The big melt of the perennial snow patches and glaciers in the autumn of 2016 in the northern part of the northern Japanese Alps

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1. Tateyama Caldera Sabo Museum

Under the influence of significant little snow in 2015/2016 winter, the perennial snow patches and glaciers in the northern Japanese Alps melted remarkably in 2016 autumn. We report the area and thickness of the Tsurugisawa, Shirouma and Kuranosuke snow patches and Gozenzawa glacier in 2016 autumn based on field observation, aerial photos analysis and ground penetrating radar soundings.

Keywords: glacier, perennial snow patch, the northern Japanese Alps, unmanned aerial vehicle, ground penetrating radar

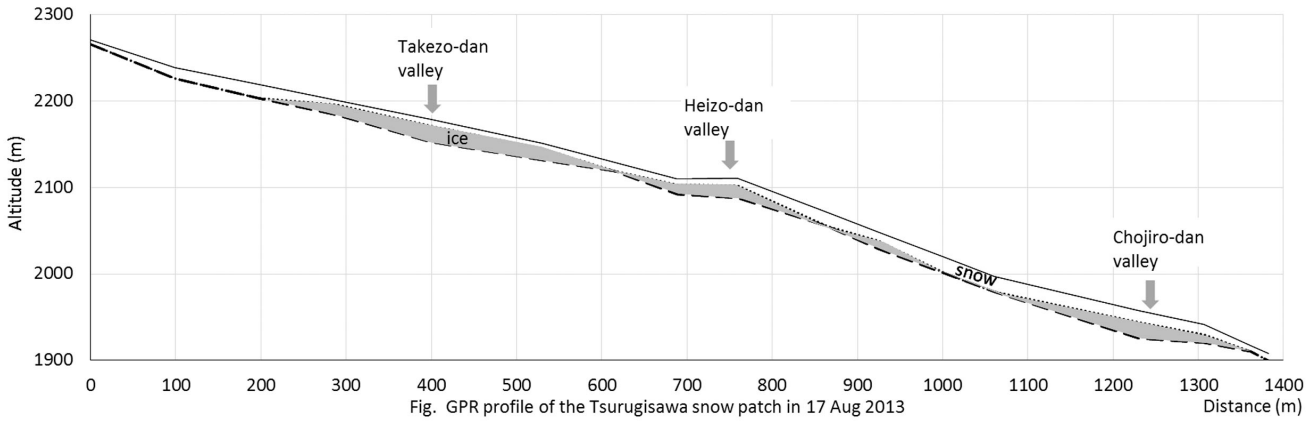

Fig. GPR profile of the Tsurugisawa snow patch in 17 Aug 2013

Annual mass balance and geomorphological condition of glacier and snow patch in the northern Japanese Alps.

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In the Gozensawa, Komado, and Sannomado Glaciers and Kakunesato-sekkei, Kuranosuke-sekkei and Hakuba-daissekei in the Northern Japanese Alps, we investigated annual mass balance using DSMs (Degital Surface Models) produced by aerial degital images (Oct 2015, March 2016 and Sep 2016) and SfM-MVS softwear. Maximum snow depth is 18.8 m in Sannomado Glacier, and minimum snow depth is 7.6 m in Kakunesato-sekkei. According to the statistical analysis of topographic elements in drainage basin, the maximum elevation of drainage basin is the most important element for the glacier and snow patche development.

Keywords: glacier, snow patch, annual mass balance, the Northern Japanese Alps

Response of surface runoff to rainfall and snowmelt in the Mt. Norikura alpine area

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In this paper, we present the spatiotemporal variations in physical and chemical characteristics of surface runoff due to rainfall and snowmelt in the Mt. Norikura alpine region, northern Japanese Alps. This investigation was conducted from June 22, 2016 to October 13, 2016.
In addition to a water quality investigation, rainfall investigation with a rain gauge was conducted. Despite discuss the potential of surface runoff generation. We used the method of API (antecedent precipitation index) for discuss the potential of surface runoff generation. Result from rain gauge data, we quantify tendency transition from base flow to direct flow. Consequently, we achieved quantitative assessments of surface runoff using API, and became able to grasp the presence of direct flow.
During the late period of melting season, we were not able to observe the surface runoff at some of investigation points. Despite during a non-rainfall period, surface runoff is observed every time at one investigation point only (elevation 2550 m a.s.l). This observation suggest that snow patch stably supply below a ground water quality locally.
From the results obtained in water quality investigation, it was found that HCO_3^- concentration of spring water is higher than that of melt water of snow patch.
The pH, electric conductivity and HCO_3^- concentration surface runoff were changed during flow event following rain. After it started raining, immediately these values rose and declined within a few hours. Afterwards, these values tend to gradually rose with declining water level.

Keywords: antecedent precipitation index, snow patch, ground water

Heat Balance Analysis during the Snow Covered Season in the Alpine Area

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This study investigates the characteristics of snowmelt in Norikura highland using heat balance method to calculate the amount of snowmelt and ablation process of snow cover. Since, snowmelt varies according to regions this study is vital in showing the various features of snowmelt in different environment; climate, vegetation and snowmelt seasons.Meteorological observation station was installed on the site of Norikura highland located at 1590 m. a. s. l. and heat balance analysis was carried out on the snow surface during the snow cover seasons. The following meteorological data were obtained: air temperature, related humidity, wind speed, atmospheric pressure, precipitation, net shortwave radiation, net longwave radiation and snow depth. Heat balance was used to analyze the energy budget and the turbulent flux on a snow surface for the four snow cover seasons.The result showed that multi-year datasets of meteorological observation had some characteristics like low air temperature, weak wind speed and low vapor pressure. Throughout each snow covered seasons: net radiation offered almost 100-110 % energy ratio to the total snowmelt energy, sensible heat flux occupied 10-15 % of energy and latent heat did about -20 % respectively. Days were classified into rainy hours or not rainy hours and the result showed that the former net shortwave radiation decreased to about 20-30 W m^{-2} while net longwave radiation increased to about 40-50 W m^{-2}. In addition, latent heat and sensible heat also increased to about 2-3 W m^{-2} and 11-13 W m^{-2} respectively. However, conducted heat from rain is little and consequently when it rains larger snowmelt energy was offered. In late snowmelt season, the measured volumes of melt water equivalent with the result of heat balance method were compared. Each method of snowmelt water equivalent was almost corresponding. In conclusion, meteorological features in this site showed specific snowmelt properties. Low temperature, low vapor pressure and weak wind speed caused small turbulent heat flux which shows that net radiation controlled the snowmelt process in this site. More snowmelt energy was supplied when it rained because, the cloud strengthens the downward longwave radiation, atmospheric temperature and vapor pressure is increased. Finally, appropriate policy suggestions were highlighted.

Keywords: heat balance analysis, snowmelt, meteorological observation

Extreme Low Temperature in the Snow Covered Season at Kamikochi

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Meteorological element, especially temperature is an essential factor for many field studies. It is more important in mountain regions than lowlands because of complex terrain which makes spatial temperature variation complicated. So we have been conducted high-resolution weather observation since 2011 in Kamikochi-Yari-Hotaka Region, Central Japan Alps, to reveal vertical distribution of air temperature. The result of this observation showed that cold air pools formation occurs frequently and extreme low temperature appears occasionally in wintertime at Kamikochi. In this study, condition and cause of extreme cold events were discussed particularly associated with snow cover. The number of days that minimum temperature became lower than -18℃ (defined as “extreme low temperature” in this study) occupied 10 percent during snow covered seasons. The most coldest cases, which were below -23℃ minimum temperature only appeared within 3 days after latest snowfall events. Strong cold air pools also occurred intensively within 1.5 to 3 days. These may be why cooling effects of new snow such as snow-albedo feedback persist in few days, though these effects were lost with time passes and snow melts. Almost all cold air pools were nocturnal ones which formed and collapsed within one night, and positive relationship between duration and intensity was shown for these cases. However, there were few cases of persistent cold air pools that lasted for several days. These ones formed only in specific synoptic weather condition that was connected with advective temperature inversion.

Keywords: Cold Air pool, Snow Cover, Alpine Area

Observation of snow cover glide on Sub-Alpine Coniferous Forests in Mount Zao, Northeastern Japan

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This is the study to clarify the snow cover glide behavior in the sub-alpine coniferous forests on Mount Zao, Northeastern Japan, in the winter of 2014-2015. We installed the glide-meter which is sled type, and measured the glide motion on the slope of *Abies mariesii* forest and its surrounding slope. In addition, we observed the air temperature, snow depth, density of snow, and snow temperature to discuss relationship between weather conditions and glide occurrence.
The snow cover of the 2014-15 winter started on November 13 and disappeared on April 21. The maximum snow depth was 242 cm thick, it was recorded at February 1. The snow cover glide in the surrounding slope was occurred first at February 10, although maximum snow depth recorded on February 1. The glide motion in the surrounding slope was continuing and its velocity was 0.4 cm per day. The glide in the surrounding slope stopped at March 16. The cumulative amount of the glide was 21.1 cm. The snow cover glide in the *A. mariesii* forest was even later occurred first at 21 February. The glide motion of it was intermittent and extremely small.

Keywords: snow cover glide, snow depth, snow water equivalent, Abies mariesii, sub-alpine zone, Zao

Distribution change of the mountainous peaty wetlands in Japan.

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Today, it is worried about a vegetation change with the global warming. We examined distribution change of the mountainous wetlands in wide-area of Japan. We chose 24 wetlands to the study site in Kinki, Chubu, Kanto and Tohoku. We compared the area of wetland in old and new aerial photos to clarify a change of the vegetation, at that area. As a result, area of all wetlands has been decreasing. And results vegetation survey, the Sasa kurilensis and Pinus pumila was invading to the wetland and it reduced the area of wetland. Then, we analyzed weather data measured on the study site or near by, and examined the association with the vegetation change. As a result, it is thought that a decrease in snow-cover period is the main factor of the vegetation change. Because, mountainous wetlands vegetation are having a growth limitation by snow cover period, and this snow cover periods were reduced at almost site. In other hand, the summer temperature was not increasing at almost site.

Keywords: peaty wetlands, Sasa kurilensis , Pinus pumila, warmth index, snow, climate change

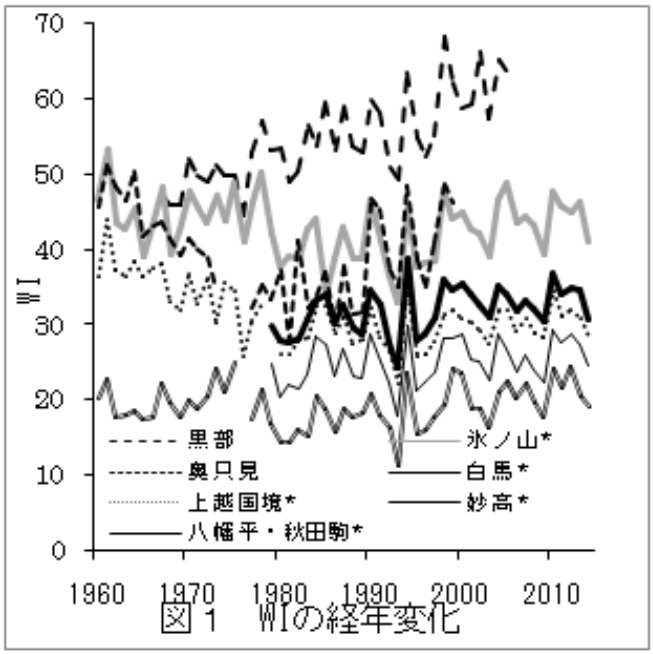

図１　WIの経年変化

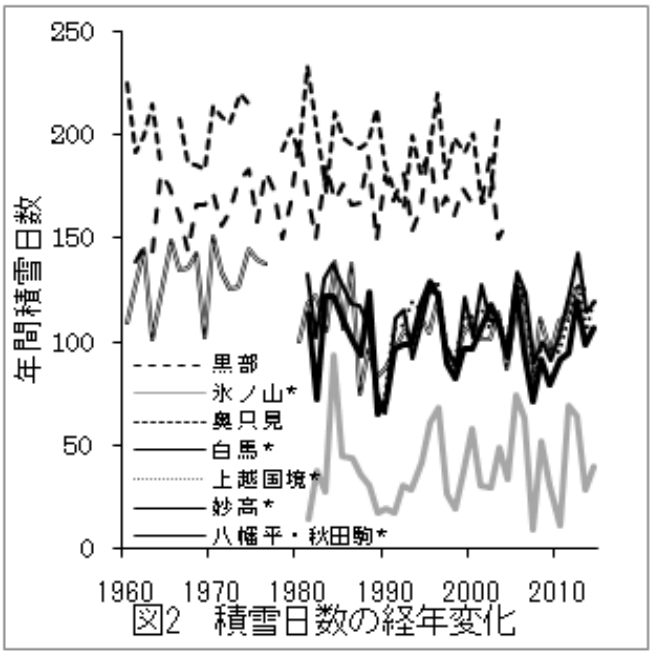

図2　積雪日数の経年変化

Annual variations in snowmelt timing and phenology of green-up and autumnal color for alpine plants at Tateyama Murodo and Senjojiki

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Introduction: In alpine ecosystems existing isolated under severe cold climate, due to recent accelerated global warming, changes in their habitat and phenology, such as green-up, flowering, autumnal leaf color and fall, have been reported. In addition, because of different environmental responses, mismatch of life cycles occurs between plants and insects or animals. Alpine ecosystems are particularly vulnerable to the effect of climate change, and the necessity for monitoring of alpine ecosystems is recognized. The snow fall and snow melt are the key factors for the growth of alpine plants in Japanese alpine zone. We have launched continuous monitoring of snowmelt timing and vegetation phenology in Japanese alpine ecosystems by using automatic time-lapse camera. In this present study, our objectives are to derive the spatial and temporal variations of both snowmelt timing and phenology at a local scale by means of image analysis. And then we investigate and clarify the relationships of the phenology and meteorological factors.
Methods: We set up time-lapse cameras at Tateyama Murodo (2450m a.s.l) in Japanese Northern Alps and at Senjoujiki (2650m a.s.l) in Japanese Central Alps. About 18000 and 11000 images captured with each camera, respectively, were used for analysis. RGB digital counts were derived from each pixel within JPG format images. The snow-cover and snow-free pixels were statistically classified, spatial and temporal patterns of snowmelt were investigated. For further quantitative assessment for the phenology of green-up and autumnal leaf and the brightness of autumn leaf color, time-series of the ratios of Green and Red against the sum of RGB were calculated, respectively, as indices for greenness and redness, within the areas of two specific alpine plants (*Sorbus matsumurana* and *Betula ermanii*) captured in images.
Results: During the winter season in 2015-2016, as snowfall was the least in these few years and the temperature was relatively high, the snowmelt timings were approximately 22 and 38 days faster than usual, respectively, at Murodo and Srnjojiki. The fastest snowmelt attributed the fastest green-up dates and the longest growing periods among these few years. The annual variations of autumnal leaf color timing were usually strongly correlated to the average temperature during late August to mid-September, however that in 2016 was irregularly faster despite high temperature. Therefore, we predicted the autumnal leaf timing by a regression formula with green-up date in addition to average temperature for explanatory factors, taking account of leaf longevity. The brightness of the autumnal color was relatively lower in 2016 at both sites. We found the relationships between annual variations of the brightness and the amount of solar radiation during summer and also large decline in minimum temperature in September. Monitoring alpine ecosystems using time-lapse cameras allowed us to track the snowmelt timings and plants phenology at high temporal and spatial resolutions, and to compare them quantitatively at multiple sites and times as well. Further research using meteorological data will make progress in assessment of affects and prediction of phenology under future climate change.

Keywords: Time-lapse camera, Image analysis, RGB, Leaf longevity, Brightness of autumnal leaf color

Spatial and temporal variations of subalpine coniferous (*Abies mariesii*) forest distribution during the past 2,500 years in Mt. Hachimantai and Akita-Komagatake, NE Japan

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This study aimed at clarifying the trends of *Abies mariesii* distribution and the environmental factors that determine moisture conditions in wet meadows, such as landform, and surface geology. Further, it aimed to discuss the factors underlying the difference in distribution of *A. mariesii* forests between the subalpine (Mt. Hachimantai) and the pseudo-alpine zone (Mt. Akita-Komagatake).
In Mt. Hachimantai, the landform consisted of volcanic original surface (angle: 1-10˚), dissected slope (angle: >10˚). This area had a high percentage and density of wet meadow distribution. Thick *A. mariesii* forest tended to be distributed around wet meadows on volcanic original surface. Surface geology survey revealed that loam layers composed of clay were present in all the sites. *A. mariesii* forest area in the southern part was narrower than that in the northern part. According to pollen analysis, *Abies* pollen started to occur approximately 2,500 years ago in the northern part and landslide area, and approximately 1,000 years ago in the southern part (Morita, 1985).
In Mt. Akita-Komagatake, the landform was similar to that of Mt. Hachimantai. Wet meadow distribution in the northern part was similar to that in Mt. Hachimantai in terms of density of wet meadow distribution. In the southern part, the percentage of wet meadows was extremely low. The thickest *A. mariesii* forest in either part of Mt. Akita-Komagatake was narrower than that in Mt. Hachimantai. Scoria and pumice composed of granule gravel characterized the surface geology of the southern part. According to pollen analysis, *Abies* pollen started to occur approximately 1,000 years ago in the northern part, and approximately 2,500 years ago in southern part (Morita, 1985; Ikeda, 2002).
Evidently, it can be concluded that the present distribution of *A. mariesii* forest has been determined by the starting time and the speed of expansion of *A. mariesii* forests, which are affected by environmental conditions such as wet meadows.

Keywords: Abies mariesii forest, Subalpine zone, Spatial and temporal variations, Mt. Hachimantai, Mt. Akita-Komagatake

Chemical composition of snow cover and vegetation damage caused by volcanic gas in Jigoku-dani, Mt. Tateyama

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Volcanic activity has increased in Jigoku-dani, Mt. Tateyama, since the Great Eastern Japan Earthquake in March 2011, and so has the amount of HCl and SO_2 contained in volcanic gas collected there. This makes necessary careful surveillance throughout the year, but the severe climate hinders it in winter. In this study we analyzed the chemical composition of snow in Jigoku-dani for two purposes; (1) to infer the volcanic activities during the winter months, and (2) to estimate the damage to plants by volcanic gas components.
The results of our analysis of the major chemical components and isotope ratio of the samples of snow collected at several points in the study area between 2013 and 2016, along with the elution experiment on alpine plants collected in 2016, are summarized as follows.
1) By (i) estimating the time of snowfall from the d-excess of snow cover, and (ii) comparing the volcanic gas component in snow with minute changes in the altitude of the mountain, it was possible to trace the past volcanic activities in winter.
2) The pH of the snow around the fumaroles during the years 2013-2015 ranged from 2.85 to 4.93. The closer to the fumaroles, the more acidic the snow was. Because nss-Cl- accounted for about 90% of $[H^+]$ in 2013 and 2014, it is inferred that nss-Cl^- from volcanic gas strongly contributes to the acidification of snow cover. In 2015, the contribution of nss-Cl^- decreased and its vertical distribution also changed. This is attributed to elution of ingredients due the melting of snow. nss-SO_4^{2-} measurements remained between 3.1 −5.0% over the three years, and little variation was observed across the layers of the snow.
3) Comparing the $[SO_4^{2-}]$ and $[Cl^-]$ on snow surface, the concentration of SO_4^{2-} was higher than that of Cl^- and it was speculated that Cl^- rapidly eluted with the melting of snow and SO_4^{2-} eluted gradually.
In conclusion, it is suggested that nss-Cl^- leads to strong acidification of the environment, including the snow cover.

Keywords: volcanic gas, snow, vegetation, Jigoku-dani, Mt. Tateyama

Elucidation of the relationship between glacier melting water and water resources of mountain foothills using isotopic altitude effect in Mt.Kenya

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Mt. Kenya(5199 m) has a glacier on its top despite being on the equator. However, the glaciers of Mt. Kenya have been shrinking by recent global climate change, which is causing changes in the local ecosystems. In the area around Mt. Kenya, the rainfall can’ t stably supply water to farmland and daily life because the precipitation is less and its fluctuation is large. Coffee, tea, roses and so on have been produced by the availability of ground water derived from the mountain body in this area. However, the degree of the contribution of glacial melt water to the water environment of the area around Mt. Kenya has not been made clear.

The purpose of this study is to elucidate the condition of water environments of Mt. Kenya, assess the degree of the contribution of glacial melt water to the groundwater in Mt. Kenya and, ultimately, to estimate the impact of the ongoing reduction of the glaciers on the water environments in the local area. The sampling of glacial ice, spring water, river water, and rain water was done in the alpine and moorland areas(>3000m a.s.l.), and the sampling of river water was done in the foot areas(<3000m a.s.l.)in Mt. Kenya. The oxygen and hydrogen stable isotope ratios of these water samples were analyzed to confirm the altitude of source of both river water and spring water sampled in mountain foot(2000m a.s.l). I brought these samples back to Japan and measured oxygen and hydrogen isotope ratios.

We can figure out the high altitude effect that the higher-altitude rainfall of mountain indicates lower oxygen isotope ratio, from the oxygen isotope ratio of the rainfall sample in Mt.Kenya.
By the calculation of this high altitude effect, we were able to estimate altitude of source of spring and river water that are used at mountain foot. The oxygen isotope ratio of Thigedi river (altitude:1997m) was -3.089 ‰. I assign this value to the high altitude effect line (y = -469.35x +3630.4), it becomes 5080.2 (m). This altitude area is covered with glacier and a lot of snow. Therefore, these results suggest that the foot river water is more likely to receive the melting water of glacier and snow. On the other hand, the estimate of altitude of spring water (altitude: 1997m) is 5191.8 (m). It is suggested that a glacier and the snowfall of the mountaintop part greatly contribute to the spring of a mountain foot.

From the data of water level (1985 - 2016) of Naromoru River , it was confirmed that the amount of river water in the mountain foot tends to decrease. On the other hand, the rainfall in the high altitude zone does not show a large decreasing trend. Therefore, the decrease of the river water level at the mountain foot is considered to be affected by the recent rapid decrease of the glacier melting water.
Tritium, CFCs and oxygen isotope were also analyzed. The result of analysis indicates that it take 40-60 years since water of glacial area around 5000m in altitude was absorbed in the body of Mt. Kenya until it comes out as spring water in the mountain foot. The area of 5000m of Mt. Kenya had large glaciers 40-60 years ago. These results mean that the past (40-60 years ago) glacial melt water has come out to the present foot area. Consequently, the present glacial reduction of Mt. Kenya suggests that water volume of the foot area will decline in the future. It is expected that this decrease of water resource greatly affect the local agriculture and daily life in near future.

Keywords: East Africa, Glacier reduction, Water environment, Stable isotope

Utilizing new special information techniques based on the understanding of mountain science

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The brittleness of Japanese mountain has long been pointed that causes significant difficulties in forecasting sediment disasters in the mountain area. Abundant ground water brought by the pluvial climate and the brittle bedrocks occasionally cause serious sediment disasters such as deep-seated landslide. At the same time, it underlies the tremendous biodiversity of Japanese mountains. Understanding the both diversities of ecosystem and subsurface environment in Japanese mountains will be a critical important subject to utilization and conservation of Japanese mountains based on understanding its nature. The high spatial resolution vegetation and terrain data produced by the new sensing technologies such as airborne LiDAR and the visualization techniques will bring about great progress in this new field.

Keywords: microlandform, high resolution DEM, mountain science

Glacial Retreat and Global Warming in Relation to Vegetation Succession in Mt. Kenya and the Bolivia Andes

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1. Glacial retreat and vegetation succession in relation to recent global warming in Mt. Kenya

Although the Tyndall Glacier retreated at an average rate of ca. 2.9 m year^{-1} from 1958 to 1997, the rate increased to 9.8 m year^{-1} from 1997 to 2002, 14.8 m year^{-1} from 2002 to 2006, 8.2 m year^{-1} from 2006 to 2011, and 11.0 m year^{-1} from 2011 to 2016. The pioneer species such as *Senecio keniophytum* and *Arabis alpina* to establish after glacial retreat, advanced at a rate similar to that of glacial retreat. The distributions of lichens, mosses, and *Agrostis trachyphylla* also advanced. Since 1997, these species advanced at a faster rate than years past as the glacier retreated.

Both the number of plant clumps and the proportion of vegetation cover in the permanent plot (80m x 20m), established in 1996 near the edge of the glacier, increased significantly between 1996 and 2011. The values of both were also higher at a distance of 16–18 m from the glacier edge than at 0–14 m away in 1996. This indicates that the distance from the glacier edge affects both the number of plant clumps and the proportion of vegetation cover in areas of recent deglaciation. Many seedlings of *Senecio keniophytum* were likely produced 5–6 years after deglaciation, as the rate of glacial retreat from 1984 to 1996 was 2.9 m year^{-1}. However, this effect of distance from the glacier edge was not verified in areas where deglaciation exceeded 15 years.

Monthly mean minimum and maximum temperature increased by >2˚C during the 48-year from 1958 to 2011. In contrast, precipitation did not significantly decline during the 55-yr period starting in 1956, although annual fluctuations did occur. The rate of retreat of Tyndall Glacier could be explained by the increases in monthly mean minimum temperature at 4500 m a.s.l. around the study area. The movement of *Senecio keniophytum*, as well as that of *Arabis alpina* to some degree, could be explained by the rate of glacial retreat.

Although *Helichrysum citrispinum* had not grown at altitudes higher than the Tyndall Tarn (4470 m) prior to 2006, 32 clumps of this species were identified on lateral moraines above 4470 m in 2009. I postulate that their range expansions may not be directly related to glacial retreat; rather, their advance to upper slopes may be linked to increases in air temperature. The expansion of *Helichrysum citrispinum* was likely favored by the increment of about 1˚C during the growing season from March to September of 2009.

2. Environmental conditions affecting the vegetation around Tyndall Glacier

Movement of the leading edges of *Senecio keniodendron* and *Lobelia telekii*, common large woody rosette plants, appeared to be unrelated to glacial retreat until 1997; since then, however, these species have advanced upslope. The succession of these species does not appear to be directly related to glacial retreat but may instead be linked to soil development brought by the advancing pioneer species, stability of land surface, and increasing temperature.

3. Glacial recession and vegetation succession in Cerro Charquini of Bolivia Andes

The moraines and their vegetation were surveyed in the West Cirque of Cerro Charquini, Bolivia Andes (Cordillera Real) in 2012-14. The moraines in the West Cirque of Cerro Charquini are classified in Moraine 1 to 10 by Rabatel (2005). The five permanent plots (10 m x 10 m) were established at Moraine 2 (1700±12), Moraine 3 (1739±12), Moraine 6 (1791±10), and Moraine 9 (1873±9) dated by Rabatel (2005), and Moraine 11 without date. The vegetation distribution and the size distribution of debris covering land surface were investigated at each plot (2 m x 2 m) in the permanent plot. The vegetation close to the glacial edge was also surveyed. The date of Moraine 11 was estimated to 1970’s.

The newer the moraine, the size of debris covering land surface become larger, and the number of plant species and the proportion of vegetation cover in the plot become lower. The altitude of present end of glacier is 4990 m. The species growing near the margin of glacier are limited to *Perezia* sp. (*Perezia multiflora* ?), *Deyeuxia chrysantha*, and *Senecio rufescens*. They grow by the large rocks and their vegetation coverage is very low.

Keywords: global warming, glacial retreat, vegetaion succession, tropical high mountain

Characteristics of the basin topography of glacial lake: a case of the Bhutan Himalayas

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This presentation will introduce the characteristics and its topographical implication of glacial lake in The Bhutan Himalayas, based on a research and international cooperation project in 2009 –2012. The project title is ‘Study on Glacial Lake Outburst Floods in the Bhutan Himalayas’ (Principal Investigator: Prof. Nishimura, K., Nagoya University).
These surveyed lakes have deepest part at upper lake basin (opposite side of outlet part). In addition, some bathymetric map show ridge-like topography which is submerged end-moraine. This presentation will highlight a comparison of these bottom topography and surrounded land shape, and discuss the determination of the GLOF risk.

Keywords: bathymetric survey, mountain glacier, moraine, hazard assessment, global warming, GLOF

The distribution of rockfall and topographical change in Shirouma Daisekkei, the Northern Japanese Alps

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Shirouma-Daisekkei is one of the three largest snow patches in the Japanese Alps. More than 10,000 climbers pass on the snow patch every year. On the other hand, the rockfall accident at Shirouma-Daisekkei is the largest number of mountaineering accidents except for the slipping down accidents that occurred in 1992 - 2013 in the mountains of Japan. In August 2005, rock slip at the rock wall of Shakushi-dake causes injured two people, and also in August 2008, rock slip at upper part of snow patch causes two climbers sacrificed (Kariya et al. 2008). In this study, we carried out field survey 2014 - 2016 for the purpose of investigating the actual condition of rockfall and rock slip, and the topographical change around Shirouma-Daisekkei.
From the interval camera set up from July to August of 2014 images, the boulders produced from the rock wall onto the snow patch was slight, and most of the boulders scattered innumerably on the snow patch were melted from the inside of snow patch. In 2015, there were more snow than usual, and melting line did not reach the surface of the snow rice at the end of the previous year's melting, so there were few boulders melted from the inside of the snow patch. Focusing on the surface inclination angle obtained from the 50 cm resolution DEM prepared using UAV aerial photographs, the gentle slope and the steep slope are alternately present in the Shirouma-Daisekkei main stream, and re-rolling and re-sliding of a lot of boulders was confirmed from the interval imaging to the steep slope. When erosion zones were extracted from the difference of airborne laser data DEM of plural years, there was a difference in erosion pattern depend on geology. In the geologic region of the felsic rocks, erosion (linear type) along the valley was observed in many cases. However, in the ultramafic rock and the felsic tuff, such features were not observed, and the surface erosion was unity. In addition, due to GPR investigation and distribution of crevasses, the location of the stream at the bottom of the snow patch and a huge tunnel were revealed.

Keywords: rockfall, Shirouma-Daisekkei, topographical change, ice radar, UAV

Development of paleolakes related to landslide activities in the late Pleistocene epoch on the eastern foot of Mount Kushigata, the Koma Mountains in central Japan

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A north-south strike elongated depression 5 km long and 1-1.5 km wide is present on the eastern piedmont of Mount Kushigata, west of the kofu basin in central Japan. This depression is filled by older landslide deposits formed in the middle Pleistocene epoch. The older landslide deposits are covered with thick lacustrine sediments consisting of peat and silt, bearing On-Pm1 (100 ka) and On-In (90 ka) pumice layers. Stratigraphy, petrography, lithofacies, and the result of pollen analysis of the lacustrine sediments reveal the historical development of paleolakes on the older landslide bodies. The lacustrine sediments are seen at several outcrop localities with different altitudes in the depression, suggesting the presence of several lakes or ponds. The water bodies were formed initially during from Marine Isotope Stage 6 to 5d (185-110 ka) and had persisted for ten thousand or a few tens of thousands years. The paleolakes were buried by the younger landslide deposits after 90 ka. The historical development of the depression and paleolakes would be related to large-scale gravitatiolal slope deformation of Mount Kushigata as well as the displacement of Ichinose fault located between Mount Kushigata and the Kofu basin.

Keywords: Landslide, Lacustrine sediments, Tephrochronology, Pollen analysis, On-Pm1 tephra, On-In tephra

Application of Quaternary organic sediments filling landslide-induced depressions to paleoenvironmental and paleoecological studies in the Japanese Alps

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Pleistocene and Holocene paleoenvironments of the Japanese high mountains have not always been understood. This is because, appropriate deposits including macro-micro plant fossils and datum beds such as tephras are tend to be eroded on mountain slopes. Erosion rate in the Japanese high mountains is quite faster than the world average values. Under these circumstances, landslide-induced closed and semi-closed depressions on ridge-top or valley side slopes provide effective opportunities for better understanding of the Quaternary environmental changes in high mountains. Those depressions are often filled by organic-rich sediments that can be used for ^{14}C dating and bear plant fossils and tephras. The Japanese high mountains are prone to form landslide-induced depressions as high relief terrains, high precipitation, high activities of earthquake and volcanism, complex geological settings, and high uplift rate.
Here, we will demonstrate some examples of geomorphic features, distributions, and historical developments of landslide-induced depressions particularly those in the Japanese Alps in central Japan. We also show geologic and chronological evidences of organic-rich sediments in the depressions. In addition, we show a method of drilling and excavation on depressions using portable instruments. The areas introduced are Mts. Asahi-dake, Shirouma-dake, Eboshi-dake, Tsugaike Plateau, Takamagahara basin, Kamikochi Valley, and so on. We will discuss and share the efficacy and future possibility of organic-rich sediments in landslide-induced depressions for integrated studies of environmental changes in the Japanese high mountains.

Keywords: deep-seated gravitational slope deformation, landslide, Quaternary sciences, alpine-subalpine zones

Large-scale bedrock landslides in Japanese Alps: an implication to the influence of climate change in shaping mountainous landscapes

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Several recent heavy rainfall events in Japan reveal the sensitive nature of deep-seated landslide occurrence to rainfall anomaly, which invokes potential influence of both of natural and anthropogenic climate change on such catastrophic mass movements in mountainous terrains. A combination of river incision under long-term tectonic activity and episodic deep-seated landsliding by climate forcing may progress the mountainous landscape evolution. The present study attempts to verify the role of climate change in shaping the mountainous landscapes by dating of paleo bedrock landslides using terrestrial cosmogenic nuclide ^{10}Be in Japanese Alps. Samples for exposure dating were collected from top of a boulder on landslide deposits or bare rock slip surface exposed since the landslide. Effect of snow shielding on nuclide production were corrected for accurate determination of exposure ages, and the correction procedure was calibrated by ^{14}C dating for some deposits yielded by the identical landslide event. The ages of landslide deposits concentrated in Holocene epoch especially at just after the Termination I (transition from the last glacial to present interglacial stage) and also recent period during the last 3 kyr. These results imply that climate change has potentially instigated the landslide occurrence and thus contributed to form and maintain bedrock dominated steep topography adjacent to incised valleys in mountainous ranges.

Keywords: deep-seated bedrock landslide, exposure dating, river incision, glacial-interglacial cycles, quasi dynamic equilibrium, landscape evolution

