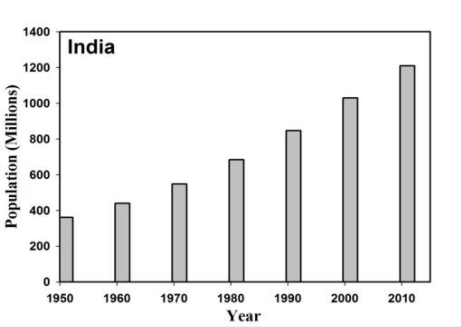
Ozone and trace gases in India: Effects of transport and emissions

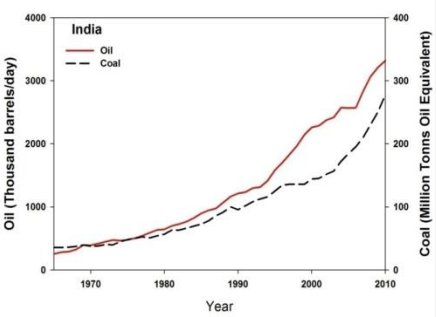
Shyam Lal
Physical Research Laboratory, Ahmedabad

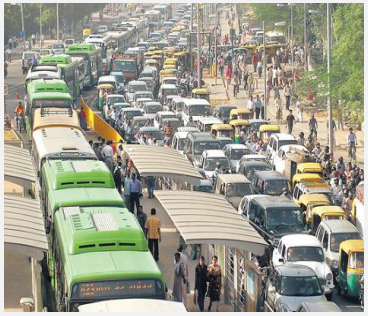
Second Workshop on Atmospheric Composition and the Asian Monsoon (ACAM),
8-10 June, 2015
Bangkok, Thailand

Asian region a source of increasing anthropogenic pollution

- High population (India ~ 1.2 billion, China ~ 1.3, Asia ~ 4.2)
- Higher economic and industrial growth
- Increasing demand for energy
- Increasing emissions

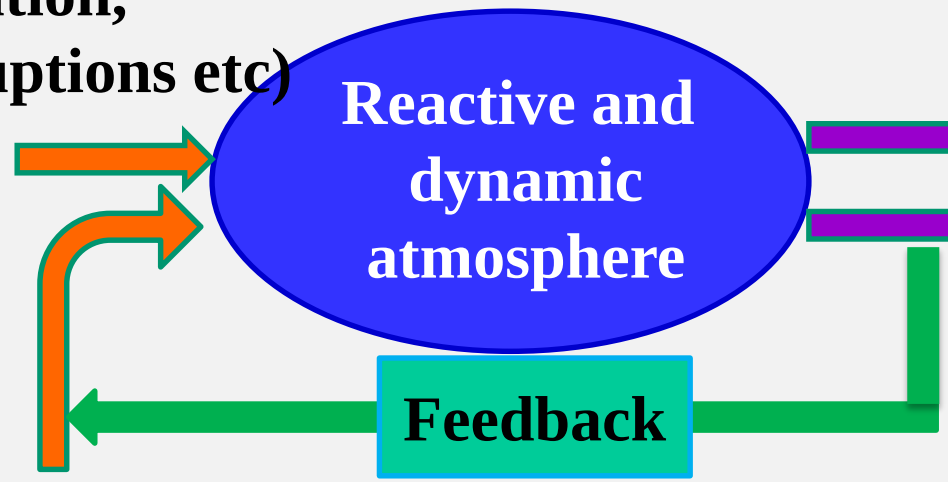






Chemistry and climatic changes in the atmosphere

Natural forcings (Solar radiation, volcanic eruptions etc)



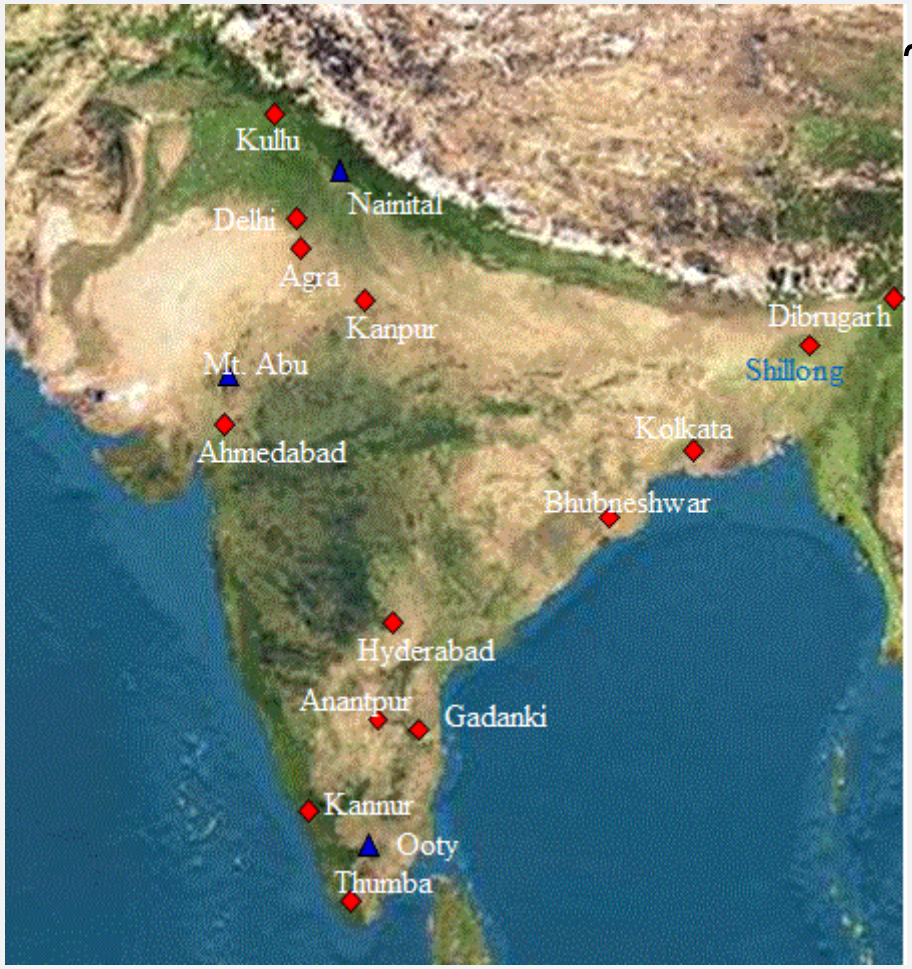
Changes in Composition

Environment, monsoon, climate … Changes

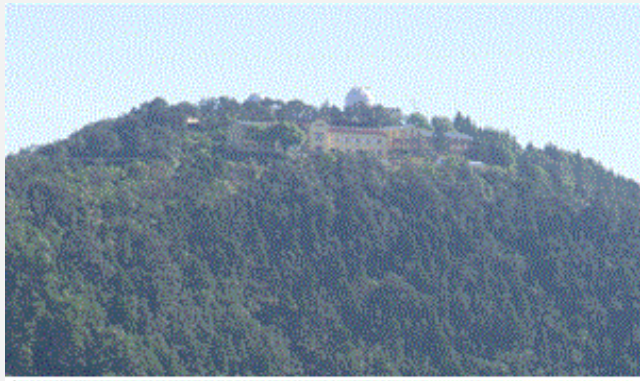
Anthropogenic Forcings (emissions, land use change etc)

Study of atmospheric chemistry in different environments in India: Atmospheric Trace gases – Chemistry, Transport and Modeling (ATCTM) project of ISRO- GBP.

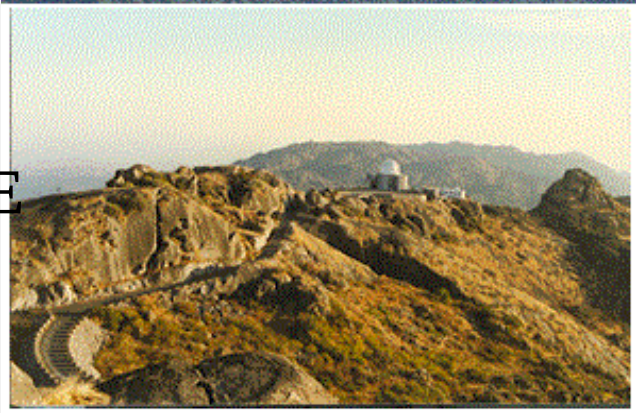
About 17 sites



Nainital
29.4N,79.4E
~2.0 km

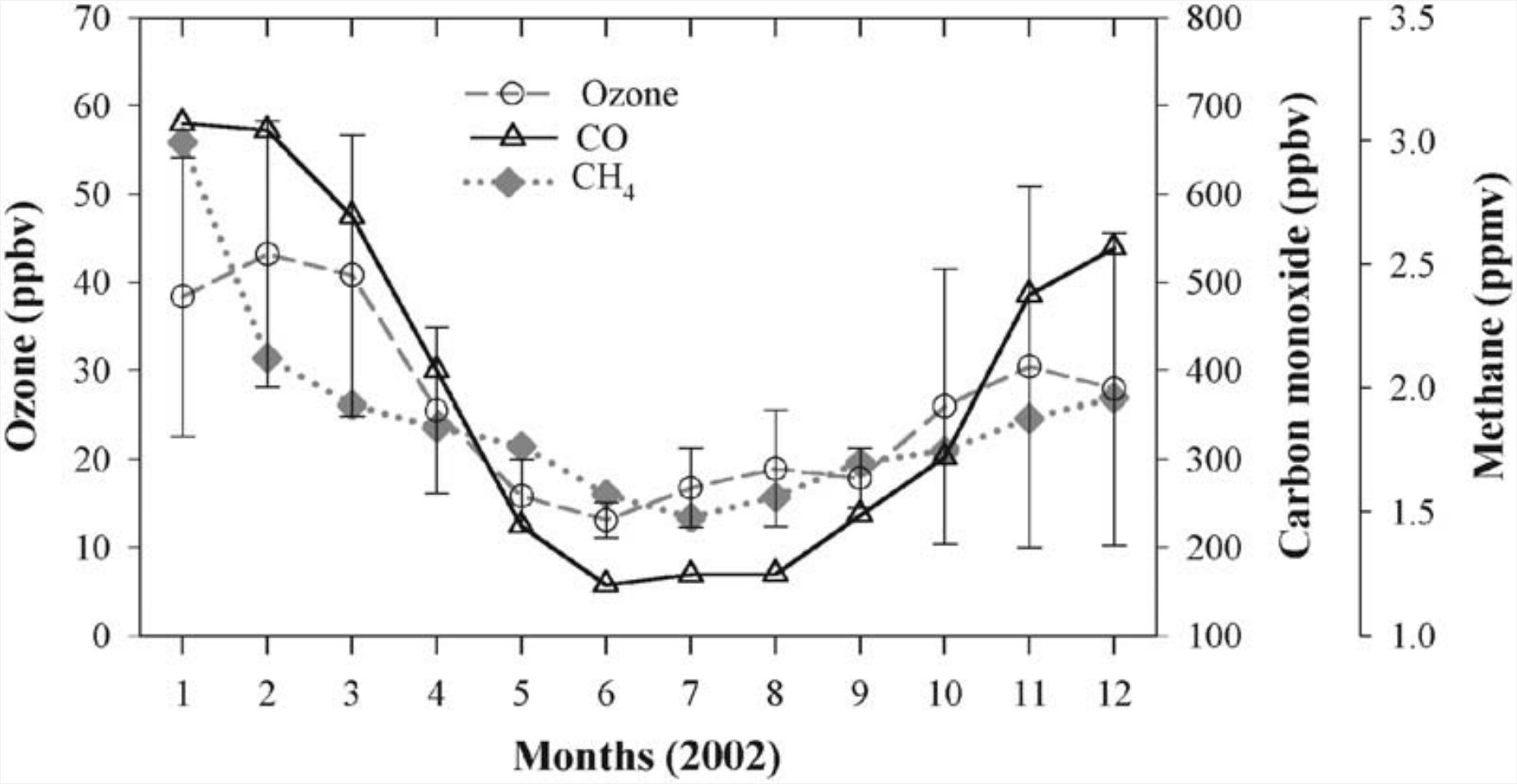


Mt. Abu
24.6N,72.6E
~1.7 km



Ooty
11.4N,76.7E
~ 2.5 km

Seasonal variations of Ozone, CO and CH_4 at Ahmedabad



Sahu and Lal, AE 2006

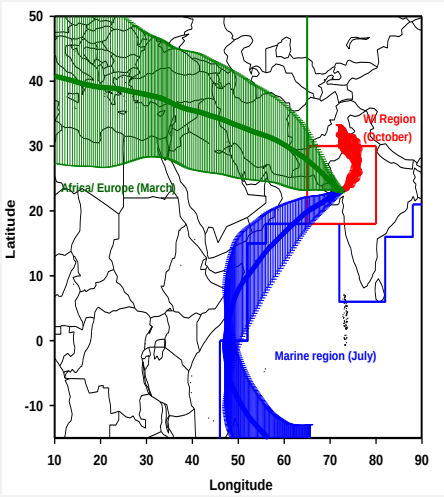
Transport effects

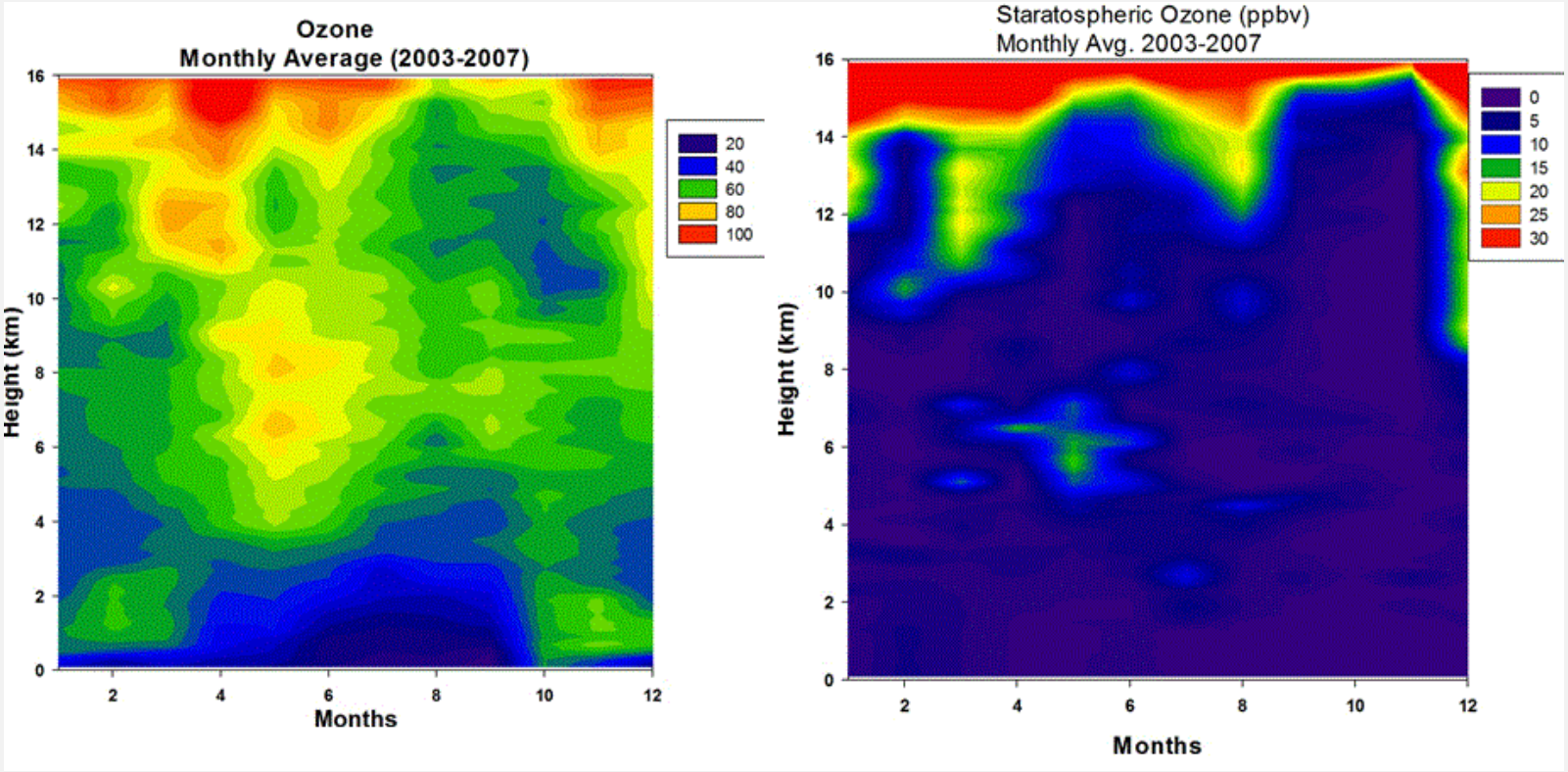
Ozone distribution over Ahmedabad

Ozone is measured using balloon-borne ECC sensor

May 2003 to July 2007

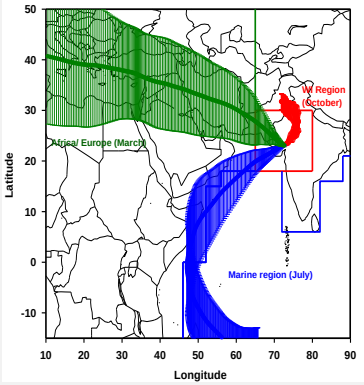
Together with Flexpart trajectory model results of NOAA, Boulder





Lal et al., JGR 2014

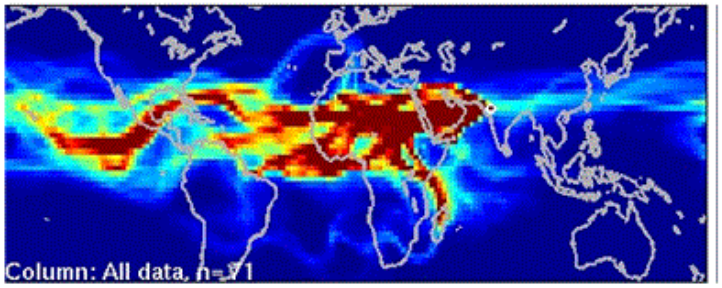
Transport pathways over Ahmedabad using Flexpart trajectory model



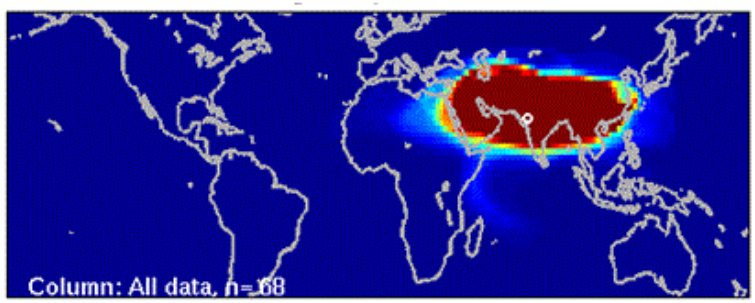
A retroplume consists of 40,000 back trajectory particles released from the time and location of the balloon launch in 0.1x0.1^{o} x 200m and advected back in time over 12 day period.

Ht = 12-13 km

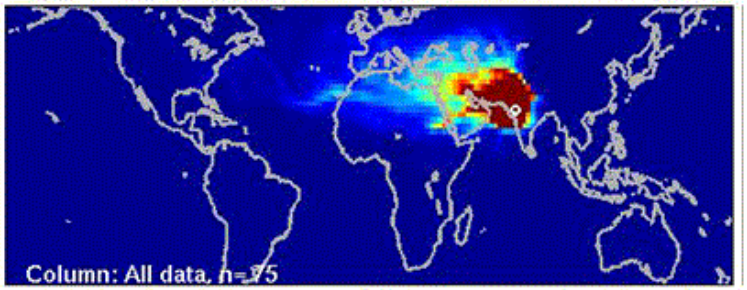
Winter

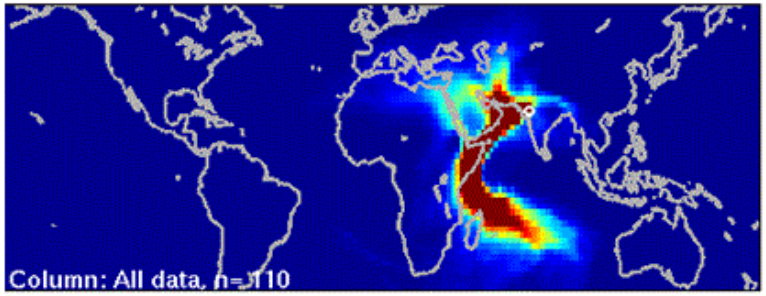


Summer



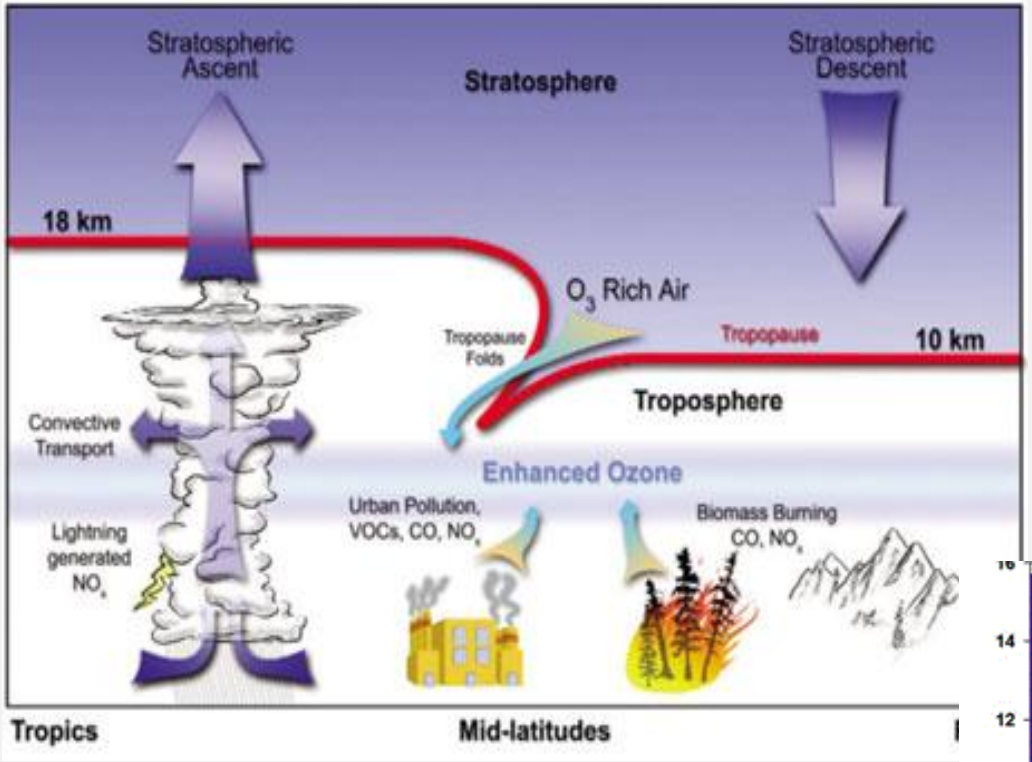
Ht= 0-1 km

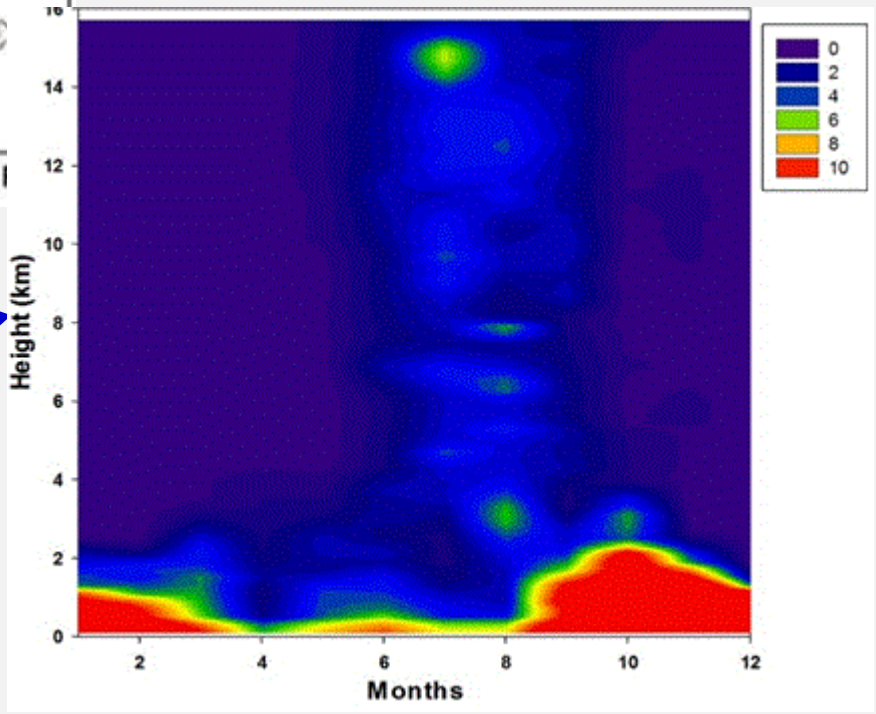




Lal et al, 2014

Effects of Convection during summer monsoon

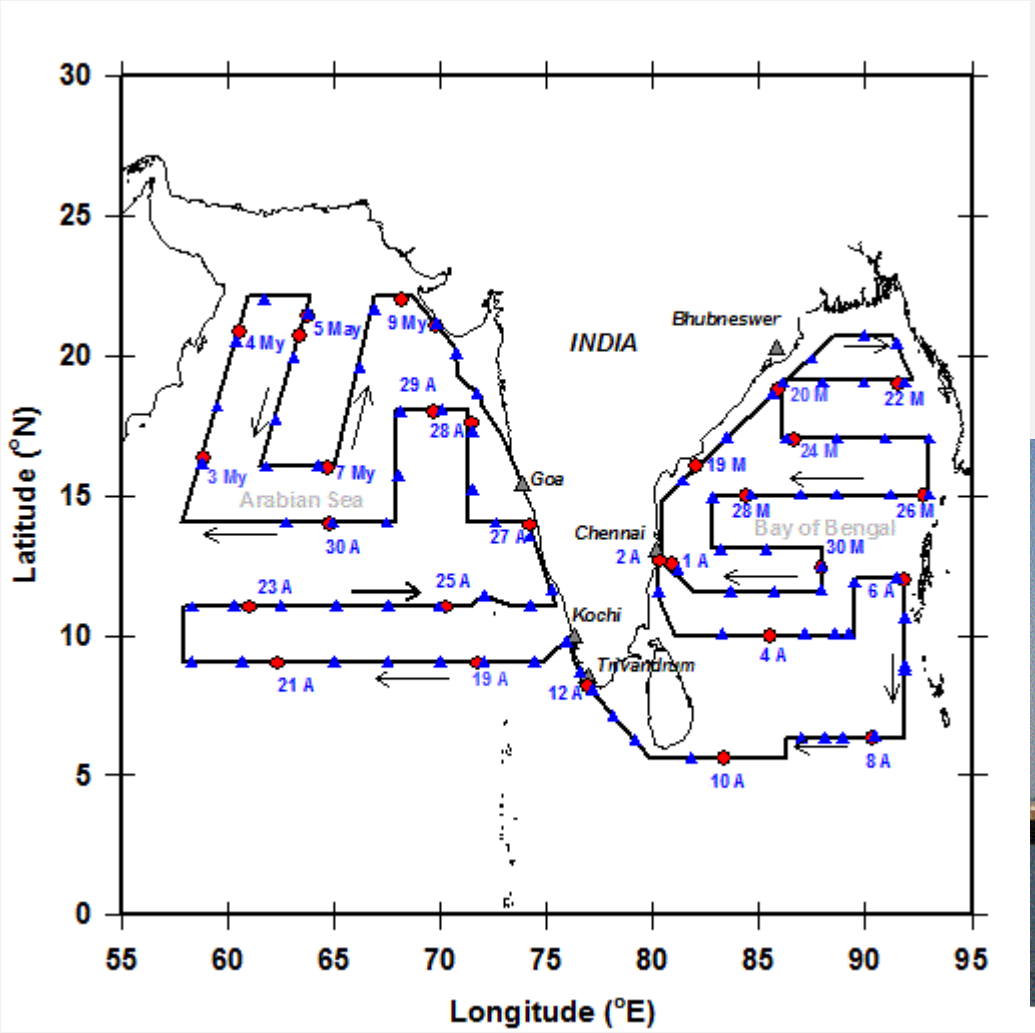




NOx over India emitted from anthropogenic sources lifted up into the troposphere.

In collaboration with NOAA, Boulder (Lal et al, 2014)

Study of ozone distribution over the Bay of Bengal and the Arabian Sea

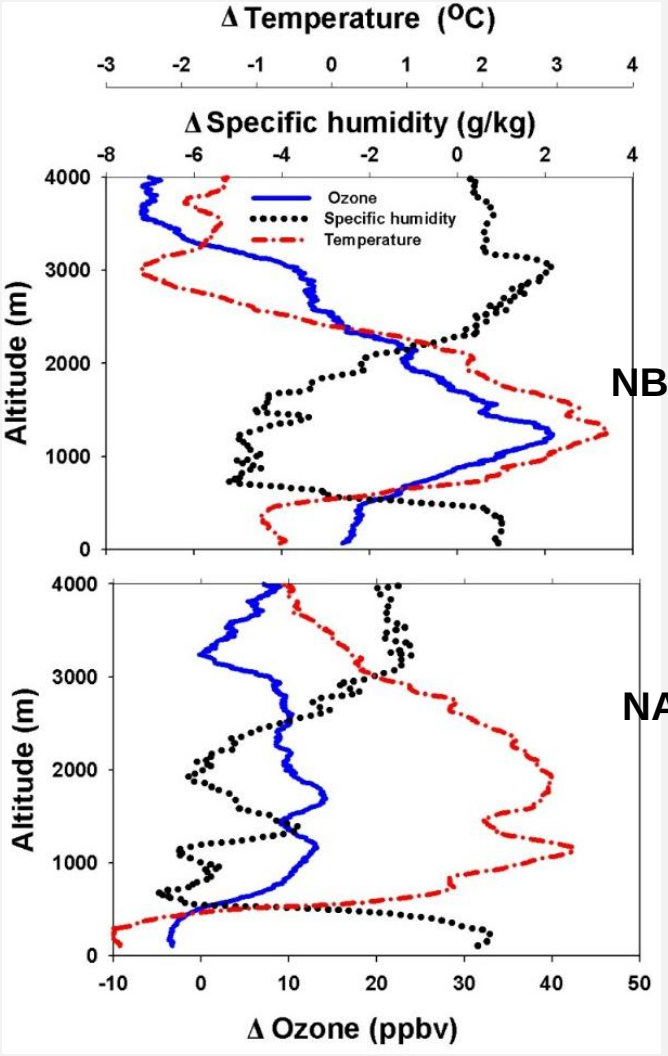


Integrated Campaign for Aerosols, gases and Radiation Budget (ICARB) - 2006

18 Mar – 11 May

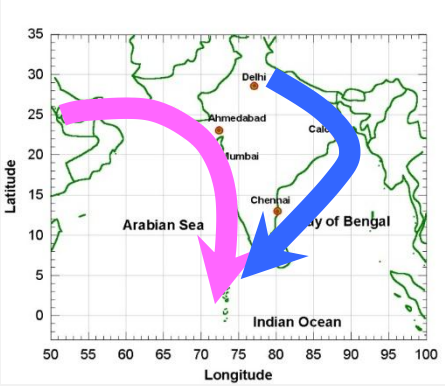
14 Soundings Bay of Bengal (BOB)
15 Soundings Arabian Sea (AS)

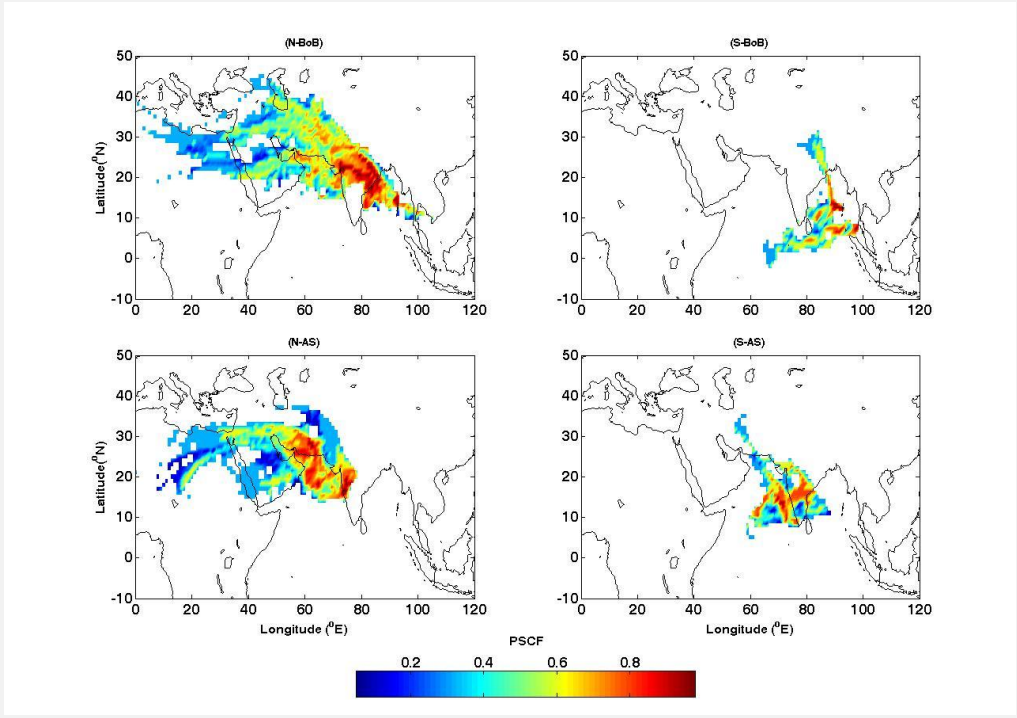
Total potential source contribution function (PSCF) analysis: Identification of source location



NBoB - SBoB

NAS – SAS

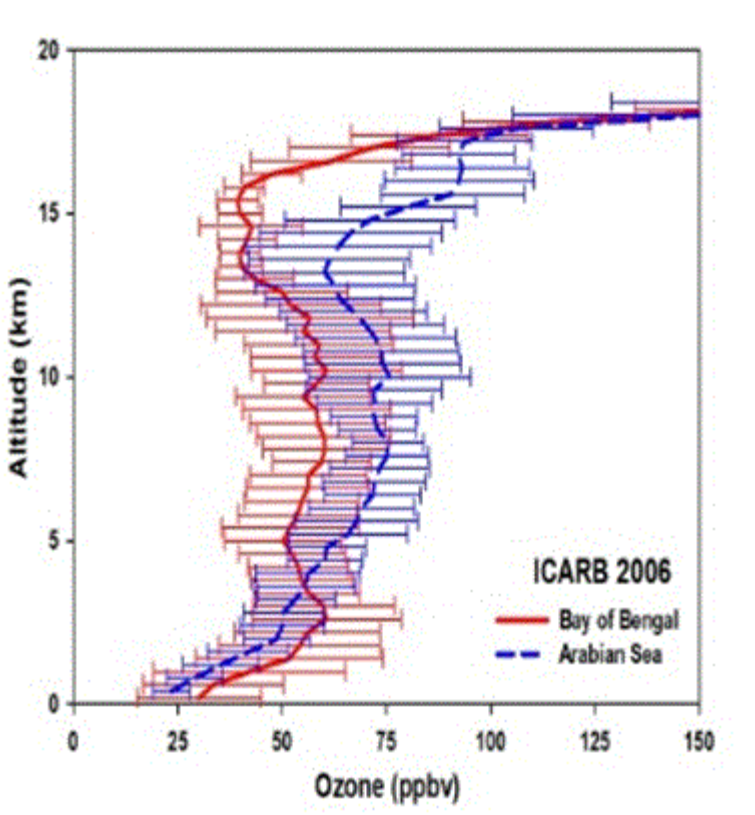


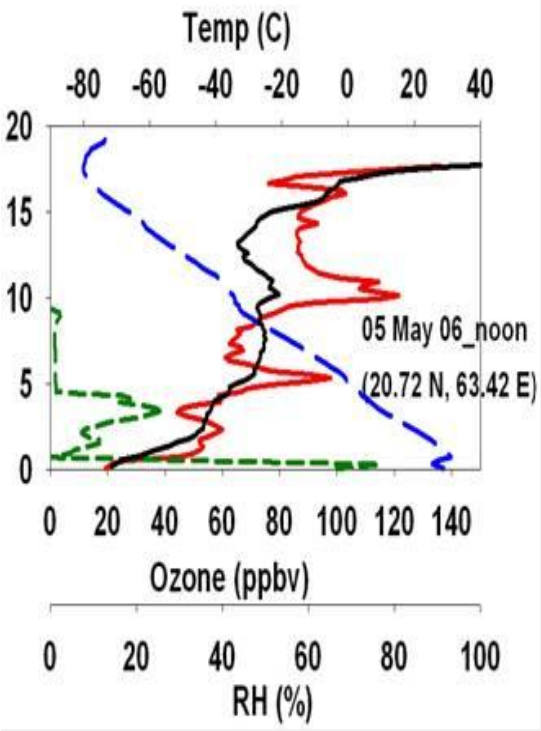


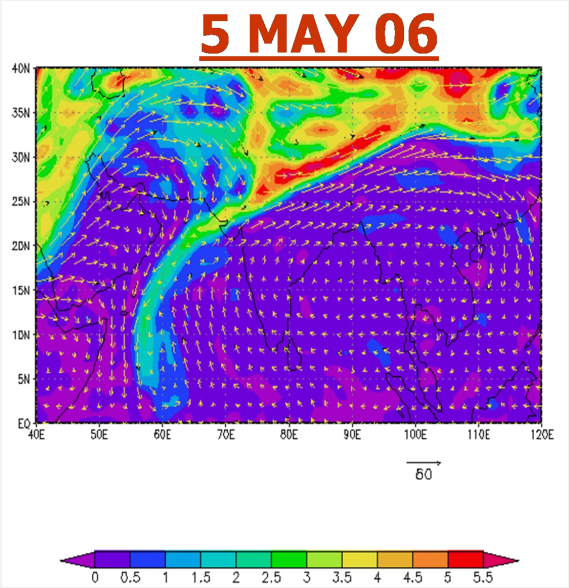
Srivastava et al., JGR 2011

Ozone over the marine regions

Stratospheric ozone into the troposphere over the Arabian Sea







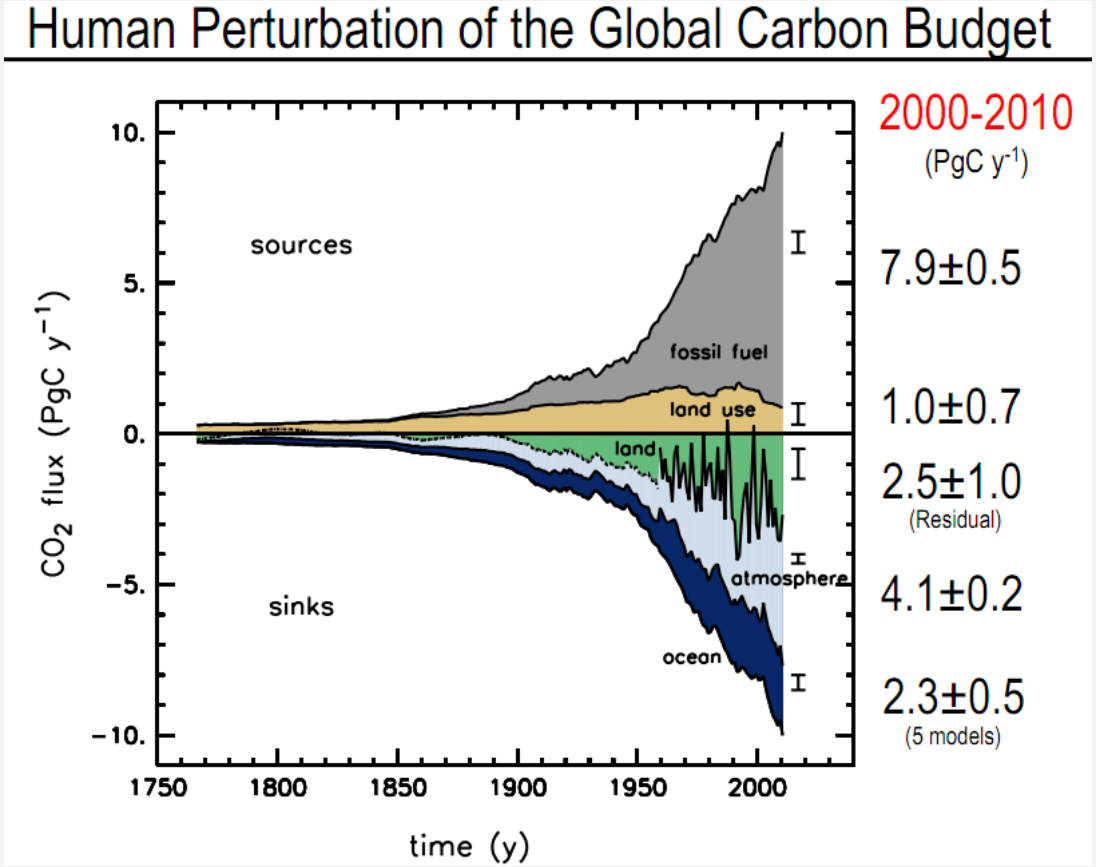
Sharp PV gradient along the subtropical jet stream around 20−30N, which is the location where active stratospheric-tropospheric exchange occurs.

Lal et al., JGR 2013

Atmospheric CO2

It is the most important anthropogenic gas contributing to the greenhouse effect.

Perturbation of the global carbon cycle caused by anthropogenic activities, averaged globally for the decade 2002–2011 (PgC/yr)



1 Pg = 1 Petagram = $1x10^{15}$g = 1 Gigaton

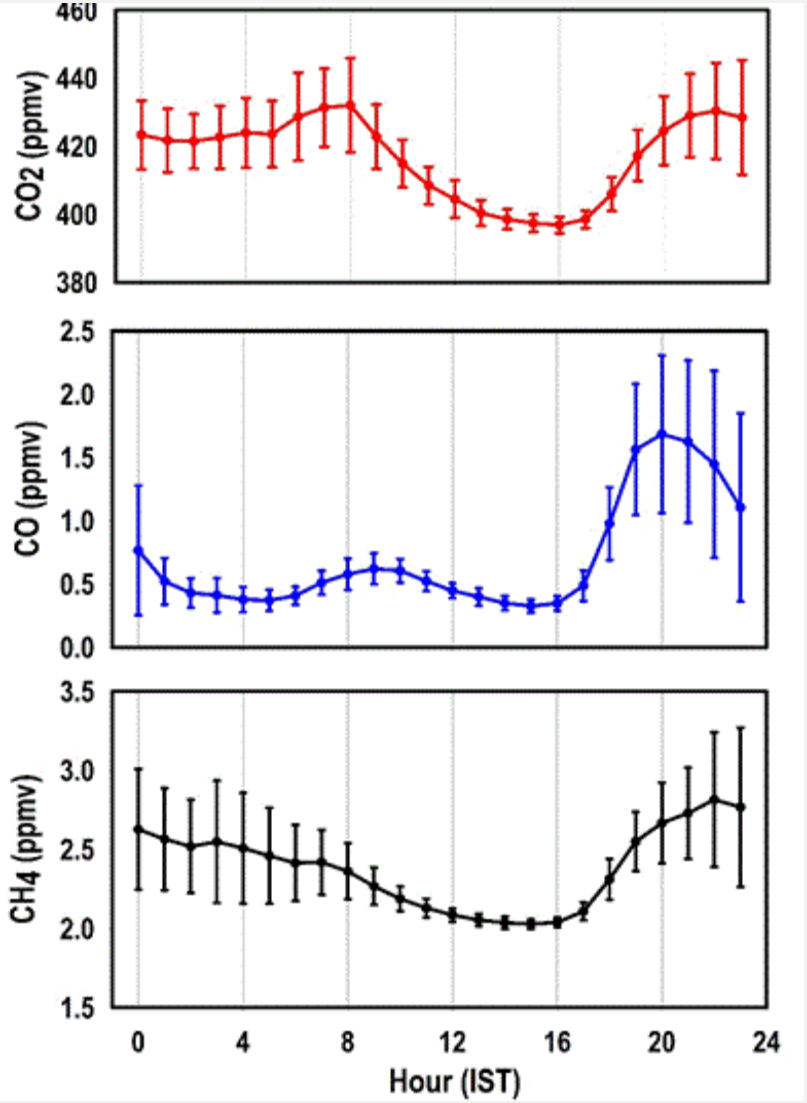
Le Quéré et al. 2012; Global Carbon Project

Study of CO_2 and related trace (CH_4 & CO) gases using a Cavity Ring Down Spectrometer (CRDS) at Ahmedabad.

Initiated in Nov. 2013

Similar measurements are being made at Nainital also.

CO shows highest variability.



Air Quality, Environment and Health

Air pollution is world's top environmental health risk -WHO

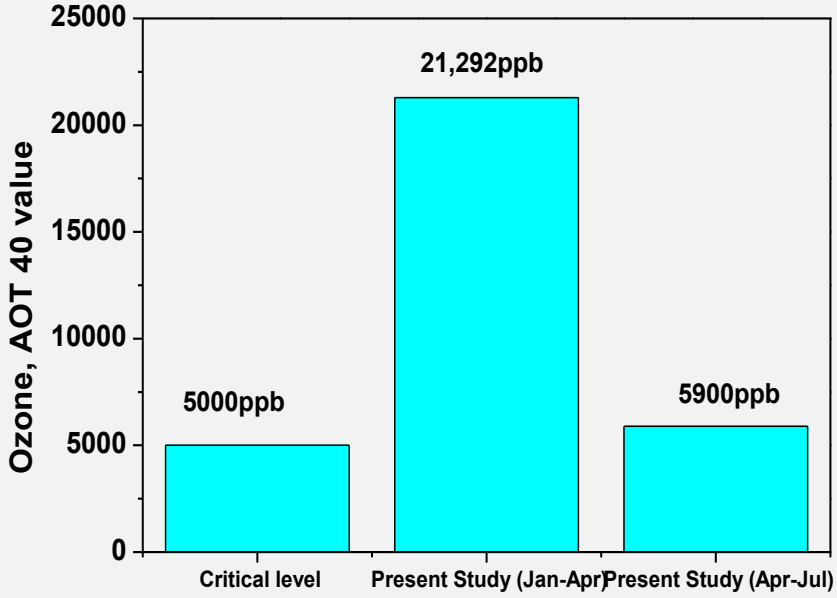
WHO's assessment points to a huge surge (four fold - > 8 million) in disease burden and deaths due to air pollution exposure across the globe over the past decade. China and India are by far the worst affected countries. Delhi and Beijing most polluted cities in the world

Apart from development of respiratory diseases, exposure to air pollution leads to severe risk of cardiovascular diseases, such as strokes and ischaemic heart disease.

EFFECT OF AMBIENT OZONE ON YIELD OF POTATO DURING TWO SEASONS at Ooty, India

January-April 2012

April-July 2012



Calculated AOT40 ppbh

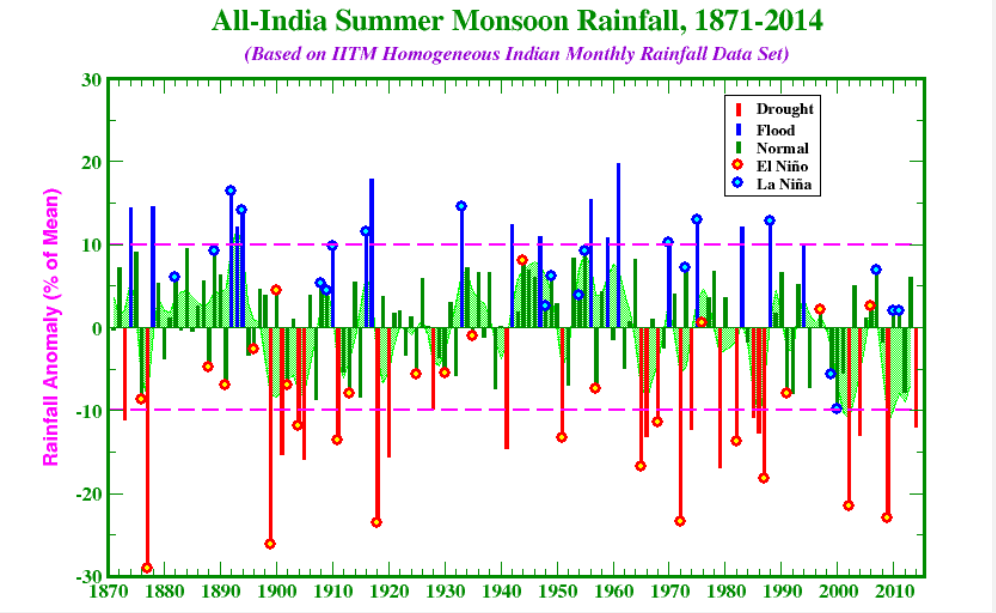
Winter grown potato genotypes showed up to 19.9% reduction due to higher AOT40 over winter than summer.

Summer crop recorded 4.5% yield reduction

Udaisoorian et al, TNAU, Coimbatore, India

Trace Gases, Aerosols, Clouds & Monsoon

Indian Summer Monsoon



Flood years : 19 major flood years ... 1983, 1988, 1994

Drought years: 25 major drought years .. 2002, 2004, 2009, 2014

Alternating periods extending to 3-4 decades with less and more frequent weak monsoons.

i) 1921-64 witnessed just three drought years; Monsoon less correlated with the ENSO.

ii) 1965-87 - had as many as 10 drought years out of 23,
Monsoon strongly linked to the ENSO.

Source : Indian Institute of Tropical Meteorology (IITM) Pune, India

Summary and future needs

Varibilities in the distributions of several trace gases, which are important in atmospheric chemistry and climate, are being made at PRL, Ahmedabad and several other places in India under a project of ISRO.

Increasing levels of emissions due to anthropogenic activities are changing the atmospheric chemistry as well as climate.

Monsoon winds and clouds during June-September strongly affect the levels of these gases, photochemistry, biogenic emissions etc.

Vertical distributions are affected by boundary layer dynamics, long-range transport and influence of downward transport from the stratosphere.

Summary and future needs (Contd.)

We need to quantify natural and anthropogenic changes and plan mitigation policies for minimum environmental changes. We need to progress!

Monsoon is the lifeline of food in this region. Are these perturbations in the chemical composition changing the monsoon if so then how? Can we predict the monsoon?

I thank you for your attention

shyam@prl.res.in