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Vertical profiling of rain using passive microwaves over the Atlantic ITCZ, and its implications about flights AF447 on 1 June 09 and AF445 on 1 Dec 09

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We developed a method to use co-located simultaneous observations by the space-borne Tropical Rainfall Measuring Mission (TRMM) precipitation radar and microwave imager to train the microwave radiometer to retrieve vertical profiles of precipitation in the absence of radar observations. This radar-trained passive-microwave approach was initially developed for mid-latitude precipitation regimes, where it was found that the main impediment to the estimation of the vertical distribution of rain from the passive microwave brightness temperatures was the significant contribution of the surface to the radiative signatures, which becomes more significant as the inhomogeneity of the rain within the radiometer field of view increases. We therefore modified the original approach to constrain the brightness-temperature combinations used in the retrieval to lie in the orthogonal complement to the two main clear-sky principal components in brightness-temperature space, and applied this modified approach to observations over the Atlantic Inter-Tropical Convergence Zone during May 2009, deriving estimates of the uncertainty in passive-microwave retrievals of the storm-top height (as determined by the radar, and hence well below the cloud-top height as determined by the IR measurements) and of the first vertical principal component of the precipitation. The results are illustrated on a serendipitous granule of data taken while the TRMM radar was unfortunately not operational, about twenty minutes after the last transmission from the ill-fated flight AF447 on June 1, 2009. Our analysis indicated that
- there was a very active deep convective cell centered almost exactly on the plane trajectory released by the Bureau d'Enquetes et d'Analyses,
- this cell was the deepest and strongest of four cells in the general vicinity, and
- the storm tops of this strongest cell were higher than the estimated flight level of the plane.
We also analyzed the precipitation first-principal-component and storm-top height estimates over the Atlantic ITCZ during the transition months of May-June and November-December over the past ten years, to look for trends that might shed light on the circumstances surrounding AF447 as well as those surrounding flight AF445 on December 1, 2009, as it encountered severe turbulence while crossing the ITCZ. We conclude with the sketch of a concept for a large-aperture radar in geostationary orbit that would generate three-dimensional estimates of precipitation reflectivity and line-of-sight Doppler across the ITCZ every 15 minutes.