Rainfall over the Tropical Western Pacific in relation to SST and mesoscale gradients thereof

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**Introduction:**
We have examined 4-year of satellite-derived SST (GHRSSST) and rainfall data (CMORPH) in anticipation of a relationship between SST structure and the excitation of convective rainfall. Rainfall distribution and event Regimes are discussed, followed by the study of SST morphology and lower boundary forcing.

**Figure 1:** a) SST daily, b) SST climatology. Daily SST areas and gradients thereof are multi-scale and extend over a larger dynamic range.

**Figure 2:** Hovmöller diagrams of characteristic monthly periods at 5N and EQ. SST in background; contoured precipitation events. Precipitation regimes include westward propagating, local diurnal, eastward propagating and suppressed conditions.

**Figure 3:** U-wind profile as stratified by categories of total precipitation per event (kg). Systematic precipitation increase is associated with an increase in shear, which is mainly associated with increasing lower tropospheric westerly flow (Sep 2009).

**Figure 4:** a) Multi-scale variation of large amplitude SST gradient field, cellular structure throughout and temporally coincident with a maximum of surface convergence (LSSTmax)

**Figure 5:** 4-year distribution of rainfall-onset SST and background SST. Mean onset-SST is slightly higher than background mean. Overall, onset occurrence is disproportionately concentrated in mid-SST range. The warmest SST areas are neutral with respect to frequency of onset.

**Figure 6:** 4-year background SST orientation distribution (black), onset orientation distribution (red). Phase change suggests onset is less favored at southward-pointing SSTG and preferred at eastward-pointing SSTG (west side of warm anomaly in westerly flow).

**Figure 7:** Distributions of rainfall onset in relation to LSST and SST for a) Sep 2009, b) Jan 2008. The dash lines near zero - LSST are 3 σ uncertainty of background convergence (converted to LSST unit) about zero. LSST values plotted are the largest absolute value, conserving sign of the local area average within GHRSSST (microwave) footprint.

**Figure 8:** SST - LSST distribution before and after onset events: (a) previous day (b) following day. As expected, there is a large shift from convergent to divergent curvature of LSST at 29-29.5°C SST.

**Figure 9:** The before-after onset shift in relation to background - LSST. The shift represents approximately a factor of two from background frequency in each phase.

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**Reference:** Yanping Li, R. E. Carbone, 2011: Excitation of rainfall over the tropical western Pacific. Submitted to JAS.

**SST morphology and lower boundary forcing**

**Gravity wave Approximation:**
\[
\frac{\partial^2 \mathbf{w}}{\partial z^2} = \frac{1}{c_s^2} \frac{\partial^2 \mathbf{u}}{\partial t^2} + \frac{1}{\rho} \frac{\partial p}{\partial z} = \frac{1}{\rho} \frac{\partial \mathbf{u}}{\partial z} \frac{\partial \mathbf{u}}{\partial z} + \frac{1}{\rho} \frac{\partial \mathbf{u}}{\partial z} \frac{\partial \mathbf{u}}{\partial z} 
\]

Assume PBL height H=350m, horizontal scale 50km, temperature difference drops 50% at PBL top, $\Delta T \sim 0.5°C$

\[ c_s^2 = 18.1300 \times 10^{-5} \text{ s}^{-1} \]

Assume PBL height H=350m, LSST = 6.0°C/100km$^2$, $\Delta T = 3\times10^{-5} \text{ s}^{-1}$

Background convergence: at 925 hPa $\nabla \mathbf{u} = 3 \times 10^{-5} \text{ m s}^{-1}$

**Estimation of LSST derived local convergence**

**Gravity current Approximation:**

Assume PBL height H=350m, horizontal scale 50km, temperature difference drops 50% at PBL top, $\Delta T \sim 0.5°C$

\[
\nabla \mathbf{u} = \frac{1}{\rho} \frac{\partial \mathbf{u}}{\partial z} \frac{\partial \mathbf{u}}{\partial z} + \frac{1}{\rho} \frac{\partial \mathbf{u}}{\partial z} \frac{\partial \mathbf{u}}{\partial z} 
\]

Assume PBL height H=350m, LSST = 6.0°C/100km$^2$, $\Delta T = 3\times10^{-5} \text{ s}^{-1}$

Background convergence: at 925 hPa $\nabla \mathbf{u} = 3 \times 10^{-5} \text{ m s}^{-1}$