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Short communication

Middle Holocene humidity increase in Florida: climate or sea-level?

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ABSTRACT

Florida climate in highly sensitive to both high and low latitude climate perturbations due to its latitudinal position surrounded by water masses that transport heat northward. A well-studied aspect is that middle Holocene conditions became significantly wetter in Florida, initiating widespread peat accumulation in the Everglades. This environmental change has been attributed to various climate forcings, such as migration of the Intertropical Convergence Zone (ITCZ), increases in tropical storm intensity, position of the Bermuda High, intensification of the El Niño Southern Oscillation (ENSO), and post glacial sea level rise (SLR). Discerning between these forcings is only possible with quantitative reconstructions from a transect of sites that are affected differentially. Application of a transfer function on a north-to-south gradient of pollen records from Florida lakes here shows that the pattern of increasing precipitation during the middle Holocene cannot be explained by SLR, but that ENSO intensification is an important contributing factor. Seasonal-resolved proxy records with improved age models are urgently needed to further solve these issues.

1. Introduction

The Florida peninsula has an enhanced sensitivity to long-term climatic changes as it is influenced by both high-latitude and tropical climate systems, resulting in a gradient from warm-temperate to tropical vegetation between 25 °N and 31 °N (Fig. 1). Surrounded by warm surface currents, Florida climate responds sensitively to both Northern Hemisphere cold events (Grimm et al., 2006) and movements of the Intertropical Convergence Zone (ITCZ) (Poore et al., 2003; Van Soelen et al., 2012). As a result, it is a key area to detect changes in low-latitude heat build-up due to slowdowns in the Atlantic meridional overturning circulation (AMOC) (Donders et al., 2011). The northern, central and southern portions of the Florida peninsula are differentially regulated by sea-surface temperatures and circulation patterns in the Atlantic and Gulf of Mexico (Enfield et al., 2001). A further key climatological forcing in the SE United States is the El Niño Southern Oscillation (ENSO). El Niño events produce significantly increased winter precipitation anomalies (Vega et al., 1998; Enfield et al., 2001; Donders et al., 2013). Since most precipitation falls in summer, this additional EN-forced winter peak is a significant ecological factor extending the hydroperiod of the Florida wetland vegetation (Donders et al., 2005b).

Holocene changes in ENSO intensity e.g. (Moy et al., 2002; Riedinger et al., 2002) are therefore likely to have affected the vegetation, wetlands, and lakes of Florida. The middle Holocene wetland expansion and rise in peat formation in Southern Florida (Donders et al., 2005a; Willard and Bernhardt, 2011) is consistent with a humidity increase and a more pronounced ENSO cycle. However, these observations are not independent of sea level rise, which that reached a maximum during the middle Holocene (Toscano and Macintyre, 2003; Törnqvist et al., 2004) (Fig. 2), and a maximum northerly position of the ITCZ around this time (Haug et al., 2001; Van Soelen et al., 2012). The impact of ENSO on Florida precipitation is more pronounced toward the south (Enfield et al., 2001; Donders et al., 2013) and, hence, a north-to-south transect of sites should show an increased southward response to the intensification of ENSO during the middle and late Holocene. To disentangle the respective impacts of ENSO, ITCZ migration, and sea-level rise (SLR) a transect of sites with quantitative palaeo-precipitation reconstructions is needed.

I apply a recently developed transfer model (Donders et al., 2011) to provide a quantitative reinterpretation of previously published pollen records from Florida and examine a north-to-south gradient of precipitation in Florida during the Holocene. Updated chronologies of the sites, based on recalibrated radiocarbon ages and new age-depth modelling, provide an improved

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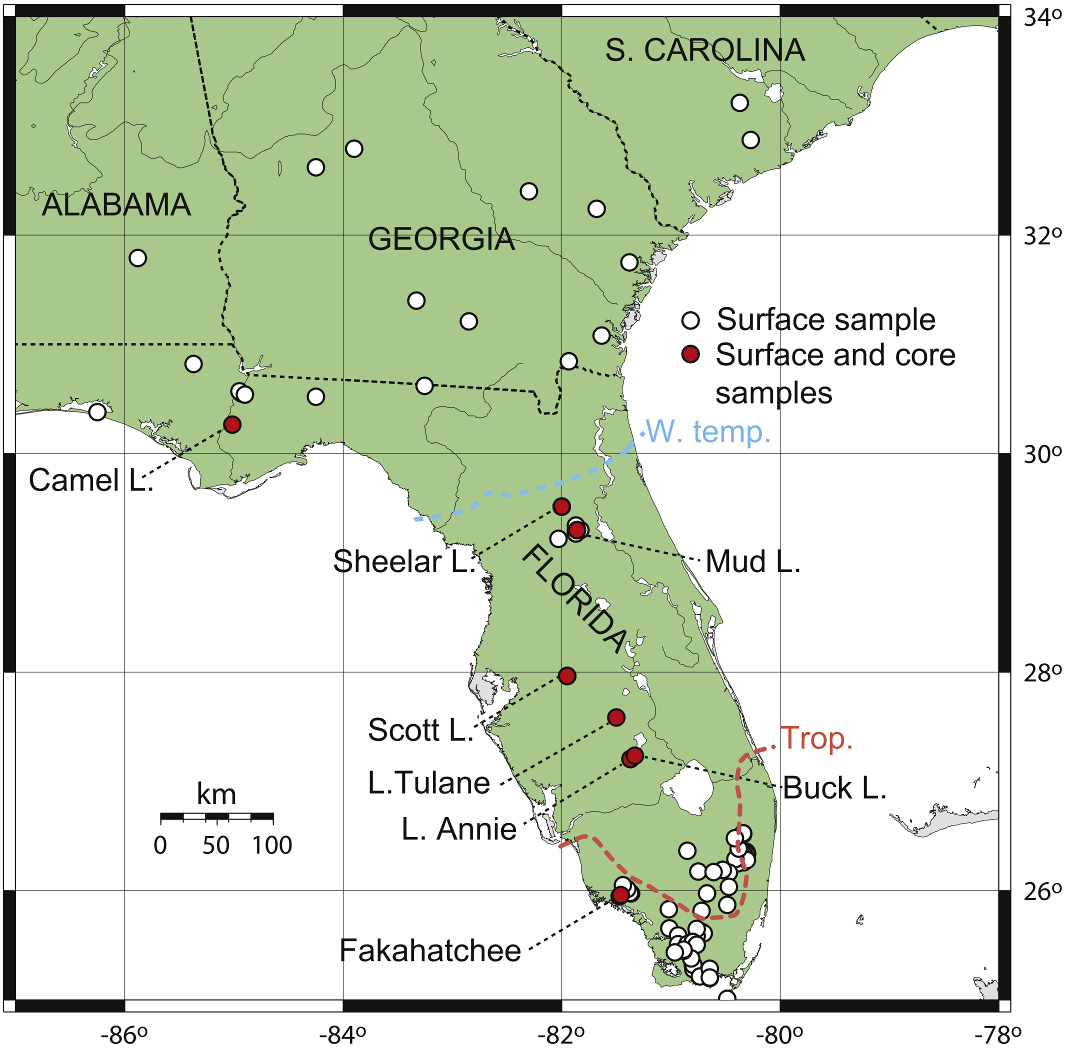

Fig. 1. Position of Florida and the surface and core sampling sites of the pollen data used in this study. For locations of the sea level reconstructions see Toscano and Macintyre (2003) and Törnqvist et al. (2004).

regional comparison. Seven lake sites from the interior of Florida were selected (Table 1, Fig. 1) since, relative to the coastal wetlands, these are less dependent on groundwater and sea level changes. Postglacial SLR of the broad western Florida shelf sharply decreased the distance of all sites to the sea, and any effect upon precipitation would have affected all sites to a similar degree. Alternatively, a dominantly climatological forcing would likely have been a regionally divergent. For the southernmost transect sites, Lake Tulane (LT) (Grimm et al., 1993, 2006) and Lake Annie (LA) (Watts, 1975), quantitative reconstructions are already available (Donders et al., 2011). The same transfer function is used to obtain estimates from additional localities (Fig. 1).

2. Methods

Data selection is based on the available radiocarbon-dated pollen records from lakes (Table 1) that cover the most part of the Holocene. The quality of the chronology varies significantly and most sites required age calibration as original publications reported ^{14}C ages only. Calibration was performed with Calib 7.0 (Stuiver et al., 2013) using the IntCal13 NH calibration curve (Reimer et al., 2013). Calibrated ages are reported as median probabilities based on the 1-sigma interval. For sites with few radiocarbon ages (Buck Lake [BL, (Watts and Stuiver, 1980; Watts et al., 1996)], Mud Lake [ML, (Watts, 1969)], Camel Lake [CL, (Watts et al., 1992)], Scott Lake [ScL, (Watts, 1971)] a simple linear interpolation was used for age-depth modelling. Radiocarbon ages from two parallel records from Sheelar Lake (ShL) were combined (Watts and Stuiver, 1980; Watts and Hansen, 1994) through pollen stratigraphic correlation, and a cubic B-spline interpolation was applied using Tilia 1.7 (Grimm, 1991–2011). The LT pollen record was originally based on a non-calibrated ^{14}C chronology (Grimm et al., 1993). A subsequent study of LT (Grimm et al., 2006) provided an updated and high-resolution chronology based on AMS radiocarbon dating of new sediment cores. The percentage data and climatic interpretation of new pollen record from LA and LT were published in Donders et al. (2011). The new age model of LA is reported in detail in Quillen et al. (2013).

Reconstruction of summer precipitation is based on the transfer function for Florida described in Donders et al. (2011). The transfer function provides very robust results as it is limited to a fixed set of common regionally important taxa, and local aquatic wetland taxa were largely removed to avoid imprint of local vegetation changes and/or basin type. Highly permeable soils in the central Lake Wales Ridge of Florida indicate greatest sensitivity to the main summer precipitation peak (Grimm et al., 2006). In the 122-sample training