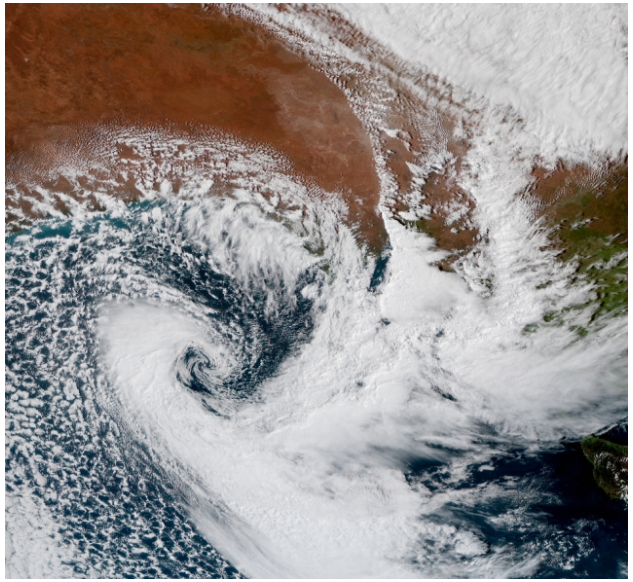
A case study of South Australia's severe thunderstorm and tornado outbreak (28 September 2016)



AFAC 2019

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Australian Government
Bureau of Meteorology

bushfire&natural HAZARDSCRC

Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Programme

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- On September 28 2016 one of the most significant severe thunderstorm outbreaks affected central and eastern parts of South Australia
- Intense low pressure system contributed to multiple supercell thunderstorms, producing at least 7 tornadoes, destructive wind gusts, large hail and intense rainfall
- Triggered state-wide power outage

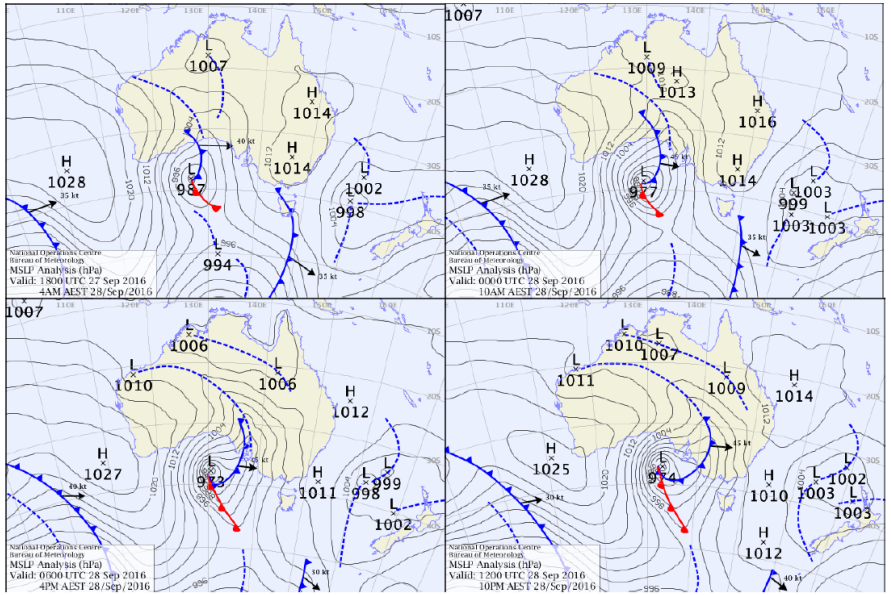


Figure 4: *Synoptic mean sea level pressure charts for 28 September 2016. from top left to bottom right - 3:30 am (CST), 9:30 am (CST), 3:30 pm (CST) and 9:30 pm (CST).*

http://www.abc.net.au/news

http://www.bom.gov.au/announcements/sevwx/

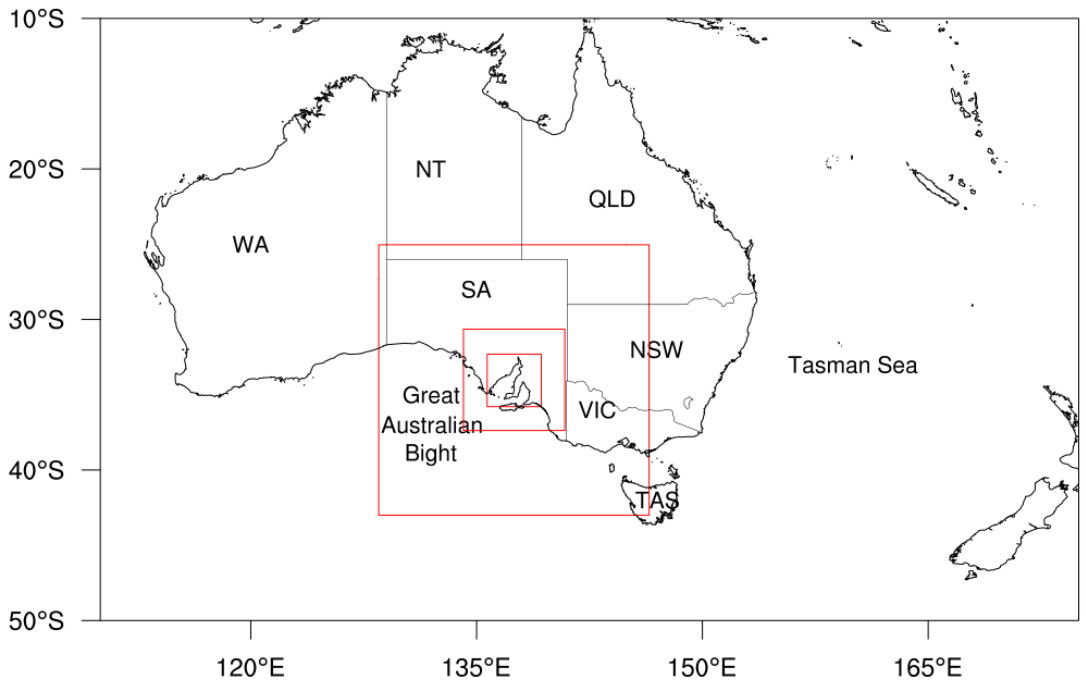
Modelling set-up

Deterministic simulations:

- High-resolution simulations of ACCESS nested model (global, 4.0 km, 1.5 km and 400 m), vn10.6
- The mid-latitude regional science configuration (RA1M)
- Initialised at 1500 UTC 27 September 2016

Ensemble simulations:

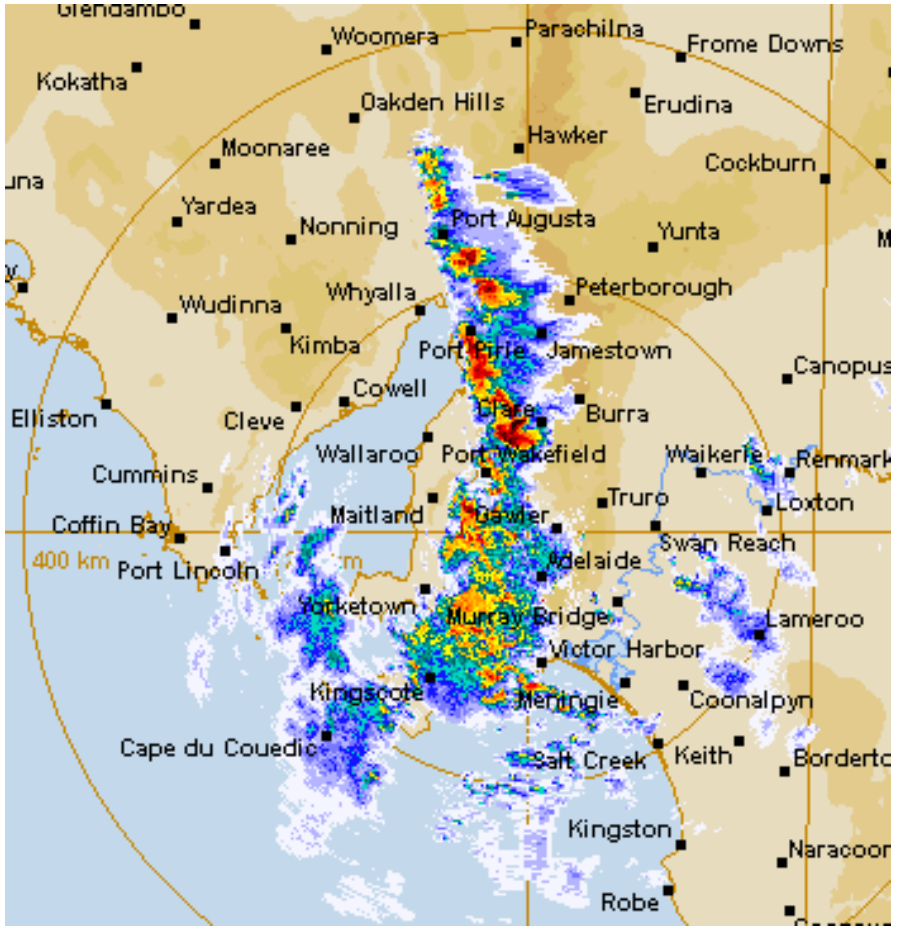
- Ensemble nesting suite vn11.1
- 6 members
- Initialised at 1200 UTC 27 September 2016 using MOGREPS-G
- Global (~ 33 km), 4 km, 1.5 km and 400 m
- RA1M science configuration

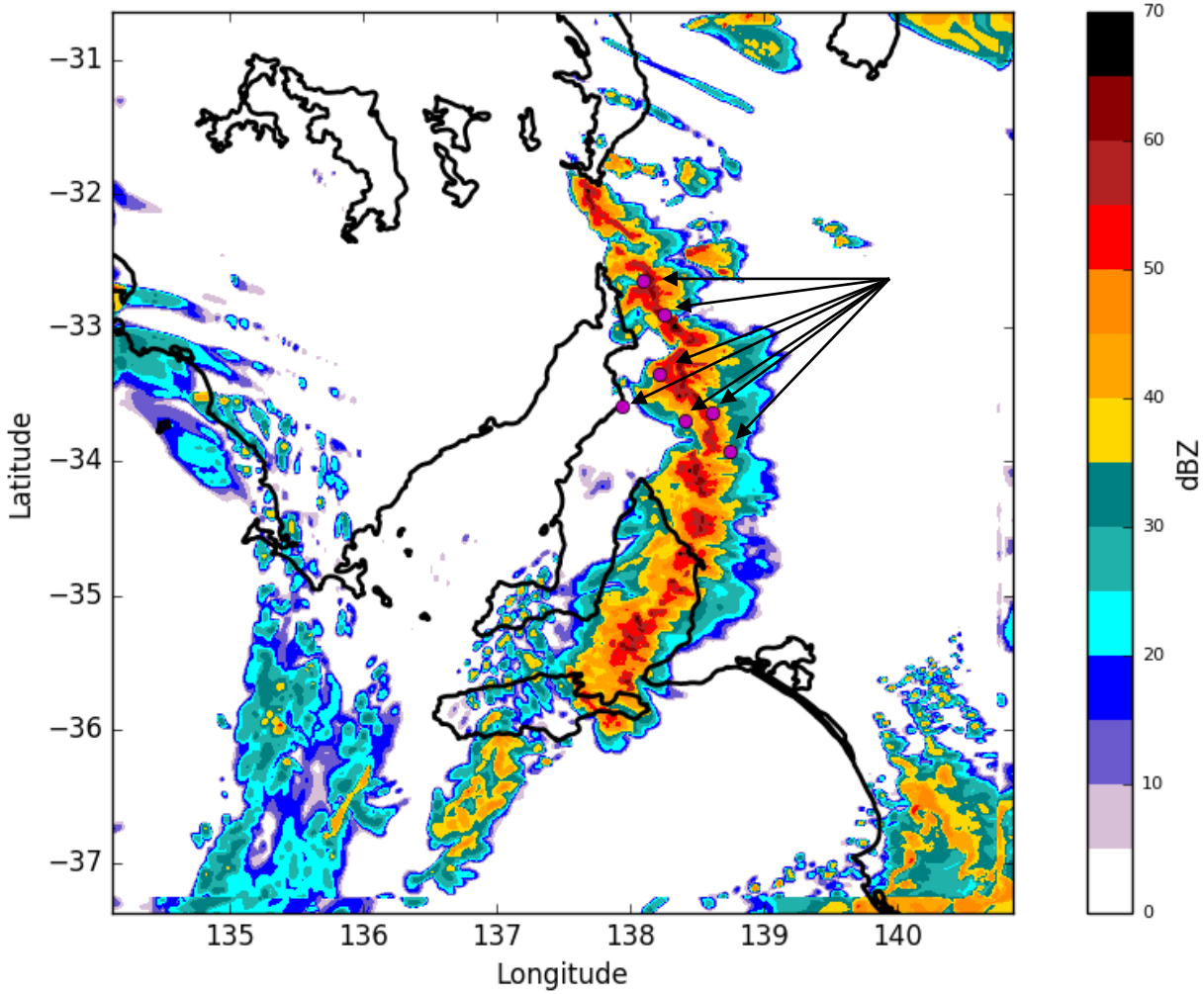


Deterministic simulations

0600 UTC 28 September 2016

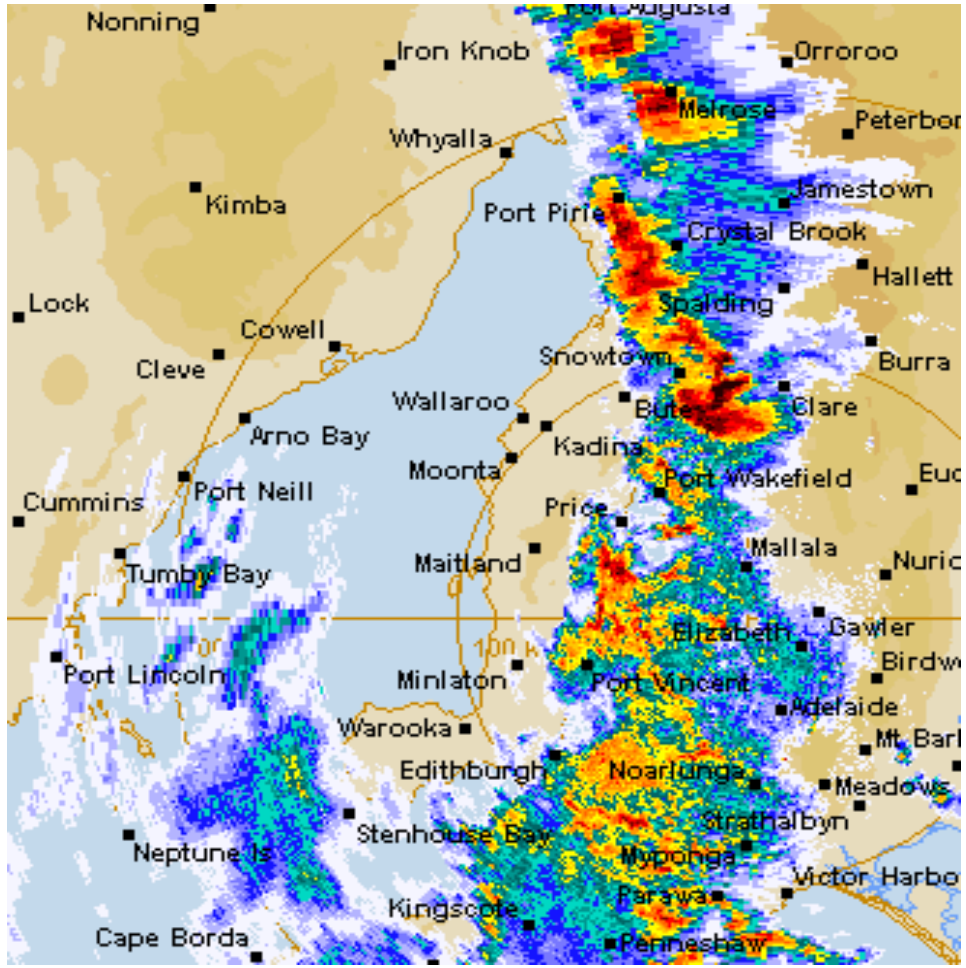
Actual rainfall rate (left) and 1.5-km simulated radar reflectivity (right)

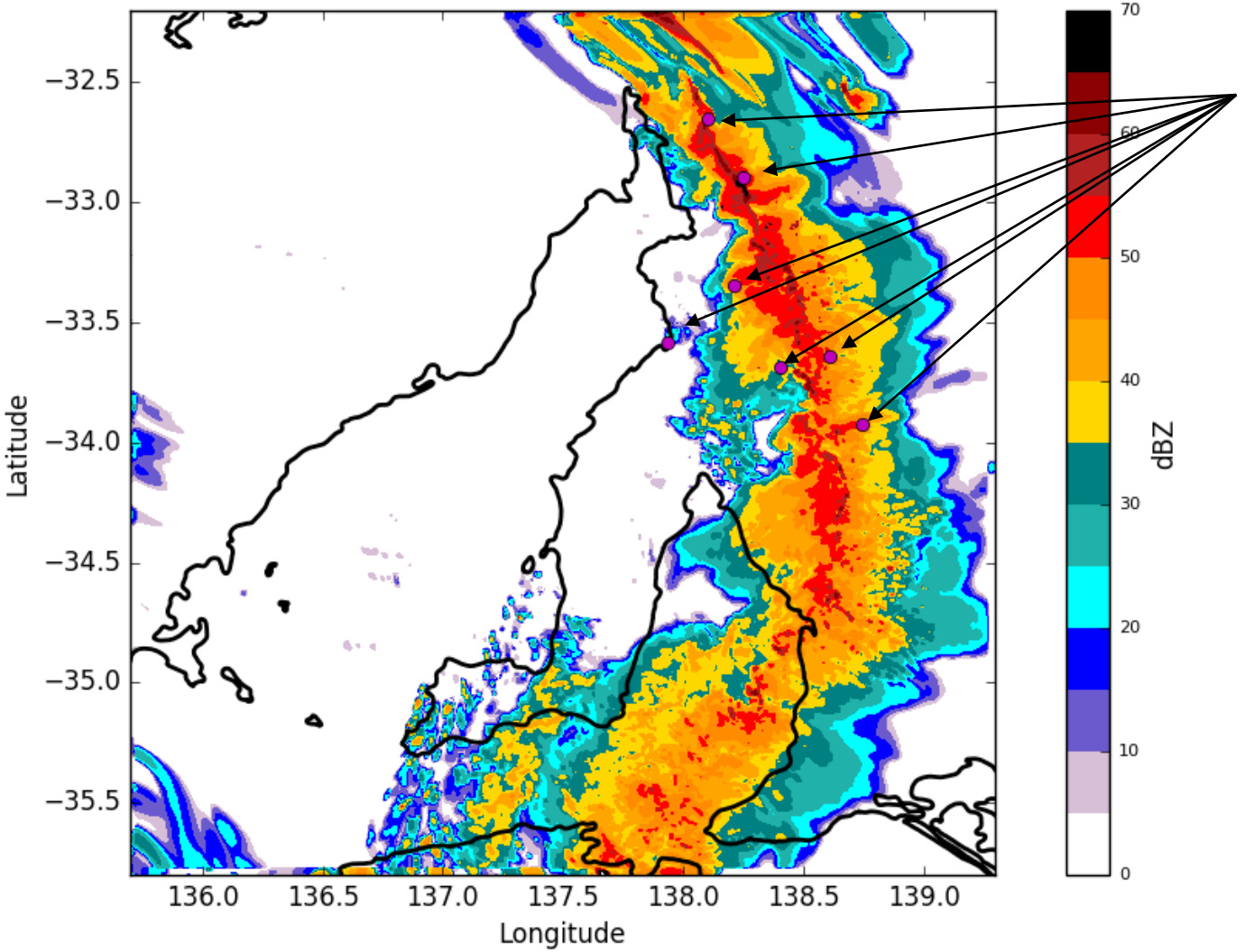




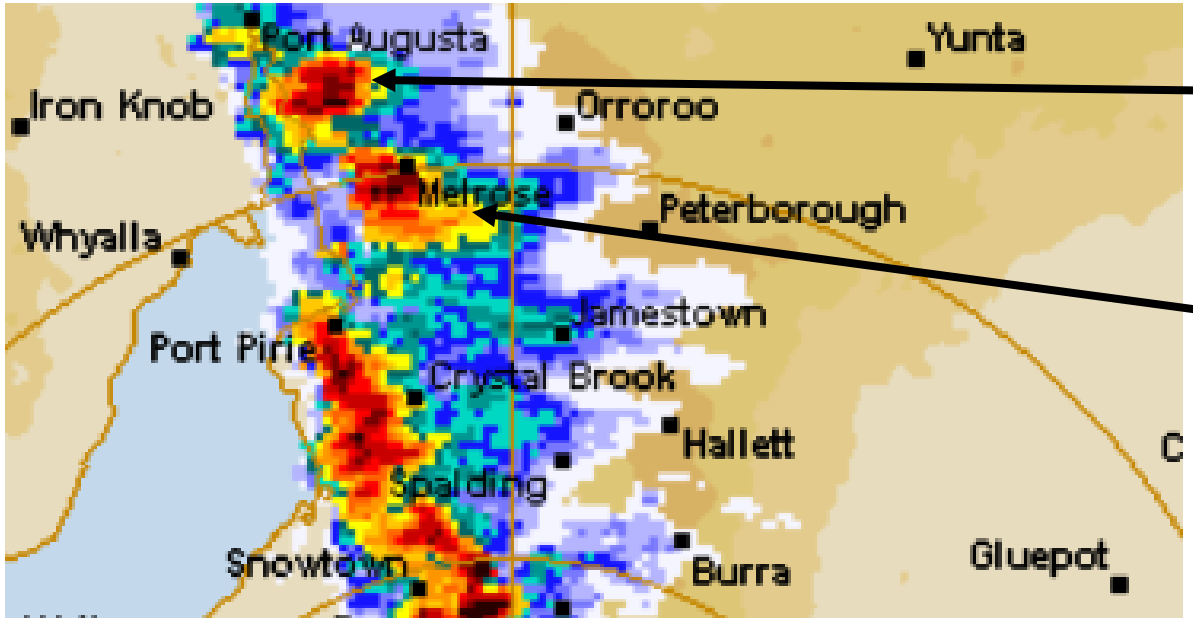
7 magenta dots represent 7 tornado locations that were reported between 02:30 pm and 04:30 pm (local time)

0600 UTC 28 September 2016
Actual rainfall rate (left) and 400-m simulated radar reflectivity (right)

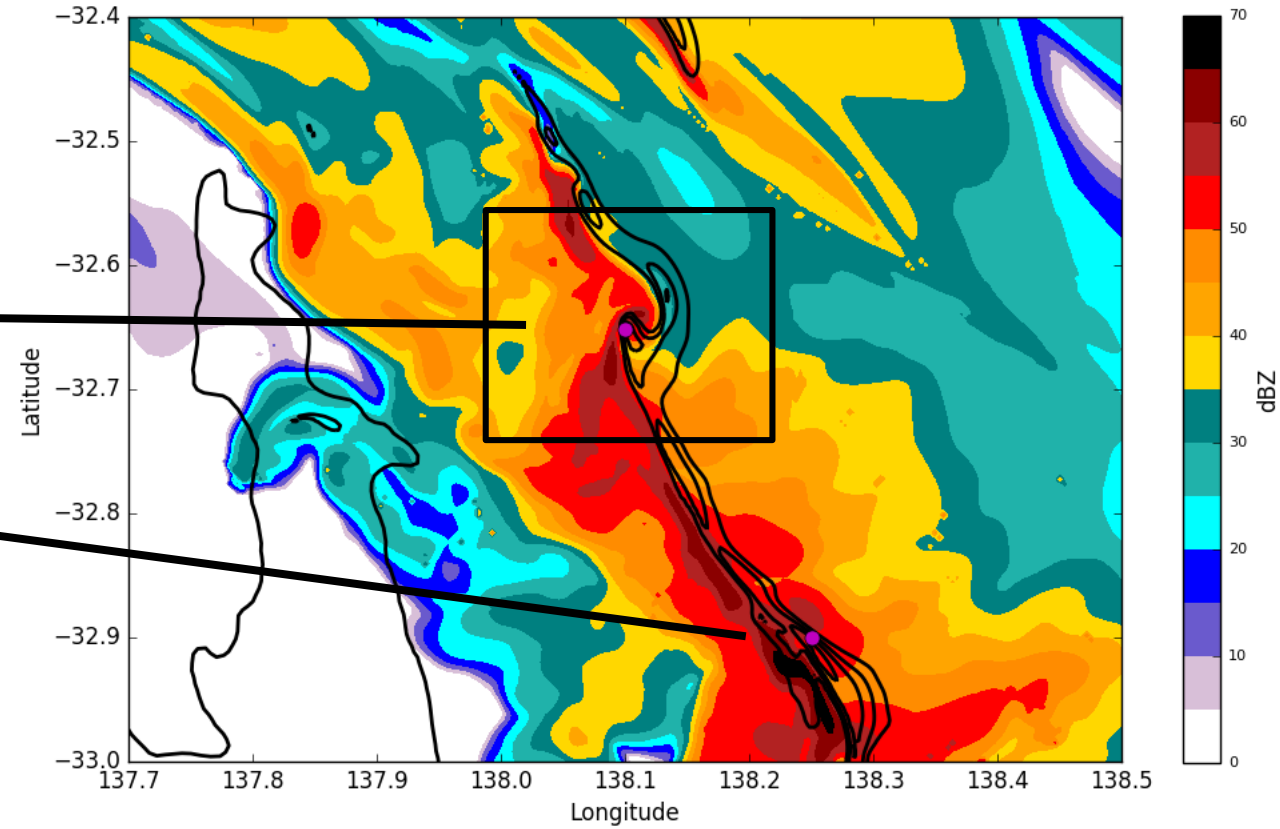




0600 UTC 28 September 2016



Simulated radar reflectivity and upward vertical velocity (black contours)



- Hook-echo pattern (black box) indicates meso-cyclone and coincides with the location of one of the observed tornadoes.

What does this look like if you're standing right next to it?

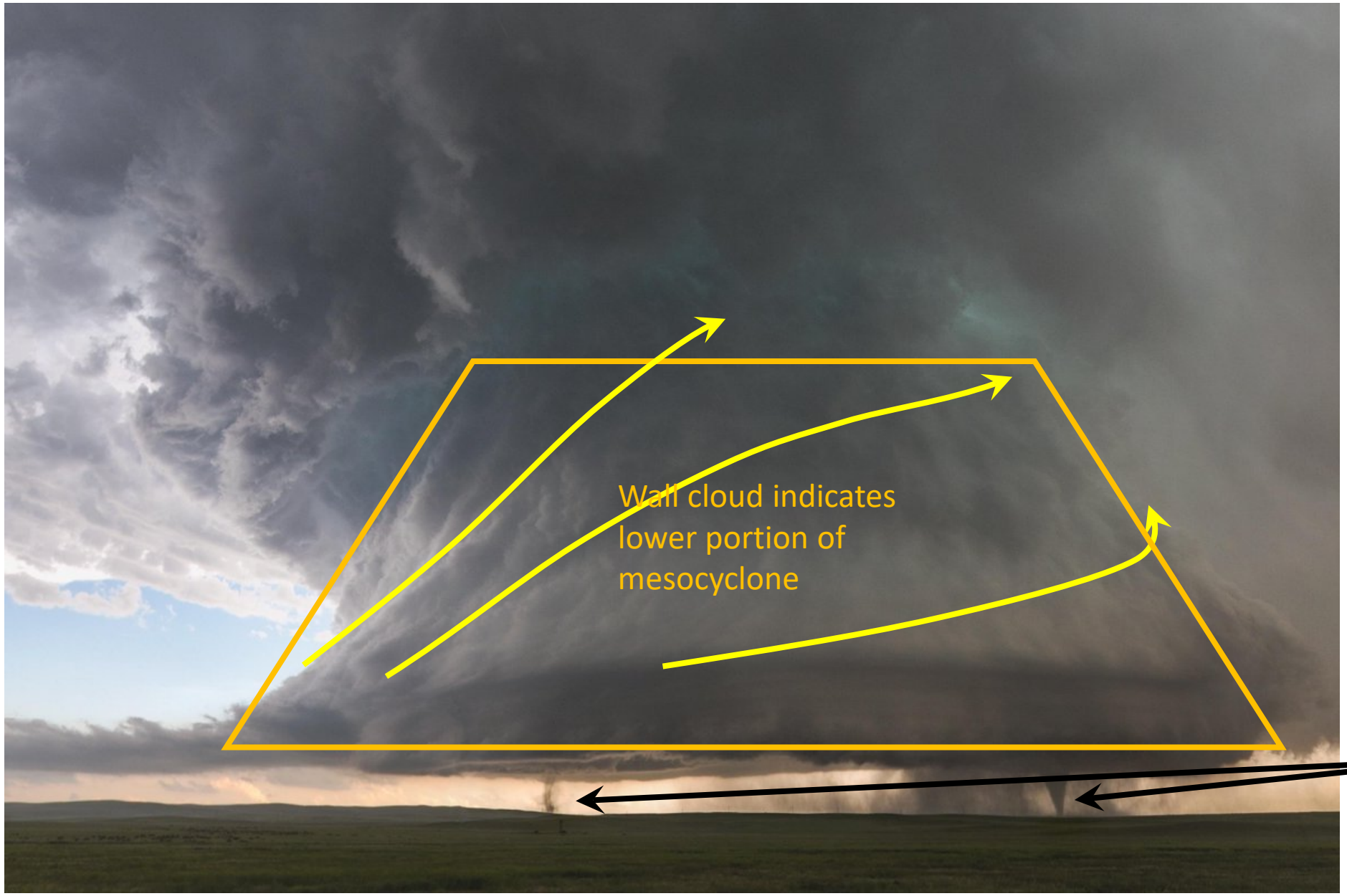
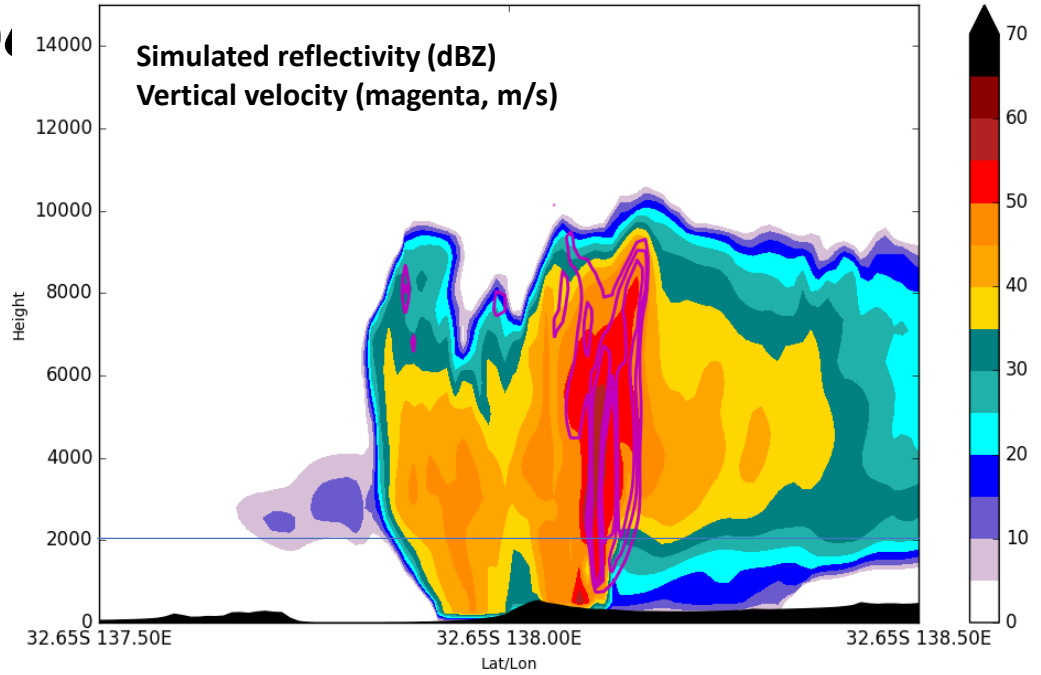
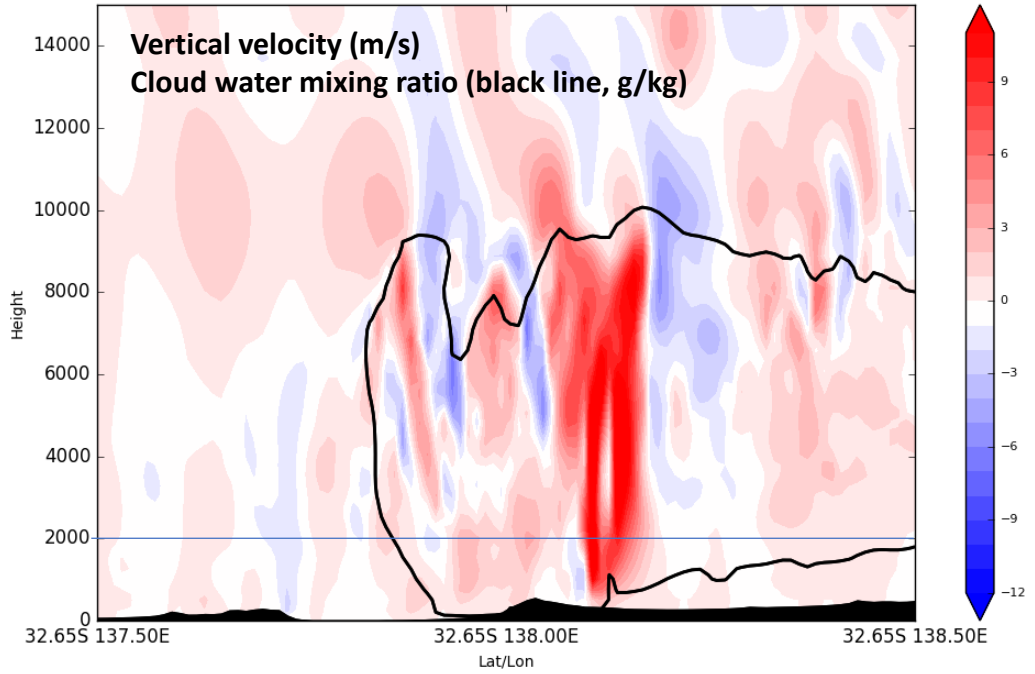


Photo: Kelly DeLay





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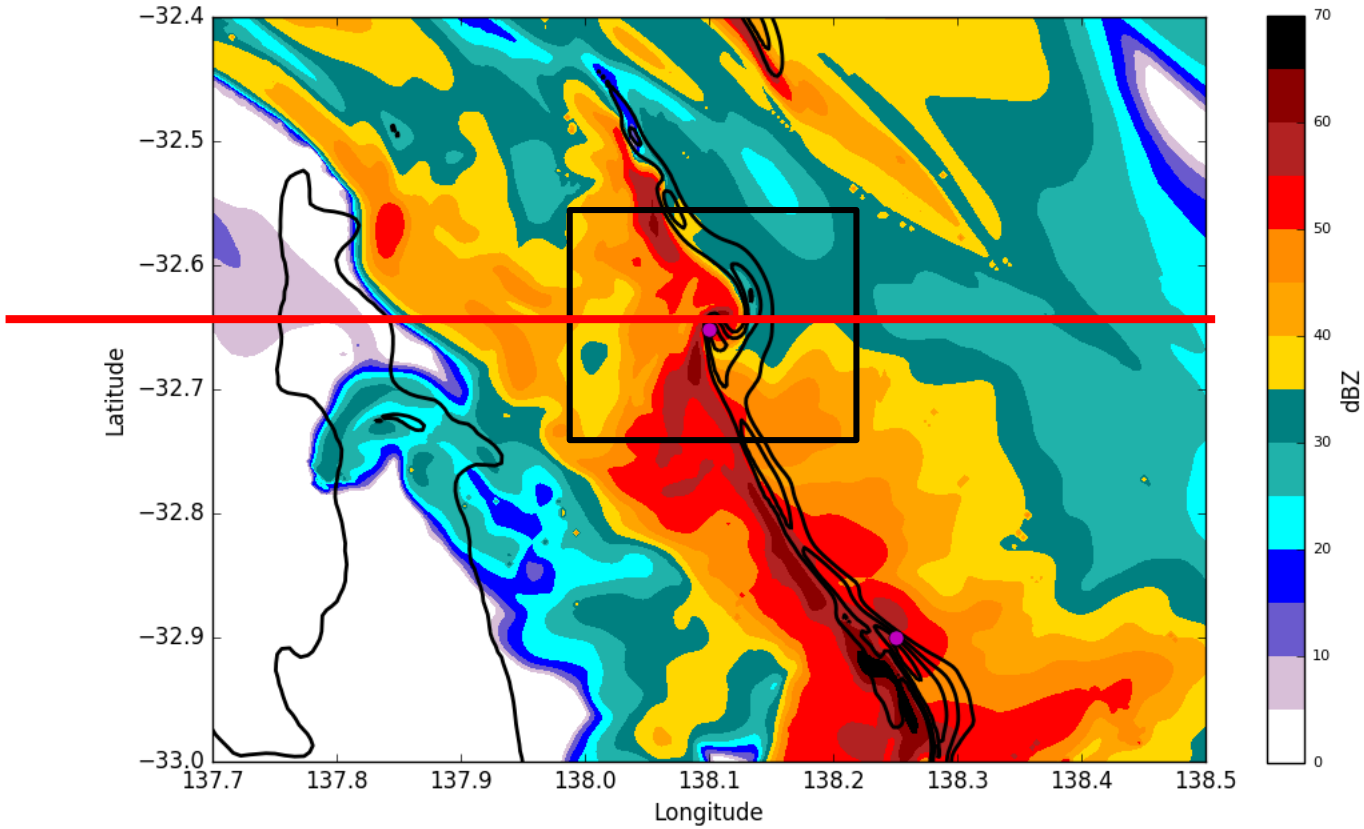
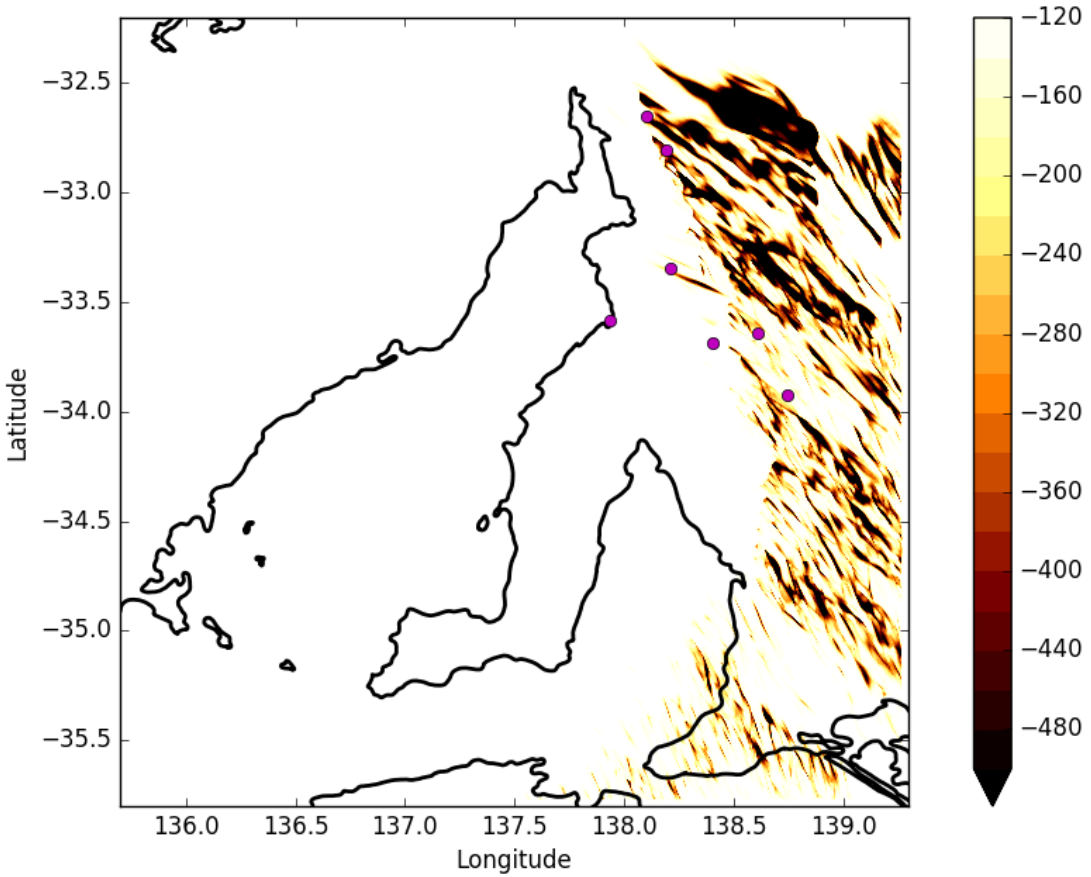


- Hook-echo pattern (black box) indicates meso-cyclone and coincides with the location of one of the observed tornadoes.

Updraft helicity diagnostic field

- Designed to identify the ***potential*** for updraft rotation in simulated storms
- Product of vertical velocity (updraft) and vertical vorticity

Hourly min updraft helicity ($m^2 s^{-2}$) for (first) 0500-0600 UTC and (second) 0600-0700 UTC 28 September 2016



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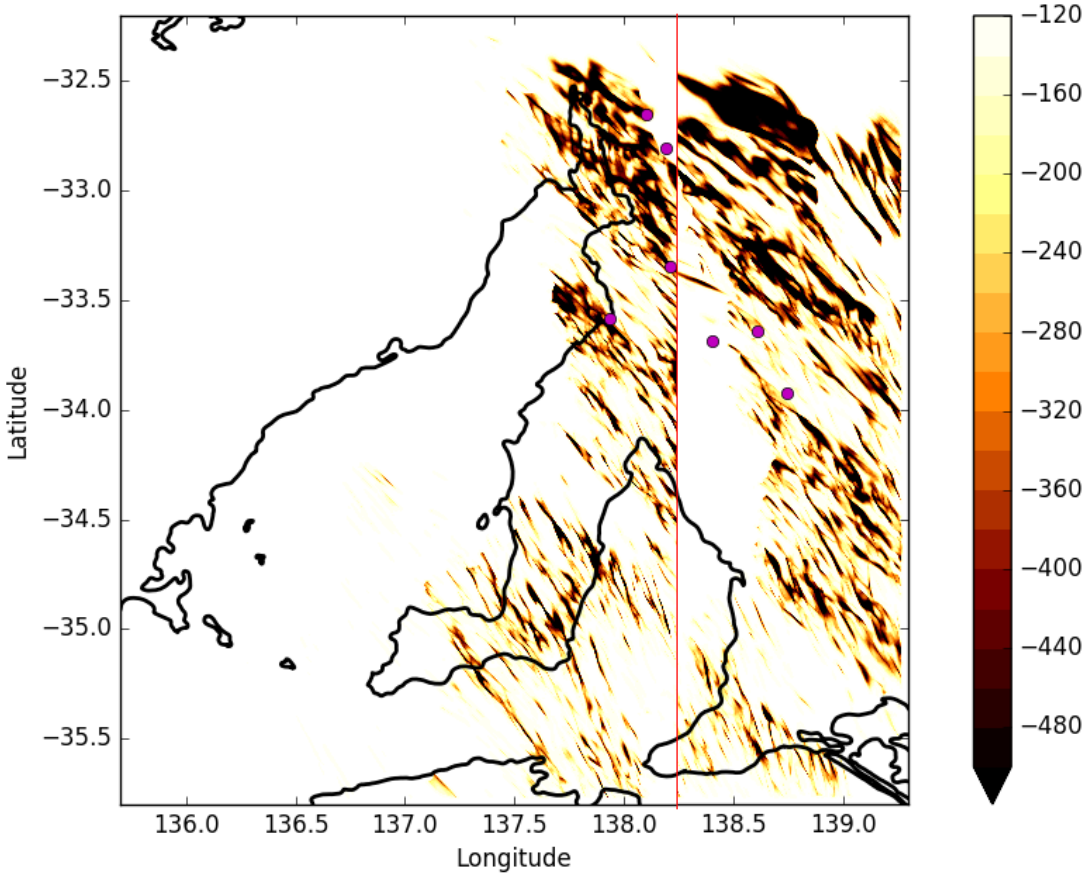


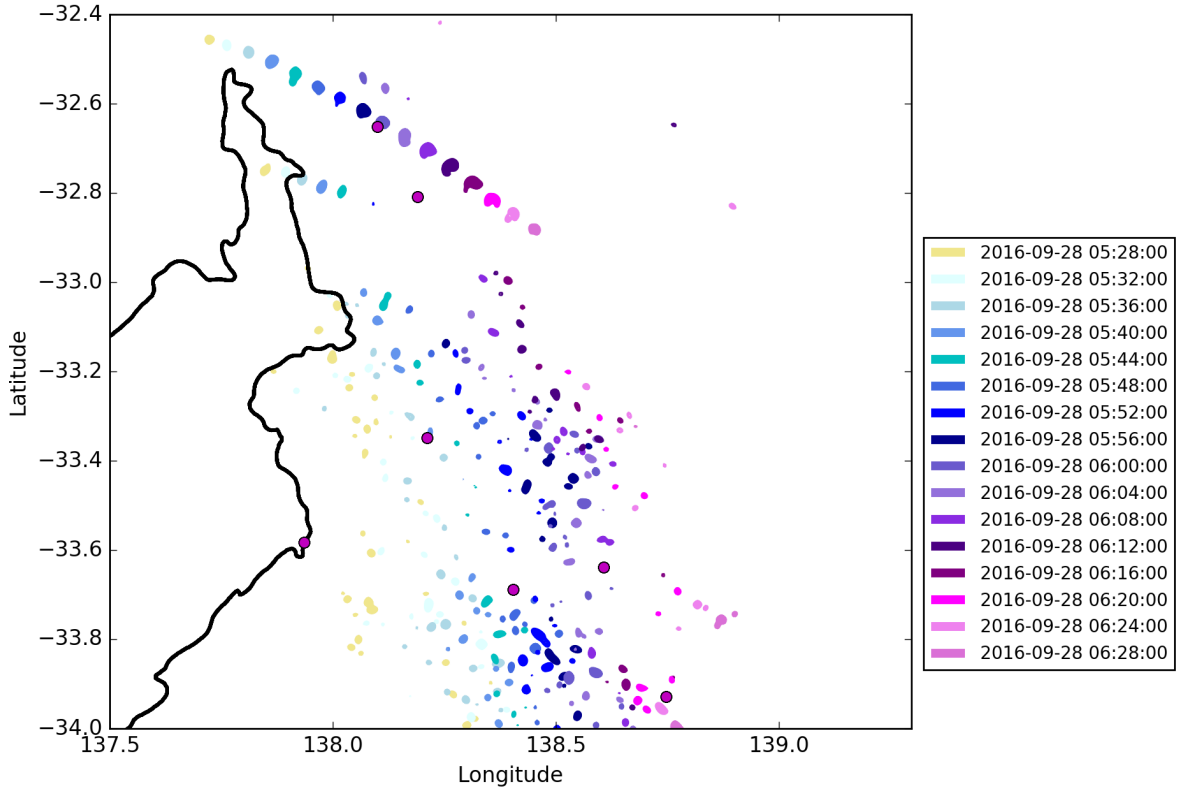
Okubo-Weiss parameter

- UH was designed to identify the ***potential*** for updraft rotation development
- We considered a diagnostic that also identifies the ***presence*** of a rotating updraft
- Layer averaged Okubo-Weiss parameter – identifies vortex cores

$$OW = \left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right)^2 - \left\{\left(\frac{\partial u}{\partial x} - \frac{\partial v}{\partial y}\right)^2 + \left(\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right)^2\right\}$$

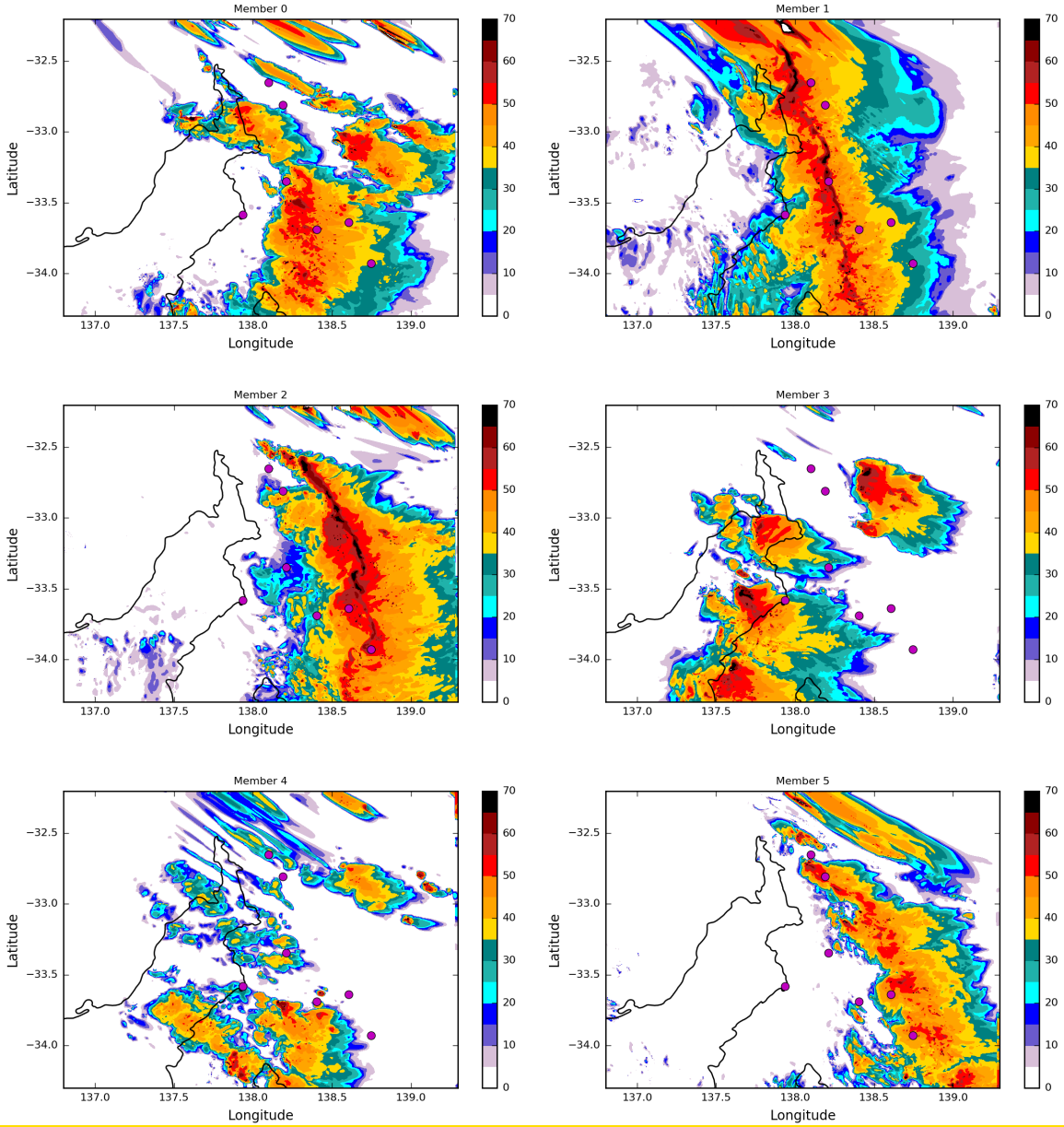
$$(\text{Vorticity})^2 - \{(\text{Shear Def.})^2 + (\text{Stretch Def.})^2\}$$

1 km to 4 km layer average

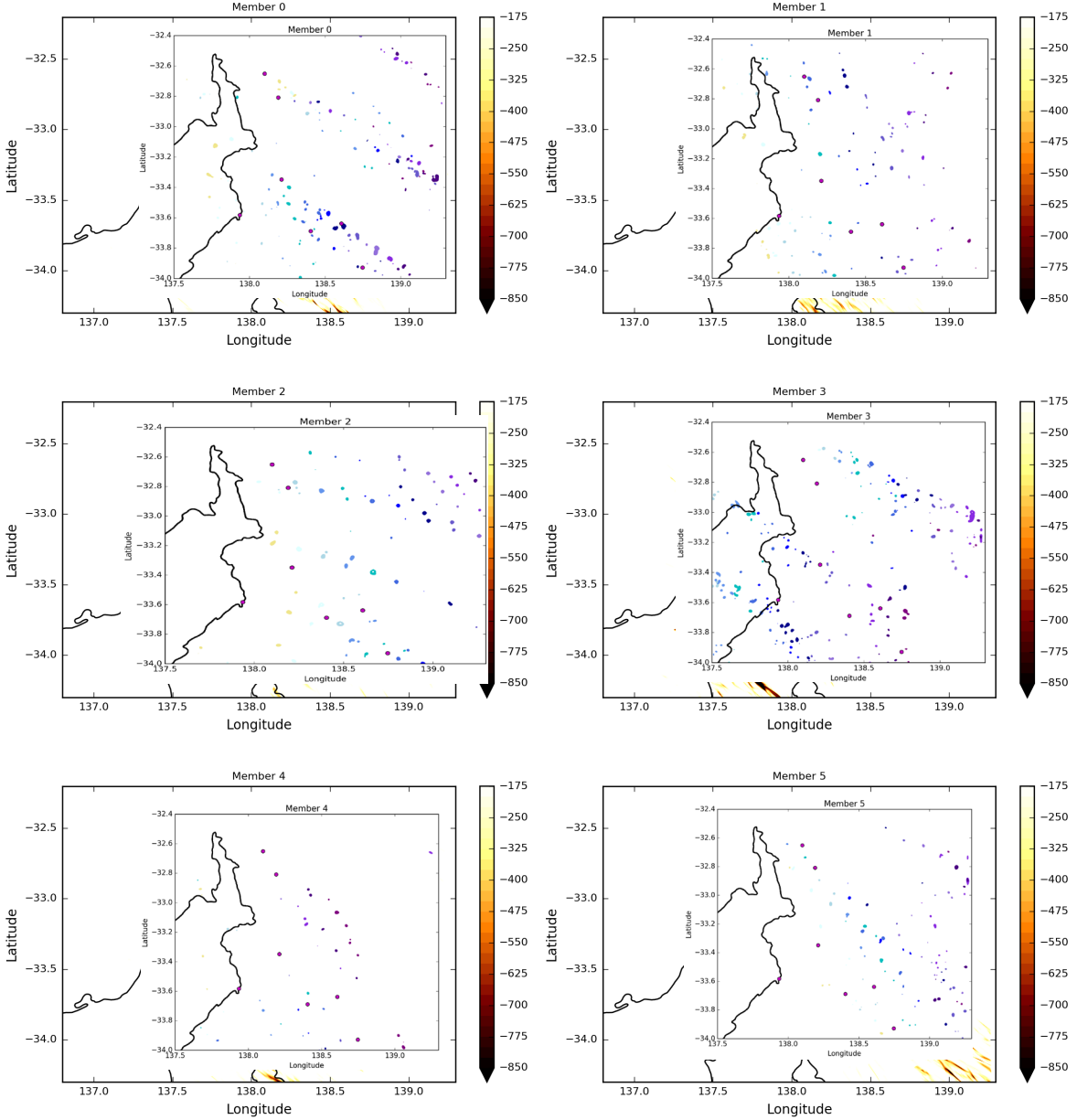


Ensemble simulations

Simulated radar reflectivity at 0530 UTC 28 Sep 2016



Okubo-Weiss, 1 – 4 km layer average (4:50 -6:50 UTC 28 September 2016)



Summary

- Overall, deterministic simulations capture well the orientation and timing of the convective systems associated with the tornado outbreak
- Updraft helicity successfully identifies the tornado threat regions
- Okubo-Weiss parameter identifies the ***presence*** of mesocyclones and the ***potential*** for meso-cyclone development
- Ensemble simulations highlight the uncertainty associated with timing, location and intensity of the convective systems that spawned the tornadoes