Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

ACC32-01 Room:102A Time:May 24 09:00-09:15

Ice loss in small glacier systems of the Arctic Islands (Iceland, Svalbard, the East Arctic Islands) revealed by GRACE

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The islands in Arctic region (Arctic Islands) are covered by water ice (i.e. ice sheet, glacier, and ice cap) over 80 % of their land area and form the largest store of water ice in Northern Hemisphere. Arctic Islands consist of Greenland, the Canadian Arctic Archipelago, Iceland, the West Arctic Islands (Svalbard) and the East Arctic Islands (Novaya Zemlya, Severnaya Zemlya, and Franz Joseph Land). The total of ice covered area in Arctic region is about ˜2,000,000 km^2, and most of them are composed of ice sheet in Greenland (˜ 1,750,000 km^2). As for glaciers and ice caps, about half (˜ 150,000 km^2) is located on the Canadian Arctic Archipelago, another quarter is found around the Greenland region (˜ 76,000 km^2), and the other quarter is on Iceland, and the West, East Arctic Islands (˜ 100,000 km^2).

In recent years, rapid shrinking of continental ice sheets and mountain glaciers due to global warming has been reported in many parts of the world. A system of twin satellites Gravity Recovery and Climate Experiment (GRACE), launched in 2002 to measure time-variable gravity field, detected such large-scale mass changes as slight changes in the satellite-to-satellite range, and enabled direct and quantitative measurements of them. GRACE observation in the last decade revealed ice loss rates of 190 +/- 77 Gt/yr in Antarctica (e.g. Chen et al., 2009), 115 +/- 20 Gt/yr in Alaska (e.g. Tamisiea et al., 2005), 47 +/- 13 Gt/yr in Asian High Mountain Ranges (Matsuo and Heki, 2010), and 28 +/- 11 Gt/yr in Patagonia (Chen et al., 2007). As for the Arctic Islands, ice loss rates of 252 +/- 28 Gt/yr in Greenland (e.g. Schrama and Wouters, 2011), 62 +/- 10 Gt/yr in the Canadian Arctic Archipelago (Gardner et al., 2011), and 9 +/- 4 Gt/yr in Svalbard (Memin et al., 2011) have been reported until now. However, those in the other islands, such as Iceland and the East Arctic Islands, still remain uninvestigated.

In this study, we focus on the Arctic glaciers where their ice loss rates have not been reported yet, i.e. Iceland and the East Arctic Islands, and try to estimate current ice loss rates there using GRACE time-variable gravity data during 2003-2011. Here, we followed the method proposed by Matsuo and Heki (2010) as the estimation method of mass loss rate from GRACE data. And we used the Glacial Isostatic Adjustment (GIA) model presented by Paulson et al. (2007) in order to remove their contribution. Finally, we got 10.9 +/- 0.7 Gt/yr for Iceland and 10.6 +/- 3.1 Gt/yr for the East Arctic Islands (6.9 +/- 1.5 Gt/yr for Novaya Zemlya, 2.6 +/- 0.9 Gt/yr for Severnaya Zemlya, 1.1 +/- 0.7 Gt/yr for Franz Joseph Land) as current ice loss rates, which are substantially faster rates in comparison to those estimated by field observations during 1961-2001 of 2.5 +/- 8.7 Gt/yr for Iceland and 0.8 +/- 4.1 Gt/yr for the East Arctic Islands (Dyurgerov and Meier, 2005). This suggests that the global tendency of accelerating ice loss also can be seen for these Arctic glaciers.

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Keywords: Glacial melting, Space geodesy, GRACE, The Arctic, Global warming, Sea level rise

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ACC32-02 Room:102A Time:May 24 09:15-09:30

Diversity of Glacier Surface Velocity in the West Kunlun Shan, NW Tibet, Detected by Synthetic Aperture Radar

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Many mountain glaciers are developed in West Kunlun Shan (WKS) located in NW Tibetan plateau. Annual temperature and precipitation in WKS is 13.4 degree C and ˜460mm, respectively (Zheng et al., 1988). Precipitation mainly occurs in warm season (May-Sept) (Kang and Xie, 1989). Glacier type in WKS are polar or poly-thermal glacier (Thompson et al.,1992), and clean type glacier. These previous studies, no/less short term velocity changes were expected at WKS. In this study, we detected surface velocity fields of a number of valley glaciers in West Kunlun Shan, using pixel-offset technique based on Synthetic Aperture Radar (SAR) data. We assumed that glaciers flow parallel to surface topography and converted results to surface velocity field. From our results, we elucidated diversity of glacier surface velocity in WKS. For example, we detected seasonal variation on Duofeng glacier, north-slope of WKS. Surface velocity during June-July was up to ˜170% above winter background values. Surface velocity increased in warm season, so melt water probably caused seasonal variation in WKS. N2 and West Kunlun glacier was accelerated and advanced. Zhonfeng glacier, south-slope of WKS, was clearly decelerated and velocity distribution changed. Surface velocity abruptly decreased in the middle of a stream and no/less flowed in lower part (stagnant flow). These results coincided with glacier surge. Glacier surge caused acceleration / deceleration of surface velocity and advancing of terminus. According to result of Zhonfeng glacier, stagnant flow probably reflected quiescent period of glacier surge (Murray et al, 2003). Consequently, there were possibilities that precipitation and melt-water in warm season and glacier surge caused diversity of surface velocity of mountain glacier in WKS.

Keywords: SAR, mountain glacier, surface vlosity, West Kunlun Shan, glacier surge, seasonal variation

ACC32-03 Room:102A Time:May 24 09:30-09:45

Flow velocity measurement of Hubbard Glacier, Alaska, by L-band Synthetic Aperture Radar, ALOS/PALSAR

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Hubbard Glacier is the largest tidewater glacier in North America, whose length is about 120km from the flanks of Mt. Logan (5989m) in Yukon, Canada. It terminates in Disenchantment Bay and Russell Fiord in Alaska. The terminus has been previously observed due to its complicated and seasonal fluctuations (e.g., Ritchie et al., 2008). However, it remains unknown how the middle and upper parts will behave in terms of both their spatial and temporal characteristic. That is why we focus on the middle stream part and investigate the flow velocity.

We use ALOS/PALSAR data, which was launched by JAXA in 2006. SAR stands for Synthetic Aperture Radar, and it enables us to detect surface deformation with high spatial resolution regardless of sunlight and weather. In order to detect the glacier flow velocity, we performed pixel offset (feature tracking) technique applying to the SAR intensity images. Moreover, we estimate the 3-D flow field by using ASTER GDEM Ver.2. Because there are 14 SAR images around the Hubbard Glacier, we could derive the flow velocity maps at 7 epochs so that we could examine the spatial and temporal changes in the flow velocity field.

Two major findings at the time of this writing are as follows. First, the maximum velocity is about 1.3m/day. Secondly, the velocity in winter is 80% faster than that in summer. We have currently no idea how to explain the second observation result. But, if it is true, this result is consistent with the terminus changes (advance in winter and retreat in summer) in Ritchie et al (2008).

We are also going to show some results of other glaciers in Yukon.

ACC32-04 Room:102A Time:May 24 09:45-10:00

Space and Time Variations of Glacier Flow Velocities in Patagonia Icefield, Inferred from ALOS/PALSAR and Envisat/ASAR

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Recent studies of the Greenland and Antarctic ice sheets show that the ice sheets are thinning but accelerating, and contribute increasingly to global sea level rise. Meanwhile in the Patagonia Icefields, which are the world's largest temperate ice masses, flow velocity fields remain largely unknown because of the difficulty of field-based studies. There are a lot of glaciers, and most of these are reported to have been retreating recently. In order to estimate the effects of variation in glaciers and ice sheets on global sea level, it is important to understand the glacier flow in the Patagonia Icefields. In this study, we estimate flow velocity fields of glaciers in Patagonia, using Synthetic Aperture Radar (SAR), one of the all-weather microwave remote sensing techniques.

In this study, we detected glacier flow at some glaciers in the Southern Patagonia Icefield (SPI), including Perito Moreno glacier, using Pixel offset (Feature tracking) technique based on ALOS/PALSAR (2006˜2011) and Envisat/ASAR (2002˜) data. Then, we estimated flow velocities, assuming that the glaciers flow parallel to surface topography based on SRTM4 digital elevation model (DEM).

In addition, we estimated 3-D displacements of Perito Morerno glacier in another way without terrain information, using two SAR data acquired from ascending and descending orbits. We compared these results to the results of the above method.

The results show flow velocity fields at some glaciers in SPI from 2002 to 2011.

In Perito Moreno glacier, the inferred flow velocity reached a maximum of 3 m/day. This result is mostly consistent with previous studies. There are few temporal changes in the velocity fields between 2003 and 2011. In addition, we compared the results by two methods and found apparent differences in the vertical components of the flow velocities.

PioXI glacier shows rapid acceleration near the terminus in 2003 and 2005. This cannot be explained only by the seasonal variation, and is different from those at other glaciers.

We are also going to show our measurement results at Upsala glacier, Occidental glacier, and so on.

Keywords: ALOS, PALSAR, feature tracking, Patagonia, glacier flow

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ACC32-05 Room:102A Time:May 24 10:00-10:15

CHARACTERISTICS OF INHOMOGENEOUS GLACIER AREA CHANGE IN BOLIVIAN ANDES

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The changing sizes of glaciers in the Bolivian Andes between 1987 and 2010 were determined using cloud-free Landsat Thematic Mapper (TM) images. A method of extracting glaciers was developed that uses the ratio of bands L4 and L5 computed from at-sensor radiance. A 30-m digital elevation model (DEM) derived from ASTER data helped to group the glaciers according to their catchments and slope orientations. Advanced Land Observing Satellite (ALOS) AVNIR-2 data were used to validate the method and identify glacier boundaries.

Glaciers in Bolivian Andes such as Condoriri, Tuni, and Huayna Potosi tended to be more affected by slope orientation, with their greatest area loss on wet-facing slopes. This phenomenon may be partly explained by analyzing meteorological conditions. Assuming that glacier melt occurred when the air temperature over glacier surfaces and incoming shortwave radiation values were both positive, this happened between 09:30 and 18:30 during dry season, whereas between 07:30 and 20:30 in the wet season. In both seasons, the time spans were shorter before noon and longer after noon. As a result, west-facing slopes received solar radiation for a longer span of time each day, which may partly explain why glacier shrank faster on west-facing slopes. Furthermore, incoming longwave radiation reached its peak value in afternoons, which may also have enhanced glacier melt by providing more energy. In addition, hill shade also showed strong influence on glacier melting.

Keywords: Glacier retreat, Slope orientation, Landsat, ALOS, Band ratio

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ACC32-06 Room:102A Time:May 24 10:15-10:30

Radar characterization of the basal interface across the grounding zone of an ice-rise promontory in East Antarctica

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Radar power returned from the basal interface along a 42 km long profile over an ice-rise promontory and the adjacent Roi Baudouin ice shelf, Dronning Maud Land, East Antarctica, is analyzed to infer spatial variations in basal reflectivity and hence the basal environment. Extracting basal reflectivity from basal returned power requires an englacial attenuation model. We estimate attenuation in two ways: (1) using a temperature-dependent model with input from thermomechanical ice-flow models; and (2) using a radar method that linearly approximates the geometrically corrected returned power with ice thickness. The two methods give different results. We argue that attenuation calculated using a modeled temperature profile is more robust than the widely used radar method, especially in locations where depth-averaged attenuation varies spatially or where the patterns of basal reflectivity correlate with the patterns of the ice thickness.

Keywords: Antarctica, ice sheet, ice shelf, radar

ACC32-07 Room:102A Time:May 24 10:45-11:00

Glacial lake formation and its impact on dynamic thinning of glaciers in the Bhutan Himalaya

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A number of supraglacial lakes formed on the termini of debris-covered glaciers in the Bhutan Himalaya as a result of glacier retreat due to climate change. The terminal part of the lake-terminating glaciers flow faster than that of the land-terminating glaciers because the basal ice motion is enhanced by high subglacial water pressure generated by lake water. Increased ice flux caused by the accelerated glacier flow could be dissipated through the calving process which reduced the glacier thickness. It is important to understand the interaction between lake formation and glacier dynamics. Although glacier flow velocity has been measured by remote-sensing analysis in several regions of the Himalayas, glacier thinning rates have been observed by neither in-situ nor remote-sensing approaches. We investigate the influence of the presence/absence of glacial lakes on glacier dynamics and changes in surface elevation.

We study two debris-covered glaciers in the Lunana region, the Bhutan Himalaya. Thorthormi Glacier is a land-terminating glacier with some supraglacial lakes while Lugge Glacier is a lake-terminating glaciers. We surveyed the surface elevation of debris-covered areas of the two glaciers in 2004 and 2011 by a differential GPS. Change in surface elevation of the lake-terminating Lugge Glacier (-5.7– -2.5 m a^{-1}) was much more negative than that of the land-terminating Thorthormi Glacier (-3.3–0.7 m a^{-1}). Surface flow speed of the Thorthormi Glacier measured during 2002–2004 was faster in the upper reaches (90 m a^{-1}) and reduced toward the downstream (40 m a^{-1}). In contrast, the surface flow speed at the Lugge Glacier measured in the same periods was 40–55 m a^{-1} and the greatest at the lower most part.

Observed spatial distribution of surface flow velocity at both glaciers were evaluated by a two-dimensional numerical flow model. Calculated emergence velocities are 1.9–18.8 m a^{-1} at the Thorthormi Glacier while -12.0–2.7 m a^{-1} at the Lugge Glacier. This result suggests that decreasing in flow velocity towards the terminus in the Thorthormi Glacier causes compressive flow. It suggests that the compressive flow of the Thorthormi Glacier counterbalanced surface melting, resulting in inhibition of the surface lowering. In contrast, the extensional flow of the Lugge Glacier accelerated the surface lowering. Speed up of glacier terminus induced extensional flow regime causes the thinning of ice and increase in basal motion, which will lead to further flow acceleration. Such positive feedbacks have been found over the ice streams in the polar ice sheets. In this study we showed the observational evidences, in which the similar feedbacks make contrast the terminus behaviours of glaciers in the Bhutan Himalaya. If the supraglacial lake on Thorthormi Glacier expanded, the surface lowering may be accelerated in the future.

Keywords: Glacier, Glacier lake, Glacier flow

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ACC32-08 Room:102A Time:May 24 11:00-11:15

Elevation changes in Lirung Glacier by field surveys 1996-2008 in Langtang valley, Nepal Himalaya.

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Larger parts of glacier surface in the Himalayas are covered with debris. Changes in elevation are essential for monitoring fluctuations in debris-covered glaciers because the supraglacial debris mantle makes it difficult to detect changes in area. Therefore, an approach using remotely sensed (RS) digital elevation models (DEMs) is feasible solutions to evaluate how fast Himalayan glaciers are changing in volume. Because the RS-DEMs generally include various errors, validation and calibration using field measurements data are necessary for accurate estimation of elevation. However, few ground-based observational studies have been available because of remoteness and high altitude in the regions.

We calculate changes in elevation of the glacier surface using field geodetically measurement (theodolite with laser distance finder) in 1996, 1999, and differential GPS (DGPS) measurements in 2008 at Lirung Glacier in Langtang Himal, Nepal Himalaya. Individual surveys were co-registered by referring to benchmarks installed on bedrock around the glacier in 1996. Those points data were converted to 30-m-grid DEMs for calculating changes in elevation. We also calculated changes in elevation of the glacier surface using multi-temporal RS-DEMs calibrated with DGPS data in 2008. The calibration is co-registration of each RS-DEM against DGPS derived DEM in 2008 by minimizing the root mean square error over glacier-free terrain, where no elevation change is expected. RS-DEMs used in this study are topographical map derived DEM in 1992, SRTM DEM in 2000, and ASTER DEMs between 2001 and 2004. Temporal changes in elevation is calculated by generating a weighted least square linear regression model. We will show the result in presentation.

Keywords: glacier, Himalaya, GPS, remote sensing, DEM, Langtang

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ACC32-09 Room:102A Time:May 24 11:15-11:30

A variation in chlorophyll concentration during the thaw period in the snowpack of Tohkamachi City, Niigata-Prefecture

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It is known that snow algae breed on the surface of the snowpack in thawing season. Breeding of snow algae colors the surface of the snowpack with red and causes the phenomenon of red snow. Snow algae are the special organism which was adapted to cold environment. But, about detailed ecology, such as conditions of breeding, it does not understand in many cases. Although especially acidification of the snowfall in Japanese each place in recent years, come flying of yellow sand, and change of the snowfall by global warming are considered to have influence also on the ecology of snow algae, it is not known at all about those details. Snow algae in snowpack can be evaluated quantitatively by analysis of chlorophyll concentration. Then, in this study, I analyze the chlorophyll concentration on the surface of snowpack in the period of winter to spring, and aim at clarifying the seasonal variation and clarifying the environmental factor of the change. Comparison with the chlorophyll concentration and the snow cover model.

The target samples are snowpack of the Tohkamachi Experimental Station, FFPRI in this research. The samples extracted every about two weeks were analyzed until the snowpack was disappeared in the period from January to April in each year in 2009 to 2011. The analysis items of the samples are EC, pH, and chlorophyll concentration.

As a result of analysis, there is almost no change of the chlorophyll concentration on the snowpack in the period from January to March in 2011 below at 3.29microg /L, and it increased to 20microg /L from 5microg /L rapidly from the end of March. As a result of comparing with the meteorological data which the Tohkamachi Experimental Station, FFPRI observed, it became clear that the thawing season in Tohkamachi in 2011 began in the end of March. It is related to the increase in the amount of thaw and chlorophyll concentration, and it is thought that water content of snow has influenced.

When compared with change of chlorophyll concentration on the snowpack surface in 2009 and 2010, it became clear similarly that chlorophyll concentration increased to 25microg /L from 5microg /L in the end of March also 2010. As a result of correlation with the analysis results from 2009 to 2011, and EC, pH, the water content, the density, the temperature, and depth of each snowpack in 2009 to 2010, correlation was accepted by the amount of chlorophyll, the water content, the density, the temperature, and depth of snowpack in 2011. But, there was a parameter without correlation for other years. From this result, the factor which chlorophyll concentration increases may exist besides the water content of snowpack. In addition to the parameter which correlation above, there is a possibility that solar radiation and nutrient salt have affected chlorophyll concentration.

Keywords: snow algae, chlorophyll, the thawing season, the snow cover model

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ACC32-10 Room:102A Time:May 24 11:30-11:45

Free Translation of Ice Ih Induced by Field Gradient Force

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Magnetically induced translation was newly observed for crystals of mm-sized ice (Ih) in micro-gravity condition produced by a chamber-type drop shaft. Here the crystals were released in an area of monotonously decreasing static-field filled with N2 gas medium (P=10E5 Pa). It was deduced from a Newton equation that terminal velocity of the translating ice outside the field was independent to mass m of crystal; in a given field distribution, the velocity is uniquely determined by intrinsic diamagnetic susceptibility (per unit mass) of the material. Value of susceptibility obtained from observed terminal velocity agreed fairly well with the published value of ice Ih; 8x10-7emu/g. Relationship between susceptibility and m value of crystal was experimentally examined in a range of m = 30-5 mg. No sign of m dependence was seen for the measured susceptibilities above the extent of experimental error. The above two results indicated that the observed translation of ice followed the assumed Newton equation. The experimental setup developed in this work will become the basis to observed magnetic ejection of other volatile solids that are the major solid components in the outer solar system; namely, carbon-dioxide, ammonia, or methane. The above translation observed in micro-gravity can be applied to detect susceptibility of a single small particle, because the method is not affected by interferences of the sample holder used in conventional methods; the new method is also free of mass measurement. Provided that sample motion is observable, susceptibility is obtained for a small sample irrespective of its size [2]. Based on the obtained efficiency of measuring susceptibility, possibility of constructing a compact apparatus of material identification is discussed, which can analyze the volatile dust particles in a simple manner during a mission orientated toward the outer solar-system.

The above translation was previously observed for popular diamagnetic materials such as calcite, corundum, forsterite, graphite and alpha-quartz[1]. Magnetic orientation of magnetically stable axis with respect to field direction was reported as well for the above crystals including ice; the rotation was caused by diamagnetic anisotropy. Possibility of magnetically-induced dynamical motions, namely translation & rotation, has been recognized only on materials that possess spontaneous moments or strong paramagnetic moments. A chamber type drop shaft was developted to study the procedure of releasing the ice sample in our home laboratory. The compact drop shaft was recently adopted in an educational program performed at a senior high school; there, a two fold capsule system was introduced to improve the level of micro-gravity[2].

[1] C.Uyeda et al, J.Phys.Soc.Jpn. 79 (2010) 064709
[2]Kasugaoka Senior High School (Osaka-Pref.) JpGU meeting 2011 & 2012. Union session, Poster presentations by senior high school students.

Keywords: chamber type micro-gravity system, ice Ih, magnetic ejection, diamagnetic susceptibility, magnetic orientation, material identification