Modeling Studies on Blowing Snow/ Polynya Interaction Associated with Extreme Arctic Weather

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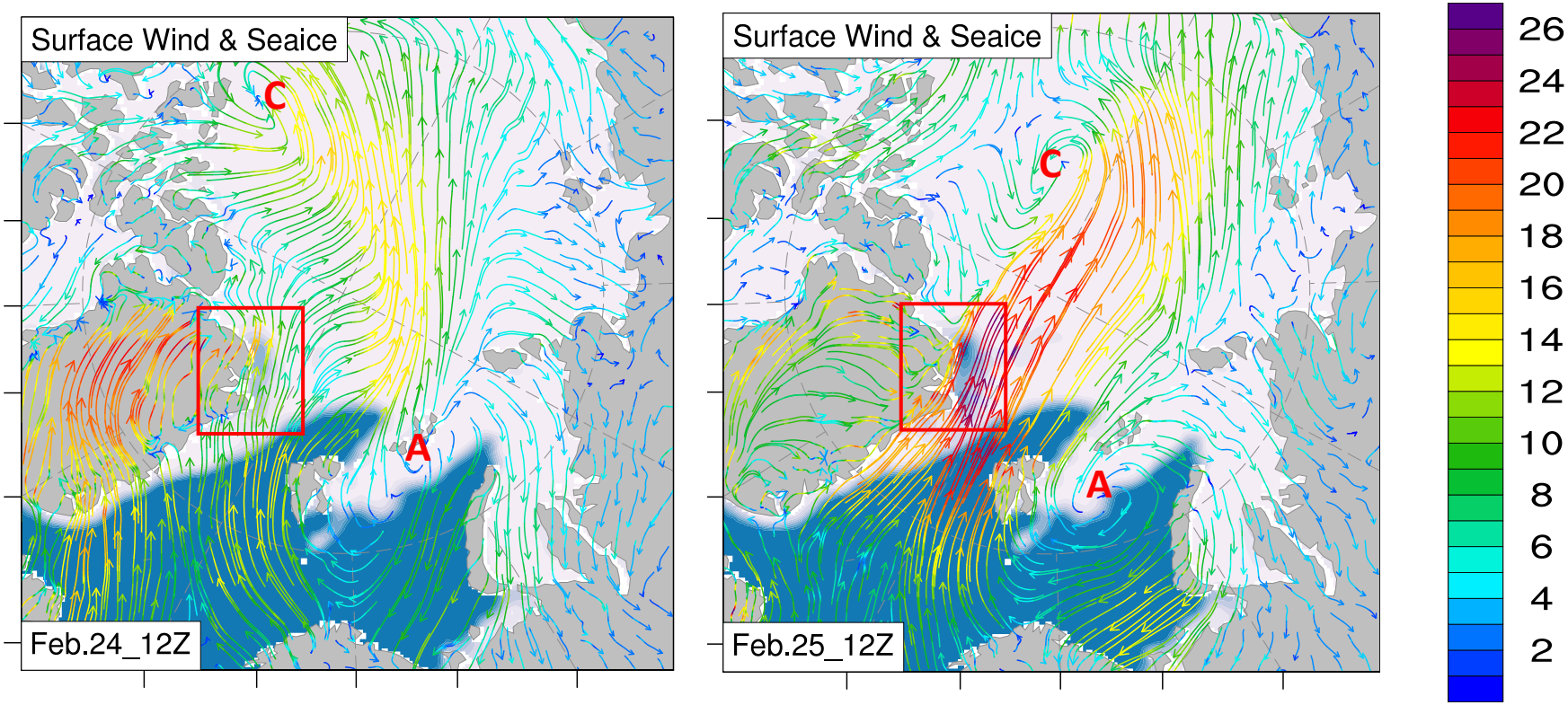
Introduction

Concurrence of a strong anticyclone and an intense cyclone in the Arctic resulted in a strong wind event in February 2018, causing an extreme polynya event north of Greenland.



Blowing Snow

Extremely strong winds at the surface can also cause another important physical process - blowing snow, an uplift and horizontal transport of surface snow by winds.

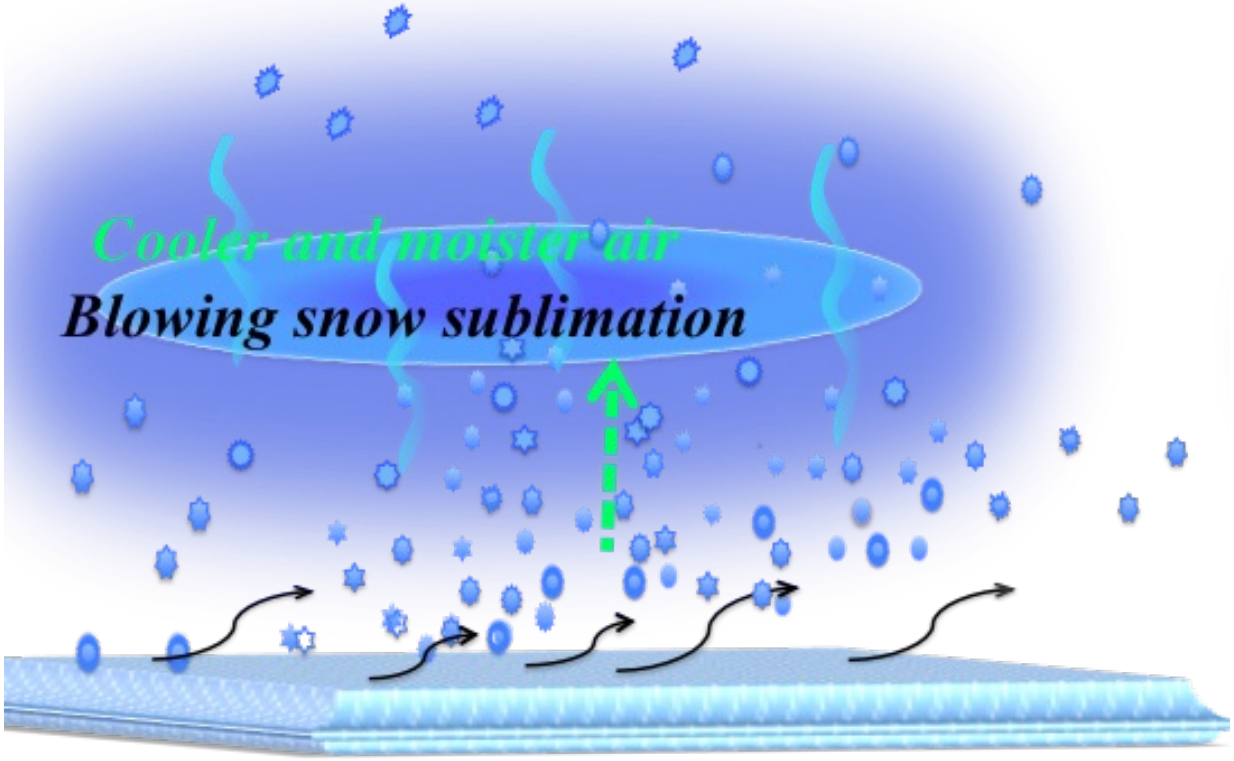


Figure 10a in Luo et al., JGR, 2021

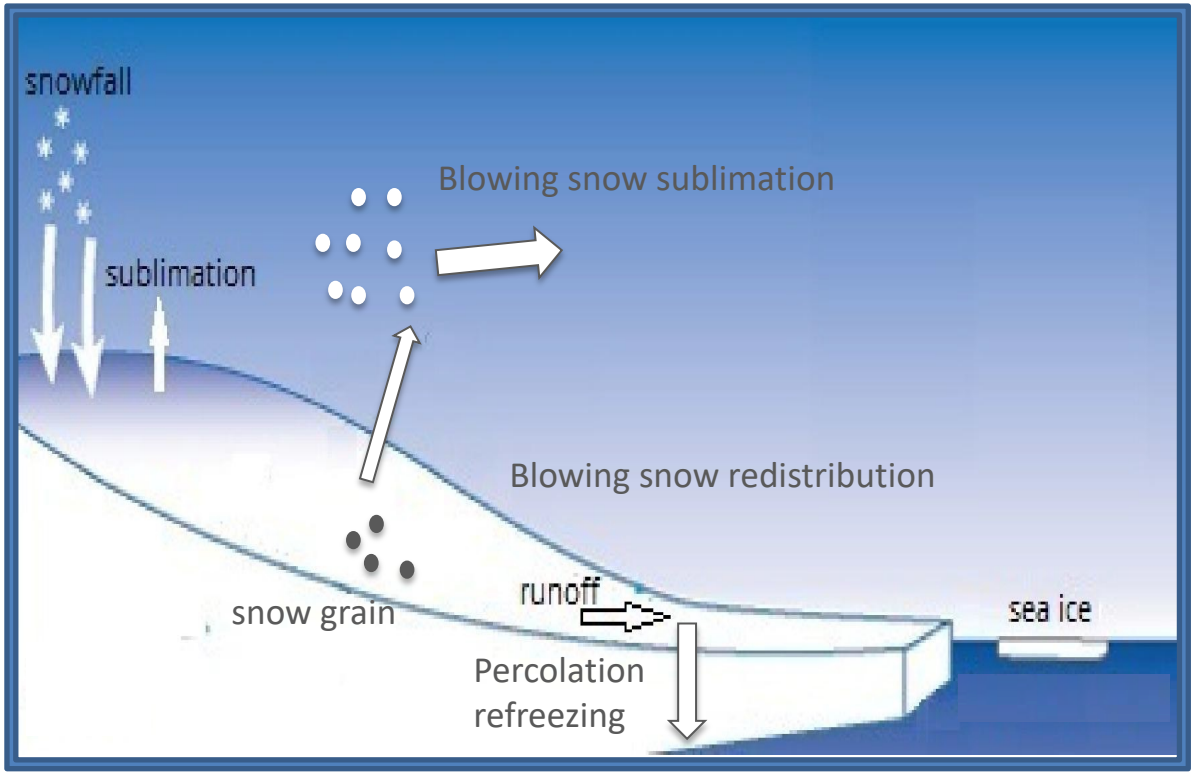
Question

How does the blowing snow impact the air-sea interaction over polynya?

WRF-ice Model

The snow/ice enhanced Weather Research & Forecasting (WRF-ice) model includes three extra modules of:

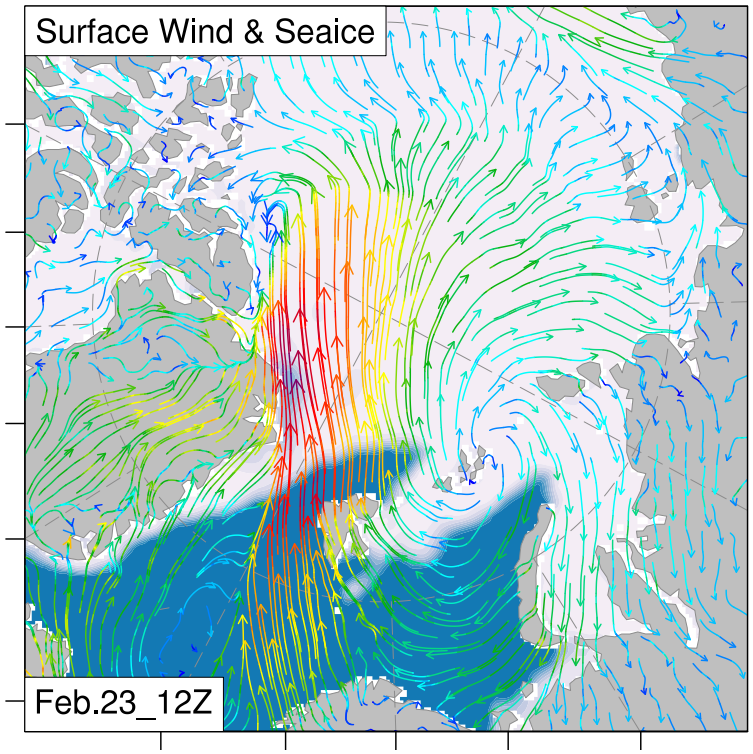
- Sea ice thermodynamics (Zhang and Zhang 2001, Zhang et al. 2013)
- Ice-sheet/shelf thermodynamics (Yao et al. 2016; Luo et al. 2021)
- Blowing snow physics (Dery and Yau 2001)



Design of the Simulations

Grid settings	20 km resolution, 49 vertical levels with the top at 10 hPa
Forcing data	ERA5 dataset
Simulation period	22-26 Feb 2018
Cloud scheme	Morrison 2-moment
Radiation scheme	RRTMG long/short-wave
PBL schemes	MYNN-2.5 + blowing snow
Surface schemes	Noah Surface + blowing snow sea-ice ice-sheet/shelf

Grid configuration

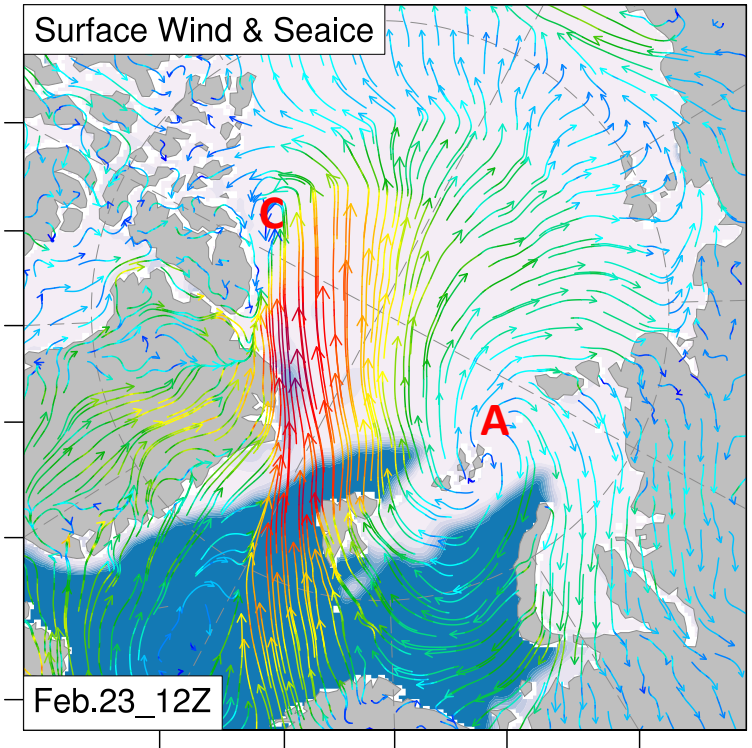


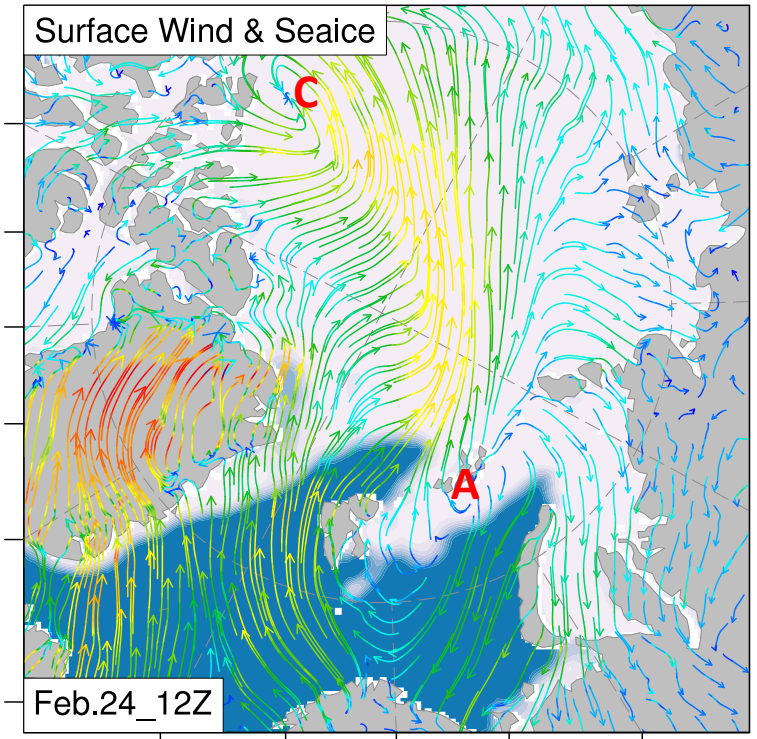
Design of the Simulations – Cont.

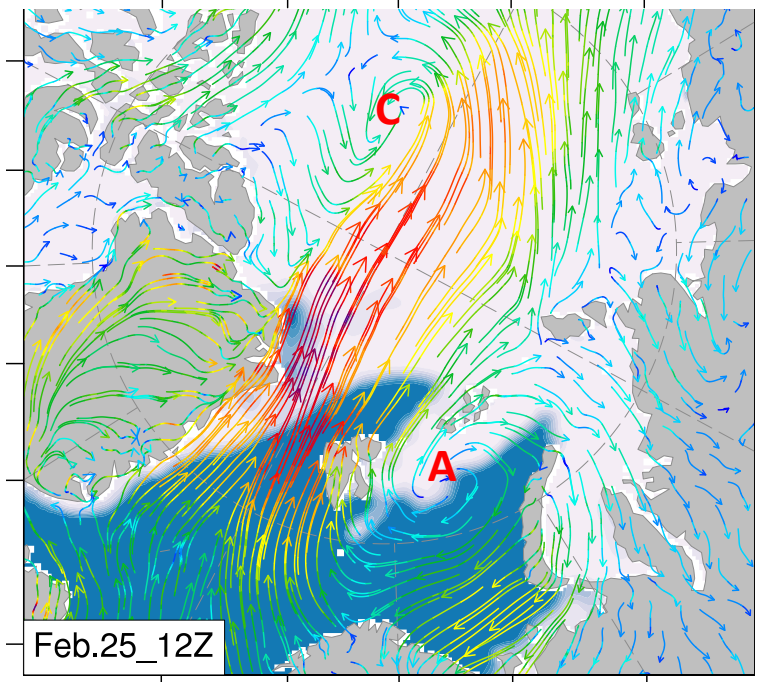
Simulation Experiments	Polynya + blowing snow (PB)	100% ice + blowing snow (IB)	Polynya only (P)	100% ice (I)
Polynya	yes	no	yes	no
Blowing snow	yes	yes	no	no

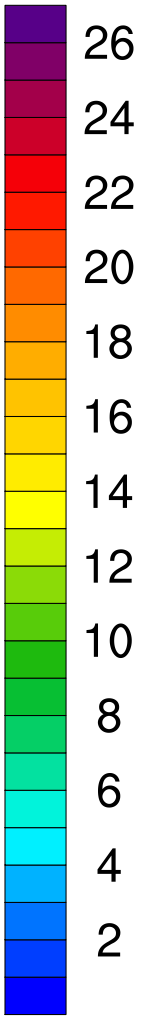
Blowing snow impacts on air-sea interaction over the polynya will be investigated by comparing the results among the sensitivity experiments PB, IB, P, and I.

Strong winds captured by the WRF-ice simulation of PB experiment

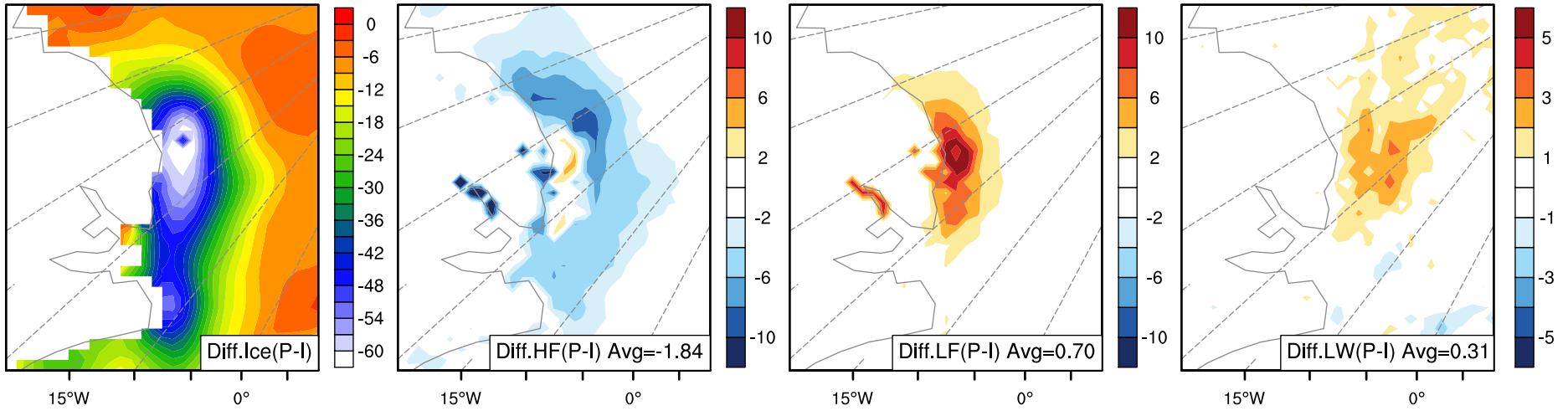




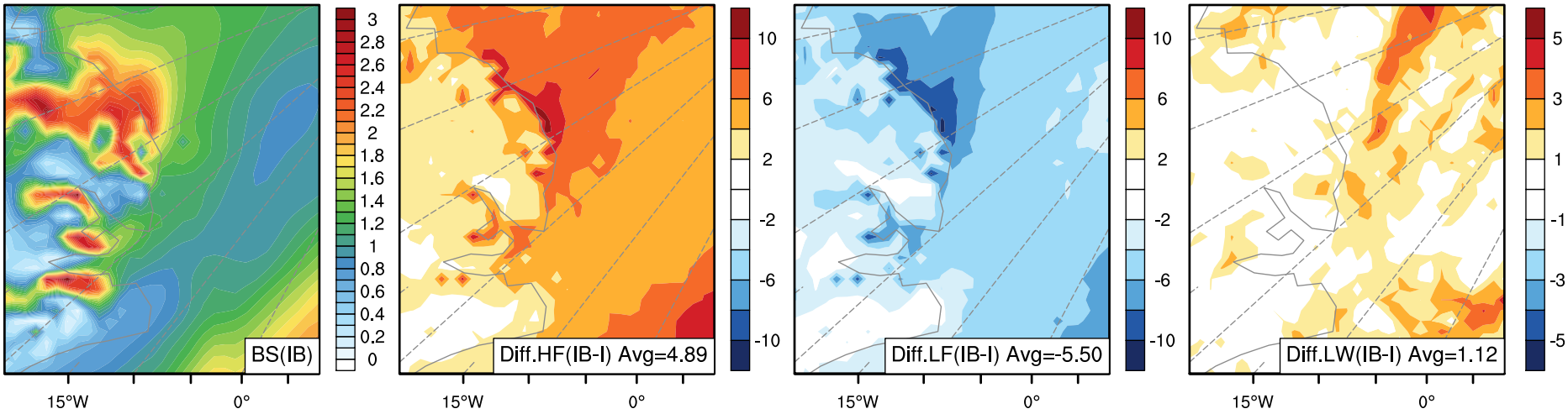




Impacts of polynya & blowing snow on the surface energy fluxes

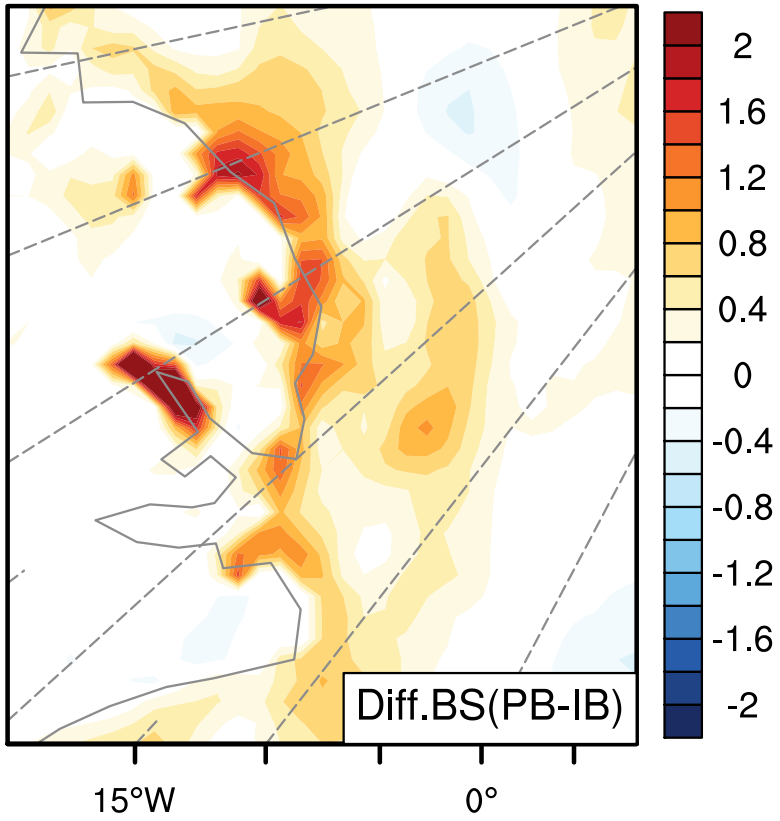


Differences of sea ice coverage (%), surface sensible, latent heat fluxes, & downward longwave radiation (w/m^2) between simulations of polynya (P) and 100% ice cover (I).

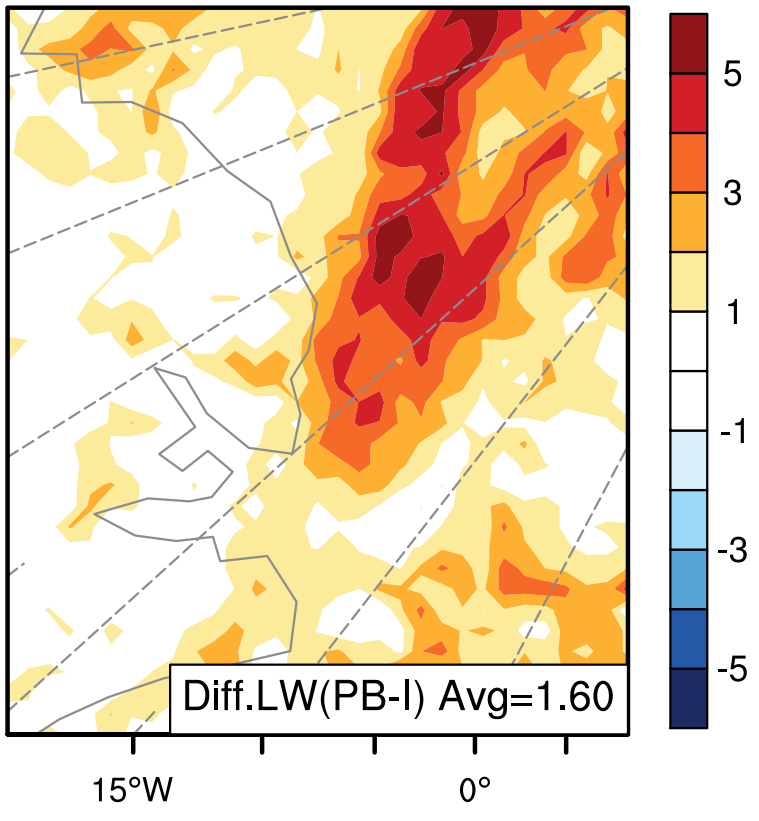


Blowing snow sublimation (10^{-2}mm/hr) in the IB simulation and differences of surface sensible, latent heat fluxes, & downward longwave radiation (w/m^2) between simulations IB

Blowing snow sublimation is stronger over the polynya, so is the downward longwave radiation when blowing snow interacts with polynya.

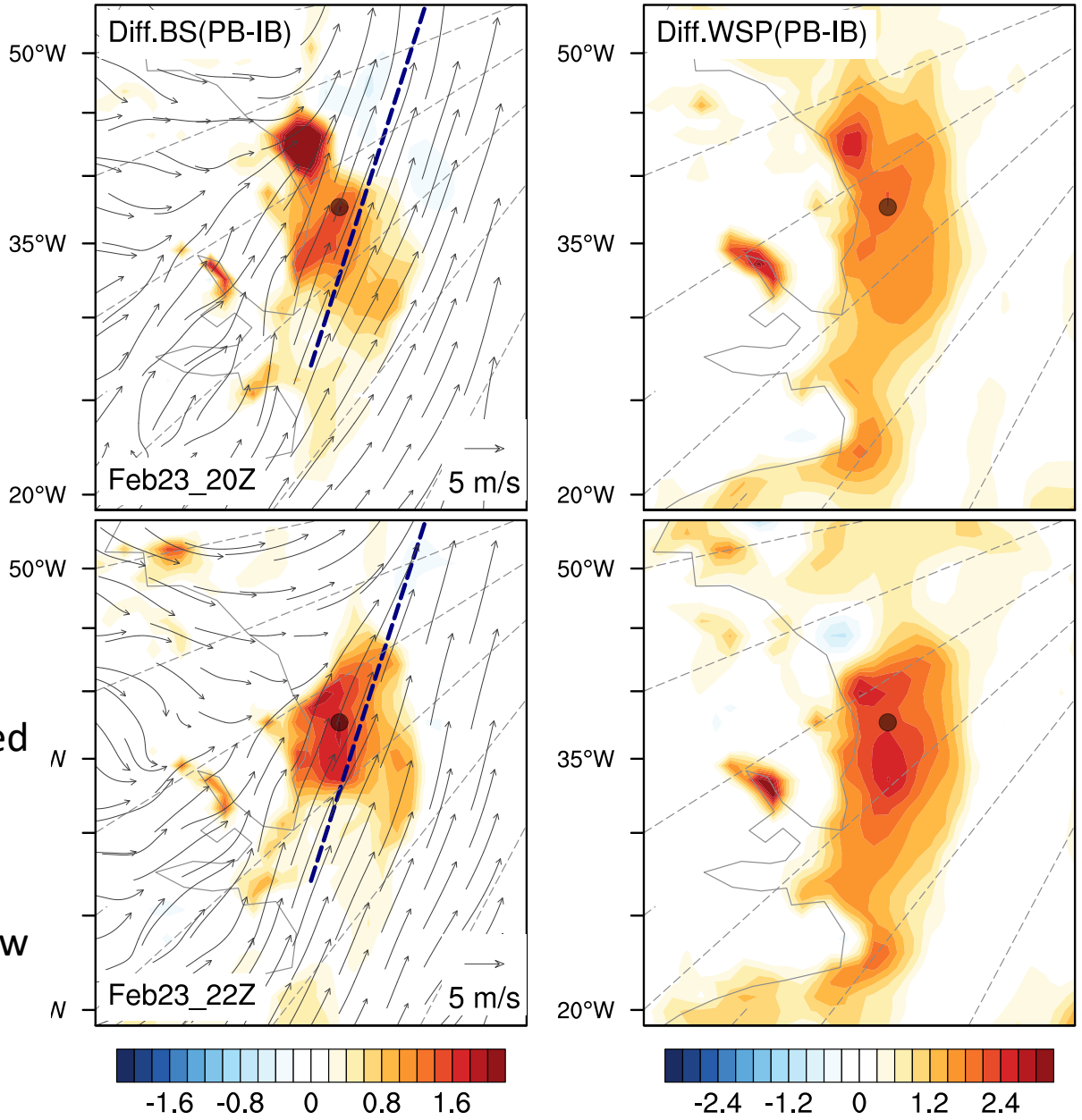


Differences of blow snow sublimation (10^{-2}mm/hr) between simulations PB and IB



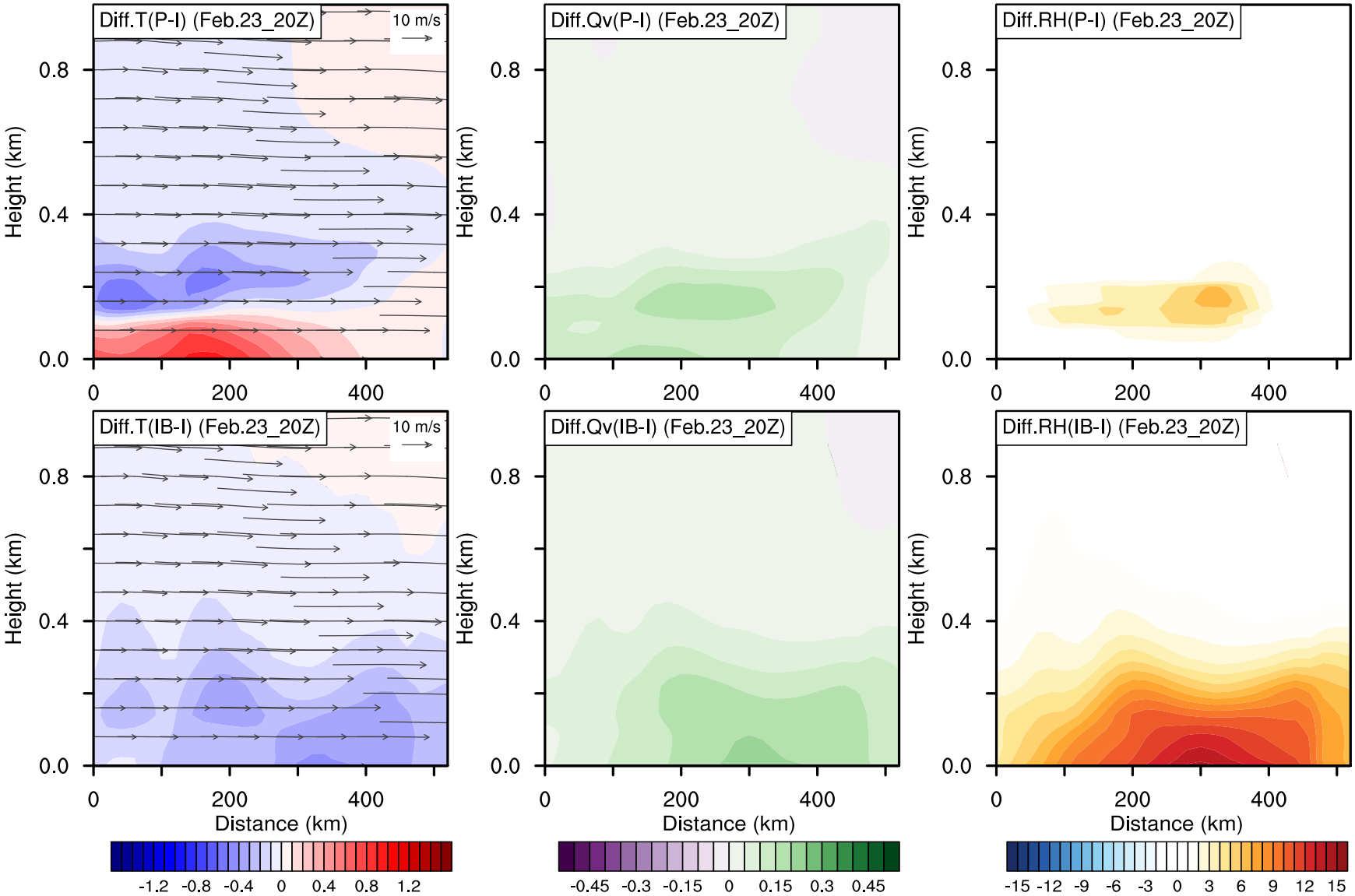
Differences of surface downward longwave radiation (w/m^{-2})between simulations PB and I

Stronger surface winds associated with polynya enhance blowing snow sublimation

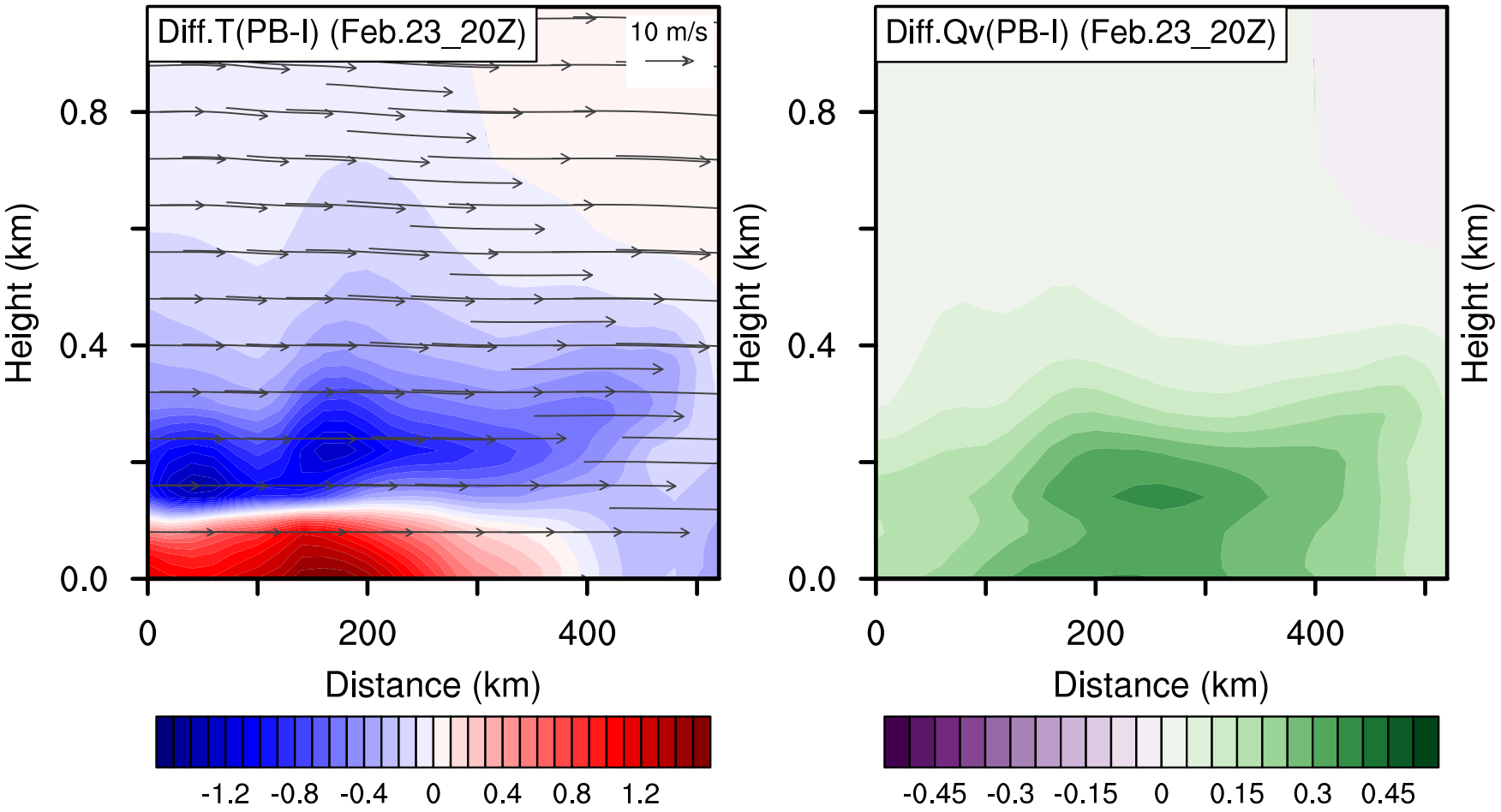


Differences of blowing snow sublimation (10^{-2}mm/hr, left panel) and surface wind speed (m/s, right panel) between simulations PB and IB at 20Z (top) and 22Z (bottom) Feb 23, when strong blowing snow sublimation occurred

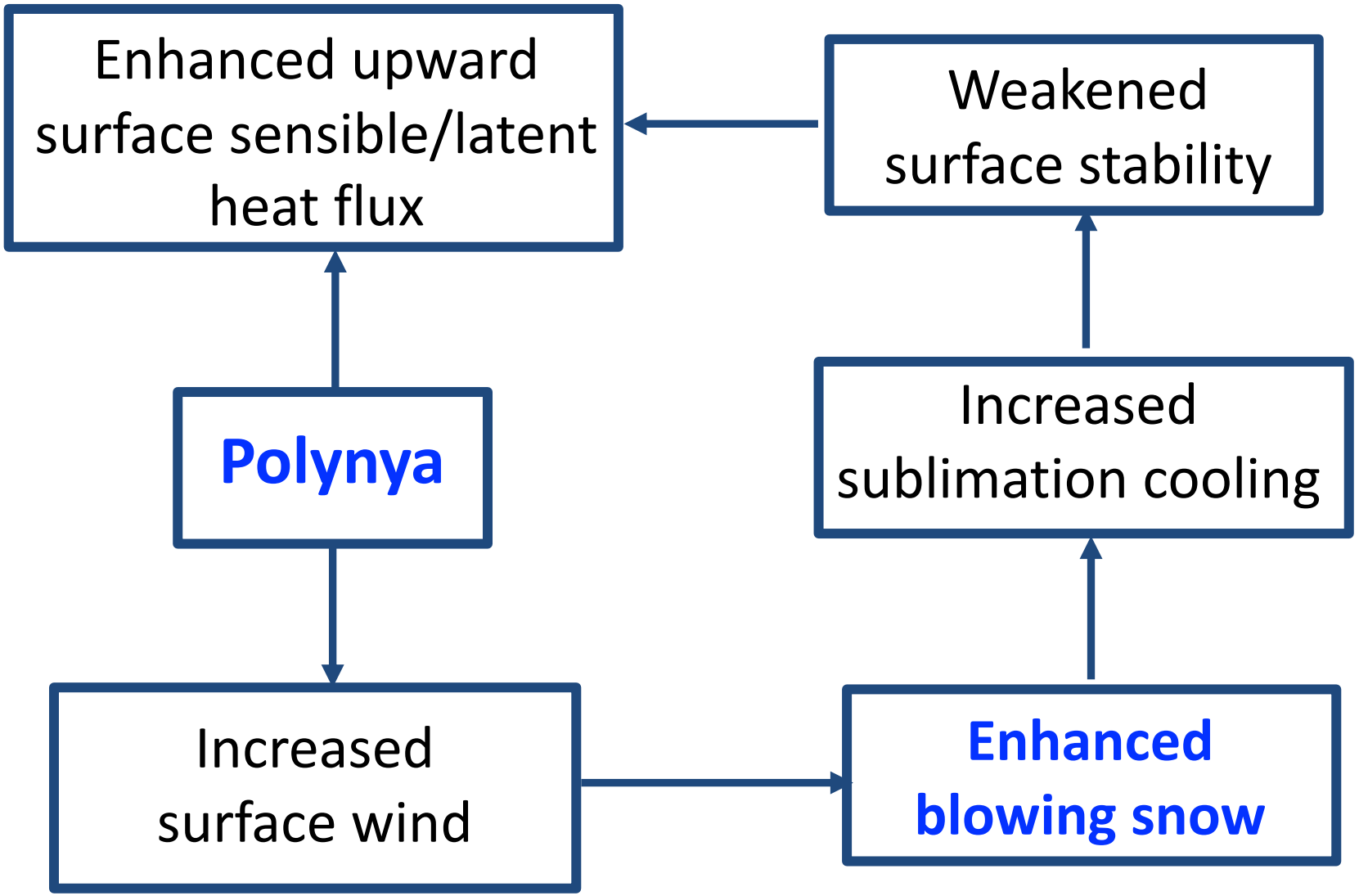
Changes of temperature (C), water vapor (g/kg), and relative humidity (%) profiles by polynya and blowing snow



Greater changes in temperature (C) and water vapor (g/kg) profiles when polynya and blowing snow interact



Summary


Enhanced upward surface sensible/latent heat flux
Weakened surface stability
Polynya
Increased sublimation cooling
Increased surface wind
Enhanced blowing snow