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Tropical Precipitation Studies: Combining Radar, Radiometer, and Radio Propagation Measurements

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This presentation aims to highlight research conducted primarily in the tropical location of Kolkata, India, near the land-sea boundary. The study is based on combined findings from radar, radiometer, and radio propagation techniques, focusing on the dynamics of tropical precipitation, the microphysics of rain, the impacts of aerosols, and instrument performance. Key aspects include characterizing rain microphysics, observations for nowcasting, atmospheric monitoring with radiometers, propagation impairment studies on Ka-band SATCOM links, rain attenuation and depolarization measurements using Ku-band signals, non-rainy attenuation estimation, and applications of ground-based microwave radiometers [1].

Experimental data from tropical regions emphasize the necessity for region-specific XPD models, particularly in under-researched tropical climate. Non-rainy attenuation, particularly from water vapor at 19.7 GHz, exceeds temperate levels in the tropics, making signal propagation more vulnerable.

Aerosols modulate rain microstructure: larger cloud effective radii correlate with smaller raindrops, while reduced anthropogenic aerosols during COVD-19 lockdowns, potentially altering DSD. Seasonal airflow patterns govern aerosol type and distribution, affecting precipitation processes.

Microwave radiometers are adept at monitoring the atmosphere under varying weather conditions by measuring brightness temperatures across different frequency bands. These measurements provide real-time profiles of atmospheric parameters such as temperature and humidity. The adaptation of radiometer retrieval techniques to varying weather and climatic conditions, especially in tropical regions, has significant implications.

The relation between radar reflectivity/rain attenuation and rain rate (R) varies based on origin, topography, and drop evolution. Convective rains, with significant presence in tropical tropical regions, are characterized by larger drops and distinct Z-R relationships compared to stratiform rain. Studies also observe vertical rain structure using space-borne and ground-based radars at a tropical location, utilizing data from the Global Precipitation Measurement (GPM) core observatory's dual-frequency precipitation radar (DPR) to analyze rain [2].

Multiple techniques, including micro rain radar (MRR), electric field monitor (EFM), radiometer, and disdrometer measurements, have been deployed to classify precipitation into stratiform and convective categories. The observations on the bright band structure by MRR and on differential brightness temperature at 31.4 and 22.23 GHz by a radiometer are utilized to classify mixed rain types.

The microphysical characteristics of Tropical Cyclone Biporjoy occurring, which formed in the Arabian Sea in 2023, were investigated using GPM data. A method was presented to determine rain DSD using a three-parameter gamma model based on GPM dual-frequency radar reflectivity measurements. This novel approach employs an optimization method to determine the most suitable μ–Λ relationship for observations during a GPM satellite pass without the need for local supporting data.

The above studies highlight the importance of localized *Z-R* models, multi-instrument datasets, and adaptive retrieval algorithms to improve tropical precipitation forecasting, satellite communication resilience, and weather prediction, especially for tropical regions.

1. A. Maitra and R. Chakraborty, "Prediction of Rain Occurrence and Accumulation Using Multifrequency Radiometric Observations," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 56, no. 5, pp. 2789-2797, May 2018, doi: 10.1109/TGRS.2017.2783848.

3. A. Maitra, G. Rakshit and S. Jana, "Three-Parameter Rain Drop Size Distributions From GPM Dual-Frequency Precipitation Radar Measurements: Techniques and Validation With Ground-Based Observations," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 60, pp. 1-11, 2022, Art no. 4110711, doi: 10.1109/TGRS.2022.3227622.