Estimates of present and future discharges of the river Rhine in the SWURVE project

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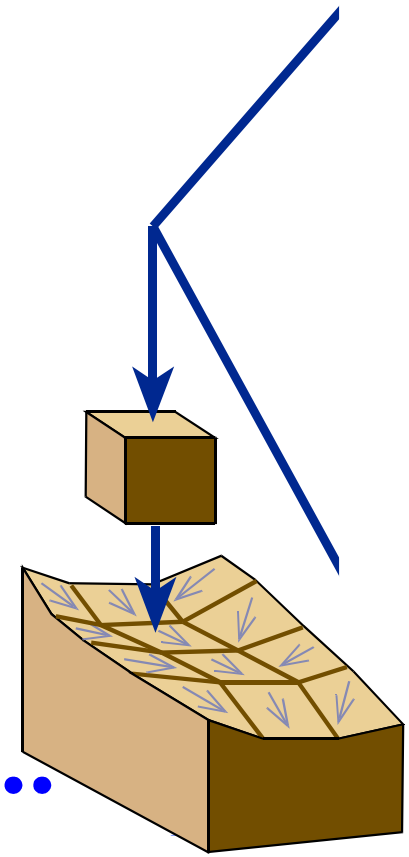
Overview

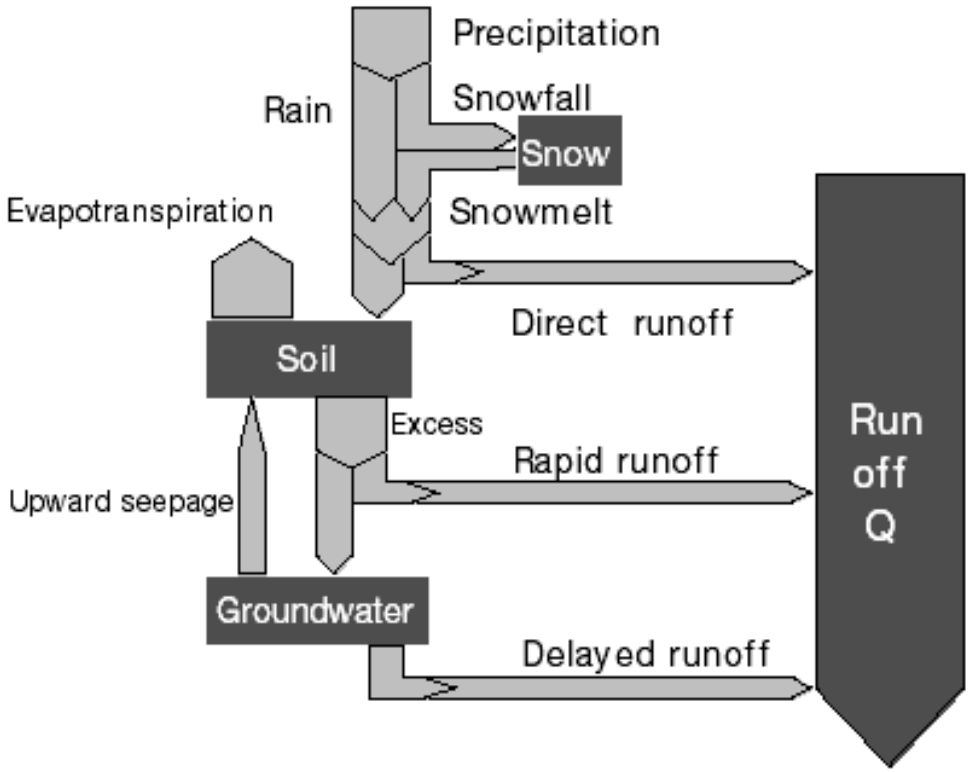
- Introduction RhineFlow (RF)
- HadRM2/3 and scenario construction
- Forcing RF directly with present day HadRM3
  - The role of “bias” correction
  - Mean flow and extremes
- Future projections
- Discussion

Water balance model - RHINEFLOW

- Output: Monthly or 10-day mean discharges of the Rhine and major tributaries
- Input: Mean, Max. and Min. Temperature, Precipitation and Potential Evaporation



Flow diagram of hydrological processes in the RHINEFLOW model



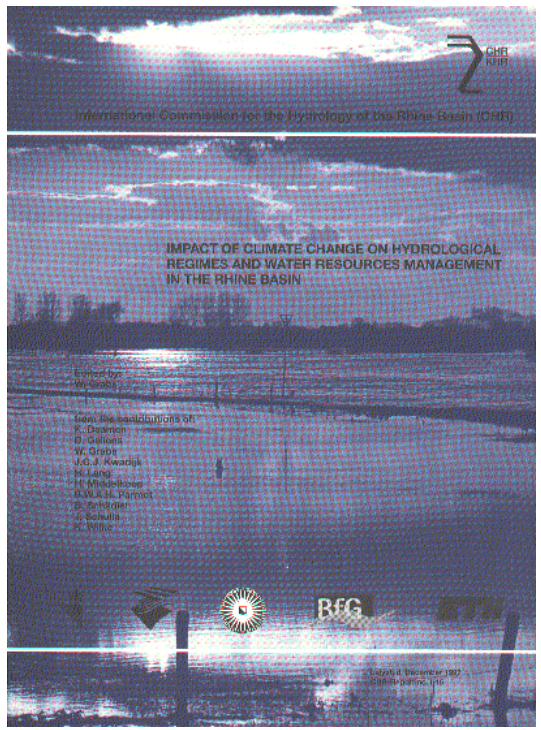
Use of Rhineflow (RF I) in CHR project 1997: Changes in discharge regime Rhine 2050 (Lobith)

Winter: increased discharges (~ 15 %)

- Decreased storage of snow
- Increased precipitation

Summer: decreased discharges (~10-20 %)

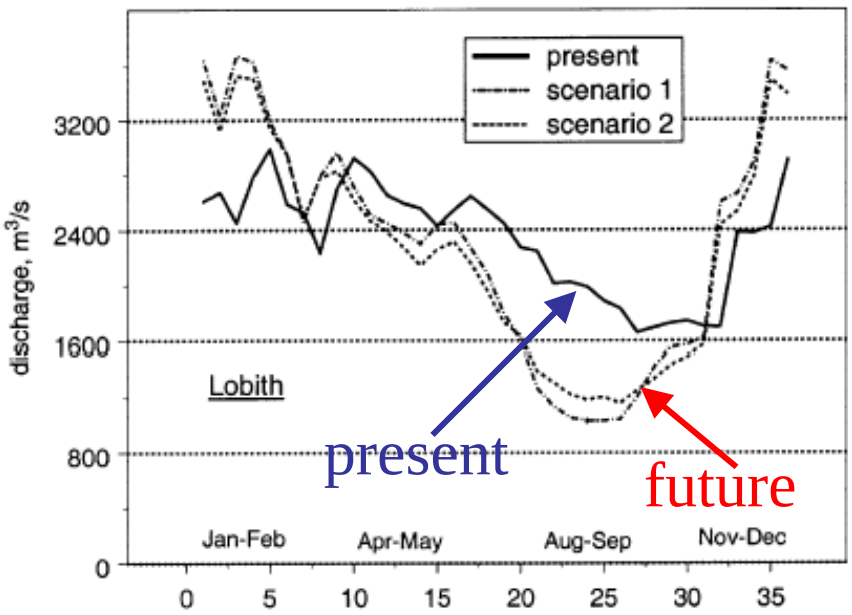
- Decreased snow melt
- Increased evaporation



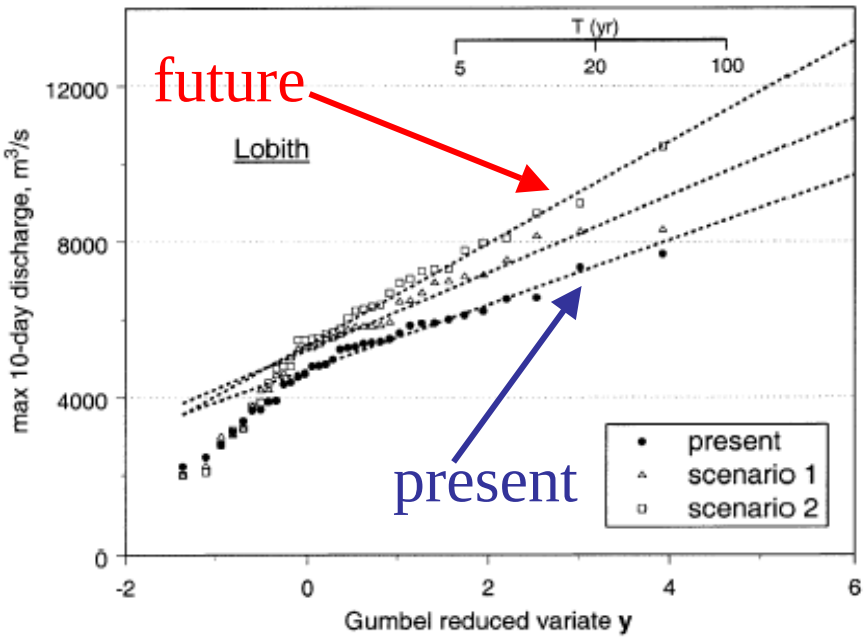
RhineFlow (RFII) in the SWURVE project
previous work by Marina Shabalova

(Clim. Res., 2003, 23, 233-246: reprint available)

Mean flow



Yearly maximum



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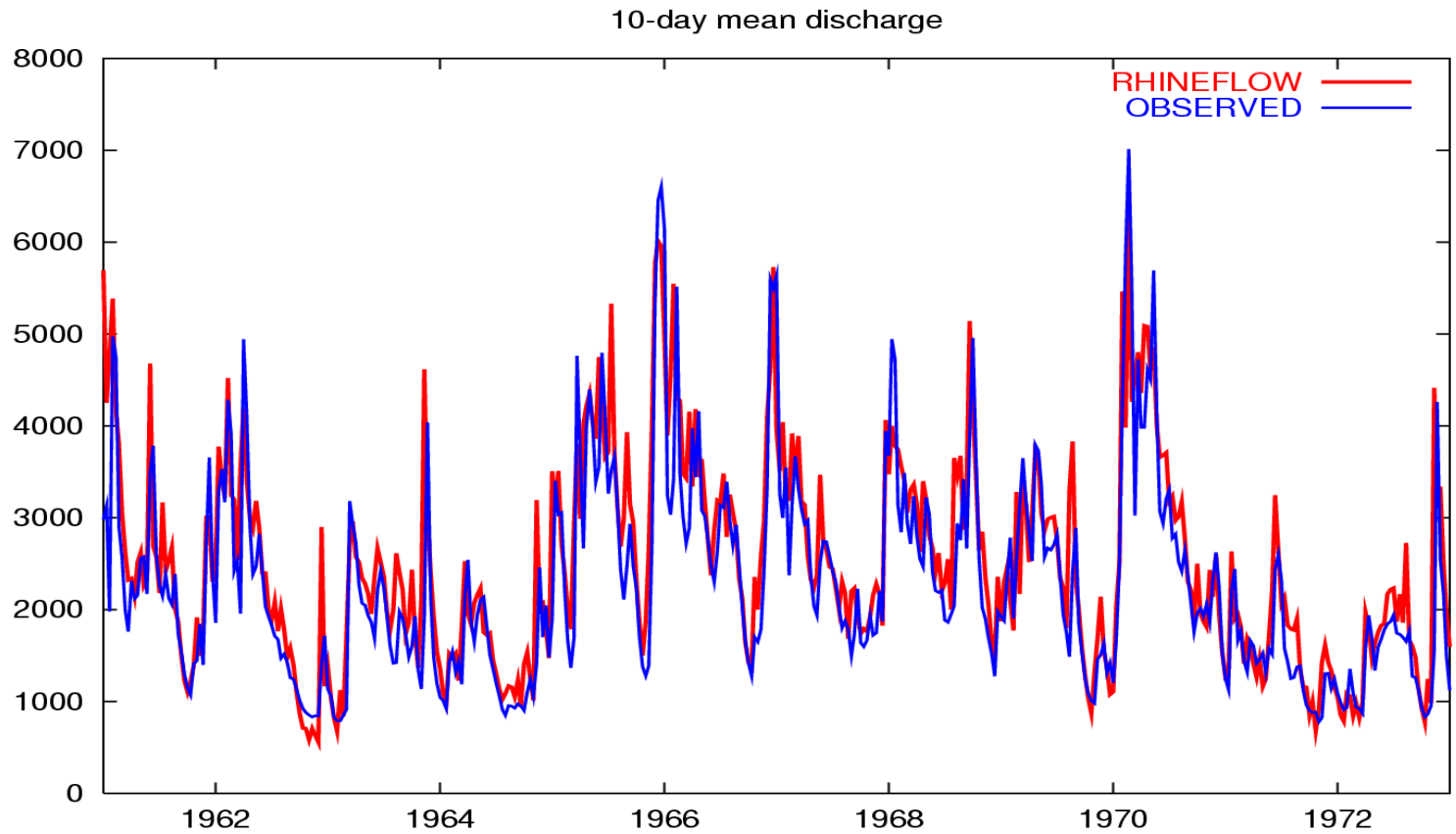
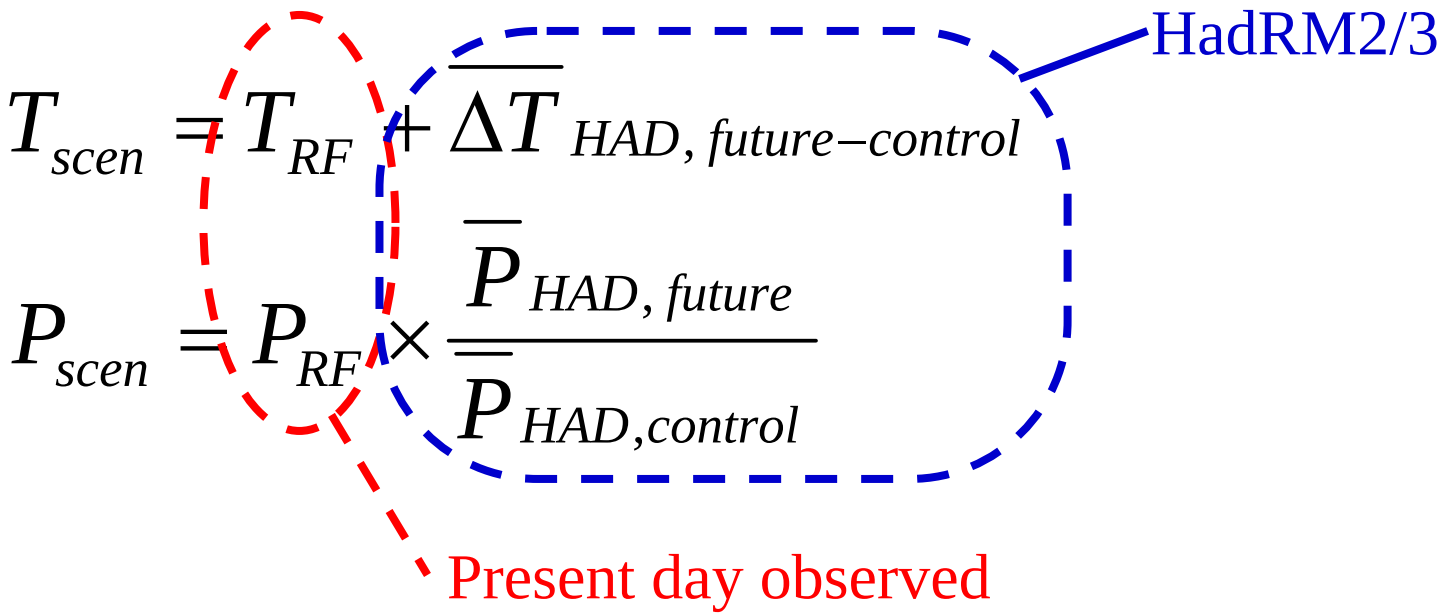
RhineFlow (III) compared to observations at Lobith



Scenario construction using HadRM3 (or HadRM2) (previous approach)

- HadRM3: 3 x 30 year control +
  3 x 30 year future (2070-2100) (SRES A2 emission)



Scenario construction using HadRM3 (or HadRM2)
(new approach: "direct forcing")

$$T_{pres} = T_{HAD,control} + \overline{\Delta T}_{HAD,control-RF,control}$$

$$P_{pres} = P_{HAD,control} \times \frac{\overline{P}_{RF,control}}{\overline{P}_{HAD,control}}$$

$$T_{scen} = T_{HAD,future} + \overline{\Delta T}_{HAD,control-RF,control}$$

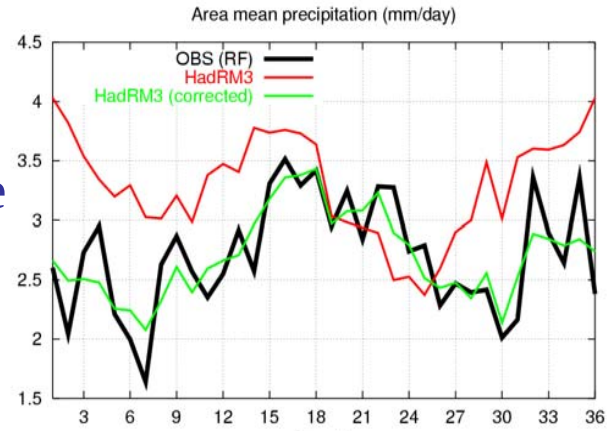
$$P_{scen} = P_{HAD,future} \times \frac{\overline{P}_{RF,control}}{\overline{P}_{HAD,control}}$$

"Bias" correction

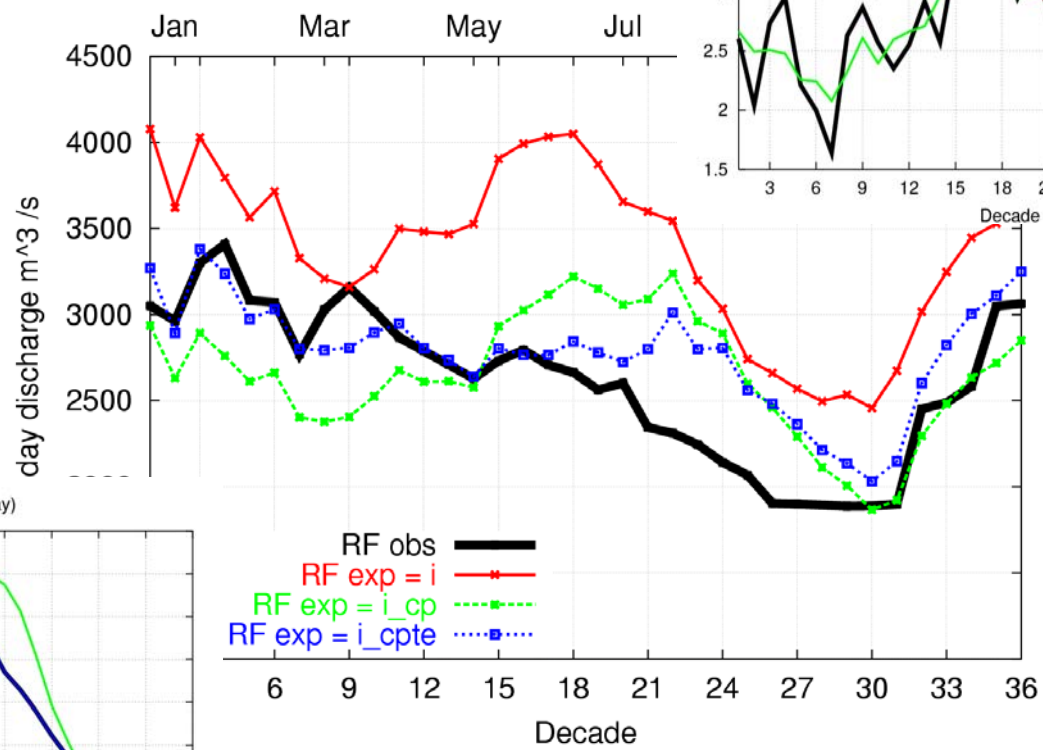
HadRM3

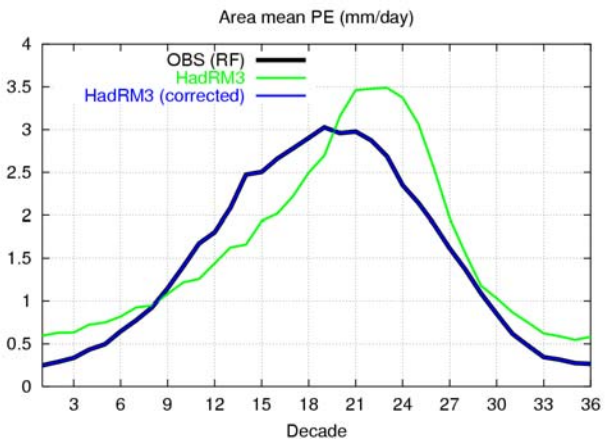
Present climate

Bias correction precipitation



Mean discharge





Bias correction potential evaporation (+temperature)

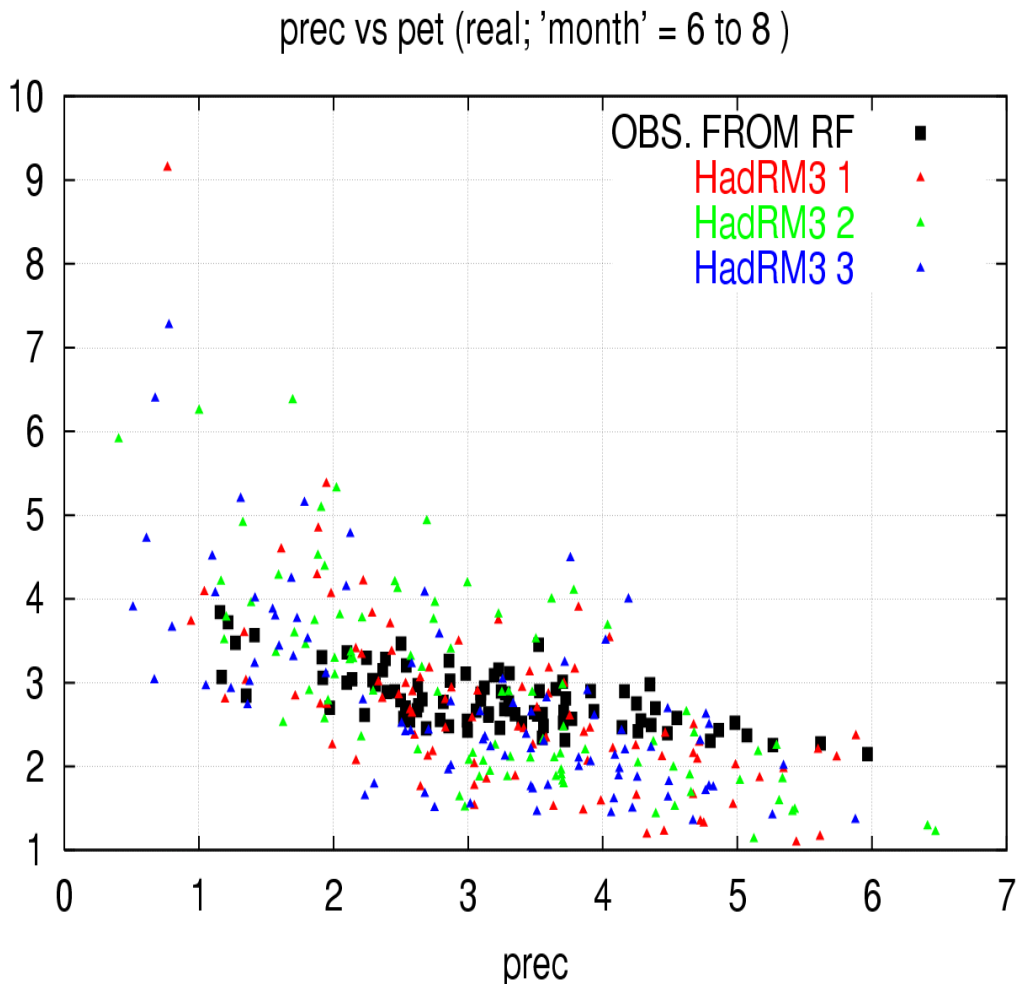
Summer PE against Prec

E_{pot} based on Penman
(saturation deficit+radiation)

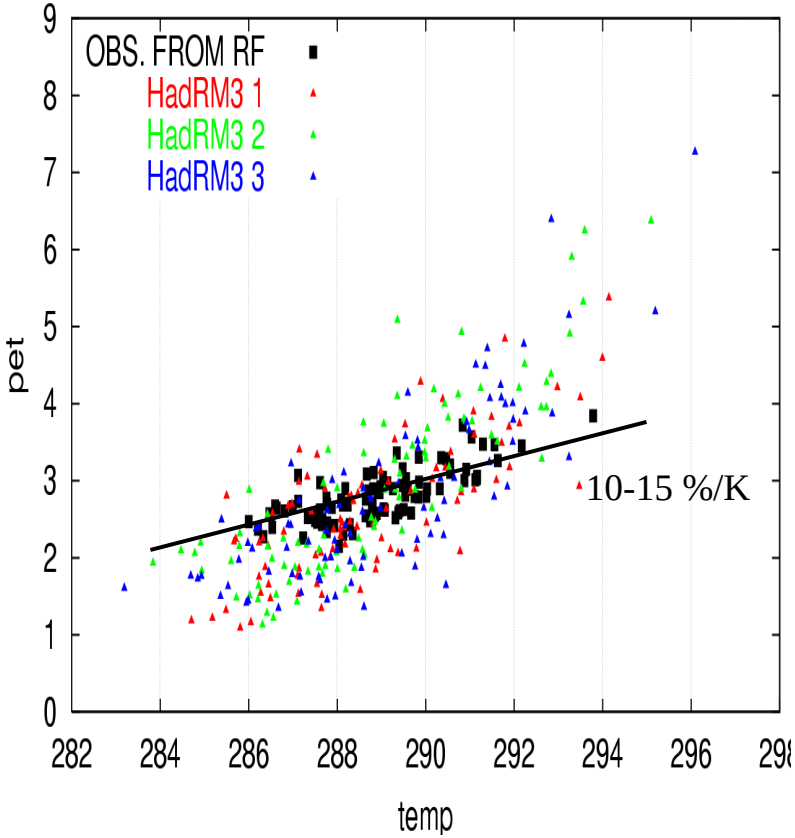
$$E \approx E_{pot} w$$

$$\overline{E} \approx \overline{E_{pot}}\,\overline{w} + \overline{E_{pot}' w'}$$

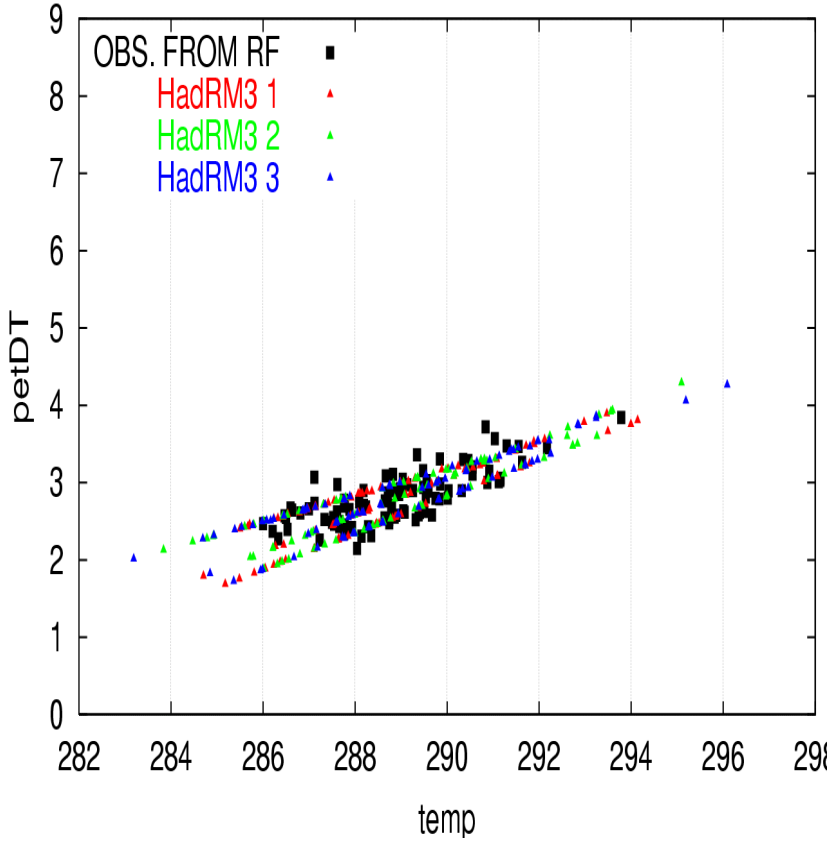
w : soil moisture



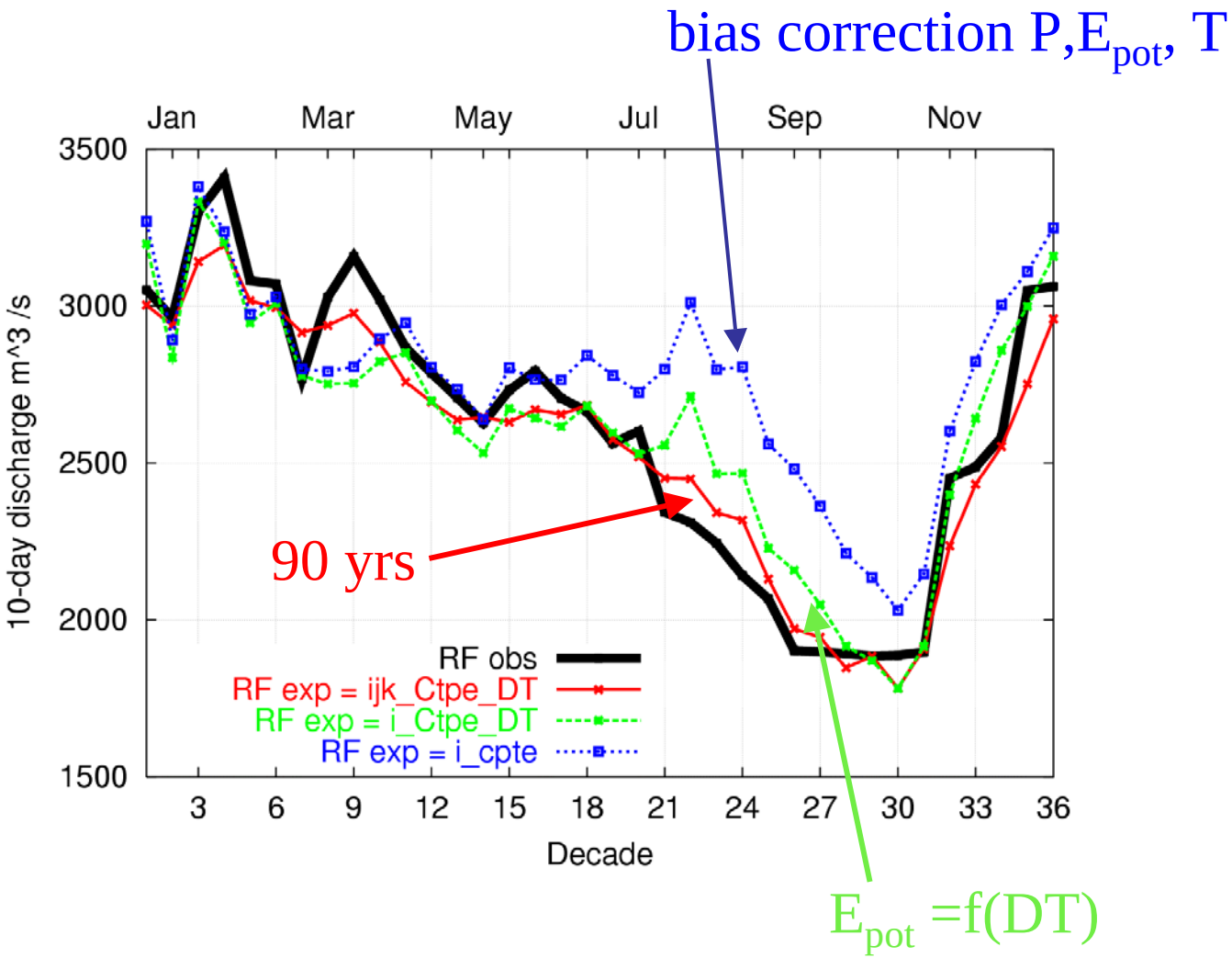
PE from HadRM3



PE based on temperature



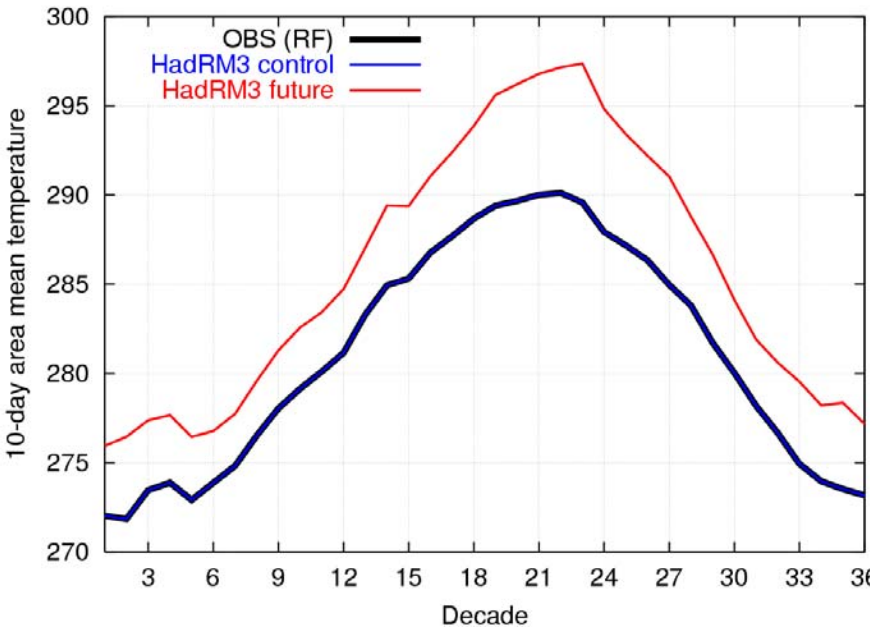
Present Climate



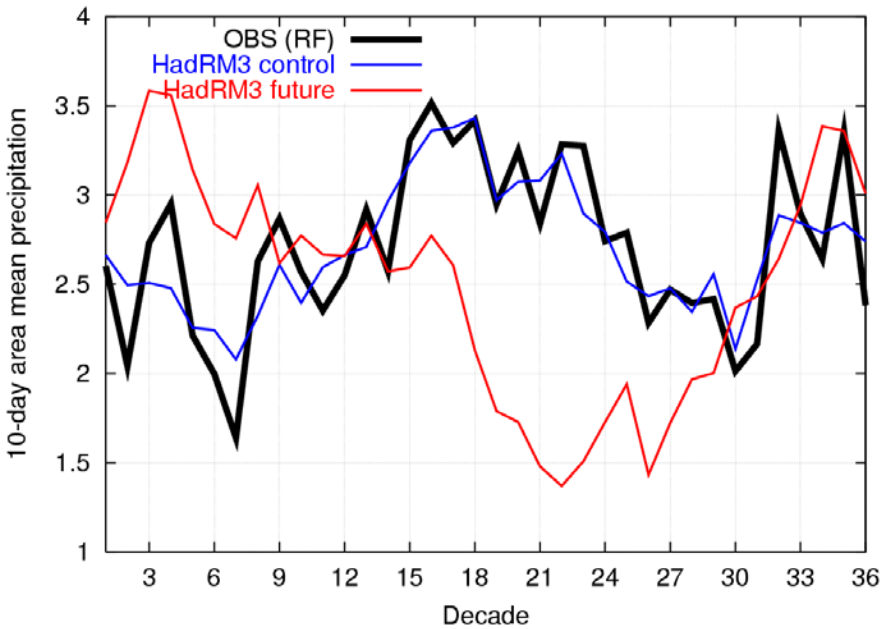
Future Scenarios

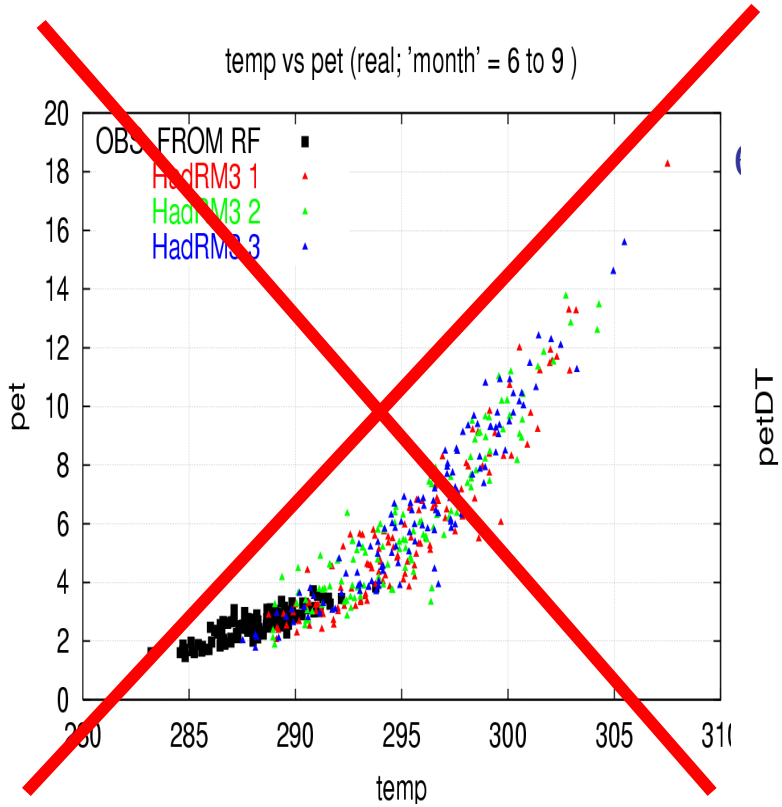
(change temperature and precipitation after bias correction)

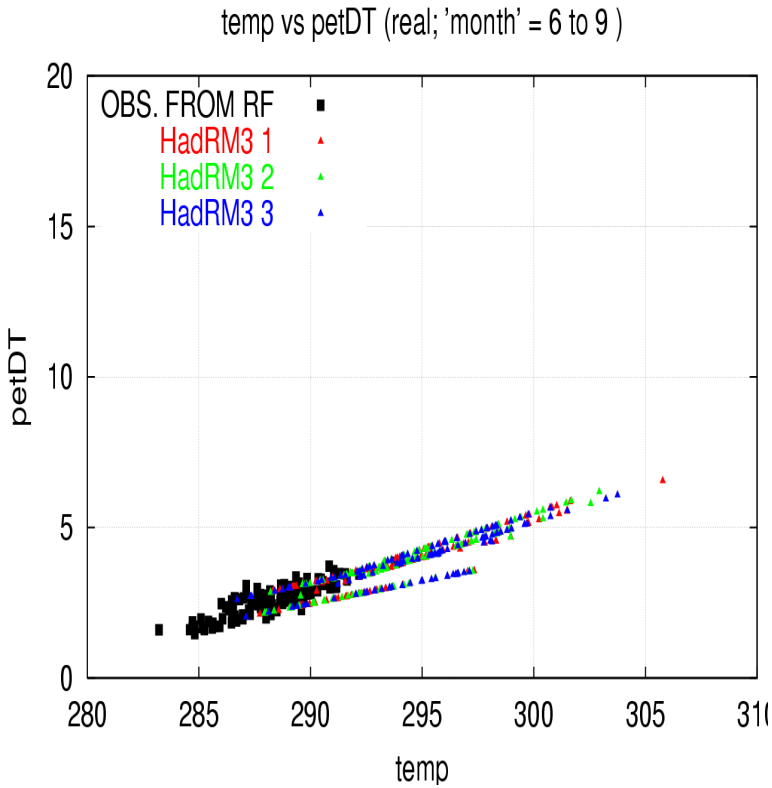
temperature



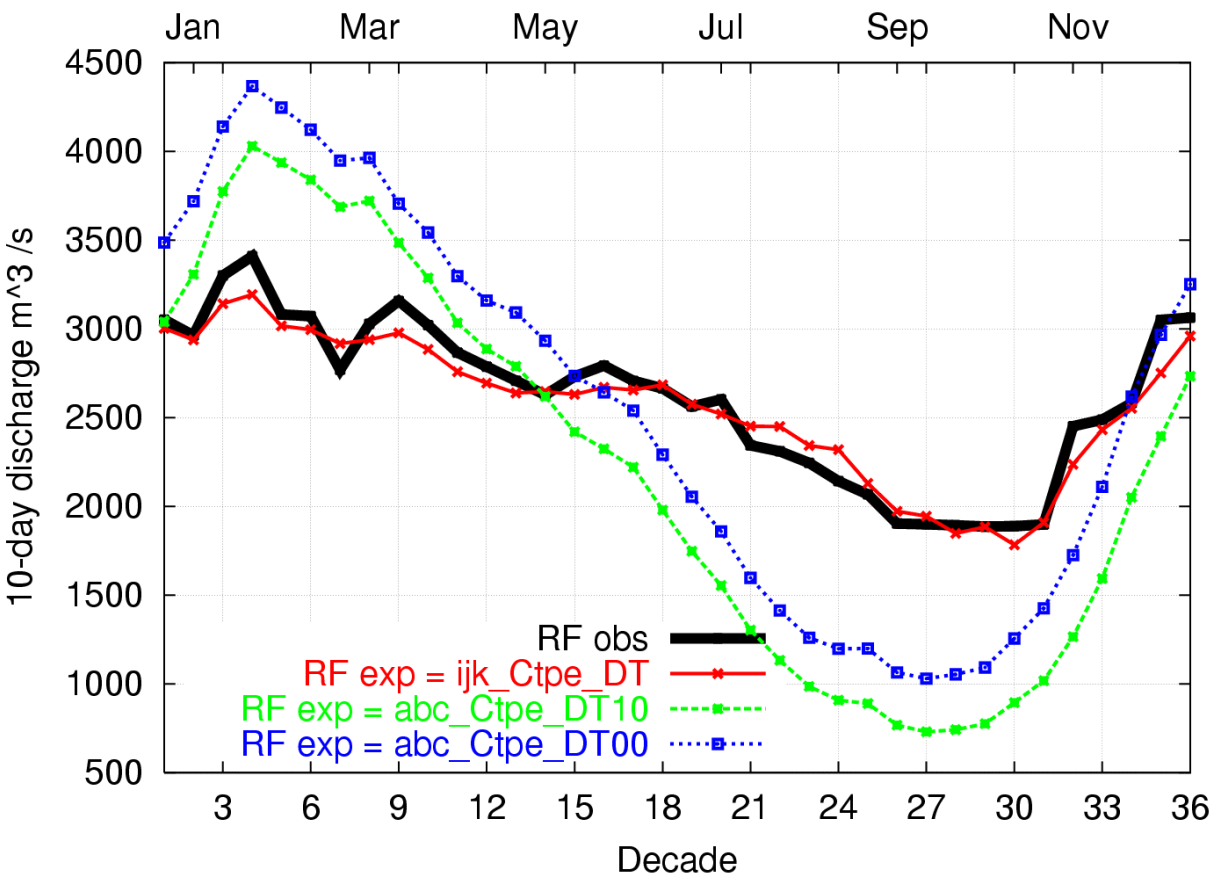
precipitation

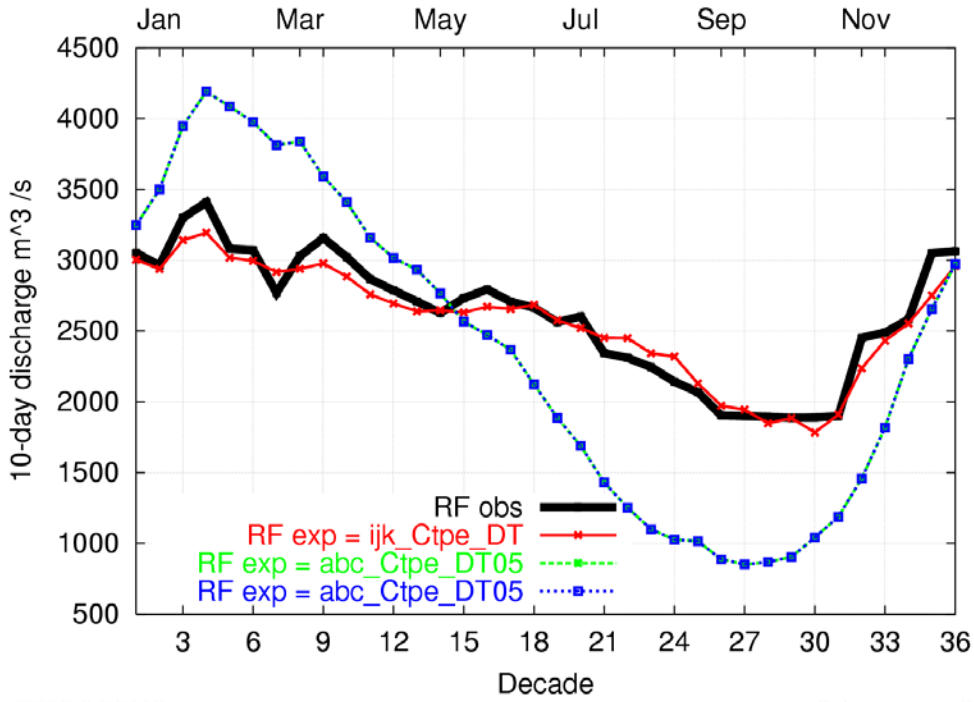


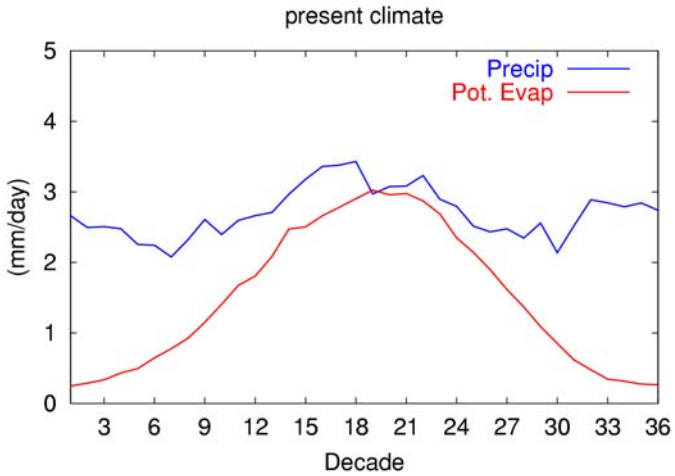


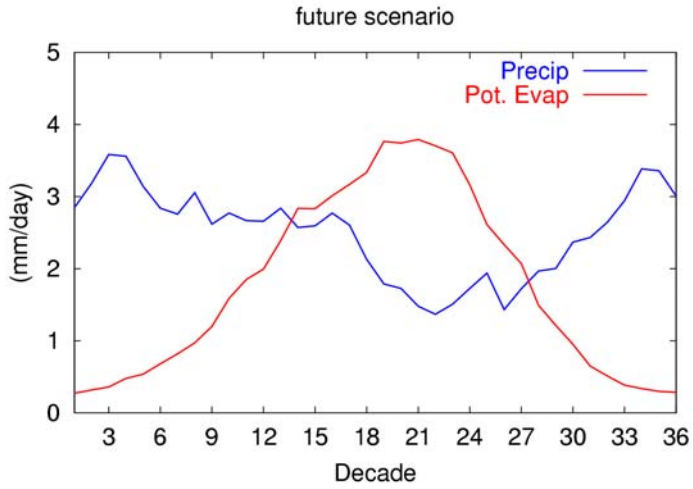


Future climate

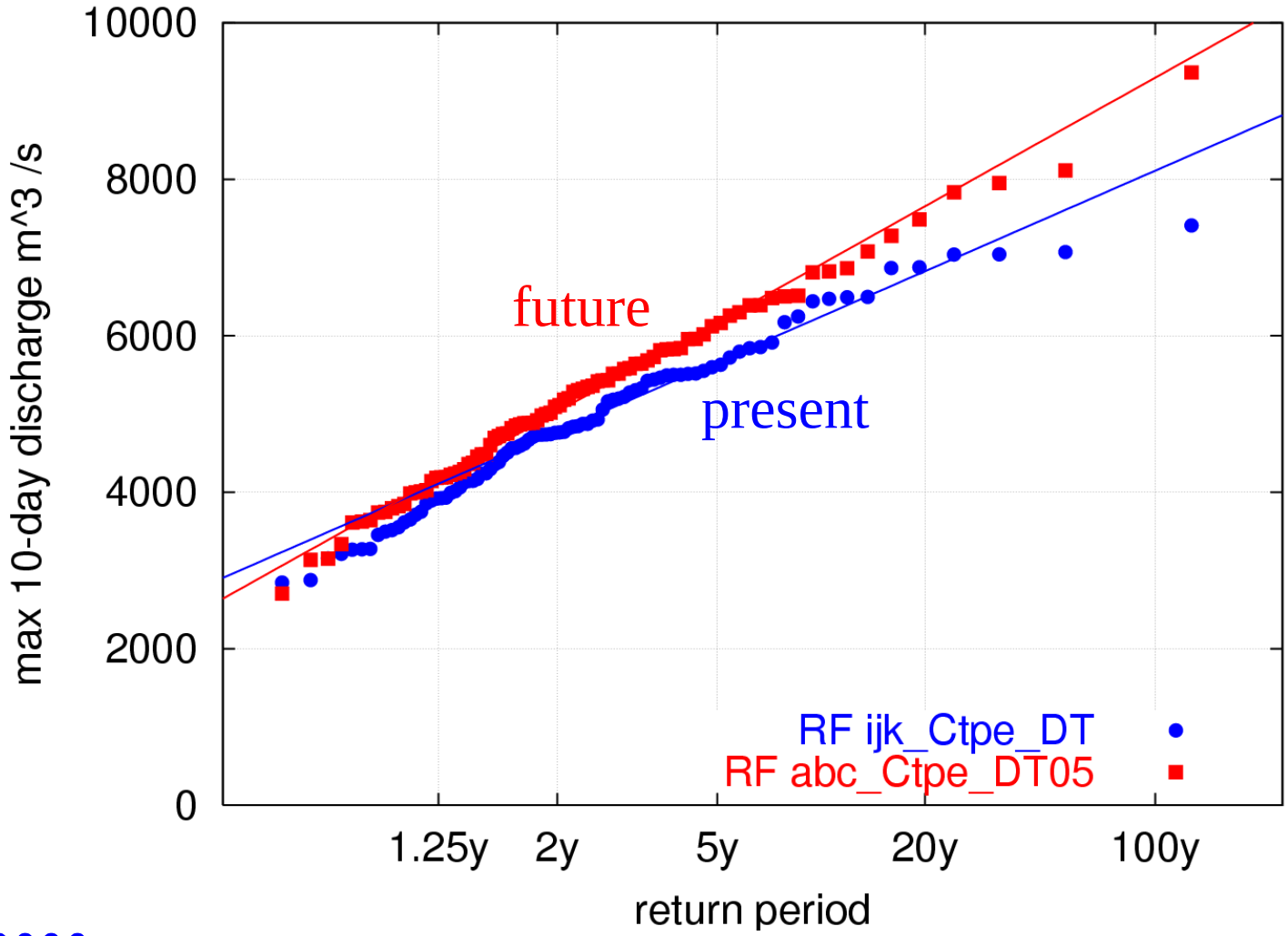






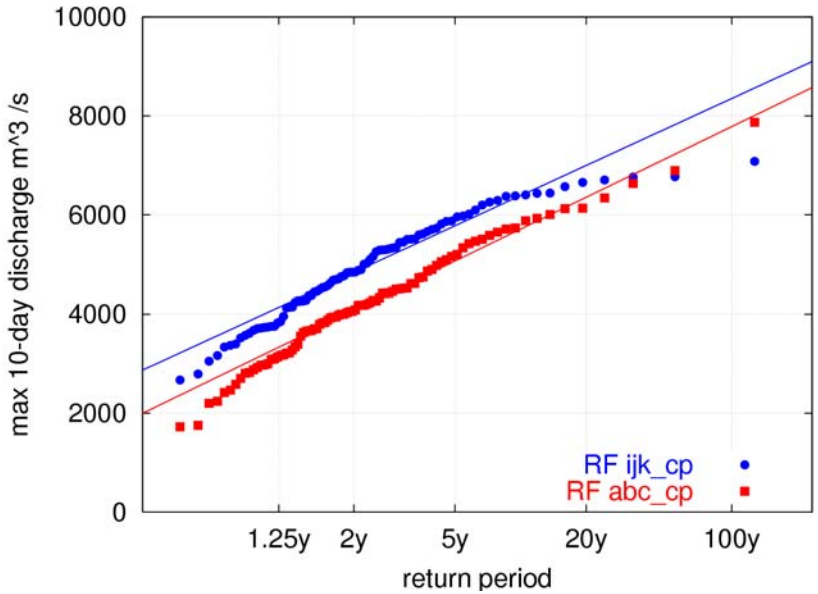


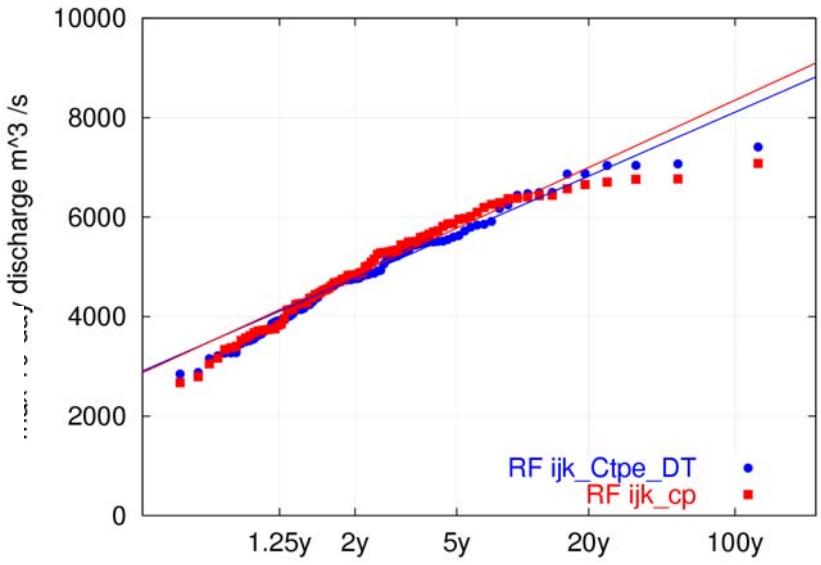
Gumbel plot extremes

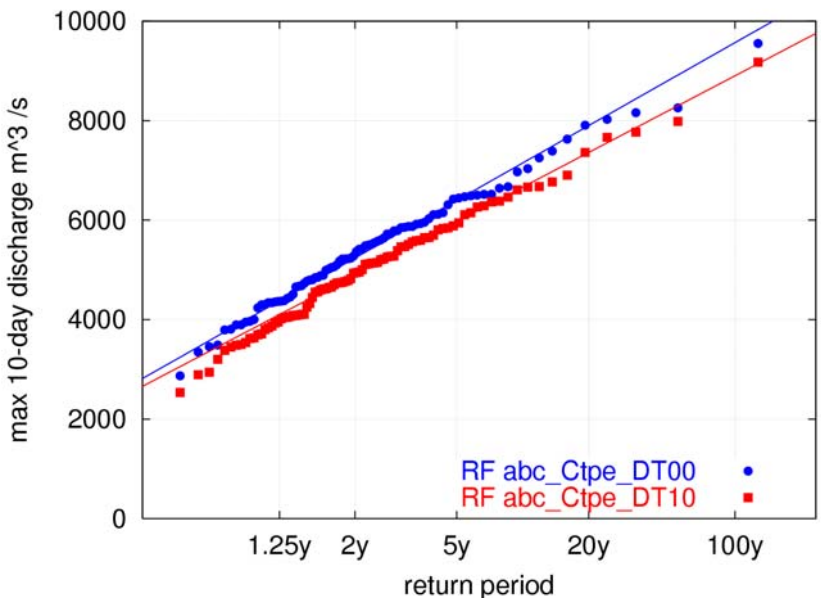


Conclusions

- direct forcing approach RF only possible after (bias) corrections to HadRM3 data
- Potential Evaporation in HadRM3 problematic, possibly (likely) due to too strong feedbacks in the hydrological cycle
- After corrections:
  - Good results present climate
  - Future projections:
    1. Mean: + 30 % winter, - 40 % summer (summer response questionable)
    2. Extremes: 100-year event +1000 m^3/s







RhineFlow in present-day climate