Arctic Synoptic Regimes: Comparing domain wide Arctic cloud observations with CAM4 and CAM5 during similar dynamics

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Motivation

Arctic Average Comparisons

Bridging the gap: Analyze GCM Arctic cloud production over a large domain with a knowledge of the dynamics.
Data and Models

• Analysis and Model Initialization Data
  – ECMWF Year of Tropical Convection (YOTC) Analysis; ERA-YOTC
  – April 2008 to February 2010
  – Interpolated to 3 hour temporal resolution (original 6)
  – Interpolated to 1.25° Longitude by 0.94° Latitude

• Cloud Data
  – GCM Oriented CALIPSO Cloud Product
  – Cloud fractions calculated along-track at 3-hour temporal resolution
  – About 2 passes every 3 hours

• CAM4 and CAM5 run in *forecast* mode
  – Initialized from the ERA-YOTC analysis, Reynolds SSTs, and NCEP sea-ice
  – CALIPSO cloud simulator
  – Day 2 output analyzed
Synoptic Regimes: A $K$-means clustering approach

Input Variables:

$\theta_{700} - \theta_{\text{LML}}$

$\omega_{500}$

- Largely followed Rossow et al. 2005 to determine number of clusters
HS = High Stability Regime; S = Stable Regime; VHS = Very-High Stability Regime; UL = Uplift Regime

Frequency of Occurrence: HS = 36%, S = 29%, VHS = 24%, UL = 11%

- Assigned GCM clusters by determining the minimum Euclidean distance between the ERA-YOTC cluster centroids and the $\theta_{700} - \theta_{LML}$ and $\omega_{500}$ in the GCMs
HS = High Stability Regime; S = Stable Regime; VHS = Very-High Stability Regime; UL = Uplift Regime
CALIPSO simulator

CALIPSO

CAM4

CAM5

HS = High Stability Regime; S = Stable Regime; VHS = Very-High Stability Regime; UL = Uplift Regime
HS = High Stability Regime; S = Stable Regime; VHS = Very-High Stability Regime; UL = Uplift Regime
# LWPs

<table>
<thead>
<tr>
<th>Eureka, Canada</th>
<th>Observations (g m⁻²)</th>
<th>CAM4 (g m⁻²)</th>
<th>CAM5 (g m⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS</td>
<td>16.4</td>
<td>69.4</td>
<td>15.5</td>
</tr>
<tr>
<td>S</td>
<td>30.8</td>
<td>200.5</td>
<td>21.7</td>
</tr>
<tr>
<td>VHS</td>
<td>6.4</td>
<td>22.1</td>
<td>0.0</td>
</tr>
<tr>
<td>UL</td>
<td>64.9</td>
<td>220.2</td>
<td>6.1</td>
</tr>
</tbody>
</table>

HS = High Stability Regime; S = Stable Regime; VHS = Very-High Stability Regime; UL = Uplift Regime

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Is the Cloud Response to Changes in Sea Ice dependent on the Thermodynamics and Dynamics?
Conclusions

• **K-means clustering** technique successfully separated *distinct Arctic synoptic regimes*.

• **CAM4 and CAM5 lower tropospheric stabilities** were *larger* than ERA-YOTC in the day 2 forecast.

• *Cloud response* to the removal of *sea ice* is *dependent* on the overlying *thermodynamics*.

• The *improved* boundary layer turbulence and cloud microphysics scheme in *CAM5* resulted a better *boundary layer cloud* compared to CAM4.
Thank You/Questions?

Recently submitted to JGR