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 competition.

Fill in the blanks:
“\text{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 between ____ and ____ people.”

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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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Operational Highlight: Flood Risk Management Commission

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For discussion: Are we getting the best possible information from climate information?
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.
Types of Bureau of Meteorology hydrologic prediction services

Flash flooding

Currently a meteorological (rainfall based) severe weather product
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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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Short-term forecasts (began 2013, planned public release 2015)
Hydrographs, centralized, automated, hourly, deterministic, GR4J model
Types of Bureau of Meteorology hydrologic prediction services

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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.
Seasonal Streamflow Forecasting Approach

- POAMA Global Climate Model
- Rainfall, Streamflow Data
- Atmosphere, Sea Surface Monitoring Data
- Rainfall Downscaling
- Dynamic Models
- Statistical Models
- Merging
- Probabilistic Forecast of Streamflow Monthly and 3 Monthly

Current (statistical)
Seasonal Streamflow Forecasting Approach

Registered User
Release: Nov 2014
(Dynamic)

POAMA Global Climate Model

Rainfall Downscaling

Dynamic Models

Rainfall, Streamflow Data

Atmosphere, Sea Surface Monitoring Data

Statistical Models

Merging

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Registered User Release: Nov 2014 (Dynamic)

Current (statistical)

POAMA Global Climate Model

Rainfall, Streamflow Data

Atmosphere, Sea Surface Monitoring Data

Dynamic Models

Statistical Models

Merging

Probabilistic Forecast of Streamflow Monthly and 3 Monthly

Registered User Release: July 15 (Merged)
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)

Seasonal forecast products

Tercile maps

Water year in perspective

Cumulative flow statistics

- Climatology 25% to 75%
- Climatology Median
- Observed 2014
- Forecasts 25% to 75%

Exceedance probabilities

Acheron River at Taggerty (405209)
Forecast period: Sep 2014 - Nov 2014

Box plots

Murray River at Biggara (401012)
Forecast period: Jul 2014 - Sep 2014

Probability distributions

Terciles from historical data

Murray River at Biggara
Last twelve months of streamflow

Tercile forecasts

Fifteen Mile Creek at Greta South (403213)
Forecast period: Jul 2014 - Sep 2014

Percentage of forecast in each tercile

- Near median flow: 38.1%
- Low flow: 12.4%
- High flow: 40.5%

Terciles applied to forecast distribution

- Tercile 1 (Low flow)
- Tercile 2 (Near median flow)
- Tercile 3 (High flow)
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.

<table>
<thead>
<tr>
<th>Model</th>
<th>Domain</th>
<th>Resolution</th>
<th>Leadtime</th>
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<tbody>
<tr>
<td>ACCESS-G</td>
<td>Global</td>
<td>~40km</td>
<td>10 days</td>
</tr>
<tr>
<td>ACCESS-R</td>
<td>Regional</td>
<td>0.11° (~12km)</td>
<td>3 days</td>
</tr>
<tr>
<td>ACCESS-C</td>
<td>City</td>
<td>0.036° (~4km)</td>
<td>1.5 days</td>
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<tr>
<td>ACCESS-TC</td>
<td>Relocatable</td>
<td>0.11° (~12km)</td>
<td></td>
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</tbody>
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Outlines: Flood model catchments (containing dozens of subareas)

ACCESS-G forecast
(40 km, +10 days)
What currently feeds
the short-term
deterministic flow forecasts
Spatial scales of hydrologic and weather models

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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)
Catchment-average ACCESS rainfall forecast skill vs leadtime

Daily rainfall vs Catchment average (daily)
Hourly rainfall vs Catchment average (hourly)

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

Simple rainfall scenario (e.g. 50 mm everywhere over 12 hours)

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)
Meteorologist input on the 3hrPop, DailyPop, DailyPrecip

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.
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

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