LETTERS

Atlantic hurricanes and climate over the past 1,500 years

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Atlantic tropical cyclone activity, as measured by annual storm counts, reached anomalous levels over the past decade[1]. The short nature of the historical record and potential issues with its reliability in earlier decades, however, has prompted an ongoing debate regarding the reality and significance of the recent rise[2–5]. Here we place recent activity in a longer-term context by comparing two independent estimates of tropical cyclone activity over the past 1,500 years. The first estimate is based on a composite of regional sedimentary evidence of landfalling hurricanes, while the second estimate uses a previously published statistical model of Atlantic tropical cyclone activity driven by proxy reconstructions of past climate changes. Both approaches yield consistent evidence of a peak in Atlantic tropical cyclone activity during medieval times (around AD 1000) followed by a subsequent lull in activity. The statistical model indicates that the medieval peak, which rivals or even exceeds (within uncertainties) recent levels of activity, results from the reinforcing effects of La-Niña-like climate conditions and relative tropical Atlantic warmth.

A number of past studies have attempted to place modern Atlantic tropical cyclone activity in a longer-term context using regional proxy evidence of past landfalling Atlantic hurricanes (tropical cyclones with maximum sustained surface winds exceeding 74 miles per hour)[6–8]. Some studies[4] have sought to infer past changes in activity from plausible local conditioning factors such as wind strength and sea surface temperature (SST), though the interpretations of these studies have been contested[5]. Qualitative comparisons between palaeo-hurricane reconstructions appear to show some temporal coherence[8,9]. However, no past studies have attempted to synthesize multiple records from distinct regions into a basin-integrated reconstruction of Atlantic hurricane activity. Moreover, no past studies have sought to quantitatively relate estimated variations in hurricane or tropical cyclone activity to reconstructions of the key large-scale climate factors known to have a significant influence on modern Atlantic tropical cyclone activity. Here we produce an empirical record of past landfalling Atlantic hurricane activity by combining information from multiple sedimentary records of hurricane-induced overwash. Further, we compare these resulting estimates to independent statistical model predictions of past tropical cyclone activity driven by proxy-based large-scale climate reconstructions.

Sediment-based overwash reconstructions of hurricane landfall are limited in number, but span a wide geographic area across the North Atlantic basin affected by hurricanes. Our compilation includes (see Fig. 1) a site from the Caribbean (Vieques, Puerto Rico[6,9,10]), one from the US Gulf Coast[7], one from the southeastern US coast[11], three from the mid-Atlantic coast (one from New York[8] and two from New Jersey[12,13]) and two from southeastern New England (one from Rhode Island[14] and another from Massachusetts[15]), yielding five distinct regional series. We obtained a probabilistic estimate of past basin-wide landfalling hurricane activity using an appropriately weighted combination of the information from these five regional series, and incorporating radiocarbon age model uncertainties.

An independent estimate of past tropical cyclone activity was obtained using a statistical model for Atlantic tropical cyclone counts. This previously developed and validated[3,16] statistical model conditions annual Atlantic tropical cyclone counts on three key large-scale climate state variables tied to historical variations in Atlantic tropical cyclone counts: (1) the SST over the main development region (MDR) for tropical Atlantic tropical cyclones, which reflects the favourability of the local thermodynamic environment; (2) the El Niño/Southern Oscillation (ENSO), which influences the amount of (unfavourable) vertical wind shear; and (3) the North Atlantic Oscillation (NAO), which affects the tracking of storms,

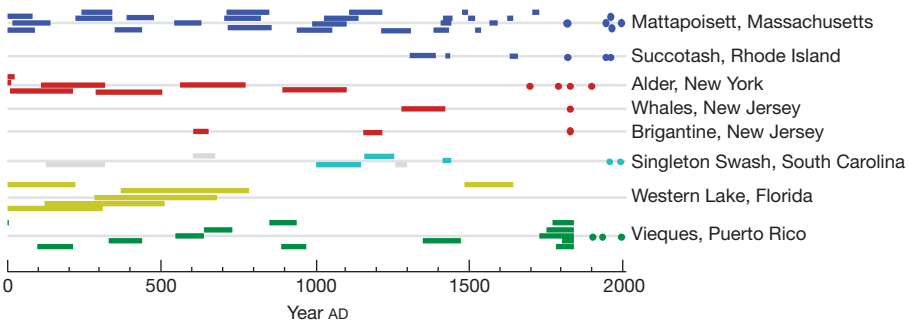

Figure 1 | Overwash sediment records of landfalling hurricanes. Event histories are shown for New England (blue), Mid-Atlantic (red), the southeastern US coast (turquoise; grey denotes oyster-bed events not used for reasons discussed by ref. 28 and in the Supplementary Information), the Gulf Coast (yellow) and the Caribbean (green). The horizontal width of shaded rectangles indicates the $\pm 1\sigma$ age model uncertainties. Circles indicate historical hurricane events.

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