Bias Correction
The ISI-MIP Method

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IIASA

Outline

- **The aim of ISI-MIP**
- **Bias corrected climate input?**
- **A trend-preserving method**

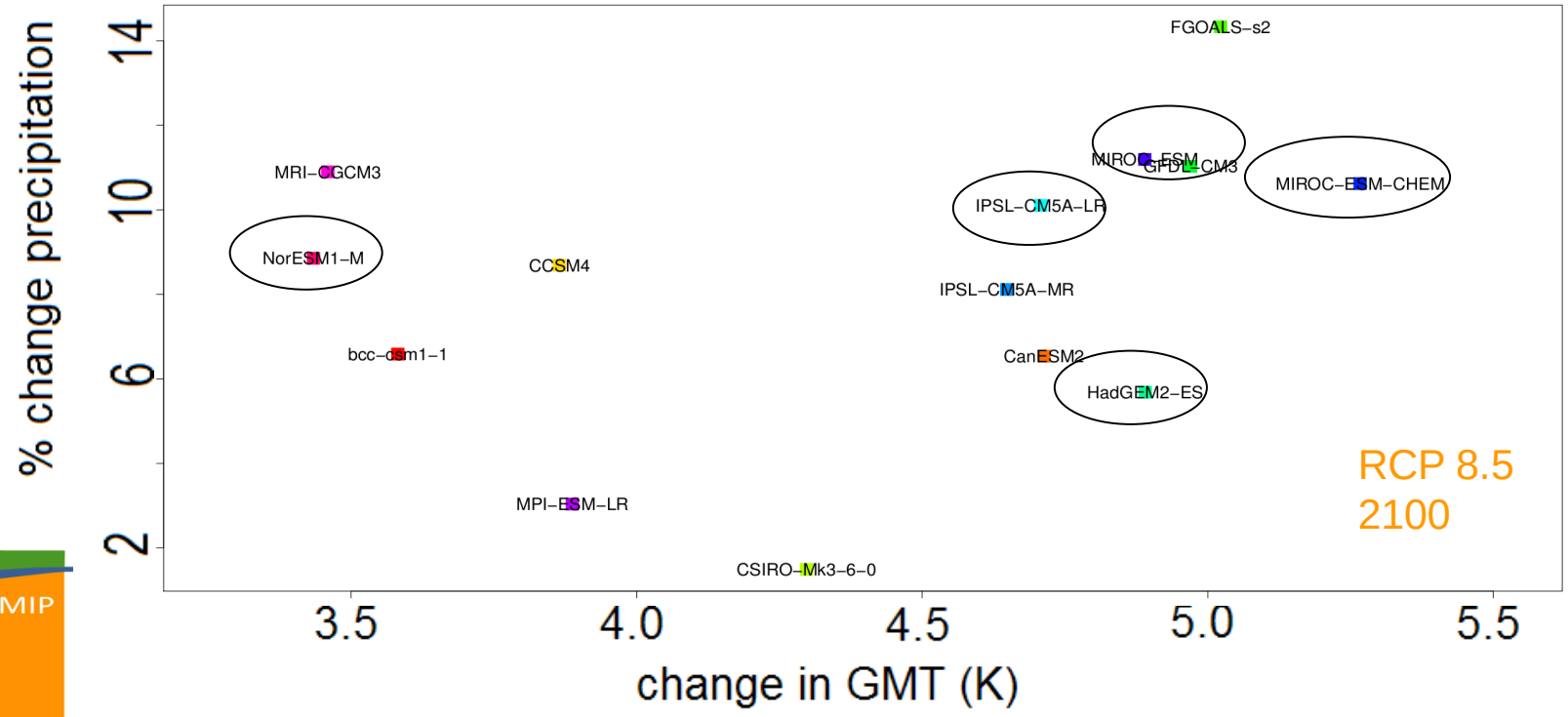
What is ISI-MIP

- First Inter-Sectoral Impact Model Intercomparison project
- Main research questions:
  - What are the **impact projections** in agriculture, water, biomes, health and infastructure sectors at **different levels of global warming**?
  - How big is the **uncertainty** arising from different **climate inputs** and individual **impact models**?

http://www.isi-mip.org/

Selecting the climate input for the fast track

- Common climate input for different sectors
  → availability of many climate variables
- Impacts at different levels of global warming
  → climate projections until 2100 for multiple RCPs
  → predicted temperature and precipitation changes span a large range



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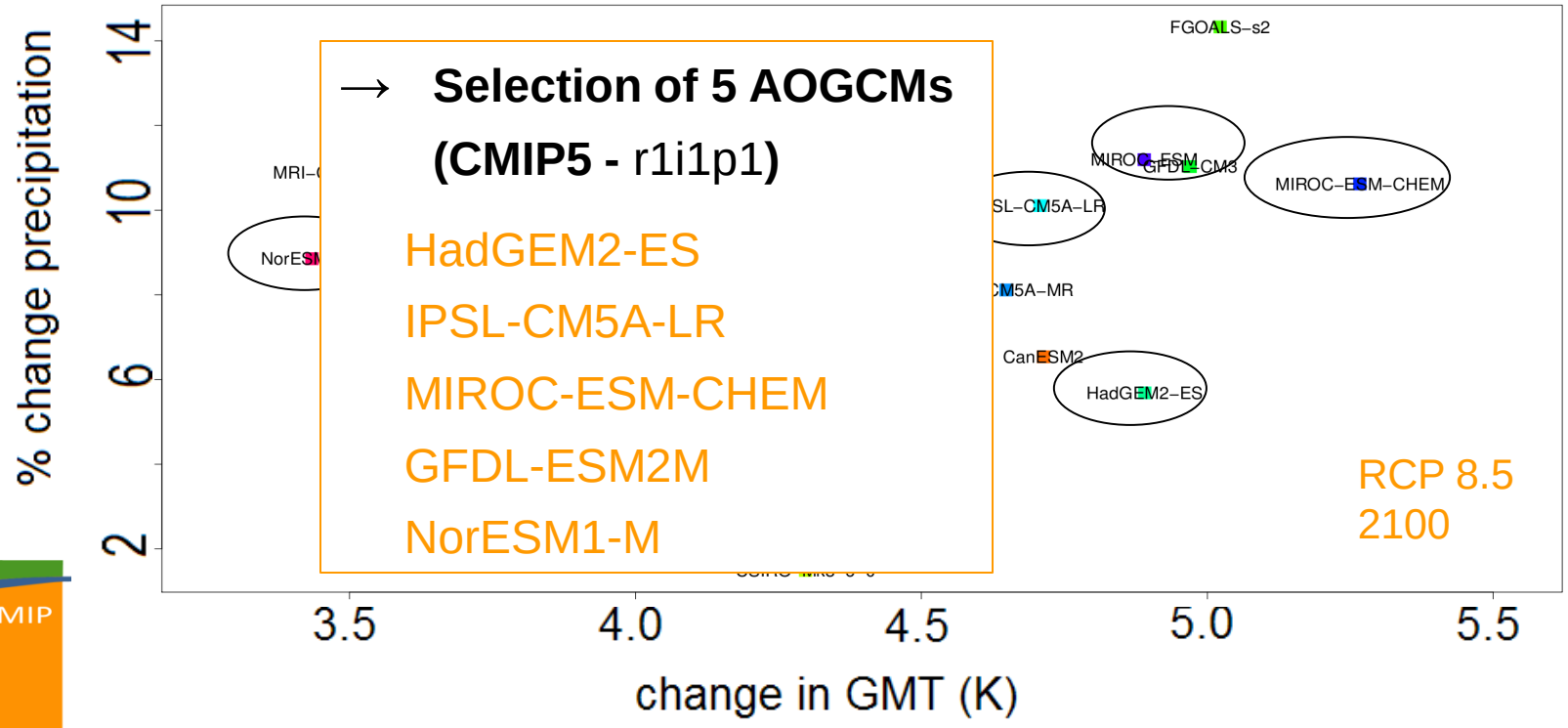

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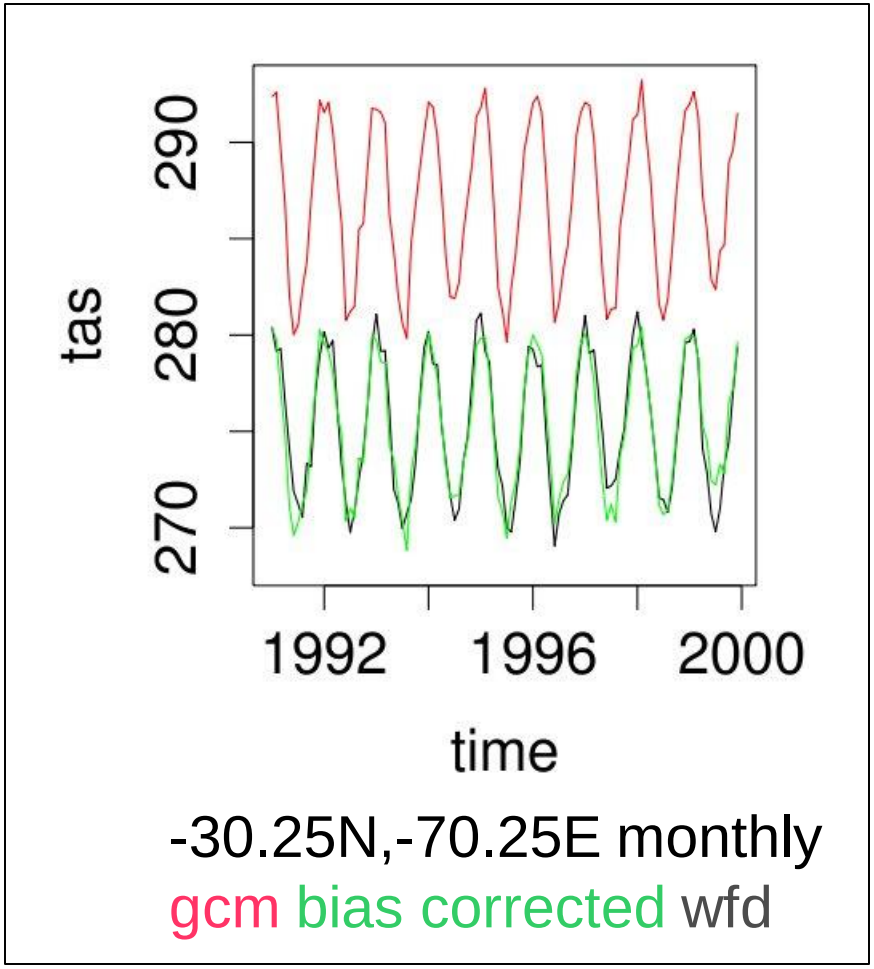
Pros of Bias Correction

- Provide **realistic** climate data
- **Compare** observed and simulated impacts during **historical** reference period
- Smooth **transition** into future
- **Activation-threshold** behavior
- More detailed **altitude information**
- **Variance** of downscaled data



Cons of Bias Correction

- Quality of observational data limits quality of correction
- Errors of major circulation system cannot be corrected
- Stationarity must be assumed
- Even most basic methods may destroy physical consistency
- **Potential to change the trend (i.e., if mean and variablility are adjusted the climate signal is changed)**

In ISI-MIP we modified the method of statistical bias correction described by Piani et al (2010) to preserve the trend

ISI-MIP

Bias correction – Methodology

- Construction period: 01-01-**1960** – 12-31-**1999**
- Application period: 01-01-**1950** – 12-31-**2099**
- Model data **corrected to** Watch Forcing Data **[WFD]**
- **Interpolation** of GCM data to **0.5°** grid and **standard calendar**
- Two steps:
  - Correction of long-term monthly mean
  - Adjustment of daily variability
- **Trend** of temporally interpolated data is **preserved** with respect to the **monthly mean**

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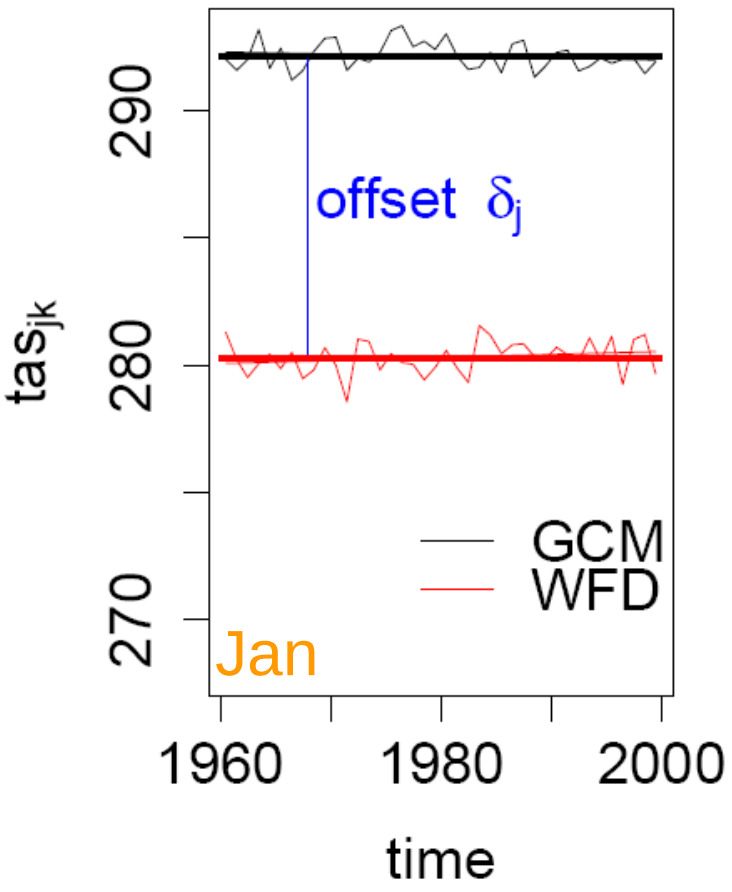
Temperature Algorithm – Step 1



- Aim: Preserve absolute trend
- 40 year long-term mean of average temperature for each month calculated from GCM and WFD

$$\delta_j = \underset{ik}{mean}(tas_{ijk}^{WFD}) - \underset{ik}{mean}(tas_{ijk}^{GCM})$$

$$i...day,\ j...month,\ k...year$$

- Constant offset to adjust the reference starting level to observational data

$$\overline{tas}'_{jk} = \underset{i}{mean}(tas_{ijk}^{GCM}) - \delta_j = \overline{tas}_{jk} - \delta_j$$

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Temperature Algorithm – Step 2

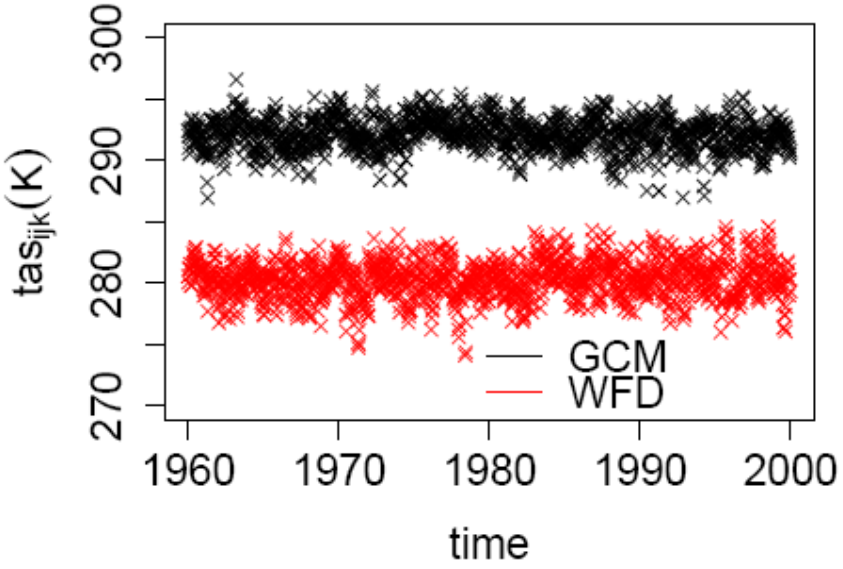
- Remove actual montly means

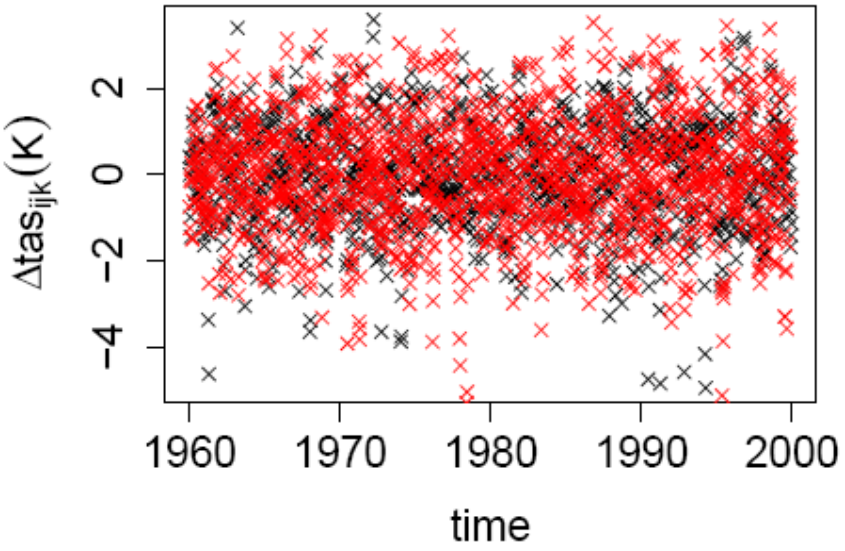
$$\Delta tas_{ijk} = tas_{ijk} - \overline{tas}_{jk}$$

$$tas_{jk} = \underset{i}{mean}(tas_{ijk})$$

$$i...day,\ j...month, k...year$$

for WATCH and GCM
(construction/application period)





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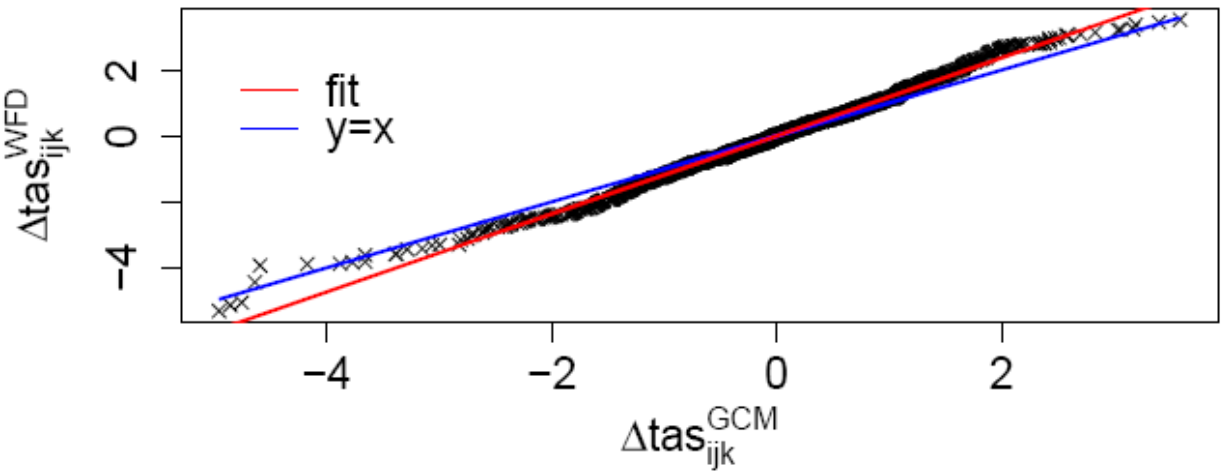
Temperature Algorithm – Step 2

- Construct linear transfer function for the residuals



- Apply transfer function to residuals and add old monthly mean

$$tas'^{GCM}_{ijk} = \delta_j + b \cdot \Delta tas^{GCM}_{ijk} + \overline{tas'}^{GCM}_{jk}$$

$$i...day,\ j...month, k...year,$$

$$\delta_j ...longterm\ \ mean,\ \ b...slope,\ \ \overline{tas}^{GCM}_{jk}\ \ ...monthly\ \ mean$$

Precipitation Algorithm – Step 1

- Multiplicative correction due to **positivity constraints**
- Aim: Preserve the **relative** trend
- Correct frequency of dry days and dry months

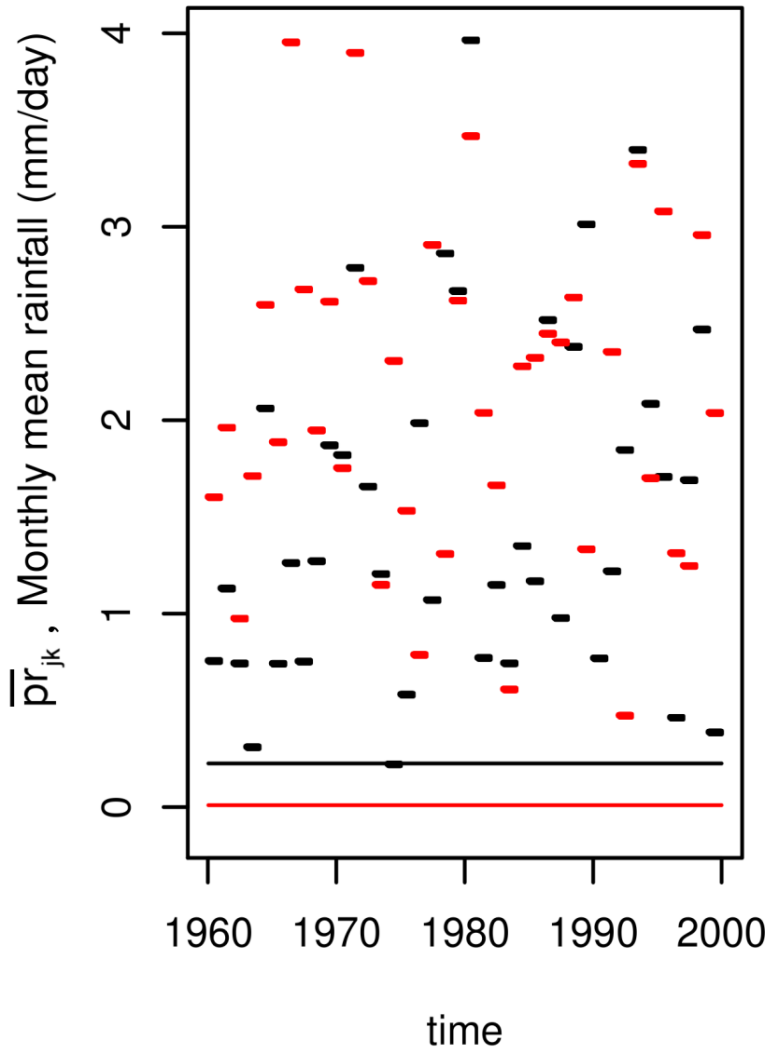
  - 40 year long-term mean

$$\rho_j = mean_{ik}(pr_{ijk}^{WFD}) / mean_{ik}(pr_{ijk}^{GFD})$$

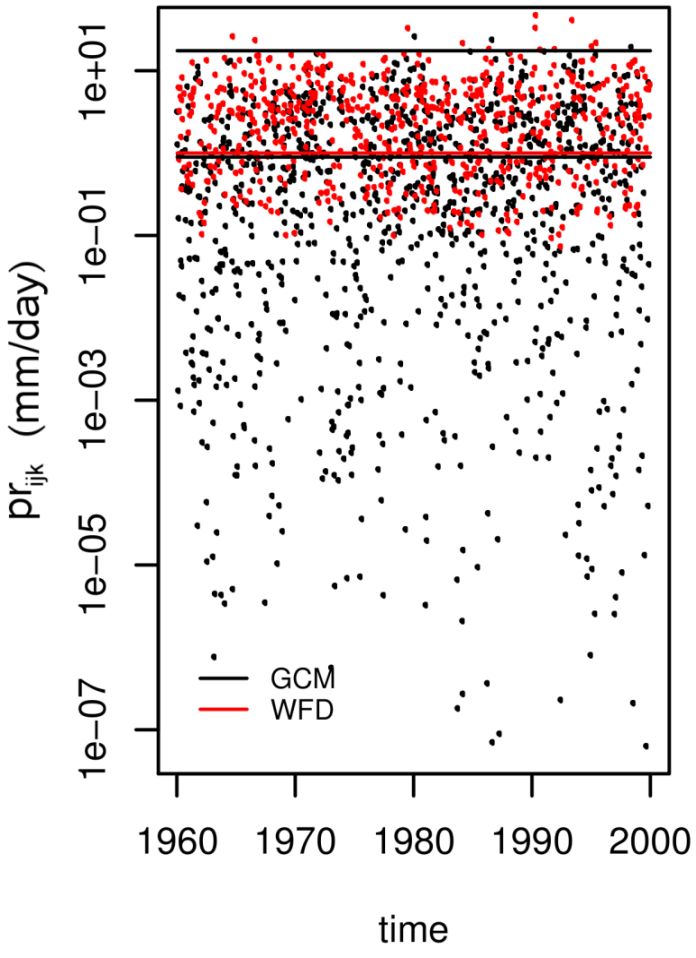
$$i...day,\ j...month,\ k...year$$

  - Constant ratio to adjust reference starting level

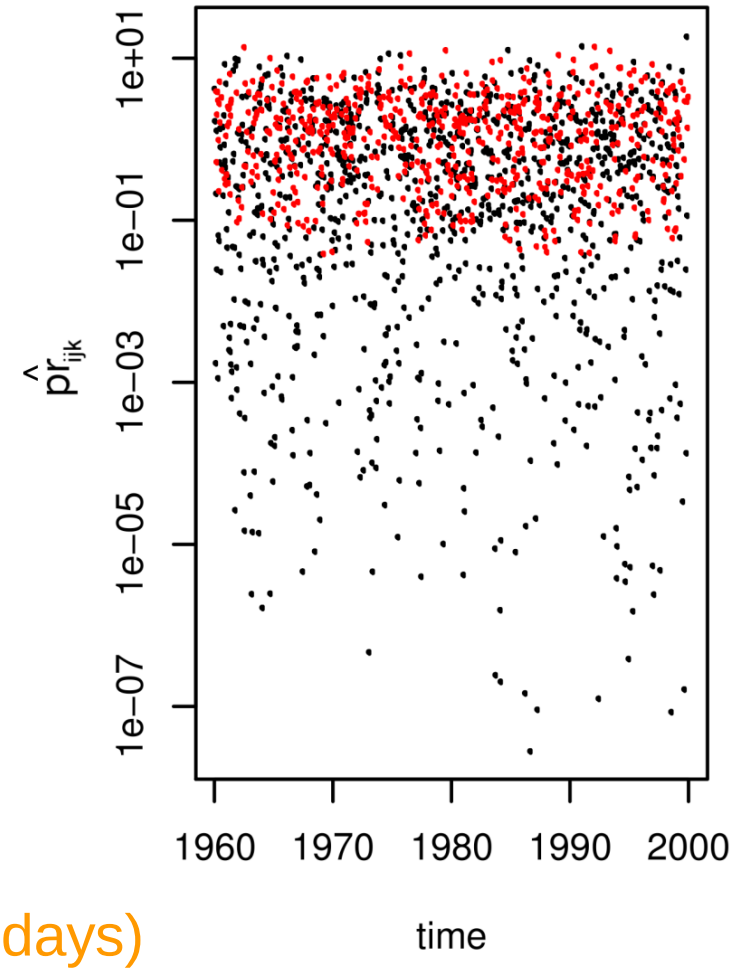
$$\overline{pr'}_{jk}^{GCM} = \rho_j \cdot \overline{pr}_{jk}^{GCM}$$



Precipitation Algorithm – Step 2



divide each month by its mean (each year)



Some day (dry days) omitted from fit

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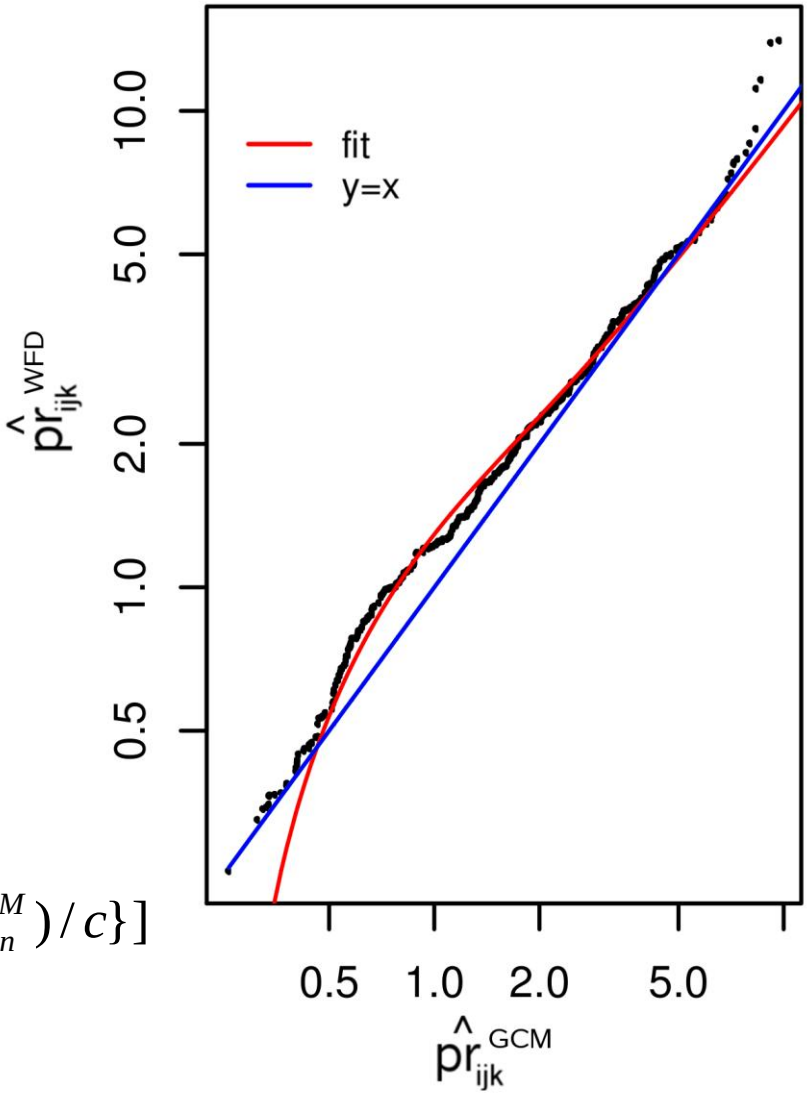
Precipitation Algorithm – Step 2

- Derive a (nonlinear) transfer function from the normalized values

  → Choose linear or exponential fit



$$pr'^{GCM}_{ijk} =$$

$$[a + b \cdot (pr^{GCM}_{ijk} - pr^{GCM}_{mean})][1 - \exp\{-(pr^{GCM}_{ijk} - pr^{GCM}_{mean})/c\}]$$

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Ongoing challenges

- Classification of **dry months** and **dry days**
- **Ratio** of 40 year monthly mean ρ_j
  - can be **zero** in very dry regions or **blow up**
- Multiplicative correction
  → **unphysically high** daily precipitation values
- **Drizzle days truncated** to adjust freqency of dry days
  → reduced monthly mean
  → **redistribution** of rain
- Adjust **daily variability of normalized data** → mean affected
- **No correction of monthly variability**
  → some GCM exhibit highly unrealistic monthly variability

Correction of other variables

- Pressure, radiation and total wind use precipitation algorithm to preserve relative trend
- Minimal and maximal daily temperature corrected by a factor preserving the distance to the average temperature
- Snowfall corrected as fraction of total precipitation
- Wind components corrected with the same factor as total wind

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Summary – Bias correction status

variable	monthly mean	daily variance
tas	additive	additive
tasmin/tasmax	from tas	from tas
pr	multiplicative	only partially
prsn	from pr	only partially
rlds/rsds/ps/wind	multiplicative	only partially

- Validate extended multiplicative algorithm
  → ISI-MIP fast track & amended bias corrected climate input will be made available to the public
- Integration to Climate and Environmental Retrieval and Archive (CERA) is scheduled for spring 2013

http://http://www.dkrz.de/daten/

Thank You

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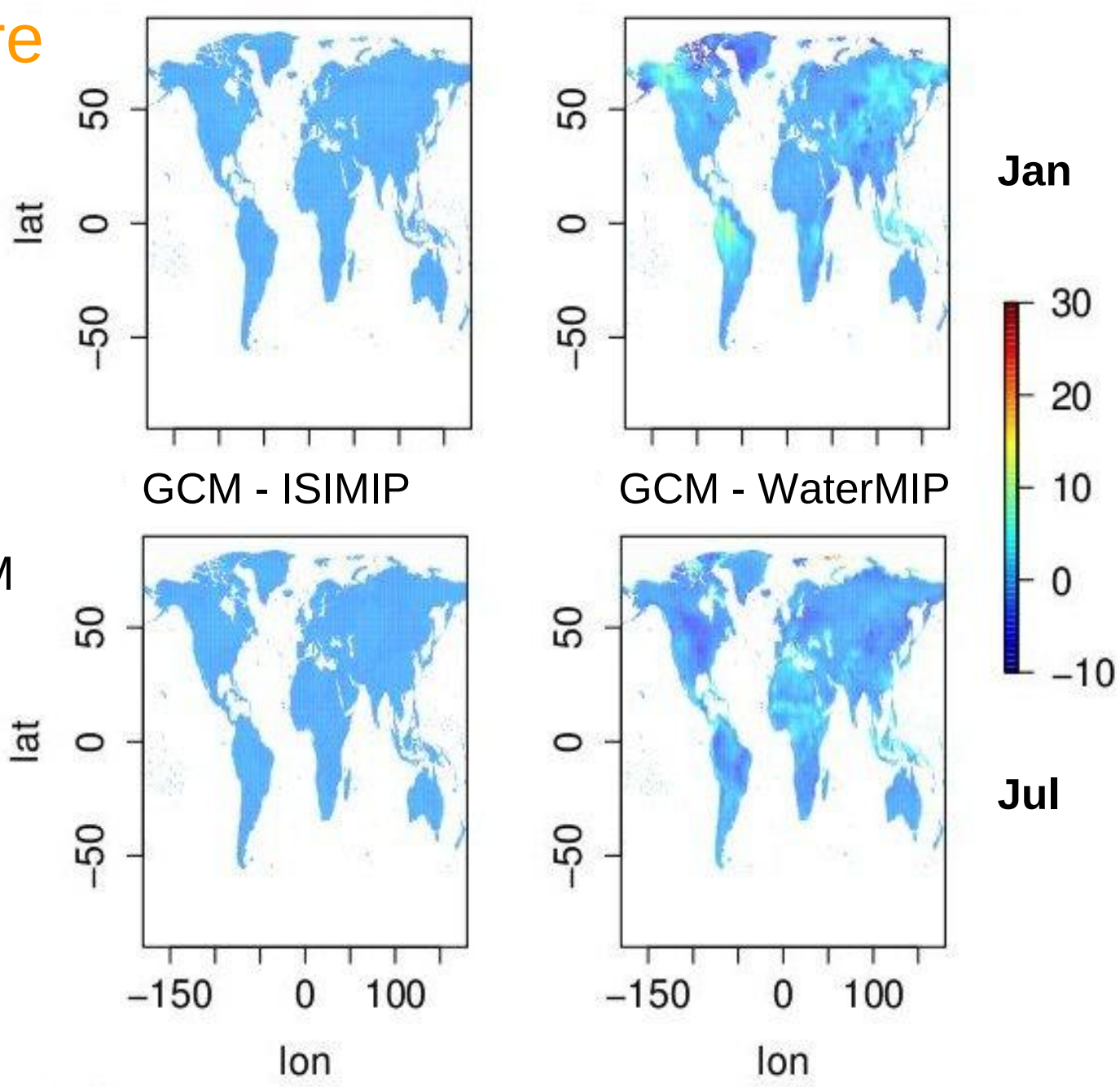
Temperature Trend

- New method preserve absolute temperature trend of GCM (2091-1961)



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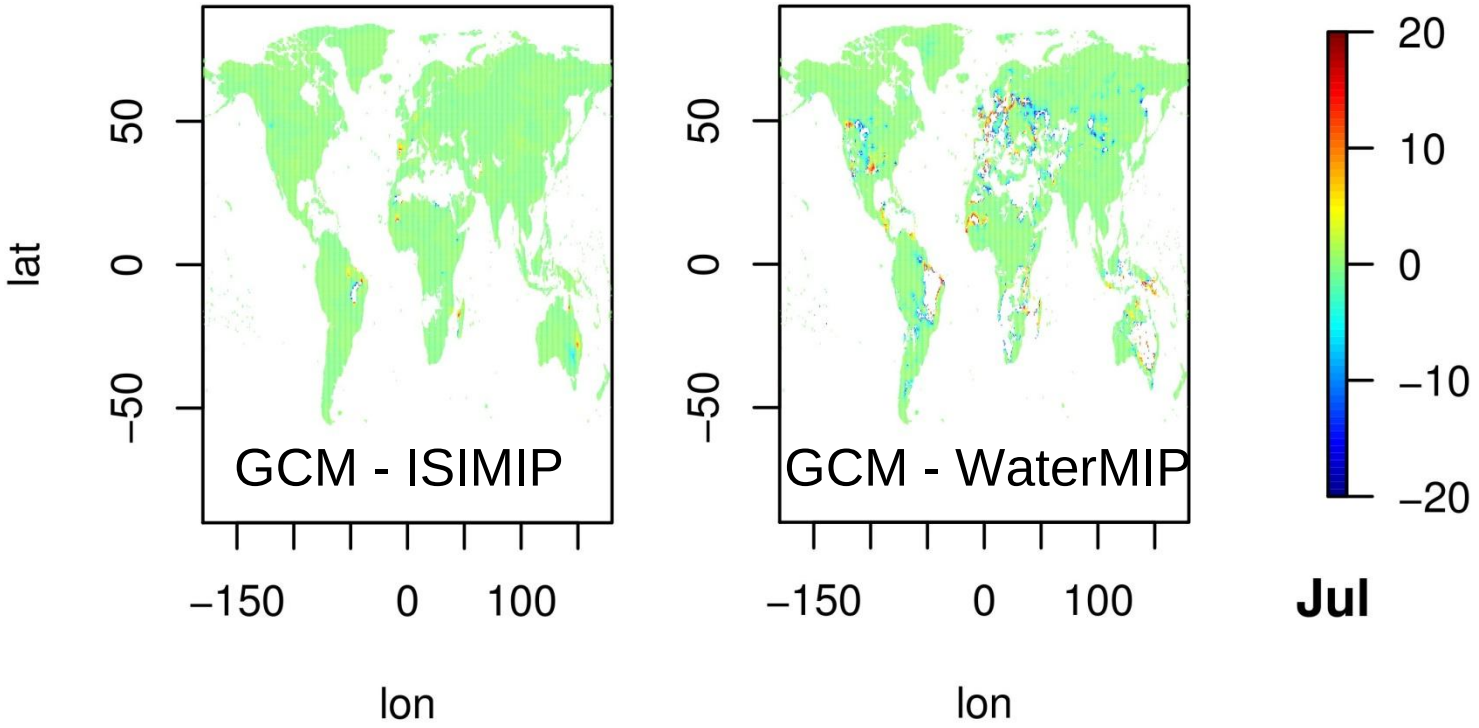
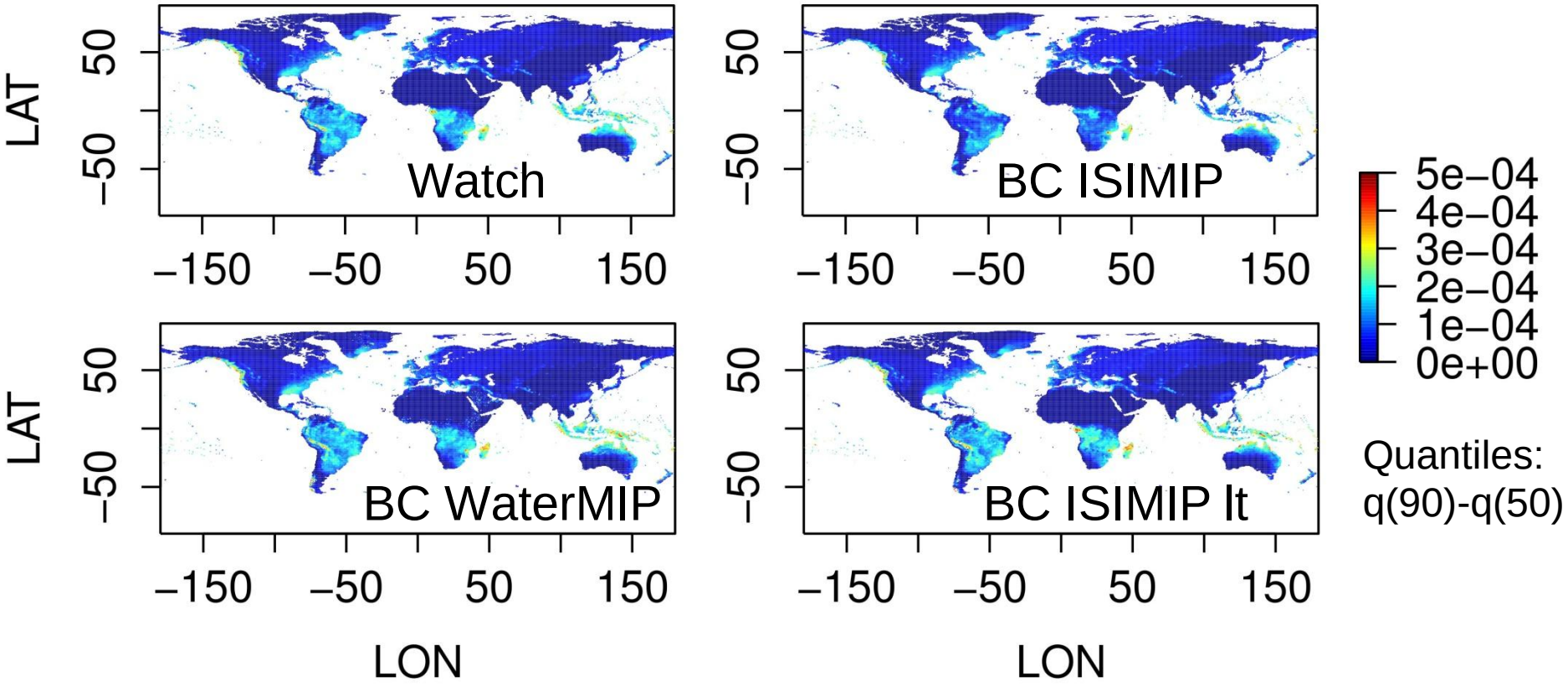
Precipitation Trend – Deviation to GCM output



- Relative trend (2091/1961) of GCM is almost preserved
- Small deviations due to temporal interpolation
- If monthly mean zero in one year / dataset then no comparison

Adjustment of daily rainfall distribution



- World map of interquantile distance (1960-1999, Jan)

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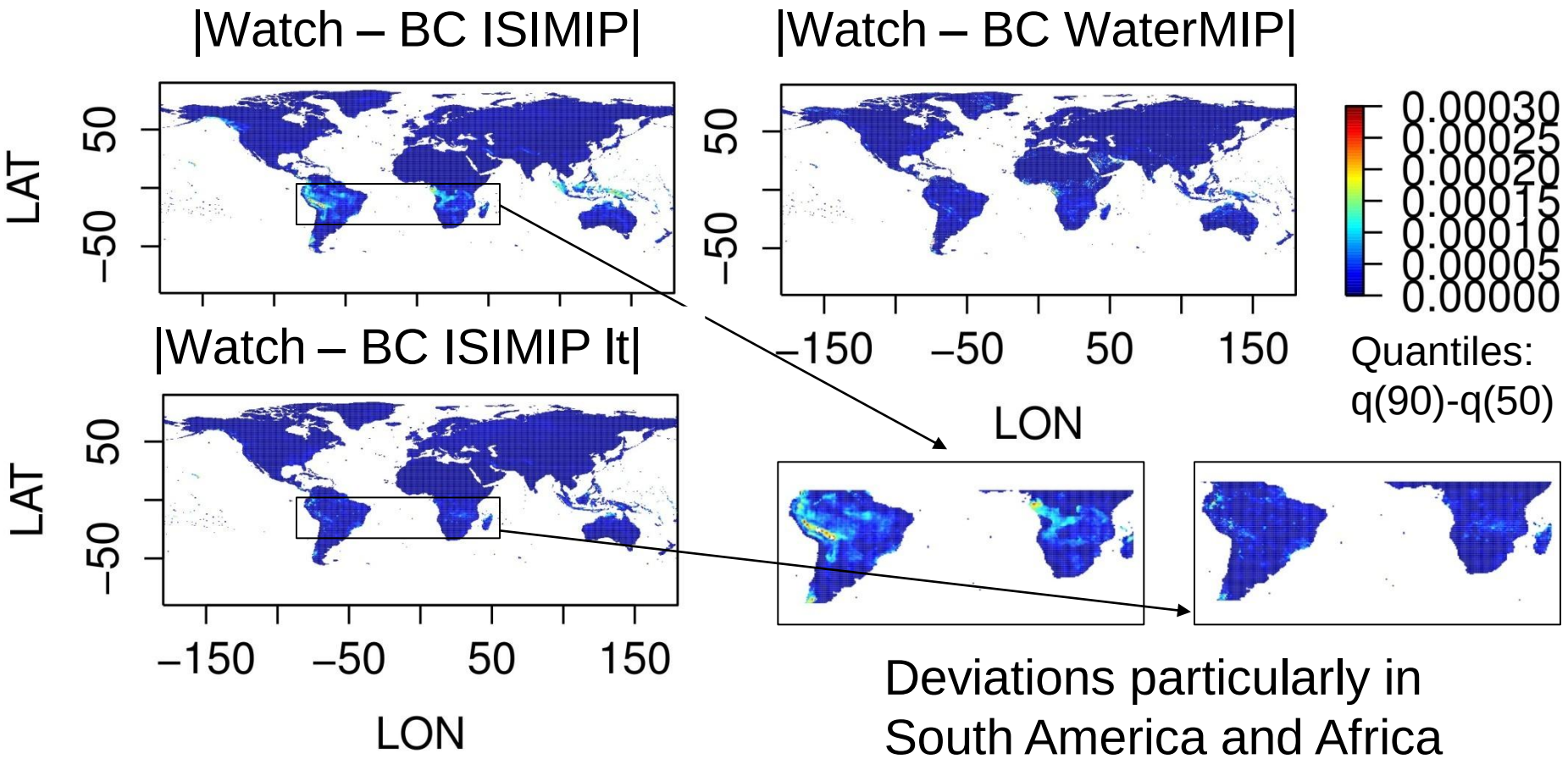

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Research Questions

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- How big is the **uncertainty** arising from different **climate inputs** and individual **impact models**?

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Method

- Inter-Sectoral Impact Model Intercomparison project
- Common climate (and socio-economic) input
- Different climate models, scenarios and impact models
- Trend-preserving bias correction

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