Ozone Recovery in a Changing Climate

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NOAA Climate Attribution

• **PSD Climate Attribution Group**
  – Key player in emerging NOAA Climate Service
  – Lead of NOAA’s attribution activities

• **Climate Attribution**
  – establishing the principal causes or physical explanation for observed climate conditions

• **Why is NOAA involved?**
  – Increasing public interest in climate information
  – Policy makers don’t just want to know what happened, but *why it happened*.... the answer to the latter influences decisions.
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“The cat did it.”

“The ozone hole did it”
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Conditions in the atmosphere will be different in the future from those observed during periods before ozone depletion.

- When is the ozone layer expected to recover?
- What is the impact of the Antarctic ozone hole recovery on Southern Hemisphere circulation?
When is the ozone layer expected to recover?

Equivalent Effective Stratospheric Chlorine

<table>
<thead>
<tr>
<th>Region</th>
<th>EESC</th>
<th>Ozone</th>
</tr>
</thead>
<tbody>
<tr>
<td>60°N-60°S</td>
<td>2035-2050</td>
<td>2025-2035</td>
</tr>
<tr>
<td>Antarctica</td>
<td>2060-2080</td>
<td>2035-2095</td>
</tr>
</tbody>
</table>

UNEP/WMO (2007)
Potential Factors that will influence 21st century ozone layer recovery

• Stratospheric cooling
  – accelerates ozone recovery in upper stratosphere
  – delays ozone recovery in polar stratosphere

• Water vapor changes
  – increase would delay recovery

• Volcanic Aerosol
  – temporarily reduce global ozone amounts under high-chlorine conditions
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SAM - The Southern Hemisphere Annular Mode  
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Observed Changes in SAM

Seasonal cycle of 3-month overlapping Changes in SAM index (1969-1999)

500hPa Heights 1979-1999 Dec-May

Thompson and Solomon (2002)
Attribution of SAM Changes to Ozone Depletion (Thompson and Solomon, 2002)

Changes in polar cap temperature and geopotential heights, 1969-1998

30-yr linear trends in $T$

30-yr linear trends in $Z$

Both GHG increases and ozone depletion contributed to observed shift of summertime SAM index towards positive phase with ozone forcing dominating.
Projection of Future Changes in SAM Index (2001-2049)

Seasonal cycle of 3-month overlapping changes in SAM index

- AR4 models forced with GHG increase
- AR4 models forced with GHG increase and ozone recovery
- GEOS-Chemistry Climate Model
Simulated Changes in Summertime Zonal Winds 2001-2049 (Son et al. 2008)

CCMs

Simulated tropospheric impact of ozone recovery is larger in CCMs than in IPCC AR4 models.

IPCC AR4 Climate models with ozone recovery
Summary: Ozone recovery is an important forcing of 21st Century Climate Change

Next steps in climate modeling

• For climate simulations of the next IPCC assessment report, an ozone recovery scenario will be defined
• Assessment of biases in CCMs
  – Report on CCM process-oriented evaluation
  – Relevant for Ozone Assessment Report 2010
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