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CLIMATE MODULATION OF NORTH ATLANTIC HURRICANE TRACKS: OBSERVATIONS AND IMPLICATIONS

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1. INTRODUCTION

In addition to the direct effects of changing the ambient thermodynamic state that tropical cyclones move through, climate variability also relates to hurricane activity through indirect pathways that affect basin-wide circulation patterns. For example, modes of variability such as the Atlantic Meridional Mode (AMM), El Niño / Southern Oscillation (ENSO), North Atlantic Oscillation (NAO), and Madden-Julian Oscillation (MJO) have been shown to affect North Atlantic hurricane activity through changes in atmospheric steering currents and vertical wind shear, among other pathways. These modes affect hurricane genesis location and track, which affect storm duration. This leads to another factor modulating hurricane intensity since storms that last longer also typically achieve greater intensities. Thus hurricane intensity is modulated directly by local ambient thermodynamic conditions and indirectly by broader-scale regional conditions. In addition to the more obvious importance of hurricane tracks as they relate to landfall occurrence, there is then a critical need to better understand the controls of track in order to adequately assess how intensity changes as climate varies.

Here we will summarize our recent analyses of North Atlantic tropical storm and hurricane tracks, and demonstrate how these tracks are modulated on intraseasonal to multidecadal time scales by local and remote climate factors (Kossin et al. 2010). We will further discuss how the addition of track variability can squelch the observed trend in the broader regional-mean thermodynamic state, which effectively removes any secular trend in the storm-ambient thermodynamic state (Kossin and Camargo 2009).

2. SUMMARY OF RESULTS

North Atlantic tropical storm and hurricane tracks from 1950 to 2007 were objectively separated into four clusters (Fig. 1) and analyzed to identify intrabasin variability and trends, and their relationships with modes of climate variability. The clusters capture a meridional separation between more tropical systems and their higher latitude counterparts that interact with a more baroclinic environment. The zonal separation captured by the cluster analysis identifies the subsets of Gulf of Mexico storms, and storms spawned within the subset of African easterly waves that form on the northern side of the African easterly jet. Cluster climatologies show differences in seasonality and general characteristics of the storms within each cluster, and marked inter-cluster differences in storm intensity and duration, and the proportion and destructiveness of landfalling storms can be identified.

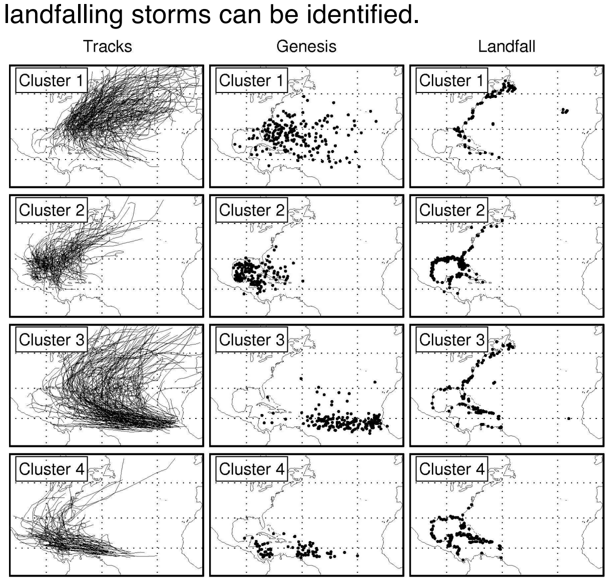

Figure 1: North Atlantic tropical storm and hurricane tracks, genesis locations, and landfall locations during the period 1950–2007, as separated by the cluster analysis.

In addition to basin-wide variability, North Atlantic tropical storms and hurricanes exhibit clear intra-basin differences in frequency and track variability when objectively separated and grouped by clusters. For example, proportions of cluster members exhibit decadal shifts in addition to inter-annual variability, and these shifts often alternate in sign between clusters (Fig. 2). The transition to the present regime of proportionally more tropical and fewer baroclinic systems appears to have begun in the early- to mid-1980's, ten years or more before the very active 1995 Atlantic hurricane season signaled the end of a multi-decadal period of quiescence. Additionally, in the period 1950–2007 the steepest positive storm frequency trends are found within the more tropical systems, which comprise more than 70% of the major hurricanes and overall power dissipation, while Gulf of Mexico storms, which comprise more than 40% of the total number of landfalling storms, exhibit no trend in this time period.

Intra-basin differences in the relationships between storm and climate variability were also identified and quantified using composite and regression analyses. The tropical cluster members are most strongly modulated by the Atlantic Meridional Mode (AMM) and El Niño – Southern Oscillation (ENSO), while the Madden-Julian Oscillation (MJO) modulates Gulf of Mexico storms and the North Atlantic Oscillation (NAO) modulates the higher latitude storms outside of the Gulf of Mexico.

Our analyses support the observation that it is not optimal to consider Atlantic tracks as a whole when attempting to quantify the climatic control of tropical cyclogenesis and track. Since storm intensity also depends on genesis location and track, this further suggests that all aspects of hurricane activity are more optimally considered after some type of track stratification is performed when identifying trends and associations with climate variability. This should be accounted for when exploring how tropical storms and hurricanes have been responding to climate variability, and is a potentially important factor to consider when making future projections of Atlantic hurricane activity. Systematic track changes occurring in response to climate change are expected to affect probability distributions of storm intensity and duration, as well as landfall statistics. This adds to the challenge of predicting future activity because it requires that climate models capture systematic changes in regional atmospheric circulation patterns as well as mean thermodynamic state changes.

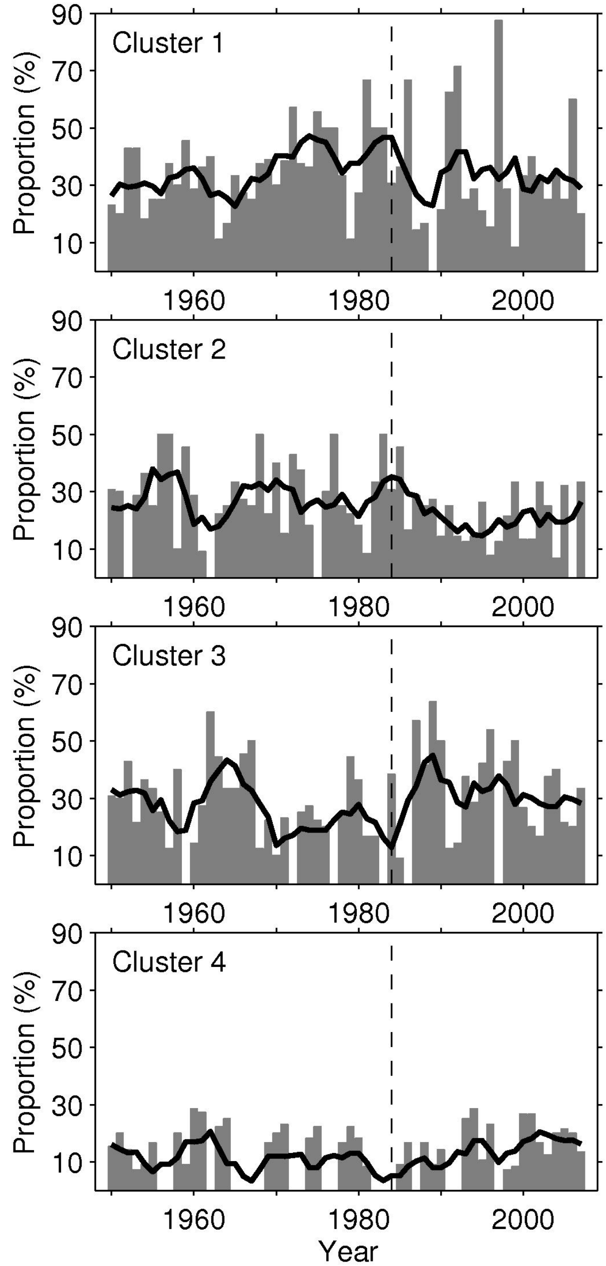

Figure 2: Percent contribution of each cluster to the total number of storms that year. Dashed lines identify the early- to mid-1980's shift toward proportionally more deep tropical systems. The bold line shows the time series filtered with a centered 5-yr moving window.

REFERENCES

Kossin, J. P., S. J. Camargo, and M. Sitkowski, 2010: Climate modulation of North Atlantic hurricane tracks. *J. Climate*, to appear.

Kossin, J. P., and S. J. Camargo, 2009: Hurricane track variability and secular potential intensity trends. *Climatic Change*, **97**, 329-337.

(Available at http://www.ssec.wisc.edu/~kossin/pubs.html)