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Using CloudSat Cloud Retrievals to Differentiate Satellite-Derived Rainfall Products over West Africa

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Daily precipitation retrievals from three algorithms [the Tropical Rainfall Measuring Mission 3B42 rain product (TRMM-3B42), the Climate Prediction Center morphing technique (CMORPH), and the second version (RFEv2) of the Famine Early Warning System (FEWS)] and CloudSat retrievals of cloud liquid water, ice amount, and cloud fraction are used to document the cloud structures associated with rainfall location and intensity in the West African monsoon. The different rainfall retrieval approaches lead to contrasting cloud sensitivities between all three algorithms most apparent in the onset period of June and July. During the monsoon preonset phase, CMORPH produces a precipitation peak at around 12°N associated with upper-level cirrus clouds, while FEWS and TRMM both produce rainfall maxima collocated with the tropospheric–deep convective cloud structures at 4°–6°N. In July similar relative displacements of the rainfall maxima are observed. Conditional sampling of several hundred convection systems proves that, while upper-level cirrus is advected northward relative to the motion of the convective system cores, the reduced cover and water content of lower-tropospheric clouds in the northern zone could be due to signal attenuation as the systems there appear to be more intense, producing higher ice water contents. Thus, while CMORPH may overestimate rainfall in the northern zone due to its reliance on cloud ice, TRMM and FEWS are likely underestimating precipitation in this zone, potentially due to the use of infrared based products in TRMM and FEWS when microwave is not available. Mapping the CloudSat retrievals as a function of rain rate confirms the greater sensitivity of CMORPH to ice cloud and indicates that high-intensity rainfall events are associated with systems that are deeper and of a greater spatial scale.