Drivers’ decision-making supported by The Snow Visibility Information system

Kokubu, T.,
Takechi, H., Harada, Y., Omiya, S., and Matsuzawa, M
Civil Engineering Research Institute for Cold Region (CERI), PWRI, Japan
Introduction

Hokkaido is the northernmost island of Japan.

Hokkaido

Sapporo, CERI

Jan 30, 2012 Iwamizawa 30km (19miles), NE. of Sapporo

Max: 208cm = 6ft 9in
Causes of national road closure in Hokkaido

- **Snowstorm**: 40%
- **Snowfall**: 9%
- **Road flooded**: 7%
- **Landslide**: 3%
- **Risk of avalanche**: 5%
- **Risk of landslide**: 21%
- **High wave**: 6%
- **Bank collapsed**: 1%
- **Road flooded**: 1%

*40% of road closures - snowstorms*
Background

Reduce damage caused by snowstorms ...

Road: Installation of blowing-snow control measures

Driver: Help drivers to make safer decisions

Snowstorm visibility information

* Control measures are installed in areas storms frequently occur.
* Recently, bomb cyclones cause blowing-snow.
* Snow-control facilities require much time and cost to construct, so cannot address sudden storms.
Objectives

“Northern Road Navi” Website
- Portal Site for Road in Hokkaido -

Hokkaido Road Information Website

Contents

- What’s New
- Distance & Time
- Mountain Pass / Live Camera
- Road Map
- Links to Weather Info

✔ Snowstorm visibility information

URL: http://northern-road.jp/navi/
Method of estimating visibility during snowstorms

Relationship between visibility during snowstorms and the mass flux of snow

\[ \text{Vis} = 10^{-0.886 \times \log(Mf)} + 2.648 \]  
(1) (Takechi, 2009)

- **Vis [m]** : Visibility
- **Mf [g/m}^2{/s]** : Mass flux of snow

✓ The mass flux of snow is the mass of snow particles passing through a specific unit cross-section during a particular unit time.
Relationship between the mass flux of snow and the snow concentration

\[ Mf = N \times V \]  
\[ \text{Mf} \ [\text{g/m}^2/\text{s}] : \text{Mass flux of snow} \]
\[ \text{N} \ [\text{g/m}^3] : \text{Snow concentration} \]
\[ \checkmark \text{The snow concentration is the mass of snow particles in a particular unit space} \]
\[ \text{V} \ [\text{m/s}] : \text{Wind velocity} \]

\[ \text{Mass Flux of snow} = \text{Snow Concentration} \times \text{Wind velocity} \]
Method of estimating the snow concentration

Estimation using snowfall intensity, wind velocity and air temperature

\[ N(z) = \frac{P}{w_f} + \left( N_t - \frac{P}{w_f} \right) \left( \frac{z}{z_t} \right)^{\frac{w_b}{kU^*}} \]  

\[ (Matsuzawa et al, 1998) \]

**Snowfall**
- **P [g/(m²s)]:** Snowfall intensity
- **wₐ [m/s]:** Falling velocity of snowfall particles ( = 1.2 [m/s])
- **wₐ [m/s]:** Falling velocity of suspended snow particles ( = 0.35 [m/s])
- **z [m]:** Height of the viewpoint of small-vehicle drivers ( = 1.2 [m])
- **zₜ [m]:** Reference height (0.15 [m])
- **Nₜ [g]:** When snowfall intensity is high. \( N_t = 0.166 \cdot e^{0.309 \cdot V_{10}} \)
  
  When snowfall intensity is low or zero \( N_t = 0.274 \cdot e^{0.401 \cdot V_{10}} \)
  
  (Where, \( V_{10} \) is the wind velocity at a height of 10 m)

**Drifting snow**
- **U*:** Friction velocity ( = 0.036 × \( V_{10} \))
- **K:** Karman’s constant ( = 0.4)
In providing the information, to facilitate understanding of visibility during snowstorms, the estimated visibility was classified into five levels ranging from 1,000 m or more to less than 100 m.
Snowstorm Visibility Information System

Snowstorm Visibility Information for smart phone

As of March 10 2015, 15:00 (It’s renew 30 minitues)

Forecast

24 hour later

Area: 221 areas in Hokkaido
**Conditions for Automatic E-mail Delivery**

<table>
<thead>
<tr>
<th>Area</th>
<th>Users select areas for poor visibility forecasts. (Multiple selections acceptable)</th>
</tr>
</thead>
</table>

1. **Area**

   Reduction of visibility in the Nemuro north area 200 m is expected over the next 6 hours due to snowstorm. Please monitor conditions and consider your safety when driving during this period.

2. **Delay**

   - Nemuro north area
   - Nakashibetsu town 1 hour delay: visibility less than 100m
   - Shibecha town 1 hour delay: visibility less than 100m

3. **Details**

   ↓↓ for details ↓↓

4. **For PC website**

   [http://northern-road.jp/mini/touge/fubuki.htm](http://northern-road.jp/mini/touge/fubuki.htm)
The number of visitors to the Snowstorm Visibility Information Website (this winter)

MAX: 30,547 views

The Japan Meteorological Agency announced that the snowstorm would be on a scale of that occurring only once in several years.

Mean for Nov. 28 through Mar. 31: 4,154 views per day
Implemental method: questionnaire is the home page.

Period of the execution: 2015. 4.21 ～ 5.20

The number of respondents: number of 483
Users questionnaire.

Aim of a questionnaire survey:

- Of the user, to grasp the Utilization of snowstorm visibility information.
- And, we want to clarify the validity.
- We wants to clear the future problem.

- Website service
  - satisfaction
  - change is doing plane
- E-mail service
  - satisfaction
  - behavir change planning answers
The attribute of the questionnaire respondent

The age composition

- More than 70 years old: 3%
- 60 Year Old Generation: 13%
- 50 Year Old Generation: 33%
- 40 Year Old Generation: 35%
- 30 Year Old Generation: 13%
- 20 Year Old Generation: 3%
- 50 Year Old Generation: 33%

Respondents: 473

The main use purpose

- Commuting: 21%
- Work (transport): 6%
- Work (road management): 10%
- Go to hospital and shopping: 16%
- Traveling: 17%
- Work (other): 26%
- Other: 4%

Respondents: 429
How satisfied are you with the services provided by the Snowstorm Visibility Information System?

Website for PCs
- Satisfied: 46%
- Somewhat satisfied: 29%
- Somewhat dissatisfied: 10%
- Dissatisfied: 2%
- Very dissatisfied: 0%

Respondents: 259

Website for smartphones
- Satisfied: 43%
- Somewhat satisfied: 32%
- Somewhat dissatisfied: 10%
- Dissatisfied: 4%
- Very dissatisfied: 0%

Respondents: 263
Questionnaire survey results on almost Change behavior visibility forecast information provided

How likely is it for you to change your schedule or travel plans when poor visibility of less than 200 m is predicted by the Snowstorm Visibility Information System?

Respondents: 448

- 79% I always or often change my travel plans or schedule.
- 19% I always or often keep my travel plans or schedule unchanged.
- 3% Poor visibility of 200 m or less has never been predicted in the forecast area.

Breakdown:

- 60% I changed my departure time.
- 59% I refrained from going out or traveling.
- 40% I changed my route.
- 22% I brought a shovel and warm clothing.
- 7% I canceled my driving plans and used public transport.
- 4% Other

Multiple answers (Respondents 352) Excluding two respondents who gave no answers
We do cross-tabulation of the questionnaire. The attributes of the respondents I be classified as follows.
Of the respondents whose main purpose in accessing the website is to check on snowstorms before private, many canceled their travel plans.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Changed or Often Changed</th>
<th>Not Changed or Often Changed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commuting (N=95)</td>
<td>77%</td>
<td>23%</td>
</tr>
<tr>
<td>Work (N=184)</td>
<td>77%</td>
<td>23%</td>
</tr>
<tr>
<td>Private (N=154)</td>
<td>88%</td>
<td>12%</td>
</tr>
</tbody>
</table>

The behavior and the schedule are changed or often changed.
The behavior and the schedule are not changed or often changed.
Questionnaire survey results on the usefulness and response to information E-mail service

How satisfied are you with the e-mail delivery services?

- Satisfied: 44%
- Somewhat satisfied: 33%
- Somewhat dissatisfied: 7%
- Dissatisfied: 1%
- Very dissatisfied: 2%

How did you make use of the e-mail information?

- Visited the Snowstorm Visibility Information website for detailed information: 63%
- Checked the information received via e-mail alone: 8%
- Checked weather warnings and other information: 17%
- Referred to the information received via e-mails in making travel plans: 27%
- Didn’t make use of the information received via e-mail: 1%
- Other: 1%

Respondents: 259

Respondents: 263
Summary

With an aim of supporting drivers' decision-making during snowstorms, the authors conducted tests by providing road users with snowstorm visibility information. It was confirmed that the information provided was useful as summarized below:

- The result a lot of people of the questionnaire was Good with this website

- The results of a questionnaire survey showed that users of the Snowstorm Visibility Information System change their travel plans by referring to the information on this website.

- The results of another questionnaire survey showed that users of the e-mail delivery service actively seek related information after receiving e-mails about poor visibility
Thank you for your kind attention