



April 2010

**Near-real- time observations of
Atmospheric Brown Cloud
transport to high Himalayas by
Nepal Climate Observatory – Pyramid, 5079 m**



NCO-P is part of the ABC UNEP Observatory network

NCO-P web-cam images of Khumbu valley

evk2 - isac - cnr 2010-04-07 10:46:08

Morning conditions



evk2 - isac - cnr 2010-04-07 16:46:08

Afternoon conditions

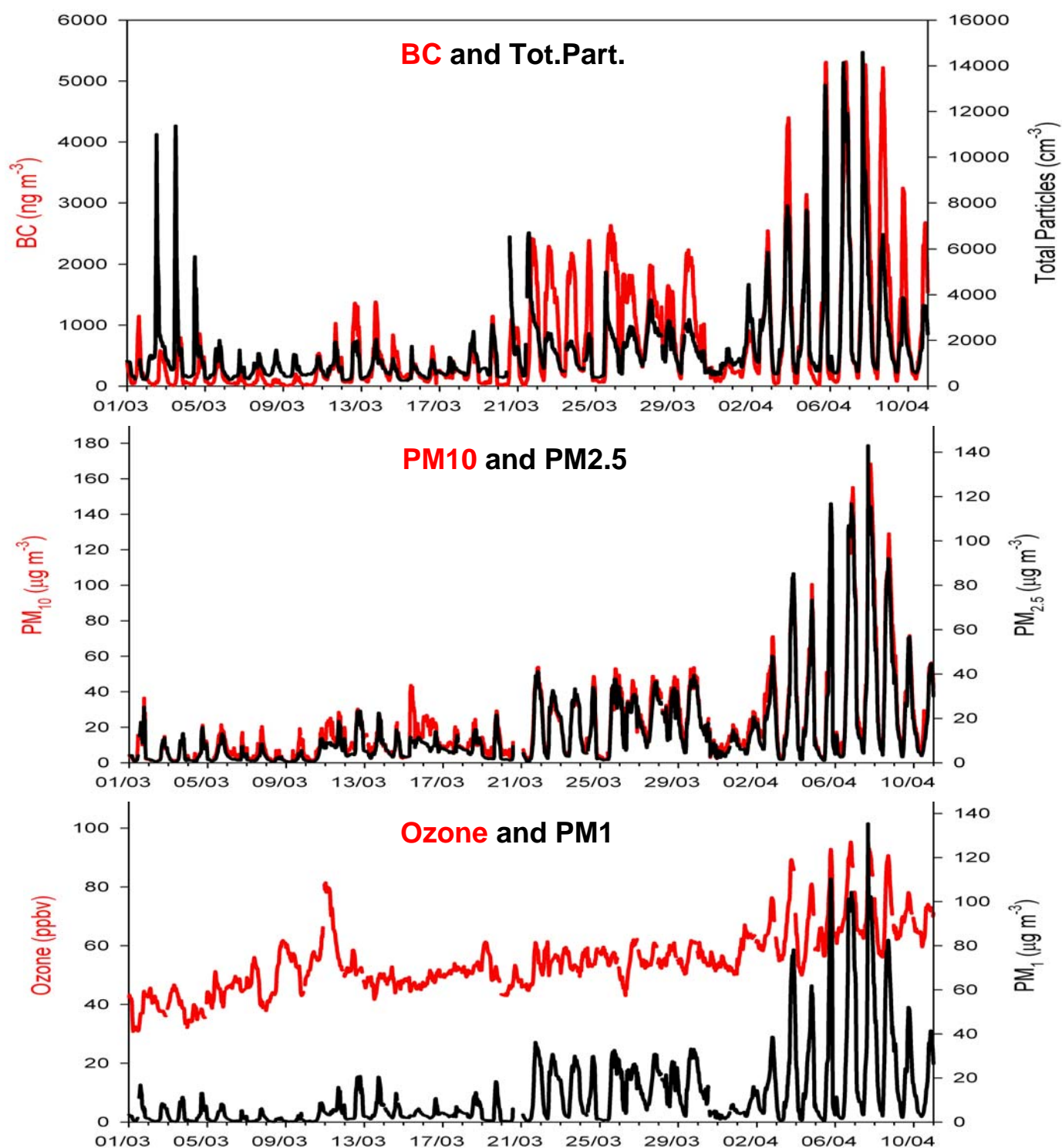


Starting from 2nd April 2010, valley winds favoured the transport to high Khumbu valley and NCO-P of large amount of ABC pollutants (BC, PM, ozone).

A thick haze is clearly discernible by NCO-P web-cam images taken on **April 7** during **morning** and **afternoon** conditions, testifying the extension of Atmospheric Brown Cloud up to high Himalayas. Unusually **high AOD values** were detected at the NCO-P station by the in-situ **AERONET** measurements; high AOD values also characterized Kathmandu and Pokhara site. Aerosol profiles by **CALIPSO** confirm the extension and the strength of this event.

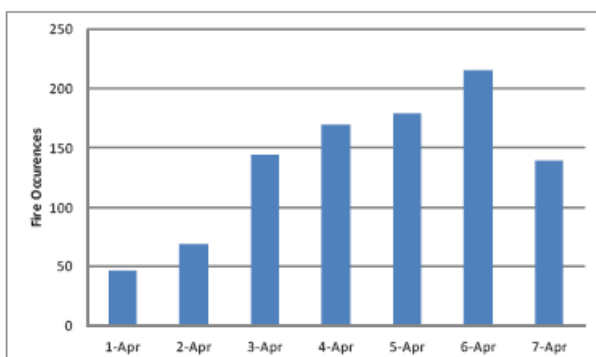
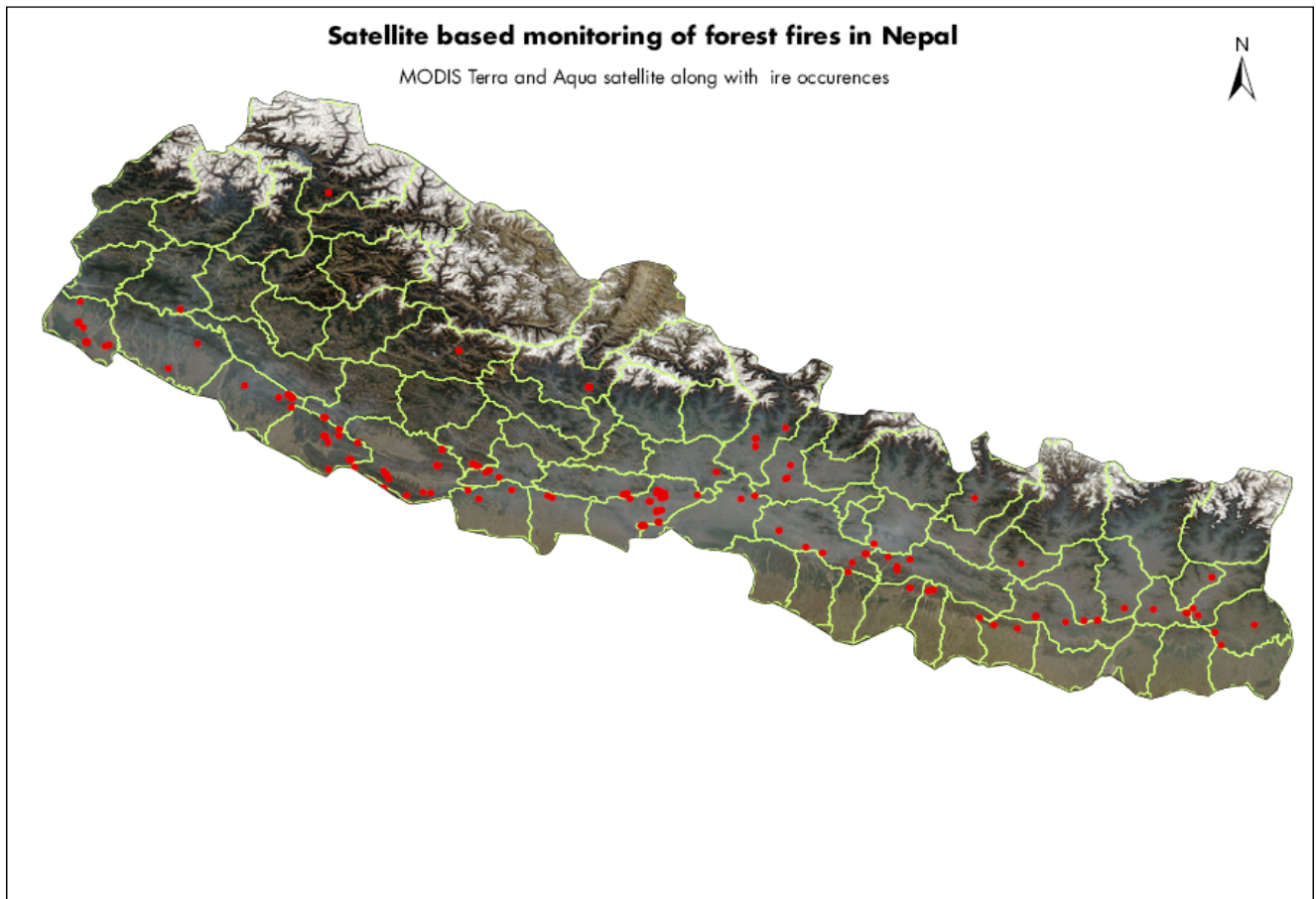
BC, total particles, PM1, PM2.5, PM10 and surface ozone

In the period 2–10 April 2010, very high values of pollutants have been observed at NCO-P, with **BC values often exceeding $5\mu\text{g}/\text{m}^3$** : these represents the highest BC values ever recorded at NCO-P from March 2006. **Ozone concentration peaked to 90-95 ppb** ($180\text{-}190\mu\text{g}/\text{m}^3$) during April 6–8 while **PM1, PM2.5 and PM10 exceeded the $100\text{ ng}/\text{m}^3$** .



In India, Nepal and South Asia fire season in forest areas was from February to May, and that in croplands varied with geographical location, with peaks in April and October, corresponding to the two major harvest seasons.

April 2010, 1 – 7: MODIS fires in Nepal

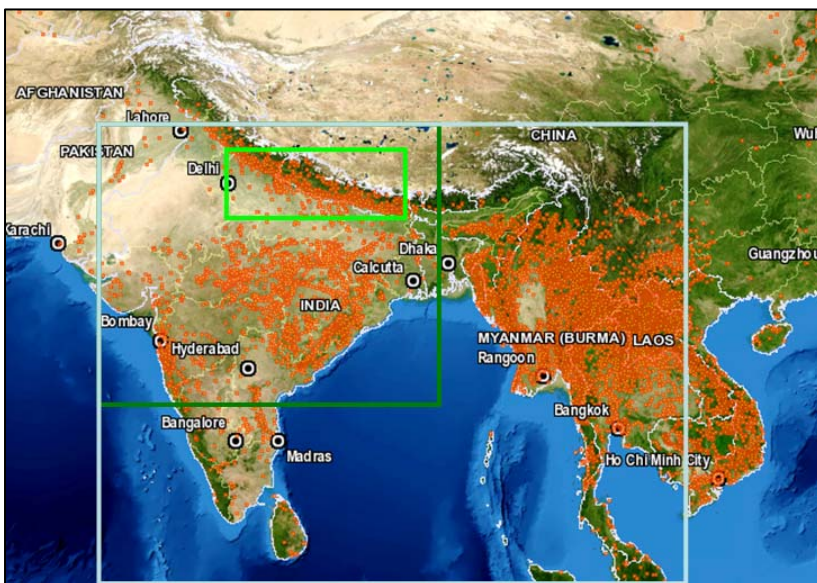
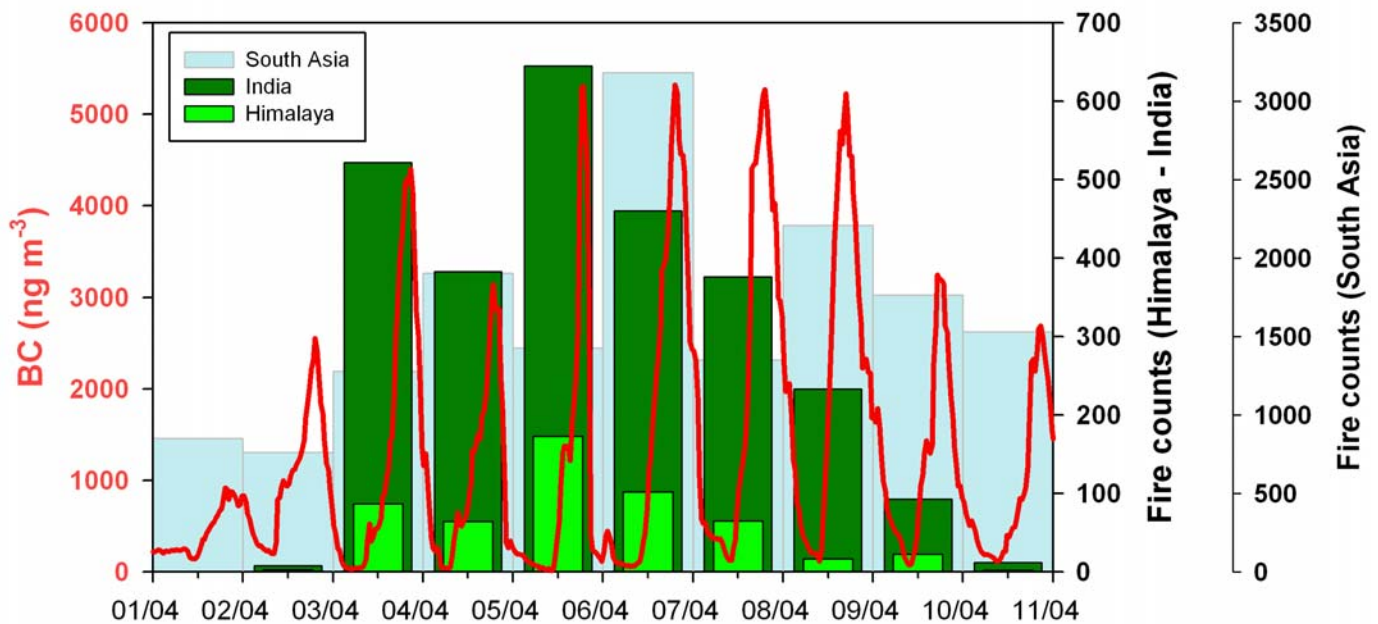


Key points:

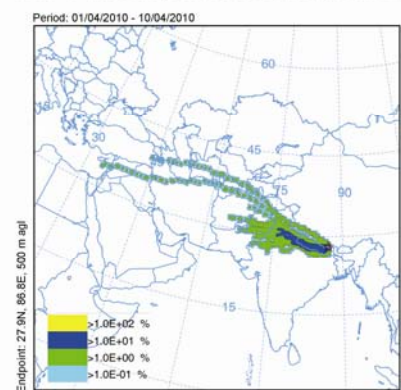
- Large scale incidence of fires observed in Nepal
- Increase in fire occurrence compare to previous year
- Haze, smoke plumes are clearly visible in the mid-mountain range
- Over the week, fire occurrence showed increasing trend


BC and biomass burning fires

APRIL 1-10, 2010: BC concentrations at NCOP (red line) and numbers of fires detected by MODIS (confidence level > 75) obtained by FIRMS Web Fire Mapper over the MODIS "South Asia subset" (blue bars), India (dark green bars) and Himalaya (light green bars) boxes as defined in the map below reported.



NCO-P back-trajectories analysis (HYSPLIT)



April 1-10, 2010:
Back-trajectory analyses
for the NCO-P
NOAA-ARL HYSPLIT 

NASA/University of Maryland, 2002.

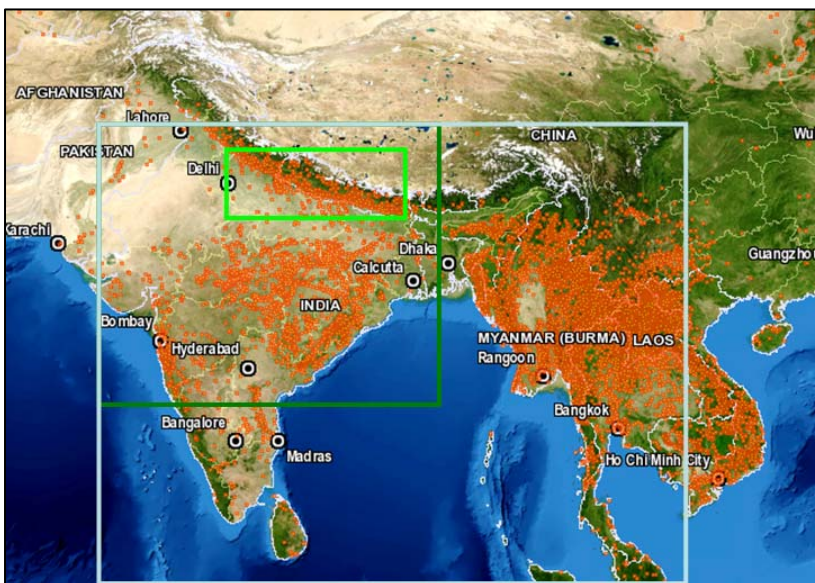
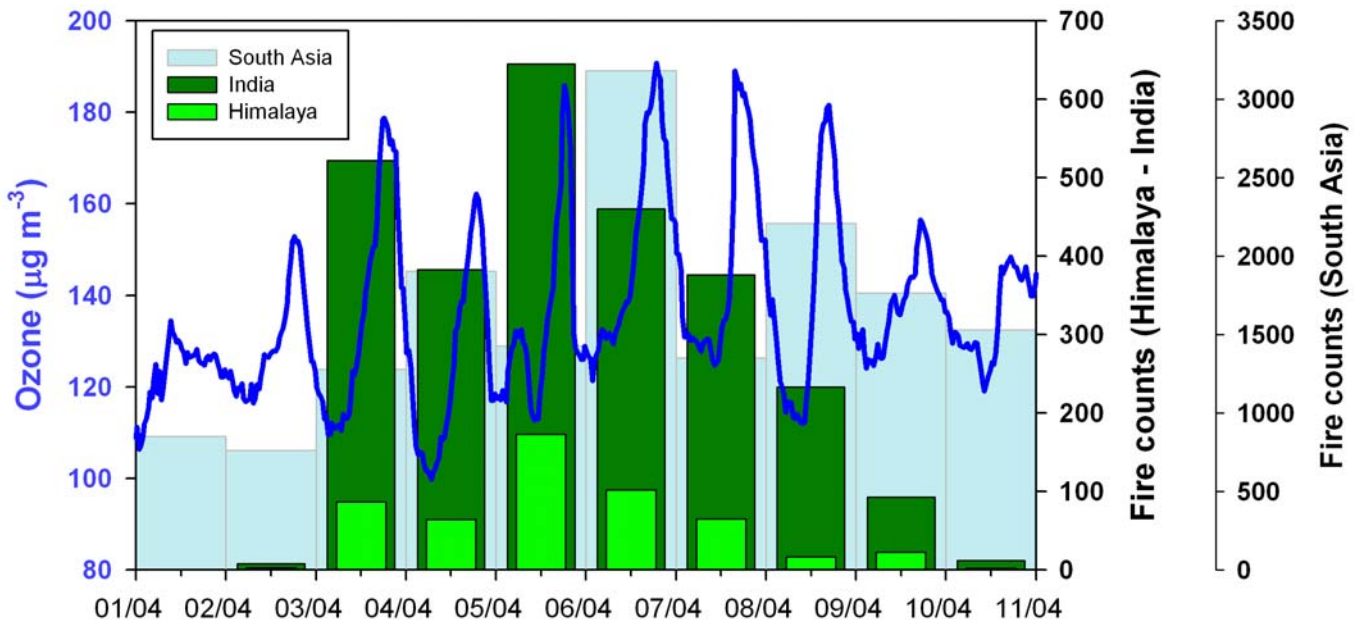
MODIS Hotspot / Active Fire Detections.

Data set. MODIS Rapid Response Project, NASA/GSFC [producer],
University of Maryland, Fire Information for Resource. Management
System [distributors] Available on-line [<http://maps.geog.umd.edu/firms/>]

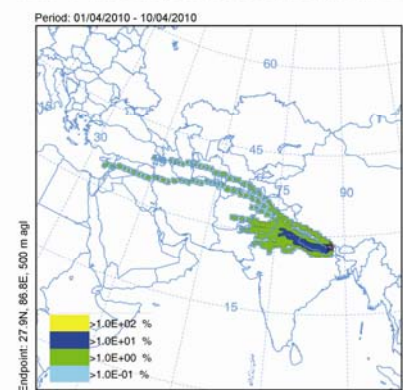



Surface ozone and biomass burning fires

APRIL 1-10, 2010: O₃ concentrations at NCOP (blue line) and numbers of fires detected by MODIS (confidence level > 75) obtained by FIRMS Web Fire Mapper in the MODIS "South Asia subset" (blue bars), India (dark green bars) and Himalaya (light green bars) boxes as defined in the map below reported.



NCO-P back-trajectories analysis (HYSPLIT)



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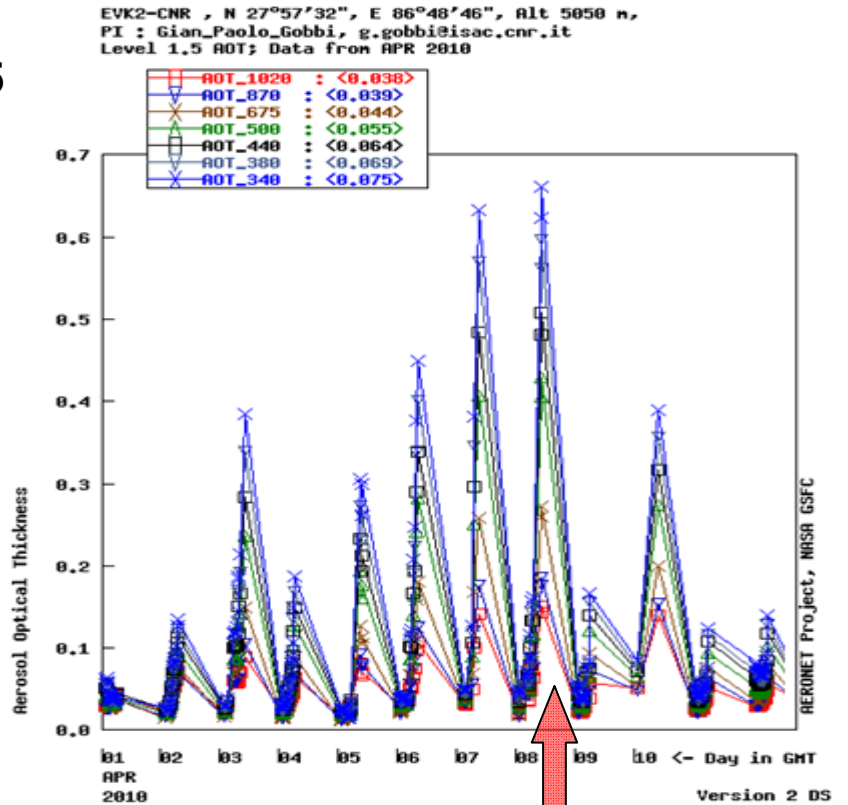
Data set. MODIS Rapid Response Project, NASA/GSFC [producer],
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System [distributors] Available on-line [<http://maps.geog.umd.edu/firms/>]



**EVK2-CNR (NCO-P)
AOD AERONET, Level 1.5
April 1–10, 2010**



High AOD values at 500 nm (>0.3 in respect to typical winter value of 0.05) carried out with Cimel photometer have been registered.



MODIS (Terra) true-color (8 April 2010)

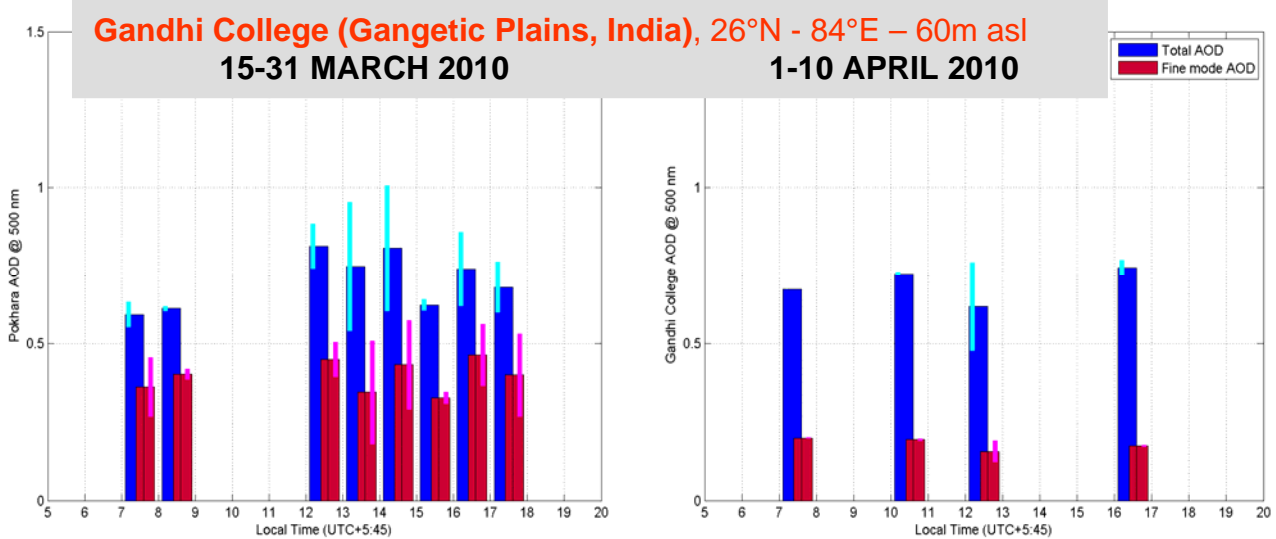


As shown by the **MODIS** image, a **thick wide spreading haze** is piling up against the **Himalayas** ridges and impinging valleys. As shown by MODIS Rapid Fires in the previous pages, starting from the beginning of April 2010, several fires characterised the Himalayan foothills, the Indo-Gangetic plains and South Asia, likely strongly contributing to the high pollution levels observed at NCO-P.

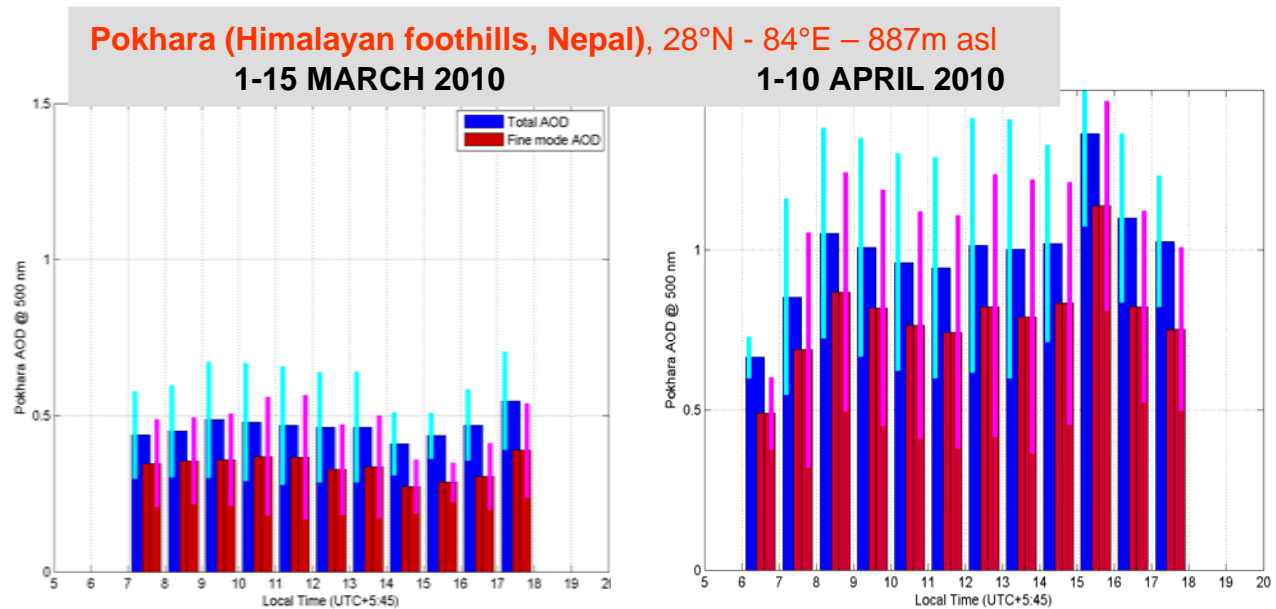
AERONET 500 nm Aerosol Optical Depth

HOURLY AVERAGES AND STANDARD DEVIATIONS

TOTAL (BLUE BARS) AND FINE MODE (RED BARS)



At **Gandhi College (Gangetic Plains, India)**, total AOD is constant in April and March. Fine-mode AOD decreases in April with respect to March. Mineral dust possibly dominates the AOD in April.

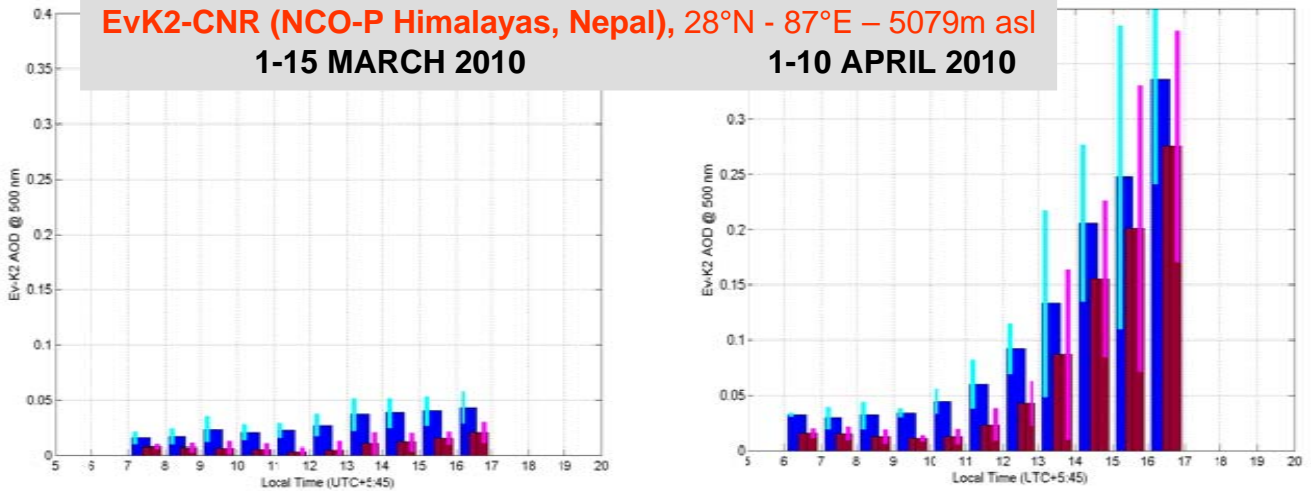


At **Pokhara (Himalayas foothills)**, the AOD is mostly fine-mode and shows a little daily cycle in April. Total AOD sharply increases in April with respect to March and is mostly fine-mode (likely biomass burning).

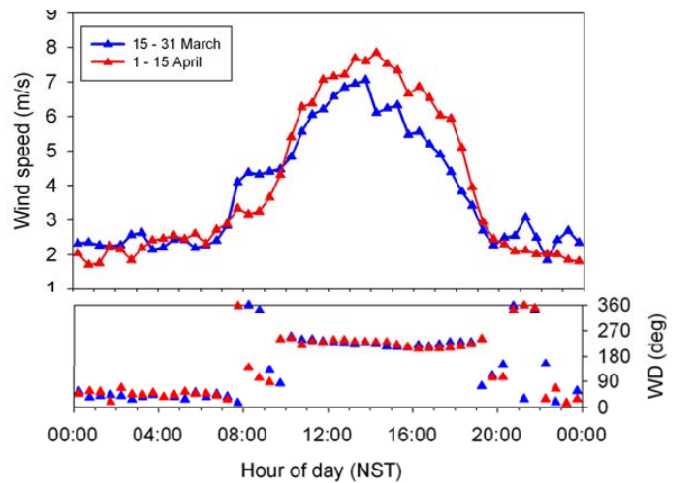


AERONET 500 nm Aerosol Optical Depth

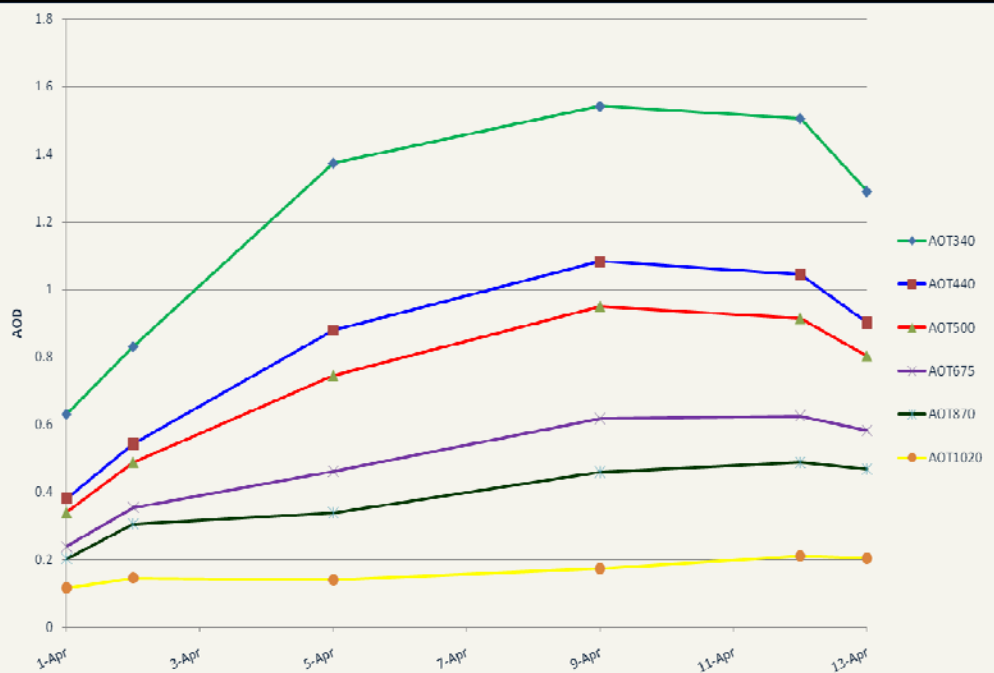
HOURLY AVERAGES AND STANDARD DEVIATIONS



At **NCO-P (EvK2-CNR Aeronet station in Himalayas)** total AOD sharply increases in April with respect to March and is mostly due to fine particles (likely biomass burning). At NCO-P, a tenfold increase in AOD between morning and afternoon was observed, thus magnifying the role of valley circulation.

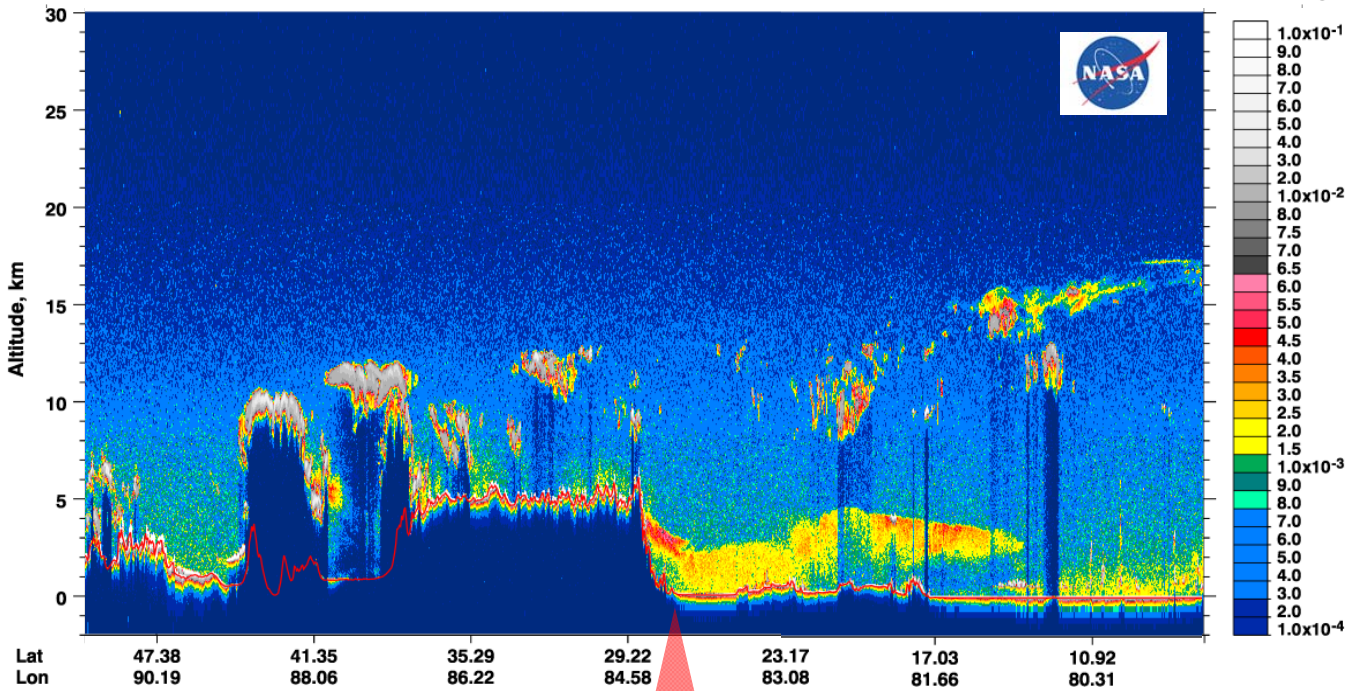


At the **Nepal Climate Observatory - ICIMOD HQ (Kathmandu, close to NCO - Godavari)**, the AOD value at 500 nm has almost reached the value 1.0, indicating the high pollution condition in the area.



CALIPSO, April 8, 2010

532 nm Total Attenuated Backscatter, $\text{km}^{-1} \text{sr}^{-1}$ UTC: 2010-04-08 20:14:33.7 to 2010-04-08 20:28:02.4 Version: 3.01 Nominal Nighttime

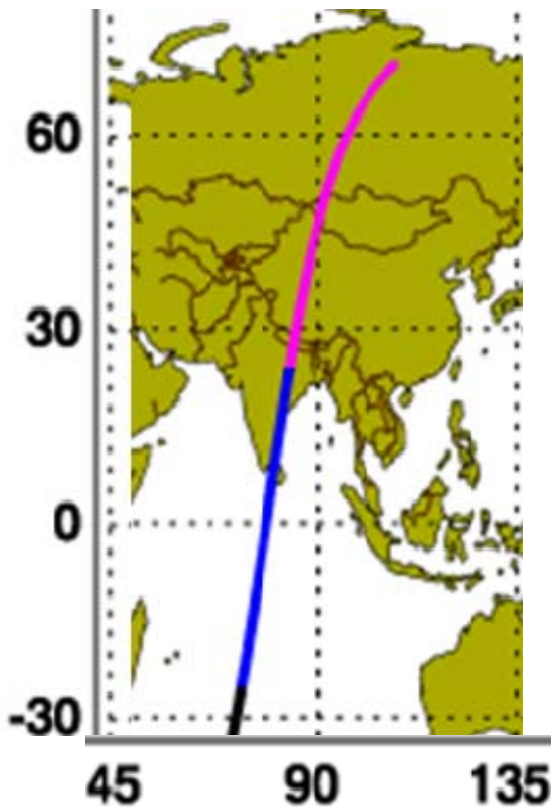


As shown by CALIPSO observations showed in this composite image a thick layer rich of aerosol (red and yellow plume) clearly covers the Indian plains up to 3000-4000 m asl.

The Himalayan ridge and the breeze circulation system push up the polluted layer towards the higher altitude.

The image is for the April 8, 2010 at about 20.25 GMT, corresponding to 1 AM (Nepal local time) on April 9. At the same time, very high BC concentrations ($\approx 2000 \text{ ng/m}^3$) were measured at the NCO-P.

On the left the paths (pink and blue) traced by CALIPSO, *Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation*, over the Asian continent for the April 8, 2010.





The **Nepal Climate Observatory - Pyramid** (Nepal, 27.95 N, 86.82 E) is located at 5079 m a.s.l. in the southern Himalayan region, not too far from Everest Base Camp and at the confluence of the secondary valley of Lobuche (oriented NNW-SSE) and the main Khumbu valley. **NCO-P** is part of GAW-WMO program, Aeronet-NASA network and SHARE Ev-K2-CNR project.



Nepal Climate Observatory – Godavari and NCO –ICIMOD–HQ (near Kathmandu and coordinated by ICIMOD - International Centre for Integrated Mountain Development) together with NCO-P are the Nepalese observatories of the Atmospheric Brown Cloud project by UNEP - United Nations Environment Programme.

<http://evk2.isac.cnr.it/realtime.html>

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