ICIMOD

FOR MOUNTAINS AND PEOPLE

Information series on geographical information and remote sensing systems in mountain environments

Geographical information and remote sensing systems play a special role in the Hindu Kush-Himalayan region in support for informed decision making. This series of information sheets presents information on basic technologies, approaches, and applications related to geographical information and remote sensing, and used or developed by ICIMOD, as a background for understanding for policy makers, development workers, and others.

Atmospheric Brown Cloud

Regional monitoring and assessment

The presence of an atmospheric brown cloud (ABC) over the Indo-Gangetic plains was first documented during the Indian Ocean Experiment (INDOEX) conducted in the Maldives in February 1999. In March 2001, at the request of the United Nations Environment Programme (UNEP), ICIMOD facilitated a visit by the Nobel Laureate Paul Crutzen and the ABC Project Chief Scientist, Prof V Ramanathan to Kathmandu. During the visit, an aerial survey was conducted to explore the intensity of the haze over the Hindu Kush-Himalayan region, which indicated the need for further studies. Pilot studies over the course of a year, showed the presence of a brown cloud over the Himalayan region. The initial study showed that 80 percent of the haze was composed of man-made pollutants, and that thorough follow-up investigations with long-term monitoring were needed to fully understand the phenomenon. The ABC Asia Project, for which UNEP is the Secretariat, established two monitoring stations in Nepal known as the Nepal Climate Observatories; these two observatories are managed by ICIMOD.

What is an atmospheric brown cloud?

The atmospheric brown cloud, or high level brown haze, over South and Southeast Asia is caused by air pollution, mainly sub-micron size aerosol particles, emitted from a wide range of anthropogenic and natural sources. This layer of polluted air absorbs and scatters incoming solar radiation, which has implications for regional and global climate and climate change. The cloud consists of sulphate aerosols (produced by burning fossil fuels), nitrate aerosols (from vehicular emissions), and black carbon (from the incomplete combustion of diesel fuel, burning biomass, and cooking with solid fuels). These pollutants have mixed effects; the sulphates and nitrates reflect sunlight back into space and cool the atmosphere, but the black carbon particles act as a low albedo blanket that absorbs solar radiation and produces a heating effect. The presence of carbon dioxide (CO_2) also causes warming, but the mechanism is different – greenhouse gases like CO_2 warm the atmosphere by preventing long-wave infrared radiation from leaving the Earth and going back into space.

ABC and climate change

Atmospheric pollution, and 'brown clouds' in particular, are major contributors to climate change in the Hindu Kush-Himalayan region and beyond. In this region, brown clouds are a relatively localised phenomenon that is typically seasonal: during the four to eight months dry season of the monsoon cycle there is no rain to wash pollutants from the air with the result that a brown haze clouds the sky.

The brown clouds can weaken the subsequent monsoon circulation and decrease monsoon rainfall by changing the properties of cloud droplets. As aerosol concentrations increase, the water in the cloud disperses over more particles causing droplet size to decrease. Smaller particles fall more slowly and can extend the cloud's lifetime thus reducing or shifting rainfall patterns. The extent to which carbon particle aerosols contribute to the solar heating of the atmosphere is suspected to be as important as the contribution made by greenhouse gases – especially in explaining the anomalously large warming trends observed in elevated regions like the Himalayas. When the snow and ice of high mountain areas are covered by carbon particles, the albedo is lowered and they reflect less (and absorb more) solar radiation. Prof V Ramanathan reports that there is an increasing acceptance of this theory and that carbon particulates are now regarded as one of the major contributing factors causing accelerated glacial melting in the Hindu Kush-Himalayan region.

What are aerosols?

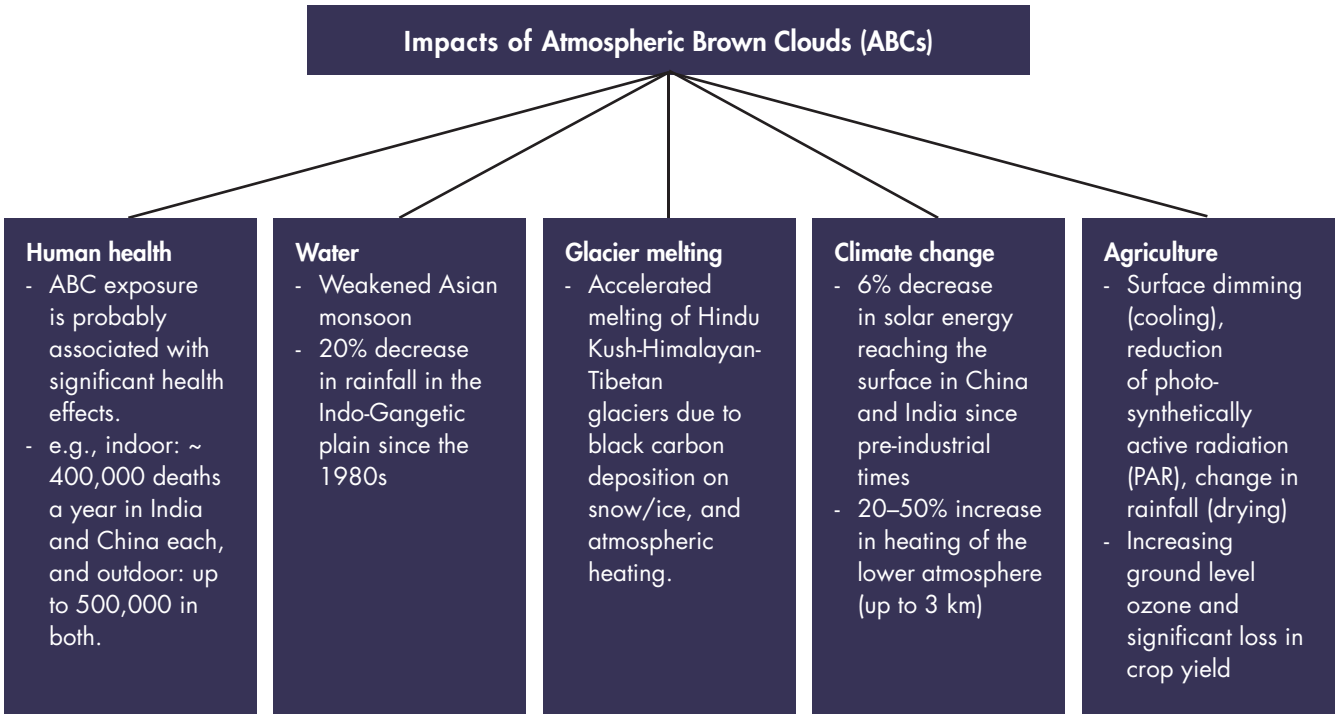
Aerosols are minute particles suspended in a gas. Atmospheric aerosols – particles suspended in the earth's atmosphere – can be solid and/or liquid and produced by natural processes (e.g., volcanoes) or by human industrial and agricultural activities (e.g. soot, sulphates, and nitrates). Depending on their composition, aerosol particles can reflect or absorb incoming energy from the sun and thereby modify how much energy clouds reflect. In so doing, they can change atmospheric circulation patterns – in short, aerosols can modify our climate.

What is haze?

Haze is an atmospheric phenomenon in which dust, smoke and other tiny dry particles suspended in the atmosphere obscure the clarity of the sky. At high concentrations, these particles scatter and absorb sunlight, resulting in diminished horizontal visibility and give the atmosphere a characteristic opalescent appearance.

Global distribution of atmospheric brown clouds

By combining sampling information on atmospheric brown clouds with new satellite observations and chemistry transport models, scientists have been able to produce global maps showing regional hotspots, and to make preliminary predictions of their impacts on regional climate. The major regional hotspots are the Indo-Gangetic plains in South Asia, Southern Africa, East Asia, and the Amazon Basin, although the problem is by no means confined to these areas.

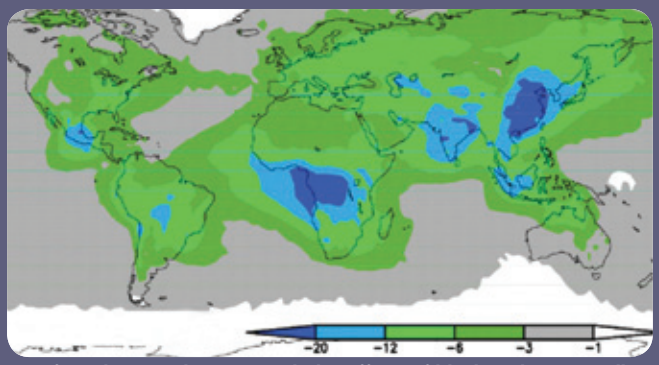


Climate observatories in the Hindu Kush-Himalayan region

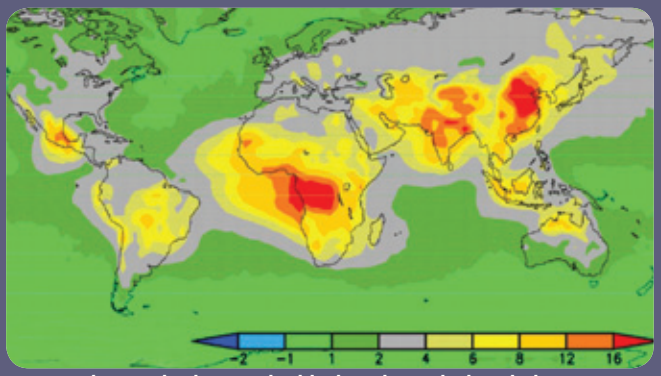
The ABC Asia Project, for which UNEP is the Secretariat, aims to study the major environmental challenges in Asia over the coming years by investigating the consequences that black carbon, aerosols, and other air pollutants can have on the climate and the environment. There are six major components: observation, impact assessment, mitigation, glacier melting, knowledge management, and an ABC policy forum.

ICIMOD is participating by hosting two monitoring stations, the Nepal Climate Observatories, which support a focus on the Himalayan region. The observatory housed at ICIMOD's headquarters in Khumaltar monitors radiation and aerosols; and the observatory housed at ICIMOD's Godavari Demonstration and Training Centre records rainfall and aerosol measurement. The Italian National Research Council's Ev-K2-CNR hosts a further observatory in Nepal at its Pyramid Laboratory situated in the high Himalayas at the base of Mount Everest. Together, the data gathered at these observatories will allow scientists to investigate the transport of air pollutants across the Himalayas.

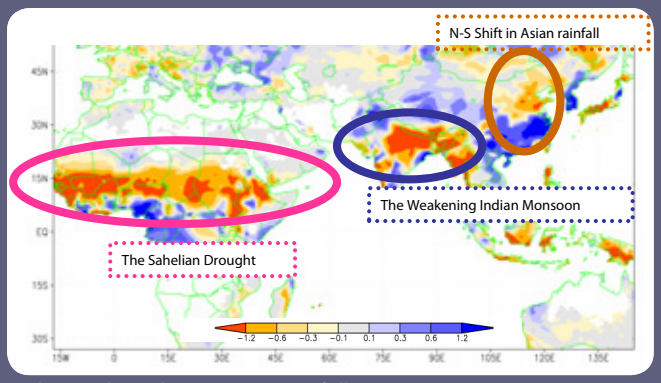
Studies carried out by ICIMOD at low altitudes near urban centres showed a large concentration of particulates and substantial aerosol loading in the atmosphere during the dry season when forest fires are a major contributing factor. Data recorded in the pristine environment of the Pyramid Laboratory in the high Everest region showed the mean monthly black carbon concentration for the year 2007 to lie between 20 and 400 ng/m^3, suggesting that even high mountains can be affected by local, regional, and long range transportation of polluted air masses, particularly during the dry season.



Surface dimming by ABCs includes effects of black carbon as well as other aerosols



Atmospheric solar heating by black carbon which includes absorption by organics



Observed trends in summer rainfall (1950-2002)

Source: UNEP (2002) Atmospheric brown clouds, Regional assessment report with focus on Asia. Nairobi: UNEP

Sun tracker and pyranometers

Medium volume sampler

Automatic weather station

Wet only collector (plastic and glass)

Regional capacity building initiative

Satellite observations show that atmospheric brown clouds are transboundary, transcontinental, and transoceanic and that they can spread to cover large parts of a continent or an ocean basin within a few days. The challenge in the Hindu Kush-Himalayan region is, as described in the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report, that the region is effectively a 'white spot' in terms of data, with almost no consistent long-term data. In one of the most underdeveloped and impoverished areas of the world, there are many challenges to collecting long-term monitoring data. A necessary first step is to develop regional capacity to support regional resources for research.

Regional capacity building under the ABC programme will

- facilitate the training of regional students and postdoctoral researchers to promote scientific research: this work can involve monitoring and modelling climate, investigating the long-term effects of pollution on agriculture and health, and studying air pollution-related policy issues;
- improve regional capacity to monitor the different manifestations of climate change; and
- encourage scientific exchange between Asia, Europe, and the USA.

The ABC programme will develop several regional resources including

- a regional training and calibration centre
- an Asian climate modelling centre
- an integrated data centre which can compile and correlate information on climate, agriculture, public health and other related data
- a regional climate-ecology systemic response model

ABC project monitoring sites

Maldives Climate Observatory - Hanimaadhoo (MCO-H)
Maldives Climate Observatory - Gan (MCO-G)
Indian Climate Observatory - Pune (ICO-P)
Indian Climate Observatory - Kharagpur (ICO-K)
Nepal Climate Observatory - Godavari (NCO-G)
Nepal Climate Observatory - Pyramid (NCO-P)
Thailand Climate Observatory - Phimai (TCO-P)
Japan Climate observatory - Okinawa (JCO-O)
Korea Climate Observatory - Gosan (KCO-G)
Pacific Climate Observatory - Momote (PCO-MT)
Pacific Climate Observatory - Midway (PCO-MW)
Pacific Climate Observatory - Mauna Loa (PCO-ML)
National Atmospheric and Climate Obs. - Trinidad Head (NACO-T)

Looking ahead

With the successful establishment of a network of atmospheric brown cloud observatories, the formation of impact assessment groups, and the initiation of impact assessment studies, the ABC Programme has successfully completed Phase 1. A solid foundation has been laid for Phase 2, which will encompass long-term monitoring in the Hindu Kush-Himalayan region, expansion to other regional hotspots, comprehensive and scientific impact assessment studies, the dissemination of findings, and the initiation of policy dialogue.

For further information contact

Bidya Banmali Pradhan: bbanmali@icimod.org
Pradeep Dangol: pdangol@icimod.org
Suyesh Pradhan: suypradhan@icimod.org

Photos: Pradeep Dangol, Bidya Banmali Pradhan

International Centre for Integrated Mountain Development
GPO Box 3226, Kathmandu, Nepal
Tel +977-1-5003222 **email** info@icimod.org **web** www.icimod.org

Prepared by ICIMOD Publications Unit, September 2010