道路構造と風向の変化を考慮した吹雪視程予測技術に関する研究

Research on Technology for Forecasting Visibility during Snowstorms Considering the Road Structure and Changes in Wind Direction

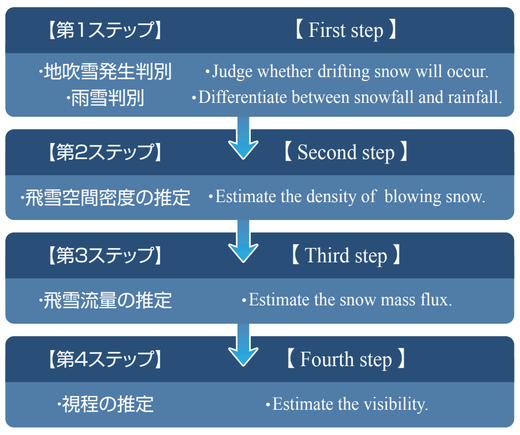
近年では、吹雪の発生頻度が低い地域においても極端な暴風雪に起因した吹雪により多重衝突事故が発生している。この様な暴風雪に起因した交通障害の予防軽減に向けては、道路管理者による道路除雪及び道路通行止めなどの道路管理をより適確に行って行くことが重要となります。本研究では、暴風雪時における道路管理者の判断支援に資する、路線上における吹雪視程予測技術の開発を目指しています。

In recent years, blowing snow-induced multi-vehicle collisions have occurred during extreme snowstorms, even in areas where the frequency of snowstorms in average years has been low. To mitigate traffic problems caused by such snowstorms, road administrators need to manage roads more appropriately by clearing snow and closing the roads to traffic in a timely manner. This research aims to develop a technique for predicting snowstorm-induced visibility reductions on routes in order to assist road administrators in their decision-making on road management during snowstorms.

気象条件に基づく吹雪時の視程推定手法とその課題

A method for estimating visibility during snowstorms based on weather conditions, and issues toward its development

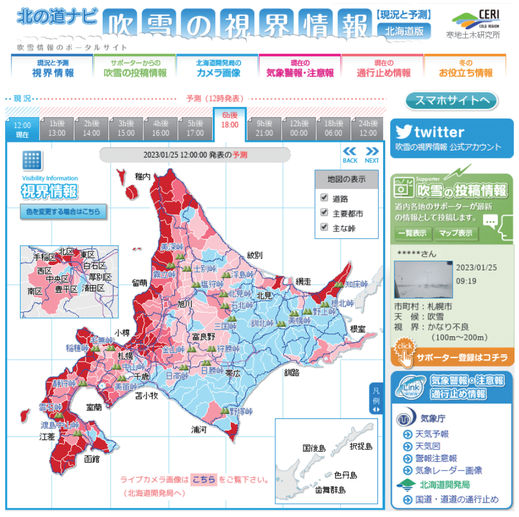
寒地土木研究所では、一般に入手可能な気象データ（気温、風速、降水量、相対湿度）に基づき、地吹雪発生について推定し、道路のドライバーの目線高さにおける飛雪流量[g/(m²・s)]から吹雪時の視程(m)を推定する手法（図１）を開発しました。開発した手法は道路利用者への吹雪の視界情報の提供に活用しています（図２）。しかし、この手法により推定される視程は、風上に平らな雪原（吹走距離）が存在する地点において吹雪が十分発達した状態を想定した結果です。このため、道路上における視程障害の状況とは厳密には一致しない恐れがあります。



▲図１ 気象条件に基づく吹雪時の視程推定の流れ

Fig. 1 Flow for estimating visibility during snowstorms based on the weather conditions

Based on generally available meteorological data (air temperature, wind speed, precipitation, and relative humidity), the Civil Engineering Research Institute for Cold Region has developed a technique (Figure 1) for estimating the occurrence of drifting snow on the road and for estimating the visibility (m) during snowstorms using the snow mass flux [g/(m²s)] at the driver's eye level on the road. The technique is used in the Snowstorm Visibility Information System, which is geared to road users (Figure 2). However, the visibility estimated using this technique is based on the assumption of well-developed blowing snow at points where a flat snowfield exists windward of the road section (a considerably long fetch). Therefore, the actual visibility reduction on the road may differ from the predicted results.



▲図２ 吹雪の視界情報
（道路利用者（ドライバー等）へ試験提供）

Fig. 2 Snowstorm Visibility Information System (experimentally provided to the road users (drivers))

道路上の視程障害

Visibility hindrance on the road

道路上での吹雪による視程障害は、沿道環境や道路構造などの条件の違いによって複雑に変化することが確認されています。図３は、視程障害移動観測車によって測定した路線上の視程と沿道環境を併記し比較した結果の一例です。風上の平坦地が長く開けた区間で視程が低下していることが確認できます（図3(b), (d)）。一方、橋梁区間、平坦地の短い区間、市街地内では視程があまり低下していないことが確認できます（図3(a), (c),(e)）。

It has been found that visibility reductions caused by blowing snow on roads are complex and that they vary depending on the roadside environment, road structure, and other conditions. Figure 3 shows an example of the relationship between the roadside environment on a route and the visibility measured using an on-road visibility observation vehicle. The figure shows that visibility is lower on road sections with flat, open land on the windward side (Figures 3(b) and (d)). It can be observed in Figure 3 that the visibility is not reduced much on the bridge section (a), the section with narrow flat land on the windward side (c), and the section that runs through an urban area (e).

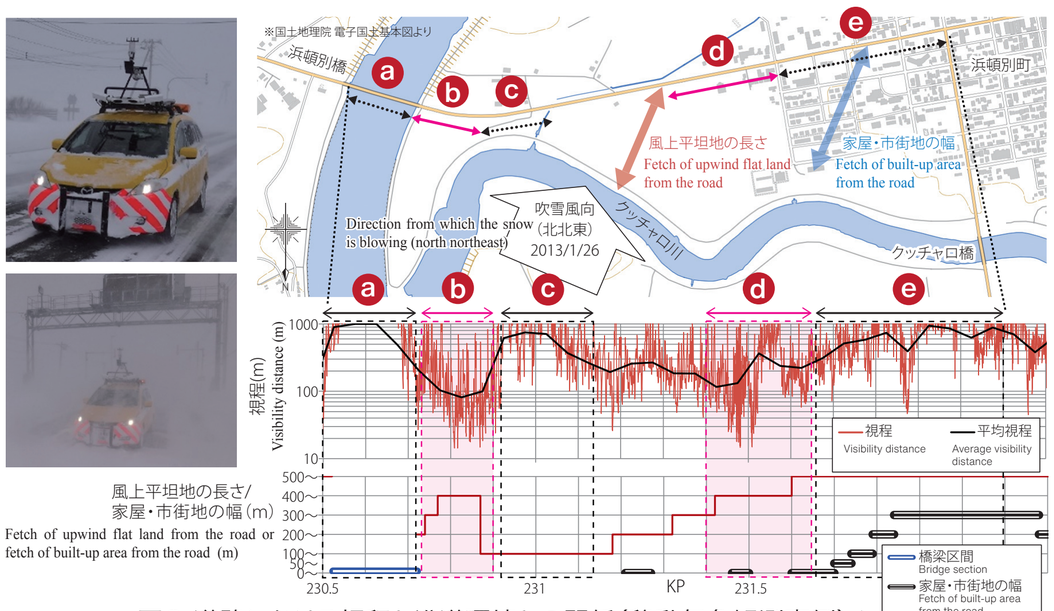


図３ 道路における視程と沿道環境との関係（移動気象観測事例）▲

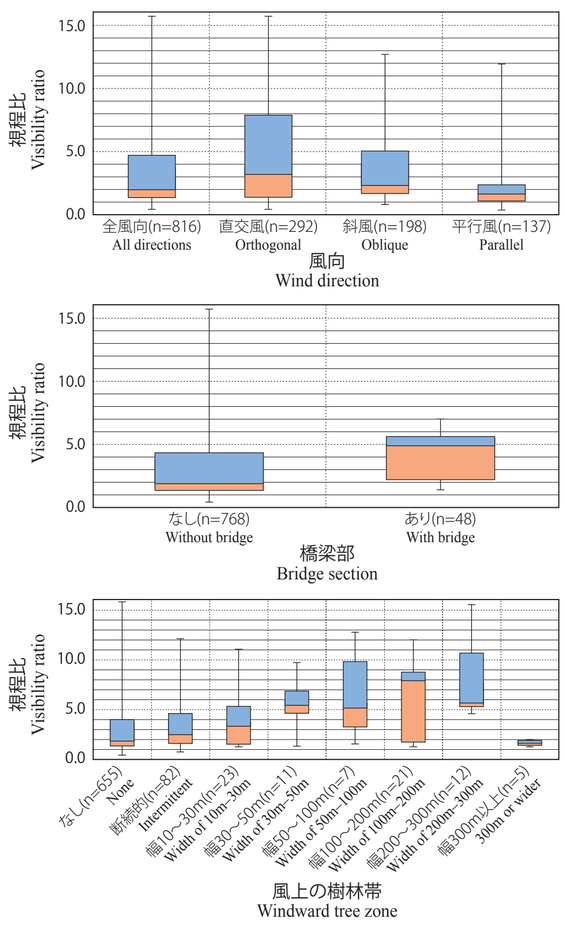
Fig. 3 Relationship between visibility and road environment (a case using measurements from a visibility observation vehicle)

道路上の視程観測値と気象条件に基づく視程推定値の比較

Comparison between the onsite observed visibility and the visibility estimated based on the weather conditions

一般に入手可能な5km格子点の気温[℃]及び風速[m/s]と1km格子点の降水量[mm/h]のデータに基づき推定した視程（視程推定値）、道路上で測定された視程（視程観測値）の比（視程比=視程観測値/視程推定値）について解析しました（図4）。その結果、道路に対する風向が平行風に比べ直交風で視程比のバラツキが大きい傾向が見られました。道路構造では、橋梁部で視程比が大きい傾向が見られました。また、風上の樹林帯の幅が長いほど視程比が大きい傾向が見られました。

We analyzed the ratio of estimated visibility (i.e., visibility estimated based on generally available data of air temperature [°C] and wind speed [m/s] at 5-km grid points and on precipitation [mm/h] at 1-km grid points) to observed visibility (i.e., visibility measured on the road) (Figure 4). It was found that this ratio tended to vary more when the wind direction was orthogonal to the road than when the wind direction was parallel. Regarding the relationship between visibility ratio and road structure, the visibility ratio tended to be higher at the bridge section. The visibility ratio tended to be higher the wider was the windward tree zone.

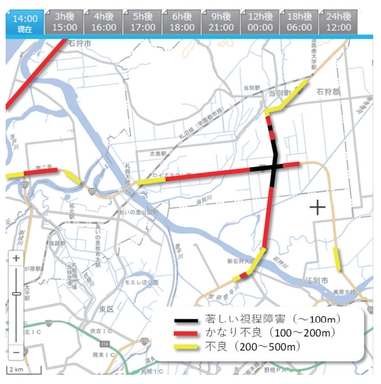


▲図4 視程比=視程観測値/視程推定値

Fig. 4 Visibility ratio = observed visibility/ estimated visibility

吹雪時における路線上の視程障害推定と予測情報の提供

Estimation of snowstorm-induced visibility reduction on routes and the provision of forecast information



道路管理者へ暴風雪時における道路管理状況についてヒアリングなどにより実態を調査するとともに、必要な情報や表示方法などについて検討を行っています。本研究の成果や既存技術などを活用し、道路管理者の暴風雪時の判断支援に資する路線上の視程予測情報提供システム（図５）の開発を目指しています。

▲図５ 暴風雪時の判断支援システム（イメージ図）（道路に沿った視程障害情報）

Fig. 5 Support system for decision-making during snowstorms (concept) (information on visibility reductions along routes)

We are interviewing road administrators to investigate how roads are managed during snowstorms. We are studying ways of prioritizing the type of information they need and the best methods for displaying that information. By utilizing the results of this research and existing technologies, we aim to develop a system for providing visibility forecast information on routes (Figure 5) in order to assist road administrators in making decisions during snowstorms.

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