# TRIAL COUNTERMEASURES AGAINST POOR VISIBILITY CAUSED BY DRIFTING SNOW

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## ABSTRACT

Niigata Prefecture in north-western Japan, facing Sea of Japan, is one of the heaviest snowfall regions on the earth for its geographical features; spine of mountains in winter capture much of icy clouds brought by north-westerly strong seasonal wind, which are formed in the process of passing across the sea. East Nippon Expressway Company Limited, hereinafter NEXCO East, has carried out a series of addresses for approximately 30 years to ensure the safe, reliable, and comfort service in winter months through compiling kinds of manuals, developing snow and ice control facilities, making operations more efficient, providing traffic information to customers and so forth. Drifting snow and heavy snowfall, however, often reduces visibility, which forces expressways to be closed even in recent years. The cause by poor visibility occupies over 50% of all the closure time and length; therefore, it is regarded as the one of the most urgent issues.

This paper describes the following points;
a) General winter conditions in Niigata and existing countermeasures
b) Trial approach by introducing a forecasting system for poor visibility and its outcomes
c) Future direction

## 1. GENERAL WINTER CONDITIONS AND EXISTING COUNTERMEASURES

### 1.1. General winter conditions in Niigata

Figure 1 represents the location of Niigata, weather characteristics and expressway networks. Niigata is located at 37 degrees north latitude, relatively low latitude region,

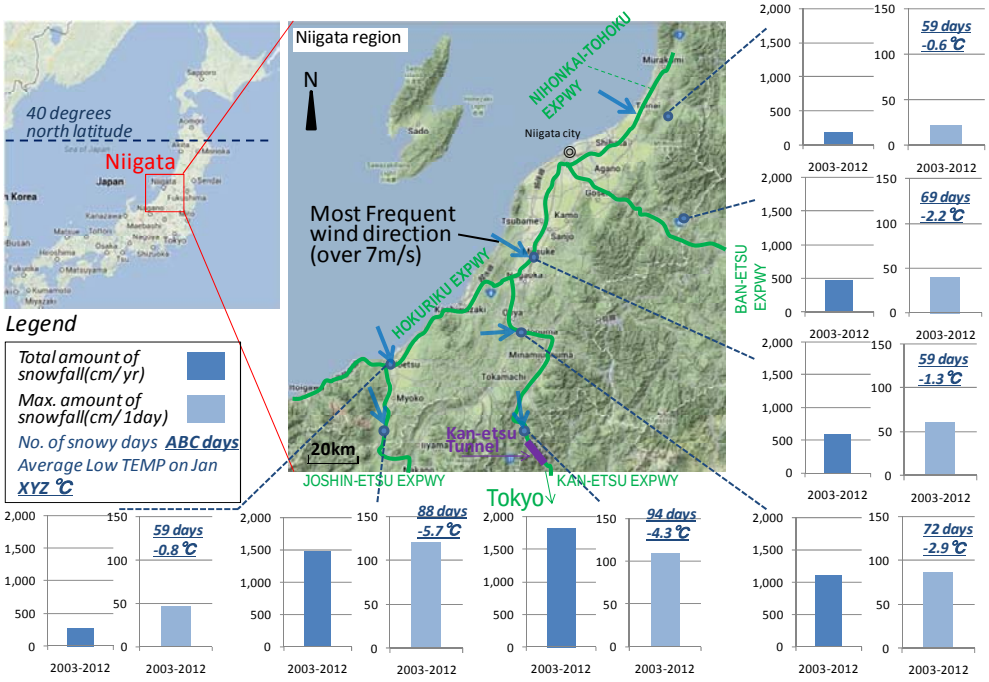



Figure 1 - Location of Niigata, weather characteristics and expressway networks

however it has heavy snowfall. Let us focus on the amount of snowfall. A lot of difference can be seen within the narrow region, which extends to only 100-200km. In the mountain area, the snow sometimes piles up to 1 meter within just one day.

Now, let us look at the relationship between average low temperature on January and total amount of snowfall through one year, shown in Figure 2. In comparison with other cities, data on Niigata cities distribute at the right and upper side. It is reasonable to consider that the Niigata is relatively high temperature with a lot of snowfall.

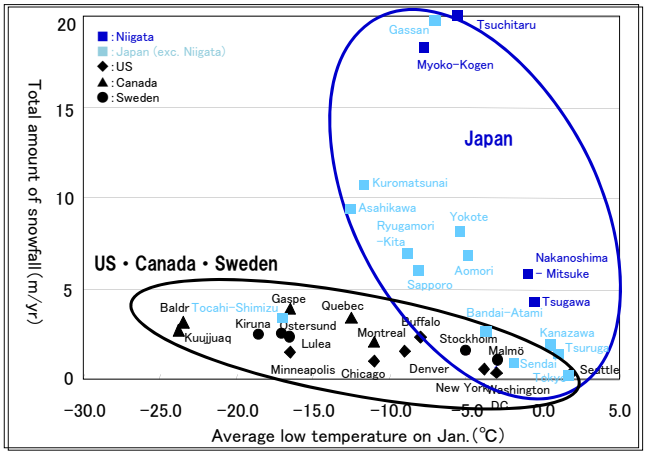



Figure 2 - Low temperature and snowfall

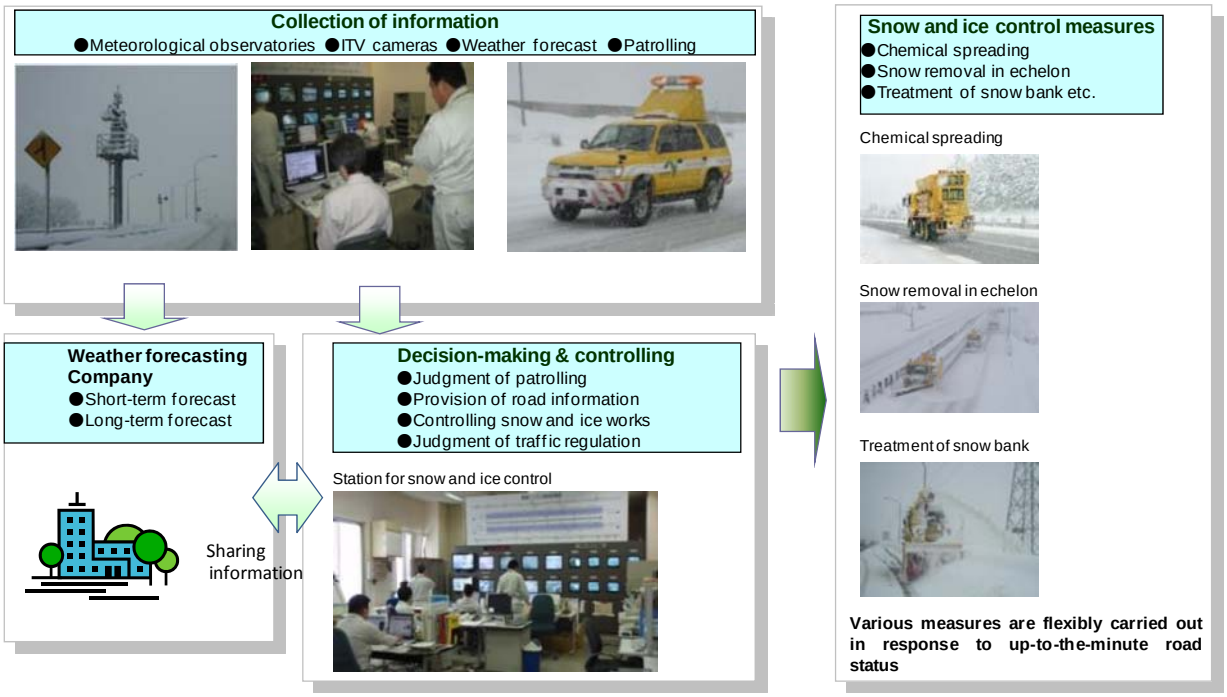



Figure 3 - Snow and ice control by NEXCO East

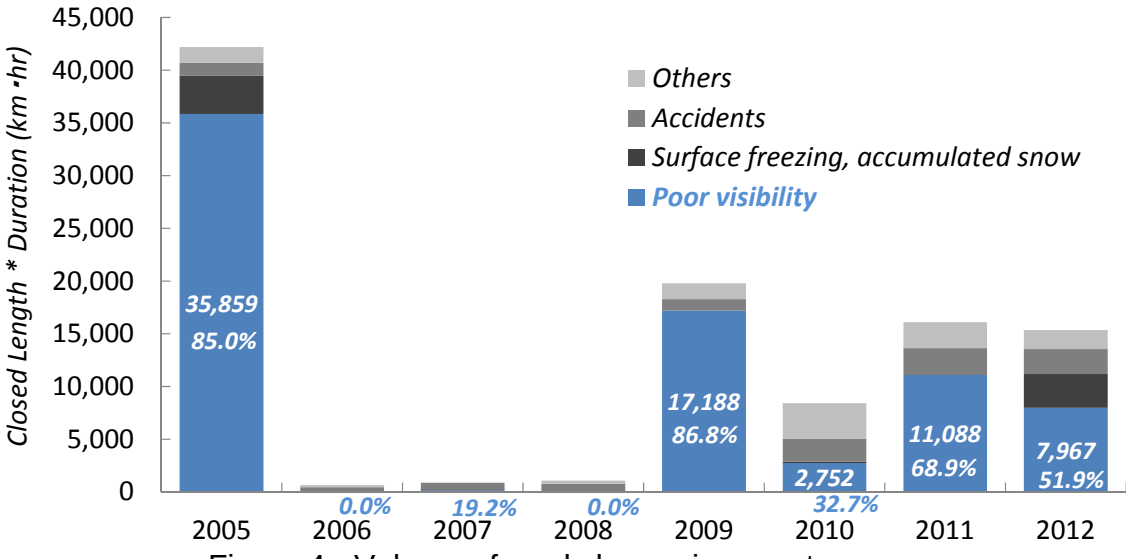



Figure 4 - Volume of road closure in recent years

Let me introduce snow and ice control flowchart by NEXCO East, described in Figure 3. In winter months from the beginning of December through the end of March, smooth and swift measures for road closure is continuously ensured by those staffs staying at the operation stations on an alternative shift basis. Road closure by poor visibility is taken into consideration in case that the visibility is below approximately 50m and securing safety is deemed to be difficult. Through mutual dialogue with traffic police, decision-making for closure is basically implemented. Once the closure is completed, NEXCO East and the traffic police individually carry out patrols over the closed sections. It is not until the weather is improved that each patrolling party judges that safety must be ensured and that dialogue between NEXCO East and traffic police should be organized to reopen the closed sections. Standards on decision-making have been traditionally qualitative, described hereinafter;

Photo 1 - Poor visibility on an expressway

I. First, meteorological data from weather stations along expressways (e.g. wind speed, wind direction, temperature and visibility meter) is confirmed.
II. Second, NEXCO East keeps in touch with a contracted weather forecasting company to acquire the up-to-the-second weather information.
III. Lastly, visual confirmation by patrolling on-site staffs mostly plays a key role.

ITV cameras to keep an eye out for present traffic situation are placed along expressways; however, the cameras are set too high positions to confirm accurate visibility from drivers. The visibility from drivers is generally poorer in comparison with that from ITV cameras, since it is degraded by drifting snow particles from snow bank on shoulders and on road surface as well as by passing vehicles. Therefore, decision-making based on up-to-the-minute reports from on-site patrolling staffs is inevitable to close and reopen expressways.

The current major issues on poor visibility are summarized hereinafter;

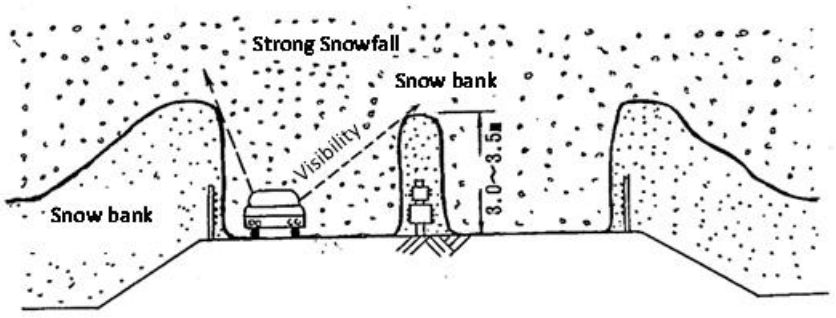
I. It has been difficult to relieve the issues independently and actively by only NEXCO East's snow and ice control measures.
II. It largely depends on the weather condition regarding closing and reopening expressways.

At this stage, NEXCO-East has almost no choices but to confront the issue of poor visibility in a relatively passive manner.

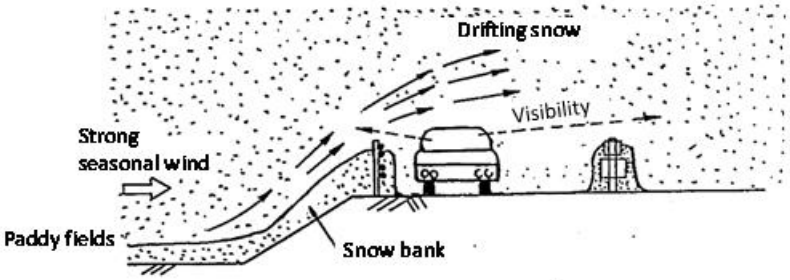
Now, Figure 4 shows volume of road closure in recent years. Photo1 is an example of poor visibility on an expressway. Excluding the data on 2006 through 2008, in which we had abnormally warm winters, more than 50% of the volume, more than 80% in harsh winters, was occupied by poor visibility.

### 1.2. Existing countermeasures

Features of poor visibility are classified into two main categories in Niigata region from the point of views of meteorological and topographic aspects; mountain area and coastal area. The features are summarized hereinafter.




(a) Mountain area




(b) Coastal area

Figure 5 - Geographical features on poor visibility

Table 1 - Pros and cons regarding various kinds of possible countermeasures

| Area | Strategy | Specific countermeasures | Result of survey | |
|---|---|---|---|---|
| Mountain area | Measures against **strong snowfall** | Lighting  | • Effective, but economically inefficient | N/A |
| | | Visual guidance (Light-emitting delineator)  | • Cost efficient<br>• Placing visual guidance into center median is recommended to avoid interfering snow removal works and being buried into accumulated snow wall.<br>• Center median is more economical; electric cable and supporting post combined into one line. | OK |
| Coastal area | Measures against **drifting snow** | Windbreak forest  | • It is not until trees grow up to be 3 or 4 meters high that the forest fulfill an adequet function. | N/A |
| | | Snow fence  | • Economically inefficient to ensure clear visibility on 4 lane expressway<br>• Snow removal by conveyance is required.<br>• Predominant wind direction and road direction should be orthogonal. | N/A |

Expressways passing through mountain area meteorologically have heavy snowfall; therefore, snow bank on both sides of shoulders and centre median reaches as high as three meters, as illustrated in Figure 5 (a). It is not unusual that snowfall rate is up to 10cm/h. In worse case, so-called whiteout occurs and drivers have great difficulty to distinguish traffic lane from snow bank.

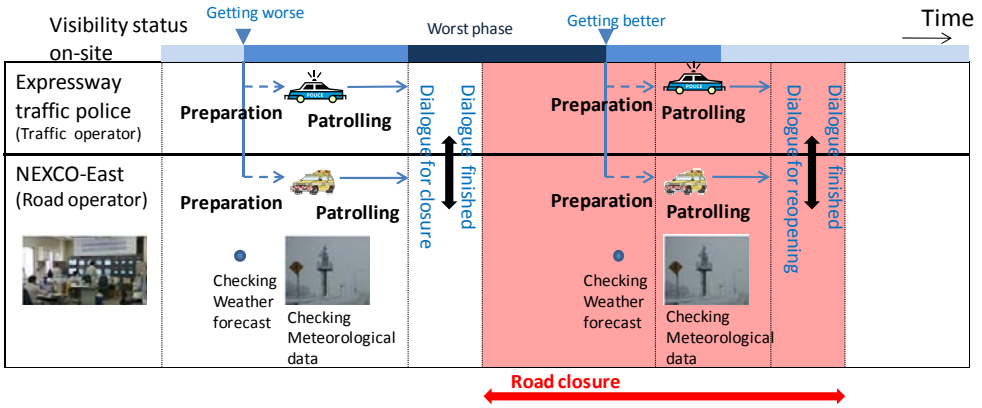
Expressways in coastal area, on the other hand, pass thorough vast paddy fields in the shape of embankment. Coastal areas have less snowfall in comparison with those in mountain area; hence, snow bank on the shoulders and centre median does not grow taller. Nevertheless, expressways in coastal areas are meteorologically affected by strong seasonal wind. That is to say, newly fallen snow on upwind side of paddy fields often drifts on the air and flies towards expressway insomuch that visibility on the expressway degrades, as illustrated in Figure 5(b).

Based on these detailed surveys, pros and cons regarding various kinds of possible countermeasures were weighed two decades ago, and accordingly the most effective measure, that is light-emitting delineator, was decided to be constructed, as listed in Table.1. A follow-up survey was implemented in 2001 to review the effectiveness of the delineators, concluding that the volume of road closure was generally reduced by this measure. Nevertheless, the issue of road closure caused by poor visibility remains unsettled, as discussed in the preceding section.

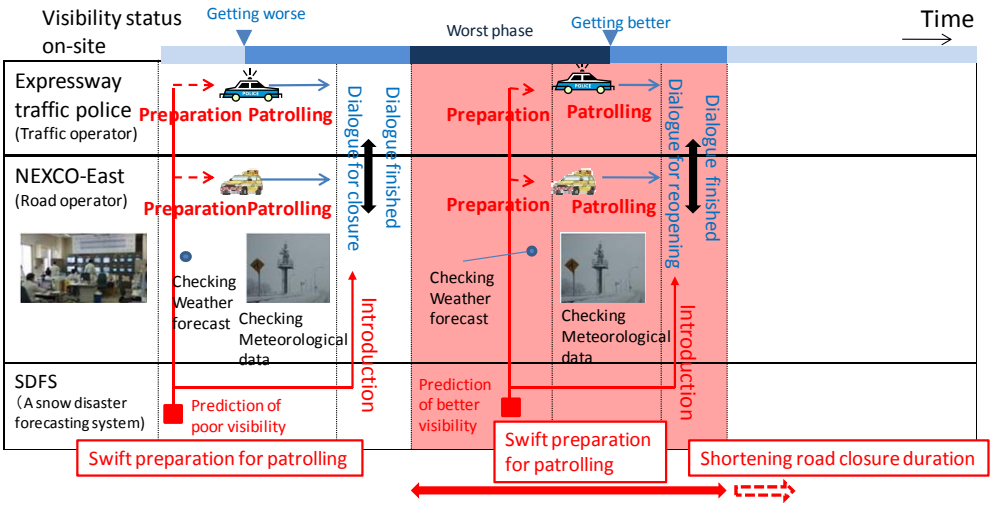
## 2. TRIAL APPROACH TOWARDS MORE EFFECTIVE TRAFFIC OPERATION

### 2.1. Introduction of a forecasting system on poor visibility

Long term closure of expressways has a considerable impact on the intercity logistics and regional economy; hence, how swiftly reopen closed sections is the centre of discussion at this time. Decision-making on reopening basically depends on eyesight of on-site patrolling staffs as well as existing weather forecasting information, illustrated in Figure 6 (a).




(a) Current status




(b) Introduction of SDFS

Figure 6 - Introduction of SDFS on poor visibility

From the standpoint of countermeasures by infrastructure development, the effective approach, which is the light emitting delineator, has already been implemented around 20 years ago; hence developing further infrastructures as countermeasures is not deemed to be a realistic option from a cost-effectiveness perspective.

For the reason mentioned above, NEXCO East and Snow and Ice Research Center of National Research Institute for Earth Science and Disaster Prevention (SIRC/NIED) commenced a trial approach towards more effective traffic operation from 2012 by introducing A Snow Disaster Forecasting System (SDFS), which was constructed by SIRC/NIED as illustrated in Figure 6 (b). Concept and details on SDFS were described in Nakai et al.(2012) [1]. SDFS informs NEXCO East on estimated degree of visibility as well as timing, duration, location and so forth. Accurately estimating the timing will surely enable swifter preparation for patrolling by both NEXCO East and traffic police.

Figure 7 describes the outline of SDFS. The evaluation calculation for forecasting is implemented twice a day, 4 a.m. and 4 p.m., which provides NEXCO East a series of estimated data by every 1.5km$^2$ on a specific map with colour scale on the subsequent 14 hours. Figure 8 illustrates the prediction model of SDFS. A series of parameters were previously identified by kinds of experiments such as wind tunnel testing.

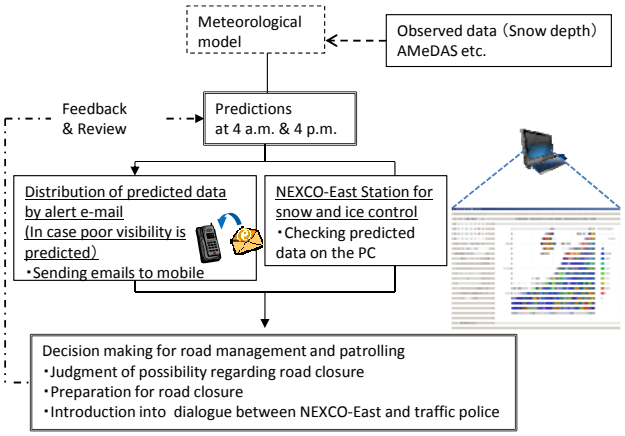



Figure 7 - Outline of SDFS

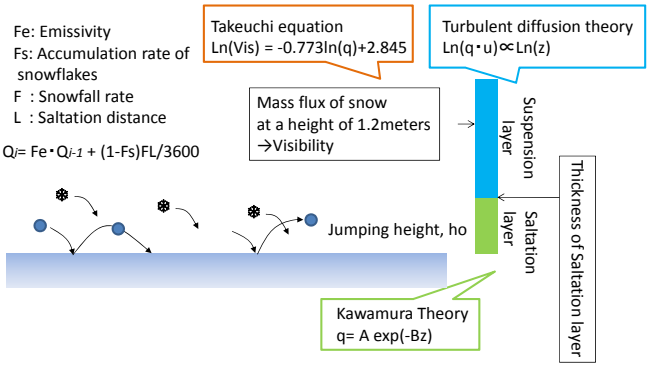


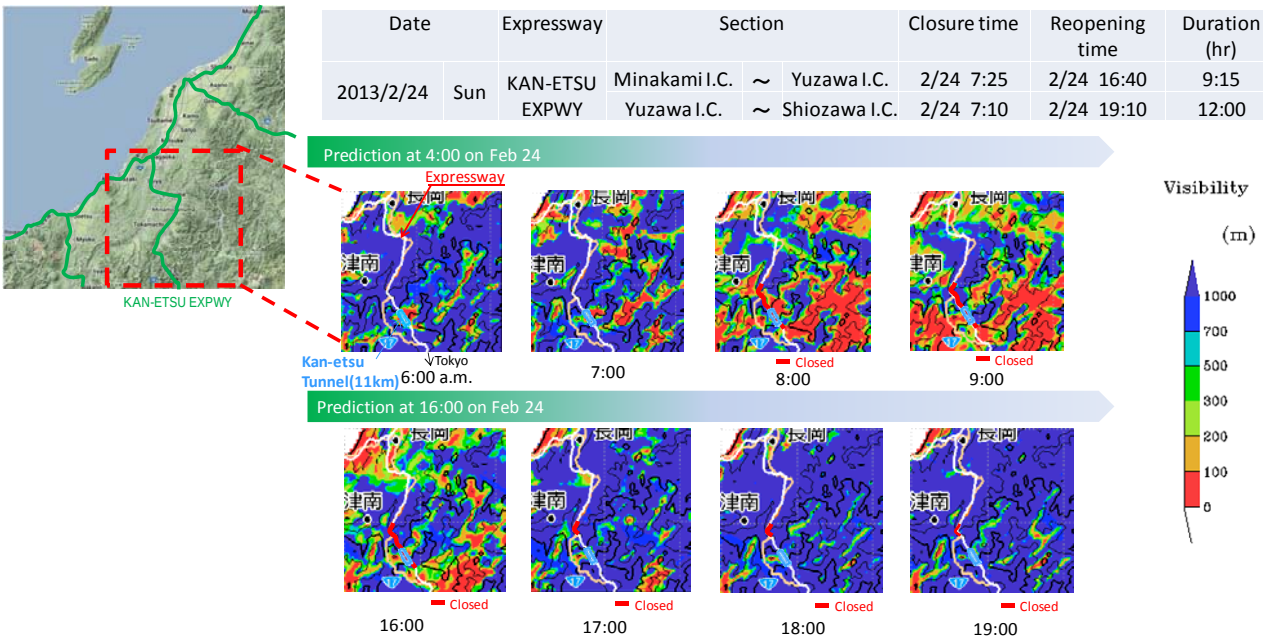

Figure8 - Prediction model of SDFS

## 2.2. Case studies

### *2.2.1. Case on mountain area*

A road closure on KAN-ETSU EXPRESSWAY was implemented by poor visibility across the Kan-etsu tunnel on Feb 24, 2013. Another arterial road is solely NH17, which passes over tall mountain area with unfavourable road alignment, whereas KAN-ETSU EXPRESSWAY, 85% of all traffic is diverted to, passes through the area with the Kan-etsu tunnel. The closure was continued up to 9 to 12 hours. Unfortunately, the day was on the weekend, which caused enormous impacts on many tourists from Tokyo metropolitan area and intercity logistics as well. The commencement of the closure was carried out on 7 o'clock in the morning, and the reopening was at 16:40 for the section between Minakami I.C. to Yuzawa I.C. and subsequently at 19:10 for between Yuzawa I.C. to Shiozawa I.C.

Now let us focus on Figure 9, which illustrates the predicted data by SDFS and the actual closed sections depicted by red lines. The forecast at 4 a.m. shows that the area of visibility under 100m will expand dramatically at around 7 to 8 a.m. This trend is deemed to be similar to the measured wind speed, as shown in Figure 10. Subsequently, the forecast at 4 p.m. says that the area will contract considerably at around 5 p.m. Let us focus on




| Date | | Expressway | Section | | | Closure time | Reopening time | Duration (hr) |
|---|---|---|---|---|---|---|---|---|
| 2013/2/24 | Sun | KAN-ETSU EXPWY | Minakami I.C. | ~ | Yuzawa I.C. | 2/24 7:25 | 2/24 16:40 | 9:15 |
| | | | Yuzawa I.C. | ~ | Shiozawa I.C. | 2/24 7:10 | 2/24 19:10 | 12:00 |

Figure 9 - Road closure in mountain area on February 24, 2013

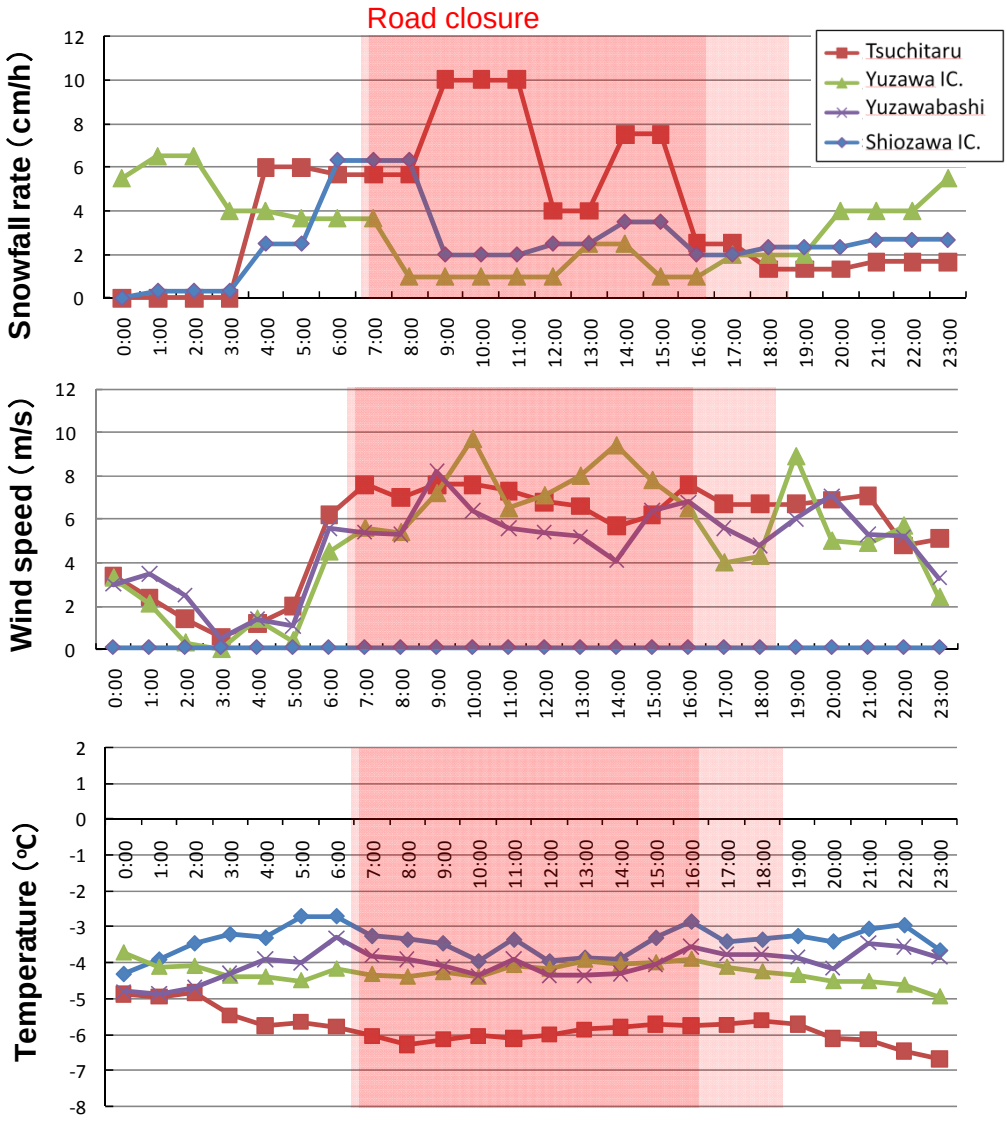



Figure 10 - Weather data on February 24, 2013

measured snowfall rate in Figure 10. Snowfall rate at Tsuchitaru decreased at 4.p.m., which trend is analogous to those of predicted data by SDFS. From these data, it would be reasonable to conclude that the forecasting system is possible to predict the tendency of area, time and duration regarding the poor visibility with acceptable accuracy.

2.2.2. *Case on coastal area*

Many sections were forced to be closed throughout Niigata region on January 26, 2013. The day was unfortunately on the weekend as well; therefore, it had a great impact on daily life of local residents.

Red lines in Figure 11 depict the closed sections. The forecast at 4 a.m. estimates that the area of poor visibility under 100m maximizes at noon, and subsequently will contract step by step. The forecast at 4.p.m., on the other hand, estimates that the area will diminish rapidly, excluding some remaining areas with poor visibility.

On that day, the event continued over the night, hence it took a relatively long period of time to confirm safety on expressways by direct eyesight of on-site patrolling staffs by both NEXCO East and traffic police, which deemed to be the reason why reopening timing differed from the data on estimated visibility by SDFS.

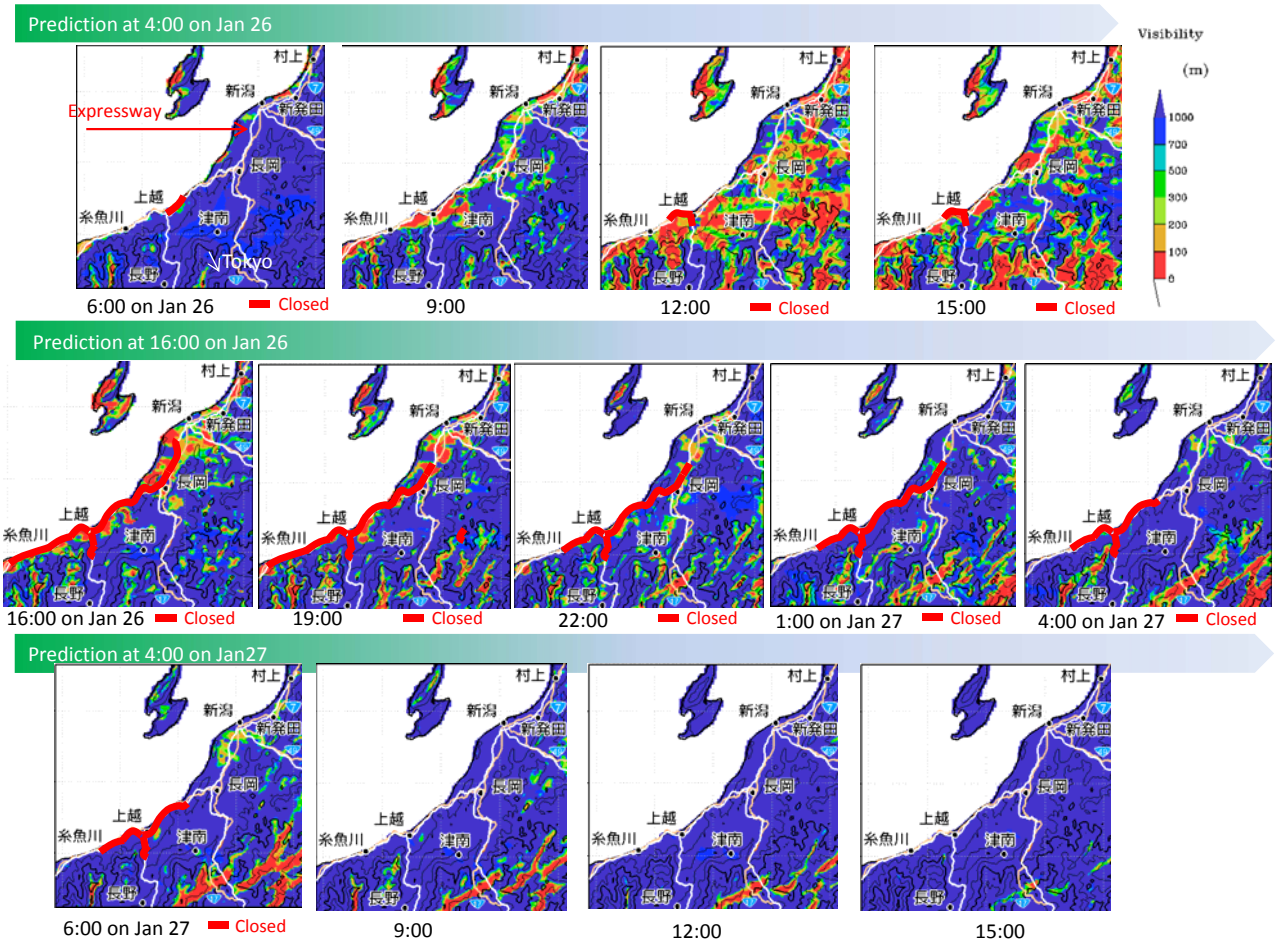



Figure 11 - Road Closure in coastal area on January 26-27, 2013

## 3. CONCLUSIONS

In 2012, NEXCO East and SIRC/NIED commenced a collaboration project to make a more effective operation on expressways throughout Niigata region. The clarified outcomes through the trial project are listed hereinafter;

- ✓ Through the trial introduction of SDFS over the last winter, NEXCO East and SIRC/NIED examined that estimated areas with poor visibility can be identified at a glance, and moreover the data could be useful thanks to their quantitative scale.
- ✓ The outcome could be available for mutual dialogue between NEXCO East and the traffic police.

Following points are what we learned and should be improved.

- ✓ Informing every staff at on-site offices regarding the detail of SDFS; a series of snow and ice measures are continuously implemented around-the-clock on a rotating basis.
- ✓ Modifying usability of the system (e.g. display software on PC); this would be preferable in order to be widely used.
- ✓ Implementing further case studies in addition to those in 2012 and continuously carrying out for the purpose of integrating this system into the flowchart of existing regular ice and snow works

In 2013, NEXCO East and SIRC/NIED are planning to estimate the possibility of road closure more accurately in consideration of cases in 2012. Furthermore, defining a specific standard on visibility for road closure has been another centre of the discussion in order to build response actions more swiftly. Through these approaches, we would like to ensure safer, more reliable and comfort service on expressways during winter months.

## REFERENCES

1. Sento Nakai, Takeshi Sato, Atsushi Sato, Hiroyuki Hirashima, Masaki Nemoto, Hiroki Motoyoshi, Katsushi Iwamoto, Ryohei Misumi, Isao Kamiishi, Toshiichi Kobayashi, Kenji Kosugi, Satoru Yamaguchi, Osamu Abe, Masaaki Ishizaka (2012). A snow Disaster Forecasting System (SDFS) constructed from field observations and laboratory experiments. Cold Regions Science and Technology. Vol70, pp53-61