

Beyond Average: Variability and Extremes in a Changing Climate

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Future Forest Ecosystems Scientific Council Project 014



Min. Forest, Lands and Natural Resource Ops.

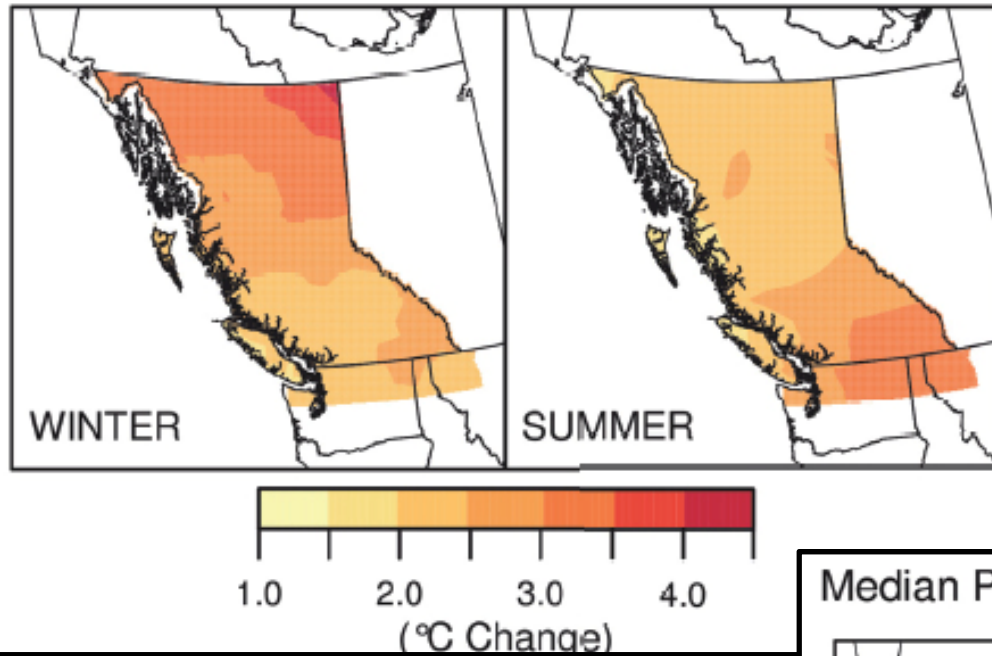
Tongli Wang, UBC



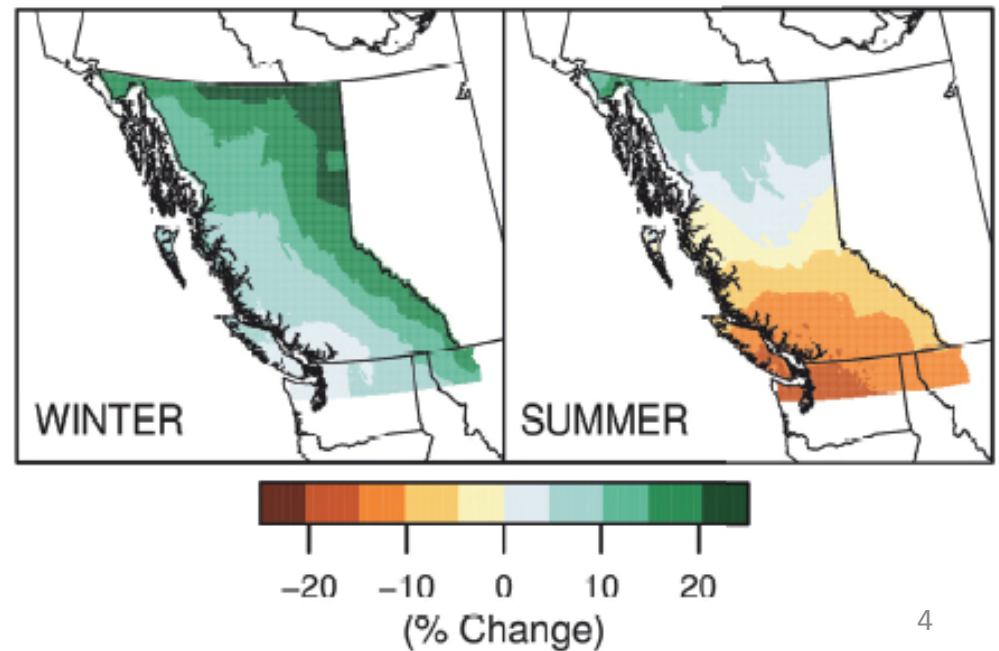
Outline

- Variability and extremes
- Downscaling methods
- Application – Monthly and daily time series, climate indices ,return periods
- Future research & application

Median Temperature Change Projected for the 2050s



Median Precipitation Change Projected for the 2050s

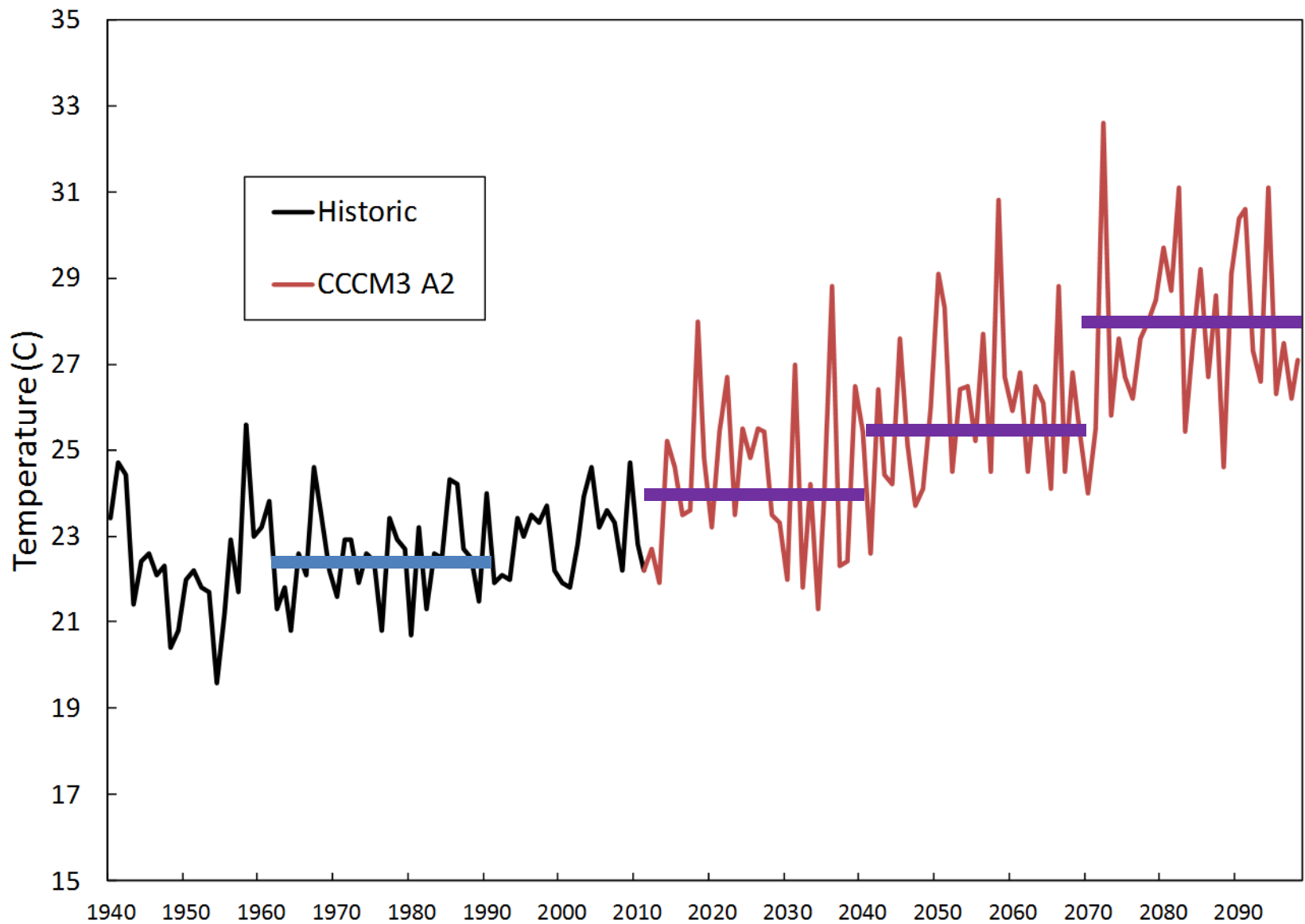


(Zweirs et al. 2011, PCIC)

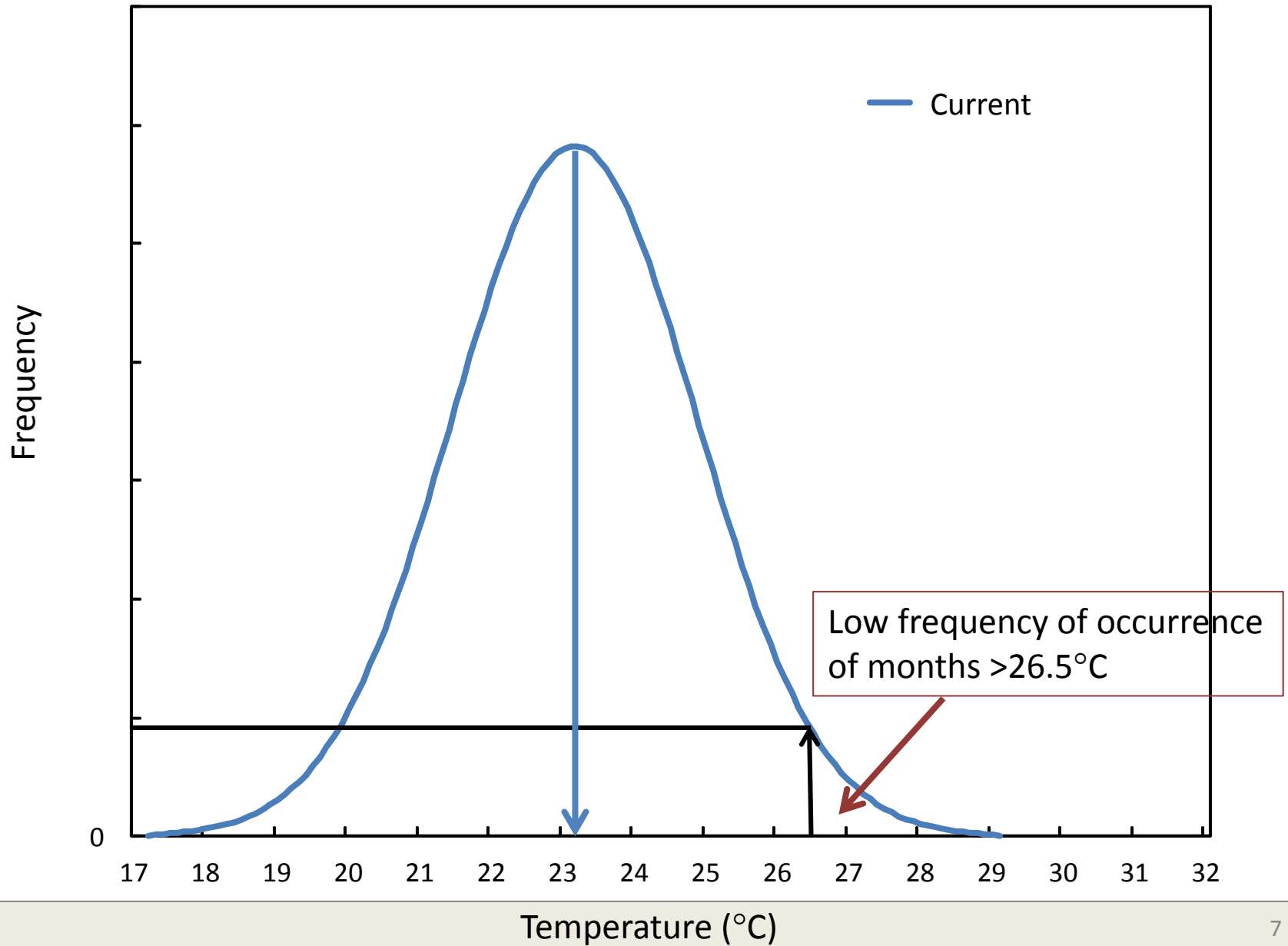
Variability and Extremes: Weather

- Weather systems, jet stream, Pineapple Express, Arctic outbreak, Pacific High
- Solar variation – diurnal and annual cycle
- Ocean temperature, extent of Arctic ice
- El Niño-Southern Oscillation
- PDO, PNA, AO
- Volcanoes

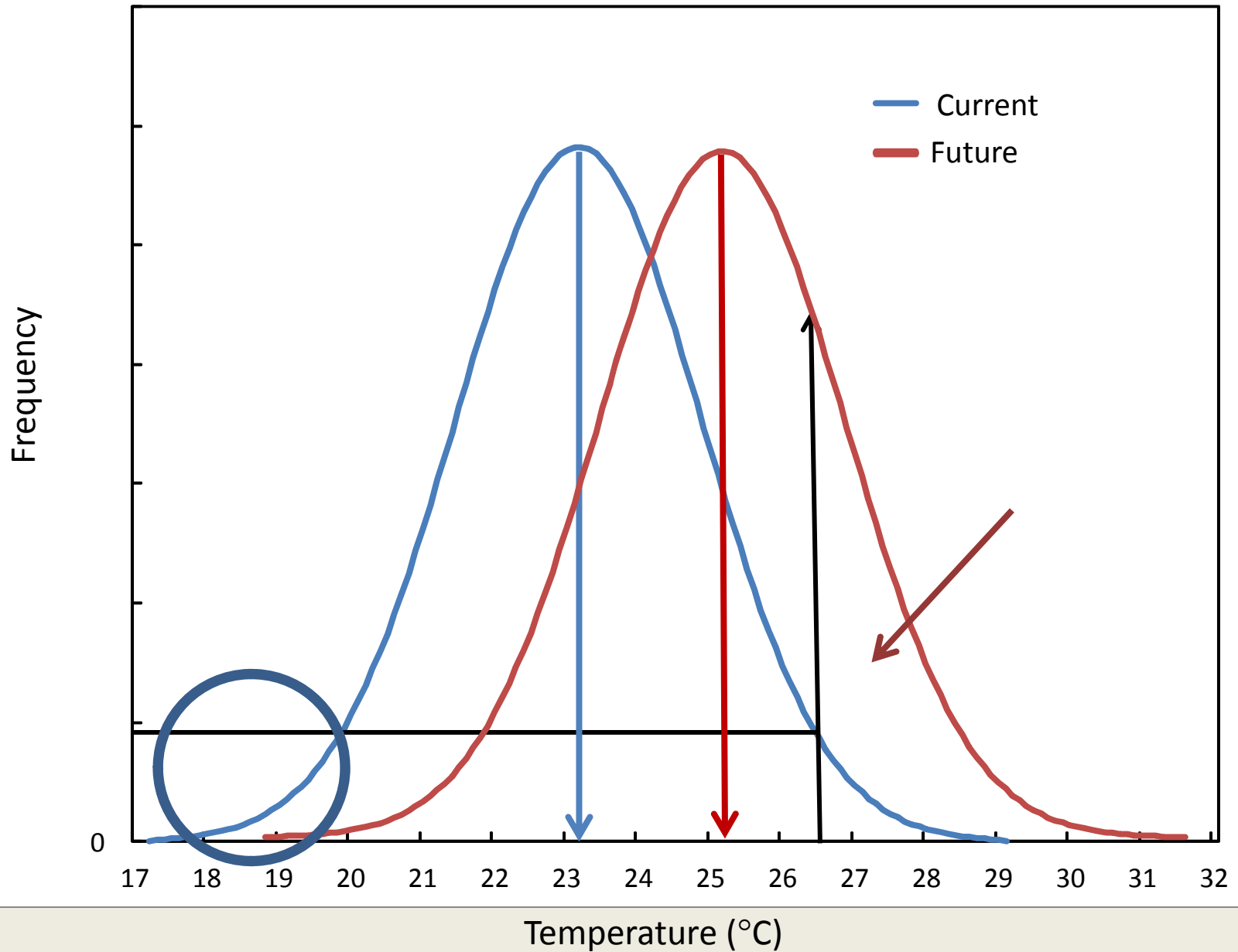
Victoria A Annual Maximum Monthly Air Temperature



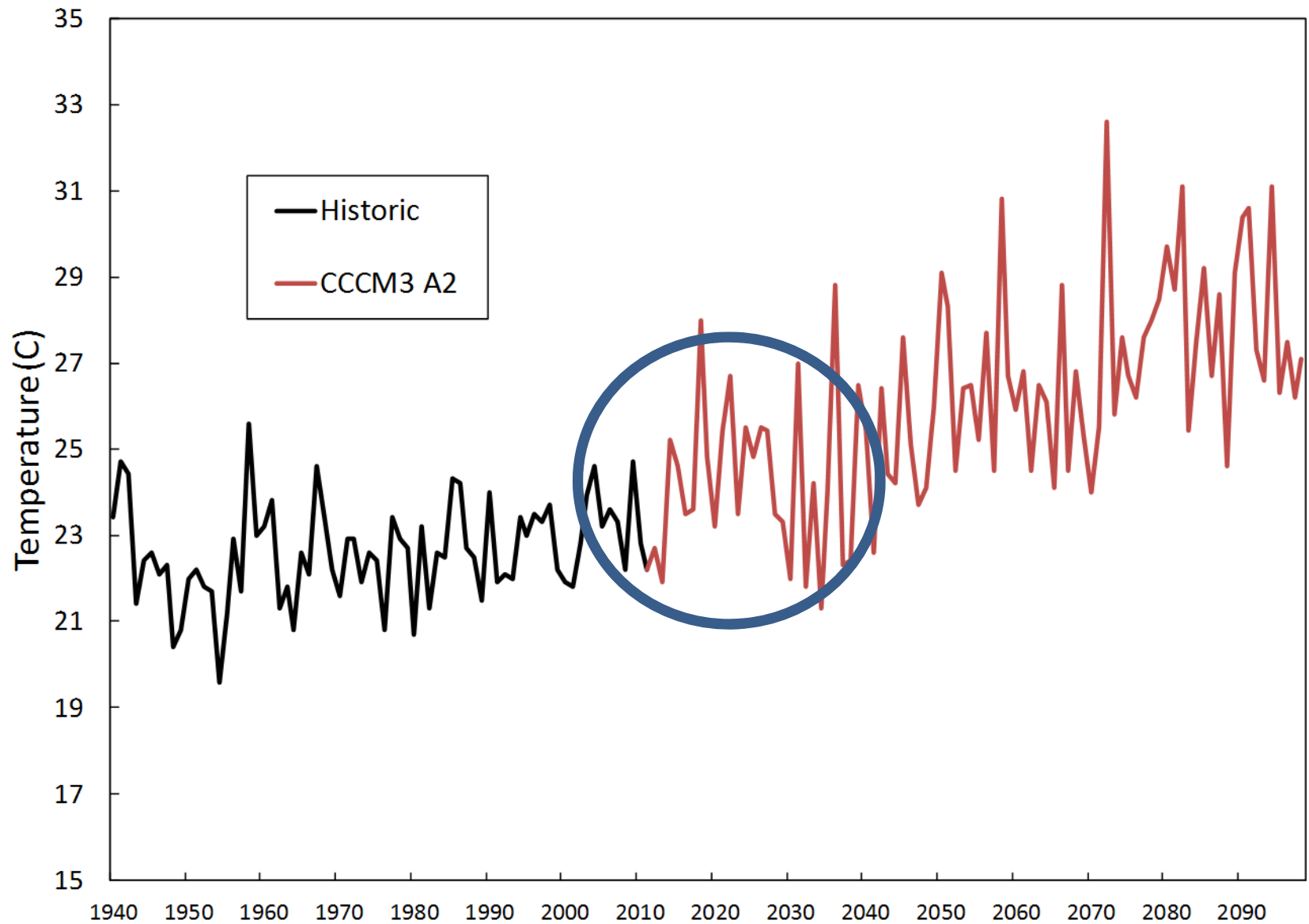
Maximum monthly air temperature



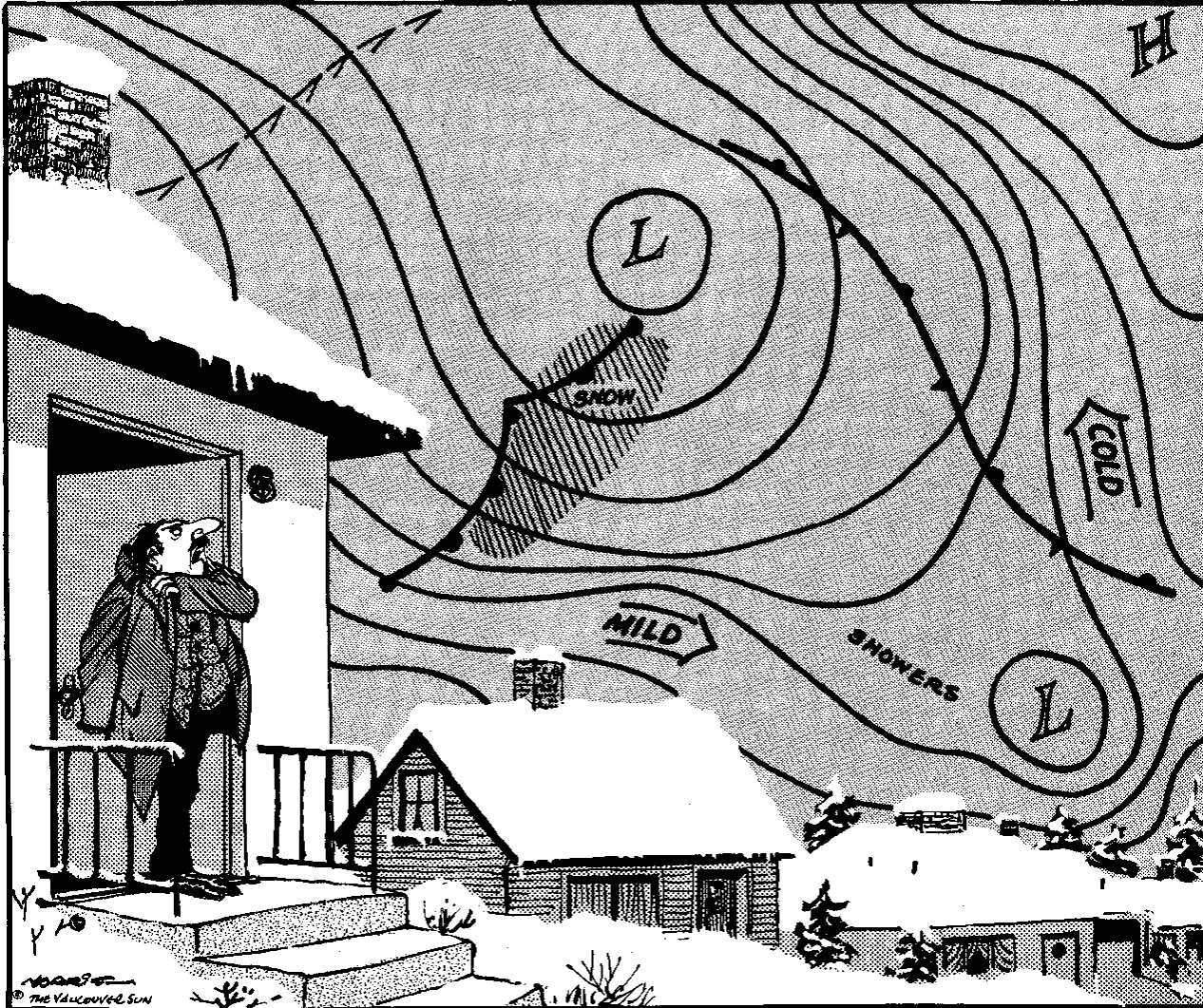
Maximum monthly air temperature



Victoria A Annual Maximum Monthly Air Temperature



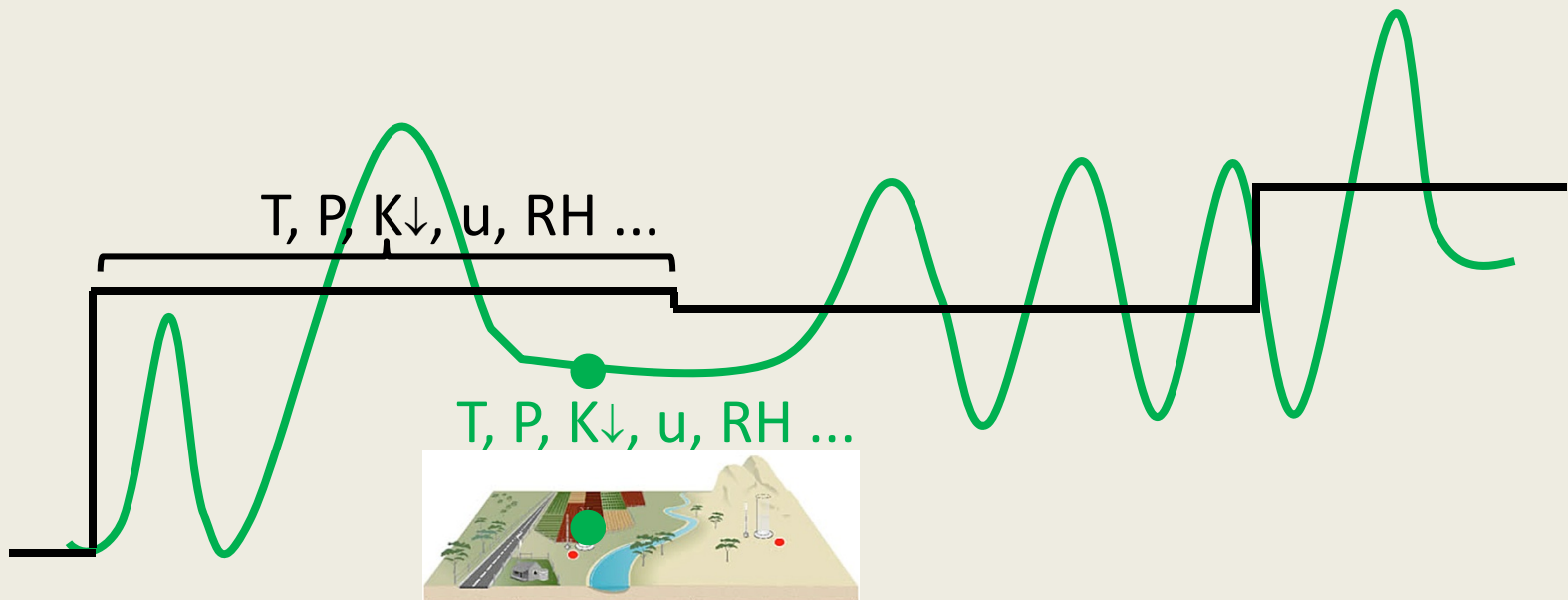
Downscaling



"Frankly, I don't like the look of the weather."

Downscaling global climate models to specific locations

— BC profile
— GCM profile



Downscaling monthly temperature and precipitation

1961-90 normals

GCM surface $T_{\text{norm}}, P_{\text{norm}}$

Location



Downscaling monthly temperature and precipitation

1961-90 normals

Projection

GCM surface

$T_{\text{norm}}, P_{\text{norm}}$

$$\Delta T = T_{\text{proj}} - T_{\text{norm}}$$

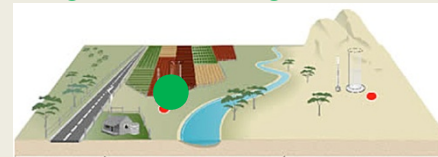
$$\Delta \text{PPT} = ((P_{\text{proj}} - P_{\text{norm}}) / P_{\text{norm}})$$

Location

$T_{\text{norm}}, P_{\text{norm}}$

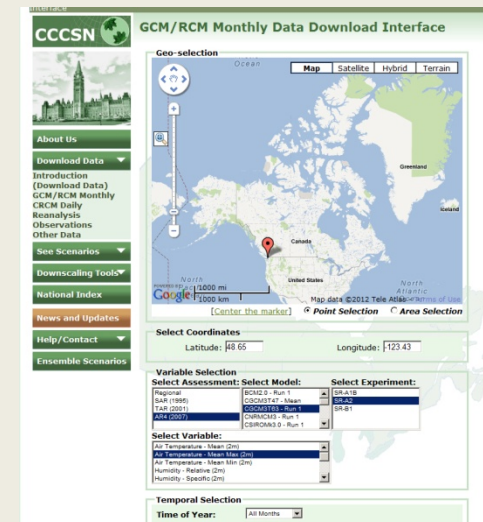


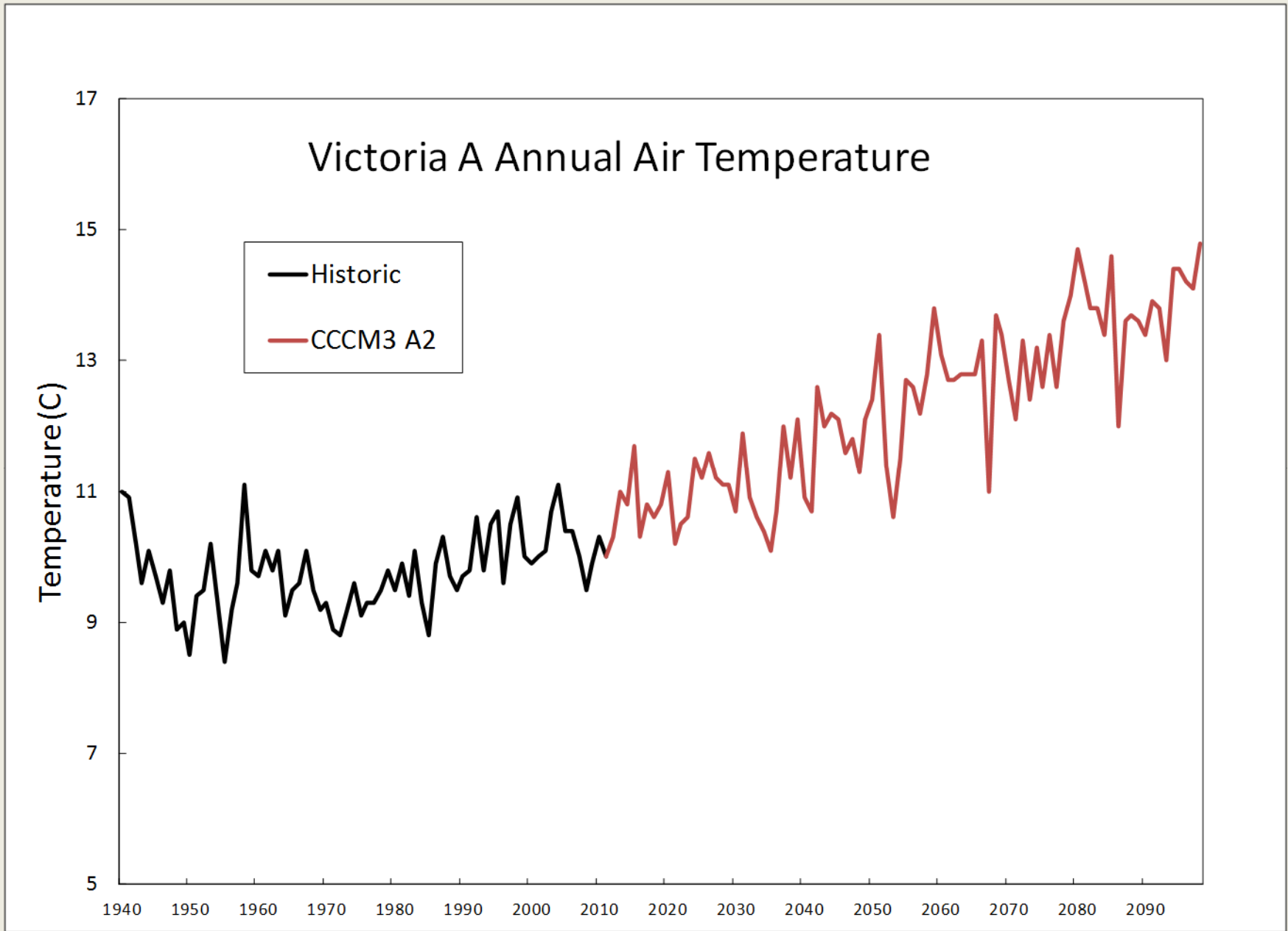
$T_{\text{norm}} + \Delta T$
 $P_{\text{norm}} + (P_{\text{norm}} * \Delta \text{PPT})$



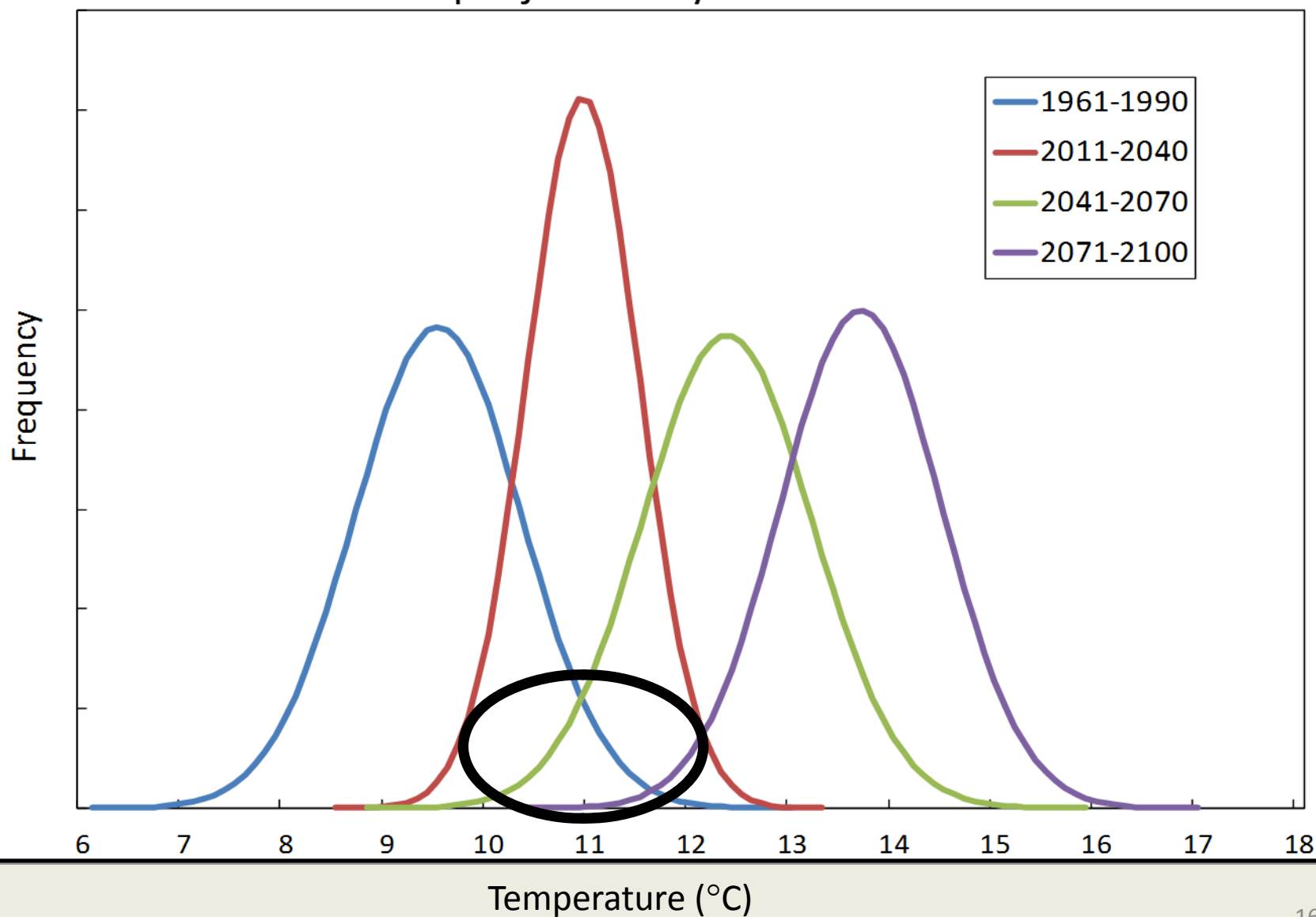
Application

- Monthly historic station data 1940-2011
– Environment Canada archives
- GCM monthly 1961-90 data and climate projections – Canadian Climate Change Scenarios Network <http://www.cccsn.ec.gc.ca/?page=main&lang=en>
- Calculate monthly anomalies for projections for 2011-2100
- Create time series – Add anomalies to station 1961-90 normals

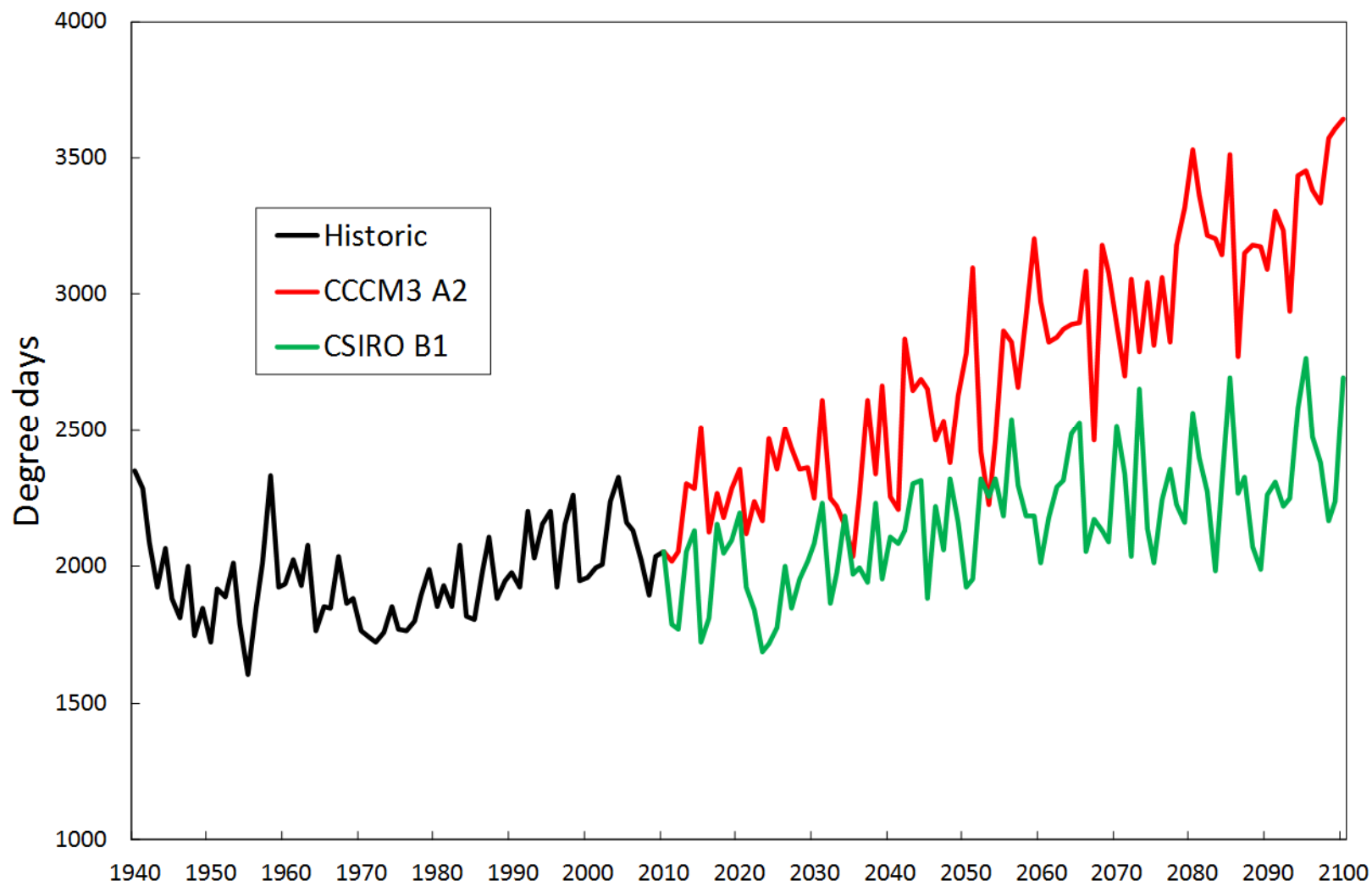




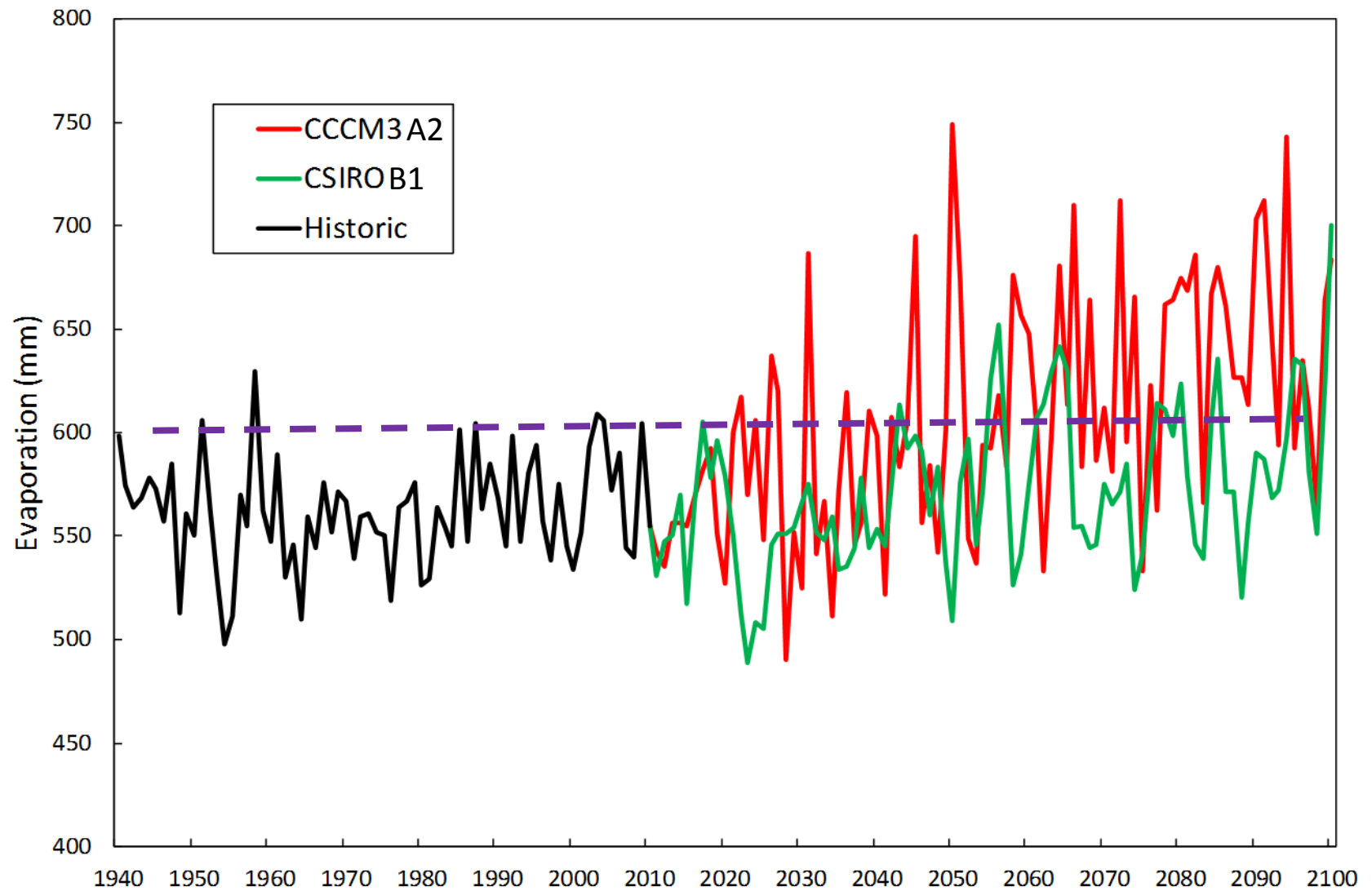
Annual temperature, Victoria A, 1961-90 and projected by CCCM3 A2



Annual degree days >5°C



Evaporative demand - April-October, Victoria A, 1940-2100



Climatic water deficit (CMD)

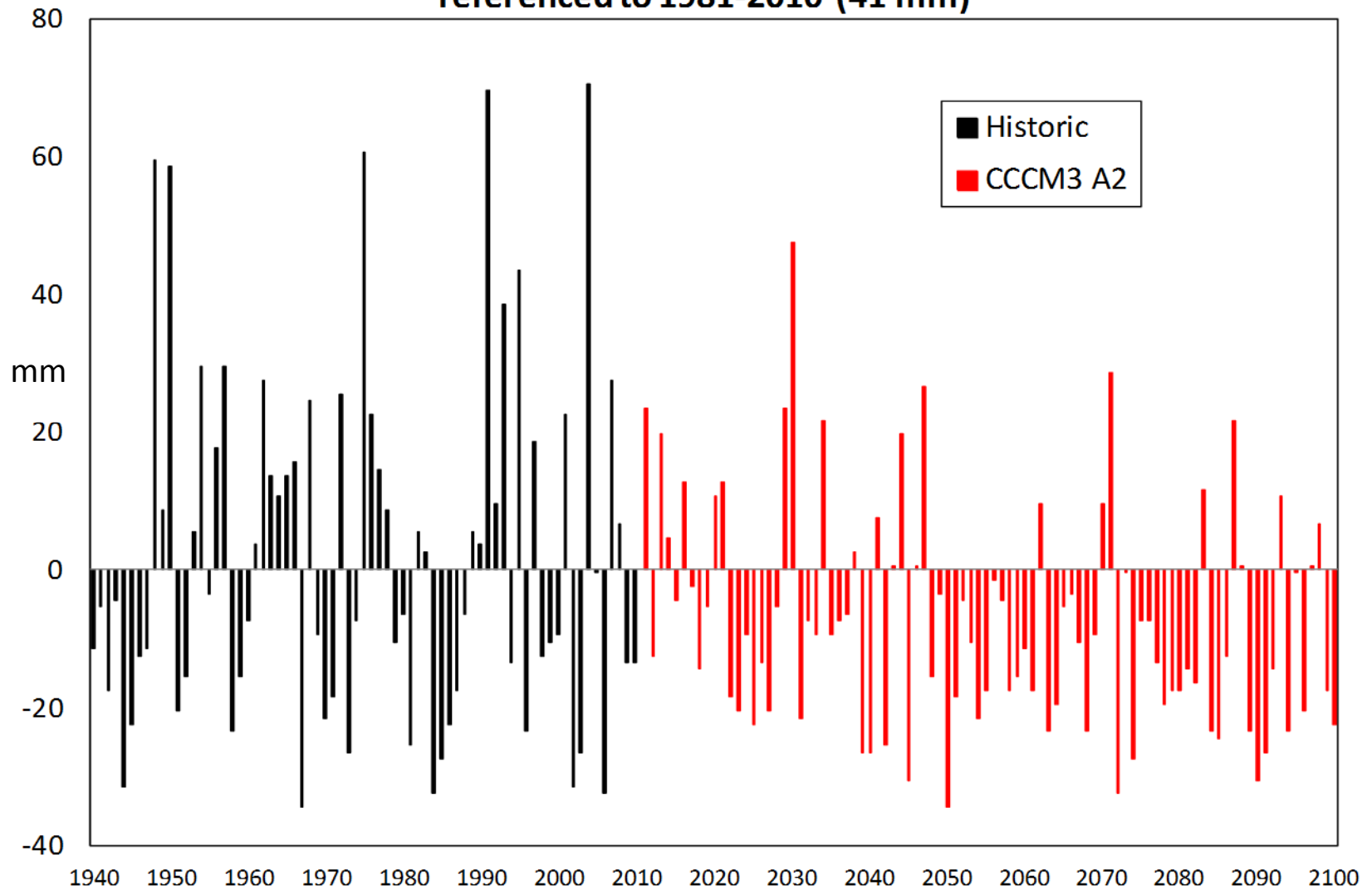
IF $\text{Precip}_m > \text{Evaporation}_m$, $\text{CMD}_m = 0$

Else

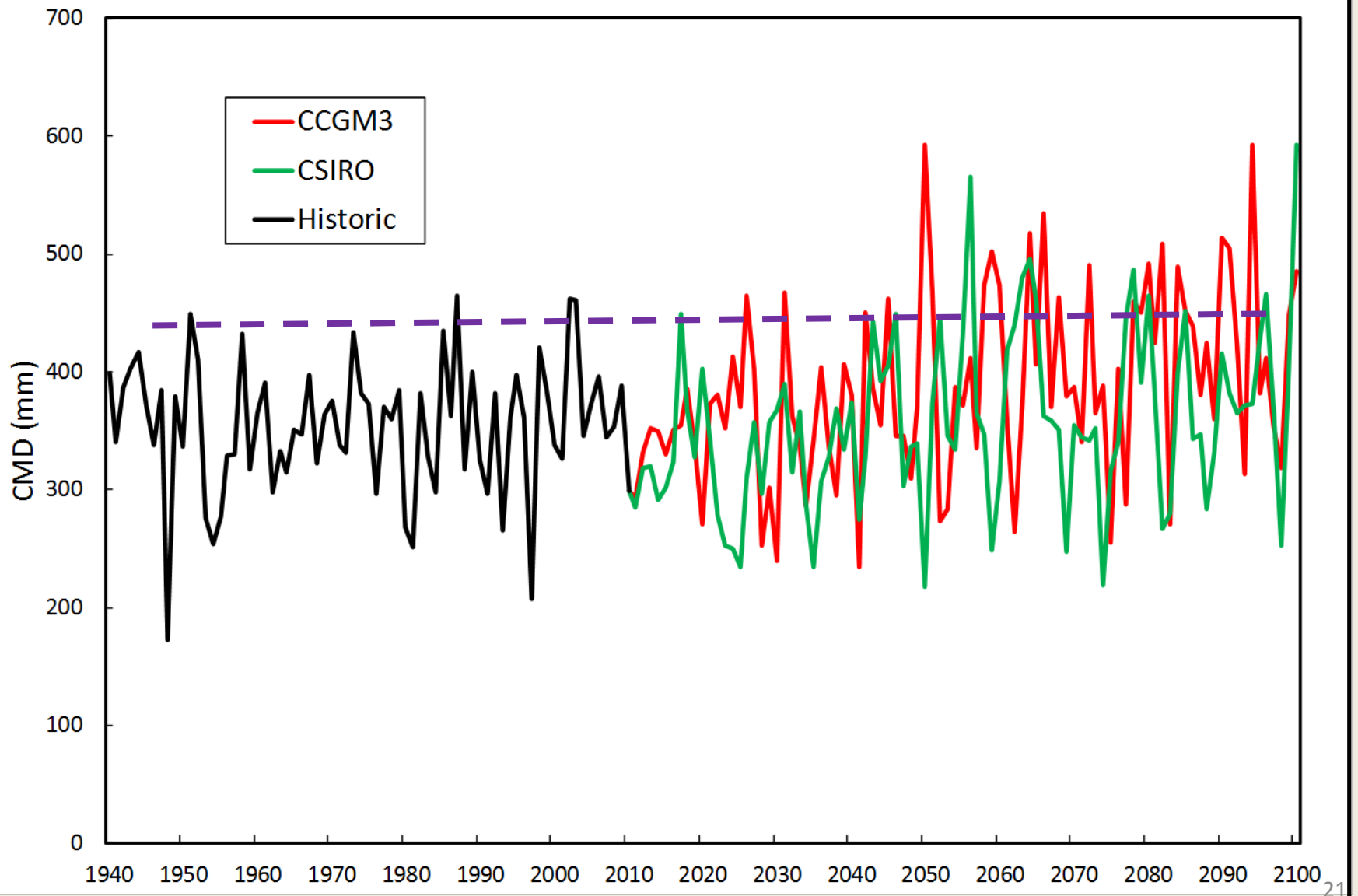
$$\text{CMD}_m = \text{Evaporation}_m - \text{Precip}_m$$

$$\text{CDM} = \sum \text{CMD}_m$$

**July + August precipitation anomaly Victoria A, 1940-2021,
referenced to 1981-2010 (41 mm)**

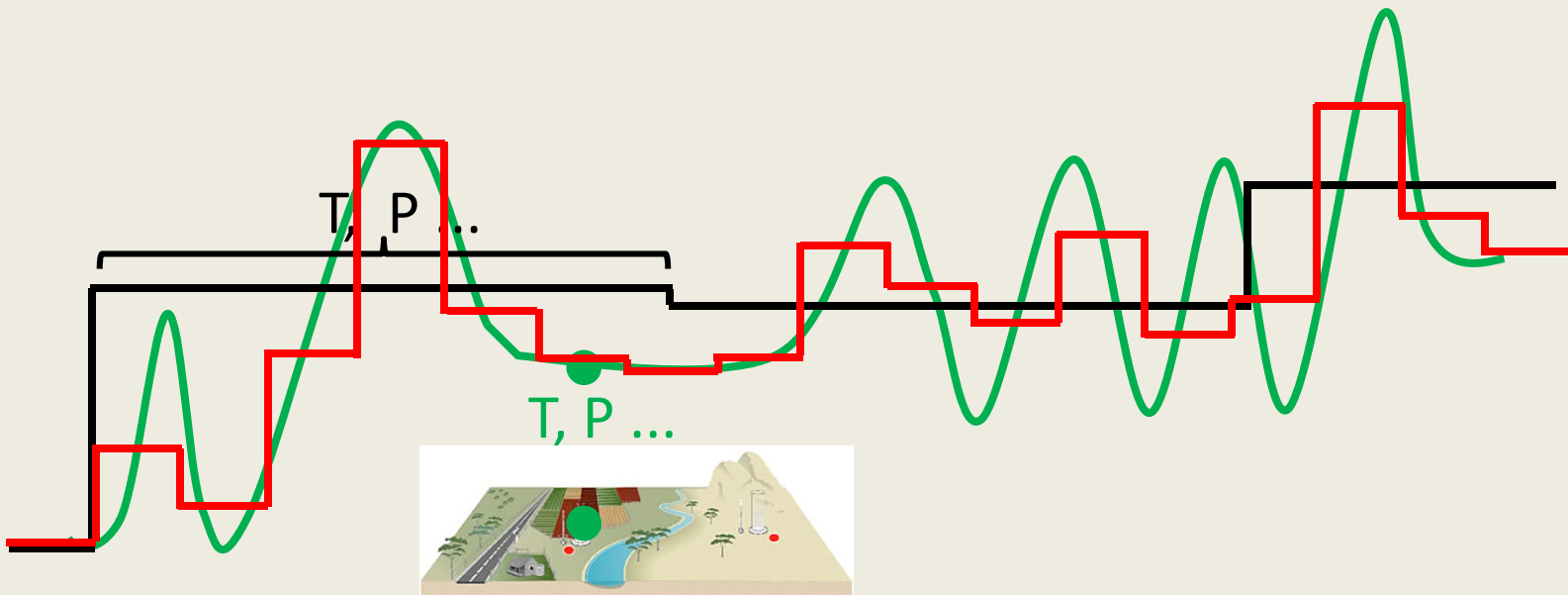


Climatic moisture deficit April-October, Victoria A, 1940-2100



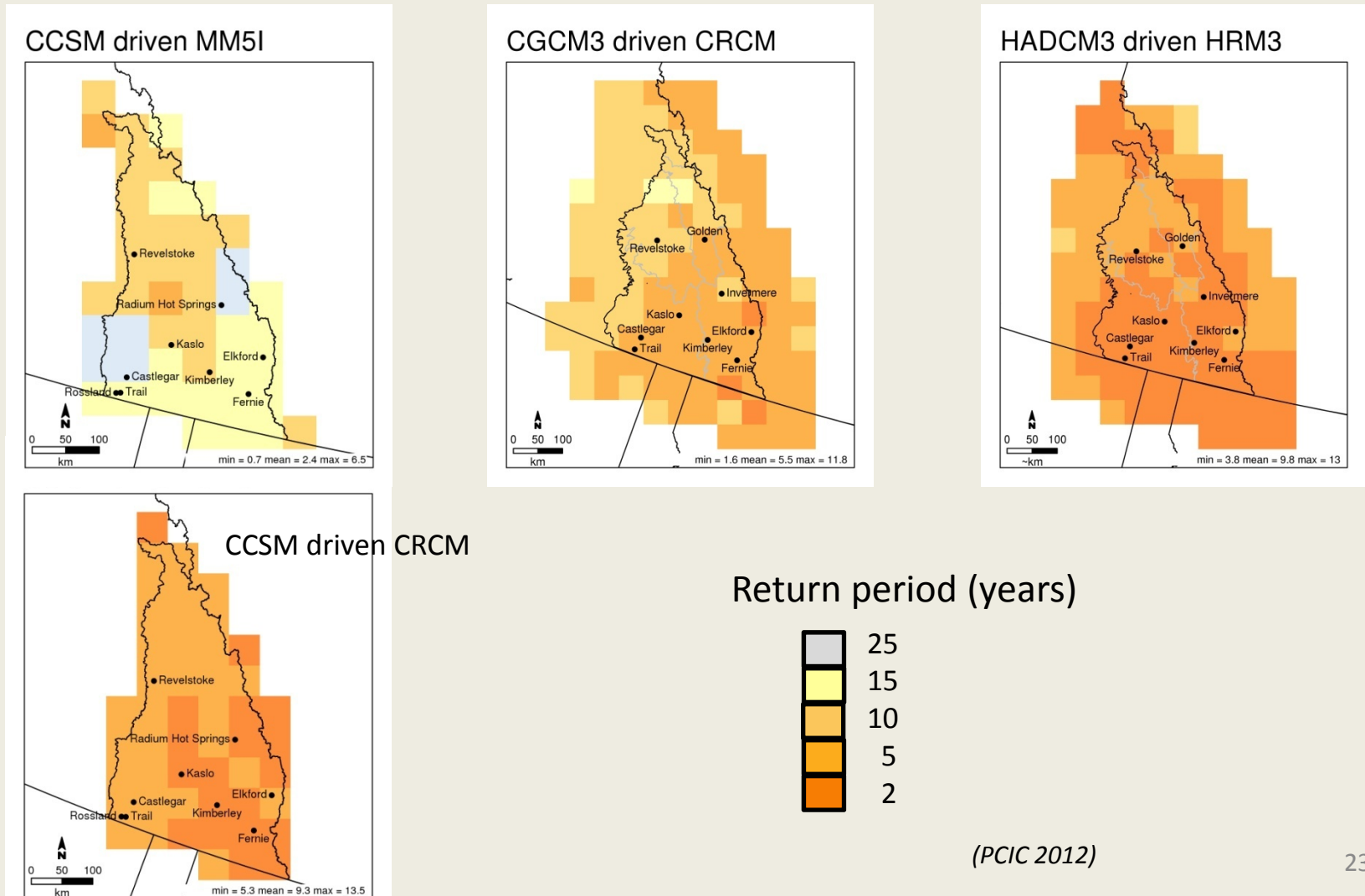
Downscaling with regional climate models

- BC profile
- GCM profile
- RCM profile



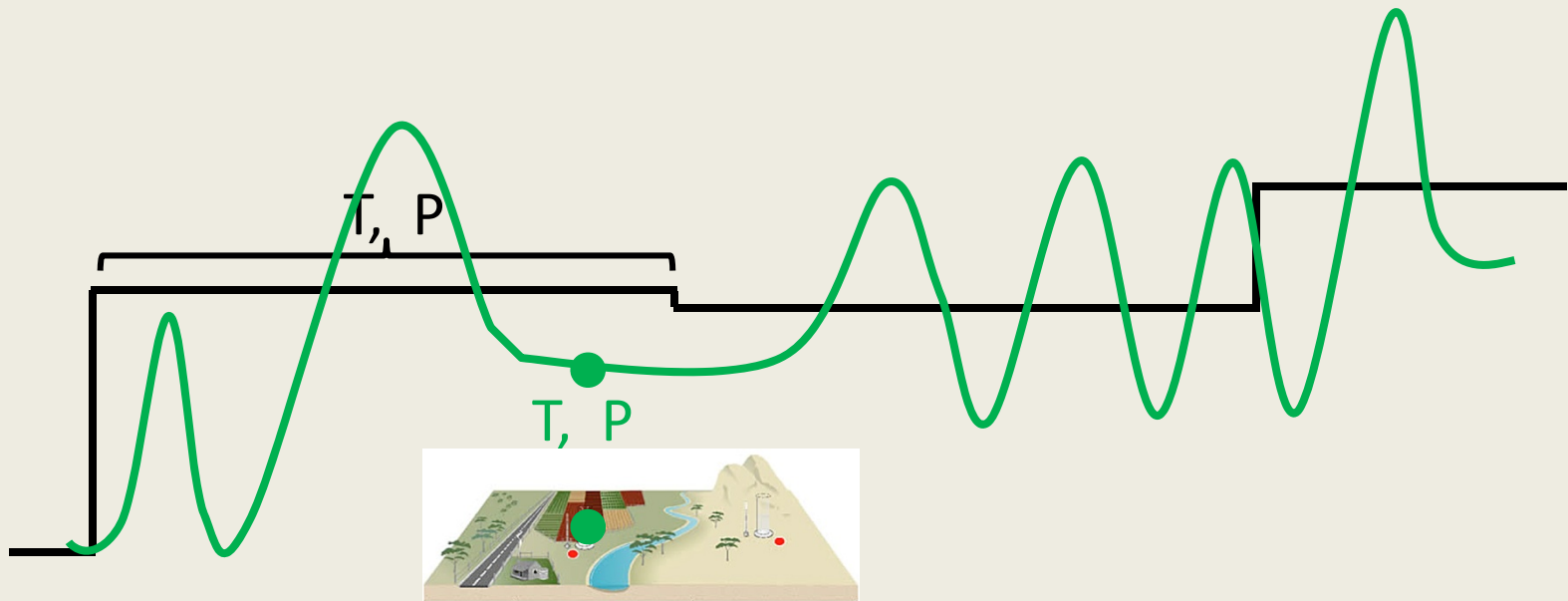
Change in occurrence of 25 year extreme warm temperature event projected for 2050s, Columbia Basin

- small, medium and large warming

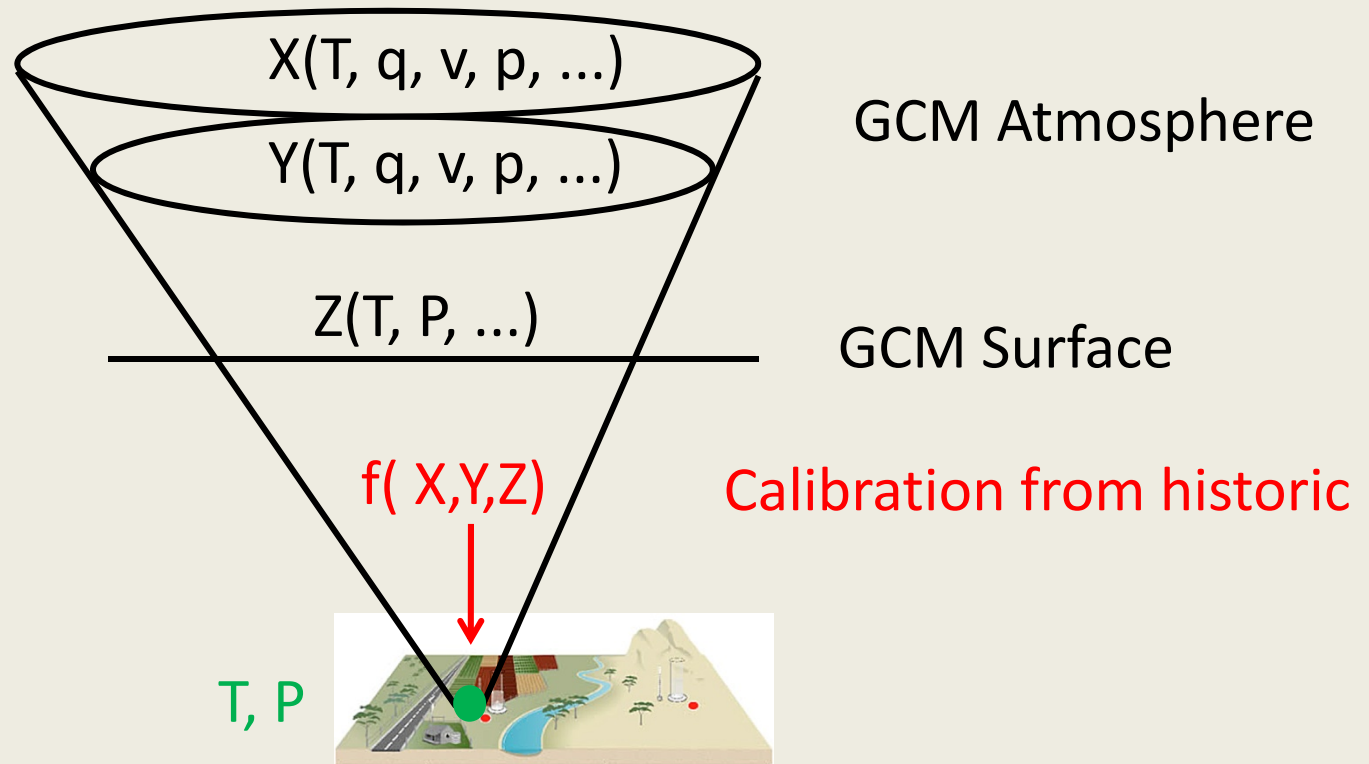


Downscaling daily global climate model data to specific locations

— BC profile
— GCM profile



Downscaling for daily temperature and precipitation



Methods evaluated

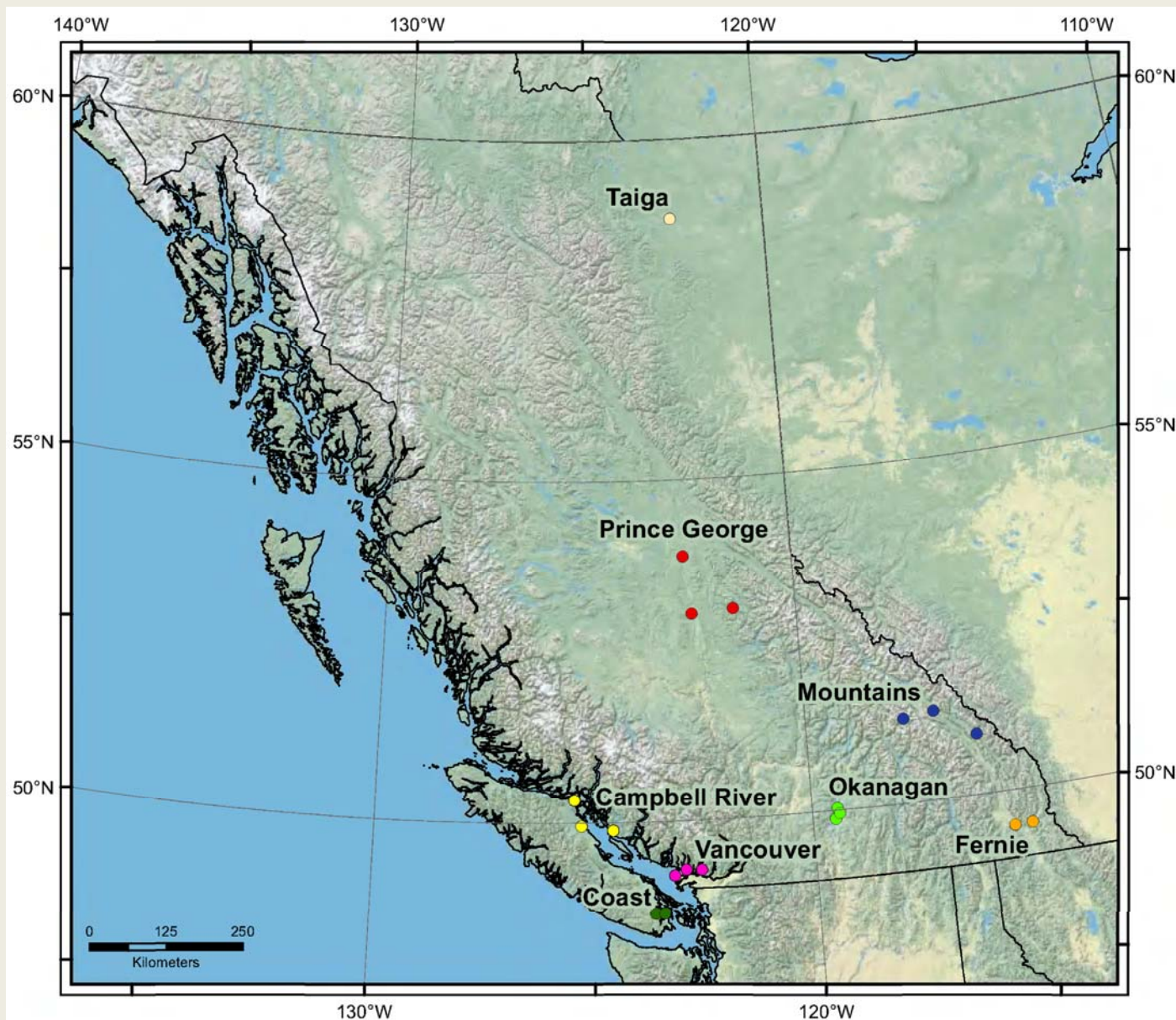
- BCSD – Bias correction spatial disaggregation
- EDS – Expanded downscaling
- QRNN - Quantile regression neural network
- TG – TreeGen
- CDFt –cumulative distribution functions
- DQM -detrended quantile mapping
- BioSim – stochastic weather generator
- LARS-WG - stochastic weather generator

(Bürger et al. 2012)

Testing with historic daily data

- BCSD, EDS, QRNN, TG
- Training 1971-1990, testing 1991-2010
- Historic upper atmosphere data – NCEP Reanalysis
- Historic weather station data – Environment Canada archives
- 1 GCM simulation

Weather stations



(Bürger et al. 2012 in review)

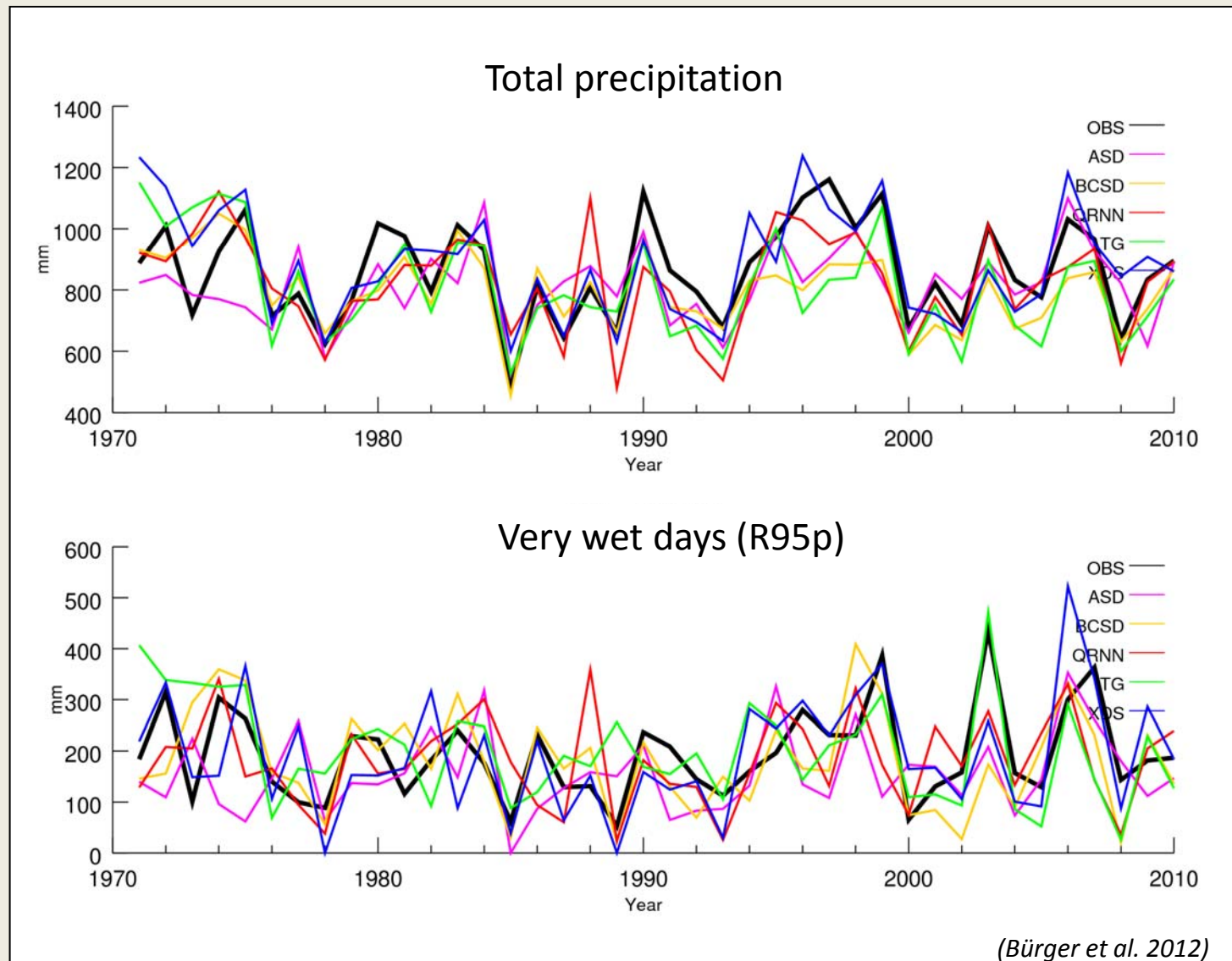
ClimDEX Indices

- Annual metrics of temperature and precipitation
- 16 for Temperature – extreme maximum and minimum, days $T_{\min, \max} > 90^{\text{th}}$ percentile, length of frost free period, duration of heat wave....
- 11 for Precipitation – total, intensity, length of dry (wet) period...

Results – testing on historic climate

- Ability to simulate inter annual variability (anomalies)
- Ability to simulate distribution

Downscaled (colours) and observed (black) annual values of total precipitation and very wet days for Victoria A



Results – testing on historic climate

- Track anomalies but may not do as well on the distribution
- ClimDEX temperature metrics better predicted than precipitation metrics
- Predicting ClimDEX parameters - limited coherence across variable, metric and location
- EDS “best” method – computationally intensive - BCSD close second

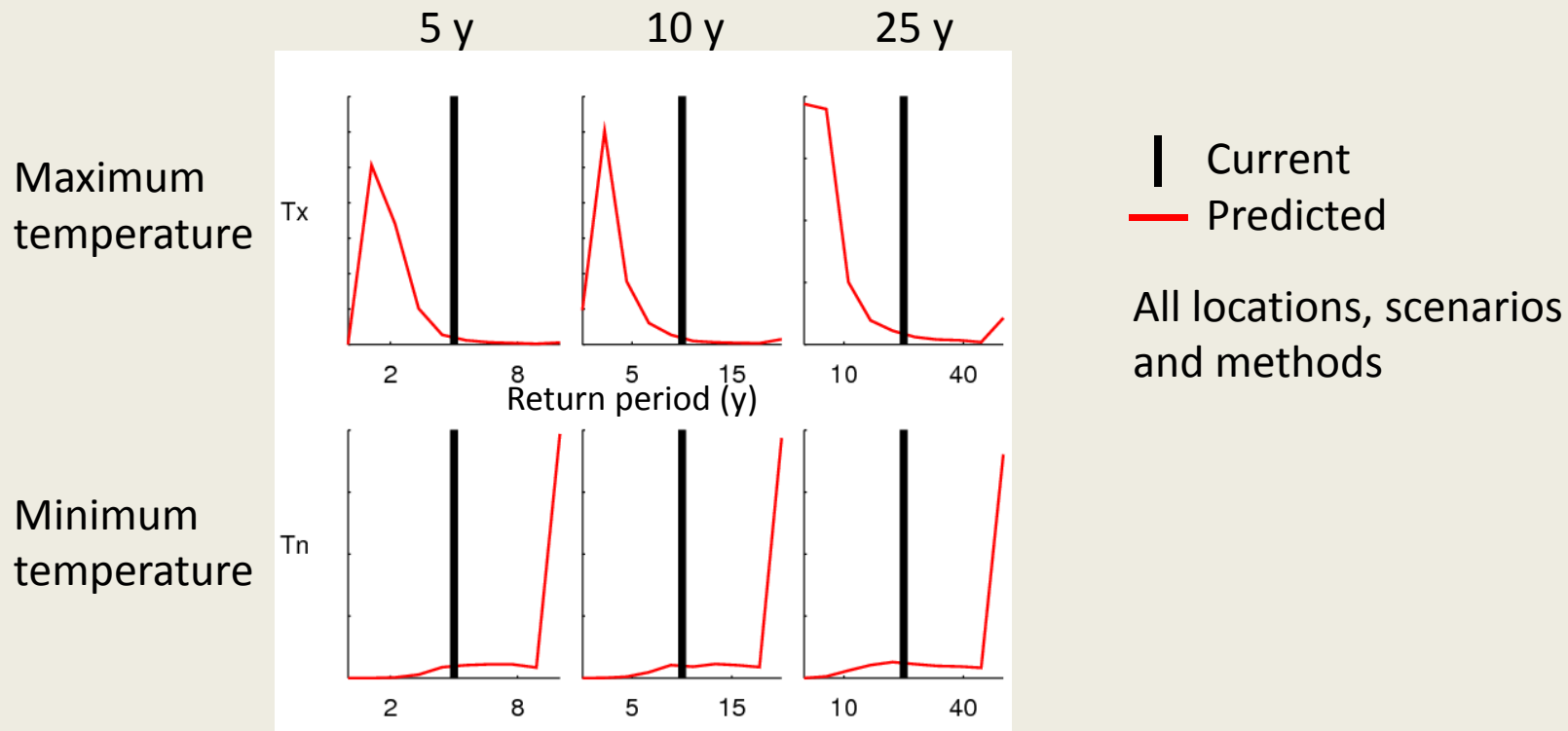
Future climate

- Daily data from 6 GCMs from CMIP3 for 2046-2065
- Emission scenarios - A1, A1B, A2
- Calibrations with NCEP reanalysis data and station data
- ClimDEX indices and return periods
- Eight methods

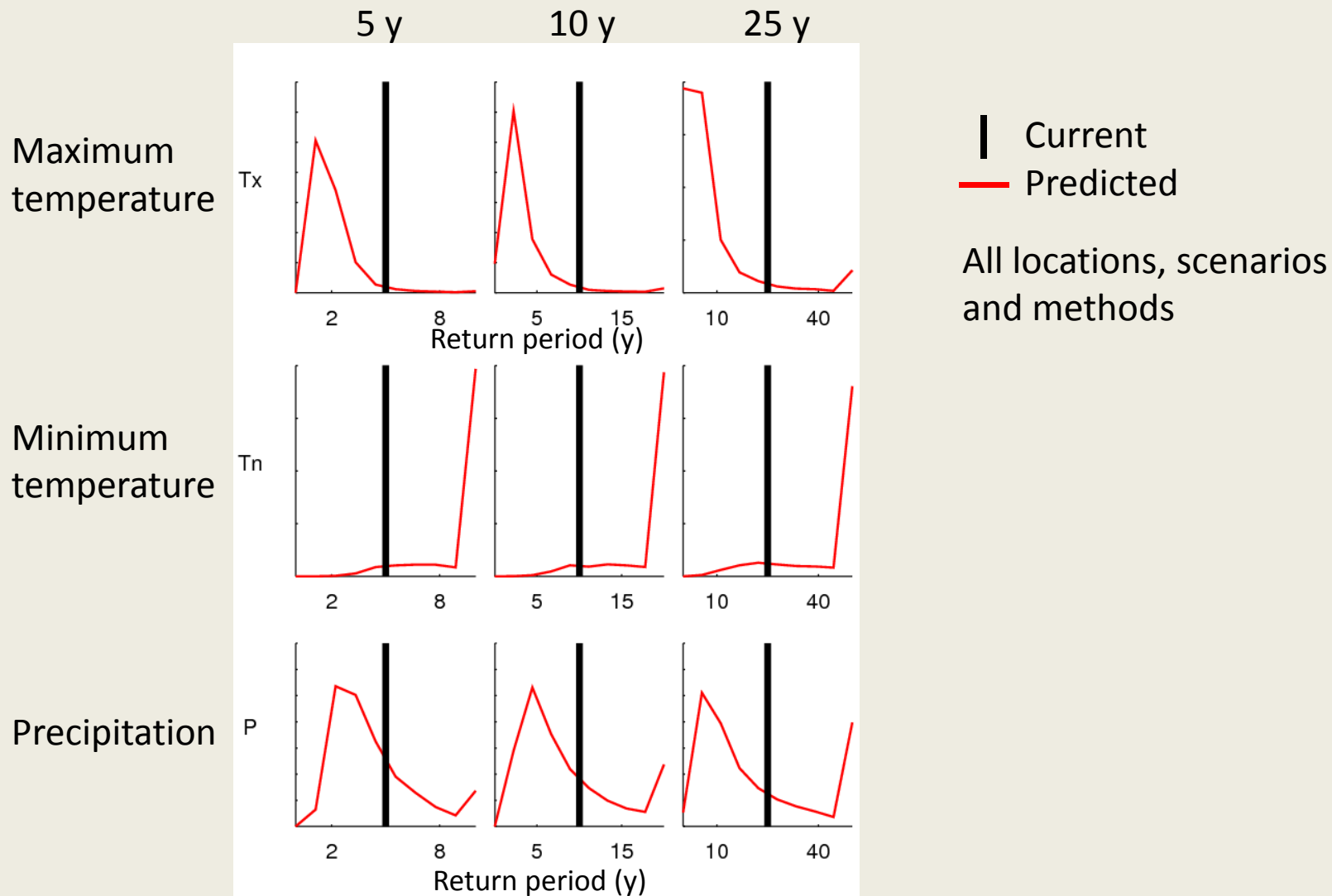
Results

- Weather generators tended to be outliers
- Agreement between methods better for temperature than precipitation
- EDS, QRNN and BCSD appear to be the “best” methods
- Need to test on a seasonal basis and using RCM data

Return periods – 2050s



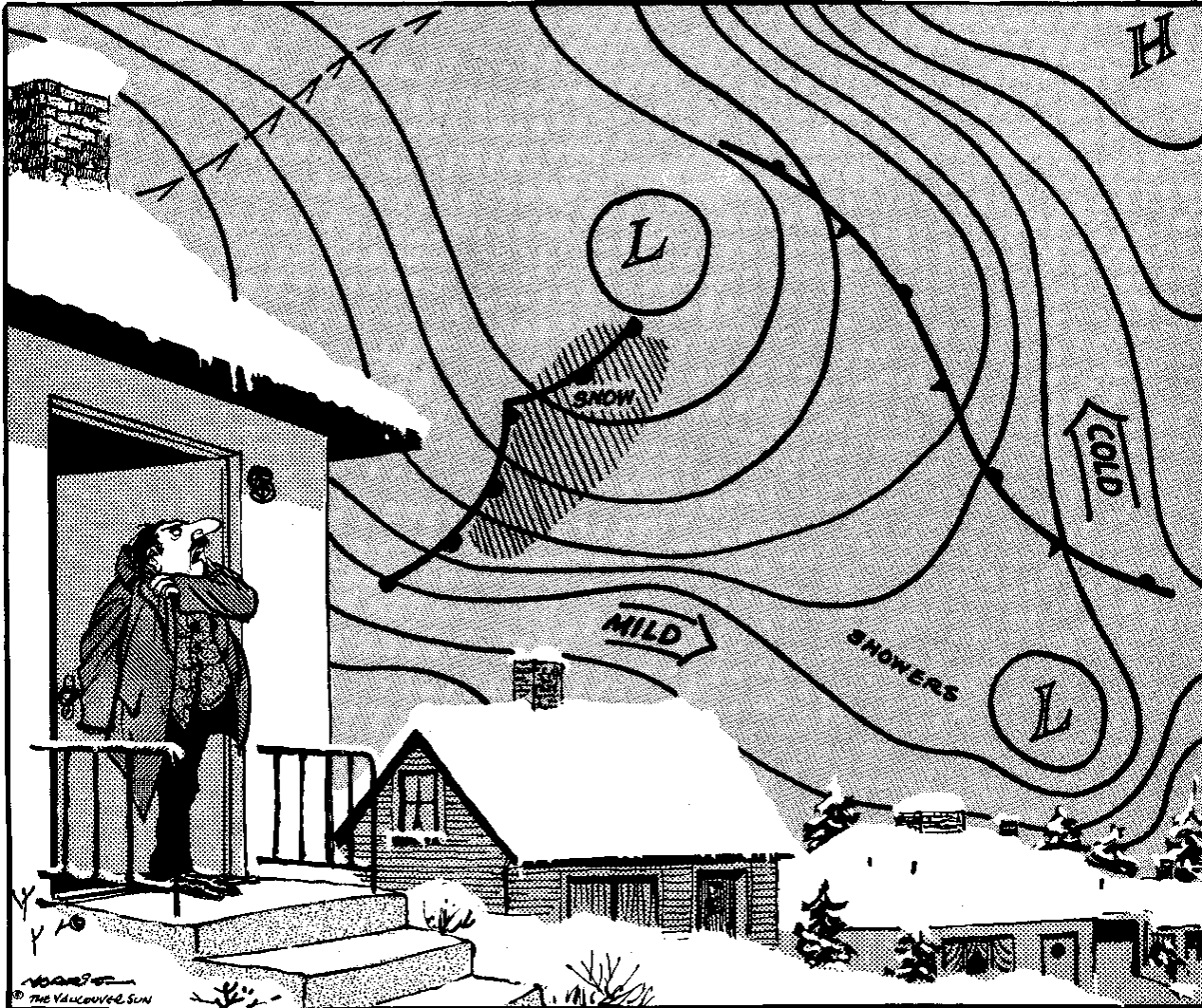
Return periods – 2050s



Future research & application

- Monthly times series downscaling for points
- ClimDEX from CMIP5 – global initiative
- Season-based downscaling BC locations
- Daily and monthly time series of gridded data for BC at 10 km
- Incorporate monthly time series into ClimateBC
- New base layer and historic layers for ClimateBC/WNA

Thanks for listening – Questions?



“Frankly, I don’t like the look of the weather.”