



2017
Guangzhou

Linking Atmospheric Pollution to Cryospheric Changes over “*The Third Pole*” Region

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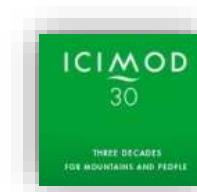
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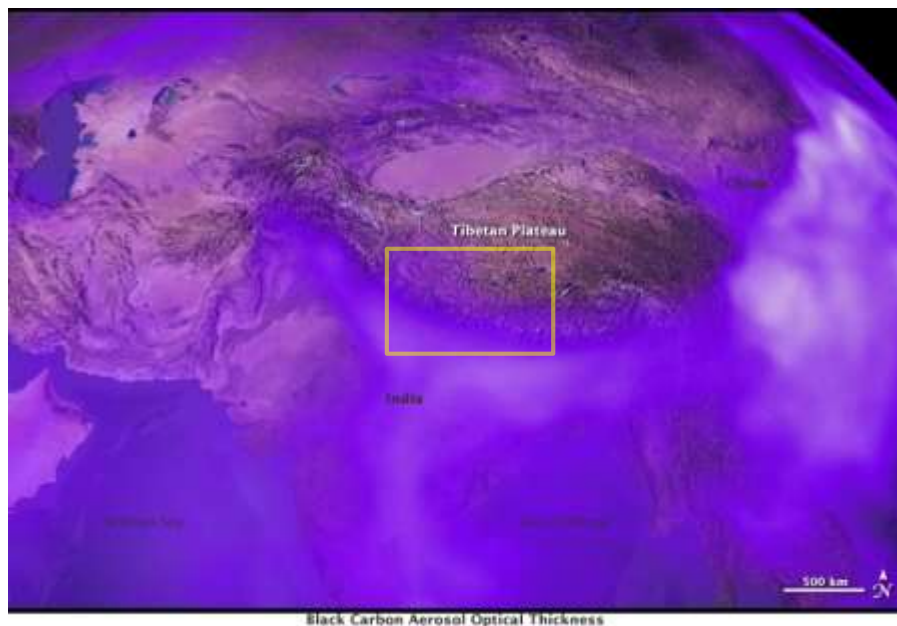


Maheswar Rupakheti

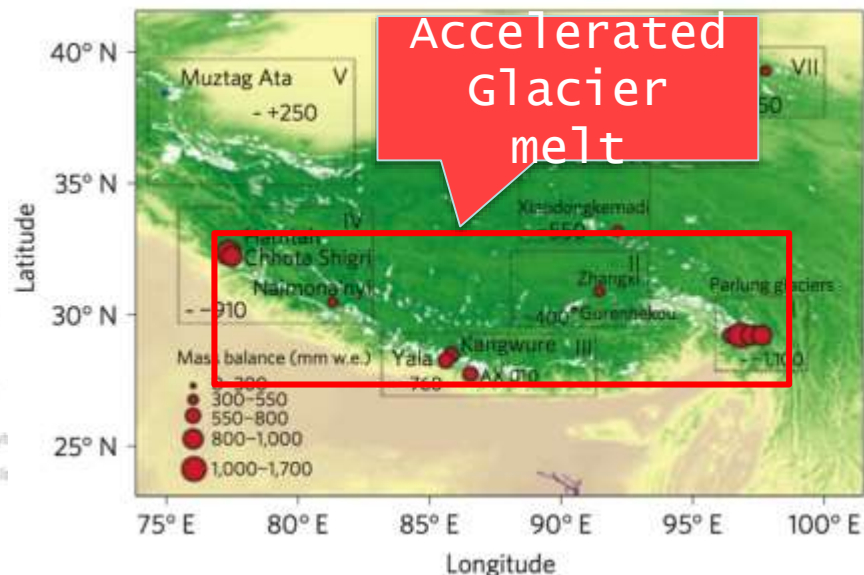
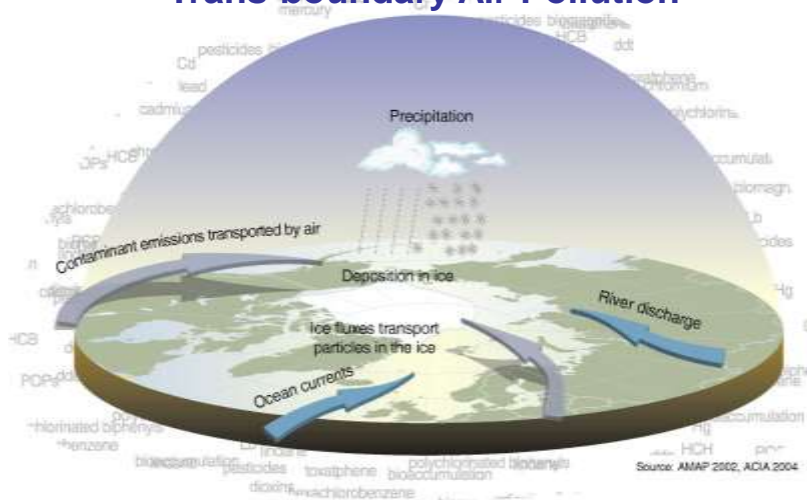


Arnico K. Panday

Air Pollution & Atmospheric Brown Clouds



Trans-boundary Air Pollution



Atmospheric Brown Clouds – Impact

Impacts of Atmospheric Brown Clouds (ABCs)

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graph TD; A[Impacts of Atmospheric Brown Clouds (ABCs)] --> B[Human health]; A --> C[Water]; A --> D[Glacier melting]; A --> E[Climate change]; A --> F[Agriculture];
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Human health

- ABC exposure is probably associated with significant health effects.
- e.g., indoor: ~ 400,000 deaths a year in India and China each, and outdoor: up to 500,000 in both.

Water

- Weakened Asian monsoon
- 20% decrease in rainfall in the Indo-Gangetic plain since the 1980s

Glacier melting

- Accelerated melting of Hindu Kush-Himalayan-Tibetan glaciers due to black carbon deposition on snow/ice, and atmospheric heating.

Climate change

- 6% decrease in solar energy reaching the surface in China and India since pre-industrial times
- 20–50% increase in heating of the lower atmosphere (up to 3 km)

Agriculture

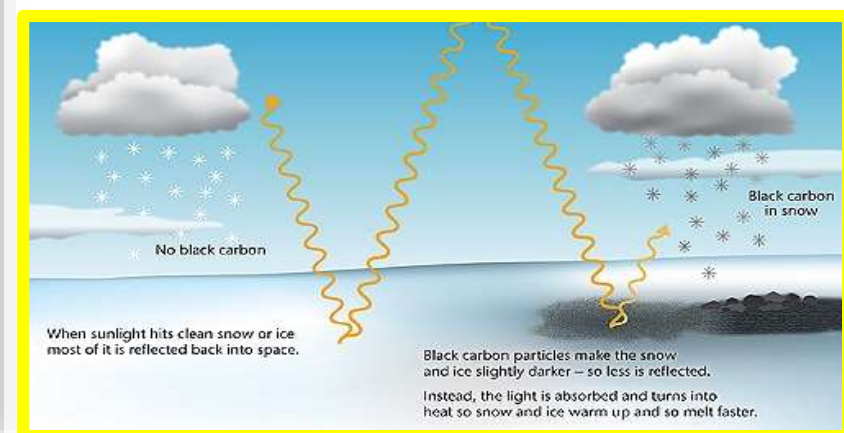
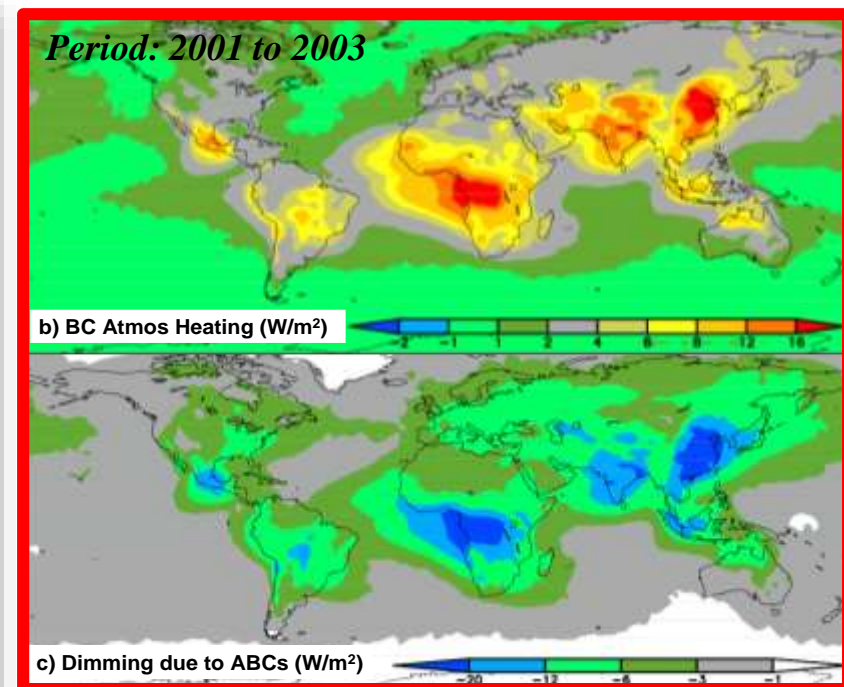
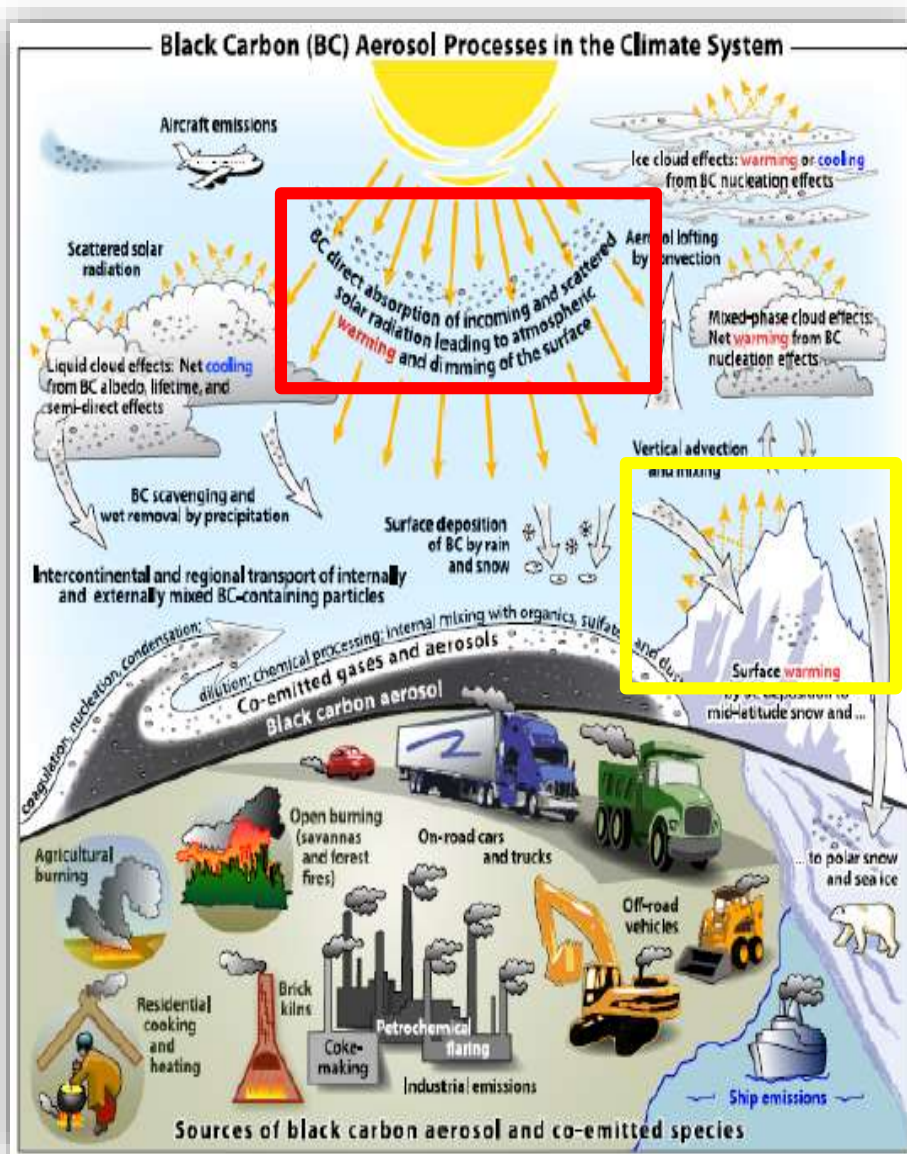
- Surface dimming (cooling), reduction of photo-synthetically active radiation (PAR), change in rainfall (drying)
- Increasing ground level ozone and significant loss in crop yield

From ICIMOD Atmospheric Brown Cloud Regional monitoring and assessment

Transport? Impact?

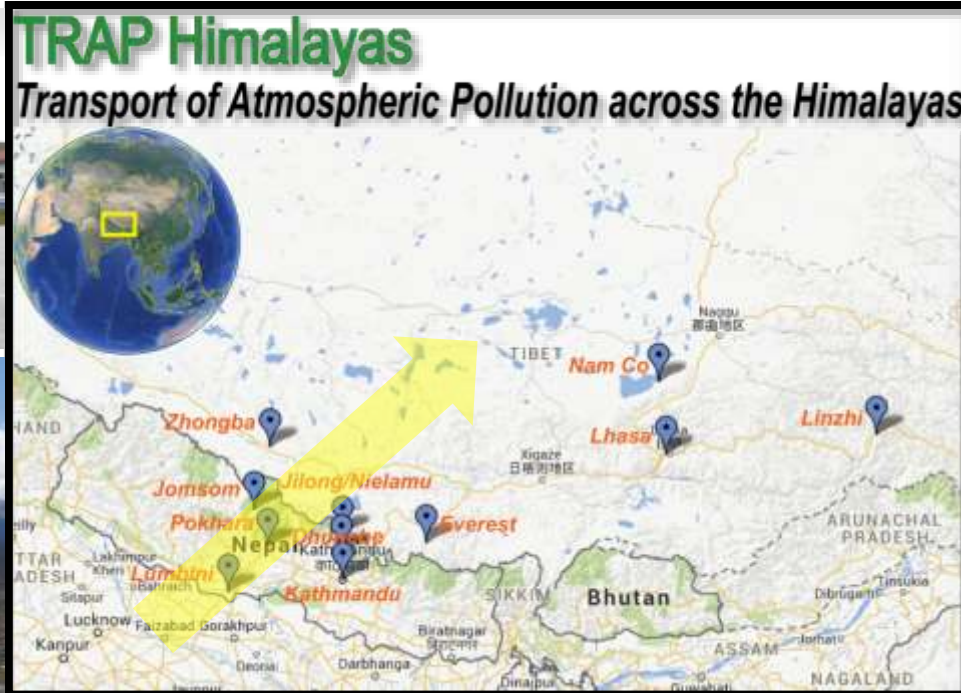


Black Carbon and Climatic Effects



Monitoring Network: A Prototype

Zhongba
仲巴



Nam Co
纳木错



Jomsom
乔姆索



Lhasa
拉萨



Lumbini
蓝毗尼



Pokhara
博卡拉



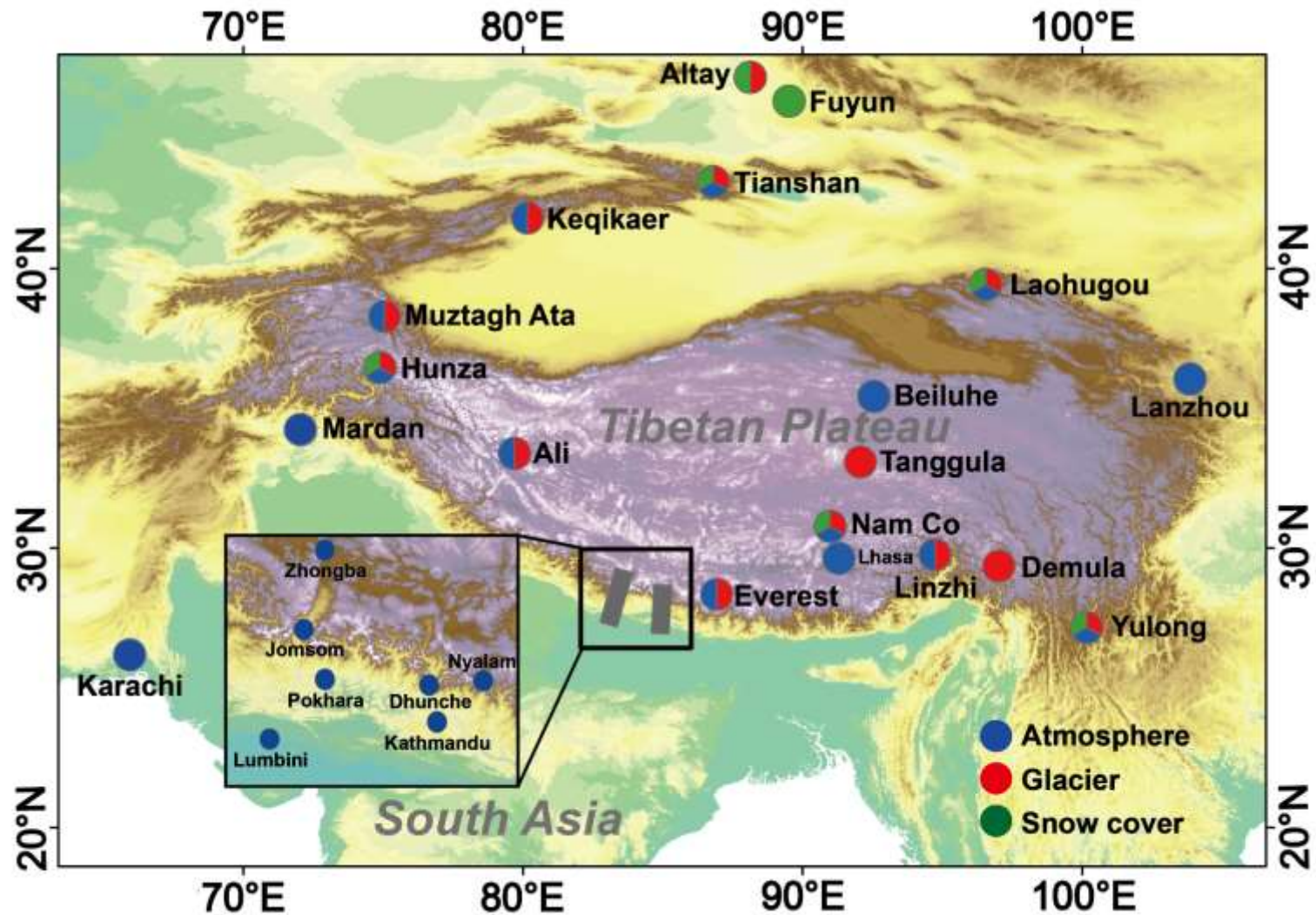
Kathmandu
加德满都



Dhunche
东启



Atmospheric Pollution and Cryospheric Change



Aerosol: 30













Glacier: 14

Snow cover: 6

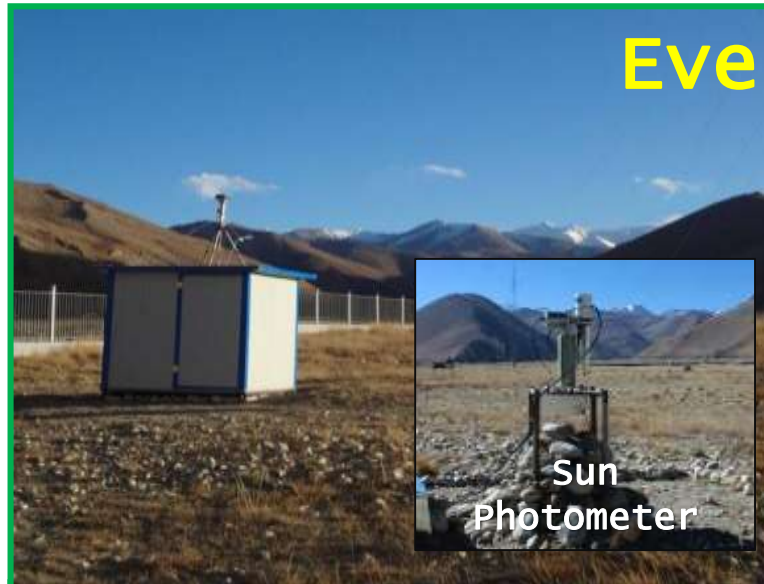
Observational parameters, instrumentation, and temporal resolution

Research content	Sampling/Observational parameters	Instrumentation	Frequency
Online measurement	Aerosol optical properties	CIMEL Sunphotometer	hourly
	Aerosol concentration: PM _{2.5} , PM ₁₀	Thermo RP1400	hourly
	Gaseous precursors: SO ₂ , NO _x , CO, O ₃ ; Toxic gas (Atmospheric mercury)	Thermo 42I, 43I, 45I, 49I analyzer; Tekran 2537	hourly
	BC	Aethalometer AE33	hourly
Filters	Total suspended particles: EC/OC, brown carbon (BrC), inorganic ions, trace element, and isotopes, and organic tracers.	TSP sampler (KC-120H)	3-6 days
Glacier & Snow cover	Snow/ice samples: Dust, EC/OC, BrC, WSOC, inorganic ions, trace element, and isotopes, and organic tracers		1-2 times per year
	In-situ Albedo	ASD Handheld 2 spectroradiometer	

Atmospheric Pollution and Cryospheric Change

<i>Logo</i>	<i>Name</i>	<i>Monitoring Content</i>
	Super Station	Meteorology, Trace Gas, Active Aerosol sampling, Passive Sampling    
	Station	Meteorology, Active Aerosol sampling, Passive Sampling   
	Site	Low resolution active sampling + Passive sampling  

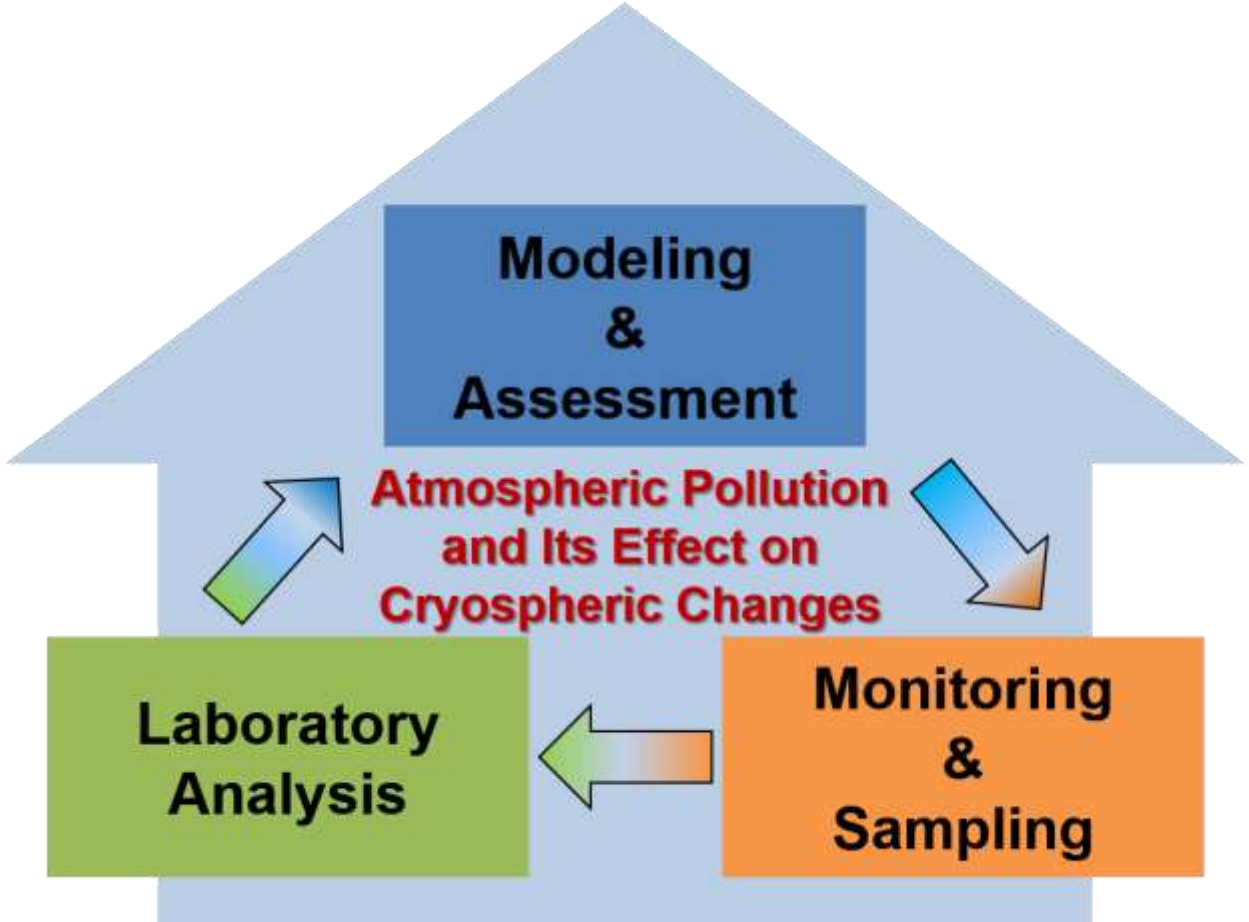
Atmospheric Pollution and Cryospheric Change



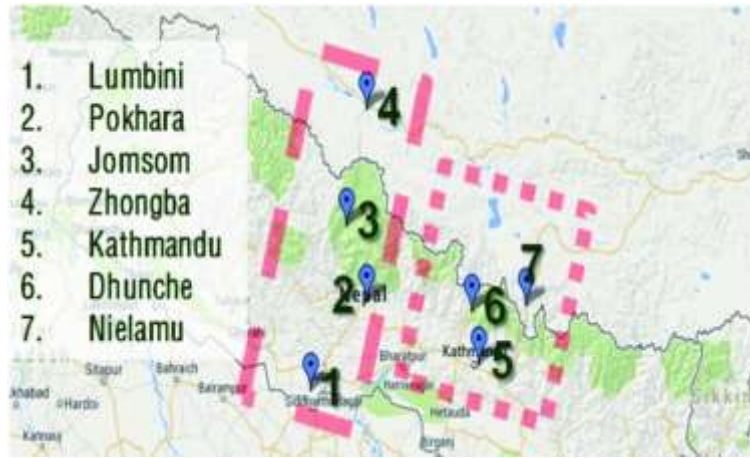
Aims and Tasks

- ❑ Characterize the chemical composition and levels of atmospheric pollutants, depict their spatial and seasonal variation over the HTP.
- ❑ Identify the sources of atmospheric pollutants and reveal the transport pathway and mechanisms of trans-boundary atmospheric pollution to the HTP.
- ❑ Investigate the role of atmospheric pollutants (deposited as LAIs) in the melting of glacier and snow cover and further quantify the contribution of LAIs to the glacier and snowpack melting. Determine the fate of environment-relevant pollutants within glacier and snowpack and their scavenging process during snow/ice melting.
- ❑ Assess the impact of atmospheric pollution on the cryospheric changes over the HTP

Basic Design



Trans-Himalayan Filters

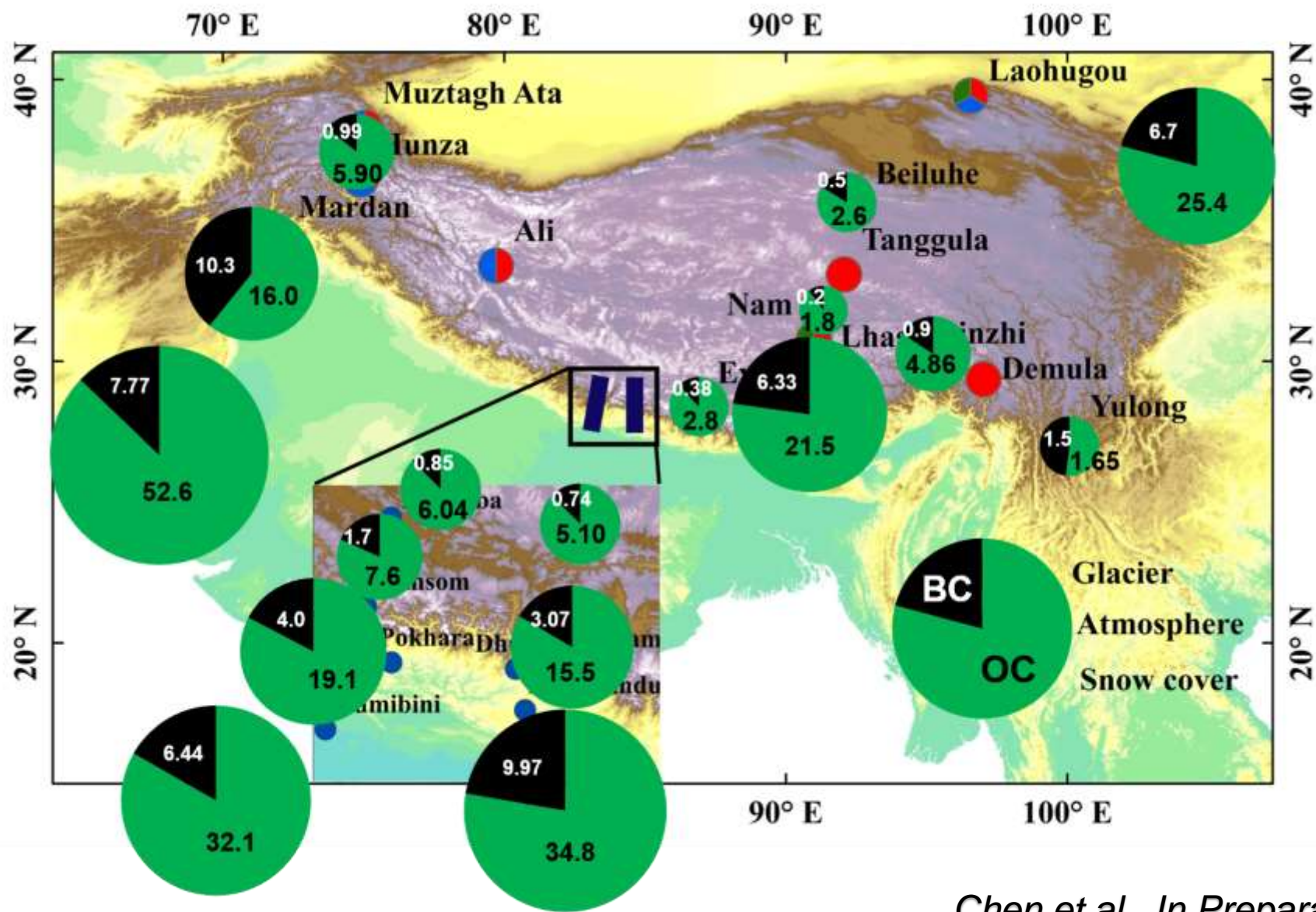


A filter sample at Kathmandu
Before VS After

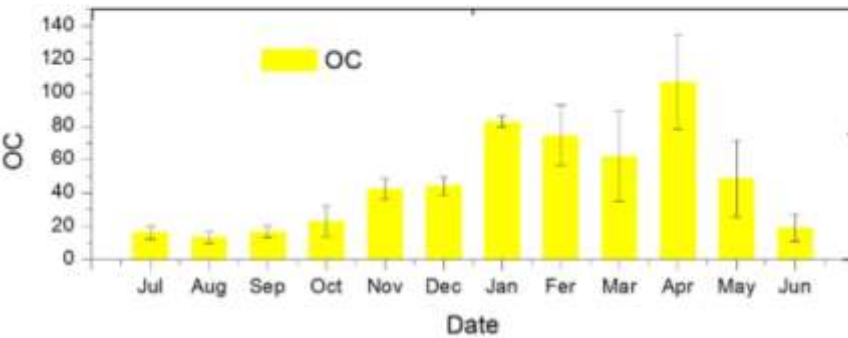
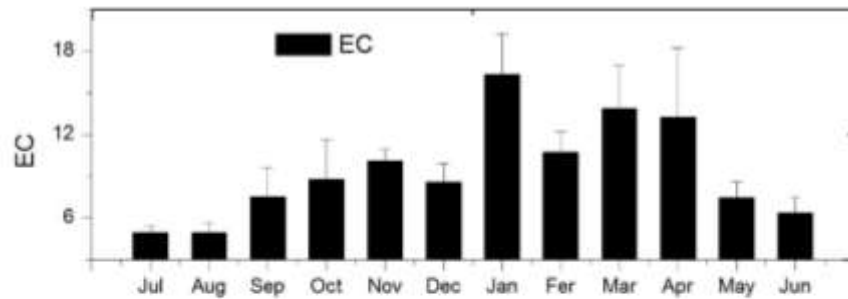


April 5-10, 2013

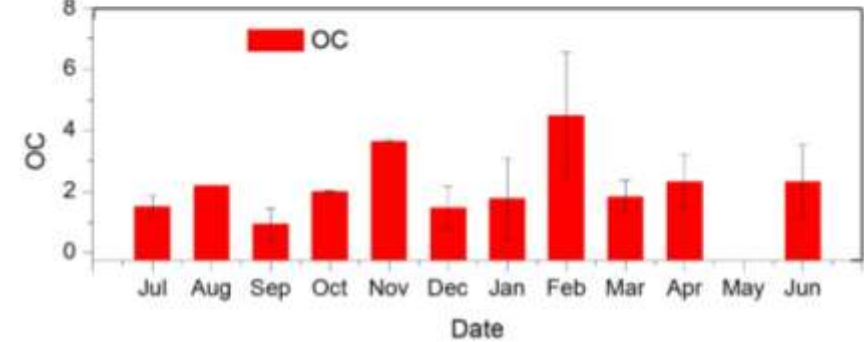
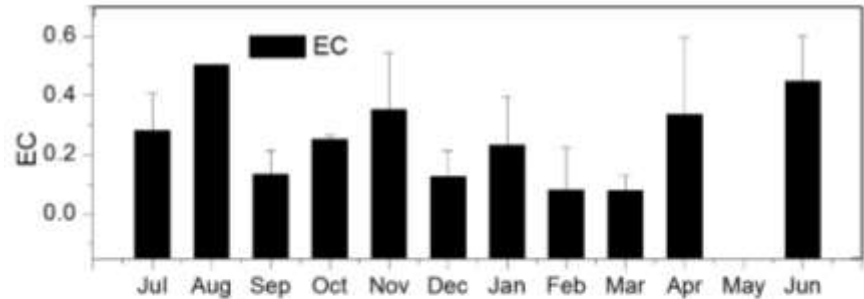
BC and OC in aerosols



Seasonal variation of BC and OC

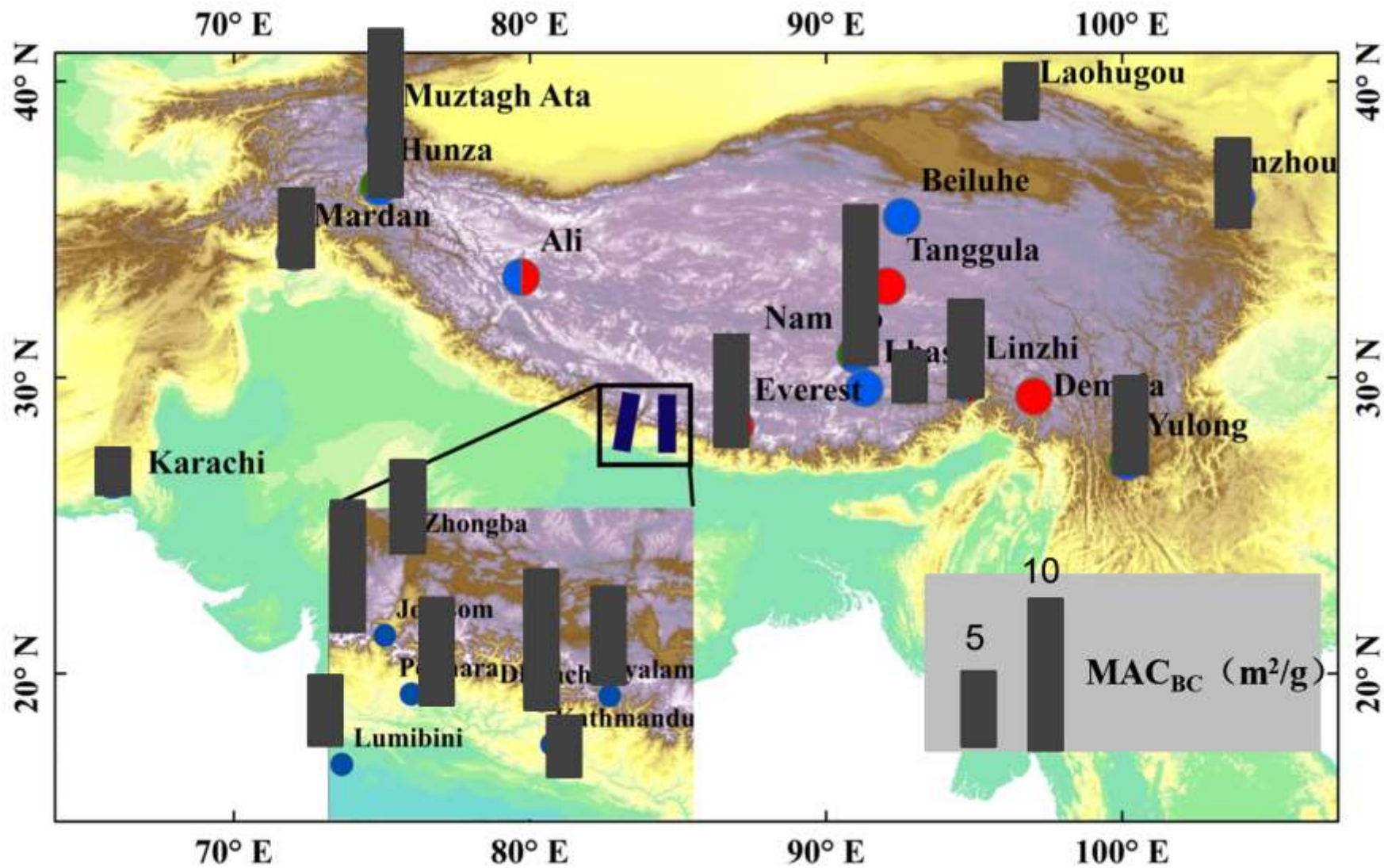


Kathmandu

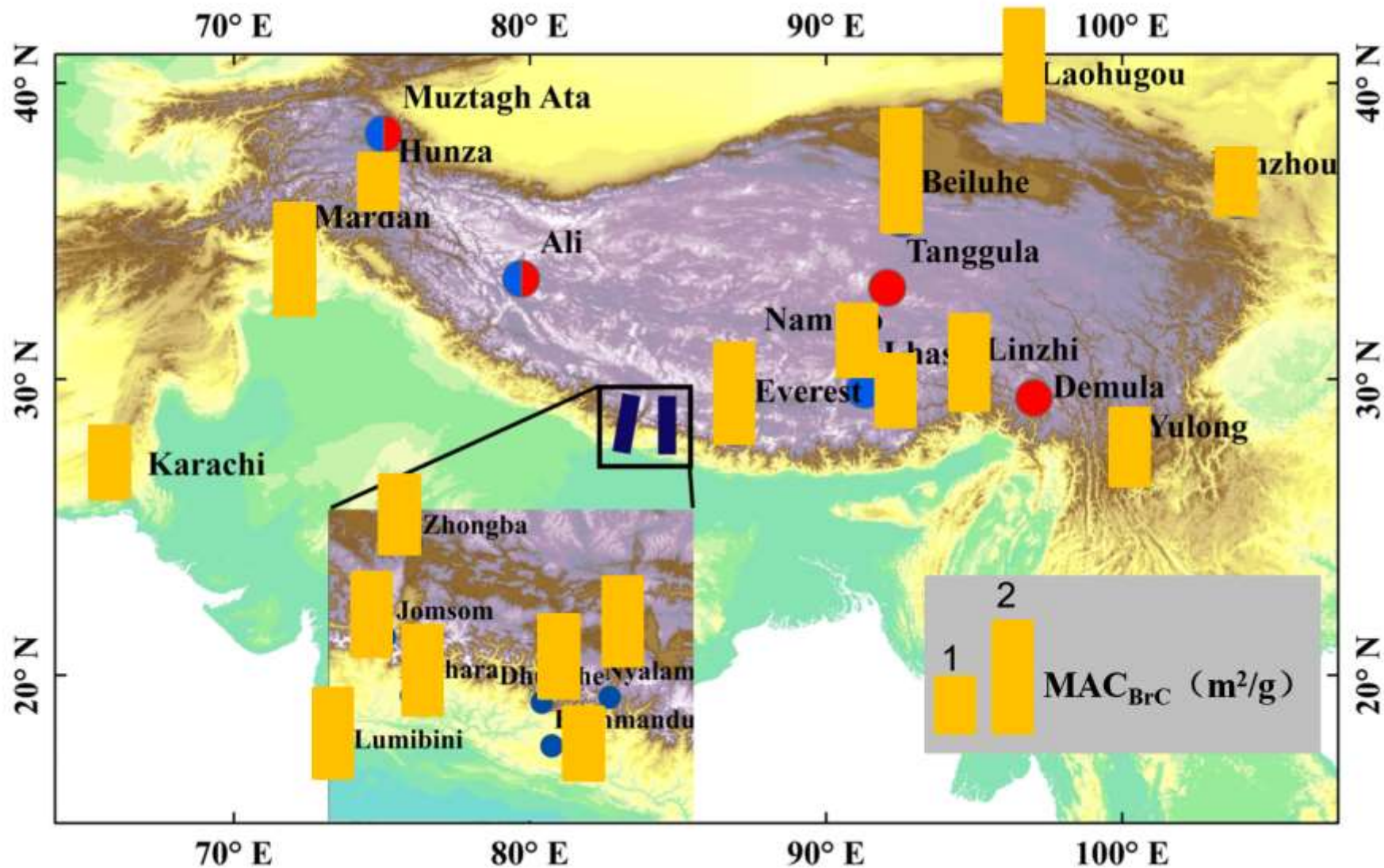


Nam Co

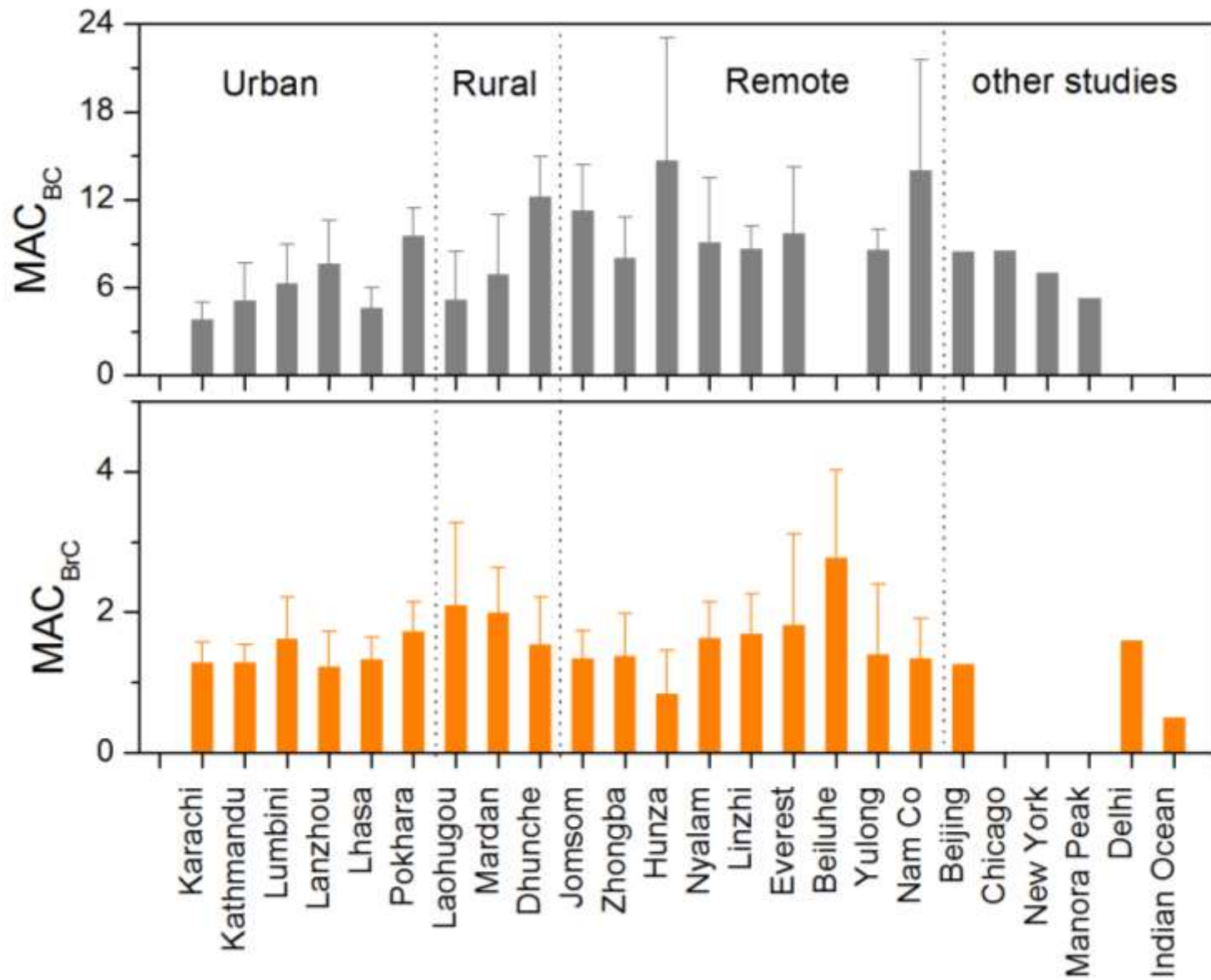
Mass Absorption Cross section (MAC): BC



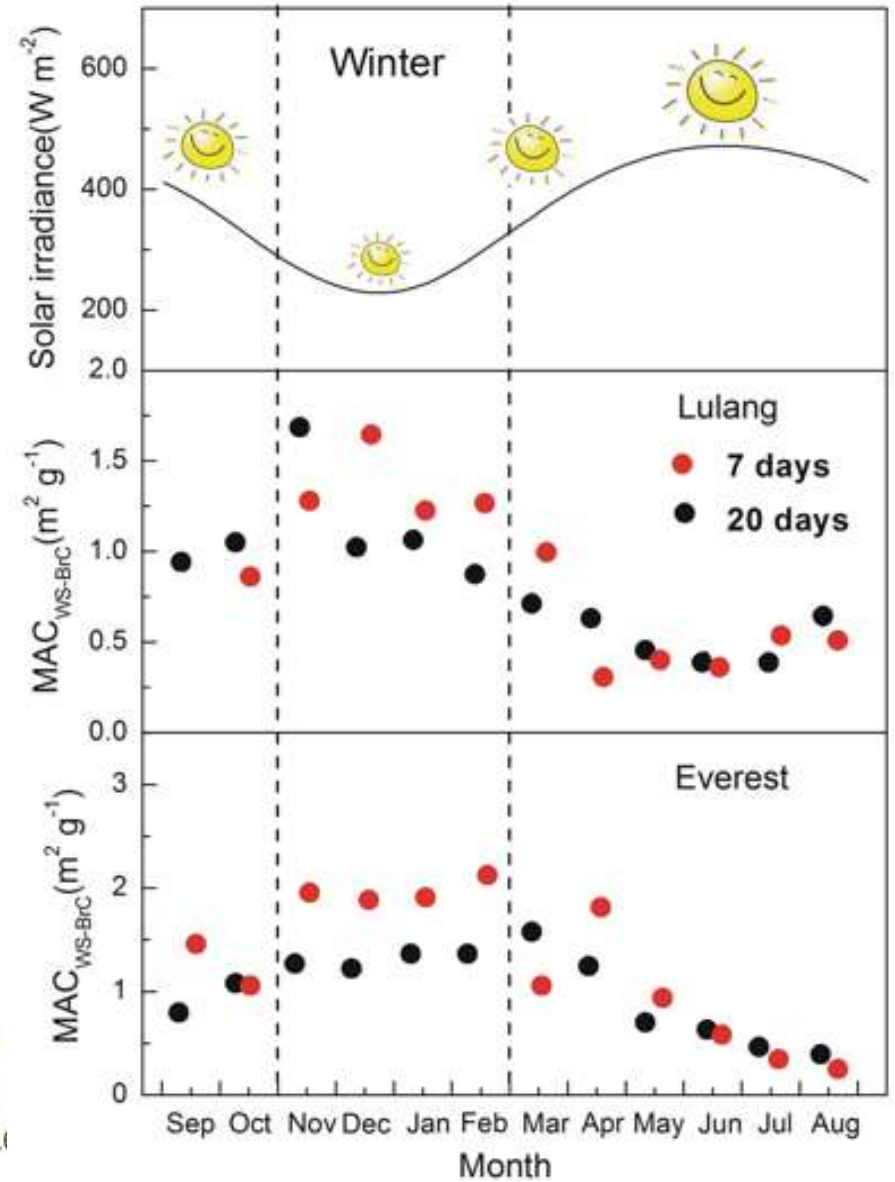
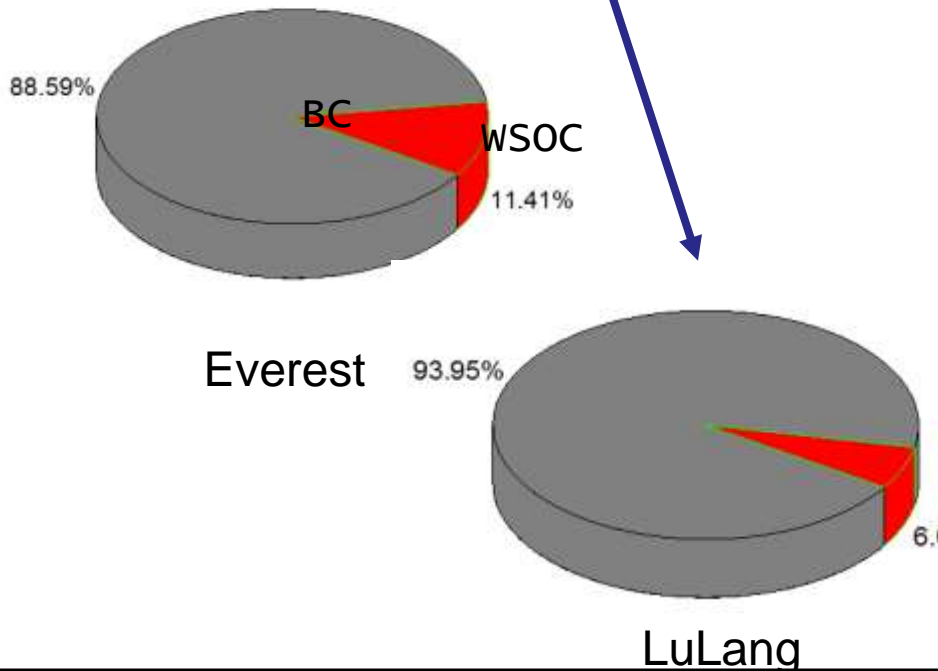
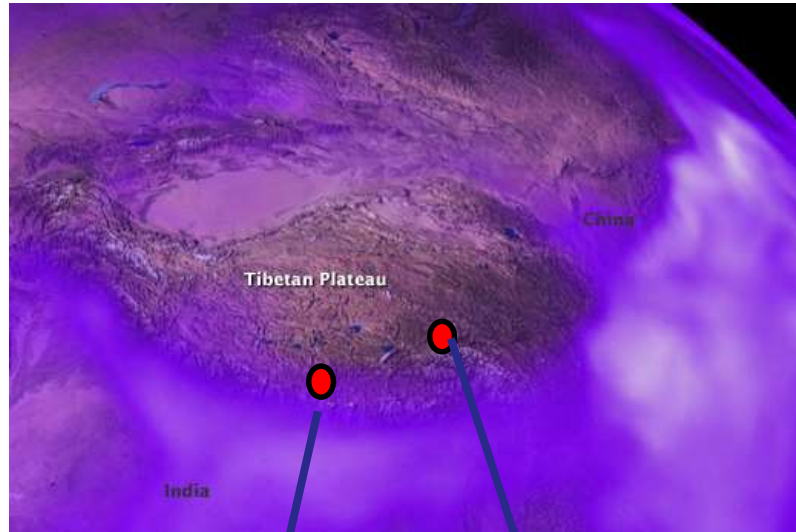
MAC-BrC



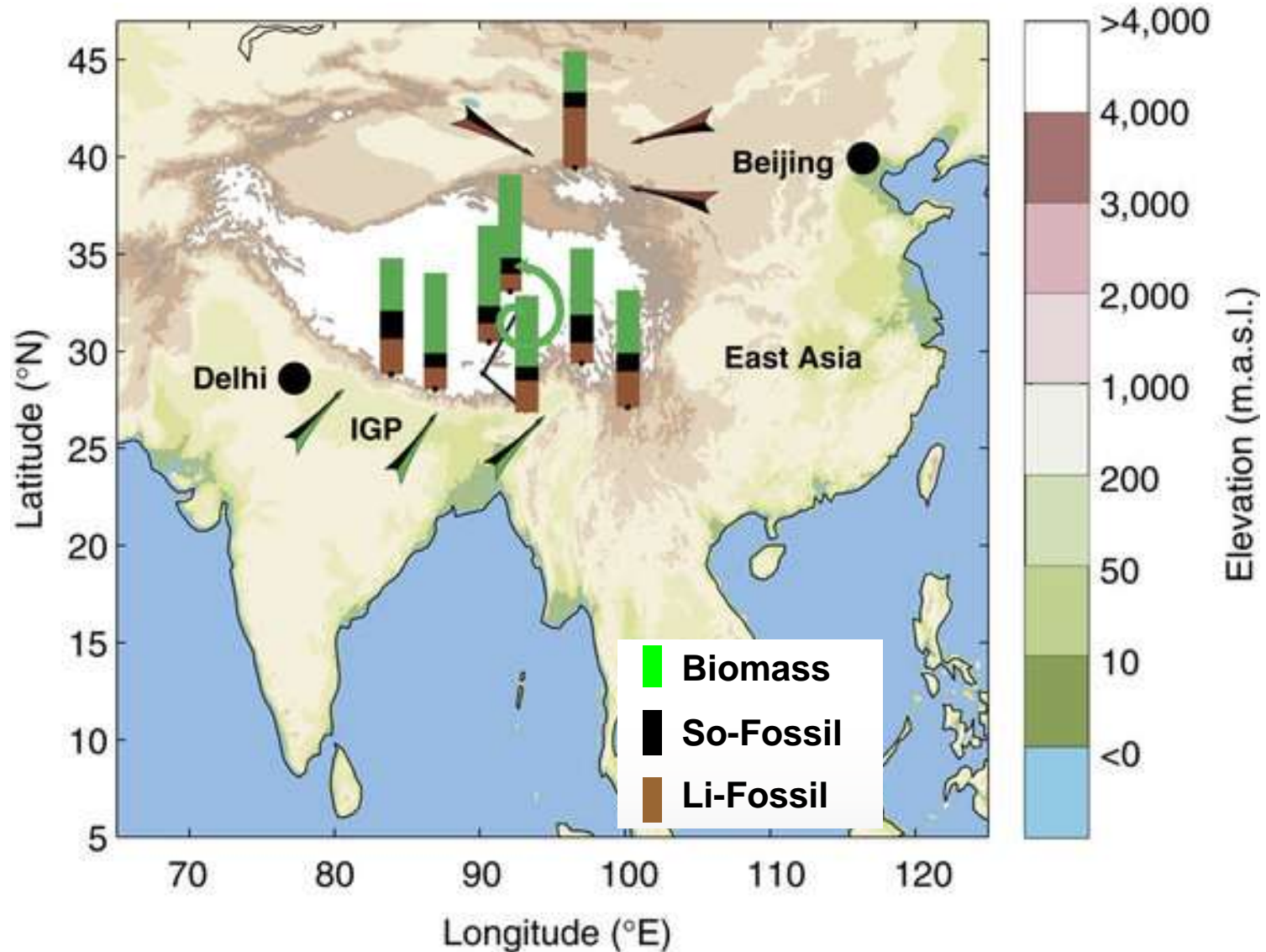
Comparison of MAC



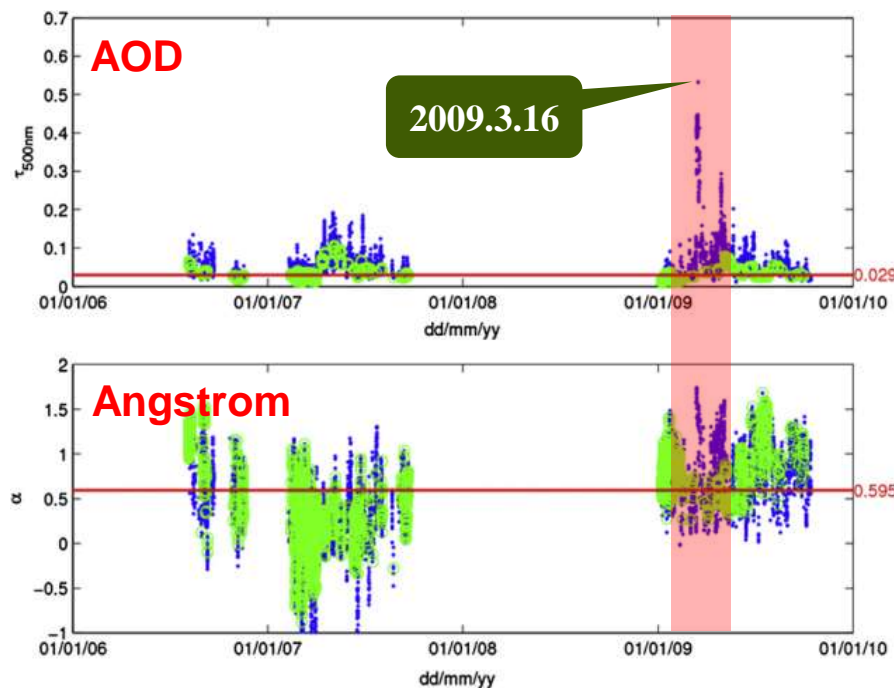
Seasonal Variation of MAC



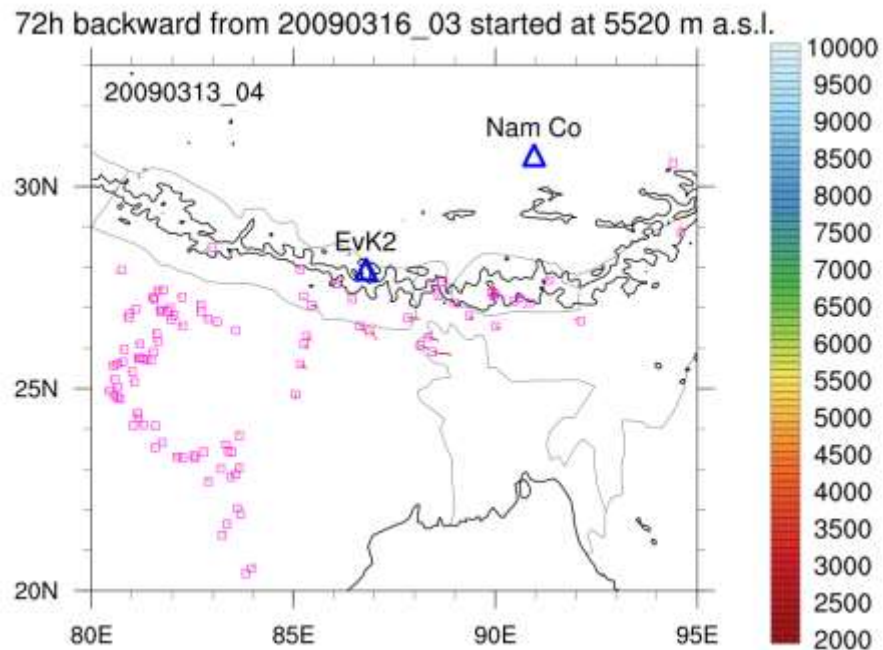
Source of BC to Glacier snow: Isotopic Signature



Trans-Himalayan Pollution Plume: An Event

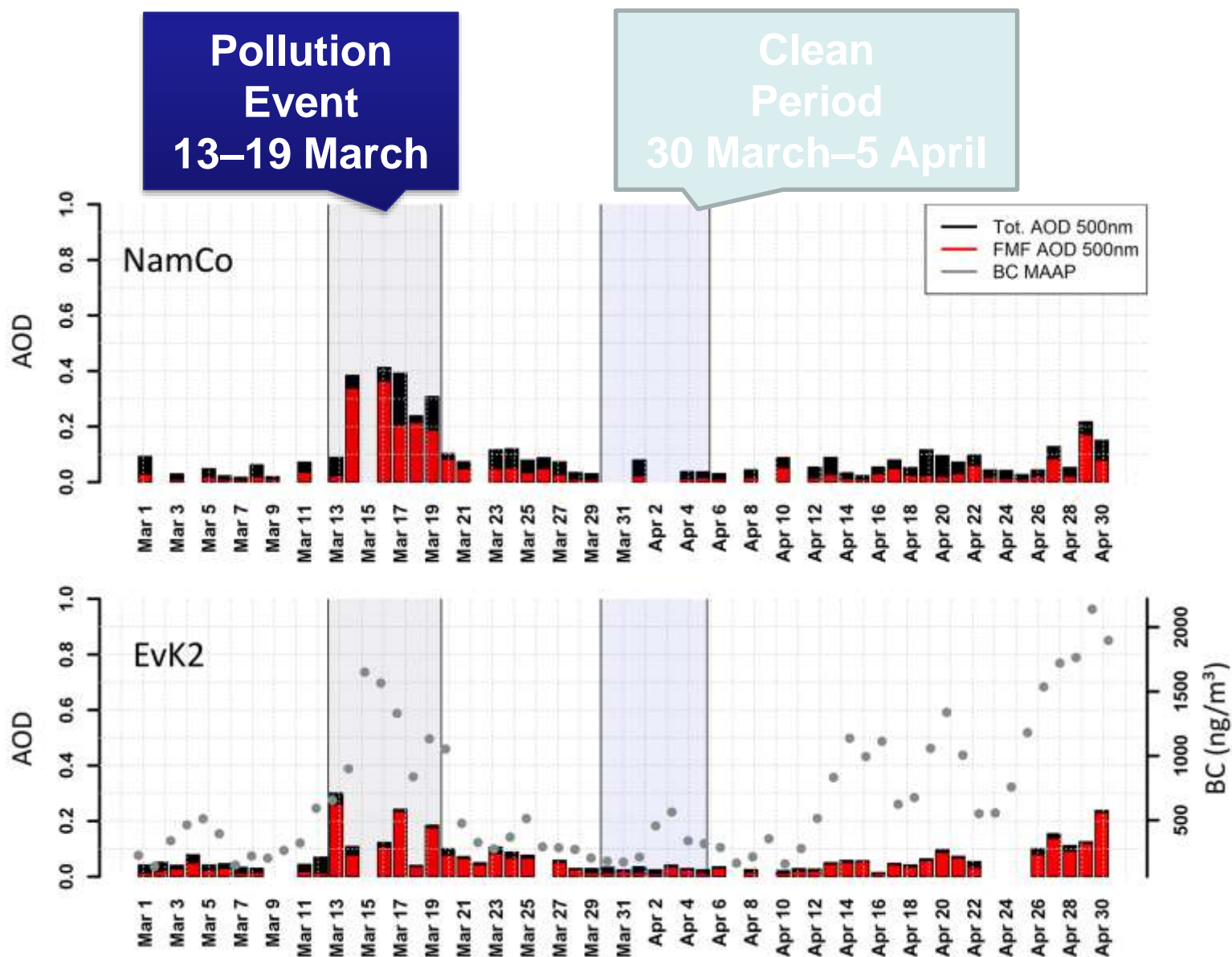


AOD at Nam Co Station



Air mass trajectories simulated by COSMO

Trans-Himalayan Pollution Plume: An Event

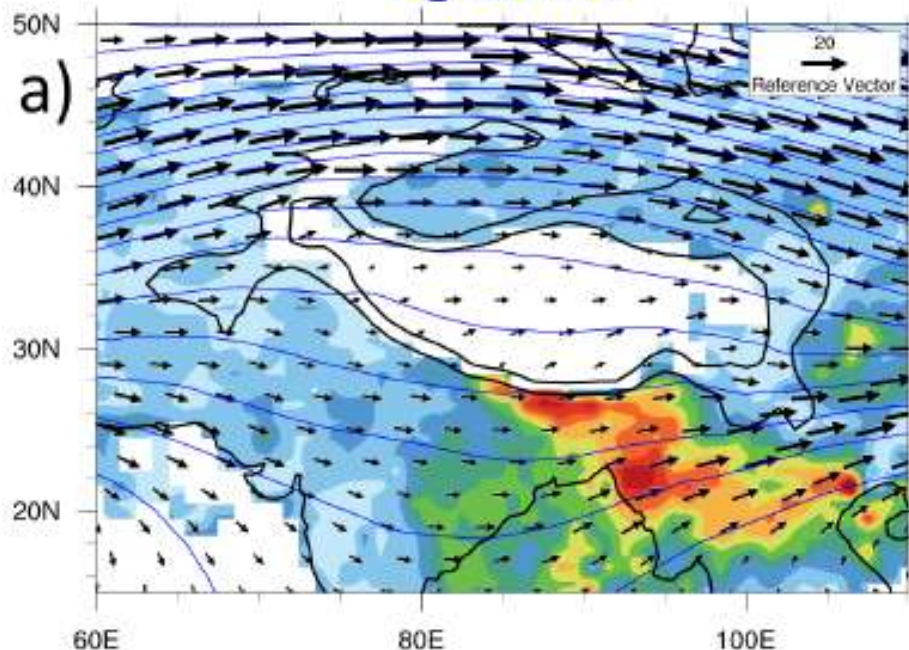


Trans-Himalayan Pollution Plume: An Event

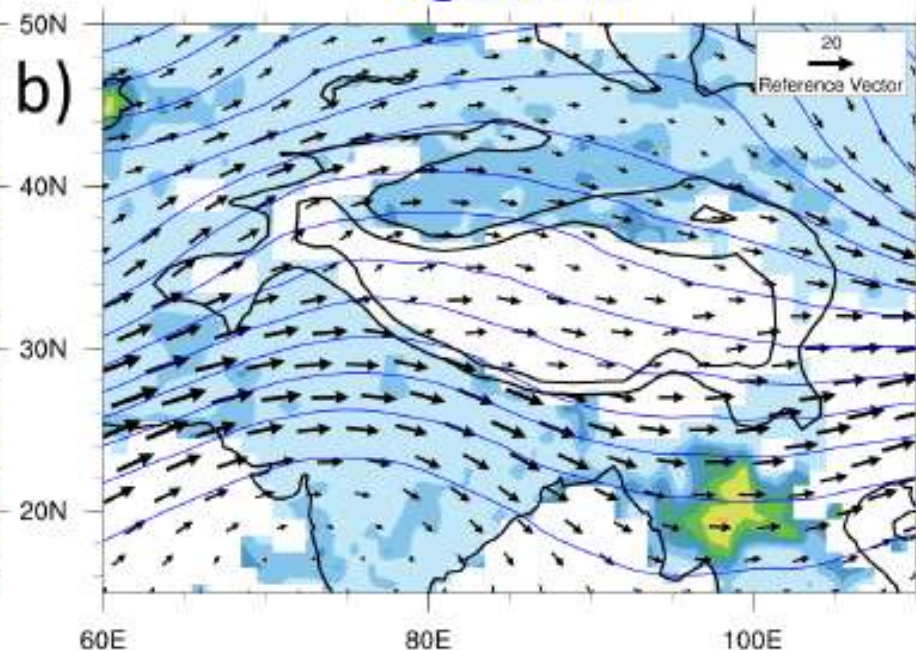
**Pollution
Event
13–19 March**

**Clean
Period
30 March–5 April**

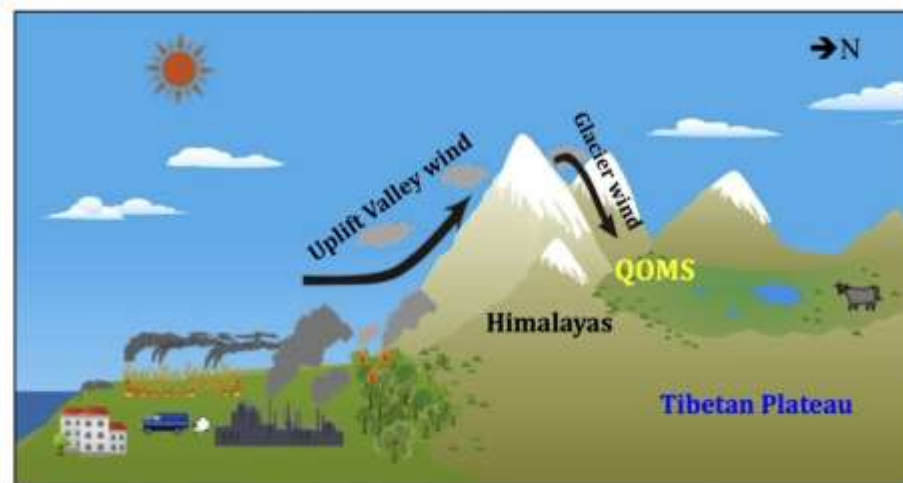
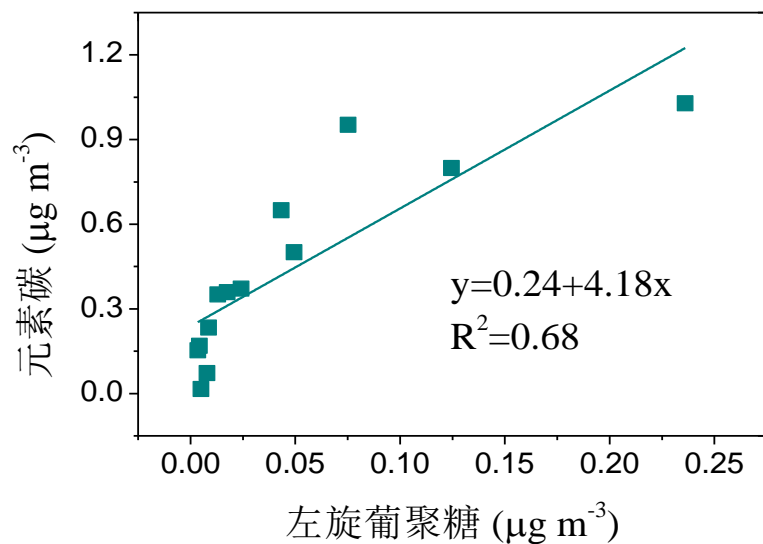
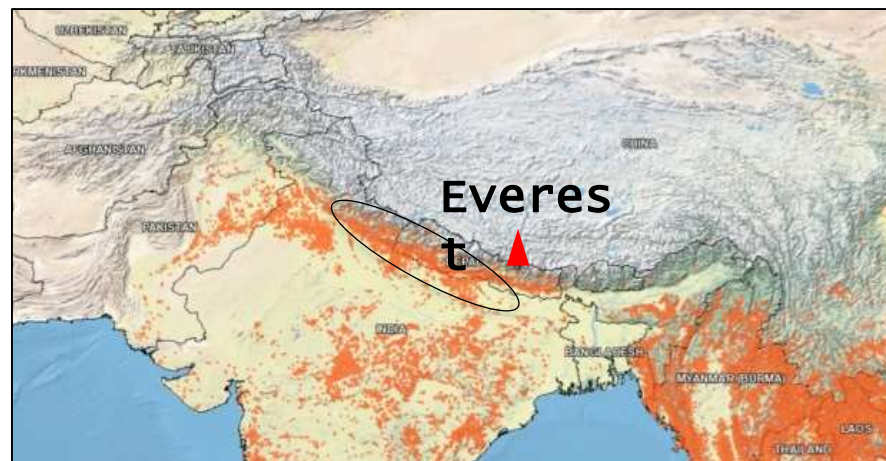
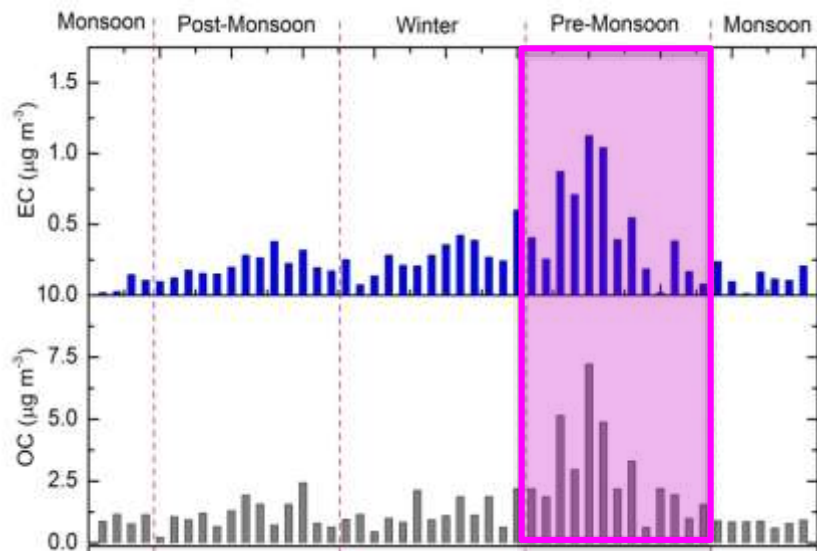
Z @ 500 hPa



Z @ 500 hPa

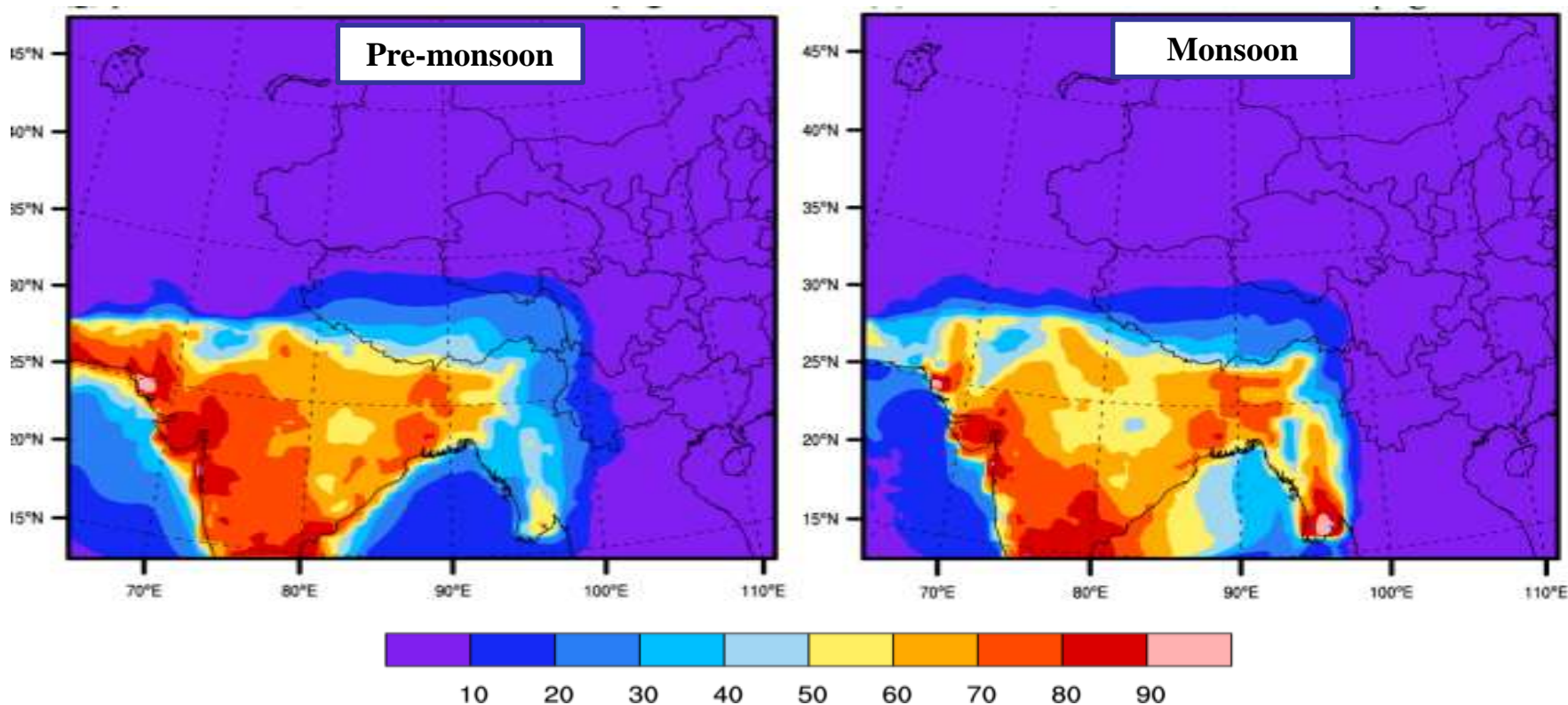


Trans-Himalayan Pollution through the Valleys



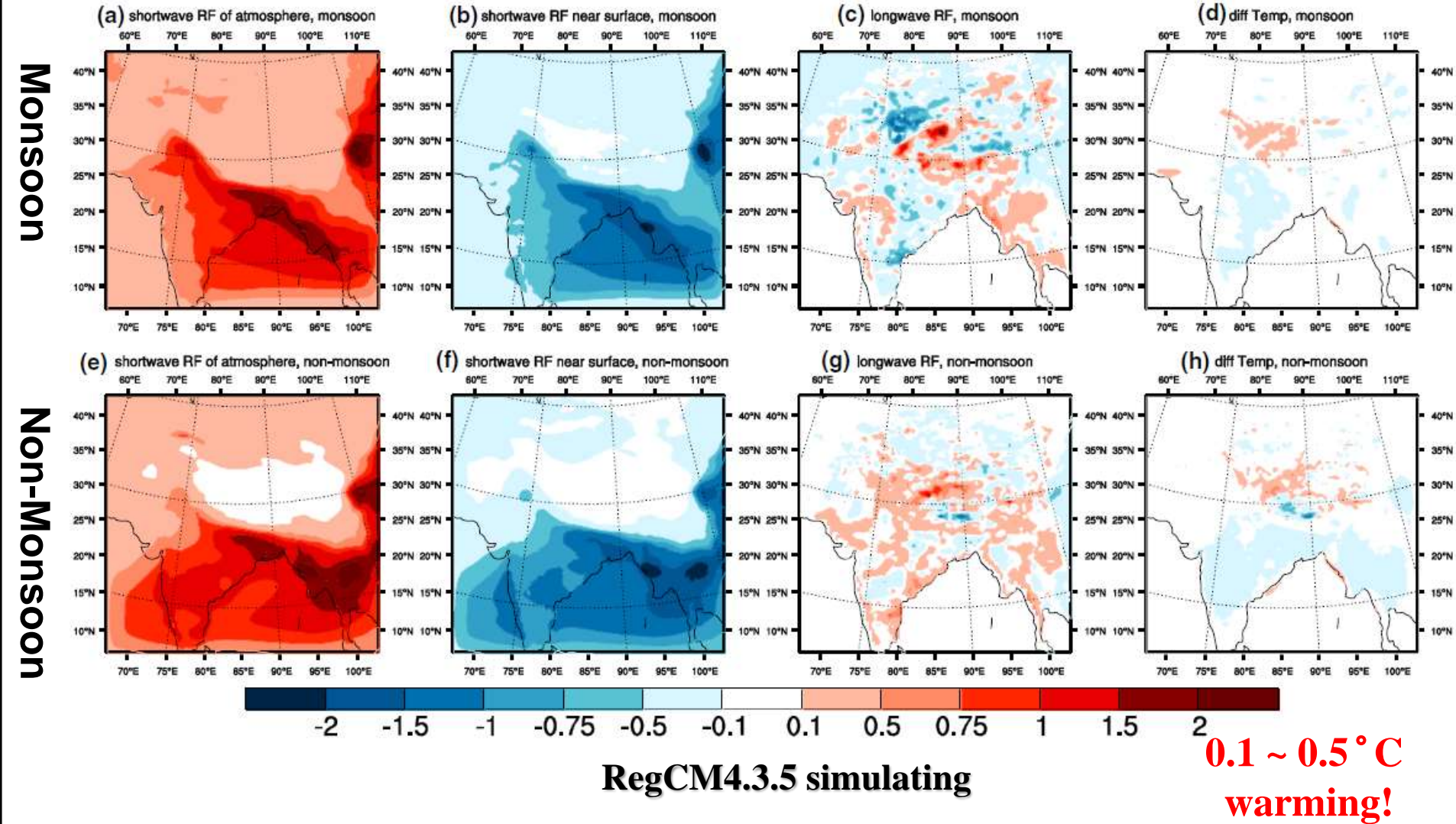
Contribution of BC from South Asia

About 10-40% of atmospheric BC in the southern TP is from anthropogenic emission from South Asian



WRF-Chem simulating in 2013

Climatic Effects of Carbonaceous Aerosols



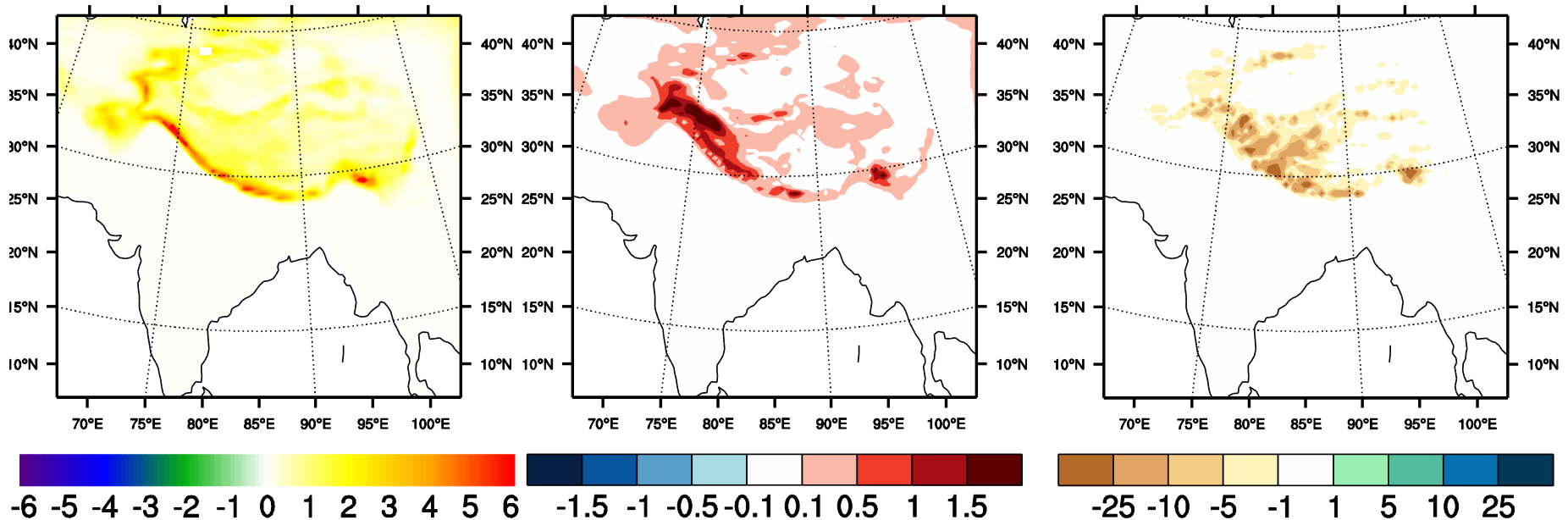
Climatic Effects of Carbonaceous Aerosols

Effects of BC-snow radiative feedback

RF
1-6 W/m²

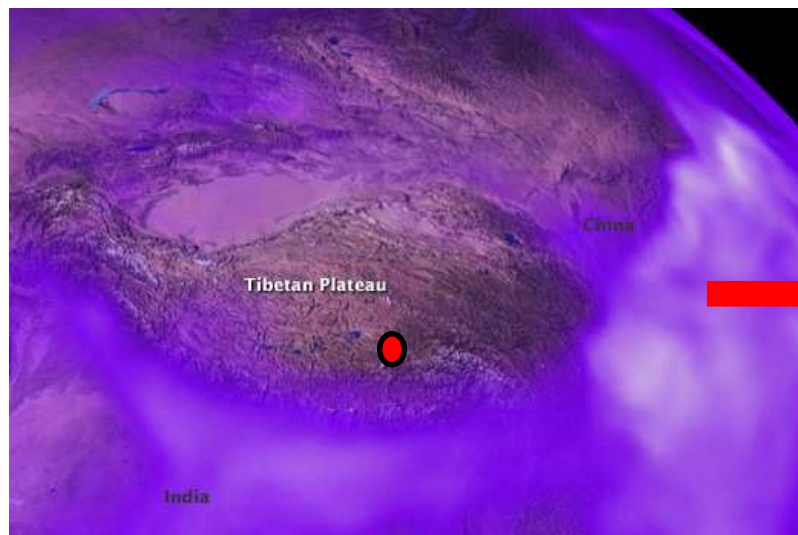
Increasing Tem.
0.1-1.5 °C

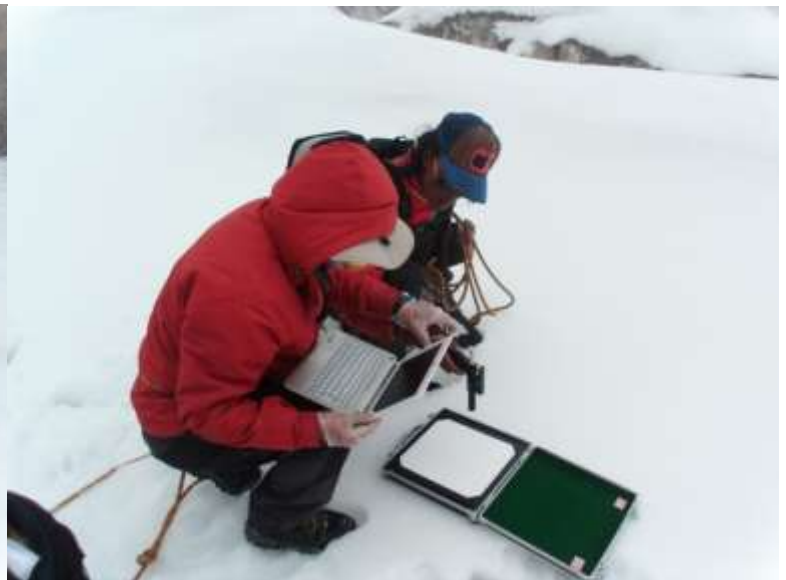
Snow melt
10-25 mm (w.e.)

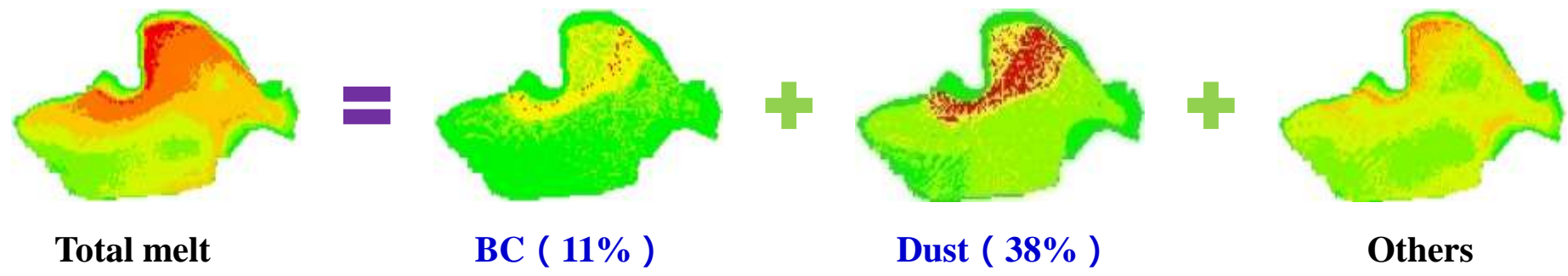
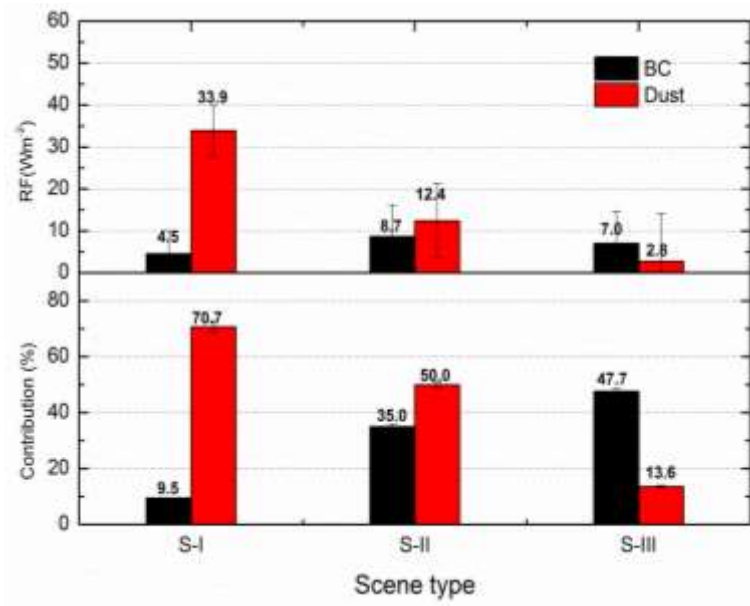
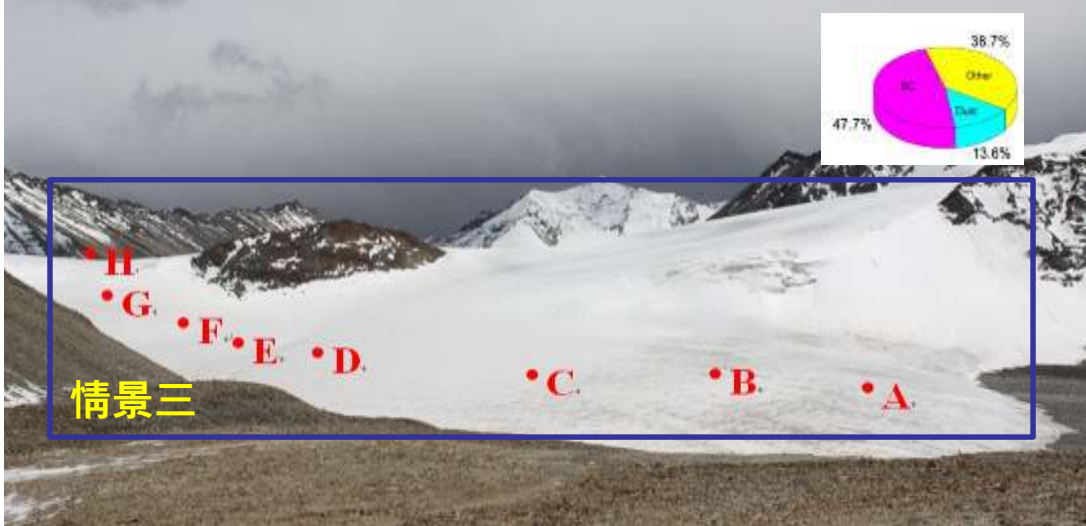
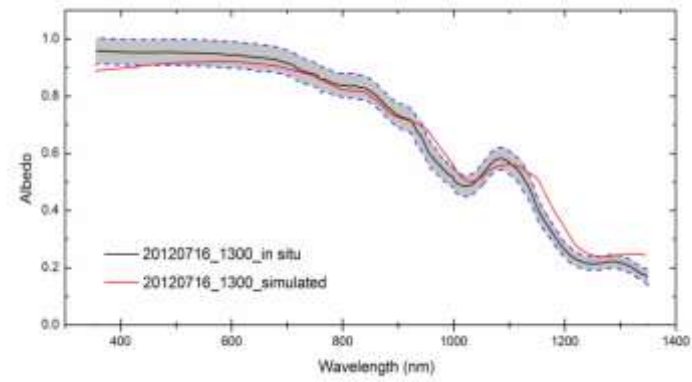
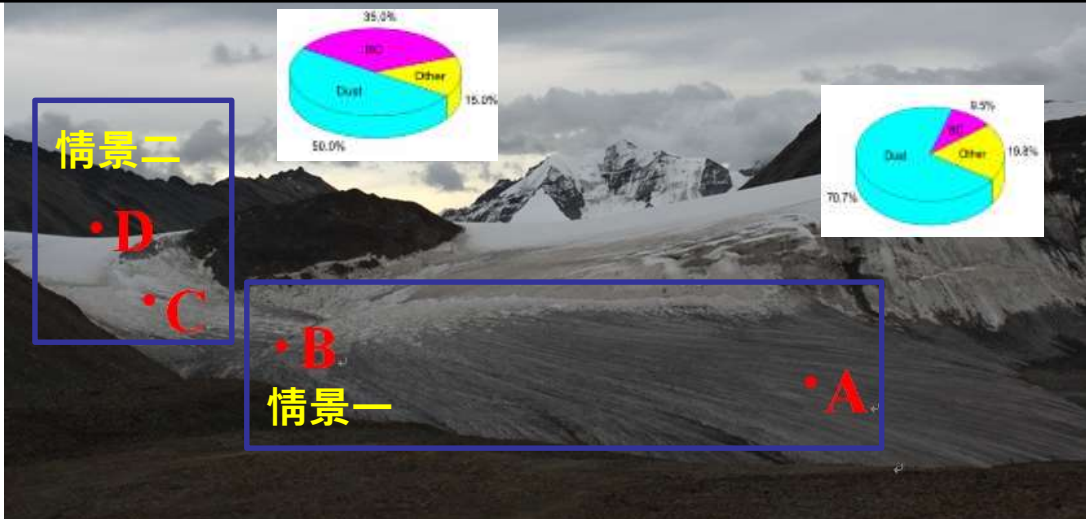


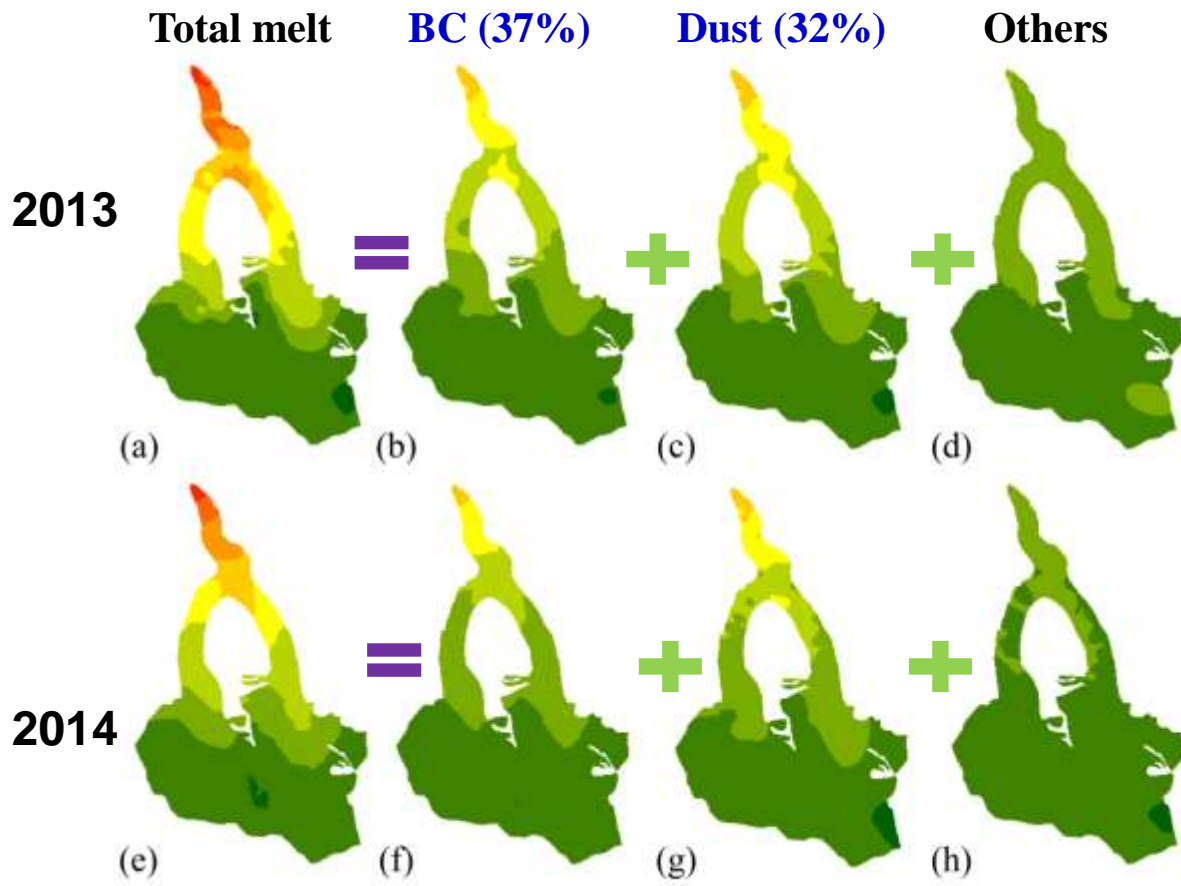
RegCM4.3.5 + SNICAR

Role of BC, Dust and Others in Glacier Melt









Summary of Major Research Achievements

■ Atmospheric pollutants are sourced from burning of biomass and fossil fuel, and dust emission, peak at winter and pre-monsoon.

■ Atmospheric pollution is accumulated in the southern foot of Himalayas.
■ Episodic cross-Himalayan pollution can be transported through the major south-north valleys and by being lifted and advected over the Himalayas.

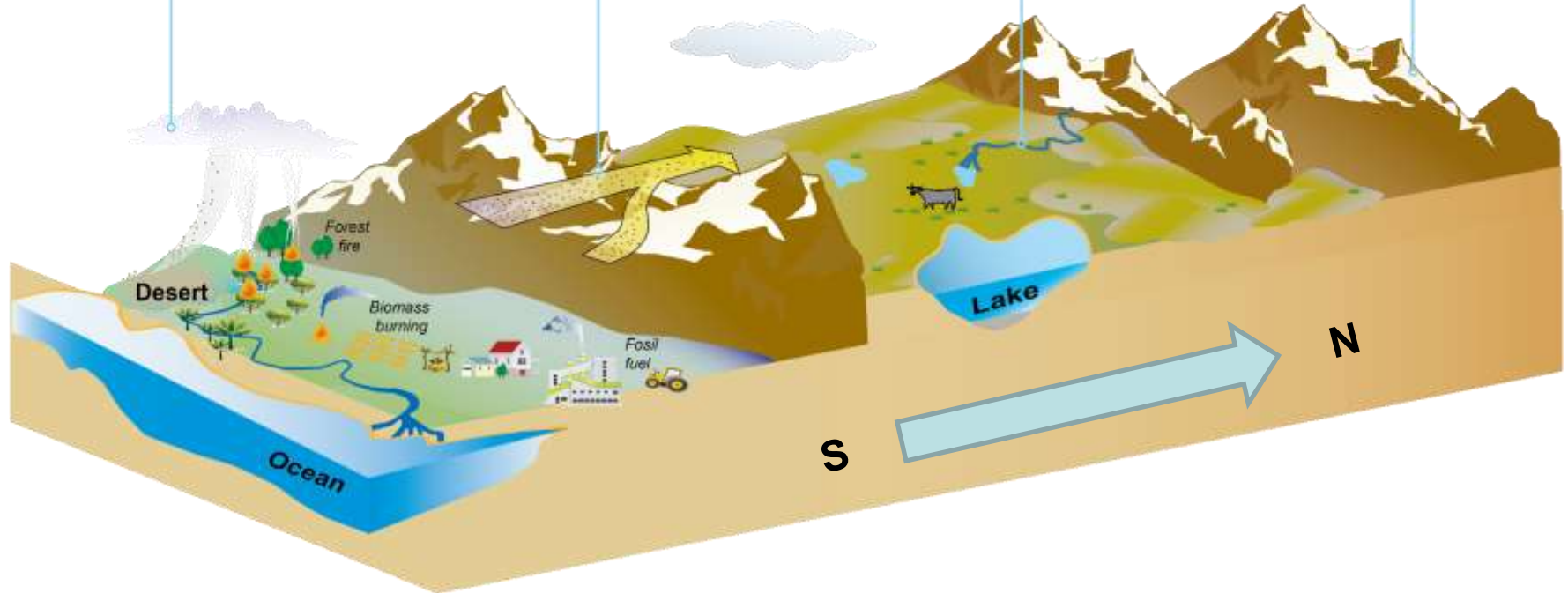
■ Melting glaciers are important sources releasing legacy pollutants into downward ecosystems.

■ BC and dust can be accumulated in glacier surface, and further enhancing glacier melt during ablation seasons.

Himalayas:
FF: $46 \pm 11\%$

Inner HTP:
FF: $30 \pm 10\%$

Northern HTP:
FF: $66 \pm 16\%$



Thank you!



1921



2007

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