The Association between Canadian Climatic Extremes and Interannual and Interdecadal Oscillations

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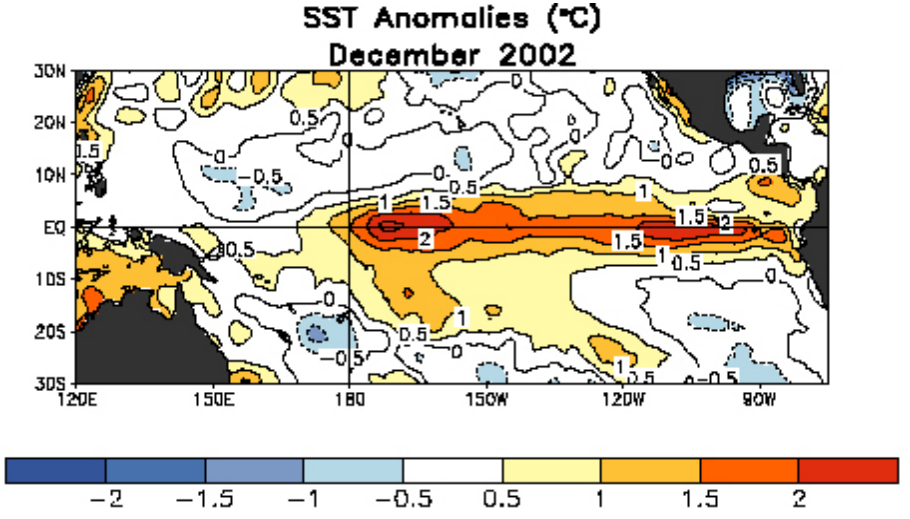
Outline

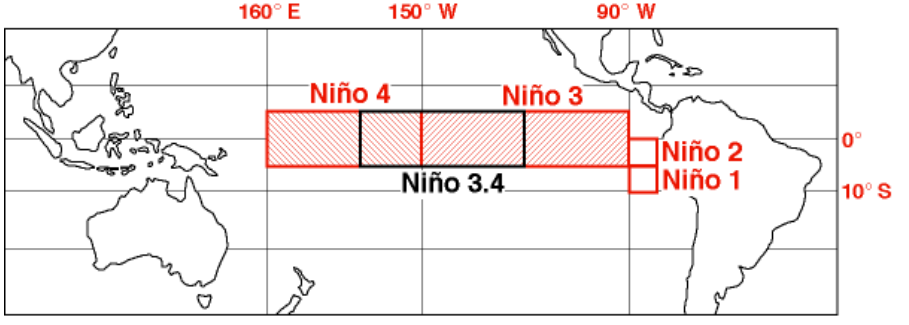
- Describe climatic indices and interannual (ENSO) and interdecadal oscillations (PDO, AMO)
- Using composite and regression analysis show individual and combined effects of oscillations
- Examine circulation features associated with composites
- Composites of SPI and related moisture flux and divergence of moisture flux

Climatic Indices – Winter (Dec-Feb)

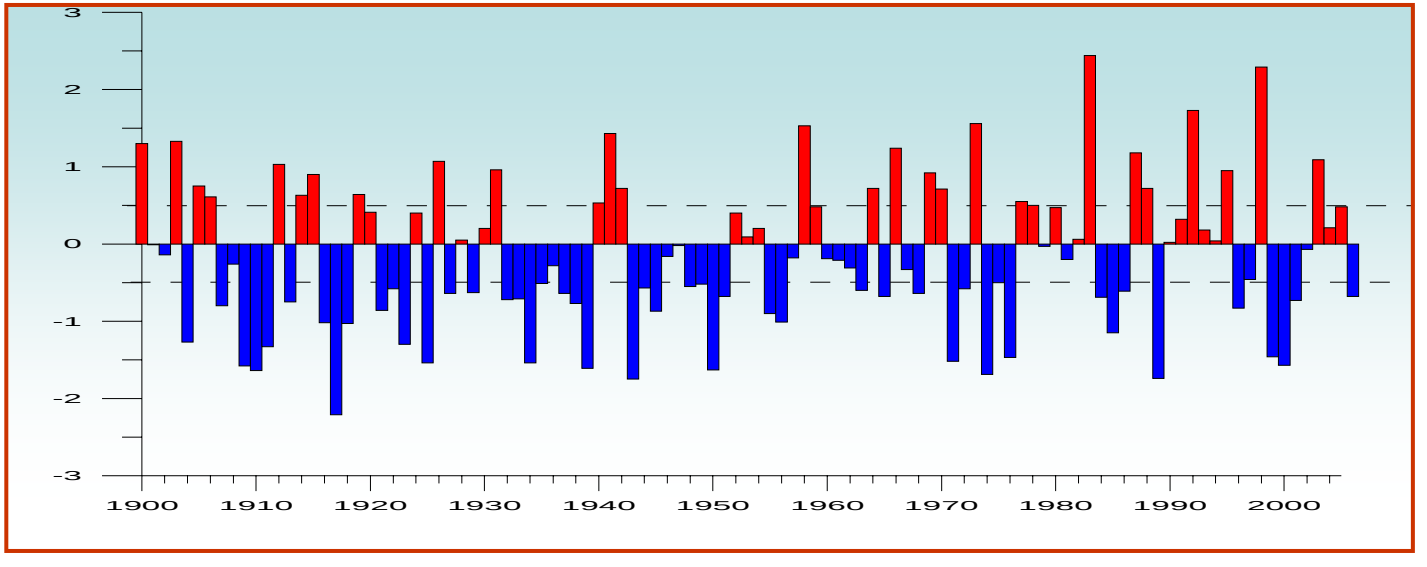
- Number of days with Tmax above 90th percentile (warm days) **Ndx90**
- Heat wave frequency index (number of wave: 3-days with Tmax above 90th percentile) **Hwfi**
- Standardized Precipitation Index (**SPI**)

The El Nino-La Nina Cycle (ENSO)





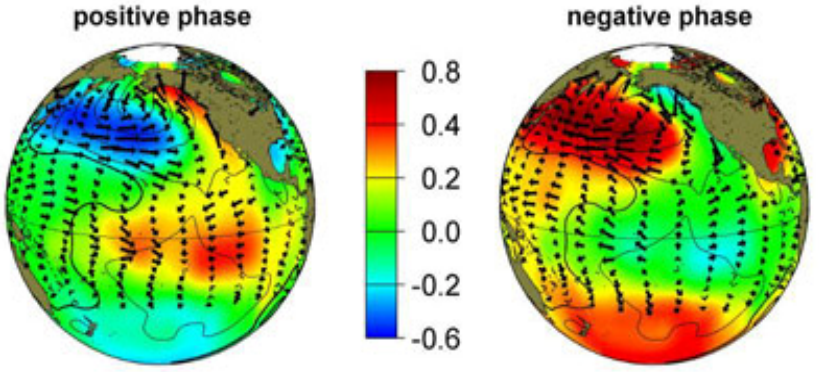
Standardized Nino3.4 Index

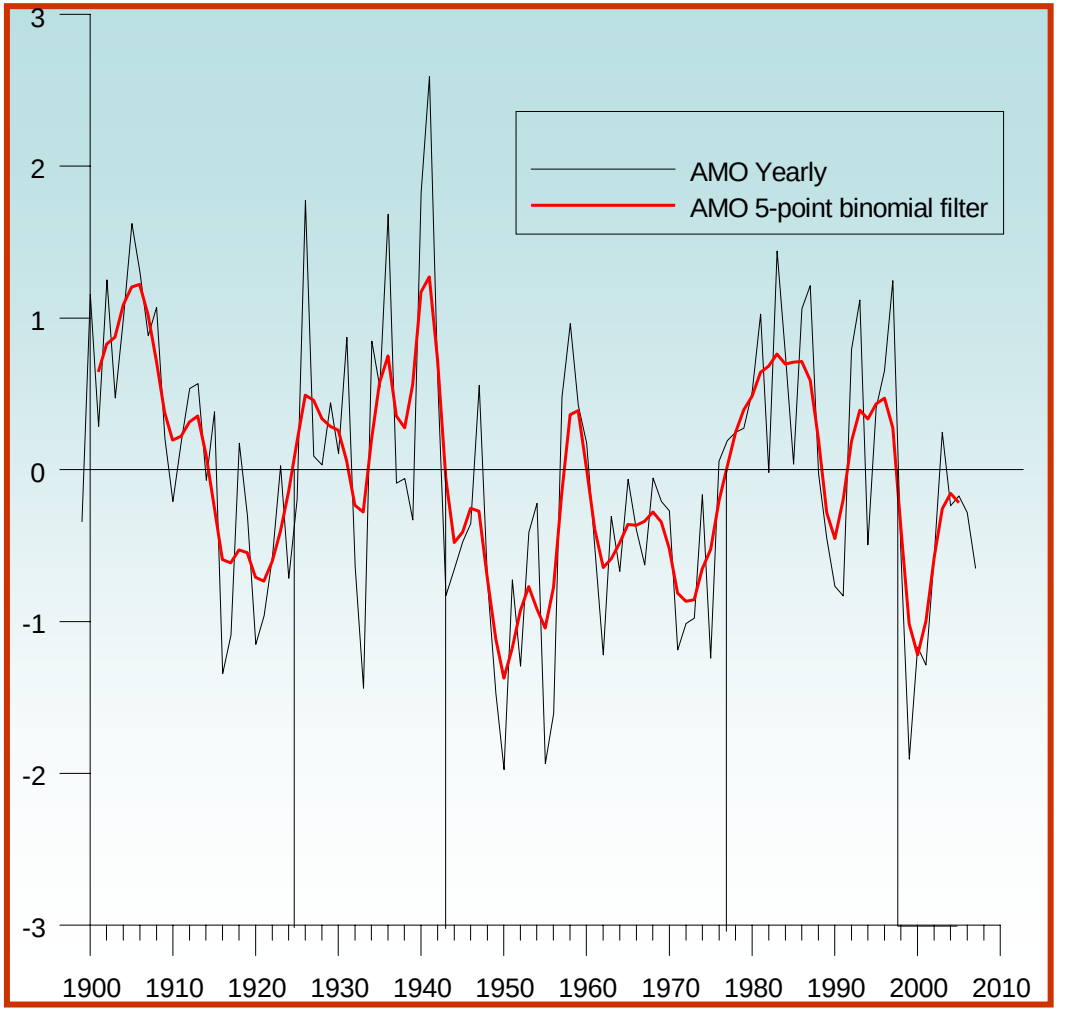


Pacific Decadal Oscillation (PDO)

- Leading mode of Natural Variability in the North Pacific
- It has a 25-year cycle. Currently cycle has shifted into negative phase

Correlation between PDO and SST and wind anomaly

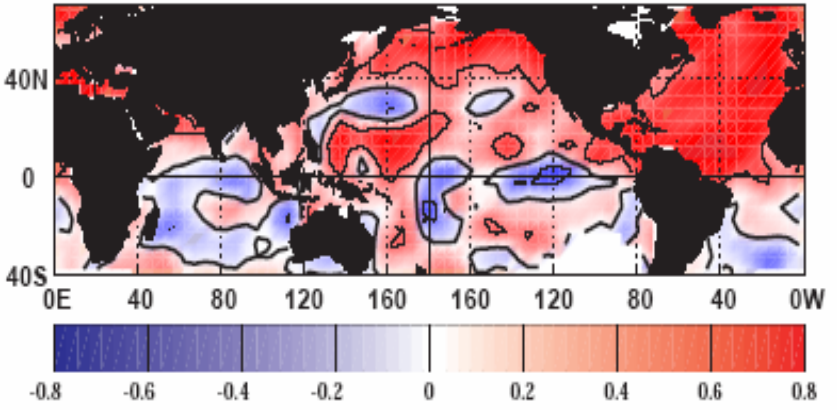


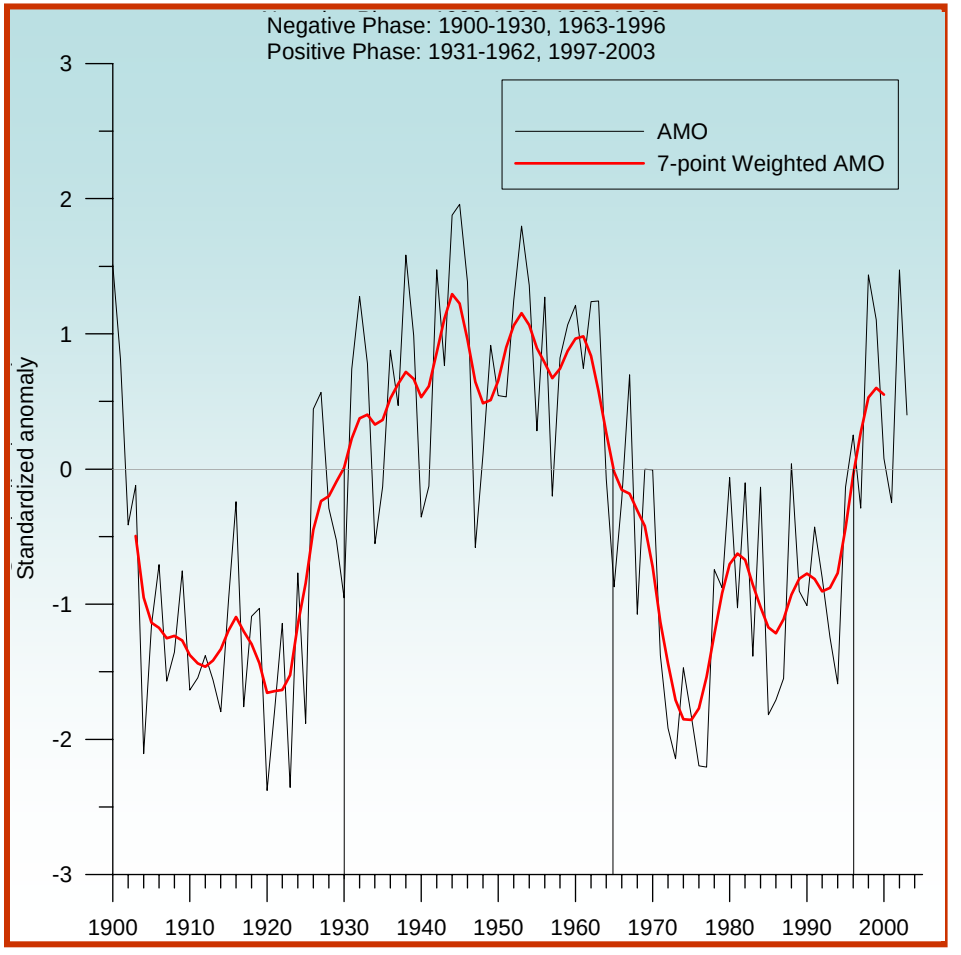


Atlantic Multidecadal Oscillation (AMO)

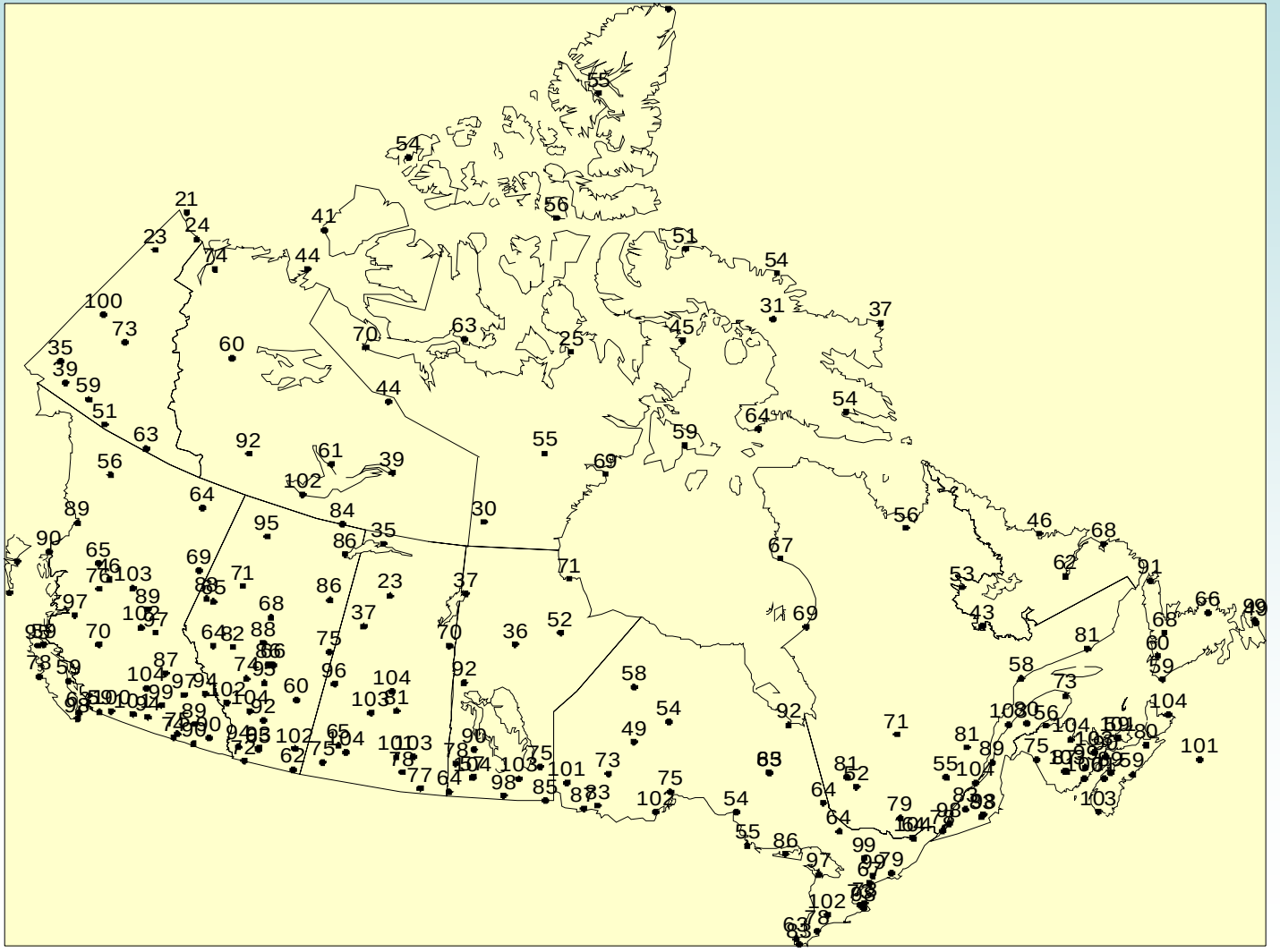
- Natural variability in the North Atlantic sea surface temperature anomaly with linear trend removed.
- It has 65-80 year cycle and has a range of 0.4ºC

Correlation between AMO and SST anomaly

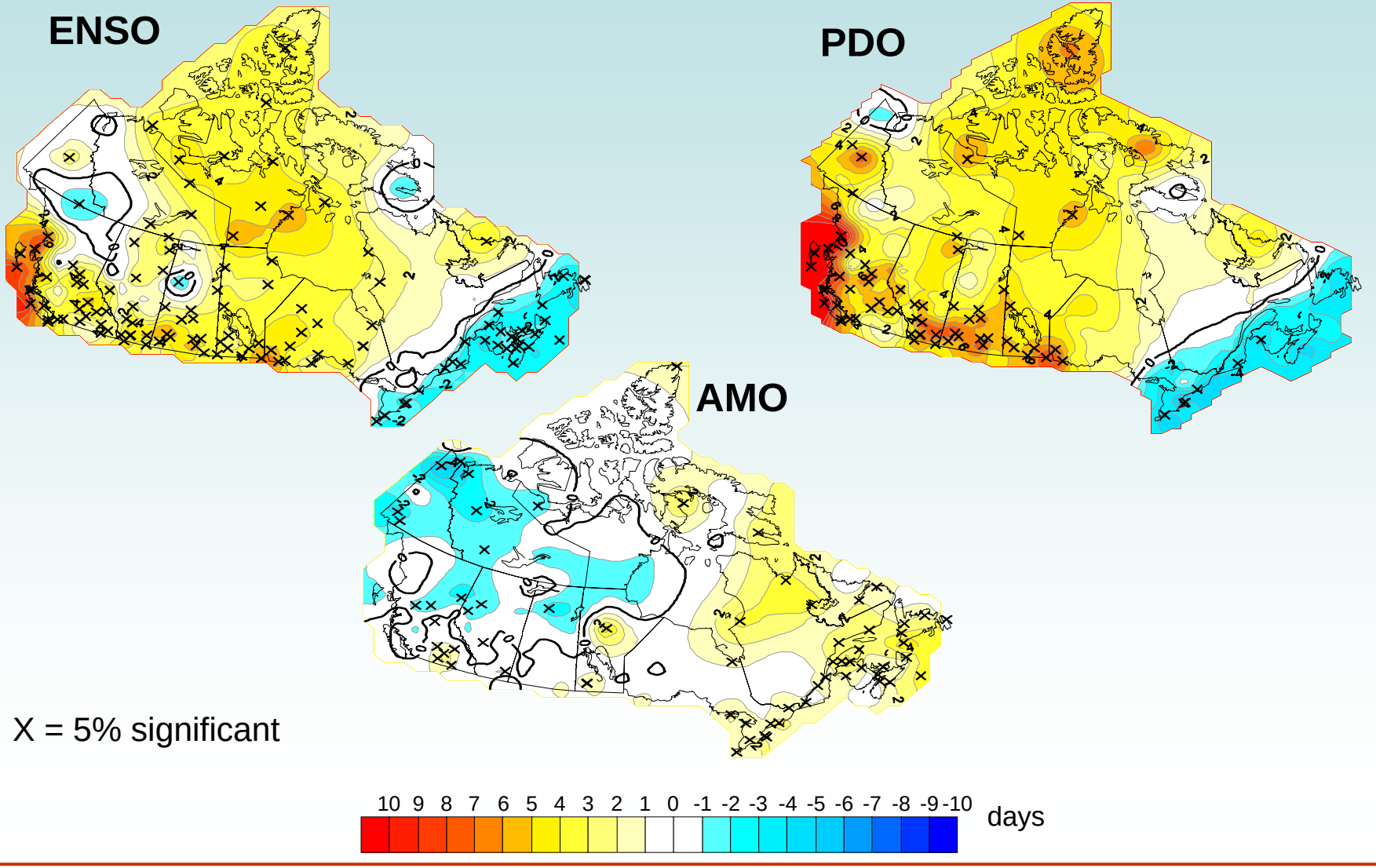




Number of Temperature Observation (years)

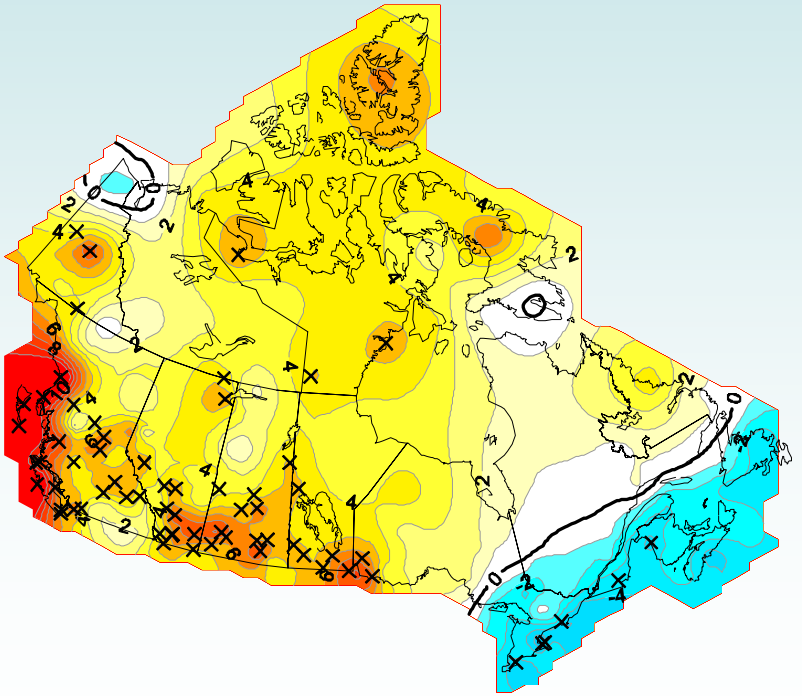


Composite Diffference: Number of Days with Tmax above 90th Percentile (Ndx90)

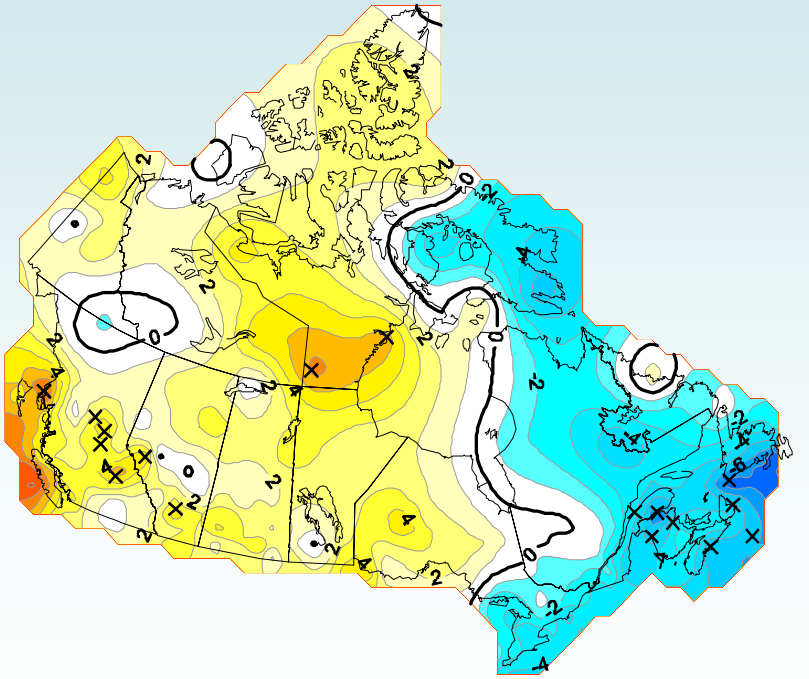


Interaction between Interannual and Interdecadal Oscillations (Ndx90)

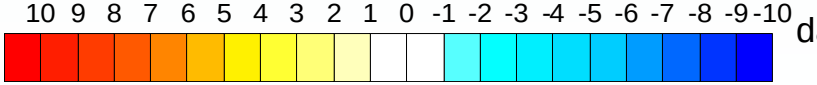
ENSO & PDO



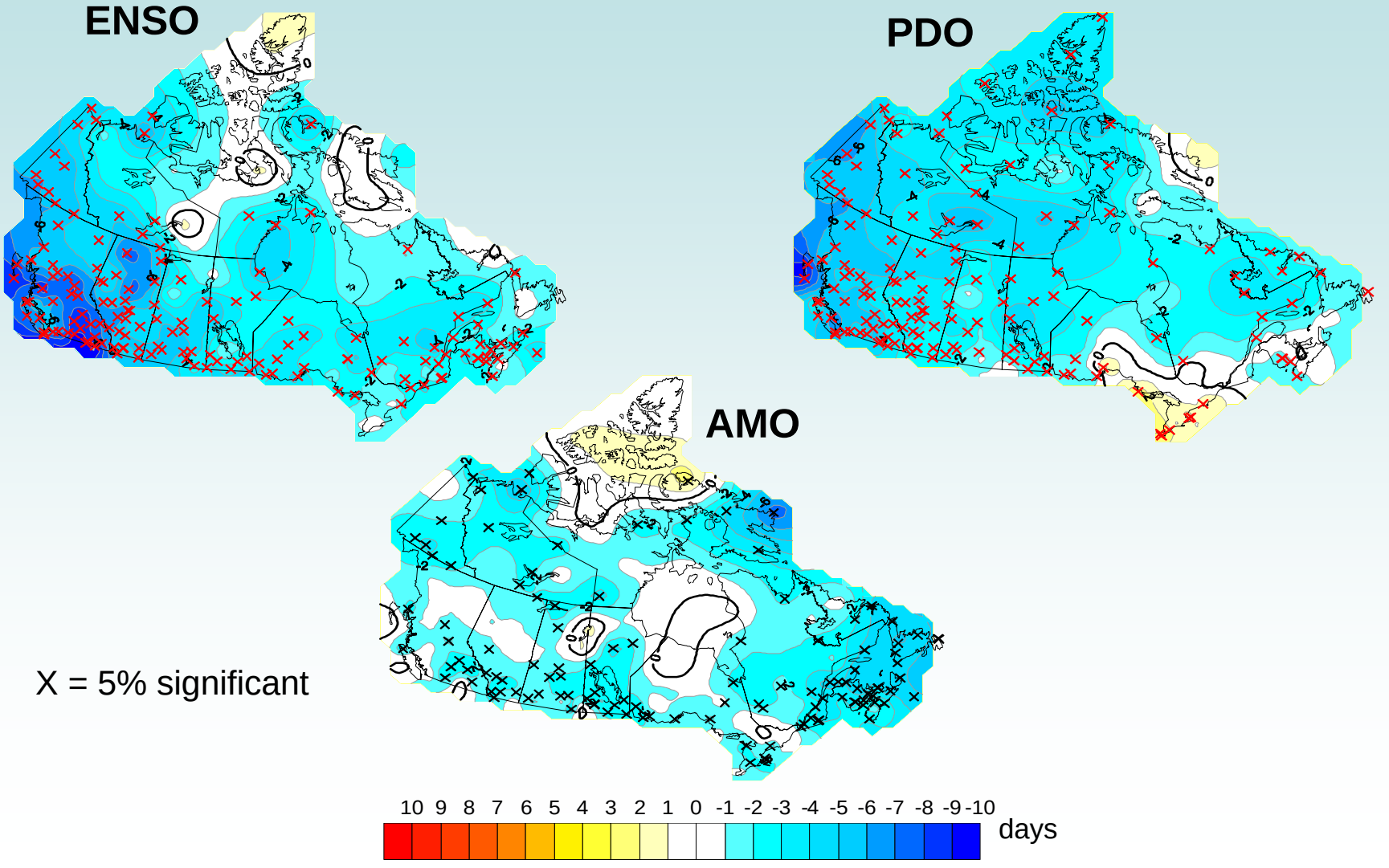
Pos ENSO & Neg AMO



X = 5% significant

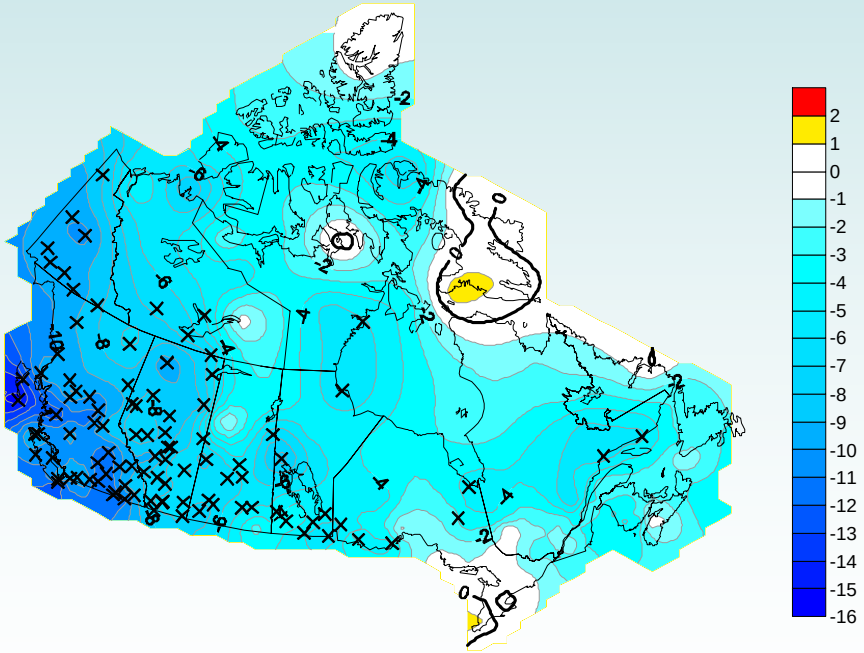


Composite Difference: Number of Days with Tmin below 10th Percentile (Ndn10)

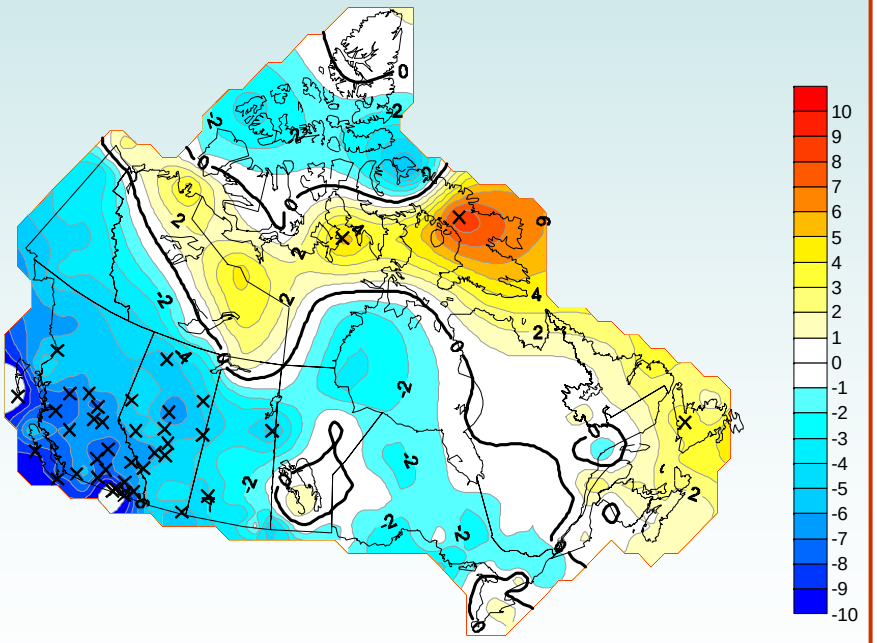


Composite Difference: Interaction between Interannual and Interdecadal Oscillations (Ndn10)

ENSO & PDO



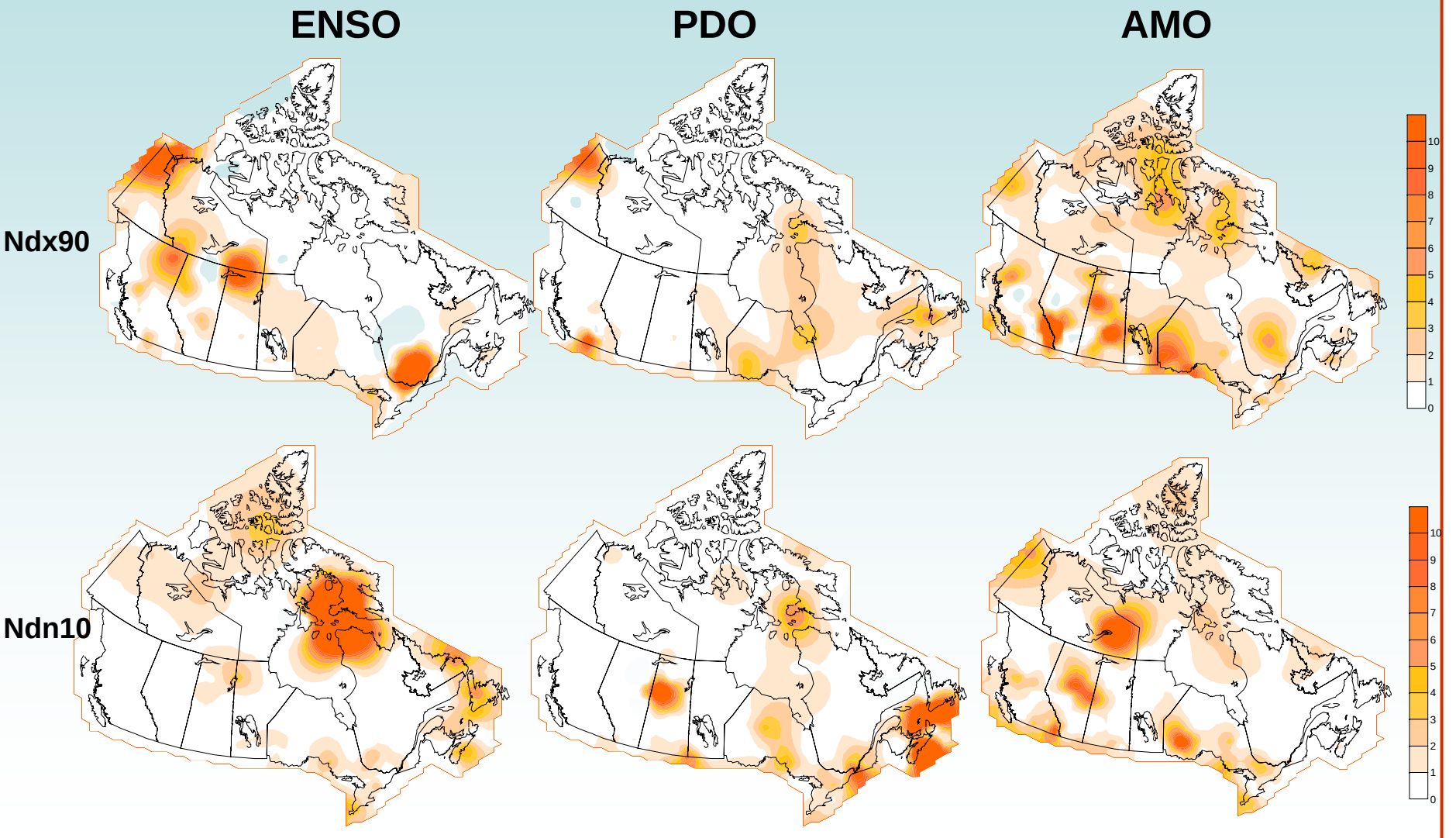
ENSO & Neg AMO



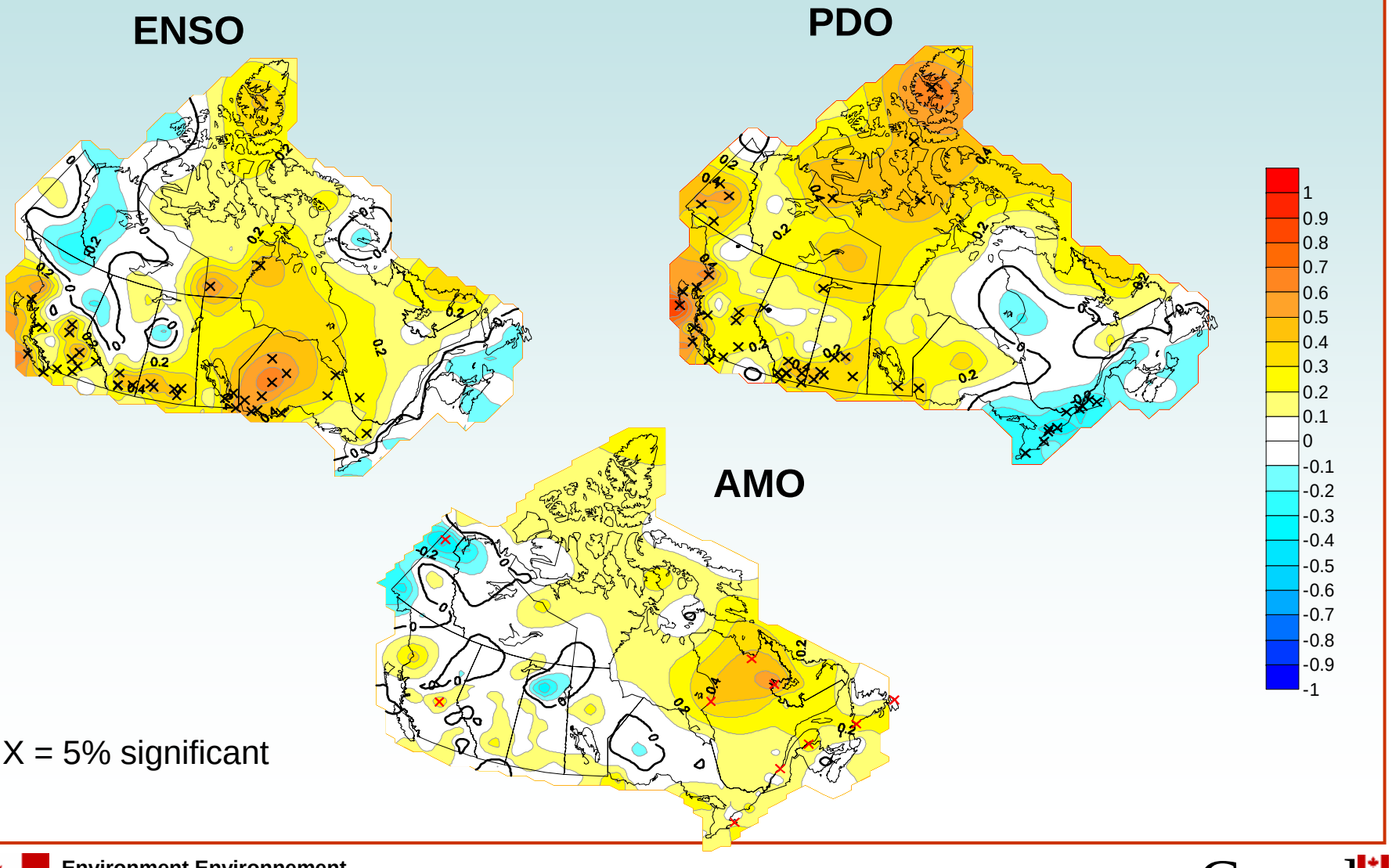
X = 5% significant

Nonlinearlity in Temperature Indices

Ratio(Sum$_{composite}$, Diff$_{composite}$)

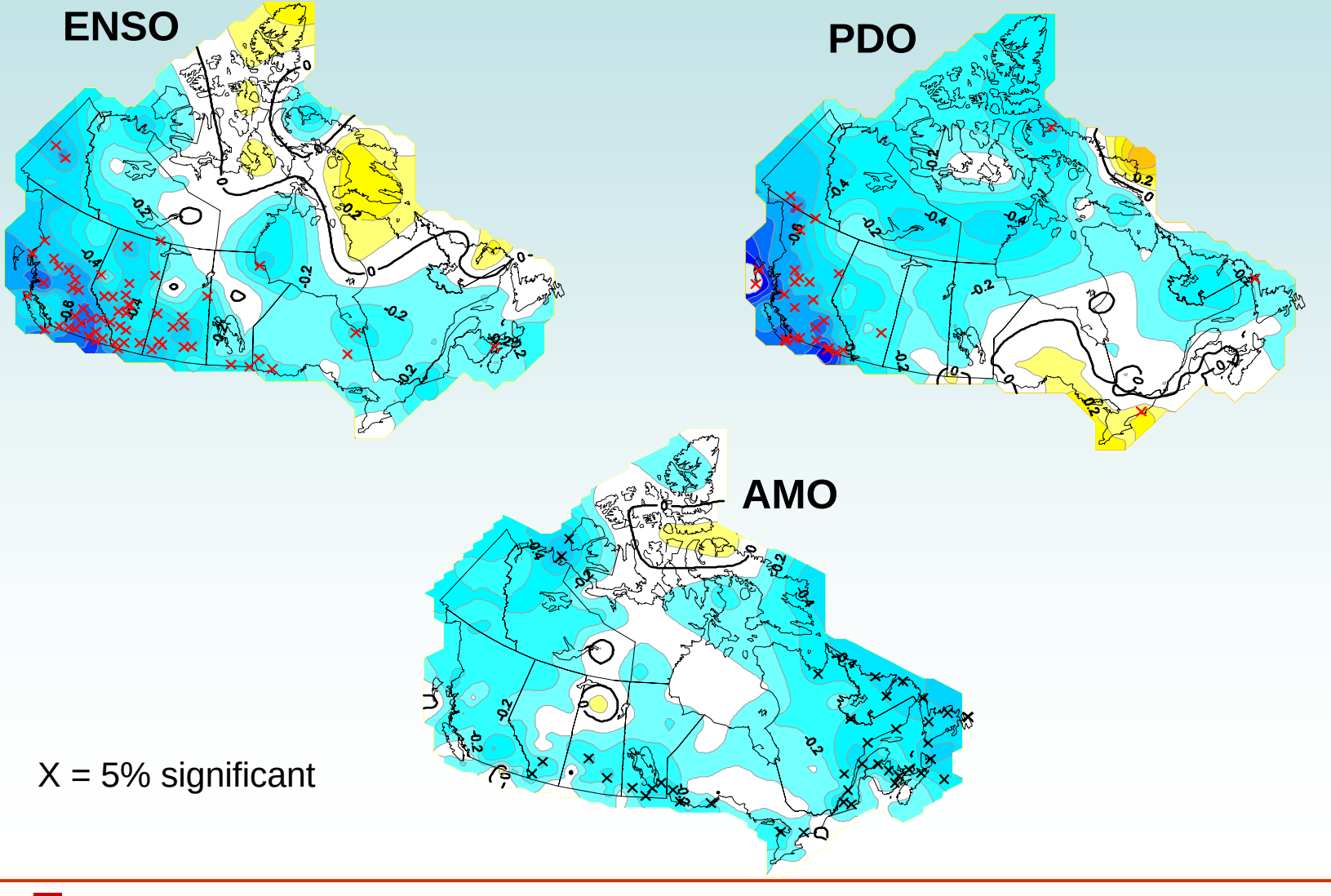


Regression: ENSO, PDO and AMO on Number of Heat waves (Hwfi)



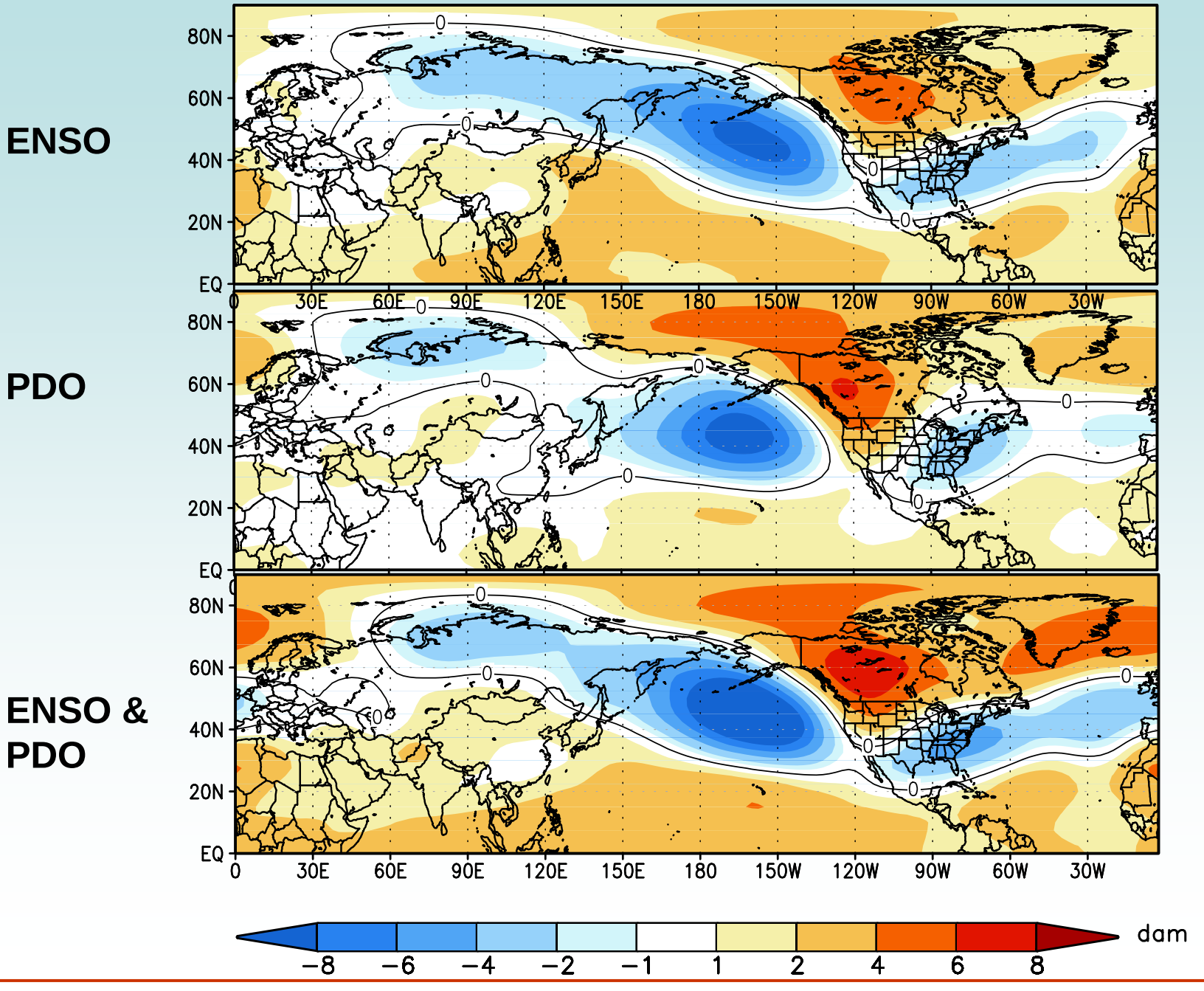
X = 5% significant

Regression: ENSO, PDO and AMO on Number of Cold waves (Cwfi)



X = 5% significant

Composite Difference 500 hPa Anomaly



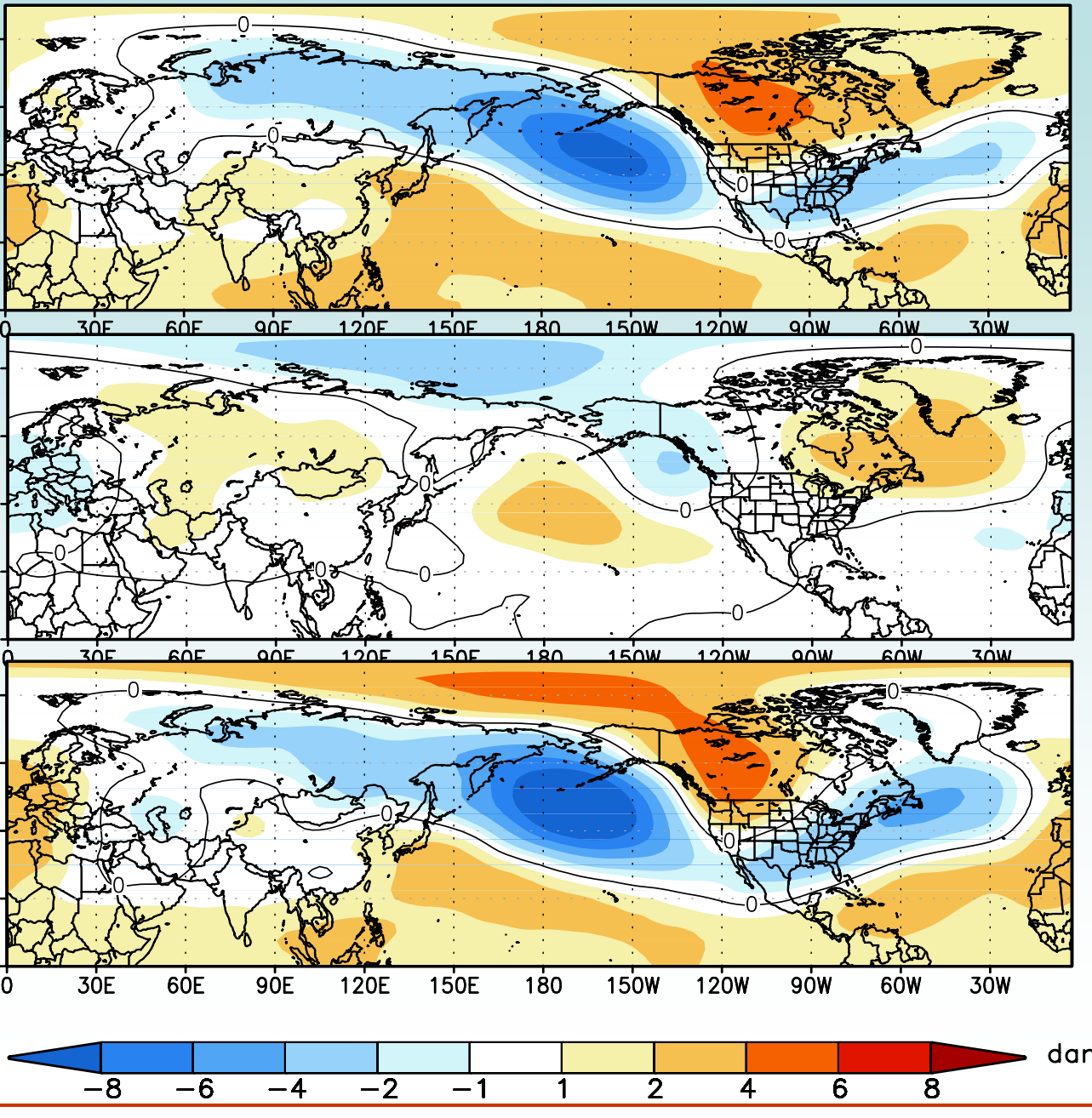
Composite Difference 500 hPa Anomaly

ENSO

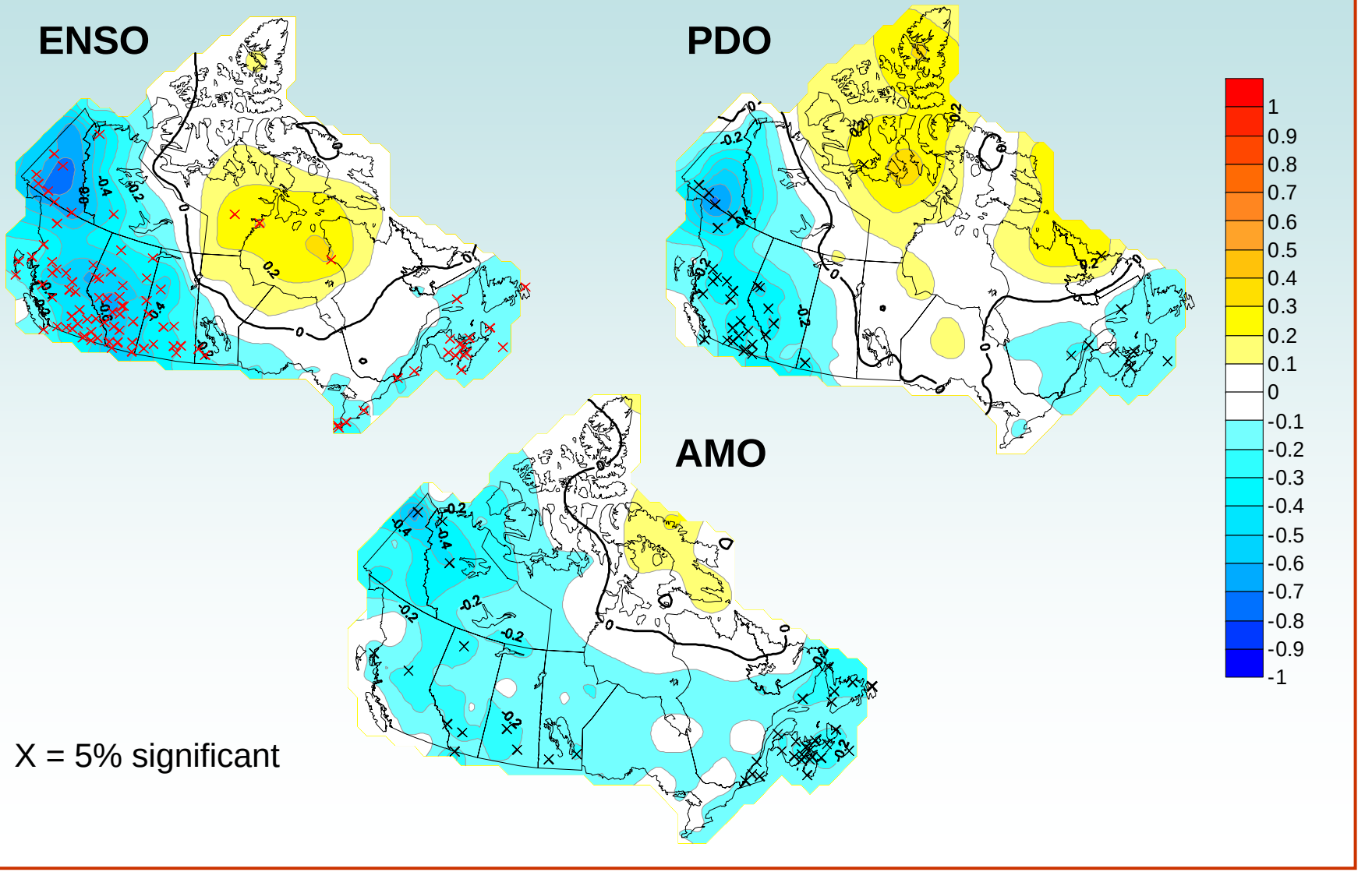
AMO

ENSO & AMO

(opp sign)



Regression: ENSO, PDO and AMO on Intraseasonal Variability



X = 5% significant

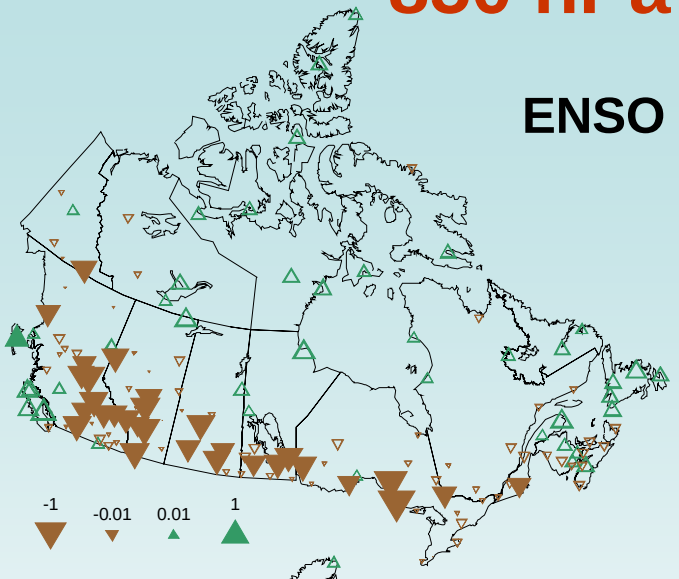
Standardized Precipitation Index (SPI)

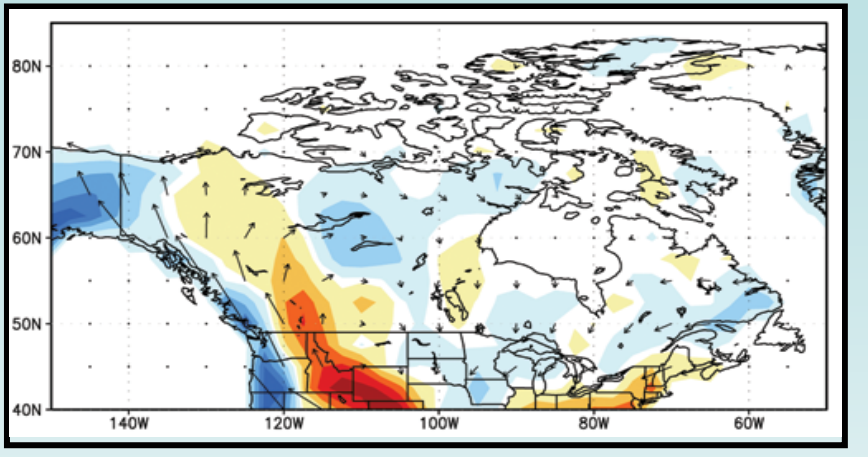
- SPI provides a single precipitation values which can be compared across regions with markedly different climates
- SPI is the standardized anomaly
- Precipitation is transformed so that it follows a normal distribution

SPI Value	Category
>=2.00	Extremely Wet
1.50 to 1.99	Severely Wet
1.00 to 1.49	Moderately Wet
-0.99 to 0.99	Near Normal
-1.00 to -1.49	Moderately Dry
-1.50 to -1.99	Severely Dry
<= -2.00	Extremely Dry

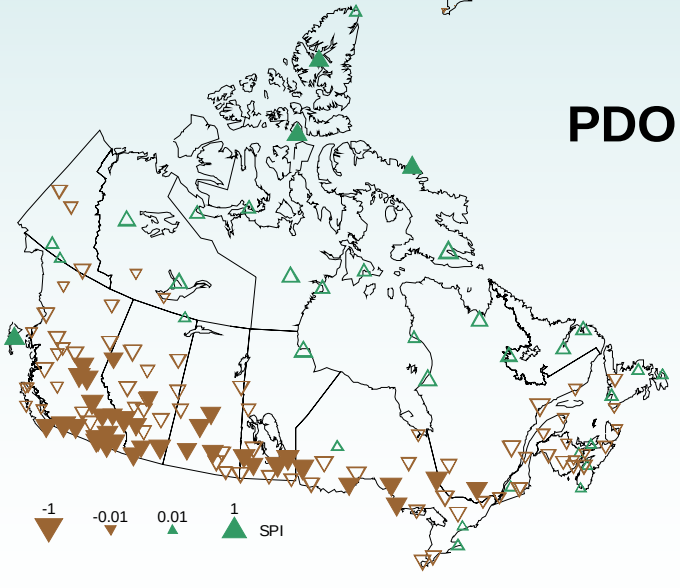
Composite Difference SPI and 850 hPa Moisture Flux

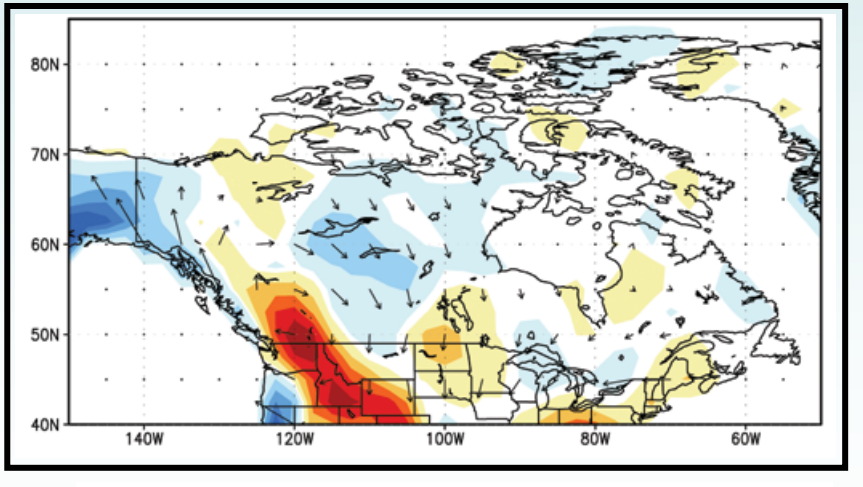
ENSO

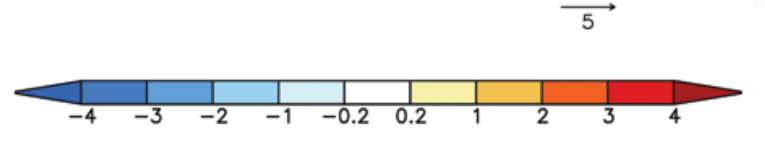




PDO





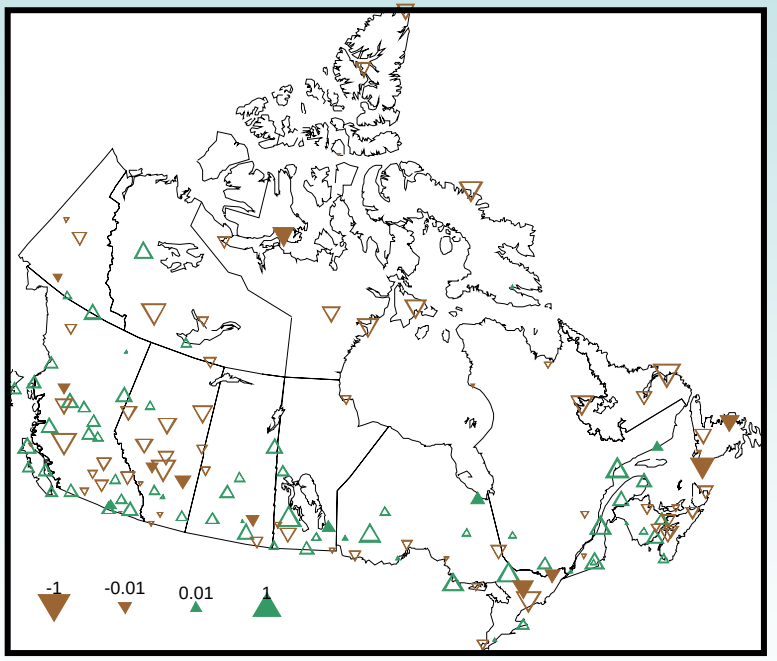


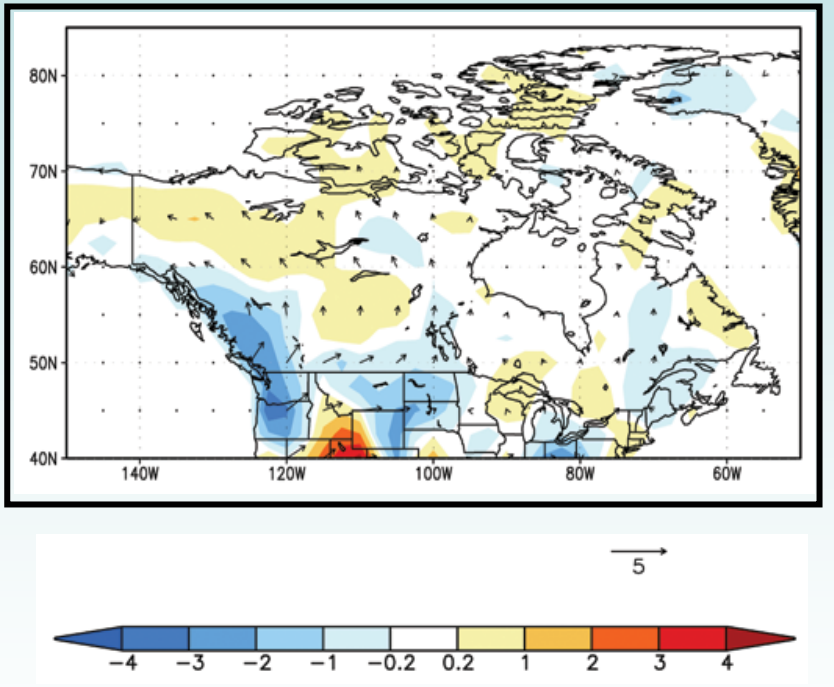
Solid Triangle: 5% significant

Flux: $gkg^{-1}ms^{-1}$, Div: 10^{-6}

Composite Difference SPI and Moisture Flux

AMO

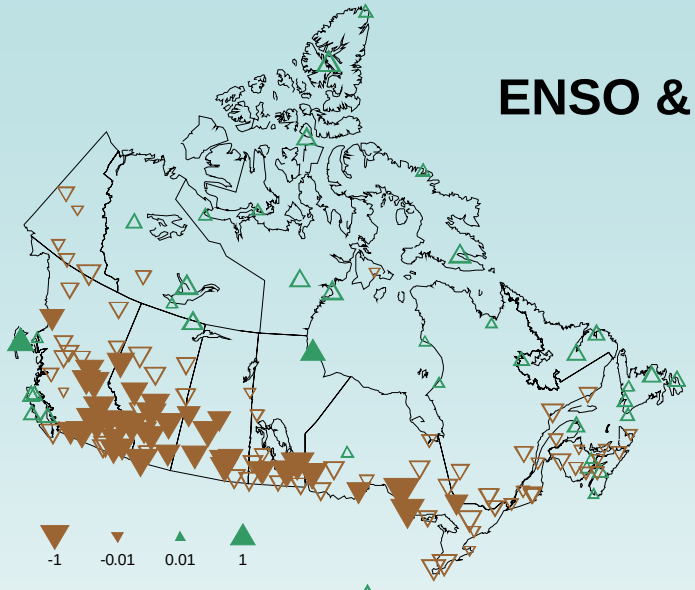




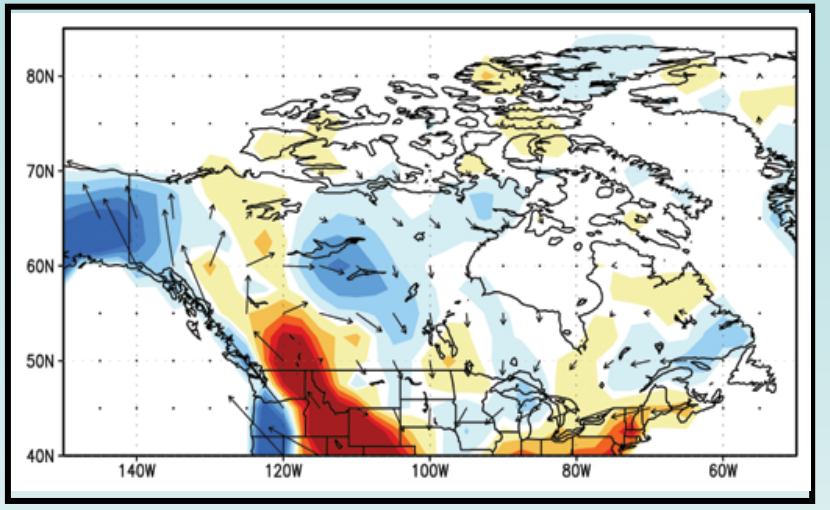
Solid Triangle: 5% significant

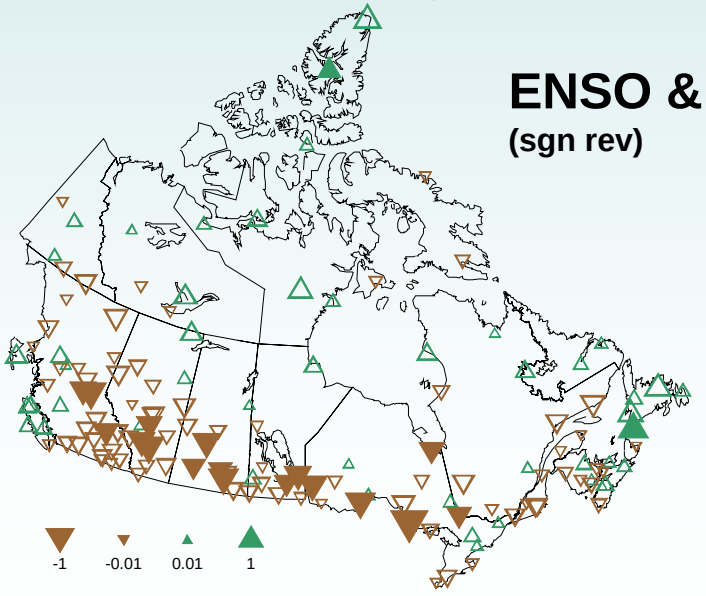
Flux: $gkg^{-1}ms^{-1}$, Div: 10^{-6}

Composite Difference SPI and Moisture Flux

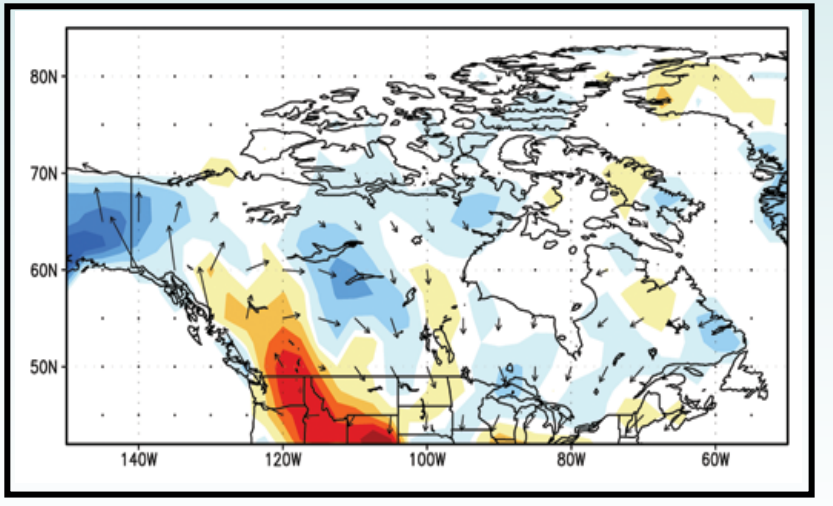


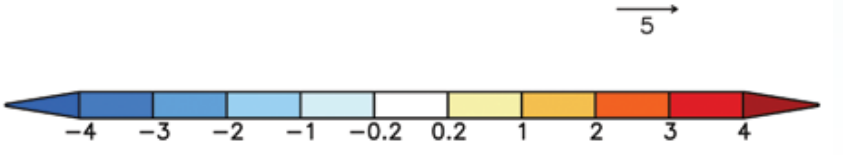
ENSO & PDO





ENSO & AMO
(sgn rev)





Solid Triangle: 5% significant

Flux: $gkg^{-1}ms^{-1}$, Div: 10^{-6}

Summary

- ENSO and PDO significantly increases number of warm days and frequency of heat waves across most of southern Canada. In phase relationship further enhances this effect
- Opposite relationship holds for cold days and frequency of cold waves
- Negative phase of AMO reinforces climate response over Atlantic Canada
- Intraseasonal variability is significantly reduced during ENSO, PDO and AMO
- There is significant nonlinearity during ENSO, PDO, but especially during AMO

Summary

- Mid-tropospheric circulation features support extreme temperature response
- SPI shows extreme dryness across most of southern Canada during the positive phase of ENSO, PDO and negative phase of AMO
- These findings are supported by low level moisture flux and divergence of moisture flux


Thank You