Evolution in Cloud Population Statistics of the MJO: From AMIE Field Observations to Global-Cloud Permitting Models Final Report

This is a multi-institutional, collaborative project using a three-tier modeling approach to bridge field observations and global cloud-permitting models, with emphases on cloud population structural evolution through various large-scale environments. Our contribution was in data analysis for the generation of high value cloud and precipitation products and derive cloud statistics for model validation. There are two areas in data analysis that we contributed: the development of a synergistic cloud and precipitation cloud classification that identify different cloud (e.g. shallow cumulus, cirrus) and precipitation types (shallow, deep, convective, stratiform) using profiling ARM observations and the development of a quantitative precipitation rate retrieval algorithm using profiling ARM observations. Similar efforts have been developed in the past for precipitation (weather radars), but not for the millimeter-wavelength (cloud) radar deployed at the ARM sites.

For the development and evaluate of the Ka-band ARM zenith radar (KAZR) based algorithm, two scanning precipitation radars (NCAR S-PolKa and Texas A&M University SMART-R), and surface precipitation during the DYNAMO/AMIE field campaign were used.

The resulting convective/stratiform classification from KAZR was evaluated against precipitation radars. Precipitation occurrence and classified convective/stratiform rain fractions from KAZR compared favorably to the collocated SMART-R and S-PolKa observations. Both KAZR and S-PolKa radars observed about 5% precipitation occurrence. The convective (stratiform) precipitation fraction is about 18% (82%). Collocated disdrometer observations of two days showed an increased number concentration of small and large raindrops in convective rain compared to dominant small raindrops in stratiform rain. The composite distributions of KAZR reflectivity and Doppler velocity also showed distinct structures for convective and stratiform rain. These evidences indicate that the method produces physically consistent results for the two types of rain.

A new KAZR based rain rate estimation was developed for both convective and stratiform rain was developed. A 1-dimensional, simple, steady state microphysical model is used to estimate impacts of microphysical processes and attenuation on the profiles of radar observables at 35-GHz and thus provide criteria for identifying situations when attenuation or microphysical processes dominate KAZR observations. KAZR observations are also screened for signal saturation and wet radome effects. The algorithm is implemented in two steps: high rain rates are retrieved by using the amount of attenuation in rain layers, while low rain rates are retrieved from the reflectivity–rain rate (Ze–R) relation. Observations collected by the KAZR, rain gauge, disdrometer and scanning precipitating radars during the DYNAMO/AMIE field campaign at the Gan Island of the tropical Indian Ocean are used to validate the proposed approach. The differences in the rain accumulation from the proposed algorithm are quantified. The results indicate that the proposed algorithm has a potential for deriving continuous rain rate statistics in the tropics.

The classified convective/stratiform precipitation identifier and surface rain rates have been generated and analysis for MJO cycles observed during AMIE/DYNAMO project.

References:

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