Modelling rainfall errors within a Bayesian rainfall-runoff inference framework

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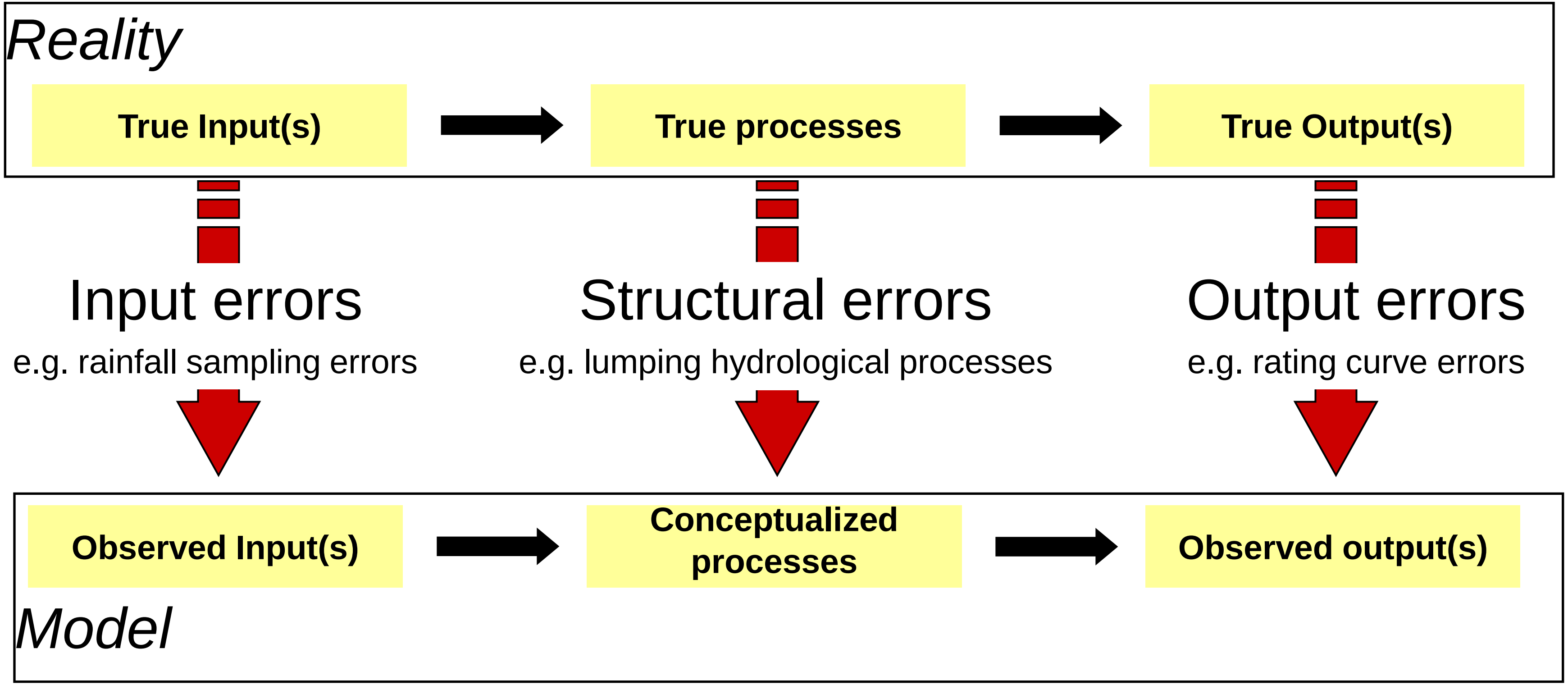
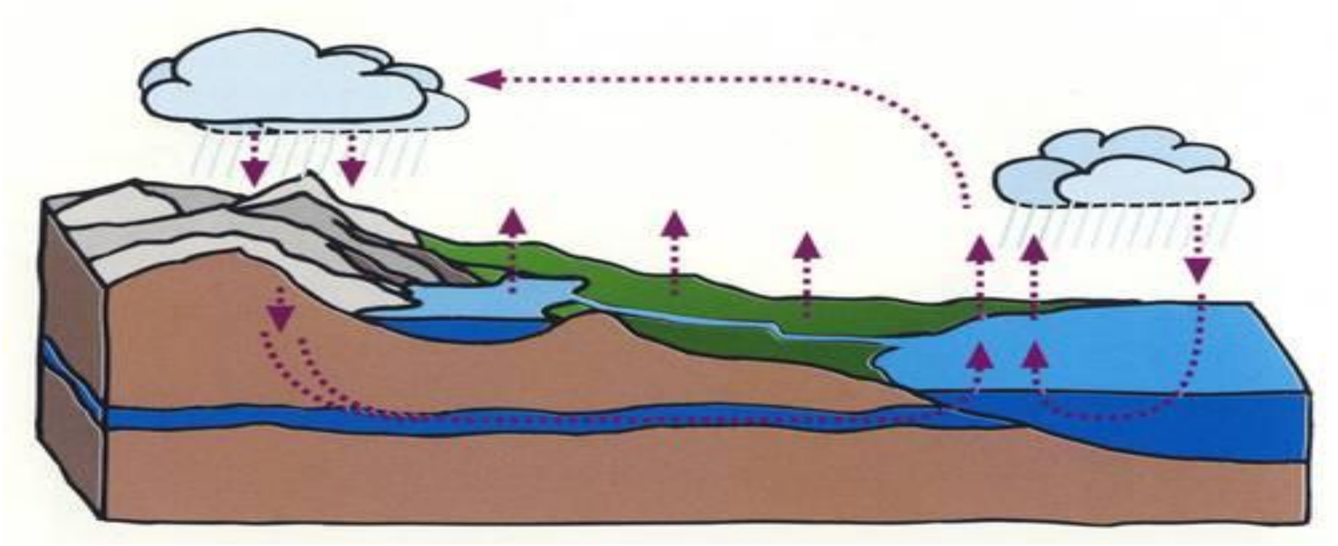
Errors in Environmental Modelling



Motivation

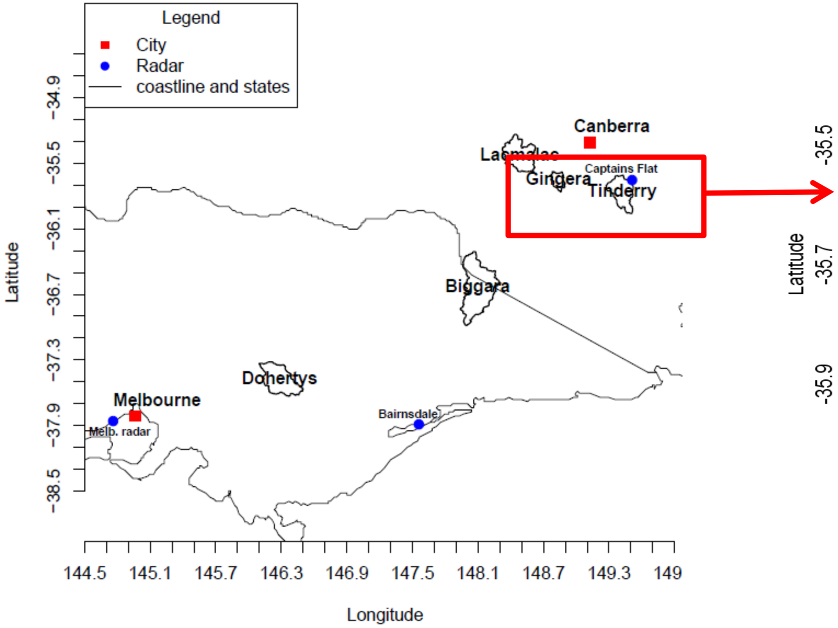
1. Rainfall is the major driven in hydrological modeling

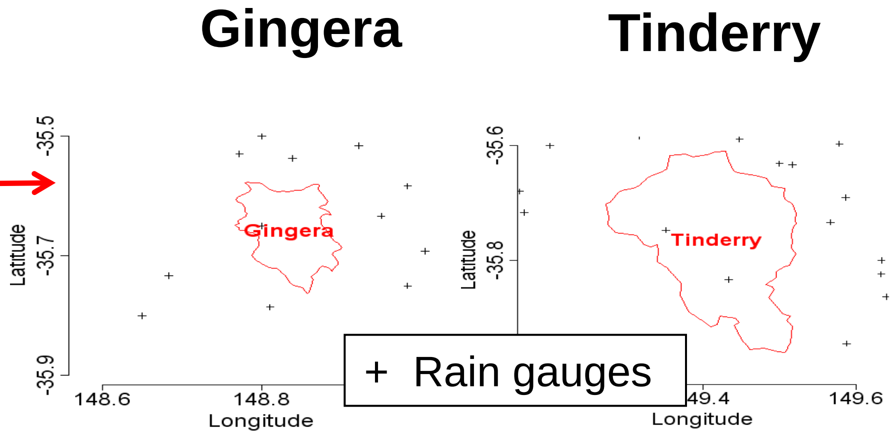


Motivation

2. Uncertainty of rainfall measurements is high:

because rainfall fields are highly variable in time and space, but sparsely sampled, especially in large catchments



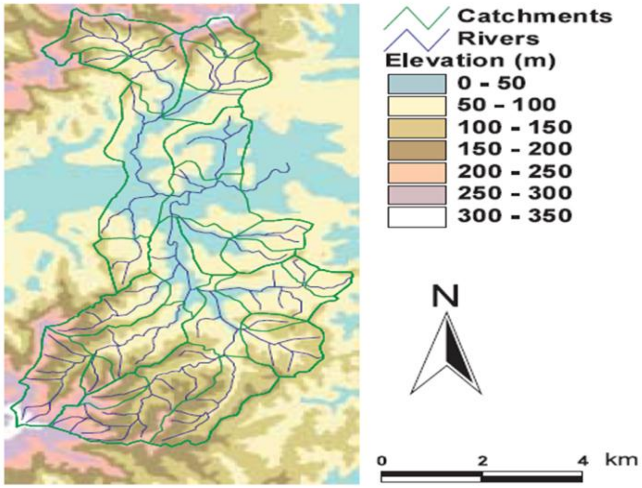


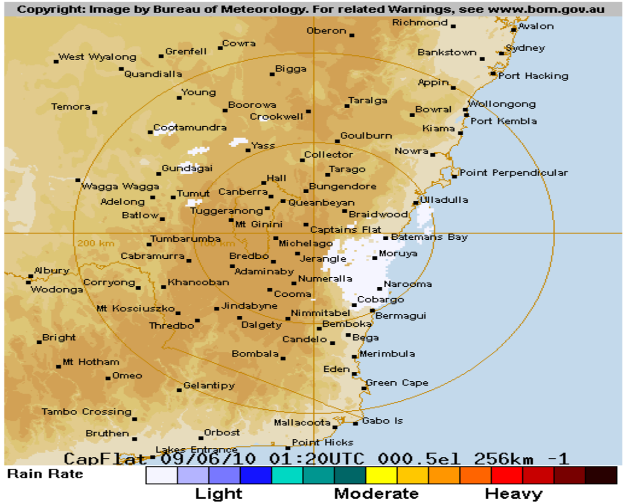
Motivation

3. clearly important for meaningful hydrological modelling, but poorly understood

- **Spatial uncertainty** can be described using probability
- **a rainfall error model** can be incorporated into BATEA framework using:

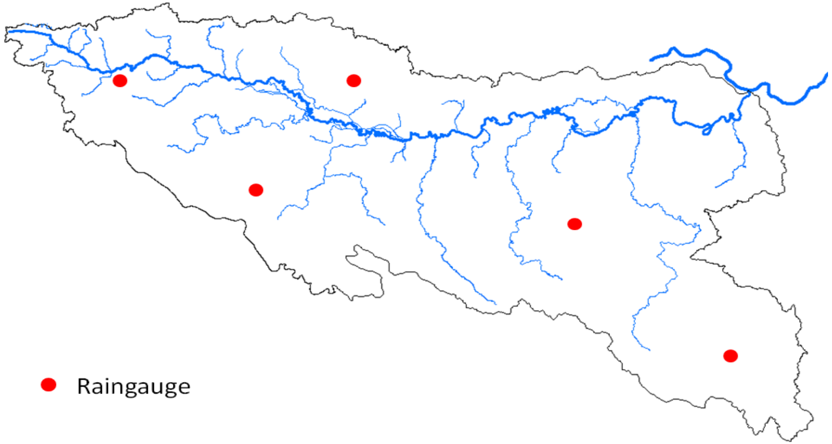
Dense rain gauges network **and/or** **radar data**





Rainfall Errors: Spatial Uncertainty

R_{TRUE} → R_{OBS}



Rainfall Errors: Spatial Uncertainty

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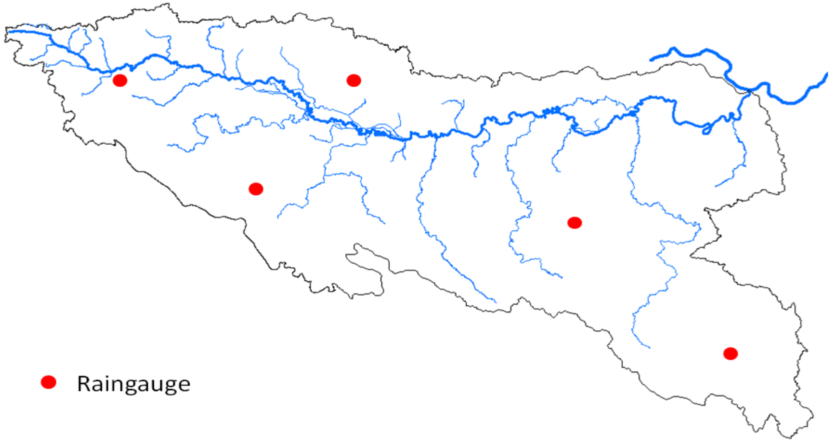
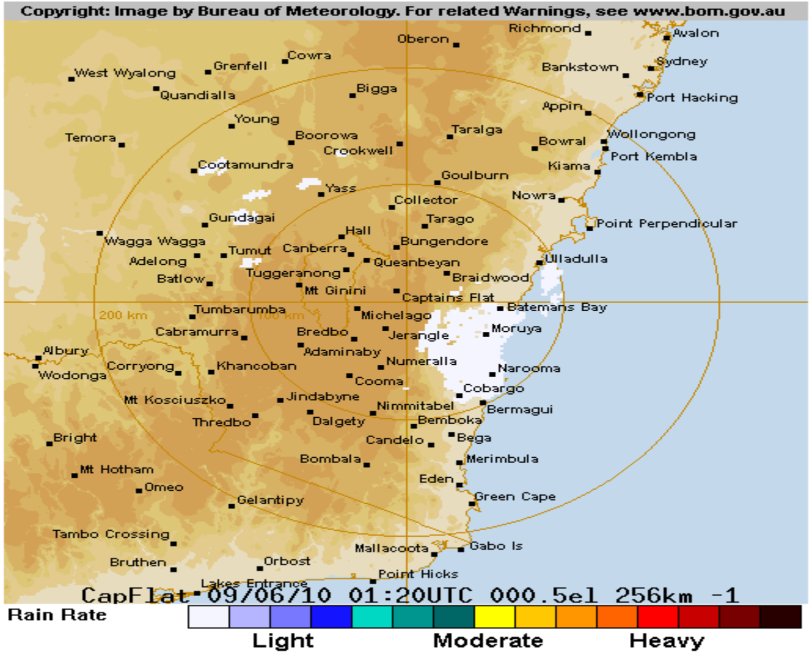


Here, we study multiplicative errors → $\text{Rainfall multiplier} = \frac{R_{TRUE}}{R_{OBS}}$

Rainfall Errors: Radar-Based Multiplier



Can exploit radar rainfall data to estimate probability distribution of catchment rainfall multipliers

Rainfall *r* versus radar reflectivity *z*

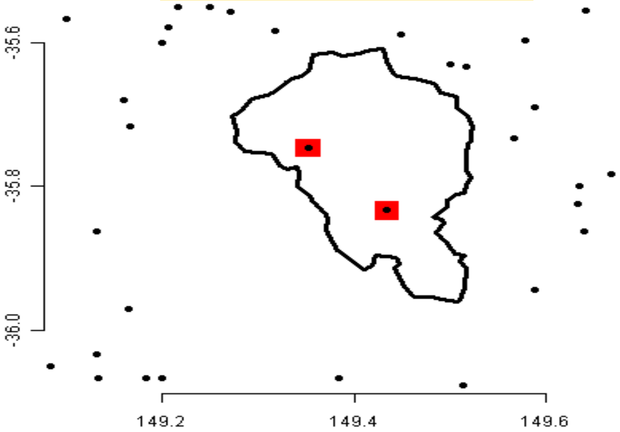
$$z = \alpha \cdot r^{\beta}$$

α varies from storm to storm

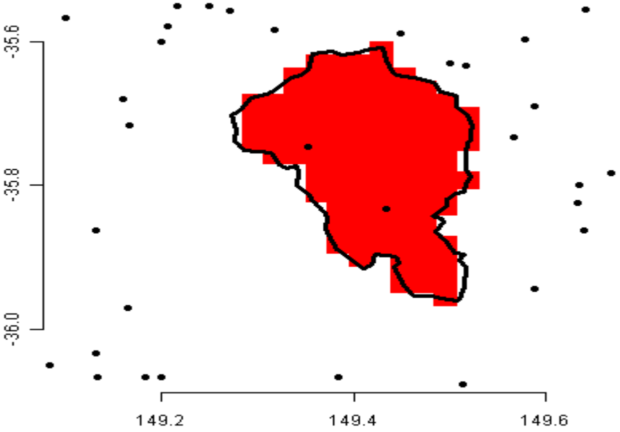
β is relatively constant

Rainfall Errors: Multiplier Estimation Using Radar

Raingauge



Radar



$$R_{OBS} = \sum_i w_i R_i$$

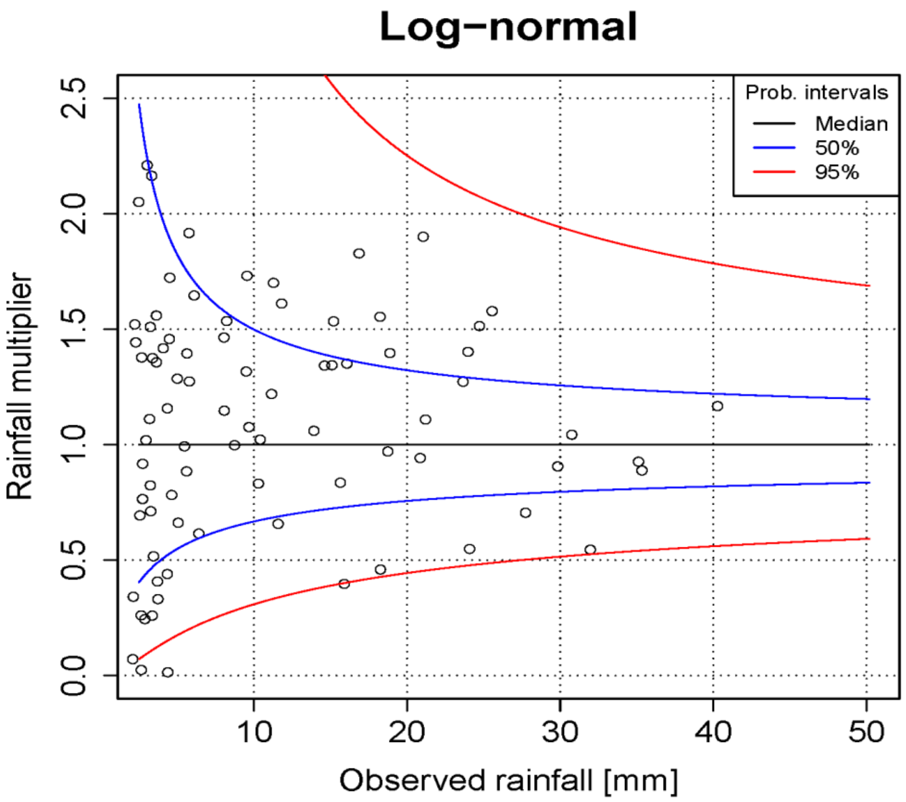
where

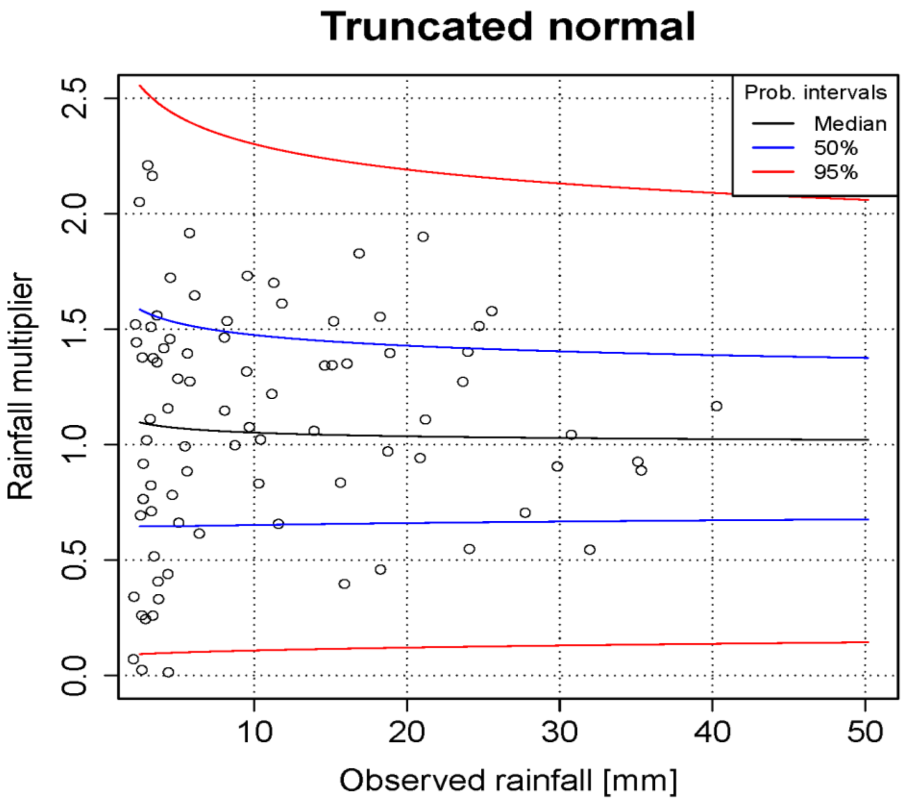
w_i=Thiessen polygon weight for gauge *i*

R_i=radar rainfall at pixel closest to gauge *i*

R_{TRUE} = average of radar rainfall over all pixels in catchment

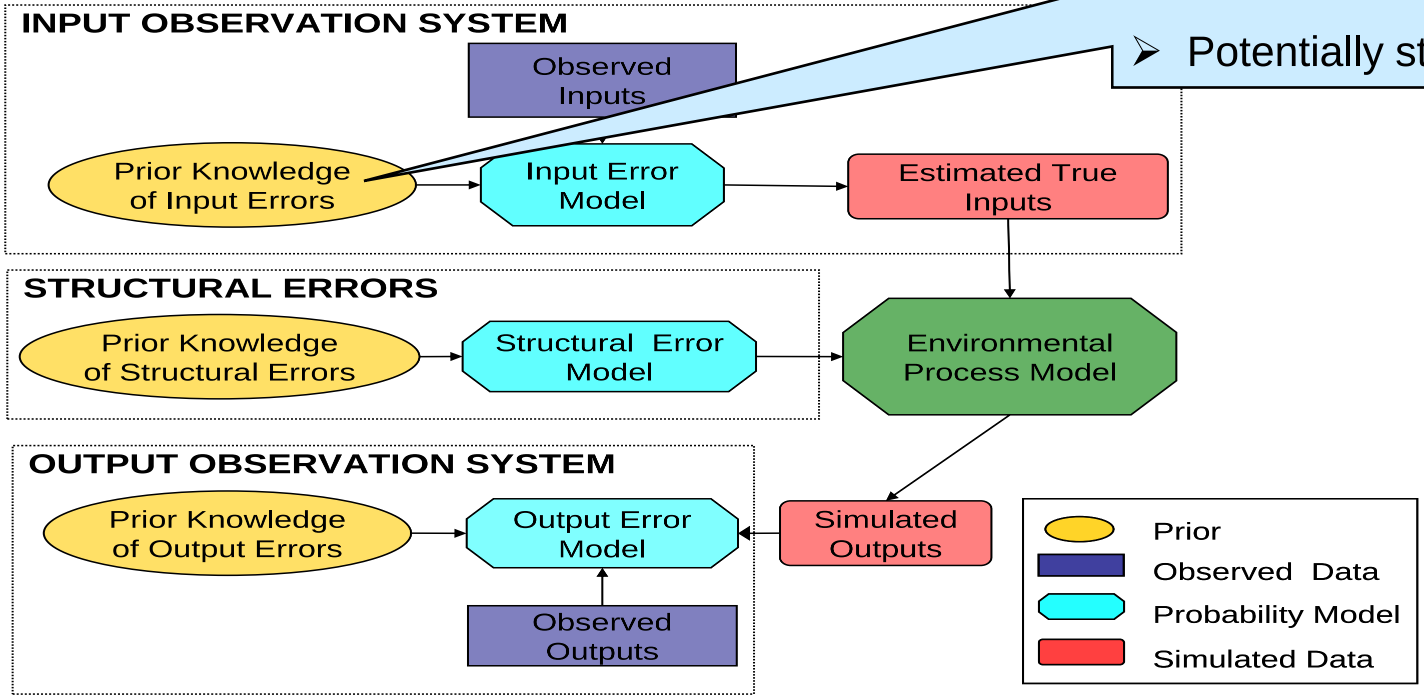
Rainfall Errors: Radar-Based Multipliers





BATEA: Exploit independent information: Rainfall error

- Independent understanding of rainfall errors can be derived from radar data
- Potentially strong prior



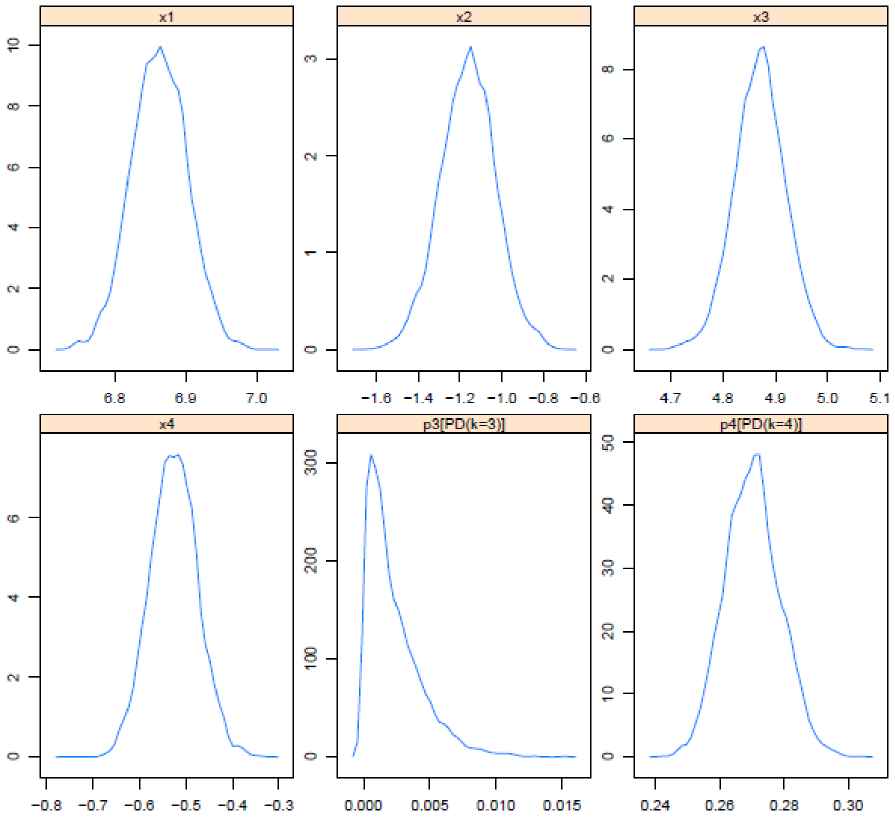
Hypothesis

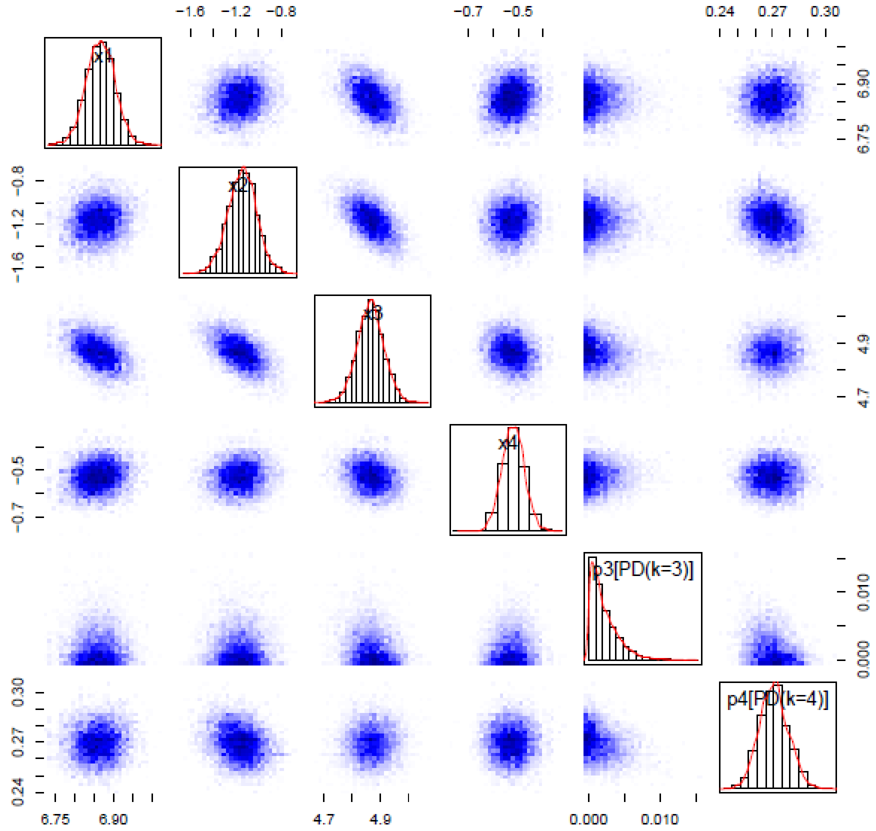
- Runoff errors and remnant errors are heteroscedastic and conditioned on the simulated runoff

- Different assumptions for rainfall errors
  - Assumed to be exact (*WLS*)
  - Vague rainfall prior (HI_a)
  - Precise rainfall prior from radar data (HI_b)

- Model GR4J (Perrin et al., 2003): 4 fitted parameters

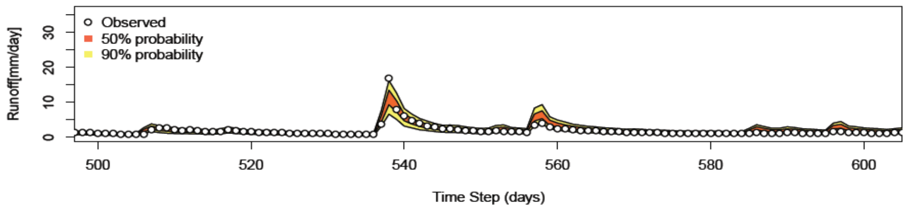
MCMC simulation



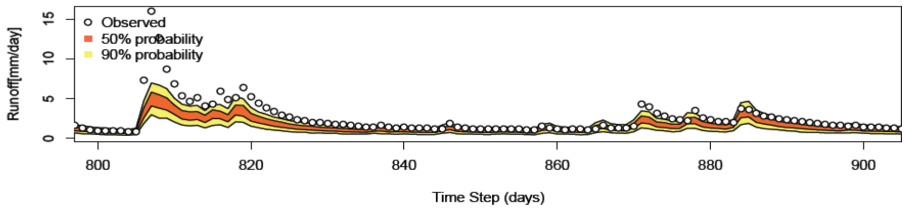


Predicted runoff

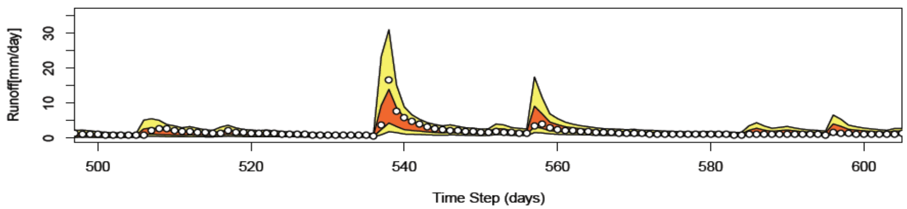
GR4J−Gingera−WLS



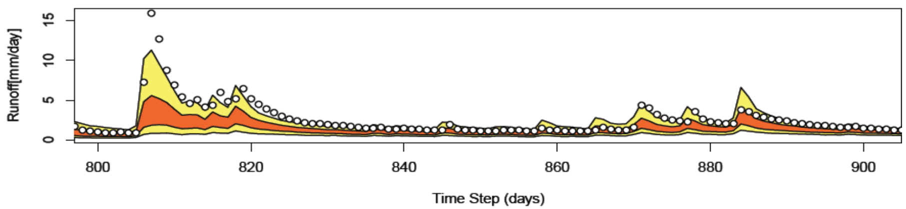
GR4J−Gingera−WLS



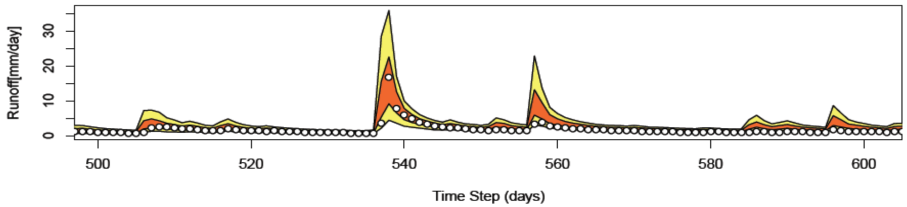
GR4J−Gingera−HIa



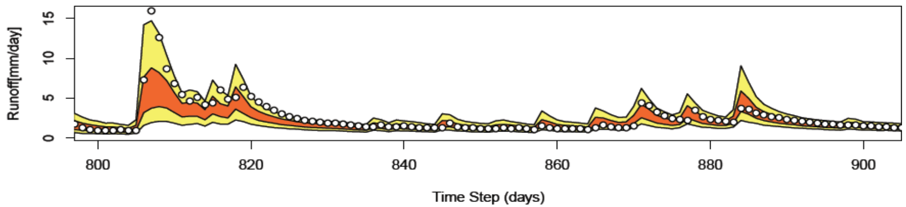
GR4J−Gingera−HIa



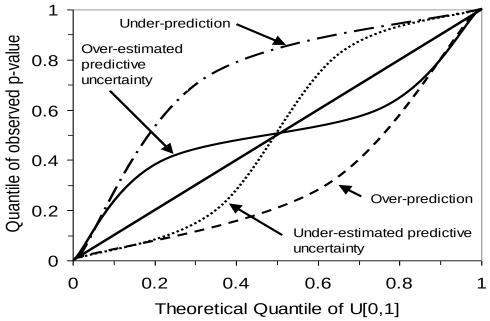
GR4J−Gingera−HIb

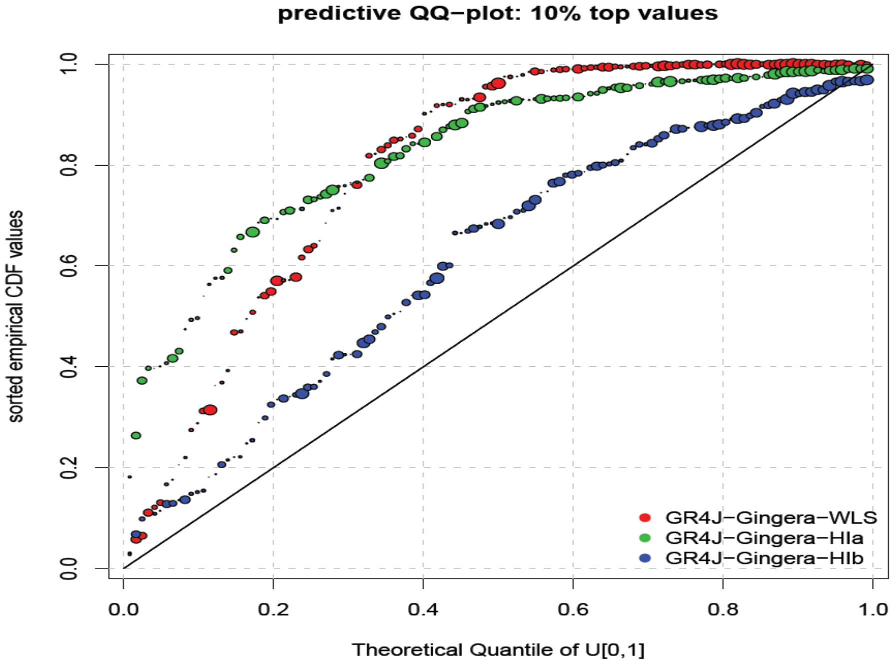


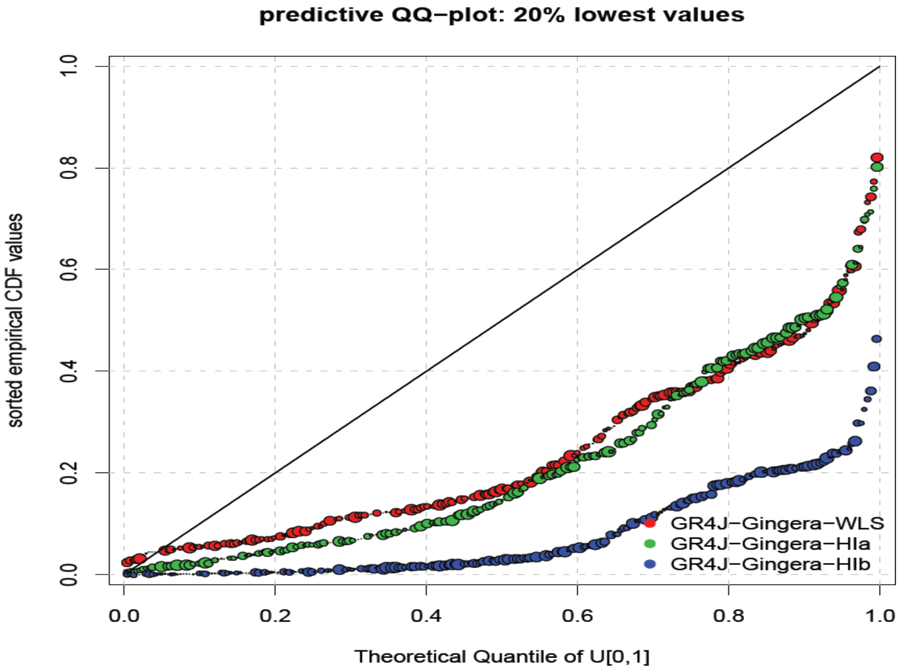
GR4J−Gingera−HIb



QQ-plots of the predicted runoff







Conclusions

- BATEA framework incorporates the information about rainfall uncertainty
  - High variance for low rainfall (patchiness)
  - Asymptote to a constant variance for large rainfall

- Despite considerable uncertainty, rainfall error can be analysed using radar data
  - A precise prior for rainfall -> better decomposition of the different sources of uncertainty
  - Need to treat structural errors more adequately