Tropospheric Chemistry over the IGP and the Central Himalayas

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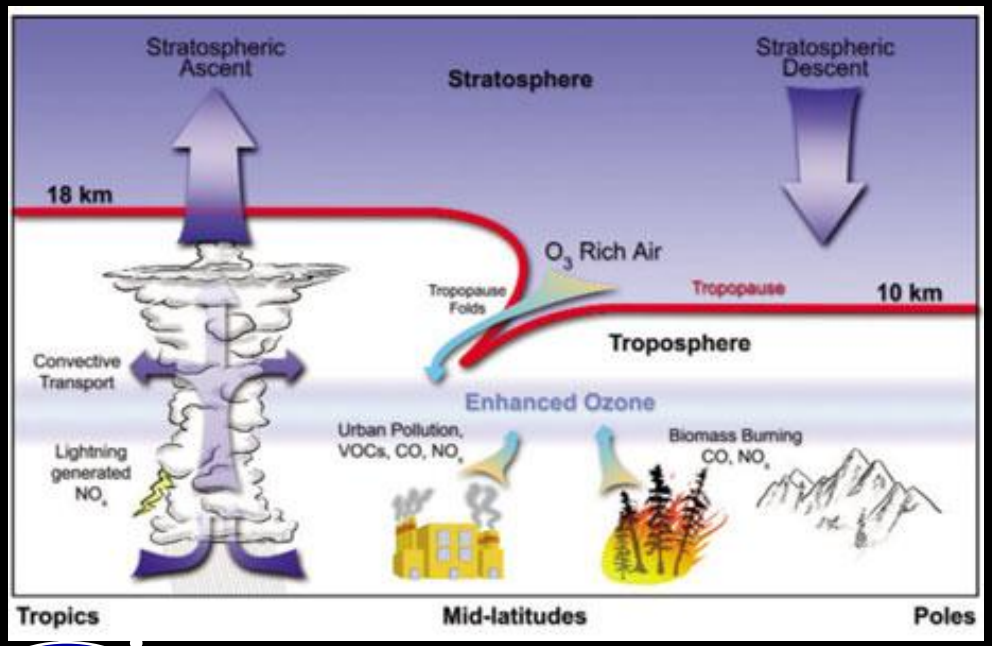
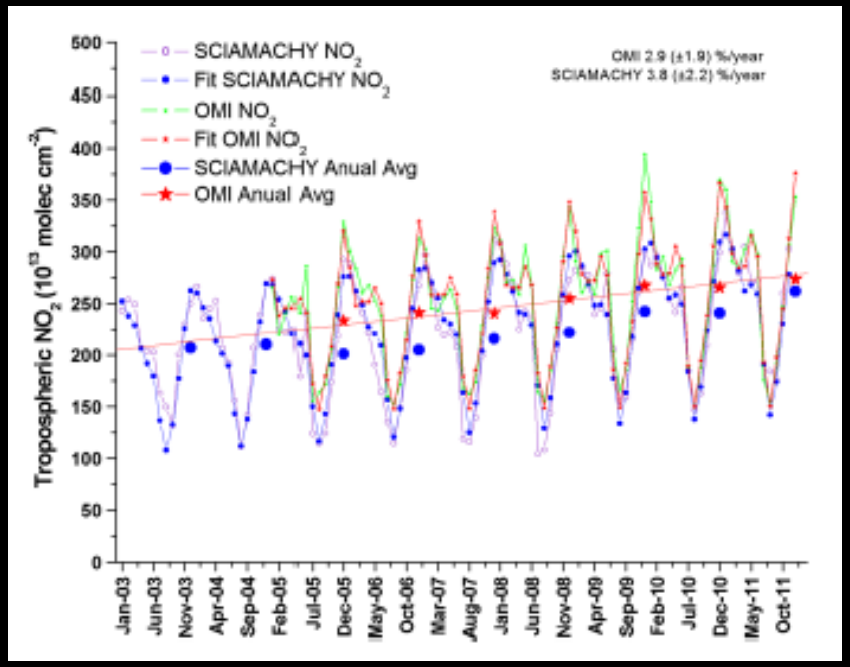
[ARIES], Nainital

International workshop on
Changing Chemistry in Changing Climate: Monsoon,
IITM, Pune [1-3 May, 2013]

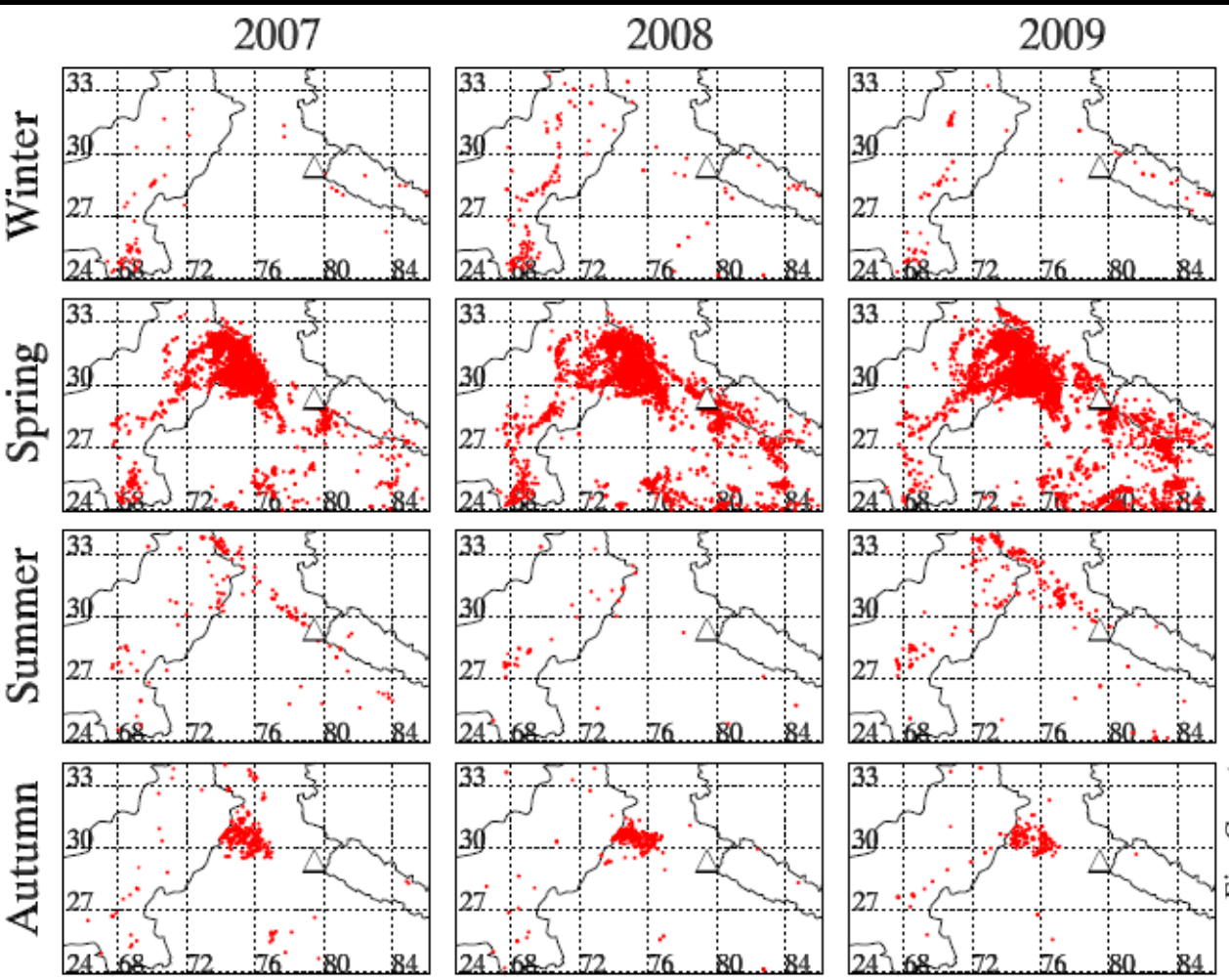
- The IGP region is undoubtedly one of the most polluted region in India.
  - Most densely populated region
  - Home to large agricultural activity, hence crop residue burning
- This region is also dominated by western disturbances.
- The Central Himalayas is in the transition region from tropical to mid-latitude tropopause and characterized by the tropopause-break.



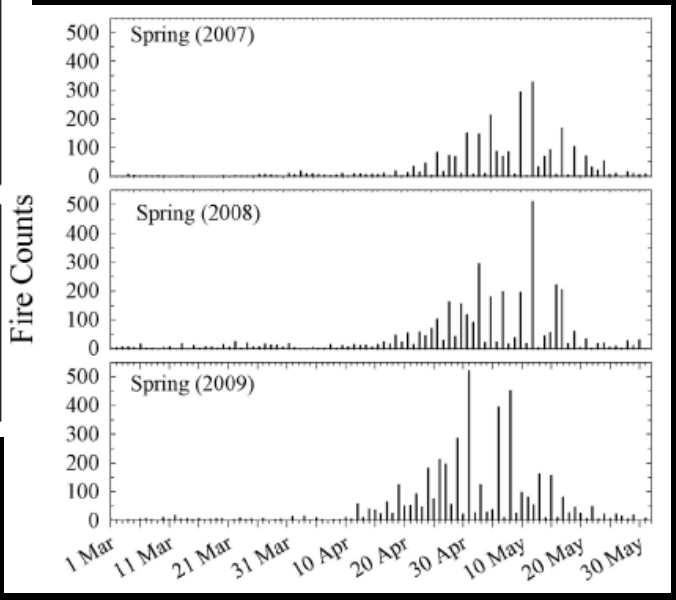


Ghude et al., JGR 2013

MODIS Fire (Northern India)



[April 20 – May 20]

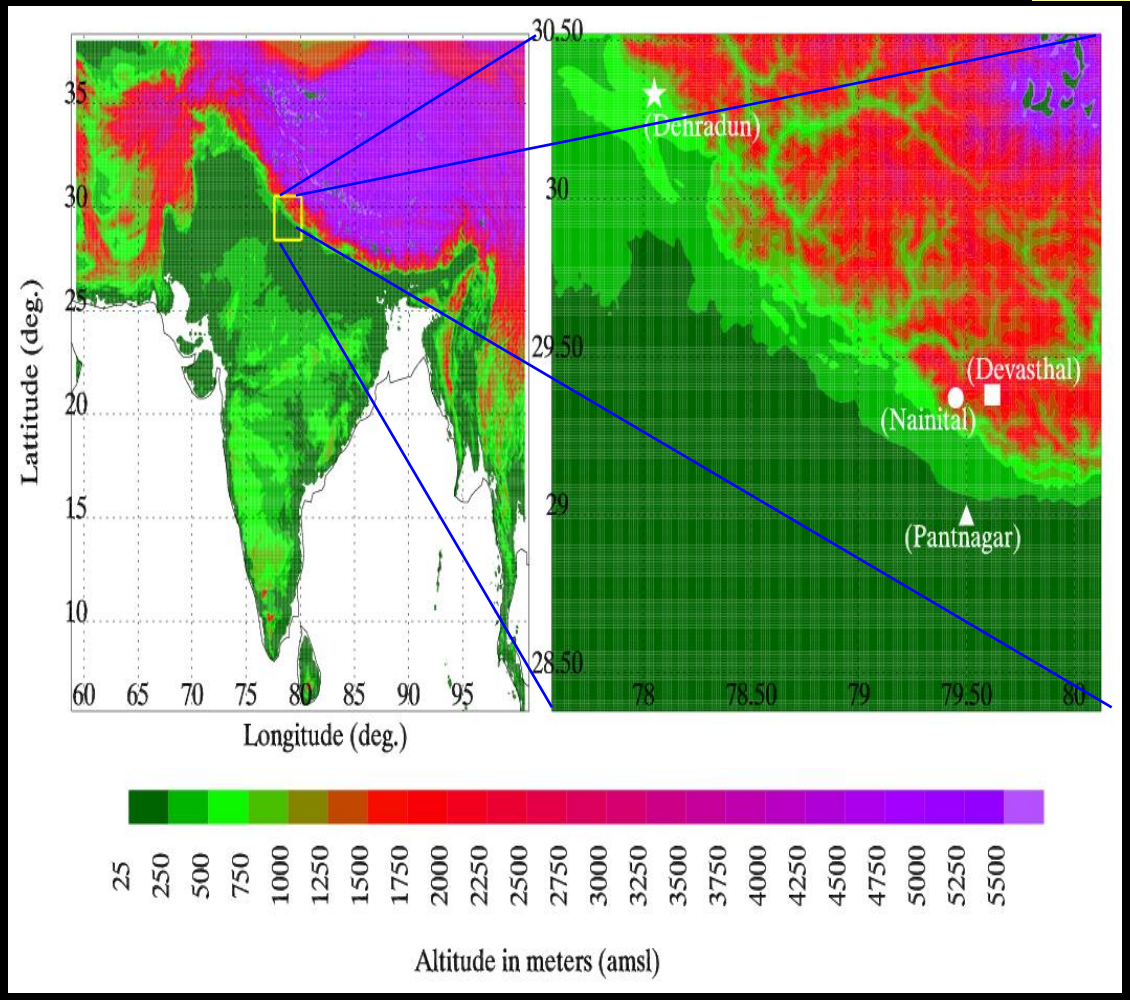


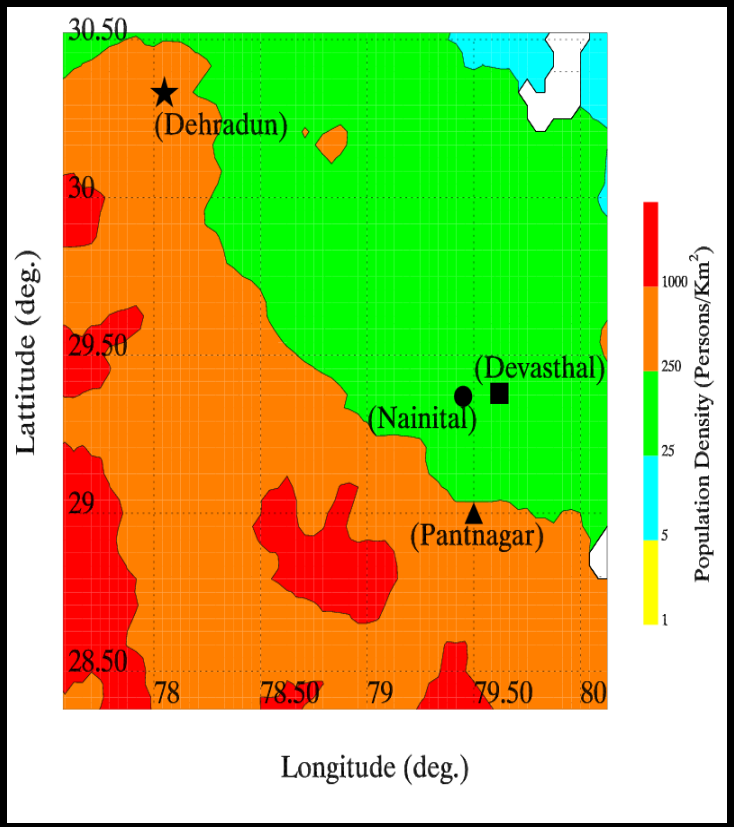
[Kumar, Naja et al., JGR 2011]

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, ~640 m





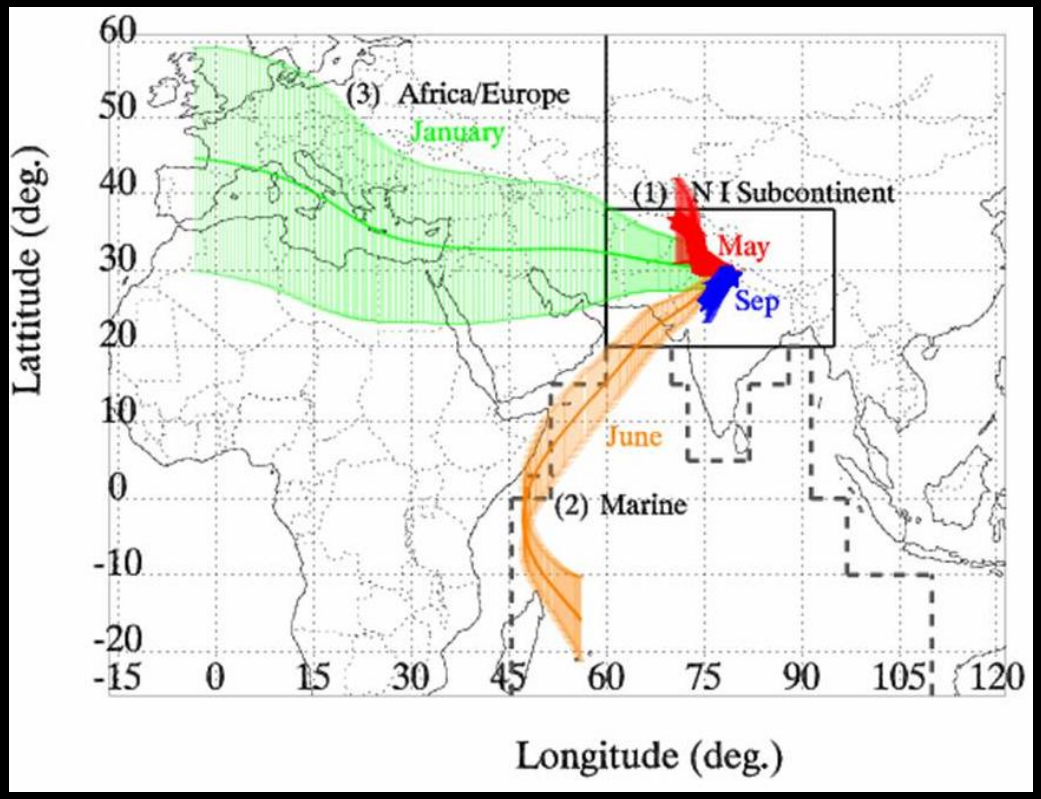
Population Density

IGP – 1000-more persons/km^2
Nainital – 25-100 persons/km^2

Observational facilities at ARIES

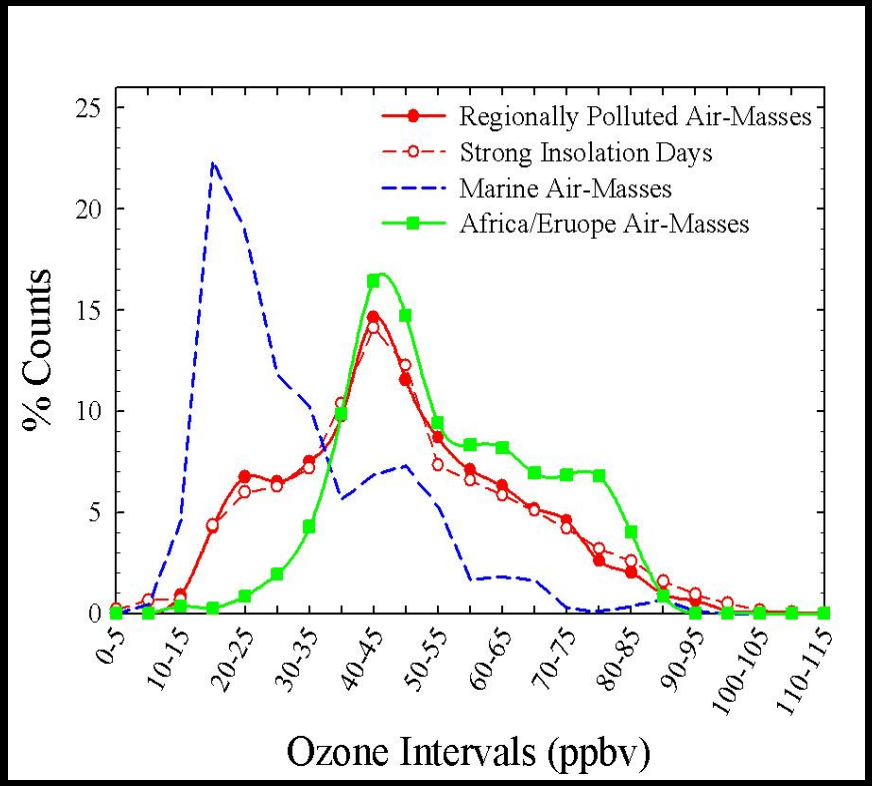
- Aerosols
  - AOD (MWR and Microtops)
  - Black Carbon
  - Aerosols number concentrations
  - Particulate Matter
- Trace Gases
  - Pollutants (Ozone, CO, NO, NOy, CH_4 , NMHCs, SO2)
  - Balloon-borne observations of ozone and met parameters
  - Greenhouse gases (CO_2, CH_4, N_2O and SF_6)
- Lidar
  - Aerosols
- Met Tower
- ST Radar (upcoming)

Influences over the Central Himalaya: A Natural Laboratory



Kumar, Naja et al., JGR 2010

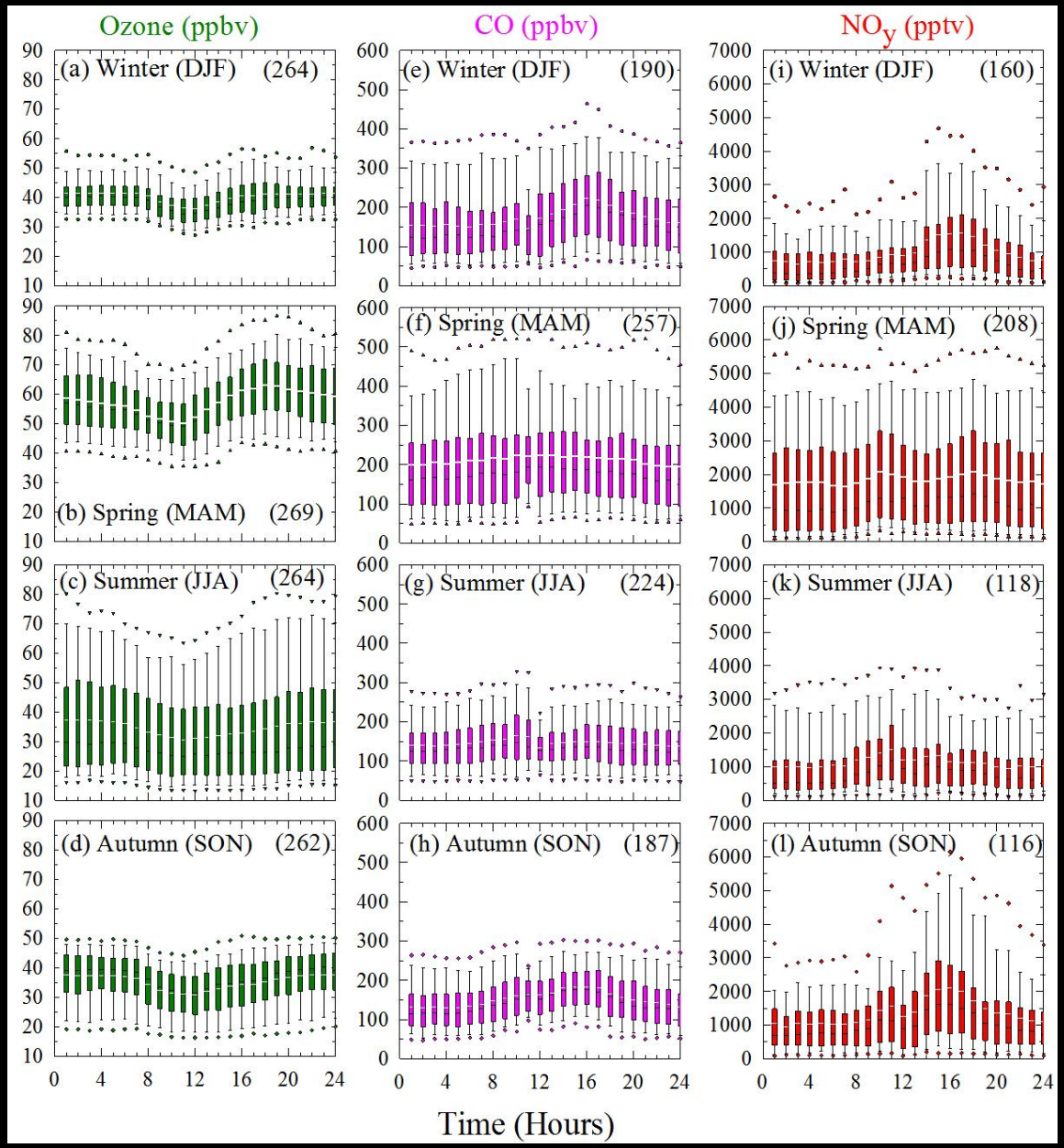
Northern India is under the influence of air-masses arriving from Africa/Europe and Marine regions and also affected by emissions from IGP.



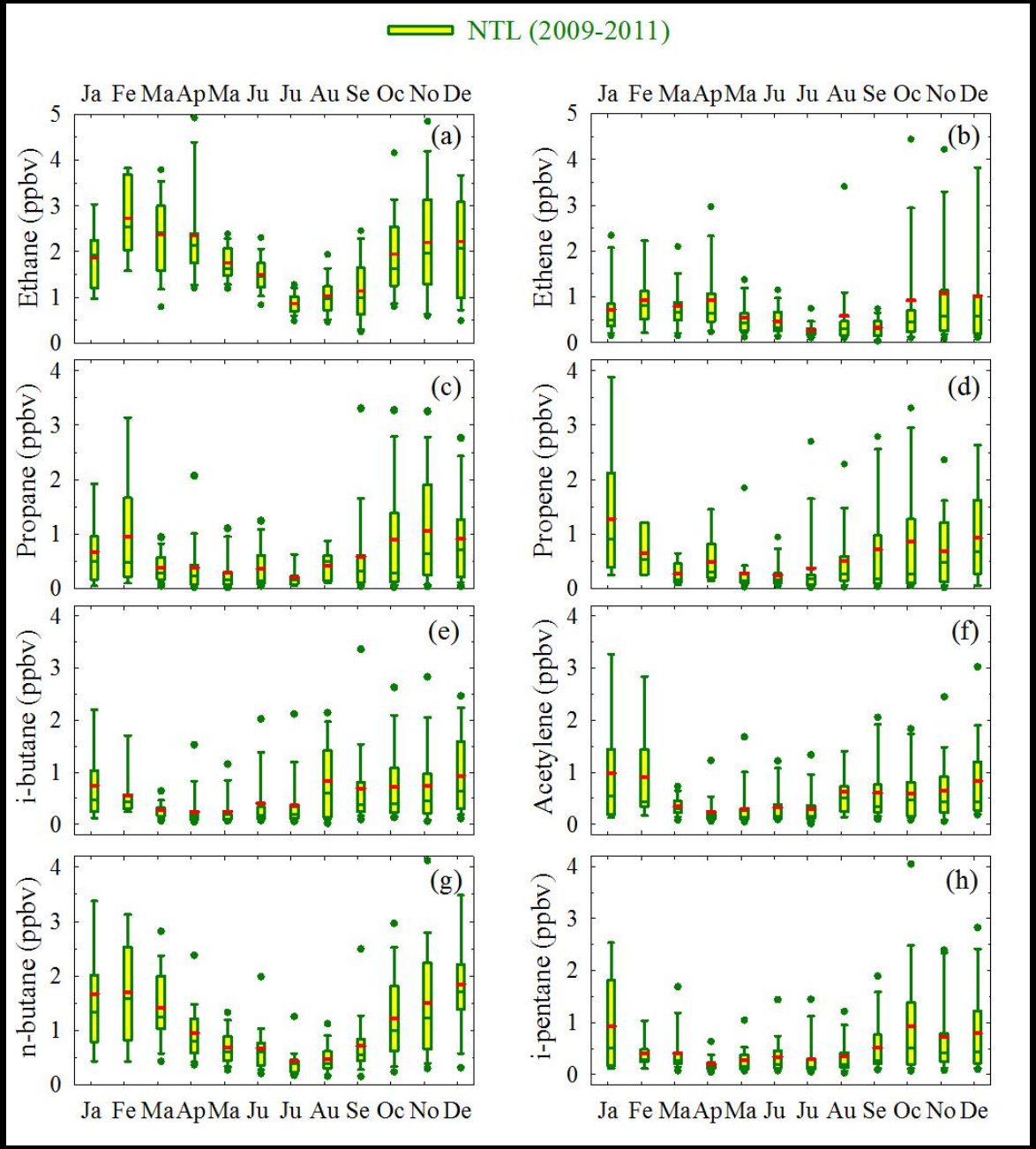
Nainital: A Regional Representative site for N. India / Central Himalaya

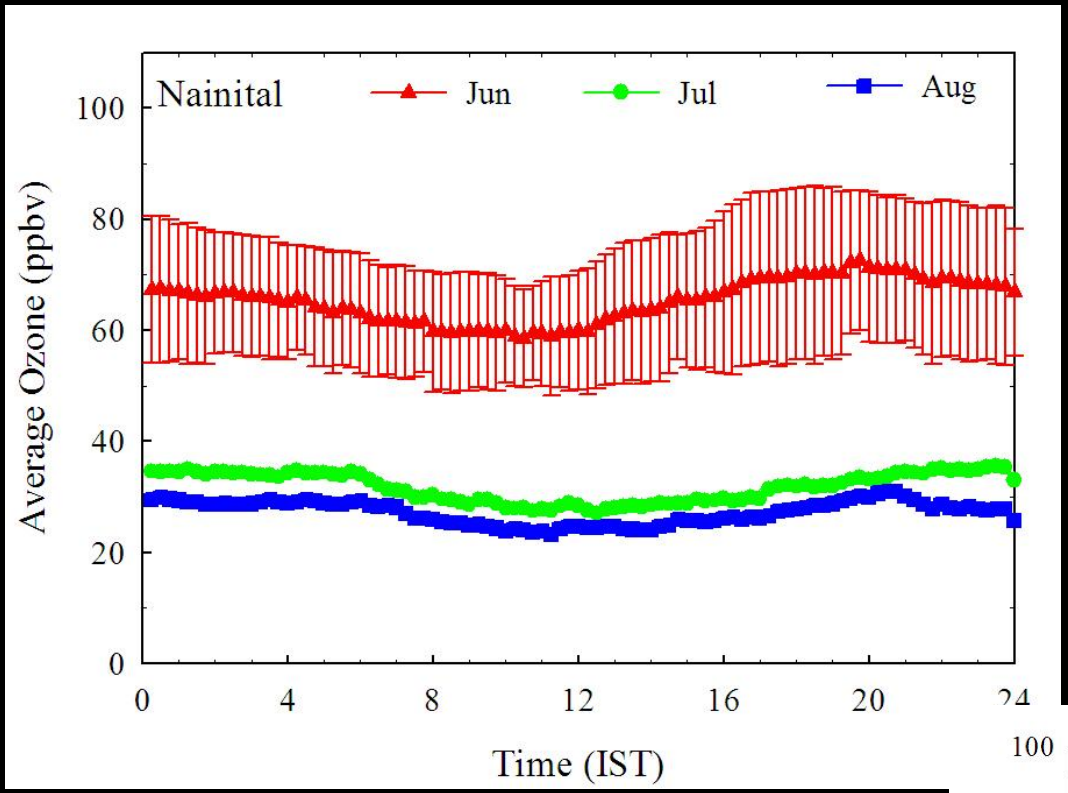
ARIES, Nainital [~ 1958 m]

Average diurnal variations in Ozone CO NOy during four seasons



NMHCs (C1-C5) at ARIES, Nainital

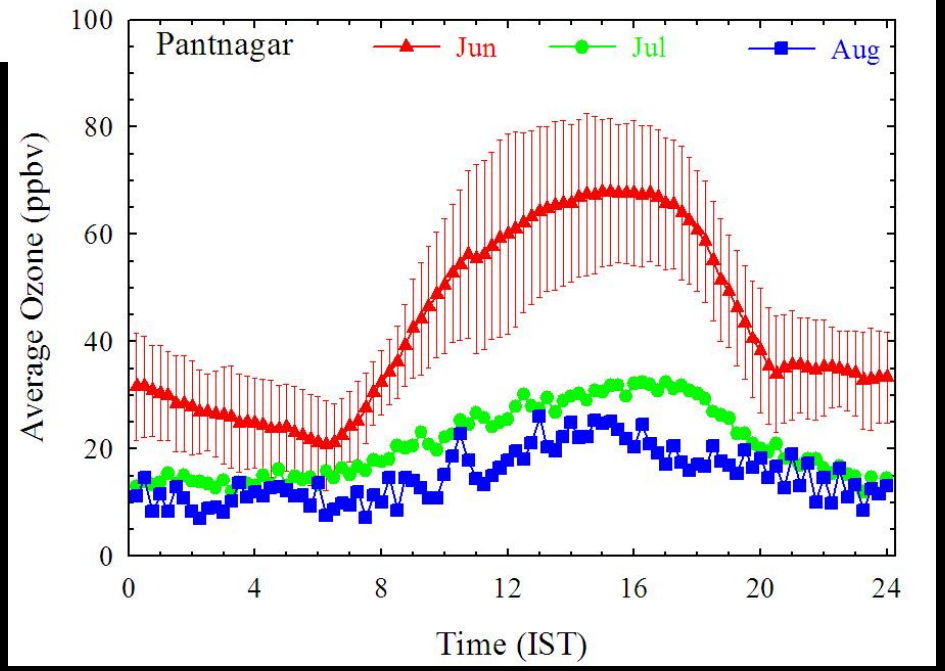




Nainital
(Central Himalayan site)

Pantnagar
(IGP site)

Both the sites are
about 30 km apart



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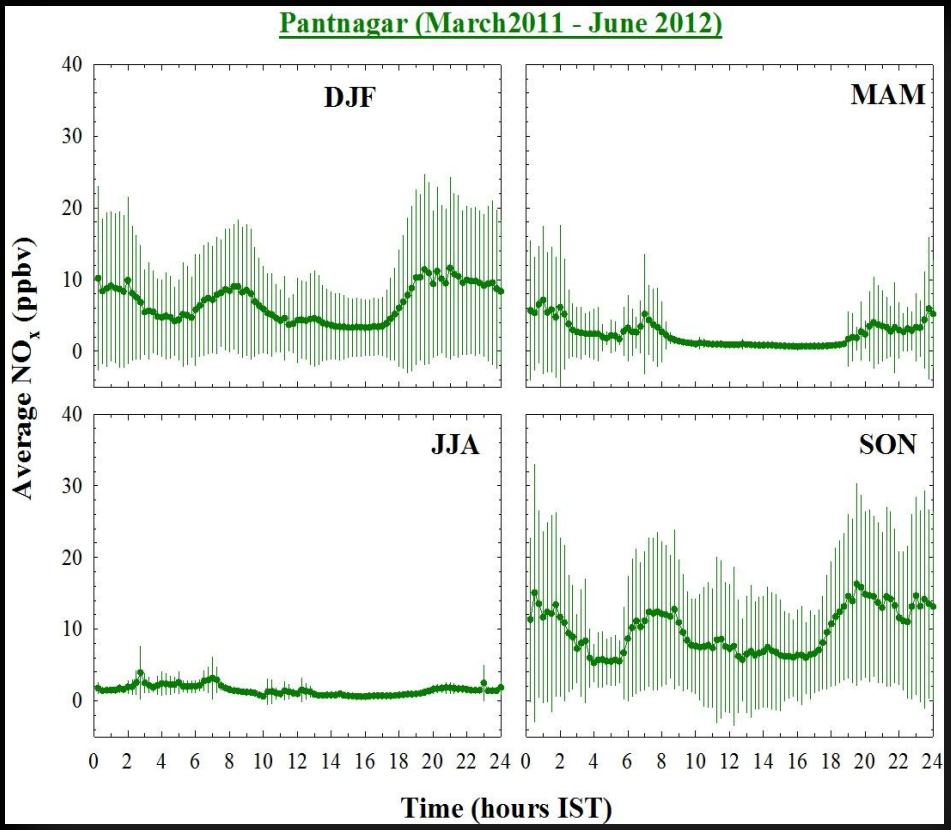
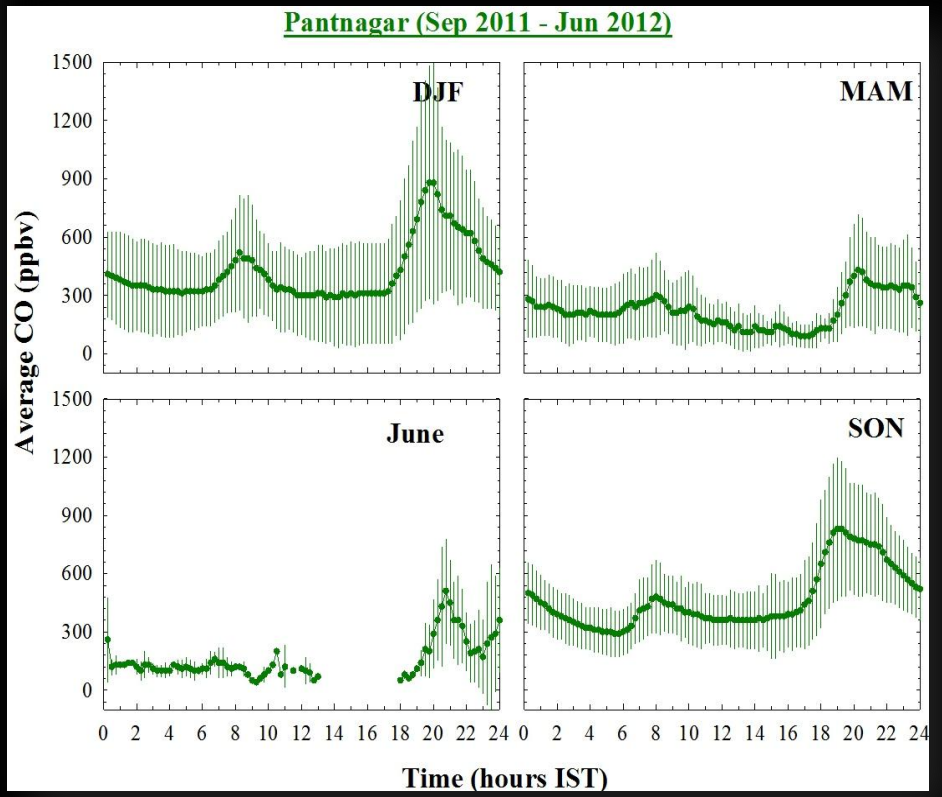
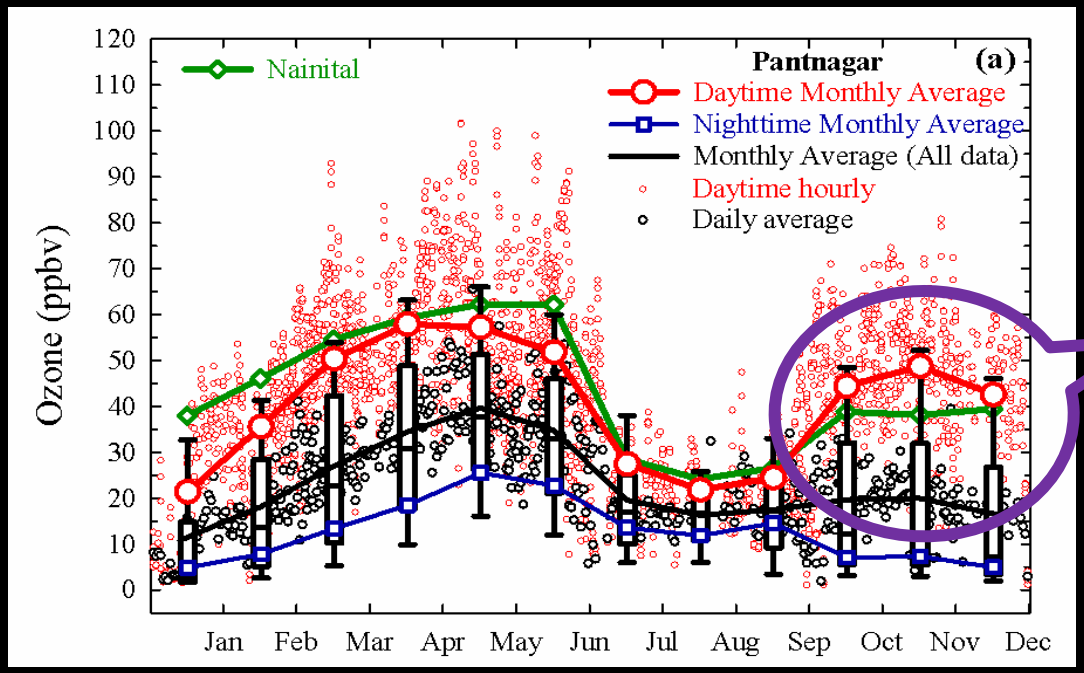
Nitrogen Oxide (NO_x)

IGP site (Pantnagar)

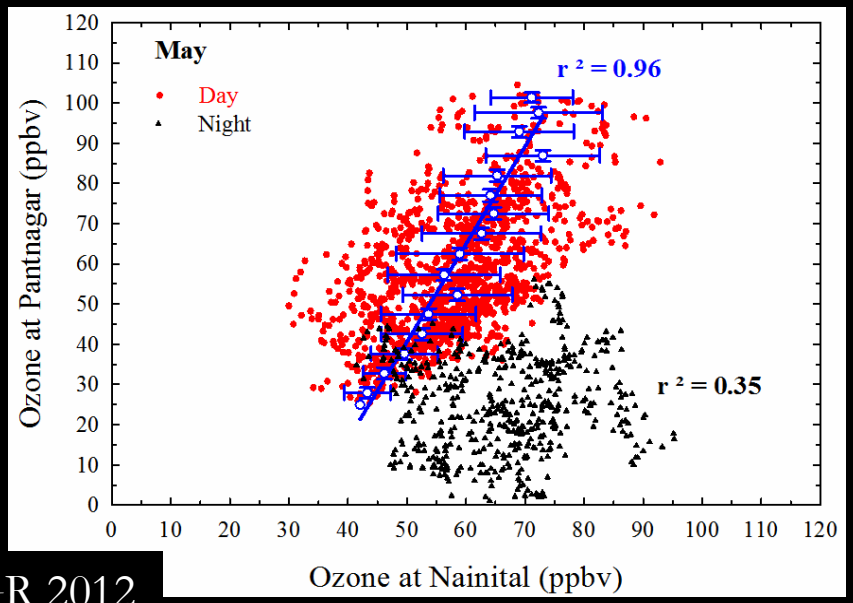


Carbon Monoxide (CO)





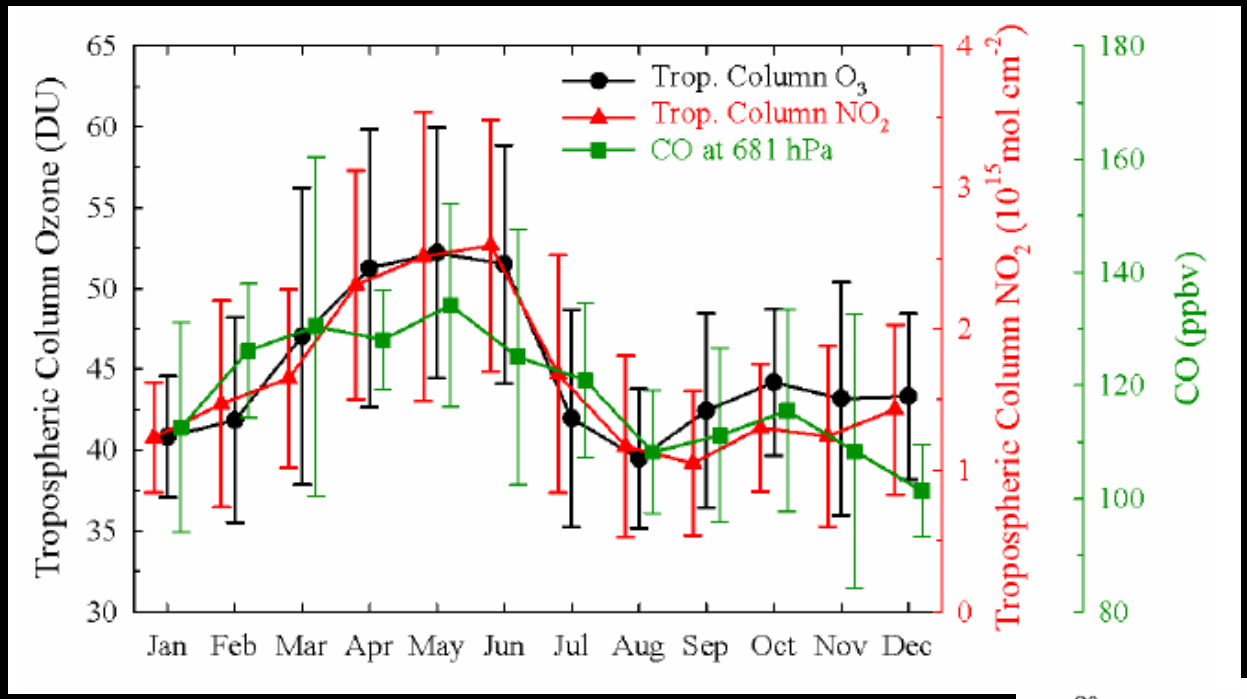
Note the differences between **Pantnagar** and **Nainital**



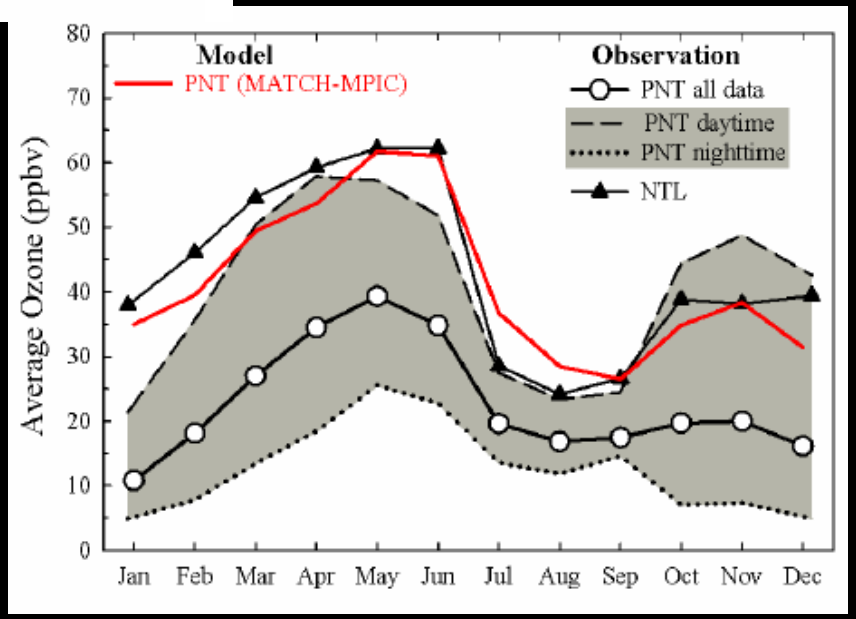
Daytime and Nighttime correlation between ozone at Pantnagar and Nainital

Ojha, Naja et al., JGR 2012

Comparison with OMI, TES and Model

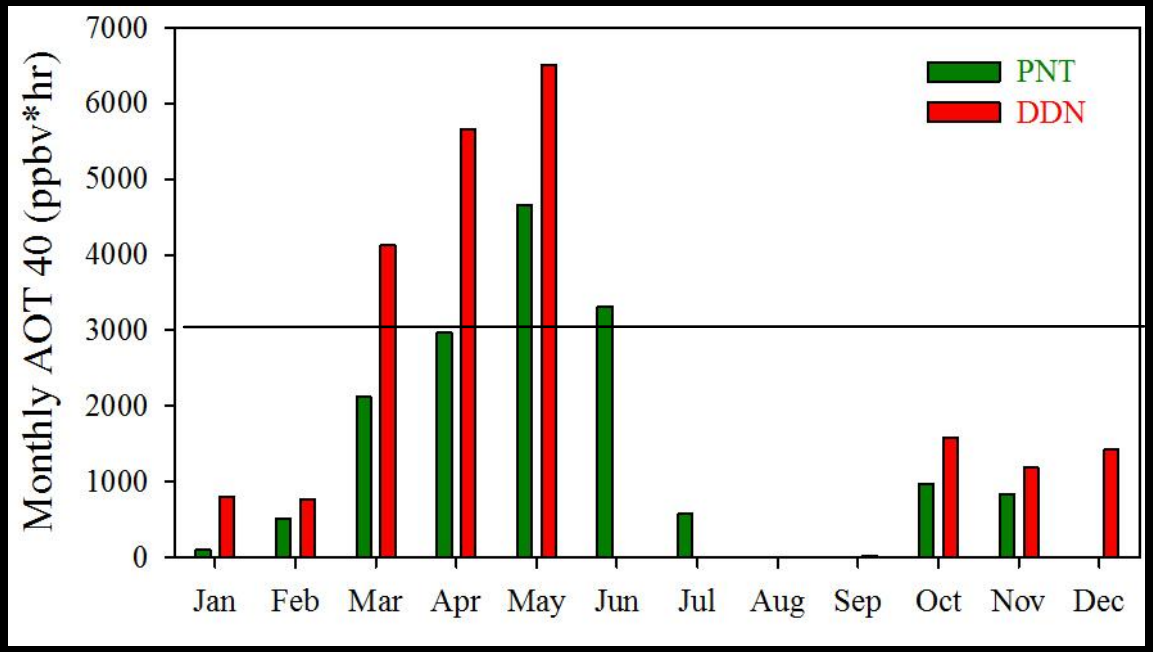


Model captures observed ozone seasonality but overestimates ozone levels



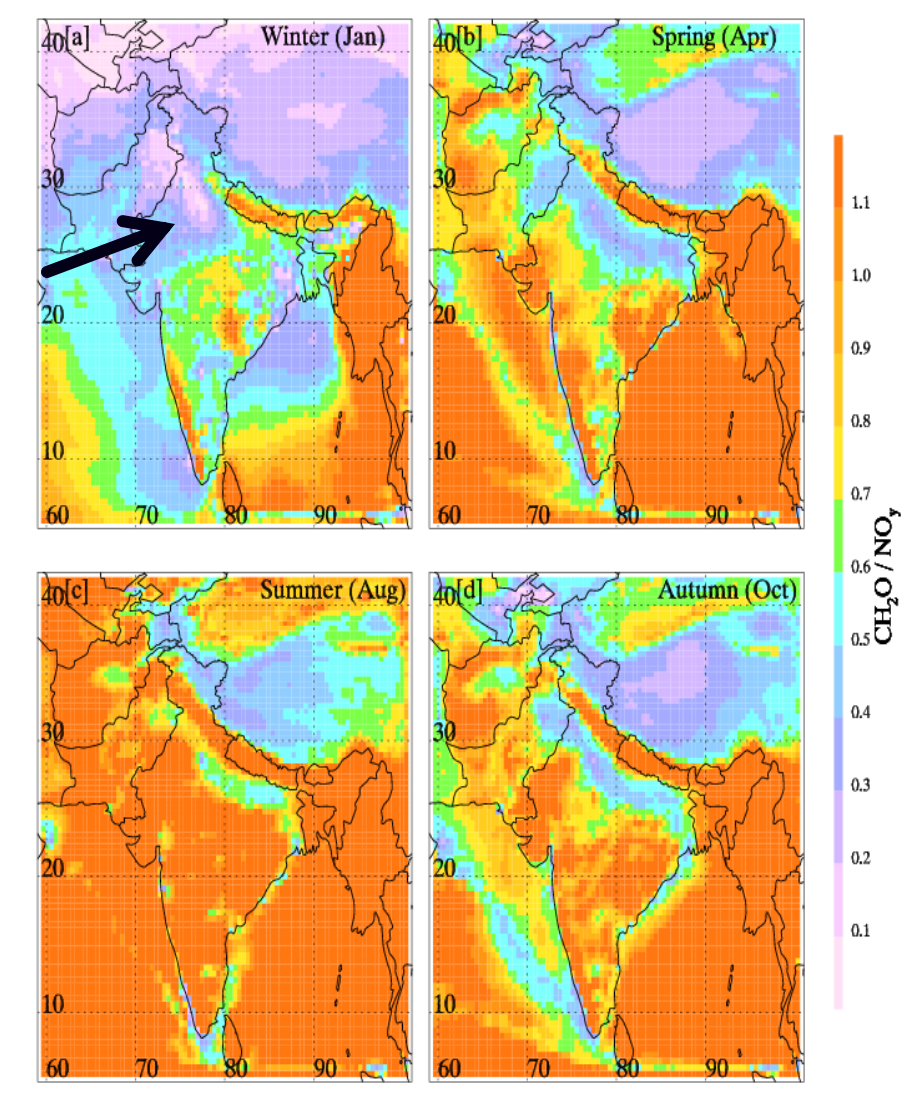
Ojha, Naja et al., JGR 2012

Accumulated Ozone Exposure Index (AOT40) at two IGP sites



AOT40 values are significantly higher than critical level (3000 ppbv*hr) ➔ **Threat for vegetations** over this region.

WRF-Chem Simulation



Kumar, Naja et al., GMD 2012

Ozone control

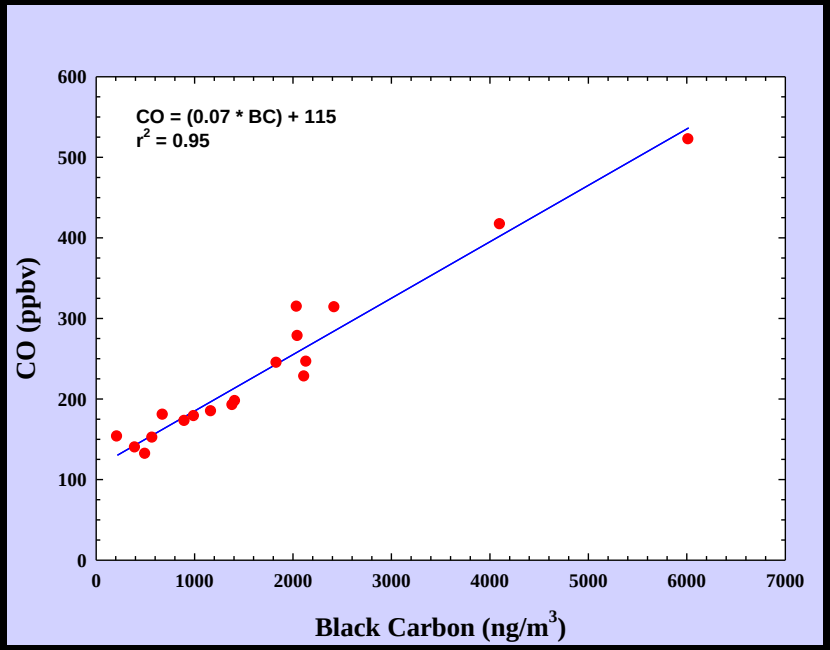
CH_2O/ NO_y

<0.28 VOC limited regime

>0.28 NOx limited regime

Mostly NOx limited region

But IGP show tendency of VOC limited region, mainly in Winter/Spring !!



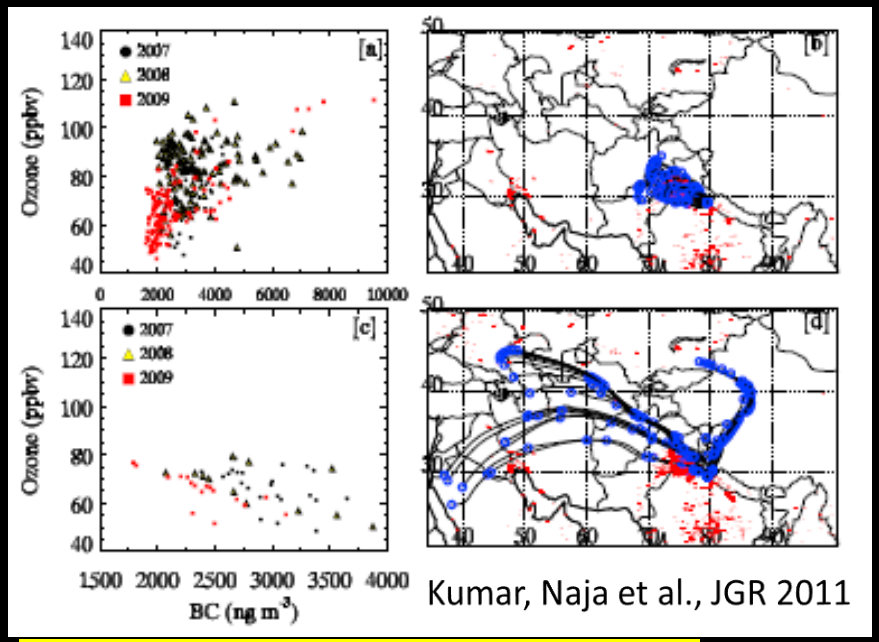
CO & BC

Automobile combustion

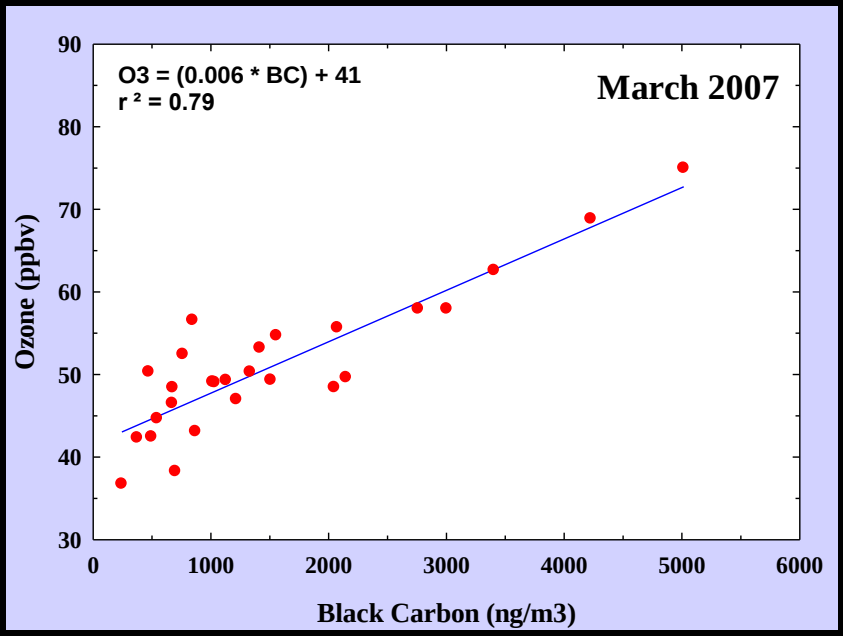
Such influences/correlations are seen away from the source regions

O_3 & BC

Influence of fresh combustion

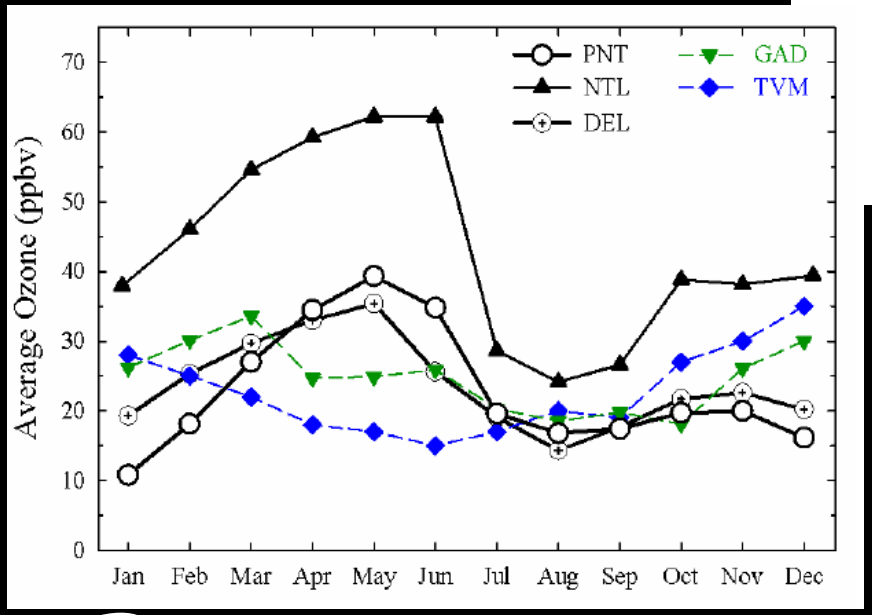


Biomass burning event

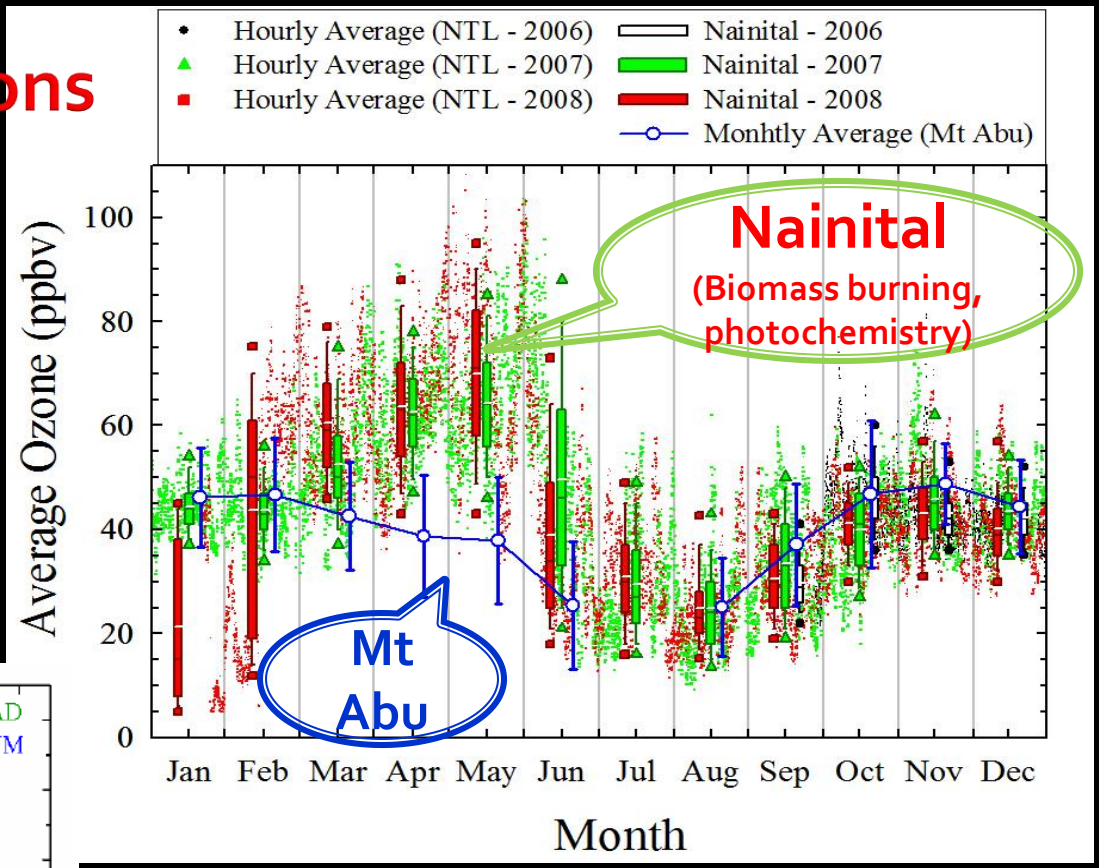


Ozone seasonal variations

Differences among N India, W India and S India



Ojha, Naja et al., JGR 2012



Kumar, Naja et al., JGR 2010

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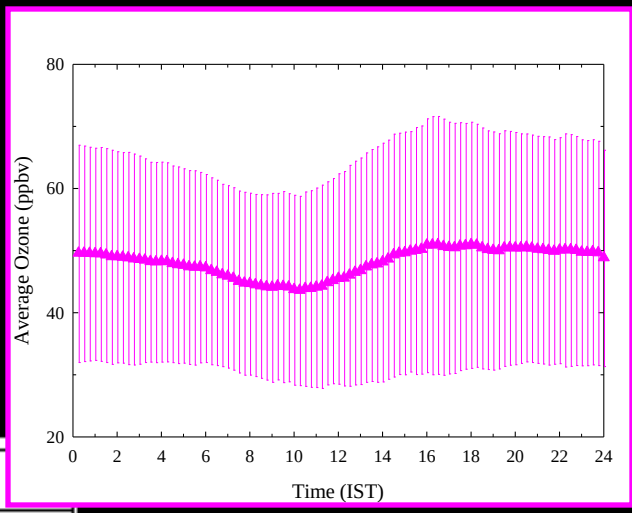
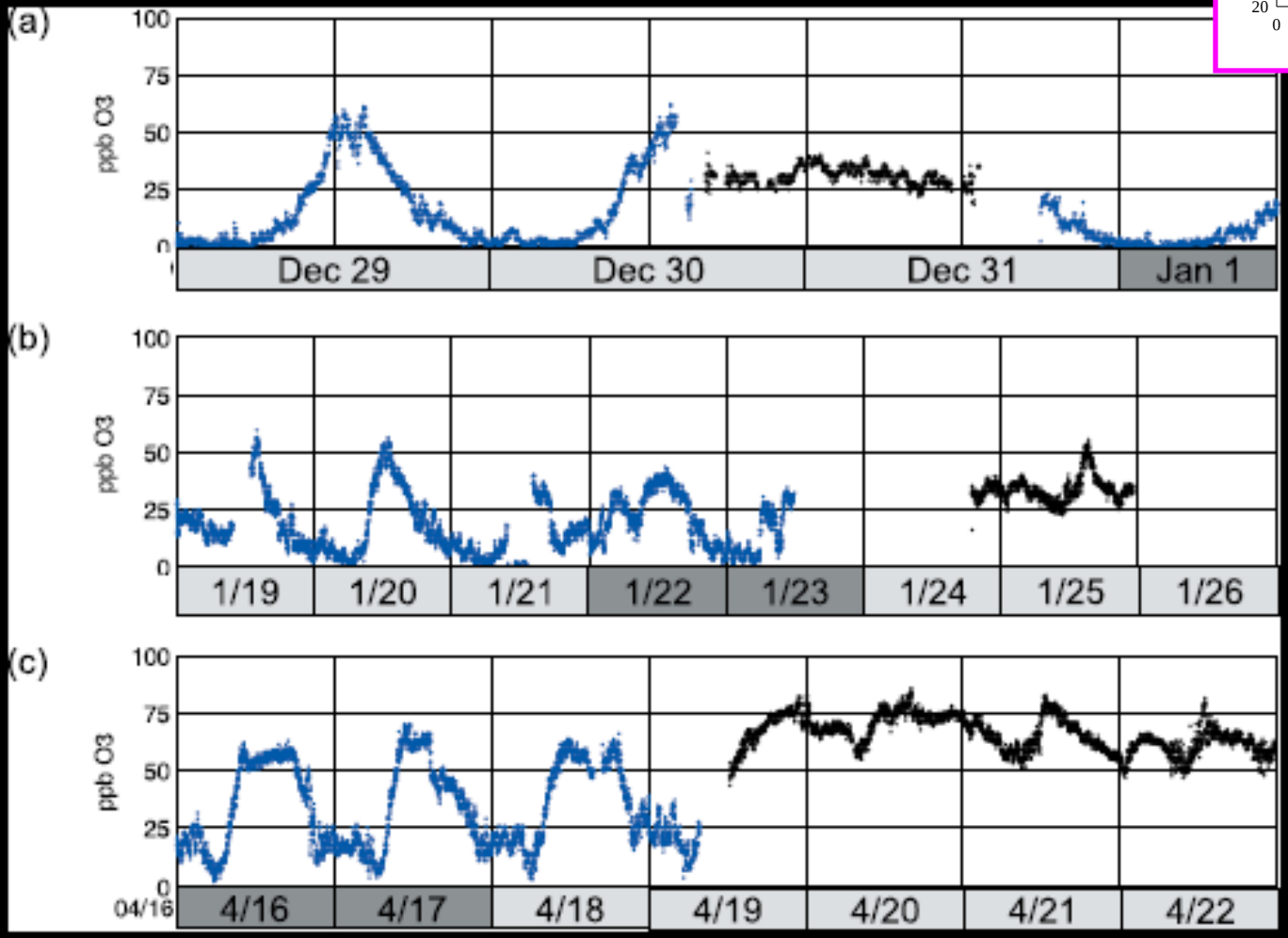
Ozone at Nainital

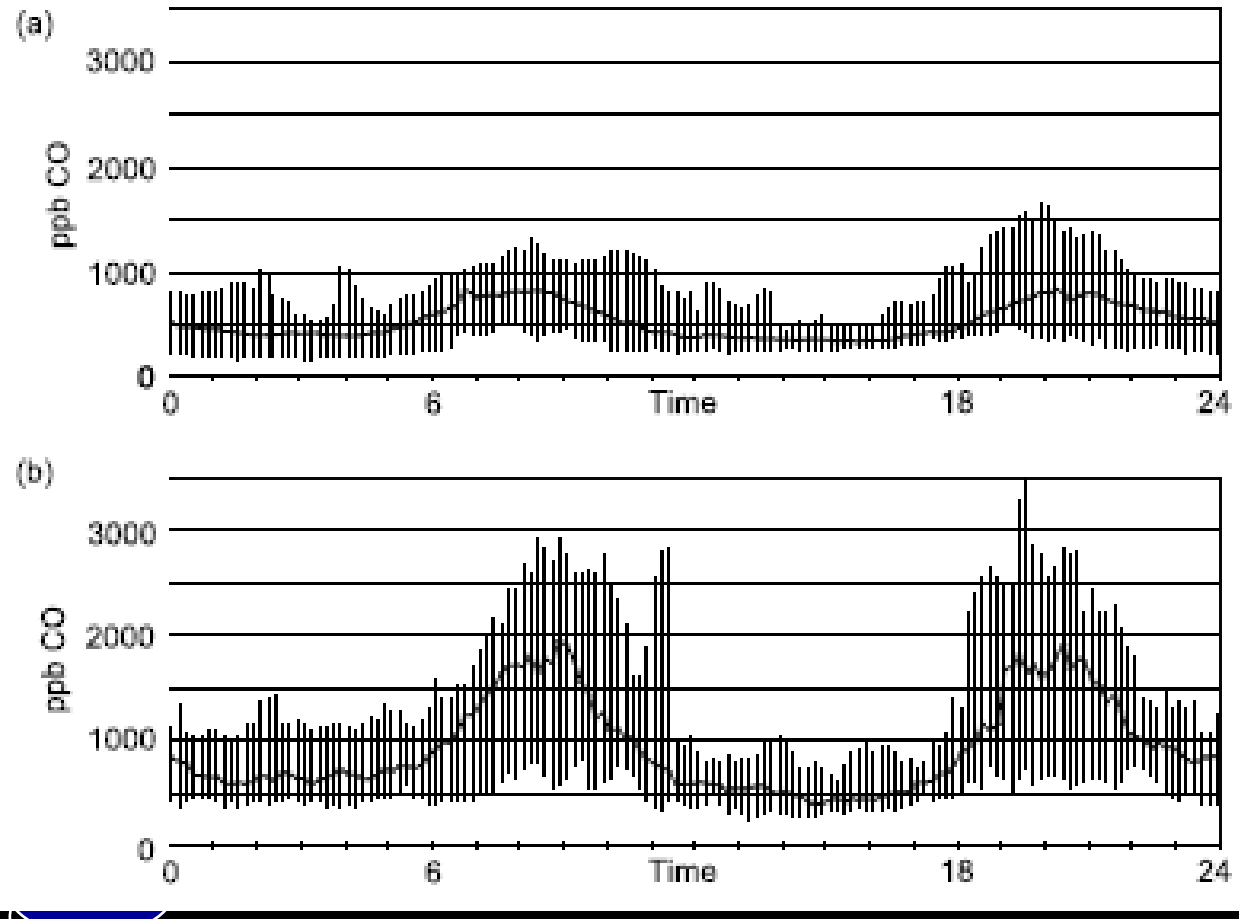


Ozone at Boudha, Nepal [2004-05]

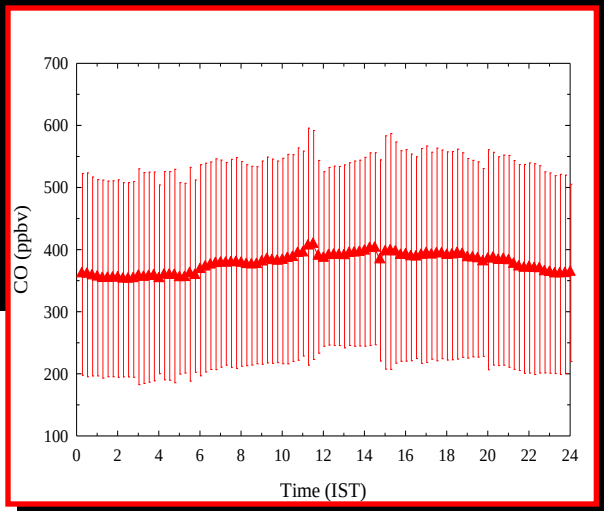


Pandey et al., 2009

CO at Boudha, Nepal



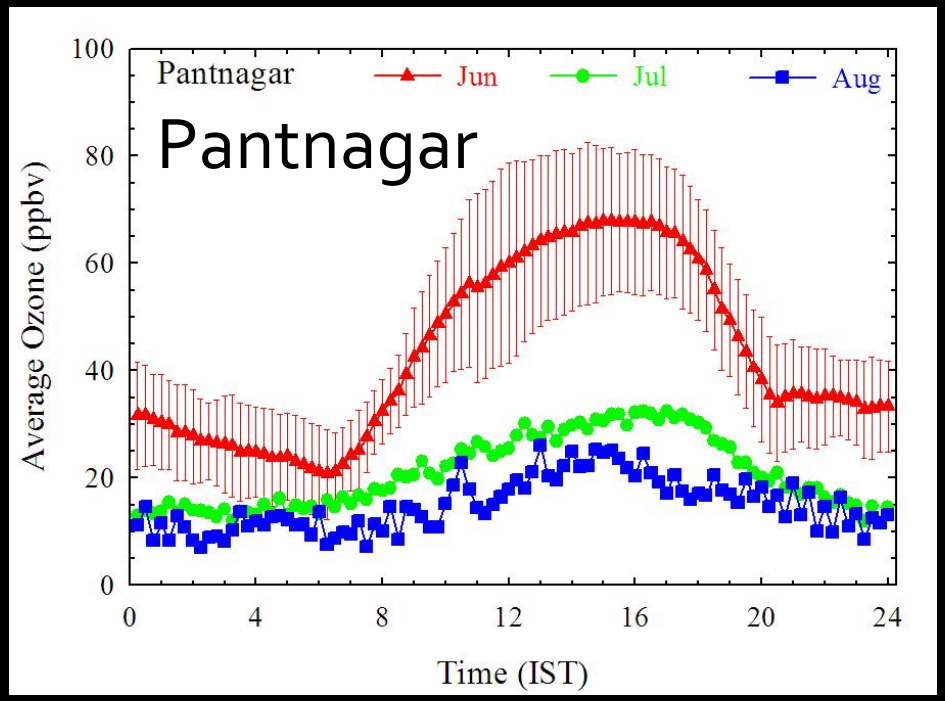
Nainital

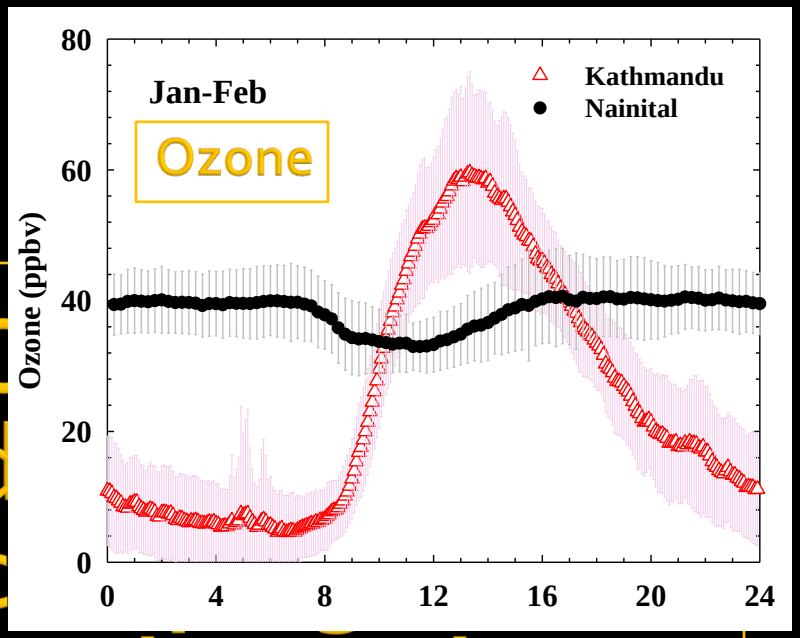


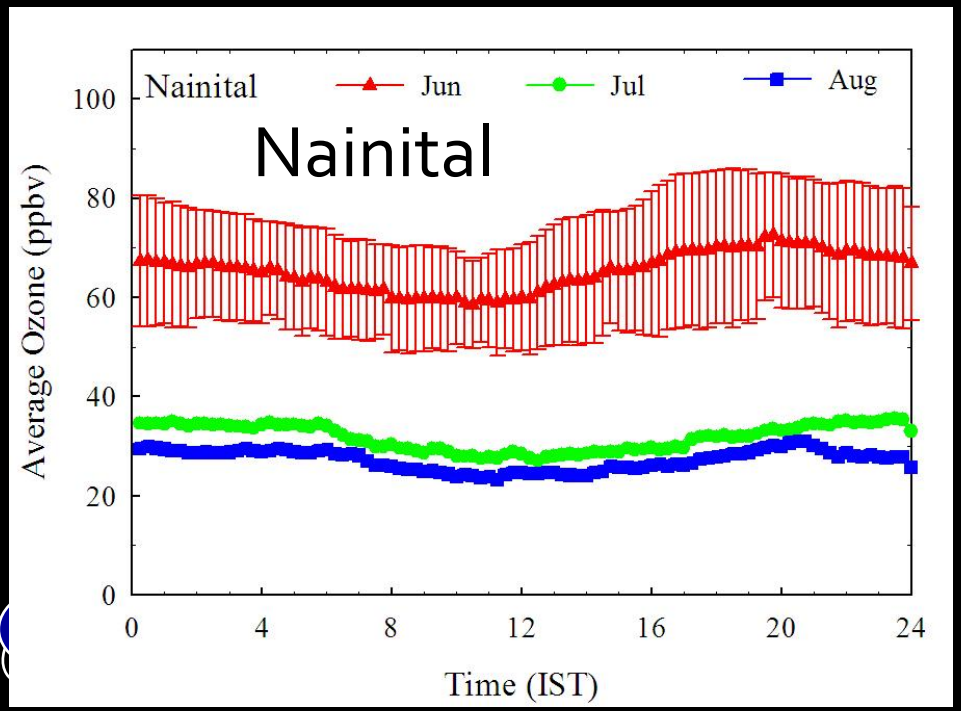
Oct 04

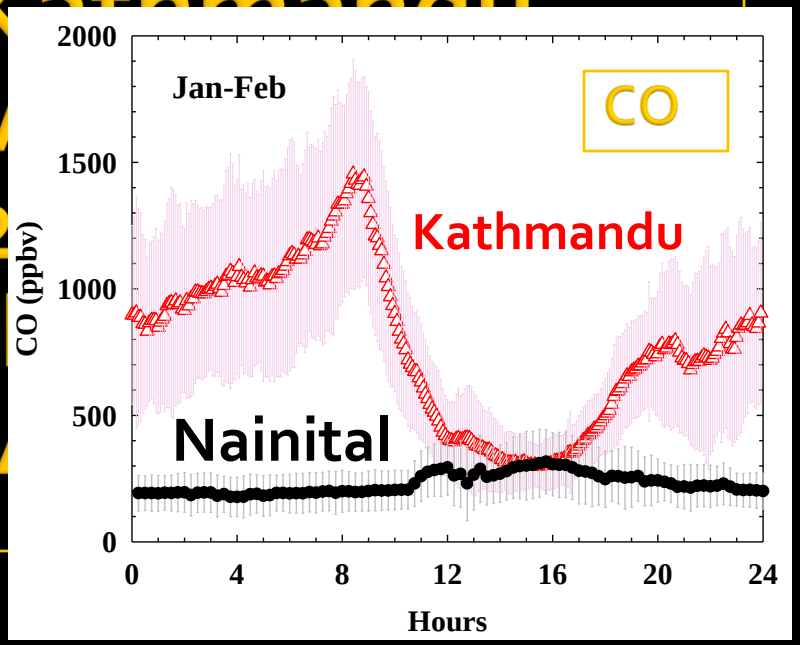
Jan 05

Pandey et al., 2009



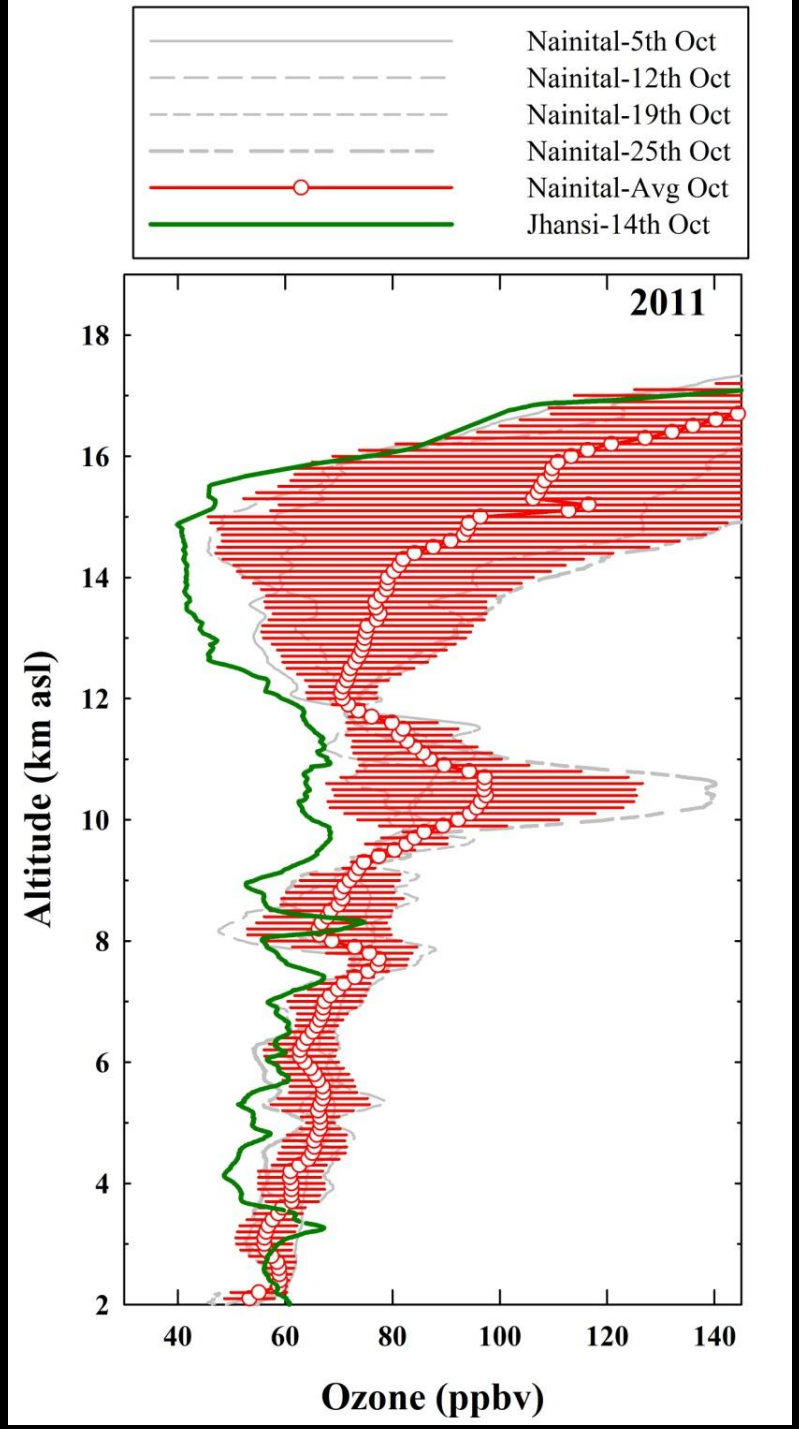




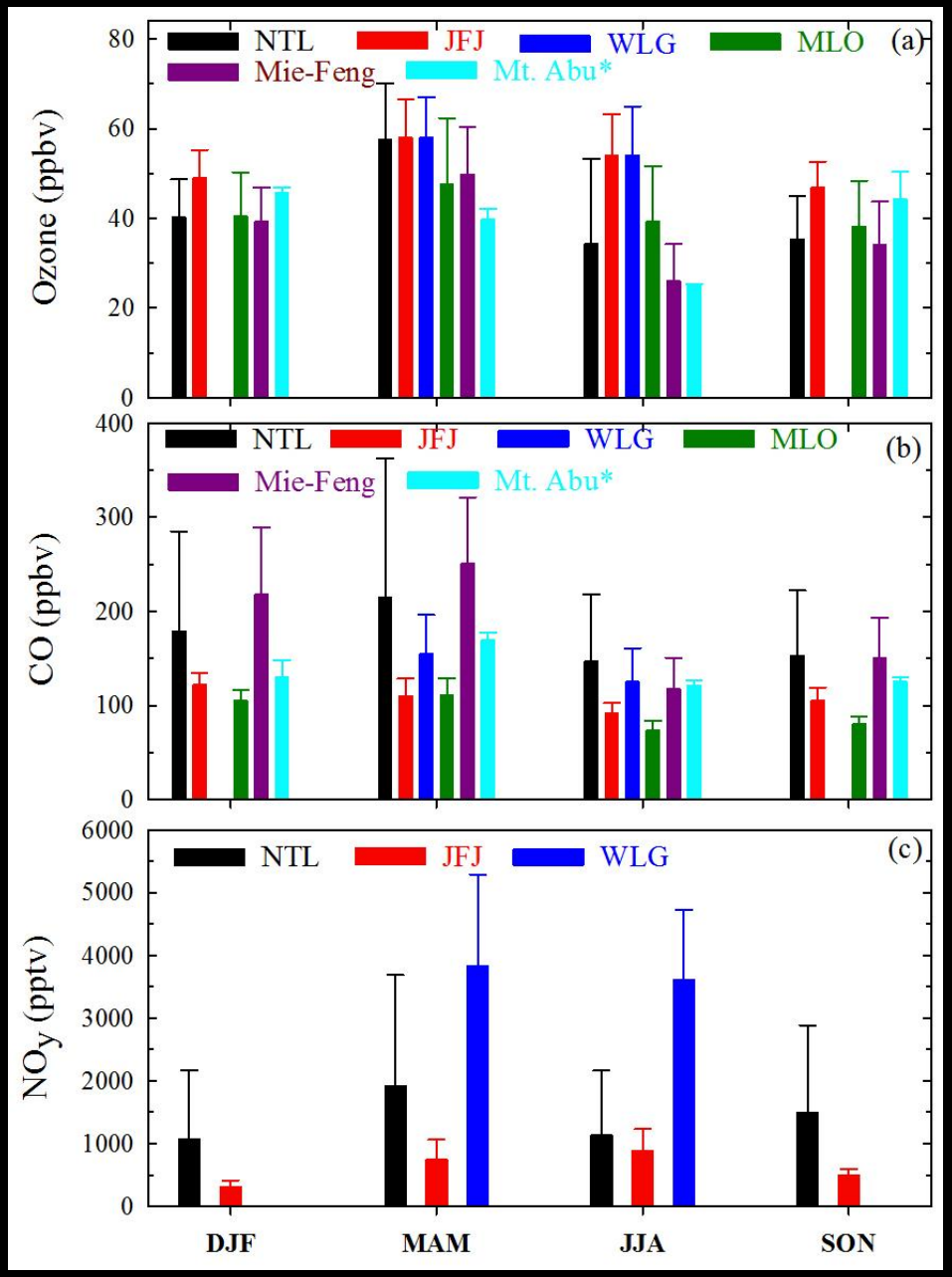


SUSKAT Campaign, 2013

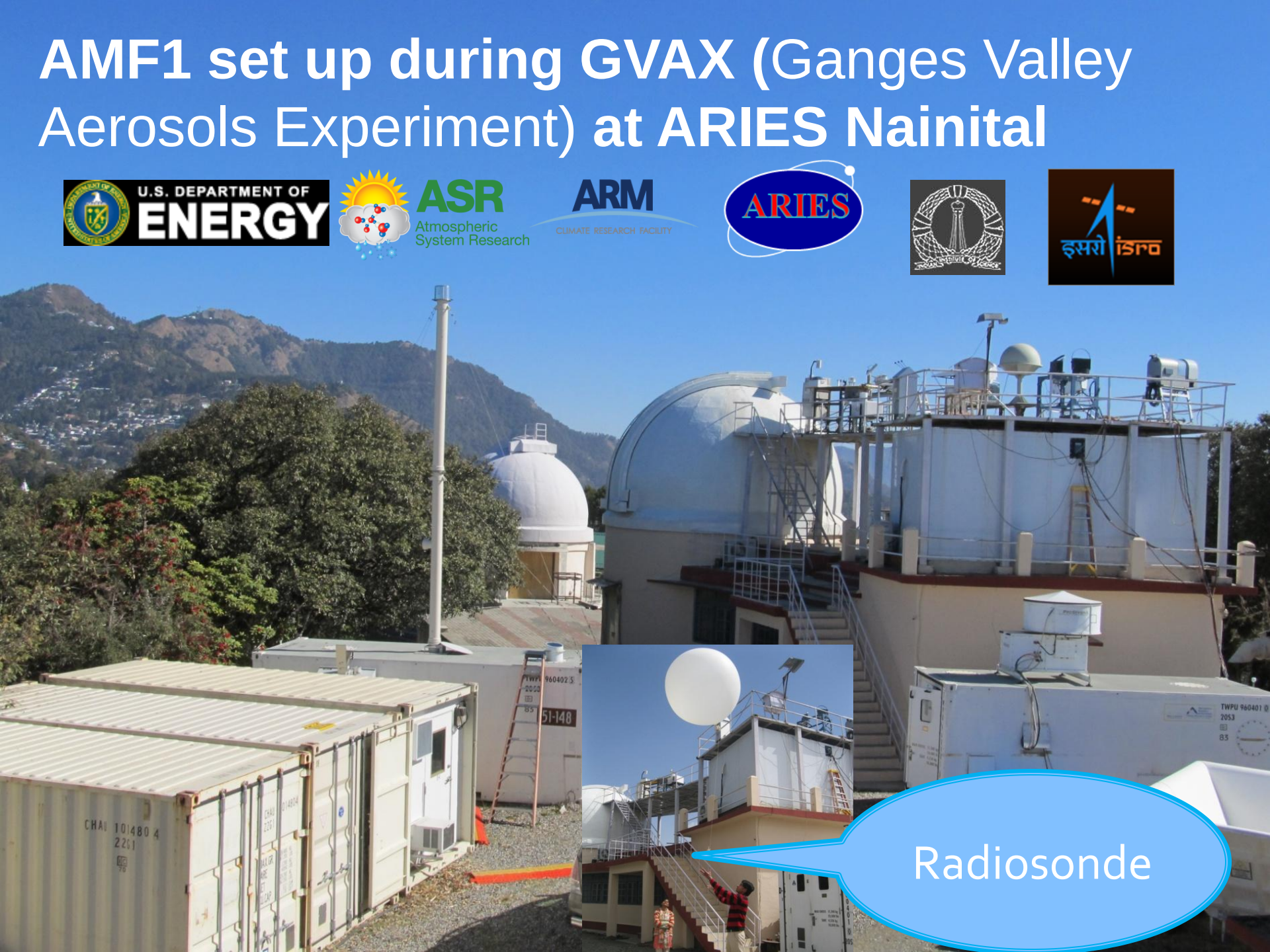
Ozone sounding at the central Himalayas Vs the Central India



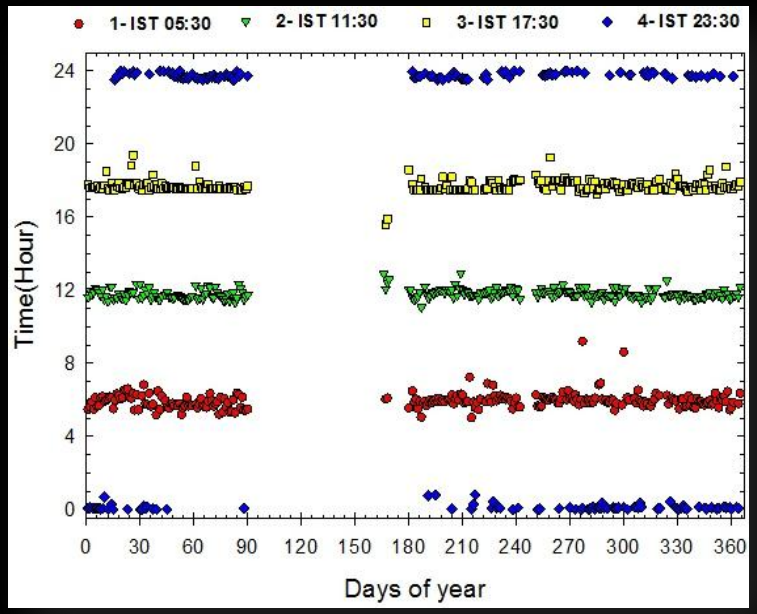
A comparison with few other higher altitude sites



AMF1 set up during GVAX (Ganges Valley Aerosols Experiment) **at ARIES Nainital**



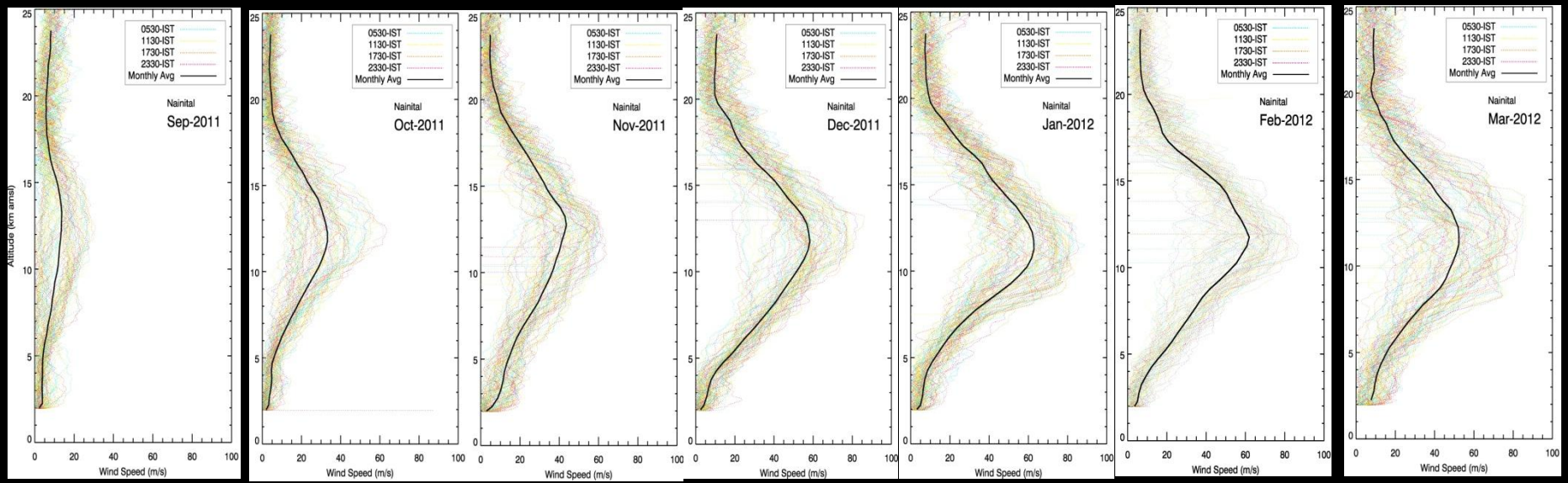
GVAX Balloon flights (ARM Mobile Facility-1, DOE, USA)



The high frequency radiosonde (1061) measurements were carried out during Ganges Valley Aerosol eXperiment 2011-2012.

Flight Time	Jan	Feb	Mar	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
IST 0530 hrs	30	26	30	3	31	29	28	25	26	29	**257**
IST 1130 hrs	30	27	30	6	29	30	30	30	30	30	**272**
IST 1730 hrs	31	29	28	3	30	27	30	31	29	31	**269**
IST 2330 hrs	31	30	28	0	28	26	30	31	29	30	**263**
	122	**112**	**116**	**12**	**118**	**112**	**118**	**117**	**114**	**120**	**1061**

Wind Speeds



Wind speeds are highest in winter (~ 80m/s) months, indicating a presence of subtropical jet.

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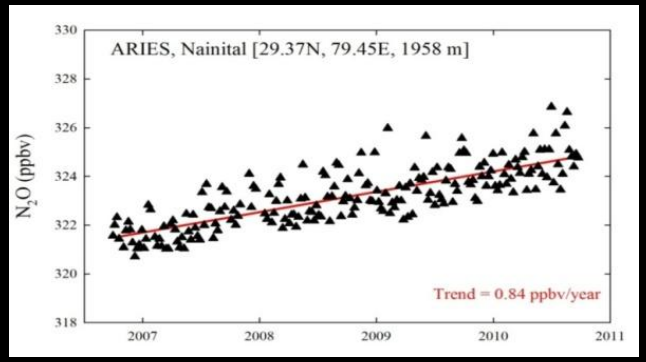
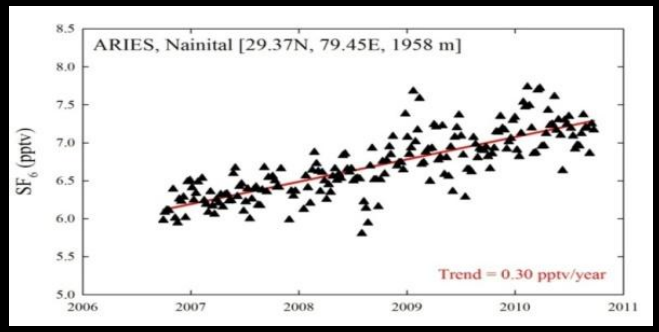
Greenhouse Gases [Since 2006]

CO_2

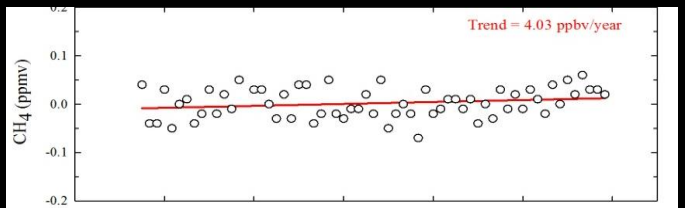
N_2O



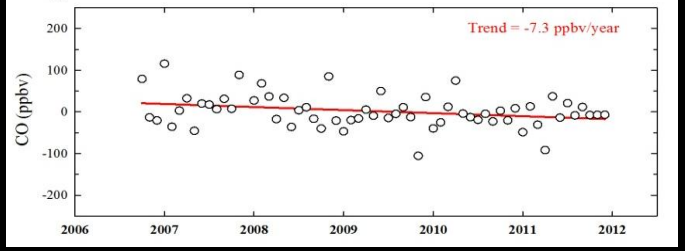
SF_6

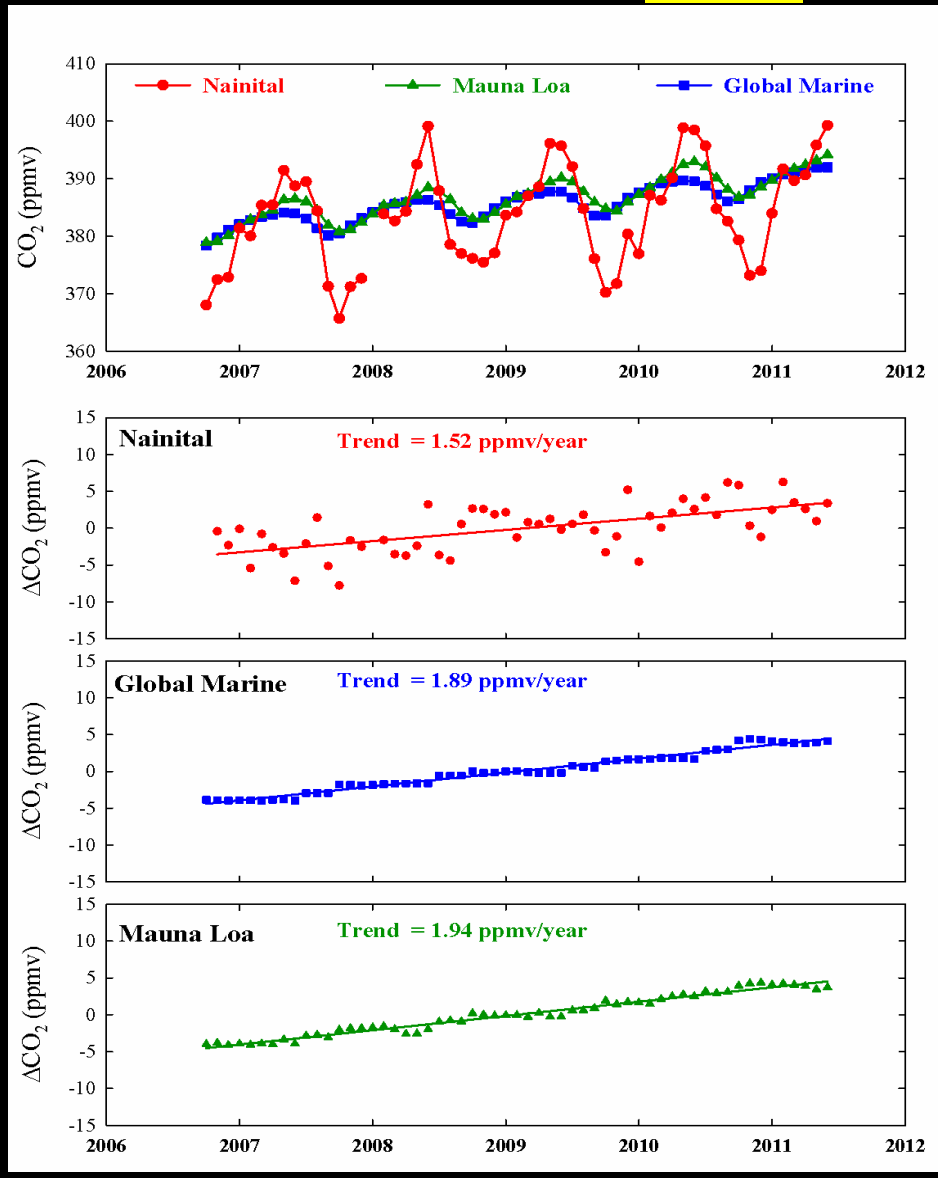


CH_4



CO





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NIES, Tsukuba, Japan

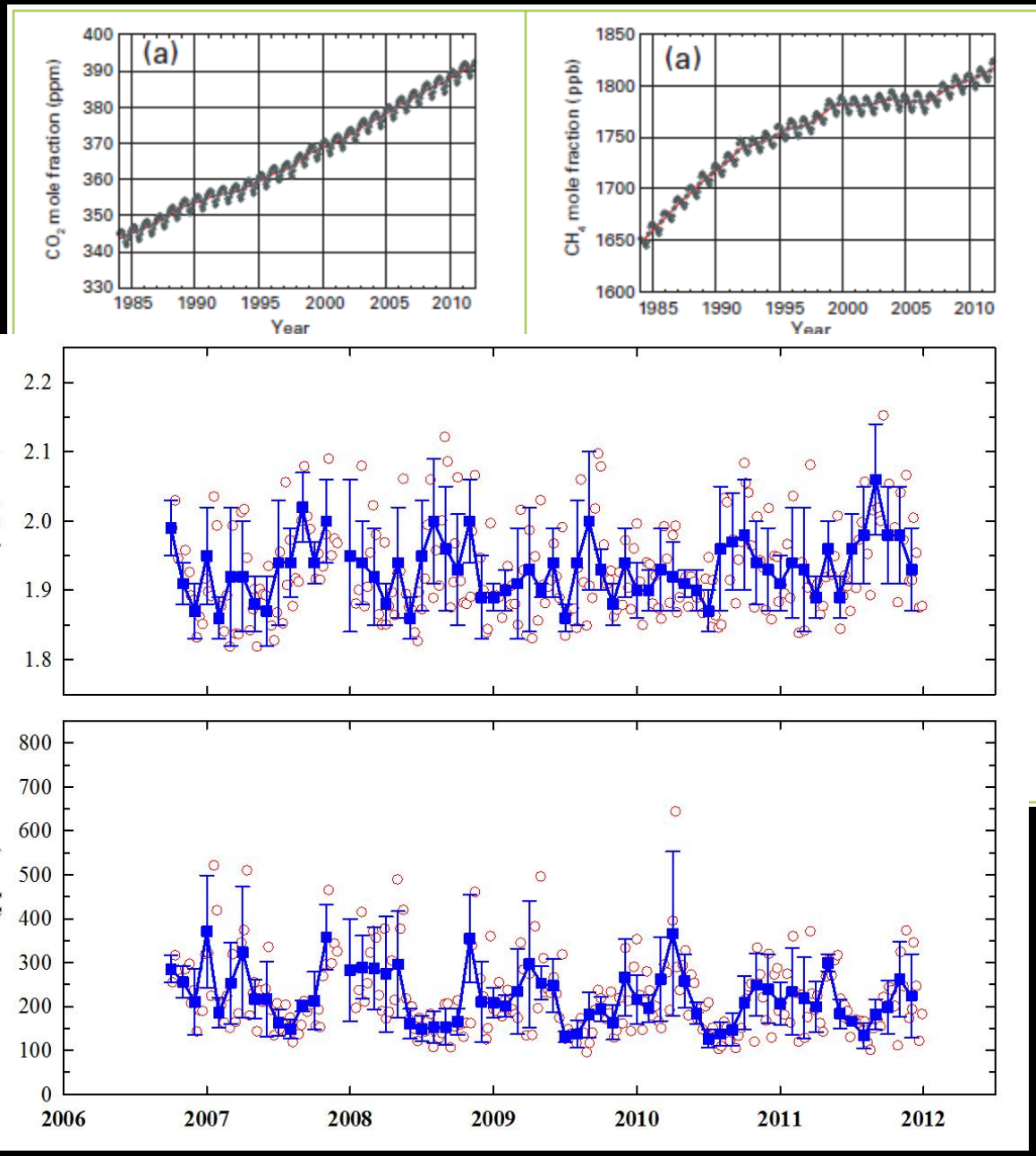
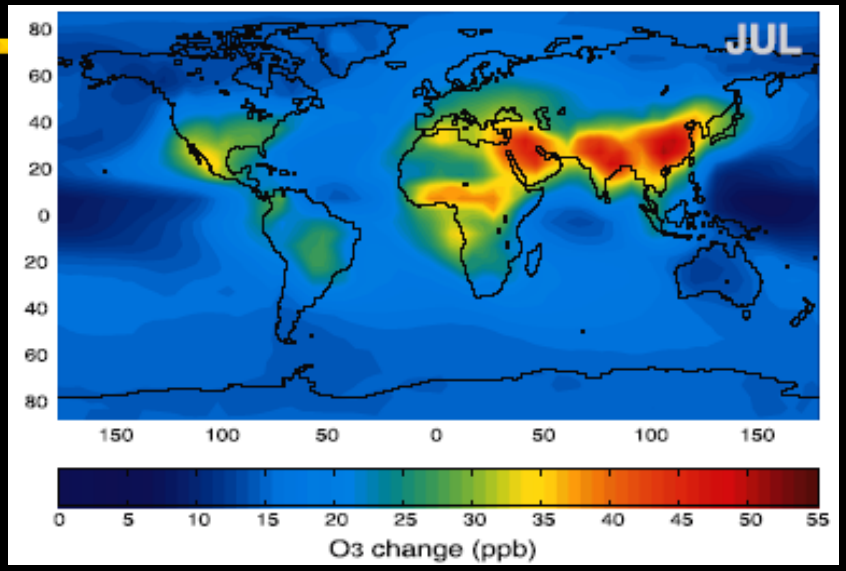


Figure 5. Globally averaged N_2O mole fraction (a) and its growth rate (b) from 1980 to 2011. Annually averaged growth rate is shown by columns at (b).

GAW Bulletin no 8, Nov 2012

Future Change .....



Acknowledgment:

..... it is in the tropics

- ISRO and DST
- Rajesh, Narendra, Tapaswini, Piyush, Hema
- Shyam Lal, M C Barth, G. Pisfter, G P Brassuer, Mark Lawrence

Thank you very much

ARIES

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

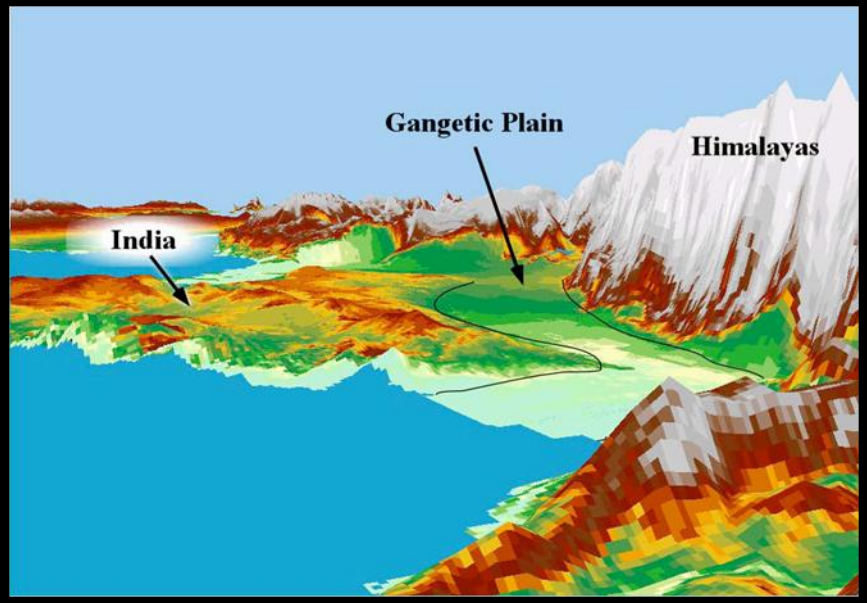
RAWEX-GVAX

Regional Aerosols Warming Experiment

Ganges Valley Aerosols Experiment

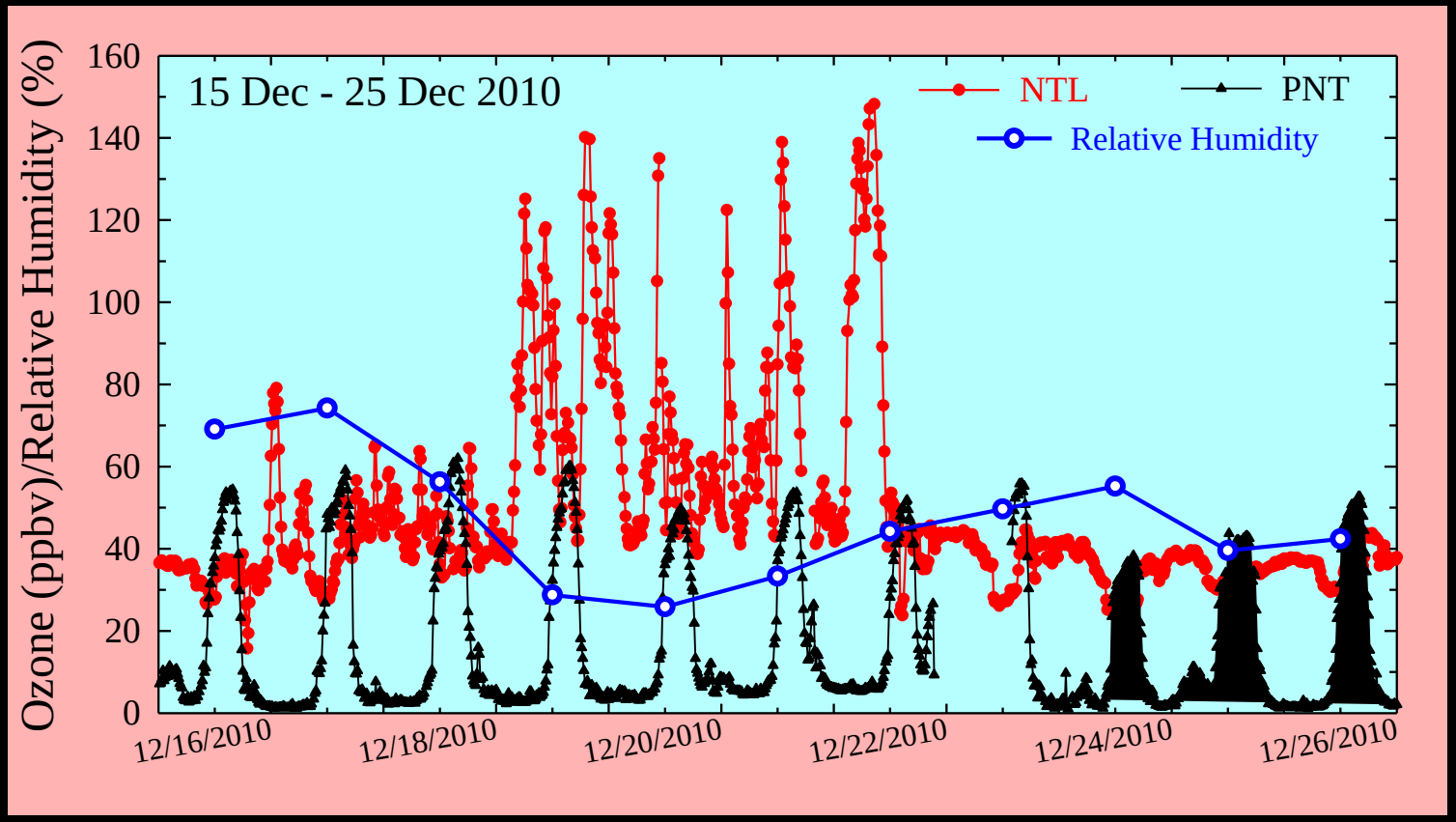
A multi institutional project

DOE (USA), ISRO, IISc and ARIES



A major international initiative after about 13 years

High ozone event at Nainital



Contribution from dynamics, apart from Photochemistry

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