Snow albedo retrieval from SGLI/GCOM-C measurements using asymptotic radiative transfer theory

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Theory

Snow reflectance *R* is related to the snow spherical albedo *r* with the following equation (Zege et al, 1991; Kokhanovsky, 2021) :

$$R(\mu, \mu_0, \psi) = R_0(\mu, \mu_0, \psi) r^x .$$

$R_0(\mu, \mu_0, \psi)$ is reflectance of snow in the visible at the cosine of the solar zenith angle μ_0, cosine of the viewing zenith angle μ and the relative azimuthal angle ψ. It follows (Kokhanovsky, 2021):

$$x = \frac{u(\mu)u(\mu_0)}{R_0}, \quad u(\mu_0) = \frac{3}{5}\mu_0 + \frac{1+\sqrt{\mu_0}}{3}, \; r = \exp(-\sqrt{\alpha L}).$$

Here, α is the bulk ice absorption coefficient and *L* is the effective absorption length (EAL).
Therefore, it follows at two S-GLI channels in assumption that the influence of atmospheric effects can be neglected:

$$R_1 = R_0 \, exp\,(-x\sqrt{\alpha_1 L}\,), \; R_2 = R_0 \, exp\,(-x\sqrt{\alpha_2 L}\,).$$

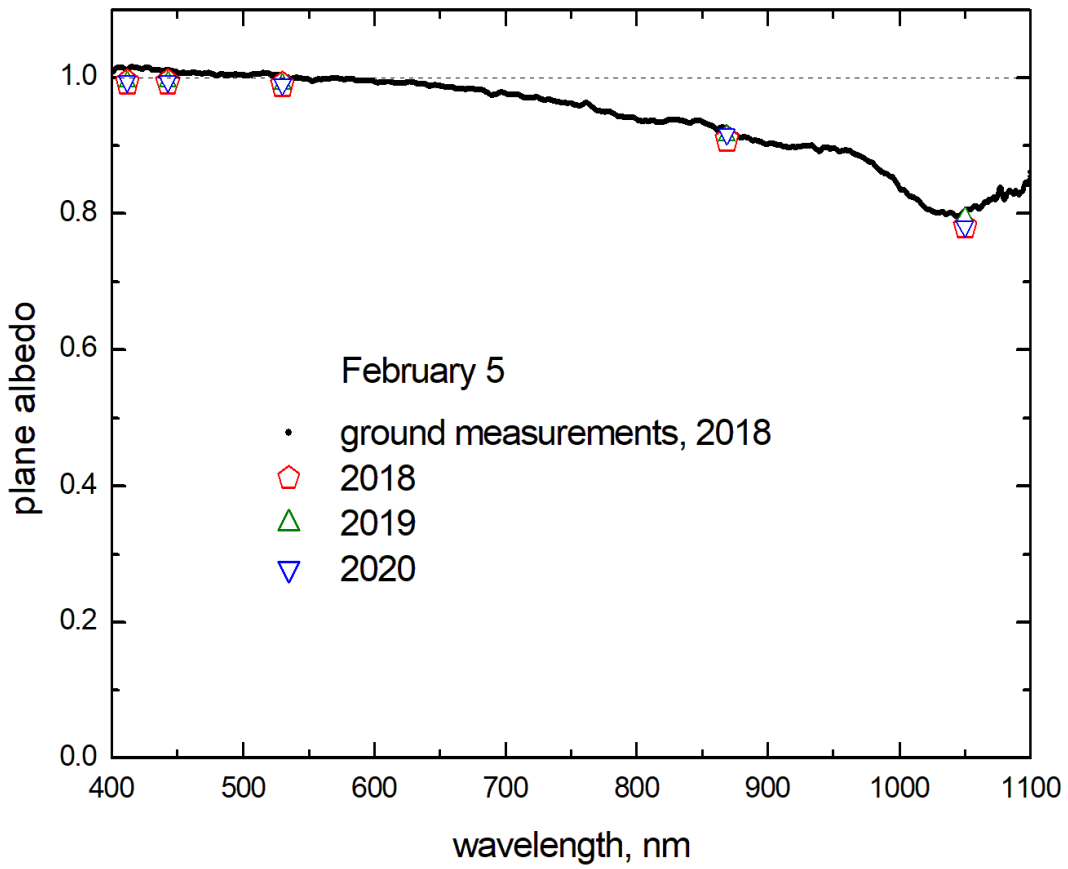
This makes it possible to derive EAL:

$$L = \frac{1}{x^2 \alpha_2} ln^2\left(\frac{R_2}{R_0}\right),$$

where $R_0 = R_1^{\epsilon} R_2^{1-\epsilon}, \quad \epsilon = \frac{1}{1-b}, \; b = \sqrt{\alpha_1/\alpha_2}.$

The derived value of *L* makes it possible to determine the snow spectral albedo as at any wavelength in the visible and near - infrared.

The intercomparison with ground measurements



plane albedo $r_p = r^{u(\mu_0)}$

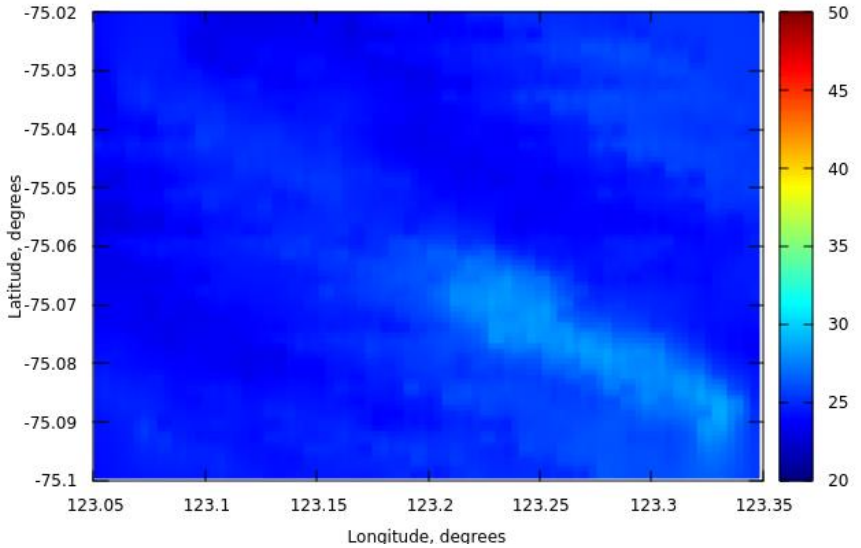
SGLI channels used:
868.5nm, 1050nm

The results of retrievals using SGLI measurements around Dome C (Antarctica, see next slide) for the values of the effective absorption length (EAL), the effective grain diameter (EGD), snow specific surface area (SSA), and broadband albedo (BBA) on February 5, 2019/2020. The coefficient of variance is given in brackets.

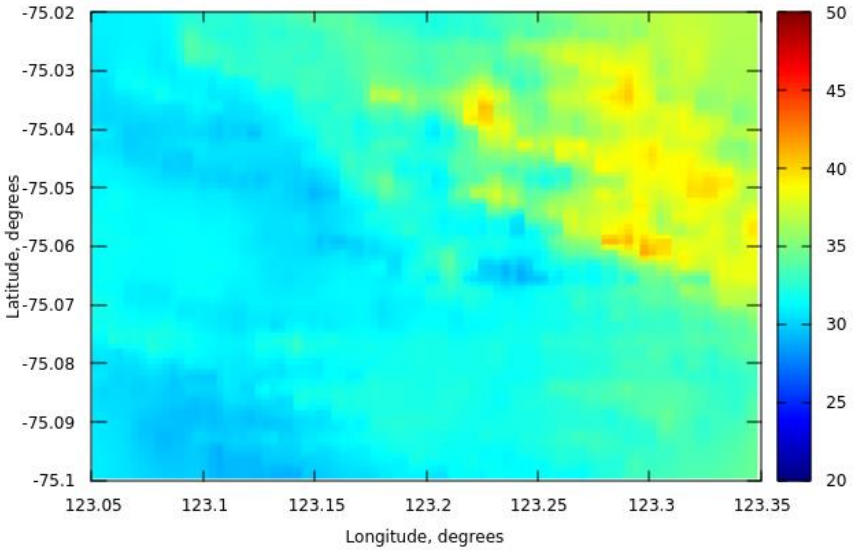
snow parameter/year	2019	2020
EAL, mm	4.255 (5.0)	3.209 (8.2)
EGD, mm	0.266 (5.0)	0.201 (8.2)
SSA, m^2/kg	24.67 (5.2)	32.86 (8.9)
BBA	0.8150 (0.2)	0.8188 (0.3)

The spatial distribution of snow parameters

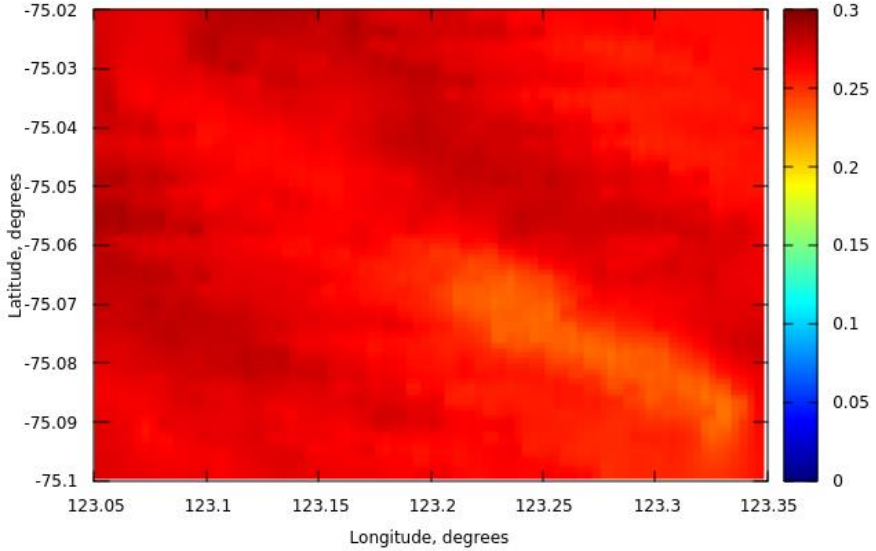
2019

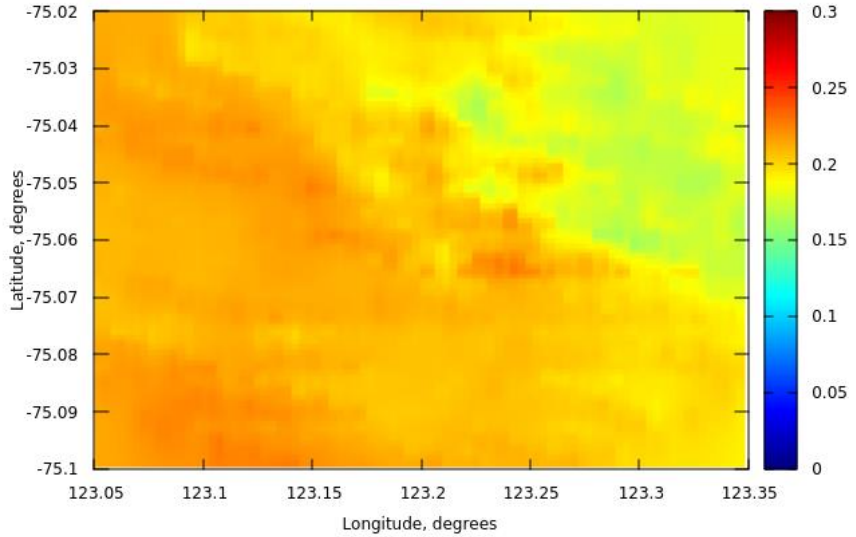


2020



SSA, m^2/kg





EGD, mm

Conclusions

- Simple and robust snow albedo, grain size, and snow specific surface area satellite retrieval algorithm based on SGLI measurements has been developed
- The algorithm has been validated using ground spectral albedo measurements at Dome C (Antarctica)

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