Sea Ice and Snow Cover

Retrieval of snow physical parameters with consideration of underlying vegetation

Teruo Aoki[1] and Masahiro Hori[2]
1 Meteorological Research Institute
E-mail: teaoki@mri-jma.go.jp
2 Japan Aerospace Exploration Agency
E-mail: hori@eorc.nasda.go.jp

Abstract
The Global Imager (GLI) aboard the ADEOS-II satellite launched in December 14, 2002 observed sunlight reflection and infrared emission from the Earth's surface globally, and detected various geophysical parameters (e.g. snow and sea-ice cover extent, snow grain size and impurity). Although the satellite stopped operation on October 25 due to a power supply decrease from the bus system, GLI data obtained during the 7-month scientific operation phase will contribute to investigation of global hydrological cycle and radiation budget that are primal factors of the global climate change. Preliminary analysis results of the GLI snow products with a few months data and their validation results are presented.

1. Introduction

Various snow physical parameters such as snow/ice cover extent, snow grain size, temperature and mass fraction of impurity etc. are to be retrieved as standard snow products from the ADEOS-II/GLI data acquired during its 7-month scientific operation phase (April 2nd ~ October 24th, 2003). Those snow parameters are of significant importance to understand how and where the snow melting process proceeds on the global scale being influenced by air pollution and the global warming. Calibration of sensor radiances and validation of those snow products are currently going on by using other satellite sensor's snow product (e.g. Near Real-Time SSM/I EASE-Grid Daily Global Ice Concentration and Snow Extent) and results of a field validation experiment conducted at Barrow, Alaska in April, 2003. This paper describes the preliminary results of GLI data analysis and its validation results.

2. Data Analysis

2.1 Cloud-free Composite of around the Northern Polar Region

To evaluate the performance of GLI snow algorithms daytime cloud-free composite images of around the Northern Polar region (Lat. > 40deg. N) were made using one month GLI Level-1B data (calibrated radiance) (**Fig. 1**). Pixel selection criteria is the minimum brightness temperature difference between GLI band 30 (3.7 μ m) and 35 (11 μ m) which is designed to ensure that clouds over snow surface are eliminated preferentially.

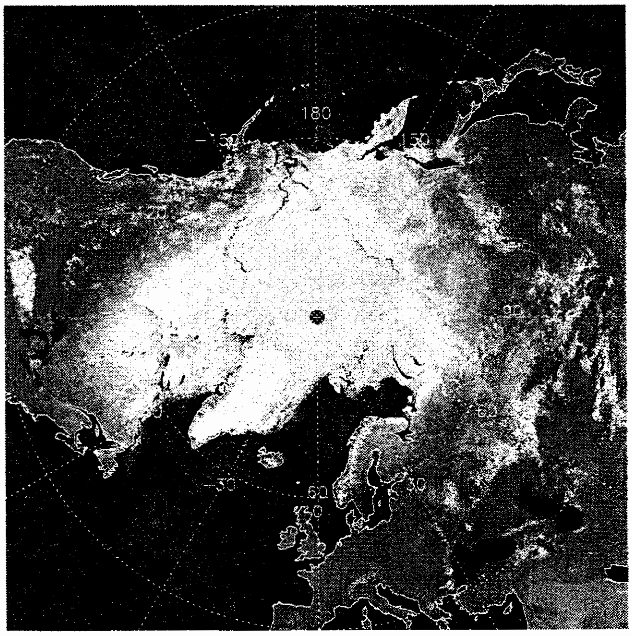

Fig. 1. Daytime cloud-free composite image of around the northern polar region (April, 2003).

2.2 GLI Snow Algorithms

Two GLI snow algorithms are defined as standard; 1) cloud/clear and snow/ice discriminator and 2) the retrieval of snow grain size and mass fraction of impurity mixed in snow layer both developed by Japan Aerospace Exploration Agency (JAXA) with joint researches with K. Stamnes, Stevens Institue of Technology (Hori et al, 2001). The first algorithm identifies if IFOV is clear or not, and if the IFOV is clear then determines surface type such as snow, sea-ice, land or open ocean by using spectral information of sensor observed reflectances in the visible to near infrared wavelength regions and also of brightness temperatures in mid- to thermal-infrared regions. The second algorithm retrieves snow grain size (radius in μ m) and mass fraction of impurity (soot in ppmw) from two channel reflectances at the GLI band 5 (460nm) and 19 (865nm) by making use of the dependence of snow reflectance upon both grain size and impurity concentration at those channels (Warren, 1982, Li et al., 2001).

3. Analysis Results and Validation

3.1 Analysis Results

Fig. 2 shows the spatial distribution of snow grain size and brightness temperature of snow surface at the window channel (11 μm) retrieved from the GLI cloud-free composite image of April, 2003. Spatial distribution of snow grain size indicates significant latitudinal dependence which is very much consistent with that of snow temperature. As the latitude decreases from the Pole to south, snow grain size and temperature increases coincidentally. There is a belt (around 40~65°N) where snow grain rapidly increases due to high snow temperature of around the melting point of ice. Snow impurity distribution is somewhat different from those mentioned above. Greenland and the northern Canadian Arctic region are identified as the cleanest area in the Arctic, while sea-ice area in the Arctic Ocean, particularly north of Siberia, is likely to be polluted by aerosols (or covered with shallower snow with low visible albedo).

Snow grain size exhibits significant dependence upon snow surface temperature (**Fig. 3**). Below the melting point (m.p.) of ice snow grain size moderately increases with increasing snow temperature due to the sintering process, while around m.p. grain size steeply increases in the melting process. Snow impurity also seems to correlate with snow temperature. These dependences indicate the close connection among those parameters.

3.2 Validation

To evaluate the accuracy of snow parameters retrieved, ground-based validation experiment were conducted at a snow field near Barrow, Alaska in April, 2003 and obtained ground truth data for snow grain size and impurity. Grain sizes measured at the ground were consistent with the satellite-derived grain size, while impurity data obtained at the ground tend to be apparently larger than those of satellite data. The latter is due to that the algorithm for satellite data analysis assumes pure soot as impurity, whereas ground observation measures the weight of actual impurity containing not only soot but also soil dust particles which is heavier than soot. Thus at the moment the satellite derived parameters are consistent with the truth data.

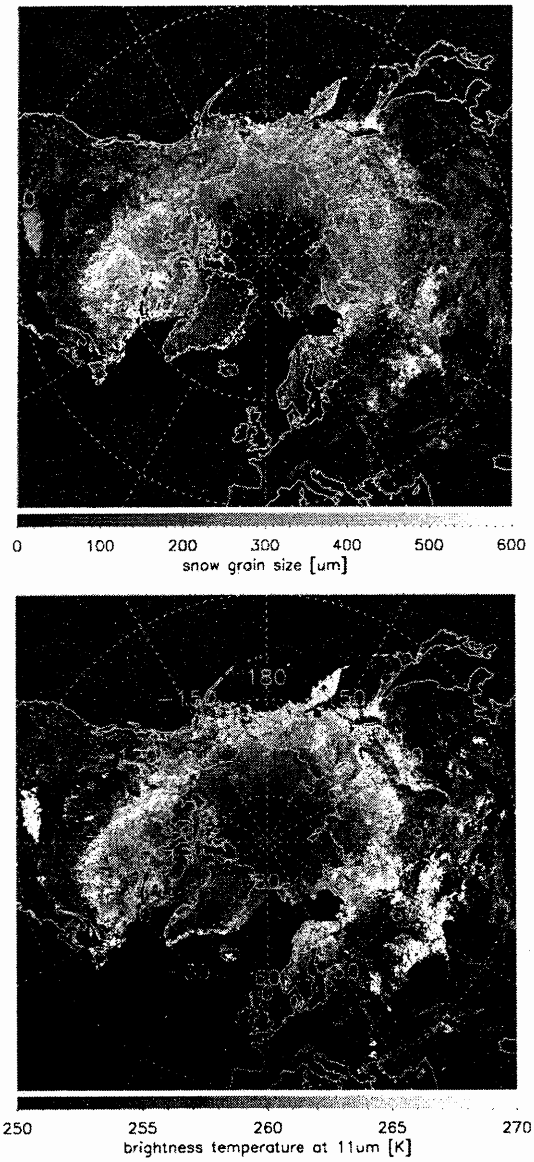

Fig. 2. Spatial distribution of snow grain size (upper) and brightness temperature at 11 μm (lower) of around the northern polar region retrieved from the composite data of April, 2003.

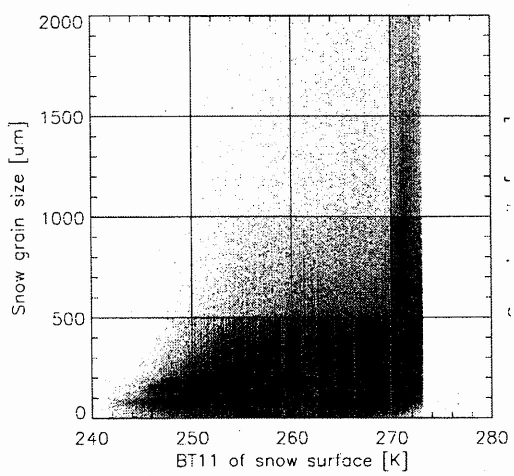

Fig. 3. Dependence of snow grain size upon $BT_{11\mu m}$ retrieved from the GLI composite data of April, 2003.

References

Hori, M., Te. Aoki, K. Stamnes, B. Chen and W. Li, Preliminary validation of the GLI algorithms with MODIS daytime data. *Polar Meteorol. Glaciol.*, 15, 1-20, 2001.

Li, W., K. Stamnes, B. Chen, and X. Xiong, Snow grain size retrieved from near-infrared radiances at multiple wavelengths. *Geophys. Res., Lett.*, 28, 1699-1702, 2001.

Warren, S.G., Oprical properties of snow. *Rev. Geophys. Space Phys.*, 20, 67-89, 1982.