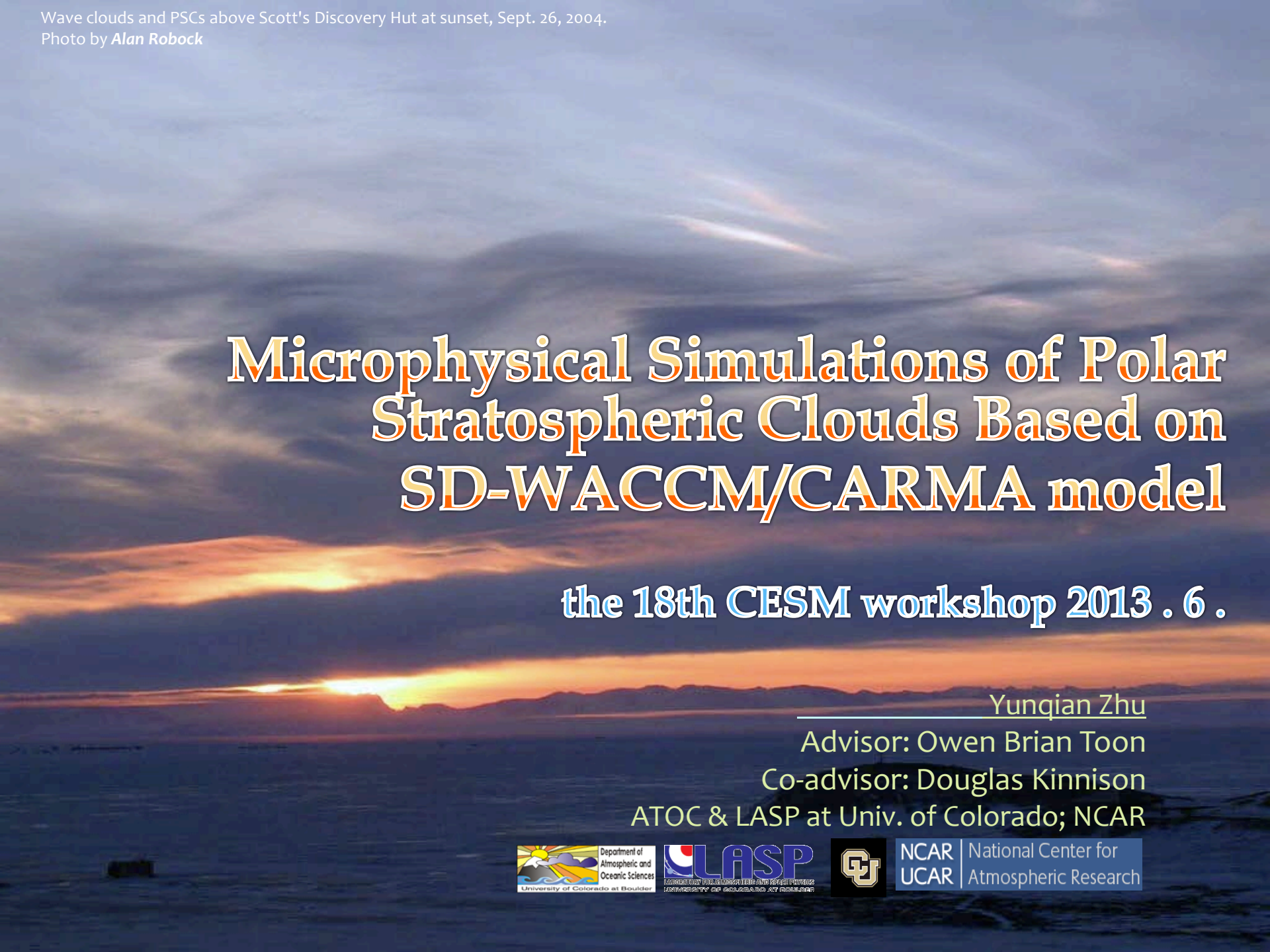

Microphysical Simulations of Polar Stratospheric Clouds Based on SD-WACCM/CARMA model

the 18th CESM workshop 2013 . 6 .

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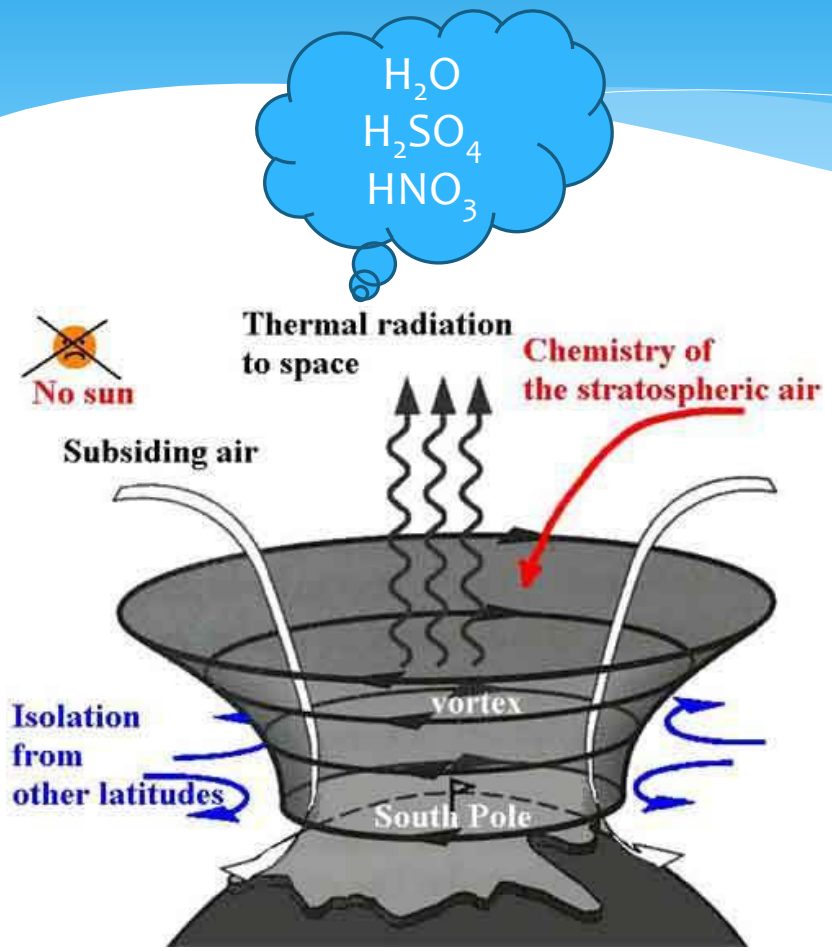
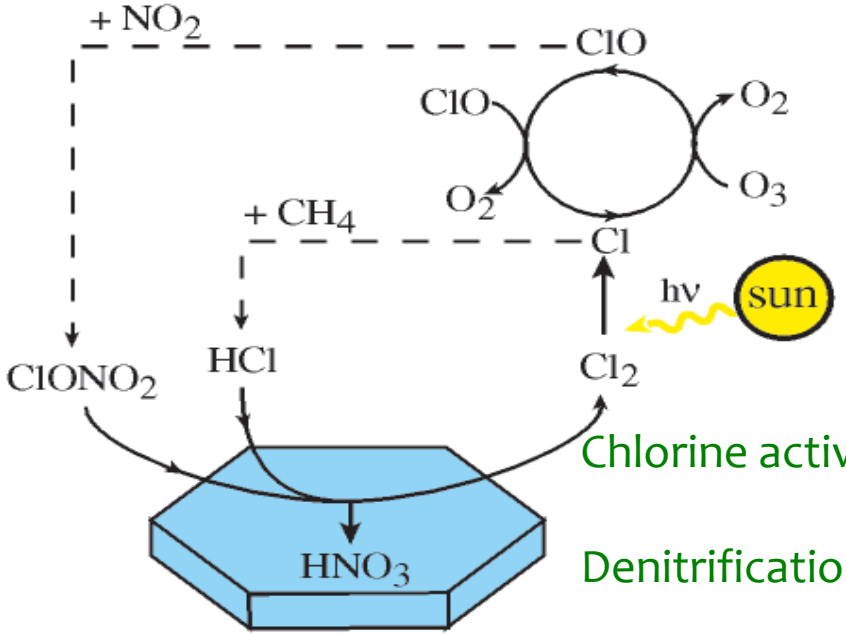
NCAR UCAR National Center for Atmospheric Research

What are PSCs? Why are PSCs important?

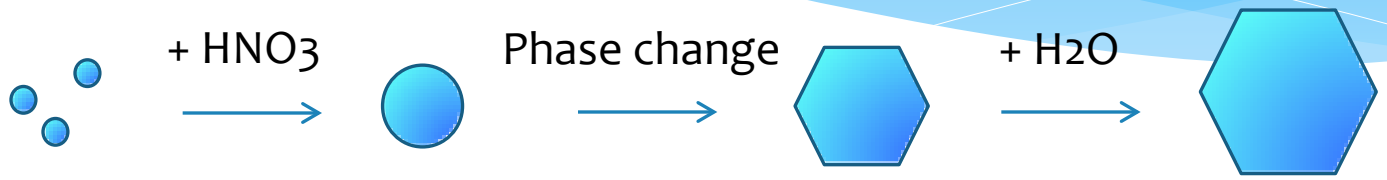


K. Mohanakumar, 2008



S Solomon, 1986

What are the types of PSCs?



H_2SO_4 aerosol

STS (Supercooled Ternary solution)

NAT (Nitric acid trihydrate)

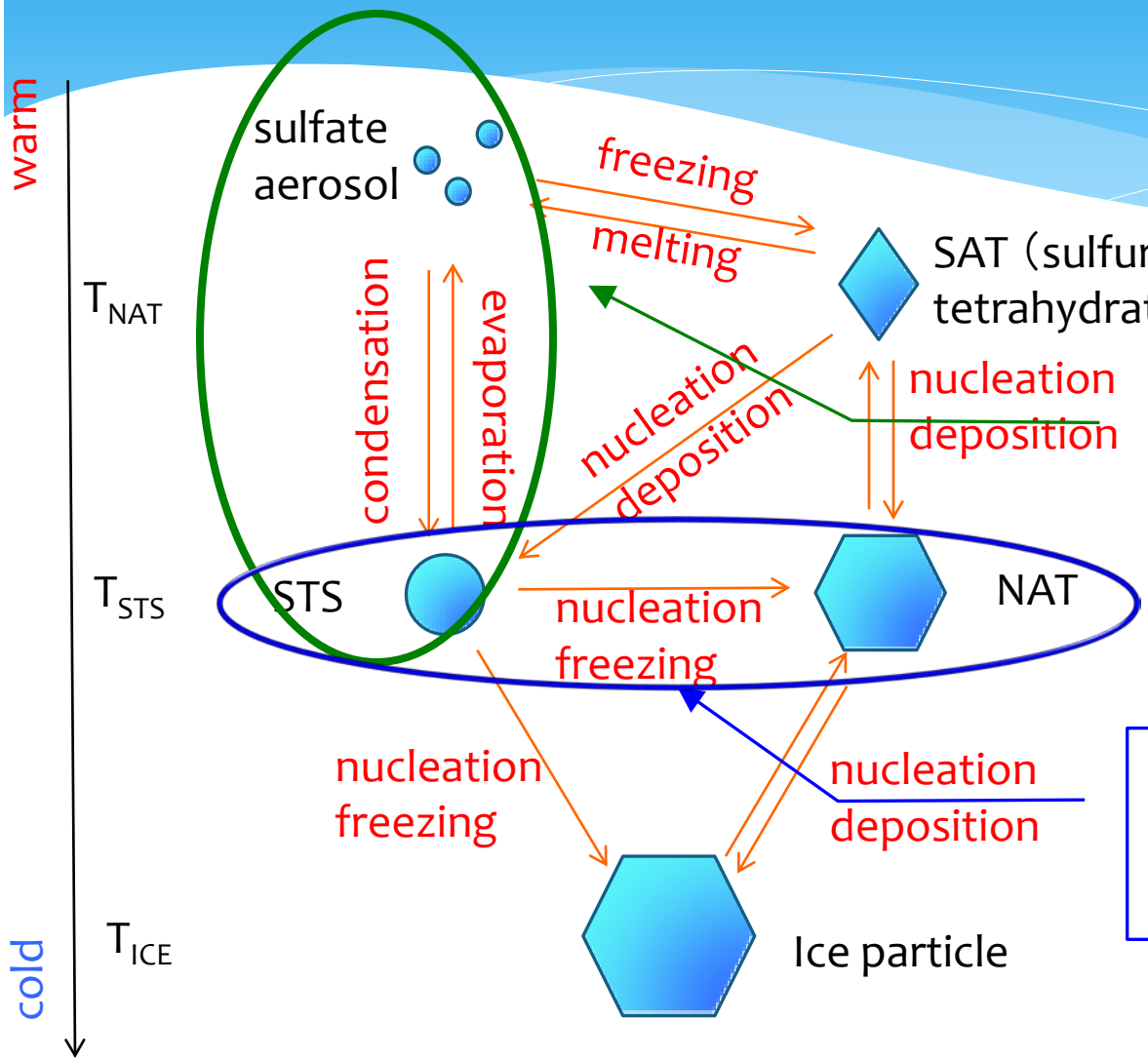
Ice particle

Chlorine activation

Denitrification

Dehydration

How do different types of PSCs convert to each other?



1st step: Growth and evaporation of STS based on sulfate aerosols

2nd step: Homogeneous nucleation of NAT from STS particles

The PSC model in WACCM/CARMA

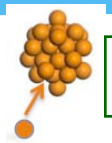
CARMA

4. Condensational growth

H_2SO_4, HNO_3 and H_2O gases condense/evaporate on aerosols and PSC particles

CARMA

3. Nucleation



H_2SO_4 and H_2O gases form sulfate aerosol

2.5° x1.9° resolution

Dynamics/Transport

SD-WACCM

CARMA

5. NAT nucleation

STS nucleates to form NAT

WACCM

2. Chemistry

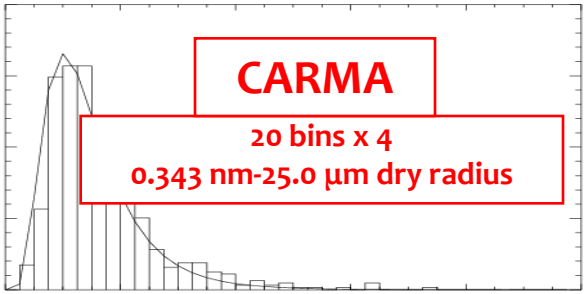
Sulfur chemistry H_2SO_4 formed

Turn off PSCs parameterization

CARMA

20 bins x 4

0.343 nm-25.0 µm dry radius



CARMA

6. Coagulation

WACCM

1. Emissions

SO_2, OCS

WACCM

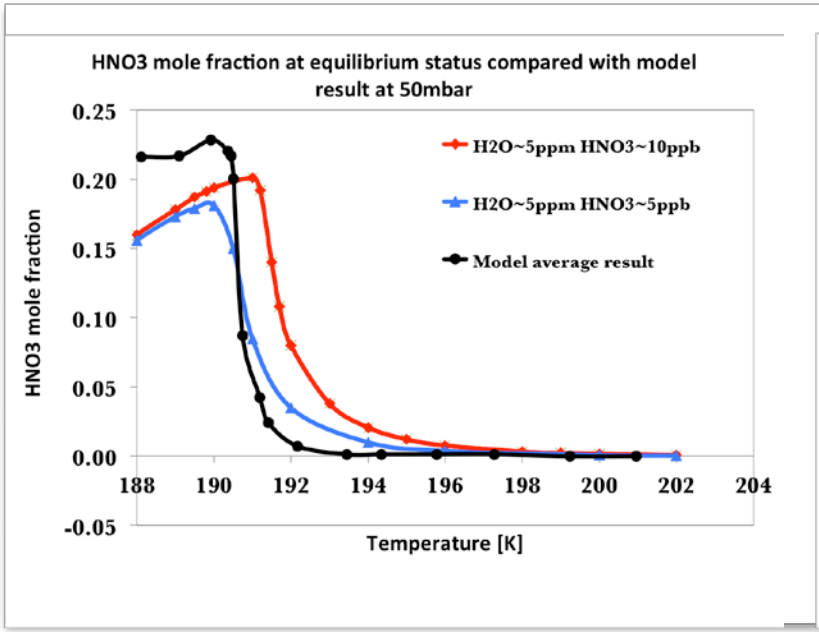
7. Deposition

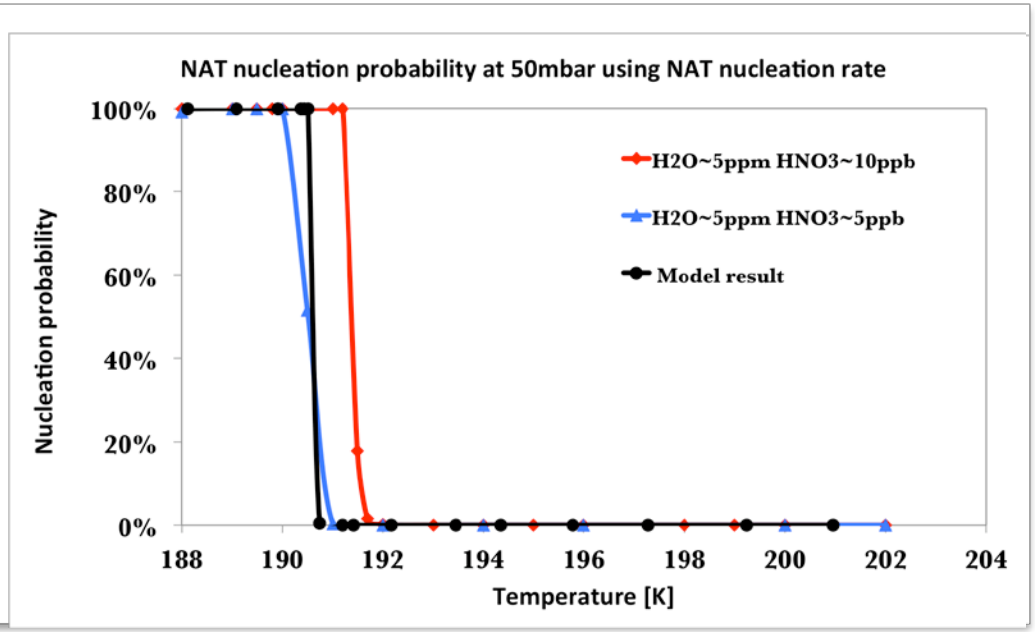
CARMA

Sedimentation

NAT homogeneous nucleation scheme

The NAT nucleation probability is as a function of temperature and HNO3 mole fraction of the STS particles [Tabazadeh, 2002].

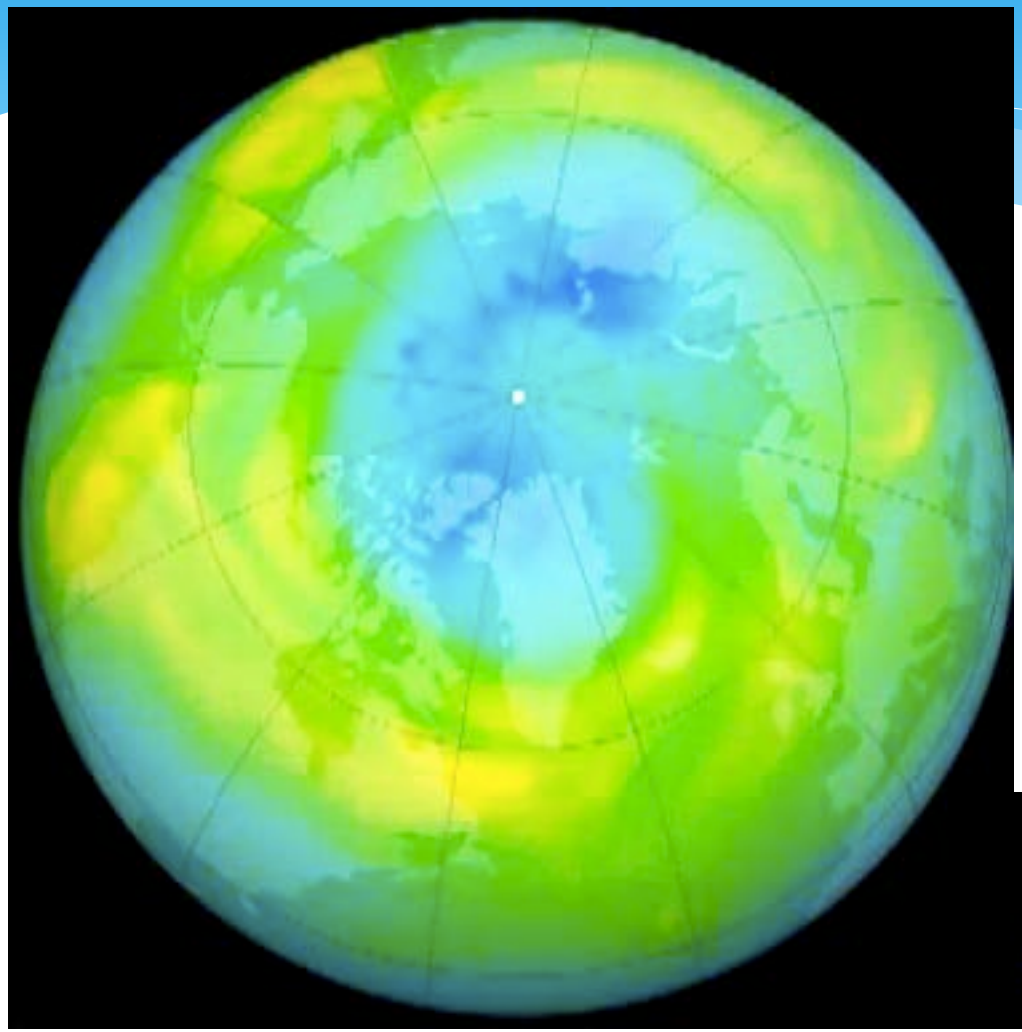




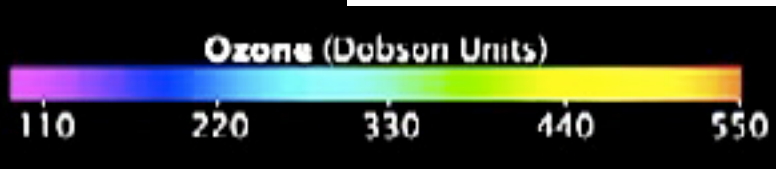
The NAT nucleation temperature is highly related with H2O and HNO3 amount.

SD-WACCM results: 2010-2011 winter

CESM 1.1.1
CARMA 3.0
1.9x2.5 resolution



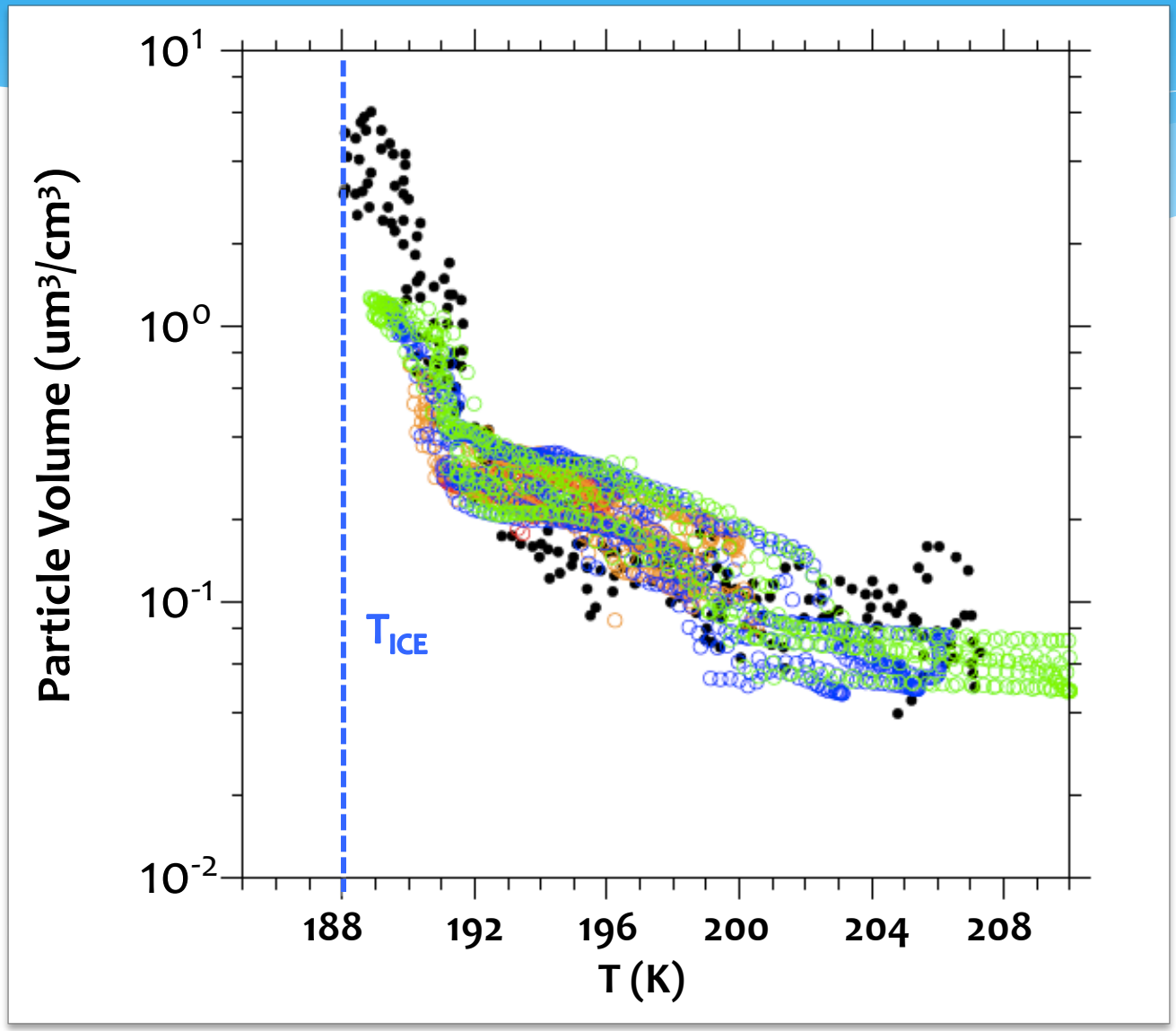
OMI 2011 March



Part 1: Microphysics features

STS particle volumes compare well with aircraft observations at 55 mbar

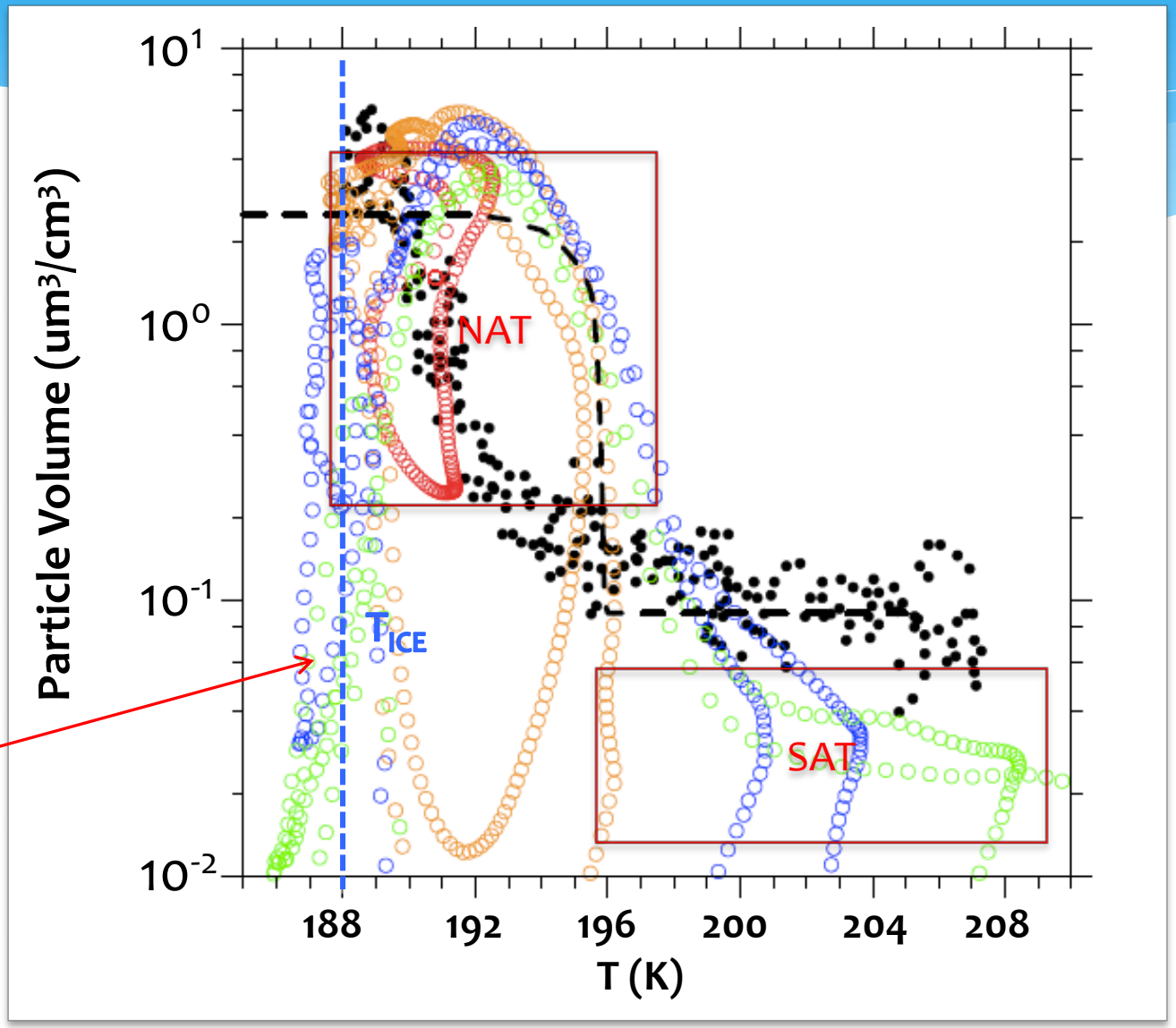
Obs (Dye, 1992) ●
90°N – 86°N ○
82°N – 78°N ○
74°N – 70°N ○
66°N – 62°N ○



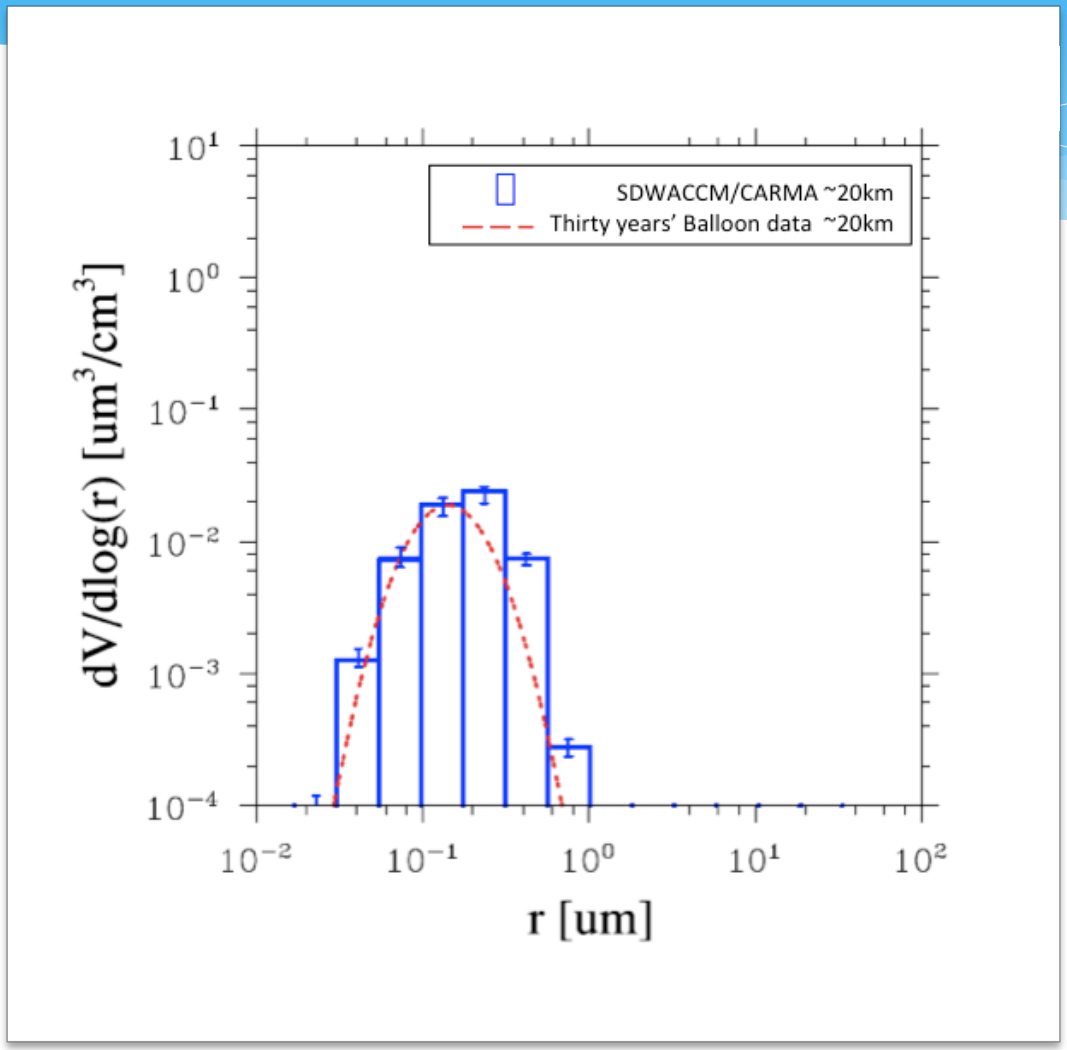
NAT particle volumes compare well with Carslaw's thermodynamic model at 55 mbar

Obs (Dye, 1992) ●
Carslaw (1994) – – -
90°N – 86°N ○
82°N – 78°N ○
74°N – 70°N ○
66°N – 62°N ○

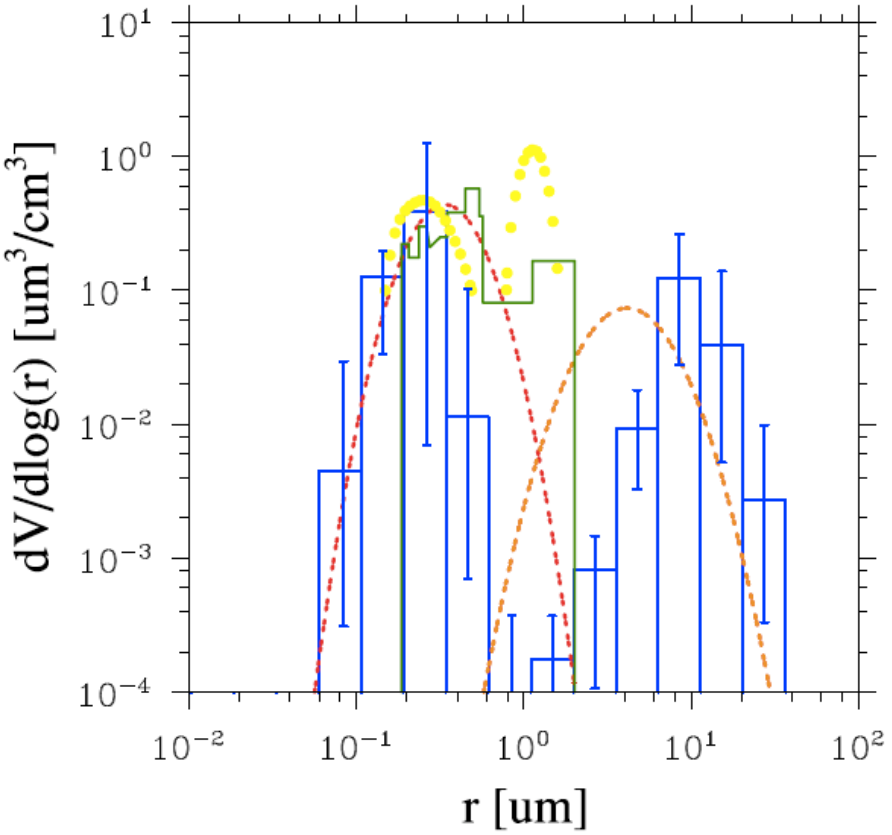
Some of the NAT particles don't nucleate until 188K, which could be because of the H_2O or HNO_3 amount are small in that specific area.

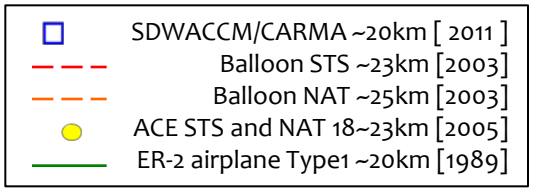


The model has a typical sulfate aerosol size distribution outside the polar vortex



The model size distribution produces two modes like the data





Part 2: PSCs evolution and denitrification

The model HNO3 partial column compares well with MLS observations

Total HNO_3

CARMA no-sedimentation ——

Gas phase HNO_3

CARMA -·-·-·

MLS - - - -

MOZART -·-·-·

Condensed phase HNO_3

CARMA: total ——

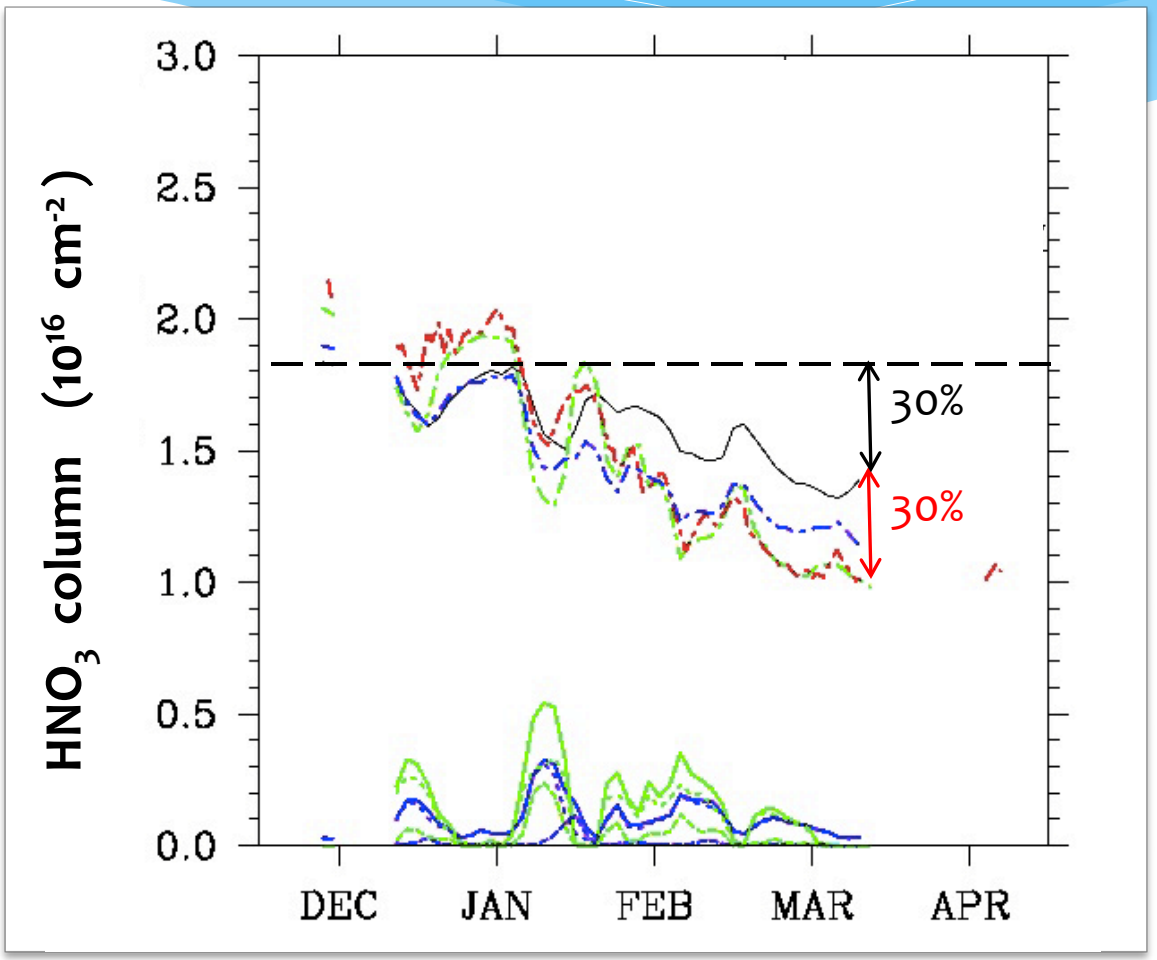
CARMA: STS ·····

CARMA: NAT – – –

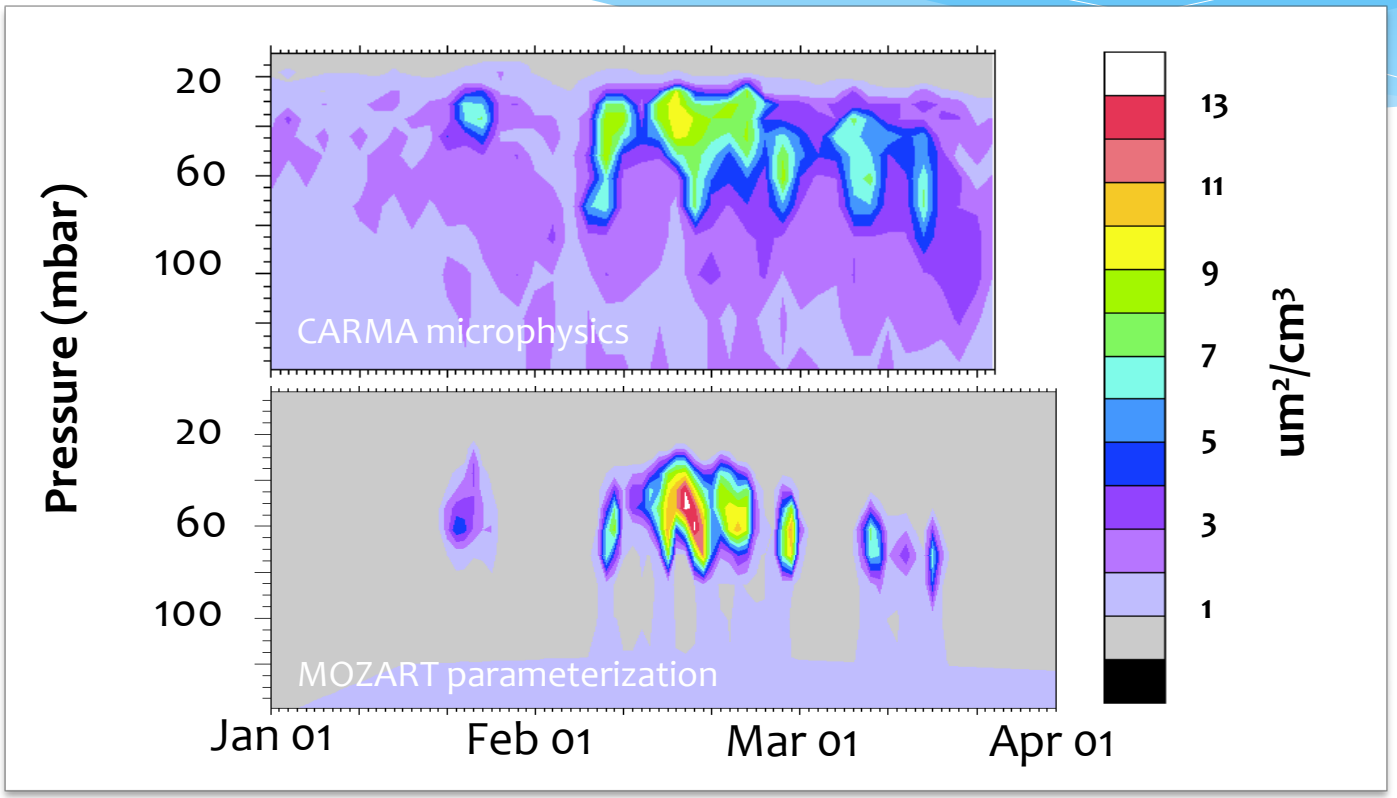
MOZART: total ——

MOZART: STS ·····

MOZART: NAT – – –



The CARMA model and the MOZART parameterization produce similar surface area densities



Conclusion

* The PSC model in SD-WACCM/CARMA captures the microphysics features (size distribution and particle volume) very well.

* About 30% of HNO_3 inside the vortex in 2010-2011 spring removed by NAT particles in SD-WACCM/CARMA model, which will accelerate the ozone loss.

* SD-WACCM/MOZART parameterization and SD-WACCM/CARMA produce the similar surface area densities.

Future work

* Tune the NAT homogeneous nucleation scheme to have better denitrification for 2010/2011 year.

* add ice particles to create a full PSC model.

Yunqian 2013. 6.