UPEI
UNIVERSITY
of Prince Edward
ISLAND

Climate Observations and Data Analysis

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Climate Observations and Data Analysis

1. Acquiring Climate Observational Data

2. Quality Controlling Climate Data

3. Analyzing Climate Data

Glossary

- Tmax = maximum temperature
- Tmin = minimum temperature
- Tmean = mean temperature
- Ptotal = Total Precipitation

- DJF = Winter
- MAM = Spring
- JJA = Summer
- SON = Autumn

1. Acquiring Climate Observational Data

1. Canada's National Climate Data and Information (NCDI) Archive
2. US National Climatic Data Center (NCDC)
3. NCEP Reanalysis
4. homogenized data sets
5. selecting a climate station
6. downloading data

Acquiring Climate Observational Data

- Connections
- $

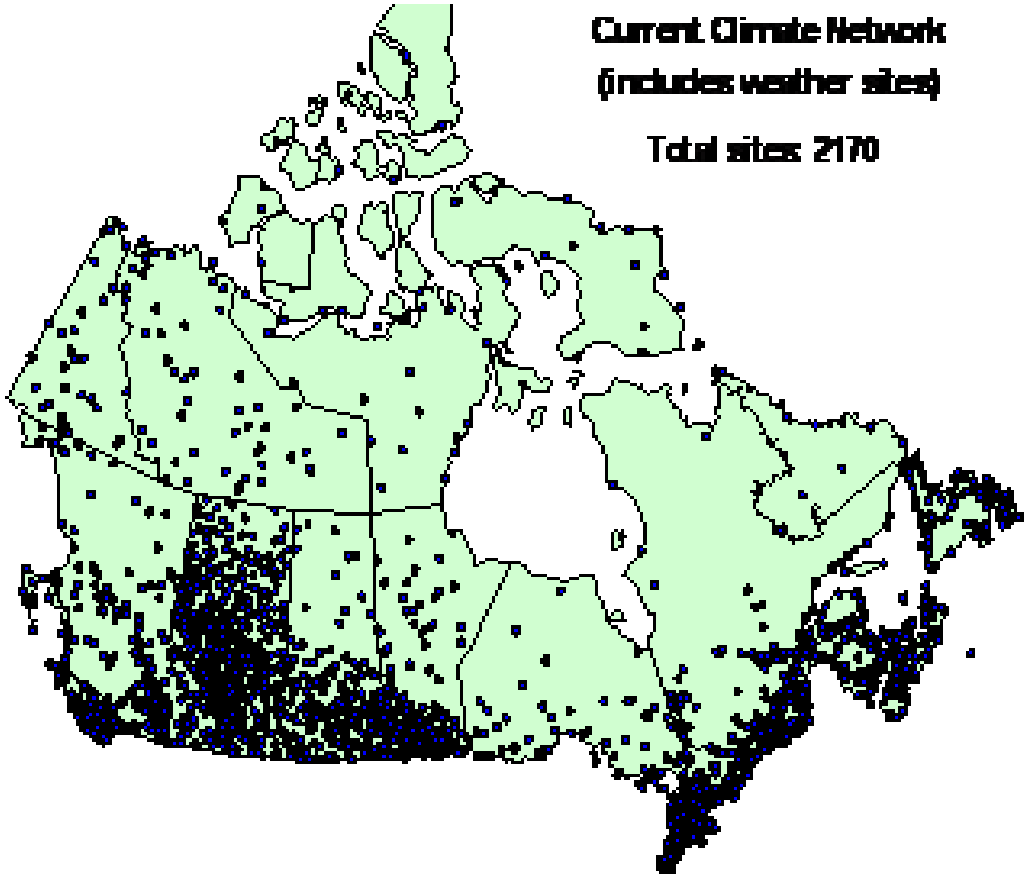
1. Canada's National Climate Data and Information (NCDI) Archive

www.climate.weatheroffice.ec.gc.ca/climateData/canada_e.html

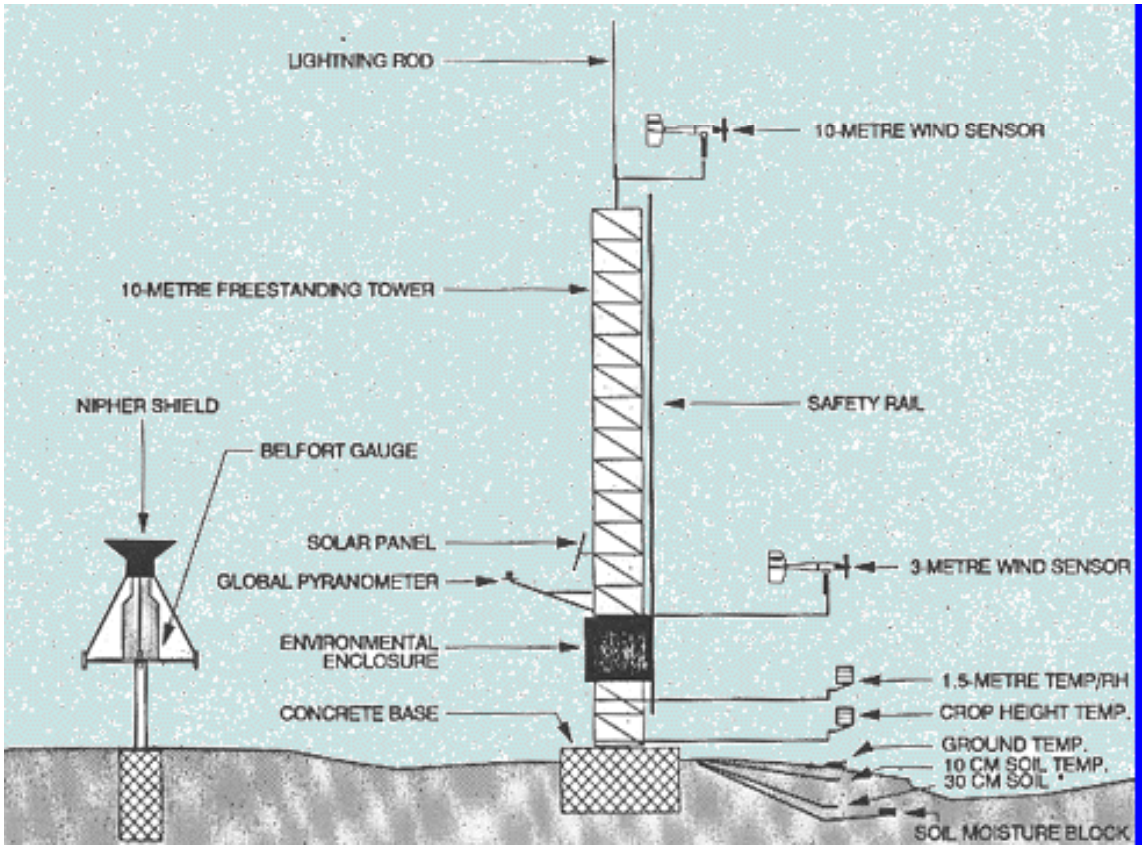
Climate Data available at NCDI

Hourly	Daily	Monthly	Almanac
Temperature	Maximum Temperature	Mean Maximum Temperature	Average Maximum Temperature
Dew Point Temperature	Minimum Temperature	Mean Temperature	Frequency of Precipitation
Relative Humidity	Mean Temperature	Mean Minimum Temperature	Frequency of Precipitation
Wind Direction	Heating Degree Days	Extreme Maximum Temperature	Highest Temperature
Wind Speed	Cooling Degree Days	Extreme Minimum Temperature	Lowest Temperature
Visibility	Total Rainfall	Total Rainfall	Greatest Precipitation
Station Pressure	Total Snowfall	Total Snowfall	Greatest Rainfall
Humidex	Total Precipitation	Total Precipitation	Greatest Snowfall
Wind Chill	Snow on Ground	Snow on Ground on Last Day	Most Snow on Ground
Weather	Direction of Maximum Gust	Direction of Maximum Gust	
	Speed of Maximum Gust	Speed of Maximum Gust	

Climate Stations Reporting (as of March 2008)



Automated Weather Stations



Volunteer Observers

Roy Westland - Devon, Alberta since 1915

Yukon farmer Hugh Bradley receiving 50 years certificate

Canada's National Climate Data and Information (NCDI) Archive

What is available?

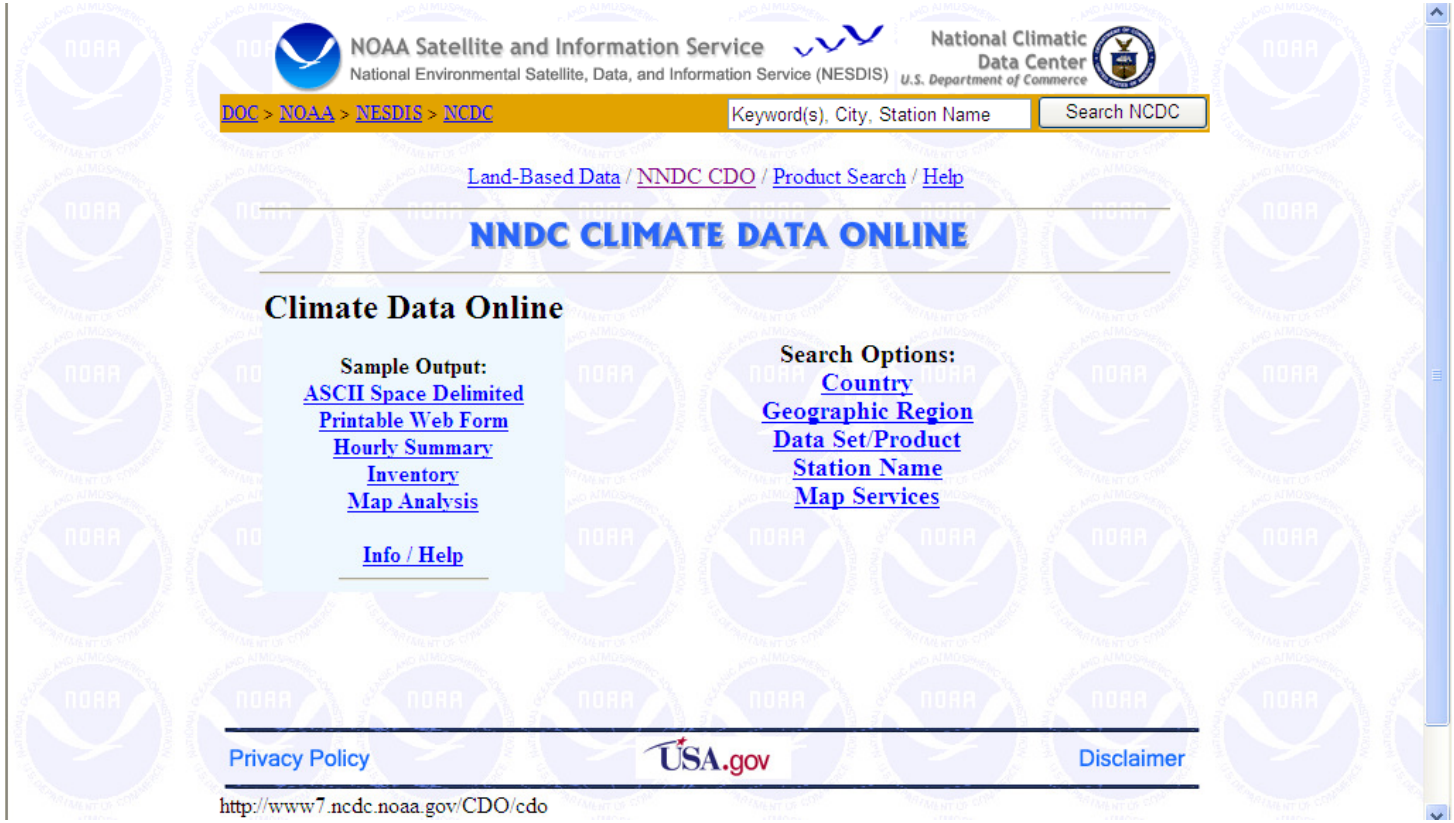
- more than 7 billion observations
- collected across Canada
- over the past 150 years

What is needed?

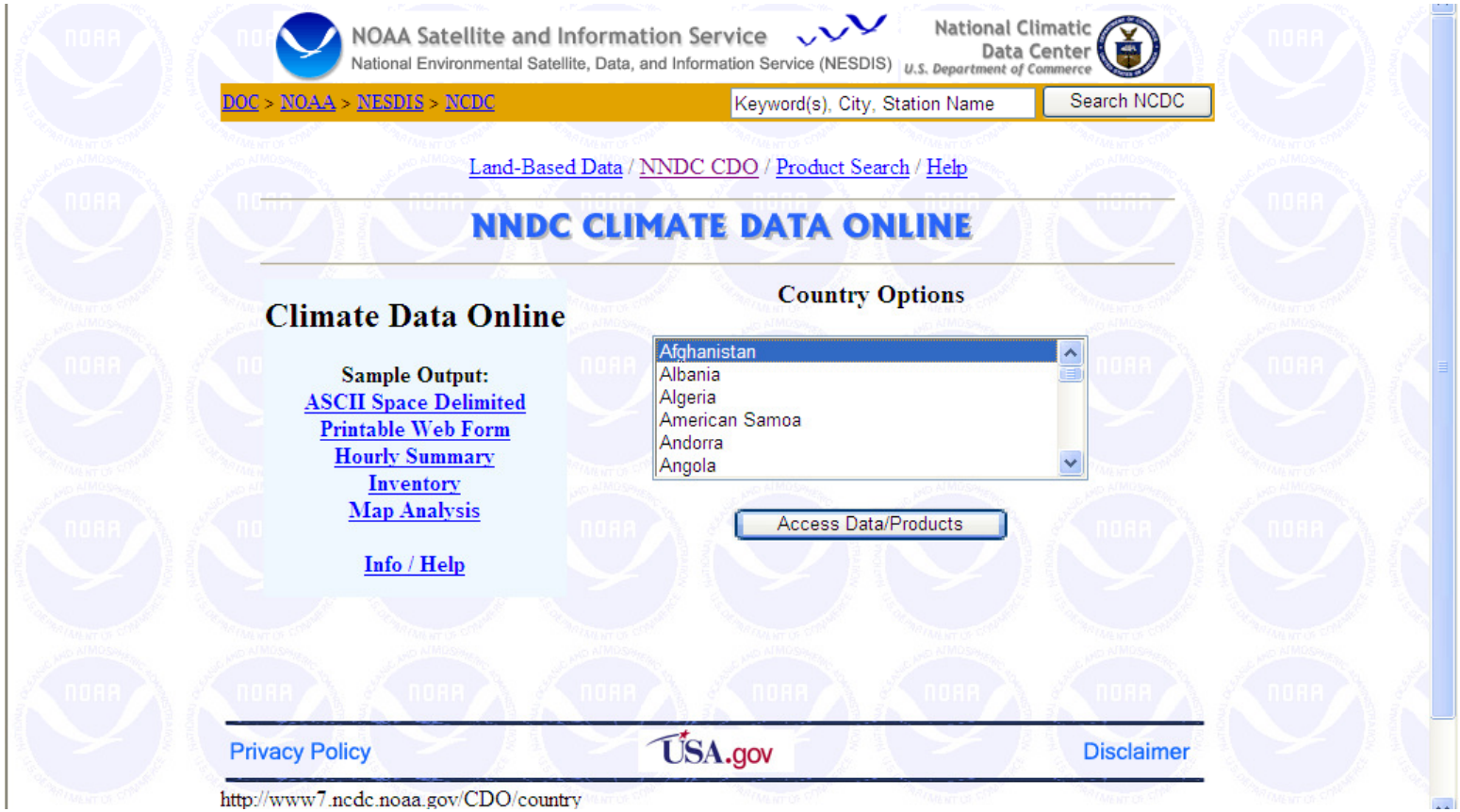
- observations of Tmax and Tmin as well as Ptotal should be available on a daily basis, with a record length of at least thirty years of data

2. US National Climatic Data Center

http://www7.ncdc.noaa.gov/CDO/cdo



Climate data available from about 200 countries



Climate Data available at NCDC

- Mean temperature (.1 Fahrenheit)
- Mean dew point (.1 Fahrenheit)
- Mean sea level pressure (.1 mb)
- Mean station pressure (.1 mb)
- Mean visibility (.1 miles)
- Mean wind speed (.1 knots)
- Maximum sustained wind speed (.1 knots)
- Maximum wind gust (.1 knots)
- Maximum temperature (.1 Fahrenheit)
- Minimum temperature (.1 Fahrenheit)
- Precipitation amount (.01 inches)
- Snow depth (.1 inches)
- Indicator for occurrence of: Fog Rain or Drizzle, Snow or Ice Pellets, Hail, Thunder, Tornado/Funnel Cloud

OVER 9000 STATIONS WORLDWIDE

- based on data exchanged under the World Meteorological Organization (WMO) World Weather Watch Program according to WMO Resolution 40 (Cg-XII)

World Meteorological Organization
Working together in weather, climate and water

3. NCEP Reanalysis

http://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis.html

- When no climate data (observations) are available for your area of interest, one can try reanalyzed data
- NCEP/NCAR Reanalysis 1 project uses a state-of-the-art analysis/forecast system to perform data assimilation using past data from 1948 to the present
- joint project between the National Centers for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR)
- available as 4 times daily format and as daily averages
- E. Kalnay *et al.,* 1996. The NCEP/NCAR 40-Year Reanalysis Project. *Bulletin of the American Meteorological Society*

Issues Using NCEP Reanalysis

- Data available as GRIB files

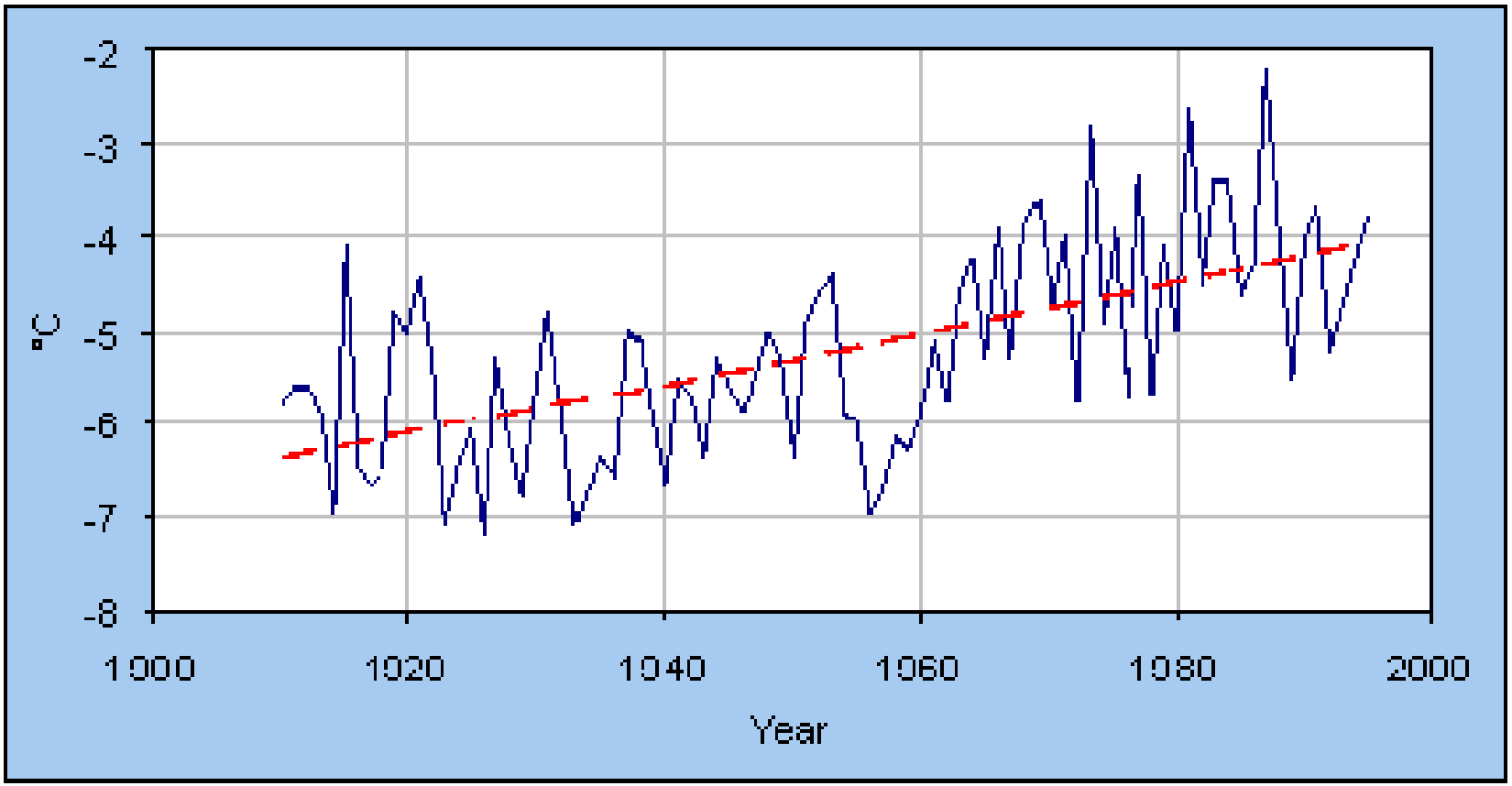
  (WMO format for gridded data used by operational meteorological centers for storage and the exchange of gridded fields as typically 1/3 smaller)
- Need to download and read in Fortran, C or Basic computer language

4. Homogenization of Data

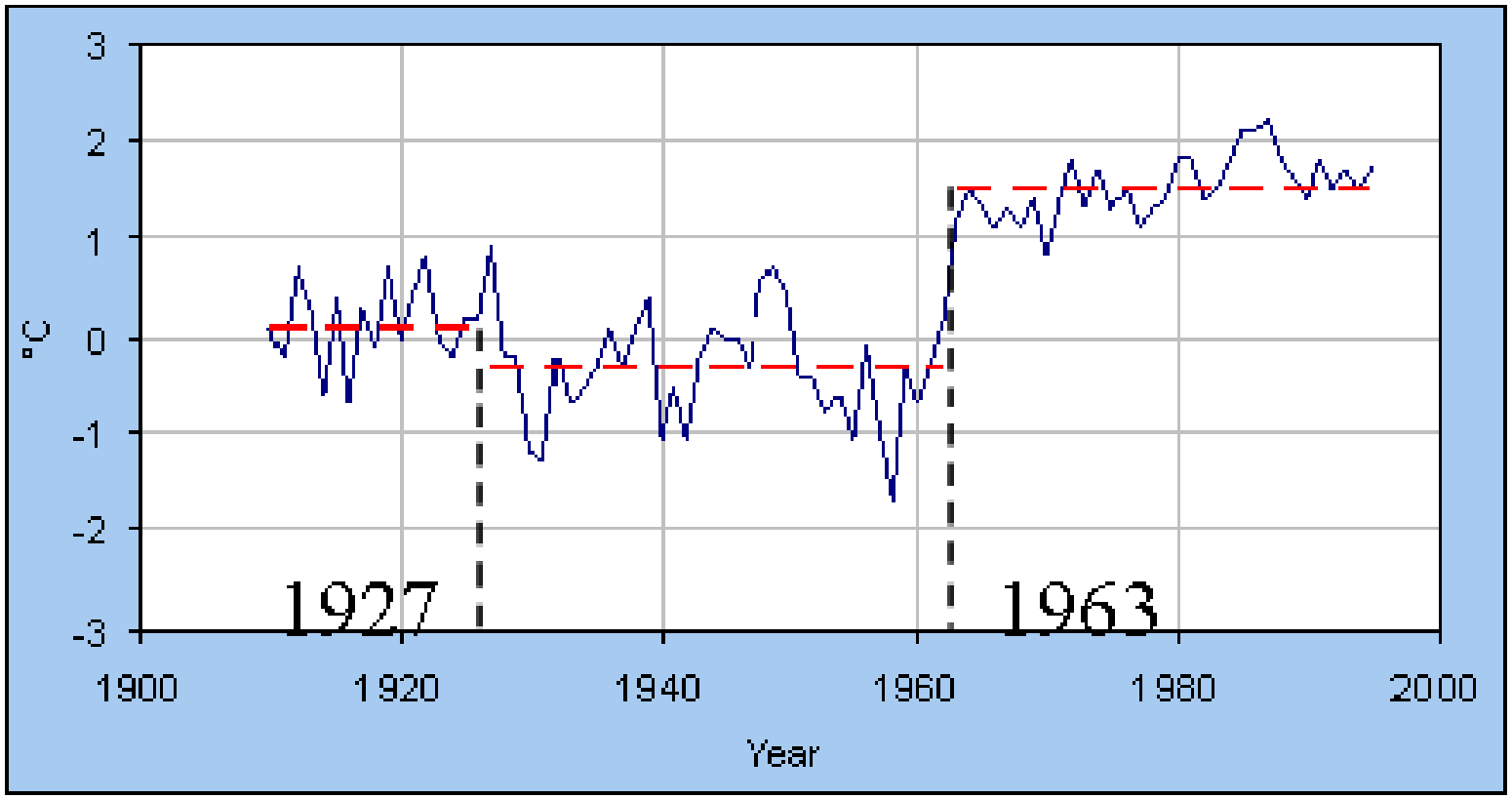
- data should be free of variation not caused by the atmosphere
- 2 examples (Zhang, 2004)
- station is moved from a hill top location to the valley floor 300 meters lower in elevation, analysis of its temperature data will likely show an abrupt warming at the time of the station relocation.
- a station located in the garden of a competent and conscientious observer for 50 years, and suppose a tree was planted west of the garden at the time the observation station was established. The instruments are maintained in good condition and the observer accurately records the temperature in the garden. The tree slowly grows up and shades the observing site during the late afternoon when the daily maximum temperature is observed.

Example of Data Homogenization Amos, Quebec, Canada

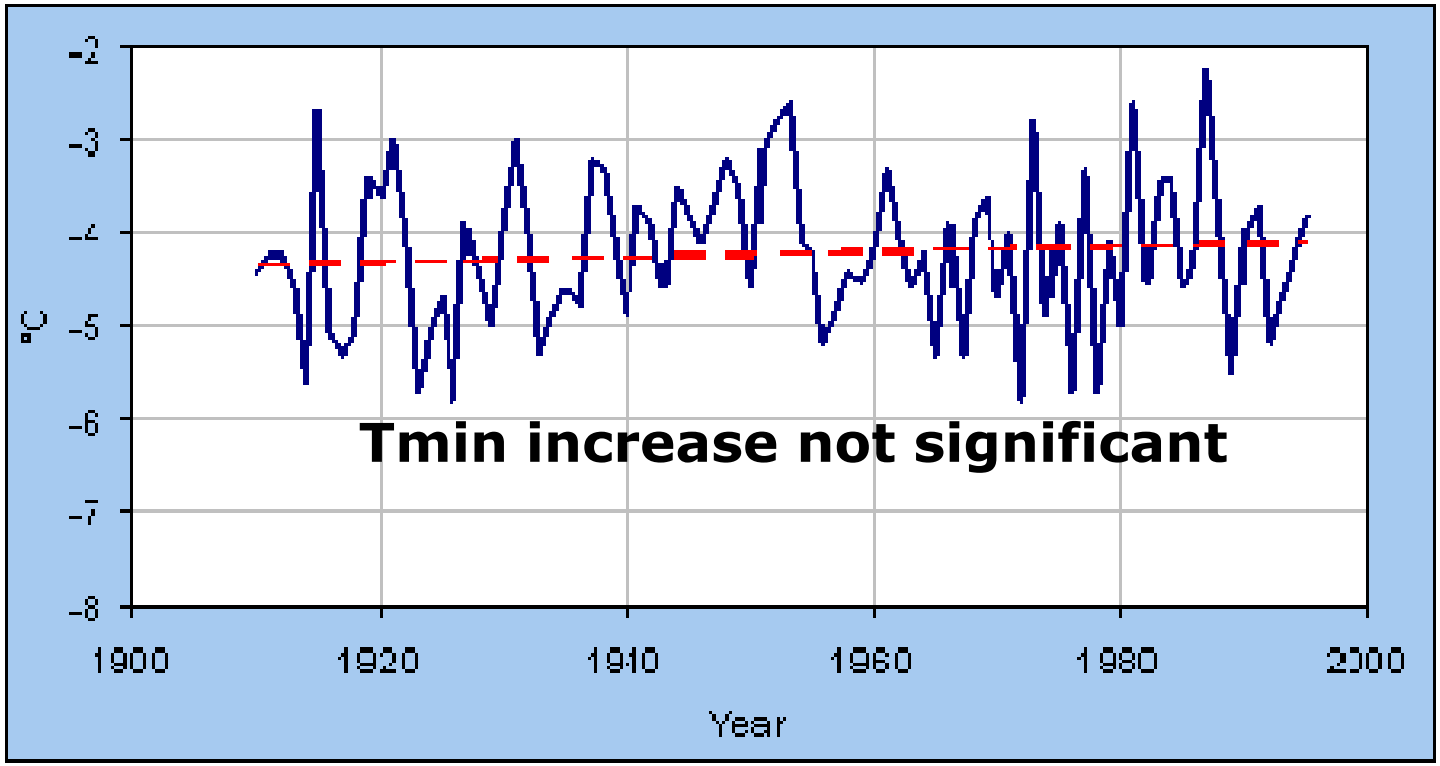
Original Analysis – increase 2.8°C in Tmin



2°C Tmean Jump in 1963 due to relocation

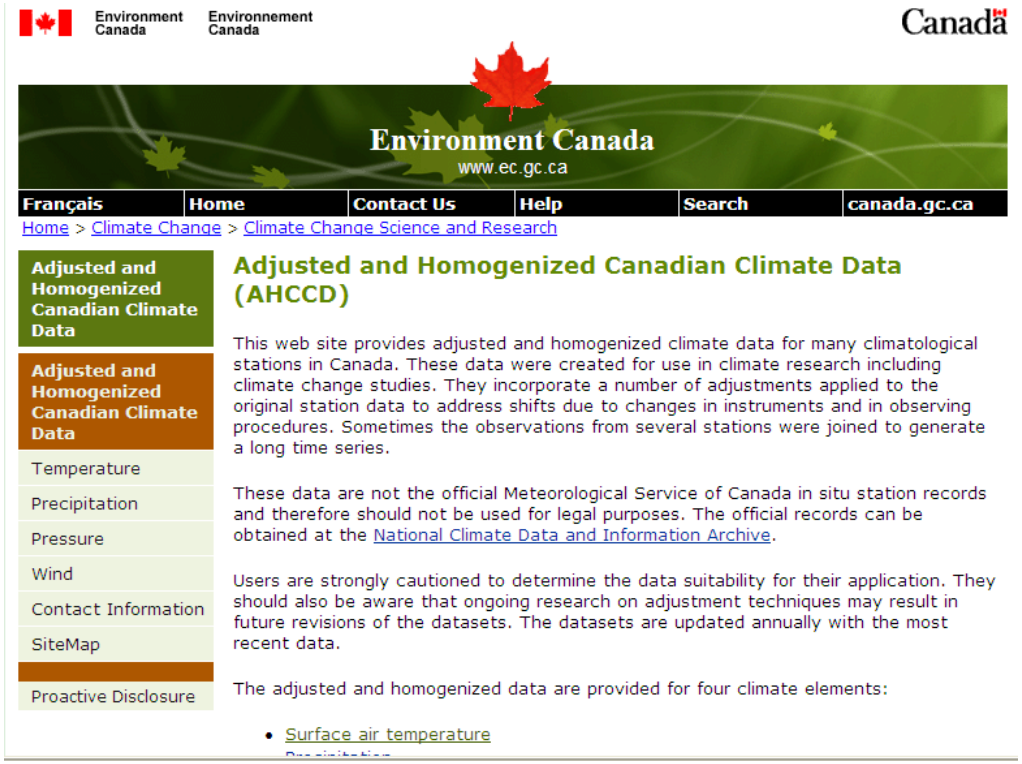


data homogenization removes the artificial jump



Adjusted Historical Canadian Climate Data

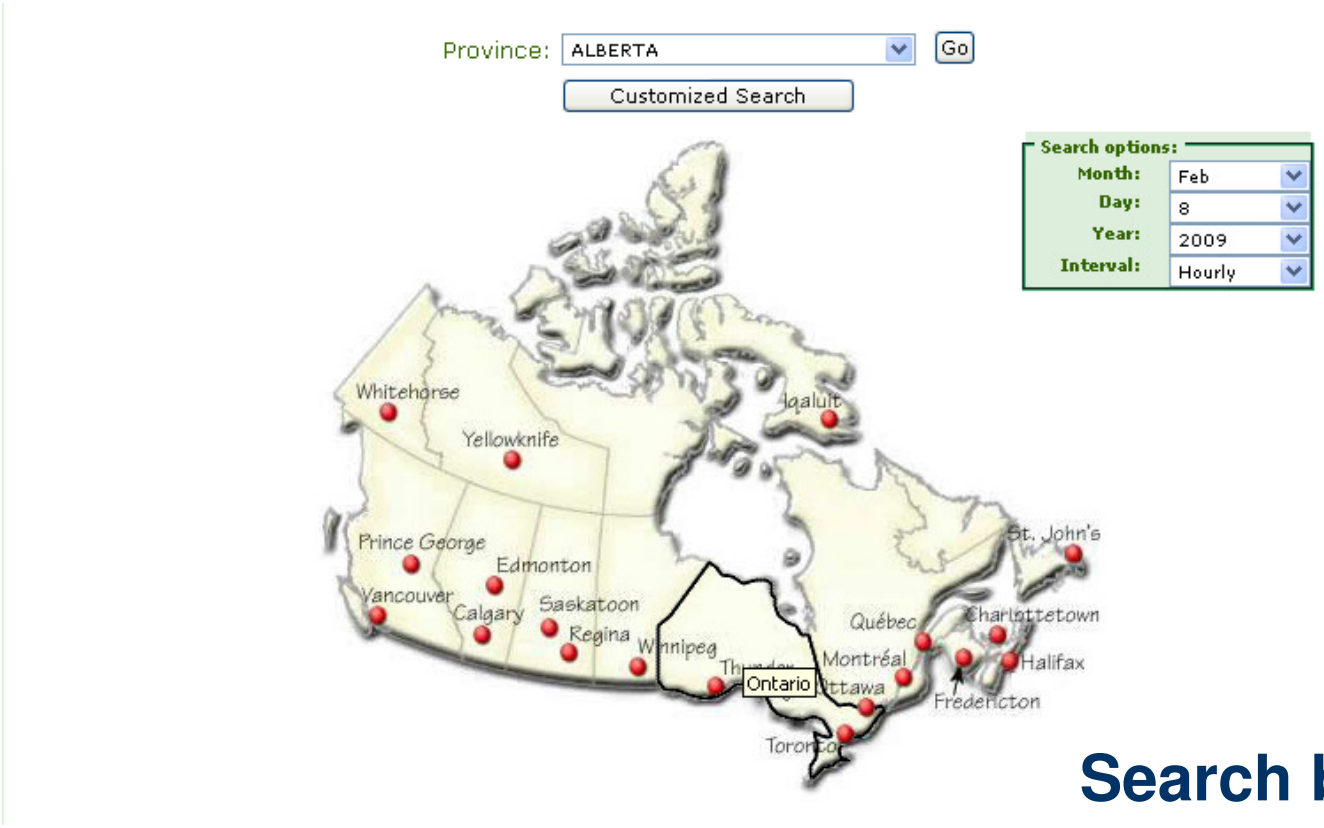
http://ec.gc.ca/dccha-ahccd/



Issues Using Homogenized Data Set

- **Limited Number of Stations (>200)**
- **Limited variables**
  1. Surface air temperature
  2. Precipitation
  3. Surface pressure
  4. Surface wind speed

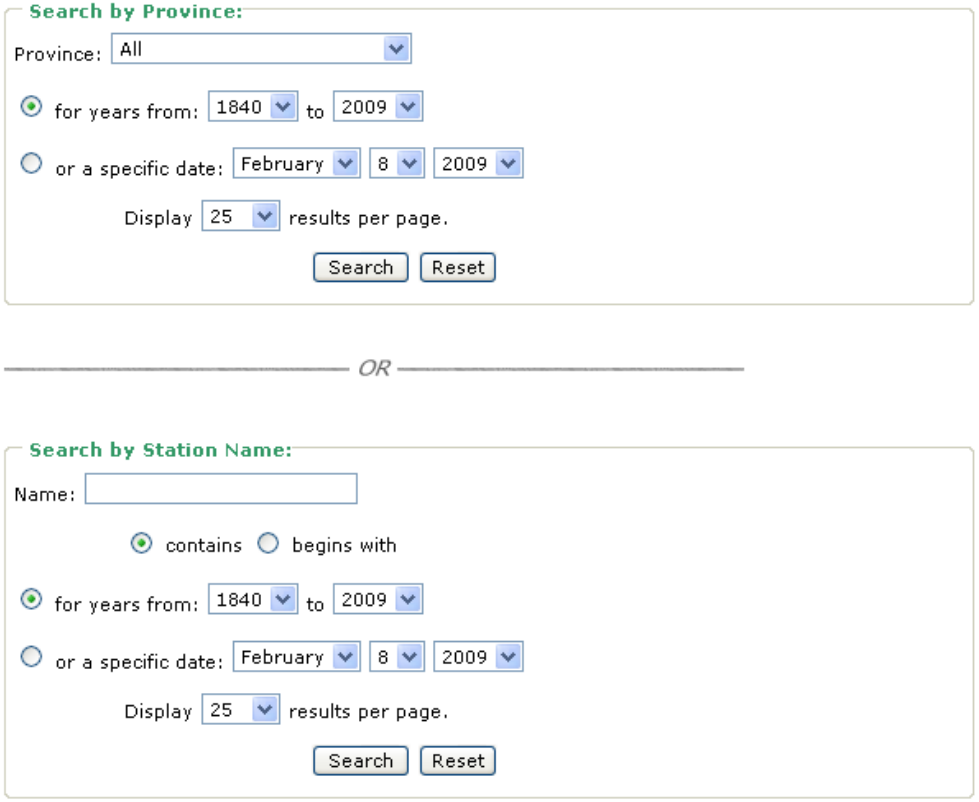
5. Selecting a Climate Station Using NCDI



Search by province

By Province or Station Name

To determine data availability for a custom location and date, please complete and submit one of the following searches:



Or by Proximity

OR

Search by Proximity:

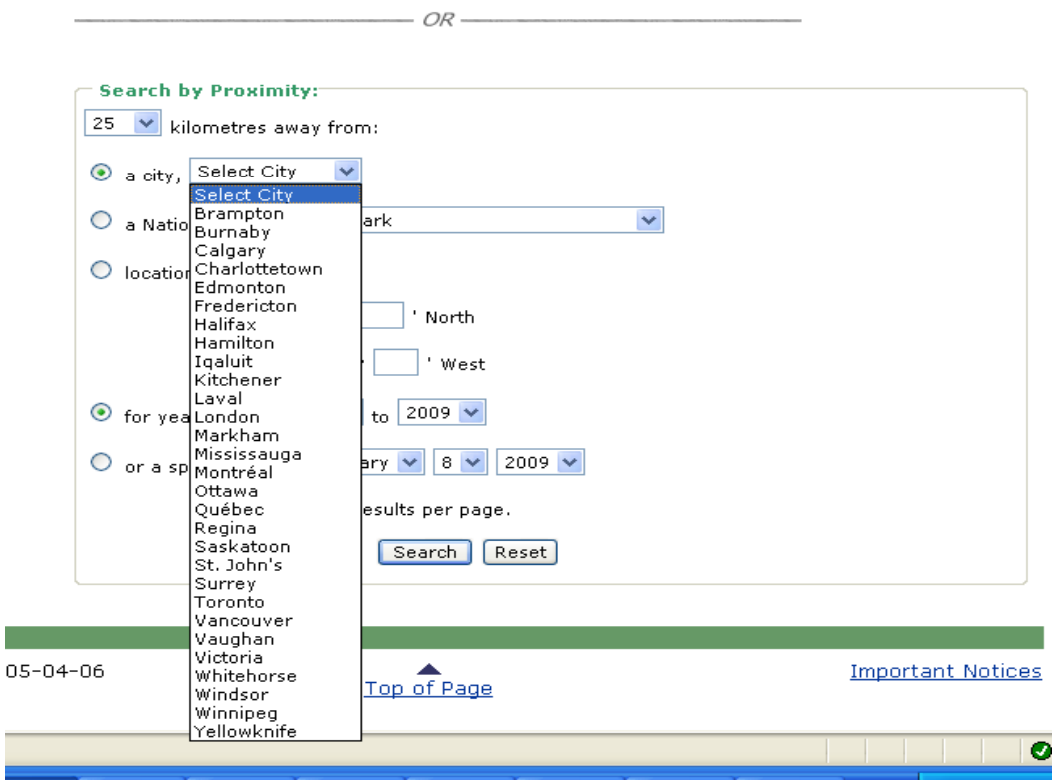
25 kilometres away from:

- a city, Select City
- a National Park, Select Park
- location coordinates:
  - latitude: ° ' North
  - longitude: ° ' West
- for years from: 1840 to 2009
- or a specific date: February 8 2009

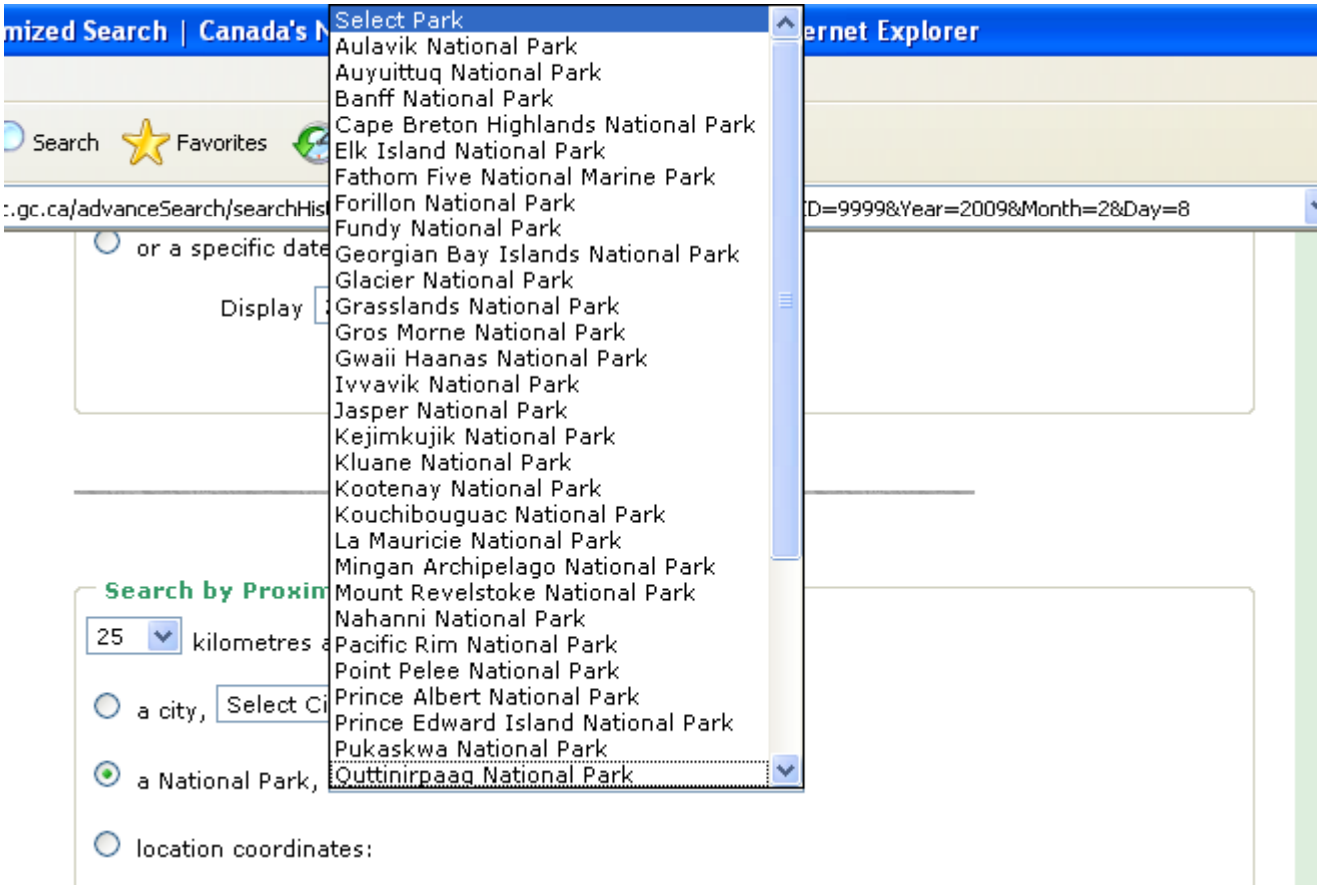
Display 25 results per page.

Search Reset

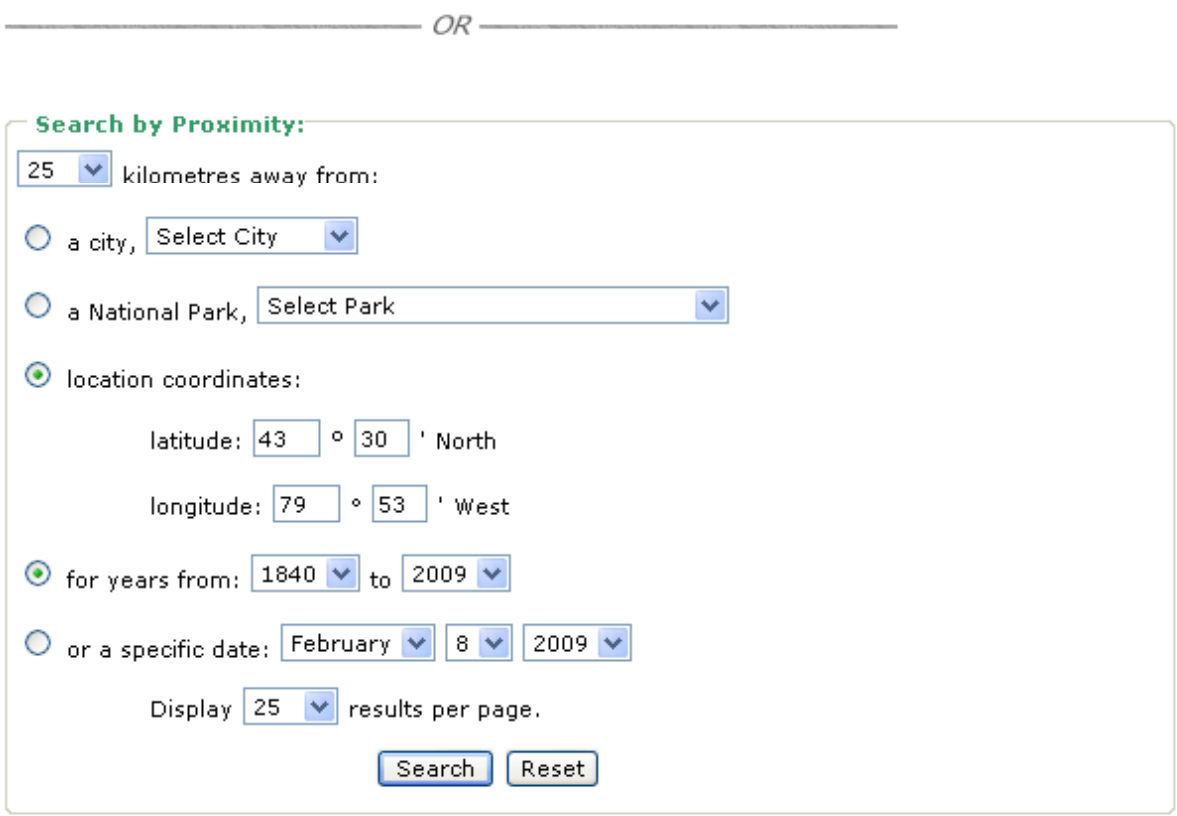
By City (limited)



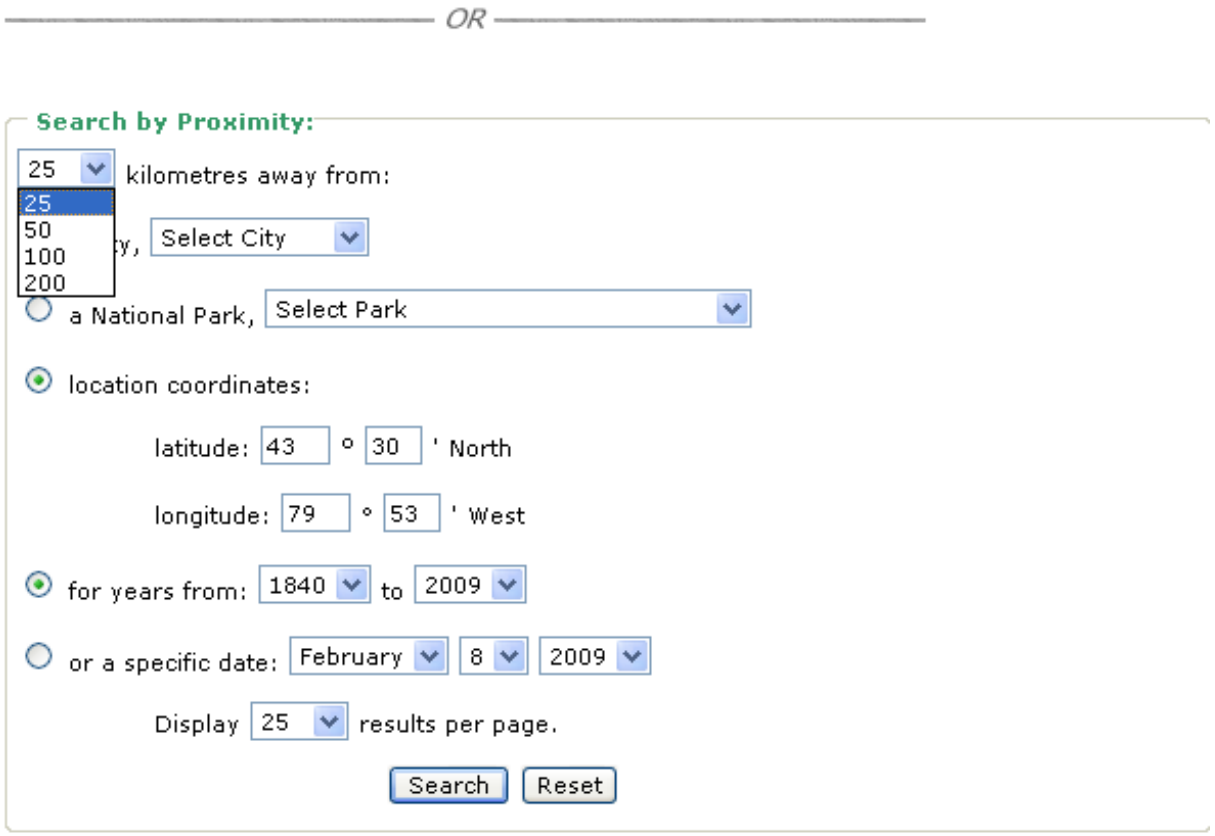
By National Park



Or by Co-ordinates



Within 25, 50, 100 or 200 kms



Selecting a climate station

- Length of record (30 years of data)
- Continuous records
- Up to present

- Proximity to impact study

Example – Searching climate stations within 25 kms of Windsor, ON

Station Results

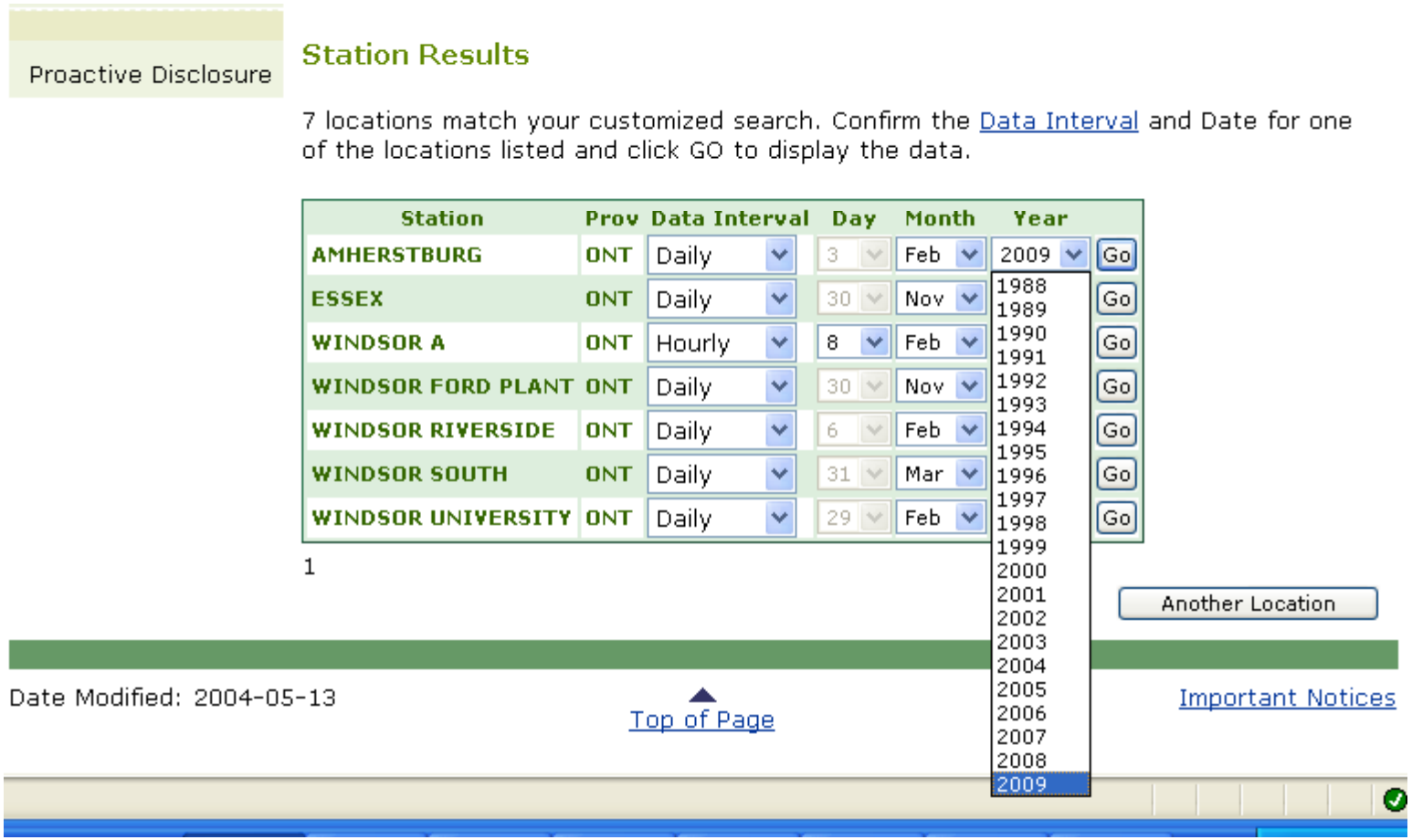
7 locations match your customized search. Confirm the Data Interval and Date for one of the locations listed and click GO to display the data.

Station	Prov	Data Interval	Day	Month	Year	
AMHERSTBURG	ONT	Daily	3	Feb	2009	Go
ESSEX	ONT	Daily	30	Nov	1968	Go
WINDSOR A	ONT	Hourly	8	Feb	2009	Go
WINDSOR FORD PLANT	ONT	Daily	30	Nov	1993	Go
WINDSOR RIVERSIDE	ONT	Daily	6	Feb	2009	Go
WINDSOR SOUTH	ONT	Daily	31	Mar	1955	Go
WINDSOR UNIVERSITY	ONT	Daily	29	Feb	1980	Go

1

Another Location

Click on year to determine length of record



Example

- 2 possible sites given criteria

  - **Windsor A** (1953 to 2011)

  - **Windsor Riverside** (1866 to 2011)

Location and Elevation Similar

WINDSOR A
ONTARIO

Latitude: 42° 16.800' N Longitude: 82° 57.600' W Elevation: 189.60 m

Climate ID: 6139525 WMO ID: 71538 TC ID: YQG

Previous Month February 2009 Go

Daily Data Report for February 2009

Day	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days °C	Cool Deg Days °C	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm
01†	4.4	-0.5	2.0	16.0	0.0	0.0	0.0	0.0	17
02†	0.8	-6.4	-2.8	20.8	0.0	0.0	T	T	13
03†	-2.2	-10.6	-6.4	24.4	0.0	0.0	0.8	0.6	10
04†	-9.6	-15.9	-12.8	30.8	0.0	0.0	T	T	10
05†	-7.8	-18.5	-13.2	31.2	0.0	0.0	0.0	0.0	10
06†	0.4	-11.5	-5.6	23.6	0.0	0.0	0.0	0.0	10

Notes on Data Quality.

WINDSOR RIVERSIDE
ONTARIO

Latitude: 42° 19.800' N Longitude: 82° 55.800' W Elevation: 188.40 m

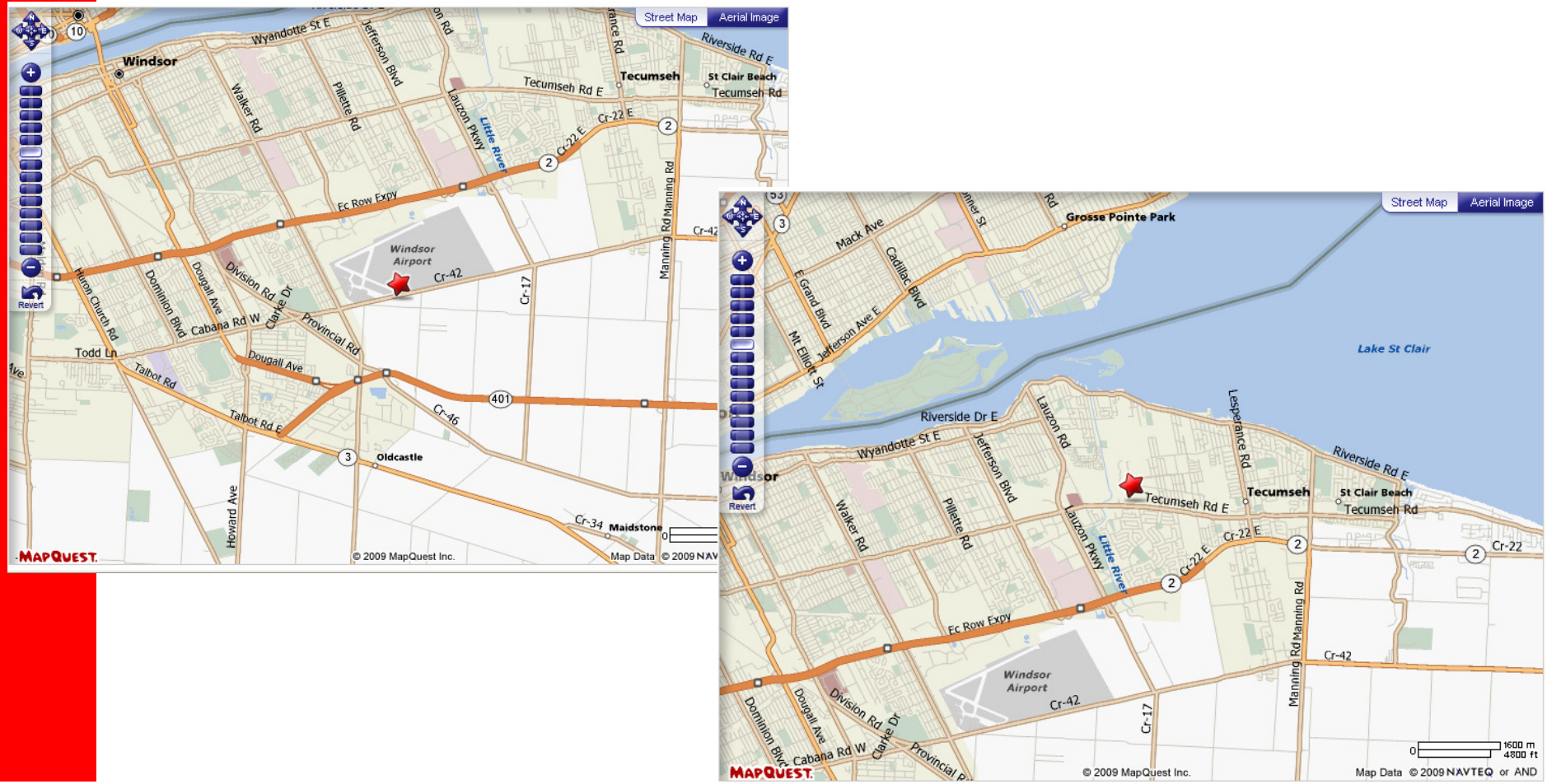
Climate ID: 6139520 WMO ID: TC ID:

Previous Month February 2009 Go

Daily Data Report for February 2009

Day	Max Temp °C	Min Temp °C	Mean Temp °C	Heat Deg Days °C	Cool Deg Days °C	Total Rain mm	Total Snow cm	Total Precip mm	Snow on Grnd cm	Dir of Max Gust 10's Deg	Spd of Max Gust km/h
01†	7.5	-7.0	0.3	17.7	0.0	0.0	0.0	0.0	28		
02†	4.0	-7.0	-1.5	19.5	0.0	0.0	0.2	0.2	26		
03†	-0.5	-10.5	-5.5	23.5	0.0	0.0	0.8	0.8	27		
04†	-8.5	-14.0	-11.3	29.3	0.0	0.0	0.0	0.0	28		
05†	-7.0	-19.0	-13.0	31.0	0.0	0.0	0.0	0.0	27		
06†	6.0	-11.0	-2.5	20.5	0.0	0.0	0.0	0.0	27		

Locations mapped



Quick Data Check to Help Select Site

- **Windsor Riverside** missing data 1935 to 1995

- **Windsor A** data appears okay

6. Downloading Data using NCDI

07†	8.4	0.4	4.4	13.6	0.0	0.0	0.0	0.0	9	21	50
08†	6.0	-1.6	2.2	15.8	0.0	0.0	0.0	0.0	1	30	37
Sum				**176.2***	**0.0***	**0.0***	**0.8***	**0.6***			
Avg	**0.1***	**-8.1***	**-4***								
Xtrm	**8.4***	**-18.5***								**21***	**50***

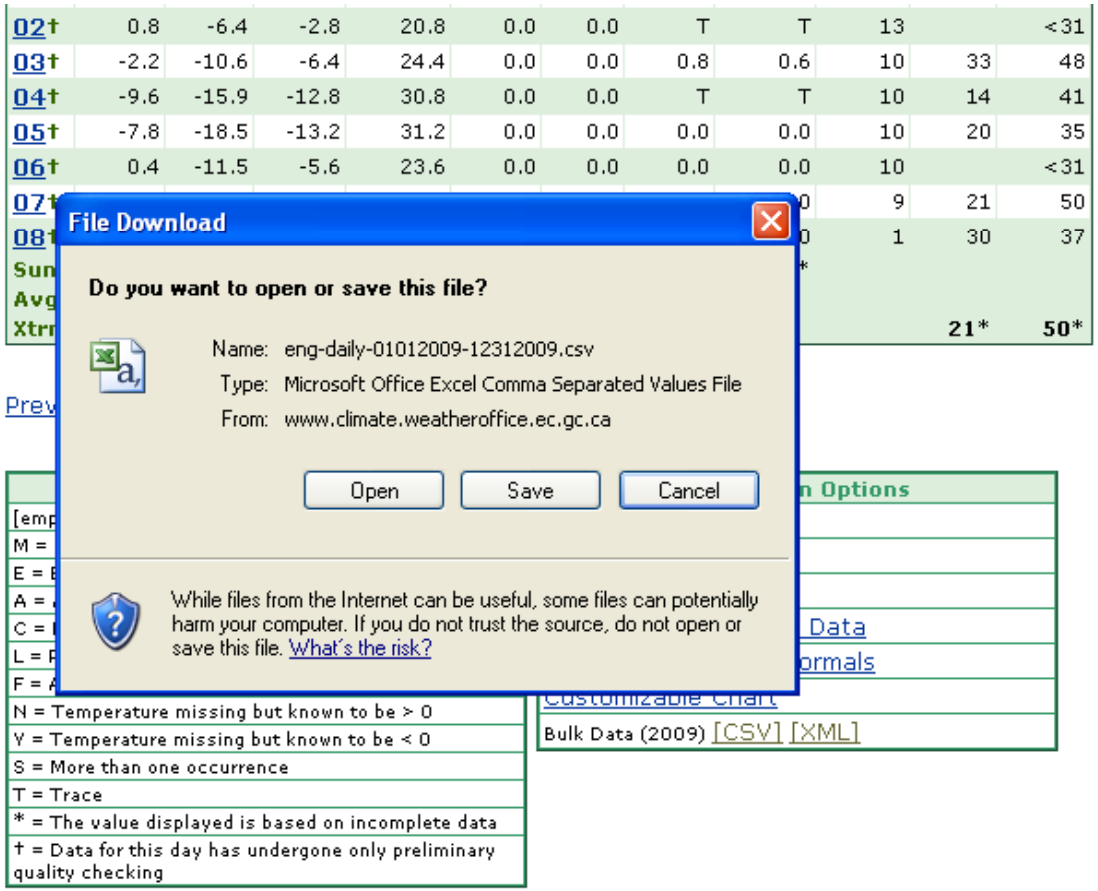
Previous Month February 2009 Go

Legend
[empty] = No data available
M = Missing
E = Estimated
A = Accumulated
C = Precipitation occurred, amount uncertain
L = Precipitation may or may not have occurred
F = Accumulated and estimated
N = Temperature missing but known to be > 0
Y = Temperature missing but known to be < 0
S = More than one occurrence
T = Trace
* = The value displayed is based on incomplete data
† = Data for this day has undergone only preliminary quality checking

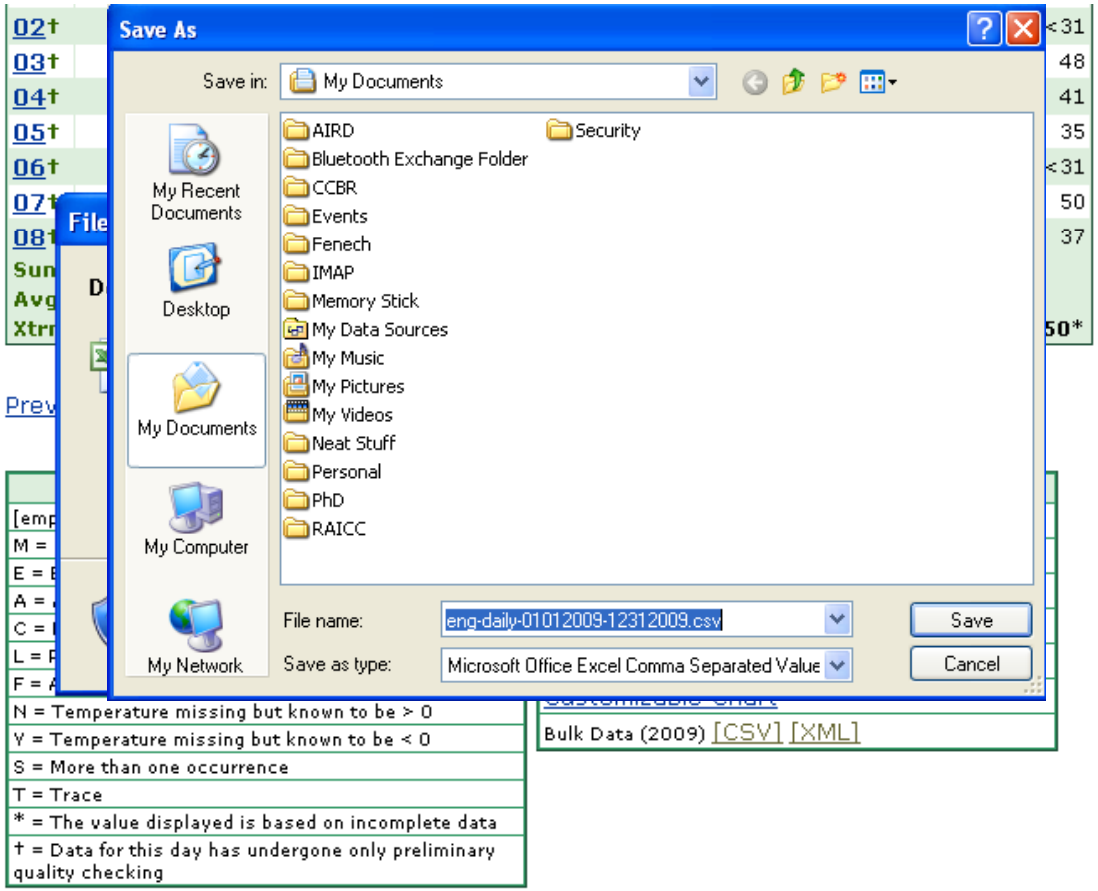
Navigation Options
Canada Map
Ontario Map
Customized Search
Nearby Stations with Data
1971-2000 Climate Normals
Customizable Chart
Bulk Data (2009) [CSV] [XML]

- **Bulk Data download CSV (comma delimited)**
- **For daily data, 1 year per download**

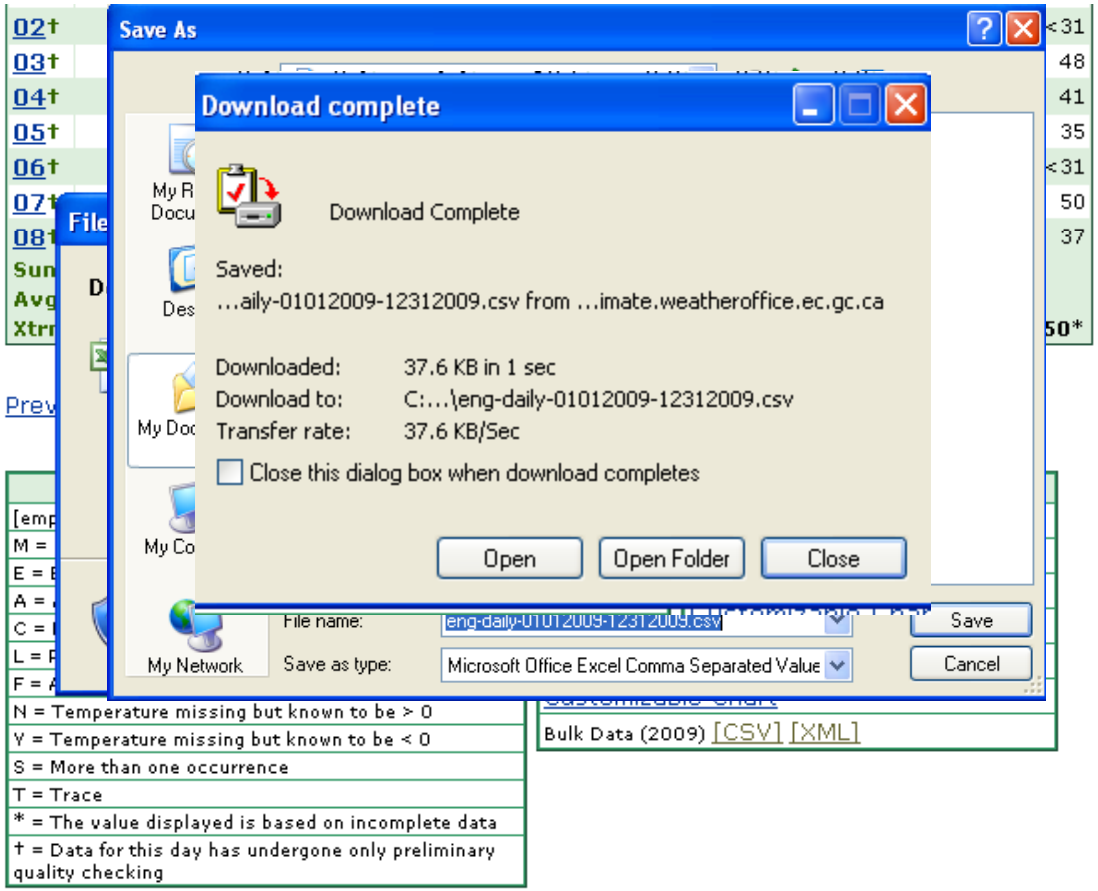
Save to Folder



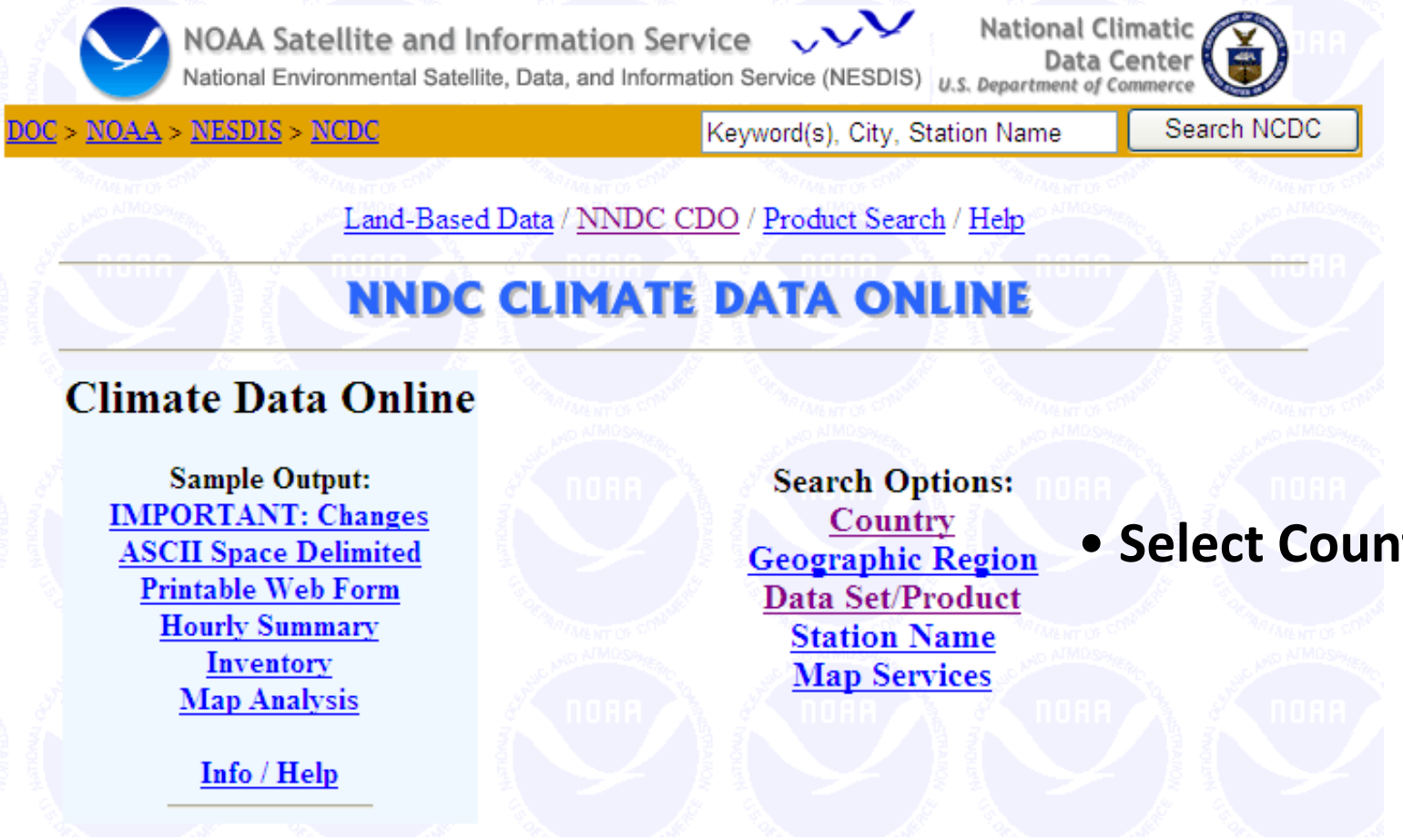
Save to Folder



Save to Folder

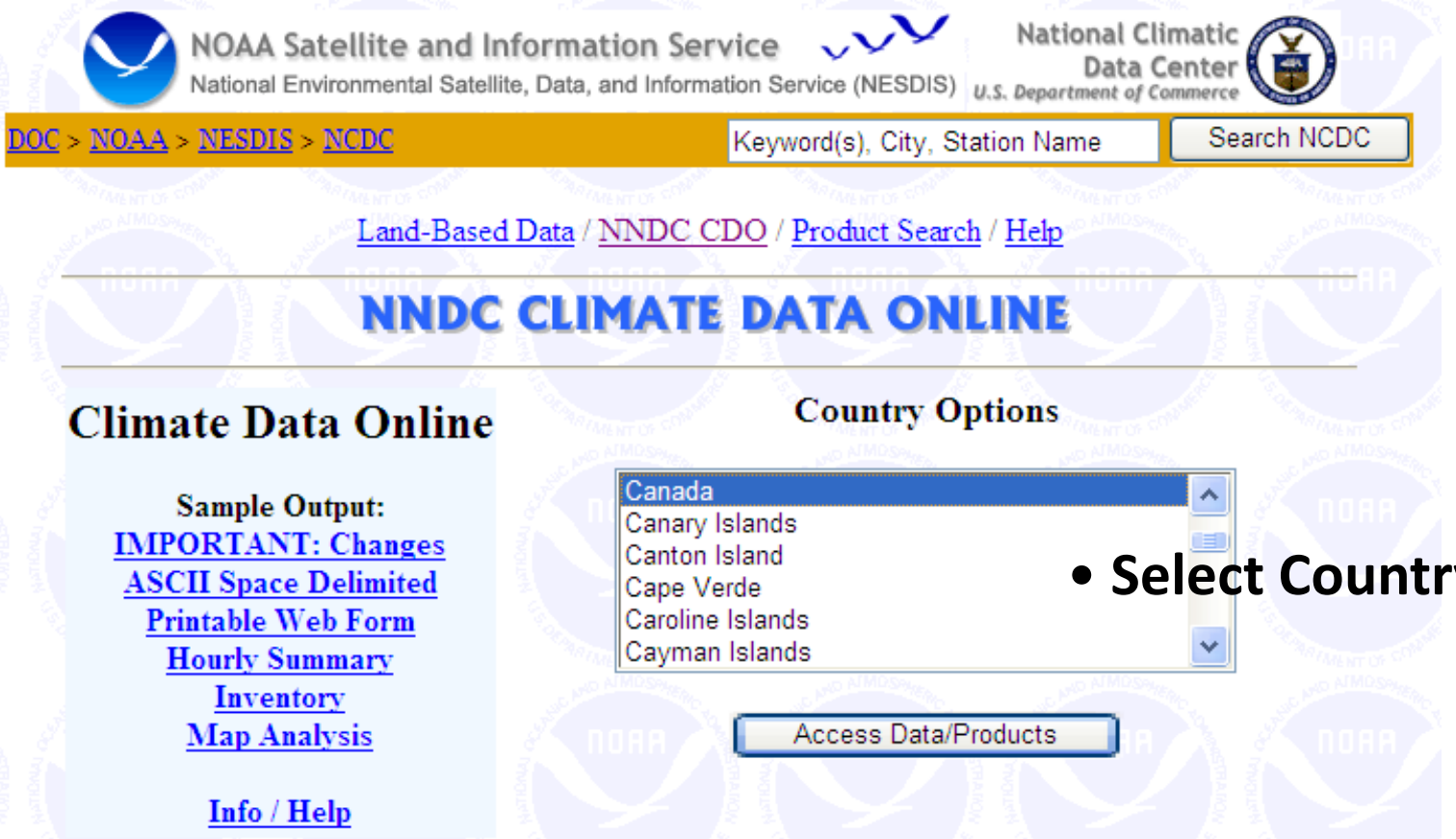


Downloading Data using NCDC



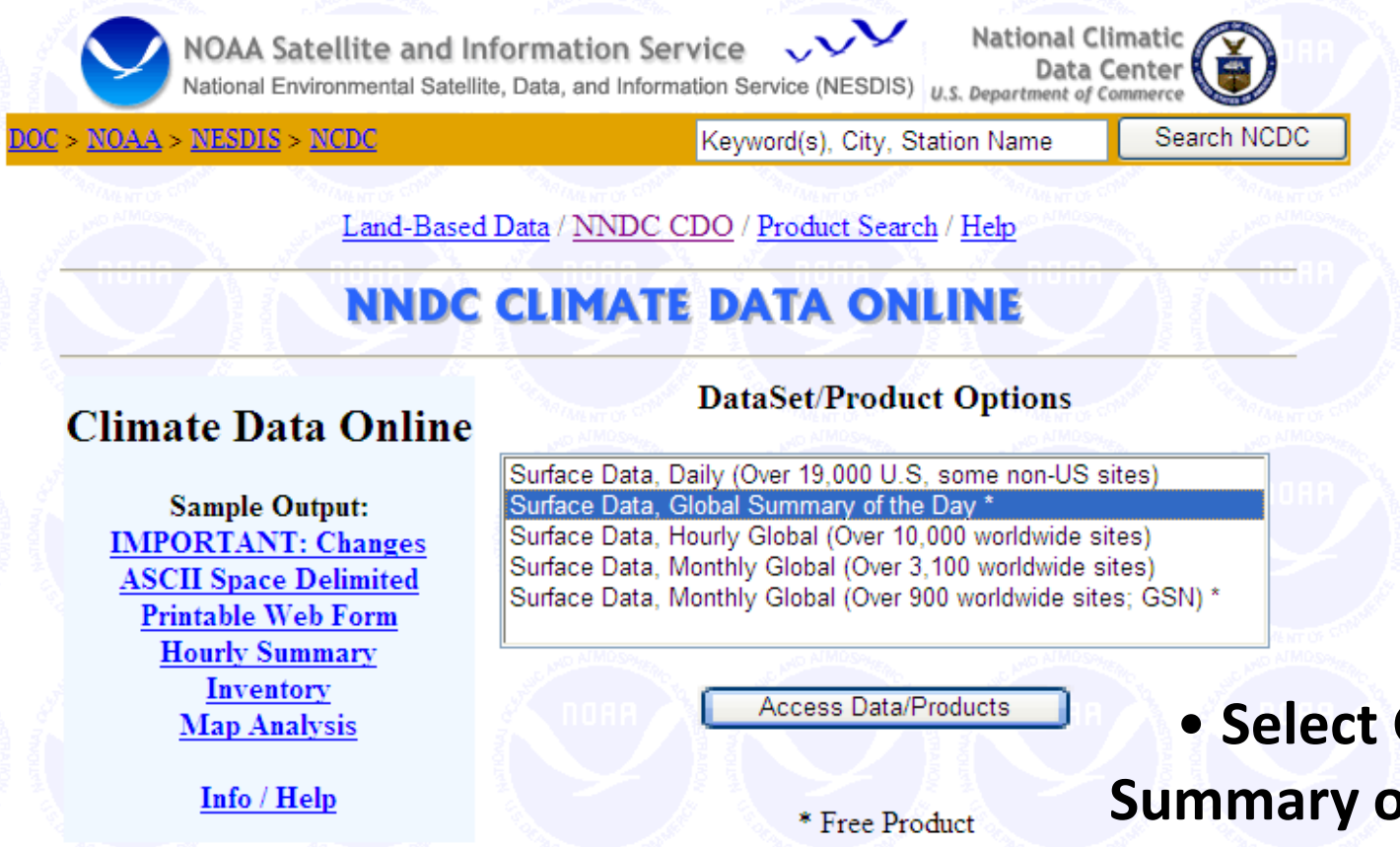
- **Select Country**

Downloading Data using NCDC



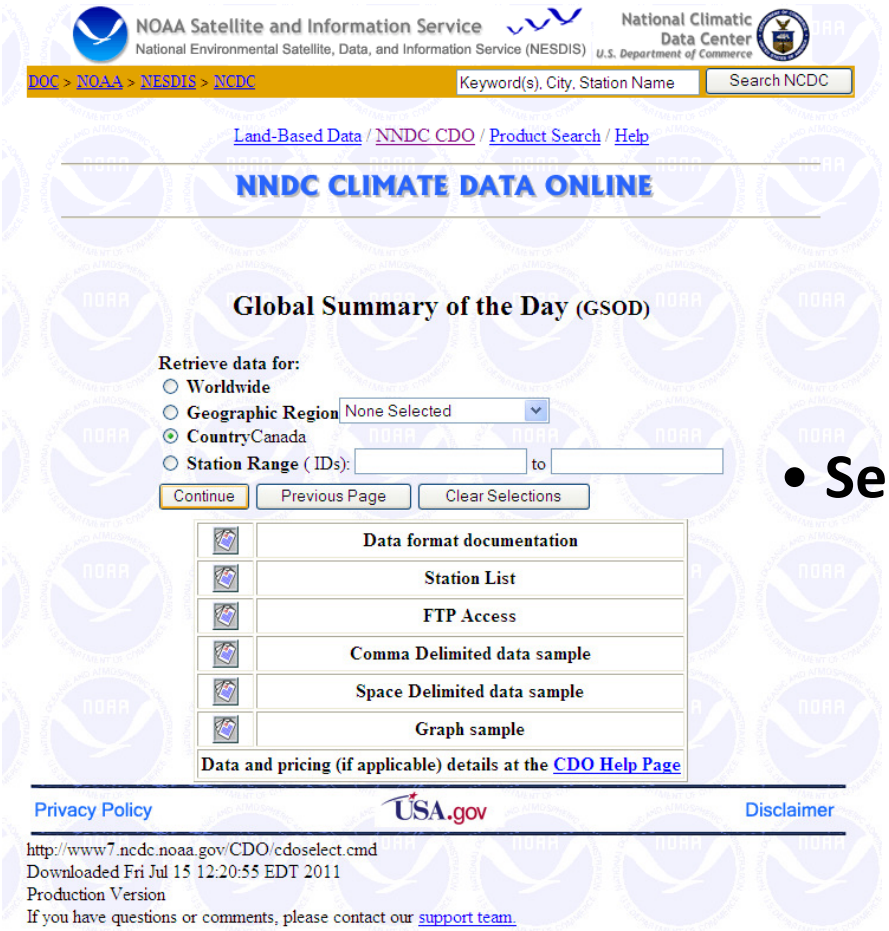
- Select Country

Downloading Data using NCDC



- **Select Global Summary of the Day**

Downloading Data using NCDC

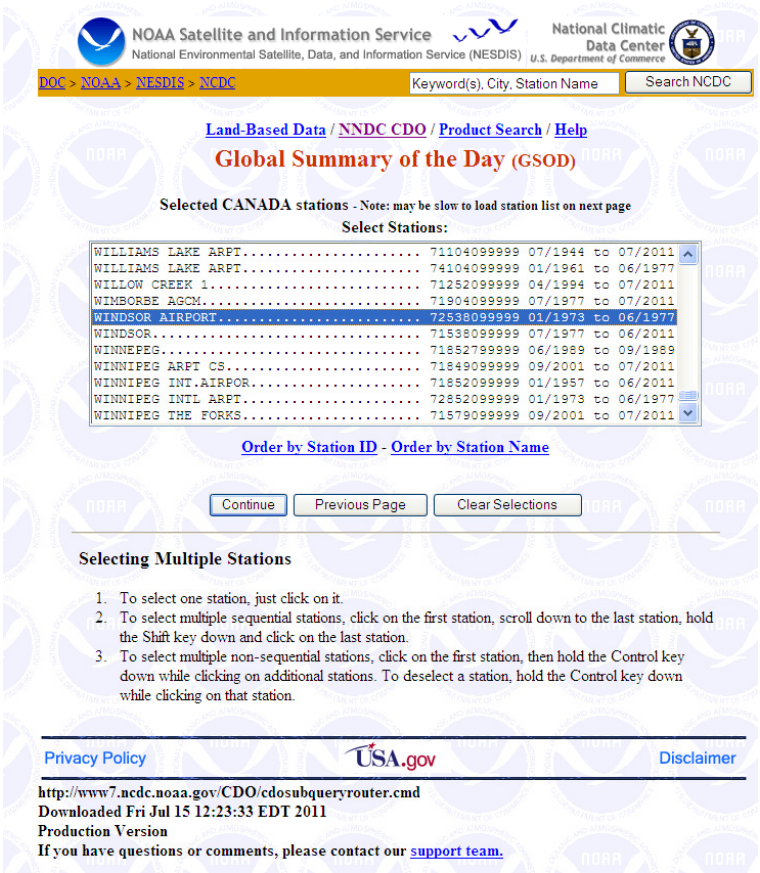


- **Select Continue**

Downloading Data using NCDC

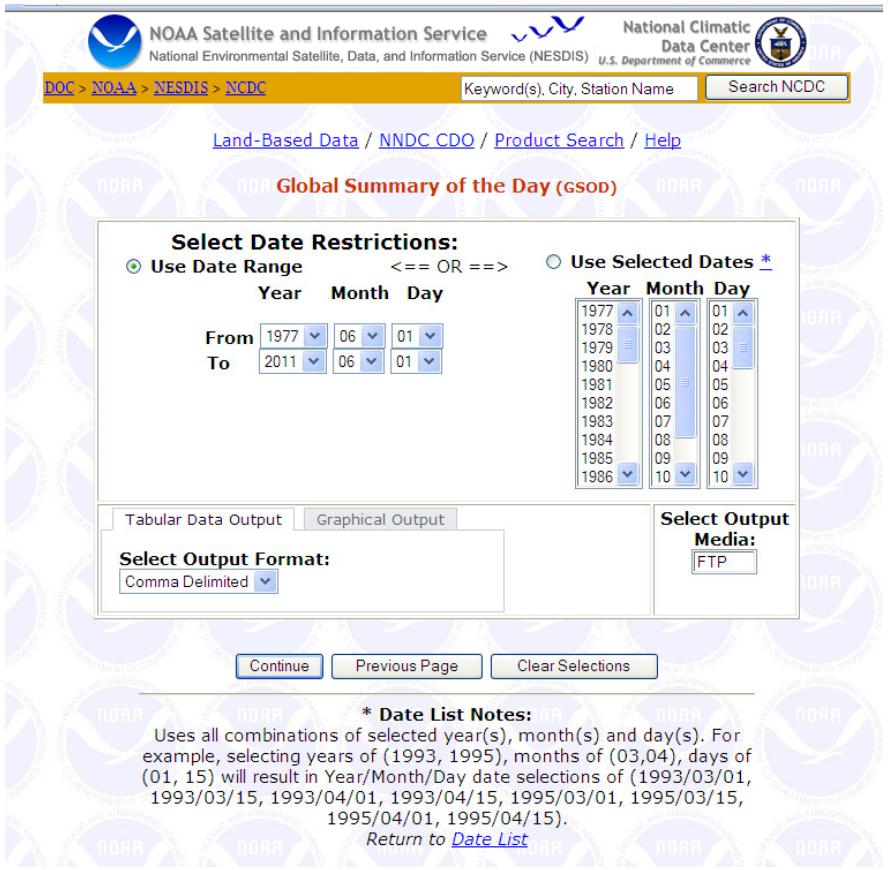
- Select Continue again

Downloading Data using NCDC



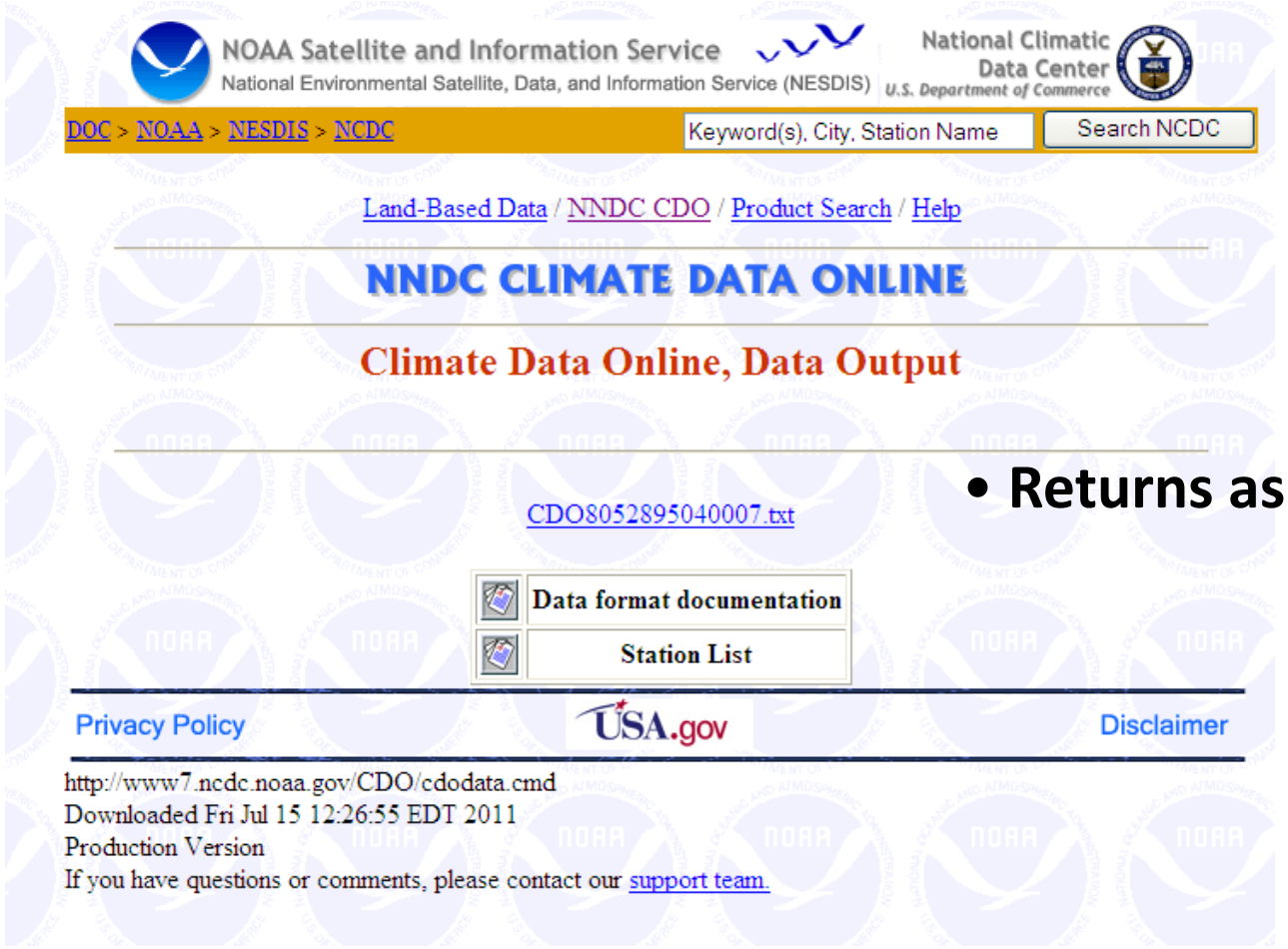
- **Select Station**

Downloading Data using NCDC



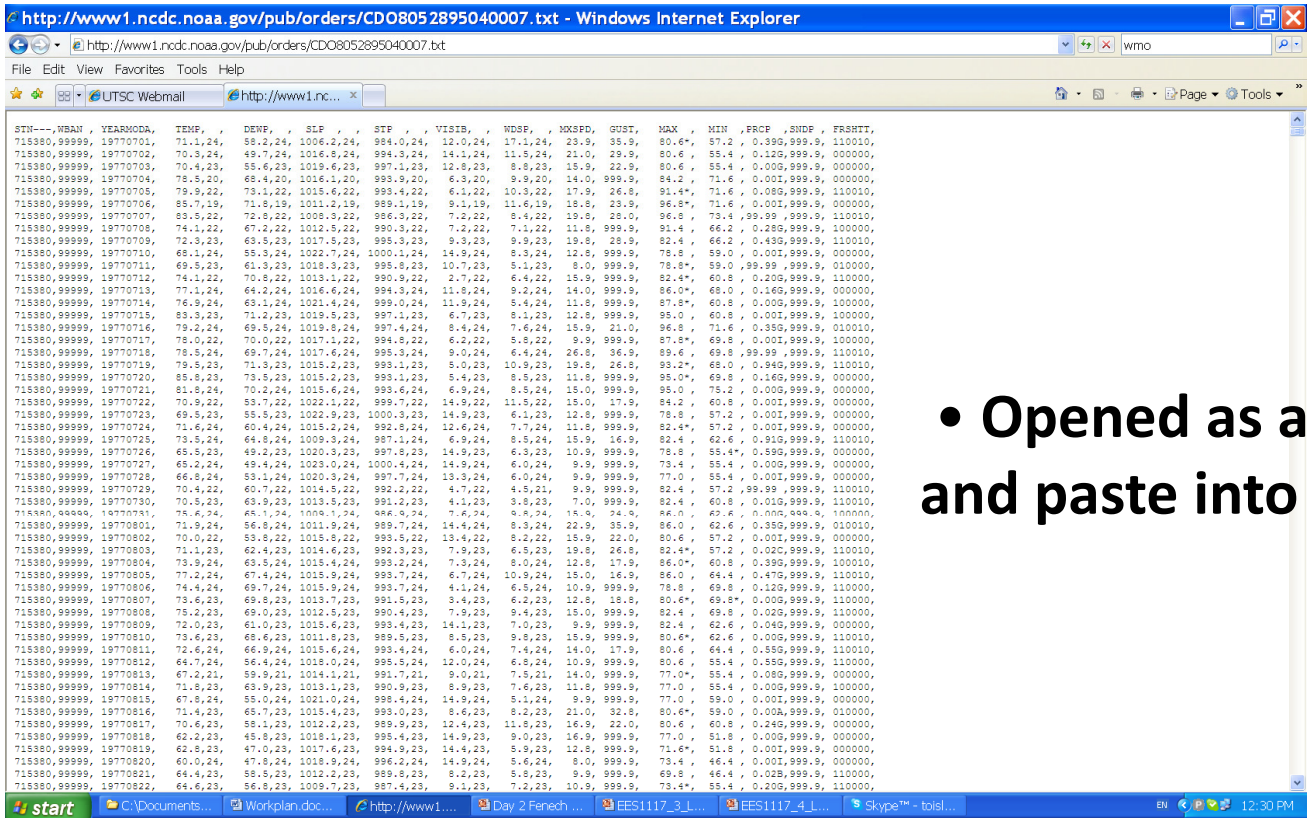
- **Select Date Restrictions, Output Format**

Downloading Data using NCDC



- **Returns as an Output file**

Downloading Data using NCDC



- **Opened as a file to be cut and paste into a spreadsheet**

2. Quality Controlling Observational Data

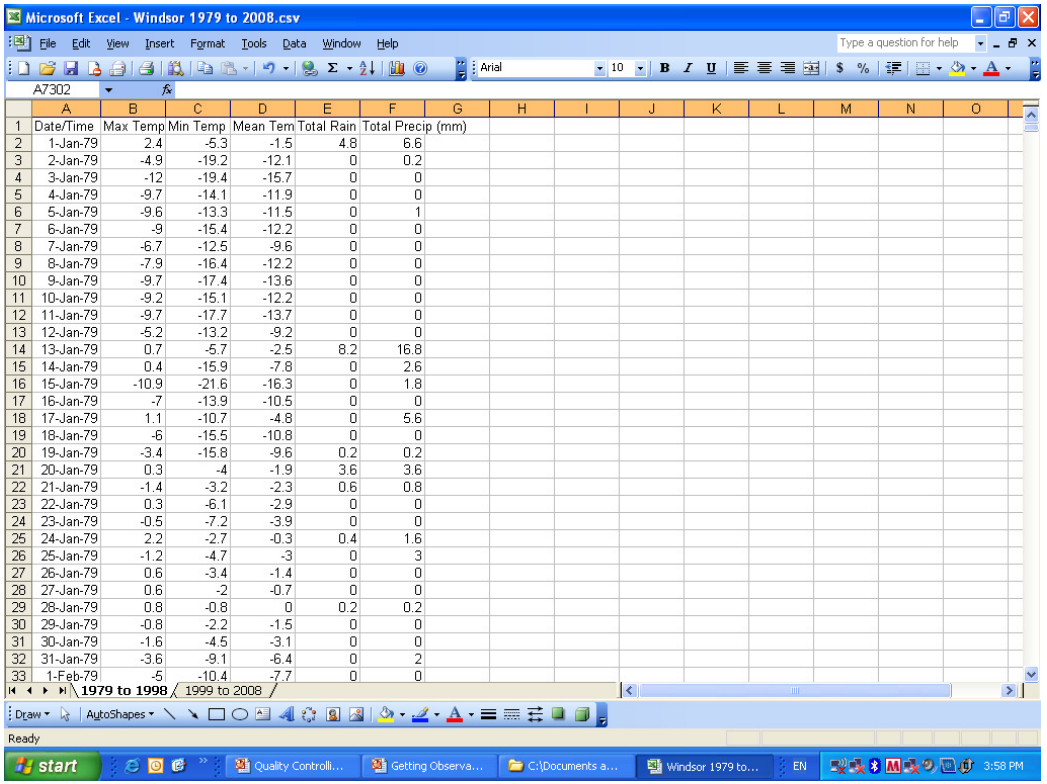
1. organizing and viewing data
2. data checks (range, visual, missing data)
3. data summaries (monthly, annual)

1. Organizing and Viewing Data

Open ***Charlottetown A Climate*** file

Datasets

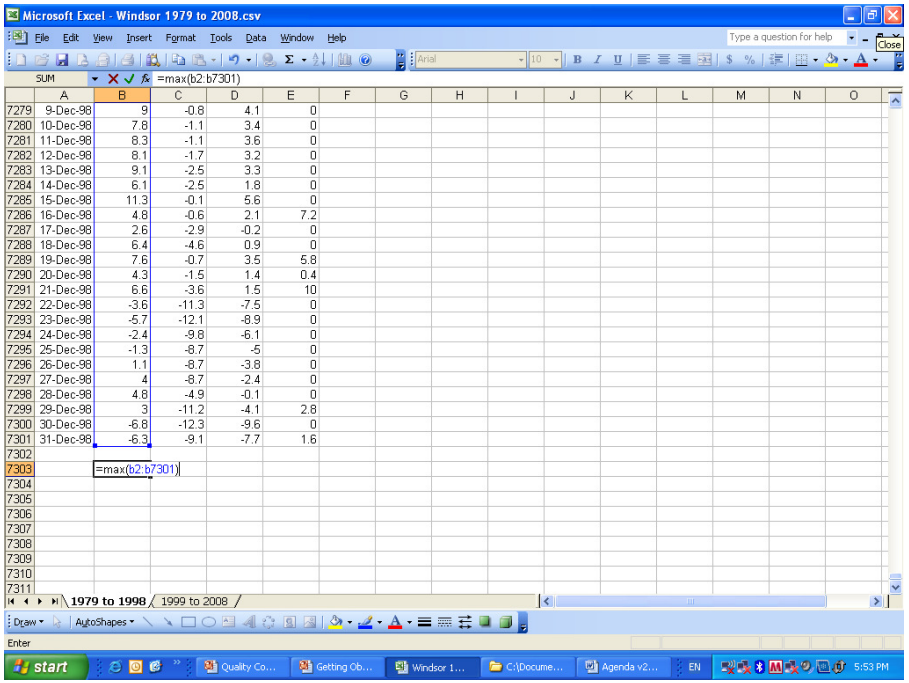
Full 30-year worksheets should contain 10,958 rows



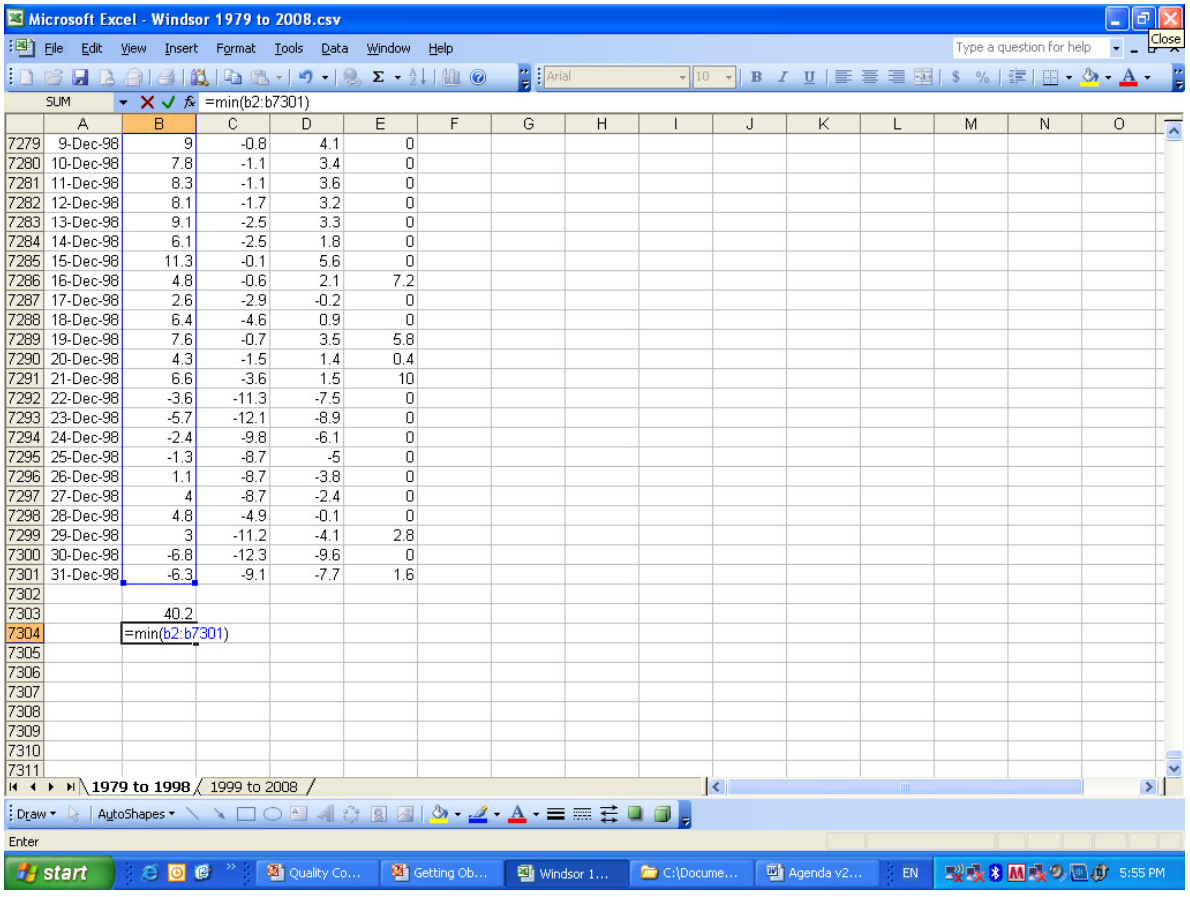
	A	B	C	D	E	F
1	Date/Time	Max Temp	Min Temp	Mean Tem	Total Rain	Total Precip (mm)
2	1-Jan-79	2.4	-5.3	-1.5	4.8	6.6
3	2-Jan-79	-4.9	-19.2	-12.1	0	0.2
4	3-Jan-79	-12	-19.4	-15.7	0	0
5	4-Jan-79	-9.7	-14.1	-11.9	0	0
6	5-Jan-79	-9.6	-13.3	-11.5	0	1
7	6-Jan-79	-9	-15.4	-12.2	0	0
8	7-Jan-79	-6.7	-12.5	-9.6	0	0
9	8-Jan-79	-7.9	-16.4	-12.2	0	0
10	9-Jan-79	-9.7	-17.4	-13.6	0	0
11	10-Jan-79	-9.2	-15.1	-12.2	0	0
12	11-Jan-79	-9.7	-17.7	-13.7	0	0
13	12-Jan-79	-5.2	-13.2	-9.2	0	0
14	13-Jan-79	0.7	-5.7	-2.5	8.2	16.8
15	14-Jan-79	0.4	-15.9	-7.8	0	2.6
16	15-Jan-79	-10.9	-21.6	-16.3	0	1.8
17	16-Jan-79	-7	-13.9	-10.5	0	0
18	17-Jan-79	1.1	-10.7	-4.8	0	5.6
19	18-Jan-79	-6	-15.5	-10.8	0	0
20	19-Jan-79	-3.4	-15.8	-9.6	0.2	0.2
21	20-Jan-79	0.3	-4	-1.9	3.6	3.6
22	21-Jan-79	-1.4	-3.2	-2.3	0.6	0.8
23	22-Jan-79	0.3	-6.1	-2.9	0	0
24	23-Jan-79	-0.5	-7.2	-3.9	0	0
25	24-Jan-79	2.2	-2.7	-0.3	0.4	1.6
26	25-Jan-79	-1.2	-4.7	-3	0	3
27	26-Jan-79	0.6	-3.4	-1.4	0	0
28	27-Jan-79	0.6	-2	-0.7	0	0
29	28-Jan-79	0.8	-0.8	0	0.2	0.2
30	29-Jan-79	-0.8	-2.2	-1.5	0	0
31	30-Jan-79	-1.6	-4.5	-3.1	0	0
32	31-Jan-79	-3.6	-9.1	-6.4	0	2
33	1-Feb-79	-5	-10.4	-7.7	0	0

2. Data Checks (range, visual, missing)

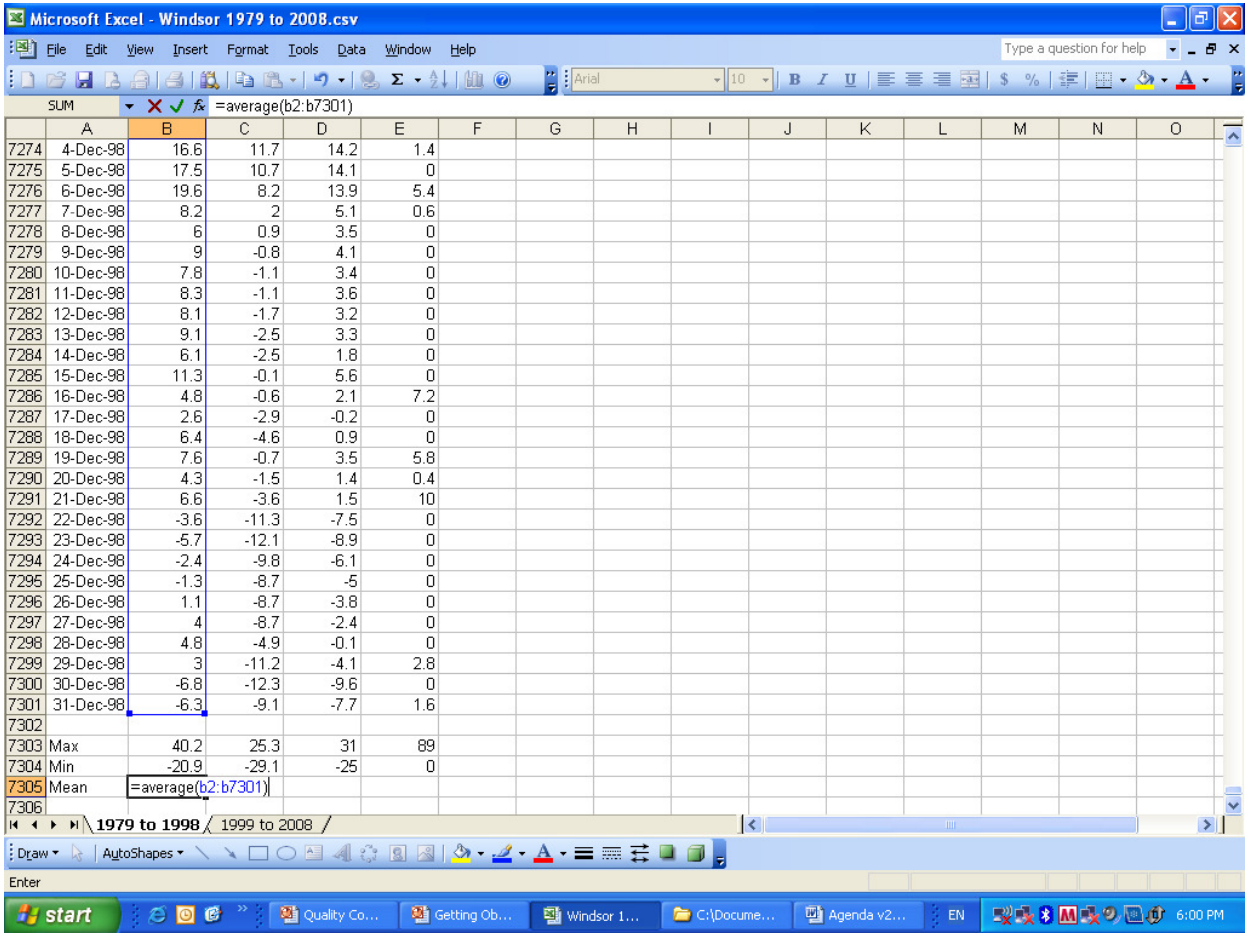
- **Calculate maximum value in column (=max(range))**



Calculate Minimum (=min(range))



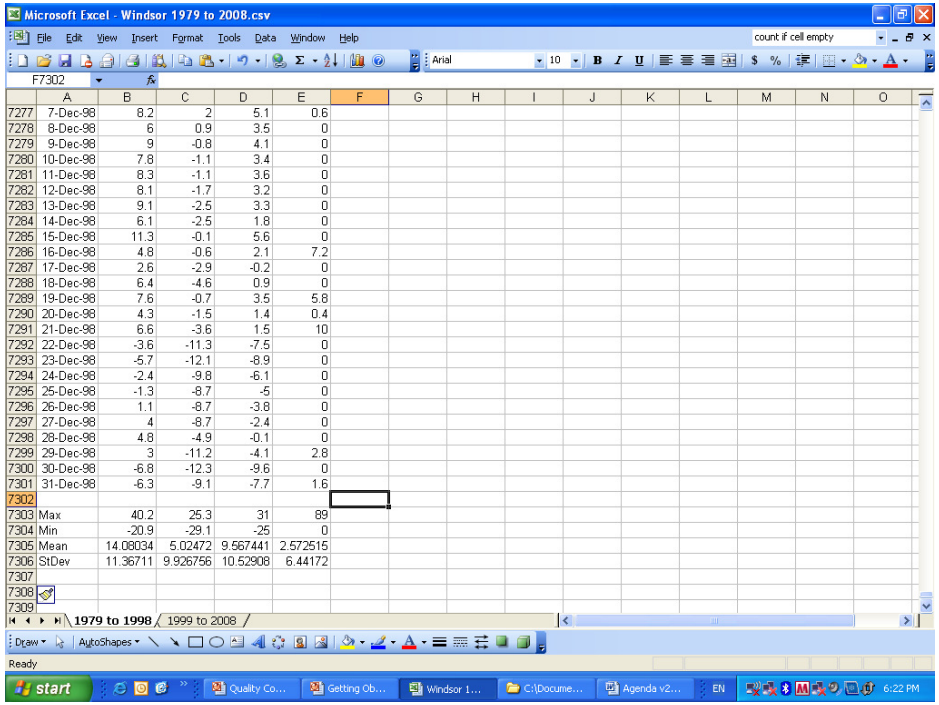
Calculate Mean (=average(range))



Max/Min/Mean

- **Check Max/Min/Mean values for consistency**

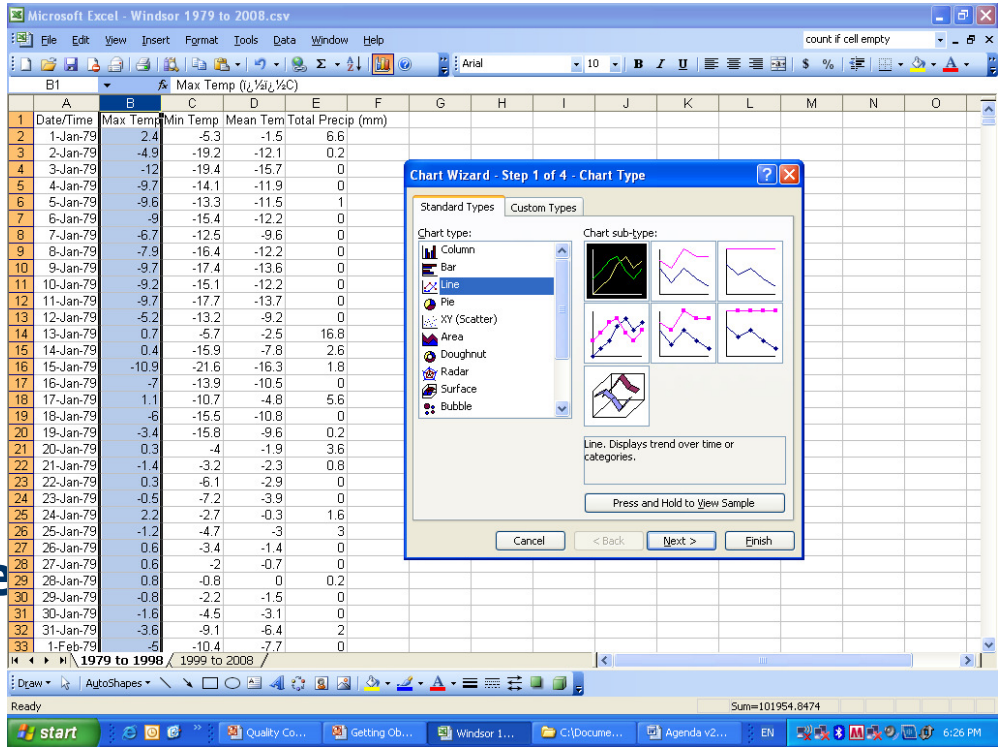
i.e. Tmean falls between Tmax and Tmin



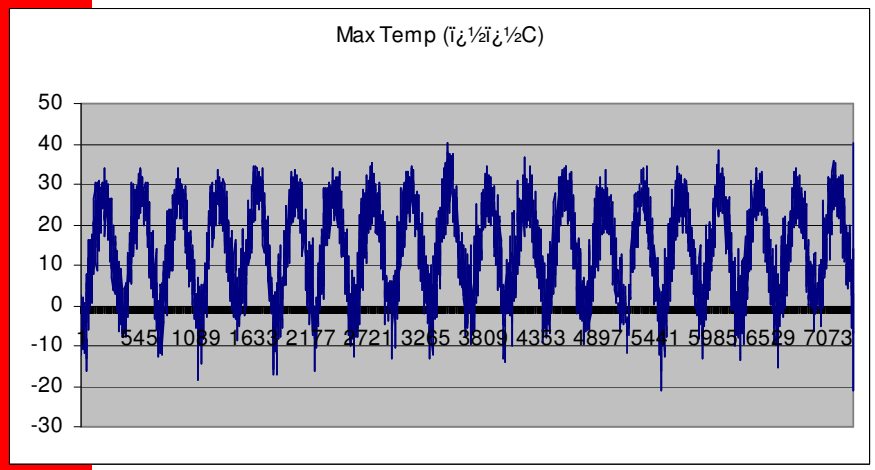
	A	B	C	D	E
7277	7-Dec-98	8.2	2	5.1	0.6
7278	8-Dec-98	6	0.9	3.5	0
7279	9-Dec-98	9	-0.8	4.1	0
7280	10-Dec-98	7.8	-1.1	3.4	0
7281	11-Dec-98	8.3	-1.1	3.6	0
7282	12-Dec-98	8.1	-1.7	3.2	0
7283	13-Dec-98	9.1	-2.5	3.3	0
7284	14-Dec-98	6.1	-2.5	1.8	0
7285	15-Dec-98	11.3	-0.1	5.6	0
7286	16-Dec-98	4.8	-0.6	2.1	7.2
7287	17-Dec-98	2.6	-2.9	-0.2	0
7288	18-Dec-98	6.4	-4.6	0.9	0
7289	19-Dec-98	7.6	-0.7	3.5	5.8
7290	20-Dec-98	4.3	-1.5	1.4	0.4
7291	21-Dec-98	6.6	-3.6	1.5	10
7292	22-Dec-98	-3.6	-11.3	-7.5	0
7293	23-Dec-98	-5.7	-12.1	-8.9	0
7294	24-Dec-98	-2.4	-9.8	-6.1	0
7295	25-Dec-98	-1.3	-8.7	-5	0
7296	26-Dec-98	1.1	-8.7	-3.8	0
7297	27-Dec-98	4	-8.7	-2.4	0
7298	28-Dec-98	4.8	-4.9	-0.1	0
7299	29-Dec-98	3	-11.2	-4.1	2.8
7300	30-Dec-98	-6.8	-12.3	-9.6	0
7301	31-Dec-98	-6.3	-9.1	-7.7	1.6
7302					
7303	Max	40.2	25.3	31	89
7304	Min	-20.9	-29.1	-25	0
7305	Mean	14.08034	5.02472	9.567441	2.572515
7306	StDev	11.36711	9.926756	10.52908	6.44172
7307					
7308					
7309					

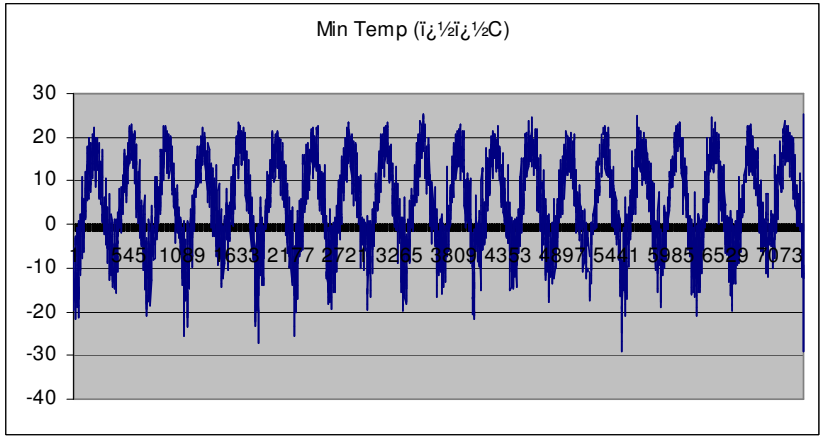
View Data

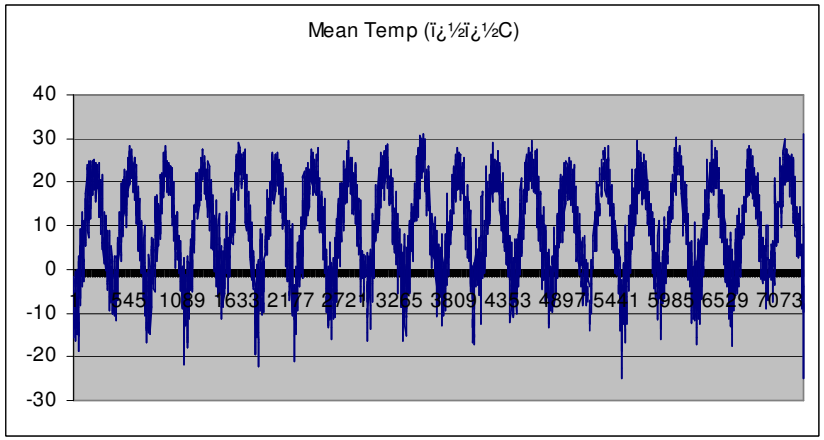
- **Select column**
- **Select Chart Wizard Icon**
- **Select Line Chart**
- **Select Chart sub-type**



View Data for Tmax, Tmin, Tmean

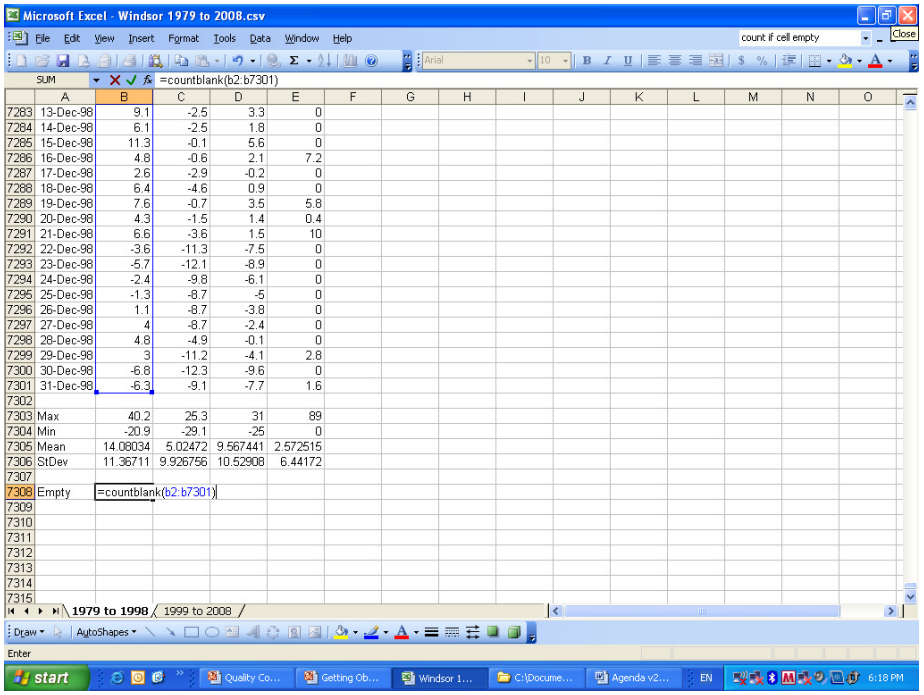






Missing Data

- Count empty cells (=countblank(range))
- 3 and 5 rule
- If 3 consecutive days data missing in month, then cannot use that month's data
- If 5 days of data missing in month, then cannot use that month's data

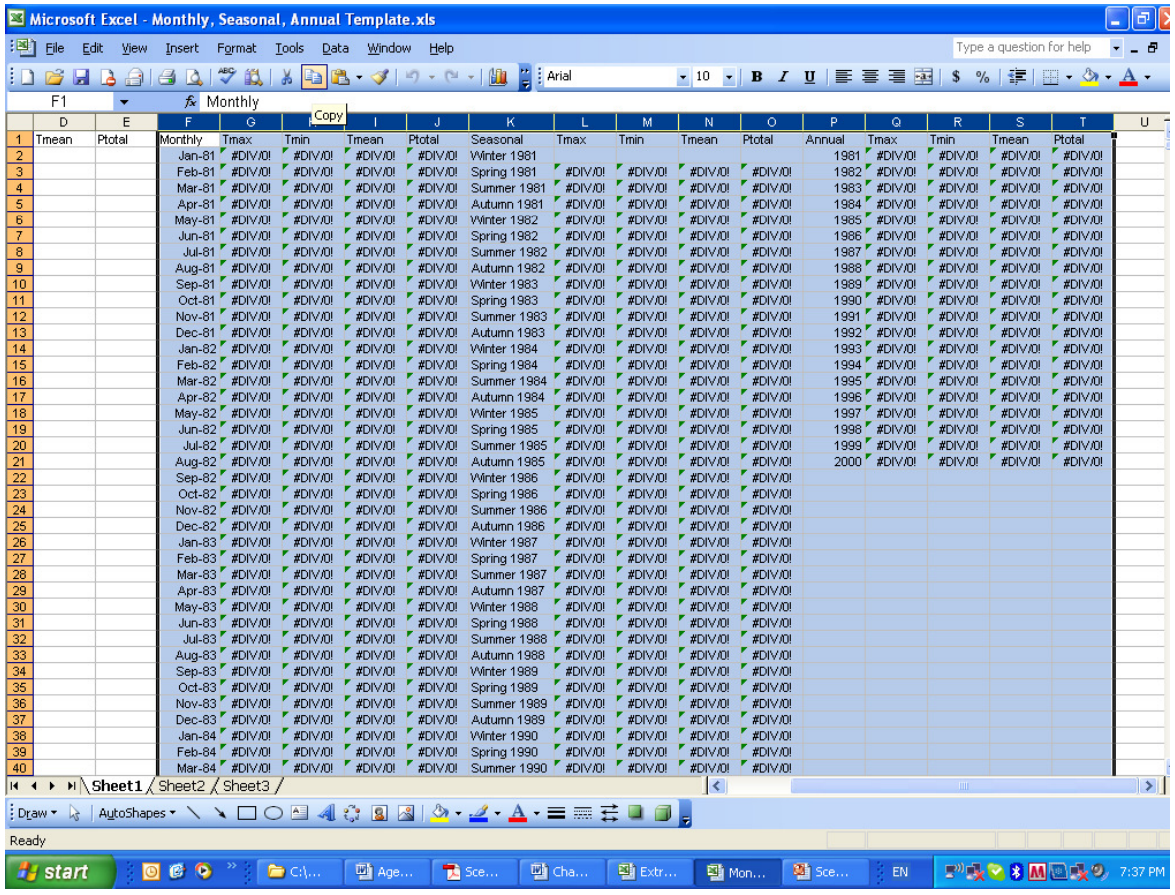


3. Data Summaries

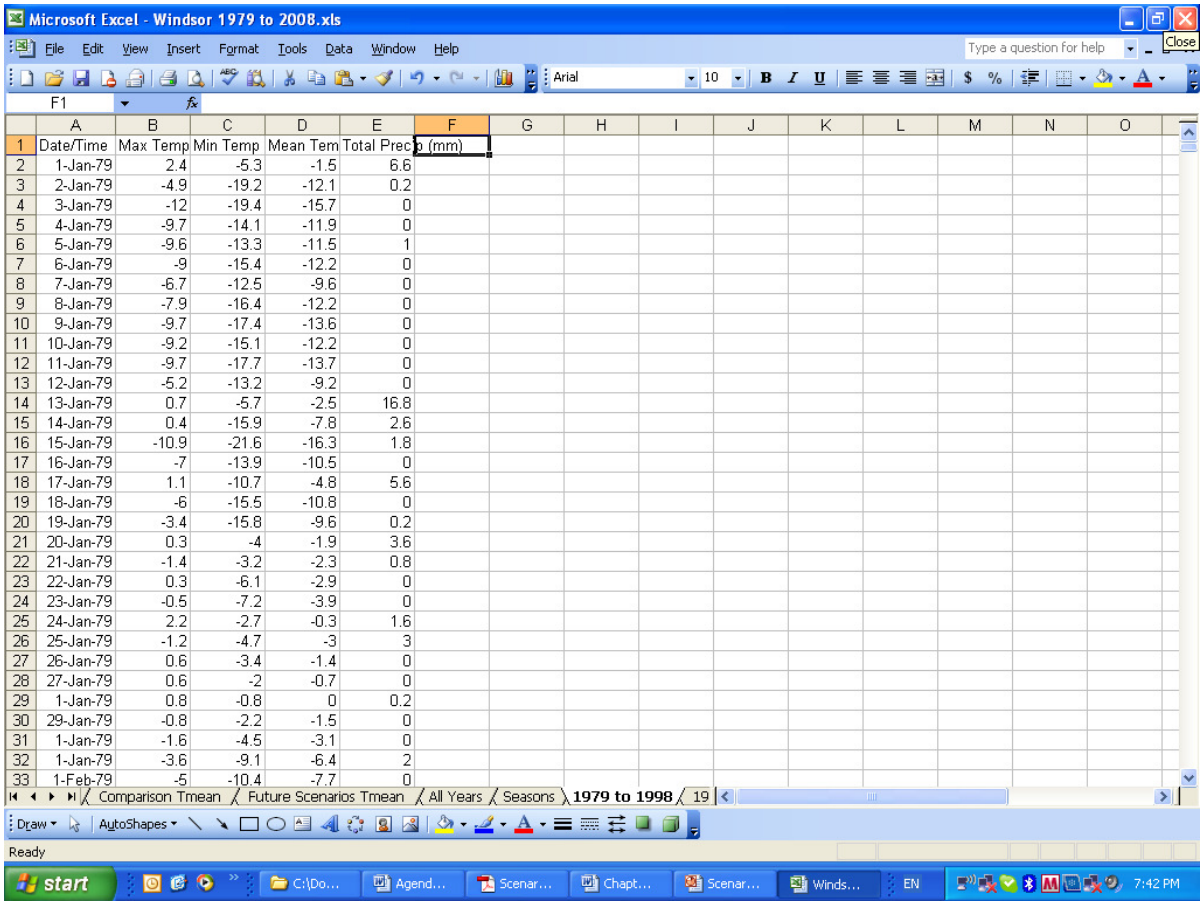
Go get the

“Monthly, Seasonal, Annual Template”

Copy columns F to T

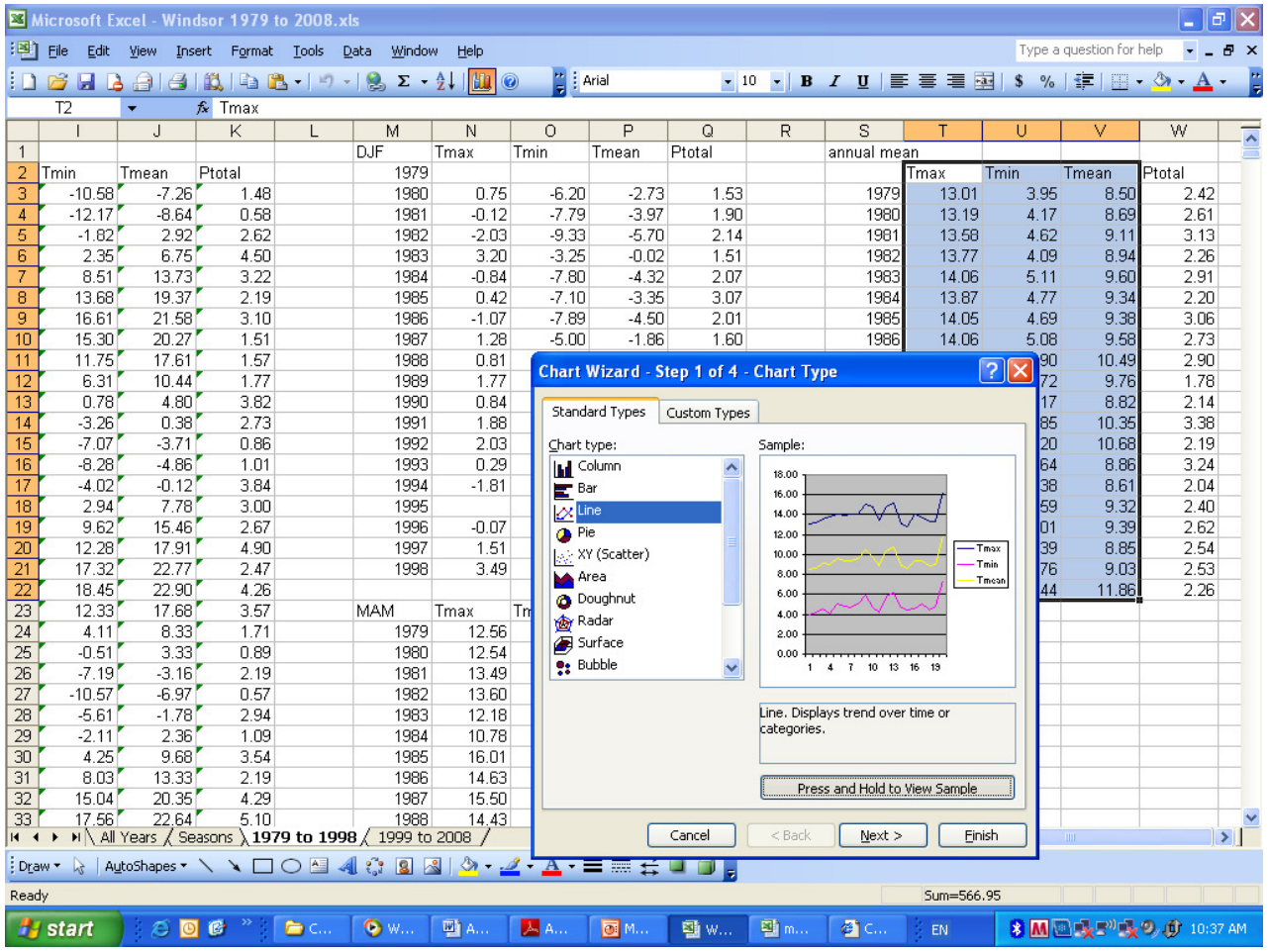


Paste into 30-year climate worksheet at cell F1



	A	B	C	D	E	F
1	Date/Time	Max Temp	Min Temp	Mean Tem	Total Precip (mm)	
2	1-Jan-79	2.4	-5.3	-1.5	6.6	
3	2-Jan-79	-4.9	-19.2	-12.1	0.2	
4	3-Jan-79	-12	-19.4	-15.7	0	
5	4-Jan-79	-9.7	-14.1	-11.9	0	
6	5-Jan-79	-9.6	-13.3	-11.5	1	
7	6-Jan-79	-9	-15.4	-12.2	0	
8	7-Jan-79	-6.7	-12.5	-9.6	0	
9	8-Jan-79	-7.9	-16.4	-12.2	0	
10	9-Jan-79	-9.7	-17.4	-13.6	0	
11	10-Jan-79	-9.2	-15.1	-12.2	0	
12	11-Jan-79	-9.7	-17.7	-13.7	0	
13	12-Jan-79	-5.2	-13.2	-9.2	0	
14	13-Jan-79	0.7	-5.7	-2.5	16.8	
15	14-Jan-79	0.4	-15.9	-7.8	2.6	
16	15-Jan-79	-10.9	-21.6	-16.3	1.8	
17	16-Jan-79	-7	-13.9	-10.5	0	
18	17-Jan-79	1.1	-10.7	-4.8	5.6	
19	18-Jan-79	-6	-15.5	-10.8	0	
20	19-Jan-79	-3.4	-15.8	-9.6	0.2	
21	20-Jan-79	0.3	-4	-1.9	3.6	
22	21-Jan-79	-1.4	-3.2	-2.3	0.8	
23	22-Jan-79	0.3	-6.1	-2.9	0	
24	23-Jan-79	-0.5	-7.2	-3.9	0	
25	24-Jan-79	2.2	-2.7	-0.3	1.6	
26	25-Jan-79	-1.2	-4.7	-3	3	
27	26-Jan-79	0.6	-3.4	-1.4	0	
28	27-Jan-79	0.6	-2	-0.7	0	
29	1-Jan-79	0.8	-0.8	0	0.2	
30	29-Jan-79	-0.8	-2.2	-1.5	0	
31	1-Jan-79	-1.6	-4.5	-3.1	0	
32	1-Jan-79	-3.6	-9.1	-6.4	2	
33	1-Feb-79	-5	-10.4	-7.7	0	

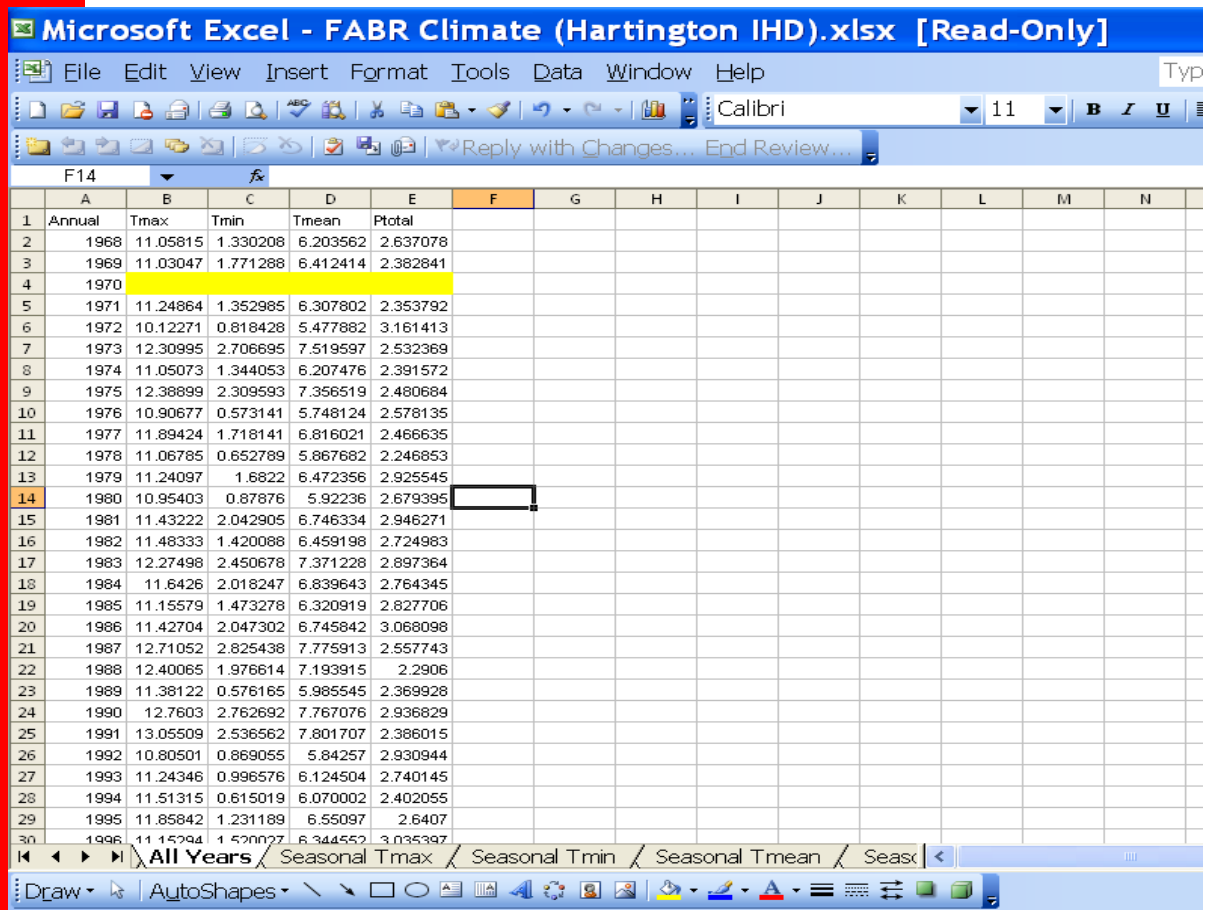
Select columns to view and chart



3. Analyzing Climate Data

1. Annual, Seasonal and Monthly Climate Data
2. Climate indices
3. International/IPCC/national climate indices
4. Calculating climate indices

1. Annual, Seasonal and Monthly Climate Data



Microsoft Excel - FABR Climate (Hartington IHD).xlsx [Read-Only]

File Edit View Insert Format Tools Data Window Help

Calibri 11

Reply with Changes... End Review...

F14

	A	B	C	D	E
1	Annual	Tmax	Tmin	Tmean	Ptotal
2	1968	11.05815	1.330208	6.203562	2.637078
3	1969	11.03047	1.771288	6.412414	2.382841
4	1970				
5	1971	11.24864	1.352985	6.307802	2.353792
6	1972	10.12271	0.818428	5.477882	3.161413
7	1973	12.30995	2.706695	7.519597	2.532369
8	1974	11.05073	1.344053	6.207476	2.391572
9	1975	12.38899	2.309593	7.356519	2.480684
10	1976	10.90677	0.573141	5.748124	2.578135
11	1977	11.89424	1.718141	6.816021	2.466635
12	1978	11.06785	0.652789	5.867682	2.246853
13	1979	11.24097	1.6822	6.472356	2.925545
14	1980	10.95403	0.87876	5.92236	2.679395
15	1981	11.43222	2.042905	6.746334	2.946271
16	1982	11.48333	1.420088	6.459198	2.724983
17	1983	12.27498	2.450678	7.371228	2.897364
18	1984	11.6426	2.018247	6.839643	2.764345
19	1985	11.15579	1.473278	6.320919	2.827706
20	1986	11.42704	2.047302	6.745842	3.068098
21	1987	12.71052	2.825438	7.775913	2.557743
22	1988	12.40065	1.976614	7.193915	2.2906
23	1989	11.38122	0.576165	5.985545	2.369928
24	1990	12.7603	2.762692	7.767076	2.936829
25	1991	13.05509	2.536562	7.801707	2.386015
26	1992	10.80501	0.869055	5.84257	2.930944
27	1993	11.24346	0.996576	6.124504	2.740145
28	1994	11.51315	0.615019	6.070002	2.402055
29	1995	11.85842	1.231189	6.55097	2.6407
30	1996	11.15294	1.520027	6.344552	3.035397

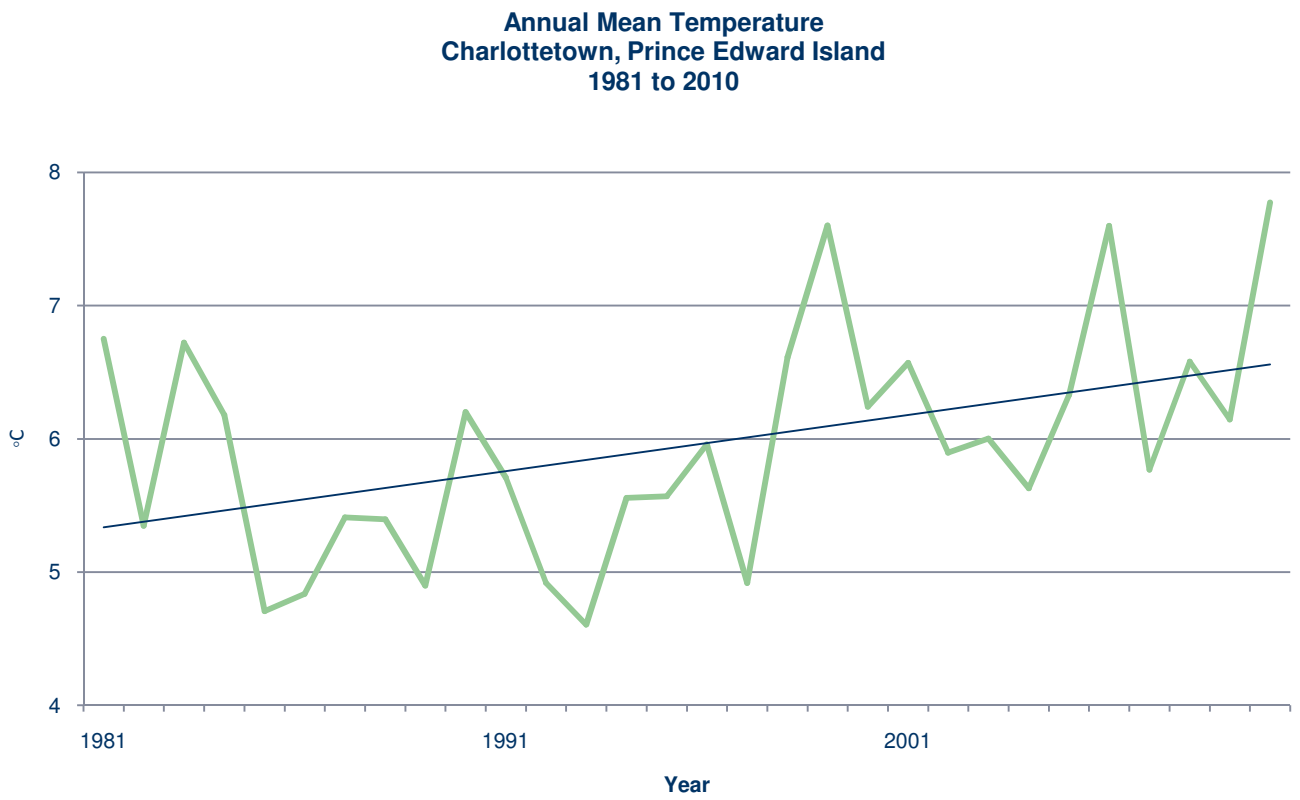
All Years / Seasonal Tmax / Seasonal Tmin / Seasonal Tmean / Seasc

Draw AutoShapes

In Annual Summaries

*indicate missing data with highlites

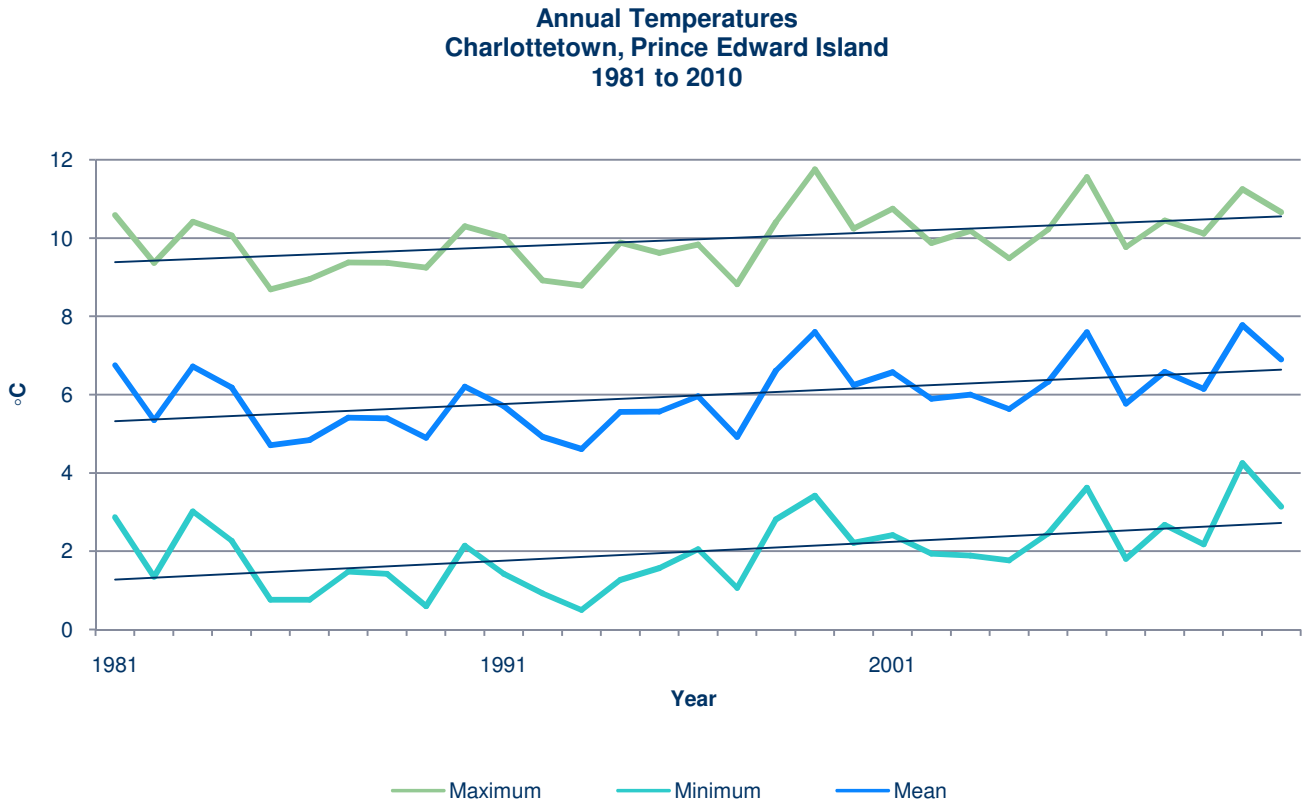
Annual Mean Temperature



Graph Tmean with linear trend line

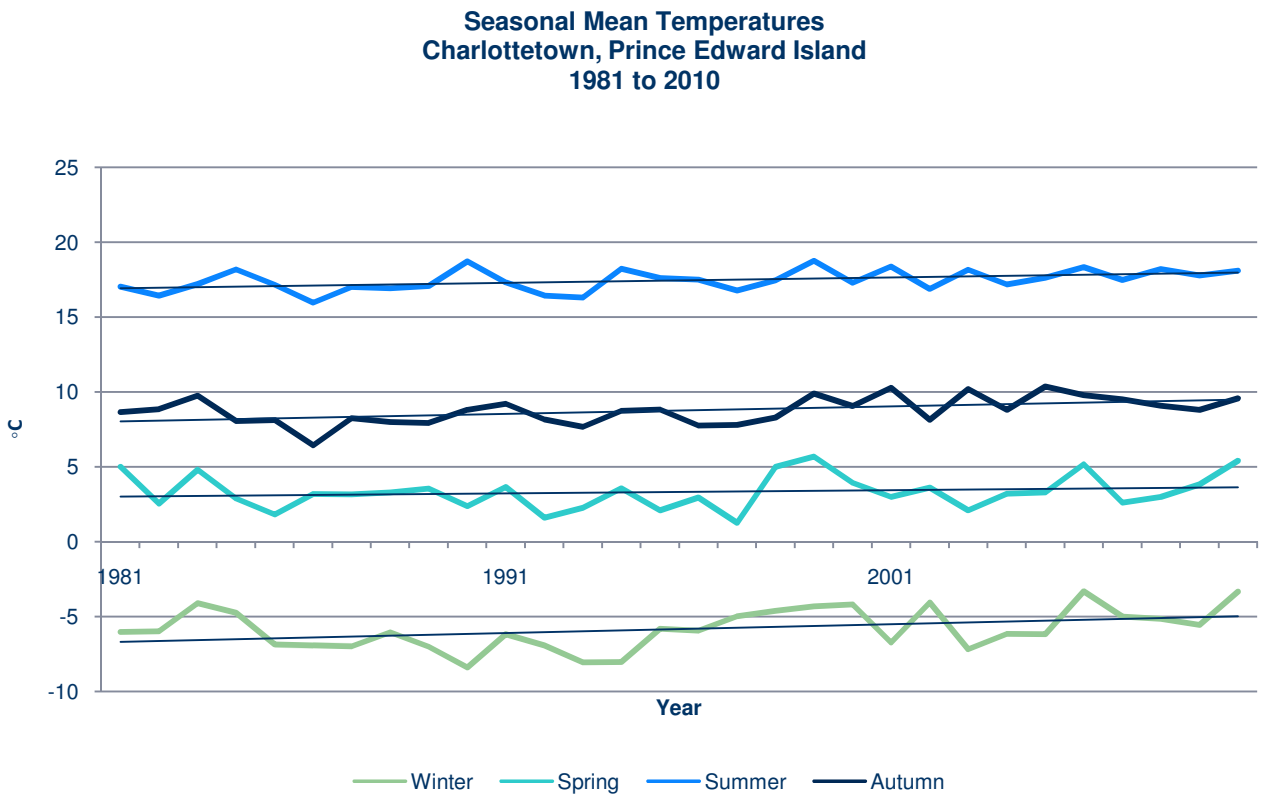
*remember means can hide large changes

Determine driver of Tmean changes



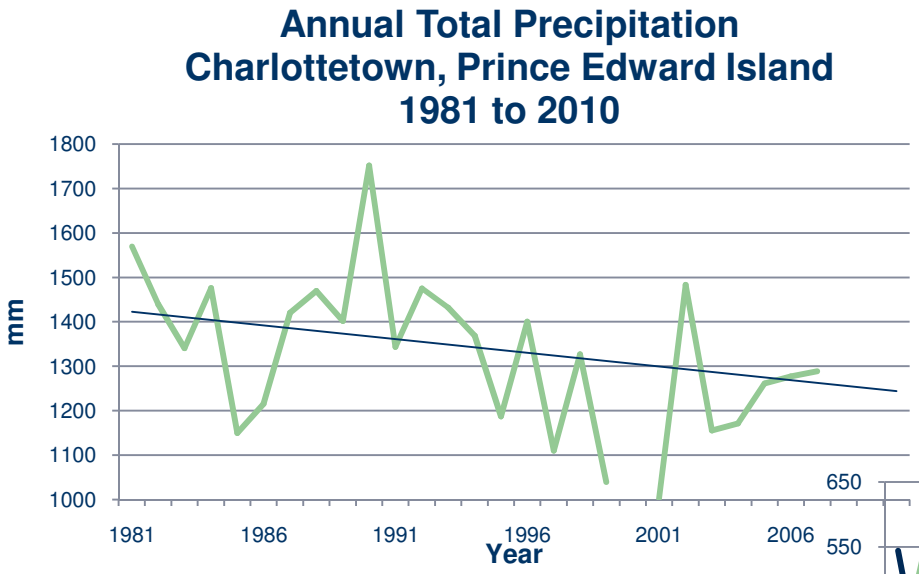
Graph Tmean, Tmax and Tmin

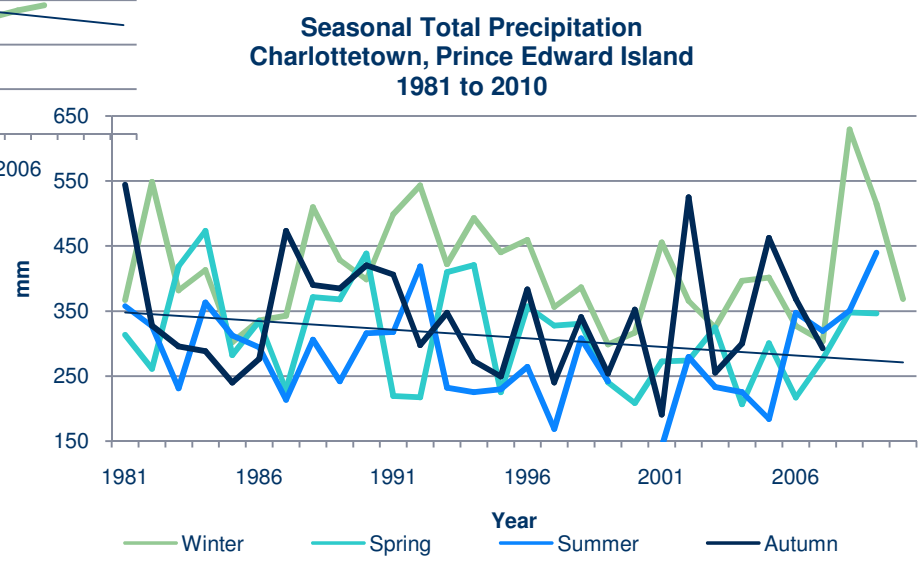
Determine Seasonal Driver



Graph seasonal data to determine driver

Do same with Ptotal





2. Climate Indices

Ott, W. 1978. Environmental Indices: Theory and Practice

Indices are used to summarize and present a complex set of multivariate (several variables at the same time) changes so that the results can be easily understood and used in policy decisions made by non-specialists in the field.

Over 400 Climate Indices

ClimDex. 2001. ClimDex Version 3.1: User's Guide. cccma.seos.uvic.ca/ETCCDMI/ClimDex/climdex-v1-3-users-guide.pdf

Frich, P., L. V. Alexander, P. Della-Manta, B. Gleason, M. Haylock, A. M. G. Klein Tank and T. Peterson. 2002. Observed coherent changes in climatic extremes during the second half of the twentieth century. Clim. Res., 19:193-212.

European Climate Assessment. 2008. European Climate Assessment and Dataset. eca.knmi.nl/

Klein Tank, A.M.G., J.B. Wijngaard, G.P. Können, R. Böhm, G. Demarée, A. Gocheva, M. Mileta, S. Pashiardis, L. Hejkrlik, C. Kern-Hansen, R. Heino, P. Bessemoulin, G. Müller-Westermeier, M. Tzanakou, S. Szalai, T. Pálsdóttir, D. Fitzgerald, S. Rubin, M. Capaldo, M. Maugeri, A. Leitass, A. Bukantis, R. Aberfeld, A.F.V. van Engelen, E. Forland, M. Mietus, F. Coelho, C. Mares, V. Razuvaev, E. Nieplova, T. Cegnar, J. Antonio López, B. Dahlström, A. Moberg, W. Kirchhofer, A. Ceylan, O. Pachaliuk, L.V. Alexander, and P. Petrovic, 2002. Daily dataset of 20th-century surface air temperature and precipitation series for the European Climate Assessment. Int. J. Climatol., 22, 1441-1453.

Kiktev, D., D. Sexton, L. Alexander and C. Folland. 2003. Comparison of modelled and observed trends in indicators of daily climate extremes. J. Clim., 16, 3560-71.

Stardex. 2008. Statistical and Regional dynamical Downscaling of Extremes for European regions. www.cru.uea.ac.uk/projects/stardex

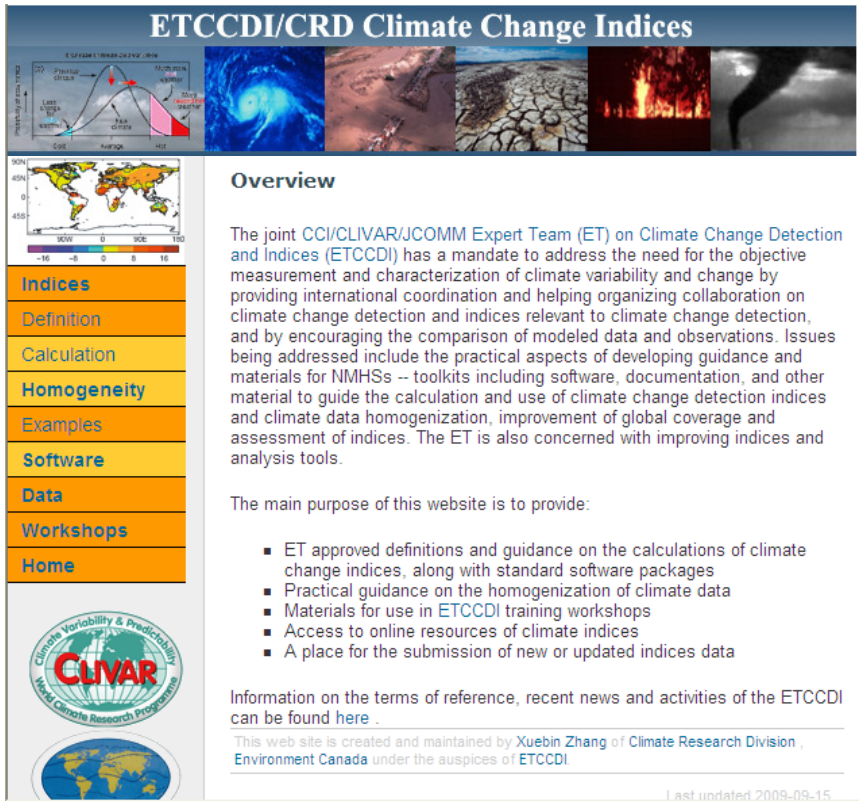
Bonsal, B.R., X. Zhang, L.A. Vincent and W.D. Hogg. 2001. Characteristics of daily and extreme temperatures over Canada. Journal of Climate 14 :1959-1976.

Klein Tank, A.M.G. and G.P. Können, 2003. Trends in indices of daily temperature and precipitation extremes in Europe, 194699. J. Climate, 16, 3665-3680.

3. International/IPCC/National Climate Indices

- International - WMO CCI/CLIVAR/JCOMM
- Xuebin Zhang Environment Canada
- Uses free statistical package “R”
- Does QC, homogeneity testing and creates 27 indices

- cccma.seos.uvic.ca/ETCCDMI/



Intergovernmental Panel on Climate Change (IPCC)

Extremes indices

The following ten "extremes indices" are described in Frich, P, Alexander LV, Della-Marta P, Gleason B, Haylock M, Klein Tank AMG, Peterson T, 2002: Observed coherent changes in climate extremes during the second half of the twentieth century, *Climate Research 19*: 193-212. Frich et al. describe these as "derived data in the form of annual indicator time series" and present them (as derived from observations) as a function of longitude, latitude, and year. See http://www.cru.uea.ac.uk/cru/projects/stardex for sample computer code and documentation.

Table A4: **Extremes indices (longitude, latitude, time:year) from Frich et al. (their Table 1).**

	output variable name	units	notes
1	fd	days	Total number of frost days (days with absolute minimum temperature < 0 deg C)
2	etr	K	Intra-annual extreme temperature range: difference between the highest temperature of any given calendar year (T_h) and the lowest temperature of the same calendar year (T_l)
3	gsl	days	Growing season length: period between when T_{day} > 5 deg C for > 5 d and T_{day} < 5 deg C for > 5 d
4	hwdi	days	Heat wave duration index: maximum period > 5 consecutive days with T_{max} > 5 deg C above the 1961-1990 daily T_{max} normal
5	tn90	%	Fraction (expressed as a percentage) of time T_{min} > 90th percentile of daily minimum temperature, where percentiles are for the 1961-1990 base period.
6	r10	days	No. of days with precipitation greater than or equal to 10 mm d^{-1}
7	cdd	days	Maximum number of consecutive dry days (R_{day} < 1 mm)
8	r5d	kg m^{-2}	Maximum 5 d precipitation total
9	sdii	kg m^{-2} s^{-1}	Simple daily intensity index: annual total / number of R_{day} greater than or equal to 1 mm d^{-1}
10	r95t	%	Fraction (expressed as a percentage) of annual total precipitation due to events exceeding the 1961-1990 95th percentile

National
Gachon Indices of Climate Extremes

18 indices for extreme temperature and precipitation for Canadian regions

- must represent regional Canadian climate conditions;
- must be relevant to climate change impact studies; and
- must be adapted to the main characteristics of climate conditions at the regional scale.

"providing a good mix of information – precipitation indices characterize the frequency, intensity, length of dry spells, magnitude and occurrence of wet extremes while temperature indices refer to variability, season lengths and cold and warm extremes in terms of magnitude, occurrence and duration."

Gachon Indices of Climate Extremes

INDEX		DEFINITION	UNIT	TIME SCALE
Frequency		Percentage of wet days (Threshold=1 mm)	% days	Season
Intensity		Simple daily intensity index : sum of daily precip/number of wet days	mm/wet d	Season
Extremes		Maximum number of consecutive dry days (<1 mm)	days	Season
Magnitude		Maximum 3-days precipitation total	mm	Season
and		90th percentile of rainday amount ((Threshold=1 mm)	mm/days	Season
Occurrence		Percentage of days Prec>90th percentile (61-90 based period)	% days	Season

Gachon Indices of Climate Extremes 2

Daily variability		Mean of diurnal temperature range	°C	Season
		Percentage of days with freeze and thaw cycle (Tmax>0°C, Tmin<0°C)	% days	Month
Season length		Frost season length :Tday<0°C more than 6 d.and Tday>0°C more than 6 d.	days	Year
		Growing season length :Tday>5°C more than 6d.and Tday<5°C more than 6 d.	days	Year
Extremes		Sum of sequences > 3 days where Tmin< daily Tmin normal - 5°C	days	Winter
cold & hot		Sum of sequences > 3 days where Tmax> daily Tmax normal + 3°C	days	summer
Extremes		10th percentile of daily Tmax	°C	Season
Magnitude		90th percentile of daily Tmax	°C	Season
and		10th percentile of daily Tmin	°C	Season
		90th percentile of daily Tmin	°C	Season
Occurrence		Percentage of days Tmax>90th percentile (61-90 based period)	% days	Season
		Percentage of days Tmin<10th percentile (61-90 based period)	% days	Season

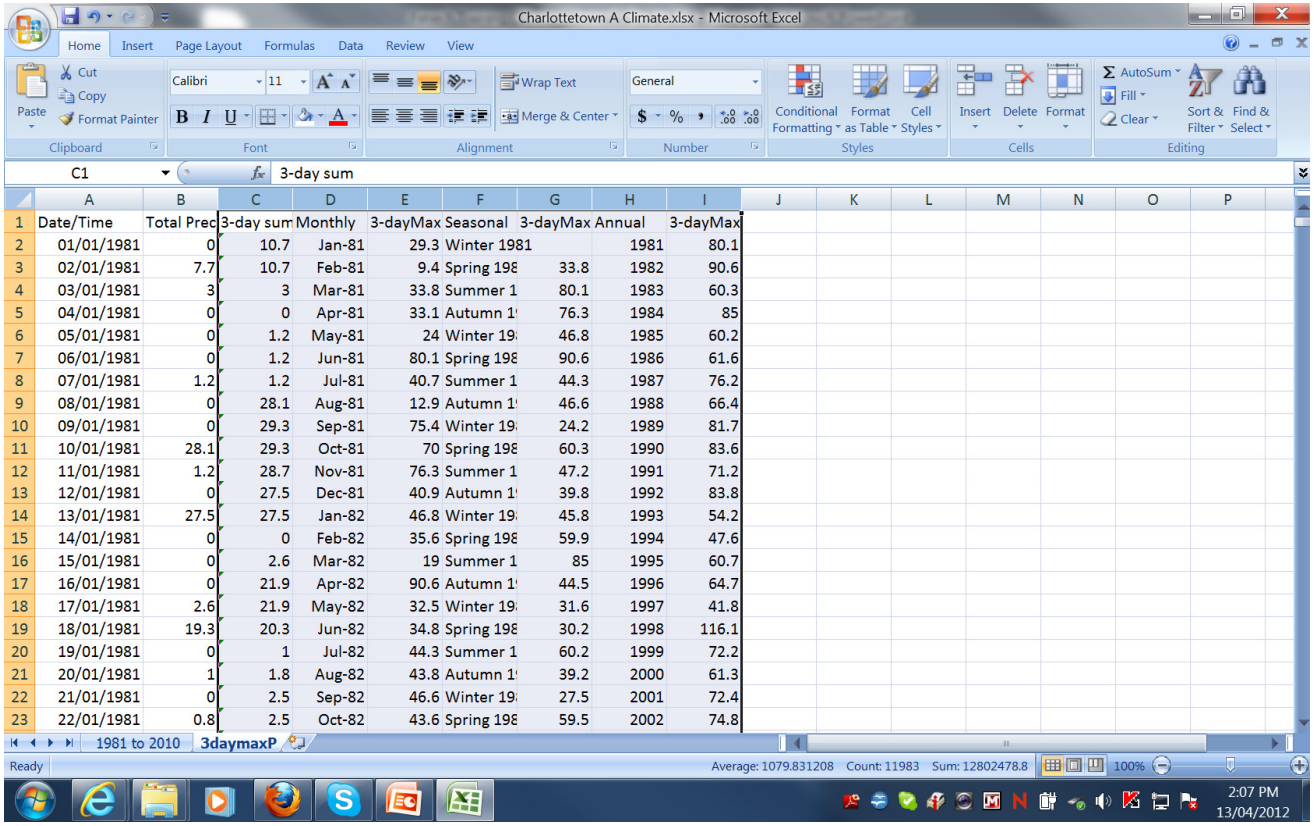
4. Calculating Climate Indices

An example – 3 day Max P

1. Create new worksheet 3 day Max P
2. Select Date and Ptotal columns from 30-year climate dataset
3. Cut and Paste into new worksheet

Identify max for each season

Use template to fill



	A	B	C	D	E	F	G	H	I
1	Date/Time	Total Prec	3-day sum	Monthly	3-dayMax	Seasonal	3-dayMax	Annual	3-dayMax
2	01/01/1981	0	10.7	Jan-81	29.3	Winter 1981		1981	80.1
3	02/01/1981	7.7	10.7	Feb-81	9.4	Spring 198	33.8	1982	90.6
4	03/01/1981	3	3	Mar-81	33.8	Summer 1	80.1	1983	60.3
5	04/01/1981	0	0	Apr-81	33.1	Autumn 1	76.3	1984	85
6	05/01/1981	0	1.2	May-81	24	Winter 19	46.8	1985	60.2
7	06/01/1981	0	1.2	Jun-81	80.1	Spring 198	90.6	1986	61.6
8	07/01/1981	1.2	1.2	Jul-81	40.7	Summer 1	44.3	1987	76.2
9	08/01/1981	0	28.1	Aug-81	12.9	Autumn 1	46.6	1988	66.4
10	09/01/1981	0	29.3	Sep-81	75.4	Winter 19	24.2	1989	81.7
11	10/01/1981	28.1	29.3	Oct-81	70	Spring 198	60.3	1990	83.6
12	11/01/1981	1.2	28.7	Nov-81	76.3	Summer 1	47.2	1991	71.2
13	12/01/1981	0	27.5	Dec-81	40.9	Autumn 1	39.8	1992	83.8
14	13/01/1981	27.5	27.5	Jan-82	46.8	Winter 19	45.8	1993	54.2
15	14/01/1981	0	0	Feb-82	35.6	Spring 198	59.9	1994	47.6
16	15/01/1981	0	2.6	Mar-82	19	Summer 1	85	1995	60.7
17	16/01/1981	0	21.9	Apr-82	90.6	Autumn 1	44.5	1996	64.7
18	17/01/1981	2.6	21.9	May-82	32.5	Winter 19	31.6	1997	41.8
19	18/01/1981	19.3	20.3	Jun-82	34.8	Spring 198	30.2	1998	116.1
20	19/01/1981	0	1	Jul-82	44.3	Summer 1	60.2	1999	72.2
21	20/01/1981	1	1.8	Aug-82	43.8	Autumn 1	39.2	2000	61.3
22	21/01/1981	0	2.5	Sep-82	46.6	Winter 19	27.5	2001	72.4
23	22/01/1981	0.8	2.5	Oct-82	43.6	Spring 198	59.5	2002	74.8

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