Snow cover heterogeneity and its impact on the Climate and Carbon cycle of Arctic regions (SnowC^2)

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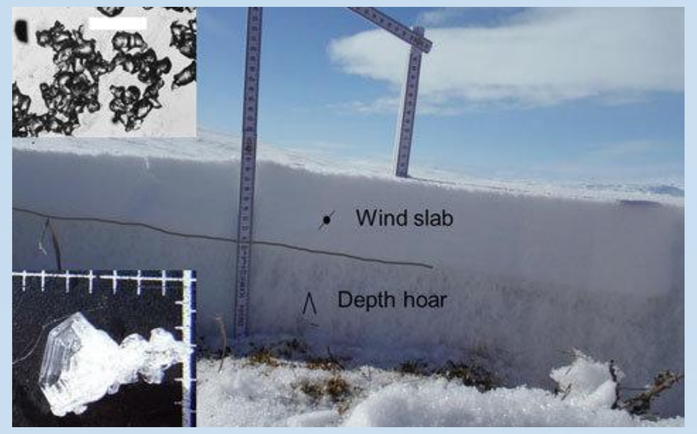
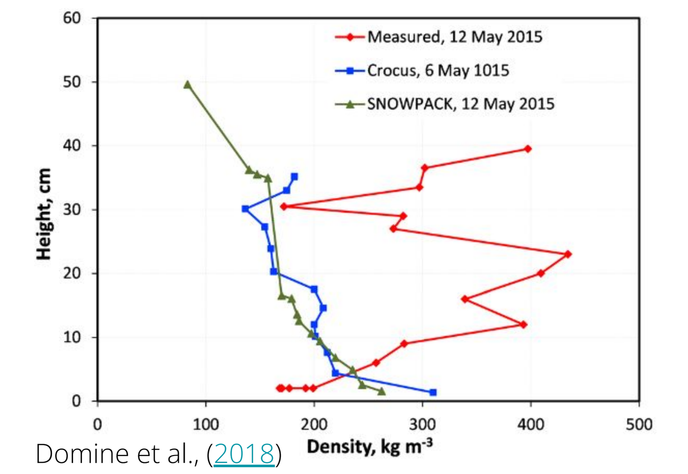
Problematic

- The Arctic has warmed 2 to 3 times faster than the global average (e.g., Cohen et al., 2014) ; nearly four times faster than the globe since 1979 (Rantanen et al., 2022)
- Impacts on ecosystems and human activities such as transportation, resource extraction, water supply, land use and infrastructure among others.
- Current snow models fail to capture essential aspects of Arctic snowpacks (depth hoar + wind slab + spatial heterogeneity).



Domine et al., (2019)



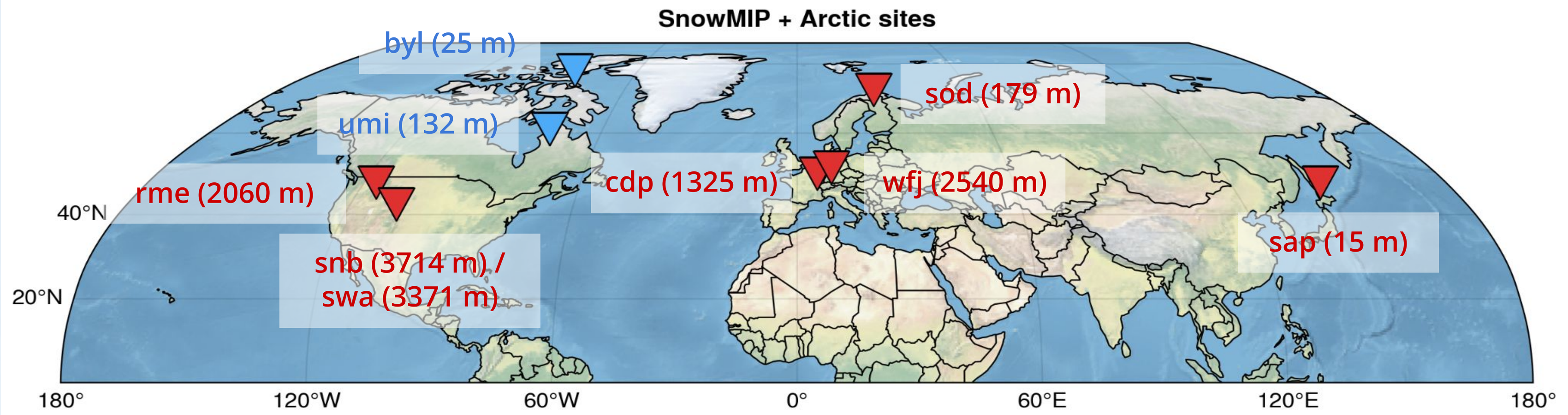
Domine et al., (2018)

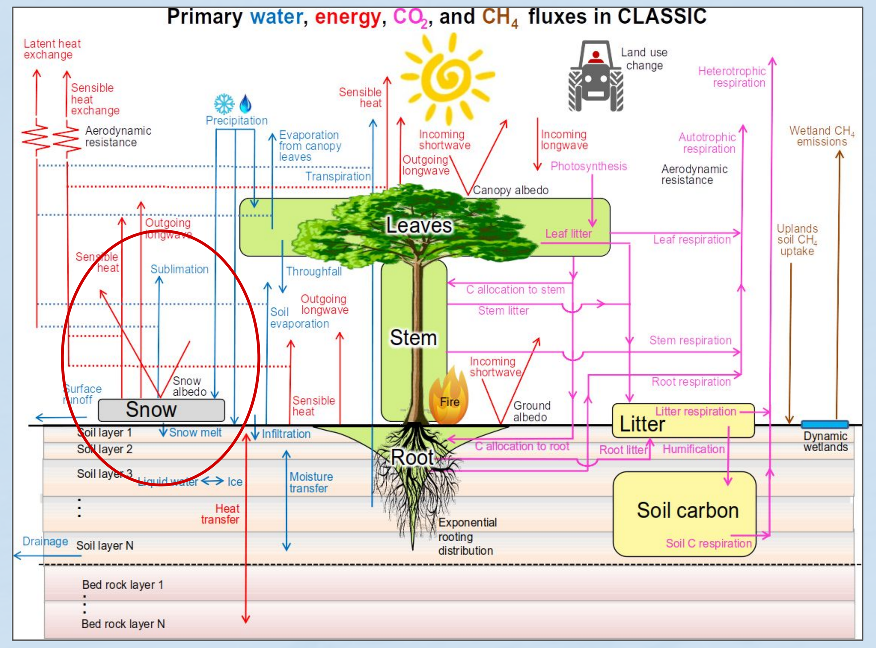
Figure 3. Comparison of measured snow density profiles at Bylot Island in May 2015 with those simulated using the detailed snow models Crocus and SNOWPACK. Crocus runs of 6 May are shown because Crocus simulates melting on 7 May, and this extra process makes comparisons irrelevant on 12 May.

Objectives

1. **This poster:** adapt the current snow model of the Canadian Land Surface Scheme Including Biogeochemical Cycles (CLASSIC) LSM to the Arctic conditions (1D simulations)
2. **Next work:** include new snow cover fraction parameterizations + Arctic adaptations in spatial Arctic simulations → use of ESA CCI data (snow, land type, etc.) to calibrate and assess these new developments
3. Produce improved Arctic simulations with new snowpack (snow, energy/carbon fluxes, etc.)

Methods

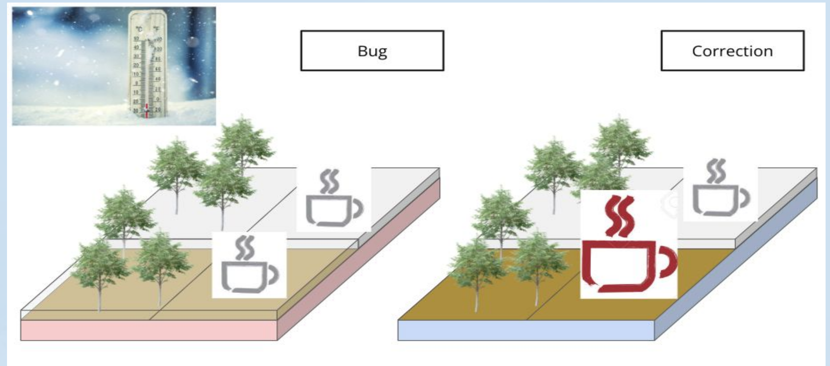




Melton et al. (2020)

- CLASSIC v1.0 LSM (Melton et al., 2020)
- → couples CLASS 3.6.2 (physics energy/water fluxes; Verseghy et al., 2017) and CTEM 2.0 (photosynthesis, carbon cycle, etc.; Melton & Arora, 2016)
- → single layer snow model (quadratic temperature profile, percolation and refreezing, interception, etc.) + one of the best snow model (Menard et al., 2021)
- → used operationally within the Canadian Earth System Model (CanESM; Swart et al., 2019) for climate change impact assessment (CMIP6, SnowMIP, Global Carbon Project, etc.)

Model improvements

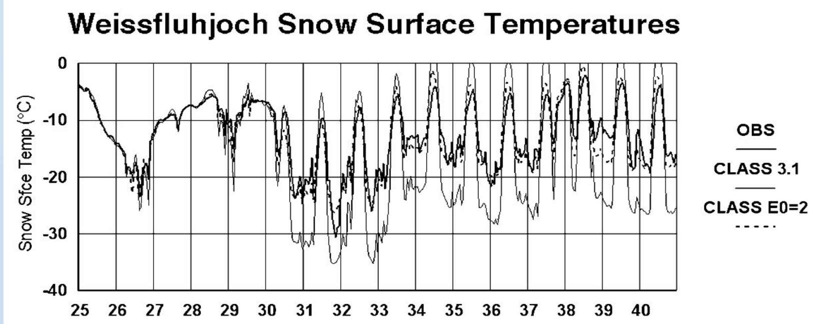


Physics improvements

- Soil conductivity under snow (bug)
- Bottom snow temperature (TSNB)

$$\frac{\Delta z_{snow} T_{snow} + \Delta z_{soil_1} T_{soil_1}}{\Delta z_{snow} + \Delta z_{soil_1}} \rightarrow \frac{\frac{1}{\Delta z_{snow}} T_{snow} + \frac{1}{\Delta z_{soil_1}} T_{soil_1}}{\frac{1}{\Delta z_{snow}} + \frac{1}{\Delta z_{soil_1}}}$$

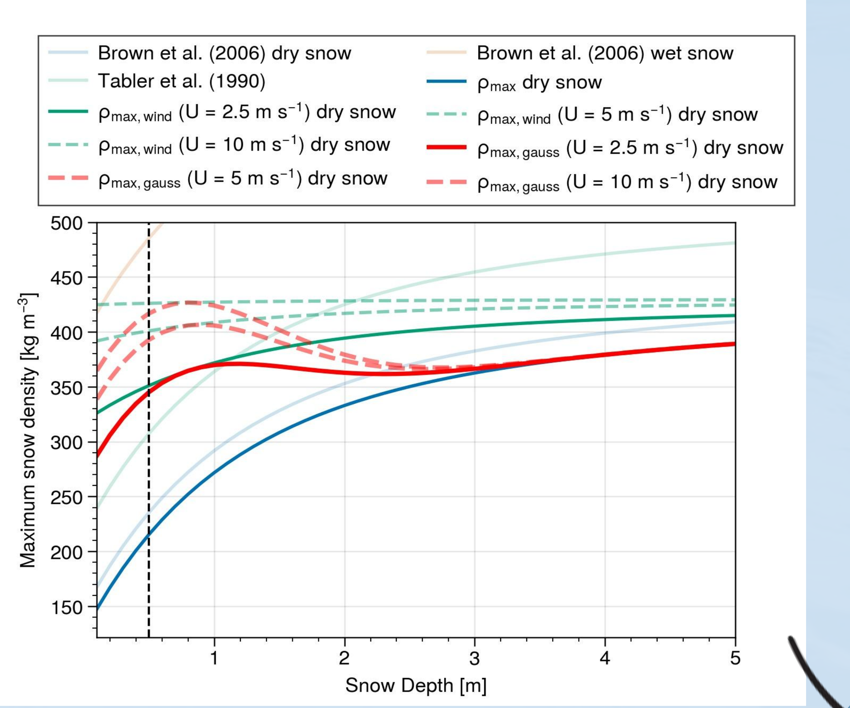
- Windless exchange coefficient (EZERO)



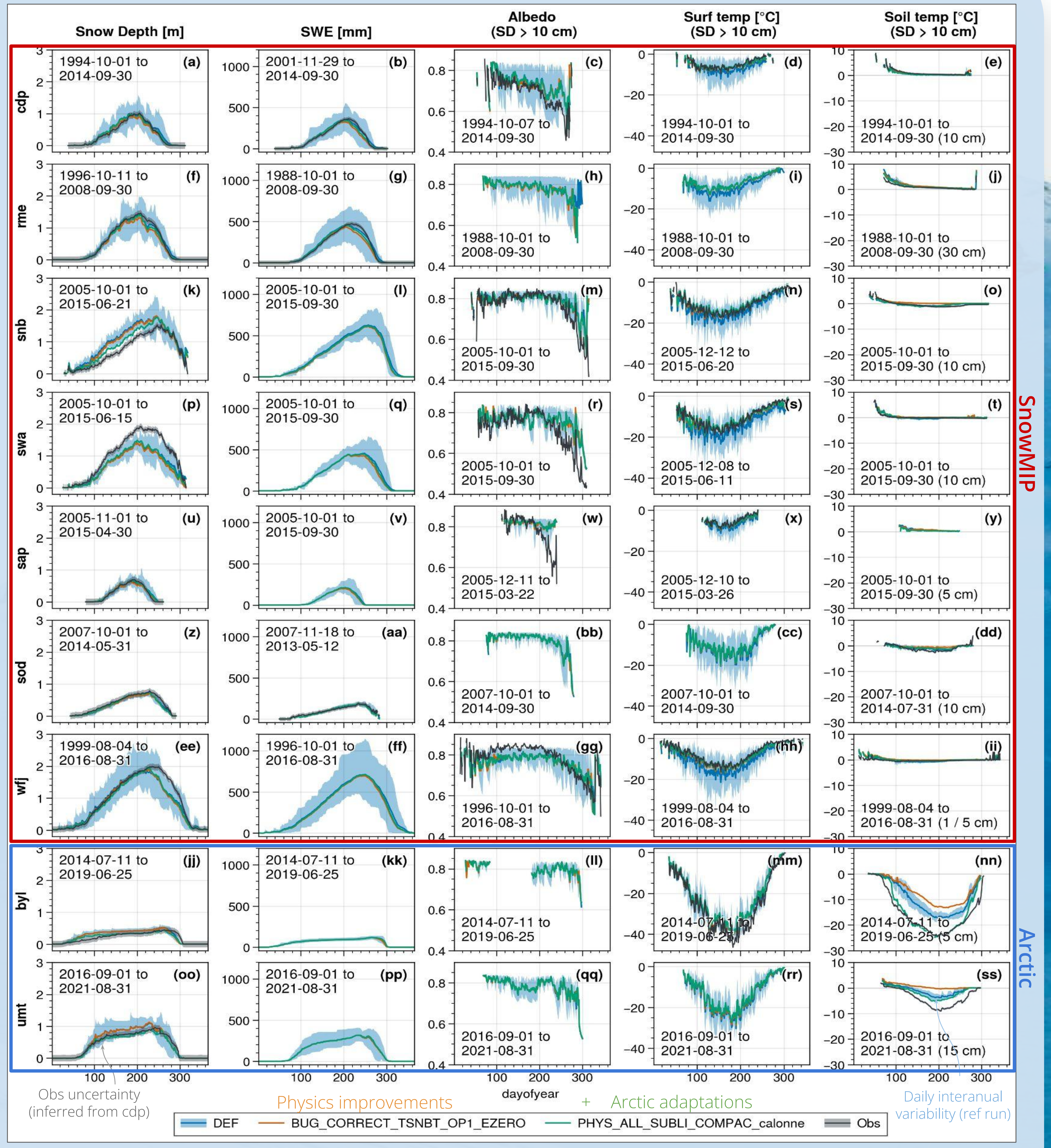
Brown et al., (2006)

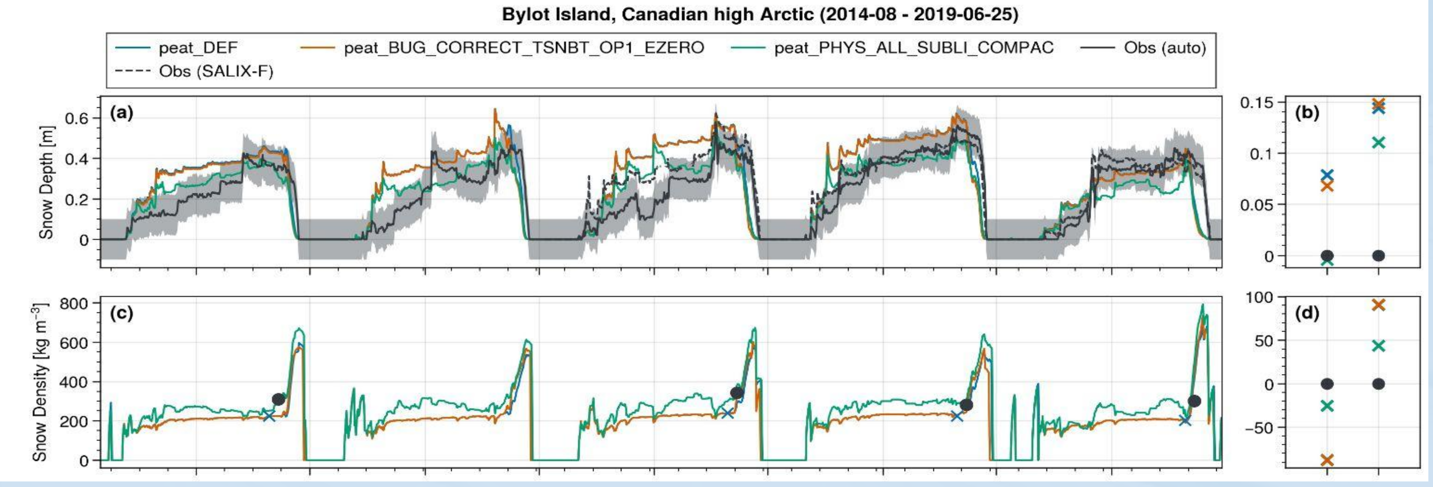
Arctic adaptation

- Blowing snow sublimation losses (Gordon et al., 2006)
- Wind effect on snow compaction
- Snow conductivity (Sturm et al., 1997 → Calonne et al., 2011)



Results: in-situ model assessment





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ReMoTE-Nord
RIVE Centre de recherche sur les interactions bassins versants - écosystèmes aquatiques (RIVE) / Centre for Research on Watershed-Aquatic Ecosystem Interactions (RIVE)
GLACIOLAB Laboratoire de recherche en environnement des régions froides / Chaire de recherche du Canada en hydrologie de la cryosphère
CENTRE D'ÉTUDES NORDIQUES / CEN Centre for Northern Studies
esa European Space Agency