Environmental factors associated with snow algal bloom in the deciduous forest of Mt. Gassan, Yamagata prefecture, Japan

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Snow algae are photosynthetic microbes inhabiting alpine and polar snow fields. They bloom on melting snow and change snow color from white to red or green. Colored snow appears widely in mountainous regions in Japan. However, the conditions for the algal bloom are still not understood well. In this study, we aim to describe the temporal change of snow algae and physical and chemical conditions of surface snow in Mt. Gassan, Yamagata prefecture, Japan. Study site is located in the Japanese beech forest at an elevation of 750 m a.s.l. Field studies were carried out three times from April to May of 2016. We collected samples of surface snow and snow pit down to the ground surface at the study site. In laboratory, we measured chlorophyll-a concentrations, EC, pH, and soluble chemical compositions in the samples.
Field observations revealed that algal green snow appeared patchy after the late April. The algal patches were frequently observed in the snow surface under trees compared with the open sunny surface. The chlorophyll-a concentration in the surface snow gradually increased during the study period. The analysis of major soluble ions revealed that the phosphate concentration in the surface snow under the trees increased up to 51.4 μeq/L while it in the open snow surface kept low value during the study period. Results suggest that the phosphate is supplied with rain water from canopy of the trees to the snow surface and that it causes the patchy algal bloom on the snow surface.

Keywords: snow algae, nutrients, deciduous forest

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Effect of snow impurities on albedo observed during 8 winter seasons in Sapporo

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Recently, snow accumulation area and snow covering period are decreasing mainly in the Arctic region. As the snow and ice surface has generally high albedo, the albedo decreases due to melting of snow and ice accompanying by global warming. As a result, absorption of solar radiation by the ground increases, which could accelerate global warming furthermore. In Sapporo, a typical domestic snow cover area, it is reported that the snow albedo depends strongly on snow grain size and snow impurity concentration (Aoki et al., 2003, 2007). In this study, we investigated the effect of snow impurity concentration on albedo in Sapporo using physical based snow albedo model (PBSAM) developed by Aoki et al. (2011). The observation site is the meteorological observation field (43° 04' 56"N, 141° 20' 30"E, 15 m a.s.l) of the Institute of Low Temperature Science of Hokkaido University. The observation period is 8 winter seasons from 2007 to 2015. We compared the observed broadband albedos with the theoretical values calculated by inputting the observed snow and radiation data into the PBSAM. In addition, numerical sensitivity experiments on albedo changes due to snow impurities were conducted.
Comparing the time series of the observed albedo and the model calculated value in each year of the analysis period, it is found that the simulated albedo variations due to the change in snow grain size and impurity concentration agreed well with the observations. The determination coefficient (R^2) and the root mean square error (RMSE) in the whole period obtained from the albedo comparison between the observation and the calculation in the shortwave (SW) region were 0.831 and 0.045, respectively, confirming the high accuracy of PBSAM. Next, sensitivity experiments were conducted on albedo changes in the visible (VIS), near-infrared (NIR), and SW regions depending on the presence or absence of snow impurities which consist of black carbon (BC) and mineral dust. The albedo change due to snow impurities (BC + dust) in the whole period was -0.085 in the VIS region, -0.016 in the NIR region, and -0.053 in the SW region. We also investigated the contributions from BC and dust to the total SW albedo change, which were -0.043 and -0.009 by BC and dust, respectively. In addition, the ratio in SW albedo change during accumulation period and melting period (melting period / accumulation period) was 4.1 times for BC, 12.0 times for dust, and 4.9 times for BC + dust.

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Observational study on spatial development structure of blowing snow

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Reducing visibility and forming snow drifts by blowing snow are still social natural disaster and a major problem. Although a large number of studies have been made on the vertical development of blowing snow, little is known about the horizontal development of blowing snow especially focused on near the snow surface. For a better understanding of spatial development structure of blowing snow, observations about the horizontal development of blowing snow near the surface have been carried out. The results obtained by the cold wind-tunnel experiments showed if the wind became strong, the development to a horizontal direction became weaker than that to a vertical direction. In addition, the results of field observations in blowing snow at Sapporo showed blowing-snow flux remarkably increased when the wind blew from the direction of a long fetch. It is necessary to carry out the spatial observation above the blowing snow layer using such as a kite in the field in future while investigating the horizontal development of blowing snow experimentally in detail.

Keywords: blowing snow, spatial development

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Assimilation of all-sky GCOM-W/AMSR2 brightness temperature using a strongly coupled atmosphere-land data assimilation system in snowy Siberia

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Coupled numerical models address the interaction between processes in the atmosphere, ocean, land surface, biosphere, chemistry, cryosphere, and hydrology. Including the interaction between such processes can potentially extend the predictability and eventually help in reducing the uncertainty of the prediction. Coupled data assimilation is a branch of data assimilation that deals with coupled modeling systems. There are two kinds of coupled data assimilation systems such as weakly and strongly coupled data assimilation. Recently we developed a strongly coupled atmosphere-land data assimilation system (Suzuki et al., 2017). In this article the fundamentals of bias correction for the all-sky GCOM-W/AMSR2 brightness temperature using coupled data assimilation are described. Through a series of data assimilation experiments, we analyze the effectiveness of bias correction coefficients and predictors. Through this study, we analyze the impact of all-sky brightness temperature in reanalysis. Finally, applying coupled data assimilation can visualize more details of coupled atmosphere-land interaction.

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Keywords: Coupled data assimilation, Atmosphere-Snow interaction, Snowfall

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The method for identification of the cryoconite distribution by using satellite image

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Cryoconite, which is very small dark substance on glacier containing cyanobacteria and growing tangling with minerals, can absorb sunlight much, causing the faster melting than usual white snow. The valuable field survey enables us to study the cryoconite, albeit applying in the small area and with long interval. And a few remotesensing study uncover the glacier darkening and regression. Nevertheless no one knows how to point out its distribution over a wide area.
Here, according to luminance difference of between the glacier and the cryoconite, we propose new method with using multispectral bands of Landsat8 (resolution 30m), band2(450-515nm, B2) and band5(850-880nm, B5) to distinguish those two by making a new formula” (B5-B2)/(B5+B2)” (R). In the range of B2, the cryoconite’s reflectance is about 10 %; otherwise the glacier has high percentage. In the range of B5, the cryoconite’s one is about 20%; in contrast the glacier’s almost half. The satellite images we use in 2016 July 30th, are analyzed since the cryoconite appeared widely and well in the period of 2016 late July to the beginning of August. We were successful in remove the shadow on this image by comparing R and RGB image. If a pixel in R is brighter than the other images, the place of the pixel should be cryoconite or sand.
The calculated index(R), in their spectra from previous study, applied that both of the cryoconite and the sand take a positive value while the glacier take a negative value in the pixel. The criterion will be shown in the presentation.

Keywords: cryoconite, remote sensing, glacier

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Retrieval of ice surface temperature and thin ice area using thermal infrared bands of Himawari-8/AHI

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Ice surface temperature (IST) has been an important observation target from space not only for calculating radiation budget but also for estimating the production of thin ice thickness in the cryosphere. In particular, the latter is important for assessing the amount of dense water with high salinity produced under newly formed thin ice. In this study we developed an algorithm for estimating IST and emissivity simultaneously using a semi-empirical emissivity model which can simulate the dependence of spectral emissivity on the surface snow/ice type and exitance angle. In this analysis we neglected the effect of water vapor absorption in the atmosphere and applied the algorithm to the data of AHI sensor onboard the Japanese geostationary satellite Himawari-8. Channel 13 (center wavelength: 10.4 μm) and 15 (12.4 μm) were used for the retrieval. The results show that emissivity as well as IST seemed to be successfully retrieved over the Okhotsk ice areas (but not validated with in-situ data). From the retrieved emissivity image, the area of thin sea ice such as nilas were easily determined. In addition, from the comparison with the case using a fixed emissivity for all snow and ice type, possible error in the IST retrieval with the fixed emissivity could be estimated to be up to a few Kelvin, which is due to the low emissivity of thin sea ice and the large viewing zenith angle of AHI around 60 degrees when observing the area of Okhotsk Sea. The same approach can also be applied to the data of polar orbit satellite such as the coming Japanese satellite mission “Global Change Observation Mission-Climate” (GCOM-C) to be launched in 2017.

Keywords: Ice surface temperature, Ice type, Emissivity, Remote Sensing, AHI, SGLI

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Inter-annual modulation of seasonal glacial velocity changes in the Eastern Karakorum detected by ALOS-1/2 data

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Whereas the ice sheets all over the world are receding, the glaciers in Karakoram are either stagnant or advancing, which is known as ‘Karakoram anomaly’. The surging dynamics and mass balance have been extensively studied in this area. However, in the Eastern Karakorum Range, the spatial and temporal changes in glacial velocity have been so far poorly understood. We have analyzed nearly all the available ALOS-1/2 data in this area and have examined the inter-annual modulation of five glaciers. The glaciers with size >30km, i.e. Siachen, Baltoro and Eastern tributary of Kundos, are mostly showing a considerable velocity change in their various parts, accompanying clear seasonal changes both in ALOS-1/2 data. However, this change mostly depends upon the individual glacier and is variable in space and time. On the other hand, the smaller glaciers (<30km), i.e. Singkhu, Gasherbrum and Western tributary of Kundos glaciers, are showing a slowdown in ALOS-2 data. Analysis of the local air surface temperature data at five observatories indicates that during the same season, the temperature trend in the study area is uneven and probably varies significantly between different glaciers. It can result in localized warming/cooling that can affect the availability of melt-water for an individual glacier. The excess surface melt-water at each individual glacier may undergo a variety of en/sub-glacial hydraulic and hydrological processes that are further different at each glacier. Thus, it will result in a complex velocity behavior in this region.

Keywords: Eastern Karakorum, Pixel offset, Glacier velocity, Inter-annual modulation

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Measurement of mass balance with high altitude, and thermal property of debris-covered area at the Trambau Glacier, Nepal

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Shrinkage of Himalayan glaciers is unabated and thus contributes to sea level rise. In this region, in-situ measurements of mass balance of large glaciers have been conducted at few glaciers due to the difficult accessibility to their accumulation area. Moreover, many large glacier tongues are covered with debris, which makes the ablation process complicate. Thus, it is required to carry out in-situ measurement at debris-covered glaciers with accessible accumulation area.
We carried out in-situ measurements at Trambau glacier in the Nepal Himalaya pre- and post-monsoon seasons in 2016. We installed stakes network from ablation to accumulation area, and obtained direct mass balance data. An automatic weather station was set beside the glacier to obtain basic meteorological data during observation period. In order to establish a model for ablation at debris-covered ice, we also measured thermal conductivity and water content in debris layer, and set temperature sensors at different depth in the debris layer. Observed mass balance ranges from -2.62 m to +0.12 m w.e. a^{-1} during the period. The maximum ablation is found at 5280 m a.s.l., which is the lower bound of debris-free area, and a liner relationship is found between mass balance and elevation ($r = 0.94$, $p < 0.01$). In contrast, no significant correlation is found between mass balance and elevation in debris-covered area whereas a coefficient correlation between mass balance and thermal resistance, which is a proxy of debris thickness, is 0.71 ($p < 0.05$).

Keywords: glacier, Himalaya, mass balance, debris cover

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Quantitative evaluation of global-scale free DEMs for mountain glaciology

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Aerial and space-borne stereo photogrammetry provides topographic data, digital elevation model (DEM), which has been developed in various ways, resulting in several kinds of DEM dataset. Earth observation satellite generated DEMs which have an important role in obtaining homogeneous-quality geospatial information in remote high mountain areas, thereby contributing to studies of mountain glaciology. This study validates the accuracy of ASTER GDEM, SRTM, ALOS World 3D-30m (AW3D30), which use 30-m pixel spacing and have recently been released free of charge, against check points (CPs) managed by GSI in glacialized topography in the Northern Alps, the hillslope of Mt. Fuji, and the alluvial plain of the Tone River in Japan.
Statistical results of elevation differences at each study site show that AW3D30 has the nearest elevation values to those of CPs. The largest variability is seen in the Northern Alps, where ASTER GDEM and SRTM1 are 13-18 m lower than the CPs, with a 15-20 m standard deviation (elevation difference to CPs). There are fewer differences between the accuracies of the three DEMs with gentler-sloped topography, and an equivalent accuracy between SRTM1 and AW3D30 (+0.1+/-3.1 m) is denoted in an almost flat paddy field in Tone. In addition, at this site, the mean difference and standard deviation of difference to CP elevation values of ASTER GDEM is in a range of less than 5 m. Our results thus determine that the various DEMs have differing levels of accuracy in association with particular types of topography. AW3D30 has the highest accuracy in steep topography of the Northern Alps, and SRTM1 has a better accuracy in moderate reliefs.
DEMs generally contains no-data area (“void”) where original stereo-pair data have an inadequate number of matching points. The characteristics of void distributions are important factors when selecting a DEM for a particular study purpose. The void distribution of the three above-mentioned DEMs are thus compared in the Nepal Himalayas. AW3D30 is mainly found to contain voids around the important peaks of the Himalayan main range; this is probably related to the continuous snow covering in high elevation areas around the peaks, which makes tie point acquisition from ALOS optical stereo pair-images difficult. SRTM1, voids are mainly distributed in areas of lower elevation with steepness of around 45°, which can be reasonably explained by steep mountain slopes hampering the acquisition of original SAR data, thereby resulting in shadowing and/or layover. ASTER GDEM, which was generated using the longest-term observation record of ASTER stereo pair images, has no voids in the study region and is therefore of use in cases that require moderate accuracy without any missing data, such as regional-scale watershed generation.

Keywords: SRTM, GDEM, AW3D

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InitMIP-Greenland experiments with the ice sheet model SICOPOLIS

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The Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6) brings together a consortium of international ice sheet and climate models to explore the contribution from the Greenland and Antarctic ice sheets to future sea level rise. For such projections, initialisations are required that provide initial states of the respective ice sheet. Therefore, as one of the first initiatives within ISMIP6, InitMIP-Greenland was launched in order to explore this issue for the Greenland ice sheet across a variety of models and initialisation techniques. Two different initialisation techniques are common, namely spin-up methods (paleoclimatic simulations until the present) and assimilation methods (assimilation of observations of the present-day ice sheet). We contribute to InitMIP-Greenland with the ice sheet model SICOPOLIS and two different spin-up techniques, (1) a SeaRISE-legacy spin-up over 125 ka with essentially fixed topography, and (2) a new spin-up over 135 ka with freely evolving topography. New methods applied for spin-up (2) are monthly-mean (rather than mean annual) input data for the present-day precipitation, a sub-grid-scale ice discharge parameterisation and an iterative correction of the present-day precipitation based on the misfit between the simulated and observed present-day ice thickness. The agreement between simulated and observed ice topography is naturally better for the fixed-topography case (1) than for the freely evolving case (2). Both spin-ups produce a realistic distribution of the surface velocity, including the major ice streams and outlet glaciers (at 5 km horizontal resolution). InitMIP-Greenland also comprises two future climate scenarios, ctrl (present-day climate over 100 a) and asmb (prescribed schematic surface mass balance anomaly over 100 a due to global warming), both to be run with freely evolving ice topography. The response of the ice sheet (mass loss) to the asmb forcing is, in absolute terms, ~50% larger for spin-up (2) than for spin-up (1), and relative to the respective control run ctrl even ~85% larger. This demonstrates impressively that, even with the same ice sheet model, different initialisation methods can lead to a major spread of results of future climate experiments.

Keywords: Greenland, Ice sheet, Climate change, Sea level rise, Modelling

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The Effects of H2SO4 on the Flow and Fabric of Polycrystalline Ice

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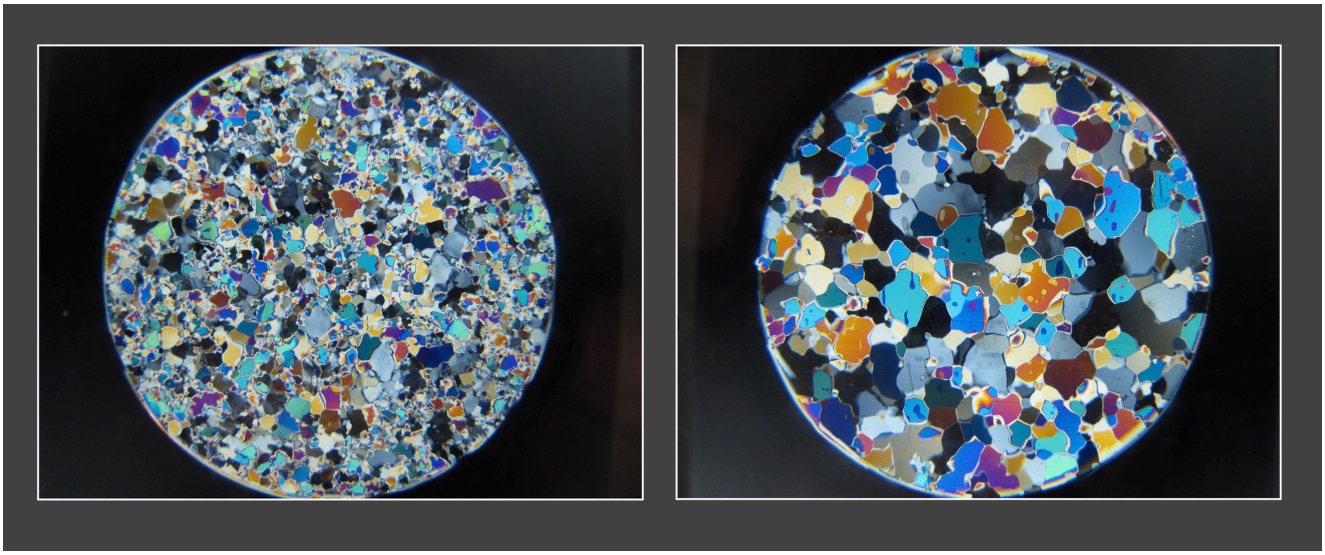
It is well established that the Earth’ s large continental ice sheets contain a variety of naturally occurring impurities, both soluble and insoluble. Understanding how these impurities affect the rheology, intrinsic thermodynamic properties, and ultimate fate of these ice sheets is much less understood. Previous work has shown that H_2SO_4 dramatically reduces the strength and increases the ductility of single crystal ice, but its effects on polycrystalline ice are unknown. In order to investigate the effects that trace amounts of H_2SO_4 have on the flow and ductility of polycrystalline ice a series of mechanical tests were conducted at -6˚C, -10˚C, -12˚C, and -20˚C using laboratory-prepared ice with a mean grain diameter of 1 mm and doped with 1-10 ppm of H_2SO_4. Parallel tests were performed on identical, but undoped polycrystalline ice. Mechanical testing included uniaxial tensile creep tests at a constant load of 38 kg (0.75 MPa initial stress) and uniaxial compression tests at constant strain rates ranging from 1×10^{-6} s^{-1} to 1×10^{-4} s^{-1}. The tensile tests showed that H_2SO_4-doped specimens exhibited faster creep rates than undoped ice, while the compression tests demonstrated that H_2SO_4-doped specimens exhibit a significantly lower peak stress than undoped ice. Post-mortem microstructural analyses were performed using cross-polarized light thin section imaging, X-ray computed microtomography, Raman spectroscopy, and electron backscatter diffraction. These analyses showed that H_2SO_4-doped specimens had a much larger grain size at strains 15%, and an earlier onset of micro-cracking at lower strain rates than the undoped ice. Further, a liquid-like phase containing H_2SO_4 appears to be present at the grain boundaries of the H_2SO_4 doped ice.

Keywords: Ice, Sulfuric , Acid, Microstructure, Rheology



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