Abstracting ENSO Spatial Patterns' Impact on Atlantic Tropical Cyclone Seasonal Frequency

2012-05-14

1 Introduction

The ability to forecast individual cyclogensis events is of tremendous scientific and societal interest. However, current gaps in both knowledge and technology make cyclogensis forecasts a daunting challenge. As a resort, seasonal forecasting has been an active field of research. While seasonal forecasts cannot not inform us of the frequency or intensity of landfalling hurricanes – a subject of keen public interest – they are still useful to policy makers and insurance companies. Furthermore, increased accuracy in seasonal predictions would allow scientists to infer the environment's response to such seasonal activity such as ocean heat transport and phytoplankton bloom. One of the well-documented influencers of Atlantic tropical cyclone (TC) activity on seasonal timescales are Pacific sea surface temperatures (SST). Traditionally, Pacific SST's impact of the Atlantic has been abstracted by monitoring the warming of fixed oceanic regions (e.g. NINO3.4). However increasing evidence is suggesting that the spatio-temporal context of the warming must be considered (relative SST, NINO Modoki, etc.) We propose a new index that accounts for the spatial distribution of warming of Pacific SSTs and are able to explain 60% of the seasonal variability in Atlantic TC frequency. The index is able to resolve the large-scale conditions during the Atlantic hurricane season better than warming-based indices. Such an index, coupled with other seasonal prediction methods based on Atlantic variables (e.g. Kneuston et al 2007, Emanuel et al 2008) can prove to be a significant addition to dynamical and statistical forecast models.

2 Claim 1: Monitoring the spatial warming patterns of the Tropical Pacific Ocean provides better insight on the Pacific's impact on Atlantic tropical cyclone (TC) frequency than warming-based indices

Instead of monitoring static regions in the Pacific, we propose to adopt an index that is more representative of the physical pathway that warming in the Pacific would impact the large scale conditions over the Atlantic, and subsequently TC activity. Our new index, S-ENSO, focuses on the spatial distribution of warming in the Pacific and its impact on deep convection. The index is a linear combination (multivariate linear regression) of:

1. The longitude of the warmest 10° (lat) by 40° (lon) region in the Pacific (using SST anomalies)
2. The mean surface pressure of the region identified in (1)
3. The mean OLR of the region identified in (1)
4. The longitude of the 10° by 40° region with the lowest surface pressure in the Pacific
5. The longitudinal distance between the warmest and coldest 10° by 40° region in the Pacific

The first three elements of the index are selected to capture the impact of deep convection from SST warming. The fourth item is a proxy to identify the location of tropical cyclones (typhoons) in the Pacific. The idea is that on an interannual scale low pressure systems such as TCs tend to organize along well defined tracks. Therefore identifying regions with low pressure is analogous to monitoring TC activity in the Pacific which has been weakly linked to TC activity in the Atlantic [1]. Finally, the last component was designed to better capture the evolving ENSO phenomenon by tracking the location warm and cold regions of the Pacific. When the cold region is to the west of the warm one it is more likely that El-Nino event is occurring. When the cold region is to the east, it is a La-Nina. We build S-ENSO by running a L1-regularized regression model on the 5 predictors and Aug-Oct TC counts.

S-ENSO explains 60% of the interannual variability in Atlantic TC counts, a near double improvement over traditional NINO indices. When analyzed further we found that the 0.82 linear correlation coefficient is significant at the 99% interval using rigorous randomization tests to address the small sample size and the data's auto-correlated nature.

We analyzed which variables within the index explain the majority of TC variability. We ran a variable importance analysis using a 1000-tree random forrest. Each tree in the forest is built using a random sample of available predictors. For each predictor, we analyze the trees in which it has appeared and the increase/decrease in prediction accuracy it contributed to the model. Our analysis found that the most important variables were: (i) The longitude of the warmest region; (2) its mean surface pressure; and (3) the distance between the warmest and coldest regions.

Forests - Null Distribution with Permutation Tests-1.pdf

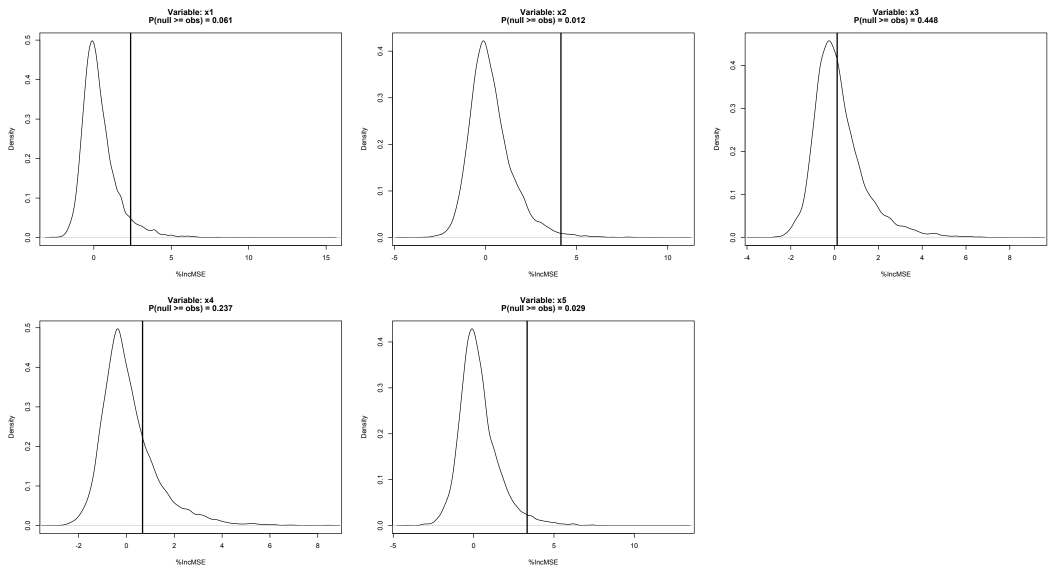

Figure 1: caption

3 Claim 2: Monitoring the spatial warming patterns in the Pacific allows us to by-pass the ENSO predictability barrier

4 Claim 3: Monitoring the spatial distribution of the warmest and coldest SST anomaly regions in the Pacific encapsulates the Pacific SST EOF

References

[1] C. Wang and SK Lee. Is hurricane activity in one basin tied to another? *Eos, Trans. Amer. Geophys. Union*, 91, 2010.