Regional Climate Change

21 November 2016
Cowichan Watershed Board: Forest Practices Workshop
Duncan, BC

Photo: F. Zwiers

Trevor Murdock
Climate Scientist
Pacific Climate Impacts Consortium

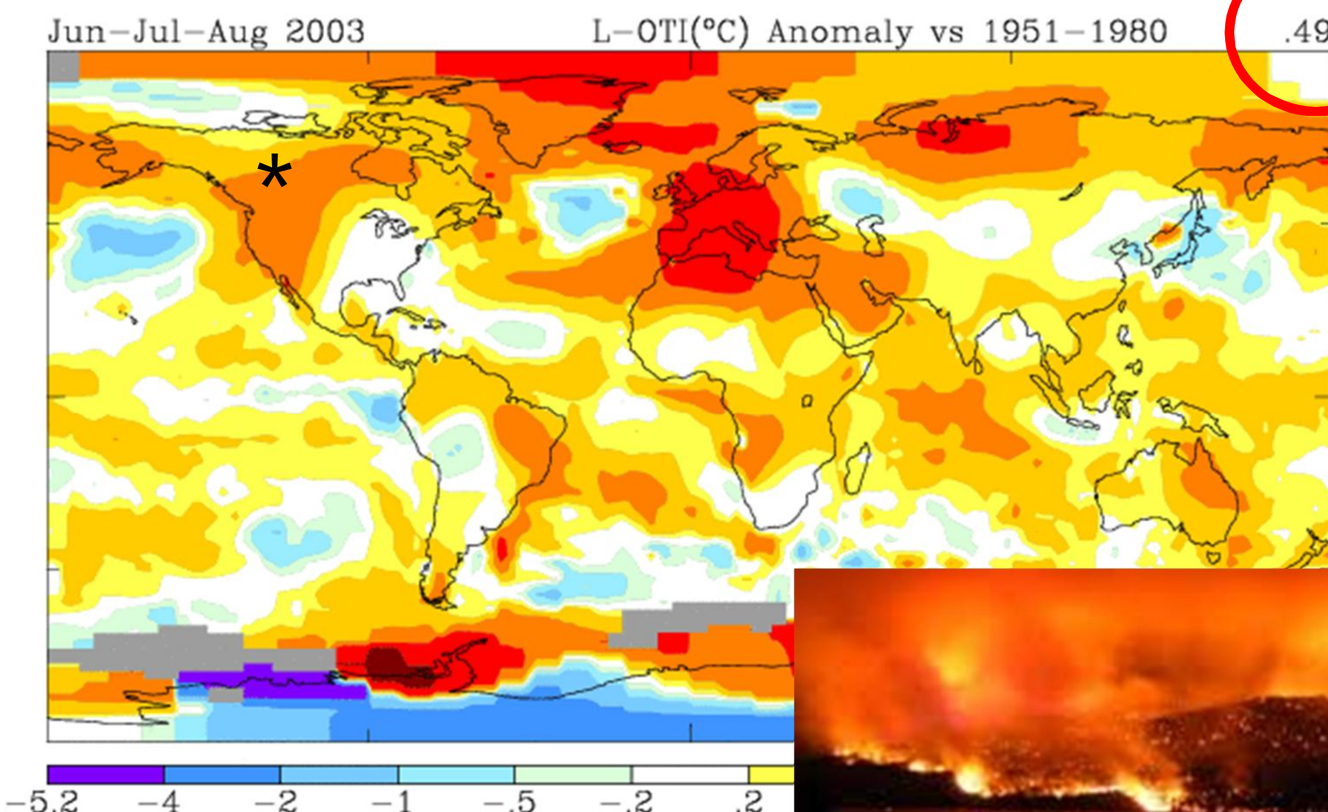
1. Climate variability and trends
2. 2015: a new normal?
3. The future in BC
4. The future in Cowichan Valley

Refresher: weather and climate

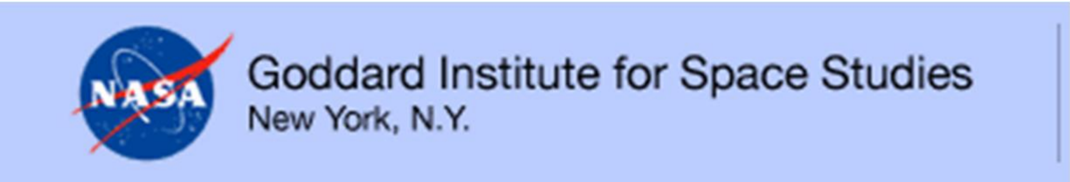
- Weather is at a given location on a given day
  - 02 Dec 2005
    - 19°C sunny in ________
    - -5°C snowing in ________

- Climate is the long term statistics of weather
  - 1971-2000 average December
    - 4°C, 14 cm snow ________
    - -6°C, 48 cm snow ________

Climate varies in space

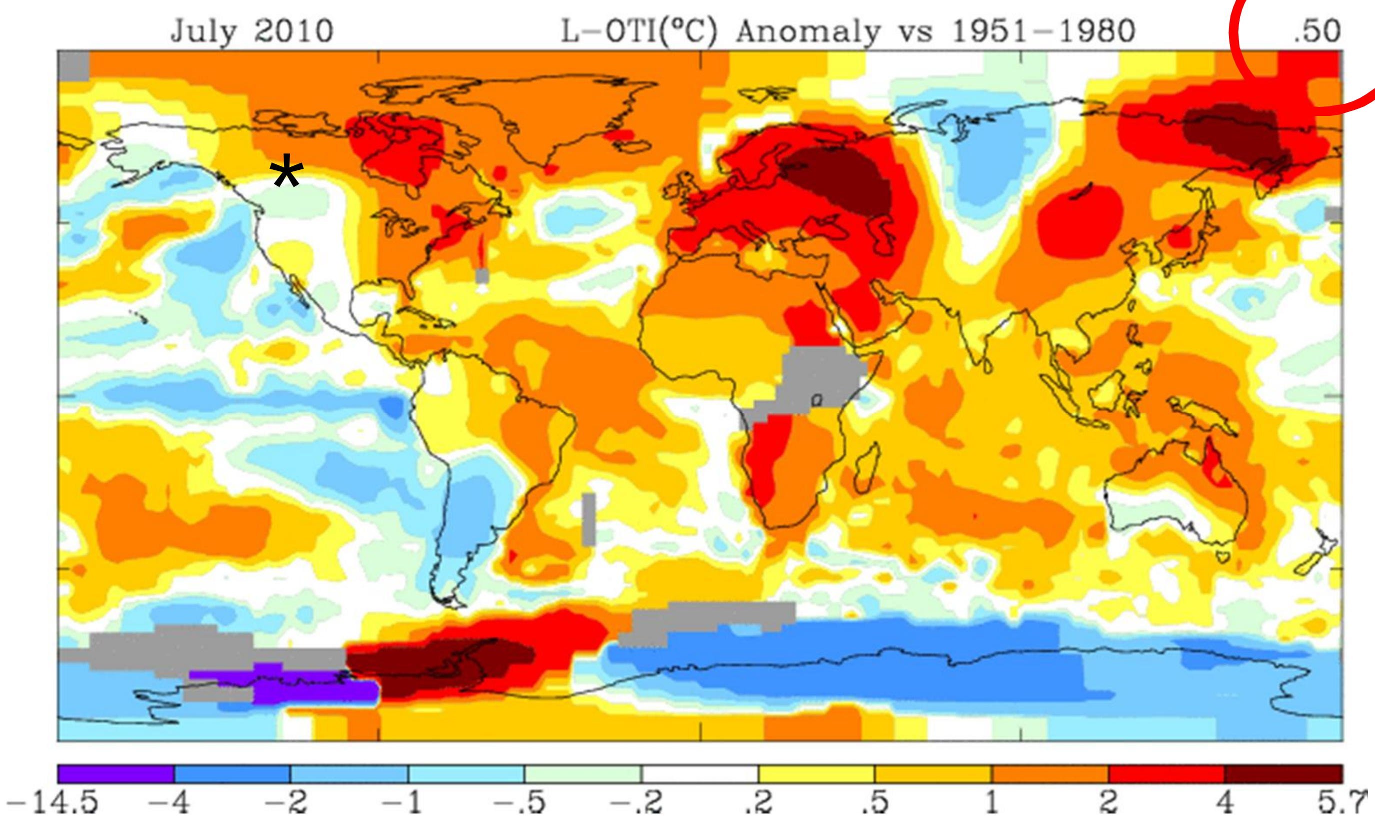


Temperature Ano



Climate varies in space

750,000 hectares



Temperature Anomaly ^{0}C

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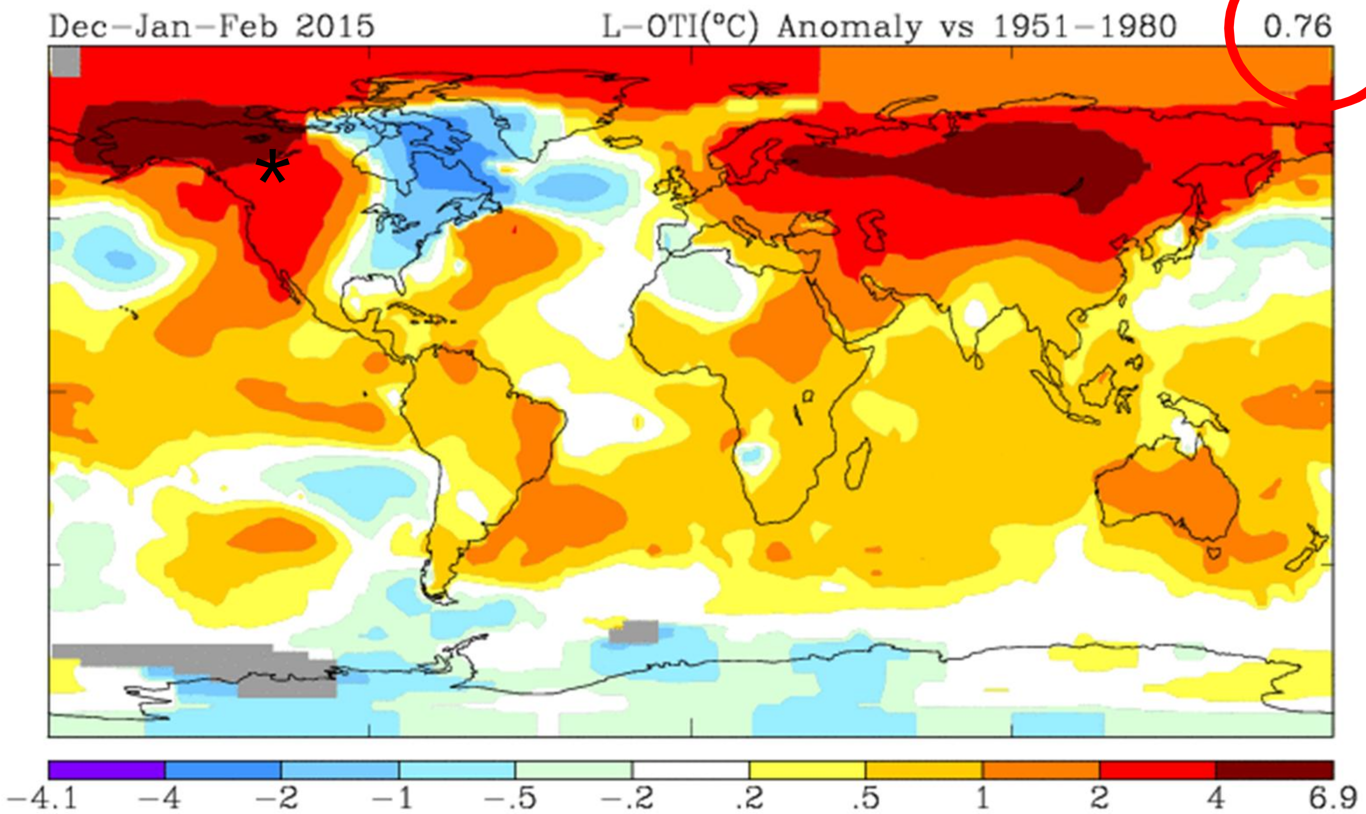
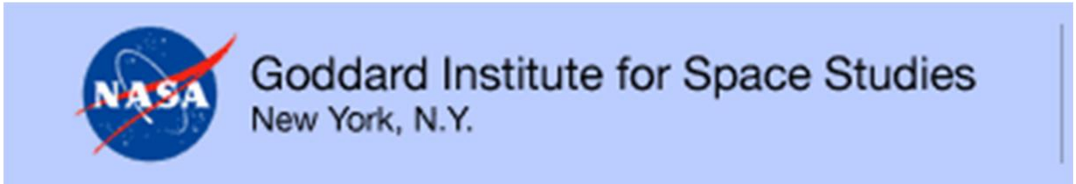
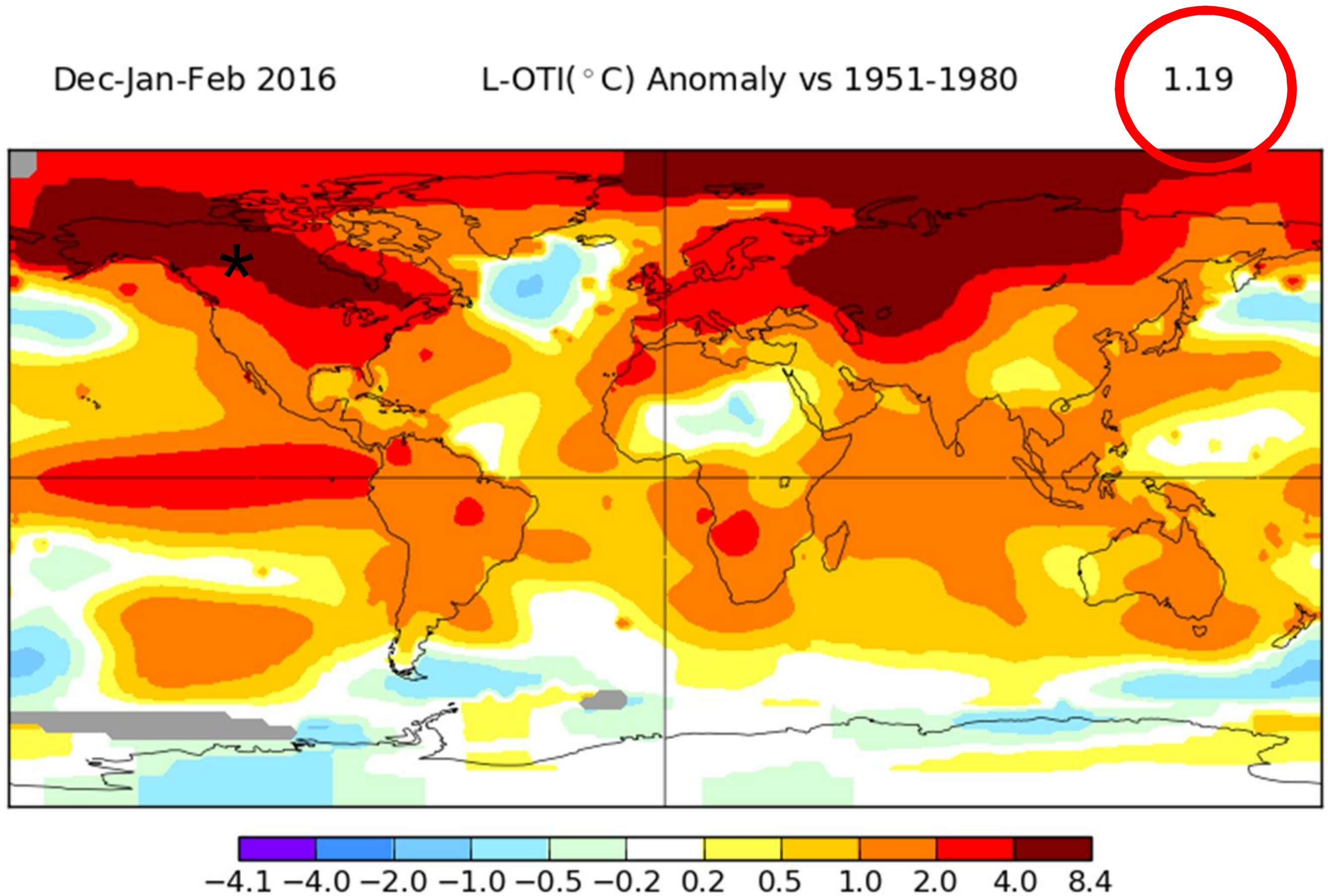
Climate varies in space



Temperature Anomaly ^{0}C



Climate varies in space



Temperature Anomaly ^{0}C

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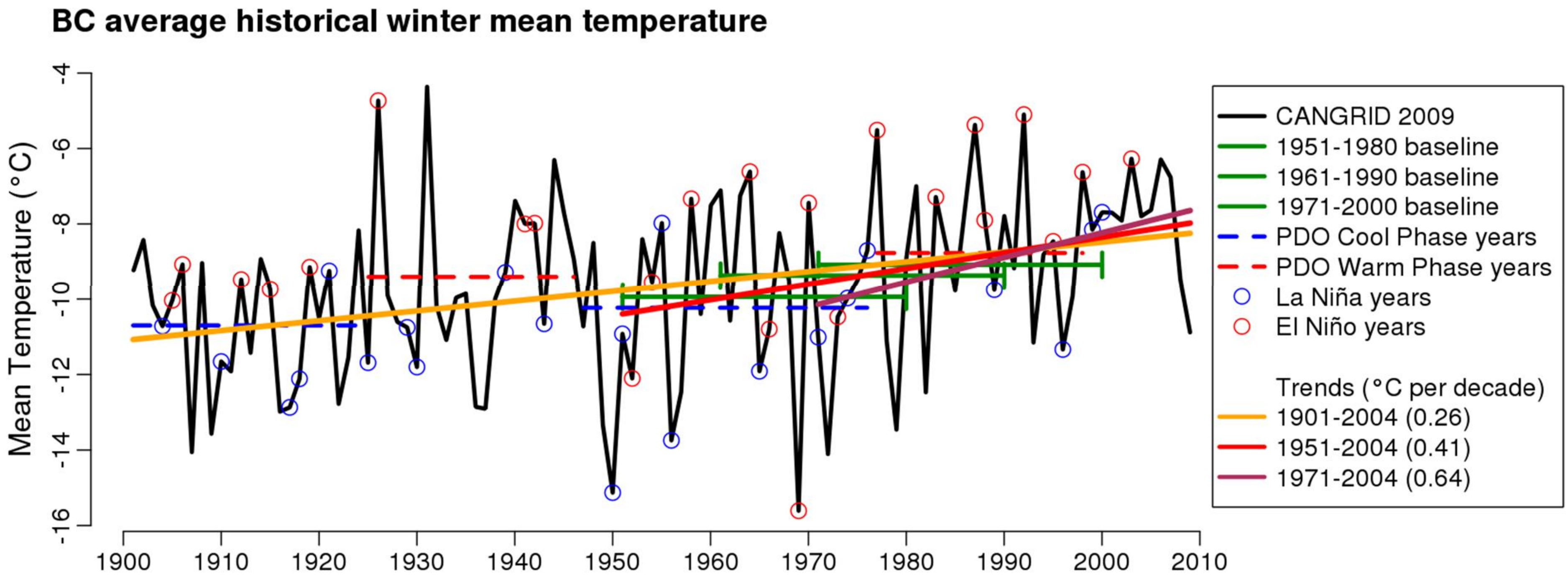
New York, N.Y.

Climate Normals	Climate Variability	Climate Oscillations	Climate Change
Long term averages (e.g., 1961-1990)	Short term : (years to decadal) rises and falls about the trend line (ENSO)	Multi-decadal oscillations in regional climate: (e.g. PDO)	Long Term Trends or major shifts in climate: (centuries)



- "Normals" change
- Climate variability is ongoing - need to plan for variability
- Note that short-term negative trends in climate warming will occur
- http://pics.uvic.ca/education/climate-insights-101

Trends

Can historical trends be extended to predict the future?

a) Yes

b) No

Trends

Can historical trends be extended to the future?

a) Yes – they are more certain than climate models
b) Yes – give context to future projections
c) Yes – they reflect what actually happened

Can historical trends *alone* be extended to predict the future?

a) No – the climate system is not linear
b) No – trends change through time
c) No – even the direction of change can depend on the historical period considered

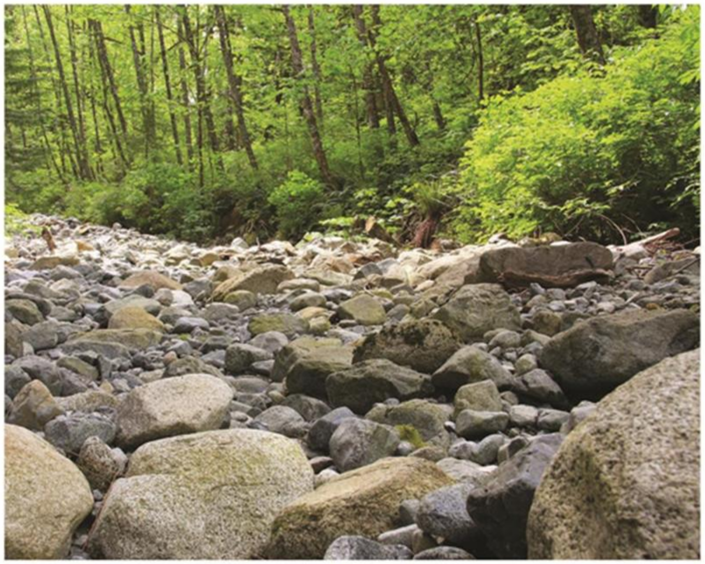
“Prediction is hard, especially about the future”

- Yogi Berra
- Albert Einstein
- Winston Churchill
- Mark Twain
- George Bernard Shaw
- Will Rogers
- Woody Allen
- Dan Quayle
- Confucius

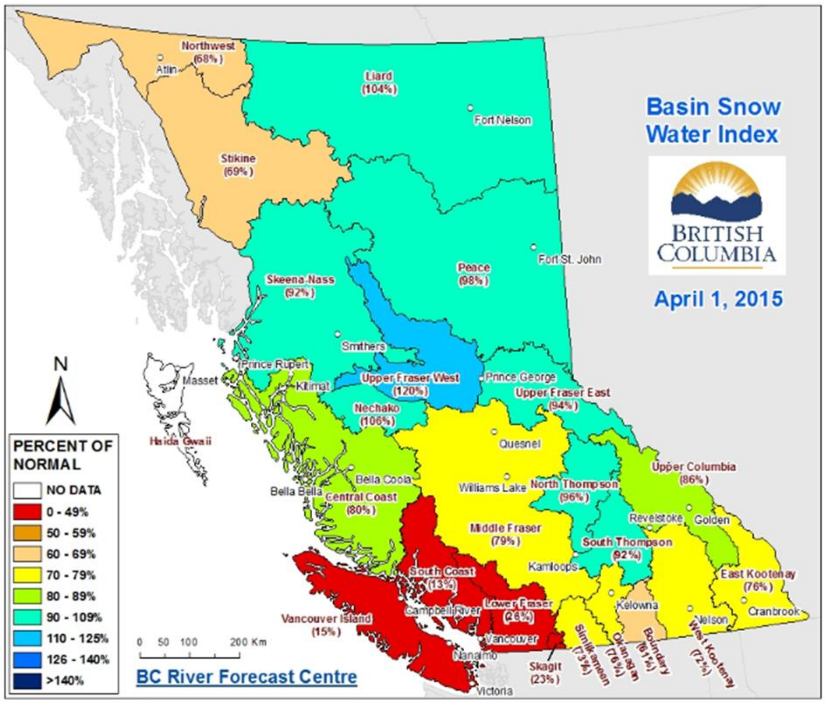
2015: a case study in the new normal?

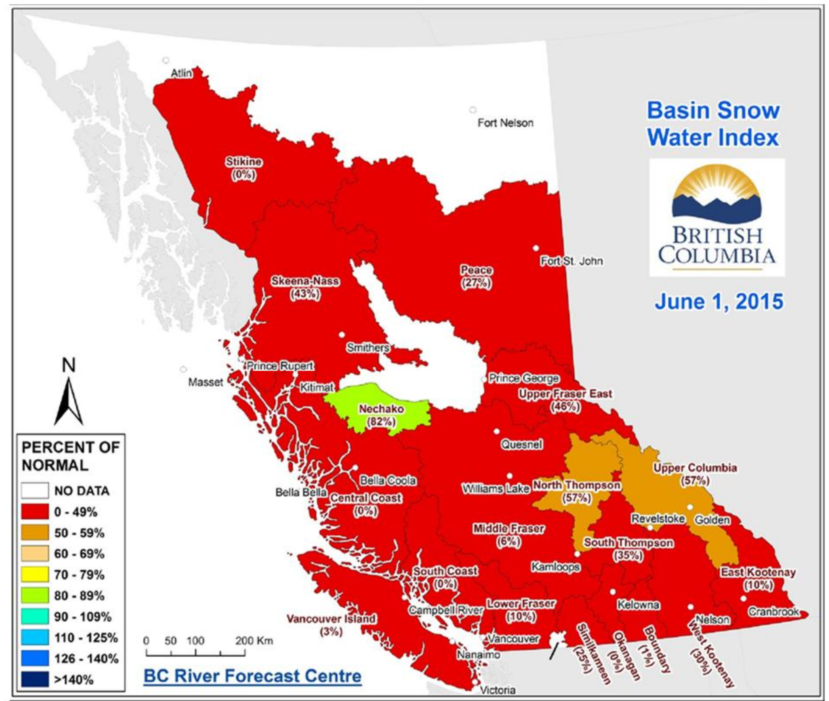
BC Hydrological Impacts

- Early snowpack melt
- Rivers saw near record flows – high and low
- Soil moisture all-time low
- Evaporation all-time high

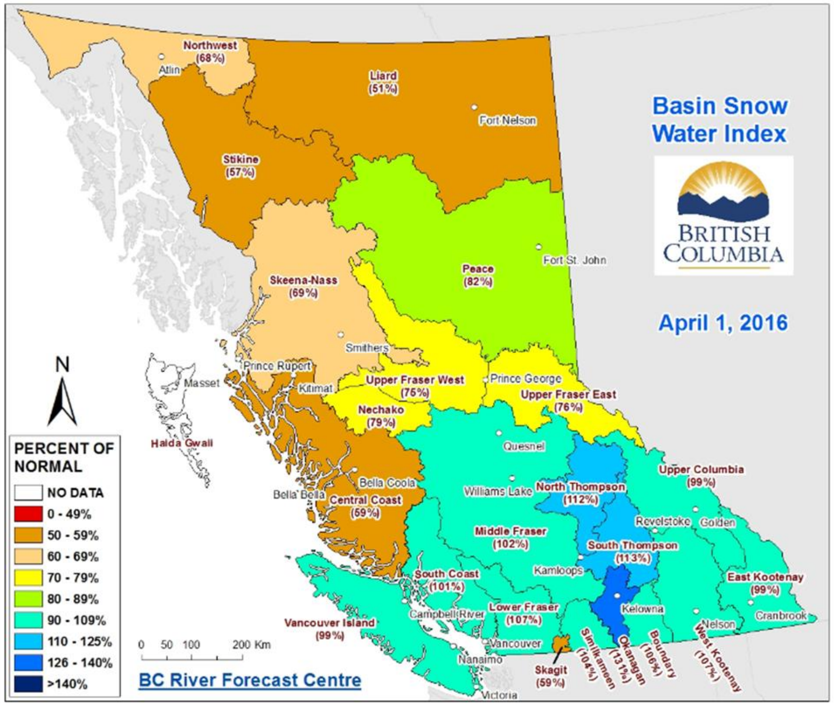


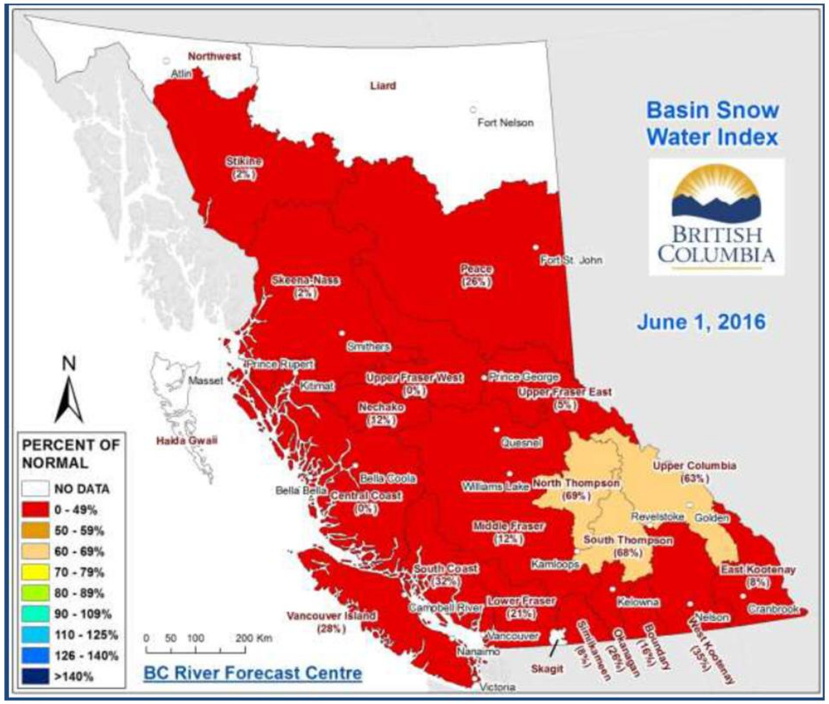
2015 snowpack Apr 1 → June 1





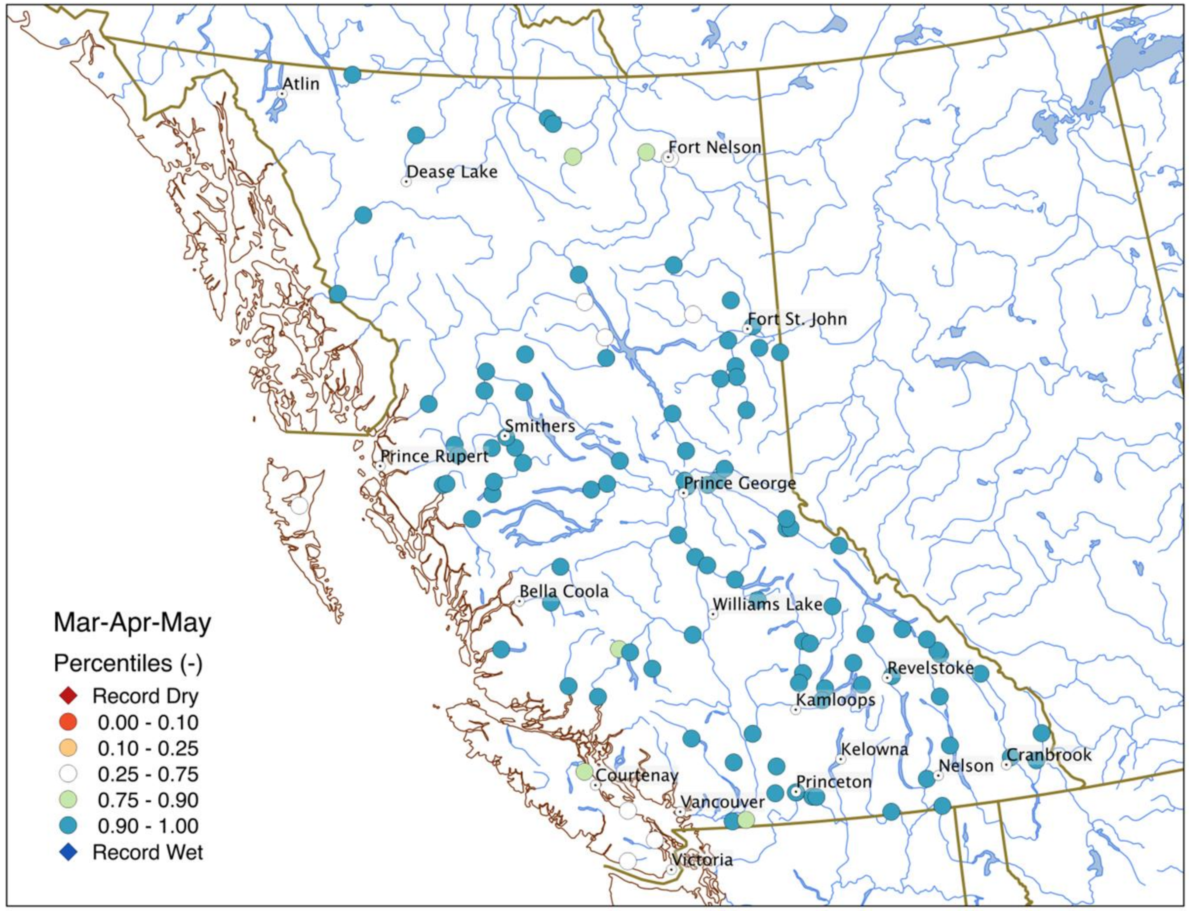
2016 snowpack Apr 1 → June 1





High spring → low summer flows

Very high spring flows



Very low summer flows

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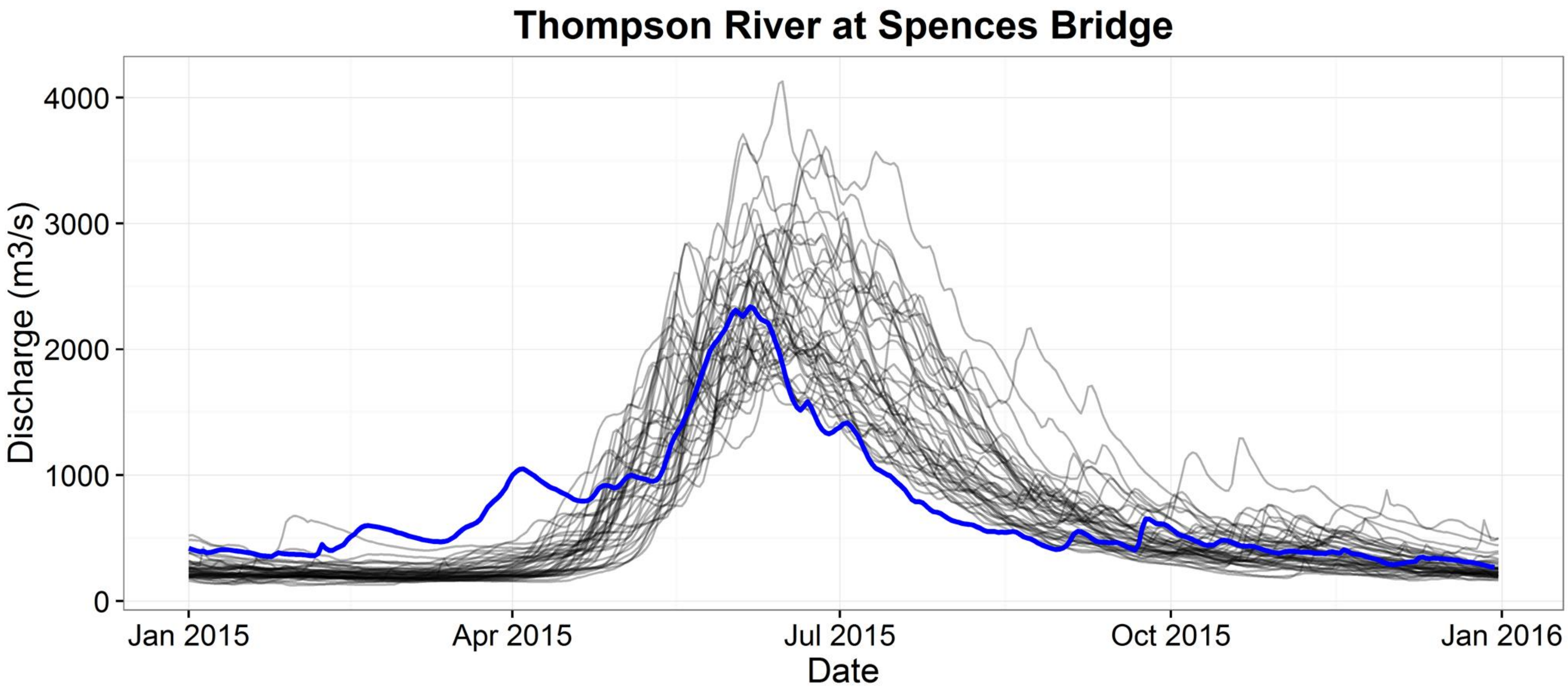
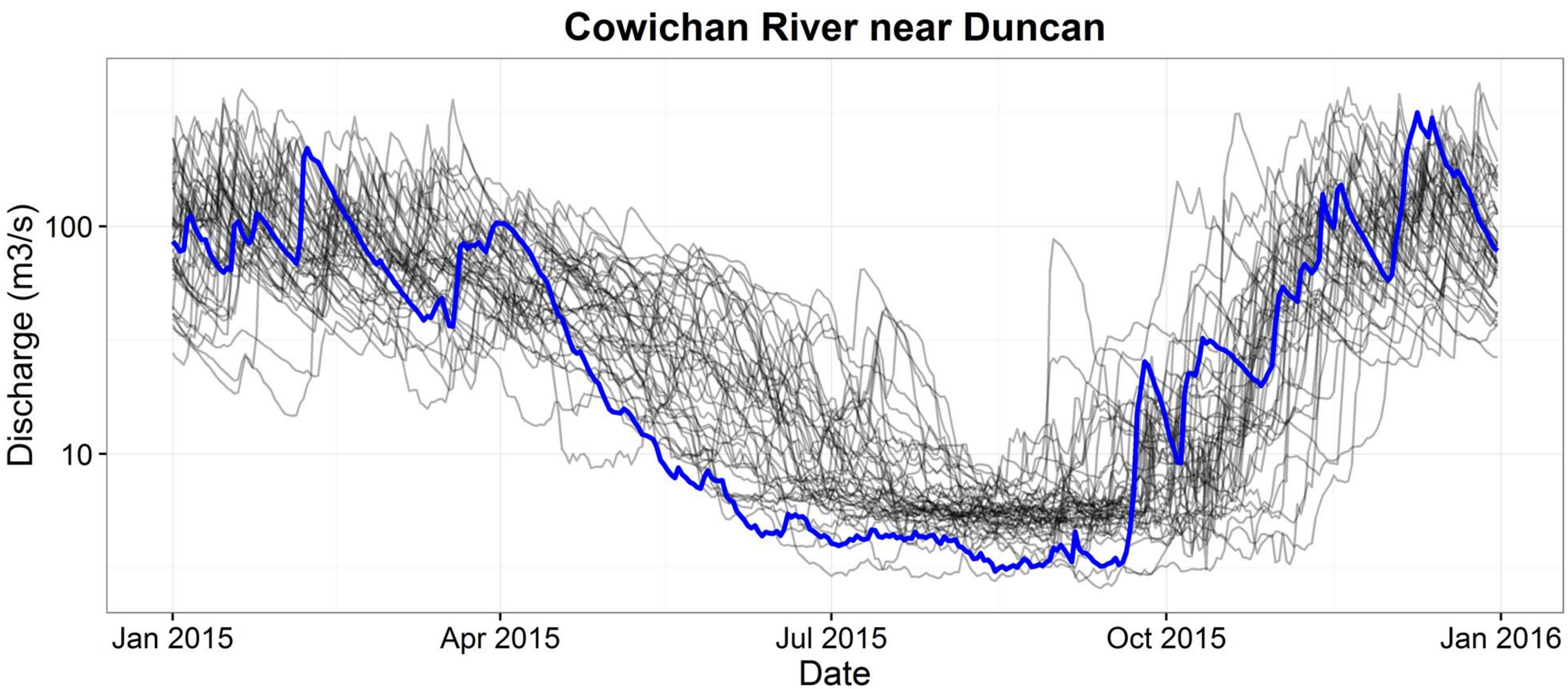
Record high and low flows



Near record low flows



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High evaporation low soil moisture

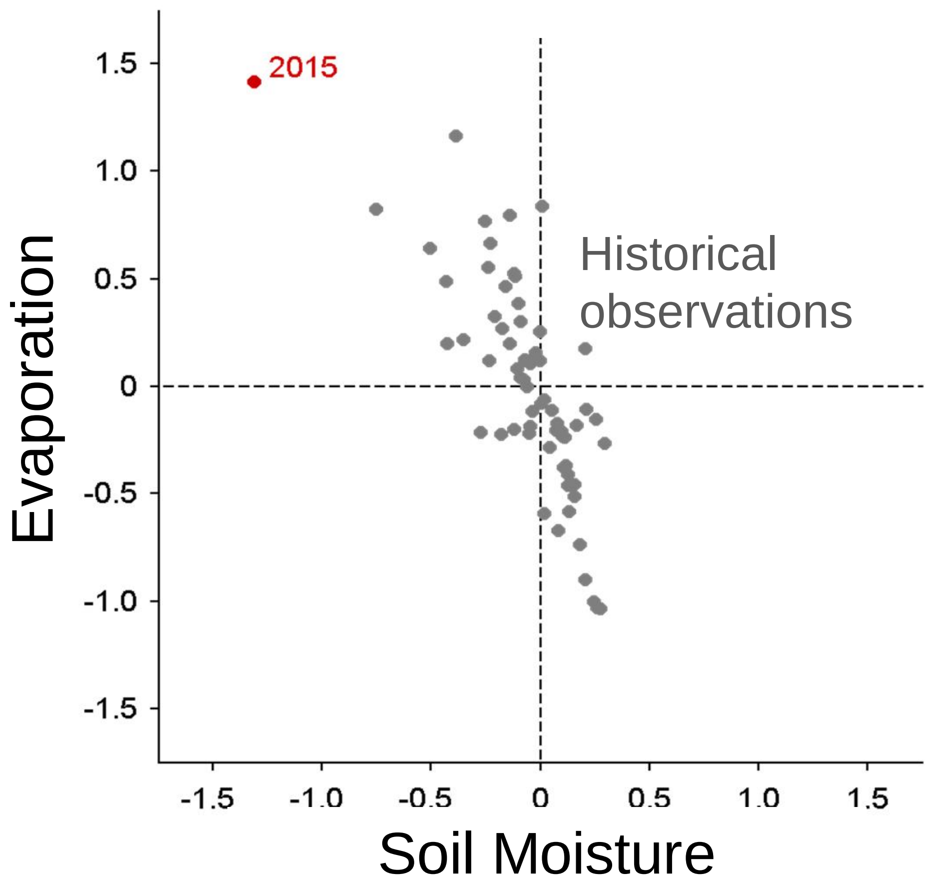

Figure courtesy
Robbie Hember

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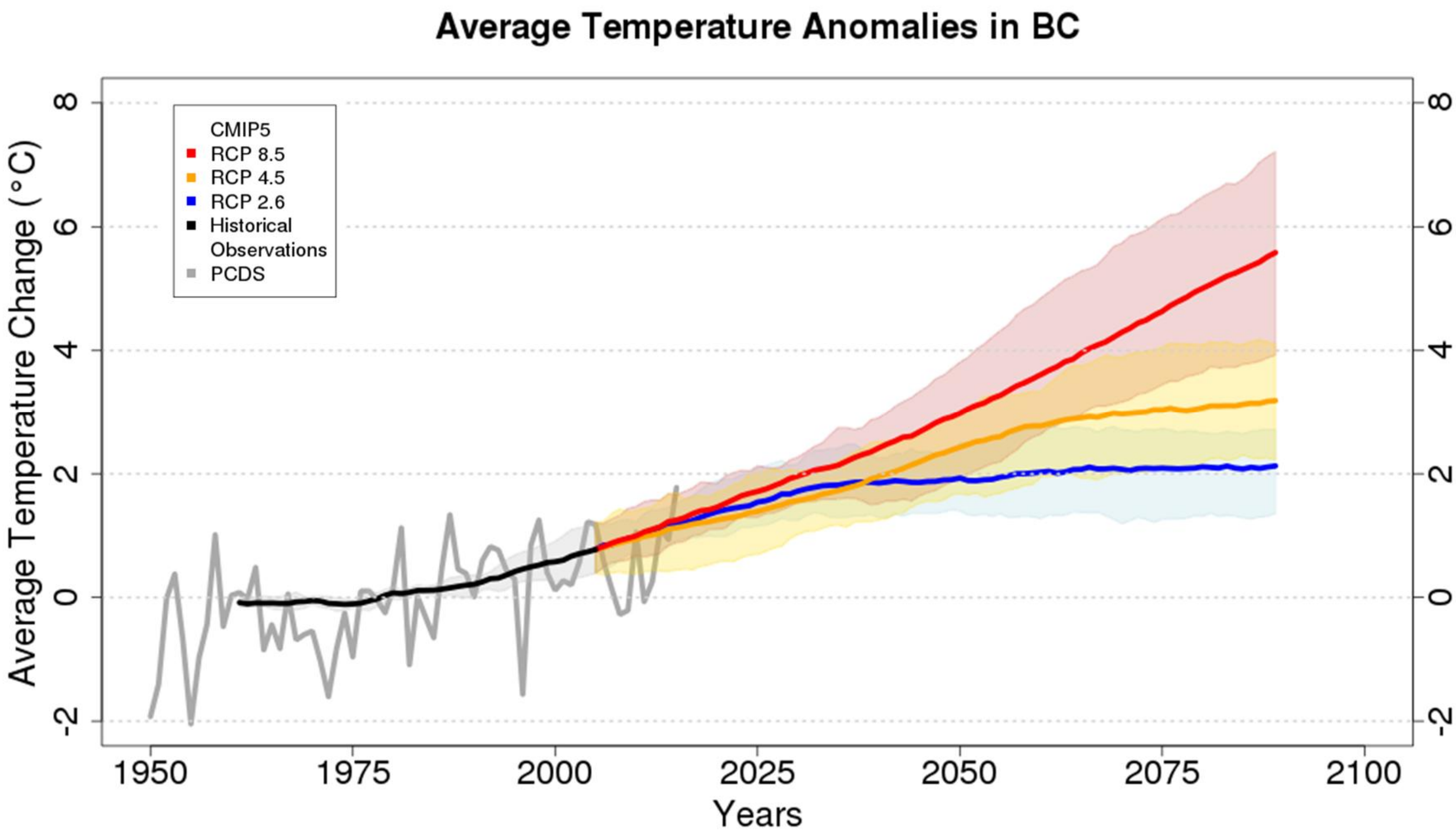
Projected BC warming



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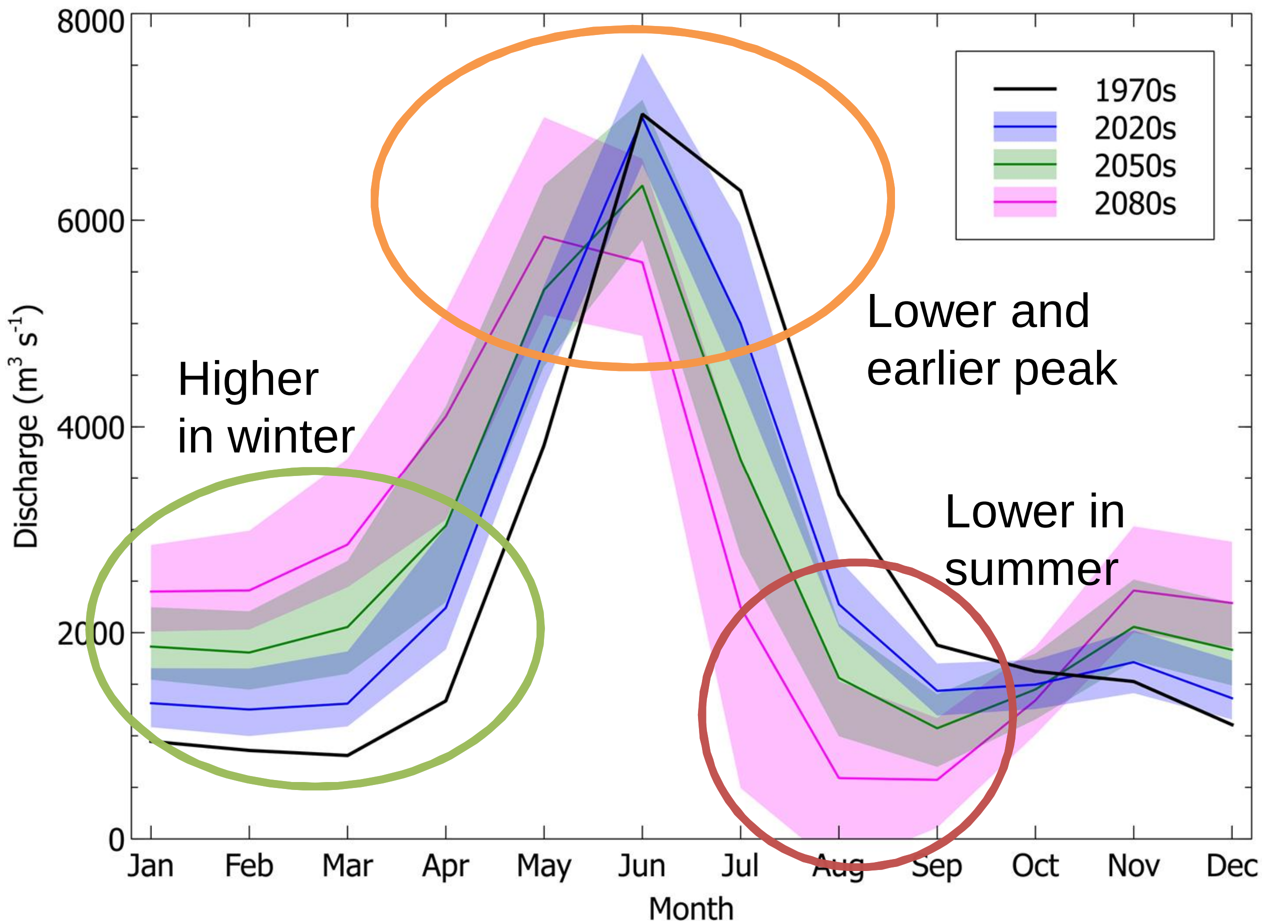
Projected streamflow



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Projected evaporation & soil moisture

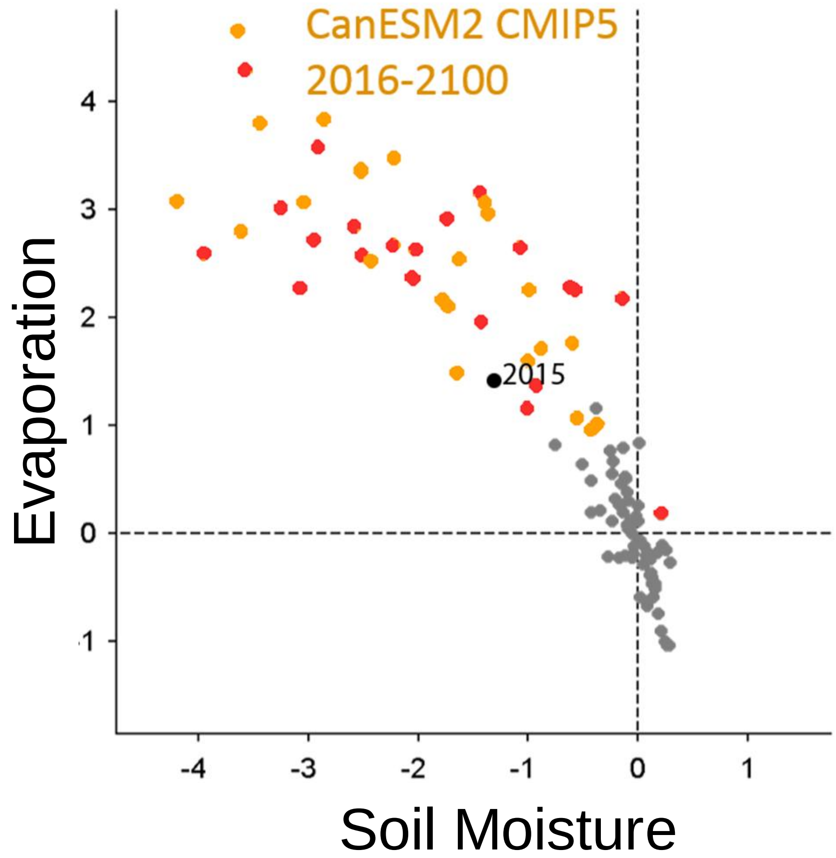
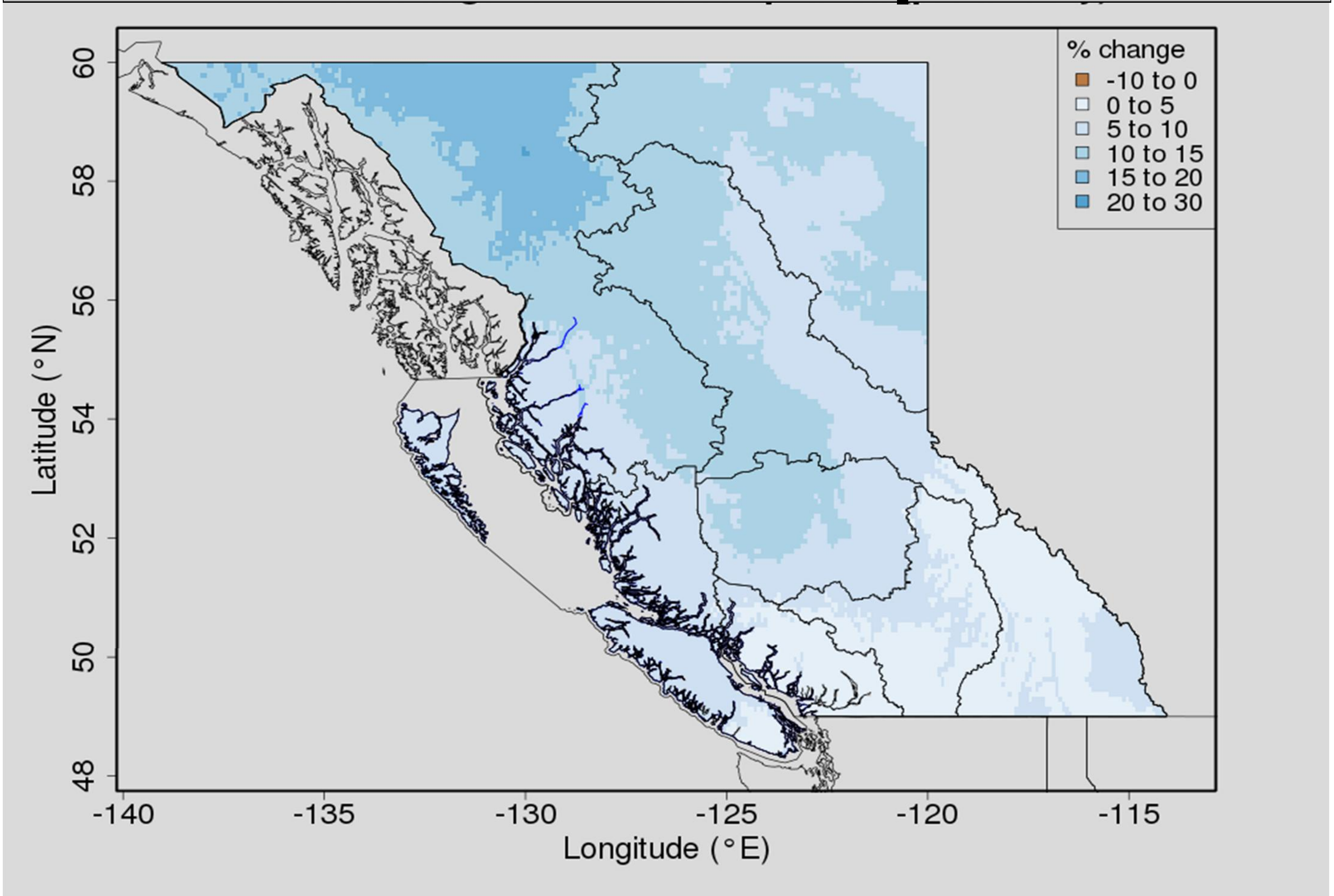
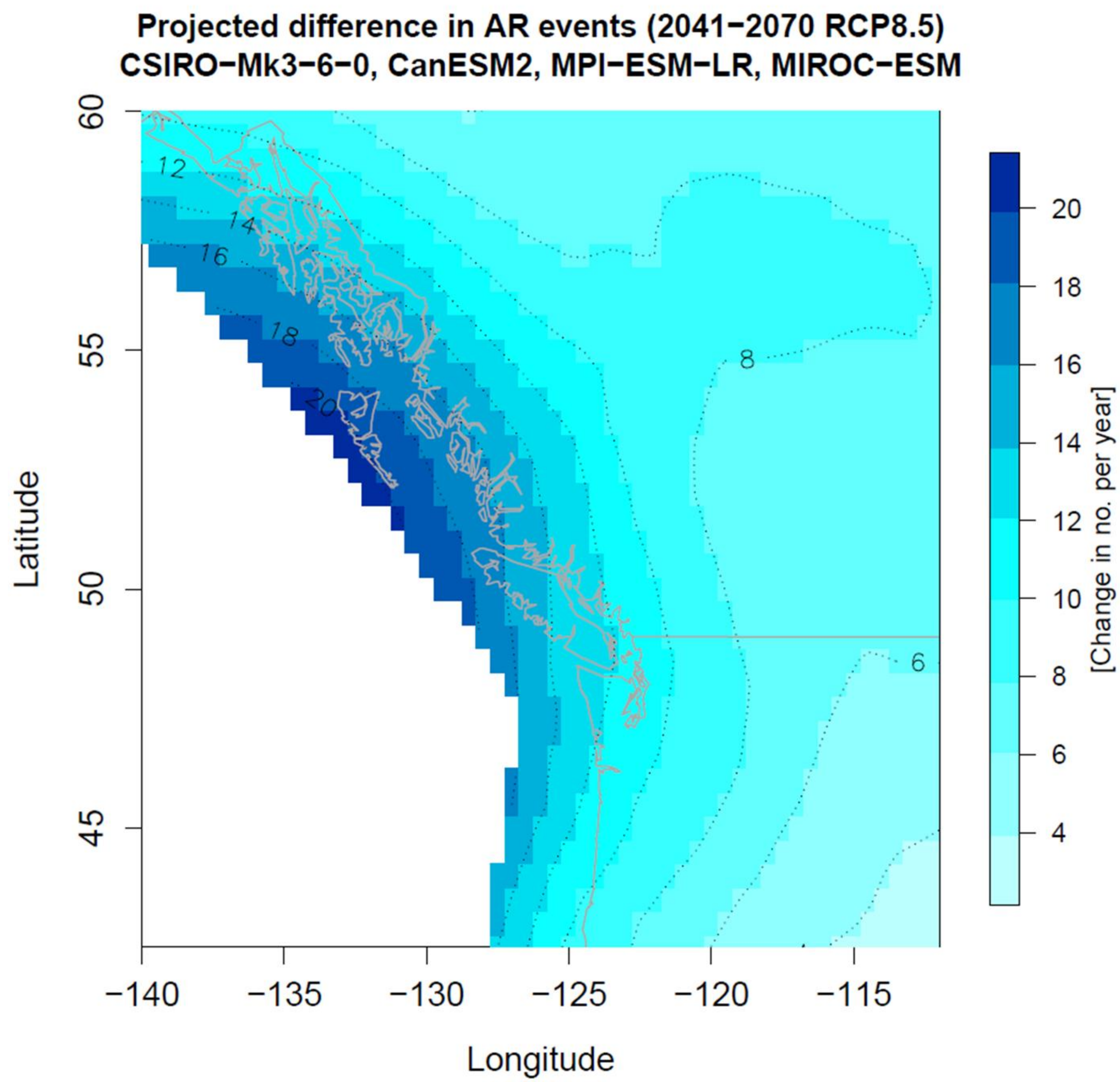


Figure courtesy
Robbie Hember

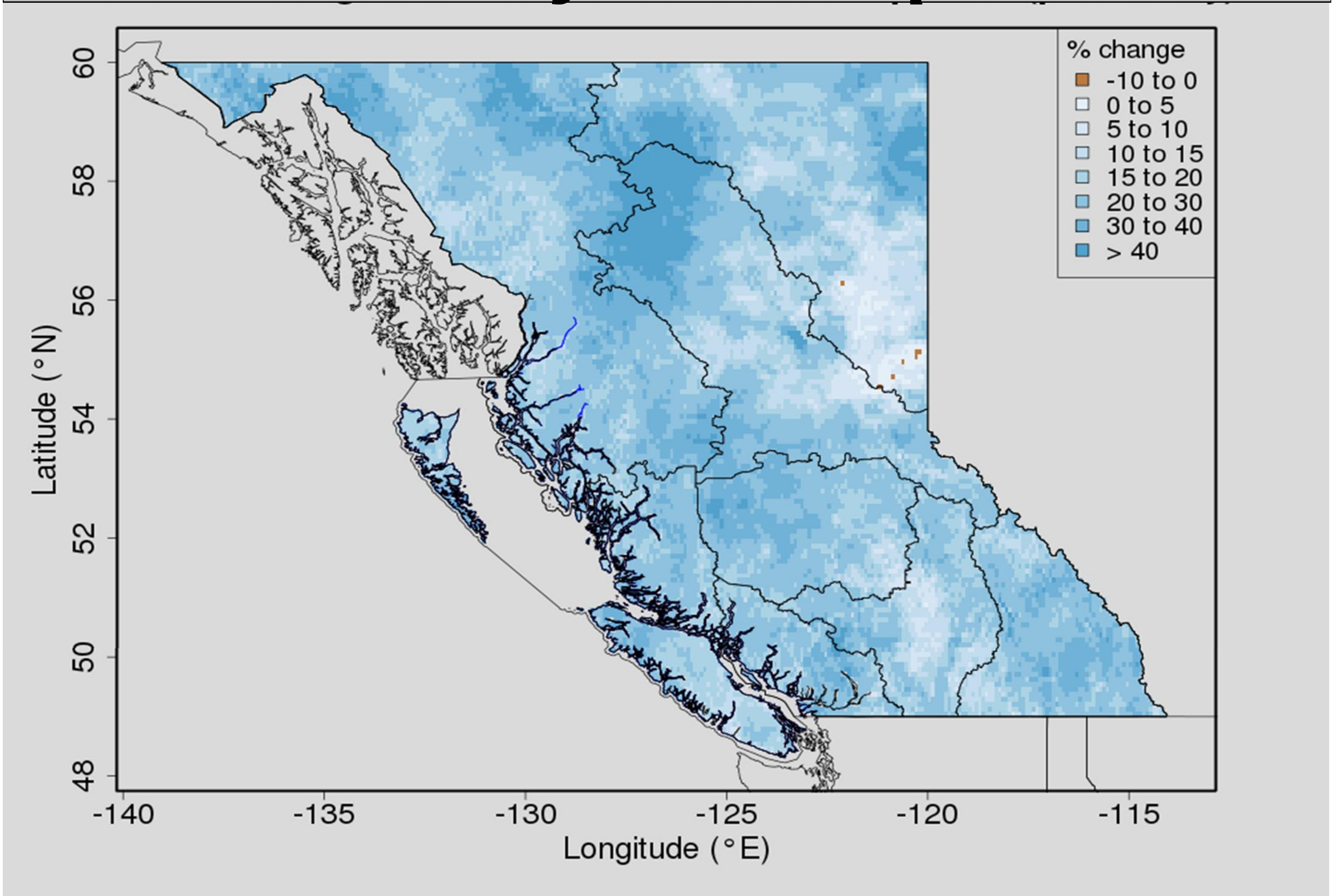
2050s Annual Precipitation

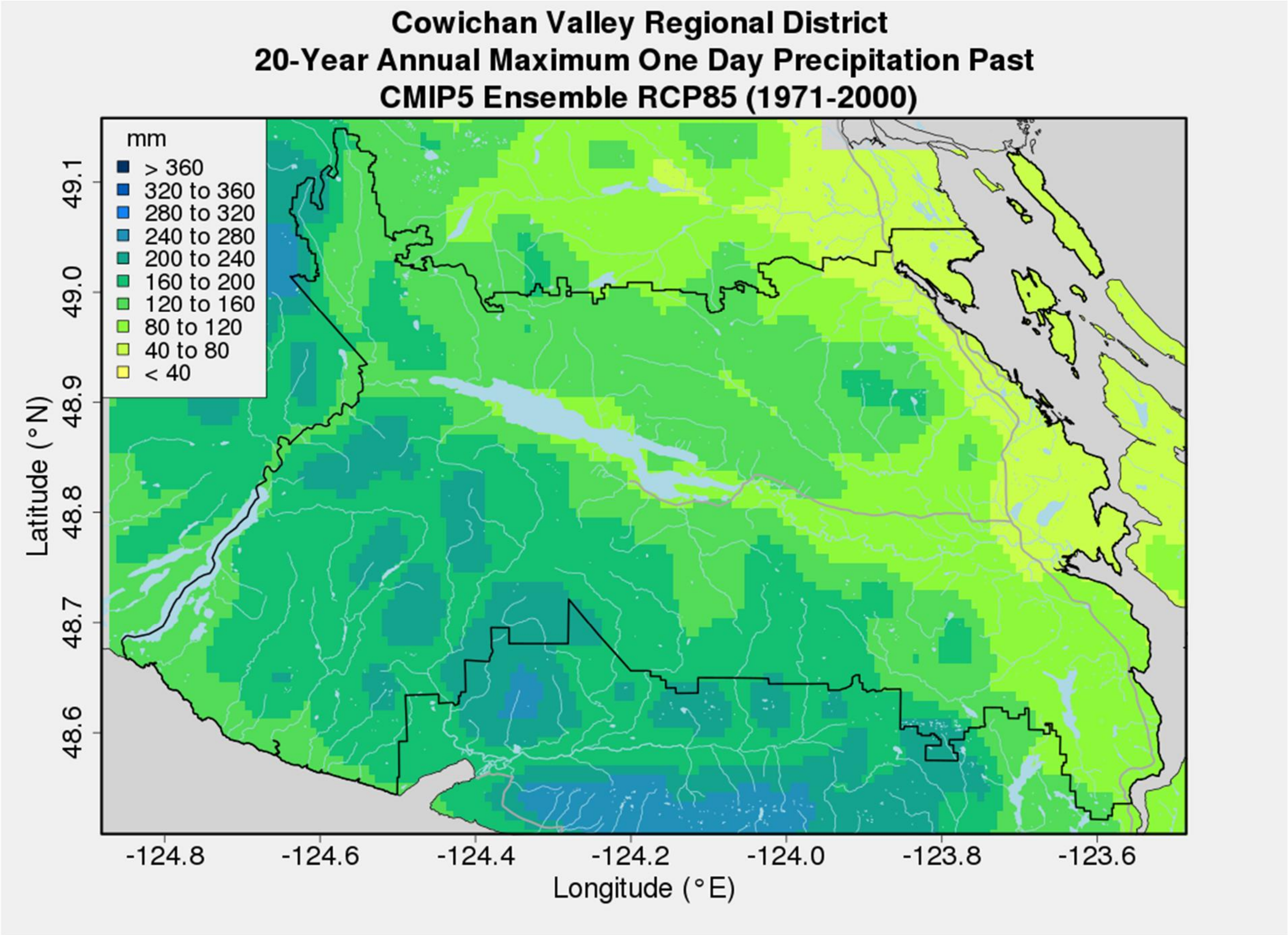


2050s Atmospheric River events

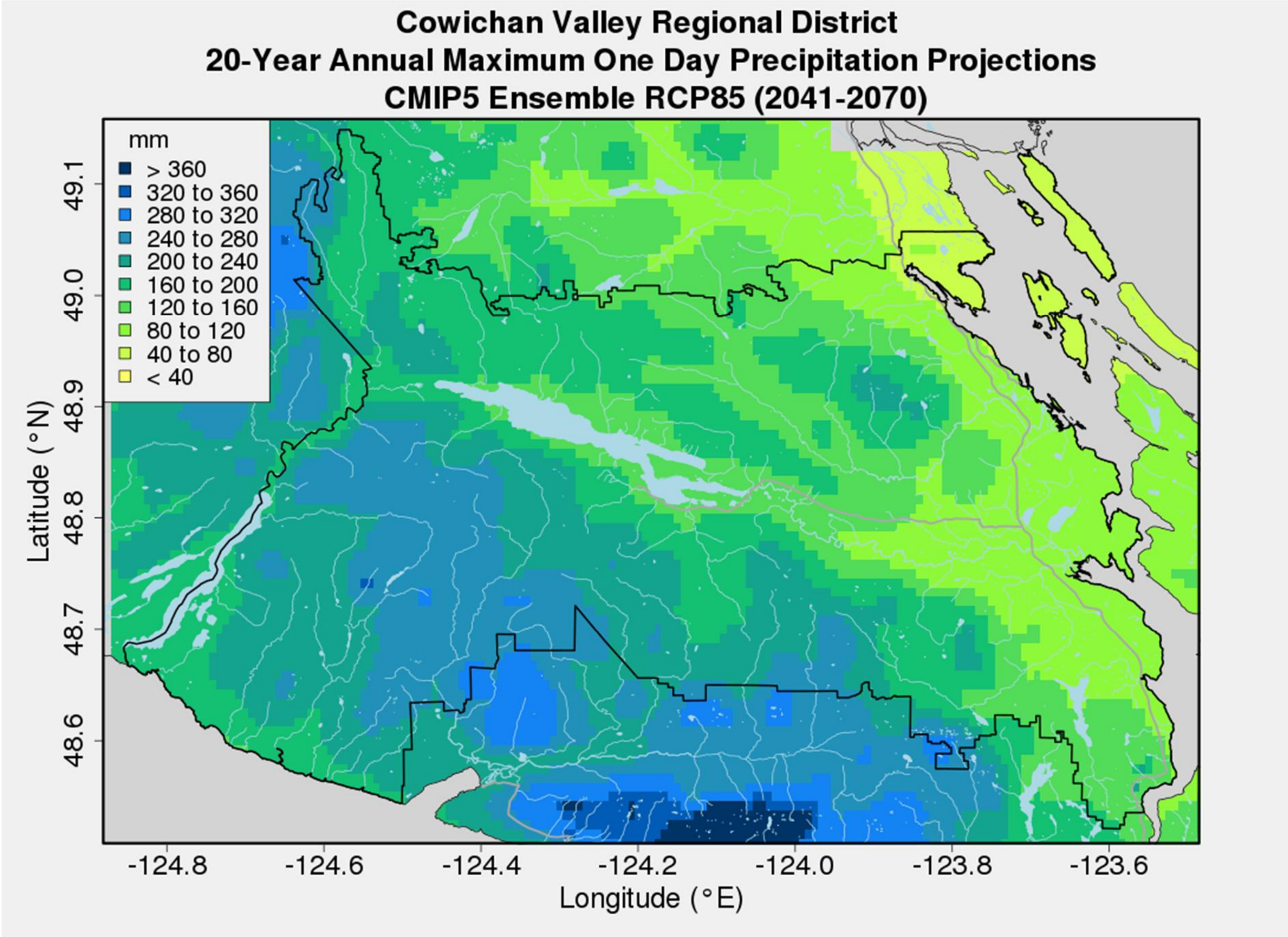


2050s 20-yr return period

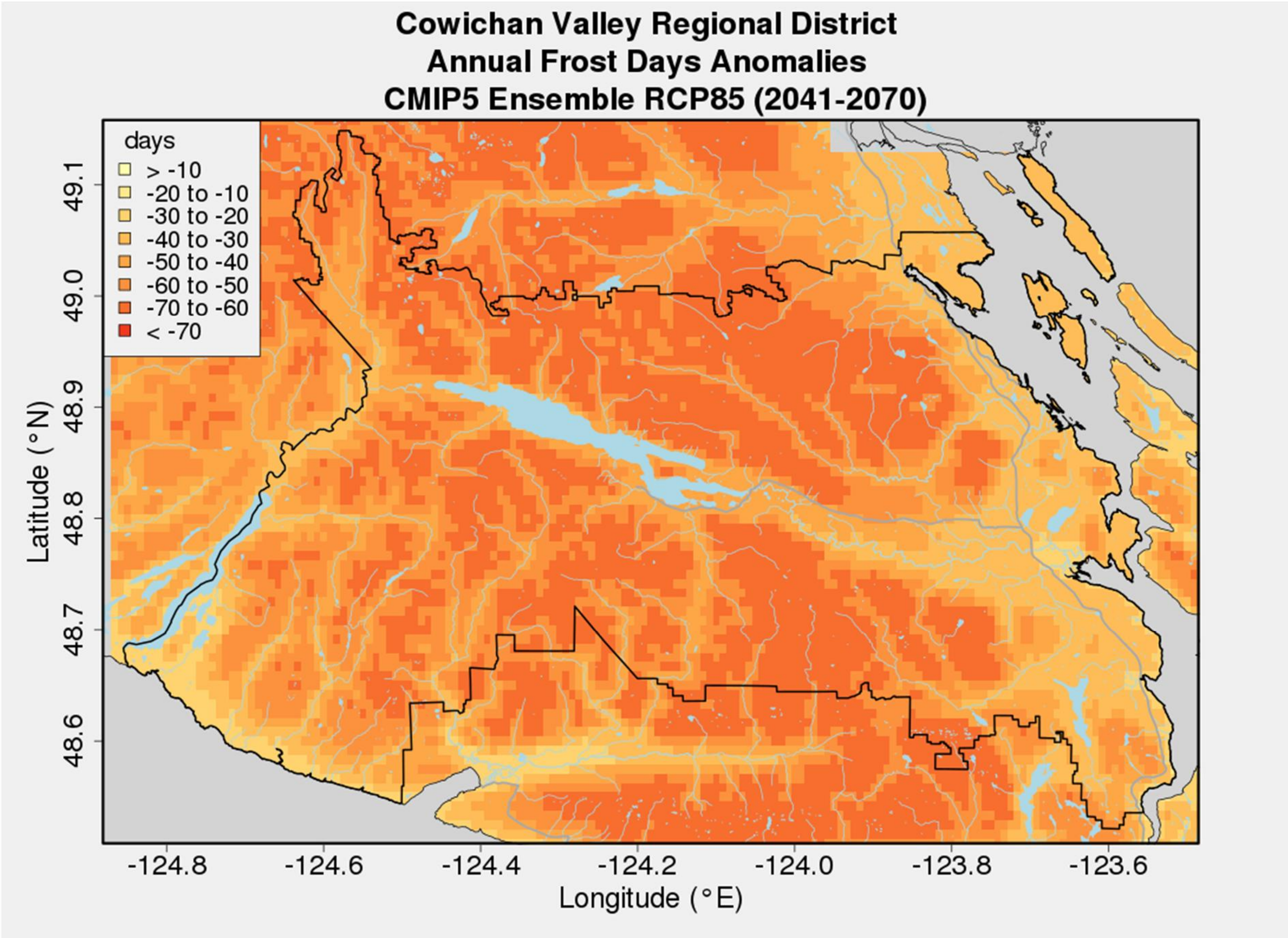




Baseline: 112 mm


Cowichan Valley Regional District
20-Year Annual Maximum One Day Precipitation Projections
CMIP5 Ensemble RCP85 (2041-2070)
mm
> 360
320 to 360
280 to 320
240 to 280
200 to 240
160 to 200
120 to 160
80 to 120
40 to 80
< 40
Latitude (°N)
49.1
49.0
48.9
48.8
48.7
48.6
-124.8
-124.6
-124.4
-124.2
-124.0
-123.8
-123.6
Longitude (°E)

+21% (0% to +40%)


Cowichan Valley Regional District
Annual Frost Days Anomalies
CMIP5 Ensemble RCP85 (2041-2070)
days
> -10
-20 to -10
-30 to -20
-40 to -30
-50 to -40
-60 to -50
-70 to -60
< -70
Latitude (°N)
49.1
49.0
48.9
48.8
48.7
48.6
-124.8
-124.6
-124.4
-124.2
-124.0
-123.8
-123.6
Longitude (°E)

-63% (-49% to -78%)

Take away messages

- Climate varies on multiple time scales

- Projected impacts
  - warming
  - changes to precipitation (“wet wetter and dry drier”)
  - indices of extremes
  - storminess
  - reduced snowpack
  - changes to species suitability
  - streamflow

- 2015/2016 analogue for near normal to much colder than normal depending on emissions

Questions?

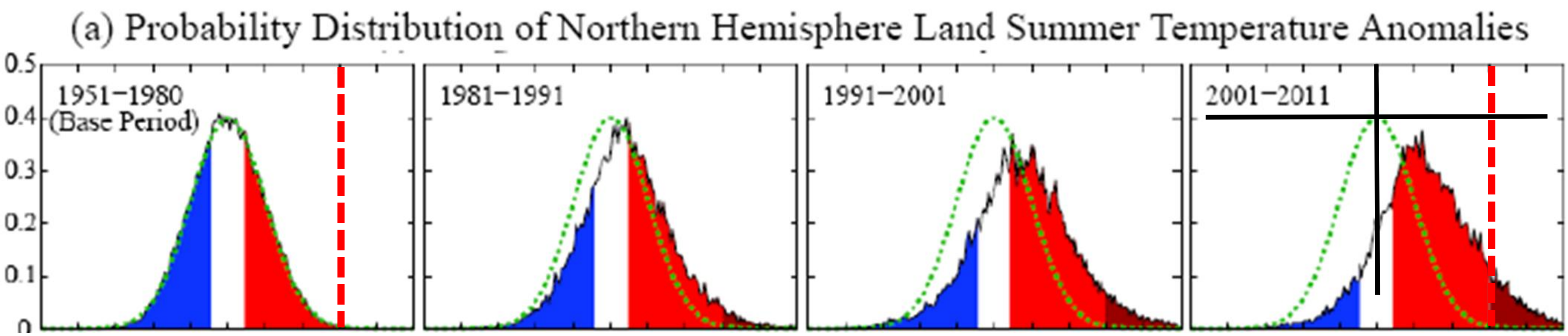
Thank you

For more information
www.PacificClimate.org

Funding support is acknowledged from:

- BC Hydro
- BC Ministry of Environment
- BC Ministry of Forests, Lands, and Natural Resource Operations
- Columbia Basin Trust
- Natural Resources Canada
- Local governments: Victoria, Delta, North Vancouver, Surrey, Vancouver, Metro Vancouver, Capital Regional District

Trends in Extremes



0.1 – 0.2 %

4 – 13 %

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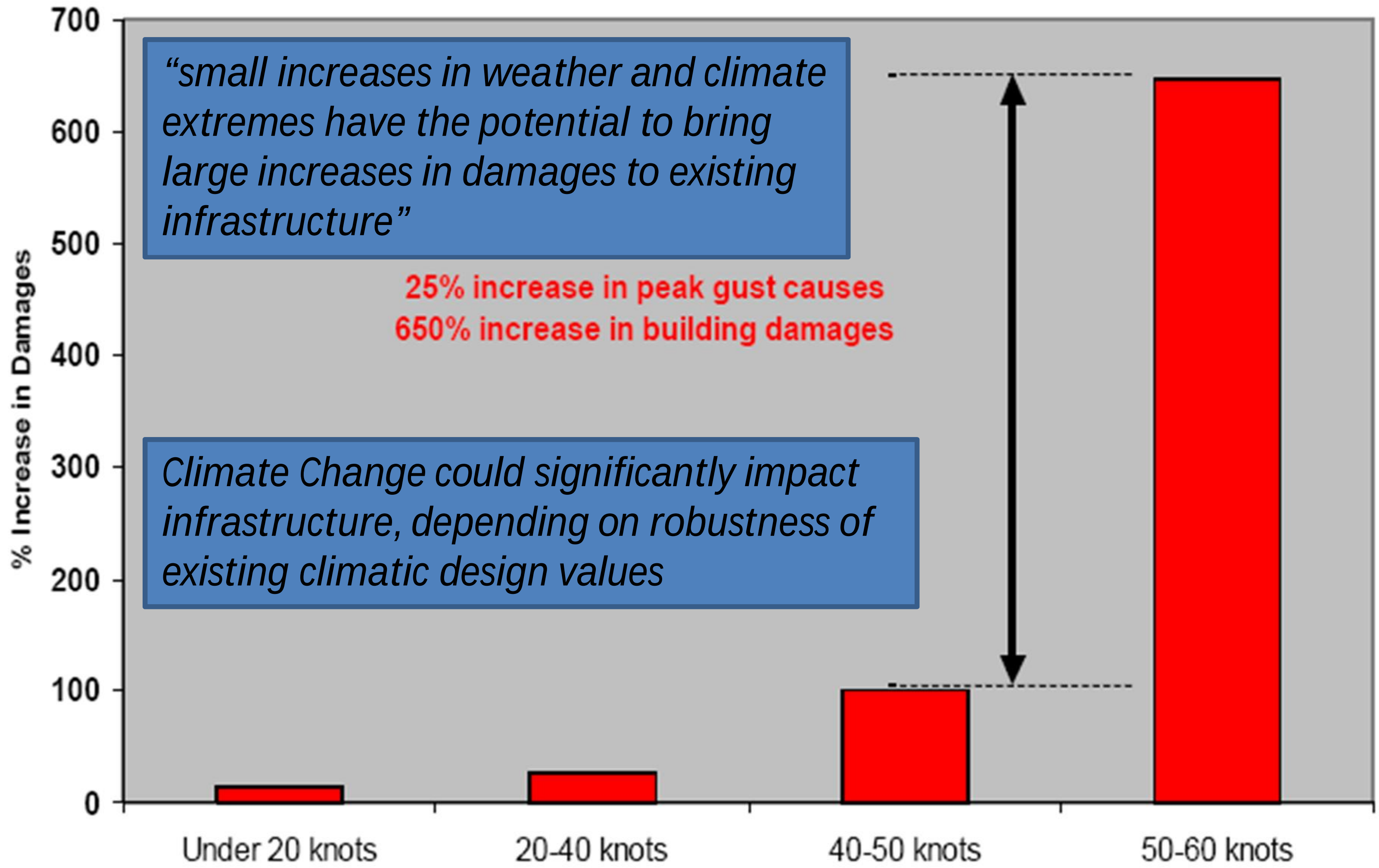
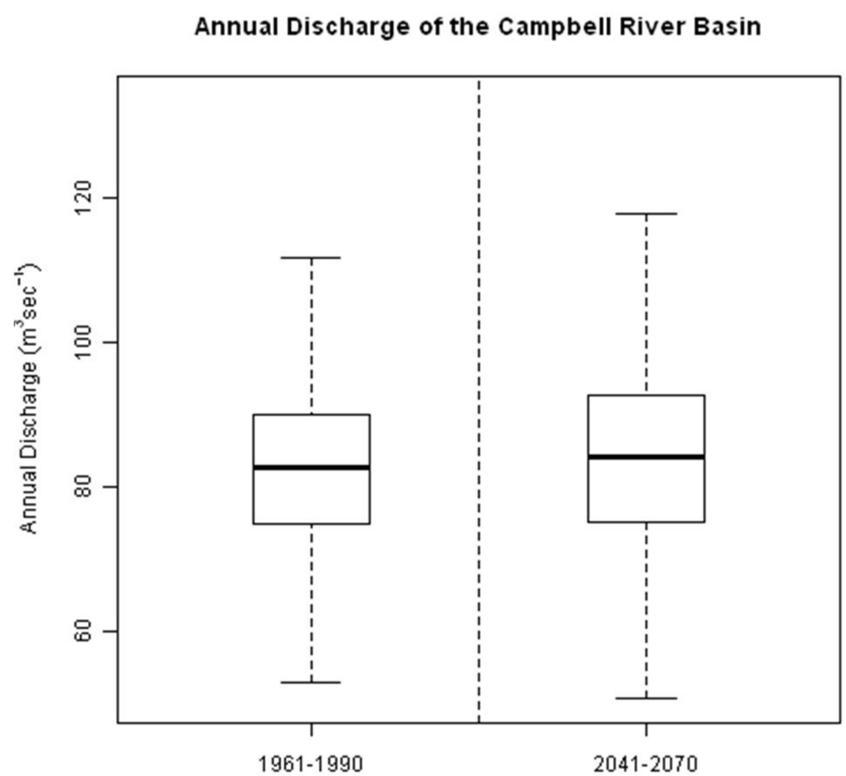
New York, N.Y.

Small Increases = Escalating Infrastructure Damage

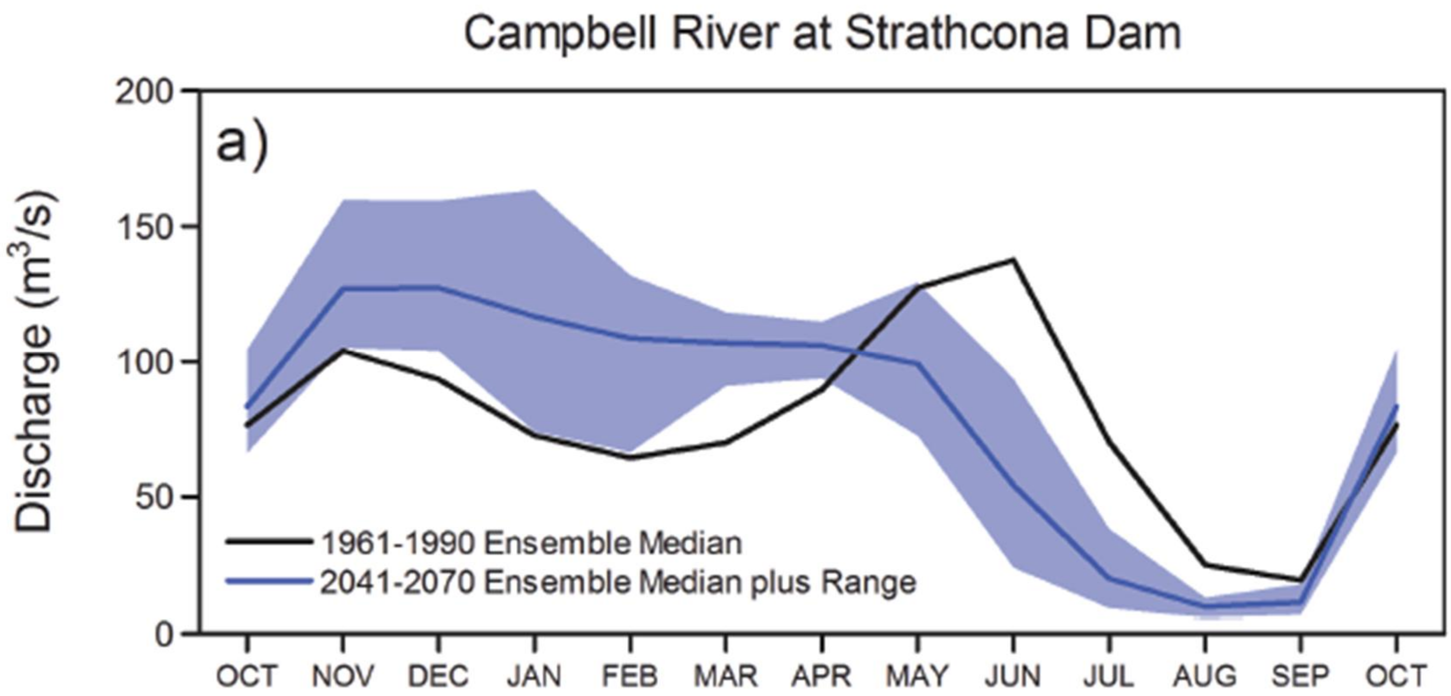


Source: David Lapp, Engineers Canada

What you ask for matters



Seasonal streamflow



Pacific Climate Impacts Consortium

- Launched 2005, sister organization to PICS
- Partner with researchers and users
- Applications to management, planning, decision-making

Regional Climate Impacts

- developing, providing and interpreting future projections of regional climate change

Hydrologic Impacts

- quantifying the hydrologic impacts of climate change and variability

Climate Analysis and Monitoring

- serving the need for past climate information and its interpretation

Communication

3.33 Weather

More Applied

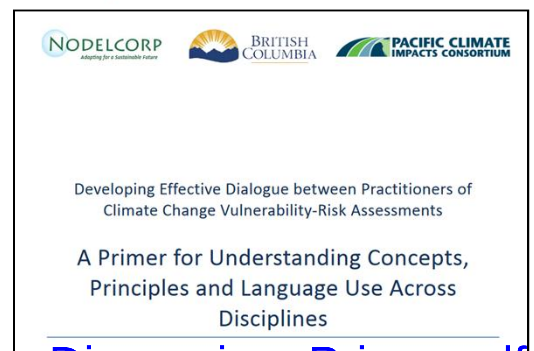
Engineers like others, may not distinguish between climate and weather. Engineers are concerned with weather such as extreme weather events as they must design infrastructure to taking these and their frequency and intensity into account.

More Theoretical

Meteorological conditions that occur at a specific location and time. Statistics may be computed from weather data to establish climatological norms.

Potential Source of Confusion

When the engineer is referring to climate or climate events, they may actually be referring to specific weather events such as extreme values (temperature, precipitation) at a particular location and time. In contrast, the scientist will use the term weather to refer to specific events and the term climate to refer to the tendency of events to occur over a specific time period.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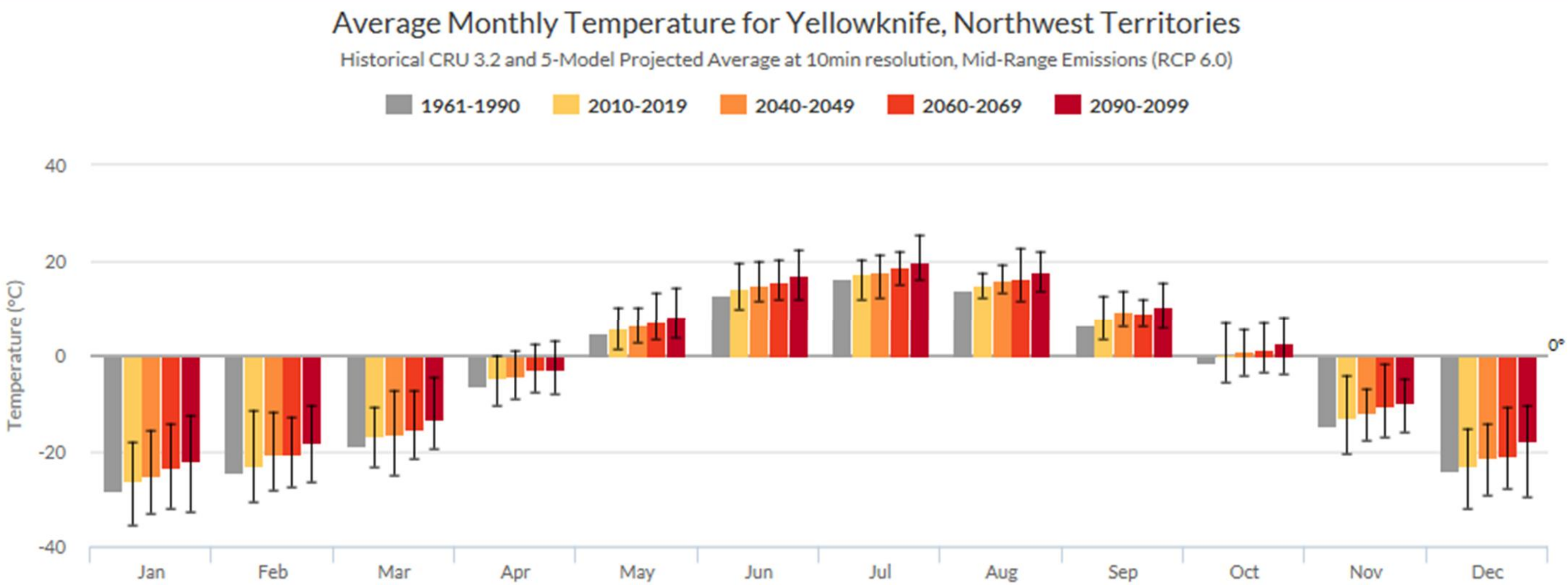
Developing Effective Dialogue between Practitioners of Climate Change Vulnerability-Risk Assessments

A Primer for Understanding Concepts, Principles and Language Use Across Disciplines

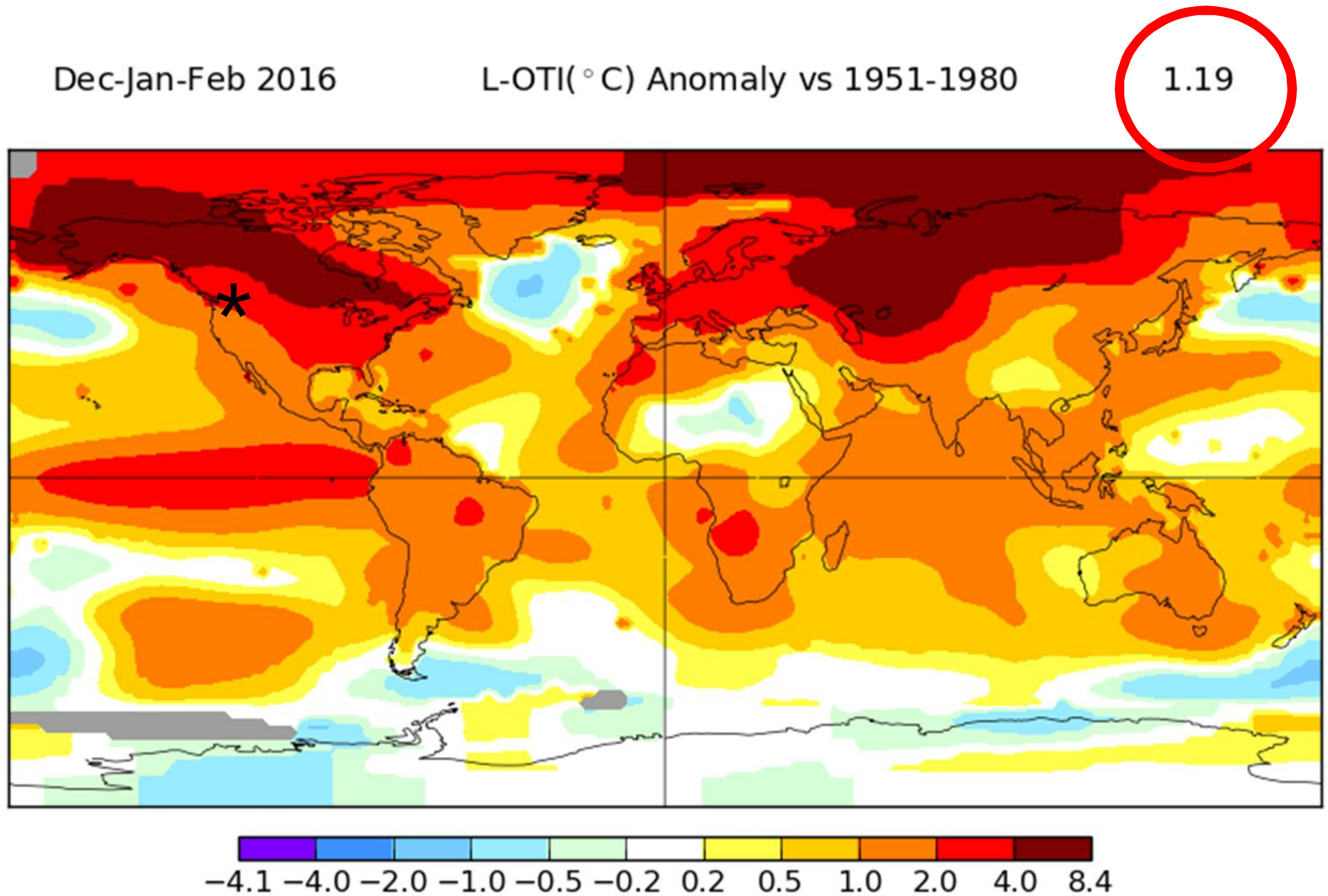
http://www.th.gov.bc.ca/climate_action/documents/Climate_Data_Discussion_Primer.pdf

Projected Yellowknife warming



Source: Brian Sieben www.nwtclimatechange.ca / tinyurl.com/snap-nwt tool

Climate varies in space



Temperature Anomaly ^{0}C

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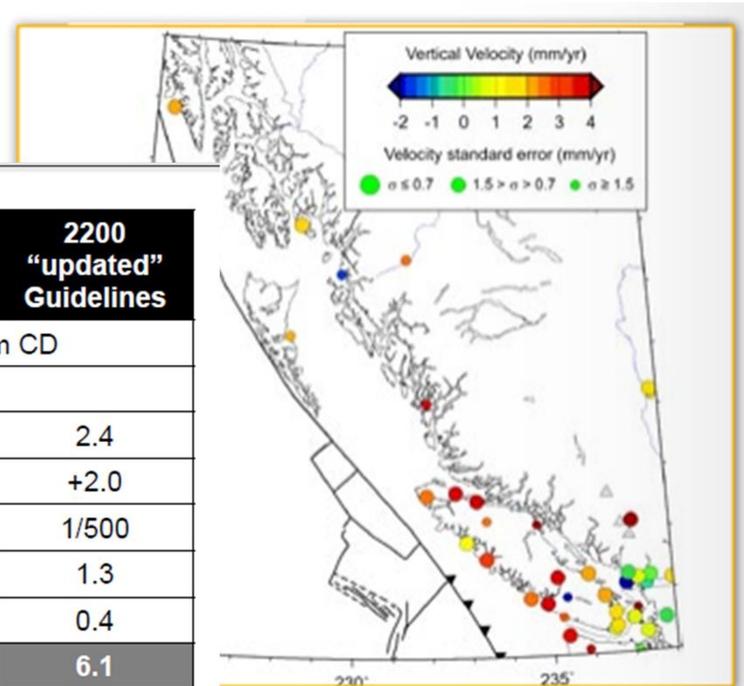
New York, N.Y.

Sea Level Rise

- http://www.env.gov.bc.ca/cas/adaptation/sea_level.html
- Guidelines based on
  1 m / century



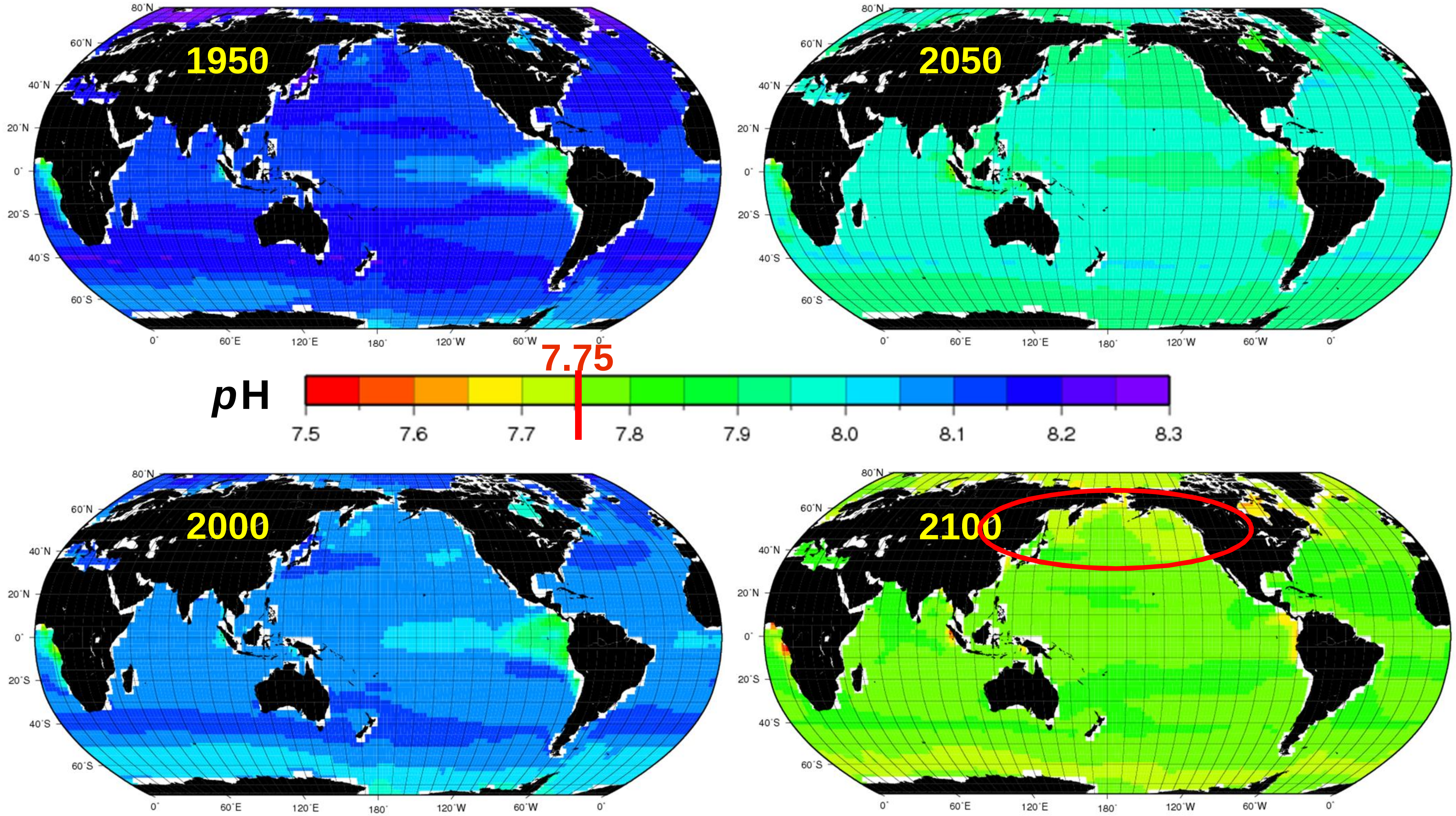
; of uplift (mm per year) of the land along coastal e the high rates on southwestern Vancouver Island y to the east to zero near Vancouver.

Richmond West

CASE	2010 "existing" Guidelines	2100 " updated" Guidelines	2200 "updated" Guidelines
Reference vertical plane	CGD = MWL = +2.9 m CD		
Elevation of Toe of Sea Dike	+1.5 m CGD		
Regional SLR (m, wrt MWL)	0	1.2	2.4
Reference Tide level (HHWLT) (m)	+2.0	+2.0	+2.0
Storm Surge AEP	1/200	1/500	1/500
Storm surge height (m)	1.25	1.3	1.3
Local wind set up (m)	0.3	0.4	0.4
Designated Flood Level (m, CGD)	**3.55**	**4.9**	**6.1**
Wave Runup (R 2%) m	1.5	2.7	3.8
Runup elevation for "green" water alone (m, CGD)	5.1	7.6	9.9
Crest Elevation for 10 L/s/m (m, CGD)	4.6	6.8	8.7
Crest Elevation for 1 L/s/m (m, CGD)	5.1	7.8	10.6
Freeboard (m)	+0.6	+0.6	+0.6

Comment:
The values in the Table above **Designated Flood Level** are site specific and those shown are guideline values for these examples. The values in the Table below **Designated Flood Level** result from the site specific values based on the procedures defined in the Standards and Guidelines referenced in this document

The Acidification of the World Ocean



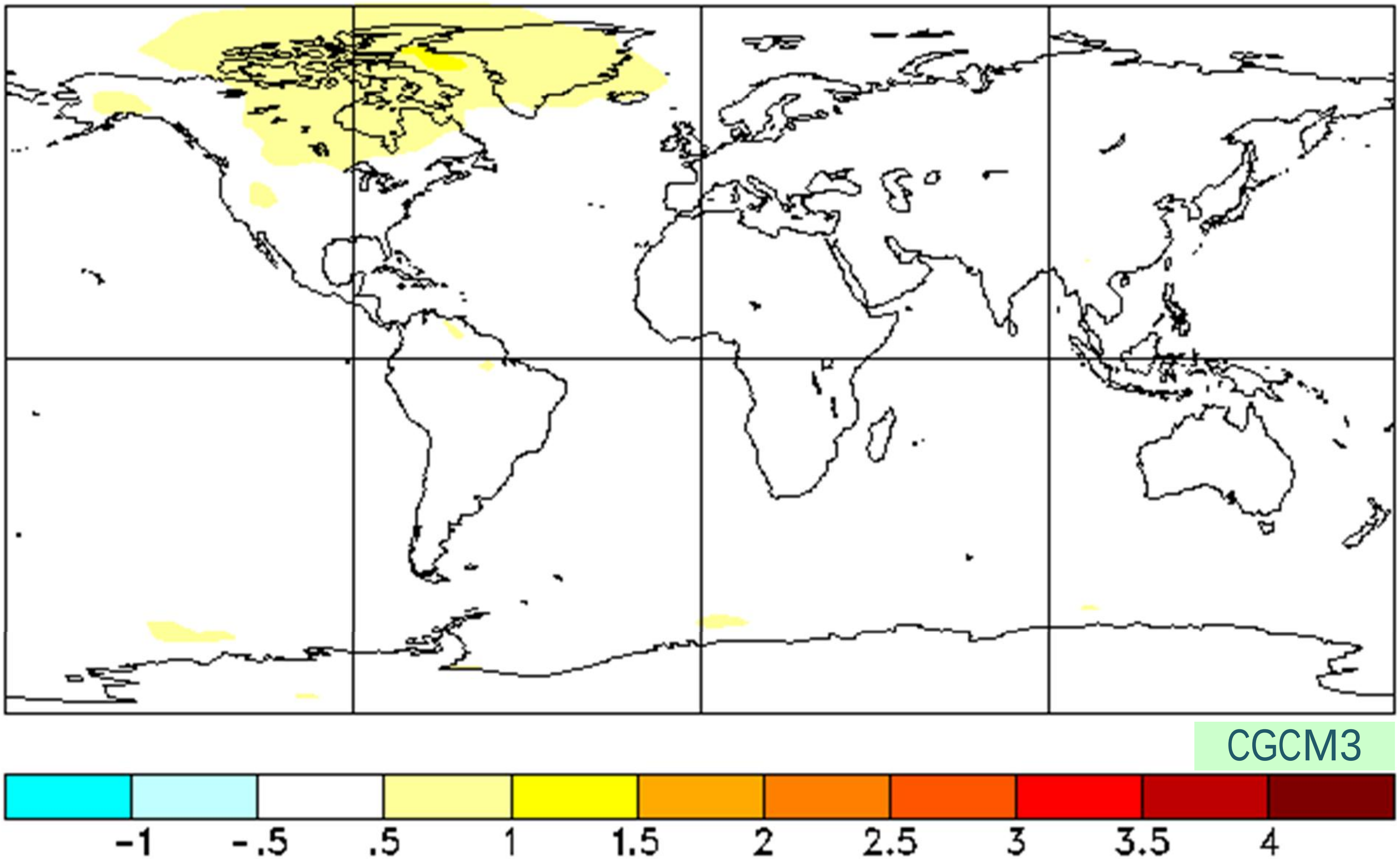
'A2' Scenario from the Canadian Centre for Climate Modelling and Analysis (CCCMA) Earth System Model CanESM1: ***Zahariev, Christian & Denman, 2008; Arora et al., 2009, J. Climate; Christian et al., under re-review, JGR-Biogeosciences***

Slide used with permission of ken.denman@ec.gc.ca

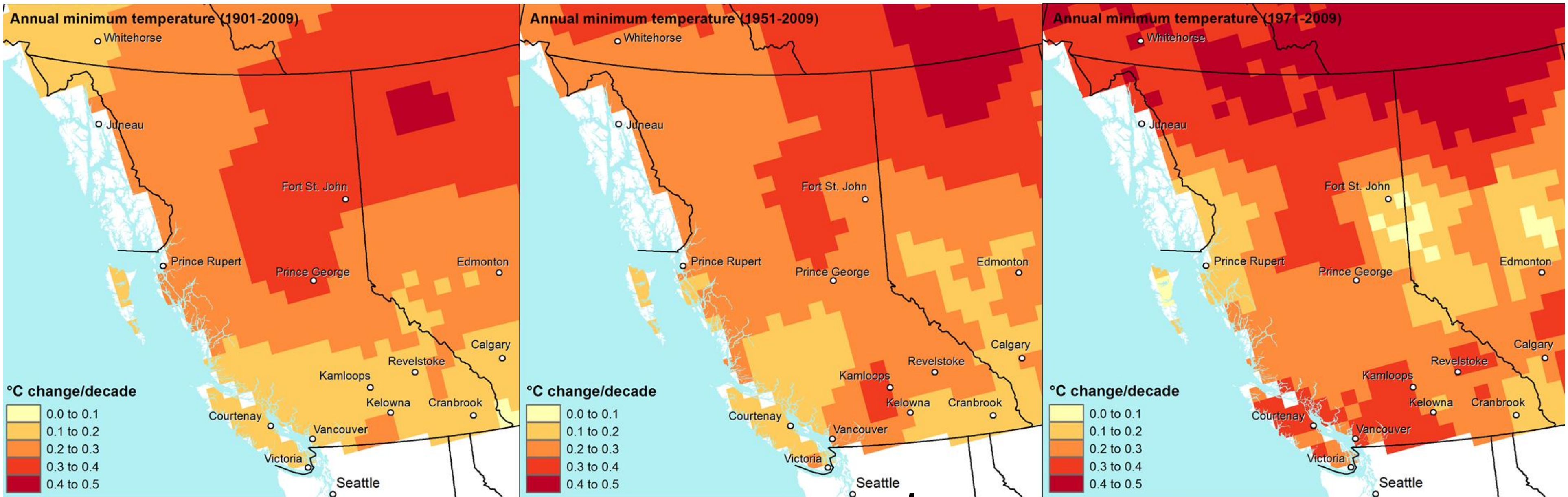
Global Climate Model temperature

Year 2000 Année

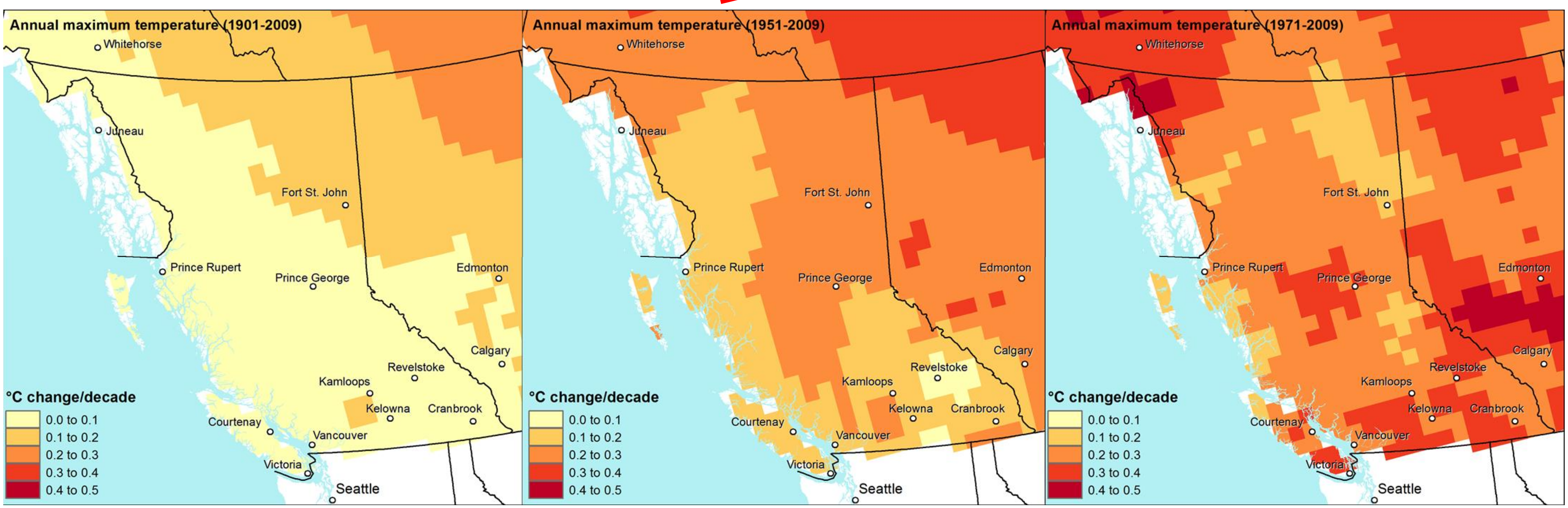
Courtesy CCCma



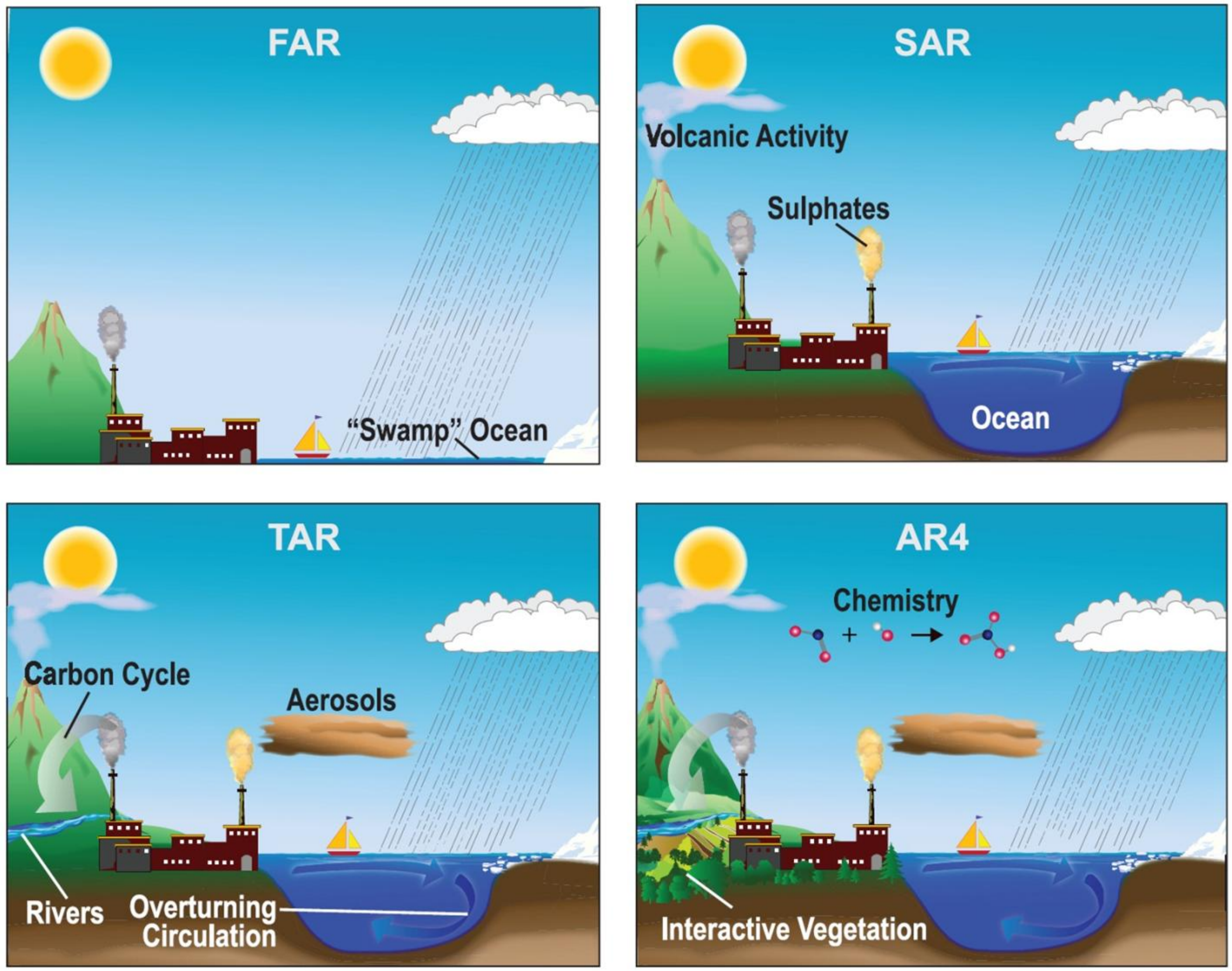
Nighttime low



Daytime high

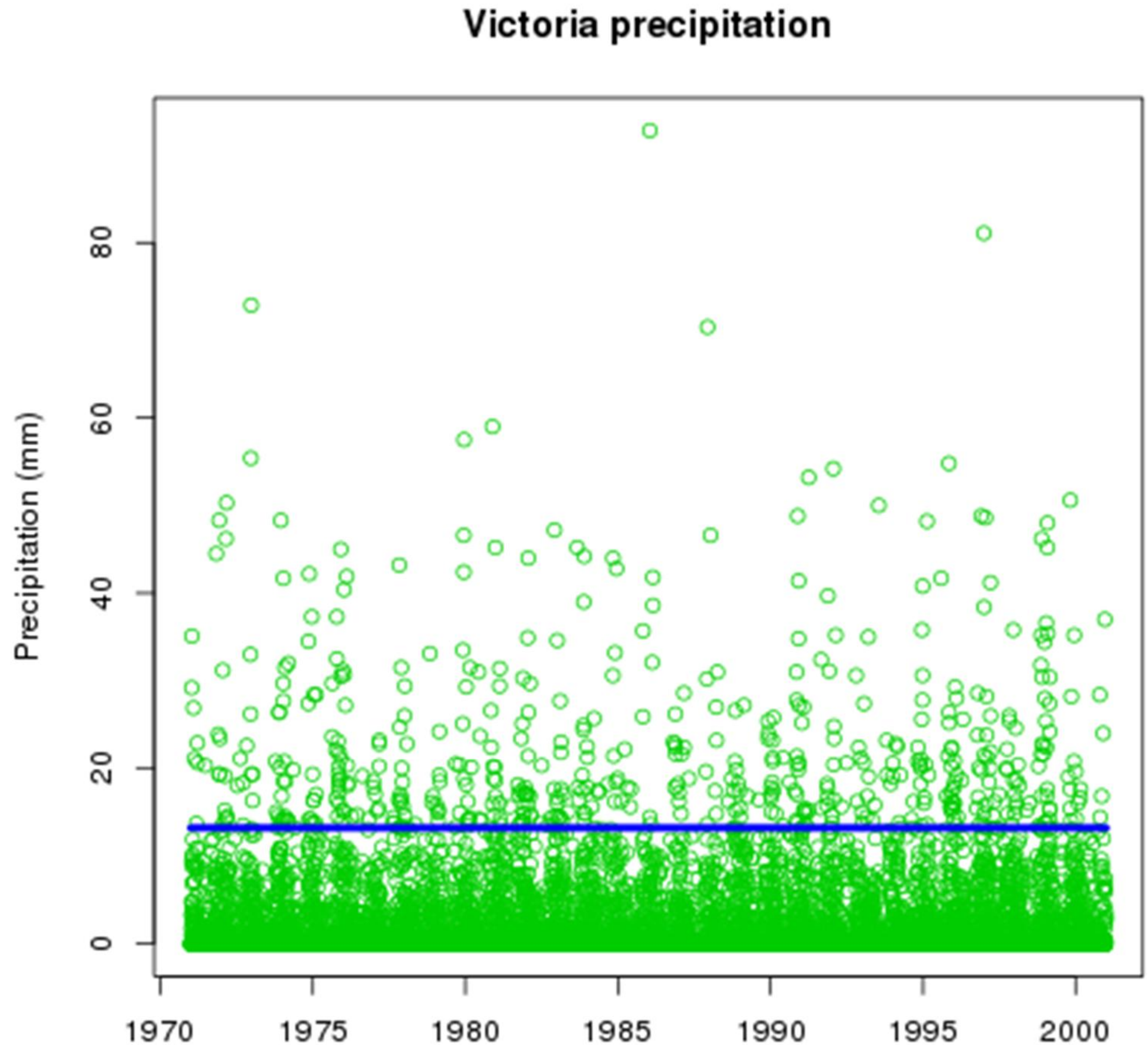


Development of Global Climate Models

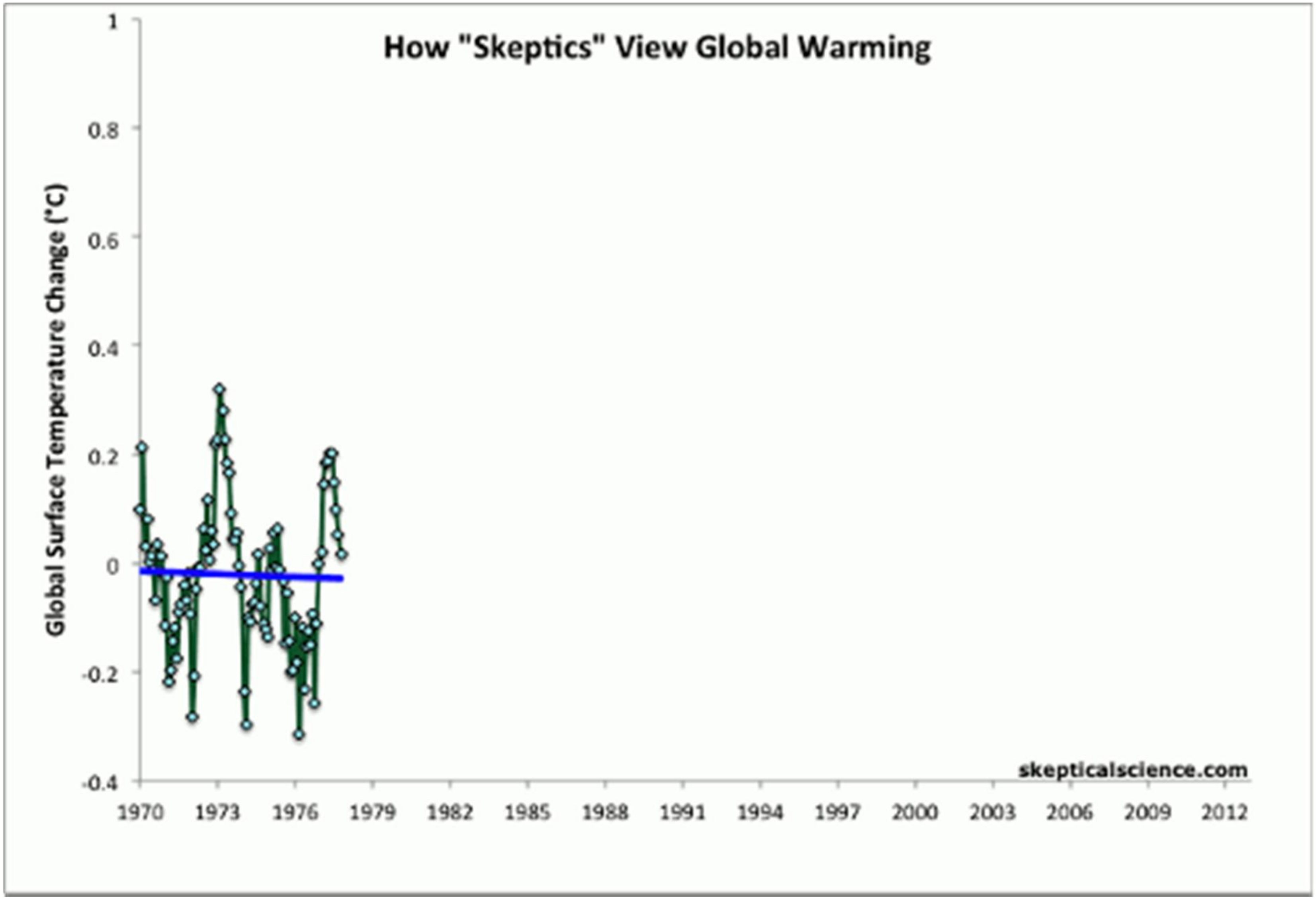


More info http://pics.uvic.ca/insights/lesson4/player.html

IPCC AR4 Report, 2007



Victoria precipitation
Precipitation (mm)
0
20
40
60
80
1970
1975
1980
1985
1990
1995
2000


How "Skeptics" View Global Warming
Global Surface Temperature Change (°C)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
skepticalscience.com

www.Plan2Adapt.ca

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- Summary
- Region & Time
- Temperature
- Precipitation
- Snowfall
- Growing DD
- Heating DD
- Frost-Free Days
- Impacts
- Notes
- References

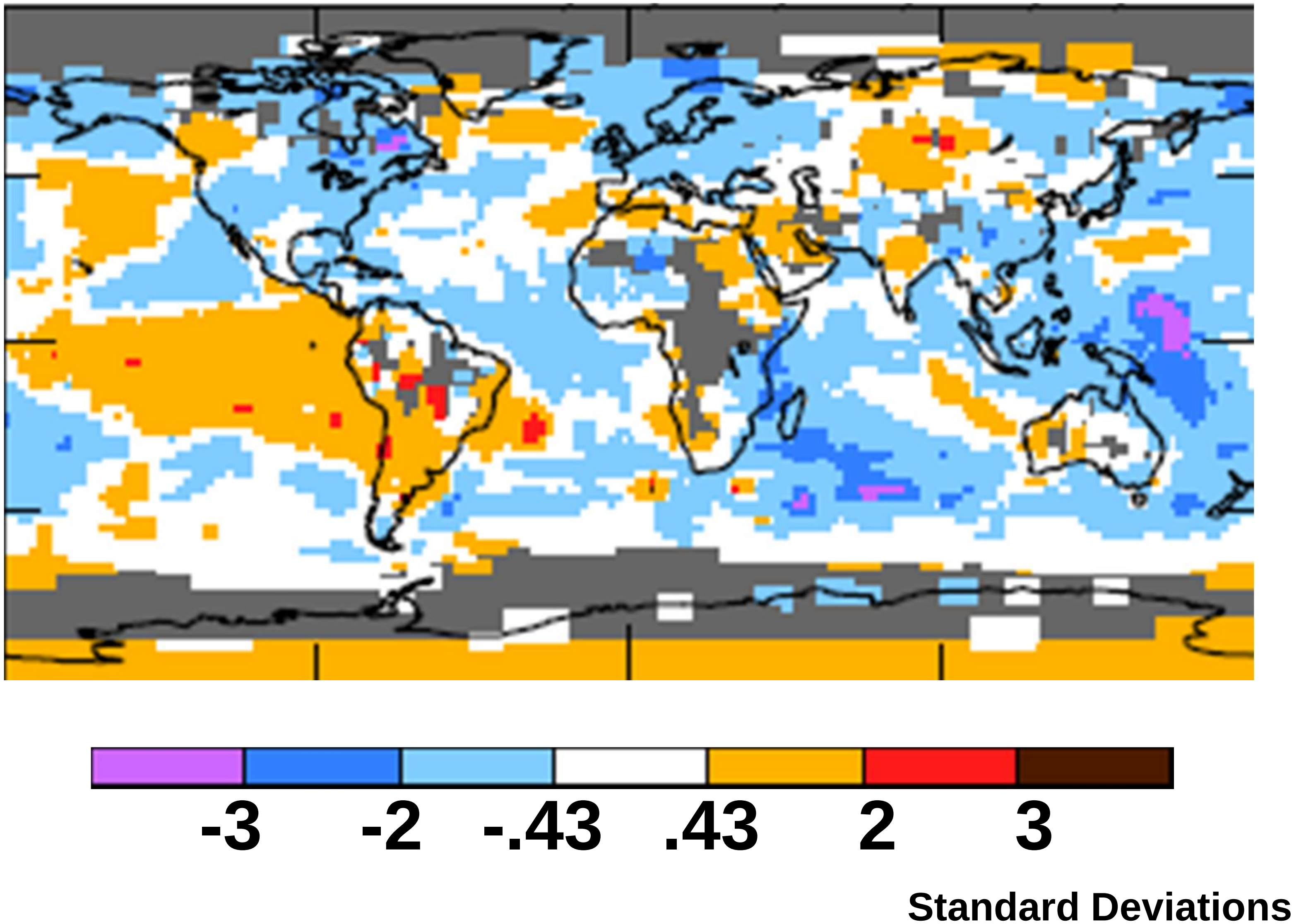
Summary of Climate Change for British Columbia in the 2050s

Climate Variable	Season	Projected Change from 1961-1990 Baseline	
		Ensemble Median	Range (10th to 90th percentile)
Mean Temperature (°C)	Annual	+1.8 °C	+1.3 °C to +2.7 °C
Precipitation (%)	Annual	+6%	+2% to +13%
	Summer	-1%	-8% to +7%
	Winter	+8%	-2% to +15%
Snowfall* (%)	Winter	-10%	-17% to +2%
	Spring	-58%	-71% to -11%
Growing Degree Days* (degree days)	Annual	+283 degree days	+177 to +429 degree days
Heating Degree Days* (degree days)	Annual	-648 degree days	-955 to -454 degree days
Frost-Free Days* (days)	Annual	+20 days	+12 to +29 days

The table above shows projected changes in average (mean) temperature, precipitation and several derived climate variables from the baseline historical period (1961-1990) to the **2050s** for the **British Columbia** region. The ensemble median is a mid-point value, chosen from a PCIC standard set of Global Climate Model (GCM) projections (see the 'Notes' tab for more information). The range values represent the lowest and highest results within the set. Please note that this summary table does not reflect the 'Season' choice made under the 'Region & Time' tab. However, this setting does affect results obtained under each variable tab.

* These values are derived from temperature and precipitation. Please select the appropriate variable tab for more information.

1965 1, 4, 40, 35, 21, 0, 0%



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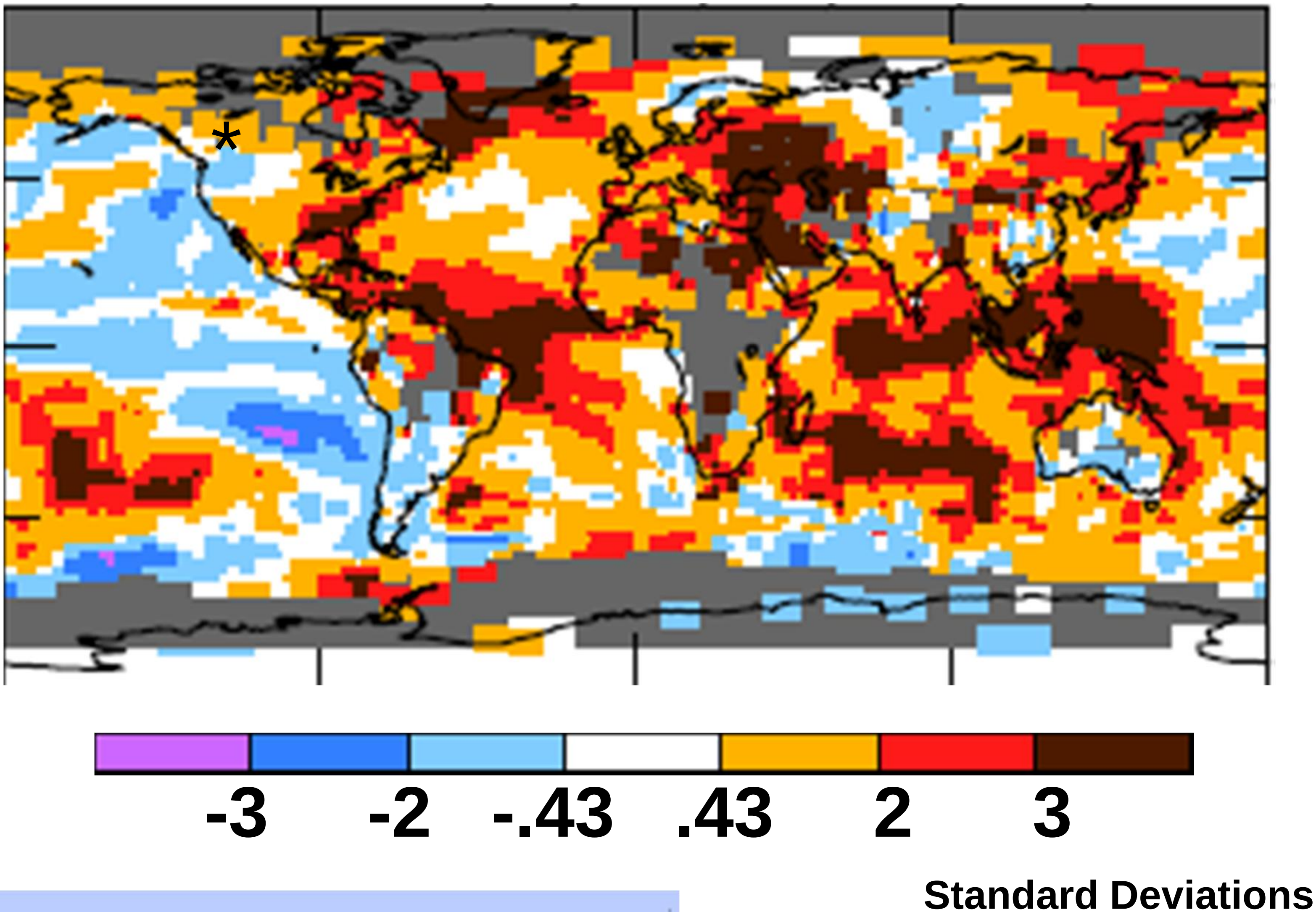
New York, N.Y.

2010



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Extremes affected in different ways

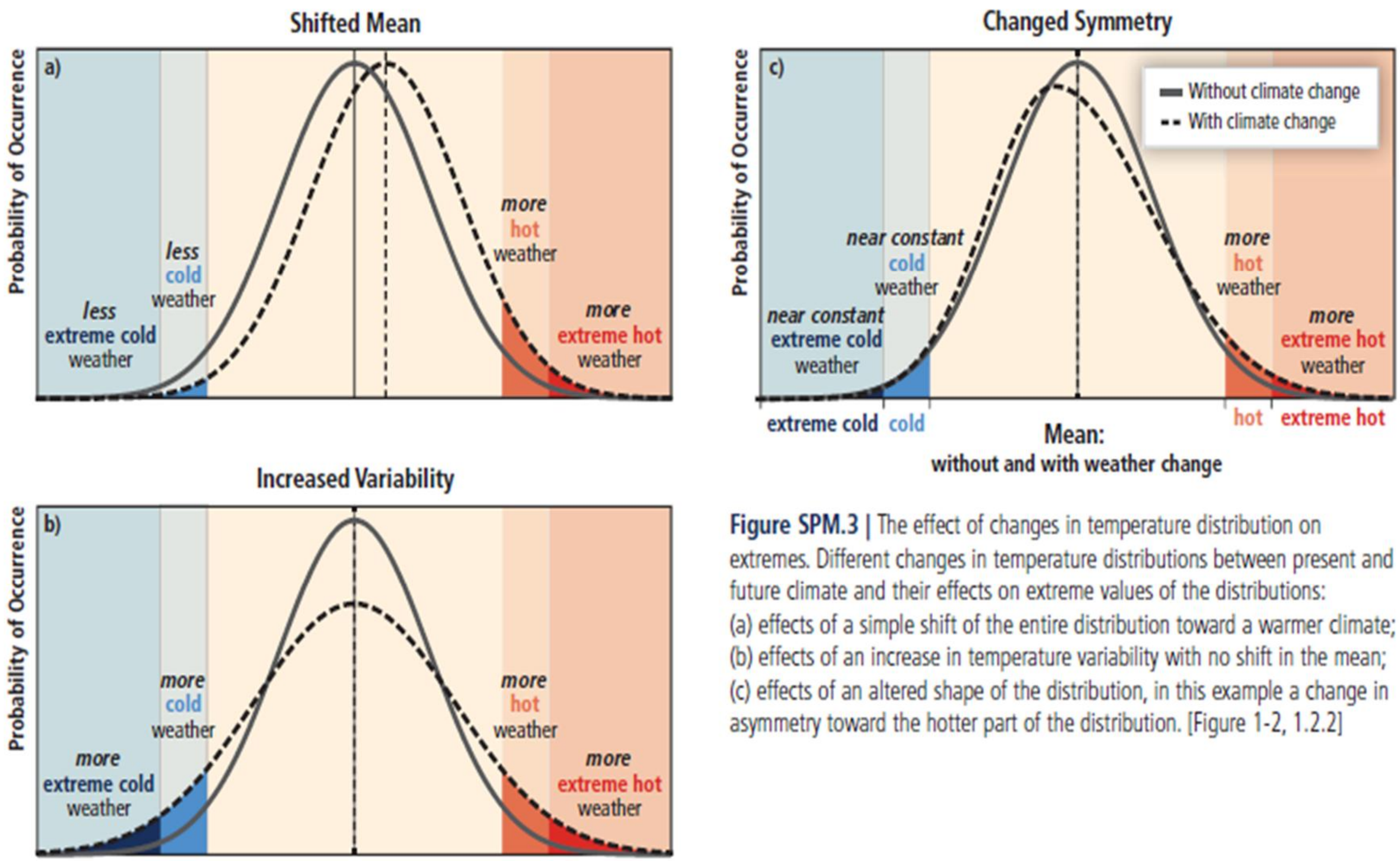
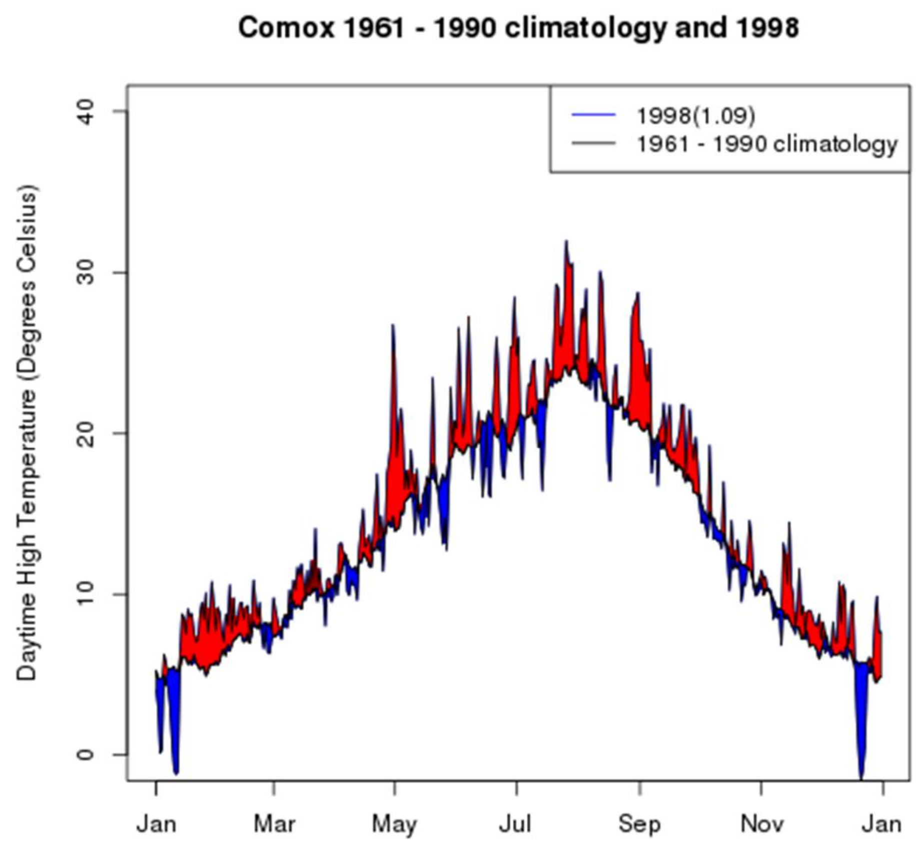
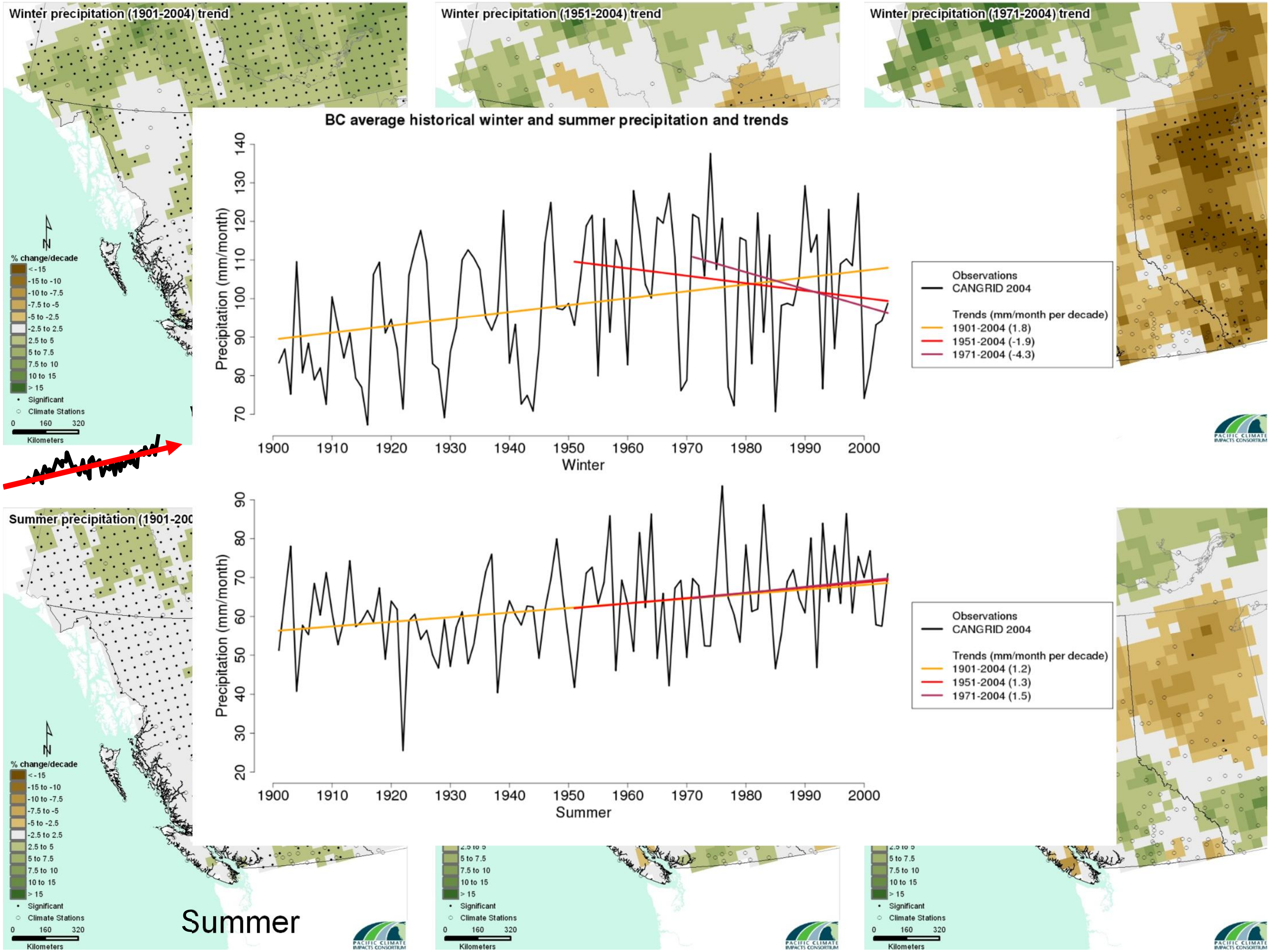


Figure SPM.3 | The effect of changes in temperature distribution on extremes. Different changes in temperature distributions between present and future climate and their effects on extreme values of the distributions: (a) effects of a simple shift of the entire distribution toward a warmer climate; (b) effects of an increase in temperature variability with no shift in the mean; (c) effects of an altered shape of the distribution, in this example a change in asymmetry toward the hotter part of the distribution. [Figure 1-2, 1.2.2]

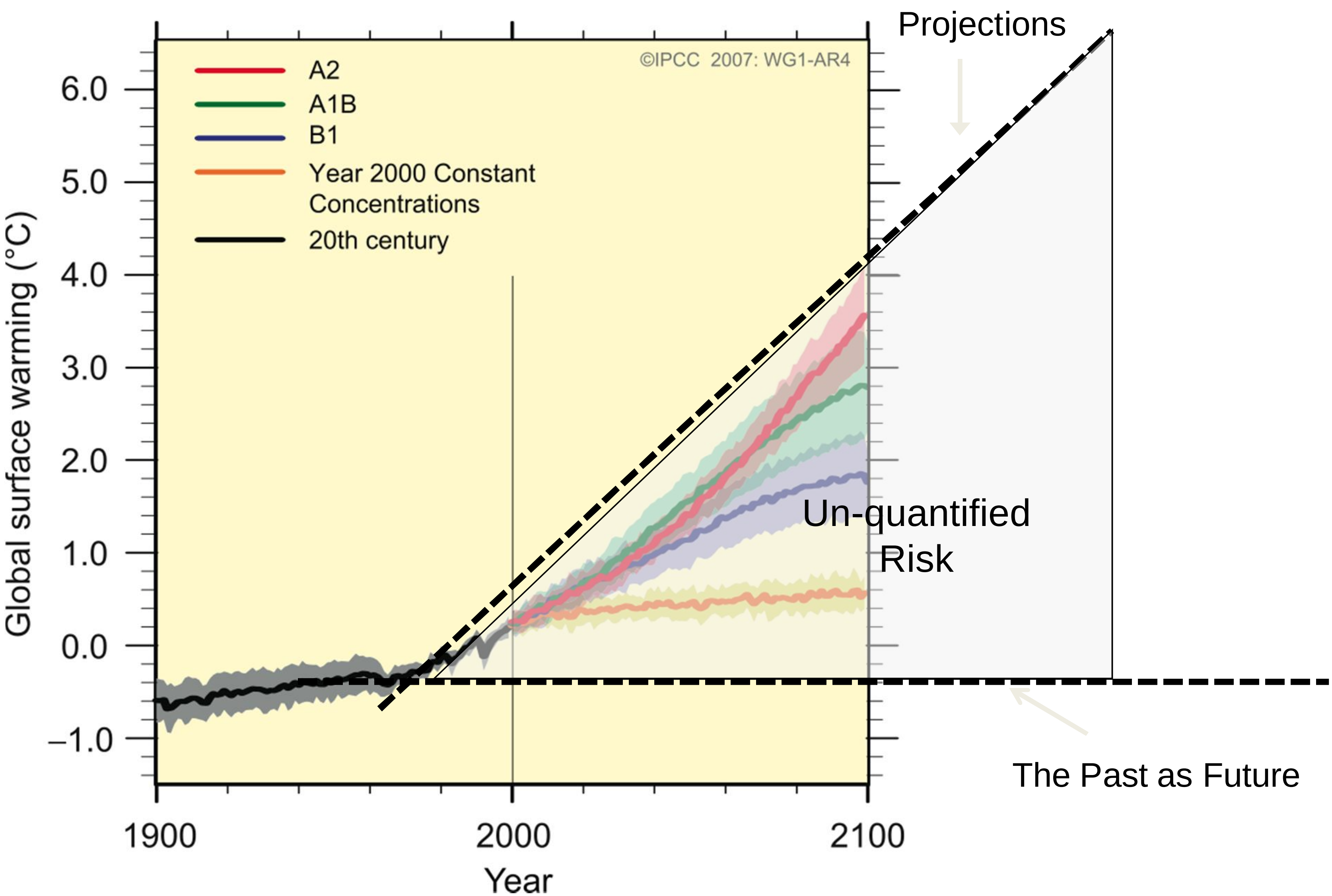
IPCC Special Report on Extremes Figure SPM.4

1°C warmer than normal is a lot

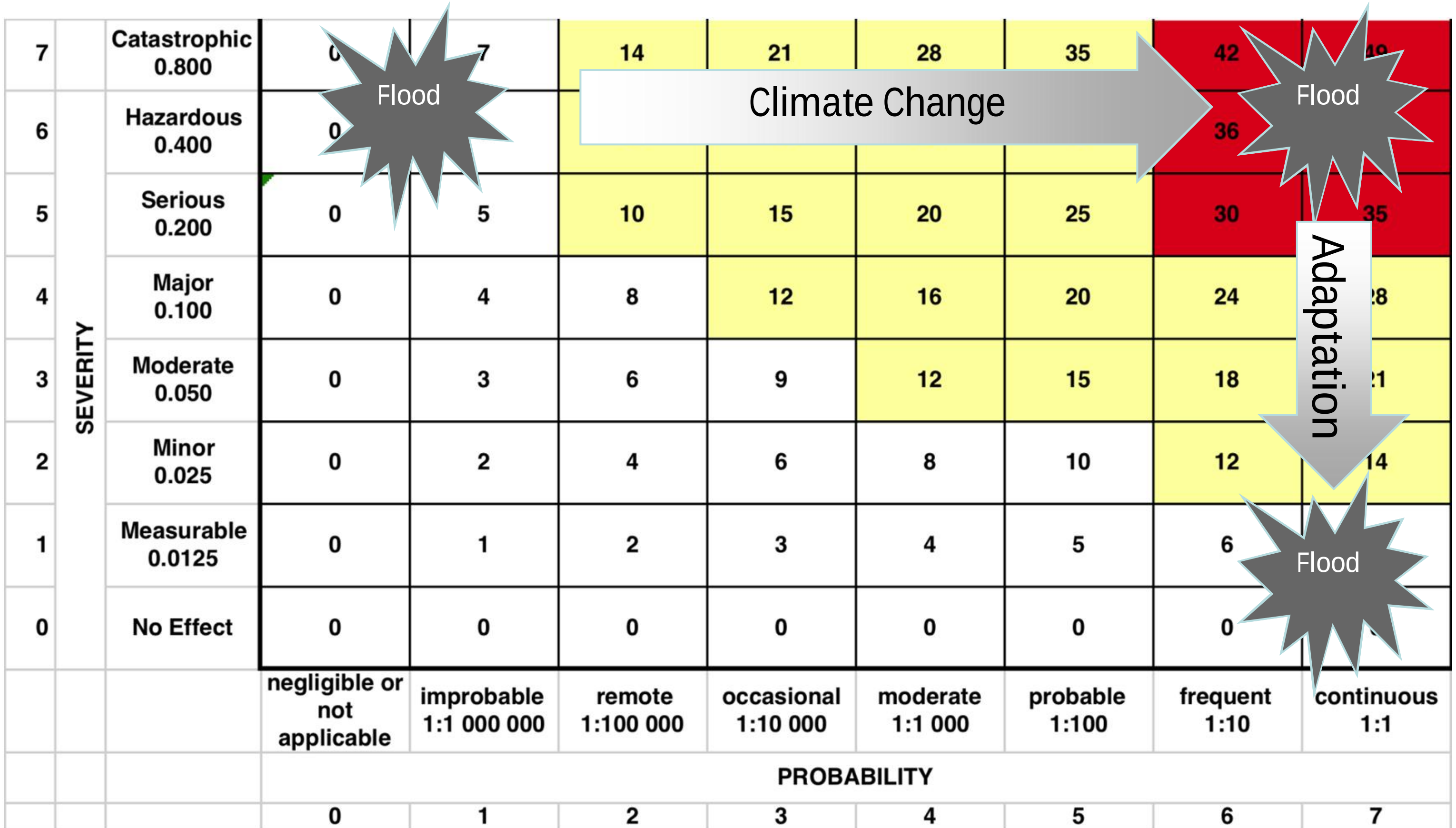



Winter precipitation (1901-2004) trend
Winter precipitation (1951-2004) trend
Winter precipitation (1971-2004) trend
Summer precipitation (1901-200
BC average historical winter and summer precipitation and trends
Precipitation (mm/month)
Winter
Summer
Observations
CANGRID 2004
Trends (mm/month per decade)
1901-2004 (1.8)
1951-2004 (-1.9)
1971-2004 (-4.3)
1901-2004 (1.2)
1951-2004 (1.3)
1971-2004 (1.5)
% change/decade
< -15
-15 to -10
-10 to -7.5
-7.5 to -5
-5 to -2.5
-2.5 to 2.5
2.5 to 5
5 to 7.5
7.5 to 10
10 to 15
> 15
Significant
Climate Stations
Kilometers
Summer

The Past IS NOT the Future



Climate Change Risk Mitigation through Adaptation



Source: David Lapp, Engineers Canada

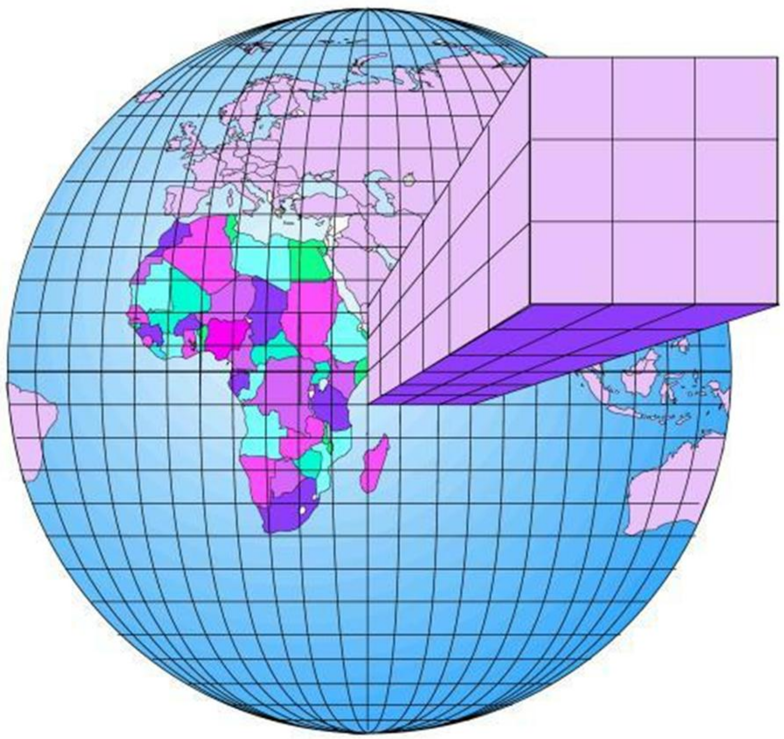
What are Global Climate Models?

- Mathematical representations of the global climate system

- Used to understand and predict changes in the global climate system

- GCMs are the

  "…only credible tools currently available for simulating the physical processes that determine global climate..." [IPCC]



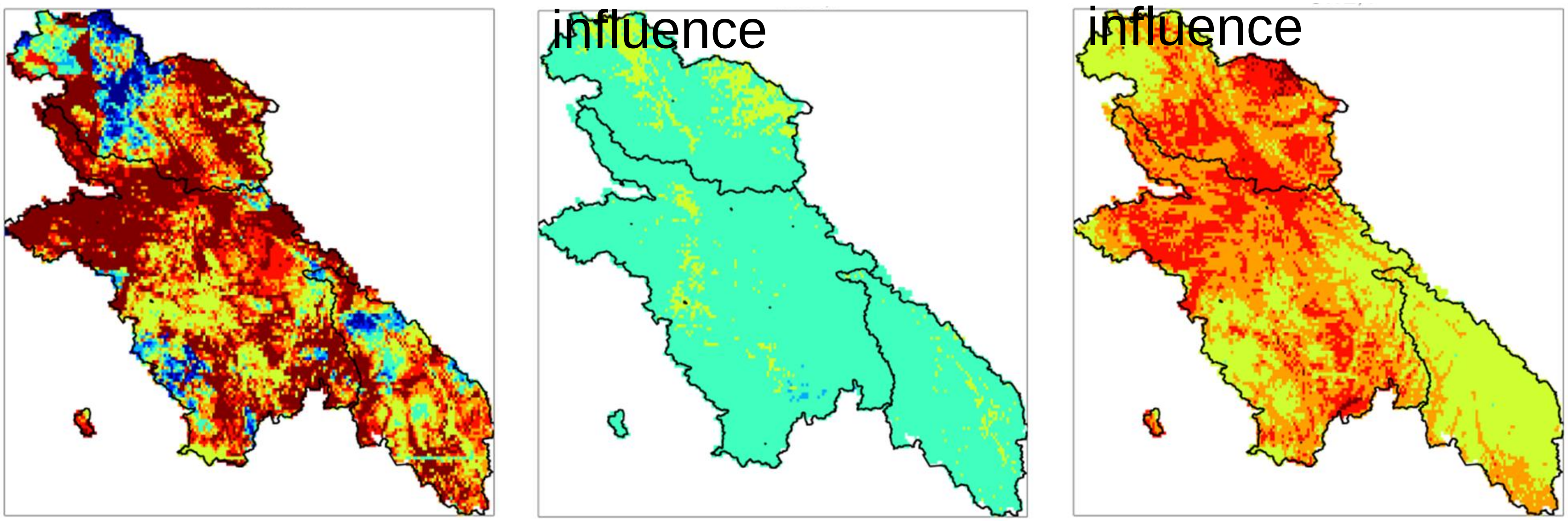
http://pics.uvic.ca/insights/lesson4/player.html

Figure courtesy John Fyfe, CCCma

Observed trends in April 1st snowpack

Modeled trends with no human influence

Modeled trends with human influence



1961 – 2005

Najafi *et al.*

PACIFIC CLIMATE IMPACTS CONSORTIUM