Convection and parameterization

from observations

for models

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Disclaimer:

This is a discussion and not a formal presentation.
Please feel free to interrupt, ask questions & give suggestions when clarity is missing.

Broad Theme: Multiscale nature of convection focusing on the relationship between

- Synoptic scale forcing & MCS
- MCS & storms
- Diurnal forcing over land

Data used:

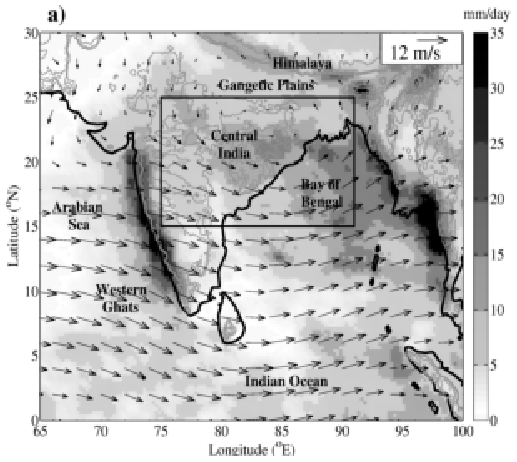
1. INSAT Kalpana IR data for the years 2010,2012-16
   Temporal resolution: 30 minutes
   Resolution at sub-satellite point: 8 km x 8 km

2. IMD DWR Data: 2012 (CTCZ Program)
   2016 (INCOMPASS)

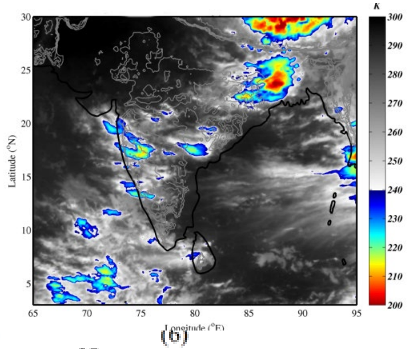
3. ERA5 reanalysis products

Definitions/terminologies:

1. **Synoptic scale forcing: 850 hPa vorticity averaged over the box area is used as a proxy.**

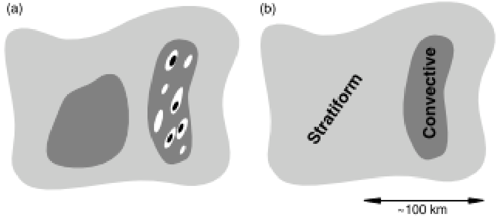


EV→ Enhanced vorticity phase > 2x10^{-5} s^{-1}
SV→ Suppressed vorticity phase < 2x10^{-5} s^{-1}

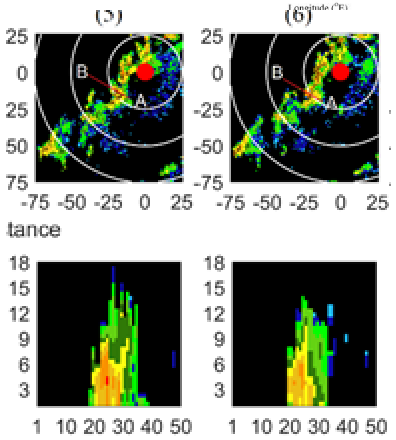


2. **MCS** : Based on TB threshold of 208 K in IR imagery, and square root of the area of connected pixels > 100 km; life>=3 hrs.

3. **Storm**: **Connected convective pixels in a 3D radar Ze field with Ze >30 dBZ and volu** … **n et al. 1993). Convective Cell**

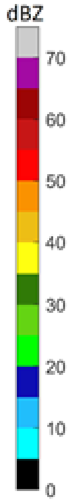


(Schematic of MCS, *Houze*)

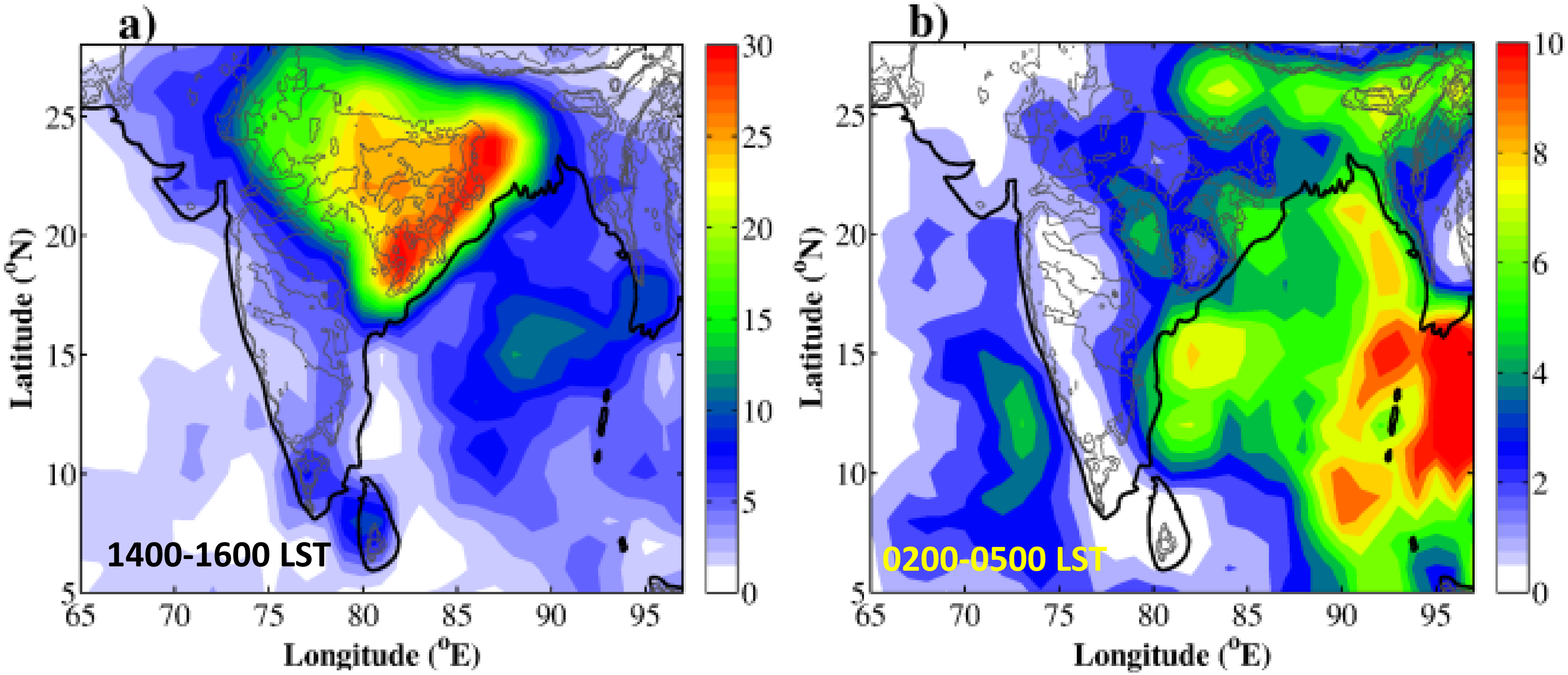


Projection of max Ze

Vertical section



Q1: Where & when MCSs are triggered? Traced back to when size was 2000 km^2.



Key points:

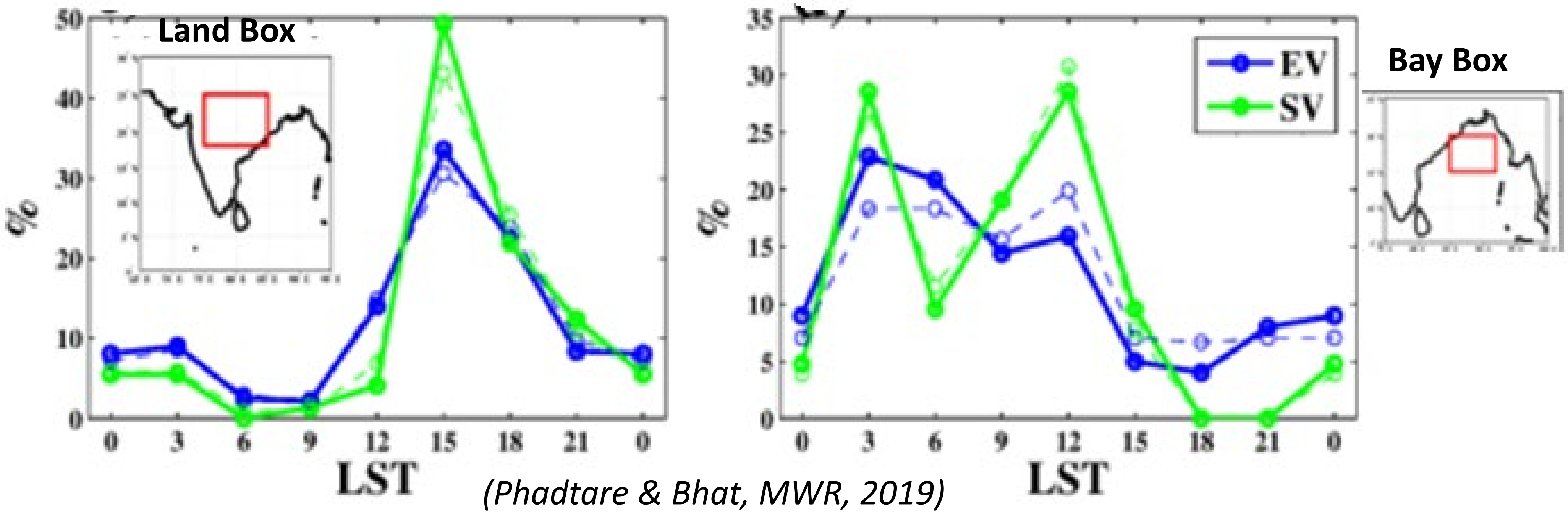
1. DV is everywhere
2. Orography seem to have a role in triggering
3. Also tied to diurnal forcing

Total number of CSs triggered per 1° x 1° box during (a) 1400-1600 LST, and (b) 0200-0500 LST, divided by the time interval in hours.

Contour lines are surface elevations drawn at 500 m interval.

Note that scales in panels a) and b) are different.

Q2: Is diurnal dependence of CS triggering different during strong & weak synoptic forcing?



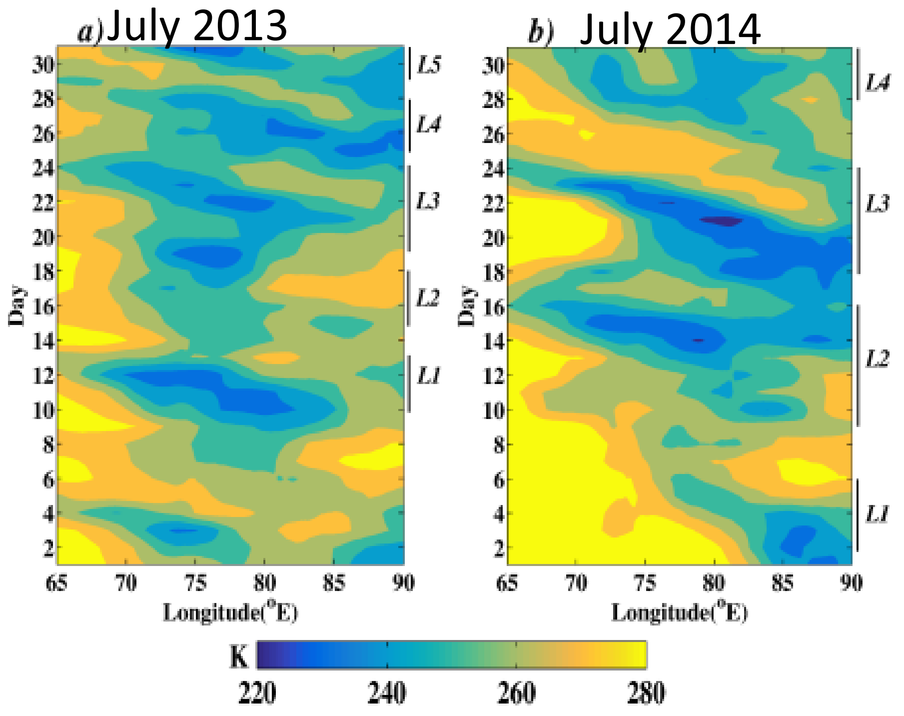
(Phadtare & Bhat, MWR, 2019)

Key Points:

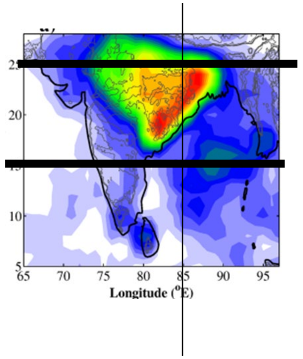
1. **Over land, irrespective of synoptic forcing, maximum number of MCSs are triggered in the afternoon hours.**
2. **Over the BoB box, maximum numbers are triggered ~3 a.m. during both EV & SV. SV also has a preferred time around noon.**

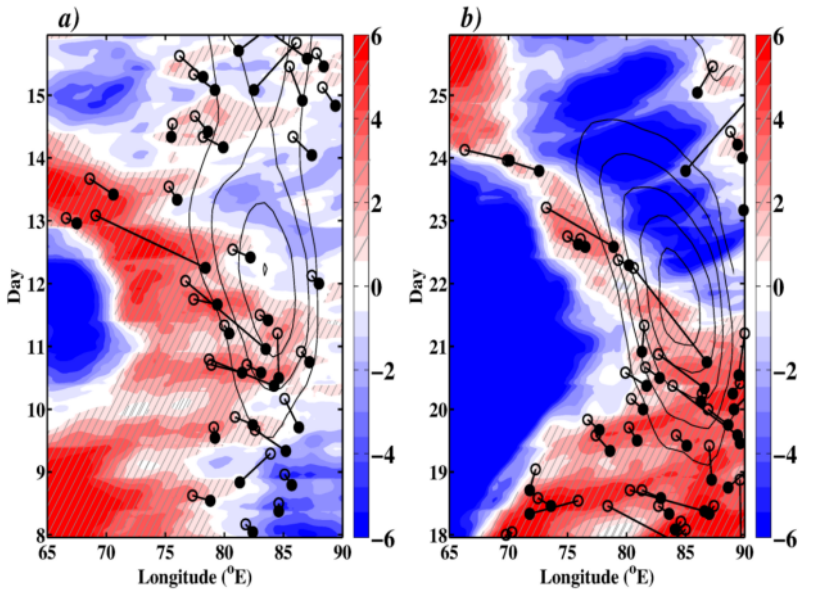
- **Synoptic forcing field is present (I suppose) for several days.**
- **We have seen a prominent role of diurnal forcing.**

Q3: What is the interplay between synoptic forcing & diurnal cycle over land?

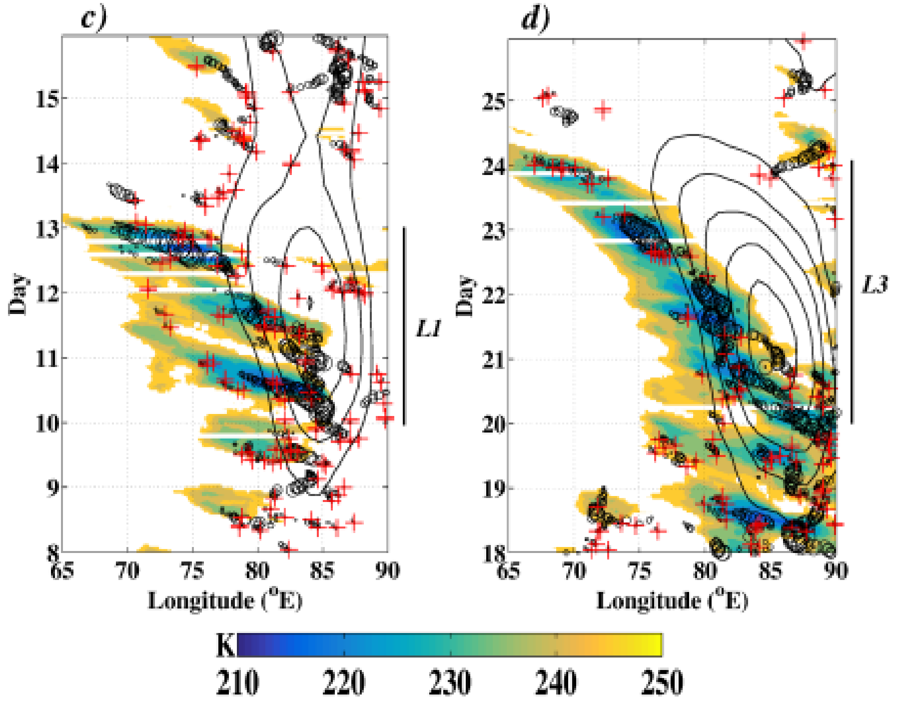


Longitude-time Hovm¨oller diagram of IRBT (in shading) averaged between 15◦N-25◦N.





total column water vapor



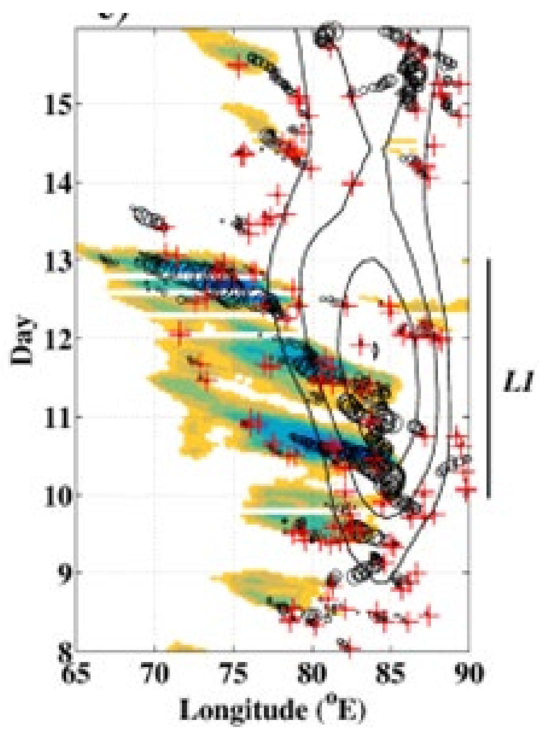
Zoomed-in view. IRBT > 250 K not shown.

CSs triggering ('+' sign) and their subsequent positions (black circles). Radius of the circle proportional to the size of the CS at that instant.

The contour lines: relative vorticity at 850 hPa averaged over same latitudinal band. Contours from 2×10^{-5} to 4×10^{-5} s^{-1}, at an interval of 0.5×10 10^{-5} s^{-1}

(Phadtare & Bhat, MWR, 2019)

Westwards of 85°E (i.e., mainly over land), CSs develop in the afternoon hours preferentially in the western flank of ζ850 field where the gradient in ζ850 is high. Thereafter, CSs propagate westward and move out of the zone of high ζ850 region and dissipate around mid-night when diurnal forcing becomes weak and surface conditions are less favorable for deep convection. Propagation of CSs is mainly zonal (westward) and meridional propagations are not that prominent (Fig. 4). Next day around mid-day, CSs develop in areas having large ζ850 gradient and around/behind the longitudes where the previous day's CSs had dissipated, and the cycle repeats. Each day, formations and westward propagations of CSs take the large-scale cloud envelop westwards.

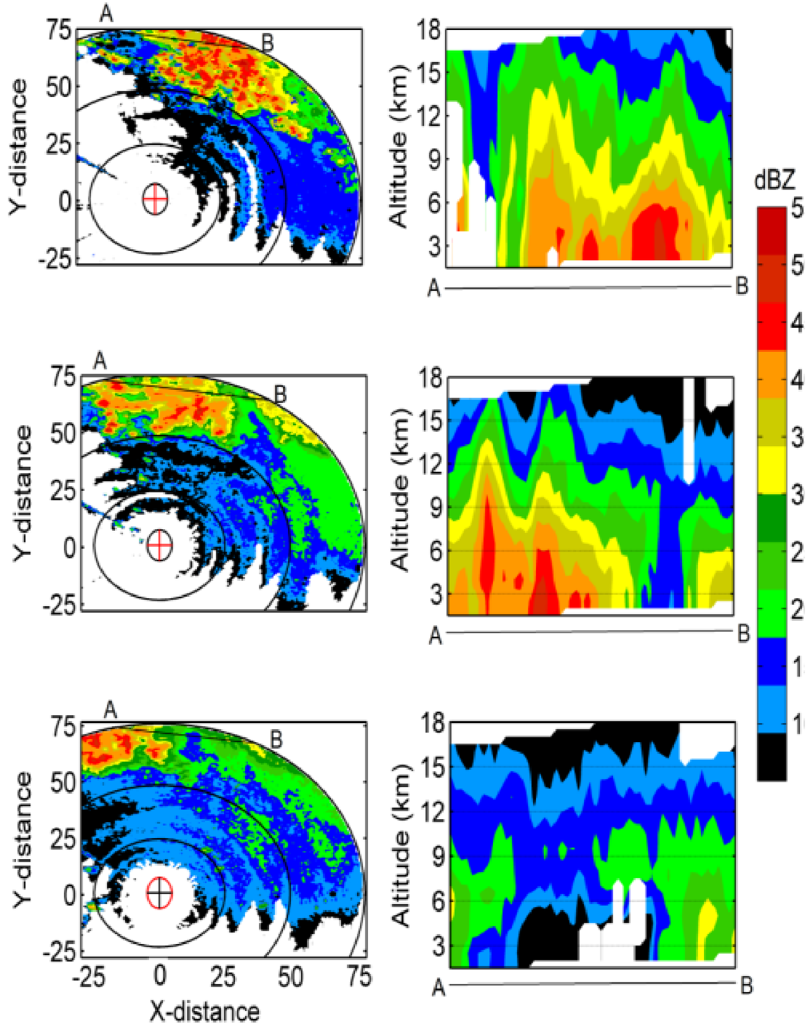


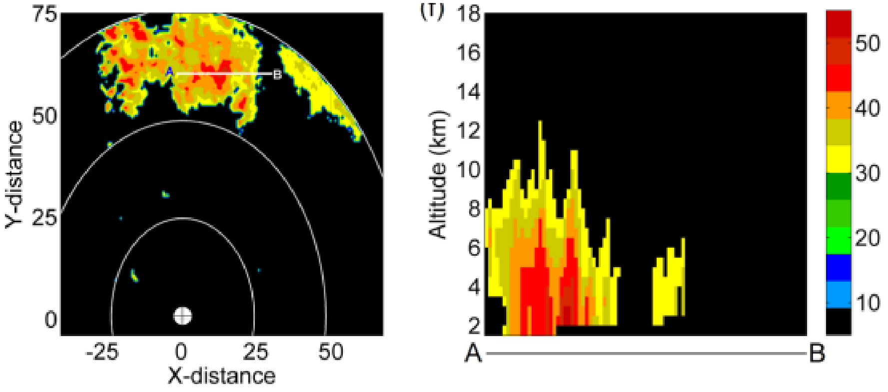
Secondly, the CSs have a wider range of propagation speeds with an average speed of 7.5 m s^{-1}. This discrepancy between speed of propagation of CS and cloud-streak is due to the stron upper-level easterly jet which is invariably present during the monsoon season (Fig. 1b) that rapidly advects stratiform cloud mass westwards.

Thirdly, the vorticity field which is associated with the synoptic system, propagates westwards at a slower speed of around 2-3 m s^{-1}.

Broadly, three types of propagations are embedded. Firstly, deep cloud cover that spreads further westwards of CSs (which sometimes is called a 'cloud-streak', e.g., Carbone et al. (2002)). Average speed of the streaks is around 20 m s^{-1}.

(Phadtare & Bhat, MWR, 2019)

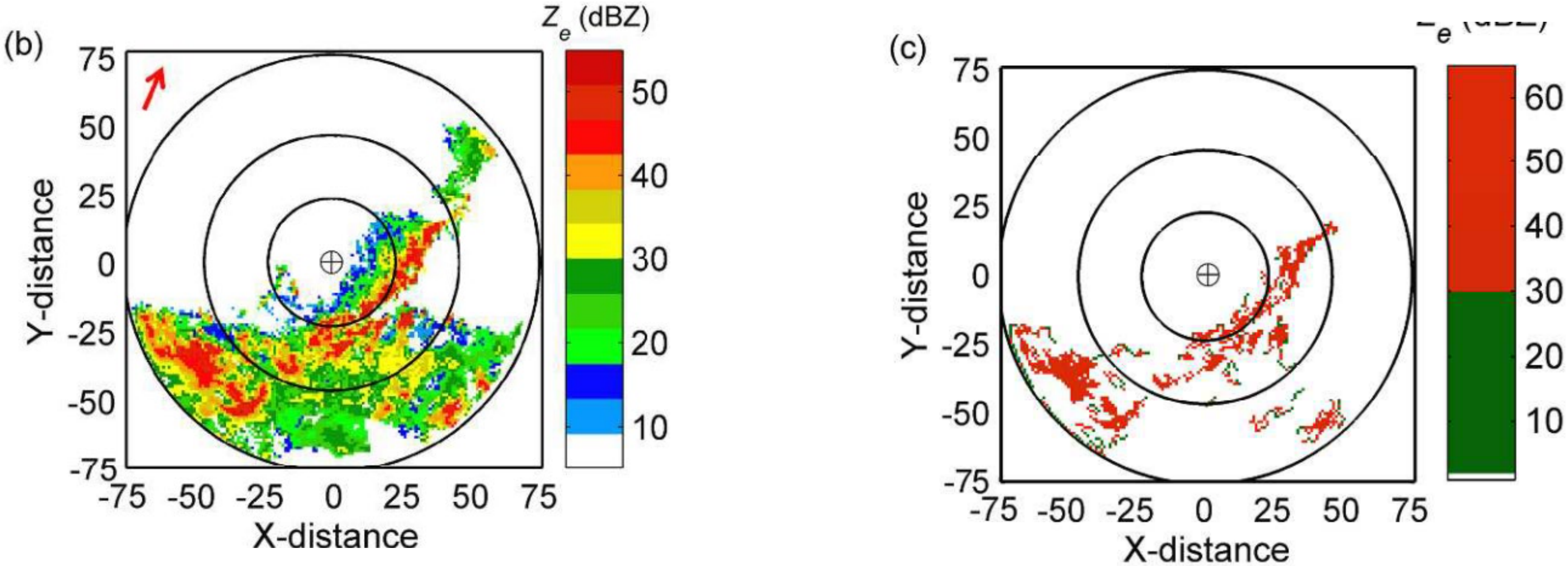


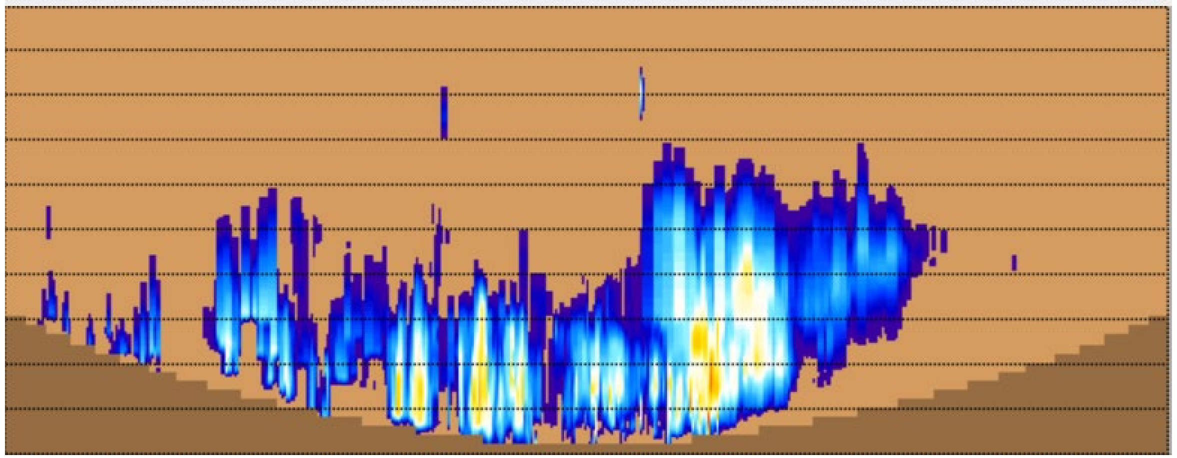


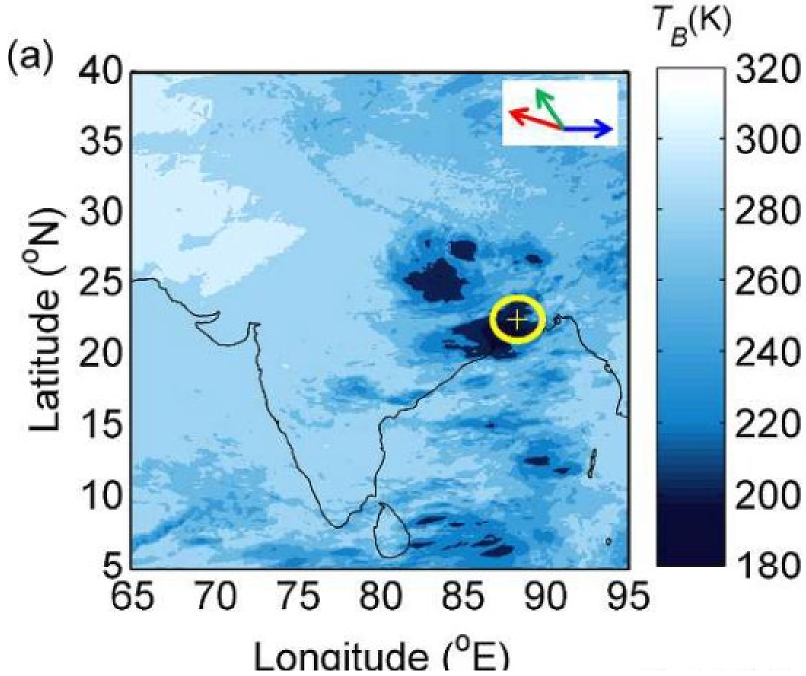
Left panel shows the projection of column maximum Z h . Right panel a vertical section long line AB shown in left panel. Date is 11 June 2013 and top, middle and lower panels were observed at 0530 IST, 0630 IST and 0730 IST, respectively.

Storm: an intense convective cell.

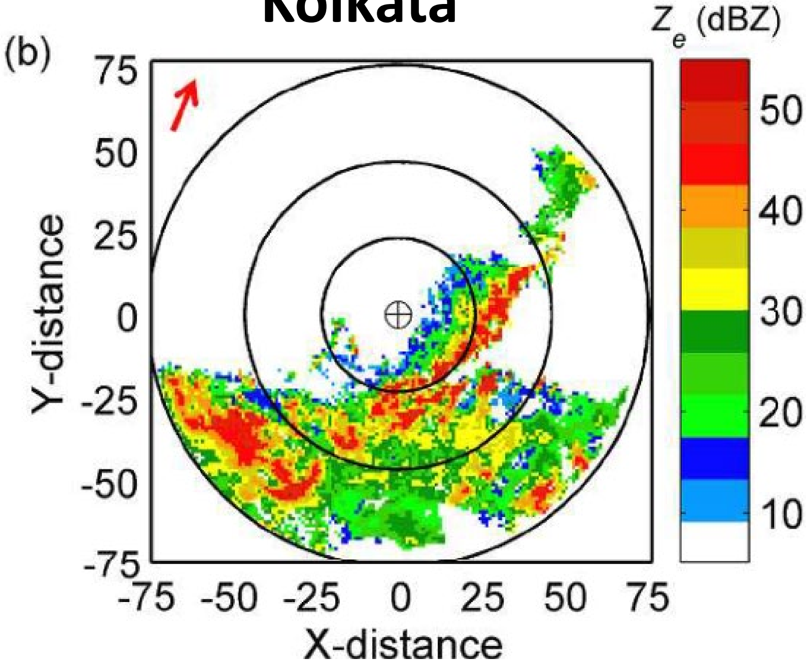
Connected convective pixels in a 3D radar Ze field with Ze >30 dBZ and volume > 50 km^3 (Dixion et al. 1993)





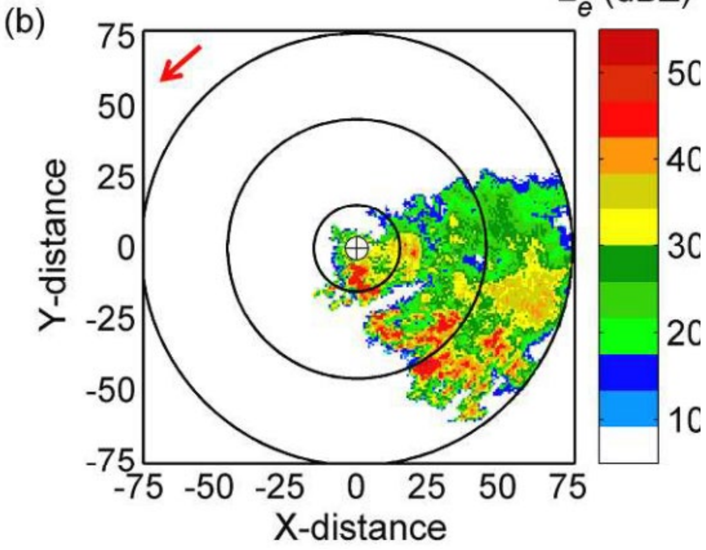


Kolkata

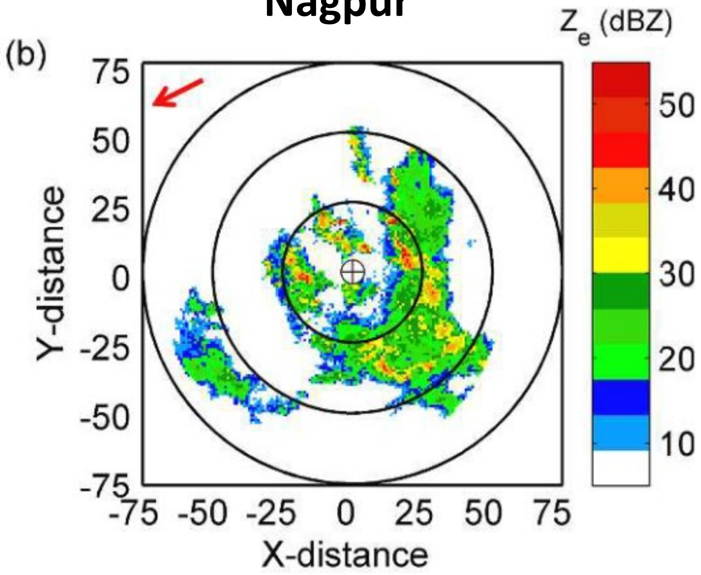


Examples of MCSs seen by DWR in different parts of India (*Sindhu & Bhat, QJRMS* 2018)

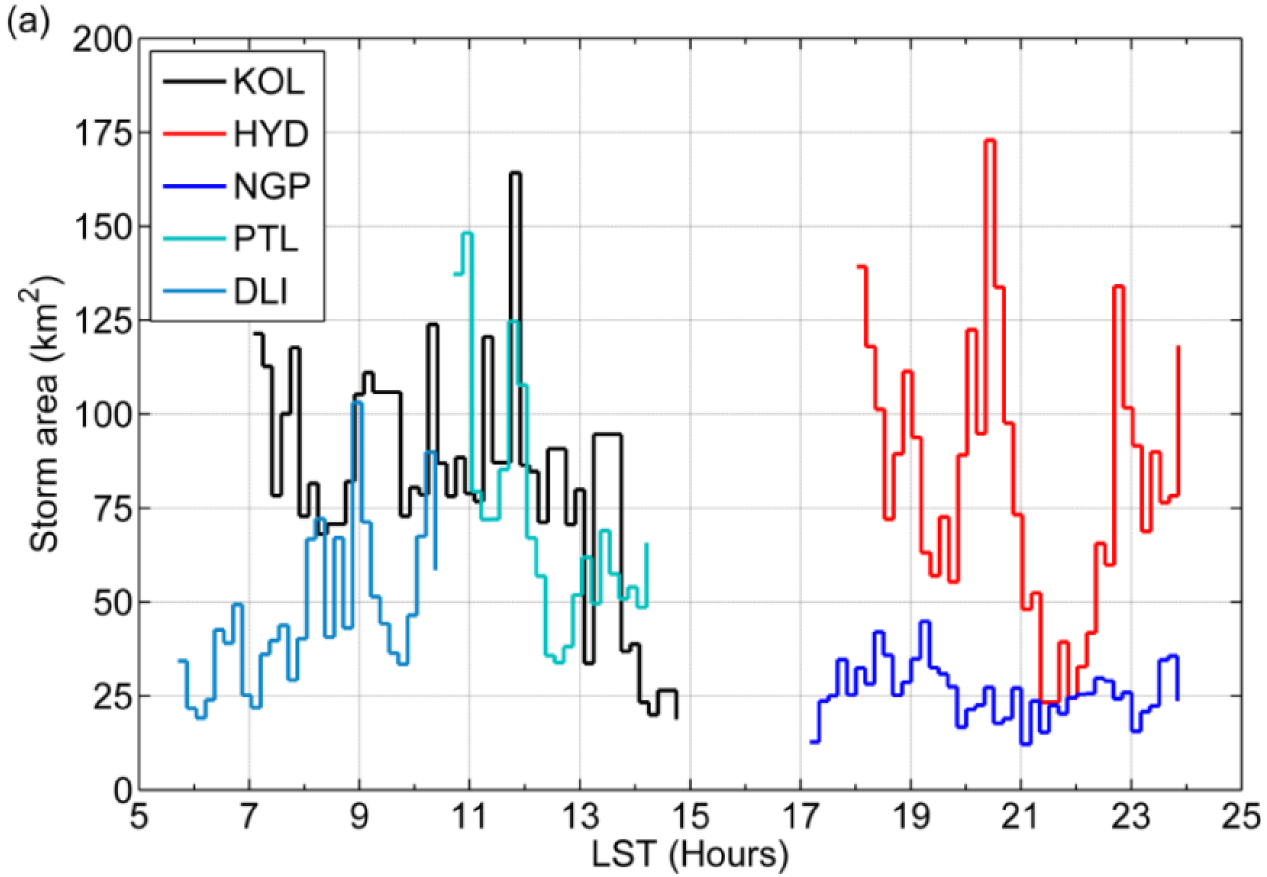
HYDERABAD



Nagpur



Storm in MCSs are identified & tracked.



1. Storms occupy 31-71% of the convective area and contribute 90-97% of the convective precipitation.

2. Average storm area in monsoonal cloud systems varies from ~20 to 170 km^2 .

- **Storms are made of a cluster of Cb clouds**
- **Major fraction of convective rain is from storms**
- **Size ~ grid of a GCM/regional model**
- What it means for CP? Especially when laterally entraining plume model of cloud is assumed?

Thank you