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TRANSIENT INVERTED TROUGHS INTERACTING WITH THE NORTH AMERICAN MONSOON SYSTEM

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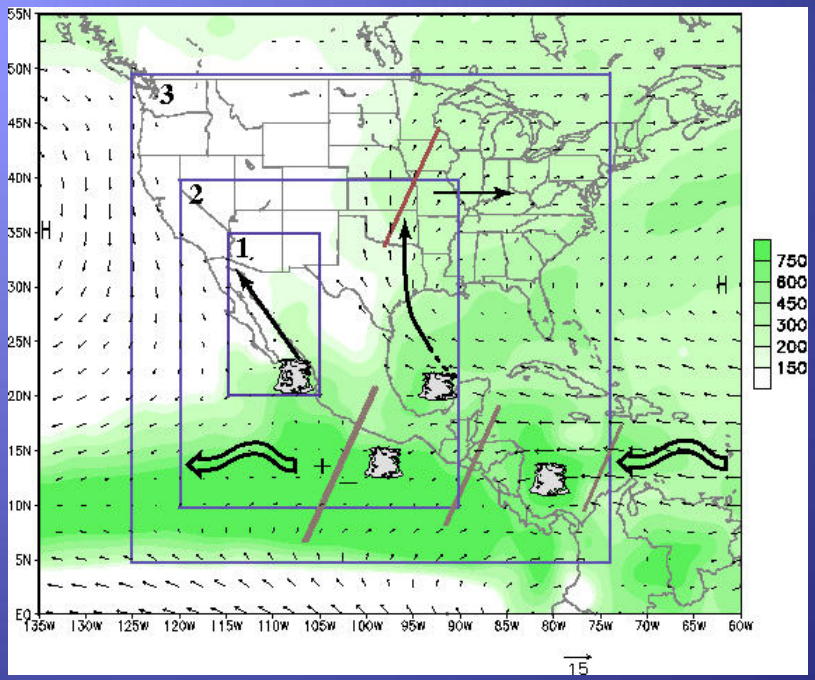
Motivation for Research

- Collaborative effort between National Weather Service, Tucson, AZ WSFO and the University of Arizona Dept. of Atmospheric Sciences.
- To provide an overview of inverted troughs, which are important synoptic scale features related to monsoon rainfall.
- Continued work from Pytlak et al. (2005), and analysis conducted during 2003-2005.
- These were also focused on during the NAME field campaign.

NAME Regions Tier I and II



Source: NAME Science Plan 2004

Definition of Inverted Trough

- Cyclonic circulation moving in a general westward direction across the NAME Tier I region. These are features in the middle and upper-troposphere with maximum vorticity occurring above 500 mb, and are typically "cold core" in nature (i.e. 500mb temps below -6C).

Source: NAME Science Operation Plan (2004)

Conceptual Model of IV's

Source: Pytlak et al. (2005)

Datasets

- Time Frame: May 15 – September 30
- Years covered: 1980 – 2006
- Primary Datasets Used:
  - North American Regional Reanalysis (1980-2006): 3 hour time resolution
  - Lightning Data, courtesy of VAISALA, Inc whose months were constrained to June 1 – Sept 30 (1996-2005): 1 hour time resolution
- Secondary Datasets Used:
  - NOAA Daily Weather Maps (1980-2006)
  - SPC Upper Air and Surface Archive Datasets (2002-2006)
  - NAME data archives (2004 field campaign)
  - Most of the datasets were used as a sanity check against NARR.

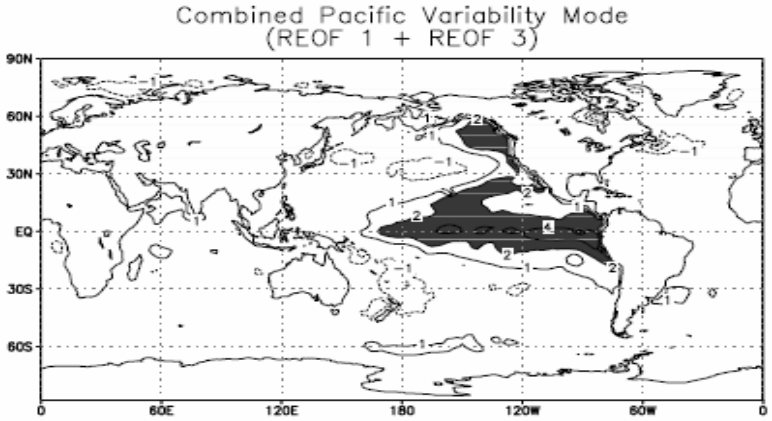
Region covered:

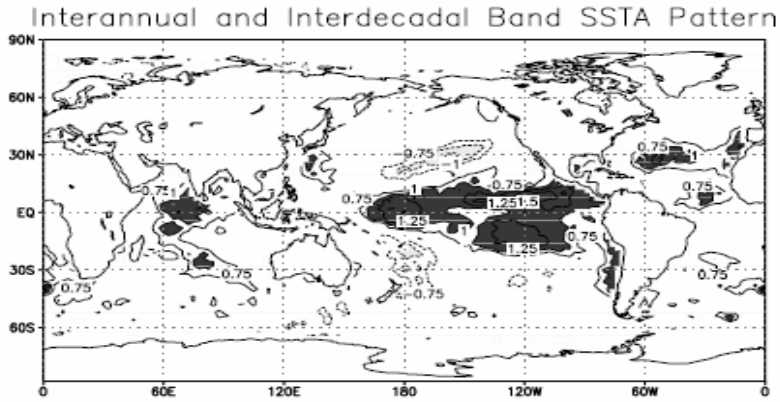
- NARR - boundaries were 10N – 42N, 122W – 90W (basically NAME Tier II).
- Lightning Data –boundaries were 27.5N-40N, 120W-100W.

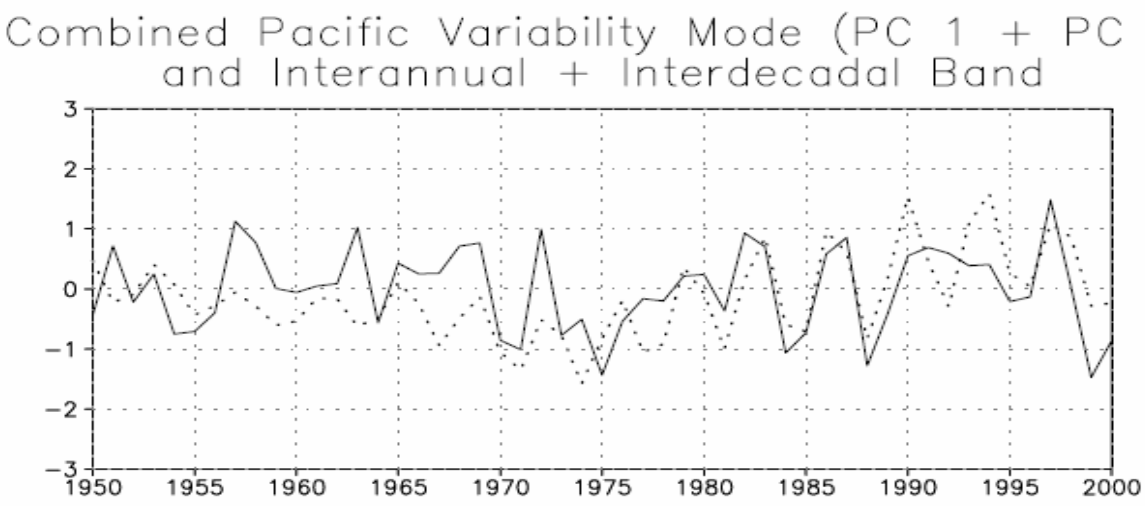
Definitions

- IV days – for the lightning composite, days that an inverted trough passed north of 23N, and between 100W and 120W.
- CPVM – Combined Pacific Variability Mode: uses the two (2) rotated EOFs of global SSTs which are associated with interannual and interdecadal variability in the tropical Pacific Ocean. Has a known relationship with NAMS variability at onset. (referenced in Castro et al. 2007, *J. Climate*)

CPVM





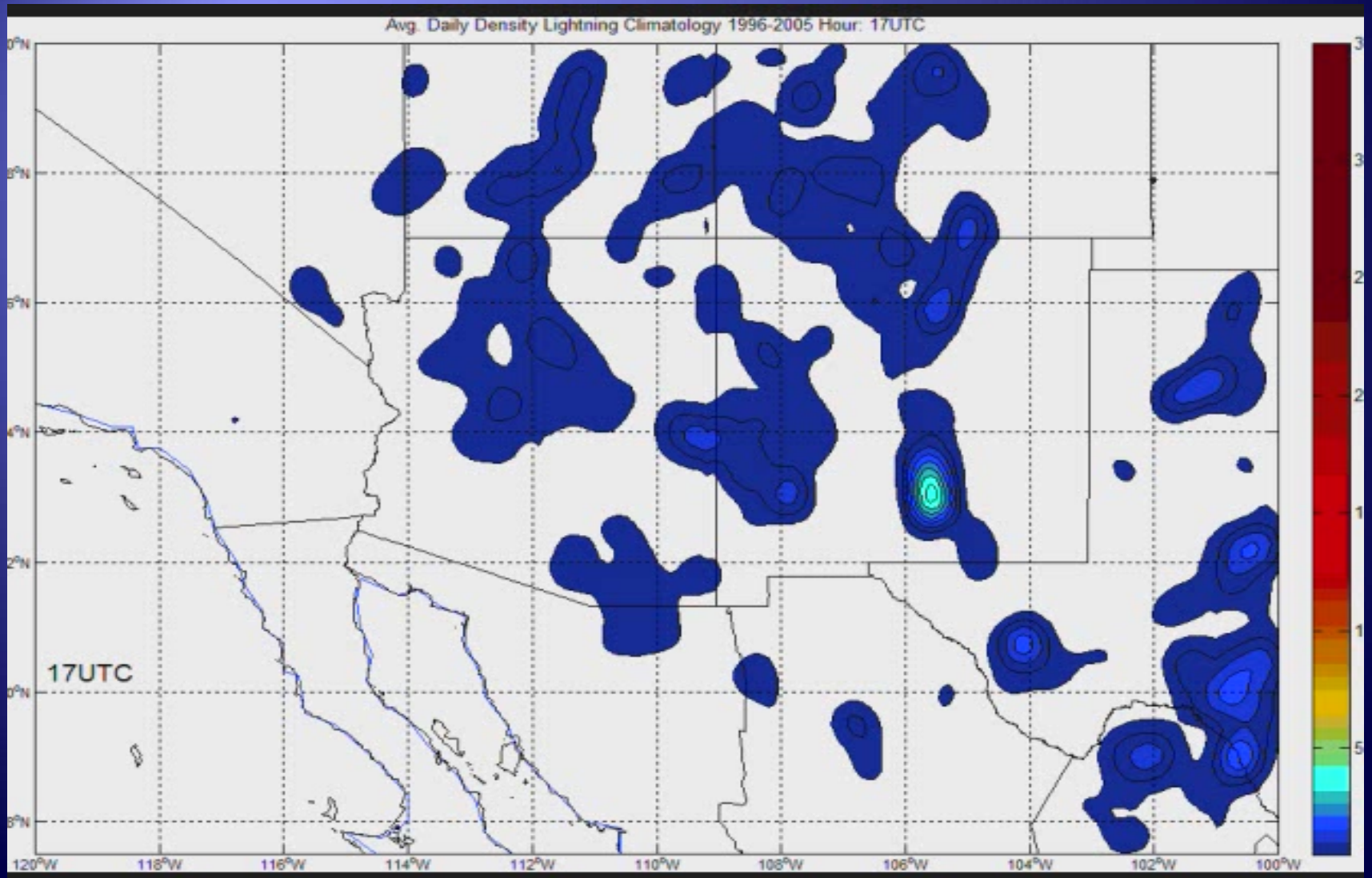


Source: Castro et al. (2007)

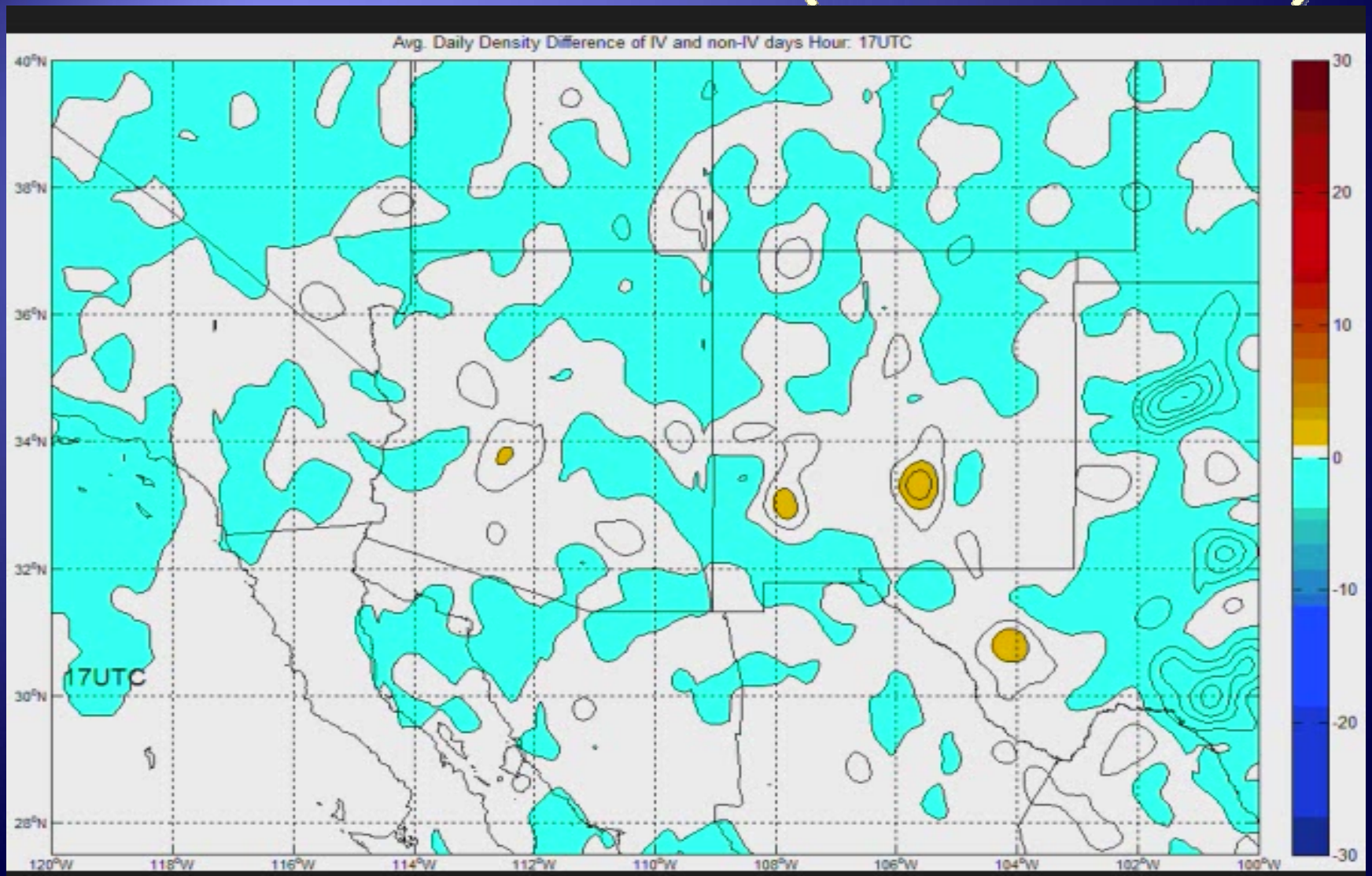
Methods of Analysis

- Lightning composites for IV days and non-IV days every hour were compared using a difference of means test for local significance and a field significance test (e.g. Livezey and Chen 1983).
- Track density composites for CPVM negative and positive years were compared using the same method as above. The lightning and Tier II regions considered.

Lightning Climatology – Diurnal Cycle

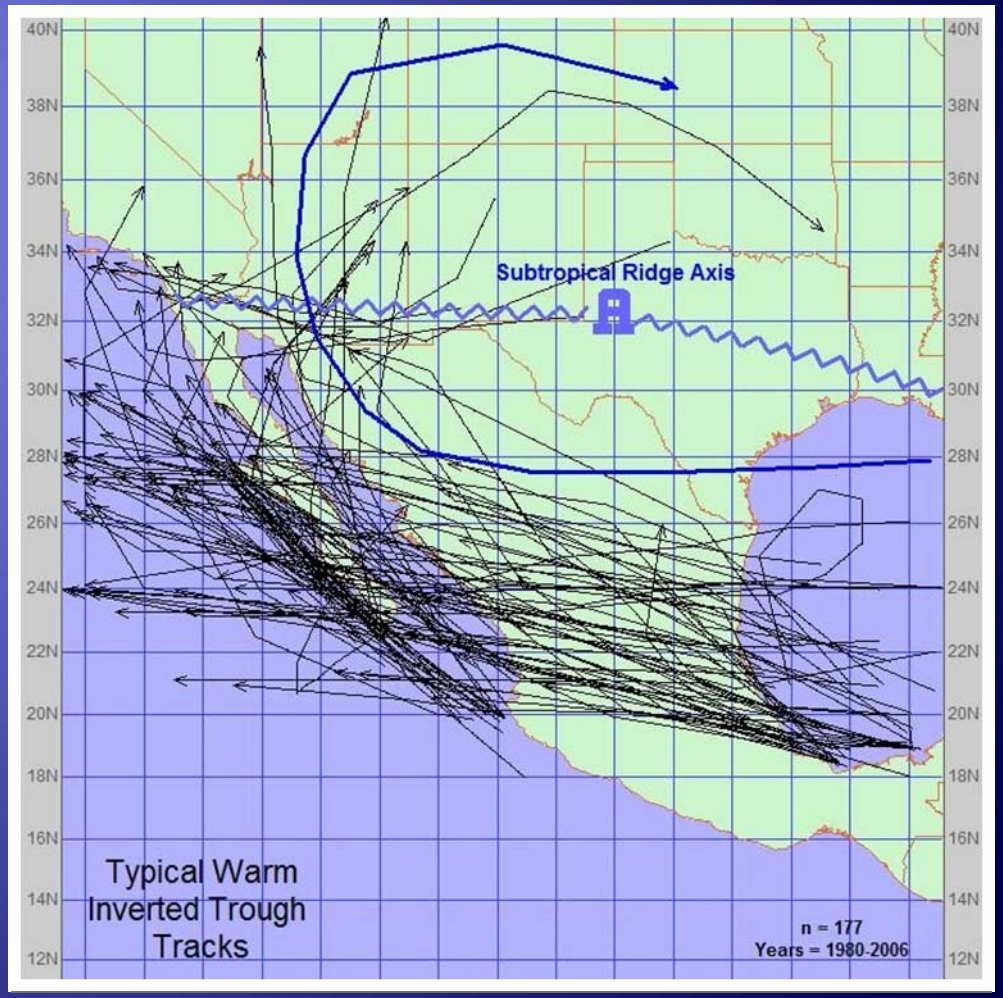


Difference of Means (IV vs. Non-IV)



IV Tracks

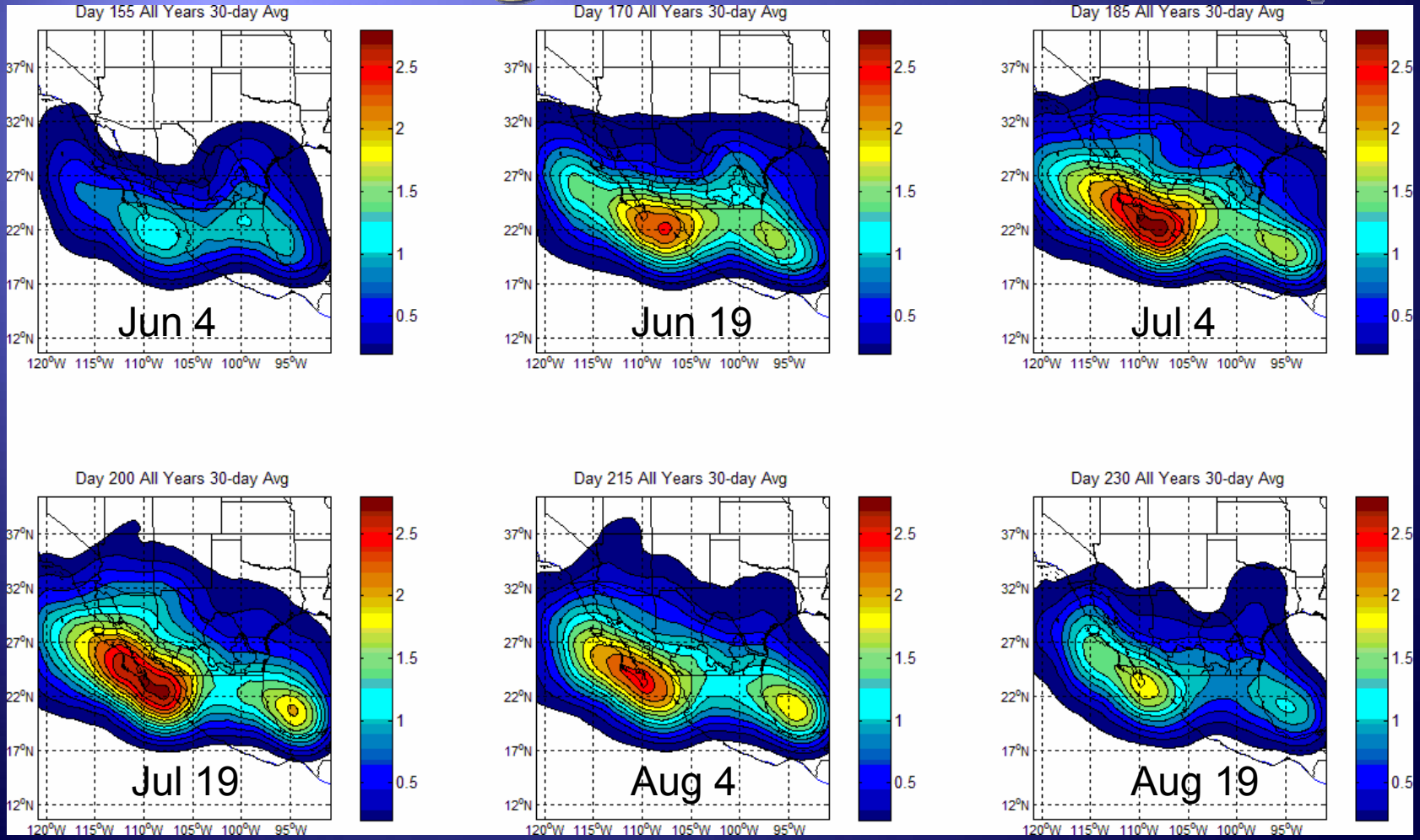
This is an example, using Douglas and Englehart (2006) classification.



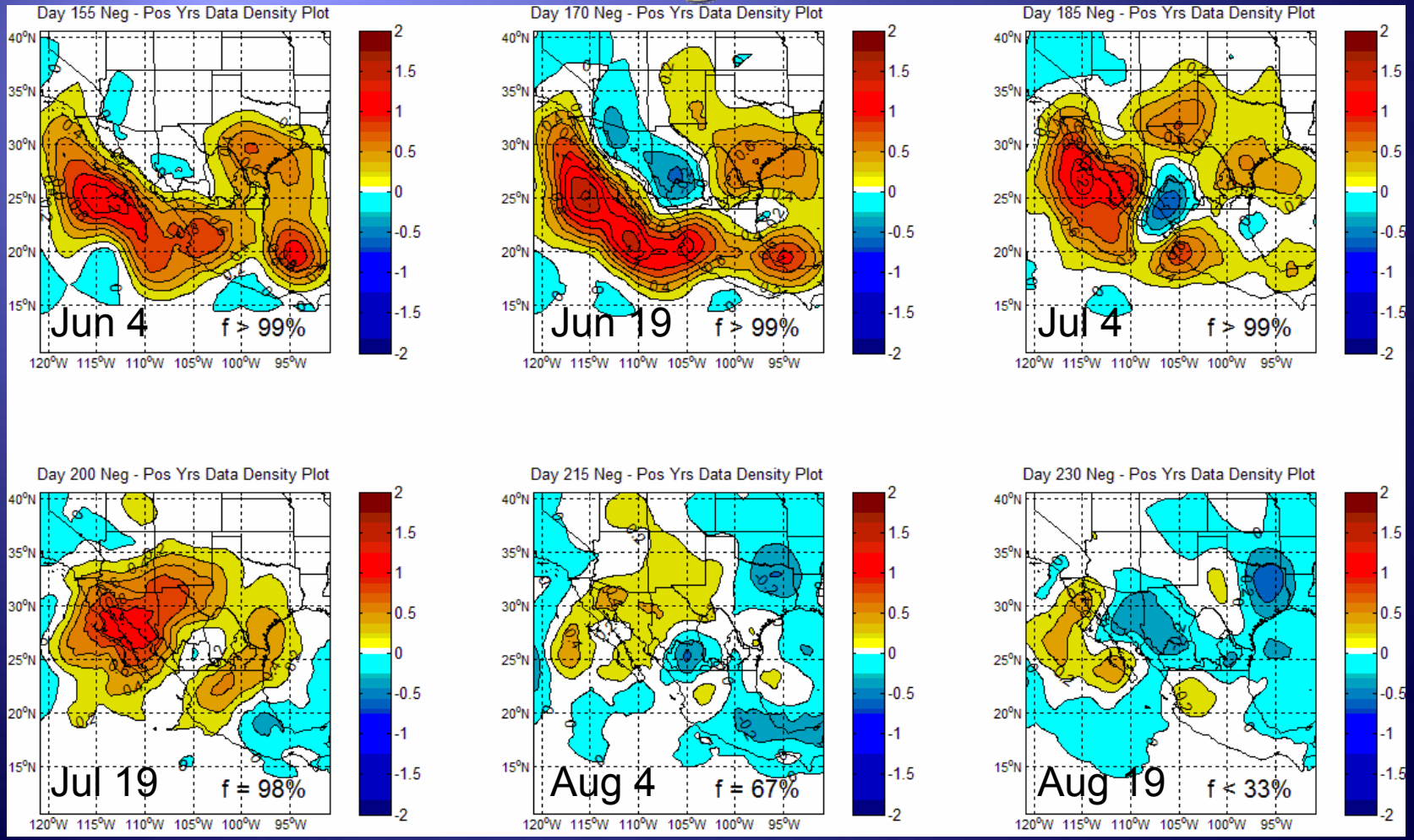
Plotting Track Densities

- The primary mechanism for identifying the IV's will be through the use of the NARR's 250mb, 300mb, 500mb and 700mb heights, 500mb temperature and relative vorticity by way of identifying a distinguishable upper-tropospheric (or lacking that, mid to lower tropospheric) center.
- Lacking any distinguishable center, relative vorticity will be used to help identify a region within the trough itself.
- Lacking the prior two, a discernible inverted trough in the easterlies (using the 500mb geopotential height 585 dm line or as close to that as possible).
- After applying the above methods, an equation using lat-lon points was applied where 1 was the center, and a distance of 1 degree (approx. 4Δx of NARR) from the lat-lon point was zero.

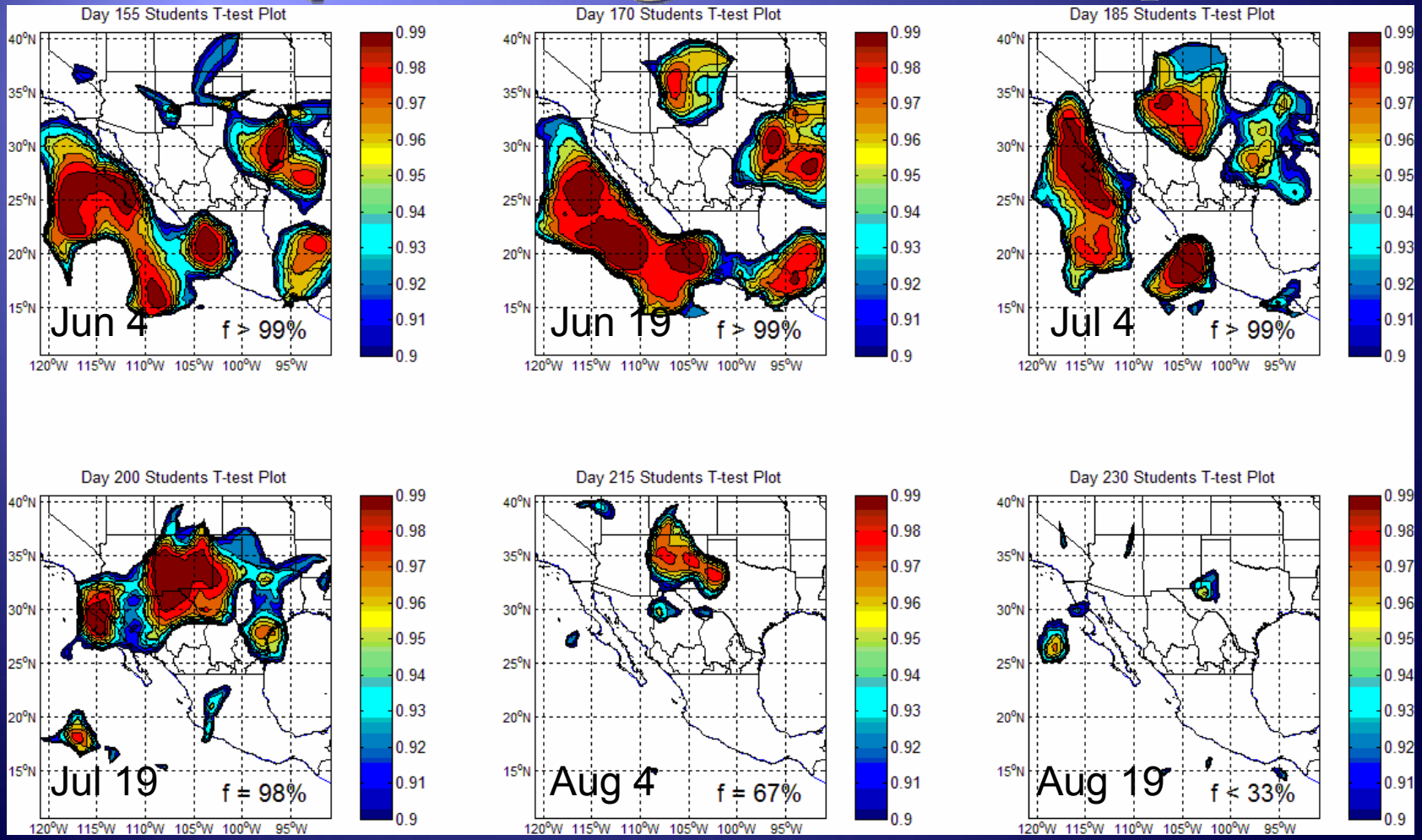
Climatological Track Density



Track Density Difference (CPVM Neg – Pos Yrs)

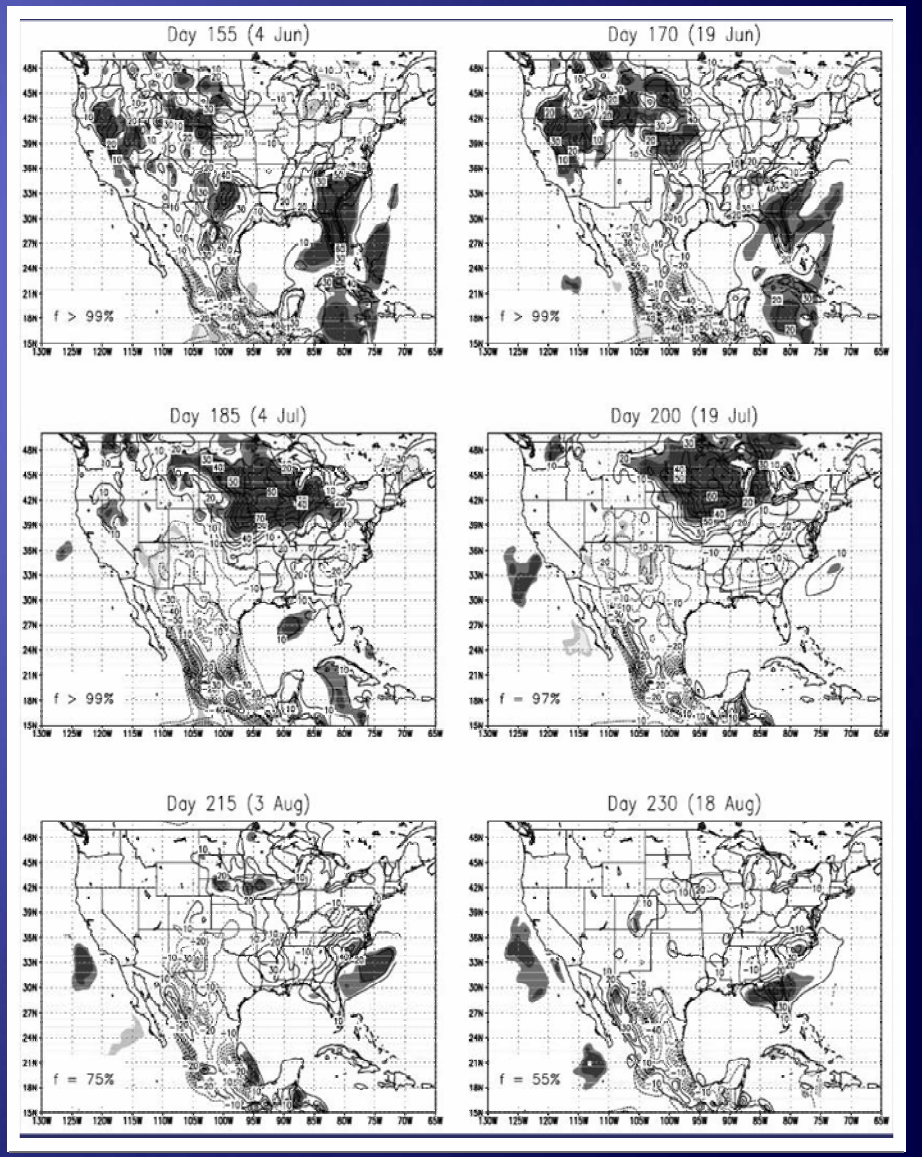


Corresponding T-stat at 90%+



Model Precip w/CPVM (Castro et al. 2007)

CPVM Positive – CPVM Negative Years showing the same basic principle.



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Discussion

- Inverted Troughs bring the necessary mechanisms (divergence aloft, instability, possible Gulf Surges) to enhance the diurnal cycle during the monsoon.
- The enhancement caused by these IVs are most pronounced and statistically significant during the hours of 18z – 09z.

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Discussion

- From the standpoint of diagnosing interannual variability, the CPVM is a powerful tool for forecasters in the NAM region.
- Transient IVs from a climatological standpoint track over central Mexico, and tend to reach a maximum just south of Baja California.
- During CPVM negative years, these tracks are either enhanced (+1 track/year) or deviated more northerly until around August (Julian Day 215). This enhances the rainfall in the core monsoon region.

Conclusions

- Transient IVs are pronounced features of the NAMS that enhance the diurnal cycle and account for a large portion of the lightning activity over only a third of the days in the analysis period.
- From a long term standpoint, knowing what the CPVM index is will give a good sense of how many and where the IVs will track during the upcoming monsoon season. ***This year it worked very well as it was very wet in Tucson in July! …I was also very OVERWORKED…***

Acknowledgements

- Drs. Mullen and Castro for serving as my co-Advisors and providing their expertise.
- Mr. Pytlak for his collaboration with this research.
- Dean Comrie for taking time out of his extremely busy schedule to provide input and serve on my committee.
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- Angel Otarola for helping me with MATLAB concerning NARR datasets.

Questions or Comments?

- Thank you for your time! ☺