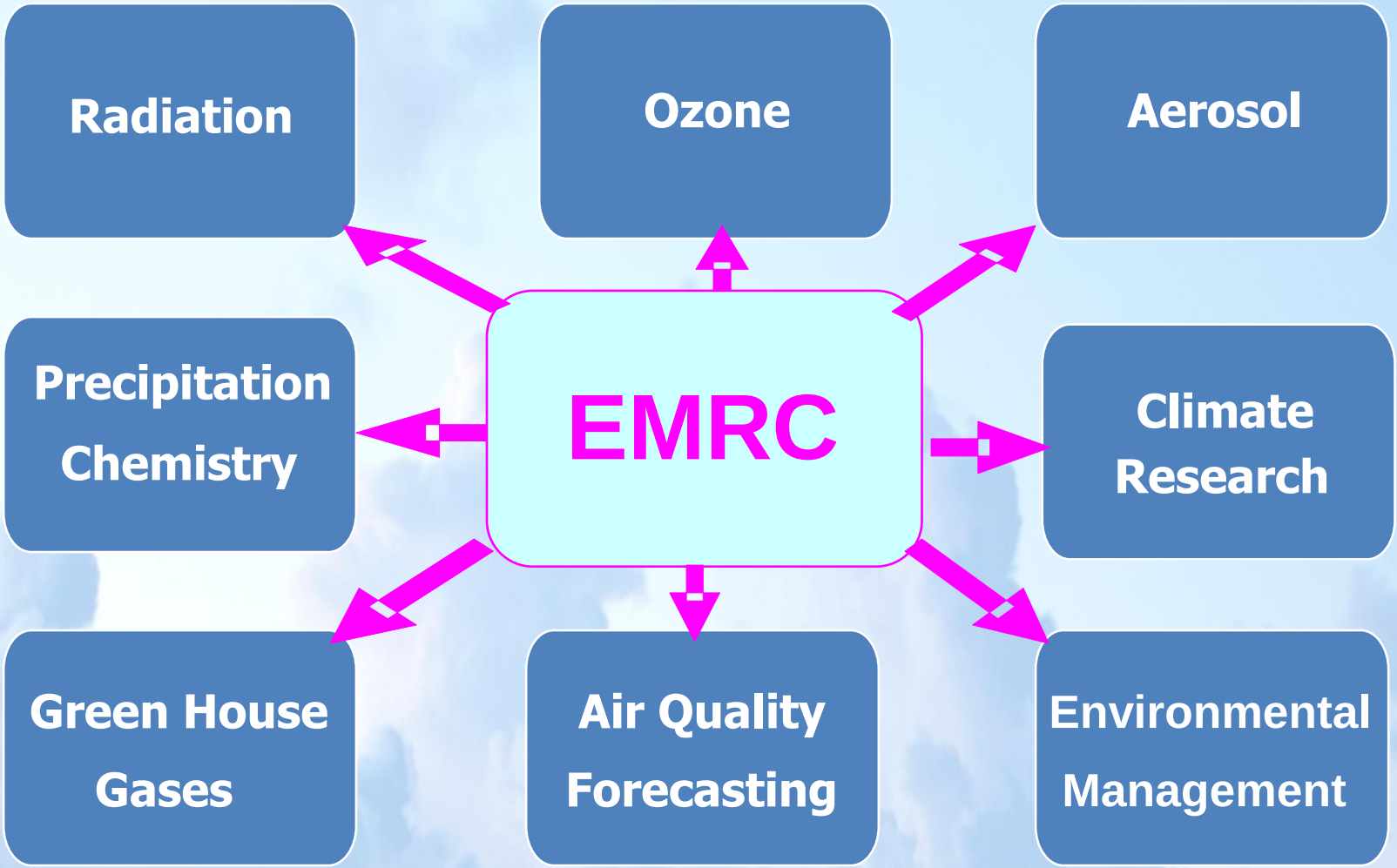
Introduction to Environmental Monitoring System

Anikender Kumar

भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

ENVIRONMENT MONITORING & RESEARCH CENTRE (EMRC)



Environmental Monitoring and Research

Air Quality Monitoring, Modeling & Forecast

Air Quality Early Warning System

a) 3 Km SILAM regional air quality forecast Model (3-days in advance)
b) ENFUSER street level forecast Model for Delhi
c) IITM WRF-Chem

Salient Features:

a) air quality forecast at 400 meters for Delhi region for 3-days and outlook for next 7-days
b) air quality forecast for entire India and specifically for several non-attainment cities (Pune, Mumbai, Bangalore, Kolkata, Varanasi, Lakhnow, Hyderabad, Patna)
c) real time observations of air quality over Delhi region, fire counts, AOD
d) details about natural aerosols like dust (from satellite and model forecast)
e) Near real-time fire information over India
f) forecast of the contribution of non-local fire emissions,
g) Weather Information
h) Day to day verification of forecast product.

https://ews.tropmet.res.in
https://nwp.imd.gov.in/silam_imd.php

Ozone Monitoring

- Total Columnar ozone (2): Dobson Spec.
- Surface Ozone monitoring (7)
- Vertical Distribution of Ozone (3)
- Maitri and Bharati (Antarctica)

Monitoring of Aerosol Optical Properties & Radiative Effects

- Skyradiometer (12 + 8)
- Black Carbon Monitoring (16+9)
- Nephelometer Stations (12)

Precipitation and Aerosol Chemistry Monitoring (11)

Background Station – Ranichauri

OGICAL DEPARTMENT

Global Atmosphere Watch (GAW) Programme

The World Meteorological Organization (WMO) established the Global Atmosphere Watch (GAW) programme in 1989 to coordinate observations implemented by diverse countries and organizations. The mission of GAW is to:

- Reduce environmental risks to society and meet the requirements of environmental conventions.
- Strengthen capabilities to predict climate, weather and air quality.
- Contribute to scientific assessment in support of environmental policy.

WMO Global Atmosphere Watch

- **WMO/GAW was established 1989 by merging GO_3OS and BAPMoN established respectively in the 1950s and 1960s.**
- **GAW focuses on global networks for GHGs, ozone, UV, aerosols, selected reactive gases, and precipitation chemistry.**
- **GAW is a partnership involving contributors from more than 100 countries.**
- **GAW is coordinated by the Environment Division of WMO under the purview of WMO Commission for Atmospheric Science.**
- **Currently GAW coordinates activities and data from 24 Global stations, 637 regional stations, and 19 contributing and associate stations.**
- *IMD is maintaining a network of GAW stations of regional category in India.*
- *Precipitation Chemistry - 11 stations*
- *Ozone*
  - *Surface Ozone – 6 + 10 stations*
  - *Column Ozone – 6 (Dobson and Brewer Spectrophotometer)*
  - *Ozone sonde – 3*
- *Solar Radiation – 21 stations (WRDC stations)*
- *AOT -20 stations*

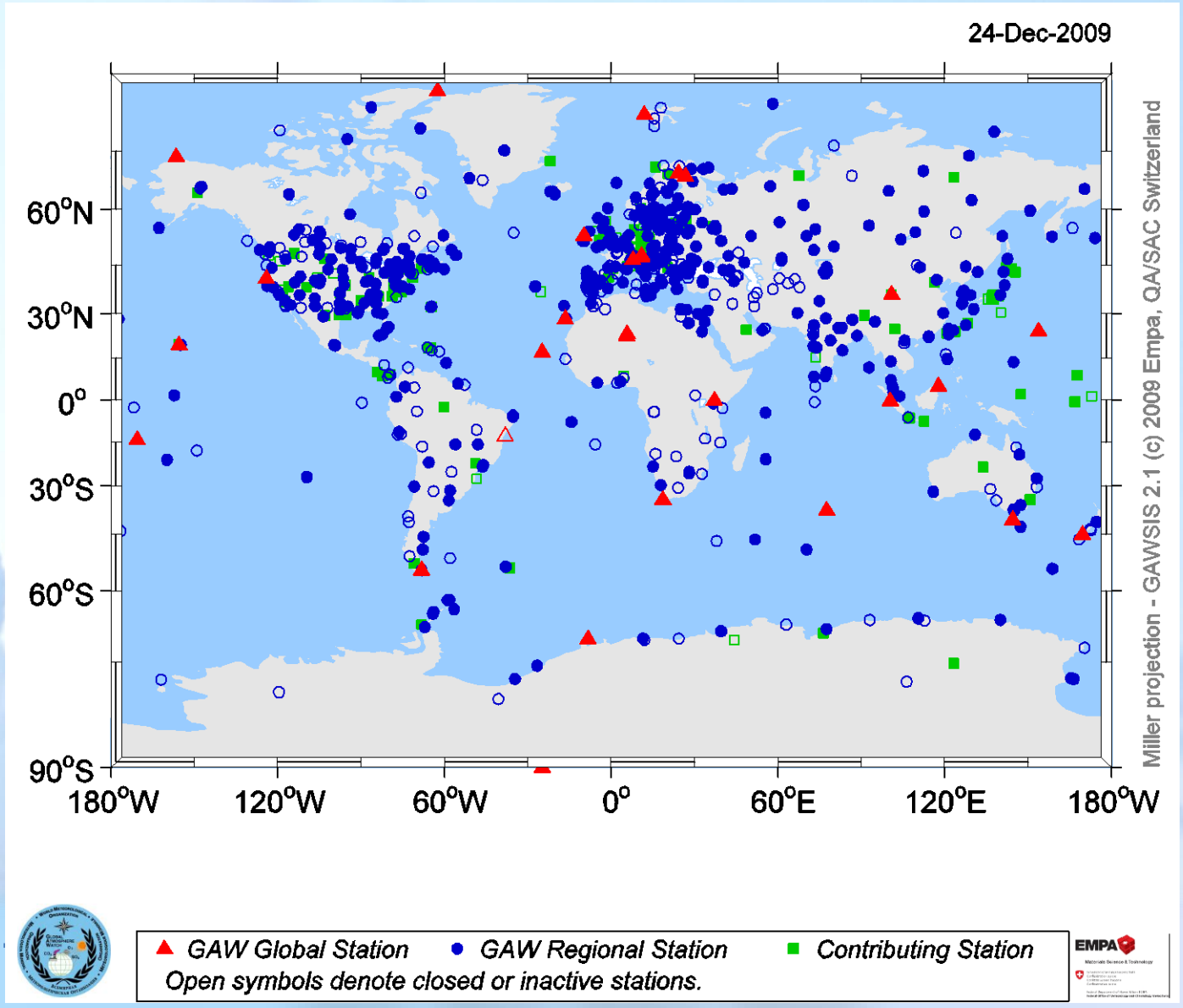
Global Atmosphere Watch (GAW) Programme

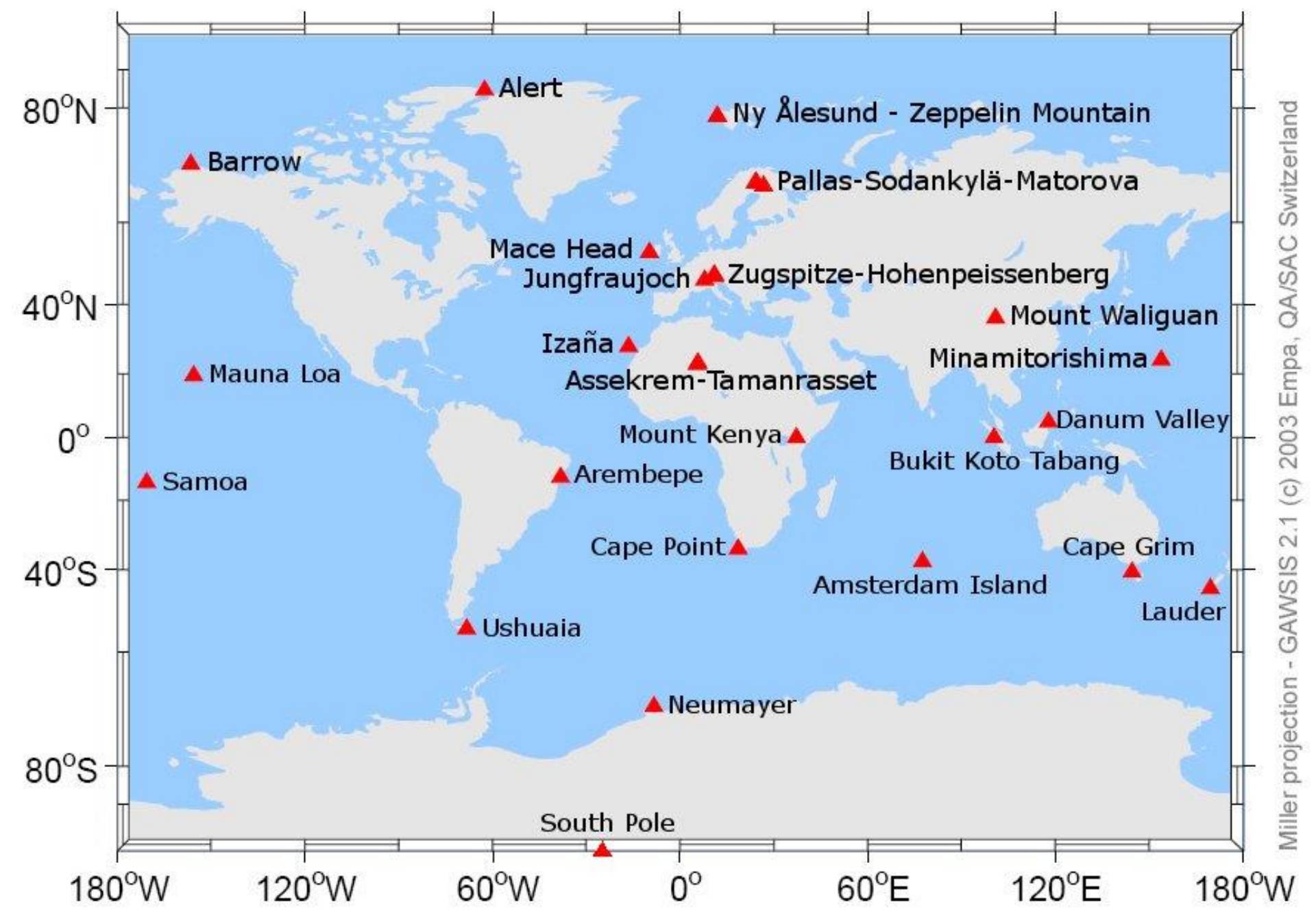
Six GAW World Data Centres (WDCs) have been established for

1. Greenhouse Gases (JMA, Japan)
2. Ozone/UV (Met Services of Canada)
3. Precipitation Chemistry (QA/SAC, Univ. of Albany, USA)
4. Solar Radiation
   (Russian Federal Service for Hydrometeorology and Environmental Monitoring, St Petersberg)
5. Aerosols and AOD
   (Climate Change Unit of the Institute for Environment and Sustainability, Ispra, Italy)
6. Remote Sensing of the Atmosphere
   (German Aerospace Center)

The purpose is to gather, archive and provide observation data from various platforms all over the world.

Global Atmosphere Watch Network




Alert
Ny Ålesund - Zeppelin Mountain
Barrow
Pallas-Sodankylä-Matorova
Mace Head
Jungfraujoch
Zugspitze-Hohenpeissenberg
Mount Waliguan
Izaña
Minamitorishima
Mauna Loa
Assekrem-Tamanrasset
Danum Valley
Mount Kenya
Bukit Koto Tabang
Samoa
Arembepe
Cape Point
Cape Grim
Amsterdam Island
Lauder
Ushuaia
Neumayer
South Pole
80°N
40°N
0°
40°S
80°S
180°W
120°W
60°W
0°
60°E
120°E
180°W
Miller projection - GAWSIS 2.1 (c) 2003 Empa, QA/SAC Switzerland

GAW Program Stations

More than 100 WMO member countries are currently operating about 700 GAW stations and 24 of them are operating Global Stations. Remaining stations represent the GAW network of Regional and contributing stations. About ten countries provide GAW central facilities.

Two Categories of GAW Stations

1. Global Stations: are representative of large geographic areas. They continuously measure a broad range of atmospheric parameters over decades (vertical distribution of O3, total O3, GHGs, precipitation chemistry, aerosol components, reactive gases and UV radiation.

2. Regional Stations: are representative of smaller geographic regions. They generally carry out a narrower set of observations. Data are typically applied to regional issues such as acid deposition, transport of trace gases and aerosols, and local UV radiation.

Wet-only Precipitation Chemistry Network

Stations	Precipitation Collector
ALLAHABAD	1975
JODHPUR	1974
KODAIKANAL	1976
MINICOY	1976
MOHANBARI	1974
NAGPUR	1976
PORTBLAIR	1975
PUNE	1973
SRINAGAR	1976
VISAKHAPATNAM	1976
RANICHAURI	2009

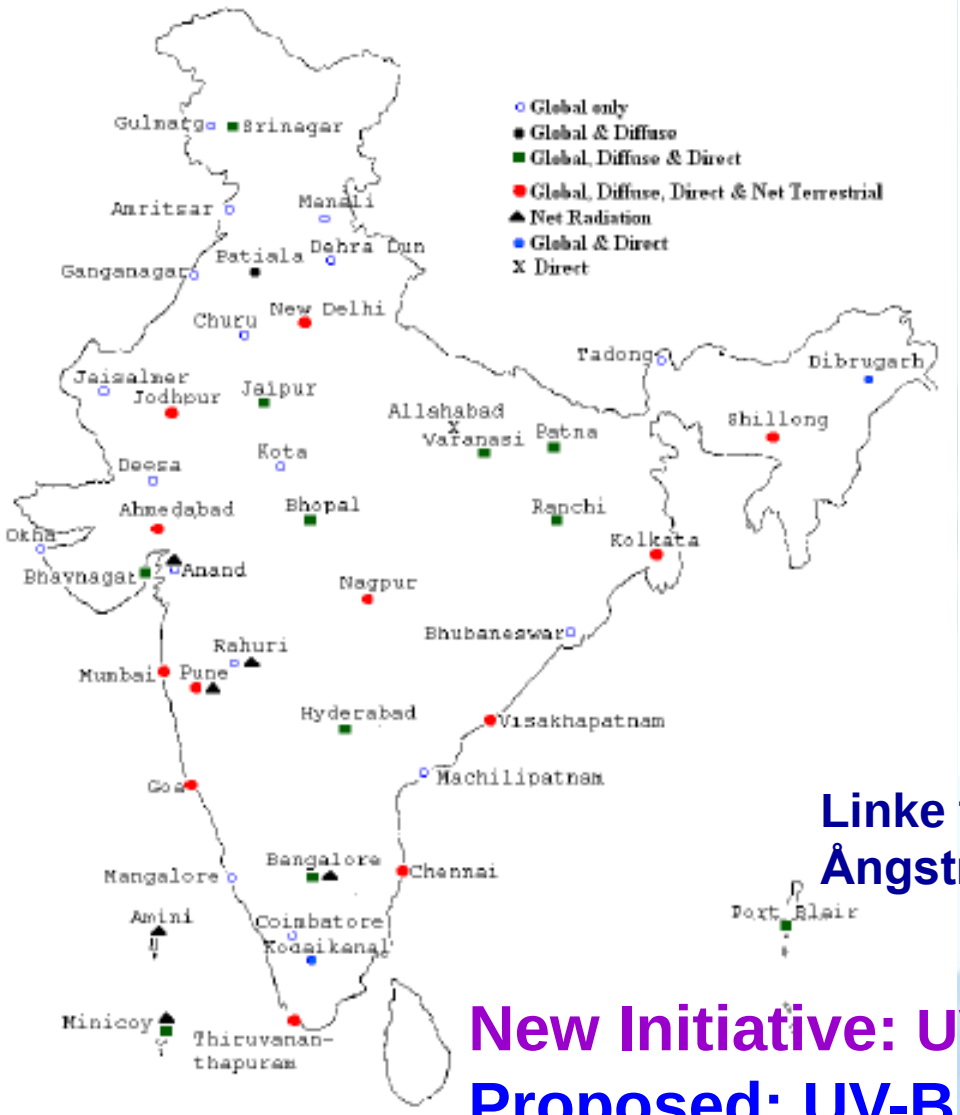
Laboratory Measurements at Pune

- **Atomic Absorption Spectrophotometer with Graphite Furnace** (Perkin Elmer AAnalyst300)
  Metallic ions Ca^{2+}, Mg^{+}, Na^{+}, K^{+} etc
  Range: ppm to sub ppb level
- **Ion Chromatograph** (Dionex DX600)
  Ions: SO_4^{2-}, NO_3^{-}, Cl^{-}, F^{-}, PO_4^{2-}, and NH_4^{+}
  All Major cations and anions including transition metals
- **pH and Conductivity meter**
- **Ultra-pure Deionized Water Purification Syste** (MilliQ Synthesis)

All calibrations using NIST certified Standards.

Precipitation Chemistry Laboratory at Pune participates in WMO's Laboratory Intercomparison Program conducted twice in a year by WMO World Data Center for Precipitation Chemistry (WDCPC).

Solar Radiation Network of IMD



Global solar irradiation	43 stations 38 pyranometer 2 bimetallic pyranograph 3 Bellani pyranometer
Diffuse solar irradiation	24 stations
Direct solar irradiation	14 stations six times a day 10 stations using solar trackers
Net terrestrial radiant energy	12 stations
Net total radiant energy	6 stations

Linke turbidity factor T – 22 stations
Ångström turbidity coefficient β - 14 stations.

New Initiative: UV-A measurement at 45 stations
Proposed: UV-B measurement

Surface Ozone Network 10 stations

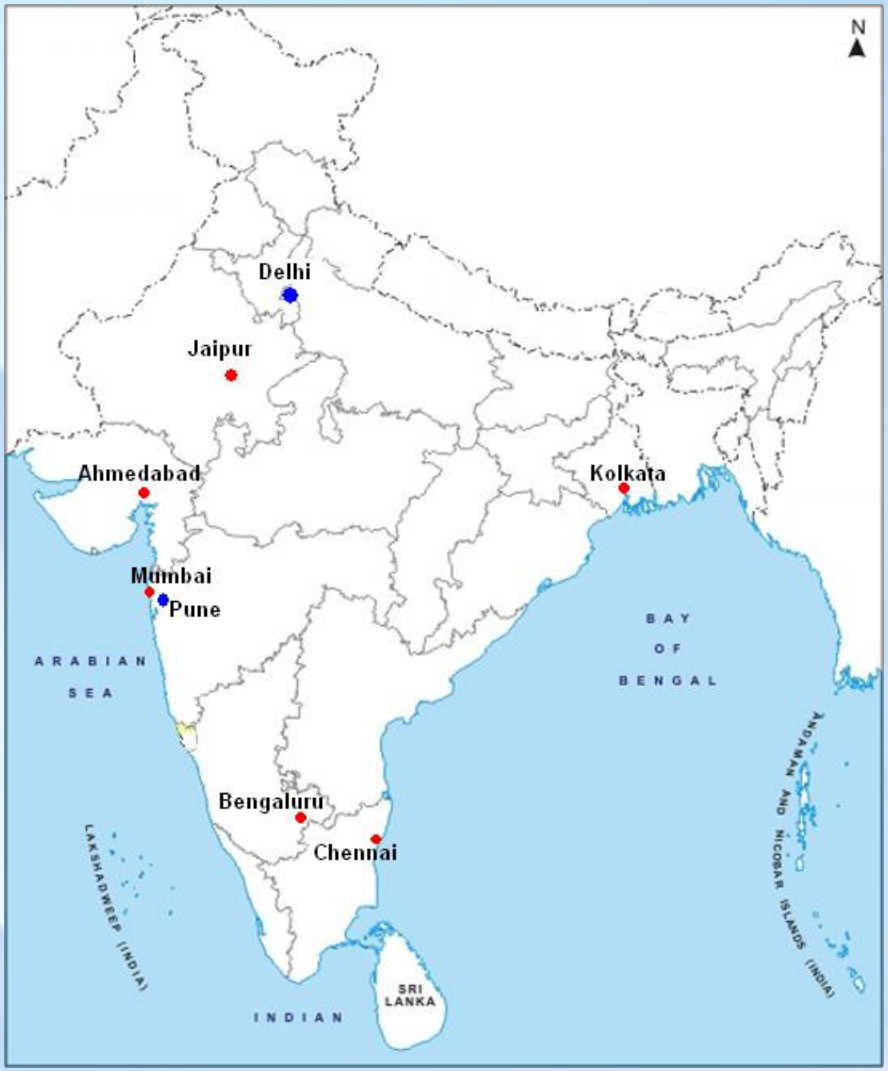
1. New Delhi
2. Ranichauri
3. Varanasi
4. Nagpur
5. Pune
6. Kodaikanal
7. Thiru'puram
8. Port Blair
9. Guwahati
10. Maitri

- **UV absorption photometer determines O_3 concentration by measuring the attenuation of UV light due to O_3 in the absorption cell.**
- **Absorption wavelength is 254 nm.**
- **The concentration of O_3 is directly related to the absorbance.**
- **Each station has external calibrator also.**
- **LDL 0.5ppb, Range 0-20ppm**
- **Data are being received at NOC through internet.**

Aerosol Monitoring Network
(20 Sky Radiometer Stations)

AIR QUALITY MONITORING AND PREDICTION

The **S**ystem for **A**ir **Q**uality **F**orecasting and **R**esearch (**SAFAR**) was used to monitor and forecast air quality during the commonwealth games-2010 held in Delhi. Air Quality Monitoring and Forecasting for Delhi and other metro cities will be operationalized by IMD. This is a joint project of IITM and IMD.



BLACK CARBON MEASUREMENT PROGRAMME

BACKGROUND STATION, RANICHAURI

Station at a remote location in Uttarakhand

Measurement Started

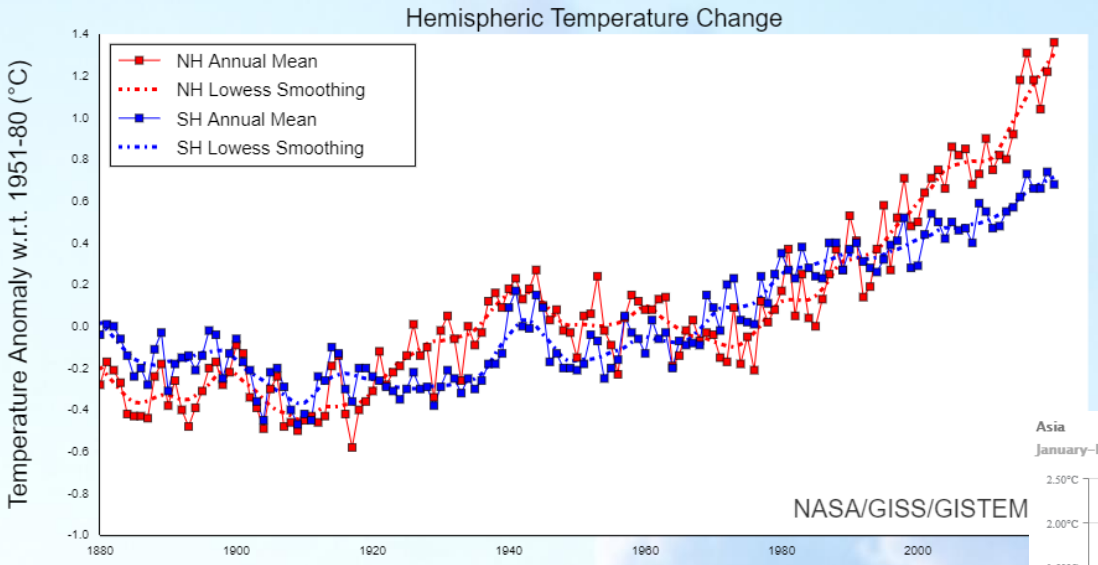
Trace Gas Measurement SO_2, NOx
Precipitation Chemistry
Solar Radiation
Micrometeorology
Ozone
Sunsky Radiometer

Black Carbon
Size Segregated Aerosol Chemical Composition
Continuous Greenhouse Gas Measurement

Proposed Measurements:
LIDAR

Air Quality and Climate Change

GLOBAL TEMPERATURE TRENDS

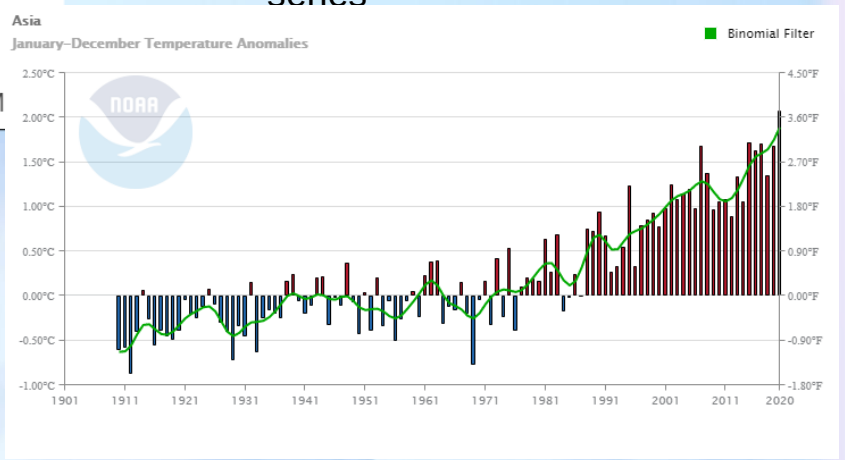


Annual and five-year running mean temperature changes with the base period 1951-1980 for the northern (red) and southern (blue) hemispheres.

2020 : 1.02 ºC warmer than the baseline 1951-1980 mean

The last seven years have been the warmest seven years on record

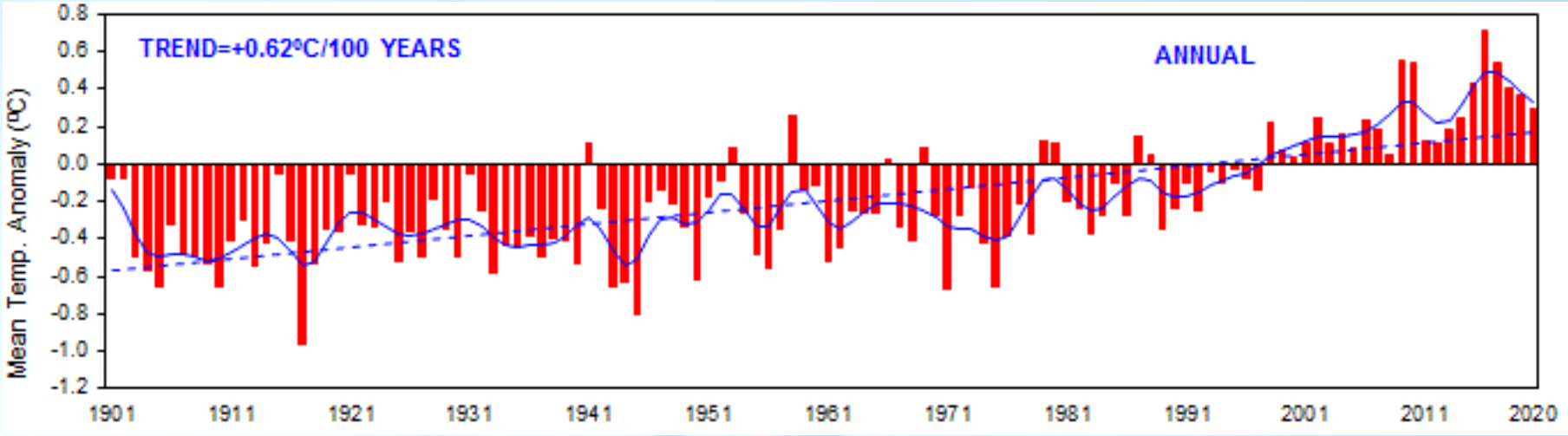
2016 is remarkably the third record year in a row in this series

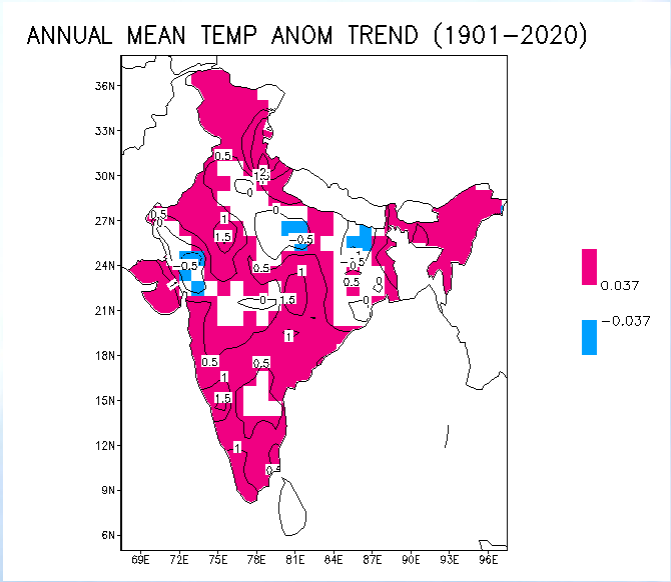


NASA GISS Surface Temperature Analysis

Global instrumental temperature data suggests unprecedented warming

ALL INDIA ANNUAL MEAN TEMPERATURE ANOMALIES *(Departures from the 1981 - 2010 average)*



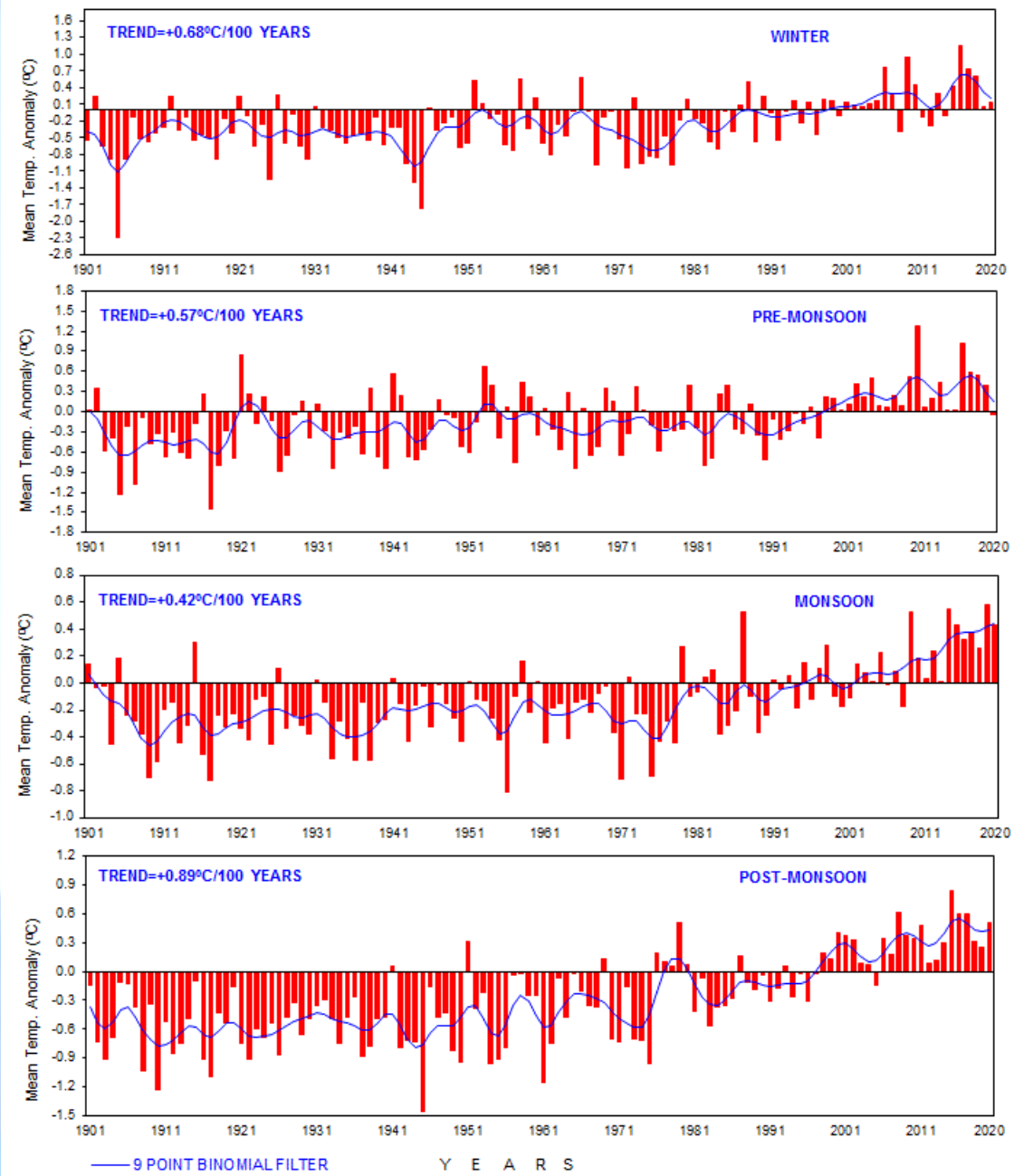


12 warmest years were from the recent past fifteen years (2006-2020).

Annual mean temperature(1901-2020): increasing trend of 0.62^{0}C/100 years

Max Temp trend: (0.99^{0}C/100 years),

Min Temp: (0.24^{0}C/100 years).



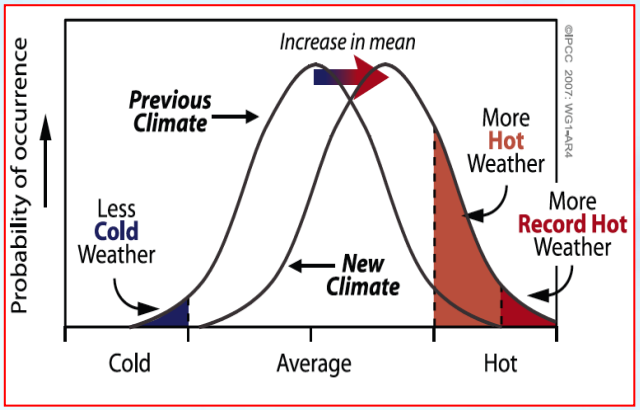
Winter

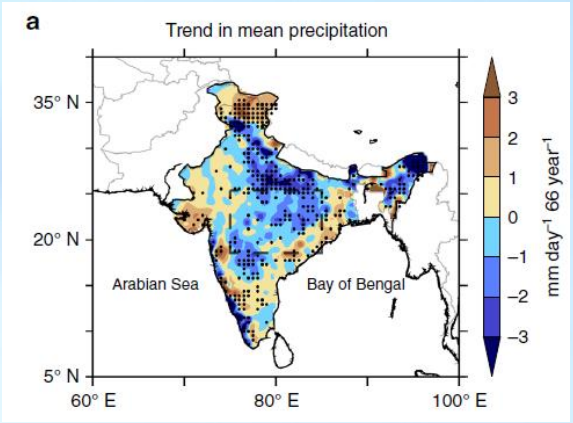
Pre-monsoon

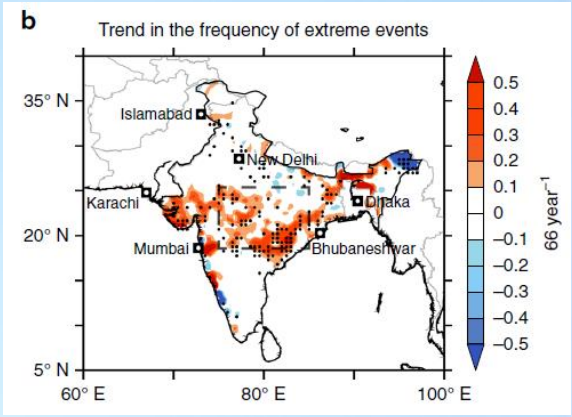
Monsoon

Post-monsoon

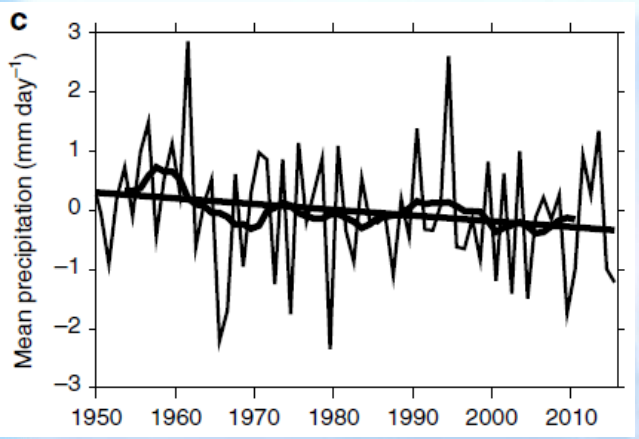
Extreme Weather Events

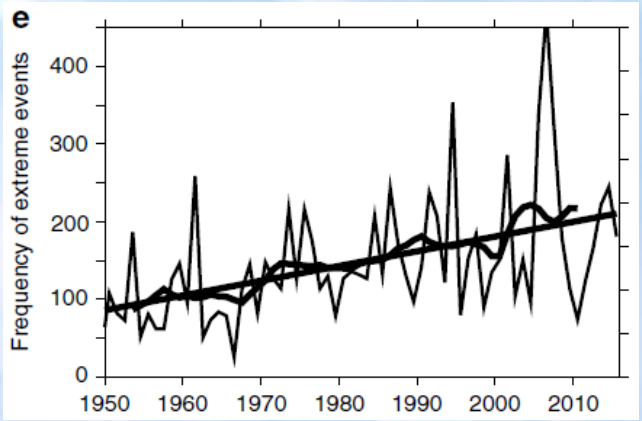


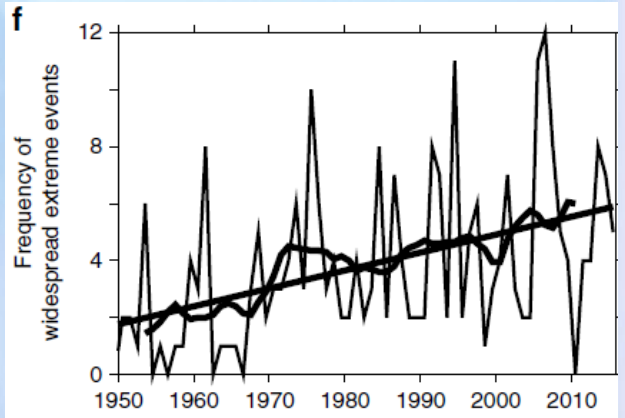




Trends in summer monsoon mean and extreme precipitation during 1950–2015. Observed trend in summer a mean precipitation anomalies (mm day^{-1} 66 year^{-1}) and b the frequency (66 year^{-1}) of extreme precipitation events (precipitation ≥ 150 mm day^{-1}).

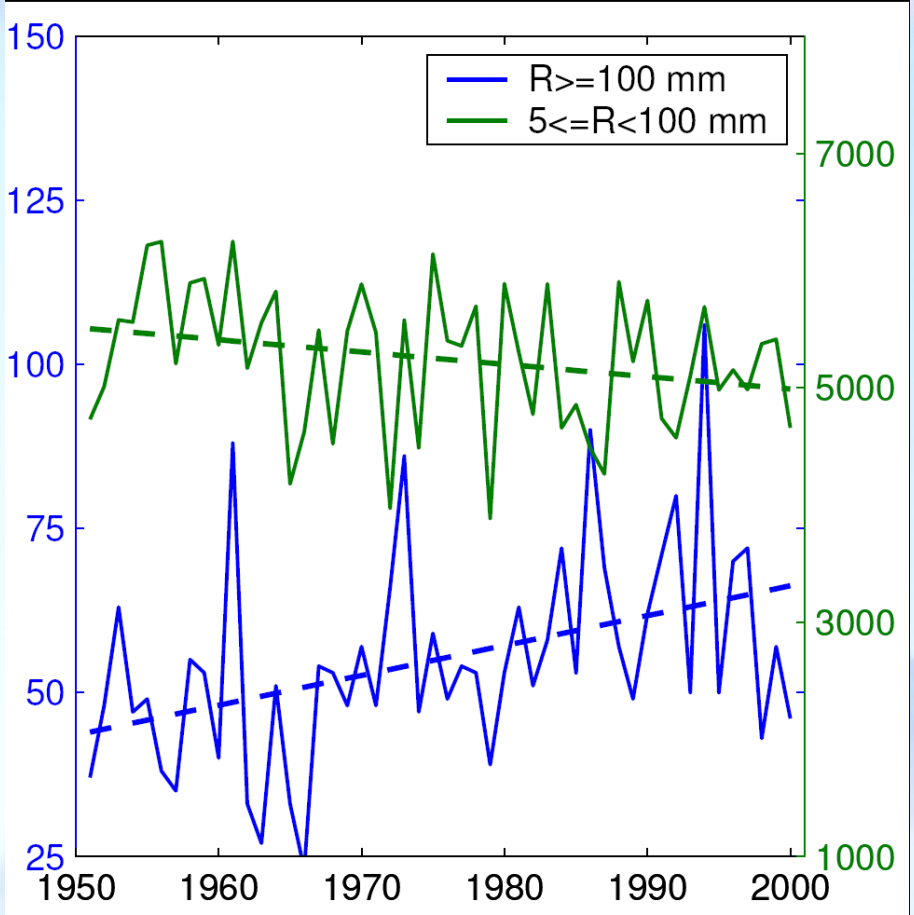


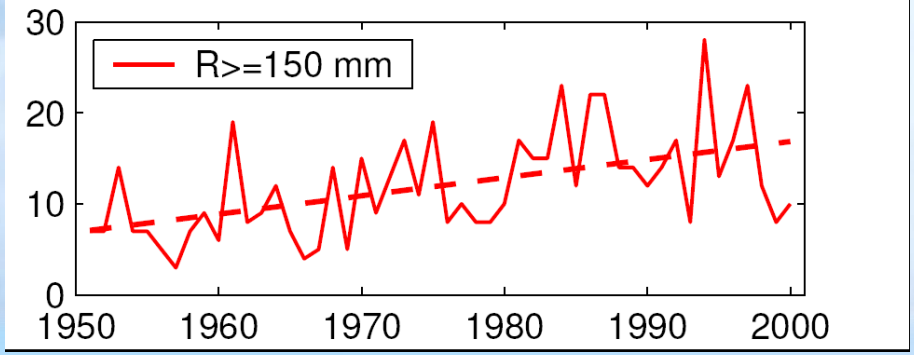




Roxy et al (2017) Nature, DOI: 10.1038/s41467-017-00744-9

Analysis based on daily gridded rainfall data, at 0.25° horizontal resolution, available from the India Meteorological Department (IMD) https://www.imdpune.gov.in/





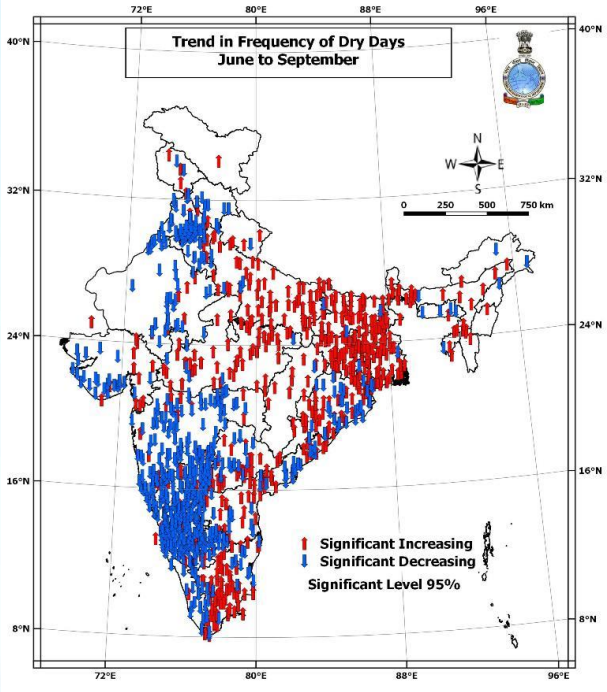
Low & Moderate RF events

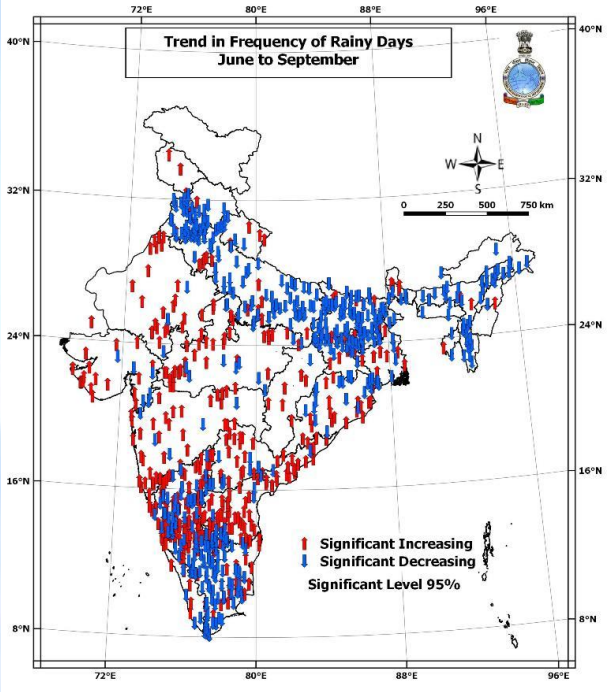
Heavy events (>100 mm)

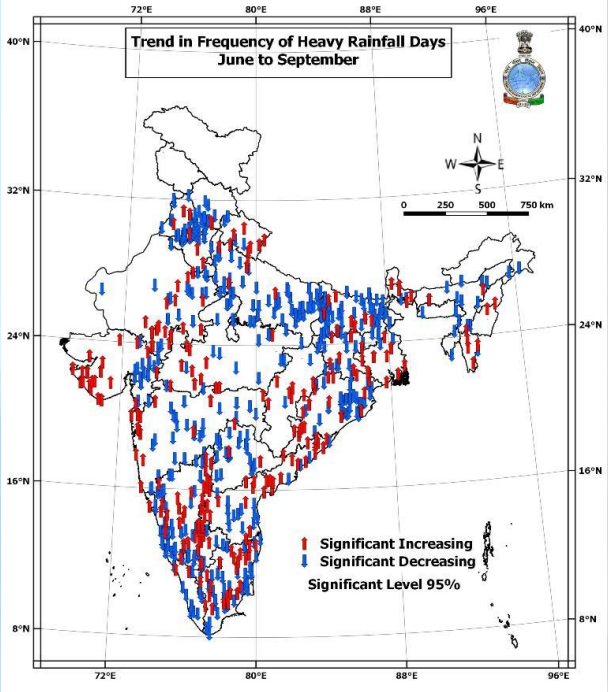
V. Heavy events (>150mm)

Goswami et al. 2006, Science, 314, 1442

High Impact Weather Events: Rainfall

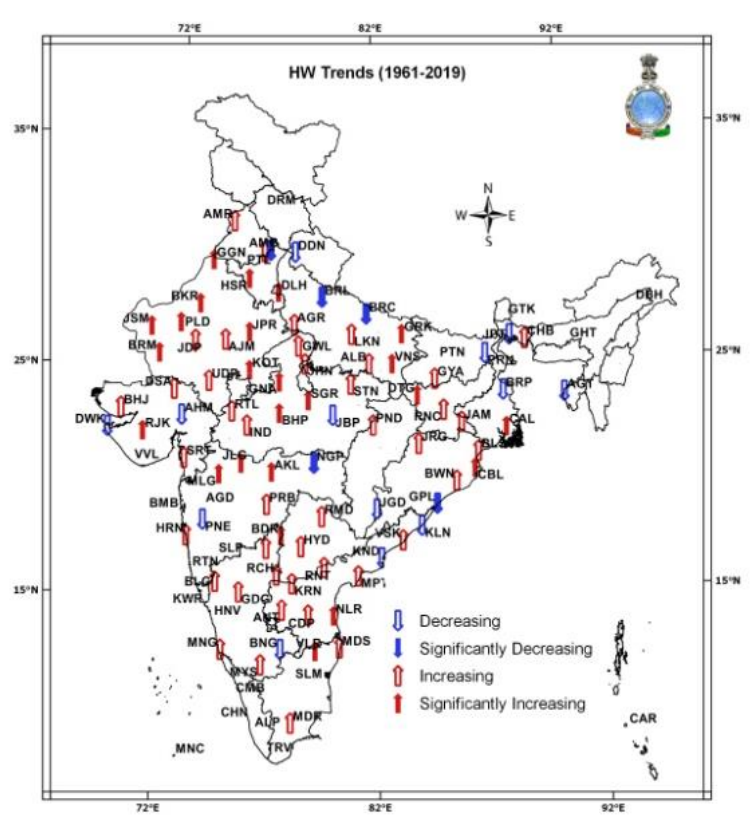




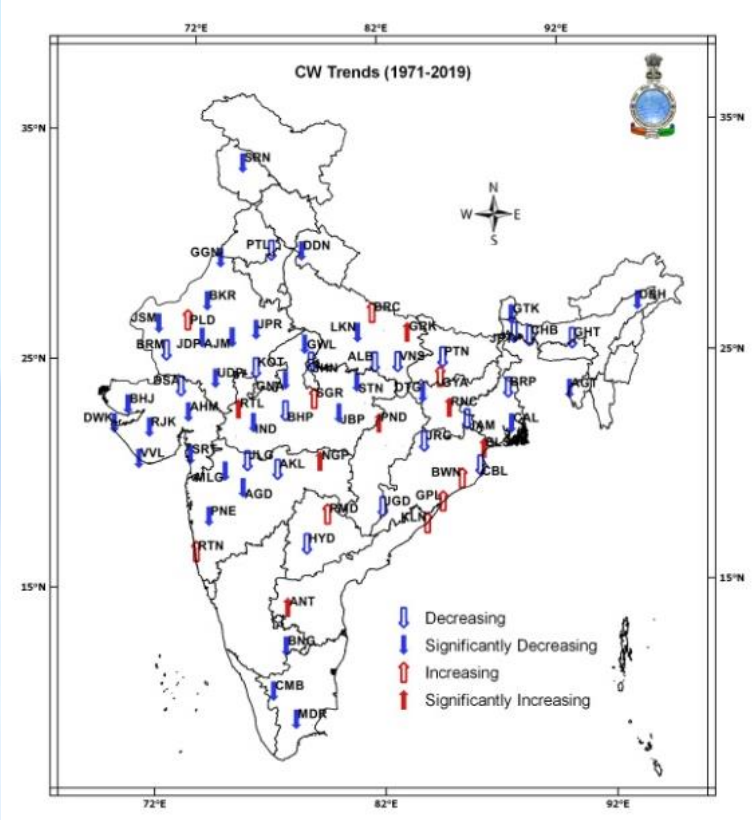


Spatial distribution of trend in frequency of (i) Dry Days (ii) rainy days (daily rainfall of 2.5 mm or more but less than 70 mm) (iii) heavy rainfall events (rainfall greater than equal to 70 mm) during southwest monsoon season over India based on 30 years of data (1989-2018)

Heatwave and Coldwave Trends over India



Trends in the Heat Wave (HW) days during April, May and June for the period 1961–2019



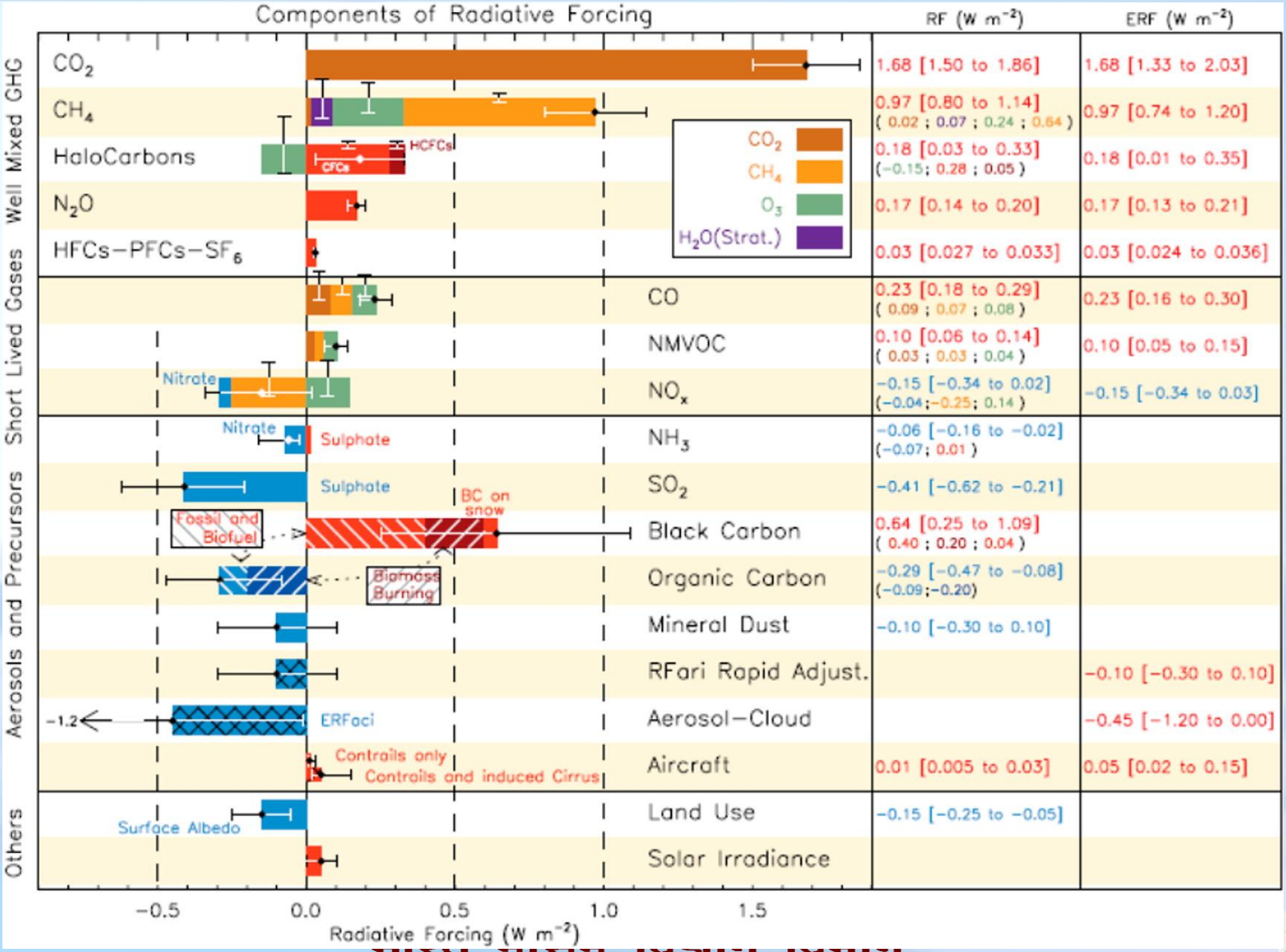
Trends in the Cold Wave (CW) days during the December, January and February for the period 1961–2019

GHGs and Air Pollutants

- **GHGs:**
  - **CO2, O_3, CH_4, N_2O, HFC, PFC, SF_6**
- **Air pollutants with direct radiative forcing:**
  - **SO_2, aerosols (black and organic carbon, PM2.5)**
- **Air pollutants with indirect effects on radiative forcing:**
  - **All gases that influence OH (NO_x, CO, VOC, H_2O, etc.),**
  - **O_3 precursors (NO_x, VOC, CO),**
  - **Aerosol precursors (primary and secondary, including NH_3)**

The dominant sources of air pollution and GHGs are the same:
fossil fuels combustion
Biomass burning, including forest fires
agriculture emissions

GHGs, Air Pollutants and their Radiative Forcing



Source: IPCC AR5

NO_x and climate change

Increase in NO_x leads to

- **decreased lifetime of CH_4 and HFCs (via OH): ↓ radiative forcing**
- **increase in O_3: ↑ radiative forcing**
- **increased N deposition → fertilization → CO_2 uptake: ↓ radiative forcing**

Net effect not yet clear, but significant impacts on radiative forcing expected for 2100.

Regional climate effects of aerosols

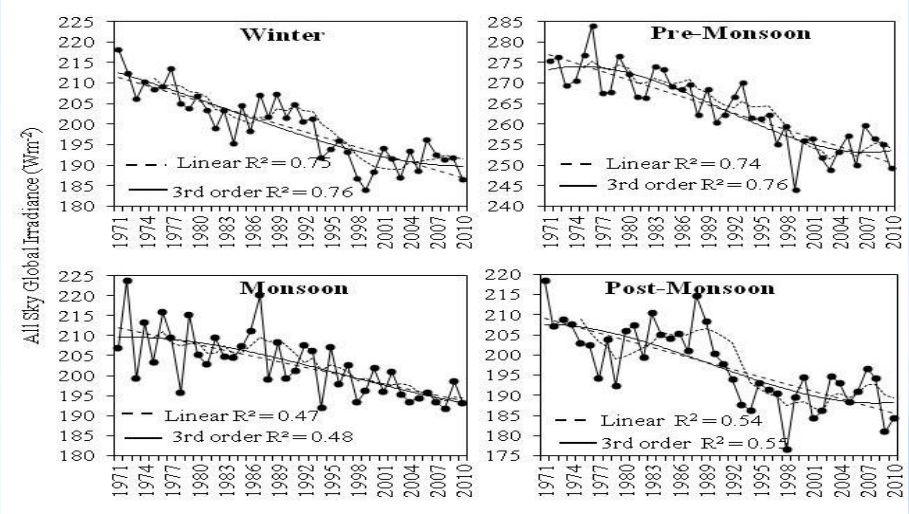
- **Sulfates, Nitrate:**
  - **Cooling effect**
  - **Changes in precipitation observed in many countries related to increase in SO_2**
- **Black carbon:**
  - **Warming effect**
- **Organic carbon:**
  - **Cooling effect**
  - **Net effect of PM from different sources?**

Global Dimming and Drying

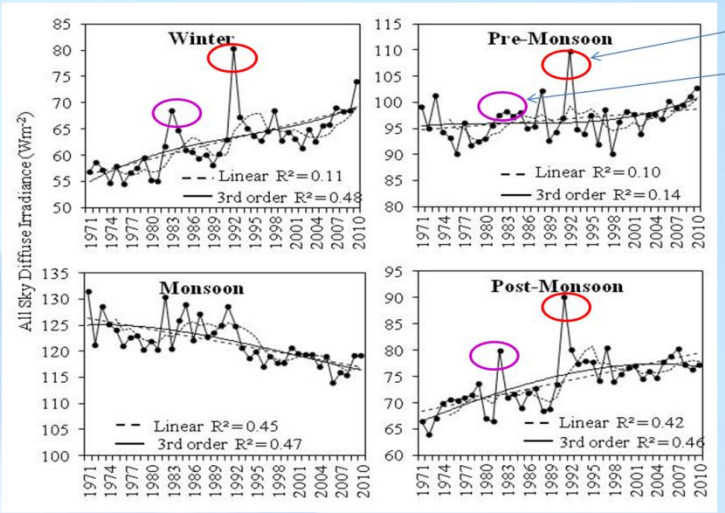
Aerosols intercept sunlight and reduce the amount of sunlight at the surface, which is commonly known as *Global Dimming*.

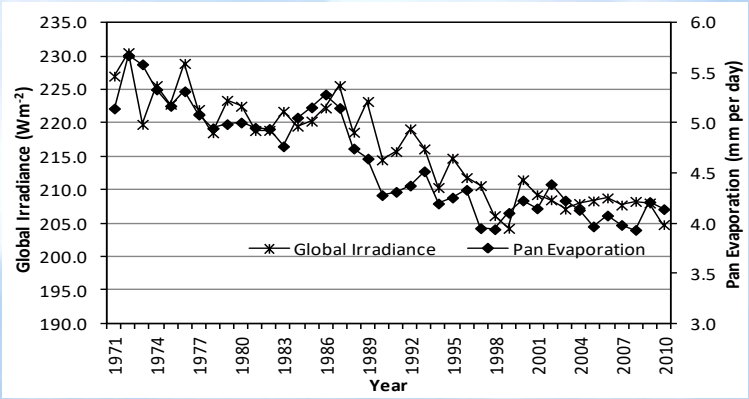
The dimming leads to a decrease in evaporation.

All Sky Global Solar Irradiance: Seasonal Trends

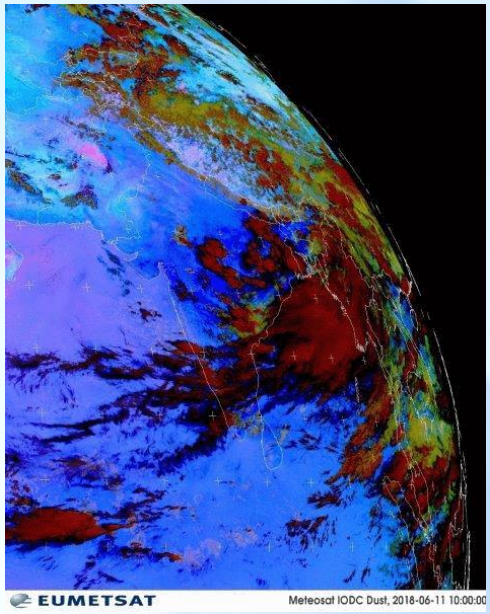


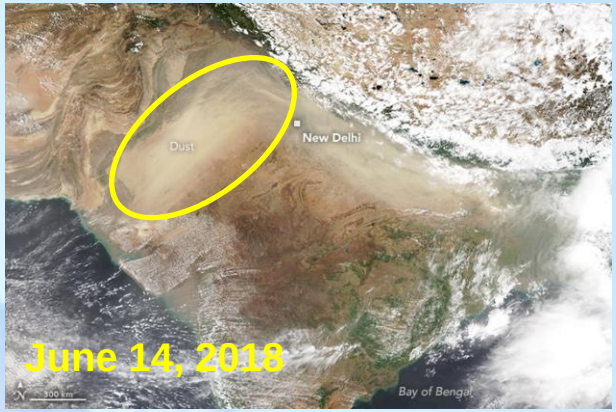
Diffuse Irradiance: Seasonal Trends



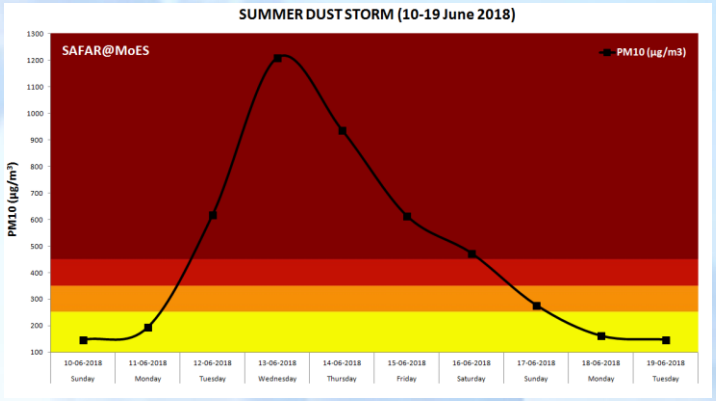


Dust Transport in 11-14 June 2018



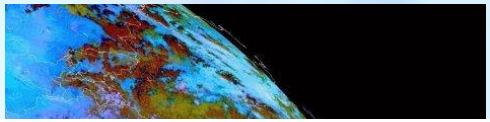


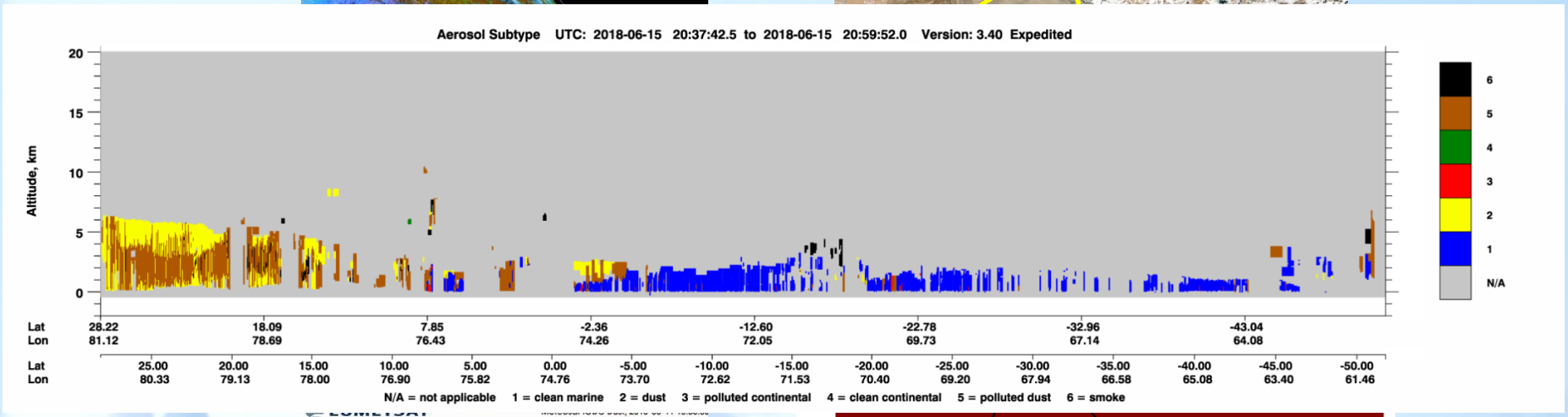
Air Quality Index, Delhi June 2 - 17, 2018

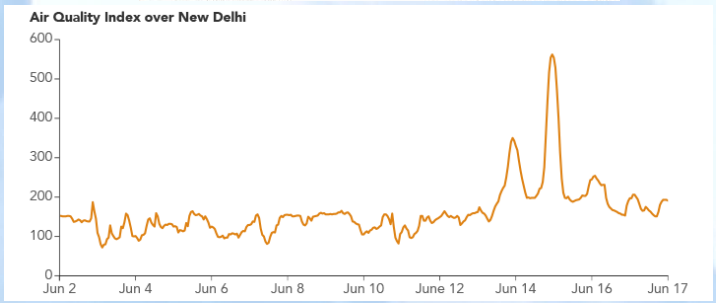


Surface PM10 Concentration at Delhi

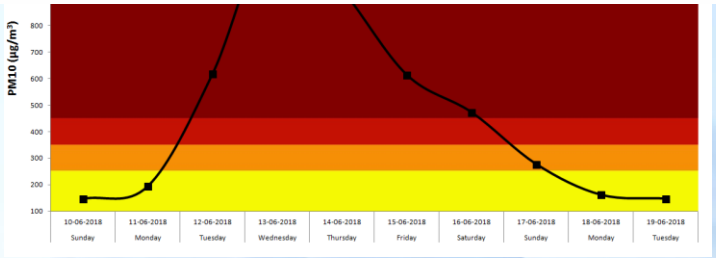
Dust Transport in 11-14 June 2018





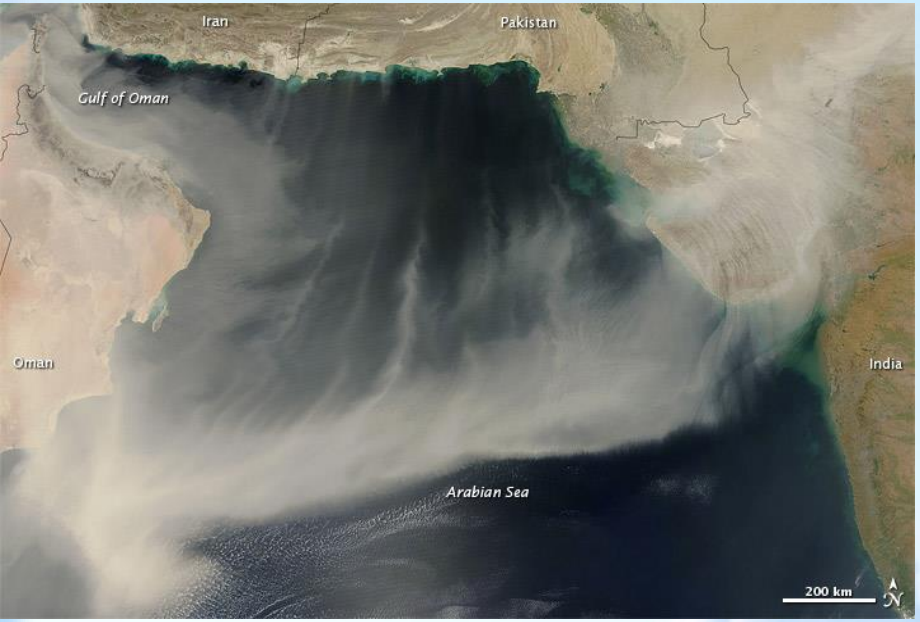


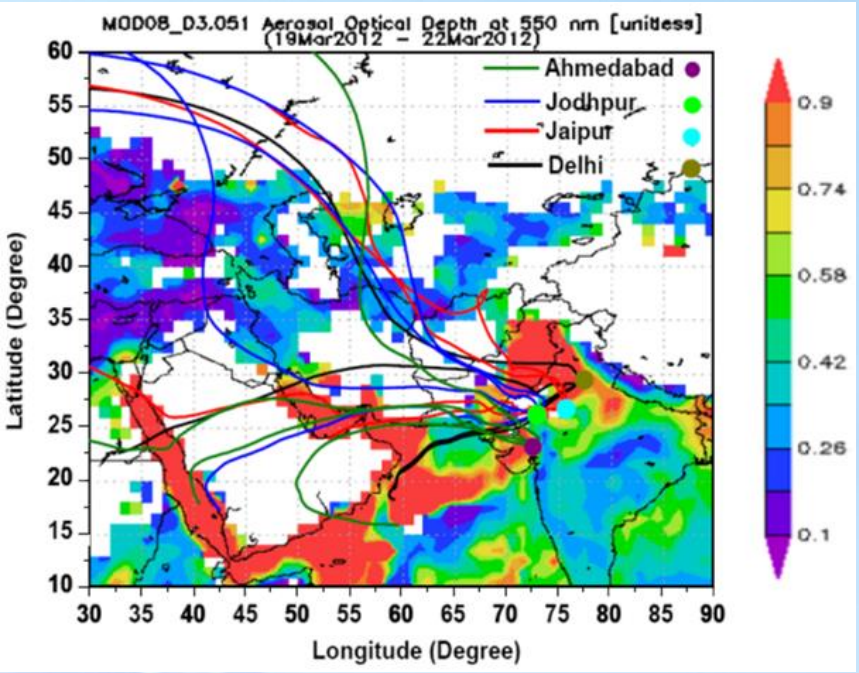
Air Quality Index, Delhi June 2 - 17, 2018

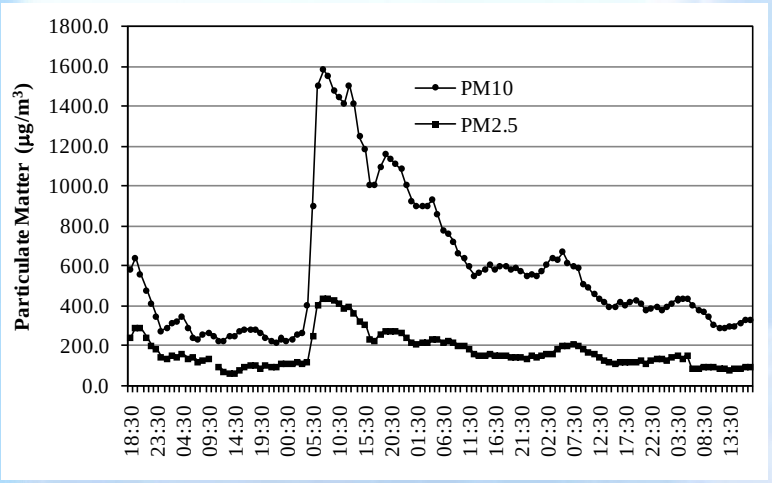


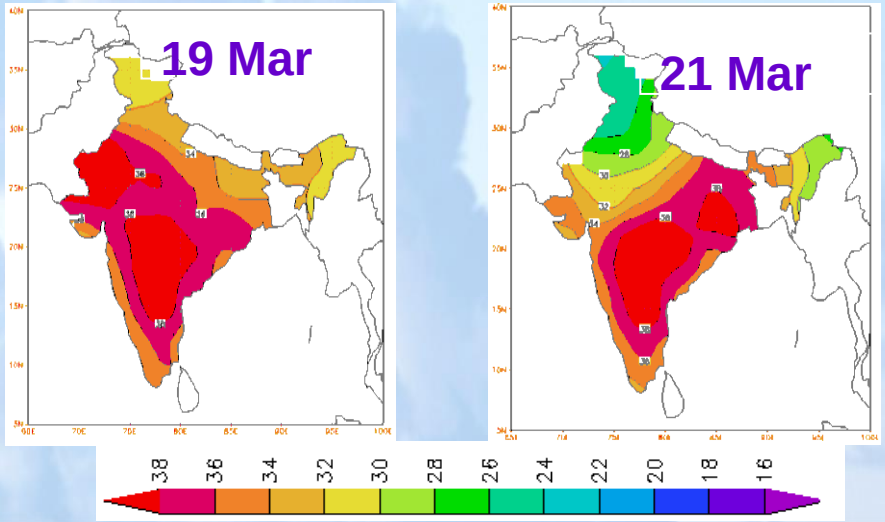
Surface PM10 Concentration at Delhi

MODIS







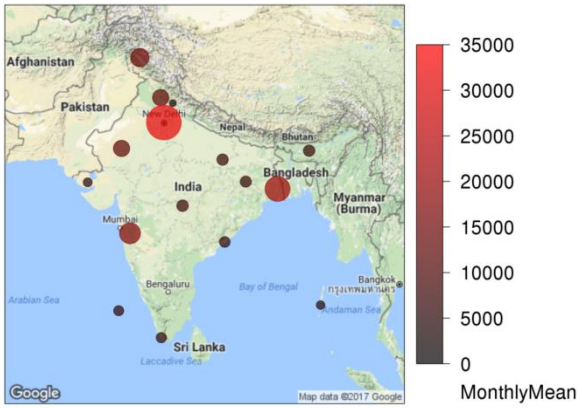


Soni et al (2014), Science of Total Environment
Soni et al (2018), Mausam

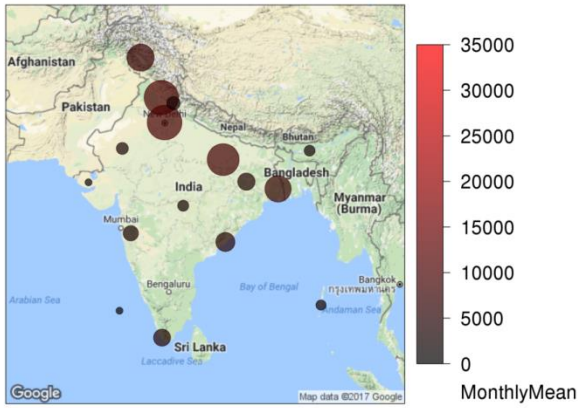
भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

Monthly Black Carbon Concentration: Spatial Variability

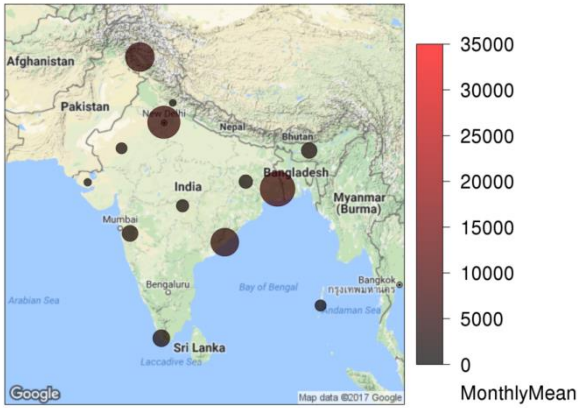
201601 [eBC]



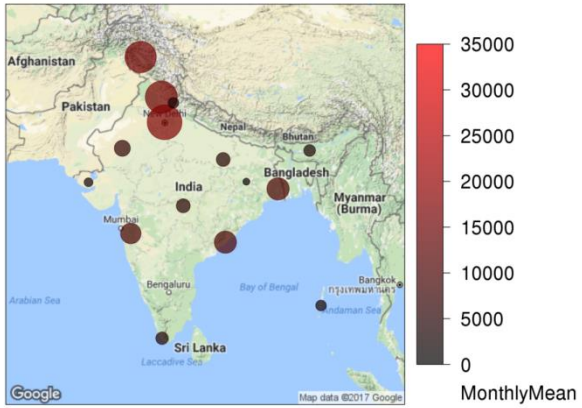
201605 [eBC]



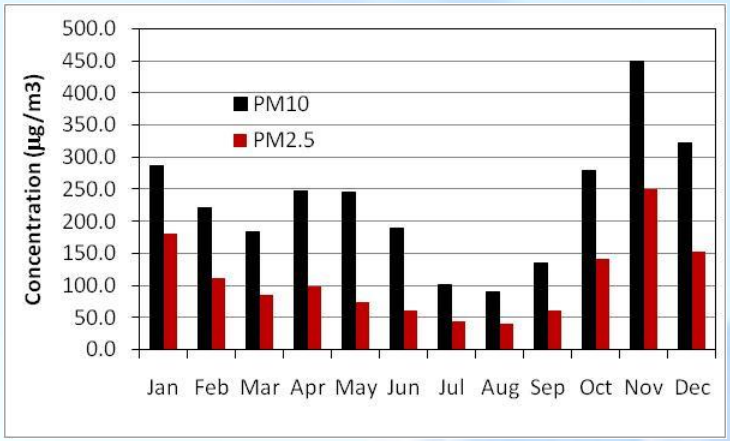
201607 [eBC]

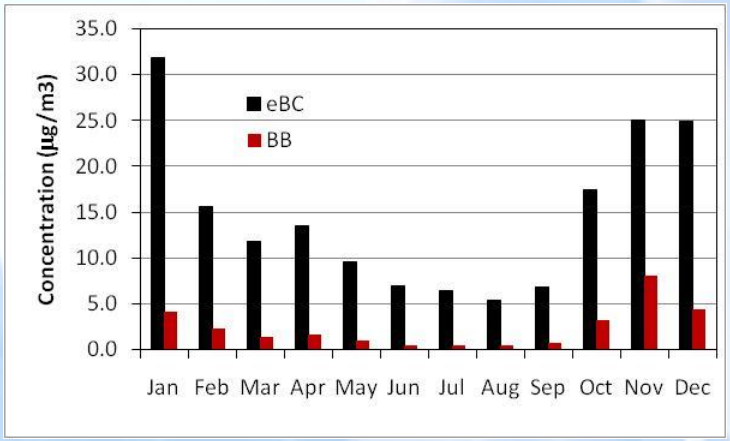


201610 [eBC]

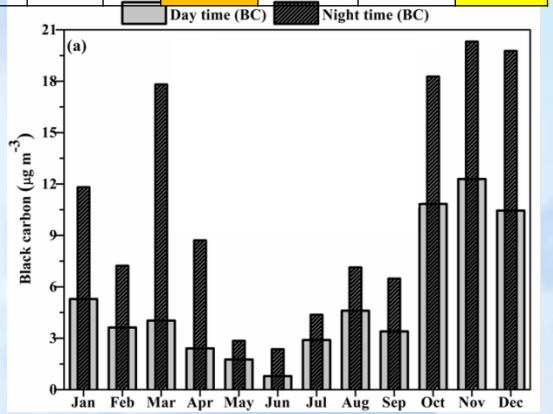


IMD Black Carbon Monitoring: Delhi





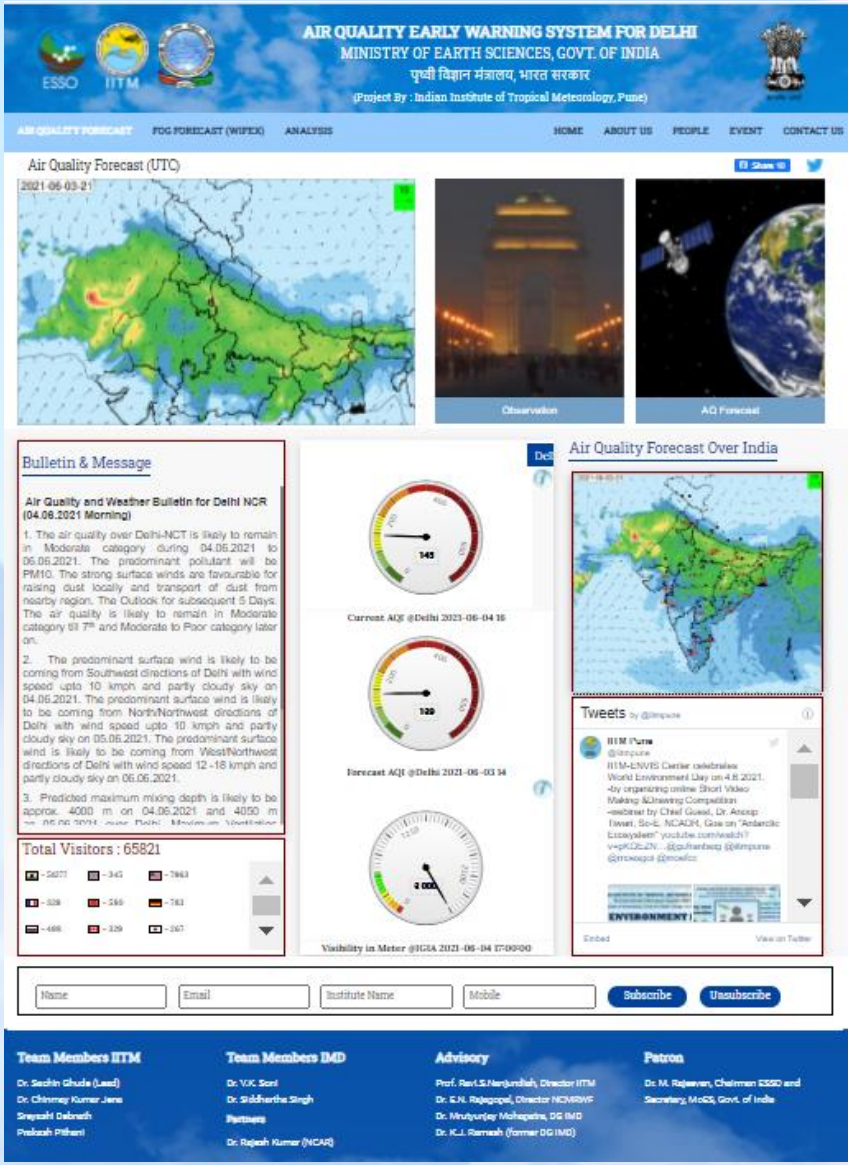
	eBC	BB	%BB in BC	PM2.5	PM10	%BB of PM2.5
Jan	31.8	4.2	13.1	182.0	286.8	2.3
Feb	15.6	2.4	15.1	112.3	220.7	2.1
Mar	11.9	1.4	11.8	85.8	183.5	1.6
Apr	13.5	1.6	12.2	100.0	247.0	1.6
May	9.6	1.0	10.5	74.6	245.9	1.3
Jun	6.9	0.5	7.3	61.2	188.5	0.8
Jul	6.5	0.5	7.4	44.8	101.1	1.1
Aug	5.4	0.6	10.3	41.8	90.0	1.3
Sep	6.8	0.8	12.4	62.0	134.3	1.4
Oct	17.4	3.2	18.6	143.0	278.6	2.3
Nov	25.0	8.1	32.2	251.2	450.3	3.2
Dec	24.9	4.4	17.7	153.9	321.9	2.9



THANKS

https://ews.tropmet.res.in/

https://mausam.imd.gov.in/Delhi/



भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT