

Arctic snow is thin — so why does it matter so much?

How a few tens of centimetres of snow can control soil temperatures, permafrost, carbon fluxes, and challenge climate models.

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Postdoc Coffee – 13 November 2026

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TAKUVIK

My path through snow models



Mickaël Lalande

Snow & climate modelling

2019–2022

Grenoble



ORCHIDEE

PhD
Mountain snow cover

CMIP6 projections in HMA

SCF param in ORCHIDEE

2023–2025

Trois-Rivières



CLASSIC

ESA SnowC²
Empirical Arctic improvements

CLASSIC paper

2026–2027

Québec

ArcSnow

ArcSnow

With Florent Dominé
New snow physics

Potential next step

France

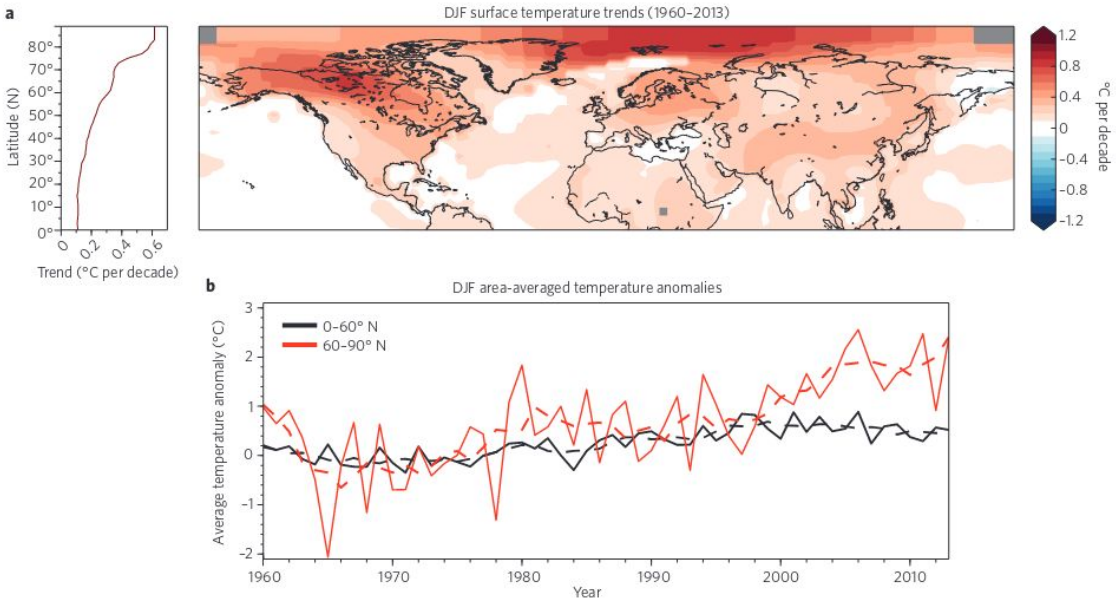
ORCHIDEE

IPSL climate model

MSCA proposal

Proposal submitted
Arctic climate impacts

Context: Arctic Amplification

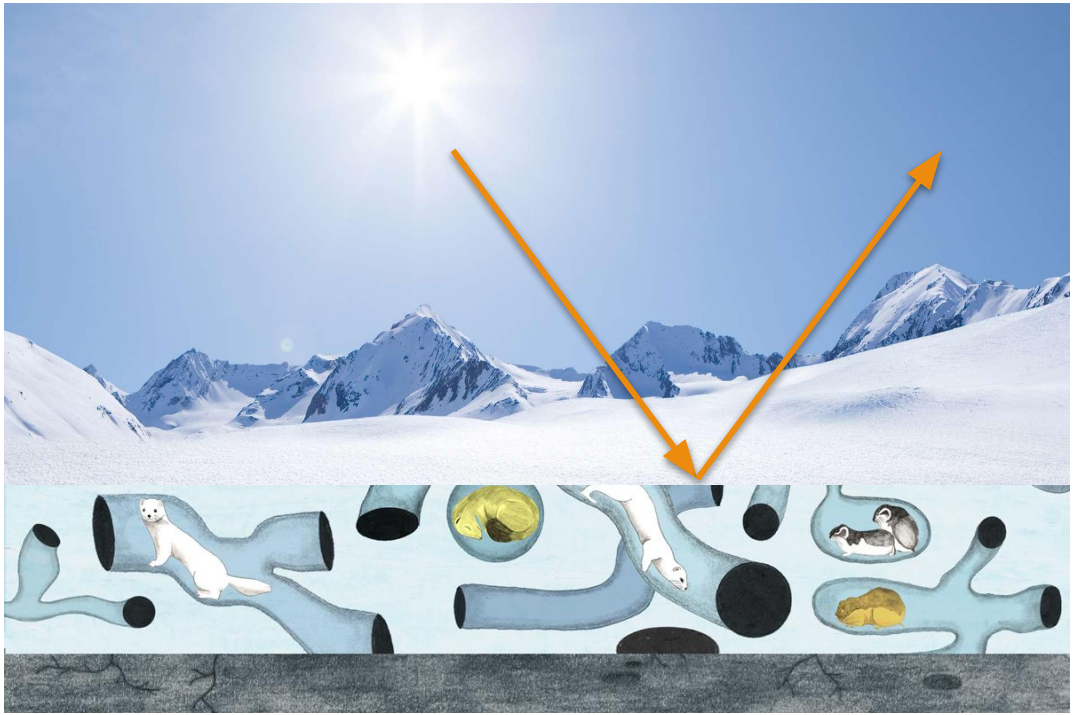


Cohen et al., (2014)

- The Arctic has warmed 2 to 3 times faster than the global average (e.g., Cohen et al., 2014); nearly 4 times faster than the globe since 1979 (Rantanen et al., 2022)
- ⇒ melting of Arctic sea ice and spring snow cover
- Impacts on ecosystems and human activities such as transportation, resource extraction, water supply, use of land and infrastructure among others.
- Northern permafrost soils store nearly twice as much carbon as the atmosphere. Thawing can release CO_2 and methane, amplifying warming. (Schuur et al., 2022)

Snow: essential component of the climate system

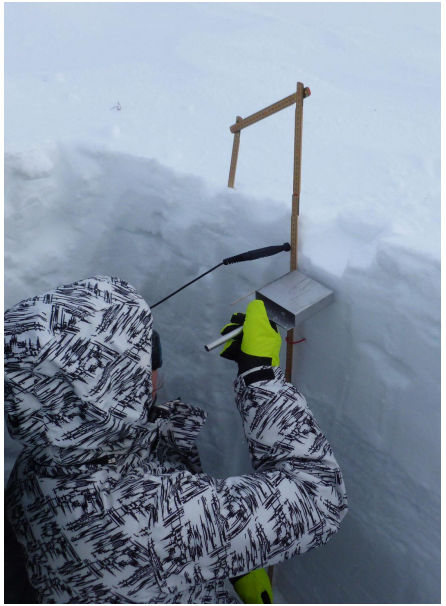




Arctic snow has its own structure

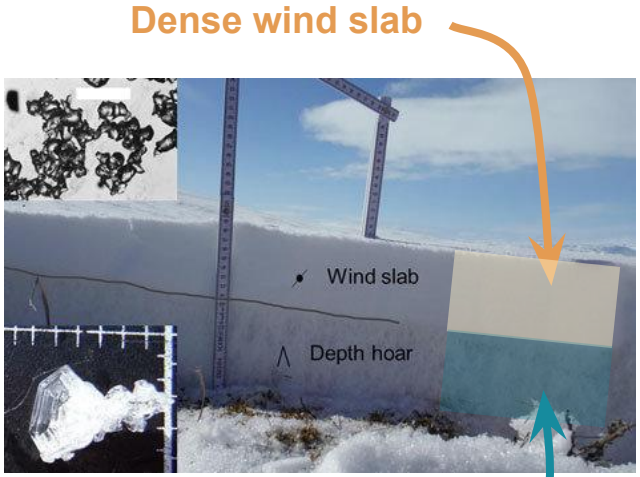
Mountain snow

Often metres deep



Arctic tundra

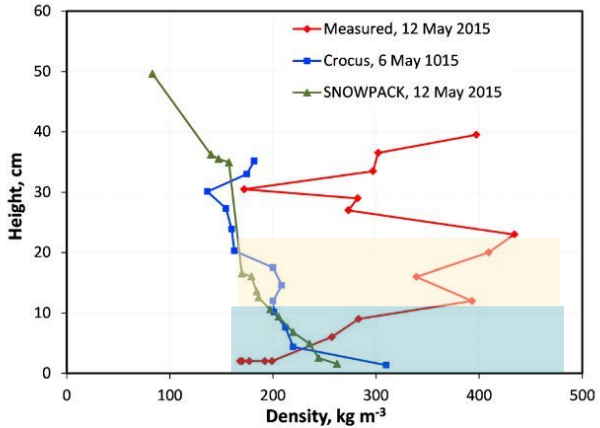
A few tens of centimetres



Domine et al., (2018)

Measured vs modelled

Bylot Island, May 2015



Domine et al., (2019)

Red: measurements

Blue / green: model examples

The models miss the dense top and light base

Arctic snowpack: solution?

Physical solution

Implement the water vapor fluxes explicitly in the snowpack (→ snow mass redistribution):

- IVORI project (Marie Dumont, ERC ~2M €)
- Jafari et al., (2020, 2022); Fourteau et al. (2021); Simson et al. (2021); Brondex et al. (2023); Jafari and Lehning (2023, 2026);...

Option still under exploration → significant theoretical and computational challenges!



Practical solution

Increase the compaction due to the wind + reduce the density of the lower layers, e.g.:

- Barrere et al. (2017); Gouttevin et al. (2018); Royer et al. (2021); Lackner et al., (2022); Woolley et al. (2024); Lalande et al. (2026)

Ad hoc solutions often lacking physical considerations...

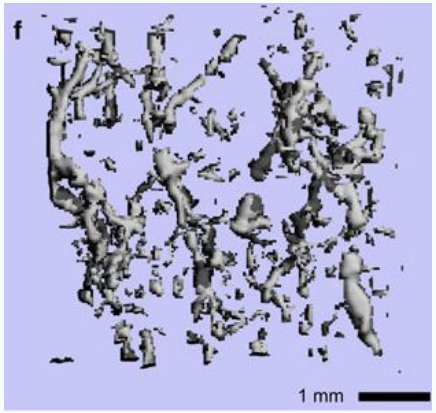
ArcSnow

Ice structure and resistance to settling

LABORATORY

Ice connections carry weight

Tomography + mechanical simulation



≈2× **slower settling**

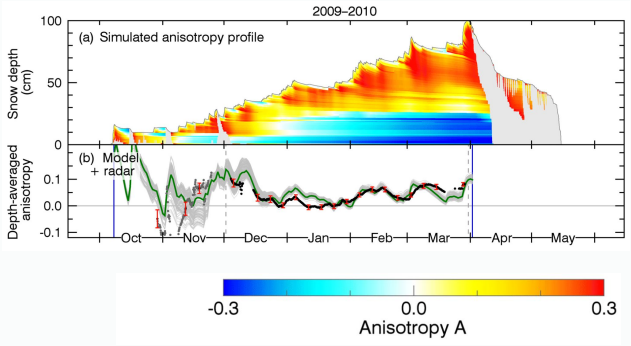
Under strong temperature gradients

Wiese & Schneebeli (2017)

SNOWPACK

Tracking structural anisotropy

Geometrical orientation



Thermal history shapes snow structure

Leinss et al. (2020)

ArcSnow

Hypothesis to test

New snow descriptor

Mechanical anisotropy

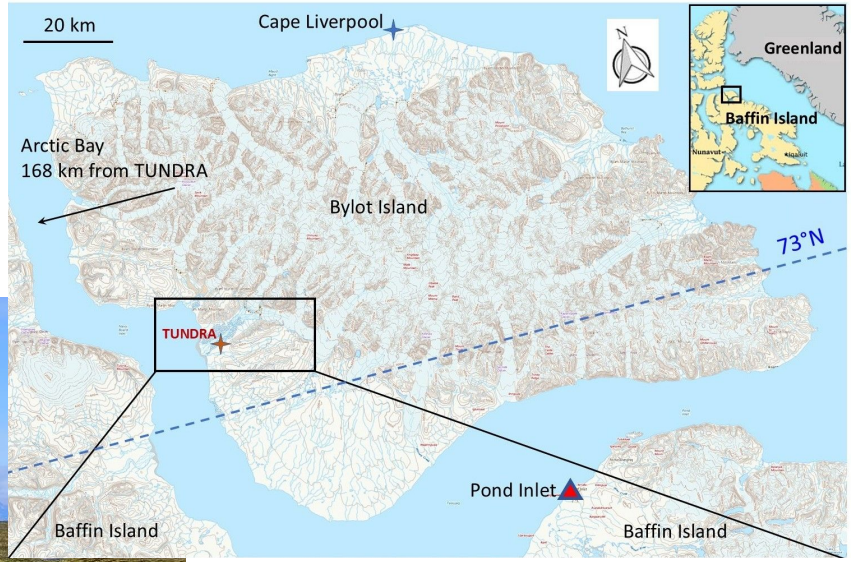
Viscosity

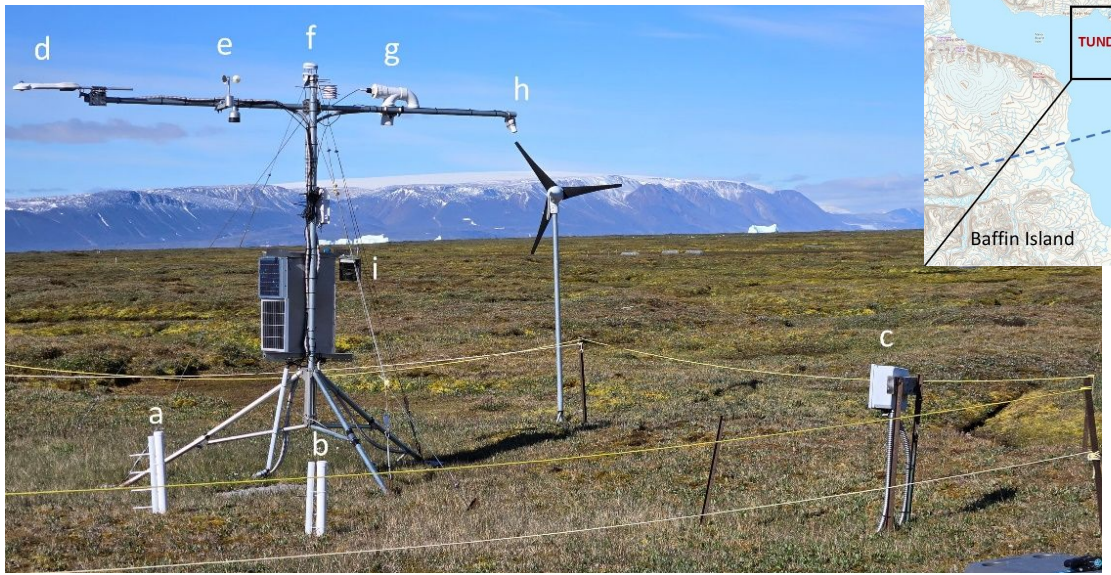
Resistance to settling

Compaction rate

ArcSnow + Bylot (13 years of data)

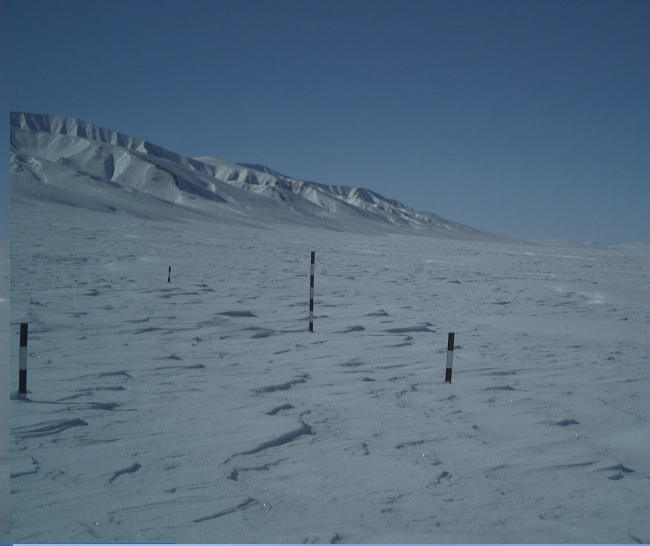
- **Forcing:** Temperature, radiation, wind speed, humidity, air pressure, precipitation
- **Evaluation:** snow height, snow and soil temperature + thermal conductivity at various depths, profiles (density, SSA, keff), etc. + camera time lapses





Challenges: strong wind (snow drift / blowing snow), remote places, frost, polar night, animals, etc. -> measurements highly uncertain










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