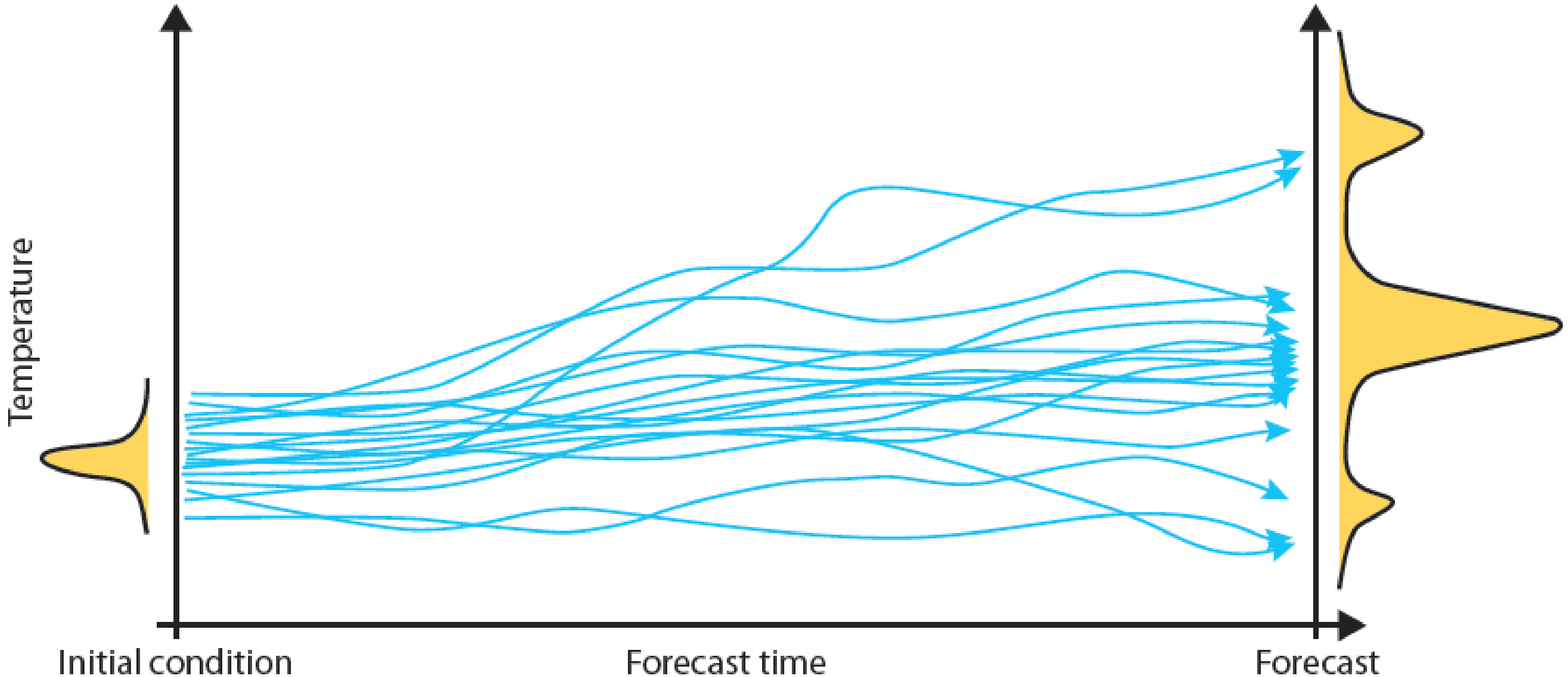
WHY USE ENSEMBLE PREDICTION?

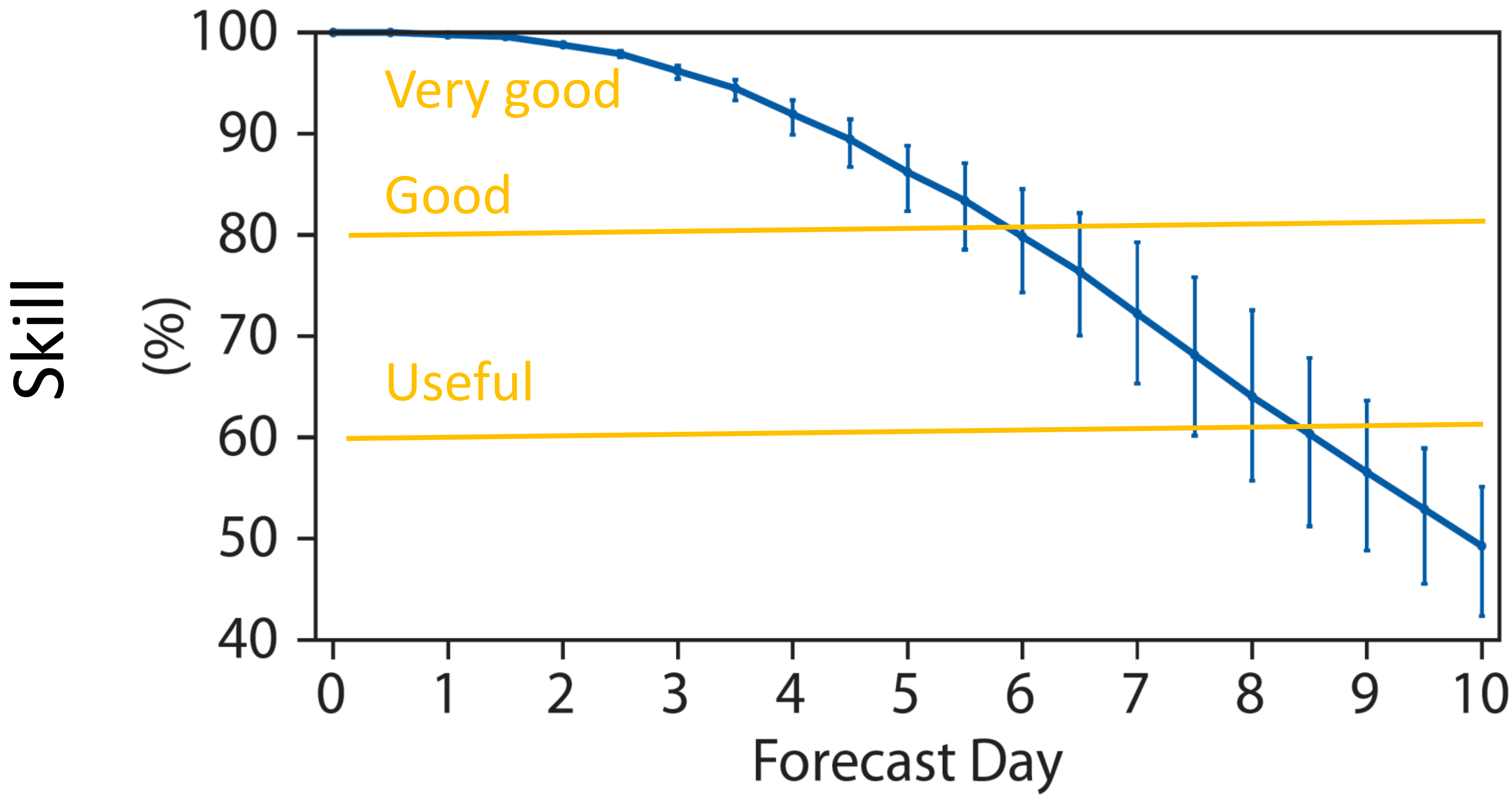
Jeffrey D. Kepert
High Impact Weather Research
Bureau of Meteorology

Australian Government
Department of Industry, Innovation and Science
Business Cooperative Research Centres Programme

WHAT IS ENSEMBLE PREDICTION?



FORECAST MODELS ARE LIKE FOOTBALL TEAMS

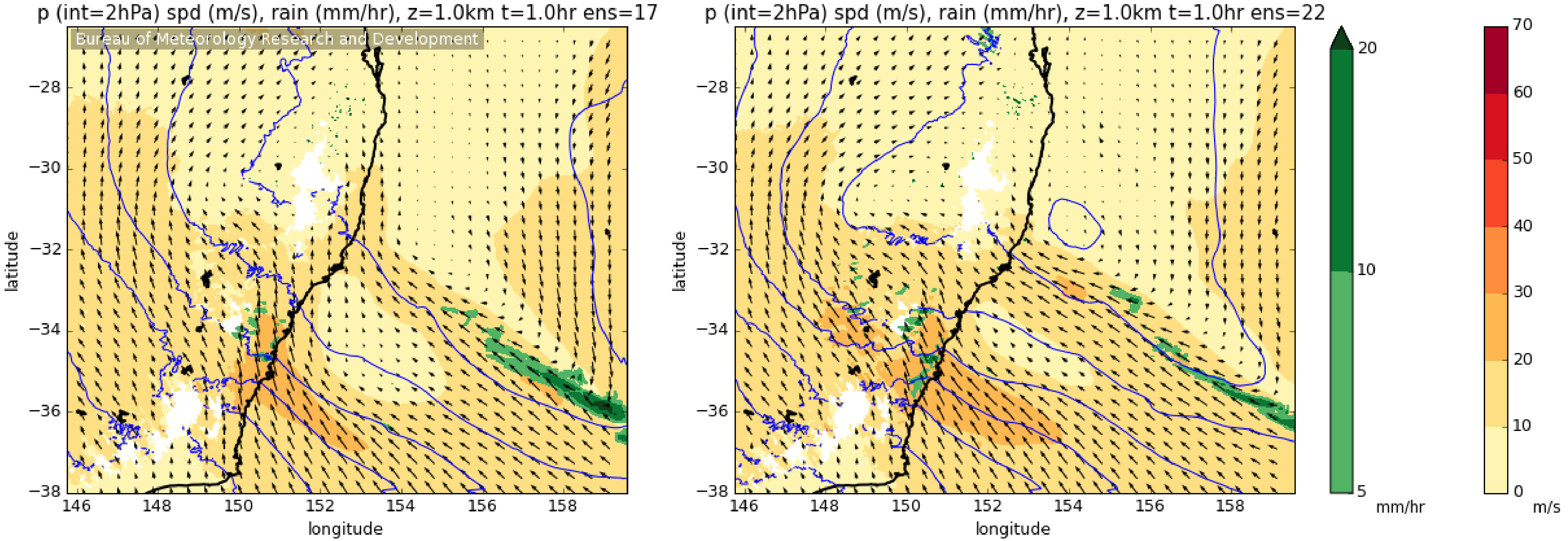


Australian Government

EAST COAST LOW

1) 20 – 23 April 2015
2) Intense low pressure systems that form close to NSW coast
3) Strong winds, heavy rain, major flooding, major waves and coastal erosion
4) 4 deaths
5) Dozens of roofs lost, trees down, > 200000 houses without power, 57 schools closed

TWO MEMBERS OF ENSEMBLE



TWO MEMBERS OF ENSEMBLE

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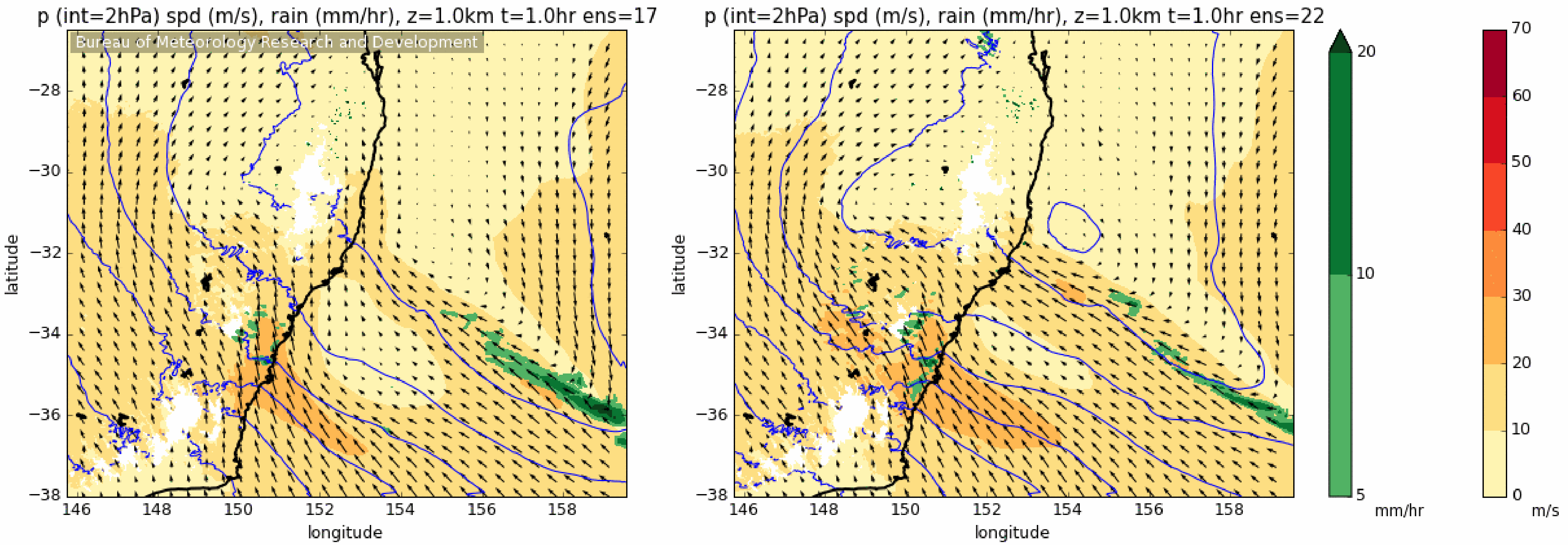
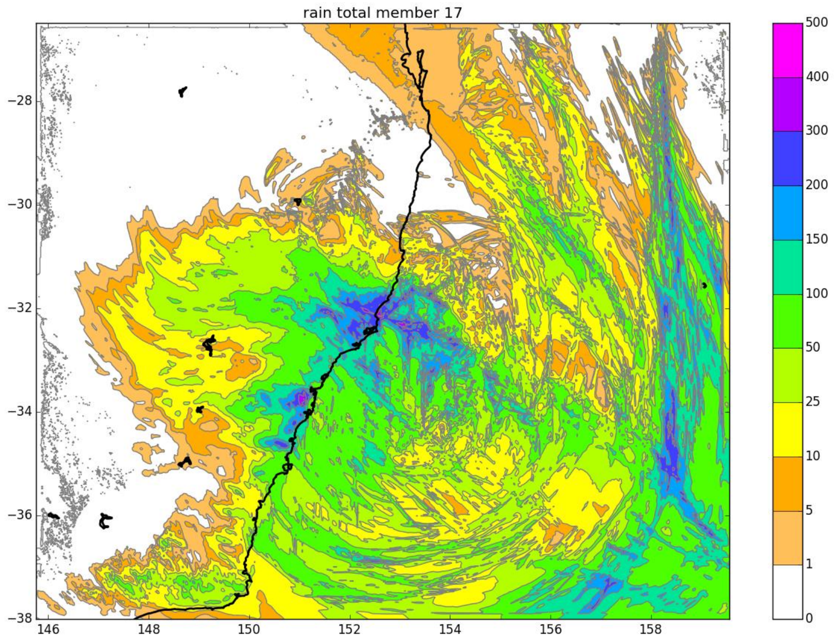
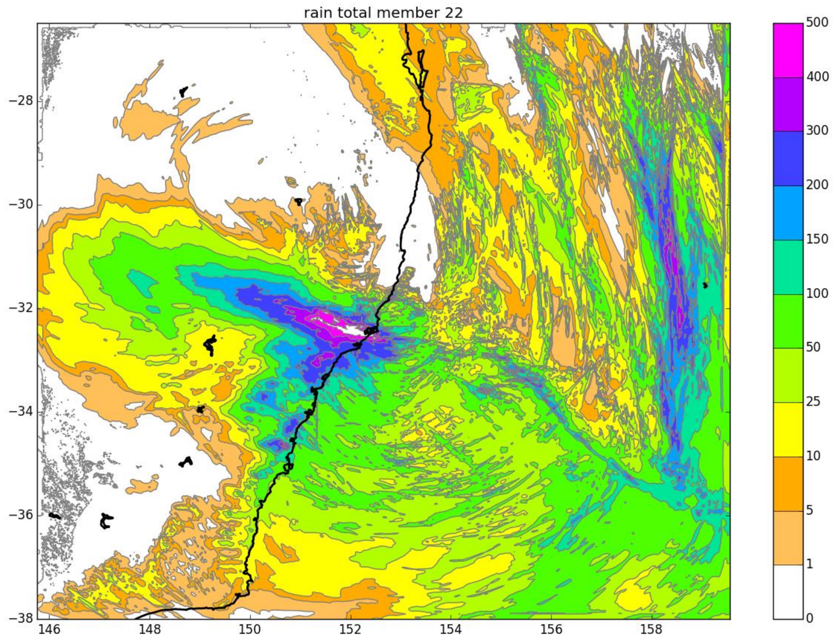


48-HOUR RAINFALL TOTALS





Probabilistic prediction
Greater accuracy
Data assimilation
Observation targeting
Preemptive forecasts
Develop understanding

Once you have an ensemble, many of these are relatively cheap to compute.

WHY USE ENSEMBLE PREDICTION?

Australian Government
Bureau of Meteorology

Risk management
Seamless prediction
Handle inherent uncertainty

PROBABILISTIC PREDICTION

RISK MANAGEMENT

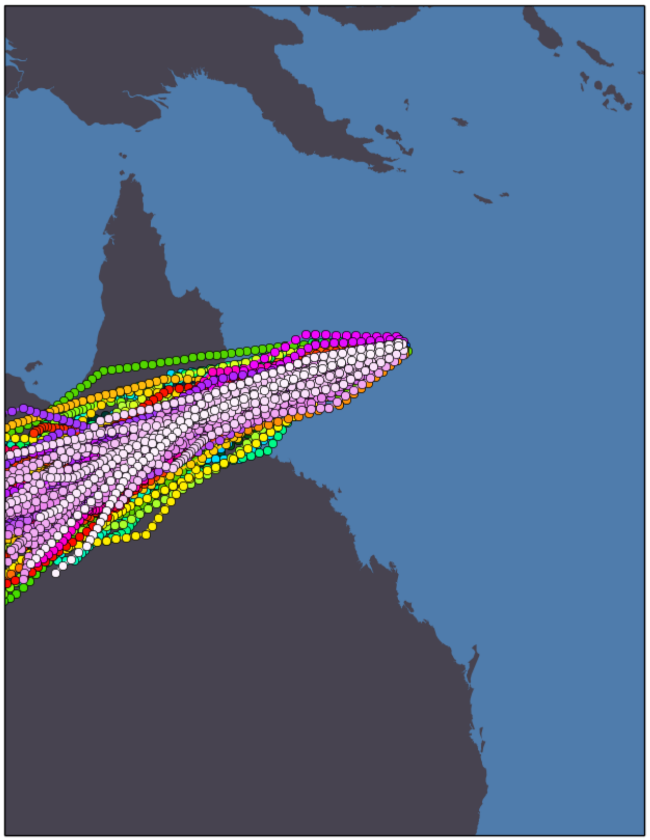
Impact →

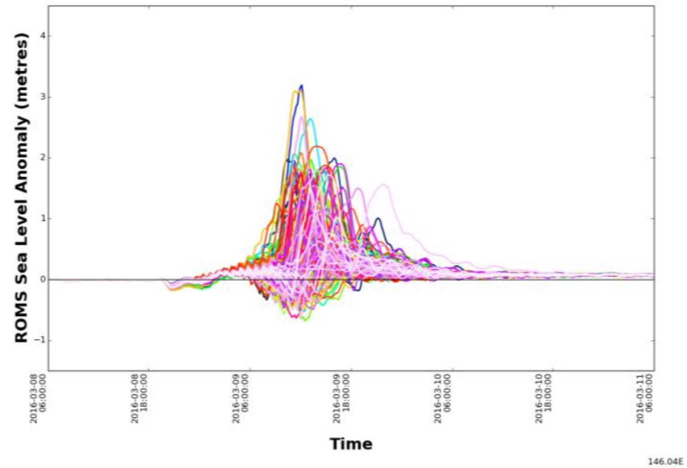
Likelihood ↑

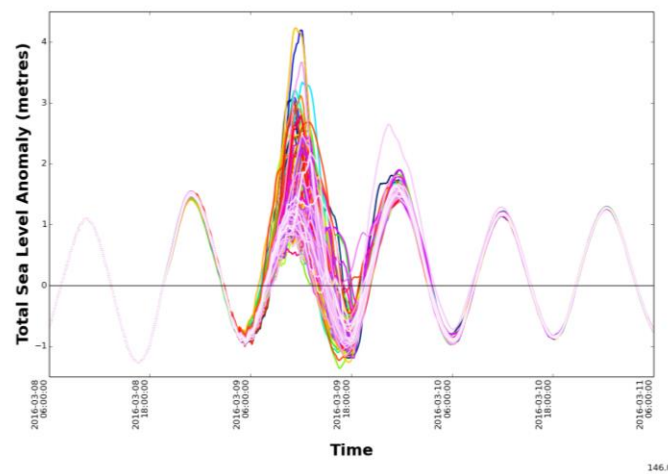
	Negligible	Minor	Moderate	Significant	Severe
Very Likely	Low Med	Medium	Med Hi	High	High
Likely	Low	Low Med	Medium	Med Hi	High
Possible	Low	Low Med	Medium	Med Hi	Med Hi
Unlikely	Low	Low Med	Low Med	Medium	Med Hi
Very Unlikely	Low	Low	Low Med	Medium	Medium

CARDWELL – TC YASI STORM SURGE

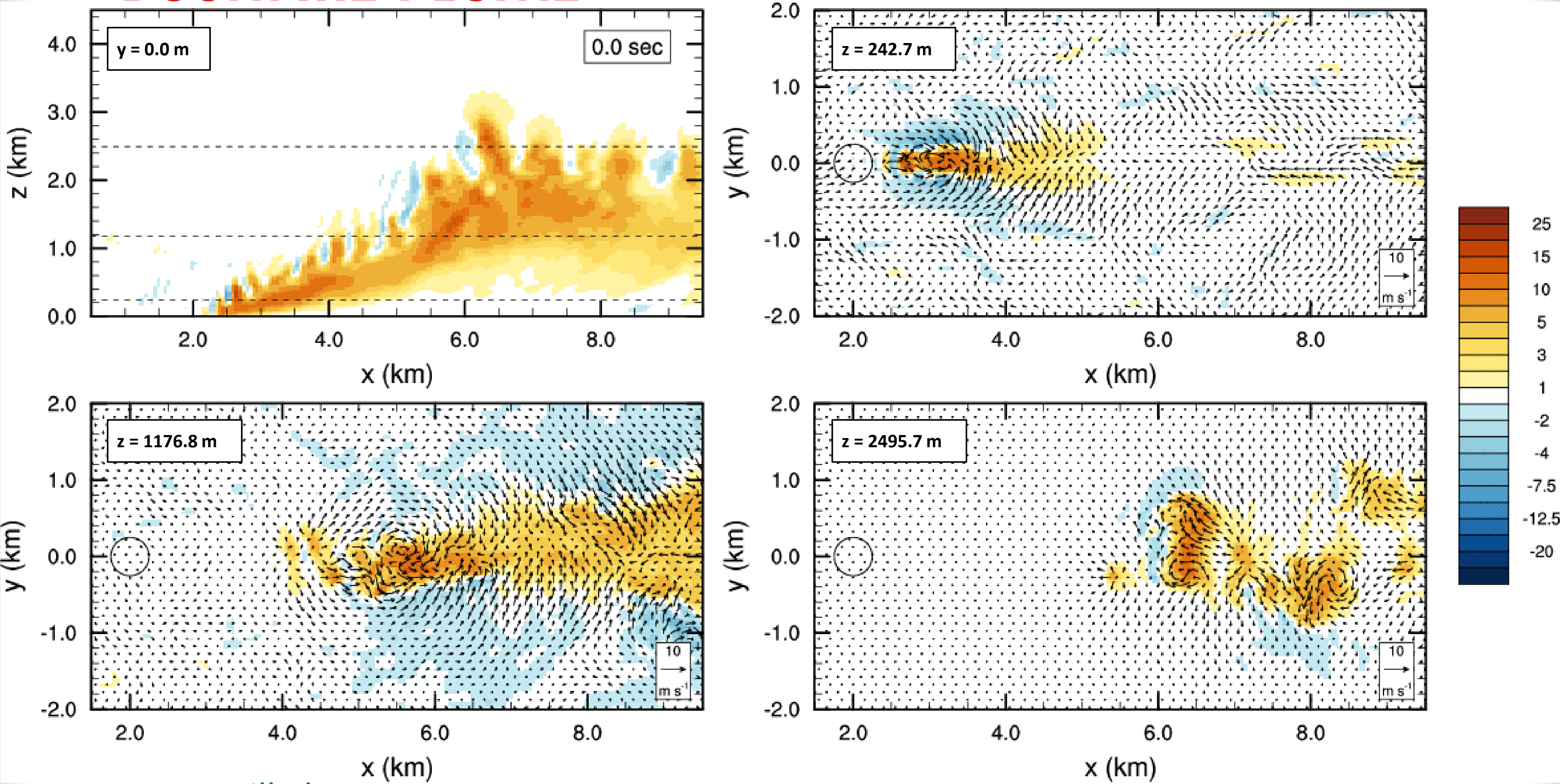
TC YASI – 200 ENSEMBLE MEMBERS







HIGH-RESOLUTION SIMULATION OF A BUSHFIRE PLUME



Courtesy Will Thurston
(see his talk at 2 pm)

FIREBRAND TRANSPORT

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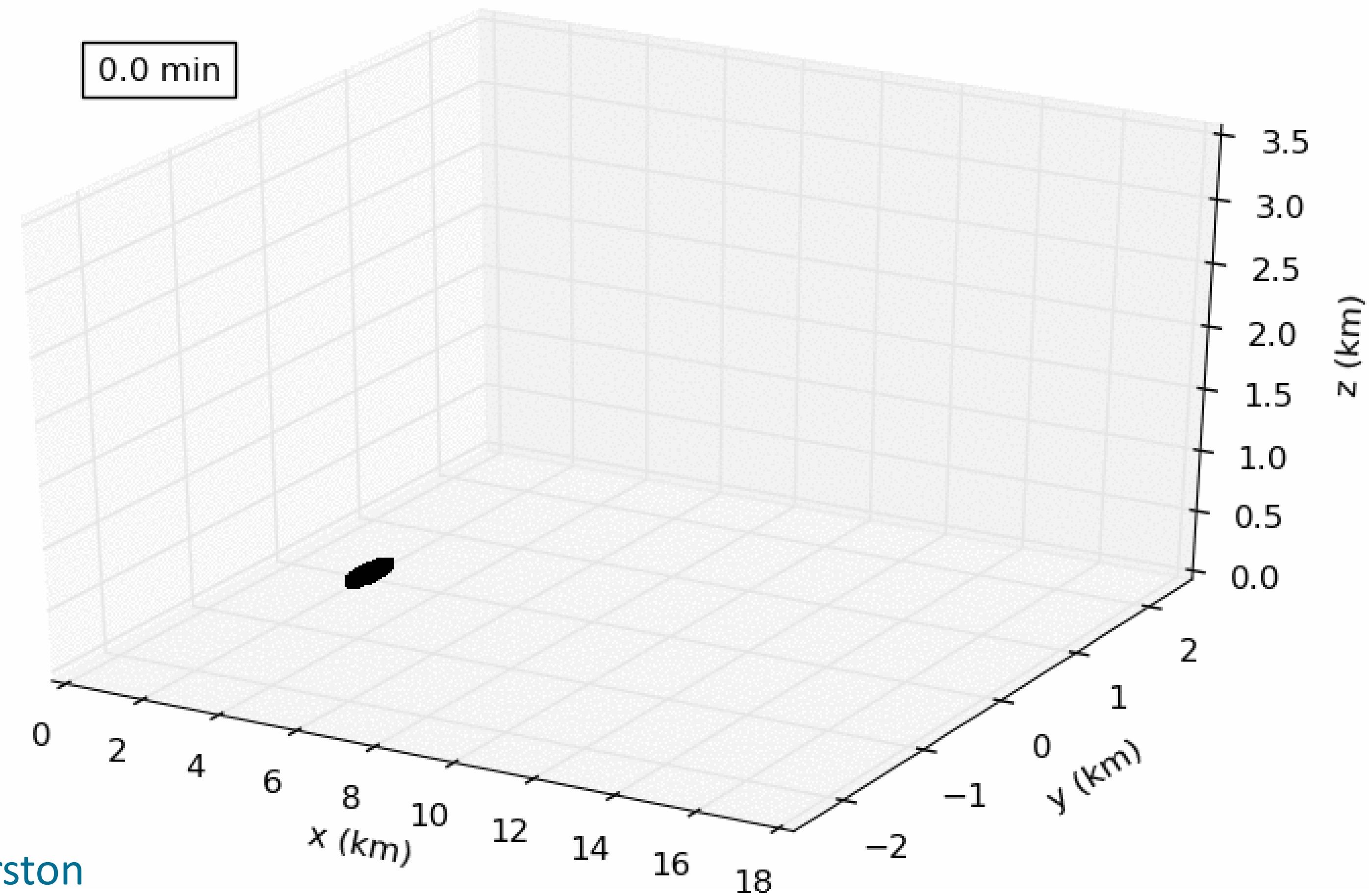
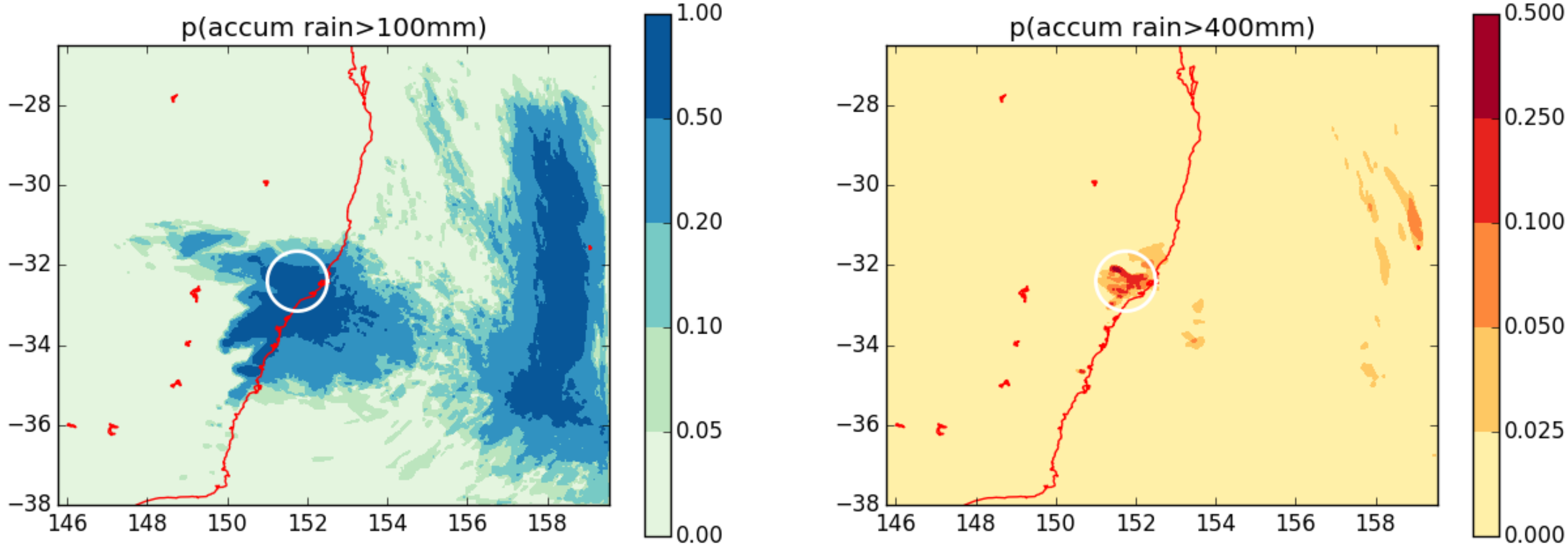


Courtesy Will Thurston
(see his talk at 2 pm)

RAINFALL PROBABILITIES

Australian Government
Bureau of Meteorology



Probabilities of 48-hour total rainfall exceeding 100 mm and 400 mm

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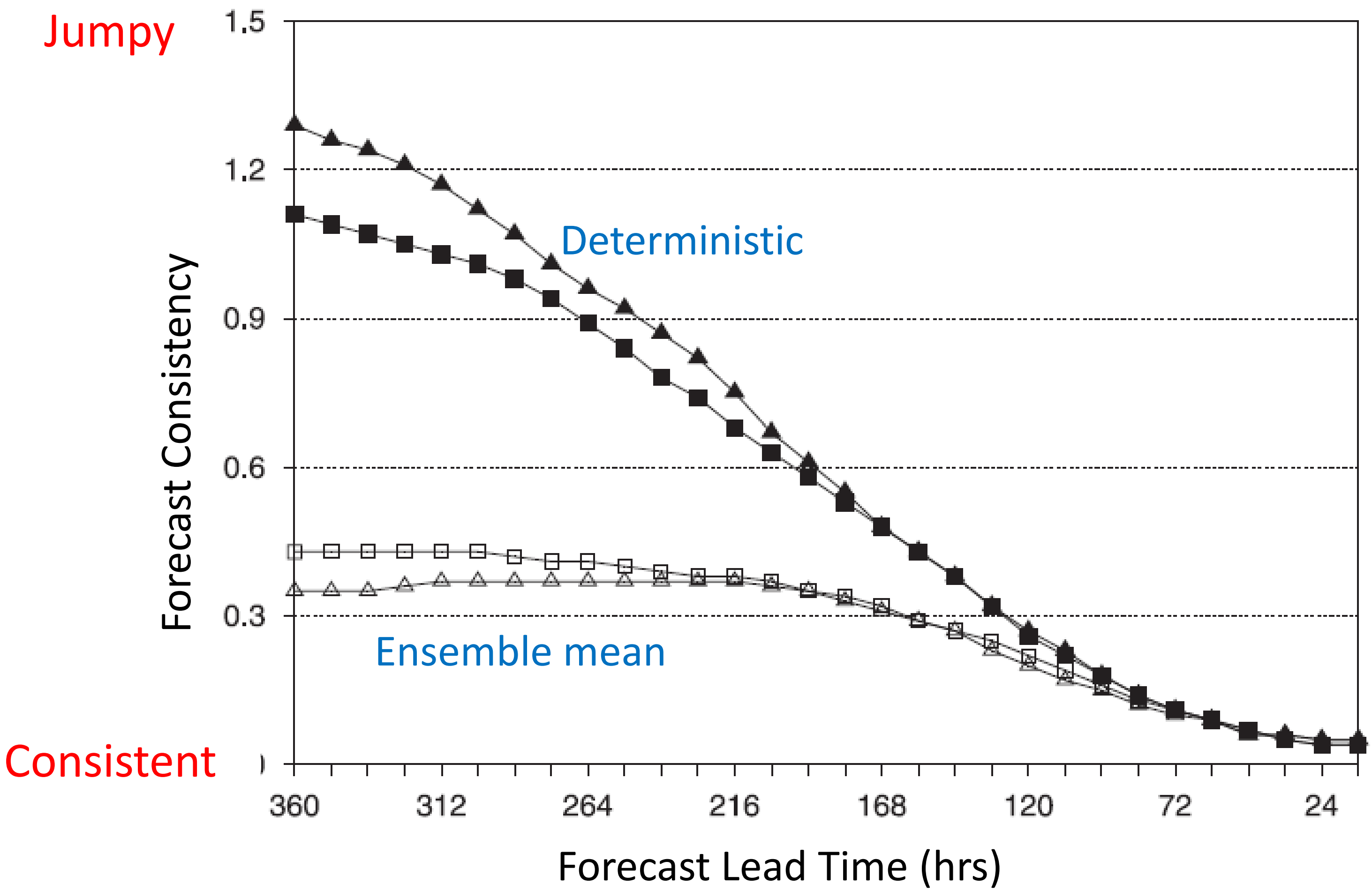
Bureau of Meteorology

Ensemble predictions systems are more consistent

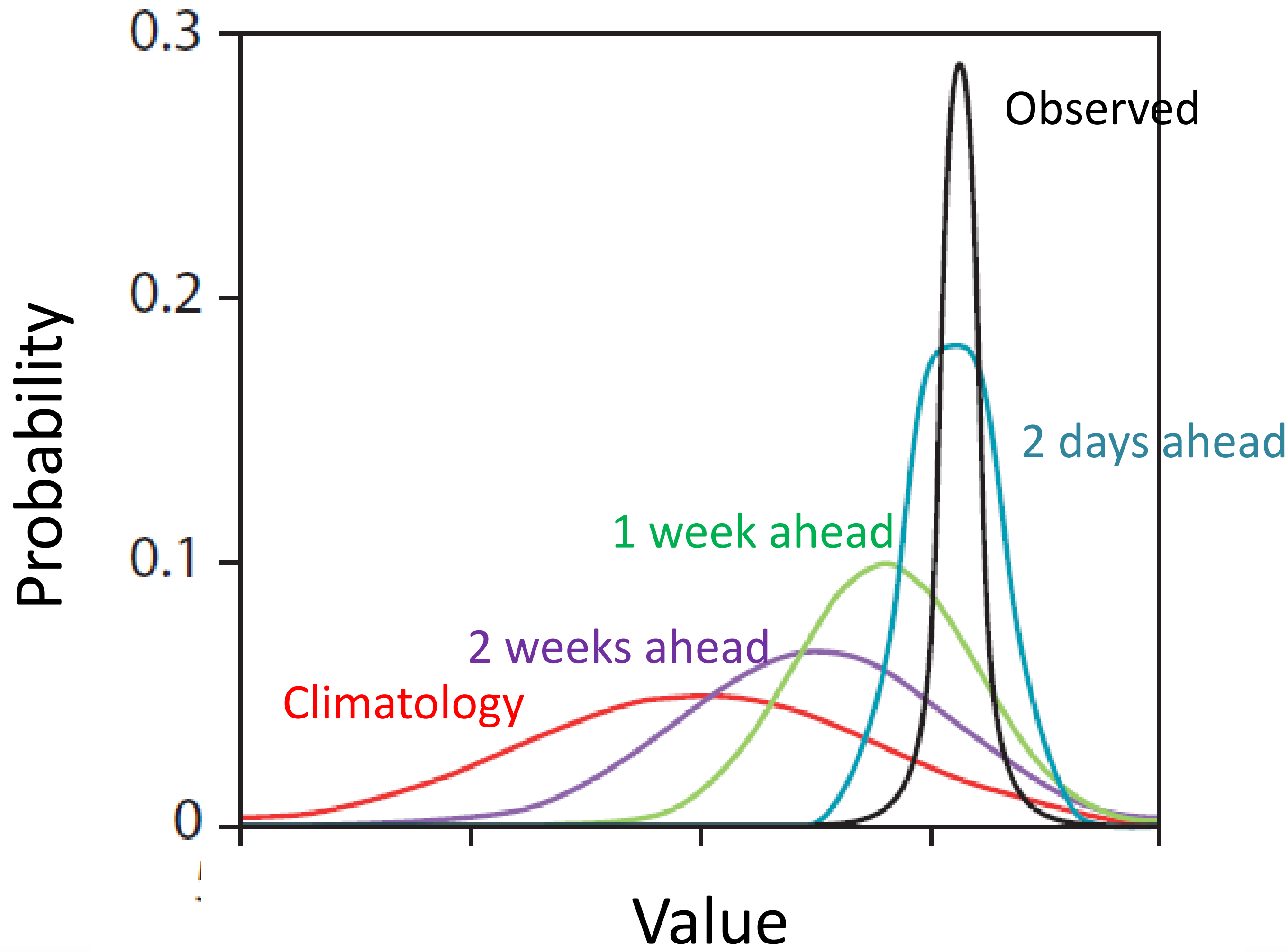
SEAMLESS PREDICTION

THE ENSEMBLE MEAN IS MORE CONSISTENT



Zsoter et al. (2009 QJRMS)

SEAMLESS PRECISION

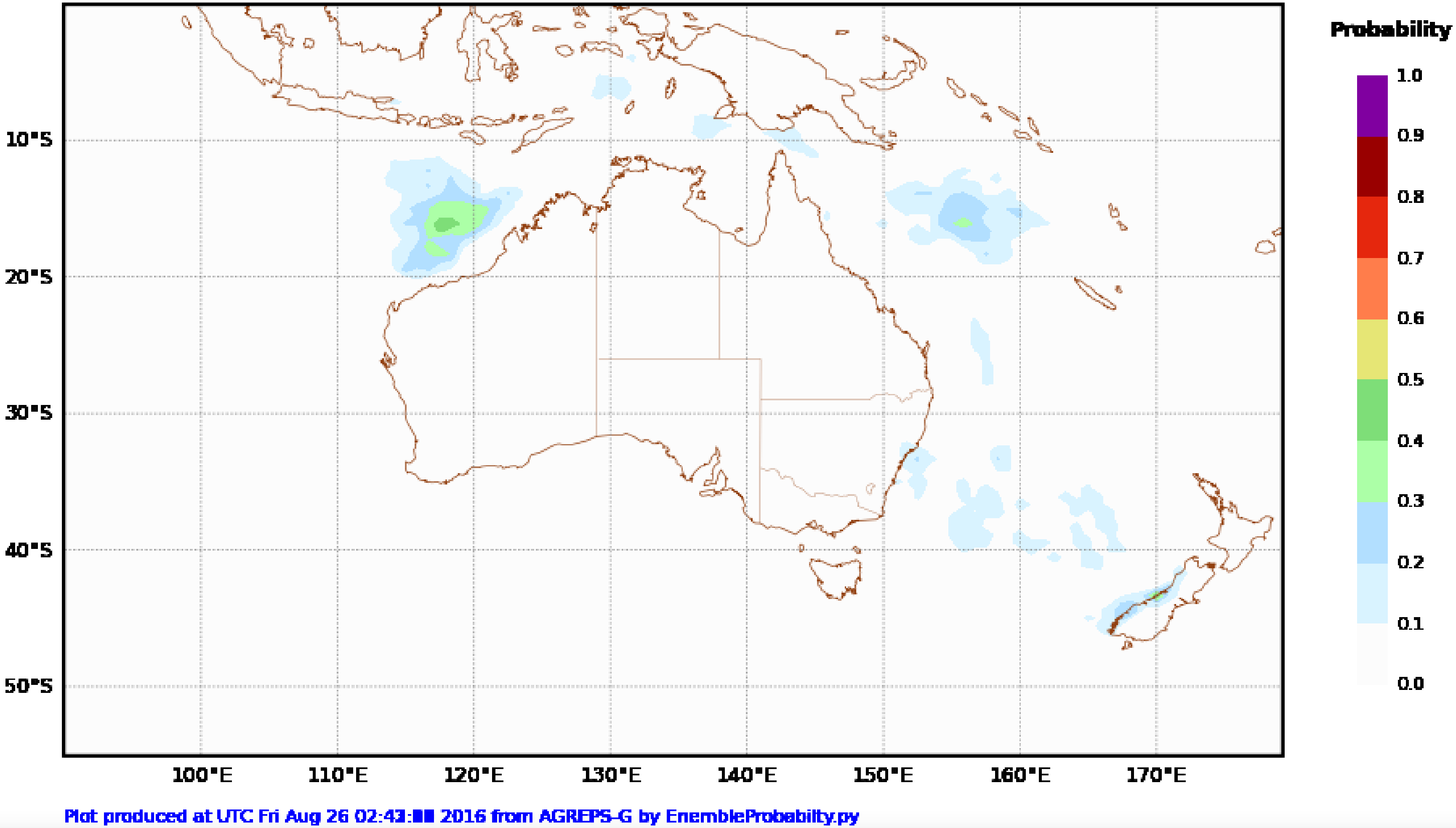


EAST COAST LOW PROBABILITIES

Australian Government
Bureau of Meteorology

Probability of 24 hr rainfall > 25 mm

T + 7.5 days



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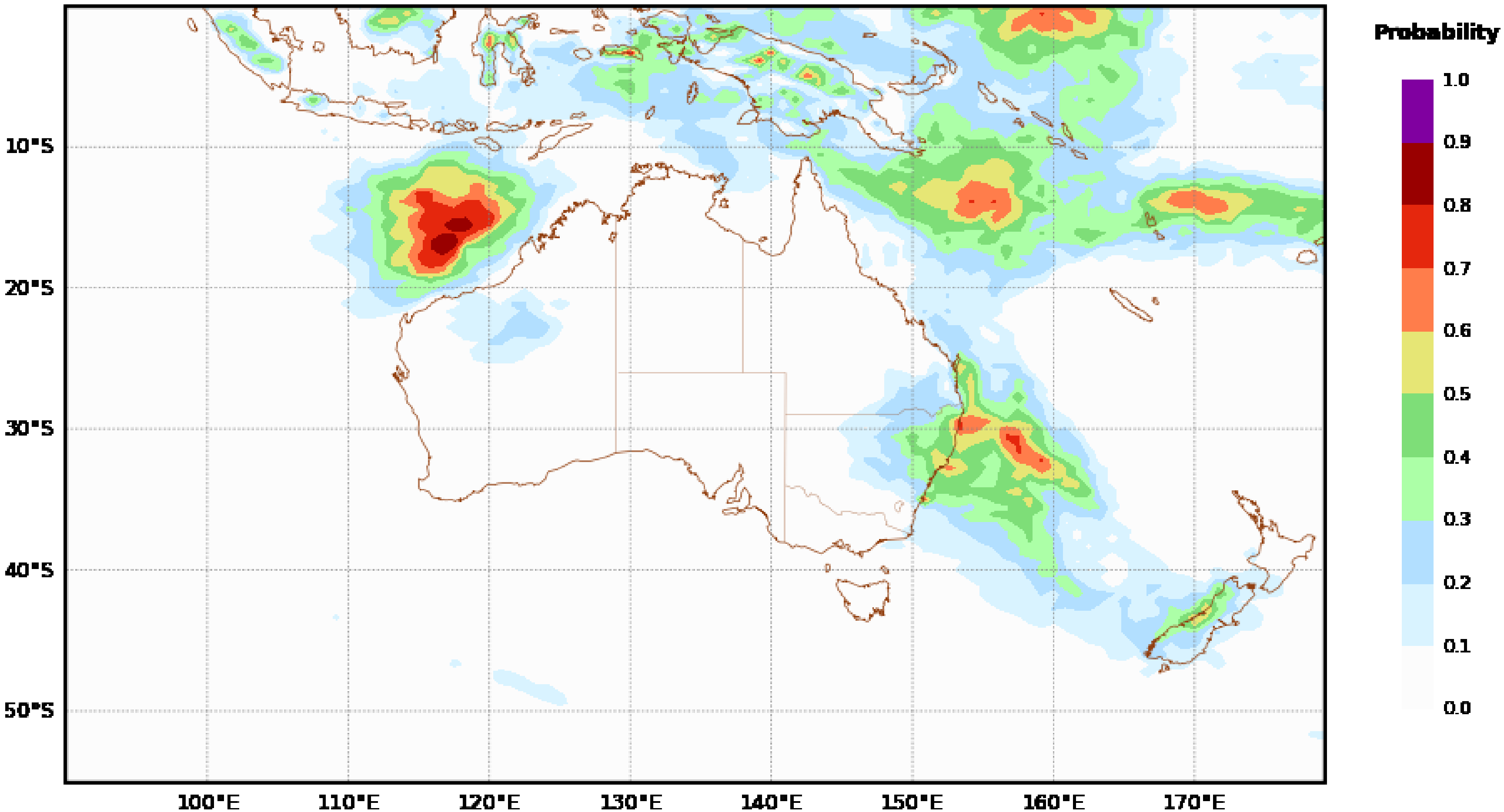
Bureau of Meteorology

EAST COAST LOW PROBABILITIES

Probability of 24 hr rainfall > 25 mm

T + 6.5 days

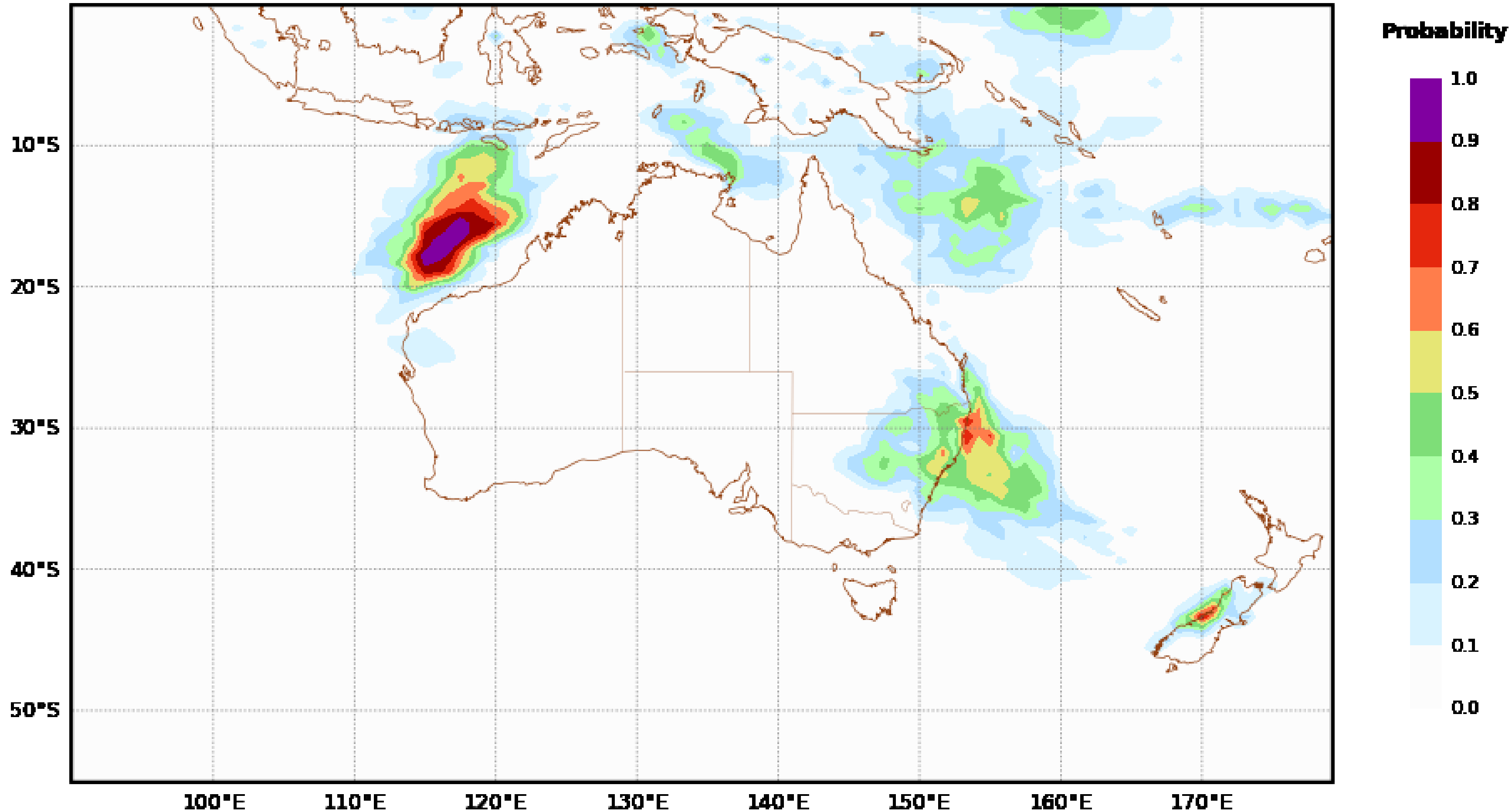


Plot produced at UTC Fri Aug 26 01:22:[redacted] 2016 from AGREPS-G by EnembleProbabilty.py

EAST COAST LOW PROBABILITIES

Probability of 24 hr rainfall > 25 mm

T + 5.5 days

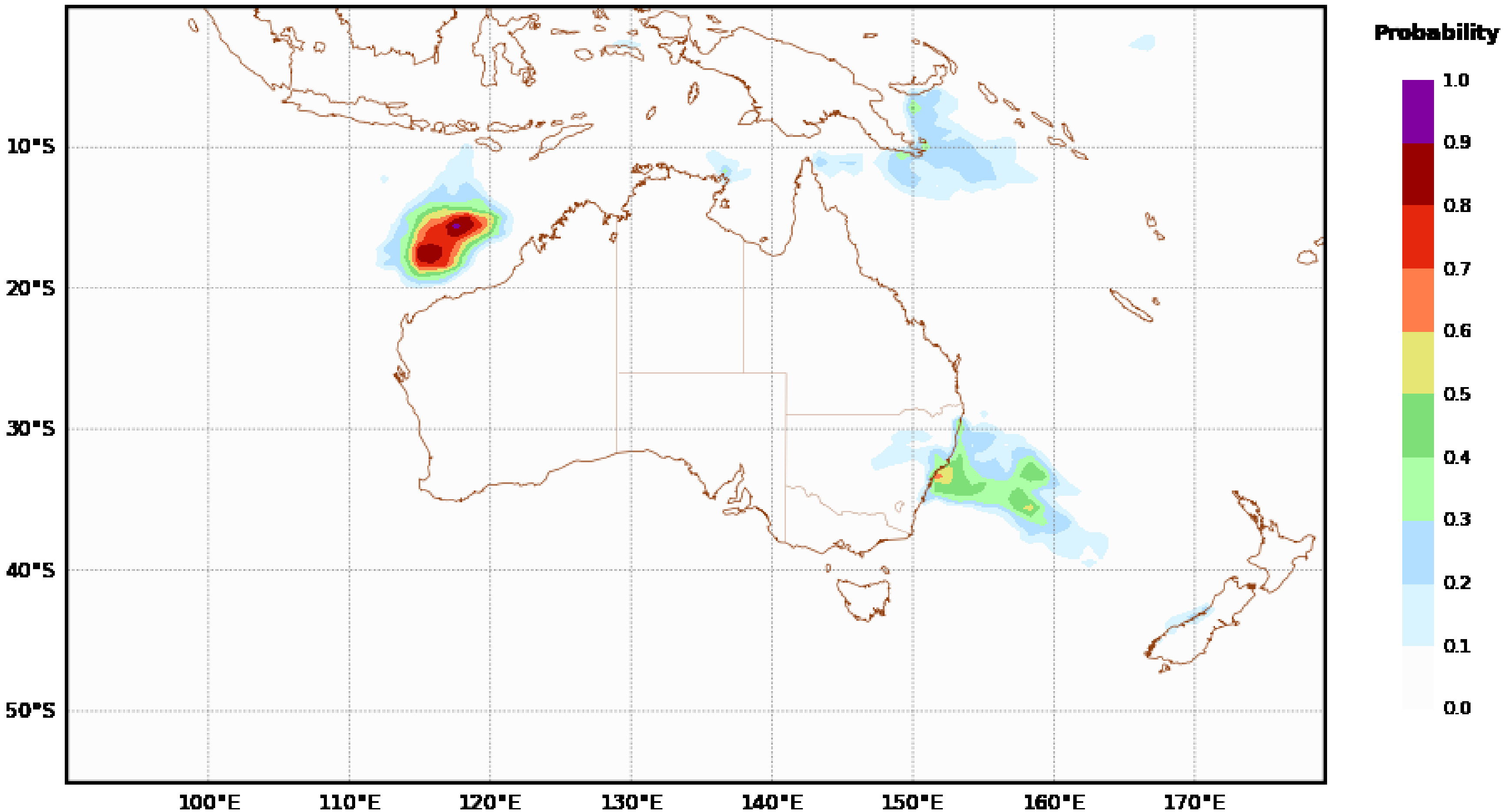


Plot produced at UTC Fri Aug 26 01:0■:■■ 2016 from AGREPS-G by EnembleProbabilty.py

EAST COAST LOW PROBABILITIES

Probability of 24 hr rainfall > 25 mm

T + 4.5 days



Plot produced at UTC Fri Aug 26 00:4[illegible] 2016 from AGREPS-G by EnembleProbabilty.py

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EAST COAST LOW PROBABILITIES

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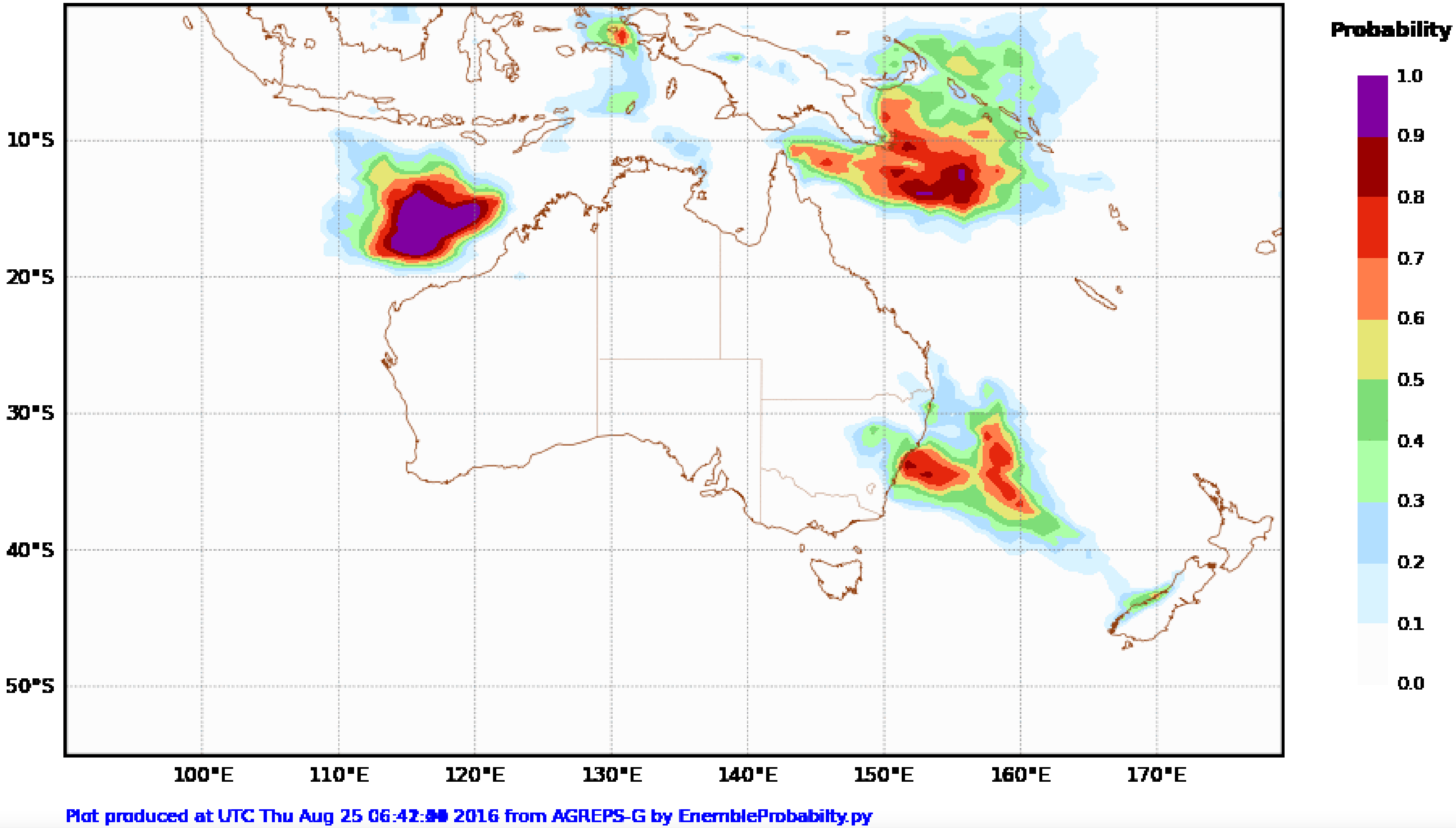
Probability of 24 hr rainfall > 25 mm

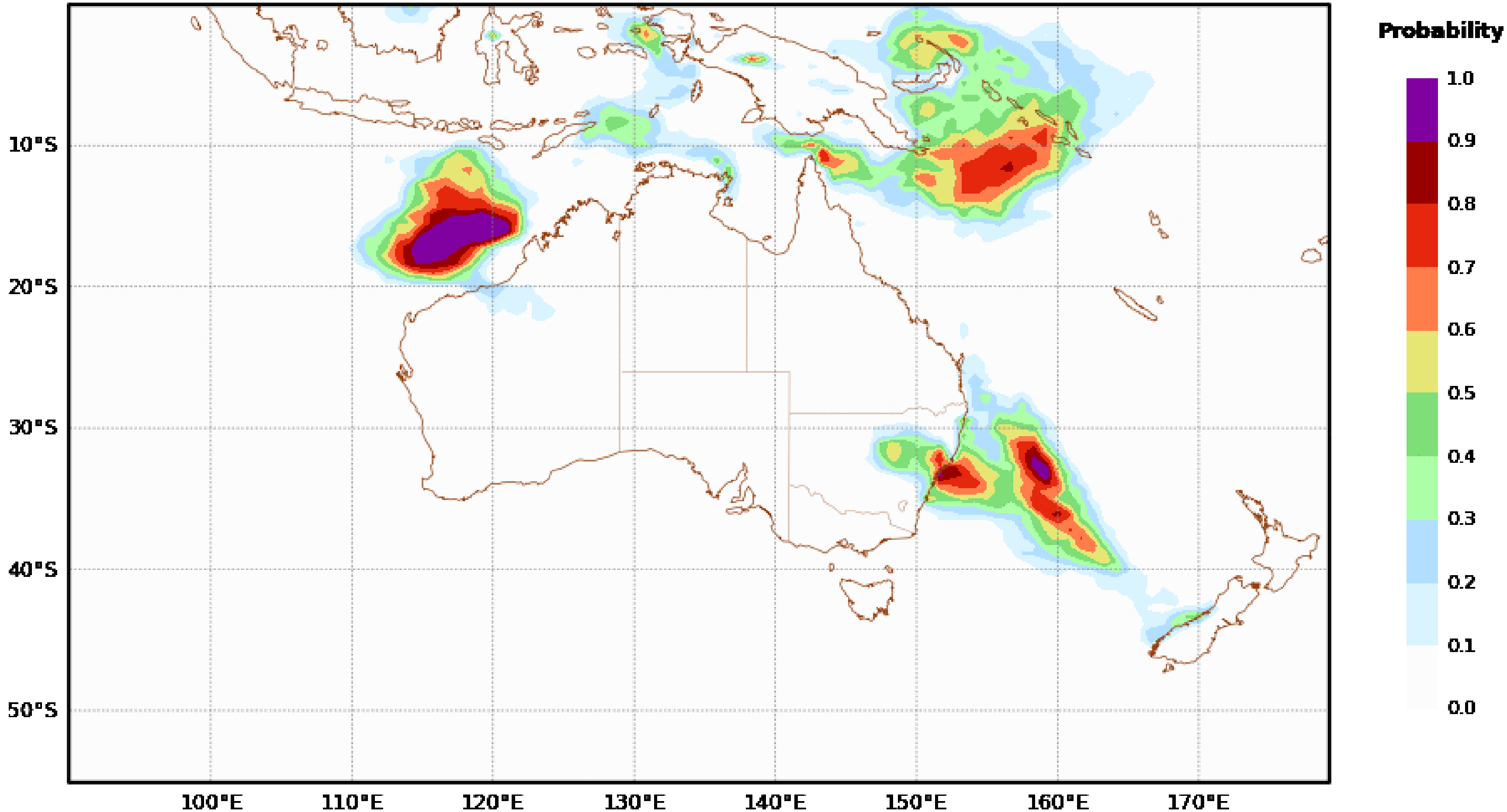
T + 3.5 days



EAST COAST LOW PROBABILITIES

Probability of 24 hr rainfall > 25 mm

T + 2.5 days

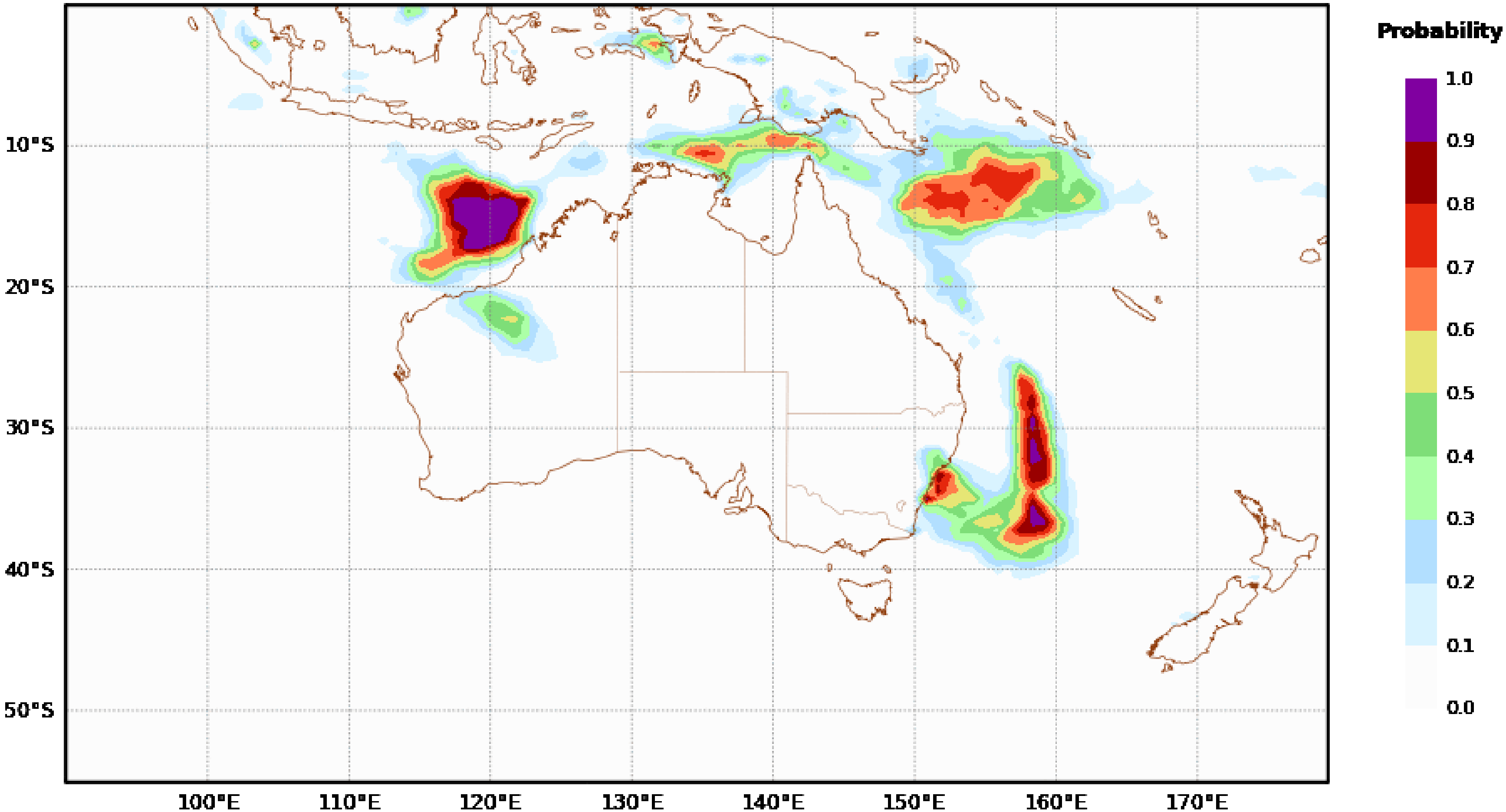


Plot produced at UTC Thu Aug 25 07:13:00 2016 from AGREPS-G by EnembleProbabilty.py

EAST COAST LOW PROBABILITIES

Probability of 24 hr rainfall > 25 mm

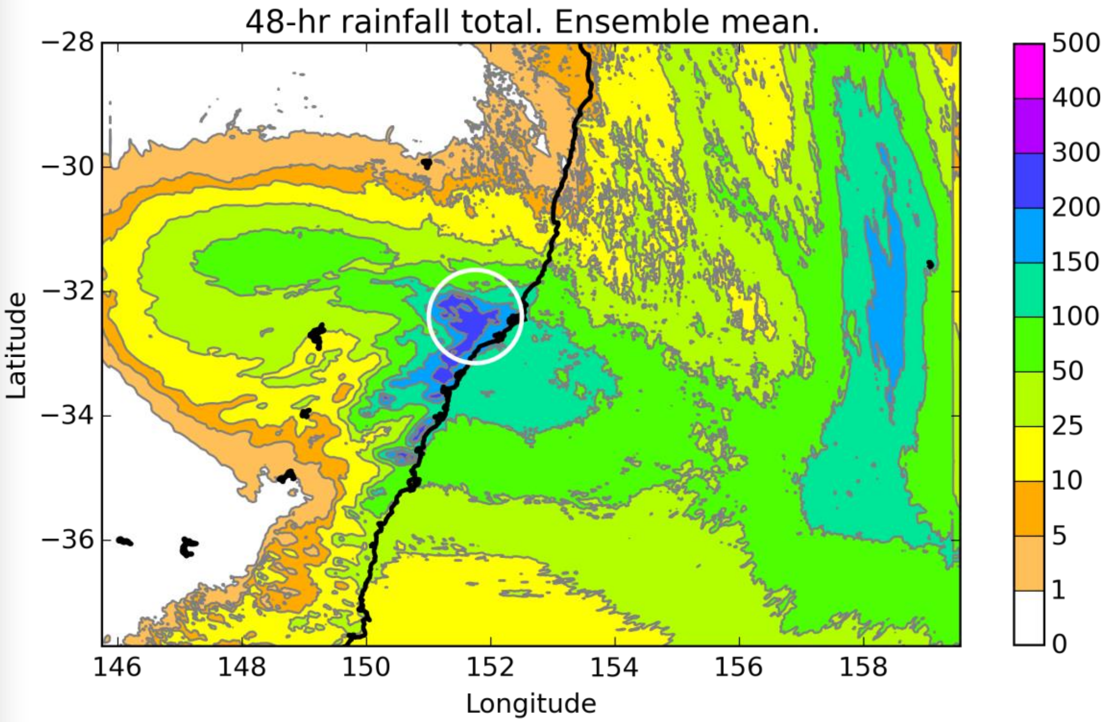
T + 1.5 days

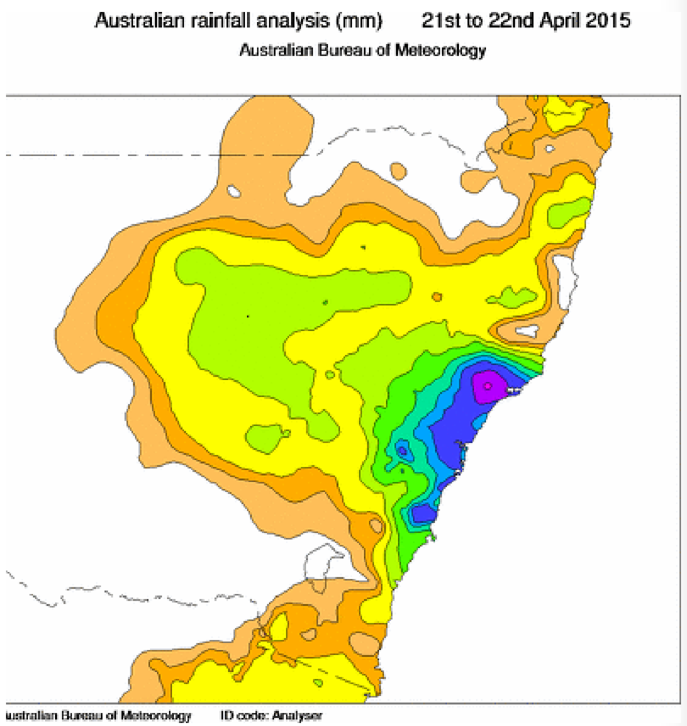


Plot produced at UTC Thu Aug 25 07:32:[illegible] 2016 from AGREPS-G by EnembleProbabilty.py

GREATER ACCURACY

48-HR RAINFALL ENSEMBLE MEAN





PROBABILITY-MATCHED ENSEMBLE MEAN

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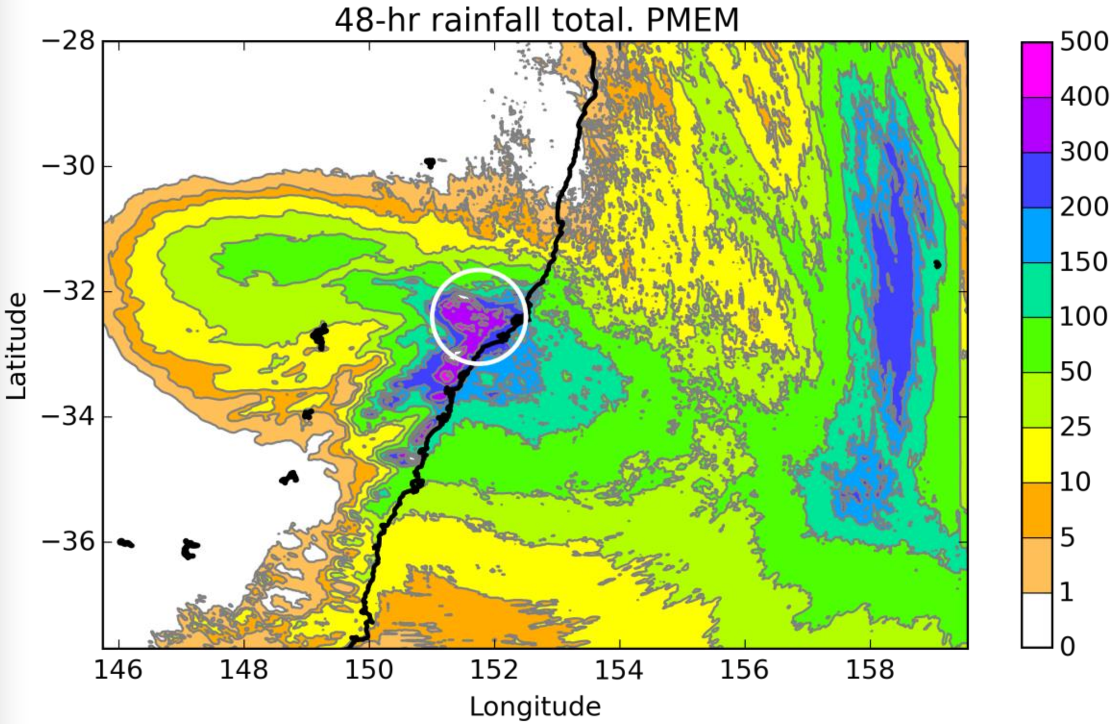

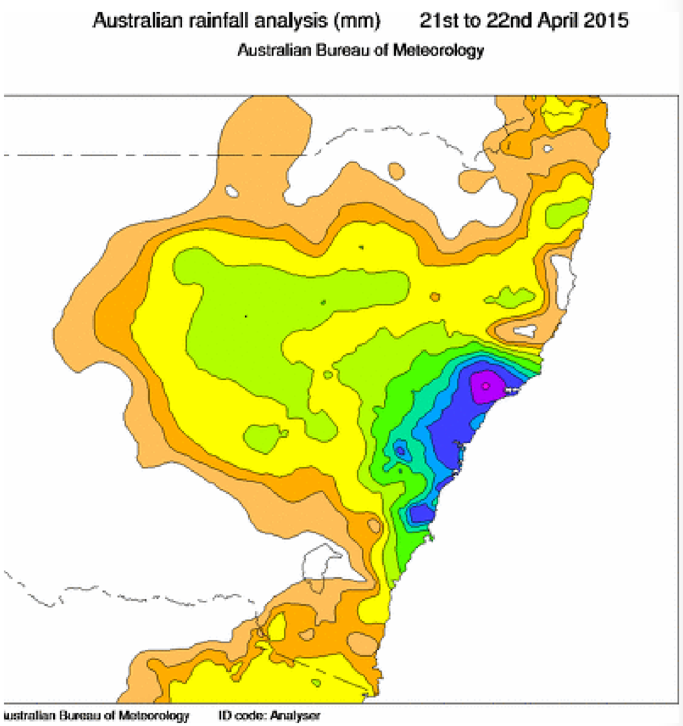

Ensemble DA
Fire model DA

DATA ASSIMILATION

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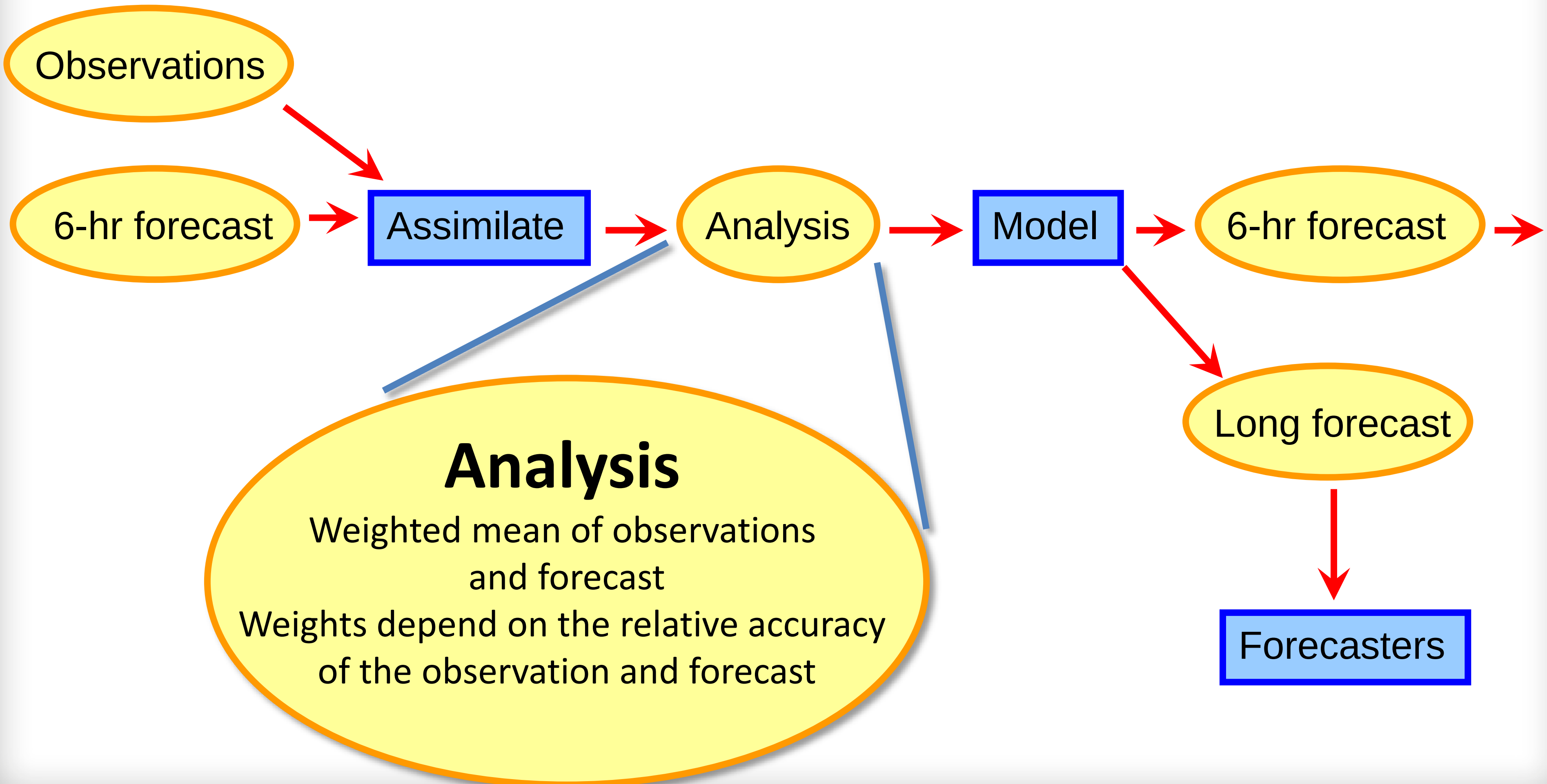
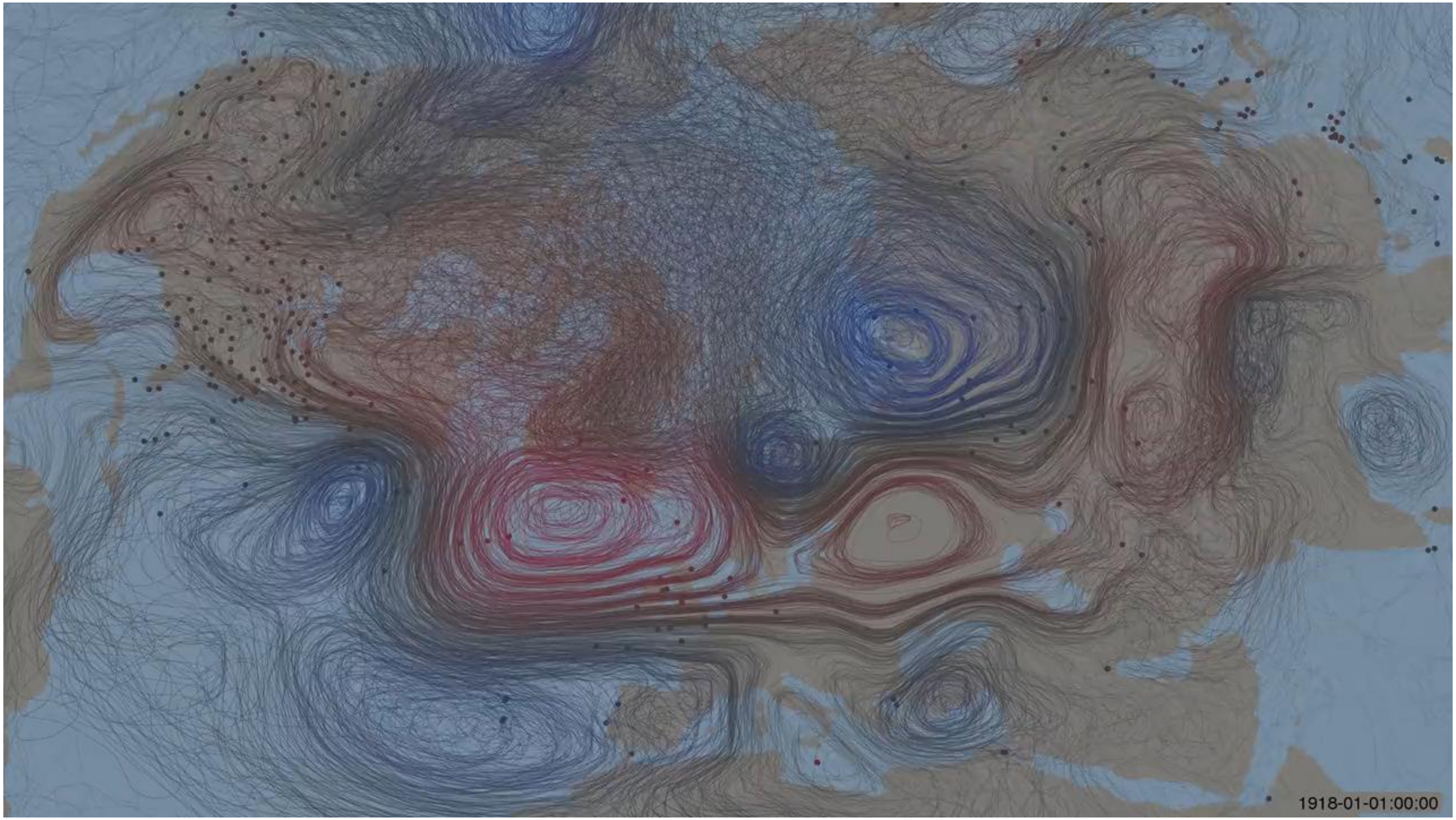
THE NUMERICAL WEATHER PREDICTION CYCLE

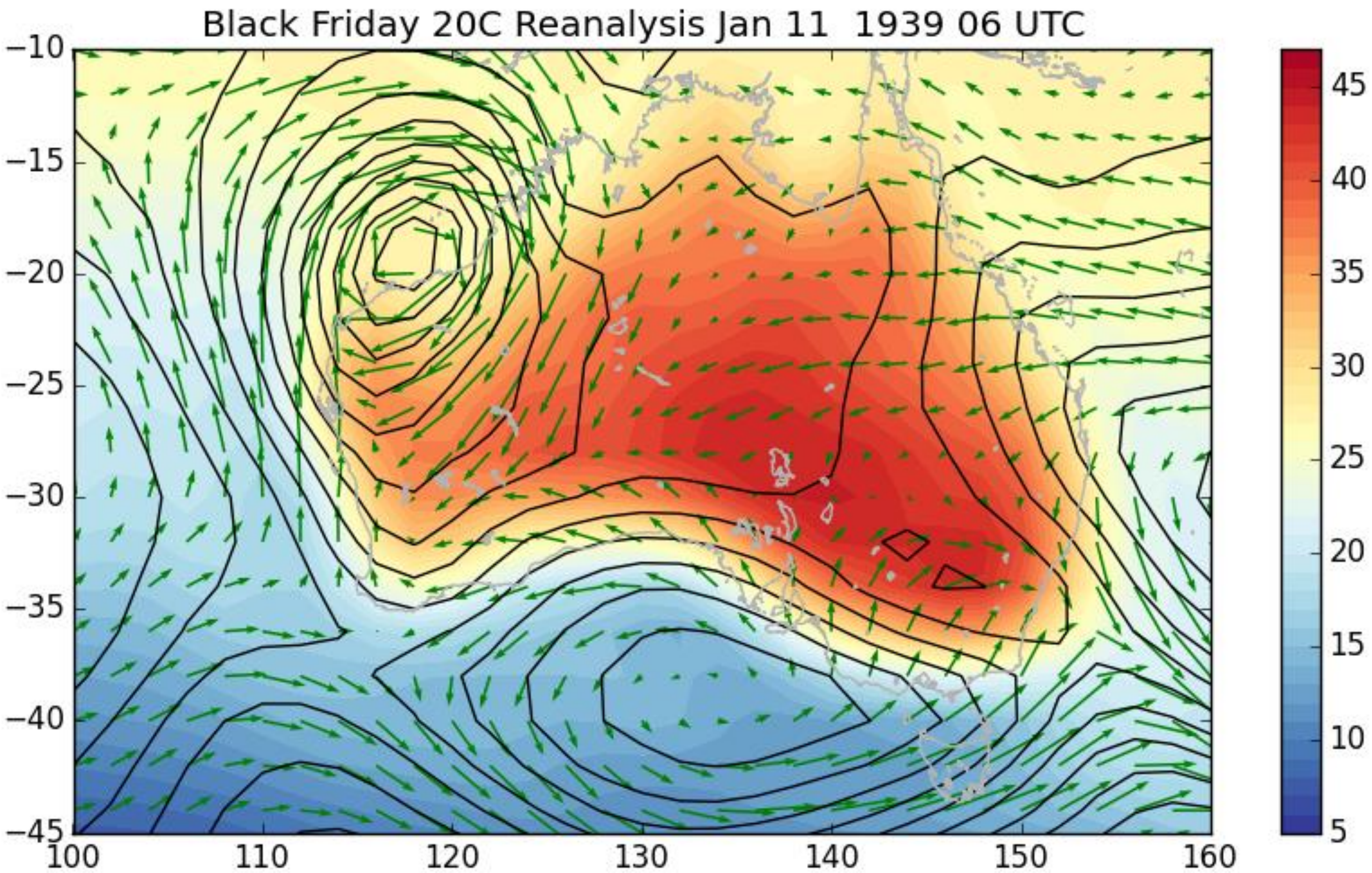


20C REANALYSIS EXAMPLE



BLACK FRIDAY 1939

Australian Government
Bureau of Meteorology



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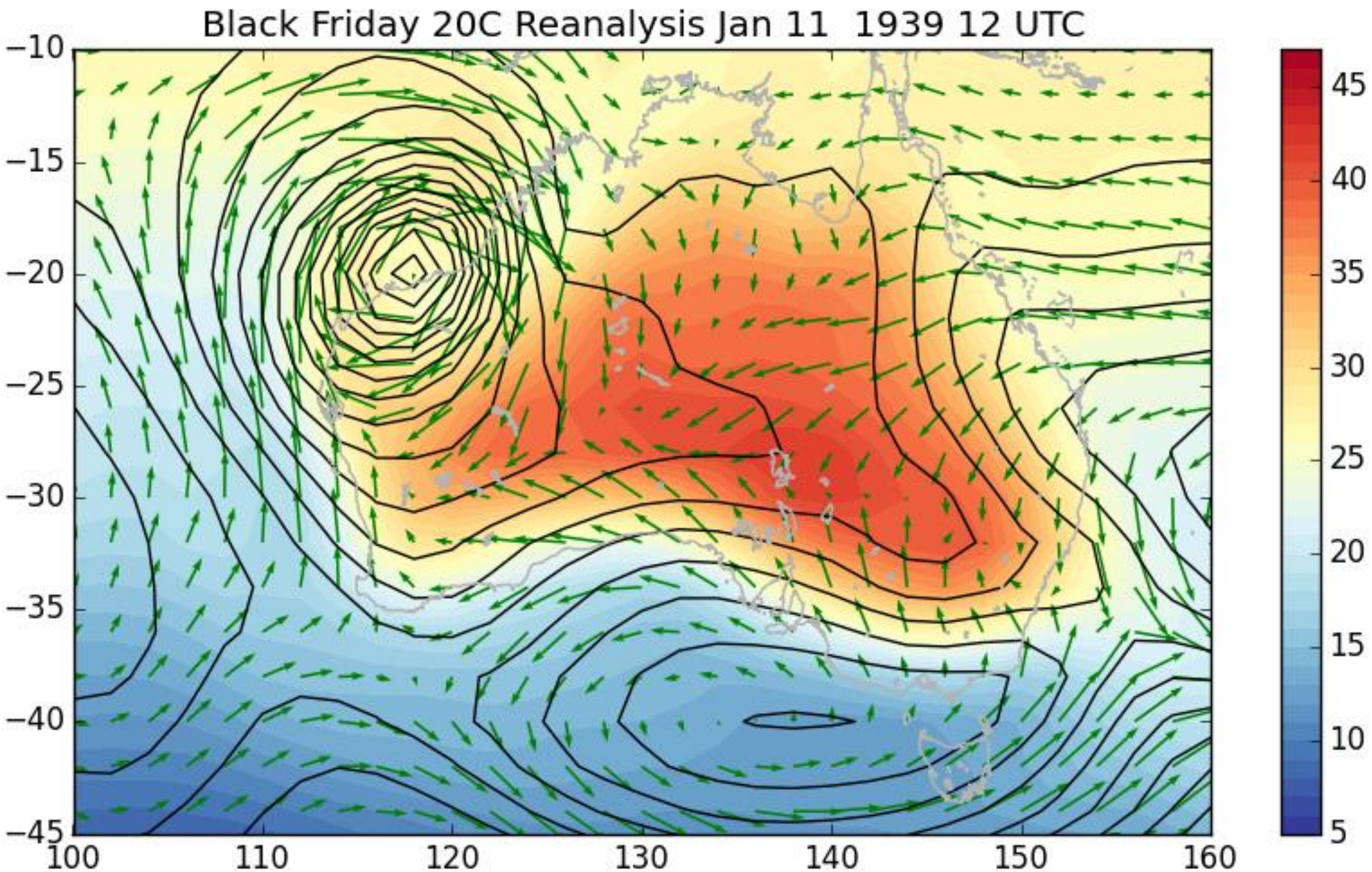

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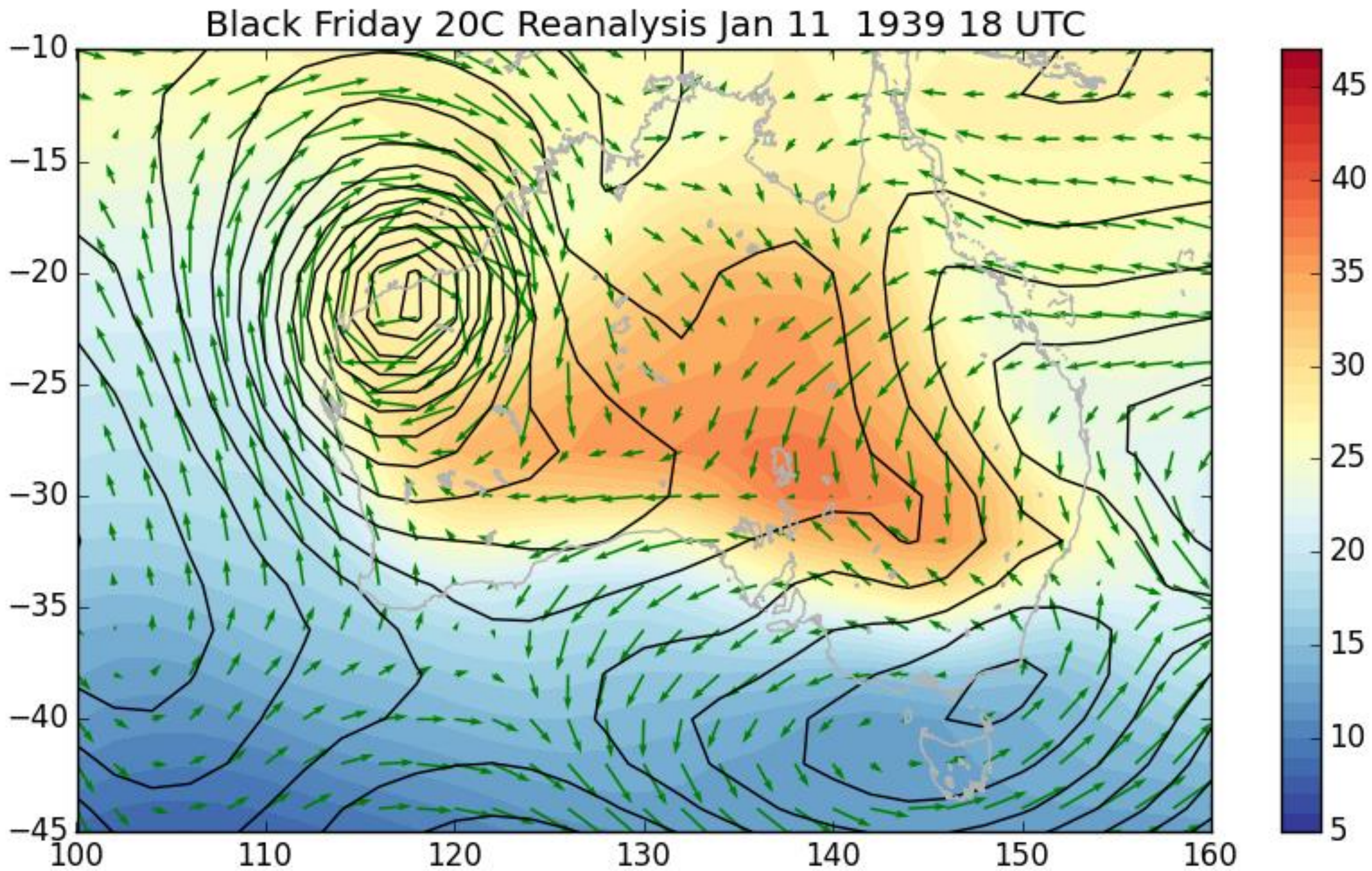

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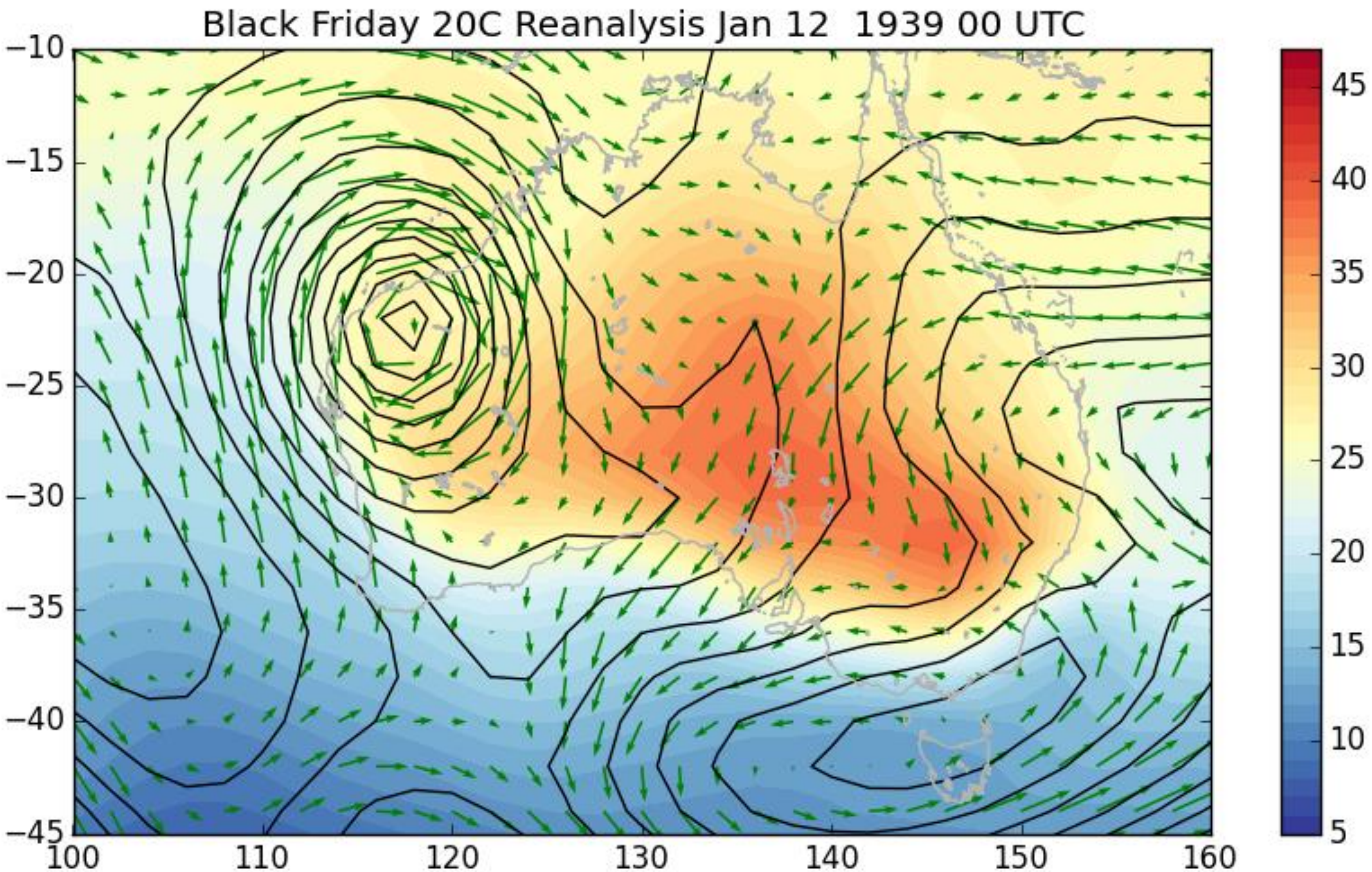

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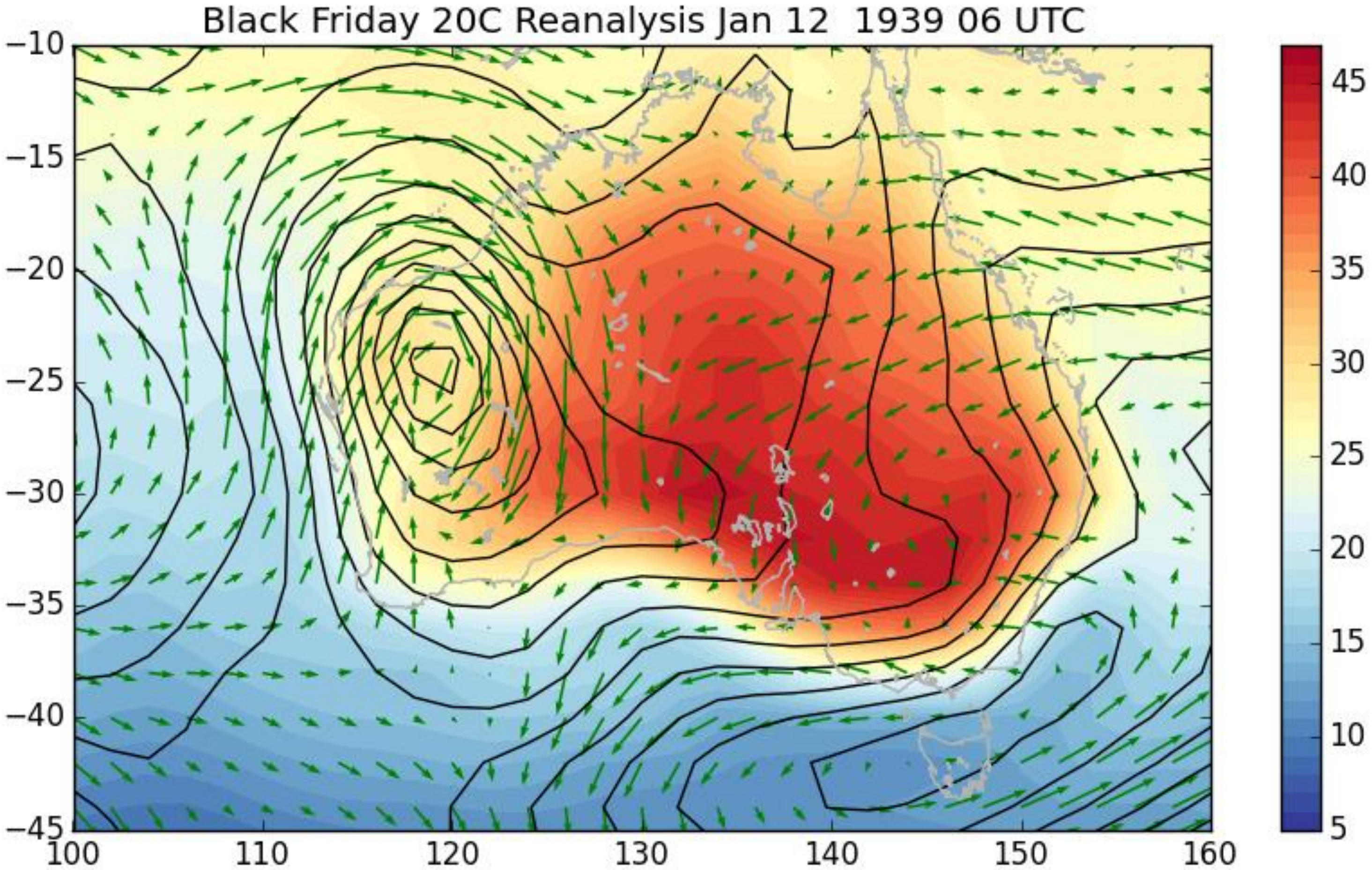

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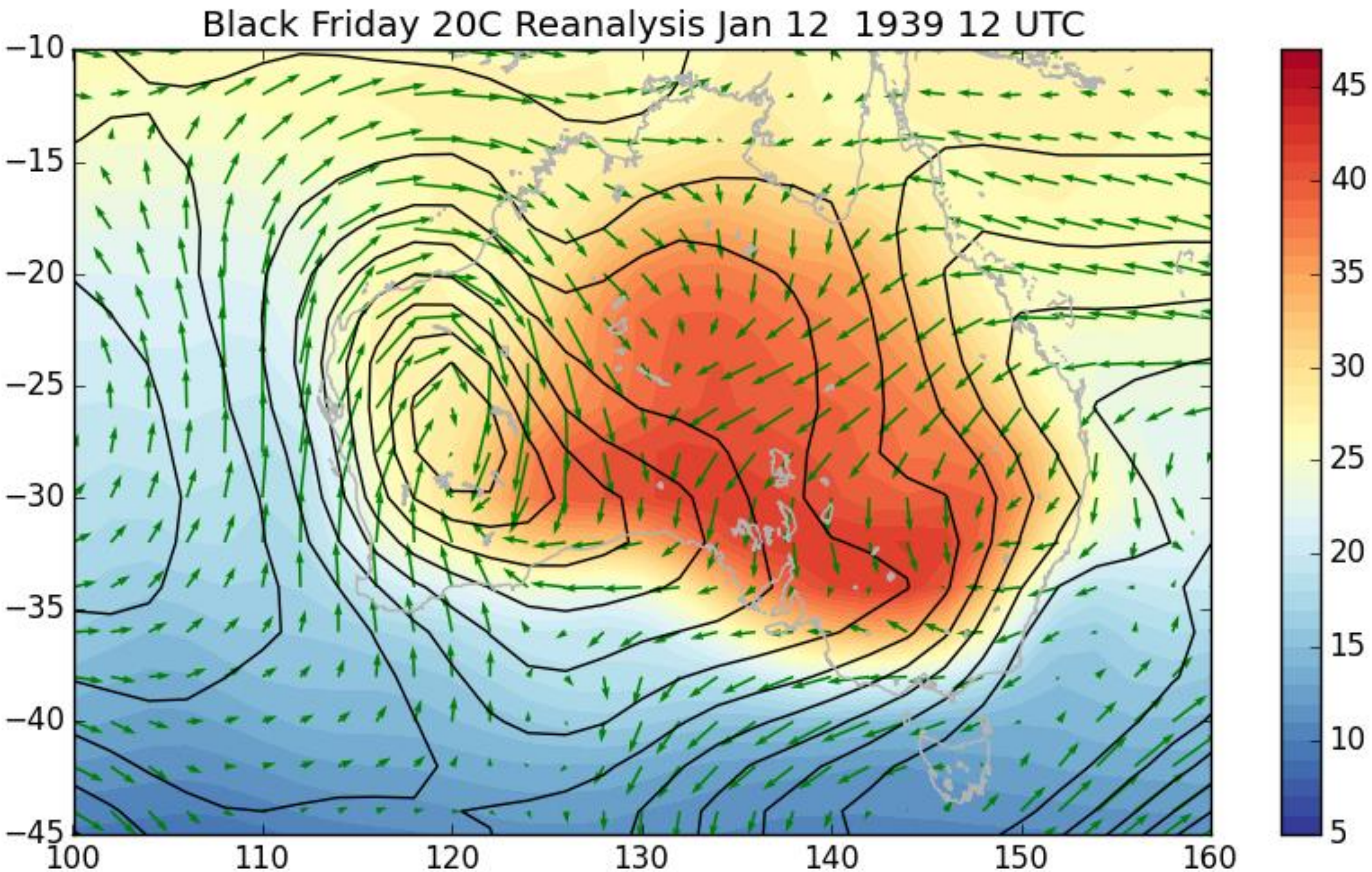

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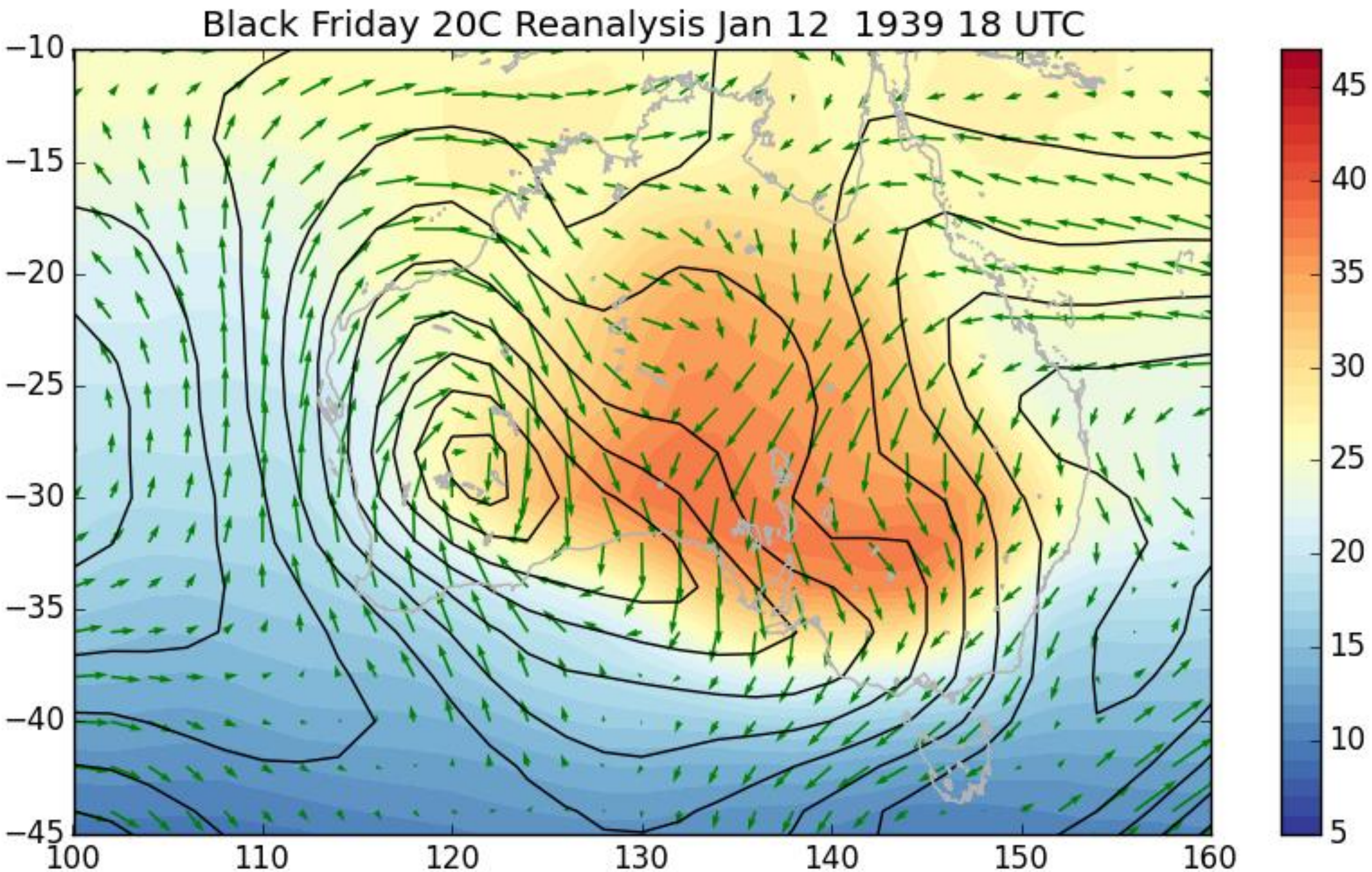

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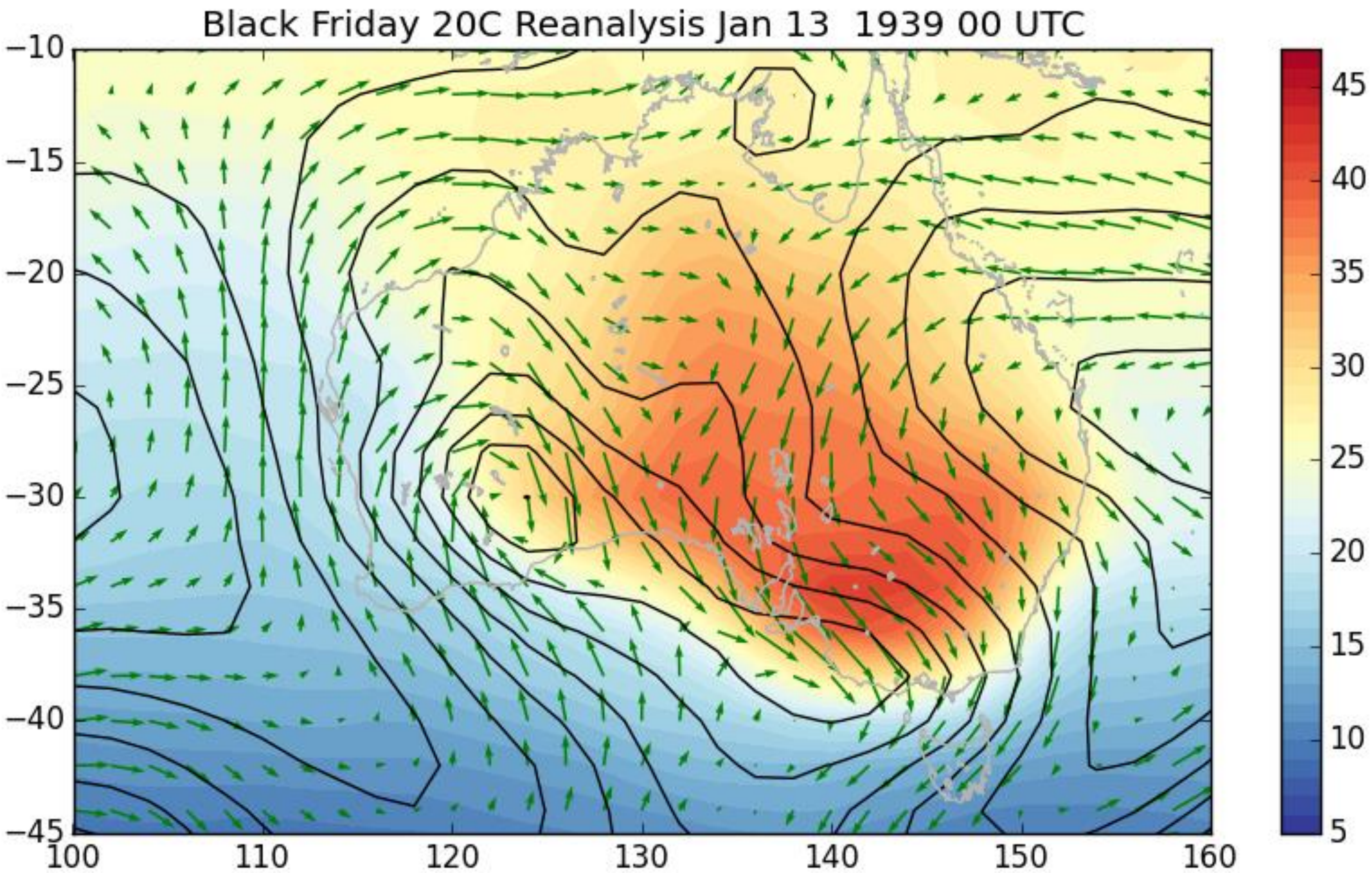

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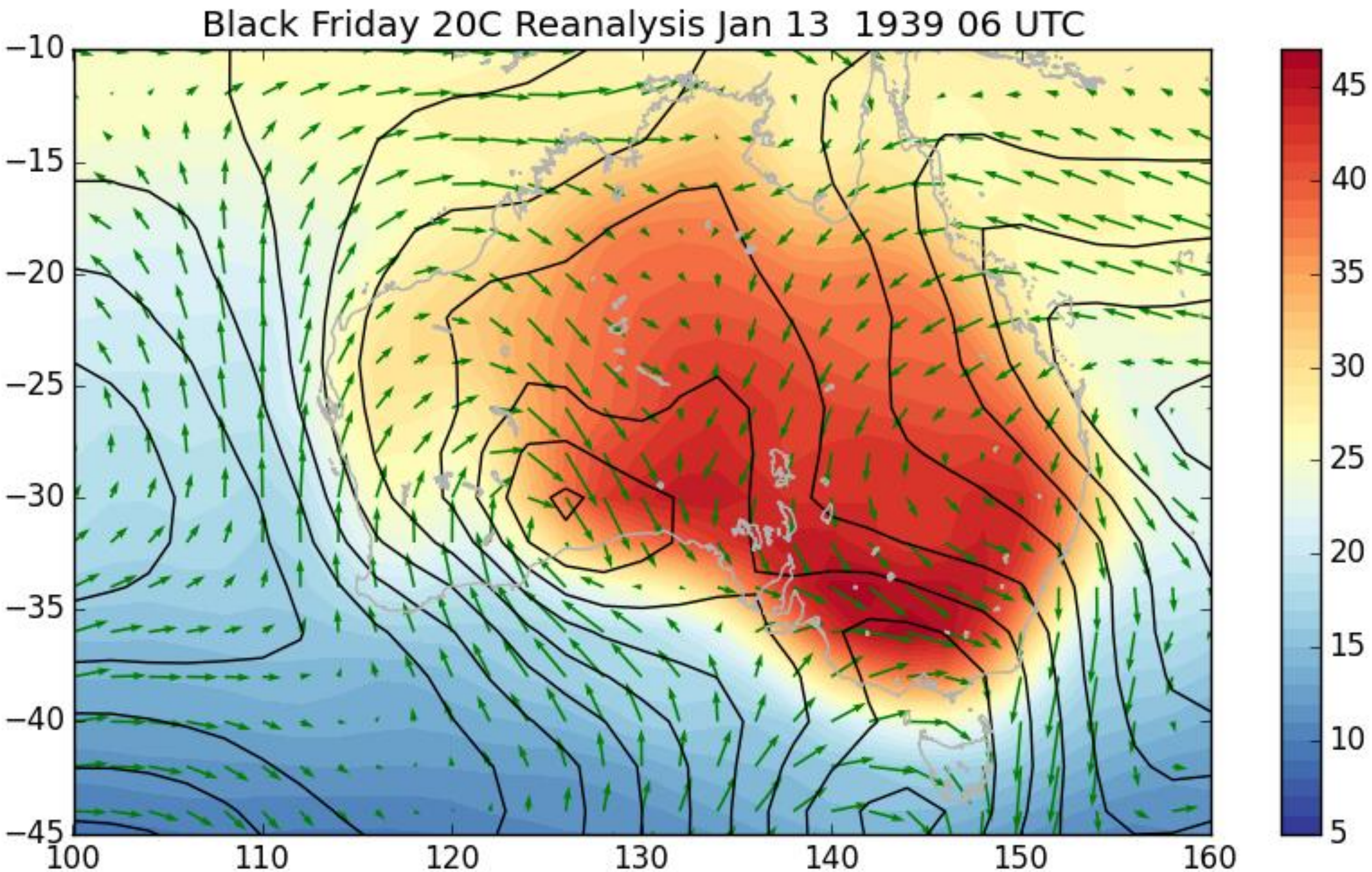

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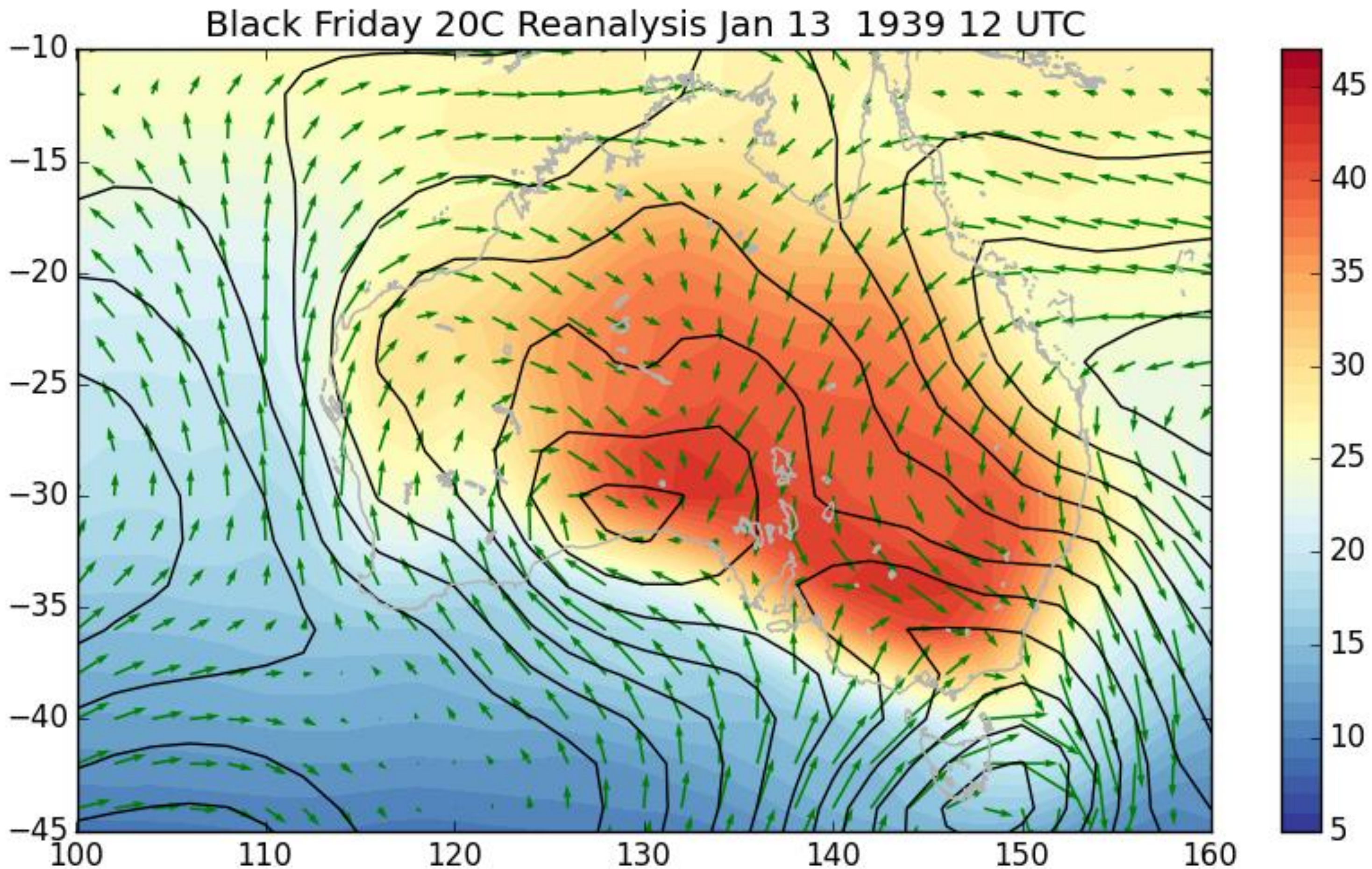
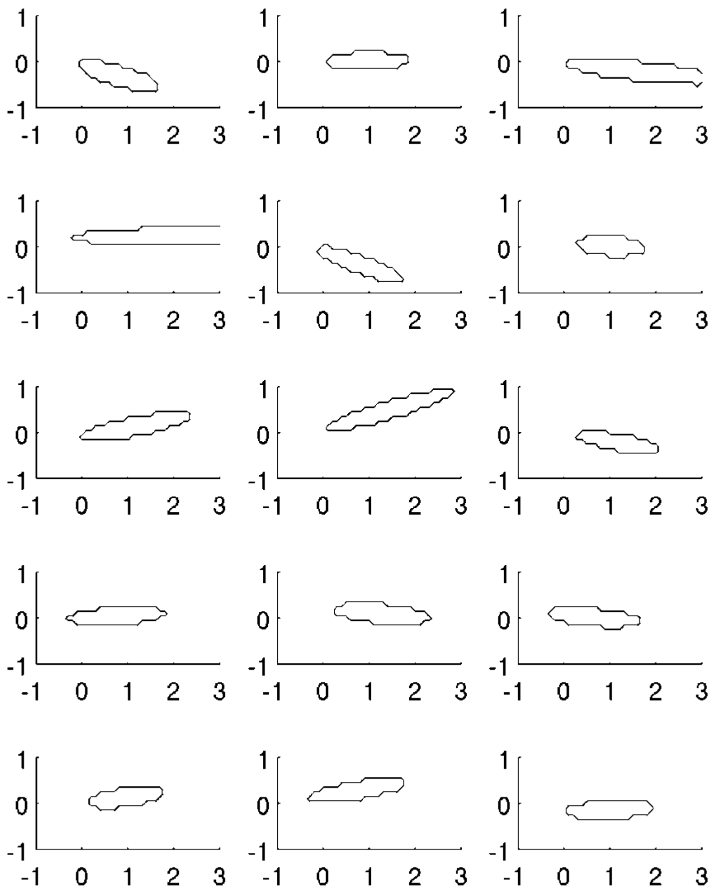
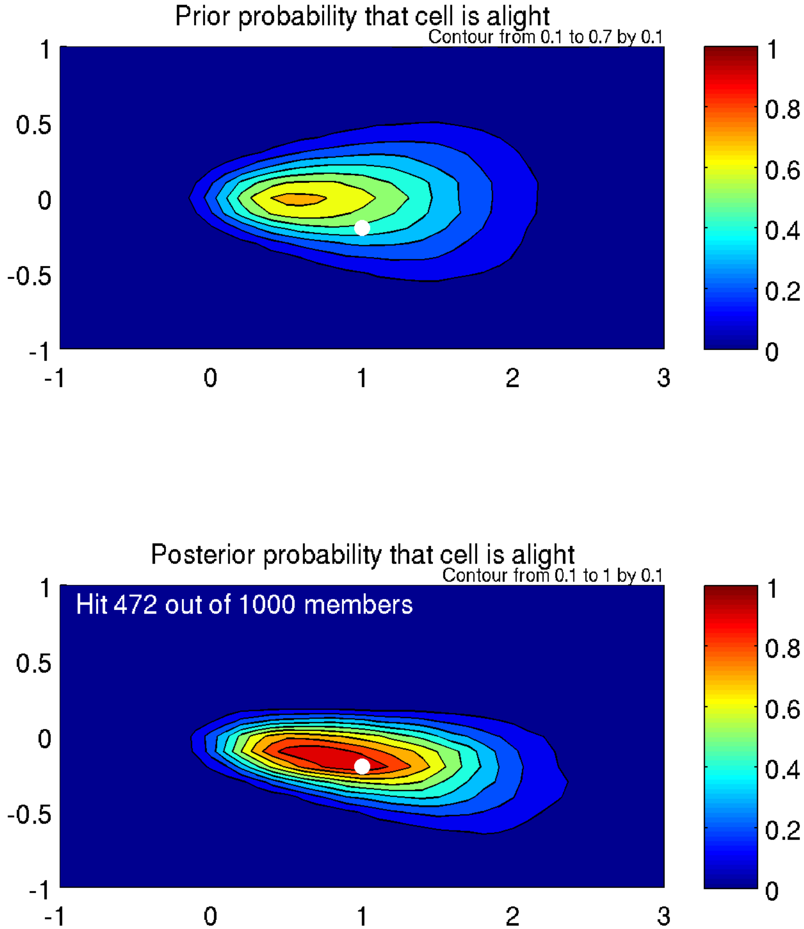


ASSIMILATION IN A TOY FIRE MODEL



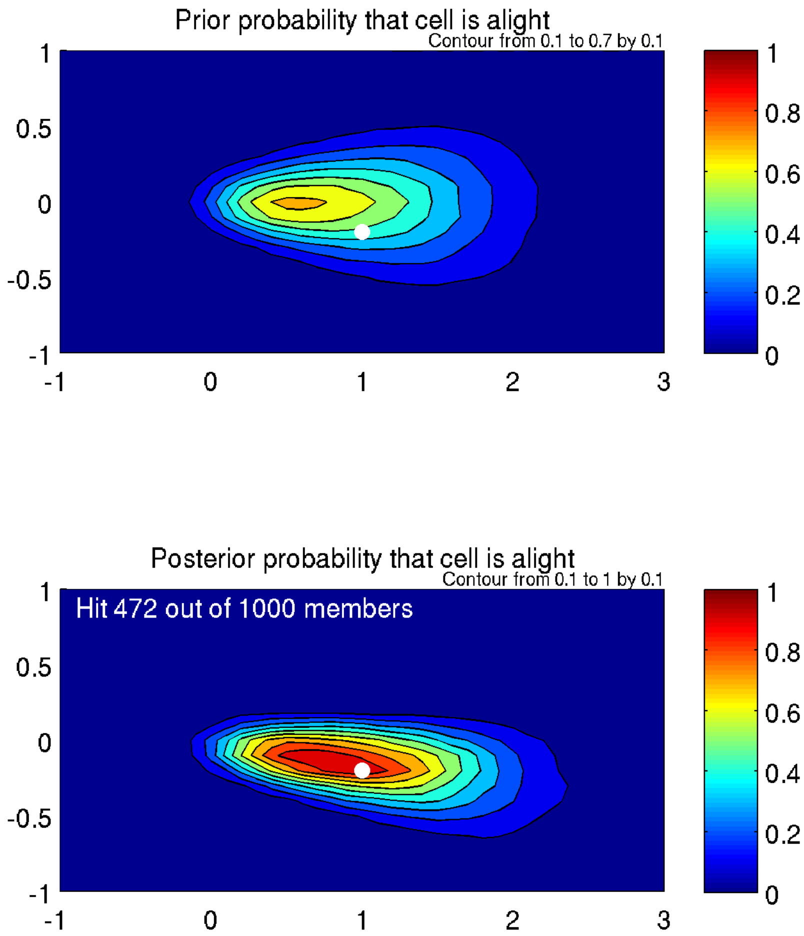
1) Model state is a grid of cells, each cell is either burning or not
2) Ensemble generated as a random set of ellipses of fire perimeter

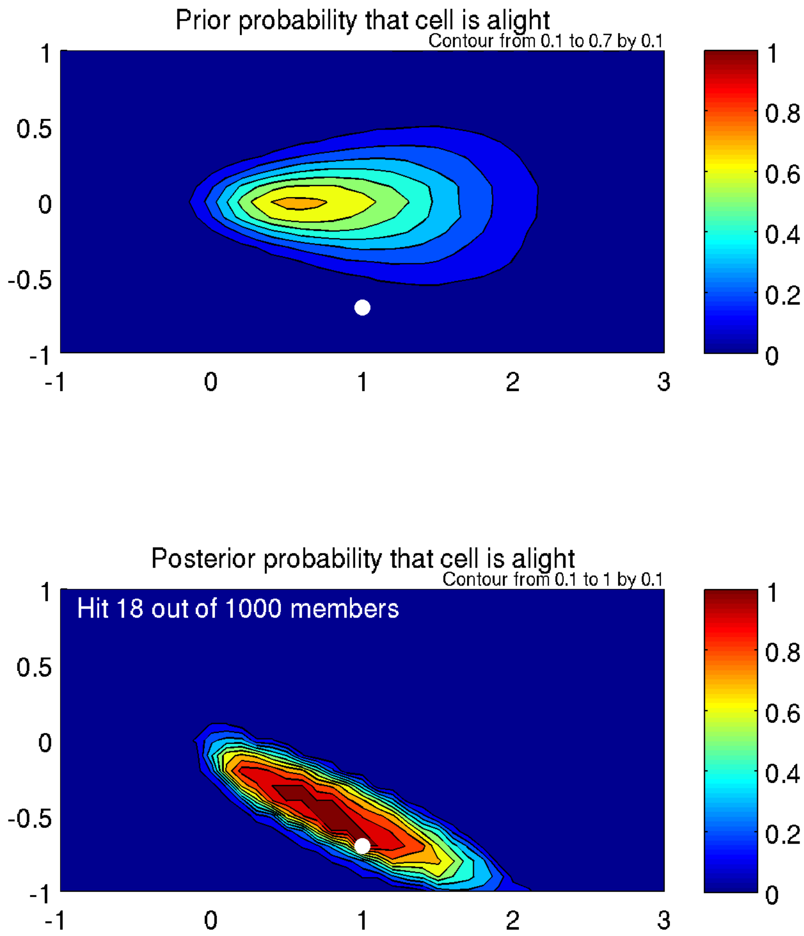
ASSIMILATION IN A TOY FIRE MODEL



1) Top is the probability that a cell is burning before data assimilation
2) Obs: white dot is burning
3) Bottom is the probability that a cell is burning after data assimilation

MOVE THE OBSERVATION






OBSERVATION TARGETING

TARGETING HURRICANE IRENE

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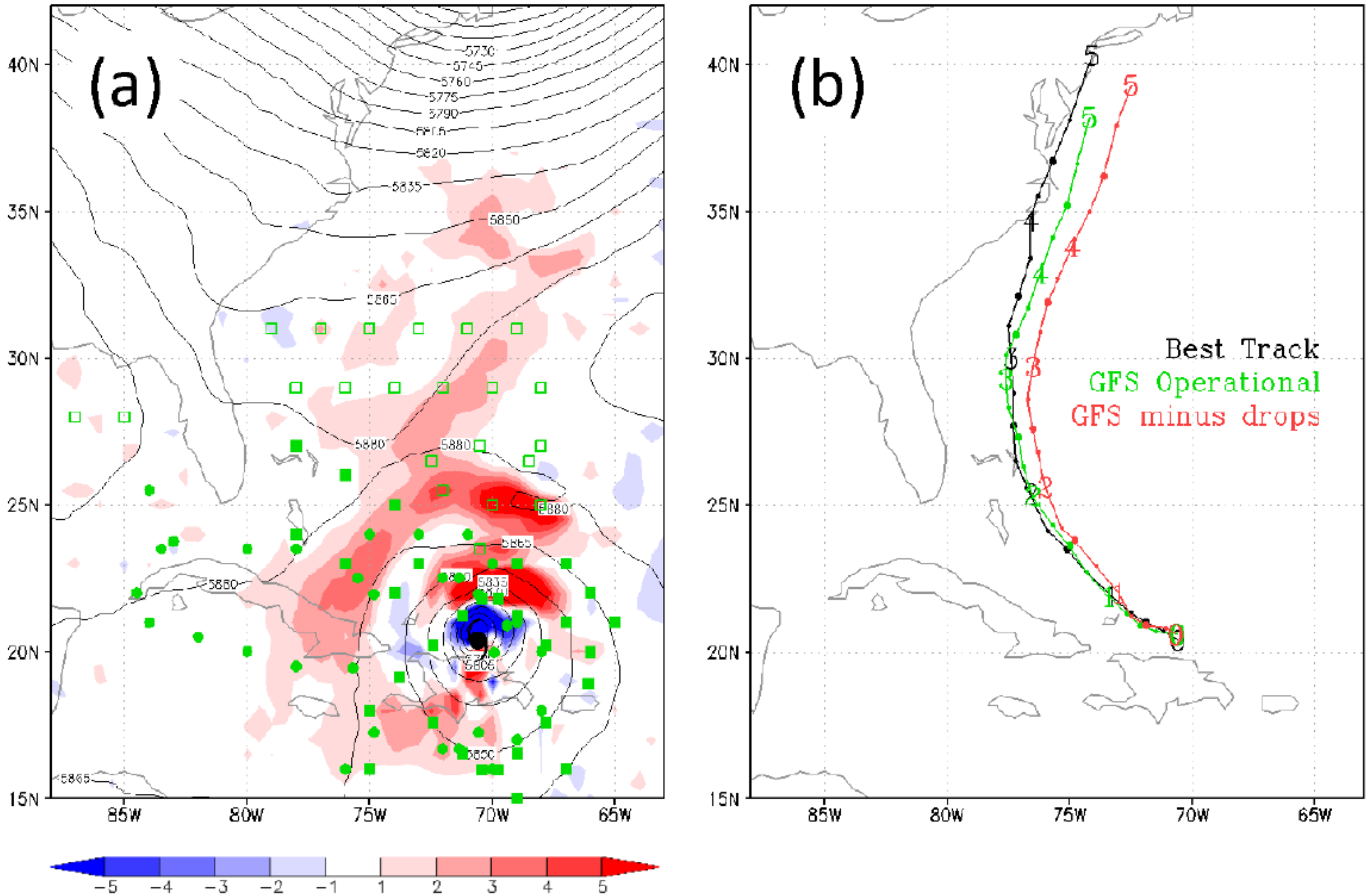
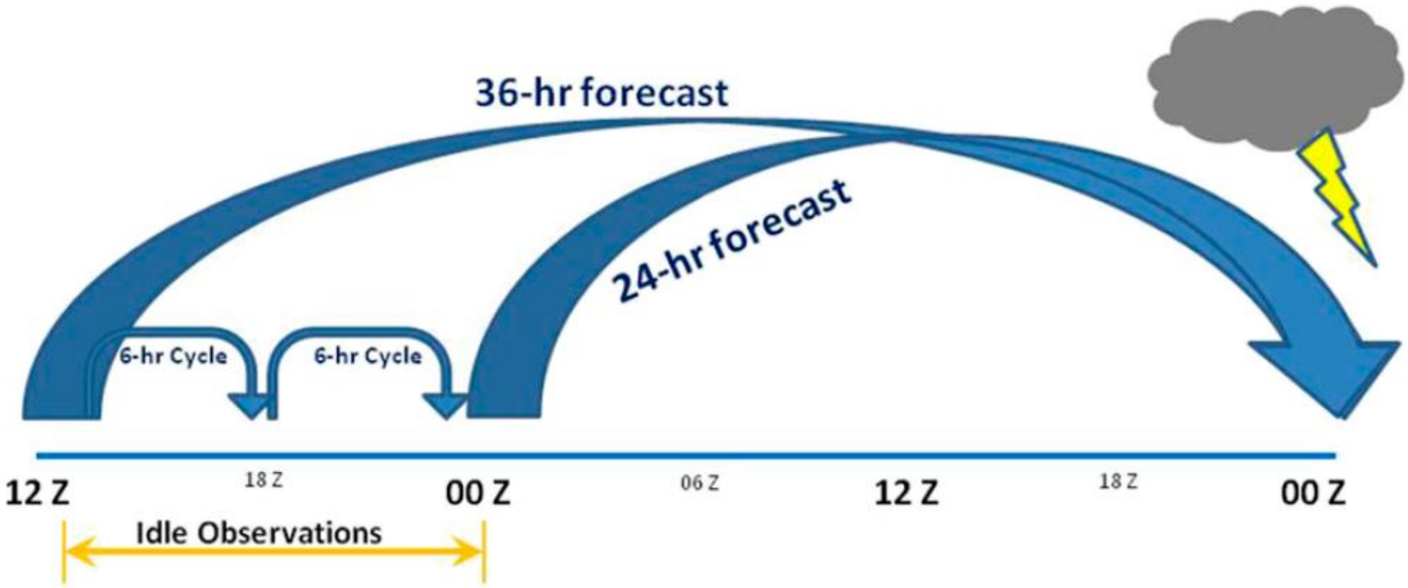


Majumdar et al., *WMO TD No 15*, 2011

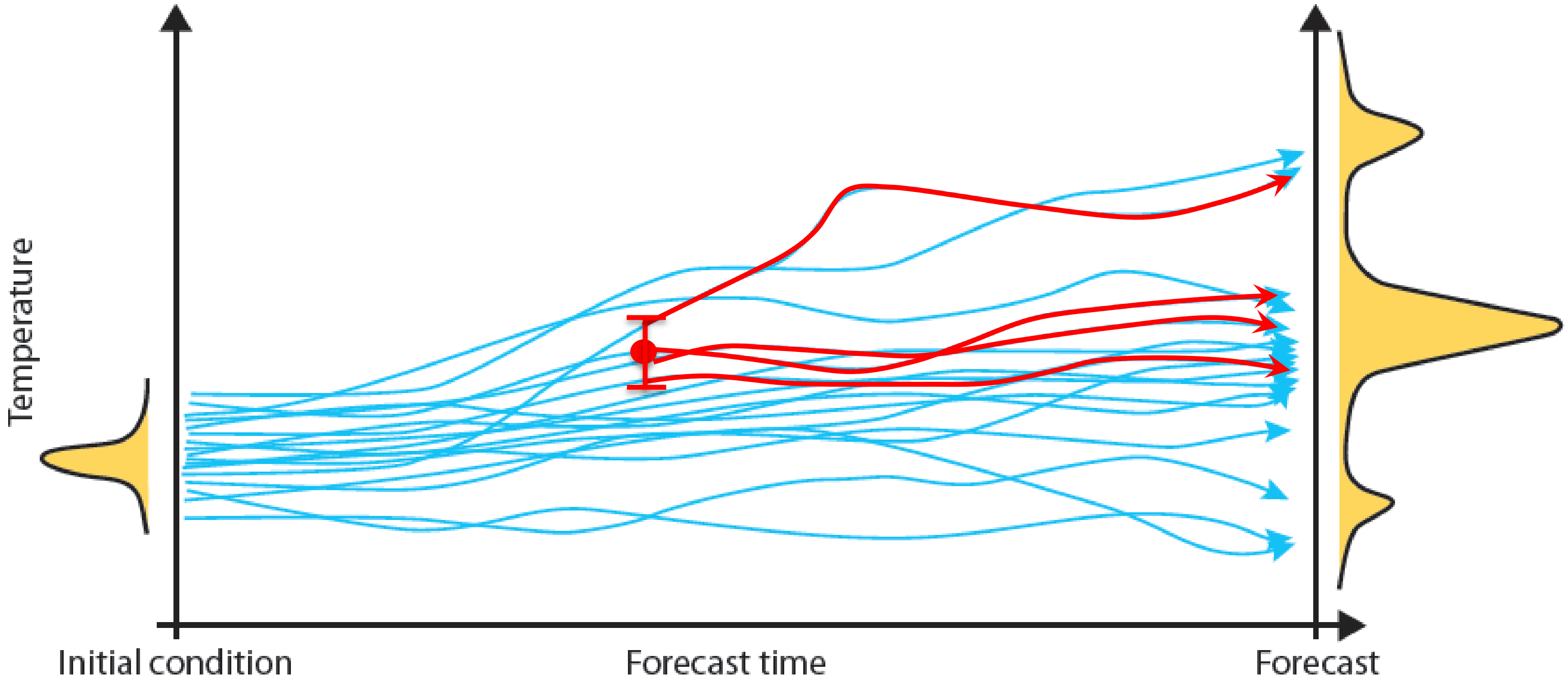


What happens after we've run the ensemble?

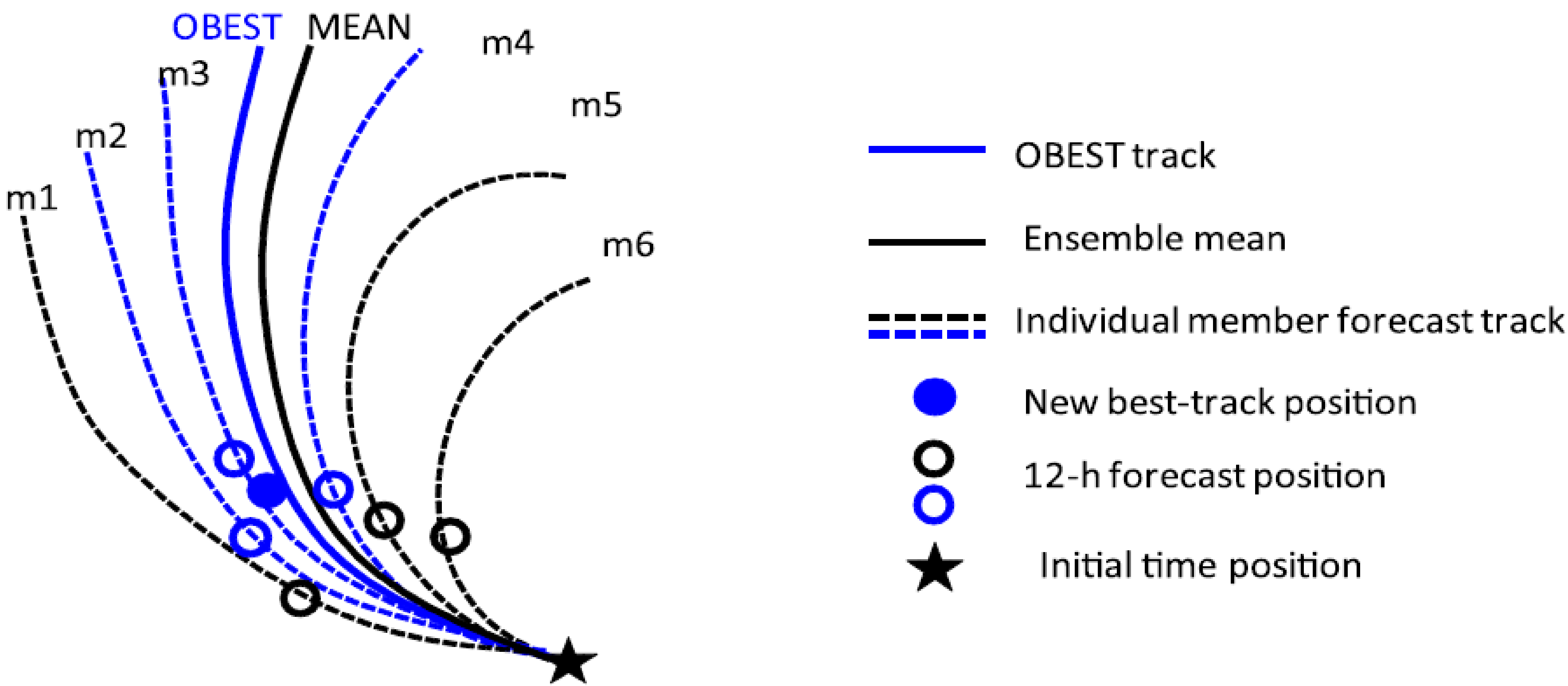
PRE-EMPTIVE FORECASTS

Image: Brian Ancell

PRE-EMPTIVE FORECASTS

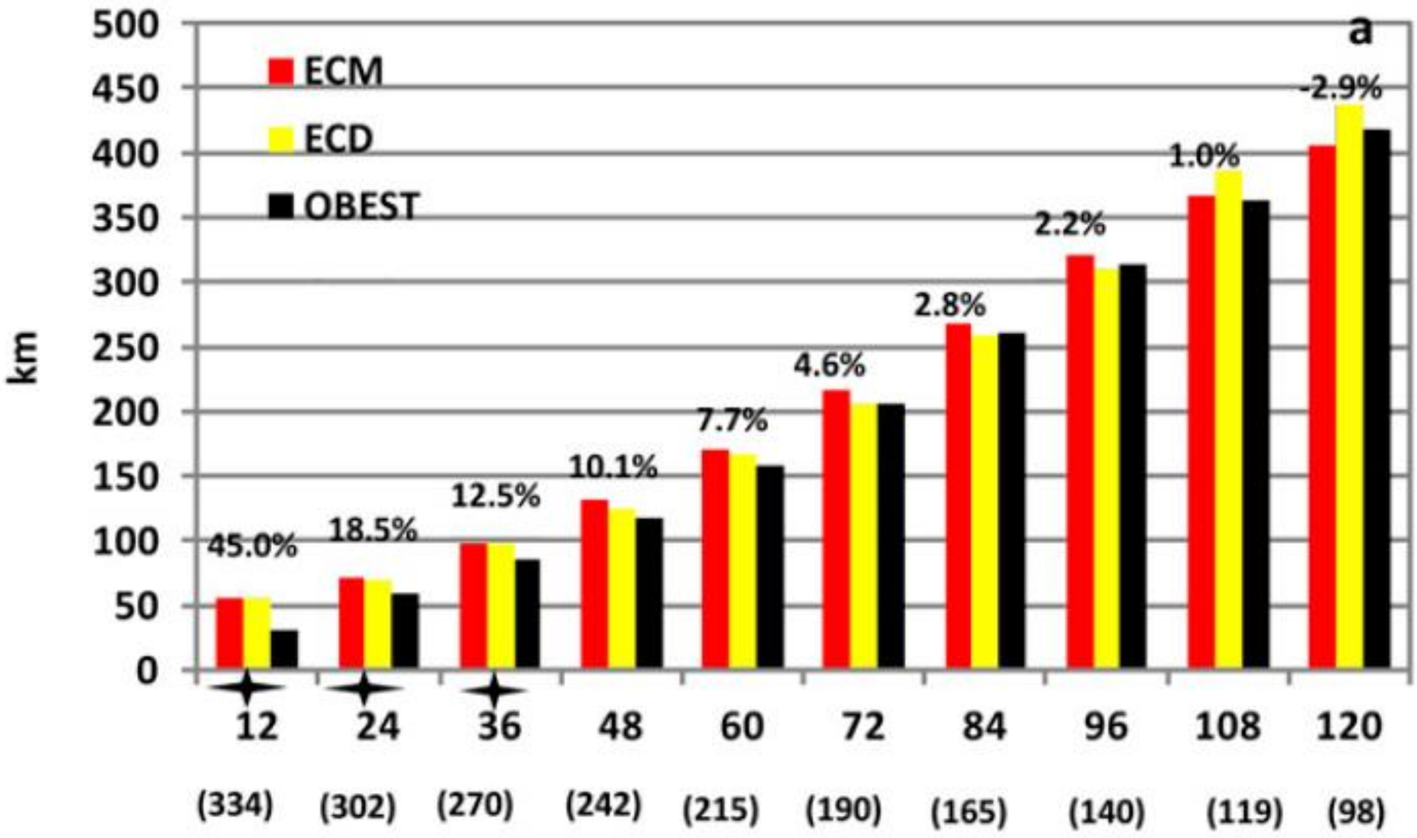


ENSEMBLE SUBSET TECHNIQUE FOR TROPICAL CYCLONE TRACK



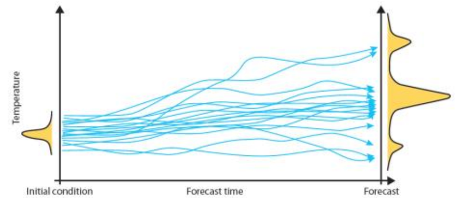
Dong and Zhang *Weather and Forecasting* 2016

ENSEMBLE SUBSET TECHNIQUE FOR TROPICAL CYCLONE TRACK



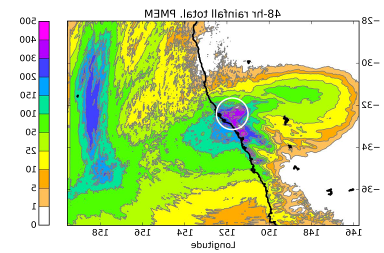
Dong and Zhang *Weather and Forecasting* 2016

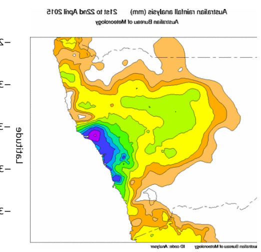
SUMMARY



Ensemble predictions

- Are more accurate
- Are more consistent
- Objective probabilistic prediction
- Support risk management
- Improve data assimilation
- Help target observations
- Pre-emptive forecasts





Impact →

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