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Diagnosing the Atmospheric/Oceanic Phenomena Associated with the Onset, Demise and Mid-Summer Drought of the Rainy Season in Mesoamerica

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I. INTRODUCTION

Rainfall plays a crucial role in the food security and economies of Mexico and Central America (Mesoamerica). This research aims to compare methods of defining the Mesoamerican rainy season's onset, demise and mid-summer drought (MSD). The relevance of this work is related to the key crops grown in this region: coffee, bananas, corn, and rice. These crops rely heavily on the timing and intensity of rainfall. The goal of this research is to link the physical and dynamical mechanisms that cause the Mesoamerican rainy season and MSD in order to better understand the phenomenology and predictability of Mesoamerican rainfall and ensure the health and safety of these key crops.

II. DATA

To calculate the onset/demise/MSD characteristics of the rainy season, rainfall data (given in mm/day) is used from the Climate Prediction Center (CPC) Unified Gauge-Based Analysis of Global Daily Precipitation (Xie et al. 2007). For each method, the rainfall is area-averaged over the Mesoamerican domain, which is 7-28 ºN and 77-109 ºW. The Climate Prediction Center Unified Gauge-Based Analysis of Global Daily Precipitation (hereafter CPC-Uni) is a retrospective dataset available daily from January 1, 1979 through December 31, 2005, on a global scale and only covers land area rainfall. The grid spacing is 0.5º by 0.5º.

Other meteorological components are taken from the second Modern-Era Retrospective analysis for Research and Applications (MERRA-2; Molod et al. 2015). MERRA-2 is a NASA product available from January 1, 1980 until present. The grid spacing is 0.625º longitude by 0.5º latitude. This corresponds to a 50km grid spacing in the latitudinal direction. For this study, the quantities used from MERRA-2 were daily eastward winds (m/s) at 925mb and temperature (K). These quantities were used to analyze atmospheric conditions prior to and around the time of onset, in order to determine the atmospheric precursors that foreshadow the onset.

III. ALGORITHMS TO DEFINE ONSET/DEMISE

a. MINCA

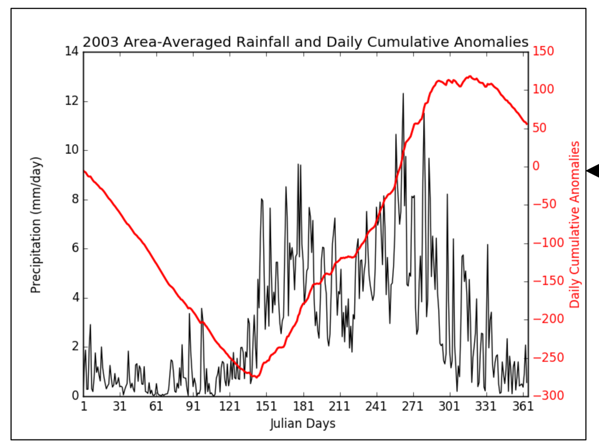
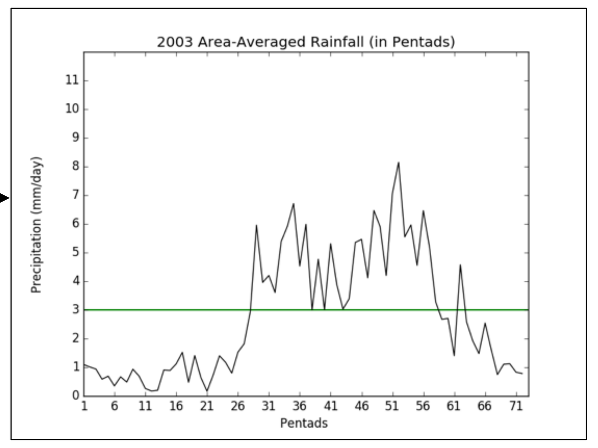


Fig. 1. The MINCA method (Liebmann et al. 2007) defines the onset as the minimum of the the daily cumulative anomalies (red line). The demise is the maximum of the daily cumulative anomalies. The daily cumulative anomalies are found by subtracting the climatological rainfall value from the daily rainfall amount and then adding them throughout the year.

b. THRESH

Fig. 2. The THRESH method (Nakaegawa et al. 2015) defines the onset as the first pentad that exceeds 3 mm/day for its mean area-averaged rainfall, with three consecutive pentads above 3 mm/day. The demise is the opposite, with the first of three pentads with area-averaged rainfall below 3 mm/day.



c. SLOPE

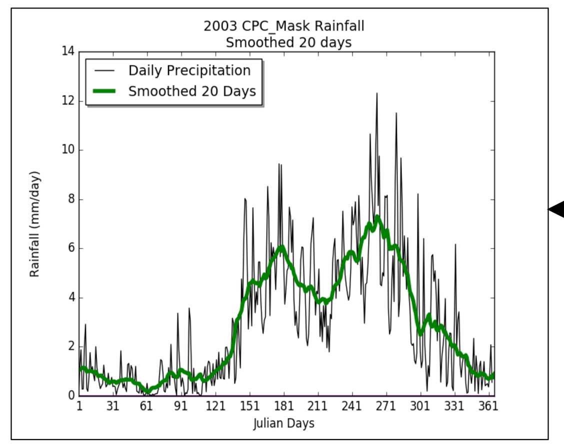


Fig. 3. The SLOPE method smooths the daily rainfall using a 20 day running mean (thick green line), and then calculates the slope of every 5 days. The onset is defined as the date when the slope is greater than or equal to 0.01 for at least 10 consecutive days. The demise is defined as the end date when the slope is less than or equal to -0.01 for at least 14 consecutive days, after Julian Day 245.

- MINCA and THRESH represent the period of heavy rains, whereas SLOPE represents the period of sudden increased/decreased rain. The onset and demise of SLOPE define a broader period than for MINCA and THRESH.

IV. INTERANNUAL VARIABILITY OF ONSET/DEMISE DATES

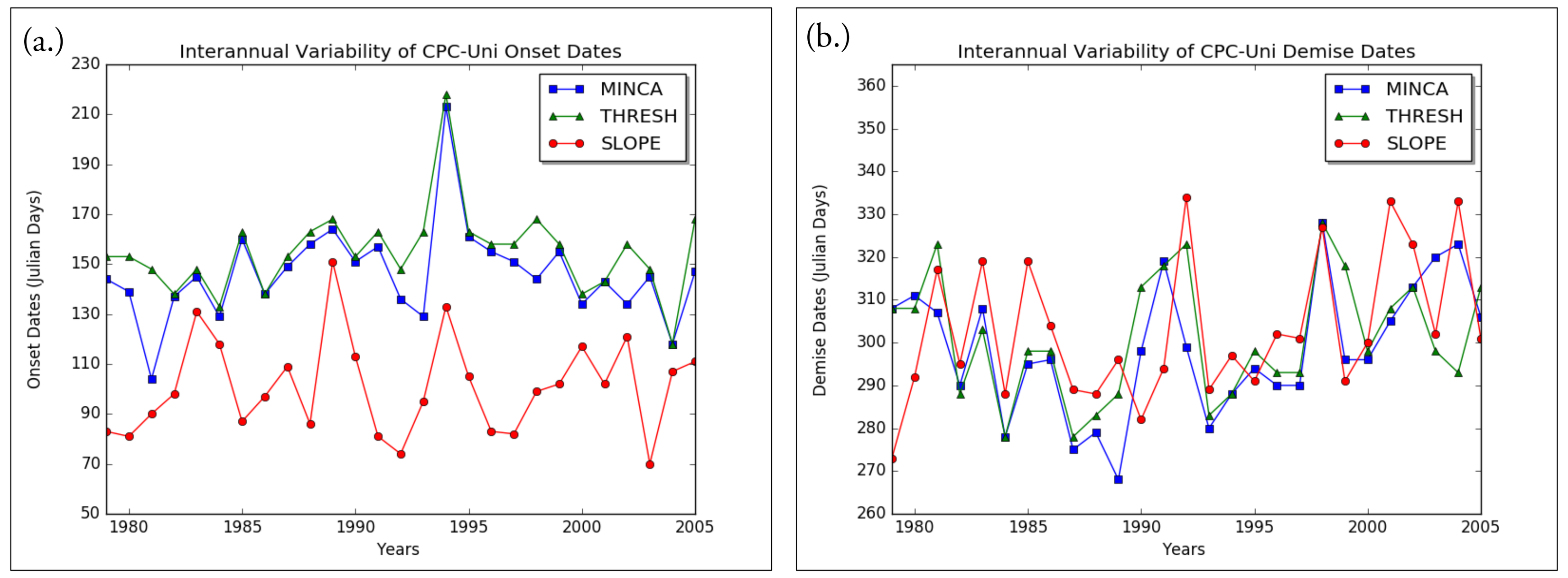


Fig. 4. Interannual variability of (a.) onset and (b.) demise dates for the 27 years of the CPC-Uni dataset from 1979-2005. MINCA (blue squares), THRESH (green triangles), and SLOPE (red circles) methods are compared.

V. MID-SUMMER DROUGHT

In order to identify the MSD, a smoothing technique is applied to the daily, area-averaged rainfall, same as the technique used in the SLOPE method. The start and end of the MSD are both characterized by an increasing slope (or near zero slope) followed by a negative slope. There are two peaks of rainfall, with a reduction in rainfall in between. This typically occurs in July/August, but does not necessarily show up each year for this dataset.

Years with the MSD: 1981, 1984, 1986, 1988, 1990, 1991, 1993, 1994, 1997, 1998, 1999, 2002, 2003

Years without the MSD: 1979, 1980, 1982, 1983, 1985, 1987, 1989, 1992, 1995, 1996, 2000, 2001, 2004, 2005

VI. PRECURSORS TO LIGHT RAINFALL

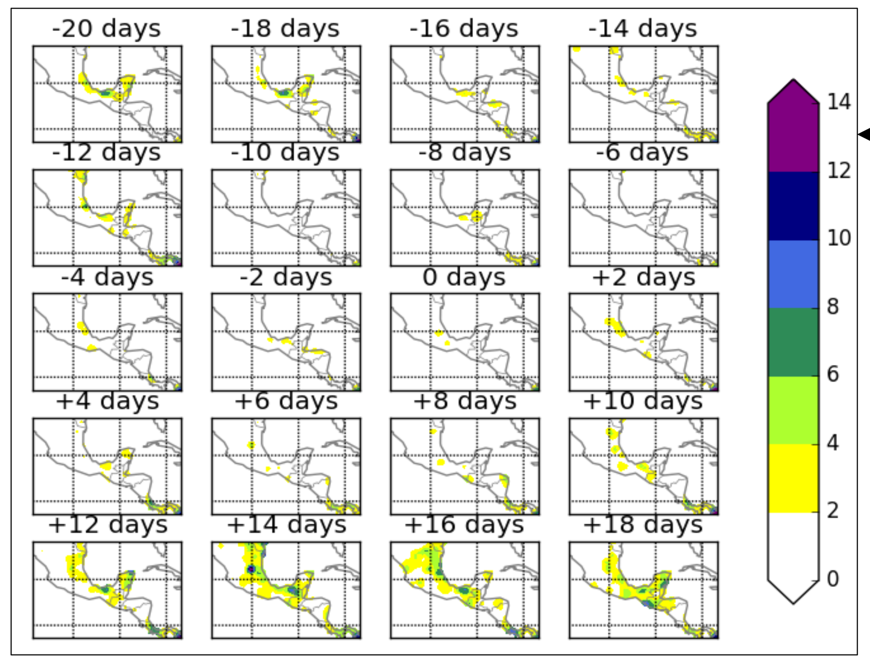
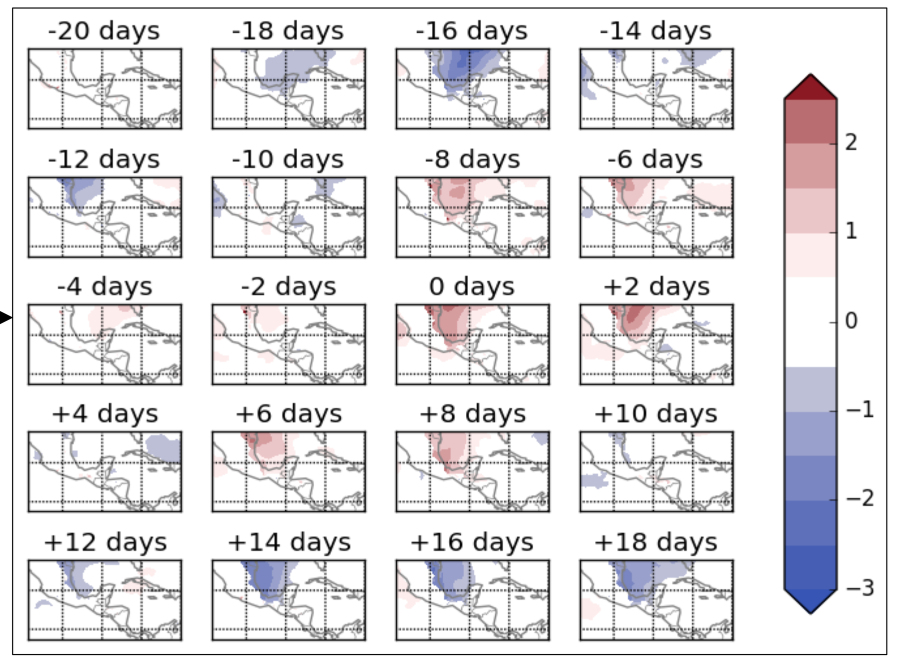


Fig. 5. Climatology of rainfall (mm/day) evolution 20 days before through 18 days after the climatological onset using the SLOPE method. This represents the start of the light rainfall in this region.

Fig. 6. Climatology of the de-seasonalized temperature anomalies at the 925mb pressure level 20 days before through 18 days after the climatological onset of the light rain using the SLOPE method. Red represents warm temperature anomalies whereas blue represents cold temperature anomalies.



VII. PRECURSORS TO HEAVY RAINFALL

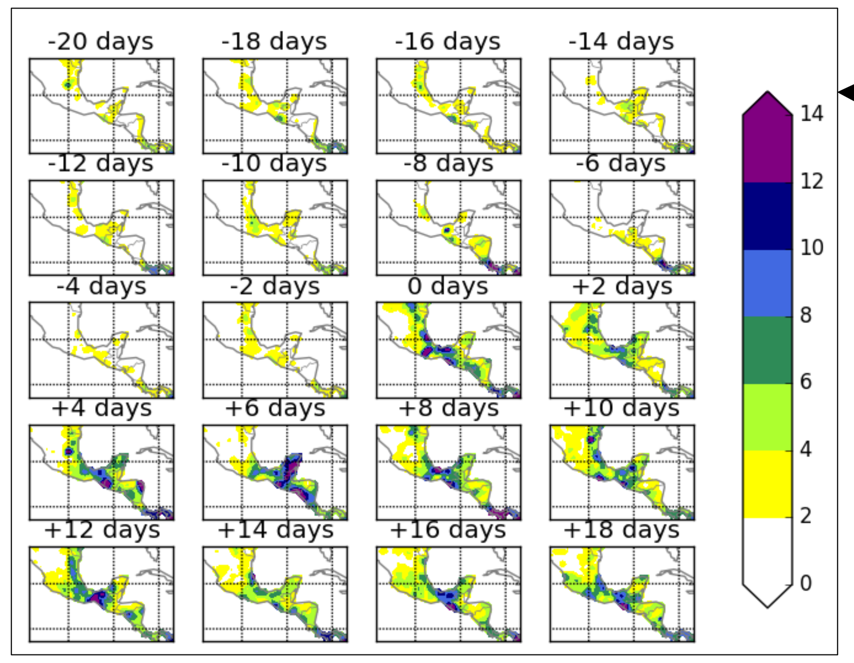
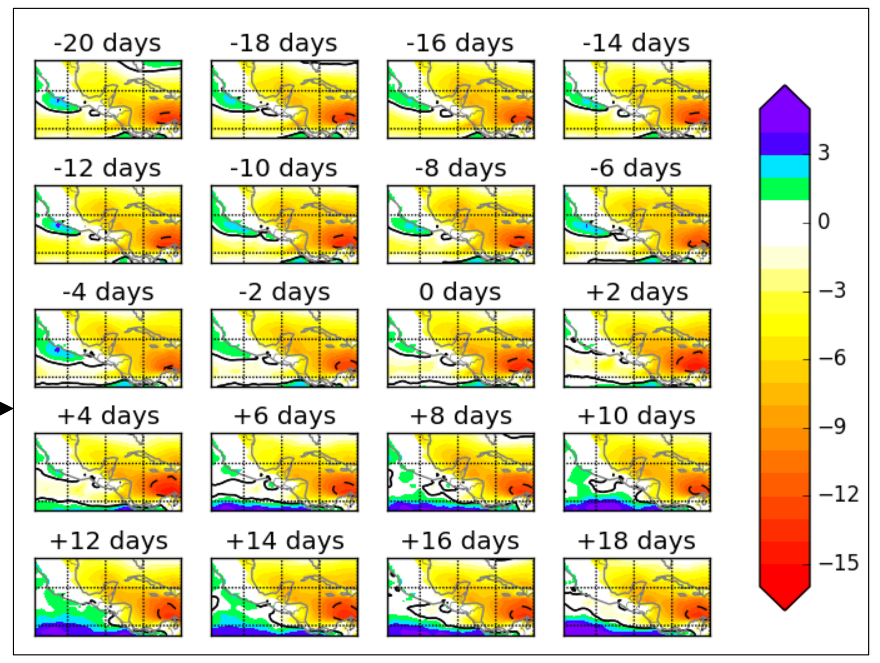


Fig. 7. Climatology of rainfall (mm/day) evolution 20 days before through 18 days after the climatological onset using the MINCA method. This represents the start of heavy rainfall in this region.

Fig. 8. Climatology of u-winds (m/s) at 925mb (from MERRA-2 Reanalysis) 20 days before through 18 days after the climatological onset using the MINCA method. Positive values indicate westerly and negative values indicate easterly winds. The black line denotes the monsoon trough. The Caribbean Low Level Jet (CLLJ) is outlined in black dashed line.



VIII. CONCLUSIONS

Precursors of light rainfall (SLOPE):

- Cold surge event occurring approximately 16 days before the onset of the rainfall.
- A week before through a week post-onset, warm temperature anomalies dominate.
- Further work needs to be done to analyze the physical and dynamic mechanisms contributing to the cold-surge event.

Precursors of heavy rainfall (MINCA and THRESH):

- Monsoon trough moving northward into the Mesoamerican domain, starting 6 days prior to onset.
- 8 days post onset, westerly winds dominate the Pacific side of the domain.
- The size and intensity of the CLLJ may be involved in the evolution of the rainfall somehow and needs to be further investigated.

IX. ACKNOWLEDGEMENTS

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X. REFERENCES

Liebmann B, Camargo SJ, Seth A, Marengo JA, Carvalho LMV, Allured D, Fu R, Vera CS., 2007: Onset and end of the rainy season in South America in observations and the ECHAM 4.5 atmospheric general circulation model. *J. Climate*, 20: 2037–2050.

Molod A M, Takacs L L, Suarez M and Bacmeister J, 2015: Development of the GEOS-5 atmospheric general circulation model: evolution from MERRA to MERRA2, *Geosci. Model Dev.*. 8: 1339–56.

Nakaegawa T, Arakawa O, Kamiguchi K., 2015: Investigation of climatological onset and withdrawal of the rainy season in Panama based on a daily gridded precipitation dataset with a high horizontal resolution. *J. Climate.*, 28: 2745–2763.

Xie, P., A. Yatagai, M. Chen, T. Hayasaka, Y. Fukushima, C. Liu, and S. Yang, 2007: A gauge-based analysis of daily precipitation over East Asia, *J. Hydrometeorol.*, 8: 607-626.