Karlsruhe Institute of Technology

ESM Advanced Earth System Modelling Capacity

Impact of aerosol deposition on snow albedo: improvement of snow optical properties with respect to grain size

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Albedo: Reflectivity of a Surface

Surface Energy Balance

Temperature

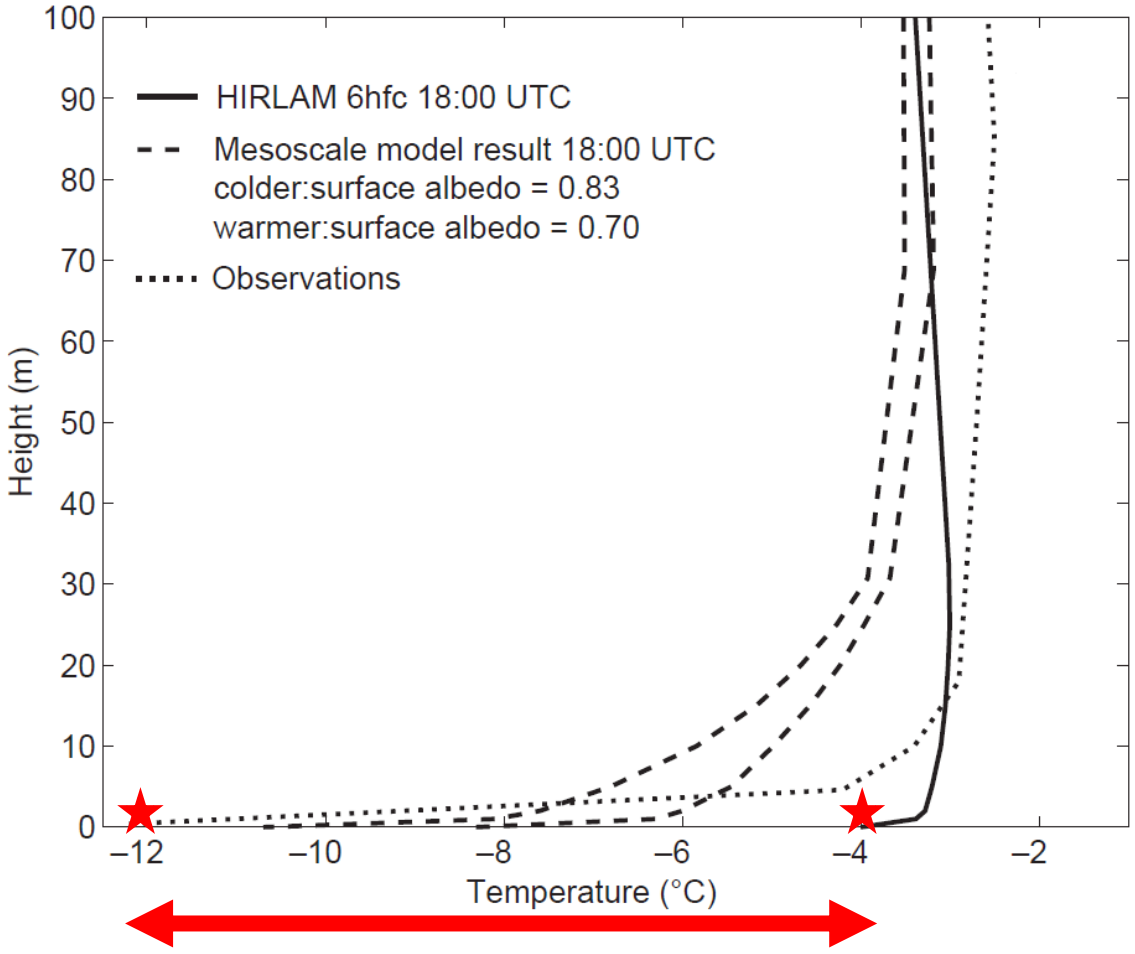
Snow Melt

Atmosphere

Hydrology

Soil

Model Sensitivity: Pirazzini et al., 2002

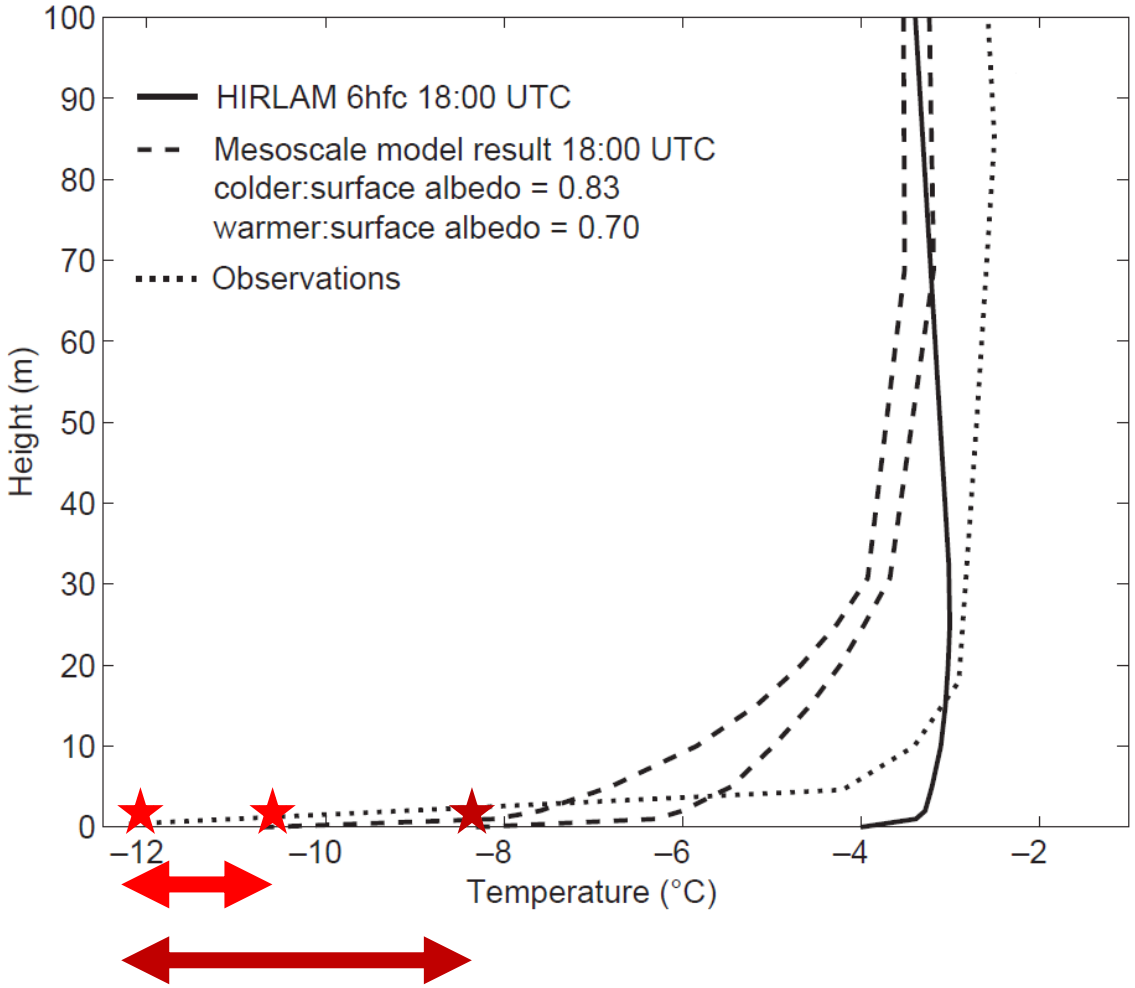


Albedo has a significant impact on

⇨ **surface temperature**

⇨ **2m air temperature**

Model Sensitivity: Pirazzini et al., 2002



Albedo has a significant impact on

⇨ **surface temperature**

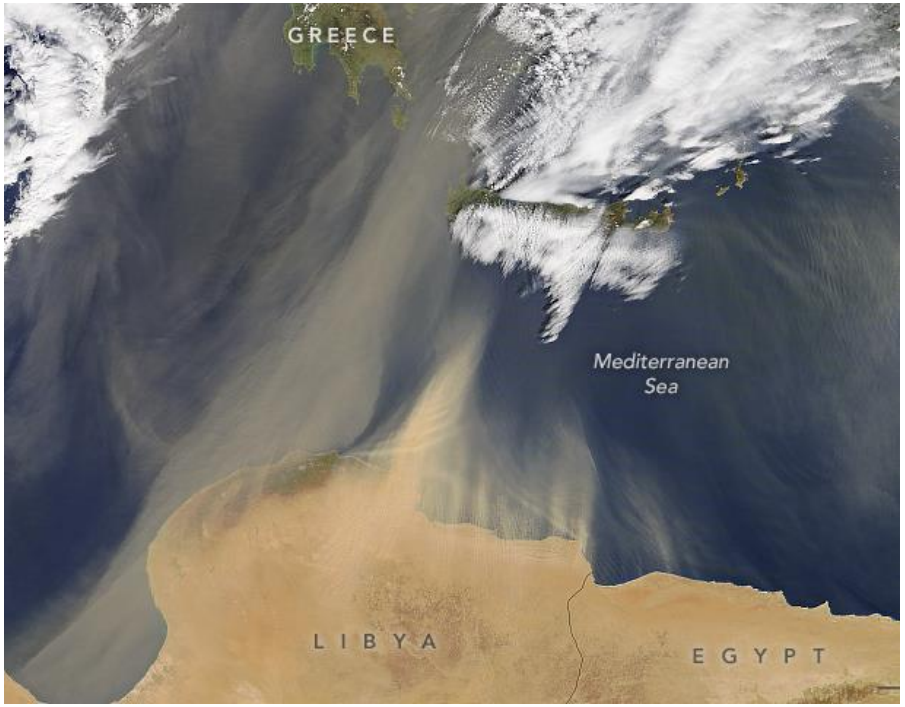
⇨ **2m air temperature**

Aerosols:

solid/fluid particles

suspended in the atmosphere

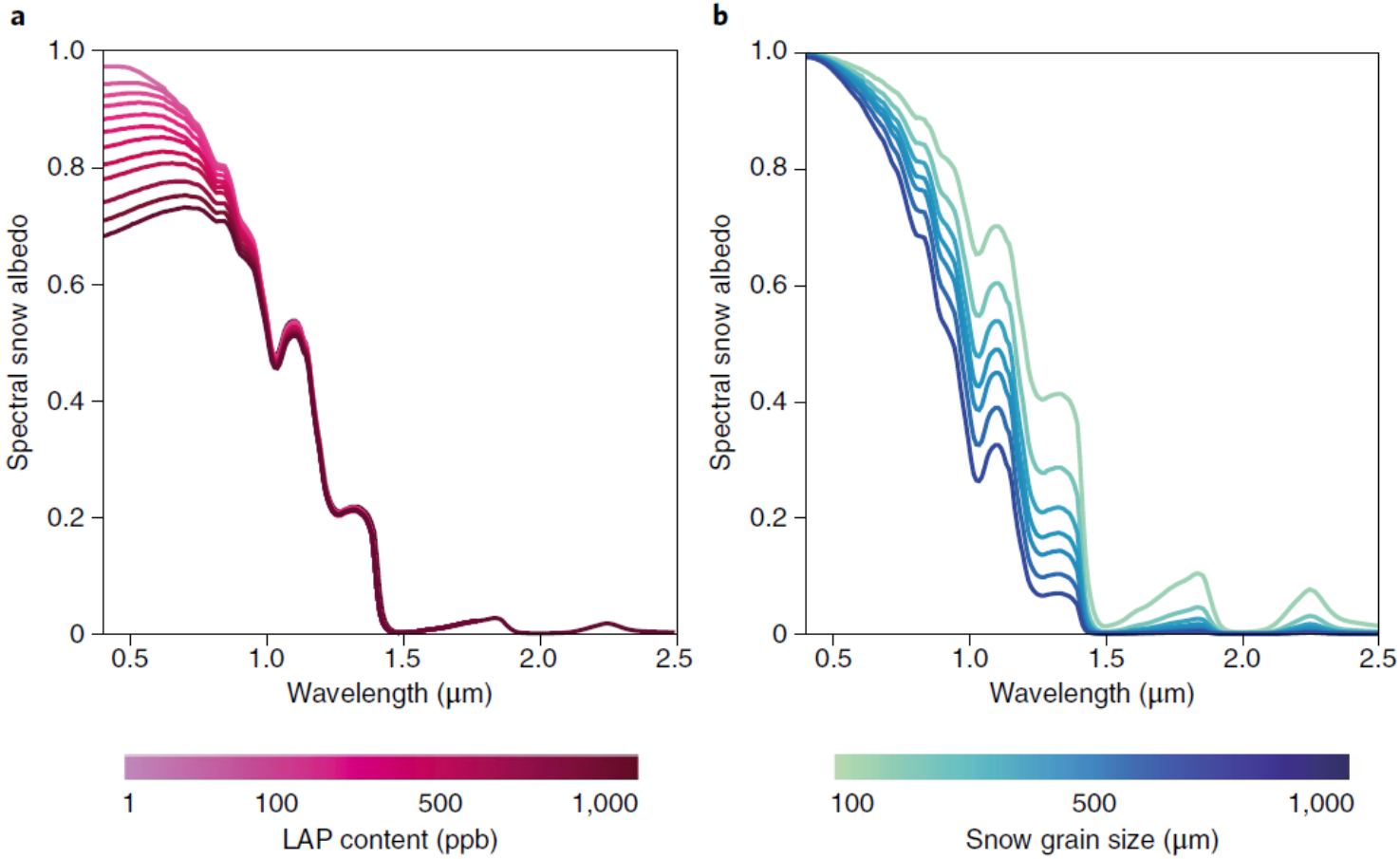
(e.g. mineral dust, volcanic ash, black carbon, …)



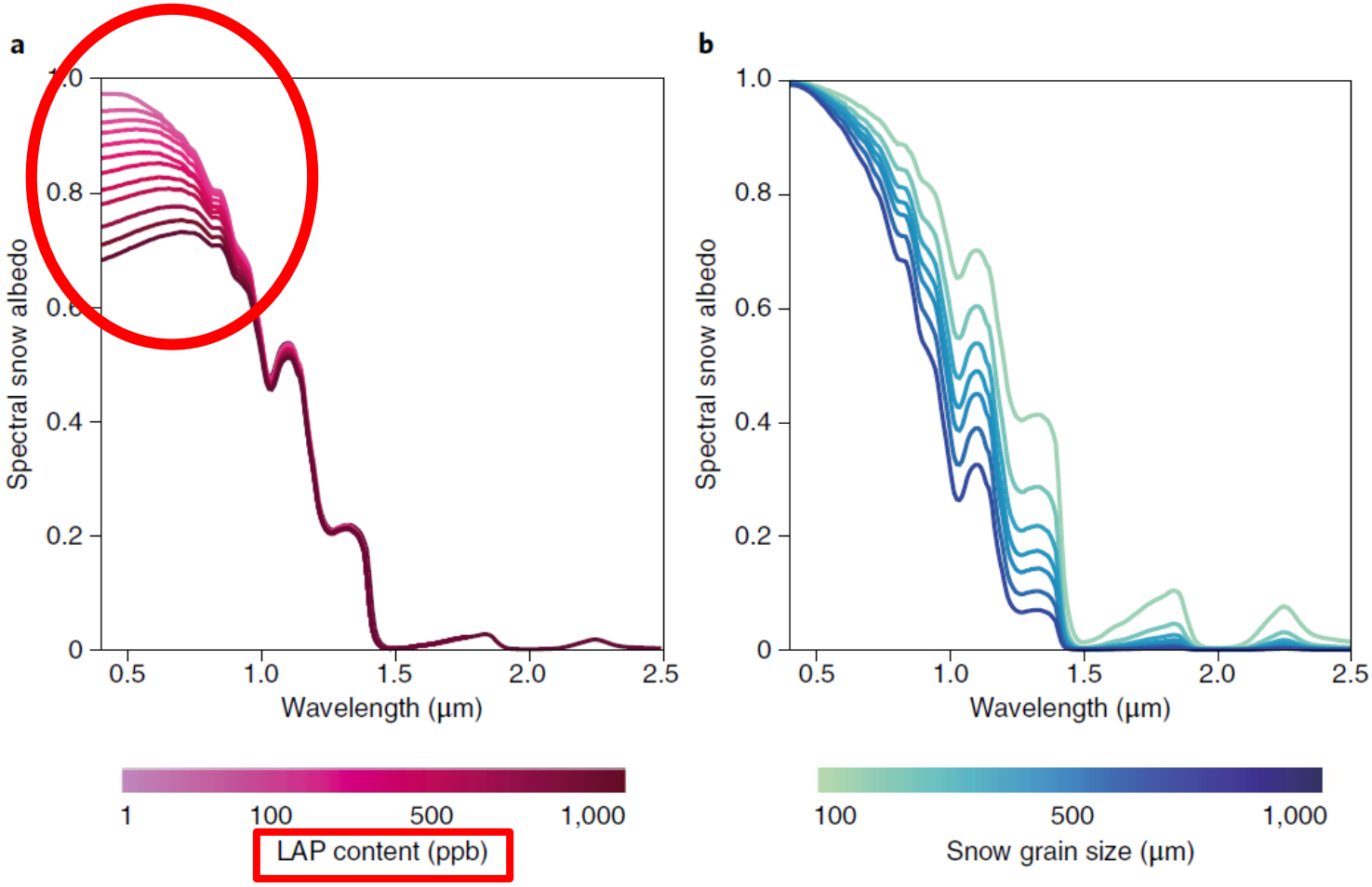
NASA

Colorado Rockies snowpack in 2009. Credit: S. McKenzie Skiles, Snow Optics Laboratory, NASA/JPL

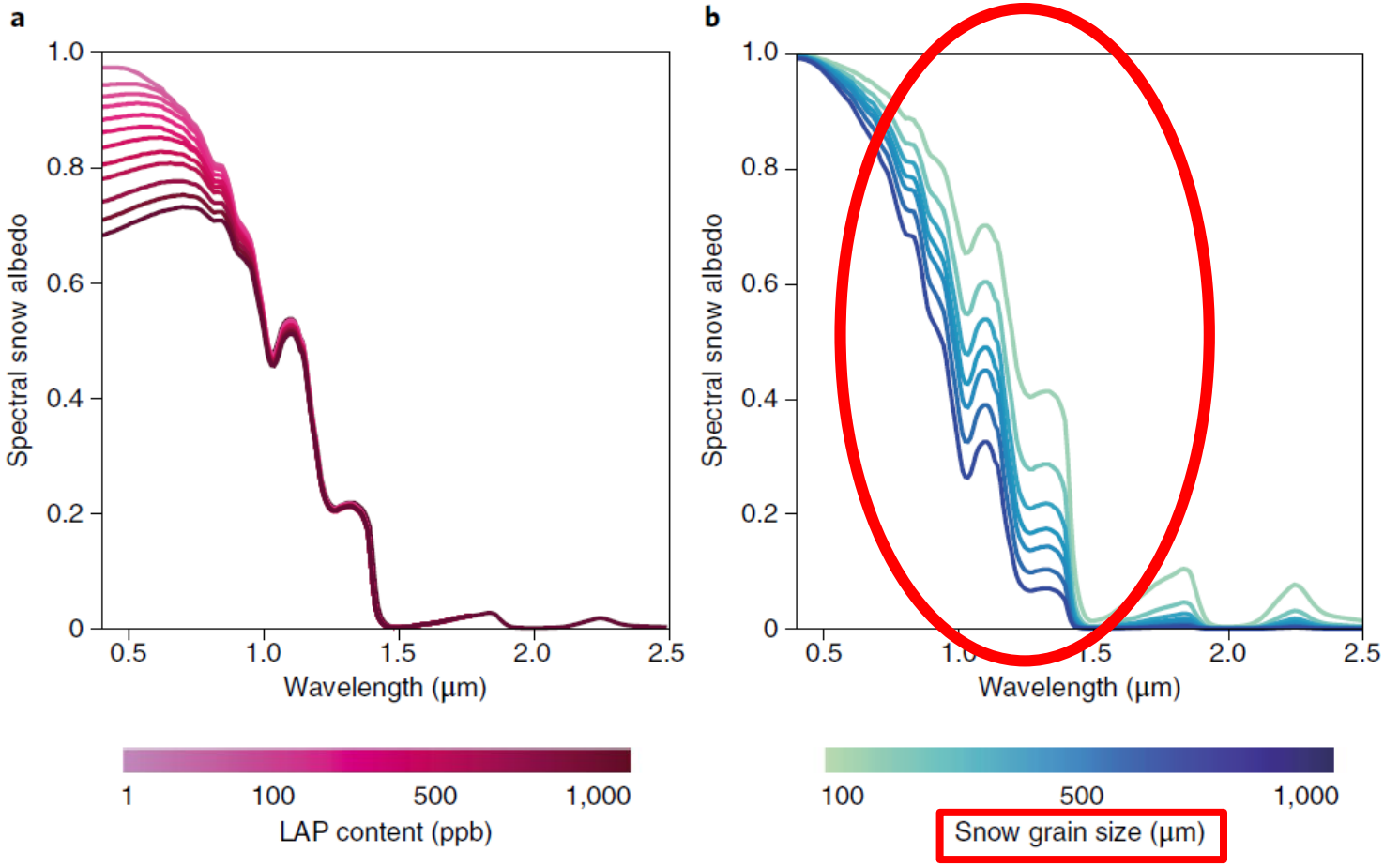
Snow Albedo: Skiles et al., 2018



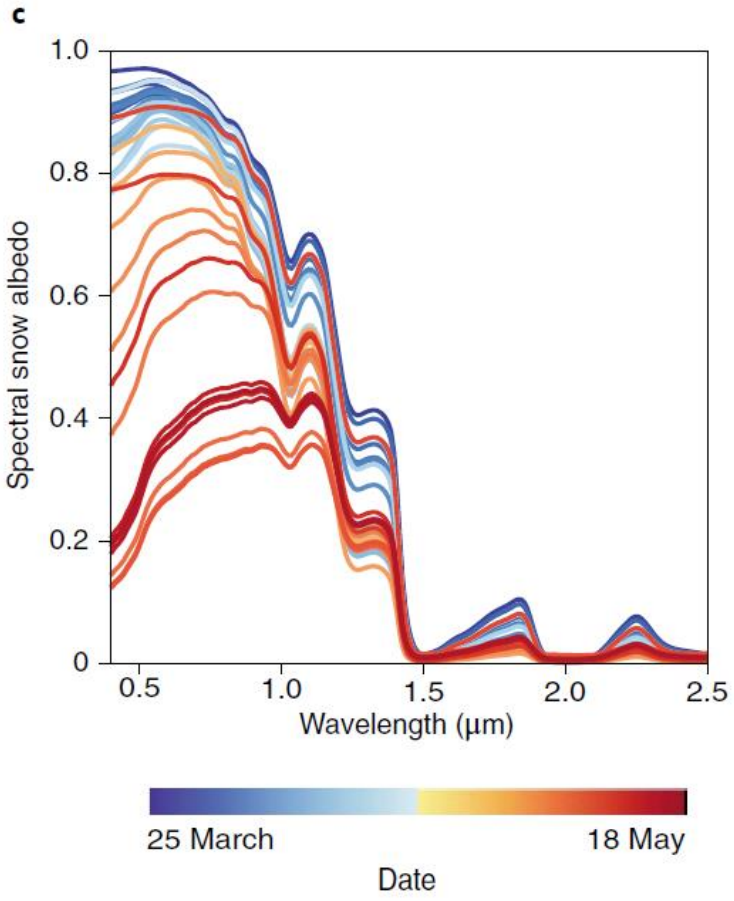
Snow Albedo: Skiles et al., 2018



Snow Albedo: Skiles et al., 2018



Snow Albedo: Skiles et al., 2018



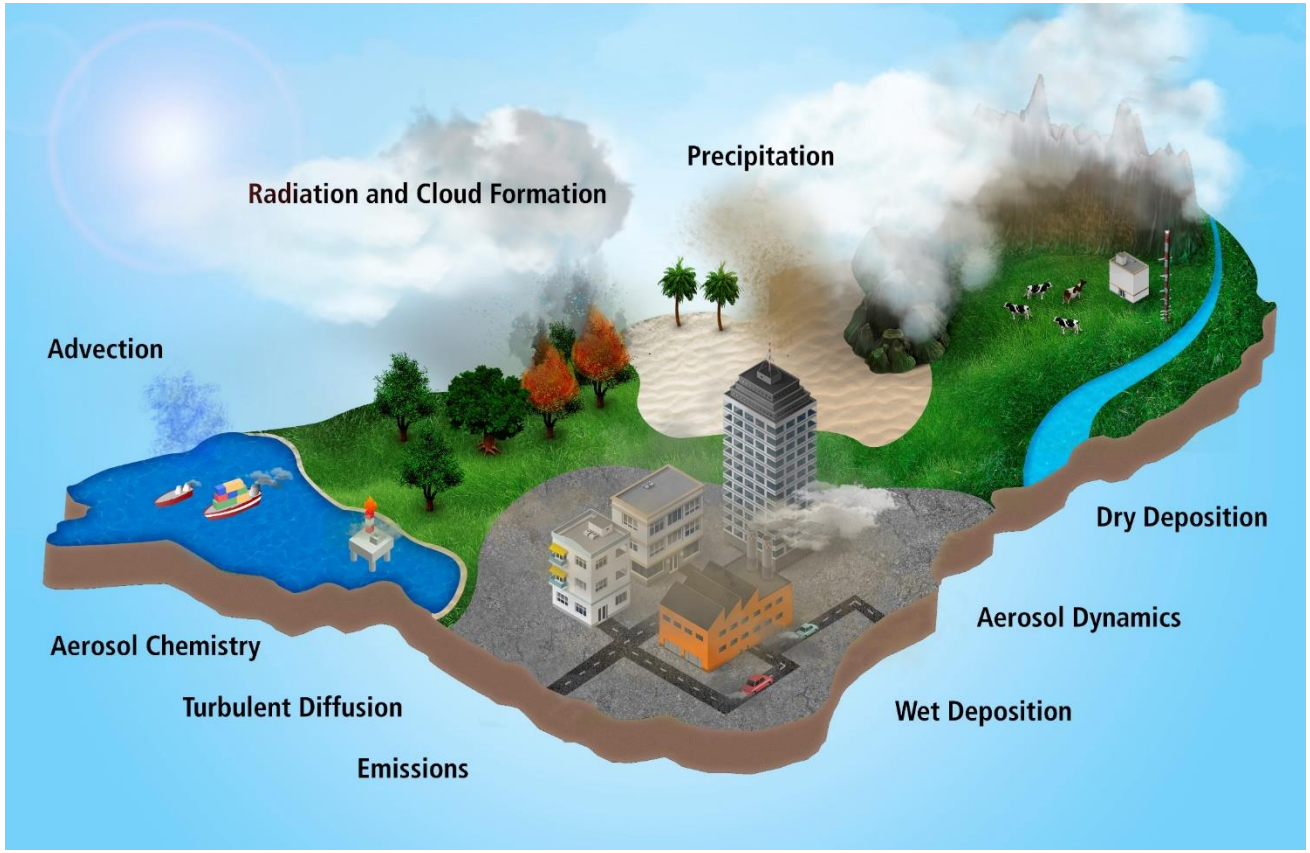
Combined effect of

⇨ **Light Absorbing Impurities**

⇨ **Snow Metamorphism**

Senator Beck Basin,
San Juan Mountains, Colorado
Skiles et al., 2017

Aerosols in ART



including optical properties of aerosols

Snow Model in ICON

Soil Vegetation Atmosphere Transfer (SVAT) scheme TERRA:

- 1-layer snow model (operational)
- multi-layer snow model

Snow Albedo:

- limited to fixed values
- no distinction between VIS and NIR
- aging of albedo as function of time

⇨ **No optical-equivalent snow grain size**

Optical Snow Grain Radius

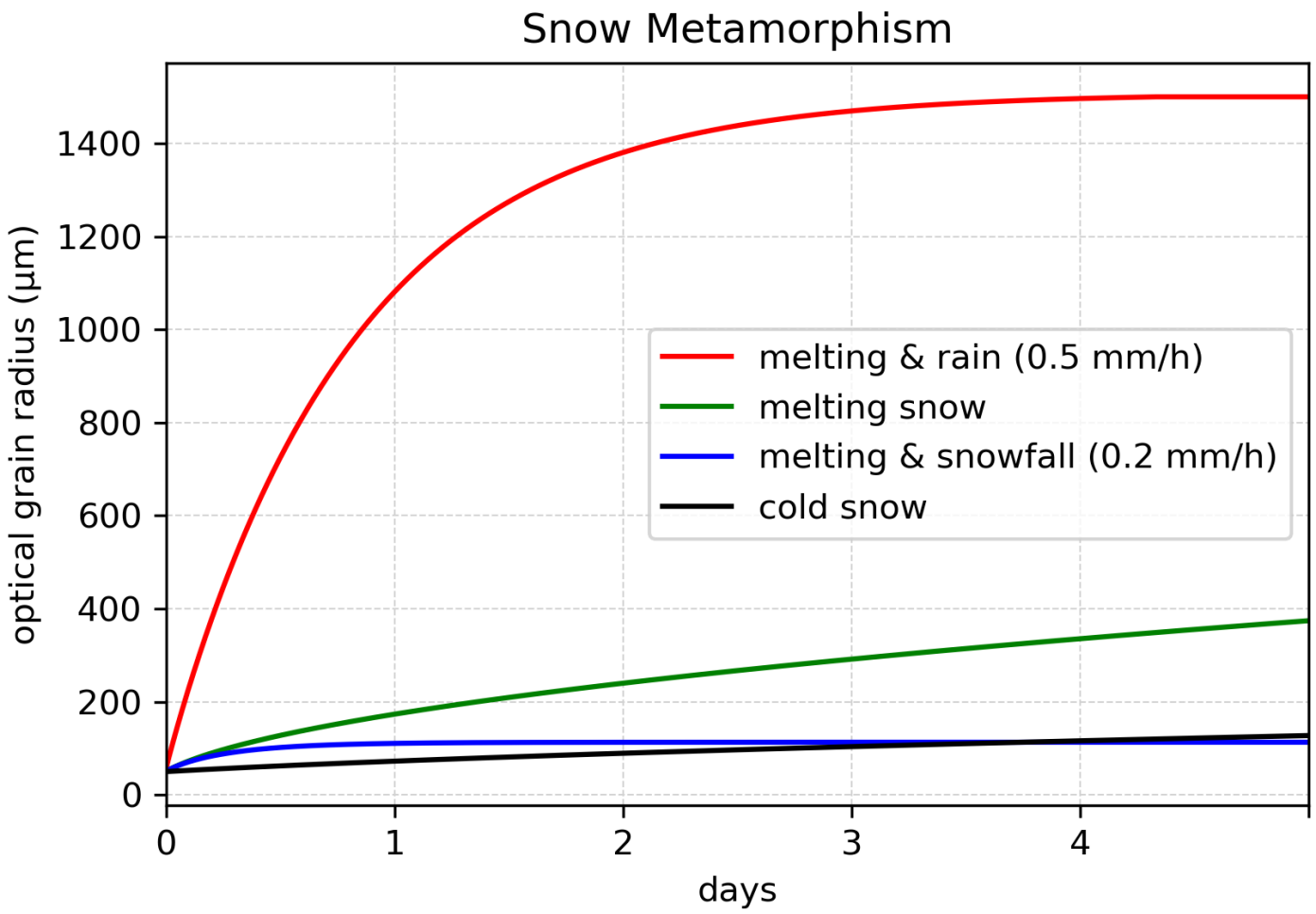
modified equation from MOSES 2.2 (Essery et al., 2001)

$$r(t+\Delta t) = \left[r(t)^2 + \frac{G_r}{\pi}\Delta t \right]^{1/2} - [r(t) - r_0]\frac{S_f \Delta t}{d_0} + [r_{max} - \mathrm{r}(t)]\frac{z_{rain}\Delta t}{z_{rain,max}}$$

- **gr**owth factor
- **s**now **f**all
- **rain** fall

$$G_r \begin{cases} 1\ \mu m^2 s^{-1} & T_* = T_m \quad (melting\ snow) \\ 0.1\ \mu m^2 s^{-1} & T_* < T_m, r < 150 \mu m \quad (cold\ fresh\ snow) \\ A exp(^{-E}/_{RT_*}) & T_* < T_m, r > 150 \mu m \quad (cold\ aged\ snow) \end{cases}$$

Optical Snow Grain Radius



Snow Albedo: Clean Snow

based on **Wiscombe & Warren, 1980**

- Mie Calculations:

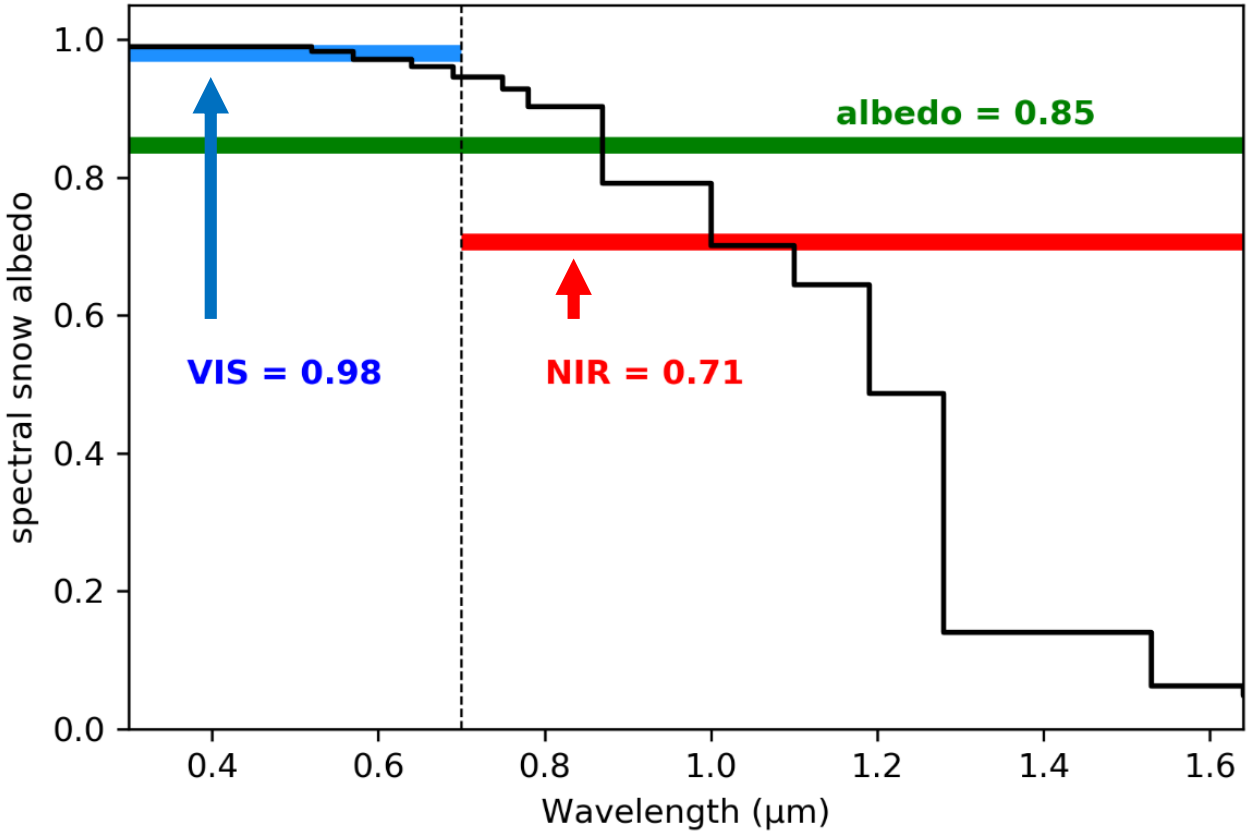
  Extinction & Scatter properties ($\sigma_{ext}, \sigma_{sca}, g$)

$$a_d^{\infty} = \frac{2\,\tilde{\omega}^*}{1+P}\left\{\frac{1+b^*}{\xi^2}\left[\xi - \ln(1+\xi)\right] - {}^{b^*}/_{2}\right\}$$

$$a^* = 1 - \tilde{\omega}^* g^* \qquad \xi = \left[3\,a^*(1-\tilde{\omega}^*)\right]^{1/2}$$

$$b^* = {}^{g^*}/_{a^*} \qquad \mathrm{P} = {}^{2\,\xi}/_{3a^*}$$

Snow Albedo: Clean Snow

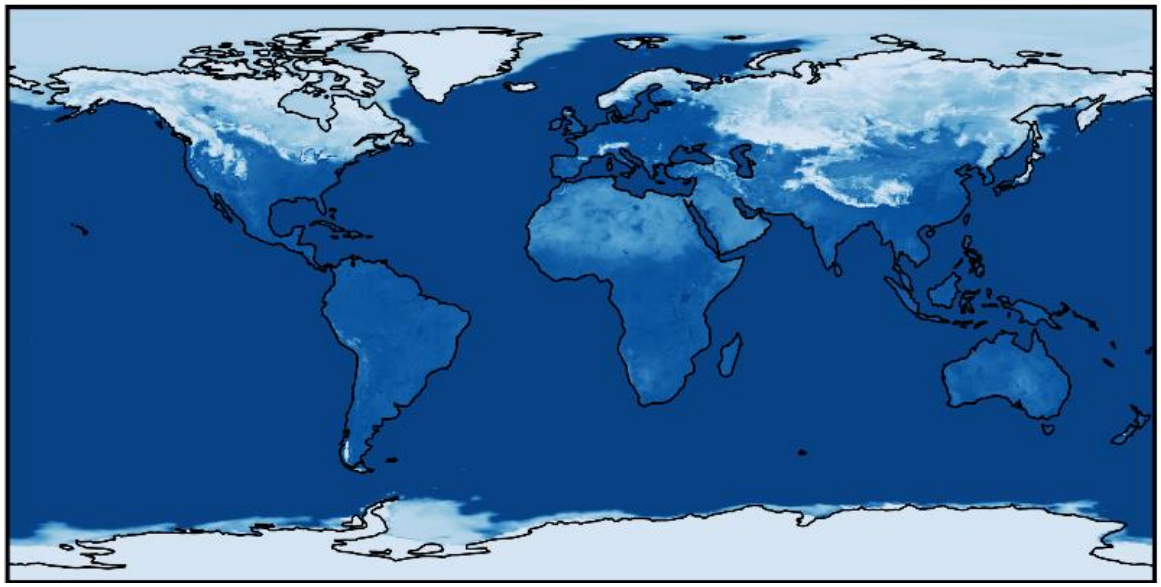


distinction between

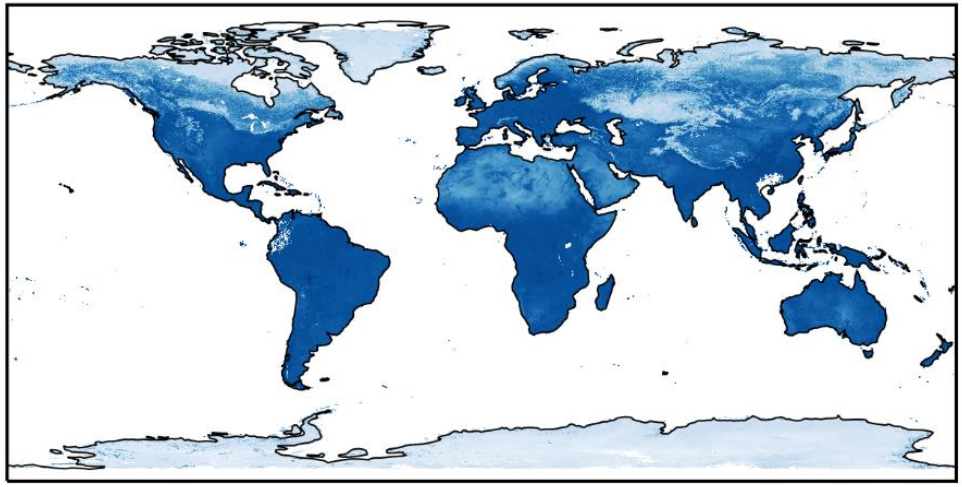
⇨ **VIS**

⇨ **NIR**

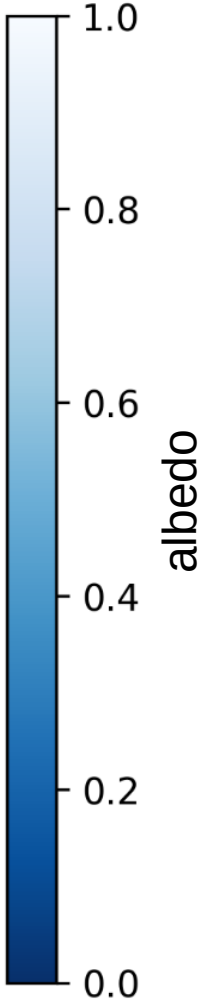
Snow Albedo: Clean Snow



ICON
15.03.2014

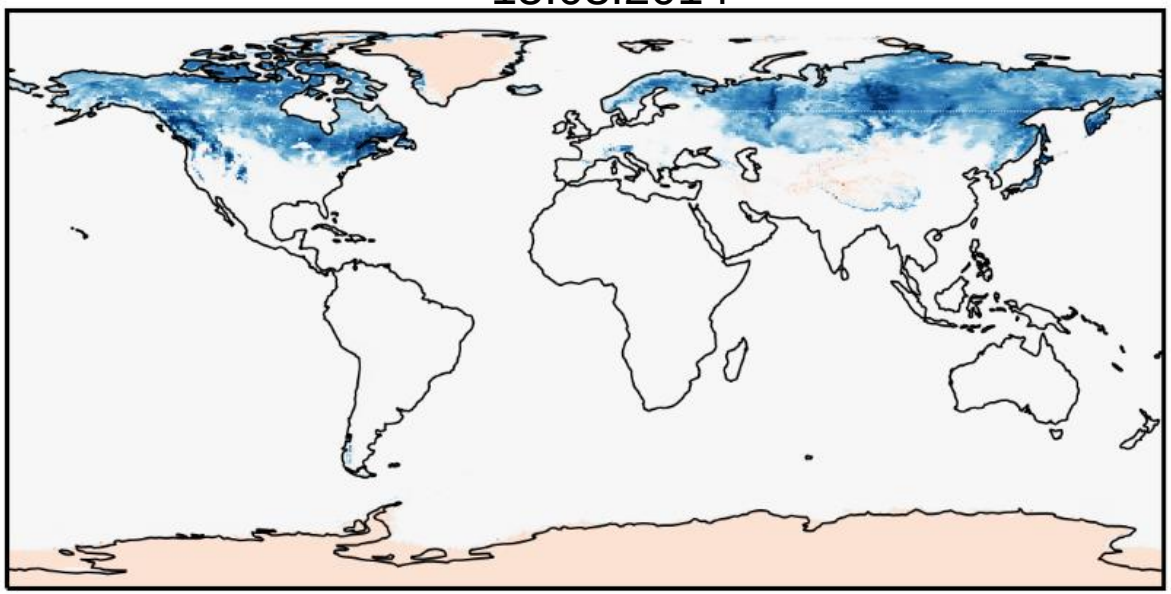


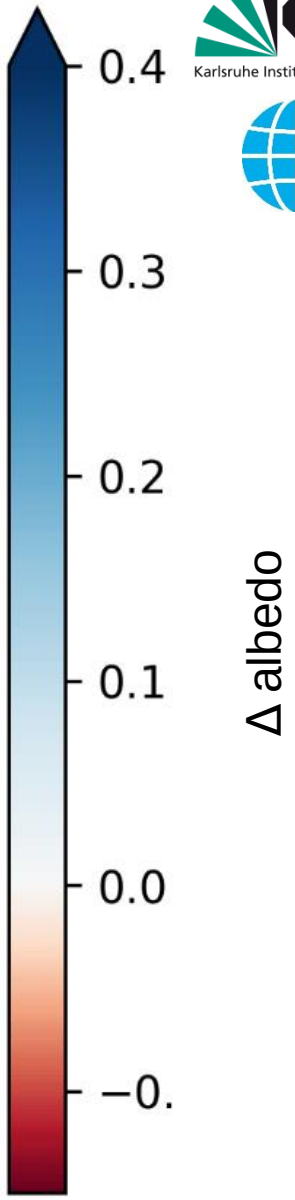
MODIS



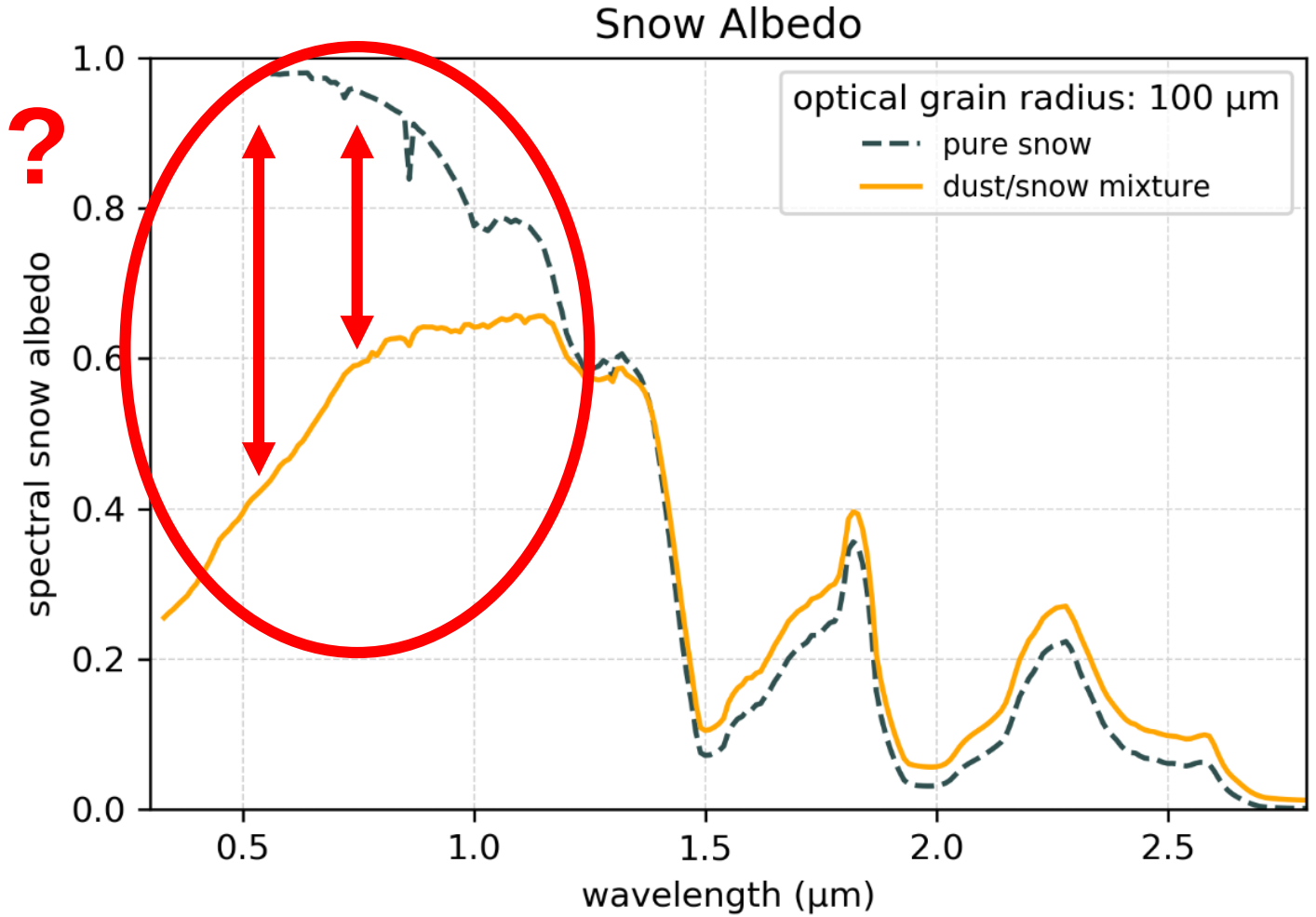
Snow Albedo: Clean Snow

new – reference
15.03.2014





Snow Albedo: Impact of Aerosols



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