Paleoclimatological Analysis of an 8500 Year-Long Sediment Core from Baie des Baradères, Haiti

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1. INTRODUCTION

- Using Paleoclimatological data to assess pre-observational environmental variations is key to understanding how climate factors such as hurricanes, floods, and droughts will change as a result of global warming.
- High temporal resolution paleo records spanning long (millennial) timescales are rare, especially in the Caribbean.
- Specifically, in Haiti, there exist very few Paleolimnological study sites, and there are, to our knowledge, no Paleotempestological (Hurricane) study sites, despite the fact that the country falls within the hurricane belt.
- This project analyses an ~9-meter-long sediment core from coastal Haiti to add to the growing inventory of Palaeoclimatological records in the Caribbean and improve spatial distribution of such records.
- We also hope to qualitatively link past hurricane activity to possible climate characteristics in the Caribbean (ITCZ, El Nino, Sea-level rise) to assist with the general understanding of regional long-timescale hurricane dynamics.

2. STUDY SITE

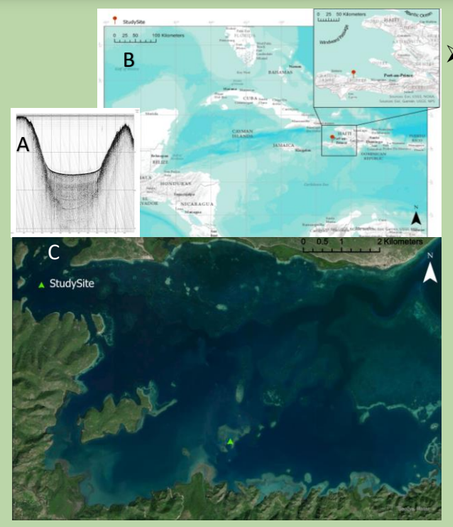

Figure 1: The study site-

A) A cross-section of the blue hole from which the sample was taken- photo taken with sub-bottom profiler during fieldwork, snapshot created by Nicole D'Entremont at WHOI.

B) Study site within the North Atlantic Basin, created with ArcGIS.

C) Study site within Baie des Baradères. Blue hole and other underwater features are visible in the bay. Figure created using ArcGIS world imagery basemap.

- The study site is in Baie des Baradères, which is on the southwestern peninsula of Haiti. The core was collected from an underwater karst basin with vertical depth of approximately 11.5m (Figure 1A), at coordinates 18.514571° N, 73.628903° W (Figure 1B), approximately a kilometer away from the Baradères River delta (Figure 1C). The initial interest in this location was due to its proximity to the delta, which could likely preserve interesting land-use changes as well as high energy marine events such as hurricanes and flooding.

3. RESEARCH QUESTIONS

1) **Does the site record sedimentary and/or geochemical evidence of climate variability during the Holocene and if so, what is the nature of this variability?**
2) **How does this compare to recent paleoclimatological work in the region?**
3) **What millennial-scale climate factors best account for this variability?**

4. METHODS

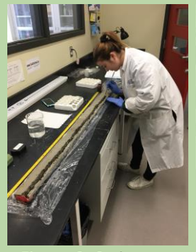

Figure 2: Sydney sampling the core at 1-cm intervals for grain-size analysis in the wet lab at Bishop's University.

Figure 3: Corals and shell fragments found near the bottom of the sediment core.

Laboratory Methods:

- Grain-size analysis was performed by sampling the core at 1-cm intervals to separate particles into size fractions, where the percent sand in each subsample is used as a proxy for high-energy (i.e. hurricanes/floods) or aeolian events, and nature of sedimentation.
- X-ray fluorescence (XRF) core scanning was used to assemble elemental composition of the sediment at the mm-scale to be used as a proxy for regional climate changes.

Age-Depth Model:

- An age-depth model was built using Bayesian statistical modeling under the « Bacon » package v2.3.9 using four radiocarbon dates, revealing that the core contains close to 8500 years of sediment data.

Statistical Methods:

- Multivariate statistics (Principal Component Analysis) were performed on grain-size and geochemical data to reduce dimensionality and identify correlated variables.
- Data was standardized to have mean 0 and standard deviation 1 in order to be statistically comparable.

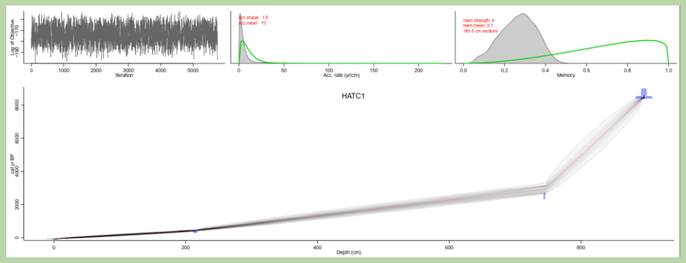

Figure 4: Preliminary age-depth model for core HATC1 from Baie Des Baradères, Haiti. Model shows distinct elbow at ~2500 cal yr BP, likely related to a rise in sea level exposing the basin to increased sedimentation from the delta.

5. RESULTS

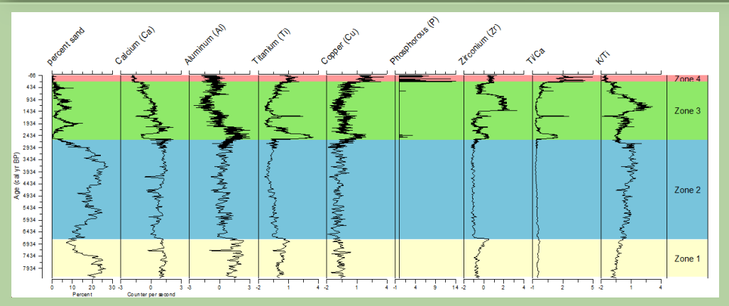

Figure 5: Stratigraphic diagrams of proxies from core HATC1, sectioned into four zones, each with it's own distinct pattern. Zone 1 occurred in the early-mid Holocene when sea-level was rising rapidly (evident in K/Ti and Zr). Zone 2 is relatively stable in most elements, and contains coral fossils until ~3600 cal yr BP, indicating clean and shallow waters in the basin. Zone 3 contains significant variability, with an inversed trend for marine versus terrestrial elements, likely indicating that the basin became exposed to the delta and it's associated characteristics abruptly. Zone 4 remains relatively stable in marine-derived elements and ratios such as Ca and K/Ti, whereas terrestrial elements such as Ti, Cu, P, and Ti/Ca indicate anthropogenic signals of historic-era deforestation and erosion in the past ~200 years.

- Our results demonstrate a dynamic shift in environmental conditions of the basin in the last 2500 years BP.
- Peaks in terrestrially-derived elements and ratios are associated with high silt and clay, which may be due to enhanced discharge from the Baradères river.

References: Gischler, E., Shinn, E., Oschmann, W., Fiebig, J., & Buster, N. (2008). A 1500-year Holocene Caribbean climate archive from the Blue Hole, Lighthouse Reef, Belize. *Journal of Coastal Research,* 24(6), 1495–1505.
Gregory, B., Peros, M., Reinhardt, E., & Donnelly, J. (2015). Middle–late Holocene Caribbean aridity inferred from foraminifera and elemental data in sediment cores from two Cuban lagoons. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 426, 229–241.
Hadden, R. L., and Minson, S. G. (2010). The Geology of Haiti: An Annotated Bibliography of Haiti's Geology, Geography and Earth Science. *Army Geospatial Center*.