Overview

• Background and motivation
• Data
• Climatology of mid-to-high latitude winter MILs in SABER, MLS, and WACCM
• Roles of planetary waves in the formation of MILs
Mesospheric Inversion Layers (MILs) Diagnostics

Definitions:

**MIL Altitude** – altitude of upper large triangle at MIL top

**MIL Temperature** – Temperature of upper large triangle at MIL top

**Thickness** – vertical distance between large triangles (MIL top minus MIL base, km)

**Amplitude** – temperature difference between large triangles (MIL top minus MIL base, K)

_Gan et al. [2012]_
MILs affects atmospheric stability

- Stability
  - Enhanced stability between large triangles
  - Enhanced turbulence and gravity wave breaking above MIL
- Energy Transfer

Gan et al. [2012]
High latitude MILs atop anticyclones in WACCM

MIL location occurs preferentially above the positive geopotential anomalies.

Sassi et al. [2002]
Goals of this Work

• What is the climatological geographical distribution of MILs in the context of the polar winter vortex and anticyclones?
• What is the role of planetary waves in generating climatological mid-latitude winter MILs as discussed by Salby et al. [2001] and Sassi et al. [2002]?
• How well does WACCM reproduce the observed geographical distribution of MILs?
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### MLS and SABER

<table>
<thead>
<tr>
<th></th>
<th>Temperature Retrieval</th>
<th>Vertical Resolution</th>
<th>Profiles per Day</th>
<th>Date Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MLS (v3)</strong></td>
<td>O₂ emissions at 118 GHz and 190 GHz</td>
<td>6 km</td>
<td>~3500</td>
<td>Aug 2004 - present</td>
</tr>
<tr>
<td><strong>SABER (v2)</strong></td>
<td>from 15 µm and 4.3 µm bands of CO₂</td>
<td>3 km</td>
<td>~2200</td>
<td>Jan 2002 - present</td>
</tr>
</tbody>
</table>

SABER has better vertical resolution but limited coverage.
• Community Earth System Model 1.0.3 WACCM4

• 40-year free running simulation, year 2000 time slice

• Finite-volume dynamical core [Lin, 2004]

• Non-orographic gravity wave parameterization for deep convection and frontal systems [Richter et al., 2010]

• 1.9° latitude by 2.5° longitude

• 3.5 km vertical resolution above 65 km [Garcia et al., 2007]
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WACCM MIL statistics are in good agreement with MLS and SABER.
• Max MIL frequencies above the Aleutian High

• Few MILs above the vortex
Southern Hemisphere MILs: zonal asymmetries

• Early winter MILs confined to lower latitudes in the data.
• Why are MIL frequencies so high in WACCM?

-> Differences in PWs.
MILs + Planetary wave amplitudes

MILs occur when PWs are large
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We can express the lapse rate in terms of the geopotential:

\[ \Gamma = -\frac{\partial T'}{\partial z} \]

\[ \frac{\partial \Phi}{\partial z} = \frac{RT'}{H} \]

\[ \Gamma = -\frac{H}{R} \frac{\partial^2 \Phi'}{\partial z^2} \]

Breaking the lapse rate into a zonal mean and wave component:

\[ \Gamma = \bar{\Gamma} + \Gamma' \]

\[ \Gamma' = -\frac{H}{R} \frac{\partial^2 \Phi'}{\partial z^2} \]

From Salby et al. [2001]
Positive curvature is well correlated with MIL formation.

In both MLS and WACCM, MILs occur in regions of large curvature.
Conclusions

• MILs are driven by the decay of vertically propagating planetary waves in the mesospheric surf zone
• MILs occur climatologically atop the stratospheric anticyclones
• MILs in WACCM occur in the same geographical regions as in observations, though it generally overestimates PW amplitudes and MIL frequencies
Thanks!