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Local Snow Sampling with Grade School Children

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ABSTRACT

Over the winter of 1997, a project was undertaken that involved grade school students with the sampling of falling snow and snow on the ground. Five classes of students, primarily at a grade 5 or 6 level, from across central south-western Ontario were given the opportunity to participate in the local snow surveying program. On a weekly basis, the students collected data on the local accumulation of snow, crystal type, crystal size and the corresponding air temperature during specific storm events. These data were used to show the variation in depth across the study area and attempted to illustrate the relationship between the near surface air temperature and size and type of falling snow crystal. The most important impact of the project was the education opportunity. The school children had a chance to learn about science, in particular weather, the water cycle and measurement through external instruction and hands-on learning.

Key words: education, snow sampling, children

INTRODUCTION

Snow is beautiful, white, fluffy and fun! It's also heavy, wet, cold, and as all people living in a northern climate know, a nuisance to shovel. Northern winters are filled with snowball fights, snowmen building, skiing, tobogganing and other winter fun that one never outgrows. Snow has dramatically affected the lives of many people on the earth. For example, an entire industry of snow management, which employs many people in Canada and the northern United States, has been developed to supply products such as snowblowers and snow tires, and to provide services such as snow removal. Snow also plays an important role in affecting our environment by providing animal habitats and insulation for plants, while creating flood levels in streams and rivers, and introducing pollution into our water systems. Unfortunately, very few people understand the white stuff that so strongly affects their lives.

This study was an opportunity to present some information about ice crystal formation, snowfall, snow accumulation and snowmelt to various children. Not only will the exposure of children at a young age to this unique project likely have a lasting influence, but during the study, the students passed on much of what they learned through discussion and observation to friends and family not directly involved with the project.

OBJECTIVES AND SCOPE

The main objective of this project was to introduce school children observers to aspects of weather, hydrology, and data collection. A second objective was to observe the local accumulation of snow, as well as crystal types and sizes for specific storm events. This is part of a larger project that uses weather radar to predict snowfall quantities, and hydrologic modelling to simulate the snowpack throughout the winter and the melt process, in order to predict the spring hydrograph. The coverage of the weather radar operated by the Atmospheric Environment Service is a 220 kilometre radius centred at King City, Ontario, approximately 20 kilometres north of Toronto. This central south-western Ontario coverage extends to Lake Huron in the west and Lake Erie in the south.

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With the cooperation of school principals and teachers at five schools across central south-western Ontario, grade one to six students performed snow sampling over the winter of 1996/97. The schools were located across the radar coverage, giving a spatial distribution in the data.

BACKGROUND

Precedent

Student observers have been used to assist in several snow investigations. Prior to the formulation of this project, the following two investigations were found that provided a precedent:

1) During the winter of 1972-73, fifty-five high school and junior high school student observers from the Oswego, New York area (north of Syracuse) were recruited to provide additional data for a radar snowfall measurement study (see Peck *et al.* 1974, Wilson 1974). The students measured snow depths and water equivalents using snow boards during the months of January and February for 14 observation periods. They also obtained some limited information on the type and size of the snowflakes.

2) Professor Dick Chisholm teaches technical communication at Plymouth State College in Plymouth, New Hampshire. The college students taking his course use the snowpack as the topic of investigation. Although the subject of study is not particularly relevant to the course, snow provides an excellent topic. Professor Chisholm (1995) feels that:

> "*snowpack study provides a common experience in science ... the students not only gain knowledge about the physics of snow stratigraphy and metamorphism, but develop skills at observing, recording and interpreting data.*"

After the project, a third study was discovered on the Internet that resembled the local snow sampling project. At Pearl Creek School in Fairbanks, Alaska, Mrs. Gerke's first grade class undertook an experiment from October 13, 1994 to February 2, 1995 to answer the question "Is the snow the same depth at everyone's house?" Nine students installed snow stakes into the ground outside of their homes and recorded the snow depths every Thursday. The hypothesis was that the snow depth would not be the same at each house, since the students live in different parts of town. From their observations, they concluded that the snow depth was different at each site since the snow storms are different at each house. The experiment has been summarized in a world wide web site prepared by one of the students (see Estes 1995).

Snow Properties

Prior to this project, it was hypothesized that the initial characteristics, i.e., size and shape, of falling snow accumulating on the ground can be estimated using temperature, local meteorological conditions, and remote sensing. The local conditions within the cloud environment, especially temperature, influence the shape of snowflake that is formed, for example, at an air temperature of -15°C, flat dendrites are formed, whereas at -5°C, long thin needle shaped flakes are formed. However, near the ground the meteorological conditions and flake shape can be quite different than within the clouds.

METHODOLOGY

The use of students to collect the data was precipitated from the desire to gather data at several locations throughout central south-western Ontario. Four classes of grade 5 and 6 students and one group of grade 1 to 3 students, under the direct supervision of their teacher, participated in a local snow surveying.

It was proposed that the students undertake the following sampling procedure:

i) the students were to be given a brief presentation about the research and their involvement;

ii) prior to the first snowfall, a sampling strategy was to be developed by each participating class, based on a minimum requirement of one measurement per week. It was hoped that some of the sampling would be performed during snowfall events.

iii) the students were to periodically measure total snowpack depths at five locations, the depth of the top layer of new snow, air temperature, and identify snowflake types and size for five flakes;

iv) the students were to record their findings with the date, time and location of sampling on data sheets. Average snow depths were to be recorded on a line graph posted in the classroom; and

v) after the winter season, there was to be wrap-up session to provide closure for the students.

It was proposed that each class would be divided into groups of four or five students. Each week one group, known as the lead group, would decide when to sample. A second group, know as the reserve group, would go out and sample at the time decided upon by the lead group. The following week, the reserve group would become the lead group, and a new reserve group would be called up. The groups would cycle through the reserve-lead system, such that each group would sample several times throughout the winter season. With this methodology, the students would see short term and long term variation in snowflake and snowpack properties.

Actual Procedure

The proposed methodology was similar to the actual procedure that the students followed, however, the procedure undertaken by the students differed in the following ways:

i) the students did not use the two team approach to sampling, and at some schools the length of observation was as short as 5 weeks, instead of for the entire length of the snow season; and

ii) some of the datasheets were incomplete. In several instances, the time, air temperature, multiple depths, and multiple flake observations were missing.

For closure, the wrap-up session included a final visit to explain the results, and popsicles to recall the past winter gone by. For one class of students the wrap-up visit was a visit to the University of Waterloo to see various facilities in Civil Engineering and several other departments at the university. The tour of the Civil Engineering Department started with a summary lecture of the snow sampling project, and proceeded to examine several aspects of water resources research, namely, remote sensing and hydrology with computer models, groundwater and geotechnical studies with bench scale models, and fluids and hydraulics with large scale models.

Equipment

Each class was supplied with rulers, magnifying glasses, a sufficient number of data sheets, and thermometers. The student observers were each given a snowflake identification guide. This guide, termed the Snow Identi-Guide, is a laminated card with an example of the six basic flakes types on the obverse (see Figure 1a). The reverse of the flake guide (see Figure 1b) presents three grids (1, 2, and 3 millimetre) to estimation flake sizes, a depth ruler for measurement of the top layer, and the location of the web site describing the project (see Fassnacht 1998).

It should be noted that some of the flakes used to create the Snow Identi-Guide were taken from Bentley's photographs (Bentley and Humphreys 1962). Other flakes were redrawn from Bentley or from personal observation. At present the Snow Identi-Guides are being considered for use in a student environmental kit being prepared by the Waterloo County Board of Education.

Why were six flakes chosen to categorize snowflakes in the identification guide? The 1954 NRC classification (National Research Council 1954) described 10 basic flake types. Nakaya (1954) expanded this classification to 80 type based on observation of flakes grown in the laboratory, while Magono and Lee (1966) refined the classification to more accurately categorize 80 different snowflakes types observed in nature. Since the Magono and Lee classification is based on variations in distinctive flake structures, their grouping could be simplified into eight basic flake types. The use of six basic flakes in the Snow Identi-Guide is derived from five distinctive categories in the NRC classification and four basic types described by Magono and Lee, as well as a catch-all crystal (termed "irregular") that lumped the NRC's spatial dendrite, irregular, graupel, ice pellet, and hailstone crystals together. The catch-all crystal was used since distinction between these five NRC types is difficult to the inexperienced observer. As well, the "irregular" crystals are all generally spherical in shape and thus size is the discriminating characteristic. Similarly, Teel and Teel (1996) identify six basic types, that can be defined as the more beautiful flakes. The dendrite and star flakes identified by Teel and Teel have been lumped together as stellars on the Snow Identi-Guide.

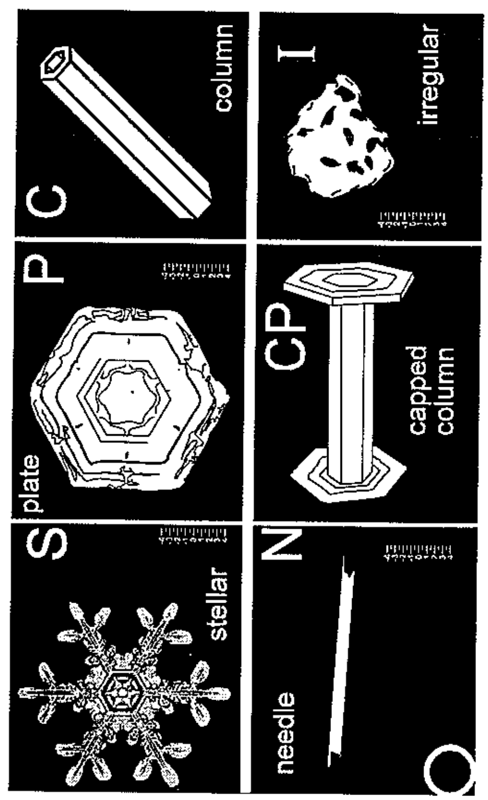

Figure 1a. The Snow Identi-Guide illustrating the six basic flakes types.

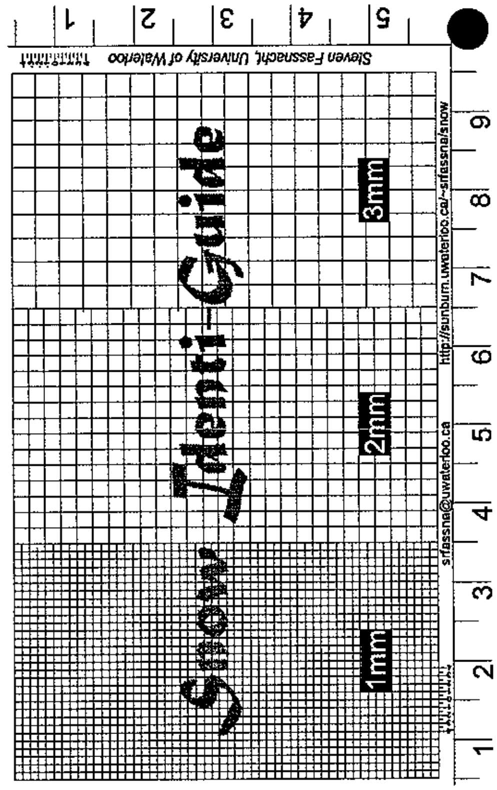

Figure 1b. The reverse of the Snow Identi-Guide illustrating the measurement grid.

OBSERVATIONS

Data were collected at five schools across central southern Ontario from November 27, 1996 through March 18, 1997. The following data were measured and recorded along with the date and time: snow depths at 1 to 5 locations depending on the school, air temperature, and flake size and type for 1 to 5 flakes per sampling session, again depending upon the school.

The results of the snow depth sampling are presented as the average snow depth variations in the vicinity of the five schools over mid-winter 1996/97 (see Figure 2). Although the sampling was often too infrequent to create a continuous depth record and the number of depths measured per observation was too few to produce a representative mean snow depth, the student measured averages agree in terms of a spatial depiction of snowfall trends across the study area. In central southern Ontario, the greatest snowfall depths occur closest to Lake Huron since heavy accumulation occurs in the lee of the lake. Not only does less snowfall accumulate near Toronto, the increased temperatures in the area dictate that less snow remains on the ground. With the exception of later measurements at Mary Johnston School in Waterloo, the average snow depths follow the spatial trends that exist across central southern Ontario. The snow depth at both Waterloo schools were very similar for the end of January and the beginning of February, representing agreement in the data. The outliers in the Mary Johnston data are due to the sampling area around that particular school, in particular, it is the only school with a naturalized area that accumulates more snow since mid-season losses are less and redistributed snow collects in the area.

A relationship between snowflake type and air temperature was derived from the 79 observations on 31 occasions, as illustrated in Figure 3. The trend agrees with the theoretical formation temperatures for snowflakes. The problems are accurate measurement of air temperature (by grade school students) and evaluation of the qualitative differences between flake types.

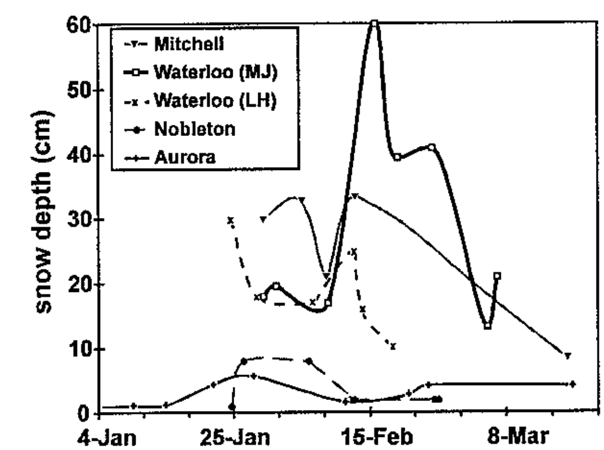

Figure 2. Graphical snow depth log for the five schools.

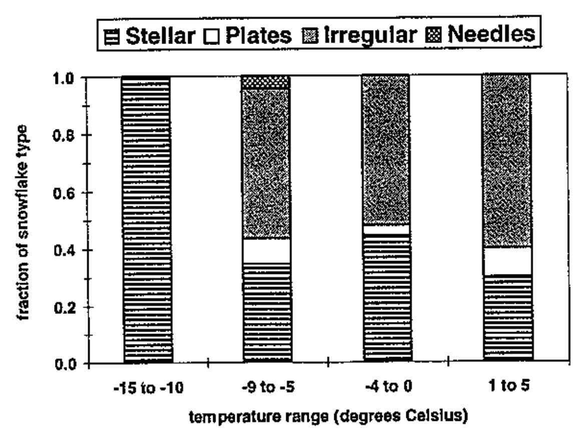

Figure 3. Flake type versus observed near surface temperature range.

DISCUSSION

A description of the project, the information given to the students, datasheets, sample Snow Identi-guides, and links to assorted snow related web pages are available on the Internet at the web site "http://sunburn.uwaterloo.ca/~srfassna/snow/." Enough information is available at this web site for a class of grade 3 to 6 students to undertake the project on their own.

There are two issues of importance that resulted from this project: the influence of the project on the student observers, and the meaningfulness of the data. The project's relevance to education is its notable contribution, and will be discussed in the subsequent section. The quality of the data collected is a function of the repeatability and the representativeness of the sampling site. The primary improvements are increases in the quantity and intensity of data collection, i.e., more data per observation date and on more days, which would fill in gaps in the depth record and provide a wider range of temperatures. Methods to improve the quality of data are discussed in the future endeavours section.

The distinction between flake types was the most difficult observation, especially to the untrained eye. Flake identification could be made reliable through training, however, examination of flakes was primarily a tool to pique the interest of student observers by showing them some of the beauties of nature and illustrate what one can discover through scientific observation (see Figure 4).

Figure 4. Student snowflake observers.

Relevance to Education

The observation of falling snowflakes gave the children a chance to enjoy the beauty and the complexity of falling snowflakes as seen by scientists throughout the ages. An example is the physicist Kepler, who in 1611 wrote an entire treatise called The Six-cornered Snowflake pondering the shape of snowflakes. The students were also given the opportunity to wonder about the conditions that must have existed during formation of the snowflakes and the conditions below the clouds through which the flakes fell.

The students were taught the importance of snow within the hydrologic cycle and they were exposed to the depth of possibilities in the study of snow. The students were shown data collection and graphing, and they clearly learned through a practical application of the scientific method.

Future Endeavours

The 1996/97 data collection effort was successful for educating the 139 students involved, their teachers, and possibly their friends and family, but not very useful for research. This exercise should have either been more closely monitored, or the project should have been more definite, with the responsibility being placed on the students instead of on the teachers. Therefore, the strategy for another season of sampling will be to maintain the education component and to develop several different thoroughly structured programs from which each teacher can choose. There should also be a focus on a limited number of schools, such that the researchers should get useful data from the project.

Any future undertaking of this project would require further definition of the objectives. For education of students, the hydrologic cycle, in particular the importance of snow in northern climates, environmental variability, data collection, statistics and the scientific method can all be emphasized. The following two types of snow data would be collected: quantitative data, i.e., depths, densities (SWE), and temperatures (air and snowpack), and qualitative data, i.e., flake size and type.

Future sampling projects should emphasize individual data collection, ensuring that each student be responsible for sampling several times over a winter. At the end of the winter, the student should submit a short report describing the difference between short-term changes and long term changes, either based on weekly observations, or a series of strategic observations. The series of observations should be a set of 2 samples, one week apart, followed by 2 more weekly samples, one month later. Depending on the grade level, various aspects of the sampling program used by Chisholm (1995 and 1997) could be incorporated.

SUMMARY

Although the data collected by the students were not as useful as was initially expected, the researchers are satisfied with the "Local Snow Sampling" project. The students were given the opportunity to learn about the snow, and they all benefitted from the experience.

Future sampling projects should emphasize individual data collection, ensuring that each student be responsible for sampling several times over a winter. A more in-depth involvement by the students (at least at the grade 5 level) will facilitate a more thorough understanding, will spark greater interest in the topics of hydrology, snow, and science in general, and will result in more valuable data. With more development, a program like this could be implemented across the country to create an impressive database. However, irregardless of the usefulness of the data, subsequent versions of this project will be considered successful if the students involved have fun and learn.

In order to understand, manage and co-exist with our environment, children and adults must never stop learning about it. Projects such as "Local Snow Sampling" can help children better understand their environment and their connection to it. For Canadians, similar to learning about the national railway and the maple leaf as parts of Canadian heritage, learning about snow can help a country's people to understand an aspect of its environment that is so inextricably connected to Canadian culture.

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