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VARIABILITY IN GLOBAL SCALE CIRCULATIONS AND THEIR IMPACTS ON ATLANTIC TROPICAL CYCLONE ACTIVITY

Matthew Rosencrans and Patrick Harr
Department of Meteorology
Naval Postgraduate School
Monterey, CA 93943

1. INTRODUCTION

Atlantic tropical cyclone activity exhibits large variability on many time scales (Gray 1984a,b). The governing factors that regulate the level of tropical cyclone activity can often be related to variations in global-scale atmospheric conditions. On the interannual time-scales, previous studies such as Gray (1984a,b) and Goldenberg and Shapiro (1996), have related the El Niño-Southern Oscillation (ENSO) to seasonal tropical cyclone activity. On the intraseasonal time-scale, Maloney and Hartmann (2000a,b) and Mo (2000) have documented that the downstream effects of the tropical intraseasonal oscillations (TIOs), of which the Madden-Julian oscillation (Madden and Julian 1994, MJO) is the dominant mode, can be related to tropical cyclone activity over the eastern North Pacific, the Gulf of Mexico, and the entire Atlantic Basin.

While the impact on tropical cyclone activity over intraseasonal time scales due to the MJO, which is based in tropical region, can be significant, Kiladis and Weickmann (1992) state that extratropical influences on the tropics are maximized on shorter time-scales. Primary components of extratropical variability may be captured by the Arctic Oscillation, and the Antarctic Oscillation (Thompson and Wallace (2001). Burton (2005) examined periods when fluctuations in the mid-latitudes of the SH, as measured by the Antarctic Oscillation (AAO) during the Northern Hemisphere summer, excited anomalous circulations in the equatorial western Pacific via Rossby-wave dispersion. These anomalous circulations had previously been related to tropical cyclone formation by Delk (2004). Using the framework of Delk (2004) and Burton (2005) the primary objective of this study is to investigate the potential for tropical-extratropical interactions that originate in the Southern Hemisphere winter flow and impact the tropical Atlantic circulation. Furthermore, it is hypothesized that changes in the SH extratropical circulation are related to shifts between positive and negative phases of the Antarctic Oscillation Finally, the impact of changes in the large-scale circulation over the tropical Atlantic is examined with respect to altering the conditions favorable for increasing and decreasing the potential for tropical cyclone formation.

Corresponding author address: Mathew Rosencrans, Dept. of Meteorology, Naval Postgraduate School, Monterey, CA 93943 email: mrosencr@nps.edu

2. DATA AND METHOD

Numerous methods will be employed to locate temporal and spatial patterns that lead to equatorward Rossby-wave propagation from the south Pacific, across South America and toward the equatorial Atlantic. For this study, the data used are daily mean global gridded analyses from the National Centers for Environmental Prediction (NCEP) / National Center for Atmospheric Research (NCAR) reanalysis for the period 1 January 1979 to 31 December 2003. Initially, a daily AAO index is defined by an empirical orthogonal function (EOF) analysis of 700-hPa height anomalies between 20^{o}S-90^{o}S. The principal component (PC, Fig. 1) associated with the leading EOF mode (Fig. 2) is defined as the daily AAO index.

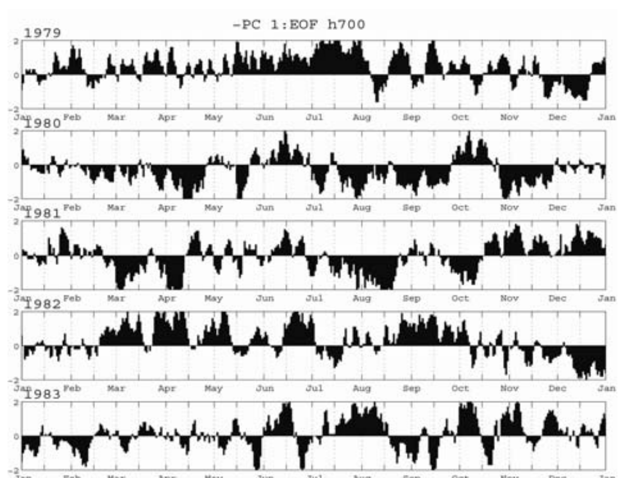

Fig. 1 The leading principal component of the EOF analysis of 700-hPa anomalies between 1 January 1979 – 31 December 1983.

The second and third EOF modes (Fig. 3) define a pattern of alternating negative and positive height centers that were centered along 45^{o}S with a spatial scale that is approximately wavenumber three. Furthermore, the spatial patterns associated with the two modes are nearly in quadrature, which indicates that the EOF modes represent a propagating pattern of long waves over the SH midlatitudes. The EOF modes are similar to those of Pacific-South American Pattern as defined by Mo and Paegle (2001). The three leading modes will be used to identify periods of coherent wave patterns, defined by EOFs 2 and 3, in associations with variation in the AAO (EOF1).

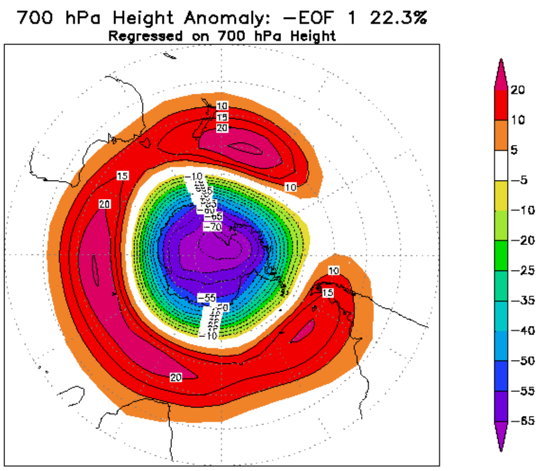

Fig. 2 The pattern of 700-hPa height anomalies (m) defined from a regression onto the leading EOF mode constructed between 20°s-90°S from 1 January 1979-31 December 2003.

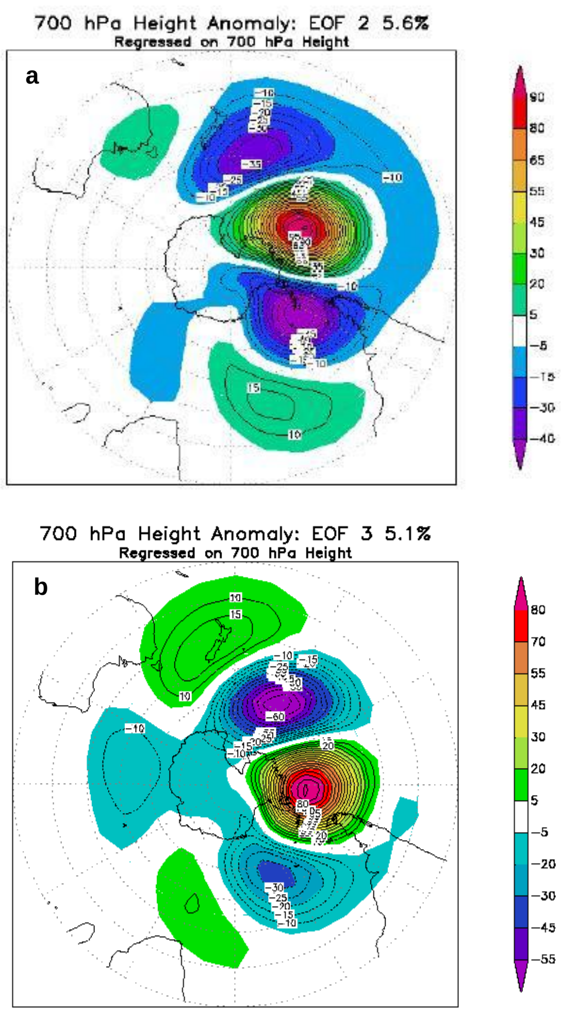

Fig. 3 (a) As in Fig. 2 except for mode 2. (b) As in Fig. 2 except for mode 3.

3. ANALYSIS

The coupled modes defined by EOFs 2 and 3 define a center of height variability near 60°S, 120°W. This region is known as a preferred area for atmospheric blocking (Nascimento and Ambrizzi 2001). The region also exhibits highly variable upper-level jet structures during the austral winter (Bals-Elsholz 2001).

The variability over this region was examined using a wavelet analysis (Torrence and Compo 1998) of the time series of height anomalies over the center defined by the EOF analysis. The global wavelet spectrum (Fig. 4) indicates that there is significant power over a variety of periods that range from short time scales to the ENSO scale. Mo and Paegle (2001) also identified a significant relation between the Pacific South American pattern and ENSO. In the global wavelet spectrum of Fig. 4, there is significant power in the 15-25 day period range, which was also found by Burton (2005) in a spectral analysis of the daily AAO index (Fig. 1). The robustness of this period range was examined by re-constructing the EOF modes from data that were bandpass filtered in the 15-25 day range with a Lanczos filter. The spatial and temporal characteristics of the initial three modes of the EOF analysis on filtered data (Figs. 5 and 6).were essentially the same as those constructed from the unfiltered data.

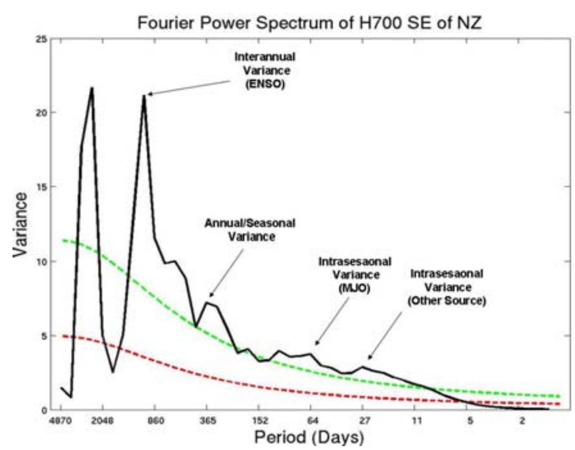

Fig 4 Global wavelet spectrum (solid line) of the daily 700-hPa height anomaly index centered on 60°S, 120°W The Upper dashed line is the 99% confidence spectrum and lower dashed line defines the red noise spectrum based on the lag 1 autocorrelation in the height index time series.

Because of the similarity in the spatial patterns between the unfiltered and filtered EOF modes 2 and 3, the variability contained in the region centered near 60°S, and 120°W is examined

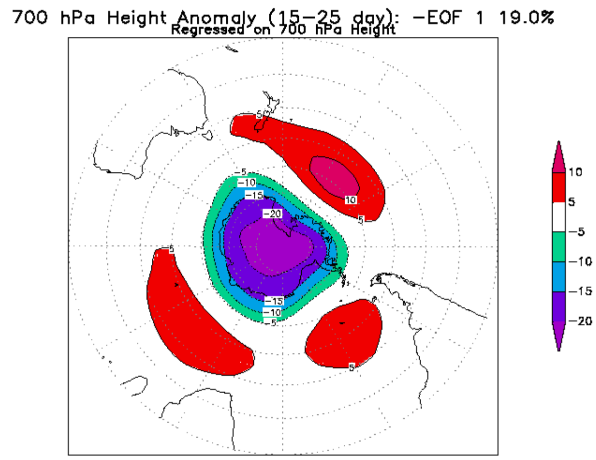

Fig. 5 As in Fig. 2, except for 700-hPa height anomalies that have been bandpass filtered at 15-25 days.

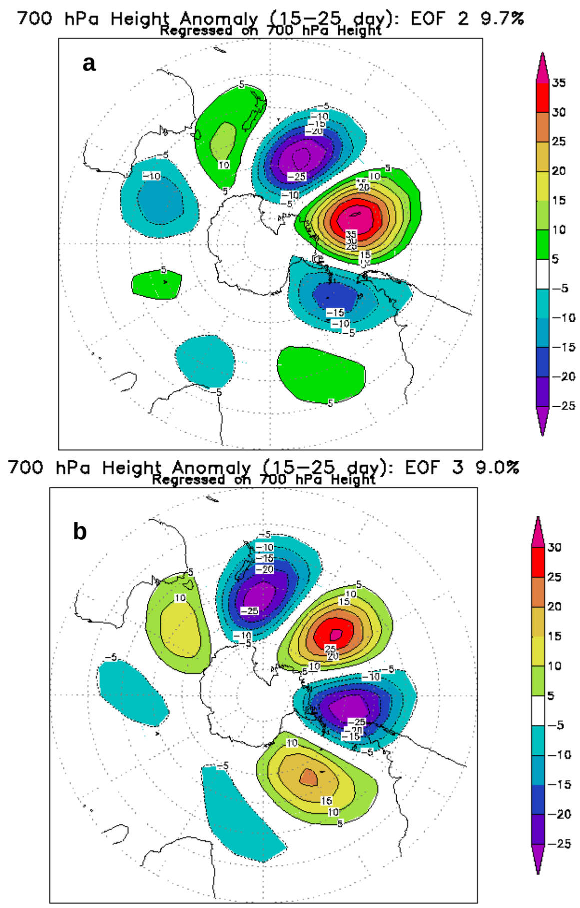

Fig. 6 As in Fig. 3, except for 700-hPa height anomalies that have been bandpass filtered at 15-25 days.

over the 15-25 day period range. The PCs of the filtered modes 2 and 3 (Fig. 7) indicate that there are pronounced time periods when the propagating pattern defined by the two modes is present with significant amplitude. Furthermore, the majority of the times during which the propagating-wave pattern exhibits significant amplitude occurs during the SH winter. Therefore, the impact of these large-scale, slowly-varying waves is to be examined in terms of their spatial and temporal variability. The filtered PC series are used to identify periods of coherent structure and significant amplitude. Composite patterns of height and streamfunction are constructed to identify the potential for these wave structures to influence the equatorial regions. Finally, the correspondence to periods of significant 15-25 wave activity as defined by the EOF 2 and 3 patterns is examined with respect to variations in the AAO, which includes changes from positive and negative AAO states.

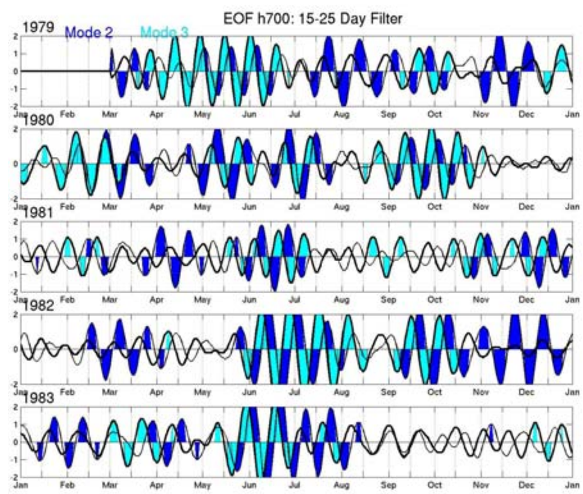

Fig 7. Principal components for EOF 2 and EOF 3 for 15-25 day filtered 700-hPa heights during 1 January 1979 – 31 December 2003. Shading indicates significant amplitude, which is defined as exceeding plus or minus one standard deviation.

ACKNOWLEDGMENTS
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