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Supplemental Climate Information: Nipigon (Lake Superior NMCA Office)

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Contents

Preface

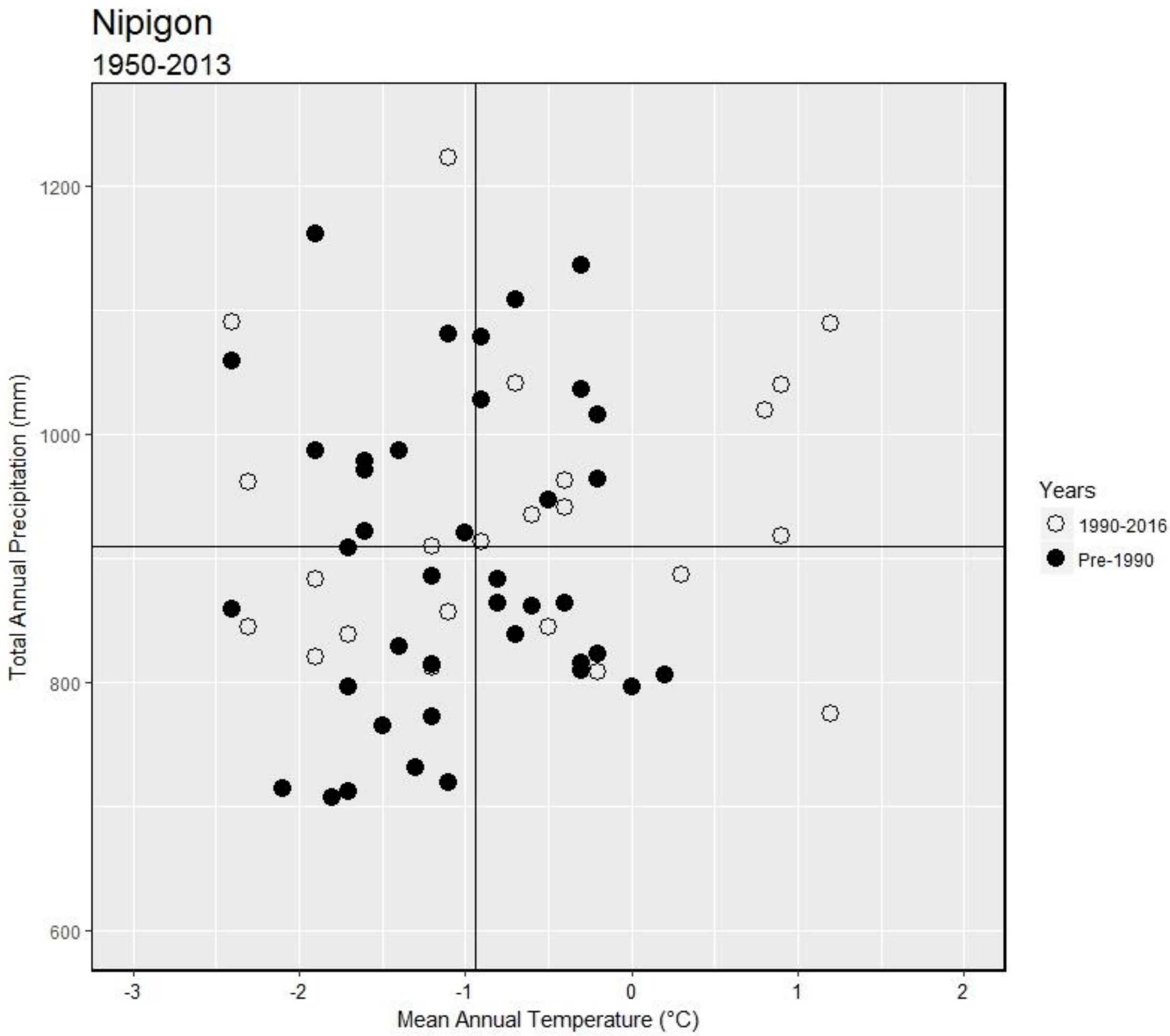
This document is a detailed supplement to the "Let's Talks about Climate Change: Great Lakes Region" report (Parker, 2017) and is intended to support climate change discussions and planning for the Parks Canada facilities in Nipigon, Ontario (Lake Superior National Marine Conservation Area).

Future climate projections are modelled with several greenhouse gas concentration trajectories, called **Representative Concentration Pathways (RCP)** (Vuuren *et al.*, 2011). They describe possible climate futures and are named after respective radiative forcing values in the year 2100 relative to pre-industrial values (i.e., +2.6, +4.5 and +8.5 watts/m^2). **RCP 2.6** assumes we take action and greenhouse gas emissions peak in 2010-2020 and decline thereafter. **RCP 4.5** assumes emissions peak around 2040 and then decline. **RCP 8.5** assumes we take no action and emissions continue to rise throughout the 21st century.

<u>Disclaimer</u>

Views, statements, findings and conclusions are solely those of the author and do not necessarily reflect the views and policies of Parks Canada. Although the author has made every effort to ensure that the information is accurate, complete and correct, neither Parks Canada nor the author can guarantee its integrity. Readers are encouraged to review original sources.

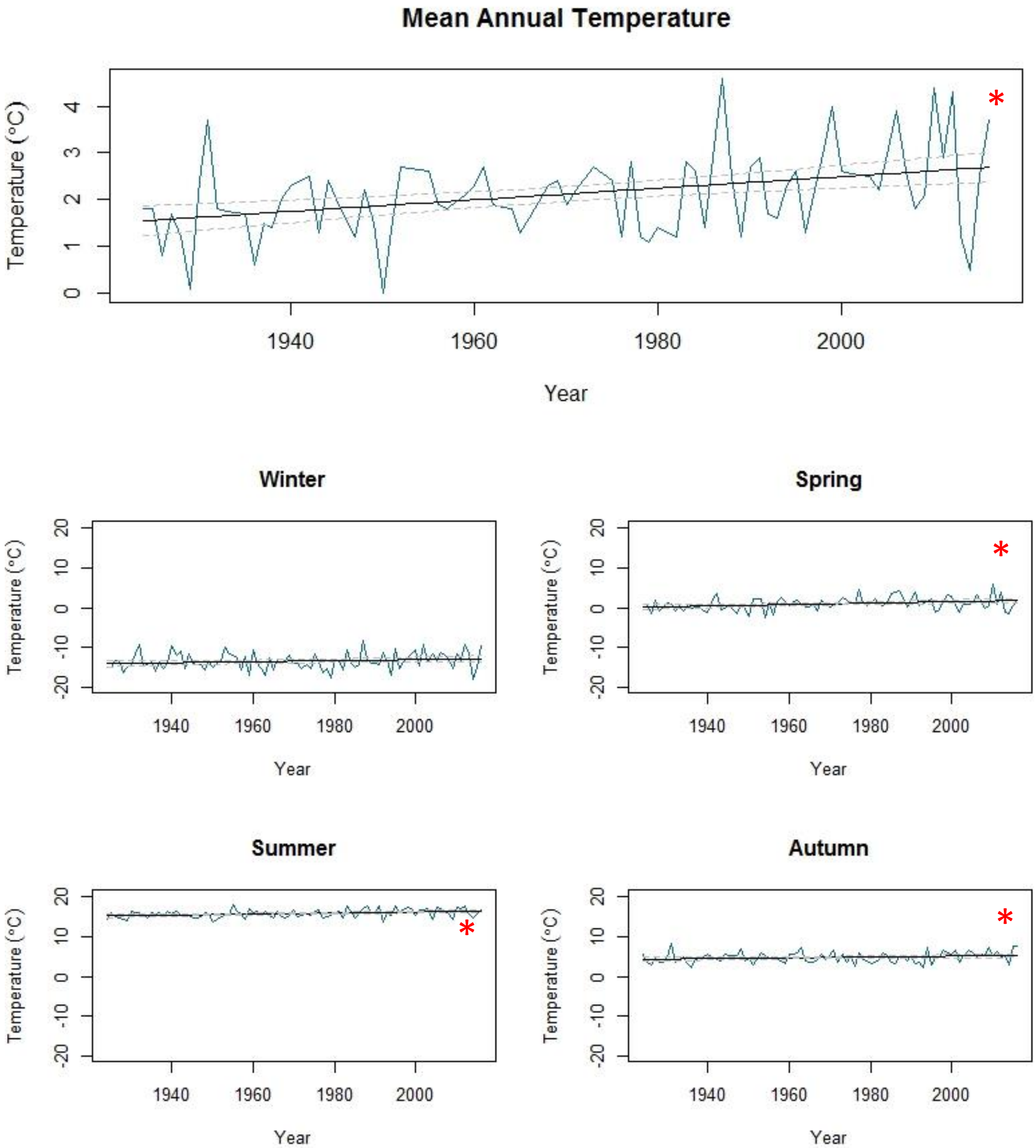
1. Observed Climate Trends



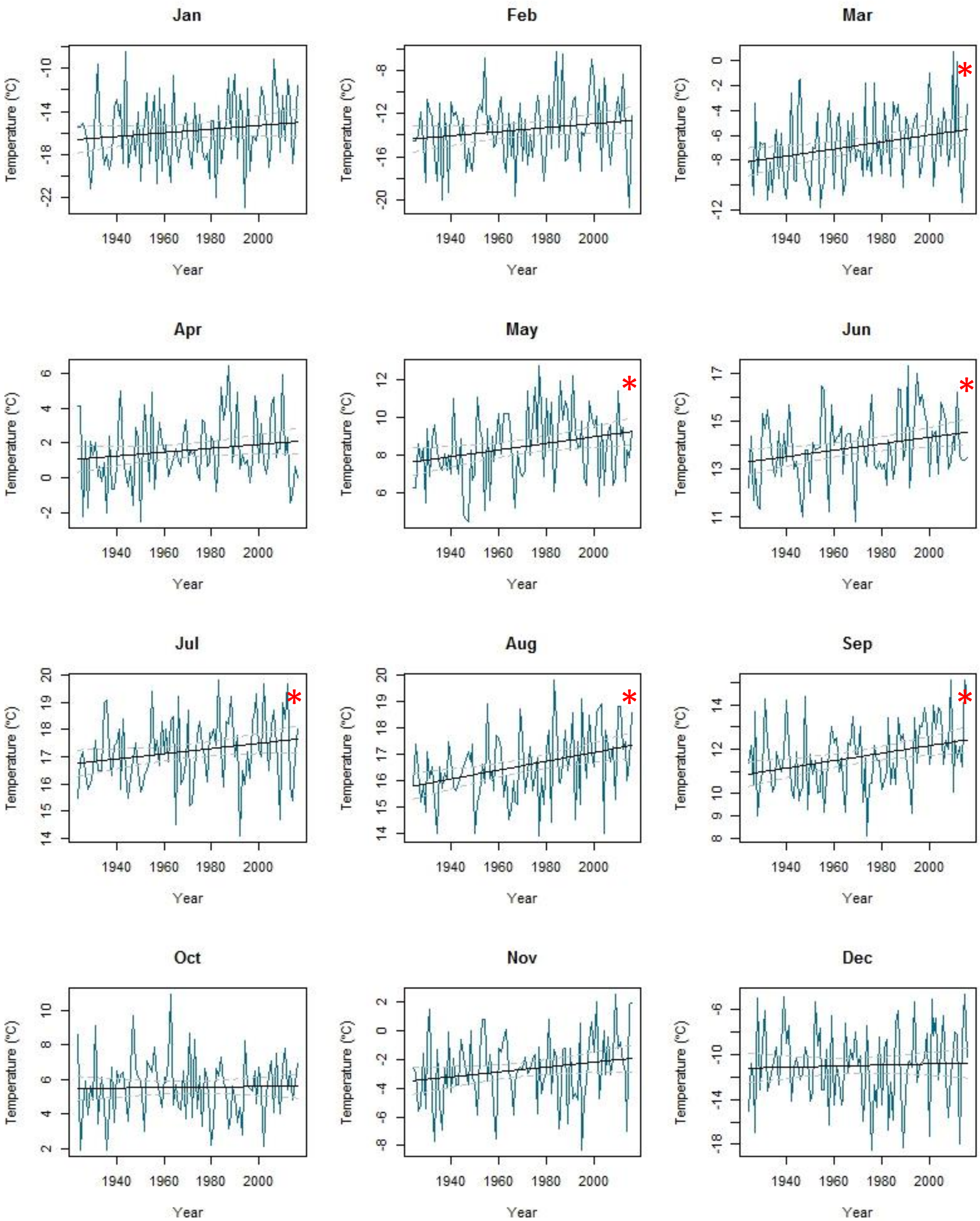
Scatter plot of mean annual temperature and total annual precipitation for each year from 1950 to 2013 for Nipigon, ON. This is interpolated data from ClimateNA v5.10 software package, available at *http://tinyurl.com/ClimateNA*, based on methodology described by (Wang *et al.*, 2016).

1.1 Temperature

Mean annual and seasonal temperature from the Cameron Falls meteorological station (just north of Nipigon) from 1924 to 2016. Trend determined using a generalized linear model (GLM) including 95% confidence intervals (R Core Team, 2014). "*" = statistically significant trend ($P<0.05$).



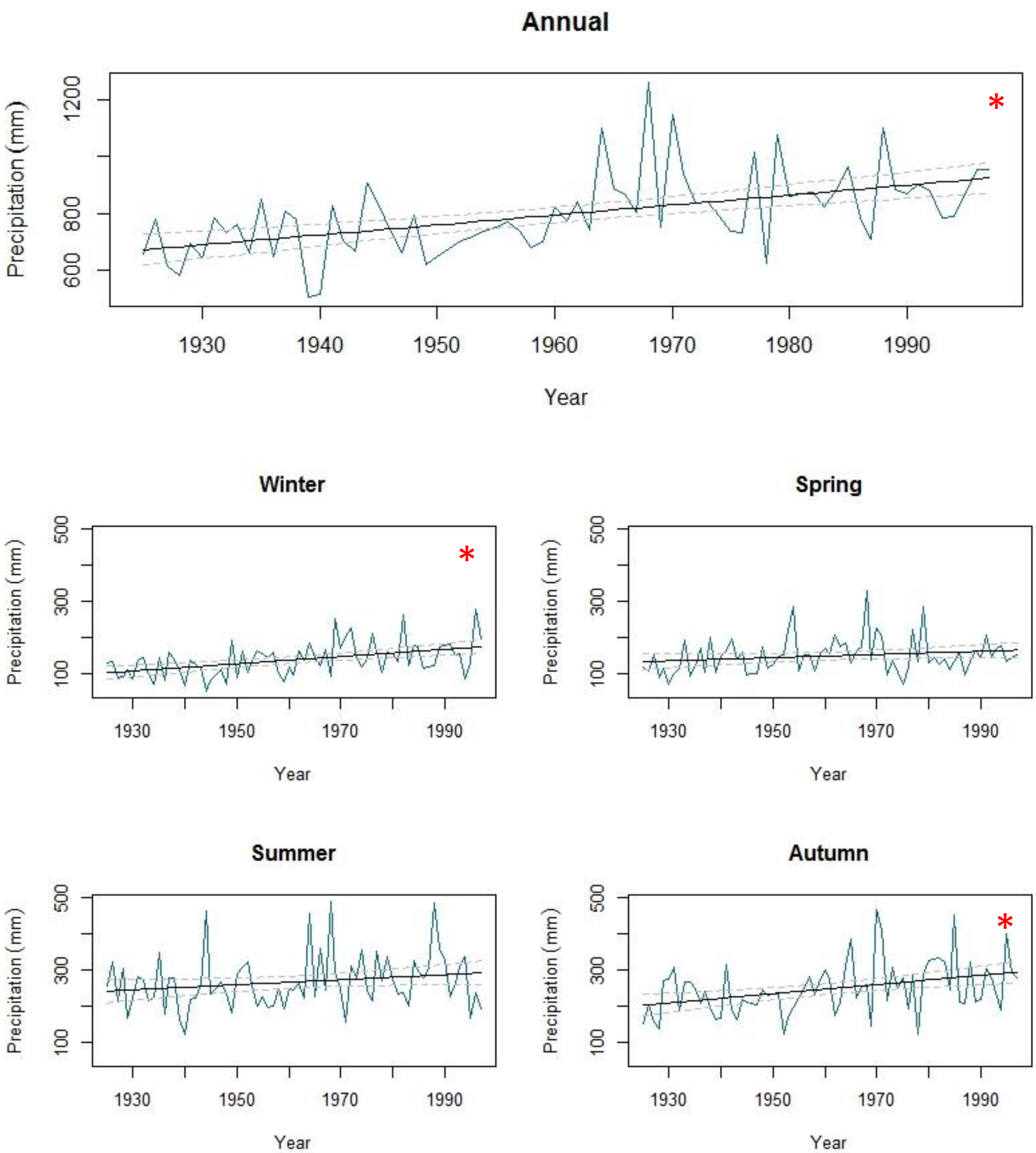
Cameron Falls mean annual and seasonal temperature. Statistically significant ($P<0.05$) increase in mean annual temperature, ~1.1˚C increase from 1924 to 2016. Greatest increase observed in spring (Mar, Apr, May), ~1.9˚C increase from 1924 to 2016.



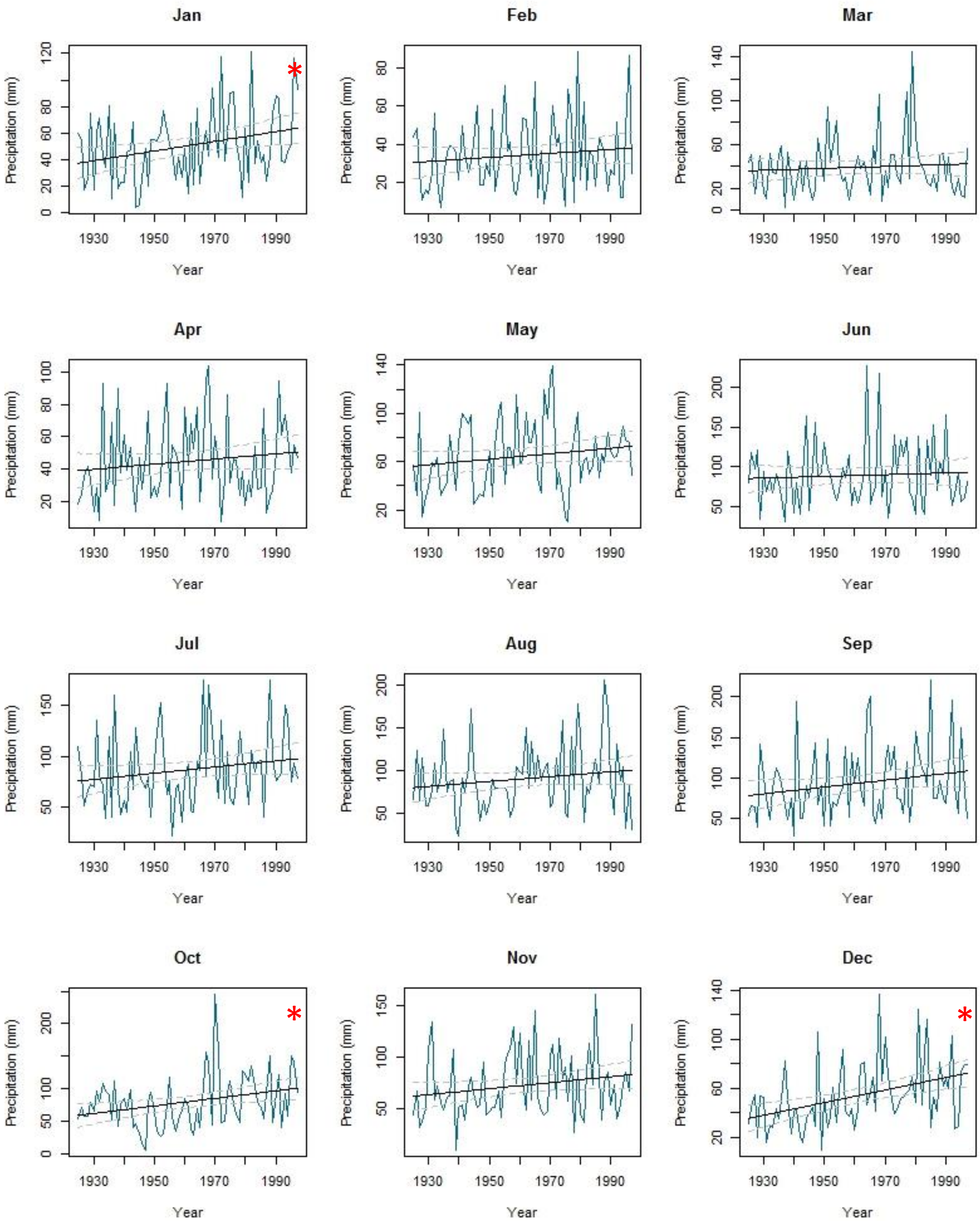
Cameron Falls mean monthly temperature. Mar, May, Jun, Jul, Aug, and Sep all demonstrated a statistically significant ($P<0.05$) increase. The greatest increase was observed for Mar, ~3°C since 1924.

1.2 Precipitation

Mean annual and seasonal total precipitation at the Cameron Falls meteorological station (just north of Nipigon) from 1925 to 1998. Trend determined using a generalized linear model (GLM) including 95% confidence intervals (R Core Team, 2014). "*" = statistically significant trend (P<0.05).



Cameron Falls total annual and seasonal precipitation. Statistically significant (P<0.05) increase in total annual precipitation, ~61% increase from 1925 to 1998. Greatest increase observed in autumn (Sep, Oct, Nov), ~76% increase from 1925 to 1998.

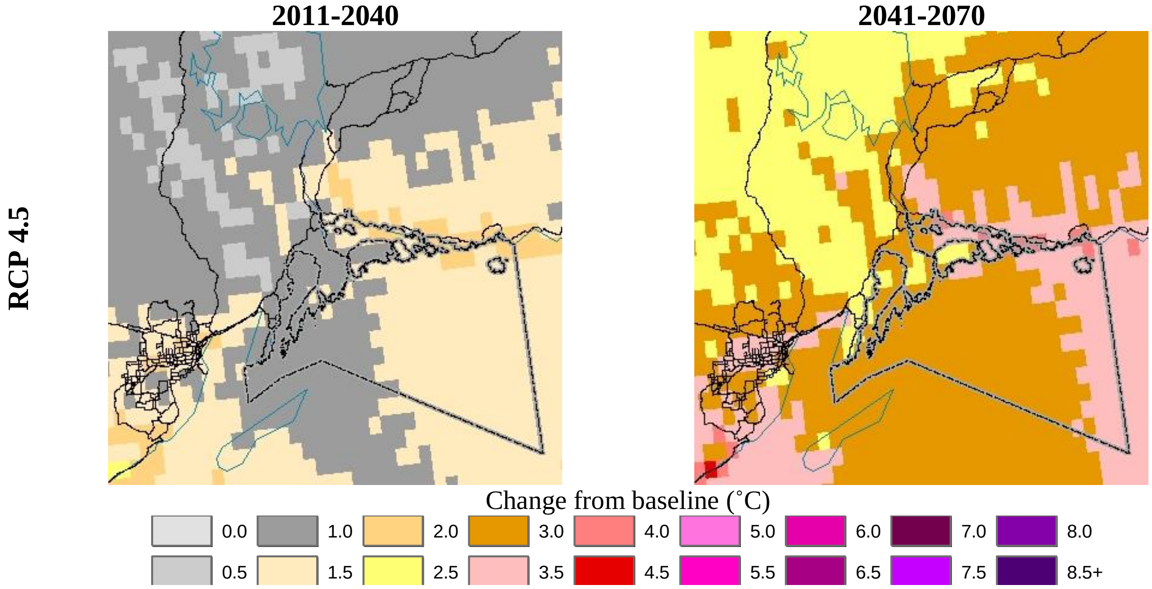


Cameron Falls total monthly precipitation. Jan, Oct and Dec all demonstrated a statistically significant (P<0.05) increase in total annual precipitation from 1925 to 1998. The greatest increase was observed for Oct, ~128% from 1925 to 1998.

2. Future Projections

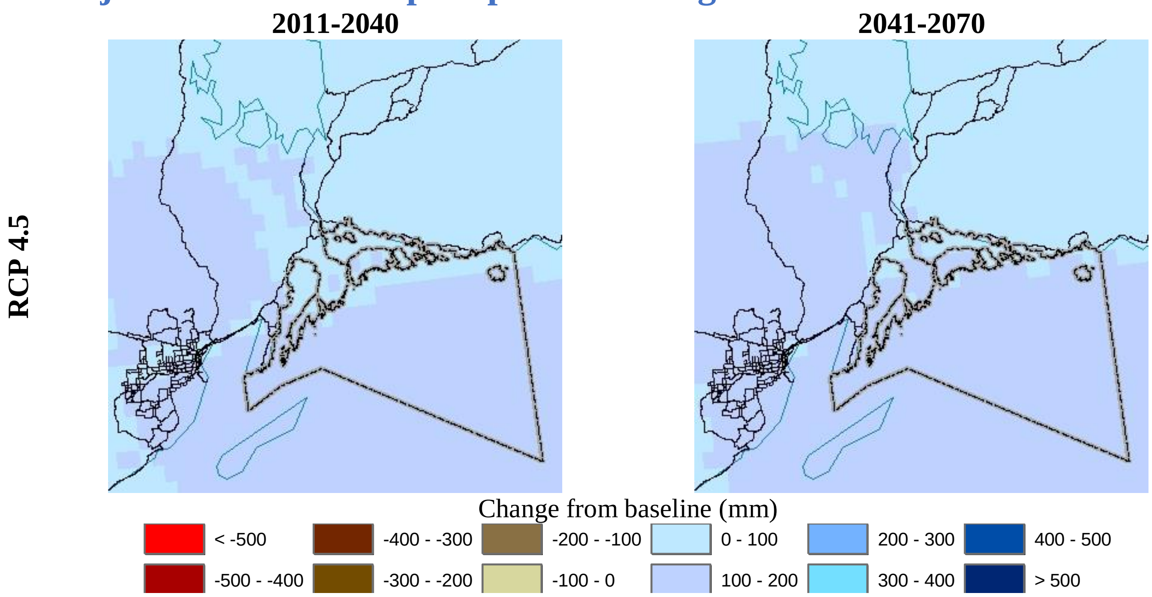
The following reflects a composite projection of four Global Circulation Models: CanESM2, CESM1CAM5, HADGEM2ES and MIROCESM. Data source: Natural Resources Canada, http://cfs.nrcan.gc.ca/projects/3 (Price *et al.*, 2011). RCP 4.5 reflects a realistic least change scenario.

2.1 Projected mean annual temperature change from a 1980-2010 baseline.



Results from this and other models (see review in: Huff and Thomas, 2014) suggests that air temperature will continue to increase by as much as 3 to 4.5˚C by 2100.

2.2 Projected total annual precipitation change from a 1980-2010 baseline.



Results from this and other models (see review in: Huff and Thomas, 2014) suggests that annual precipitation will continue to increase slightly (5 to 15%) by 2100.

2.3 Rainfall Intensity, Duration and Frequency (IDF)

A. Rainfall intensity calculated with Generalized Extreme Values (GEV) and an ensemble of climate models within IDF_CC Tool 3.0 (http://beta.idf-cc-uwo.ca/; see Simonovic *et al.* (2017)) for Nipigon.

Baseline total precipitation amounts (mm) for Nipigon from 1973-2012.

T (years)	2	5	10	25	50	100
5 min	8.01	11.00	13.03	15.67	17.69	19.75
10 min	11.49	15.86	18.82	22.63	25.51	28.43
15 min	13.74	19.57	23.69	29.20	33.53	38.05
30 min	17.00	24.38	29.62	36.72	42.38	48.36
1 h	20.68	29.38	35.63	44.25	51.26	58.86
2 h	24.85	34.30	41.08	50.45	58.15	66.57
6 h	32.53	42.71	50.37	61.47	71.03	81.90
12 h	38.12	51.14	61.01	75.28	87.42	101.03
24 h	43.90	58.70	70.02	86.78	101.52	118.65

Future total precipitation amounts (mm) projected for Nipigon for 1940-2100 under RCP 4.5 scenario

T (years)	2	5	10	25	50	100
5 min	8.84	12.26	15.38	19.11	22.83	27.13
10 min	12.68	17.68	22.21	27.60	32.92	39.05
15 min	15.17	21.81	27.96	35.61	43.27	52.27
30 min	18.76	27.17	34.97	44.79	54.69	66.43
1 h	22.82	32.73	42.06	53.96	66.16	80.87
2 h	27.43	38.23	48.49	61.53	75.05	91.45
6 h	35.90	47.60	59.46	74.97	91.67	112.52
12 h	42.07	56.98	72.02	91.82	112.82	138.79
24 h	48.45	65.41	82.66	105.83	131.02	163.00

B. Rainfall intensity calculated with the Ontario Ministry of Transport IDF database, http://www.mto.gov.on.ca/IDF_Curves/terms.shtml.

2010 baseline total precipitation amounts (mm) for Nipigon

Rainfall depth (mm)

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr
2-yr	9.4	11.6	13.1	16.2	19.9	24.5	34.1	42.0	51.8
5-yr	12.7	15.7	17.7	21.8	26.9	33.1	46.1	56.8	70.0
10-yr	14.9	18.4	20.8	25.6	31.5	38.8	54.0	66.5	82.0
25-yr	17.6	21.7	24.5	30.2	37.2	45.8	63.8	78.6	96.8
50-yr	19.6	24.2	27.3	33.7	41.5	51.1	71.2	87.7	108.0
100-yr	21.7	26.7	30.2	37.2	45.8	56.4	78.5	96.8	119.2

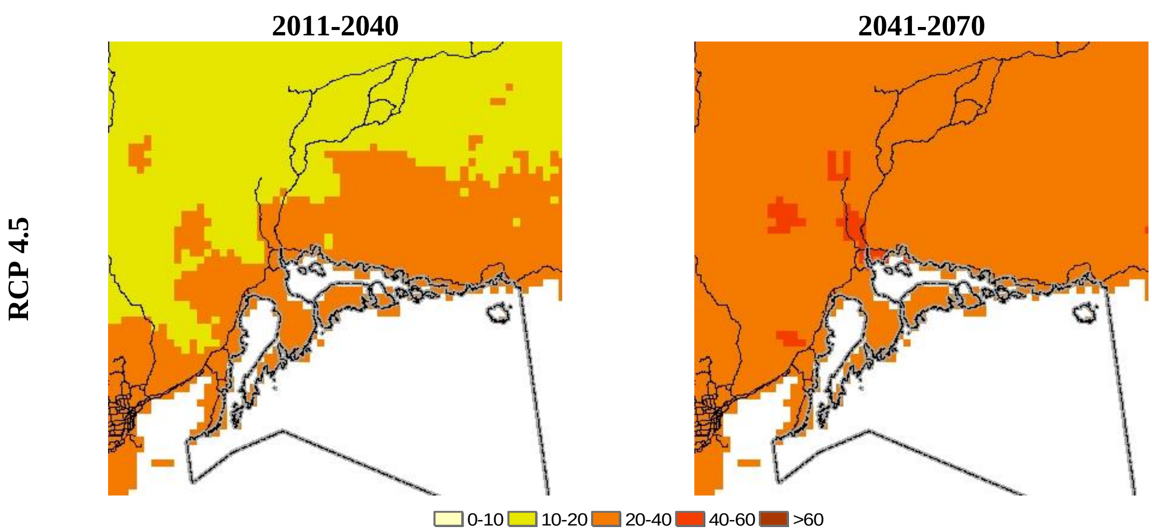
2050 total precipitation amounts (mm) for Nipigon

Rainfall depth (mm)

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr
2-yr	9.7	12.1	13.7	16.9	21.0	26.2	36.6	45.6	57.6
5-yr	13.0	16.1	18.3	22.6	28.0	34.8	48.6	61.2	74.4
10-yr	15.2	18.8	21.3	26.4	32.6	40.4	57.0	70.8	86.4
25-yr	17.9	22.2	25.1	31.0	38.3	47.4	66.6	82.8	103.2
50-yr	20.0	24.7	27.9	34.5	42.6	52.8	73.8	91.2	112.8
100-yr	22.0	27.2	30.7	38.0	46.9	58.0	81.0	100.8	124.8

Both tools appear to project that rainfall intensity (mm/hr) and amounts (mm) will increase from current baselines. For example, from the IDF_CC Tool, todays "one in 100 year" event (i.e., 118.65 mm/day) is projected to become a "one in 25-50 year" event, while the "one in 100 year" event will increase to 163 mm/day.

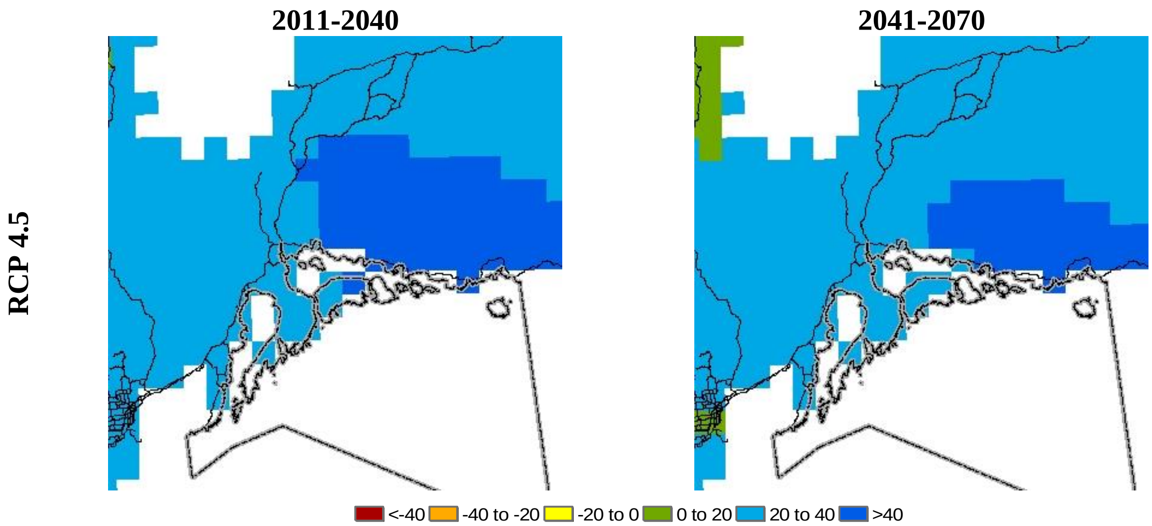
3. Wildfire Season



Projected increase in wildfire season for Nipigon **area**. **Increased length in days from baseline (1981-2010) under RCP 4.5 scenario. Data: Natural Resources Canada, http://cfs.nrcan.gc.ca/fc-data-catalogue.**

4. Climate Moisture Index

The Climate Moisture Index is calculated as the difference between annual precipitation and potential evapotranspiration



Projected change in Climate Moisture Index for Nipigon area from reference period (1981-2010) under RCP 4.5 scenario. A positive value = wetter conditions, while a negative value = drier conditions. Data: Natural Resources Canada, http://www.nrcan.gc.ca/forests/climate-change/forest-change/17772.

5. Plant Hardiness

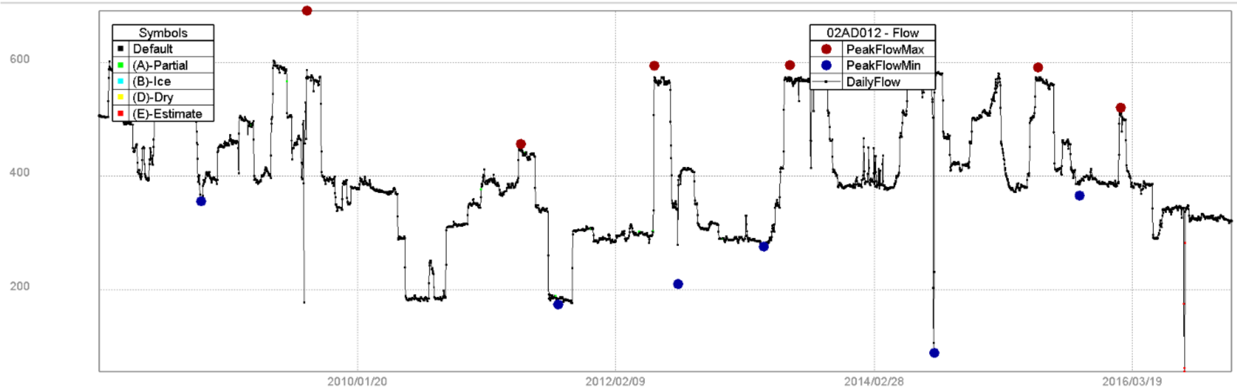
Plant hardiness is associated with probabilities of plant survival in relation to average, broad scale climatic conditions. As the climate continues to change, habitat suitability for plant species will also change. The Canadian Forest Service maintains a database of plant species which includes current core range as well as predicted core range for species (McKenney *et al.*, 2001). Link here to see plant lists for Nipigon: http://www.planthardiness.gc.ca/index.pl?lang=en&m=11&tx=-88.26835167420&ty=49.01980234300

6. Hydrology

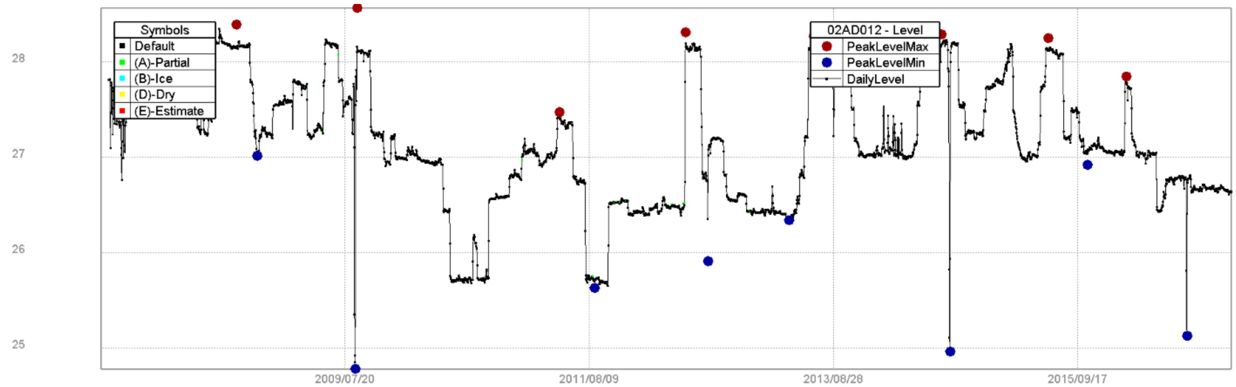
6.1 Nipigon River

Water flow and levels on the Nipigon River are regulated by Ontario Power Generating, i.e., Pine Portage GS, Cameron Falls GS and Alexander GS.

Environment and Climate Change Canada maintains a hydrographic station (flow and level) on the Nipigon River below the Alexander Generating Station (02AD012) and the data is available through ECDataExplorer: https://ec.gc.ca/rhc-wsc/default.asp?lang=En&n=0A47D72F-1. A summary of historic trends is available here.



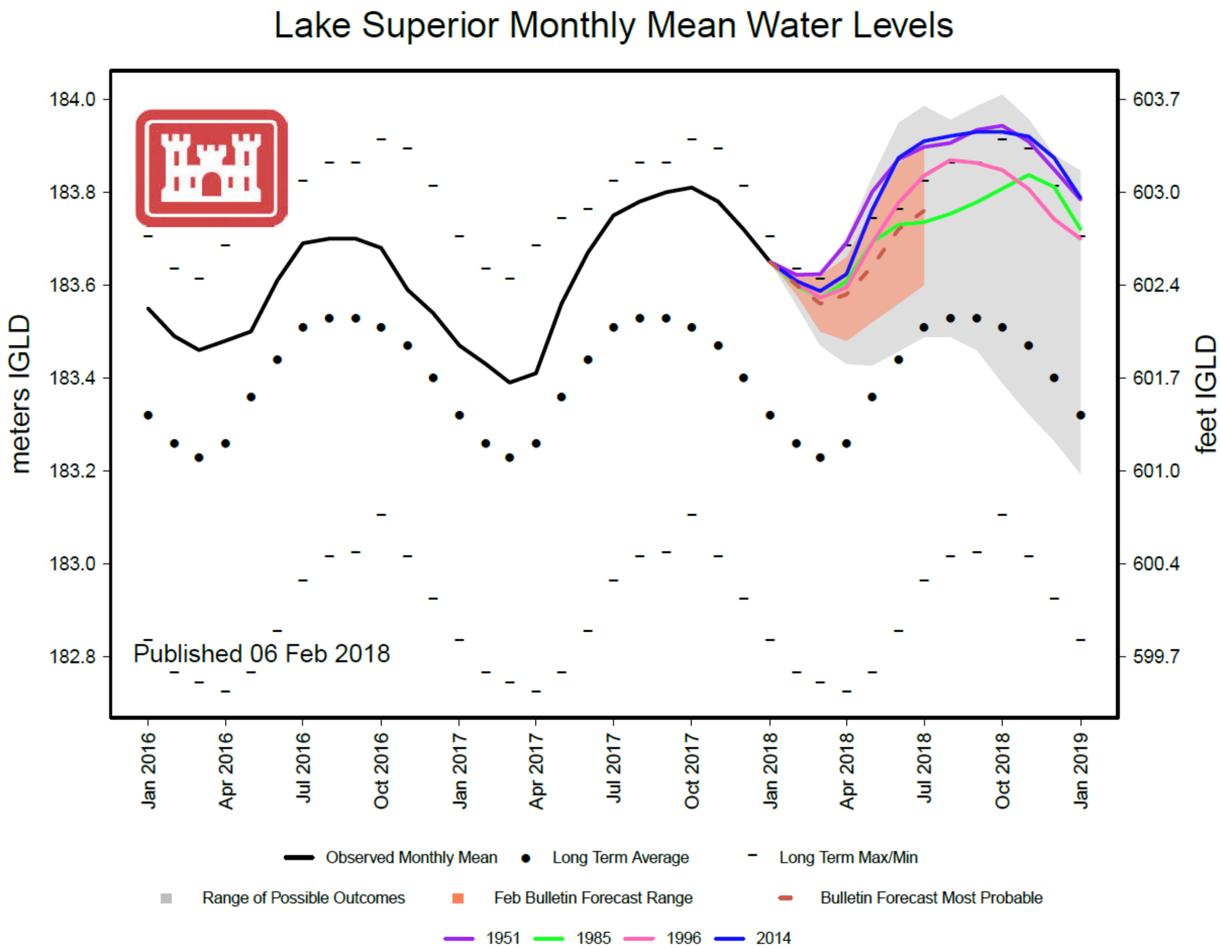
Daily flow at the Nipigon River below Alexander Generating Station. A GLM analysis of the annual peak flow values did not reveal a statistically significant trend (P<0.05) from 2008 to 2016.



Daily levels at the Nipigon River below Alexander Generating Station. A GLM analysis of the annual peak level values did not reveal a statistically significant trend (P<0.05) from 2008 to 2016.

6.2 Lake Superior

Lake levels naturally vary on daily, seasonally and on decadal cycles by as much as 1m due to shifts in climate (e.g., temperature, precipitation, evaporation). Most future projections report a decreasing trend in lakes levels (e.g., Huff and Thomas, 2014; IJC, 2012).



As of January 1st 2018, all the Great Lakes, including Lake Superior, are expected to experience water levels above their long-term average. Most long-term models project a decreasing trend by 2040-2100 (Huff and Thomas, 2014). Figure source: http://www.lre.usace.army.mil/Missions/Great-Lakes-Information/Great-Lakes-Water-Levels/Water-Level-Forecast/Water-Level-Outlook/

7. Other Observations and Trends

- The period of open-water for the inland Nipigon region is expected to increase by 7 to 28 days by 2041-2070, with spring break-up occurring 3 to 12 days earlier and freeze-up 3 to 16 days later (Minns *et al.*, 2014).
- The extent of ice cover has decreased on Lake Superior (e.g., 2%/yr) (Assel *et al.*, 2013; Wang *et al.*, 2012) and are projected to continue to decrease (see review in: Huff and Thomas, 2014)
- A query of the Canadian Disaster Database (https://www.publicsafety.gc.ca/cnt/rsrcs/cndn-dsstr-dtbs/index-en.aspx) confirmed a flood event in Thunder Bay ON, May 28, 2012. “Heavy rain and subsequent flooding caused the city of Thunder Bay to declare a state of emergency. Nearly

100 mm of rain was recorded at some weather stations in Thunder Bay on May 28. The flooding caused road closures, damages to thousands of homes, and interfered with utility services. Thunder Bay Hydro cut power to 50 customers (approximately 1,500 individuals) as a precaution to prevent electrical fires in severely flooded areas."

- McKenney et al. (2010) provides additional information on climate trends for the ecoregion (3W) and also projects warmer and wetter conditions.
- Although there are no Public Infrastructure Engineering Vulnerability Committee (PIEVC) case studies in this area, the City of Sudbury Road Infrastructure Assessment (https://pievc.ca/city-sudbury-road-infrastructure-assessement) may be of some relevance.
- Forest fire and flood are considerations in the Township or Nipigon Emergency Response Plan (https://nipigon.net/wp-content/uploads/2017/12/Updated-Nipigon-Emergency-Plan-without-numbers-Dec-2017.pdf). A floodplain risk map is available for Nipigon.
- Wind speeds are increasing (e.g., 0.05 m/s per year) over the lake (Austin and Colman, 2007; Desai *et al.*, 2009) and are expected to continue to increase.
- Annual average lake surface water temperatures have increased (e.g., 2.5 ˚C between 1979 and 2006) and are projected to increase (e.g., 4.6 to 6.7 ˚C by 2100) (Austin and Colman, 2007; Huff and Thomas, 2014; Larouche and Galbraith, 2016; Trumpickas *et al.*, 2009).

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