Short-range precipitation forecasts – lessons for hydrological forecasting applications

David Robertson, Durga Lal Shrestha, James Bennett and Q.J. Wang
Events and activities

Biennial Workshop – Melbourne 2018
Conference special sessions
• AGU
• EGU
• European Meteorological Society
• MODSIM

Weekly blog posts
Seasonal forecasting testbed
Generating streamflow forecasts

Hydrological model

Model Parameters
What do streamflow forecast users want?

• Accuracy
• Skill
• Reliability
• Sharpness
• Coherence
• Consistency
• …
Ensemble forecasting framework

1. Observed rainfall and streamflow
2. Data processing
3. Processed data
4. Climate and NWP model outputs
5. Post-processing
6. Rainfall forecast ensembles
7. Hydrological modelling
   Bias correction
8. Streamflow forecast ensembles
9. Stochastic updating
10. Streamflow forecast ensembles
11. Forecast verification
12. Forecast skill and reliability
Talk outline

• How good are precipitation forecasts at the catchment scale?
• What does this mean for streamflow forecasts?
• Can we improve the precipitation forecasts for hydrological applications?
Many precipitation forecast products available

NWP output (ACCESS)

<table>
<thead>
<tr>
<th>Version</th>
<th>Spatial Resolution</th>
<th>Temporal Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>25km</td>
<td>3hr to 240hrs</td>
</tr>
<tr>
<td>Regional</td>
<td>12km</td>
<td>1hr to 72hrs</td>
</tr>
<tr>
<td>City</td>
<td>4km</td>
<td>1hr to 36hrs</td>
</tr>
</tbody>
</table>

Forecaster Updated (MetEye)

Combined NWP output (Poor Man’s Ensemble)
How good are forecasts at the catchment scale?

South Esk (~3300 km²)

Shrestha, Robertson, Bennett, Wang (2015) MWR
Rainfall forecast errors – spatial patterns

Observations

Raw ACCESS-G

Rainfall (mm/day)
What about other forecast products?

<table>
<thead>
<tr>
<th>Forecast product</th>
<th>Horz. resolution (Km x Km)</th>
<th>Issue time(s) (UTC)</th>
<th>Forecast time step (h)</th>
<th>Lead time available (h)</th>
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<tbody>
<tr>
<td>ACCESS-G1</td>
<td>~50x40</td>
<td>00, 12</td>
<td>3</td>
<td>240</td>
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<tr>
<td>PME</td>
<td>~50x50</td>
<td>00,06, 12, 18</td>
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<td>228</td>
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<td>ACCESS-GE</td>
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<td>3</td>
<td>240</td>
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<tr>
<td>ADFD</td>
<td>~5x5</td>
<td>Every 3 hr*</td>
<td>3</td>
<td>48</td>
</tr>
</tbody>
</table>

* Updates several times in 24 hr
What about other forecast products?
What about other forecast products?
Implications for streamflow forecasts

South Esk (~3300 km²)
How can rainfall forecast be improved?

Rainfall forecast post-processing (Robertson, Shrestha, Wang, 2013, HESS)

**Step 1: Apply statistical model to each location and lead time**

Function: Correct bias, quantify uncertainty and ensure coherence

Bayesian joint probability (BJP) model
- Treatment of zero data
- Continuous bivariate normal distribution

**Step 2: Instill temporal and spatial patterns**

Function: Ensemble members look like rain storms and accumulations have appropriate uncertainty

Schaake Shuffle (Clark, et al, 2004, JHM)
- Form ensemble members using historical rank correlation
Rainfall forecast post-processing

South Esk (~3300 km²)

Shrestha, Robertson, Bennett, Wang (2015) MWR
Rainfall forecast post-processing

Observations

Raw ACCESS-G

Post-processed ACCESS-G
Post-processing of other forecast products
Post-processing of other forecast products

Ensemble Spread

Stanley River

(246 km²)
Performance of streamflow forecasts

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

South Esk (~3300 km²)
Precipitation forecasts for hydrology - Lessons

Many precipitation forecast products available

Each product has its own characteristics

Raw forecasts contain bias and can be worse than climatology

Ensemble forecasts generally have lower errors

Effective post-processing techniques exist to correct bias, quantify uncertainty and ensure coherence

Benefits of post-processing precipitation forecasts are substantial

Availability of historical precipitation forecasts is a significant challenge
Dr David Robertson
Principal Research Scientist

t +61 3 9545 2431
e david.robertson@csiro.au
Challenges facing short-term streamflow forecasting

- Australian hydrology
- Availability of NWP forecasts
- Sub-daily rainfall observations and analysis