Retrieval of snow grain size and soot concentration of sea ice

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Introduction

The albedo of sea ice is
- determined by snow reflectance and soot concentration
- important for the global radiative balance

SGSP algorithm

Retrieval of snow grain size and soot pollution (SGSP) from satellite data

based at the realistic model of snow as a mixture of non-spherical close-packed grains of various shapes

uses the analytical asymptotic solution (instead of radiative transfer computations)

No use of *a priori model* of snow grain shape

Fast satellite data processing

Analytical retrieval

$$a_{ef} = \left[\frac{1}{A(q_j - q_i)\, g(\theta)\, g(\theta_0)} \left(\frac{R_i^{q_j}}{R_j^{q_i}} \right)^{\frac{1}{q_j - q_i}} \ln\left(\frac{R_i}{R_j} \right) \right]^2$$

$$\frac{\ln R_i - \ln R_j}{\ln R_j - \ln R_k} = \frac{q_i - q_j}{q_j - q_k} \qquad q_i = \sqrt{4\pi \frac{\chi_i + \kappa C_{st}^*}{\lambda_i}}$$

R_i - the spectral radiance coefficients measured in MODIS *i-th* channel at wavelength λ_i

θ, θ_0 - zenith angles of the sun and observation

X_i - imaginary part of the ice refractive index at λ_i

$g(\theta_i) = \frac{3}{7}(1 + 2\cos\theta_i)$

MODIS channel combination: 3, 2, and 5

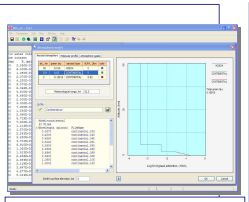
Conclusions

Snow grain size and soot concentration can now be determined
- independently of particle shape
- at low sun elevations typical for high latitudes
- operationally (fast processing)

Details see Damocles Deliverables D1.2-07 and D1.2-08.

Snow reflectance simulator

SRS (Snow Reflectance Simulator)
- developed for modeling the response of atmosphere-snow system



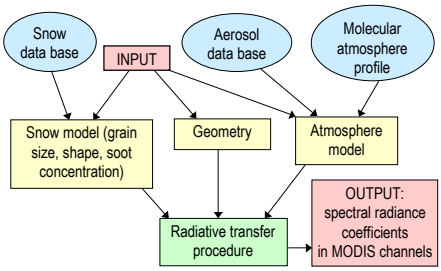
Adjusting aerosol atmosphere parameters

SRS includes data banks on
- optical parameters of atmospheric aerosols
- profiles of atmospheric pressure and temperature
- profiles of ozone and water vapor in atmosphere
- optical models of snow

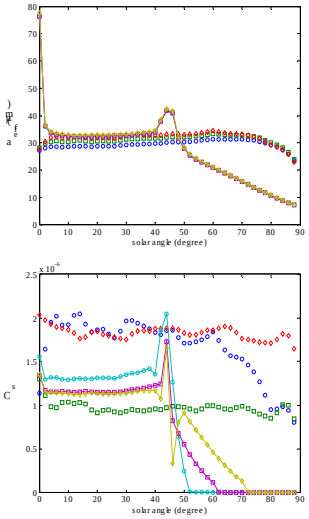
SRS allows to user to
- build detail optical model of Arctic atmosphere taking in account stratification and composition of aerosol, molecular, and gas constituents
- create optical model of stratified snow with layers of different microphysical and optical properties

SRS calculation procedures provide
- precision and fast computations of spectral radiance coefficients on the top of coupled atmosphere-snow system with allowance for light polarization in atmosphere and special Arctic features (low Sun position over horizon and high snow reflectivity).

SRS flow chart



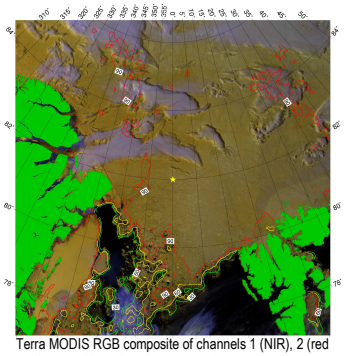
Comparison of *SGSP* with method of Stamnes et al.



- grain size and soot concentration retrieval with SGSP method (symbols only) and with method of Stamnes et al. (connected symbols)
- true grain size: 30 µm, true soot concentration: 10^{-6}
- SGSP provides a reliable retrieval even at oblique solar angles: This is of great importance for the Arctic!

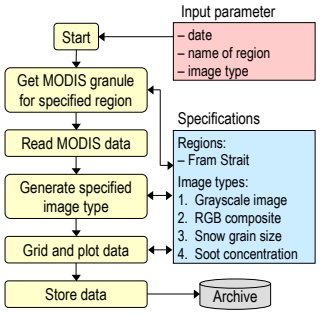
Stamnes K., W. Li, H. Eide, T. Aoki, M. Hori, and R. Storvold, "ADEOS-II/GLI Snow/Ice Products – Part I: Scientific Basis", *Remote Sensing of the Cryosphere, Special Issue,* Vol. **111**, No. 2-3 (2007).

SGSP in NRT MODIS processing chain



Terra MODIS RGB composite of channels 1 (NIR), 2 (red light), and 5 (SWIR), overlayn are ASI ice contours at 30% (green), 60% (yellow), 90% (red) ice concentration

processing chain



Near-Real Time (NRT) processing of MODIS data

Input data
- MODIS Level 1B granules
- 1 granule: 2030 x 1354 km
- resolutions: 250 m, 500 m, 1 km

Output maps
- RGB composite image
- snow grain size image
- soot concentration image

Processing
- maps computed on daily basis
- for selected regions

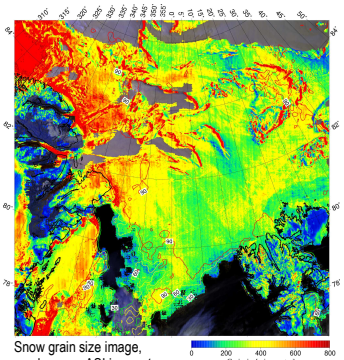
RGB composite
- snow / sea ice (yellowish), clouds (whitish), and water (black)
- ASI ice contour lines (from passive microwave data) nicely fit with the optical MODIS image

Snow grain size
- high snow grain values at upper right corner are from cloud structures

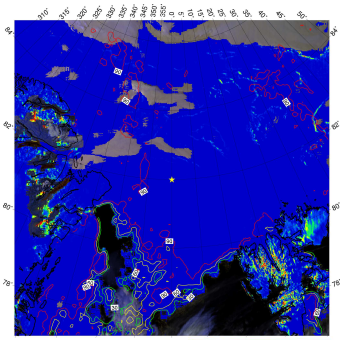
=> improvement of cloud screening necessary

Soot concentration
- soot values on Svalbard and Greenland are partly from rocks sticking out in the snow

=> analysis of data only in flat areas meaningful



Snow grain size image, overlayn are ASI ice contours



Soot concentration image, overlayn are ASI ice contours