July 31, 2019

Supplemental Climate Information: Abbot Pass Refuge Cabin (Banff National Park)

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Preface

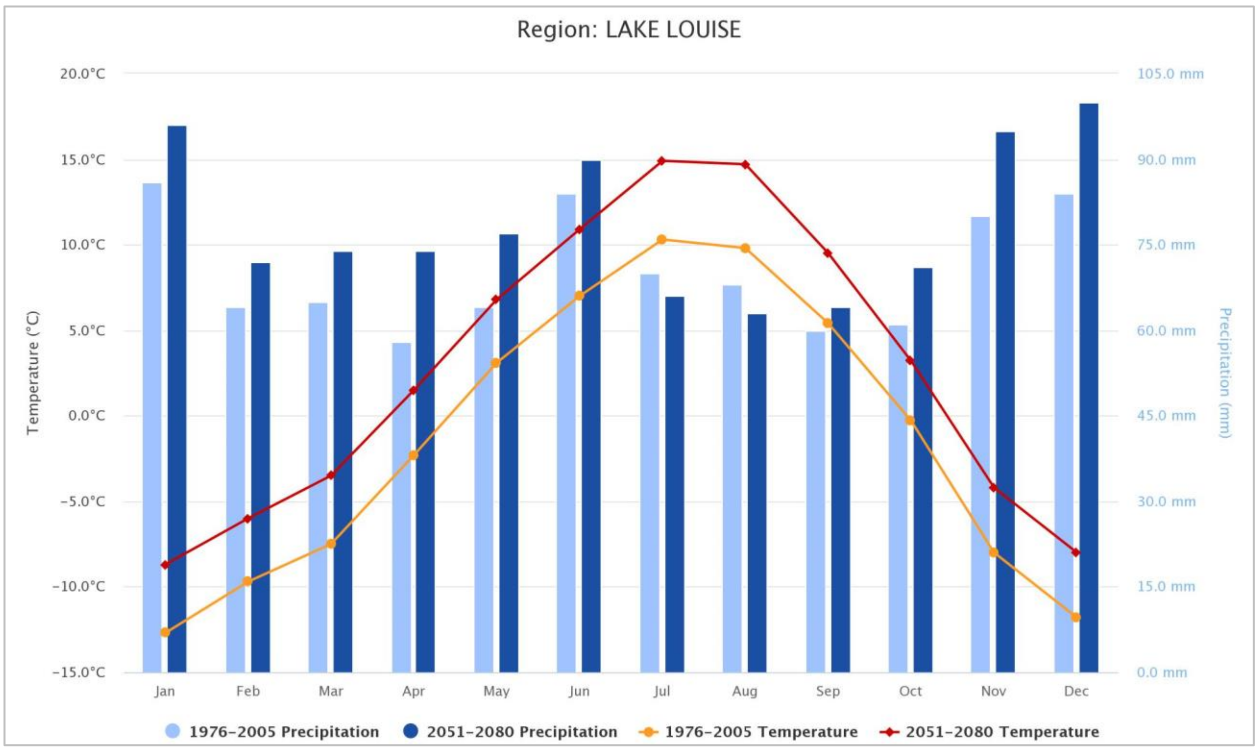
Built in 1922 by Swiss mountain guides the Abbot Pass Refuge Cabin is a high altitude (2925 m) alpine shelter in Abbot Pass, a col between Mounts Lefroy and Victoria and on the border between Banff and Yoho National Parks. The cabin is operated by the Alpine Club of Canada as a shelter for mountaineers and was declared a National Historic Site in 1992. Major slope erosion in 2018 initiated a geotechnical evaluation and stabilization project. The steep, unconsolidated slope is vulnerable to thawing and surface-water erosion – impacts projected to increase with climate change.

This document is a detailed supplement to the "Let's Talks about Climate Change: Mountain Region" report (Parker, 2017) and is intended to provide reference material to support climate change discussions for the Abbot Pass Refuge Cabin, Banff National Park. The climate in the region varies considerably in space and time and is influenced by factors such as latitude, topography and elevation. To better understand regional climate patterns see Janz and Storr (1977).

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/m2). 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.

Summary

- Mean annual temperature for Abbot Pass has increased by about 1.4 °C since 1948 and the winter season has experienced the greatest degree of warming by about 2.8 °C.
- The warming trend is projected to continue with an increase in mean annual temperature of 2.0-6.0 ˚C by 2100.
- Total annual precipitation for Abbot Pass has increased by about 6.5% since 1948 but has decreased for the winter season by about 33%. This trend is similar to that reported for Lake Louise (Pidwirny *et al.*, 2018) and Golden (Parker, 2018).
- Today's "one in 100 year" rainfall event (23 mm/hr) is projected to become closer to a "one in 25 year" event and the future "one in 100 year" event is projected to increase by an additional 12 mm/hr.
- Climate change is leading to permafrost thaw and increased slope failure in other alpine areas (e.g., Huggel *et al.*, 2012; Huss *et al.*, 2017).



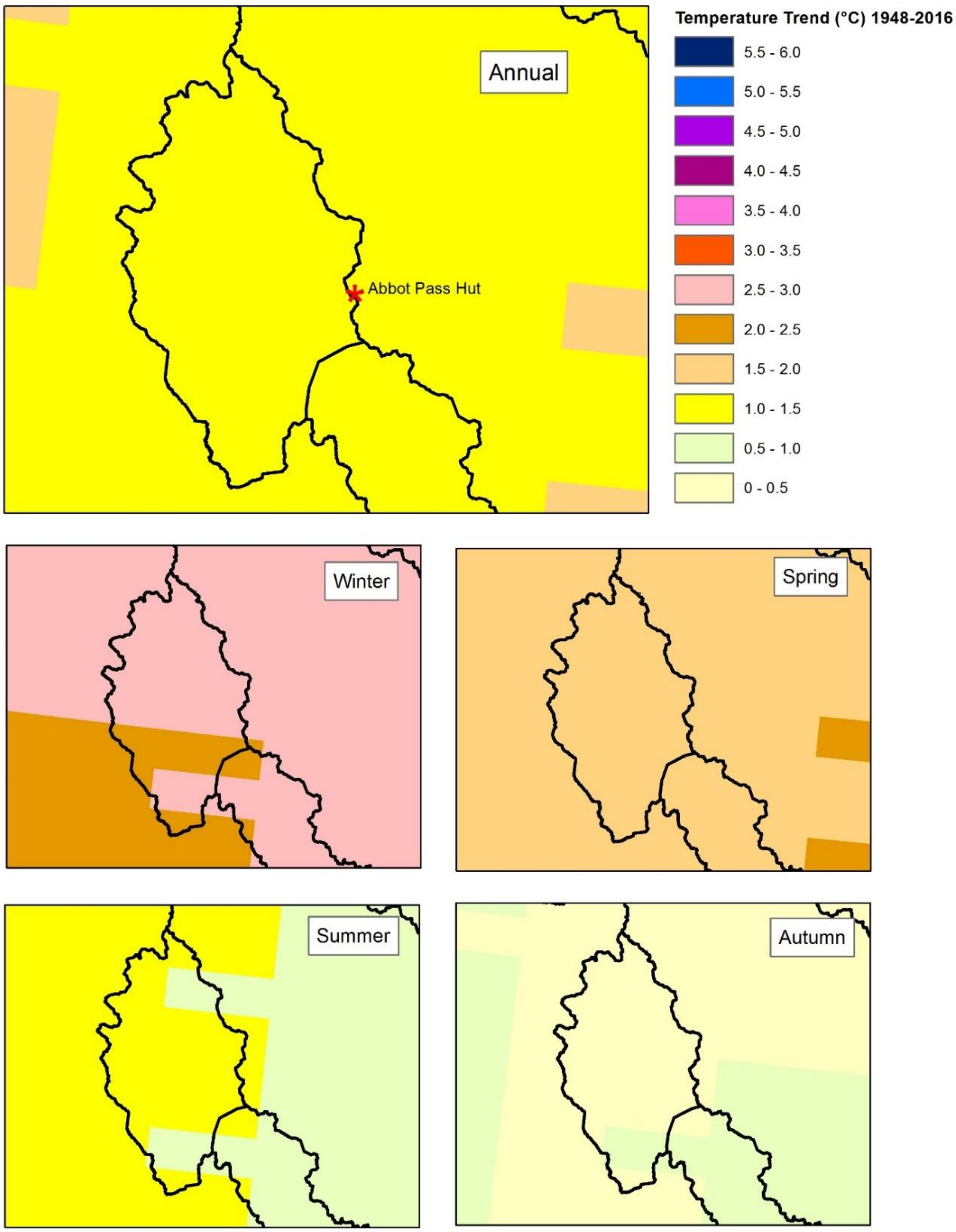
Projected (RCP 8.5) monthly mean temperature and total precipitation for the 1976-2005 (baseline) and 2051-2080 period for the Lake Louise region. Vertical bars represent precipitation and lines represent temperature. Figure source: Climate Atlas of Canada (https://climateatlas.ca/).

Disclaimer

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.

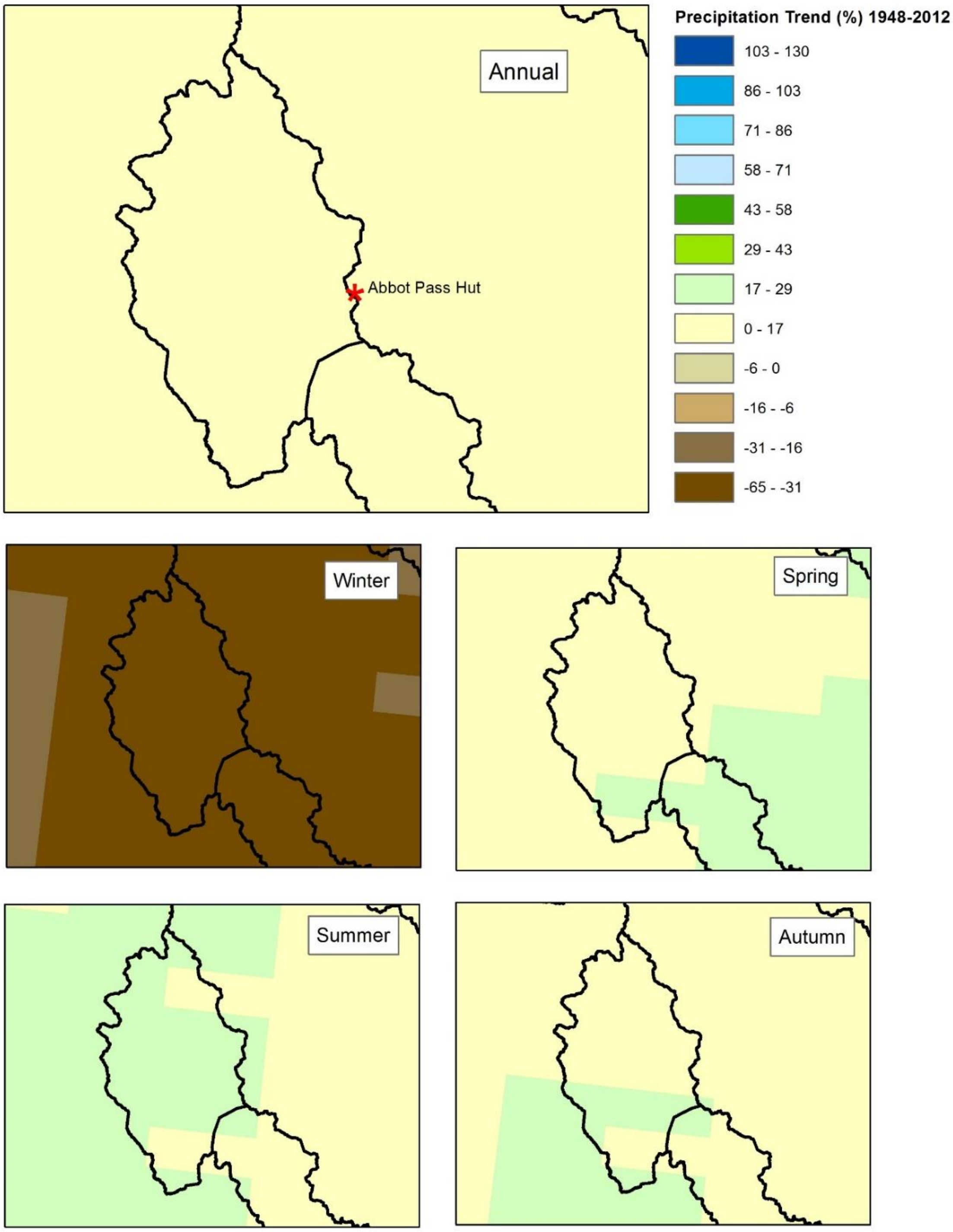
1. Historical Trends

1.1 Temperature



Change in mean annual and seasonal temperatures (˚C) for Yoho National Park from 1948 to 2016. Canadian gridded data (CANGRD): https://climate-change.canada.ca/climate-data/#/historical-gridded-data.

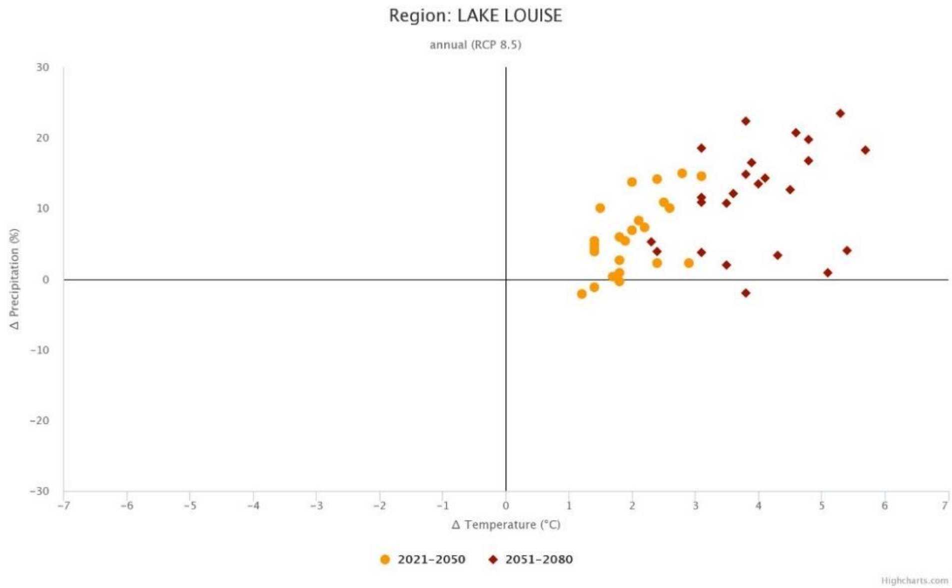
1.2 Precipitation



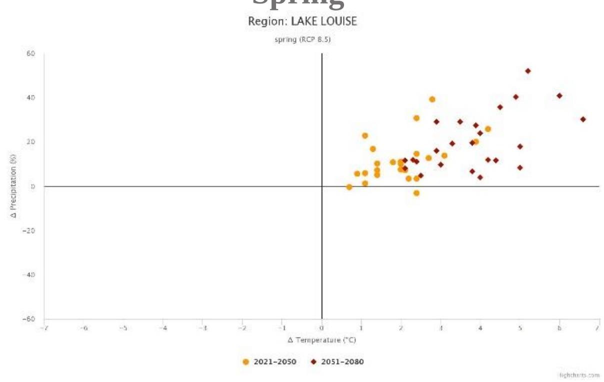
Percent change in total annual and seasonal precipitation for Yoho National Park from 1948 to 2012.
Canadian gridded data (CANGRD): https://climate-change.canada.ca/climate-data/#/historical-gridded-data.

2. Future Projections

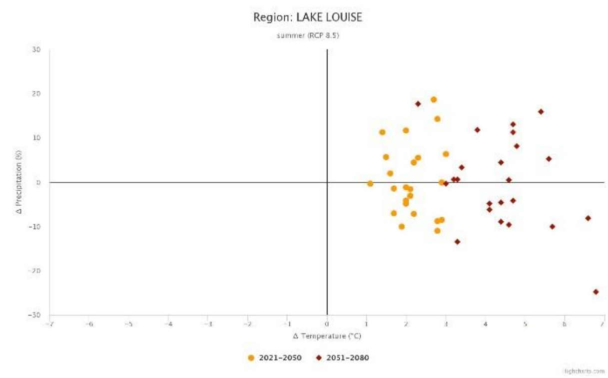
Annual



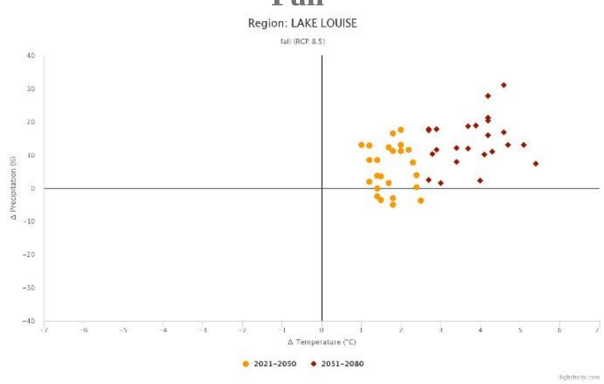
Spring



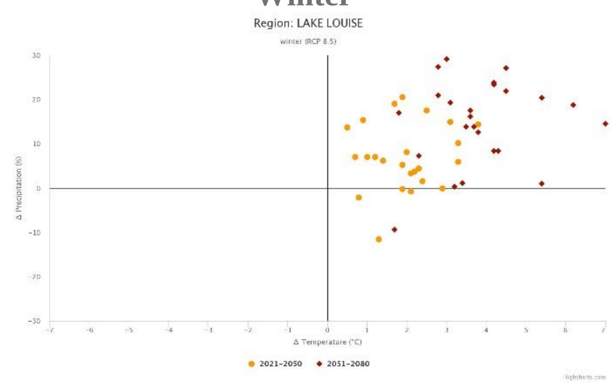
Summer



Fall

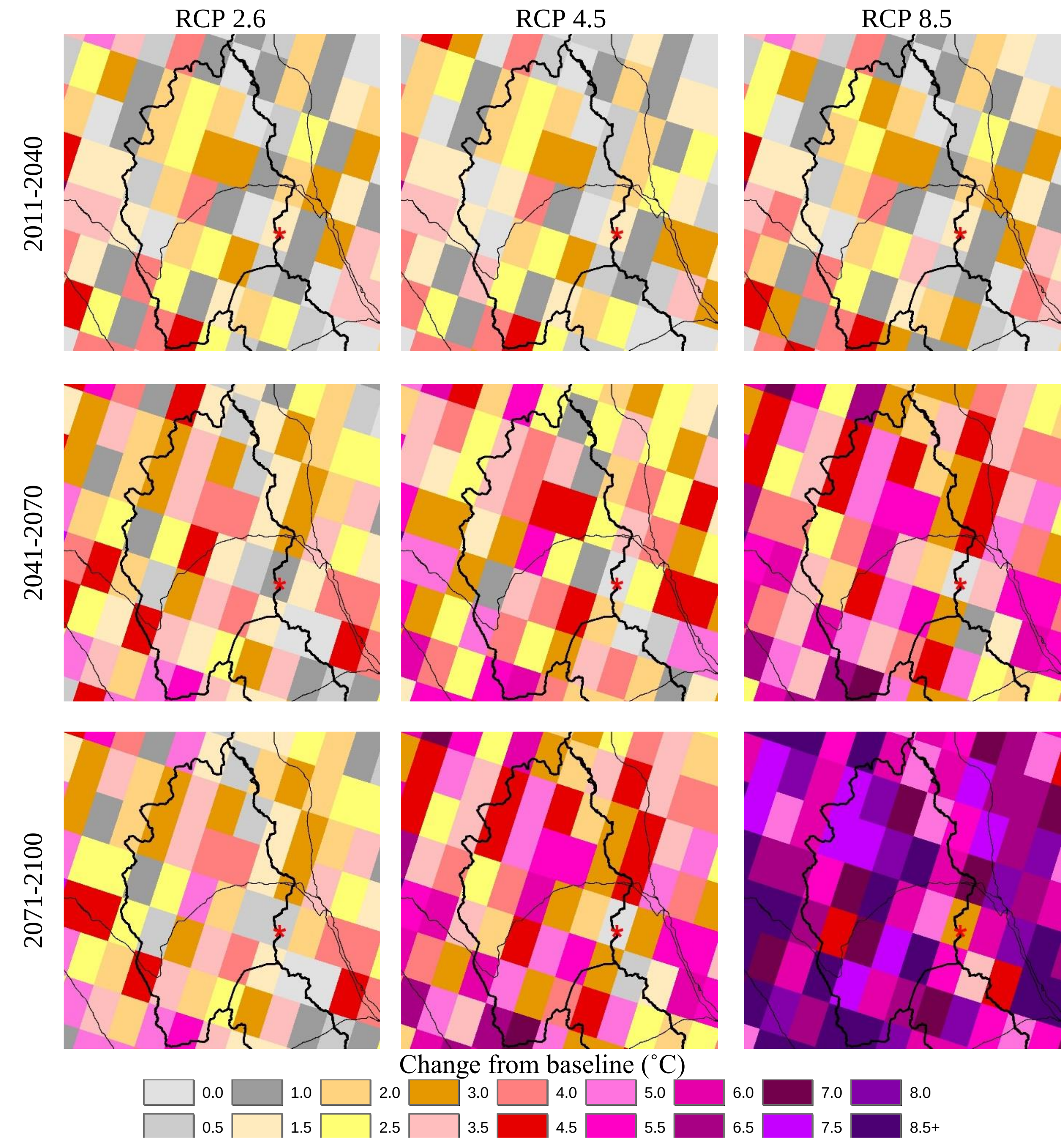


Winter

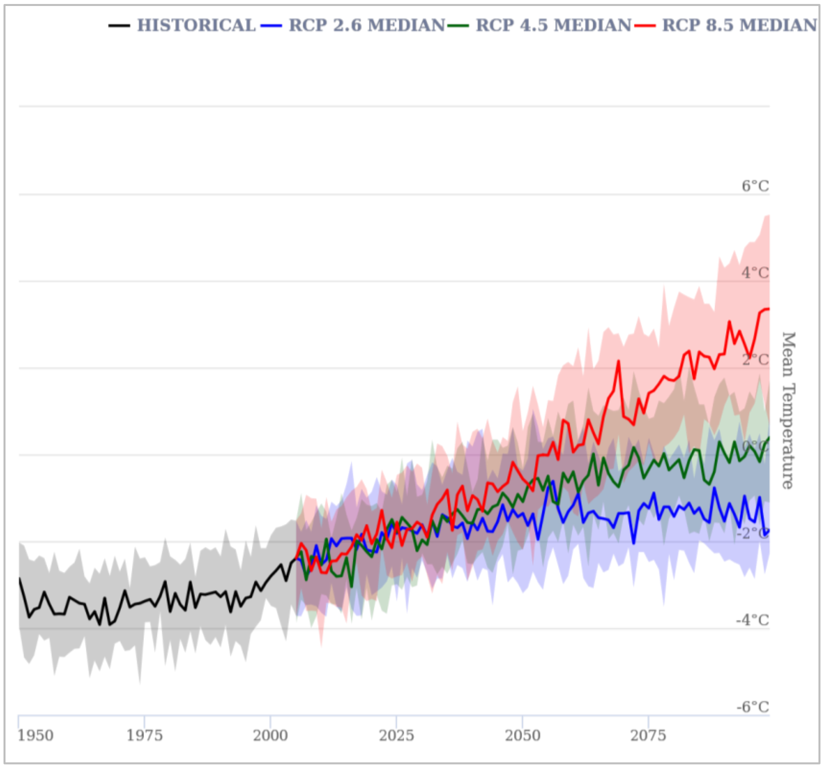


Climate models for the Lake Louise region (centred on the 1:50,000 NTS grid; area approx. 1,000km^2**).** Each point represents a single model-simulated temperature/precipitation response to the **RCP 8.5** scenario. Plots and statistically downscaled data (Bias Corrected Spatial Disaggregation; BCSD) derived from 12 CMIP5 global climate models (https://climateatlas.ca/; PCIC, 2014). All models project warmer temperatures and most project an increase in total annual precipitation, summer precipitation appears variable (both wetter and drier conditions).

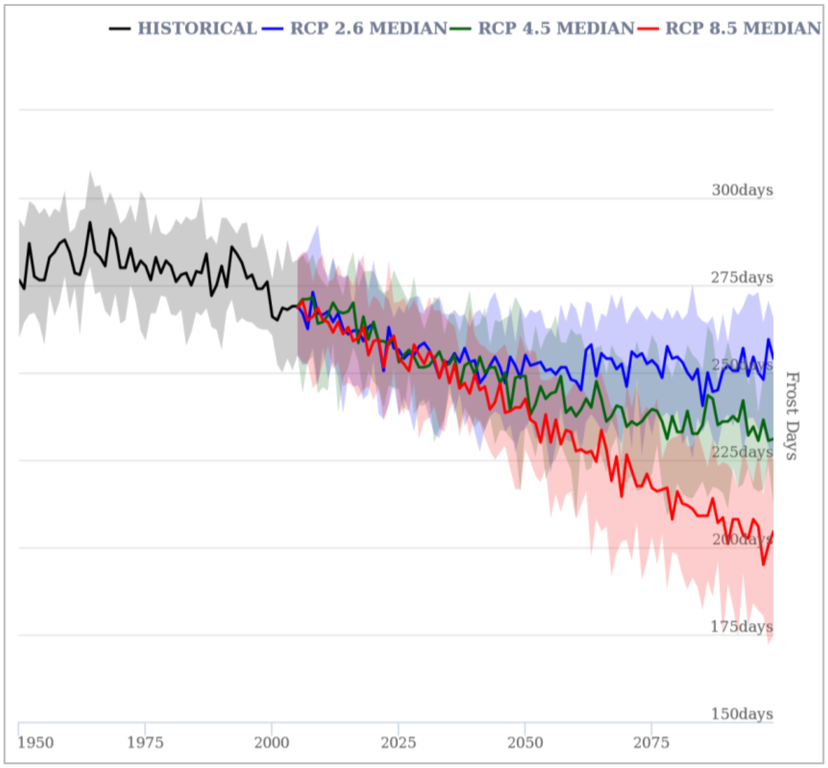
2.1 Temperature



Projected mean annual temperature increase for Yoho NP (Abbot Pass =*) from the 1980-2010 baseline. Composite projection of CanESM2, CESM1CAM5, HADGEM2ES and MIROCESM. Data source: Natural Resources Canada, Canadian Forest Service, http://cfs.nrcan.gc.ca/projects/3 (Price *et al.*, 2011). Park boundaries and Trans-Canada Hwy included for scale.

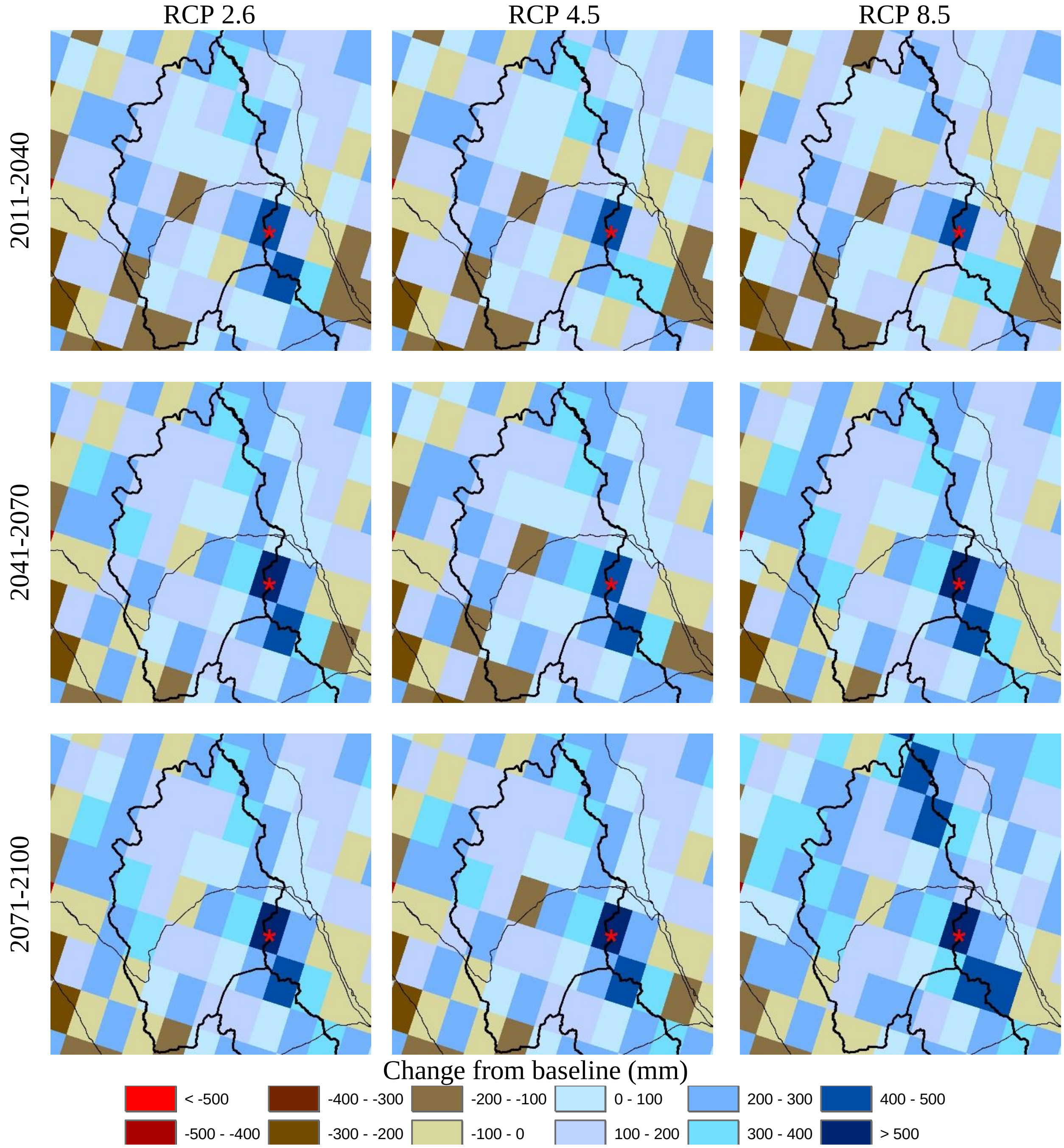


Mean annual temperature projections for Abbot Pass based on an ensemble of 24 climate models and the BCCAQv2 method. Figure and data source: Climatedata.ca, https://climatedata.ca/.

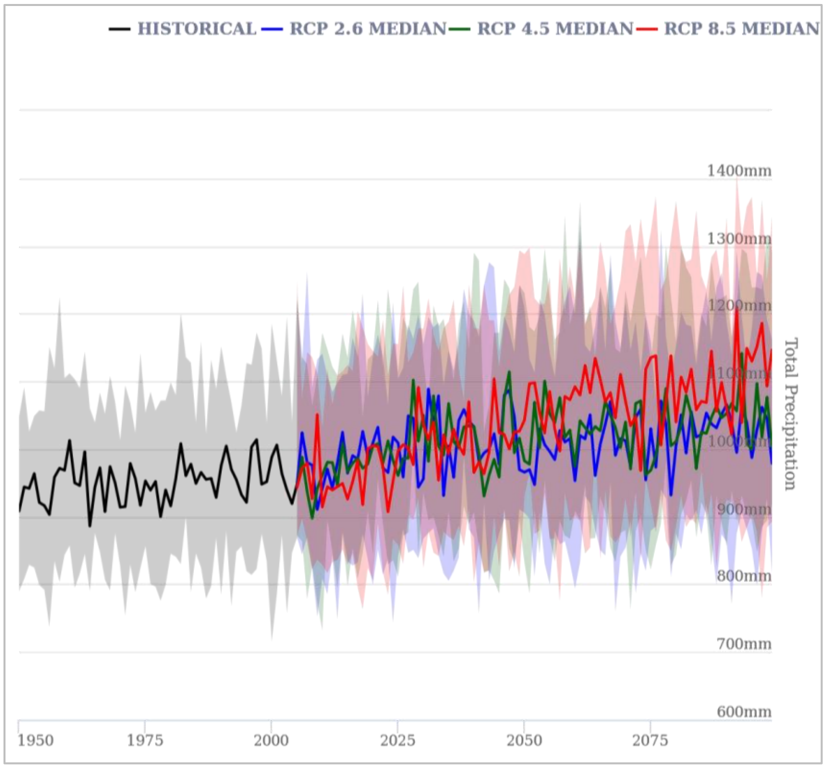


Number of days when daily minimum temperatures is less than 0°C (Frost Days) for Abbot Pass based on an ensemble of 24 climate models and the BCCAQv2 method. Figure and data source: Climatedata.ca, https://climatedata.ca/.

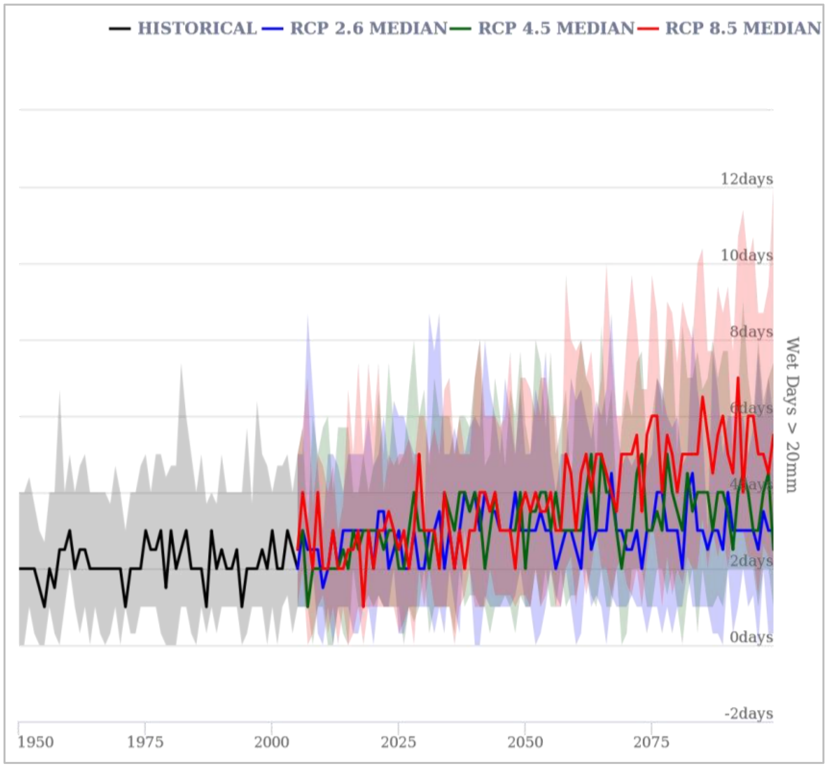
2.2 Precipitation



Projected total annual precipitation change for Yoho NP (Abbot Pass = *) from the 1980-2010 baseline. Composite projection of four spatially interpolated downscaled Global Circulation Models: CanESM2, CESM1CAM5, HADGEM2ES and MIROCESM. Data source Natural Resources Canada, Canadian Forest Service, http://cfs.nrcan.gc.ca/projects/3 (Price *et al.*, 2011). Park boundaries and Trans-Canada Hwy included for scale.



Total annual precipitation (rain and snow) for Abbot Pass based on an ensemble of 24 climate models and the BCCAQv2 method. Figure and data source: Climatedata.ca, https://climatedata.ca/.



Number of days with daily precipitation totals greater than 20 mm for Abbot Pass based on an ensemble of 24 climate models and the BCCAQv2 method. Figure and data source: Climatedata.ca, https://climatedata.ca/.

Rainfall Intensity, Duration and Frequency (IDF)

These rainfall IDF values are calculated with IDF_CC Tool 3.5 (http://www.idf-cc-uwo.ca/) using Generalized Extreme Values (Simonovic *et al.*, 2017).

Baseline total precipitation amounts (mm) for Abbot Pass.

T (years)	2	5	10	20	25	50	100
5 min	2.97	4.51	5.80	7.32	7.81	9.64	11.81
10 min	4.14	6.19	7.91	9.95	10.61	13.10	16.06
15 min	4.89	7.04	8.79	10.80	11.45	13.83	16.59
30 min	5.95	8.26	10.28	12.76	13.56	16.70	20.58
1 h	7.70	10.28	12.47	15.11	15.97	19.23	23.17
2 h	10.33	13.65	16.32	19.38	20.35	23.92	28.05
6 h	15.87	20.92	24.85	29.25	30.64	35.65	41.38
12 h	21.18	27.87	32.36	36.87	38.16	42.60	47.20
24 h	26.73	34.95	39.81	44.30	45.42	49.28	52.91

Projected (2050-2100) precipitation (mm) for Abbot Pass using an ensemble of models and **RCP 8.5**.

T (years)	2	5	10	20	25	50	100
5 min	3.46	5.52	7.42	9.88	10.73	13.98	18.10
10 min	4.82	7.58	10.12	13.43	14.57	19.00	24.63
15 min	5.69	8.62	11.25	14.58	15.72	20.05	25.44
30 min	6.92	10.11	13.15	17.22	18.63	24.22	31.55
1 h	8.96	12.58	15.96	20.40	21.93	27.89	35.52
2 h	12.02	16.71	20.88	26.15	27.95	34.70	43.00
6 h	18.47	25.59	31.79	39.47	42.07	51.71	63.45
12 h	24.65	34.10	41.40	49.75	52.40	61.79	72.37
24 h	31.12	42.77	50.93	59.79	62.37	71.48	81.12

Abbot Pass (Lat: 51.36417 º, Lon: -116.29000 º) IDF observations and projections. Today's "one in 100 year" rainfall event (i.e., 23.17 mm/hr) is projected to be closer to a "one in 25 year" event by 2050-2100 and the future "one in 100 year" rainfall event is projected to increase in intensity (i.e., 35.52 mm/hr).

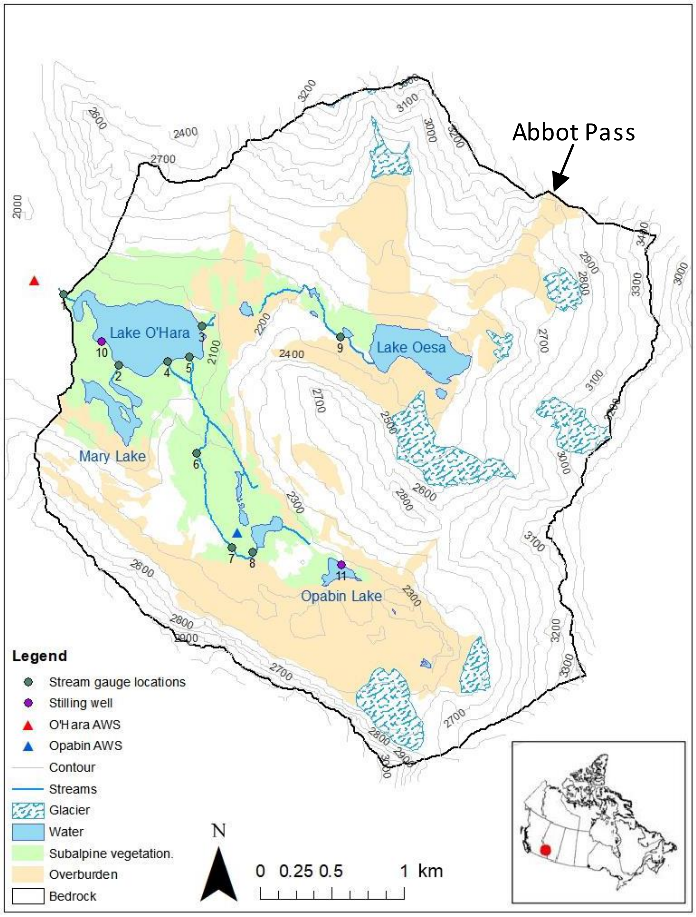
3. Related Information

This report only highlights information specific to the Abbot Pass Refuge Cabin and does not consider regional changes to river hydrology, biodiversity, wildfire regimes, etc… For region-wide information see the climate supplemental reports for LLYK (Lake Louise, Yoho and Kootenay) and Jasper NP, link here.

Additional notes:

- Pidwirny *et al*. (2018) assessed climate change risks and impacts to Lake Louise Ski Area and report since 1901 a warming trend in winter mean temperatures (+0.18°C per decade), a decrease in winter degree days <0°C (-16.1°C per decade), and a decrease in winter snowfall (-8.6 mm water equivalent per decade, about a 25% decline). While the temperature trends are projected to continue, they report that the amount of snowfall is less certain and may potentially be slightly higher

The Abbot Pass Refuge Cabin in early September 2016 and in early August 2018. There are concerns with permafrost thaw (discontinuous) and erosion near the base of the stone structure (left: Steve Andersen; right: Kate Hurley; https://www.cbc.ca/news/canada/calgary/parks-canada-abbot-pass-hut-climate-change-access-to-information-1.5192594)



Lake O'Hara research basin hydrological and meteorological stations (He and Hayashi, 2019). AWS = automatic weather stations. Data is available here: https://dx.doi.org/10.20383/101.035

- The Lake O'Hara research basin, adjacent to Abbot Pass, was established by the University of Calgary in 2004 with support from Parks Canada. Research efforts here include studies on snow hydrology, alpine groundwater hydrology, stream–groundwater interaction, alpine permafrost, and glacier mass and energy balance (e.g., He and Hayashi, 2019; Hood and Hayashi, 2015; Kurylyk and Hayashi, 2017; Langston *et al.*, 2011; Muir *et al.*, 2011). Access to real-time (http://giws.usask.ca/telemetry/) and historic (https://dx.doi.org/10.20383/101.035) meteorological data for the basin is available on-line.
- The CMIP5 models generally project a slight decrease in mean annual and seasonal surface wind speeds for the region (https://climate-viewer.canada.ca). However, Cheng *et al.* (2014) project that the frequency and intensity of wind gust events will increase slightly for the region.
- Harrington and Hayashi (2019) recently applied a "distributed temperature sensing" method (along a fibre-optic cable at high resolution) to measure ground surface temperatures and map permafrost distribution in the Helen Creek watershed, Banff NP.
- An explanation of glacier fluctuations, including the Wapta Icefield (northwest of Abbot Pass in Banff/Yoho NPs), under the influence of climate is provided by Demuth and Ednie (2016).

- Clarke *et al.* (2015) project that by 2100, the volume of glacier ice in western Canada will shrink by 70 ± 10% relative to 2005. Clarke also developed deglaciation animations based on this work, including a series of animations for the glaciers in the Lake Louise - Yoho area (http://couplet.unbc.ca/data/RGM_archive/RGM_movie_archive/).
- Demuth and Horne (2017) examined decadal-to-centenary variability in glacier mass changes in Jasper NP. Over the last several decades, the studied glaciers experienced negative annual mass changes (i.e., loss) at a rate equal to or greater than 3 times that of the long-term annualized centenary value.
- SnowCast (http://www.snowcast.ca/) provides estimates of snowpack over the region.

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