



Thunderstorms

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Scales of systems (Space):

Planetary scale : Characteristics horizontal length ~ 5000 km

Synoptic scale : Characteristics horizontal length ~ 1000 km

Meso-scale : Characteristics horizontal length ~ 100 km

Micro scale : Characteristics horizontal length ~ 1 km



Scales of systems (Time):

Planetary scale : Characteristics horizontal length ~ 5 days or more

Synoptic scale : Characteristics horizontal length ~ 1day

Meso-scale : Characteristics horizontal length ~ 5 hrs

Micro scale : Characteristics horizontal length ~ 10 minutes

In general, larger the horizontal length scale, longer is the time scale



Importance of Meso-scale systems

- ❖ Hazardous weather
- ❖ Synoptic scale systems in tropics derive most of their energy through meso-scale systems
- ❖ Difficult to capture with synoptic scale observations
- ❖ Due to importance of meso-scale systems, international efforts have been made for special studies
- ❖ FDP STORM has been taken up by SAARC countries



Tropical Convection

- Convection: Mesoscale in Nature

Horizontal scale of ~ 10 sq km

Vertical extent averaging ~ 15 km

Time scale of about 1-6 hr

- It interact with large-scale flow results in the development of mesoscale convective systems like **SEVERE THUNDERSTORMS** and associated severe weather phenomenon like **HAIL STORMS, SQUALL & Lightning.**



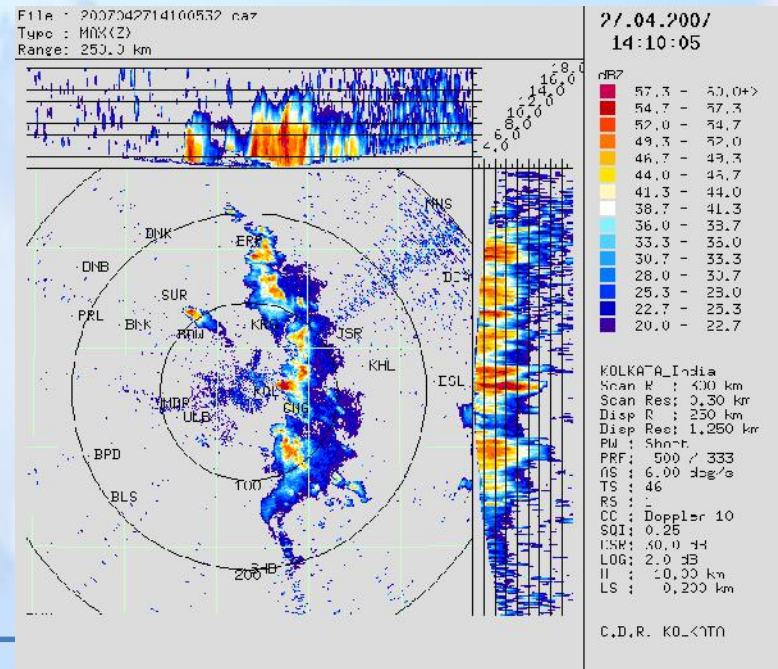
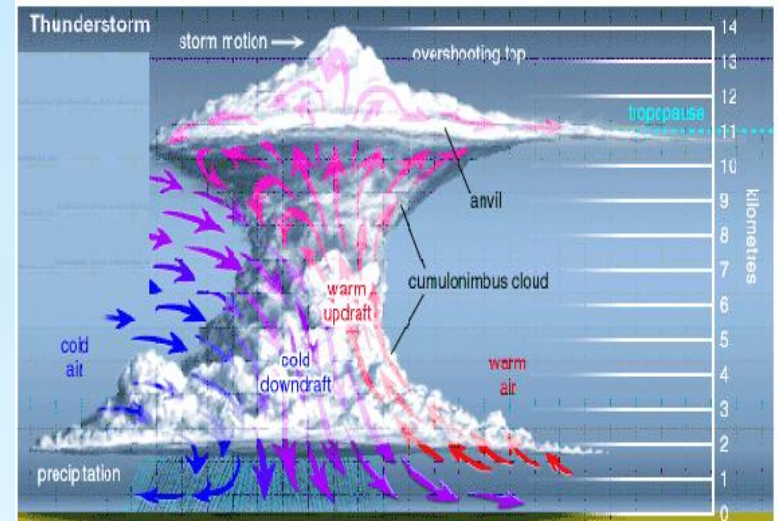
Thunderstorm

☐ Moderate Thunderstorm

Loud peals of thunder with frequent lightning flashes, moderate to heavy rains and maximum wind speed 29 to 74 kmph

☐ Severe Thunderstorm :

Continuous thunder and lightning, heavy rains and maximum wind speed ≥ 75 kmph

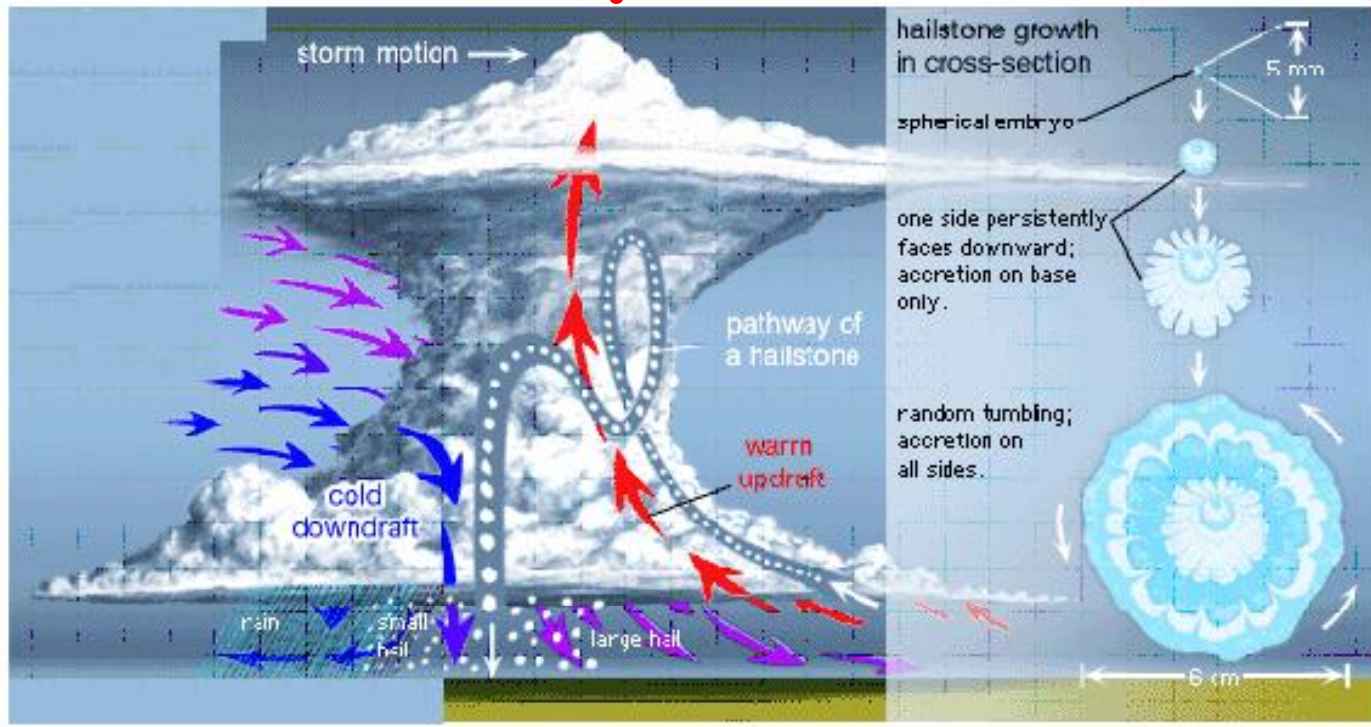


Thunderstorm

- ❑ These are the most violent convective systems in the atmosphere and are associated with cumulonimbus (Cb) cloud.
- ❑ One of the ingredients needed for thunderstorm development is moisture, preferably in the lower and mid levels.
- ❑ Originate mainly over the heated land masses that heats up the air mass above it and initiates convection.
- ❑ In India, these thunderstorms reach severity when continental air meets warm moist air from ocean.
- ❑ The eastern and north eastern part of the country gets affected by severe thunderstorms mainly during April-May.
- ❑ The presence of upper level shear adds severity to the storm since it differentiates the zone of the updraft from the zone of downdraft at this stage. It also extends the life time of the cell.



Squall



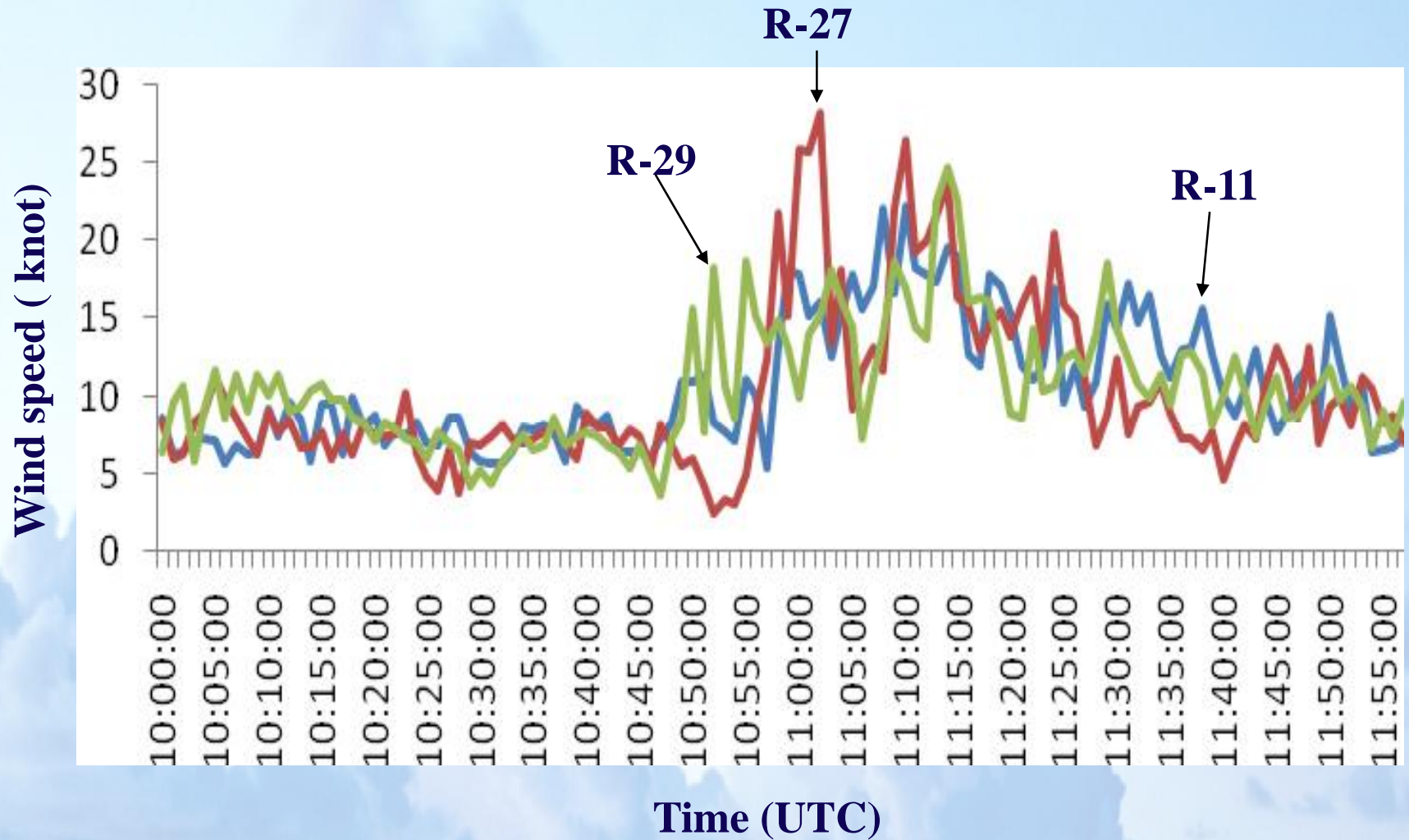
SQUALL: A sudden increase of wind speed by at least 29 kmph(16 kts), the speed rising to 40 kmph (22 kts) or more and lasting for at least one minute

Moderate: Surface wind speed (in gusts) upto 80 kmph

Severe: Surface wind speed (in gusts) > 80 kmph



Wind speed recorded at different Runways (R-29,R-27,R-11) during thunderstorm and squall on 22.10.2010.

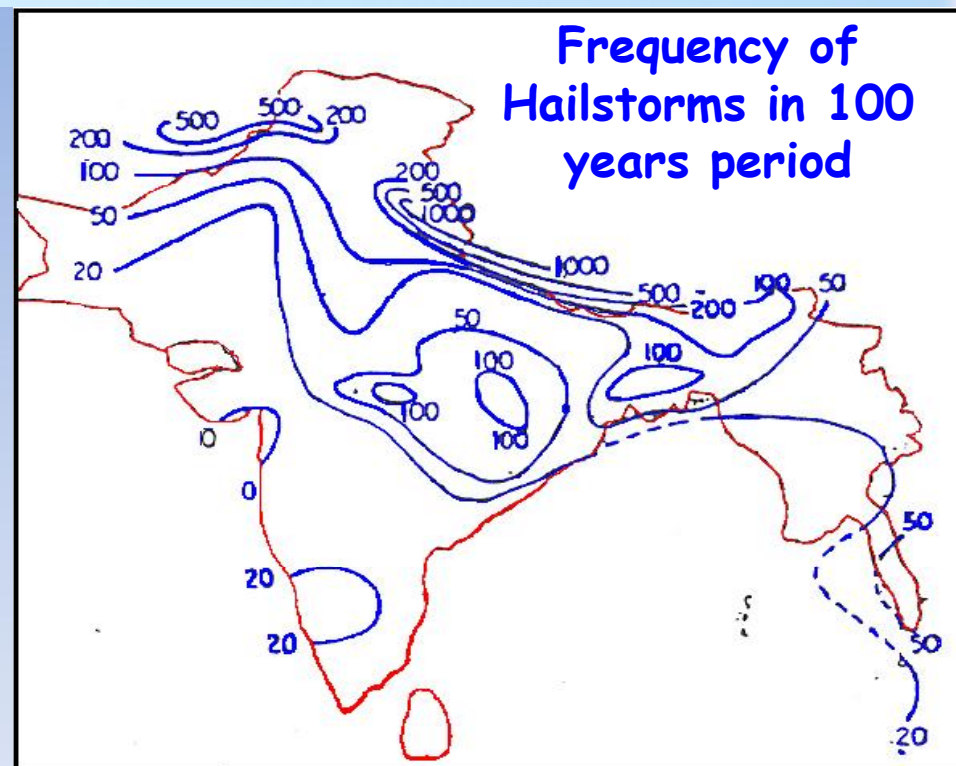


Hailstorm

Slight Hailstorm :
Sparse, usually small size
and often mixed with rain

Moderate Hailstorm :
Fall abundant enough to
whiten ground

Heavy Hailstorm :
Includes at least a
proportion of large stones



Duststorm

- ❑ Duststorms, which are raised dust in the air occur only in the plains of Northwest India. Locally these are known as 'ANDHIS'.
- ❑ Duststorm activity starts in April and continues up to June. Their frequency of occurrence is at maximum in June.
- ❑ On a few occasions duststorms are followed by thundershowers.
- ❑ Intense surface heating, western disturbances and westerly trough are the causes of duststorms.



Duststorm

Duststorms may be categorized into two types namely

(i) The Pressure Gradient Type and (ii) The convective type.

- ❑ **Pressure gradient type thunderstorm:** When the seasonal low pressure area over NW India becomes marked strong gradient builds up to the south of the low causing strong winds (about 30 kts). These strong winds raise the dust particles in the air reducing the visibility below 1.0 km such pressure gradient type duststorms occur frequently over Rajasthan in May and June. .
- ❑ **Convective type thunderstorm:** It occurs in the later part of the day or night. In this type of duststorms the dust particles are raised by the down draft winds of Cb-clouds in such cases the dust particle may go up to a height of 2 to 3 kms. Convective type duststorms often go before thunderstorms.



KALBAISAKHI / NORWESTERS

- The eastern and northeastern parts of our country i.e Gangetic West Bengal, Jharkhand, Bihar, Orissa, and States in NE India get affected by severe thunderstorms during pre-monsoon months of March to May.
- These storms usually travel from northwest to southeast direction and are called "Norwesters". They are locally known as "Kalbaisakhi".
- These severe thunderstorms have very significant socio-economic importance for eastern and northeastern parts of the country.



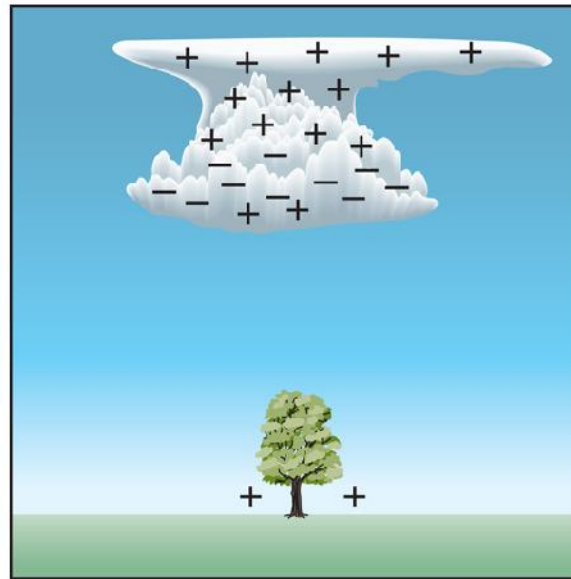
Lightning

Source of lightning: the cumulonimbus cloud

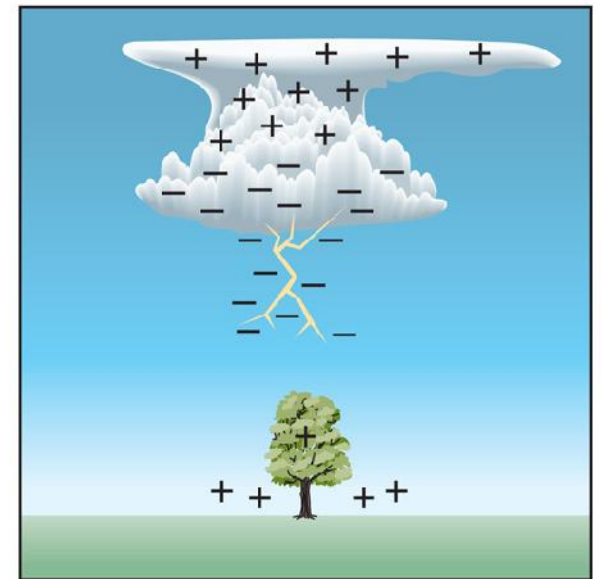
- Collisions between supercooled cloud particles and hail cause clouds to become charged
- Most of the base of the cumulonimbus cloud becomes negatively charged - the rest becomes positively charged (positive electric dipole)
- Net transfer of positive ions from warmer object to colder object (hailstone gets negatively charged & fall toward bottom - ice crystals get + charge)



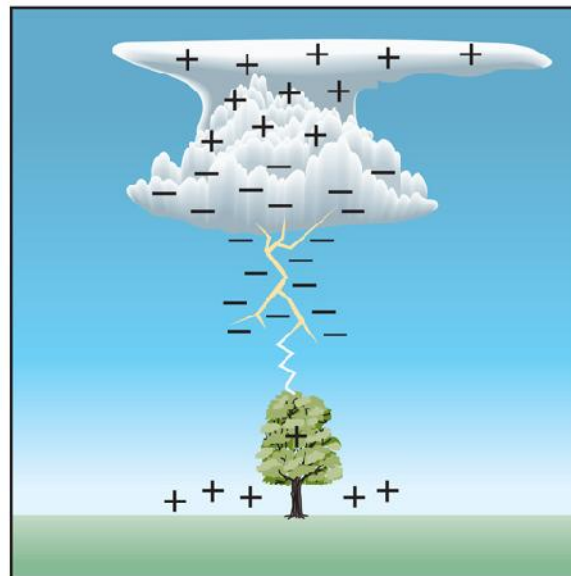
Development of lightning



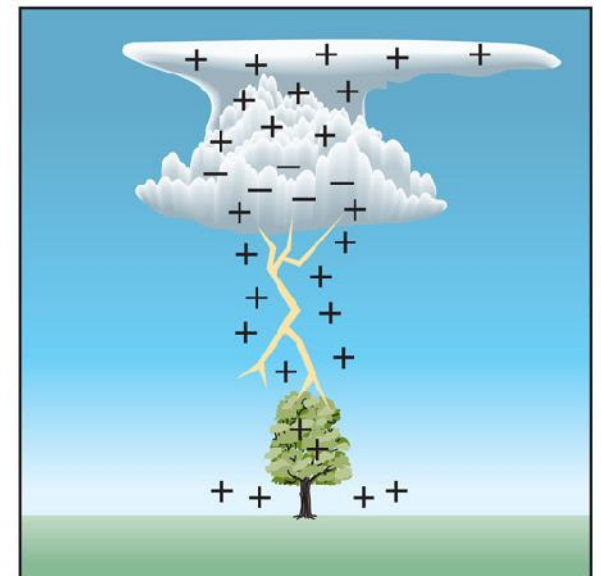
(a)



(b)



(c)

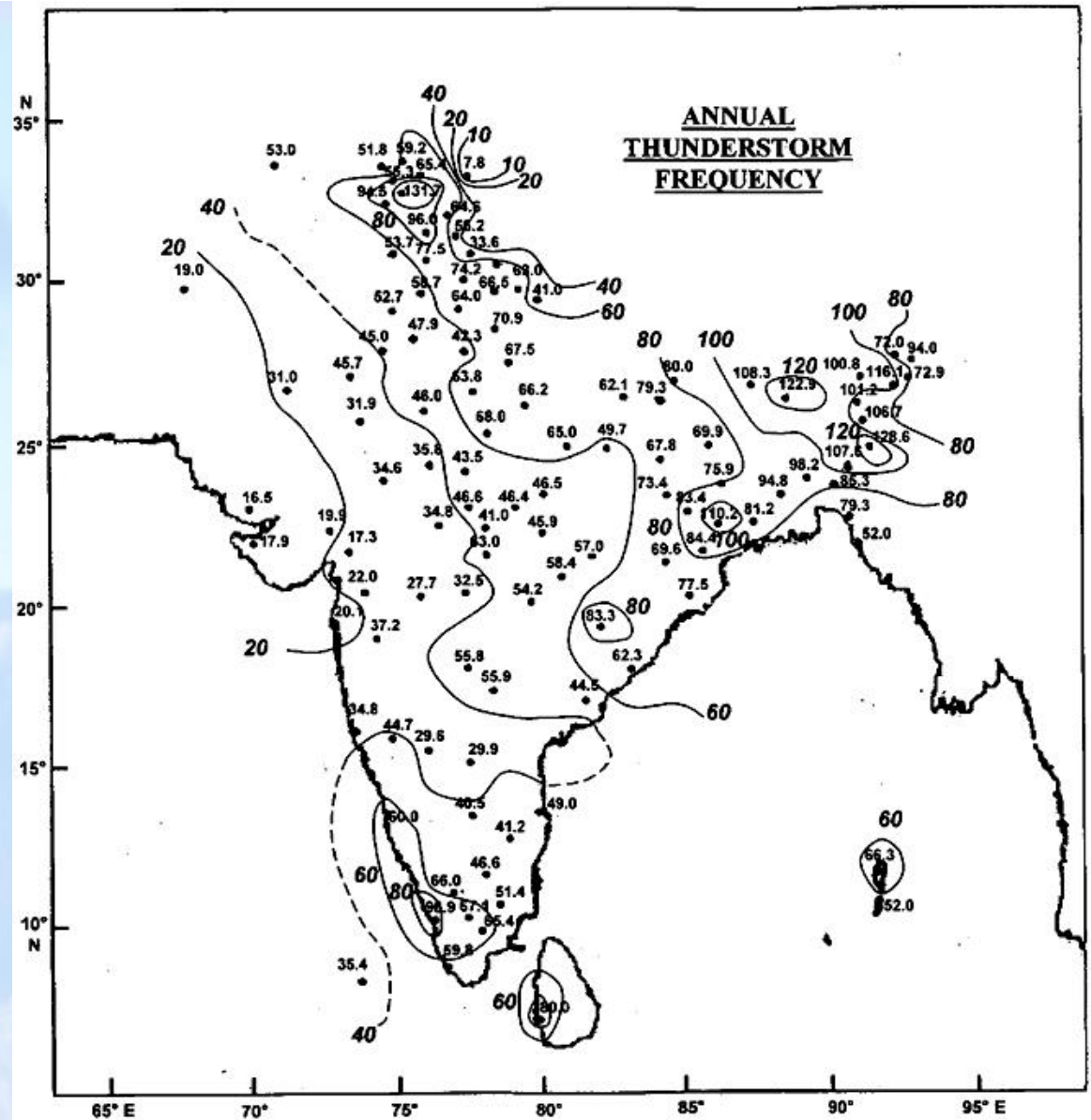


(d)



The areas of highest activity of thunderstorms exceeding 120 days in the year are seen over Assam, Sub Himalayan West Bengal and windward side of Pir Panjal range in Jammu and Kashmir.

The occurrence of thunderstorms is mainly controlled by the local orography.



Ajit Tyagi (2009), Mausam



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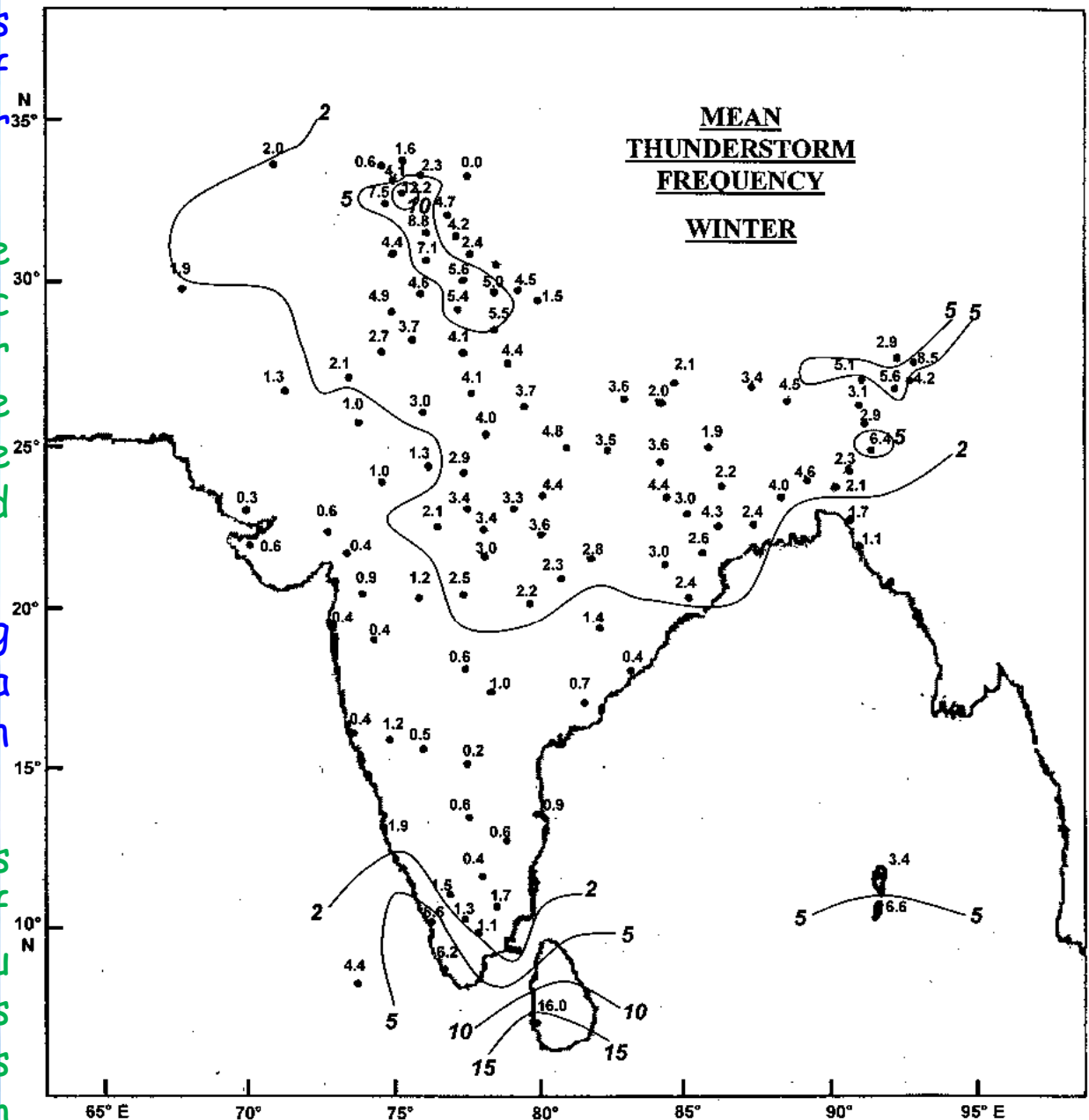


Country as a whole records the lowest number of thunderstorms during winter season.

It is primarily due to stable and dry atmospheric conditions prevailing over most parts of the subcontinent with the exception of Srilanka and southern Kerala.

Highest frequency during this season is over Sri Lanka (16 days) associated with northeast monsoon activity.

Second maxima (13 days) is seen over windward side of Pir panjal range over Jammu and adjoining region. This maxima is associated with western disturbances.



Pre monsoon season is characterized by increase in thunderstorm activity over all parts of the country with significant increase over northeast India, Bangladesh, West Bengal, south peninsula and Jammu region.

Topography, insolation and advection of moisture under favourable wind regime contribute to thunderstorm maxima over these areas.

Synoptically, Western Disturbances and induced lows in the north and easterly waves in south provide favourable conditions for the occurrence of thunderstorm over these

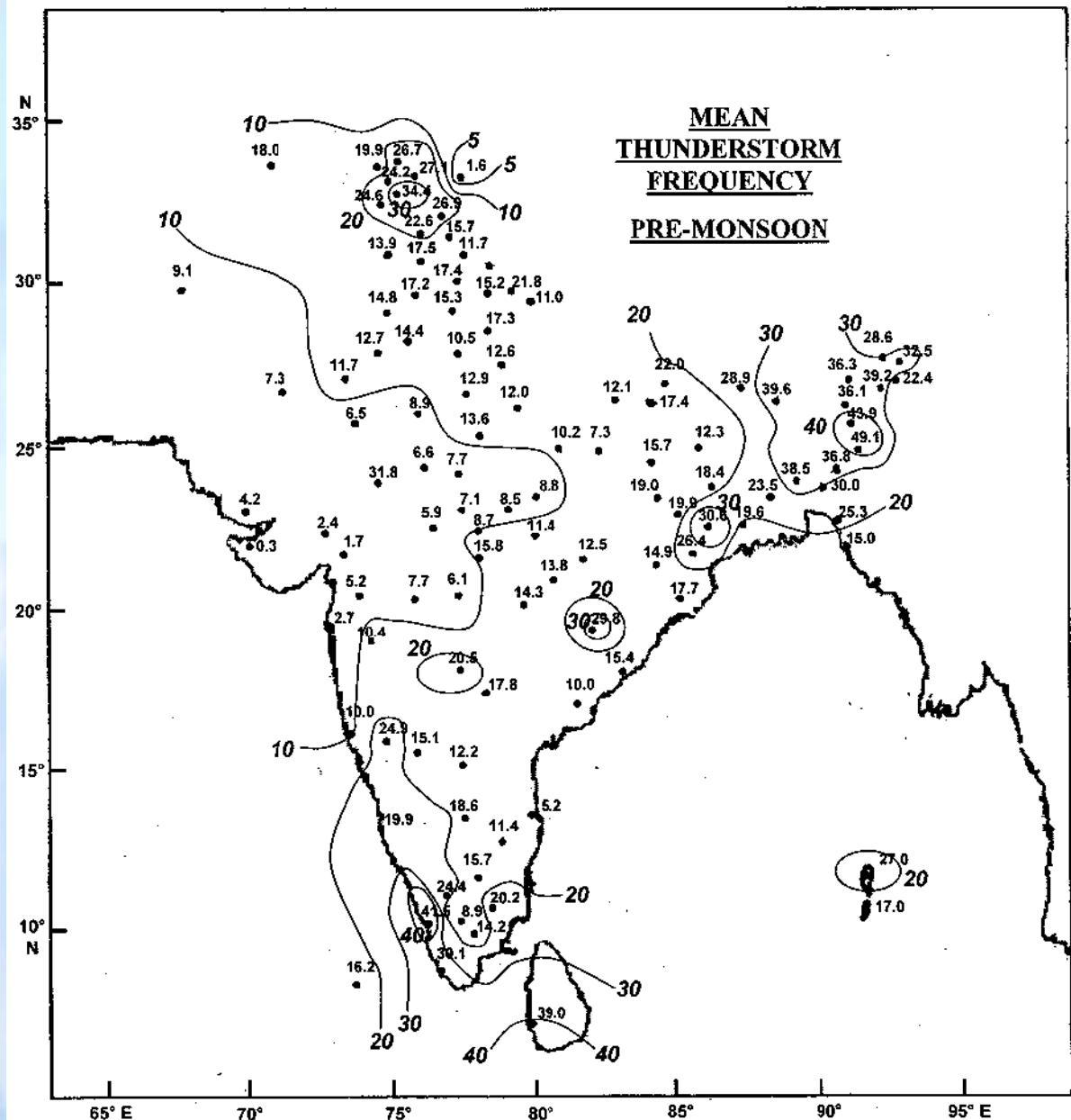
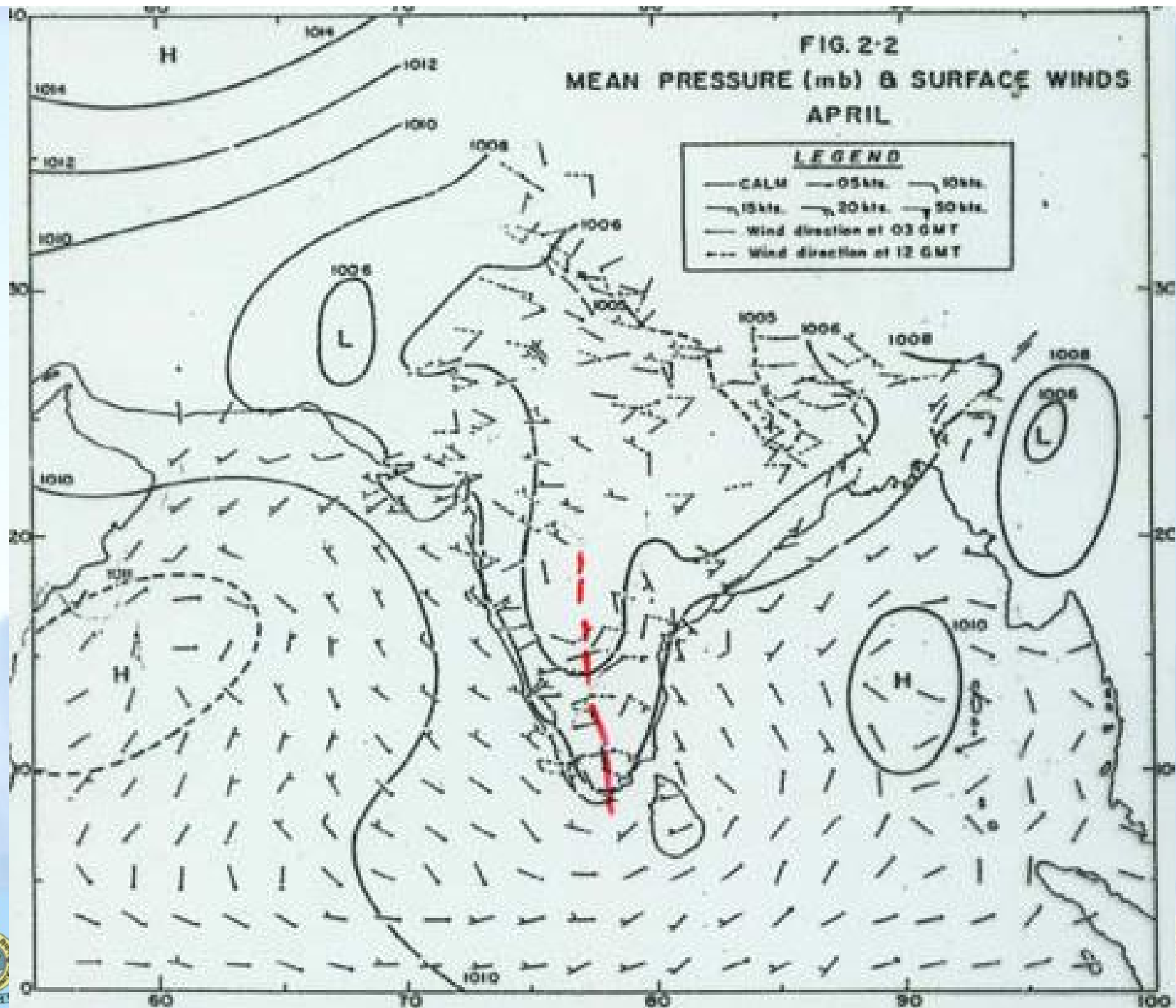


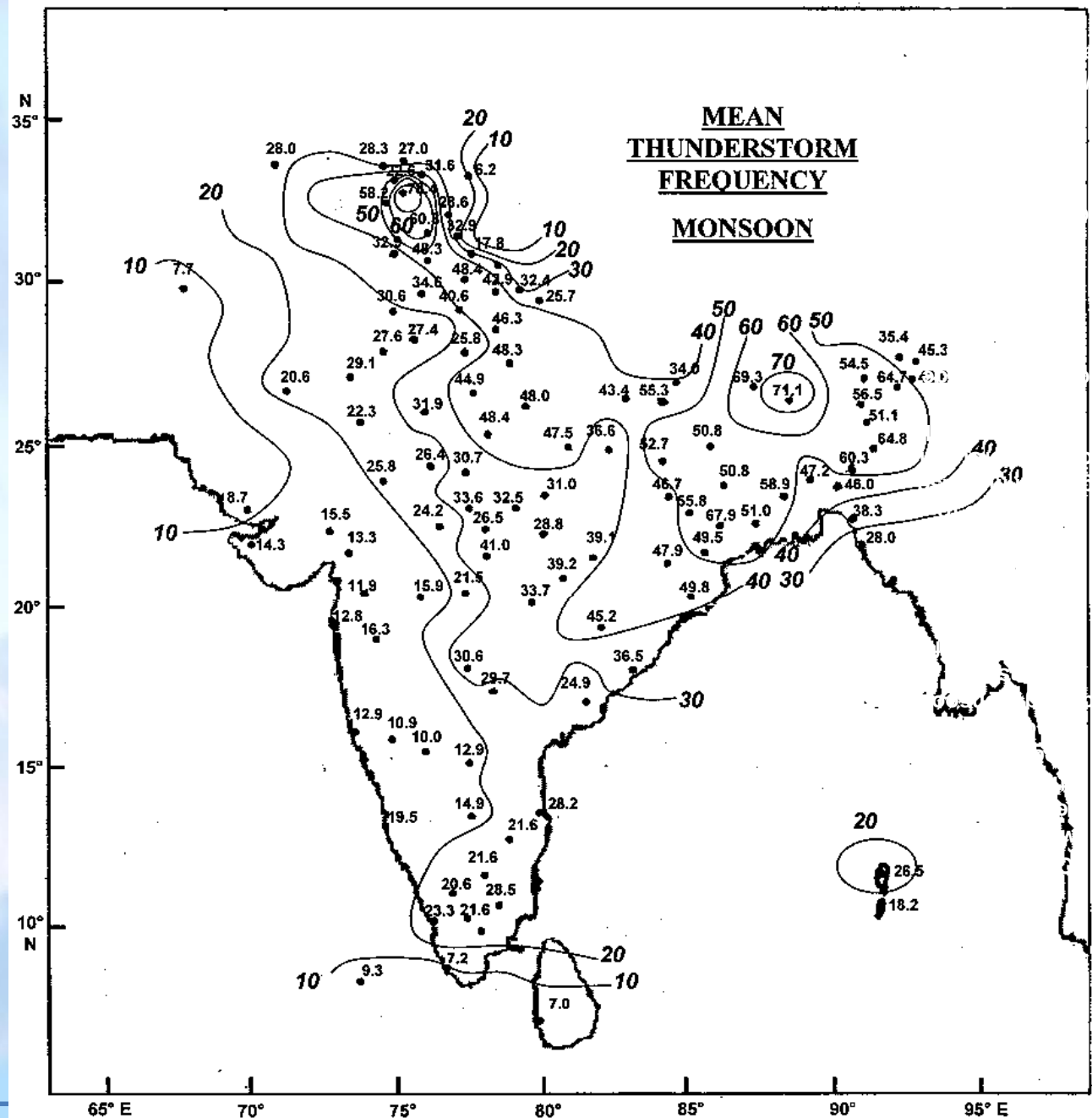
FIG. 2-2
MEAN PRESSURE (mb) & SURFACE WINDS
APRIL



Country as a whole records the highest frequency of thunderstorms during monsoon season.

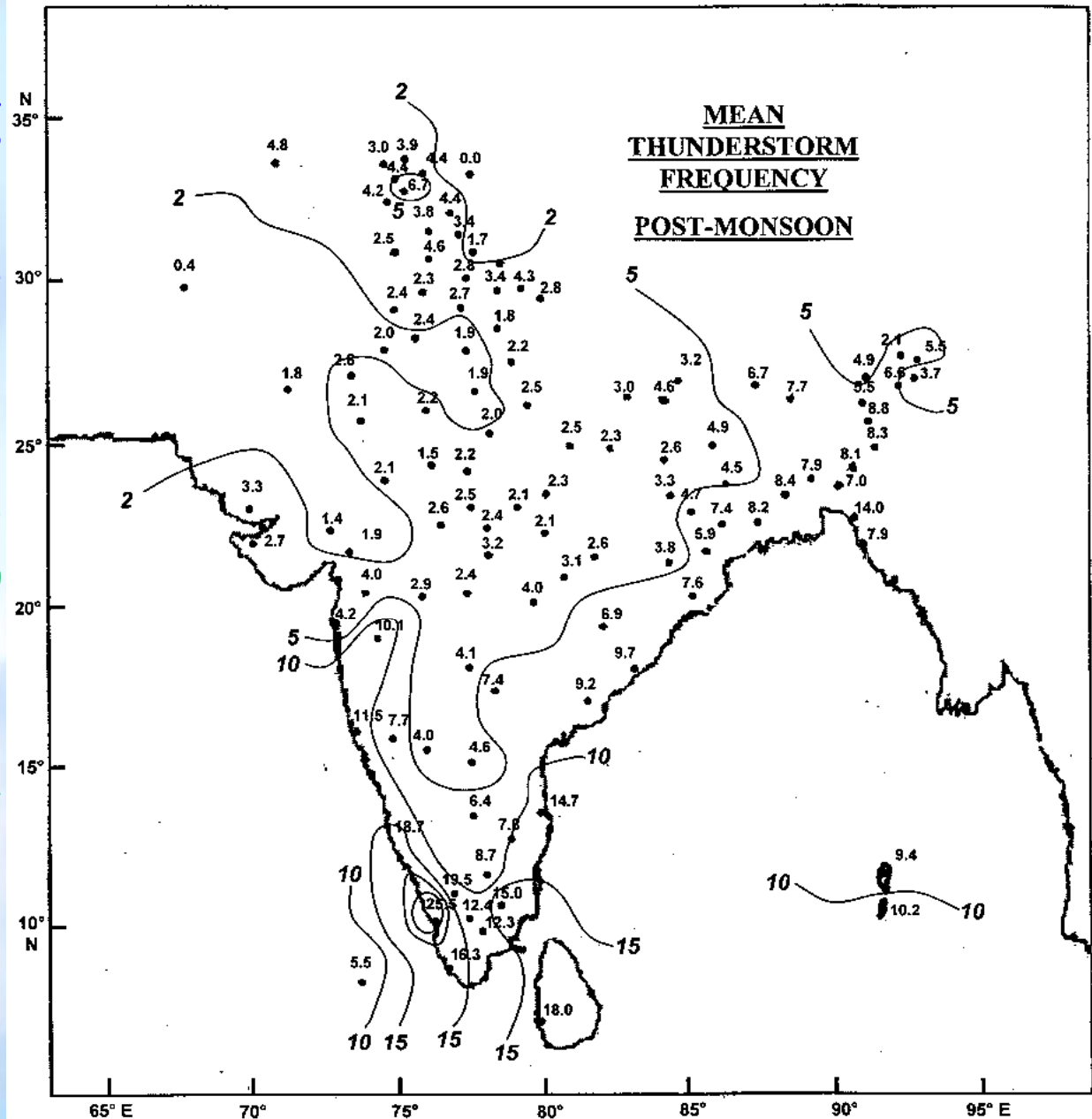
Availability of moisture and favourable synoptic features contribute to general increase of thunderstorm activity over all parts of the country outside Kerala.

The highest thunderstorm activity in the country continues to be over northeastern states, Bangladesh, West Bengal and adjoining states, which record more than 50 days



After the withdrawal of monsoon, country outside Tamil Nadu coastal AP and Kerala witnesses marked decrease in thunderstorm activity.

Highest number of thunderstorms during this season occur over Kerala (20 to 25 days) whereas neighbouring state Tamil Nadu has frequency of 10 to 15 due to northeast monsoon.



Socio-Economic Impact of Severe Thunderstorm

- ❖ Severity of NORWESTERS: next to Tropical Cyclones
- ❖ Average frequency of occurrence:
Kalbaisaki is 28 (± 5) in pre-monsoon period
- ❖ Hail Storms and Squall Winds:
Loss of human life and animals;
Extensive damage to standing crops and property
- ❖ Highest lightning-associated casualty in the world.
- ❖ Highest frequency of hail storms in the world.
- ❖ Frequency of occurrence is second highest to that in the central regions of United States.
- ❖ May lead to flood in NE India, Bangladesh
- ❖ Major aviation hazard; with several reported air plane accidents.
- ❖ Most Tornadoes in the country are associated with Kal-Baisaki

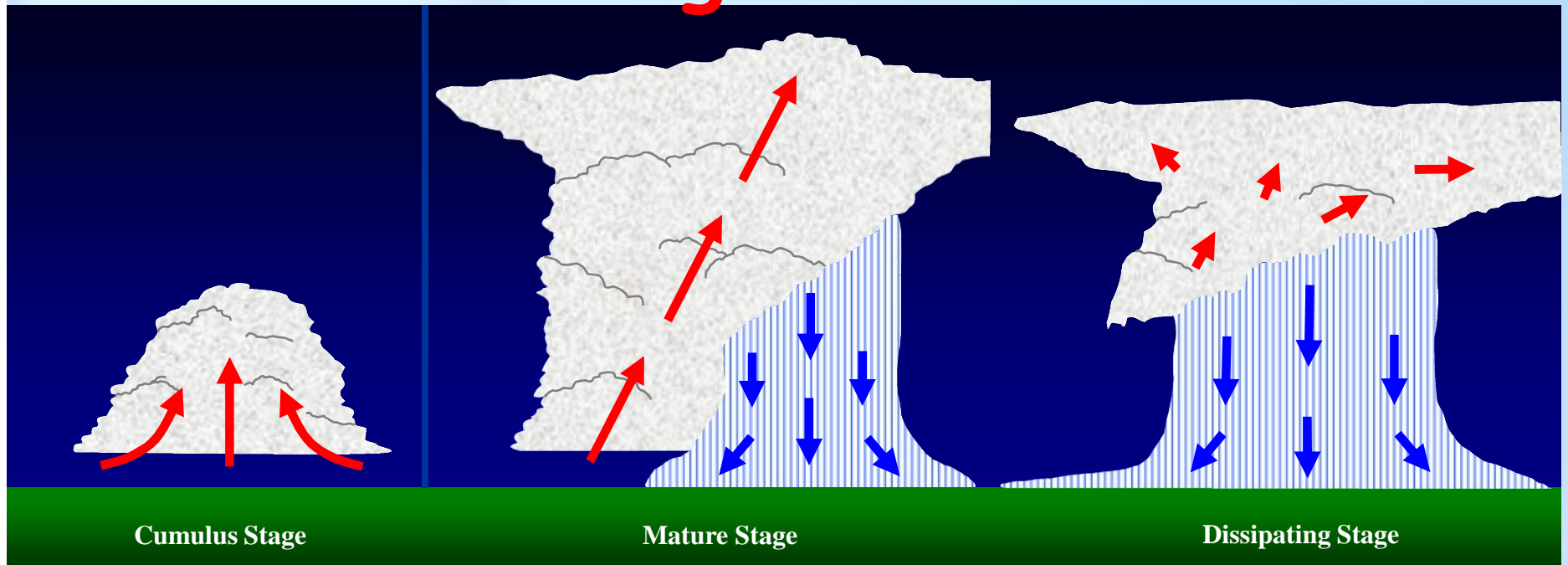


Thunderstorm Type

- Single cell
- Multi-cell cluster
- Multicell line (squall line)
- Super cell



Single cell

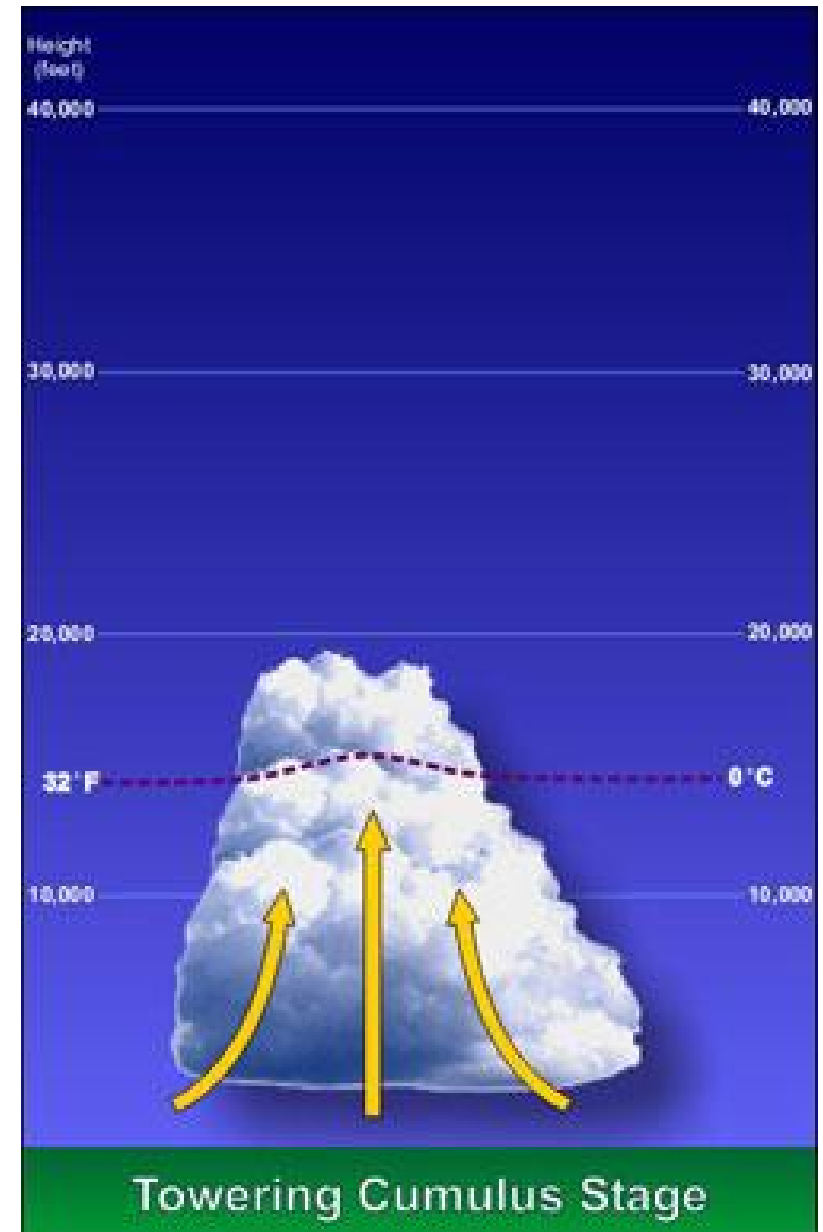


- Short-lived afternoon summer TS. 30- 60 minute duration.
- Usually not associated with tornado
- Moves with mean environmental wind over 5-7 km.
- Rainfall can be moderate to heavy, small hail is possible.
- Vertical wind shear is small.
- Updrafts cut off by downdrafts



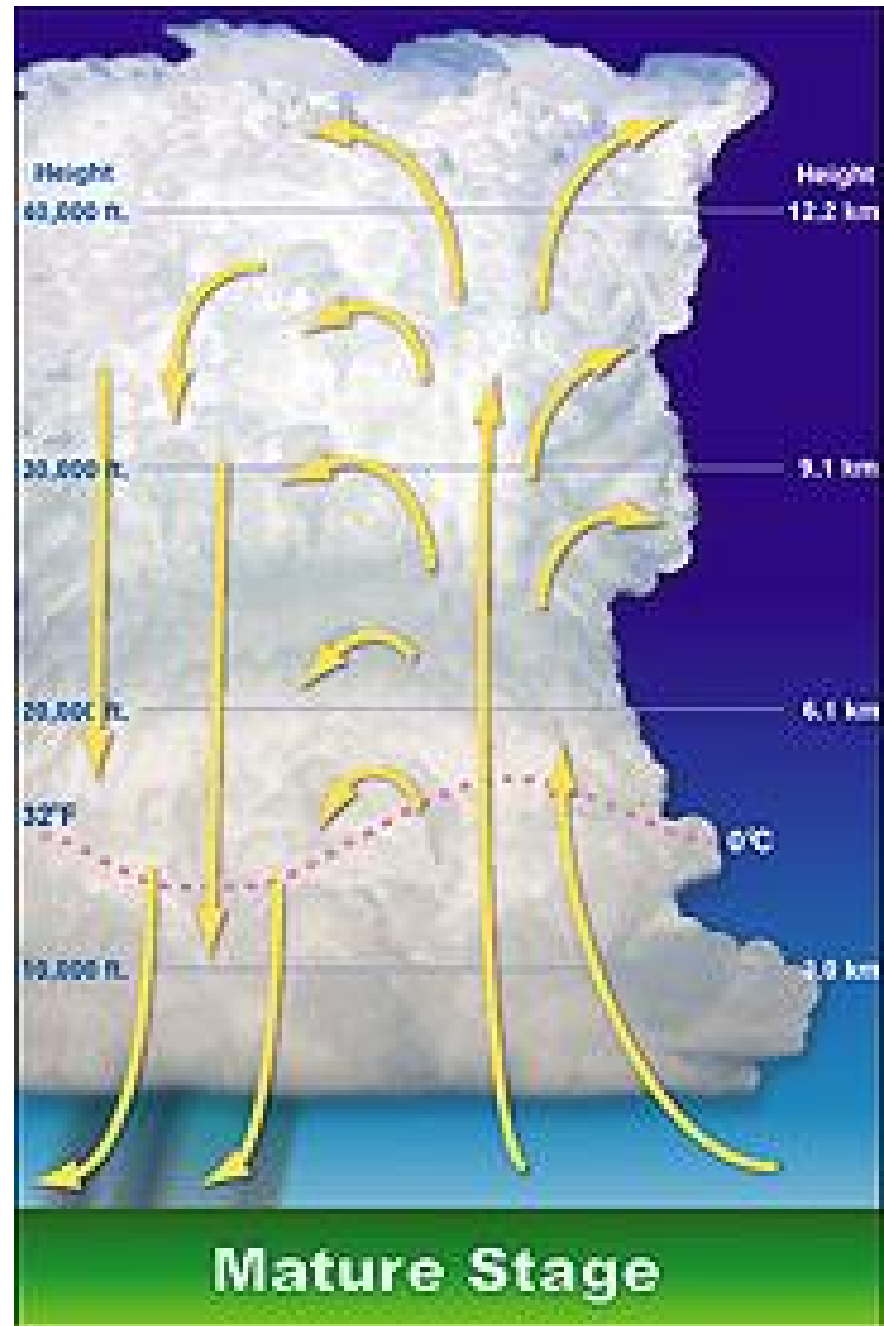
CUMULUS STAGE

- Sun heats the land
- Warm, humid air rises
- Condensation point is reached, producing a cumulus cloud
- Grows quickly (minutes) because of the release of latent heat
- Updrafts suspend droplets
- 'Towering cumulus'



MATURE STAGE

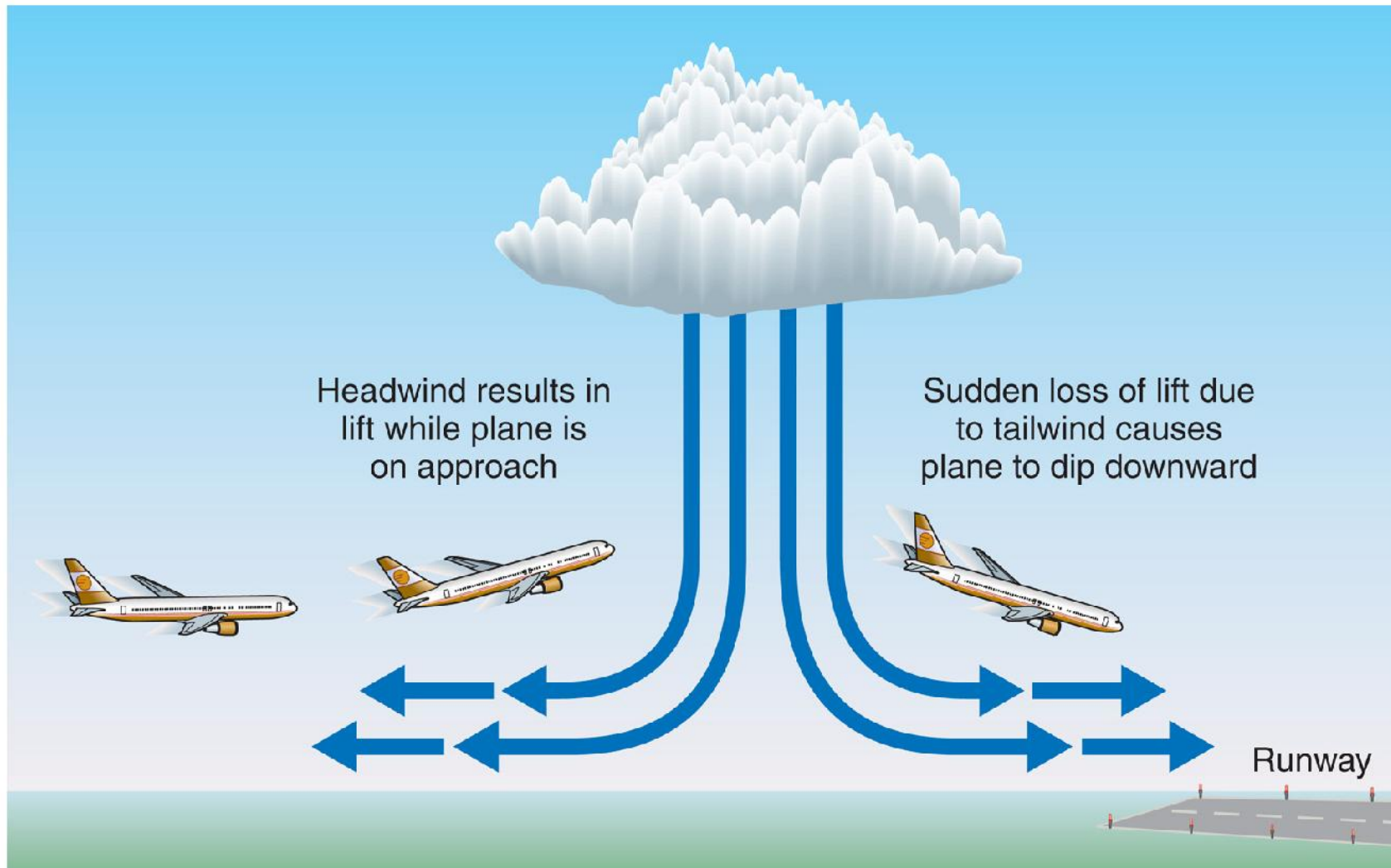
- Droplets large enough to overcome resistance of updrafts (rain/hail)
- "Entrainment" Drier air is drawn in
- Air descends in downdraft, due to evaporative cooling and falling rain/hail
- Anvil head when stable layer reached (cloud follows horizontal wind)
- Strongest stage, with lightning and thunder



Mature, ordinary cell thunderstorm with anvil head

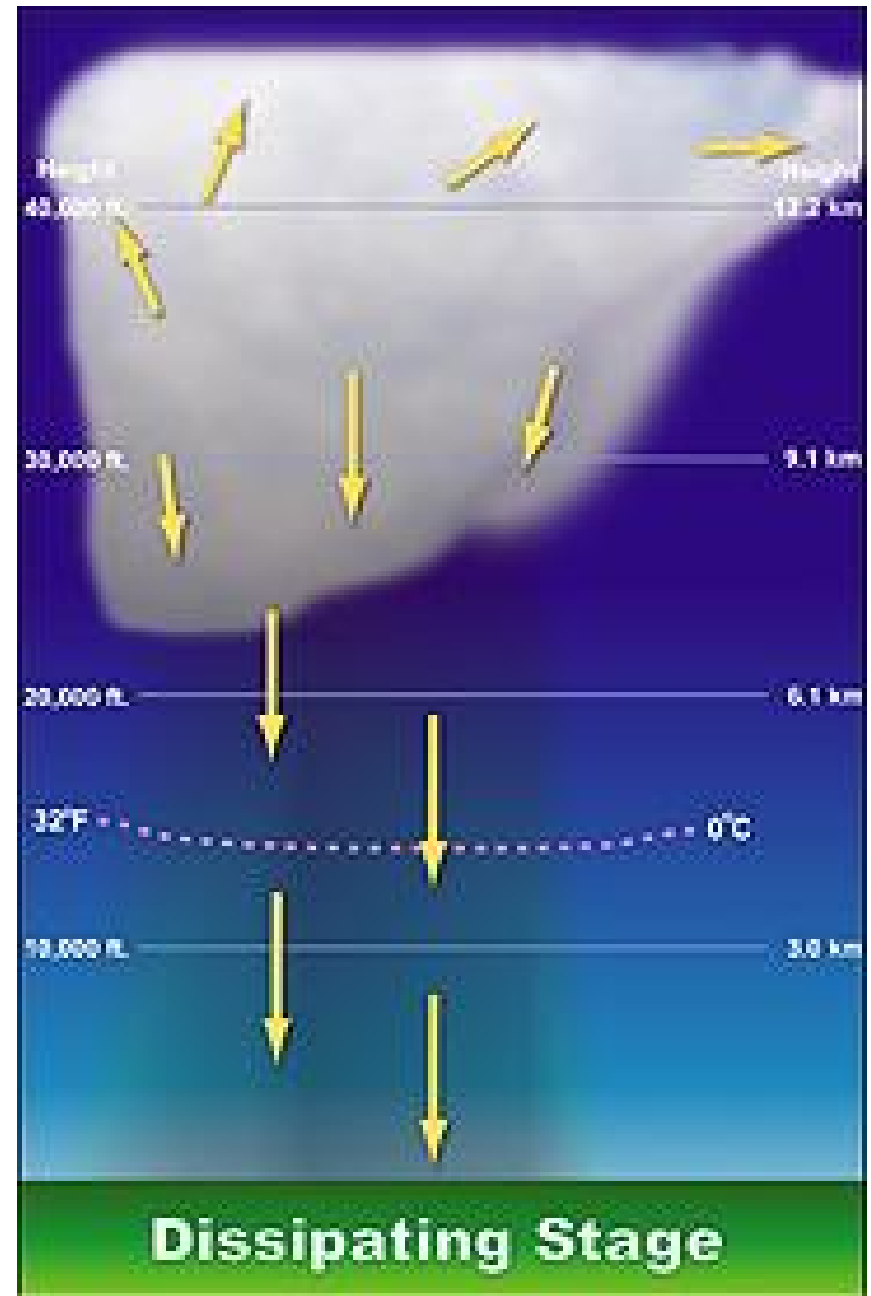


Microbursts create aviation hazards



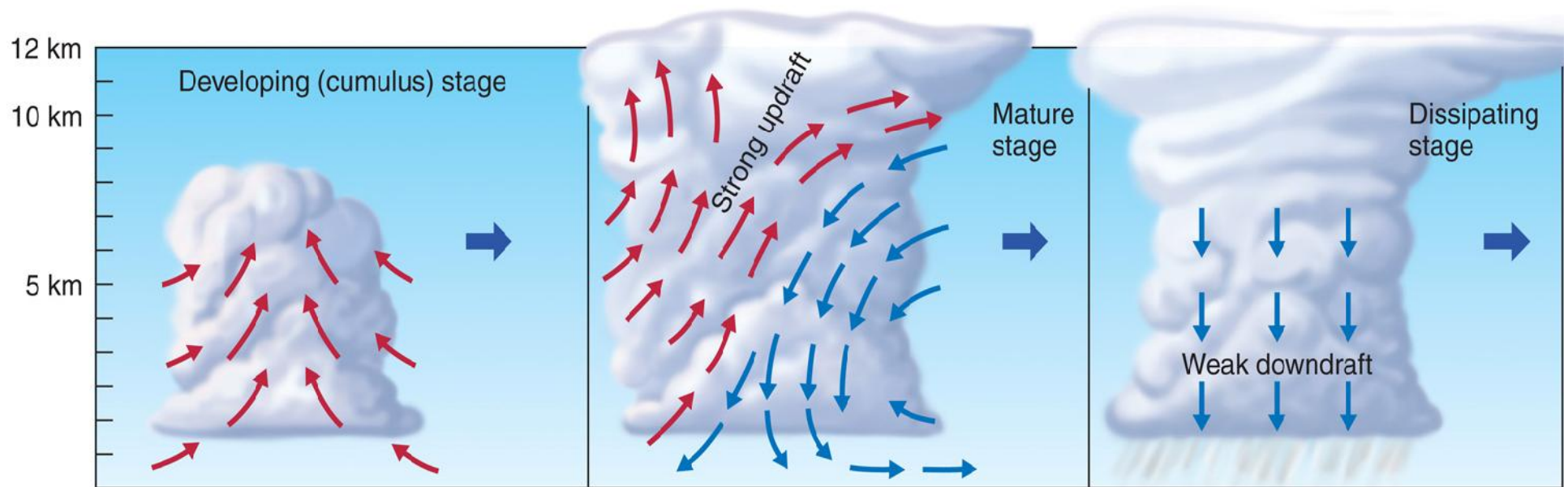
DISSIPATING STAGE

- Downdrafts dominate over Updrafts and cut off the storm's "fuel supply"
- No warm humid rising air
- No more release in latent heat
- Precipitation continuous along with strong wind
- Ordinary cell thunderstorms may pass through all three stages in only 60 minutes

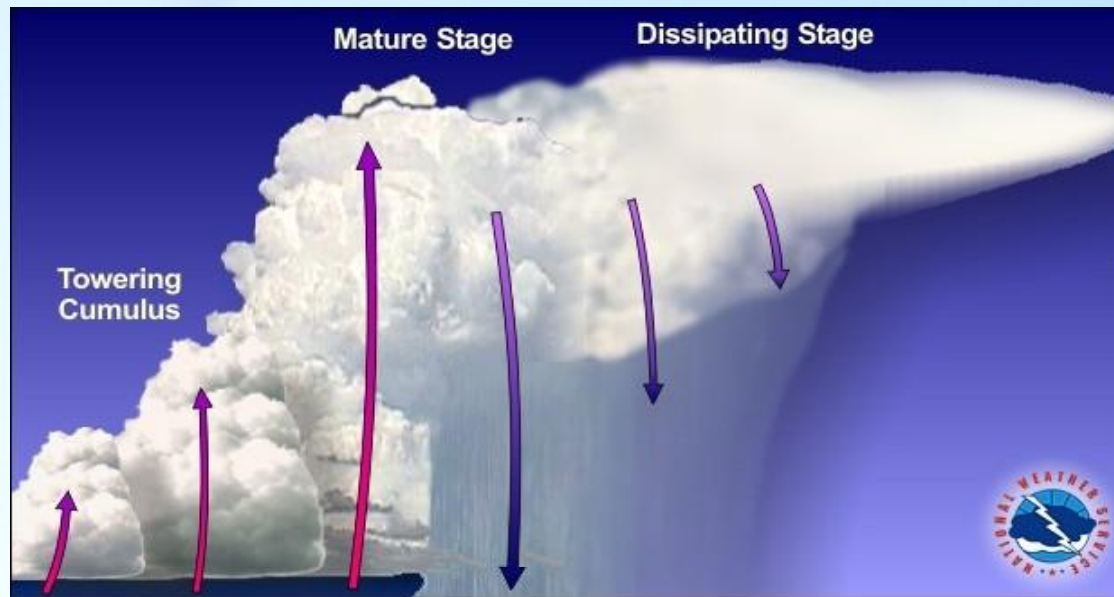


Review of Stages:

Developing (cumulus), mature and dissipating



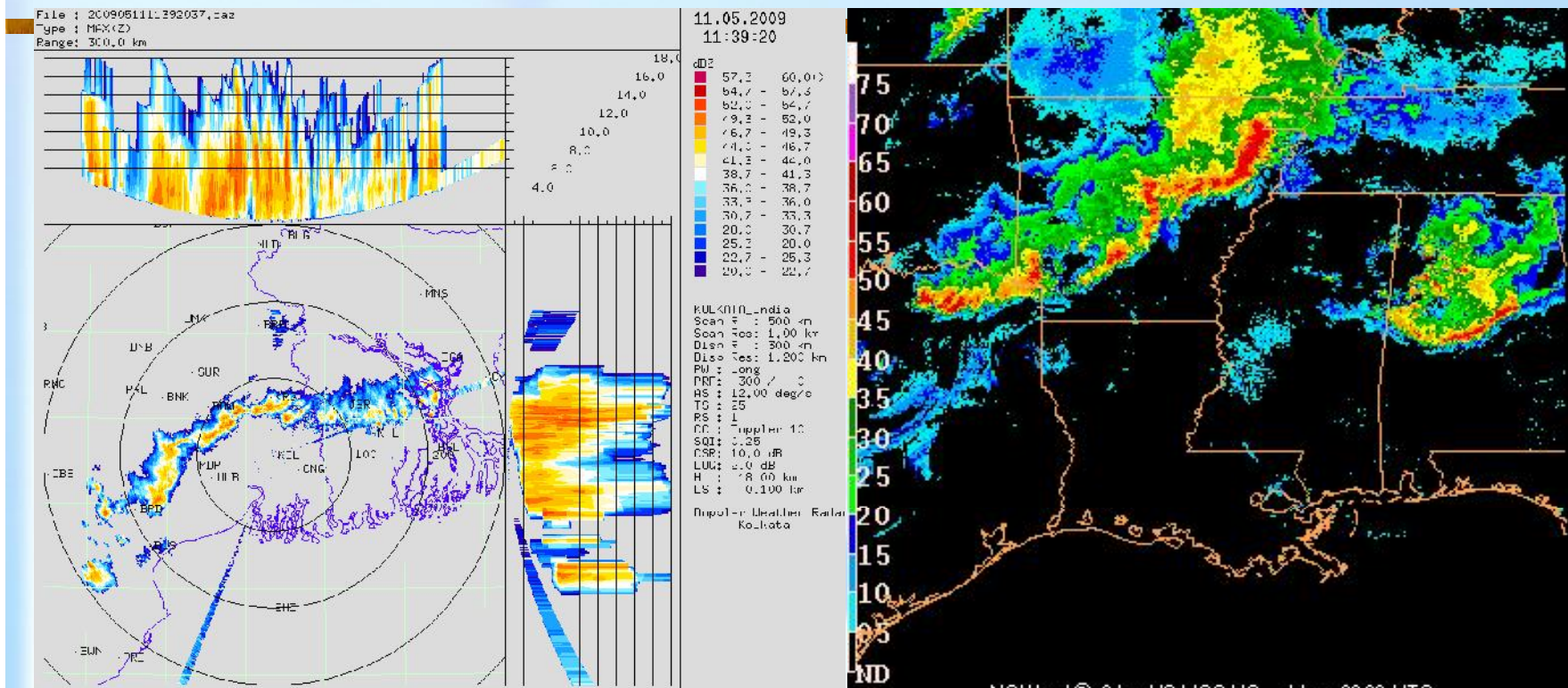
Multicell Thunderstorm



- ❑ Sometimes thunderstorms form in clusters with many cells in various stages of development merging together.
- ❑ Unlike ordinary single cells, cluster storms can last for several hours producing large hail, damaging winds, and isolated tornadoes.



Squall Line



- A squall line is any line of convective cells.
- It may be a few tens of km long or 1000 km long (>500 nm);
- The characteristic squall line life cycle is to evolve from a narrow band of intense convective cells to a broader, weaker system over time
- Stronger shear environments produce stronger long-lived lines composed of strong leading line convective cells



Forecasting of Thunderstorm

Favourable factors :

1. Intense heating
2. Moisture Incursion
3. Instability
4. Triggering Mechanism



Forecasting of Thunderstorm

When convective instability and lifting mechanism are present, convection is favoured. Following meso-scale phenomena provide these favourable conditions:

1. Upper level jets
2. Low level strong wind
3. Dry line
4. Meso-scale low pressure systems
5. Gravity waves



Forecasting of Thunderstorm

- ❖ Essential component of thunderstorm monitoring
 - ❖ Monitoring of weather parameters
 - ❖ Knowledge of synoptic systems to trigger convection
 - ❖ Climatology of weather parameters and synoptic systems based on observations
 - ❖ Thermodynamic indices (current value and climatology)



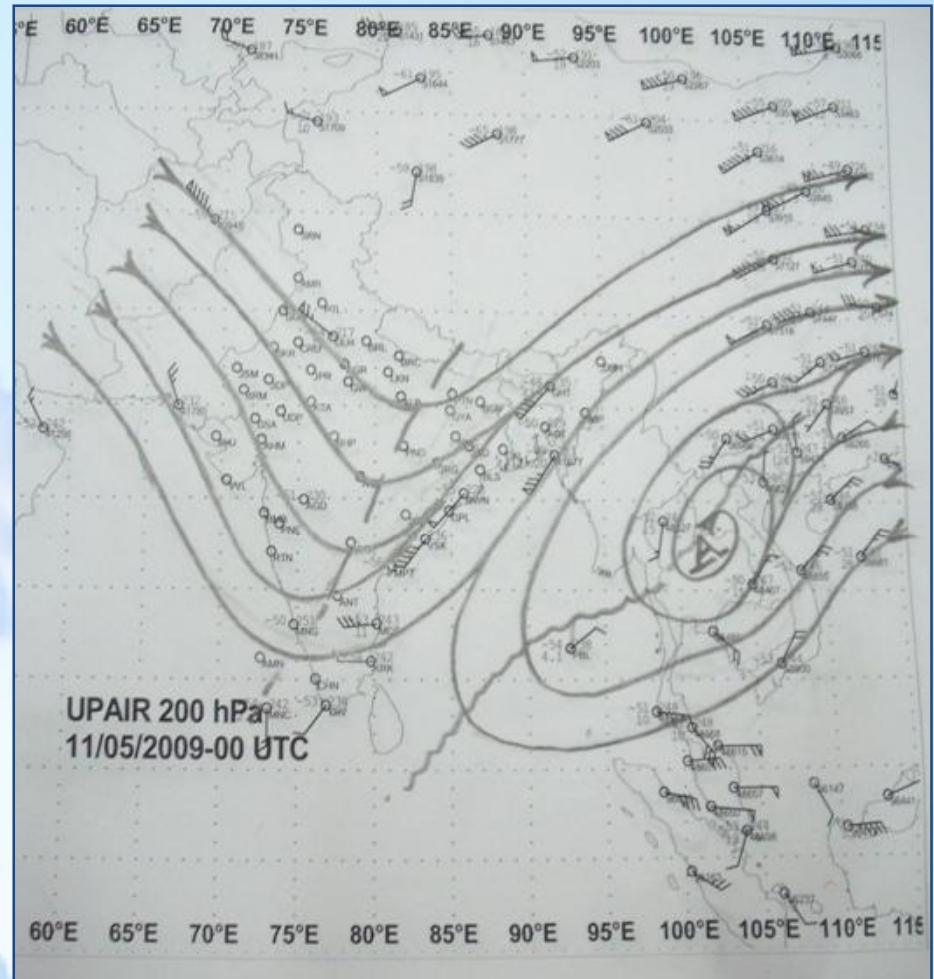
Role of vertical wind shear

- ❖ The shear perpendicular to the convective line supports updraft
- ❖ Most important is the shear in the lowest layer reaching from the surface up to 2-3 km
- ❖ Cells developing within strong vertical shear have long lifetime and severe weather
- ❖ Most intense thunderstorms develop when there is change both in speed and direction of the wind



Upper level Jet:

- In broad strong wind current, the strongest horizontal winds and vertical shear are generally of meso-scale dimensions.
- There are dynamically favourable sectors (right entrance and left exit in upper tropospheric westerly jet) for upward motion and convective development.



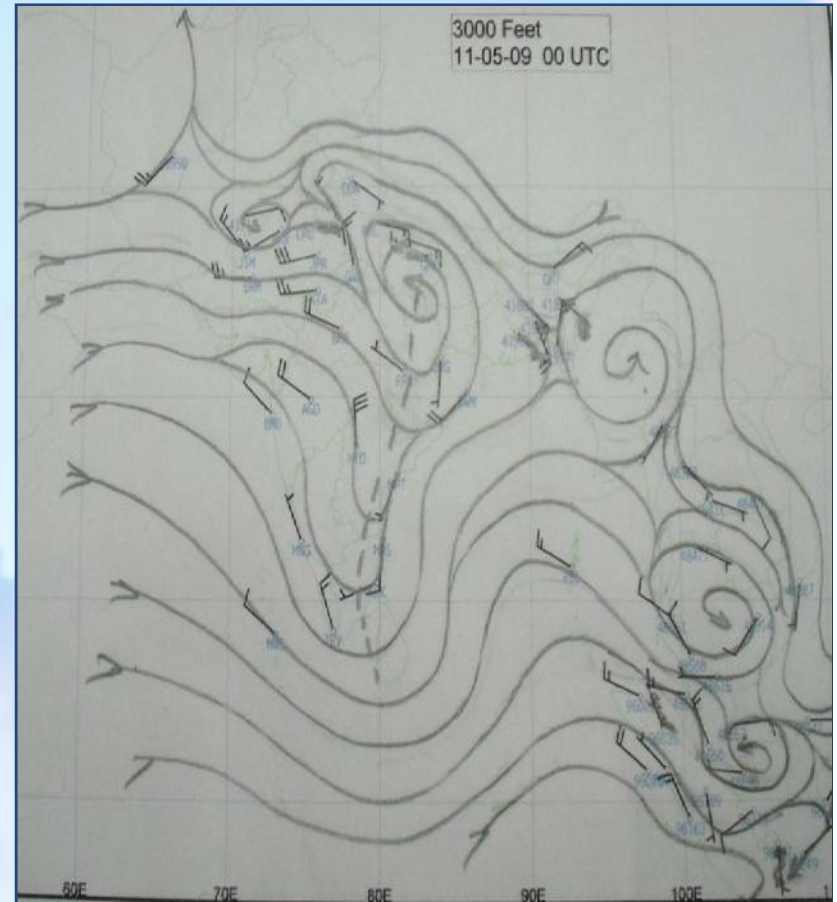
Low level Wind

The low level strong wind located in the regions,

where the underlying surface has large variations of topography.

Heating of air during day time and cooling of air at night time,

Strong gradient of temperature and pressure.

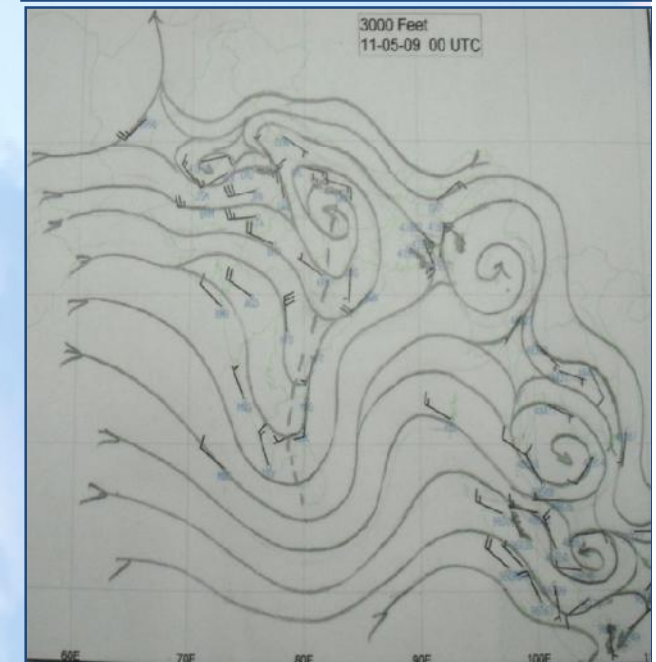
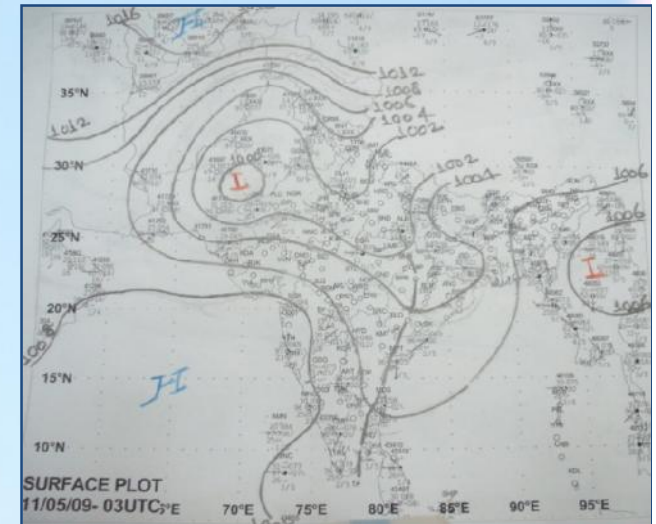


As a result, meso-scale regions of convergence and divergence of low level winds get generated. Regions of low level convergence are favourable for convection.



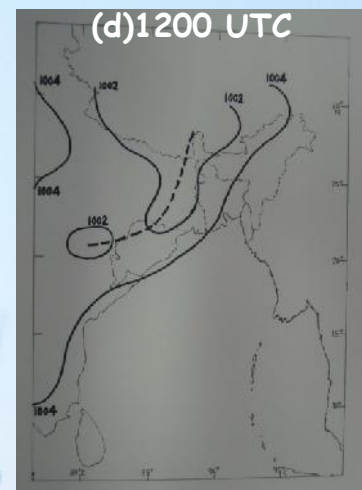
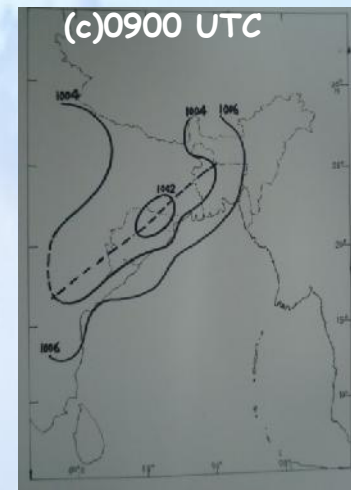
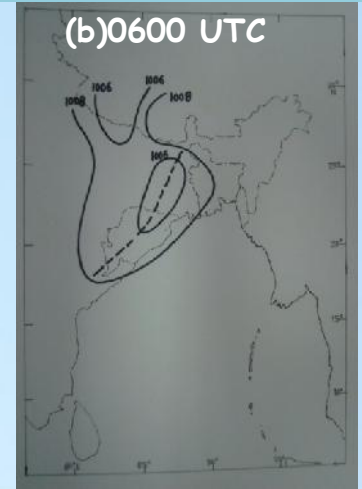
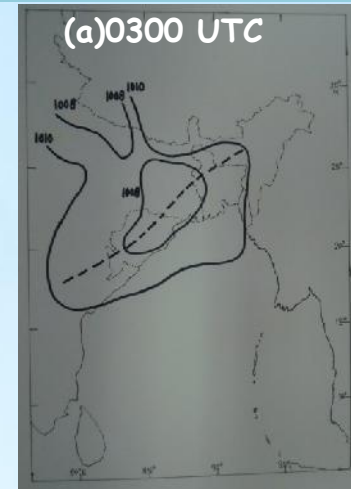
Dry line:

- A dry line is a narrow, almost vertical transition zone, across which there is a sharp moisture gradient.
- Separates moist and dry air.
- Regions of these wind discontinuities are also trough lines of low pressure.
- Air on the moist side of the wind discontinuity is convectively unstable and hence gives rise to CB clouds through frictional convergence.



Meso-scale low pressure systems:

- Severe thunderstorms sometimes occur in association with low pressure systems having diameters upto a few hundred kms.
- Generally they are weaker in the tropics than in the extra tropics.
- Due to feebleness of meso lows and lack of high density network of observations, knowledge about meso lows is inadequate.

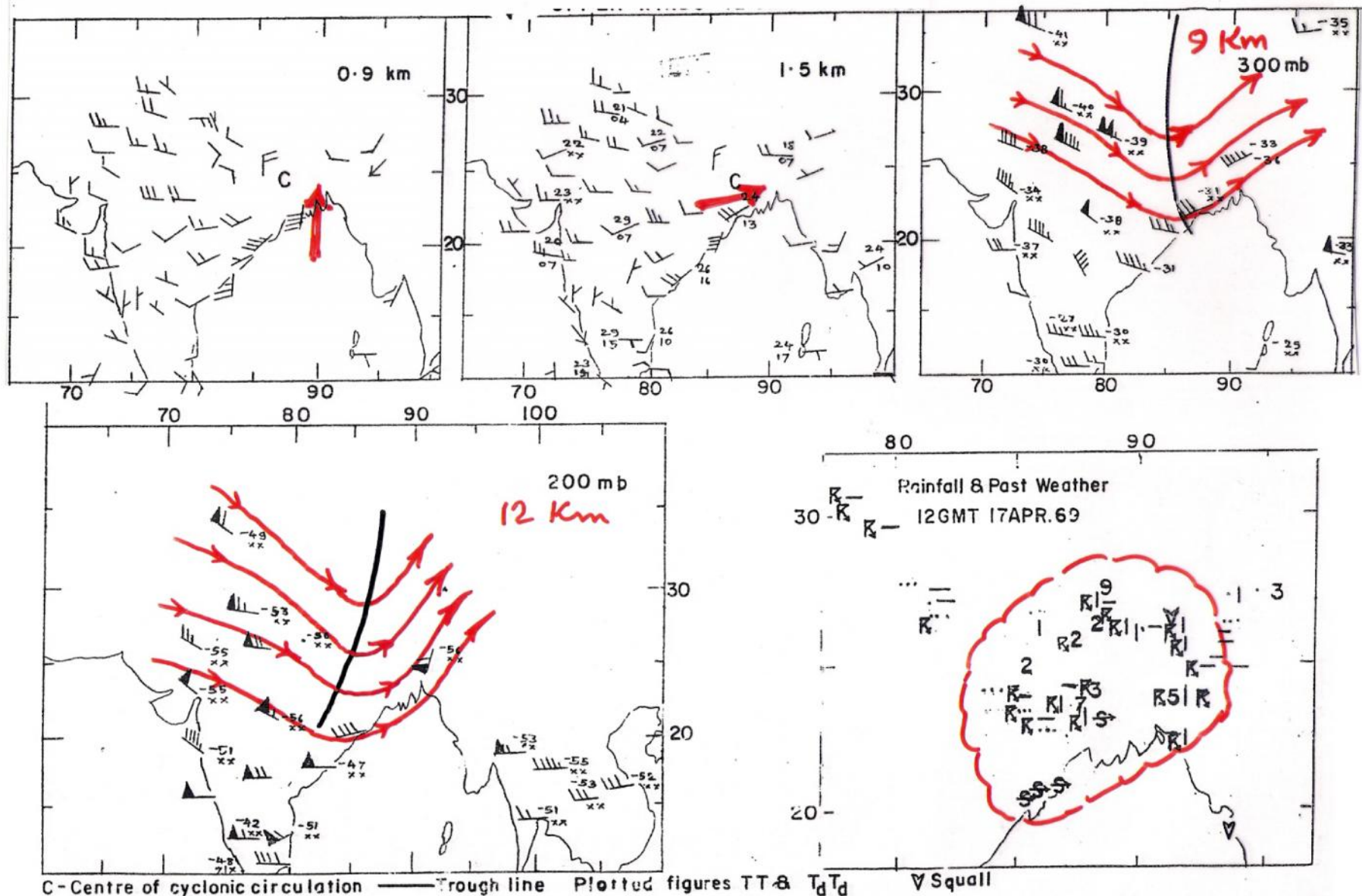


• 31st March 2009



ENVIRONMENT FOR WIDE SPREAD THUNDERSTORM

(Example :taken from IMD's Forcasting Manual)



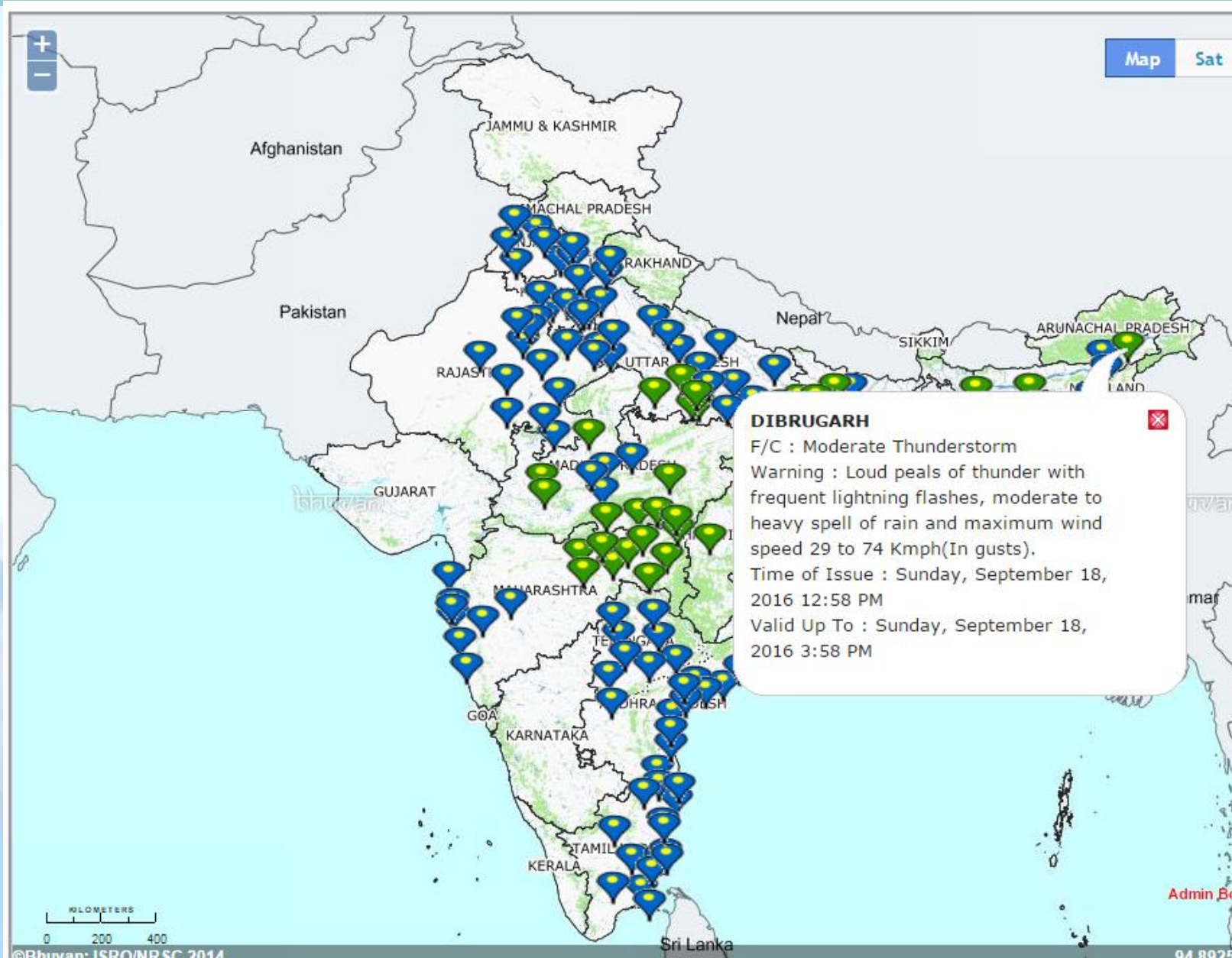
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Spatial and Temporal domains of Forecast

- ☐ **Nowcasting for next 6-12 hours**
(Venue/ location specific)
- ☐ **Short Range for next 72 hours (Location/District/
State/Met Sub-division)**
- ☐ **Medium Range for next 3-7 days**
(District)
- ☐ **Extended range for 10-15 days**
(Met Subdivision/State/ Homogeneous regions)
- ☐ **Long range for month/season**
(Homogeneous regions/country)



NOWCAST FOR THUNDERSTORM



3. WARNING CATEGORY

EXTREMELY SEVERE

VERY SEVERE

SEVERE

NO WARNING

Heavy Rain



Heavy Snow



**Thunderstorm/
Hailstorm**



**Dust Storm/
Sand Storm**



Strong Winds



Squal



Cold Wave



Heat Wave

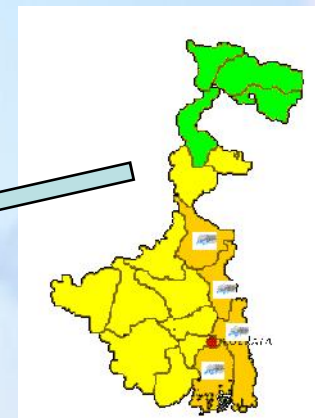
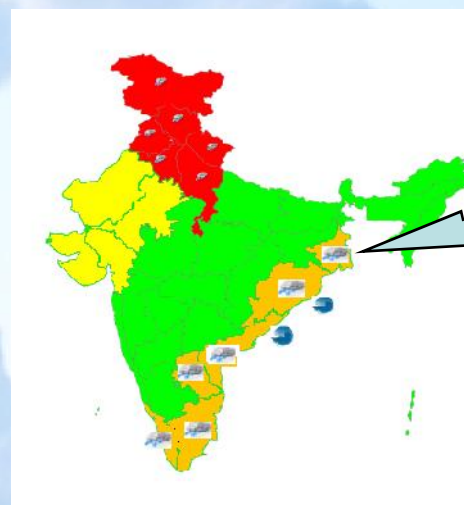
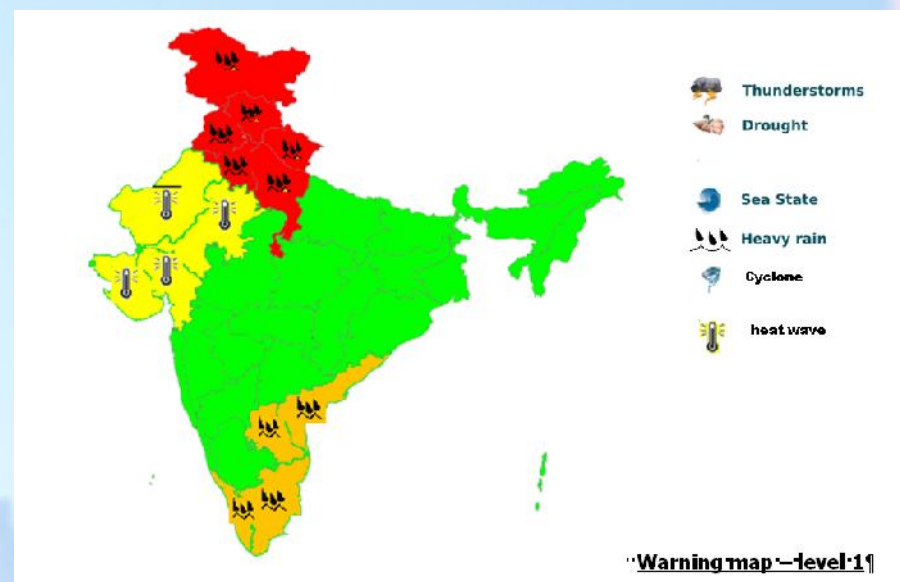


Cyclone



Multi-hazard warning system

- ❖ Systematic Warning Map for high impact weather events
- ❖ Colour system for highlighting
- ❖ Warning production and dissemination in a single system
- ❖ Link between IMD and Disaster management
- ❖ Relation with other stake holders



Multi Hazard Warning System

- **Thundersquall with heavy rain over Assam , Meghalaya, Arunachal Pradesh & NMMT**
- **Moderate thundersquall over West Bengal , Bihar Jharkhand, Chattisgarh and Orissa .**
- **Isolated dust-storm over Rajasthan.**



Thanks



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