

AMF1 MEASUREMENTS AT NAINITAL AND RELATED RESEARCH AT ARIES

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AMF₁ deployment is under GVAX program, funded by ARM, DOE
PI – Rao Kotamarthi, CO-PIs – SK Satheesh, R. Sagar

**ASR Fall Working Group meeting
[12-16 Sep 2011]**

Director

Ram Sagar

Scientists

P. Pant, M. Naja, N. Singh, Phani Kumar, U. C. Dumka,
Vimlesh Kumar

Engineers

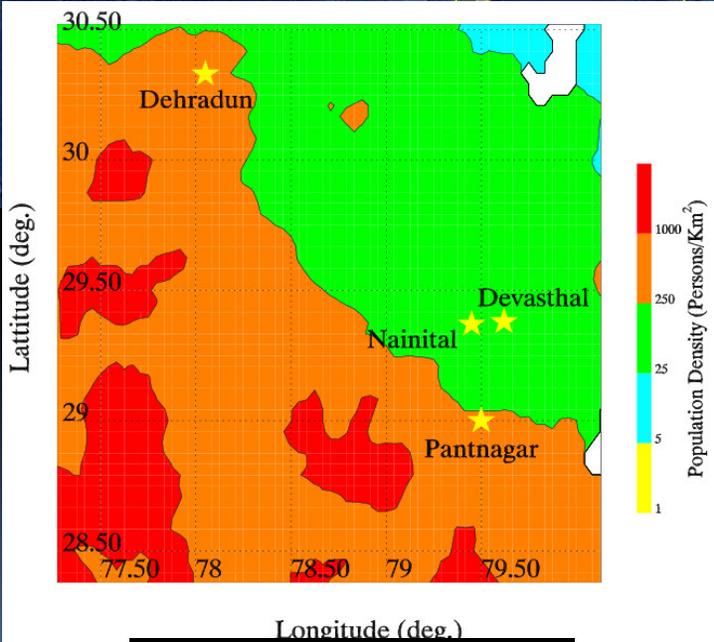
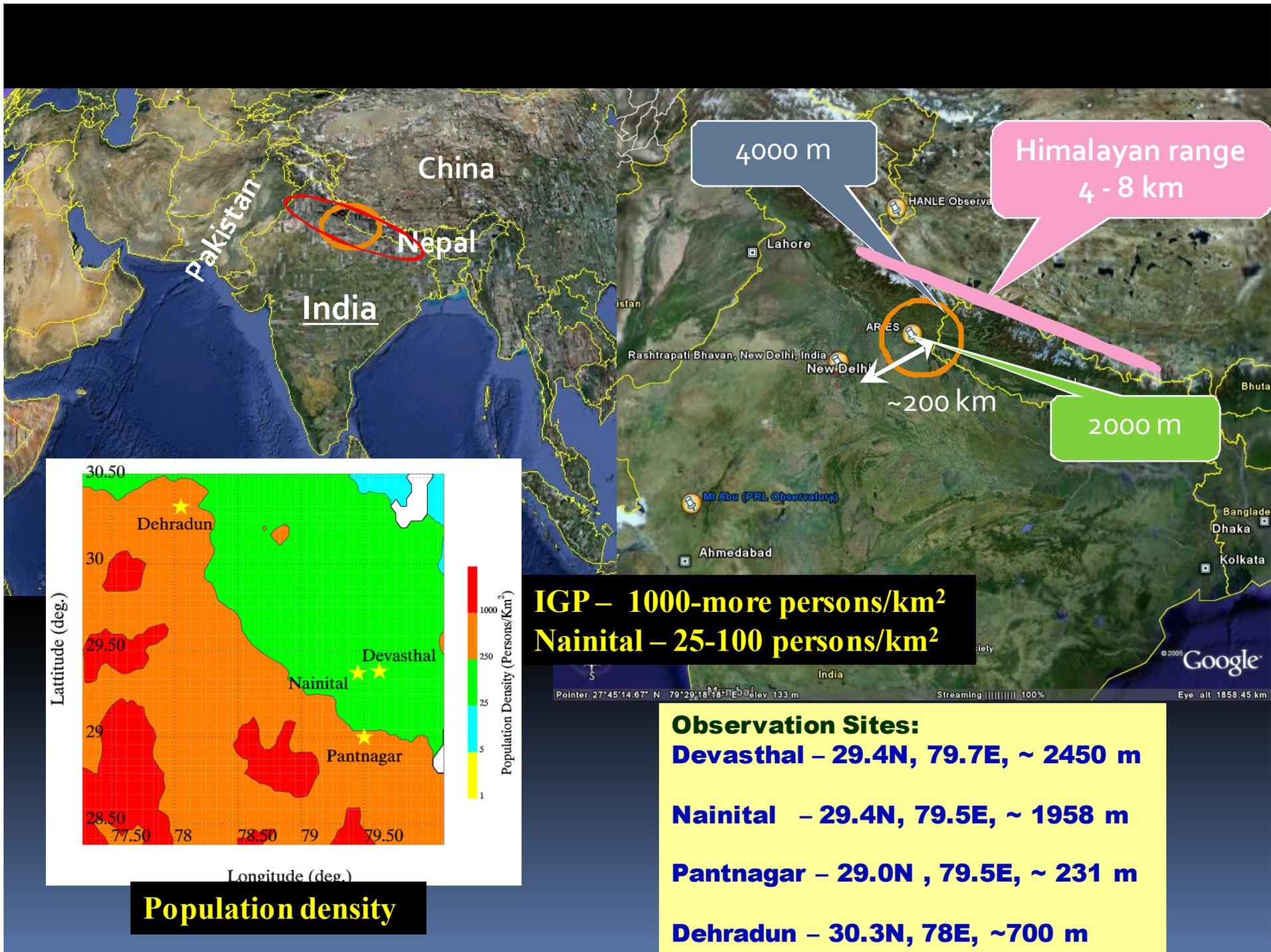
S. Bhattacharjee, C. Prakash, Ashish Kumar

PDF

S. Sahai

Ph D students

Rajesh Kumar, N. Ojha, T. Sarangi, H. Joshi, K. Shukla, P.
Bhardwaj, R Solanki

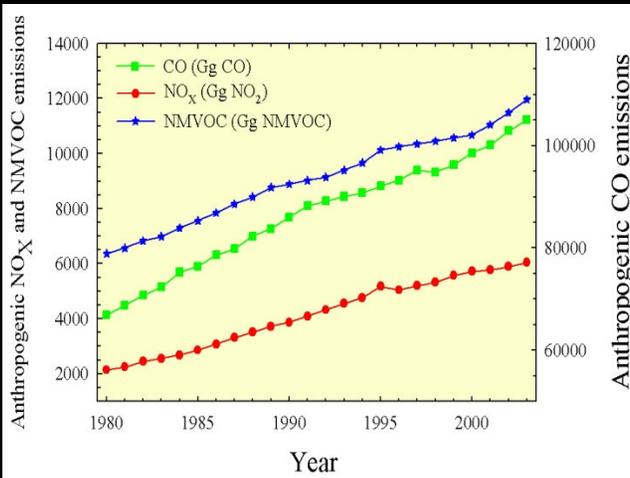


Population density

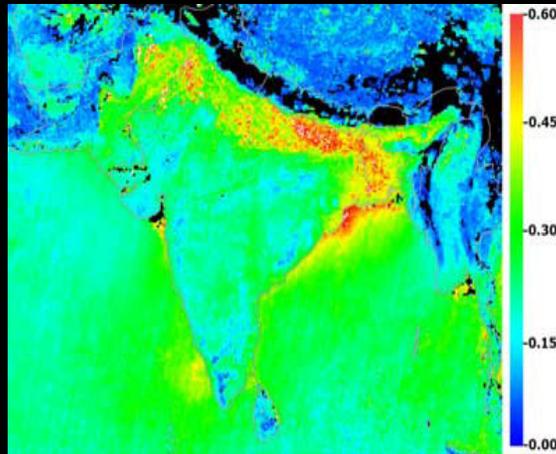
IGP – 1000-more persons/km²
Nainital – 25-100 persons/km²

- Observation Sites:**
Devasthal – 29.4N, 79.7E, ~ 2450 m
Nainital – 29.4N, 79.5E, ~ 1958 m
Pantnagar – 29.0N, 79.5E, ~ 231 m
Dehradun – 30.3N, 78E, ~700 m

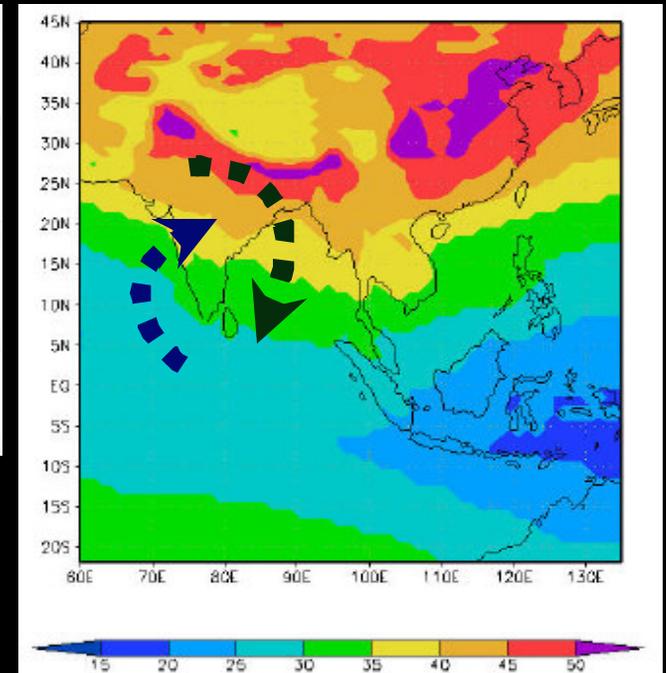
Motivation



AOD



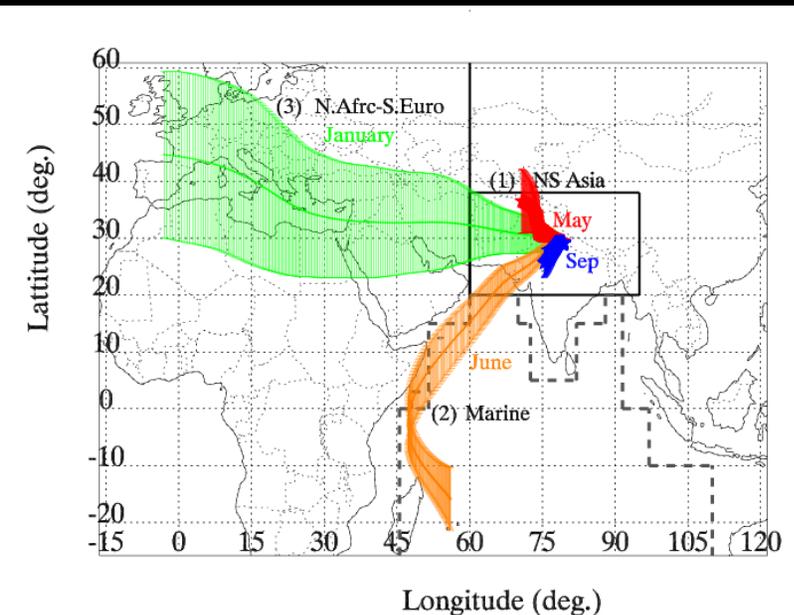
TTO Ozone



- Anthropogenic emissions are increasing
- **IGP** – Highest Polluted Region
- Higher solar radiation leads to higher water vapor content and intense photochemistry

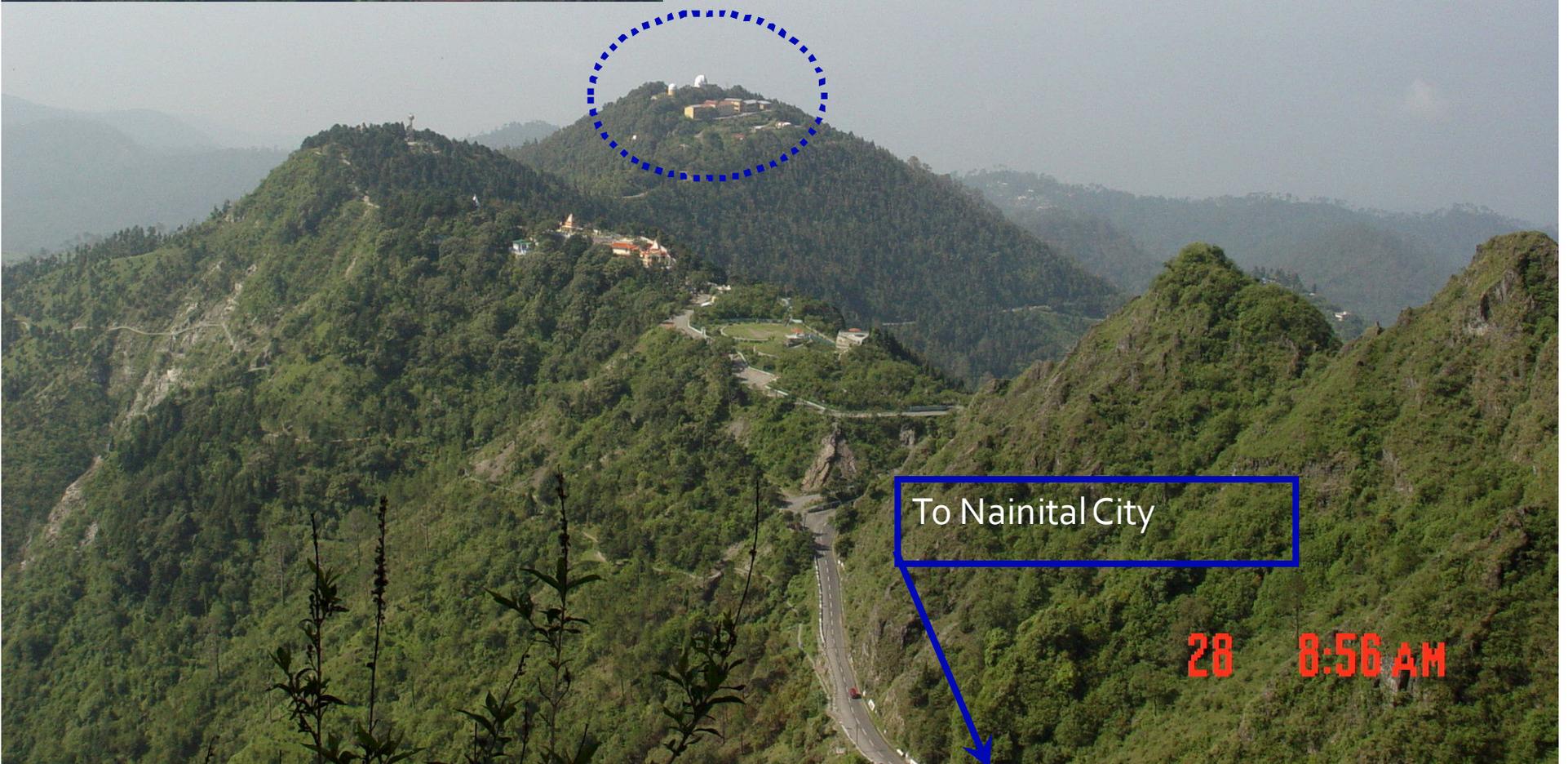
Central Himalayas

- Better Regional Representative
- Long-range Transport





ARIES 29.36N, 79.45 E, 1958 m



To Nainital City

28 8:56 AM

Atmospheric Science Group

■ Aerosols (Since January 2002)

- AOD (MWR, Microtops & AERONET)
- Black Carbon
- Aerosols number concentrations
- Particulate Matter

■ Trace Gases (Since September 2006)

- Pollutants (Ozone, CO, NO, NO_y, CH₄, NMHCs, SO₂)
- Greenhouse gases (CO₂, N₂O and SF₆)

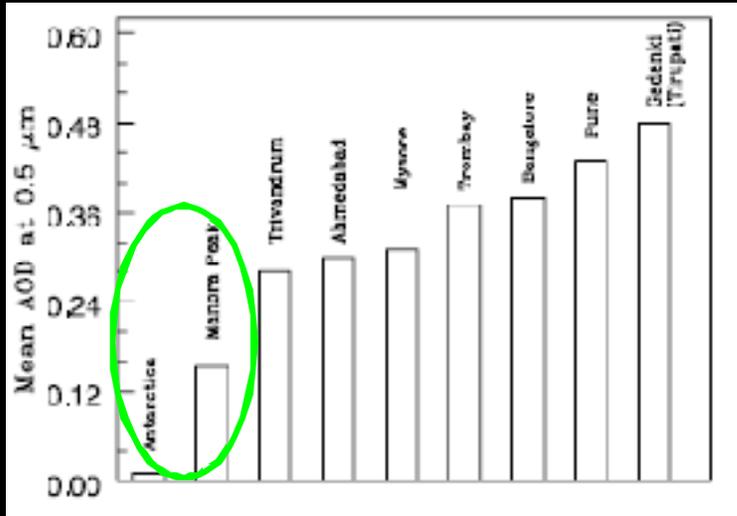
■ Lidar

- Aerosols

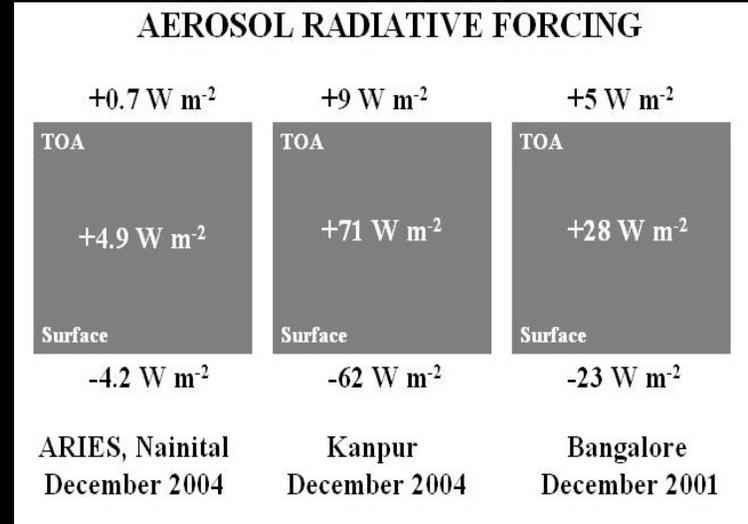
■ ST Radar (upcoming)



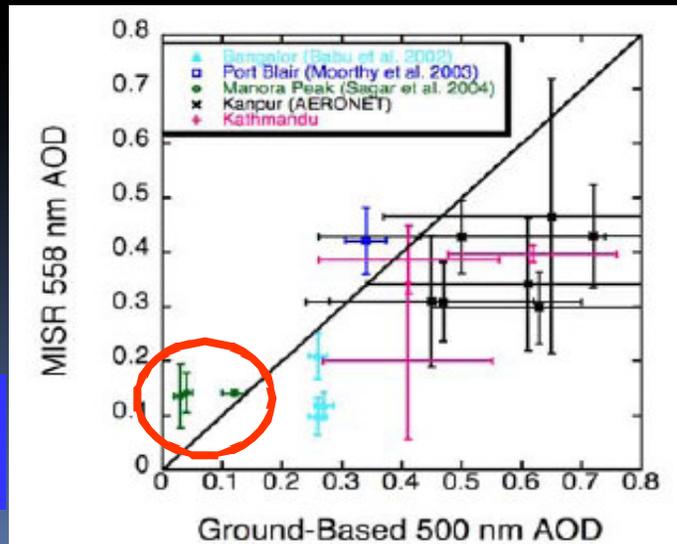
Important Results



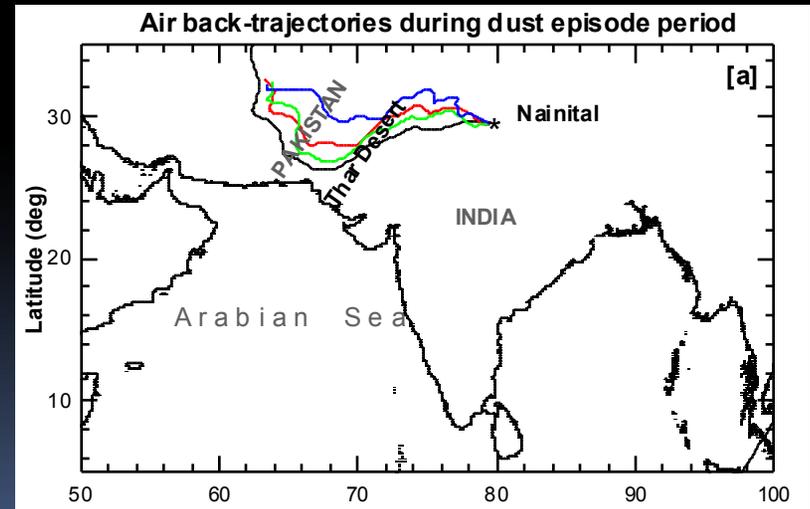
Lower value of AOD, particularly in winter. (JGR)



Aerosols RF is much lower at Nainital (JGR)



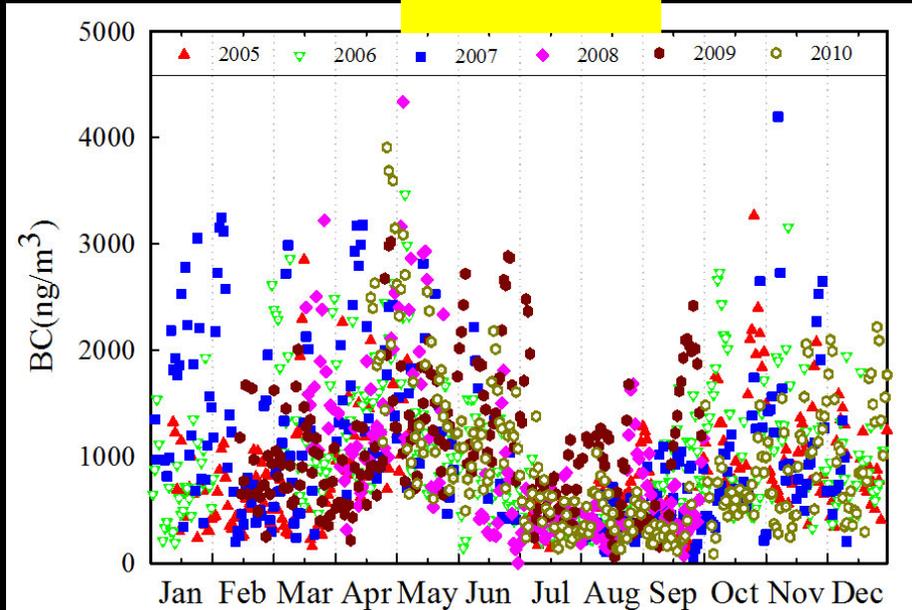
Comparison with MISR



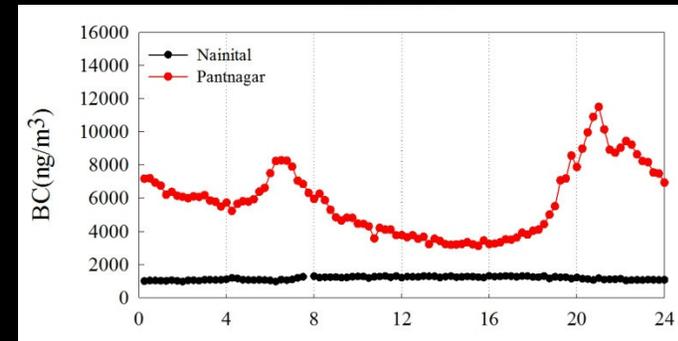
Long-range transport from Thar Desert (GRL)

Black Carbon at Nainital & Pantnagar

Nainital

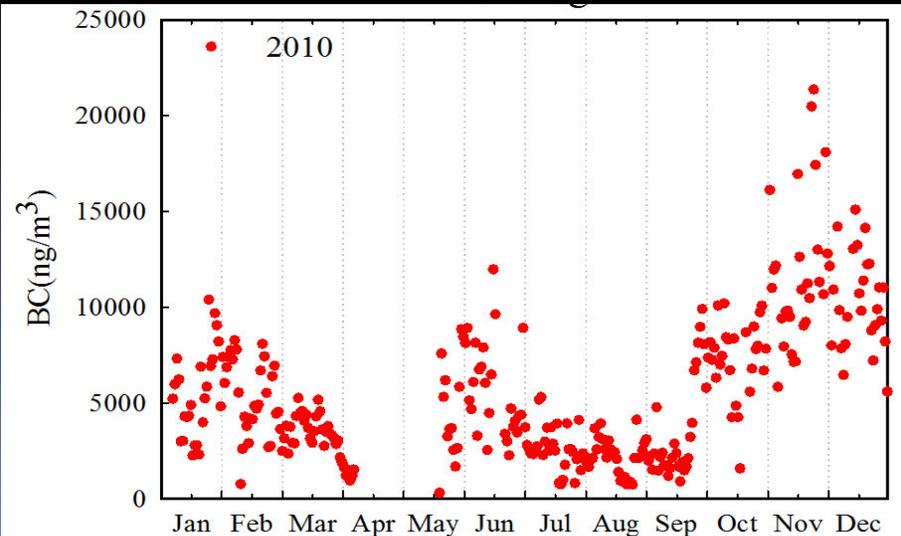


Diurnal changes at Nainital-Pantnagar

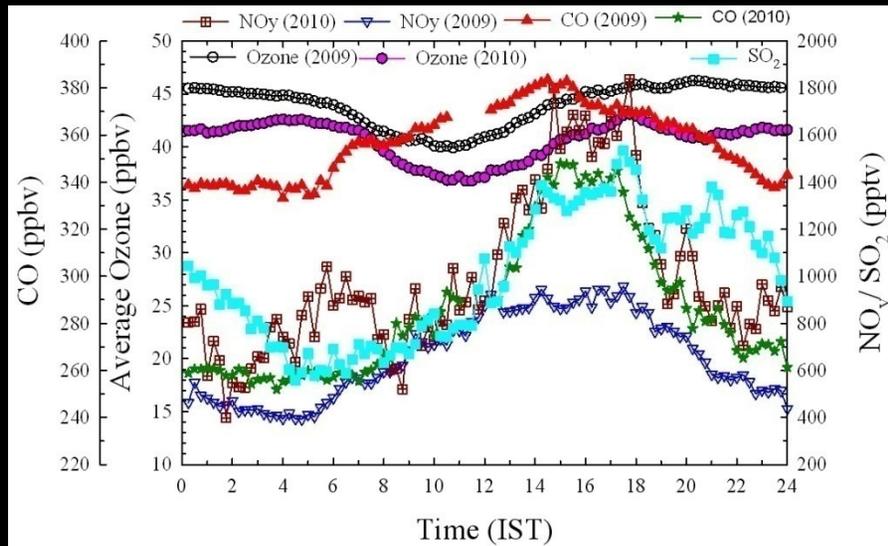


Pantnagar

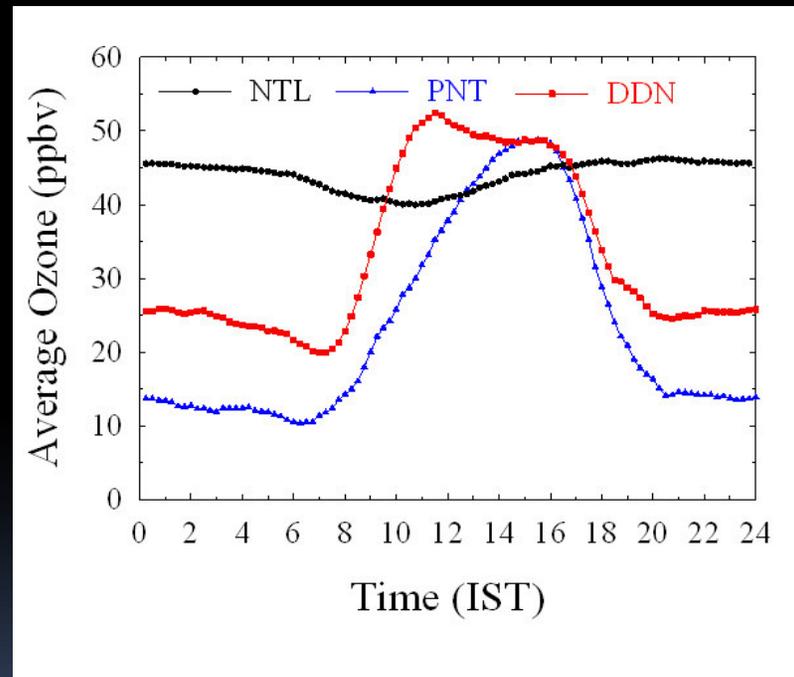
BC levels at Pantnagar
– higher by 5-6 times



Diurnal Variations at Nainital, Pantnagar and Dehradun



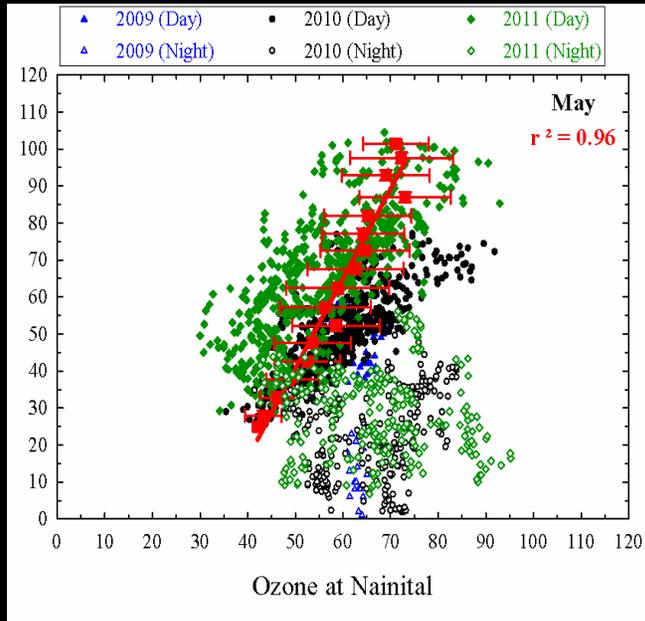
Ozone levels show clear daytime peak at Pantnagar and Dehradun in contrast with Nainital



Nighttime ozone levels are lower at Pantnagar (..... Ozone titration chemistry is stronger)

Surface ozone at Pantnagar and Nainital

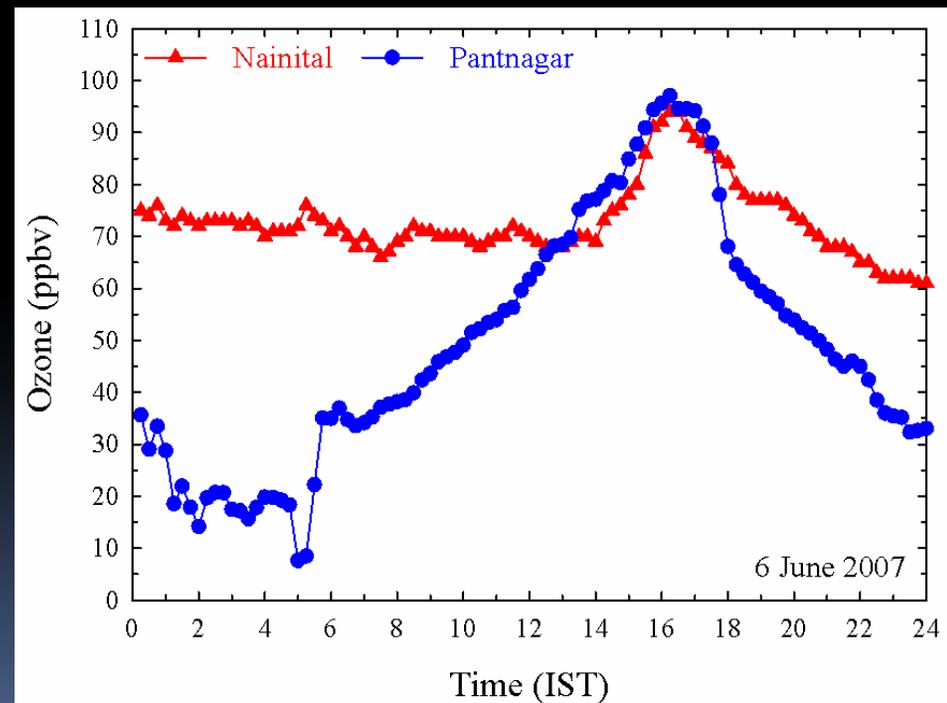
Ozone at Pantnagar (ppbv)



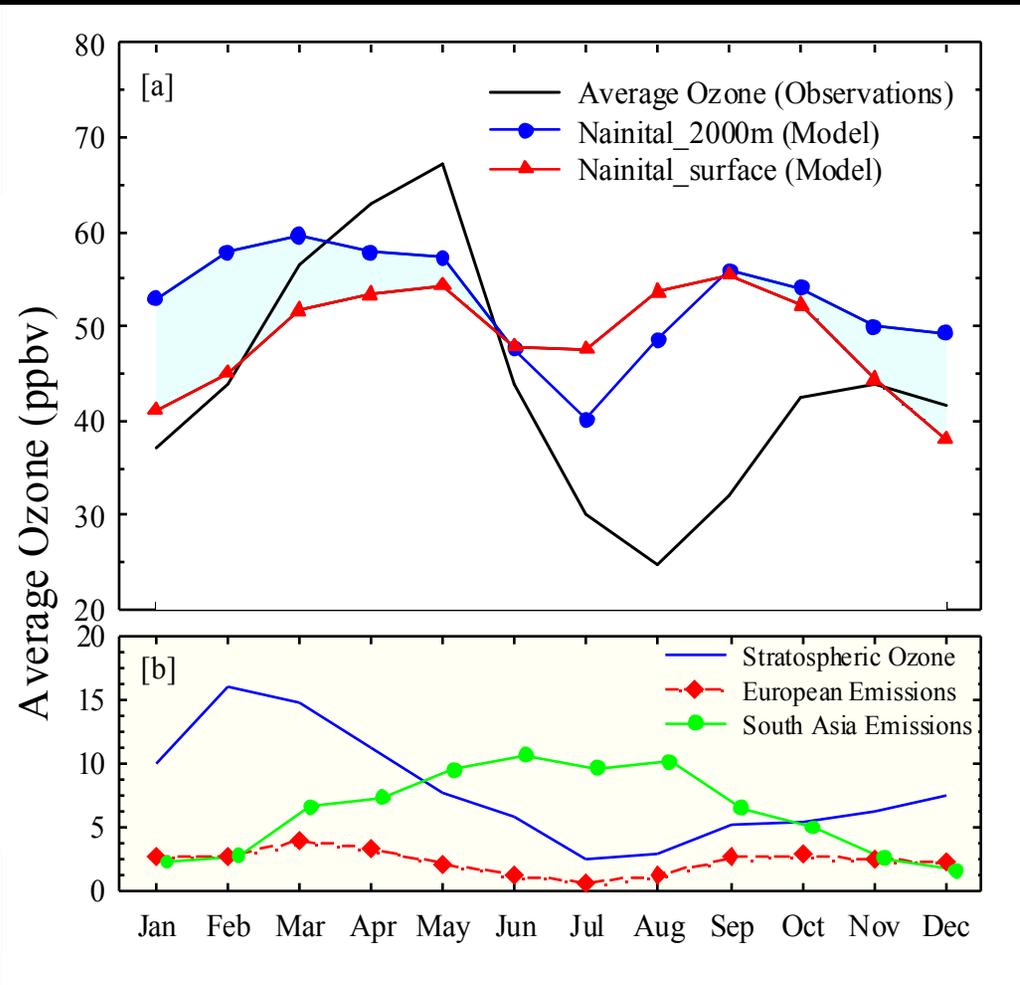
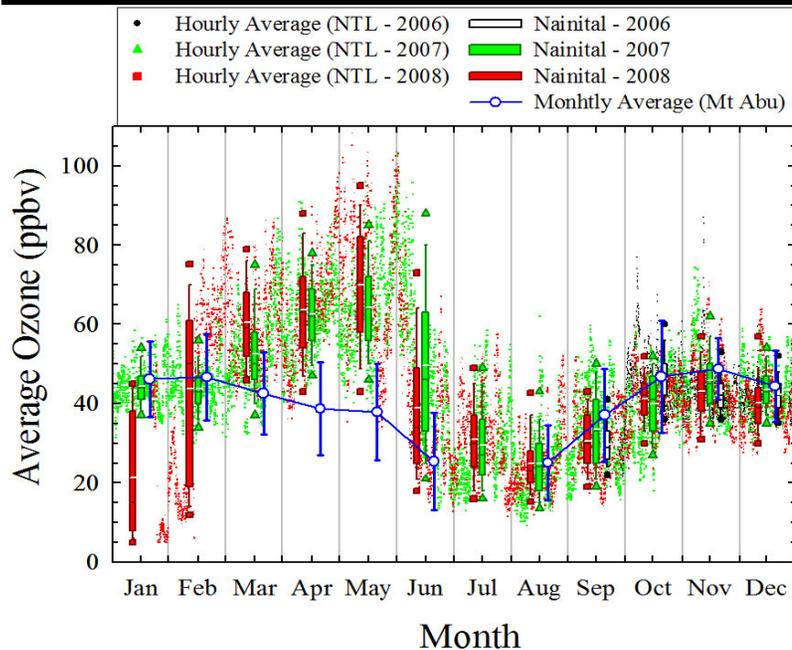
Ozone at Nainital



Daytime: the atmospheres of NTL and PNT gets coupled due to boundary layer evolution.



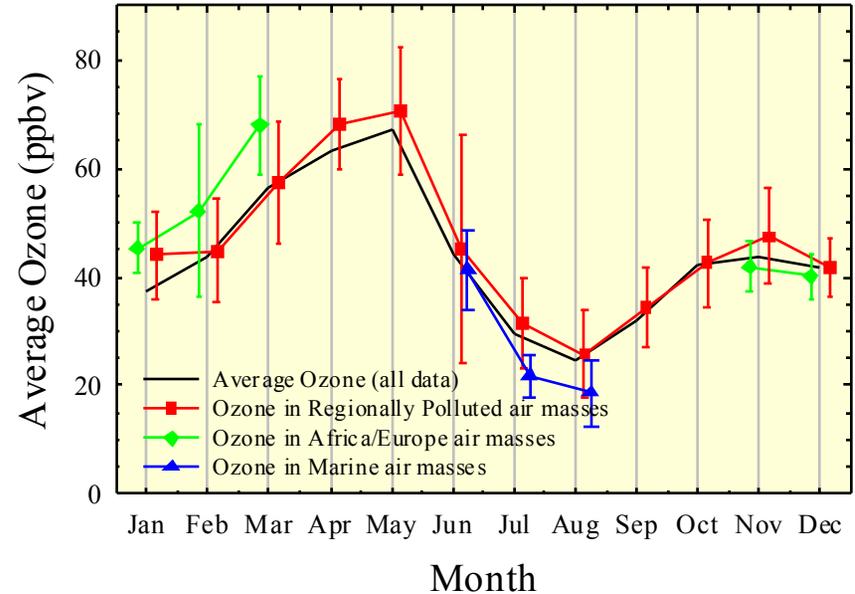
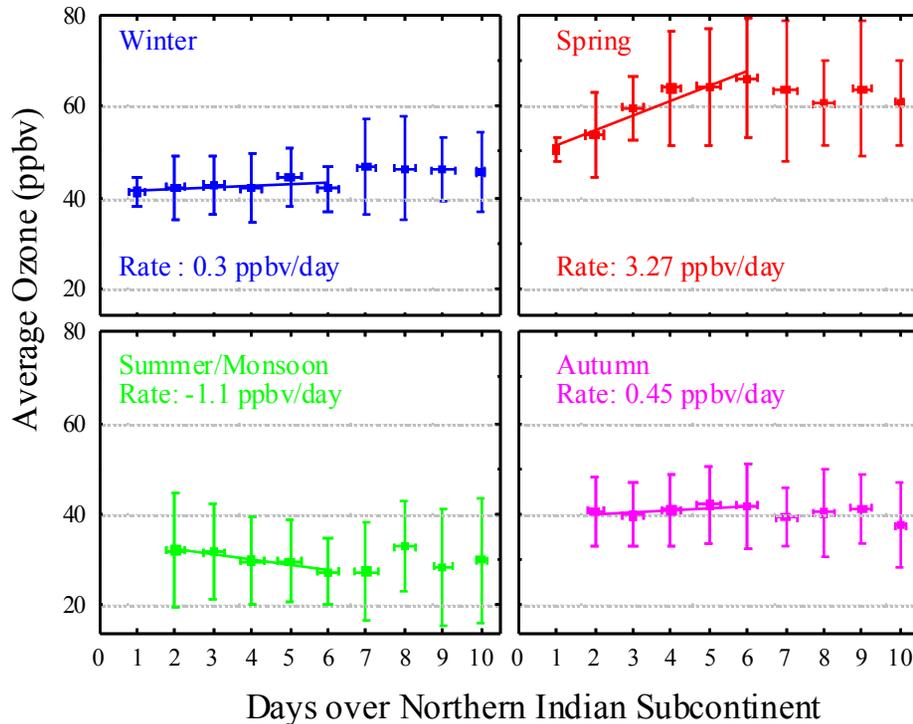
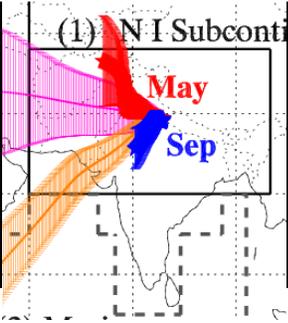
Surface Ozone Seasonality at Nainital



[JGR 2010]

- Differences in model and observations may be due to coarser resolution, emissions uncertainties and errors in meteorology of global model.
- Model and trajectory based estimates of contributions from downward transport is about 4-6 ppbv

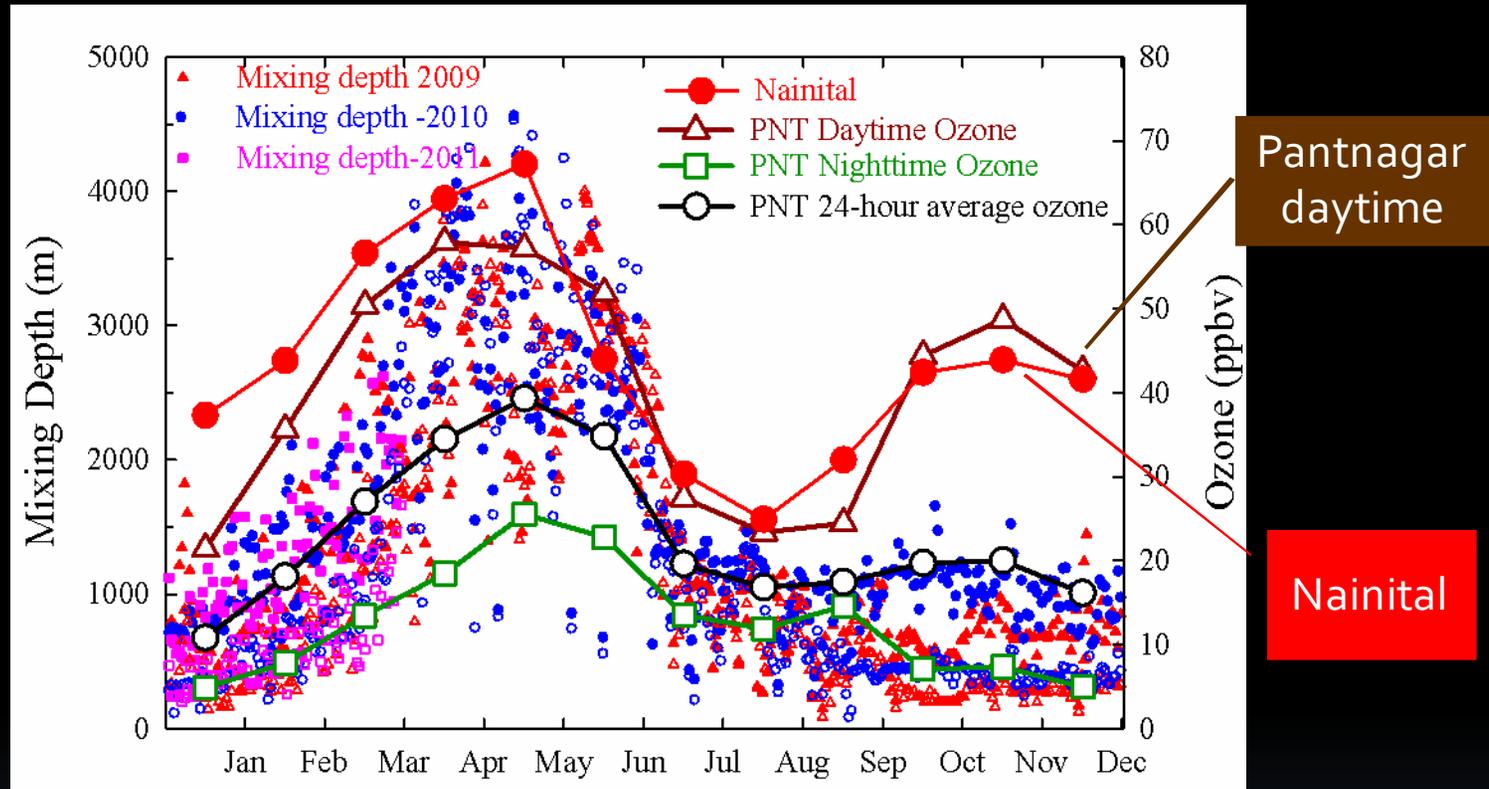
Ozone and Air Flows



| Season | Reg. BG O ₃ (ppbv) |
|--------|-------------------------------|
| Winter | 41.4 ± 2.9 |
| Spring | 48.3 ± 5.0 |
| Summer | 34.7 ± 2.8 |
| Autumn | 39.2 ± 2.9 |

| Air-Mass | O ₃ (ppbv) |
|---------------------|-----------------------|
| Regionally Polluted | 47.1 ± 16.7 |
| Marine | 29.7 ± 11.7 |
| Africa/Europe | 57.7 ± 15.4 |

Seasonal variations in surface ozone at Pantnagar



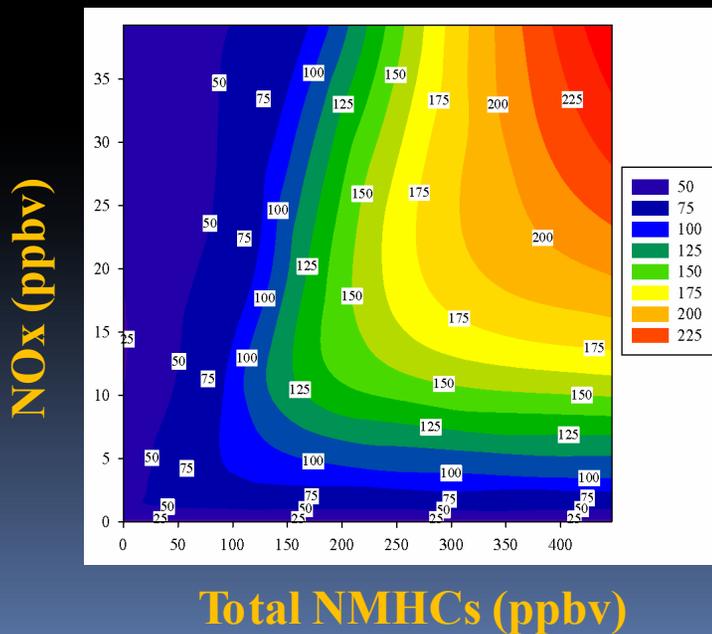
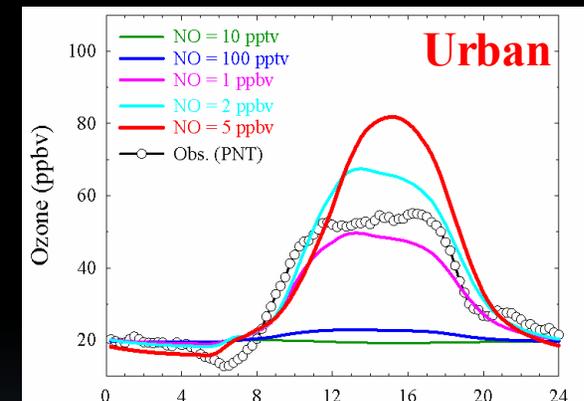
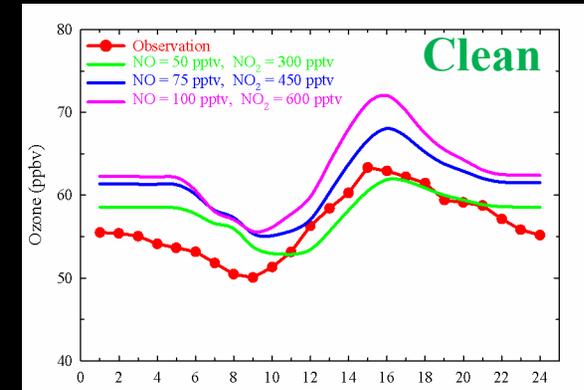
➤ Ozone seasonality is characterized by springtime maxima (55-60 ppbv) and summer/monsoon minima (10-15 ppbv).

➤ Mixing depth at Pantnagar (from HYSPLIT) also shows maxima (3 to 5 km) during spring.

➤ Interestingly, daytime ozone levels at Pantnagar show similar variations as at Nainital (Role of Mixing)

Chemical Box model simulations (NCAR Master Mechanism)

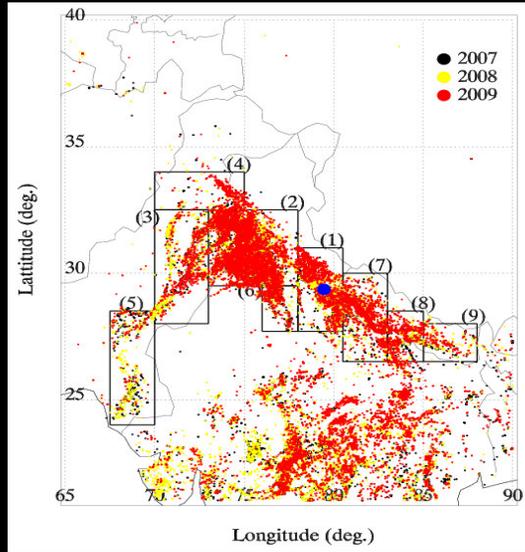
- To simulate the chemical evolution of an air parcel, neglecting any coupling between chemistry and dynamics, however, it includes boundary layer evolution.
- Basic inputs to the model are site parameters, boundary layer, meteorological conditions (Temperature, clouds), species of interest, emissions, initial & background concentrations.
- Ozone diurnal variations, simulated for Nainital (Clean) and Pantnagar (urban) shows reasonable agreement with the observations.



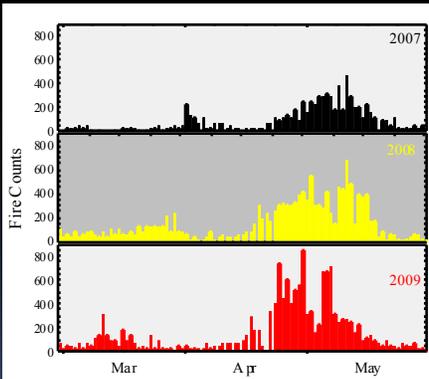
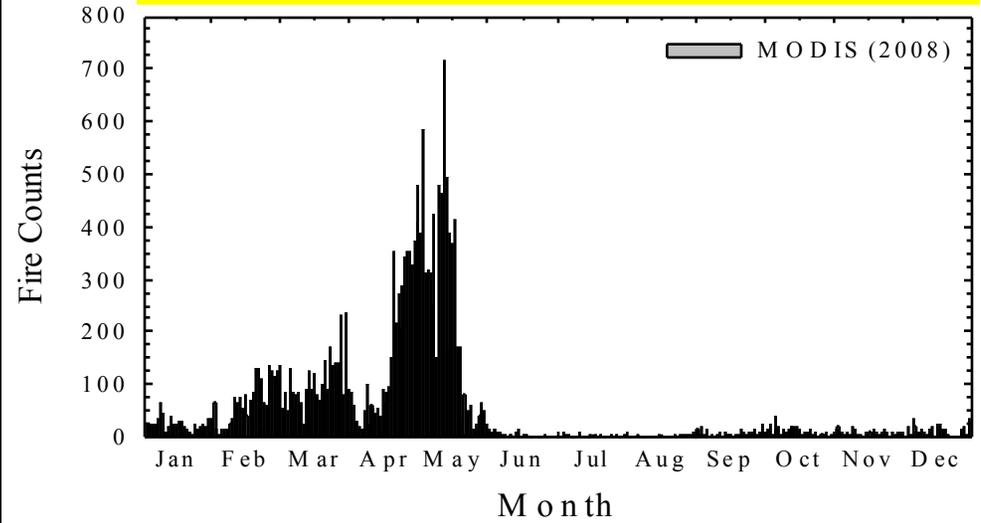
❑ Ozone production is more sensitive to NO_x at Pantnagar.

❑ Possible future increase in emissions from this region would result in rapid increase in ozone.

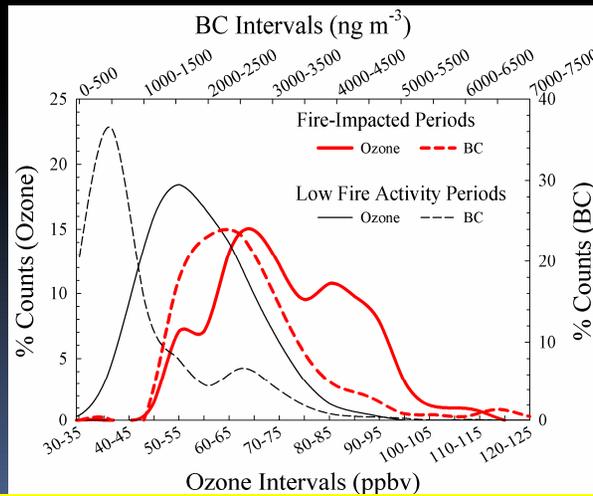
Biomass Burning



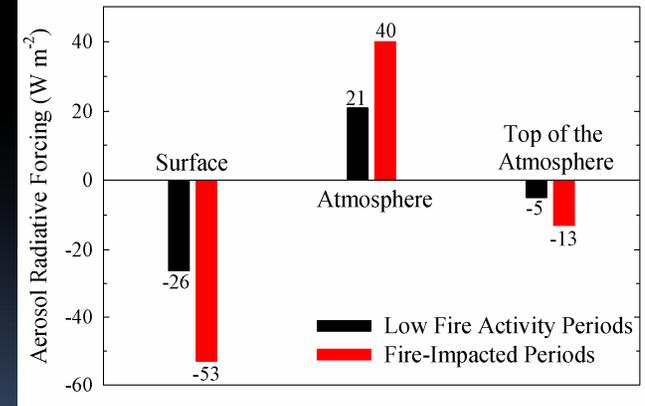
Fire over the Northern India



Max fire activity
(15 April – 30 May)



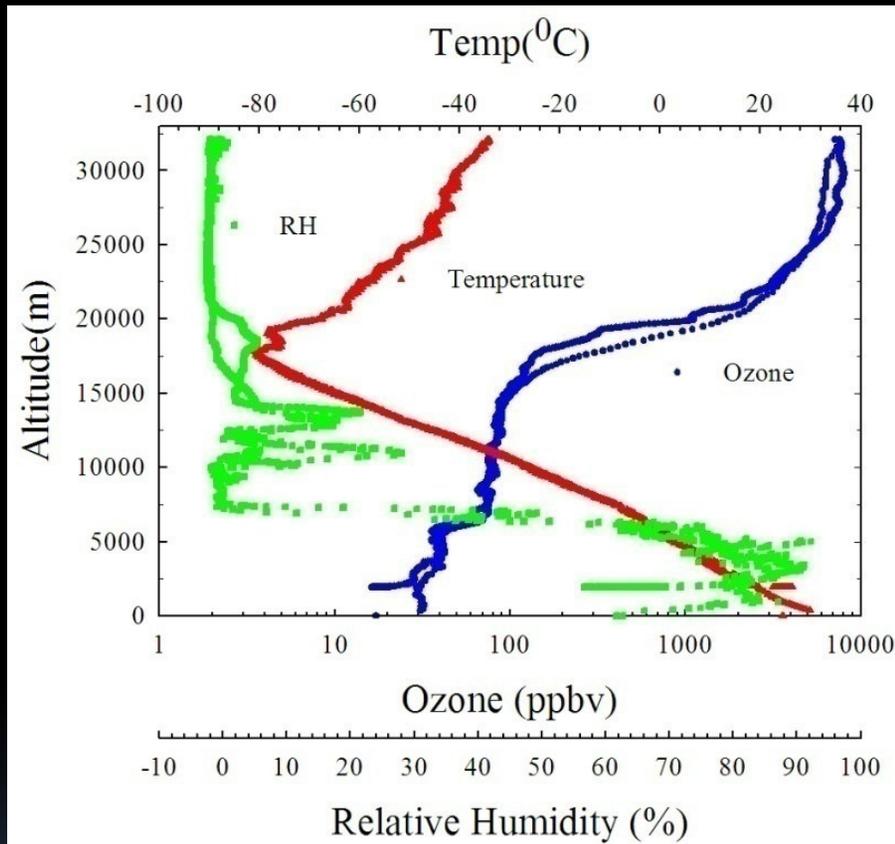
Enhancement in BC and Ozone



Enhancement in Radiative forcing

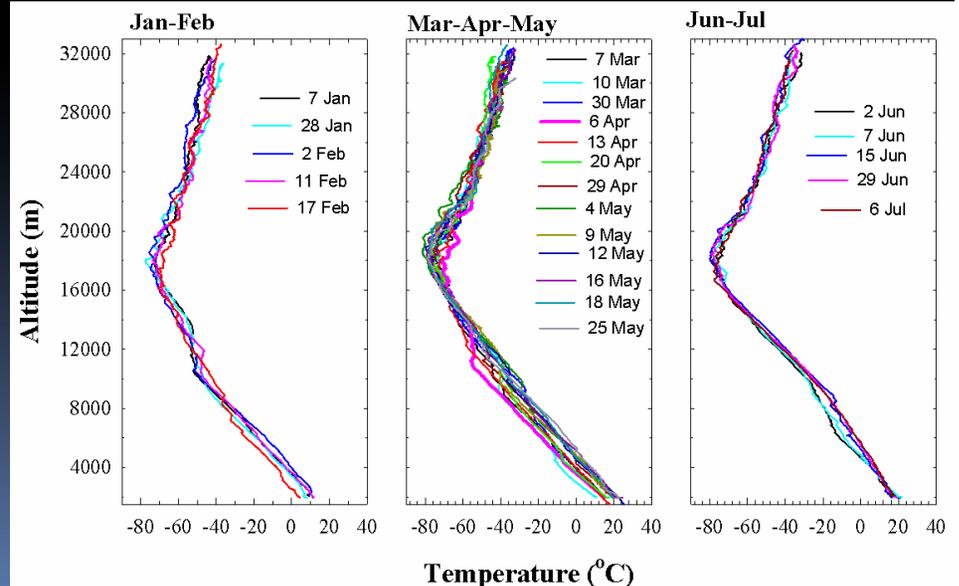
[JGR 2011]

Ozonesonde and Radiosonde at ARIES:

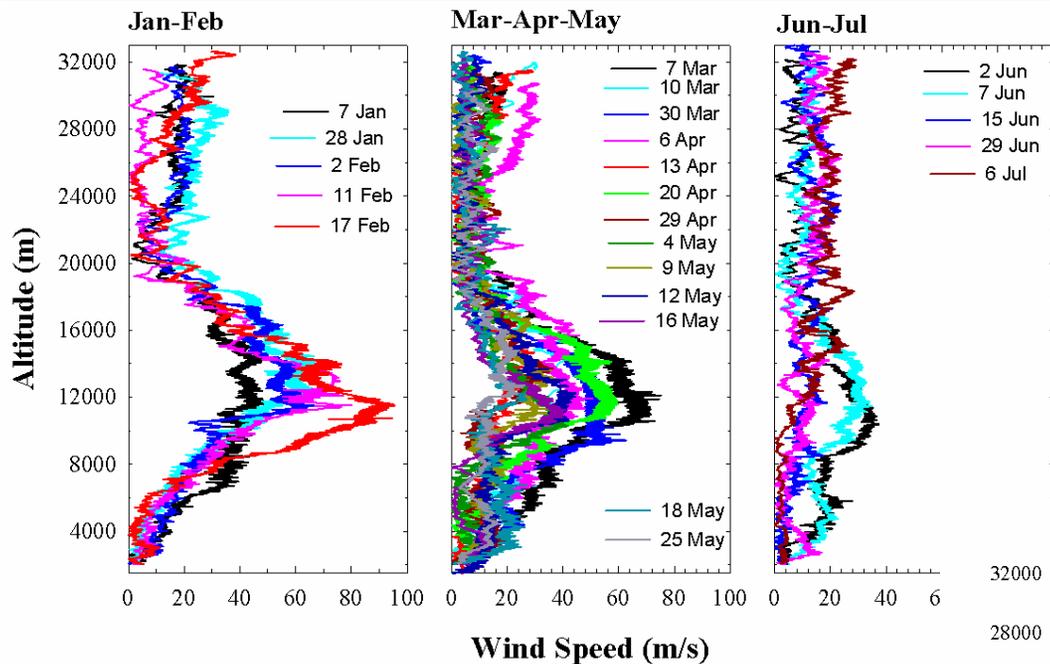


Vertical distribution
of Temperature,
Relative Humidity
and Ozone at
ARIES, Nainital.

Temperature

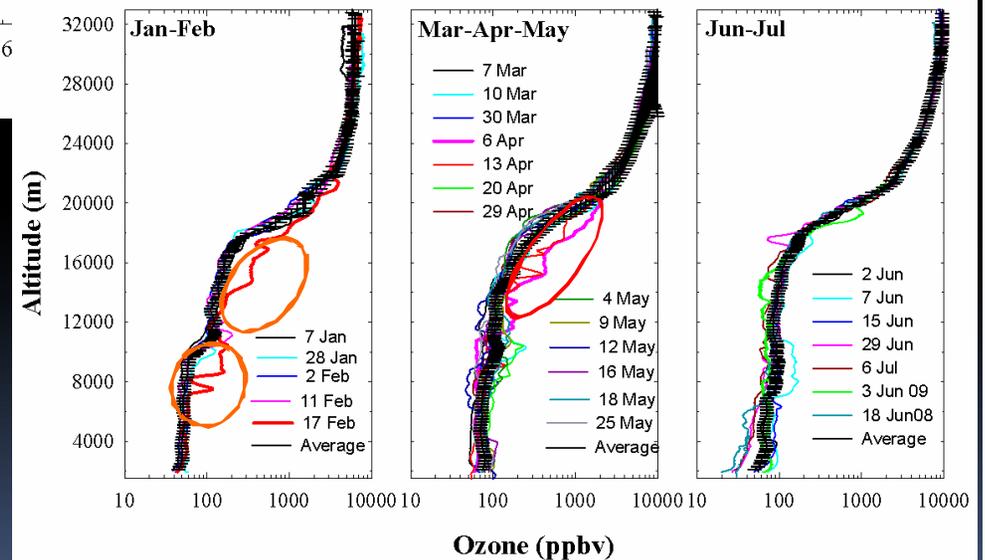


Wind Speed



Occasionally very high wind speed (50 m/s) are observed in middle and upper troposphere. (may be associated with tropical Jets)

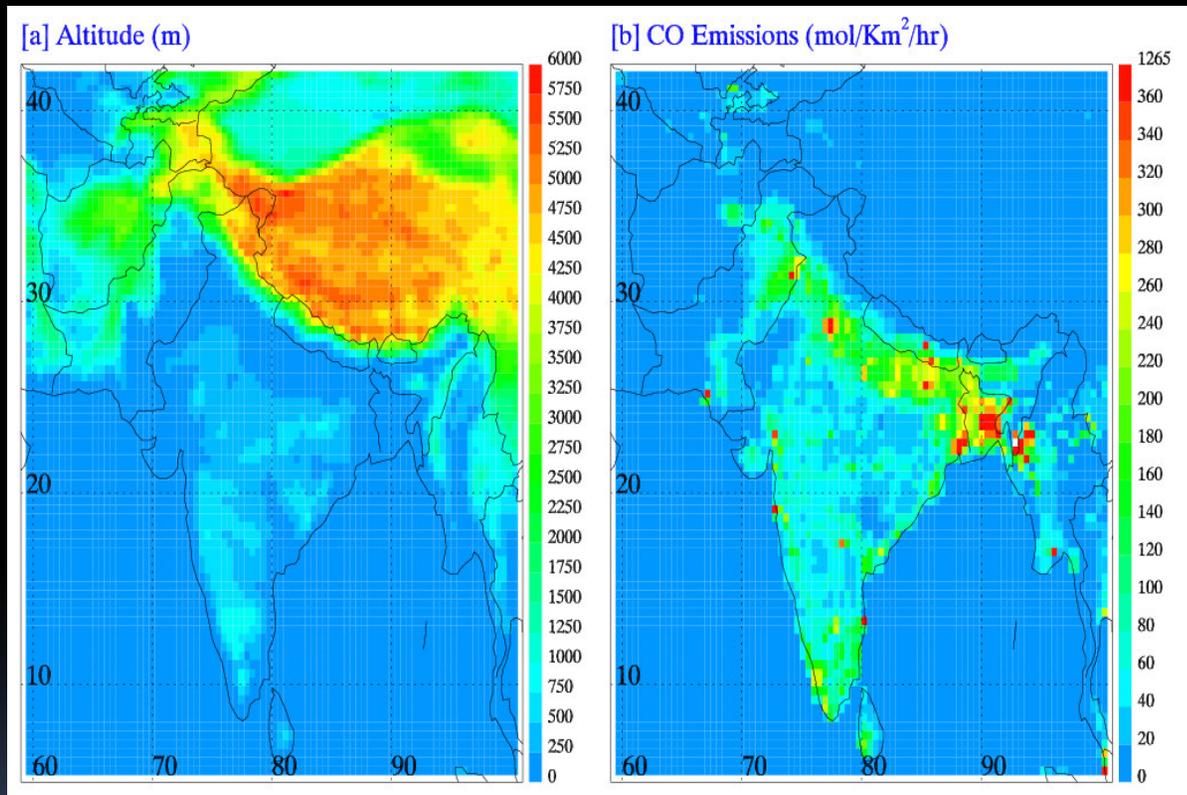
Ozone



- Elevated ozone is noticed in the middle and upper troposphere.
- Signatures of Stratospheric intrusions are seen in preliminary analysis.

WRF-Chem Model

Thanks to NCAR, Boulder group (G Pfister, M Barth and G P Brasseur)



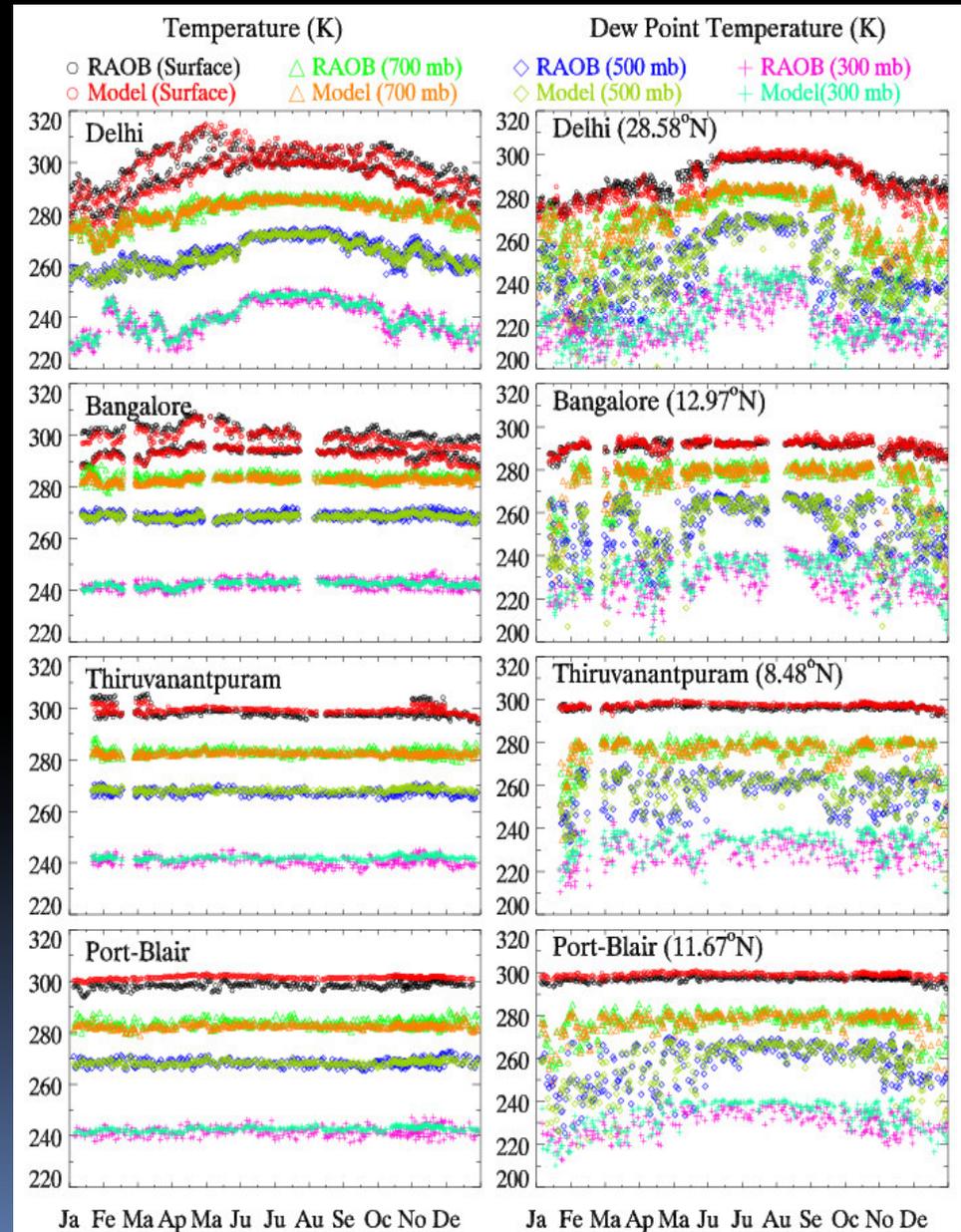
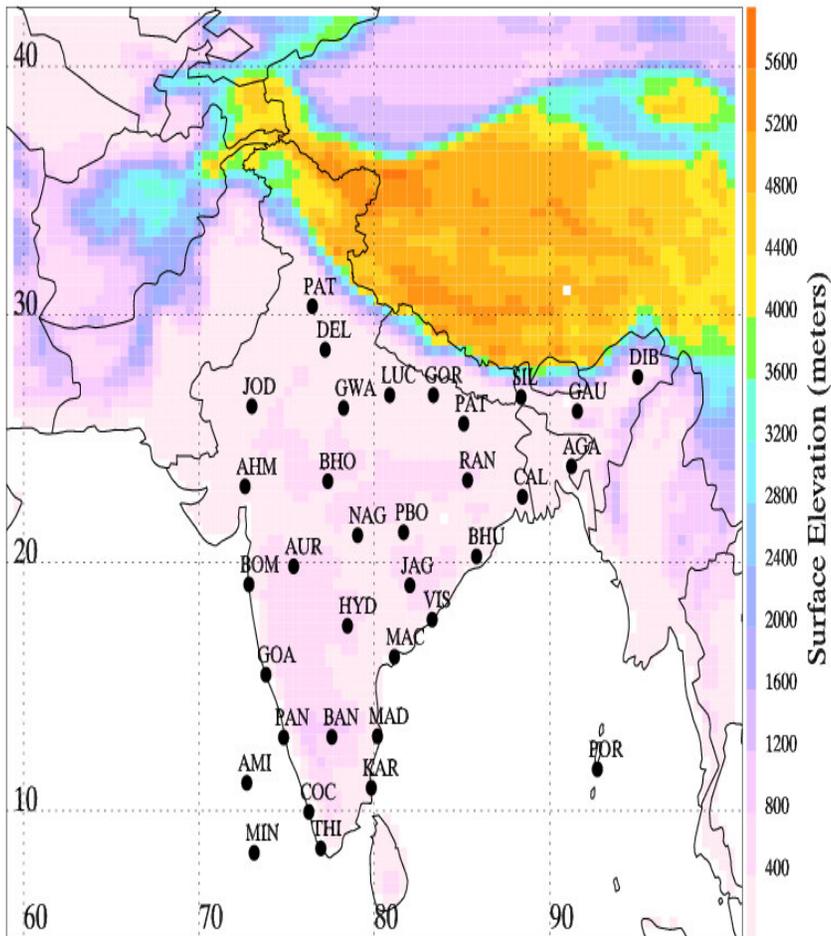
Input Data

- Geographical Data – USGS
- Meteorological Data – FNL
- Anthropogenic Emissions – RETRO/ Zhang et al. (2009)
- Biogenic Emissions - MEGAN
- Fire-Emissions – Wiedinmyer et al. (2006)
- Initial and lateral boundary conditions for chemical species – MOZART 4

Grid Spacing : 45 Km; **Model Top Pressure**: 10 hPa; **Center lon (lat)**: 80° E(25° N)

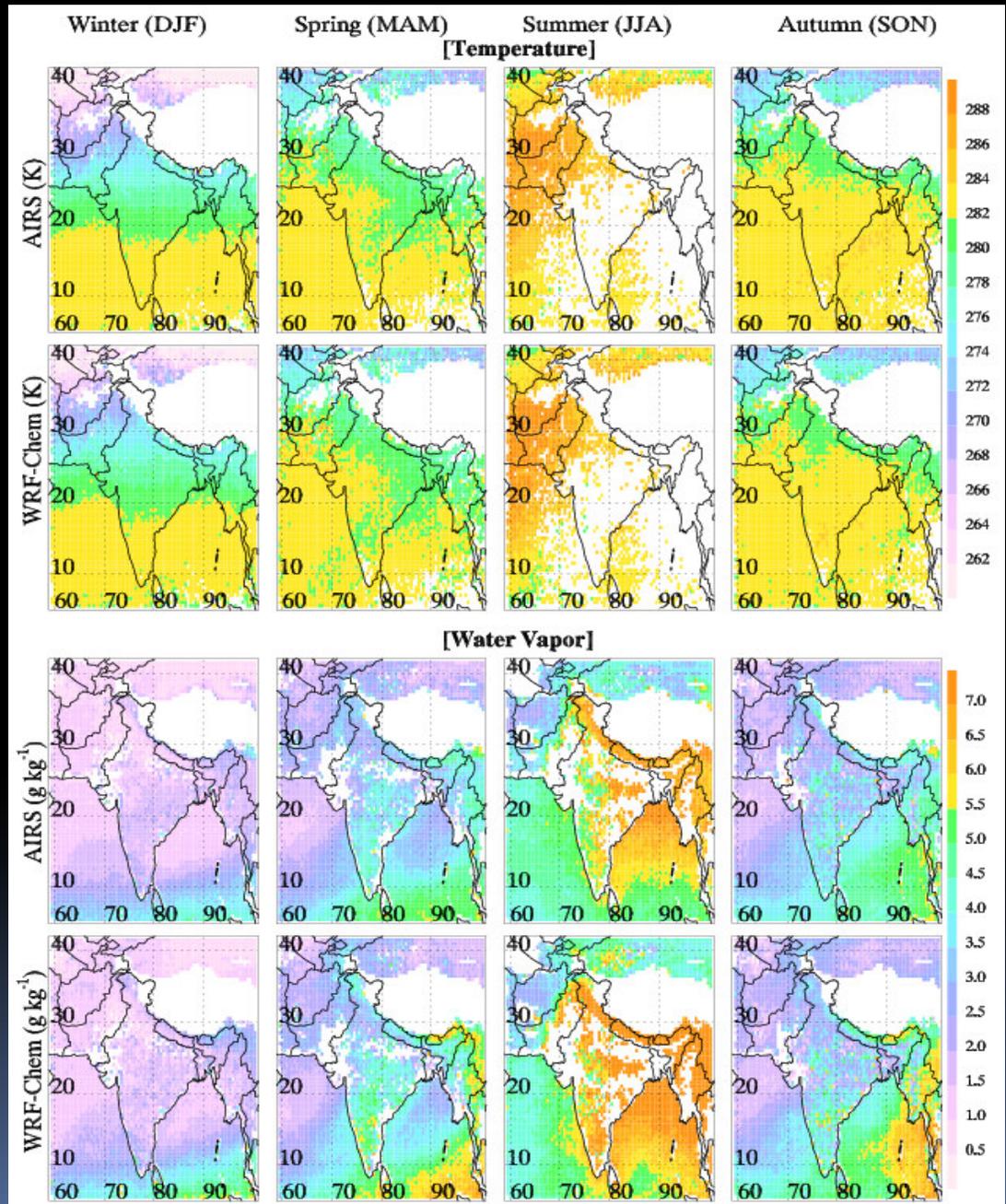
Grid Points (x,y,z): (90,90,51); **Simulation Time Step**: 4*grid spacing = 180 secs

WRF-Chem: comparison with RAOB

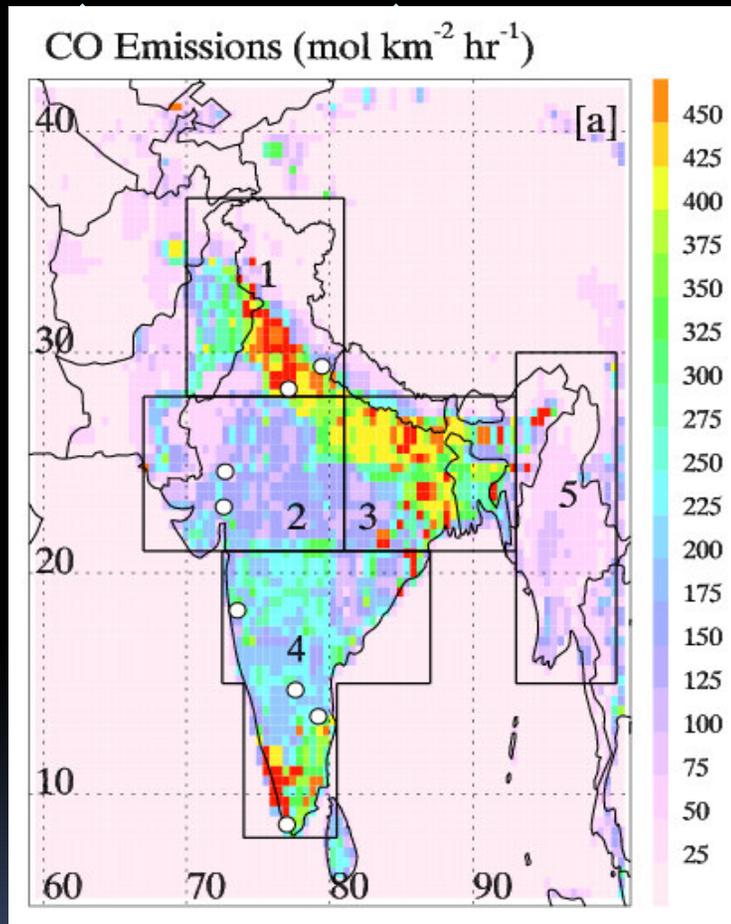


Radiosonde data from 34 stations within India are used for evaluating temperature and dew point temperature

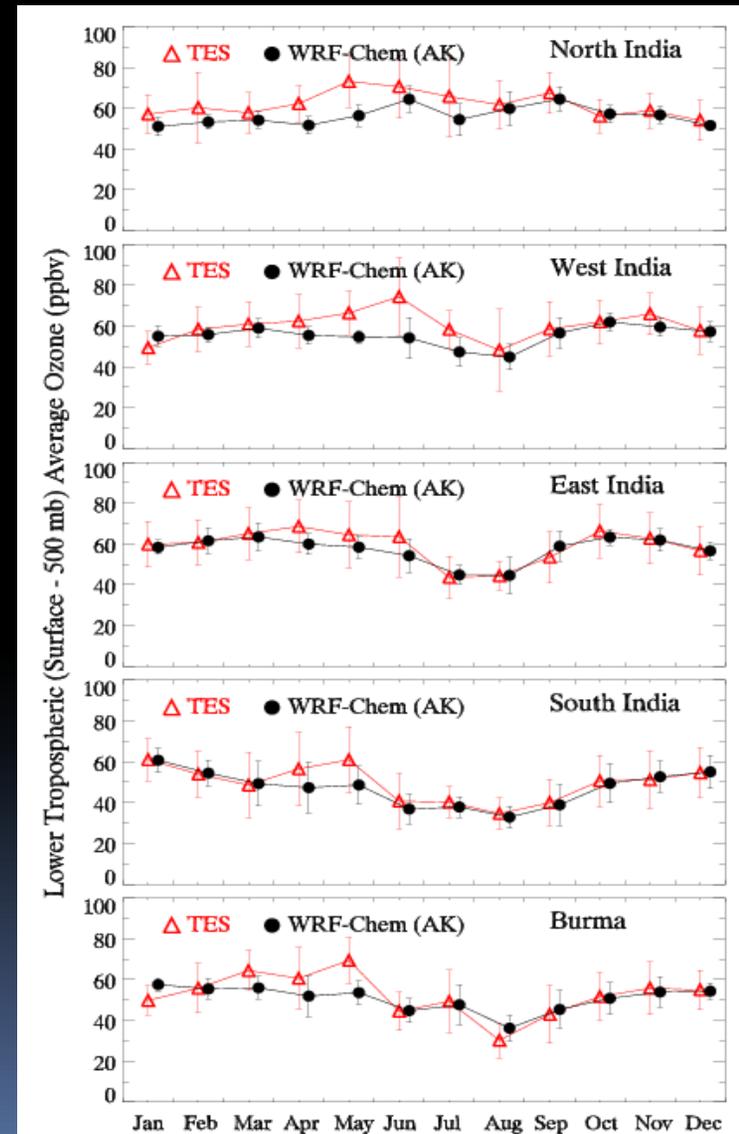
WRF-Chem Vs AIRS



WRF-Chem Vs TES Ozone

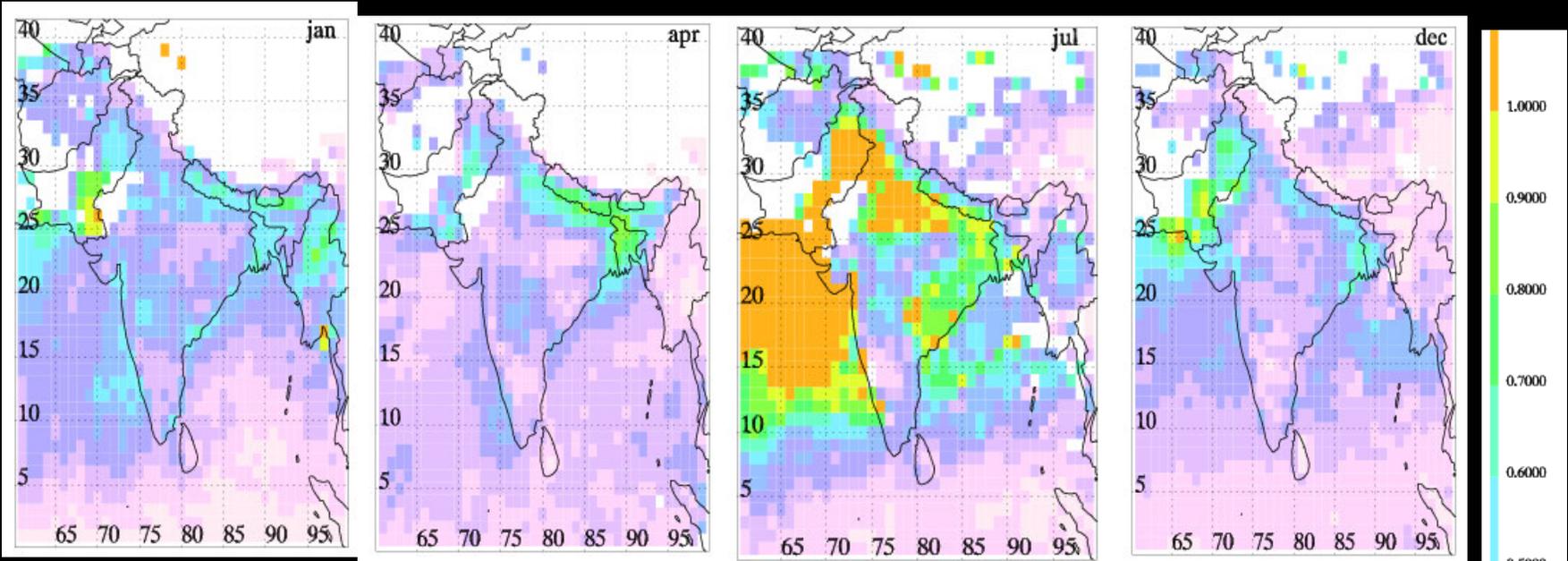


1 – North India, 2 – West India, 3 – East India,
4 – South India, 5 – Burma

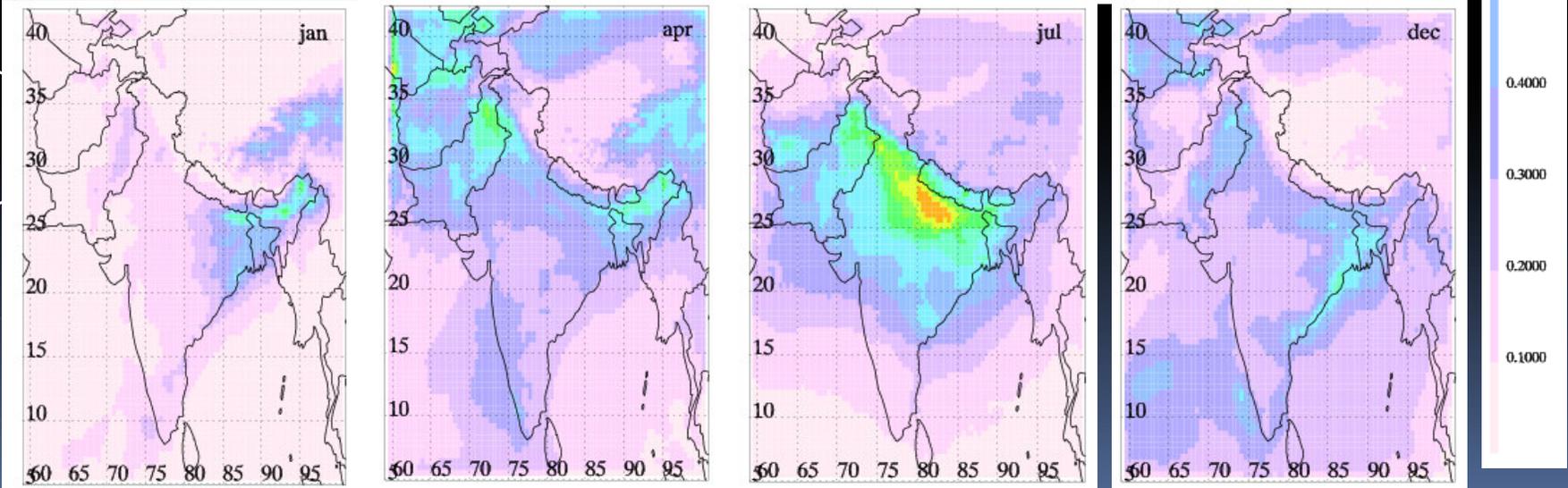


WRF-Chem Vs. MODIS Terra AOD (550 nm)

MODIS (1 deg.)



WRF-Chem (45 km)



Greenhouse gases

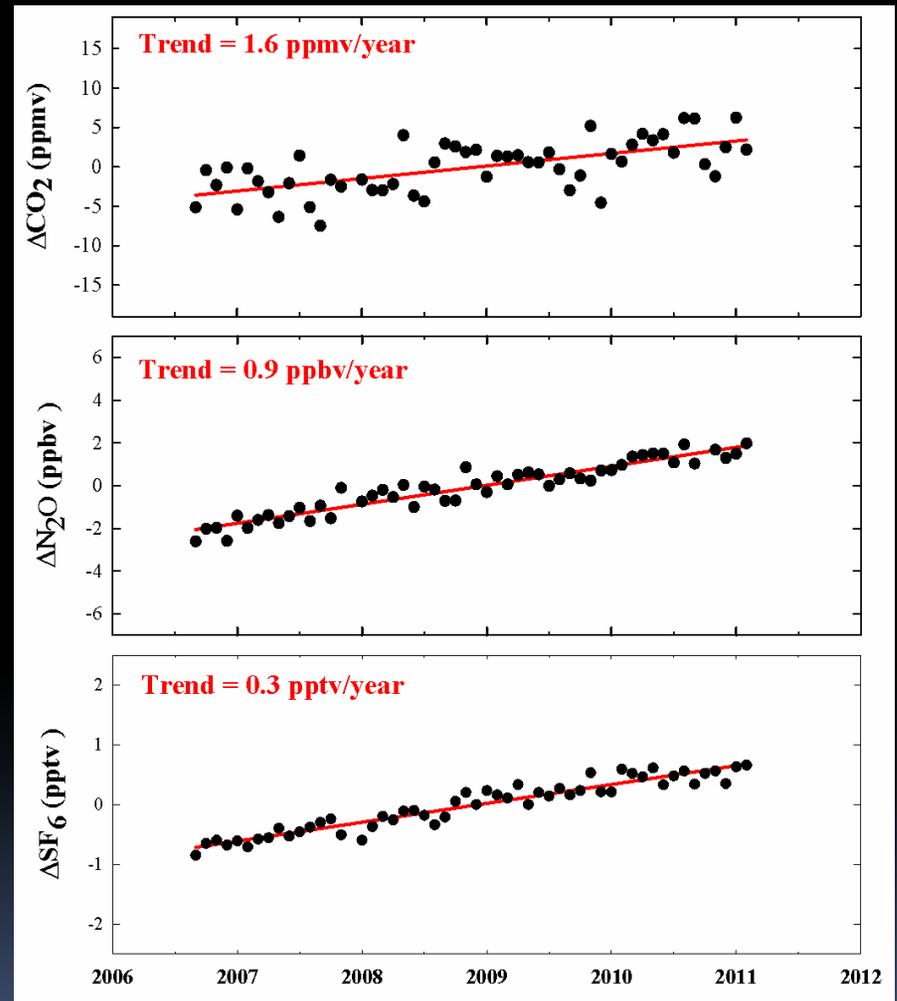
- Weekly Air samples (1400 Hours IST) are collected at a cold trap (-30°C)
- Analysis is done using NDIR analyzer and GC at NIES, Japan



Global growth rates:

$\text{CO}_2 \rightarrow 1.65 - 2.38 \text{ ppmv/yr}$, $\text{N}_2\text{O} \rightarrow 0.75 \text{ ppbv/yr}$, $\text{SF}_6 \rightarrow 0.24 \text{ pptv/yr}$

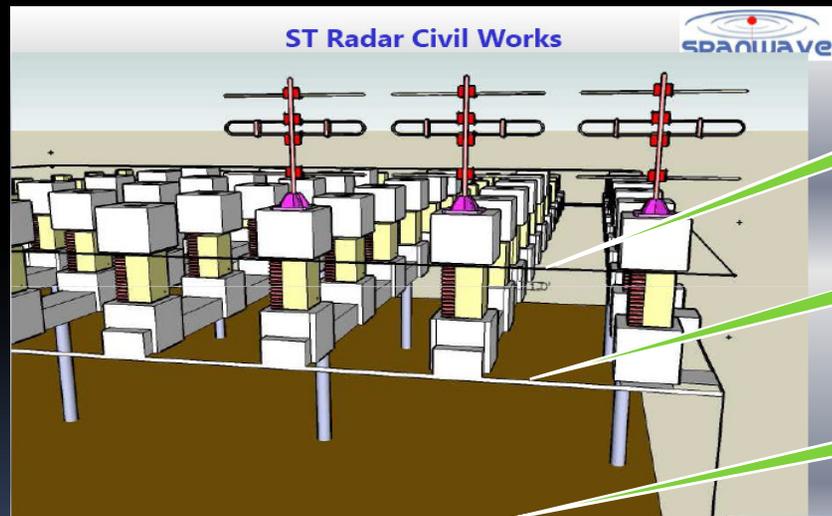
De-Seasonalized Long term trend



Stratosphere Troposphere (ST) Radar (upcoming)

Highlights:

- Studies on winds, monsoon dynamics and Troposphere Stratosphere exchange
- Frequency : 206.5 MHz
- Area Covered : 30x30 m
- Continuous and high resolution winds
 - ~10 min for full profile
 - 50 to 300 m
 - Velocity resolution : 0.1 m/s to 2 m/s



Antenna floor
(Roof top)

Arrangement to put
T/R modules

T/R module floor
(Ceiling for GF)

**Ground Floor
(control room & work place)**

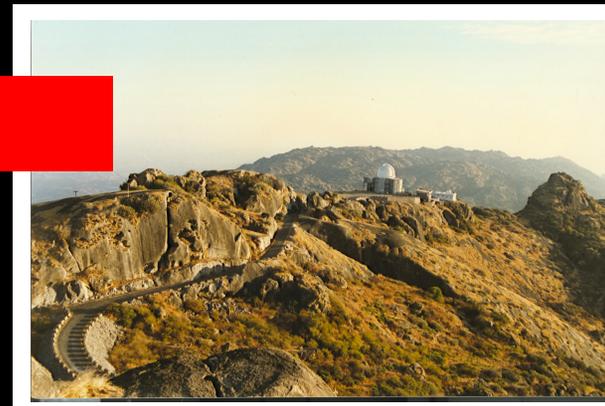


High altitude background sites under ISRO network

- Model Validation
- Background levels
- Regional Pollutions
- Long Range Transport



Mt. Abu



Nainital



Ooty

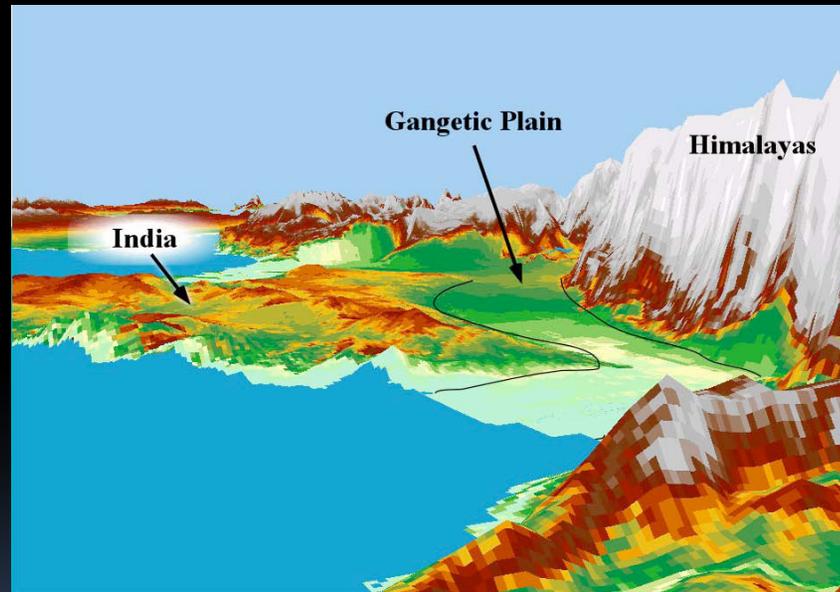


RAWEX-GVAX

Regional Aerosols Warming Experiment Ganges Valley Aerosols Experiment

A multi institutional project

DOE (USA), ISRO, IISc and ARIES

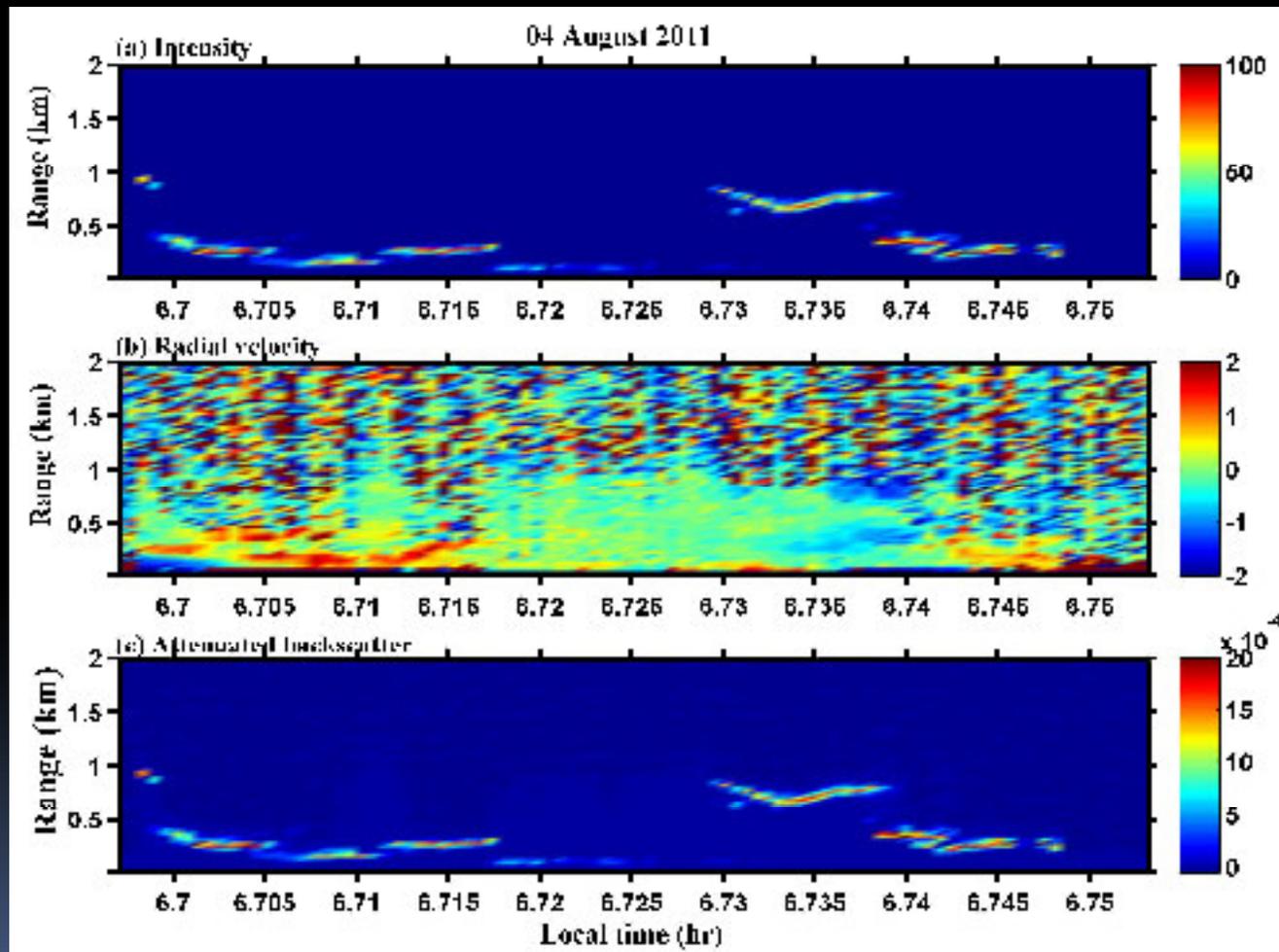


A major international initiative after about 13 years

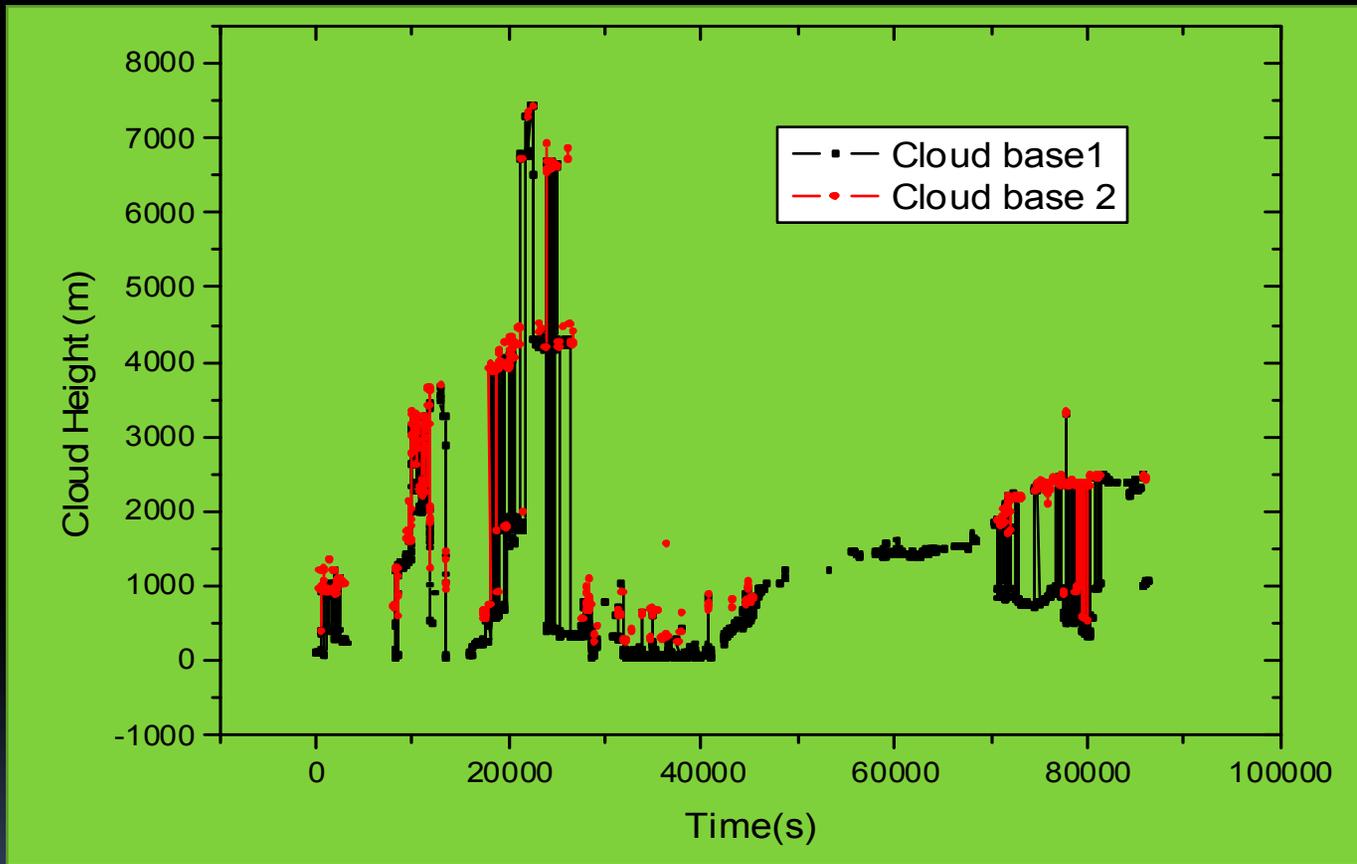
AMF₁
set up
at
ARIES
Nainital



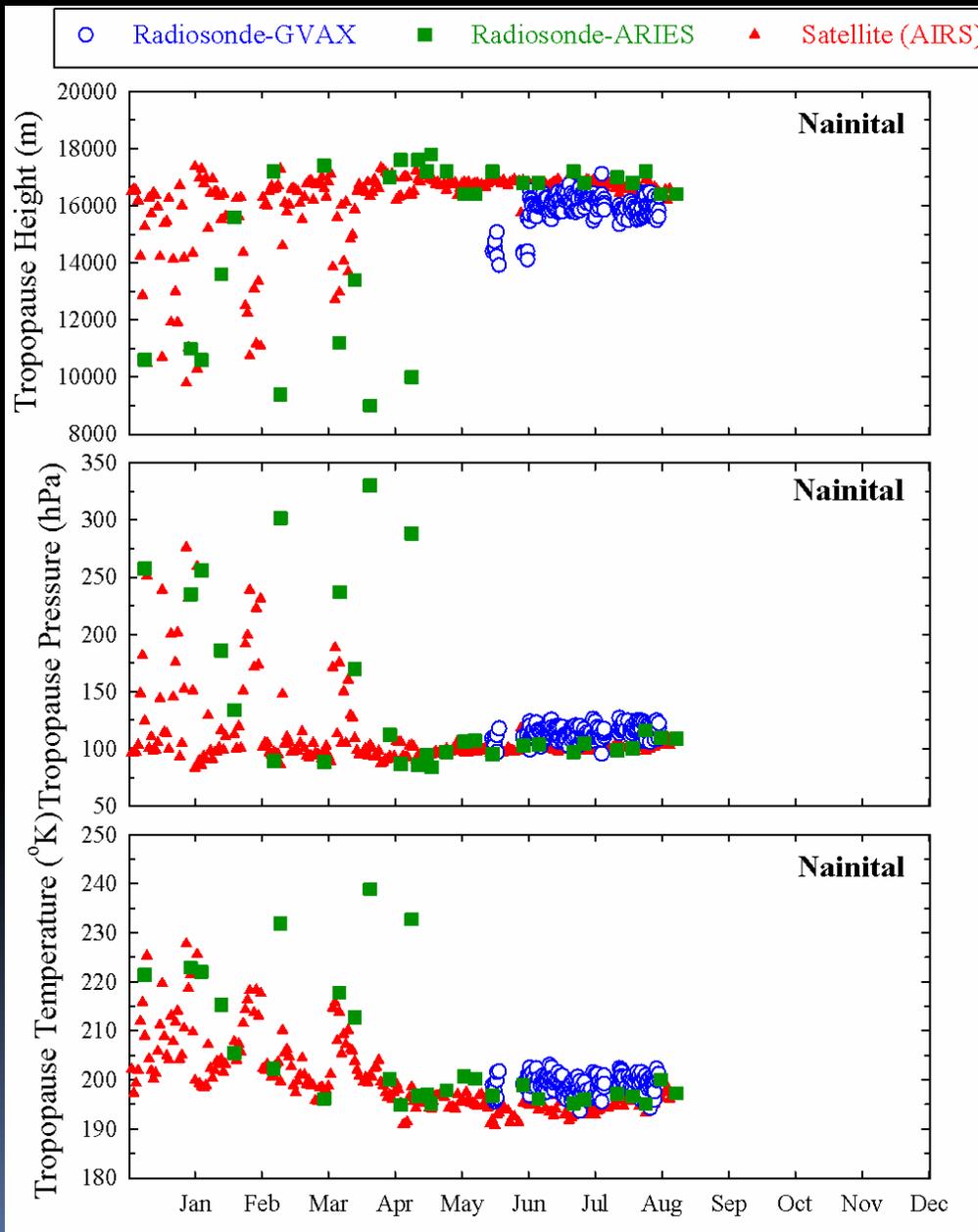
Doppler Lidar



Ceilometer



Tropopause Characteristics over Nainital



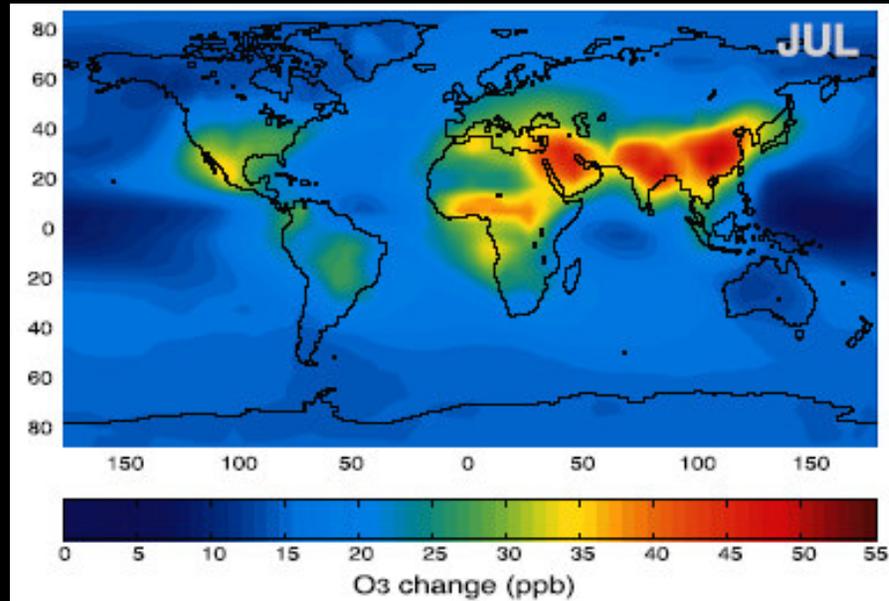
☐ Tropopause characteristics show significant variability over this region.

☐ Reasonably good agreement is seen between radiosonde and satellite observations.

☐ Generally Tropopause is located between 14 to 18 km while on few occasion it is observed at lower altitudes (possibility of multiple tropopause).

Tropopause estimation has been made using WMO criteria. .

Future Change



..... it is in the tropics

Thanks for the attention