What makes strong wind gusts?

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Wind gusts are bursts of high wind speed (≥ 25 m/s) that are sustained for at least a few seconds, causing significant structural damage. Severe convective wind gusts are produced when downbursts, which are strong downdrafts originating from thunderstorms, descend to ground level with significant momentum and spread out.

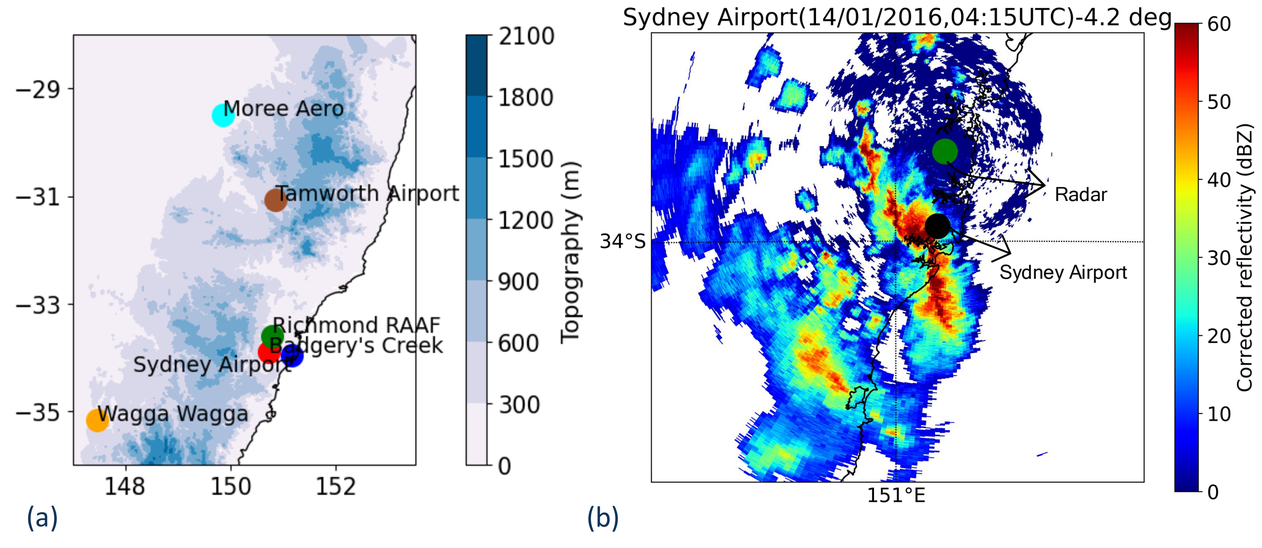
Through a case study approach, we aim to investigate the skill of the large-scale diagnostics to indicate observed severe convective winds in New South Wales.

MOTIVATION

- **Previous studies have used various established diagnostics calculated from reanalysis datasets in forecasting severe thunderstorms and have done their statistical analysis to study their ability to indicate observed convective winds (Brown et al. 2019, Brown et al. 2021).**
- **Many of those diagnostics were associated with high false alarm rate value , which means they identified lot of severe wind events that did not produce severe winds.**

DATA

- **Extreme wind events from the BoM severe storm archive during the period 2000-2019, for which gust speeds were recorded at any automatic weather stations (AWS) with a constraint that there be associated radar data were shortlisted.**
- **From those cases, six strong cases were selected for this study.**
- **BARRA-SY reanalysis (hourly, 1.5km horizontal grid spacing) is used to look at various flow fields and to calculate the diagnostics.**



- Surface air temperature started dropping ~15 minutes before the event
- The MSLP shows a rise ~15 minutes before the event and a drop at the time of the event.

Figure 1: (a) Map of the six Automatic weather stations in NSW where extreme wind gust events were recorded. (b) Radar corrected reflectivity image for the event recorded at Sydney Airport. (c) Time series of surface air temperature (top panel) and MSLP (bottom panel) from the AWS data (each line in Figure 1c is an event recorded at the station marked by the same color in Figure 1a).

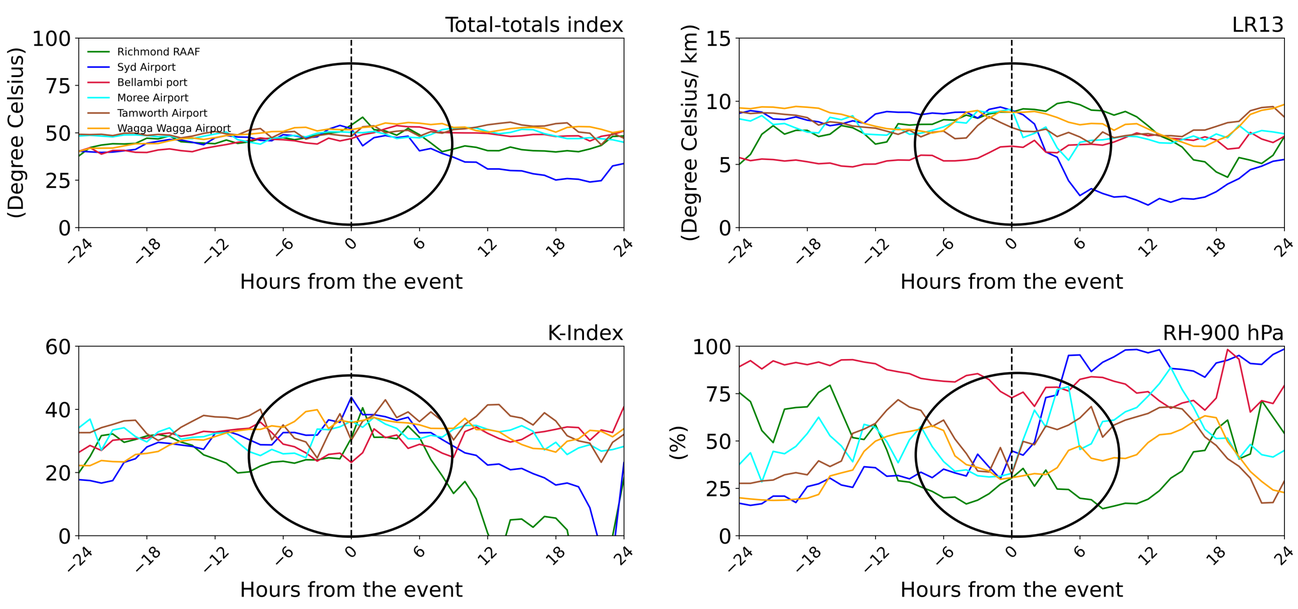


Figure 2: Time series of six diagnostics for the recorded wind gust events. Each event is represented by a different color.

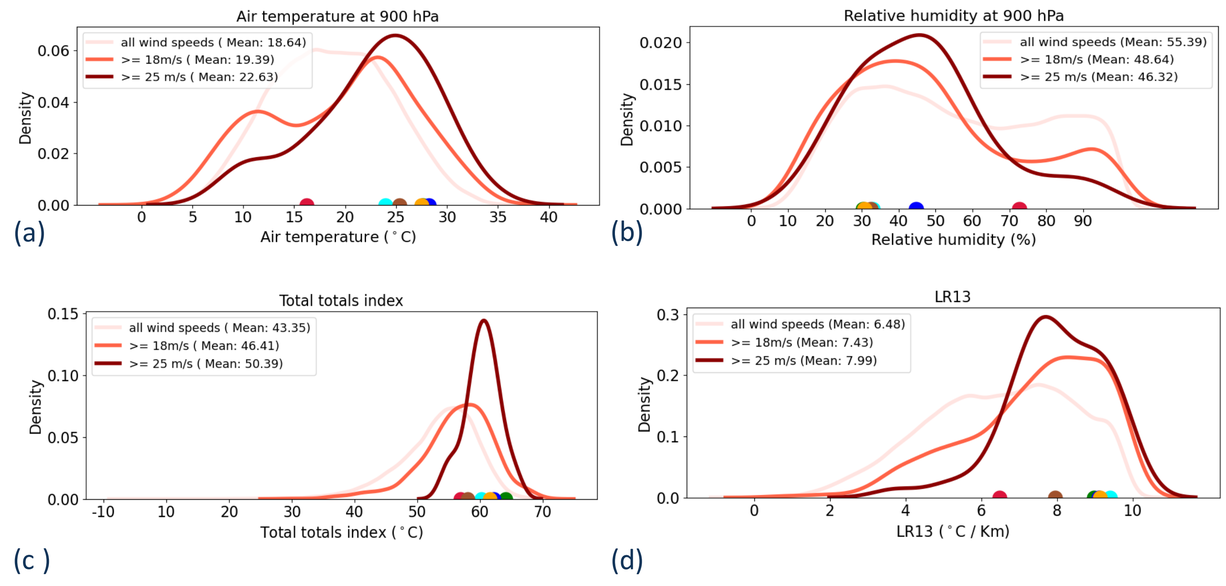


Figure 3: Kernel density estimate plots for (a) low-level air temperature, (b) low-level relative humidity, (c) Total totals index, and (d) low-level lapse rate, calculated over the period 2001-2019 afternoon hours of the warm season for three categories of wind speed (shown in the inset of each figure).

- No significant variation in indices was observed at the time of the event.

- Other than the event recorded at the Badgerys Creek AWS, all the events are very dry.

TAKE-HOME MESSAGES

- **Six cases considered in this study are associated with different types of parent storms, and the recorded events were found on the edge of some storm cell.**
- **There are notable changes in the surface air temperature and MSLP at the time of the event, which are the characteristics of a passing gust front, which can lead to the formation of new storms.**
- **No individual index effectively indicates all of these observed wind gust events.**
- **Low-level relative humidity, lapse rate, air temperature, and Total Totals index values at the time of the event are outliers to the mean climatology of all the stations. The only exception is the Badgerys Creek event, which makes it unique.**

FUTURE WORK

Calculation of more diagnostics that are useful for indicating severe convective wind events (indicating convective instability, environmental wind speeds and shear, etc..) and continuing the analysis.