PCC Project Summary
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Advisors: Deahyun Kim (Dept. Atmospheric Sciences) and Julian Sachs (Dept. Oceanography)
Project Title: Examination of intraseasonal coral luminescence peaks during the Mid-Holocene

Summary of Project

In this project, Dr. Daehyun Kim (Dept. Atmospheric Sciences) and I partnered with Dr. Julian Sachs (Dept. Oceanography) to examine a hypothesis presented by Lough et al. (2014). The authors examined streamflow and rainfall in the current and mid-Holocene climates using coral luminescence and found that there was an increase in the number of peaks in coral luminescence, hence heavy rain events, per year during the mid-Holocene, indicating an increase in intraseasonal variability of precipitation. In the modern climate, more than one annual peak of luminescence is rare. Lough et al. (2014) hypothesized that the increase in intraseasonal peaks in the mid-Holocene were driven by a stronger Madden-Julian Oscillation (MJO), which is the dominant source of intraseasonal precipitation variability in the tropics.

This fellowship project opened many doors to me that I would have never experienced. Through Dr. Sachs I was introduced to Dr. Janice Lough, from the Australian Institute of Marine Science, who not only shared her monthly coral data from the modern period and mid-Holocene period from three different sites in the Great Barrier Reef, but also took the time to help me understand how to correctly use the data by answering numerous questions. For example, Dr. Lough highlighted some possible errors that can cause unrealistic trends in the coral data that are caused by decay in skeletal density. Dr. Lough has been extremely helpful and I am very grateful to have gotten connected with her during the course of this project. Working with experts in very different areas I found a way to connect my work with the MJO to streamflow and coral proxy which I had never worked with before and find interesting results.

One of the most interesting results we found was related to the seasonal cycle of the coral luminescence. The mid-Holocene seasonal cycle shows a different pattern than the modern seasonal cycle (Figure 1). The positive anomalies of luminescence correspond to relatively wet season when precipitation causes higher streamflow into the Great Barrier Reef. In the modern climate, there is a large range in the seasonal cycle with a clear peak in the March-April-May season and a clear minimum in October. The mid-Holocene data also had a clear minimum in October, but the range in the luminescence seasonal cycle is reduced, which is consistent with a reduced seasonal cycle of the southern hemisphere during the mid-Holocene due to changes in insolation (Clement et al., 2000; Luan et al., 2012; Joussaume et al., 1999; An and Bong, 2017). The mid-Holocene seasonal cycle has a lower peak but a longer period from February to August, which may indicate that the wet season during the mid-Holocene was longer. The longer wet season may be an indication of a longer duration Australian monsoon and may also explain the existence of intraseasonal peaks in the luminescence data seen by Lough et al. (2014).

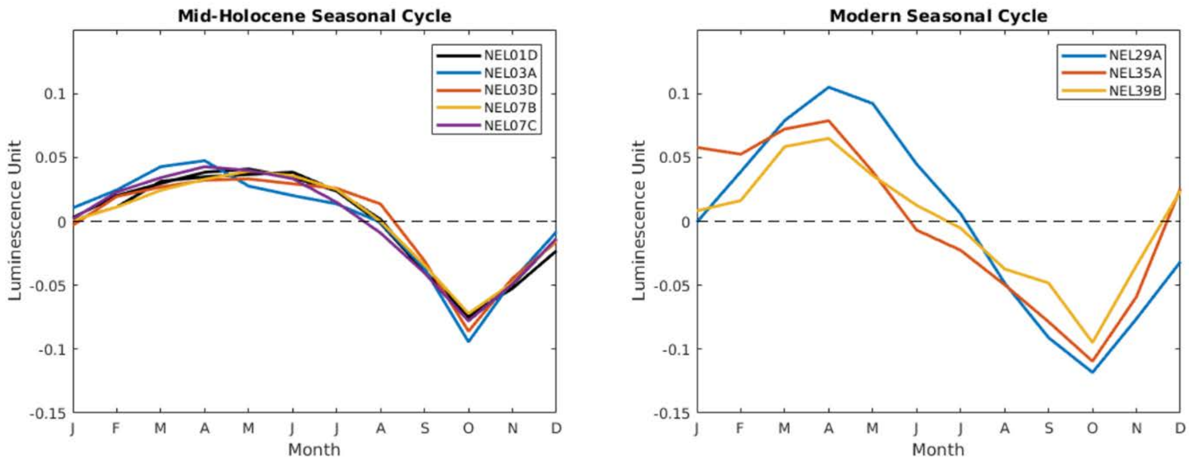

Figure 1: Coral Luminescence Seasonal cycle for the Mid-Holocene (Left) and Modern (Right).

The monthly coral luminescence data allowed us to examine the seasonal cycle of luminescence and its relationship to precipitation. We used a proxy for precipitation, outgoing longwave radiation (OLR) to examine patterns of rainfall over the period of the modern coral. The OLR was taken over Northeastern Australia and filtered to the intraseasonal period during the boreal winter, the intraseasonal OLR data is well correlated (0.6), to coral luminescence, which is encouraging for examining the MJO using coral data.

We used two models from the CMIP5 archive that simulate the MJO well to examine the MJO in the mid-Holocene. During the mid-Holocene surface temperatures are cooler, the moisture gradient changes are very small, and the static stability is lower. The MJO phase speed is slower and the wavenumber increases in the mid-Holocene. These models show small changes to the MJO amplitude in the mid-Holocene compared to the preindustrial control simulation, but these change are not significant, which may indicate that the increase in intraseasonal peaks of luminescence are not due to MJO amplitude changes, but may still be a result of a change in the phase speed and wavenumber.

The PCC fellowship has presented opportunities for me to grow as a scientist by allowing me to experience collaboration across fields and work with people with different backgrounds. The connections made between myself, Dr. Kim, Dr. Sachs and Dr. Lough have made this project exciting and completely different than anything I've done before. I hope I could continue to work with them in the future. The opportunity to work with paleoclimate data has allowed me to explore an area of science that I otherwise wouldn't have been exposed to and we have found interesting new results we hadn't expected. I have loved learning about corals and paleoclimate, and this is an area of research that I hope to do more work in.

Future Work

This project has taken a different turn than initially expected. The difference in the seasonal cycle of the mid-Holocene and modern climate has motivated a new hypothesis: The duration of wet period associated with the Australian monsoon was longer in the mid-Holocene than in the current climate, and may explain the intraseasonal peaks seen in the mid-Holocene coral luminescence data. Future work for this project will turn its focus from the MJO to the Australian Monsoon to examine changes to the dynamics of the Australian Monsoon. Changes in the Australian Monsoon amplitude and onset and break times from the modern and mid-

Holocene will be calculated to examine a possible lengthening of the monsoon period. Additionally, we will look into paleoclimate pollen proxies which may show a longer growing season in Northeastern Australia during the mid-Holocene caused by a longer rainy season.

References

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