The Relationship of Transient Upper-Level Troughs To Intraseasonal and Interannual Variability of the North American Monsoon System

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1. Introduction

The relationship between transient upper level (inverted) tropospheric troughs and warm season convective activity over the southwest U.S. and northwest Mexico are explored. Multiple datasets were acquired during the investigation, including various variables of the North American Regional Reanalysis (NARR) 3 hour dataset and VAISALA's lightning dataset (NLDN). In this summary, the difference between a climatological difference of means using both precipitation and lightning in the presence of a upper level tropospheric trough, and normal background monsoon conditions when no trough is within a bounded region will be shown. A climatological study is further carried out to ascertain whether influences from Pacific sea surface temperatures would have any influence on the track densities of these transient features and is also shown.

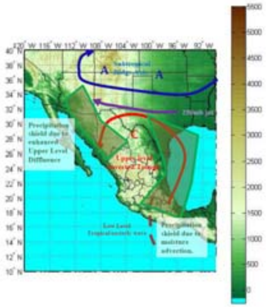

Figure 1: Conceptual Model of Inverted Troughs/Subtropical Ridge interaction overlaid on topography of study region

2. Intraannual Precipitation Variability

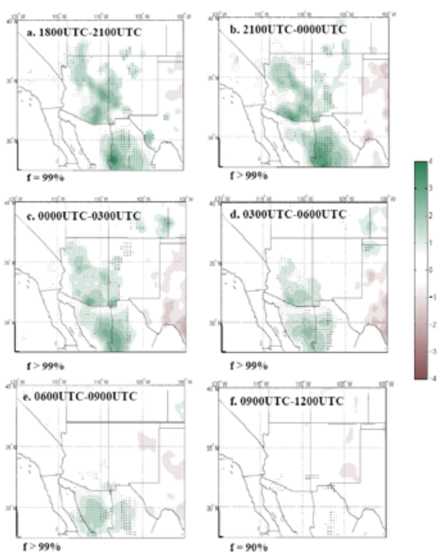

Figure 2a-f: Precipitation climatological difference between trough and non-trough days every 0.5 mm for the given region. Stippling indicates local significance at 99%, with hours in UTC and field significance given within each figure caption.

The NARR representation of precipitation enhancement is reasonable, but deficiencies are noted. Data assimilation issues are noticed along the border between the United States and Mexico. However, despite this issue, precipitation enhancement occur most dramatically in the time period between 1800UTC to 0900UTC.

Regions such as the southern deserts of Arizona, the Mogollon Rim country of central Arizona and the Sierra Madre Occidental received, on average, 6 mm over the duration of a given day. Transient inverted troughs have led to catastrophic flooding events. One such event was the catastrophic 27-31 July 2006 Sabino Canyon floods near Tucson, AZ, where an estimated 265 mm of rainfall fell over a 3 day period.

3. Intraannual Lightning Variability

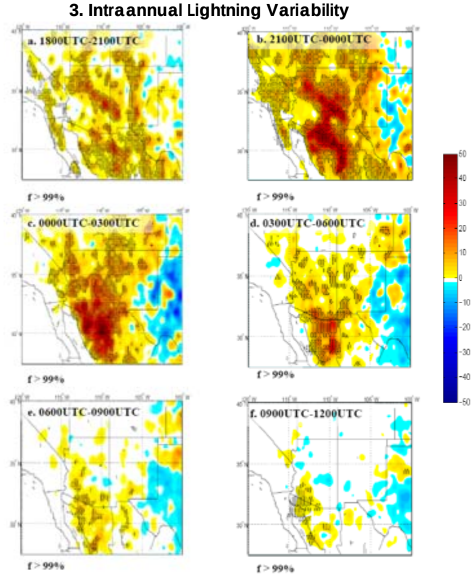

Figure 3a-f: Lightning climatological difference between IV days minus non-IV days every 10 counts km^{-2} (3 hr)$^{-1}$ for the lightning region. Stippling indicates regions of local significance at 99%. Hours in UTC and field significance are noted within each figure caption.

The NLDN dataset is reasonable, especially along the border between the United States and Mexico. The enhancement is already significant by 1100 LST (Fig. 4a), with distinct maximum over the climatologically favored high terrain of the Mogollon Rim and Sierra Madre Occidental. The differences during mid-afternoon (Fig. 4b) grow, and expand away from these ranges, consistent with the idea of convection propagating from the mountains. Increased likelihood of propagation is very evident starting 1700 LST (Fig. 4c), which shows a marked increase over the lower deserts of south central Arizona and NW Sonora. Largest positive differences are centered over the southern portion of the SMO by early evening (0200 LST, Fig. 4d). Despite the small positive differences, the nighttime panels (Figs. 4e, f) indicate that local significance is essentially confined to extreme southwest of Arizona, western Sonora, and the northern Gulf of California, clear evidence of an increased likelihood of westward propagating convection during IV days.

Discrepancies between the NARR and the NLDN are not surprising in the study region. We have observed similar differences near the Arizona-Sonora border region between the CG data and composites based on the 1° U.S. Climate Prediction Center (CPC) precipitation product (results not shown), which is the precipitation input during the NARR assimilation.

4. Global SST Patterns and the Combined Pacific Variability Mode

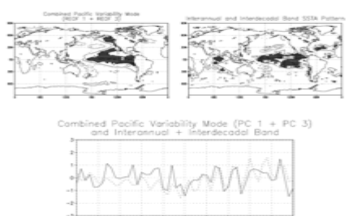

Figure 4: Two modes of global Sea Surface Tempature Anomalies, as found by Castro et al. (2007) in the *Journal of Climate.*

Many studies have documented that sea surface temperatures, especially the Pacific Ocean, greatly influences large scale weather patterns. This is no different when investigating interannual climate variability, such as one completed by Castro et al. 2007 in the *Journal of Climate*. As a summary background, the dominant patterns of summer global SST and their associated time series were determined using a rotated principal component analysis. SST modes 1 and 3 are centered in the Pacific and strongly govern North American summer climate and, when taken together, comprise the Combined Pacific Variability Mode (CPVM). SST mode 1 is ENSO and varies on a timescale between 2 to 5 years. SST mode 3 is probably related to the Pacific Decadal Oscillation.

5. Summer Inverted Trough Teleconnections

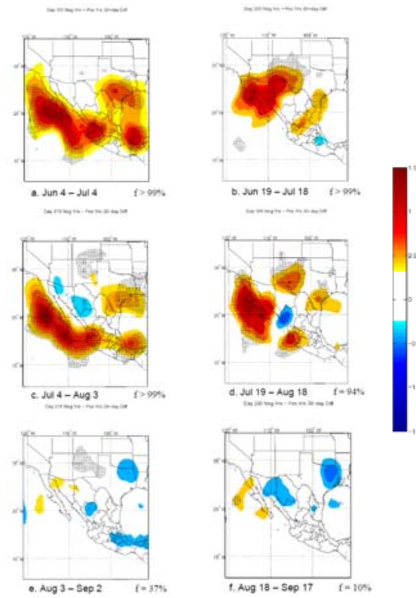

Figure 5a-f: Two modes of global Sea Surface Tempature Anomalies, as found by Castro et al. (2007) in the *Journal of Climate.*

Years are grouped according to the dominant SST modes in the Pacific using composite analysis, and years whose combined 1st and 3rd modes were either positive or negative were grouped accordingly. Specific and significant patterns in the geopotential height are associated with the SST modes in the Pacific. These patterns evolve in time and are predominant at the beginning of the summer. At that time, the position and intensity of the monsoon ridge is modulated.

This modulation is important for the North American Monsoon, a more northerly deviation introduces a favorable tropical flow regime. In addition, upper level tropospheric troughs can be 'caught' and pushed westward into the core North American Monsoon Region (Figures 5a-d). A northerly deviation of the North American Monsoon ridge is favored during La Niña/negative PDO-like conditions, and vice versa.

6. Acknowledgements

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