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# Sr/Ca and $\delta^{18}$O in a fast-growing *Diploria strigosa* coral: Evaluation of a new climate archive for the tropical Atlantic

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[1] This study provides the first monthly resolved, 41-year record of geochemical variations ($\delta^{18}$O and Sr/Ca) in a fast-growing *Diploria strigosa* brain coral from Guadeloupe, Caribbean Sea. Linear regression yields a significant correlation of coral Sr/Ca ($\delta^{18}$O) with instrumental sea surface temperature (SST) on both monthly and mean annual scales (e.g., $r = -0.59$ for correlation between Simple Ocean Data Assimilation (SODA) SST and Sr/Ca, and $r = -0.66$ for $\delta^{18}$O; mean annual scale, $p < 0.0001$). The generated coral Sr/Ca ($\delta^{18}$O)-SST calibration equations are consistent with each other and with published equations using other coral species from different regions. Moreover, a high correlation of coral Sr/Ca and $\delta^{18}$O with local air temperature on a mean annual scale ($r = -0.78$ for Sr/Ca; $r = -0.73$ for $\delta^{18}$O; $p < 0.0001$) demonstrates the applicability of geochemical proxies measured from *Diploria strigosa* corals as reliable recorders for interannual temperature variability. Both coral proxies are highly correlated with annual and seasonal mean time series of major SST indices in the northern tropical Atlantic (e.g., $r = -0.71$ for correlation between the index of North Tropical Atlantic SST anomaly and Sr/Ca, and $r = -0.70$ for $\delta^{18}$O; mean annual scale, $p < 0.001$). Furthermore, the coral proxies capture the impact of the El Niño–Southern Oscillation on the northern tropical Atlantic during boreal spring. Thus fast-growing *Diploria strigosa* corals are a promising new archive for the Atlantic Ocean.

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## 1. Introduction

[2] The reconstruction of long-term climate variability in the tropical Atlantic sector is crucial in order to understand and predict important climate changes, such as rainfall over sub-Saharan West Africa, the nordeste Brazil and the Caribbean/Central American region [*Marshall et al.*, 2001,

references therein], and to capture the competing impacts of El Niño–Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO) in the north tropical Atlantic region. Sea surface temperature (SST) is arguably one of the most important climatic parameters on interannual to decadal timescales. The dominant pattern of SST variability over the tropical Atlantic is characterized by anomalous SSTs in the north tropical Atlantic (NTA), between 5°–25°N and 60°–20°W [*Czaja et al.*, 2002]. NTA variability is most pronounced in boreal spring when the impact of remote forcing due to the ENSO and the NAO is strongest [*Czaja et al.*, 2002; *Czaja*, 2004]. ENSO and the NAO influence the trade winds over the northern tropical Atlantic, which in turn drive SST anomalies [*Carton et al.*, 1996]. Both observational and modeling studies rely on the accuracy of available observational data. However, observations of tropical Atlantic SST are limited in quality and particularly in length. The available SST data are rather short to study variability on decadal and longer scales [*Dommenget and Latif*, 2000]. Therefore multidecadal to century-long proxy-based reconstructions of past sea surface temperatures from the Atlantic region are greatly needed in order to (1) extend the temporally limited data sets into the past, (2) enhance useful predictability of tropical Atlantic SST anomalies [*Penland and Matrosova*, 1998], and (3) as calibration and validation data for numerical climate models.

[3] A large number of studies have shown that SSTs can be reconstructed by measuring geochemical parameters ($\delta^{18}$O and Sr/Ca) on carbonate samples extracted from reef coral skeletons [*Cole et al.*, 1993; *Marshall and McCulloch*, 2002; *Zinke et al.*, 2004]. Relative variations of coral $\delta^{18}$O (Sr/Ca) follow thermodynamic properties and are influenced by temperature and the $\delta^{18}$O (Sr/Ca) of seawater. Over the past several hundred years, seawater Sr/Ca changes are negligible [*Gagan et al.*, 2000] and several studies have used the Sr/Ca ratios to develop paleothermometers for the reconstruction of SSTs [*Marshall and McCulloch*, 2002]. At sites where $\delta^{18}$O seawater variations are small and negligible, coral $\delta^{18}$O also records SST variations [e.g., *Pfeiffer and Dullo*, 2006]. Many coral $\delta^{18}$O records were shown to recover large-scale climate phenomena which are related to local SST and/or SST covariant changes in seawater $\delta^{18}$O [*Evans et al.*, 2000]. However, the majority of coral-based reconstructions of climate variability have been done using massive growing corals of the genus *Porites*, which are abundant in the tropical Indo-Pacific ocean [*Cole et al.*, 1993, 2000; *Quinn et al.*, 1998; *Pfeiffer et al.*, 2004]. In the tropical Atlantic, there is currently no continuous multidecadal or longer coral record available with monthly temporal resolution. In the Atlantic, primarily *Montastrea* sp. corals have been used for climate reconstructions [e.g., *Swart et al.*, 1996, 2002; *Winter et al.*, 2000]. However, laborious high resolution sampling techniques (>20–50 samples/year) are necessary in order to resolve the full annual temperature cycle using *Montastrea* sp. [*Leder et al.*, 1996; *Watanabe et al.*, 2001, 2002]. Recent studies have demonstrated that corals of the genus *Diploria labyrinthiformis* from Bermuda are also eligible for reconstructions of oceanic parameters in the northern Atlantic [*Cohen et al.*, 2004; *Goodkin et al.*, 2005; *Kuhnert et al.*, 2005], although the low growth rates of Bermuda corals (∼3–4 mm/year) are causing problems. For example, *Goodkin et al.* [2005] proposed a growth-dependent Sr/Ca-SST calibration that includes the effect of varying skeletal extension rates and thereby reduces biases in the coral SST reconstruction.

[4] With the objective to evaluate a new and easily accessible oceanic archive, we have developed proxy records using the widely distributed, but so far under-utilized coral species *Diploria strigosa*. The coral stems from the eastern Caribbean Sea (Guadeloupe). This paper presents a continuous multiproxy ($\delta^{18}$O and Sr/Ca) time series extending from 1958 to 1999. In order to assess the robustness of our proxies, we have correlated each proxy with a local air temperature record, and with local SST data from global gridded SST products to derive proxy-temperature calibrations. Finally, the ability of the coral proxies to record large-scale SST variability in the tropical North Atlantic is evaluated.

## 2. Data and Methods

### 2.1. Sampling

[5] The Guadeloupe archipelago, which is part of the Lesser Antilles (Leeward Islands), covers an area of ∼1821 sq. km (15.95°–16.5°N, 61.2°–61.8°W) and consists of two principal main islands, Grande Terre and Guadeloupe or Basse Terre. Core Gua1 was recovered in April 2000 from a hemispherical *Diploria strigosa* colony growing in a fringing reef located south of Grand Terre near Isle de Gosier (16.20°N, 61.49°W). The colony exhibited a diameter of 1.5 m and grew in a

water depth of 1.7 m. Core Gua1 was drilled vertically. The core is 1.26 m long and has a diameter of 36 mm. The core was sectioned longitudinally into 7 mm thick slabs. The coral slabs were x-rayed in order to expose annual density band couplets. A chronology was generated by counting the well-developed annual density bands. Core Gua1 extends continuously from 1895 to 1999. The skeletal extension rate estimated from the annual density bands averages 9.2 mm/year (±1.39 mm).

### 2.2. Coral $\delta^{18}$O and Sr/Ca

[6] The upper 41 years of Gua1 were sampled for stable isotope and trace element analysis. Powdered samples were collected using a low-speed micro drill with a 0.7 mm diameter diamond drill bit. The slabs were sampled continuously along the corallite walls (theca), in order to avoid mixing of sample powder from different skeletal elements. Samples were retrieved at approximately 0.8 mm intervals, yielding on average 10–12 samples per year. The powdered samples were split into separate aliquots for stable oxygen isotope ($\delta^{18}$O) and trace element (Sr/Ca) analysis. Sr/Ca was measured with an ICP-OES at the University of Kiel following the techniques described by *Schrag* [1999] and *de Villiers et al.* [2002]. Analytical precision on Sr/Ca determinations is 0.15% RSD or 0.01 mmol/mol ($1\sigma$) (n = 367; 1 standard after every 6 samples). The reproducibility of Sr/Ca ratios from multiple measurements on the same day and on consecutive days is 0.09% RSD ($1\sigma$). The $\delta^{18}$O was analyzed using a Thermo Finnigan Gasbench II Deltaplus at IFM-GEOMAR. The isotopic ratios are reported in ‰ VPDB relative to NBS 19, and the analytical uncertainty is less than 0.06‰ ($1\sigma$) (n = 367; 2 standards after every 10 samples). The overlapping parts of sampling transects along different thecal walls were compared for proxy validation. The reproducibility is excellent (RSD is 0.36% for Sr/Ca, and 1.88% for $\delta^{18}$O; n = 24).

### 2.3. Coral Chronology

[7] The age model was established on the basis of the pronounced seasonal cycle in the Sr/Ca record. The maximum (minimum) Sr/Ca was tied to March (September), which is on average the coolest (warmest) month in the study area. The coral $\delta^{18}$O and Sr/Ca time series were linearly interpolated between these anchor points using the Analyseries software [*Paillard et al.*, 1996] to obtain monthly proxy time series. The uncertainty of the age model is approximately 1–2 months in any given year. The $\delta^{18}$O and Sr/Ca records presented here extend from January 1958 to March 1999. Core Gua1 exhibits a gap of three years from October 1978 to October 1981, because a small piece from the 2nd core section broke off during drilling, and the remaining parts of the core do not contain any thecal walls suitable for sampling. However, the gap did not affect the development of the chronology, since the core sections could be fit together on the basis of the density bands on the X-radiographs.

### 2.4. Instrumental Data

[8] Monthly mean air temperatures were recorded at Pointe-à-Pitre airport (16.27N, 61.53W; WMO station 78897, 11 m altitude) between 1951 and 2000. Pointe-à-Pitre airport is located approximately 8 km to the northwest of the coral sampling site. The data are available online at http://climexp.knmi.nl [*van Oldenborgh and Burgers*, 2005]. The Simple Ocean Data Assimilation (SODA) data set (version 1.4.2) is a model-based reanalysis of oceanic parameters and covers a 44-year period from 1958–2001. The data are available at monthly temporal and 0.5° by 0.5° spatial resolution [*Carton et al.*, 2000] (data available online at http://iridl.ldeo.columbia.edu/SOURCES/.CARTON-GIESE/.SODA/.v1p4p2/). We have extracted SST data from the grid-box centered at 16°N, 61°W. Additionally, monthly SSTs for the 2° latitude by 2° longitude box including the coral site (centered at 16°N, 62°W) were extracted from the Improved Extended Reconstruction of SST (ERSST.v2) compilation for the same time period [*Smith and Reynolds*, 2004]. The ERSST uses statistical methods to fill in gaps in the instrumental database [*Smith and Reynolds*, 2004]. The SODA and ERSSTv.2 data sets are highly correlated on monthly ($r = 0.96$, $p < 0.0001$) and annual mean scales ($r = 0.94$, $p < 0.0001$). Table 1 summarizes basic statistics of the temperature products. The Pointe-à-Pitre air temperature record also correlates strongly with grid-SST ($r = 0.75$, $p < 0.0001$ with SODA SST; $r = 0.74$, $p < 0.0001$ with ERSSTv.2).

## 3. Results and Discussion

### 3.1. Calibration of the Coral Proxy Data

[9] The coral $\delta^{18}$O and Sr/Ca records display clear seasonal cycles, and the records are well correlated over the entire time period on monthly ($r = 0.72$, $p < 0.001$) and on mean annual scales ($r = 0.77$, $p <$

**Table 1.** Basic Statistics of the Temperature Data Sets for the 1958–1999 Time Period[a]

| | Seasonal Cycle | | | | | | |
|---|---|---|---|---|---|---|---|
| Data Set | Summer | Winter | Average | Max | Min | Range | STD AnnM |
| SODA SST | 28.73 | 26.29 | 27.60 | 29.43 | 25.03 | 4.40 | 0.317 |
| ERSST | 28.67 | 26.29 | 27.55 | 29.46 | 25.34 | 4.12 | 0.273 |
| Air Temp. | 27.40 | 24.20 | 25.90 | 28.80 | 22.30 | 6.50 | 0.634 |

[a] In °C; n = 458; STD AnnM is standard deviation of mean annual values.

0.001). The correlation between annual mean coral growth rates and annual mean $\delta^{18}$O (Sr/Ca) is low, r = 0.17 (r = 0.03) and not significant. To assess the reliability of coral $\delta^{18}$O and Sr/Ca as recorders of local temperature variability, we calibrated both coral proxies with the local air temperature record from Pointe-à-Pitre airport and with the local grid-SST extracted from the SODA and ERSST products. Table 2 compares the calibration equations for monthly, annual mean and seasonal extreme values (maxima/minima) of the proxy records.

[10] The correlation between local air temperature and coral Sr/Ca is high (r = −0.65 for monthly, and r = −0.78 for annual means; $p < 0.0001$, Table 2). Coral Sr/Ca also correlates significantly with grid-SST extracted from the SODA (Figure 1) and ERSST.v2 data sets. The slope of the monthly Sr/Ca-SST calibration ranges from −0.041 to −0.042 mmol/mol/°C for SODA and ERSST.v2, respectively. A linear regression using only the minimum/maximum values in any given year (March/September) confirms the Sr/Ca-SST slope values obtained using the monthly data (Table 2). The correlation between coral Sr/Ca and instrumental SST remains high on an annual mean scale (Table 2). However, the slope values of the annual mean Sr/Ca-SST regression are larger than those of the monthly regression. With SODA, we obtain −0.074 mmol/mol per 1°C, and with the ERSST we obtain −0.066 mmol/mol per 1°C. Taking into account the statistical uncertainties of the estimated slope values (Table 2), only the annual mean Sr/Ca-SODA SST

**Table 2.** Regression Equations Between Coral $\delta^{18}$O (Sr/Ca Ratios) and Several Instrumental Temperature Data Sets[a]

| Data Set | Resolution | Slope | SE-sl | Intercept | SE-int | $R^2$ | R | p Value | SE, $\sigma$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *Sr/Ca* | | | | | |
| SODA SST | | | | | | | | | |
| 1958–1999 | monthly | −**0.041** | 0.002 | **9.986** | 0.058 | 0.45 | −**0.67** | <0.0001 | 0.042 |
| 1958–1999 | extreme values | −**0.049** | 0.004 | **10.226** | 0.109 | 0.68 | −**0.82** | <0.0001 | 0.043 |
| 1958–1998 | annual mean | −**0.074** | 0.017 | **10.902** | 0.476 | 0.35 | −**0.59** | <0.0001 | 0.033 |
| ERSSTv.2 | | | | | | | | | |
| 1958–1999 | monthly | −**0.042** | 0.002 | **10.013** | 0.063 | 0.42 | −**0.65** | <0.0001 | 0.043 |
| 1958–1999 | extreme values | −**0.050** | 0.004 | **10.258** | 0.112 | 0.68 | −**0.82** | <0.0001 | 0.043 |
| 1958–1998 | annual mean | −**0.066** | 0.022 | **10.696** | 0.617 | 0.21 | −**0.45** | <0.005 | 0.036 |
| Pointe-à-Pitre (air temperature) | | | | | | | | | |
| 1958–1999 | monthly | −**0.027** | 0.001 | **9.578** | 0.039 | 0.43 | −**0.65** | <0.0001 | 0.043 |
| 1958–1998 | annual mean | −**0.048** | 0.006 | **10.106** | 0.169 | 0.61 | −**0.78** | <0.0001 | 0.025 |
| | | | | $\delta^{18}O$ | | | | | |
| SODA SST | | | | | | | | | |
| 1958–1999 | monthly | −**0.184** | 0.007 | **0.952** | 0.189 | 0.61 | −**0.78** | <0.0001 | 0.138 |
| 1958–1999 | extreme values | −**0.202** | 0.012 | **1.456** | 0.321 | 0.80 | −**0.90** | <0.0001 | 0.126 |
| 1958–1998 | annual mean | −**0.198** | 0.039 | **1.341** | 1.063 | 0.44 | −**0.66** | <0.0001 | 0.073 |
| ERSSTv.2 | | | | | | | | | |
| 1958–1999 | monthly | −**0.196** | 0.007 | **1.282** | 0.199 | 0.62 | −**0.79** | <0.0001 | 0.136 |
| 1958–1999 | extreme values | −**0.209** | 0.011 | **1.635** | 0.316 | 0.82 | −**0.90** | <0.0001 | 0.121 |
| 1958–1998 | annual mean | −**0.196** | 0.050 | **1.276** | 1.378 | 0.31 | −**0.56** | <0.0004 | 0.081 |
| Pointe-à-Pitre (air temperature) | | | | | | | | | |
| 1958-1999 | monthly | −**0.113** | 0.005 | −**1.170** | 0.142 | 0.49 | −**0.70** | <0.0001 | 0.158 |
| 1958–1998 | annual mean | −**0.107** | 0.017 | −**1.334** | 0.443 | 0.54 | −**0.73** | <0.0001 | 0.066 |

[a] All equations are computed using ordinary least squares (OLS) regression with zero-lag, 95% confidence limits for slope and intercept are given (SE, standard error). Equations are in the form $\delta^{18}O = m*SST + b$, and $Sr/Ca = m*SST + b$.

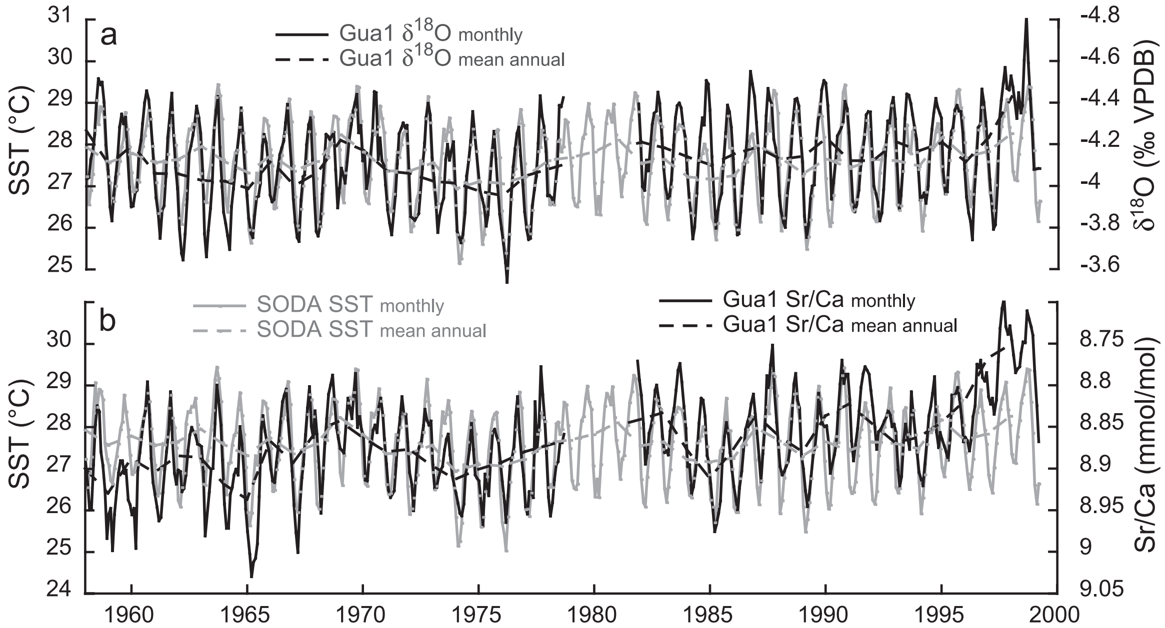

**Figure 1.** Calibration of monthly resolved coral (a) oxygen isotope data and (b) Sr/Ca elemental ratios (solid black lines) with instrumental SST (solid gray line) from the SODA reanalysis data set [*Carton et al.*, 2000] for the 1958–1999 period. Dashed lines are mean annual values. Note: The years 1998/99 represent the uppermost part of the coral core (core-top), where living organic coral tissue is still present. This organic layer is also clearly observable in the upper part of the analyzed coral slab and most likely the cause for the observed deviation in coral proxies, though the Sr/Ca elemental ratios seems to be affected more strongly than oxygen isotopes.

relationship is significantly different from the monthly and extreme value calibration.

[11] At present, there are less than a handful of published coral Sr/Ca-temperature calibrations from the tropical Atlantic Ocean. Published Sr/Ca-SST slope values range between −0.036 and −0.084 mmol/mol per 1°C for *Diploria labyrinthiformis* corals from Bermuda [*Cardinal et al.*, 2001; *Cohen et al.*, 2004; *Goodkin et al.*, 2005] and between −0.023 and −0.047 mmol/mol per 1°C for *Montastrea* sp. corals from Florida [*Swart et al.*, 2002; *Smith et al.*, 2006]. The Sr/Ca-SST slope values obtained in this study for a fast-growing *Diploria strigosa* coral lie well within the range of published Sr/Ca-SST slope values of other Atlantic corals. For all Atlantic corals, the Sr/Ca-SST relationship lies at the lower end of the published range of corals (mainly *Porites*) from the Indo-Pacific (−0.04 to −0.08 mmol/mol per 1°C [*Marshall and McCulloch*, 2002]).

[12] Over the period of 1958–1999, the coral $\delta^{18}$O record also correlates strongly with local air temperature, and with grid-SST from the SODA (Figure 1) and ERSST.v2 data sets (Table 2). The $\delta^{18}$O-SST slopes of the monthly and annual calibration are not significantly different, and range between −0.18 and −0.21 per mil per 1°C (Table 2). These values are consistent with the $\delta^{18}$O-SST slopes obtained for *Porites* corals from the Indo-Pacific, that range between −0.18 and −0.22 per mil per 1°C [*Weber and Woodhead*, 1972; *Gagan et al.*, 1994; *Wellington et al.*, 1996; *Juillet-Leclerc and Schmidt*, 2001]. Overall, the proxy-SST calibrations presented in Table 2 confirm that both coral $\delta^{18}$O and Sr/Ca record the local temperature variability at Guadeloupe.

### 3.2. Correlation With SST Anomaly Indices

[13] In order to evaluate the ability of our coral proxies to track the annual to interannual variability of SST over a wider region, we correlated our coral proxy time series against SST anomaly indices available for the Caribbean (CAR index, Caribbean Sea SST anomaly) and the North Tropical Atlantic region (NTA index, North Tropical Atlantic SST anomaly) provided by *Penland and Matrosova* [1998] (Figures 2 and 3). These indices, which are based on the COADS data set, capture the large-scale variability in the tropical North Atlantic. Figures 3a and 3b show that both the $\delta^{18}$O and Sr/Ca records of Gua1 are highly correlated with CAR and NTA SST anomalies on an annual mean scale. The correlation of annual mean coral $\delta^{18}$O

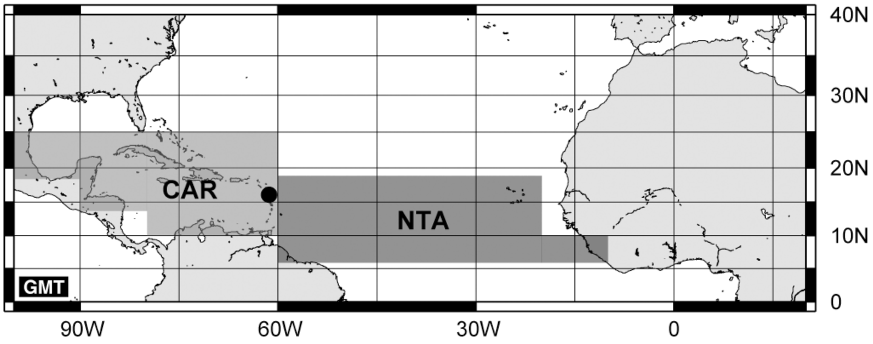

**Figure 2.** Overview map showing regions over which the SST has been averaged for the Caribbean Sea SSTa index (CAR) and the North Tropical Atlantic SSTa index (NTA). Both indices are available at the NOAA-CIRES Climate Diagnostics Center (http://www.cdc.noaa.gov/ClimateIndices). Black dot marks study site.

with CAR and NTA is $r = -0.73$ ($p < 0.001$) and $r = -0.70$ ($p < 0.001$), respectively. For coral Sr/Ca, the correlation coefficient with CAR and NTA is $r = -0.56$ ($p < 0.001$) and $r = -0.71$ ($p < 0.001$), respectively. Thus both proxy records are robust recorders of large-scale climate variability in the tropical North Atlantic.

[14] Unlike the tropical Pacific, climate in the tropical Atlantic is not dominated by any single mode of variability [e.g., *Sutton et al.*, 2000]. Rather, the region is subject to multiple competing influences. The importance of these signals varies with season [*Sutton et al.*, 2000; *Czaja*, 2004]. In March–May (MAM), the Pacific ENSO and the NAO influence NTA SST anomalies [*Sutton et al.*, 2000; *Czaja*, 2004]. Warm ENSO years tend to be associated with warm SST anomalies in the northern tropical Atlantic, while negative NAO events also lead to an anomalous warming [*Czaja et al.*, 2002]. ENSO and NAO related anomalies may add constructively to create SST anomalies in the northern tropical Atlantic, but they may also cancel each other out [*Czaja et al.*, 2002]. Equatorial Atlantic SST anomalies ("Atlantic ENSO") contribute most to NTA SST variability in July October (JASO) [*Sutton et al.*, 2000]. Thus, given the seasonal dependence of the dominant modes of climate variability in the northern tropical Atlantic, it is crucial that the coral proxies do not only capture the annual, but also the seasonal mean SST variability in the region. We have therefore correlated the mean MAM and JASO $\delta^{18}$O and Sr/Ca records with the NTA index (not shown). The correlations are high ($\delta^{18}$O: $r = -0.58$ for MAM and $r = -0.55$ for JASO; Sr/Ca: $r = -0.71$ for MAM and $r = -0.62$ for JASO) and statistically significant ($p < 0.001$). These results suggest that *Diploria strigosa* proxy records may be used to examine the relative importance of the various climate modes affecting the tropical North Atlantic on decadal to centennial timescales.

[15] Year-to-year variations of NTA SST are largest in boreal spring (MAM), when ENSO and the NAO exert maximum influence [*Sutton et al.*, 2000; *Czaja*, 2004]. Figures 3c and 3d compare the boreal winter Nino3 index (DJF) with MAM coral $\delta^{18}$O and Sr/Ca of our *Diploria strigosa* coral. The linear correlation between the coral proxies and Nino3 is high (Figures 3c and 3d), attesting to the strength of the ENSO-NTA teleconnection. Warm and cold ENSO phases (±1 standard deviation) are clearly identifiable in the coral $\delta^{18}$O (Sr/Ca) time series (e.g., the ENSO warm phases of 1966, 1987 and 1997/98 and the ENSO cold phases of 1974 and 1976). However, the large El Niño events of 1972/73 and 1982/83 are not or only weakly recorded by the coral proxies. During these years, the impact of ENSO on NTA SST is reduced due to the positive NAO phases in the preceding boreal winter [*Czaja et al.*, 2002, Figure 1] (also compare Figures 3a–3d).

## 4. Conclusions

[16] We have presented the first monthly resolved $\delta^{18}$O and Sr/Ca calibration of the Atlantic brain coral *Diploria strigosa*. Both geochemical proxies show a significant correlation with instrumental SST over a 41-year time period on both monthly and mean annual scales. We obtained proxy-SST calibrations that are consistent with previously published studies using other coral species from different regions.

[17] A comparison between the coral proxies and SST anomaly indices available for the northern

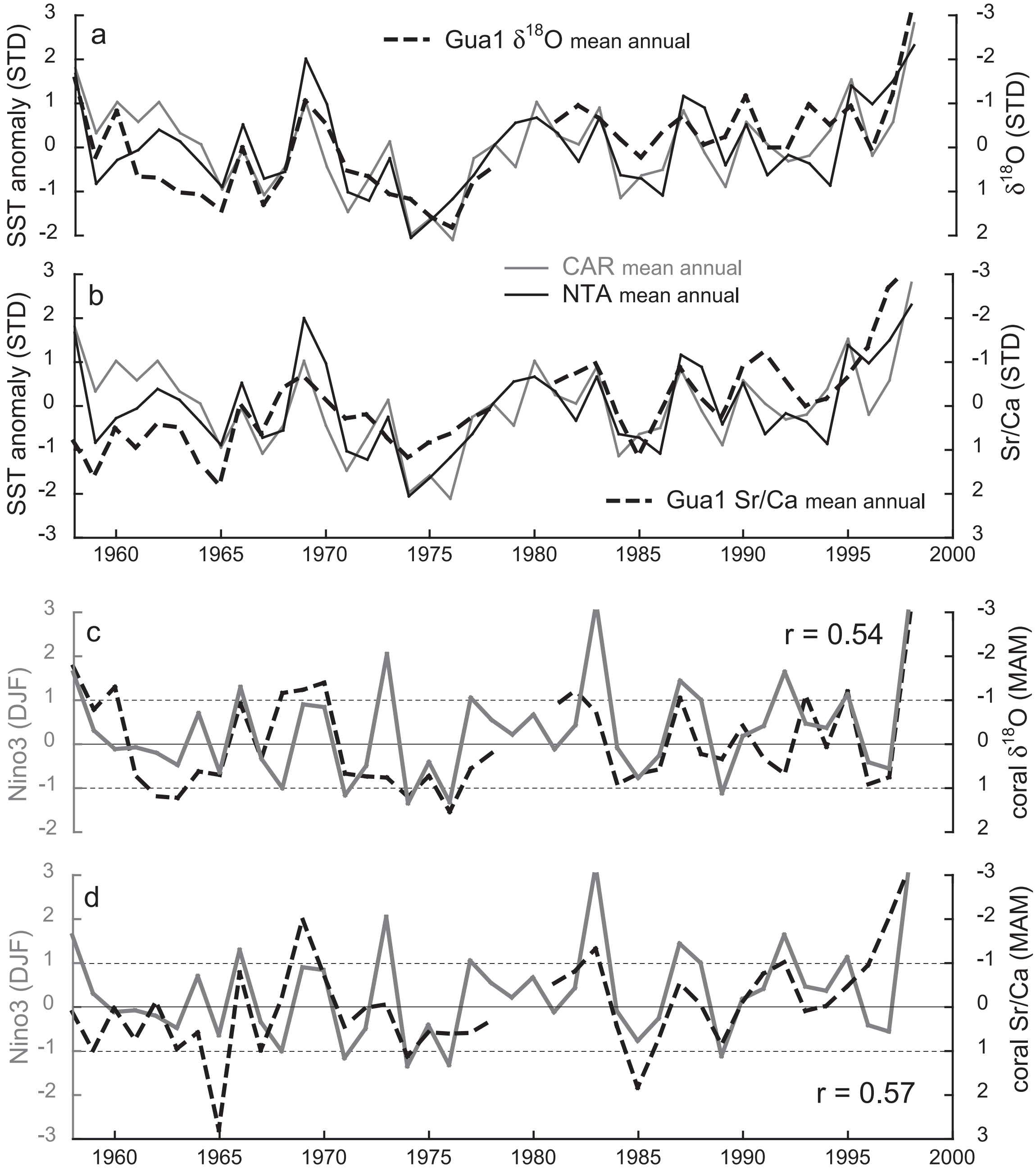

**Figure 3.** Coral (a) $\delta^{18}$O and (b) Sr/Ca time series (dashed lines) with SST anomaly indices: CAR (solid gray line) and NTA (solid black line). Data shown are mean annual values. Nino3 SST index (5°S–5°N, 90°–150°W; from NCDC [*Smith and Reynolds*, 2004]) in winter (DJF) with (c) coral $\delta^{18}$O and (d) Sr/Ca proxy data for boreal spring (MAM). All data shown are normalized to unit variance and linearly detrended (STD, standard deviation). Correlation coefficients are indicated in the panel ($p < 0.001$ for all correlations).

tropical Atlantic and Caribbean region yielded significant correlations on mean annual scales. This testifies the ability of *Diploria strigosa* to track the year-to-year variability of SST over a wide region. Moreover, the coral proxy records are able to resolve the seasonal-scale variability in the NTA, and thus can be used to detect the seasonal dependence of remote forcing on NTA SST, e.g., by Pacific ENSO events.

[18] Therefore we are optimistic that fast-growing *Diploria strigosa* corals, which can be up to 200 years old, represent a highly feasible new archive for

future paleoclimatic reconstructions. The tropical North Atlantic is a key region of Northern Hemisphere climate variability and at present there is not a single century-long coral proxy record from this region. In the future, the obtained proxy-SST calibrations from our modern coral specimen can also be used as a basis for the interpretation of fossil *Diploria strigosa* corals in order to develop long-term reconstructions of environmental variables that extend over multiple centuries.

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