COHERENT-C/CLASSIC workshop 2024

Snow cover heterogeneity and its impact on the Climate and Carbon cycle of Arctic regions

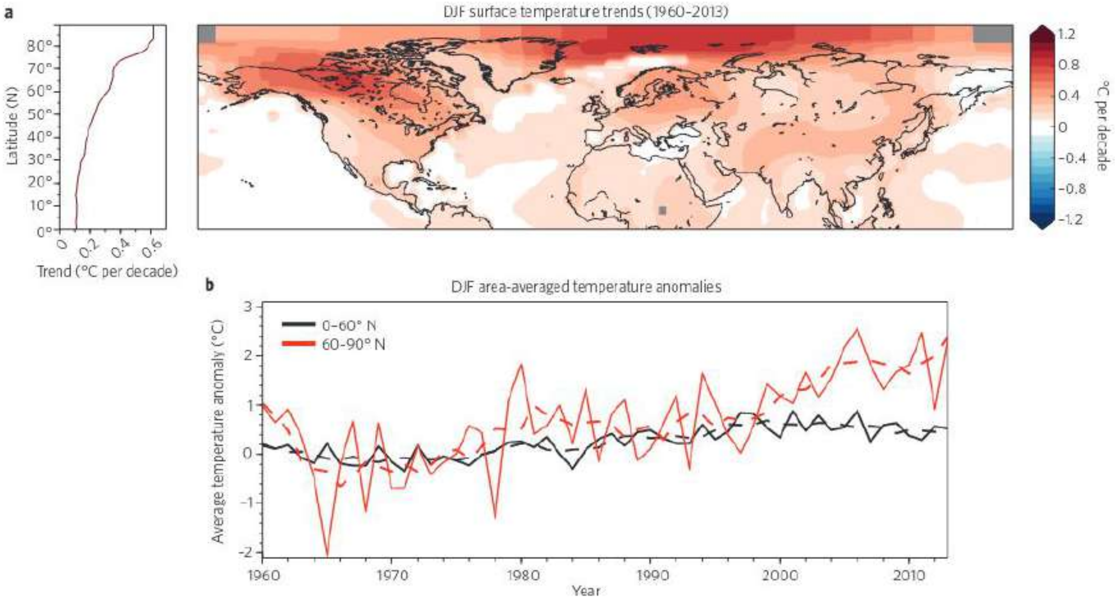
Mickaël Lalande

Postdoc at UQTR / RIVE / GLACIOLAB

ESA CCI Fellowship — 01/10/2023 to 30/09/2025 (2 years)

supervised by Christophe Kinnard and Alexandre Roy

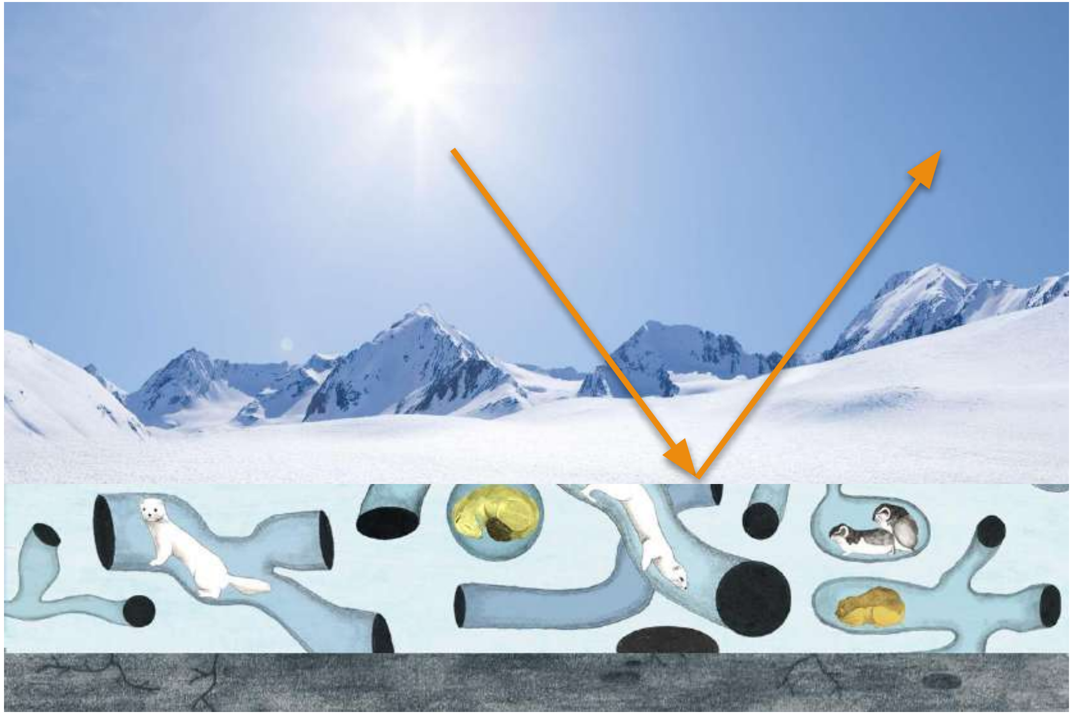
Context: Arctic Amplification



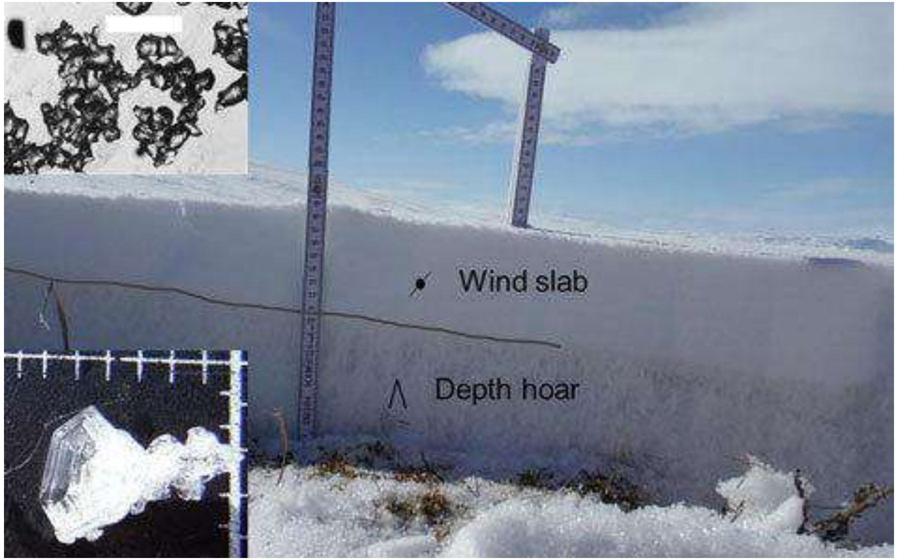
Cohen et al., (2014)

- The Arctic has warmed 2 to 3 times faster than the global average (e.g., Cohen et al., 2014) ; nearly four 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.
- 1.035 Pg-C (>66° N, 3m soil) - By 2100, 55 to 232 Pg C-CO2-e could be emitted via permafrost degradation (Schuur et al., 2022)

Snow: essential component of the climate system



Arctic snowpack



Domine et al., (2019)

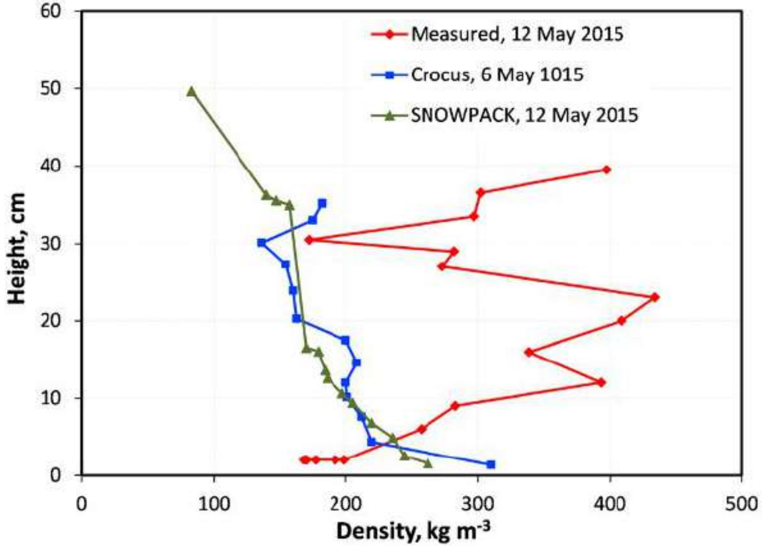
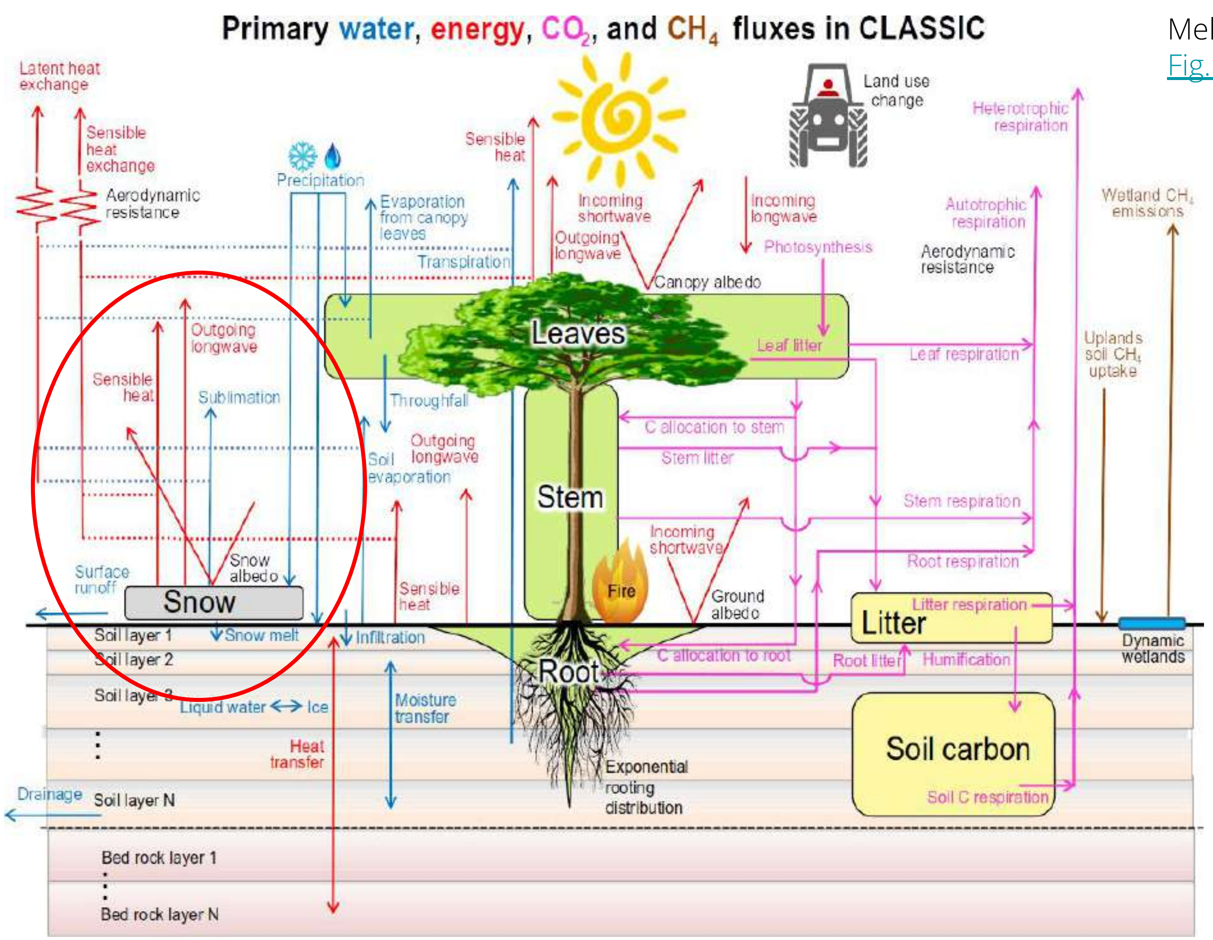


Figure 3. Comparison of measured snow density profiles at Bylot Island in May 2015 with those simulated using the detailed snow models Crocus and SNOWPACK. Crocus runs of 6 May are shown because Crocus simulates melting on 7 May, and this extra process makes comparisons irrelevant on 12 May.

Domine et al., (2018)

Snow model in CLASSIC: description



Melton et al. (2020), Fig. 1

Objectives of the project

1. Implement a multilayer snowpack in CLASSIC (1D simulations)
    - technical challenges: model not so modular and snow is included in many files/routines
    - physical challenges: include Arctic snowpack characteristics (if possible) + blowing snow, etc.
    - → assess these changes at site level simulations (SnowMIP + 3 Arctic sites)

Model development and assessments

New Arctic simulations

#1 Implement multilayer snow model in CLASSIC (site simulations)

Credit: Sawtooth Avalanche Center

Objectives of the project

1. Implement a multilayer snowpack in CLASSIC (1D simulations)
2. Test new snow cover fraction parameterizations + multilayer snowpack in spatial simulations (Arctic) → use of ESA CCI data (snow, land type, etc.) to calibrate and asses these new developments

Model development and assessments

#1 Implement multilayer snow model in CLASSIC (site simulations)

Credit: Sawtooth Avalanche Center

#2 Snow cover param + multilayer snowpack (spatial simulations)

New Arctic simulations

Objectives of the project

1. Implement a multilayer snowpack in CLASSIC (1D simulations)
2. Test new snow cover fraction parameterizations + multilayer snowpack in spatial simulations (Arctic) → use of ESA CCI data (snow, land type, etc.) to calibrate and asses these new developments
3. New simulations over the whole Arctic with new snowpack (assessment on the surfaces fluxes)

Model development and assessments

New Arctic simulations

#1 Implement multilayer snow model in CLASSIC (site simulations)


Credit: Sawtooth Avalanche Center

#2 Snow cover param + multilayer snowpack (spatial simulations)

#3 Improved Arctic simus (snow, energy/carbon fluxes, etc.)

Mickaël Lalande

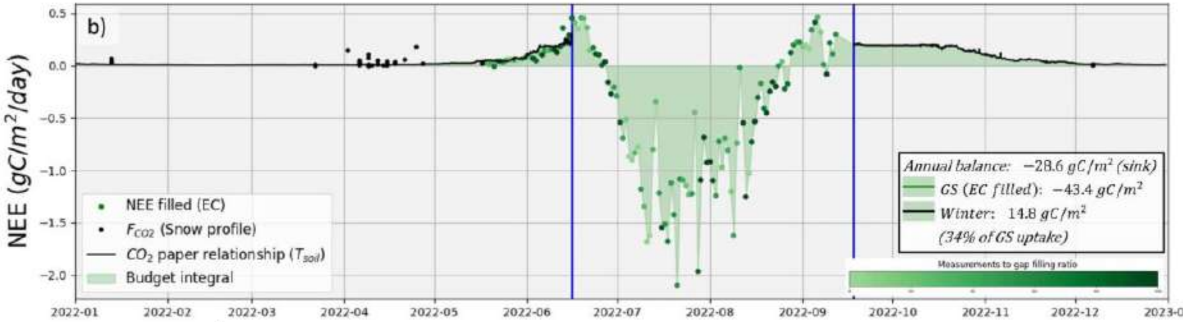
SOCIAL NETWORKS

- @LalandeMickael
- @mickaellalande
- @mickaellalande
- mickaellalande.github.io

Email: Mickael.Lalande@uqtr.ca

Supplementary slides

Arctic snowpack

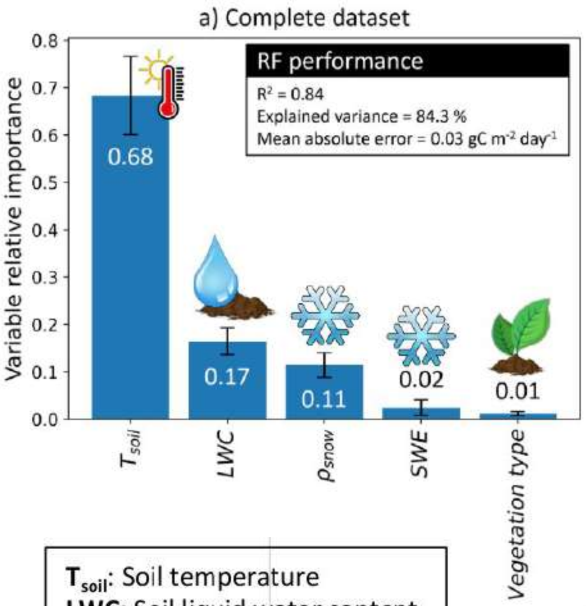


GPP: Gross primary production
NEE: Net Ecosystem Exchange

Mavrovic et al., (2024, in review)

- Arctic winter respiration can contribute up to ~30% of the net annual ecosystem exchange
- When soil is frozen, the soil temperature is the main driver of those winter carbon fluxes
- ⇒ Correctly simulating Arctic snowpacks is therefore essential to properly constrain simulated soil temperatures and hence carbon fluxes.

Régime gelé
$T_{sol} < 0°C$
$LWC \approx 0$



T_{soil}: Soil temperature
LWC: Soil liquid water content
ρ_{snow}: Snow density
SWE: Snow water content

Mavrovic et al., (2023)

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