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Bureau of Meteorology

Seasonal streamflow forecasting service for Australia

Methods, implementation and the way forward



Variability of water resources in Australia

Year	Major drought conditions
1895-1903	Federation drought
1914-15	Widespread drought, Crop failed
1918-20	Severe drought across all states
1939-45	Drought affects South East & SW
1965-68	Most of Australia affected
1982-83	A short severe drought
1997-2009	Millennium drought
2013-present	Parts of NSW and Queensland



Variability of water resources in Australia

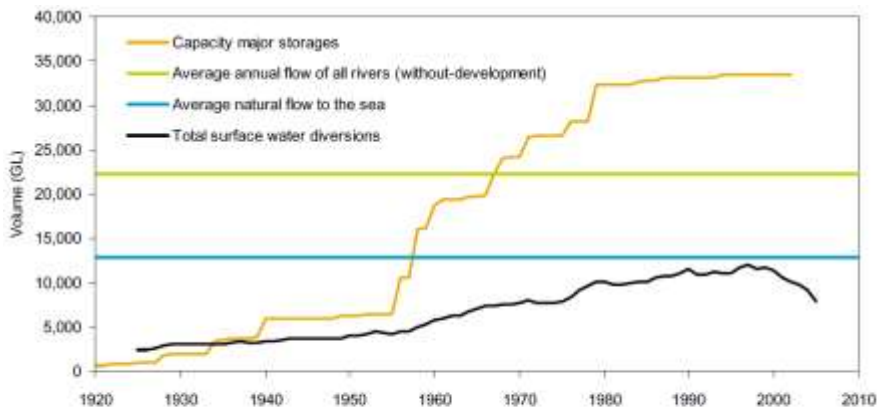
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Key drivers for water forecasting

- Intensive water uses in the Murray Darling Basin
- Large storages in headwaters



Source: CSIRO MDBSY project

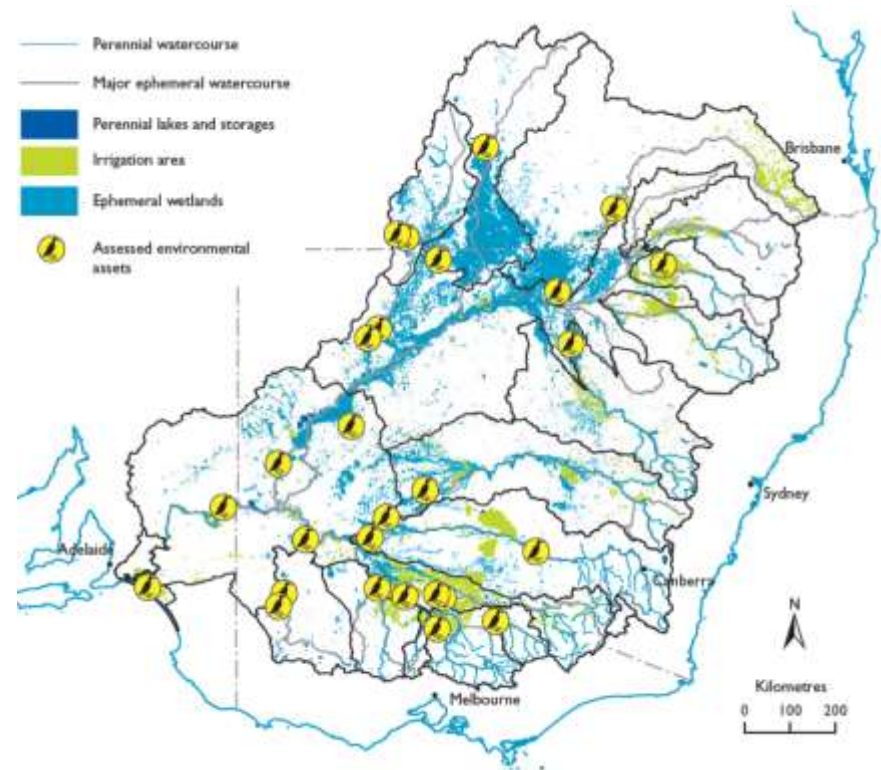


Source: MDBA



Key drivers for water forecasting

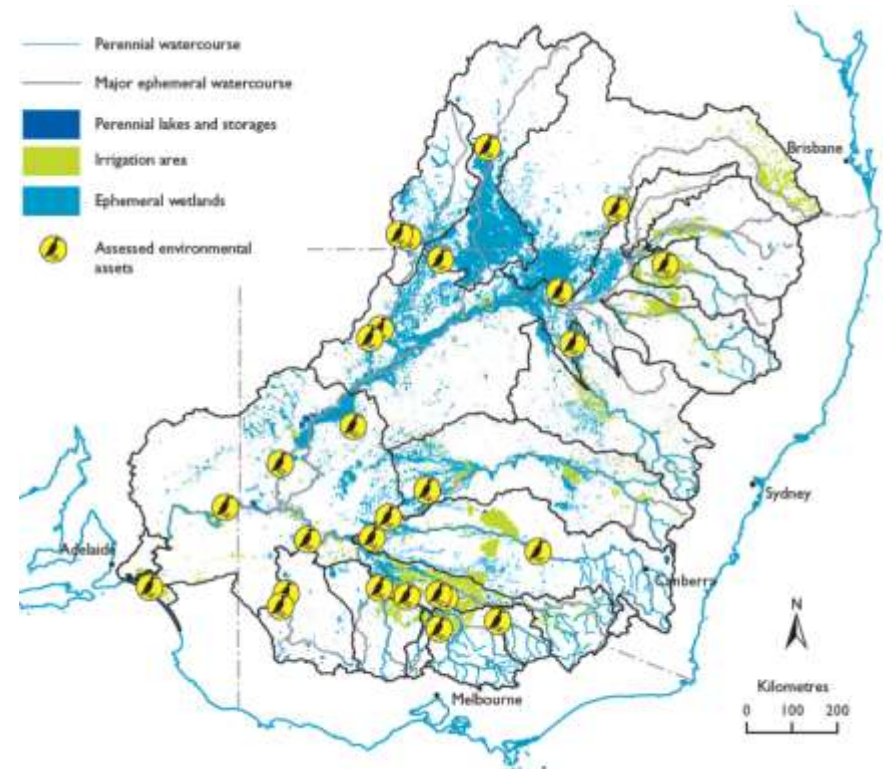
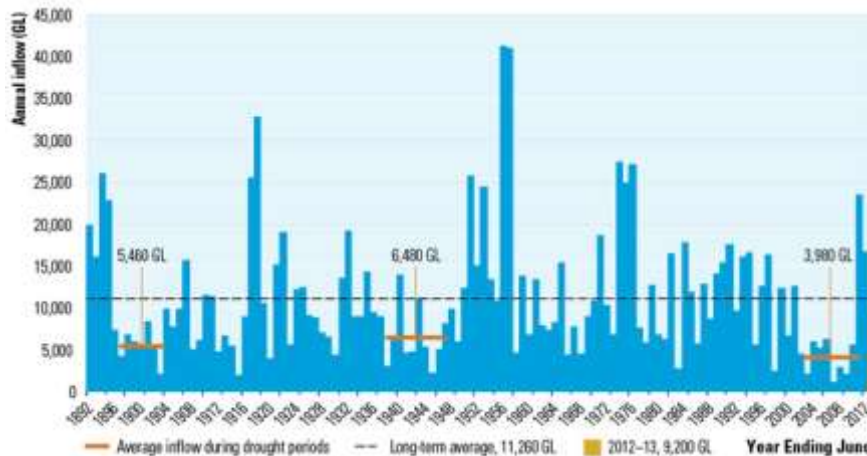
- Intensive water uses in the Murray Darling Basin
- Large storages in headwaters
- Sensitive ecosystems





Key drivers for water forecasting

- Intensive water uses in the Murray Darling Basin
- Large storages in headwaters
- Sensitive ecosystems
- Ratio of wettest and driest year > 50



Key drivers for water forecasting

- Supporting decisions related to
 - Dam operation
 - Environmental flows



Murray River, NSW



Kidston dam, QLD

Cubbie Station, QLD

Key drivers for water forecasting

- Supporting decisions related to
 - Dam operation
 - Environmental flows
 - Water allocations
 - Water restrictions
 - Cropping strategies



Murray River, NSW



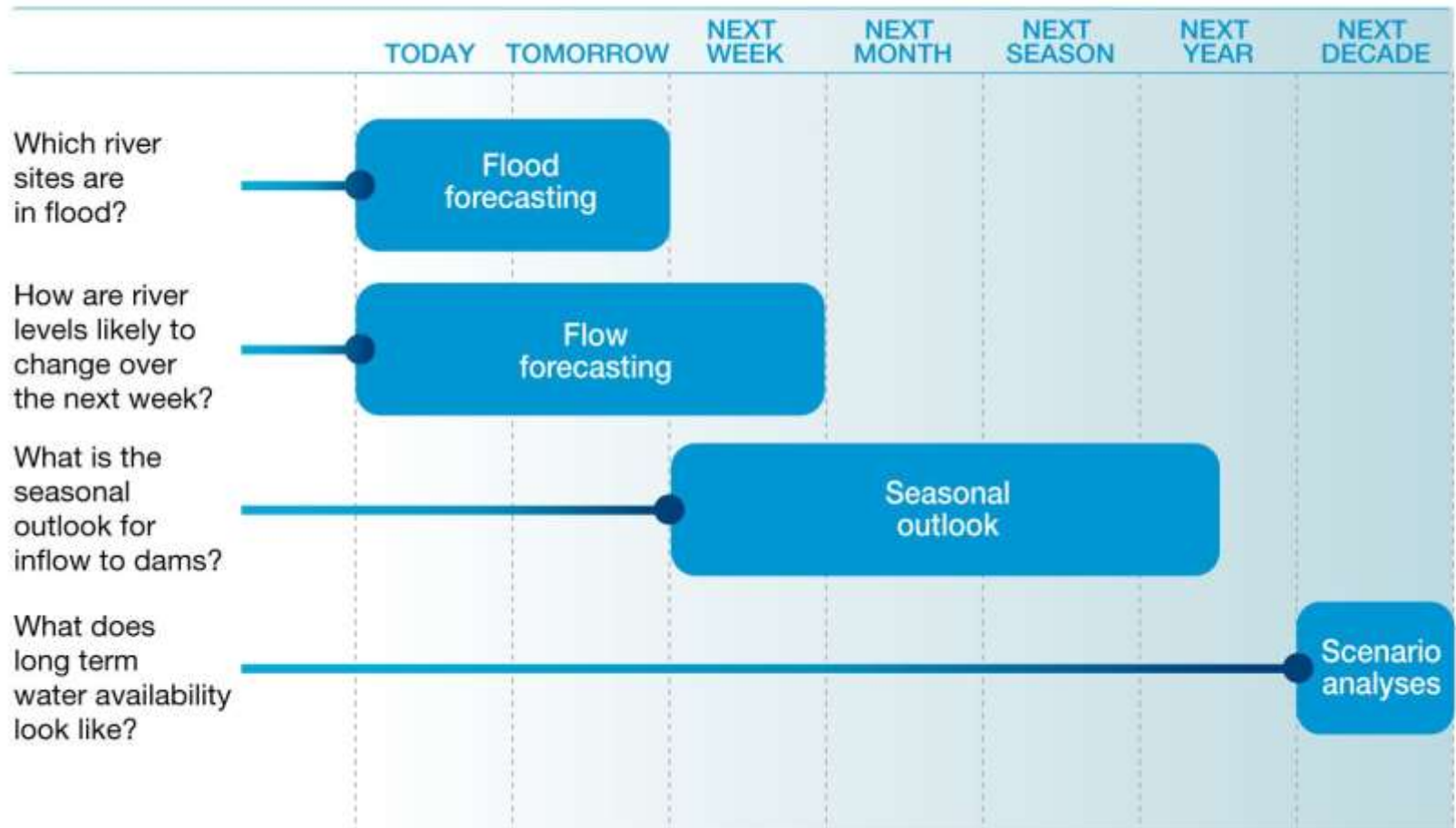
Kidston dam, QLD



Cubbie Station, QLD

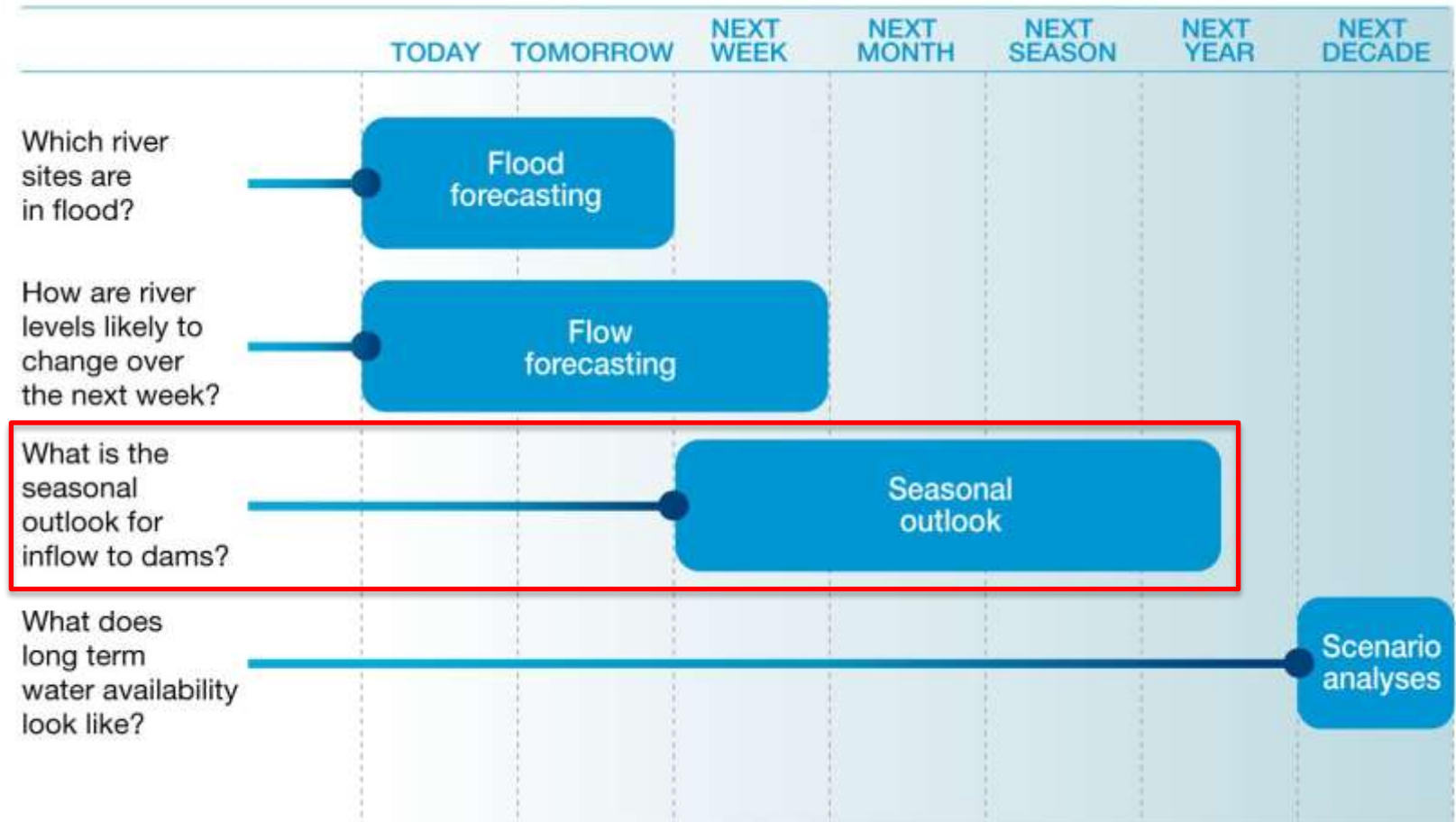


Extended hydrological predictions in the Bureau of Meteorology





Extended hydrological predictions in the Bureau of Meteorology





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Outline

- **Seasonal Streamflow forecasting service**
- **Forecasting models**
- **Forecast verification**
- **Communication and adoption**



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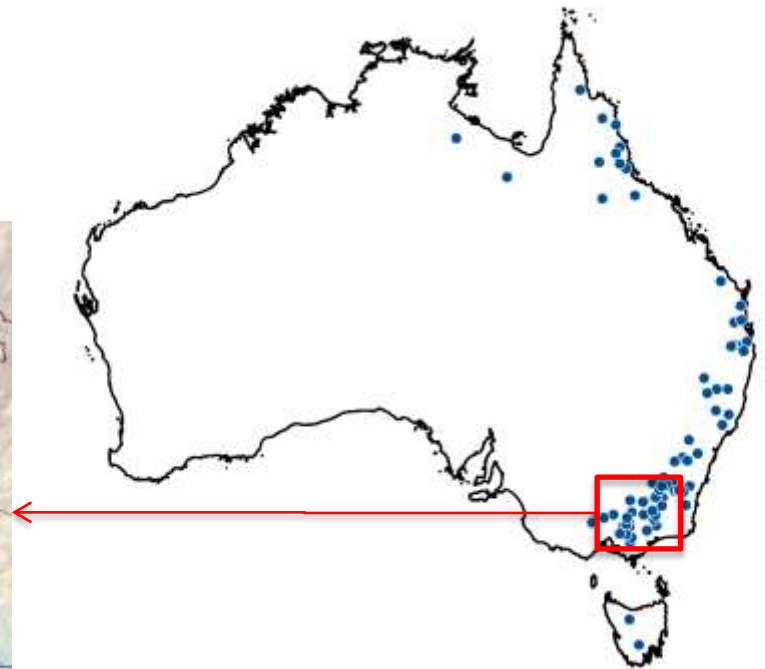
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Seasonal Streamflow Forecasting Service

- 86 forecast locations

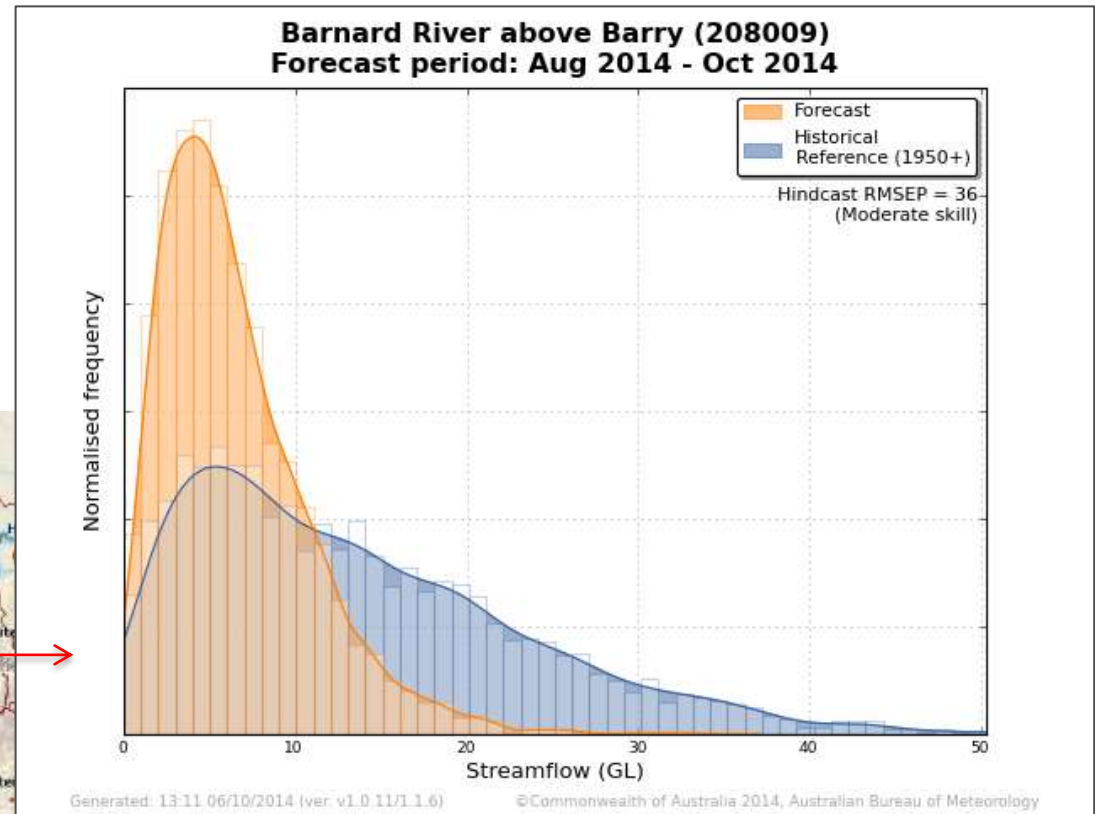
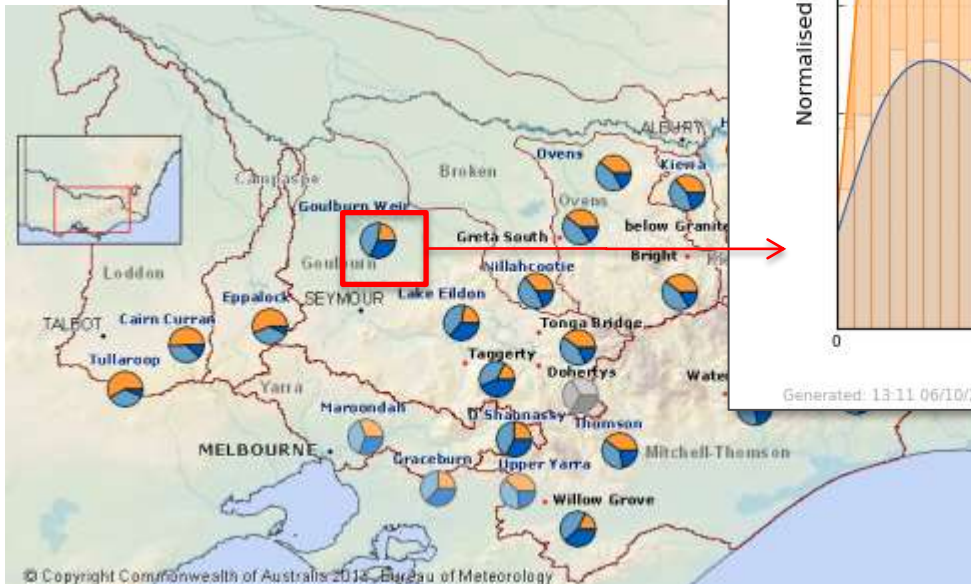




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Seasonal Streamflow Forecasting Service

- 86 forecast locations
- 3-month outlook of streamflow volumes
- Issued every month
- 5000 ensemble members





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Products

<http://www.bom.gov.au/water/ssf/forecasts.shtml>

Forecast
summary

Forecast
analysis with
links to climate

The screenshot shows the Bureau of Meteorology's website for Seasonal Streamflow Forecasts. The main heading is 'Seasonal Streamflow Forecasts' for 'October to December 2014'. Below this, there is a summary of the forecast, stating that low streamflows are more likely than average. A map of Australia is displayed, showing various forecast regions such as Northern Territory, Cape York Peninsula, Southern Queensland, Southern Queensland, and Southern New South Wales. The page also includes a section for 'September catchment conditions' and several video thumbnails for 'low information video' and 'Outlook video'. At the bottom, there are links for 'forecast sites' and 'September catchment conditions'.

Educational
video

Outlook
video

Forecast
sites

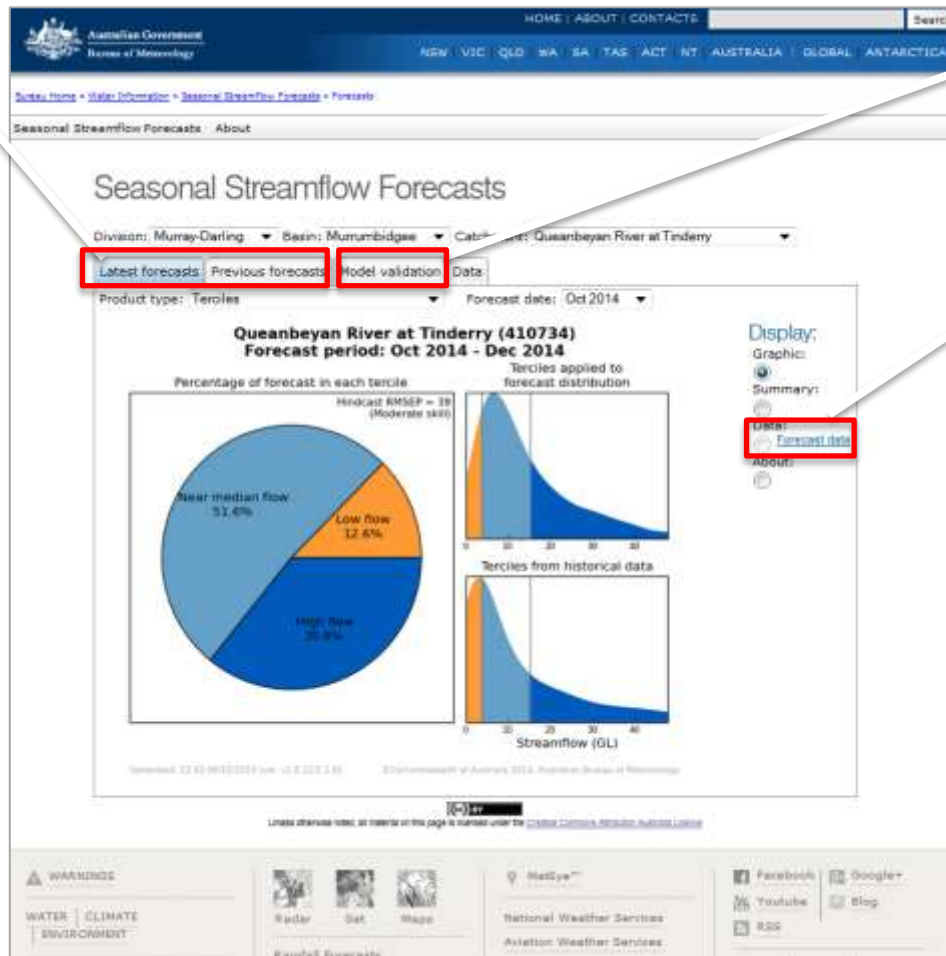


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Products

<http://www.bom.gov.au/water/ssf/forecasts.shtml>

Forecast products



Cross validation products

Data download

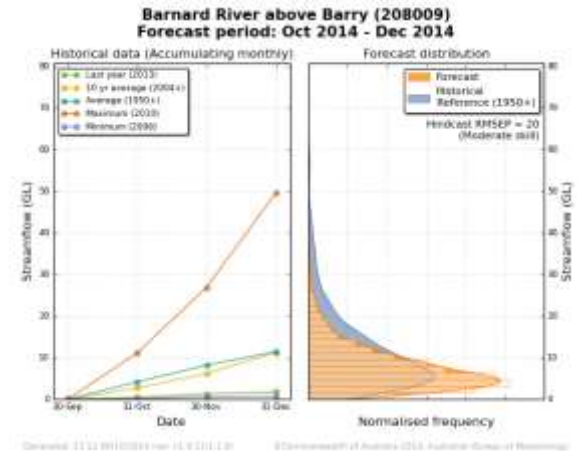
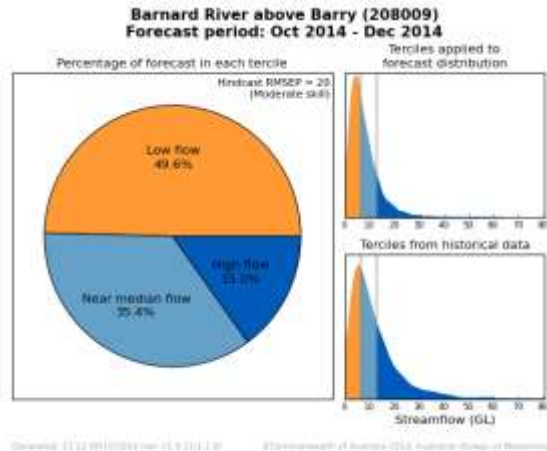


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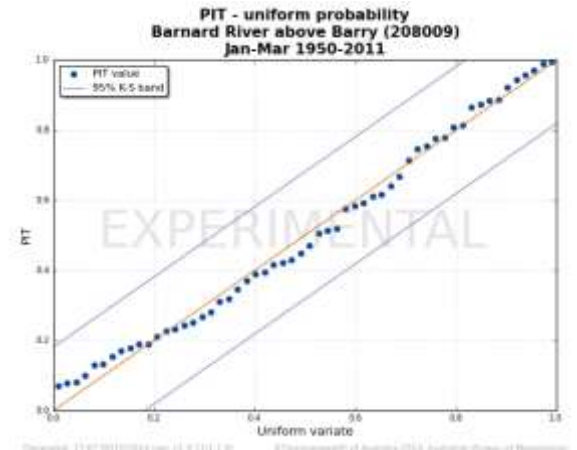
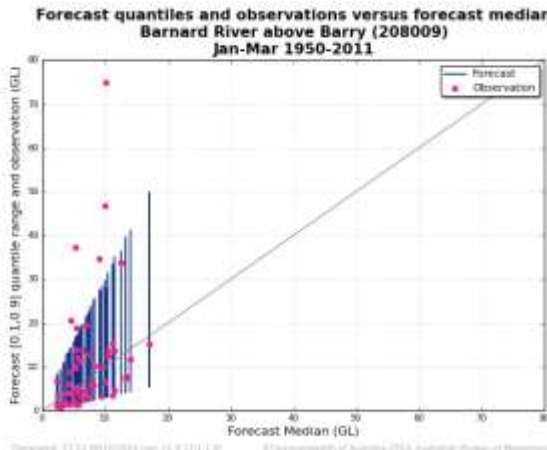
Products

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Forecasts



Cross validation
For individual
seasons





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Outline

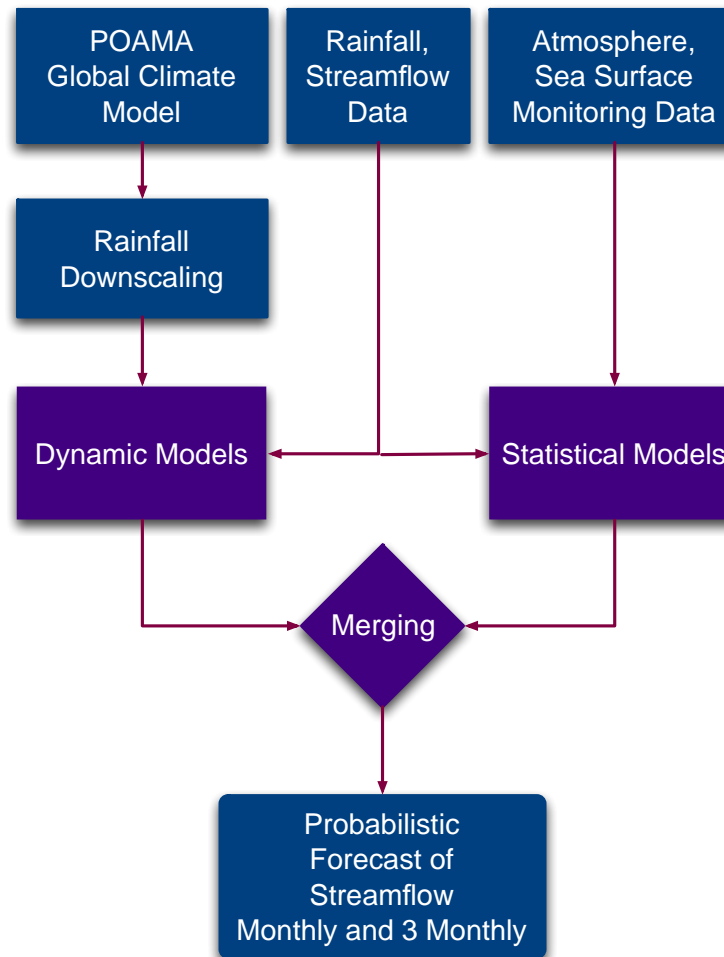
- Seasonal Streamflow forecasting service
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Forecasting models

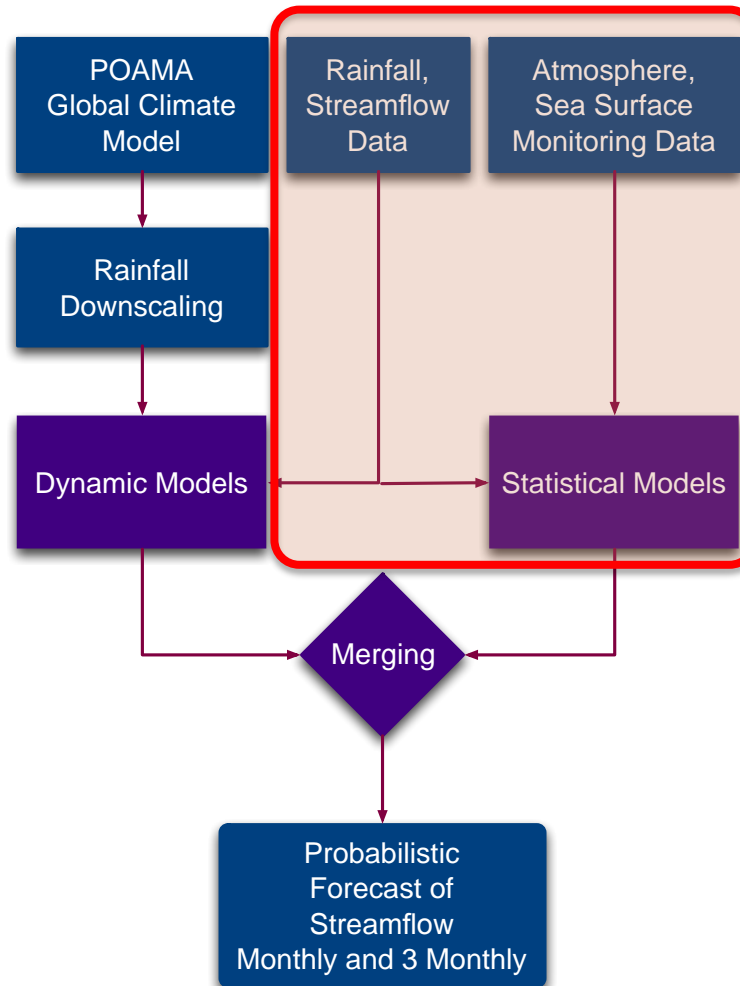




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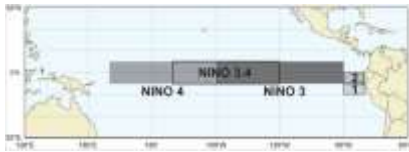
Forecasting models



Statistical Model (BJP)
Publicly Available
since Dec 2010

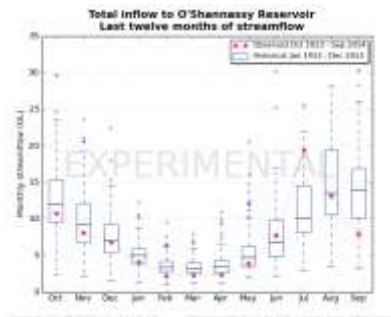
Forecasting models

- Statistical model developed by CSIRO



Climate indices

Predictors

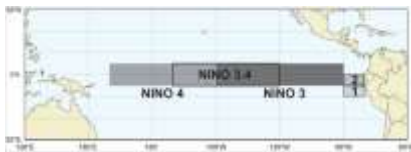


Antecedent streamflow

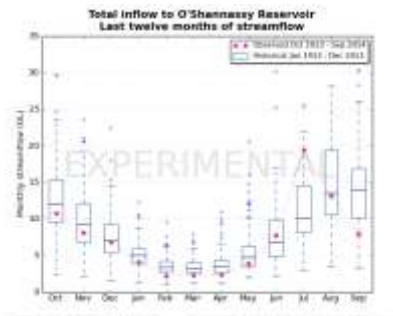


Forecasting models

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Climate indices

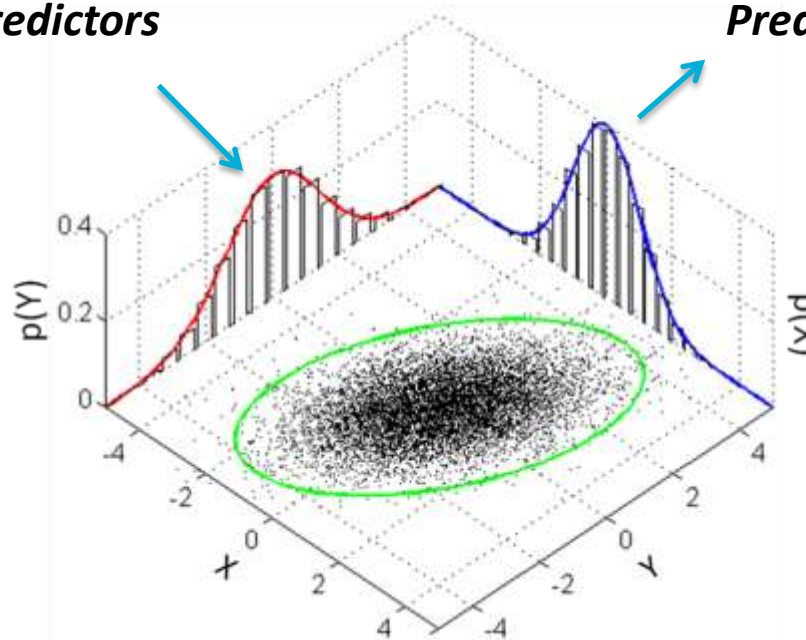


Antecedent streamflow

Predictors

Streamflow for next 3 months

Predictands



Multivariate Normal Distribution

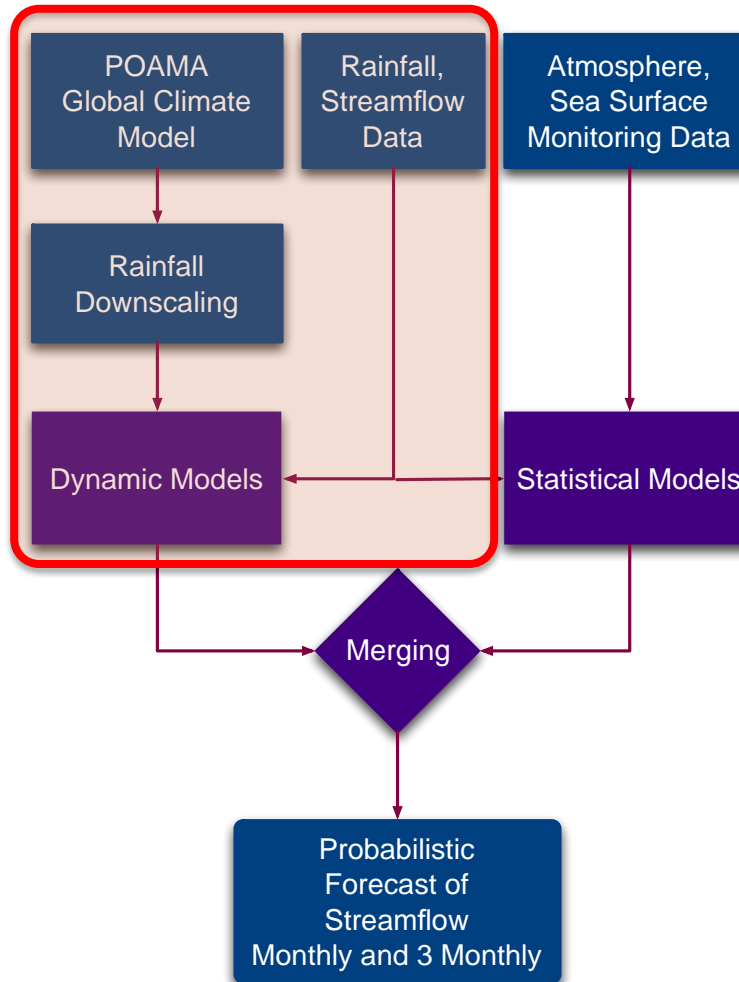
Wang, Q. J., Robertson, D. E. & Chiew, F. H. S. (2009), *A Bayesian joint probability modelling approach for seasonal forecasting of streamflows at multiple sites*. Water Resour. Res., 45, W05407, doi:10.1029/2008WR007355.

Wang, Q. J., Shrestha, D. L. & Pokhrel, P. (2012), *A log-sinh transformation for data normalization and variance stabilization*. Water Resour. Res., 48, W05514, doi:10.1029/2011WR010973.



Forecasting models

Dynamic Model
Register User
(release Nov 14)



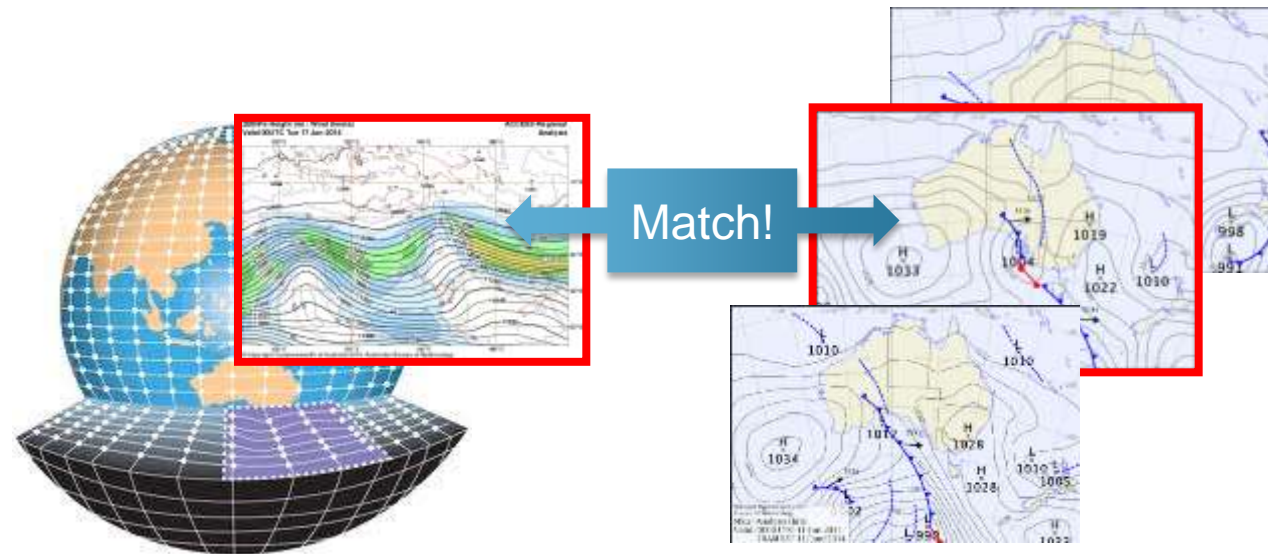


Forecasting models

- Dynamic approach : GCM Downscaling

POAMA forecast of synoptic variables (~270km, 31 ensembles)

Analogue downscaling
(5 replicates of 31 ensembles)





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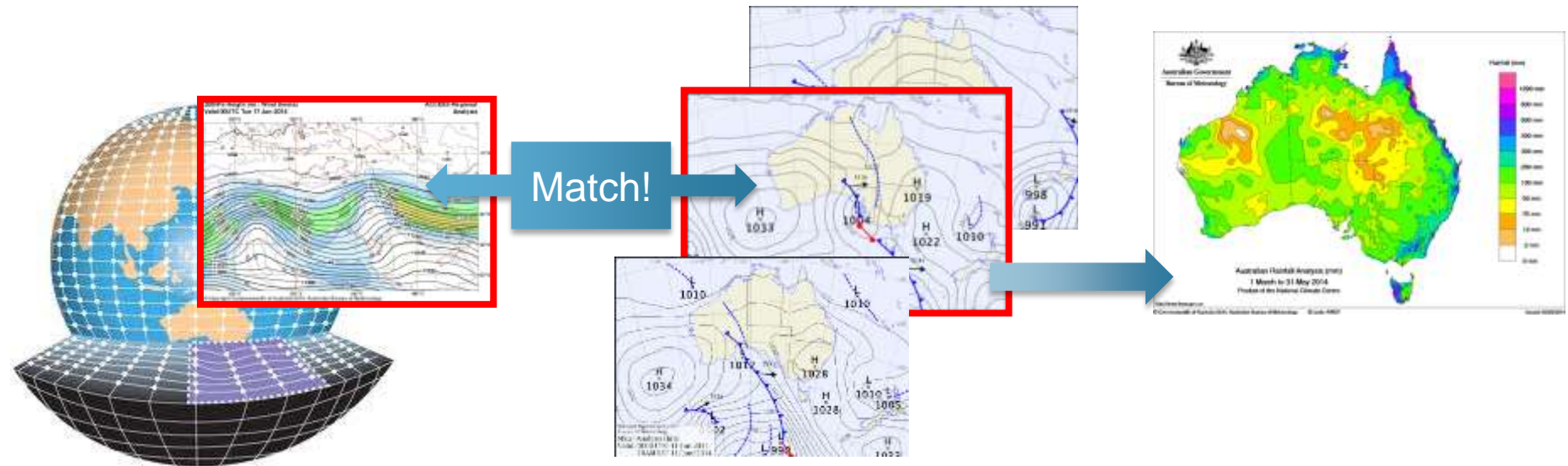
Forecasting models

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Analogue downscaling
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Downscaled rainfall
(5km; 155 ensembles)





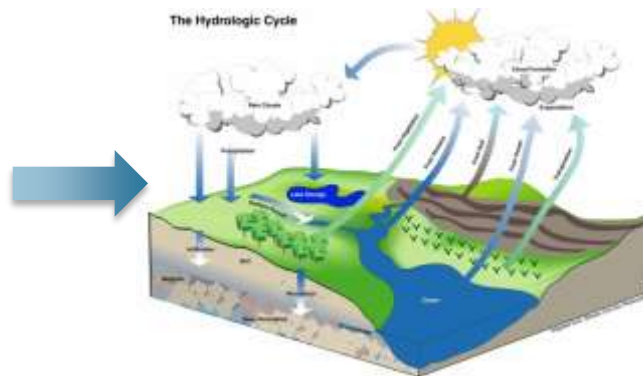
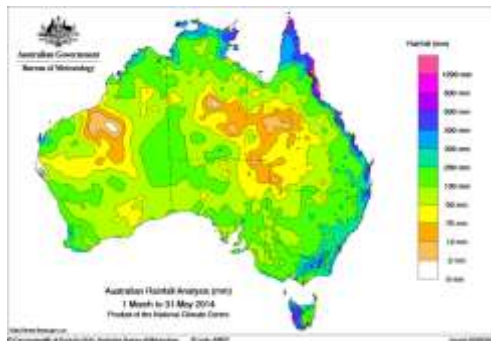
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Forecasting models

- Dynamic approach : Hydrological modelling

Downscaled rainfall
(5km; 155 ensembles)

Hydrologic uncertainty (BATEA)
(40 replicates of GR4J model)





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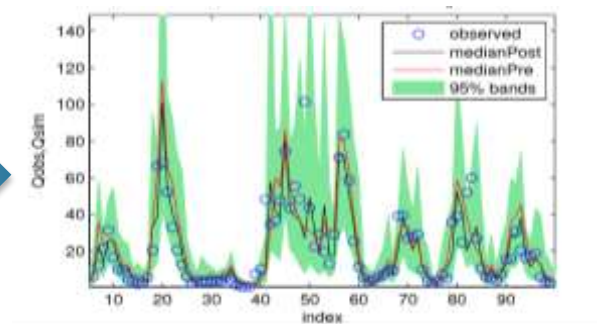
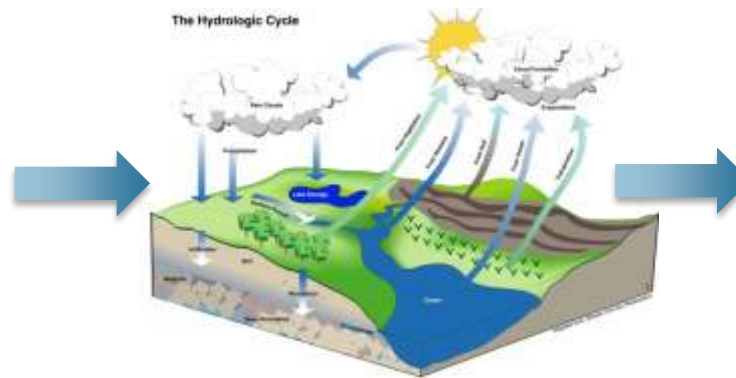
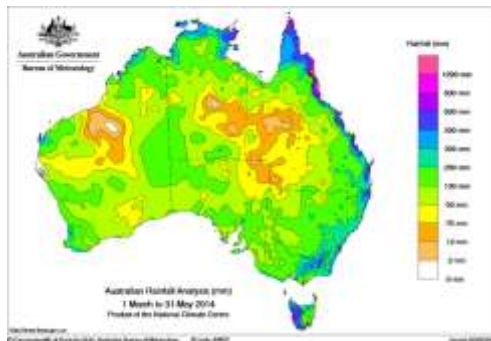
Forecasting models

- Dynamic approach : Hydrological modelling

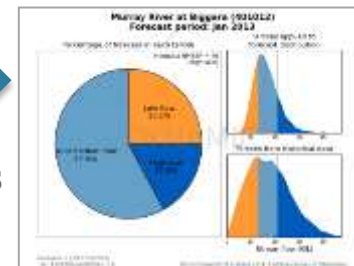
Downscaled rainfall
(5km; 155 ensembles)

Hydrologic uncertainty (BATEA)
(40 replicates of GR4J model)

Post-processed streamflow
(6200 ensembles)



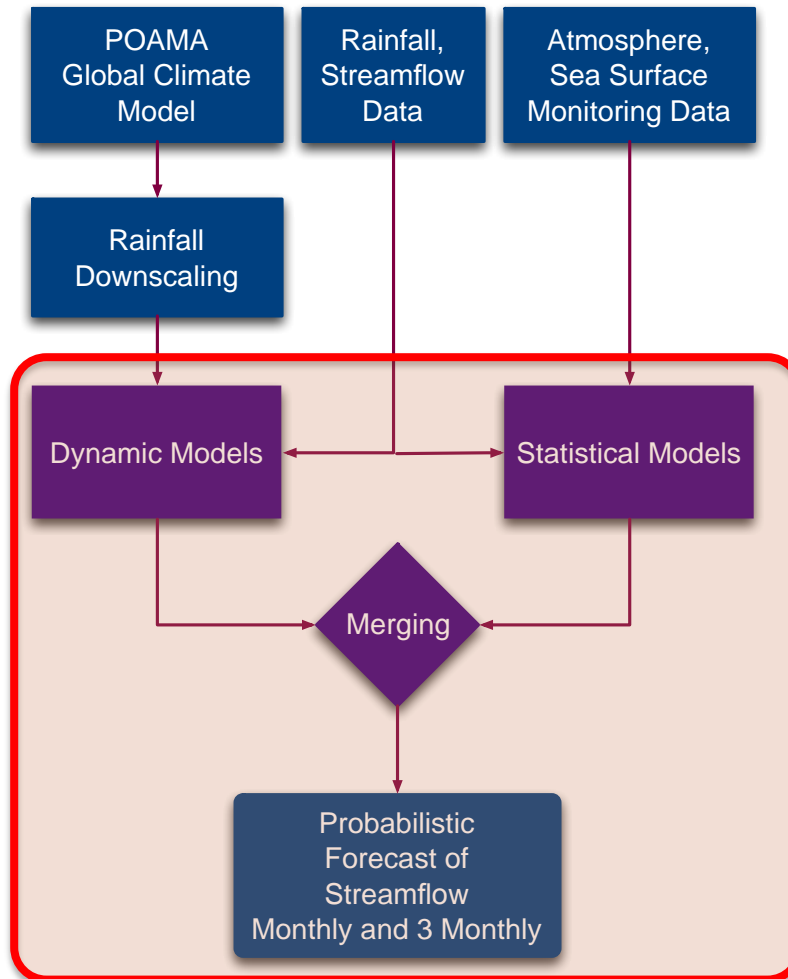
1 month & 3 month forecasts





Forecasting models

Merged forecasts
Register User
(release July 15)



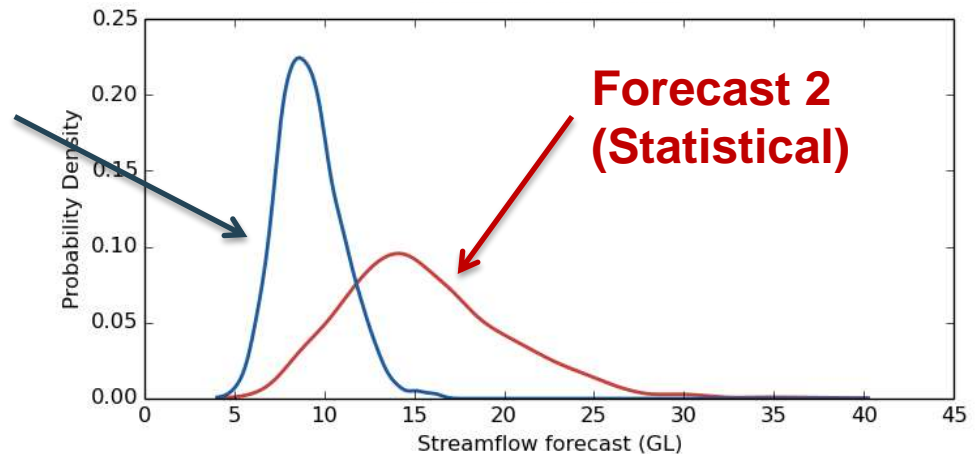


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Forecasting models

- Merged forecasts:
QMA method developed by
CSIRO

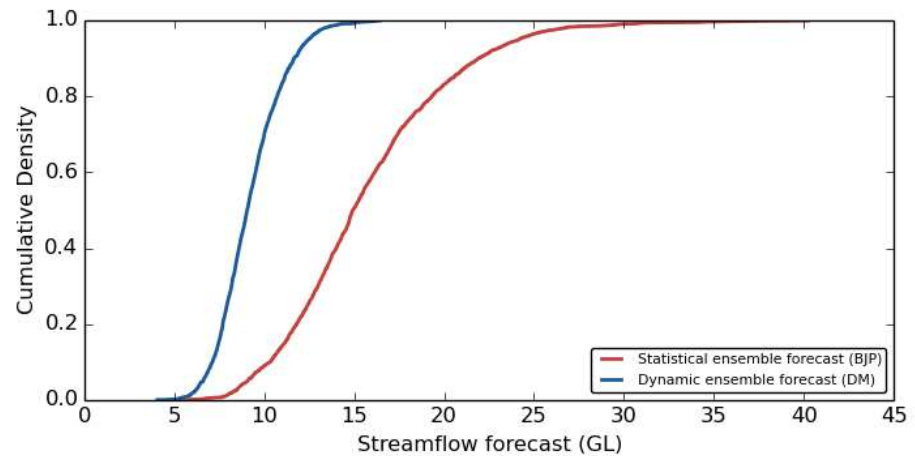
**Forecast 1
(Dynamic)**



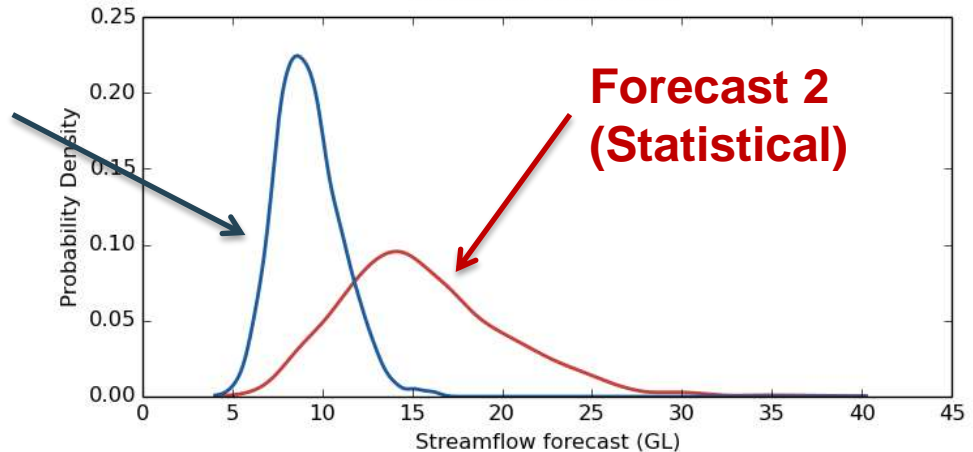


Forecasting models

- Merged forecasts:
QMA method developed by
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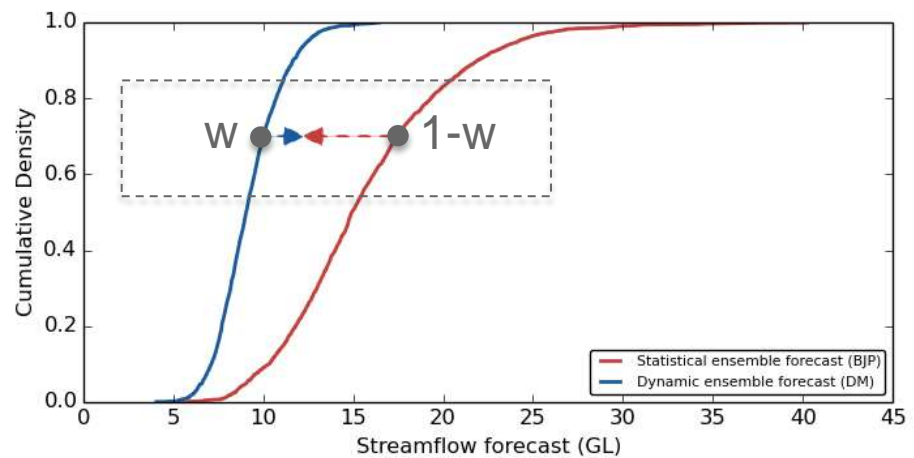
**Forecast 1
(Dynamic)**



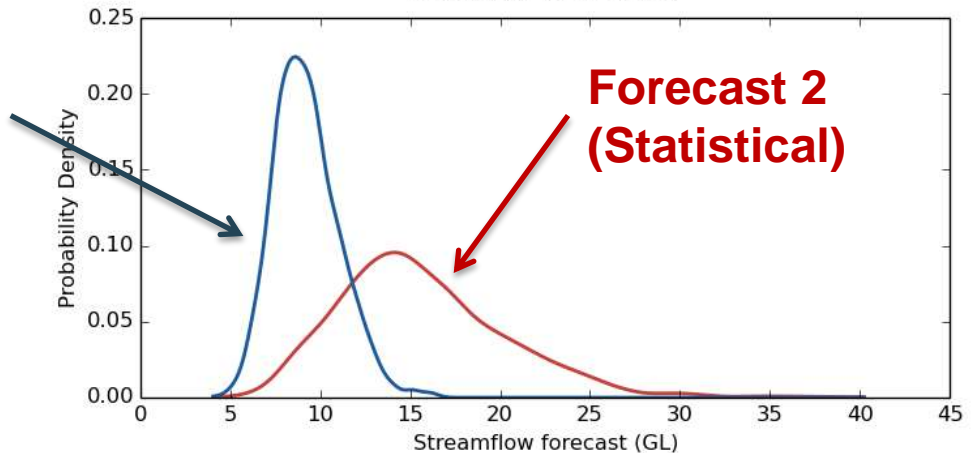


Forecasting models

- Merged forecasts:
QMA method developed by
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**Forecast 1
(Dynamic)**





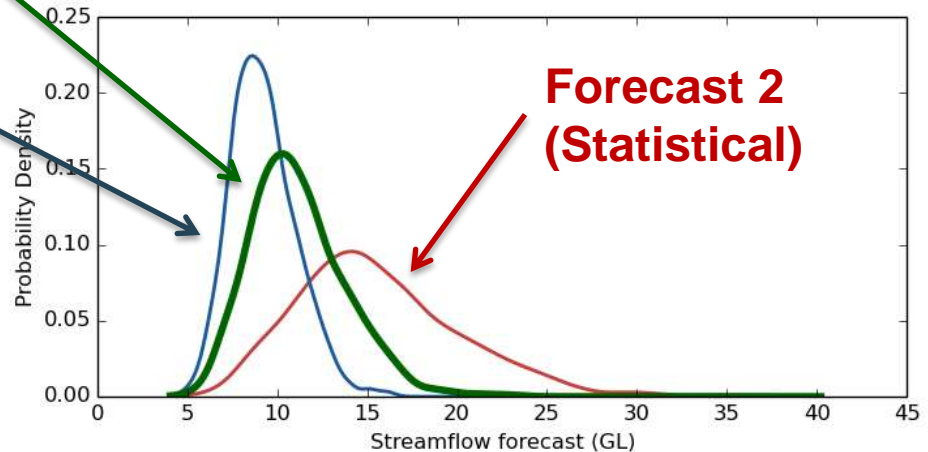
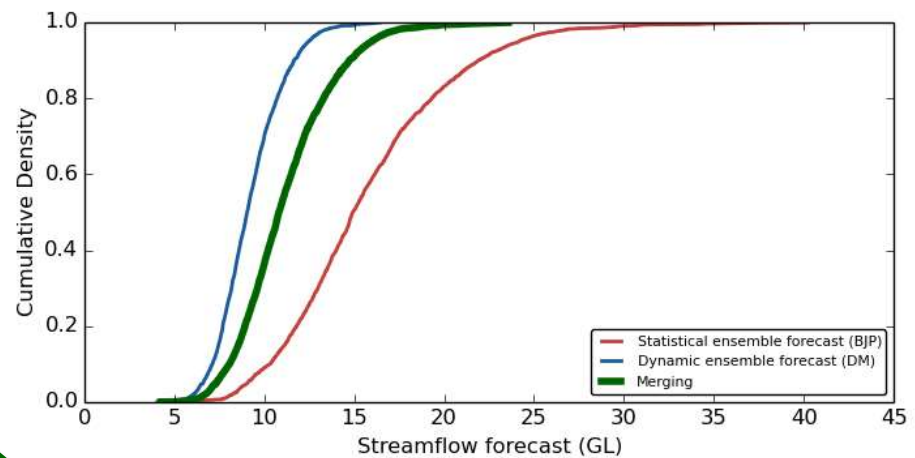
Forecasting models

- Merged forecasts:
QMA method developed by
CSIRO

**Merged
Forecast**

**Forecast 1
(Dynamic)**

**Forecast 2
(Statistical)**





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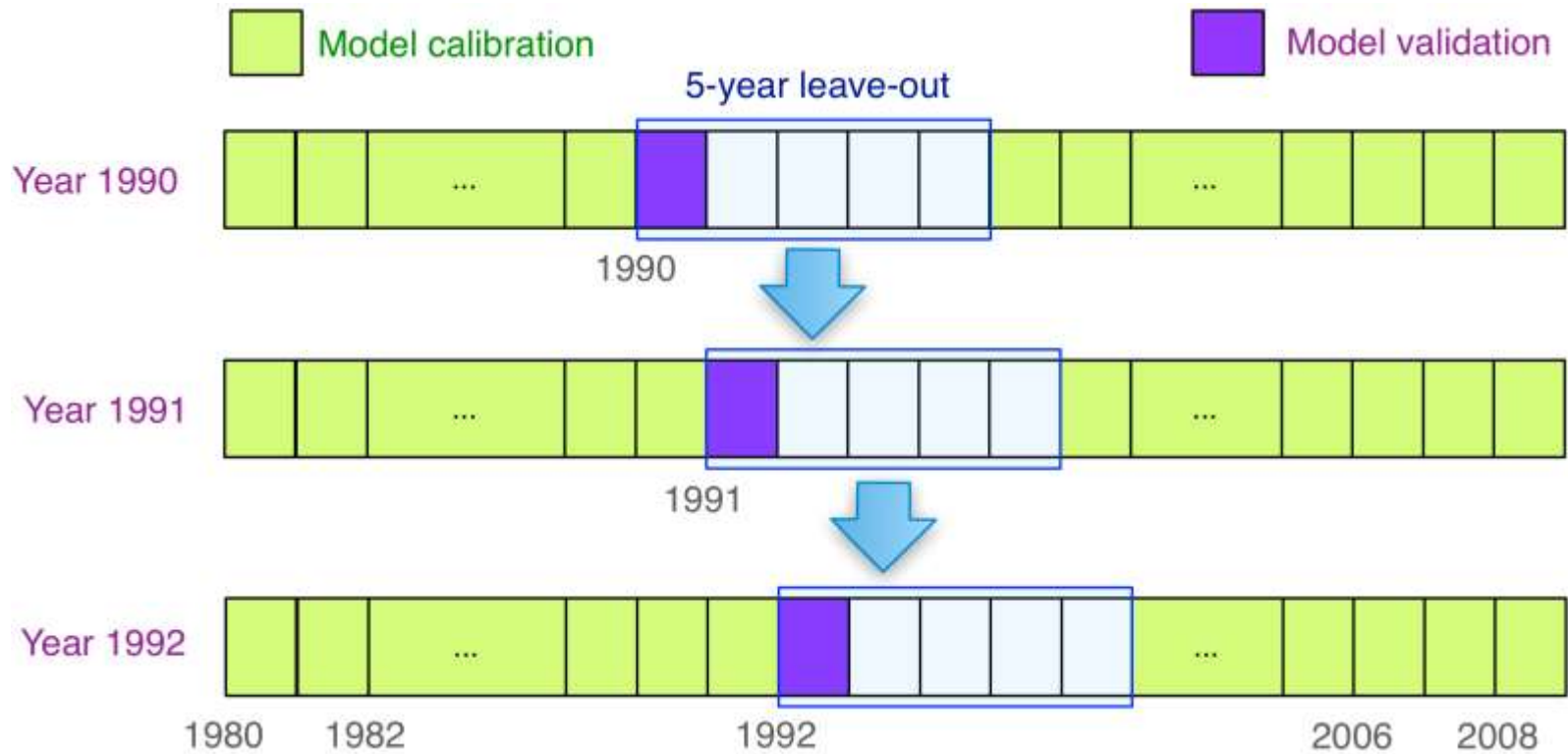
Outline

- Seasonal Streamflow forecasting service
- Forecasting models
- **Forecast verification**
- Communication and adoption



Verification process

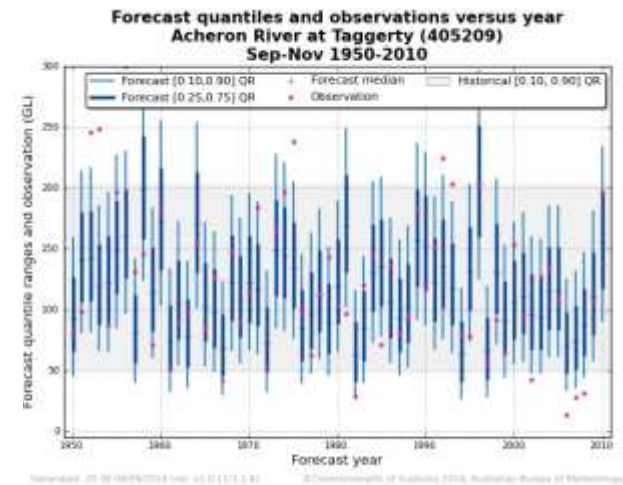
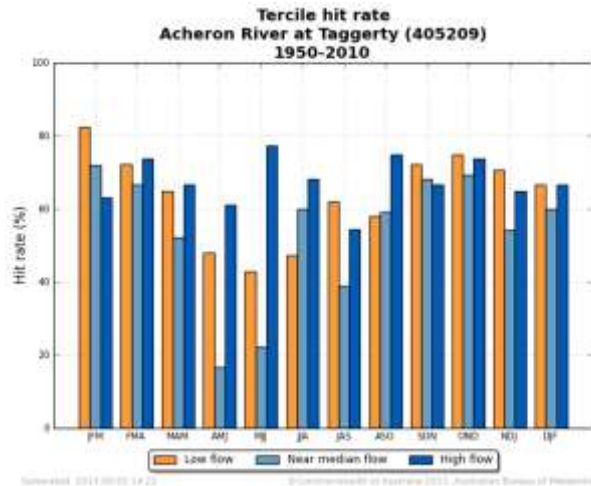
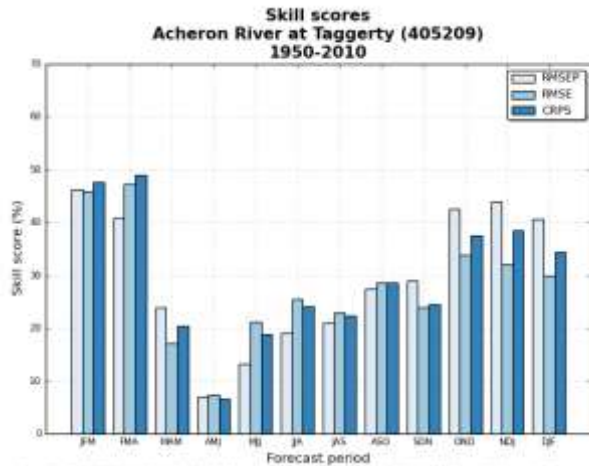
- Cross validation





Verification metrics

- Skill score: CRPS, RMSE & RMSEP
- Hit rate: Tercile hit rate for low & high flows
- Precision: Inter quantile range (10%,90%)



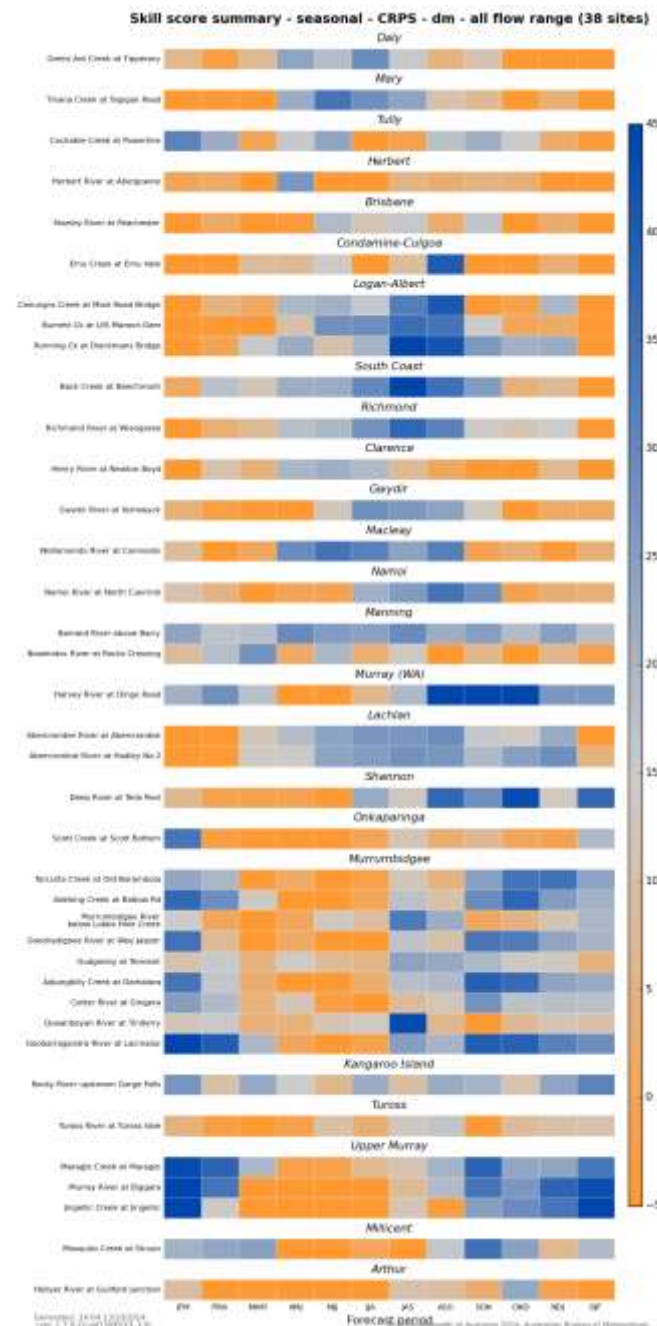
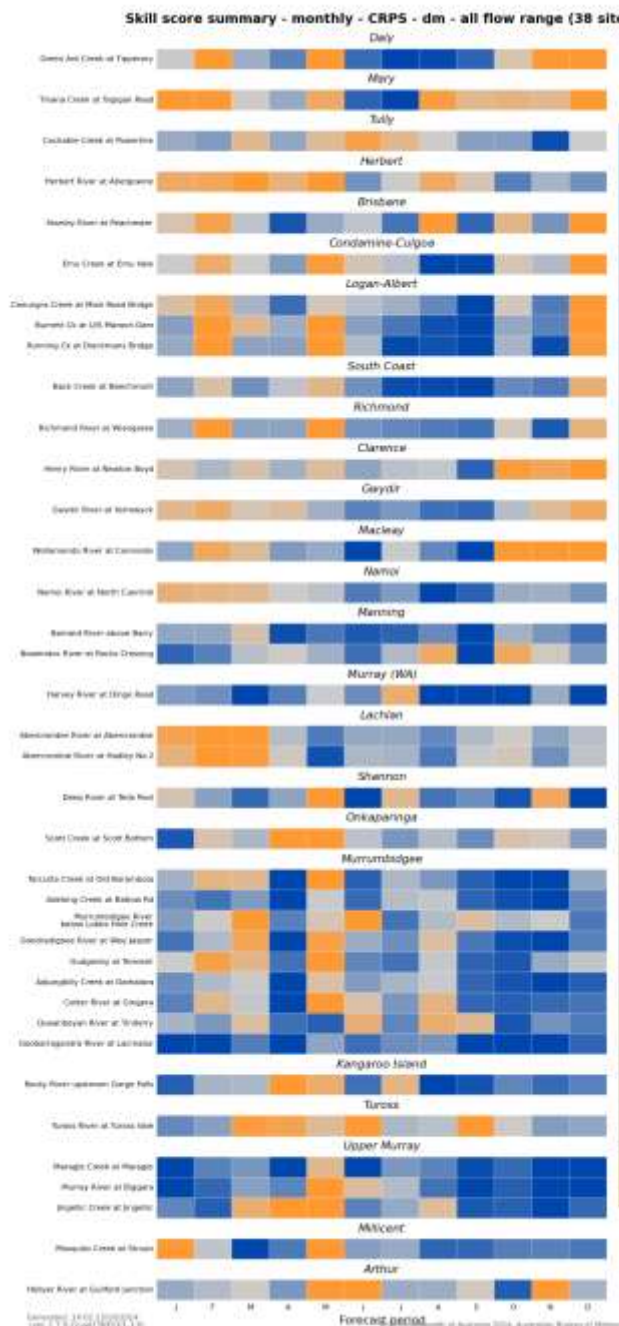
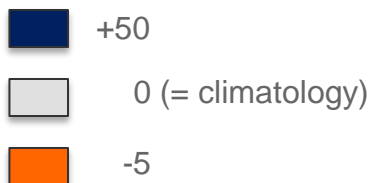
Dynamic Monthly

Dynamic Seasonal



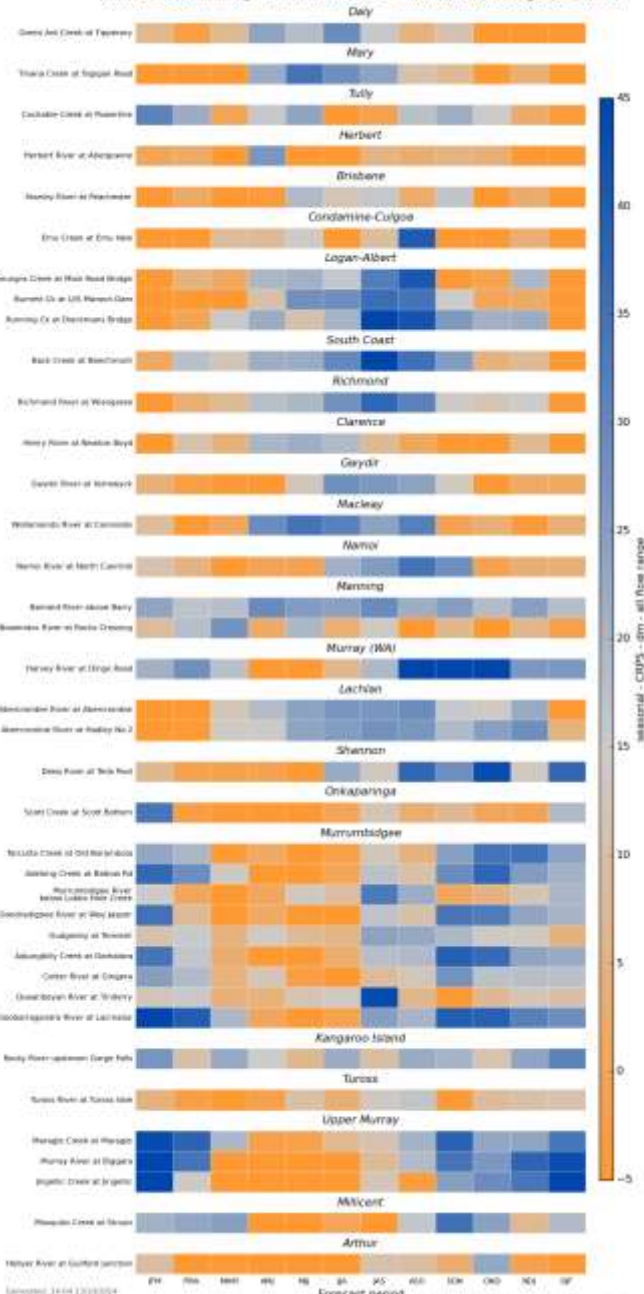
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- CRPS score Continuous Rank Probability Score
- Forecast locations grouped by basins
- Better skills of 1 month forecasts compared to 3 month forecasts



Dynamic Seasonal

Skill score summary - seasonal - CRPS - dm - all flow range (38 sites)



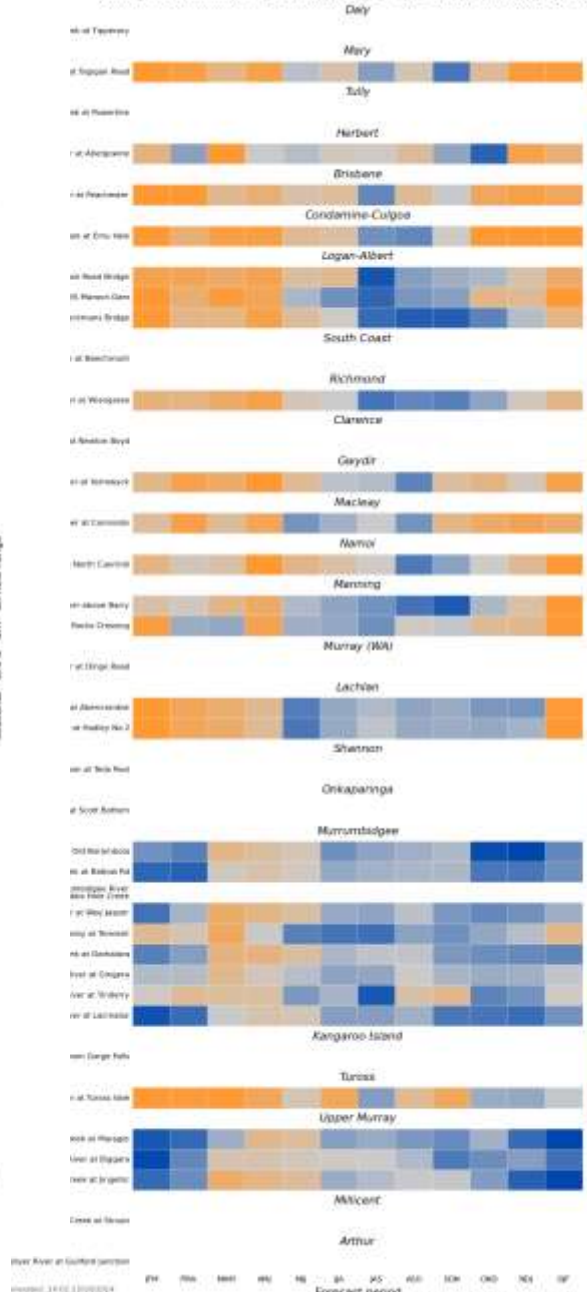
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Dynamic Seasonal

Statistical Seasonal

Skill score summary - seasonal - CRPS - dm - all flow range (38 sites)

Skill score summary - seasonal - CRPS - bjp - all flow range (38 sites)





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Communication and adoption

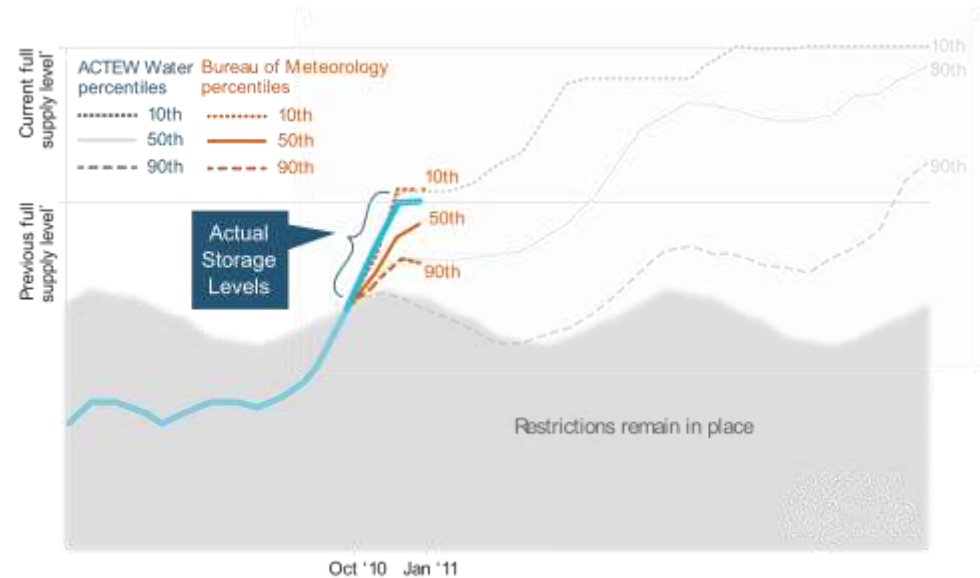
- Over 1600 subscribers
- Online survey conducted in Nov. 2013
- 88% of the key stakeholders expressed satisfaction with the SSF service
- Monthly National Climate and Water Briefings





Communication and adoption

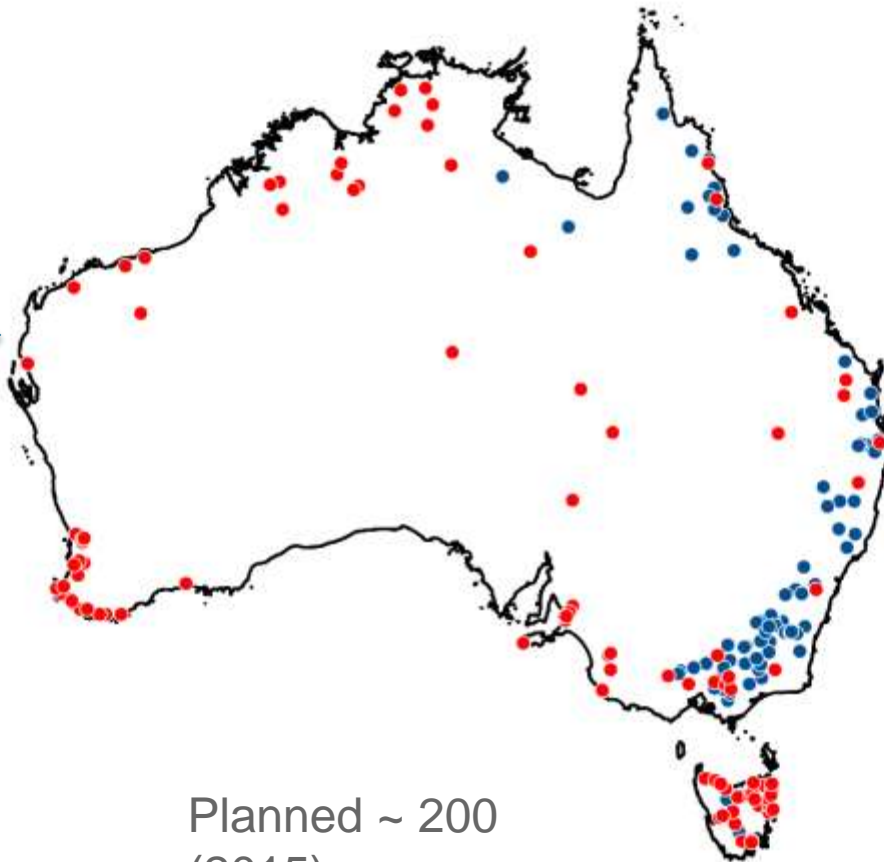
- Over 1600 subscribers
- Online survey conducted in Nov. 2013
- 88% of the key stakeholders expressed satisfaction with the SSF service
- Monthly National Climate and Water Briefings
- Case studies





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Expansion of coverage



Current 86 forecast
locations

Planned ~ 200
(2015)



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Conclusion

- Variability of water availability is a major challenge in Australia
- Seasonal streamflow forecasts support decision making by providing insight into future flow conditions
- Engaging with stakeholders meaningfully, establishing R&D alliances and transitioning research to operations is not trivial
- Communication of forecast uncertainty and performance is indeed difficult



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Thank you



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THE UNIVERSITY OF NEW SOUTH WALES



Julien Lerat
Senior Hydrologist
+33 2 6232 3578
J.Lerat@bom.gov.au

The extended hydrological prediction section (EHP)

