Northwest **Power** and **Conservation** Council

November 5, 2019

MEMORANDUM

TO: **Power Committee Members**

FROM: **Danial Hua, Power Systems Analyst**
John Fazio, Senior Systems Analyst

SUBJECT: **General Circulation Model Scenario Selection**

Presenter: Daniel Hua

Summary: Previous power plans have relied on historical variations in river flows and temperatures as input into the development of regional resource strategies. However, results from the 5th Intergovernmental Panel on Climate Change Assessment Report (IPCC AR5) indicate that this approach may no longer provide the best representation of future conditions for the Pacific Northwest. The proposal for the 2021 power plan is to use a range of future climate-adjusted river flows and temperatures derived from downscaled IPCC AR5 data. Unfortunately, time limitations do not allow staff to incorporate data from all climate scenarios provided by the River Management Joint Operating Committee (RMJOC). Thus, several representative scenarios (that cover a sufficient range in river flow and temperature variation) will be selected for the next plan. At this meeting, staff will brief the committee on a proposal for the selected climate scenarios and on the selection methodology.

Relevance: Using historic variations in river flows and temperatures will likely bias the outlook for future regional resource needs. All RMJOC climate scenarios generally forecast higher winter river flows (greater hydro generation), which when combined with higher winter temperatures (lower load) should lead to lower resource needs. Projections for summer, however, go in the

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opposite direction, with generally lower hydroelectric generation, which when combined with higher electricity demand should lead to higher resource needs. Not accounting for forecasted climate changes could lead to inappropriate resource strategies.

Workplan: A.5.2 Updates to models to get ready for 2021 power plan modeling

Background: Anticipated changes in future climate will affect both resources and demand in the Pacific Northwest. Anticipated increases in temperature will alter the pattern of electricity use. Additionally, the region may see enhanced population growth as people may choose to relocate to the Northwest from regions with more drastic climate effects. Higher temperatures tend to result in more rain and less snow during winter months, which reduces the snow pack and subsequent summer flow. Finally, state laws enacted to reduce greenhouse gases will limit future resource choices. The Council has an obligation to account for all of these factors when developing its resource strategy in order to maintain the adequacy, reliability, efficiency and economy of the regional power supply.

More Info: None

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General Circulation Model Scenario Selection

November 12, 2019

THE 2021
NORTHWEST
POWER PLAN

FOR A SECURE & AFFORDABLE
ENERGY FUTURE

Outline

- A review of the General Circulation Models (GCMs) for the northwest region: temperatures and precipitation
- For climate studies, perform downscaling and hydrological modeling of the GCM data to calculate streamflow – climate scenarios
- Data analysis of the climate scenarios: cooling and heating-degree days
- Initial subset of scenarios for the 2021 Power Plan

General Circulation Models for the Northwest Region

GCM Data Resources

- GCM data analysis perform by staff from the *River Management Joint Operating Committee (RMJOC),*

- and scientists at

- The 1st RMJOC Report:

https://www.bpa.gov/p/Generation/Hydro/hydro/cc/RMJOC-II-Report-Part-I.pdf

RMJOC General Circulation Models

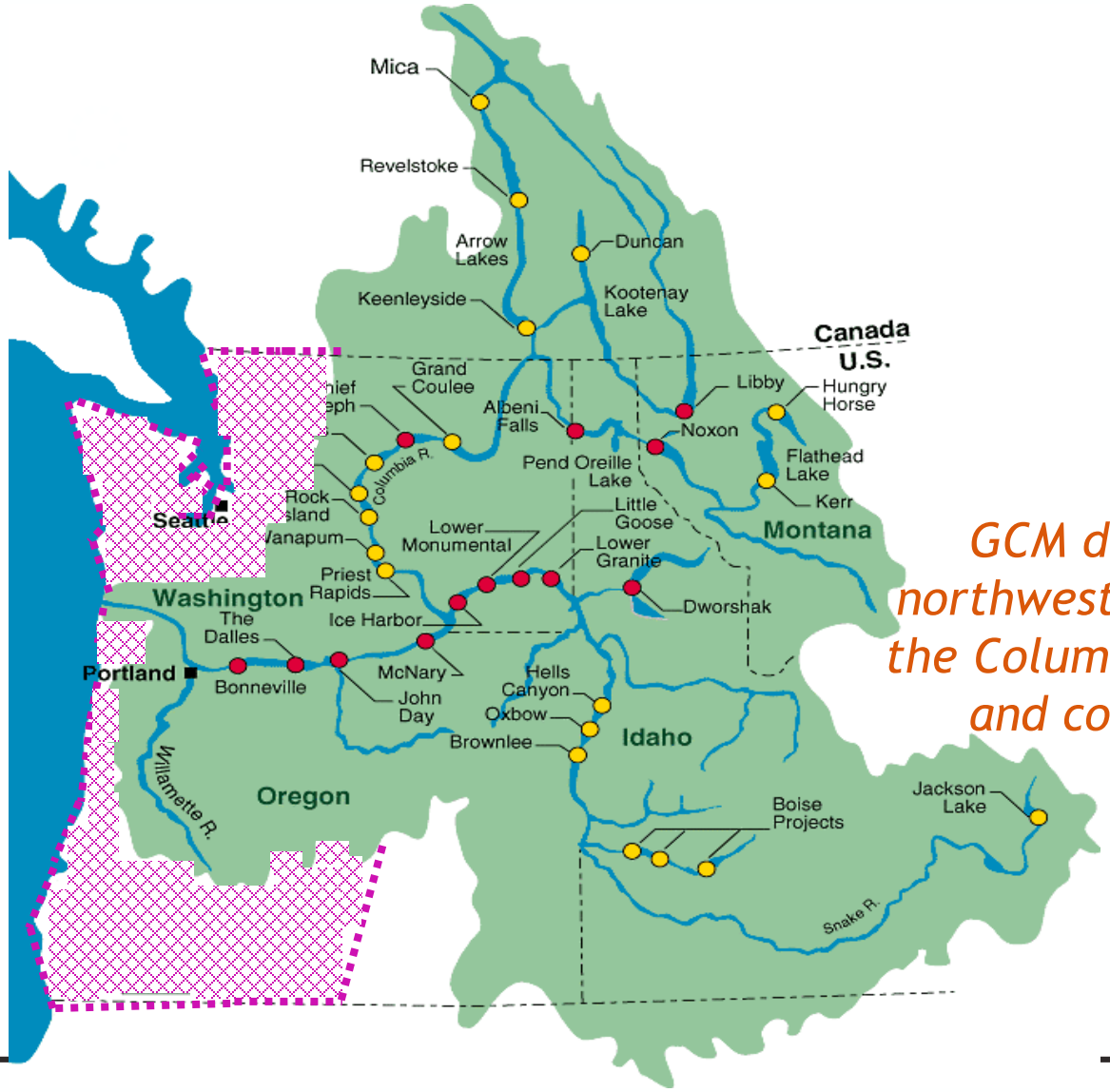
- RMJOC provided data for the 10 GCMs

1	*CanESM2*	*(CAN)*	6	*HadGEM2-CC*	*(UK)*
2	*CCSM4*	*(US)*	7	*HadGEM2-ES*	*(UK)*
3	*CNRM-CM5*	*(FR)*	8	*inmcm4*	*(RUS)*
4	*CSIRO-Mk3-6-0*	*(AUS)*	9	*IPSL-CM5-MR*	*(FR)*
5	*GFDL-ESM2M*	*(US)*	10	*MIROC5*	*(JP)*

- which had been downscaled to spatial resolution ~ 4 miles x 4 miles using two statistical methods: *BCSD* and *MACA*

- For climate change studies, choose for Representative Concentration Pathway *(RCP) 8.5 - "business as usual" emission levels*

GCM Data for the Northwest Region

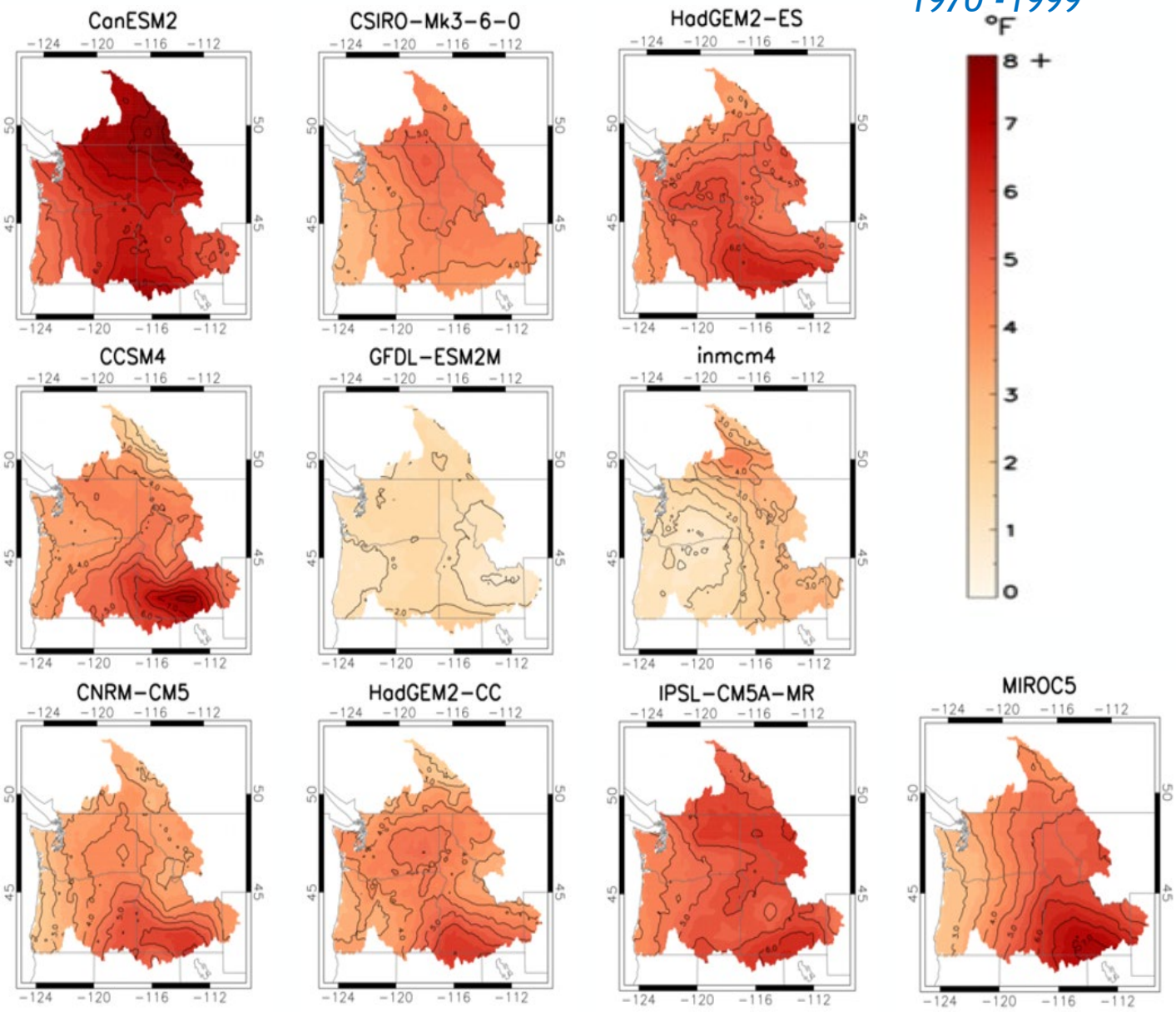


GCM data for the northwest region covers the Columbia River Basin and coastal areas

Winter GCM Data

Average Winter Temperature Warming by the 2040s*

(MACA)



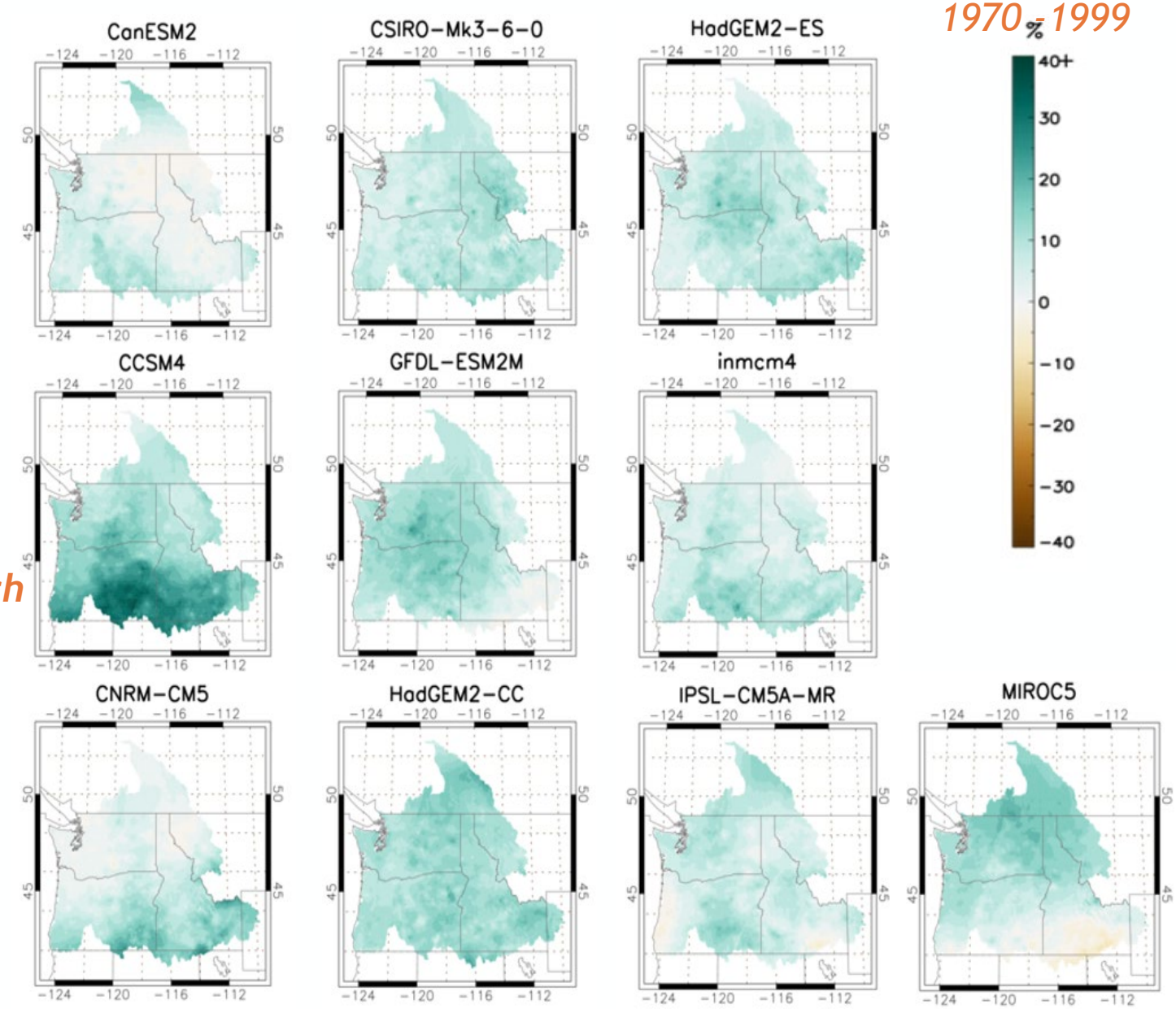
- *Warming over all northwest region*
- *Interior more warming than coast*
- *Winter loads tend to decrease*

courtesy of David Rupp at OSU

Average Winter Precipitation Changes by the 2040s*

(MACA)

- *Precipitation increases for much of basin, likely in US falling as rain instead of snow*
- *Likely to have higher winter flows*
- *Winter snowpack likely to decline over time*



courtesy of David Rupp at OSU

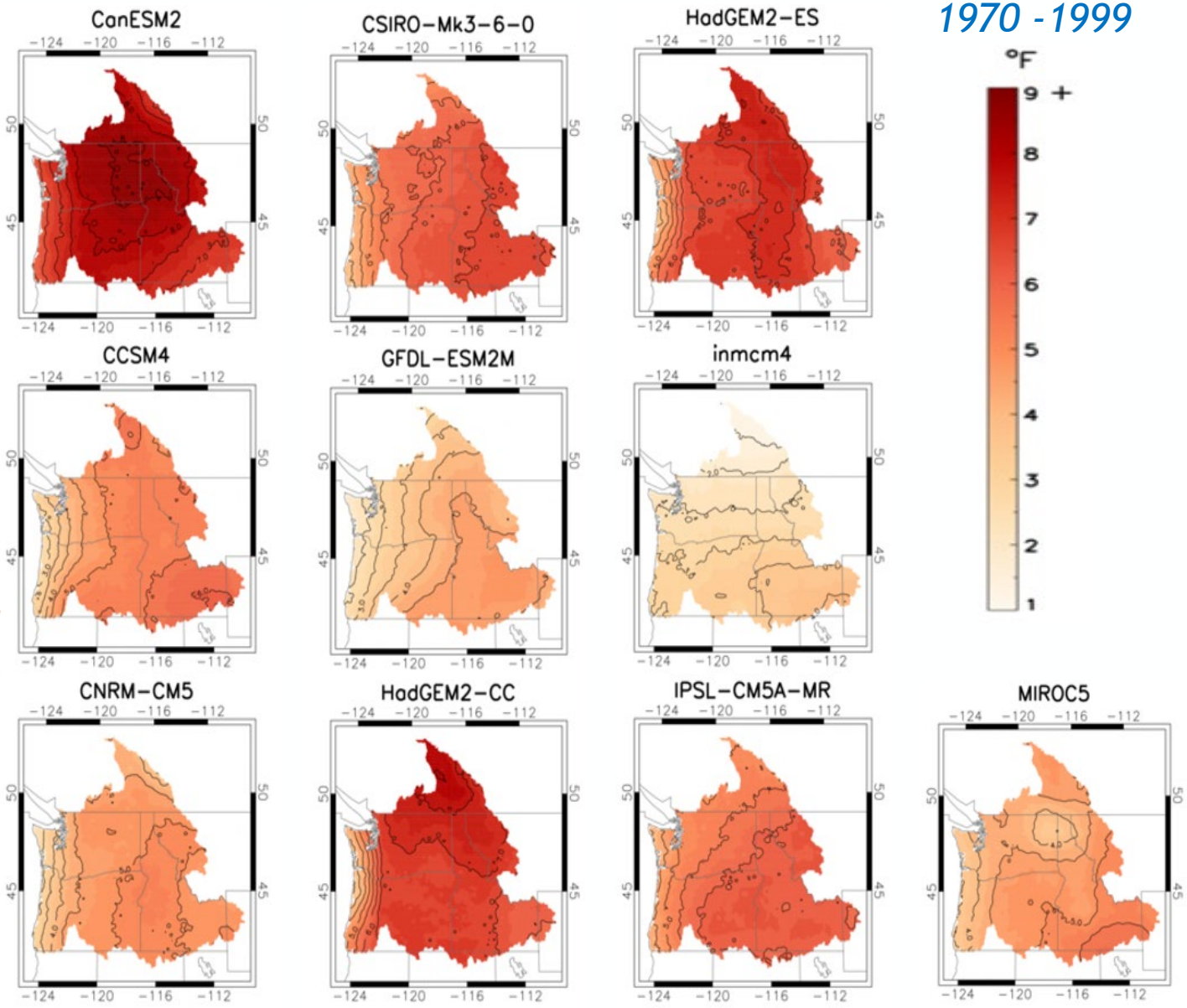
Summer GCM Data

Average Summer Temperature Warming by the 2040s*

(MACA)

- *Warming over all northwest region*
- *Interior more warming than coast*
- *Summer loads tend to increase*

Relative to 1970 -1999

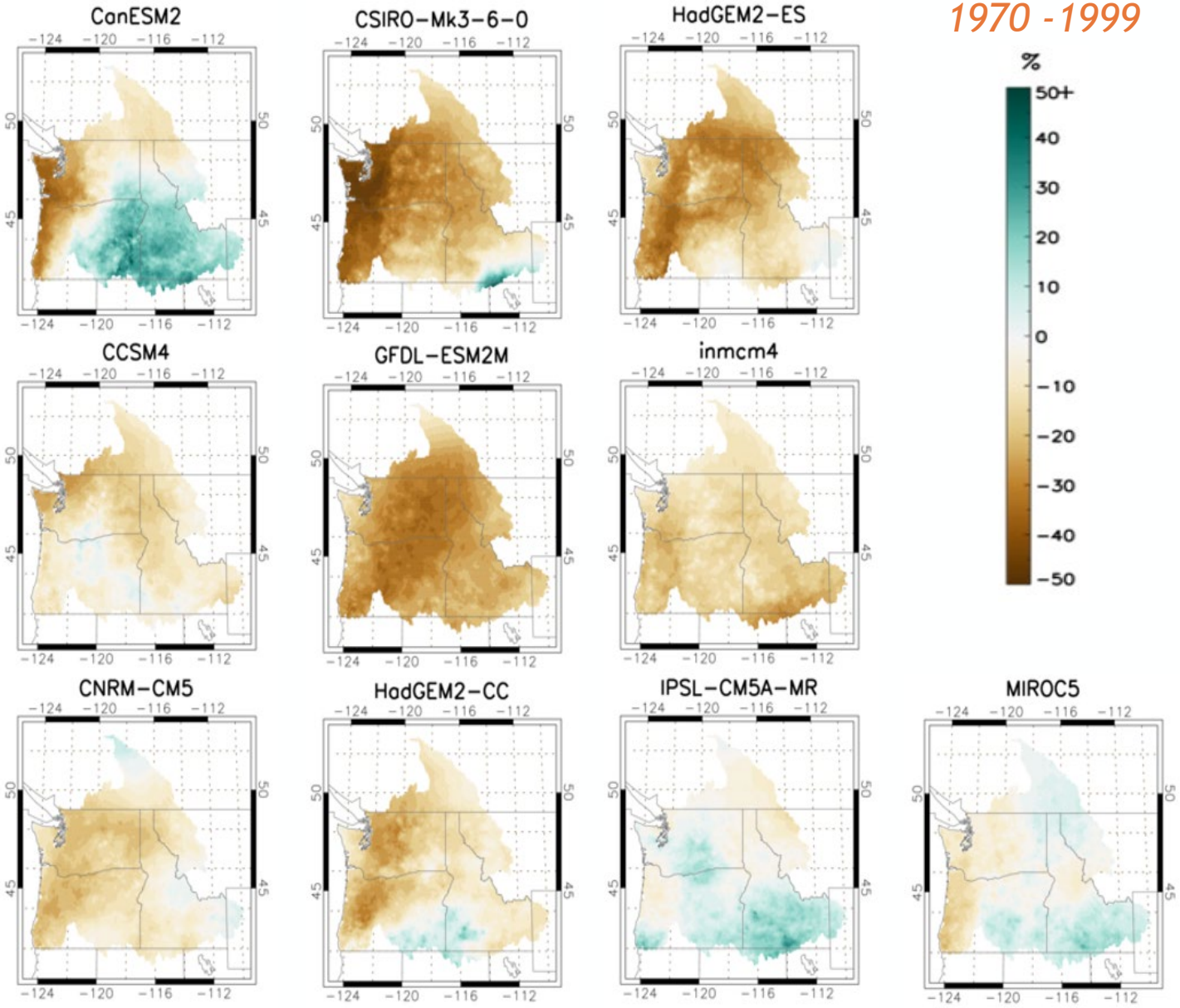


courtesy of David Rupp at OSU

Average Summer precipitation changes by the 2040s*

(MACA)

- *Precipitation decreases for many areas of basin*
- *Likely to have longer periods of low summer flows*



Relative to 1970 -1999

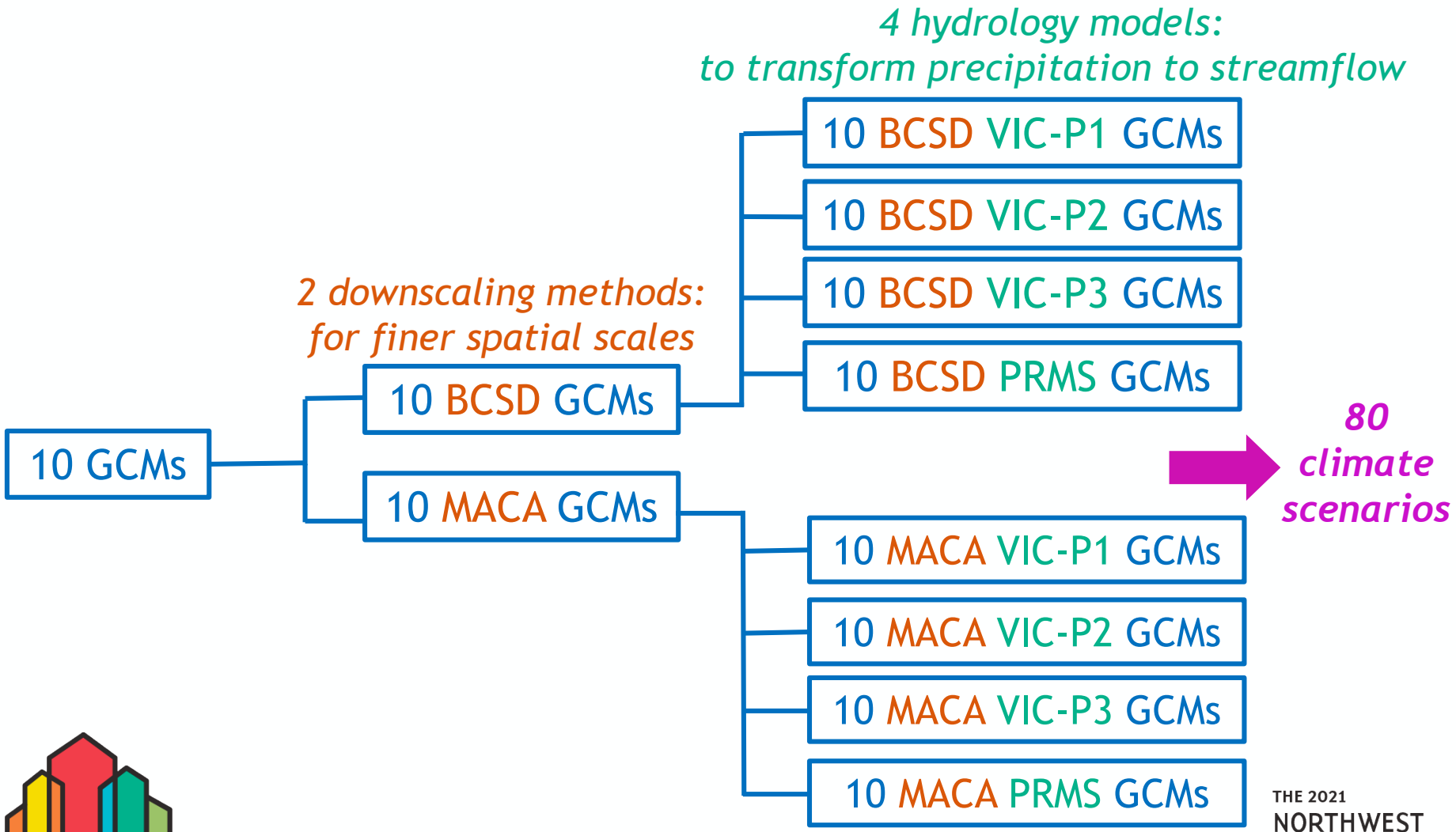
courtesy of David Rupp at OSU

Transforming GCM Data for Climate Studies

Transforming GCM Precipitation Data for Climate Studies

- GCM precipitation data are not used directly in the Council's power generation model for climate studies
- To simulate the northwest hydro system, the generation model uses streamflow data, which could be calculated from hydrological modeling of precipitation data
- RMJOC uses 4 hydrology models: *VIC-P1, VIC-P2, VIC-P3 and PRMS*

GCMs to Climate Scenarios



The 19 RMJOC Scenarios

- The RMJOC chose 19 of the 80 scenarios that encompass sufficient range of uncertainties over 6 streamflow metrics at 14 projects of interests for climate studies

A: *CanESM2_RCP85_BCSD_VIC_P1*
B: *CanESM2_RCP85_MACA_PRMS_P1*
C: *CCSM4_RCP85_BCSD_VIC_P1*
D: *CCSM4_RCP85_MACA_VIC_P3*
E: *CNRM-CM5_RCP85_BCSD_VIC_P2*
F: *CNRM-CM5_RCP85_MACA_VIC_P1*
G: *CNRM-CM5_RCP85_MACA_VIC_P3*
H: *CSIRO-Mk3-6-0_RCP85_BCSD_PRMS_P1*
I: *GFDL_ESM2M_RCP85_BCSD_VIC_P2*
J: *GFDL_ESM2M_RCP85_MACA_VIC_P1*
K: *GFDL_ESM2M_RCP85_MACA_VIC_P2*
L: *HadGEM2-CC_RCP85_BCSD_VIC_P1*
M: *HadGEM2-CC_RCP85_MACA_VIC_P1*
N: *inmcm4_RCP85_BCSD_PRMS_P1*
O: *inmcm4_RCP85_BCSD_VIC_P2*
P: *inmcm4_RCP85_MACA_VIC_P3*
Q: *IPSL-CM5A-MR_RCP85_MACA_VIC_P2*
R: *MIROC5_RCP85_BCSD_PRMS_P1*
S: *MIROC5_RCP85_BCSD_VIC_P3*

Climate Scenarios for the 2021 Power Plan

Climate Scenarios Selection

- For the 2012 Power Plan, council staff will select a subset of the 19 climate scenarios to encompass sufficient high and low ranges in regional hydro generation and loads

- Selection of the subset will be based on distributions of

  - Monthly regional *winter* and *summer hydro generations* for the 19 scenarios (***in progress***)

  - Monthly *winter heating-degree days* (HDDs) and *summer cooling-degree days* (CDDs) for the 19 scenarios (to represent temperatures effects on loads)

Climate Scenarios CDDs and HDDs

Cooling and Heating Degree Days

- Calculate a regional average daily temperature:

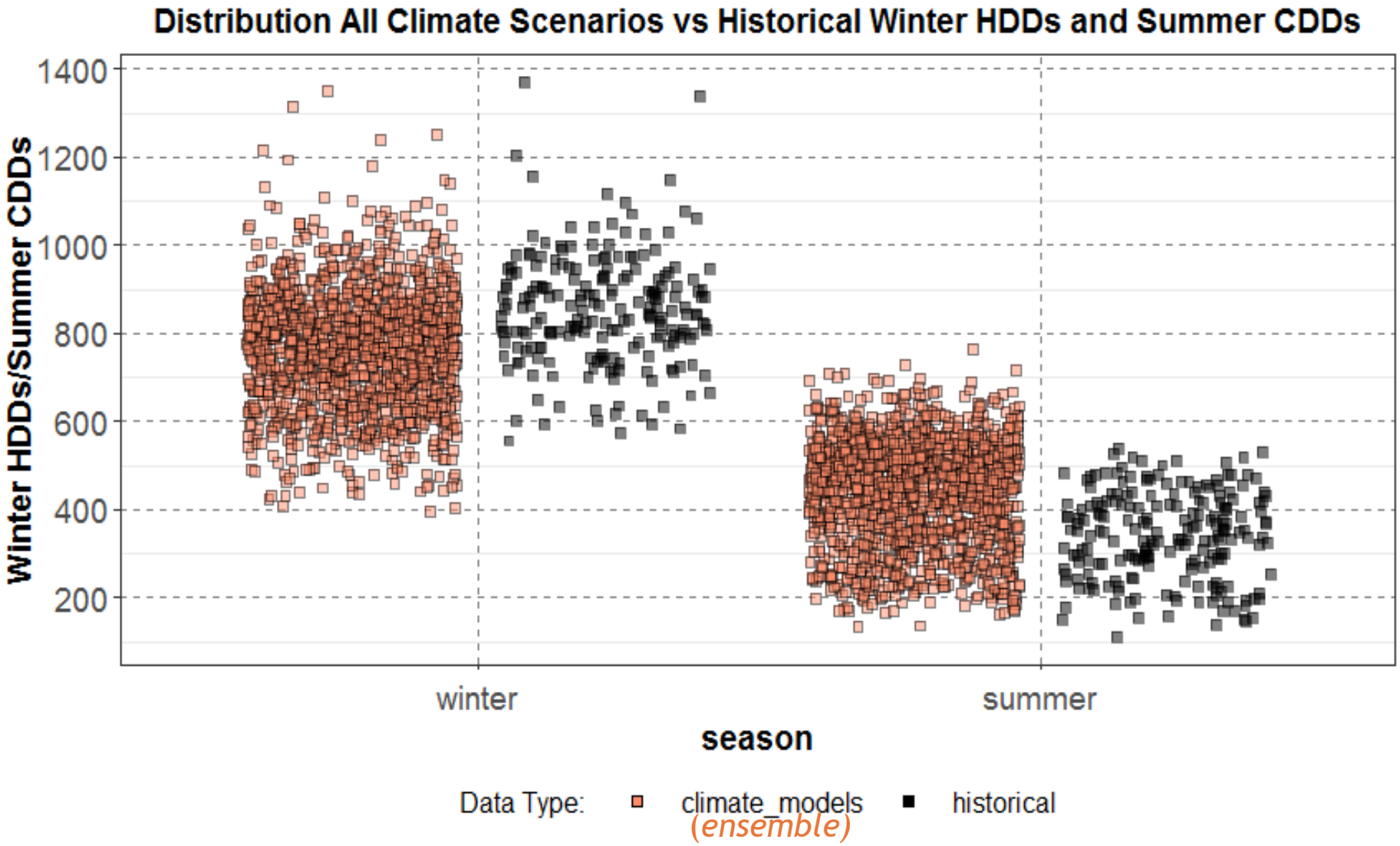
$$\overline{T_d} = a * T_{Seattle} + b * T_{Portland} + c * T_{Spokane} + d * T_{Boise} + constant$$

(a, b, c, d, constant vary by month)

- By convention:
  - *Cooling Degree Day* if $(\overline{T_d} - 55) > 0$
  - *Monthly CDDs* = $\sum_d (\overline{T_d} - 55)$ for all *d's* in a month
  - *Heating Degree Day* if $(65 - \overline{T_d}) > 0$
  - *Monthly HDDs* = $\sum_d (65 - \overline{T_d})$ for all *d's* in a month

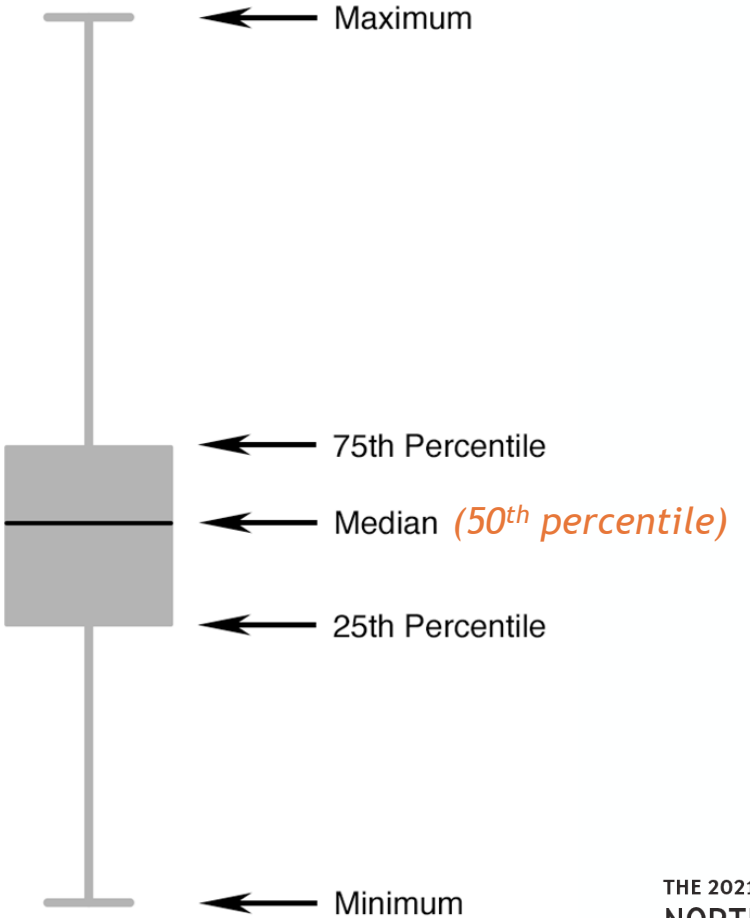
- Analyze *winter (Dec – Feb) HDDs* and *summer (Jun – Aug) CDDs* for 2020 – 2049 for the 19 climate scenarios for selection

Comparing Climate-Change and Historical CDDs and HDDs (A)

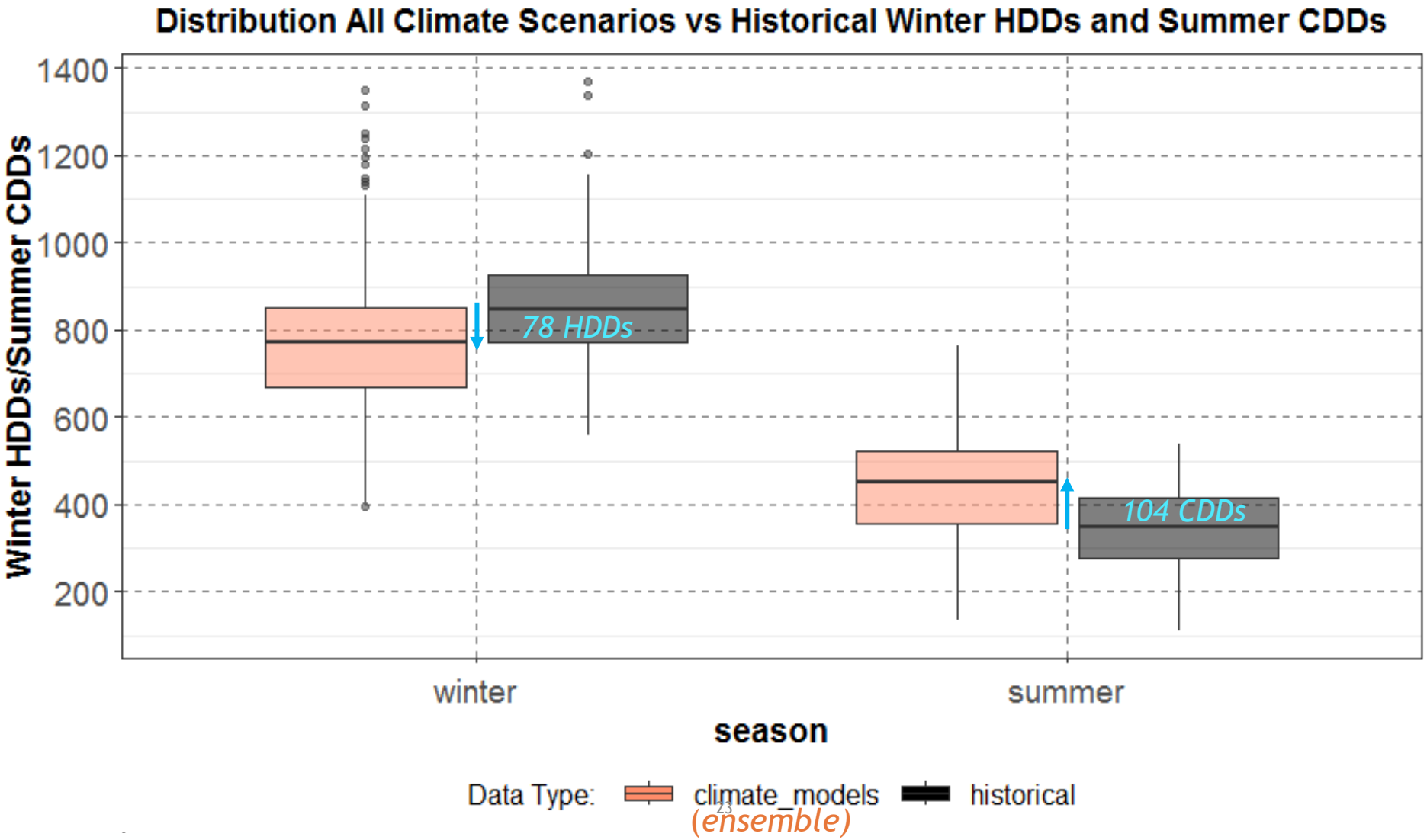


Interpreting Box-and-Whiskers Plot

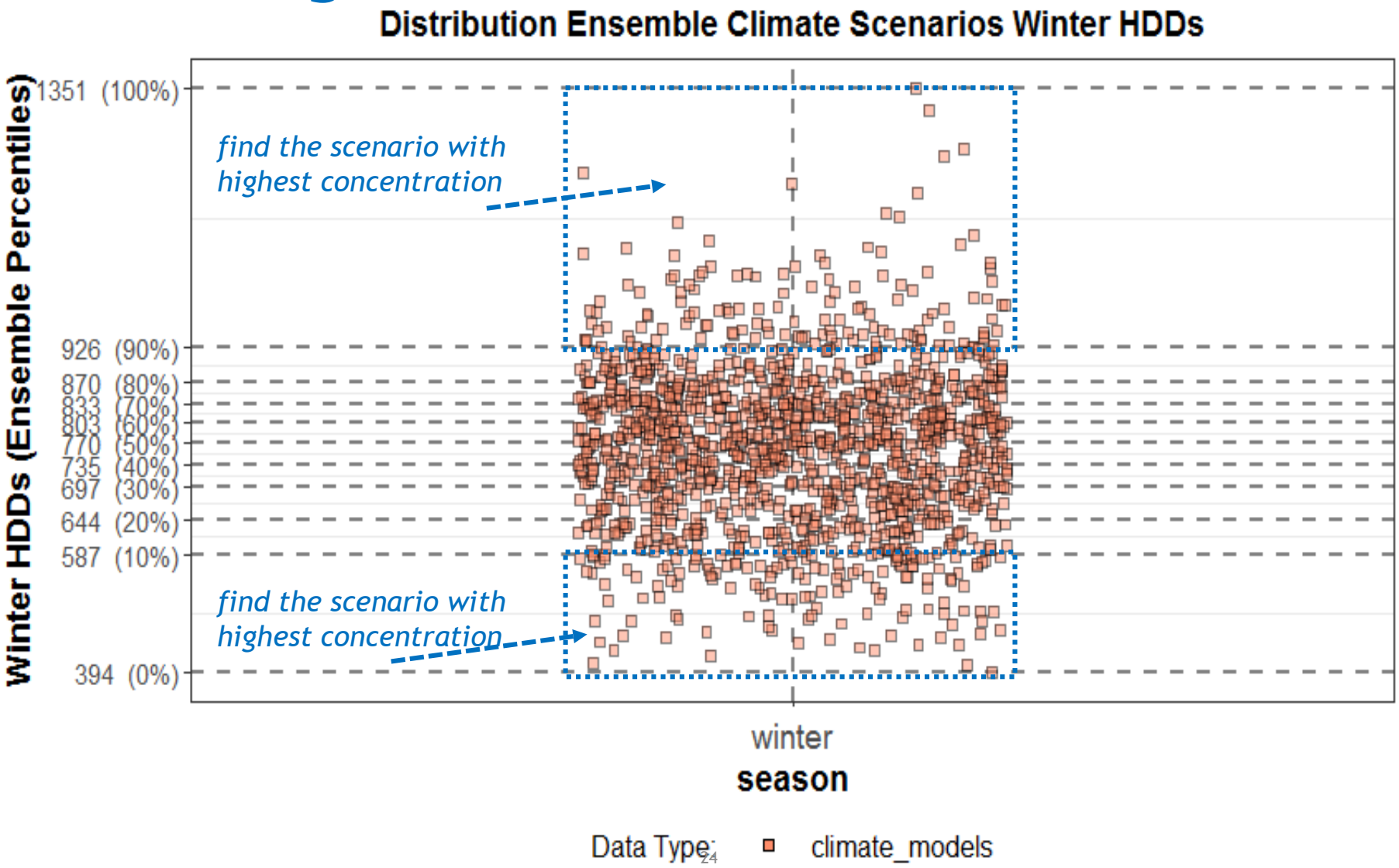
For most of the box-and-whisker plots in this presentation, the upper and low whiskers have this simple interpretation: maximum and minimum



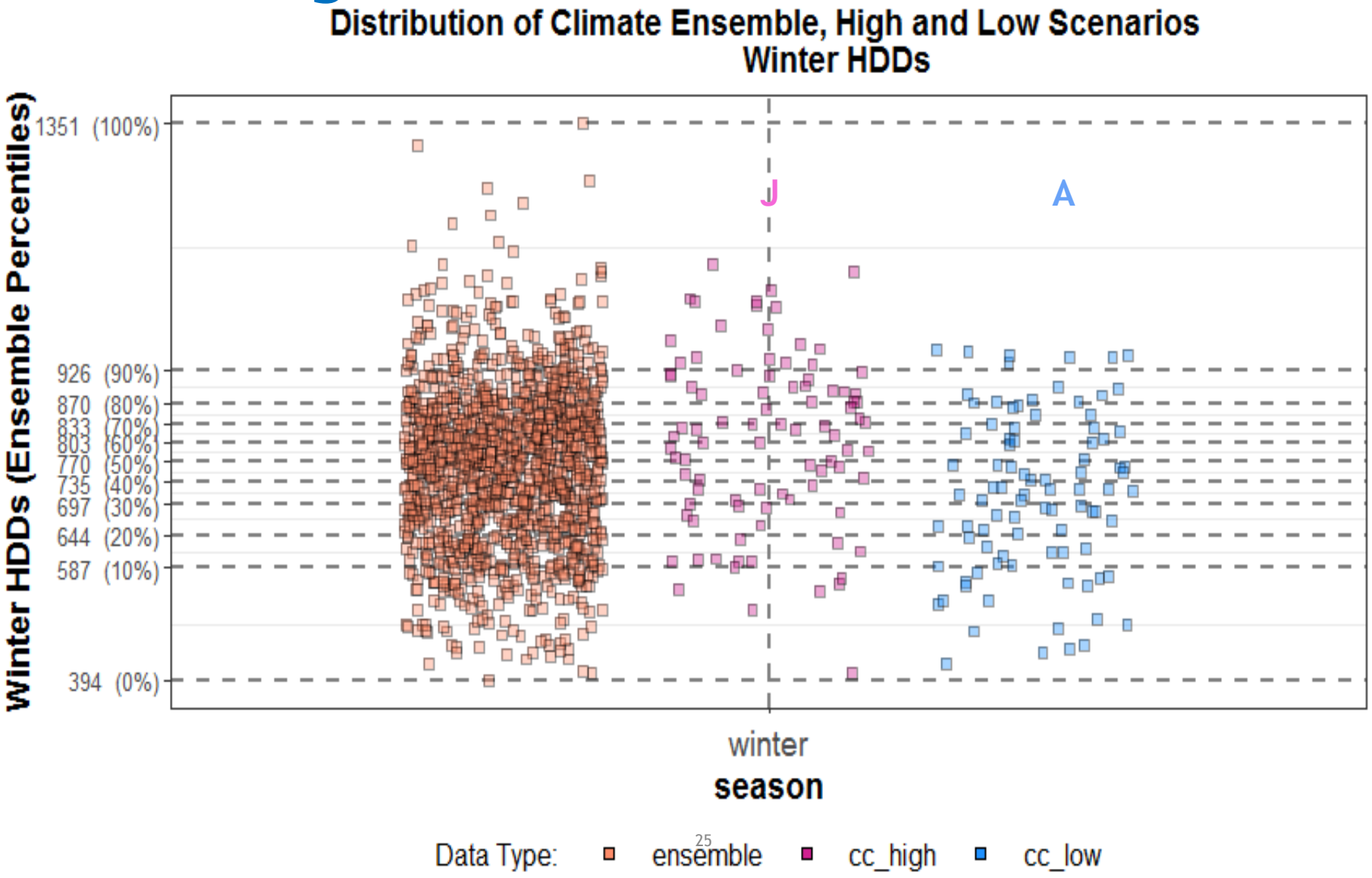
Comparing Climate-Change and Historical CDDs and HDDs (B)



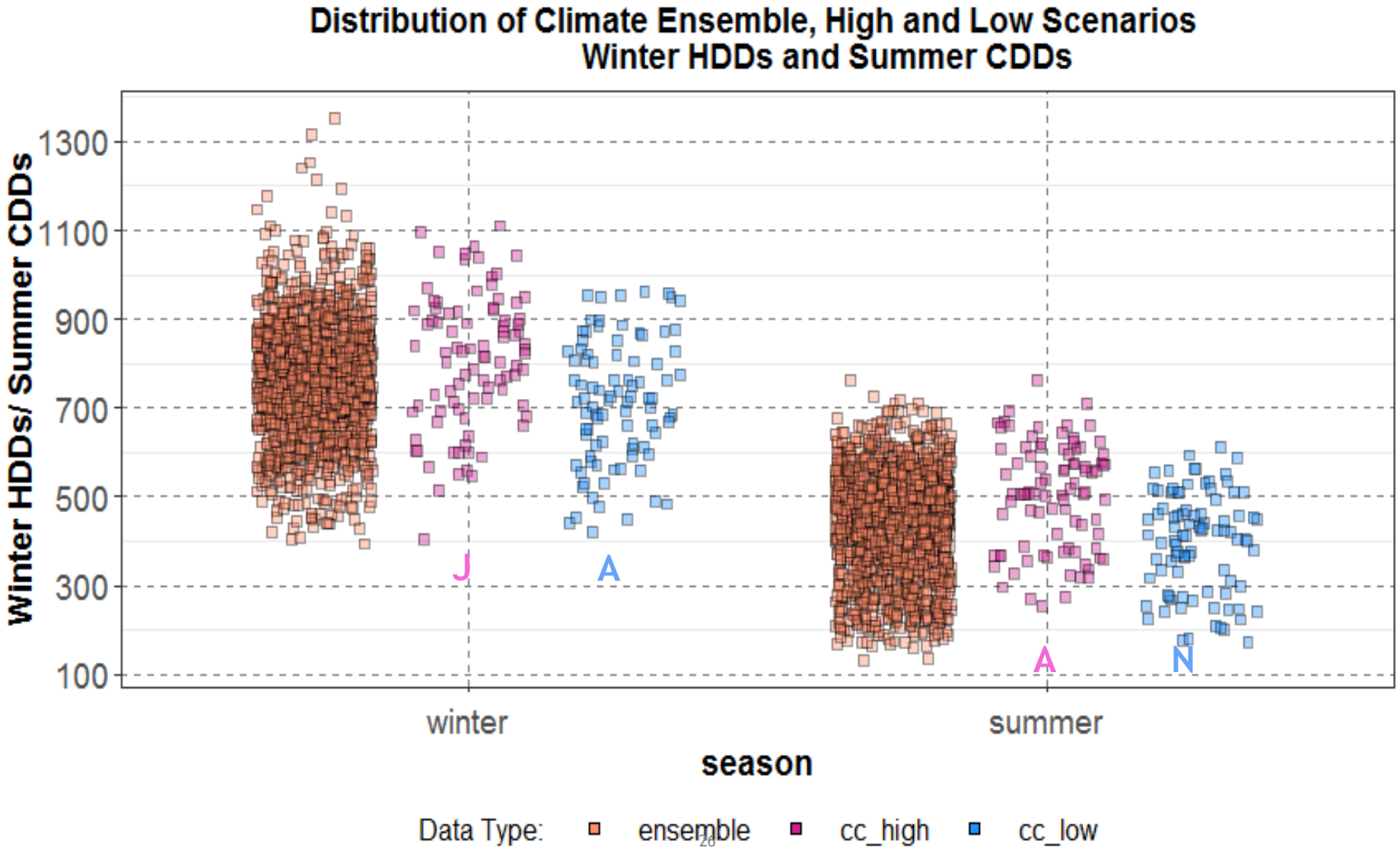
Method for Selecting Scenarios for High and Low Winter HDDs



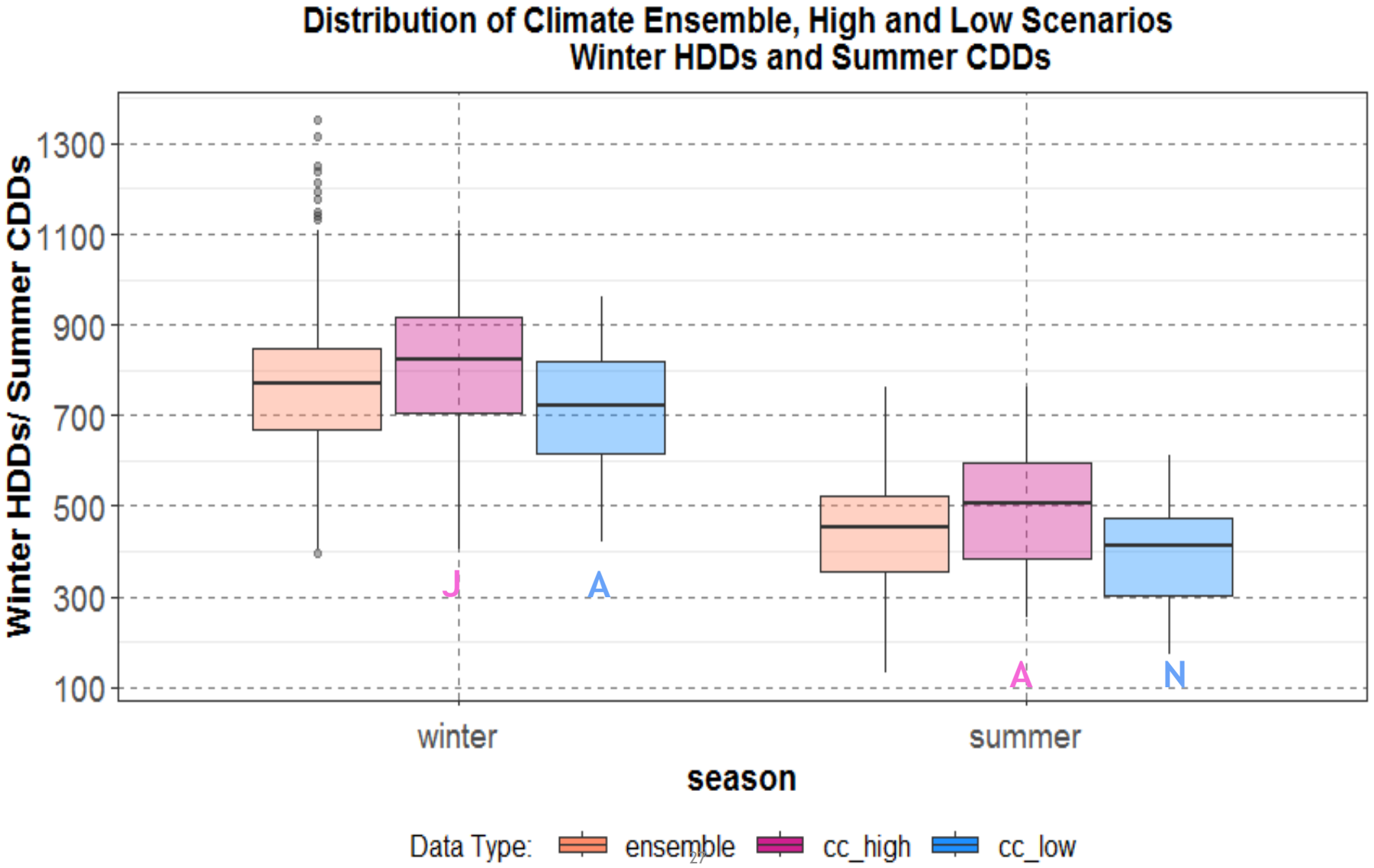
Results of Selecting Scenarios for High and Low Winter HDDs



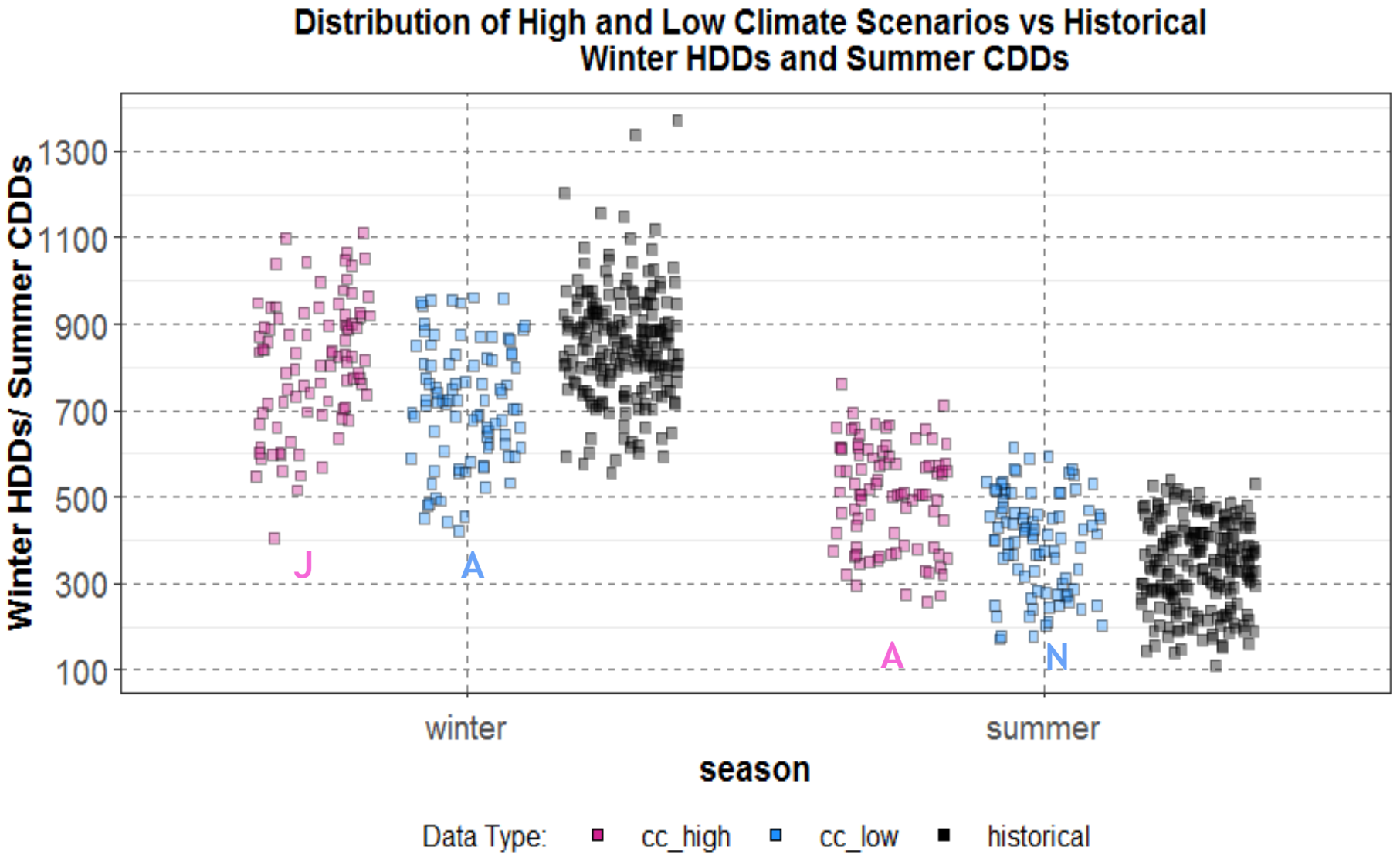
Comparing High and Low CDDs and HDDs Scenarios with The Ensemble (A)



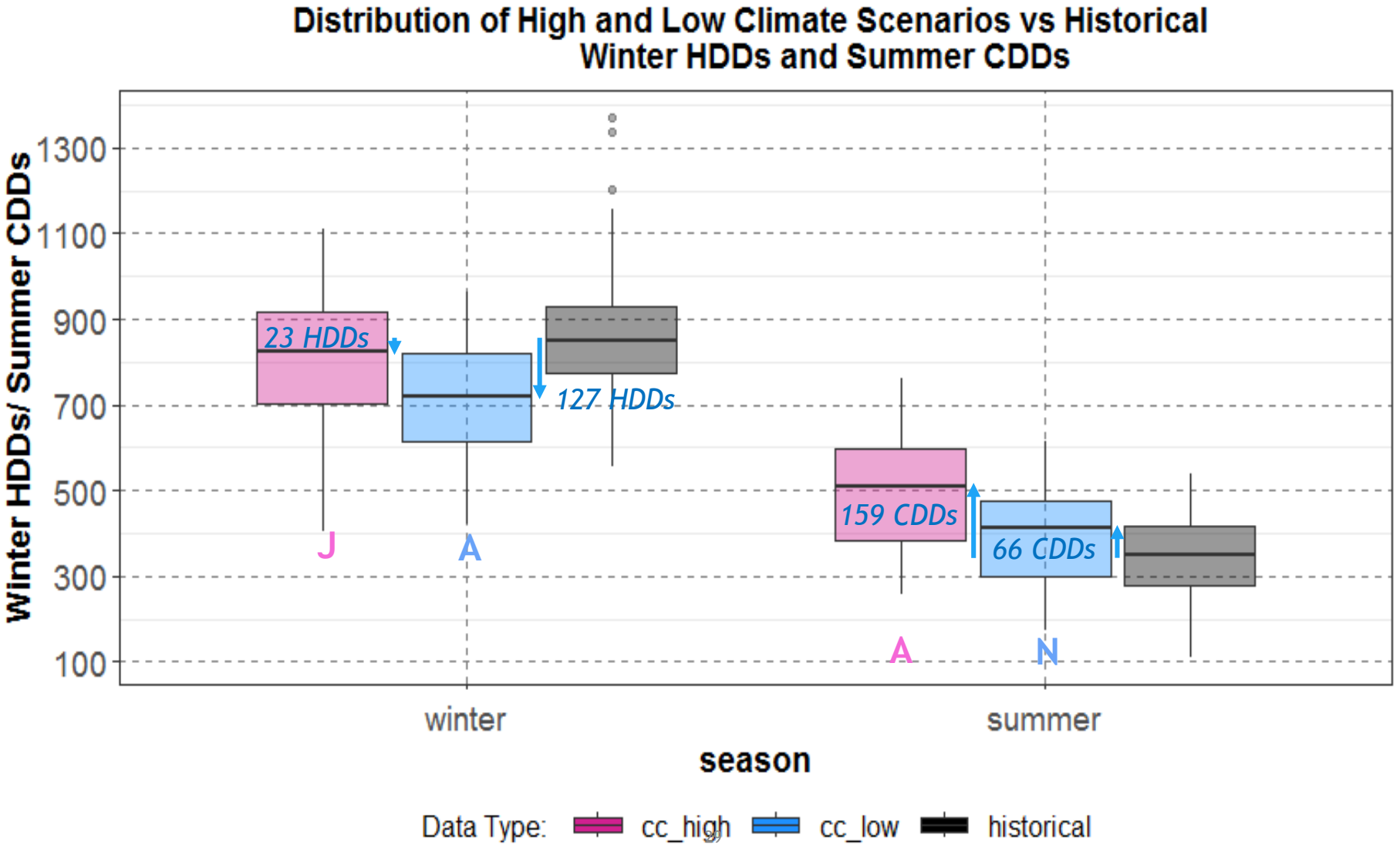
Comparing High and Low CDDs and HDDs Scenarios with The Ensemble (B)



Comparing High and Low CDDs and HDDs Scenarios with Historical (A)



Comparing High and Low CDDs and HDDs Scenarios with Historical (B)



Scenario Selection based on Monthly Hydro Generation

Initial Set of Selected Climate Scenarios

Selected Scenarios

Scenario\Metric	Winter HDD	Summer CDD
A	*low*	*high*
J	*high*	*near low*
N	-	*low*

A: *CanESM2_RCP85_BCSD_VIC_P1*
J: *GFDL_ESM2M_RCP85_MACA_VIC_P1*
N: *inmcm4_RCP85_BCSD_PRMS_P1*

high - among 19 scenarios, most population in [90% - 100%] percentiles of climate model ensemble
low - among 19 scenarios, most population in [0% - 10%] percentiles of climate model ensemble