Disdrometer Data Use in Analyzing Blowing Snow Characteristics within the Roadway Environment

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1. INTRODUCTION

Blowing snow presents a serious problem for the actions of maintenance officials. In the presents of blowing snow the mobility rate can become severely reduced. There are many factors that lead to blowing snow in the roadway environment. In events when precipitation is falling the possibility is highly dependent on wind velocity and snowfall intensity (Matsuzawa and Takeuchi, 2002). In situations where blowing snow occurs with no precipitation falling other conditions are critical. Some of these variables are surface snow age, depth temperature of snow pack, air temperature, fetch of the snow, depth of roadside ditch, surface roughness and wind velocity.

Blowing snow can also severely reduce driver visibility leading to unsafe travel. Matsuzawa and Takeuchi found that even with snow intensities of 5 mm/h visibility never dropped below 100-m, but with just wind velocities of 8 m/s the visibility dropped to less than 200m. Their work also provides a method of calculating visibility using mass flux of snow and selected meteorological conditions. To arrive at calculations of mass flux the dynamics of blowing snow needs to be investigated.
Specific knowledge must be known regarding the rolling, saltation, and suspension of an existing snow field. The rolling process results in ice crystals being suspended from the surface less than 1-cm with the snow particles continuing to translate in the direction of the force being applied. The saltation layer denotes the development of visible blowing snow. As snow particles are forced higher into the air they develop a trajectory that dislodges additional ice crystals as snow particles descend back onto the snow pack. This leads to more particles becoming accessible to the wind. The saltation layer is generally between 1-cm and 10-cm. Once the particles generally exceed 10-cm above the surface they enter the suspension layer were the turbulent flow of the boundary layer dictates their movement.

2. INSTRUMENTATION

The instrumentation used for this study is part of a larger field research project that is intended to explore physical properties associated with weather in the roadway environment. *In-situ* instruments used for the study includes, temperature/humidity sensors, snow depth sensors, three dimensional wind sensors, snow pack temperatures, precipitation gauges, and three video disdrometers at various heights. Remote instrumentation includes WSR-88D KMVX National Weather Service (NWS) weather radar, and the University of North Dakota (UND) dual-polarimetric C-band radar.

The key instruments in this study are the three video disdrometers. The disdrometers are provided through a research collaboration with the National Aeronautics and Space Administration (NASA). The video disdrometers were initially used for studies of liquid precipitation. The disdrometers consist of cameras that capture 55-60 images s^{-1} with a resolution of 0.05 x 0.01 mm^2 per pixel resolution or 0.05 x 0.05 mm^2 per pixels. Flood lamps placed three meters in front of the cameras provide illumination of the field of view. The images produced depict particles as they pass through the cameras' field of view as a dark spot on the image. These images are post-processed to provide data on the size of the particle, the grey scale intensity of the particle, and the

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equivalent diameter of the particle. The last parameter is used in calculating the mass flux of the snow. Figure 1 shows images before post-processed. Figure 2 shows the particles after the images have been post-processed and an edge detection algorithm is applied.

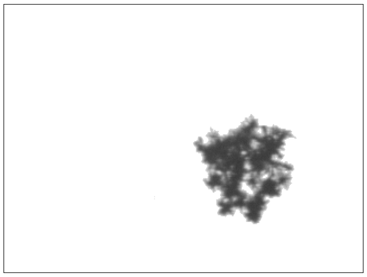

Fig. 1: This is an image of a snowflake taken by the disdrometer.

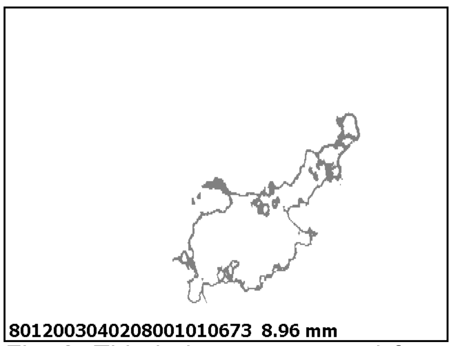

Fig. 2: This is image recreated from the ris files. This shows what the edge detection algorithm does.

3. FIELD SITE

The instrumented road weather research site is located at an adjacent to Interstate 29 approximately 35-kilometers south of Grand Forks, North Dakota. The site is developed specifically to support research into all aspects of road weather including the occurrence of blowing snow. Obtaining data in the saltation layer (1-10-cm) is difficult given the size of the video camera system. Hence, all three cameras are placed at heights in the suspension layer. These heights are 0.4-m, 1.1-m, and 2.1-m relative to the road surface (Fig. 3).

Fig 3: The grey boxes mounted on the left pole house the light sources. The grey boxes located on the tower hold the camera enclosures. The reason for the enclosures is to ensure security to both the lights and cameras. I-29 is the highway in the background and the road in the foreground is the access road to the abandon rest stop.

Temperature, relative humidity, snow depth sensors and precision precipitation gauges are located approximately 25 m from the disdrometers (Fig. 4).

Figure 4: This shows how close the precipitation gauges and other instrumentation are to the disdrometer.

Wind and additional temperature and moisture sensors at 2-m, 5-m, 10-m, and 15-m are located on a 15-meter tower 100-m south of the disdrometers.

4. DATA

The data collected from the disdrometers is transformed into an image format for further post-processed to provide the equivalent diameter of particles within the field of view. Using the equivalent diameter of each particle, a total particle area is collected. Knowing the total area of the particles versus the viewing area, the snow mass flux is computed for each image. An average snow particle flux is calculated and compared with the measured precipitation recorded every 1 minute. Combining a precipitation amount with the flux of the snow, a density of the snow is calculated. Once the density of the snow is calculated, a mass flux of the snow is determined. In situations when blowing snow is occurring and no precipitation is falling, snow density will be computed with a snow board and melting a known volume of snow to obtain a snow density. The snow mass flux at each height is used to construct a vertical profile of snow mass flux within the sublimation layer.

The occurrences of blowing snow events are divided into distinct categories for further case study development. The four categories are:

1) Blowing snow events that occur when no precipitation is falling;
2) Light precipitation falling along with light to moderate winds (<6 m/s) resulting in both blowing snow and falling snow;
3) Moderate to heavy precipitation with light wind to moderate winds. Category three does not meet blizzard conditions; and
4) The forth category is a severe winter storm event. Category four includes events that meet blizzard criteria.

For the initial study two quality events from each category are analyzed. Events occurring in category one are the most important to the research of blowing snow. The reason for this is there will be no other sources of snow in the atmosphere that can interfere with data being collected by the distrometers.

5. RELEVANCE

Blowing snow is one of the most hazardous weather conditions for travelers. The ability to diagnose and forecast blowing snow still presents a significant challenge within weather prediction models and operational forecasting for surface transportation. The need for more in-depth research on the nature of blowing snow within a roadway environment will lead to improved methods of prediction and mitigation of blowing snow impacts on transportation. The system of three disdrometers used in the present research provides a novel measurement system to document the nature of blowing snow along a roadway. Along with the adjacent measurements of momentum flux, the disdrometer data provides a method to better understand the transition of snow particles within the sublimation layer.

6. ACKNOWLEDGEMENT

The authors are grateful for the support and involvement of the North Dakota Department of Transportation with the research efforts described herein. Research support is provided by NDDOT and Federal Highway Administration Contract #ITS-999 (174). The authors would also like to thank Dr. Bliven at NASA for his expertise and for providing the video disdrometers used in this research.

7. REFERENCES

Matsuzawa, M. and M. Takeuchi, Proceedings, 2002: Study on Methods to Calculate Visibility on Blowing Snow, *11th International Road Weather Conference*, Jan 26-28, Sappora, Japan.