The Divorce of the North Atlantic Ocean and Atmosphere Attributed to Human Affairs

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Introduction: the divorce

- The NAO and AMV are happily married until about 1950 ($r = -0.62$)
- After 1950, they split up ($r = 0.06$)
- We hypothesize that the divorce signifies a change in primary mechanisms for the AMV
Introduction: AMV potential mechanisms

• Potential mechanisms for multidecadal SST variability in the North Atlantic:
  1. Atmosphere (NAO)
  2. Ocean (AMOC)
  3. External forcing (aerosols, GHGs)

(Clement et al. 2015)
• Potential mechanisms for multidecadal SST variability in the North Atlantic:
  1. Atmosphere (NAO)
  2. Ocean (AMOC)
  3. External forcing (aerosols, GHGs)

(Delworth et al. 2017)
• Potential mechanisms for multidecadal SST variability in the North Atlantic:
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Introduction: AMV potential mechanisms

- Potential mechanisms for multidecadal SST variability in the North Atlantic:
  1. Atmosphere (NAO)
  2. Ocean (AMOC)
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(Klavans et al. 2022)
Methods: Simple SST model

• Force a simple linear model for SST with each of these three terms:

\[ \frac{dAMV}{dt} = -\alpha AMV - \beta_1 NAO + \beta_2 AMOC + \beta_3 Forcing + \beta_4 \varepsilon \]

• Damping coefficient and weights on forcings are determined by linear regression on the observed AMV tendency

• Integrate the model with those weights to get a predicted SST timeseries

• Compare with observations

• Test different combinations of forcing terms, different time periods
### Methods: Data and coefficients

- **Observational data**
  - **SST:** HadISST, ERSSTv5
  - **NAO:** station-based, EOF
  - **AMOC:** EN4 reconstruction (Fraiser and Cunningham 2021), Giese et al. 2016
  - **Forcing:** CMIP5 (Miller et al. 2014)

- **Note:** global forcing, all timeseries normalized

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<th>1865 - 2007</th>
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<tbody>
<tr>
<td></td>
<td>(a)</td>
</tr>
<tr>
<td>NAO</td>
<td>-0.06</td>
</tr>
<tr>
<td>AMOC</td>
<td>0.01</td>
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<tr>
<td>Forcing</td>
<td>-</td>
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<td>R² (T)</td>
<td>0.64</td>
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Results: AMV timeseries

(a) Internal-only model captures variability between 1900 - 1950 ($r^2 = 84\%$) but less from 1951 - 2007 ($r^2 = 28\%$)

(b) Including external forcing improves simulation of 1951 - 2007 period ($r^2 = 65\%$)

- Improve explained variance by training on different periods
Results: AMV timeseries

- (a) Internal-only model captures variability between 1900 - 1950 ($r^2 = 84\%$) but less from 1951 - 2007 ($r^2 = 28\%$)
- (b) Including external forcing improves simulation of 1951 - 2007 period ($r^2 = 67\%$)
- Improve explained variance by training on different periods

Observations          SST Model
Results: NAO-AMV lagged relationship
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Discussion

• Forcing a simple SST model with observations of the NAO and AMOC reasonably recovers observed SST between 1865 – 1950
• Including external forcing significantly improves the simulation between 1951 – 2007
• Suggests a change in dominant mechanism before/after ~1950
• This change in mechanism creates the appearance of a lagged relationship between the NAO and AMV, which was previously attributed to AMOC
• That isn’t to say AMOC is not important, but rather we should be cautious when using SST as a proxy for AMOC during periods of large changes in forcing