4.6 UPGRADES TO THE MSC'S NATIONAL CLIMATE AND WATER ARCHIVES

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1. INTRODUCTION

The Meteorological Service of Canada (MSC) monitors the state of the atmosphere, hydrosphere, and cryosphere. The National Climate and Water Archives concentrates on archiving data from MSC operational monitoring networks and ensures accessibility of these data.

Data archiving is an important component of the MSC's new Data Management Framework (DMF) (Yip and Minuk 2002, 2004). The DMF is a multi-year project to improve the management of, and access to, operational meteorological, hydrometric, and air quality data and metadata. When completed, the resulting Data Management Framework will make it easier for MSC users, as well as clients and partners, to obtain authoritative responses to queries for MSC data.

With the proliferation of automatic weather and climate stations, there has been a rapid increase in the number of variables being reported. Due to the high volume of new weather and climate elements and finer sampling intervals, some climate, marine and hydrometric elements being observed are not decoded, quality controlled or ingested in the MSC digital archive. Traditionally, the Archive was designed to only handle point data (i.e. 3D: stationary latitude, longitude and elevation). With new monitoring technology, the Archive needs to be retooled to handle 4D data, volumetric radar and other image data, as well as multiple values for the same element at the same location. New database technology now has the capability of storing such data more easily.

A Doppler Radar Archive Project was completed this year, adding volume scans and image data to the MSC digital archive. Some of these data will be available on the Internet in 2006. A second initiative, the New Elements Project, was launched to archive new weather and climate elements. For the purpose of this project, new daily, hourly and one-minute data were considered as candidates for archiving. In early 2006, several of these new elements will be available for access in MSC's digital archive.

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2. DOPPLER RADAR PROJECT

2.1 *Project Overview*

Experience in the United States and Canada has shown that Doppler weather radar can be a very useful tool in improving the prediction of severe weather events. Radar has proven to be a valuable tool for measuring the intensity of rain and snowfall as well as the motion of precipitation. Most importantly, radar helps weather forecasters predict and identify, in advance, severe storms that could seriously affect the lives and property of Canadians. The goal is to be able to provide sufficient warning to the public to ensure their safety and security and to assist in the implementation of emergency planning with a view to minimizing damage and economic loss.

Environment Canada's Doppler radar network is composed of 31 radars. The National Radar Project was initiated to ensure that all Canadian radar sites would be equipped with Doppler weather radar. The first of the new Doppler weather radar sites was opened in Bethune, Saskatchewan in the fall of 1998. The network was completed in the spring of 2004 when the Timmins, Ontario site was brought into service.

This network comprises 28 Environment Canada radars and 2 Department of National Defense radars. Through financial cooperation with the radar research program of McGill University, Environment Canada (EC) also obtains data from the Marshall Radar Observatory. This Observatory is located at the Sainte-Anne-de-Bellevue campus of McGill University on the outskirts of Montréal. The network provides radar coverage for much of southern Canada and approximately 98% of the Canadian population.

A number of factors were considered in determining specific site locations, notably the location of radars in the conventional network at that time. Available coverage by the U.S. National Weather Service radars adjacent to the Canadian border was also taken into consideration. MSC's weather radars have an effective circular coverage area that is approximately 256 km in diameter

when operating in Doppler mode, and 512 km diameter in conventional mode.

Since weather knows no political boundaries, it is important that potentially life-threatening meteorological information be shared internationally. Canada and the United States have signed an agreement to share the information derived from their respective radar networks so that a continuous flow of information exists across the border. The MSC radar website contains all this information and more. You can find the URL of the site in the Useful Links Section.

2.2 *Radar Data and Metadata Available*

Radar data and metadata are stored at regional collection centers before or as well as a central storage location. The daily load per site varies between 100 and 150 MB/day/site. For all sites, the amount of space needed for storage is approximately 1.5 TB/year.

The radar data are archived in different formats and products. Volume scans, that contain raw data, are archived so that no information is lost. Image files for low level CAPPI (Constant Altitude Plan Position Indicator) and Echo top images are also archived. Lastly, intermediate metafiles are stored. They allow the flexibility of regenerating images and numerical and accumulation products.

Radar metadata contain essential information (latitude, longitude, ground height, start date, tower height, antenna type, antenna size, radome, polarization) and other data such as the format version, operating status, maintenance system, electronic logs, etc.

The central archiving of radar files (volume scans, metafiles and image files such as CAPPI's, multi-site composites and Echo Tops) started this year. These files are available from EC's climate services units on a cost-recovered basis. Public internet access to a selection of the historical image files is planned for early 2006 on EC's web site (http://weatheroffice.ec.gc.ca/canada_e.html).

3. NEW ELEMENTS PROJECT

3.1 *Project Overview*

In the past, many elements could not be accommodated by the existing alphanumeric bulletins, and consequently only the raw data were archived, but were not available in a usable format. This restriction was removed in the mid-1990's by the use of BUFR (Binary Universal Form for the Representation of meteorological data) bulletins. The self-descriptive nature of this binary bulletin format allows all forms of observed data to be encoded, therefore all these data are theoretically available for archiving upon decoding. The priority to archive new weather and climate elements was based on resources available, client requirements, and on the effort required.

Surface weather and upper air observations contain new elements that are currently available in the Archive or will be available in the near future. In the sections below, new elements are presented according to the network that acquires them.

3.2 *New Aviation Elements*

The Aviation network is composed of 132 stations of which 113 are Manned stations and 19 are Automated Weather Observation Systems (AWOS) (Durocher, 2005). This network is part of the Surface Weather Network. Table 1 presents some of the new elements reported by the Hourly Aviation network.

Table 1. New Elements, acquired by the Hourly Aviation network, available as of now (in bold) or in the near future.

Hourly Aviation Elements
Altimeter Setting
Cloud Layer 4 (Opacity, Condition, Type, Height)
Cloud Layer 5 (Opacity, Condition, Type, Height)
Cloud Layer 6 (Opacity, Condition, Type, Height)
New Obscuring Phenomena
Wind Character (Gust or Squall) at 10 m
Wind Gust Speed at 10 m

The Altimeter Setting is an hourly element recorded in inches of mercury with two fractional digits. This element has been available since July 11, 2005.

New Cloud Layers and Obscuring Phenomena were added to the Archive. In the past, up to six cloud layers were reported and an algorithm was used to compress them into four layers for the Archive. The Manual of Surface Weather Observations (MANOBS) allows up to six cloud layers from Manned stations and five from AWOS stations (a ground-based layer plus four layers aloft). Therefore, the ingest system was re-worked

to accommodate the new fourth, fifth and sixth cloud layers.

Historically, the only obscuring phenomena reported as a ground-based layer was fog. All the other obscuring phenomena were grouped in one category, "Obstructions other than Fog". The following obscuring phenomena are now specified individually: rain (including rain showers and freezing rain); hail; ice pellets (incl. ice pellet showers); drizzle (incl. freezing drizzle); ice crystals; snow (incl. snow showers, snow pellets, and snow grains); blowing snow; dust, blowing dust or dust storm; haze; sand, blowing sand or sand storm; smoke; and volcanic ash.

The hourly wind gusts or squalls were observed and quality controlled since 1994. According to MANOBS, gusts are sudden, rapid, and brief changes in the wind speed. They are reported when the highest peak speed is at least 5 knots higher than the current two-minute average and when the highest peak is at least 15 knots. Squalls are essentially gusts with a longer duration of higher speeds. Both wind gust and squall speeds will be stored in the Archive in kilometer per hour. A wind character will be used to identify whether the speed reported is for a gust or a squall.

3.3 *New RCS Elements*

The Reference Climate Station (RCS) Network is a critical network for documenting and detecting climate change and variability. In 1992, stations were identified as RCS by the quality of their temperature records. It is important for RCS stations to have long periods of uninterrupted quality observations and to be located away from population. More stations were added to the RCS network between 1997 and 2003 to have a better spatial distribution across the country. The current network contains 302 stations (Durocher, 2005).

The RCS network generates a considerable amount of new elements (Table 2). Out of the 25 new RCS elements, 16 are related to precipitation, 8 to wind (at 2 meters and 10 meters), and 1 to solar radiation.

Elements related to precipitation are of various states and are acquired with different instruments and sampling intervals. The Total Hourly Precipitation is the total precipitation amount for minutes 01 through 60, inclusive. It is measured in kg/m^2 by a weighing-type gauge or in mm per unit time (rate) by a Tipping Bucket Gauge. In the Archive, the Total Hourly Precipitation will be stored in mm and its resolution will be 0.1 mm. When using a weighing-type gauge, the Total Precipitation Amount is derived by the precipitation mass per surface unit difference (kg/m^2) over a 15-minute interval. The weights are computed for each minute of the hour based on the average of 5-seconds samples of the sensor. The Precipitation Gauge Weight is computed for a given minute (15, 30, 45, 60). The units of the Precipitation Gauge Weight element are kg/m^2, which equates to mm. It will be stored in mm in the Archive with a resolution of 0.1 mm.

Table 2. New RCS Elements available in the near future.

New RCS Elements
Total Hourly Precipitation Amount
Total Precipitation Amount (Minutes 01-15)
Total Precipitation Amount (Minutes 16-30)
Total Precipitation Amount (Minutes 31-45)
Total Precipitation Amount (Minutes 46-60)
Precipitation Gauge Weight (for Minute 15)
Precipitation Gauge Weight (for Minute 30)
Precipitation Gauge Weight (for Minute 45)
Precipitation Gauge Weight (for Minute 60)
Snow Depth (SOG) at minute 15 (ultrasonic)
Snow Depth (SOG) at minute 30 (ultrasonic)
Snow Depth (SOG) at minute 45 (ultrasonic)
Snow Depth (SOG) at minute 60 (ultrasonic)
Average Wind Speed at 2 m (Minutes 01-15)
Average Wind Speed at 2 m (Minutes 16-30)
Average Wind Speed at 2 m (Minutes 31-45)
Average Wind Speed at 2 m (Minutes 46-60)
Average Wind Direction at 2 m (Minutes 59-60)
Average Wind Speed at 2 m (Minutes 59-60)
Wind Character (Gust or Squall) at 10 m
Wind Gust Speed at 10 m
Hourly Rainfall (TBRG) Amount
One-Minute Rainfall (TBRG) Amount
Time of One-Minute Rainfall Amount (UTC)
One-Minute Global Solar Radiation

The Snow Depth element is the depth of snow on ground computed for a given minute (15, 30, 45, 60) based on the average of 5-second samples of the sensor. The output obtained from the Snow Depth will be stored in whole cm in the Archive with a resolution of 1 cm.

The Total Hourly Precipitation, 15-minute interval Total Precipitation Amount, the Precipitation Gauge Weight at a given minute, and the Snow Depth at a given minute will go through an averaging process that filters out signal noise. These precipitation elements should be available in spring 2006.

Development work is underway for the Hourly and One-Minute Rainfall Amount elements. It is estimated that they should be available in 2006. The Hourly Rainfall Amount is measured by a Tipping Bucket Rain Gauge (TBRG). The TBRG measures the rate of rainfall. This rate is transformed into an amount (kg/m^2) based on the number of tips the instrument records (0.2 mm is required to make the bucket tip). It will be stored in the Archive in mm with a resolution of 0.2 mm. The Hourly Rainfall Amount is derived from the One-Minute Amount. The One-Minute Amount is reported only if there is precipitation within the hour.

Eight new elements pertain to wind speed, direction, and character at different heights. The 15-minute Average Wind Speed at 2 meters is averaged over a 15-minute interval (01-15, 16-30, 31-45, 46-60). The wind speed is observed in m/s and will be archived in units of km/h with a resolution of 0.1 km/h. The Average Wind Direction at 2 meters, at the top of the hour (minutes 59-60), is measured in degrees true, with a resolution of whole degrees. The Average Wind Speed at 2 meters, at the top of the hour, is averaged over the interval of minutes 59-60. This element is observed in m/s and will be archived in km/h with a resolution of 0.1 km/h. For information on the wind character and gust speed, refer to Section 3.2.

The solar radiation network is in transition to a network of 50 global radiation sensors at RCS stations, plus up to 6 core stations that will record various radiation elements. The One-Minute Global Solar Radiation element is the total incoming shortwave radiation received on a flat surface. It should be available in early 2006. This element is measured in mV, transformed through a calibration equation, and will be archived in W/m^2 with a resolution of 0.1 W/m^2. More information about MSC's solar radiation data is found in Boudreau et al. (2002) and Sopoco et al. (2004).

3.4 *New Upper Atmosphere Elements*

The Canadian Upper Air Observing Program includes the Upper Air network and the Canadian Aircraft Meteorological Data Relay (AMDAR) Program (see Table 3).

According to the Technical Documentation for the Digital Archive of Canadian Climatological Data (2003), the Upper Air (UA) data are archived using standard formats based on the sampling interval. Two record formats are used: 1) Ascent record of interspersed significant and standard level data (UAS); and 2) Ascent record of wind data (UAW). Each record consists of station identification, date, time and element number followed by the data, repeated for each level or time interval, from the lowest level to the termination of the ascent.

Table 3. New in flight observation types. Items in bold are now available.

Upper Atmosphere Observations
Upper Air - UAS
Upper Air - UAW
AMDAR

The Upper Air network is composed of 31 operational sites from which radiosondes are launched. Data are usually acquired at synoptic times (i.e. 00, 06, 12, 18 UTC). However, a number of stations only report twice per day. Irregular operations also take place at about six other stations. These mobile stations are deployed from time to time in order to support environmental emergencies and special research projects.

UAS data are a mixture of derived and raw data. During the ascent, a set of observations is currently taken at up to 90 levels. Each set contains wind speed, wind direction, relative humidity, temperature, altitude, and pressure. UAW data are composed of one-minute observations and contain wind speed, wind direction, altitude above sea level, and pressure. The total duration of the recording for UAW data is currently up to 120 minutes. UAS and UAW data are available in the Archive since 1961 but there are some UA charts that exist prior to this date.

The AMDAR network is a fully automated upper air observing system in development worldwide (Fournier, 2005). It provides high quality upper air data outside synoptic times. Data are collected by aircraft flown by Air Canada Jazz. The program is being expanded with First Air, WestJet, and small regional airlines (Fournier, 2006).

AMDAR data are currently stored at the Canadian Meteorological Centre (CMC) for internal purposes (modeling, forecast, etc.) and distributed on the Global Telecommunications System (GTS) since January 4, 2005. Canadian AMDAR data are also available on the Global Systems Division (GSD) of the Earth System Research Laboratory (ESRL) website. MSC is developing an archive system that will allow the public to access this data in raw and quality controlled format. Data and metadata present in

Canadian AMDAR messages are as follows: aircraft identifier, navigation system, date (year, month, day), time (hour, minute), coordinates (latitude, longitude), height or altitude, temperature, wind direction, wind speed, turbulence (degree of, height of base and top, peak turbulence intensity (EDR)), airframe icing, aircraft registration number, wind quality flag. As these data are not associated to a fixed location (as is the case for Upper Air data), some metadata (date, time, aircraft registration number or ID, coordinates, and altitude) will be archived with all data for a given flight point. A completion date for this project has yet to be established.

3.5 *Next steps*

Other aviation and RCS elements will be added to the Archive as capacity allows. We are continually gauging the need for specific types of data and assessing priorities. Hourly soil temperatures are one of those elements that have been requested and work will begin on that soon.

The new Hourly aviation elements have been available in the raw data since 1994. Data for the One-Minute Global Solar Radiation element are available since 1988. We are considering archiving the backlogged data for the above mentioned elements.

Some of the elements listed above (altimeter, wind gust, wind character, new cloud layers) undergo quality control. For others, like the new RCS elements, Upper Air and AMDAR data, quality assurance and quality control algorithms will be developed and implemented by the DMF.

Lastly, triple configuration was approved for temperature and precipitation. It includes archiving and an algorithm to determine the official MSC value. In addition, a multi-parameter algorithm is in development to derive snowfall from snow on ground measurements. You can find more information on the latter in Fischer and Durocher (2006).

4. USEFUL LINKS

The National Radar Program and links to current radar data: http://www.msc-smc.ec.gc.ca/projects/nrp/index_e.cfm

National Climate Archive / Archive Online: http://www.climate.weatheroffice.ec.gc.ca

To find out what elements are available in the digital archive, refer to the Technical Documentation: http://www.climate.weatheroffice.ec.gc.ca/prods_servs/documentation_index_e.html

For queries and data requests, contact Climate Services. Email: Climate.Services@ec.gc.ca

5. SUMMARY

The Meteorological Service of Canada (MSC) monitors the state of the atmosphere, hydrosphere, and cryosphere. The National Climate and Water Archives concentrates on archiving data from MSC operational monitoring networks and ensures accessibility of these data.

A Doppler Radar Archive Project was completed this year, adding volume scans and image data to the MSC digital archive. Some of these data will be available on the Internet in 2006.

A second activity, the New Elements project, was initiated to archive new weather and climate elements. New daily, hourly and one-minute data were considered as candidates for archiving. These new elements are generated by the Aviation network, the RCS network and the Upper Air Observing Program. Some elements are available as of now or will be available in the near future.

The new elements from the Hourly Aviation network are the altimeter setting, fourth, fifth and sixth cloud layers, obscuring phenomena, wind character and wind gust speed. Twenty-five new RCS elements were considered: 16 are related to precipitation, 8 to wind (at 2 and 10 meters), and 1 to solar radiation.

The Canadian Upper Air Observing Program includes the Upper Air network and the Canadian Aircraft Meteorological Data Relay (AMDAR) Program. New Upper Air elements are wind speed, wind direction, altitude above sea level, and pressure. Some messages also contain relative humidity and temperature. The AMDAR network provides aircraft position, wind speed, wind direction, temperature, and in some cases humidity, turbulence and icing.

Finally, other aviation and RCS elements will be added to the Archive as capacity allows. We are continually gauging the need for specific types of data and assessing priorities.

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