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SYKE

SNOWCARBO

Carbon in pan-arctic regions : modeling aspects and sensitivity to snow

Action 14:
FMI-SYKE / CEA collaboration on modelling aspects

P. Ciais, G. Krinner, M. Menegoz, I. Gouttevin

I. How do we model C cycling at high latitudes ?

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I. How do we model C cycling at high latitudes ?

➢ C-cycling

CO_2
photosynthesis

CO_2
Autotrophic respiration

Moisture & temperature

atmospheric CO_2 concentration

CO_2 , CH_4
heterotrophic respiration / methanogenesis

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I. How do we model C cycling at high latitudes ?

➢ C-cycling

In the model

ORCHIDEE

CEA-LSCE (Paris) + LGGE (Grenoble)

Part of the IPSL- CM5 climate model

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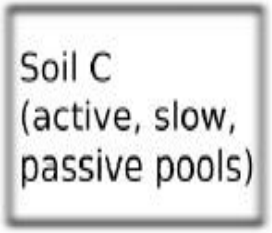
In the model

*** 13 “Plant Functional Types”**

*** 3 soil C pools**



Decomposition times at 5°C :

-Active: 0.85 yr

-Passive: 31 yr

-Slow: 1400 yr

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I. How do we model C cycling at high latitudes ?

- **High-latitude specificities**

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➢ High-latitude specificities

- **Wetlands & cold T**

=> Huge soil C stocks

, slow decomposition, CH_4

Polygonal tundra in the Lena delta (photo: AWI Potsdam)

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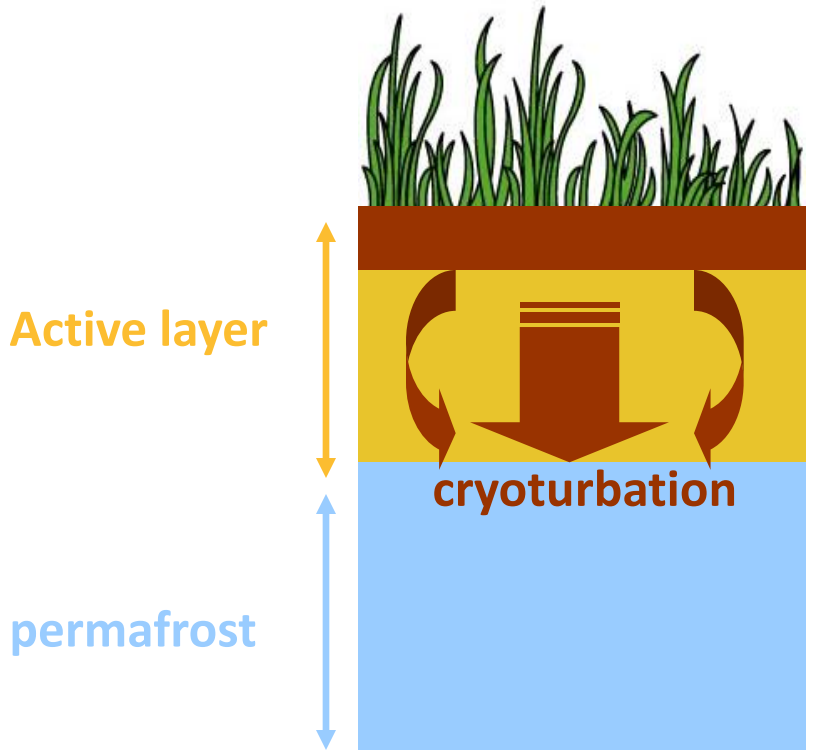
- **Cryoturbation**



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- **Cryoturbation**
- **Organic matter**

Uppermost moss & lichen layer in Abisko (photo: I.G.)

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- **Organic matter**
- **Soil freezing**

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- **Wetlands can be prescribed**
- **Methanogenesis scheme**

- **Cryoturbation**
- **Organic matter**
- **Soil freezing**

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- **Cryoturbation**
- **Organic matter (OM)**
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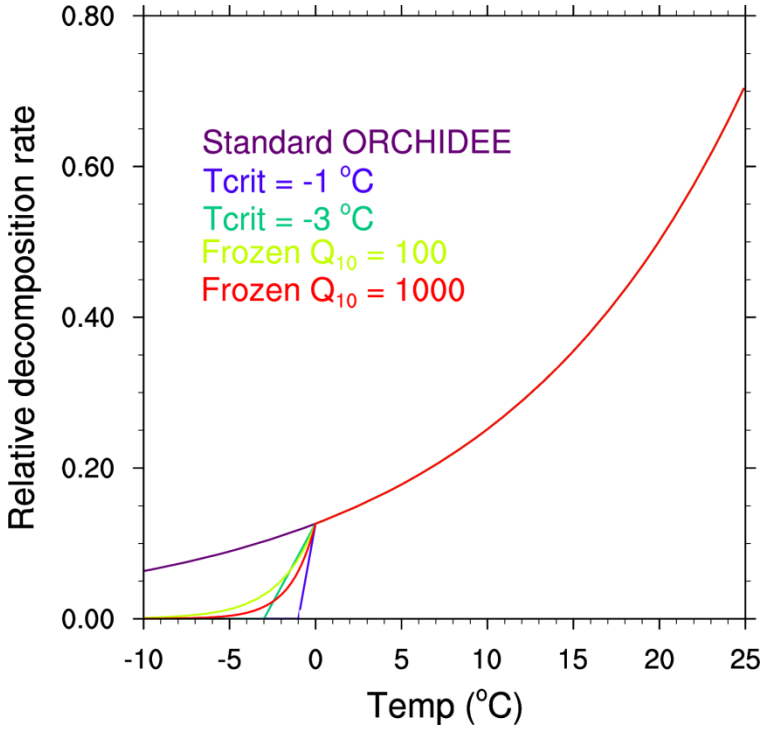
In the model



Decomposition rate as a function of temperature

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- **Organic matter (OM)**
- **Soil freezing**

• **Cryoturbation is represented via vertical diffusion of organic matter**

• **OM thermal properties are accounted for**

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Thermal & hydrological effects accounted for => better T & moisture representation (crucial for C cycling)

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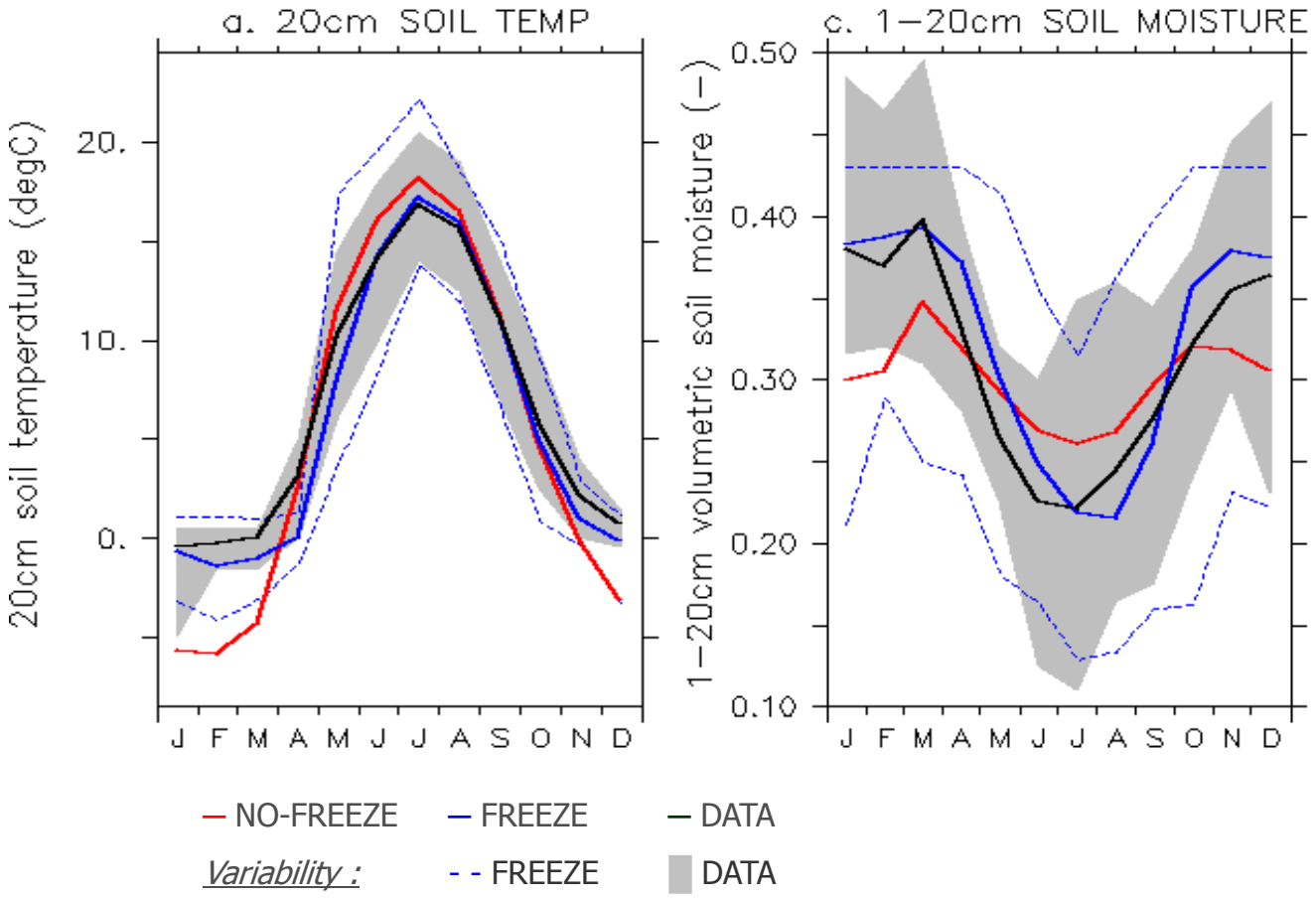
II. Impact of soil freezing on model performances

Valdai, Russia



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III. Snow: a crucial variable for C-cycling at high latitudes

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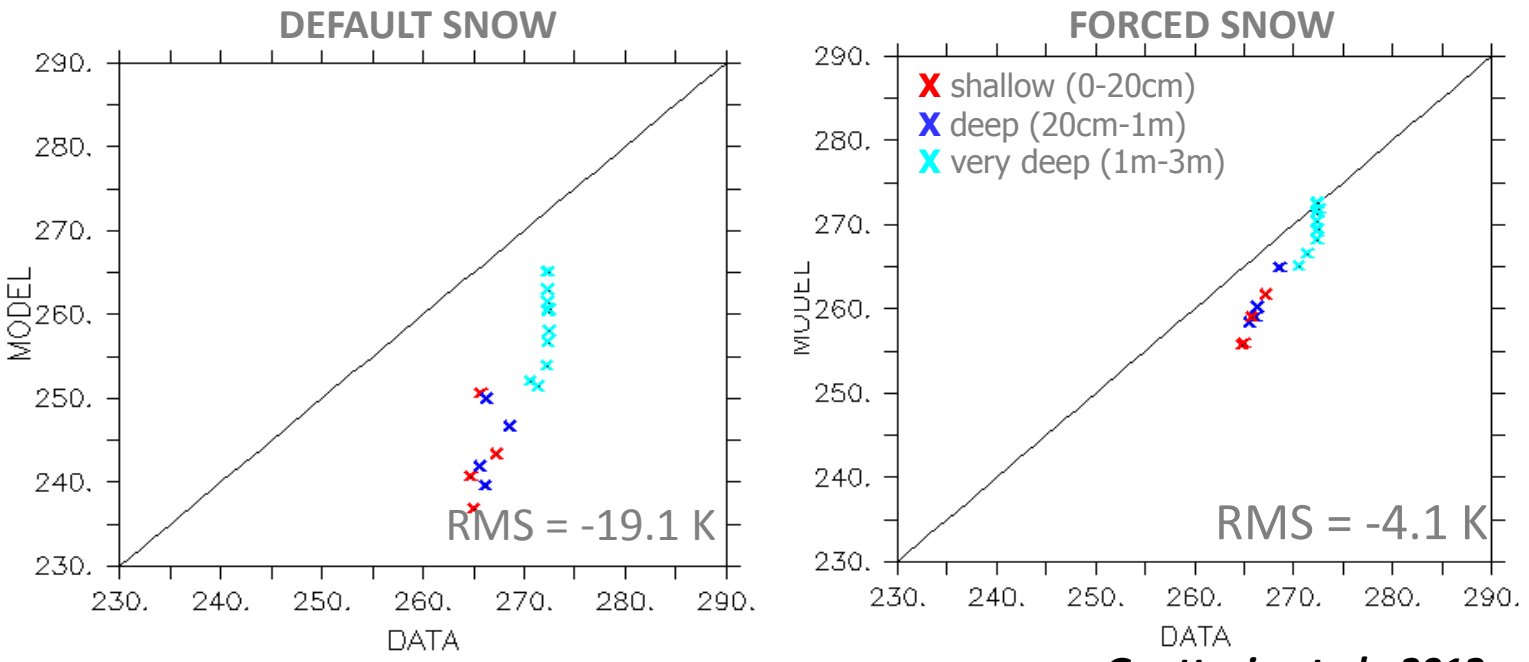
➢ thermal consequences of snow underestimation

Modelled vs observed soil temperature at Iakutsk (RU) over 1984-1994



Gouttevin et al., 2012a.

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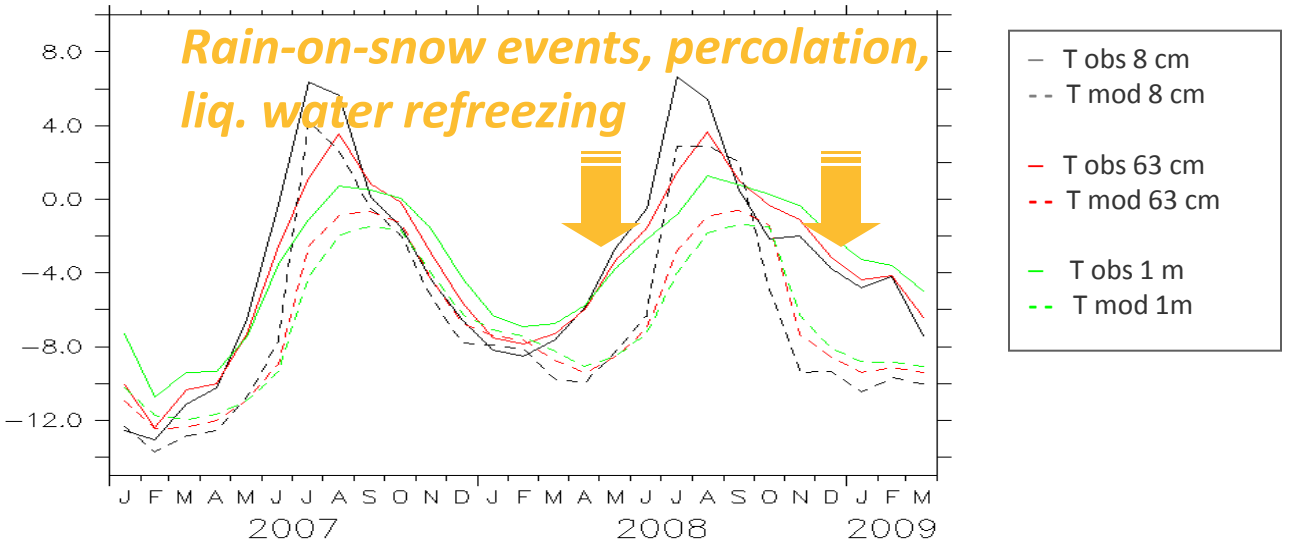
III. Snow: a crucial variable for C-cycling at high latitudes

➢ thermal consequences of misrepresented processes

Modelled vs observed soil temperature at Bayelva, Svalbard



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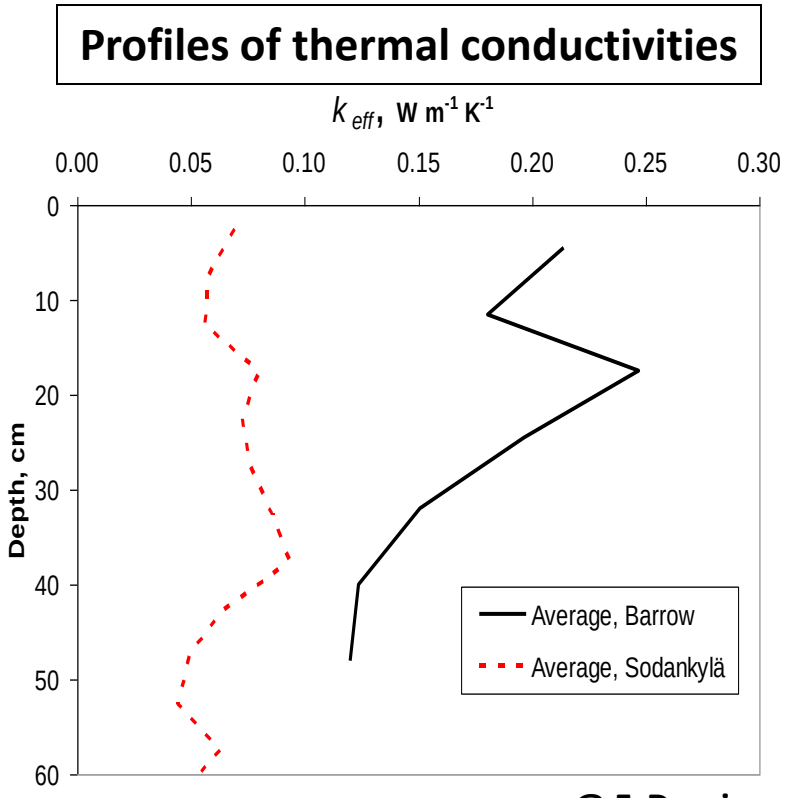
III. Snow: a crucial variable for C-cycling at high latitudes

- taïga & tundra snow are different

Barrow, Tundra

Sodankylä, Taïga



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III. Snow: a crucial variable for C-cycling at high latitudes

- taïga & tundra snow are diff

Barrow, Tundra

Sodankylä, Taïga

What consequences for soil thermal regimes and carbon cycling at high latitudes ?

Tundra & taïga biomes

60

Boike et al., 2012

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III. Snow: a crucial variable for C-cycling at high latitudes

➢ a sensitivity study to assess impact on C-cycling

- **2 simulations**

	CTRL	VARIED	
		tundra	taïga
K_{th} (W/m/K)	0.2	0.25	0.07
ρ (kg/m^3)	330	330	200

- **Soil C build-up** ***(low T respiration, cryoturbation, thermal insulation by organic matter)***

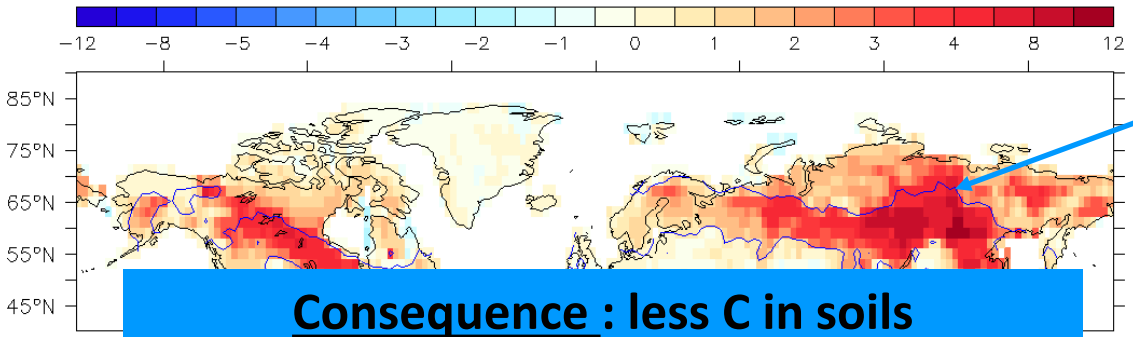
- **Results : difference VARIED – CTRL over 1970-2000**

III. Snow: a crucial variable for C-cycling at high latitudes

➢ Thermal impact

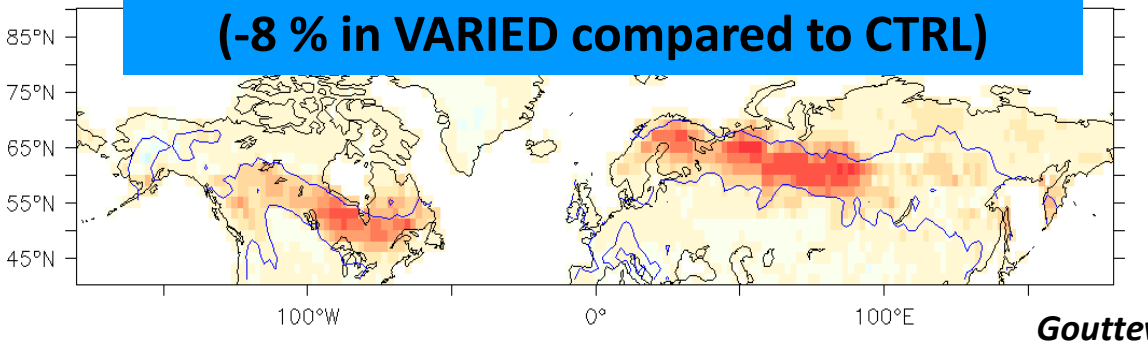
VARIED – CTRL 50 cm soil temperature, °C (1970 - 2000)

Winter (DJF)



taïga

Summer (JJA)



<u>Consequence</u> : less C in soils

(-8 % in VARIED compared to CTRL)

Gouttevin et al., 2012b.

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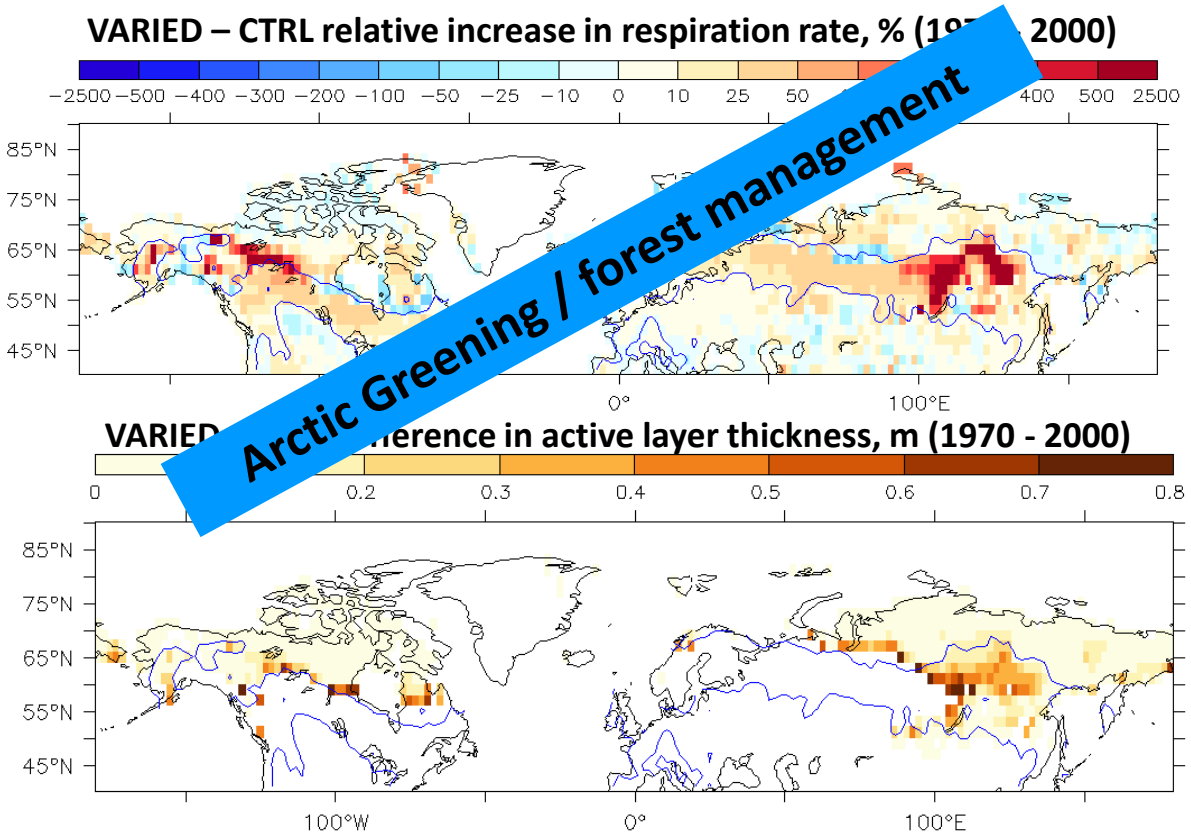
III. Snow: a crucial variable for C-cycling at high latitudes

➢ Impact on C-cycling



Arctic Greening / forest management