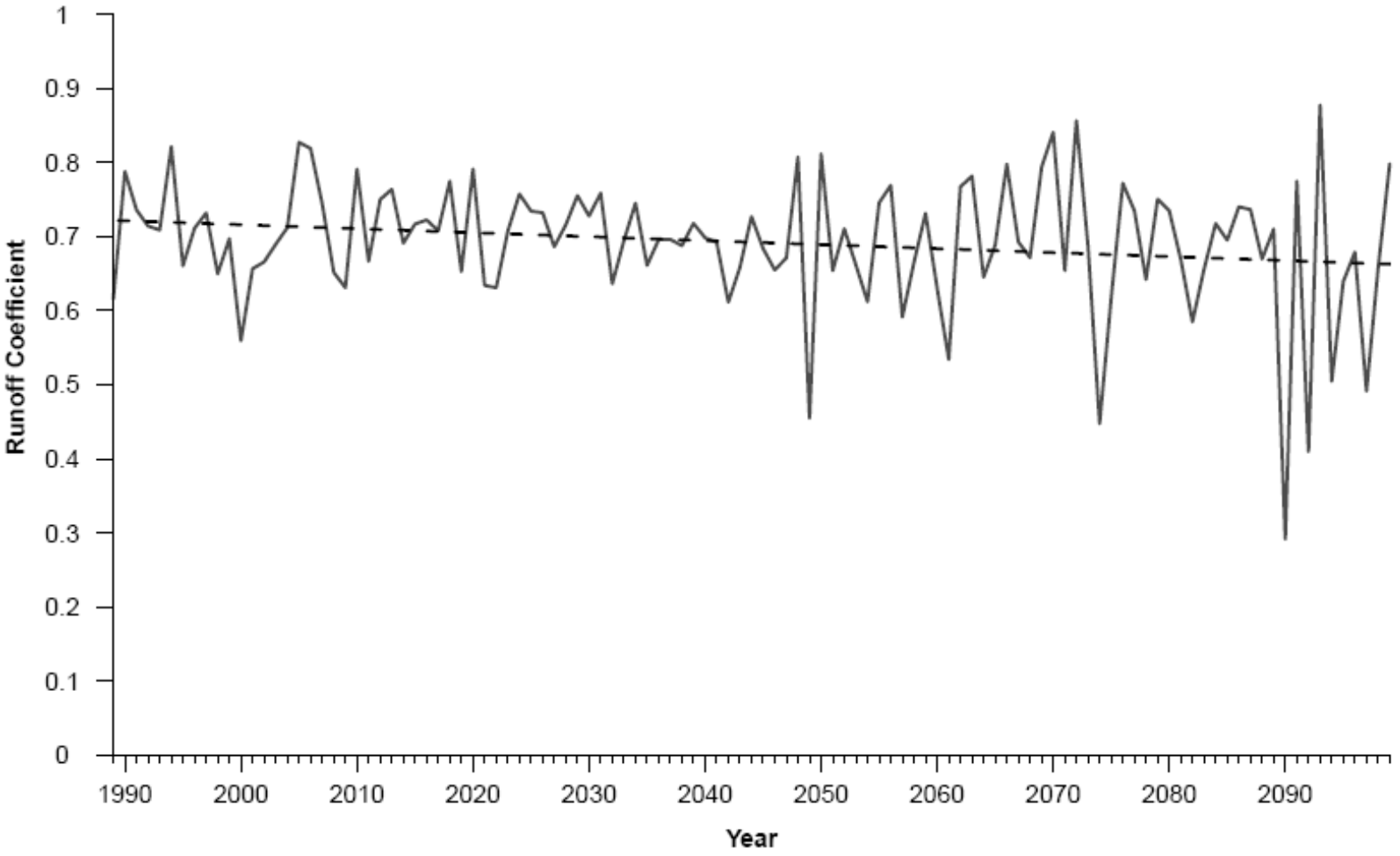
Wagner, P.D., Kumar, S., Fiener, P., Schneider, K., 2011. Hydrological Modeling with SWAT in a Monsoon-Driven Environment: Experience from the Western Ghats, India. *Transactions of the ASABE*, Vol. 54(5): 1783-1790.

Wagner, P.D., Fiener, P., Wilken, F., Kumar, S., Schneider, K., 2012. Comparison and evaluation of spatial interpolation schemes for daily rainfall in data scarce regions. *Journal of Hydrology*, accepted.

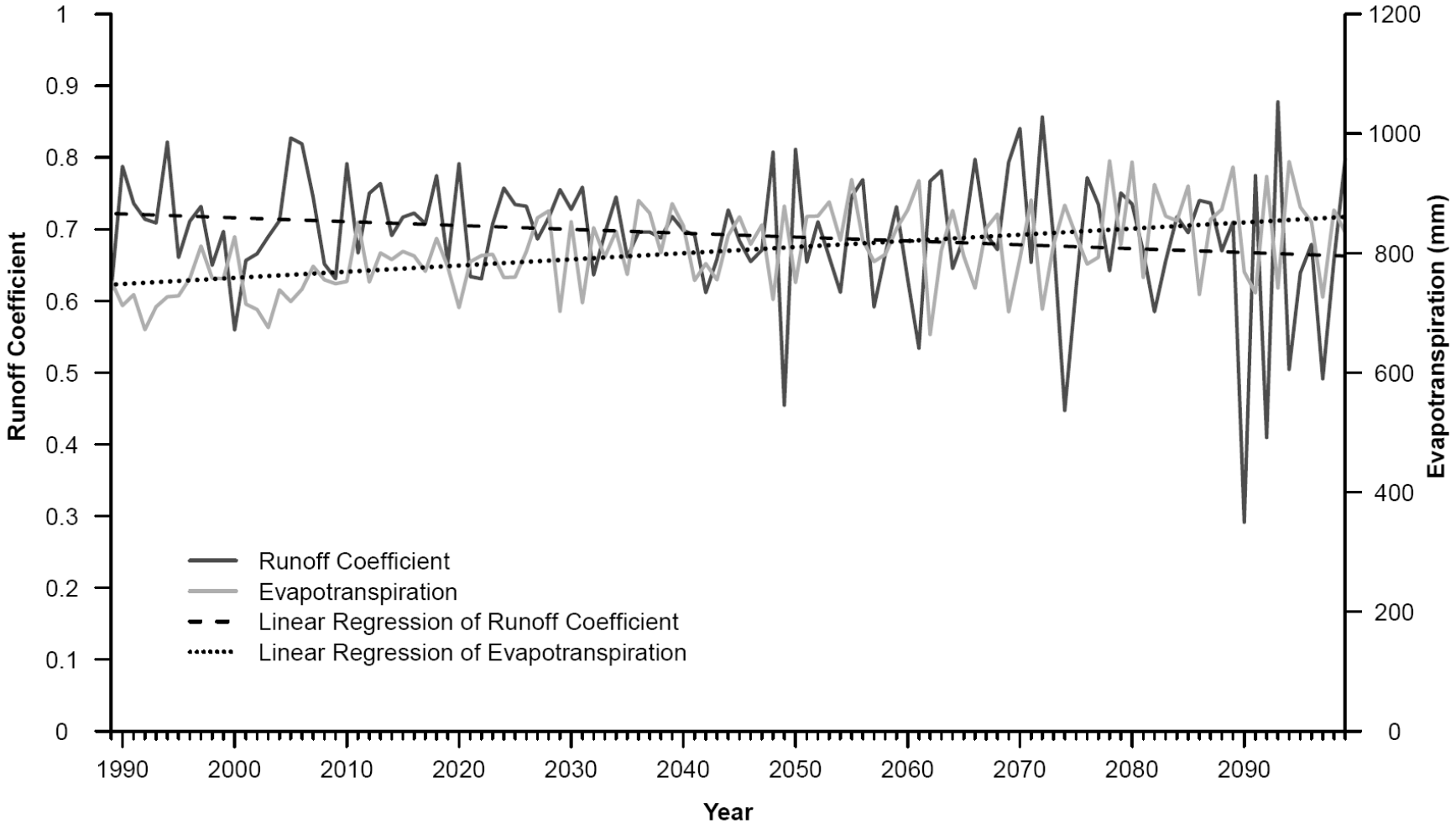
3.2.1 Impact on reservoir storage



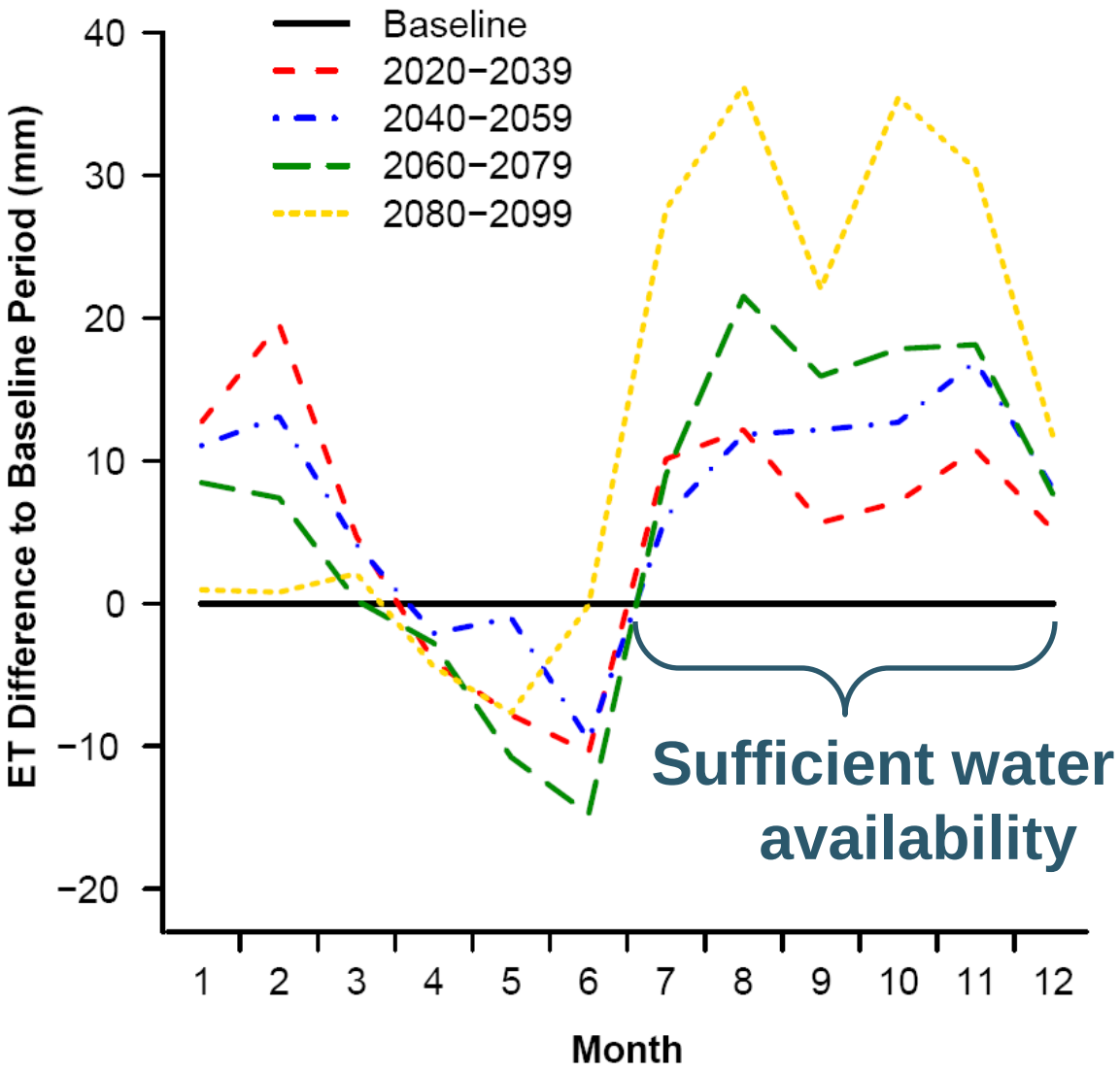
3.2.2 Impact on Runoff



3.2.3 Impact on Runoff and ET



3.2.4 Impact on the monthly ET



4. Conclusions

- **Downscaling approach**
  - ***Preserves consistent weather input***
  - ***Is limited to measured temperature range***
    - ***Underestimates second half of the scenario period***
- **Climate change impacts on the water resources**
  - ***Dry years have a pronounced impact on water availability***
  - ***Increasing temperatures result in higher evapotranspiration***
    - ***Not as pronounced as expected due to high percentage of direct runoff***

Thank you very much for your attention!

Questions welcome…

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