An analysis of SSW & elevated stratopauses generated in WACCM

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Multiple WACCM 3.5 simulations have been analyzed for SSW events (Two 50 year and one 150 year runs).

Arctic winters have been classified into 4 basic types:

- Quiet (undisturbed) winters
- Minor SSW winters - Poleward temperature gradient becomes positive but zonal mean wind at 10 hPa remains eastward.
- Major SSW winters - Poleward temperature gradient becomes positive with reversal in zonal mean wind at 10 hPa.
- Major SSW with elevated stratopause winters
1992-1993 NH winter
Major Warming

1994-1995 NH winter
Minor Warming

1996-1997 NH winter
Quiet year

1997-1998 NH winter
Elevated Stratopause

Zonal mean wind at 55-70 N
Elevated stratopause in WACCM

Chandran et al. GRL, 2011
Elevated stratopause in WACCM

WAWG meeting, Boulder, 02/17/2011
Elevated stratopause in WACCM
Elevated stratopause in WACCM
Major SSW winter

Geopotential Height at 10 HPa (km)


Major SSW & elevated stratopause winter


Vortex displacement event

Vortex Splitting event

Major SSW & elevated stratopause winter


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Quiet winter

Major SSW winter

Major SSW & elevated stratopause winter

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**Climatology of SSW in WACCM**

**Reff 1.1 climatology - 1953-2003**

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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Quiet Year</td>
<td>(0)</td>
<td>67-68, (1)</td>
<td>(0)</td>
<td>88-89 (1)</td>
<td>96-97 (1)</td>
<td>3</td>
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<tr>
<td>Minor SSW</td>
<td>58-59,59-60,60-61 (3)</td>
<td>68-69,70-71,71-72, (3)</td>
<td>(0)</td>
<td>83-84,85-86,87-88 (3)</td>
<td>94-95,00-01,01-02 (3)</td>
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<tr>
<td>Major SSW</td>
<td>54-55,55-56,56-57,57-58,61-62,62-63 (6)</td>
<td>64-65,66-67,72-73 (3)</td>
<td>75-76,76-77,77-78,80-81,81-82,82-83 (6)</td>
<td>86-87,89-90,90-91,91-92,92-93 (5)</td>
<td>93-94,99-00 (2)</td>
<td>22</td>
</tr>
<tr>
<td>Major SSW with elevated stratopause</td>
<td>53-54 (1)</td>
<td>63-64,65-66,69-70, (3)</td>
<td>73-74,74-75,78-79,79-80 (4)</td>
<td>84-85 (1)</td>
<td>95-96,97-98,98-99,02-03 (4)</td>
<td>13</td>
</tr>
</tbody>
</table>

Occurrence frequency of:
(1) quiet year - 0.06
(2) Minor SSW winter – 0.24
(3) Major SSW – 0.44
(4) Elevated stratopause – 0.26
Climatology of SSW in WACCM

<table>
<thead>
<tr>
<th>Type of SSW</th>
<th>Realization</th>
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<tbody>
<tr>
<td></td>
<td>Refb 1.1 (1953-06)</td>
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<tr>
<td>Quiet Year</td>
<td>0.06</td>
</tr>
<tr>
<td>Minor SSW</td>
<td>0.24</td>
</tr>
<tr>
<td>Major SSW</td>
<td>0.44</td>
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<tr>
<td>Major SSW with elevated stratopause</td>
<td>0.26</td>
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<tr>
<td>Quiet or minor SSW winter</td>
<td>0.30</td>
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<tr>
<td>Major SSW &amp; elevated stratopause winter</td>
<td>0.70</td>
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</tbody>
</table>

Charlton & Polvani 2007 analyzed the NCEP-NCAR and 40-yr ECMWF Re-Analysis (ERA-40) datasets and identified SSWs based on the zonal mean zonal wind at 60°N and 10 hPa, and classified them into events that do and do not split the stratospheric polar vortex.
Longitudinal Variability

Geopt Ht 10 hPa

MY 1968-69

T

January 13, 1969

WAWG meeting, Boulder, 02/17/2011
Summary & Conclusions

• WACCM with the new GW parameterization produces SSW at a realistic occurrence frequency (w.r.t. observations).

• WACCM produces elevated stratopauses with characteristics similar to recently recorded events in the Arctic.

• WACCM produces both vortex displacement and vortex splitting events.

• Some of the vortex splitting events are associated with the formation of an elevated stratopause.

• During a vortex displacement event, there are vast longitudinal variability in the temperature structure and different ground based locations might observe vastly different winters.

• This study shows that during undisturbed winters the dominant GWF is westward in the mesosphere between 40-65 N. However, during an SSW event, the dominant GWF becomes eastward poleward of 60 N
The End !! Thank you !!
Summary & Conclusions - II

- The triggering mechanism for SSW events were strong persistent westward planetary wave forcing in the stratosphere which results in a reversal of the eastward stratospheric jet.
- This reversal of the stratospheric jet then results in a change in GWF from westward to eastward in the mesosphere driven by non-orographic waves as the orographic gravity waves are filtered out at the zero wind line.
- The residual circulation shows strong down-welling in the stratosphere leading to adiabatic warming and upwelling in the upper stratosphere and mesosphere leading to adiabatic cooling of the mesopause region during the SSW event.
- The net forcing in the upper mesosphere becomes eastward due to the eastward GWs which reverses the westward jet and helps in the formation of the elevated stratopause.
- After the formation of the elevated stratopause, the eastward stratospheric jet, meridional circulation and GWF are all much more robust than before the onset of the SSW.