Ensemble forecast of floods using numerical weather predictions

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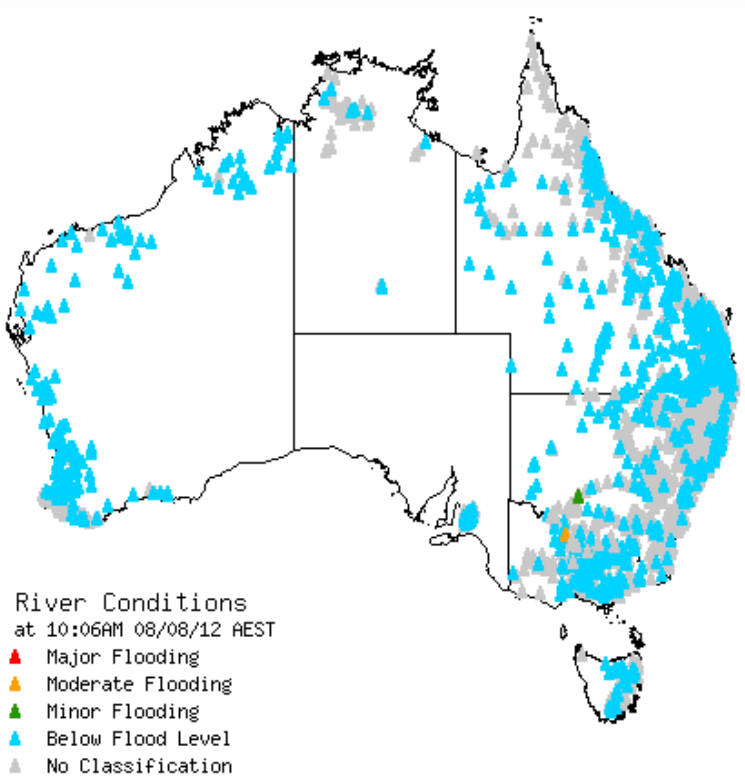
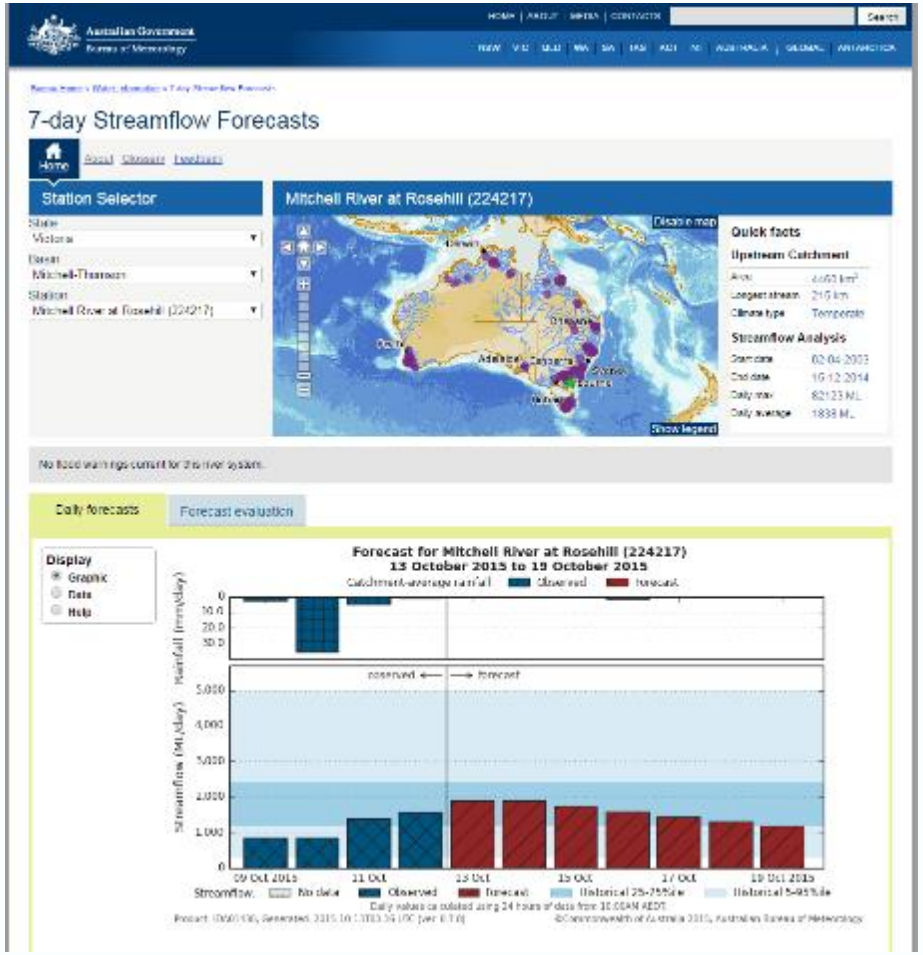
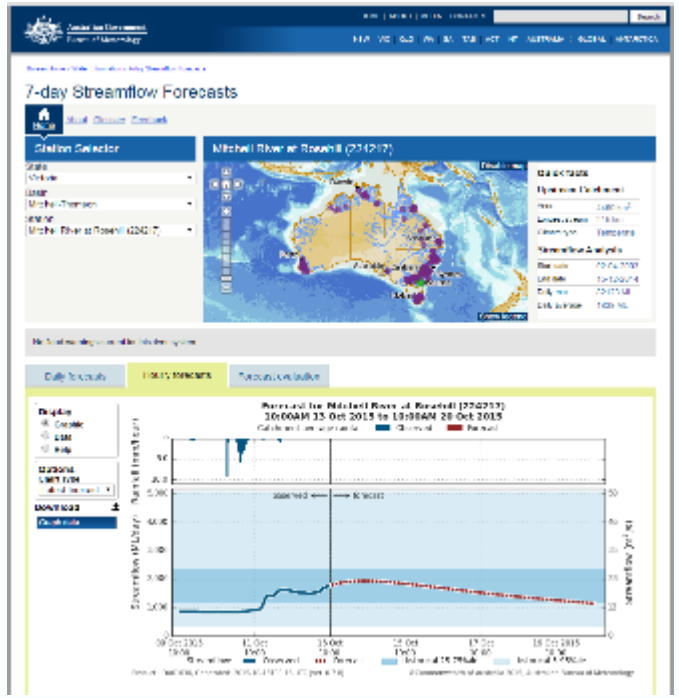
Flood and streamflow forecasting in Australia

- Existing forecasting services
  - Forecast flood events
  - Event models at sub-daily time steps
  - Ad hoc use of Numerical Weather Predictions
  - Labour intensive
- Desired forecasting services
  - Forecast entire hydrograph out to 7-10 days
  - Continuous hydrological modelling
  - Routine use of Australian NWP model output
  - Quantify forecast uncertainty
  - Build on existing service and infrastructure
  - Automation



7-day streamflow forecasts
(www.bom.gov.au/water/7daystreamflow)





An end-user's case for ensemble forecasts
(Environmental flow manager)

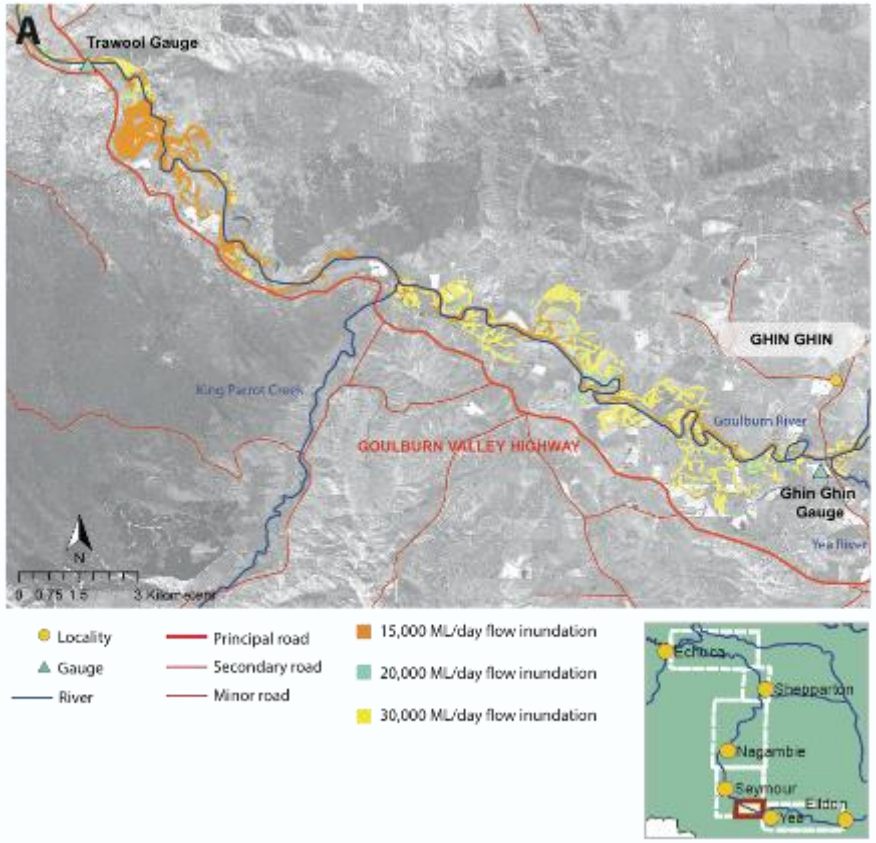
7-day forecasts will allow:

- **"understand *risk* of catchment runoff at time of release"**
- **"manage flooding *risk*"**

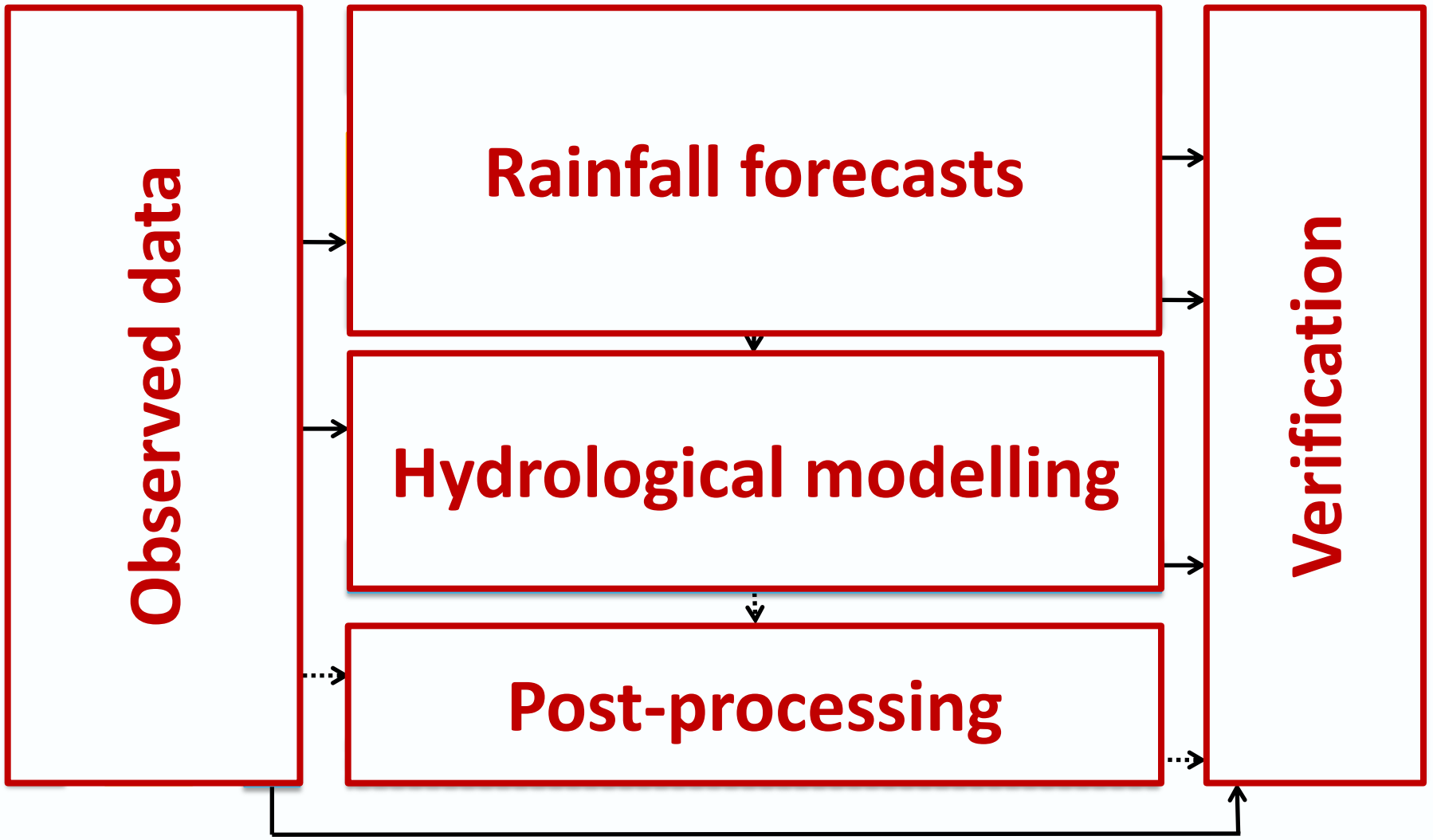
Risk = likelihood × consequence

"Good handle on consequences"

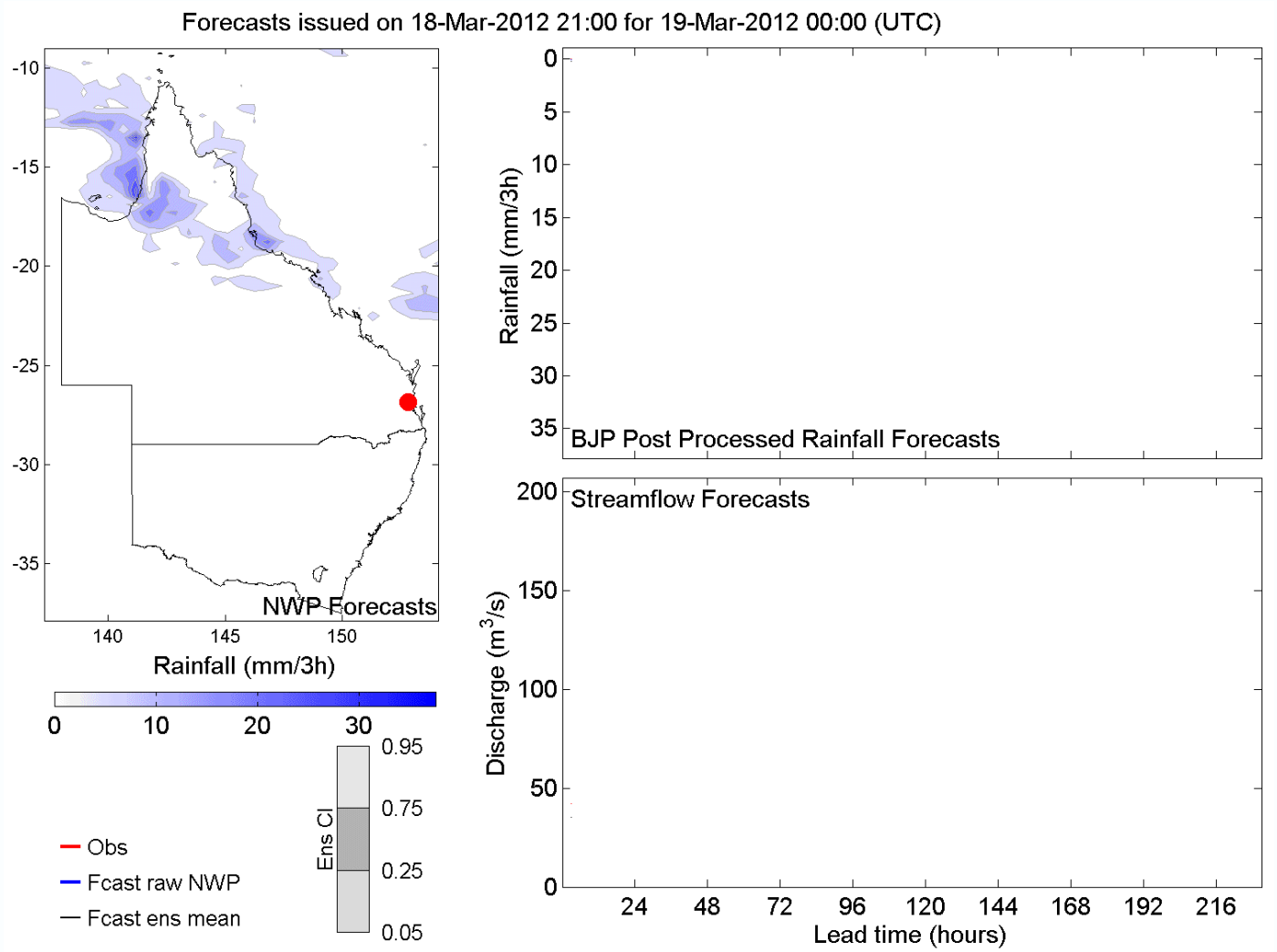
A deterministic service only gives an expected flow scenario and not likelihood of different scenarios



Ensemble forecasting framework



Streamflow forecasts - putting it all together



Bennett, Robertson, Shrestha, Wang, et al. (2014) JoH

Forecast system components

- Observed data

  Adapted from existing flood forecasting service

- Rainfall forecasts

  RPP (Bayesian rainfall post-processor)

- Runoff and routing models

  Semi-distributed; GR4J, Muskingum …

- Hydrological error

  Dual pass error correction (Pagano, Wang, Hapuarachchi, Robertson, 2011, JoH)

- Verification
  - Cross validation scheme

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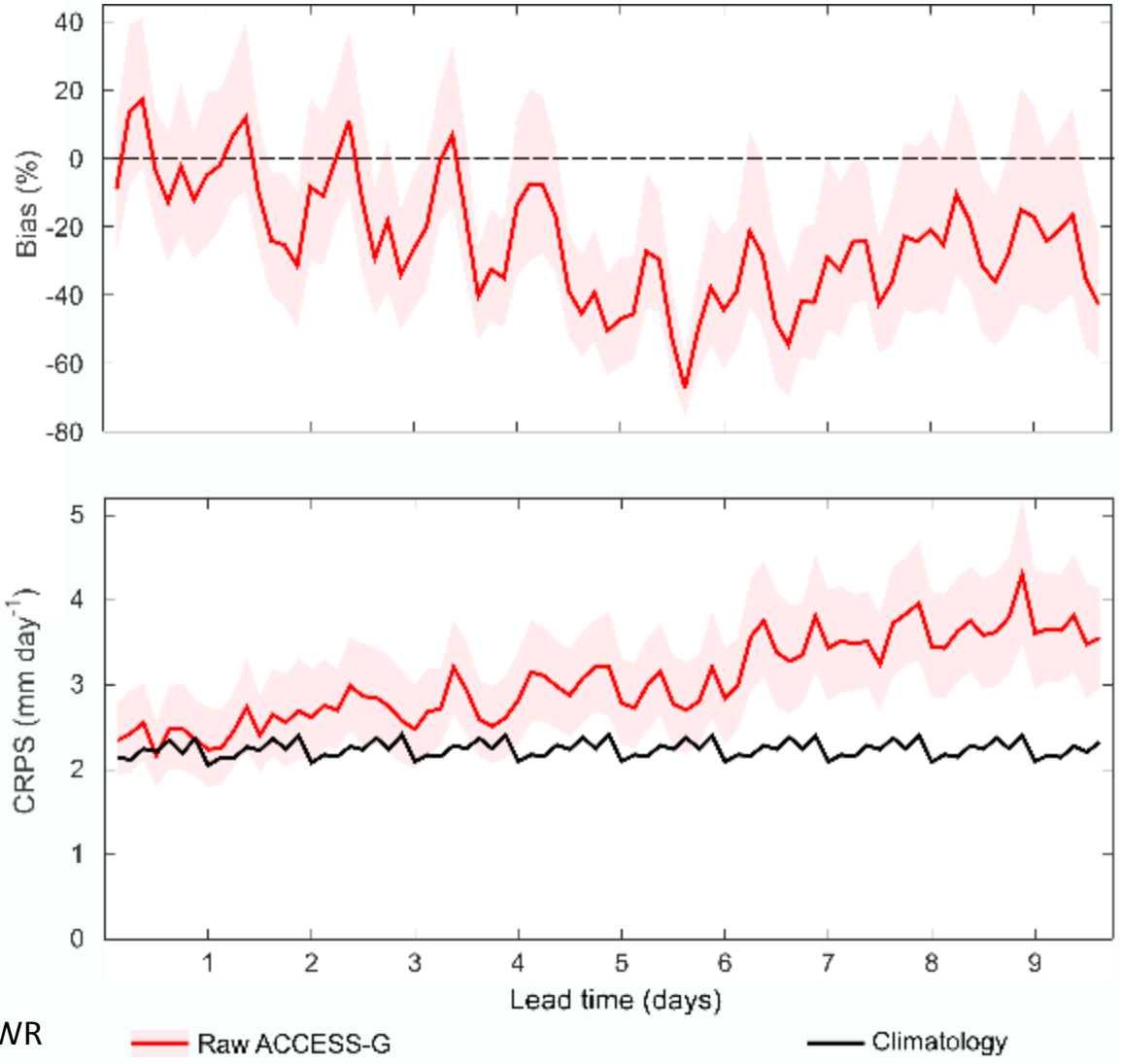
Rainfall forecasts

South Esk
(~3300 km^2)



Shrestha, Robertson, Bennett, Wang (2015) MWR

Rainfall forecast post-processing

(Robertson, Shrestha, Wang, 2013, HESS)

Step 1: Correct biases and quantify uncertainty

- Modified Bayesian joint probability (BJP) model
  - Log-sinh transformation (Wang, Shrestha, Robertson, Pokhrel, 2012, WRR)
  - Treatment of zero data
  - Continuous bivariate normal distribution

Step 2: Instill temporal and spatial patterns

- Schaake Shuffle (Clark, Gangopadhyay, Hay, Rajagopalan, Wilby, 2004, JHM)

Rainfall forecast post-processing

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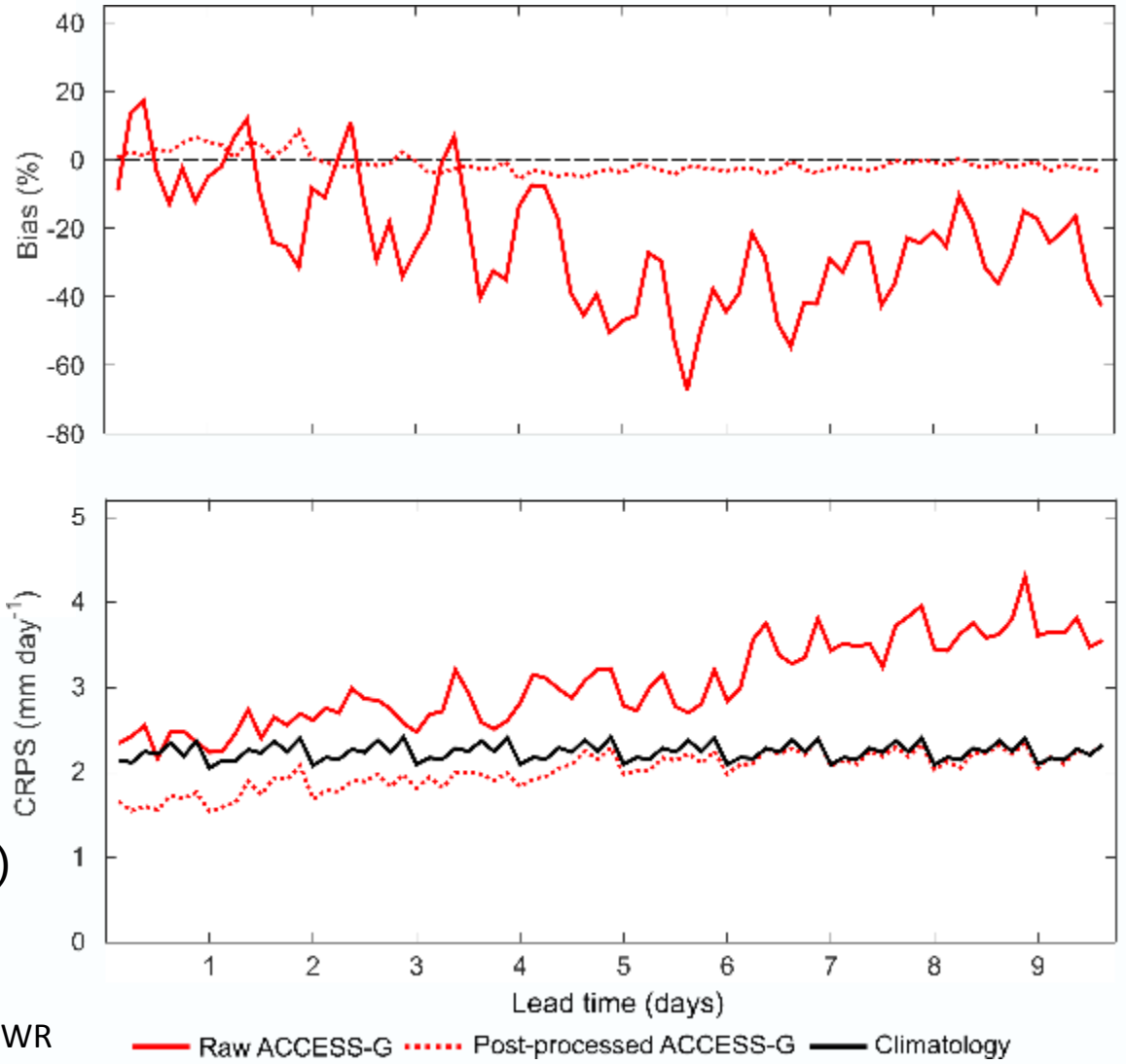
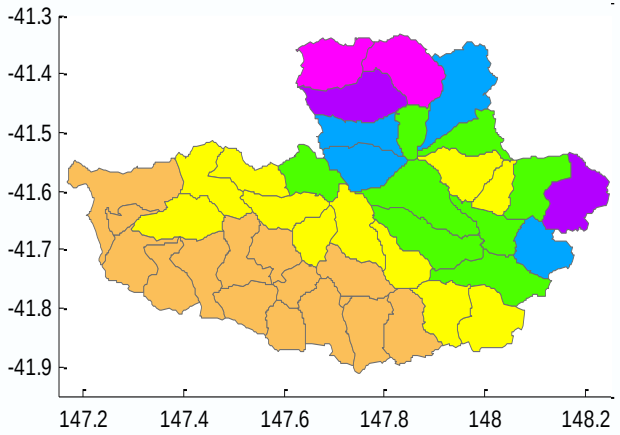


Shrestha, Robertson, Bennett, Wang (2015) MWR

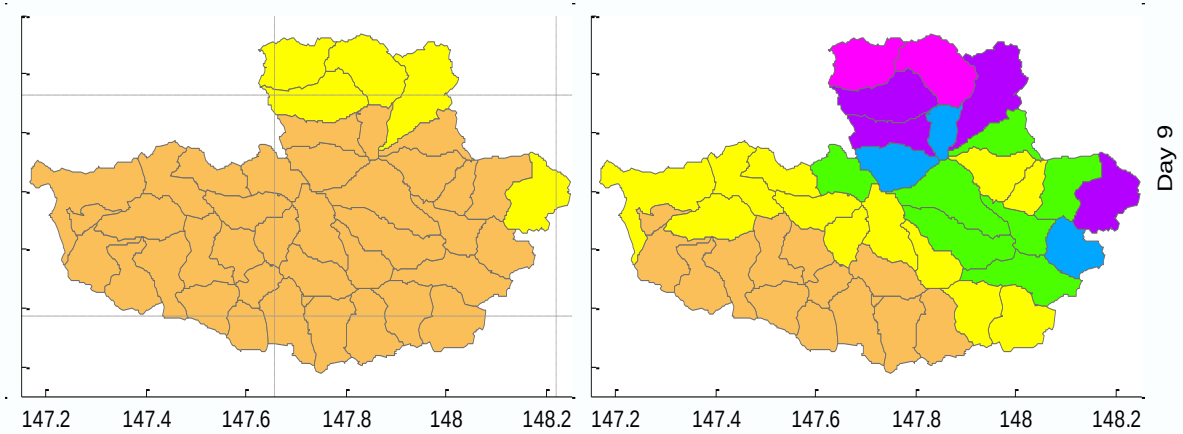
Rainfall forecast post-processing – spatial effects

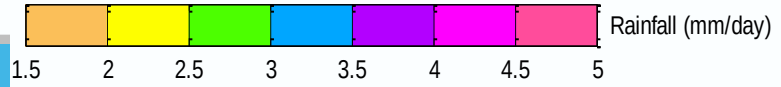
Observations



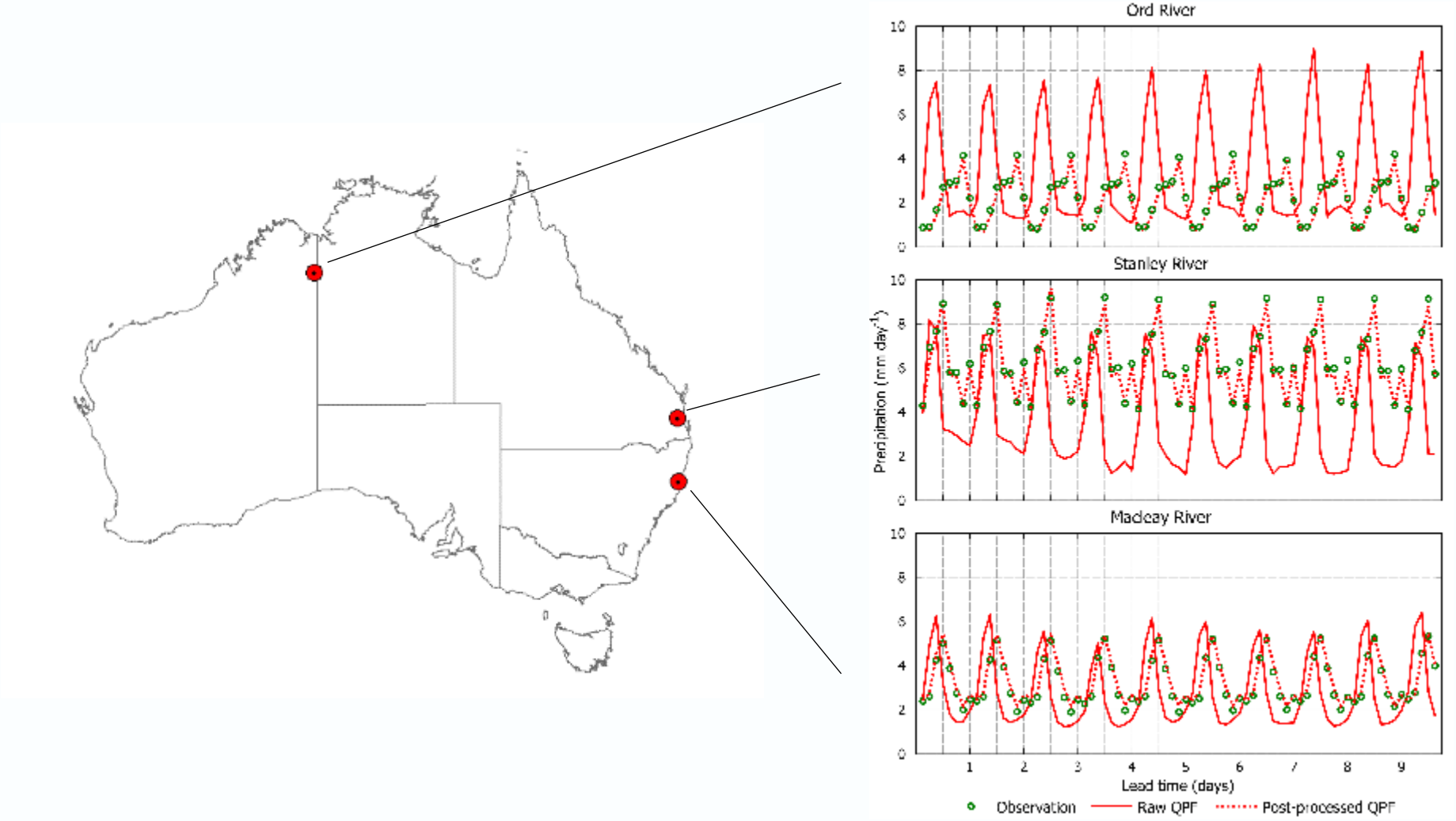
Raw ACCESS-G

Post-processed ACCESS-G





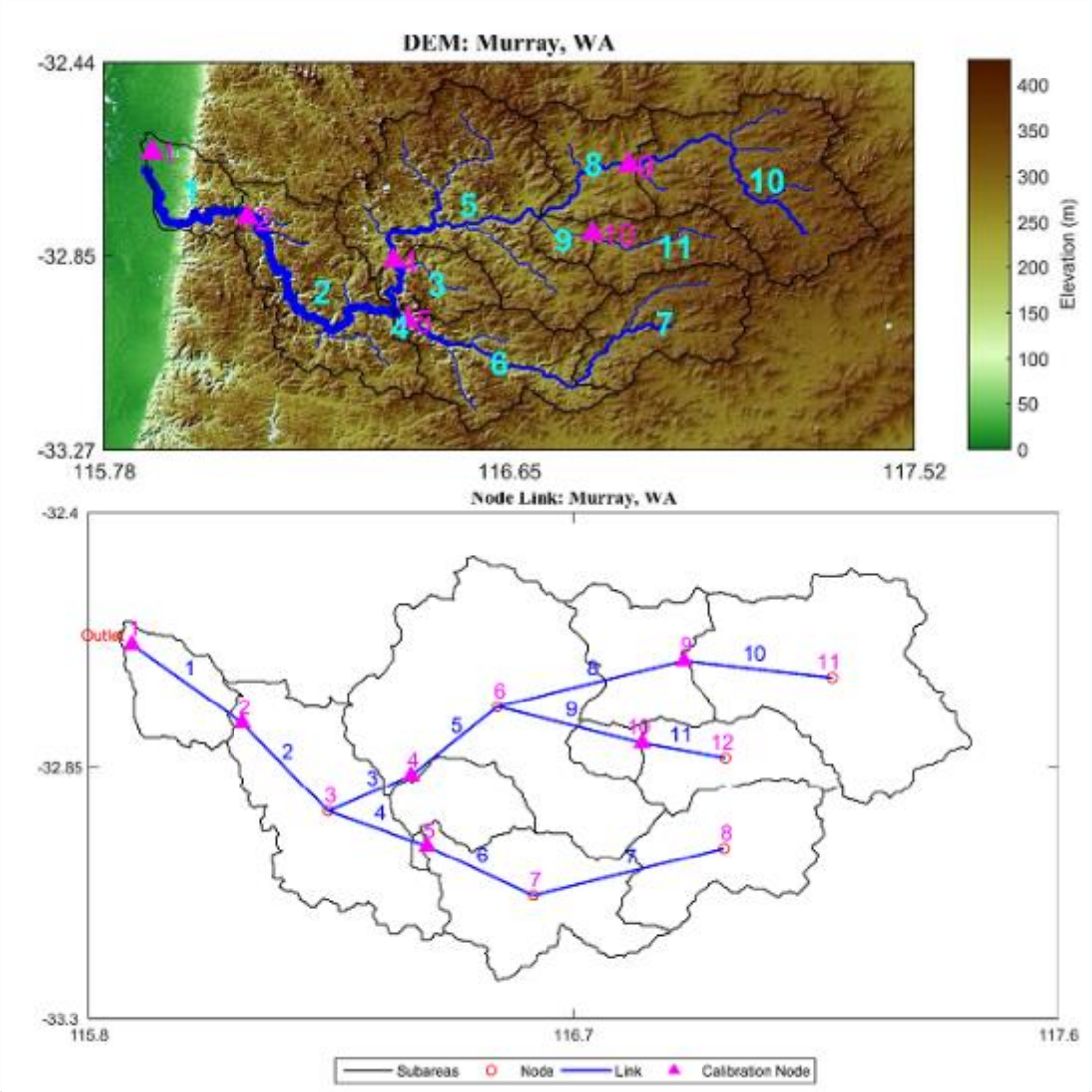
Rainfall forecast post-processing – diurnal effects



Generation of streamflow forecasts

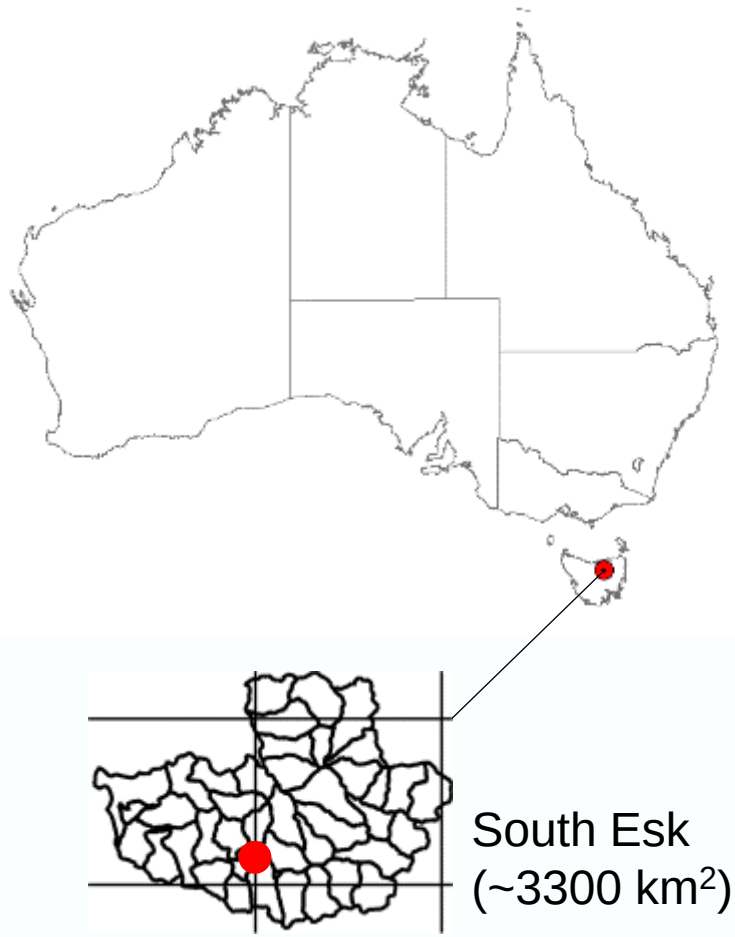
- Model calibration
- Spinning up model
- Producing ensemble streamflow forecasts using ensemble rainfall forecasts
- Updating streamflow forecasts

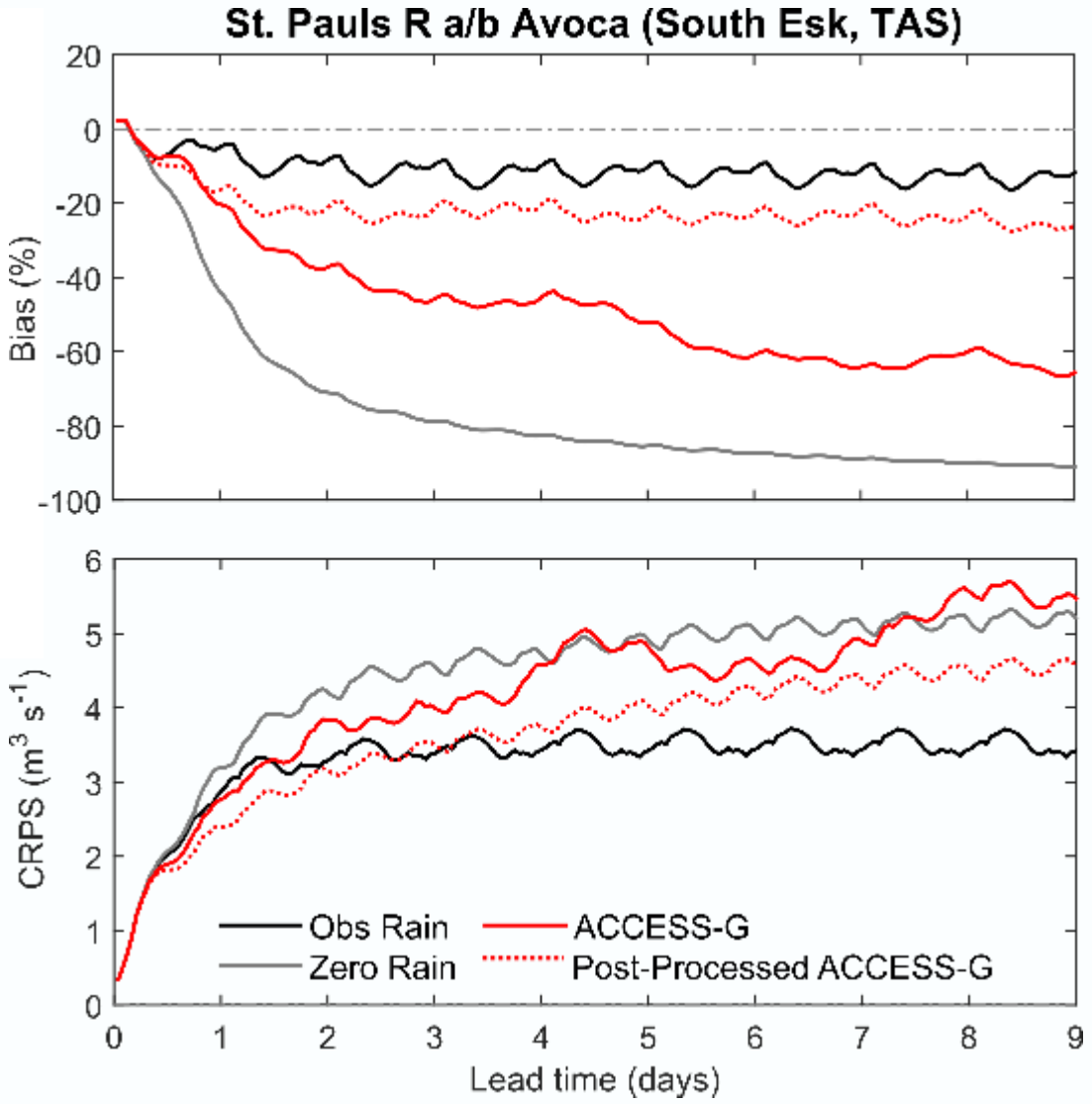
Generation of streamflow forecasts



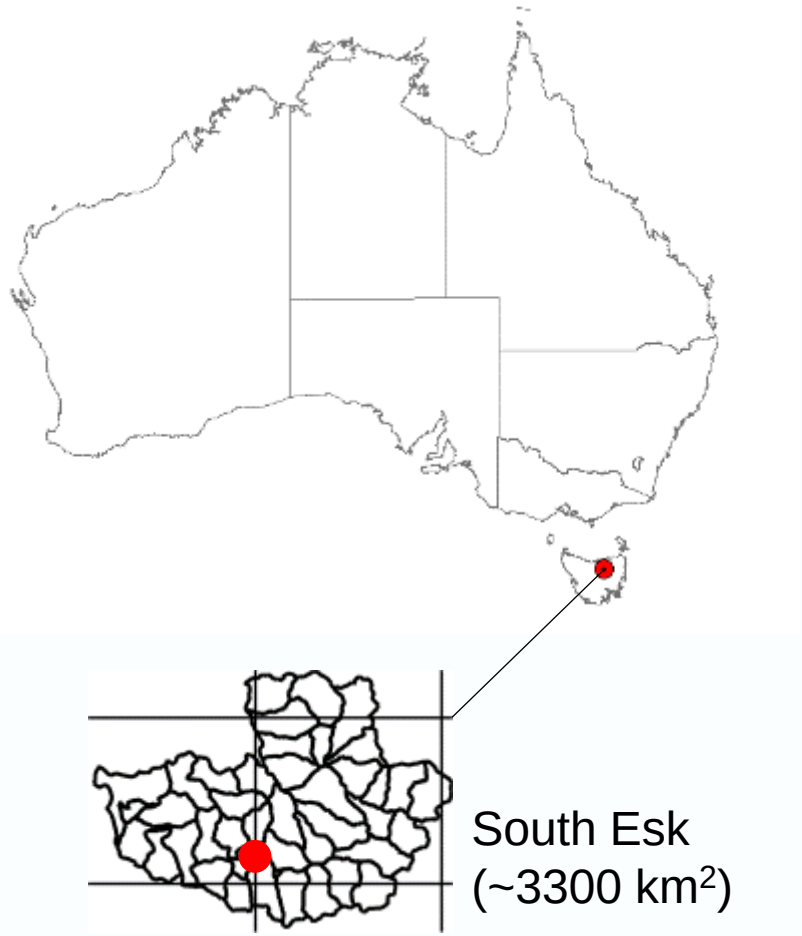
Bennett, Robertson, Shrestha, Wang, Enever, Hapuarachchi, Tuteja (2014) JoH

Performance of streamflow forecasts

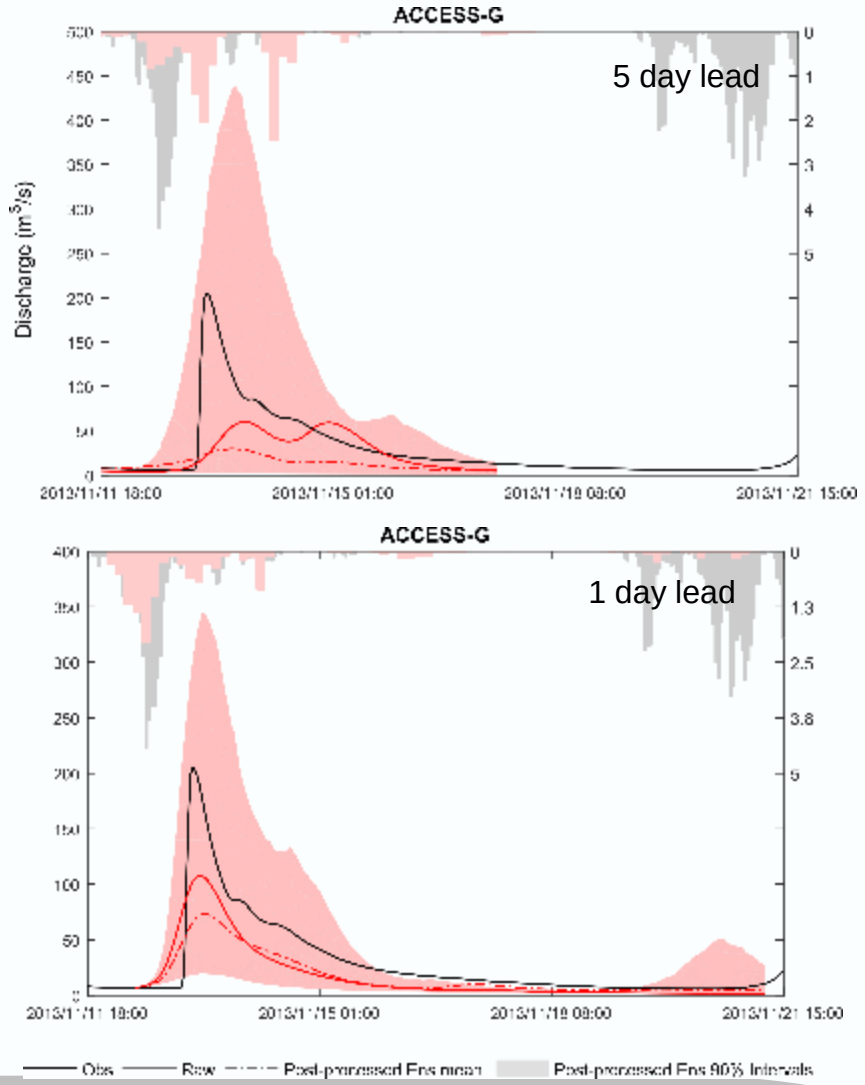




Flood forecasts (St. Pauls River a/b Avoca)



South Esk
(~3300 km^2)



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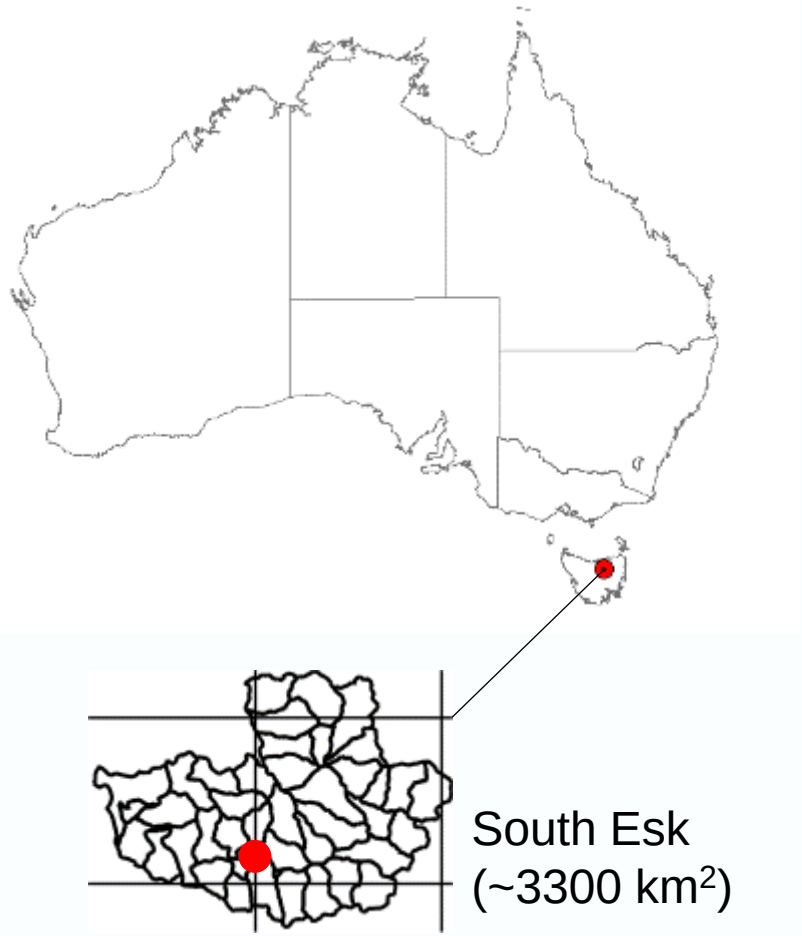

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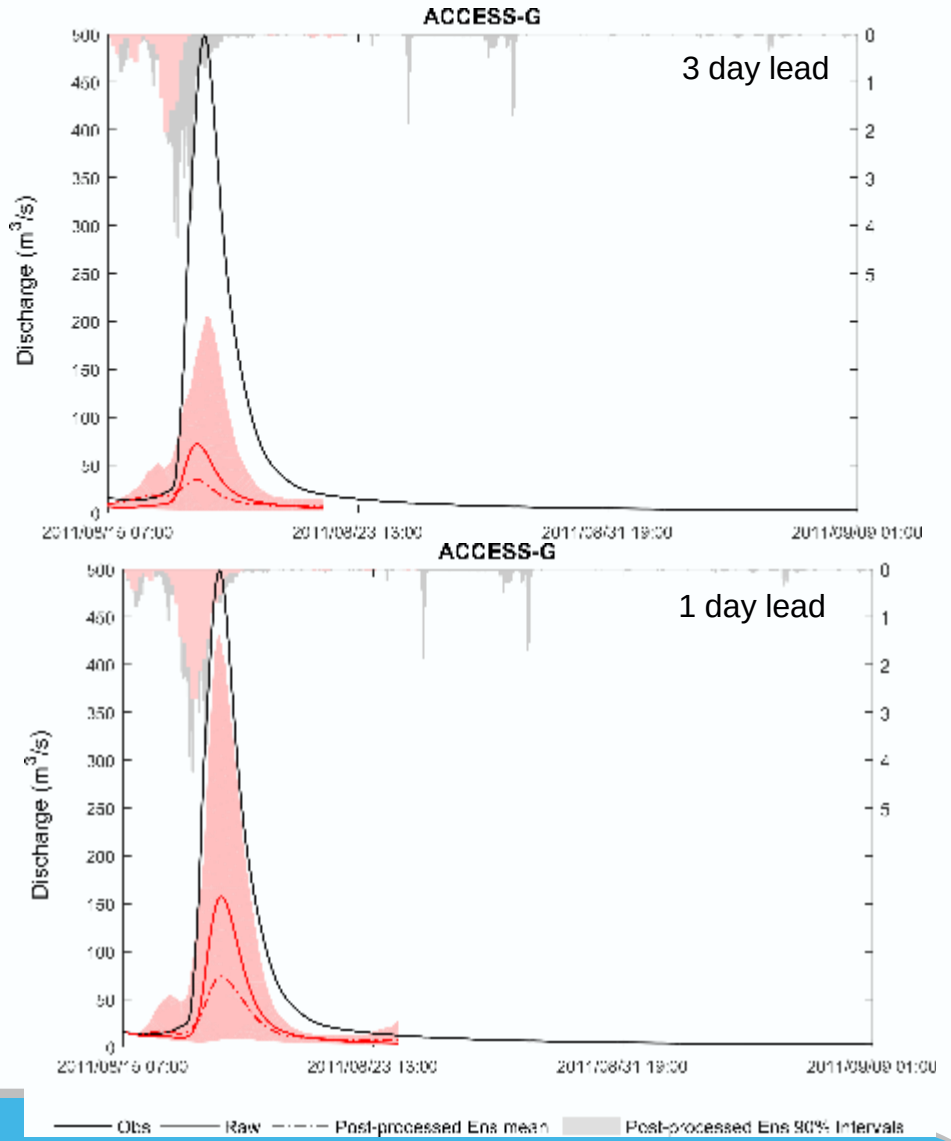
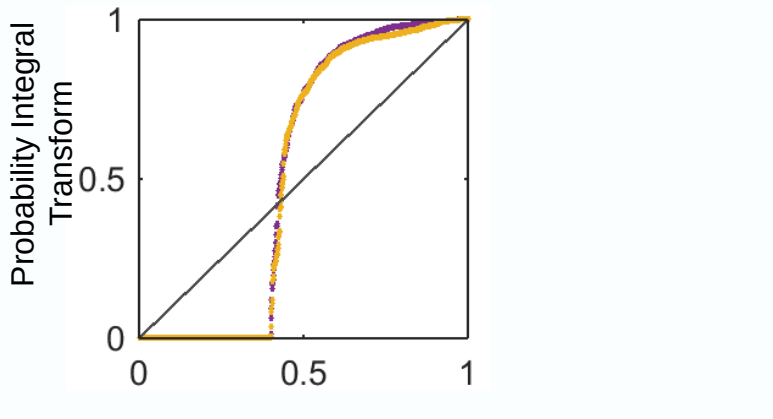
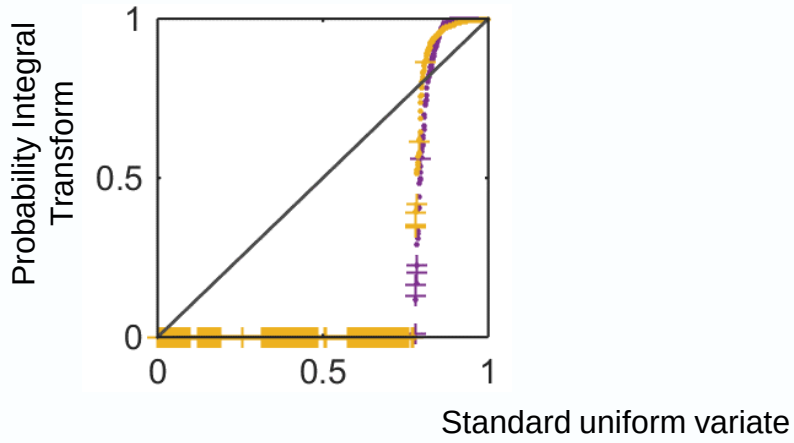


Streamflow forecast reliability

Tully River @ 12 hr lead (Perennial river)



Ord River @ 12 hr lead (Ephemeral river)



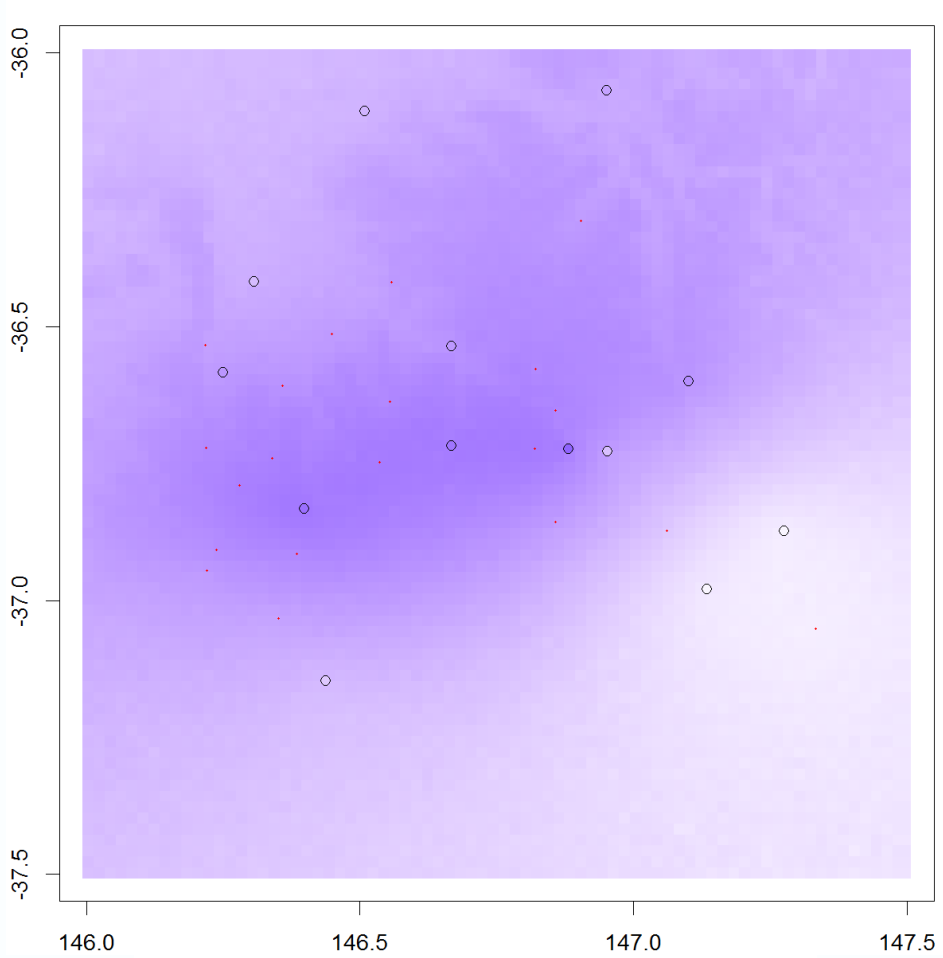
Current work to improve forecast accuracy

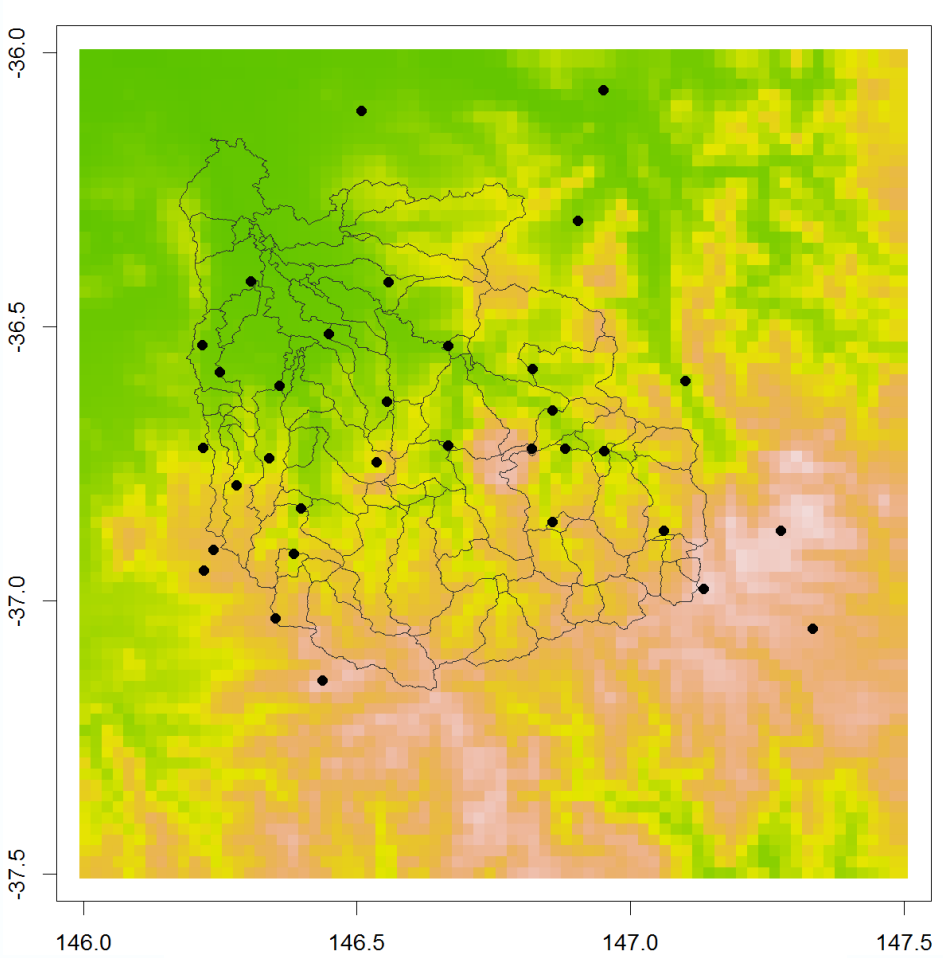
Better rainfall observations

Alternative rainfall forecasts

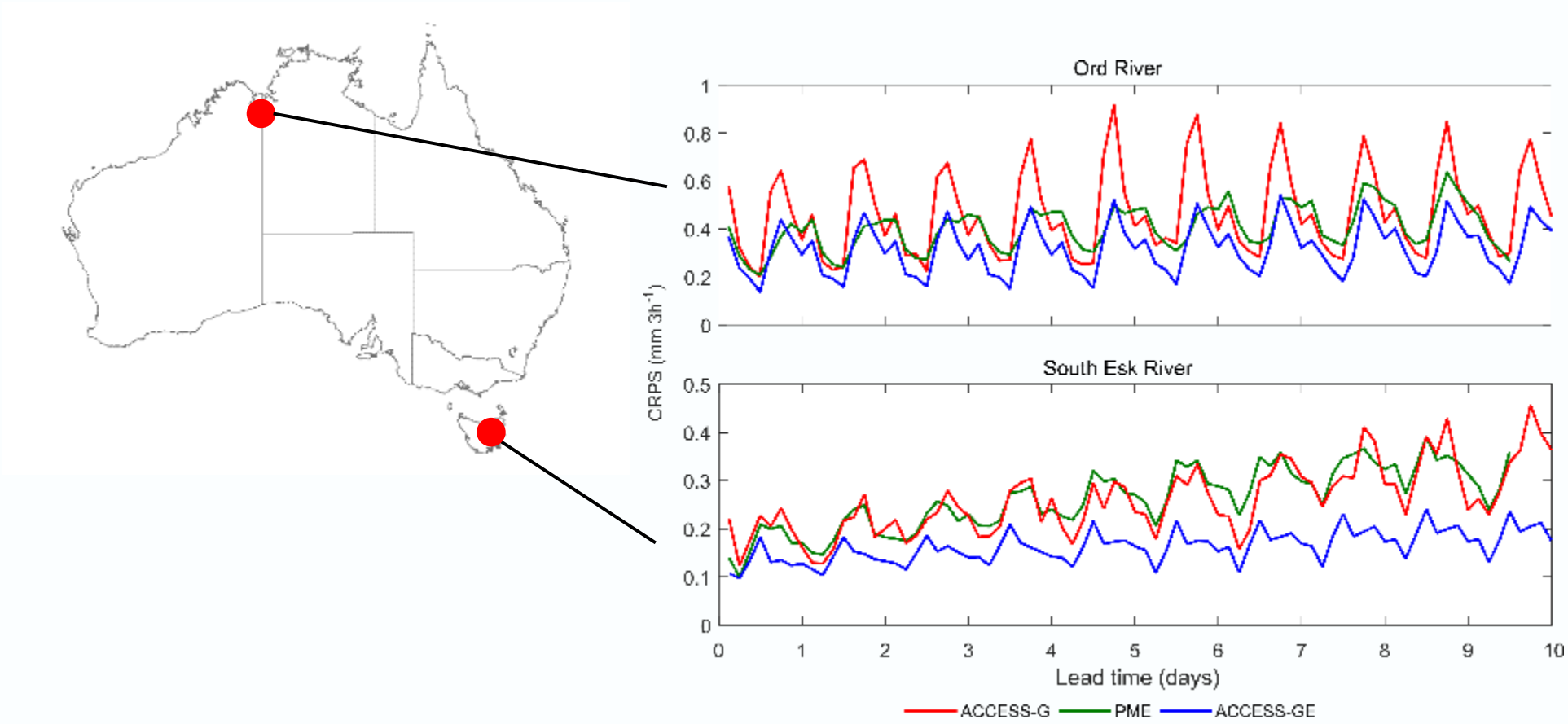
Improved modelling of hydrological errors

Catchment rainfall estimation using ESDIIM





Alternative rainfall forecasts



Improved hydrological error modelling

Dual-pass error model

ERRIS

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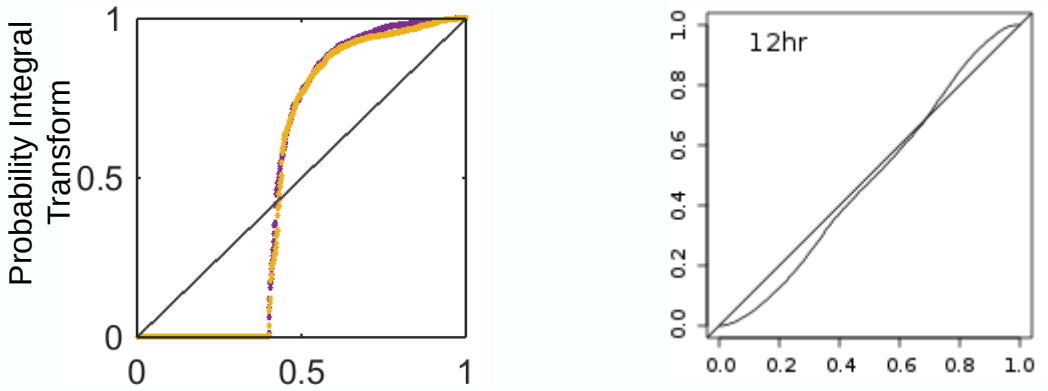

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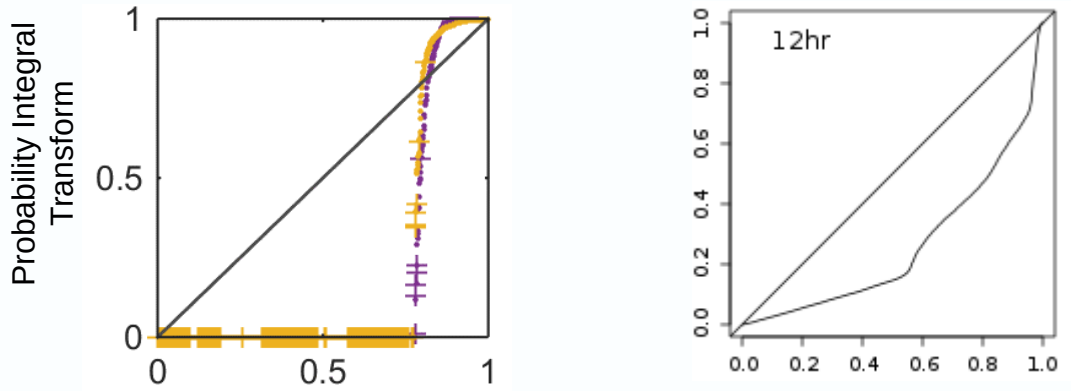

Summary

Ensemble forecasting methods support risk-based planning

Rainfall forecasts from NWP models contain errors

Post-processing can reduce forecast errors and quantify forecast uncertainty

Reliably representing forecast uncertainty requires:

- **Ensemble rainfall forecasts**
- **Modelling of hydrological model errors**

Many avenues to forecast accuracy

HEPEX

a community of research and practice to advance hydrologic ensemble prediction

Upcoming activities

- MODSIM 2015 – Gold Coast, Australia, 29/11 – 6/12
- 2015 AGU Fall meeting – San Francisco, USA, 14/12 – 18/12
- AOGS 2016 – Beijing, China, 31/7 – 5/8

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