March 12, 2021

RTRI Develops a Risk Assessment System for Snowmelt Disasters

RTRI has developed a risk assessment system for snowmelt disasters. (Fig. 1) This system assesses the risk of slope collapses caused by snowmelt water in early spring, and the first one developed for railways in Japan.

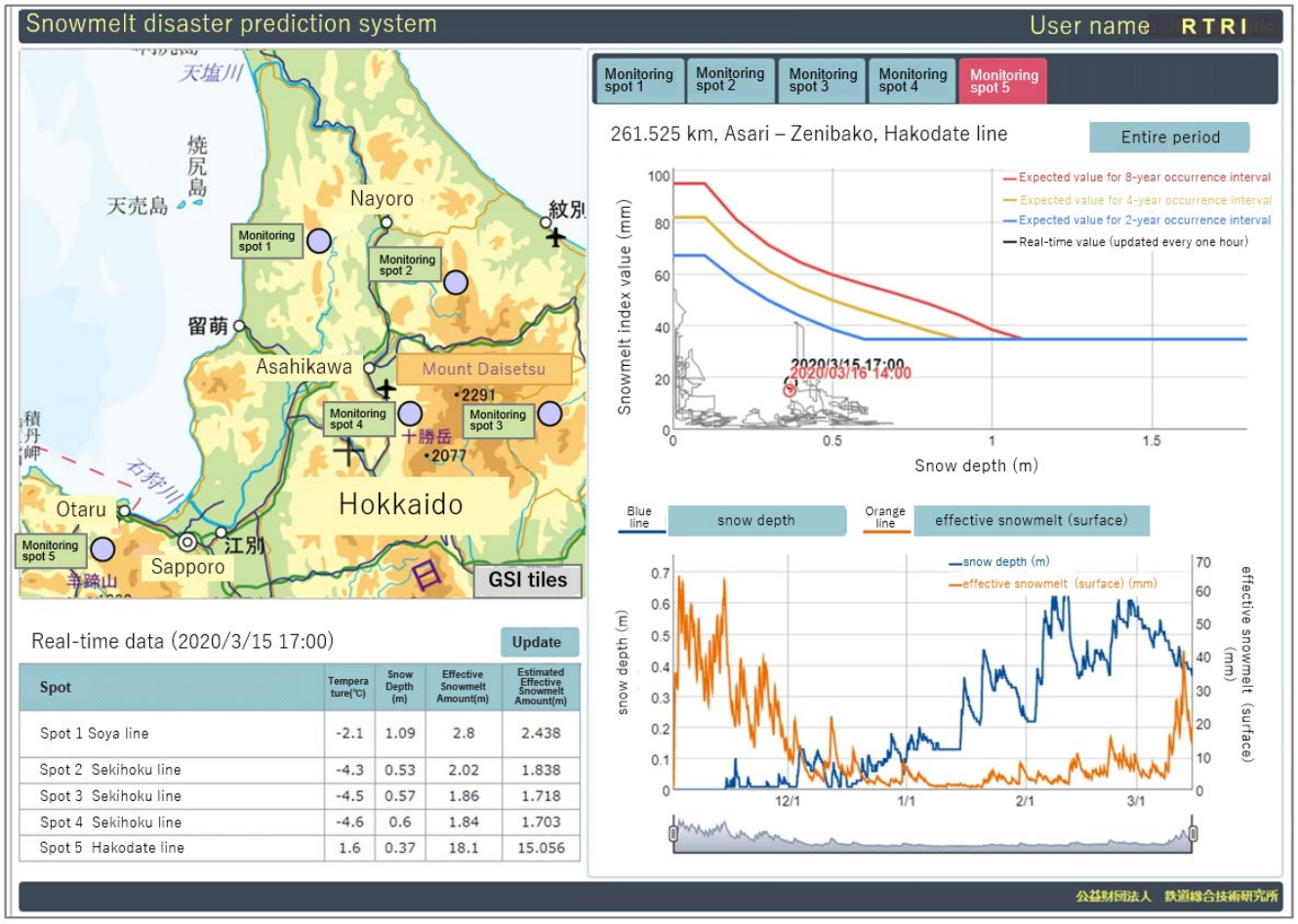


Fig. 1 The display of risk assessment system for snowmelt disasters

1. Background

In early spring, snow areas are sometimes hit by snowmelt disasters as well as avalanche. A large amount of snowmelt water as well as rainwater penetrates the ground in spring and causes slope collapses. Although the slope collapses by snowmelt occur less frequently than landslides caused by rainfalls, they tend to cause serious accidents such as derailments in addition to train delays. Railway operators have intensified trackside patrolling according to temperatures and, if necessary, lower the limit rainfall amount to restrict train operation when snowmelt is progressing, but a method to determine the necessity of patrolling based upon scientific standards have been desired.

2. Characteristics of the system

- The risk of snowmelt disasters is assessed every one hour and the data is provided to railway operators to determine the necessity of patrolling during the snowmelt season.
- As the data necessary to assess the risk is obtained from AMEDAS (Automated Meteorological Data Acquisition System) , building additional meteorological observation facilities is not required.
- By using two indicators, snowmelt amount and snow depth, the risk of snowmelt disasters can be assessed effectively.

3. Risk assessment with this system

(1) Outline

The system consists of servers managed by RTRI and applications with following functions.

- Function to gather AMEDAS data on targeted areas every one hour.
- Function to estimate snowmelt amount every one hour, convert the data to effective snowmelt amount which is an index that has a strong correlation with ground water levels, and then assess the risk level by comparing the index with the preset standard value.
- Function to post estimated effective snowmelt amount on the dedicated website and, if the values exceed the standard value, indicate it on a monitor screen and inform users of the disaster risk level.

Railway operators can check the assessment results for the predetermined spots by accessing the website using computers and tablets. The service is provided fee-based.

(2) The mechanism of snowmelt disasters and effects of the risk assessment system

Snowmelt disasters take place following the 3 steps shown in Fig. 2.

① Snowmelt water and rain penetrate the ground.
② The groundwater level rises.
③ The ground becomes unstable and slopes collapse.

This system estimates amounts of water penetrating the ground using snow depth and effective snowmelt amount and assesses the impact on the step ③, slope stability.

Railway lines extend thousands of kilometers and the risk monitoring needs to cover wide areas. Considering such conditions specific to railways, this system assesses snowmelt disaster risks using four indices, air

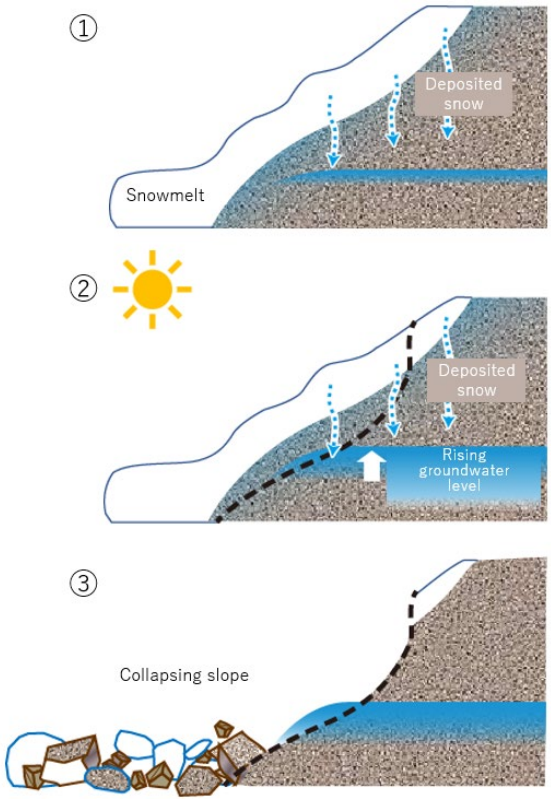


Fig. 2 Mechanism of snowmelt disasters

temperature, precipitation, wind speed and sunlight hours for every hour. The data is obtained from the nationwide AMEDAS network data.

By introducing this system, railway operators will be able to determine the necessity of patrolling based on scientific and quantitative indicators.

[Reference]

Estimation of effective snowmelt amount and other indices

This system uses effective snowmelt amount, as it is an index correlating strongly with ground water levels. Effective snowmelt amount is calculated by subtracting the outflow amount from inflow, that is, assuming that effective snowmelt amount is retained water in a sort of a tank with holes at its bottom. (Fig.3) By checking effective snowmelt amount, it is possible to monitor changes in the groundwater level over time and its peak season. (Fig.4)

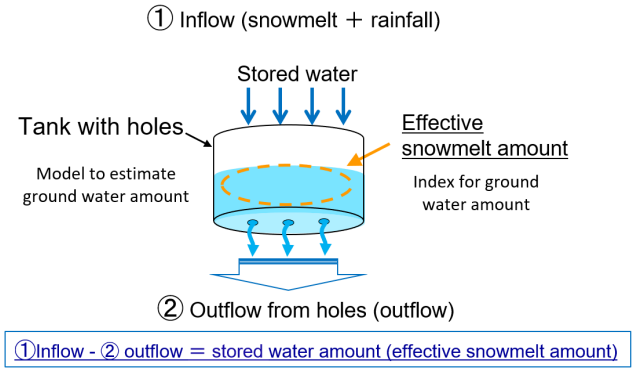


Fig. 3 Calculation of effective snowmelt

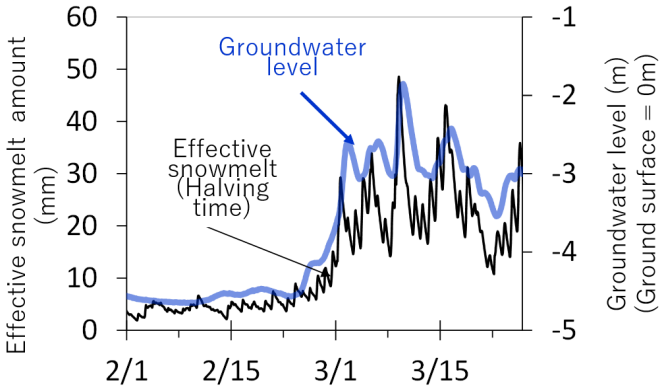
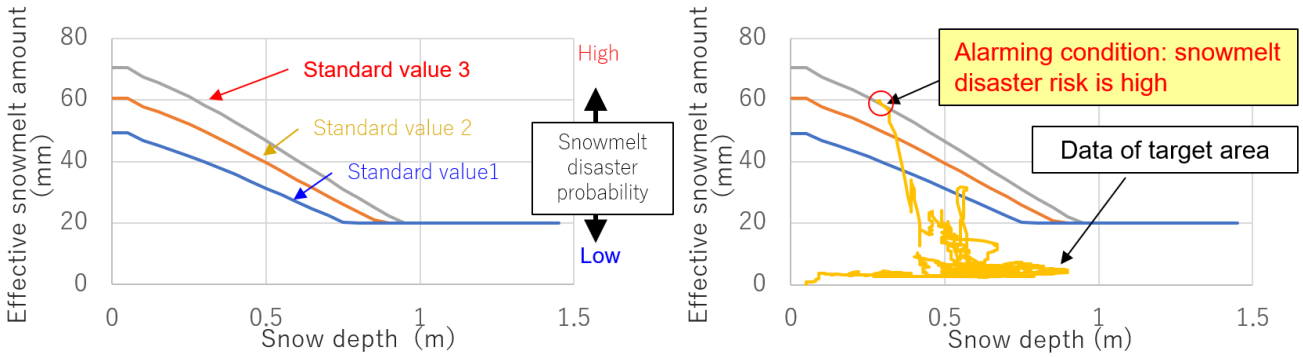


Fig. 4 Changes in ground water level and effective snowmelt

Risk assessment

Since the probability of snowmelt disasters depends on snow depth as well as effective snowmelt amount, each year's maximum effective snowmelt amount for every snow depth is calculated by the AMEDAS data for the target area for the winter in the past 20 years. Based on the results, standard values of effective snowmelt amount for each snow depth depending on reoccurrence intervals (time periods between snowmelt disasters) are predetermined (Fig. 5 (a)). The upper standard values mean higher probability of snowmelt disasters. Then, in order to check conditions of the target area, effective snowmelt amounts for respective snow depth are plotted and connected with line (black line) based on the AMEDAS data for every hour (Fig. 5 (b)). The risk is assessed by comparing the latest one of the plotted lines with the predetermined standard values.



(a) Example of standard values (b) Risk assessment

Fig. 5 Risk assessment method

Setting standard values

If the standard values are set lower, railway operators need to stay on alert longer, but If they are set higher, disaster risks are less likely to be detected effectively. Thus RTRI determines the standard values for this system through coordination with railway operators.