Environment Canada Environnement Canada

Canada

Towards the development of a Global Archive of Historical In Situ Snow Data

Core-Climax Workshop
Reading, U.K.
November 17-19, 2014

Overview of historical snow data at Environment Canada

Ross Brown
Environment Canada, Climate Research Division
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With contributions from: Chris Derksen (EC Climate Processes Section), Barry Goodison (EC/WMO-GCW ret.), Tony Colavecchia (Manager, Data Management Section), Rick Fleetwood (MSC Atlantic Operations), Dale Boudreau (Head, Business Analysis Unit, Data Management Section)

Background (for internal EC use)

- ECMWF have funding under the EU FP7 Core-Climax and EU FP7 ERA-CLIM2 projects to explore the development of a global archive of historical in situ snow data

- A workshop has been organized in Reading for Nov 17-19 with invited participants from several meteorological and data centres (NOAA NCDC, CMA, FMI, ECMWF, Meteo-France, Roshydromet, EC, GPCC)

- Workshop Objectives:
  - Review the historical in situ snow cover data holdings in national and international archives
  - Review data access mechanisms
  - Discuss options for a global database (e.g. distributed data archive with central catalogue)
  - Summarize findings in a report to be distributed to the snow and reanalysis communities

Talk Outline

Part 1: Overview of historical in situ data holdings at EC

- **Brief history of in situ snow observing programs at EC** (measurement methods, network, issues etc)
  - snow depth
  - snow course

- **Data rescue activities 1995** ("Snow CD 2000" Updated to 2003/04)
  - Quality control and filling
  - File structure
  - Meta data

- **Current status of archives** (physical structure, data format, QC, updates etc)

Talk Outline contd

Part 2: Data Access

- Current data access mechanisms (access protocols, web interfaces, data identification)
- Current/planned Web Services
- Data policy

Importance of daily snow depth obs

- Initialization of NWP models
- Climate monitoring
- Evaluation of snowpack models and remotely sensed algorithms e.g. SnowMIPs, SnowPEX
- Soil thermal regime studies (e.g. active layer monitoring)
- National Building Code snow load guidelines
- Frost penetration (construction, agriculture)
- Tourism (ski and snowmobile days)
- Hydrology applications (SWE can be readily estimated from depth)
- Ecological studies

Why do we need a Global Historical Snow Archive?

- An enhanced, coordinated database for snow observations would have huge benefits for:
  - Satellite retrieval algorithms such as GlobSnow SWE
  - Climate monitoring at hemispheric/global scales (e.g. IPCC)
  - Research into snow cover-climate variability e.g. link between Eurasian October SCE and winter AO
  - Research into the sensitivity of NWP to snow cover initialization
  - Historical analysis of daily snow depth and SWE
- Data subject to the same QC and zero/gap filling methods
- Stimulate contribution of historical snow data from countries unwilling or unable to share data in real-time

History of EC daily depth of snow on ground (SOG) observations

- Daily measurements of snow on the ground (*daily climate element 013*) began in 1941 at principal observing stations and in 1981 at most climate observing stations

- Manual ruler observations are made based on WMO guidelines and the following instructions to observers:

MANOBS 1977: *"The total depth of snow on the ground at the time of the observation shall be determined (in whole centimeters)* ***by taking a series of measurements and taking the average****. The area selected for the measurement shall be chosen with a view to avoiding drifts. Care shall be taken to ensure that the total depth is measured including the depth of any layers of ice which are present".*

An average depth of less than 0.5 cm is considered a "trace" and reported as such. If there is no snow on the ground, then zero is reported but "trace" should be reported where the ground is only partially covered by snow

History of daily SOG obs contd.

- Snow depth measurements recorded in whole inches prior to 1975 and to the nearest centimetre after (can create discontinuity in snow cover duration depending on the threshold depth used to define a day with snow on the ground); daily snow depth obs are usually made at 12:00Z

- Ultrasonic SR50 automated snow depth sensors came into service in the 1990s with the expansion of the AWS program; the 5-minute averaged depth at 12:00Z is taken as the daily value

- Autosensor reports now make up ~ 50% of the total daily SOG observations; EC is moving to a 3-sensor configuration at autostations to improve spatial sampling and QC (about 90 AWS currently configured with triple sensors)

- Increasing reliance on “partner” and cooperative networks (e.g. CoCoRaHS) and near real-time acquisition of data (e.g. “CoolTap” web data entry by observers); increasing reliance on automated approaches to data QC (regional-based man-machine QC of daily climate data no longer carried out)

Current snow depth data streams

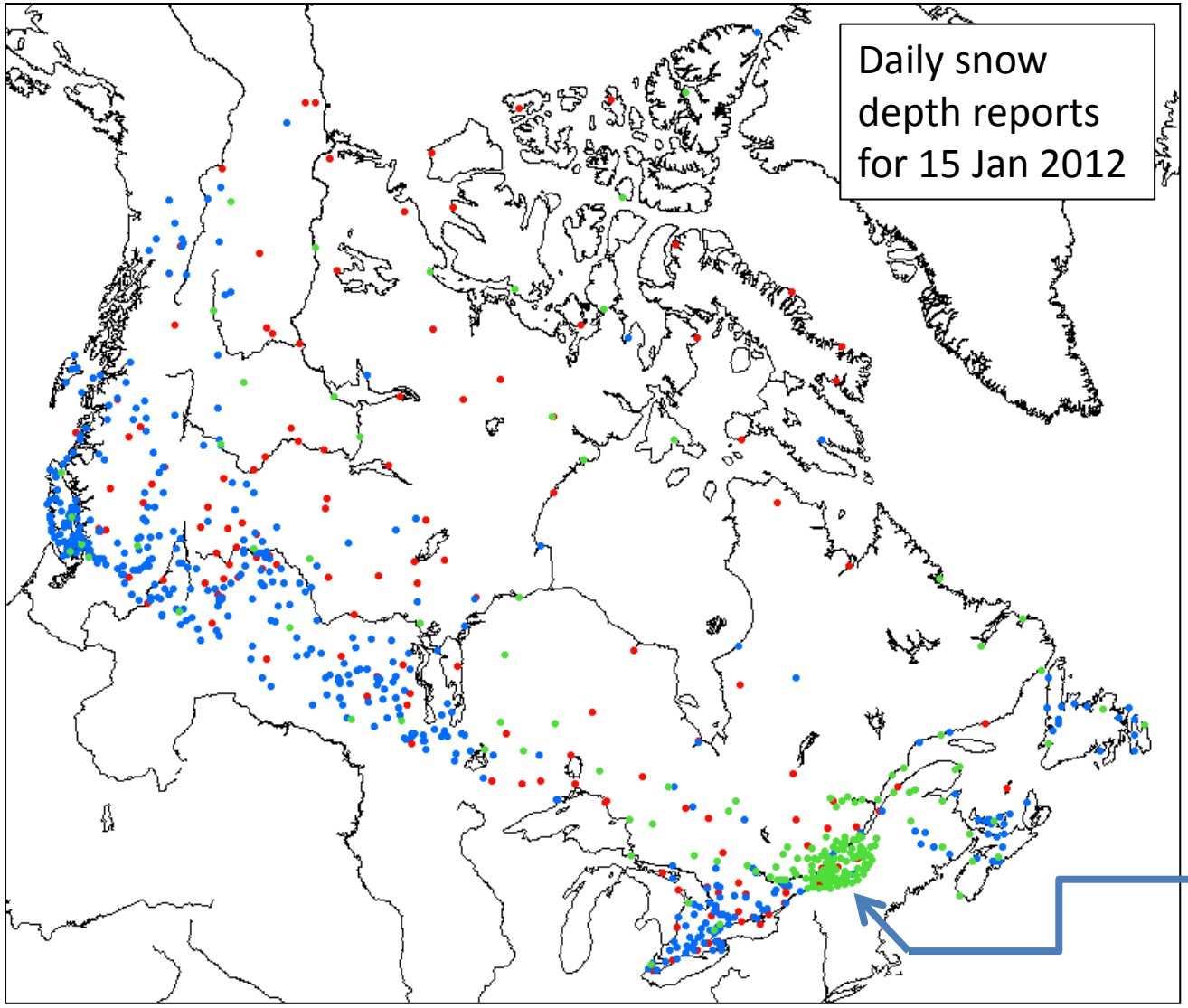
HLY01: hourly snow depth from autostations starting Jan 2006

DLY04: keypunching of **paper 2322** from Manned Aviation stations (done once or twice a year—not timely) and reports from MDDEP Quebec network [~20 % in 2012] **Most of the historical daily data up to ~2005 are in the DLY04 archive**

DLY02: decoding of FM12 ascii **synoptic message** (Manned & Auto) [~50 % in 2012]

DLY44: Volunteer daily T&P data sent via "**CoolTap"**. Once flowed into DLY04's when processed and QC'ed by the Regions (cancelled 2007). Now any paper/Excel sheets are keypunched and processed as if from CoolTap (**no Quality Control**) [~30 % in 2012]

Location of daily snow depth reports for Jan 15, 2012 in EC climate archive by data source (results of data query 7/11/2013)



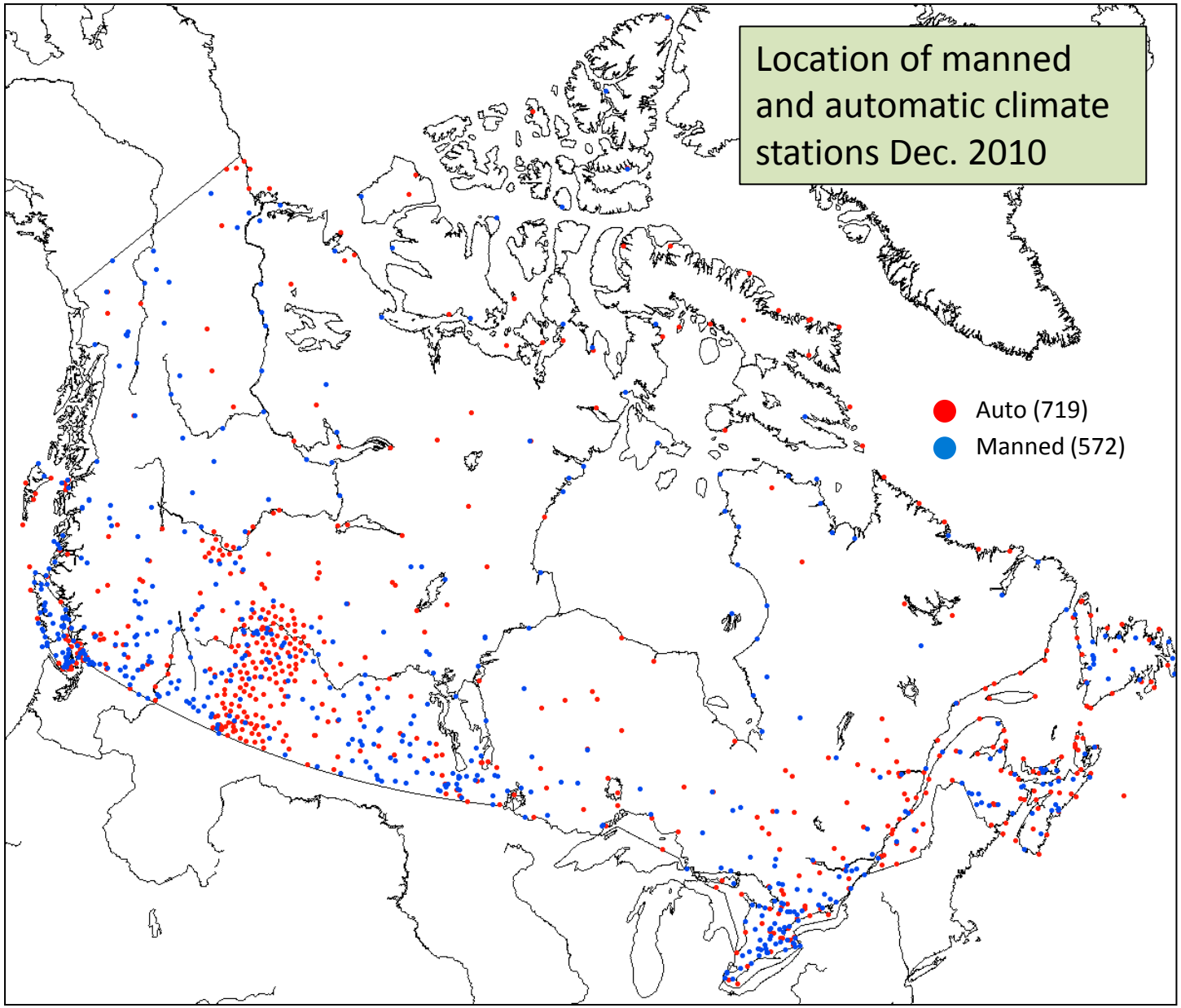
DLY02 (221 obs)

DLY44 (436 obs)

DLY04 (174 obs)

831 observations total
48 stations duplicated

DLY04 reports mostly from the MDDEP (Quebec) snow depth observing network. ~20% of the Quebec snow depth network is not covered by the EC-MDDEP contract.


Location of manned and automatic climate stations Dec. 2010
Auto (719)
Manned (572)

Historical snow data rescue, 1995

- Data rescue of paper records in 1995 (pre-1950 end of month snow depth reports plus any data missing from the digital archive); resulted in the addition of ~400 stations with varying lengths of record in the period 1883-1990.

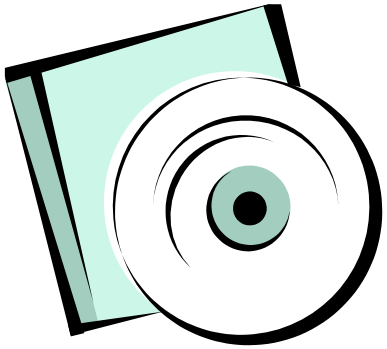
- Historical QC'd daily snow depth database created in 2000 (filled missing zeroes and reconstructed missing data using simulated snow depth from snowpack model driven with daily temperature and snowfall)

- Historical database updated to end of 2002-03 snow season

- **THESE RESCUED DATA ARE NOT INCLUDED IN THE EC DIGITAL CLIMATE ARCHIVE** [data can be searched and downloaded from the Polar Data Catalogue https://www.polardata.ca/]

Current structure of historical in situ snow data at EC

One-off datasets



"Snow CD 2000" updated to 2003

- **Daily snow depth** (1850-2003) DLY04 to 2003 + data rescue + filling of 0 and missing values
- **National compilation of bi-weekly snow course measurements** (1935-2003)

Searchable online data

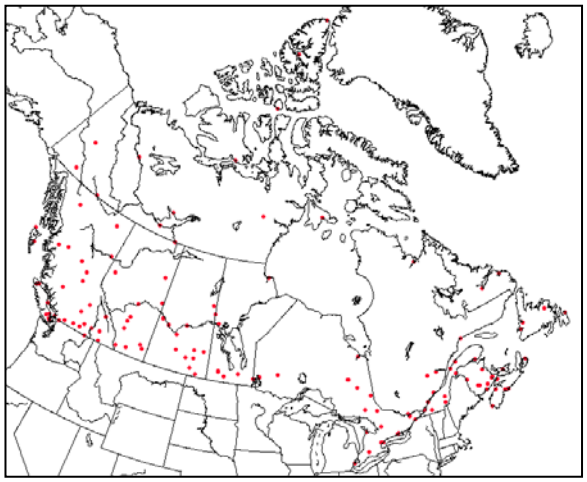
DLY04 — Main historical daily snow depth archive from manual stations (1955-)

DLY02 — Autostation snow depths (~1990-)

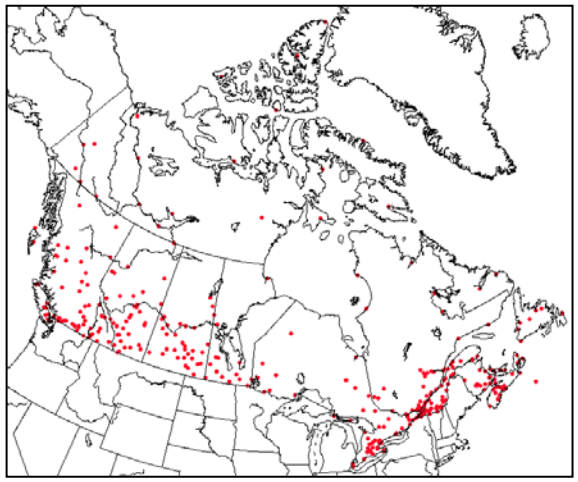
DLY44 — Real-time manual snow depths (2005-)

Known issues with the Canadian daily SOG data:

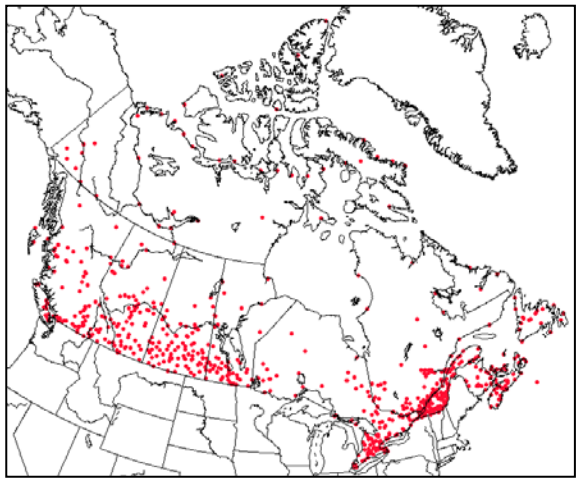
- Brown and Braaten (1998) found that manual snow depth obs were of high quality (>98.5% of obs passed internal consistency checks) **BUT…**
- Low elevation and southern biases in observing network
- Obs taken at airports in open areas may not be representative of the surrounding land cover (lower accumulation and earlier spring melt than vegetated areas); a real problem in Arctic regions where snow accumulation is closely linked to surface features (terrain, vegetation)
- Infrequent reporting of zero depths; inconsistent reporting of “trace” amounts
- Autostation data issues (early data noisy, unit errors at some sites)
- Only rudimentary QC and no consolidation of snow depth from different data sources e.g. data rescued in 1995 are not included in the online archive
- Relatively few stations with long-term continuous records for climate monitoring (station joining may help but this has not yet been looked at)



132 stations with 50 years of continuous data in 1950-2009 period

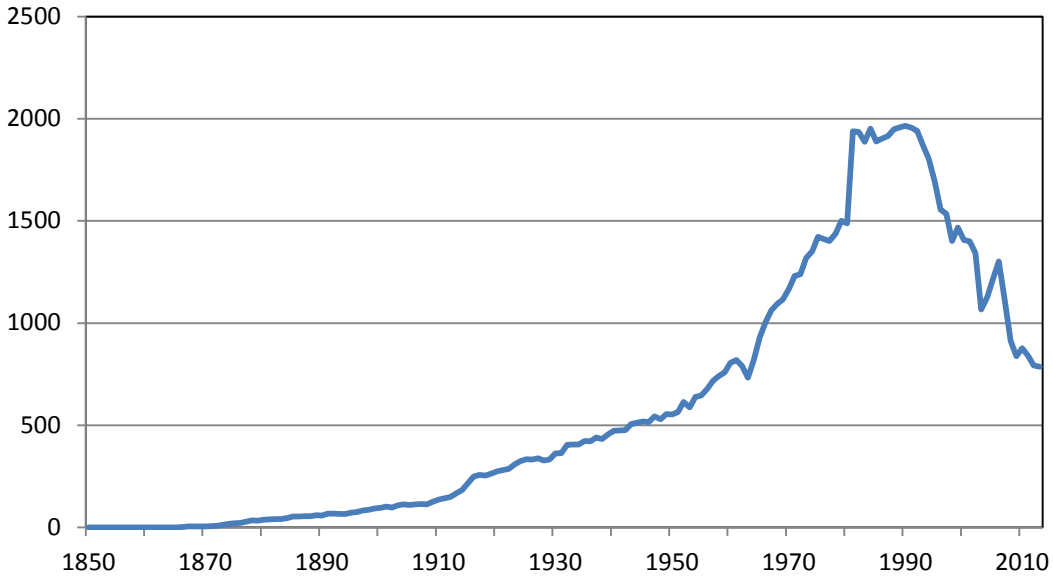


333 stations with 40 years of continuous data in 1950-2009 period



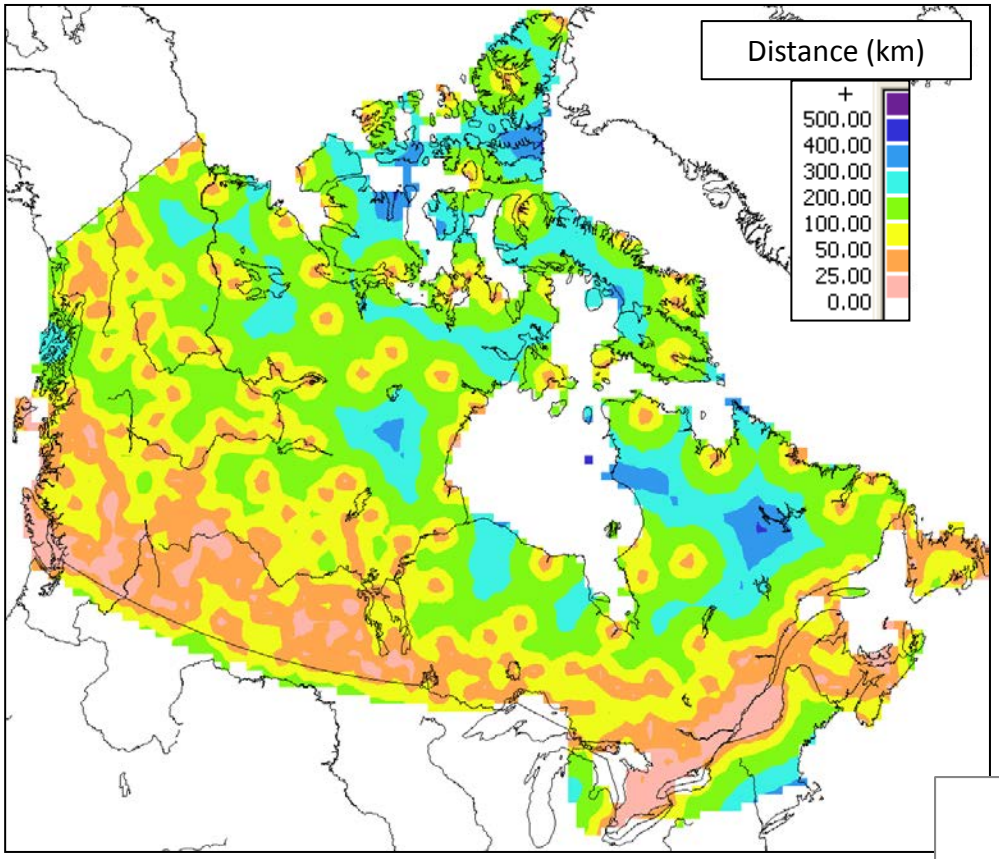
649 stations with 30 years of continuous data in 1950-2009 period

Number of stations reporting a snow depth on Feb 01



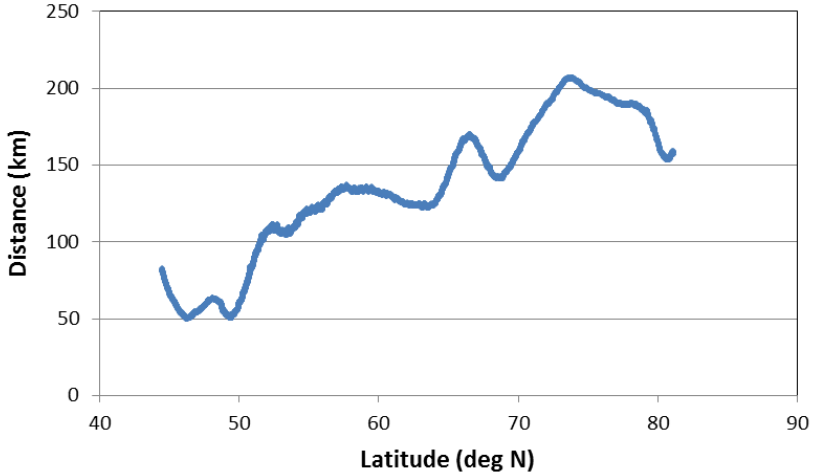
- The number of stations reporting daily snow depth peaked in the 1981-1995 period and has declined rapidly since
- The number of stations with 50+ years of continuous data is only ~130

Distance from nearest station (km) reporting snow depth on Jan 15 2012



- ~50% of land area within 100 km of observing station (most of area south of 55°N)
- Major data gaps over northern Québec, west of Hudson Bay and Canadian Arctic Archipelago

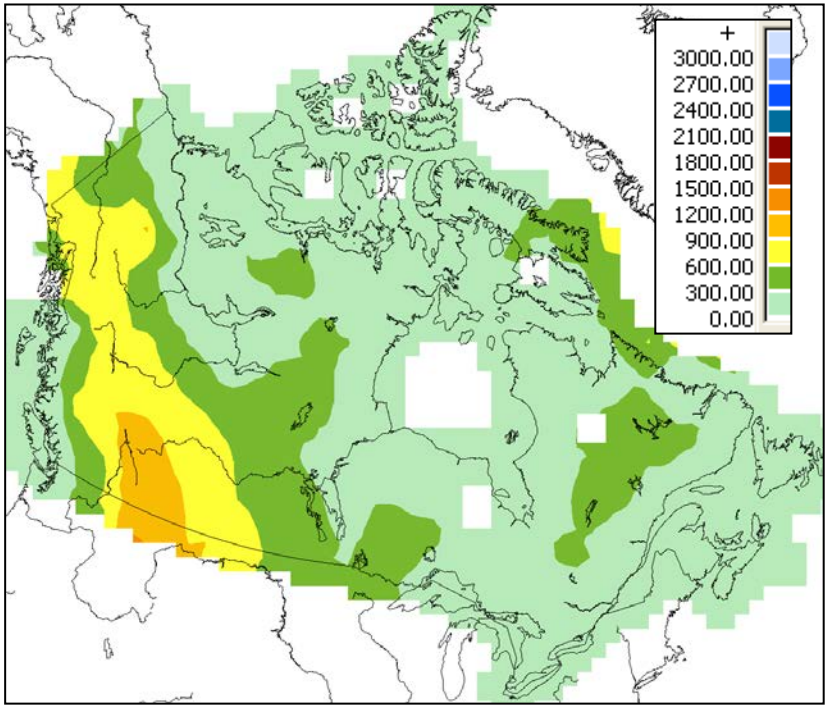
Note: snow depths can vary substantially over distances < 10 m so the above map is somewhat of an academic exercise! Derived properties such as date of snow cover onset and disappearance show more spatial coherence.



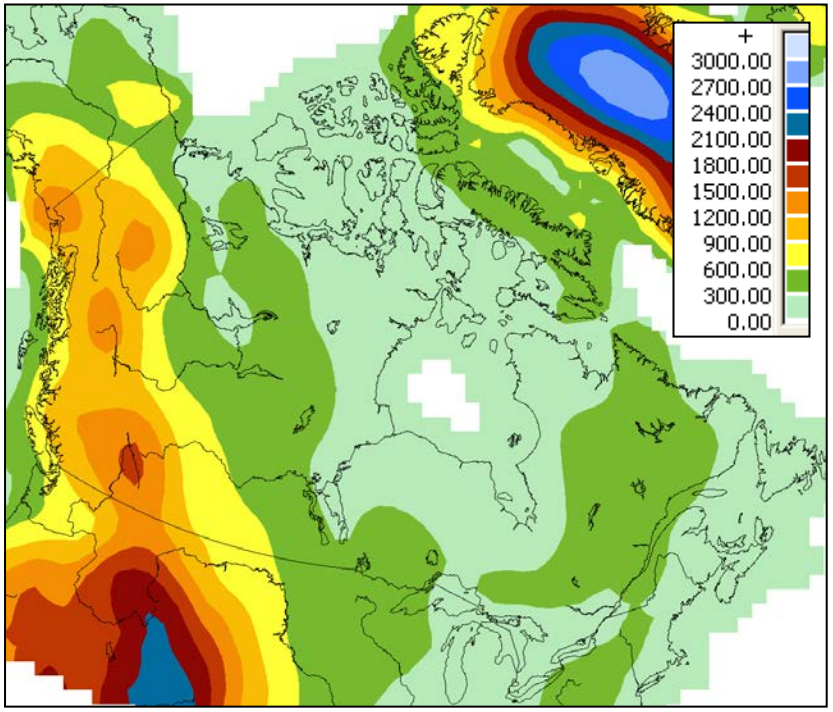
Plot generated by overlaying a 50 km PS grid on the station network and computing the distance from each gridpoint to the closest station

Illustration of the low-elevation bias in the daily snow depth observing network

Topography obtained from Climate Station Network



Topography obtained from ETOPO4



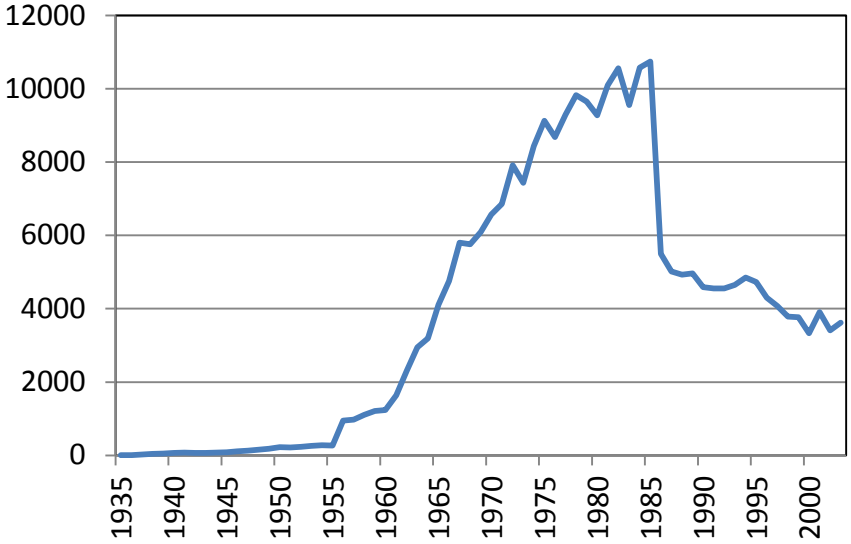
Interpolated surface elevation (m) obtained on a 100 km grid with 250 km search radius and Gaussian weighting.

Historical Snow Course Data

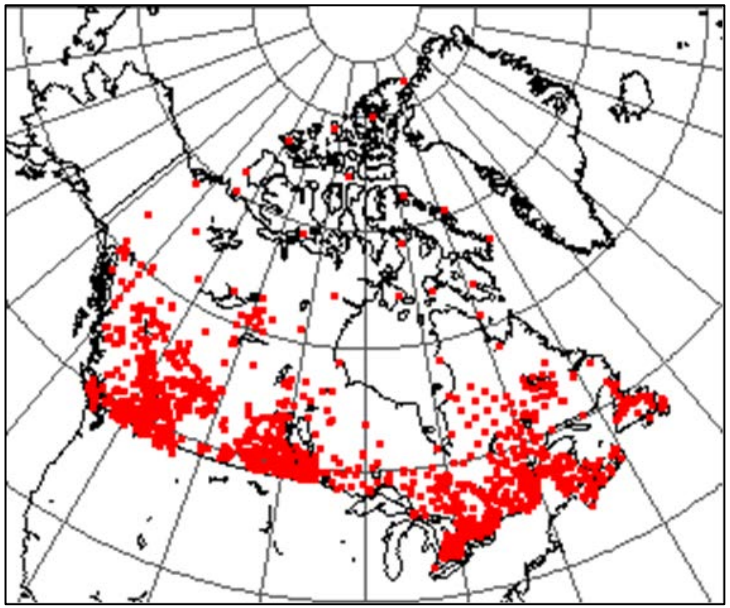
- **Manual snow surveys** (gravimetric method) made weekly or 2-weekly by provincial water resource agencies and hydro-electric companies**;** **snow pillows** reporting daily SWE used in mountain regions of BC and Alberta; measurements by water resource agencies concentrated in second half of water year to monitor **peak SWE**
- EC snow survey network relatively small and reduced in 2005 to about 10 Arctic stations; data reported in real-time on CSCN10 messages and archived in Climate Processes section of ASTD in support of research
- EC coordinated national compilations of snow course data from 1955 to 1985 (hard cover); digitized in 1995 to create a national dataset for support of climate research and applications (updated to 2003); dataset available through ***Polar Data Catalogue***
- Current number of active snow courses/pillow sites in Canada estimated to be ~2000; data from Quebec (Hydro-Quebec and partners) are not publicly available but are available to the research community upon request (e.g. SnowPEX).
- Historical dataset biased to river basins in southern Canada; network also exhibits low elevation bias; **no formal plan to update or maintain a Canadian national snow survey archive**

Canadian historical snow course dataset - updated to 2003

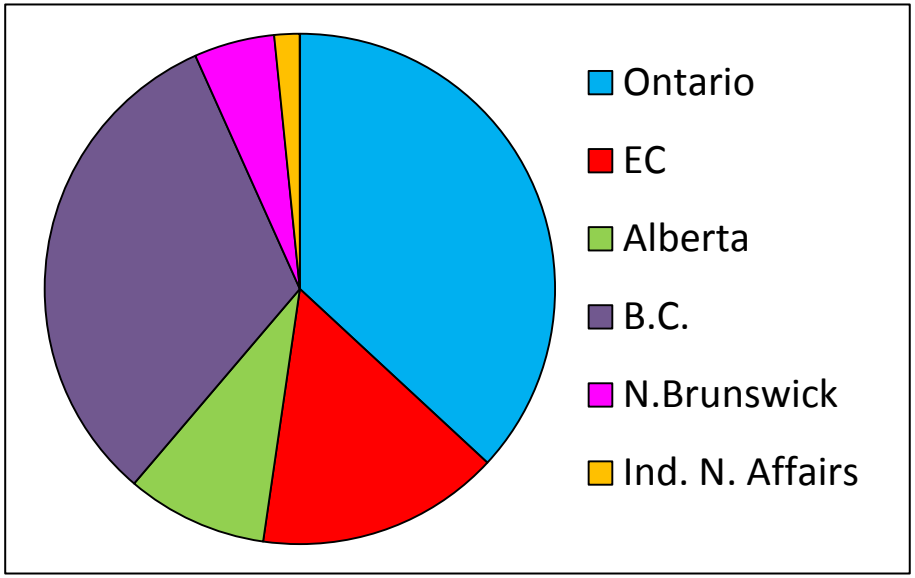
Annual number of snow course SWE observations in dataset (1935-2003)



Spatial distribution of snow courses with at least 10 years of data



Snow course source 1990-2003



- Most snow course data collected by provincial water resource authorities
- EC essentially stopped the national snow survey program ~2005
- No formal effort to maintain a national archive following the development of the historical dataset covering 1935-2003 period
- 10 Arctic sites retained as a contribution to SAON

Thank you for your attention!
Questions?

Part 2: Access to EC historical snow data

Data policy:

- All EC data subject to the “Open Government License” http://data.gc.ca/eng/open-government-licence-canada

Worldwide, royalty-free, perpetual, non-exclusive licence to use the Information, including for commercial purposes with only a few conditions… information licensed “as is” with no warranties

- EC adheres to WMO Data policy http://www.wmo.int/pages/about/exchangingdata_en.html

“…free and unrestricted exchange of data and information, products and services in real- or near-real time on matters relating to safety and security of society, economic welfare and the protection of the environment”

Public Data Access

- Current public access to EC historical climate data is fairly rudimentary – single station query through web interface at http://climate.weather.gc.ca/
- Data delivered as EXCEL sheet
- EC planning enhanced data access and analysis through Web Services
- Discovery metadata developed for the climate archive to support data discovery through the WMO Information System (WIS)
- Pilot project for WMO WOUDC (World Ozone and Ultraviolet Radiation Data Center) an example of current thinking http://beta.woudc.org/home.php

Issues/suggestions for contributing to a global historical snow database….

- Snow depth data in the EC archive are WIS compliant… **however**
- EC historical snow data (depth/SWE) are not consolidated in one place, and data have not been consistently QC'd over time (missing zeroes, data gaps, duplicate data, unit issues with some autostation data etc)
- Limited manpower for data QC means that EC is unlikely to have a unified historical snow depth and SWE archive available for online discovery and data delivery in the near-future. However, ***most of the historical snow depth data up to ~2005 are contained in the DLY04 archive***
- **Recommendation**: EC historical snow data be contributed to a ***global historical reanalysis project*** as proposed by Eric Brun (Meteo-France). The analysis process would provide the zero filling and missing data as well as feedback on data failing internal consistency checks. A gridded global daily snow depth and SWE dataset (e.g. @ 10 km) covering the period from say 1950 would also serve the user community more effectively than an archive of station data. Additional grid layers can be provided on the number of stations included in each gridcell and the estimated uncertainty. Analysing SWE and depth conjointly would provide consistent gridded data for both variables. ***A gridded historical dataset is also a strong "carrot" for countries to contribute data.***

Some questions for discussion

- Are we looking at in situ SWE as well as depth? Manual snow surveys are made every ~10-15 days and may not cover the entire snow season. Snow pillow SWE data from SNOTEL network and B.C./Alberta available daily. Snow survey data require more extensive metadata to describe vegetation and terrain. Snow survey data collected by Hydro-companies is often considered proprietary. Snow surveys in vegetated areas can be influenced by growing vegetation.
- How do we handle different data formats and QC flags? Is there a standard WMO format for daily climate data?
- Will need to develop flags for different observation methods e.g. ruler, Ultrasonic (SR50, USH-8, Judd, CIMEL, SR50 triple config …), Scanning Laser, Lidar, GPS, Russian fixed stake, snow survey point, snow survey average of xx points, others…
- Will all data in the global archive be freely available for downloading? How do we encourage data collection agencies who charge for data to contribute to this enterprise?
- Can we build on existing data infrastructure? e.g. NSIDC, GCW-portal, NCDC GHCN-Daily, METEO-RU

Thank you for your attention!
Questions?