Relationship between the development of a snowdrift and snow transport rate on a road section with a cut on one side - Observation in Teshikaga-cho during wintertime in FY2016 and FY2017 -

SIRWEC2018

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Background

In recent years, , on winter roads in Hokkaido, stranding of vehicles in snowdrifts arose due to snowstorms on cut road sections.

It is important to carry out more effective wintertime road management, which involves snow removal and road closure.

It is necessary to predict the formation of snowdrifts on cut road sections on a real-time basis.

Vehicles trapped in snowdrifts

Objective

It has been unclear what kind of impact the structure of the cut road section and weather conditions have on the process of snowdrift development.

It is necessary to clarify the process of snowdrift development on a cut road section and its relationship with the snow transport rate.

We surveyed the relationship between the depth of snowdrifts on a cut road section and the snow transport rates.

Method of investigation

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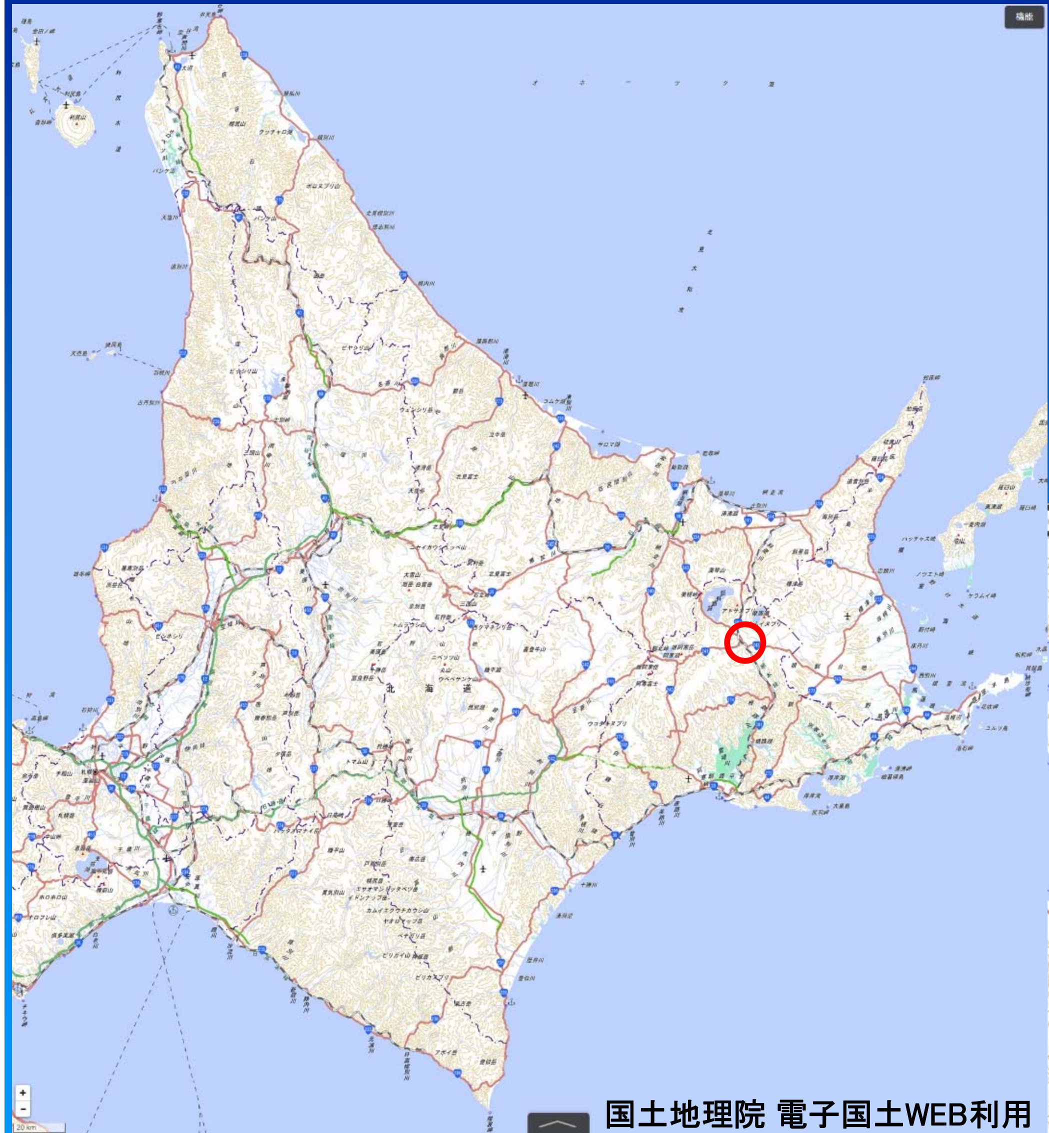


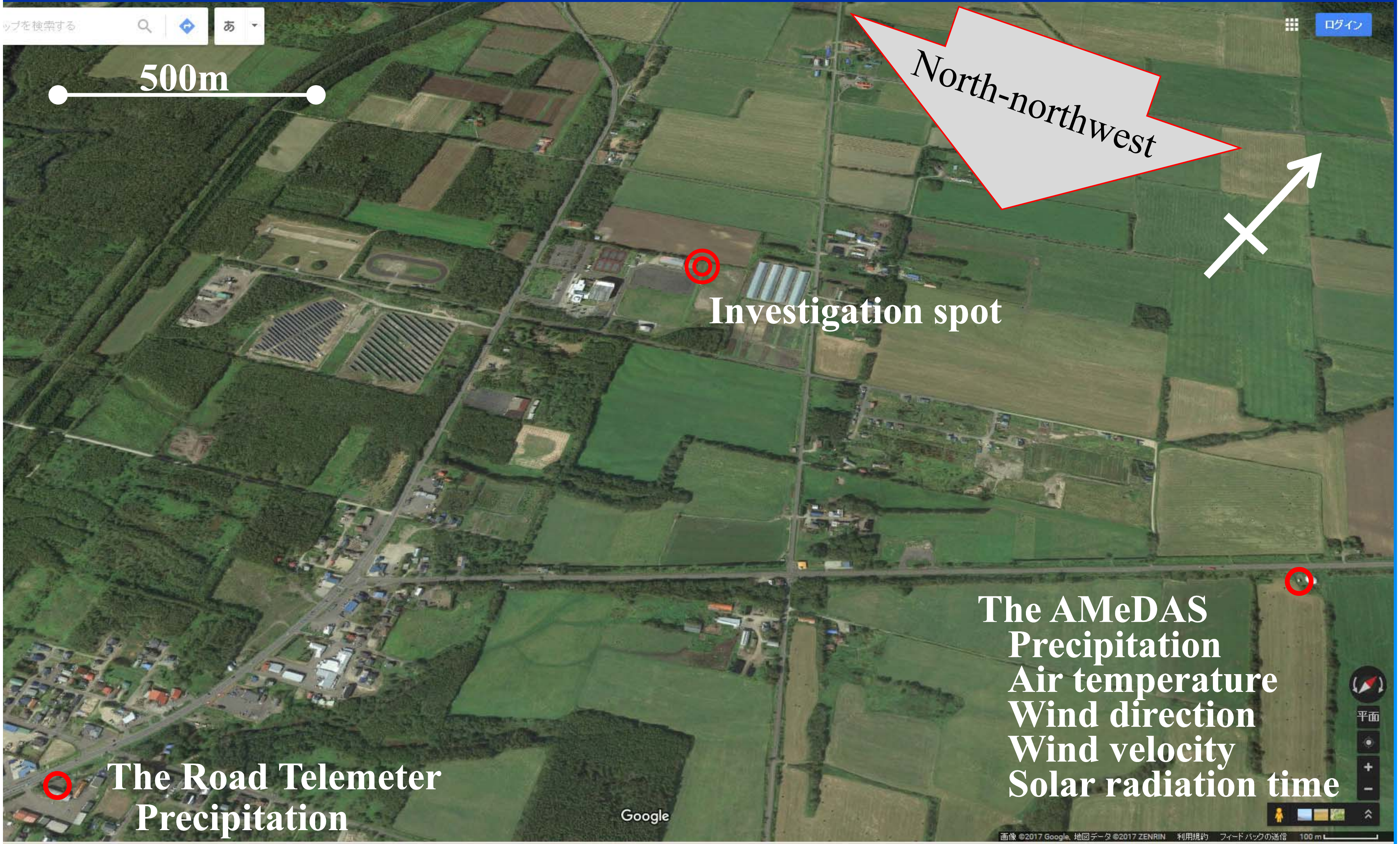
Investigation location :

Teshikaga city

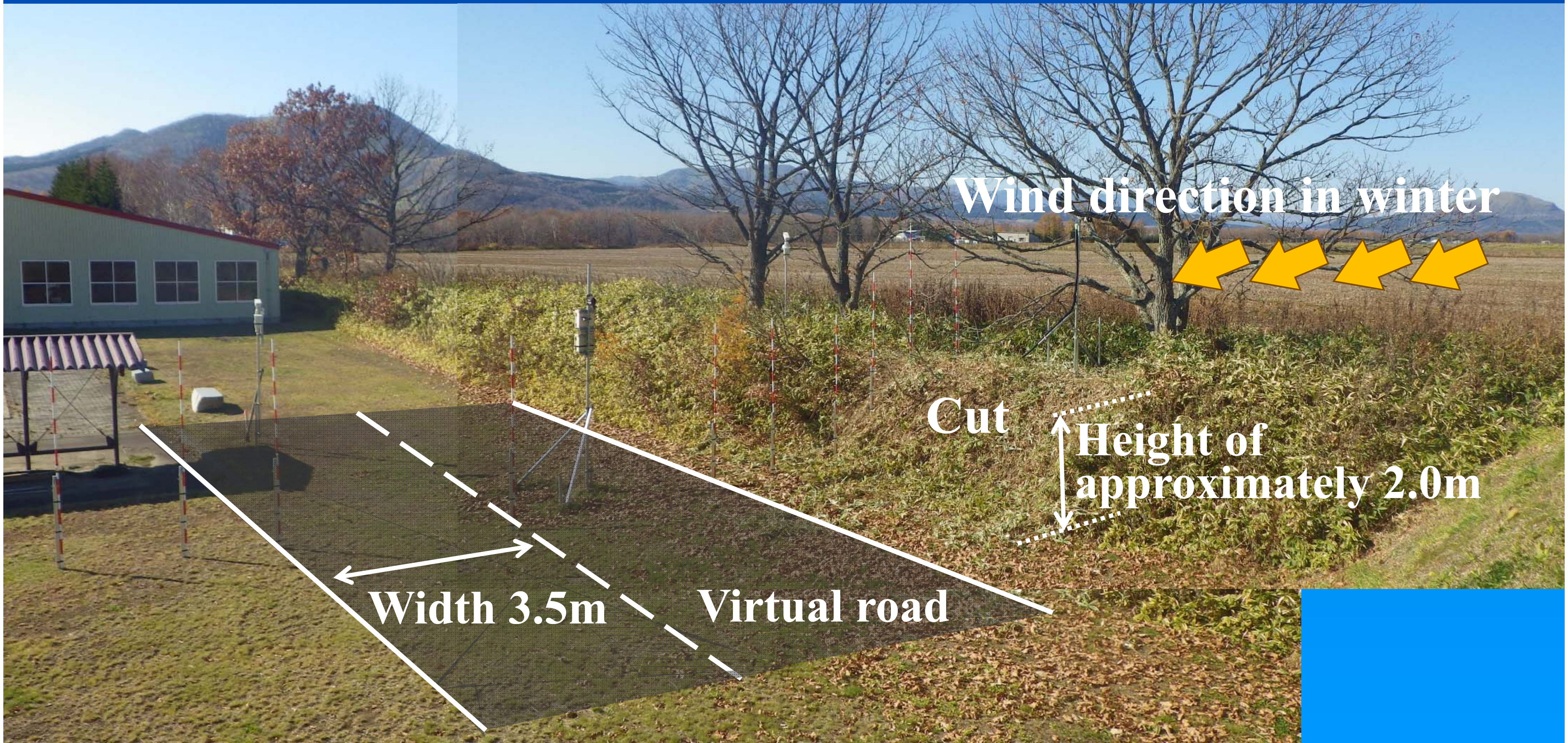
Observation period :

Two winter periods of 2016 to 2017, 2017 to 2018

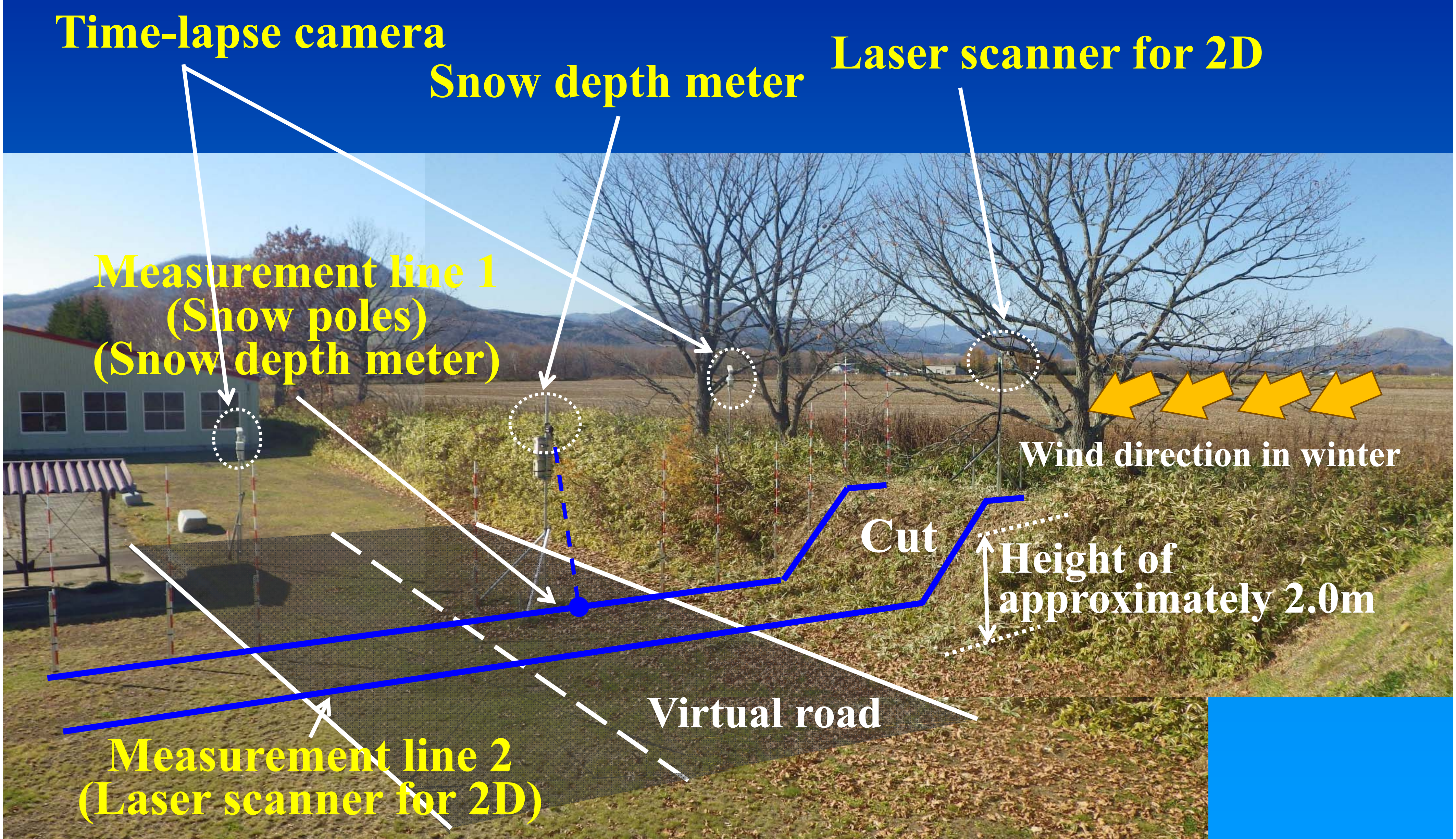
Investigation spot



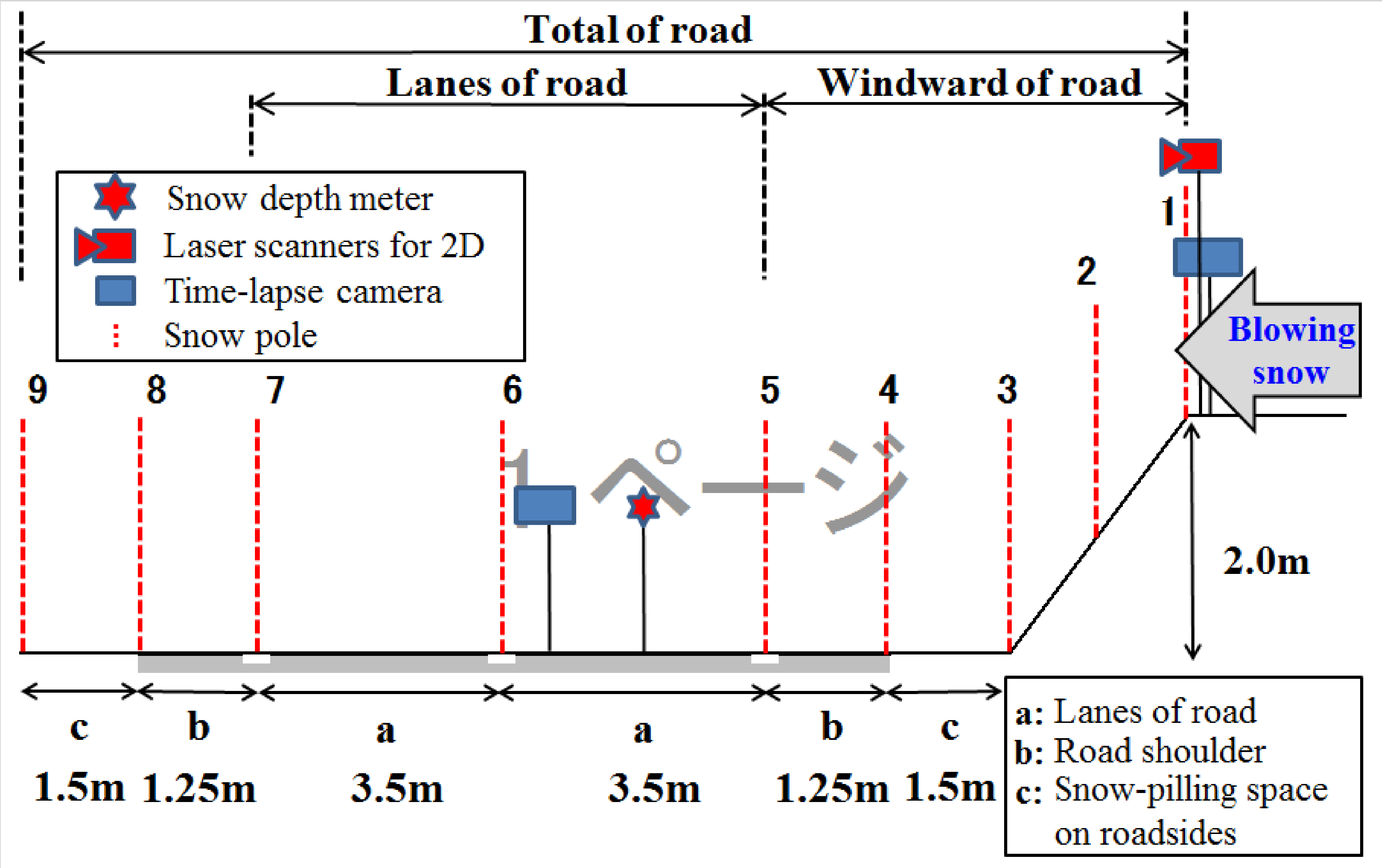
Investigation spot



Method of investigation



Method of investigation



Results of investigation

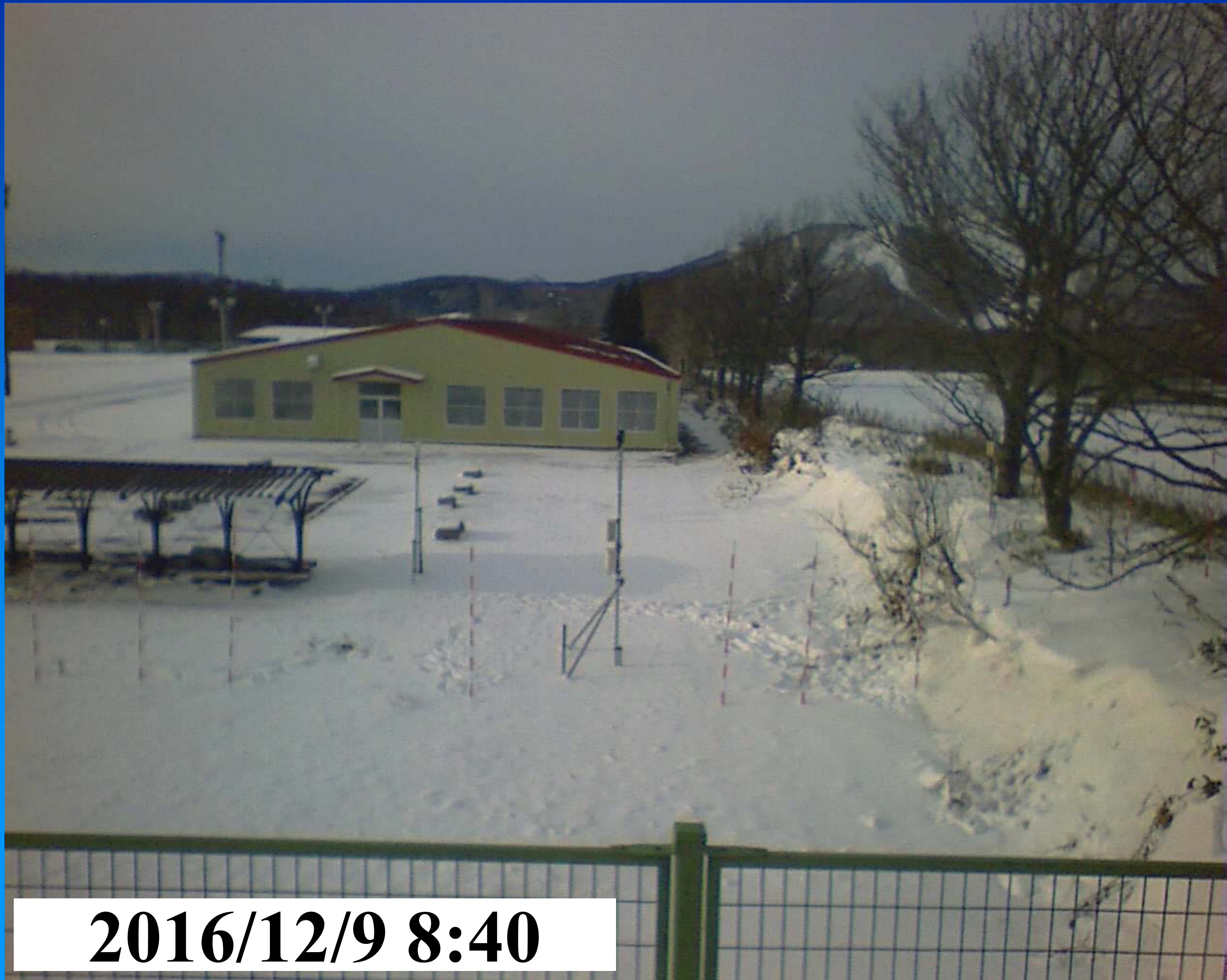
Analysis data

The three periods were events during which blowing snow formed a snowdrift on the lanes of the virtual road where there had been almost no snowdrift before the event.

[Event I] : December 9 to 12, 2016
[Event II] : December 13 to 14, 2017
[Event III] : January 3 to 4, 2018

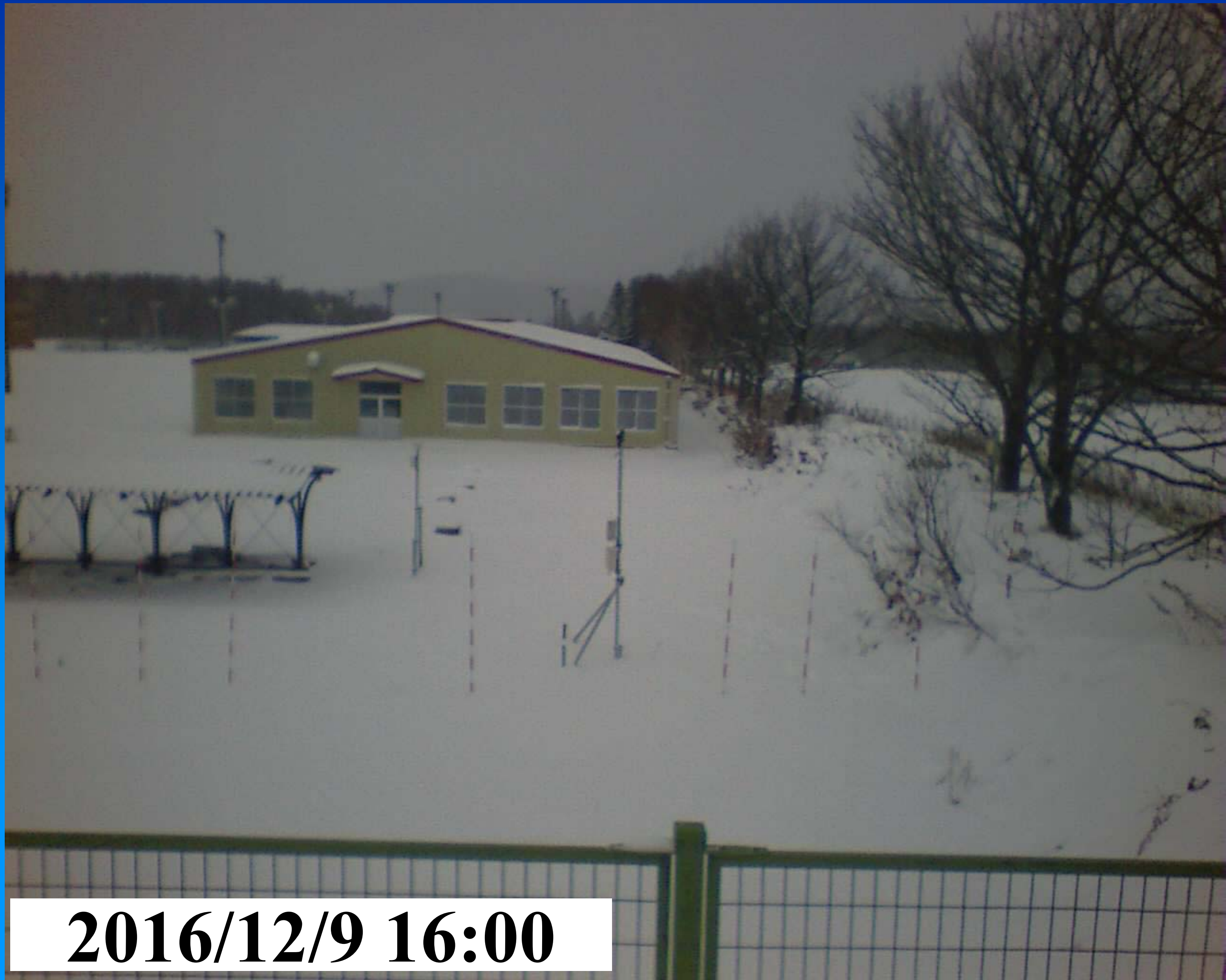
Image

[Event I] : December 9 to 12, 2016



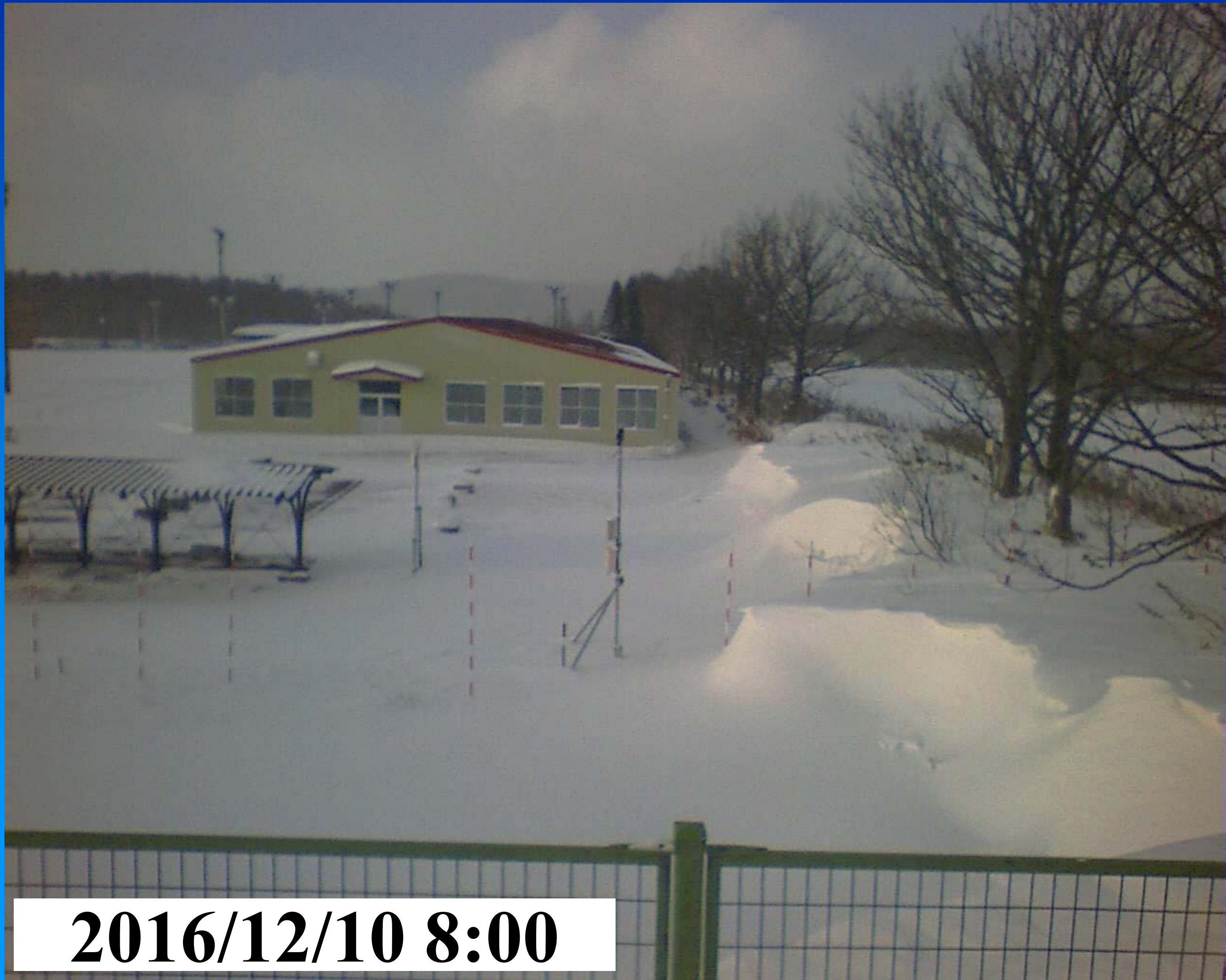
Image

[Event I] : December 9 to 12, 2016



Image

[Event I] : December 9 to 12, 2016



Image

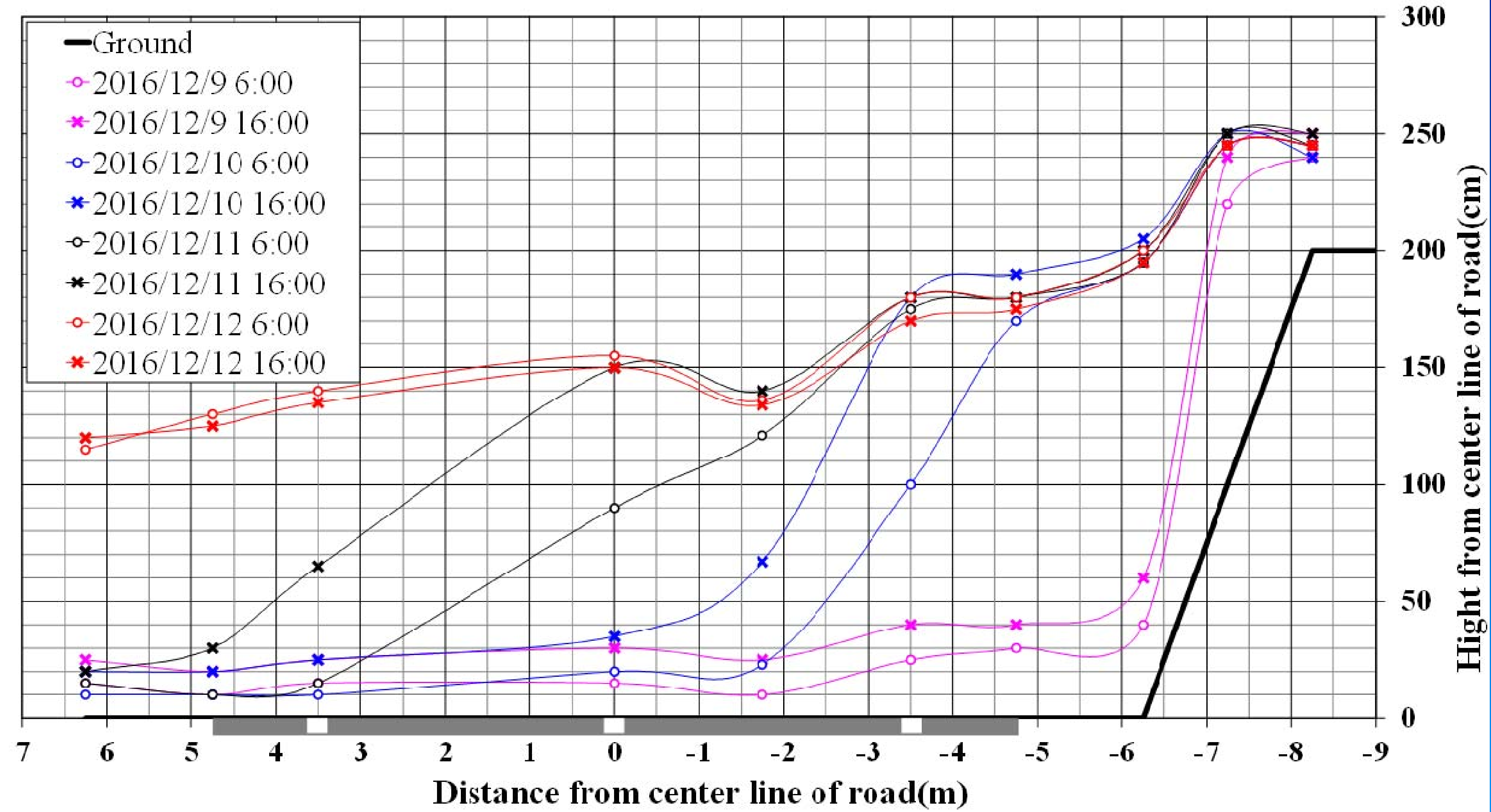
[Event I] : December 9 to 12, 2016

Image

[Event I] : December 9 to 12, 2016

Process of snowdrift development

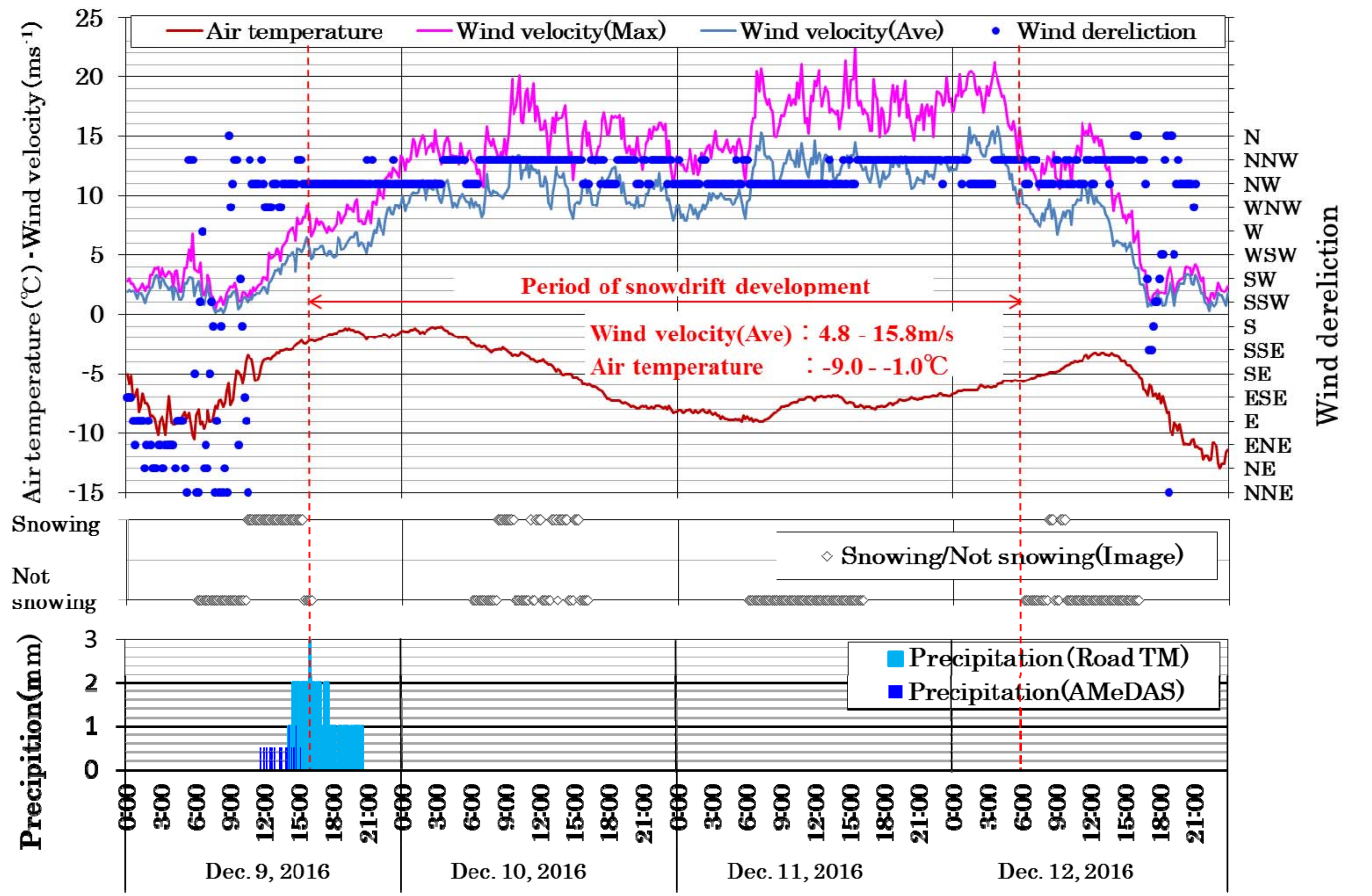
[Event I] : December 9 to 12, 2016



First, the snowdrifts started to form **on the cut slope** from 4 p.m. on December 9, 2016.
Next, the snowdrifts started to form **on the virtual road on the lee of the slope** from 6 a.m. on December 10, 2016.
The accumulation of snow on the cut slope on the windward side before the occurrence of blowing snow was 1.01m^3.

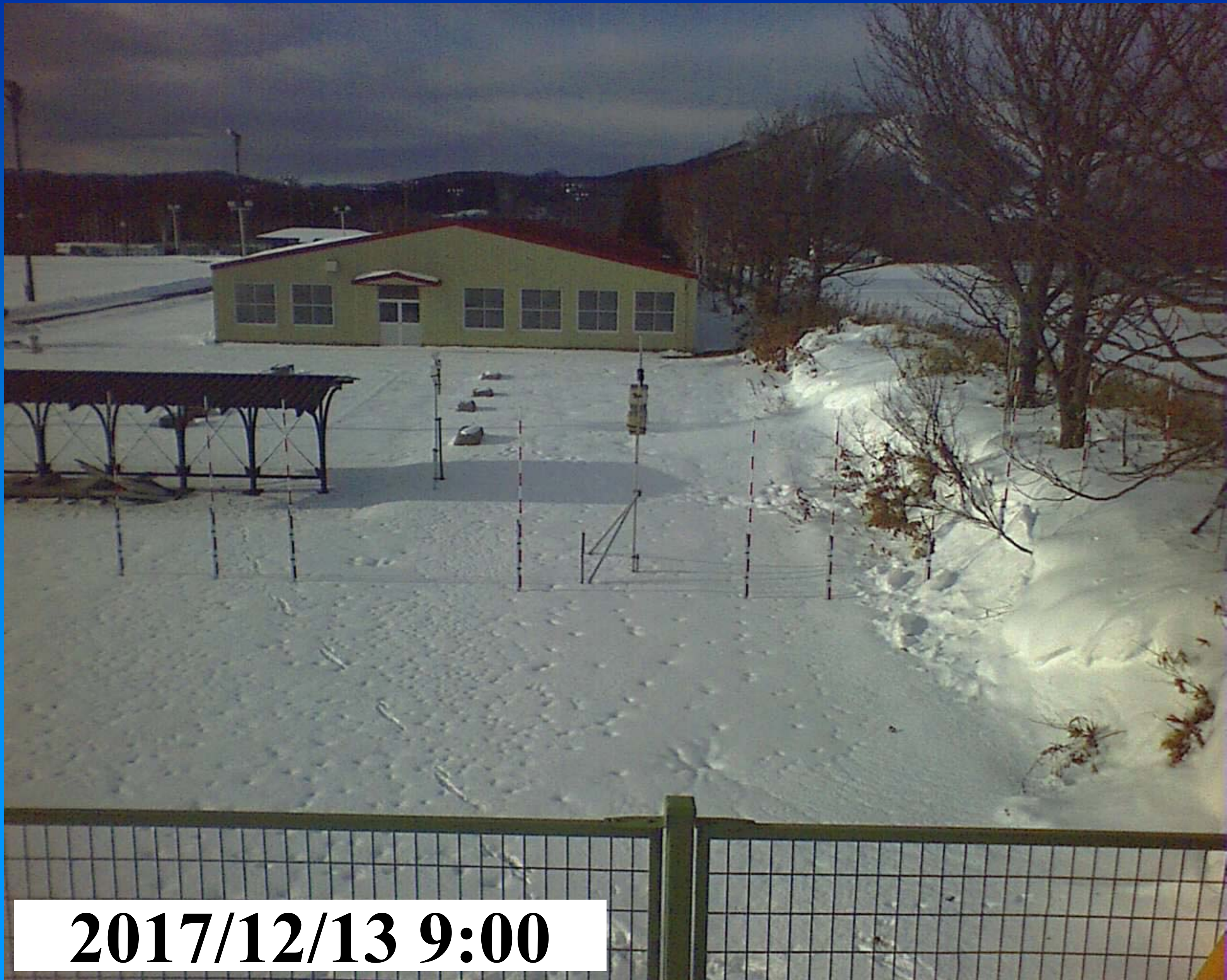
Weather condition

[Event I] : December 9 to 12, 2016



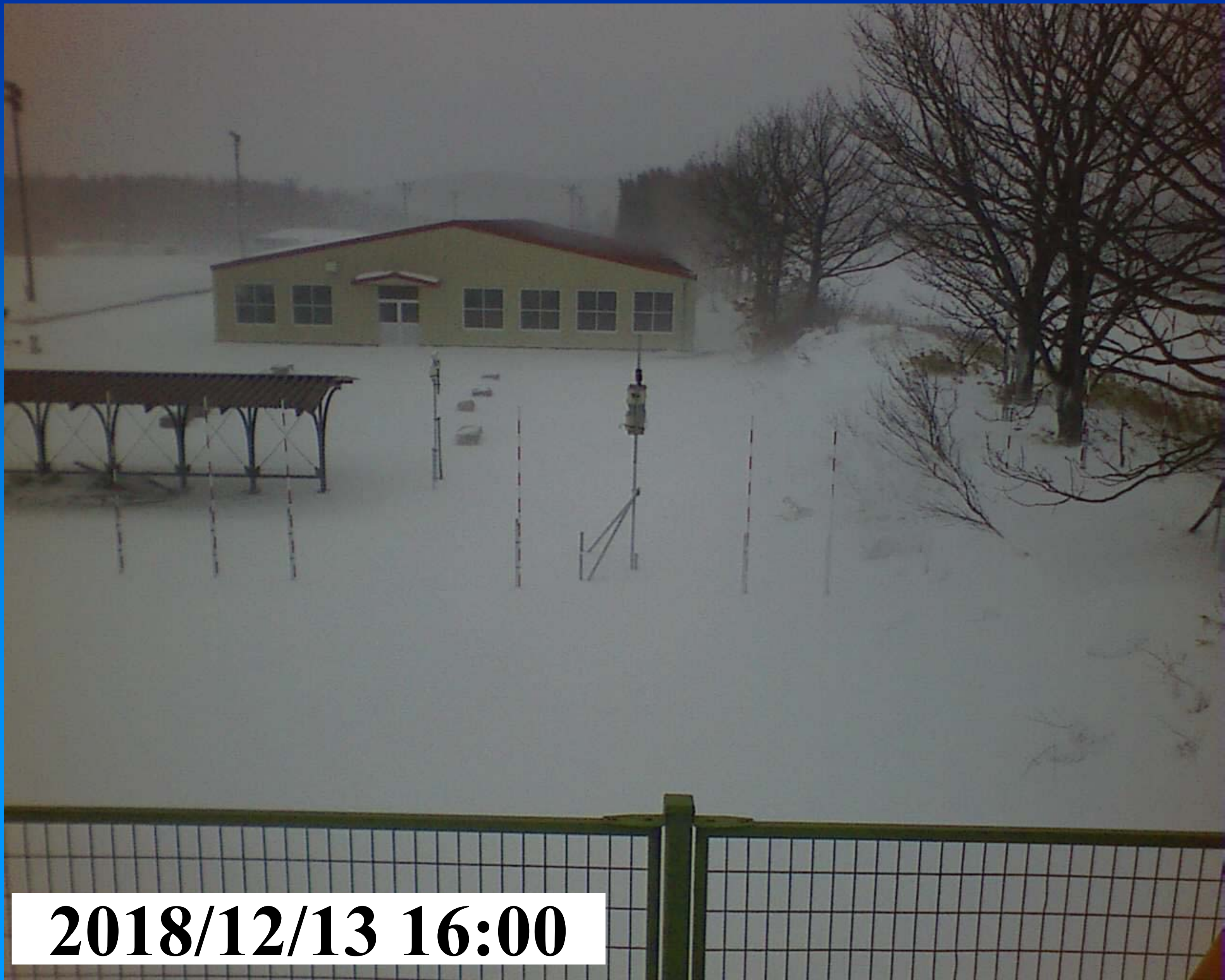
Image

[Event II] : December 13 to 14, 2017



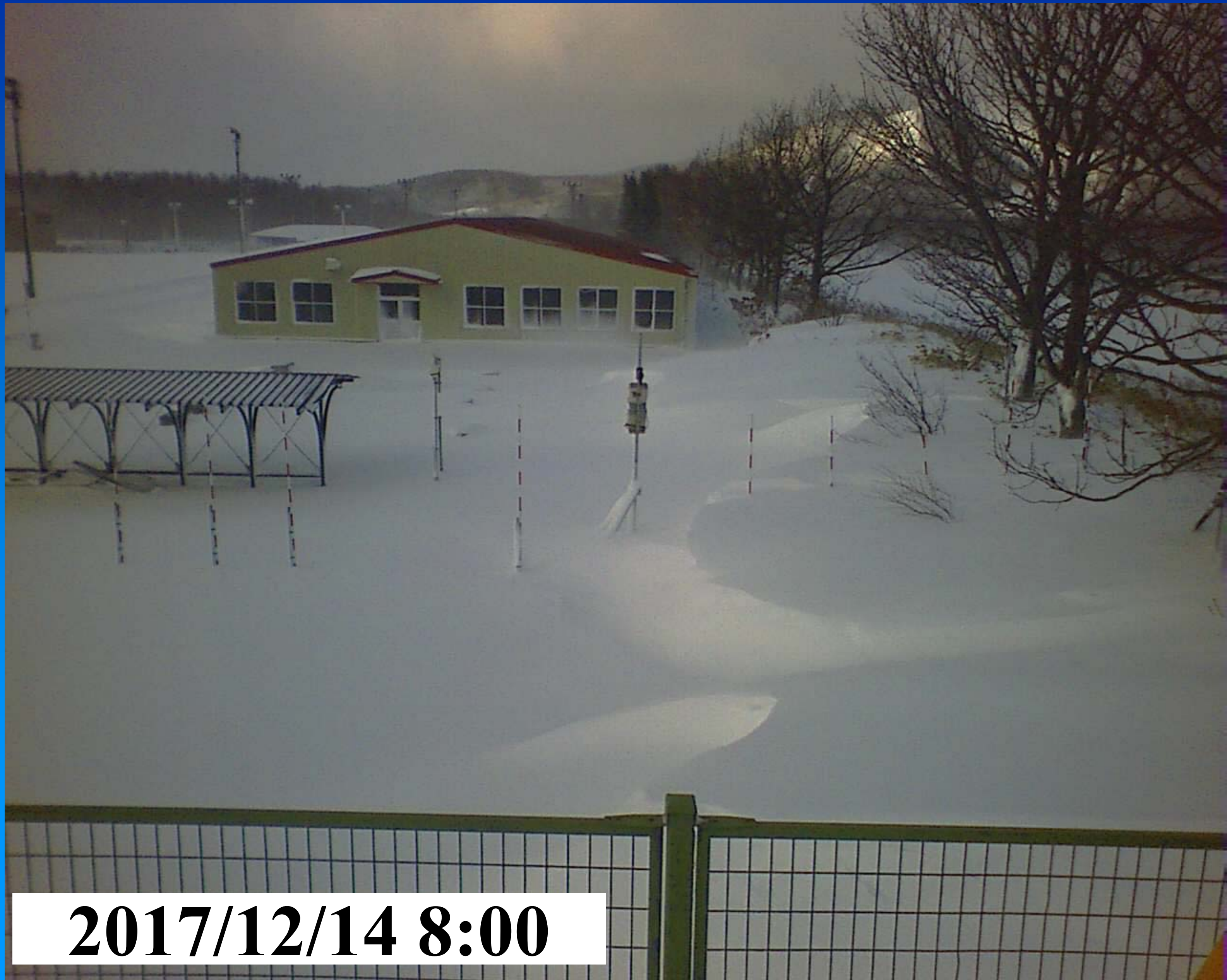
Image

[Event II] : December 13 to 14, 2017



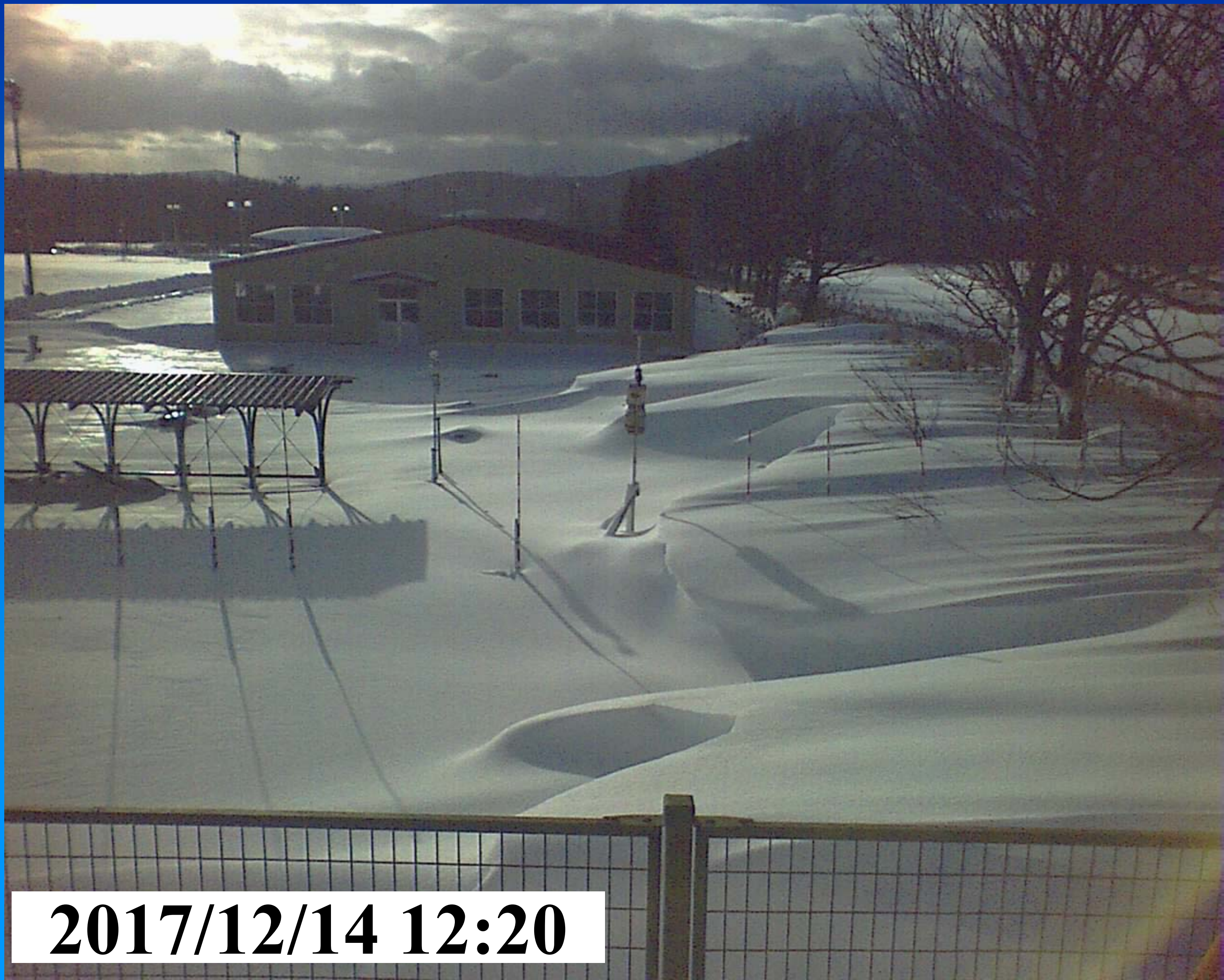
Image

[Event II] : December 13 to 14, 2017



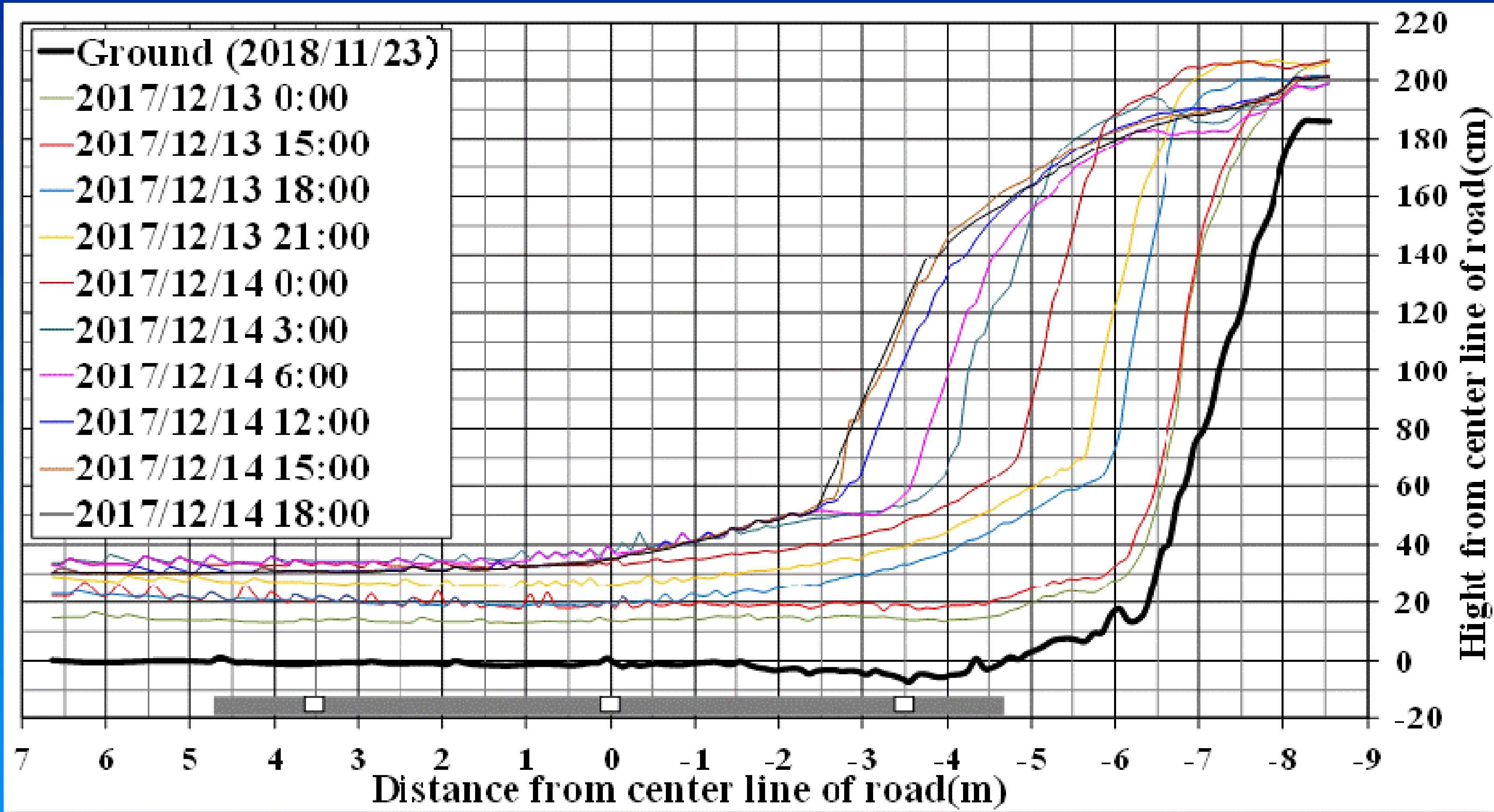
Image

[Event II] : December 13 to 14, 2017



Process of snowdrift development

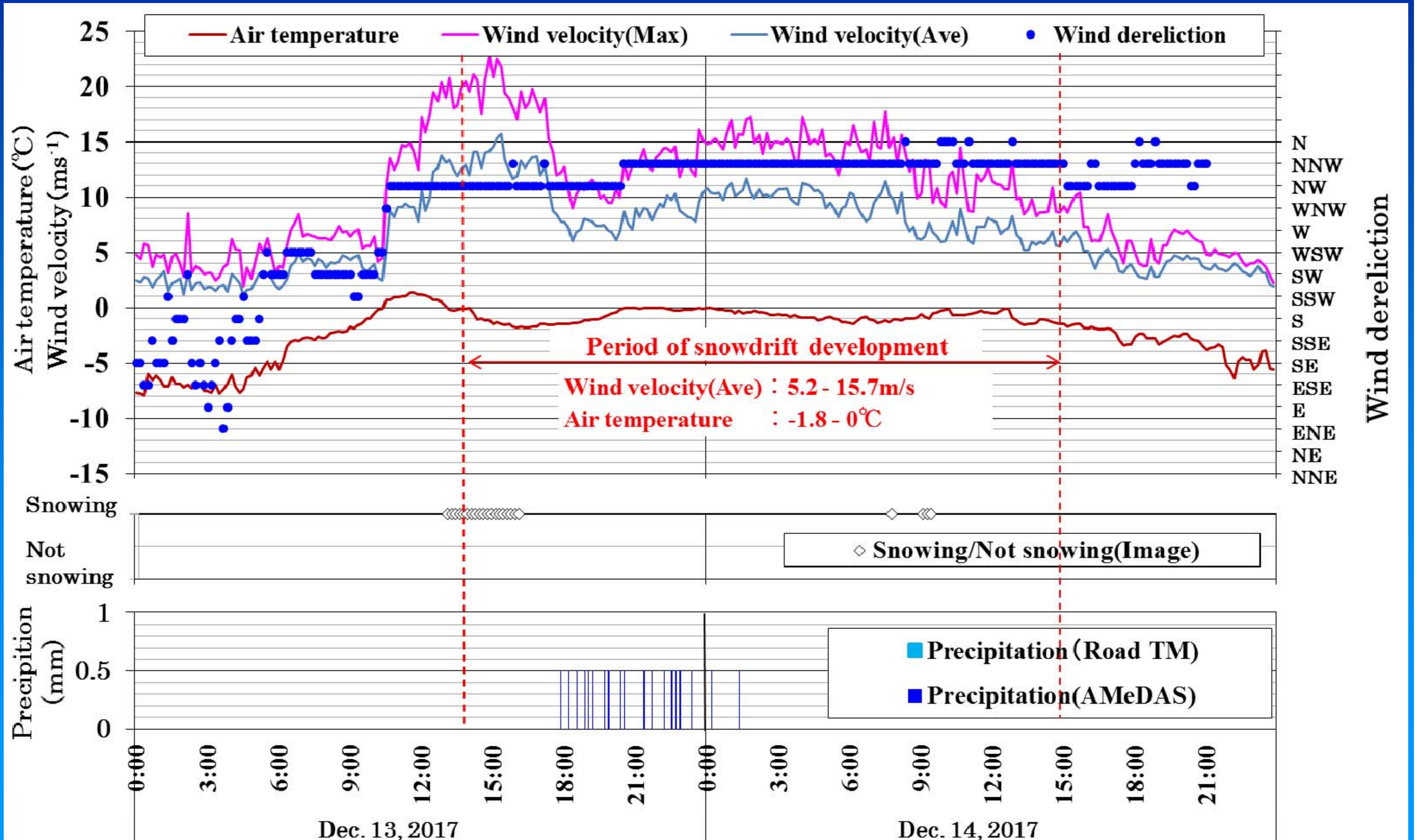
[Event II] : December 13 to 14, 2017



First, the snowdrifts started to form on the cut slope from 2 p.m. on December 13, 2017.
Next, the snowdrifts started to form on the virtual road on the lee of the slope from 6 a.m. on December 14, 2017.
The accumulation of snow on the cut slope on the windward side before the occurrence of blowing snow was $0.36m^3$.

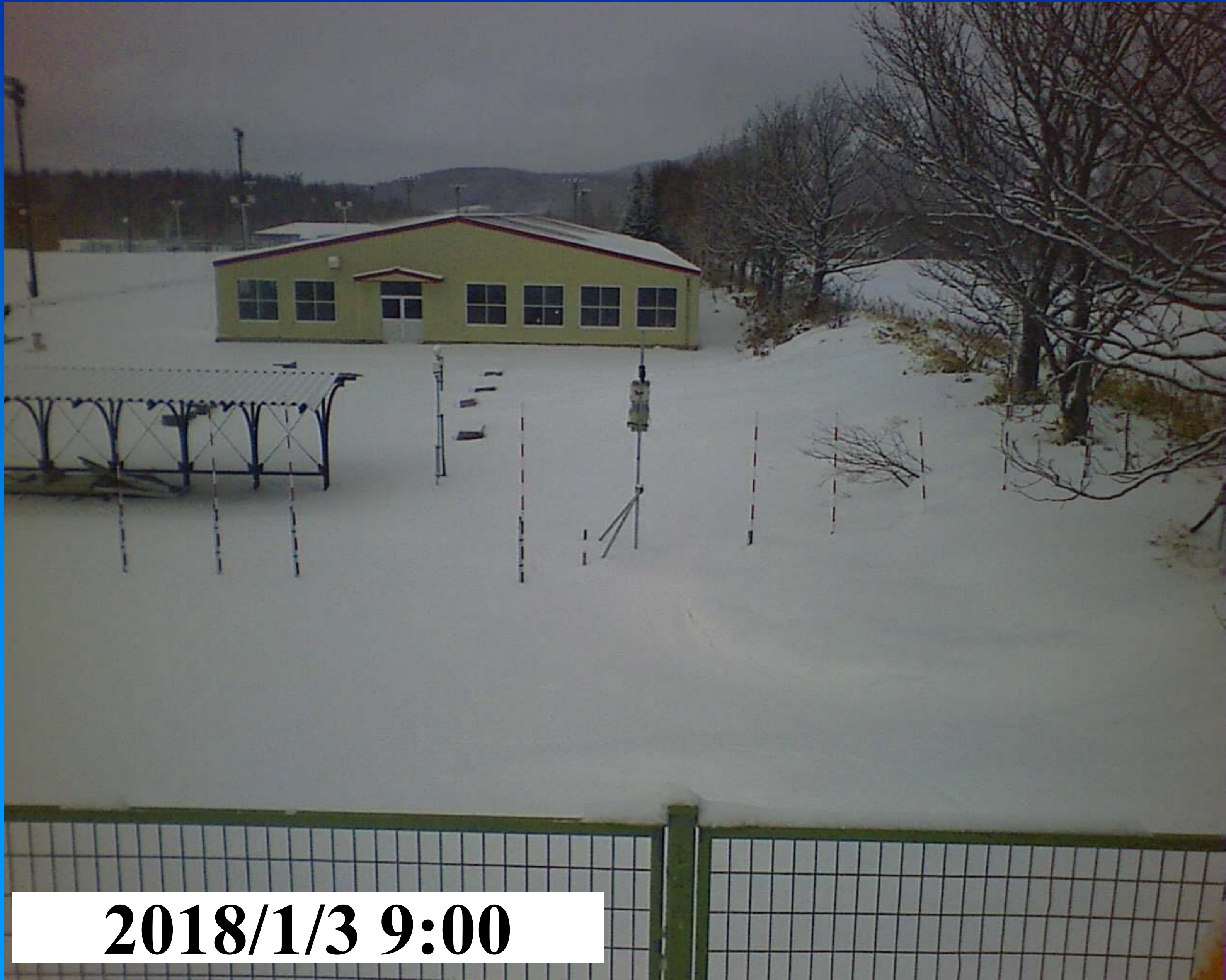
Weather condition

[Event II] : December 13 to 14, 2017



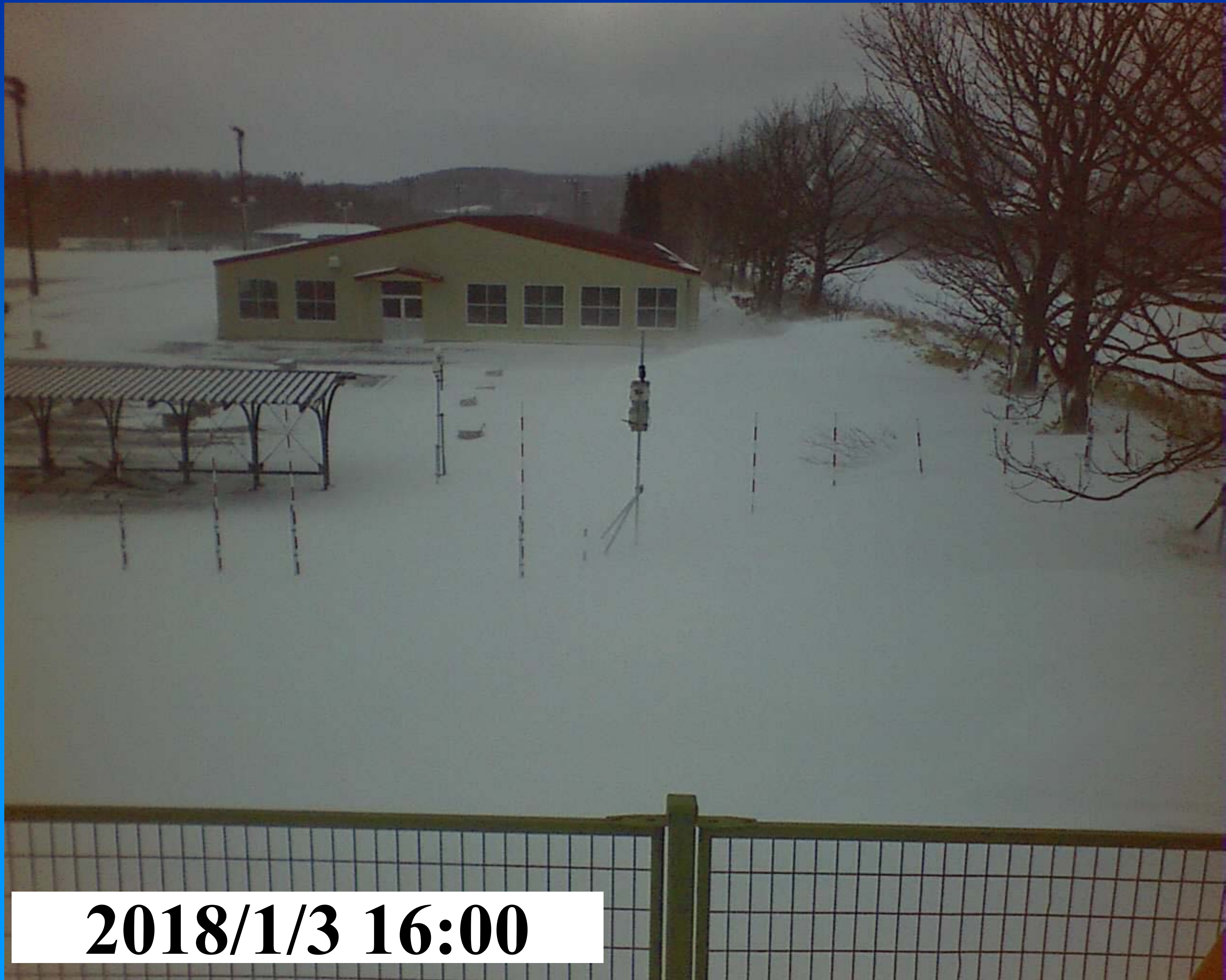
Image

[Event III] : January 3 to 4, 2018



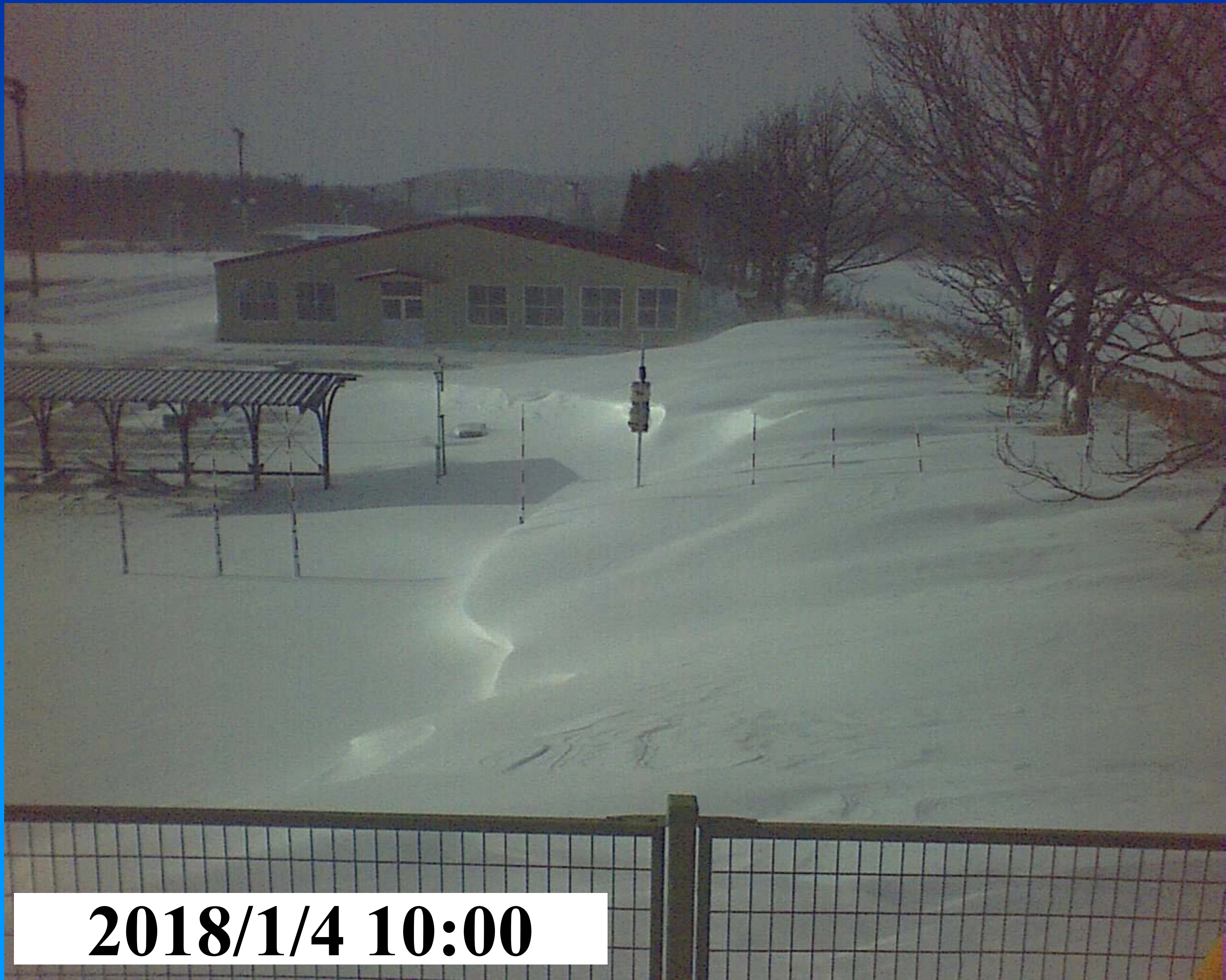
Image

[Event III] : January 3 to 4, 2018



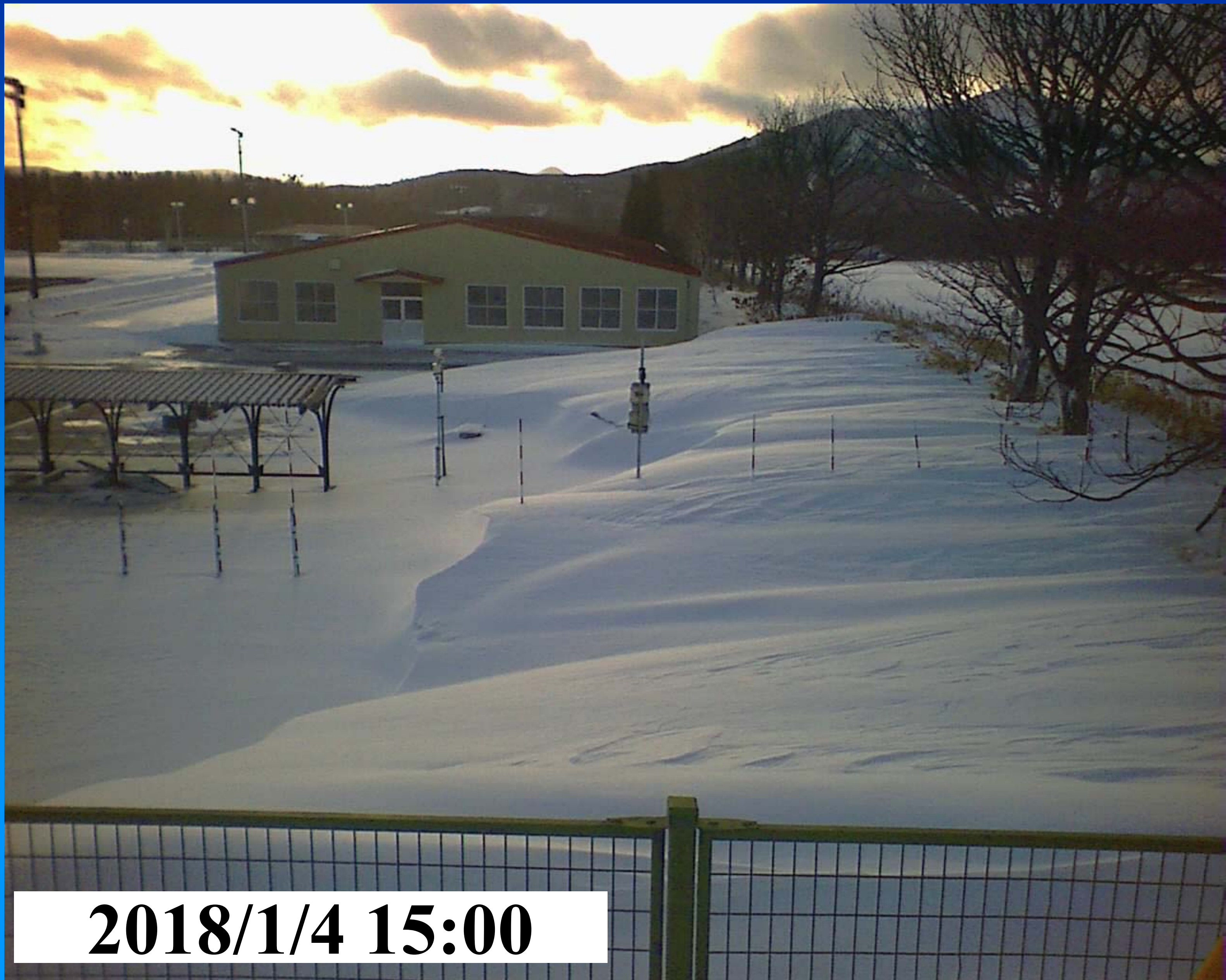
Image

[Event III] : January 3 to 4, 2018



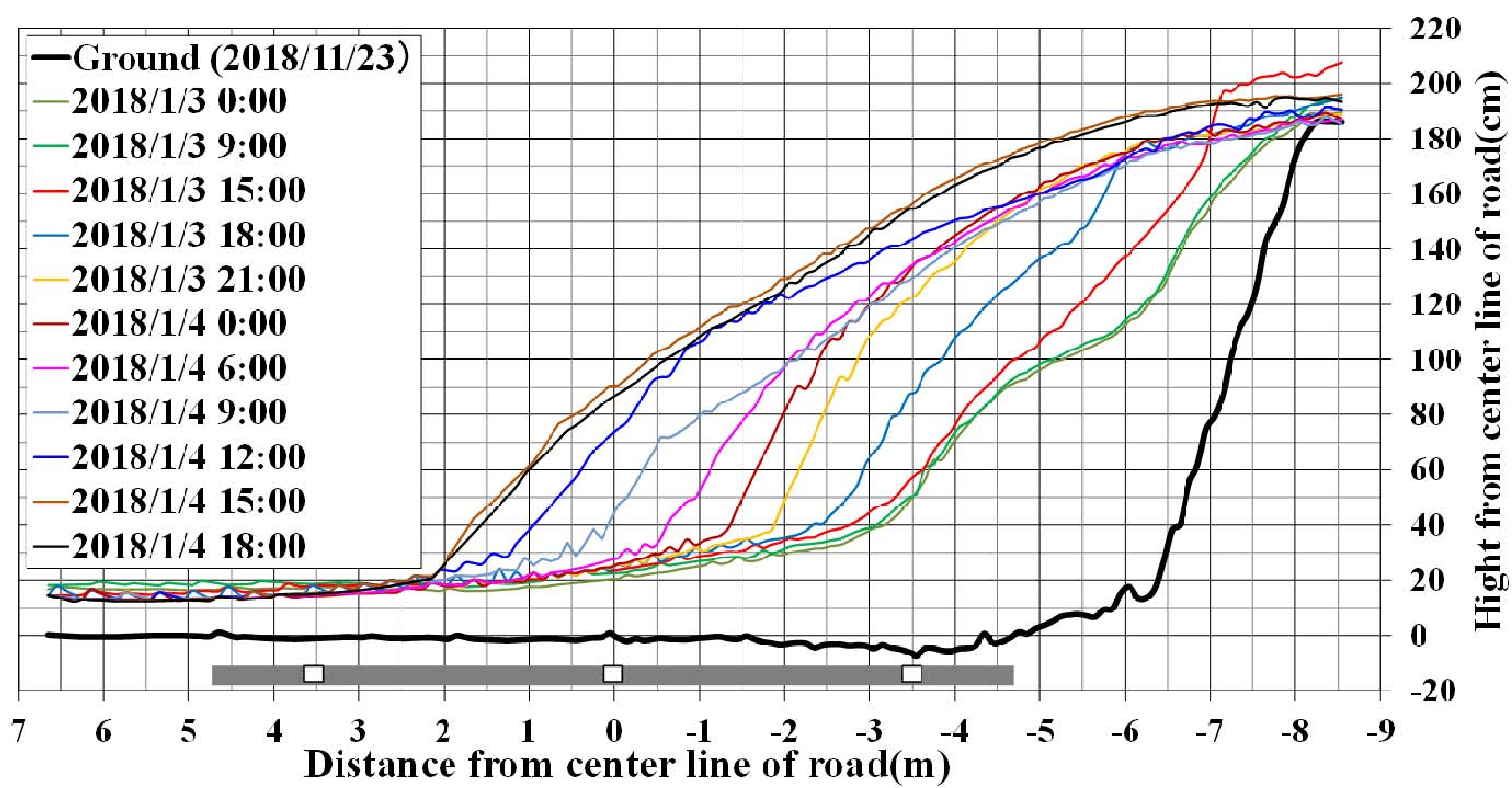
Image

[Event III] : January 3 to 4, 2018



Process of snowdrift development

[Event III] : January 3 to 4, 2018

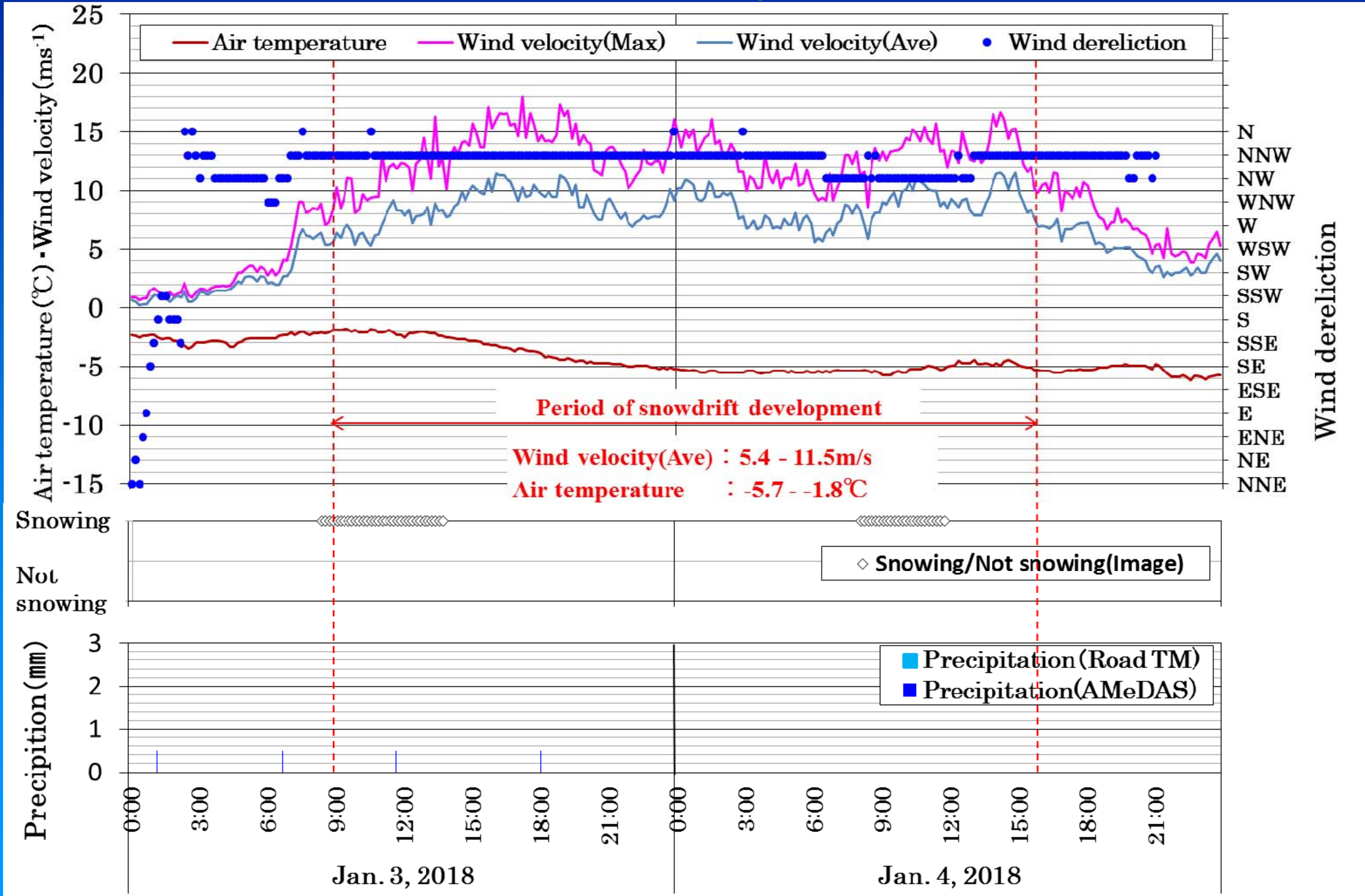


The snowdrifts started to form on the cut slope and slope and on the virtual road on the lee of the slope from 9 a.m. on January 3, 2017.

The accumulation of snow on the cut slope on the windward side before the occurrence of blowing snow was 2.48m^3.

Weather condition

[Event III] : January 3 to 4, 2018



Estimation method of snow transport rate

The snow transport rate was estimated by the following method.

1. To determine whether or not there was blowing snow

Condition 1 (snowing) :

[$T \leq -5$ ℃ and $U \geq 5 ms^{-1}$] or [-5 ℃ $< T < 0$ ℃ and $U \geq 6$ ms^{-1}]

Condition 2 (not snowing) :

[$T \leq -5$ ℃ and $U \geq 10$ ms^{-1}] or [-5 ℃ $< T < 0$ ℃ and $U \geq 11$ ms^{-1}]

T is the temperature (℃)
U is the maximum instantaneous wind velocity (ms^{-1}) at 10 m high.

We used observation values (ten-minute values) obtained by the AMeDAS located near the investigation spot for the calculation of snow transport rates.
Wind velocities at individual heights were calculated according to the logarithmic law (snow surface roughness was set at 1.5×10^{-4} m).

Estimation method of snow transport rate

2. To Estimate of snow transport rate

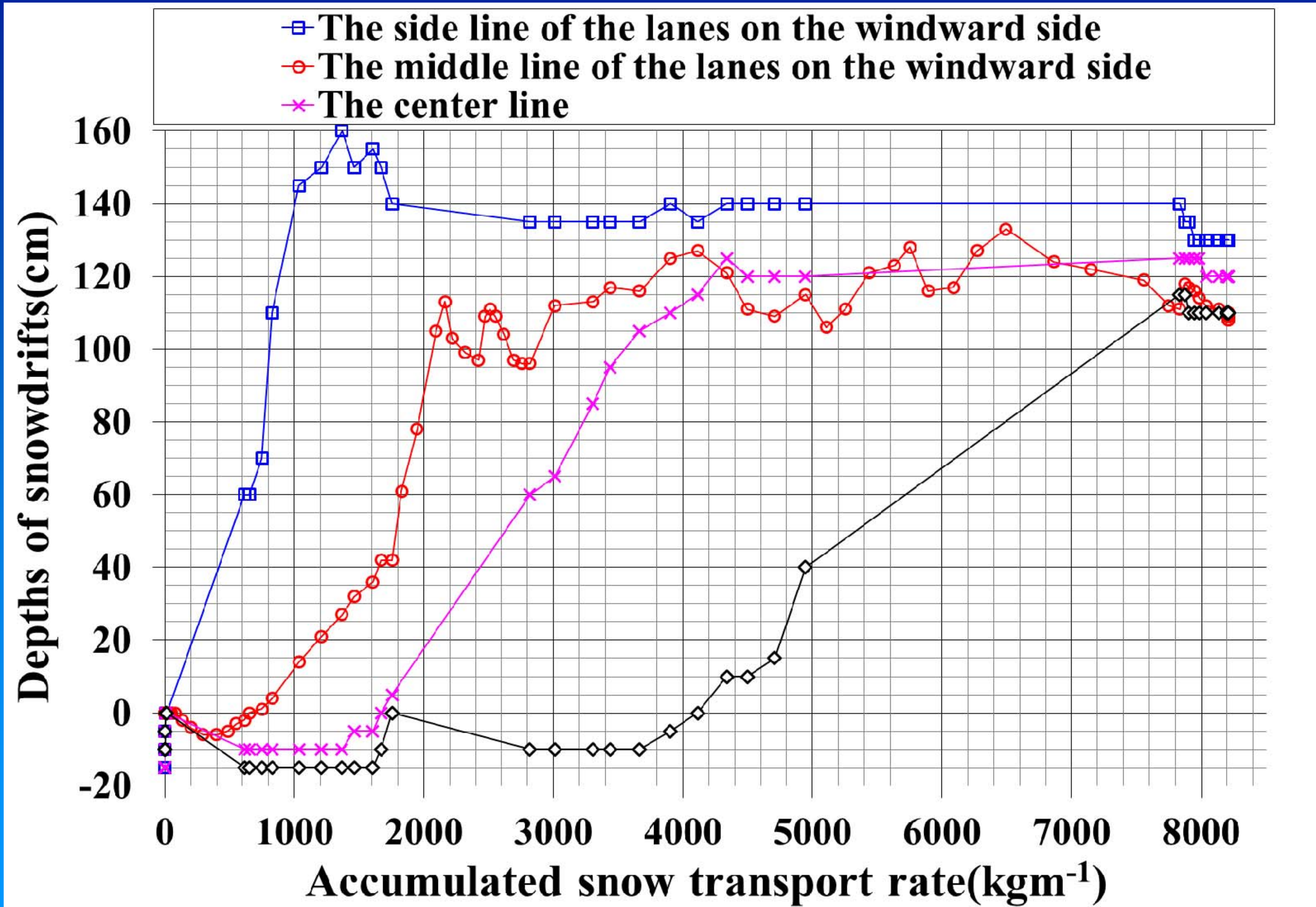
If blowing snow was occurring, we estimated the snow transport rate during such event using Formula (1), which was proposed by Matsuzawa, et al(2010).

$$Q = 0.005\, U_{1.2}^{4} \qquad \text{Formula(1)}$$

Q is the snow transport rate ($gm^{-1}s^{-1}$)
$U_{1.2}$ is the average wind velocity (ms^{-1}) at 1.2 m high

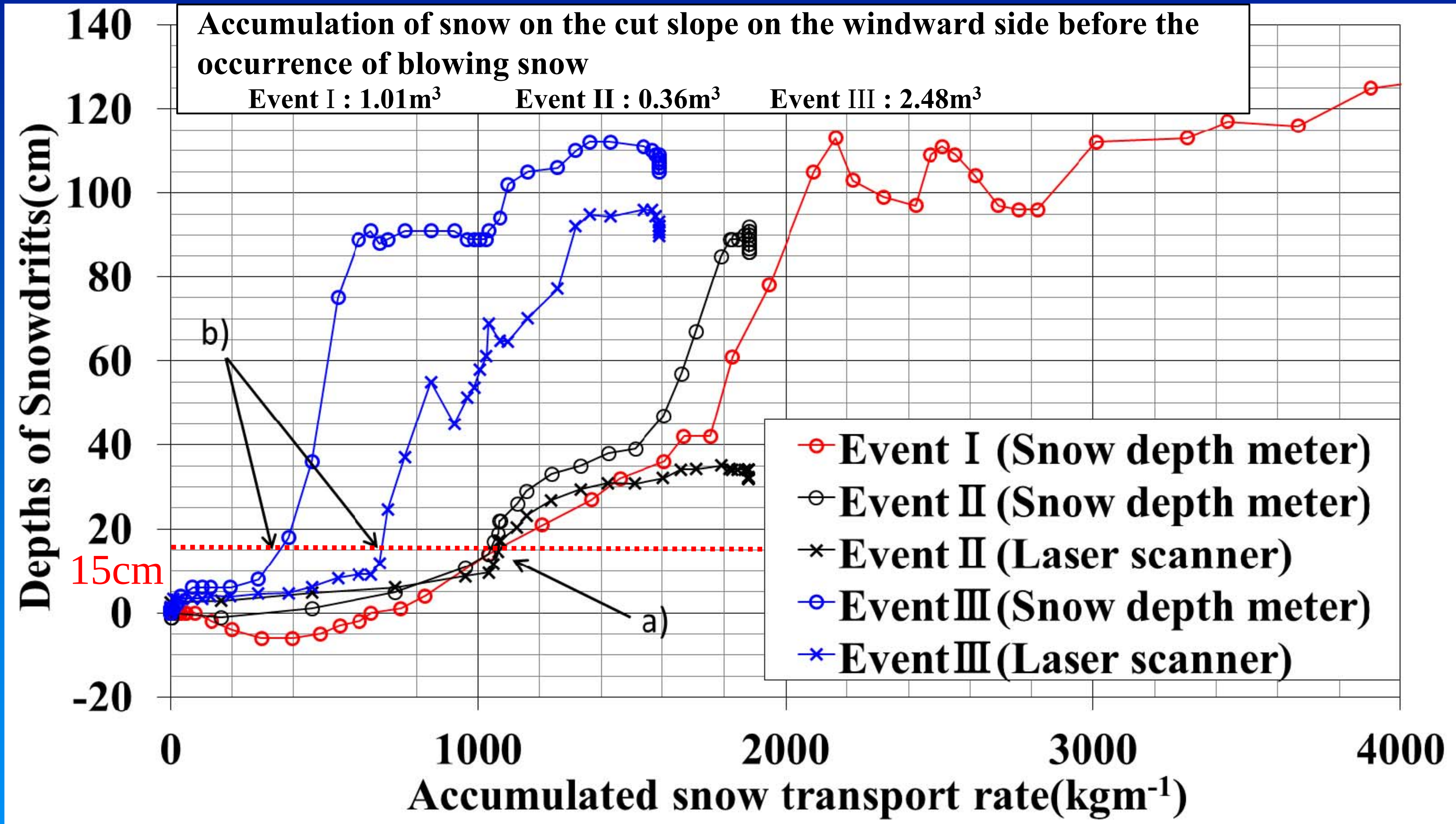
We used observation values (ten-minute values) obtained by the AMeDAS located near the investigation spot for the calculation of snow transport rates.
Wind velocities at individual heights were calculated according to the logarithmic law (snow surface roughness was set at 1.5×10^{-4} m).

The depths of the snowdrift and the accumulated snow transport rate on the middle line of the lanes on the windward side



The results show that snowdrifts are formed earlier and the development speed as a ratio to the snow transport rate is larger on the windward side near the cut slope.

The depths of the snowdrift and the accumulated snow transport rate on the middle line of the lanes on the windward side



a) In Event I and II, when the accumulated snow transport rate reached approximately 1000 kgm^{-1},

b) In Event III , when the accumulated snow transport rate reached from 300 to 700 kgm^{-1},

the depth of the snowdrift reached 15 cm

It is considered that the difference in the accumulation of snow on the cut slope on the windward side has an impact on the development speed of snowdrifts

Conclusions

This study analyzed the process of snowdrift development on a cut road section with a height of approximately 2 m and its relationship with the estimated transport rate.

As a result, it was revealed that it is important to pay attention to the accumulated transport rate and the accumulation of snow on the cut slope on the windward side before the occurrence of blowing snow in predicting the amount of a snowdrift forming on the lanes of a cut road section and the timing of the formation of the snowdrift.

Thank you

for your kind attention!