Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

ACC028-01 Room:102 Time:May 24 08:30-08:45

Changes in ice flow regime after formation of proglacial lakes in Rhonegletscher, Swiss Alps

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Alpine glaciers in the world have been retreating significantly under the influence of recent climate change. In some of these glaciers, new proglacial lakes have formed. If a lake forms at the glacier terminus, increase in subglacial water pressure accelerates ice flow. Speed-up of glacier flow might cause acceleration of glacier retreat.

To investigate changes in ice flow regime at the glacier terminus due to proglacial lake formation, ice flow speed and subglacial water pressure were measured in spatial resolutions of 100 m. The measurements were carried out at Rhonegletscher in the Swiss Alps during the summer seasons of 2007-2009. At this glacier, two proglacial lakes have formed since late 1990s as a result of glacier retreat.

Ice thickness near the terminus is thinning in a rate of -3.44 m a^{-1} from 2008 to 2009. Horizontal flow velocity at the glacier terminus increased twofold from 2006 to 2007. Water level in boreholes drilled to the bed was approximately equal to the lake level in the range of 200 m up-glacier from the terminus, suggesting that a subglacial drainage system was well developed. Subglacial water pressure exceeded ice overburden pressure in the lake shore. It is suggested that high water pressure enhanced basal sliding and caused the acceleration of glacier flow. Acceleration of ice flow at the terminus changed the flow regime in the longitudinal direction from compressive to tensile. This change was responsible for a part of the glacier thinning. Huge surface uplift associated with formation of crevasse was observed in the region where water pressure exceeded the overburden pressure. These observations suggest that if the glacier continues to thin, the entire part of the terminus may get afloat and disintegrate over the next few years.

Keywords: proglacial lake, glacier flow, Alpine glacier, Switzerland

Japan Geoscience Union Meeting 2011
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ACC028-02 Room:102 Time:May 24 08:45-09:00

3-D displacements in Perito Moreno glacier, Patagonia Icefield, inferred from ALOS/PALSAR data

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Perito Moreno Glacier is one of the most famous carving glaciers in Patagonia icefield, and flows at high velocity of 500m/year. But its continuous and high-resolution observation over wide area hasn't been carried out. Therefore, details of the flow mechanism haven't been clarified.

Synthetic Aperture Radar (SAR) allows us to detect surface deformation at high spatial resolution regardless of sunlight and local weather. In this study, we use radar images acquired by PALSAR onboard ALOS. The purpose of this study is to detect glacier flow of Perito Moreno using pixel offset (feature tracking) technique and to estimate its 3-D flow field.

Several previous studies used SAR data to measure the flow field of Perito Moreno glacier. But these studies needed complementary information other than SAR data (for example, terrain information) to constrain the flow direction. This is because pixel offset provides only two components of range and azimuth direction, which are not able to resolve the 3-D displacements. In this study, we used two data acquired from ascending and descending orbits, and estimated the 3-D displacements without using terrain information.

The inferred flow velocity field showed larger velocity at the central part and upper stream of the glacier. Our result is mostly consistent with previous SAR-based measurement.

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ACC028-03 Room:102 Time:May 24 09:00-09:15

Snow algal community on Urumqi glacier No.1 in the Tien Shan Mountains, China

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Snow algae are cold-tolerant algae growing on snow and ice on glaciers. They can reduce the surface albedo of snow and ice and significantly affect their melting. In addition, snow algae can be used as an indicator of the paleo-environment in ice core research. Thus, it is important to understand the ecology of them. However, ecological information on snow algae is still limited, in particular on glaciers. This research aimed to describe a snow algal community on Urumqi glacier No. 1 in the Tien Shan, China. Two species of green algae and six species of cyanobacteria were observed on the glacier. The algal community structure changed with altitude. Oscillatoriaceae cyanobacteria was dominant in the ice area (3770-4010m a.s.l.) and Chloromonas sp. was dominant in the snow area (4090m a.s.l.). The total algal cell volume biomass also changed with altitude. It decreased rapidly as surface environment shifted from ice area to snow area. However, the biomass did not change in ice area. These are considered to be due to physical and chemical conditions of the glacier surface which continuously changes with altitude. The algal community on Urumqi glacier No. 1 significantly differed from those on other Asian high mountain glaciers. Cyanobacteria dominated in the community on the glacier (90%) whereas green algae dominated those on the other Asian glaciers. Higher pH of Urumqi glacier No. 1 are likely to cause the distinct community structure. This result suggest the existence of a geographical boundary of algal community structures between Altai and Tien Shan, and Tien Shan and Himalaya.

Keywords: snow algae, Cyanobacteria, community structure, altitudinal distribution, geographical boundary, pH

Japan Geoscience Union Meeting 2011
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ACC028-04 Room:102 Time:May 24 09:15-09:30

Glacier Surface Velocity Fields and Spatiotemporal Variation in West Kunlun Shan, China, Detected by ALOS/PALSAR

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The Third Pole Environment (TPE) is centered on the Tibetan Plateau. Average elevation surpass 4000m and a number of Mountain glaciers developed in the Third Pole region. For the people living in arid areas around TPE, these glaciers is crucial for the water source so directly influence on social, agricultural and economic development. It is said that mountain glaciers outside of polar region was affected by global environment changes, especially small glaciers and ice cap in low latitude, and melt water raised sea-level. As index of future water supply, global climate changes and sea-level prediction, spatial and temporal observation for the Third Pole region is important. However, glacier measurement data have been limited because of political and technical issues. Observed area in our study is West Kunlun Shan (WKS) which located north-west of TPE, in China. Previous works are very few in WKS. Ice-core record at Guliya ice cap (Thompson et al. 1995) and snow covered area changes using optical satellite data (Shangguan et al. 2007) was investigated. But the spatial and temporal changes in the surface velocity fields in WKS have not been reported. Recently, remote sensing techniques using Synthetic Aperture Radar (SAR) on board satellite have been drawing attention as an important tool for determining glacier flow (Joughin et al. 1998, 2001, Pritchard et al. 2005).

We detected surface velocity fields of a number of valley glaciers in West Kunlun Shan, using pixel-offset technique based on the ALOS/PALSAR data. The temporal coverage is from 2007 to Jan. 2010 with a nominal time interval of 46 days and the spatial is ˜15000 square kilometers, over 4000m above sea level. In this study, we assumed that glaciers flow parallel to surface topography and glacier flow constantly during period of each observation. Based on these assumptions, we converted the results to daily surface velocity field.

We paid particularly attention to the lower reaches of Duofeng glacier, north side of WKS, from which glacier signals were detected both paths in all seasons. We estimated seasonal variation model using least squares method. In our estimated model, two local maximum existed in summer and winter season. Surface velocity during summer was up to 120-130% above winter background values. Relationship surface melt water and fluctuation of flow speed of glacier and ice-sheet was reported (Bartholomew, I. et al. 2010, Sundal, A.V. et al., 2011). We compared surface temperature (NCEP Operational Data) and seasonal variation. Both maximum peaks moderately corresponded. Despite of seasonal variation, mean surface velocity was slightly and regularly decelerated.

Also, in order to investigate detailed variation, we manually partition the lower reaches of Duofeng glacier to several sections and similarly estimated variation model for each sections. In summer, surface velocity rapidly increased in middle section (5100-5600m a.s.l.) and degreased in terminus section (˜5000m a.s.l.). In winter, on the other hand, surface velocity was maximum in the upper section (over 5700m a.s.l.) and gradually degreased toward terminus.

Keywords: ALOS, PALSAR, feature tracking, mountain glacier, west Kunlun Shan, seasonal variation

Japan Geoscience Union Meeting 2011
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ACC028-05 Room:102 Time:May 24 09:30-09:45

Distribution of debris thickness and its effect on ice melt at Hailuogou Glacier, southeastern Tibetan Plateau

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Debris cover is widely present in glacier ablation areas of the Tibetan Plateau, and its spatial distribution greatly affects glacier melt rates. High resolution in situ debris thickness measurements on Hailuogou Glacier, Mount Gongga, south-eatern Tibetan Plateau, show its pronounced inhomogeneous distribution in space. An analysis of transverse and longitudinal profiles indicates that the ground-surveyed debris thicknesses and ASTER-derived thermal resistances of debris layers correlate strongly over the entire ablation area. Across- and along-glacier patterns of ASTER-derived thermal resistance correspond well with spatial patterns of debris thickness, which may reflect large-scale variations in the extent and thickness of the debris cover. The ice melt rate variability over the ablation area simulated by a surface energy-balance model, in which thermal resistance of the debris layer is taken into account, clearly indicates the crucial role of debris and its spatial continuity in modifying the spatial characteristics of melt rates. Due to the inhomogeneous distribution of debris thickness, about 67% of the ablation area on Hailuogou Glacier has undergone accelerated melting, whereas about 19% of the ablation area where the debris inhibits melting, and only 14% of the ablation area where the sub-debris melt rate equals the bare-ice melt rate.

Keywords: Hailuogou Glacier, debris, ice melt, effect, Tibetan Plateau

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

ACC028-06 Room:102 Time:May 24 09:45-10:00

Temporal elevation changes in glaciers revealed by multi-temporal DEM calibrated with GPS survey in the Langtang, Nepal

Takayuki Nuimura[1*], Koji Fujita[1], Kotaro FUKUI[2], Sachiko Okamoto[1], Shuhei Takenaka[3], Yu Hoshina[1], Satoru Yamaguchi[4], Shin Sugiyama[5], Hiroto Nagai[1], Kenta Tone[5], Hiromu Nishiyama[6], Kousuke Nagai[6], Hiroki Ito[6]

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Existence of a debris mantle makes it difficult to detect temporal changes in glacier area, it is useful to calculate changes in elevation when studying fluctuations in debris-covered glaciers. Therefore, an approach using remotely sensed (RS) digital elevation models (DEMs) is feasible solutions to evaluate how fast Himalayan glaciers are changing. In generally, RS-DEMs include variable kind of errors. Hence, validation and calibration using field measurements data are necessary for accurate estimation of changes in elevation. However, few ground-based observational studies are available, because of remoteness and high altitude.

We compute annual elevation change of glacier surface using multi-temporal RS-DEMs calibrated with differential GPS data which we performed in the Langtang region, Nepal Himalaya. Annual elevation change of glacier surface by generating a weighted least square linear regression model.

Field campaigns are performed with differential GPS (DGPS) in 2008 and 2009. And the DGPS data are converted DEM, and used for calibration and validation of RS-DEMs. RS-DEMs used in this study are topographical map derived DEM in 1992, SRTM DEM in 2000, and ASTER DEMs between 2001 and 2004. We will show the result in presentation.

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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

ACC028-07 Room:102 Time:May 24 10:00-10:15

Recent changes in Himalayan glaciers and inhomogeneous wastage distribution

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A claim in the IPCC report that Himalayan glaciers could disappear by 2035 turned out to be an error. However, it is not clear exactly how fast the Himalayan glaciers are shrinking because of high altitudes and remoteness hampering measurement from the ground. We update volumetric changes by differential GPS surveys for three benchmark glaciers in the Nepal Himalaya whose observations were continued since the 1970s. We reveal that one glacier in arid climate has been continuously shrinking (~500 kg m^{-2} yr^{-1}) while shrinking rates of two glaciers in humid climate have been accelerated (~800 kg m^{-2} yr^{-1}) during the last decade. Mass balance calculations using a energy-mass balance model with downscaled climate datasets shows that equilibrium line altitudes (ELA) of the two glaciers in humid climate are now approaching to the top of glaciers so that they will disappear sooner or later while ELA of the glacier in arid climate is remaining within the glacier. We further calculate ELA trend over the Asian region (25m^o-55^{o}N, 60^o-110^{o}E). The trend map shows that the acceleration or suppression of glacier wastage rates is inhomogeneously distributed over the Asian domain. It implies that we are unable to describe change in Himalayan ice resources with a few examples though it is better than nothing.

Keywords: Himalayas, mass balance, glacier fluctuation, ELA

Japan Geoscience Union Meeting 2011
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ACC028-08 Room:102 Time:May 24 10:15-10:30

Characteristic sensitivity of snow accumulation to temperature change in the arctic glaciers

Shuhei Takahashi[1*], Konosuke Sugiura[2], Takao Kameda[1], Hiroyuki Enomoto[1]

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On the Arctic glaciers, snow accumulation on a glacier almost limited to the beginning and end of winter, because the stable high pressure stays in the winter. Therefore, the snow accumulation depends on the rain/snow period duration and much sensitive to temperature change rather than in mid-latitude area. During the observation at No.31 glacier in Suntar-Khayata, eastern Siberia, from August 2004 to August 2005, the snow accumulation was large in September and May, which agreed with the result of NCEP recalculating analysis.

According to the NCEP data from 1950 to 2009, temperature increased by 1.9oC during this 60-year period. As an example of the arctic glacier, the surface mass balance of No. 31 glacier was calculated. The ELA of No. 31 glacier is about 2350 m in present, and it will increase by150 m when temperature rises by 1oC. If the present warming lasts more next 50-60 years, the ELA will increase to about 2600 m, which is the upper end of the glacier. In this stage, the accumulation area of the glacier will disappear and the glacier tends to decline.

Keywords: Arcitc galciers, snow accumulation, temperature change, Equilibrium Line Altitude, Siberian High

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

ACC028-09 Room:102 Time:May 24 10:45-11:00

Studies on snow redistribution on the Antarctic Ice Sheet with a new blowing snow observation system

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On the Antarctic ice sheet, strong katabatic winds blow throughout the year and large amount of snow is continuously removed. This consists a significant factor in mass and energy balance, and is all the more important when predict the likely effect of global climate change. Further recent experimental work revealed the snow-drift sublimation can lead to significant mass losses during strong winds and can be an important factor in the surface mass balance of the Antarctic ice sheets.

In this study we have started to develop an Automatic Blowing snow station (ABS) by measuring the attenuation of the light intensity, which strongly depends on the blowing snow flux. A small wind turbine and a cold-proof buttery were utilized as a power source. Firstly, its performance was tested with comparing the Snow Particle Counter (SPC) in a cold wind tunnel system. Then, ABSs have been set at Ishikari and Wakkanai in Japan, Col du Lac Blane in France, and S17 near Syowa station in Antarctica. So far, the ABS seems adequately fit for practical use. However, more careful and precise calibrations and field performance tests with SPC throughout a winter are needed. In fact, wind tunnel experiment indicates the output depends on the wind speed; ABS overestimates the mass flux more or less at higher wind speeds.

Keywords: Antarctica, Blowing snow

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

ACC028-10 Room:102 Time:May 24 11:00-11:15

Effects of BC concentration recently measured in snowpack and possible change of snow grain size on albedo reduction

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Drastic melting of snow and ice has been occurring recently in the Arctic and the melting rate is in general higher than predictions by general circulation models (GCM). The one possible reason is black carbon (BC) contained in snow and ice, which could reduce the albedo. However, snow albedo strongly depends not only on light absorbing snow impurities such as BC but also on snow grain size which is associated with temperature increase. Furthermore, the albedo reduction rate per unit concentration of snow impurities depends on snow grain size. On the other hand, many efforts were dedicated to measure the BC concentrations in snowpack or ice core in the Arctic, midlatitudes and Antarctica since 1980s. Using these results we can approximately classify the ranges of BC concentrations in each area as follows: around one ppbw in Antarctica, of the order of 1 ppbw in Greenland, of the order of 10 ppbw in the Arctic except Greenland, and of the order of 100 ppbw in the midlatitudes. According to these values, we estimated the snow albedo reductions due to BC in snow together with the possible range of snow grain size change from new snow to melting snow using a physically based snow albedo model. We found that (1) BC has no effect on albedo reduction in Antarctica, (2) albedo reduction in Greenland due to BC is less than 0.01, (3) BC effect on albedo reduction (0.01-0.05) is smaller than snow grain growth effect (0.15) and it could enhance the albedo reduction when snow grain size increases in the Arctic except Greenland, and (4) BC effect (0.15) is comparable to snow grain growth effect on albedo reduction in the midlatitudes. For more accurate predictions of climate condition in cryosphere, both the effects of light absorbing snow impurities like BC and snow grain growth associated with temperature increase on albedo reduction are needed to be incorporated in GCMs.

Keywords: snow albedo, black carbon, snow grain size, Arctic, Anatarctica

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

ACC028-11 Room:102 Time:May 24 11:15-11:30

Heavy snowfalls in the winter of 2010/2011 as related to the abnormal atmospheric circulation in the Northern Hemisphere

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The snowfall in the winter of 2010/2011 is characterized by the fact that we had abnormally heavy snowfalls in southern regions such as the western part of Fukushima, the Hokuriku region and the San-in region, rather than in Hokkaido. The snowfalls were apparently caused by the atmospheric circulation driven by the pressure patterns in which lows were pushed towards the west of the Seas of Okhotsk or Japan, or placed in the relatively southern latitudes. On inspecting the daily weather charts, it has been found that these pressure patterns were realized by the westward migration of the pressure system in higher latitudes in the Far East region.

Keywords: heavy snowfall, pressure pattern, atmospheric circulation

Japan Geoscience Union Meeting 2011
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ACC028-12 Room:102 Time:May 24 11:30-11:45

Snow accumulation observation in Shiretoko Peninsula by GPR

Go Wakabayashi[1*], Shuhei Takahashi[1]

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Snow accumulation observations by GPR (Ground Penetrating Radar) has been done along a national road transvsal in Shiretoko Peninsula every March since 2005. Since the road is colsed in winter, the GPR on a sledge was pulled by a snow veihcle. The antenna of GPR was 800 MHz and data was logged ever second.

The snow accumulation was measured from a roud-trip time of reflection signal from a road surface. Since the velocity of electro-magnetic wave depends on snow density, the observation of snow density of snow accumulation or the interval measurements of snow depth by a sonde pole were necessary.

Snow accumulation was constant, about 1-2 m, along a raod in the forest area, small in ridge area by snow blown out, and large in valley area by snow drift.

Keywords: Shiretoko Peninsula, Trans Siretoko Road, Snow accumulation, GPR

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

ACC028-13 Room:102 Time:May 24 11:45-12:00

Flow of the ice body in the Gozenzawa perennial snow patch, the Tateyama Mountains, central Japan

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The Gozenzawa perennial snow patch is one of the largest perennial snow patch in Japan. The snow patch is located in the east-facing slope of Mt. Oyama (3003 m), and its width and length are about 700 m and 200 m, respectively. Based on the ice radar surveys in September 2009, we identified a large ice body, which had 30 m in thickness beneath the snow patch. Geodetic surveys of the ice body were conducted to identify the ice body flow. The positions of eleven survey points on the ice body were established in the end of August 2010 by static GPS surveys. Repeated surveys were conducted in early October 2010. The horizontal displacements of four survey points in the lower part of the ice body were between 6 and 30 cm during the survey period. Based on this result, we guessed that the ice body was active glacier.

Keywords: Glacier, Tateyama Mountains, Gozenzawa Perennial snow patch, Flow, GPS survey

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

ACC028-14 Room:102 Time:May 24 12:00-12:15

Snow chemistry at Japan Alps

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When considering the biogeochemical cycle in mountainous regions, it is essential to clarify the temporal and spatial variability of chemical concentrations and the origin of the chemical substances in precipitation. The major origins of chemicals in precipitation are sea salt, crustal material, anthropogenic and biological activity. Study area is located in the central Japan, 3000 m-class mountains are lined with mountain ranges to the Pacific from the Sea of Japan. Snowfall in the Northern Japan Alps (Hida Mountains) is caused by the winter monsoon, and the snow is due to low pressure passing the south of Honshu (Japanese main island) in the Southern Japan Alps (Akaishi Mountains). Yellow sand and the anthropogenic materials are transported in northwesterly winter monsoon from China. Furthermore, the anthropogenic materials from urban areas of west and central Japan are transported by the low pressure passing the south of Honshu. Precipitated chemical materials have been stored without changed in the snow layers before the start of snow melting. We have excavated the snow at multiple locations in the Japan Alps, and the chemistry of snow layer was studied in detail. We will report the results of chemical survey of snow pits in the Japan Alps.

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ACC028-15 Room:102 Time:May 24 12:15-12:30

Experimental study of ice lens formation in granular materials

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Ice lens is formed by the migration and accumulation of unfrozen water. Although the mechanism for ice lens formation has been developed by various theoretical model, the comparison with experiments is not well performed.

We performed the unidirectional freezing experiment for ice lens formation using granular materials. In order for understanding the ice lens formation, granular materials that have uniform properties are favorable over natural soils. Our freezing method is step-wise freezing which means the cooing temperatures are constant. We observed the configuration of ice lens with various particle sizes and cooling temperatures. Also we estimated temperature conditions of ice lens in specific conditions. As a result of experiments, we have obtained clear and systematic relationship between the ice lens and particle sizes and cooling temperatures. Ice lens is formed at farther position from cooling plate in lower cooling temperature and at closer position in higher cooling temperature. We indicate that this trend can be explained by critical freezing velocity for particle exclusion. As for the relationship between the thickness of ice lens and particle size, the ice lens is thicker in smaller particle sizes and thinner in larger particle sizes. This trend is consistent with the particle size dependence of unfrozen water.

Keywords: ice lens, granular materials

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

ACC028-16 Room:102 Time:May 24 12:30-12:45

White spot phenomenon in wet snow on the road

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On the morning of 1 November 2009, many curious white spots of 2 to 8 cm in diameter were found on asphalt roads and asphalt car parks in Kitami city and Oketo town, Hokkaido, Japan. At a first glance, the white spots were made of spherically-gathered snow; however, these spots were formed by scattering of sun light. When one of the authors (T. K.) observed the white spots carefully, he found that two layers existed on the pavement; the ice-water mixture layer of 2 to 3 mm in thickness and a thin water layer of 3 to 5 mm in thickness. Circular air bubbles of 2 to 8 cm in diameter were sporadically distributed between the two layers. Sun light was diffused at the interface between the two layers, and formed the white spots. Although similar spots on the wet snow have observed in Japan1, 2, the formation process of the spots has never been investigated. We will propose a possible formation mechanism in this presentation.

Keywords: white spot phenomenon, wet snow, snow deposition