CE 361A : Engineering Hydrology

Precipitation

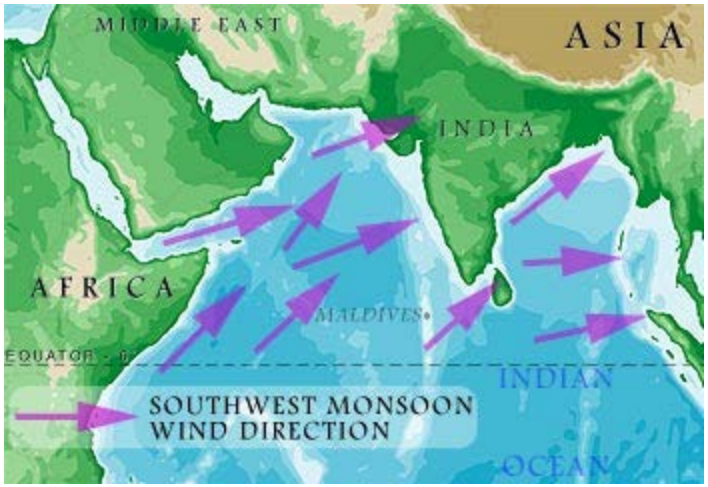
Lecture -4

Revision

- Characteristics of precipitation in India
  - South-west monsoon (Jun-Sep)
  - Post monsoon (Oct – Nov)
  - Winter season (Dec – Feb)
  - Summer season (Mar – May)
- South-west monsoon
  - Origin
  - Onset
  - Features (A&B spells, Monsoon trough, cyclones)
  - Withdrawal
  - Spatio-temporal distribution of monsoon rainfall
  - Factors influencing monsoon

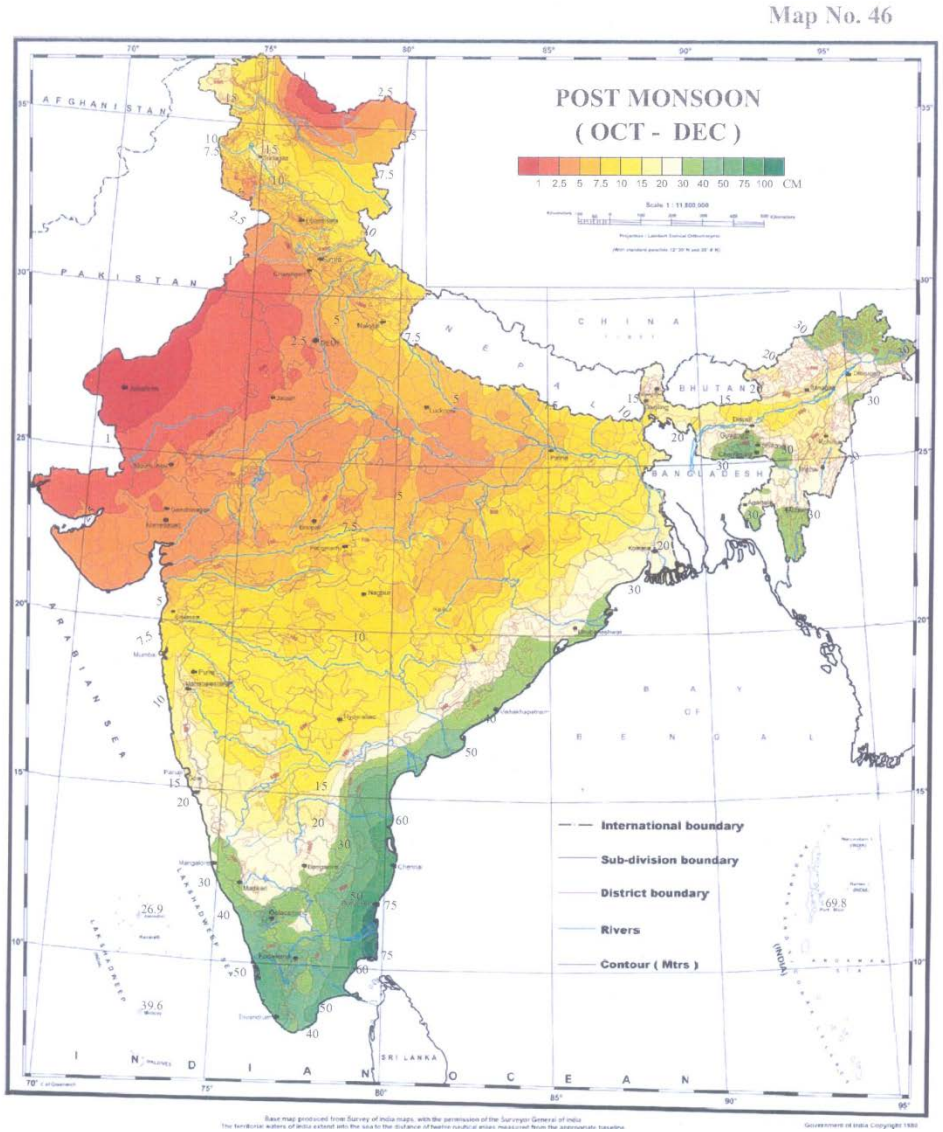
Post Monsoon (Oct-Nov)

- Retreating southwest monsoon or Northeast monsoon major source of rainfall over the southern Peninsular India
- Normal start date : October 20



Source: Public Broadcasting Service (PBS)

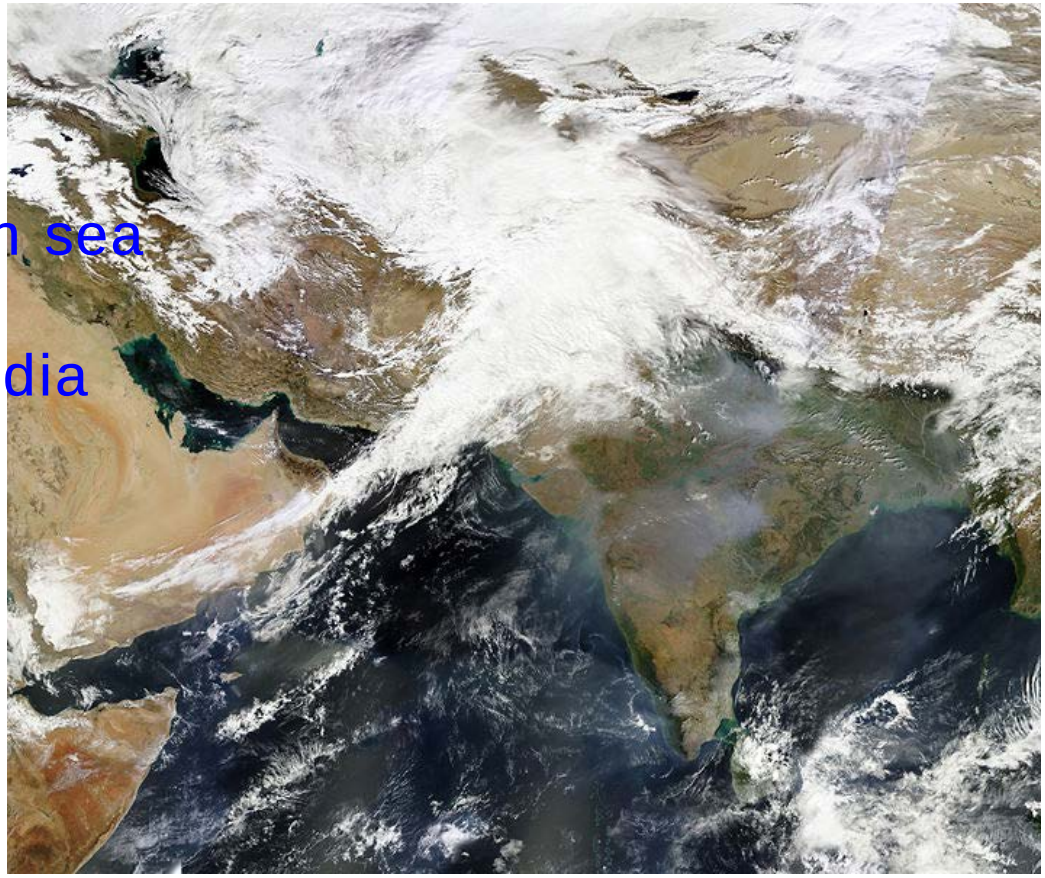
Post Monsoon



Source: IMD

Winter Season (Dec-Feb)

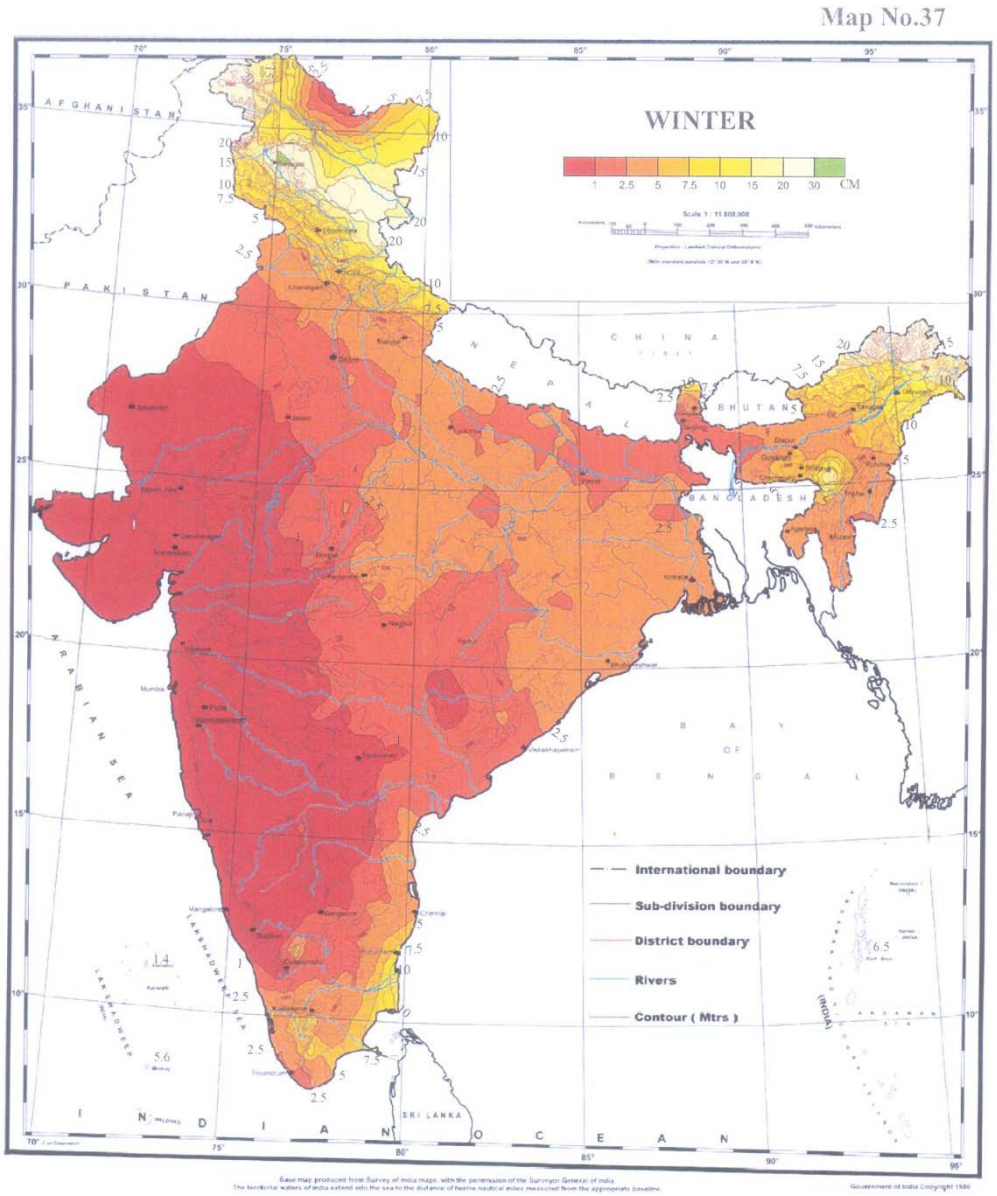
- Winter disturbances
- Originates in Mediterranean sea
- Rainfall over North-west India
- Useful for Rabi crops



Date: 3 February 2013 by NASA MODIS

Source: Wikipedia

Winter Season (Dec-Feb)

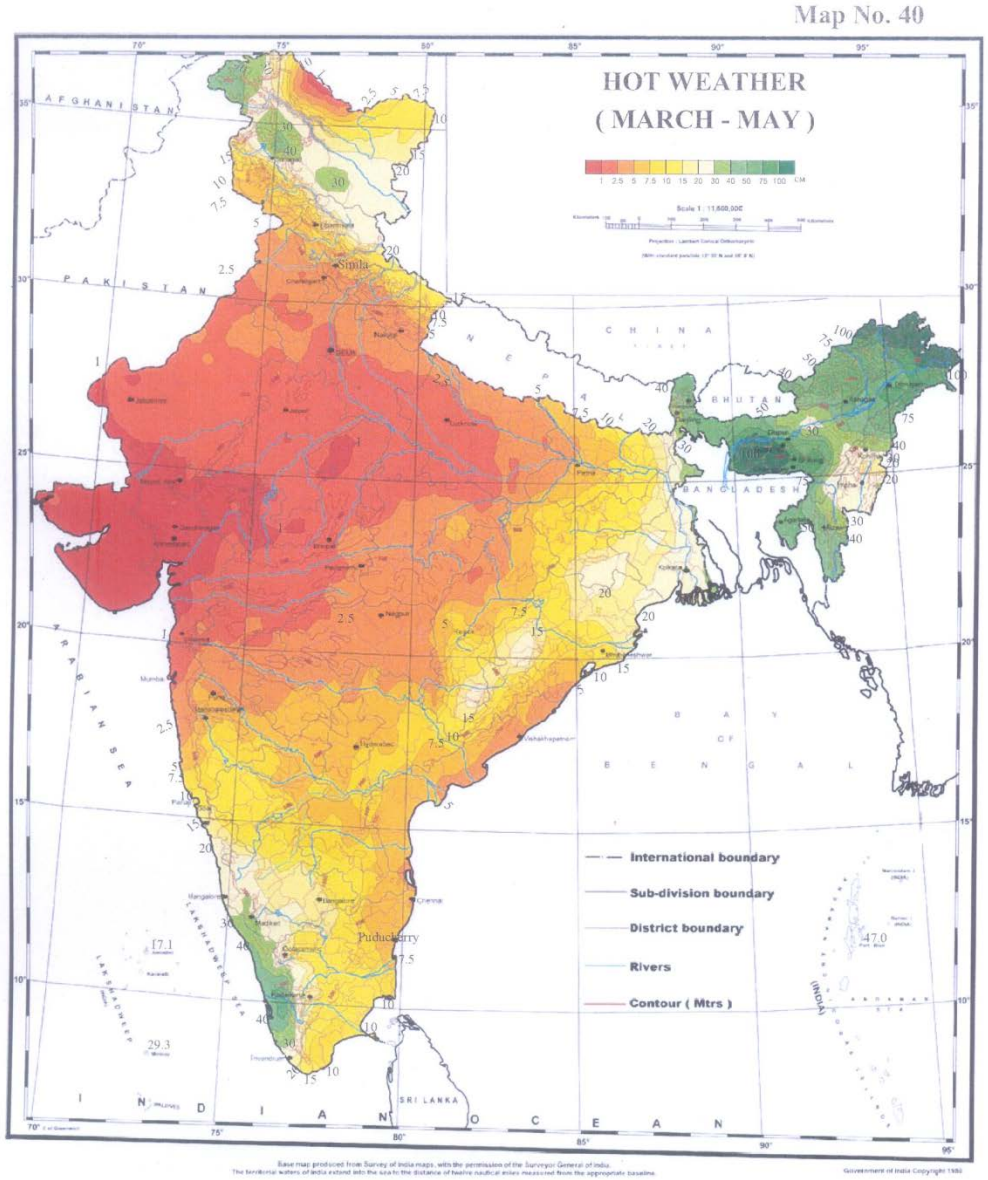


Source: IMD

Summer Season (March-May)

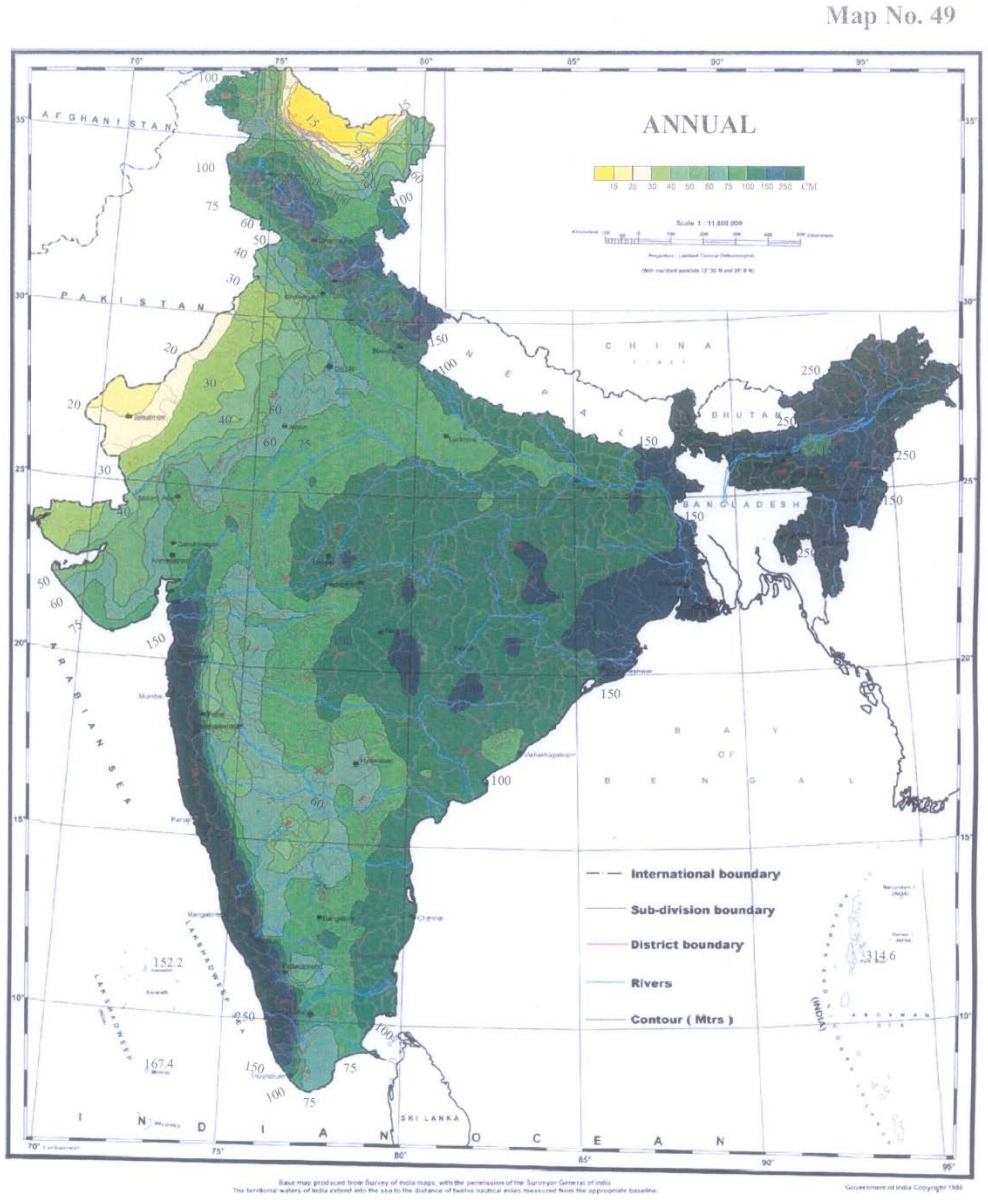
- Scanty rainfall over India
- Local convection in Kerala, West Bengal and Assam

Summer Season (March-May)



Source: IMD

Annual Rainfall



Source: IMD

Measurement of Precipitation

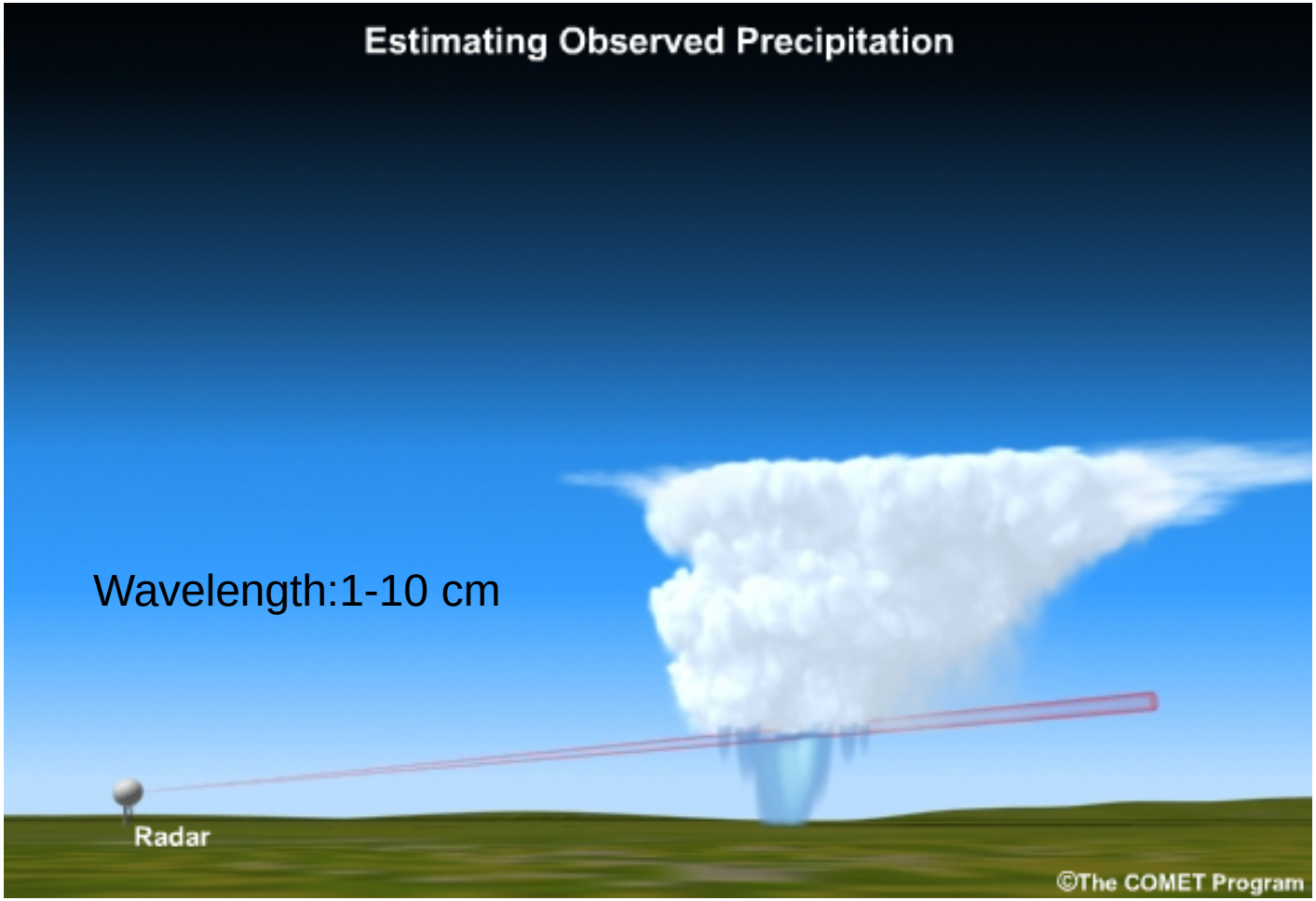
- Rainfall
  - Doppler Radars or land-based radars
  - Satellites
  - Rain gauge : (a) non-recording & (b) recording

Chapter 10 of the text book

Doppler Radar

Location : Weather Doppler Radar, Hyderabad

Doppler Radar



Wavelength:1-10 cm

Doppler Radar

Doppler radars typically measure:

1. the **intensity** or **reflectivity** of the returned (backscattered) signal;
2. the **frequency** of the returned signal; and
3. the **elapsed time** from the transmission of the pulse.

Intensity – Rainfall Relationship

- The radar's software relates the magnitude of the backscattered energy to the rainfall rate.
- Reflectivity/rainfall relationship (sometimes also called the Z-R equation)

These equations usually take the form

$$R = aZ^b$$

where

Z is the magnitude of the backscattered energy;

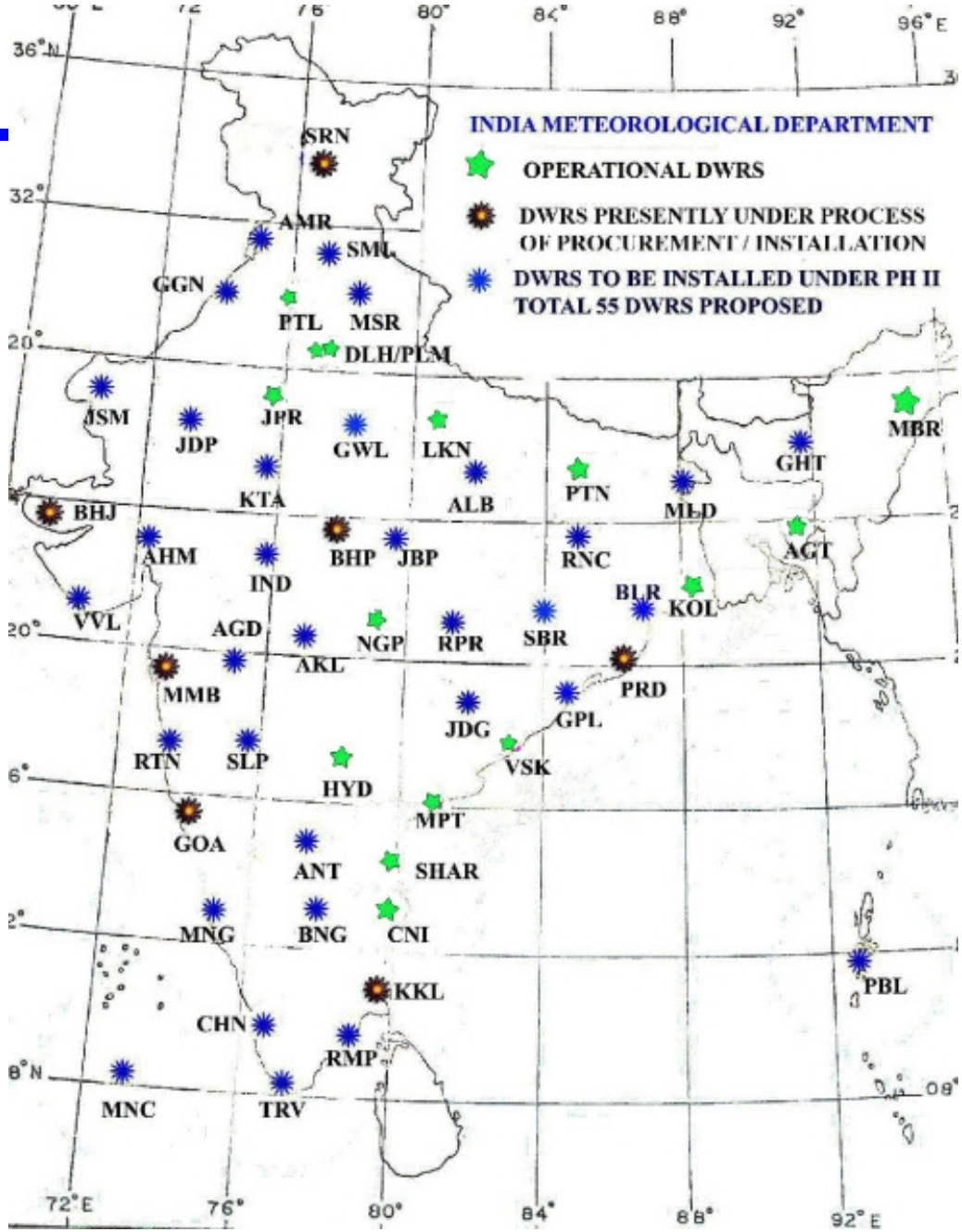
often represented as decibels of reflectivity dBZ = 10 $\log_{10}(Z)$

[dBZ : 20 - light precipitation, 60 – heavy precipitation]

R is the rainfall rate; and

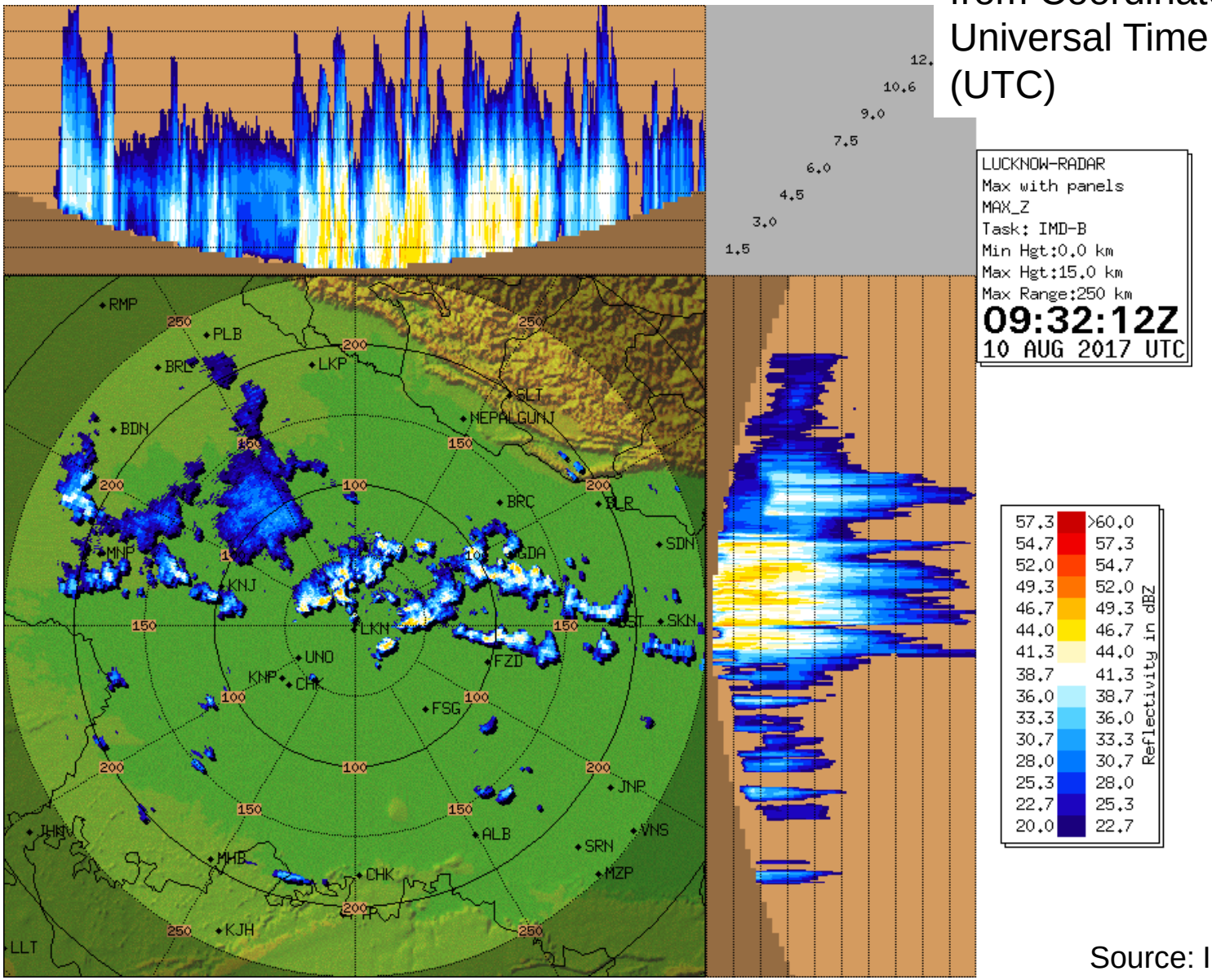
a and b empirically determined coefficients. Vary depending upon size, concentration and phase of hyddrometeors

Location of Doppler Weather Radar Stations (DWRS)



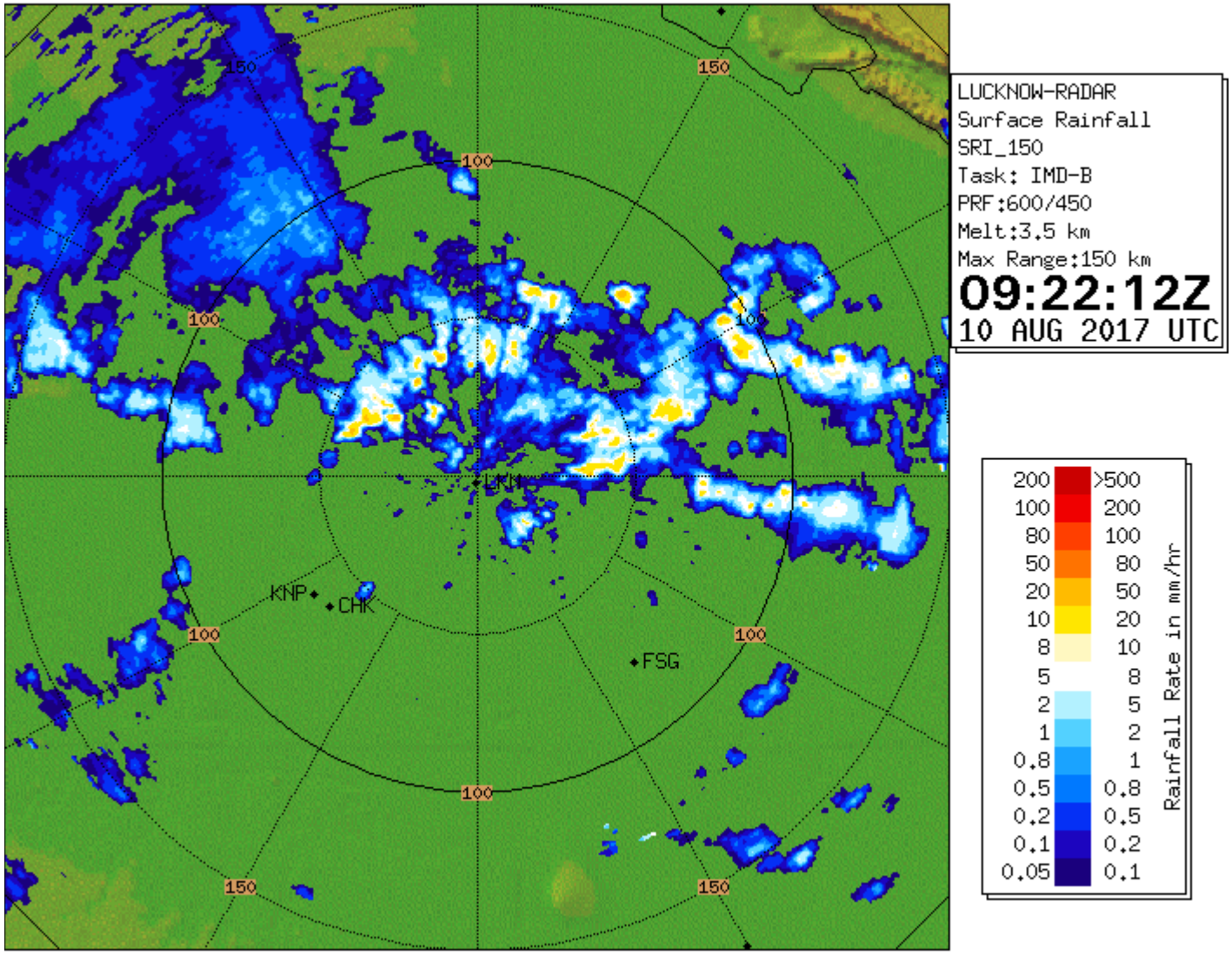
Reflectivity

Zulu Time Zone (Z) no offset from Coordinated Universal Time (UTC)



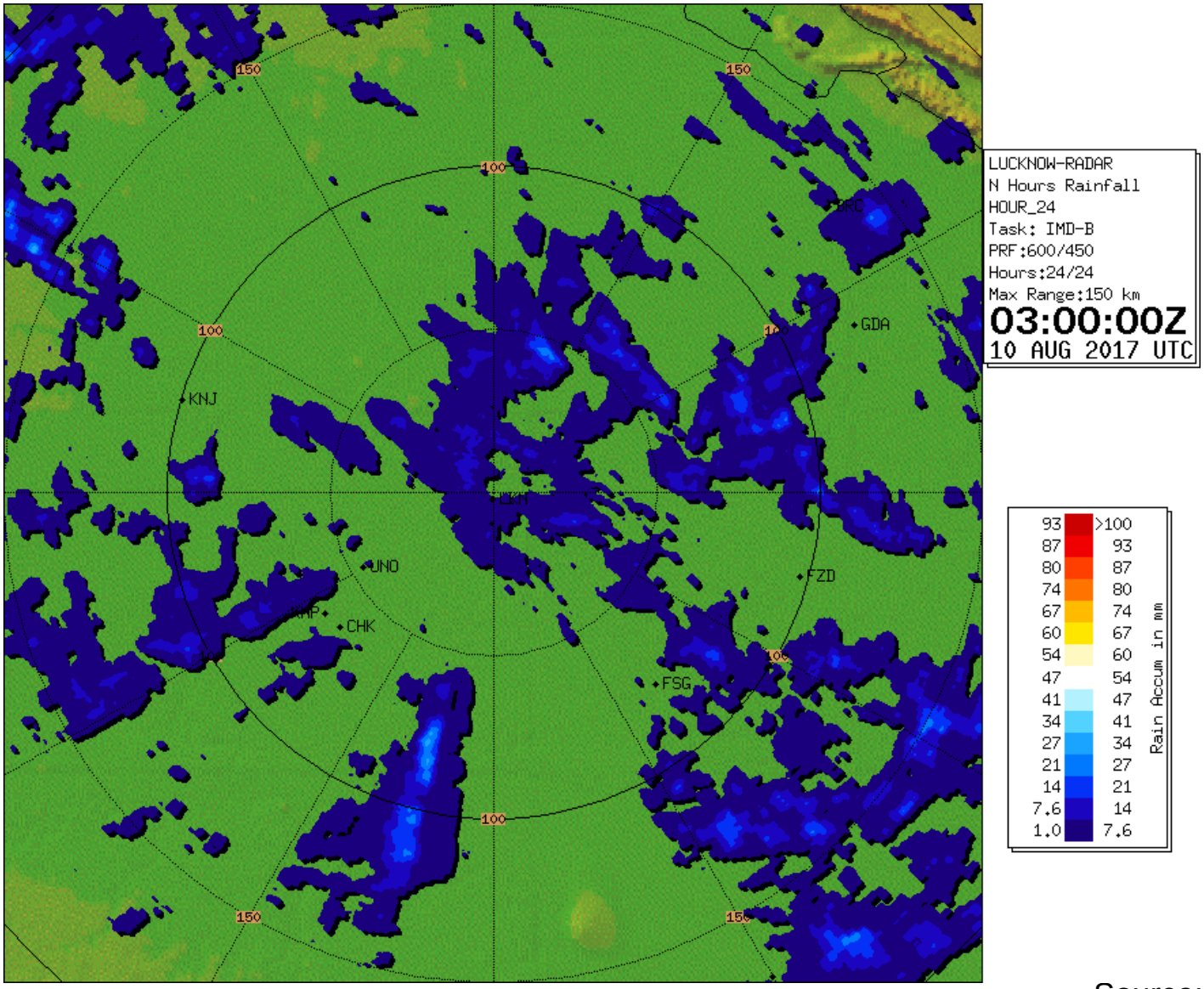
Source: IMD

Rainfall Rate



Source: IMD

Rainfall Accumulation

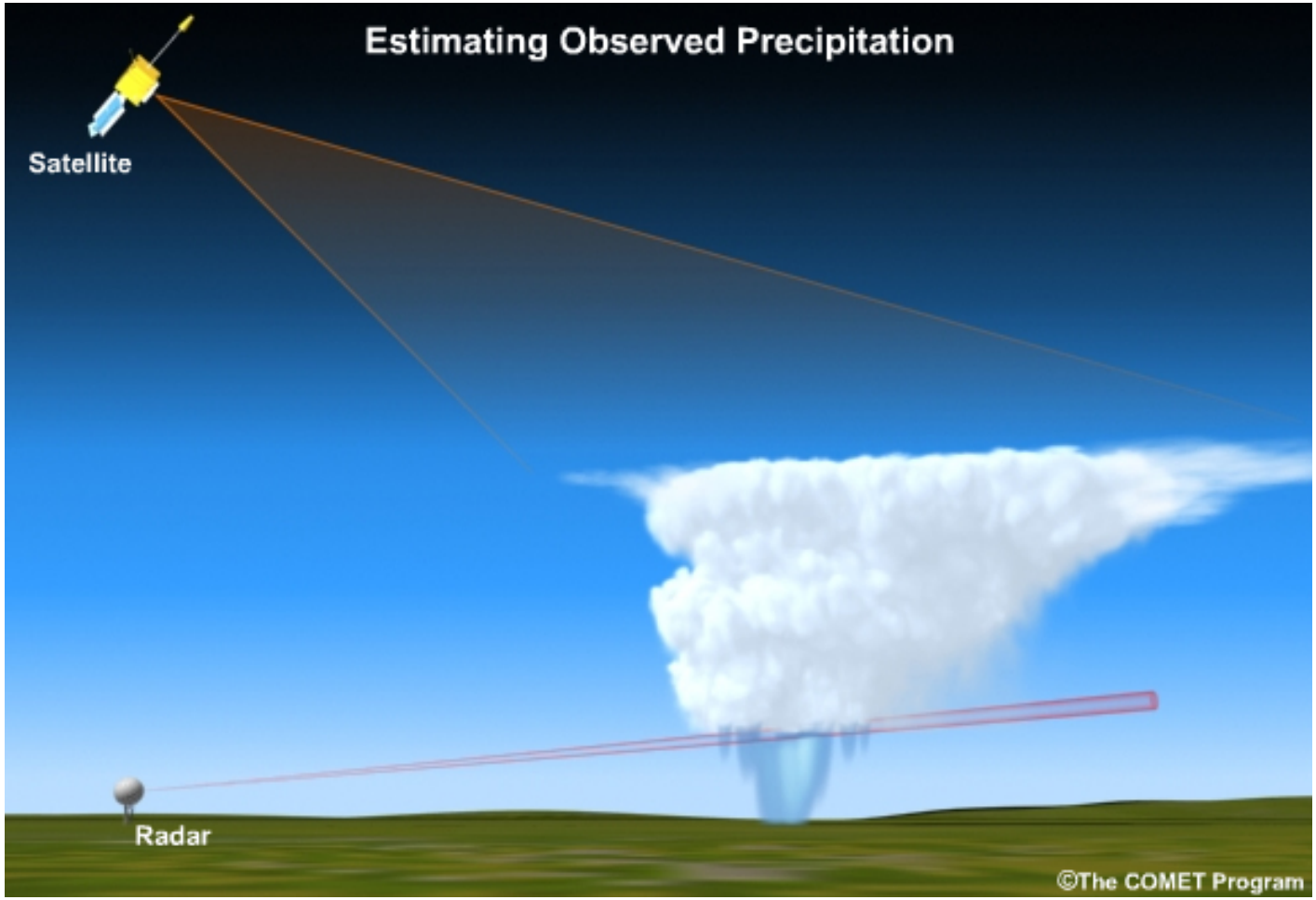


Source: IMD

Doppler Radar: Limitations

- Indirect measurement
- Longevity of records

Satellites

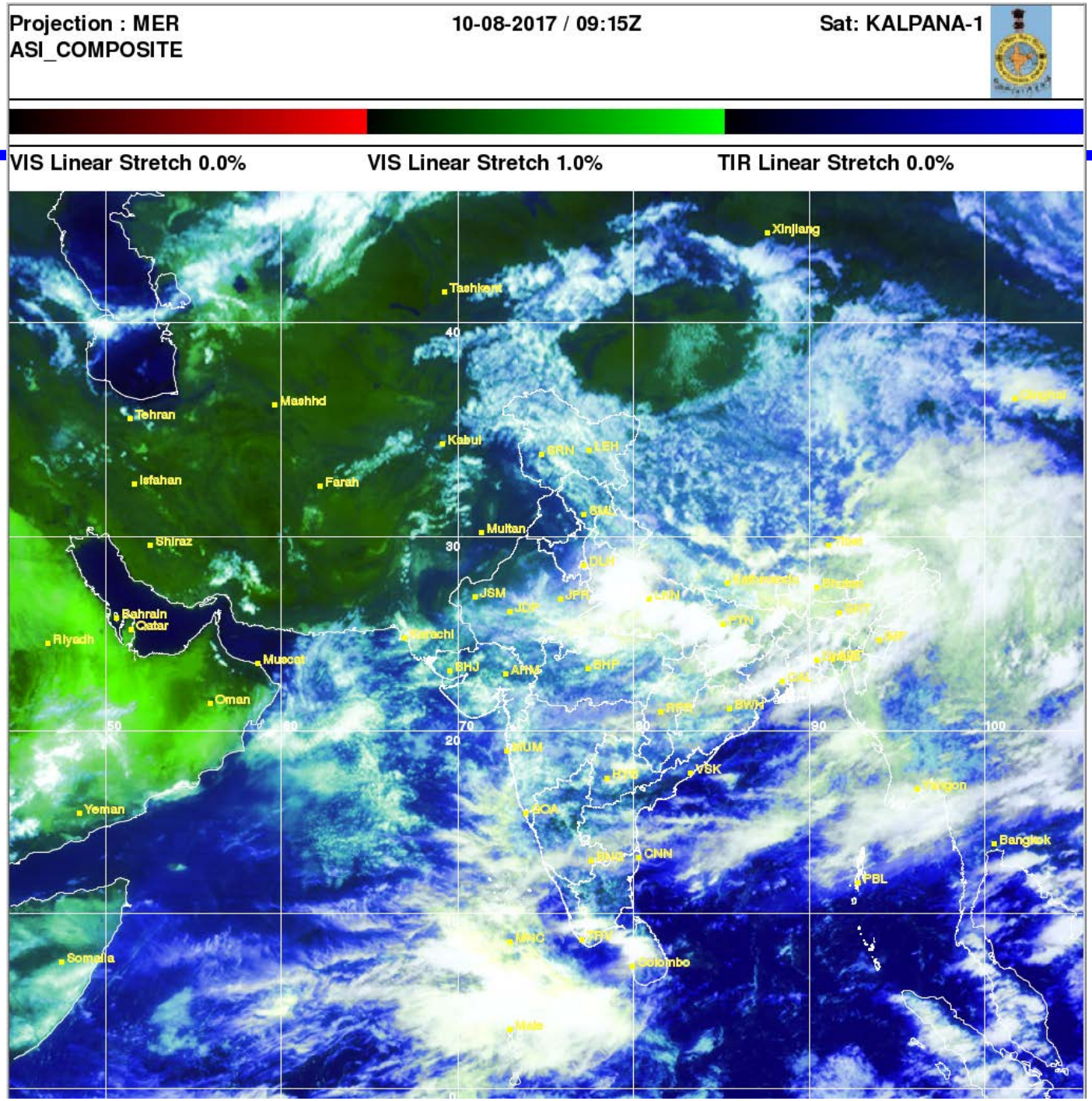

Estimating Observed Precipitation
Satellite
Radar
©The COMET Program

Satellites

- Active area of hydro-meteorological research
- Perhaps the only means to estimate precipitation over the entire globe, including
  - 2/3rd of globe covered by oceans and
  - land areas which are inaccessible

Satellites: Methods of estimation

- Cloud mapping and characterization
  - Empirical relationship between precipitation at a location and nature of overlying cloud quantified as cloud indices
- Passive measurement of cloud properties
  - Relationship between precipitation and physical characteristic of cloud like cloud top temperature or outgoing longwave radiation (OLR).
- Spaceborne radars
  - Similar to ground based radars
  - Tropical rainfall measuring mission (TRMM)


Projection : MER
ASI_COMPOSITE
10-08-2017 / 09:15Z
Sat: KALPANA-1
VIS Linear Stretch 0.0%
VIS Linear Stretch 1.0%
TIR Linear Stretch 0.0%
Xinjiang
Tashkent
Mashhd
Tehran
Kabul
Isfahan
Farah
Multan
Shiraz
Bahrain
Qatar
Riyadh
Muscat
Oman
Yeman
Somalia
Karachi
Colombo
Male
Yangon
Bangkok
Tibet
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40
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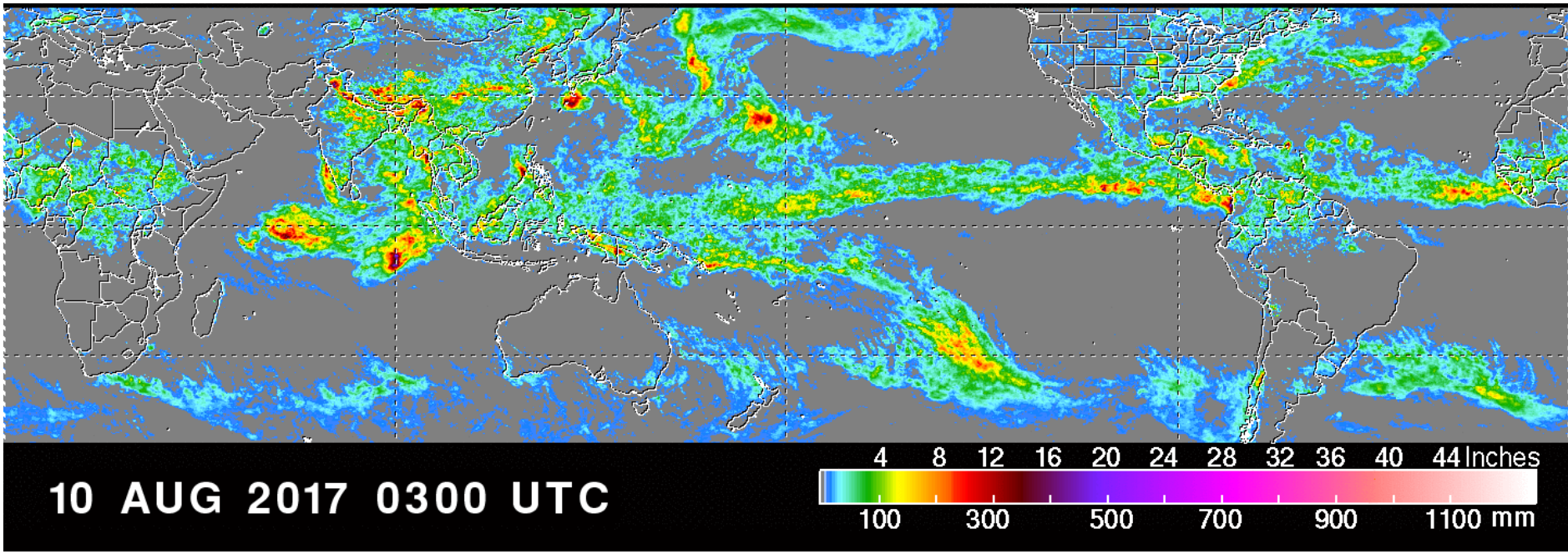
70
80
90
100

Source: IMD

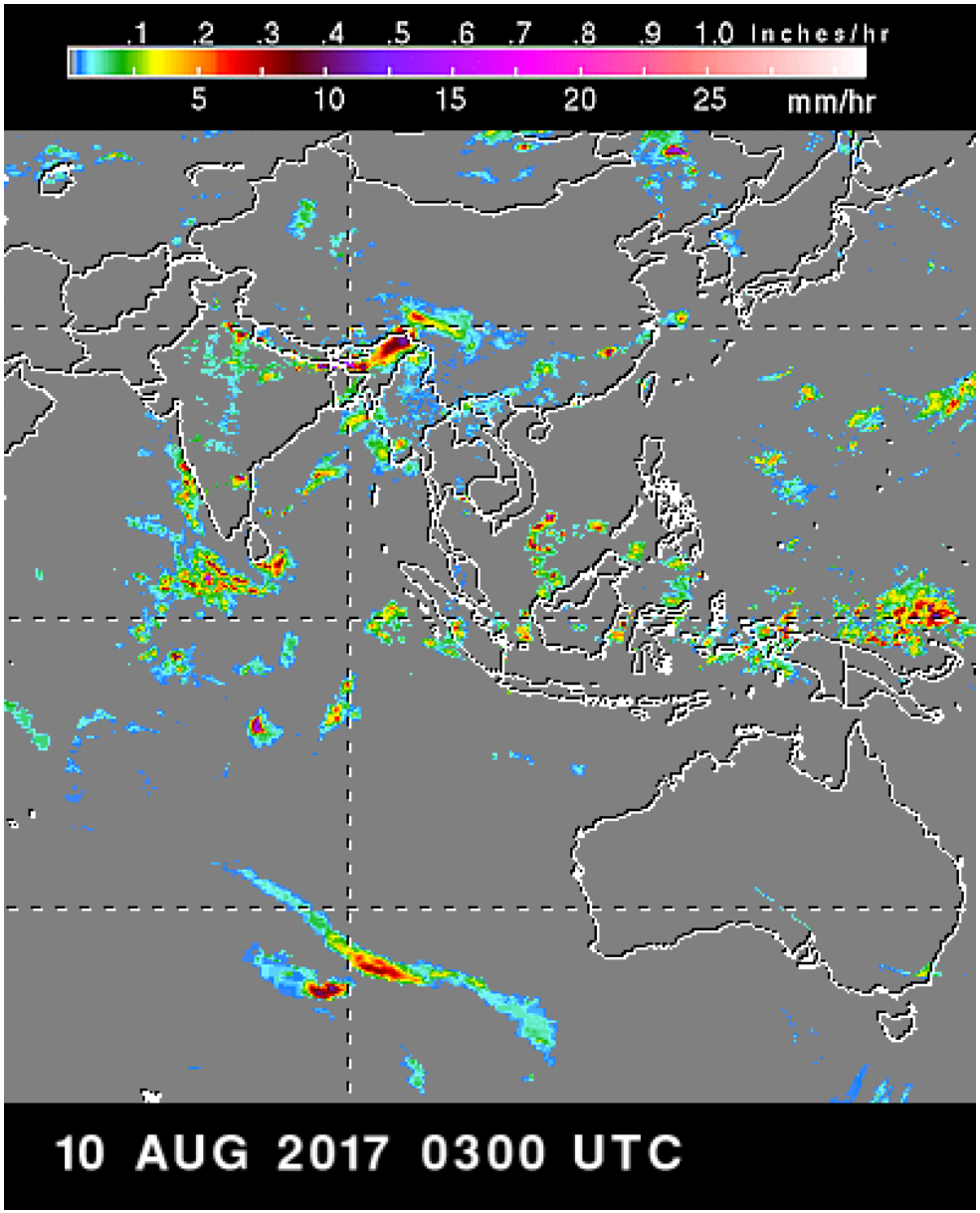
TRMM



Last Week Global Rainfall Accumulation

Source: http://trmm.gsfc.nasa.gov/

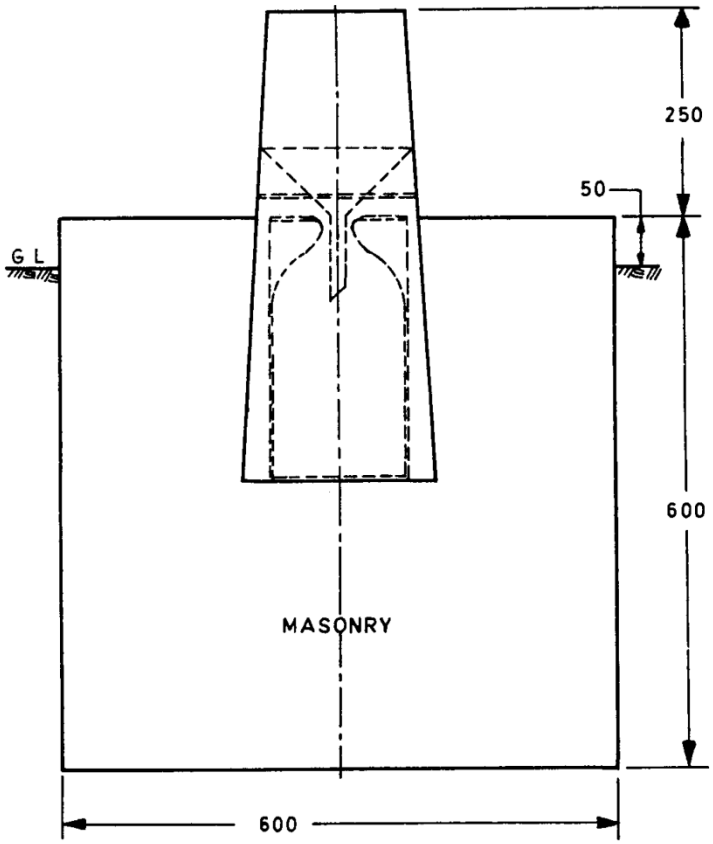
TRMM (3 hr rainfall)



Non-Recording or Ordinary Rain gauge

Indian Standard Non-Recording Gauges

IS 4986 : 2002

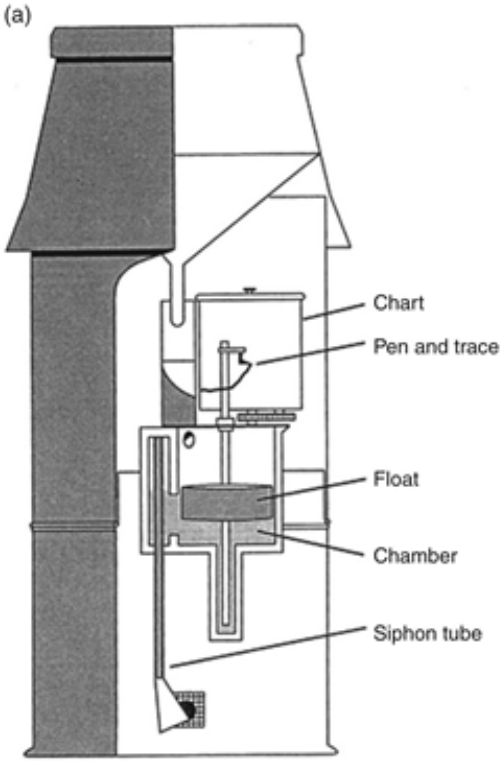


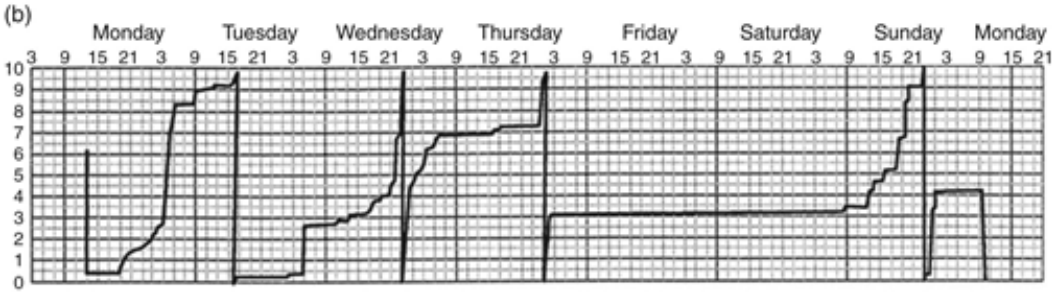
All dimensions in millimetres.

- The gauge can hold up to 10-25 cm of rain
- In Indian rainfall is measured every day at 8:30 am

Recording Rain gauge: Natural Siphon Raingauge

- Float Type gauge
- Adopted as standard recording type raingauge in India



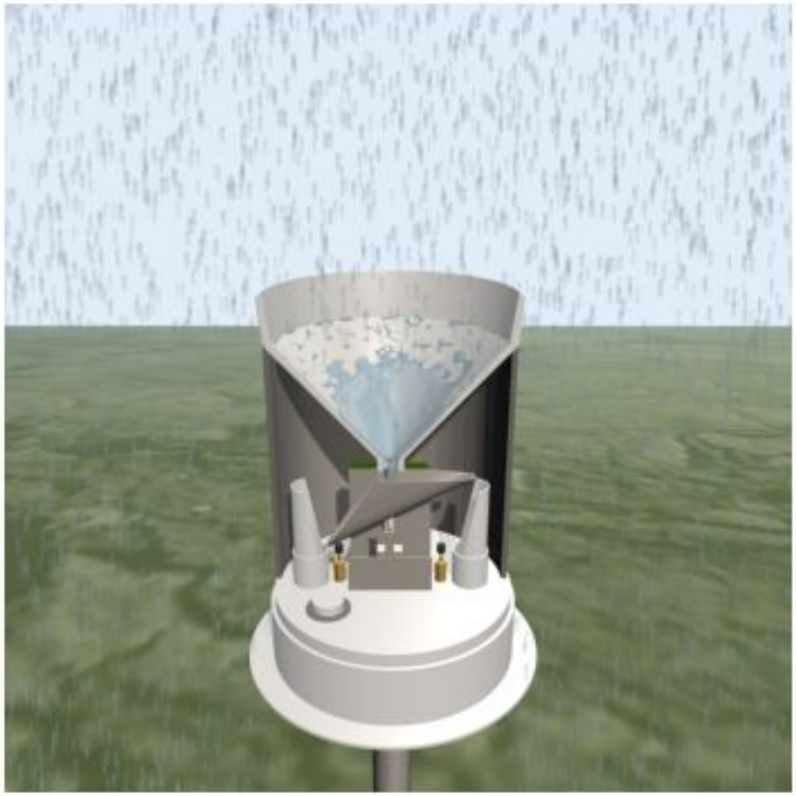


Terrestrial Hydrometeorology, First Edition. W. James Shuttleworth.
© 2012 John Wiley & Sons, Ltd. Published 2012 by John Wiley & Sons, Ltd.

Recording Rain gauge: Tipping Bucket

- Most commonly used raingauge worldwide
- Gives digital output

The Inner Workings of a Tipping Bucket Rain Gauge



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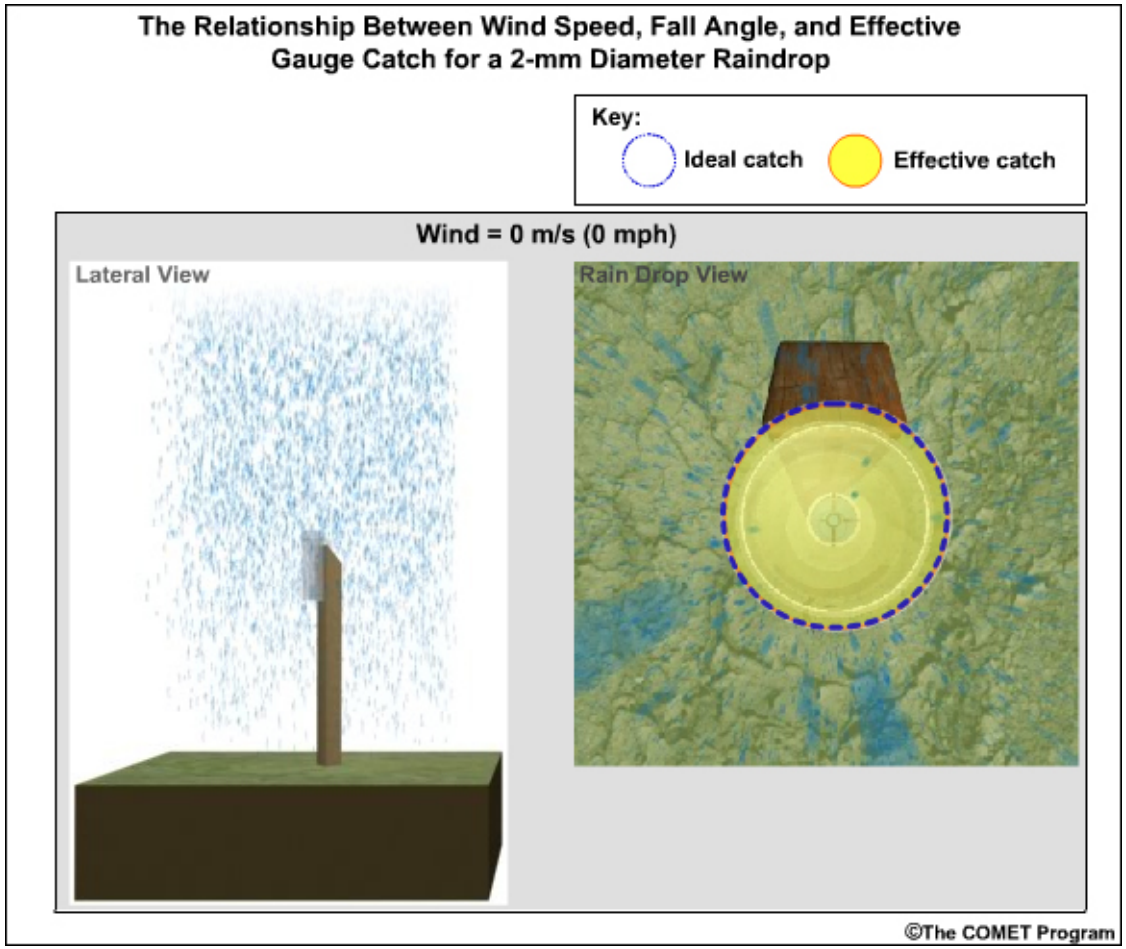
Recording Rain gauge: Weighing type

- Modern raingauge
- Have a load cell which gives digital output
- Marketed as total precipitation gauges

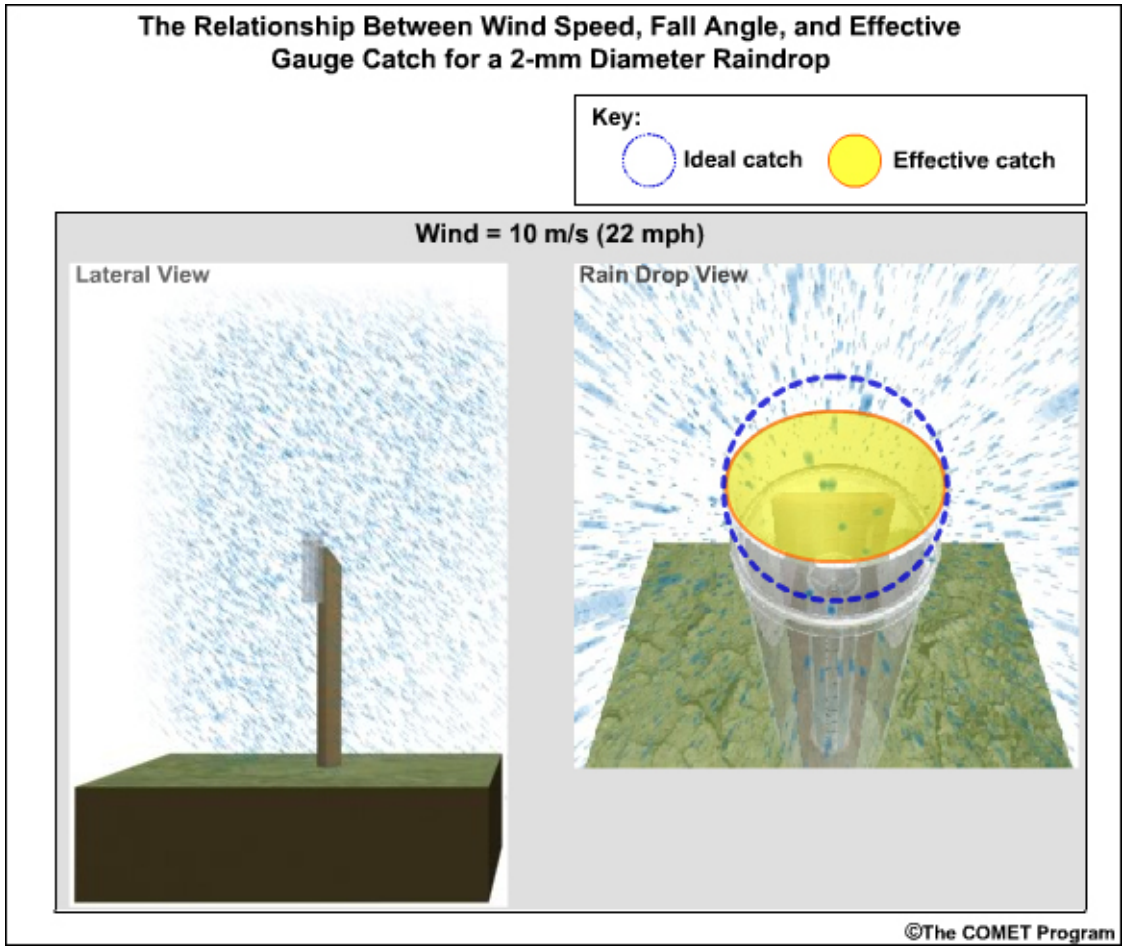
ETI's NOAH III precipitation weighing gauge

Source: http://www.etisensors.com/noah_iii.htm

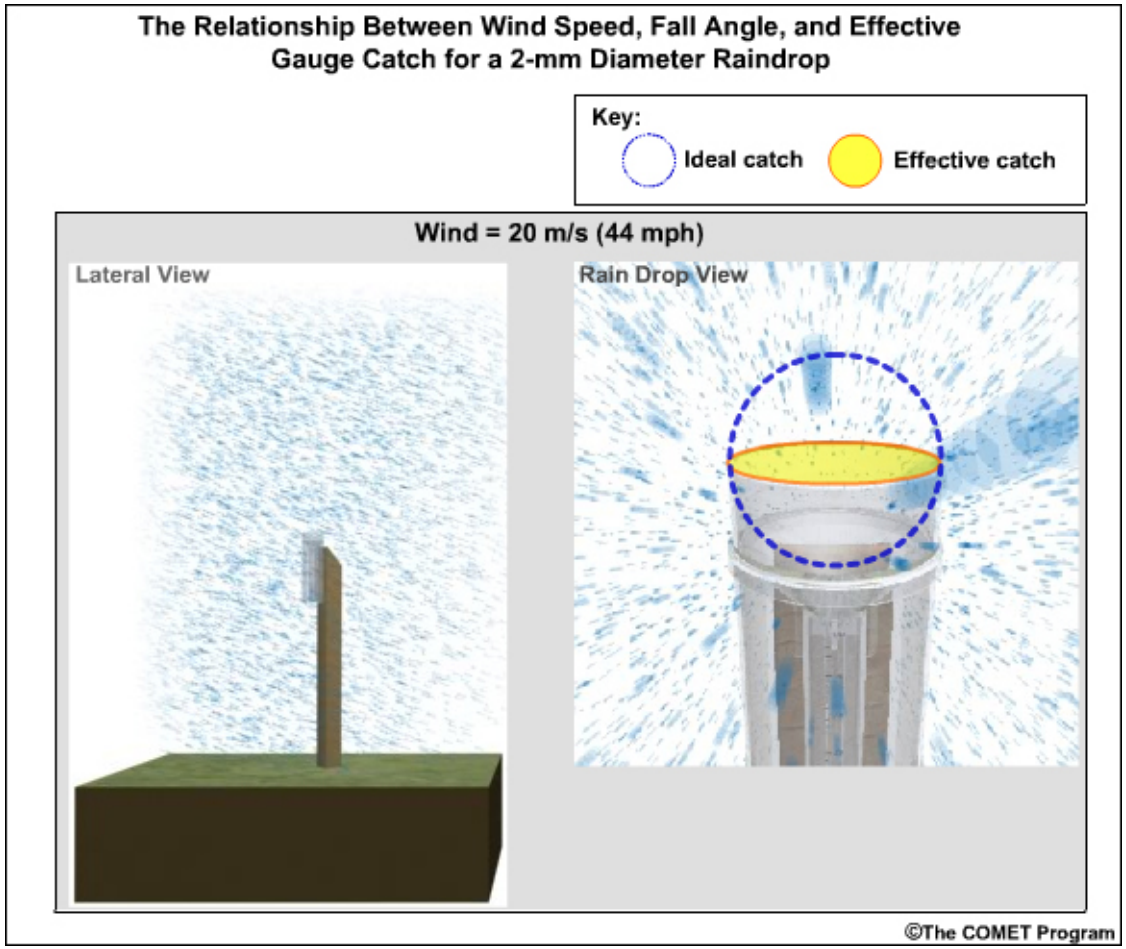
Effect of Wind



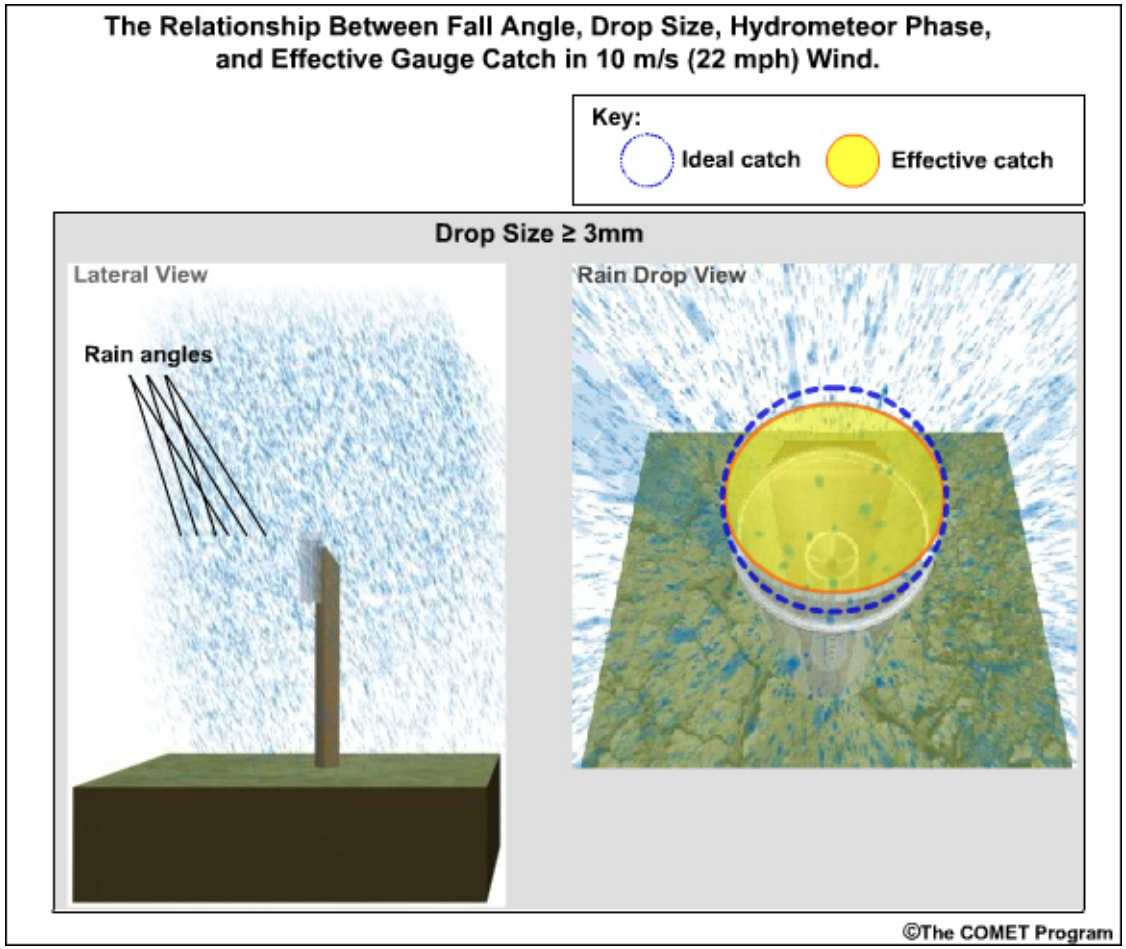
Effect of Wind



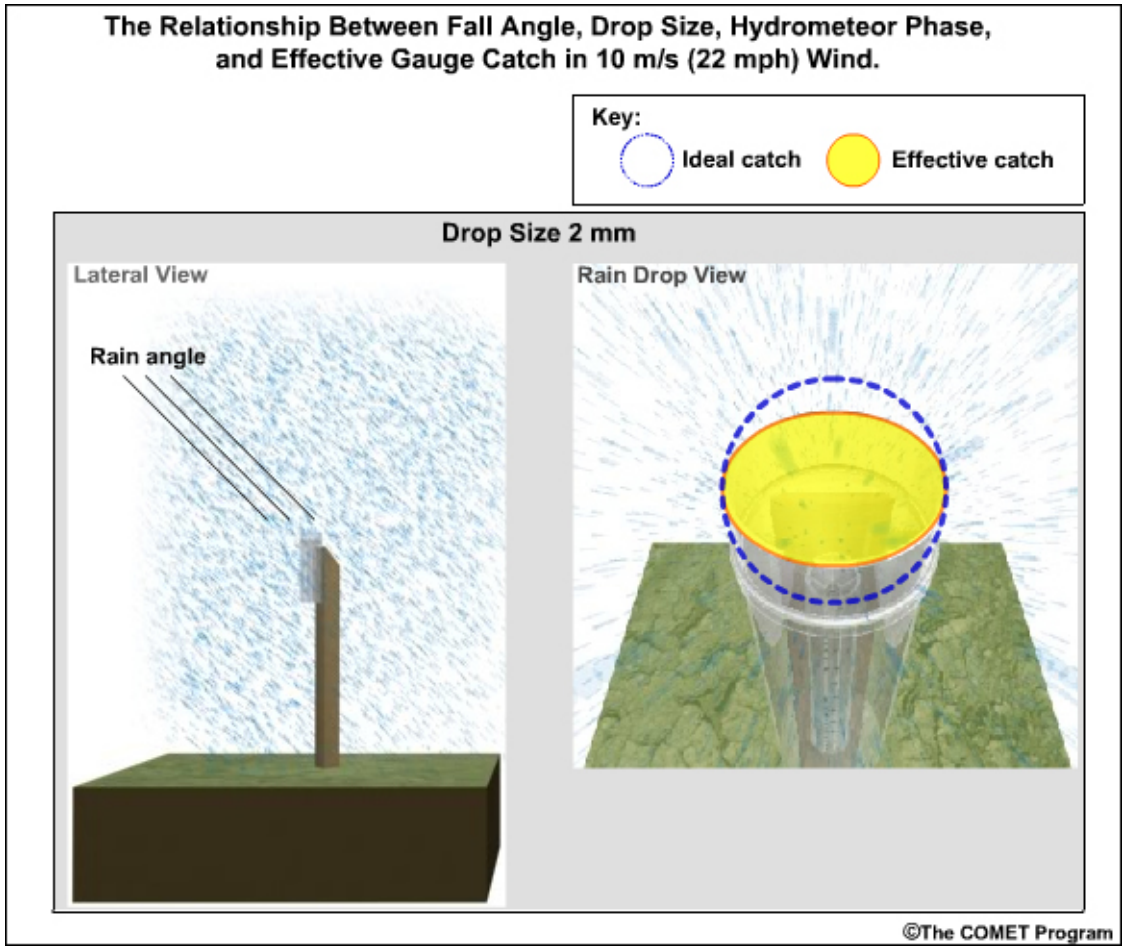
Effect of Wind



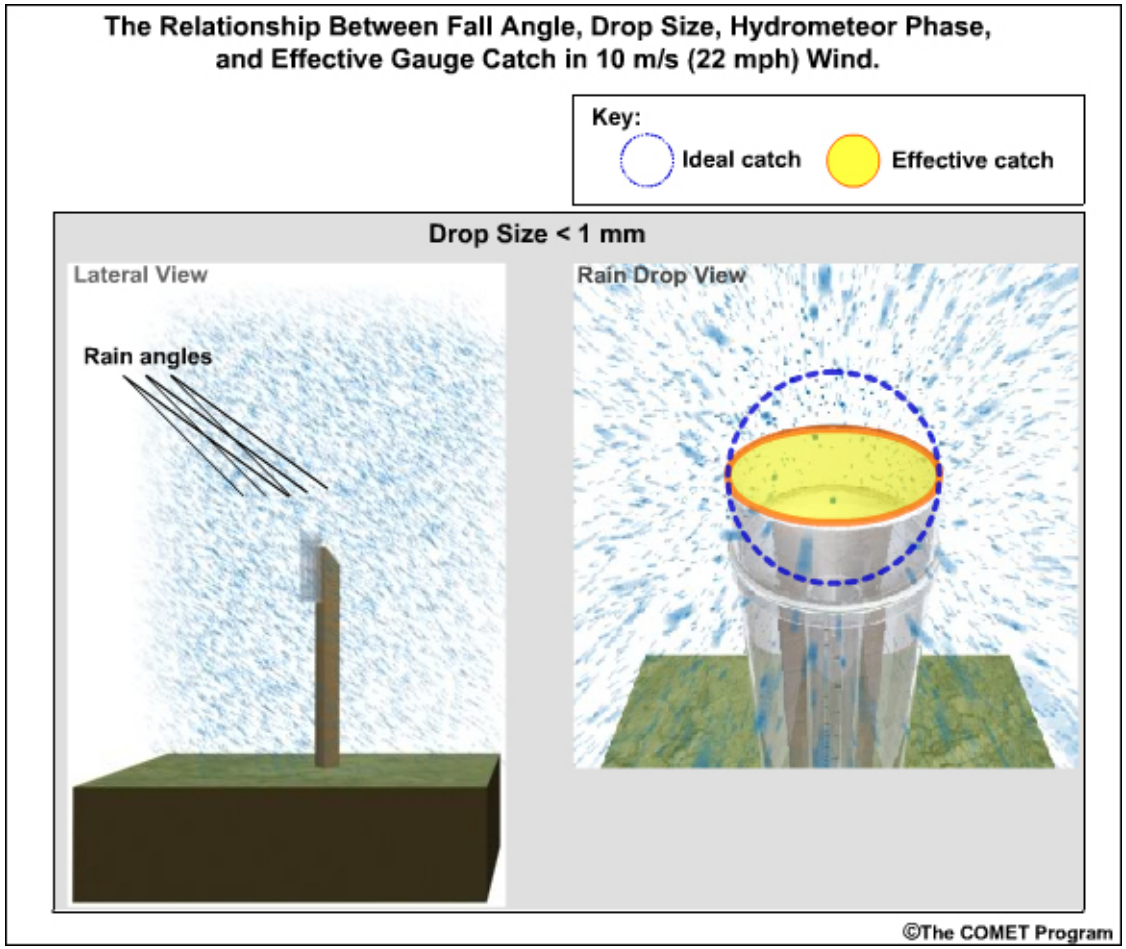
Effect of drop size



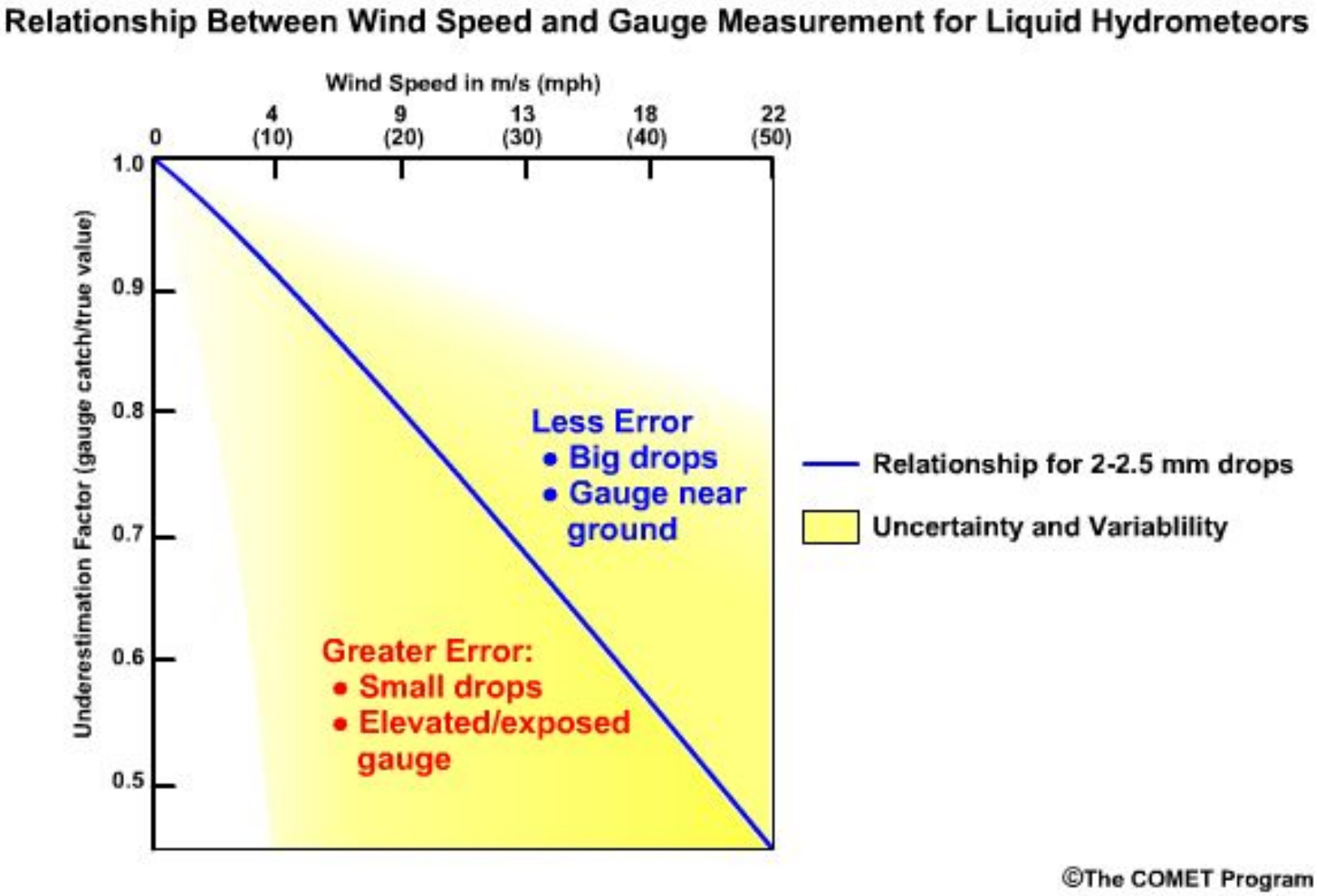
Effect of drop size



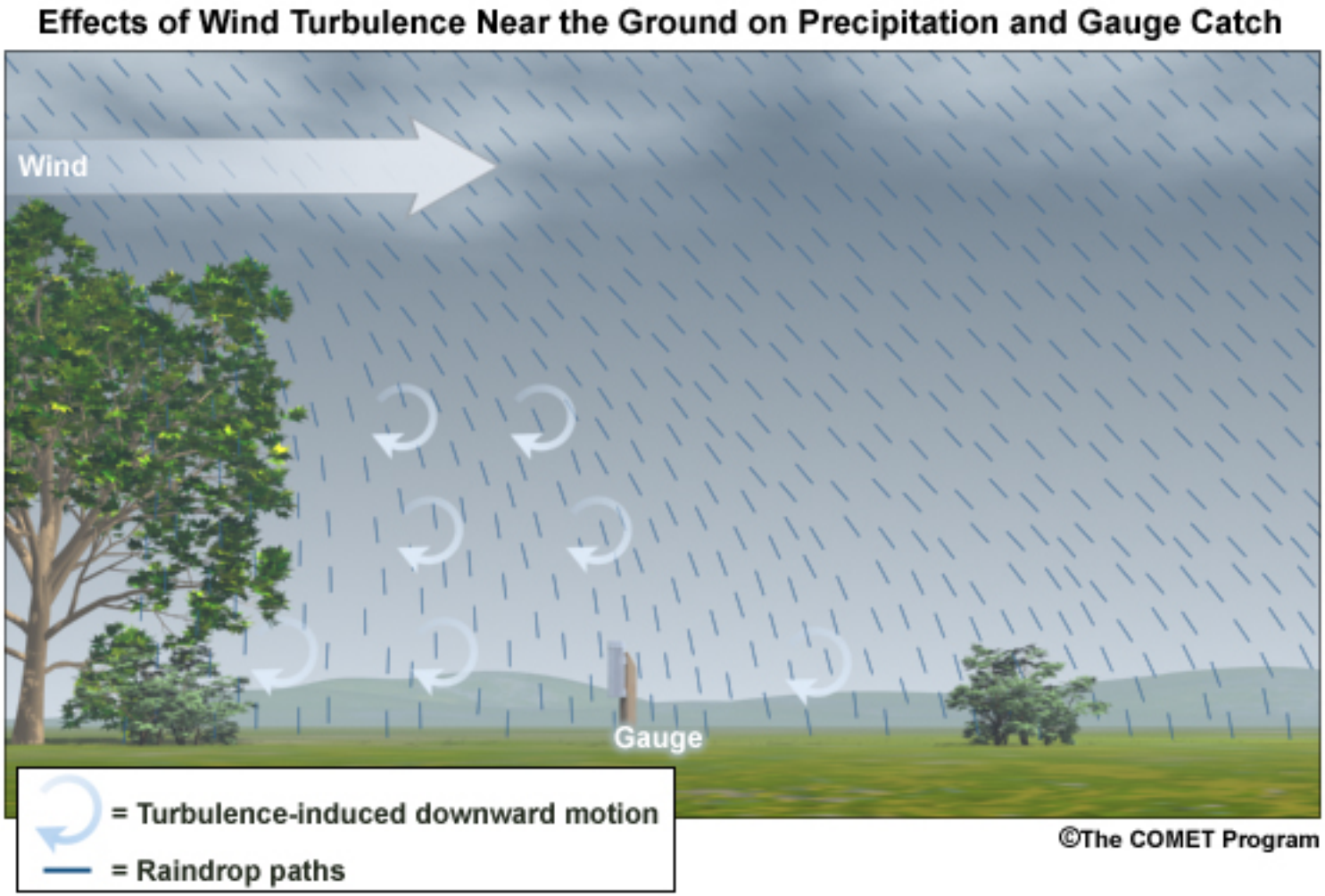
Effect of drop size



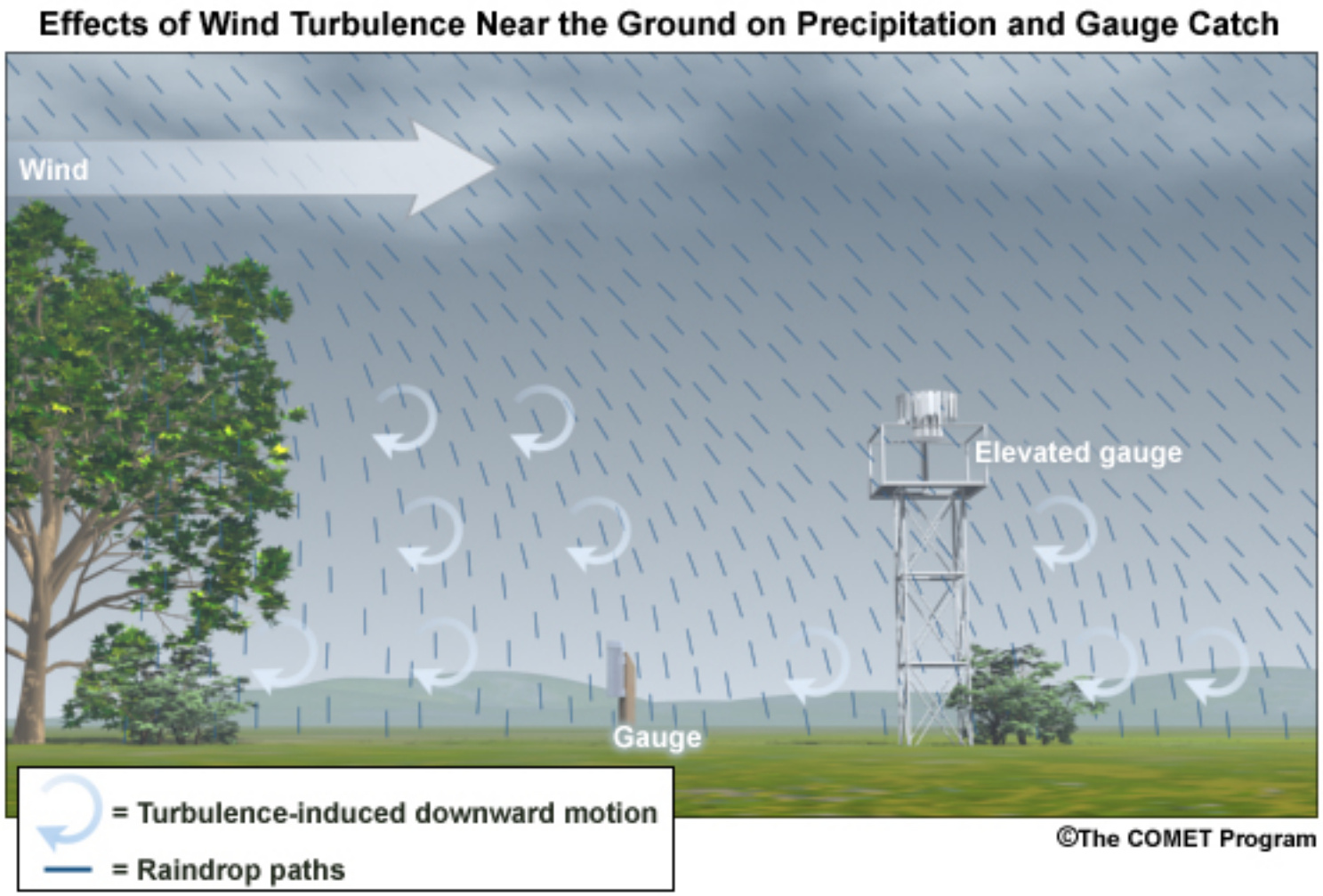
Effect of Wind



Effect of Turbulence: Ground Induced



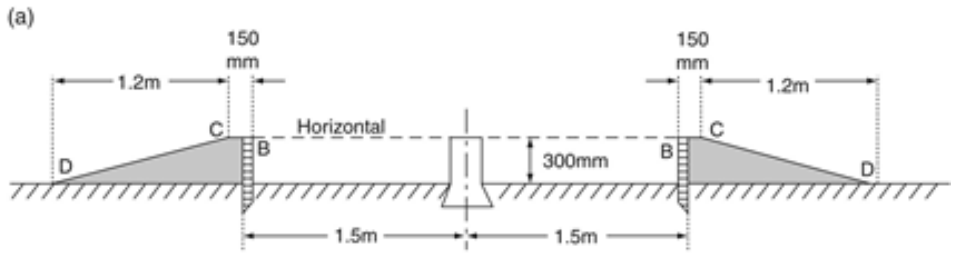
Effect of Turbulence: Ground Induced



Shielded Rain gauge: Controlled Turbulence

Source: University of Waterloo Weather Station

Shielded Rain gauge: Controlled Turbulence



Turf wall for use at exposed rain gauge sites

Source: W. J. Shuttleworth (2012) & Centre for ecology and hydrology, UK

Location of rain gauge as per IS 4986-2002

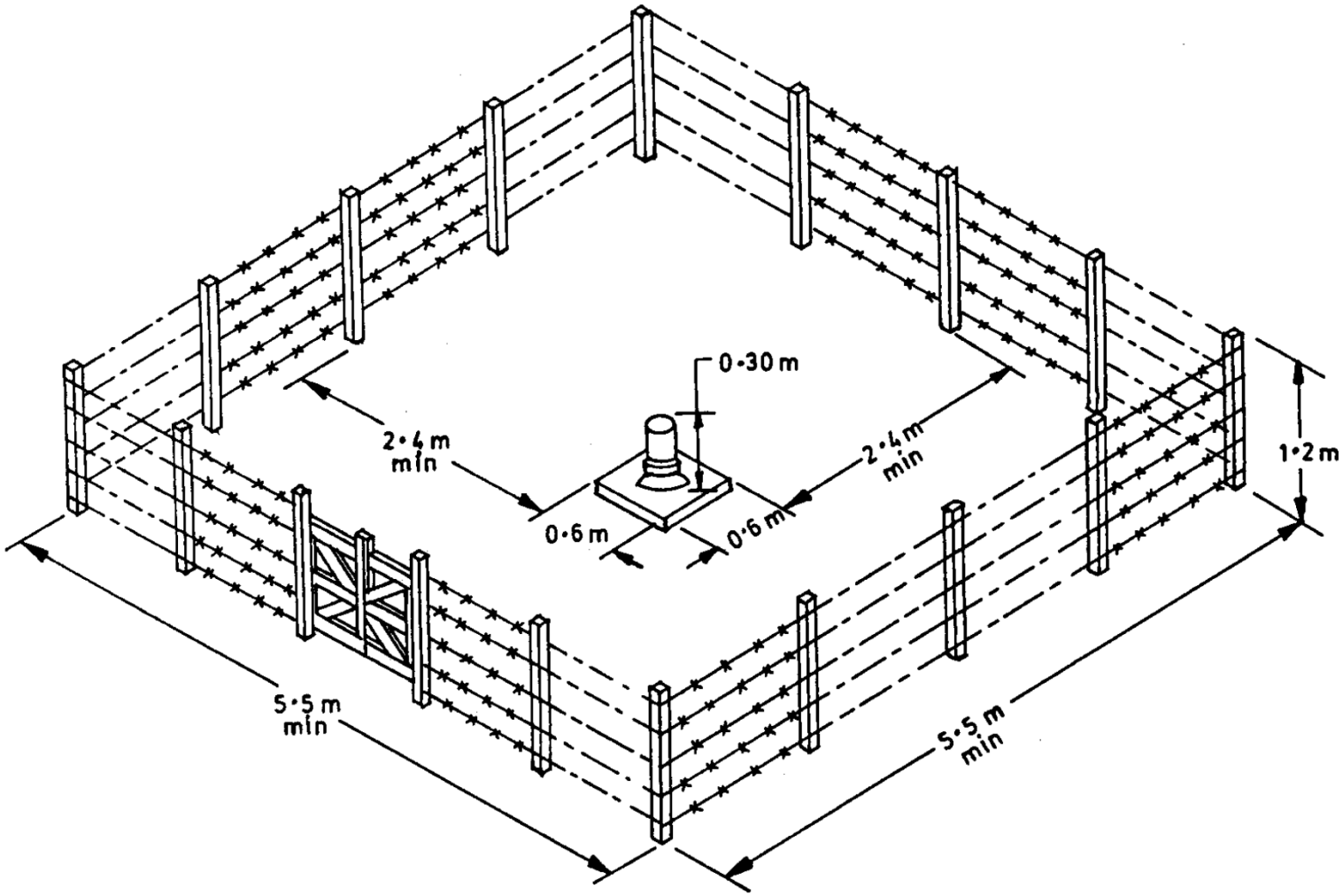


FIG. 2 A RAINGAUGE INSTALLED WITHIN FENCE

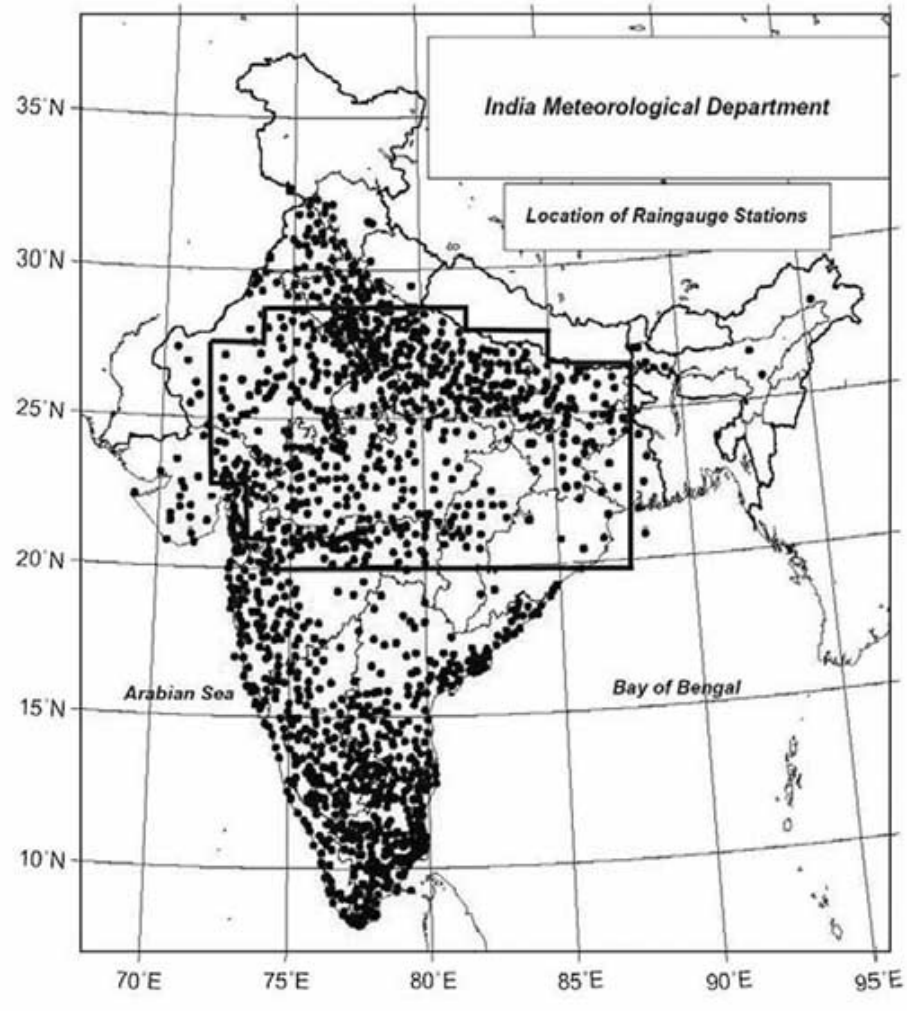
Summary: Rain gauges

- Wind reduces the rainfall gauge catch
- The effect is more pronounced for smaller rain drops
- Downward turbulence induced by gauge or ground obstructions can offset the reduction in gauge catch
- Methods are devised to induce controlled turbulence

Precipitation measurement in India

- India Meteorological Department (IMD) has been given the responsibility to measure precipitation over India
- Rainfall from non-recording gauges are measured at 8:30 am (IST)
- Indian standards
  - IS 4986-2002: Non-recording rain gauges
  - IS 8389-2003 and IS 5235-1992: Recording rain gauges
  - IS 4987-1994: Establishing raingauge network

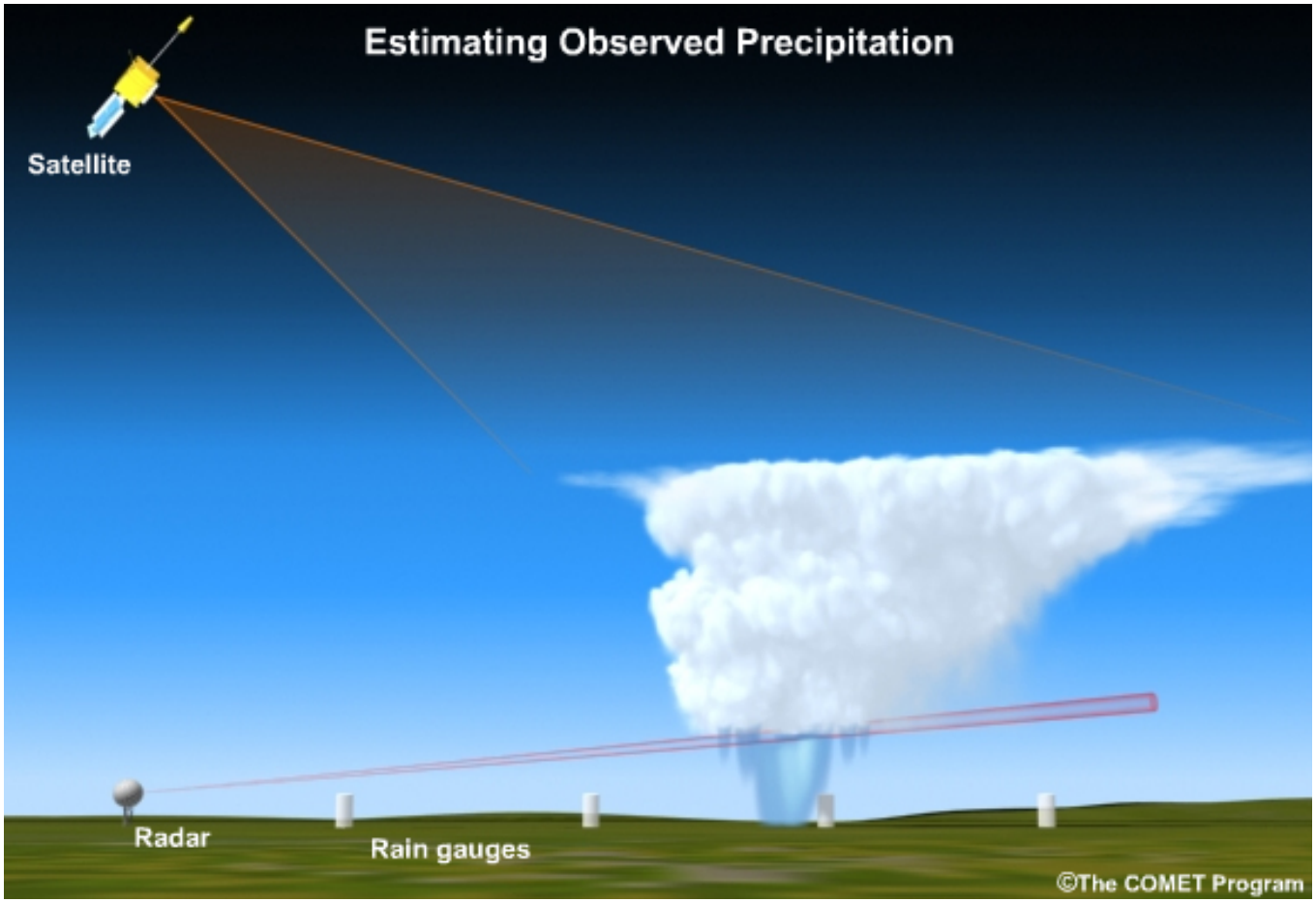
Location of IMD Gauges



1384 stations with long records

Source: Rajeevan et al. 2008

Assimilation



Combine data from various sources