TOWARDS IMPROVED ERROR MODELLING FOR SHORT-TERM STREAMFLOW FORECASTING IN AUSTRALIA

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Outline

- Introduction
- The basic model for daily streamflow forecasting
- The extended model for hourly streamflow forecasting
- Conclusion

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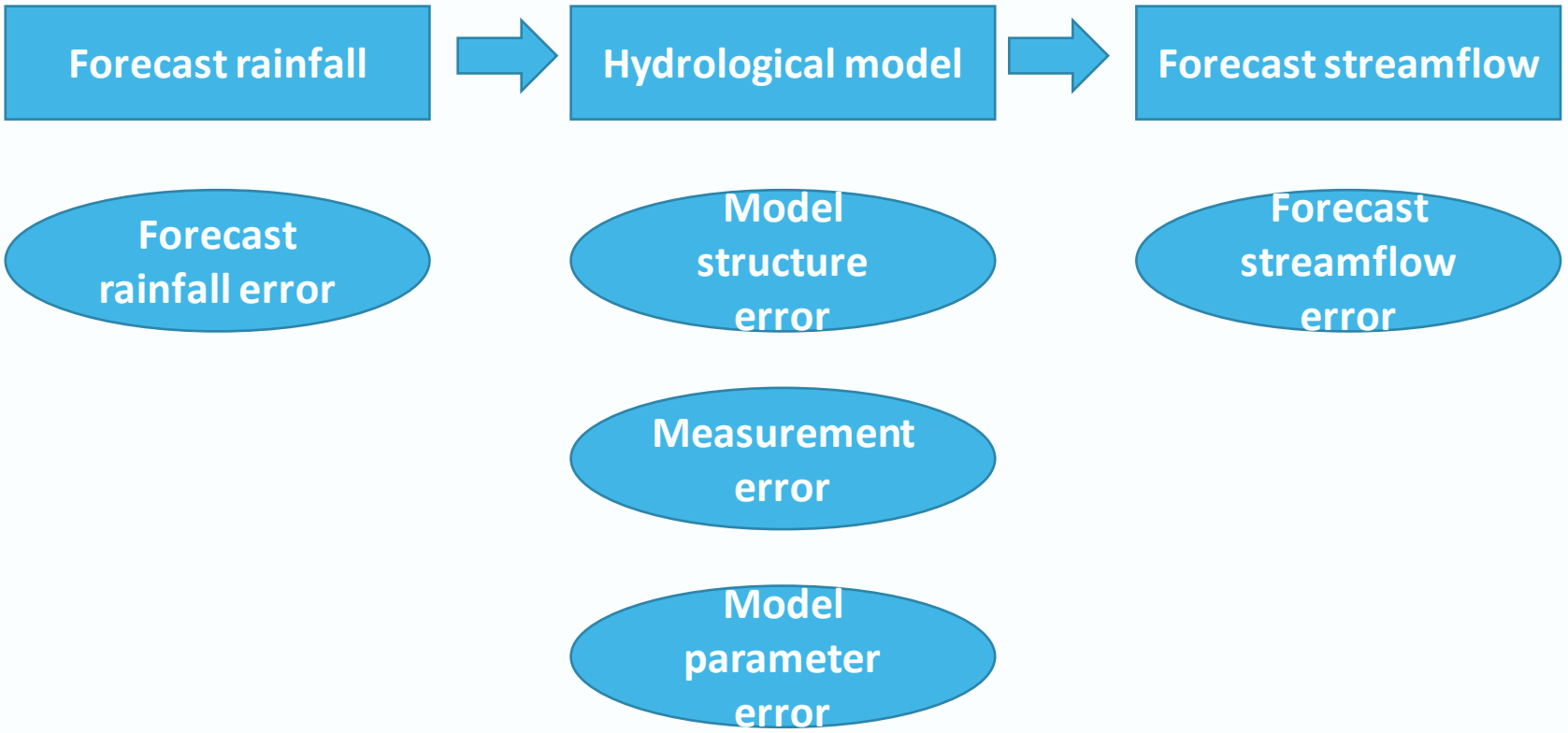
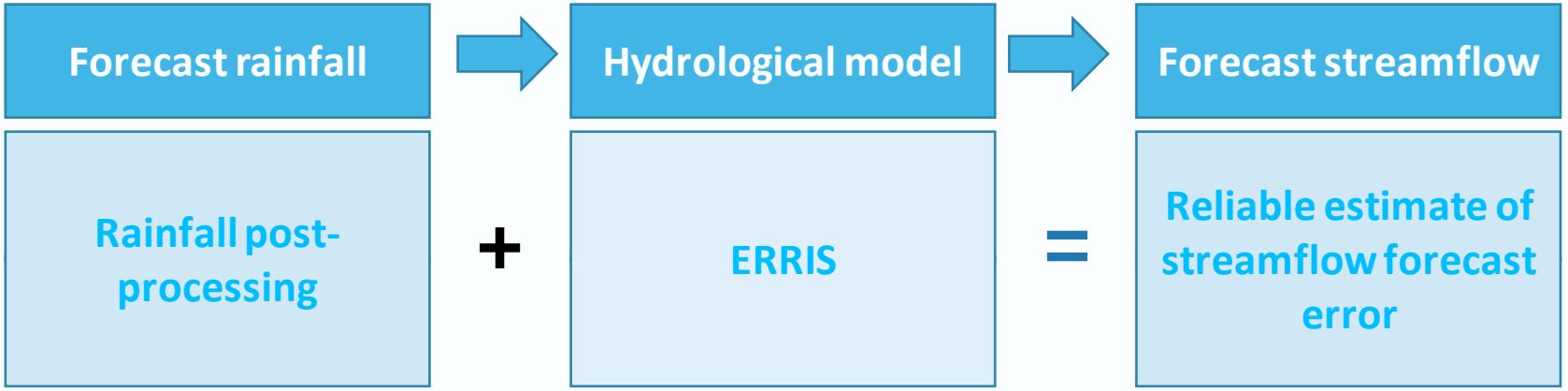
Hydrological model forecasting



Hydrological model forecasting



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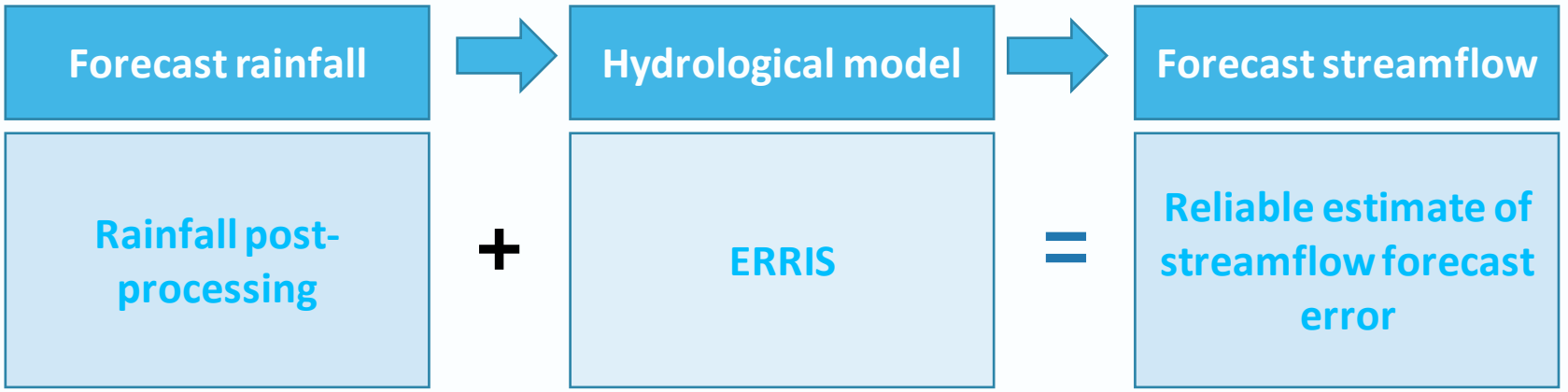

Error Reduction and Representation In **Stages**

Make forecasts more accurate

Quantify the forecast uncertainty

Use staged error models

Staged error models

- A sequence of simple error models
- Start from the simplest model at Stage 1 and introduce additional model complexity through subsequent stages
- Calibrate a small number of parameters at each stage and keep them in the subsequent stages
- Use the output from the previous stage as the input of the next stage
- Avoid parameter interference

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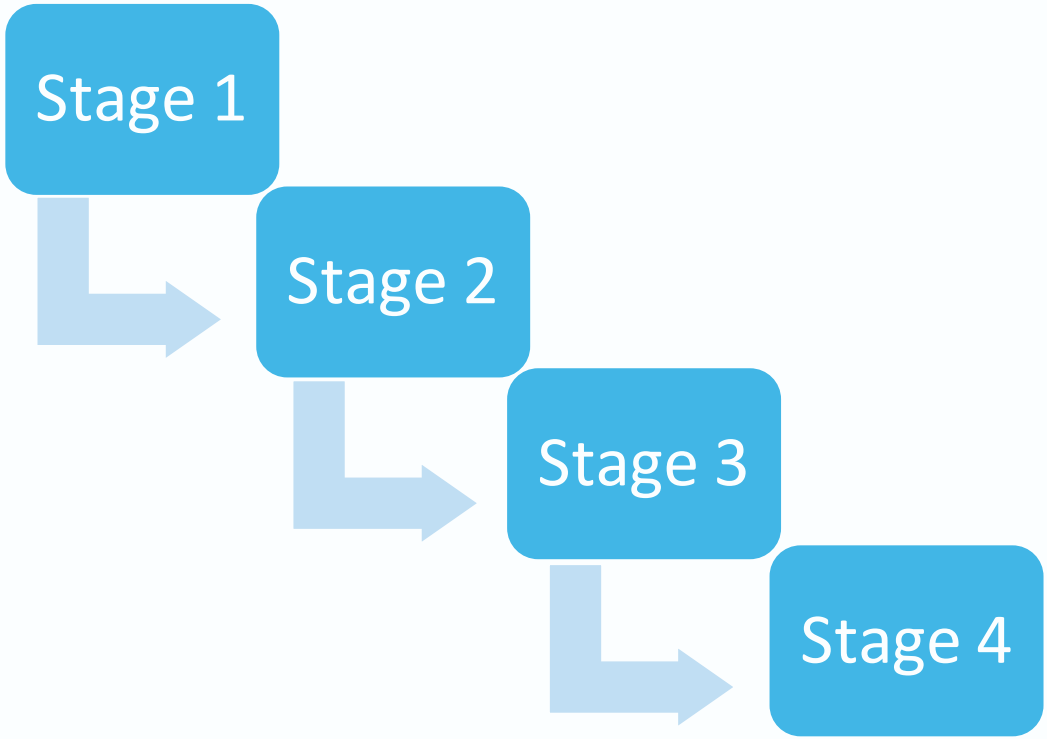
ERRIS model structure

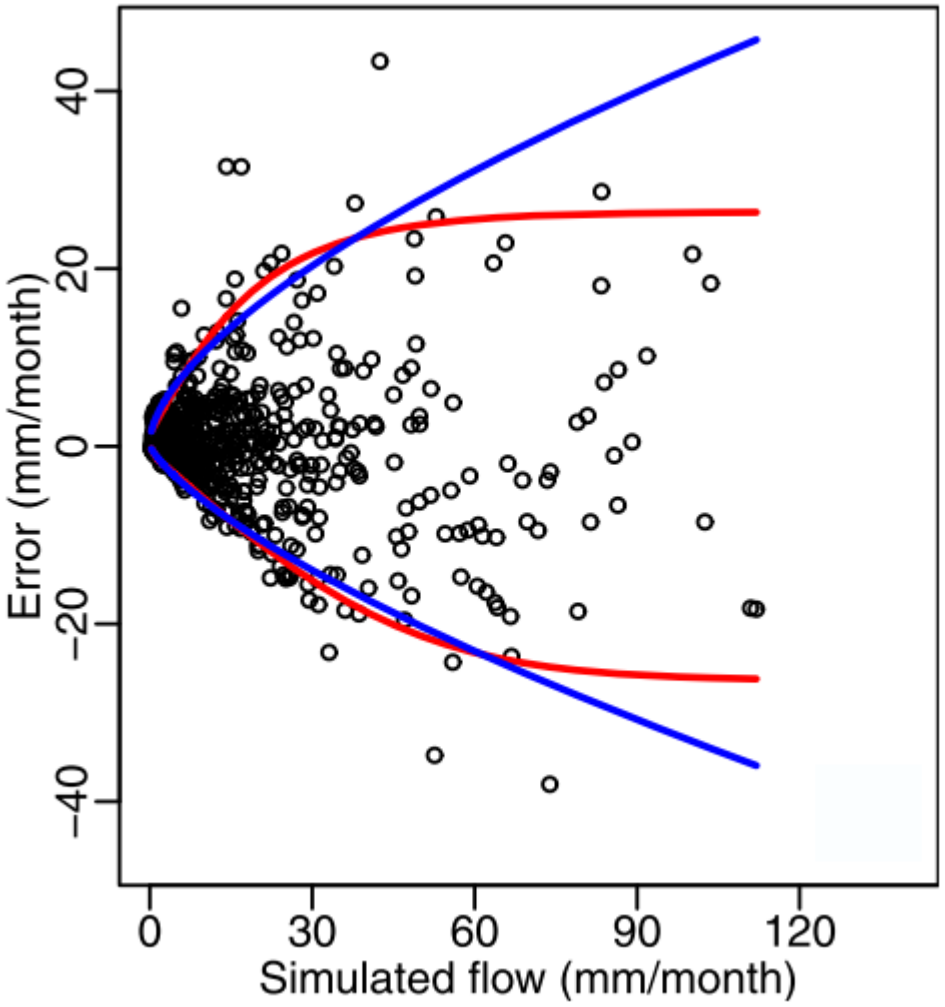


Stage 1

- **Purpose:** calibrate the hydrological model and obtain hydrological simulation
- **Assumption:** independent, transformed-Gaussian distribution
- **Parameters:** hydrological model parameters + two transformation parameters

Log-sinh transformation

$$z = h(y) = \frac{1}{\beta}\ln(\sinh(\alpha + \beta y))$$



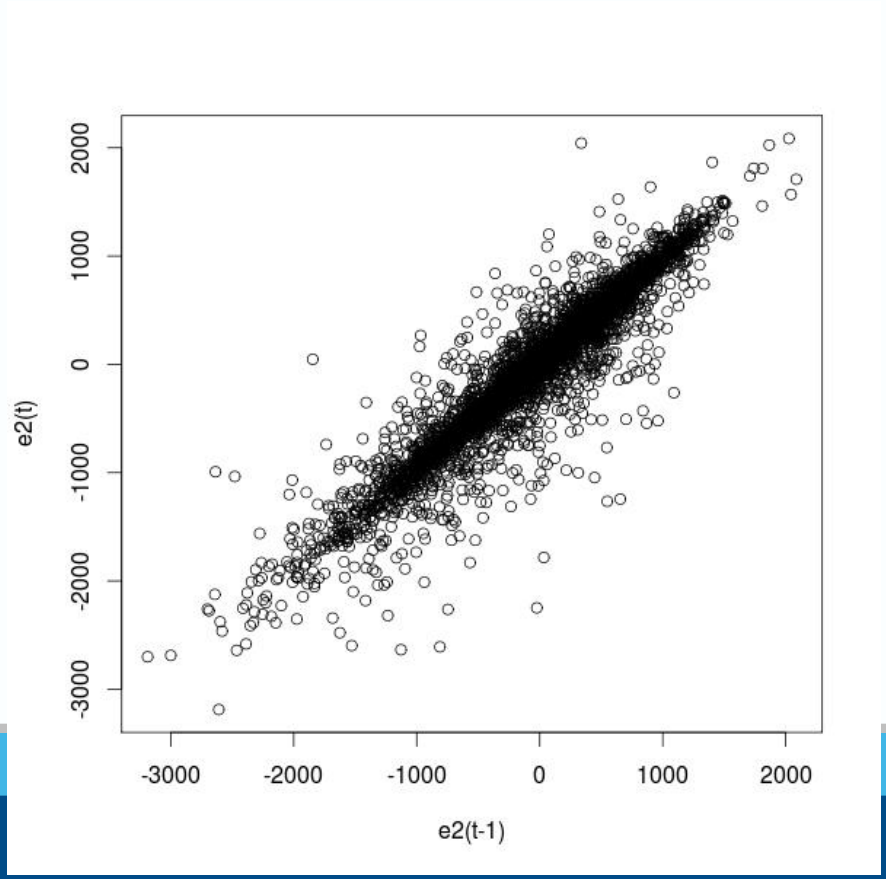
(Wang, Shrestha, Robertson, Pokhrel, 2012)

Stage 2

- **Purpose:** correct the bias of the hydrological simulation
- **Assumption:** independent, transformed-Gaussian distribution
- **Parameters:** two bias-correction parameters

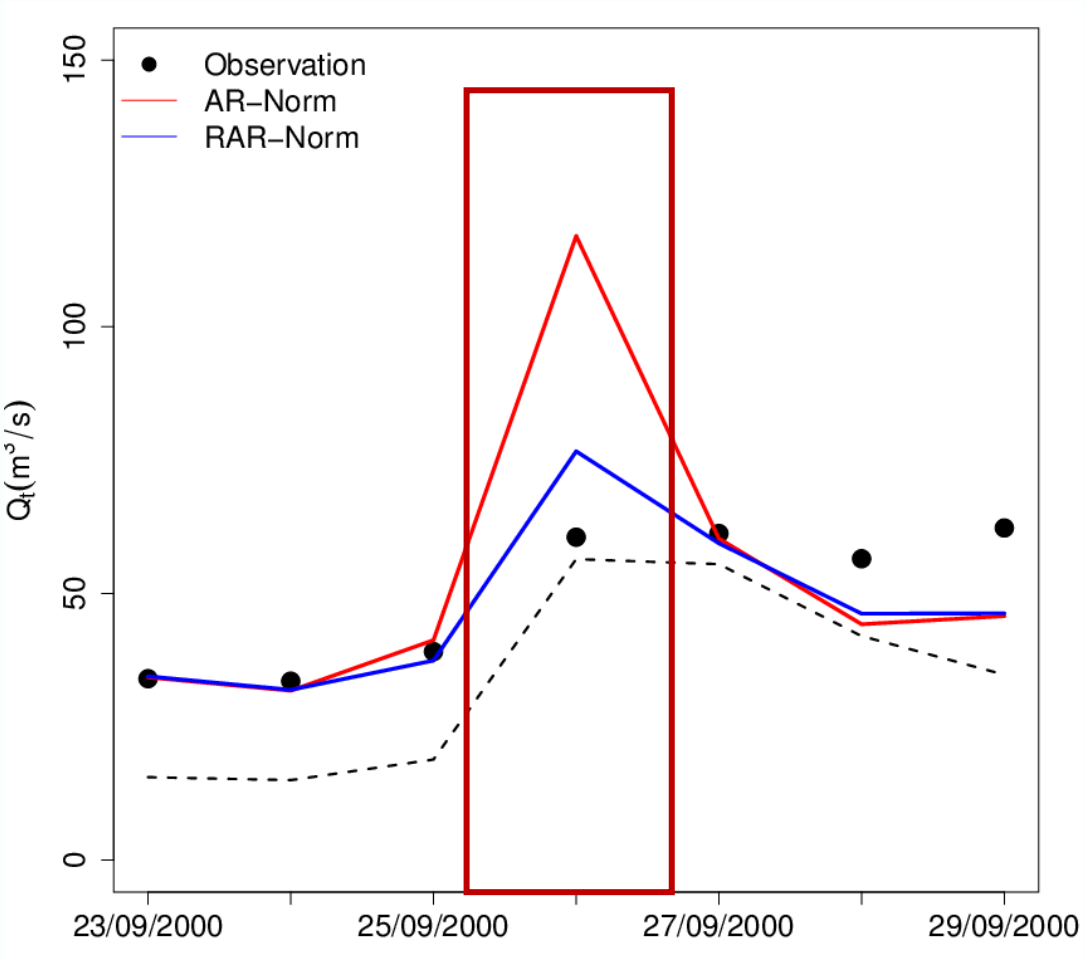
Stage 3

- **Purpose:** update the forecast by the restricted AR(1) model
- **Assumption:** auto-correlated, transformed-Gaussian distribution
- **Parameters:** one auto-correlation parameter



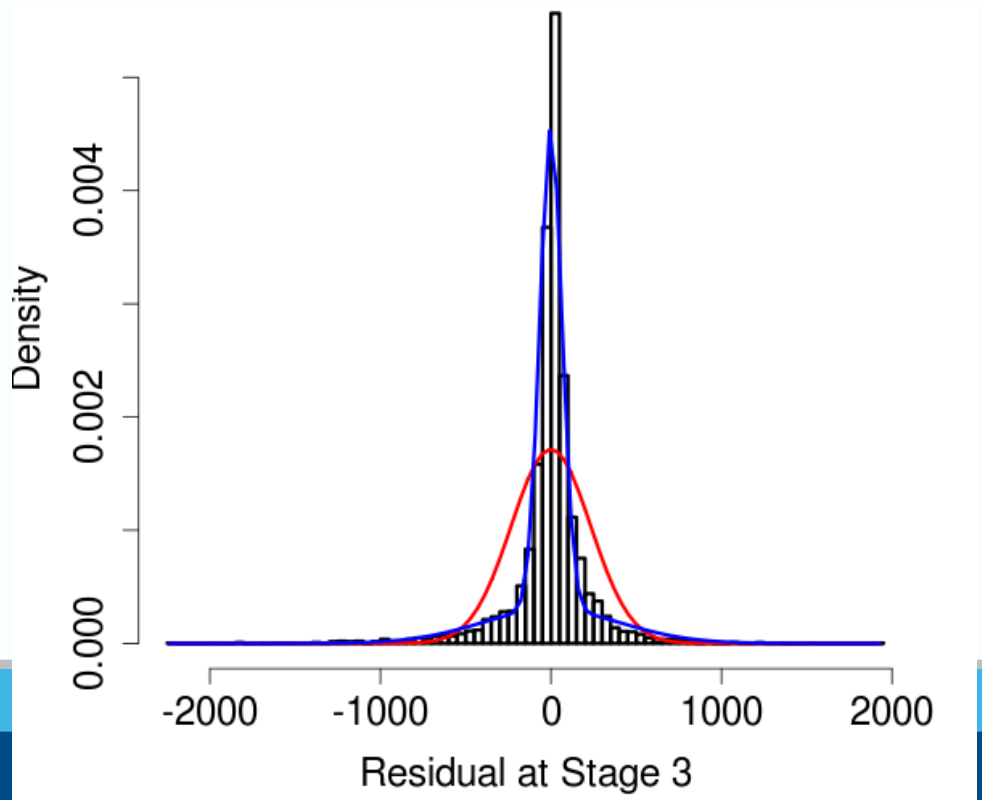
Restricted Autoregressive model

(Li, Wang, Bennett and Robertson, 2015)

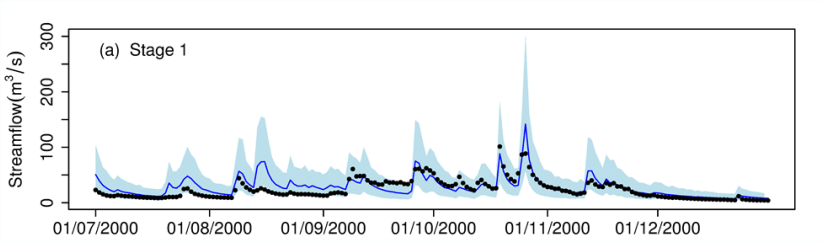


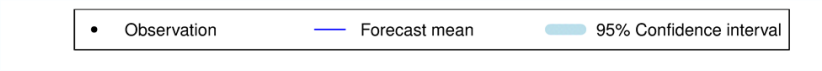
Stage 4

- **Purpose:** Adjust the residual distribution
- **Assumption:** Auto-correlated, transformed-mixed-Gaussian distribution
- **Parameters:** three distribution parameters



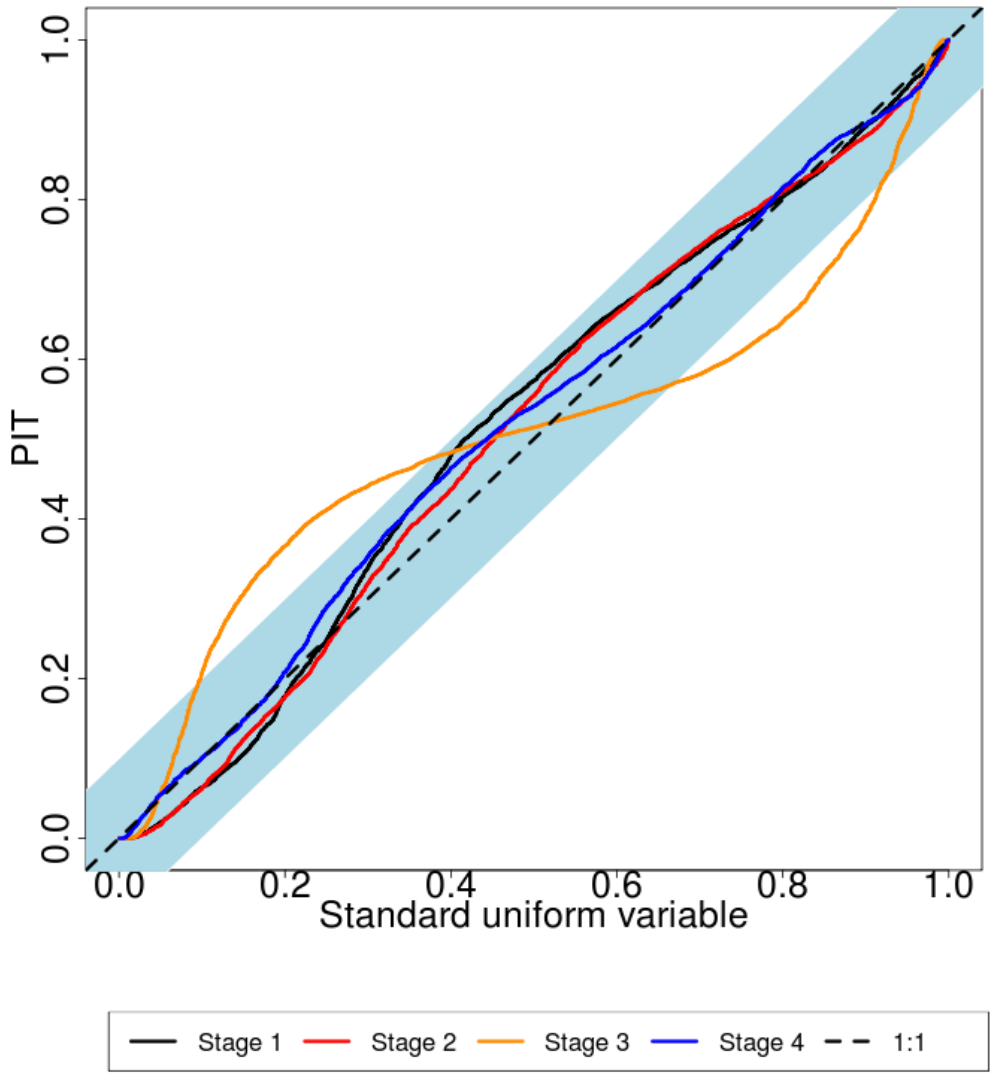
Example of 1-day ahead forecasting





- **The forecast mean becomes more accurate**
- **The confident interval becomes more narrow**

The PIT plots – check forecast reliability



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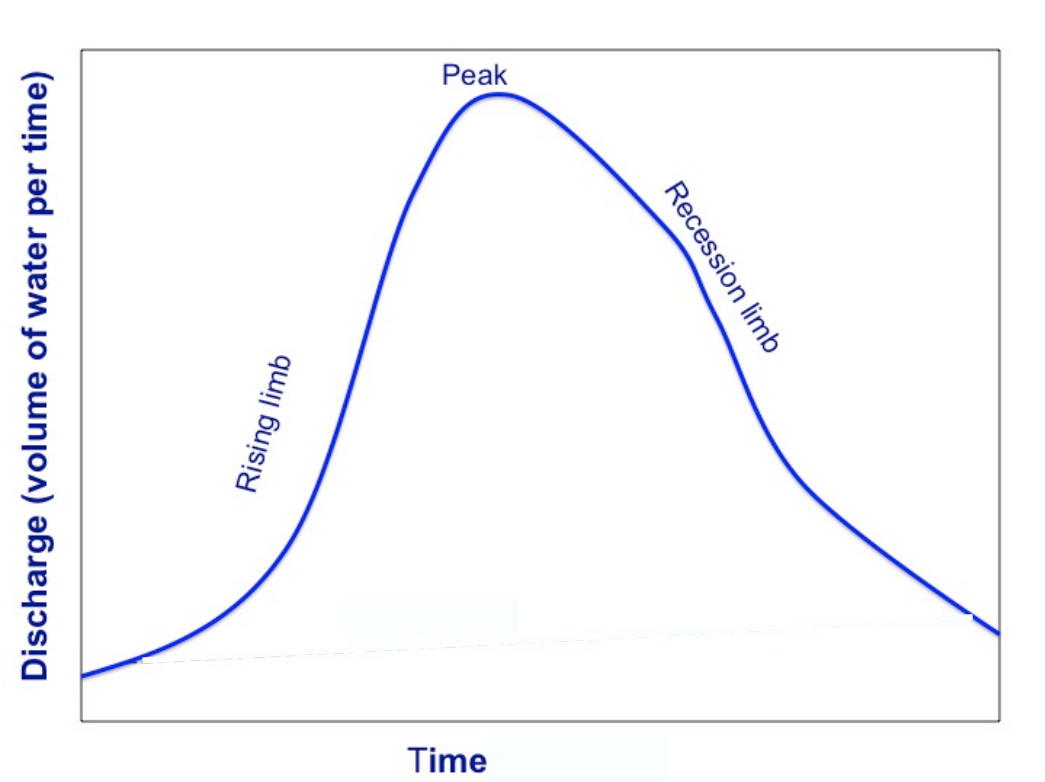
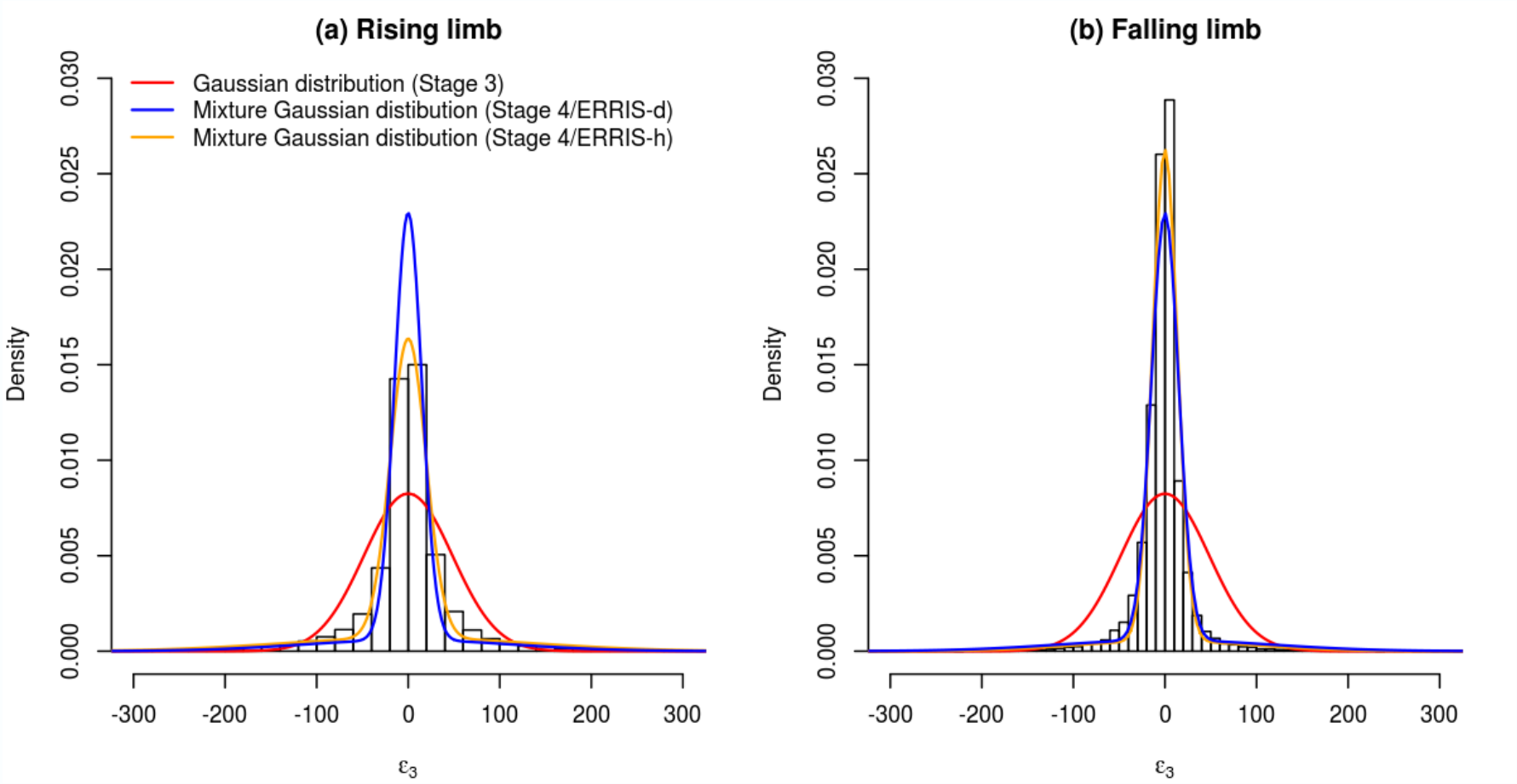
ERRIS for hourly forecasting



For hourly forecasting, separated parameters at Stage 4 are used for the rising and falling limbs of the simulated hydrograph

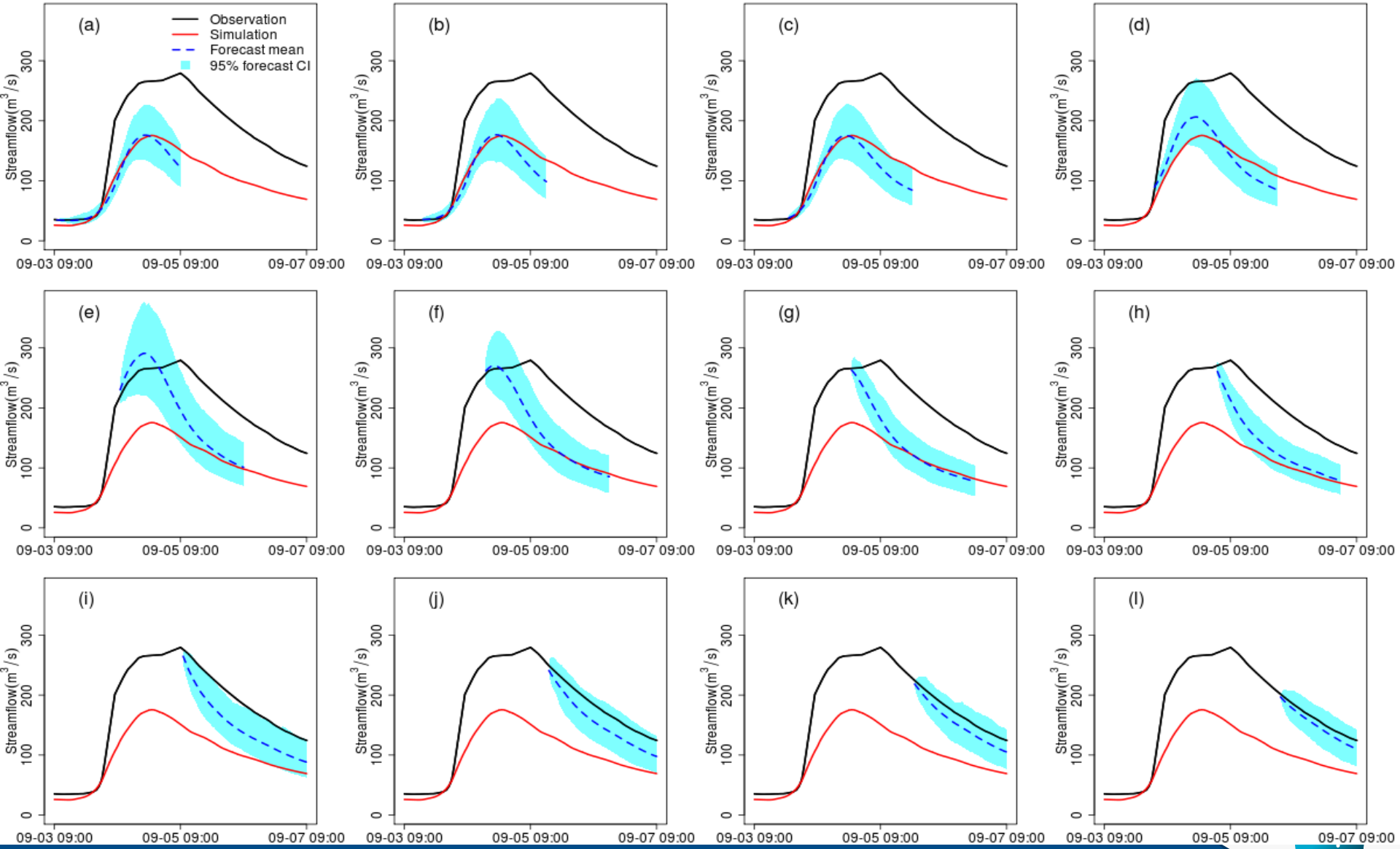
ERRIS for hourly forecasting



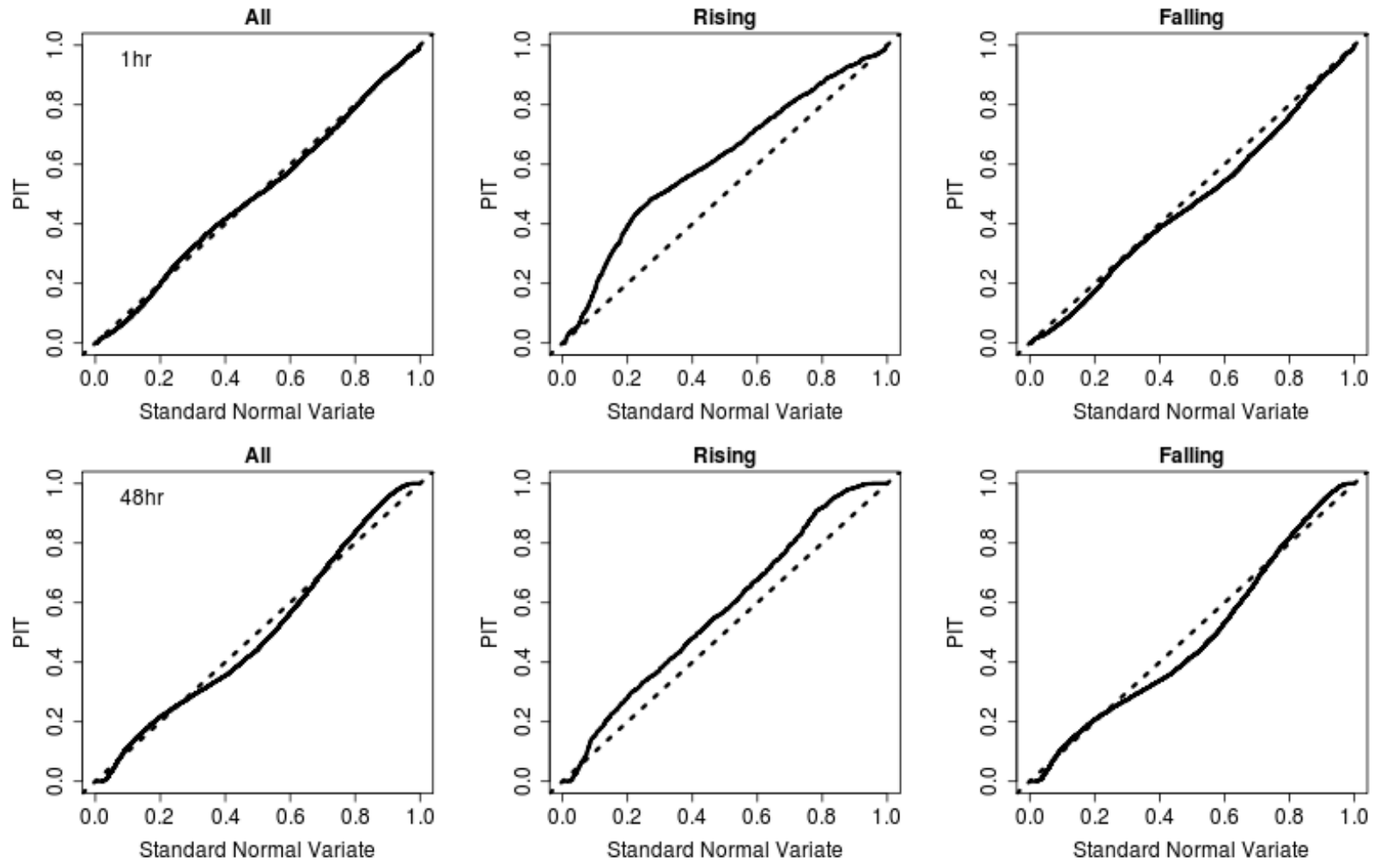
Case study

- Upper-Murray river
- Up to 48-hour lead-times
- A testing-period of five years (2007~2012)
- three-fold cross-validation
- Forecasts are issued four times a day
- 1000 ensemble members
- Hydrological model: GR4J
- Perfect rainfall forecast
- Reference forecast : Stage 1

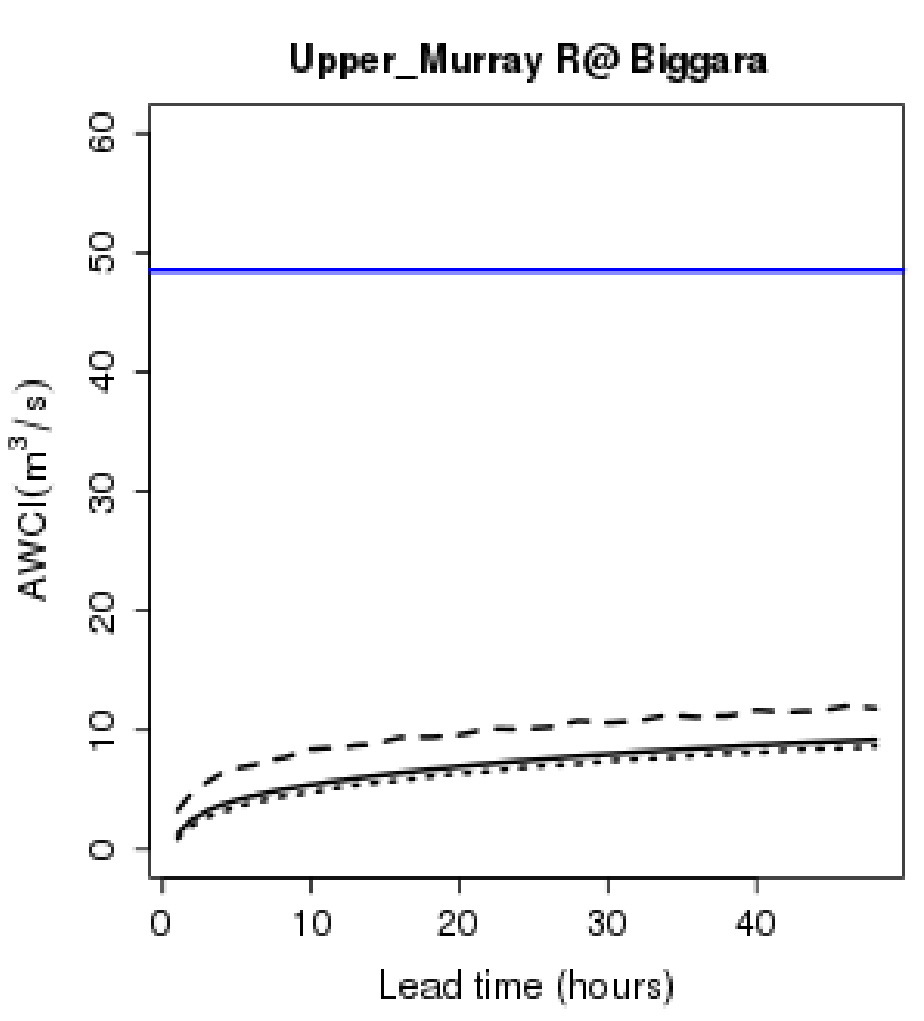
Case study


(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
(k)
(l)
Observation
Simulation
Forecast mean
95% forecast CI
Streamflow(m3/s)
0
100
200
300
09-03 09:00
09-05 09:00
09-07 09:00

Case study


All
1hr
Rising
Falling
All
48hr
Rising
Falling
PIT
Standard Normal Variate
0.0
0.2
0.4
0.6
0.8
1.0

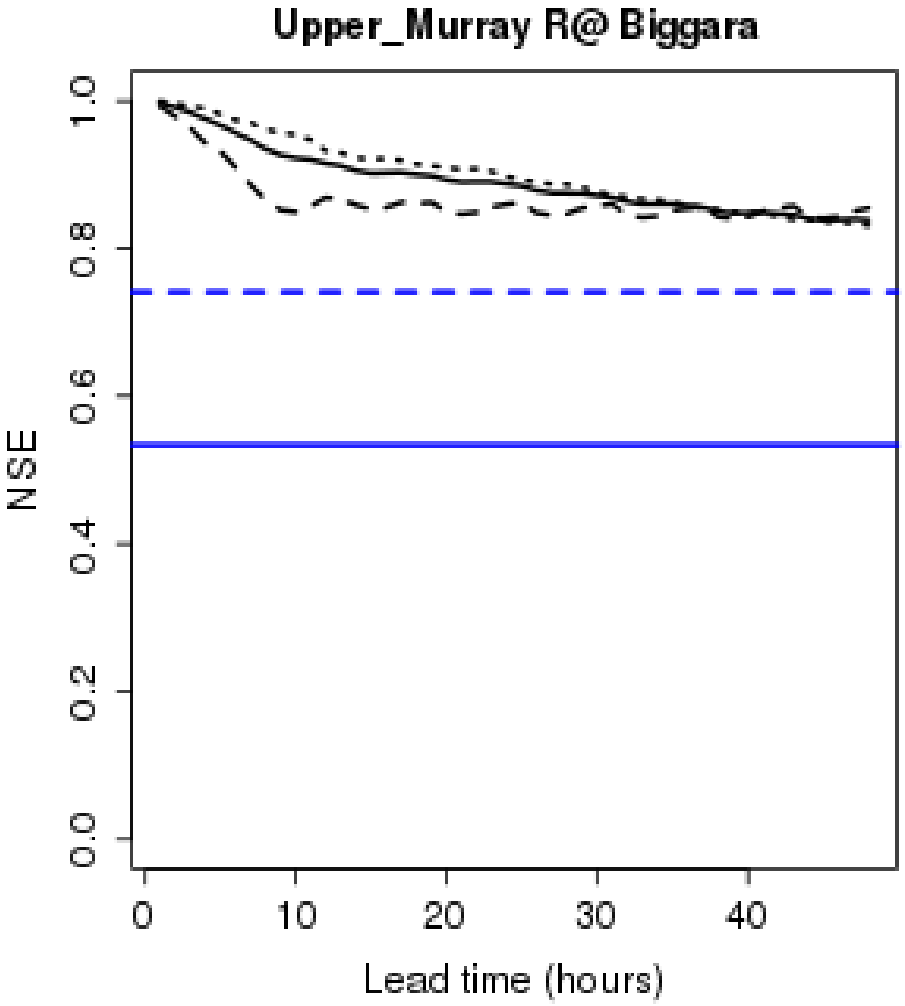
Case study



- Much sharper than the reference forecast
- The 95% confidence intervals become wider at increasing lead-times
- Rising limbs require wider confident intervals

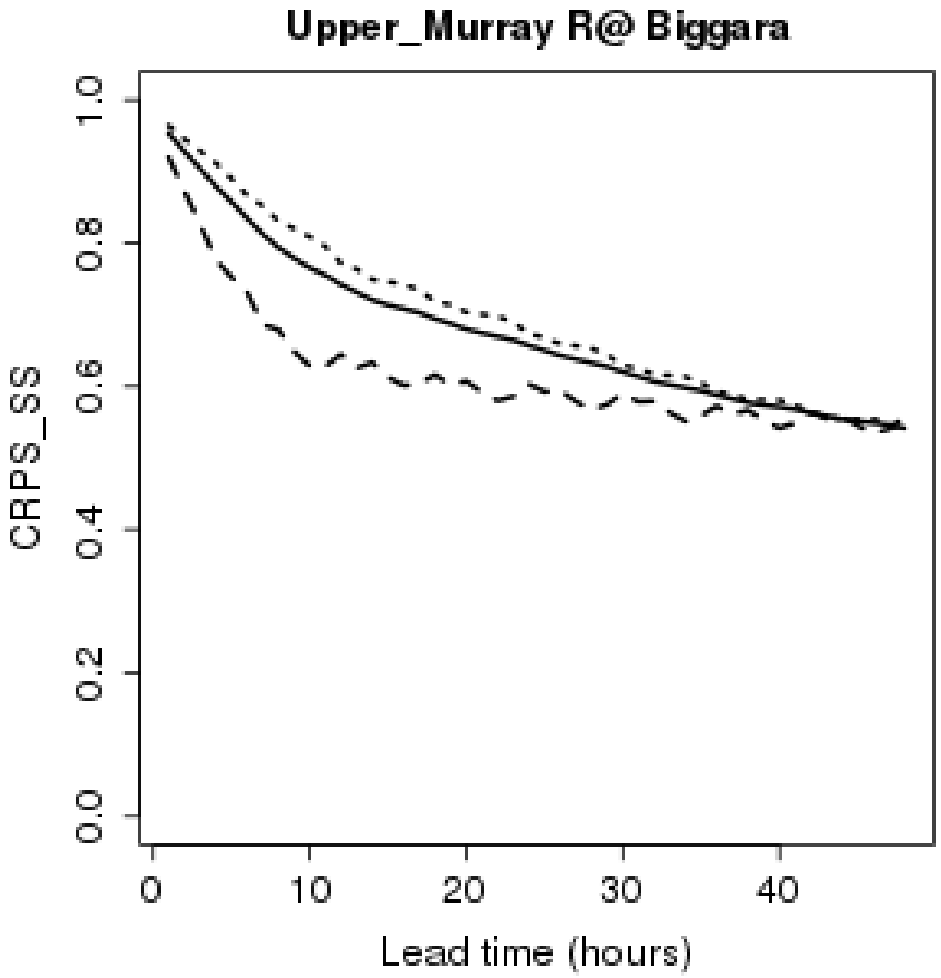
Blue solid: reference forecast
Dark solid: all observations
Dark broken: rising limbs
Dark dotted: falling limbs

Case study



- Bias-correction effectively increases NSE by 0.2
- The NSE is extremely close to 1 at 1-hour lead-time and approaches to that obtained at Stage 2

Case study



- Much more skilful than the reference forecast
- Forecasts at the rising limb is less skilful than those at the falling limb

Conclusion

- ERRIS uses staged error models to greatly simplify the model formulation
- The ensemble forecasts from Stage 4 are highly accurate and reliable
- The use of separated distribution parameters at Stage 4 makes ERRIS applicable for hourly streamflow forecasting

(Li, Wang, Bennett and Robertson, 2016, under review)

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