Characteristics of cloud vertical structure over Western Ghats using ground based cloud radar

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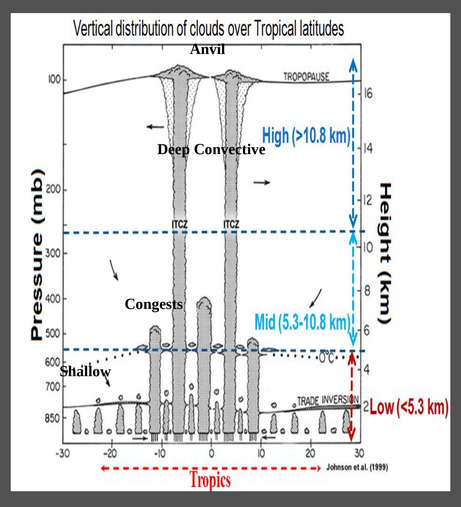
1. Introduction and Motivation

Vertical Structure of Cloud (VSC) : single parameter which can link both the cloud macro-physical and microphysical properties; provides information on the tri-modal tropical convection, besides other layered cloud type.

The VSC is also connected to the monsoon phenomenon namely low-level jet, tropical easterly jet, monsoon rainfall. Hence, the differences in genesis, processes, and the evolution of various tropical clouds can be explored through their vertical structure.

Till date, the characterization of the vertical structures of tropical cloud and precipitation systems using radiosonde /rawinsonde from the global and local aspects (Wang, 1999, 2000; Poore et al., 1995; Zhang et al., 2010, 2014) as well as TRMM and CloudSat/CALIPSO data (Masunaga et al., 2005; Liu and Zipser, 2005; Haynes and Stephens, 2007; and Zhang et al., 2007).

These obs. fails to study the cloud evolution and the monthly variation of VSC



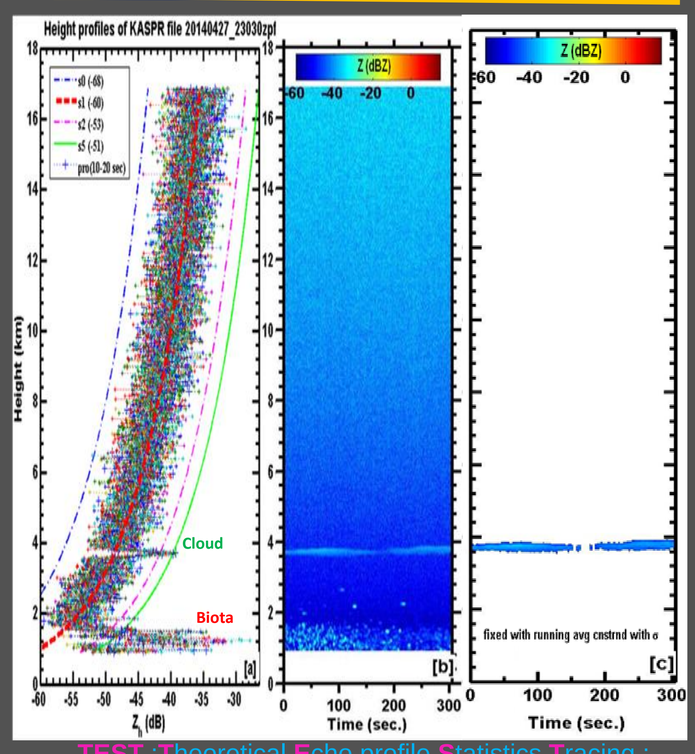
Cloud vertical structure from **ground based radar observation** provides a complete and holistic picture, facilitating better interpretation of cloud processes

2. Observational System and Data sets

IITM's Mobile Ka-band Scanning Polarimetric Doppler Radar (XSPR & KaSPR) are a cloud radar respectively that are being operational from 2013 at a tropical elevated site (Mandhardev, 18.04^0 N, 73.87^0 E, 1.35 km AMSL). KaSPR is a Doppler radar operating at wavelength of 8.5 mm with average powers of 110 W. Cloud radar is having sensitivity of the order -45 dBZ at 5 km. KaSPR is capable to make versatile operational and scanning modes and have been providing high sensitivity versatile measurements of tropical cloud and precipitation. KaSPR zenith looking observations and Complemented observations of FM-CW Micro rain radar, Disdrometer and rain gauges at radar site will be used for meeting the objective.

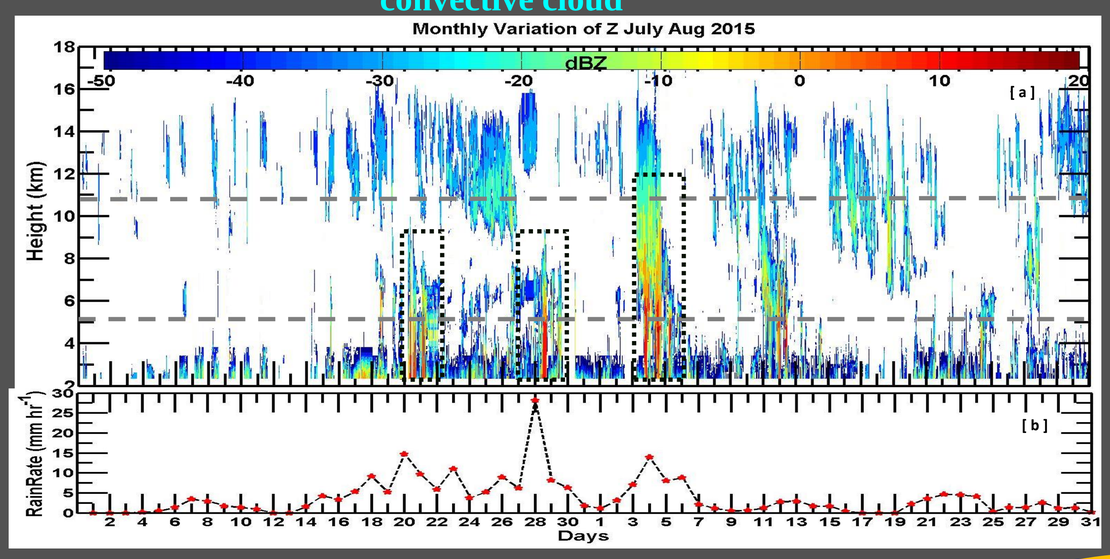
- ❖vertical profile of reflectivity (VPR) :proxy for VSC
- ❖Spatial Resolution : 25 meter
- ❖ Time resolution: 1 second
- ❖Year : MJSO 2013,MJJA 2014, JJAS2015

(>10 million profiles)



TEST :Theoretical Echo profile Statistics Tracing ; Kalapureddy et al.,(2018)

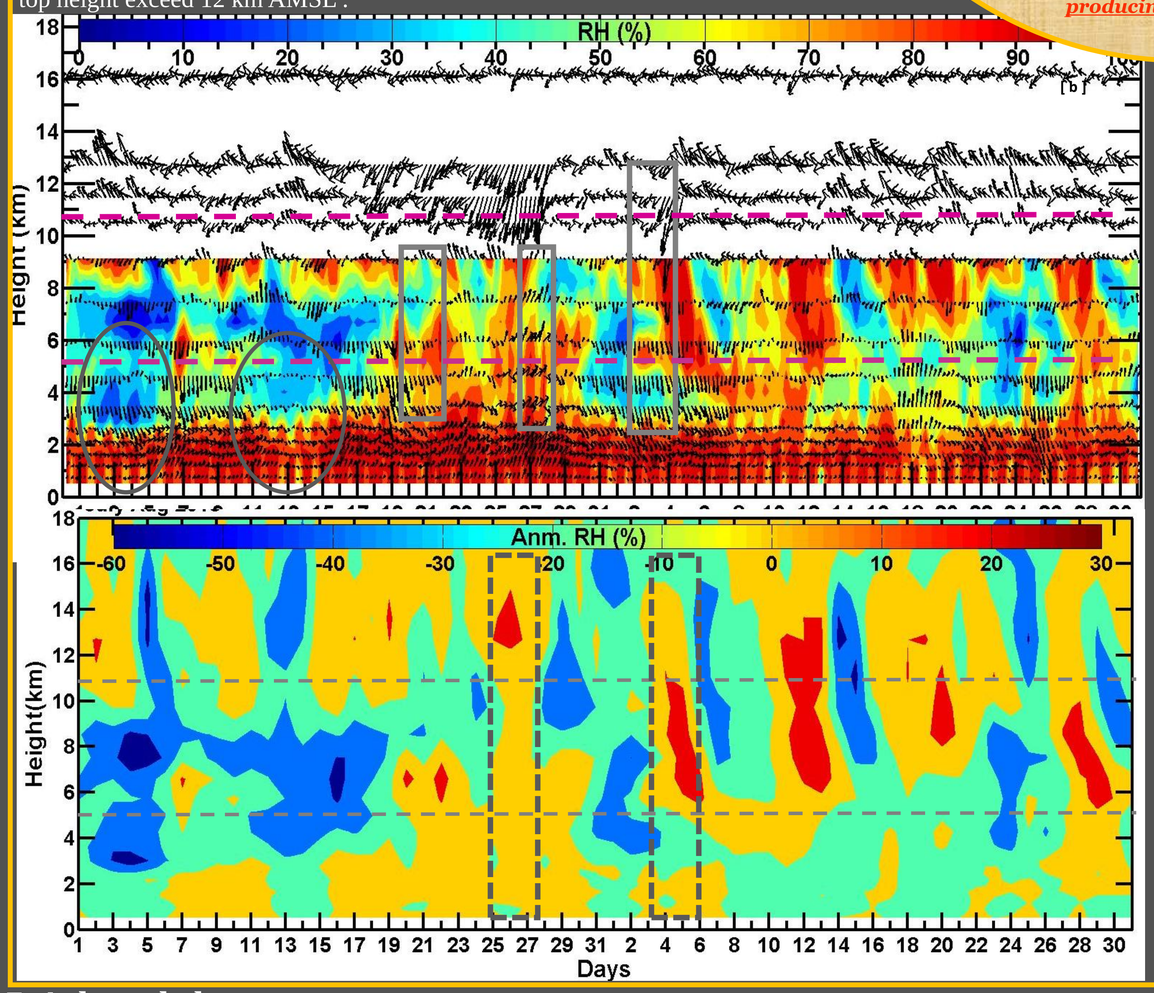
3. VSC : Transition of shallow to cumulus congests and then deep convective cloud



- Shallow cloud or no cloud at all for the first 16 days with meager presence of cirrus
- Formation to Cumulus congests on 21, 22 and 29 July
- Cirrus thickness also increases and its base comes below 10km when dBZ>-20, Ice sedimentation at the beneath of the cirrus cloud (Nair et al. 2012).
- Deep convection on 4 and 5 Aug after 5 days of occurrence of congests (Hohenegger and Stevens, 2013; Benedict and Randall, 2007)
- Rain accumulations are >5mm on congestus and deep convection day (28July Max rain acc)

4. RH & Anomalous RH : ECMWF July Aug 2015

- Mid level moistening on the day of occurrence of congests and deep cloud.
- Absence of low level cloud whenever there is weakening of low level westerly with RH<20% at the mid level (3-8 km)
- Dynamical feedback from upper level easterly to low level westerly during deep convective cloud.
- Anomalous RH shows columnar humidity is responsible for maximum rain accumulation, where as positive anomaly of RH (>20%) is important for cloud top height exceed 12 km AMSL .



5. Frequency Distribution of tri-model cloud regimes: 2013-2015

2013

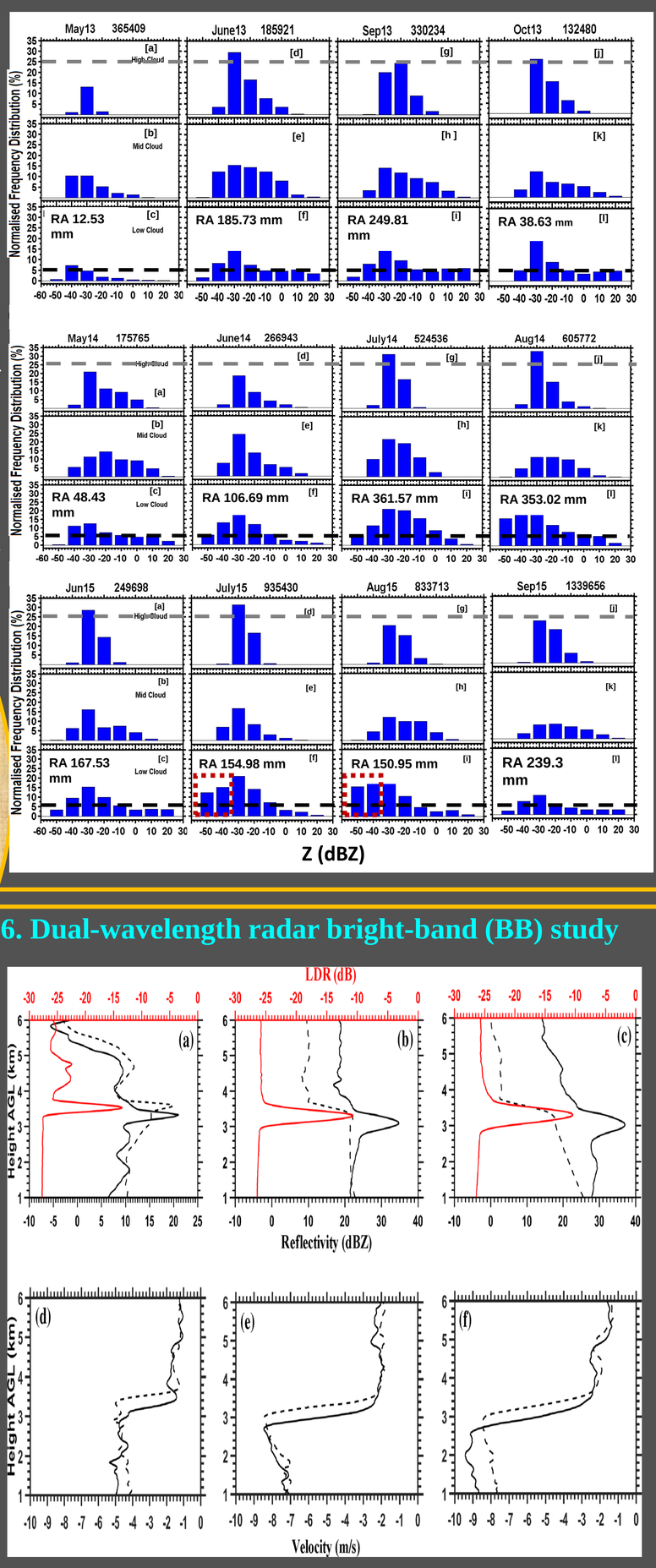
- Less occurrence (7%) in May
- Bimodal distribution : Monsoon with secondary peak (>5%) for precipitating cloud occurrence
- Less rain in May more in monsoon .

2014

- Bimodal Dist: May: high rain compared to May 2013 : more high dBZ occurrence
- Mono-modal distribution: dominance of non precipitating clouds i.e. high occurrence of negative dBZ : deficit monsoon rainfall

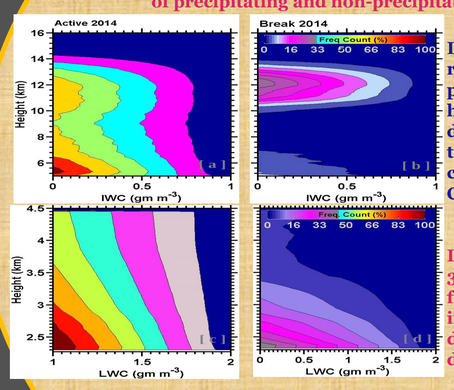
2015

- More occurrence of Weak non precipitating clouds : severely deficit monsoon rainfall



7. Summary and conclusion

1. From 2013-2015, there is a subsequent increase of shallow cloud occurrence or no cloud regimes and decrease in the occurrence of CC or deep cloud with the below normal performance of ISM.
2. Frequency distribution of Z at the low-level indicates the dominance of precipitating and non-precipitating regimes.



3. Two times high value of IWC during active days represents more ice growth processes which results in heavy rainfall whereas during break days 70% time there is no ice phase contribution in the total CVS.
4. One order less value of LWC that too limited below 3.2 km is the causative factor for cloud top inhibition below that height during break days and also deficit in rainfall.

Hence, mid-level moistening by the occurrence of CC and generation of deep cloud plays vital role in the increment of the rainfall accumulation during monsoon . Role of ice phase processes at the high level also significantly important in producing heavy rain .

6. Dual-wavelength radar bright-band (BB) study

1. BB has a more well pronounced structure in XSPR reflectivity than KaSPR
2. The BB peak intensity (except for KaSPR in heavy rain event) and thickness increase while the peak height falls with an increase in precipitation intensity from very light to heavy rain
3. The BB region detected at Ka-band is always narrower and situated at a higher altitude (266, 141 and 91 m higher in very light, light and heavy rain, respectively) than XSPR reflectivity profiles
4. LDR (-22 dB) from KaSPR can be utilized to detect and determine the bright band features.

Dual wavelength, KaSPR (dash) and XSPR (solid), radar measurements

Reference: Hari Krishna Devisetty, Ambuj K Jha, Subrata K Das, Sachin M Deshpande, U V Murali Krishna, Prasad M Kalekar and G Pandithurai (2019): A case study on bright band transition from very light to heavy rain using simultaneous observations of collocated X- and Ka-band radars, J. Earth Syst. Sci. (2019) 128:136

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