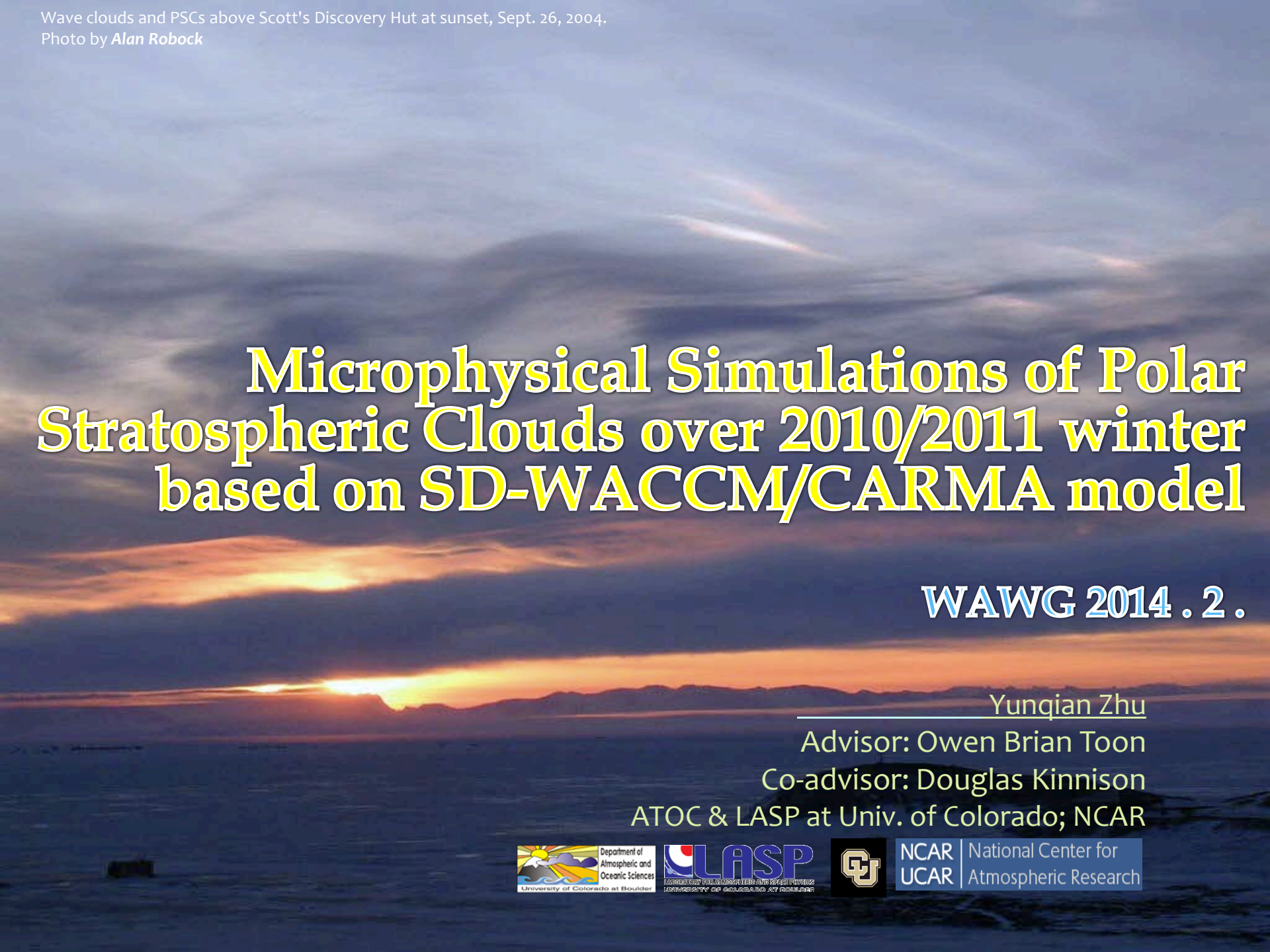

Microphysical Simulations of Polar Stratospheric Clouds over 2010/2011 winter based on SD-WACCM/CARMA model

WAWG 2014 . 2 .

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Advisor: Owen Brian Toon
Co-advisor: Douglas Kinnison
ATOC & LASP at Univ. of Colorado; NCAR

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NCAR UCAR National Center for Atmospheric Research

What are PSCs and what do they do?

H_2SO_4 aerosol

STS (Supercooled Ternary solution)

NAT (Nitric acid trihydrate)

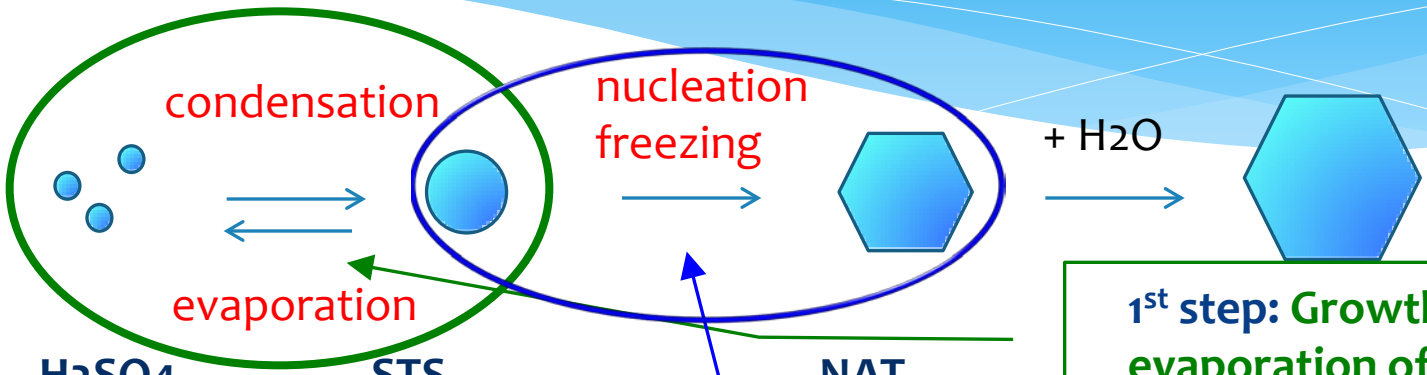
Ice particle

Chlorine activation

Denitrification

Dehydration

How do we present PSCs in the model?



H2SO4 aerosol

STS (Supercooled Ternary solution)

NAT (Nitric acid trihydrate)

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

2nd step: Homogeneous nucleation of NAT from STS particles

Chlorine activation

Denitrification

Dehydration

The PSC model in WACCM/CARMA

CARMA

4. Condensational growth

CARMA

5. NAT nucleation

CARMA

6. Coagulation

WACCM | CARMA

7. Deposition | Sedimentation

WACCM

1. Emissions

CARMA

3. Nucleation

WACCM

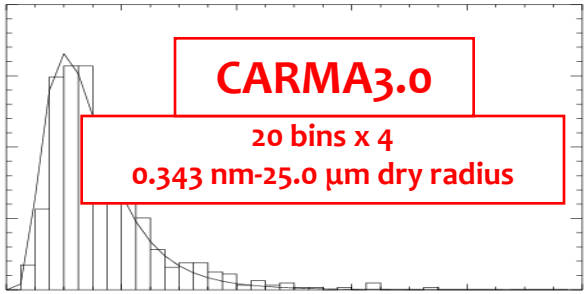
2. Chemistry

Turn off PSCs parameterization

2.5° x1.9° resolution

Dynamics/Transport

SD-WACCM (CESM1.1.1)

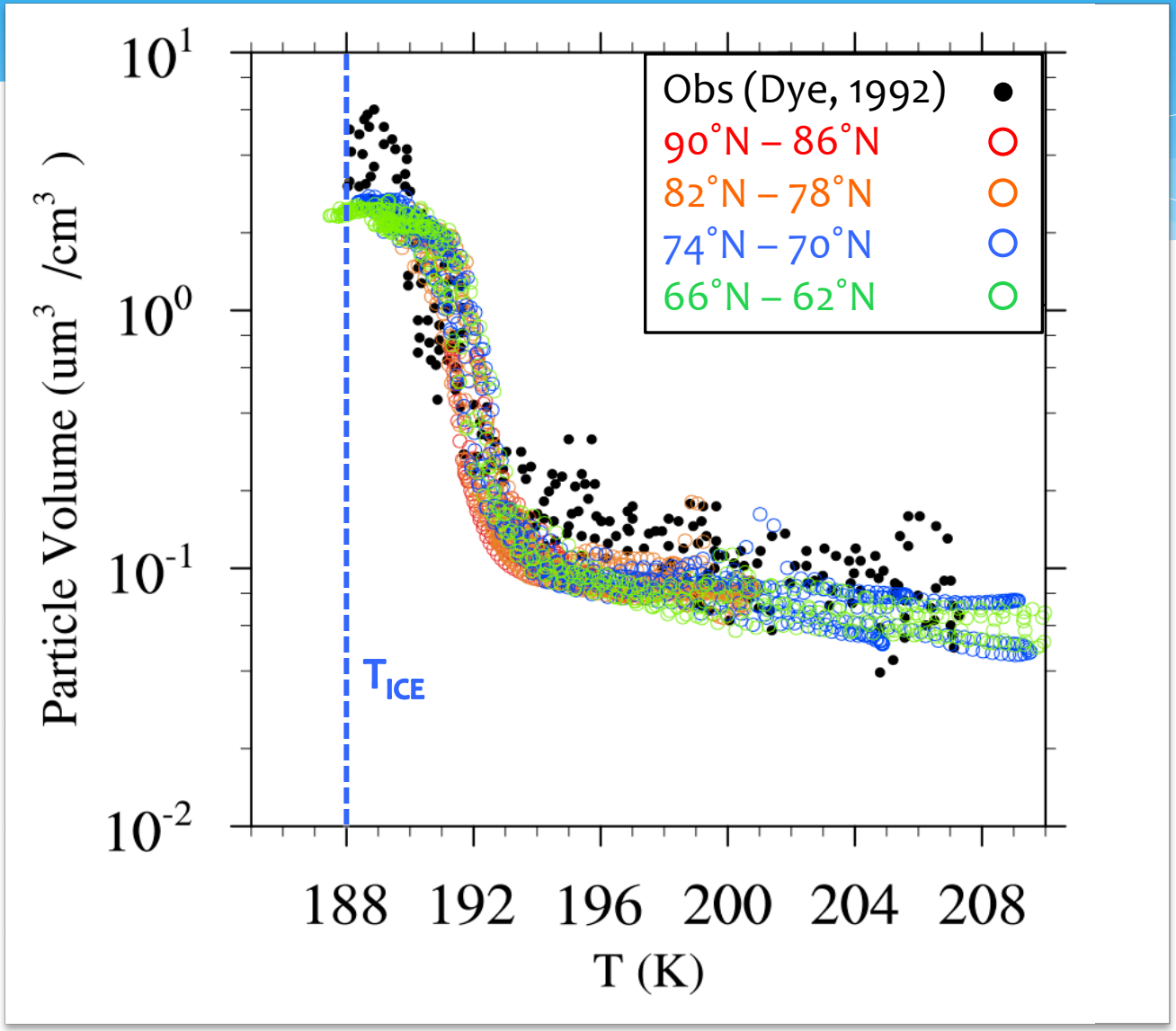


CARMA3.0

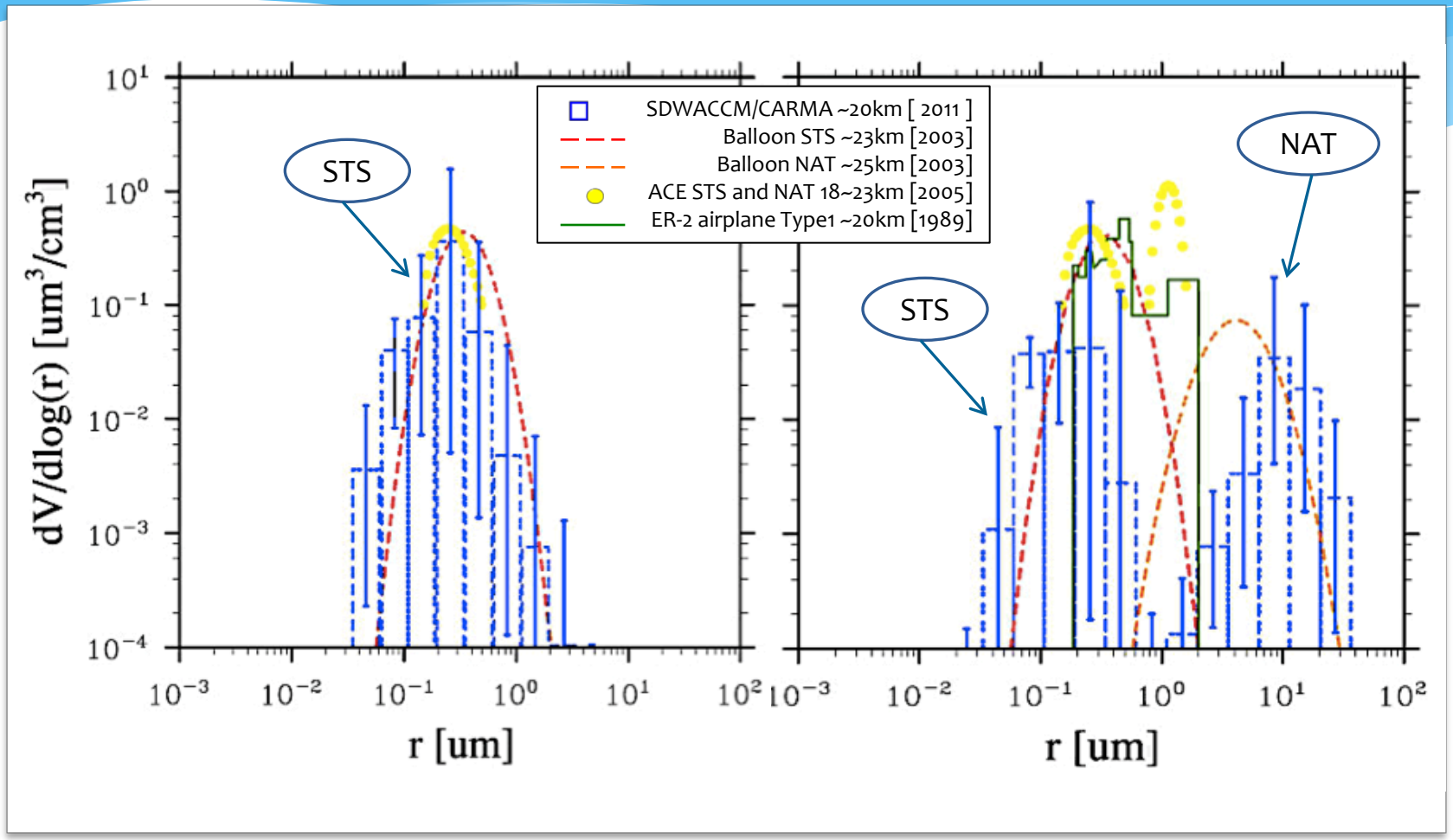
20 bins x 4

0.343 nm-25.0 μm dry radius

STS particle volumes compare well with aircraft observations at 55 mbar

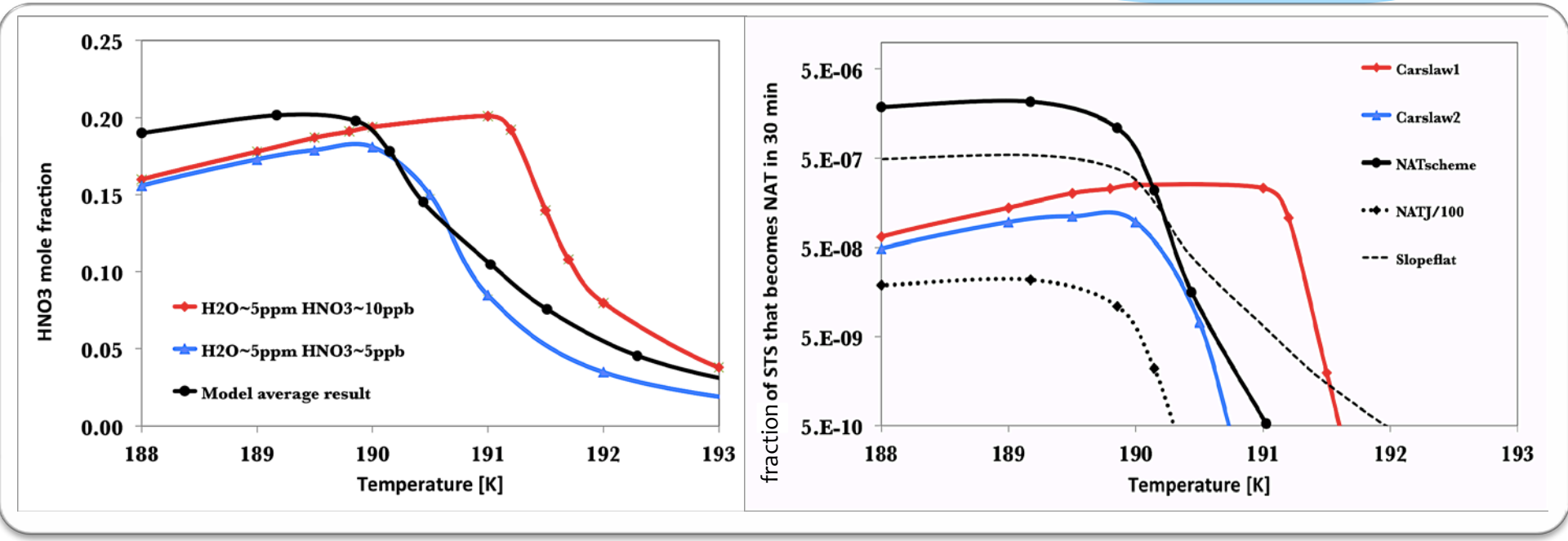


The model size distribution produces two modes like the data



NAT homogeneous nucleation scheme

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

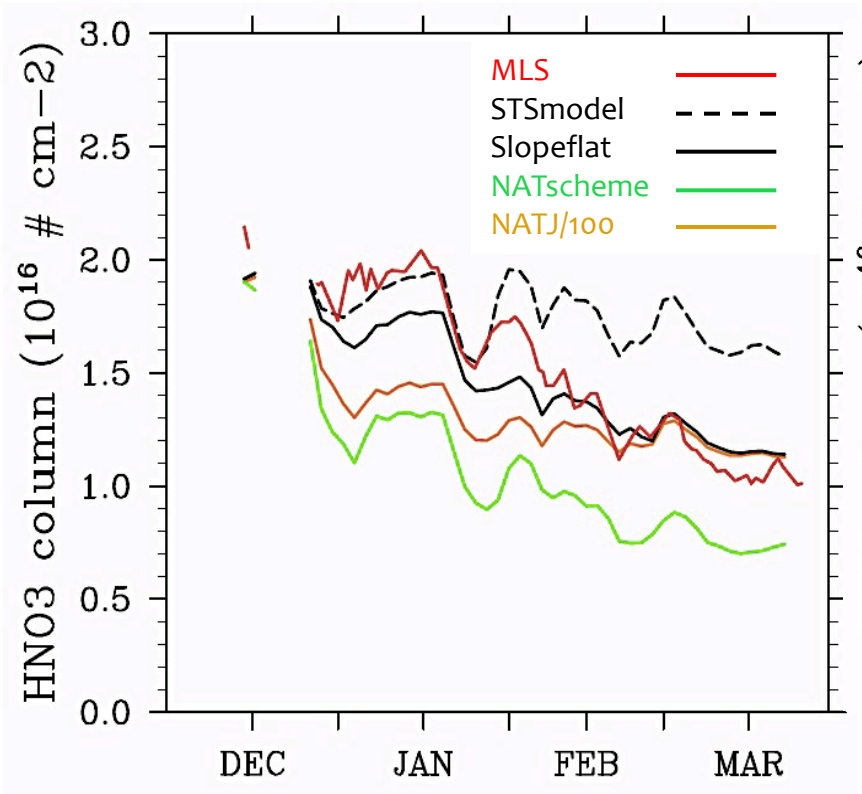


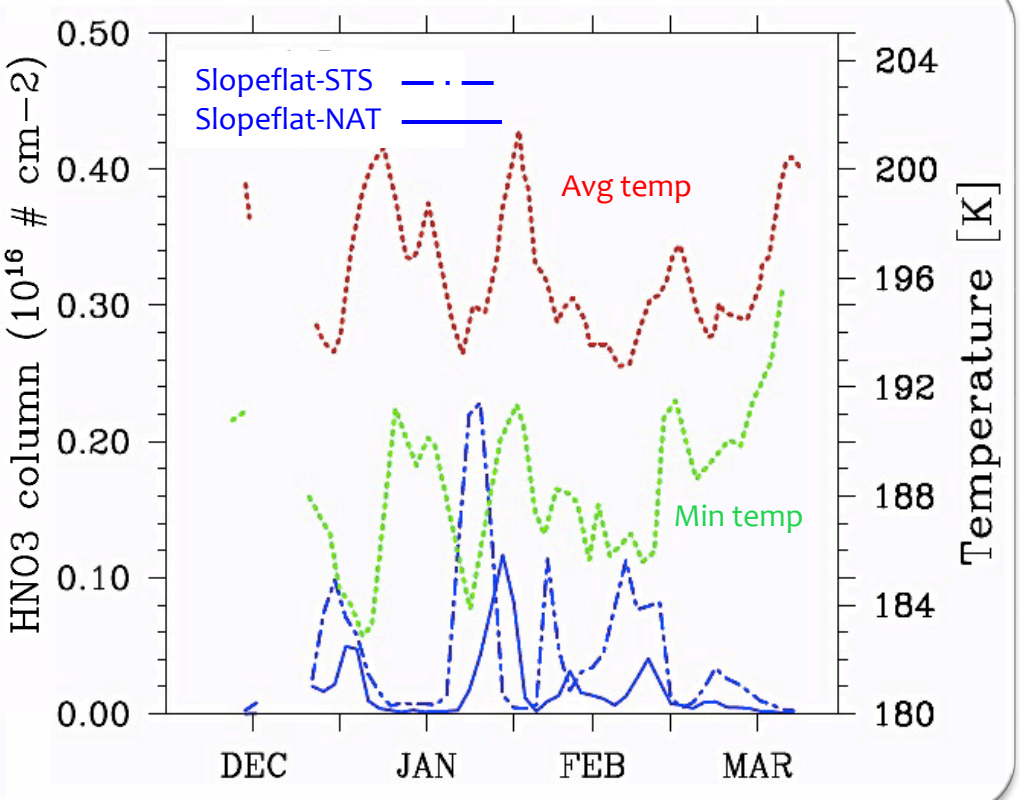
The NAT nucleation temperature is highly related with H2O and HNO3 amount.

The model HNO3 partial column compares well with MLS observations

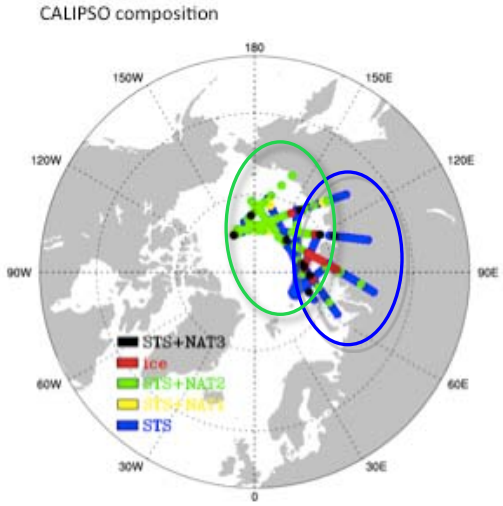
Gas phase HNO_3

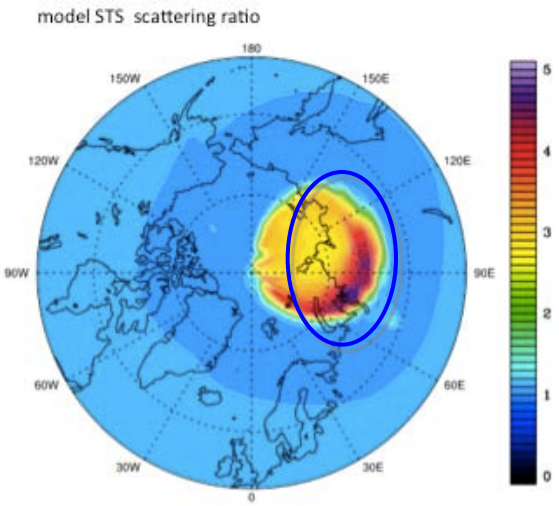
Condensed phase HNO_3

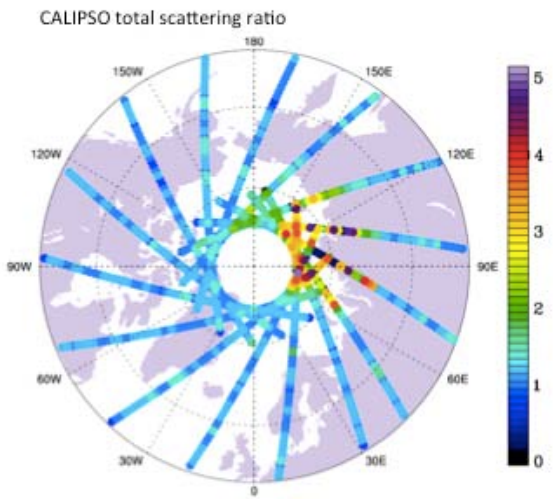


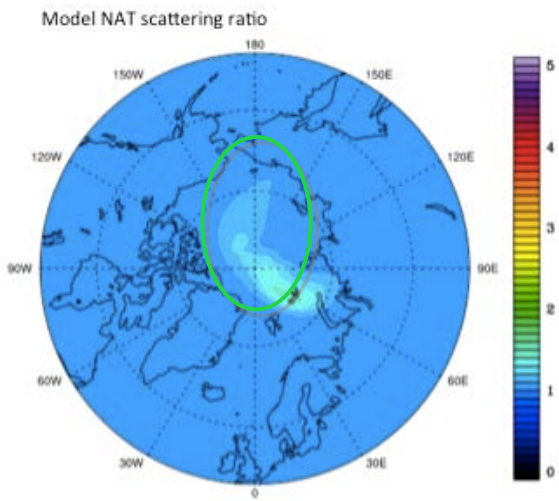


The model captures the locations of STS and NAT; and shows the same magnitude of backscattering ratio as CALIPSO does.









CALIPSO data from 22km and model output at 36 mbar (about 22 km) on Jan23, 2011

Conclusion

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

* By tuning the NAT nucleation rate, the model case Slopeflat predicts the same amount of denitrification as MLS observes.

* The backscattering ratio and PSC compositions from CALIPSO observations match the model results.

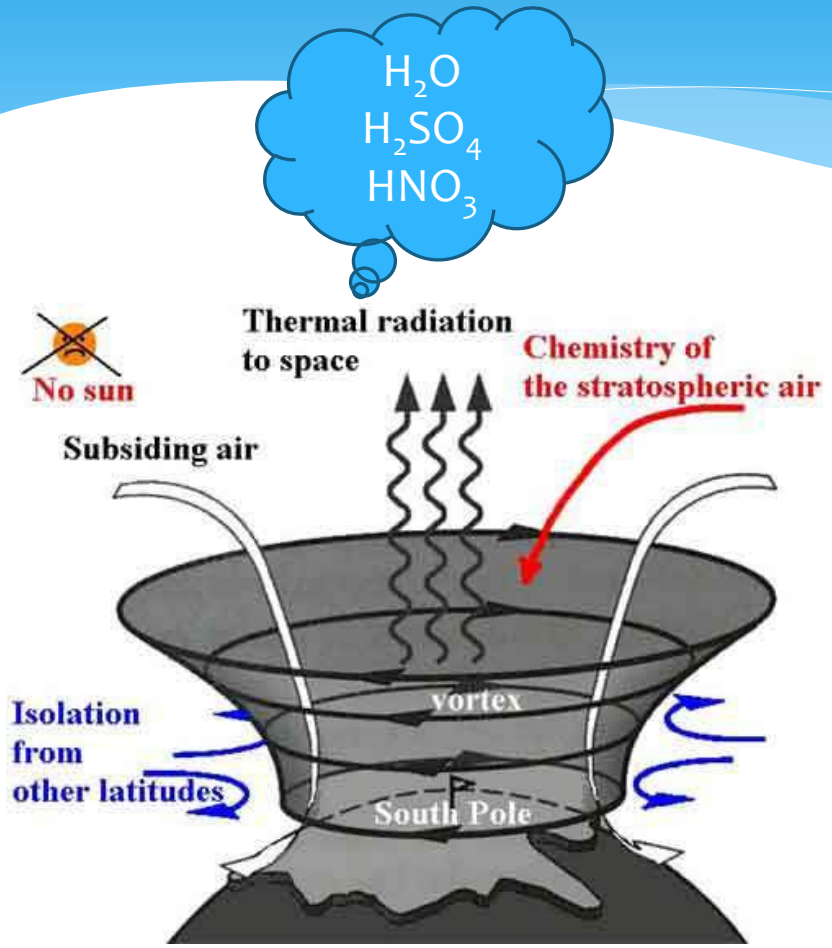
Future work

* Replace WACCM cirrus model with CARMA aerosols for ice particles and simulate the Antarctic winter.

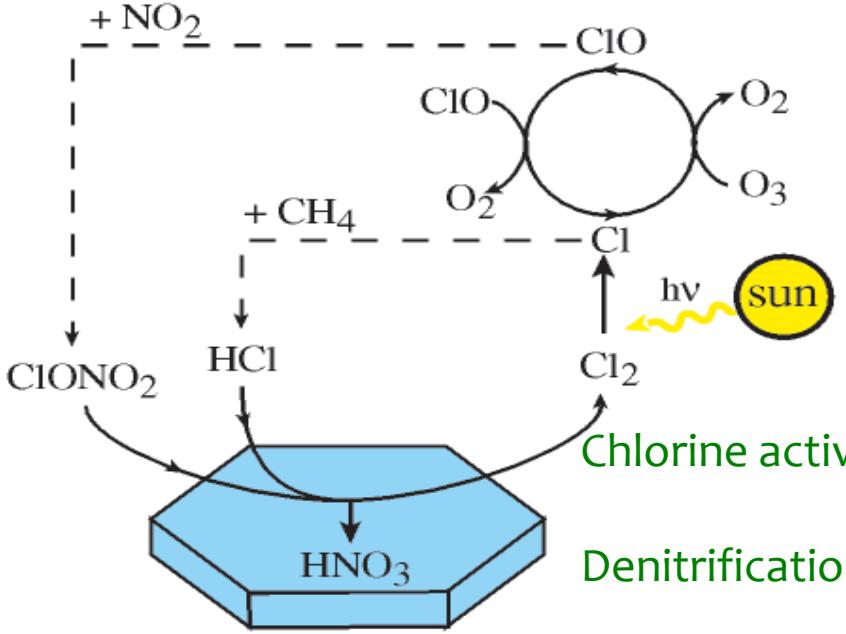
* Exam the NAT heterogeneous nucleation on micro meteorite.

Yunqian 2013. 6.

What are PSCs? Why are PSCs important?



K. Mohanakumar, 2008



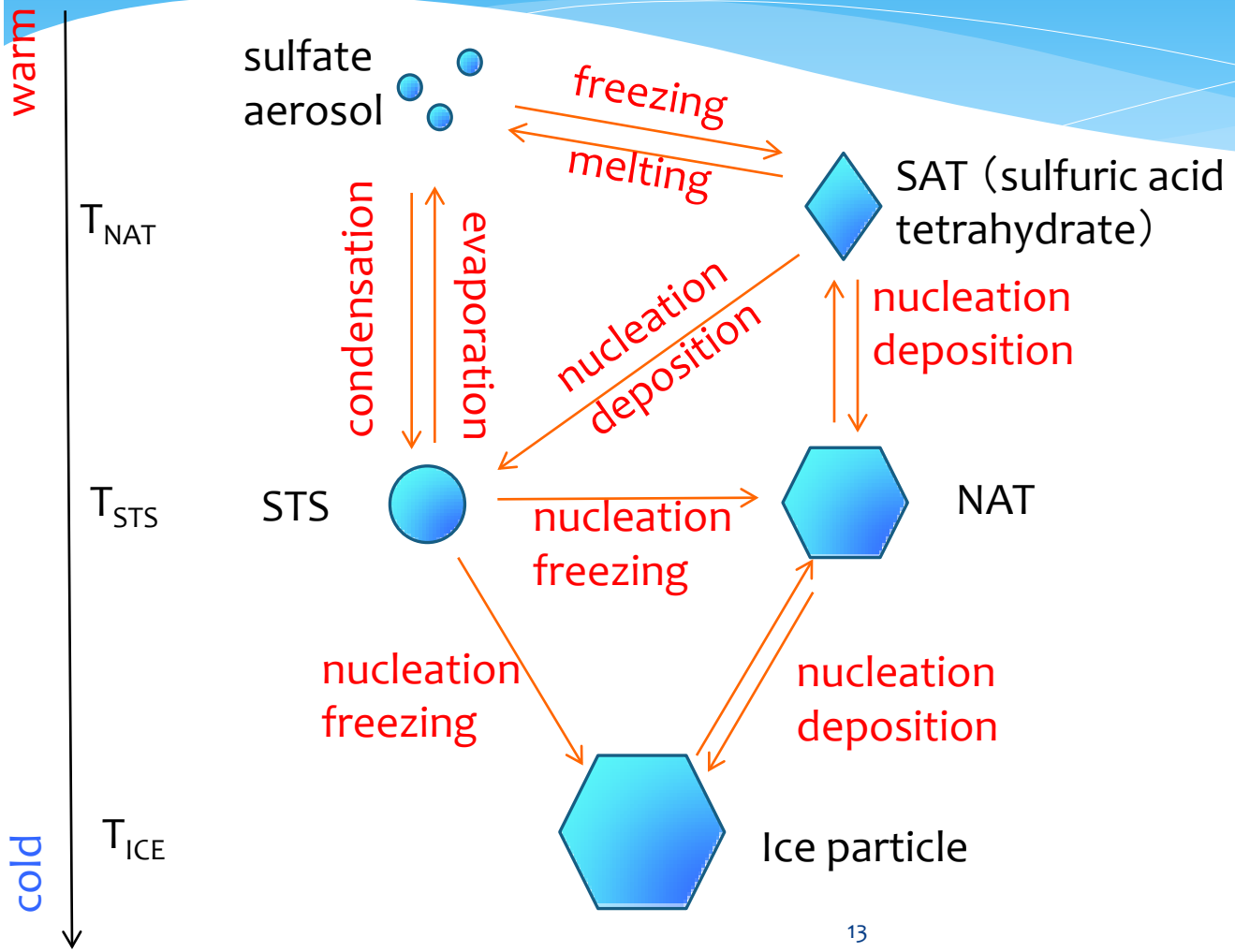
Chlorine activation

Denitrification

S Solomon, 1986

12

How do different types of PSCs convert to each other?



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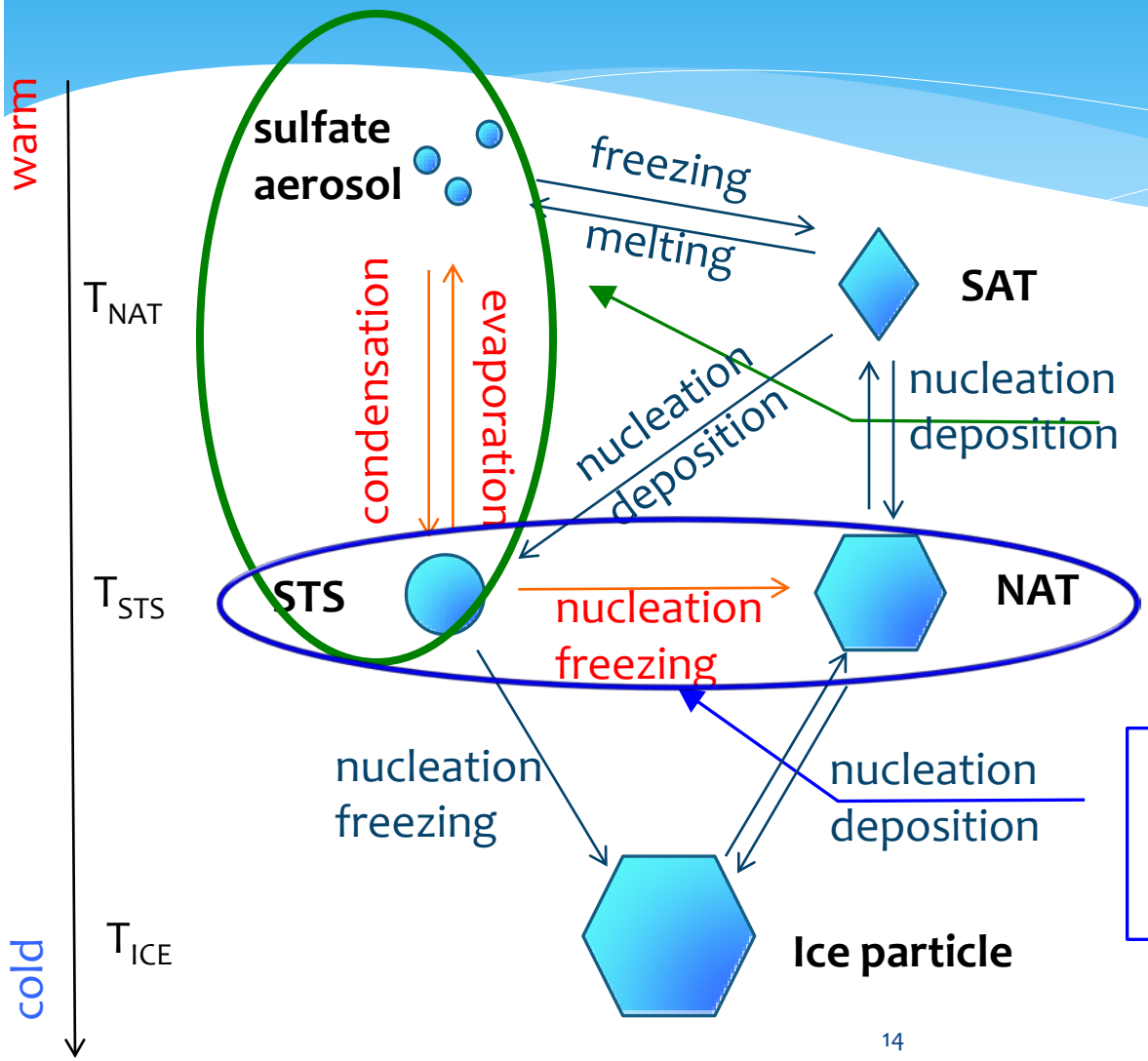

1st step: Growth and evaporation of STS based on sulfate aerosols

2nd step: Homogeneous nucleation of NAT from STS particles

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.