**Seasonal Prediction Framework for attribution of extreme events in a changing climate**

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At the Australian Bureau of Meteorology we have developed a system for the attribution of extreme events using our seasonal forecast coupled model, POAMA (Wang et al. 2016). The initial-value nature of the framework allows little time for the growth of model-driven biases, while allowing the full coupled response of the ocean– atmosphere–land system. We can thus analyse the specific event in question, rather than a 'class' of such events. The system provides the potential for analysis of the forecast events before they have occurred.

We have used the system to determine the influence that the last 55 years increase in atmospheric CO2 had on two heat events (Hope et al. 2015, (see Figure 1 below); Hope et al. 2016), a very wet month (Hope et al. 2018) and an extensive frost period (Grose et al. 2018). Results align with those using other methods; for the heat there was an excess temperature anomaly of 1 ºC due to increased CO2, the same magnitude as the temperature trend over the same period. Circulation changes driven by CO2 increases would encourage frost development in south-west Australia, but thermodynamic changes work against this trend. Our method suggests that increasing atmospheric CO2 did not enhance the big wet in south-east Australia in September 2016, however, some questions still remain. We have recently used the method to attempt to attribute the extreme fire weather (FFDI) in February 2017 to CO2 increase, but there is still further development required to allow the attribution of such complex weather phenomena as fire weather.

We can also use the method to assess whether the over-riding signal that led to an extreme event was derived from the ocean, atmosphere or land surface (Arblaster et al. 2014; Hope et al. 2015).

These methods allow better contextualisation of forecast extremes, potentially providing key information to forecasters commentating on the event, or in the post-event analysis.



**Figure 1**. The ensemble spread of the forecasts under the current climate (red), the current climate with CO2 set to 315 ppm (light blue), and a 'low-CO2' climate, with a modified ocean initial state as well as CO2 set to 315 ppm (dark blue). (From Hope et al. 2015).

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