Radiative impact of light absorbing impurity in snow : some examples and uncertainty assessment

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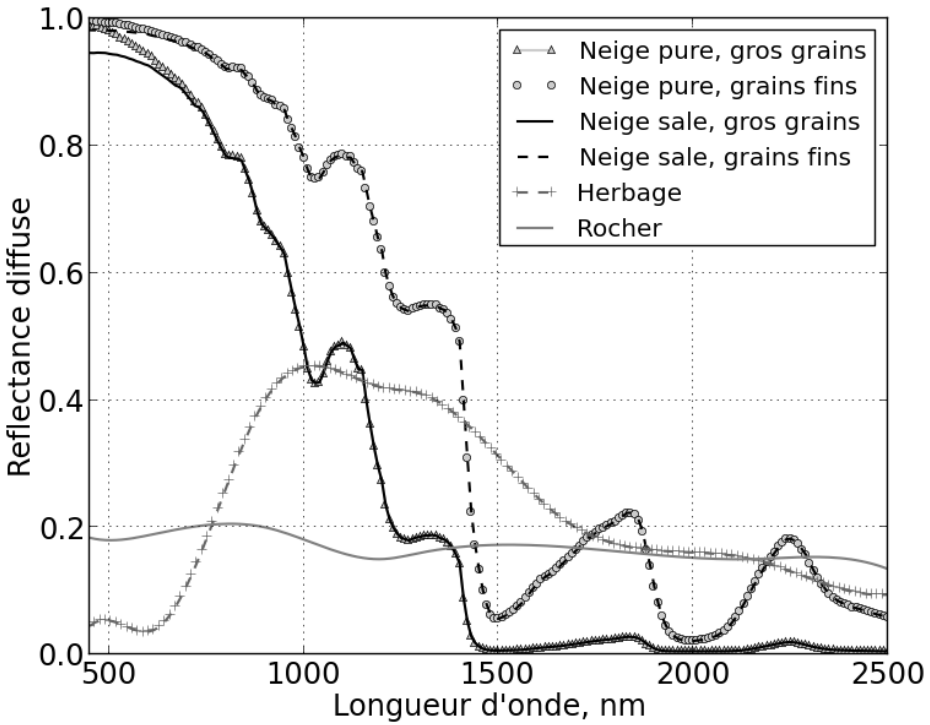
Radiative impact of impurity in snow



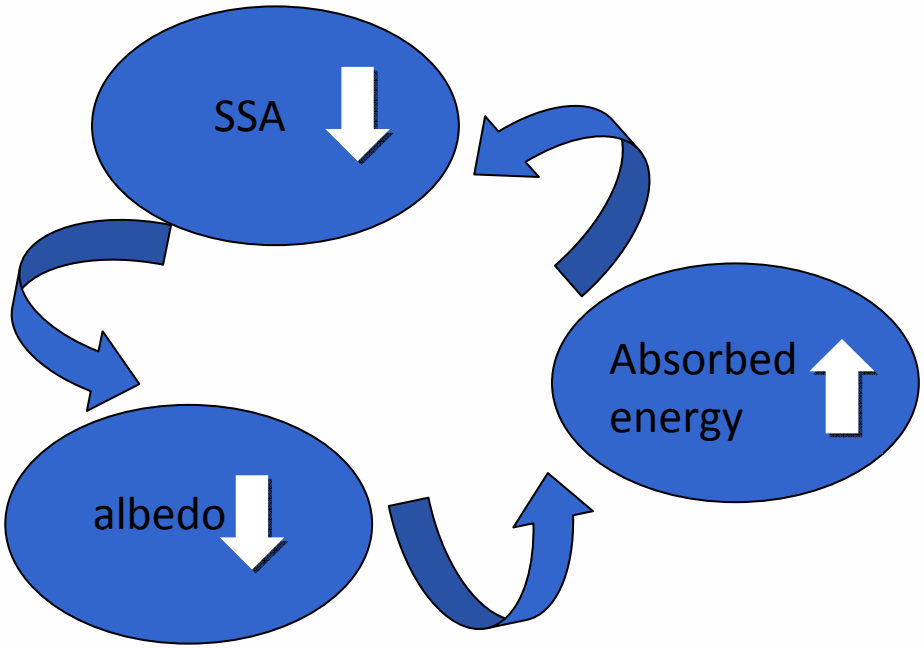
Visible albedo decrease

Enhanced for coarse grains

NIR albedo decrease due to grain size effect

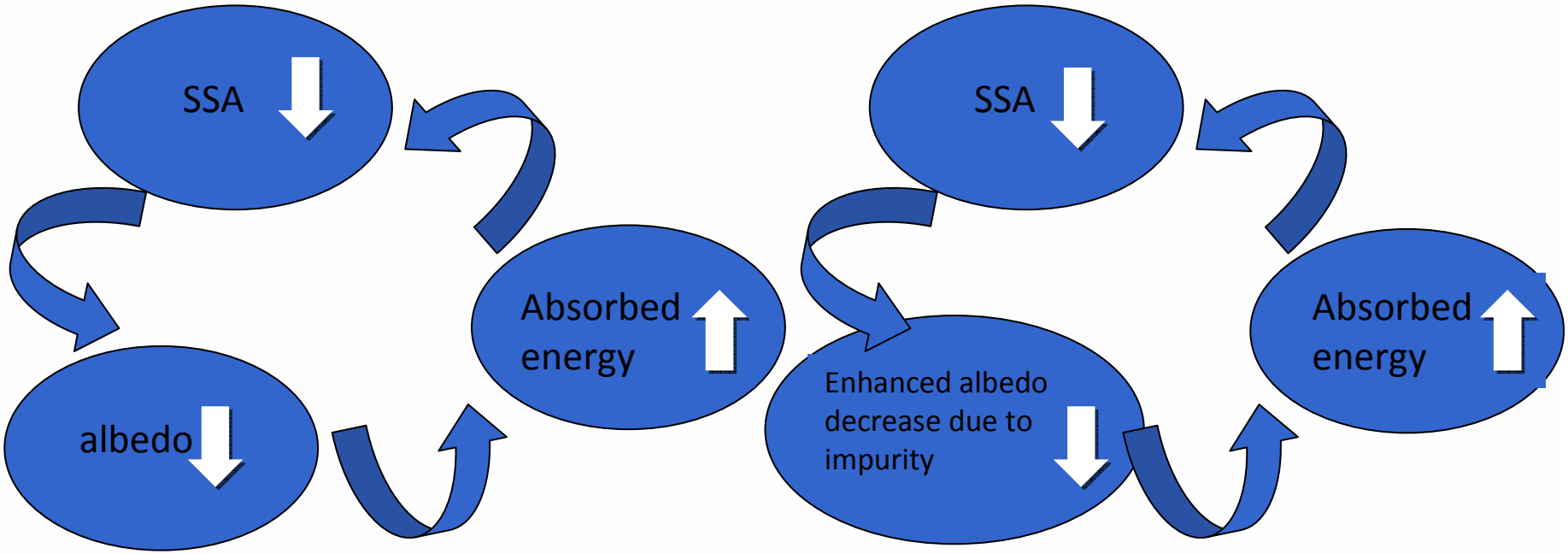
METEO FRANCE
Toujours un temps d'avance

Positive feedbacks



e.g. [Flanner and Zender, 2006]

Positive feedbacks



e.g. [Flanner and Zender, 2006]

e.g. [Doherty et al., 2013]

Colorado river basin

[Painter et al., 2012 ; Skyles et al., 2012 ; Bryant et al., 2013]

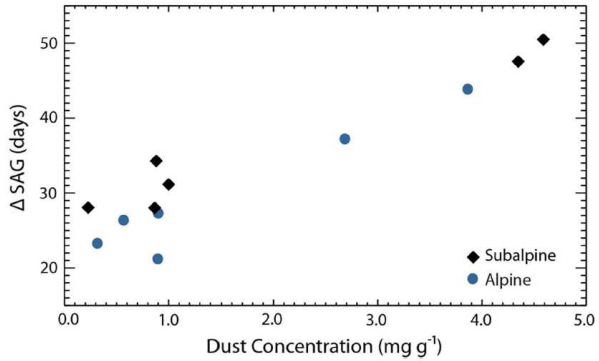
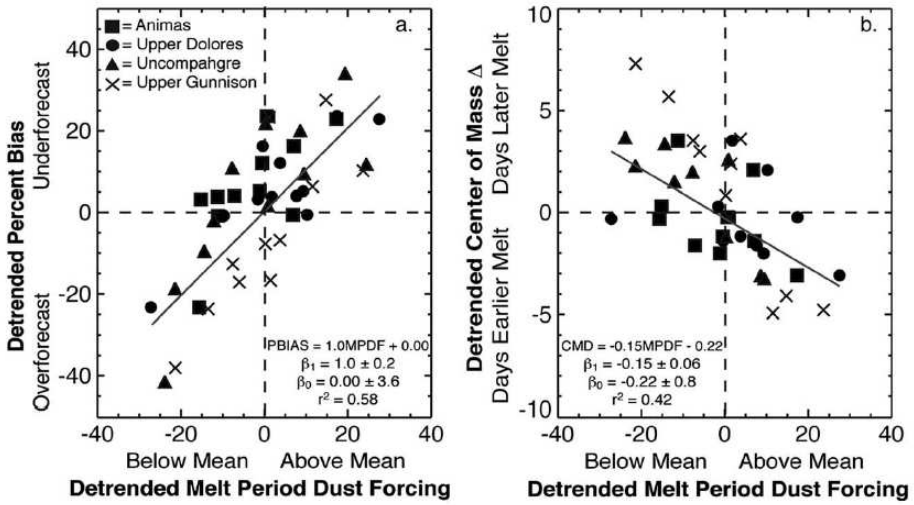
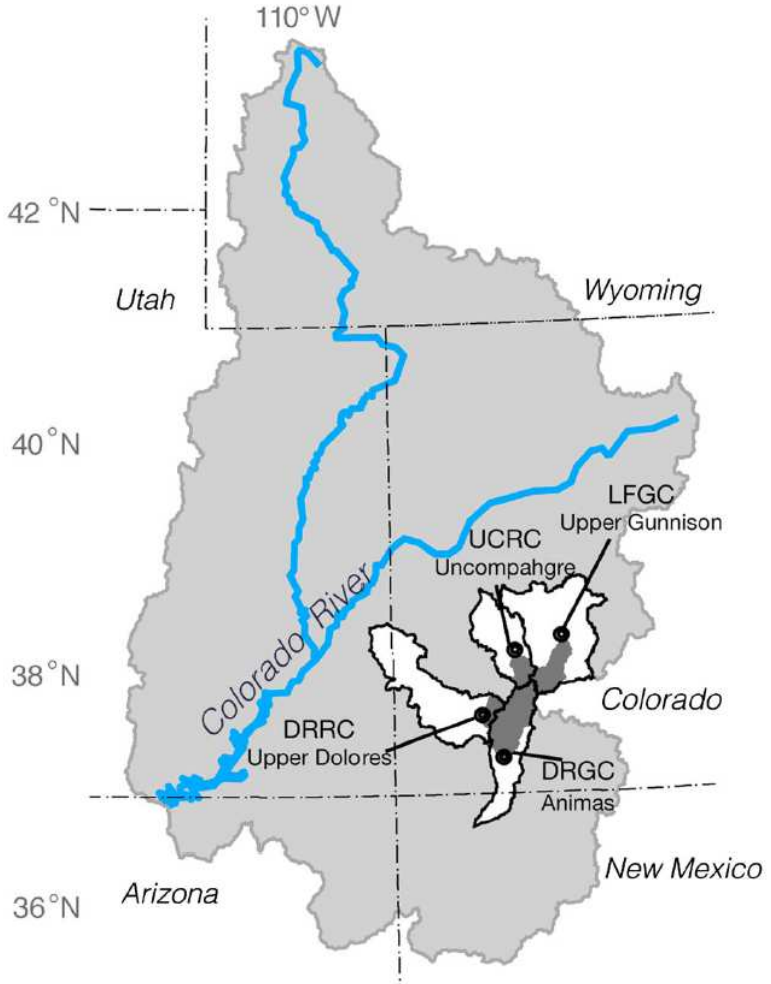
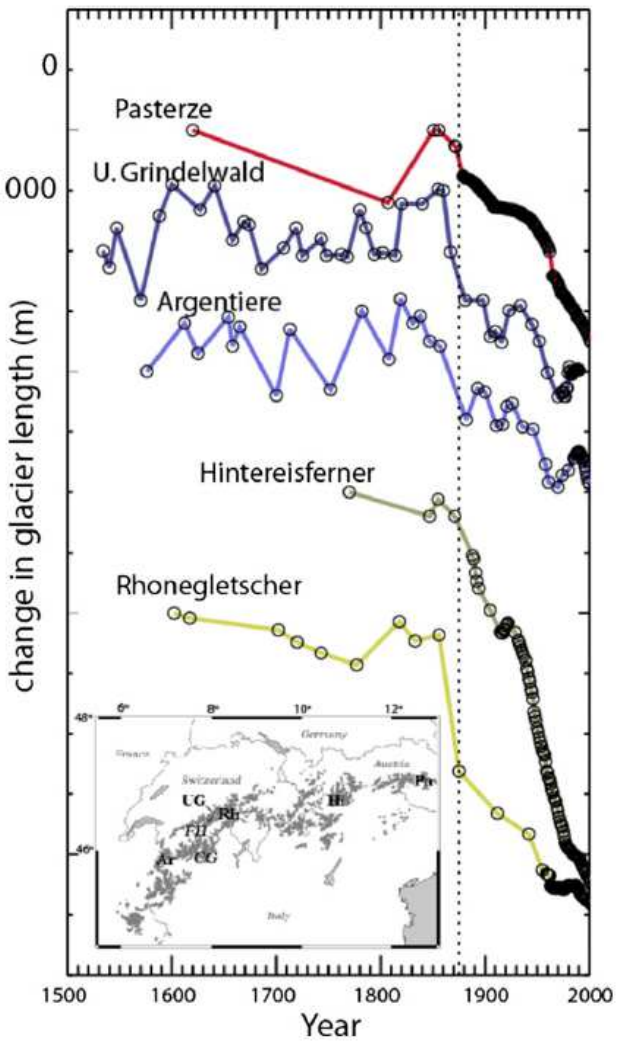


Figure 8. Change in snow-all-gone date (ΔSAG) with end of year dust concentrations. R^2 values are 0.94 and 0.92 at the subalpine and alpine site, respectively.





End of Little Ice Age [Painter et al., 2013]



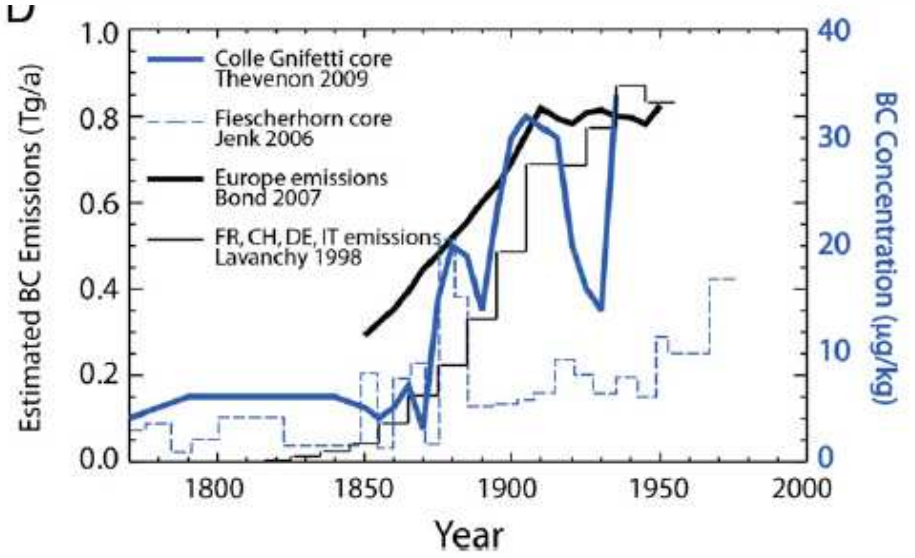
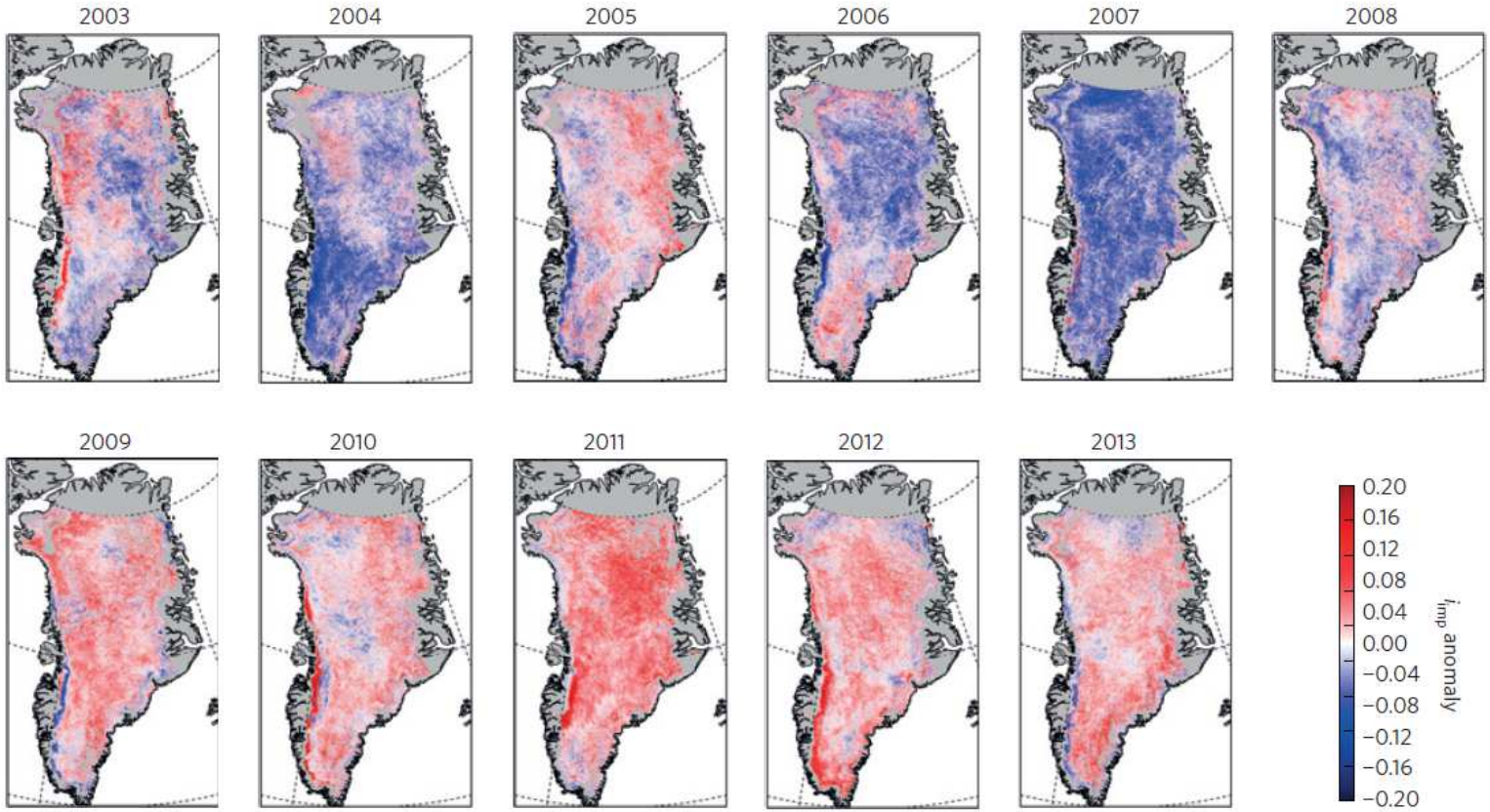


Fig. 1. Change in glacier length (m) relative to the first year of measurement for five Alpine glaciers (offset consecutively by 1,000 m for clarity). (*Inset*) The locations of Glacier d'Argentiere, Rhonegletscher, Unterer Grindelwaldgletscher, Pasterzegletscher and Hintereisferner, and Fiescherhorn and Colle Gnifetti ice cores. The underlying gray circles represent glacier locations in the Alps from the World Glacier Inventory (www.geo.unizh.ch/wgms).

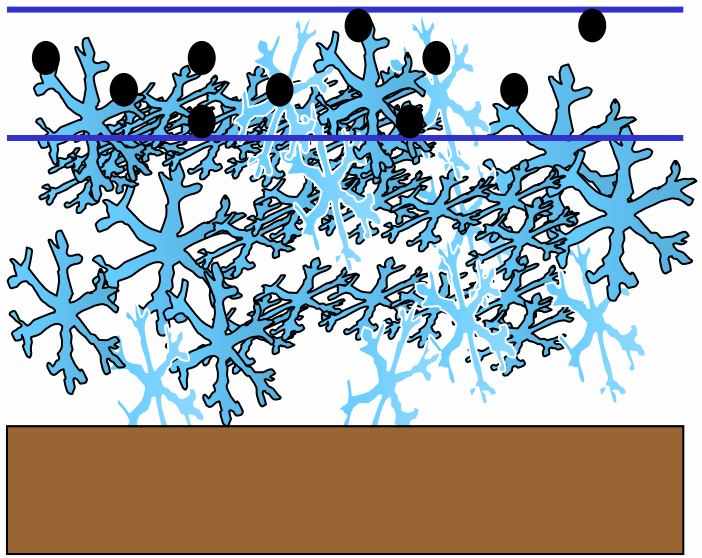
Greenland Ice Sheet [Dumont et al., 2014]



Darkening of the GrIS in late Spring due to impurities ?

$\Delta m \cong -27$ Gt yr^{-1}

Modelling uncertainties



SSA= 10 m^2kg^{-1}, ρ= 300 kg m^{-3}, d=5 cm

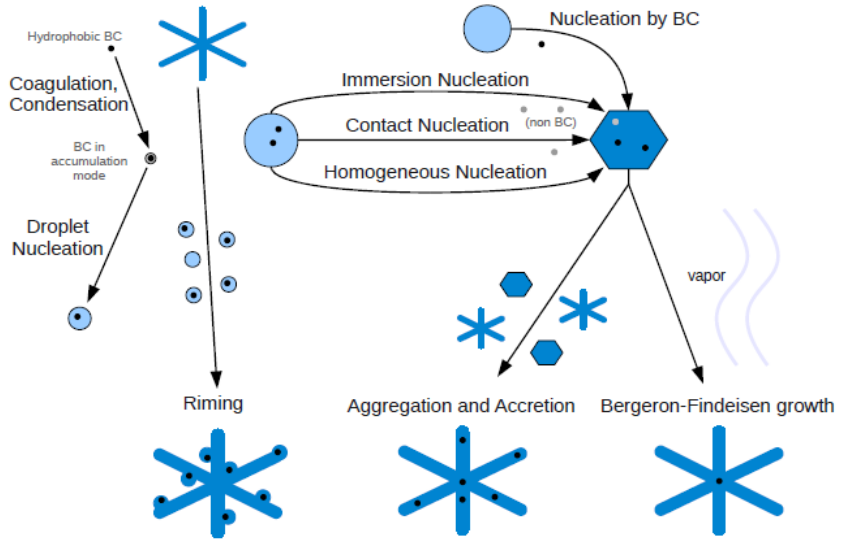
SSA= 5 m^2kg^{-1}, ρ= 300 kg m^{-3}, d=10 m

DISORT simulations, diffuse albedo

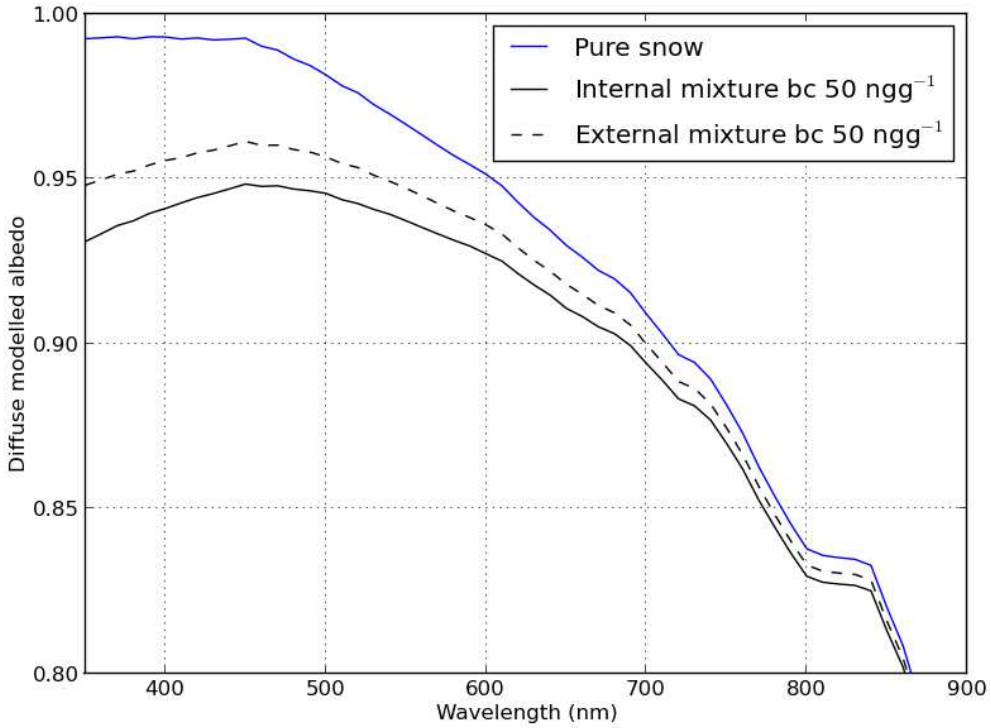
Flanner et al., 2012 formulation for BC internal mixture and physical properties

Model developed and used in **Dumont et al., 2014 ; Ginot et al., 2014 ; Carmagnola et al. 2013**

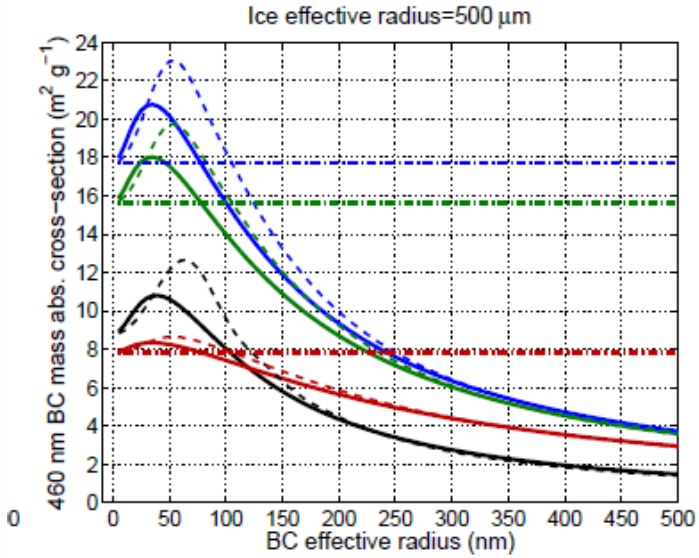
Localisation of impurities

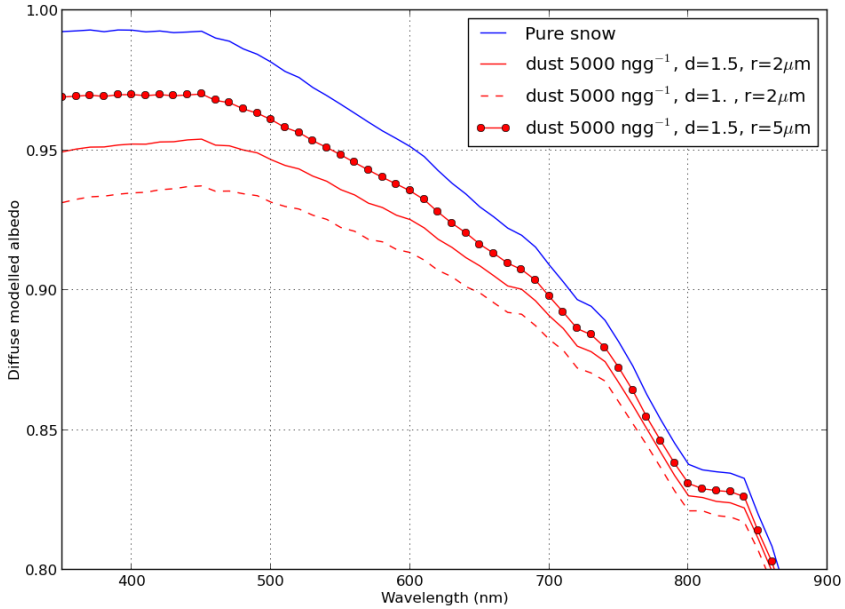


[Flanner et al., 2012]



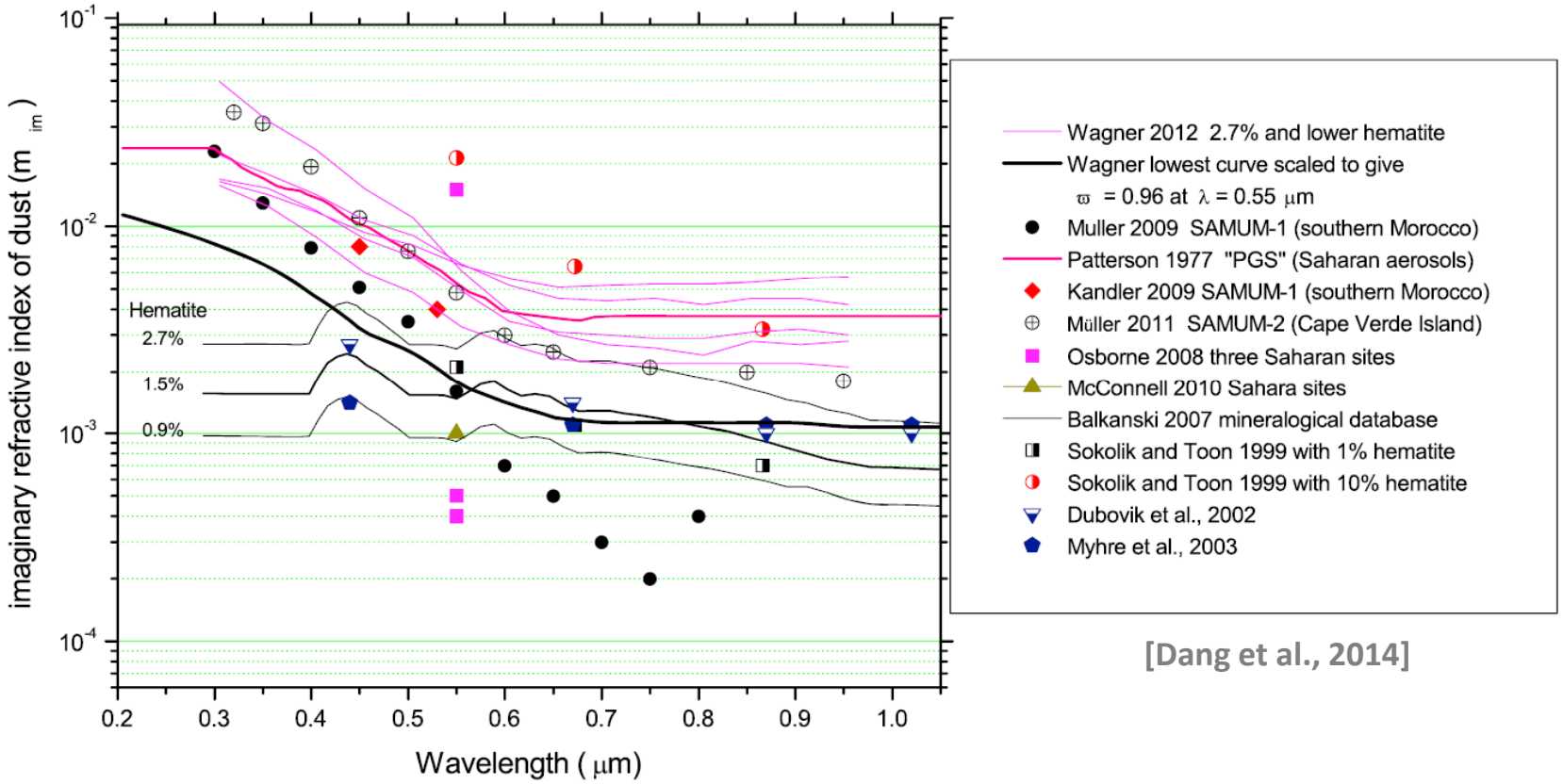
Impurities physical properties





[Flanner et al., 2012]

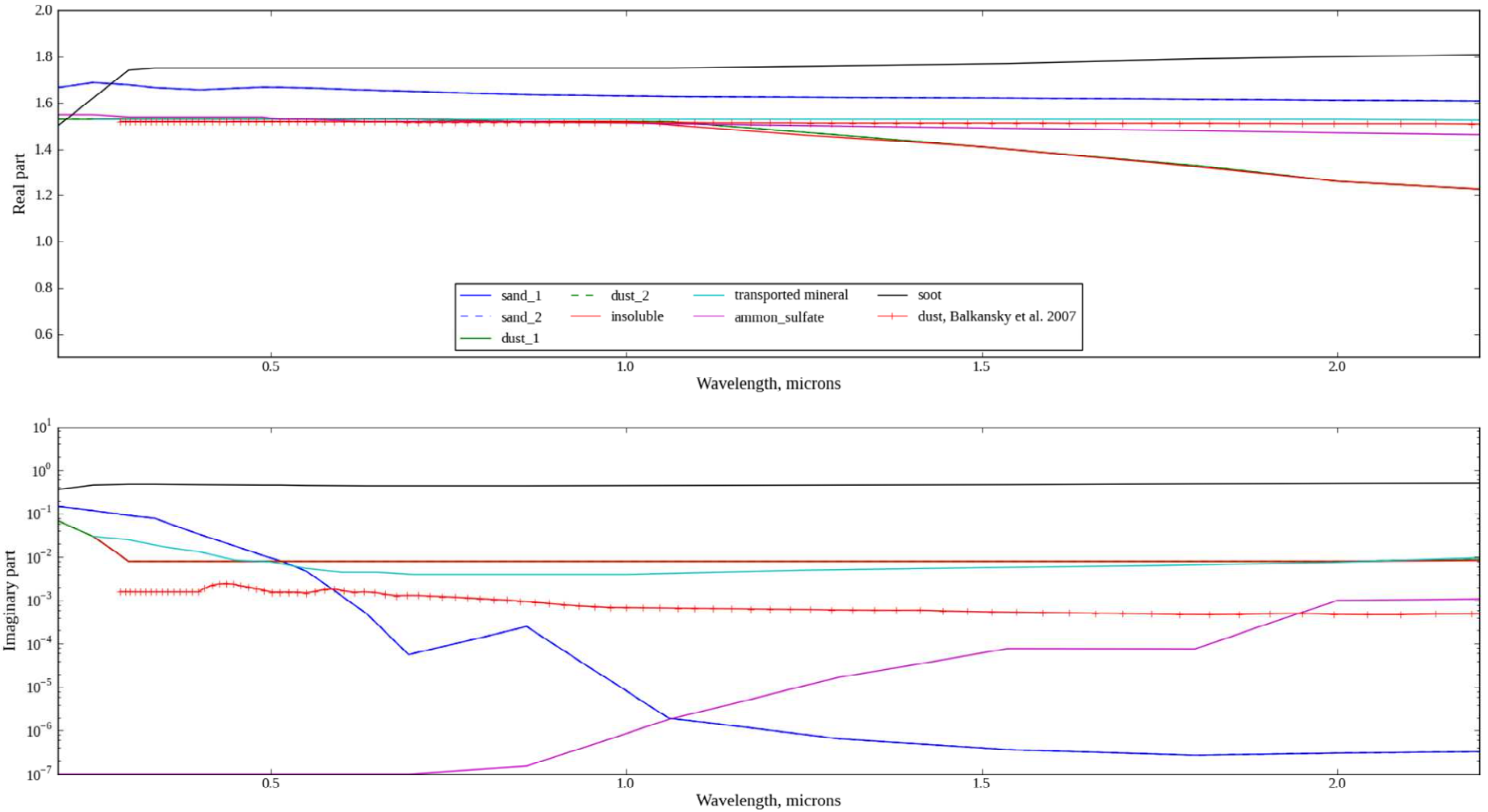
Impurities refractive indices



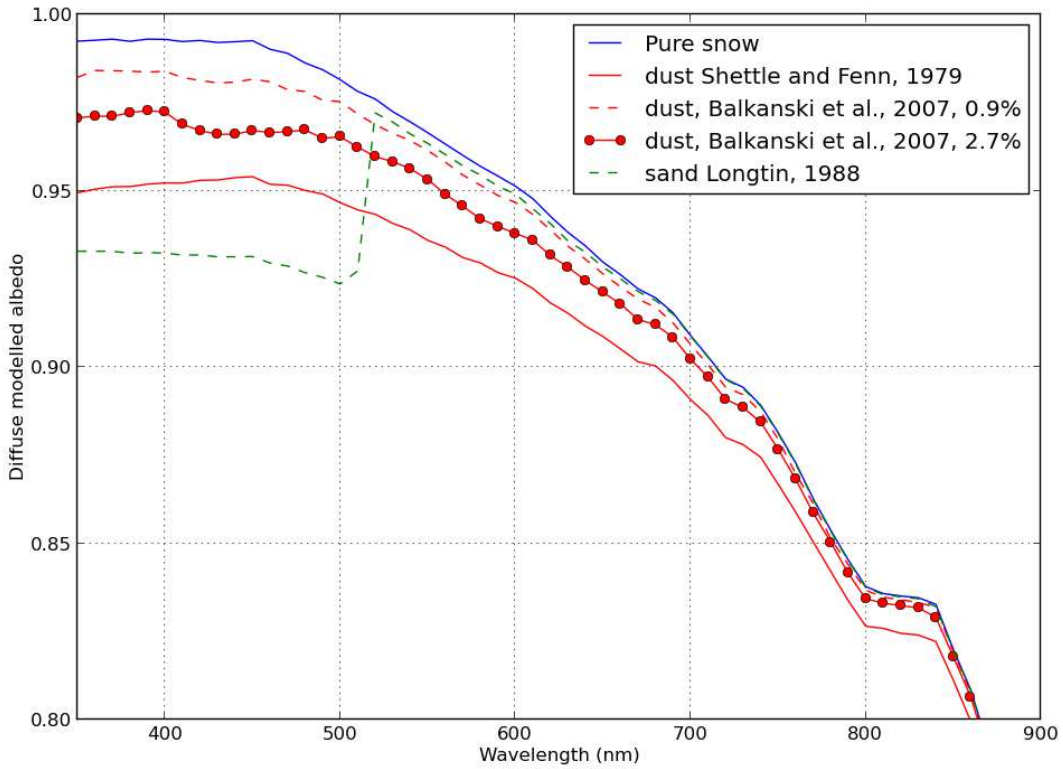
[Dang et al., 2014]

Soot refractive index is relatively well constrained but its not the case for dust …

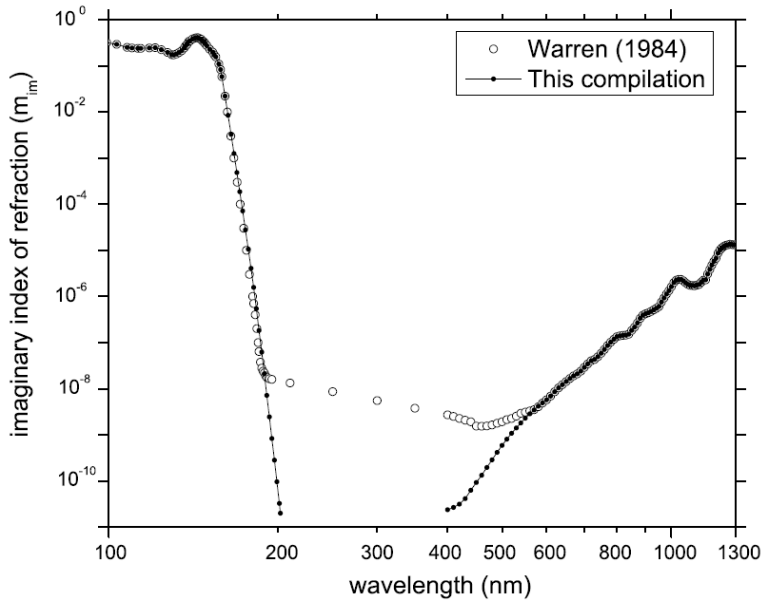
Impurities refractive indices



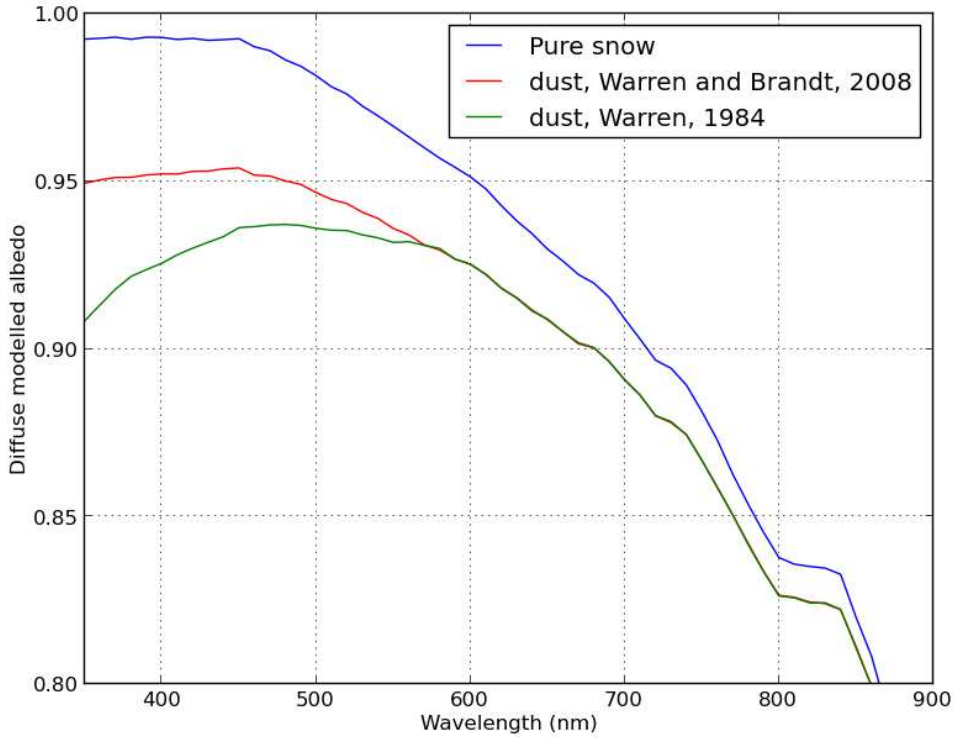
Impurities refractive indices



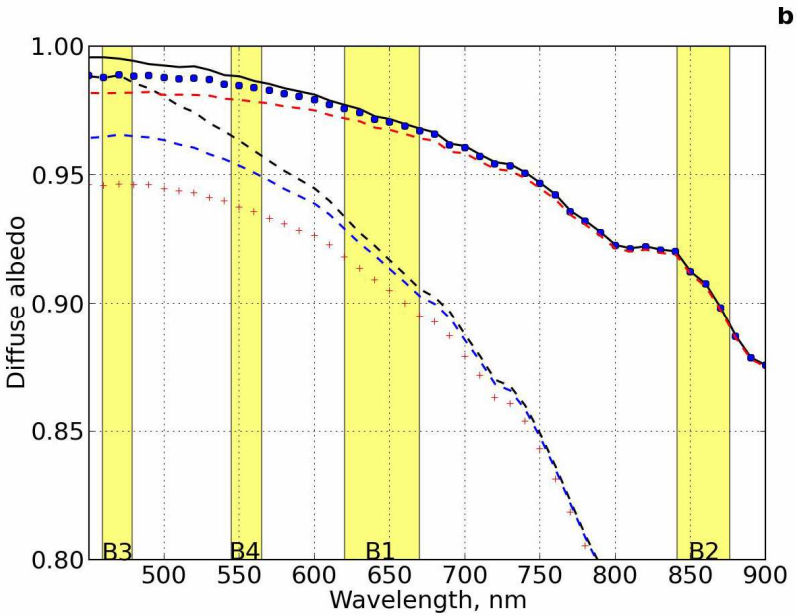
Ice refractive index



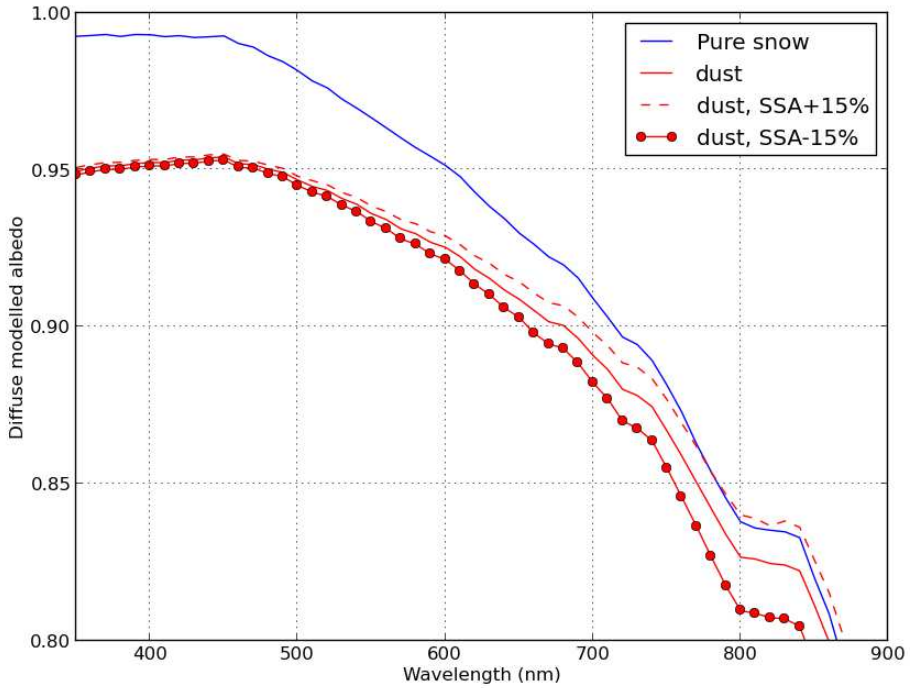
[Warren and Brandt, 2008]



Snow physical properties

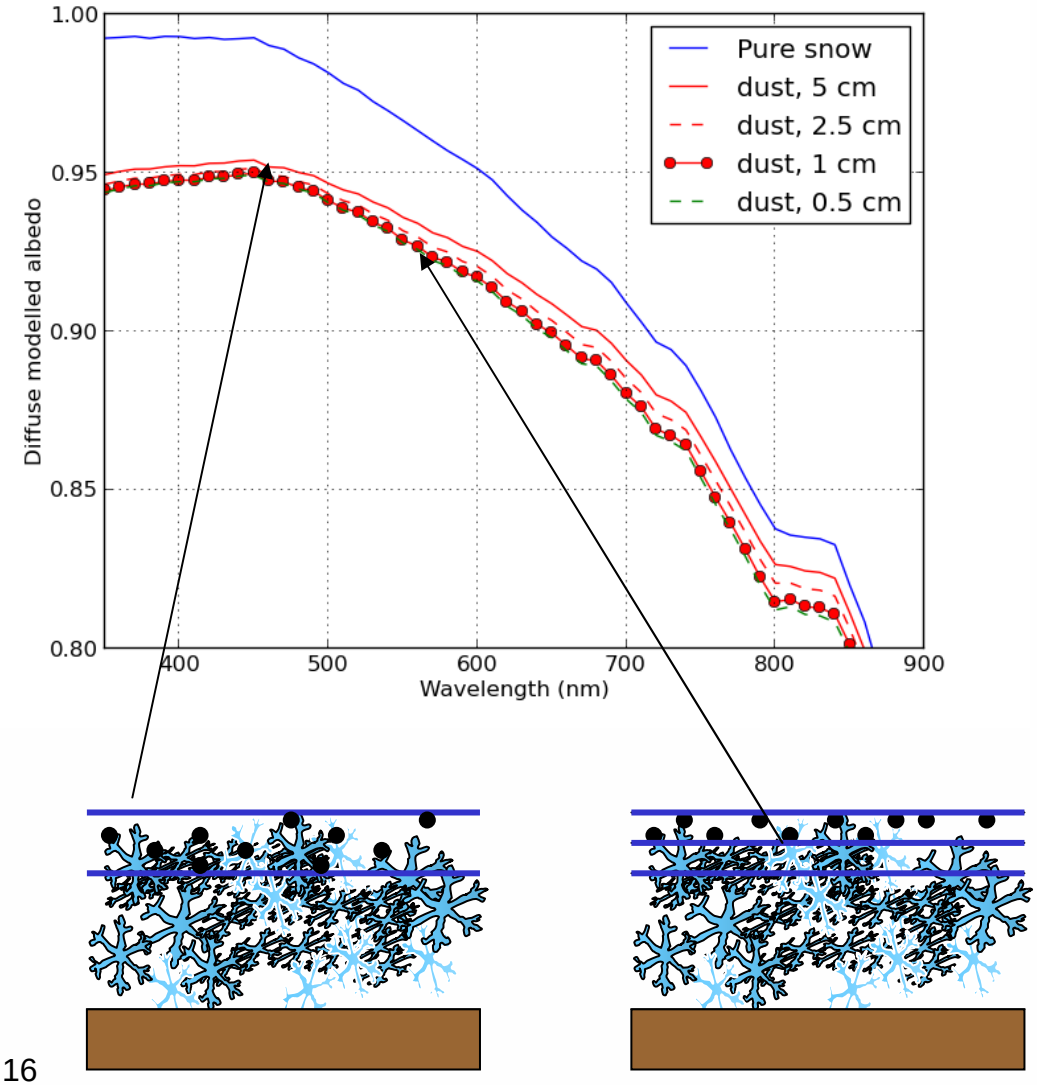


Snow simulations



Accuracy of SSA measurements in the field

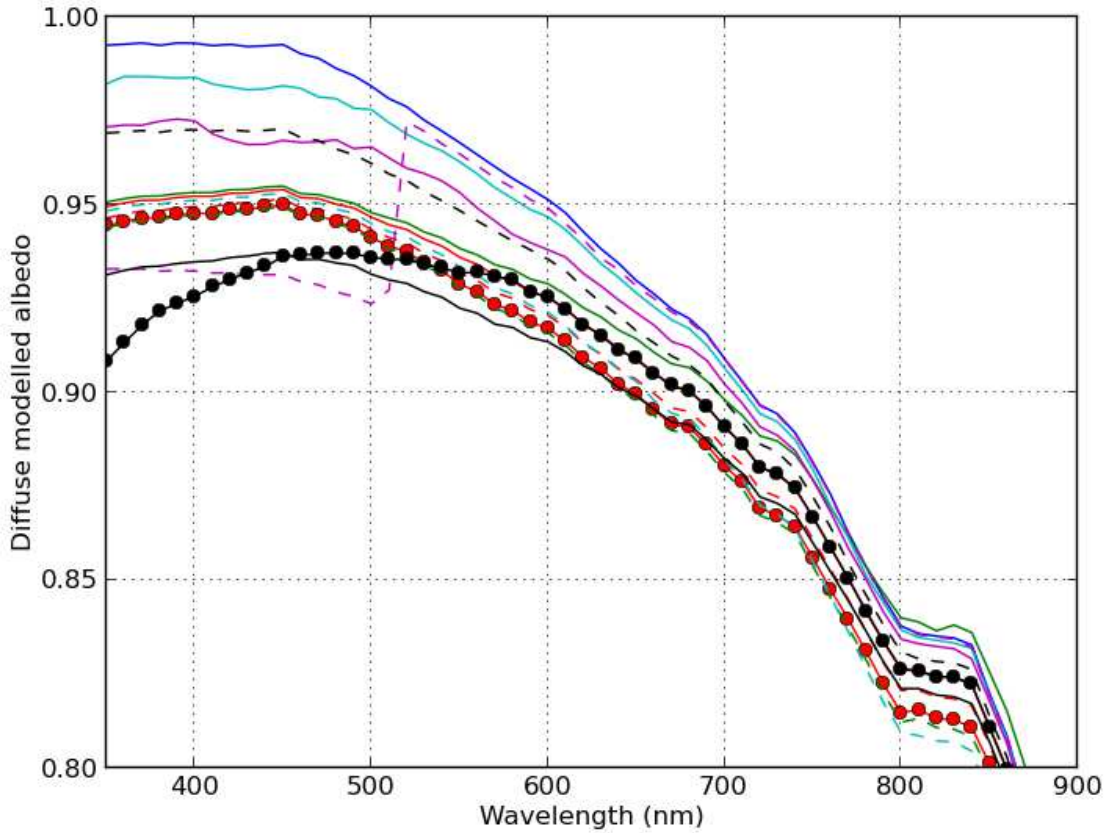
Vertical profile of impurity content



Current measurements methods for impurity content in snow often limits the vertical resolution of the impurity content profile (volume needed for filtration for exemple)

The impurity content might vary a lot in the first centimeters of the snowpack (dry deposition, impurity concentration due to melt …)

Conclusion



All these simulations have been performed with the same dust content …

Albedo decrease varies between -0.01 and -0.09 ~ in the visible wavelengths