Impacts of large-scale extreme hydroclimatic variations on ecosystem function in Southeastern Australia

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Abstract:

Predicting how ecosystems will be affected by climate change requires not only reliable forecast of future climate, but also observational evidence regarding past climate ecosystem impacts to synthesise our knowledge. Recent climatic extremes involving large-scale drought and flooding over Southeastern Australia provide unique opportunities to understand ecosystem responses to intensification of the water cycle under global warming. In this study, we investigated the impacts of early 21st-century climatic extremes on vegetation phenology and productivity over the SE Australia (Fig. 1) using Enhanced Vegetation Index (EVI) derived from Moderate Resolution Imaging Spectroradiometer (MODIS) onboard NASA's Terra satellite, and drought severity and extent were quantified using Standardised Precipitation-Evapotranspiration drought Index (SPEI) derived from ground meteorological observations.

Results revealed dramatic impacts of hydroclimatic variations on biogeographic patterns of vegetation phenology and productivity, with abrupt between year changes in the timing of phenology. An overall advancing trend in onset of growing season in wet years was observed, resulting in extended seasonal lengths in over 71% areas of SE Australia. In contrast, 61% of SE Australia exhibited shortened seasonal periods during the drought years, which was primarily attributed to an earlier end of season. Drought resulted in reduced vegetation activity and widespread weakening or loss in detectable phenology over more than 20% areas of SE Australia in 2002 (Fig. 1). Meanwhile, regional vegetation productivity was also reduced by 21% relative to the decadal average in 2002 drought year. We found ecosystem sensitivity to drought severity varied substantially across space, with semi-arid ecosystems, instead of arid ecosystems, exhibiting the greatest sensitivity to drought. This was unexpected and may suggest that Australian semi-arid ecosystems will be more vulnerable to climatic extremes and experience severe loss of ecosystem resilience with future mega-drought events (Ma et al., 2015).

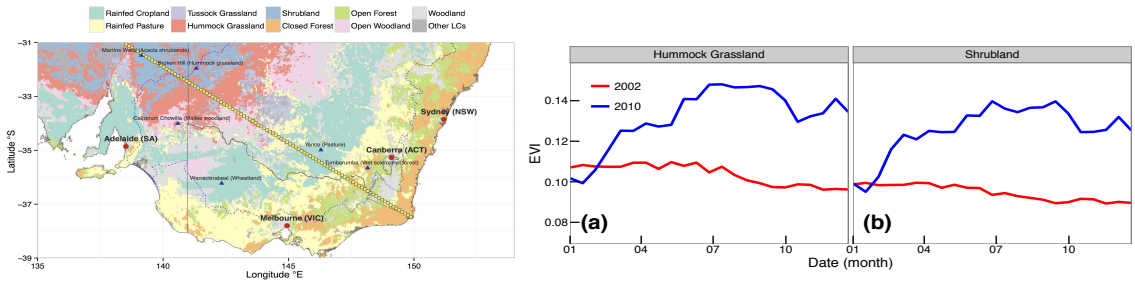

Figure 1 (Left) Land cover type of Southeastern Australia study area; (Right) Hydroclimatic variation-induced shifts in seasonality for hummock grassland and shrubland within SE Australia. Land cover data source: National Dynamic Land Cover dataset (Lymburner et al., 2011).

Keywords: *Climate extremes, carbon cycling, remote sensing, ecological resilience, semi-arid*

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