The microphysical simulation of PSCs based on SD-WACCM/CARMA model over 2010-2011 winter

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What are PSCs and what do they do?

H$_2$SO$_4$ aerosol

200K

195K

190K

180K

Temperature

Chlorine activation

SAT
Sulfuric acid tetrahydrate
H$_2$SO$_4$.4H$_2$O

NAT
Nitric acid trihydrate
HNO$_3$.3H$_2$O

STS
Supercooled ternary solution
H$_2$SO$_4$/HNO$_3$/H$_2$O

Denitrification

Ice particle

Dehydration
How do we form the PSCs in the model?

- **H₂SO₄** aerosol
- Melting
- Evaporation
- Dehydration
- Condensation
- Evaporation

**Temperature**
- 200K
- 195K
- 190K
- 180K

**H₂SO₄ gas, water vapor**

- **NAT**
  - Nitric acid trihydrate
  - HNO₃·3H₂O

- **SAT**
  - Sulfuric acid tetrahydrate
  - H₂SO₄·4H₂O

**STS**
- Supercooled ternary solution
- H₂SO₄/ HNO₃/ H₂O

**Denitrification**

**Ice particle**

**Dehydration**

**CARMA CAM**

**STS**

**NAT**

**SAT**
HNO₃ abundance is affected by variety of sources and sinks. We are interested in the denitrification.

Descending air: transports chemicals from upper layer to lower layer

Liquid PSCs form on sulfate particles

Some of STS nucleates into NAT

NAT causes permanent denitrification

Heterogeneous chemistry generates HNO₃

Approximate pressure levels and heights

15hpa 25km

27hpa 22km

50hpa 19km
The nucleation probability is as a function of temperature and HNO$_3$ mole fraction of the STS particles [Tabazadeh et al., 2002].

The NAT nucleation rate is not known, we test 3 homogeneous schemes.
First, we test the model without NAT formation. We find 60% of HNO₃ change is caused by NAT denitrifying and 40% is caused by dynamics.
Then we test NATscheme and NADscheme.
We test the slopeflat case and find it fits the MLS observations the best.
The simulations agree with MLS observations except near 400K where the model has a cold bias of 0.5K to 1K relative to MLS.
The model captures the locations of STS and NAT.
The modeled backscattering ratio is very close to the CALIPSO observation.
The PSCs coverage is overestimated in late January.
The model (solid lines) overestimates O$_3$ in Mid-March compared with MLS. The sensitivity test with -1.5K improves the prediction.
Conclusions

* Tuning the free energy in the nucleation rate improves HNO$_3$ prediction compared with NATscheme and NADscheme.

* The locations and backscattering ratio of PSCs are similar with CALI PSO observations.

* The area of the vortex containing PSCs is too high in late January because of the different threshold of NAT definition.
Future work

- We will simulate the Antarctic PSCs.
- We will add ice particle formation in our microphysical model.
Thank you!