A Preliminary Look at Arctic Feedbacks

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Why look at the Arctic?

- No comprehensive studies on arctic feedbacks.
  - Most focus on ice/snow feedbacks and their contribution to global $\Delta T_s$ (e.g., Winton 2006).
  - Others focus on just a single model - primarily NCAR CCSM (e.g., Kay et al. 2012).

- Arctic feedbacks are not important globally, but are locally.
  - Arctic feedbacks are not important for global climate sensitivity (only ~2% of surface area)
  - Do have large impact locally with important ecological and socioeconomic implications.

- Region of very rapid changes in climate which have strong local feedbacks.
  - Possible to observed feedback processes within a single CLARREO mission?

- Good sampling from polar orbiting satellites
Surface Albedo Feedback
Arctic feedbacks very different than global feedbacks.
A decadal trend from CLARREO is as reliable as ~30 years of AIRS data.
What can you see from a single decade from AIRS?

- **Freeze Onset** (winter freezing delayed by ~1 month)
- **Surface Air Temperature** (air warming by ~5 K)
- **Water Vapor** (humidity increase by ~50%)
- **Cloud Cover** (clouds increase by ~50%)

Stroeve et al. (2015)
What can you see from a single decade from AIRS?

Stroeve et al. (2015)

Skin Temp  Cloud Cover  Water Vapor  Air Temp  Freeze Onset

(a) Skin Temp: 
(b) Cloud Cover: 
(c) Water Vapor: 
(d) Air Temp: 
(e) Freeze Onset:

Legend:

<table>
<thead>
<tr>
<th>a, b, c</th>
<th>d</th>
<th>e</th>
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<tbody>
<tr>
<td>-0.4</td>
<td>-0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>-6</td>
<td>-4</td>
<td>-2</td>
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<tr>
<td>-0.2</td>
<td>-0.1</td>
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-0.4 to 0.4 range for Skin Temp and Cloud Cover.
-6 to 6 range for Water Vapor.
-0.2 to 0.2 range for Air Temp.
-6 to 6 range for Freeze Onset.
Next Steps

- Estimate feedback strengths from observed changes over satellite record
- Compare across observational data sets (AIRS, CERES, reanalyses, etc.)
- Compare to CMIP5 models
- Examine coupling to meridional energy transports
- Aerosol-cloud interactions significantly alter the cloud feedback.
- These are potentially “fast” cloud changes detectable by CLARREO.
Aerosol-mediated Cloud Response

All 3 show non-local aerosol-induced cloud changes
Aerosol-mediated Circulation Response

Historical “Truth”
Aerosol-mediated Circulation Response ($\omega_{500}$)

- Aerosol radiative interactions force changes in energy transport which drive remote changes in clouds through changes in vertical velocity ...
- These cloud changes occur on the same timescale as aerosol forcing.