Linkages between Arctic Sea Ice Loss and Mid-Latitude Weather Patterns

Session #1 – Big Picture Context: The Role of Arctic Sea Ice Loss vs. Other Forcing Factors

Introduction to Discussion
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Purpose of this Session

• Brainstorm to identify linkages, current understanding, and urgent research questions.
• Initial draft of schematic and of table summarizing linkages discussed here.
• Big Picture questions beyond scope of our talks.
What effect does Arctic sea ice loss have on midlatitude weather and extremes?

- Arctic sea ice loss is in a sense the *middle* of a story that really begins with Arctic change forced by greenhouse warming.
- So it makes sense to consider the bigger picture and how sea ice loss figures into it.
θ = 273K (September)
θ = 273K (March)

Stratospheric Polar Vortex
Tropopause

Polar Cap

Midlatitude Weather and Extremes

Arctic GHGs, Aerosols, Clouds

Poleward Eddy Transport
Equatorward Eddy Transport

Arctic PBL / Inversion

Snow

Arctic Sea Ice

Arctic Ocean

Ocean Stratification and Circulation

Modes of Variability

Wave amplitude and blocking events

North Pole

Arc0c

Sea Ice

Arc0c

Ocean

Tropopause

Arc0c

Ocean
What dynamical effect does Arctic change have on the midlatitudes?

What does this question mean?

• How does the midlatitude circulation react to realistic changes to the Arctic in the absence of other changes?

This suggests different pathways for Arctic influence.
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2. Changes at other boundaries (surface, tropopause, composition of atmospheric column).
North Pole

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Arctic PBL / Inversion

Arctic Sea
Ice

Snow

Modes of Variability

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Ocean Stratification and Circulation

Oceanic

Convection

Atmospheric

Convection

Oceans

Continents

Sea Ice

Snow

Arctic

Greenhouse

Gases

Aerosols

Clouds

Waves

Amplitude and
Blocking Events

Midlatitude

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This suggests different pathways for Arctic influence...
A change in Arctic boundary conditions (from the surface, composition, stratosphere) changes the midlatitude circulation/weather/extremes.
2. Fast Arctic Influence through Feedbacks

Change from midlatitude boundaries influences the Arctic via Polar Cap. The change feeds back to midlatitudes.
3. Fast Linkages through Modes of Variability

Arctic or midlatitude perturbations lead to responses that project onto Modes of Variability (AO/NAO/NAM) that thereby affect Arctic and midlatitudes almost simultaneously or with short lags.

This makes interpretation challenging, e.g. for stratospheric influence. Removing the part that projects onto modes can sometimes reveal the original forcing (Thompson & Wallace 2000, Kushner et al. 2001, Deser et al. 2004).
4. Slow Arctic Influence through Ocean

Arctic change influences midlatitude surface through changes in ocean stratification & circulation.
Some outcomes to aim for …

• Work on schematic and summary table of linkages (e.g. shown below).
  
  a. Define linkages carefully (season, timescale, ...).
  b. Assess confidence in and strength of linkages.
     – **ACID**: Attributable, Corroborated, Informed, Detected
     – Estimate $\partial M/\partial A$ where $M$ is midlatitude quantity (e.g. wave amplitude) and $A$ is Arctic quantity (e.g. sea ice).
  c. Identify critical research gaps (obs, model ...).
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£outines

Midlatitude Weather and Extremes

Equatorward Eddy Transport

£ = 300-310K

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Ocean Stratification and Circulation

Poleward Eddy Transport

Arctic Ocean

How can we improve this schematic?
Proposed Summary Table

<table>
<thead>
<tr>
<th>a. Linkage and Description:</th>
<th>b. Current Understanding:</th>
<th>c. Research Gaps:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Timescale (intraseasonal, decadal, ...)</td>
<td>• Basis of evidence (theory, obs, models)</td>
<td>• Observational capacity</td>
</tr>
<tr>
<td>• Season (JFM, SON, ...)</td>
<td>• Related linkages, and separability from these linkages</td>
<td>• New observational analysis</td>
</tr>
<tr>
<td>• Proposed role of Arctic (direct, through feedbacks, through modes)</td>
<td>• Level of confidence (ACID)</td>
<td>• Modeling capacity</td>
</tr>
<tr>
<td>• Motivation to study (fundamental, forecasting, socioeconomic, ecological)</td>
<td>• Quantification (e.g. sensitivity factors $\partial M/\partial A$)</td>
<td>• New model experiments and diagnostics</td>
</tr>
</tbody>
</table>

• Rubric with some suggestions on factors to consider. A draft only — please suggest changes.

• The next slide shows an example of how the table might be used.
If you’re interested, you can work on the table by downloading it at http://bit.ly/19B1hRH