bushfire&natural HAZARDSCRC

IMPROVED PREDICTIONS OF SEVERE WEATHER

to reduce community risk

Jeff Kepert, William Thurston Simon Ching, Kevin Tory and Robert Fawcett,
Bureau of Meteorology Research and Development, Melbourne

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

Australian Government
Bureau of Meteorology

OVERVIEW

1) Project is in catch-up phase
2) Four of six subprojects underway
3) Journal articles in preparation, conference presentations, etc
4) Highlights:
   a) Blue Mountains fire of October 2013
   b) East coast low of April 2015
   c) Ember transport
   d) Pyrocumulus

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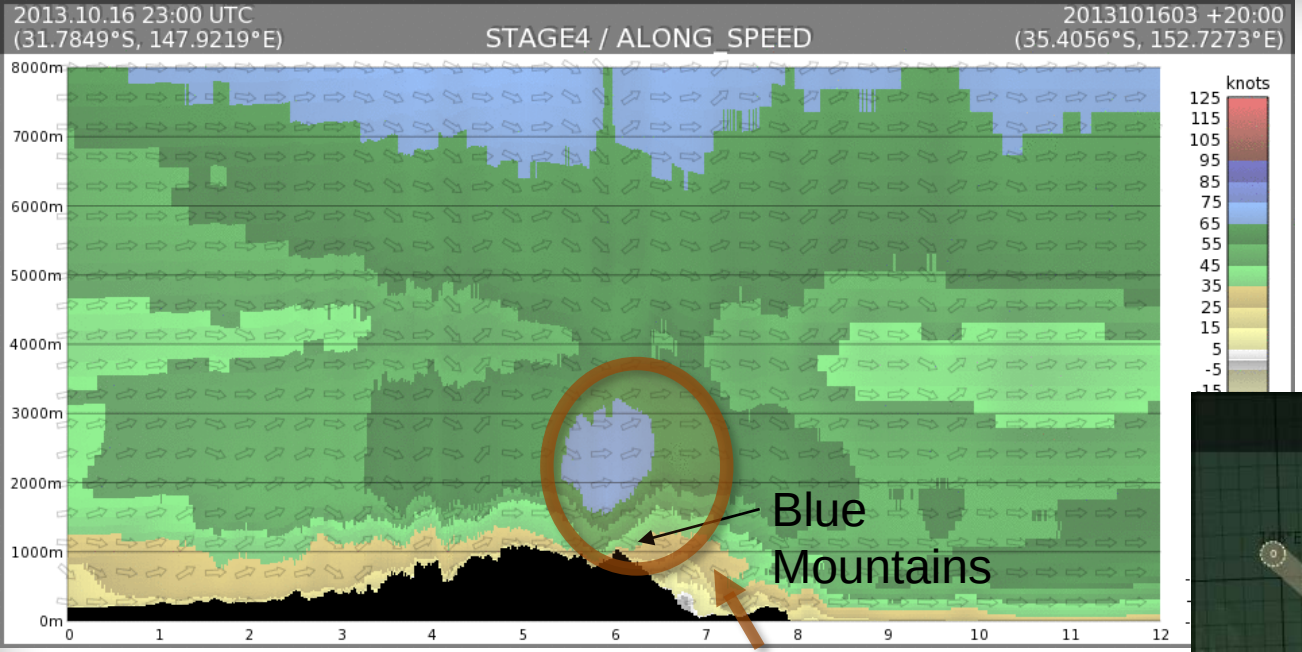
Modelling the Fire Weather of the Blue Mountains Fires of 17 October 2013

Simon E Ching[1,3], Robert J B Fawcett[2], and Jeffrey D Kepert[2,3]

[1]Bureau of Meteorology, Adelaide, South Australia
[2]Bureau of Meteorology, Docklands, Victoria
[3]Bushfire and Natural Hazards CRC, Melbourne, Victoria

This work was partly supported by the Bushfire and Natural Hazards CRC, and the computations were performed at the NCI. We are grateful to Laurence McCoy and Melissa O'Halloran of the NSW Rural Fire Service for help with the fire data.



Horizontal Wind Speed
… projected onto the
Cross Sectional Plane

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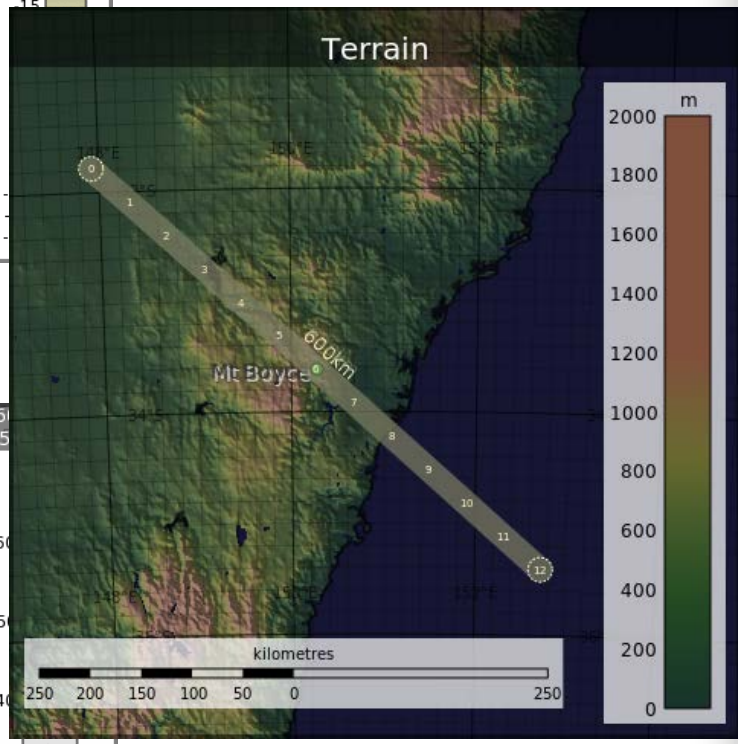
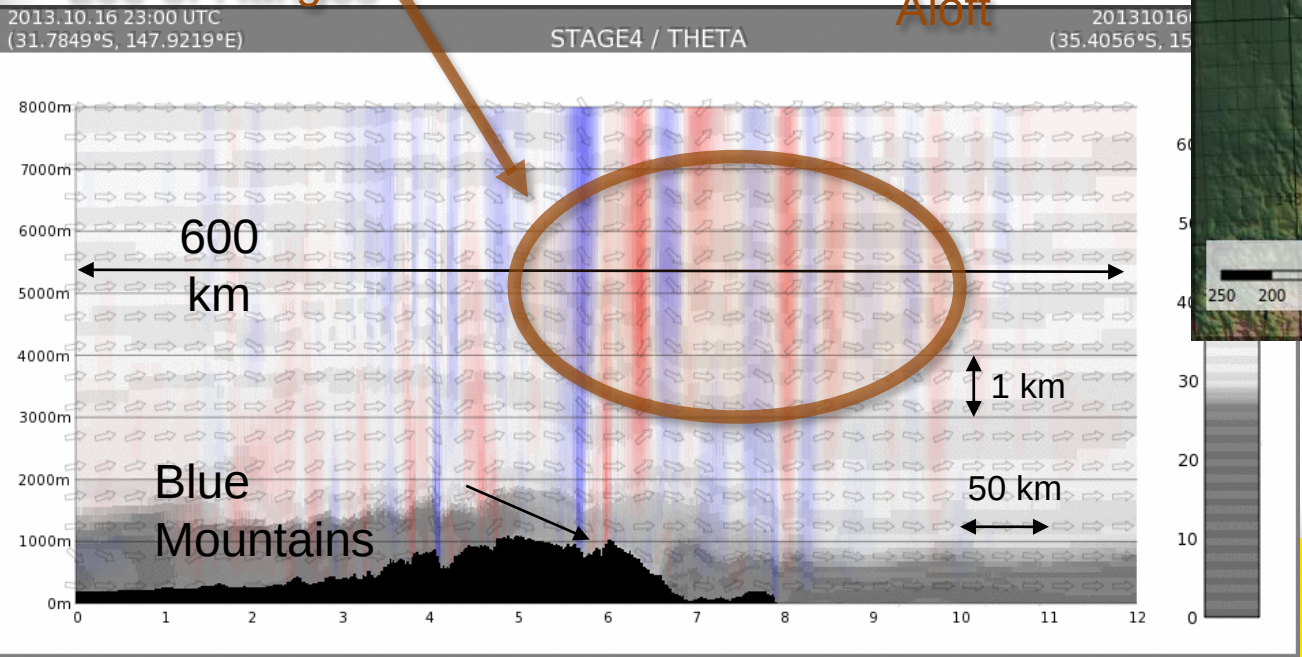
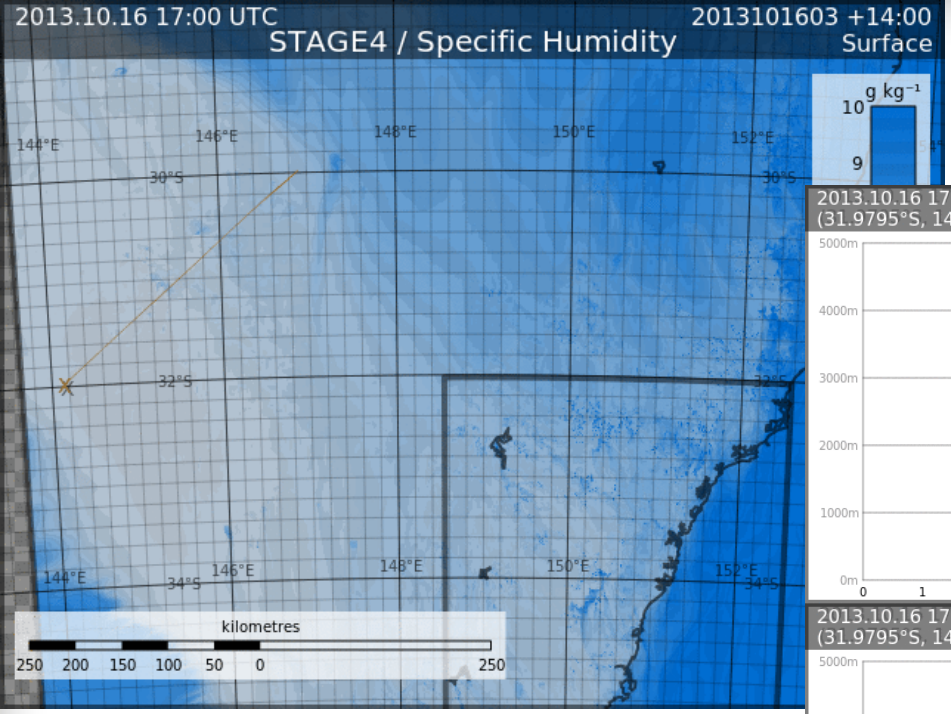


Mountain Waves
Lee of Ranges

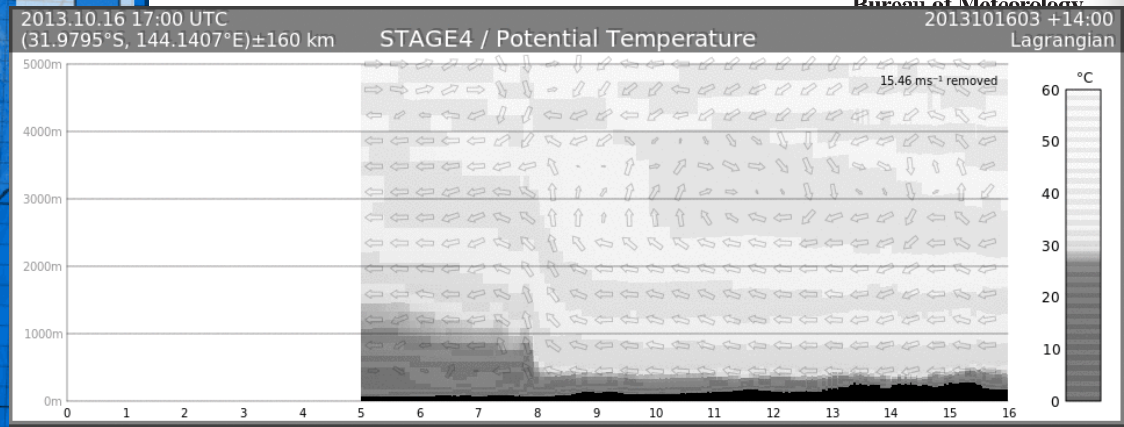
Downward extension
of Strong Winds from
Aloft

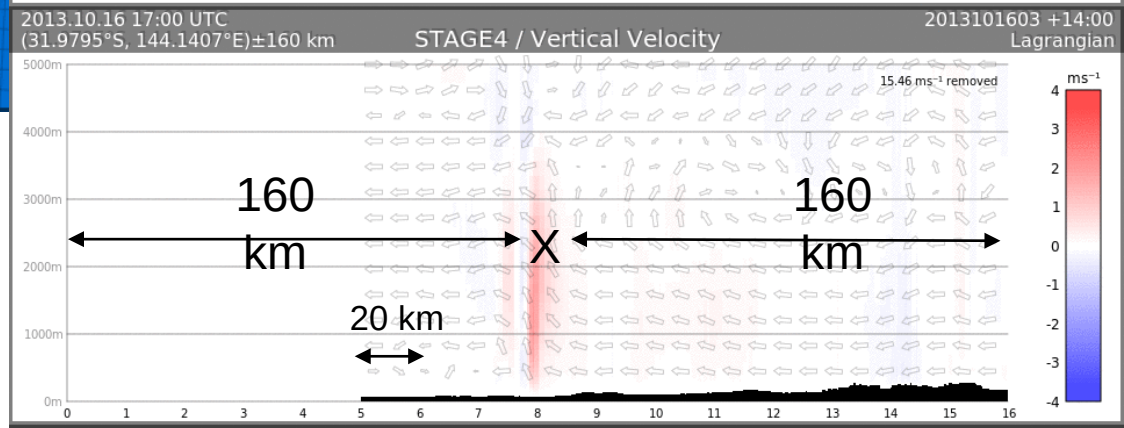


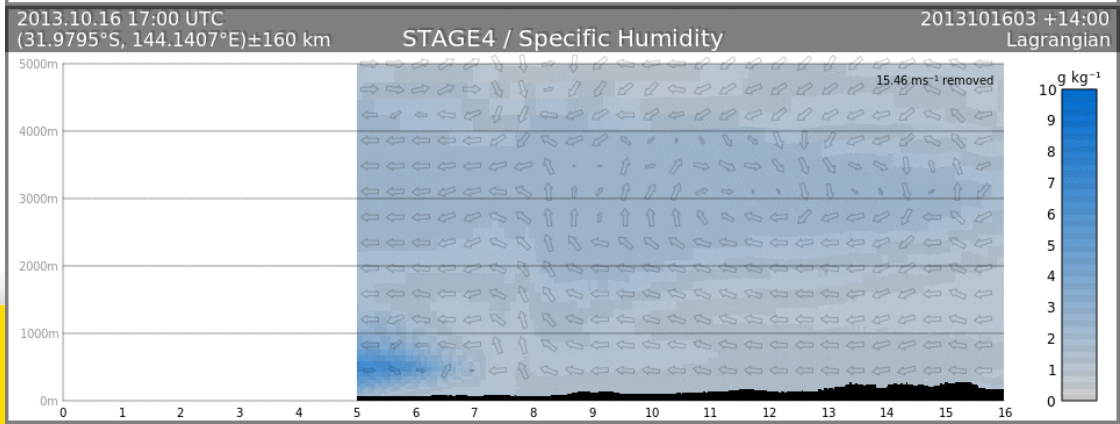
Vertical Motion
Red: Upward Motion
Blue: Downward Motion



Vertical Cross Section following X

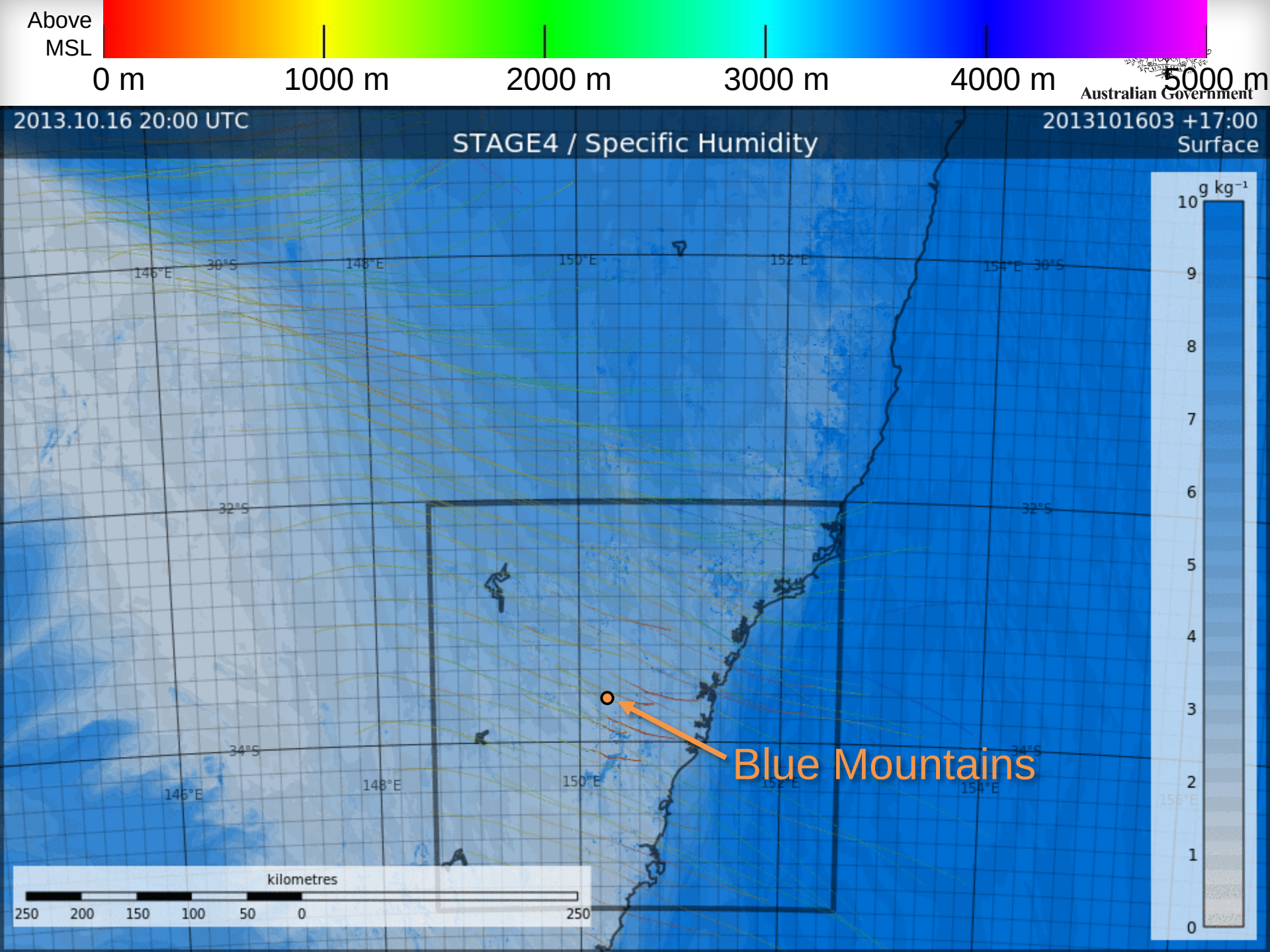






NW Portion of Dry Slot

- Frontier of density current (X) Considerably ahead of moisture front
- Dry nose attached to advancing cool moist airmass
- Collision with moist airmass in NE, Dry Nose → Dry Slot


Above MSL
0 m
1000 m
2000 m
3000 m
4000 m
5000 m
Australian Government
2013.10.16 20:00 UTC
STAGE4 / Specific Humidity
2013101603 +17:00
Surface
g kg⁻¹
10
9
8
7
6
5
4
3
2
1
0
146°E
148°E
150°E
152°E
154°E
30°S
32°S
34°S
Blue Mountains
kilometres
250
200
150
100
50
0
250

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

HIGH-RESOLUTION ENSEMBLE PREDICTION

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1) ACCESS Global Ensemble planned for ~2018
2) Operational relocatable severe weather ensemble planned for ~2020
3) UKMO vision of hourly 1.5-km rapid-update-cycle ensemble,

4) Motivation:
   a) Severe ECL, high impact + scientific interest, worthy of study
   b) Good deterministic forecast, NWP study is feasible
   c) Good case to start to look at what hi-res ensemble might deliver in severe weather (BoM operations + emergency services)
   d) Good case to look at ensemble-based sensitivity analysis

MODELLING SETUP

Australian Government
Bureau of Meteorology

1) 24-members
2) Based on test global ensemble system, 24 members, 90 km grid
3) Downscale in several steps, 40 km to 4 km to 1.3 km

48-HR RAINFALL VERIFICATION

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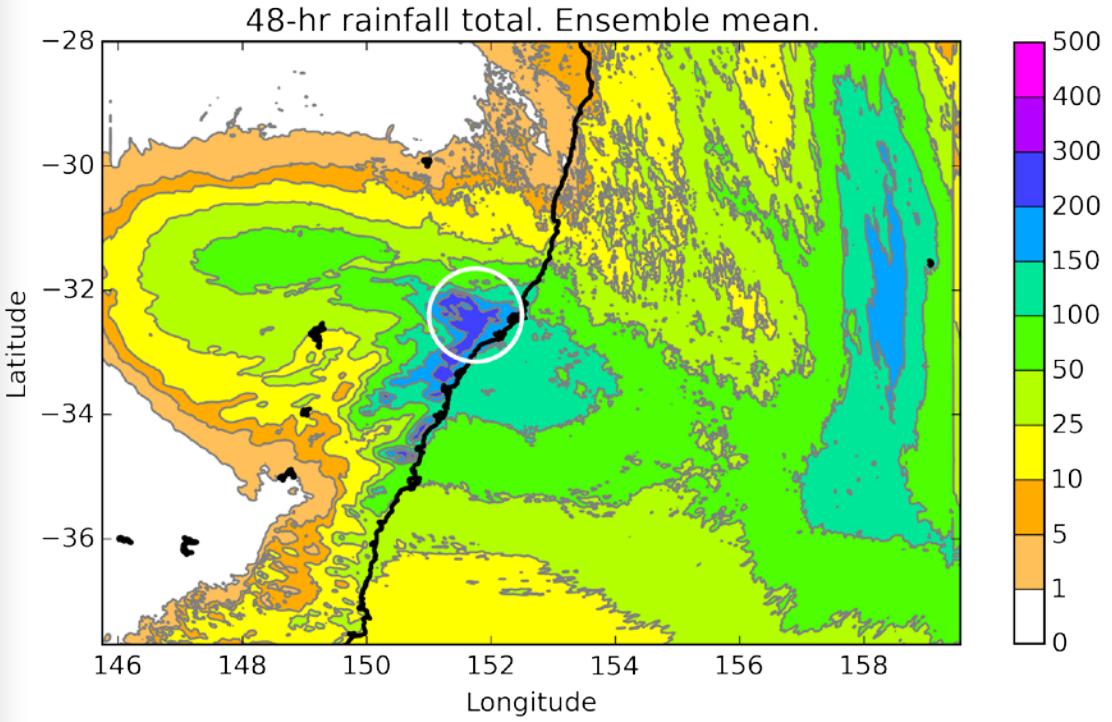

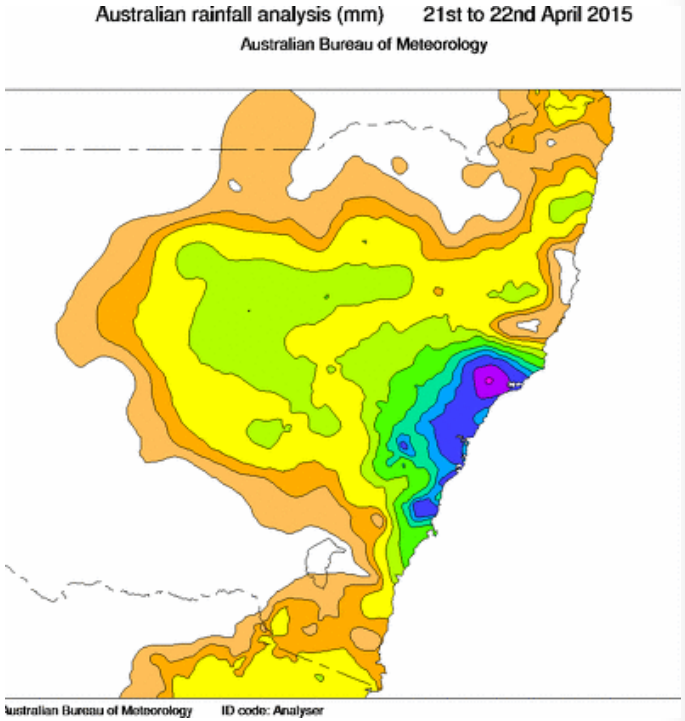

RAINFALL PROBABILITIES

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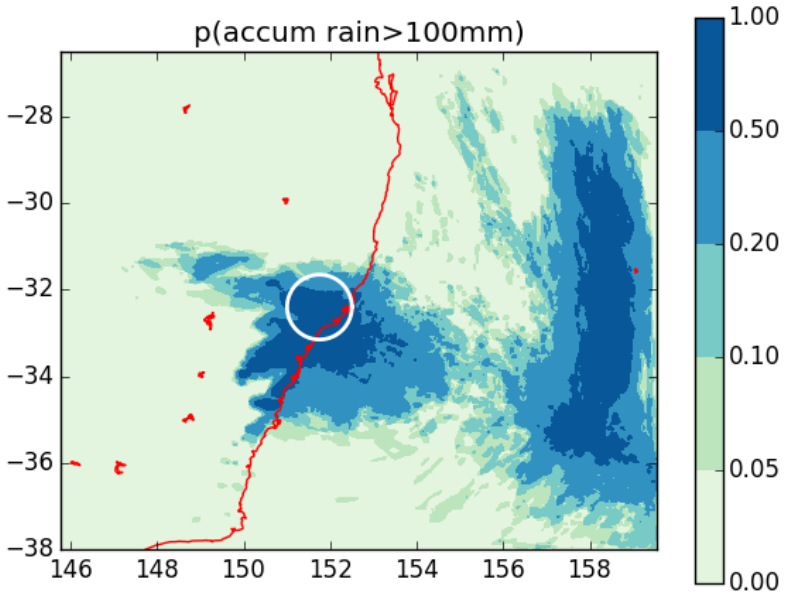

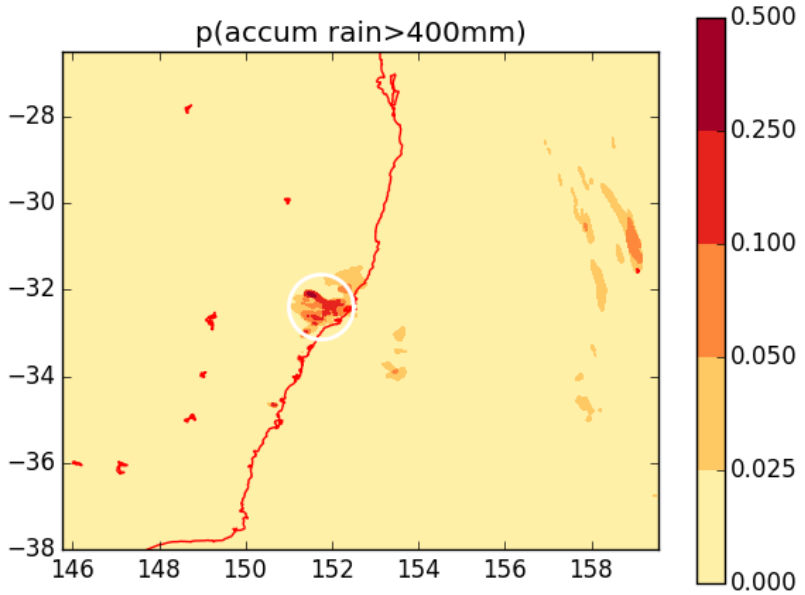

Probabilities of 48-hour total rainfall exceeding 100 mm and 400 mm

Based on ensemble member count, convolved over a radius of 5 gridpoints = 7 km.

RAINFALL DISTRIBUTION DUNGOG

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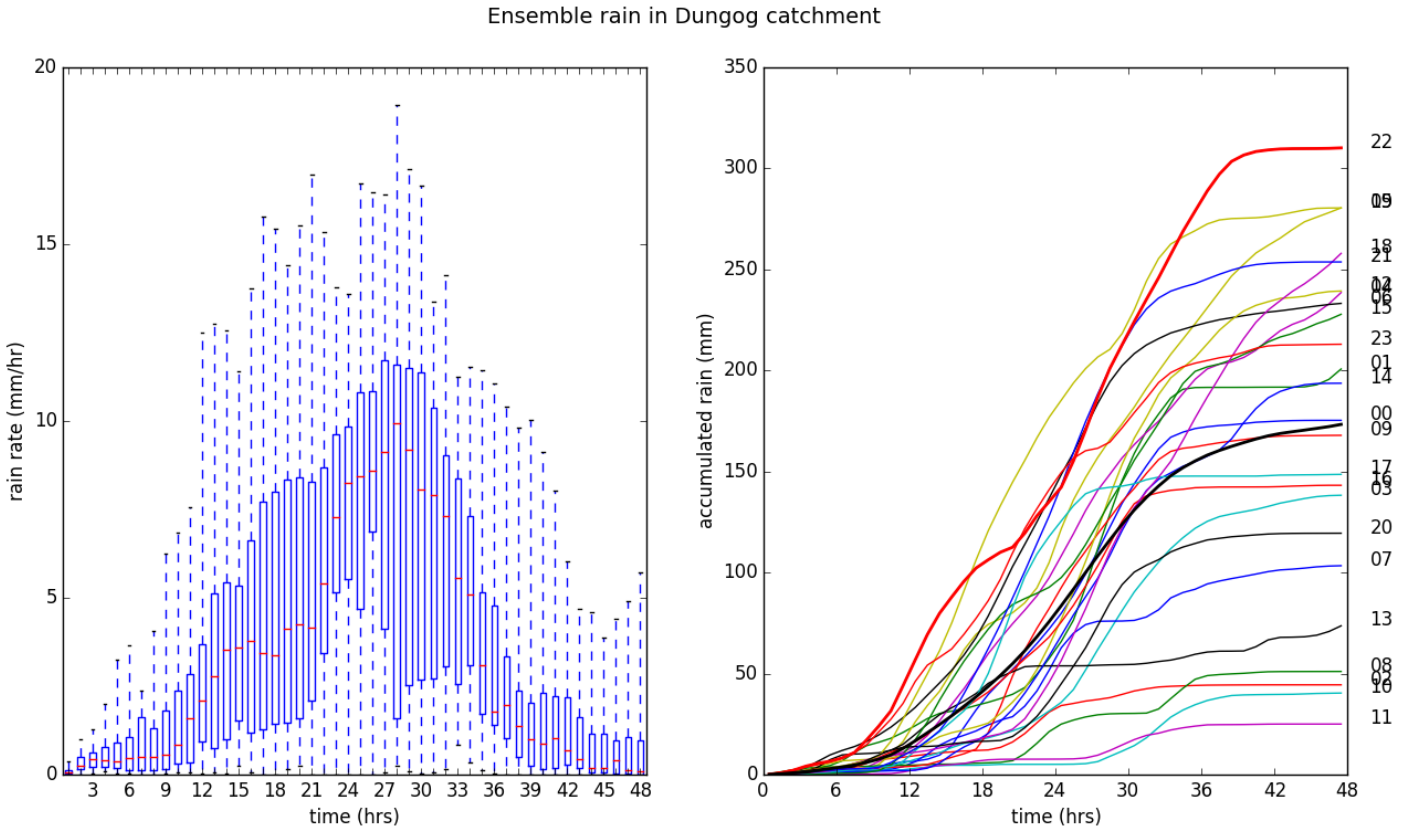

1) Left: hourly rainfall distribution
2) Right: rainfall accumulation by ensemble member
3) Averaged over 50-km circle centred on Dungog catchment

WETTEST MEMBER VS DRIEST MEMBER

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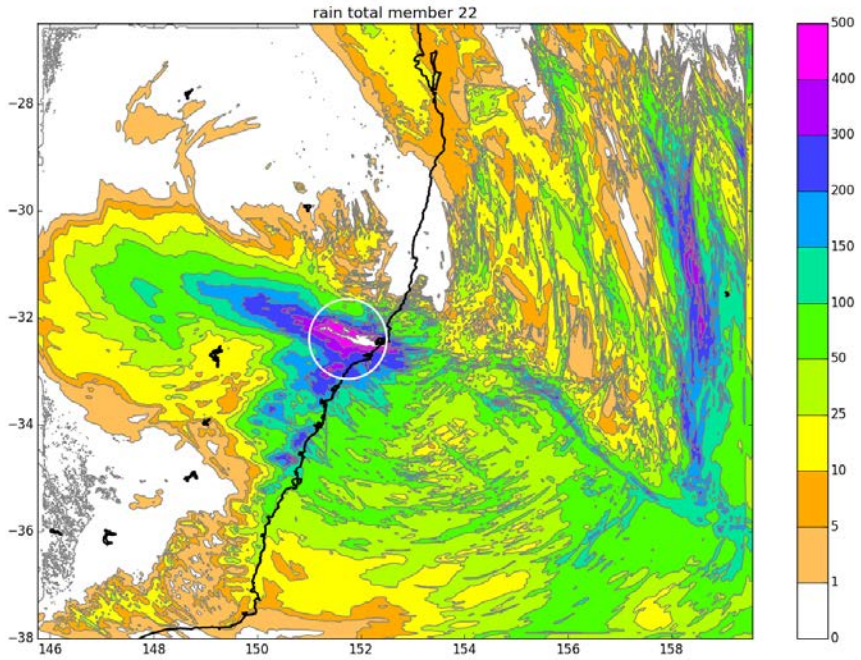
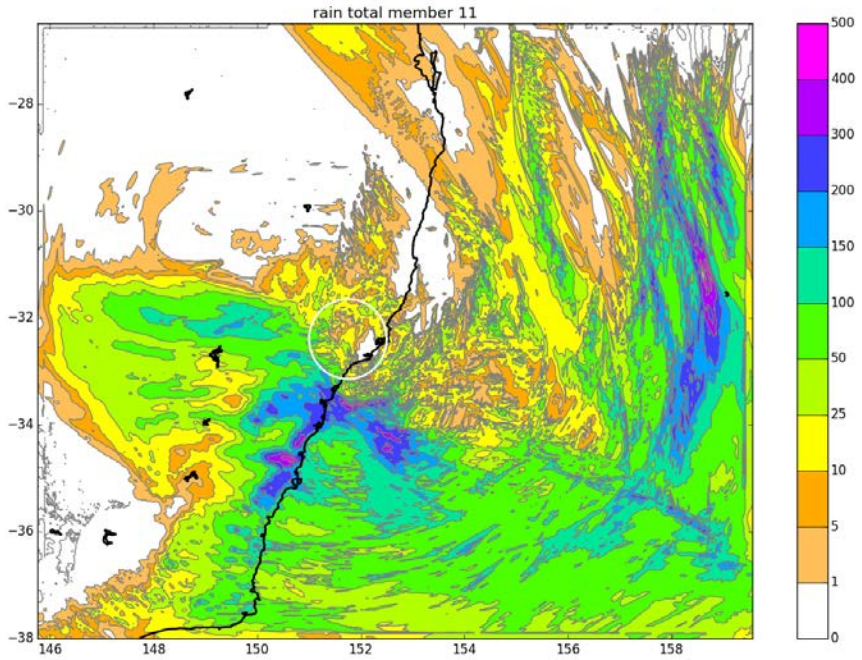




"... a number of challenging forecast issues emerged. These included estimating the location along the coast, and the intensity, of the region of maximum winds and rainfall and how these related to the position of the developing low ..."

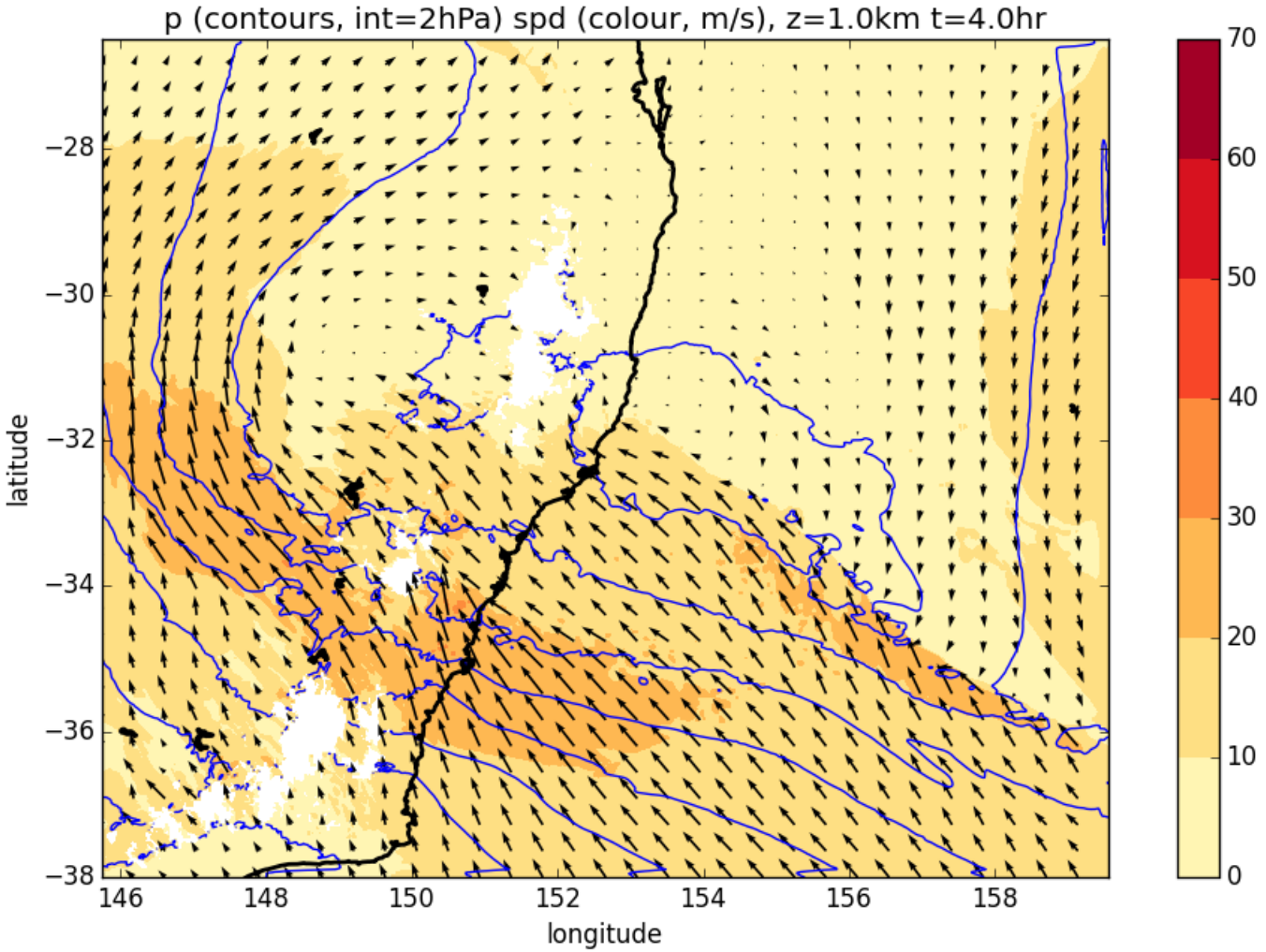
Mills et al. (2010)

CAWCR Tech Report on Pasha Bulker storm

WIND AND P AT Z=1KM, 04UTC APRIL 21

Australian Government
Bureau of Meteorology

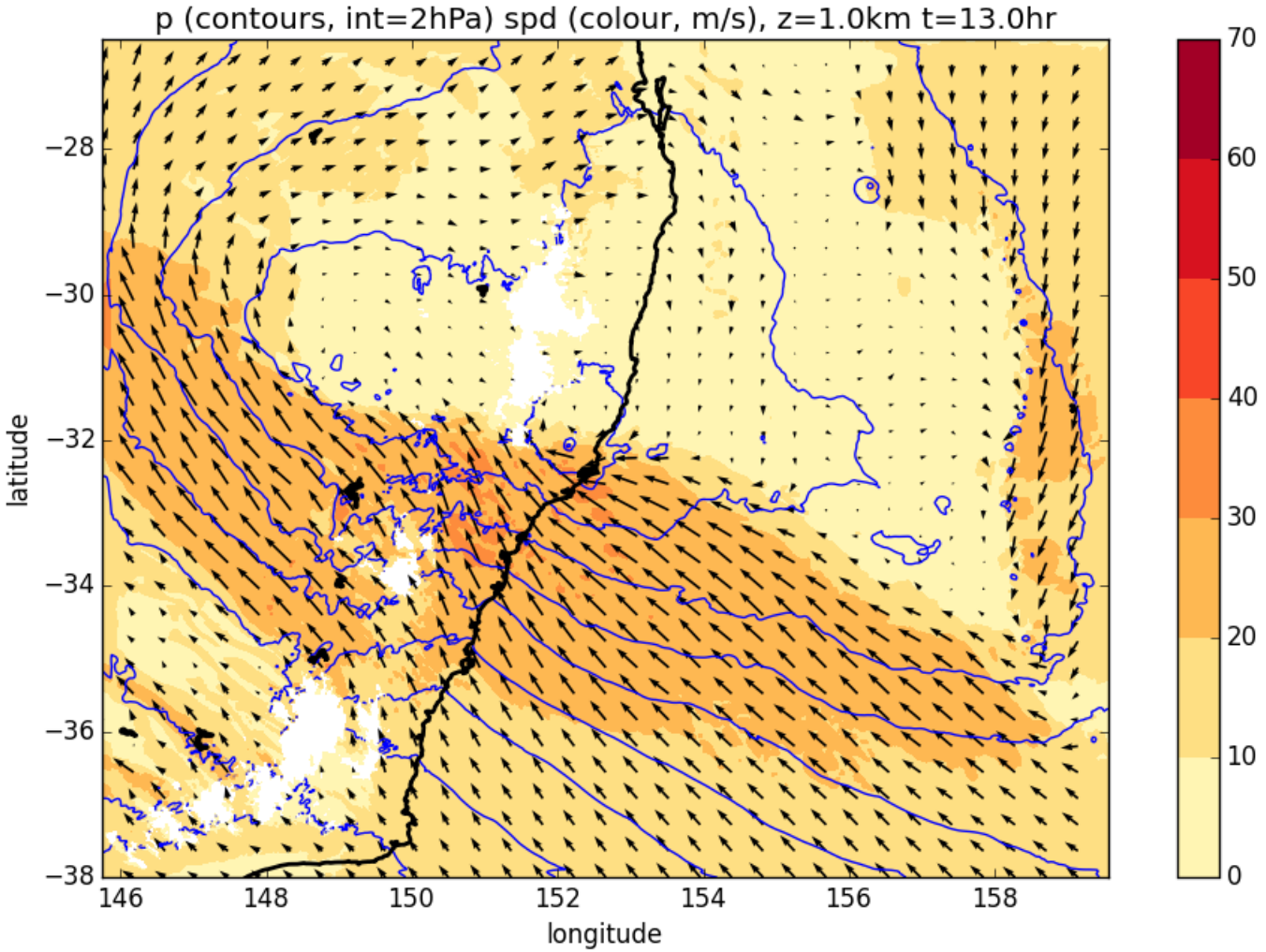
Wettest member (22)



WIND AND P AT Z=1KM, 13UTC APRIL 21

Australian Government
Bureau of Meteorology

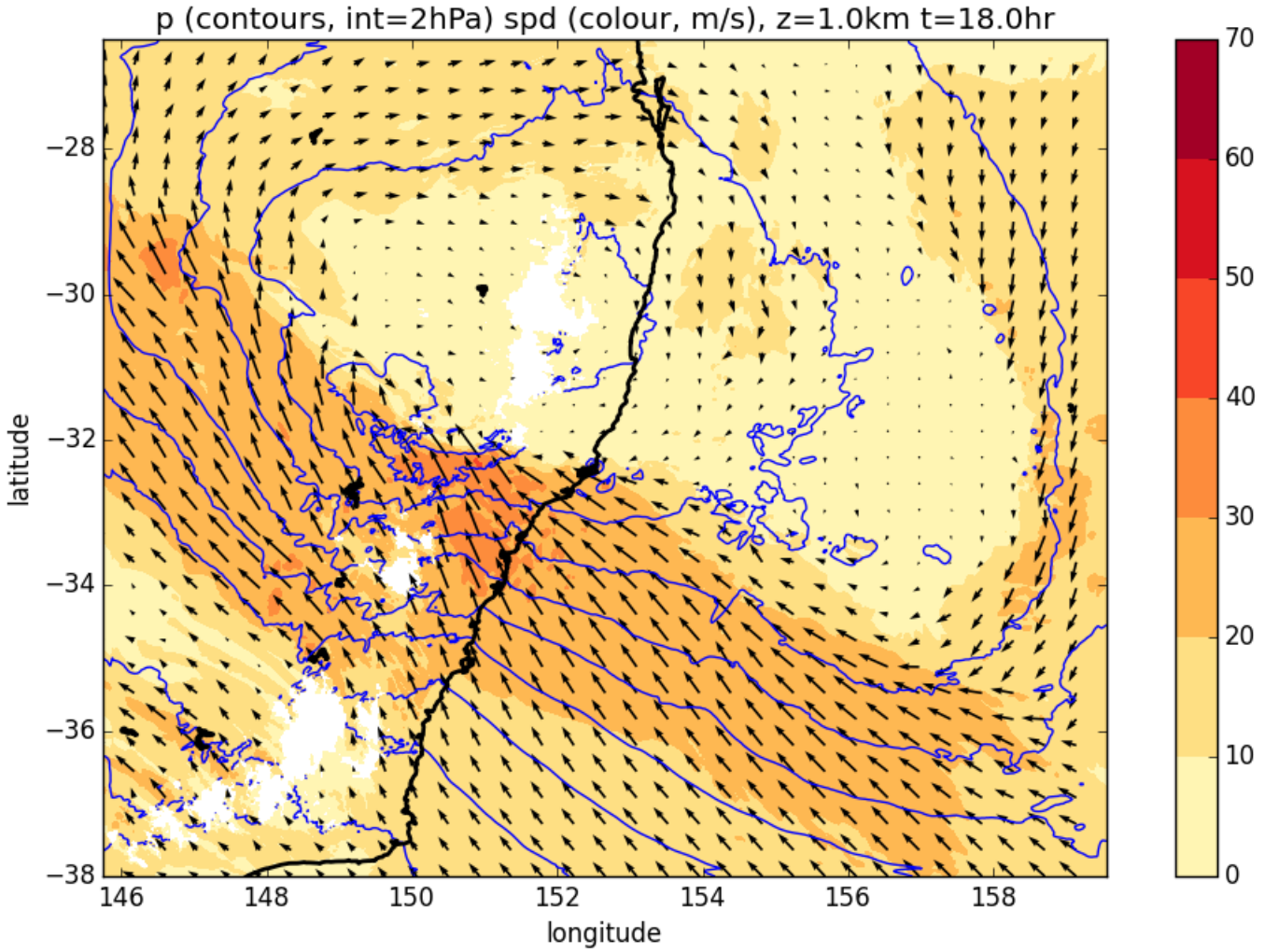
Wettest member (22)



WIND AND P AT Z=1KM, 18UTC APRIL 21

Australian Government
Bureau of Meteorology

Wettest member (22)



WIND AND P AT Z=1KM, 23UTC APRIL 21

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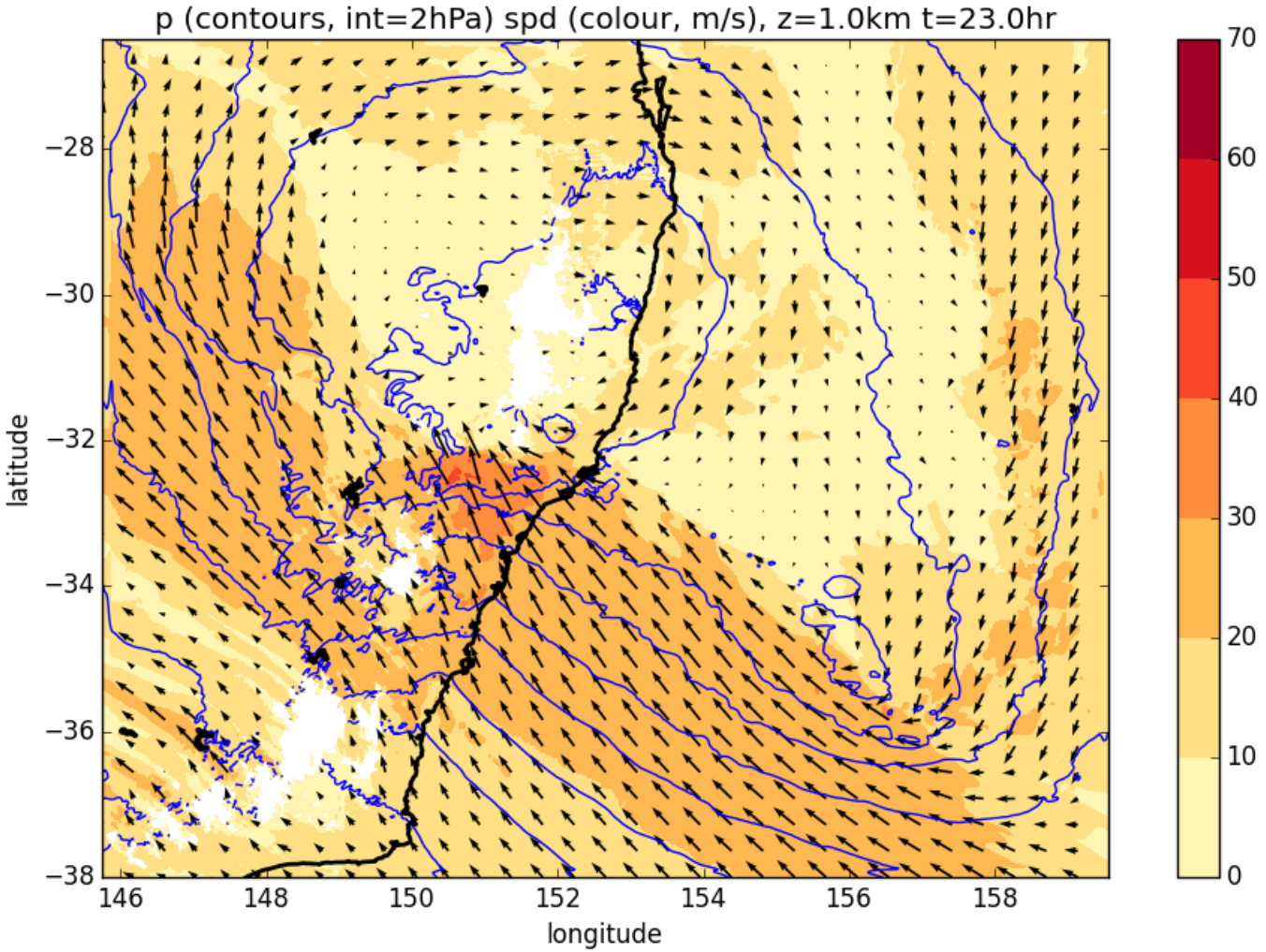
Bureau of Meteorology

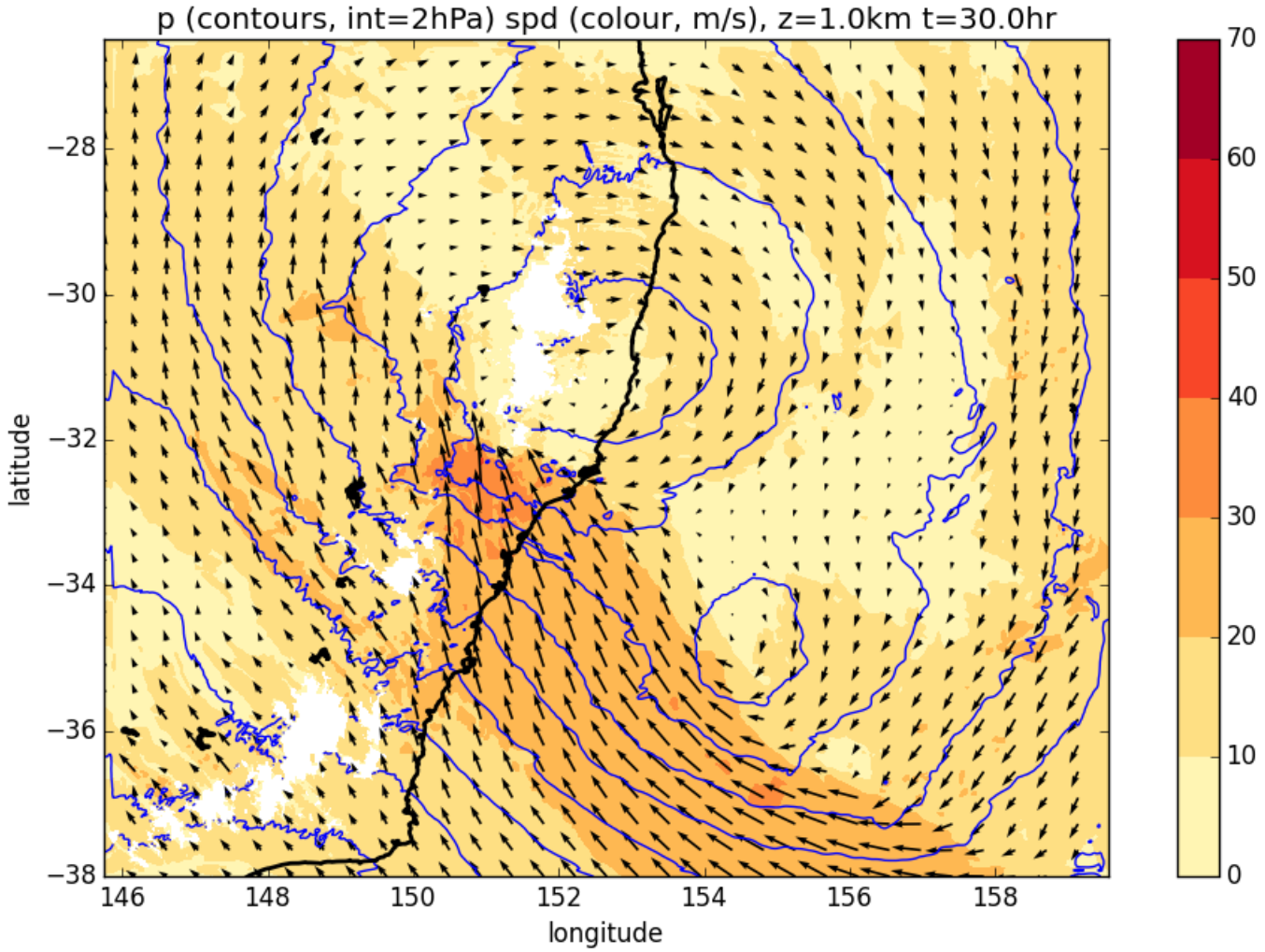
Wettest member (22)



WIND AND P AT Z=1KM, 06UTC APRIL 22

Australian Government
Bureau of Meteorology

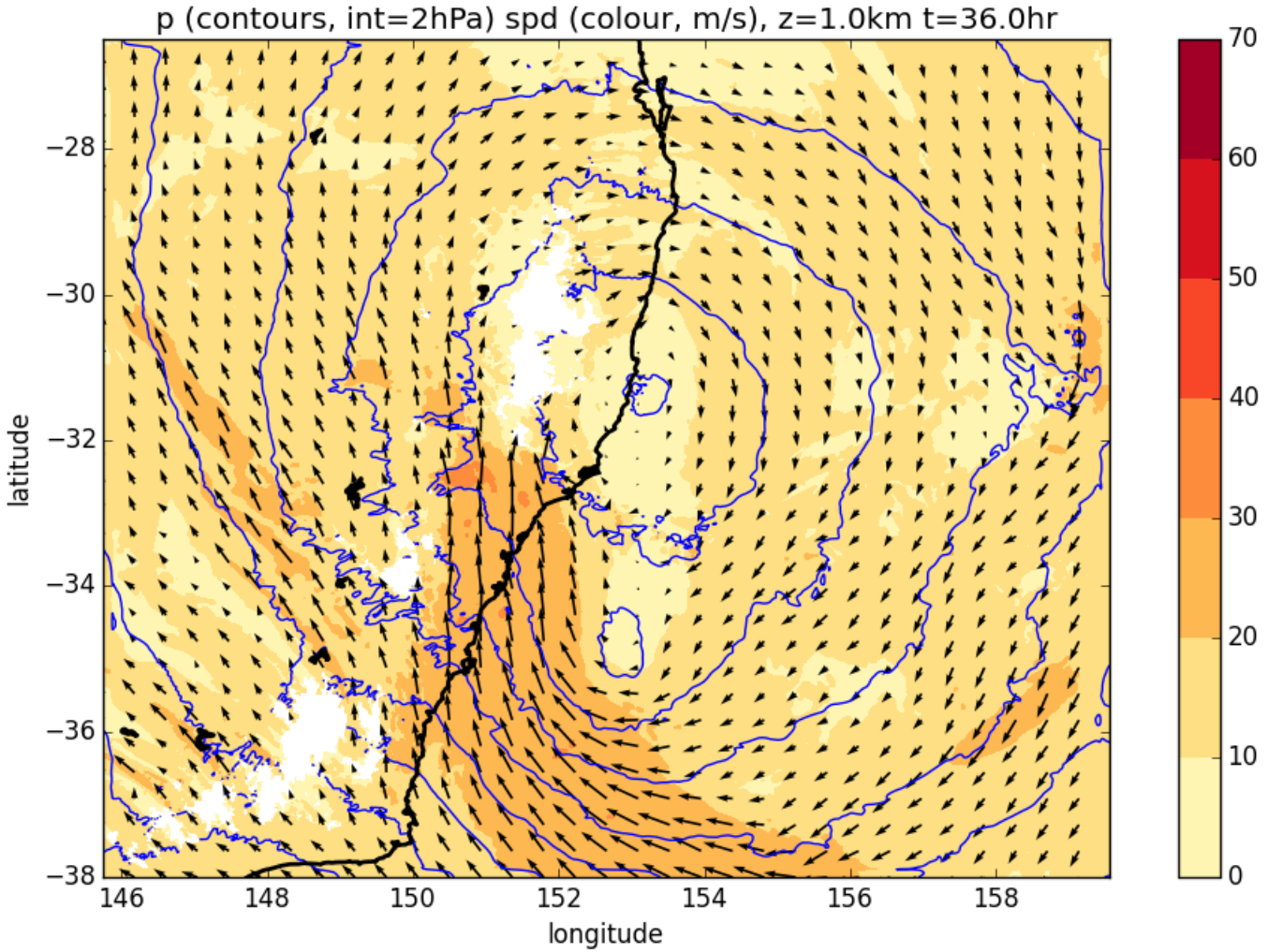
Wettest member (22)



WIND AND P AT Z=1KM, 12UTC APRIL 22

Australian Government
Bureau of Meteorology

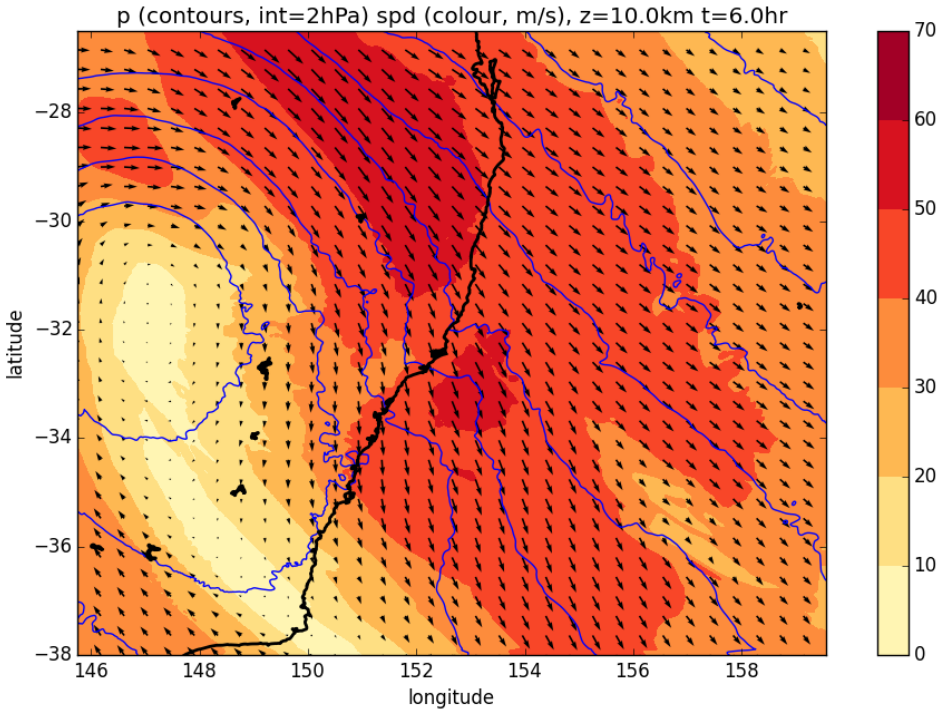
Wettest member (22)

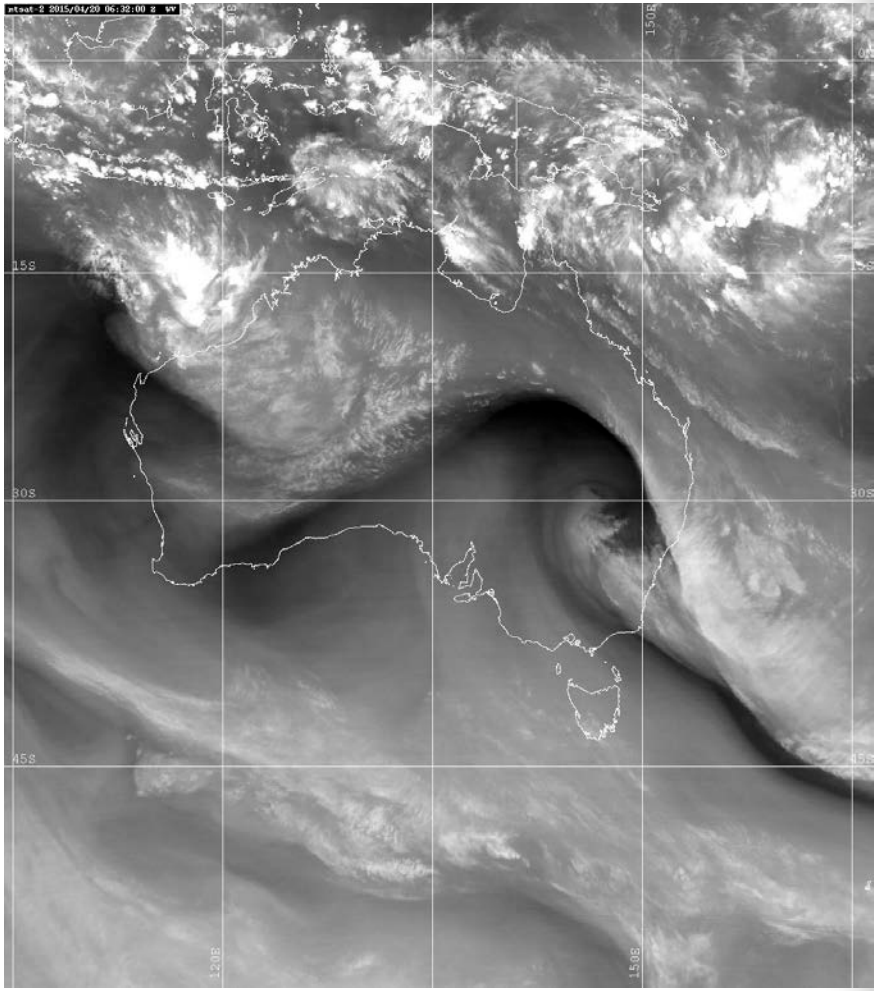


10 KM + WV IMAGERY 06 UTC APRIL 21

Australian Government
Bureau of Meteorology

Wettest member (22)

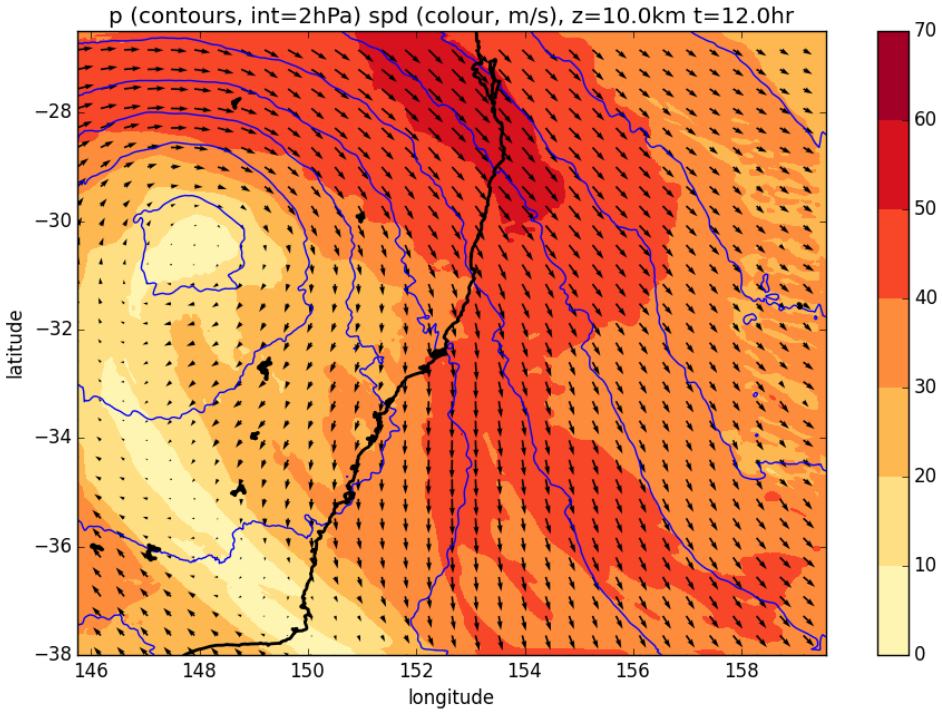


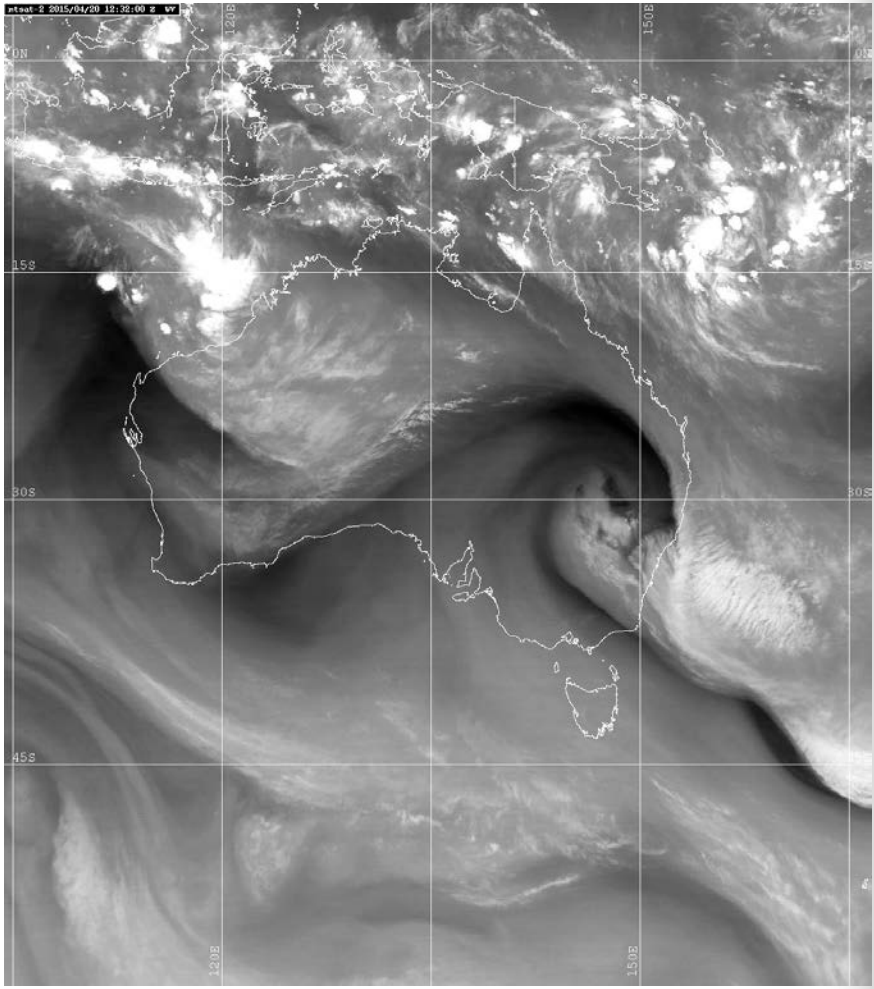


10 KM + WV IMAGERY 12 UTC APRIL 21

Australian Government
Bureau of Meteorology

Wettest member (22)





10 KM + WV IMAGERY 18 UTC APRIL 21

Australian Government
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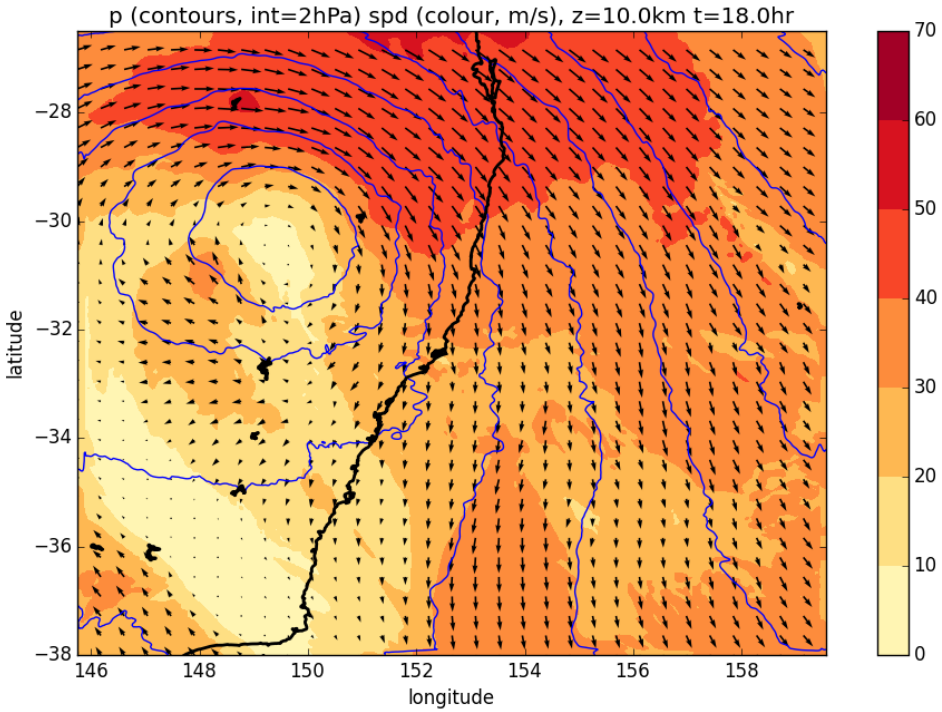
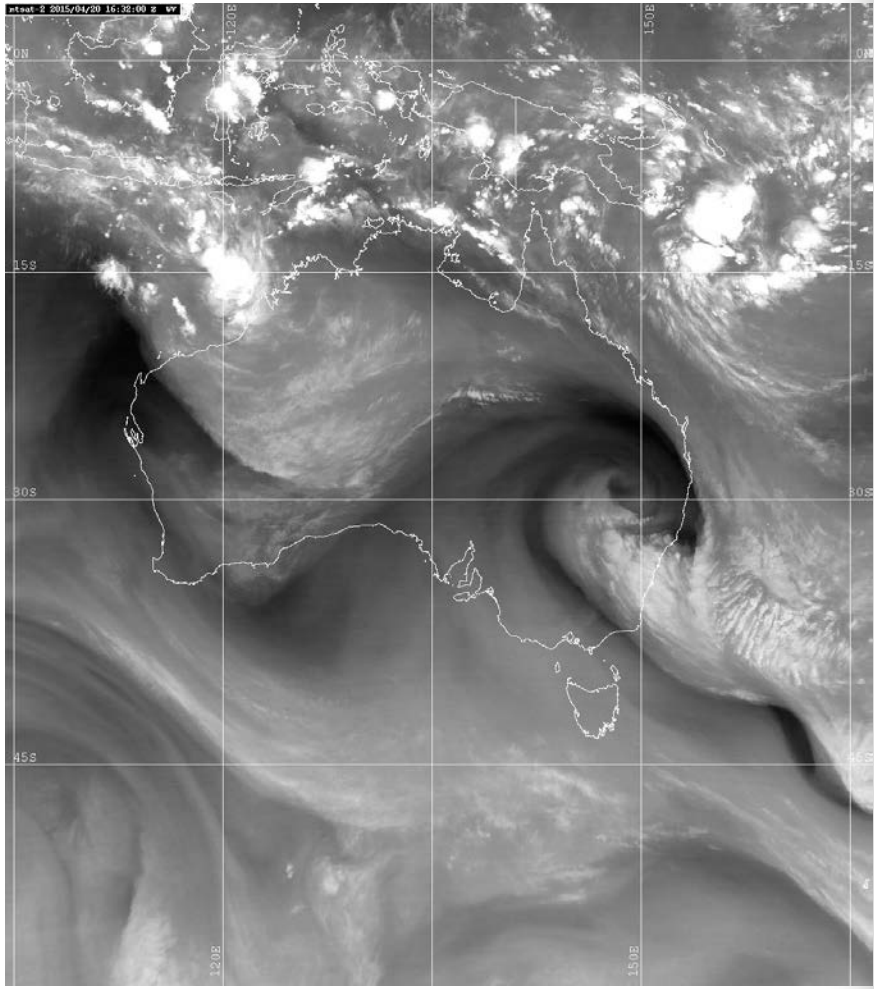
Wettest member (22)





FIREBRAND TRANSPORT – 15 M S^{-1} WIND

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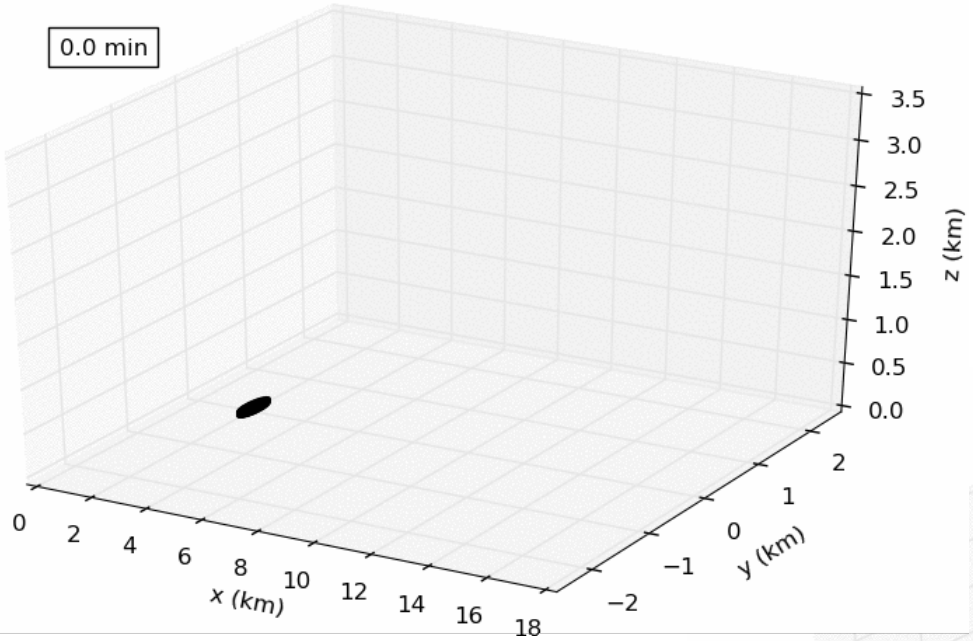

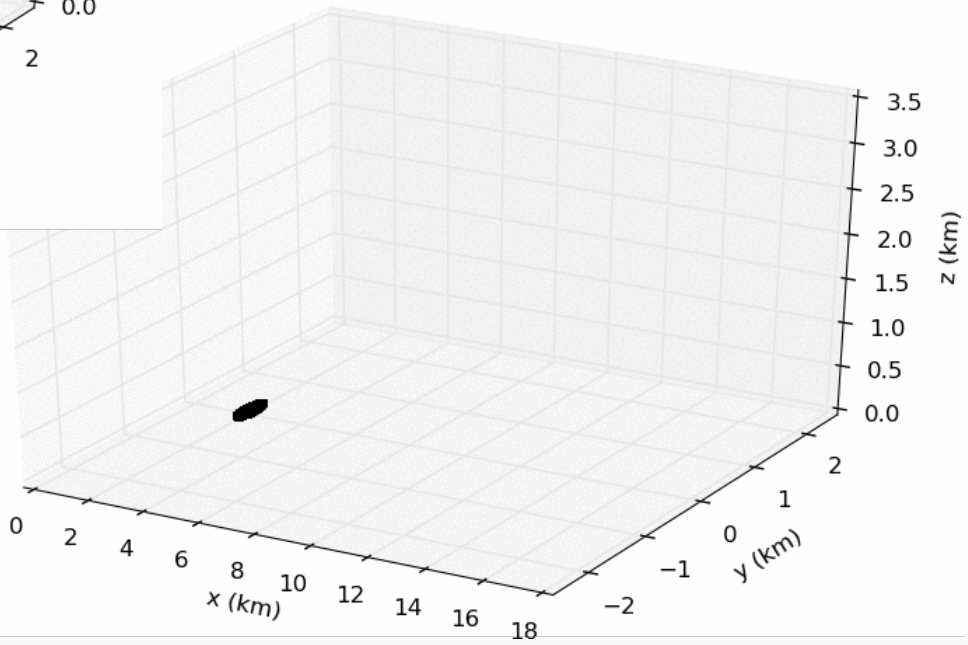

TWO-DIMENSIONAL LANDING

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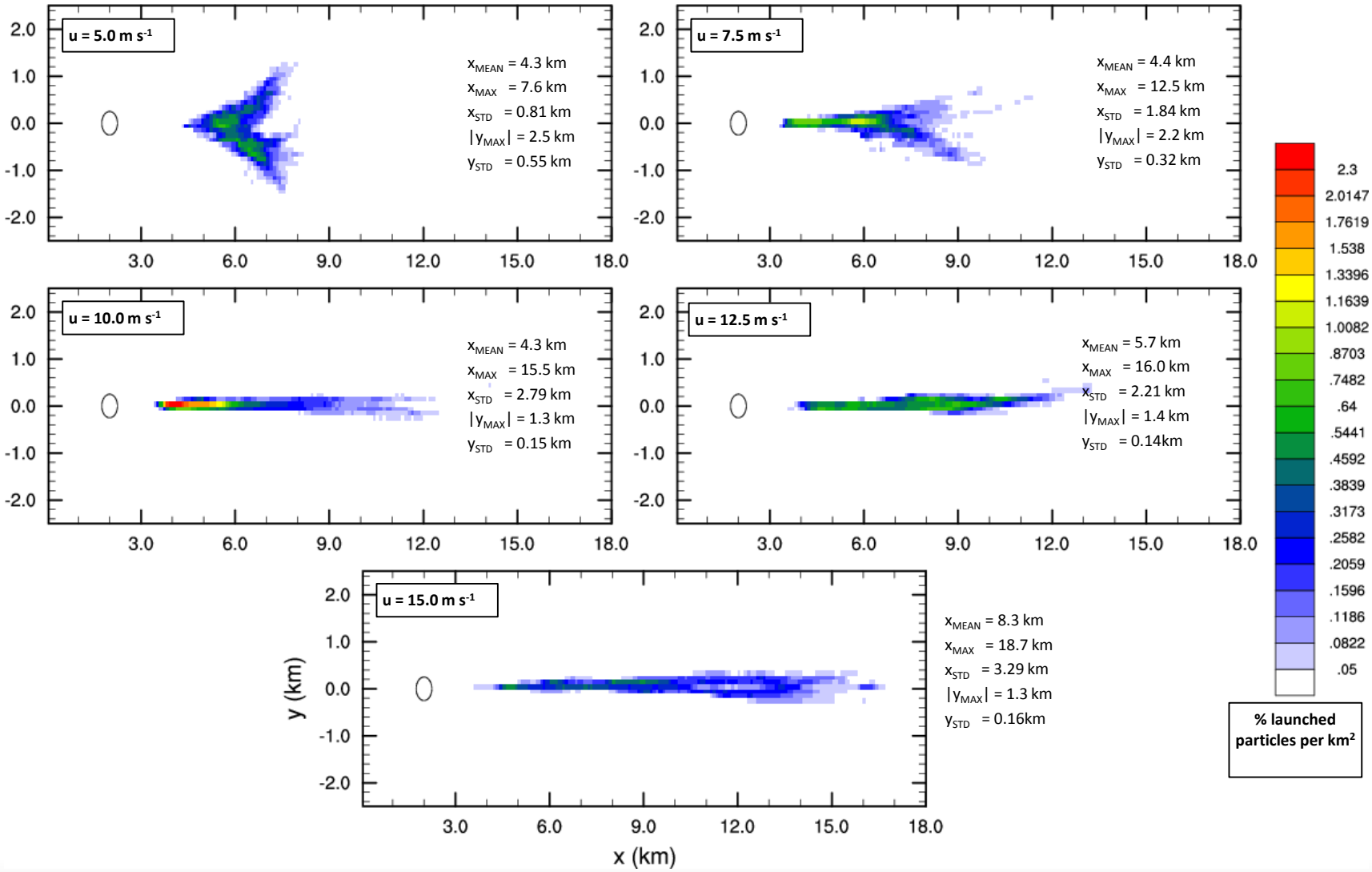
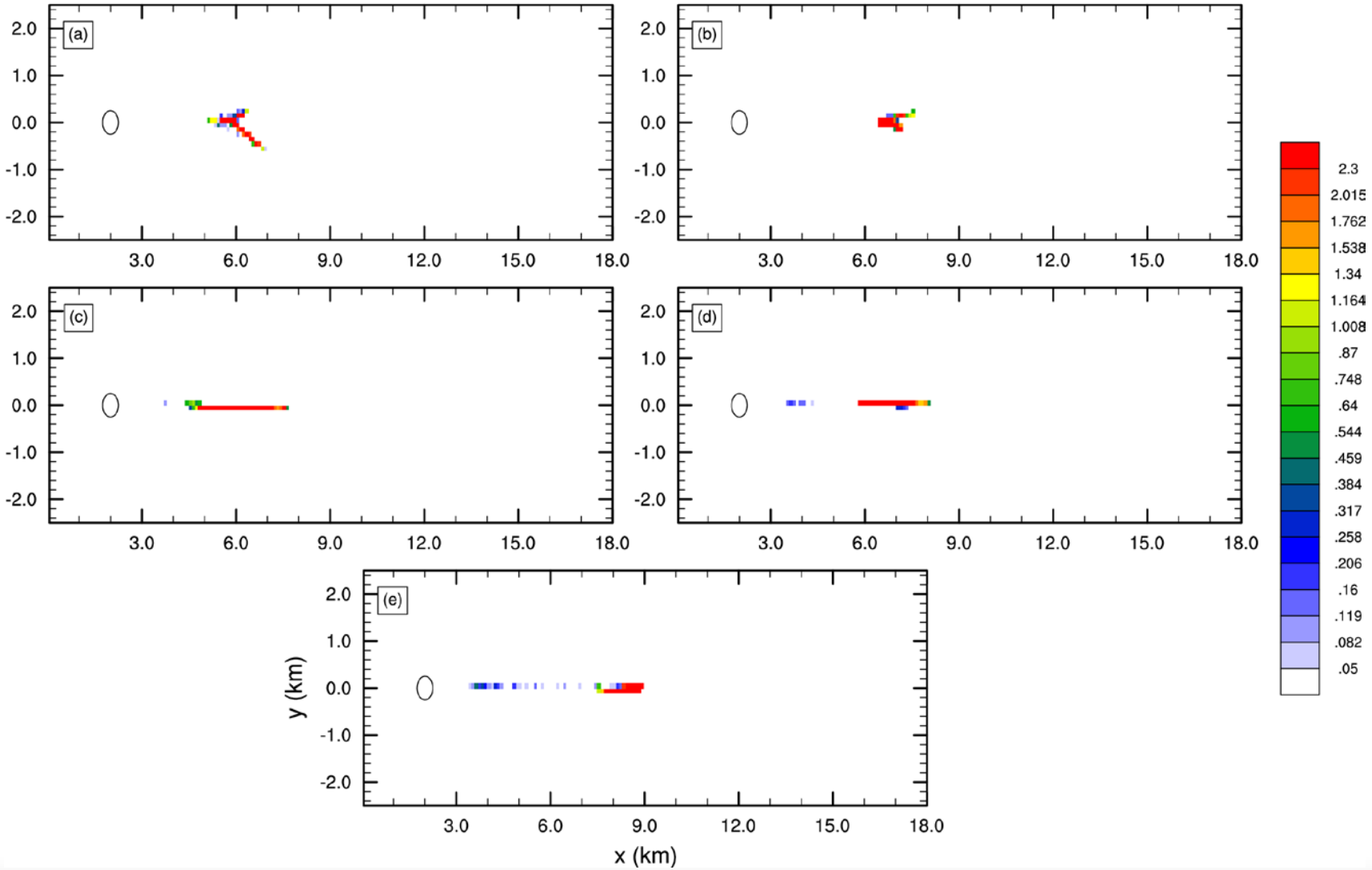


TWO-DIMENSIONAL LANDING



TURBULENCE IN THE PLUME

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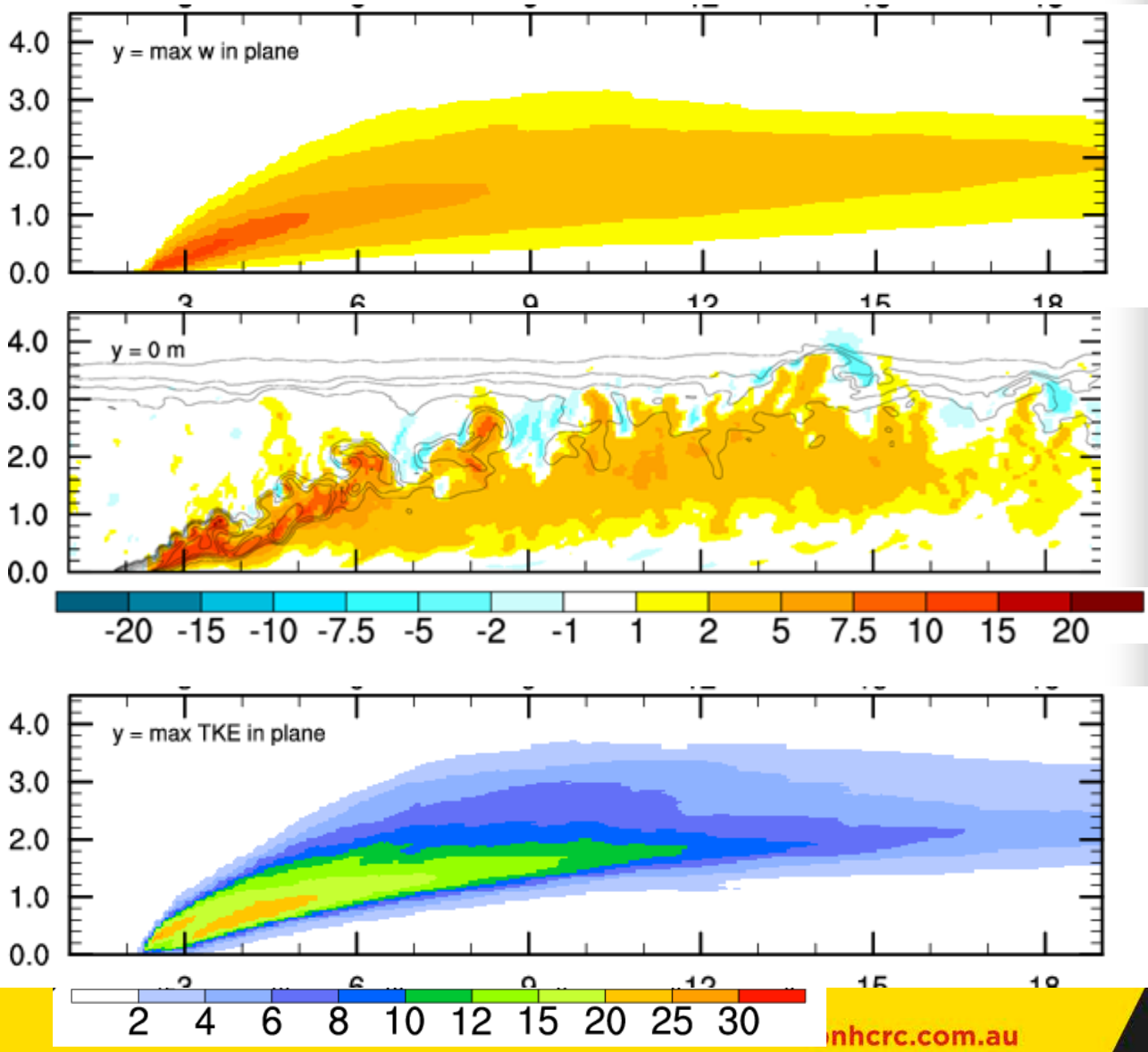
Mean plume updraft

Snapshot updraft

Turbulence intensity



PYROCUMULUS DEVELOPMENT

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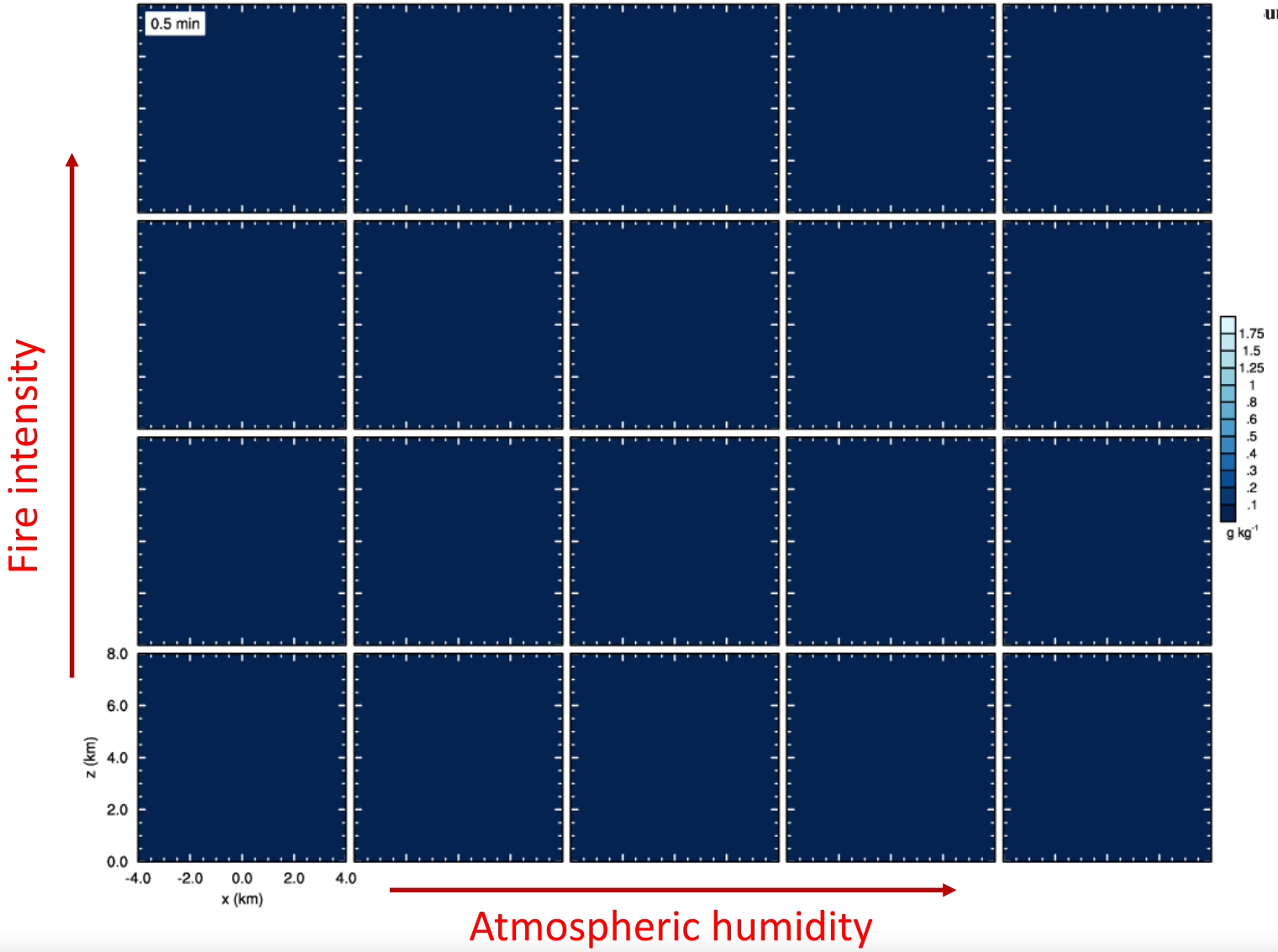

BUT FIRES ALSO PRODUCE MOISTURE …

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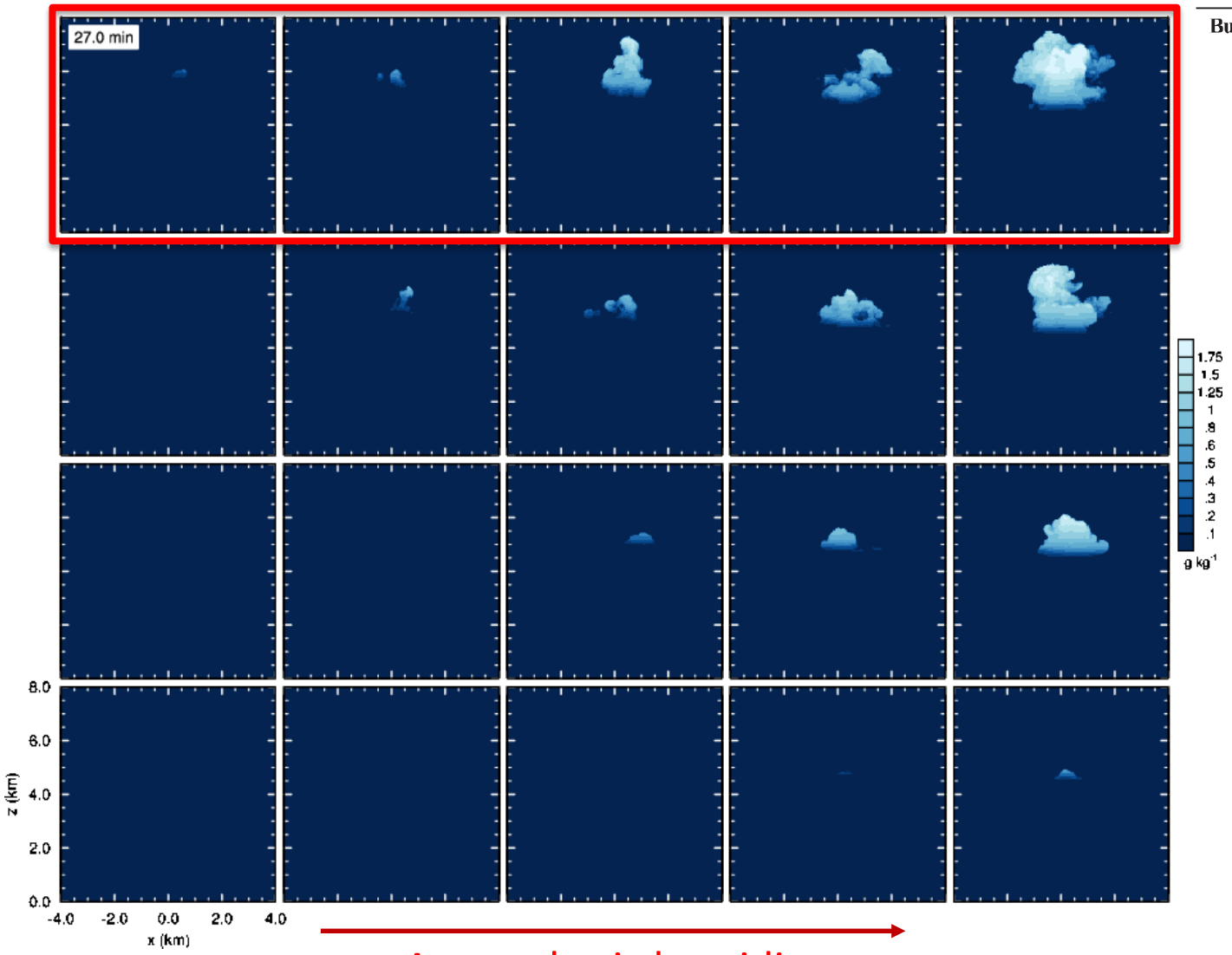

FIRES WITH COMBUSTION MOISTURE

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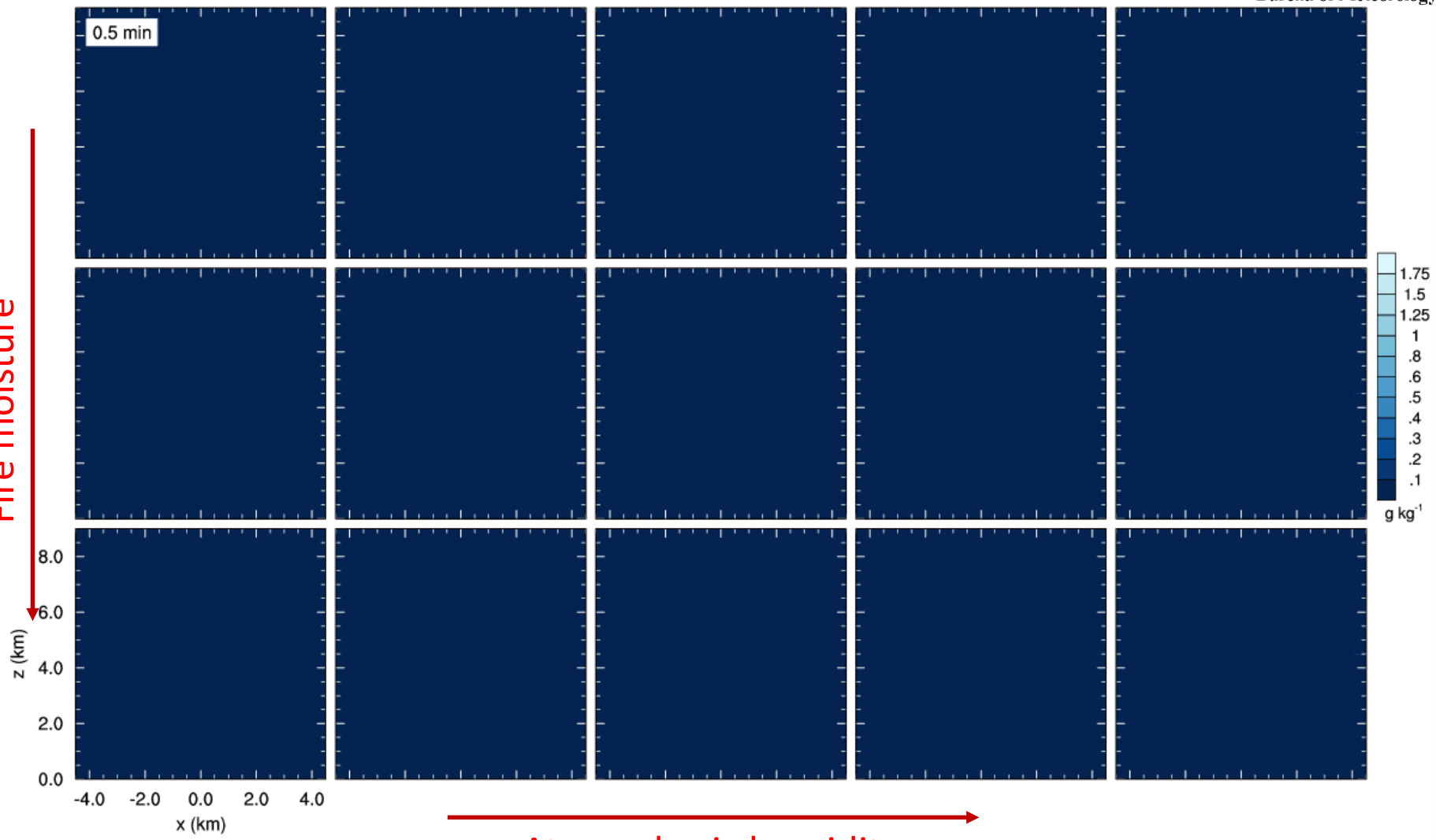

PROJECT STATUS

Australian Government
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1) BNHCRC Milestones
   a) Currently met 40/49 due, plus 2 not yet due
   b) Most unmet ones are minor: exception of paper writing
   c) Have negotiated a re-ordering of parts of the project
   d) 53% time and 36% expenditure used
2) Expect catch-up to continue
3) Significant end-user opportunities

SUMMARY

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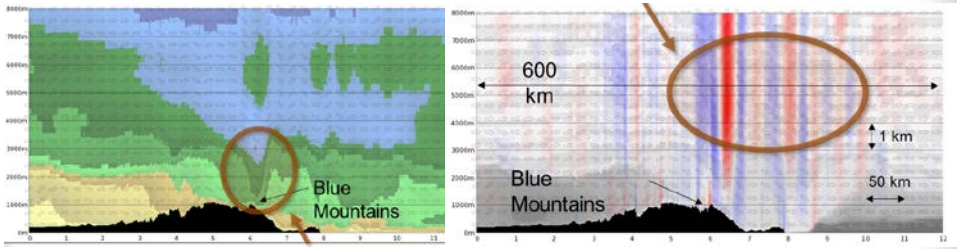
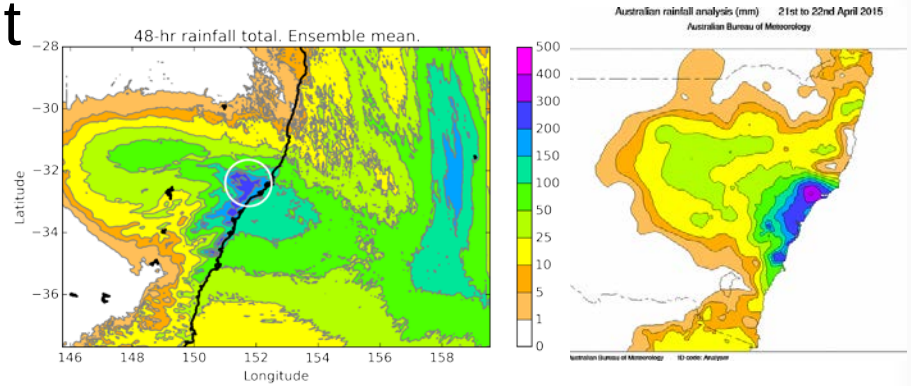
1) Blue mountains – dry slot + mountain waves



2) Ensemble prediction of east coast low



3) Ember transport – plume turbulence is crucial

4) Pyrocumulus – does combustion moisture matter?