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Lagrangian diagnostics of tropical deep convection and its effect upon upper-tropospheric humidity

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This study combines geostationary water vapor imagery with optical cloud property retrievals and microwave sea surface observations in order to investigate, in a Lagrangian framework, (i) the importance of cirrus anvil sublimation on tropical upper-tropospheric humidity and (ii) the sea surface temperature dependence of deep convective development. Although an Eulerian analysis shows a strong spatial correlation of approximately 0.8 between monthly mean cirrus ice water path and upper-tropospheric humidity, the Lagrangian analysis indicates no causal link between these quantities. The maximum upper-tropospheric humidity occurs approximately 5 h after peak convection, closely synchronized with the maximum cirrus ice water path, and lagging behind it by no more than 1 h. Considering that the characteristic e-folding decay time of cirrus ice water is determined to be approximately 4 h, this short time lag does not allow for significant sublimative moistening. Furthermore, a tendency analysis reveals that cirrus decay and growth, in terms of both cloud cover and integrated ice content, is accompanied by the drying and moistening of the upper troposphere, respectively, a result opposite that expected if cirrus ice were a primary water vapor source. In addition, it is found that a 2°C rise in sea surface temperature results in a measurable increase in the frequency, spatial extent, and water content of deep convective cores. The larger storms over warmer oceans are also associated with slightly larger anvils than their counterparts over colder oceans; however, anvil area per unit cumulus area, that is, cirrus detrainment efficiency decreases as SST increases.