Development of a Polar Stratospheric Cloud Model within CESM: Assessment of 2010 Antarctic Winter

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What are PSCs and why are they important?

- Liquid binary (H$_2$SO$_4$/H$_2$O)
- STS (H$_2$SO$_4$/HNO$_3$/H$_2$O)
- NAT (HNO$_3$-3H$_2$O with subtle H$_2$SO$_4$)
- Ice particle

- Chlorine activation
- Denitrification
- Dehydration

Ozone prediction
Stratospheric HNO$_3$ and water vapor prediction
### How do we form PSCs in the model?

<table>
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<tr>
<th></th>
<th>Liquid binary ($\text{H}_2\text{SO}_4/\text{H}_2\text{O}$)</th>
<th>STS ($\text{H}_2\text{SO}_4/\text{HNO}_3/\text{H}_2\text{O}$)</th>
<th>NAT ($\text{HNO}_3-3\text{H}_2\text{O}$ with subtle $\text{H}_2\text{SO}_4$)</th>
<th>Ice particle</th>
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<tr>
<td><strong>WACCM</strong></td>
<td>SAGE observation to provide the SAD</td>
<td>Equilibrium formation [Tabazadeh et al., 1994]</td>
<td>30% of HNO3 are allowed to be taken to form $\sim 3\text{K}$ below equilibrium temperature [Hanson and Mauersberger, 1988]</td>
<td>CAM4 Parameter (based on humidity)</td>
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<tr>
<td>[Wegner et al., 2012]</td>
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<td>[Tabazadeh et al., 1994]</td>
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<td>[Hanson and Mauersberger, 1988]</td>
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<td>[Zhao &amp; Turco, 1995]</td>
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<td>[Luo et al., 1995]</td>
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<td>[Koop et al., 2000]</td>
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<td>[Toon et al., 1989]</td>
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With the ice microphysics added in CARMA, we are able to...

1. Obtain ice size distribution for calculation of optical properties. Assume the number of ice particles is equal to 1% of the number of STS particles in the grid cell.

2. Create NAT with large number densities and small sizes that are inferred over Antarctica.
Mountain waves (temperature fluctuations) increase NAT and ice number densities by $\sim$ one magnitude.

2K temperature perturbation over major Antarctic mountains when the wind meets the criteria defined by Alexander et al. [2013]

A more realistic MW may help to improve this feature.
Results:

1. How does our model do on predicting ozone compared with WACCM?

2. How does our model do on predicting HNO3 and water vapor compared with WACCM?
The SAD in WACCM/CARMA is quite different from the SAD in WACCM parameterized PSCs.
However, the ozone predictions are quite similar between WACCM/CARMA and WACCM parameterized PSC.

In Antarctic, all the model cases provide enough surface area for chorine activation.
WACCM parameterized PSC underestimates the denitrification compared with MLS observation. WACCM/CARMA compares well with MLS, except the wave case at 21 mbar.
Our model suggests a bi-modal size distribution of NAT particles in Antarctic mid-season, which could be one of the methods to improve HNO3 prediction in WACCM parameterized PSC.
Conclusions:

1. Our model predicts a similar ozone trend compared with WACCM parameterized PSC, although the SAD in two models are very different.

2. WACCM parameterized PSC underestimates the denitrification compared to our model and MLS. We suggest a bi-modal distribution of NAT to improve the parameterization in WACCM.
Thank you!