ABSTRACT

Instrumental climate and environmental records are generally too short to determine decadal and centennial climate variability and its underlying mechanisms with sufficient accuracy. To obtain improved temporal coverage and characterization of the nature of climate variability in the pre-instrumental period, high-resolution climate and environmental proxy records must be established. Previous analyses have demonstrated that the northeastern Caribbean is a key area for the reconstruction of North Atlantic climate variability and trends. The objective of this dissertation is to reconstruct environmental parameters, such as sea-surface temperature, sea-surface salinity, precipitation, and trade wind variability through the last 2000 years in the northeastern Caribbean using a wide range of methods. The variations in these environmental parameters through time and their climatic implications are evaluated and compared with appropriate instrumental and proxy climate-records from the Caribbean and other areas surrounding the Atlantic Basin.

In part A of this dissertation, the results of studies dealing with aragonite skeletons of hermatypic coral cores retrieved outside Mona Island and Puerto Rico are presented. This work focuses on the analyses of terrestrially derived humic acids using fluorescence intensity, stable oxygen isotopes ($\delta^{18}O$), as well as D/L ratios and concentrations of amino acids. The data obtained allow reconstructions of annual changes in precipitation patterns, trade-wind variability, and sea-surface temperatures during the time period from 1685 to 1994.

In paper A1, it is shown that the fluorescence-intensity record, which reflects variations in precipitation and trade wind strength, is strongly correlated with solar irradiance at timescales of ~3.8, 5.7, and 31.8 years during the time interval 1685-1994. Periods of lower rainfall, associated with enhanced wind speed, concur with higher solar radiative output, higher Central England air temperatures, and lower northeastern Caribbean sea-surface temperatures, as inferred from the $\delta^{18}O$ record. These observations suggest that changes in solar irradiance, at least partly, affect the Hadley cell circulation and the heat transport from low to high latitudes. The mechanism involved may be solar/ozone-induced changes in the stratosphere that penetrate into the troposphere leading to a poleward migration in the northern subtropical jet and the Hadley cell circulation during higher solar input. This northward movement in the tropospheric circulation patterns results in cooler air in the descending portions of the Hadley cells. The cooler air increases the surface pressure and, in turn, the trade windspeed, which leads to enhanced wind-induced latent heat flux, lower precipitation, and cooler sea-surface temperatures in the northeastern Caribbean. These increases in pressure over the North Atlantic enhance the anticyclonic flow, which brings warmer air to higher latitudes.

In paper A2, the fluorescence-intensity record is shown to be statistically significantly cross-correlated with the frequency of intense hurricanes (categories 3, 4, or 5 on the Saffir-Simpson hurricane scale) over the Atlantic for the period 1943-1994. This correlation may arise due to a control of trade wind variability on both precipitation patterns and intense hurricane activity. The fluorescence intensity reflects intense hurricane activity indirectly through trade-wind variability. Assuming that these relationships persisted back in time, the fluorescence-intensity record indicates that the time interval from the late 1960s to early 1990s experienced few intense hurricanes compared to other periods during the time interval 1685-1994.

Paper A3 shows that the D/L ratios of the amino acids aspartic acid, glutamic acid, and alanine in hermatypic corals can be used as a chronometer through the last 250 years, after which the racemization occurs in a more unpredictable fashion. Together with diagenetic processes, such as leaching and decomposition, bacterial addition of D-amino acids may explain the changes observed in the patterns of racemization. Such contamination of D-amino acids may, for example, originate from coral bleaching.

In part B of this dissertation, marine sediment cores retrieved from the southern and western insular shelves off Puerto Rico were analyzed for lithological and mineral magnetic parameters, carbonate and organic carbon content, as well as abundances of planktonic foraminifera and stable oxygen isotope ($\delta^{18}O$) variability. For chronostratigraphic control, AMS ^{14}C and $^{210}Pb/^{137}Cs$ measurements were made.

In paper B1, sea-surface temperature and sea-surface salinity fluctuations were reconstructed through the past 2000 years using an artificial neural network trained on a modern data-base of planktonic foraminifer census data, and oxygen isotope ratios of the planktonic foraminifer *Globigerinoides ruber* (white variety). Episodes of lower sea-surface salinity with marked minima at the onsets of the Dark Ages in Europe (~ AD 500-600) and Little Ice Age (~ AD 1400) are cyclically recurrent at intervals of 200-400 years. The lower sea-surface salinity intervals coincide with arid events on opposite sides of the equator as well as with known reorganizations of the North Atlantic circulation. This may indicate that oceanic advective processes originating in low latitudes are involved in changes in the North Atlantic thermohaline circulation.

In paper B2, it is shown that harmonic analysis of the mineral magnetic parameters indicates the existence of a ~200 year-long climate cycle in the northeastern Caribbean during the last 2000 years. This cycle, reflecting the amount of deposited fluvially derived detrital material from Puerto Rico, points to periodic fluctuations in precipitation patterns and trade-wind variability over the low-latitude North Atlantic Ocean and surrounding continental areas on a time-scale of about 200 years.

Keywords: Caribbean, North Atlantic, Late Holocene, climate variability, corals, marine sediments, fluorescence intensity, oxygen isotopes, mineral magnetic parameters; geochemistry, planktonic foraminifera, precipitation, tradewind variability, temperature, salinity.