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Climate variability in south-eastern Australia over the last 1500 years inferred from the high-resolution diatom records of two crater lakes

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ABSTRACT

Climates of the last two millennia have been the focus of numerous studies due to the availability of high-resolution palaeoclimate records and the occurrence of divergent periods of climate, commonly referred to as the 'Medieval Climatic Anomaly' and 'The Little Ice Age'. The majority of these studies are centred in the Northern Hemisphere and, in comparison, the Southern Hemisphere is relatively understudied. In Australia, there are few high-resolution, palaeoclimate studies spanning a millennium or more and, consequently, knowledge of long-term natural climate variability is limited for much of the continent. South-eastern Australia, which recently experienced a severe, decade-long drought, is one such region.

Results are presented of investigations from two crater lakes in the south-east of mainland Australia. Fluctuations in lake-water conductivity, a proxy for effective moisture, are reconstructed at sub-decadal resolution over the past 1500 years using a statistically robust, diatom-conductivity transfer function. These data are interpreted in conjunction with diatom autecology. The records display coherent patterns of change at centennial scale, signifying that both lakes responded to regional-scale climate forcing, though the nature of that response varied between sites due to differing lake morphometry. Both sites provide evidence for a multi-decadal drought, commencing *ca* 650 AD, and a period of variable climate between *ca* 850 and 1400 AD. From *ca* 1400–1880 AD, coincident with the timing of the 'Little Ice Age', climates of the region are characterised by high effective moisture and a marked reduction in inter-decadal variability. The records provide context for climates of the historical period and reveal the potential for more extreme droughts and more variable climate than that experienced since European settlement of the region *ca* 170 years ago.

1. Introduction

Climates of the last two millennia have been the focus of intense research over recent decades (Jansen et al., 2007; Mann et al., 2008; Neukom and Gergis, 2012; PAGES 2k Consortium, 2013; Phipps et al., 2013). The availability of a large number of high-resolution records, and the occurrence of two distinct periods of climate change; the so-called 'Medieval Climatic Anomaly' (MCA) and the 'Little Ice Age' (LIA), provides an opportunity to understand regional responses to climate forcing and to test assumptions of global sale change. However, in order to improve understanding of climate system dynamics and gain insight into the spatial and temporal structure of past climate variations, studies of various proxies from a broad spatial distribution are required (Jones et al., 2009). In this regard, the paucity of Southern Hemisphere data is problematic, leading the Intergovernmental Panel on Climate Change to note that knowledge of Southern Hemisphere climatic variability over the last 1000–2000 years "is severely limited by the lack of palaeoclimatic records" (Jansen et al., 2007, p. 483).

As an island continent, with climates influenced by the Indian, Pacific and Southern Oceans, Australia is ideally positioned to

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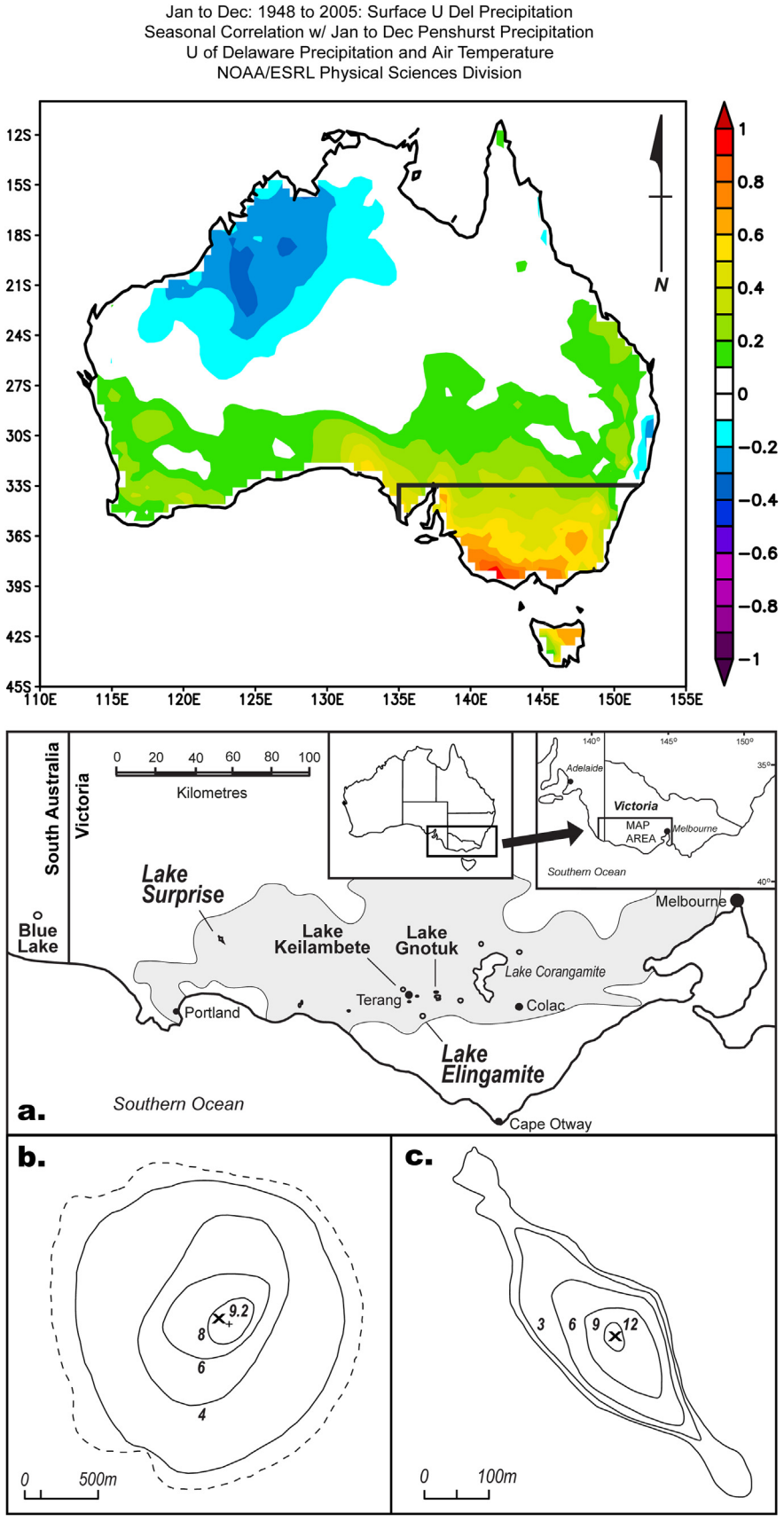

Fig. 1. Upper panel: correlation of annual rainfall at Penshurst (30 km from Lake Surprise) and surface precipitation from the University of Delaware rainfall dataset undertaken using NCEP/NCAR reanalysis. Solid black line marks the boundary of south-eastern Australia, as defined by the Australian Bureau of Meteorology a. Regional setting and location of study sites and other lakes mentioned in the text. Shaded area marks the boundaries of the volcanic plains; b. Bathymetry of Lake Elingamite (from, Timms, 1977) with contours in