5B.2 INTER-ANNUAL AND SEMI-DIURNAL VARIATIONS IN SUMMERTIME PRECIPITATION

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1. INTRODUCTION

A recent study by Carbone et al. (2002) examined diurnal and intra-seasonal rainfall patterns in the warm season over North America. The findings included discovery of long-lived precipitation "episodes" that result from coherent sequences of mesoscale convective systems, leading to compound events up to 60 h duration. Rainfall episodes result primarily from thermal forcing over the continent and thus exhibit a strong diurnal modulation. A delayed-phase diurnal behavior was also observed in the lee of mountains, especially across the central U.S. in the lee of the Rockies. Wang et al. (2003) show that a similar pattern prevails over Asia in the lee of the Tibetan Plateau.

The time series of WSR-88D data is now seven seasons long (1996-2002). During the past year we have investigated the origin of semi-diurnal signals in the dataset and we have begun to identify and quantify some patterns of inter-annual variability, each of which is briefly described in the sections below.

2. SEMI-DIURNAL VARIABILITY

Like many of our predecessors, we found strong diurnal and semi-diurnal signals in the continental precipitation pattern. Figure 1 (adapted from Carbone et al., 2002) is an average of four warm seasons (May - July, 1997 - 2000). It illustrates this point in reduced dimension where the spatial dimension preserved is longitude and averaging occurs between 30 and 48 N latitude. Both diurnal and semi-diurnal signals are evident. Specifically, three main signals emerge:

- ***Local diurnal forcing*** of precipitation circa 2300 UTC across the U.S.
- ***Remote diurnal forcing***, with a delayed-phase local occurrence of precipitation systems, owing to the systematic eastward propagation of events from the Rocky Mountains.
- ***A semi-diurnal signal*** circa 1100 UTC across the central-eastern U.S., most prominent between 85-95W longitude.

Semi-diurnal forcing of precipitation has long been associated with atmospheric tidal lifting. However, after closely examining animations of our seven-season time series (1996-2002), we could not find geographically widespread evidence of semi-diurnal precipitation regeneration. The animations did reveal one major semi-diurnal forcing of a local nature, that being the land breeze convection along the Gulf of Mexico coastline. In addition, there was a complex pattern of rainfall over the Great Lakes with semi-diurnal signal content, presumably due to land breeze effects. We put the land breeze hypothesis to the test by reproducing Fig. 1 with a raised south latitude boundary (33N), thus excluding the land breeze component of Gulf Coast (Figure 2) precipitation. The semi-diurnal maximum, previously prominent between 85-95W, has disappeared, suggesting that semi-diurnal forcing is local to the Gulf Coast land breeze and neither tidal in nature nor continental in its geographic scope.

3. INTERANNUAL VARIABILITY

As previously mentioned, our period of record spans seven seasons (1996-2002). We have examined statistics from July of each year to reveal the existence of persistent storm "corridors" across the central U.S. along which most major precipitation episodes travel for periods that may persist for a month or more. Marked synoptic scale patterns exist in mid-summer, among these the North American monsoon circulation over the desert southwest and the western mountains. In any given year, a corridor will experience excessive cumulative rainfall while nearby regions are often well below normal. Figure 3 shows the location of "corridors" for Julys 1997 through 1999, a period that spans phases of ESNO from warm to cold. The data fields for 1998 are shown whereas just the positions of the corridors are shown for 1997 and 1999. While the positions of these corridors are strongly tied to persistent patterns in the large-scale circulation, we have not yet determined any specific relationship to ENSO (something we hope to report on at the conference).

4. CONCLUSIONS

We find ourselves in substantive disagreement with the tidal-forcing interpretations that are historically associated with semi-diurnal signals in warm season precipitation data. We are inclined to declare semi-diurnal forcing at the continental-scale a myth for the North American region. While semi-diurnal signals are indeed significant, these signals stem from two sources that are essentially unrelated to tidal influences. The first of these sources is a "delayed-phase" effect from non-local *diurnal* forcing and the subsequent propagation of rainfall systems for 12 or more hours. The second source is from localized sea/lake/land breezes, principally along the Gulf of Mexico and Atlantic Ocean coasts of the southeastern U.S. Unlike

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the first example, breezes are a genuine semi-diurnal forcing. Like the first example, breezes are essentially unrelated to tidal scales of motion and are inherently local.

We believe that observed persistence in the track of precipitation episodes may be an important basis for statistical-dynamical prediction of warm season precipitation at ranges up through intra-seasonal. Provided the storm tracks can be closely associated with general circulation anomalies (e.g. related to ENSO), it may be possible to use this information for probabilistic predictions out to the inter-annual range.

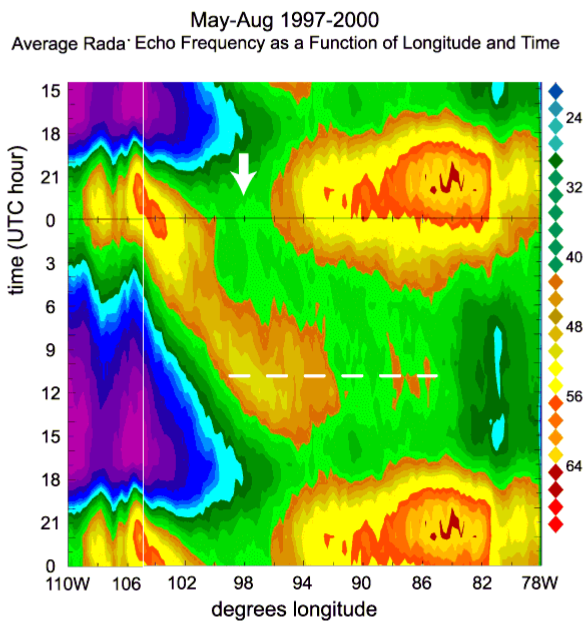

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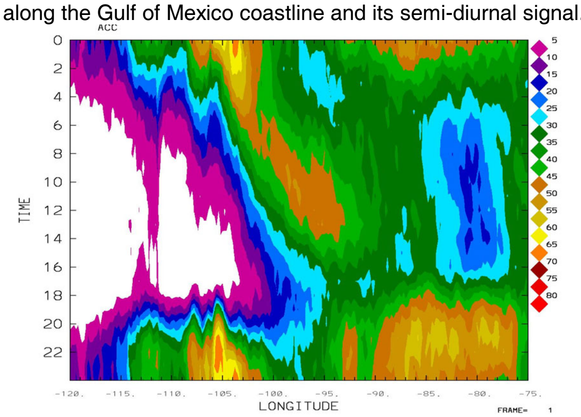
Fig. 1 (left): Fraction of time (%) radar precipitation echo is present between 30-48 N latitude, May-Aug.,1997-2002, over the diurnal cycle. Dashed line is a semi-diurnal maximum.

Fig. 2 (below): Same as lower section of Fig. 1 except for years 1996-2002 and a latitude limit of 33 N. The more northerly latitude limit excludes land breeze convection along the Gulf of Mexico coastline and its semi-diurnal signal.



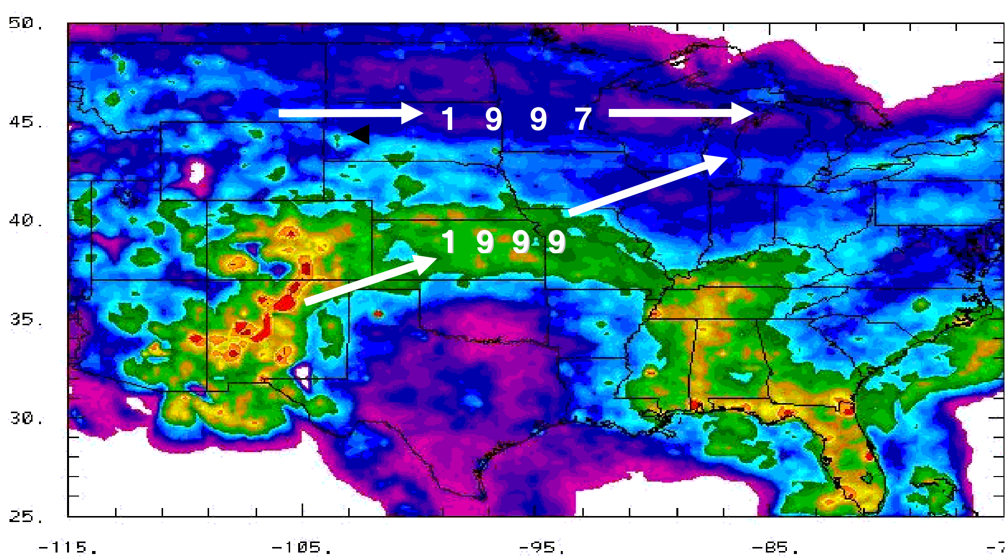


Fig. 3. Average fraction of time radar precipitation echo is present over the diurnal cycle for July 1998. Position of the rainfall "corridor" across central U.S. is also shown for 1997 and 1999.