Diagnosing atmospheric mechanisms that influence rainfall extremes

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Context

Tasmania (Fig. 1a) is Australia's largest producer of renewable energy from hydropower, an industry that is particularly sensitive to rainfall extremes. We seek to identify the atmospheric processes associated with multi-day rainfall extremes in Tasmania in observations and climate model data. Extremes at this timescale also underlie seasonal/annual rainfall anomalies (Fig. 1b). This analysis will help to evaluate CSIRO's Climate Analysis Forecast Ensemble (CAFE) in its ability to simulate and forecast atmospheric modes relevant to rainfall extremes in Tasmania.

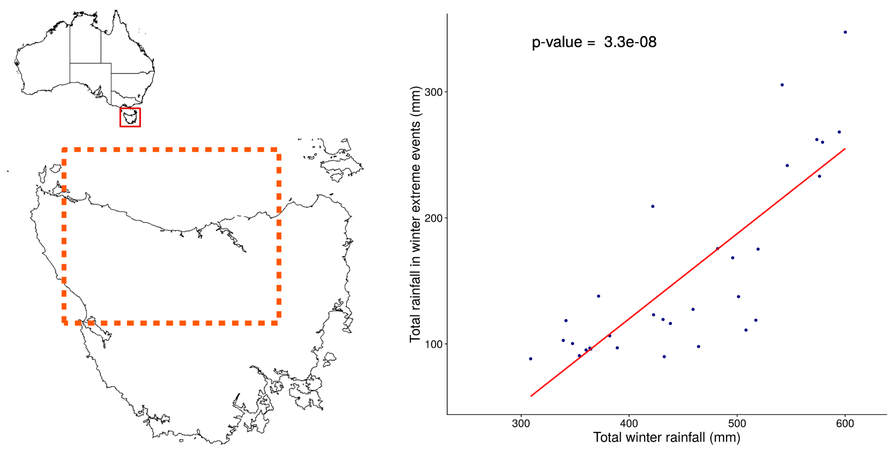

Figure 1: (a) Map of Tasmania with CAFE grid shown in orange.

(b) Relationship between observed winter rainfall in Tasmania (1958-2014) and rainfall recorded in winter extreme wet events as defined in Methods. Plot shows that winter extreme events have a significant relationship with total winter rainfall.

Data and Methods

Details of the observed and modelled data used are given in Table 1. The two key steps involved in this analysis were:

1. The identification of extreme wet events in Tasmania in both observed and CAFE rainfall datasets. Wet events were initially identified as days in a row with rainfall greater than the 50th percentile. This list was further subsetted by selecting only events with total rainfall greater than the 95th total event rainfall percentile. This process was undertaken for each season for a ~ 50 year analysis period. We show winter results here.
2. The development of atmospheric composites (i.e. average atmospheric pattern) around these events, where day 0 is the start day of the event. Multiple atmospheric diagnostics (e.g. pressure, wind, baroclinic instability) were assessed but only composite geopotential height anomalies at 500 hPa are shown here.

Table 1: Observed and modelled data details. The resolution of each dataset is given in square brackets.

	RAINFALL DATA	ATMOSPHERIC DATA
Observed	Australian Water Availability Project (AWAP) [0.05 x 0.05, averaged over CAFE grid]	Japanese Reanalysis (JRA) [1.25 x 1.25]
Modelled	CAFE C2 control run* [2.5 x 2.0]	CAFE C2 control run* [2.5 x 2.0]

Results and key findings

Fig. 2 presents the composite geopotential height anomaly patterns for winter rainfall extremes in observed and modelled data. In both cases a coherent Rossby wave train appears in the Indian Ocean at day -3. The wave train moves eastwards and a large trough moves over Tasmania by day 0 and persists for the rest of the event. As the wet event develops, the wave train becomes circumglobal in extent.

The association of wet extremes in Tasmania with hemispheric wide atmospheric organisation is an important and new finding. An additional key finding is that wet extremes in the CAFE model are associated with wave train modes similar to those identified in observations. The ability of the model to simulate processes relevant to rainfall extremes is a necessary condition for the model to subsequently forecast these multi-day extremes and seasonal/annual rainfall anomalies.

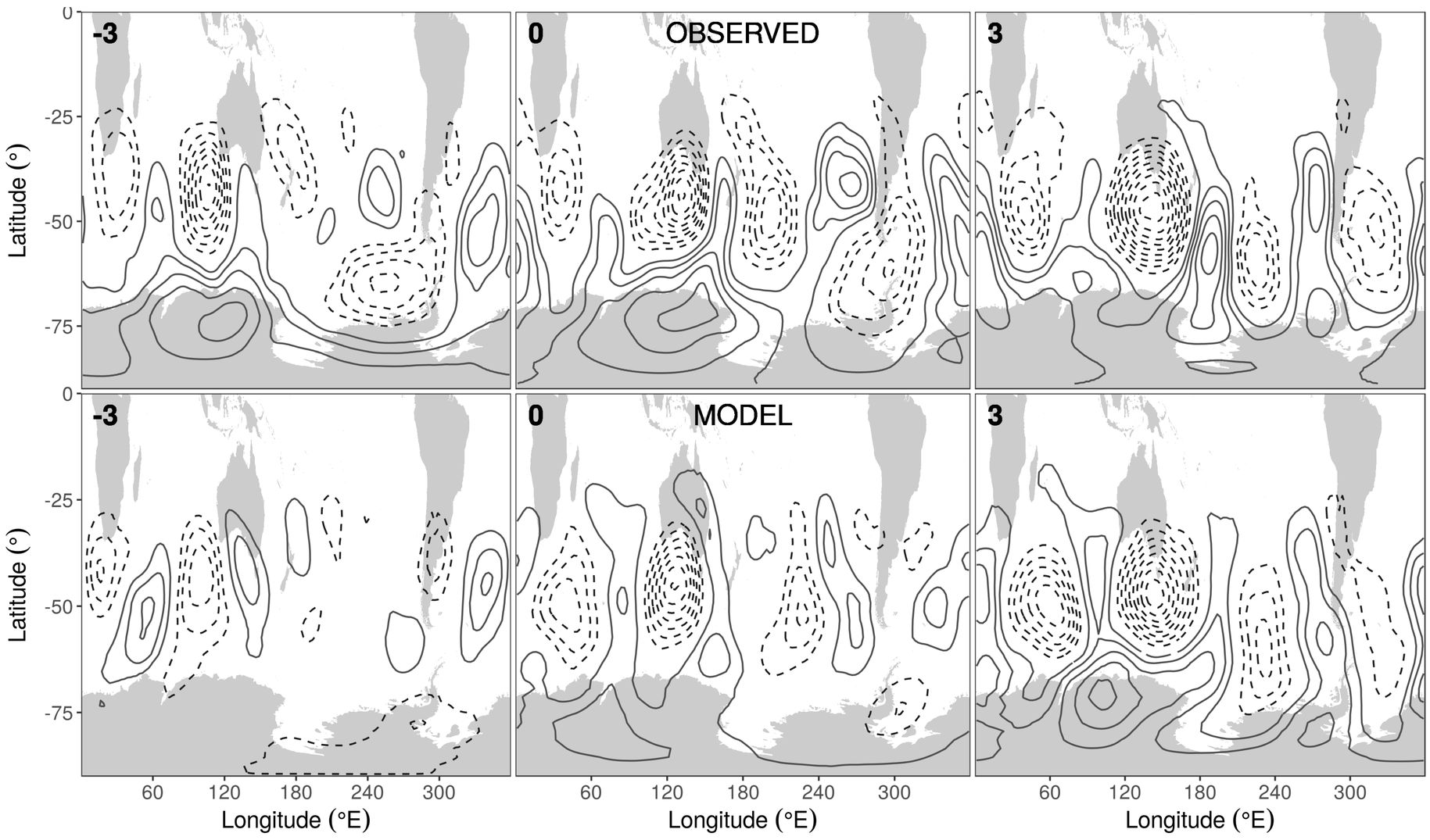

Figure 2: Composite circulation for days -3, 0, 3 for extreme wet events in Tasmania identified in observed and modelled data. Solid contours indicate positive height anomalies (high pressure systems) and dashed contours indicate negative height anomalies (low pressure systems). The day number is given in the top left hand corner of each panel

FOR FURTHER INFORMATION
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RELEVANT REFERENCES
Tozer, C.R., Risbey, J, O'Kane, T, Monselesan, D, Pook, M, The relationship between waveguide modes in the Southern Hemisphere storm track and rainfall extremes over Tasmania, Monthly Weather Review (in review).

ACKNOWLEDGEMENTS
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*The CAFE model used here is based on the Geophysical Fluid Dynamics Laboratory's (GFDL) Climate Model 2.1 (CM2.1). The ocean component of the CAFE model is MOM4p1 with an ocean grid from the ACCESS coupled model. The ocean is coupled to the atmospheric and sea ice components from CM2.1, AM2 and SIS respectively.