Changes in Tropical Rainfall and Cloud Characteristics Associated with ENSO

K.-M. LAU[1] & H.-T. JENNY WU[1,2]

1. NASA, Goddard Space Flight Center, MD, USA 2. SSAI

What we address here

- What are the tropical rain & cloud characteristics associated with ENSO?
- What are the relationships among sea surface temperature (SST), large-scale circulation, and ENSO rainfall and cloud changes?
- What are the possible mechanisms for the changes in warm low-to-middle clouds?

Our approach

- Process TRMM (1998–2009) data to a 0.5° lat by 0.5° lon by 1 day box.
- Use Nino3.4 SST to define the warm and cold DJF months of ENSO and Hadley Center SST for patterns.
- Analyze the changes in rainfall and cloud characteristics based on the probability distribution functions of TMI surface rain, VIRS brightness temperature (Tb), and PR echo-top height (ETH).
- Analyze MERRA data to examine the relationships between large-scale circulation and rain/cloud patterns associated with ENSO.

1. Climatology (DJF, 1998-2009) & Changes

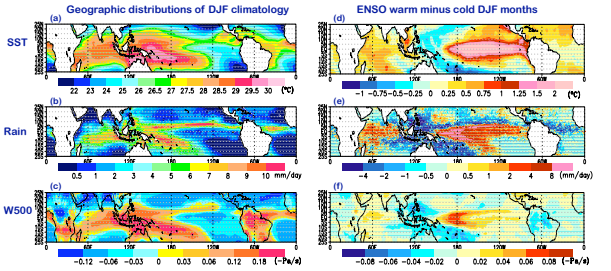

Fig. 1. Geographic distributions of DJF climatology of (a) SST, (b) total rain amount, (c) 500 hPa vertical velocity, and the associated changes in (d) SST, (e) total rain amount, and (d) 500 hPa vertical velocity from ENSO cold DJF months to warm DJF months.

2. Changes in Rain & Cloud Characteristics

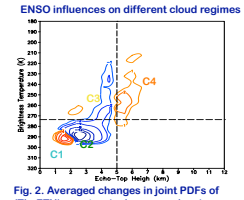

Fig. 2. Averaged changes in joint PDFs of (Tb, ETH) over tropical oceans showing ENSO influences on different cloud regimes.

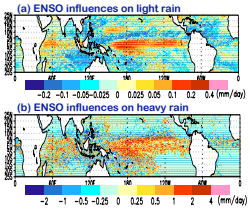

Fig. 3. Geographic distributions of changes in rain amount of (a) light (B5) rain, and (b) heavy (T10) rain. The B5 and T10 rain thresholds are defined by the pdf of TMI accumulated rain amount based on 1998 to 2009 daily data.

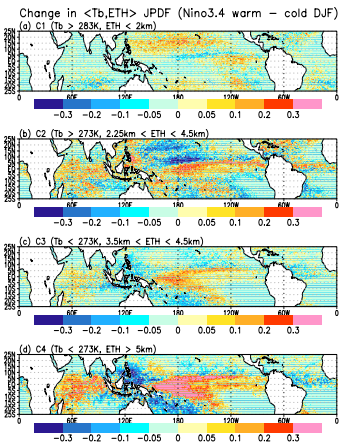

Fig. 4. Geographic distributions of changes in JPDF of (Tb, ETH) of four different precipitating cloud types: (a) boundary layer cloud, (b) warm low-to-middle cloud, (c) cold middle cloud, and (d) cold high cloud.

3. Relationships among SST, W500, & Clouds

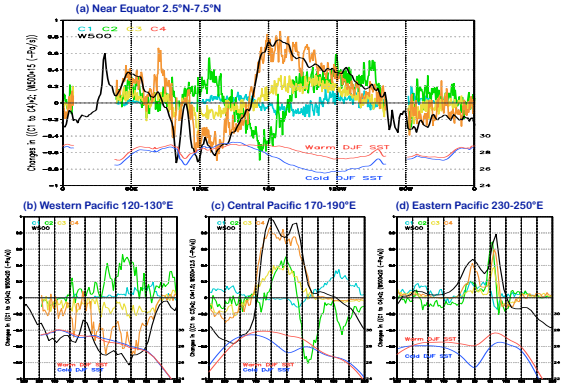

Fig. 5. Corresponding changes in 4 types of precipitating clouds (defined in Fig. 4), 500 hPa vertical velocity, and SST associated with ENSO (warm minus cold DJF months): (a) zonal section along 5°N, (b) meridional section along 180°E, (c) meridional section along 180°E, and (d) meridional section along 240°E. Also shown in each plot is the composite mean of SST for ENSO cold DJF months for reference.

4. Zonal & Meridional Circulations

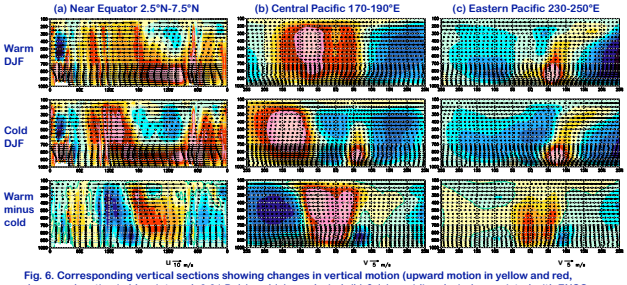

Fig. 6. Corresponding vertical sections showing changes in vertical motion (upward motion in yellow and red, downward motion in blue, interval=0.01 Pa/s) and (a) zonal wind, (b) & (c) meridional wind associated with ENSO: (a) zonal section along 5°N, (b) meridional section along 180°E, and (c) meridional section along 240°E.

Summary

- **Using a variety of TRMM products, SST, and MERRA reanalysis data, we show significant changes in tropical rainfall and cloud characteristics associated with ENSO.**
- **ENSO influences on rain and cloud depend strongly on rain and cloud types.**
- **Warm ENSO DJF months are associated with**
  - **a mild increase in mean tropical oceanic rainfall**
  - **a large increase (28%) in heavy/extreme (T10) rain**
  - **a weak reduction (5%) in light rain (B5)**
  - **an increase in precipitating boundary layer cloud**
- **Changes in cold high clouds are closely related to W500.**
- **Changes in cold middle clouds are closely related to SST.**
- **Changes in cold high clouds and warm low-to-middle clouds are negative correlated in northern western and central Pacific.**
- **Changes in eastern Pacific clouds are closely related to the changes in shallow meridional circulation.**

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For further information, please contact *Huey-Tzu.Wu@nasa.gov* (Jenny) or *William.K.Lau@nasa.gov*