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.

No sharing with friends, no i-phone.
This is a <u>competition</u>.

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:

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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?

http://hepex.irstea.fr/ **My posts as volunteer guest columnist**

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?

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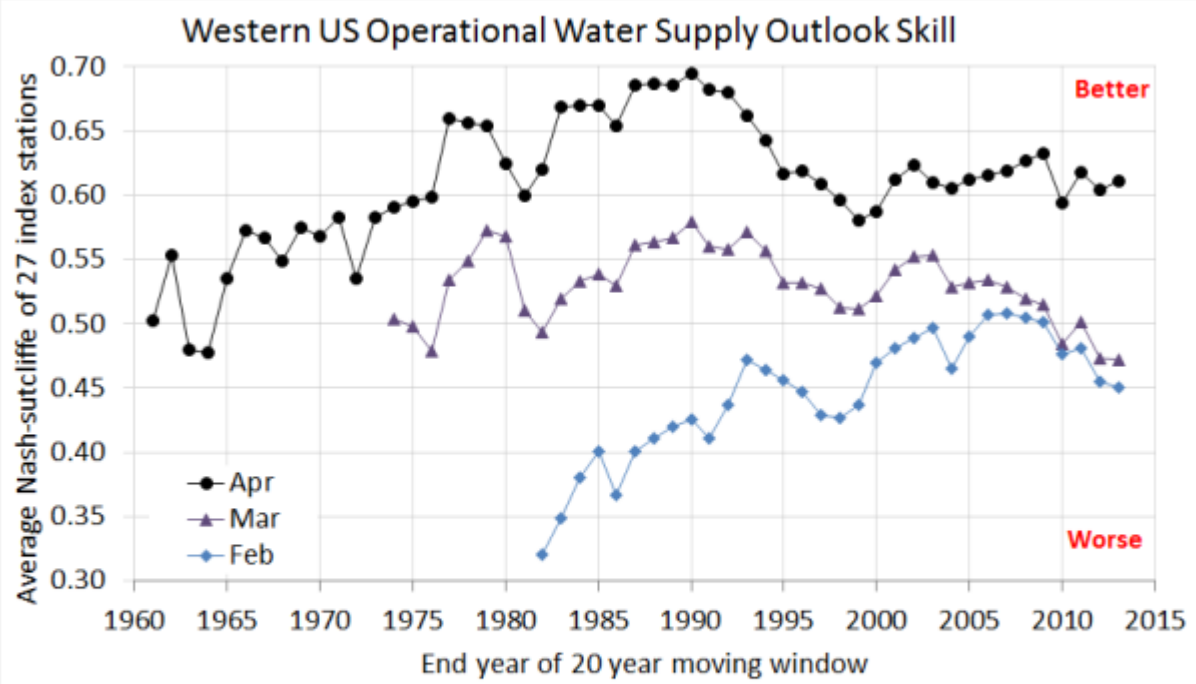
For discussion: Are we getting climate information?



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

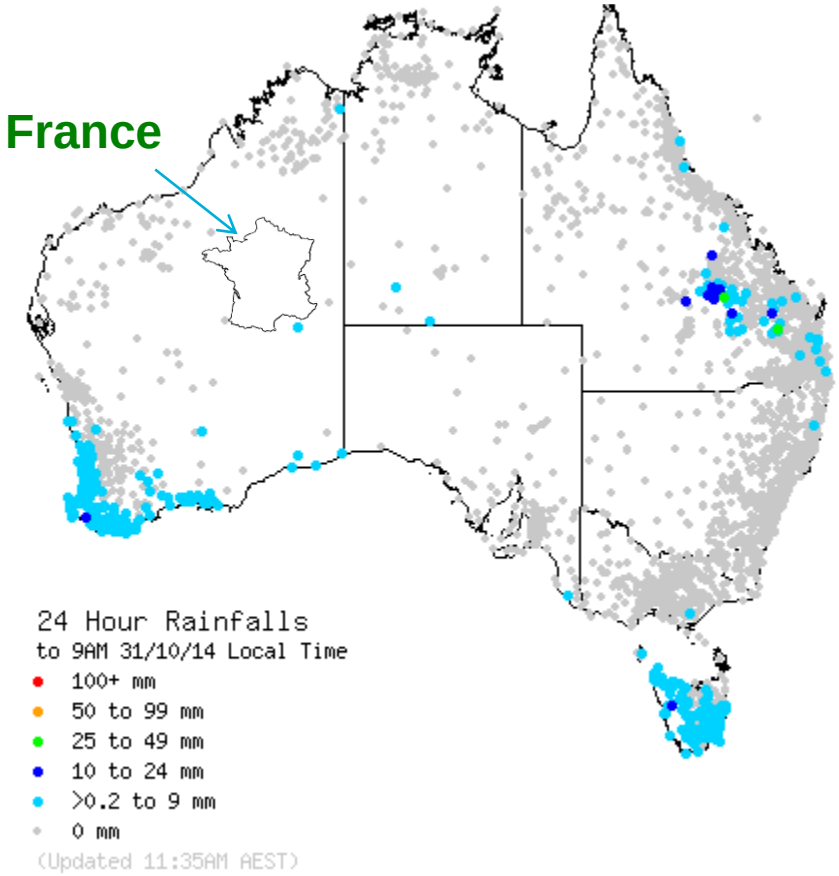
Australia provides river forecasting services for seasonal, short-term and flood timescales.

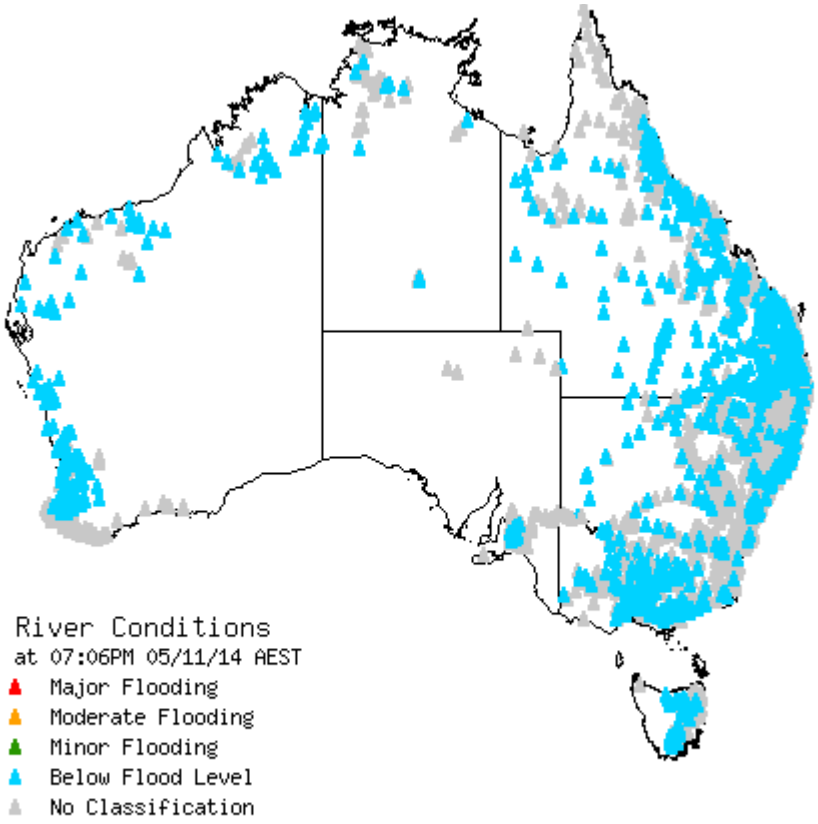
Models, methods and products differ widely by timescale, with longer-range forecasts very objective and formalized.

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

Flood warning rainfall network

River measurement network





Percent of flood warnings issued by month

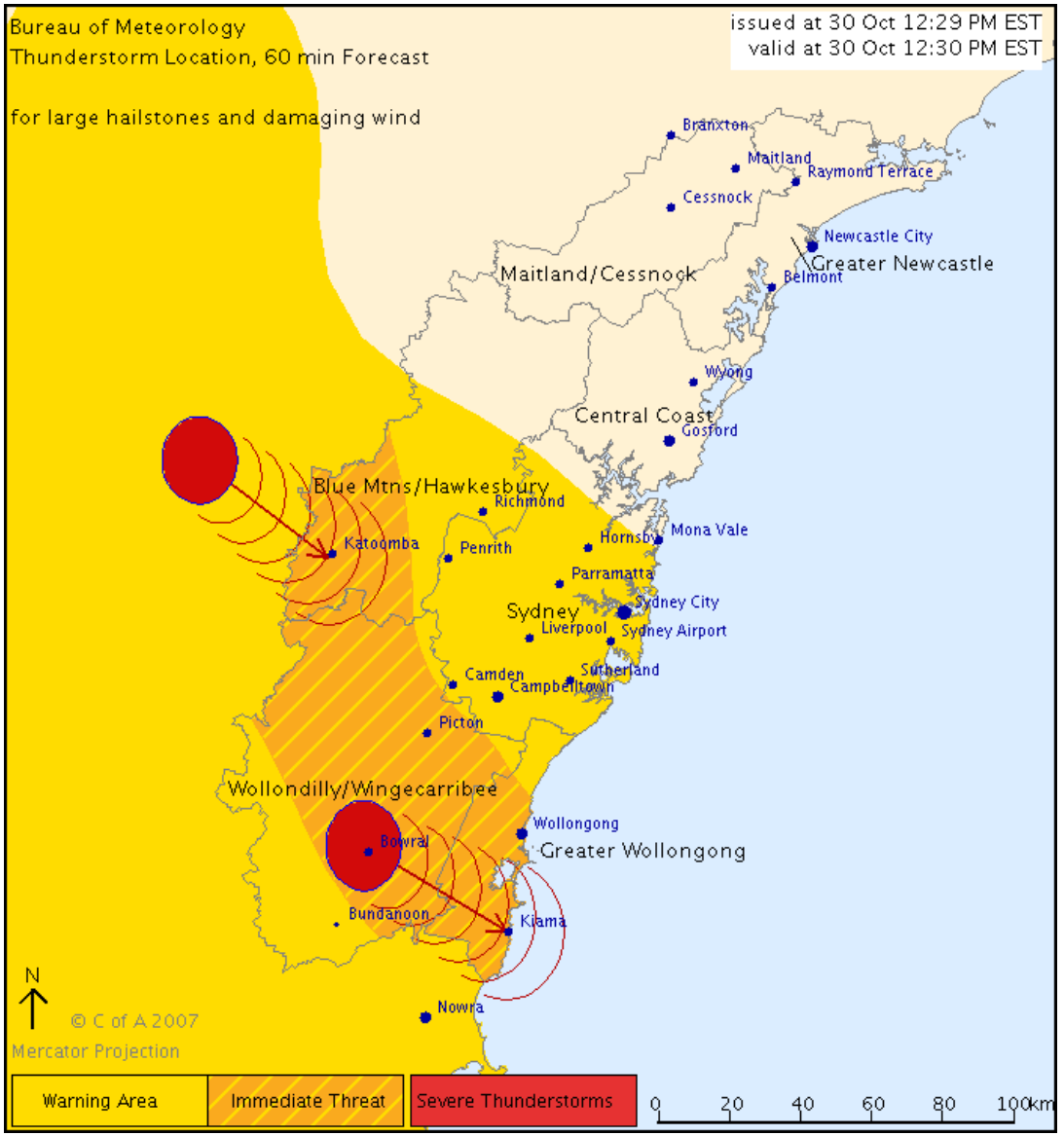
	Flood Warning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
North	NT	23%	26%	22%	9%	1%	0%	0%	0%	1%	0%	2%	16%
	QLD	25%	28%	23%	6%	1%	1%	0%	1%	1%	2%	2%	9%
	WA	22%	23%	23%	8%	2%	1%	0%	3%	1%	3%	0%	14%
Region	NSW	18%	15%	14%	5%	4%	10%	3%	3%	4%	4%	5%	15%
	SA	5%	15%	9%	2%	4%	4%	7%	16%	12%	6%	11%	11%
	VIC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



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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 Wooli 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.

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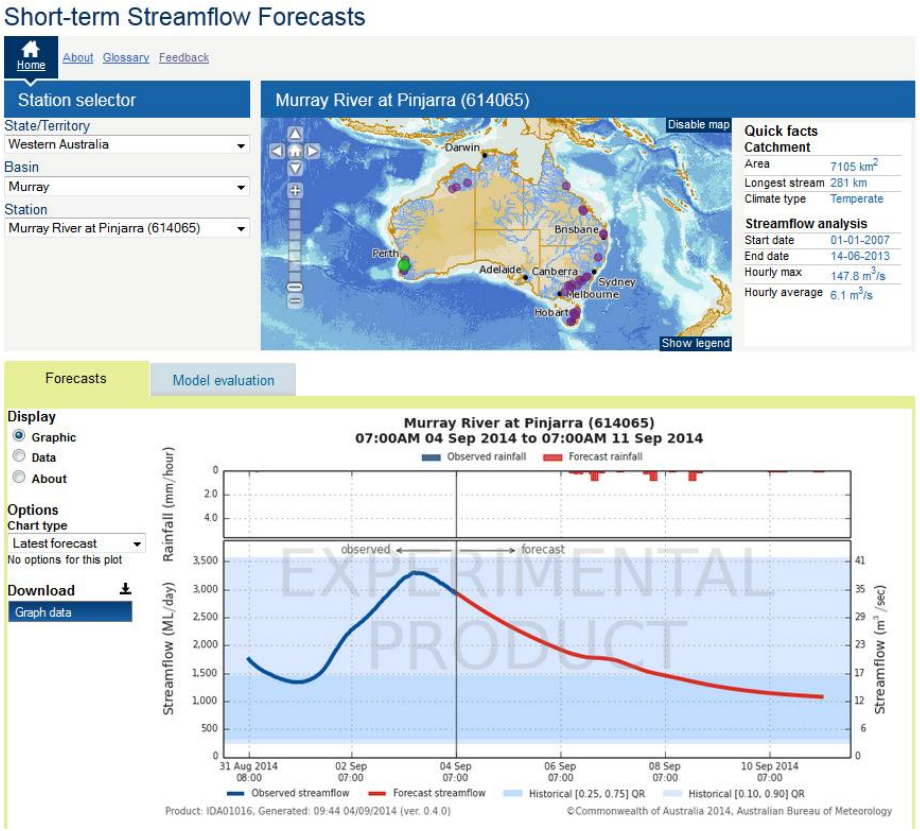
Hydrographs, centralized, automated, hourly, deterministic, GR4J model



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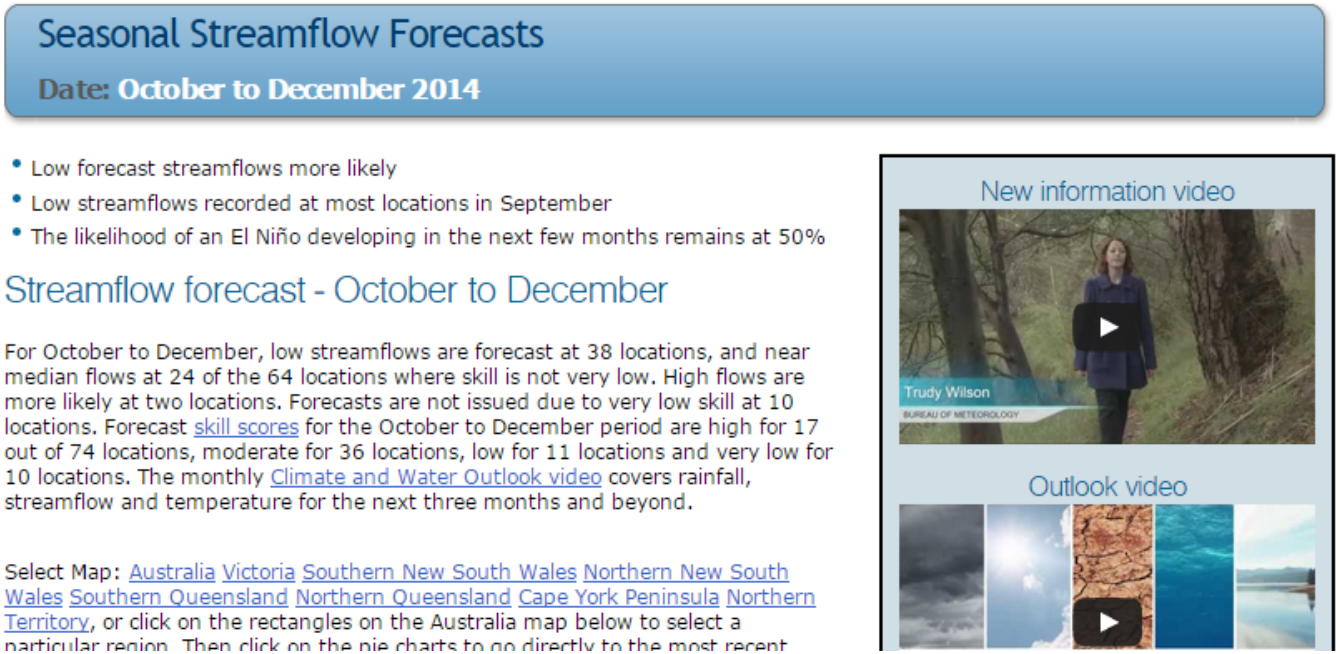
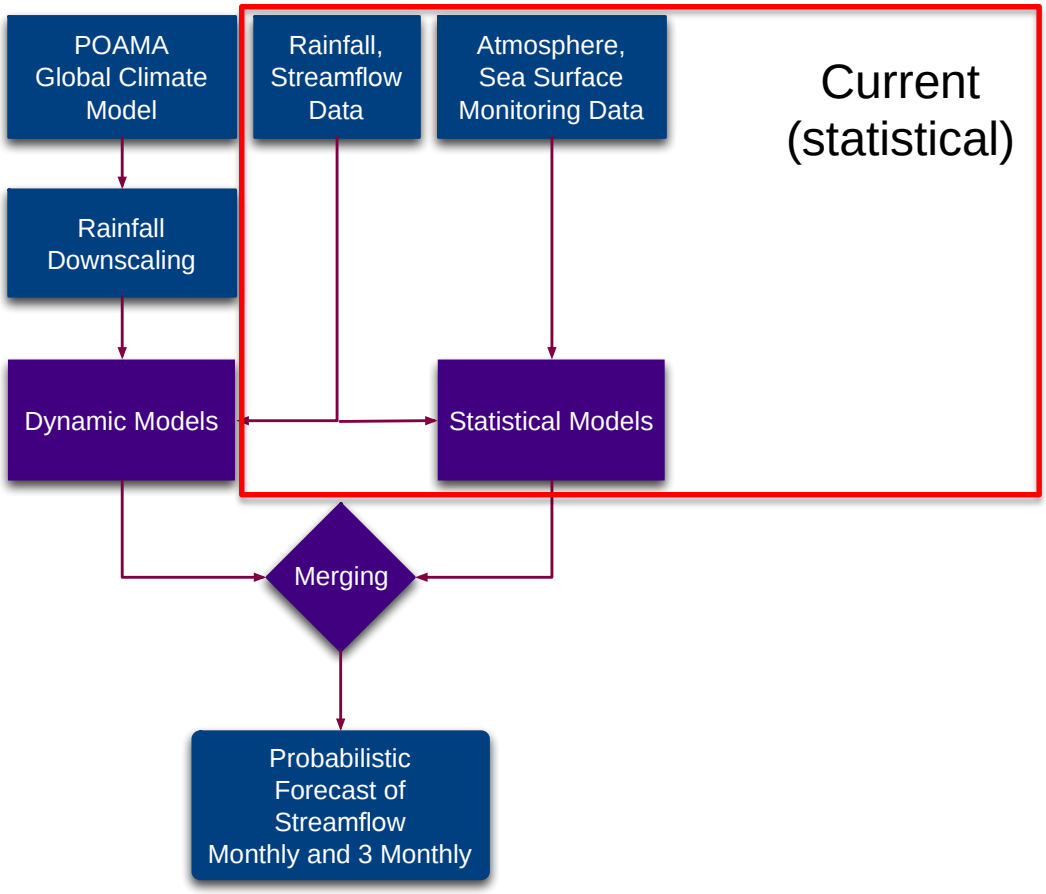
Seasonal forecasts (since 2010)

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



Seasonal Streamflow Forecasting Approach



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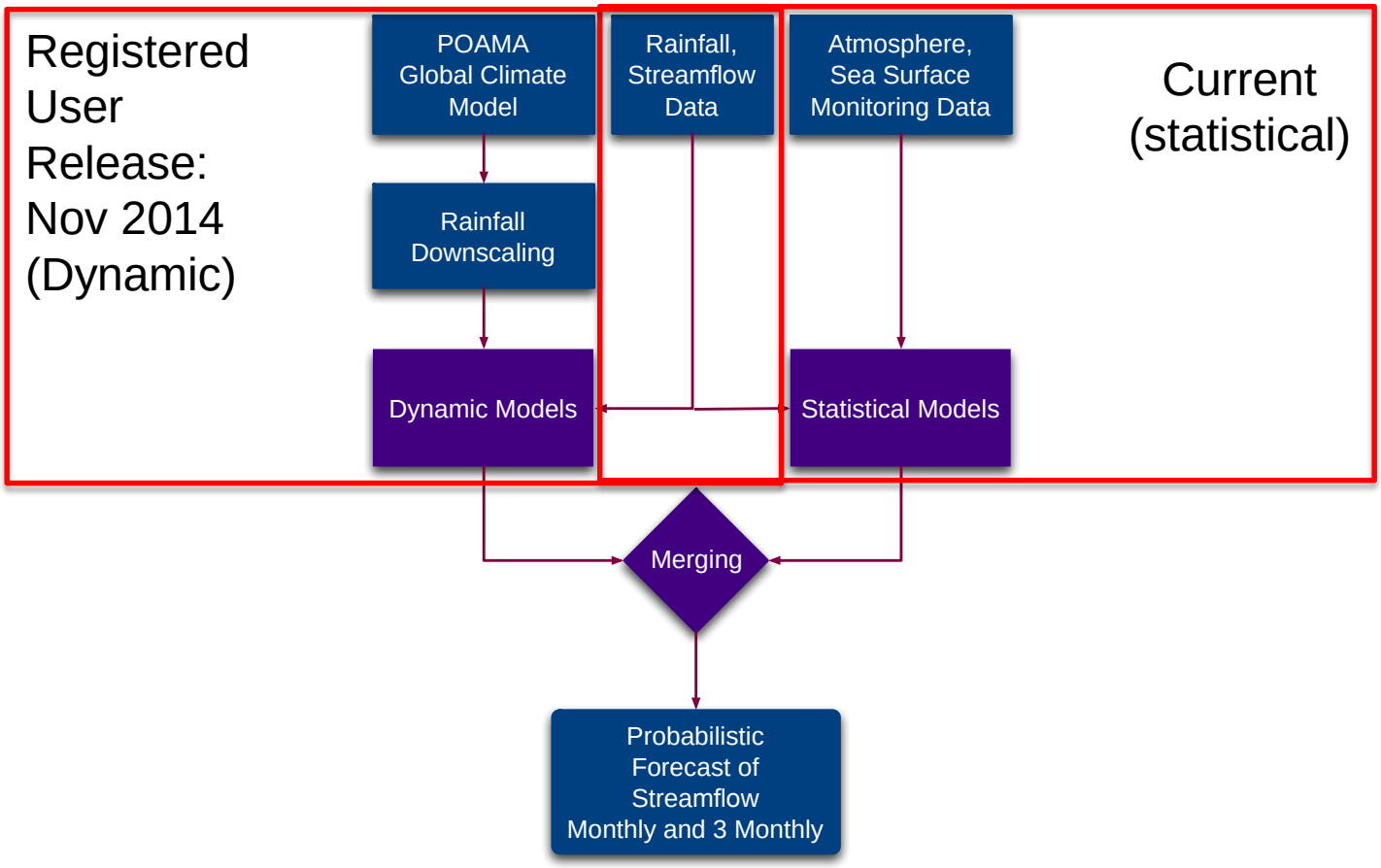
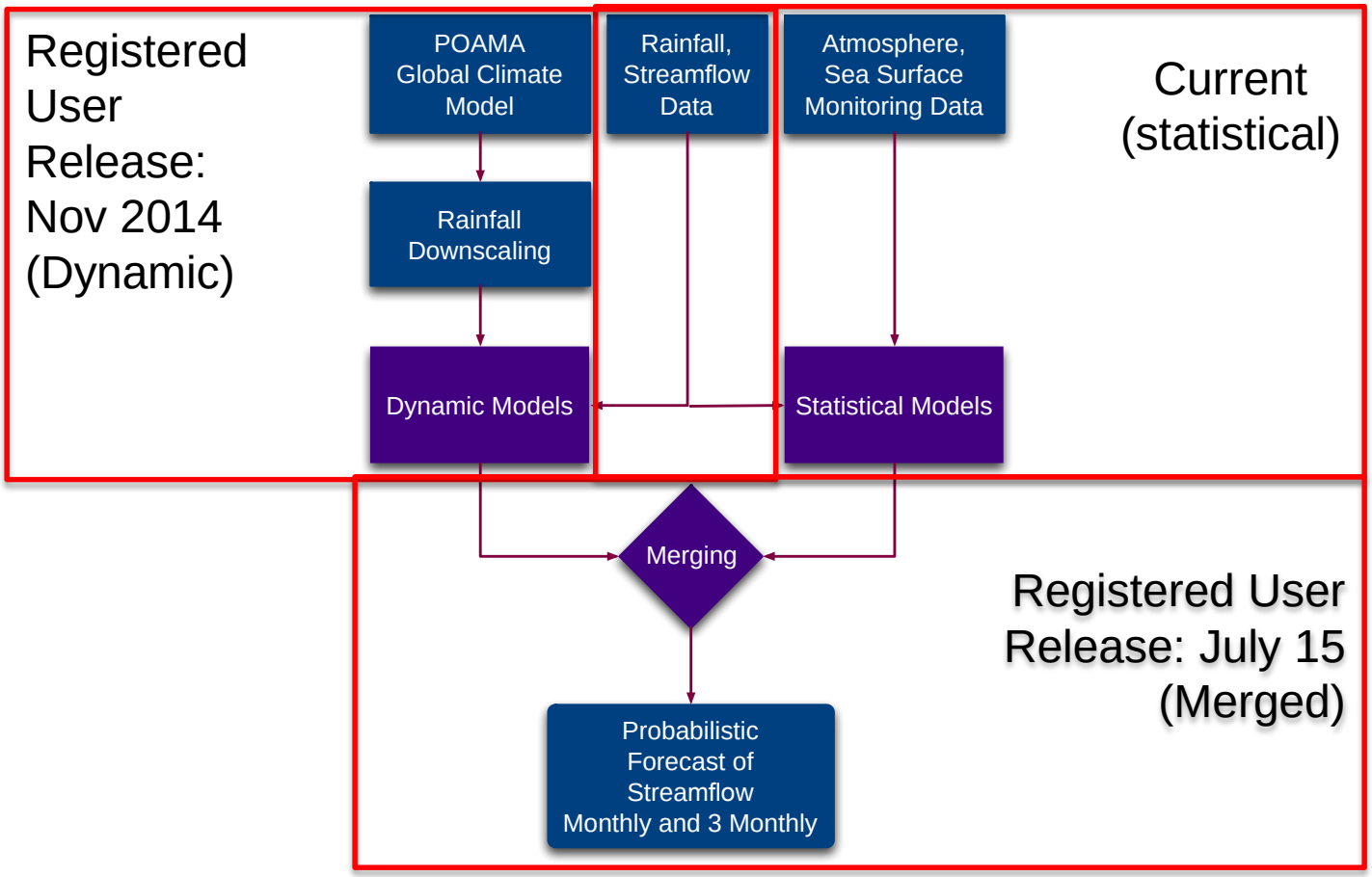


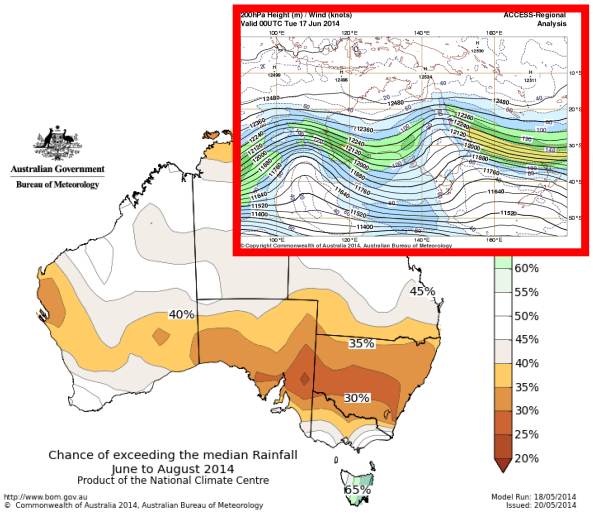
Seasonal Streamflow Forecasting Approach



Seasonal forecasting plans for dynamic approach: Rainfall Downscaling

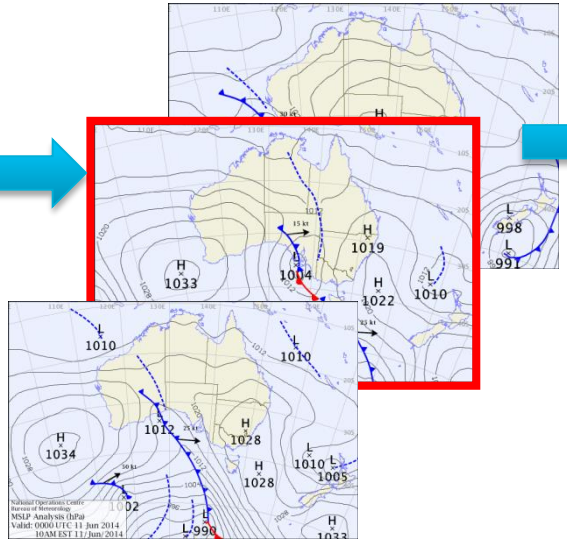
POAMA forecast of climate indices

(Press, Wind, Temp, Rain, Rhum)
(~270km)



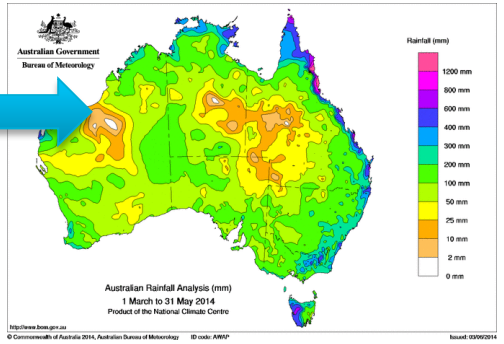
Analogue downscaling

(5 replicates of 31 ensembles)



Downscaled rainfall

(5km; 155 ensembles)



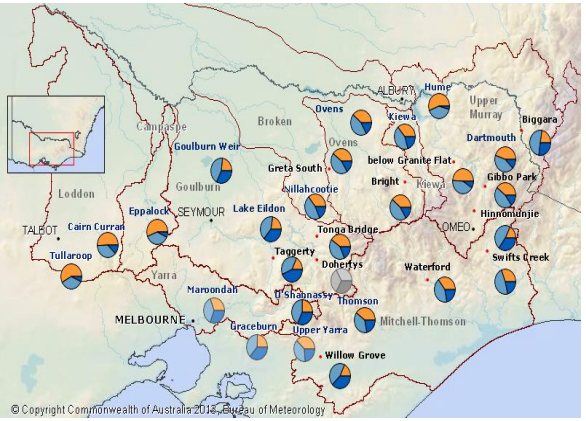
Timbal, B., Li, Z., & Fernandez, E. (2008). The Bureau of meteorology statistical downscaling

model graphical user interface: user manual and software documentation.

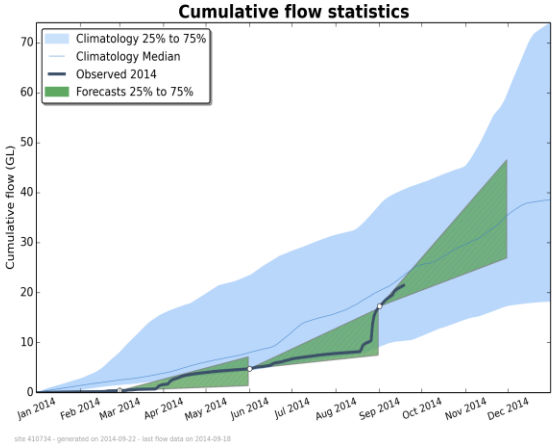
Shao, Q., & Li, M. (2013). An improved statistical analogue downscaling procedure for seasonal precipitation forecast. Stochastic Environmental Research and Risk

Seasonal forecast products

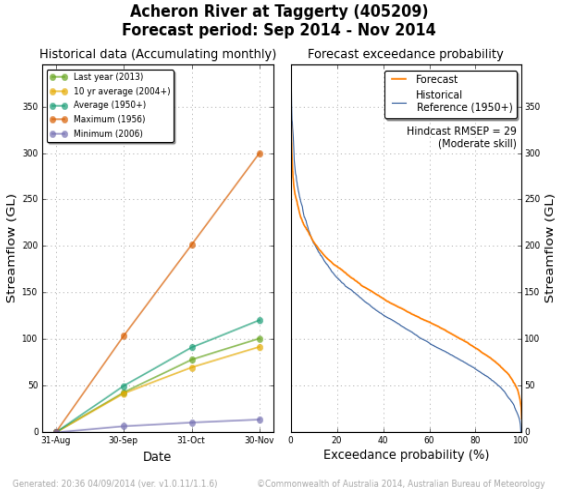
Tercile maps



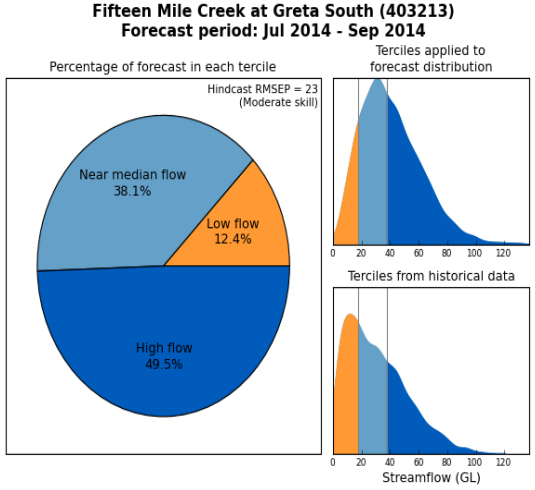
Water year in perspective



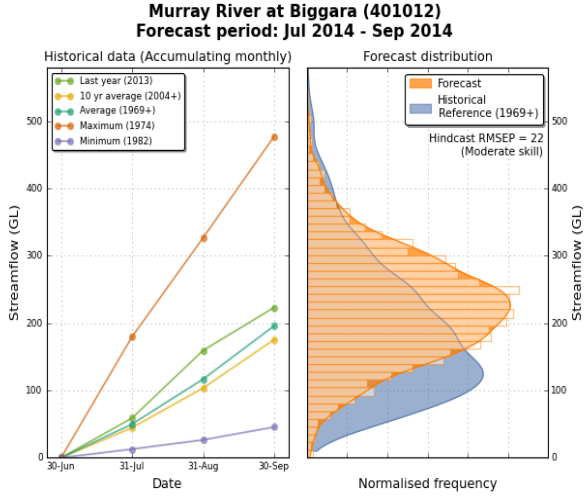
Exceedance probabilities



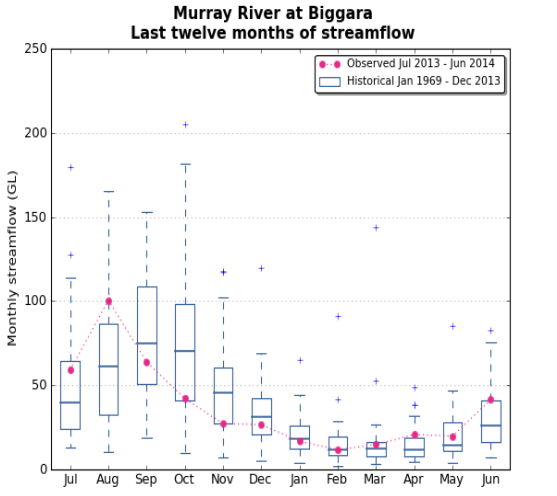
Tercile forecasts



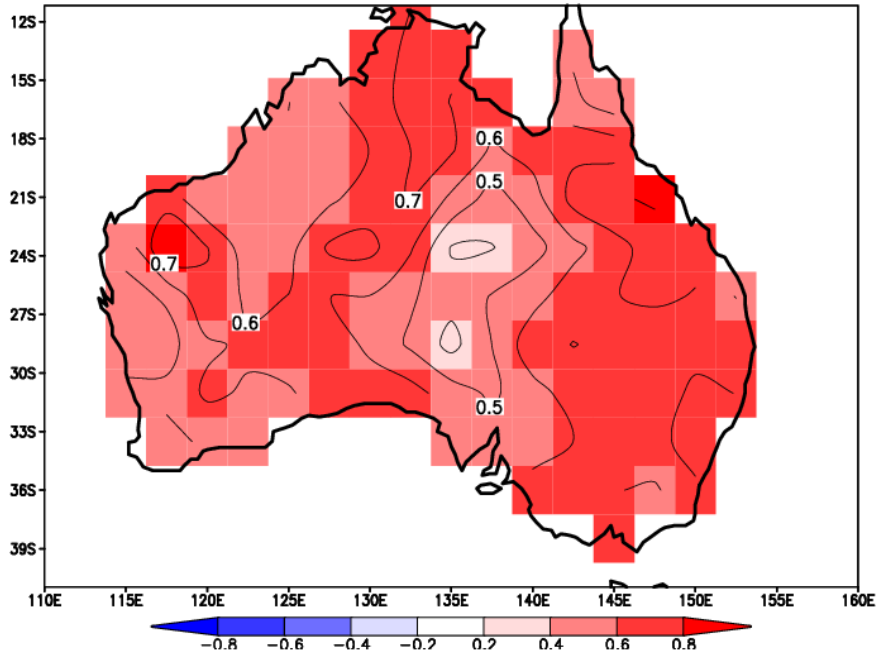
Probability distributions

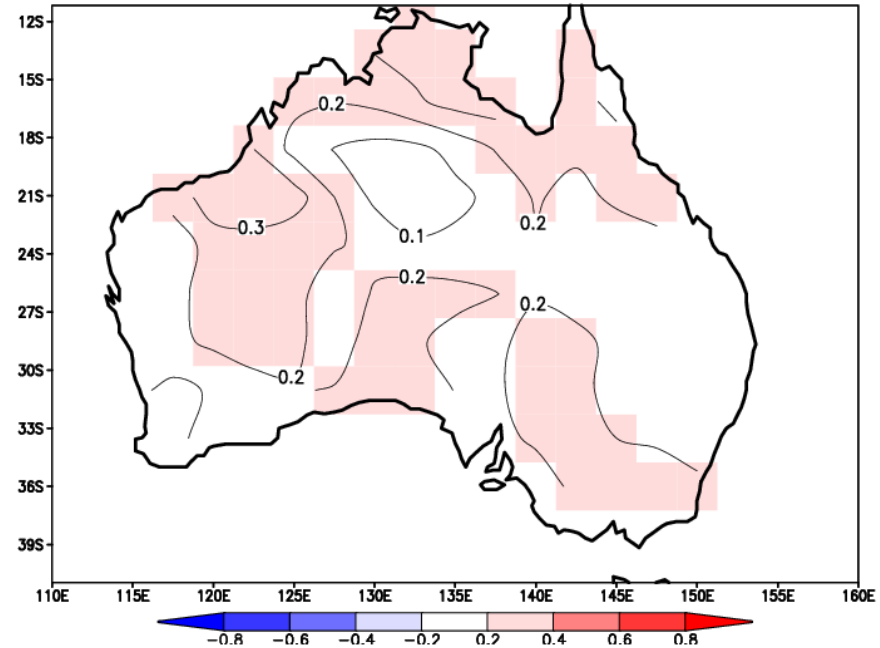


Box plots



Precipitation correlation (all months)





POAMA2 climate model

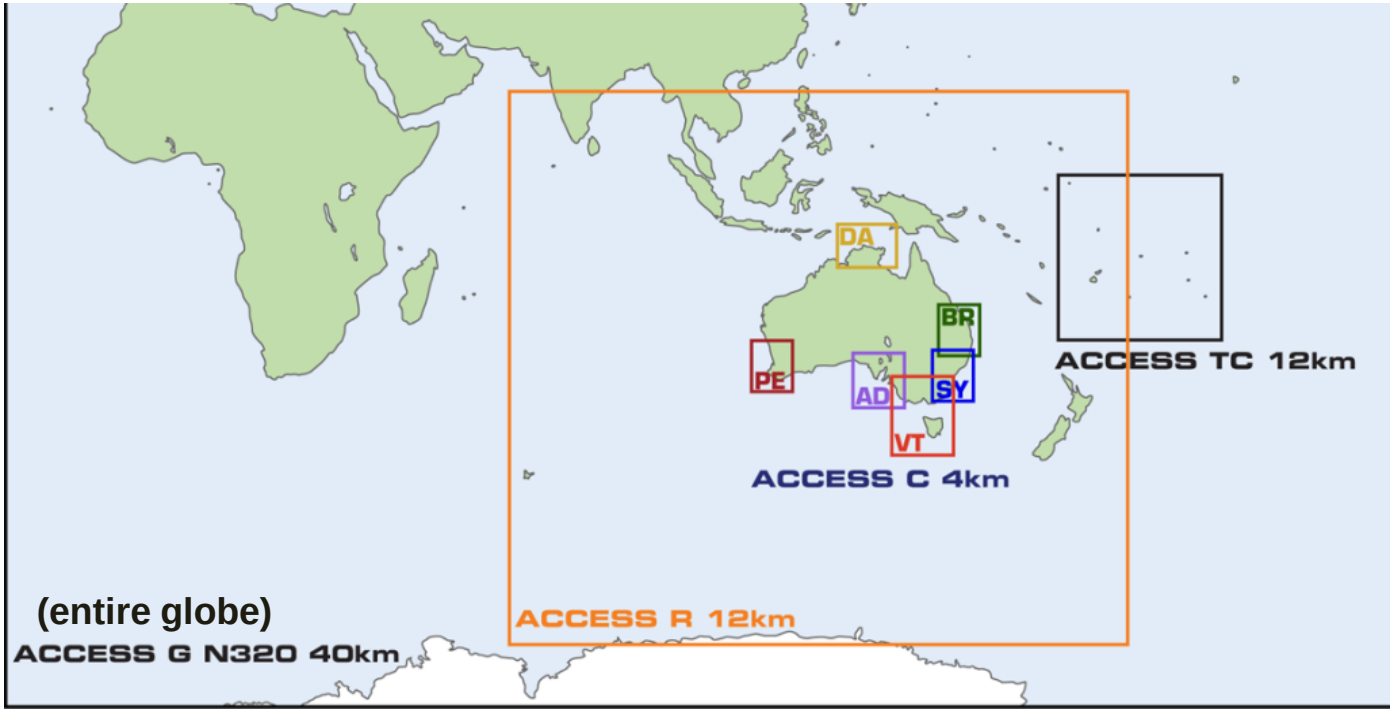
(250 km, POAMA3 will be 150 km)
1981-2014 retrospective
Ensembles for both forecast + reanalysis
33 members
Daily resolution, 9 months ahead

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.

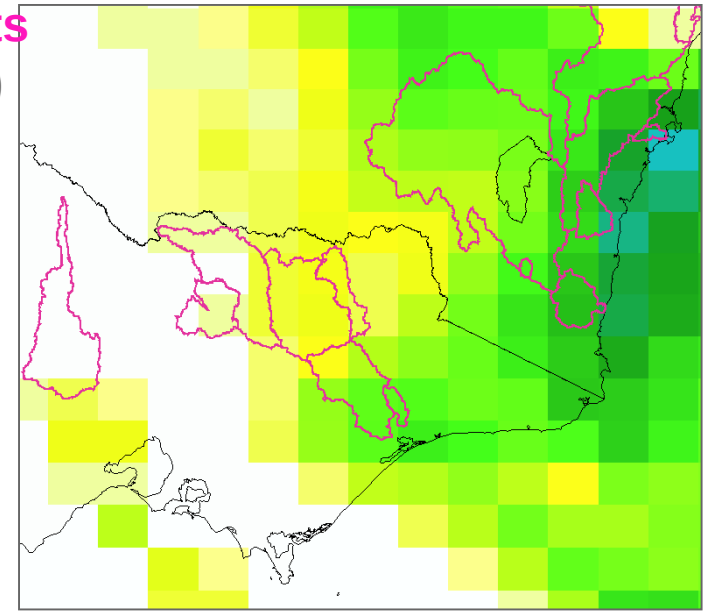


Model	Domain	Resolution	Leadtime
ACCESS-G	Global	~40km	10 days
ACCESS-R	Regional	0.11° (~12km)	3 days
ACCESS-C	City	0.036° (~4km)	1.5 days
ACCESS-TC	Relocatable	0.11° (~12km)	

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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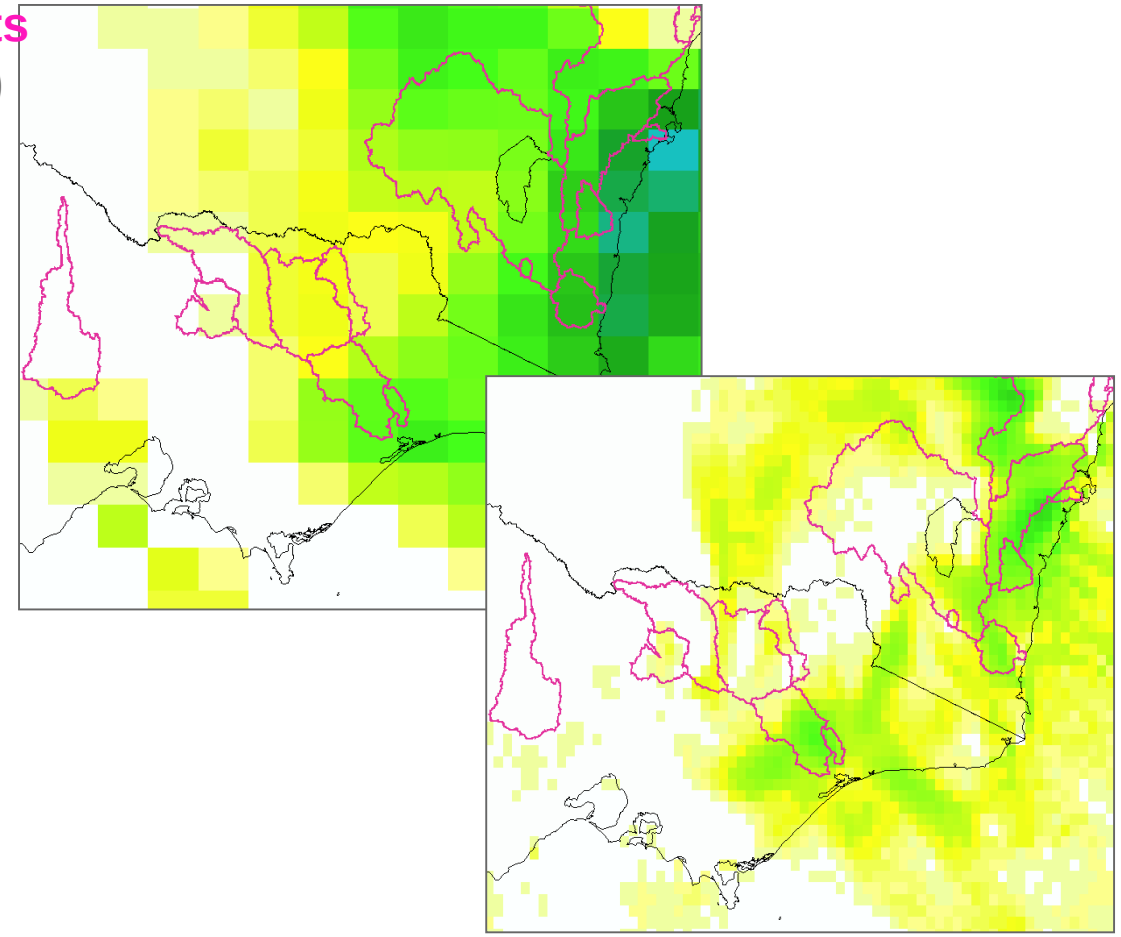

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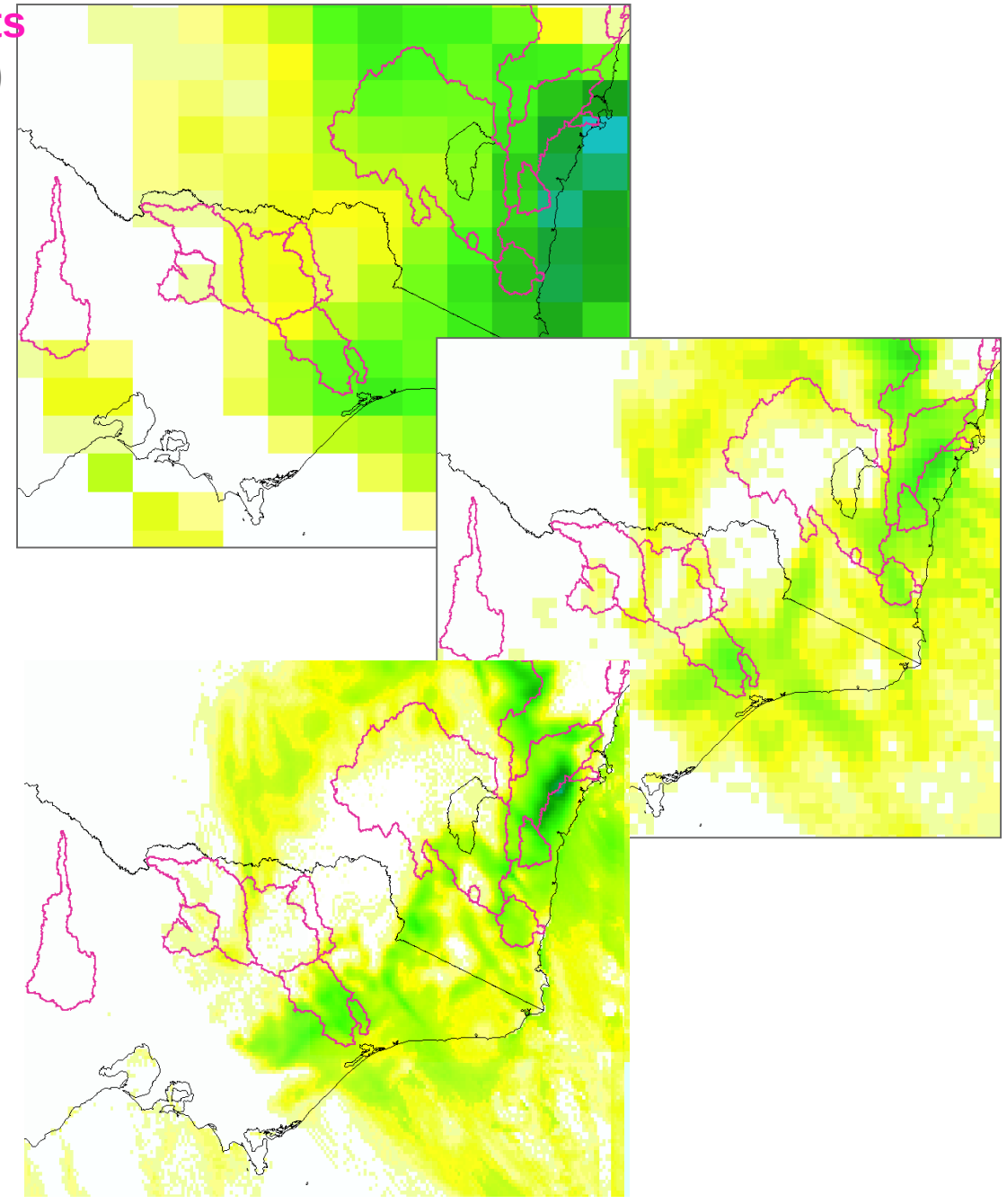
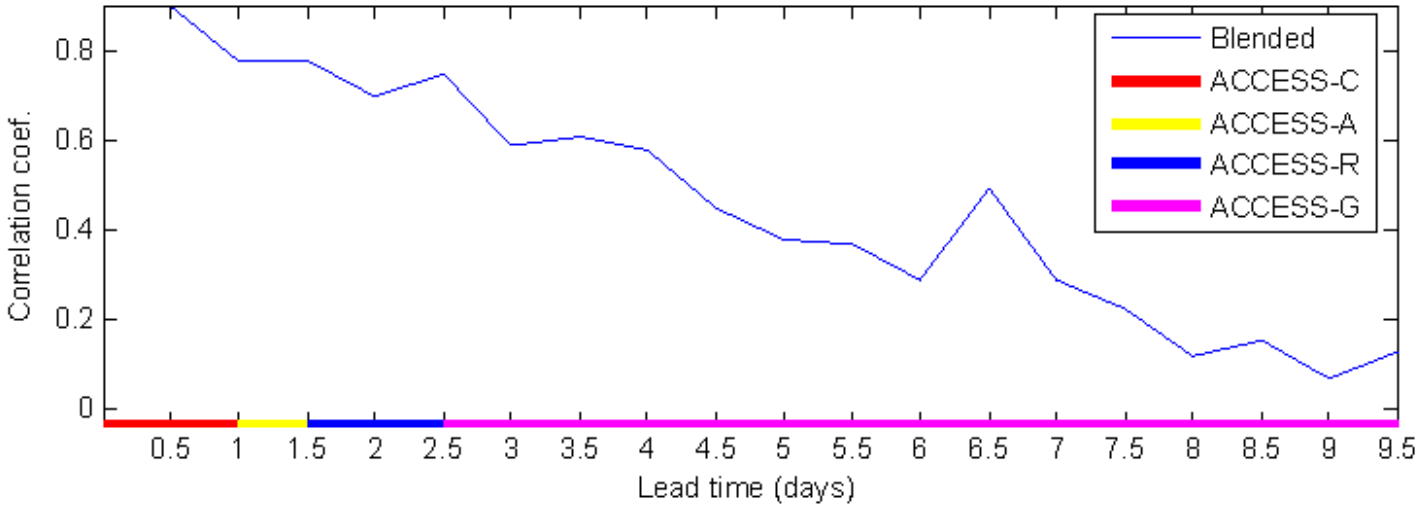
(40 km, +10 days)
What currently feeds the short-term deterministic flow forecasts

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 ~4000km^2)
31 Mar 2010 – 18 Apr 2011 (381 days of records)

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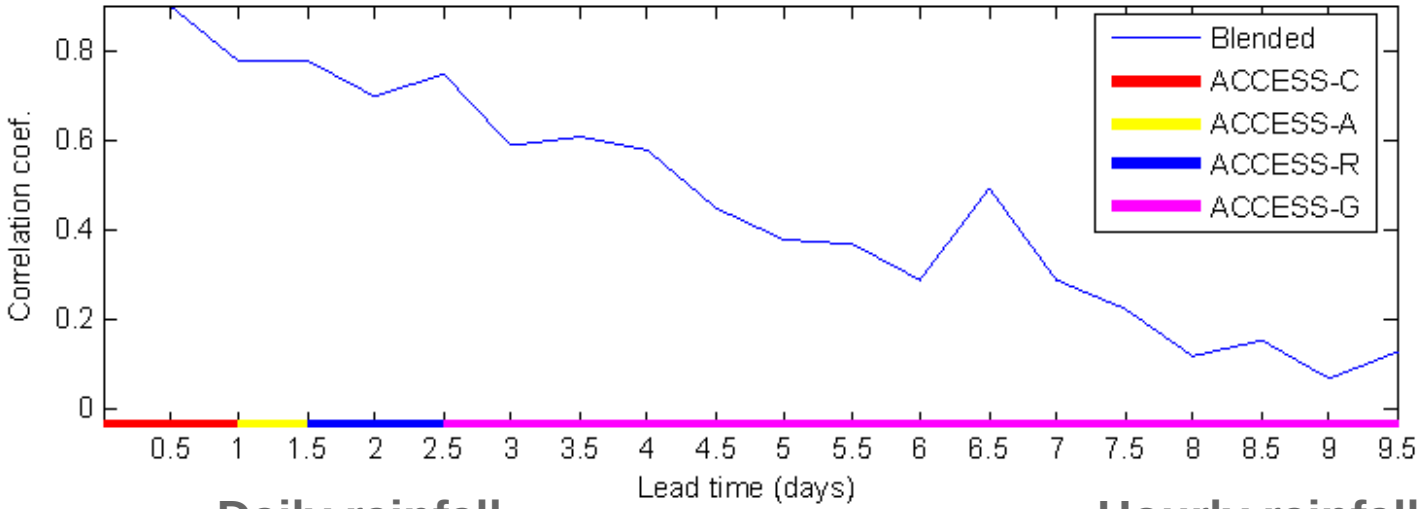
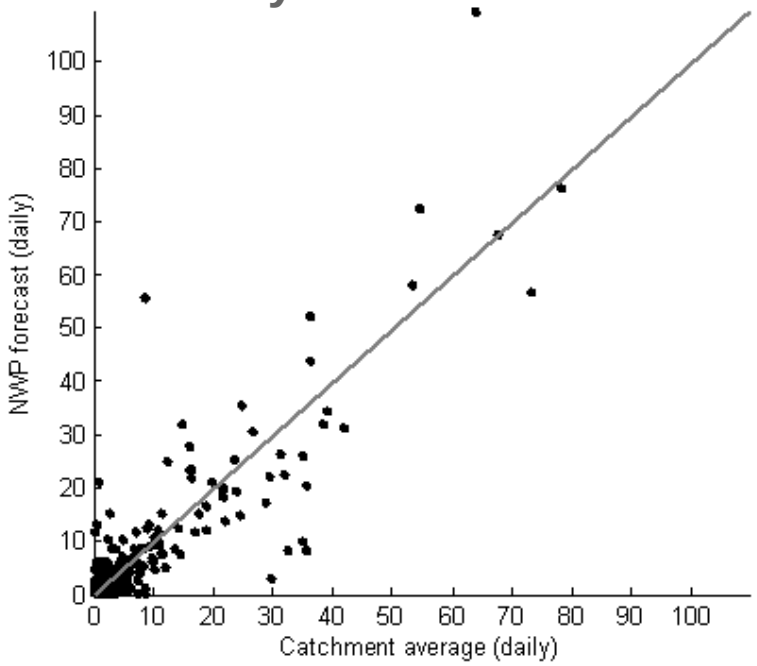
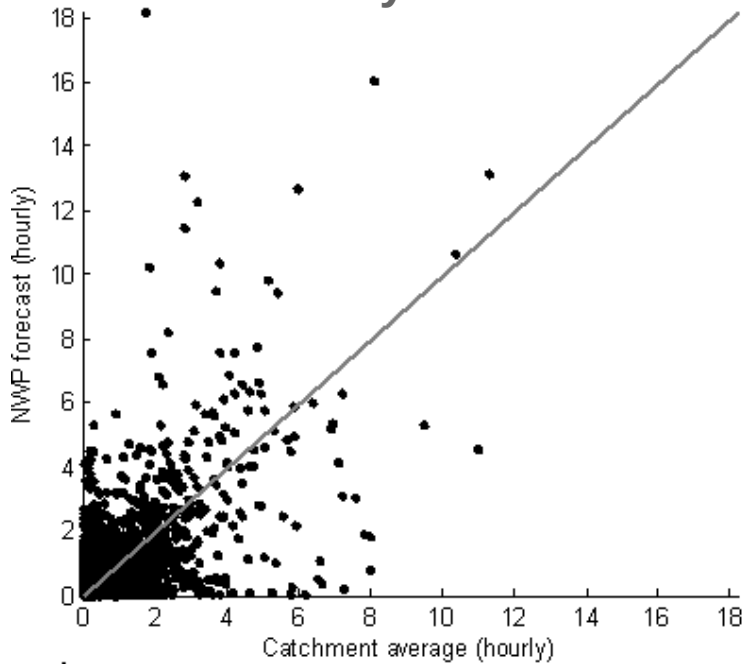


Daily rainfall



Hourly rainfall



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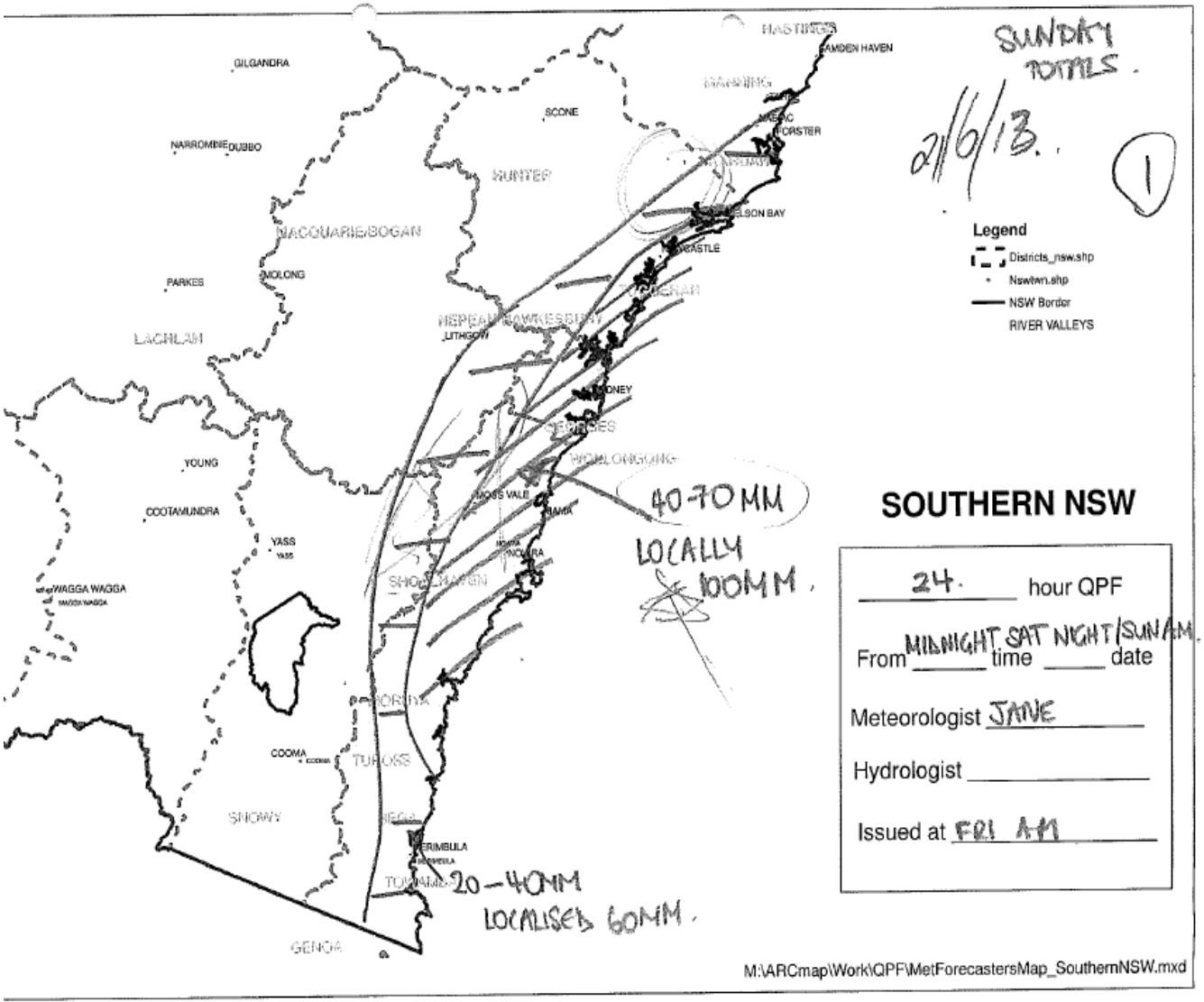
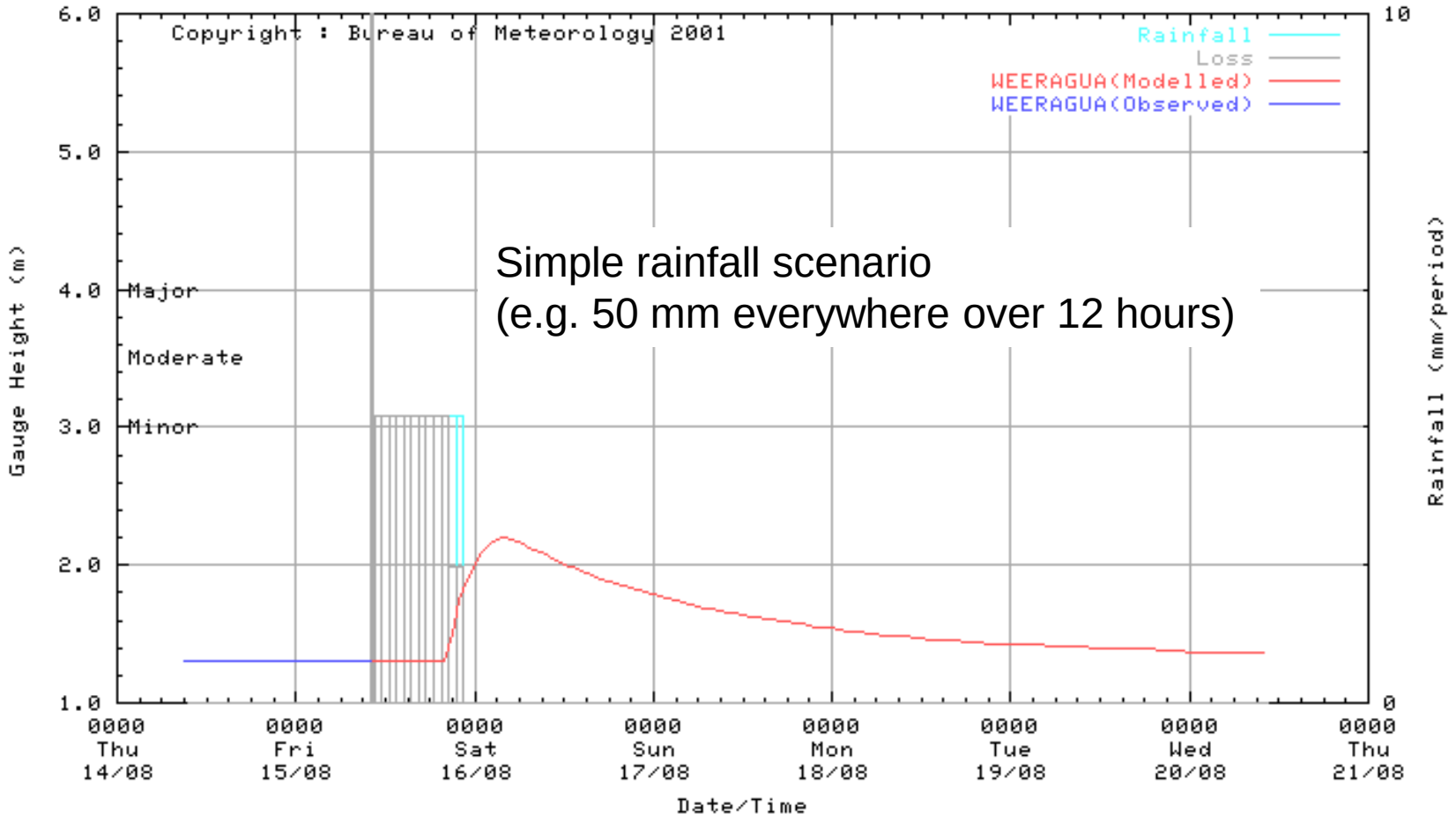
Long history of using weather predictions for flood forecasting… but not directly from weather models

Weather briefings for hydrologists

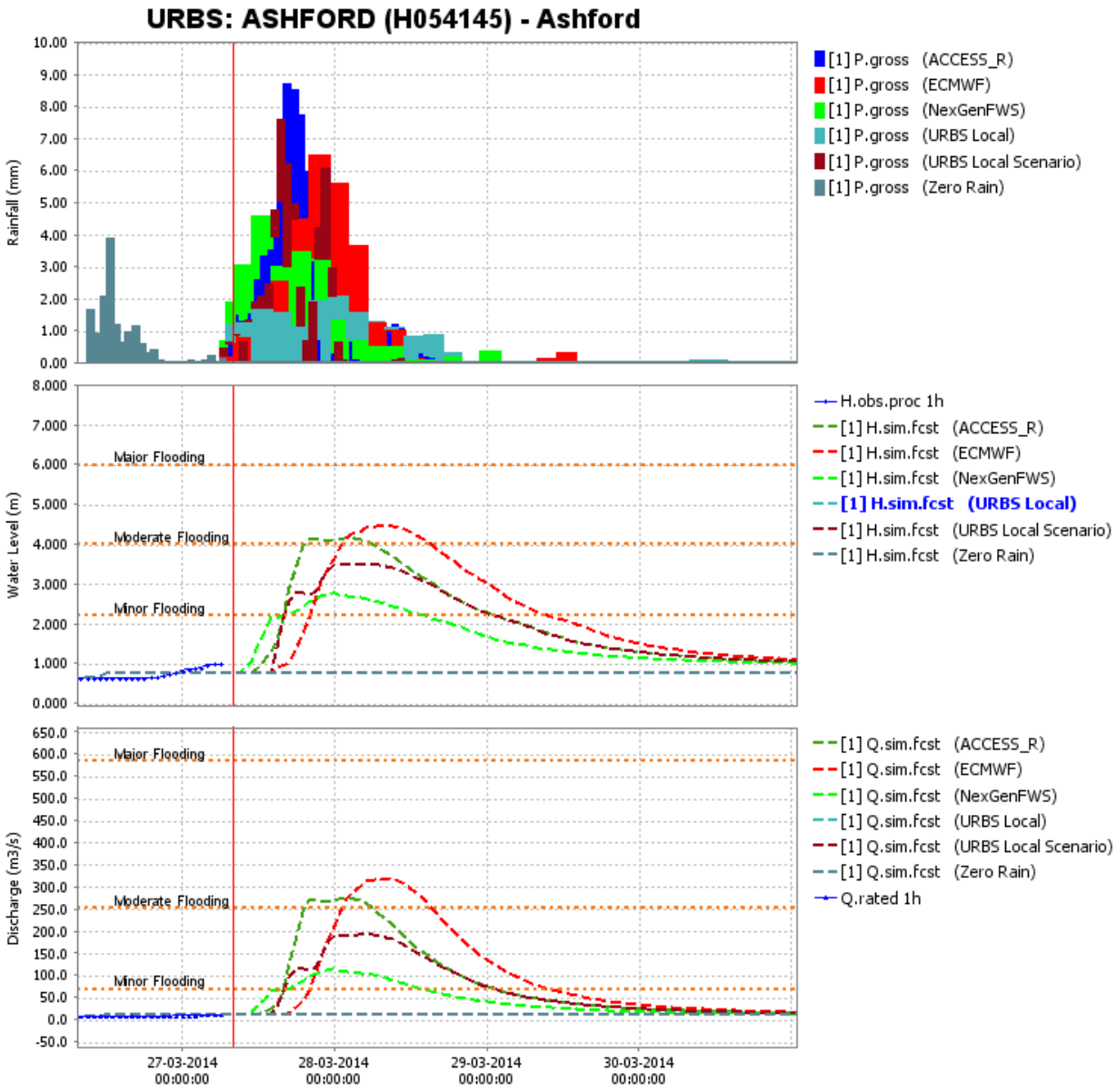


Meteorologist generated rainfall scenarios used to drive simple hydrologic models



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



New flood forecasting environment
(HyFS, based on FEWS)

Rainfall forecasts

River height forecasts

River flow forecasts

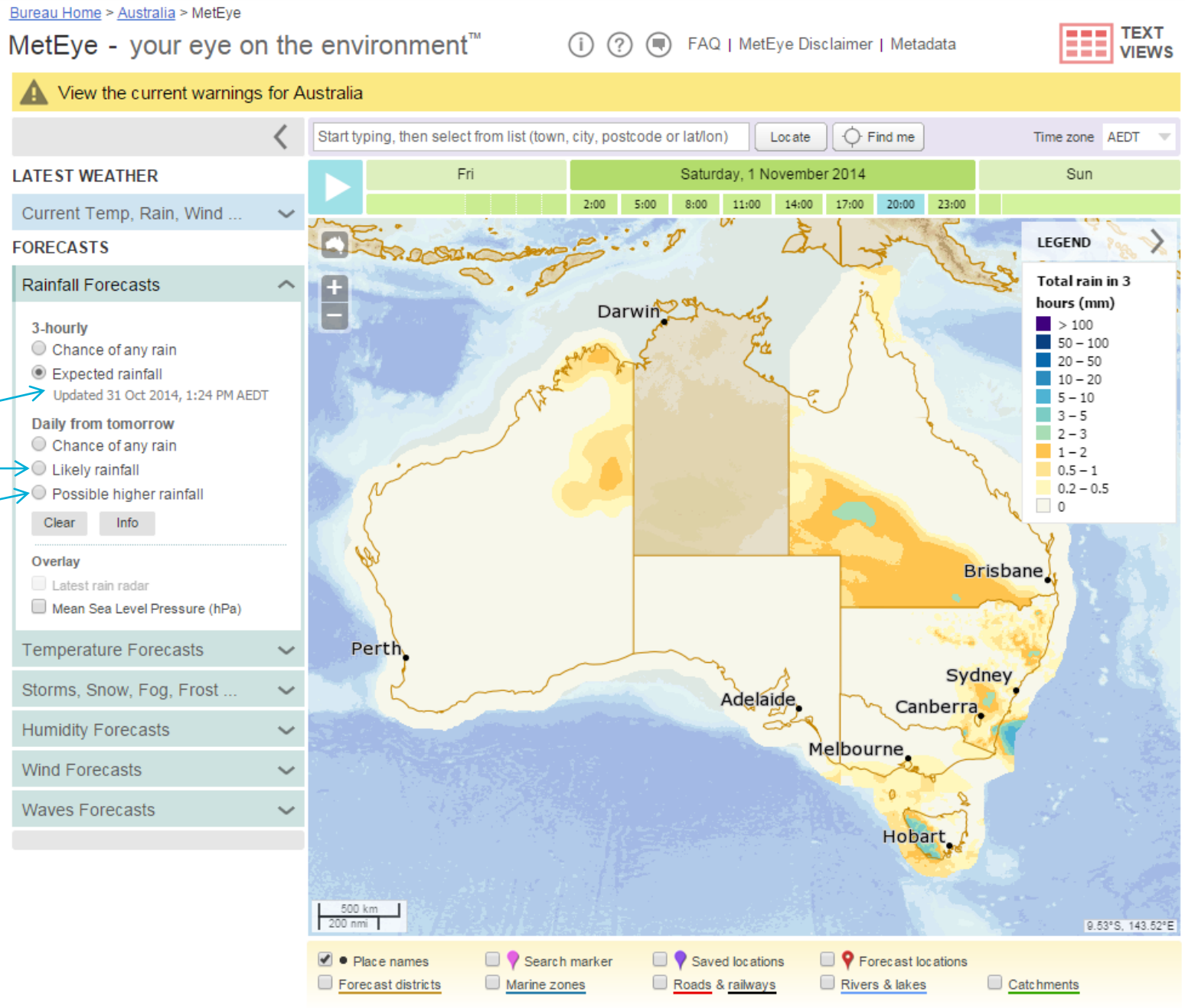
New meteorologist-generated gridded forecasts

"NextGEN" GFE-style

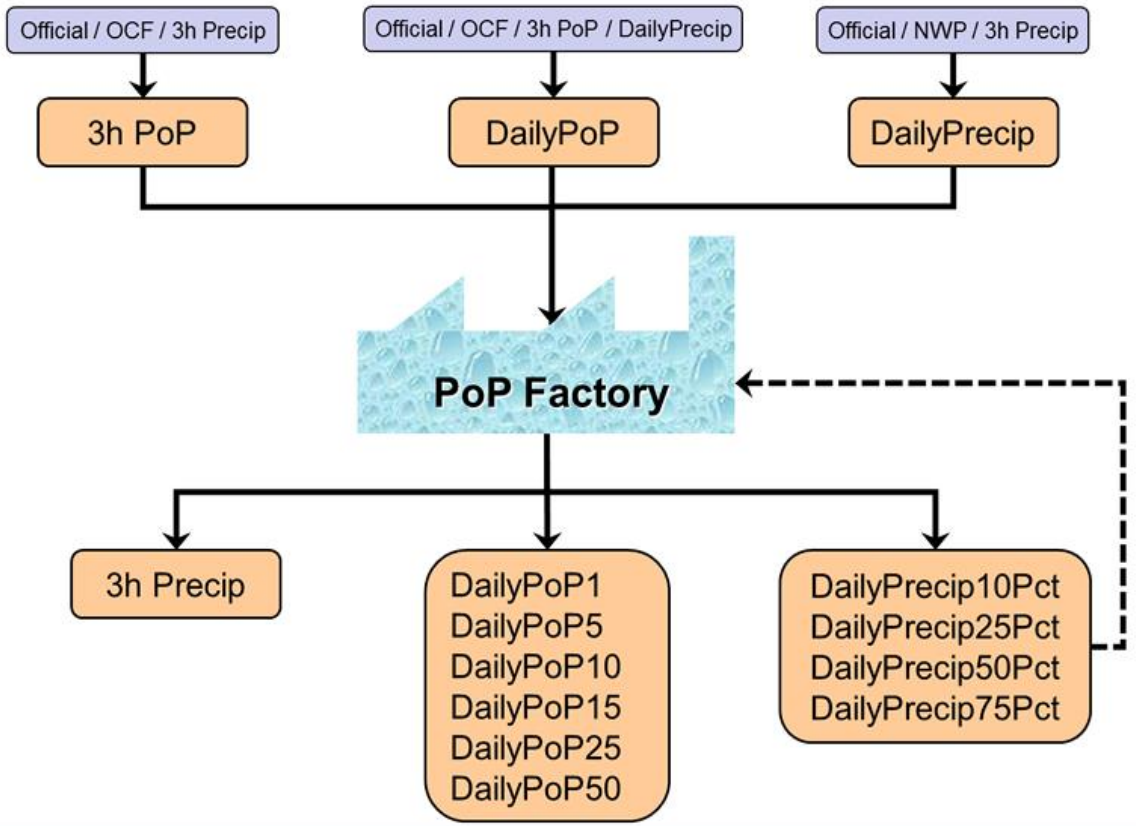
3-hr mean rain

Median rain
25% exceed

10% exceed
(internal)



Precipitation Suite Process Map



Meteorologist input on the 3hrPop, DailyPop, DailyPrcip

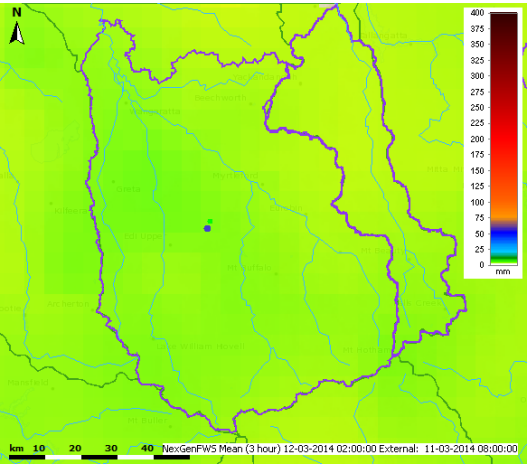
Meteorologist can also review and update the Daily 10, 25,50, 75 Precip

Statistically internally consistent across many fields.

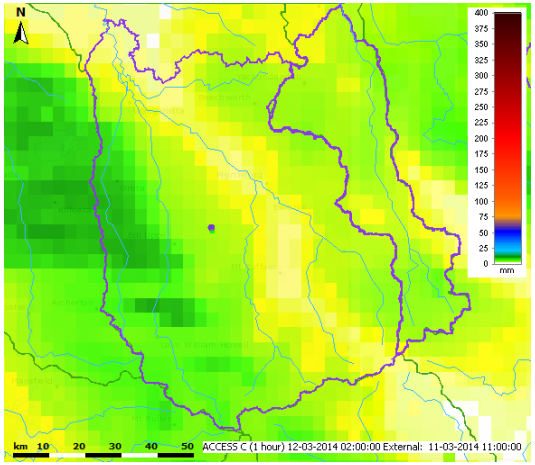
We hope that official forecasts are the best, because of forecaster expertise.

These are the official policy forecasts.

Meteorologist generated



Weather model output



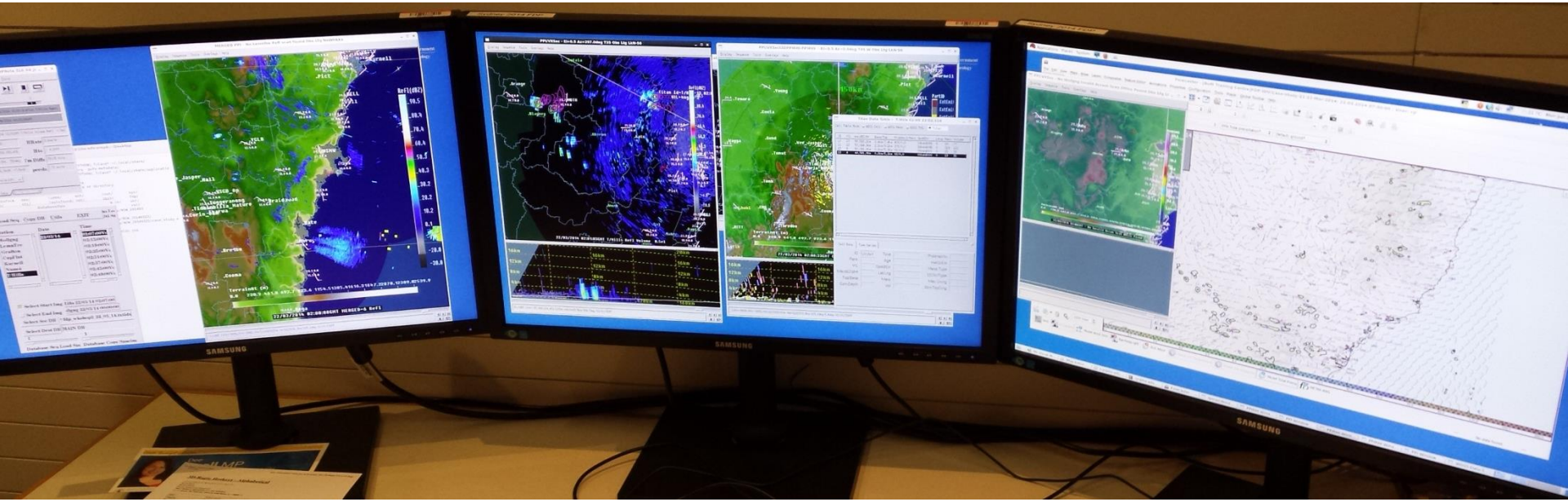
Meteorologist's fields are smoother than model's fields (similar to ensemble mean of many models).

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 km^2 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

http://scottbridle.com/my-images/gulf-of-carpentaria