A sensitivity study on modeling the Black Carbon in snow and its radiative forcing over the Arctic and Northern China

Yun Qian, Hailong Wang, Rudong Zhang, Mark Flanner, and Philip J Rasch

1. Abstract

- To quantify the magnitude of the positive feedbacks of light absorbing aerosols (LAA) and their impact on snow and ice, it is critical to explore the sensitivity and uncertainty associated with the LAA deposition and snow-melting process in current earth system models.
- In this study, we first evaluate the simulated BC in snow (BCS) against the measurements collected from multiple field campaigns over the Arctic and Northern China.
- We then conduct a series of sensitivity experiments to examine the impact of the snow aging factor and melt-water scavenging efficiency on the snow-melting and radiative forcing of BCS, and also compare the uncertainty resulting from the BC deposition with that related to the treatment of snow aging and melt-water scavenging for BC.

2. Model and Experiment

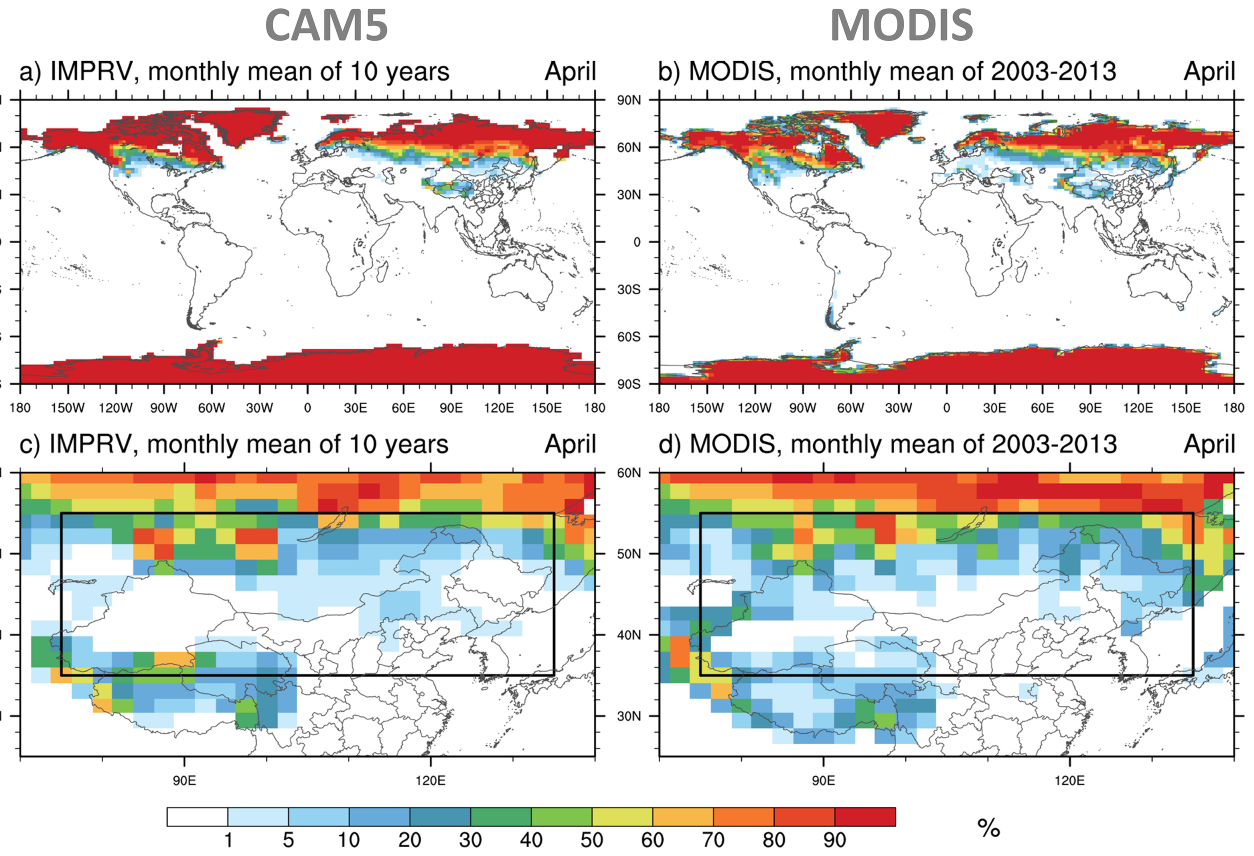
- 1.9 degree (latitude) and 2.5 degree (longitude) horizontal grids
- 30 layers in the vertical
- 11 years (10 years results are analyzed)
- Prescribed year-2000 monthly SST and sea ice
- Year-2000 monthly mean emission data for anthropogenic aerosols, including BC (Lamarque et al., 2010)

Summary of model simulations and parameter

Case	Model improvements made by Wang et al (2013a)	Melt-water scavenging efficiency for hydrophilic BC	Snow aging scaling factor
CAM5std		0.2	1.0
IMPRV	X	0.2	1.0
SEh	X	2.0	1.0
SEl	X	0.02	1.0
SAh	X	0.2	5.0
SAl	X	0.2	0.2

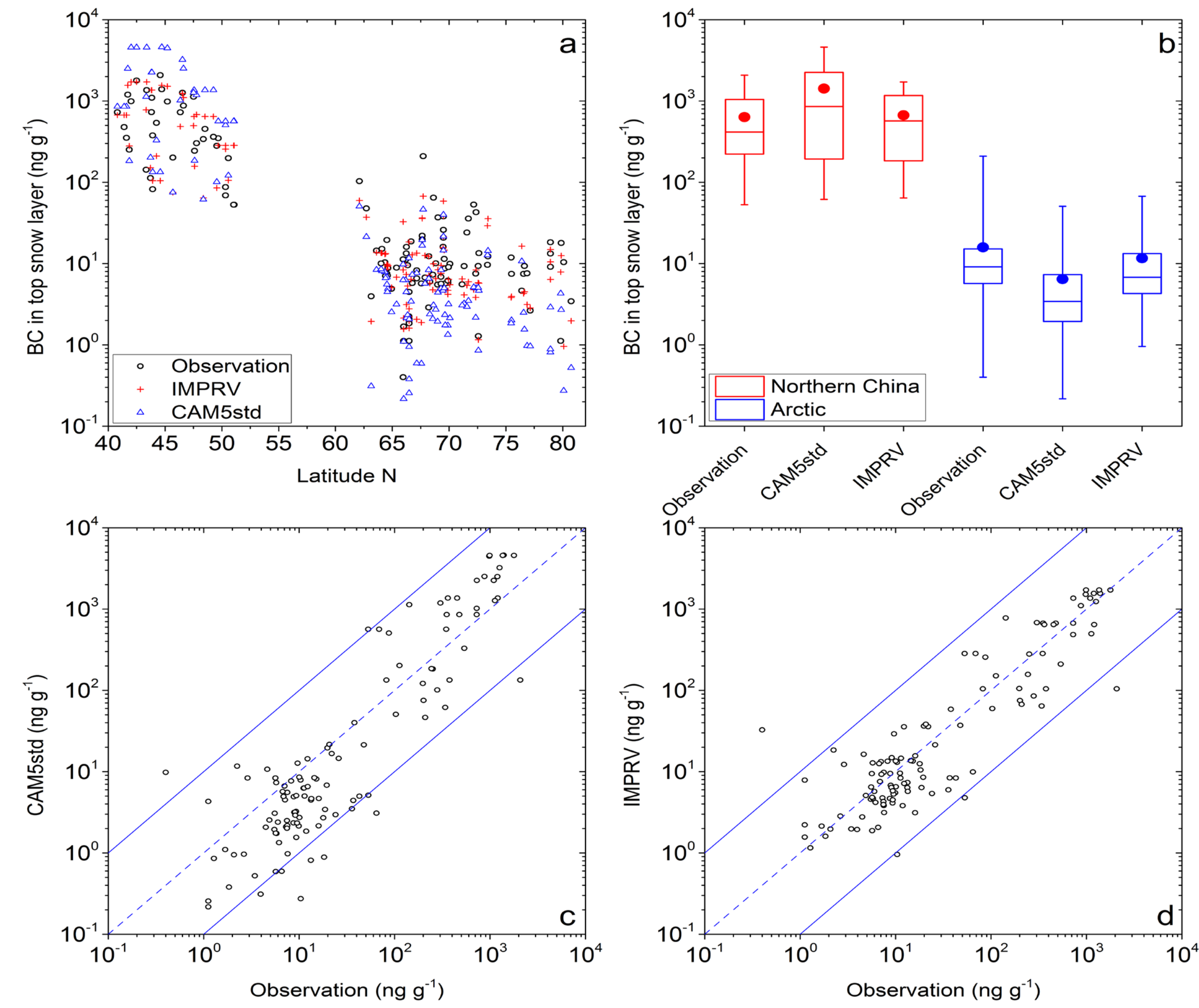
Snow Cover Fraction in April

CAM5 MODIS

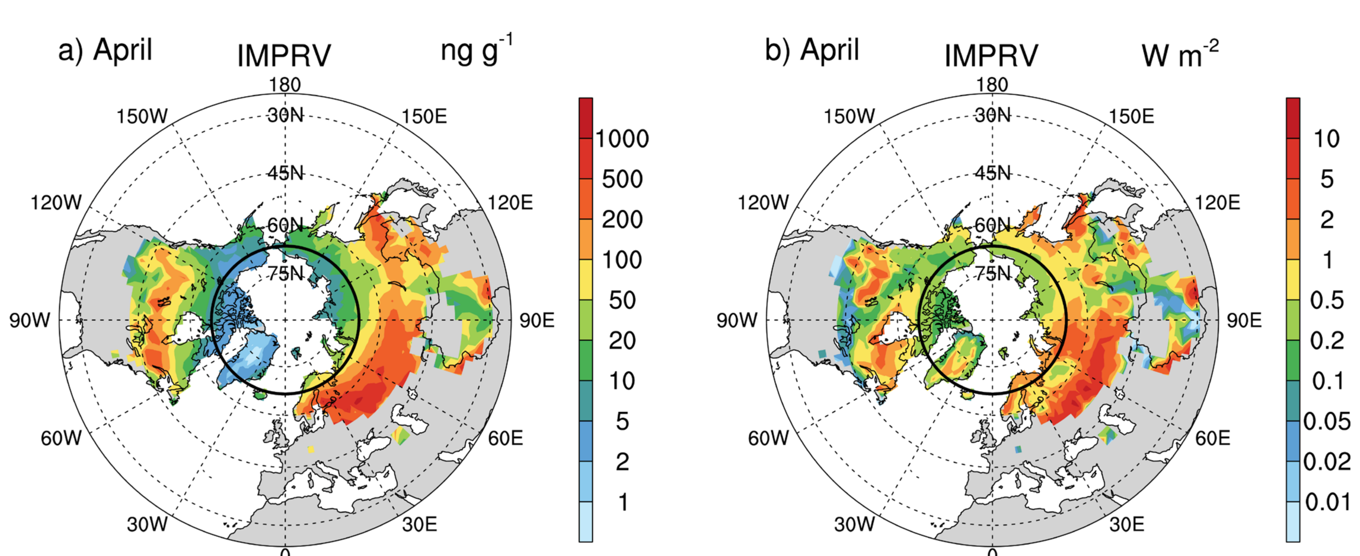


3. Results

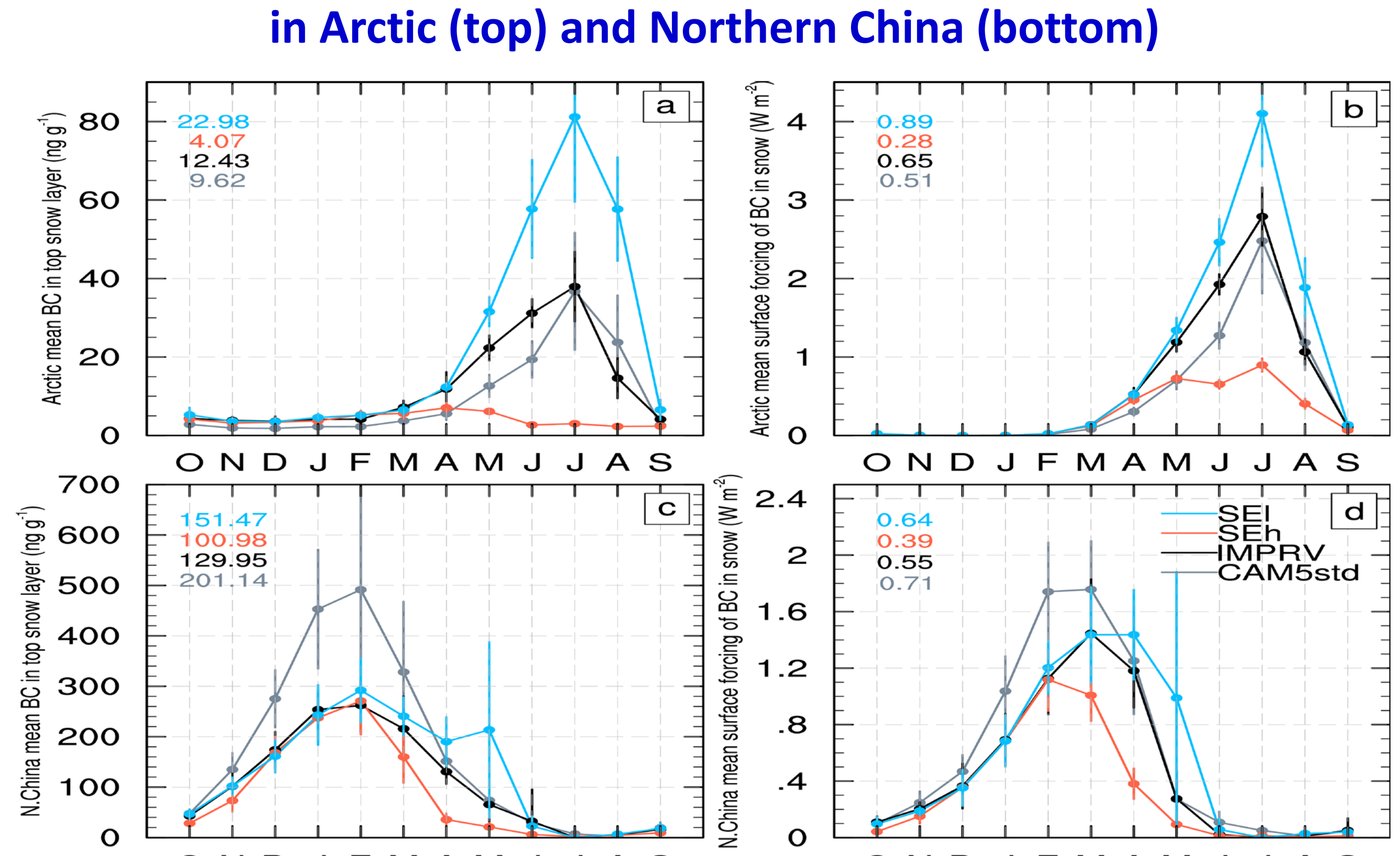
Simulated BCS concentration against observations



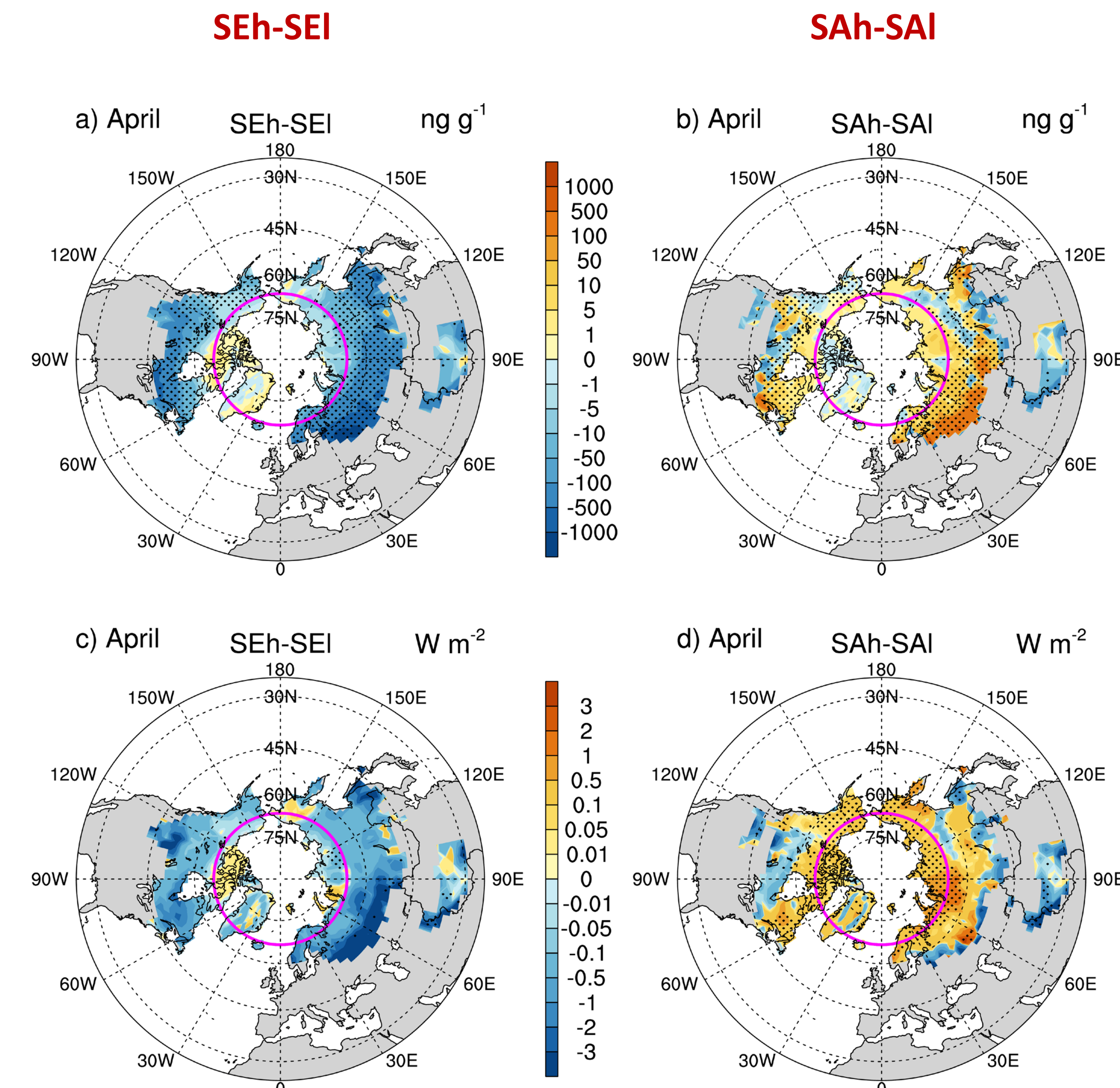
BCS concentration (left) and radiative forcing (right) in April



Monthly mean BCS concentration (left) radiative forcing (right) in Arctic (top) and Northern China (bottom)



Sensitivities of BCS concentration (top) and radiative forcing (bottom) to uncertain parameters



4. Summary

- Improvements in atmospheric BC transport and deposition significantly reduce the biases (by a factor of two) in the estimation of BC in Snow (BCS) concentration over both Northern China and the Arctic.
- Melt-water scavenging efficiency (MSE) parameter plays an important role in regulating BC concentrations in the Arctic through the post-depositional enrichment.
- MSE not only drastically changes the amplitude but also shifts the seasonal cycle of the BCS concentration and its radiative forcing in the Arctic.
- The impact of the snow aging scaling factor (SAF) on BCS shows more complex latitudinal and seasonal dependence, and overall impact of SAF is much smaller than that of MSE.
- More comprehensive in-situ observational and laboratory studies with a focus on quantifying the melt-water scavenging efficiency of BC is critical to reduce uncertainty in quantifying the radiative forcing and climatic and hydrological effects of BC in snow/ice.

U.S. DEPARTMENT OF ENERGY | Office of Science | Earth System Modeling Program

Corresponding Author: yun.qian@pnnl.gov