Characterization of cloud microphysics during rainy events over the tropical coastal station using Microwave Radiometer and Micro Rain Radar observations

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Abstract

Collocated observations from Microwave radiometer profiler (MRP) and Micro rain radar (MRR) have been used to study the liquid water content variability and humidity variability during rainy convective events and thereby understanding the cloud microphysics owing to the penetration capability of microwaves into the clouds. The convective part of the cloud characterized with the large rain drops and intense rainfall and hence large reflectivity values distributed with in the entire column of the atmosphere from surface to ~ 6 km with maximum at the surface whereas stratiform part is characterized with the small rain drops and weak rainfall and hence lesser reflectivity values distributed at a particular altitude level between 5-6 km. The knowledge of rainfall associated with stratiform or convective clouds is important in observational, modeling, and remote sensing studies since the microphysical processes and latent heat release are different for these cloud types.

1. Introduction

Cloud microphysics involves the processes that lead to the formation of clouds and precipitation particles [1]. Proper understanding of the cloud microphysical and precipitation processes is critical for the simulation of weather and climate in atmospheric models [2]. Liquid water clouds play an important role in Earth's climate through the reflection, absorption and emission of radiation and hence accurate information of the cloud water content is highly essential to account for its radiative impact.

Remote sensing by ground based microwave radiometers is a potential tool to study the cloud liquid water (CLW) and integrated liquid water (ILW) in synergy with rain radars which provide rain rate and reflectivity derived from back scattered signals from hydrometeors.

2. Data and Region of study

Ground-based, passive, multi-frequency microwave radiometer profiler (MRP) is a very powerful tool to provide vertical profiles of atmospheric parameters with temporal resolution of 3 minutes up to 10 km under almost all-weather conditions. It measures brightness temperature through a sequential scan of 5 frequencies in the K-band (22.23 GHz-30.0 GHz) and 7 in the V-band (51.2 GHz-58.8 GHz) at seven different elevation angles (15^o, 30^o, 45^o and zenith) over two contrasting surfaces such as land and sea. A zenith looking infrared (IR) radiometer and a rain detector are also attached to the radiometer for estimating cloud base height and precipitation time, respectively [3].

MRR is a frequency modulated continuous wave radar operating at 24 GHz which measures the spectra of fall velocity of rain drops from which drop size distribution, reflectivity, rain rate, liquid water content etc. could be derived.

Thiruvananthapuram (also known as Trivandrum, TVM) located at 8.5°N, 76.9°E is an equatorial coastal station which experiences tropical coastal climate with moderate temperature influenced by the Arabian Sea. The hot and humid conditions prevailing over the region are very conducive for the formation of deep convection and these systems are the major sources of the significant rainfall over this region (~45% of the annual precipitation) [4]. Both MRP and MRR are operating over this region since 2010.

3. Figures

Figure 1 shows the CLW (top panel) and relative humidity (RH) (bottom panel) as observed from MRP on December 05, 2015 (rainy event). The figure shows that CLW enhances throughout the column of atmosphere during the convective part of the rain which is identified over the region from the threshold values of reflectivity (>39 dBZ) and rain rate (>12mm/hr) [4] at ~ 16:15 LT and lasts for 40 minutes followed by a convective rain whereas the CLW increases only at the particular altitude level of the atmosphere, between 5-6 km for stratiform part of the rain which is characterized by the less reflectivity values and weak rain rate as shown in the Figure 2 .

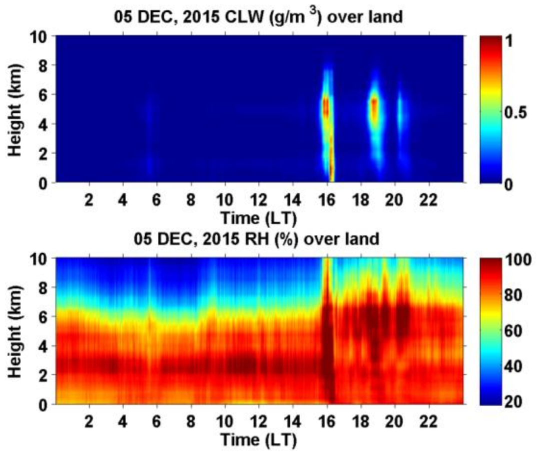

Figure 1. Cloud liquid water (CLW) distribution on a rainy event on 05 December 2015 from MRP (top panel). Corresponding Relative humidity (RH) variability from MRP (bottom panel).

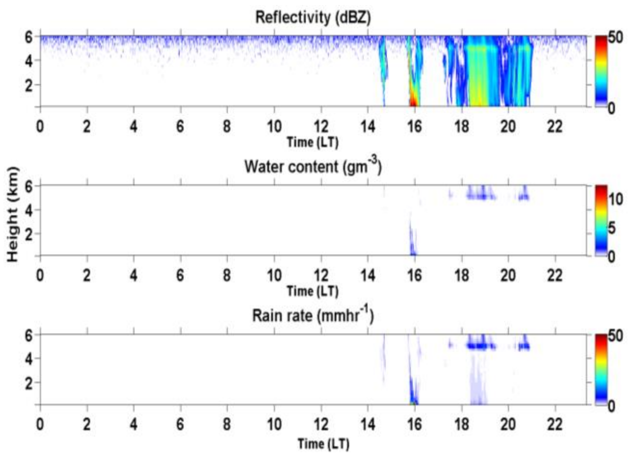

Figure 2. The top panel shows the reflectivity values on 05 December 2015 from MRR. The middle panel shows the cloud water content distribution on 05 December 2015 from MRR. The bottom panel shows the rain rate on 05 December 2015 as observed from MRR.

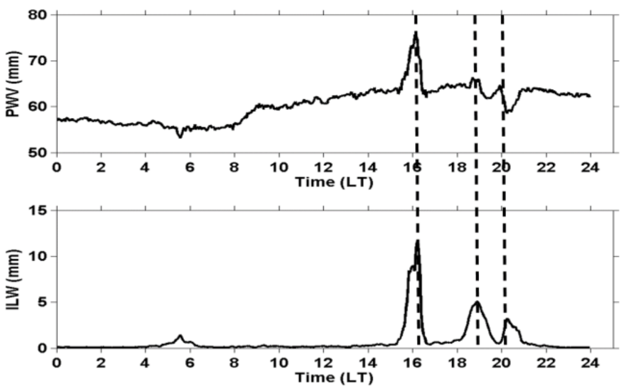

Figure 3. Precipitable water vapor (PWV) distibution on a rainy event on 05 December 2015 from MRP (top panel). Integrated liquid water (ILW) variability on a rainy event on 05 December 2015 from MRP (bottom panel). Black dashed vertical lines indicate time of rainfall.

Figure 3 shows the increase in precipitable water vapor (PWV) from 65 mm to 75 mm for convective part of the rainfall which is indicated by the dashed black line at ~16LT and followed by a stratiform rainfall at ~ 19 LT where the PWV shows a small enhancement. Integrated liquid water also shows increase of ~ 12mm during convective rain. Hence by combining observations from ground based microwave radiometer and micro rain radar, microphysics of different type of precipitation regimes from convective to mixed phase, warm to light rain and their physical processes can be addressed.

5. Acknowledgements

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6. References

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