Evidence of Multidecadal Climate Variability in the Gulf of Mexico

The northern Gulf of Mexico coastal region is vulnerable to a variety of natural hazards, many of which are linked to climate and climate variability. Hurricanes, which are one such climate-related hazard, are a major recurring problem, and the active hurricane seasons of 2004 and 2005 raised interest in better understanding the controls and risks of hurricanes.

Examination of historical records reveals intervals of alternating low and high hurricane activity that appear to be related to changes in average sea-surface temperature in the North Atlantic Ocean. Analyses of instrumental temperature records from the North Atlantic show decadal-scale oscillations of slightly higher versus slightly lower average temperature extending back in time for over 100 years. This oscillation is known as the Atlantic Multidecadal Oscillation (AMO) (fig. 1).

Comparison of landfall records of major hurricanes in the Gulf of Mexico with the AMO index shows that more major hurricanes impact the northern Gulf of Mexico when the AMO is positive (warmer sea-surface temperature) than when it is negative (cooler sea-surface temperature) (fig. 2).

Sea-surface temperature records derived from a sediment core from the Pigmy Basin in the northern Gulf of Mexico and a coral core from Puerto Rico were analyzed for evidence of AMO-like oscillations to determine if these proxy sea-surface temperature records could be used to extend the record of the AMO back in time prior to instrumental measurements. The detailed results of this study were published in December 2009 as part of a special issue of Geo-Marine Letters that documents early results from the Northern Gulf of Mexico (NGOM) Ecosystem Change and Hazard Susceptibility Project (Poore and others, 2009).

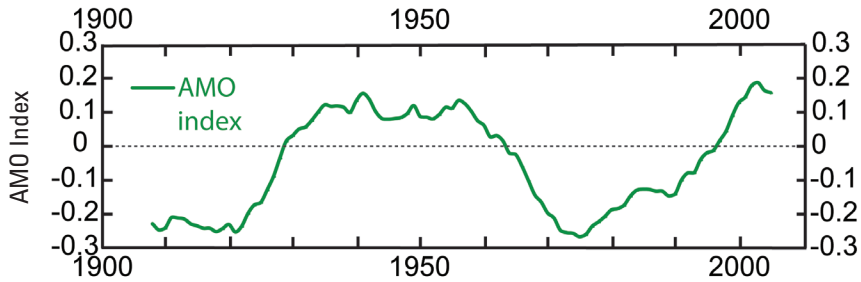

Figure 1. Plot showing variation of the Atlantic Multidecadal Oscillation (AMO) index from 1908 to present. The AMO index reflects changes of sea-surface temperature in the North Atlantic Ocean from the long-term mean annual average. Data are from NOAA (2008).

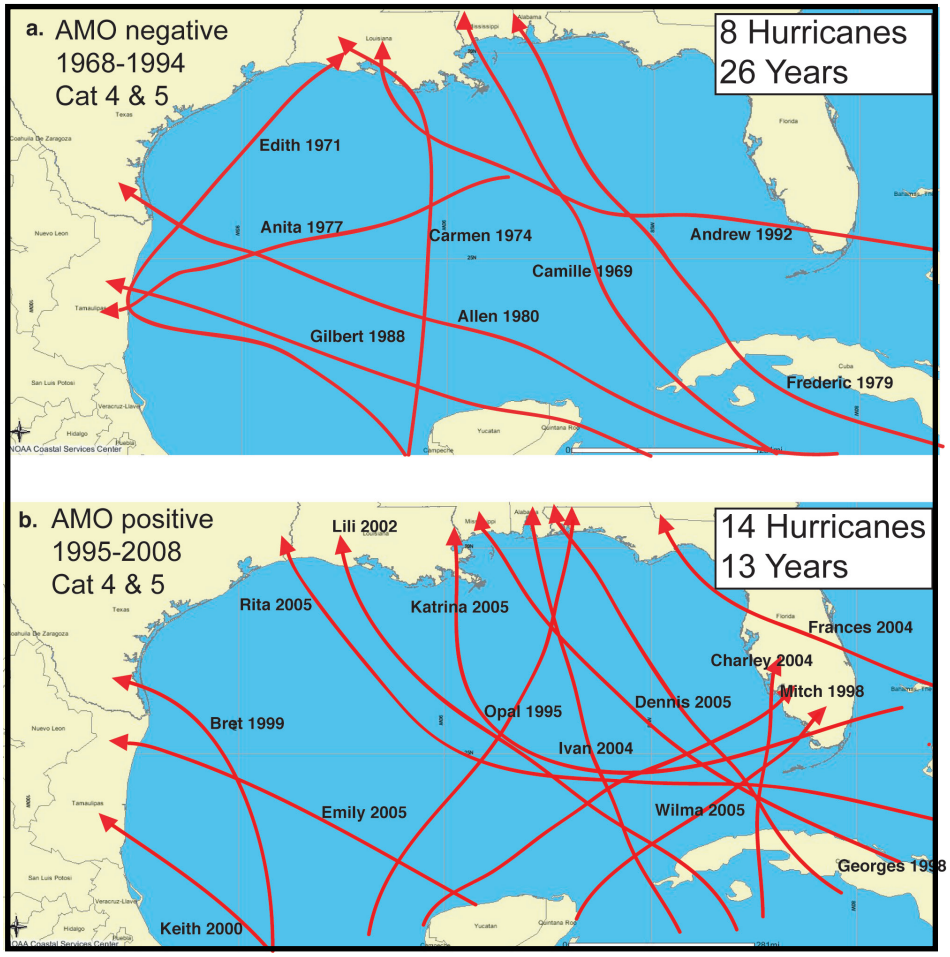

Figure 2. Map showing landfalls of major (Categories 4 and 5) hurricanes in the Gulf Coast region during intervals of time representing the (a) negative (cold) phase (1968-1994) of the Atlantic Multidecadal Oscillation (AMO), and (b) positive (warm) phase (1995-2008) of the AMO. Data are from NOAA (2006; 2008).

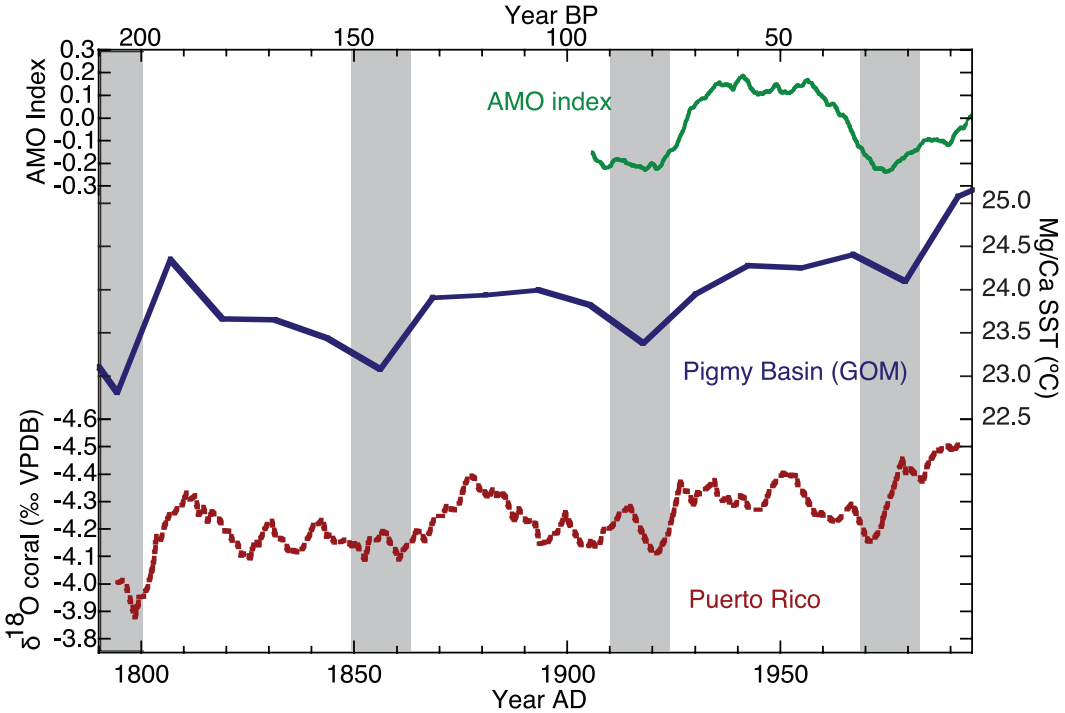

Figure 3. Comparison of AMO index (NOAA, 2008), Pigmy Basin sea-surface temperature record (Richey and others, 2007), and sea-surface temperature record from Puerto Rico coral core (Kilbourne and others, 2008). Gray bars highlight deflections to cooler temperatures. SST = sea-surface temperature; PB, before present; ‰ VPDB, per mil, Vienna Peedee Belemnite (a standard).

Comparison of Northern Gulf of Mexico and Caribbean Temperature Records with the AMO

Records of mean annual sea-surface temperature for the northern Gulf of Mexico derived from magnesium/calcium (Mg/Ca) analysis of the planktic foraminifer *Globigerinoides ruber* (white variety) in a sediment core from the Pigmy Basin (Richey and others, 2007) and a record of Caribbean sea-surface temperature developed from analyses of oxygen isotope variations ($\delta^{18}O$) in a coral core from Puerto Rico (Kilbourne and others, 2008) are compared to the AMO index in figure 3. The sea-surface temperature records show similar patterns of variation with the AMO index [see Poore and others (2009) for statistical verification]. In addition, the two sea-surface temperature proxy records show similar patterns of variability over the last two centuries. The results shown on figure 3 indicate AMO-like oscillations in sea-surface temperature have been present since at least 1800. Future work will focus on developing records to test for the presence of AMO-like oscillations farther back in time.

References Cited

Kilbourne, K.H., Quinn, T.M., Webb, R., Guilderson, T., Nyberg, J., Winter, A., 2008, Paleoclimate proxy perspective on Caribbean climate since the year 1751: Evidence of cooler temperatures and multidecadal variability: Paleoceanography, v. 23, doi:10.1029/2008PA001598.

National Oceanic and Atmospheric Administration (NOAA), 2006, Historical hurricane tracks: National Oceanic and Atmospheric Administration, Coastal Services Center, Charleston, SC, http://maps.csc.noaa.gov/hurricanes/ .

National Oceanic and Atmospheric Administration (NOAA), 2008, Climate timeseries AMO (Atlantic Multidecadal Oscillation) index: National Oceanic and Atmospheric Administration, Earth System Research Laboratory, Boulder, CO, http://www.cdc.noaa.gov/Timeseries/AMO/ .

Richey, J.N., Poore, R.Z., Flower, B.P., Quinn, T.M., 2007, 1400 yr multiproxy record of climate variability from the northern Gulf of Mexico: Geology, v. 35, p. 423-426.

Poore, R.Z., DeLong, K.L., Richey, J.N., and Quinn, T.M., 2009, Evidence of multidecadal climate variability and the Atlantic Multidecadal Oscillation from a Gulf of Mexico sea-surface temperature-proxy record: Geo-Marine Letters, v. 29, no. 6, p. 477-484.

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