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Impact of topography on black carbon transport to the southern Tibetan Plateau and its implication for aerosol climate impact during the pre-monsoon season

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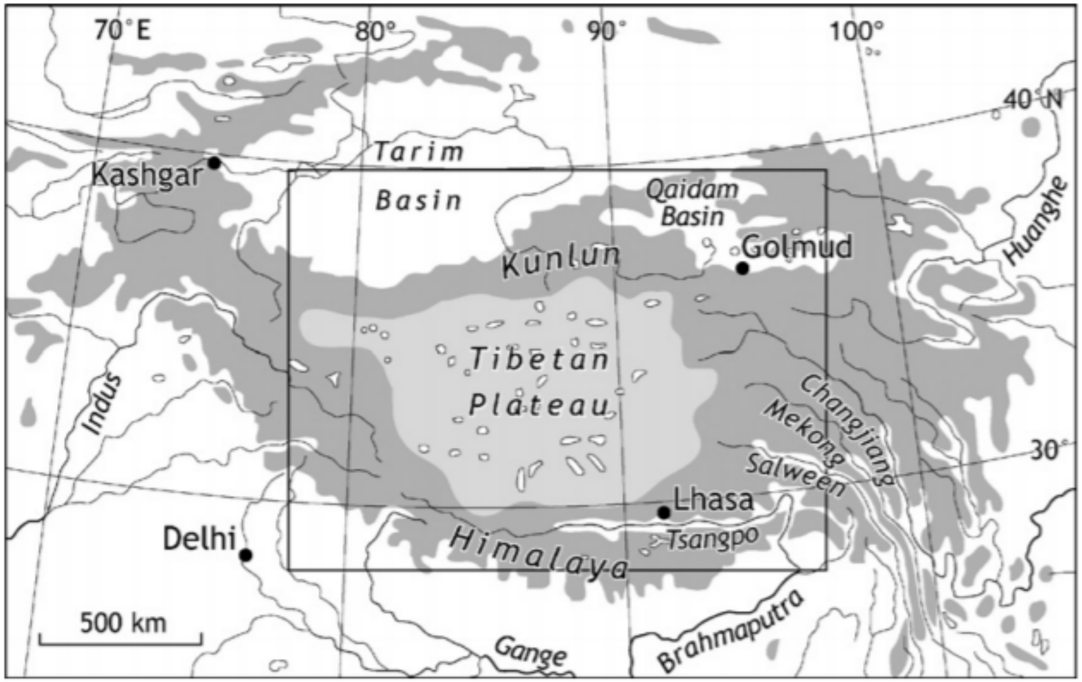
WRF and MPAS Users' Workshop 2019

2019-06-12

Background

Harris et al., 2006



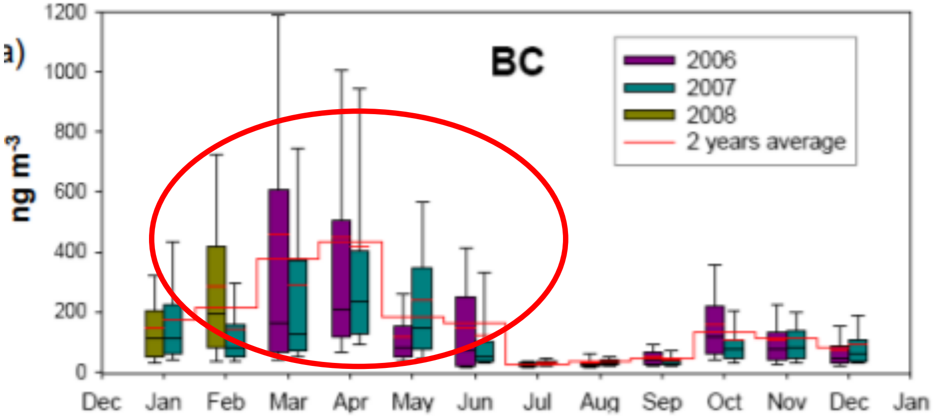
Tibetan Plateau (TP)

Impacts on **large-scale atmospheric circulation**

- Dynamic effects
- Thermal effects

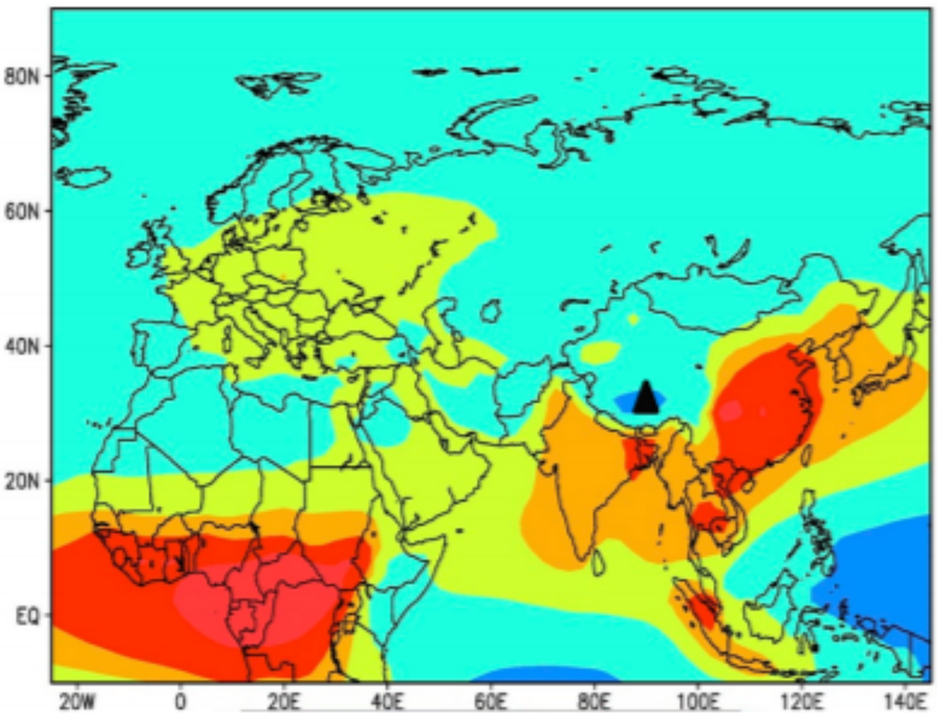
- Temperature in the TP is gradually increasing
- Warming may be related to the **absorbing aerosols** in the atmosphere or the snow cover of TP

Marinoni et al. 2010



Background

Xu et al., 2009

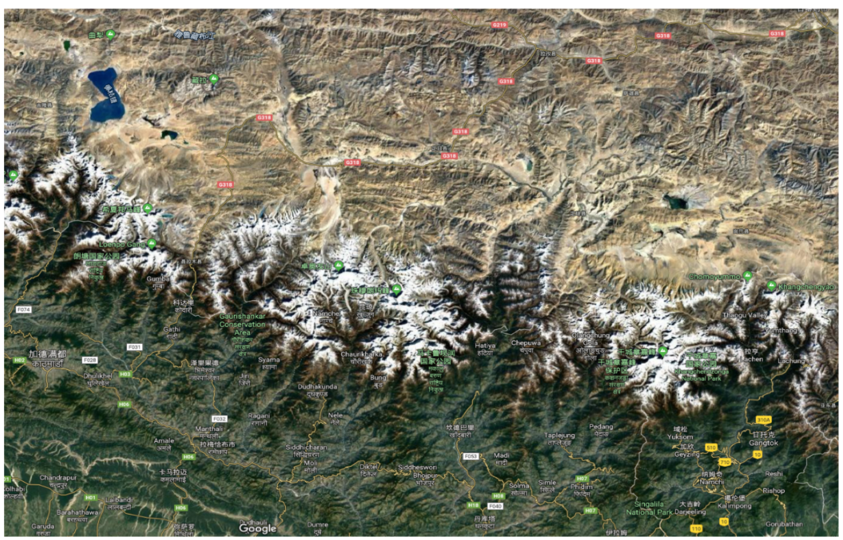


- TP surrounded by high BC concentrations
- Many studies investigated the transport mechanisms of Asian aerosols to the TP: westerly, valley wind, and etc.

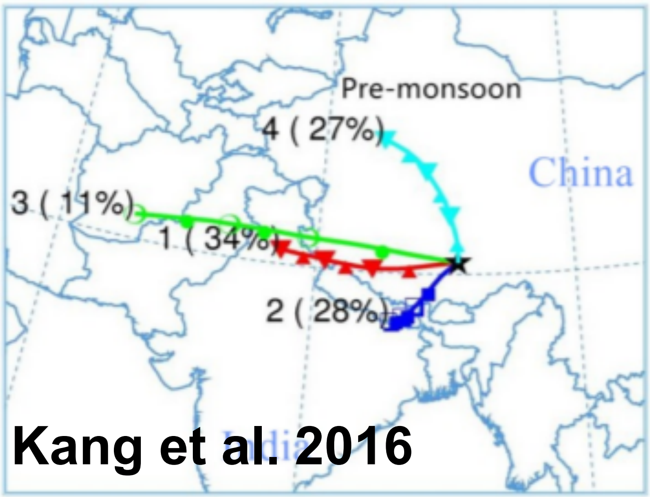
- The black carbon on the plateau is likely to be transported **from South Asia**, especially in pre-monsoon season.

Background

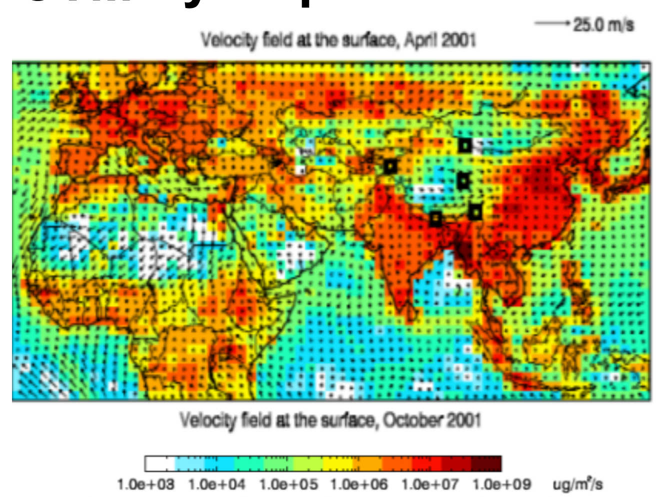
- Most of previous studies investigated transport based on observations and back-trajectory models
- Some simulated transport processes at relatively coarse horizontal resolutions (e.g., 20-100km), which hardly resolve the complex topography of southern slope of TP.



Back-trajectory

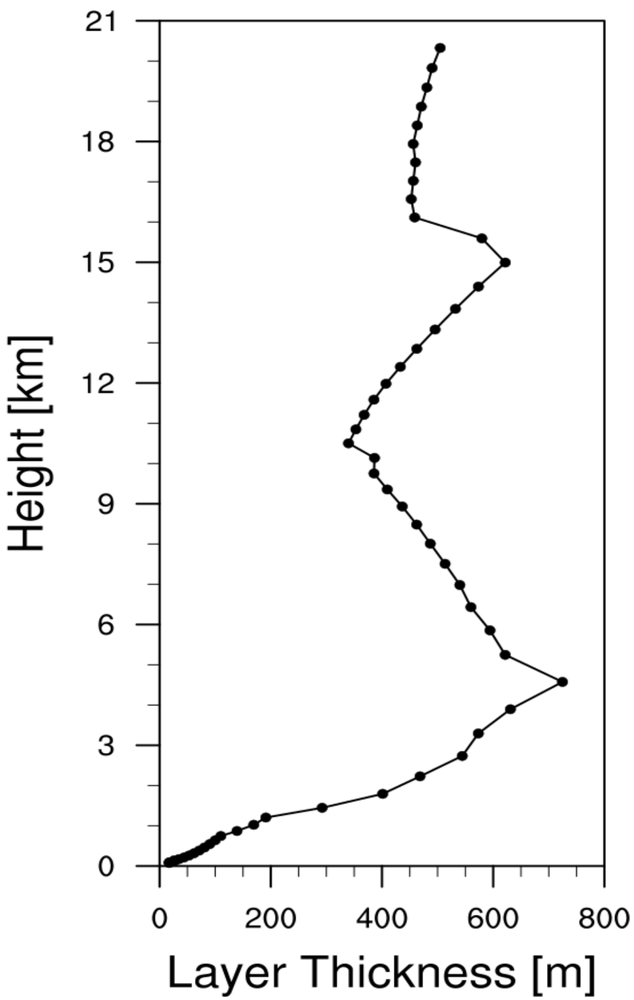


CTM by Kopacz et al. 2011



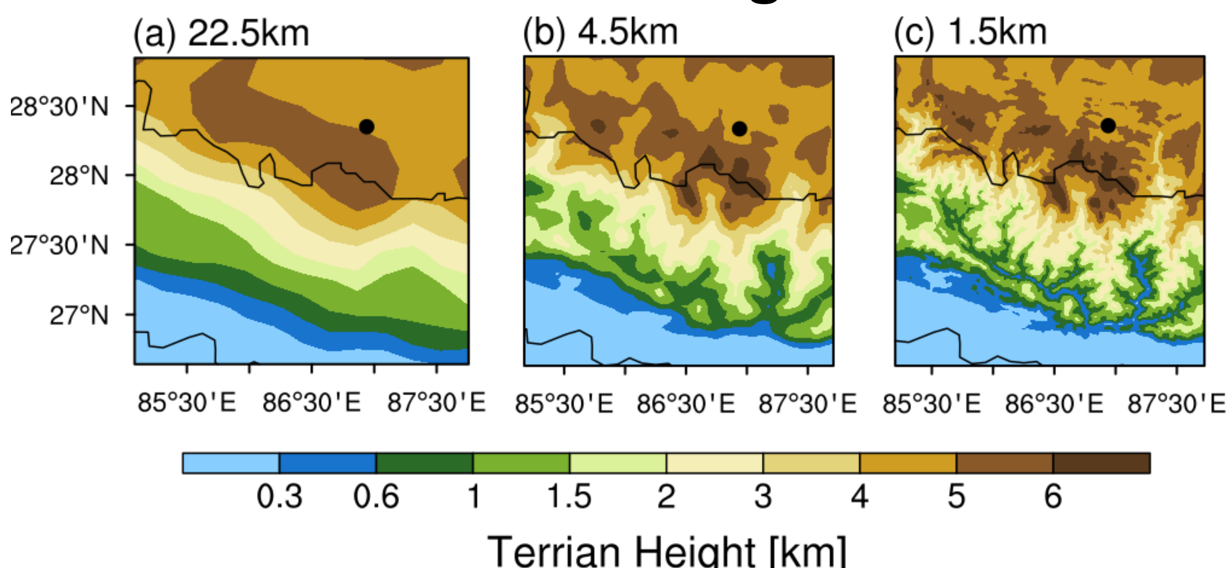
WRF-Chem Configuration

Vertical Configuration



- Three different resolutions of 22 km, 4.5 km and 1.5 km
- Simulation period: April of 2016

Terrain Height



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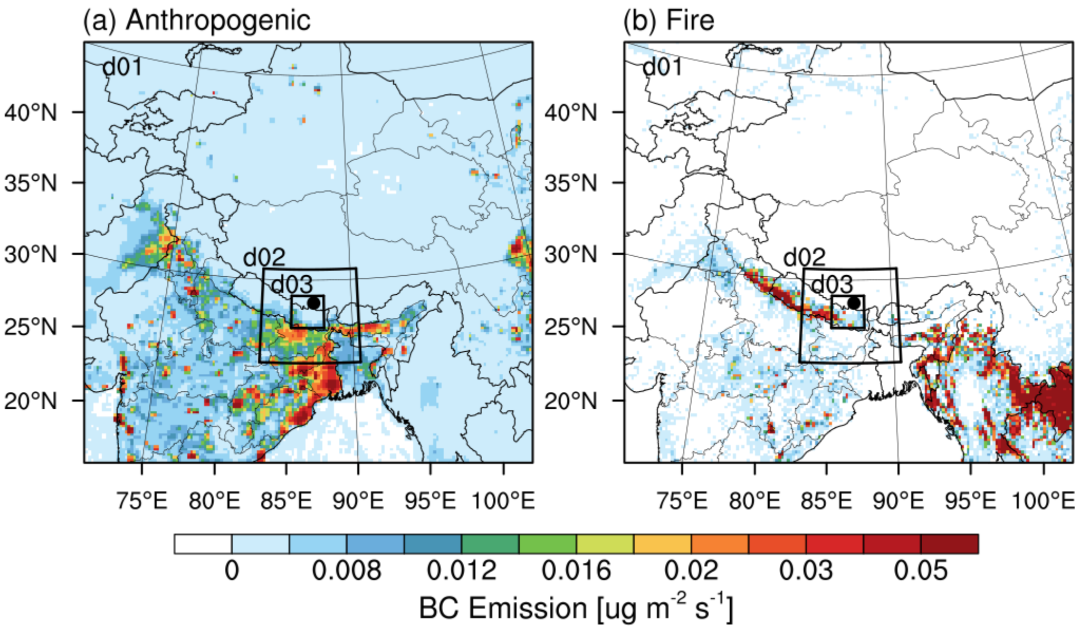
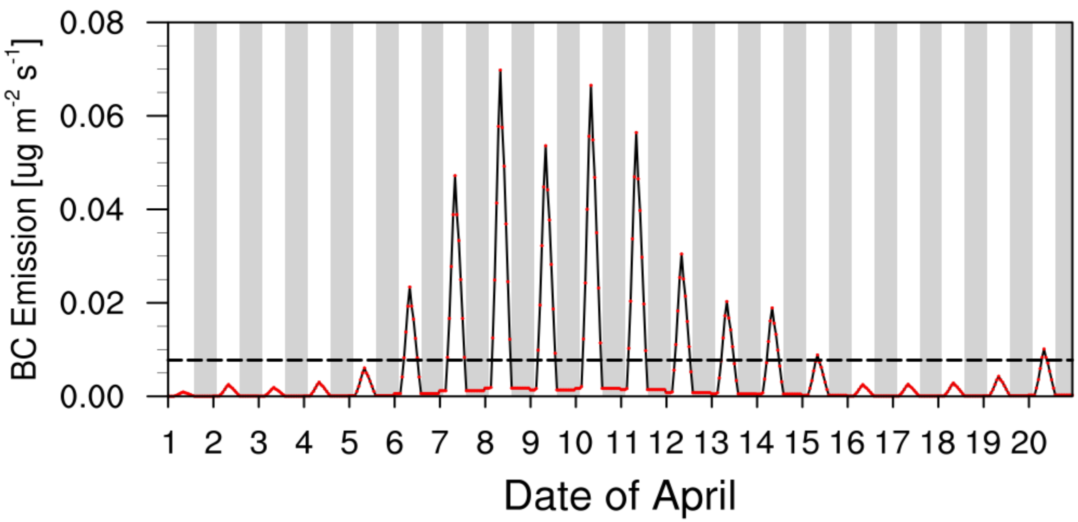
WRF-Chem Emission

Spatial distribution



Fire emissions are greater than anthropogenic emissions in South Asia near the TP



Strong fire episode in pre-monsoon season

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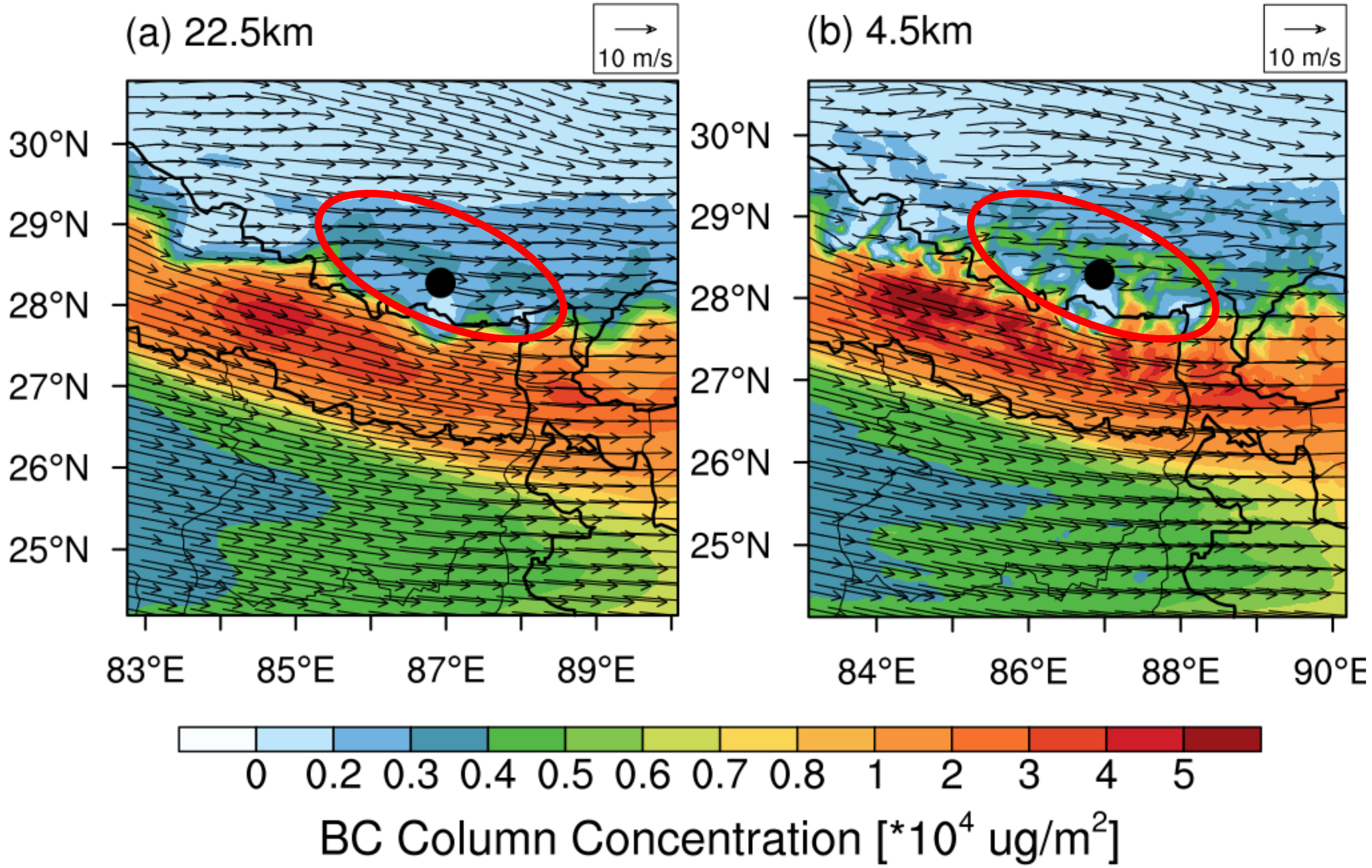
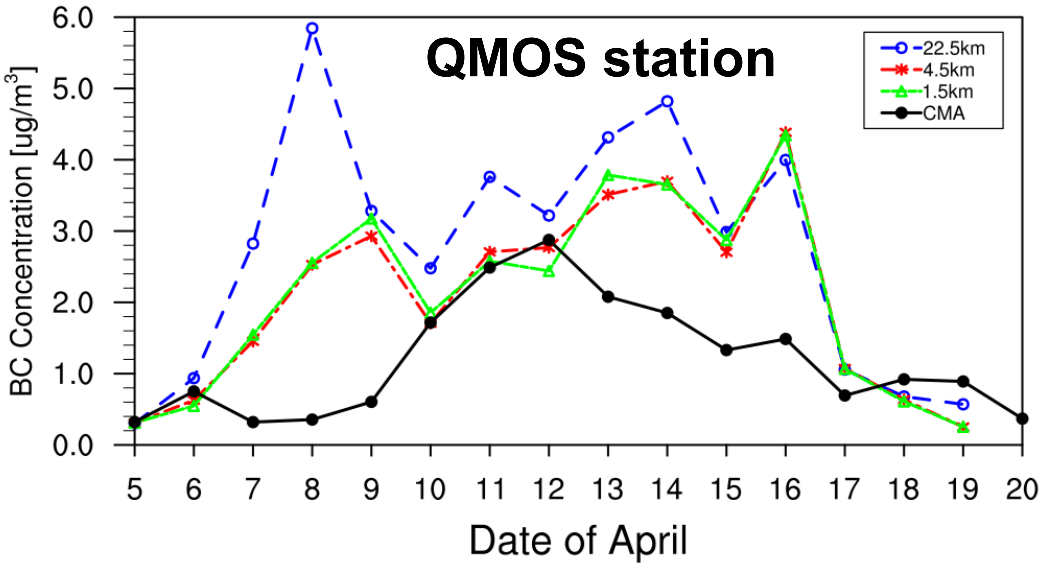
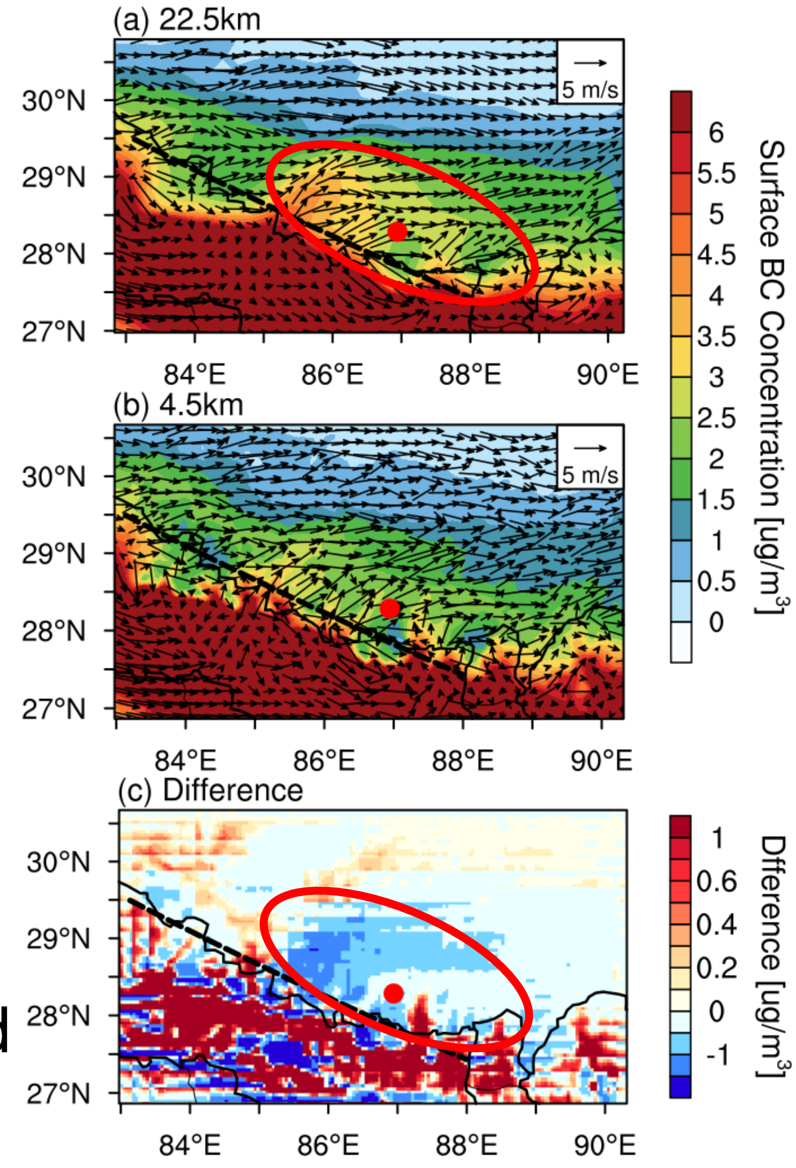
Integrated BC column mass



- Prevailing westerlies
- Column BC mass accumulates near the southern slope, and is higher at 4.5 km than that at 22.5 km over the TP

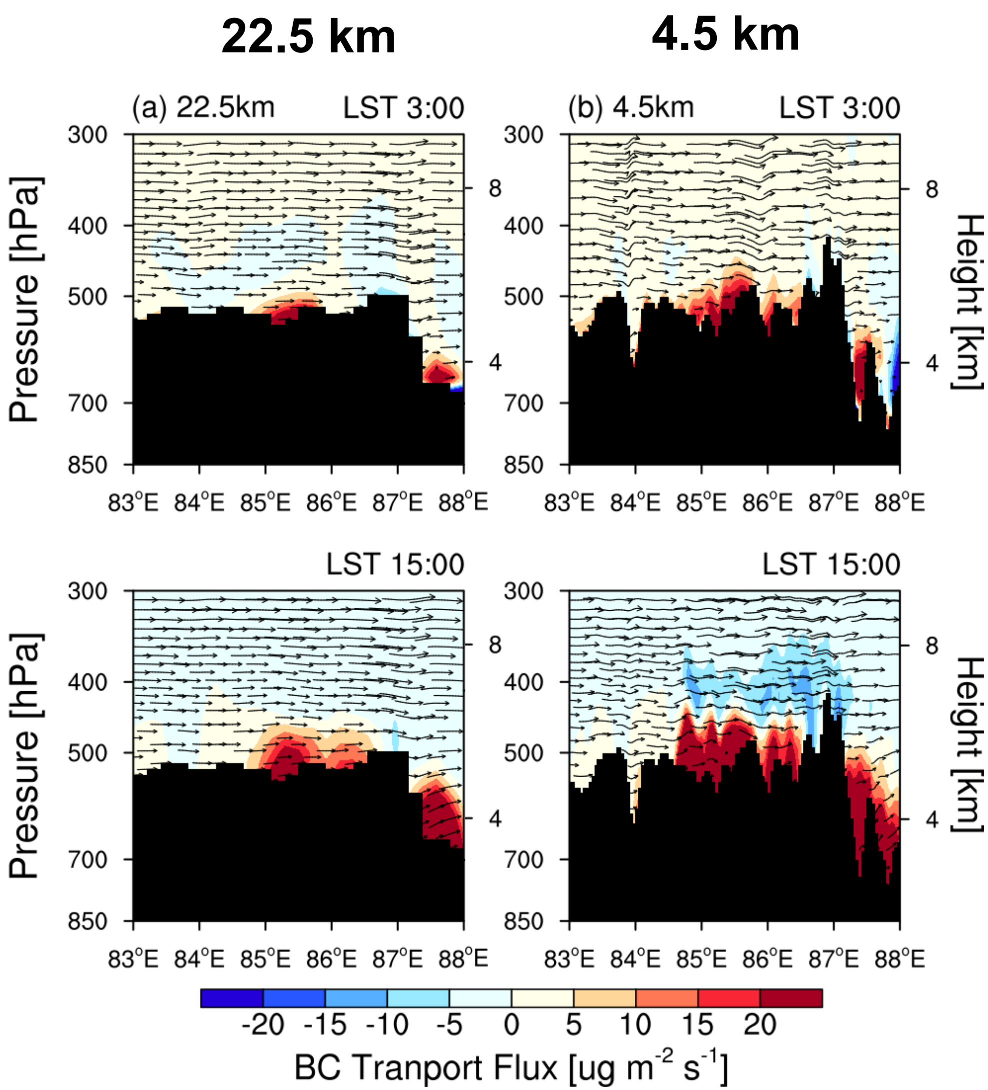
Surface BC over the TP

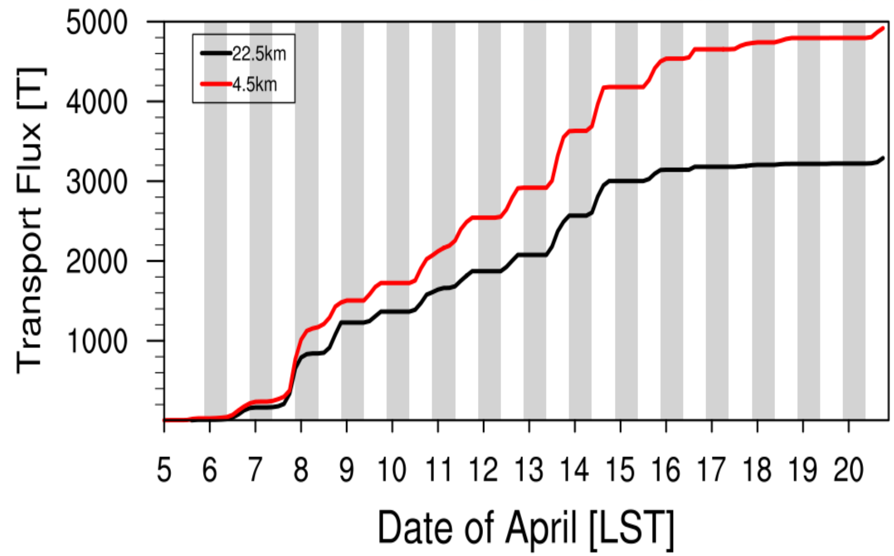




- Surface BC mass is higher at 22.5 km than that at 4.5 km over the TP near the slope.
- Simulations reproduce the episode
- The difference between 4.5 km and 1.5 km is relatively small.

BC transport flux into the TP

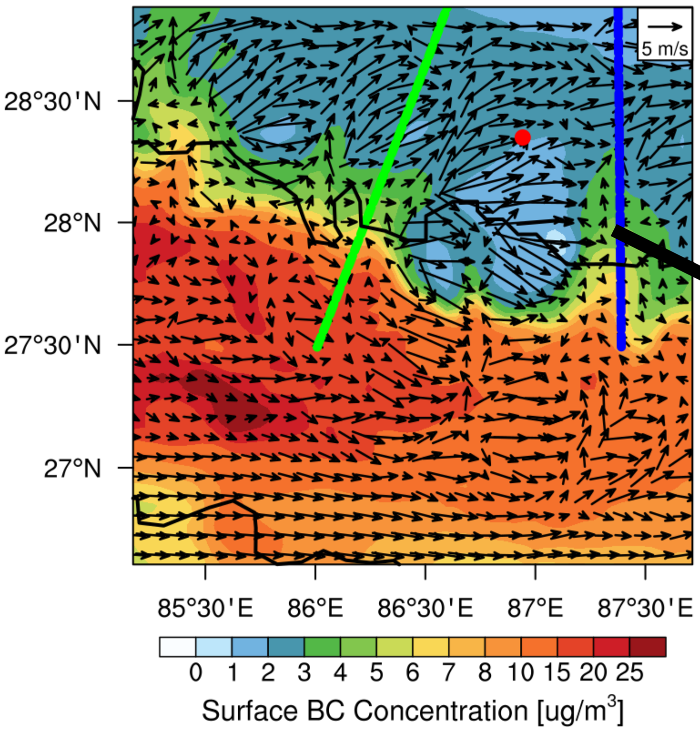


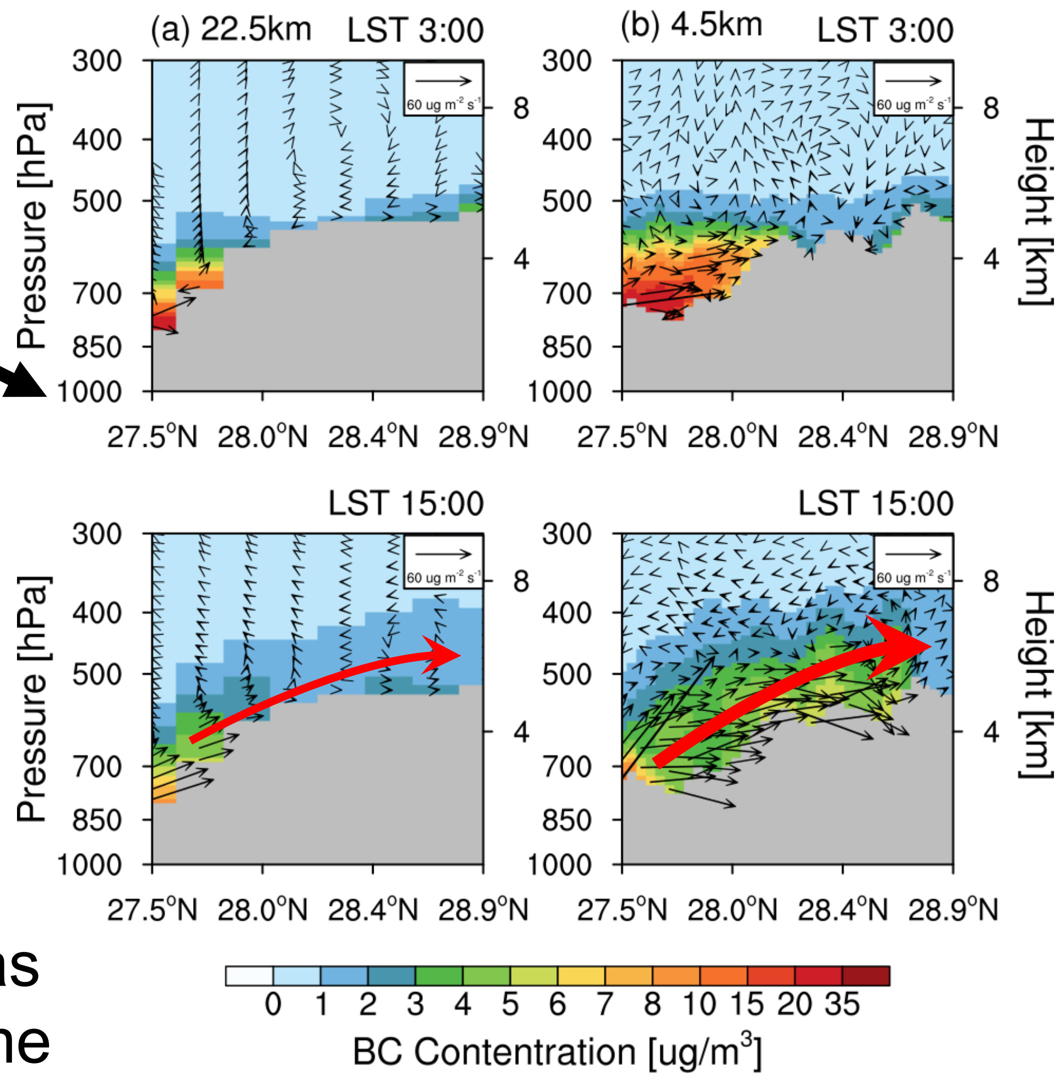


- Transport flux reaches maximum in the afternoon
- Different transport pattern. Low-level transport at 4.5 km is greater than 22.5 km
- Overall flux is higher at 4.5 km

BC transport pathways

Valley transport





- Evident valley transport as observed, uphill at daytime
- Stronger transport at 4.5 km

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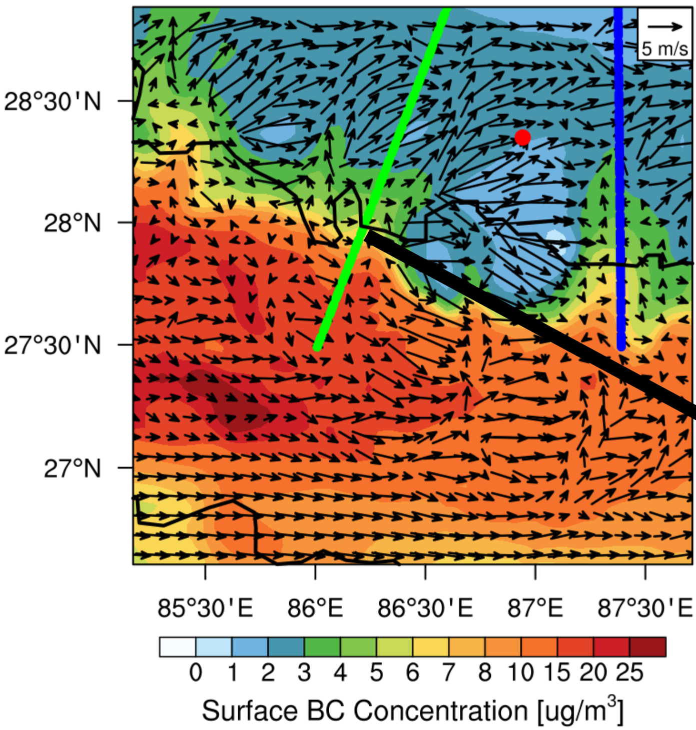
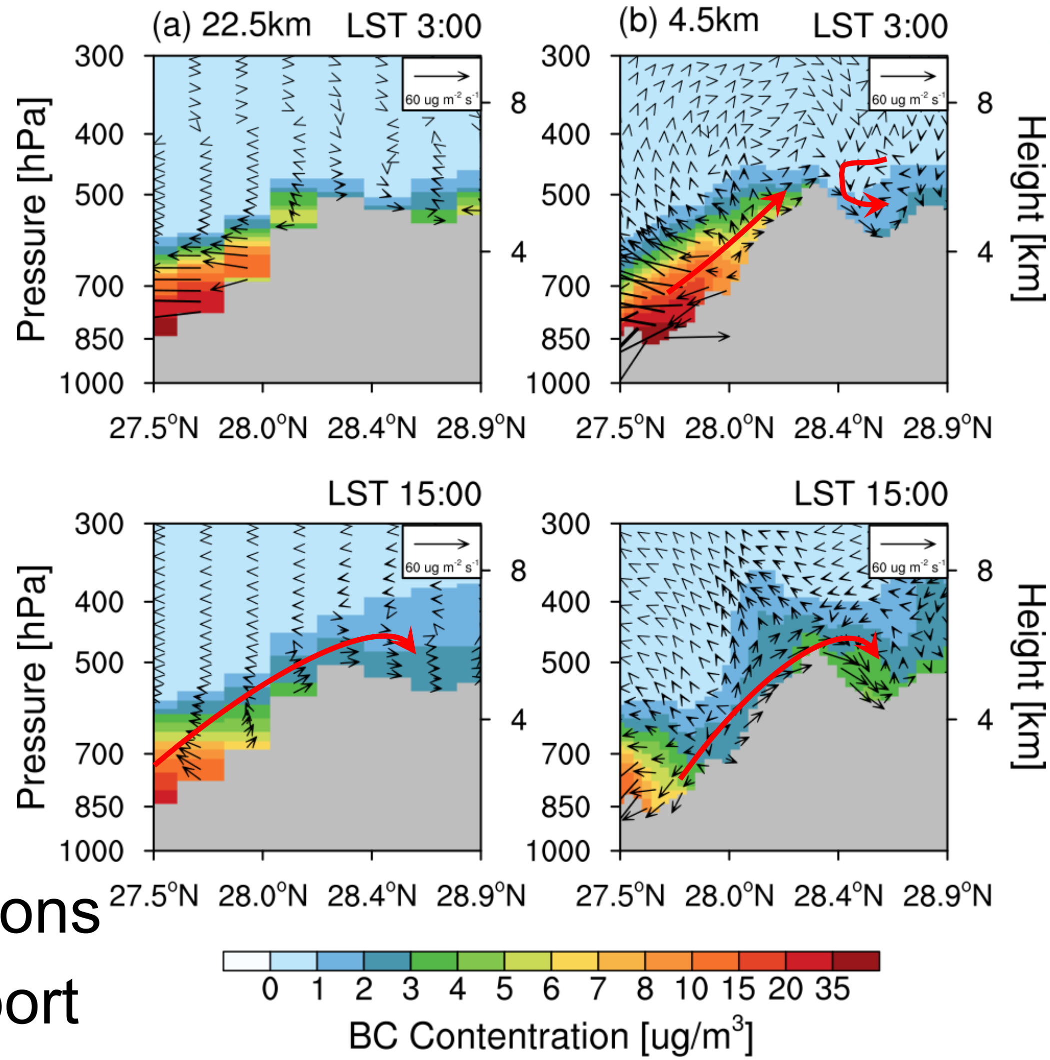
BC transport pathways





- Daytime transport across mountains at both resolutions
- Weaker than valley transport
- Uphill without glacier
- Comparable strength between two resolutions

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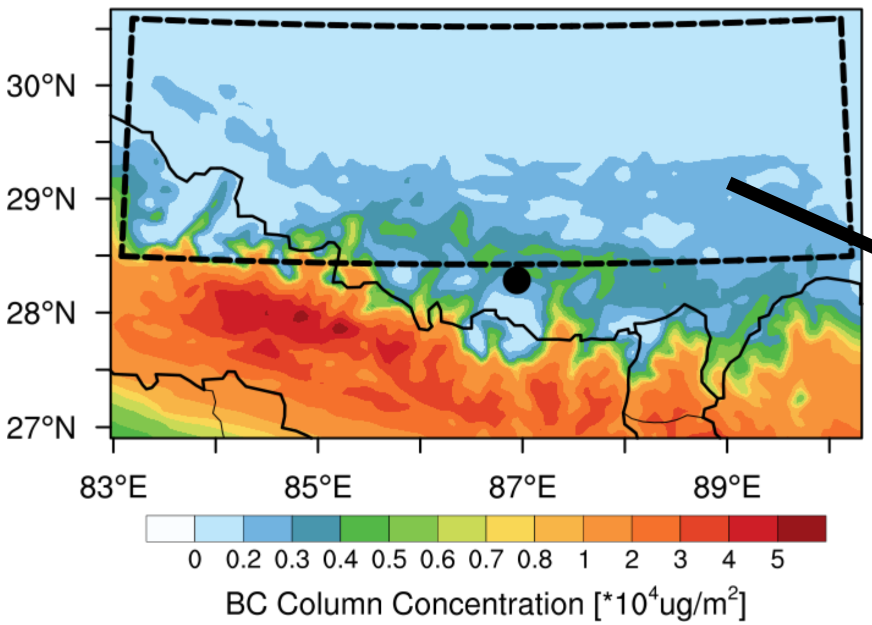
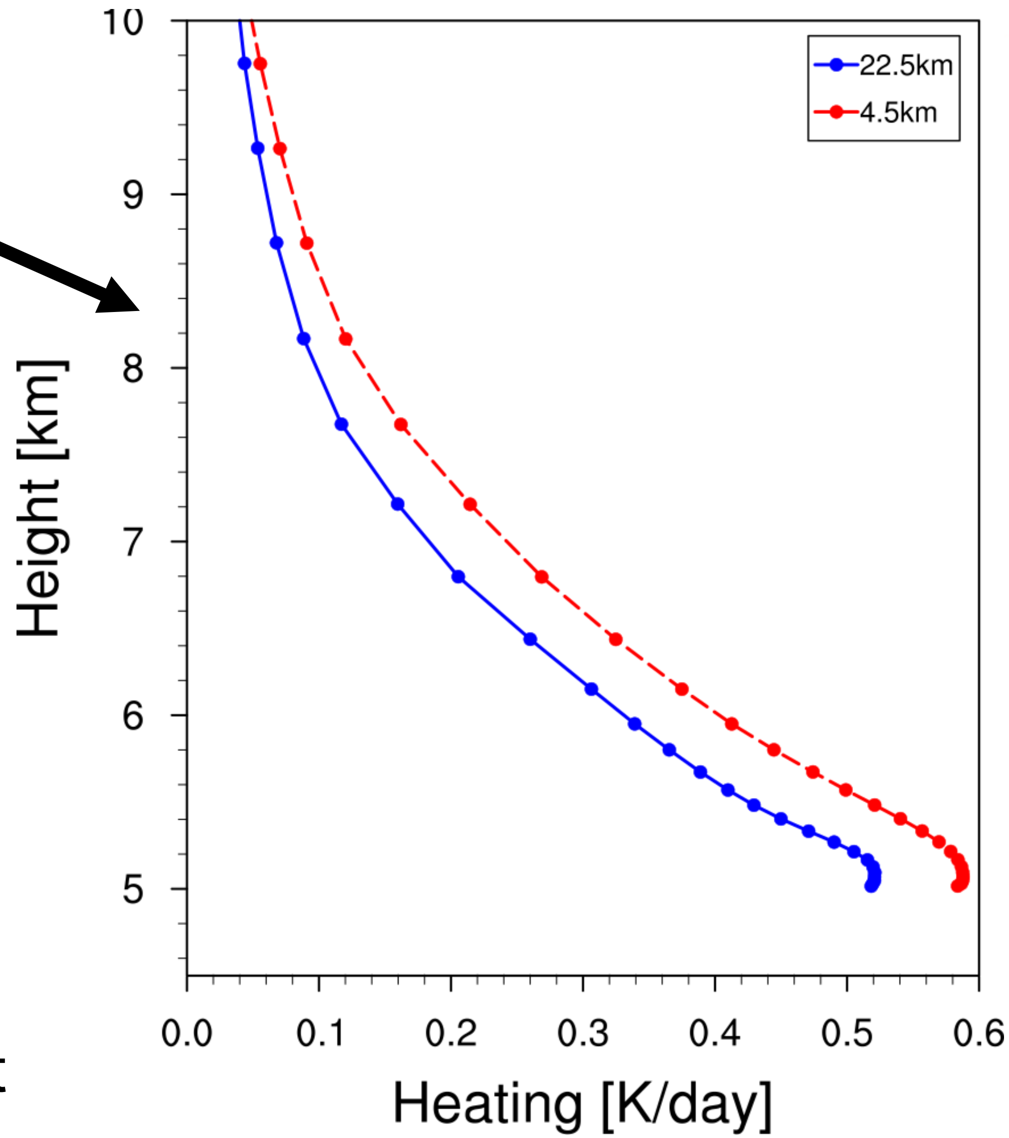
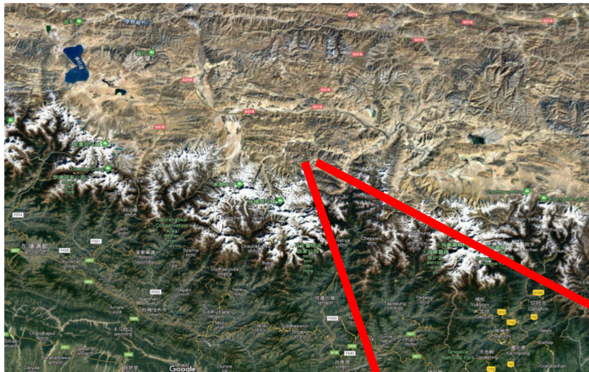
BC heating profiles over the TP



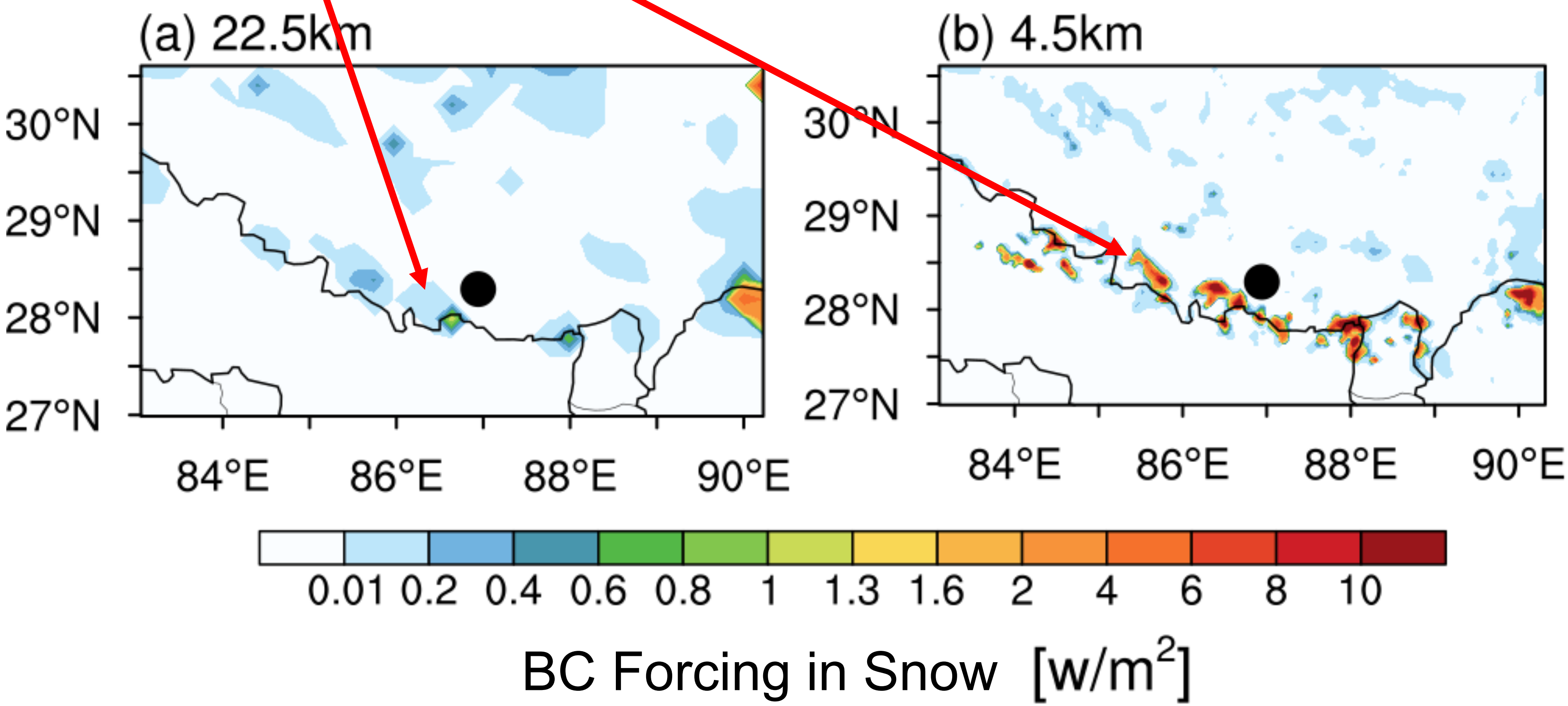


- BC over the TP results in a maximum heating rate near the surface
- Stronger radiative heating from the surface to 10 km at 4.5 km

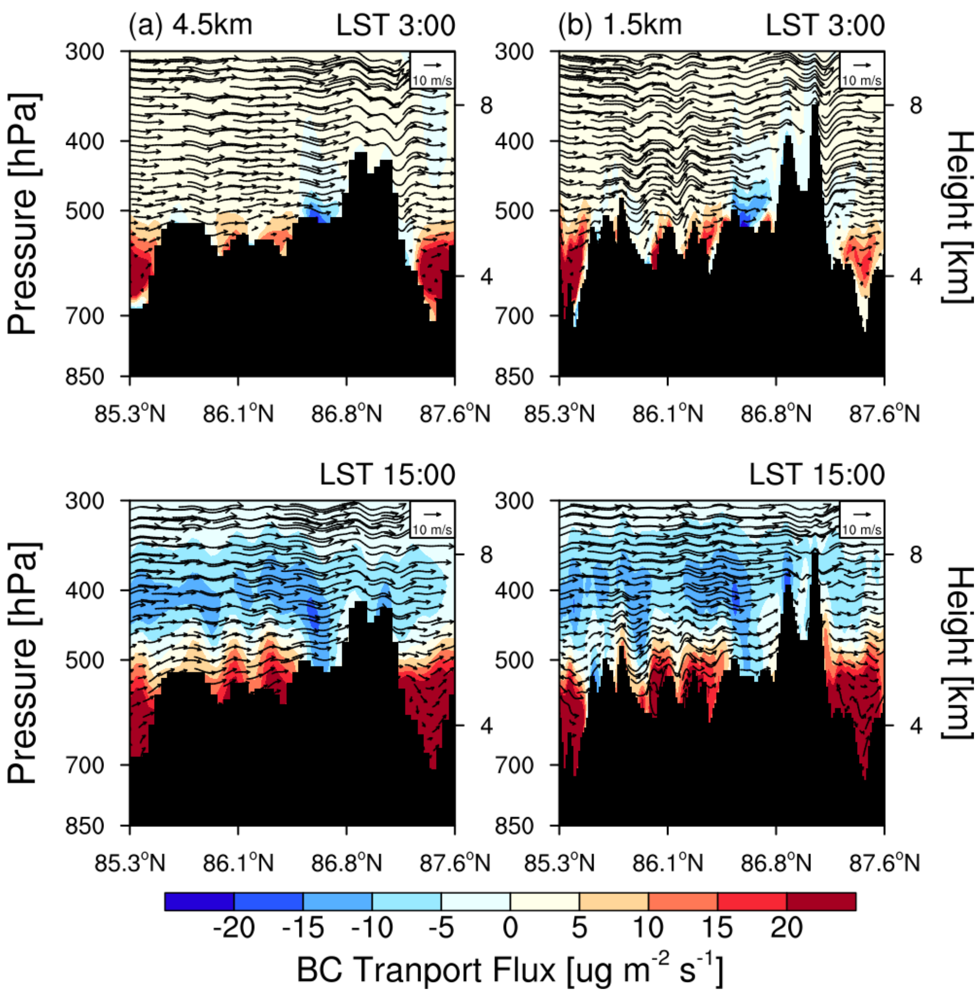
BC forcing in snow of TP

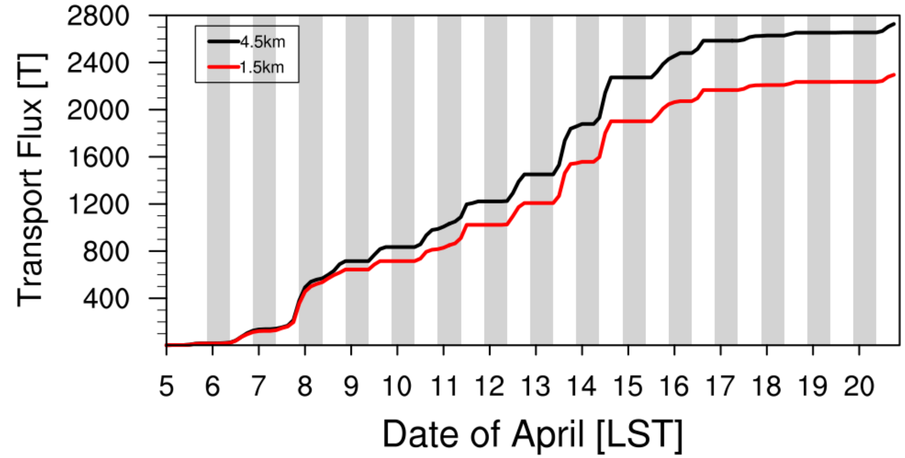


- More snow at 4.5 km
- Stronger snow forcing at 4.5 km



1.5 km versus 4.5 km





- Overall transport pattern is similar, flux reaches maximum in the afternoon
- Total flux is smaller at 1.5 km than at 4.5 km

Summary

- The simulations at all resolutions show the prevailing up-flow across the southern slope during the daytime that is dominant transport mechanism of pollutants into the TP; the valley transport is stronger than crossing mountain transport at 4.5 km.
- Different representation of topography of southern slope of TP at 22.5 km and 4.5 km lead to similar transport pathways (mountain and valley) of pollutants with different patterns and strength, which results in large difference in simulated aerosol radiative forcing in the atmosphere and surface snow of TP.
- The simulation at 1.5 km resolution has similar transport pattern with that at 4.5 km, but produces smaller amount of flux into the TP over the selected region.

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Thank you!