Adjusted station precipitation

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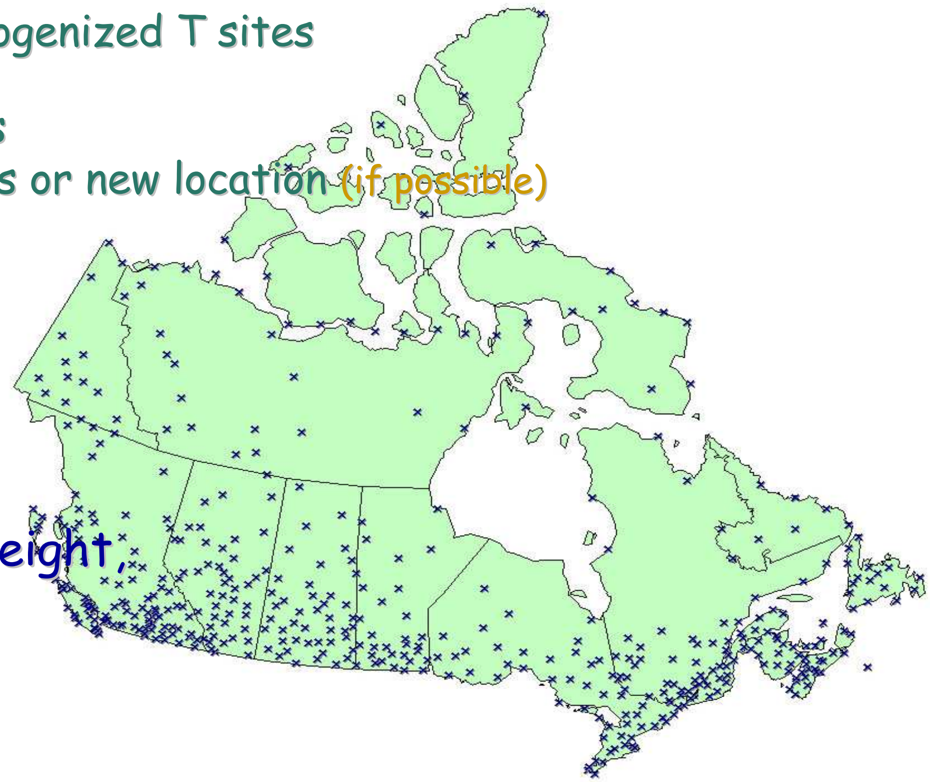
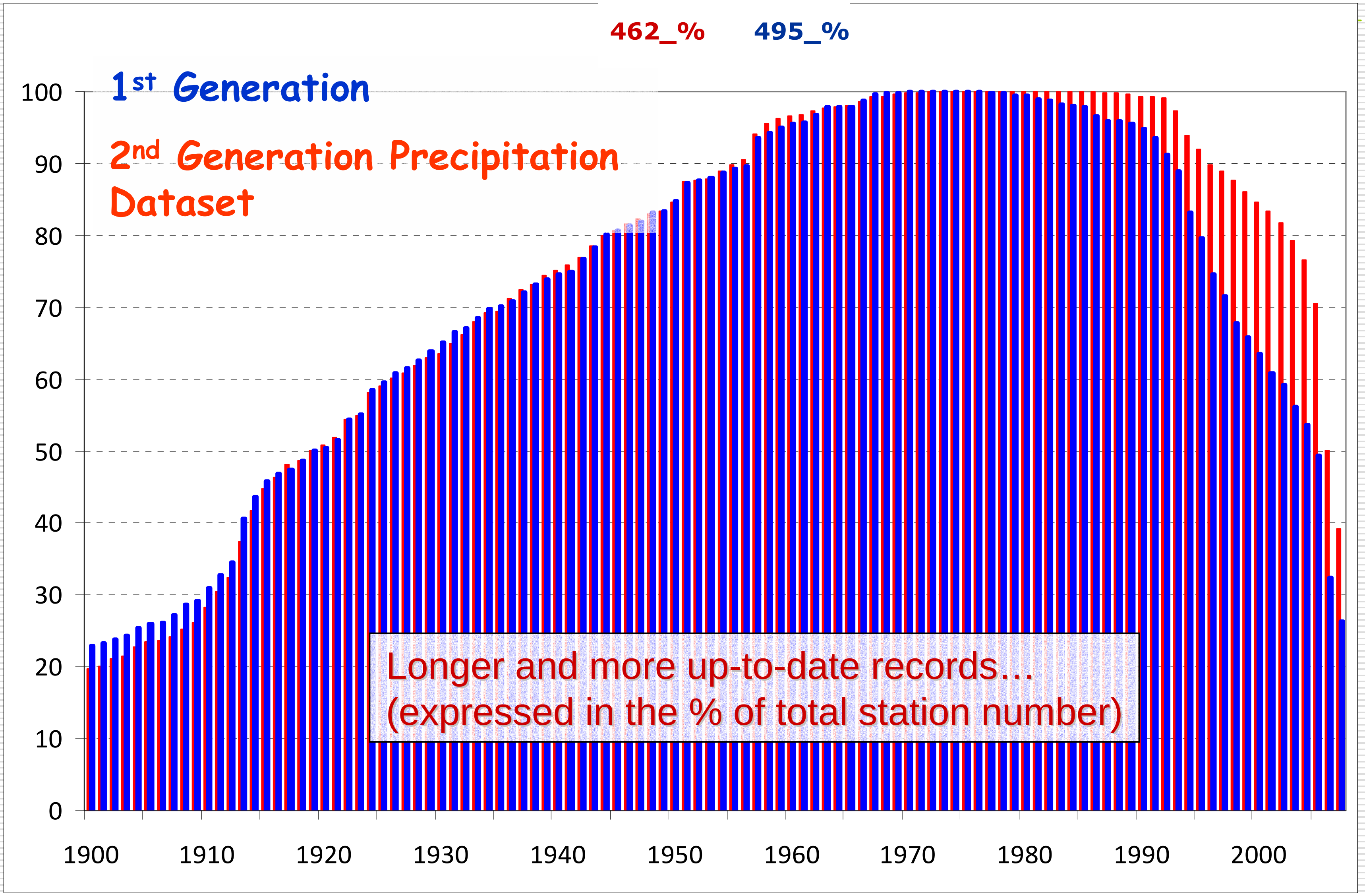
2nd Generation Precipitation Dataset

- Adjusting for **all known** issues / problems
- Daily time-step
- Rain and snow adjusted separately
- Revised station selection
  - including GSN, protected RCS, homogenized T sites
    only if long enough…
  - input from Regional Climate Experts
  - missing last 10 years – new segments or new location (if possible)
  - more unified station density
    maximize the length, minimize missing
- 462 locations across Canada
- no auto stations as of yet included



METADATA requirement:
gauge installation dates, anemometer height, type of measurement programs, etc.

Adjusted Historical Canadian Climate Data availability for climate research purposes



Background Rain Snow Trace Joining Examples

Major Steps

Adjusted rain for known instrument changes

- wetting and wind related losses, evaporation

Adjusted snow water equivalent

- not 10:1 but computed and mapped for Canada

Adjusted trace events

- constant for rain trace
- gradually decreasing snow trace correction toward North

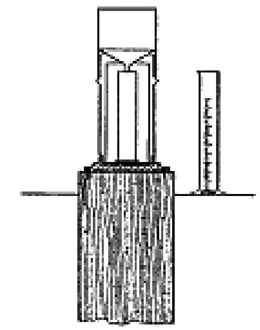
Station joining

- find connected segments
- Standardized Ratio homogeneity test of joined segments using neighbours and/or overlapping period

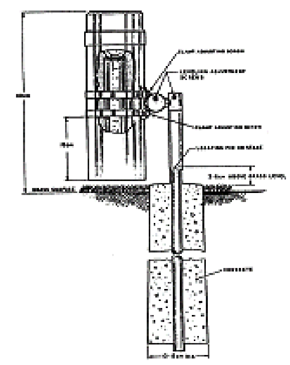
Rain gauge adjustments

$R_a = (R_m + F_c + E_c + C_c) \times (1 + W_c)$, where

- R_a = adjusted rainfall [mm]
- R_m = measured rainfall [mm]
- F_c = funnel wetting correction [mm / rain measurement period]
- E_c = evaporation in container/receiver [mm]
- C_c = container/receiver retention correction [mm / rain measurement period]
- W_c = wind correction factor [% / 100]



MSC Copper Rain Gauge



AES Type-B Rain Gauge

Type of correction	Unit	Notation	Add or Multiply	MSC, copper receiver	MSC, plastic receiver	Type B Gauge
1. Wind at Orifice level	% / 100	W_c	×	0.04	0.04	0.02
2. Wetting at Funnel area	mm	F_c	+	0.13	0.13	0.08
3. Evaporation	mm	E_c	+	0.02	0.03	0.01
4. Wetting of Receiver or Container	mm	C_c	+	0.06	0.03	0.04
Sum (2 + 3 + 4)	mm			0.21	0.19	0.13

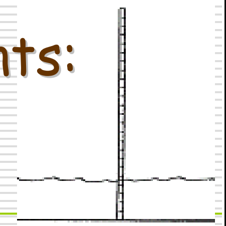
METADATA !

The actual adjustment depends on the operational rain gauge type used for measurement at any given date

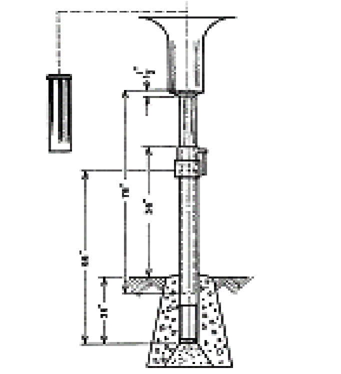
Devine, K.A. and É. Mekis, 2008. Field Accuracy of Canadian Rain Measurements. Atmosphere-Ocean 46 (2), 213-227.

Routledge, B. 1997: Corrections for Canadian Standard Raingauge, Atmospheric Environment Service Internal report, p.8.

Adjustments for Daily Snowfall Ruler Measurements: Snow Water Equivalent Adjustment Factor ρ_{SWE}



Snow Ruler



Canadian Nipher Shielded Snow Gauge System

Snow ruler measurements are used => longer and better coverage

Snow water equivalent: not 10:1 but computed and mapped for Canada

Map of mean snowfall density over Canada was created from 175 stations with more then 20 years of overlapping measurements of daily snowfall ruler depth and corrected Nipher gauge precipitation.

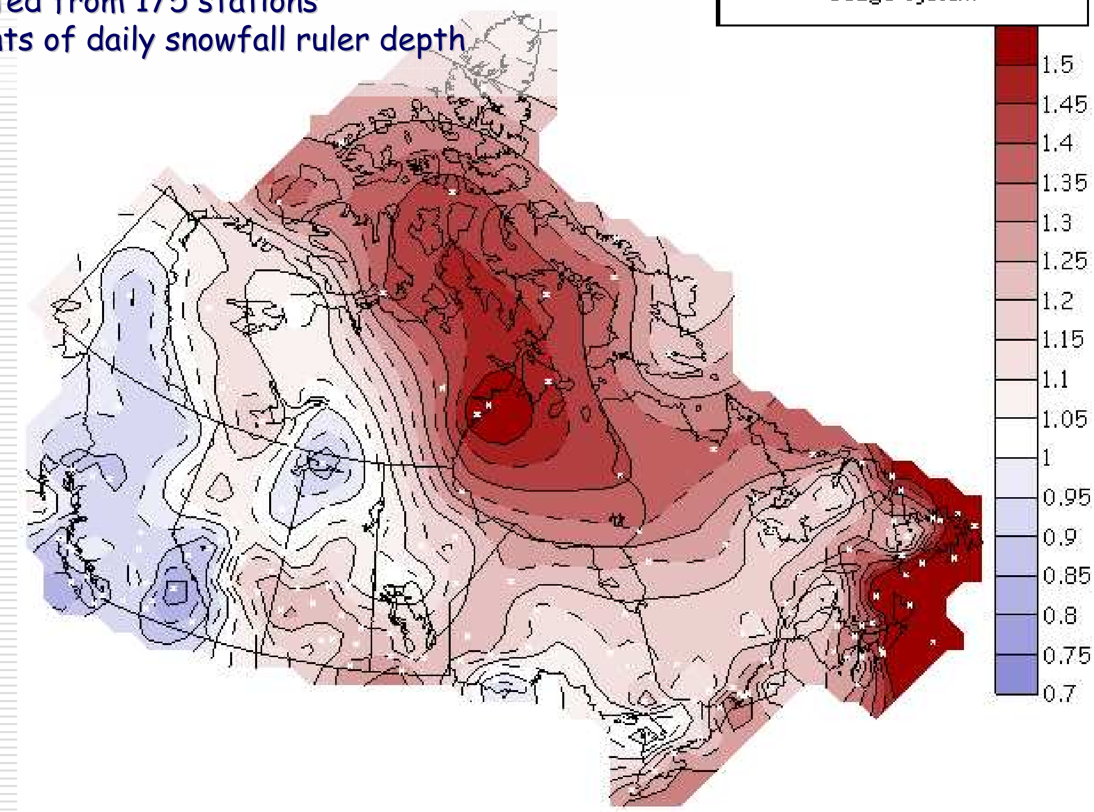
$\rho_{SWE} = N_{swe} / R_{swe}$

N_{swe}- solid part of the corrected Nipher gauge 6-hourly precipitation

R_{swe}- archived snowfall water equivalent, measured by snow ruler, assuming a fresh snowfall density of 100 kg m^{-3}

The updated fresh snowfall water equivalent adjustment factor map allows estimates of ρ_{SWE} to be obtained for all long-term climate stations in Canada, which is of particular importance in water balance and climate related studies.

ρ_{SWE} ranging from 1.5 over the Maritimes to less than 0.8 over southern-central BC.



Major problems with Trace Observation

Fact: The practice of recording trace (less then the smallest measurable amount) are NOT distributed evenly neither in time or space.

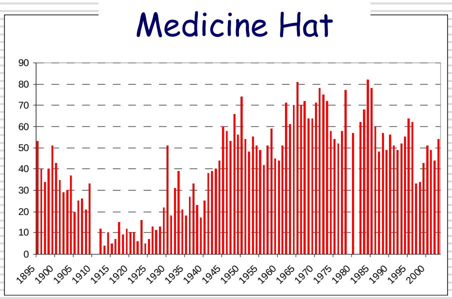
Important related factors are:

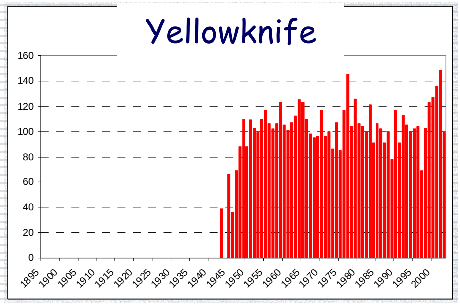
- Measurement program type
  - climate station: 1 or 2x daily observation
  - synoptic station: 2x or 4x daily observation
- Station joining (moving)
  - it comes often with new observer, new instrument, …
- Switch from Imperial to Metric system

  Minimum measurable amount is:

  0.3 [mm] for rain and 0.3 [cm] for snow before 1977-78 and

  0.2 [mm] for rain and 0.2 [cm] for snow after 1977-78.
- Evolution of Trace definition by time (MANOBS)
- Role of the observer – different training, learning curve





Trace adjustments applied in the Historical Canadian Climate Database

Rain trace correction: constant T_r = 0.07 mm per event

Snow trace correction: gradually decreasing towards North using solid trace classification (snow or ice crystal trace) in the range from 0.07 to 0.03 mm / event.

The purpose is to reduce the trace correction in proportion to the ice crystal event's frequency

Depending on the measurement program type, single archived daily trace flag could include as many as 4 trace observations

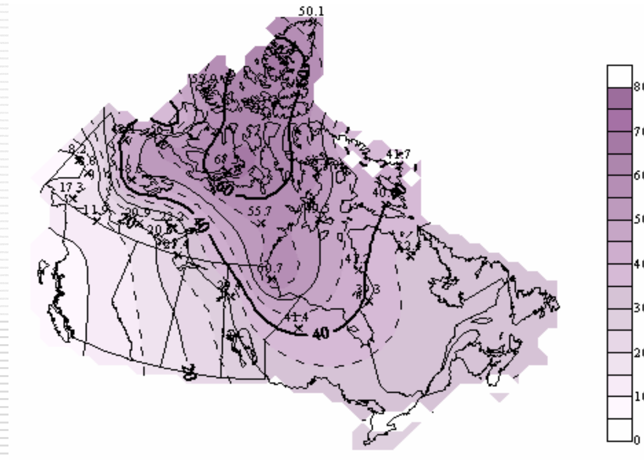
Introducing Trace Occurrence Ratio (T_{or})

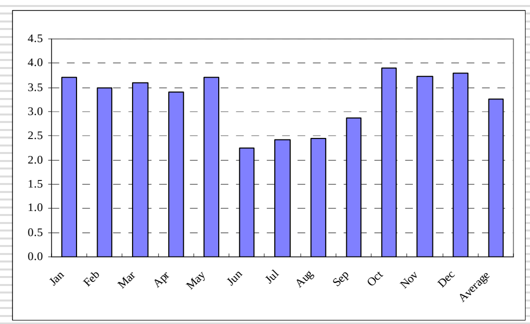
Example: Resolute

Comparison of 6 hourly and daily trace counts T_{or} = 3.28

$$\text{Trace Occurrence Ratio } (T_{or}) = \frac{\text{\# of "T" flags in 6 hourly archive}}{\text{\# of "T" flags in daily (rain and snow) archive}}$$

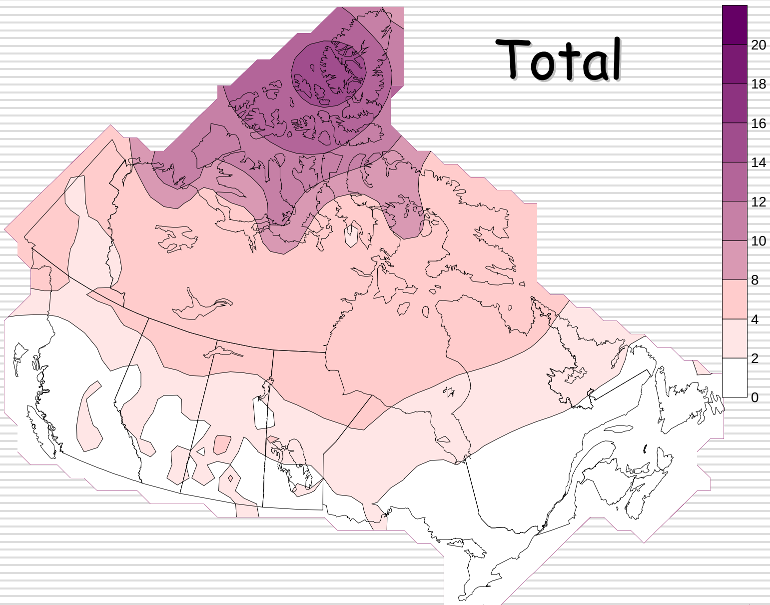
Map of Ice Crystal Ratio for Canada [%]

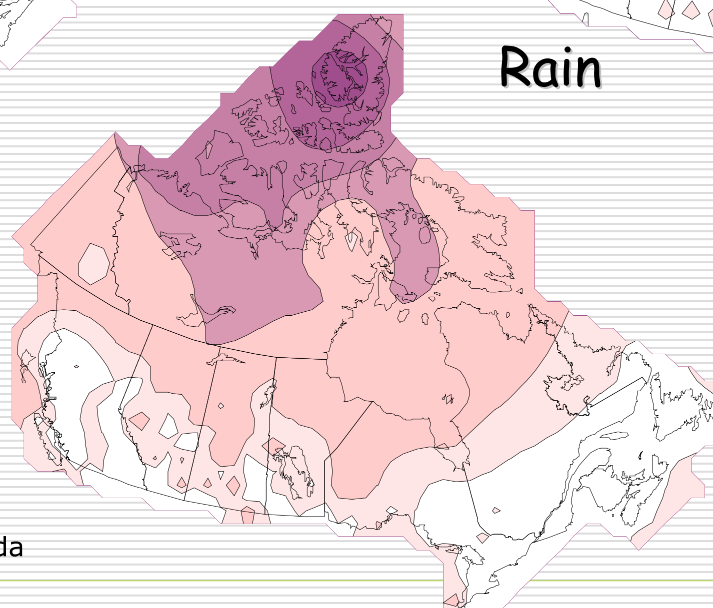


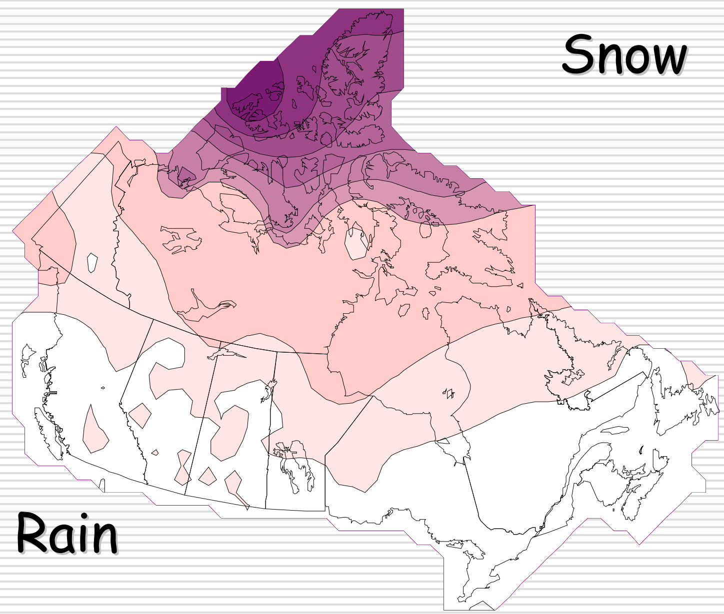


$$T_{r\text{ or }s,\text{ adjusted}} = T * T_{OR}$$

Increase of Annual Total / Rain / Snow by Trace Corrections [%] Period: 1951 - 2000





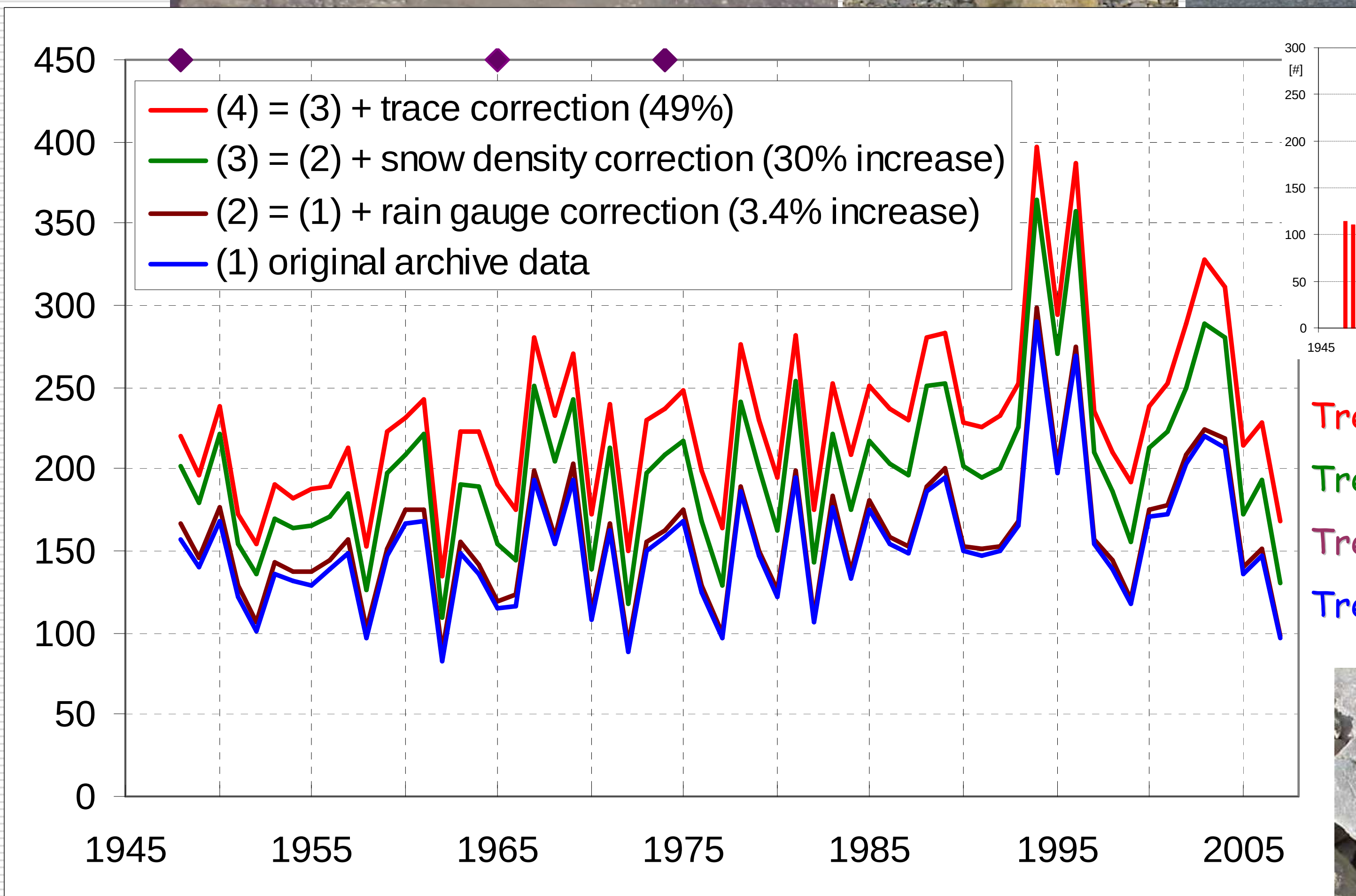


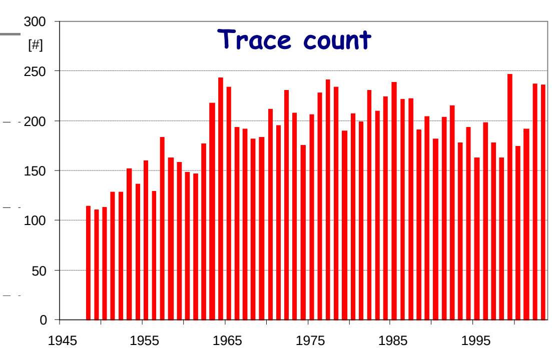
Normalized:

Divided by the 1961 -1990 value and multiplied by 100 ➔ Relative weight of trace correction is more obvious

Trace correction does increase the annual total precipitation by up to 20%. It has the biggest effect on the North.

Source: Éva Mekis, CRD, Environment Canada



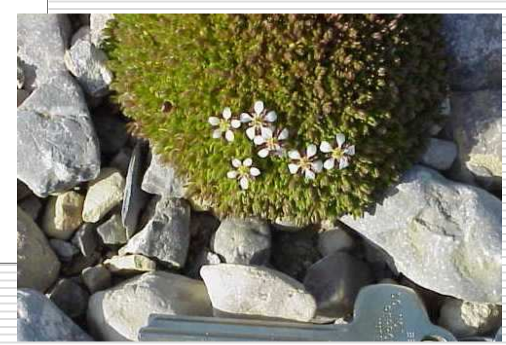


Trend (4) = 13.61 mm/decade

Trend (3) = 11.41 mm/decade

Trend (2) = 7.70 mm/decade

Trend (1) = 8.25 mm/decade



Joining connected segments
(work completed with Lucie Vincent)

- Precipitation observations are often archived under different station numbers => joining is necessary (234 out of 462 is joined)
- Merged station observations are tested for a step at the joining date
- Rain and snow observations separately (monthly and annual)
- Standardized ratio test using neighbours:

  $z_i = (q_i - Q) / s_q$ where $q_i = T_i / N_i$ is the ratio;

  T_i - monthly total rain (or snow) at the tested site for year i
  N_i - monthly total rain (or snow) at the neighbour for year i
  Q - average of q_i
  s_q - standard deviation
- Adjustments:

  $A_i = q_{ai} / q_{bi}$, where q_{bi} & q_{ai} are ratio means before & after joining date
- Validation: Overlapping observations available at both locations (min 10 yr)
- Results for rain: 79 stations needed adjustment
- Results for snow: 137 stations needed adjustment
- Considerations: Monthly versus annual correction factor to be used

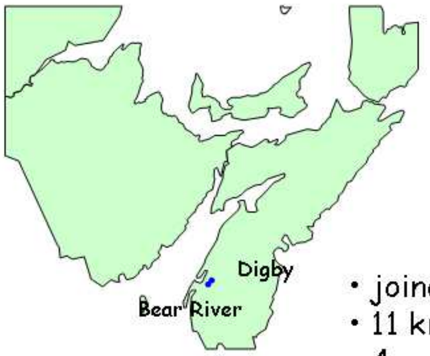
  Adjusting long period to the recent few years – not suggested

Example: Joining Digby Airport and Bear River, NS

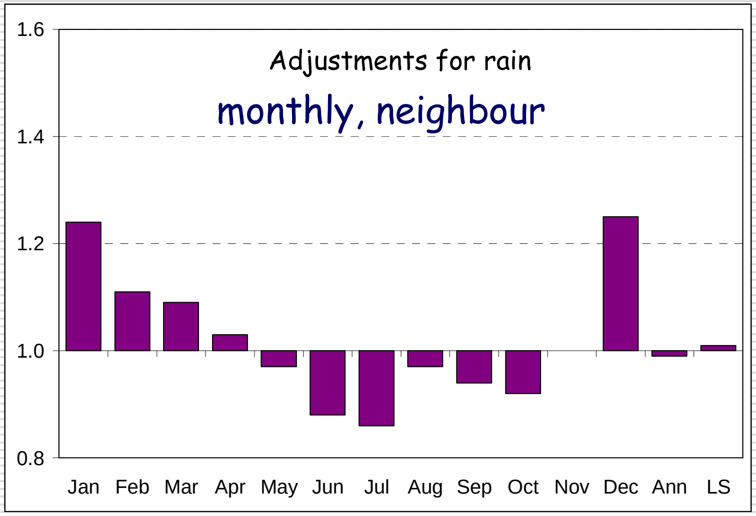
8 neighbours: distance, elevation dif. and correlation computed

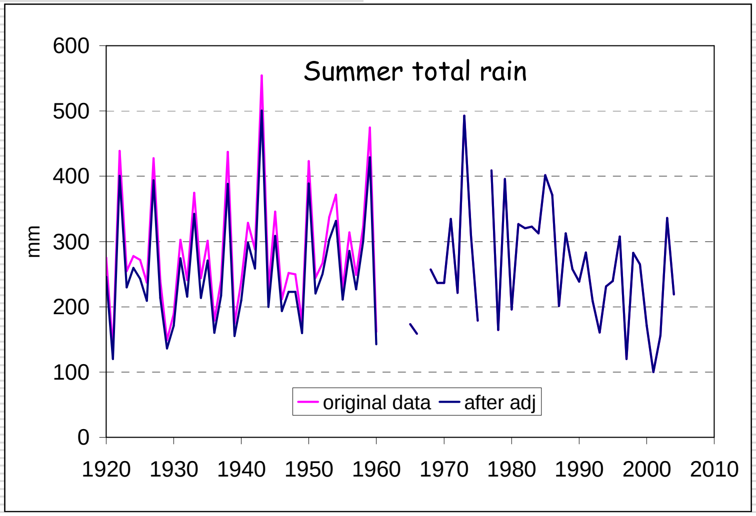
Adjustment factors – if significant, then decision to be made:

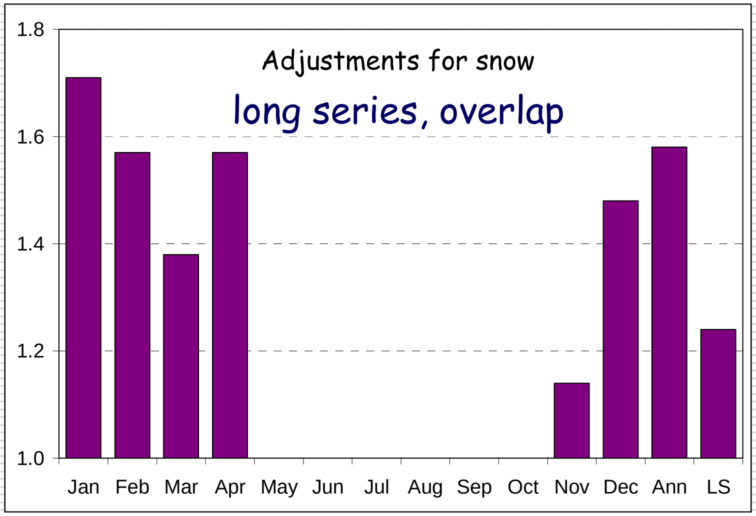
- -monthly, annual or LS adjustment applied
- -using neighbours or overlap series

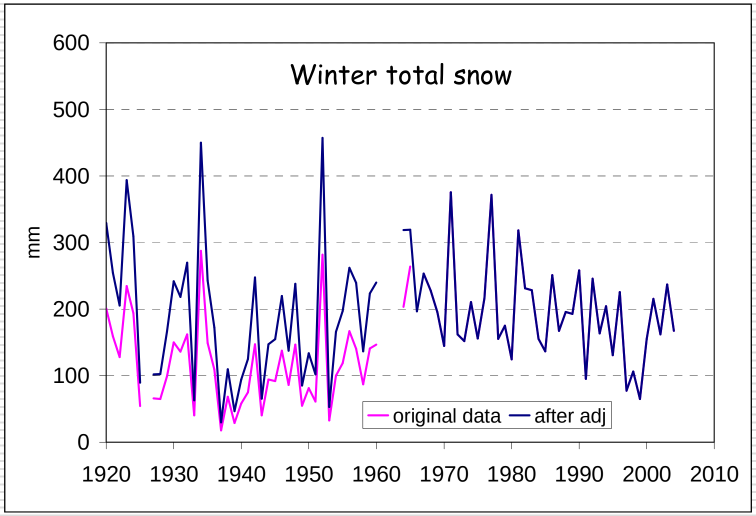


- joined in 1965
- 11 km apart
- 4 m elevation difference

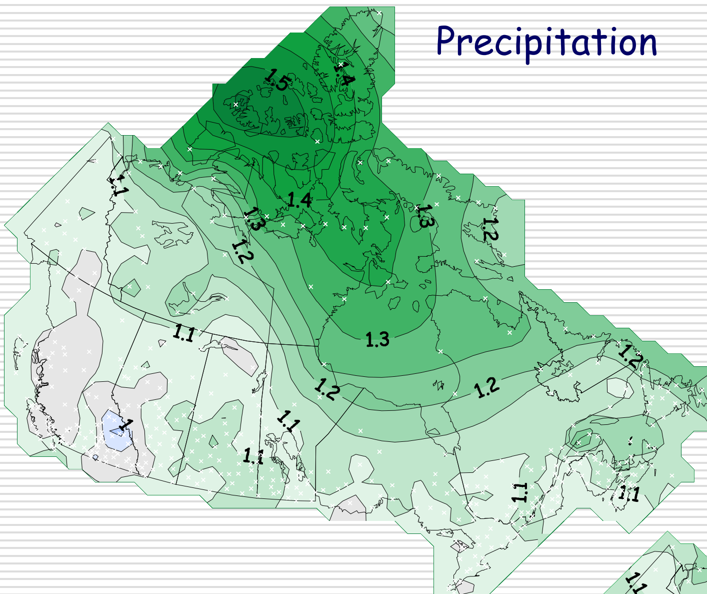


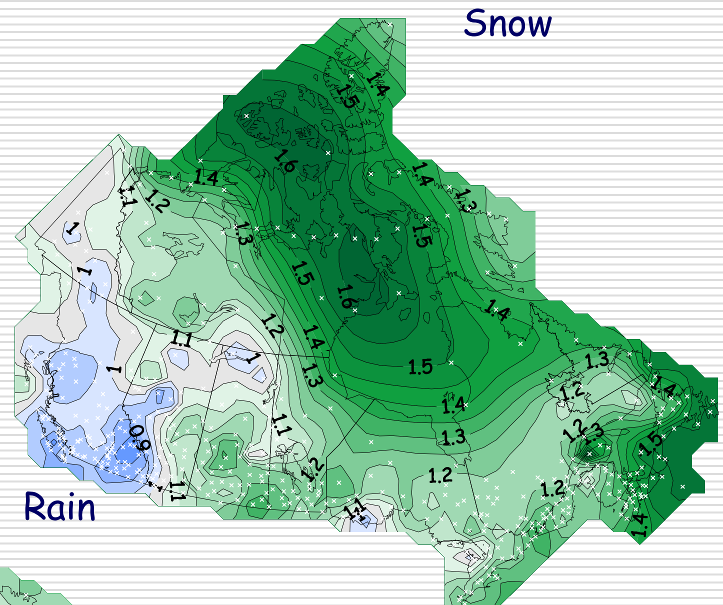


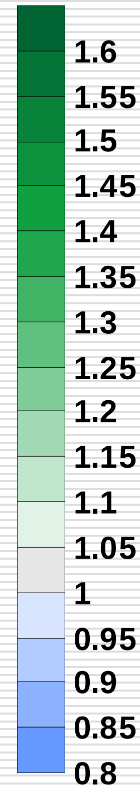


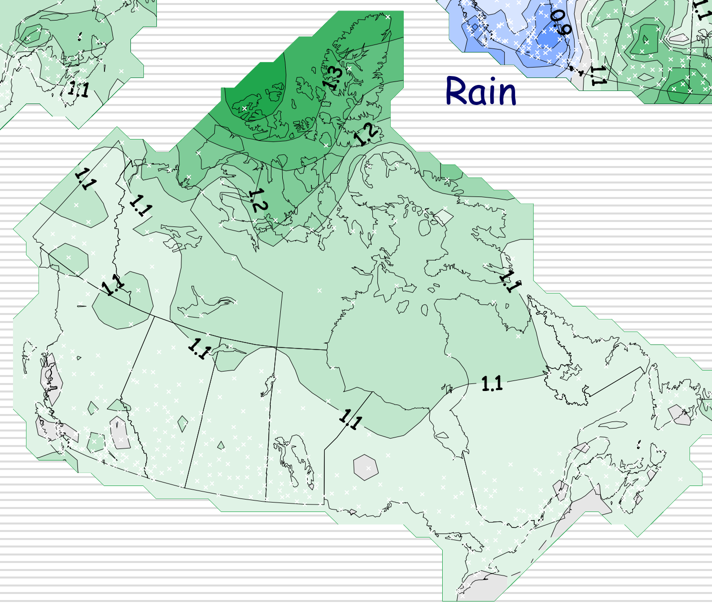


Magnitude of Correction for Precipitation









Ratio = Corrected /
Not corrected
1950 – 2008 period

Adjusted Precipitation Dataset is used in….

- Gridded datasets, like CANGRID
- 2nd version of CTVB
- Climate change indicators
- Research community:

AHCCD web site http://www.cccma.bc.ec.gc.ca/hccd/

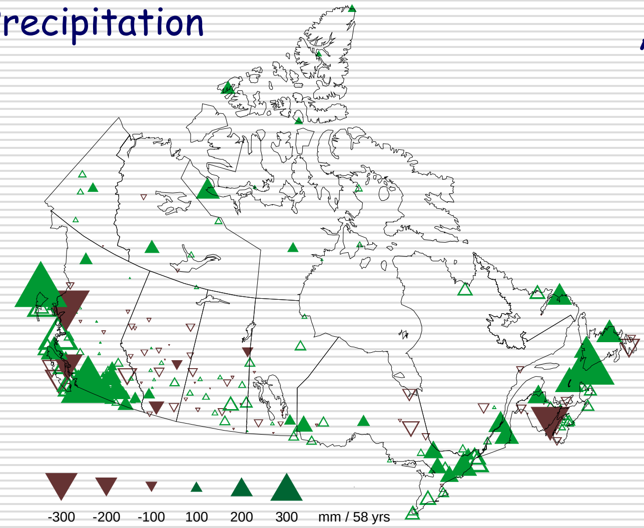
Indicator studies

Index	Description	Resolution
Total/Rain/Snowfall Precipitation	Annual/Seasonal accumulated sum of daily events	Ann/ Seas
Percent of long term average T/R/S	Annual sum divided by the mean of 1900-2007 period	Annual
Snow & Rain to Total Precip ratios	Annual accumulated snow and rain to total precip ratio	Annual
Number of days with T/R/S	Number of days with T/R/S precipitation > Trace events (Tr)	Annual
Simple day intensity index for T/R/S	Annual total T/R/S precipitation divided by the # of days with P > Tr	Annual
Maximum no of Consecutive Dry / Wet Days	Maximum Number of Consecutive Dry (Wet) Days (Trace excluded)	Annual
Highest 1, 3, 5 and 10 -day T/R/S - Not Normalized	Highest 1-day Total/Rainfall/Snowfall precipitation	Annual
Highest 1, 3, 5 and 10-day T/R/S - Normalized	Highest 1-day T/R/S divided by the annual T/R/S value	Annual
T/R/S days with ≥ 50th percentile	Number of days with total precipitation ≥ 50th percentile (median)	Annual
T/R/S days with ≥ 75th percentile	Number of days with total precipitation ≥ 75th percentile	Annual
T/R/S days with ≥ 90th percentile	Number of days with total precipitation ≥ 90th percentile	Annual
T/R/S days with ≥ 95th percentile	Number of days with total precipitation ≥ 95th percentile	Annual
T/R/S days with ≥ 99th percentile	Number of days with total precipitation ≥ 99th percentile	Annual
Days with > 10 mm total precipitation	Number of days with total precipitation ≥ 10 mm	Annual
Days with > 20 mm total precipitation	Number of days with total precipitation ≥ 20 mm	Annual
Days with > 50 mm total precipitation	Number of days with total precipitation ≥ 50 mm	Annual
Standardized Precipitation Index	1,2,3,6,9,12 and 24 month SPI	Monthly

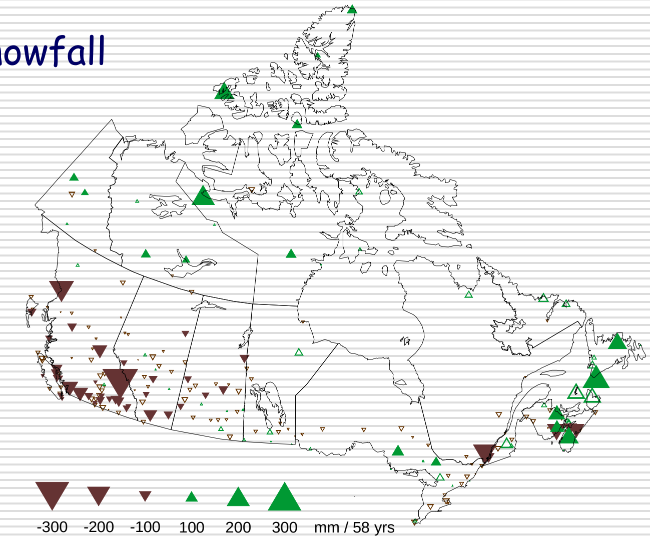
Trends are calculated for ~ 80 indices for the 1900-2007 and 1950-2007 periods respectively

Trends over 1950 - 2007

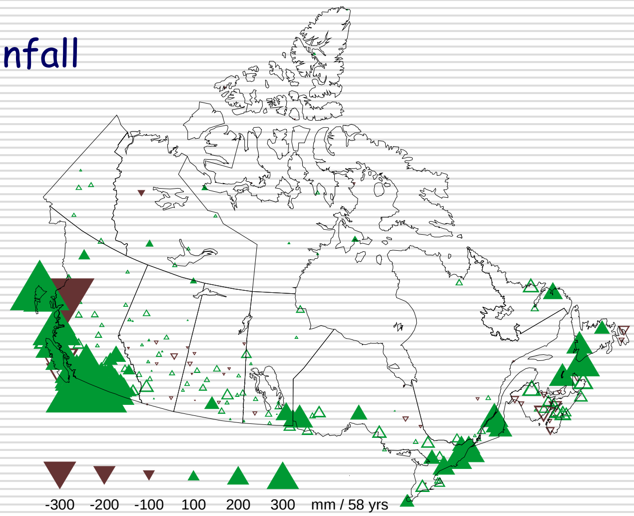
Annual Total Precipitation



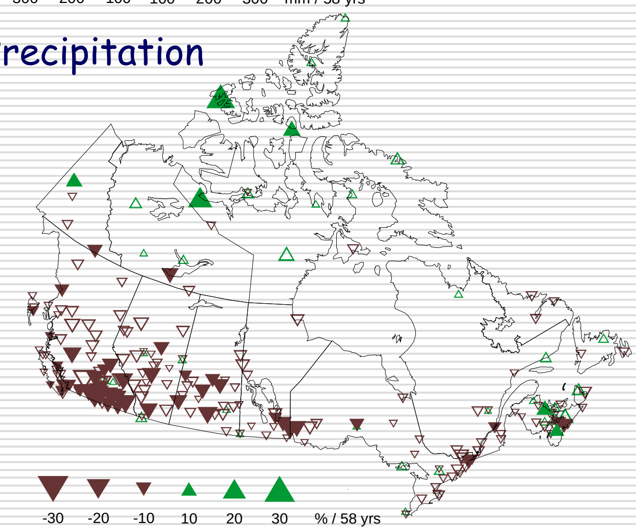
Annual Total Snowfall



Annual Total Rainfall

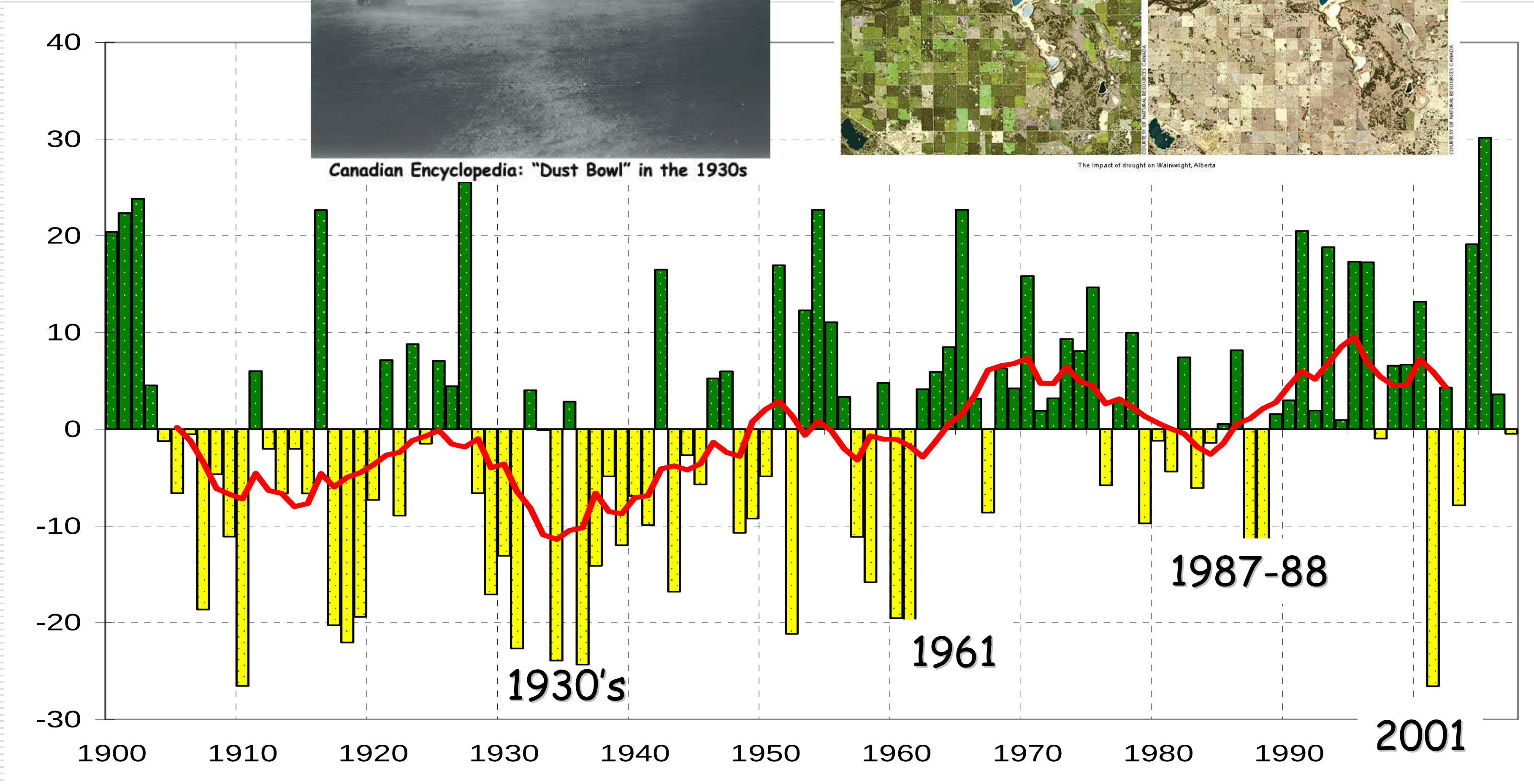


Snow to Total Precipitation

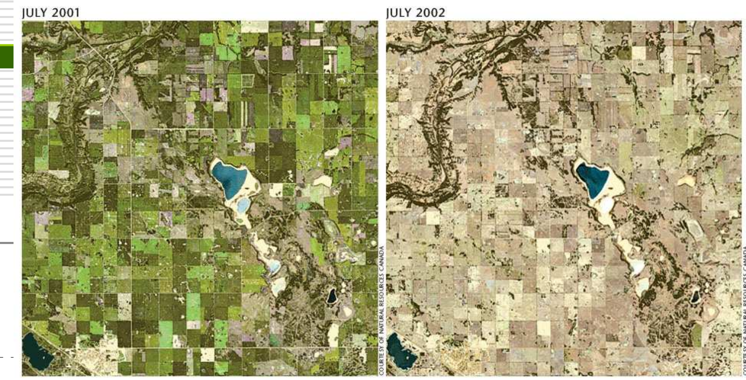


Background Rain Snow Trace Joining **Examples**

Percent of average precipitation for the Prairies calculated over the 1900-2007 base period



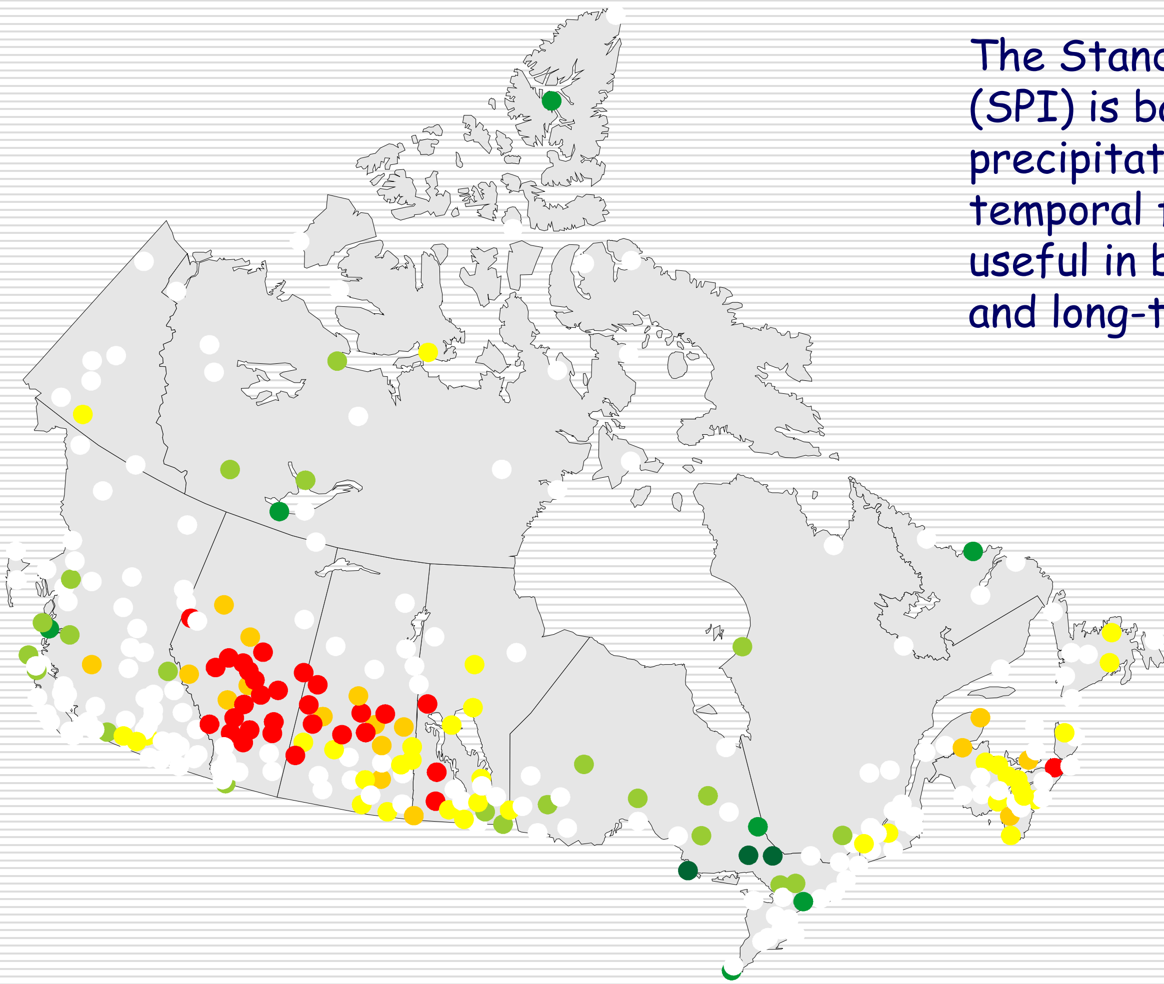
Canadian Encyclopedia: "Dust Bowl" in the 1930s



The impact of drought on Wainwright, Alberta

Background Rain Snow Trace Joining **Examples**

12-month SPI for all adjusted stations through the end of July, 2002



The Standardized Precipitation Index (SPI) is based on the probability of precipitation for any time scale. This temporal flexibility allows the SPI to be useful in both short-term agricultural and long-term hydrological applications.

SPI Values		
red	2.0+	extremely dry
orange	1.5 to 1.99	very dry
yellow	1.0 to 1.49	moderately dry
white	-0.99 to 0.99	near normal
light green	-1.0 to -1.49	moderately wet
green	-1.5 to -1.99	severely wet
dark green	-2 and less	extremely wet

Future

Status in 2008: **dly04** – fewer quality controlled T&P goes to the archive (mainly airport sites)

dly44 – regular climate stations (COOP or volunteer T&P) go here started as of 2007

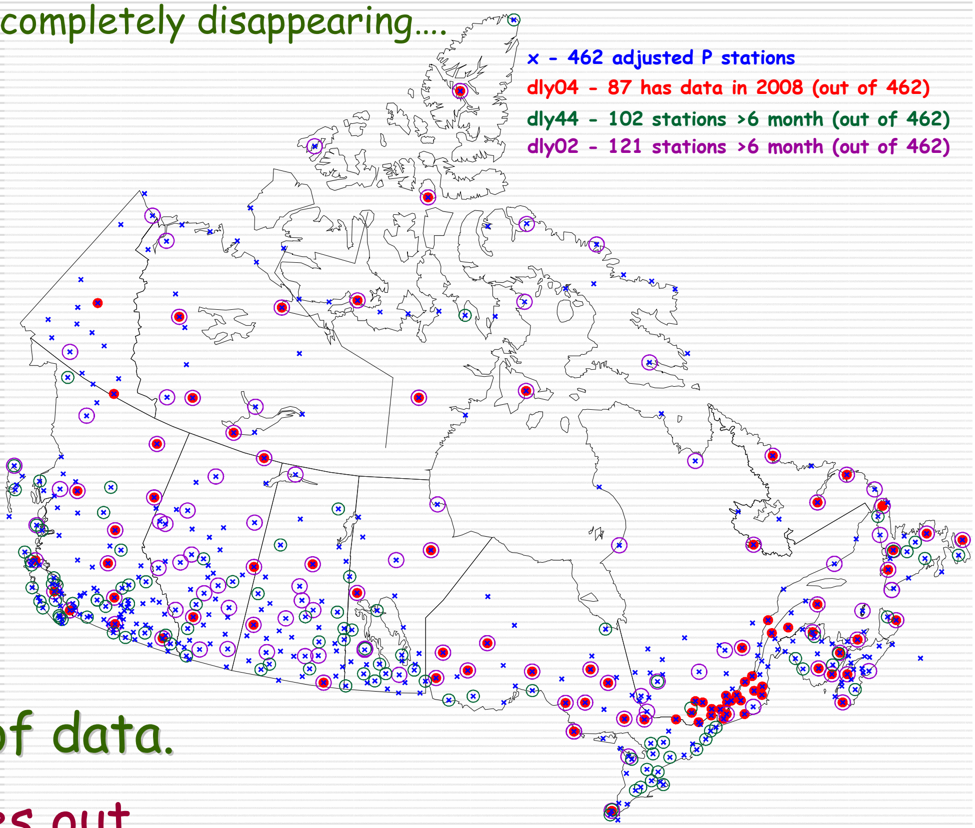
dly02 – daily T&P without QC

As the result of the combined effect of developing "paperless" network and loosing regional experts, less quality control available and some stations are completely disappearing….

Further data are keypunched, but not all

The new stations are not long enough for climate change studies

Where are the missing data?
Perhaps in a box somewhere….



All of our results depend on the density of stations and the quality of data.

What goes in determines what comes out..


THANK YOU