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Megha-Tropiques

In October 2011, the Megha-Tropiques satellite was deployed into orbit by a PSLV rocket. The satellite mission – a collaborative effort between Indian Space Research Organization (ISRO) and French Centre National d'Etudes Spatiales (CNES) – was aimed to study the water cycle in the tropical atmosphere in the context of climate change. A special section on 'Megha-Tropiques' presents a collection of articles highlighting how the data from the satellite contributes to our existing knowledge.

Balaji and Ramanujam (page 1627) propose a physically based algorithm for the retrieval of vertical cloud and rain structure from the MADRAS (Microwave Analysis and Detection of Rain and Atmospheric Structures) imager data of the Megha-Tropiques. Community developed meso-scale numerical weather simulation software (WRF), is used for simulation of thermodynamic, cloud and rain profiles for the case of a cyclone. The WRF simulated profiles are matched up with two of the rain-measuring instruments on-board the TRMM (Tropical Rainfall Measurements Mission) satellite, the TMI and the TRMM PR, to create a database of a priori cloud and rain profiles. These profiles are input to an in-house radiative transfer code. Brightness temperatures at MADRAS imager frequencies are simulated to complete the generation of a priori database. Retrievals of wind speed, column-integrated liquid water and surface rain rate done with sample MADRAS data and the results are compared against the Level 2 data of the Megha-Tropiques mission. A comparison of daily averaged rain rate with TMI retrievals is also made. The results show that the retrieval algorithm is robust and is able to retrieve the vertical cloud and rain structure even in the absence of a radar on-board the Megha-Tropiques.

Atmospheric water vapour is an important greenhouse gas that plays a major role in the hydrological cycle and radiation budget estimations. The SAPHIR, on-board Megha-Tropiques, an Indo-French mission, was launched in October 2011 with a prime focus on improving our understanding on the hydrological cycle and Earth's radiation budget by measuring atmospheric water vapour profiles using six microwave channels. Nevertheless, SAPHIR products need to be validated systematically, before they are used for scientific explorations/weather forecasts. Rao *et al.* (page 1635) focus on the evaluation of SAPHIR-derived humidity profiles against a variety of reference datasets, like measurements from GPS radiosondes and ground-based microwave radiometer, reanalysis datasets and satellite retrievals. They note that the bias and the rms errors are found to be small for near-nadir measurements than for those that are far away from the nadir. Further, the bias shows a clear height dependence with positive (negative) bias dominating in the lowest (uppermost) layers. The RH bias and rms errors are small (within 15%) in the middle layers, altitudes at which the sensitivity of SAPHIR channels is high. Comparisons with ECMWF interim reanalysis and advanced infrared sounder data, used to extend the evaluation of SAPHIR data to the entire tropics, reveal strikingly similar spatial and vertical structure in RH bias. Large biases are seen in regions adjacent to South America and Africa in the latitude band of 20–30°S and the large negative bias is seen along the Inter-Tropical Convergence Zone.

The potential of satellite-based microwave radiometer data is not completely explored over the land surfaces owing to the high and varying surface emissivities. Efforts have been made to quantify the land surface emissivities with reasonable

accuracy using theoretical models, ground-based, air-borne and satellite radiometric measurements. Among these, the emissivities derived from satellite data are found to be most suitable, as they account for the spatial heterogeneity of emissivity within the satellite footprint. These emissivities are not only useful for atmospheric parameter retrieval over the continental region, but also for studying the flood/drought extent, mineralogy mapping, identification of homogenous terrain for external calibration of space-borne radiometers, etc. Raju *et al.* (page 1643) explore the potential of 'MADRAS' payload for studying the land surface properties using polarization difference parameter and estimation of microwave land surface emissivities directly from MADRAS brightness temperature data. The derived emissivity is further used to characterize the microwave emissivity of different land surface classes. These are inter-compared with the emissivity derived from the operational TRMM Microwave Imager as well as emissivity climatology and are in reasonably good agreement.

Mathur *et al.* (page 1650) describe the operational retrieval of humidity profiles from microwave humidity sounder SAPHIR, launched on-board the Megha-Tropiques satellite, operating at six channels around 183.31 GHz. The operational algorithms have been developed based on radiative transfer simulations considering the varying observational geometry and different surface types incorporating necessary data quality parameters. The Layer-Averaged-Relative-Humidity (LARH) has been derived for six atmospheric layers from the surface to 100 mb under non-rainy conditions using SAPHIR channels only. The SAPHIR-derived LARH has been extensively compared with concurrent quality-controlled radiosonde observations as well as with ECMWF re-analysis

data. Global validation with radiosonde and comparison with ECMWF re-analysis show rms differences of ~15% and ~20% respectively, for all the six layers. More frequent data of atmospheric humidity profiles from SAPHIR over the global tropics under the non-rainy conditions are useful for the improved numerical weather predictions.

Sathiyamoorthy *et al.* (page 1656) highlight the computation of two important components of the earth-radiation budget, namely reflected shortwave flux and emitted longwave flux at the top of the atmosphere from the radiance measured by Scanner for Radiation Budget (ScaRaB) on-board Megha-Tropiques. A maximum likelihood estimation algorithm is used for identifying various earth and cloudy scenes. First, the raw radiances are corrected for spectral filtering effects followed by implementation of scene-type dependent angular correction to deduce shortwave and longwave fluxes. Results of the preliminary validation of ScaRaB flux data with Clouds and Earth's Radiant Energy System (CERES) on-board Aqua and Terra satellites suggest that the quality of the ScaRaB data is good.

The ISRO-CNES Megha-Tropiques is a unique satellite operating in a low inclined orbit for atmospheric and climate research in the tropics with high temporal observations. The only other mission exclusively devoted to the tropics is the US-Japanese TRMM, launched in 1997. Compared to the earlier Indian satellites, the realization of the spacecraft posed certain special engineering challenges chiefly due to its complex scientific payloads – their design and on-board configuration, the spacecraft design and configuration, special operational features in an inclined orbit, operation throughout the orbit and managing on-orbit operations. Three of the four science instruments needed *mechanical scanning*, thus causing significant mechanical disturbances at the spacecraft level. Apart from the conventional deployment mechanisms, one for each solar panel, the MADRAS and ROSA (Radio Occultation Sounder for Atmosphere) payloads also had to be incorporated with additional *mission-critical deployment mechanisms*.

The ISRO project team had the challenging but interesting task of interfacing with its partners in all the

tasks, specifically in realizing MADRAS, which was a joint development. MADRAS had several complex mission-critical units: MADRAS Scan Mechanism, used for rotating the MADRAS front-end at 25 rpm; the power and signal-transfer device (PSTD), having 92 contacts, interfacing functions of transferring power and signals between the rotating MADRAS RF Equipment (MARFEQ-A) and the static part; the hold-down and release mechanism, a new and mission-critical unit, designed to allow sufficient gap between the rotating and the fixed parts, during on-orbit rotation after release.

Another difficult task was to accommodate two 1.3 m-long ROSA antennas one each for the fore and aft directions. In the operational mode in space, they severely block the body-mounted spacecraft antennas. The configuration permitted the use of body-mounted antennas (before ROSA antenna deployment) only during and just after injection, thus needing to *switch over to the other pair of antennas* mounted on the ROSA antenna structure after ROSA antenna deployment in orbit. See page 1662.