Neige 5ème partie

Métamorphisme de la neige et climat

* Impact des conditions du métamorphisme sur la surface spécifique et l’albédo

* Impact des conditions du métamorphisme sur la conductivité thermique

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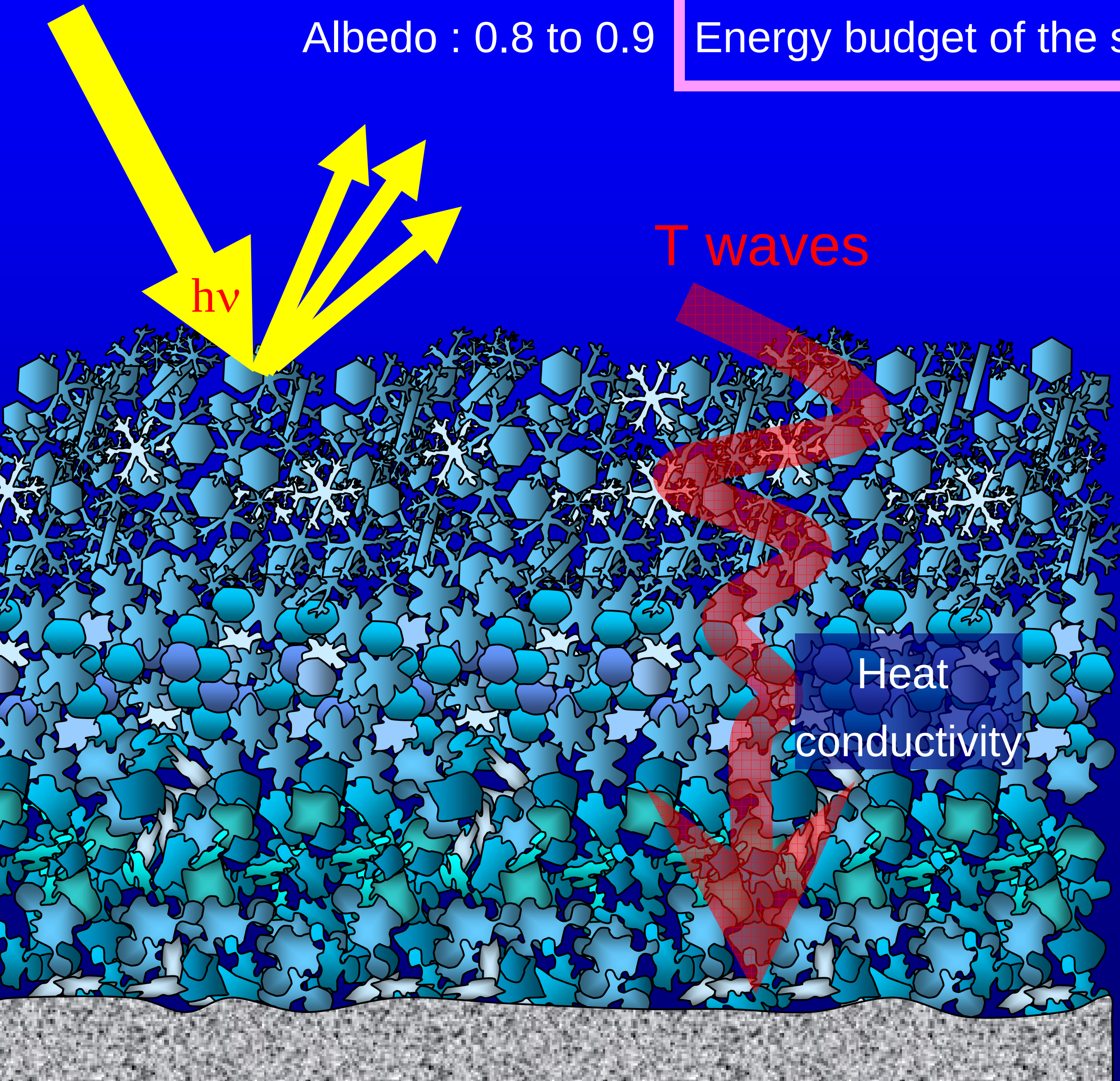
Physical properties of the snowpack

Albedo : 0.8 to 0.9

Energy budget of the surface

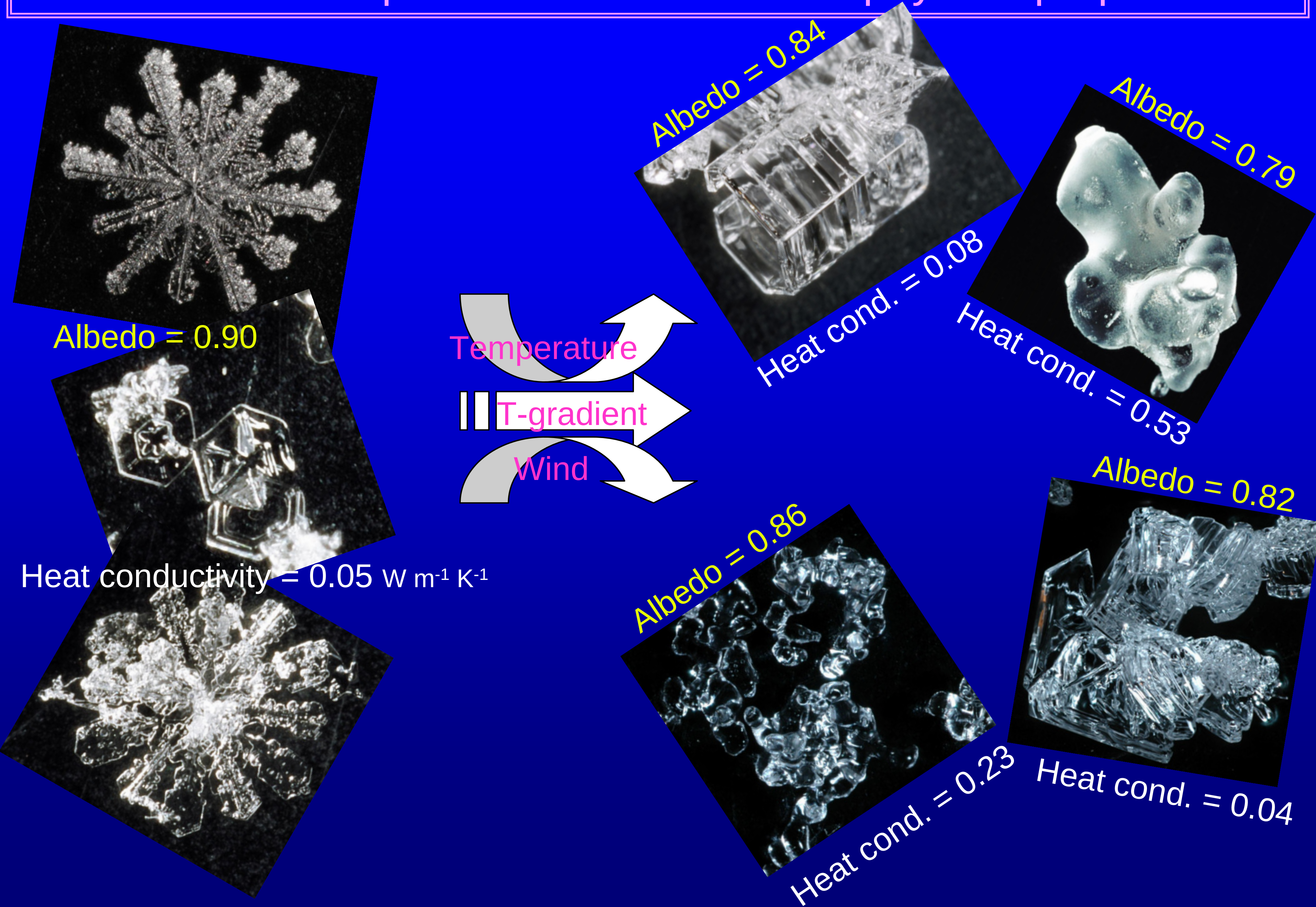


Energy budget of the soil

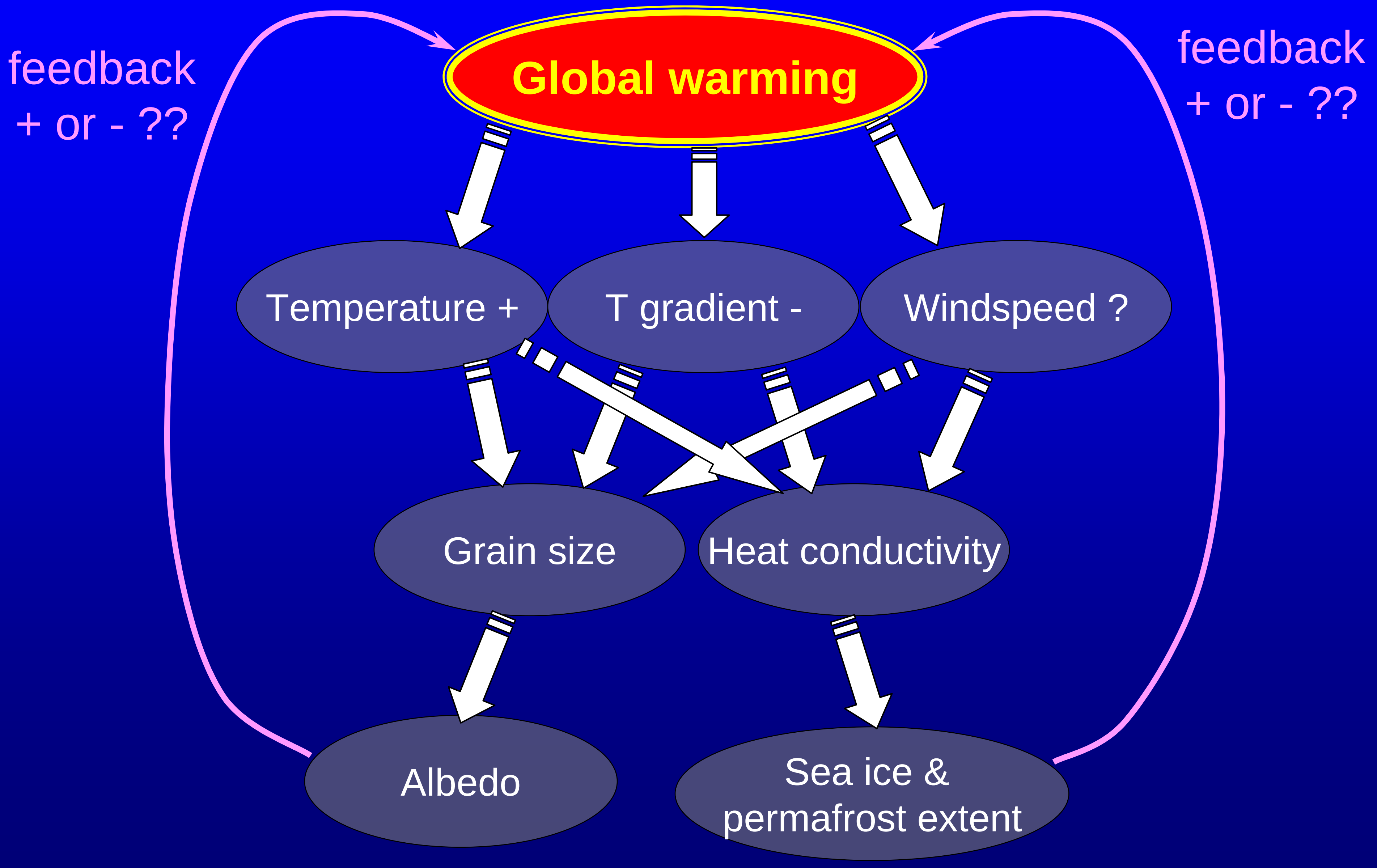
Permafrost extent

Sea ice growth

Snow metamorphism ⇒ modification of physical properties



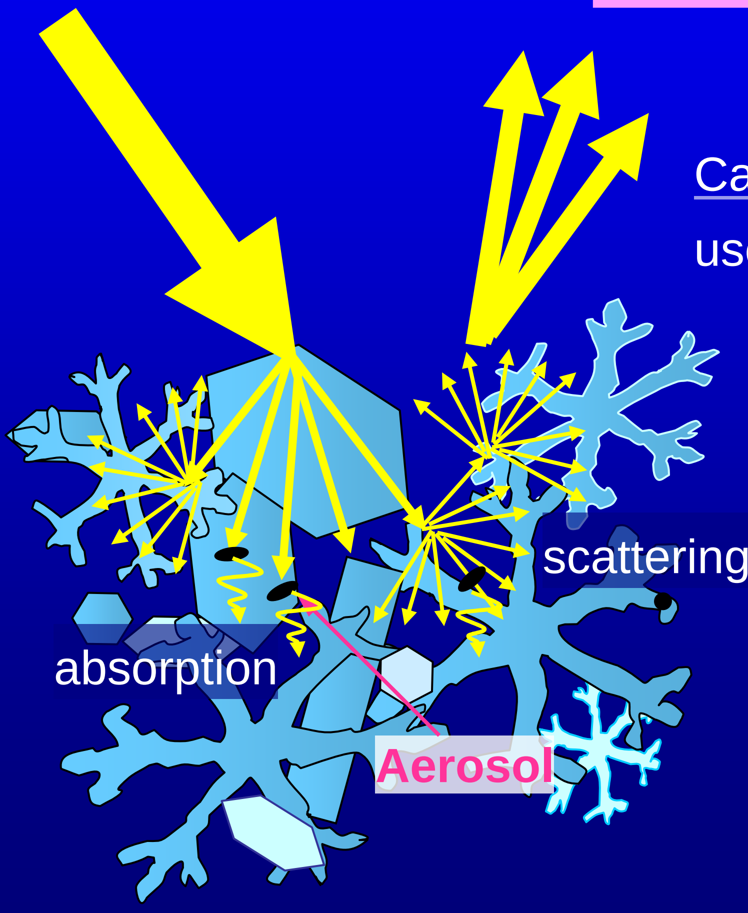
Climate, metamorphism and snow physics



Albedo

Albedo determined by

- Scattering : increases with decreasing grain size
- Absorption : increases with increasing impurity content



Calculation of scattering :

uses the equivalent size sphere = sphere of equal S / V

S / V related to Specific Surface Area

Surface area accessible to gases per unit mass

SSA = S / Vρ (cm^2/g)

Relationship Albedo- Specific Surface Area

Calculations

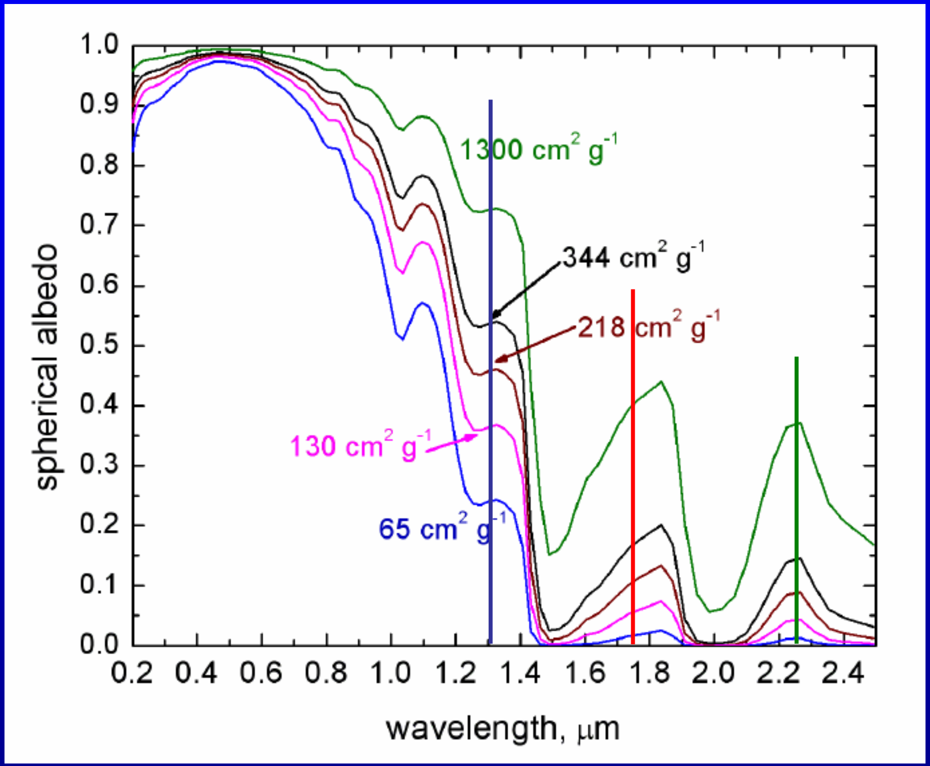
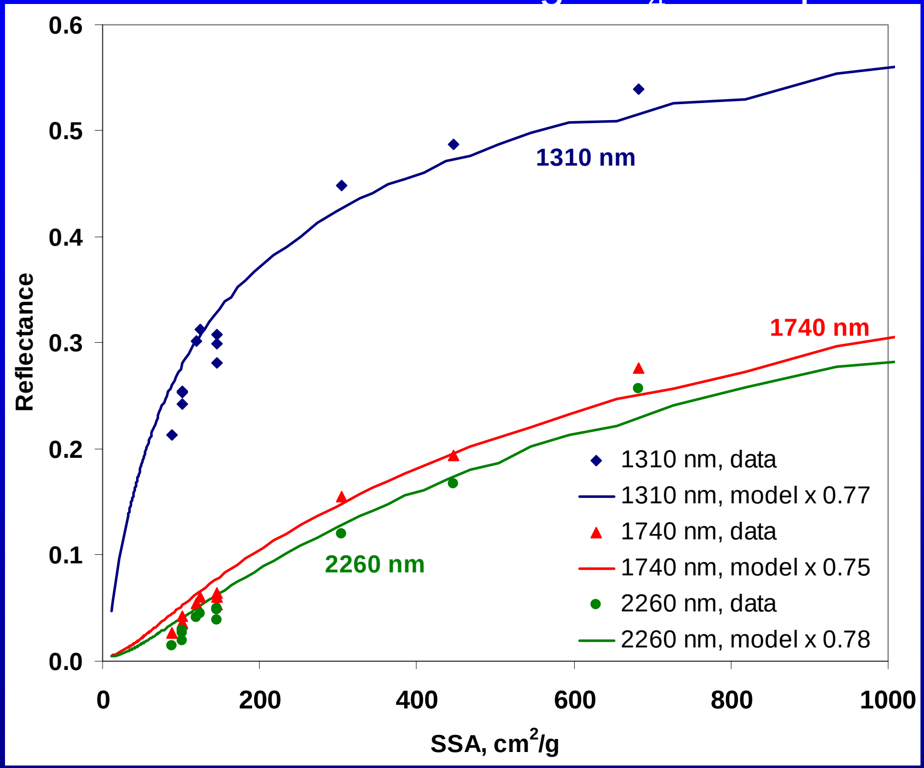


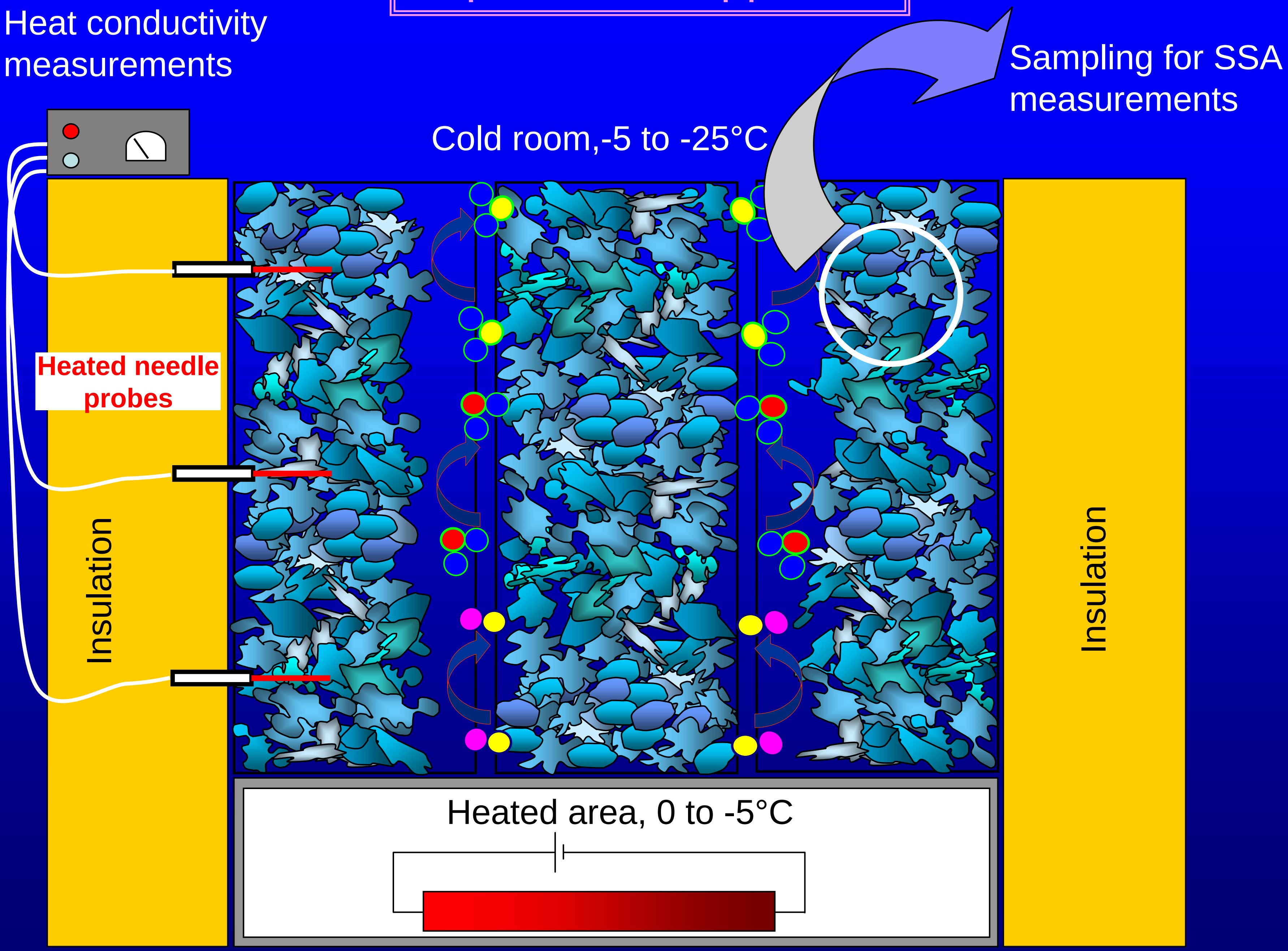
Figure after A. Kokhanovsky

SSA measurements using CH_4 adsorption



Domine et al., CRST 2006

Experimental approach



SSA decay rate

Empirical parametrization of SSA decay derived from both field and lab data :

$$SSA = f(t, SSA_0, T_{mean})$$

$$SSA = A - B \ln(t+\Delta t)$$

2 regimes observed :

ET regime, grad(T)< 10°C m^{-1} :

$$SSA(t) = A_{ET}(SSA_0, T_{mean}) - B_{ET}(SSA_0, T_{mean}) \ln(t+\Delta t_{ET})$$

TG regime, grad(T)> 20°C m^{-1} :

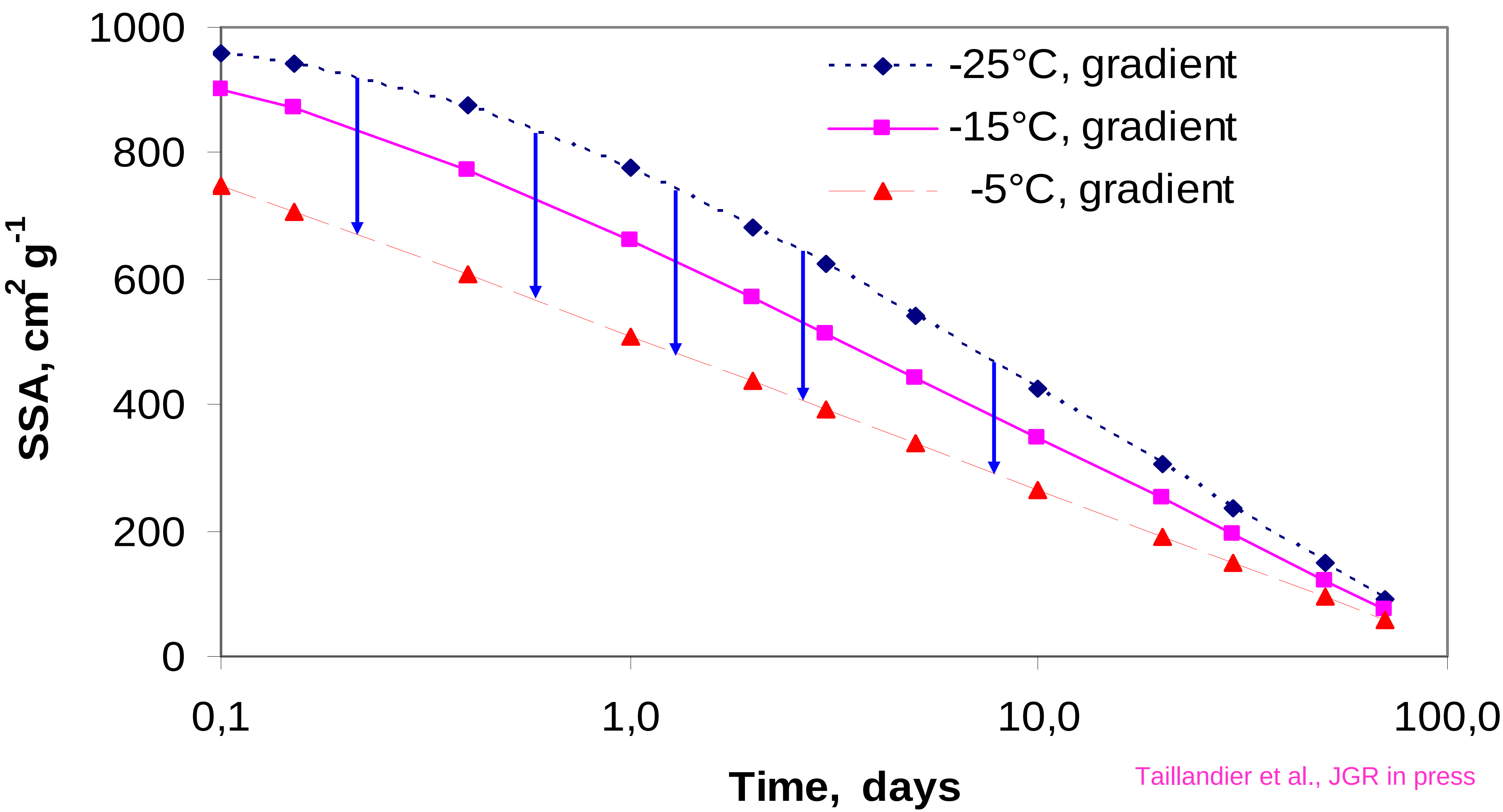
$$SSA(t) = A_{TG}(SSA_0, T_{mean}) - B_{TG}(SSA_0, T_{mean}) \ln(t+\Delta t_{TG})$$

Taillandier et al., JGR in press

SSA decay rate

Effect of T on SSA decay rate, under TG conditions

T ↗ ⇒ *SSA* ↘ ⇒ albedo ↘

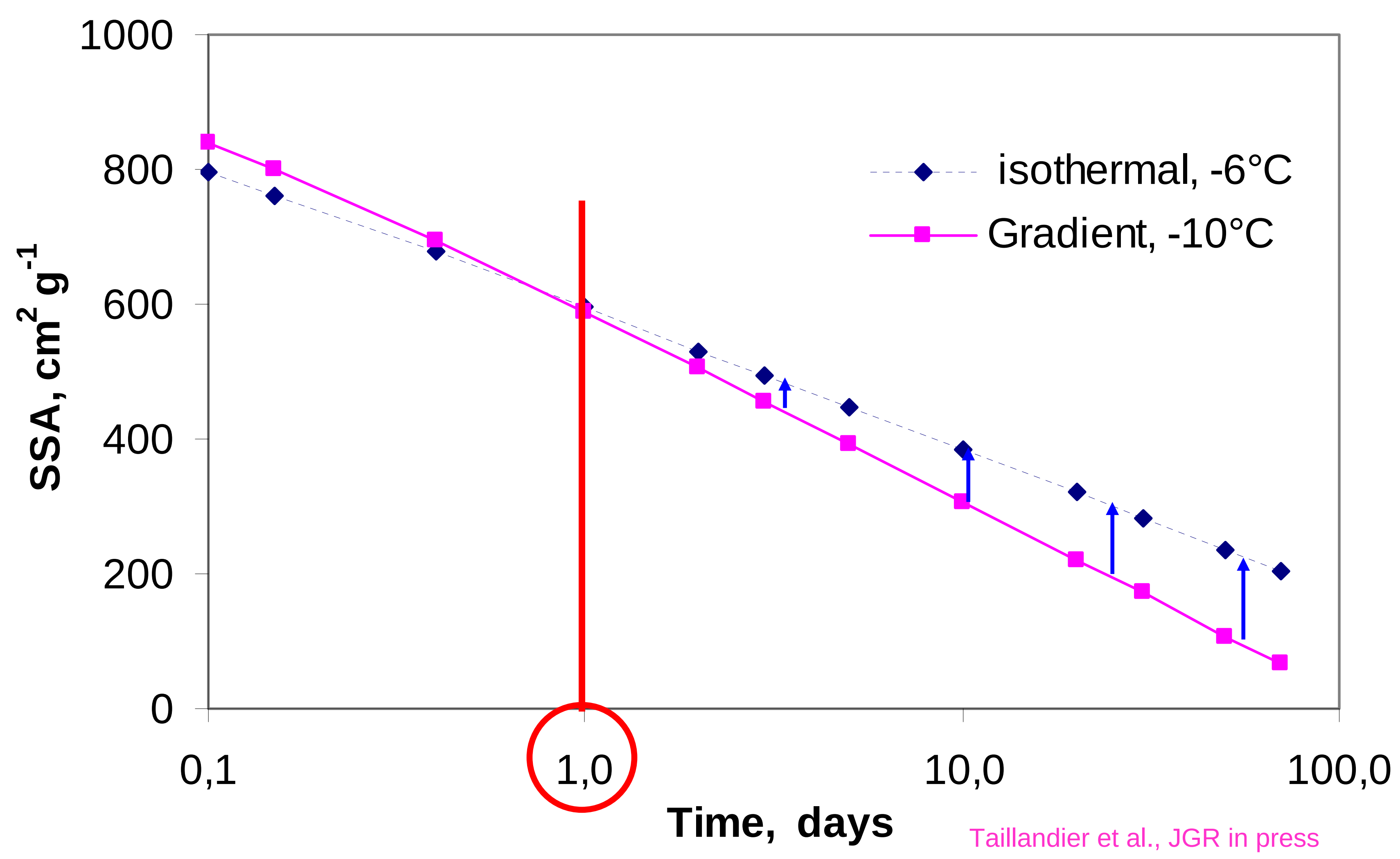


Taillandier et al., JGR in press

SSA decay rate

Increase in T (and in precipitation) ⇒ gradient (TG) → “isothermal“ (ET)

?? Effect of T increase and of a change in metamorphic regime from TG to ET ??



Taillandier et al., JGR in press

Quantifying the snow-albedo feedback

Incoming solar flux : 100 W m^{-2}

SSA change : 100 → 200 cm^2/g

⇓

Albedo : 0.75 → 0.79

Forcing = - 4 W m^{-2} ⇒ Climate effect ??

Modeling soot effect on snow :

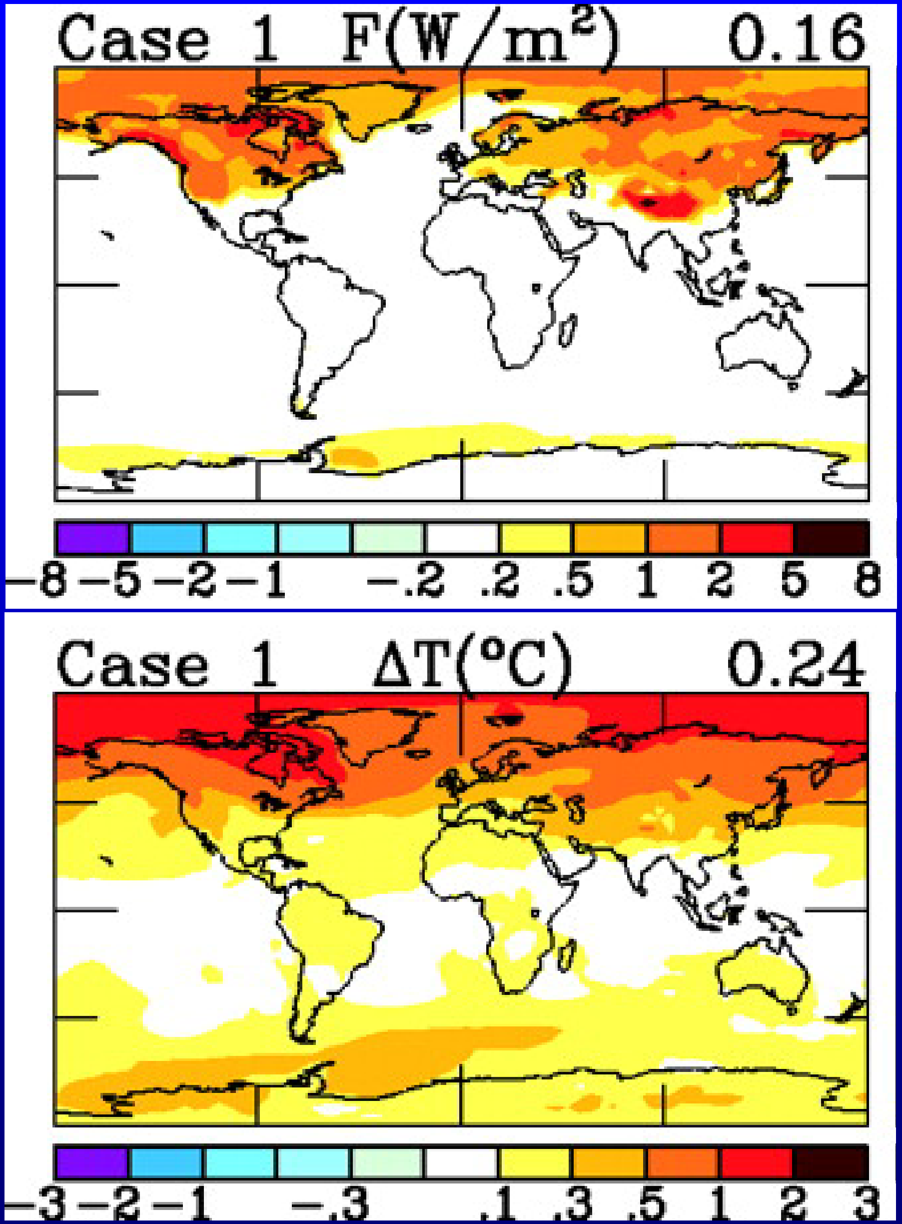
Forcing of +1.5 W m^{-2} due to soot

⇓

T change of +1 to 2 °C at high latitude

⇓

Effect of change in SSA could reach **3-4°C (cooling)**



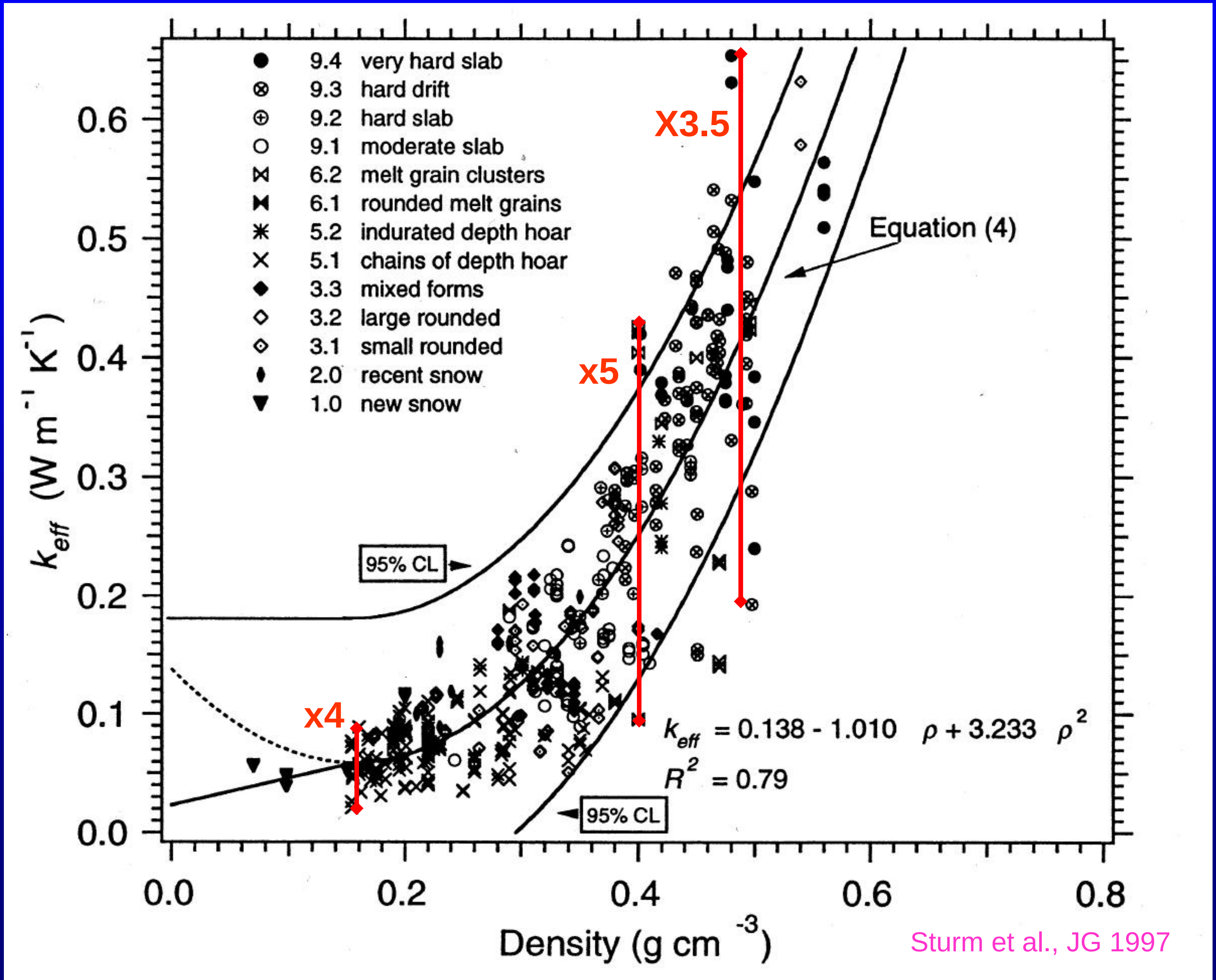
Hansen and Nazarenko, PNAS, 2004

This wonderful science generously supported by :

EXSO

Heat conductivity, k_T

With current k_T parameterizations, understanding climate-k_T interactions is not simple



Sturm et al., JG 1997

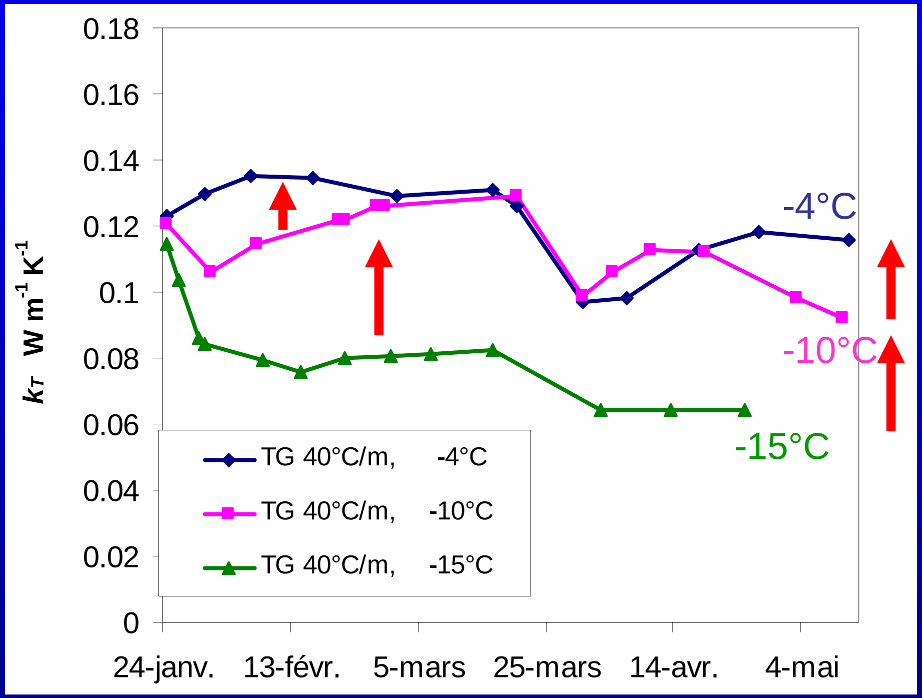
Heat conductivity, k_T

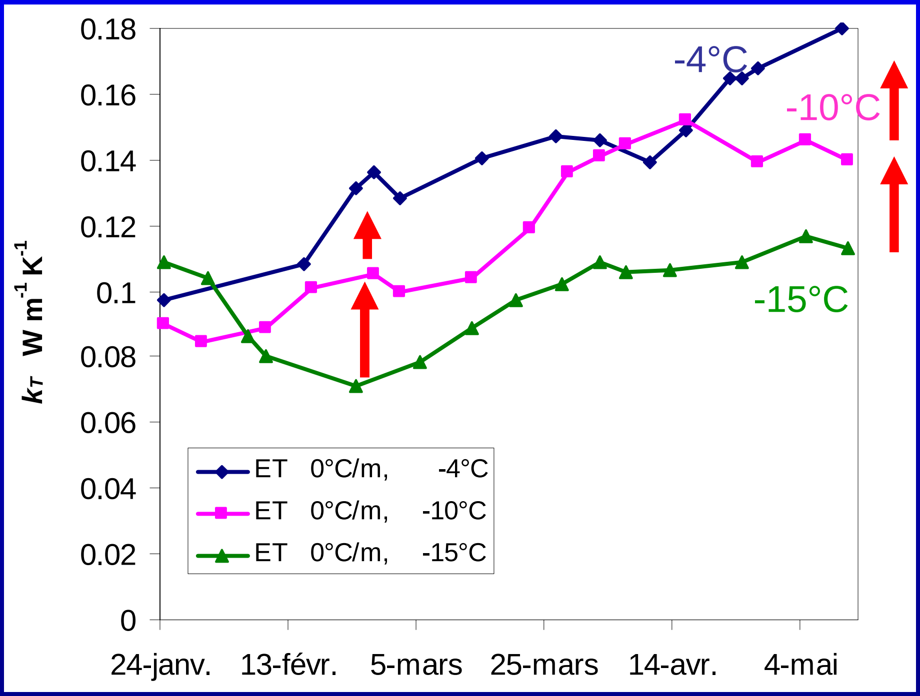
High temperature gradient conditions, 40°C/m

T ↗ ⇒ k_T ↗

Isothermal conditions, 0°C/m

T ↗ ⇒ k_T ↗



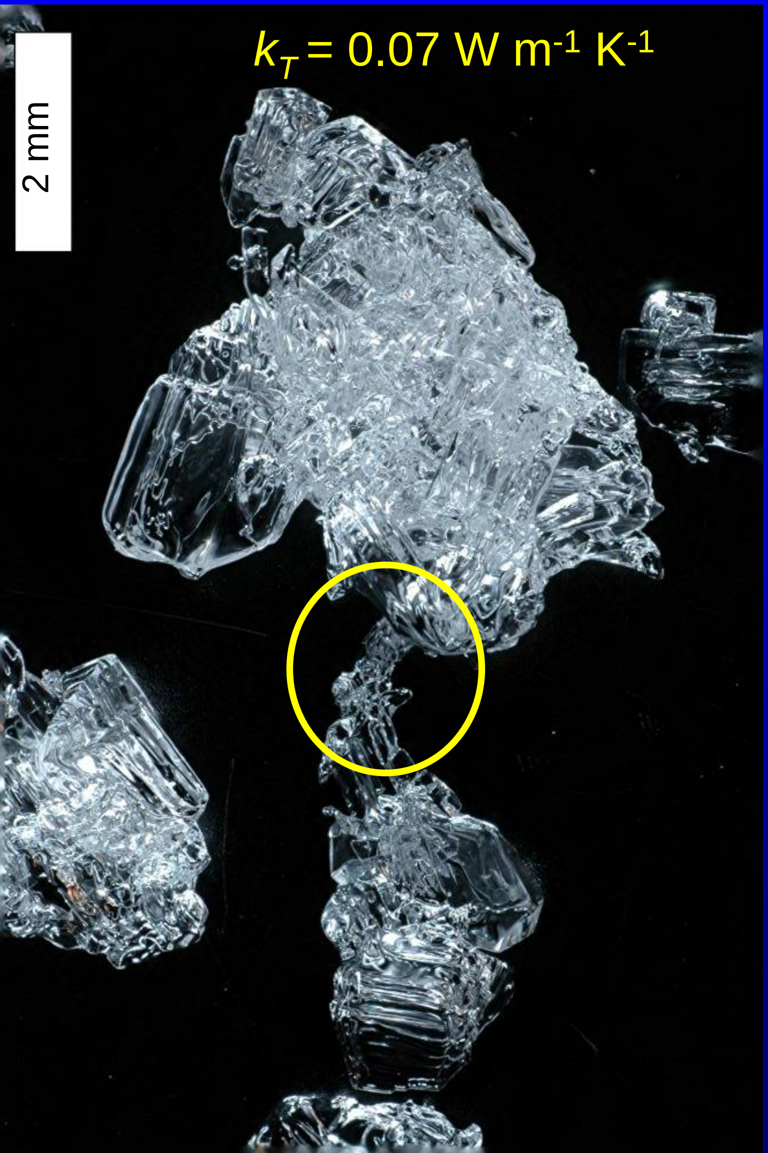


Warming ⇒ k_T ↗ in all cases

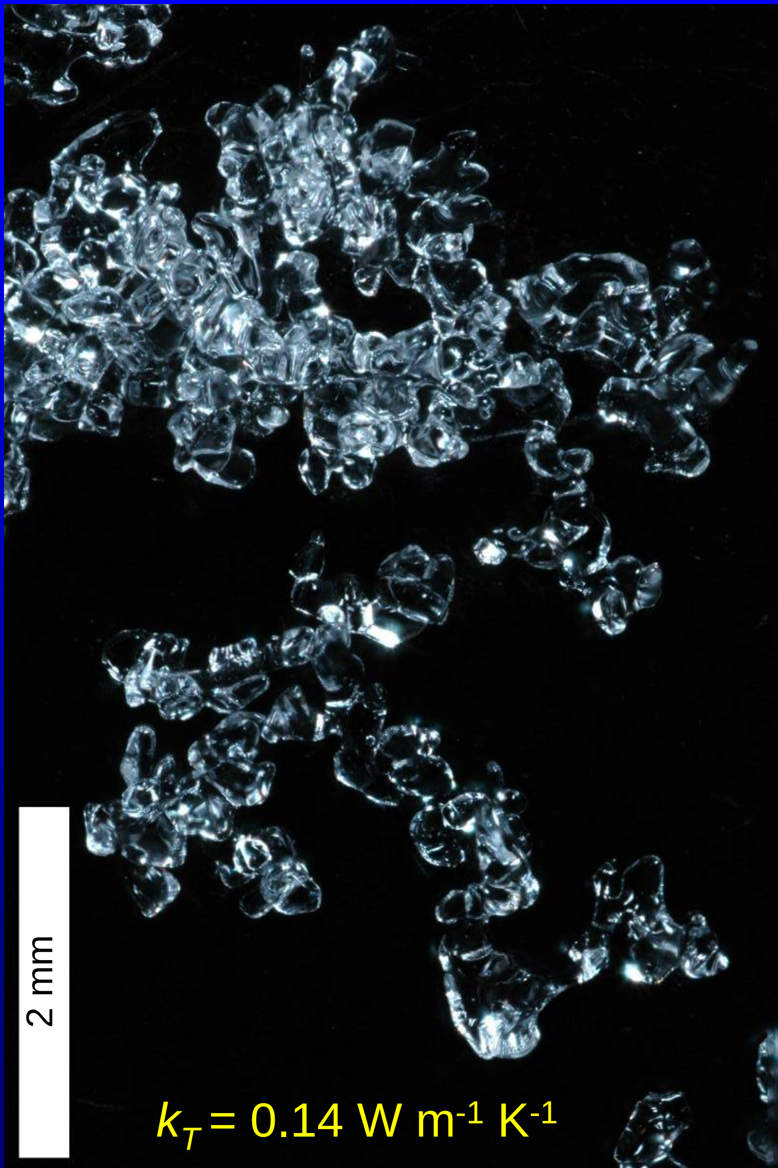
Did you think of wind changes ????

Warming AND change in metamorphic regime

High temperature gradient conditions, 40°C/m

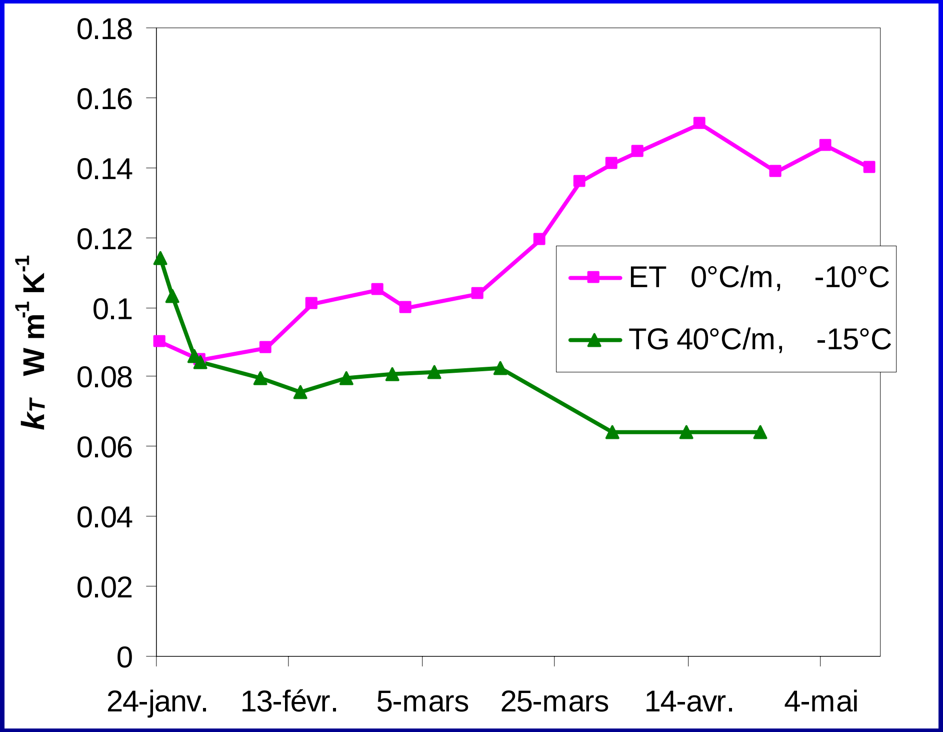


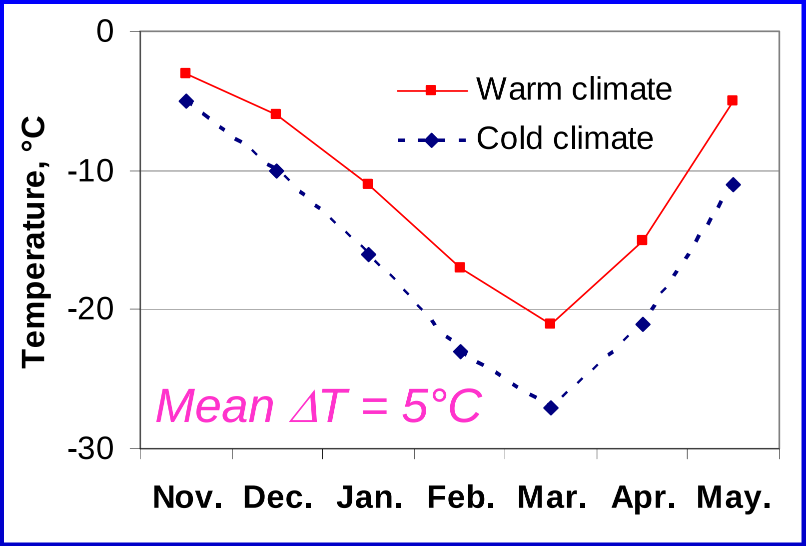
Isothermal conditions, 0°C/m

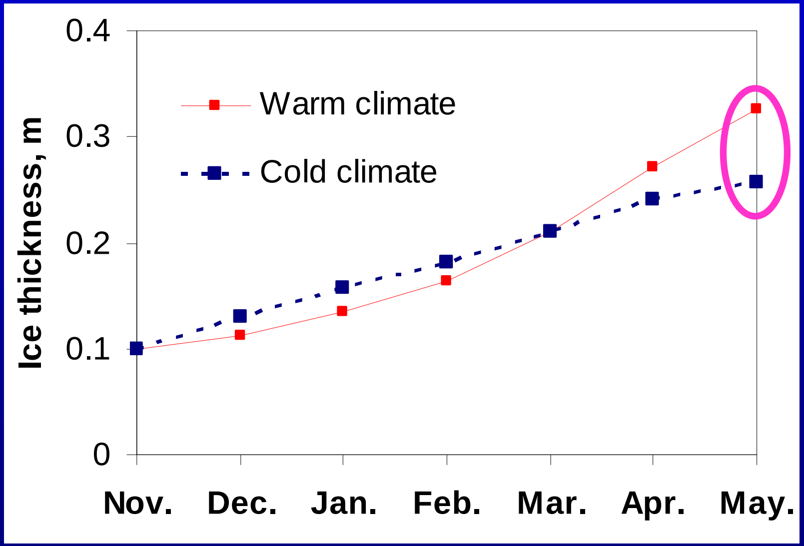


Warming AND change in metamorphic regime

Example of sea ice growth







Changes in snow physics offsets a 5°C warming !!

This cutting edge work abundantly funded by :

Captain Motors

Conclusion

Snow will save us from global warming !!

Both positive and negative snow-climate feedback exist

They need to be studied to predict Arctic climate change