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Validation of Satellite Derived Snow Physical Parameters at Saroma Lagoon, Japan (Extended Abstract)

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1. Introduction

Snow physical parameters such as snow grain size and mass fraction of impurity mixed in snow layer are important parameters to be monitored from space in order to study the relationship between snow covered areas in the Polar Regions and a climate change such as global warming (Li *et al.*, 2001). The optical sensor "Global imager (GLI)" onboard the Japanese earth observing satellite "ADEOS-II" to be launched in

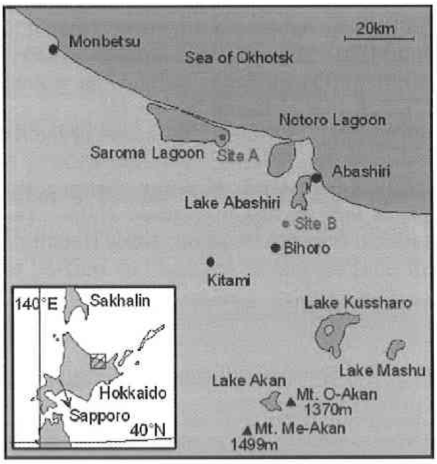

Fig. 1. Location of the observation sites

December, 2002 will observe temporal and spatial variations of snow grain size and snow impurity as well as snow/sea-ice covered area with 1 km ground resolution on a global scale (Nakajima *et al.*, 1998, Hori *et al.*, 2001). There is also a plan to validate those snow parameters to be retrieved from the satellite data at several ground observation sites (Barrow, etc.) after the launch. Before the launch, we carried out preliminary validation experiment at snow fields around Saroma Lagoon in Hokkaido, Japan in February, 2002 and obtained ground truth data which were compared with the parameters retrieved from the satellite (TERRA/MODIS) data of the same observation time. The summary of the preliminary observation at Saroma Lagoon and future validation plan are presented in this paper.

2. Approach

MODIS calibrated radiance data (MOD02) of Feb. 24, 2002 with two different types of ground resolution (1 km and 250 m) were analyzed with the GLI cryosphere algorithms (Stamnes 1999) to retrieve spatial distribution of snow grain size from the satellite observed radiance in the near infrared wavelength region (865 nm). For the atmospheric correction, the standard mid-latitude winter atmospheric profile and the rural aerosol model (visibility=23 km) were adopted from MODTRAN to simulate the top-of-atmosphere radiance. Regarding the effect of snow impurities on snow radiance, mass fraction of soot uniformly mixed in snow layer was assumed to be a typical value of 0.1 ppmw around Saroma Lagoon in this analysis. We obtained ground truth data for snow grain size by snow pit work at 9 grid points with 1 km interval on a snow field at Saroma Lagoon (Site A : 44°7′9″N, 143°55′37″E, see (Fig. 1) on Feb. 24 and at one point on a snow field at Bihoro (Site B : 43°52′5″N, 144°6′44″E) on Feb. 23 and 25. In the snow pit works we recorded three types of size of each snow grain for the comparison with the satellite derived grain sizes ; full diameter (d1), branch width (d2) and thickness (d3) (see also Fig. 2).

3. Results and Discussion

Typical vertical profiles of snow physical parameters (snow type, grain size, stratigraphy, temperature, density, mass fraction of impurity) obtained by snow pit works at the central point of the Saroma Lagoon site are shown in Fig. 2. Weather condition on Feb. 24 was clear and air temperature was -4.1°C. Snow depth ranged around 6∼32 cm on Saroma Lagoon and 47 cm at Bihoro. Most of snow surface at all sites were covered with thin new snow layer of at most a few centimeters in depth, although some parts of the surface on Saroma Lagoon were covered with bare ice in patches which were formed from sea-water penetrated from under the ice layer through cracks. Satellite images around the ground observtion sites and spatial distribution of snow grain size in radius retrieved from MODIS data with two types of ground resolution are shown in Fig. 3. Snow field on Saroma Lagoon is vast and relatively uniform, so that the retrieved snow

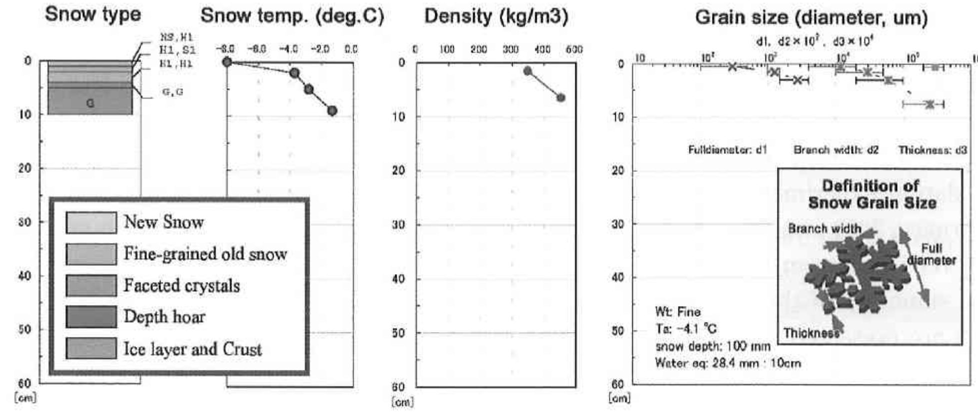

Fig. 2. Typical vertical profiles of snow physical parameters obtained by pit work at the Saroma Lagoon.

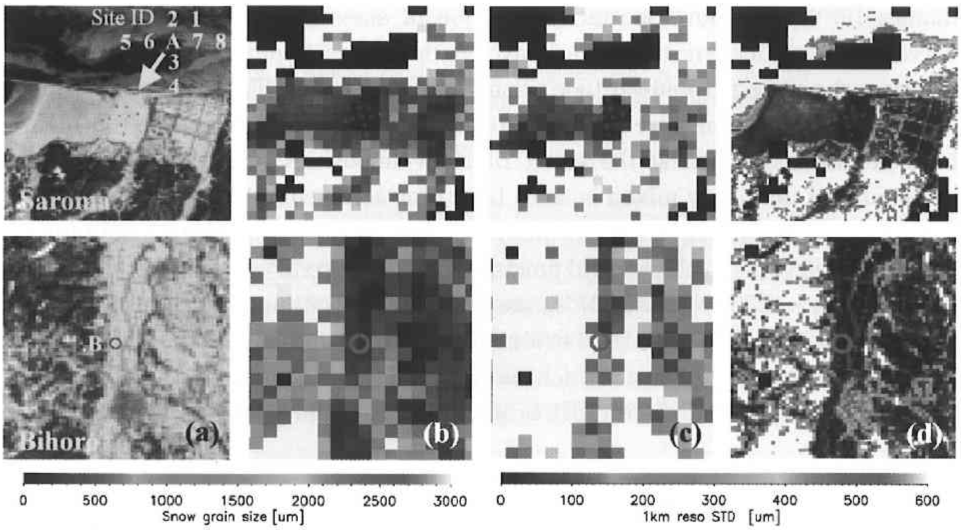

Fig. 3. Satellite images around the Saroma (upper) and Bihoro (lower) sites of (a) RGB image, (b) spatial distribution of snow grain size in radius (1 km resol.), (c) standard deviation of grain sizes from 16 pixels of 250 m resol. data within a 1 km FOV, (d) spatial distribution of snow grain size (250 m resol.).

grain sizes are uniform around the sites, and thus close to each other between 1 km and 250 m resolution dataset exhibiting low standard deviation (STD) in Fig. 3c. On the other hand, snow field at the Bihoro site is not large in area and thus can be seen from space as mixture of snow and non-snow surface such as road, vegetation and so on within a 1 km field of view (FOV). That is why relatively large difference in the retrieved grain sizes can be seen between the 1 km and 250 m cases exhibiting large STD within the 1 km FOV. These tendencies mentioned above can also be seen as small and large deviations of the data of site A and B, respectively from the 1 : 1 line in Fig. 4 where

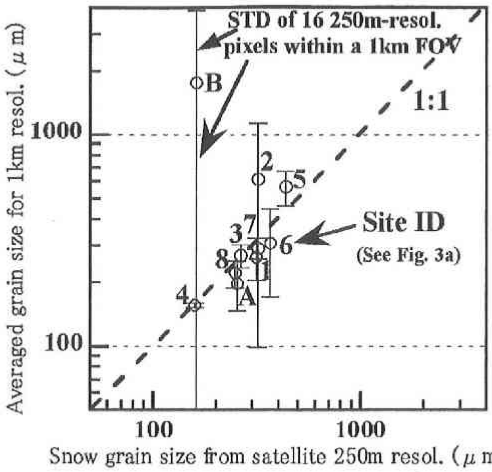

Fig. 4. The relation between snow grain size in diameter from a pixel of 250 m resol. data for each site and the averaged grain size of 16 pixels of 250 m resol. data within a 1 km FOV.

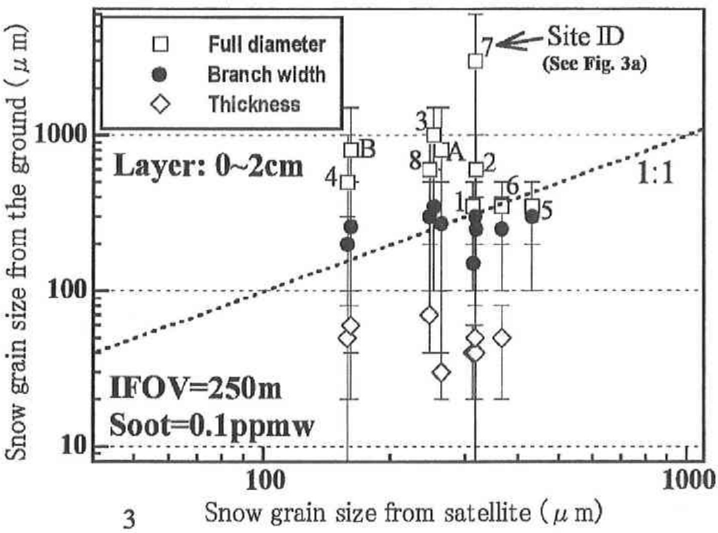

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Fig. 5. The relation between snow grain sizes in diameter derived from satellite (IFOV=250 m) and those from ground surface measurements.

the relation is shown between a grain size from a pixel of 250 m resolution data and the averaged grain size from 16 pixels of 250 m resolution data within a 1 km FOV. Therefore, the retrieval of snow physical parameters with 1km resolution from space can be sensitively affected by the spatial variation of surface type in a scale smaller than 1 km due to vegetation, road, open water and other non-snow surfaces. For global application of the GLI cryosphere algorithms, vast ice sheet, concentrated sea ice and vast snow field (e.g., the Antarctica, Greenland and the North Slope of Alaska) could be considered as good target.

Fig. 5 shows the relation between the satellite derived snow grain sizes in diameter from 250 m FOV data and the ground truth data. The satellite derived snow grain sizes from 250 m resolution data were correlated not with the full diameter or thickness of snow crystals but with the sizes of branch width of dendrite crystals measured at the ground. This correlation can be supported by the past field experiments by Aoki *et al.* (2000) who conducted the optical measurements and pit works at the same snow fields covered with new snow and confirmed that measured snow reflectances could be simulated successfully by employing branch width as the effecteive grain size in the radiative transfer calculation. Therefore in case that the surface is covered with new snow branch width can be considered as an effective minimum unit of light scattering which can characterize the optical properties of snow cover. For future improvement of the GLI algorithms different cases of snow texture (faceted particles, depth hoar, crust, etc.) or locations (northern and southern polar regions) should be investigated further.

4. Future Validation Plan

After the launch of ADEOS-II satellite, we will make validation experiments for the GLI snow products in April-May every year in Alaska to ensure that the accuracy of the snow parameters is sufficient for further applications. In Barrow, we will conduct snow pit work at several points on a vast and uniform snow field to obtain physical parameters such as stratigraphy, texture, grain size, temperature, density, mass fraction of impurity, etc. which will be directly compared with the GLI derived parameters (snow grain size and mass fraction of impurity) to validate the satellite products. In addition, optical measurements such as spectral albedo and BRDF in VNIR, emissivity in TIR, aerosol optical thickness in VNIR, etc. will also be conducted at a center position among the pit work positions which will be used to characterize the relation between snow optical properties and physical properties for the future improvement of the GLI algorithms and also used for satellite sensor calibration. After the validation process (about one year after the launch) quality assured snow products will be released to the public from NASDA.

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