Progress toward ensemble 7-day streamflow forecast for Australia

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Deterministic 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
Forecasting challenges
1. Observed rainfall and river flow
2. Data processing
3. Processed data
4. NWP outputs
5. NWP post processing
   - Bias correction
   - Uncertainty quantification
6. Rainfall forecast ensembles
7. Hydrological modelling
   - Model updating
   - Bias correction
   - Hydrological uncertainty
8. River flow forecast ensembles
9. Forecast verification
10. Forecast skill and reliability
11. Further post-processing?
12. River flow forecast ensembles?
Ensemble forecast system components

• Observed data
  Adapted from existing flood forecasting service

• Rainfall forecasts
  RPP (Bayesian rainfall forecast post-processor)

• Runoff and routing models
  Semi-distributed; GR4H, Muskingum ...

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

• Verification
  Cross validation scheme
Ensemble forecast system components

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• **Rainfall forecasts**
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Rainfall forecasts

Shrestha, Robertson, Bennett, Wang (2015) MWR

South Esk (~3300 km²)
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

Shrestha, Robertson, Bennett, Wang (2015) MWR

South Esk (~3300 km²)
Rainfall forecast reliability
Rainfall forecast post-processing – spatial effects

Observations

Raw ACCESS-G

Post-processed ACCESS-G

Day 9
Rainfall (mm/day)
1.5 2 2.5 3 3.5 4 4.5 5
What rainfall forecast product?

NWP output

Forecaster updated

Combined NWP output

ACCESS-R
ACCESS-G
ECMWF-H
ECMWF-L
JMA-GSM
UK-GC
CMC-GEM
NCEP-GFS

Lead time (days)
What forecast product?
What forecast product?
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- Verification
  Cross validation scheme
Hydrological modelling

Bennett, Robertson, Shrestha, Wang, Enever, Hapuarachchi, Tuteja (2014) JoH
Streamflow forecasts - putting it all together

Bennett, Robertson, Shrestha, Wang, et al. (2014) JoH
Performance of streamflow forecasts

St. Pauls R a/b Avoca (South Esk, TAS)

Bias (%)

CRPS (m³ s⁻¹)

Lead time (days)

Obs Rain | ACCESS-G | Zero Rain | Post-Processed ACCESS-G

South Esk (~3300 km²)
Streamflow forecast reliability

Florentine River (169 km²)
Error Reduction and Representation in Stages (ERRIS)
Performance of streamflow forecasts

Florentine River (169 km²)
Streamflow forecast reliability

Florentine River (169 km²)
Forecast reliability in ephemeral catchments

Ord River

ERRIS @ 12 hour lead

Probability Integral Transform

12hr

Standard uniform variate
Summary

Users are demanding reliable ensemble forecasts for lead-times to 7 days

Post-processing catchment precipitation forecasts
  • Necessary for forecasts to ‘beat’ climatology
  • More important that the source of forecast precipitation

Generating accurate and reliable ensemble streamflow forecasts requires
  • Reliable ensemble rainfall at the catchment scale with minimal bias
  • Correction and quantification of errors in hydrological modelling

Ongoing research directions
  • Producing reliable uncertainty in ephemeral catchments
  • Dealing with streamflow forecast bias
  • Better (ensemble) estimates of catchment rainfall
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