INTERNATIONAL WORKSHOP OF FALLING SNOW AND SNOW COVER

Abstracts

≪Date≫

January 31,2017 - February 1,2017

≪Place≫

Machinaka campus nagaoka
The 5th floor interchange room
（http://www.machicam.jp/)

NIED
National Research Institute for Earth Science and Disaster Resilience
Snow and Ice Research Center
National Research Institute for Earth Scienceand Disaster Resilience

International Workshop of falling snow and snow cover

Program

≪2017/01/31≫

Session 1: Falling snow

(13:00 – 15:00) ***Chairman : Akihiro Hashimoto***

An observation system for detection of local severe snowstorm causing snow-related disaster.
Katsuya Yamashita (National Research Institute for Earth Science and Disaster Resilience)

Radar estimation of solid precipitation intensity: A disdrometer-reference method and problems
Sento Nakai (National Research Institute for Earth Science and Disaster Resilience)

On empirical parameterizations of characteristics of falling snow particles and its applications.
Hiroki Motoyoshi (National Research Institute for Earth Science and Disaster Resilience)

Empirical Relationships for Estimating Liquid Water Fraction of Melting Snowflakes
Ryohei Mishumi *(National Research Institute for Earth Science and Disaster Resilience)*

Break (15:00 – 15:30)

Session 2: For linking falling snow and snow cover

(15:30 – 17:30) ***Chairman : Sento Nakai***

Acquisition of snowfall characters, and their relationships with density of newly fallen snow, for snowpack modeling applications
Masaaki Ishizaka (National Research Institute for Earth Science and Disaster Resilience)

Measurement of Specific Surface Area of falling snow for description of falling snow properties
Satoru Yamaguchi (National Research Institute for Earth Science and Disaster Resilience)

Application of cloud microphysics model to estimation of snowpack parameters.
Akihiro Hashimoto (Meteorological Research Institute)

Modeling of falling snow properties for snowpack models: towards a better link between falling snow and snow on the ground
Vincent Vionnet (Meteo France)

≪2017/02/01≫

Session 3: Snow cover

(09:10 – 11:40) ***Chairman : Katsuya Yamashita***

Relationship between preferential flow in snow cover with meteorological condition based on observation data of Multi-Compartment-Lysimeter
Satoru Yamaguchi (National Research Institute for Earth Science and Disaster Resilience)

Simulation of heterogeneous liquid water movement in the snowpack considering preferential flow.
Hiroyuki Hirashima (National Research Institute for Earth Science and Disaster Resilience)

Development of the NHM-SMAP regional climate model for polar regions
Masashi Niwano (Meteorological Research Institute)

Snowpack modeling in the French mountains driven by short-range high-resolution weather forecasts
Vincent Vionnet (Meteo France)

General Discussion

(11:40 – 12:00)

An observation system for detection of local severe snowstorm causing snow-related disaster

Katsuya Yamashita[1), Sento Nakai[1), Hiroki Motoyoshi[1)

1) Snow and Ice Research Center, National Research Institute for Earth Science and Disaster Resilience, Nagaoka, 940-0821 Japan

Abstract

The uncertainty of the quantitative precipitation estimation for the solid precipitation from the observation of a weather radar is large in the current state due to various assumption such as the constant snow crystal types and the constant size distribution. It is needed that the algorithm to estimate the distribution of the solid precipitation intensity at the surface using the relation between equivalent radar reflectivity and precipitation intensity for some solid precipitation types, such as graupel and aggregates. In order to accurately estimate for solid precipitation within the observation range of a weather radar, we have been developing the observation system for local severe snowfall at Niigata prefecture, a heavy snowfall area in Japan. This observation network system is composed of X-band polarimetric Doppler radar installed on the roof of Snow and Ice Research Center and six ground observation sites established within the observation range of the weather radar. The ground observation sites are installed with an active and passive remote sensing and in situ instruments. This system can measure the precipitation intensity and precipitation particle type at the ground observation sites and can estimate the exact precipitation intensity within the view of the weather radar using the measured information of precipitation particles by the ground observations. The overview of the observation system for severe snowfall, and the preliminary results will be presented in the presentation.

Radar estimation of solid precipitation intensity: A disdrometer-reference method and problems

Sento Nakai [1)]

1) Snow and Ice Research Center, National Research Institute for Earth Science and Disaster Resilience

Abstract

Estimating precipitation rate (R) quantitatively from radar reflectivity factor (horizontal) Zh is a long-standing problem. The Zh-R relation varies depending on the kind of solid precipitation particles, wet/dry, and raindrop size distribution. The variations are corrected taking account of moments of polarimetric radar observations as well as surface precipitation observations. However, surface precipitation gauges suffer from various error sources, such as wind-induced catch loss, especially for solid precipitation. We are developing a quantitative precipitation estimation (QPE) method referring to disdrometer observations. Hydrometeor classification is performed referring to solid precipitation type decided from disdrometer measurement. Then, the type is considered in the adaptive Zh-R equation. Radar-disdrometer simultaneous observation has been conducted for several winter seasons. The real-time QPE system is running experimentally this winter. The validation of this method, and comparison with the QPE based on polarimetric moments, are next job. The problems that we should solve for optimized QPE are discussed.

On empirical parameterizations of characteristics of falling snow particles and its applications

Hiroki Motoyoshi[1)]

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Abstract

For the developments of algorithms of the quantitative precipitation estimation (QPE) by optical disdrometers or weather radar, it is necessary to take into account the characteristics of individual hydrometeors in their target by parameterization. Especially, the mass and density parameterizations of hydrometeors are important because the mass or the density are the primary parameters for such QPE algorithms as well as the size of hydrometeors. Previous studies (e.g. Locatelli and Hobbs (1974)) have shown the relationships between mass, size and fall speed of hydrometeors and the relationships have been used to construct the parameterizations to estimate the fall speed of hydrometeors from observed size and mass (e.g. Mitchel (1996)) or to estimate the mass of hydrometeors from observed size and fall speed (e.g. Ishizaka et al. (2013)). However, in previous studies, measurements for the wet hydrometeors and large hydrometeors, which frequently occur in moderately warm snowy land in Japan, have been lacking. In this study, to obtain the mass, size and fall speed data of hydrometeors including the particles in wet condition or large particles and to construct the empirical parameterization of mass as a function of size and fall speed, we set up the automatic data collection system for the simultaneous measurements of mass, size and fall speed of individual solid hydrometeors. By operating this system during two winters, we were able to measure the mass of particles more than 2,000. First, we show the results of mass measurements and the empirical parameterization of mass and density depend on the size and fall speed obtained based on the measurement. Second, we show its application to the quantitative precipitation estimation from the optical disdrometer observation.

Empirical Relationships for Estimating Liquid Water Fraction of Melting Snowflakes

Ryohei Misumi[1)]

1) National Research Institute for Earth Science and Disaster Resilience

Abstract

The liquid water fraction of snowflakes is an important parameter for forecasting snow-related disasters such as snow accretion on structures and electric wires. Some advanced cloud resolving model can forecast it, but its validation is still difficult because of the lack of observation. The purpose of this study is providing data of liquid-water fraction of snowflakes based on a ground-based observation at Nagaoka, Japan, by using dye-treated filter papers that were kept at a temperature of 0°C. From the results of these measurements, which consisted of 6179 particles taken with 44 sheets of filter paper, two empirical relationships are proposed. The first is a relationship between the ratio of liquid water flux to total precipitation intensity (F_L; taking values from 0 to 1) and meteorological surface data. The second is a relationship to estimate liquid-water fraction of individual snowflakes, f, using the melted diameter of a snowflake, median mass diameter, and F_L. It was determined that the root-mean-square errors for estimating F_L and f by using these relationships were 0.160 and 0.144, respectively.

However, there was a problem that the above mentioned filter-paper technique cannot correctly measure the values when f was very small. Development of a new instrument to measure F_L in a different way is briefly introduced.

Acquisition of snowfall characters, and their relationships with density of newly fallen snow, for snowpack modeling applications

Masaaki Ishizaka[1)]

1) Snow and Ice Research Center, National Research Institute for Earth Science and Disaster Resilience (NIED), Nagaoka, Niigata, Japan

Abstract

The accurate estimation of snowfall density is one of the important issues for snowpack modeling applications as well as for forecasting snow height in winter weather prediction. Hydrometeors types and dimensions are conceived as one of the main factors to determine snowfall density in the absence of wind. Relationships between snowfall density and snow crystal types were described in previous researches, but they do not have been quantitatively given. Recently snowfall density is discussed diagnosing meteorological conditions quantitatively, and some parameterizations, for example obtained by a statistical approach or an artificial neural network, are presented. However, they are inadequate for accurate estimation, because a process relating to falling snow includes so many elements that it is hard to estimate their density by only accessible meteorological elements. In this presentation we provide an overview of our research investigating relationships between snowfall density and solid hydrometeors types, and introduce a method, deduced from our finding, for estimating new snow density from observed size-fall speed relationships of hydrometeors in a snowfall event.

Measurement of Specific Surface Area of falling snow for description of falling snow properties

Satoru Yamaguchi[1), Masaaki Ishizaka[1), Hiroki Motoyoshi[1), Akihiro Hachikubo[2),
Teruo Aoki[3), Akihiro Hashimoto[4), Sento Nalai[1), Katsuya Yamashita[1)

1) Snow and Ice Research Center, National Research Institute for Earth Science and Disaster Resilience,
2) Kitami Institute of Technology,
3) Okayama University,
4) Meteorological Research Institute

Abstract

Japan has a lot of avalanches resulting from a weak layer consisting with specific precipitation particles, such as graupel, or crystal without riming, so it is very important to introduce the idea of falling snow properties including its shape and size to snow cover models for forecasting Japanese avalanches. Specific Surface Area (SSA) is a physical parameter to show the value of surface area per unit weight or volume and it is considered that SSA of falling snow has good relations with its shape and size. In the winters of 2013/2014, 2014/2015, and 2015/2016, we measured 88 SSAs of falling snow, which were deposited in the cold room (-5 ℃） within several hours, in Nagaoka. The measured SSA showed large fluctuations in each year, the largest SSA has more than 3 times larger value than smallest one. To investigate the dominant factors of SSA of falling snow, we classified the falling snow conditions to three types: Winter monsoon type (W-type), Southern low pressure type (S-type), and complexity type (C-type). There is defined difference between SSA of falling snow under S-type and those under other two types (W-type and C-type), namely, SSA of S-type show small value resulting from few riming while SSA of W and C types show large value with rich riming. This result implies the possibility of the introduction of weak layers consisting of no riming falling snow. The values of SSA strongly depend on wind speed (*WS*) and wet-bulb temperature (*Tw*) on the ground. Then, we succeeded to get the estimating equation of SSA of falling snow using *WS* and *Tw*.

Application of cloud microphysics model to estimation of snowpack parameters

Akihiro Hashimoto[1)]

1) Meteorological Research Institute

Abstract

Hydrometeors in the atmosphere have a large diversity of characteristics such as size, shape and density. For representing the diversity, multi-dimensional microphysics model was developed in Japanese cloud microphysics community. In this model, the spectrum of physicochemical property of particles is expressed in five-dimensional parameter space that is constituted of two aerosol components, aspect ratio, volume, and mass of a particle. Accumulation of aerosol components in an ice particle indicates accretion of cloud droplets by the ice particle, representing production of rimed particle or graupel particle. Density of particle is diagnosed with the mass and volume. Small density represents snow aggregates. These characteristics of the model have great potential for linking falling snow to snowpack parameters. On the other hand, bulk microphysics model is attractive approach, since it has more efficient performance than the bin microphysics model. Application possibility of these modeling approaches to estimation of snowpack parameters will be discussed.

Snowpack modeling in the French mountains driven by short-range high-resolution weather forecasts

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Abstract

Numerical Weather Prediction (NWP) systems operating at kilometer scale in mountainous terrain offer great opportunities for forecasting snowpack-related issues such as mountain hydrology or avalanche hazard. In this study, daily forecasts of the NWP system AROME at 2.5-km grid spacing over the French Alps and the Pyrenees were considered for four consecutive winters (2010/11 to 2013/14). They were used to drive the detailed snowpack model Crocus and simulate the snowpack evolution over these regions. The evaluation was performed through comparisons to ground-based measurements of snow depth, snow water equivalent (SWE) and to snow extent derived from satellite data. Results of AROME-Crocus were also compared to snowpack simulations driven by the meteorological analysis system SAFRAN, specially developed for alpine terrain.

When evaluated locally at the experimental site of Col de Porte (1340 m, French Alps), AROME-Crocus and SAFRAN-Crocus show good agreement with measurements of snow depth and SWE. At the scale of the French Alps and the Pyrenees, snow depth simulated by AROME-Crocus exhibits an overall positive bias with strong spatial patterns. Differences in snow depth simulated by AROME-Crocus and SAFRAN-Crocus are mainly related to differences between AROME and SAFRAN seasonal snowfall. Comparison between the two reveals that high elevations areas and leeward and windward side of some mountain ranges exhibit especially significant differences. The simulation of mesoscale orographic effects by AROME allows to capture a realistic regional snowpack variability, unlike SAFRAN‑Crocus as illustrated by winter 2011/2012 in the Pyrenees. Finally, a categorical study of daily snow depth variations is carried out to provide a more detailed analysis of model results during accumulation and ablation phases. It reveals that both models underestimate strong snow accumulations and strong snow depth decreases, which is mainly due to the non-simulated wind-induced erosion and the underestimation of strong melting rates.

This study constitutes the first step towards the development of a distributed snowpack forecasting system using AROME forecasts.

The relationship between preferential flow in snow cover and weather conditions

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2) Institute of Low Temperature Science, Hokkaido University, Sapporo, Hokkaido, Japan

Abstract

Water penetration into snow cover can be classified as either uniform penetration or preferential penetration through water passages. To expand the one-dimensional water movement model for simulation of multidimensional water movement in snow cover, it is necessary to understand the conditions that generate preferential penetration through water passages. Snow and Ice Research Center, National Research Institute for Earth Science and Disaster Resilience operates a Multi-Compartment-Lysimeter (M.C.L) (3×3 m area) consisting of nine small 1 × 1 m lysimeters. Using the M.C.L, we measured the distribution of water discharged from the bottom of the snow cover since 2006. The measured data indicate Strongly Heterogeneous Distributions of water discharge (SHD) as determined by large differences between discharges at each small lysimeter. Such SHD should be attributable to the preferential flow of water through water passages due to horizontal water movement in the snow cover. We compared 9 years measured M.C.L data with meteorological data and found that SHD often occurred under the following three conditions: 1) in winters with maximum snow depth greater than the average maximum snow depth (1.4 m), 2) in the latter winter season, namely, the period after the maximum snow depth recorded, 3) in the case of a large amount of water input from melting snow and rain. Moreover, we analyzed the SHD condition using snow pit data and found that SHD occurred when strong difference of capillary force between snow layers, such as fine over coarse layers structures, exists at the shallow part in the snow cover.

Simulation of heterogeneous liquid water monement in the snowpack considering preferential flow

Hiroyuki Hirashima[1)]

1) Snow and Ice Research Center, NIED, JAPAN

Abstract

Modeling of liquid water infiltration process are important to predict wet snow avalanches and hydorogical processes. Recent numerical snowpack model consider liquid water infiltration using darcy-Backingham's law and Richards Equation. Liquid water movement has two types of flow regime: matrix flow and preferential flow. Since most of numerical snowpack models are developed in one-dimension, it can consider matrix flow but neglects preferential flow. This limitation leads to unsufficient accuracy of the prediction of water content distribution, time series of runoff amount, and snow stability for wet snow avalanches. Recently, modeling of preferential flow in the snowpack was focused. At present, there are two approaches to simulate preferential flow. The one is using three-dimensional water transport model in which we developed. The another one is using dual-domain approach in SNOWPACK model recently developed in SLF. In this presentation, we introduce mainly three dimensional water transport model with the comparison with laboratory experiment. Introduction of dual domain approach is also introduced. We also discuss the plan to apply the three-dimensional water transport model for the improvement of SNOWPACK with dual domain approach.

Development of the NHM-SMAP regional climate model for polar regions

Masashi Niwano[1)]

1) Meteorological Research Institute, Japan Meteorological Agency

Abstract

We present performance of a newly developed polar regional climate model called NHM-SMAP (Non-hydrostatic atmospheric model – Snow Metamorphism and Albedo Process). The atmospheric part of the NHM-SMAP is Japan Meteorological Agency's operational regional atmospheric model JMA-NHM (Saito et al., 2006). On the other hand, temporal evolution of physical states of snow and ice are calculated by the physical snowpack model SMAP (Niwano et al., 2012, 2014, 2015). The key feature of the SMAP model is that it calculates the snow albedo by using a physically based snow albedo model (Aoki et al., 2011), where effects of snow grain size and snow impurities on the snow albedo are considered explicitly. In addition, the SMAP model calculates vertical water movement in snowpack by employing the Richards equation (Hirashima et al., 2010; Yamaguchi et al., 2012) to improve the ice sheet (or glacier) surface mass balance estimation. In this contribution, we begin by introducing the basic configuration of the NHM-SMAP forced by the Japanese 55-year reanalysis (JRA-55). After that, validation results of the NHM-SMAP run in the Greenland ice sheet with a high horizontal resolution of 5 km are given, where reproducibility of surface meteorological and snow conditions are highlighted.

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Modeling of falling snow properties for snowpack models: towards a better link between falling snow and snow on the ground

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Abstract

Falling snow is made of different types of solid hydrometeors including single ice crystals, aggregates at different riming stages and graupel. This variability results from complex in-cloud processes (deposition, riming and aggregation) and sub-cloud processes (melting and sublimation). It has consequences for the properties of fresh fallen snow accumulating on the ground including density and specific surface area (SSA). These properties strongly affect the evolution of snow on the ground by modifying for example the albedo and the thermal conductivity. Detailed snowpack models such as Crocus or SNOWPACK use near-surface wind speed, air temperature and humidity to compute the density and SSA of falling snow. The shape, size and degree of riming of falling solid hydrometeors are not directly taken into account, which limit the accurate determination of properties of fresh fallen snow.

An alternative is offered by new bulk cloud microphysics schemes implemented in numerical weather prediction system that can be used to drive snowpack model. In particular, the scheme P3 (Predicted Particle Properties) proposes an innovative representation of all ice-phase particles by predicting several physical properties (e.g. size, rime fraction, rime density . . .). In this study, we first theoretically analyze the strengths and limitations of P3 to represent the density and SSA of falling snow. Parameterizations are then proposed to derive density and SSA from P3 output. Finally, P3 implemented in the Canadian Global Environmental Multiscale (GEM) weather prediction model is used to simulate snowfall events observed at the Falling Snow Observatory (Nagoaka, Japan). Model predictions are compared with (i) observations of the type of falling snow particles derived from disdrometer data and (ii) manual measurements of fresh fallen snow density and SSA.

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