Poster number: 10

The Use of Convective Parameters by the Australian Extreme Weather Desk in Forecasting the 16 December 2015 Tornadic Supercell

Australian Government
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Extreme Weather Desk (EWD) Convective Outlook Products

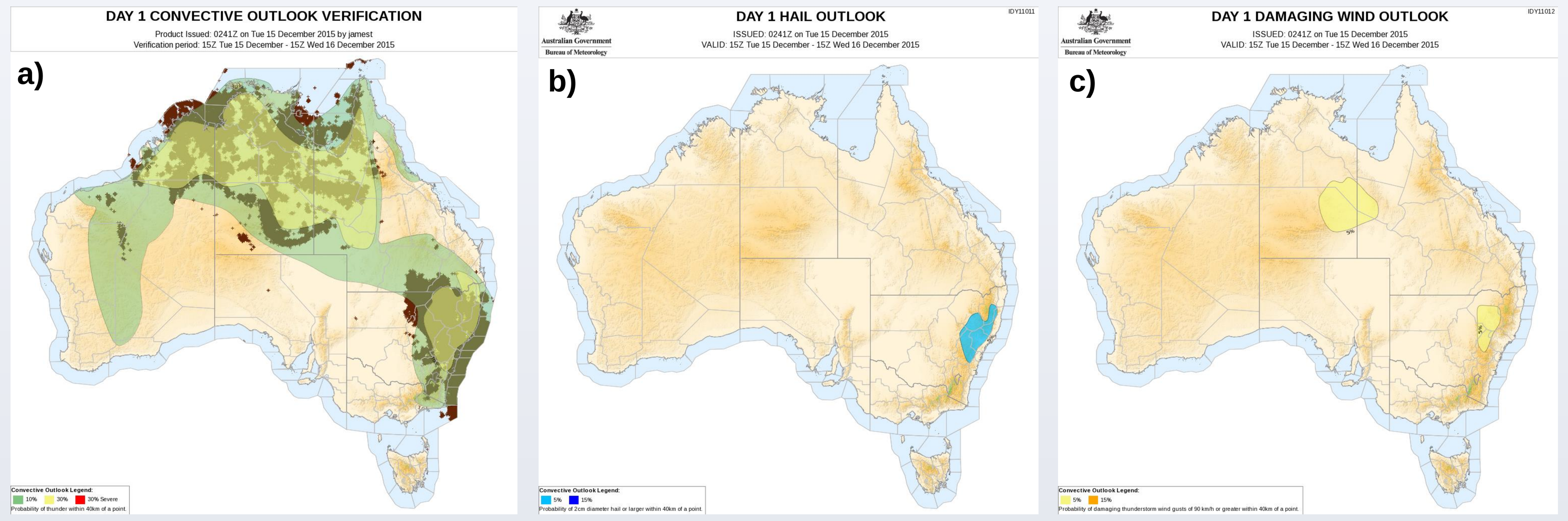


Figure 1. *Examples of the EWD Day +1 (next day) graphical forecast products for 16 Dec 2015 illustrating the probability within 40 km of a point of **a)** thunder with observed lightning; **b)** large hail (≥2 cm) and; **c)** damaging wind gusts (≥90 km/h)*

***National Convective Outlook Discussion* for Wednesday 16th December 2015**
Issued Tuesday 15th December 0230Z by JT

The upper trough evident on current WV imagery marching through WA that extends to an upper low over Tasmania is forecast to lie from central NT through NE SA and northern NSW with locally strong upper divergence ahead of the trough. Multiple surface troughs extending from heat lows across the north are likely to continue on Wednesday. There is some uncertainty in the positions of these troughs but generally there will be one through western WA, with another broad trough extending through NE SA to a weak low over northern NSW.

WA: Next upper trough will be approaching the surface trough through western WA. 12Z1412ACCR indicating WBPT in the order of 20 to 23C, the same run of EC has WBPT at least a couple of degrees less. Thunderstorm activity along the trough will be highly likely (at least >30%) if ACCR is correct. Given the uncertainty, only a 10% region has been drawn. If storms do develop along this trough then DMAPE will be >1000 j/kg leading to some potential of damaging wind gusts.

Northern SA and SW NSW: Negative 700 to -20 LI early in the morning but upper trough likely to have passed through so seems like the chance of storms <10% in this region apart from further north where a SB risk exists in the afternoon.

5% damaging wind areas: Positioned ahead of upper trough. Bulk Shear of 20-30 kts allowing for squall line potential.

5% heavy rain: Either where DLM winds seemed southerly enough that train effect could occur along NSW ranges convergent line, or DLM <10kts. Also paid some attention to the 12Z1412ACCR rainfall guidance. Tropical areas will be at risk but have not included any areas due to lack of shear and high ARIs.

5% Hail: NE NSW Sig Hail parameter not surprisingly (given the SBCAPE, and Bulk Shear) ranges between 0.5 to 1.5 with ACCR having the higher values. Given the approaching upper trough, one could argue for a 15% area, however uncertainty in placement of convergent lines to drive storms prevents certainty in where large hail is more likely. Interestingly the Sig Hail Parameter indicates values in the order of 0.2 (EC) to 0.6 (ACCR) with LCL <1000m over the western Qld region. Given the lack of shear in the region it was thought that large hail would be less likely than 5%.

Figure 2. *Example of the EWD National Convective Outlook Discussion which provides a textual description of the convective environment that supports the graphical convective outlooks illustrated in Figure 1.*

EWD Convective Forecast Process

The convective assessment of Day +1 (tomorrow) is undertaken via a structured forecast process with the guidance suite organised in a corresponding fashion.

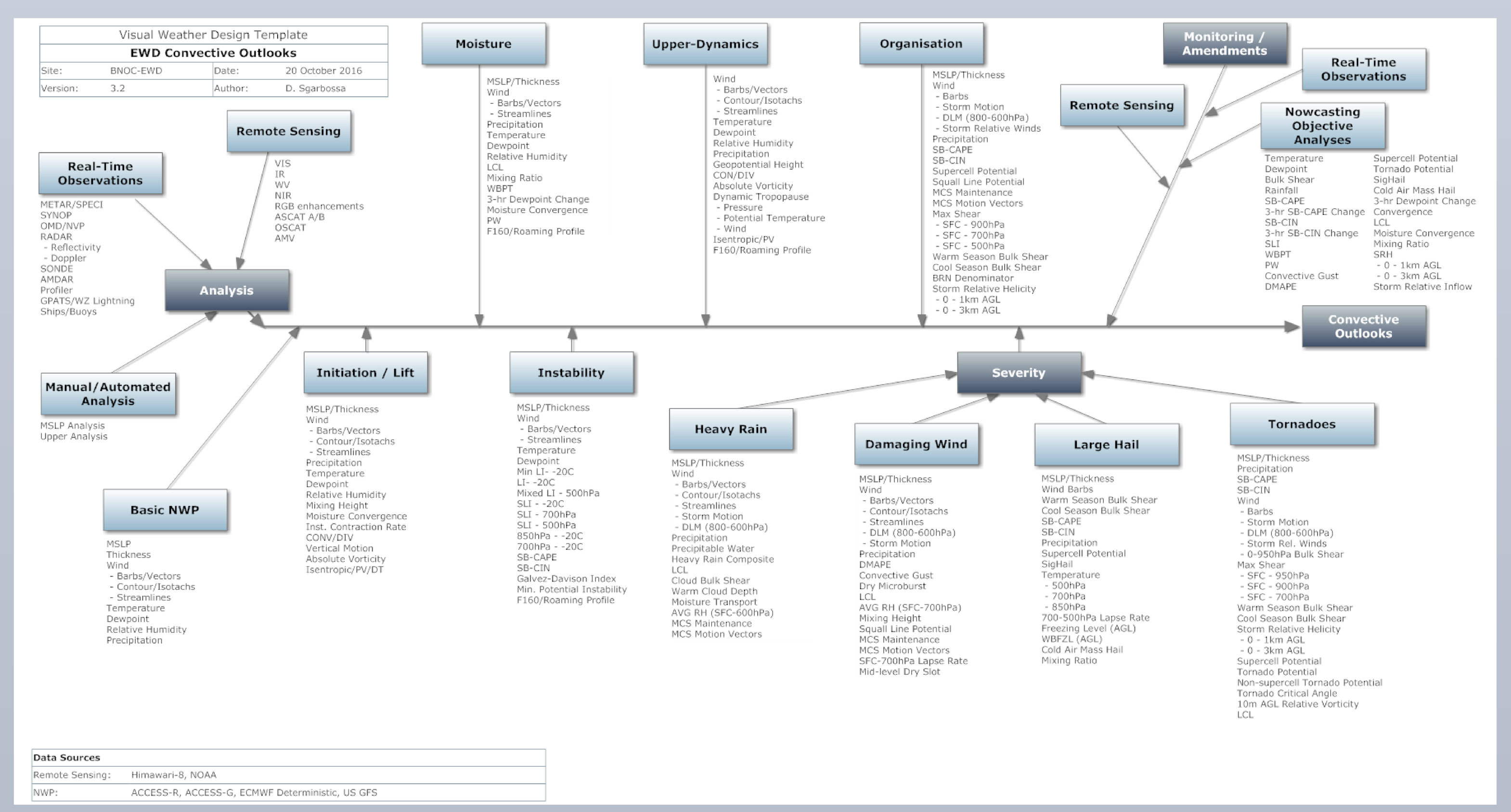


Figure 3. *Ishikawa Diagram illustrating the convective forecast process with respect to guidance and data.*

Convective Parameters

An ingredients-based forecast process is utilised within the EWD that promotes an efficient and thorough assessment of the convective environment. Stemming from the literature and best practices from the US National Weather Service Storm Prediction Centre, the EWD forecaster strategically combines atmospheric ingredients to diagnose areas of threat from significant convective phenomena. This is aided by the use of composite parameters that aim to highlight environments conducive to convective organisation and related phenomena.

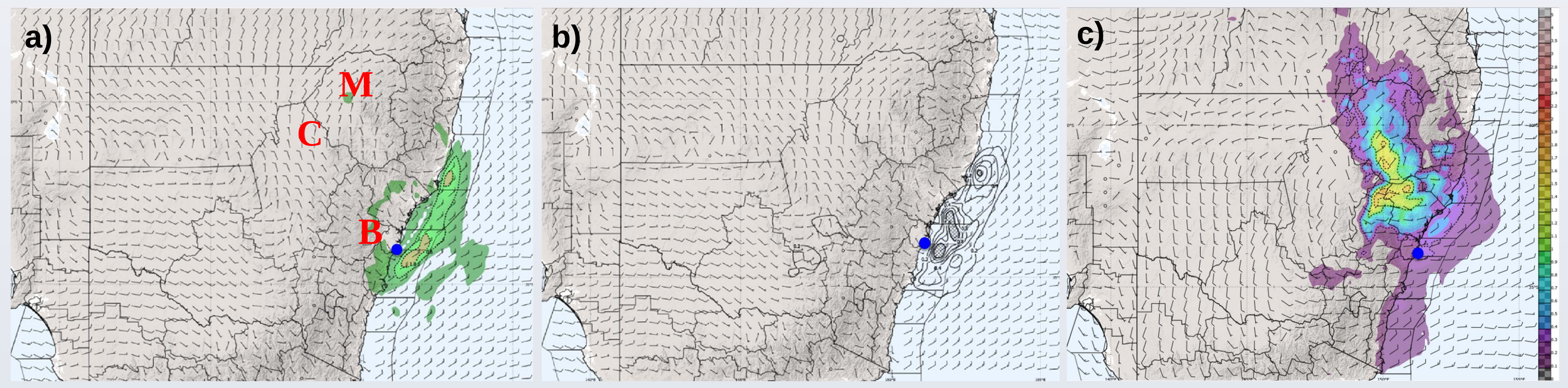


Figure 4. *18 UTC 15 Dec 2015 ACCESS-R derived composite convective parameters consisting of **a)** Significant Tornado Parameter, valid 23 UTC 15 December after Thompson et. al. (2002) and; **b)** Supercell Composite Parameter valid 23Z 15 December after Thompson et. al. (2002); **c)** Significant Hail Parameter valid 06 UTC 16 December. Location of the Kurnell tornado path is indicated by the blue dot, red letters M, C and B mark the towns of Moree, Coonamble and Blackheath, respectively.*

- 18 UTC 15 Dec ACCESS-R run suggested that the environment was conducive to tornadic supercells near Kurnell
- EWD believed the threat from marine layer-sourced convection to be low due to inhibition associated with the marine boundary layer
- Supercell Composite Parameter, Derecho Composite Parameter and Significant Hail Parameter do not contain any convective inhibition dependence, so it is not uncommon to observe large values of these parameters in capped marine boundary layers

Daily Verification

- Inclusion of verification of the previous day's forecast in the EWD is an integral step in developing expertise at a national level for convective forecasting
- Reports of severe thunderstorms and their hazards are limited in Australia, so post-event analyses commonly rely on environmental and remotely sensed data
- A daily verification product was developed that included;
    - Lightning detection overlay (Figure 1a)
    - Any reports
    - Post analysis of the environment
    - Post analysis of remotely sensed data
- The subjective verification of NWP guidance, thunderstorm guidance and composite parameters led to improved skill in forecasting thunderstorms and related hazards during the 2015-2016 season

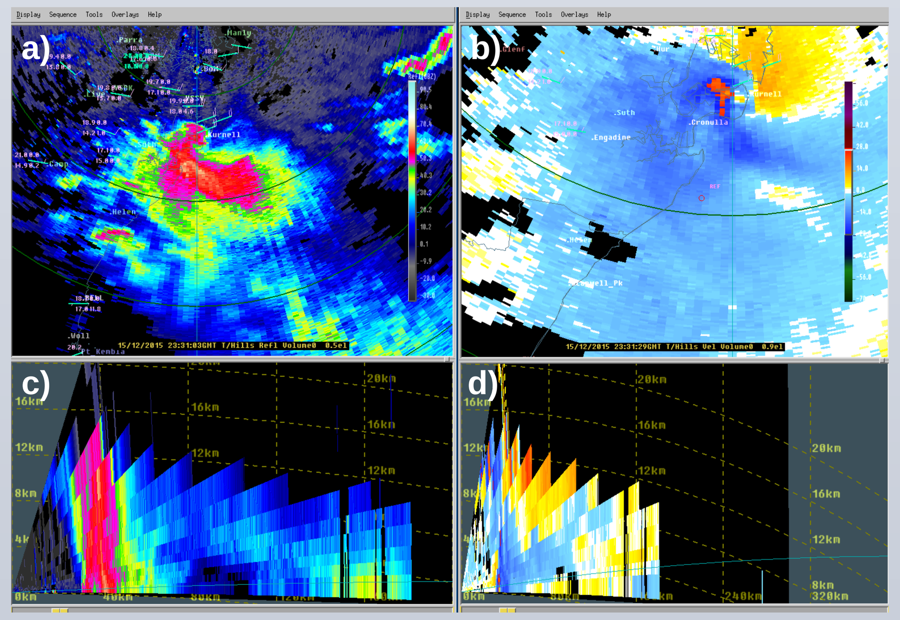


Figure 5. *Radar imagery from the Sydney Terry Hills S-band Doppler Radar valid 23:31 UTC showing **a)** 0.5° elevation PPI reflectivity; **b)** 0.9° elevation PPI Doppler radial velocity; **c)** RHI reflectivity from the Radar origin due south and; **d)** corresponding RHI Doppler radial velocity.*

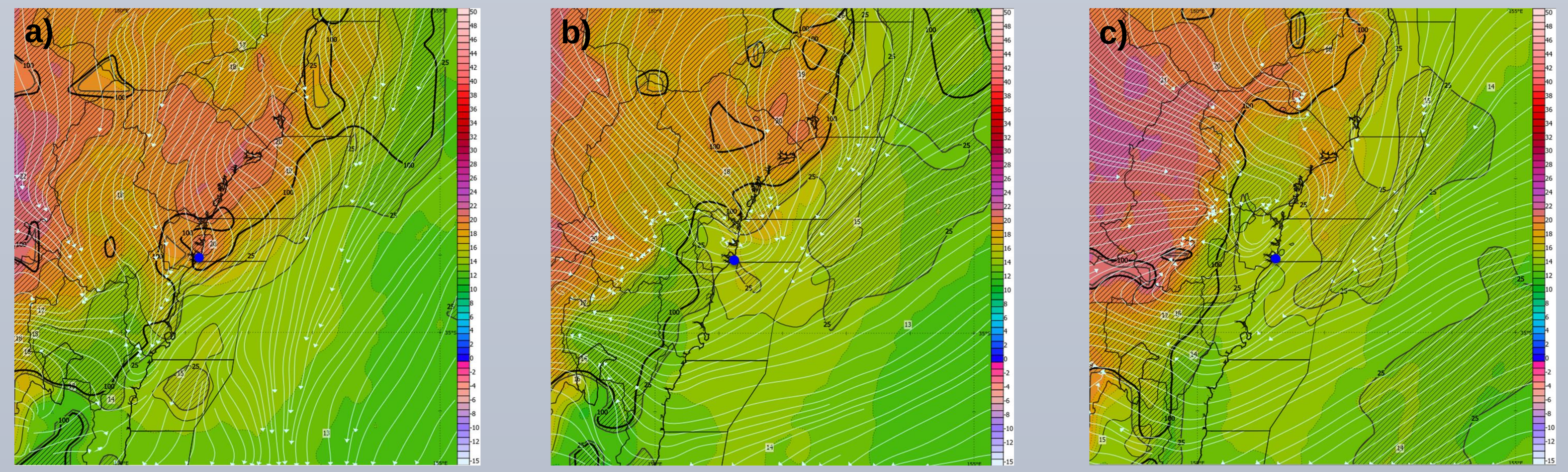
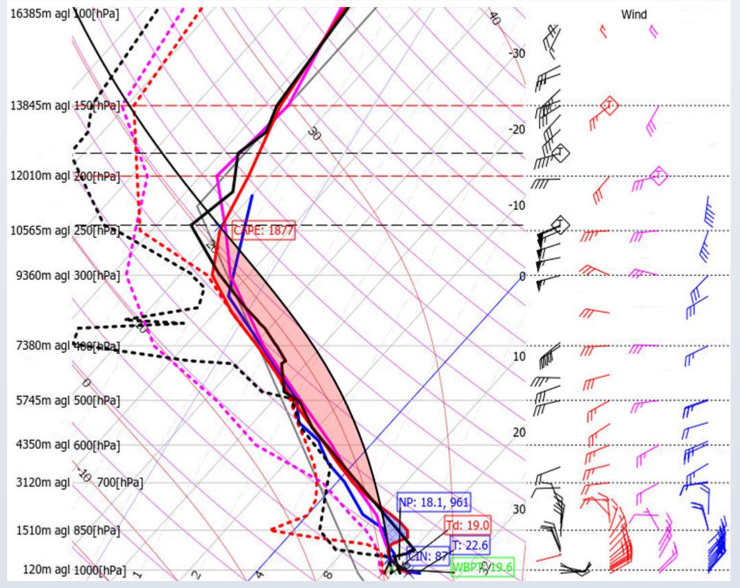


Figure 6. *18 UTC/15 December 2015 ACCESS-R 900hPa temperature (color-filled contours), surface based CIN (hashed contours) and streamlines (white) valid at **a)** 18 UTC; **b)** 21 UTC and; **c)** 00 UTC. Location of Kurnell tornado is indicated by the blue dot.*

Daily Verification Continued…

- EWD focus for severe convection was on afternoon surface-based thunderstorms over eastern New South Wales (NSW)
- Setting: approaching upper level trough, low level convergence across the NSW ranges (located approximately 50-100 km west of the coast), high levels of available moisture and steep lapse rates
- Post event verification revealed that the forecast 5 – 15% damaging wind area (Figure 1c) coincided with a severe thunderstorm during the afternoon that produced wind gusts of 117 km/h at Moree and 102 km/h at Coonamble (Fig. 4a)
- 5 – 15% risk area for large hail (Fig. 1b) coincided with a report of 3cm hail at Blackheath (Fig. 4a)



- +36hr model forecasts valid 00 UTC/16 Dec that were used to produce the convective outlooks were inconsistent with the handling of the capping inversion, leading to low confidence.
- ECMWF correctly forecast the erosion of the capping inversion between 18Z and 23Z; ACCESS-R did not
- The reduction in SBCIN within the marine boundary layer between 18Z and 00Z was well modelled by the 12 UTC 15 December model runs

Figure 7. *36-hour model soundings from ACCESS-R (red) and ECMWF (cyan) valid 00 UTC 16 Dec; 1842 UTC 15 Dec observed Sydney Airport atmospheric profile (black) and 2252 UTC 15 Dec Sydney Airport AMDAR (blue).*

- Observed profiles and model soundings generated close to the event showed the marine boundary layer CIN eroding during the morning
- SBCIN reduction possibly due to (a) advection of cooler temperatures in the 900-850 hPa layer (Fig. 6) and/or (b) evaporative cooling associated with light rain falling from high-based clouds

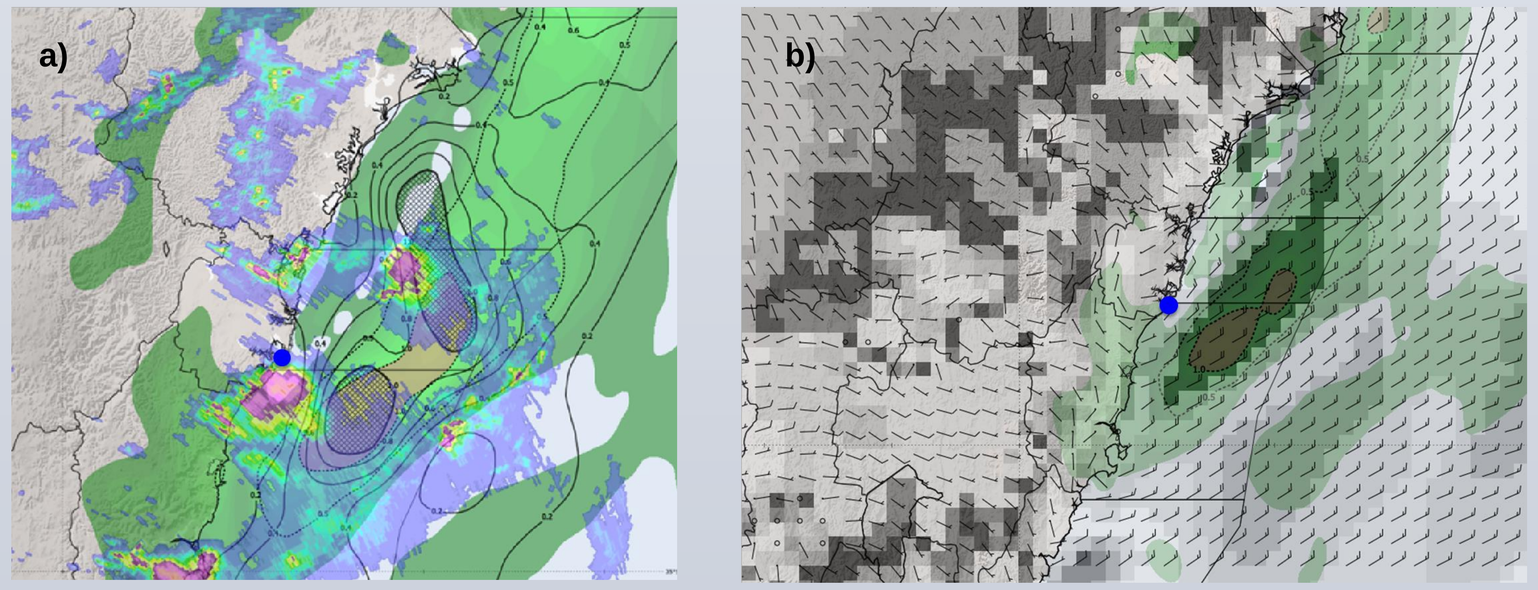


Figure 8. *18 UTC 15 Dec 2015 NWP ACCESS-R forecasts for 23 UTC of **a)** Significant Tornado Parameter (green shading), Supercell Composite Parameter (black contours) and RADAR suggesting that the observed supercell coincided within proximity of the gradients of the parameters consistent with Cohen (2010) and Thompson et. al. (2012); **b)** spatial Tornado Critical Angle mask (grey shading) after Esterheld and Giuliano (2008) and Significant Tornado Parameter overlay (green shading). The location of Kurnell indicated by the blue dot in a) and b).*

Conclusions

- In hindsight, it could be argued that the EWD forecast probability of tornado, large hail, heavy rainfall and damaging wind gusts on 16 December 2015 was an under-forecast
- EWD forecast process that includes systematic verification as part of the rostered duties provided the catalyst to further investigate marine boundary layer instability and convection which in turn has increased expertise within the EWD

Note: The conference extended abstract will include details of EWD product enhancements that have been implemented following review of the 2015/2016 Australian Severe Weather Season.

References

Thompson, R. L., Edwards, R., & Hart, J. A. (2002). J3. 2 Evaluation and Interpretation of the Supercell Composite and Significant Tornado Parameters at the Storm Prediction Center.

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