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Late Holocene precipitation variability in the summer rainfall region of South Africa

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ABSTRACT

The late Holocene history of the South African summer rainfall zone offers insights into the effects of climate on ecosystems and human societies, as well as into the accuracy of model projections of the future. However, some important aspects of this region's climatic history remain unresolved. Here we present new high-resolution diatom records representing hydrological fluctuations at Lake Sibaya, KwaZulu-Natal, during the last 1800 years. The cores were dated with ^{14}C, ^{210}Pb, ^{137}Cs, and exotic pollen, and were sampled at increments of 1–22 years. A low stand ending ~AD 150 was followed by additional decadal to century-scale droughts, most notably ~AD 1540–1760, and several periods of markedly wetter conditions ~AD 220–290, AD 790–830, AD 1470–1540, and AD 1760–1860. The Medieval Climate Anomaly was generally wetter than average and the Little Ice Age was generally drier, but hydroclimate during both intervals was highly variable. These records confirm that local tree ring and stalagmite gray scale series represent rainfall variability, but they also show that widely cited stable isotope series from Makapansgat do not represent past climate as clearly. Because many interpretations of the climatic history of southern Africa have been influenced by those isotope data, we re-examine late Holocene precipitation variability in the summer rainfall zone, and also address model projections of future precipitation in the region.

1. Introduction

The nature and causes of past climatic change in South Africa represent an important but incompletely understood chapter of African history. People have occupied the region for tens of thousands of years, and the effects of wet and arid periods are thought to have been important contributors both to human societies and to ecosystems (Hall, 1976; Huffman, 1996; Mitchell, 2000; Holmgren and Öberg, 2006; Chase and Meadows, 2007; Ekblom et al., 2011; Scott et al., 2012). In addition, paleoclimate records from locations farther north are influenced by climatic systems such as the Intertropical Convergence Zone (ITCZ) that also affect South Africa, so records from the southern sector of the continent are required for complete understanding of those systems. However, a shortage of finely resolved paleoclimate records has left South African climate variability incompletely documented.

High-resolution diatom (Stager et al., 2012) and hyrax midden records (Chase et al., 2011) have recently become available for the southwestern region where precipitation mainly falls during winter (winter rainfall zone; WRZ) and is most strongly influenced by the austral westerly wind belt. The ITCZ-sensitive summer rainfall zone (SRZ) is much larger, representing most of South Africa, but

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records of its precipitation history are still relatively scarce and often display low sample resolution, hydrologically ambiguous proxies, and/or suboptimal dating (Scott and Steenkamp, 1996; Scott, 1999a, 1999b; Ekblom, 2004; Turner and Plater, 2004; Ekblom and Stabell, 2008; Finch and Hill, 2008; Neumann et al., 2008, 2010; Norström et al., 2009; Scott et al., 2012). The late Holocene climatic history of the SRZ has been based largely upon two sources: a ~250 year tree ring series from Karkloof and stalagmite records from Cold Air Cave (CAC), in the Makapansgat Valley (Fig. 1; Lee-Thorp et al., 2001; Holmgren et al., 2003). The CAC stalagmites in particular offer long, well-dated records of oxygen and carbon isotope fluctuations since the late Pleistocene, and they have been widely used to represent past temperature and precipitation regimes (e.g. Johnson et al., 2004; Mayewski et al., 2004; Verschuren, 2004; Zinke et al., 2004; Holzkämper et al., 2009; Norström et al., 2009; Chase et al., 2010; Neumann et al., 2010; Benito et al., 2011). However, published interpretations of their climatic significance have also varied a great deal, leaving the hydrological history of the SRZ uncertain. This is largely due to the inherent complexity of climatic influences on stable isotope records, which cannot be definitively linked to specific climatic conditions without strong supporting evidence from other datasets. Unfortunately, such evidence from the northern SRZ has thus far not been available.

In this paper, we present high-resolution diatom records from Lake Sibaya, KwaZulu-Natal, which allow us to infer precipitation-evaporation (P–E) variability in the SRZ during the last 1800 years at decadal to sub-decadal resolution. In addition to representing local P–E variability in exceptional detail, these records also allow us to test the ability of the aforementioned tree ring and speleothem records to represent past hydrology in the SRZ.

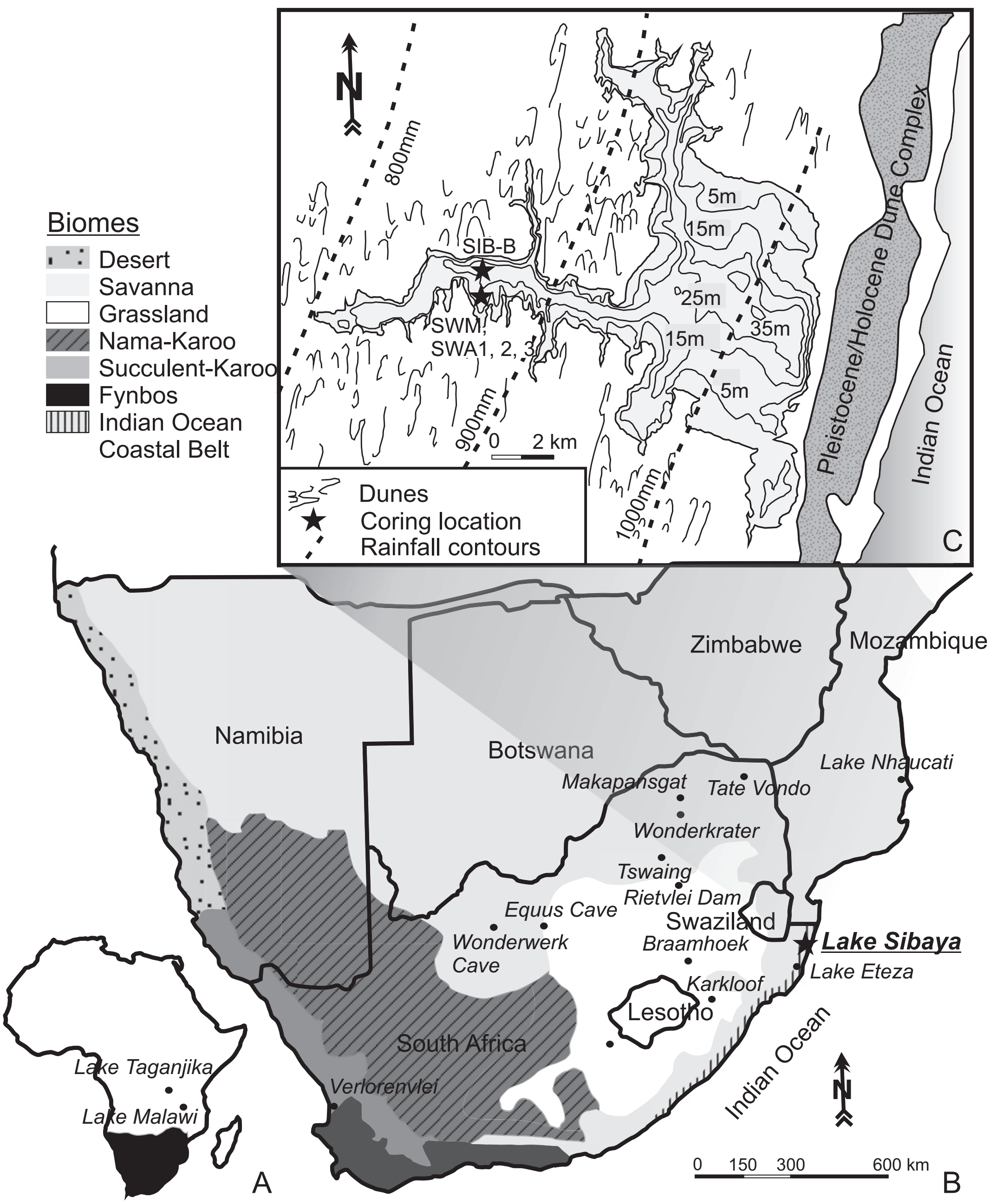

Fig. 1. Site map. Coring locations in the western arm of Lake Sibaya are indicated with stars.