

***Operational hydrometeorological forecasting
activities of the Australian Bureau of Meteorology
Thomas Pagano***

***At the start of the talk will be a trivia question.
Be prepared to write your answer.***



Australian Government
Bureau of Meteorology



**No sharing with friends, no i-phone.
This is a competition.**

Fill in the blanks:

“I am 80% confident that
the **population of Taiwan**
in September 2014 was
between _____ and _____ people.”

The person with the smallest range
that contains the observation wins a prize.

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Fill in the blanks:

“I am 80% confident that
the **population of Taiwan**
in September 2014 was
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The person with the smallest range
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Answer: 23,410,280 (Wikipedia)

**Answer:
population of Taiwan
23,410,280**

**Results from 5 countries so far:
25% of people give a wide enough
80% confidence range.**

People are naturally overconfident.

**What does this mean
for using/making
probabilistic forecasts?**

What is a good forecast?

Is a lack of competition affecting innovation in operational river forecasting?

Interview with Beth Ebert: What is good forecast verification?

Challenges of Operational River Forecasting

Operational Highlight: Flood Forecasting by the Mekong River Commission

For discussion: Have we reached the limits of what can be forecast in water, weather and climate?

For discussion: Are we getting close to integrating water and climate information?

What is a good forecast?

Is a lack of competition affecting innovation in operational river forecasting?

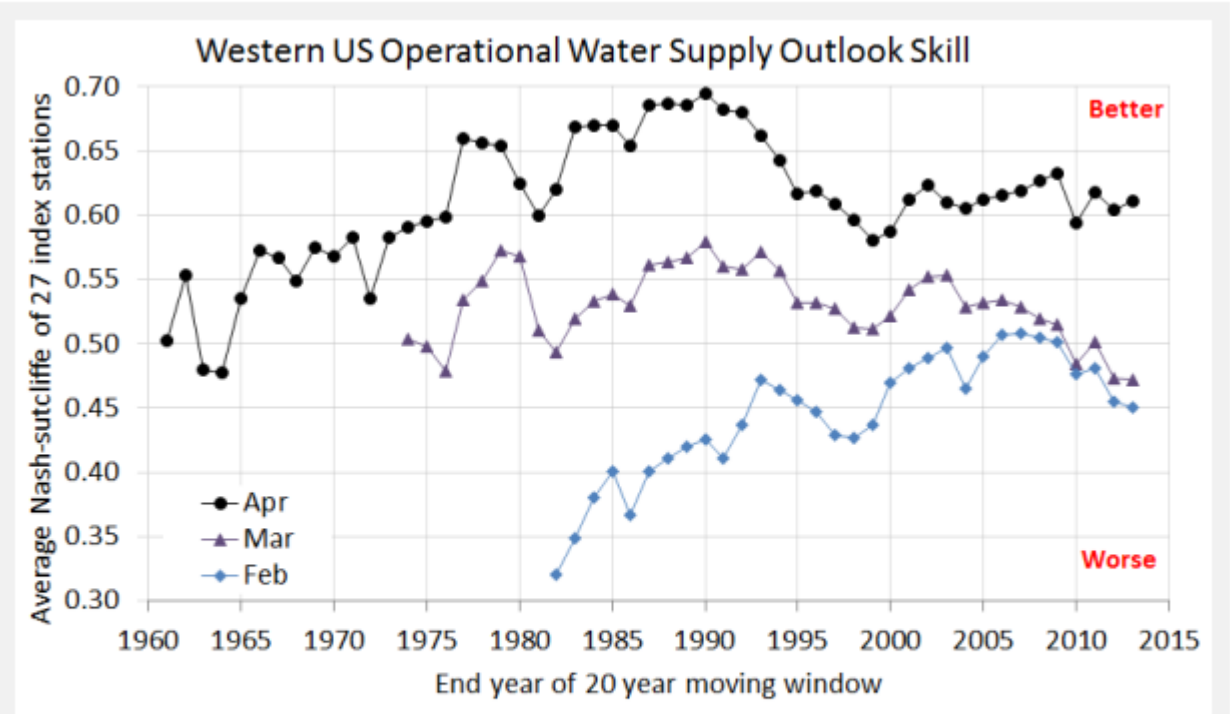
Interview with Beth Ebert: What is good forecast verification?

Challenges of Operational River Forecasting

Operational Highlight: Flood Forecasting Commission

For discussion: Have we reached a plateau in forecast skill in water, weather and climate?

For discussion: Are we getting better climate information?



Operational seasonal water supply forecast skill by leadtime (the top line is forecasts issued in April, the bottom those issued in February). The target is often April-July or April-September, depending on the location. The index is the spatial average of Nash Sutcliffe indices at 27 long-term stations for a 20-year moving window of forecasts. The period shown includes as-issued forecasts from 1941-2013. (Updated from Pagano et al. 2004)

Summary

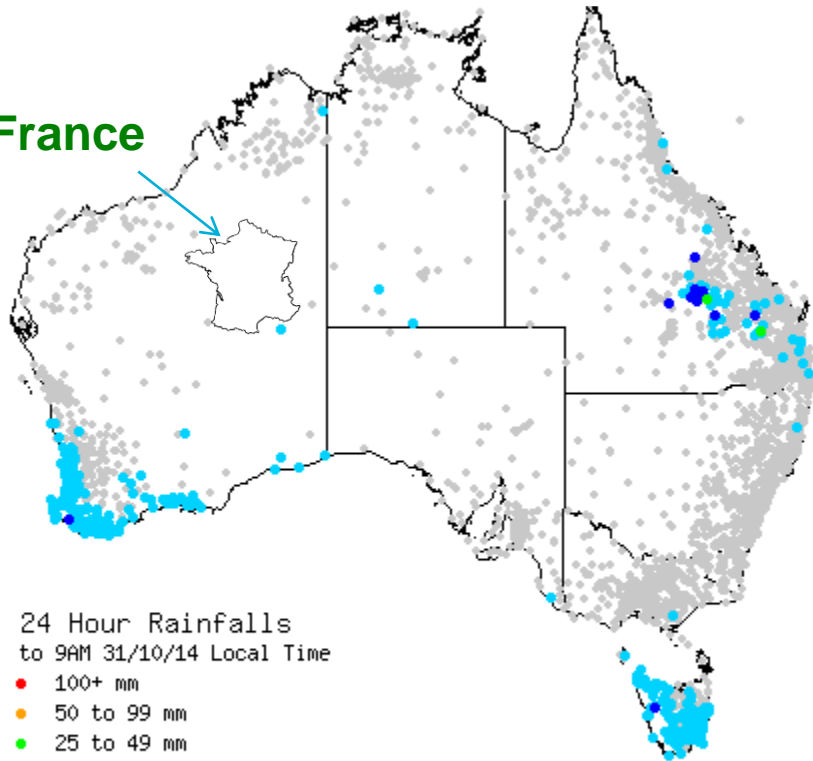
Australia provides river forecasting services for seasonal, short-term and flood timescales.

Models, methods and products differ widely by timescale, with longer-range forecasts very objective and formalized.

There are interesting practical issues for using weather forecasts for flood forecasting.

Flood warning rainfall network

France

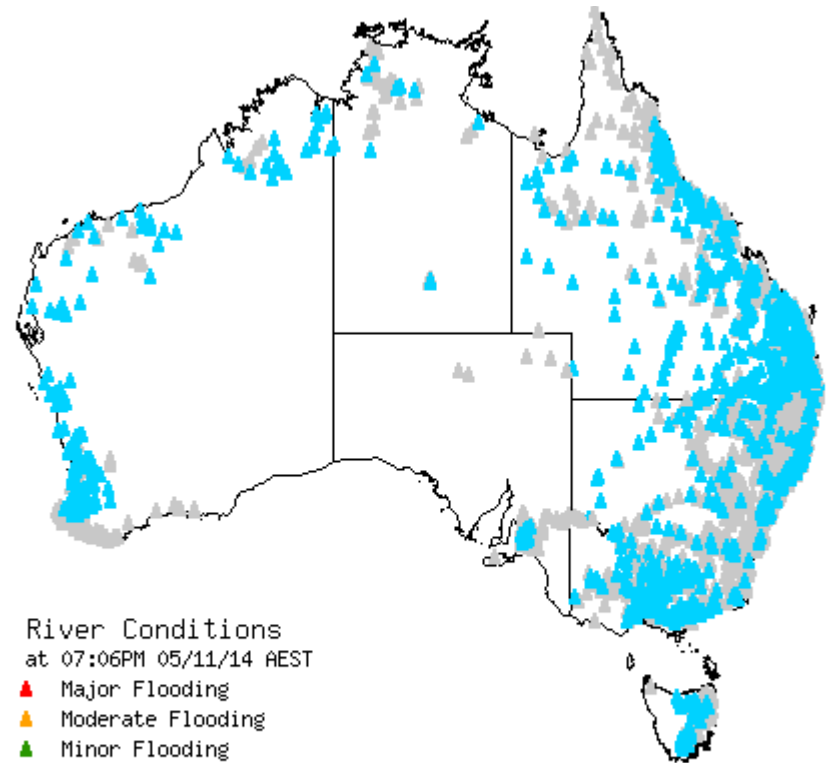


24 Hour Rainfalls
to 9AM 31/10/14 Local Time

- 100+ mm
- 50 to 99 mm
- 25 to 49 mm
- 10 to 24 mm
- >0.2 to 9 mm
- 0 mm

(Updated 11:35AM AEST)

River measurement network



River Conditions
at 07:06PM 05/11/14 AEST

- ▲ Major Flooding
- ▲ Moderate Flooding
- ▲ Minor Flooding
- ▲ Below Flood Level
- ▲ No Classification

Percent of flood warnings issued by month

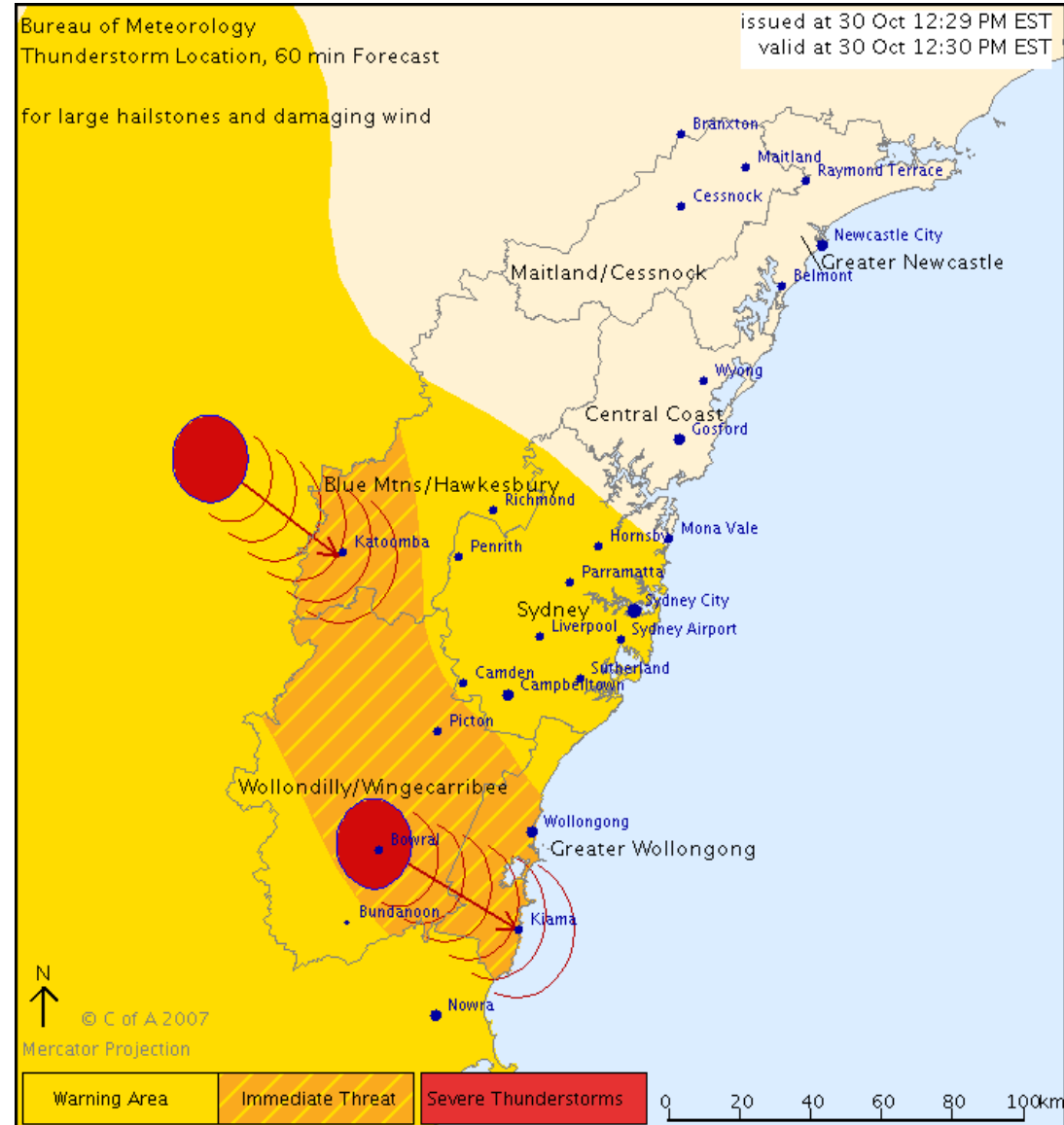
Flood Warning		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
North	NT	23%	26%	22%	9%	1%	0%	0%	0%	1%	0%	2%	16%
	QLD	25%	28%	23%	6%	1%	1%	0%	1%	1%	2%	2%	9%
	WA	22%	23%	23%	8%	2%	1%	0%	3%	1%	3%	0%	14%
Region	NSW	18%	15%	14%	5%	4%	10%	3%	3%	4%	4%	5%	15%
	SA	5%	15%	9%	2%	4%	4%	7%	16%	12%	6%	11%	11%
	VIC	7%	9%	7%	1%	2%	10%	9%	15%	15%	5%	12%	8%
South	TAS	4%	1%	4%	3%	4%	12%	13%	26%	14%	7%	8%	3%

Month of the year

Types of Bureau of Meteorology hydrologic prediction services

Flash flooding

Currently a meteorological (rainfall based) severe weather product



Types of Bureau of Meteorology hydrologic prediction services

Flash flooding

Currently a meteorological (rainfall based) severe weather product

Flood warnings and watches (since 1955)

Text bulletins, regional experts, produced as needed, event-based models

IDN36658

Australian Government Bureau of Meteorology New South Wales

FLOOD WARNING FOR THE COOKS RIVER

Issued at 10:13 pm EDT on Tuesday 14 October 2014 Flood Warning Number: 1

Heavy rainfall has fallen in the catchment upstream of Tempe. Up to 70mm of rain has been recorded in the last hour. **Flooding of the lower lying area around Tempe is imminent** as well as flooding of local roads and causeways along the Cooks and Woolli Creeks.

At this stage it **is not possible to predict the flood peak** because of uncertainty over how much more rain will fall.

Predicted River Heights/Flows:

Tempe Bridge - with forecast rain reach 1.3 metres around 1 am Wednesday morning with minor flooding.

Types of Bureau of Meteorology hydrologic prediction services

Flash flooding

Currently a meteorological (rainfall based) severe weather product

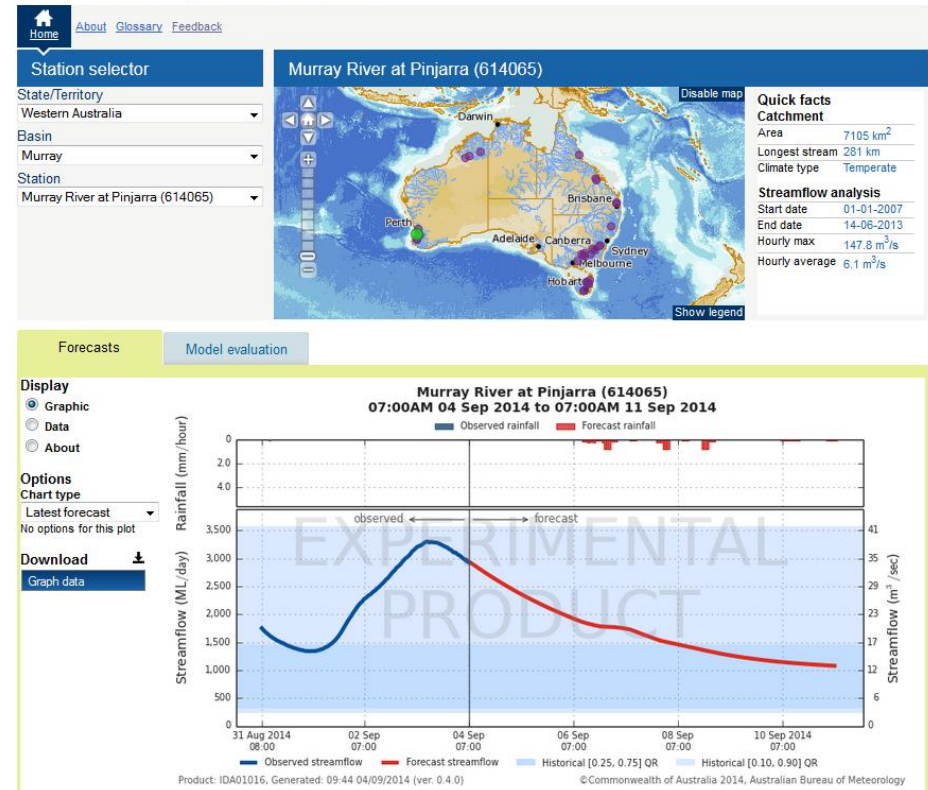
Flood warnings and watches (since 1955)

Text bulletins, regional experts, produced as needed, event-based models

Short-term forecasts (began 2013, planned public release 2015)

Hydrographs, centralized, automated, hourly, deterministic, GR4J model

Short-term Streamflow Forecasts



Types of Bureau of Meteorology hydrologic prediction services

Flash flooding

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Short-term forecasts (began 2013, planned public release 2015)

Hydrographs, centralized, automated, hourly, deterministic, GR4J model

Seasonal forecasts (since 2010)

Centralized, automated, monthly, probabilistic, statistical (dynamical soon)

Seasonal Streamflow Forecasts

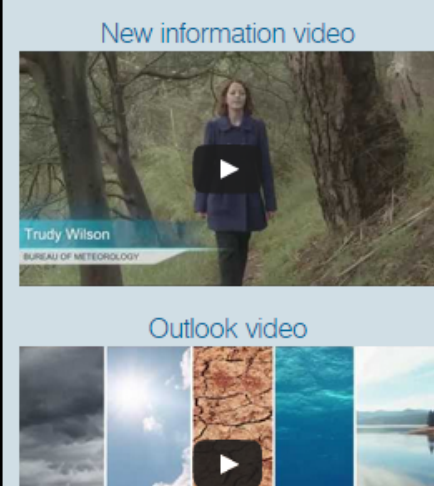
Date: October to December 2014

- Low forecast streamflows more likely
- Low streamflows recorded at most locations in September
- The likelihood of an El Niño developing in the next few months remains at 50%

Streamflow forecast - October to December

For October to December, low streamflows are forecast at 38 locations, and near median flows at 24 of the 64 locations where skill is not very low. High flows are more likely at two locations. Forecasts are not issued due to very low skill at 10 locations. Forecast [skill scores](#) for the October to December period are high for 17 out of 74 locations, moderate for 36 locations, low for 11 locations and very low for 10 locations. The monthly [Climate and Water Outlook video](#) covers rainfall, streamflow and temperature for the next three months and beyond.

Select Map: [Australia](#) [Victoria](#) [Southern New South Wales](#) [Northern New South Wales](#) [Southern Queensland](#) [Northern Queensland](#) [Cape York Peninsula](#) [Northern Territory](#), or click on the rectangles on the Australia map below to select a particular region. Then click on the pie charts to go directly to the most recent

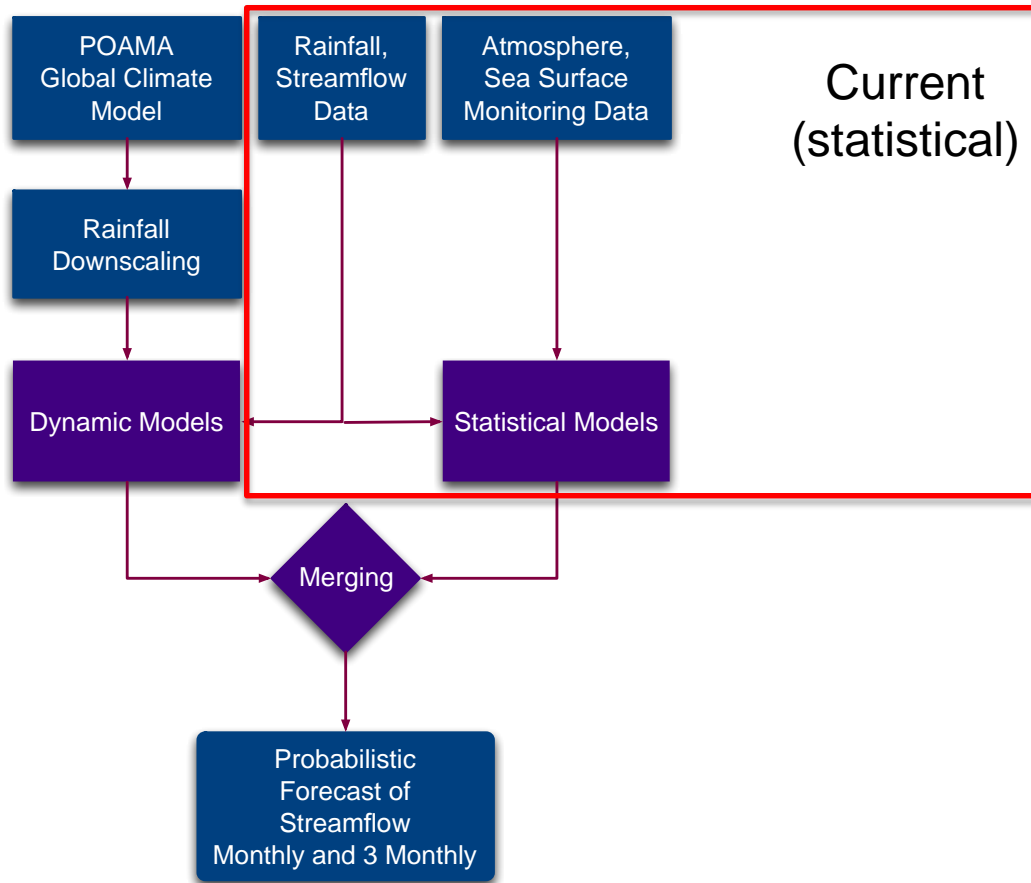


New information video

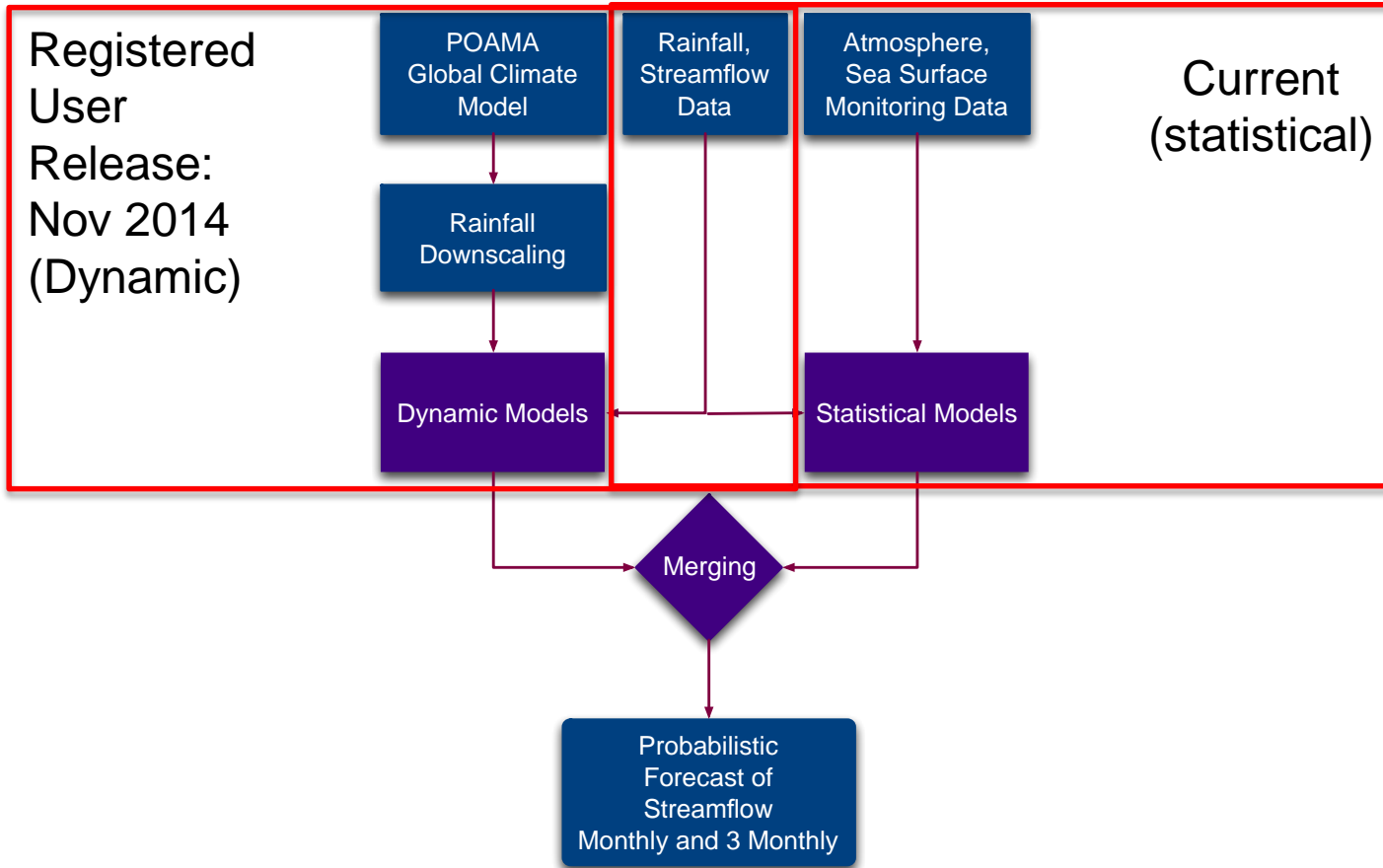
Trudy Wilson
BUREAU OF METEOROLOGY

Outlook video

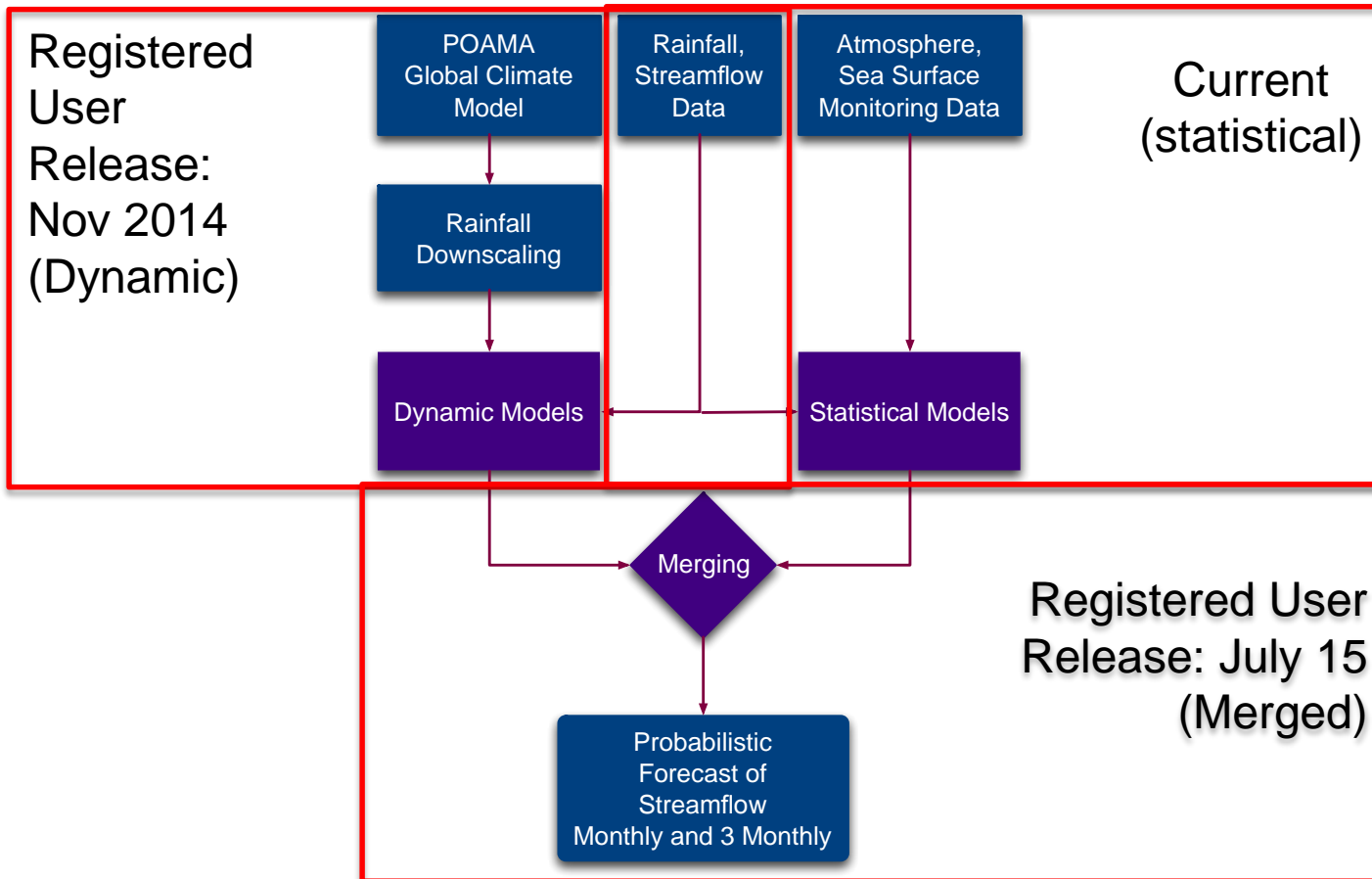
Seasonal Streamflow Forecasting Approach



Seasonal Streamflow Forecasting Approach

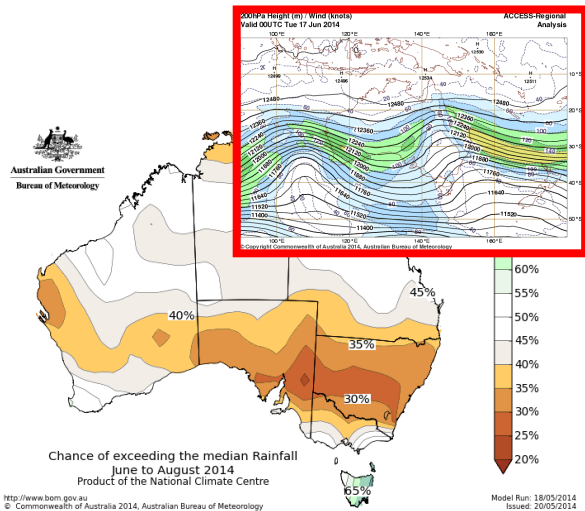


Seasonal Streamflow Forecasting Approach

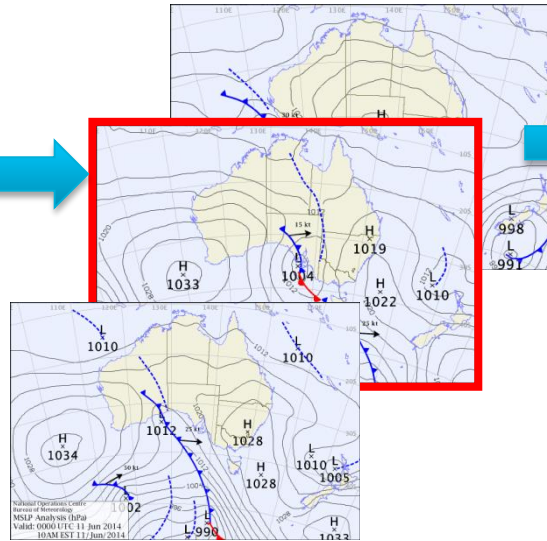


Seasonal forecasting plans for dynamic approach: Rainfall Downscaling

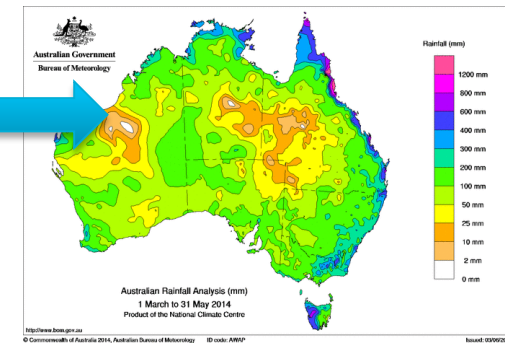
POAMA forecast of climate indices
(Press, Wind, Temp, Rain, Rhum)
(~270km)



Analogue downscaling
(5 replicates of 31 ensembles)



Downscaled rainfall
(5km; 155 ensembles)



Timbal, B., Li, Z., & Fernandez, E. (2008). The Bureau of meteorology statistical downscaling model graphical user interface: user manual and software documentation.

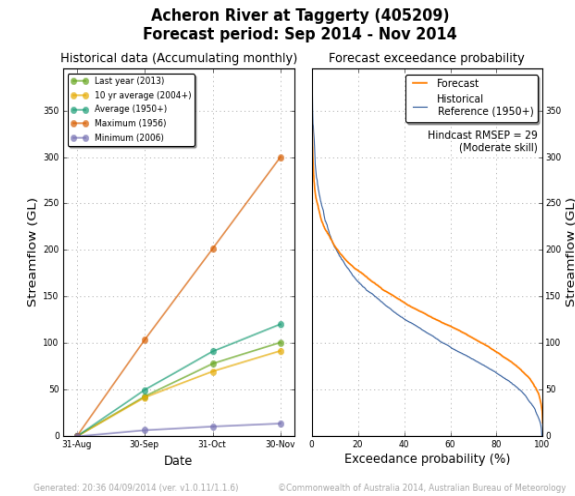
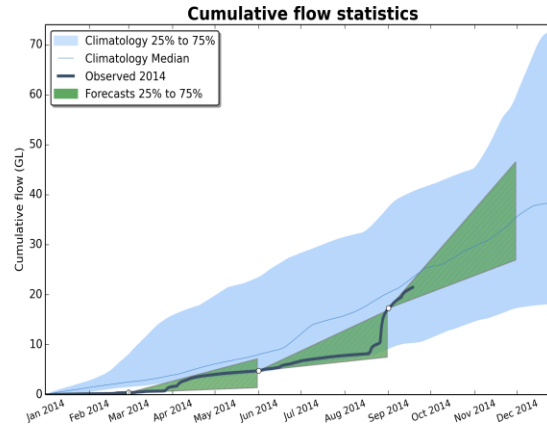
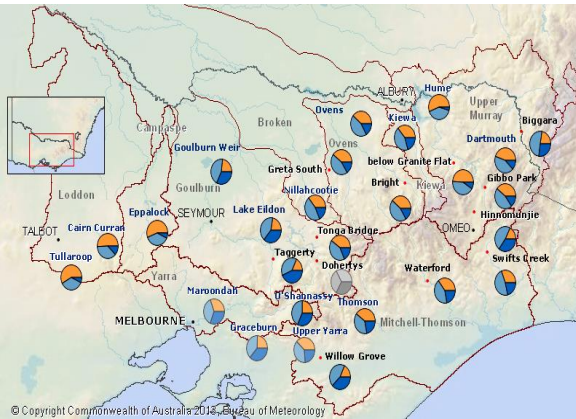
Shao, Q., & Li, M. (2013). An improved statistical analogue downscaling procedure for seasonal precipitation forecast. Stochastic Environmental Research and Risk

Seasonal forecast products

Exceedance probabilities

Water year in perspective

Tercile maps



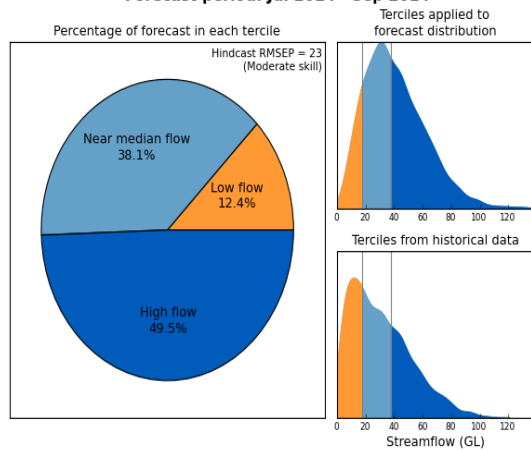
Tercile forecasts

Probability distributions

Box plots

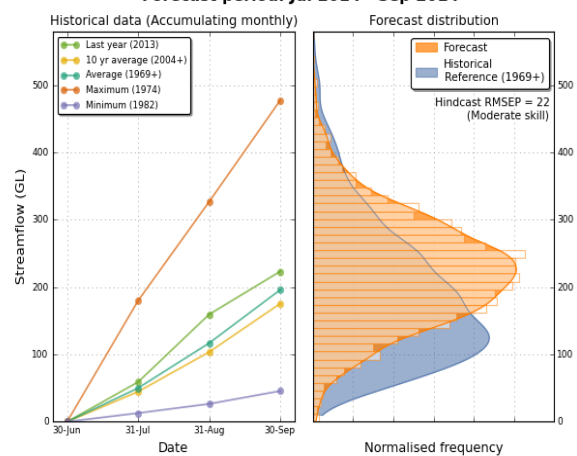
Fifteen Mile Creek at Greta South (403213)

Forecast period: Jul 2014 - Sep 2014



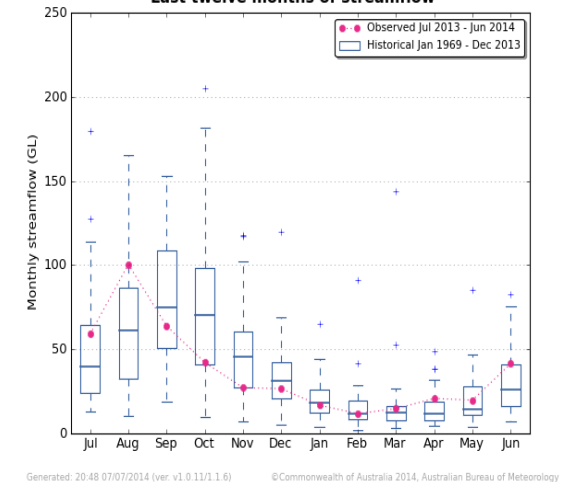
Murray River at Biggara (401012)

Forecast period: Jul 2014 - Sep 2014

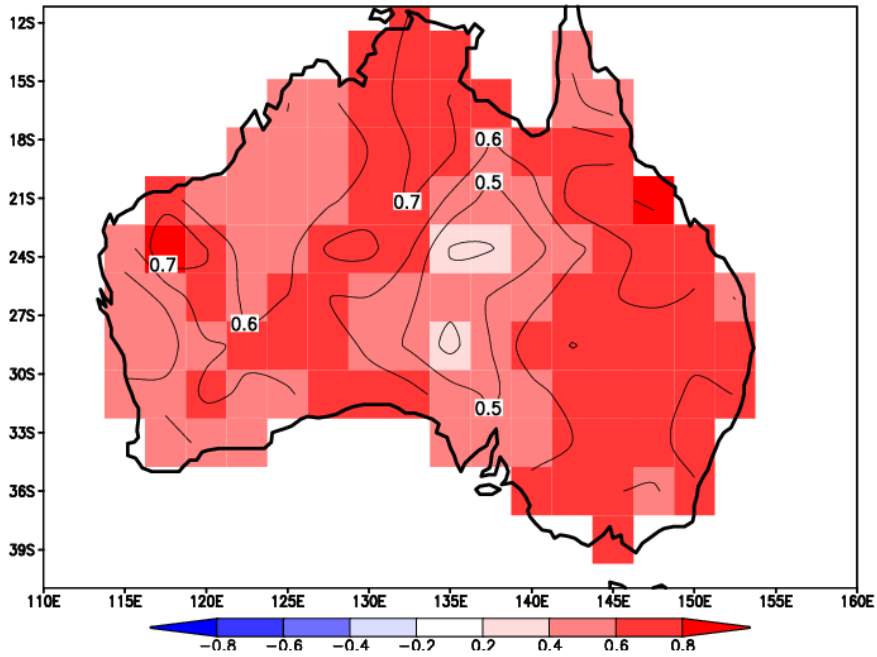


Murray River at Biggara

Last twelve months of streamflow



Precipitation correlation (all months)



POAMA2 climate model

(250 km, POAMA3 will be 150 km)

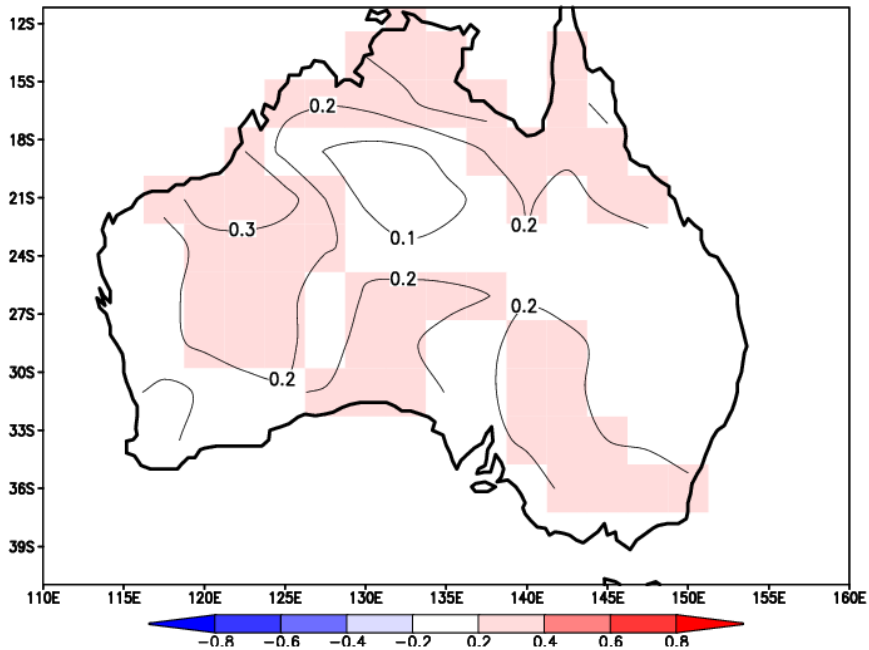
1981-2014 retrospective

Ensembles for both forecast + reanalysis

33 members

Daily resolution, 9 months ahead

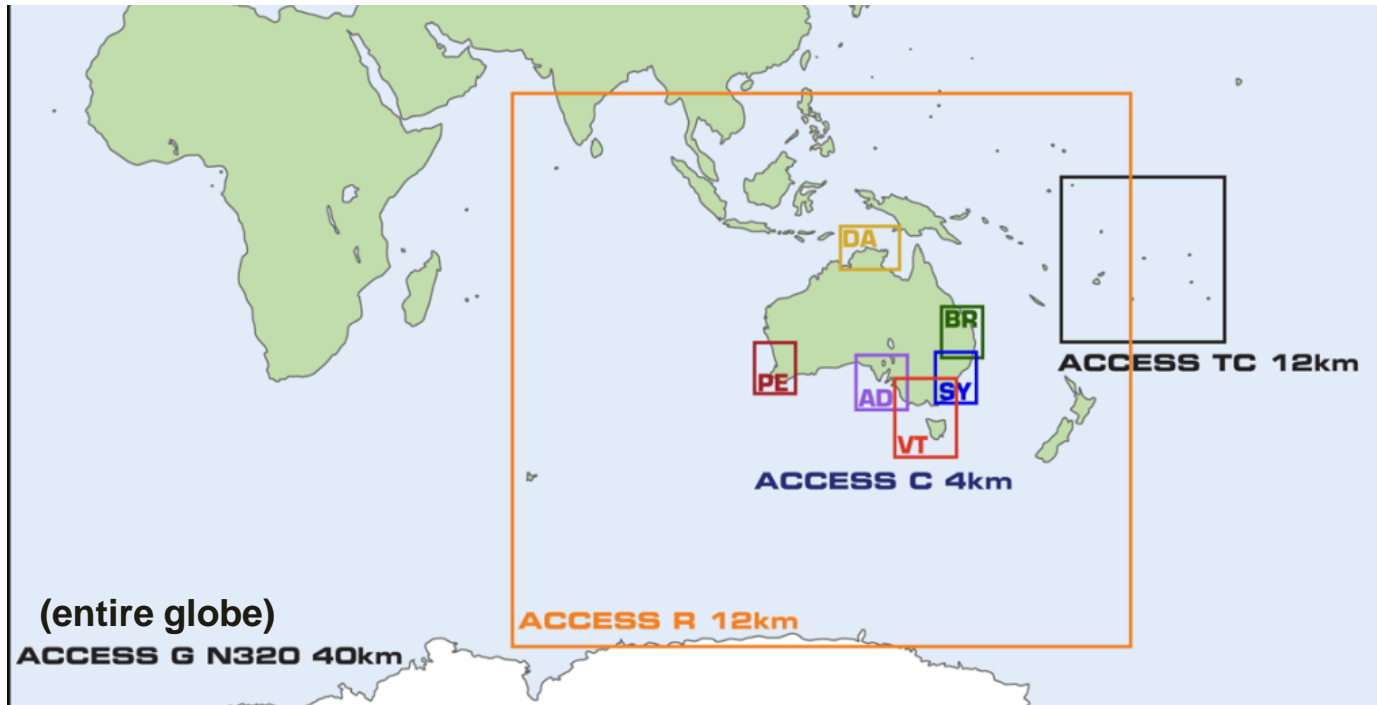
Week 1 leadtime



Week 2 leadtime

Seasonal forecasts use POAMA climate outlooks,
Short-term and flood forecasting use ACCESS weather model forecasts.

There are no retrospective ACCESS forecasts.
 NWP deterministic now, ensembles soon.



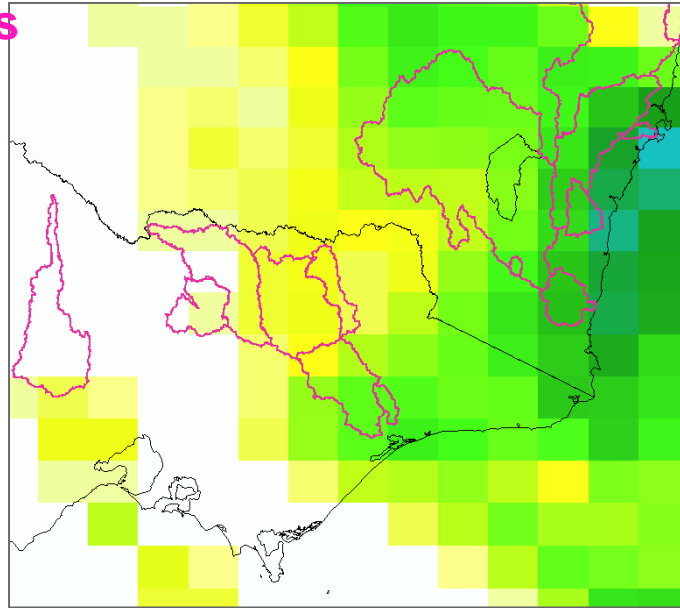
Model	Domain	Resolution	Leadtime
ACCESS-G	Global	~40km	10 days
ACCESS-R	Regional	0.11° (~12km)	3 days
ACCESS-C	City	0.036° (~4km)	1.5 days
ACCESS-TC	Relocatable	0.11° (~12km)	

Spatial scales of hydrologic and weather models

Outlines: Flood model catchments
(containing dozens of subareas)

ACCESS-G forecast
(40 km, +10 days)

**What currently feeds
the short-term
deterministic flow forecasts**



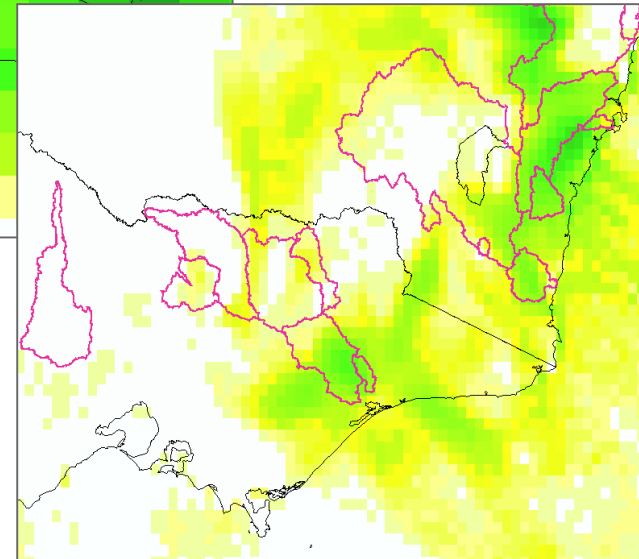
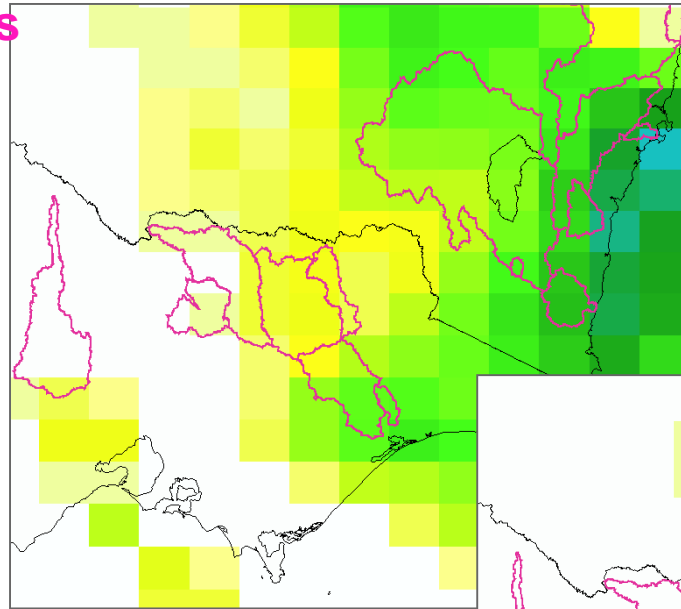
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ACCESS-R forecast
(12 km +3 days)

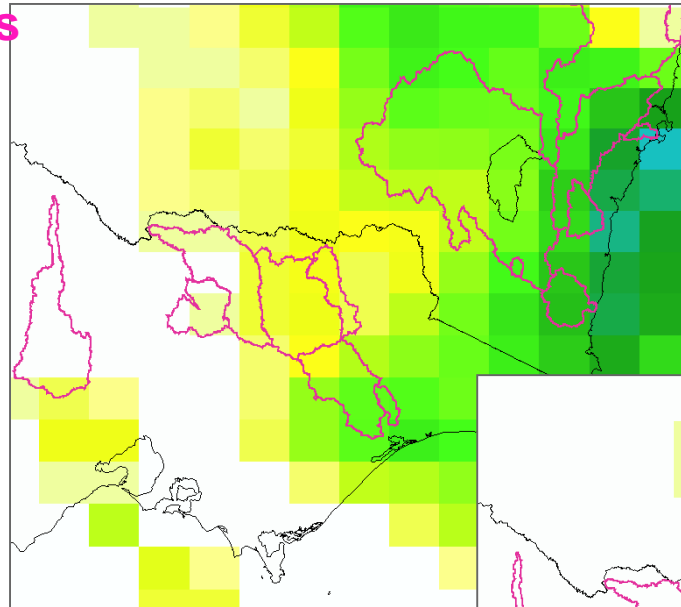


Spatial scales of hydrologic and weather models

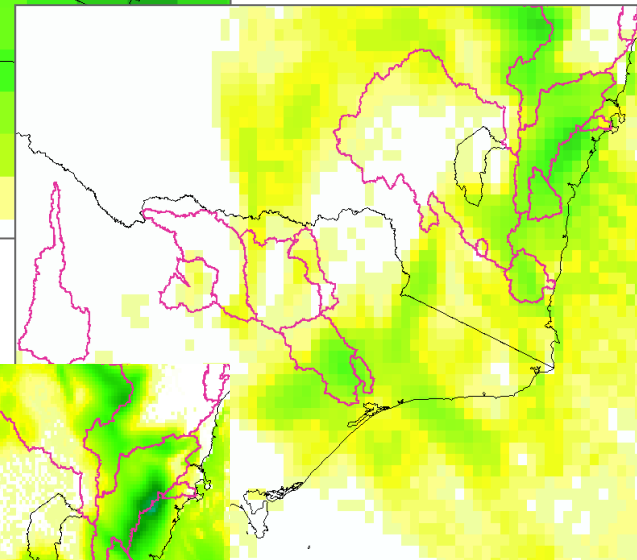
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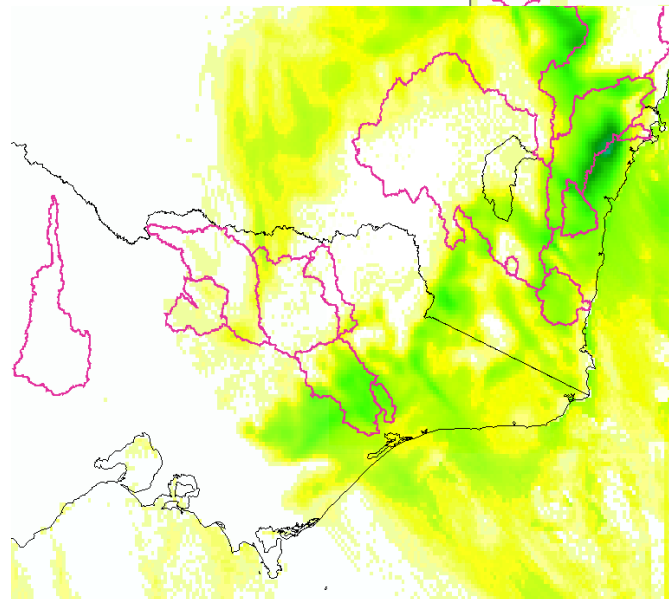
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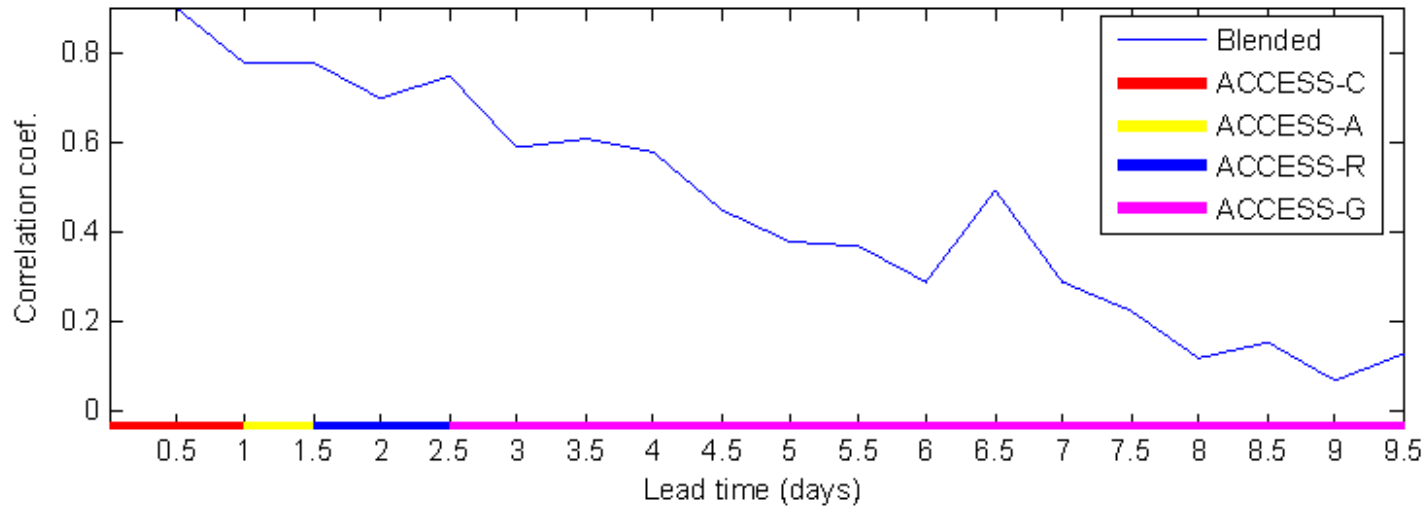
ACCESS-R forecast
(12 km +3 days)



ACCESS-C forecast
(4 km +1.5 days)
**Comparable to typical
flood model subarea**

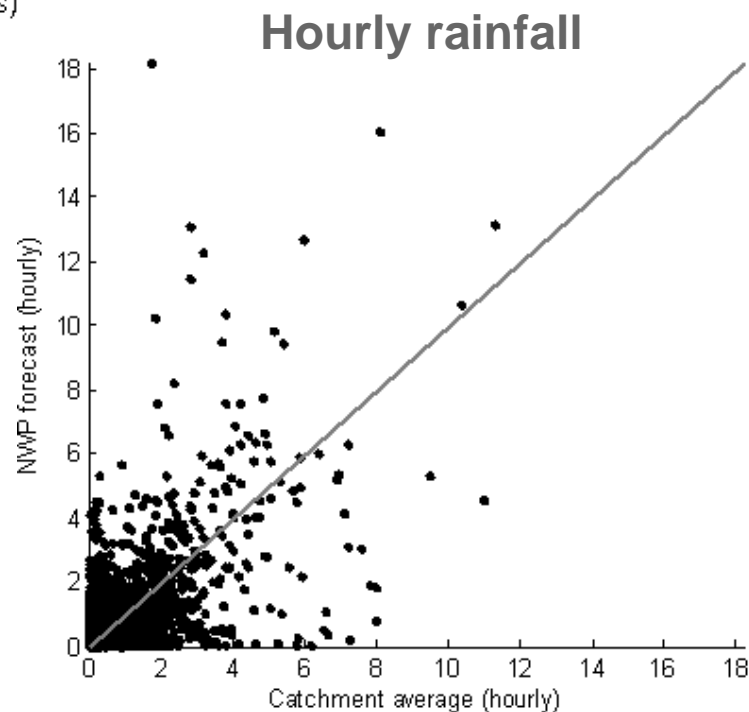
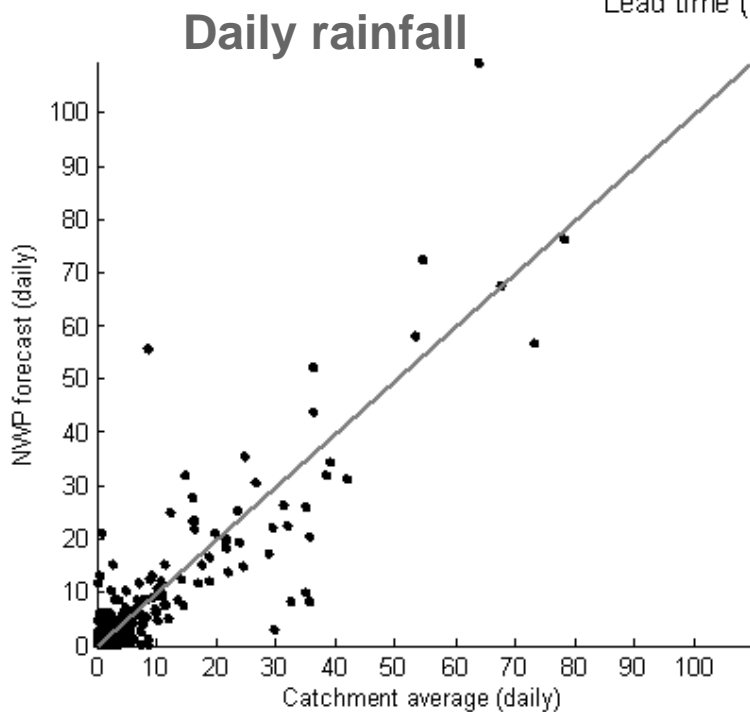
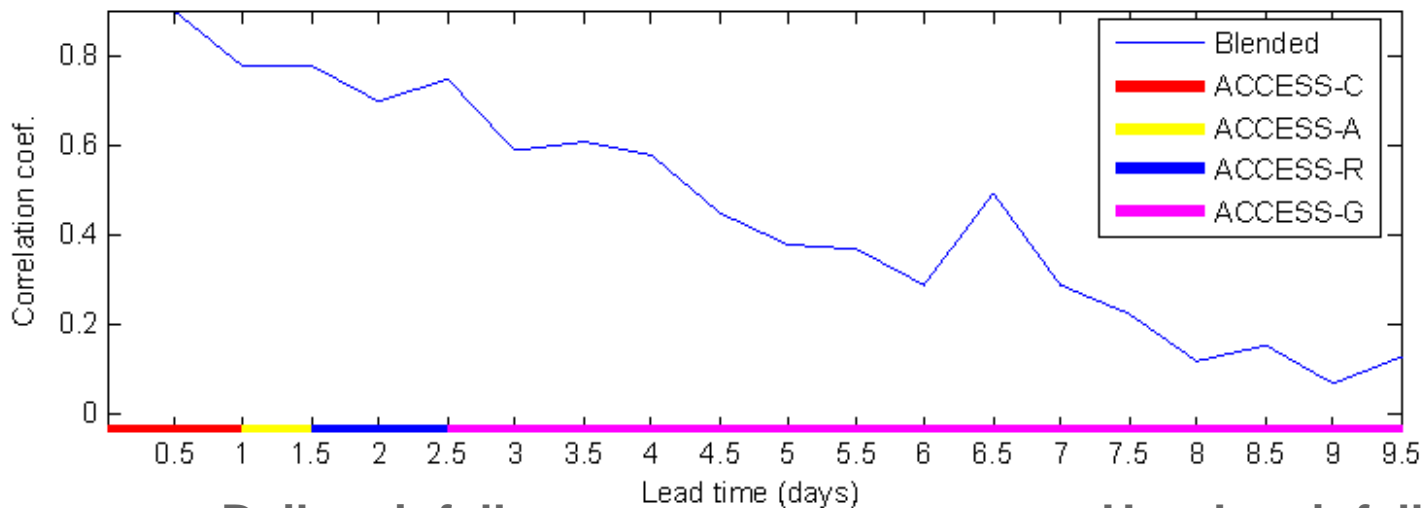


Catchment-average ACCESS rainfall forecast skill vs leadtime



**Ovens River, Australia (area average ~4000km²)
31 Mar 2010 – 18 Apr 2011 (381 days of records)**

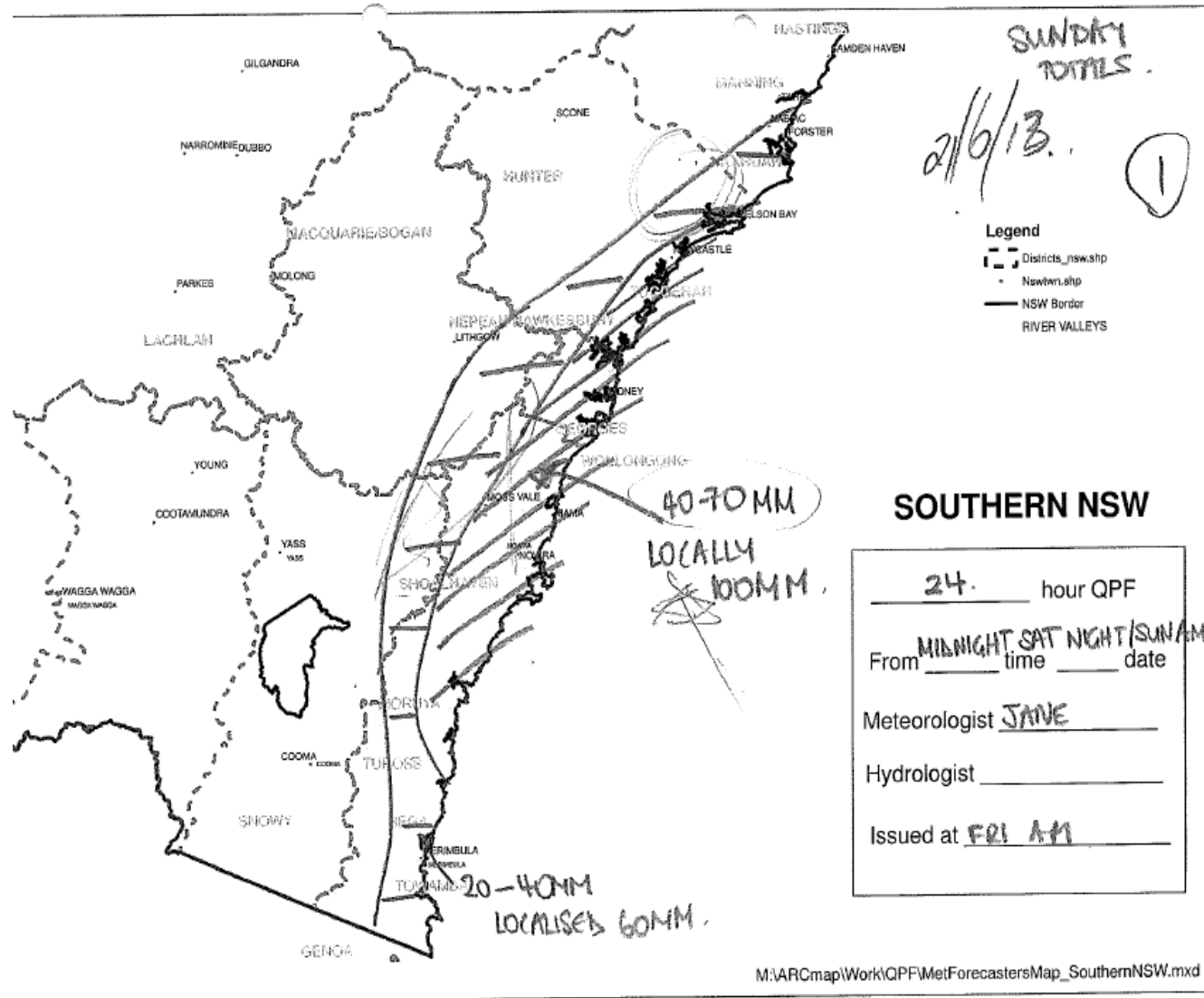
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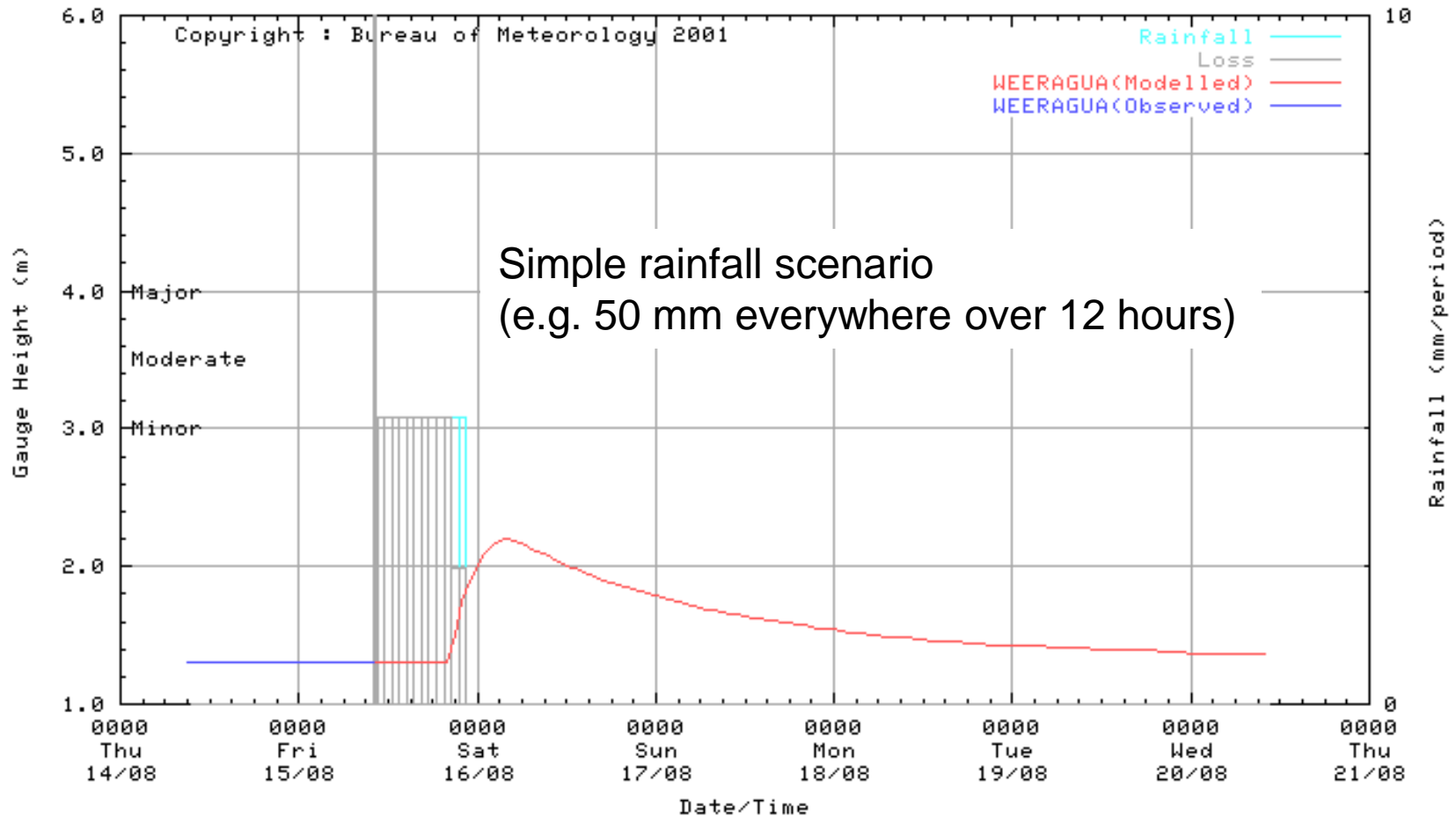
Ovens River, Australia (area average ~4000km²)
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Long history of using weather predictions for flood forecasting... but not directly from weather models

Weather briefings for hydrologists



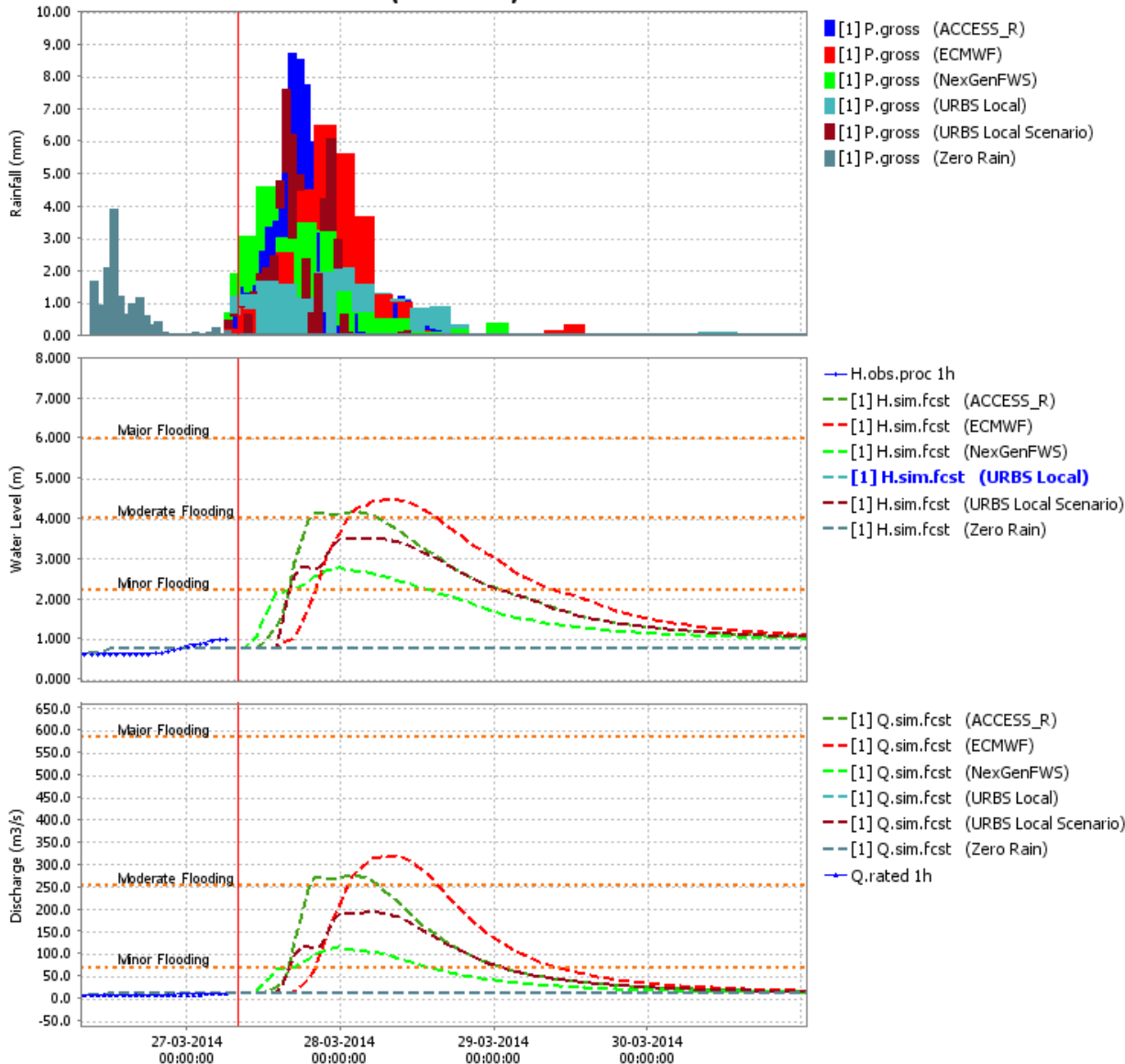
Meteorologist generated rainfall scenarios used to drive simple hydrologic models



**But now there's a wealth of weather guidance
that can go directly into the hydrology model (ACCESS, ECMWF, nowcasts...)**

At shorter timescales (<7 days) hydrologists struggling to determine best rainfall guidance

URBS: ASHFORD (H054145) - Ashford



New flood forecasting environment
 (HyFS, based on FEWS)

Rainfall forecasts

River height forecasts

River flow forecasts

New meteorologist-generated gridded forecasts

[Bureau Home](#) > [Australia](#) > MetEye

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 **TEXT VIEWS**

"NextGEN"
GFE-style

 View the current warnings for Australia

Start typing, then select from list (town, city, postcode or lat/lon) Time zone **AEDT**

LATEST WEATHER
Current Temp, Rain, Wind ...

FORECASTS
Fri | Saturday, 1 November 2014 | Sun
2:00 5:00 8:00 11:00 14:00 17:00 20:00 23:00

FORECASTS

Rainfall Forecasts

3-hourly

Chance of any rain

Expected rainfall
Updated 31 Oct 2014, 1:24 PM AEDT

Daily from tomorrow

Chance of any rain

Likely rainfall

Possible higher rainfall

Overlay

Latest rain radar

Mean Sea Level Pressure (hPa)

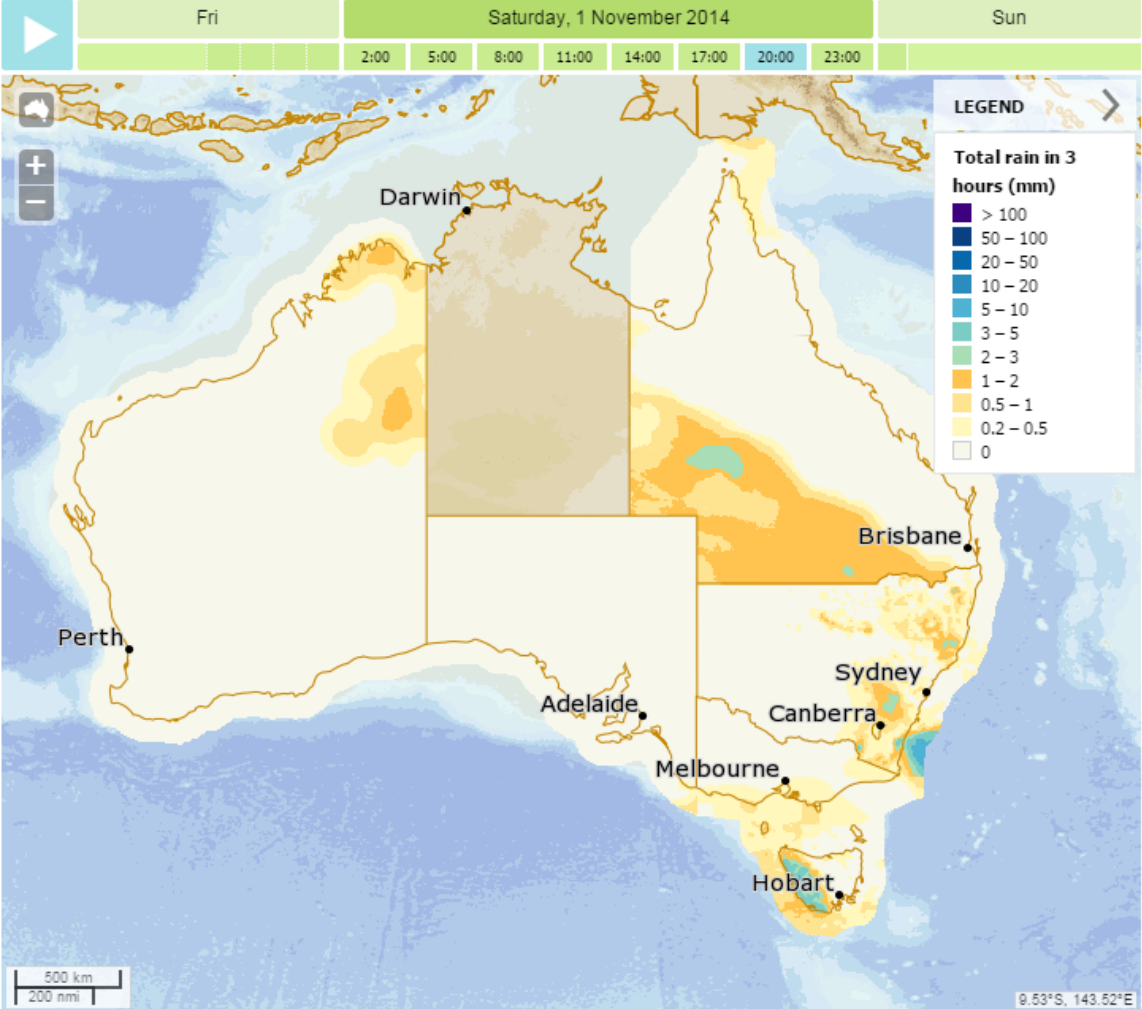
Temperature Forecasts

Storms, Snow, Fog, Frost ...

Humidity Forecasts

Wind Forecasts

Waves Forecasts



3-hr mean rain

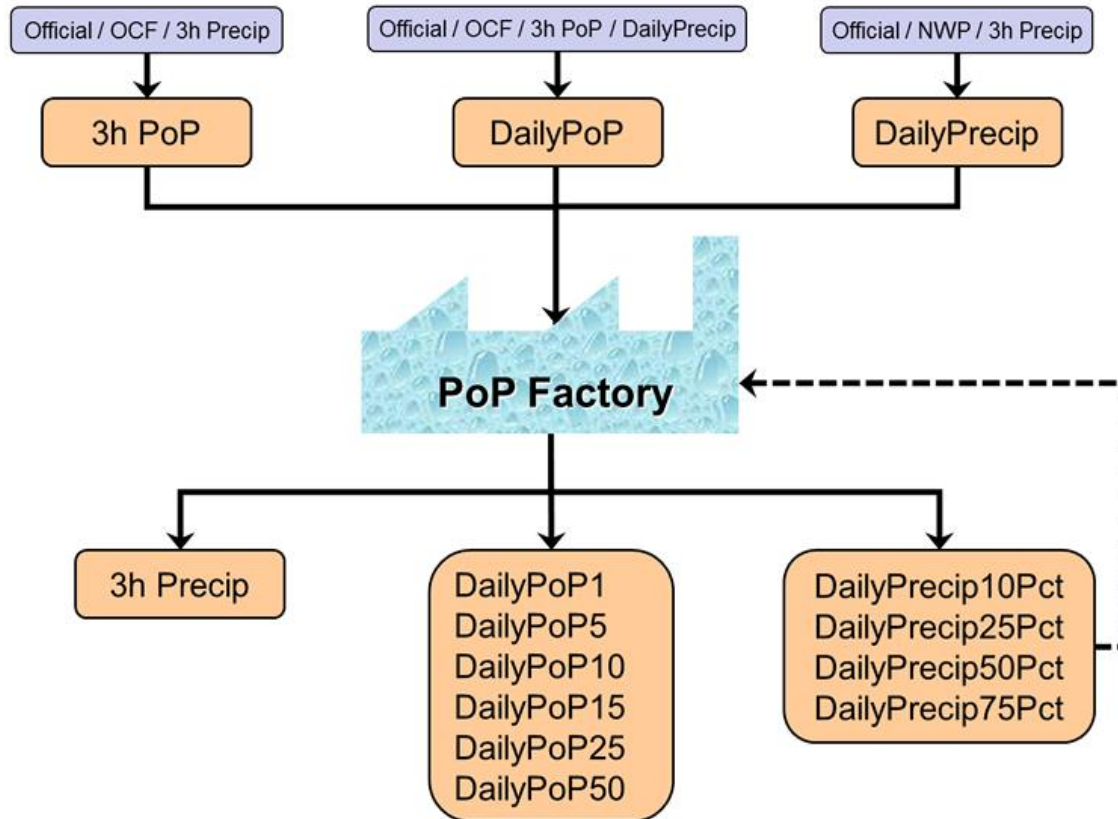
Median rain

25% exceed

10% exceed
(internal)

Place names Search marker Saved locations Forecast locations
 Forecast districts Marine zones Roads & railways Rivers & lakes Catchments

Precipitation Suite Process Map



Meteorologist input on the 3hrPop, DailyPop, DailyPrcip

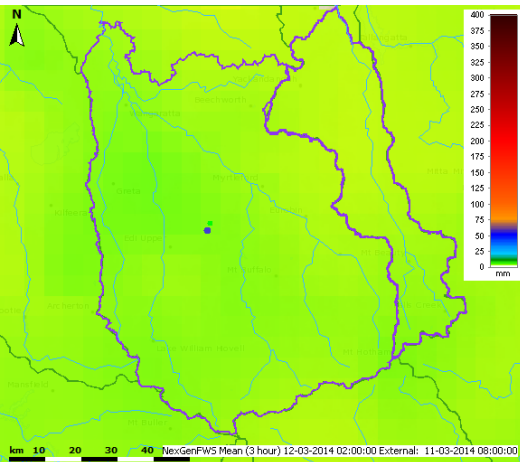
Meteorologist can also review and update the Daily 10, 25, 50, 75 Precip

Statistically internally consistent across many fields.

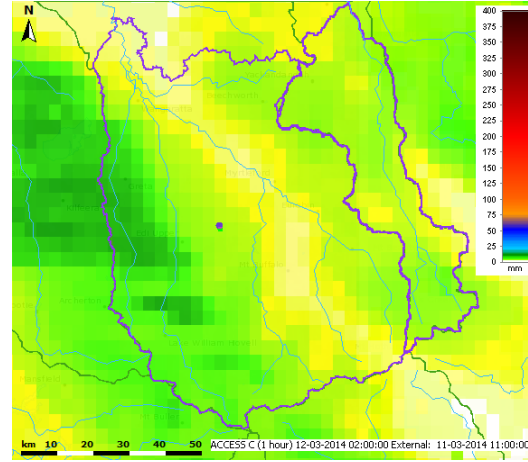
We hope that official forecasts are the best, because of forecaster expertise.

These are the official policy forecasts.

Meteorologist generated



Weather model output



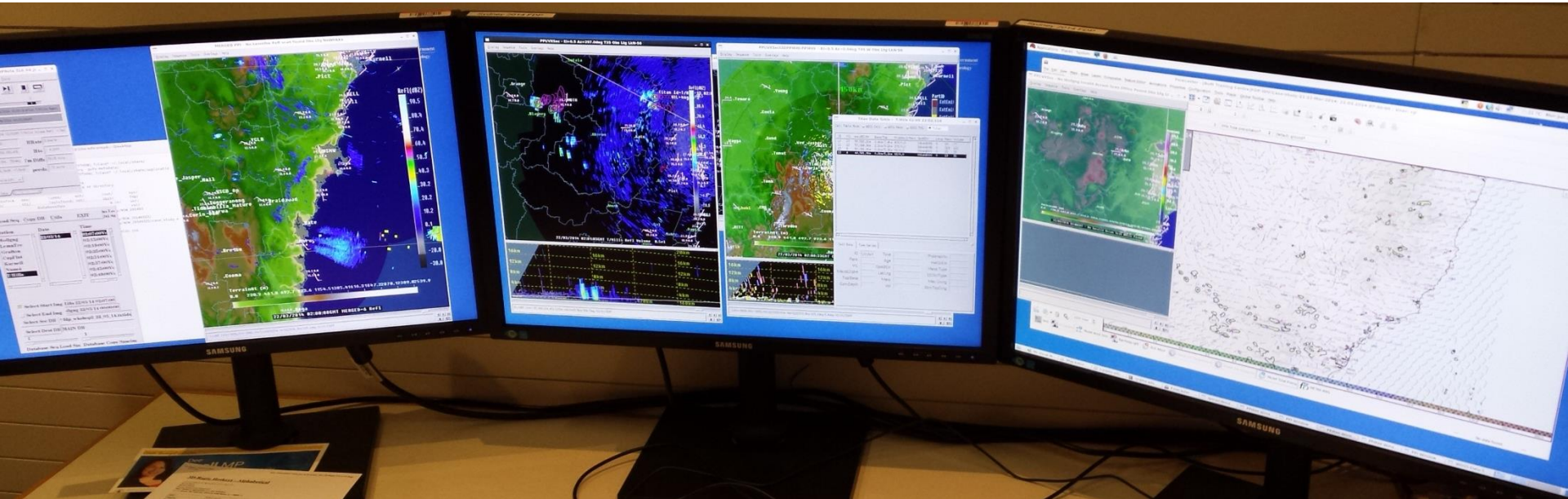
Meteorologist's fields are smoother than model's fields (similar to ensemble mean of many models).

Individual models are also smoother than reality.

When customers ask flood forecasters for "worst case scenarios", some hydrologists have been using 10% exceedence grids for this, but being point estimates, this is not realistic over a large area.

Example: 10% exceedence at point happening over 100 km² is actually 2% chance.

Advanced weather forecasts for flood forecasts



2014 Forecast Demonstration Project

Several month (temporary) campaign of high resolution (1.5 km) weather models rapidly updated (hourly) to short leadtimes (<12 hours).

Demonstrating improved radar-rainfall products and forecasts, including ensembles and nowcasts (6 minute forecasts).

Hydrology is one of 14 sub-projects (aviation, air quality, etc).

Challenges with operational hydro-meteorological forecasting

Plumbing between models has been a limitation

Statistical consistency of calibration and forecast data needed

Scale mismatches, NWP systematic/conditional bias exist

The value and liability of NWP vs official policy forecasts

Ensembles of ensembles can turn into a mountain of spaghetti

Keeping up with technology vs standard operating procedures

Thomas.C.Pagano@gmail.com

