Micro Meteorological Network in Greater Victoria Schools
www.victoriaweather.ca

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Introduction:

Academics working in the University sector have realized the importance of engaging the greater community in our research as they are the ones who, through their taxes, ultimately fund it. The task of public outreach for atmospheric and oceanic scientists is made easier since our fields of research are so relevant and familiar to the community as a whole. One of the challenges we face, however, is getting across the message to educators that weather and climate provide for easily observable applications of basic physics, chemistry and mathematics.

The March 2002 newsletter of the Canadian Association of Physicists (CAP) reported that:

> "At the fall CAP Council meeting, Pedro Goldman of UWO, Chair of the Division of Physics Education (DPE), spoke strongly to draw attention to the serious decline in undergraduate enrolments in physics. He pointed out that this is a major threat to the health of physics in Canada, and proposed a preliminary study to better understand the factors underlying it. … CAP Council agreed that the matter is so serious that seed funding should be made available."

This general observation is supported by data from the US National Center for Education. Statistics that show the total number of physics bachelor degrees has generally declined or remained stagnant since the 1960s, whereas the overall number of batchelor degrees has more than doubled since that time (Figure 1a). A trend similar to the trend in the overall number of batchelor degrees awarded exists with batchelor degrees awarded exclusively in the natural sciences, mathematics, and engineering (Figures 1b), although this overall trend is dominated by substantial increases in the computer and biological sciences as well as engineering (Figure 1c).

While the purpose of this article is not to provide an extensive survey of the literature, it is well known that one of the primary reasons for low enrollments in high school and university physics courses is that physics is perceived as being hard and of little practical importance. For example, Williams et al. (2003) conclude that:

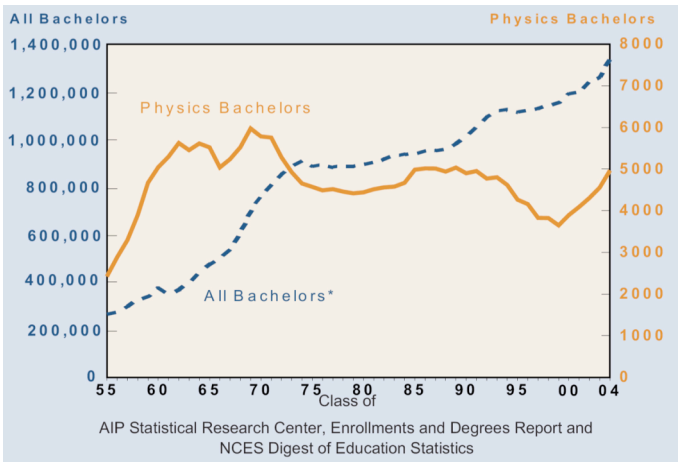
> "The major general reasons for finding physics uninteresting are that it is seen as difficult and irrelevant. … Males and females offer different reasons for finding physics boring, with males enjoying practical exercises and females valuing where physics can be seen as relevant."

whereas King and Kennett (2002) point out that:

> "Physics teaching can be made more relevant to 11-16 year-old students by setting the physics content in Earth contexts that pupils can relate to and understand."

Efforts to expose the wonders of physics and mathematics to children should occur at the elementary school level. We believe that by the time students reach high school it is too late as attitudes towards science have already developed. In fact in British Columbia, atmospheric science has been increasingly incorporated in the science curriculum almost certainly in recognition of relevance of the science of weather to our daily lives. Weather and climate are perhaps the most easily observable application of basic physics and chemistry (forces, energy etc) and that the data generated by weather stations allow for 'hands on' examples for use in mathematics and statistics.

a)



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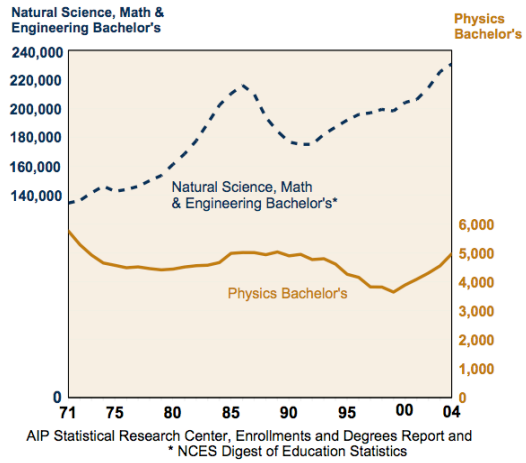

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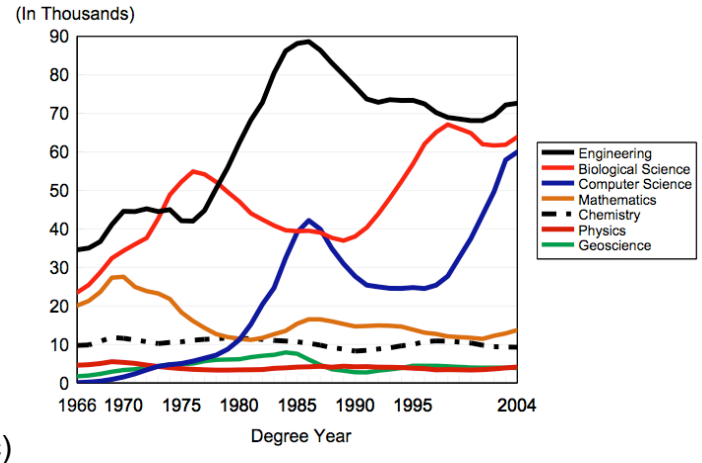


Figure 1. a) Total number of physics batchelor degrees (orange curve) compared to the total overall number of batchelor degrees (dashed line) from 1955-2004 in the United States. **b)** Total number of physics batchelor degrees (orange curve) compared to the total overall number of Natural Science, Mathematics and Engineering batchelor degrees (dashed line) from 1971-2004 in the United States. **c)** Total number of physics batchelor degrees compared to the total overall number of batchelor degrees in the United States from 1966-2004. Figures provided by Patrick Mulvey, American Institute of Physics, College Park, Maryland.

Atmospheric Sciences in the K-12 BC Education Curriculum:

The British Columbia Ministry of Education undergoes a review and revision of its K-12 curriculum every eight years to ensure that it is both "current and relevant"[1]. A substantially revised and updated K-7 science curriculum was fully implemented effective September 2005, whereas the K-7 mathematics curriculum is being revised slowly over the next few years. A revised Science 8 curriculum will be introduced in 2006-2007, with Science 9 and 10 following in 2007-2008 and 2008-2009, respectively.

The BC K-7 science curriculum is categorized by four curriculum organizers which span all grades (see Table 1). These include *Processes and Skills of Science*, *Life Science*, *Physical Science* and *Earth and Space Science*, with *Processes and Skills of Science* being integrated with and hence cross-cutting between the other three. Atmospheric science and weather play a prominent role in the *Earth and Space Science* theme of the curriculum, especially at the Grade 1 and 4 levels. Weather can also be integrated into the *Life Science, Physical Science,* and other *Earth and Space Science* themes at most grade levels.

	Processes and Skills of Science	Life Science	Physical Science	Earth and Space Science
Kindergarten	• Observing • Communicating (sharing)	Characteristics of Living Things	Properties of Objects and Materials	Surroundings
Grade 1	• Communicating (recording) • Classifying	Needs of Living Things	Force and Motion	Daily and Seasonal Changes
Grade 2	• Interpreting Observations • Making Inferences	Animal Growth and Changes	Properties of Matter	Air, Water and Soil
Grade 3	• Questioning • Measuring and Reporting	Plant Growth and Changes	Materials and Structures	Stars and Planets
Grade 4	• Interpreting Data • Predicting	Habitats and Communities	Light and Sound	Weather
Grade 5	• Design Experiments • Fair Testing	Human Body	Forces and Simple Machines	Renewable and Non-renewable resources
Grade 6	• Controlling Variables • Scientific Problem Solving	Diversity of Life	Electricity	Exploration of Extreme Environments
Grade 7	• Hypothesizing • Developing Models	Ecosystems	Chemistry	Earth's Crust

Table 1: Topics in the British Columbia K-7 Science Curriculum arranged under the four curriculum organizing themes. Taken from: MOE (2005).

Similarly, the BC K-9 mathematics curriculum is described by four curriculum organizers: *Number*, *Patterns and Relations*, *Shape and Space*, *Statistics and Probability*. The Statistics and Probability component is further broken down into two curriculum sub-organizers (*Data Analysis* and *Chance and Uncertainty*). Within this latter organizer, and in particular the *Data Analysis* sub-organizer, data obtained from weather stations would provide for real world applications. Finally, two high school courses Earth Sciences 11 and Geography 12 have extensive atmospheric science and weather components to them.

[1] Source: BC Ministry of Education website: http://www.bced.gov.bc.ca/irp/implement_sched.pdf

Goal of the project:

Over the years we have hosted a number of school tours to our laboratory at the University of Victoria and each time we witnessed first hand the fascination of children with atmospheric science-related demonstrations. We decided that it would be both useful to provide teachers with resources and state-of-the-art interactive technologies to assist them with their delivery of the K-12 science and mathematics curriculum. To this end, an application for funding was submitted to the NSERC PromoScience programme which allowed us to develop a pilot project wherein we installed weather stations (see Figure 2 for a picture of a typical installation) at 20 schools in School District 61 (Victoria).

The goals of this project are several fold. First, we wanted to raise the profile of meteorology in the school curriculum; second we wanted to demonstrate to students and teachers that physics (meteorology) has great practical importance. Our ultimate goal was to engage and inspire children and young adults in science. The project was initially done in partnership with School District 61 (SD61), through funding obtained from the NSERC PromoScience programme, NEC Corporation and in kind contributions from Davis Instruments Corporation. As detailed below, the overwhelming success of the initial pilot project led us to expand the network through collaborations with SD62 (Sooke), SD63 (Saanich), SD69 (Qualicum) and SD79 (Cowichan Valley) as well as the local AChannel (CHUM) television station.

Figure 2. Photograph of the Davis Vantage Pro2 Plus weather station installed on top of Oaklands Elementary school in Greater Victoria School District 61.

Project history:

As a first step towards the development of the network we selected 20 elementary, middle and secondary schools in Greater Victoria School District (SD61) that we believed would give the optimal spatial coverage for software development. Administrative staff from these 20 schools were invited by the superintendent of the school district to attend a meeting on January 5, 2005. At this meeting we presented the objectives of the project and announced the availability of Science Education MEd projects in collaboration with researchers in the UVic Faculty of Education. Schools were invited at the end of the meeting to be involved in the project if they wished, and every one of the 20 schools chose to do so.

The Davis Vantage Pro2 Plus weather station was selected to be installed at each school. Each weather station measures atmospheric temperature, atmospheric humidity, UV Index, incoming solar radiation, wind speed, wind direction and atmospheric pressure (corrected to

sea level). We had experience with the Davis weather station by way of the unit we installed on the roof of the Ian Stewart Complex at the University of Victoria on March 11, 2002. This instrument remained in place and provided continuous data for 2 ½ years without the need for maintenance. The first school to have a weather station installed, exactly three years after we installed the weather station at UVic, was Strawberry Vale elementary school (March 11, 2005). The remaining 20 schools on the initial list had stations installed by early June, 2005, a few weeks before the end of the school year.

In order to assist teachers with the delivery of the curriculum, two suites of lesson plans were developed and made available to teachers. The first, written by J. Ramsden (Eagle View Elementary School), provided a weather unit that incorporated the newly reorganized BC science curricula. It focused on the grade 4 science and math learning outcomes. The second, written by S. Toleikis (Monterey Elementary School) and A. Weaver (Toleikis and Weaver, 2005), provided an integrated unit for teaching the foundation of the science of weather to students in the late primary and early intermediate grades. We have supplemented the weather network learning resource with in-class visits wherein we bring in an uninstalled weather station, along with a number of other demonstrations, to engage classes in the physics of weather.

The initial pilot project received extensive media coverage and the data, available at www.victoriaweather.ca, were well utilized by both educators and the general public. In fact, during the first three months visitors to victoriaweather.ca increased from 890 in the month of April, to 4,661 in June 2005. We subsequently granted the AChannel (CHUM) the exclusive rights to use the real time data in their live television weather segments in an effort to promote public education in general in the Greater Victoria, Sooke and Saanich School Districts, as well as to build community relationships and partnerships between UVic, the local school districts and the local media.

The project became so successful that we received numerous requests from schools around Greater Victoria, elsewhere on Vancouver Island and, more recently, throughout BC to install weather stations at their schools. We have accommodated all such requests from public schools on Vancouver Island between Victoria and Qualicum Beach. We further assisted the AChannel who added several other stations to the network at Vancouver Island landmarks and tourist locations such as Butchart Gardens, Ocean Trails Resort in Parksville, Tidemark Theatre in Campbell River and Comox Harbour. At the present time we have 67 active installations in Greater Victoria and 7 additional locations on Vancouver Island (see Figure 3). One year after the victoriaweather.ca became public, visitors to our site have increased from 4,661 in the ***month*** of June 2005 to 50,372 during the ***week*** ending June 18-24, 2006. We have now created an additional site (www.nanaimoweather.ca) to host other Vancouver Island weather stations and plan to install more stations over the coming months.

Resources offered and www.victoriaweather.ca:

Each of the Davis Vantage Pro Plus weather stations provides real time observations of temperature, humidity, wind speed and direction, precipitation amount and rate, solar and UV intensity and atmospheric pressure (see also Alpert, 2006). The weather stations are solar powered and transmit data through wireless technology to a local base station which is connected to the internet. All data are visible in real time on a display on the base station which can be mounted on a wall (typically in school libraries, computer rooms or main offices) in public view. Connected to each base station in each school is a monitorless low-end PC

which requires internet access. This PC reads the data at each location and forwards them to a central database server at UVic, as well as a mirror server.

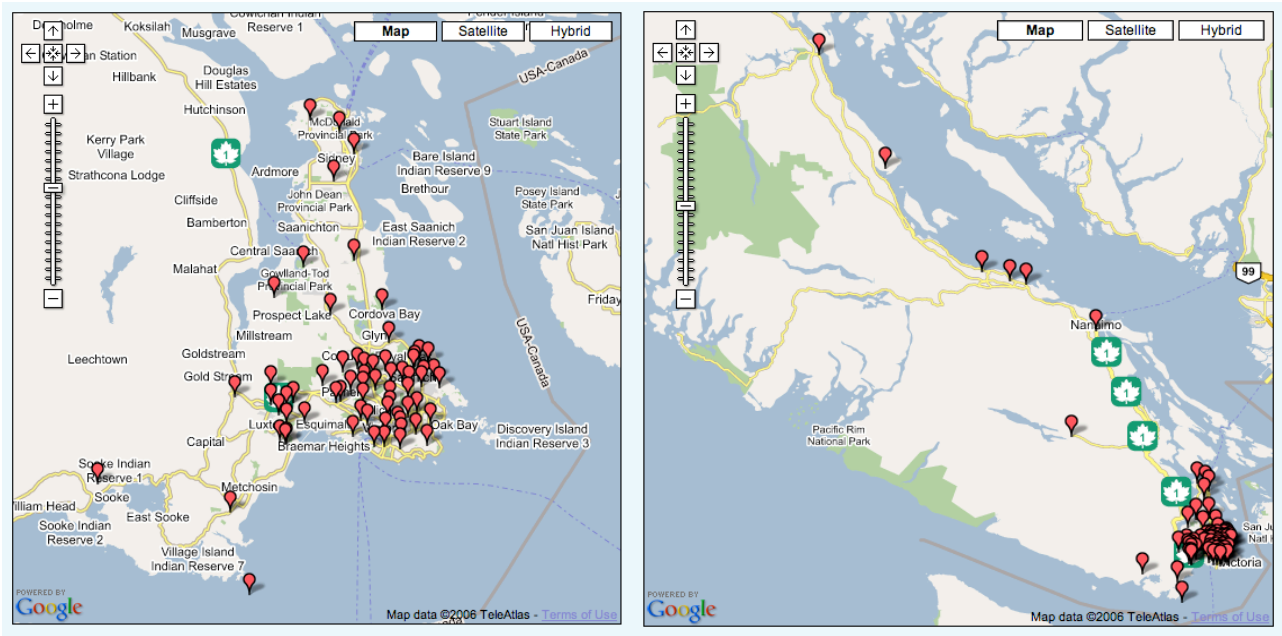


Figure 3. Left: Map showing the location of the 67 weather stations installed in Greater Victoria Schools. **Right:** Map showing the recent extension of the network to schools in Lake Cowichan, Parksville and Qualicum and, in partnership with the AChannel (CHUM), Campbell River, Comox, and Nanaimo (7 stations in total).

The web site www.victoriaweather.ca displays the data in real time (up to the minute) in digital form. Charts, graphs and the raw data are made available (see Figure 4 for some examples). Each school has its own web page which lists its local observations and daily, weekly and monthly timeseries (many schools have this linked from their homepage; other schools have students doing daily announcements of weather conditions). Extreme values are displayed for each school and a banner on the front page announces any historical records which are broken.

In addition to the individual school pages, there are summary pages that provide real time maps of weather conditions (temperature, humidity, precipitation accumulated since midnight, UV index, solar intensity, wind speed and direction) across the Victoria region (see Figure 5 for an example). We have also developed software to provide movie loops of recent conditions. Such a system allows students to watch real time movement of, for example, a cold front traveling across the city and allows them to understand the effects of localized land surface conditions and topography (mountains, hills, forests, water etc) and urbanization on the microclimate around Greater Victoria. Greater Victoria is an ideal site for such a project as there are extensive variations in the observed precipitation and temperature patterns across the city associated with different elevation, land surface type, proximity to water and direction of the wind.

As noted earlier, lesson plans and a teaching kit have been made available on the Teacher Resources page (www.victoriaweather.ca/resources.php). We have also added detailed descriptions and pictures of the sensors on the Davis Vantage Pro2 Plus and provide links to manuals on how to use the console in the school. A detailed description of how the weather stations were installed is also available on this site to assist administrators and staff with future installations.

a)

Winchelsea Elementary School

Date: **2006/07/18, 15:42**

Temperature: **19.9 C**
L: 10.1 C, H: 20.7 C

Humidity: **58 %**

Pressure: **1021 hPa** ↘

Insolation: **758 W/m^2**

UV Index: **7**

Rain: **0 mm**

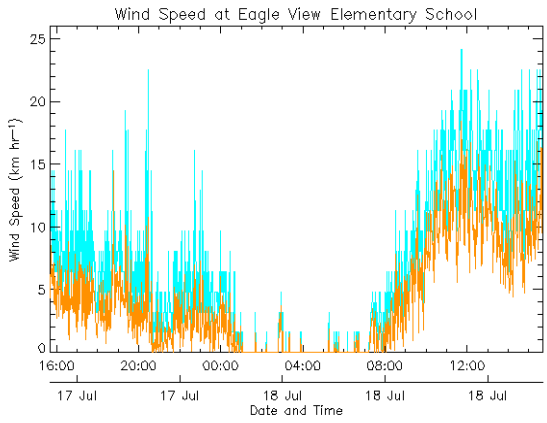
Wind Speed: **9 km/hr NE**
Max: 25.7 km/hr

b)

Extreme Values at James Bay Elementary School

Month	Maximum Temperature C	Minimum Temperature C	Maximum Daily Rain mm	Maximum Insolation W/m^2	Maximum Wind Speed km/hr	Maximum Wind Gust km/hr	Maximum Pressure hPa	Minimum Pressure hPa
January	11.9 05/2006	2.3 03/2006	24.9 29/2006	632.4 28/2006	53.1 28/2006	75.6 31/2006	1032.7 22/2006	985.2 01/2006
February	13.1 10/2006	-2.1 24/2006	12.4 04/2006	764.7 28/2006	50.7 01/2006	74.0 01/2006	1037.2 09/2006	988.5 27/2006
March	15.2 23/2006	-0.8 10/2006	12.2 08/2006	1036.0 31/2006	53.5 08/2006	67.6 08/2006	1021.0 26/2006	993.1 08/2006
April	21.1 23/2006	2.7 17/2006	10.2 01/2006	1109.0 16/2006	30.6 05/2006	53.1 29/2006	1028.9 30/2006	992.9 15/2006
May	25.7 15/2006	3.3 02/2006	13.7 22/2006	1331.2 20/2006	34.0 07/2006	54.7 07/2006	1030.2 02/2006	999.8 22/2006
June	26.3 20/2005	8.7 09/2005	7.9 17/2005	1427.0 02/2005	30.6 27/2006	46.7 16/2006	1028.1 23/2006	1001.0 16/2005
July	25.0 18/2005	10.1 16/2006	6.1 05/2005	1308.0 11/2005	30.6 06/2005	45.1 22/2005	1026.6 07/2006	1006.6 08/2005
August	24.1 25/2005	10.4 03/2005	21.8 17/2005	1068.9 29/2005	35.6 29/2005	57.9 29/2005	1022.9 30/2005	1010.1 29/2005
September	21.3 06/2005	5.6 23/2005	37.3 29/2005	1143.0 03/2005	25.4 02/2005	35.4 14/2005	1024.9 21/2005	1005.4 30/2005
October	17.2 21/2005	5.1 26/2005	19.1 17/2005	868.0 03/2005	33.9 27/2005	51.5 27/2005	1024.8 04/2005	999.0 14/2005
November	11.8 10/2005	1.0 29/2005	14.7 05/2005	596.0 06/2005	46.2 03/2005	74.0 03/2005	1036.7 14/2005	990.6 03/2005
December	13.4 24/2005	-0.8 16/2005	11.4 22/2005	427.2 08/2005	38.9 29/2005	61.2 29/2005	1034.1 04/2005	984.9 30/2005

c)



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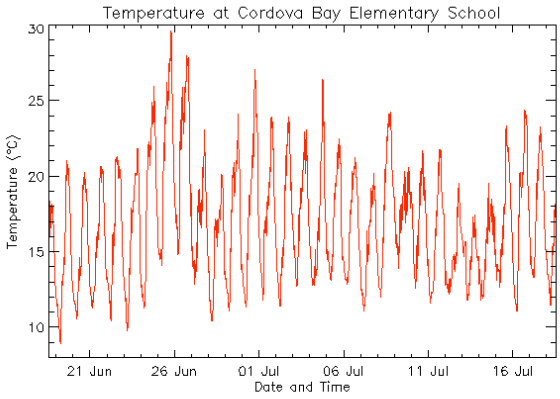

Figure 4. Sample data displayed on the individual school pages at www.victoriaweather.ca. **a)** Snapshot of real time observations at Winchelsea elementary school in Parksville. **b)** Extreme values for James Bay Elementary School. **c)** An example of a daily timeseries Shown here is the 1-minute average wind speed (orange) and maximum gust (light blue) at James Bay elementary school. **d)** A month long temperature timeseries from Cordova Bay elementary.

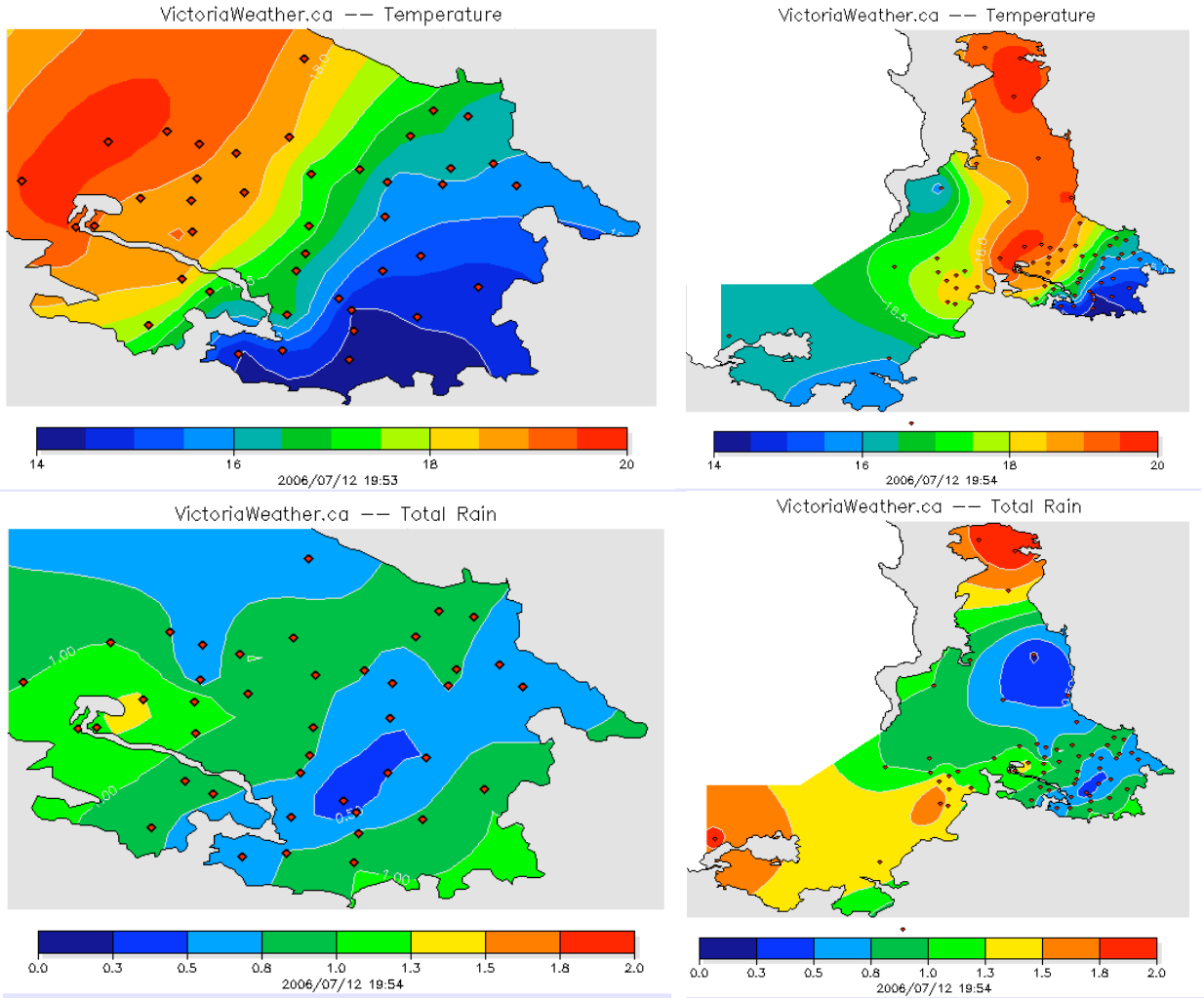

Figure 5. Left: An example of real-time temperature (**top**) and precipitation accumulated since midnight (**bottom**) data for Victoria displayed on www.victoriaweather.ca. **Right:** An example of real-time temperature (**top**) and precipitation accumulated since midnight (**bottom**) data for Greater Victoria including Sidney and Sooke displayed on www.victoriaweather.ca. The red dots indicate individual schools. Movie loops of these plots have also been developed. The data to produce these figures are archived and are available on demand.

How will the success of this project be measured:

Over the past year we received many anecdotal stories from students, parents, teachers and administrators as to how the weather stations were being used in the schools. We were amazed by the diverse range of applications. For example, at some schools young children acted as weather reporters on the morning announcements; at some schools the weather data were used in the mathematics curriculum to understand graphing, addition/subtraction etc (e.g., how much hotter is it today than yesterday); at some schools students built their own instruments and compared their observations with those from the network; at one school the weather station data were used in association with the operation of a dry kiln (drykiln.sd61.bc.ca) while at another, they were used by a class looking at the design of more energy efficient buildings.

What became clear to us was that collecting the variety of ideas together in one place and then making them available to all educators in the region should be a high priority to maximize the use of the stations. We therefore initiated a survey of teachers and administrators at the 20 schools in SD61 that were first to have their weather stations installed. The survey consisted of a written questionnaire and a voluntary follow up interview. 50 teachers and 32 administrators filled in the written questionnaire and 12 teachers and 10 administrators volunteered for a ½ hour follow-up interview. While an extensive analysis of the surveys/interviews is only just beginning, we will be using the results to:

1) improve www.victoriaweather.ca by adding additional resources as requested by teachers;

2) collating the different ways in which the weather stations have been used in schools and making this available to all local educators;

3) providing in service to teachers on professional development days.

Where do we go from here:

The micrometeorological network in Greater Victoria schools project continues to expand monthly. We recently agreed to install weather stations at five more local schools as well as throughout SD69 in the Parksville/Qualicum area. We continue to work with the AChannel to facilitate continuous monitoring of stations they plan to install in local communities throughout Vancouver Island.

A high priority is also the creation of additional teaching kits and activities for other grade levels. Over the summer we will complete a “Build a Weather Network” teaching activity for the upper primary and intermediate grade levels. We will also building an online interactive statistical package to target the middle and secondary mathematics curriculum. It is hoped that archived data, currently being used by graduate and undergraduate students at the University of Victoria, will also form the basis of Science Fair projects in local schools.

We invite you to visit www.victoriaweather.ca and we would be delighted to receive your feedback and ideas. We can be reached by email at: weather@ocean.seos.uvic.ca.

Acknowledgements:

We are grateful for funding from the NSERC PromoScience program and NEC corporation without which this project would never have been possible. Many scores of teachers, administrators and staff have assisted us across the districts for which we are extremely grateful. We are particularly indebted to J. Gaiptman, the superintendent of SD61, without whose help this project would never have been realised. While it is not possible to list everyone, we are especially grateful for the assistance from: SD61: J. Lutter, C. Parsons, J. Ramsden, S. Toleikis, W. Yee; SD62: G. Gustafson, G. Leamy, G. Treloar; SD63: B. Carbery, R. Pang, A. Sanford; SD69: J. Girard, I. Macdonald, J. Swanson; SD79: R. Rakimov, J. Turner, K. Walters; AChannel (CHUM): C. Basbaum, H. Mack, B. Williams. Finally, we thank S. Lambert of the CCCma and scores of people in Greater Victoria who view the site daily and provide us with valuable feedback.

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