Black Carbon in Western China and radiative effects

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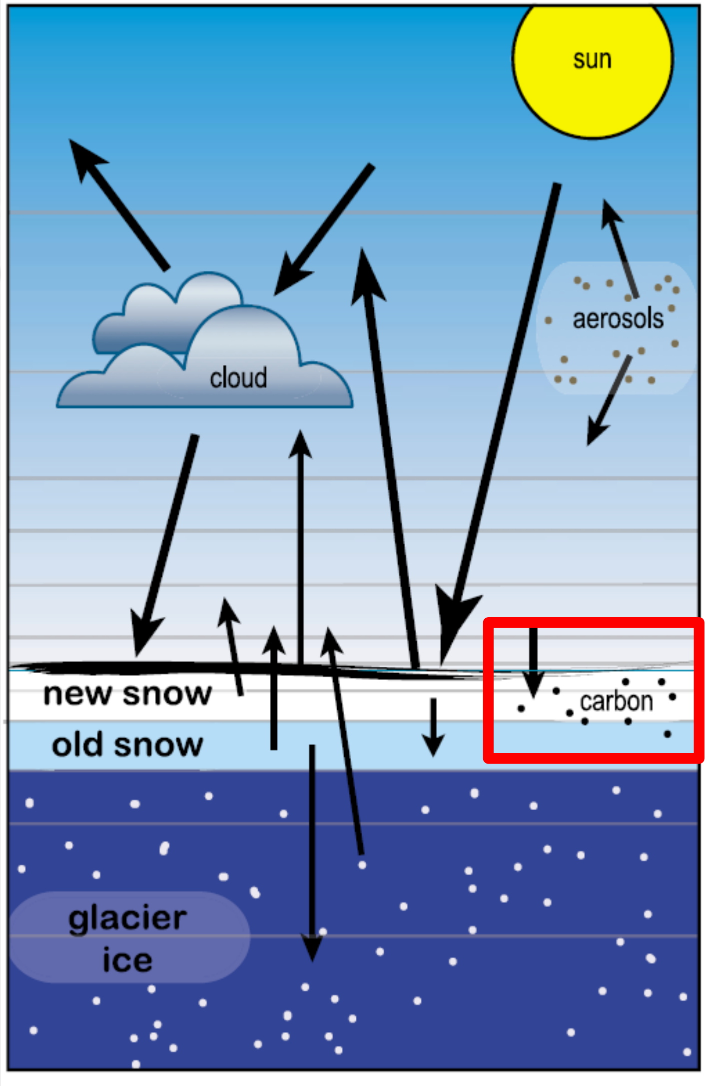
Climate Effects of BC

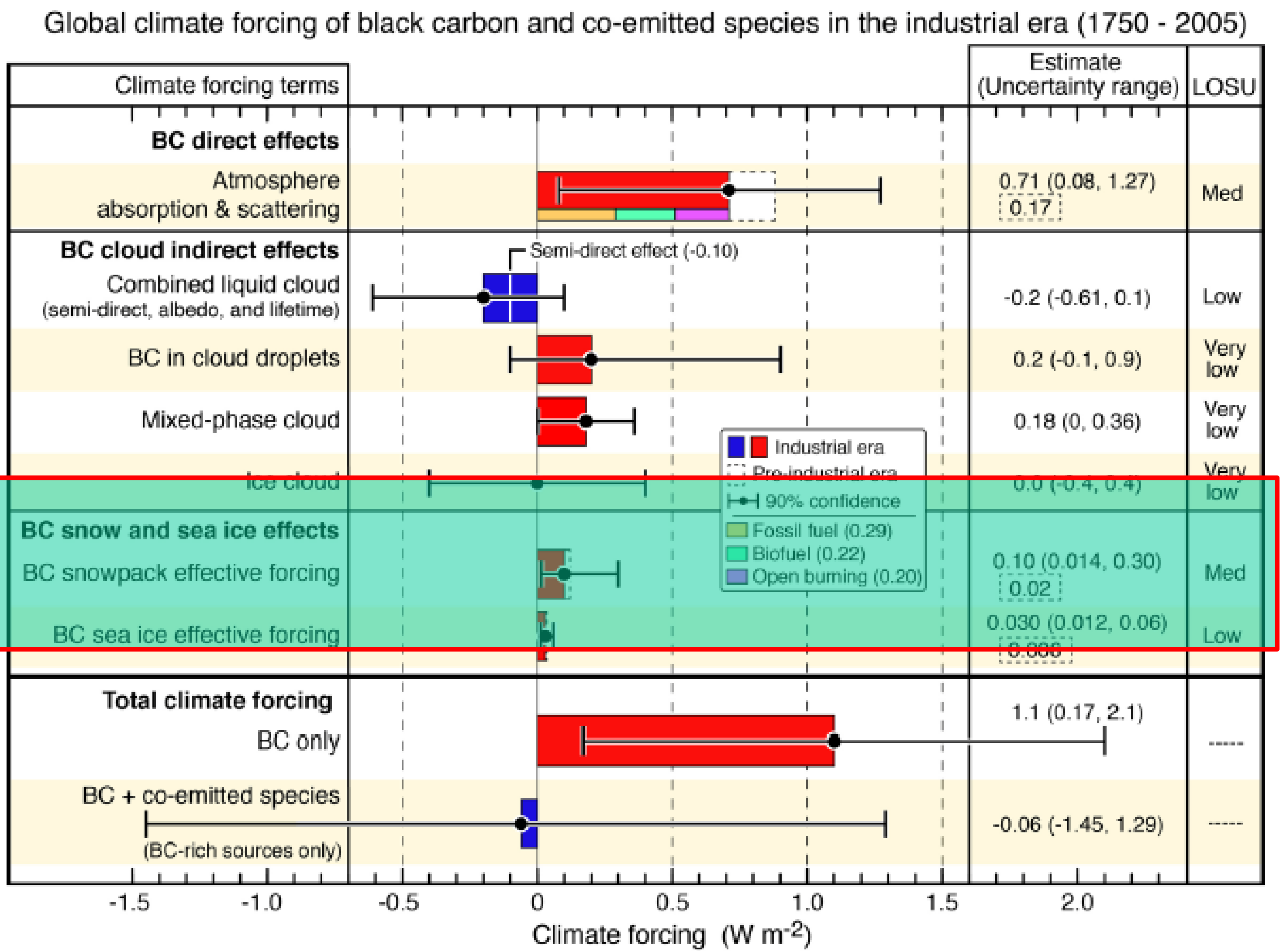
- **Heating the atmosphere**
  - **Absorbing radiation and emitting the heat**
  - **Global mean of 0.9 W m^{-2} (*Ramanathan and Carmichael, 2008*)**
- **Accelerating the snow&ice melt**
  - **Reducing the albedo of snow&ice**
  - **Accelerating the aging of snow**
  - **Global mean of 0.03 - 0.11 W m^{-2} (*Mahowald et al., 2011*)**



Gardner and Sharp, 2010; JGR

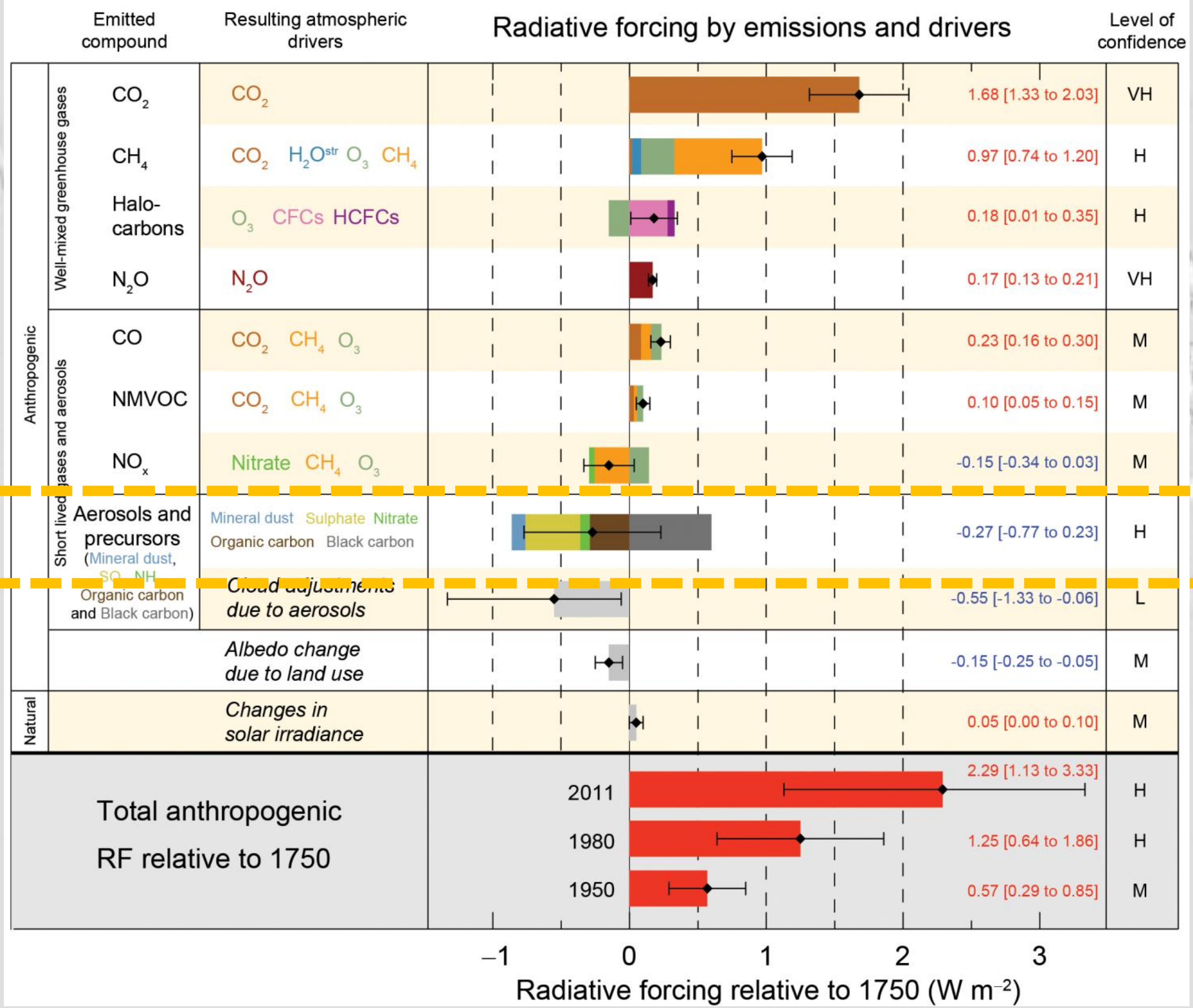
Global climate forcing of BC and co-emitted species 1750-2005

Article



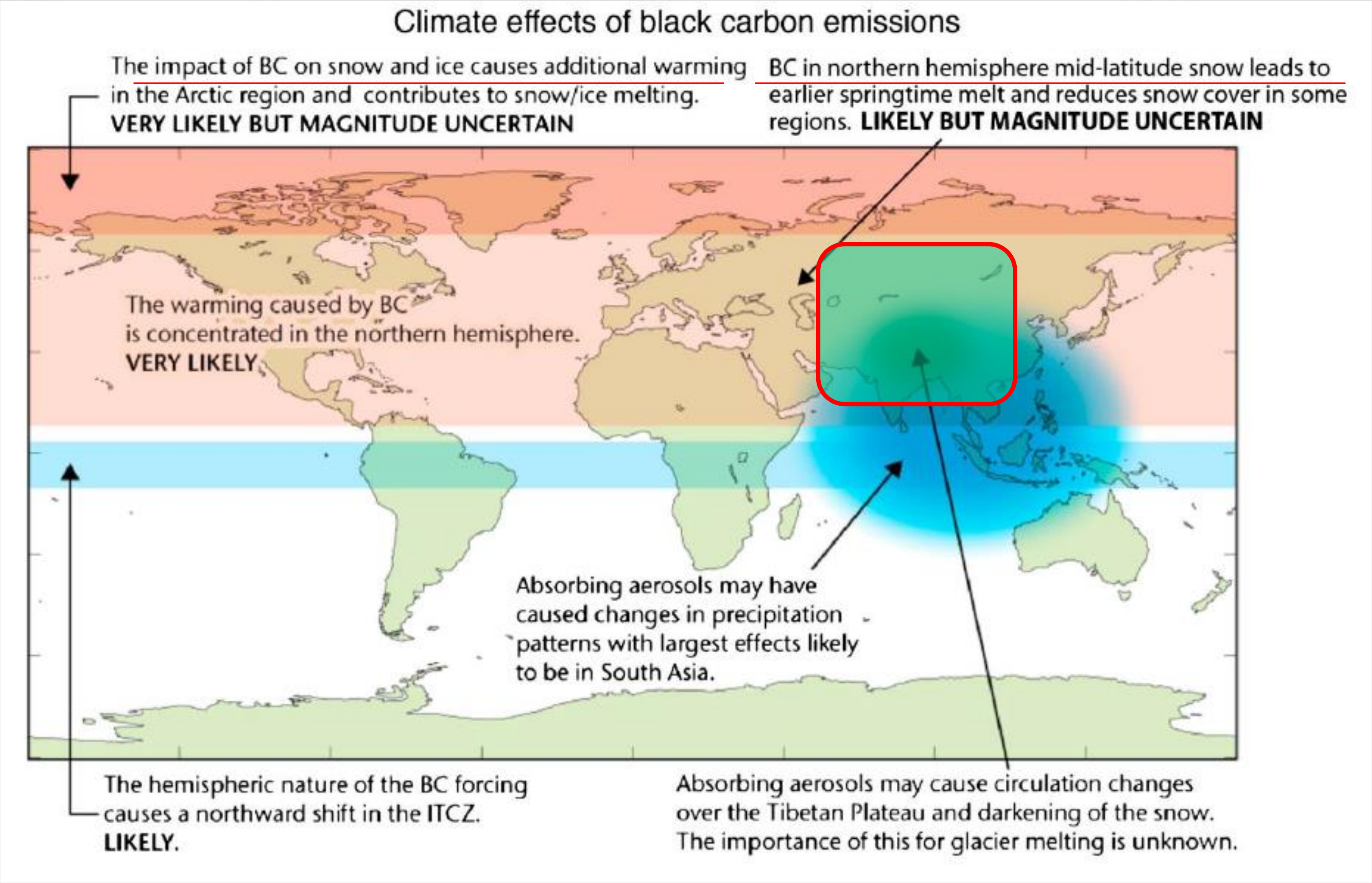
Bond et al., 2013; JGR

Radiative forcing estimates in 2011 relative to 1750



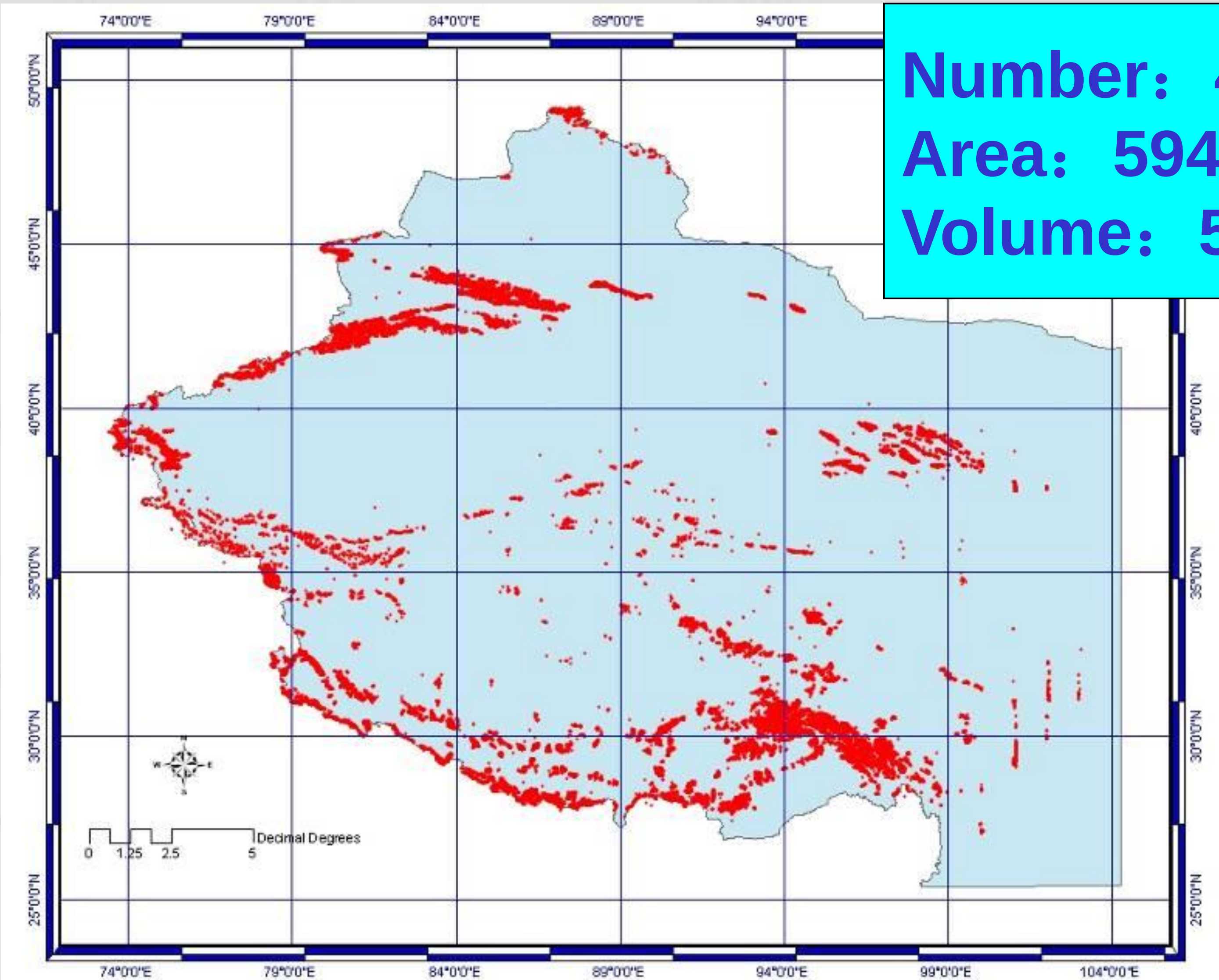
IPCC 2013

Global Impacts of BC on Climate and Environment



Bond et al., 2013

Spatial distribution of Glaciers in Western China



Number：46298

Area：59406 km^2

Volume：5590km^3

Water resources for primary Asia rivers;

central role the natural environment

● **Glaciers**

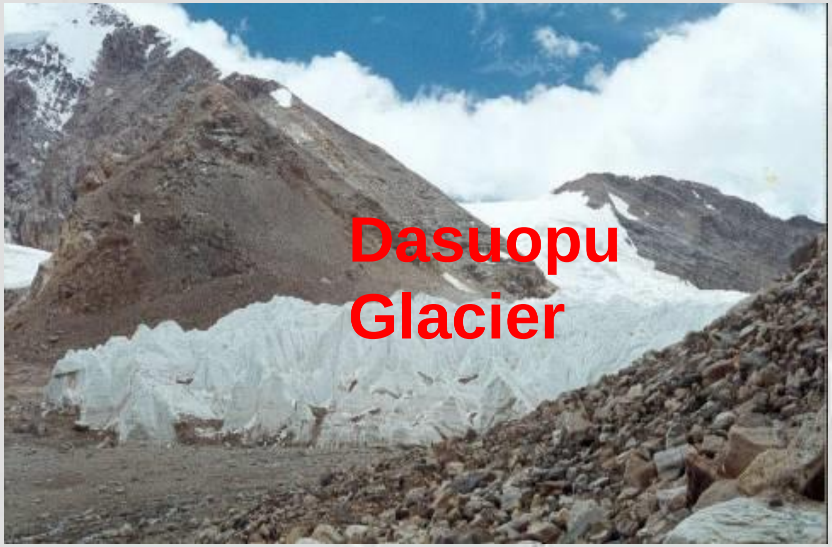

XiaoDongkemadi Glacier
DaDongkemadi Glacier

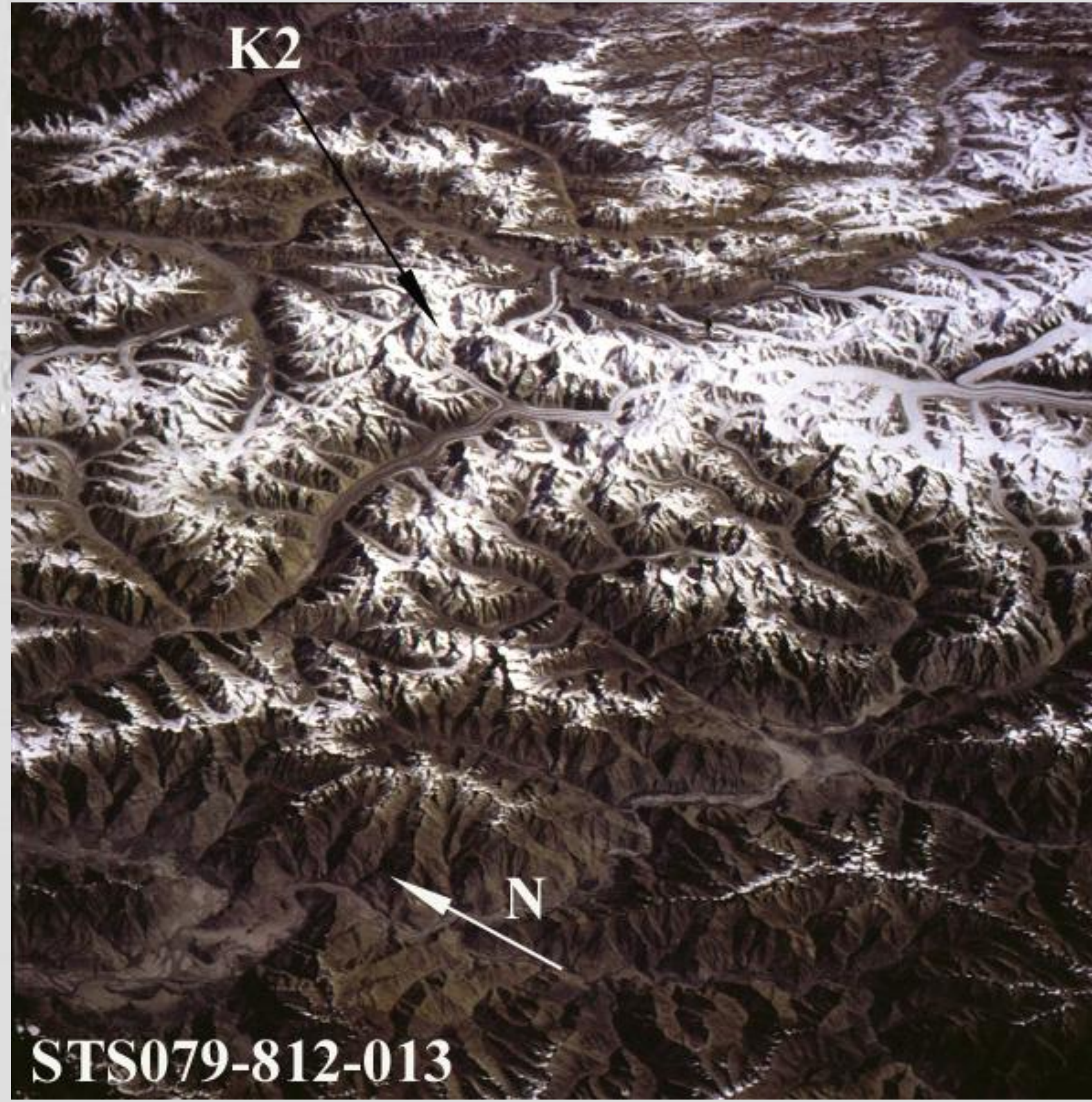

Meikuang Glacier


Puruogangri Ice Field


Dunde Ice Cap

●Glaciers

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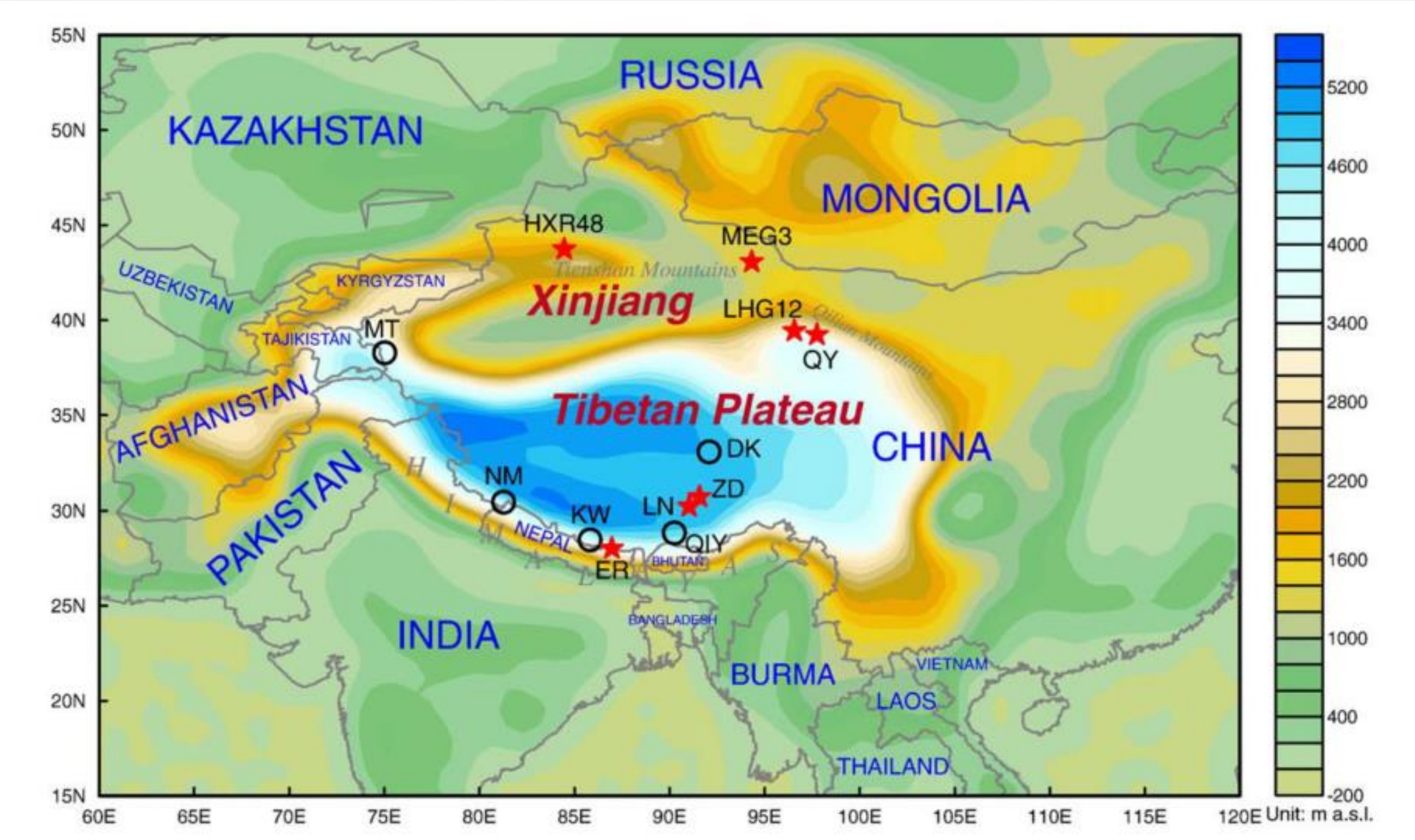
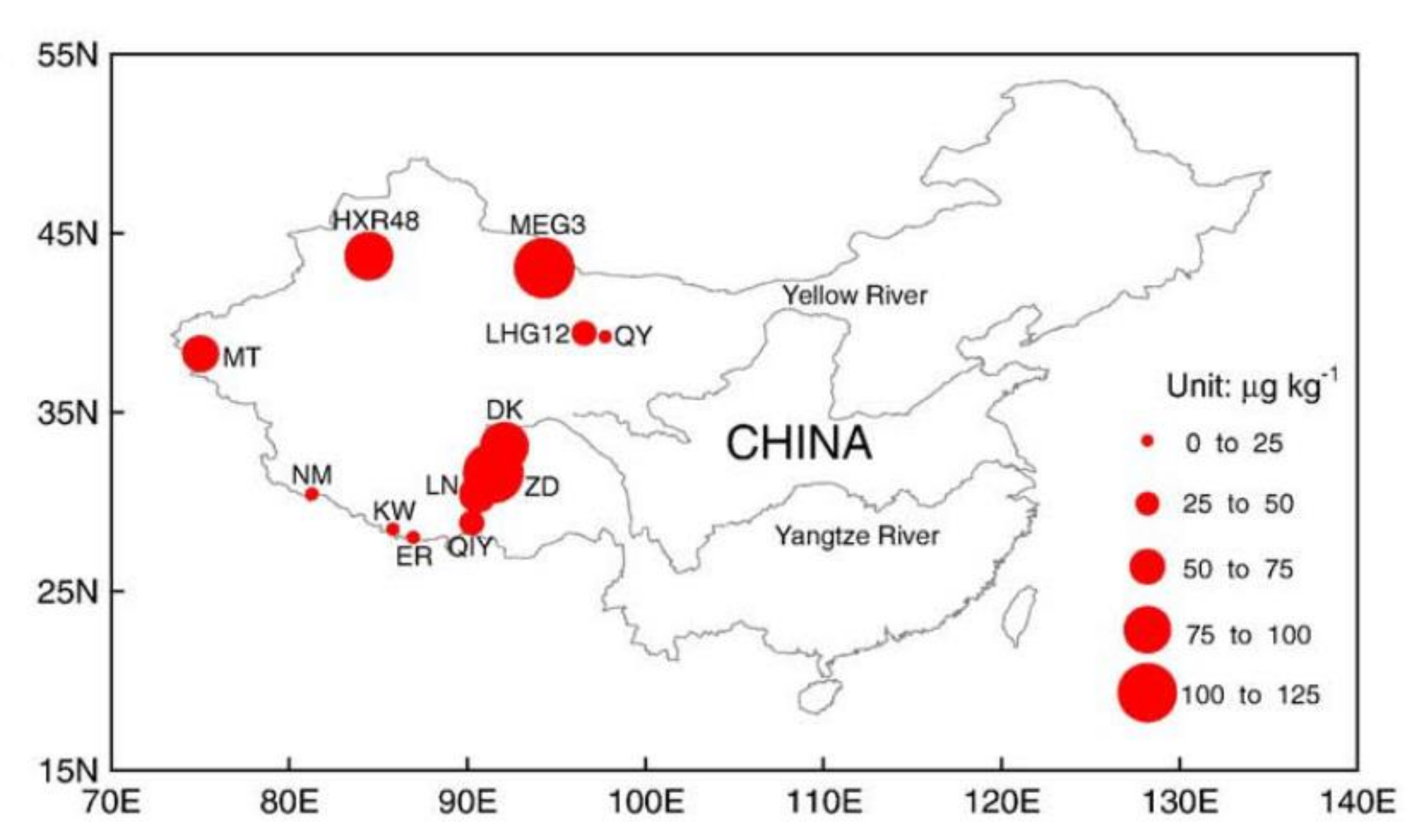
Snow sampling



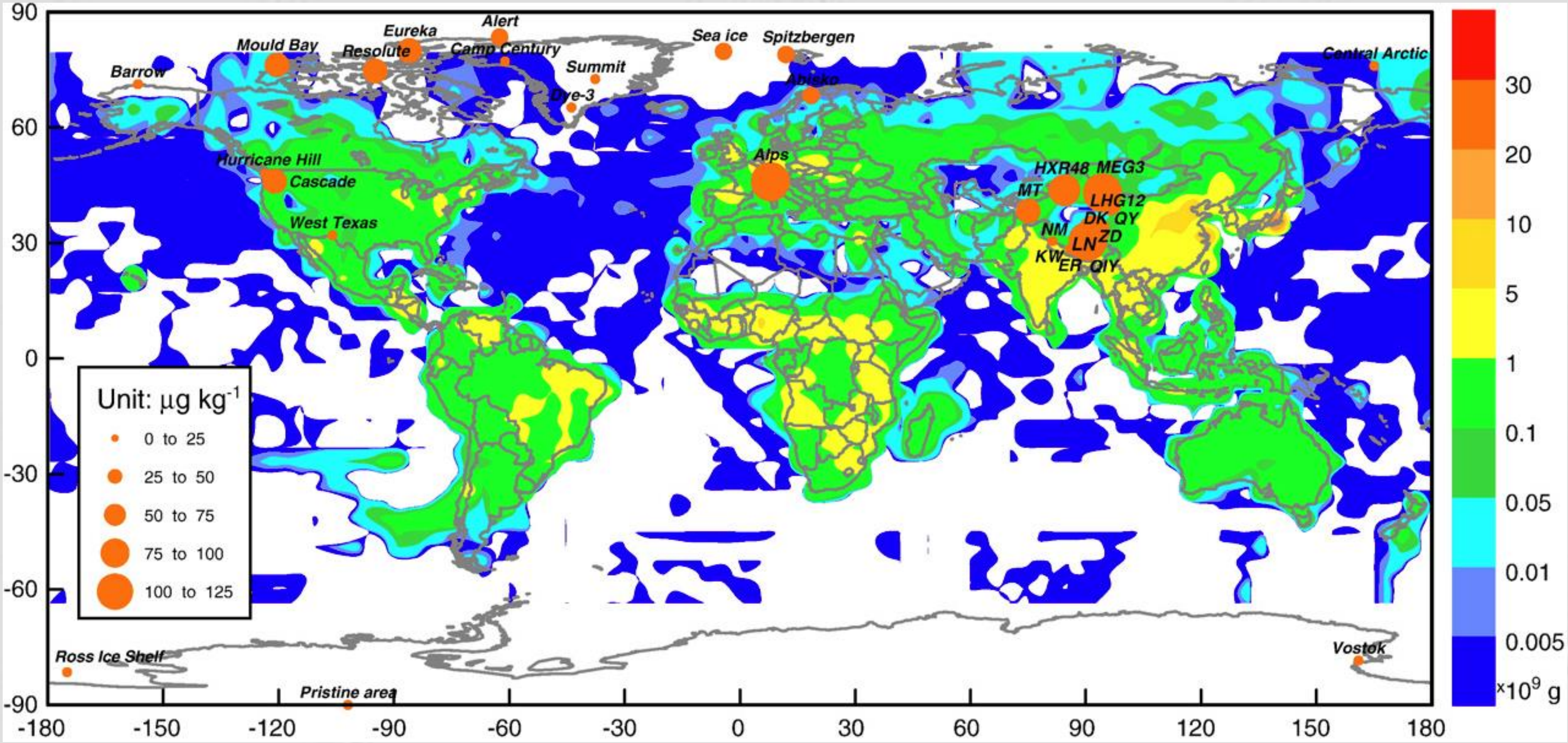
Miao'ergou No.3 glacier (MEG3), Haxilegen River No.48 glacier (HXR48) of Tienshan Mountains; Laohugou No.12 glacier (LHG12), Qiyi glacier (QY) of QilianMountains; La'nongglacier (LN) and Zhadang glacier (ZD) in the central part of TP, and the EastRongbuk glacier (ER) of the Himalayas

Spatial distribution of BC concentration in snow of west China



Ming et al., 2009, Atmos. Res.

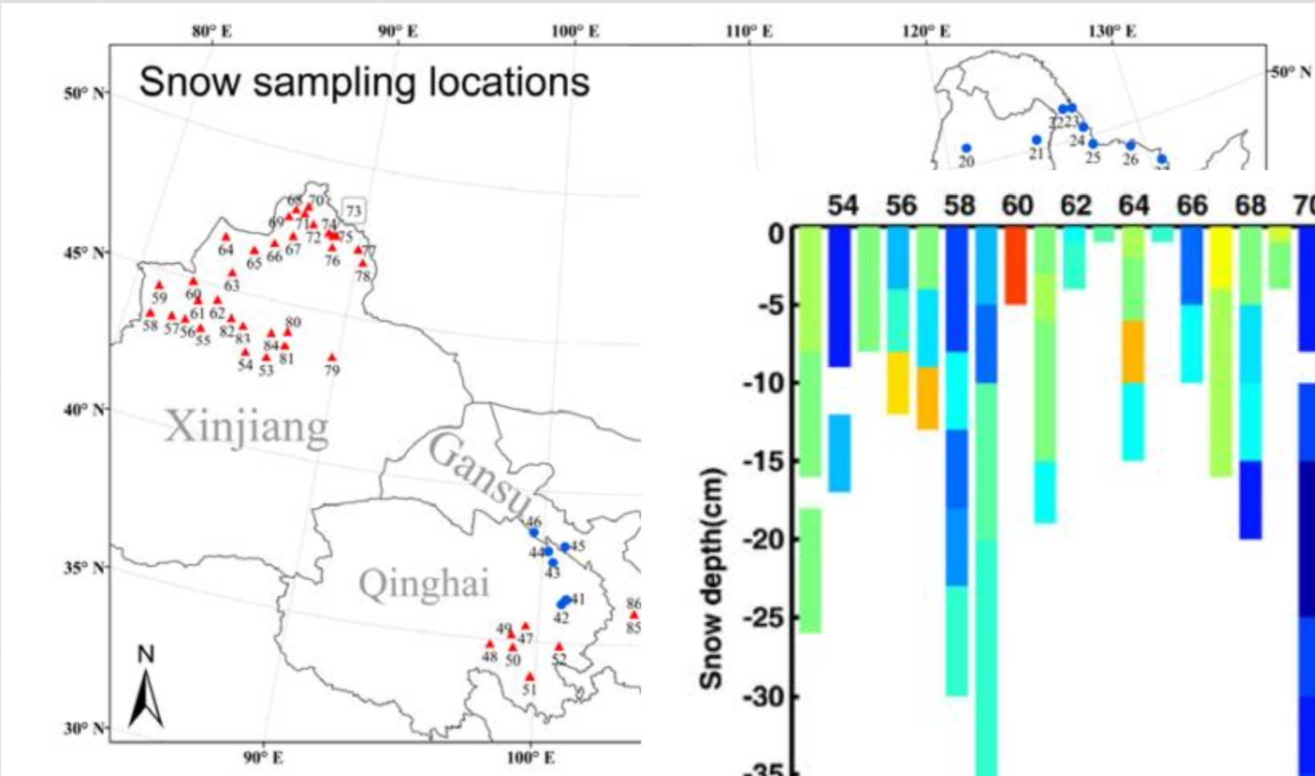
BC concentrations in snow and ice measured in the globe

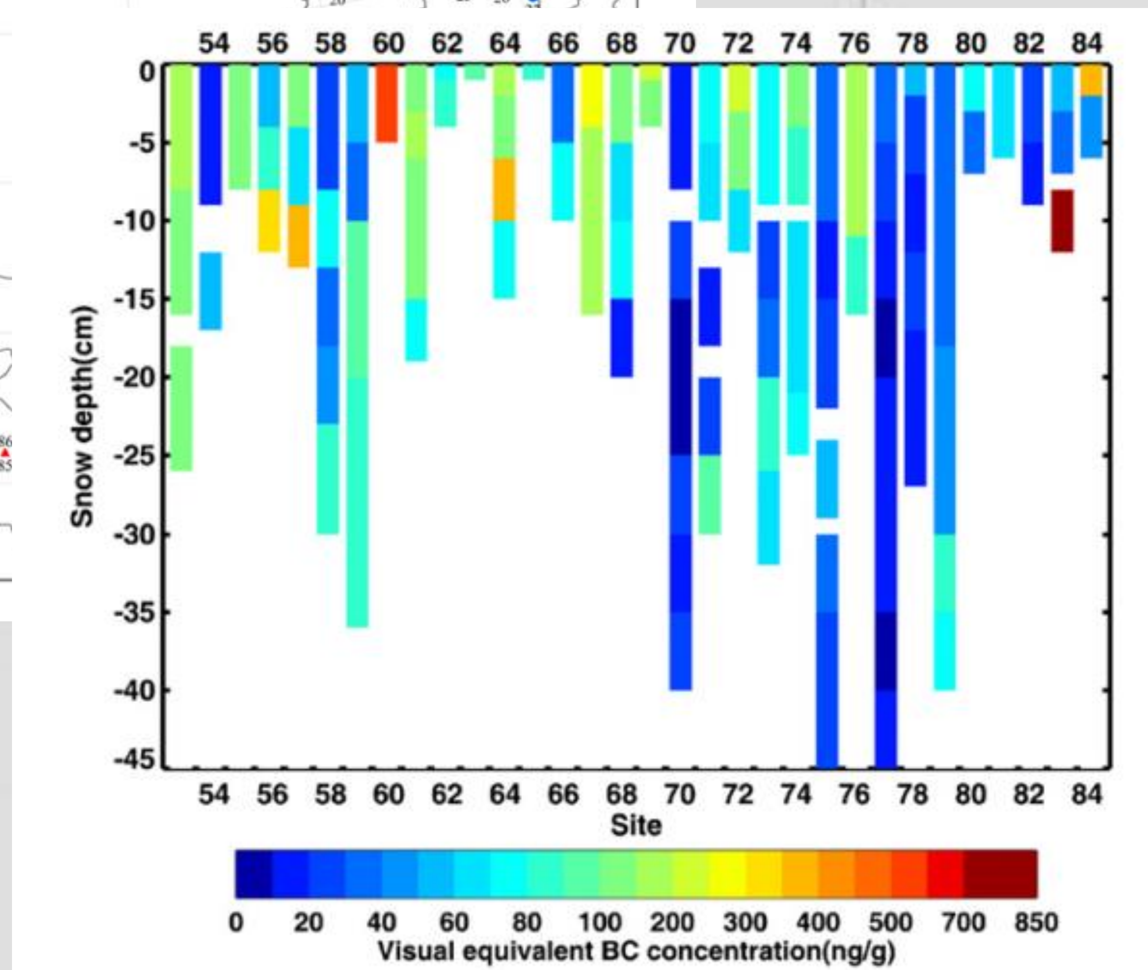


with the background of BC emissions based on Bond et al. (2004)

Ming et al., 2009, Atmos. Res.

Black carbon in seasonal snow across northern Xinjiang in northwestern China

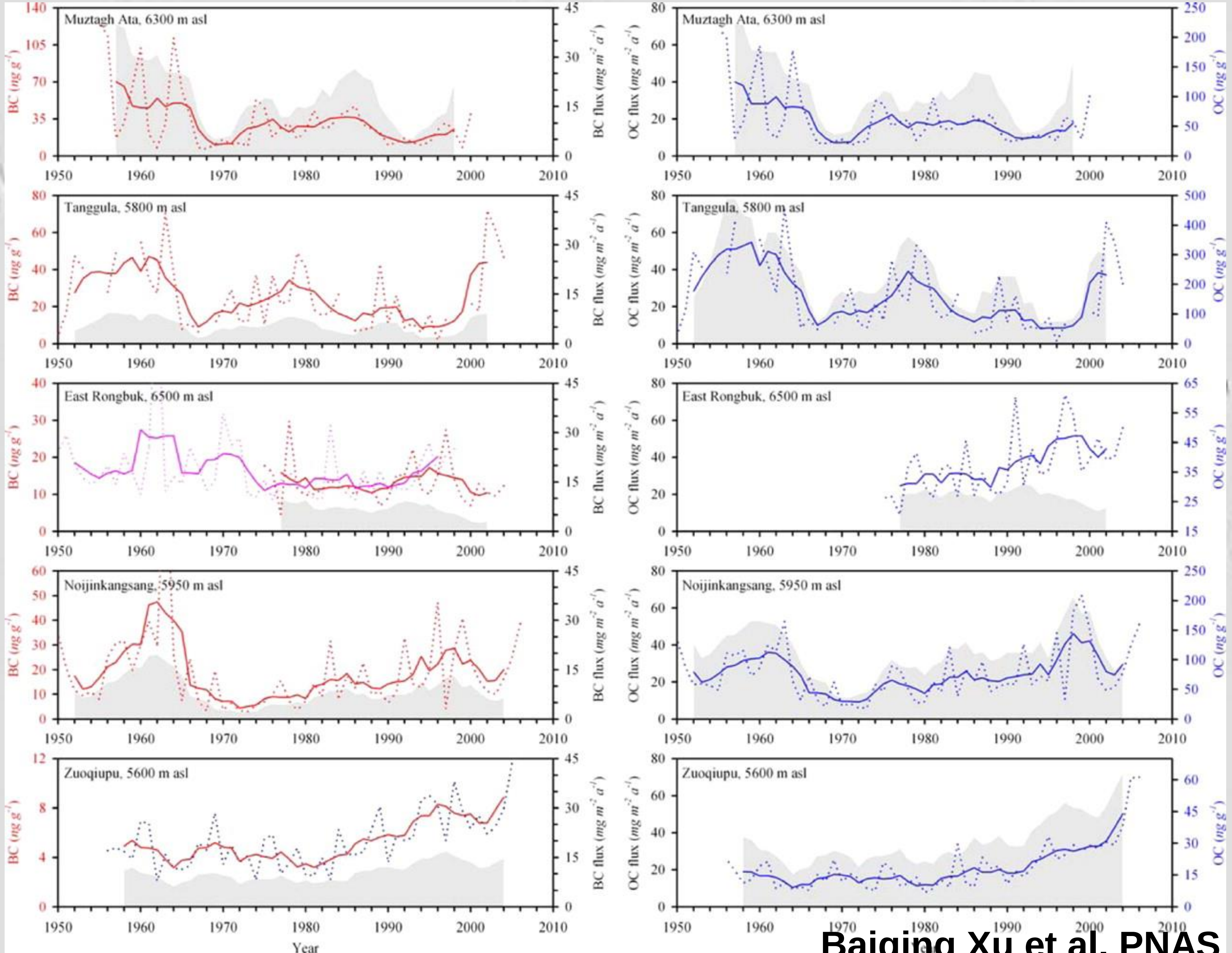




median value
~70 ng g^{-1}

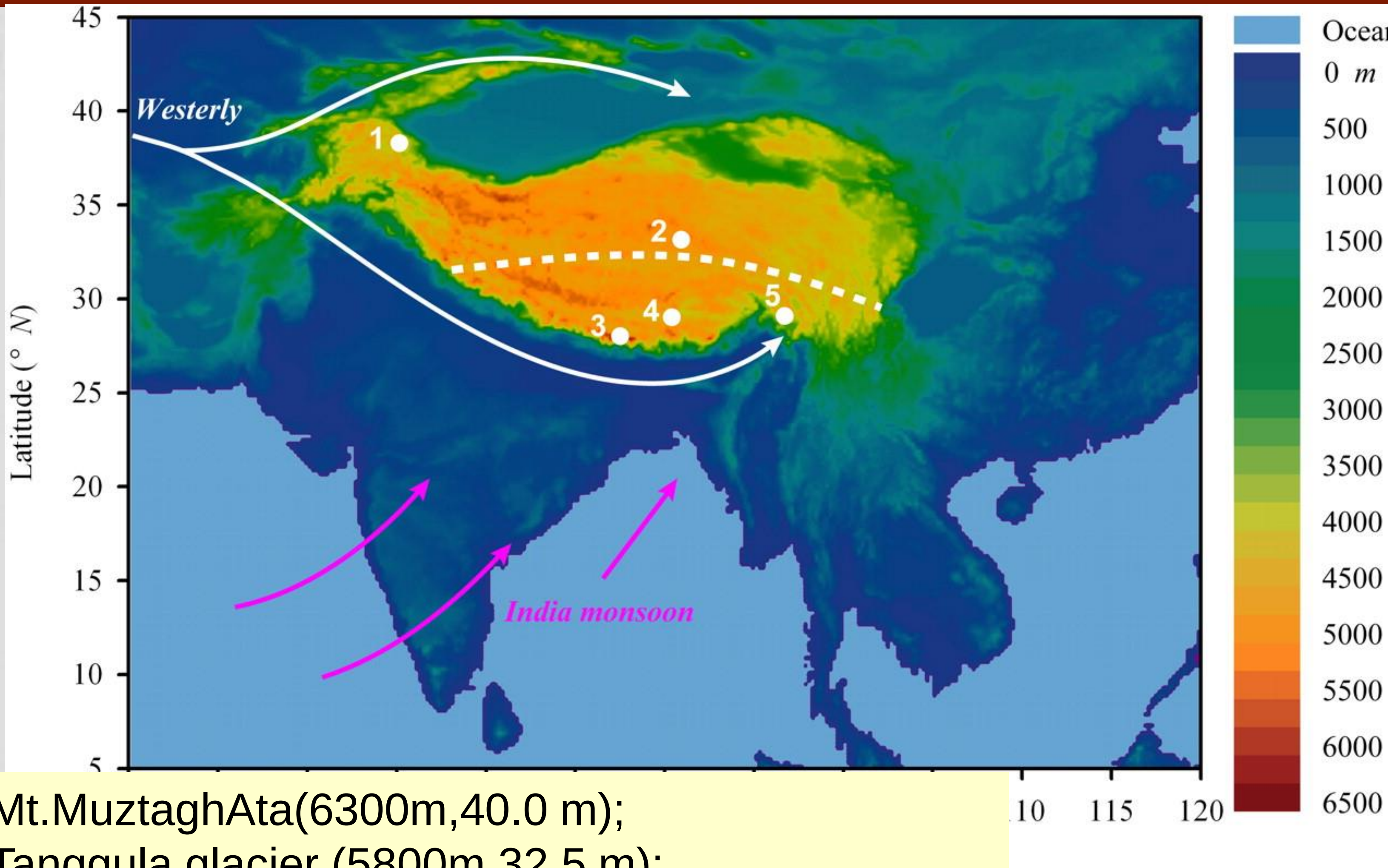
Ye et al., 2012, ERL

Long-term variation of BC and OC in western China



Baiqing Xu et al. PNAS 2009

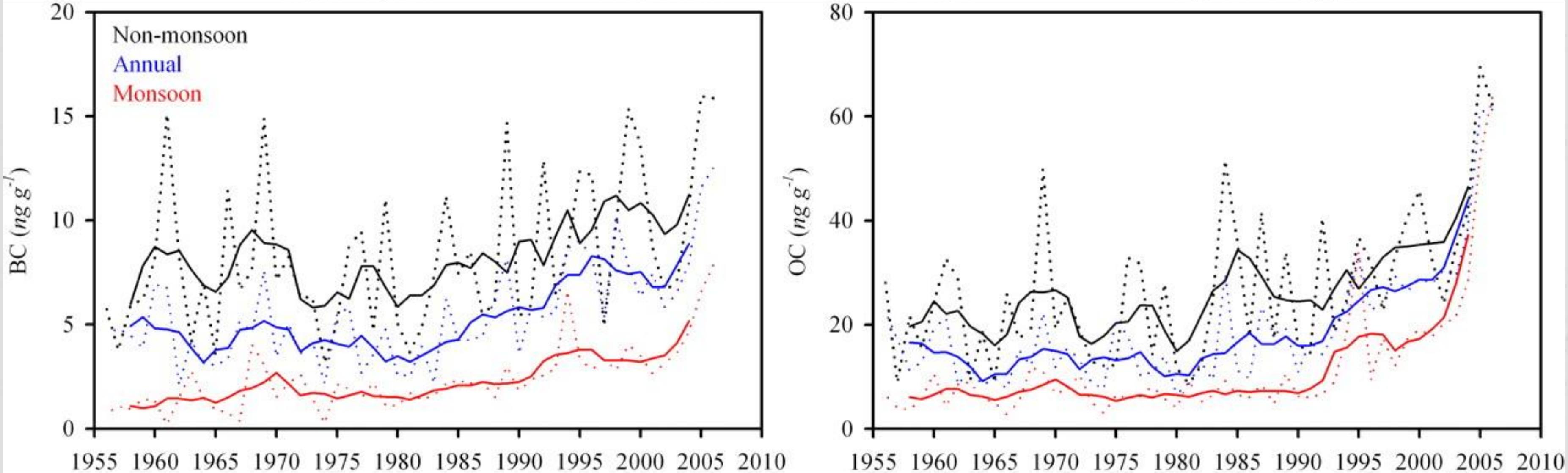
Sampling location for the ice cores



1,Mt.MuztaghAta(6300m,40.0 m);
2,Tanggula glacier (5800m,32.5 m);
3, EastRongbukglacier, Mt.Everest (6500m,22.3 m);
4, NoijinKangsangglacier (5950 m, 23.5 m);
5, Zuoqiupu glacier (5600 m, 97.0 m)

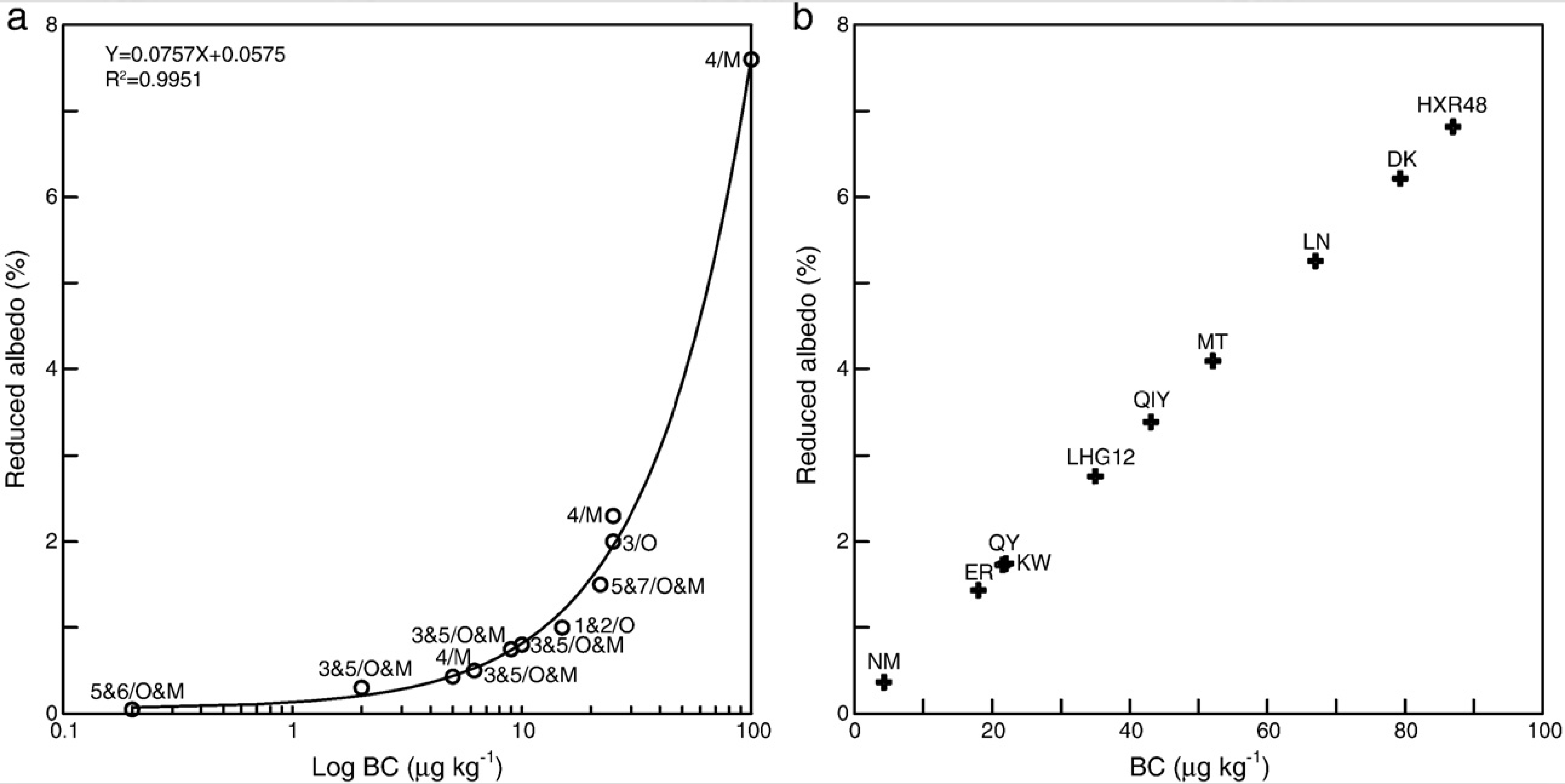
Baiqing Xu et al. PNAS 2009

BC and OC concentrations in the Zuoqiupu ice core for the monsoon (June–September) and nonmonsoon (October–May) seasons, and for the annual mean



Baiqing Xu et al. PNAS 2009

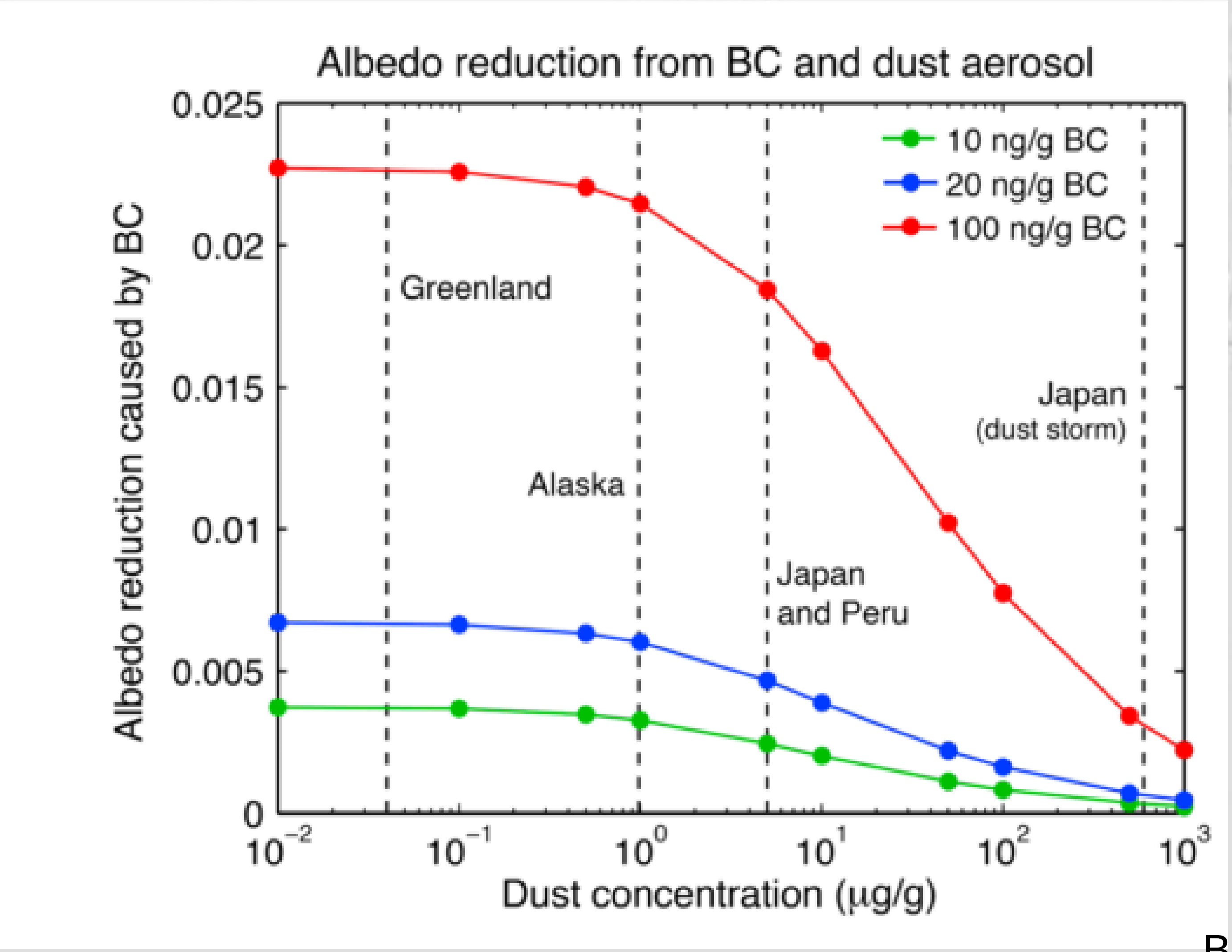
BC concentrations and reduced albedos in snow and ice



BC deposited in the surface might accelerate the melt of these glaciers in west China.

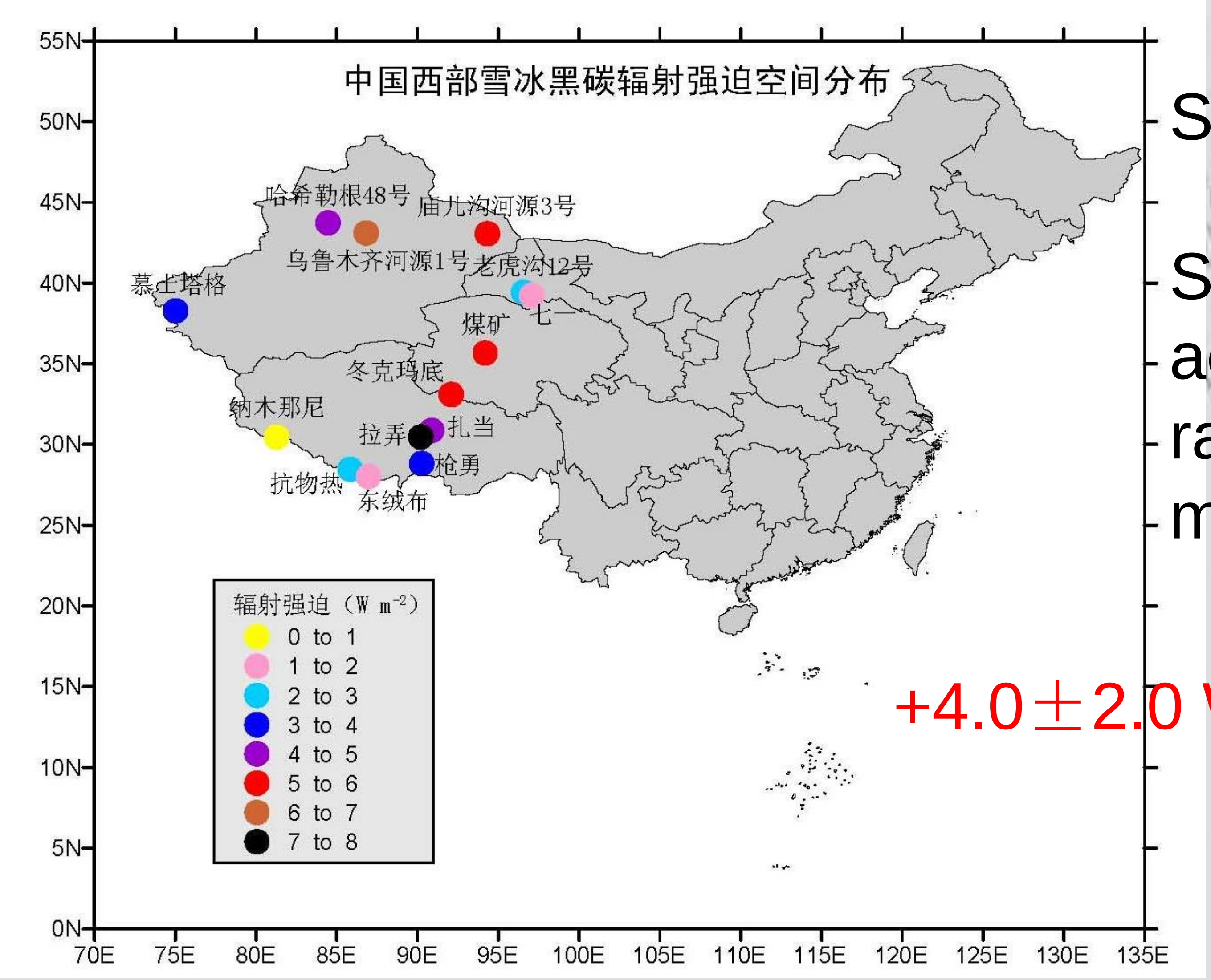
Ming et al., 2009, Atmos. Res.

Reduction in hemispheric broadband snow albedo (0.3 to 5.0 mm) caused by BC in the presence of varying amounts of dust



Bond et al., 2013

Radiative forcing of BC deposited in the surface snow of the glaciers in west China



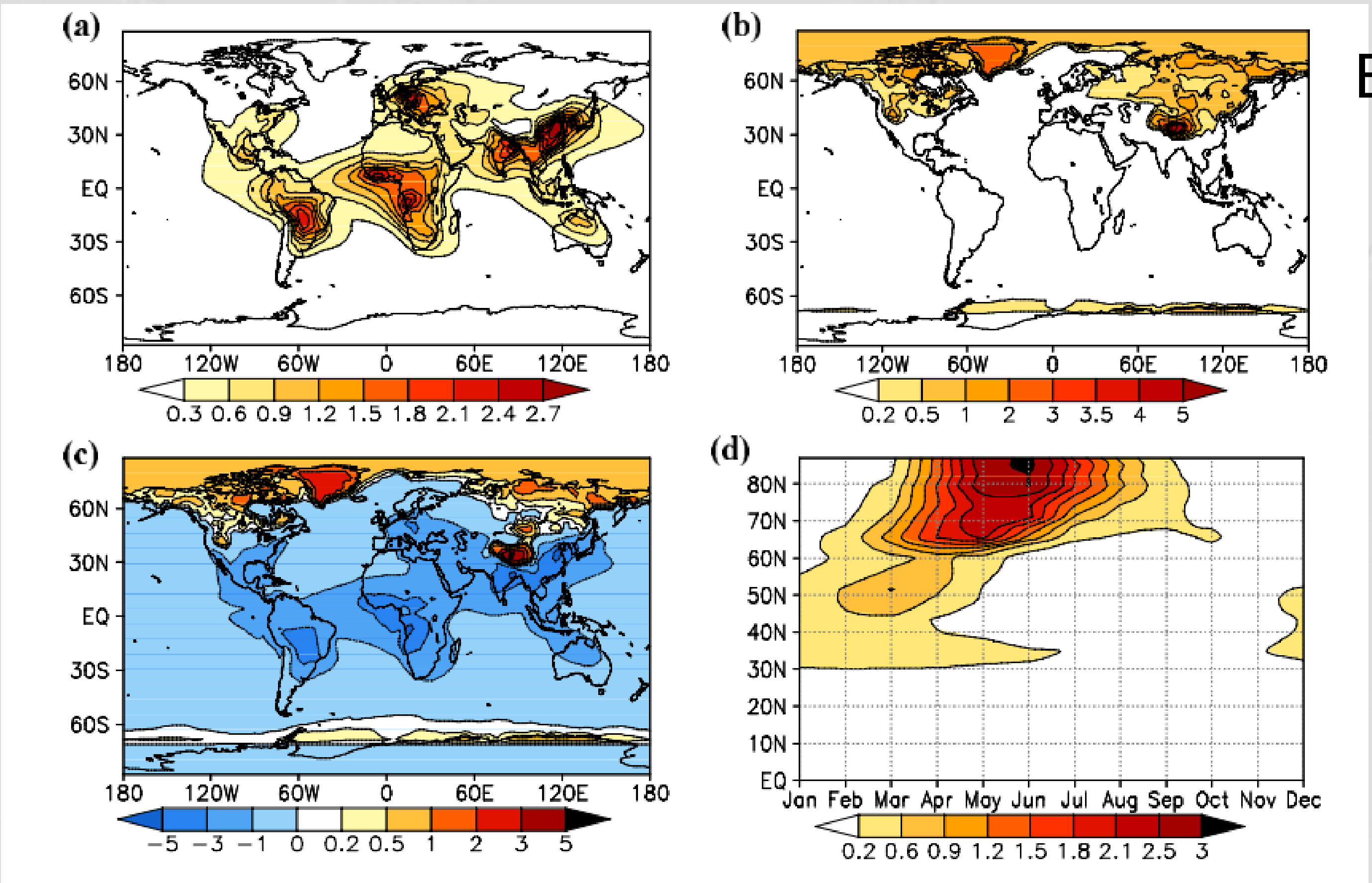
SNICAR

Snow-ice-aerosol-radiation model

+4.0±2.0 W m^{-2}

Ming et al, 2009, Adv. Clim. Change Res.

Radiative forcing due to BC in snow/ice



BCC−AGCM2.0.1

global annual mean surface radiative forcing is +0.042 W m^{-2}, with maximum forcing over the Tibetan Plateau and regional mean forcing exceeding +2.8Wm^{-2}

Greenland +2.0W m^{-2}

Annual mean distribution of (a) BC column burden (units: mg m^{-2}), (b) surface radiative forcing due to BC in snow/ice and (c) BC in snow/ice and atmosphere, and (d) the seasonal change of zonal mean surface radiative forcing due to BC in snow/ice (units: W m^{-2})

Wang et al., 2011, AAS

Atmos. Chem. Phys., 15, 3671–3685, 2015
www.atmos-chem-phys.net/15/3671/2015/
doi:10.5194/acp-15-3671-2015

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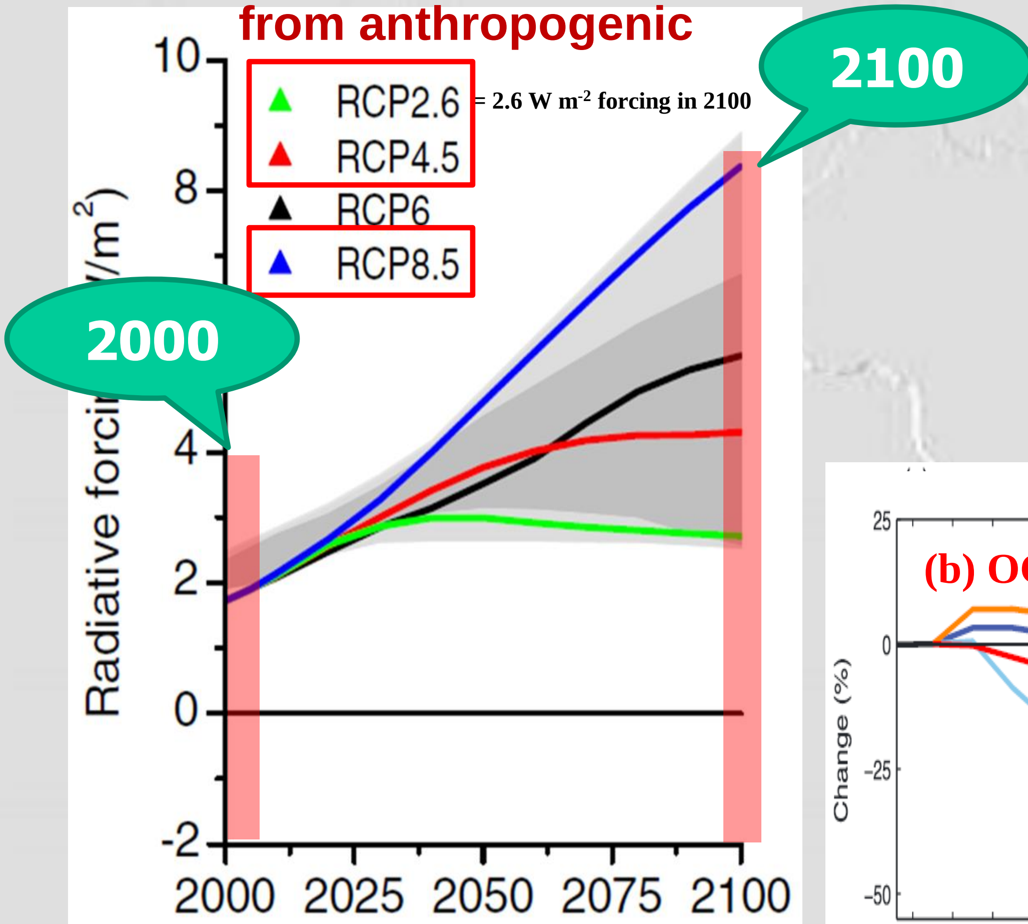
Simultaneous reductions in emissions of black carbon and co-emitted species will weaken the aerosol net cooling effect

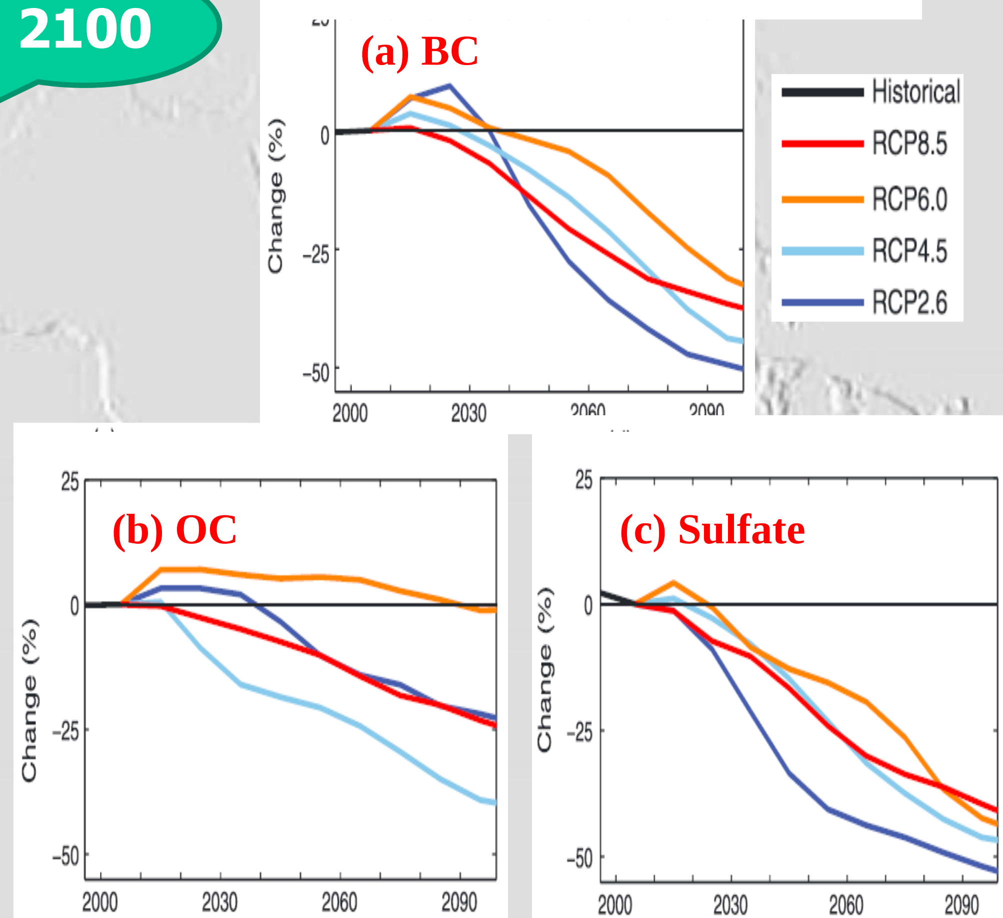
Z. L. Wang[1,2], H. Zhang[2,3], and X. Y. Zhang[1,4]

Wang et al., 2015, ACP

Radiative forcing from anthropogenic



Aerosol Emission variation



Representative Concentration Pathways (RCPs) scenarios (Moss et al., 2010, *Nature*)

Simulation setups

Based on the RCPs, using aerosol–climate atmosphere-only model BCC_AGCM2.0.1_CUACE/Aero, six simulations were run in this study.

Simulation	BC emission	OC & SO_2 emissions	Interpretation (compared to SIM1)
SIM1	year-2000	year-2000	Present-day reference scenario.
SIM2	RCP2.6 year-2100	year-2000	Maximal reduction in BC; no reductions in OC & SO2.
SIM3	RCP2.6 year-2100	RCP8.5 year-2100	Maximal reduction in BC; minimal reductions in OC & SO2.
SIM4	RCP2.6 year-2100	RCP2.6 year-2100	Simultaneous maximal reductions in BC, OC & SO2.
SIM5	RCP2.6 year-2100	RCP2.6 year-2100 BC by multiplying the ratios of OC & SO2 with BC in 2000	Maximal reduction in BC; simultaneous reductions of OC & SO2 in terms of their ratios with BC in present day
SIM6	RCP4.5 year-2100	RCP4.5 year-2100	Medium-low reductions in BC, OC & SO2.

Global annual mean differences of aerosol direct, semi-direct and indirect, and net effect at the TOA (Positive values mean incoming, units: W m^{-2}) in different simulations

	SIM1	ΔSIM2	ΔSIM3	ΔSIM4	ΔSIM5	ΔSIM6
DRF	–2.01	**–0.07**	**+0.27**	**+0.28**	**+0.25**	**+0.3**
SWCF	–49.0	–0.14	+0.87	+1.3	+1.1	+1.02
LWCF	+27.8	+0.03	–0.07	–0.2	–0.19	–0.14
CRF	–21.2	**–0.11**	**+0.8**	**+1.1**	**+0.91**	**+0.88**
FNT	–0.66	**–0.12**	**+1.7**	**+2.0**	**+1.8**	**+1.8**

*** DRF, SWCF, LWCF and CRF, and FNT in the SIM1 column are aerosol direct radiative forcing, shortwave, longwave and net cloud radiative forcing, and net radiation flux at the TOA (units: W m-2) in SIM1, respectively. Values in the ΔSIM2 – ΔSIM6 columns represent the changes of corresponding variables in these simulations vs. those in SIM1.**

Conclusions

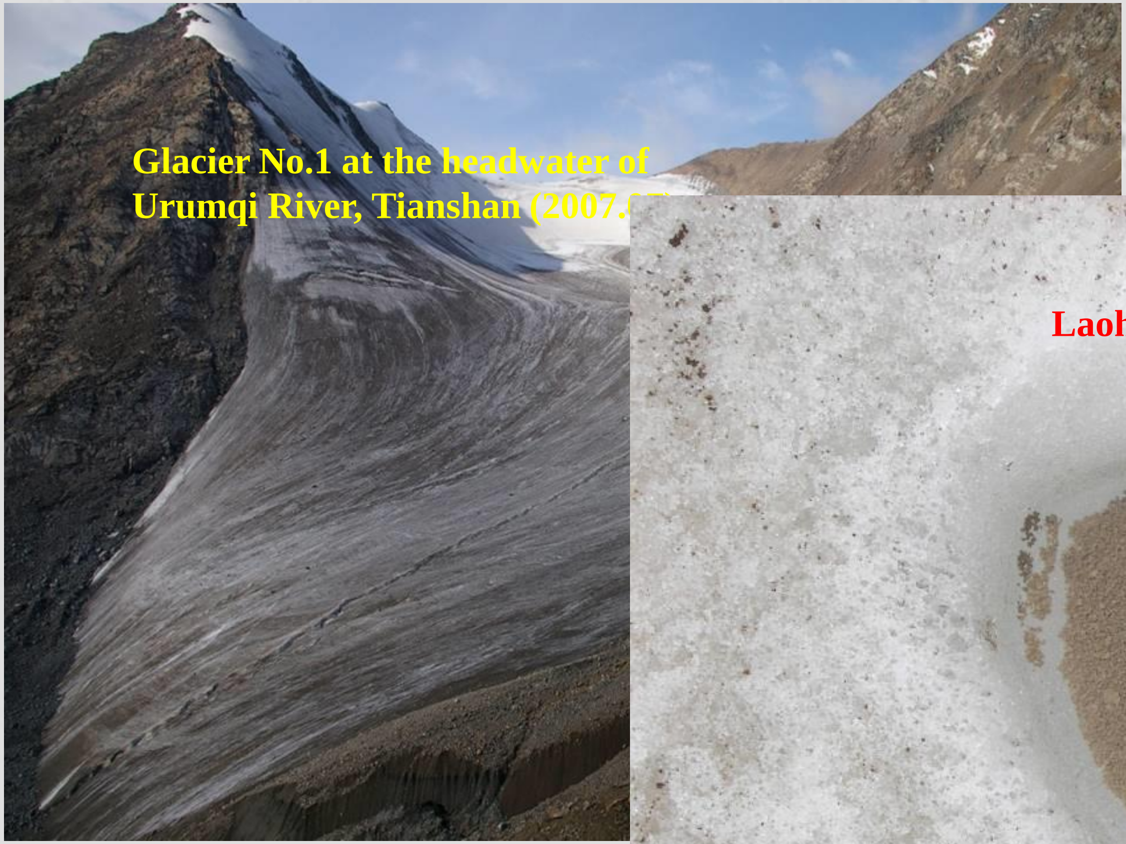
- Black carbon in the surface snow of western China is a contributor to the solar absorption.
- The mid-Himalaya glaciers' darkening since 2000 might have links with black carbon and dust, however, it needs further studies to confirm.
- Dust deposited in the snow of many glaciers in western China should be taken into account in future for their amounts of deposition and potentially large contributions to the solar absorption.

Concerns

1、Which is more important for snow-albedo feedback, BC or Dust?

2、Will BC reduction slow down the global warming?

BC or Dust ?


Glacier No.1 at the headwater of
Urumqi River, Tianshan (2007.


Laohugou No. 12 Glacier (2006.08)
2006/08/13

Thanks for your Attention!