Black carbon and ozone threats to mountain and mitigation solutions

Mountains in Peril

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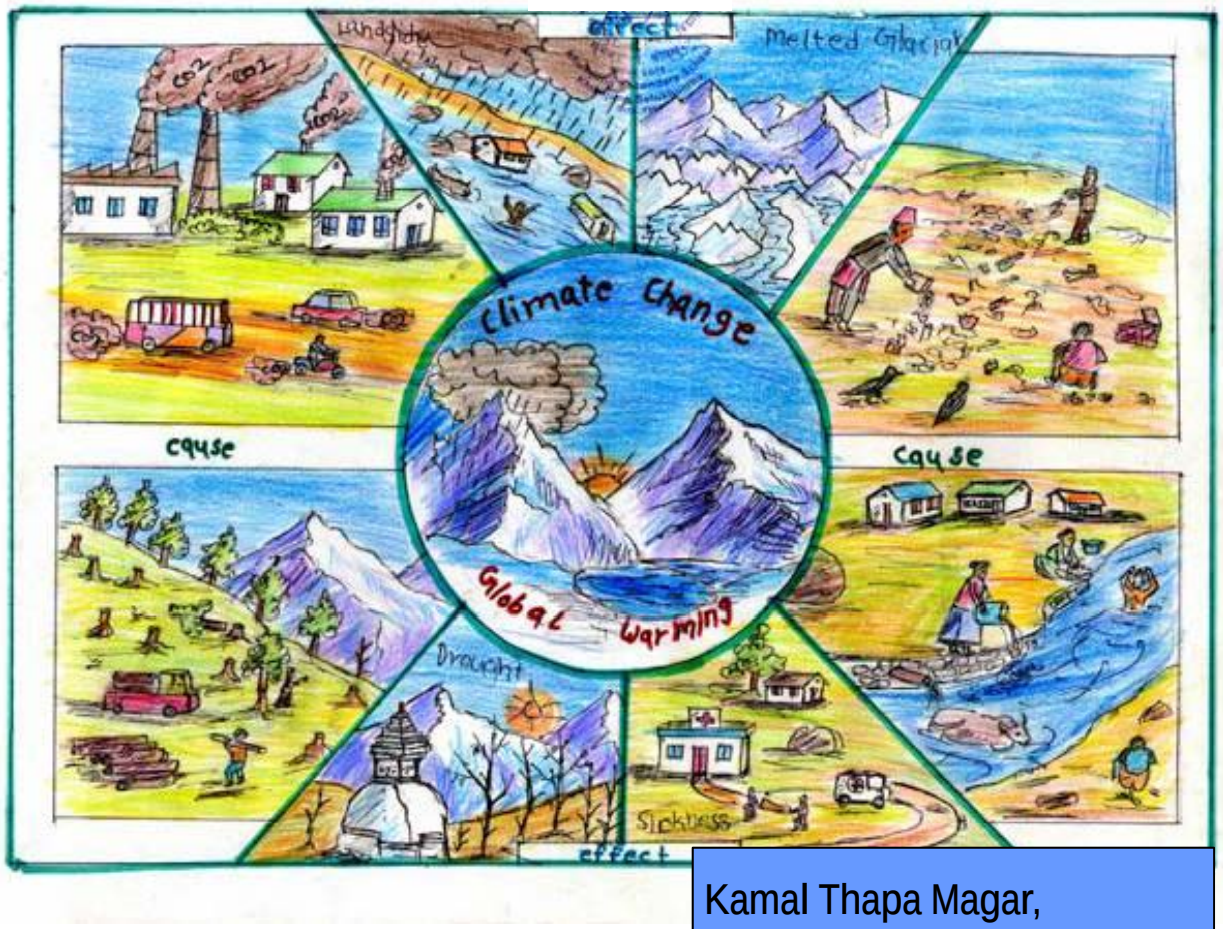
16th Conference of the Parties of the United Nations Framework Convention on Climate Change
CANCUN, Mexico November 29 – December 10

Air pollutants such as
tropospheric ozone and
black carbon (soot)
contribute to the greenhouse effect

Black carbon and tropospheric ozone
are considered among the most important anthropogenic contributor to global warming

Why Mountains?
Mountains are barometers of climate change

"***Mountains provide indications of global climate change*** *through phenomena such as modifications of* ***biological diversity, the retreat of mountain glaciers*** *and* ***changes in seasonal runoff*** *that may impact major sources of* ***freshwater*** *in the world,* ***and stresses the need to undertake actions to minimize the negative effects of these phenomena.***



Kamal Thapa Magar,
Class: 4, Khumjung High School
'Climate Change: Voices of Khumbu's Children'

Sustainable mountain development is a key component in achieving the ***Millennium Development Goals*** *in many regions of the world***."** (UN General Assembly 78th plenary meeting concerning the Sustainable mountain development, A/Res/62/196, 2008)

Why Mountains?
Mountains are barometers of climate change

Following the UN resolutions and indications Ev-K2-CNR launched the project

SHARE
Stations at High Altitude for Research on the Environment

An integrated scientific and technological research project devoted to environmental monitoring and climatic studies in mountain regions

In Himalayas these activities are carried out in collaboration with

NAST – Nepal Academy of Science and Technology

Through these activities, national and international governments and agencies are supported in order to promote sustainable development and adaptation policies against climate change effects in the mountain regions.

The Greenhouse Effect

Visible energy from the **sun** passes through the atmosphere and **heats** the ground

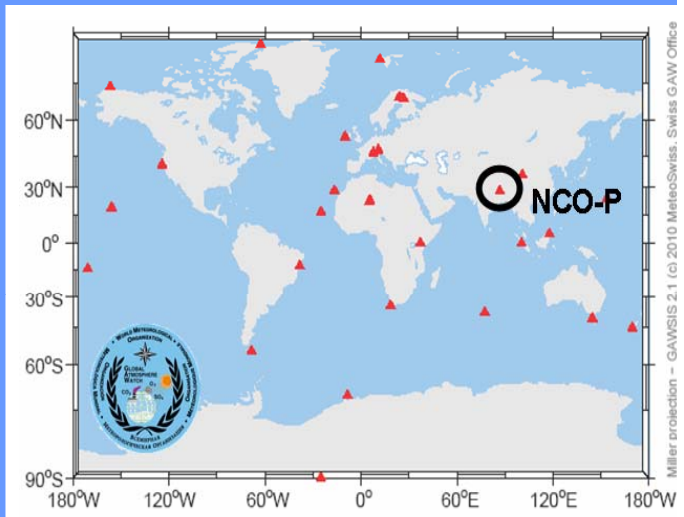
Infrared heat energy from the **ground** is partly **reflected** by the atmosphere, and some is **trapped** inside the atmosphere.

- **Without natural Greenhouse Effect the Earth mean temperature wb=** **- 18 °C**
  (i.e. the Planet without atmospheric compounds)
- **With natural Greenhouse Effect the Earth mean temperature =** **+ 15 °C**
- **+ contribution of antropogenic emissions (e.g. CO2, CH4, BC, O3) = + 15 °C + ??**

Air pollutants emitted in urban areas or coming from near or far polluted regions can be transported in the atmosphere and reach the high mountain areas:
the pollutants don't know national boundaries!

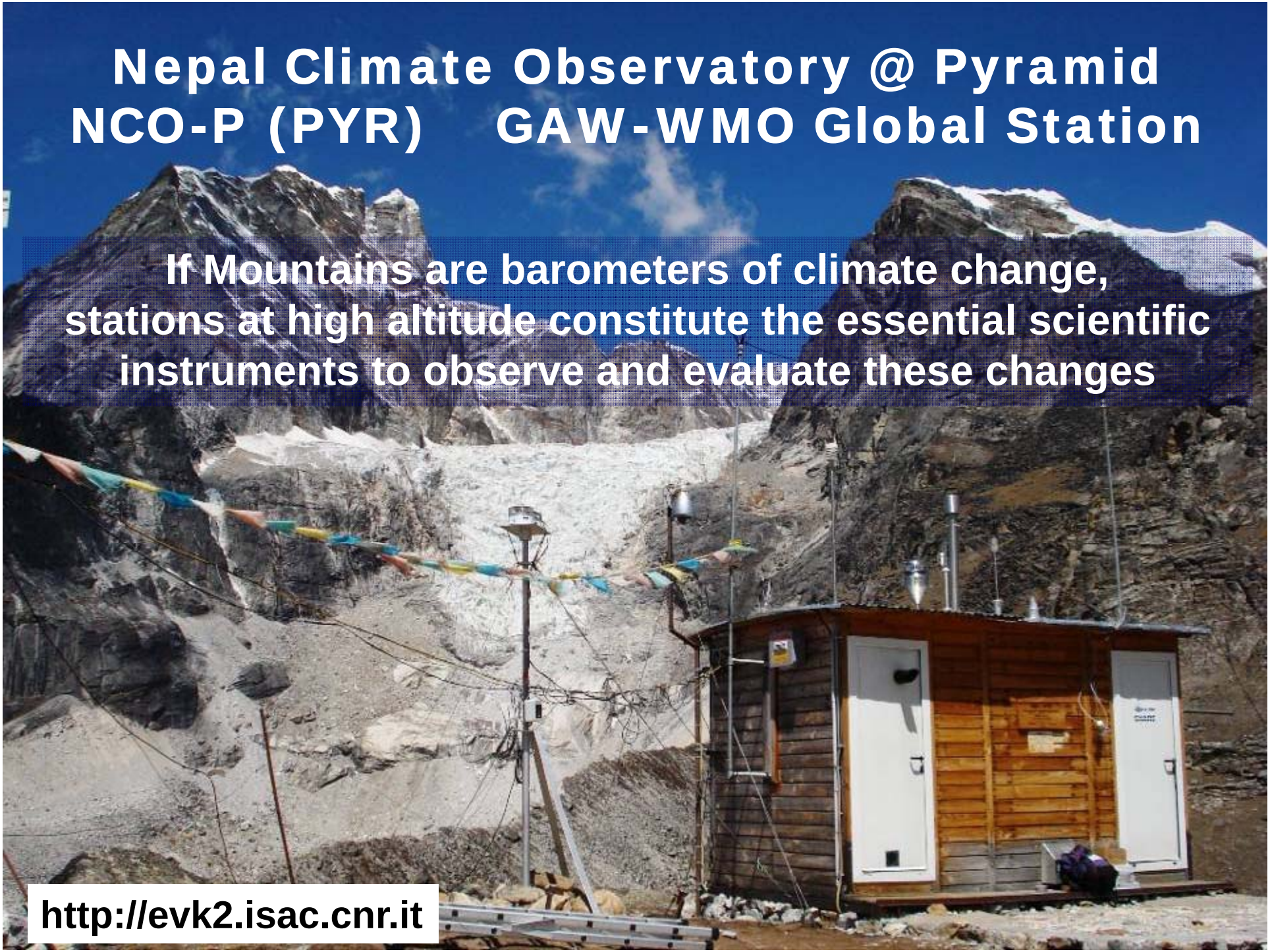
To systematically monitor and analyse atmospheric composition world wide and in order **to provide assessments and predictions for policy development,** the World Meteorological Organization (WMO) set up in 1989 **the Global Atmosphere Watch (GAW)** program

Nepal Climate Observatory @ Pyramid
sited at **5079 m** in the high Khumbu valley and not far from the Everest Base Camp, is the highest station of the GAW Global network



At present, **33 Global Stations** and over 300 regional GAW stations perform chemical and related meteorological measurements.

Nepal Climate Observatory @ Pyramid
NCO-P (PYR) GAW-WMO Global Station



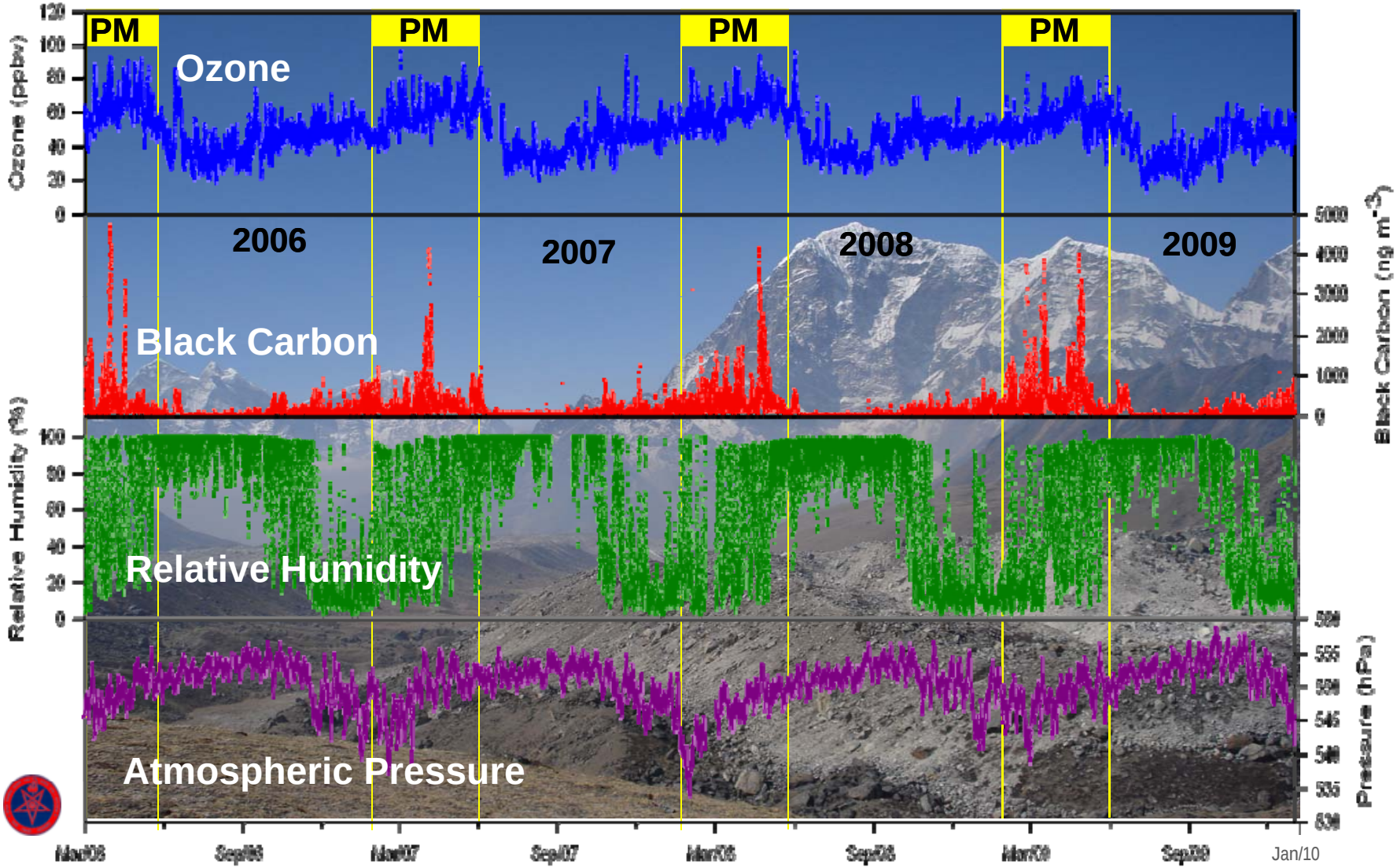
If Mountains are barometers of climate change, stations at high altitude constitute the essential scientific instruments to observe and evaluate these changes

http://evk2.isac.cnr.it

Nepal Climate Observatory @ Pyramid

GAW Global station (5079 m)

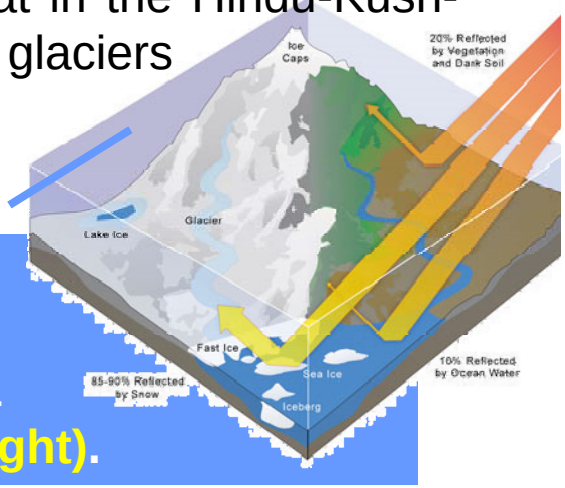
2006 - 2010



http ://evk2.isac.cnr.it/

Not only warming:
BC deposition on snow/ice surfaces

Deposition of black carbon is a major driver of glacial retreat in the Hindu-Kush-Himalaya-Tibetan region, and its impact on melting snow and glaciers may equal the impact of increased atmospheric CO_2
(*ABC Regional assessment, 2008*) *Ramanathan and Carmichael, 2009).*



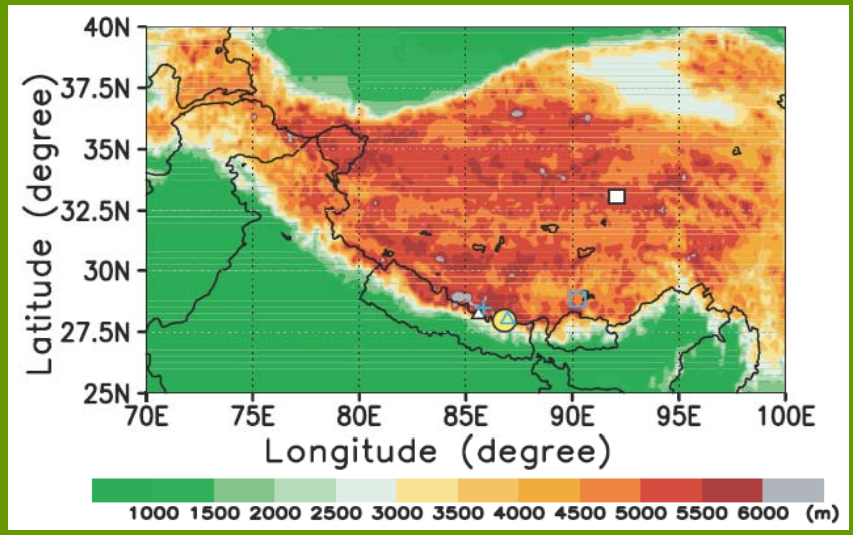
Albedo is defined as the ratio of total-reflected to incident radiation. It is a unitless **measure indicative of a surface's diffuse reflectivity**. (Albedo, derived from Latin Albus "whiteness").

The range of possible values is from 0 (dark) to 1 (bright).

OBSERVATIONS at NCO-P:

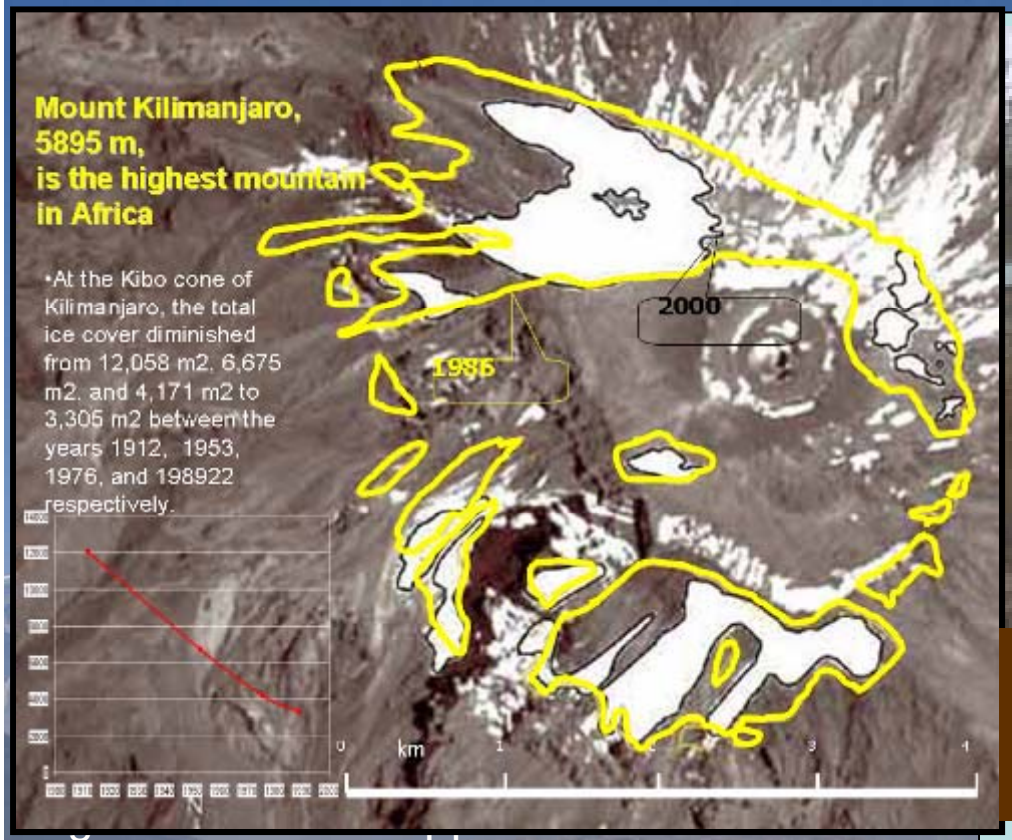
Starting from BC concentrations measured at NCO-P in pre-monsoon season was estimated:

- **2 – 5.2 % snow albedo reduction**
- **an increase of 24 % of the seasonal runoff from a typical Tibetan glacier.**



[Yasunari et al., Estimated impact of black carbon deposition during pre-monsoon season from NCO-P data and snow albedo changes over Himalayan glaciers, 10,6602-6615, ACP, 2010]

Climate Change: Glaciers and Water Towers threat



In Africa, the ice cap on the summit of Mount Kilimanjaro has dwindled down by 82% over the past century.

Yuni Condoriri glaciated mountain system, disappeared in 2009.

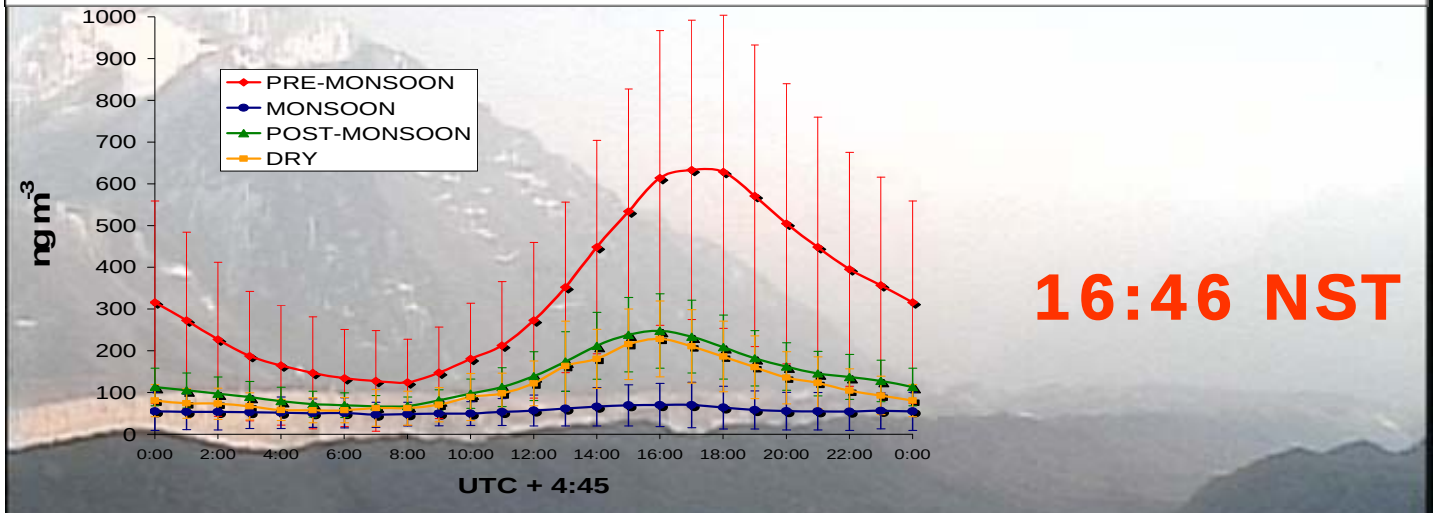
More than **1.4 billion people** depend on water from the Indus, Ganges, Brahmaputra, Yangtze, and Yellow rivers. **Meltwater** is extremely important in the **Indus** and important for the **Brahmaputra** basins that are most susceptible to reductions of flow, threatening the food security of an estimated 60 million people. The Indus is critical to Pakistan's food and water security - more than three-quarters of Pakistanis live in the Indus basin and its water irrigates 80% of the nation's cropland." *(Earth Policy Institute 2008).*

How BC & O_3 can reach the high mountains: OBSERVATIONS at NCO-P

Atmospheric Brown Clouds in the Himalayas

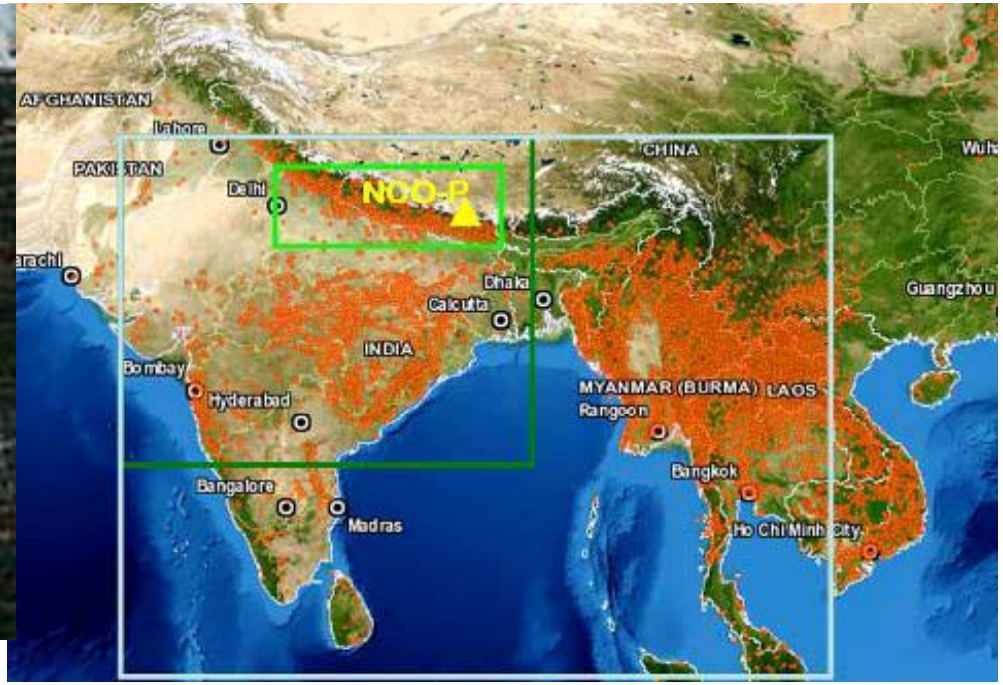
	Pre-Monsoon	ABC hotspots	
BC (ng m^{-3})	316.9±342.9	1974.1±896.1	+522%
Scattering coefficient (Mm^{-1})	11.9±10.5	57.7±28.2	in respect to seasonal values
PM_1 (µg m^{-3})	3.9±4.0	23.5±10.2	
Coarse (cm^{-3})	0.37±0.37	0.64±0.33	
O_3 (ppbv)	60.9±8.4	69.2±10.4	+14%

P. Bonasoni et al.: Atmospheric Brown Clouds in the Himalayas
Atmos. Chem. Phys., 10, 7515–7531, 2010



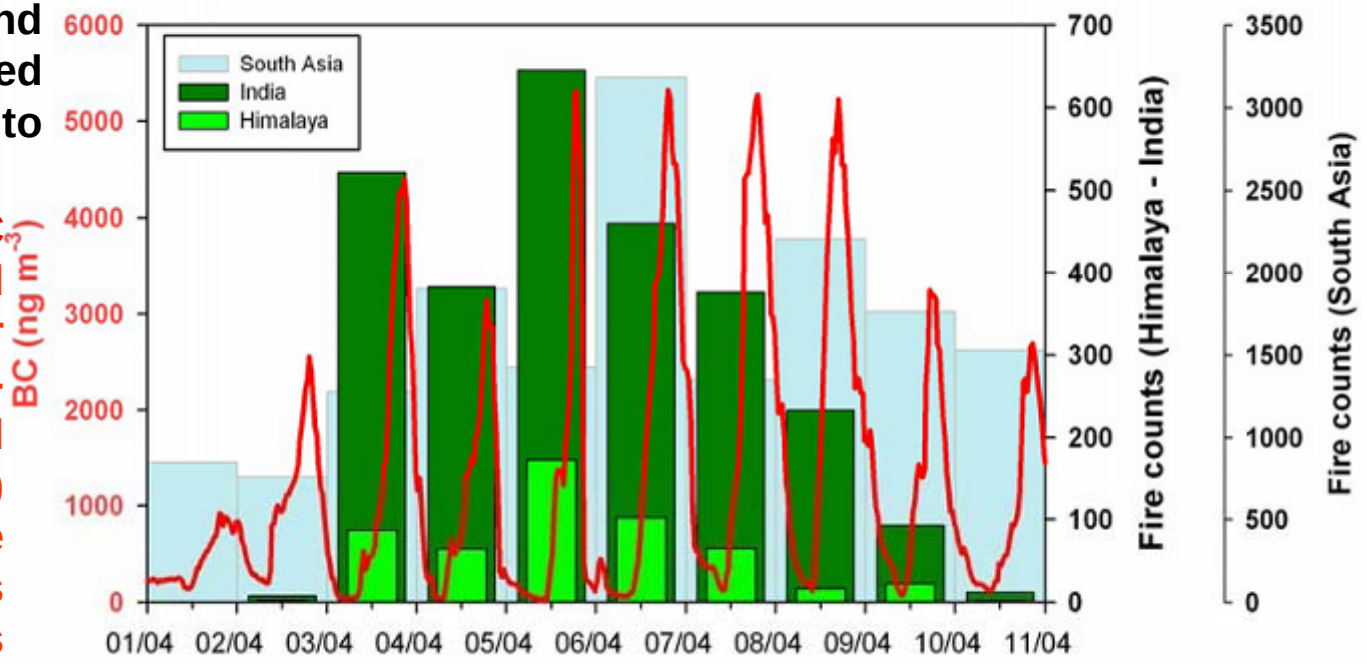
ACUTE POLLUTION EPISODE OF APRIL 2010 OBSERVED at NCO-P

A thick haze characterized by large amount of BC and fine aerosols is transported by walley wind breeze up to NCO-P and high Khumbu valley testifying the afternoon extension of the ABCs up to the high Himalayas.

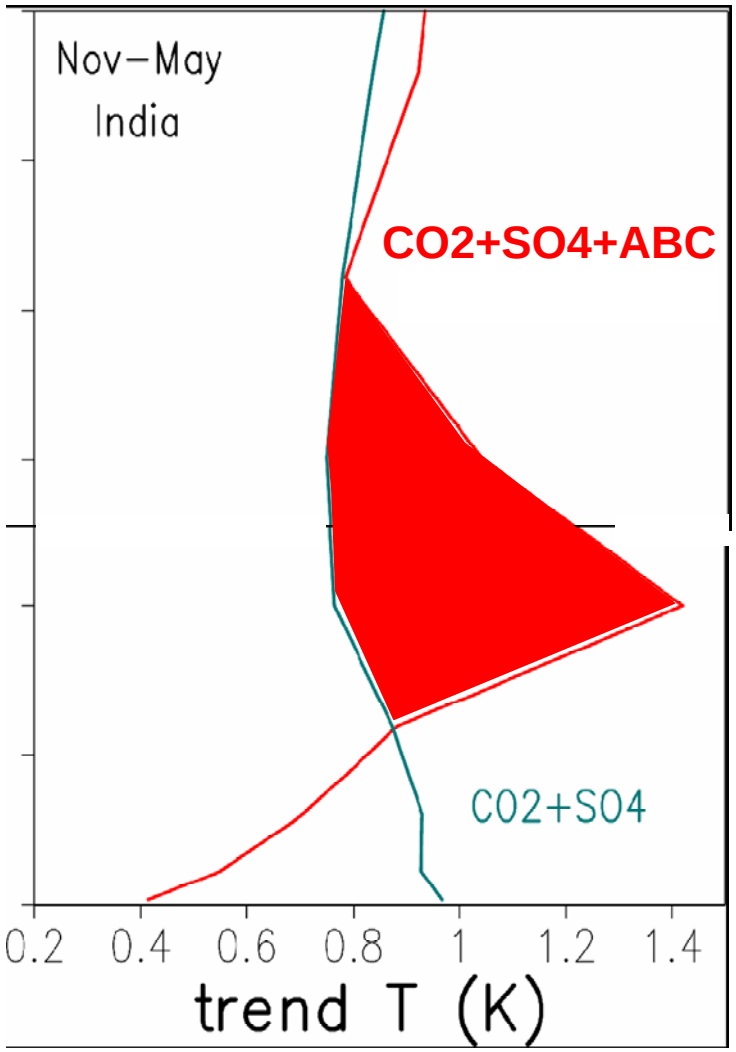


Air-masses affected by combustion emissions, rich in particulate matter and photo-chemically produced ozone, were transported to the high Himalayas.

Relationship between BC measured a t NCO-P and Hot Spot Fires over South Asia (blue), India-Nepal (green) and Himalaya (light green) indicating the source areas of biomass burning fires



Atmospheric Brown Clounds



The aerosols in **ABCs** reduce the amount of solar radiation reaching the surface and such reduction can decrease crop productivity.

?

In addition Atmospheric Brown Clouds, containing high concentration of BC and O3, increase the temperature of the atmosphere

*Estimated vertical temperature profile for the period 1950-2002 due to greenhouse gases and sulphate aerosols (CO2+SO4 curve) and that due to the addition of **ABCs** to CO2+SO4 (**ABC**+CO2+SO4) (Source: Ramanathan and others 2007).*

Not only warming:
BC emissions and health threat

Up to 90% of rural household in developing countries use **biomass fuels** in the form of wood, dung and crop residues often associated with a bad ventilation or without chimney in the houses, **especially in mountain areas in cold seasons. This produces indoor air pollution and is** recognized as a **great public health threat.**

OBSERVATIONS in the framework of SHARE

Khumbu Valley population is a particular sample

= no traffic and industry pollution

= very high indoor pollution

Indoor and outdoor pollution were measured in cooperation with the Kathmandu University.

Epidemiologic study in villages located at different altitudes: 2600-4200m. Total estimated population: 350

MEDICAL EXAMINATIONS: Spirometry, Exhaled Nitric Oxide, Exhaled air condensate (biomarkers), Electrocardiogram, Echocardiography, Urine samples (inflammation biomarkers), Eyes examination. Questionnaire

Preliminary results show a high incidence of bronchial obstruction in presence of indoor pollution. (GARD - Global Alliance Respiratory Disease)

Black carbon and ozone threats: mitigation solutions

BC and **Ozone** remain in atmosphere for period of weeks to months, instead of centuries as other GHGs, like CO2.
For these reasons reducing BC and O3 emissions provides a highly climatically-effective mitigation option.

- Make technologies to reduce BC and O3 (precursors) more accessible in order to reduce diesel emissions and to make burn biomass fuel more efficiently.
- Plan to burn a day or two before a predicted rain that will dampen the soot.
- Promote new clean-burning stove (e.g. Khairatpur, India -> SURYA Project): simple solutions can benefit on climate change and human health.

Translate scientific results in proper environmental policies supported by local governments and international agencies.

THANK YOU FOR YOUR ATTENTION

Control of short-lived pollutants black carbon and ozone offer the opportunity to actually *reduce* radiative forcing in the next decades, even if this is no substitute for the control of long-lived greenhouse gases that will ultimately be needed to stabilize temperatures (F. G Moore, 2009)

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