The Association between Canadian Climatic Extremes and Interannual and Interdecadal Oscillations

Amir Shabbar and Bin Yu
Climate Research Division
Environment Canada
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)
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 0.4°C

Correlation between AMO and SST anomaly

Environment Environnement
Canada Canada
Number of Temperature Observation (years)
Composite Difference: Number of Days with Tmax above 90th Percentile (Ndx90)

ENSO

PDO

AMO

X = 5% significant

10 9 8 7 6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6 -7 -8 -9 -10 days

Environment Environnement
Canada Canada
Interaction between Interannual and Interdecadal Oscillations (Ndx90)

ENSO & PDO

Pos ENSO & Neg AMO

X = 5% significant

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

- ENSO
- PDO
- AMO

X = 5% significant

10 9 8 7 6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6 -7 -8 -9 -10 days

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

ENSO & PDO

ENSO & Neg AMO

X = 5% significant
Nonlinearity in Temperature Indices
Ratio(\(\text{Sum}_{\text{composite}}, \text{Diff}_{\text{composite}}\))

ENSO
PDO
AMO

Ndx90
Ndn10

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

ENSO

PDO

AMO

X = 5% significant
Regression: ENSO, PDO and AMO on Number of Cold waves (Cwfi)

X = 5% significant
Composite Difference 500 hPa Anomaly

ENSO

AMO

ENSO & AMO (opps sign)
Regression: ENSO, PDO and AMO on Intraseasonal Variability

ENSO

PDO

AMO

X = 5% significant
The Standardized Precipitation Index (SPI) provides a single precipitation value that can be compared across regions with markedly different climates. SPI is the standardized anomaly, where precipitation is transformed so that it follows a normal distribution. The SPI value is categorized as follows:

<table>
<thead>
<tr>
<th>SPI Value</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;=2.00</td>
<td>Extremely Wet</td>
</tr>
<tr>
<td>1.50 to 1.99</td>
<td>Severely Wet</td>
</tr>
<tr>
<td>1.00 to 1.49</td>
<td>Moderately Wet</td>
</tr>
<tr>
<td>-0.99 to 0.99</td>
<td>Near Normal</td>
</tr>
<tr>
<td>-1.00 to -1.49</td>
<td>Moderately Dry</td>
</tr>
<tr>
<td>-1.50 to -1.99</td>
<td>Severely Dry</td>
</tr>
<tr>
<td>&lt;= -2.00</td>
<td>Extremely Dry</td>
</tr>
</tbody>
</table>
Composite Difference SPI and 850 hPa Moisture Flux

Solid Triangle: 5% significant

Flux: gkg$^{-1}$ms$^{-1}$, Div: 10$^{-6}$
Composite Difference SPI and Moisture Flux

Solid Triangle: 5% significant

AMO

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: \( \text{gkg}^{-1}\text{ms}^{-1} \), 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