Report on **Role of the diurnal cycle of precipitation in global climate model simulations**

Aaron Levine and Muyin Wang

Precipitation and precipitation changes due to climate change are a key area of uncertainty in global climate models. While there are large scale precipitation change maxims, like "wet get wetter," that work as a zeroth order understanding of the changes to future precipitation, precipitation impact on humans comes from much more local/small scale effects. The impact of the large scale precipitation pattern on smaller scales is fairly well studied. However, the impact of the smaller, diurnal, scale on the larger scale patterns and our representation of the processes involved in global scale climate models still have many open questions. Therefore, we proposed to study the role of the diurnal cycle in precipitation in global climate models taking advantage of a high resolution Indonesian precipitation and surface weather dataset. One of the key questions that we wanted to answer is if the Indonesian observational datasets, combined with other precipitation datasets, provide enough detail and clarity on the diurnal cycle of precipitation and for comparison with numerical climate models and their representation of the different process involved. We found that the answer to this question is yes and we have submitted a proposal to NSF climate dynamics to delve deeper into the processes involved in the impact of the diurnal cycle of precipitation on larger scale precipitation patterns.

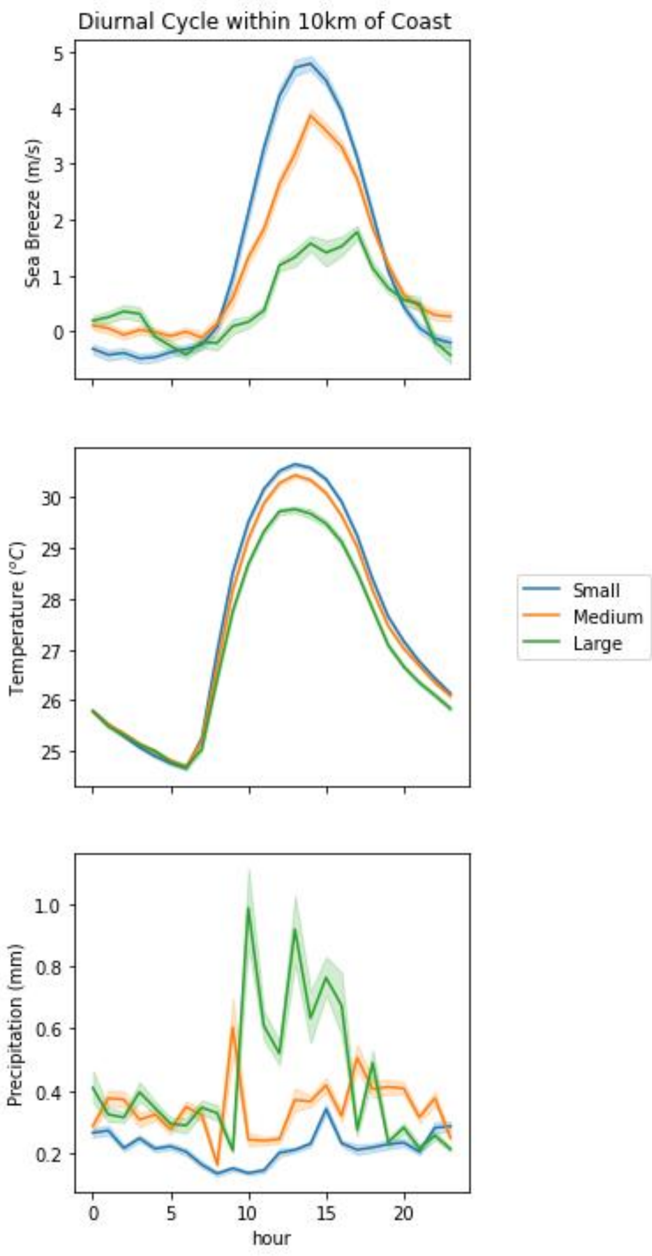

Figure 1: Diurnal cycles of sea breeze, temperature, and precipitation averaged across all stations within 10 km of the coast for the lower (small), middle (medium), and upper (large) terciles of fractional asymmetric daily sea breeze.

Over the course of the study, we found that the one key for the diurnal cycle of precipitation to have an impact on the larger climate scale is that the diurnal cycle of precipitation must be asymmetric in amplitude—that is that over the course of a day the total precipitation enhancement and the total precipitation suppression are not equal—leading to a residual precipitation that impacts the climate on longer timescales. Our results show an apparent connection with the strength and asymmetry of the land-sea breeze diurnal cycle. When each station is stratified by the difference in land breeze magnitude and sea breeze magnitude in comparison to the average at that station, the diurnal cycle of precipitation changes (Figure 1). Also, playing a key role in the difference between the precipitation at different stations is distance from the coast.

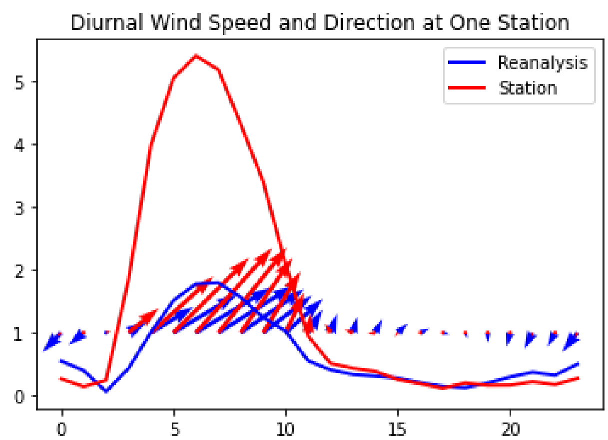

Figure 2: Comparison of diurnal cycle of wind speed and direction from a single station and the closest point from ERA-5 Reanalysis

The station sites cover a broad range of different topography, prevailing wind conditions, and distance from the coast in Indonesia. However, the sites coverage is still small compared with overall land area and with only three years of data, short in temporal coverage to full constrain this relationship. To explore in greater spatial and temporal resolution the connection of the land-sea breeze diurnal cycle asymmetry and the precipitation diurnal cycle, we used blended precipitation products and reanalysis winds to expand the study. While reanalysis has many known problems with precipitation, the surface winds do capture the diurnal cycle of the land-sea breeze and its asymmetry (Figure 2), and will provide insight into the physical processes involved in the role of the land-sea breeze diurnal cycle to the diurnal cycle of precipitation in these regions.

Based on these results, we have submitted a proposal to NSF Climate and Large Scale dynamics with the goals of further quantifying the diurnal cycle of precipitation and land-sea breezes and their asymmetry in the observations, blended precipitation products and reanalysis. Comparing these results with those of global scale models resolving diurnal scale processes like those in the publicly available DYAMOND multi-model experiment. And using an idealized cloud model (CM1), to explore the importance of different processes identified in observations, reanalysis, and models to the interaction of the asymmetries in the diurnal cycles of precipitation and land-sea breeze. We are awaiting the reviews of the proposal currently.