

THE EFFICIENCY OF MECHANIZED SNOW-REMOVAL/ANTI-FREEZE CHEMICAL SPREADING AND THE SNOWFALL / FREEZING PREDICTION SYSTEM

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1. Summary

Since fiscal 1991, a system for predicting snowfall and freezing has been introduced into the part of Japan covered by the Takada Works Office. In this paper, the authors verify the effects of the system, and show how it contributes to the efficiency of mechanized snow removal, anti-freeze chemical spreading, and other aspects of winter road maintenance.

2. Introduction

In recent years, the efficiency of mechanized snow removal and the spreading of anti-freeze chemicals have become key issues in efforts to secure winter road traffic. The Takada Works Office has spent many years developing a snowfall/freezing prediction system. By supplying prediction data to the local community, the Office has made a major contribution to efficient snow removal operations in heavy snow regions.

In this paper, the authors verify the contribution of the snowfall/freezing prediction system to the efficiency of these operations, and study the effects of data provision to the local community, as well as future improvements to the system.

3. Climatic overview

The Joetsu region of Niigata Prefecture, in which the Takada Works Office is located, lies more or less in the center of the Japanese archipelago at latitude 37 degrees north. It shares the same latitude as Seoul and Teheran in Asia, Athens in Europe, and Washington and San Francisco in the USA.

Despite its southerly latitude and relatively mild temperatures, the Joetsu region suffers the heaviest snowfall in Japan. This is because of its location to the northwest (on the Sea of Japan side) of Japan's central mountain ranges. In winter, seasonal northwestern winds carry large quantities of water vapor from the Sea of Japan, bringing heavy snow to the region.

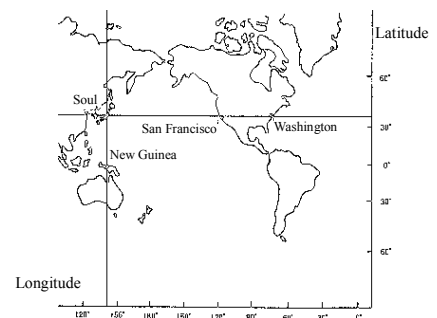


Fig. 3-1 Location of the Joetsu region on the world map

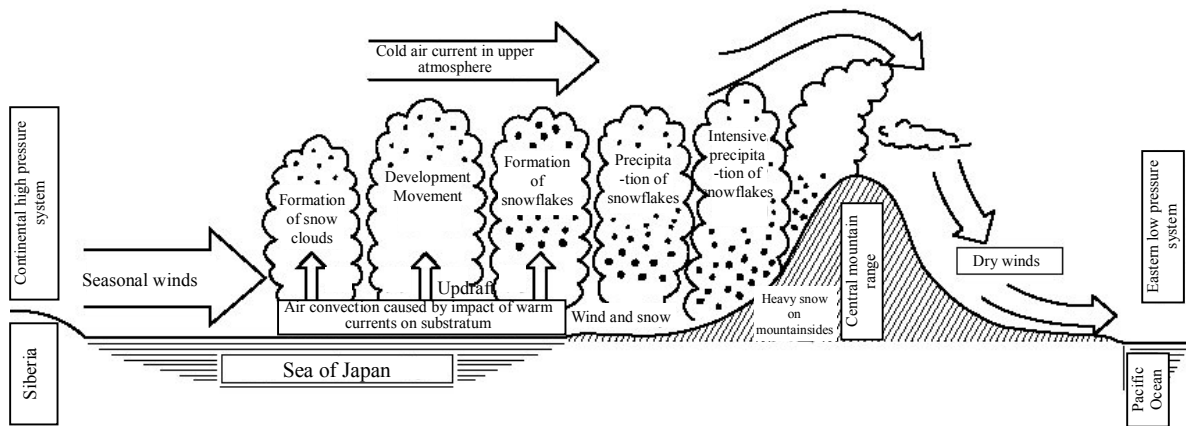


Fig. 3-2 The mechanism of snowfall

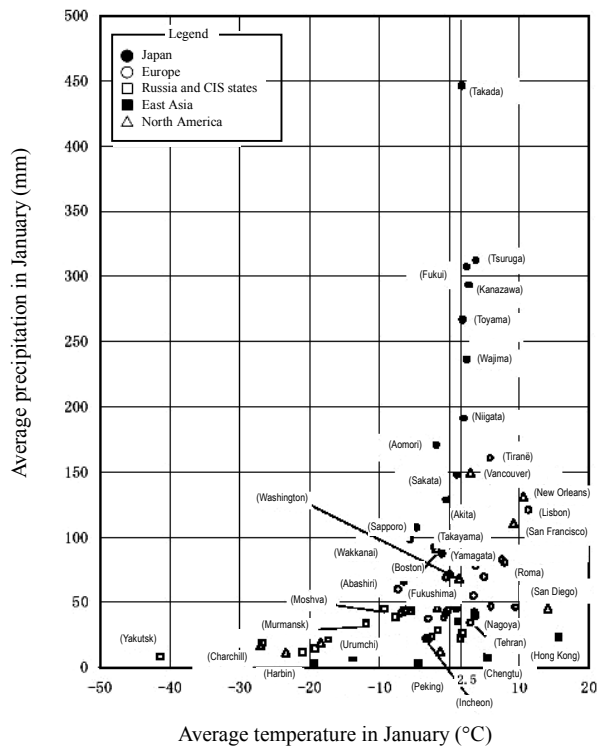


Fig. 3-3 Average temperature / precipitation in major northern hemisphere cities

4. Outline of the snowfall/freezing prediction system

Data supplied by the snowfall/freezing prediction system are widely used for winter road maintenance on National Highways 8 and 18, managed by the Takada Works Office. They are also used for winter disaster prevention in the 22 municipalities and other parts of the Joetsu Region.

The snowfall prediction system has been in operation since fiscal 1991 and the freezing prediction system since fiscal 1994. Predictions of snowfall, maximum, minimum, and average temperatures, and chronological road temperatures for 16 hours (16:00-08:00) are made for 13 principal observation points. The predictions are then quickly relayed from the Works Office to 2 branch offices, 7 snow removal bases, and 3 civil engineering offices and 22 municipalities in Niigata Prefecture by e-mail, fax, or other means.

Predictions are based on a statistical technique using local observation data and a Grid Point Value (GPV) forecasting model provided by the Meteorological Agency. Efforts are being made to improve the system and increase its accuracy every year. The accuracy of the snowfall prediction system is 80-90%, and that of the freezing prediction system about 90%.

Snowfall predictions at principal observation points

Short-term forecast

A winter pressure system is now present in the vicinity of Japan, with a midwinter cold air mass in the Hokuriku region. The winter pressure system will start to weaken gradually from the west, and the midwinter cold air mass will pass over towards evening. The forecast for tonight is cloud with occasional snow. Tomorrow, a low pressure system lying under a cold air mass will pass through the region, after which the winter pressure system will return. The forecast for tomorrow is again cloud with occasional snow.

Results of snowfall and temperature predictions in the Joetsu region (16 hours)

March 9th, 2001 (16:00-08:00)

Observation point	Predicted snowfall	Minimum temperature
Terashima	10 – 20 cm	-1.6°C
Negoya	20 – 30 cm	-3.8°C
Hiraiwa	20 – 30 cm	-4.9°C
Mori	5 – 10 cm	-1.0°C
Takada	10 – 20 cm	-2.7°C
Arai	20 – 30 cm	-2.2°C
Sekiyama	20 – 30 cm	-2.7°C
Myoko	20 – 30 cm	-6.6°C
Ogata	10 – 20 cm	-1.9°C
Yoshikawa	10 – 20 cm	-2.2°C
Yasuzuka	20 – 30 cm	-3.5°C
Yanagishima	20 – 30 cm	-2.6°C
Matsudai	20 – 30 cm	-3.3°C

Fig. 4-1 Example of screen display by the snowfall/freezing prediction system (1)

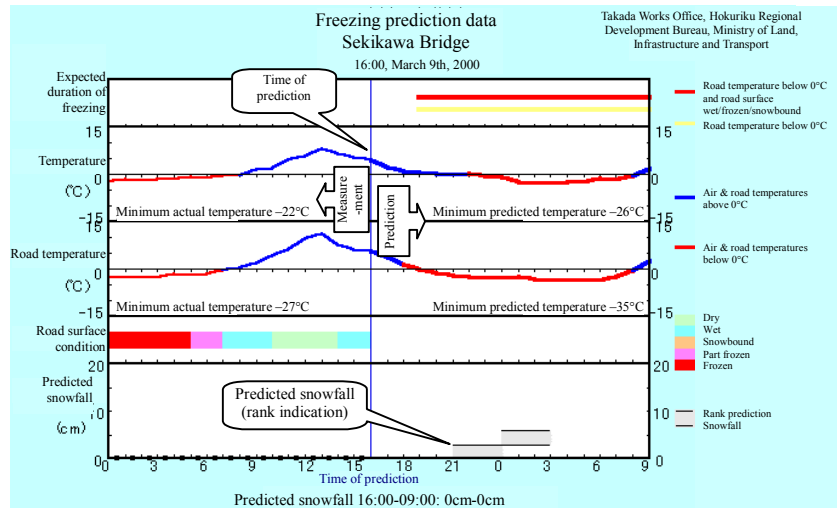


Fig. 4-2 Example of screen display by the snowfall/freezing prediction system (2)

5. Measuring the effects of the snowfall prediction system

Compared to conventional snowfall predictions by weather stations in 3 categories (mountains, plains, and coasts), this snowfall prediction system is thought to have reduced the cost of unnecessary standby when a prediction is incorrect. This is because it makes predictions at 13 observation points and its prediction accuracy is being improved every year.

To ascertain the extent to which the snowfall prediction system has reduced snow removal work, we calculated and compared the correct prediction ratio ^(*) and the legitimate standby ratio ^(**) for weather station predictions and the snowfall prediction system, respectively. The calculations were based on actual snowfall data for fiscal 2000.

(1) Calculating the correct snowfall prediction ratio

The basic rule for standby is that a standby instruction is issued when the snowfall prediction is 5cm or more. In view of this, snowfall predictions were counted as “correct” when both the prediction and the actual measurement were on the same side of 5cm. On this basis, the correct prediction ratio using the snowfall prediction system was 11.2-18.4 points (14.5 points on average) higher than the weather station predictions, proving the effectiveness of the snowfall prediction system.

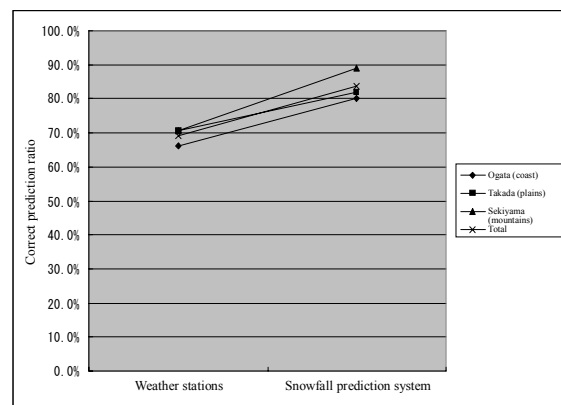


Fig. 5-1 Correct prediction ratio

(*) The ratio of correct snowfall predictions of 5cm or more and less than 5cm.

(**) The ratio of standbys for snowfall predictions of 5cm or more, when the prediction was borne out by actual snowfall and led to the dispatch of snow removal workers.

(2) Simulation based on predictions

We simulated standby, dispatch, and other snow removal activities on the assumption that snow removal work is based on prediction results only.

As a result, the legitimate standby ratio using the snowfall prediction system was 8.3-24.5 points higher (average 18.2 points), proving the effectiveness of the snowfall prediction system.

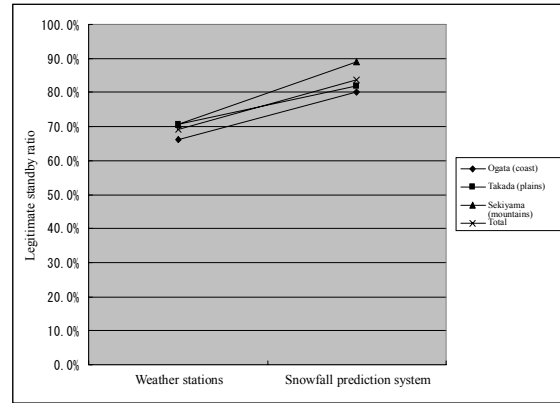


Fig. 5-2 Legitimate standby ratio

(3) Evaluation of improved efficiency using the snowfall prediction system

① Reduced standby cost using the snowfall prediction system

The snowfall prediction system has reduced the frequency of unnecessary standby for snow removal work. There have been 116 fewer cases of unnecessary standby in the snow removal area controlled by the Takada Works Office. The associated reduction in standby cost is estimated at about 7.2 million yen per year.

② Expanding the cost reduction effect

Assuming that snowfall predictions are supplied to neighboring road maintenance authorities and that snow removal work is carried out at the same level on major provincial roads, the cost reduction effect, including the amount calculated above for national highways under direct control (7.2 million yen), is estimated at about 33.4 million yen per year.

6. Measuring the effects of the freezing prediction system

The freezing prediction system is thought to have reduced the cost of unnecessary anti-freeze chemical spreading, through annual improvements and the increased accuracy of road temperature predictions, as well as chronological prediction.

To ascertain the extent to which the freezing prediction system has reduced the costs of anti-freeze chemical spreading, we compared the operational record for fiscal 1992 (before the system was introduced) with that in fiscal 2000 (after introduction). In particular, we collected and compared data on the ratio of unnecessary chemical spreading (the ratio of times when the road temperature remained above 0°C after chemicals had been spread to preventing freezing).

(1) Calculating the ratio of unnecessary chemical spreading

The ratio of unnecessary anti-freeze chemical spreading in the Joetsu / Fujisawa works section was 13% before the freezing prediction system was introduced. After introduction, however, this had been substantially reduced to 1%, proving the effectiveness of the freezing prediction system.

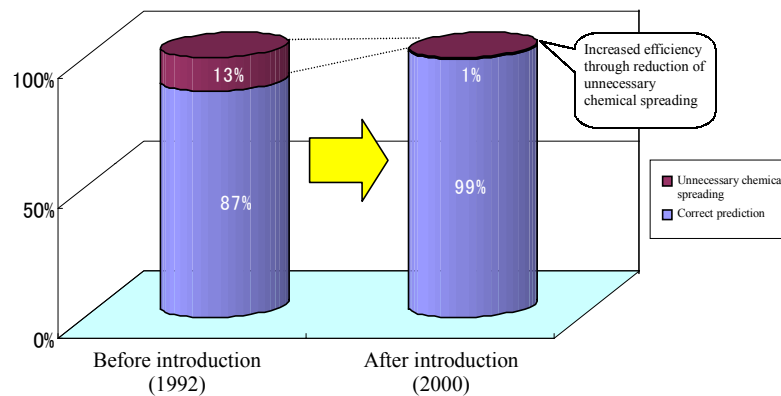


Fig. 6-1 Aggregated data on anti-freeze chemical spreading

(2) Evaluation of improved efficiency using the freezing prediction system

① Reduced standby cost using the freezing prediction system

The freezing prediction system has reduced the frequency of unnecessary anti-freeze chemical spreading. The associated reduction in cost within the snow removal area controlled by the Takada Works Office is estimated at about 2.1 million yen per year.

② Expanding the cost reduction effect

Assuming that freezing predictions are supplied to neighboring road maintenance authorities and anti-freeze chemical spreading is carried out at the same level on major provincial roads, the cost reduction effect, including the amount calculated above for national highways under direct control (2.1 million yen), is estimated at about 9.8 million yen per year.

7. Future improvements to the snowfall/freezing prediction systems

The results of our study show the cost reduction effects that can be expected from the introduction of the snowfall/freezing prediction system. Moreover, even greater cost reduction effects could be assumed if the results of the predictions were relayed to neighboring authorities.

As well as the cost reduction effect, introducing the snowfall/freezing prediction system is also thought to have improved working conditions, such as reducing worker standby time.

At present, prediction data from the snowfall/freezing prediction system are sent to neighboring authorities by e-mail or fax. In future, we will need to make these data available to the general public, as well as continuing to support efficient snow removal operations. This will be done by publishing the data on an Internet website, with the aim of expanding the range of data provision and supplying data regularly.