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Using Satellite Observations to Infer the Relationship between Cold Pools and Subsequent Convection Development

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1. Simulated and Observed Cold Pools

Cold pools impact local buoyancy and dynamics (e.g. by forcing uplifting of air), further impacting the evolution of both shallow and deep convection. Unfortunately, observations serving to inform our understanding of cold pool processes are 1. limited to select field programs/radar domains; 2. in danger of being too noisy due to rainfall contamination (satellite-perspective). In this work, I try to provide evidence suggesting that useful signals can still be extracted from satellite observations.

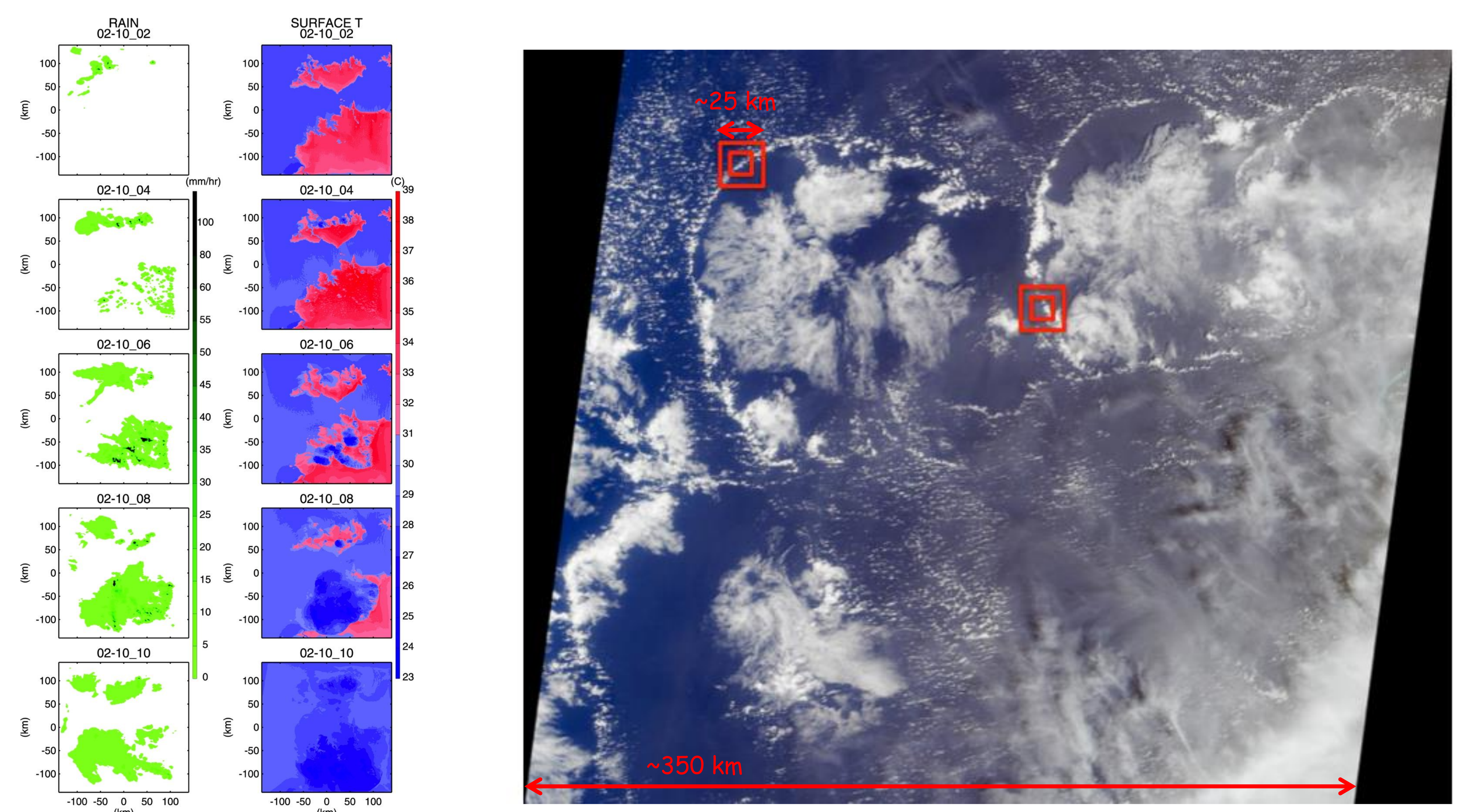


Figure 1. **Cold pools must achieve spatial scales several factors larger than the size of a sensor FOV (i.e. 1-pixel footprint) to be resolvable in observations.** In the top/left panels, the spatial extent of cold pools associated with convective outflow in a WRF simulation is shown (Del Genio et al. 2012; Fig. 6). Depressions in T are simulated over large spatial scales (~100 km by simulation end). In the top right panel (MISR image, courtesy of NASA/JPL MISR Team), the red boxes denote current spaceborne sensor FOVs (e.g. QuikSCAT, RapidScat, ASCAT) drawn on top of large cold pool arcs.

Coherent wind vector fluctuations (including signatures of divergence) and thermodynamic fluctuations must exist outside of the heavier rainfall envelope (or between raining pixels in a large cluster) so that rainfall contamination is minimized. These two requirements imply that signals of convective outflow are skewed toward the large spatial-scale part of cold pool PDFs.

2. Perspective from Current Orbiting Sensors

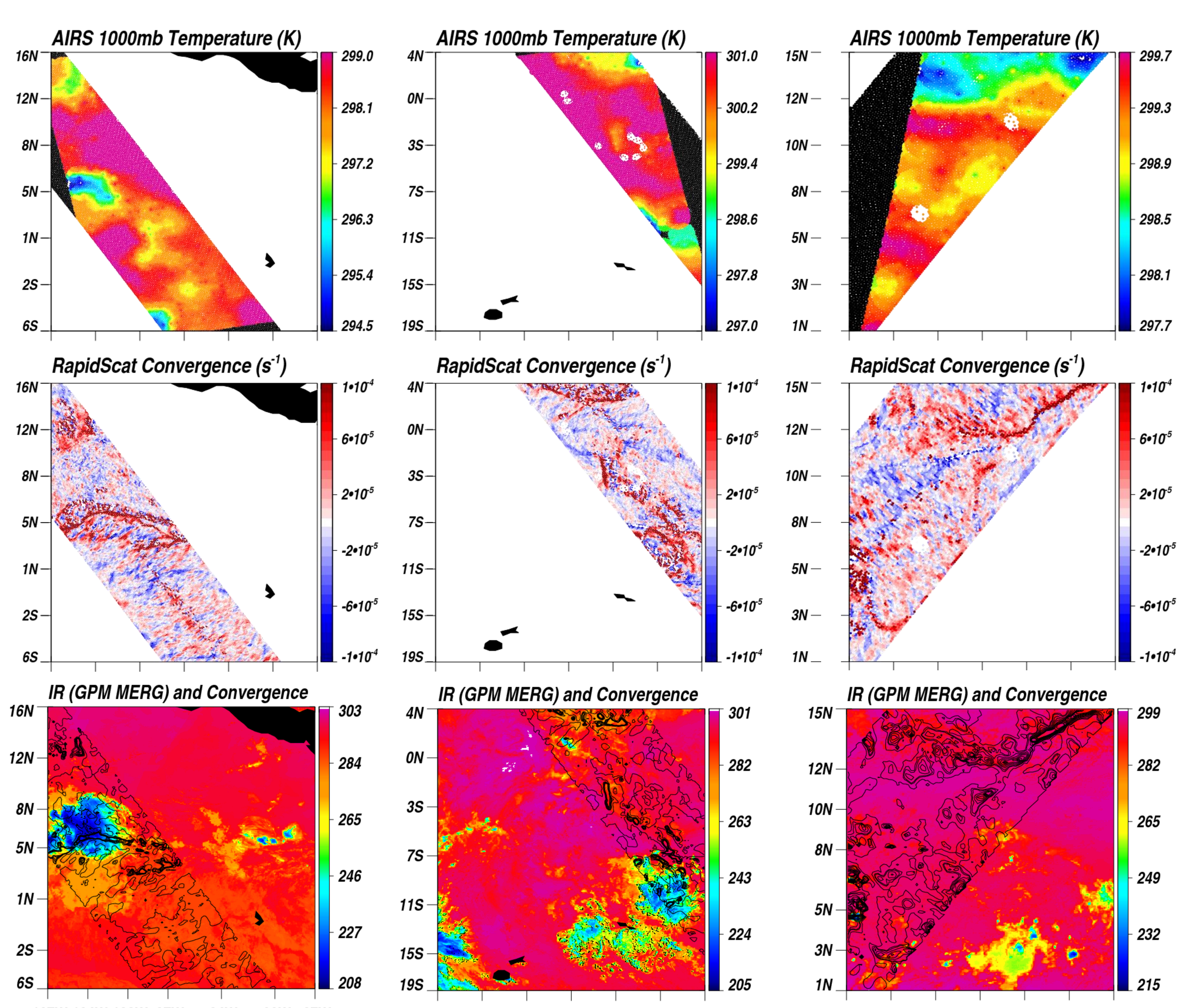


Figure 2. 3 examples of possible outflow signatures (surface T, surface convergence) found in close proximity to convection (identified from IR).

Left Column: Large E-W band of convergence associated with organized convective system extending out of raining area; ITCZ convergence may also be observed.

Center Column: Several arcs of convg. (7to10S/169W) and depressed BL temps outside of old convection; band of convg. at 3S/173W near BL temp gradient.

Right Column: Arcs of convg. near 3N/157E & 10N/163E are in regions where convection died earlier; convection redevelops later in IR images].

3. Convective System Composite Studies

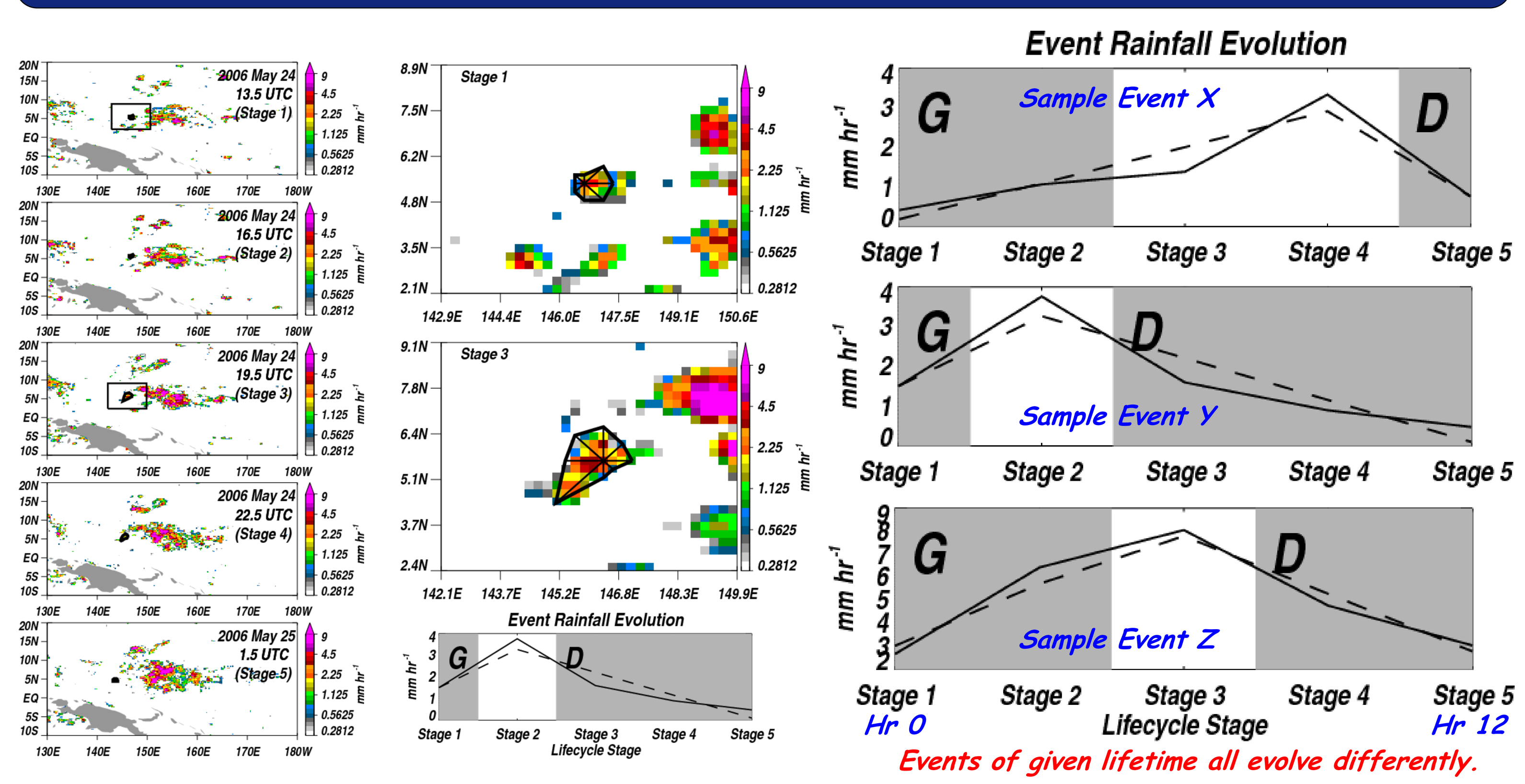


Figure 3. I investigate the features discussed in Figs. 1 and 2 with respect to propagating convective systems. Systems are tracked using 30-min-res satellite rainfall (example 12-hr system; top left). System spatial extent is defined using correlation length scales of rainfall extending radially from the system center. Growth/Decay of systems is defined as $VolRR^{-1}*dVolRR/dtime$. Systems of a given duration evolve differently (e.g. top right three panels). **Therefore, instead of compositing parameters along the system's track, I composite as a function of duration, growth rate, and decay rate prior to system passage**. Since > 90% of systems have a duration < 24 hours, these systems are the focus of this work.

4. Environment Preceding System Passage

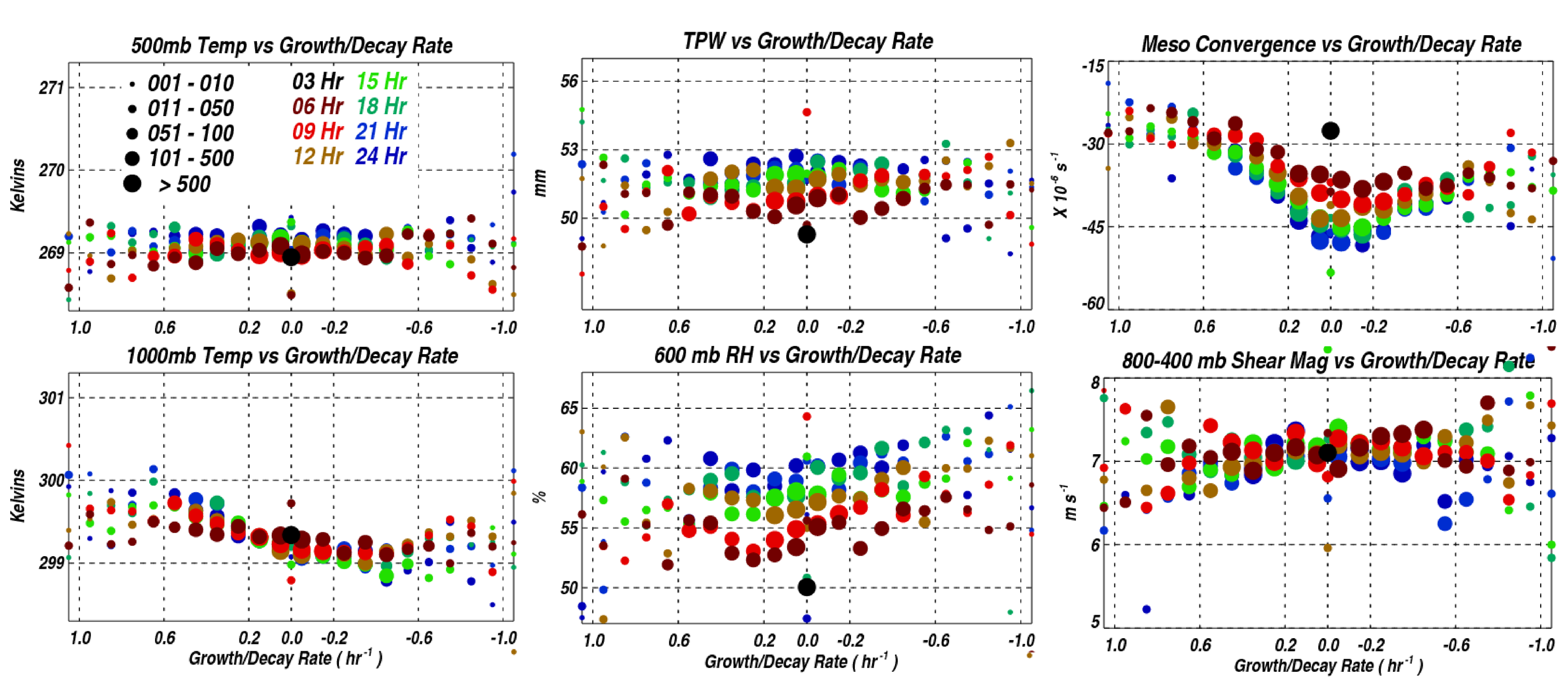
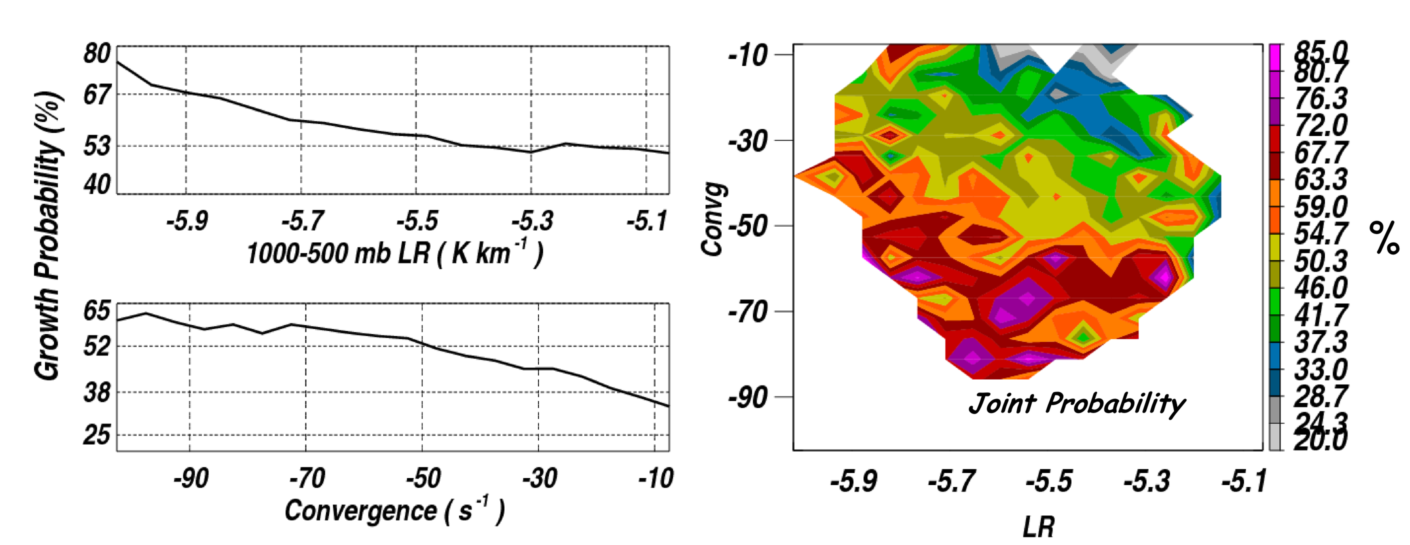
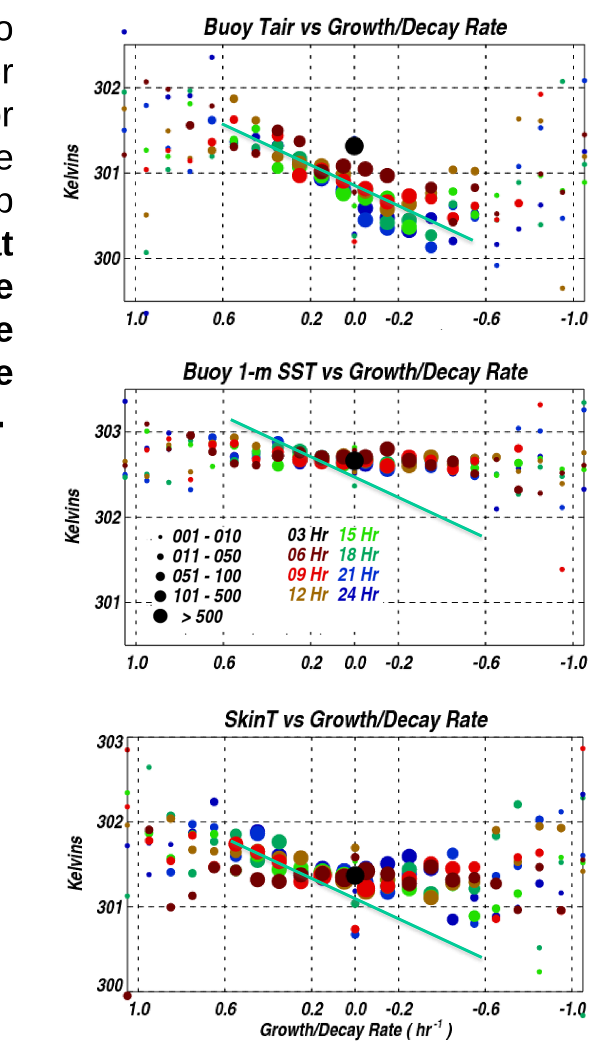


Figure 4 (top). Size of dot denotes sample-size; color denotes system-duration. **Growth (decay) of systems is characterized by warmer (colder) BL (e.g. 1000-mb T). All systems are found in high TPW and shear (NCEP) environments, and duration is not correlated with these variables.** Mesoscale convergence (QuikSCAT/ASCAT) is stronger during system decay than growth. Based on Fig 4., it is plausible that growth occurs when the environment is unstable enough for a given convergence. Convergence could be forced by the system itself (cold pools? heating profile?), or from SST gradients. In Figure 5 below, the joint probability of growth shows that growth can occur if sufficient convergence overwhelms less favorable thermodynamics.



5. Colder BL: SSTs or Cold Pools?

Figure 6 (right). Buoy T-air shows similar relationship to growth/decay as that shown in Fig. 5 (AIRS). Is cooler BL the result of convection itself (e.g. cold pools) or SST? Buoy SST -vs- growth does not show same relationship. AIRS Skin-T show some relationship between growth and warm surface, but it **appears that most of the temperature differences in the BL are not due to forcing by the ocean surface temperature. This suggests cooling of BL could be due to the system itself (or from nearby cold pools).**



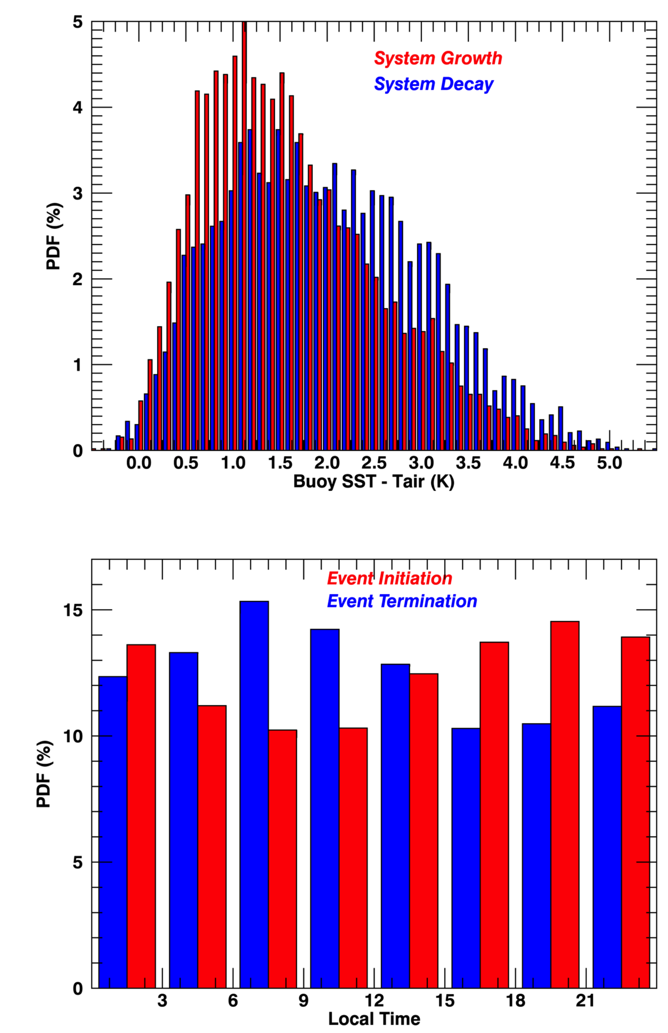


Figure 7 (left). Histogram of buoy SST minus surface air temps stratified by system growth/decay/time. Diurnal cycle of rainfall is weaker over oceans; evident in terms of initiation/termination of events, but if these bounds were determined solely by SST, PDFs should be more separated, supporting the interpretation gained from the observations in Figs. 5 and 6.

6. Conclusion/Question for Future Work

- Mid-trop RH and TPW do not delineate one composite system from another; all occur in moist environments. A cooler boundary layer is found prior to system passage during the decay portion of the lifecycle (for all systems with < 24-hr duration). This likely implies increased convective inhibition. Is a cooler boundary layer (implying less inflow of warmth/moisture) responsible for a general decay of a system? Is a shorter lived system one who was "unlucky" enough to produce sufficient boundary layer cooling and divergence to weaken itself? **Distribution of system lifetimes in a model may be related to accurate simulation of mesoscale SST field and BL cooling by current or previous convection (i.e. memory).**

7. References

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