

Millennial-scale Variability in Atlantic Hurricane Activities: Possible Links to the Hadley Circulation

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Proxy records based on paleotempestological research have revealed that catastrophic hurricane activity along the Gulf of Mexico coast varies on timescales of centuries to millennia (Liu, 1999; Liu and Fearn, 2000, *Quaternary Research* 54: 238-245). Few catastrophic hurricanes struck the Gulf coast during 5000-3700 cal yr BP and again during the most recent millennium. These quiescent intervals were separated by a hyperactive period during 3700-1000 cal yr BP, when the Gulf coast was struck frequently by catastrophic hurricanes and their landfall probabilities increased by 3-5 times. This millennial-scale variability has been attributed to long-term shifts in the position of the Bermuda High (Liu and Fearn, 2000), which may also be linked to changes in the strength of the North Atlantic Oscillation (NAO) (Elsner et al., 2000). According to the Bermuda High hypothesis, an anti-phase pattern is expected to exist between the Gulf of Mexico coast and the Atlantic coast. During the quiescent periods, a more northeasterly position of the Bermuda High would result in more hurricanes being steered towards the Atlantic coast. During the hyperactive period, more hurricanes were steered towards the Gulf coast as the Bermuda High was shifted to a more southwesterly position near the Caribbean. Such a displacement of the Bermuda High is consistent with paleoclimatic evidence that shows an abrupt onset of a drier climate in Haiti around 3200 ^{14}C yr BP, and a change towards more humid conditions in the Central Plains during the late-Holocene as more moisture was pumped up the Mississippi Valley through the Gulf coast. Preliminary data from the northern Atlantic coast seem to support the Bermuda High hypothesis. A 3000-year proxy record from a coastal lake in Cape Cod suggests that hurricane activity increased significantly during the past 500-1000 years, just as the Gulf coast was amid a quiescent period of the last millennium.

The southwestward shift of the Bermuda High 3700 cal yr ago may also be linked to a southward shift of the ITCZ during the late-Holocene, hence a contracted Hadley circulation over the western Atlantic Ocean in the northern hemisphere. The increased frequency of catastrophic hurricane strikes observed in the Gulf coast proxy records during the hyperactive period seems to mimic the dramatic fluctuations in precipitation recorded in the varved sediments in the Cariaco Basin after 3800 cal yr BP (Hughen et al., 1996; Haug et al., 2001).