Polar Heterogeneous Processes in SD-WACCM

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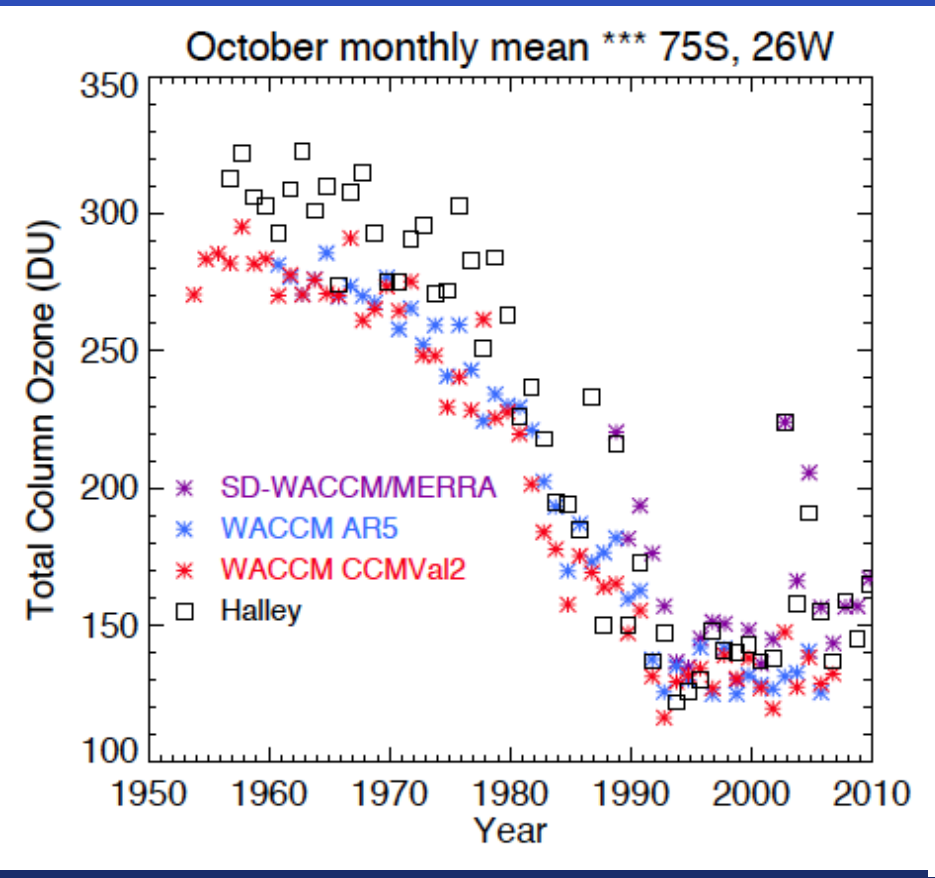
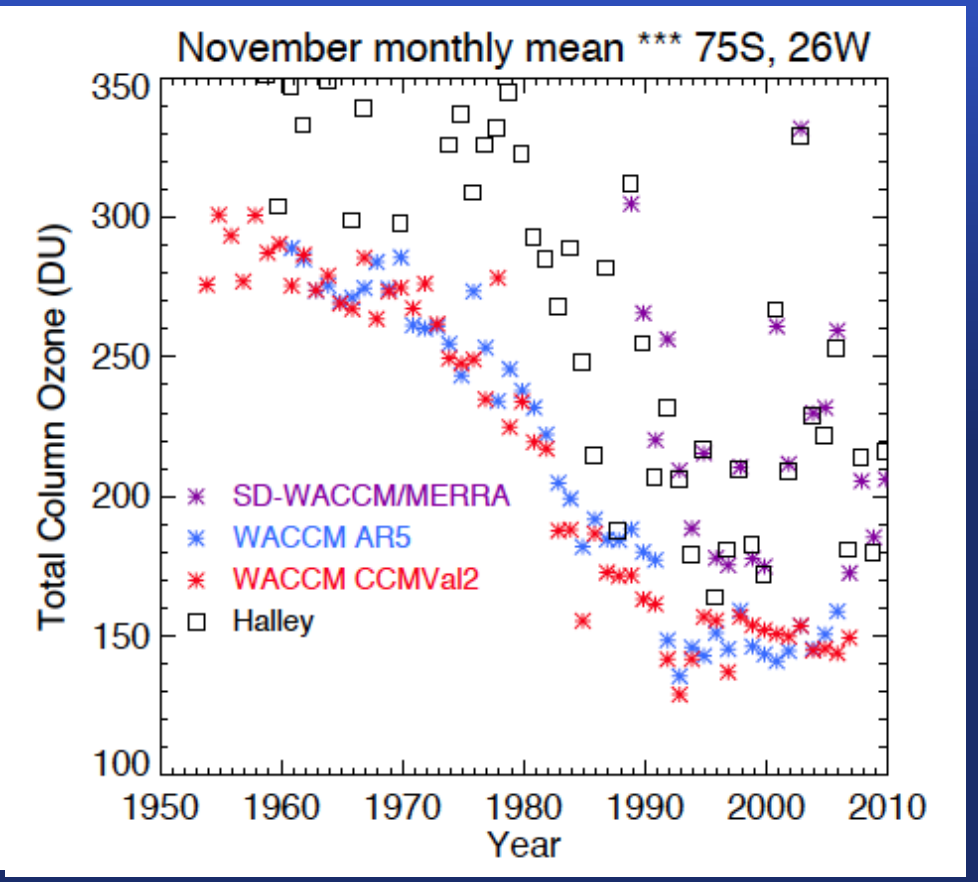
WACCM Working Group Meeting.

Comparison to Total Column Observations (DU)





SD-WACCM is the best tool to examine heterogeneous processes
- Need accurate temperatures!

Polar Stratospheric Clouds: Observations

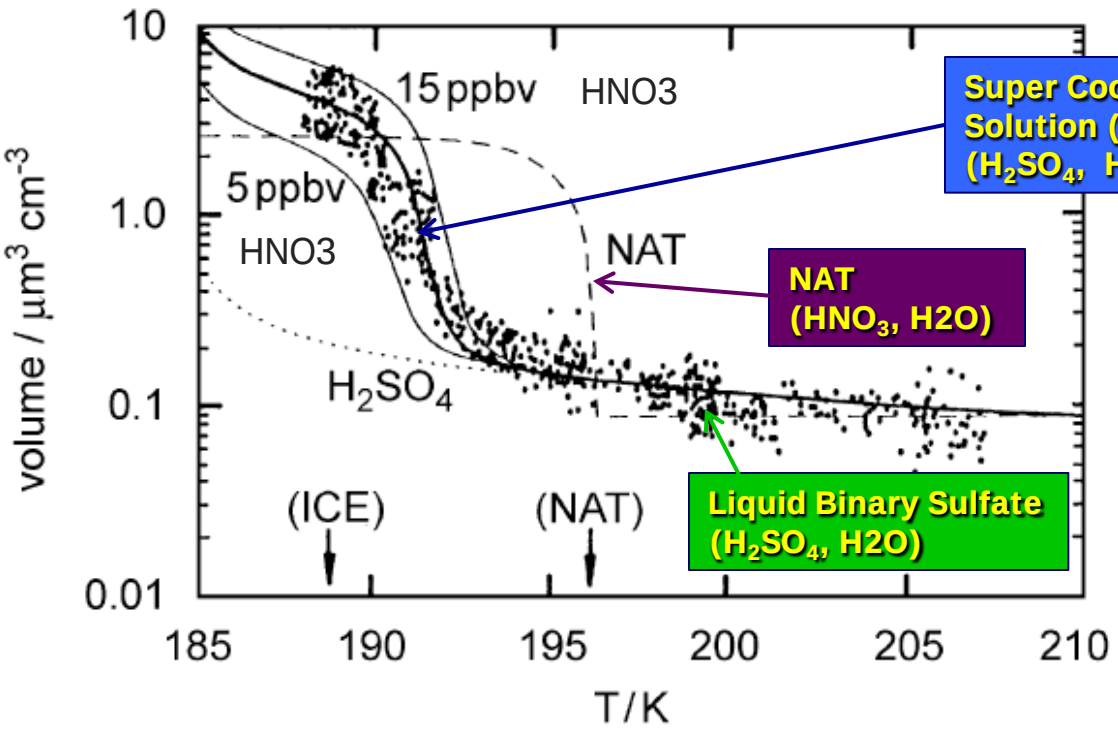
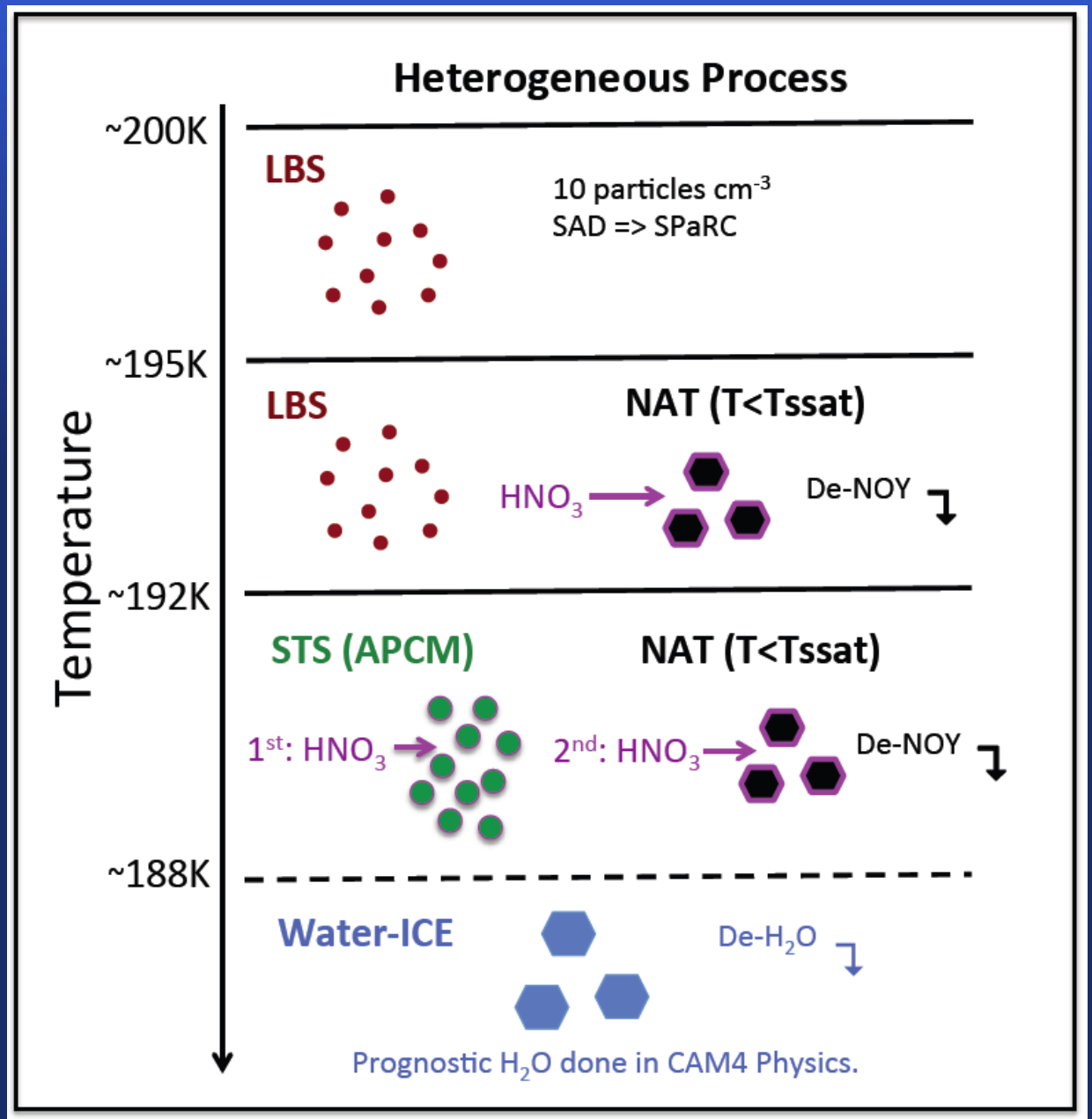


Fig. 2. Particle volumes of Dye et al. (1992) compared with model calculations. From Carslaw et al. (1994). Copyright 1994 American Geophysical Union. Reproduced with permission from American Geophysical Union.

Heterogeneous Chemistry Approach in WACCM

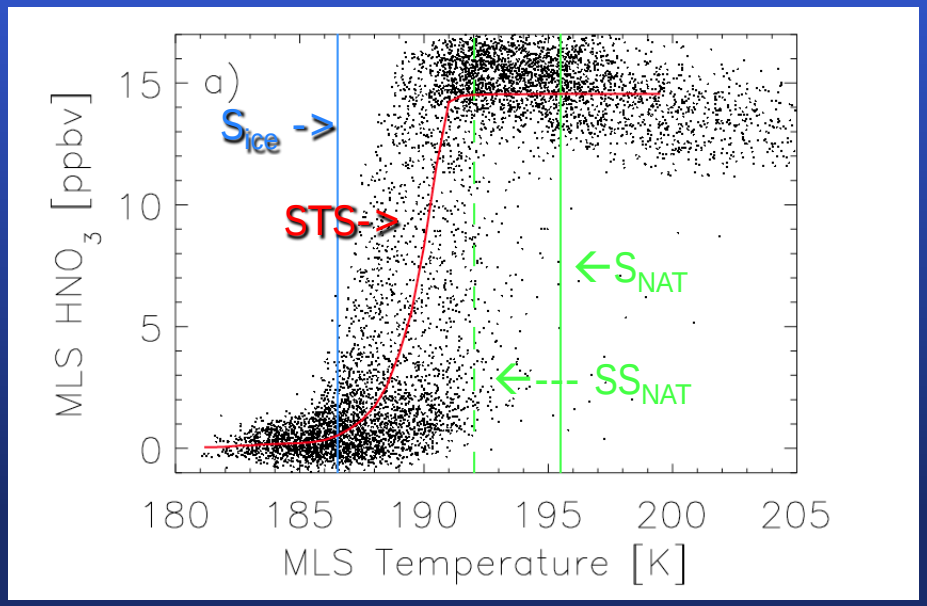


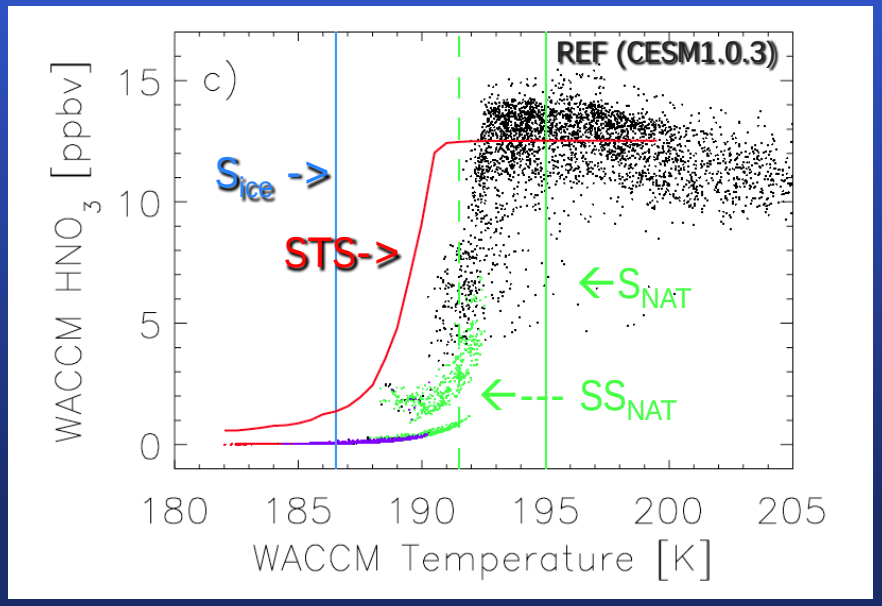
Outline

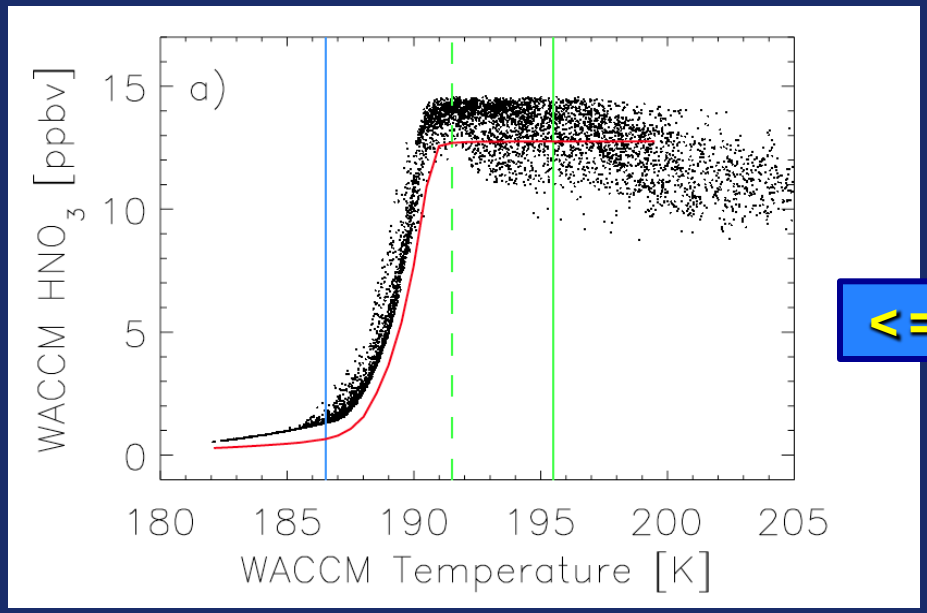
- Examine the representation of HNO_3 in WACCM -> Implications for PSC formation and composition.
  - HNO_3 split: 80% (STS) and 20% (NAT)

- Onset of HCl Loss (winter / early spring).
  - Adding HCl Solubility for STS
    - Examine the H_2O dependence on HCl Solubility
      - Increasing the saturation threshold for H_2O formation.
    - Examine temperature for HCl solubility.

HNO_3 (g) *** 475K, >80S *** May 1st to July 1st 2005

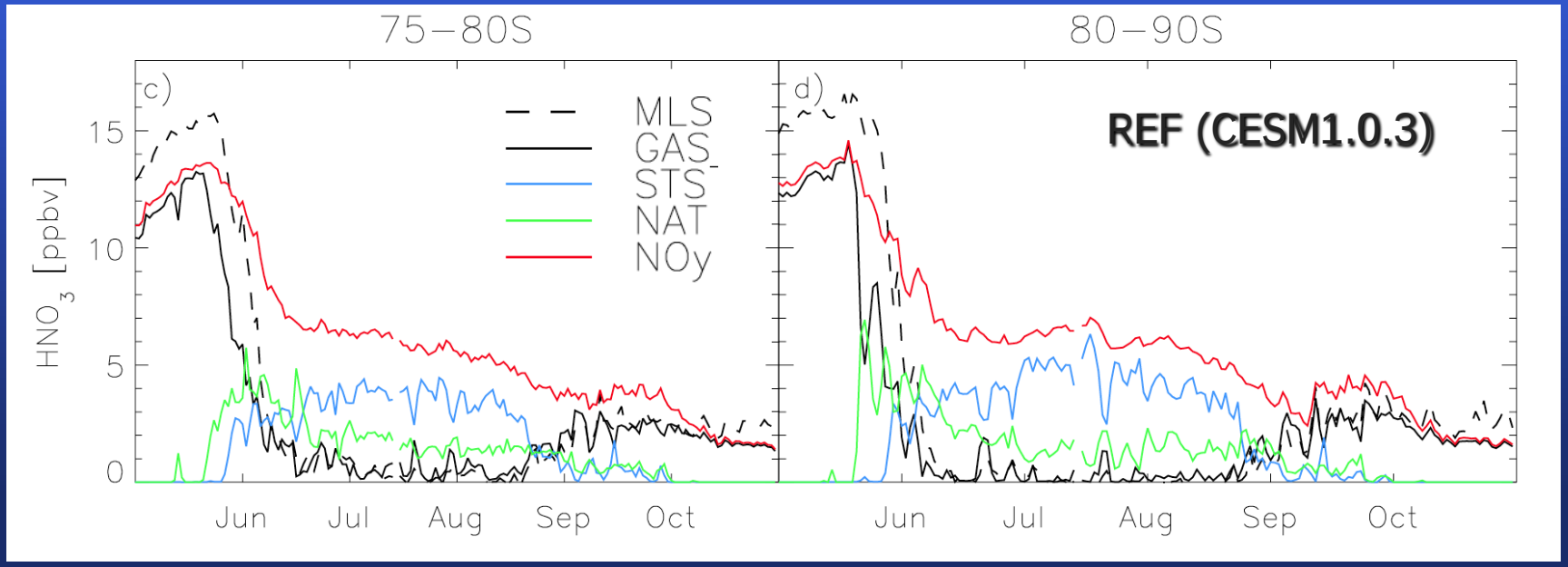


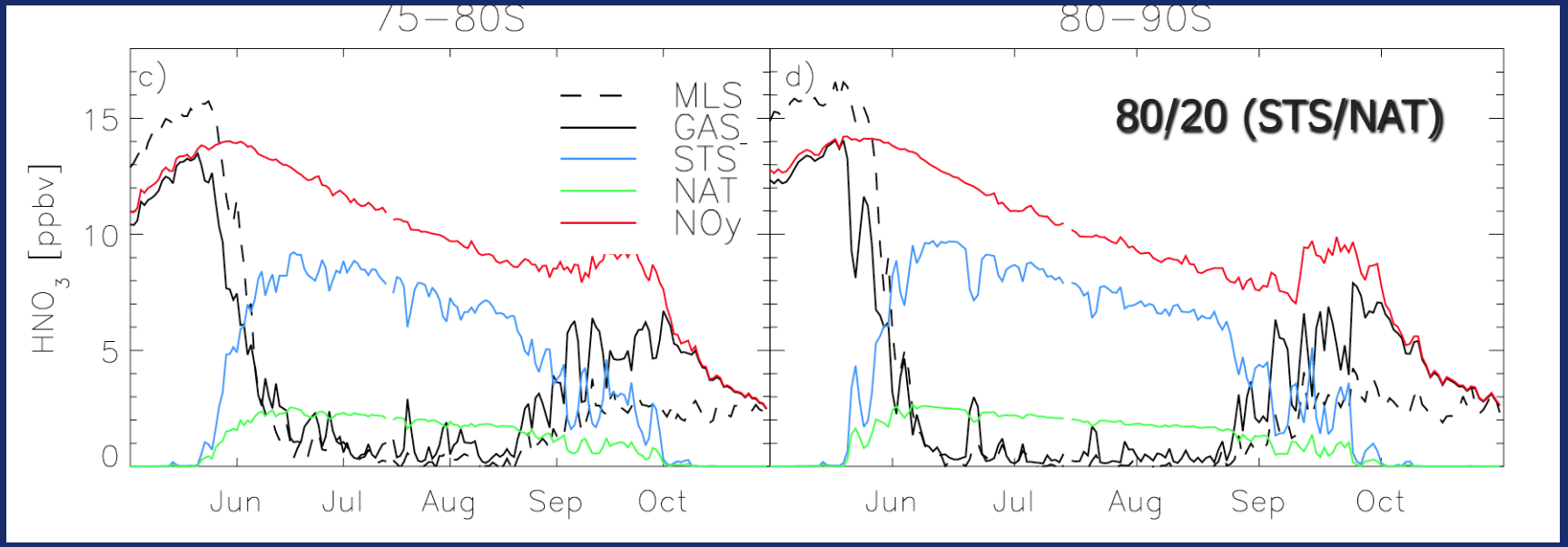




<= HNO_3 Total: 80%/20% (STS/NAT)

HNO_3 Evolution *** 475K *** 2005





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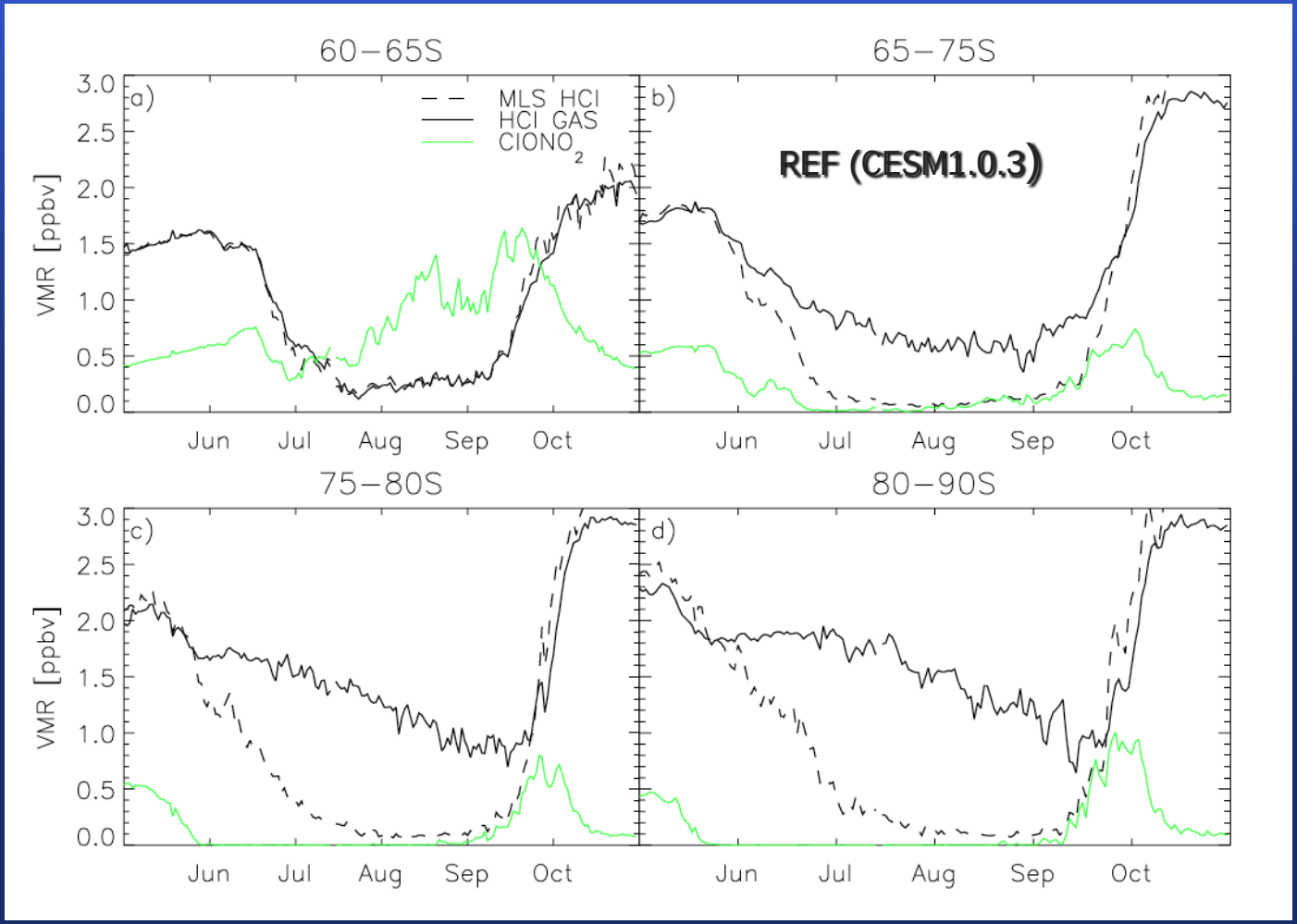
HCl Evolution *** 475K *** 2005

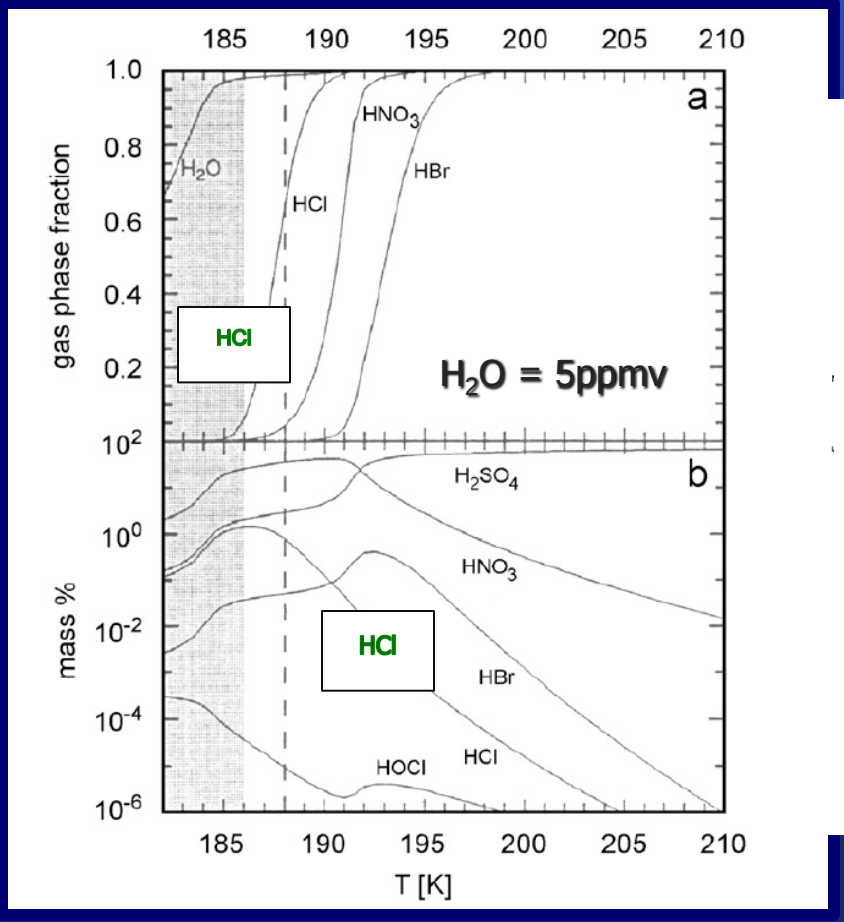


$ClONO_2 + HCl \Rightarrow Cl_2 + HNO_3$; $K = \frac{1}{4} * V * SAD * \gamma$

HCl (ppbv) *** 450K *** REF (CESM1.0.3)

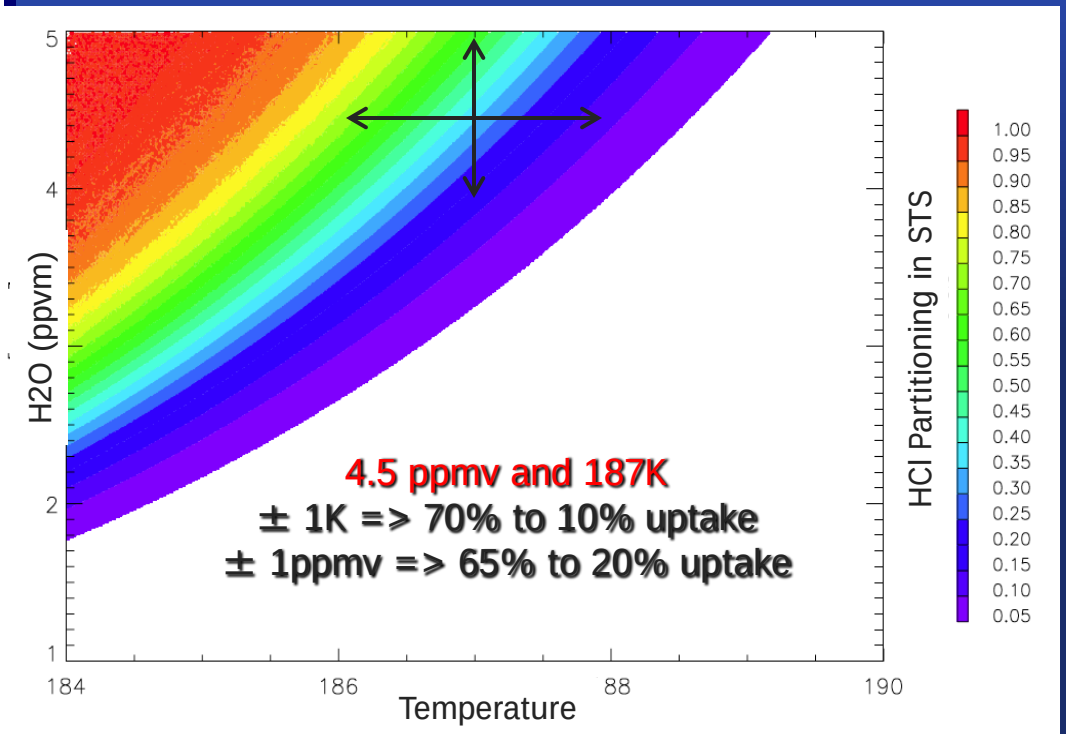
Solubility of HCl in STS?

Update of HCl in STS Aerosol

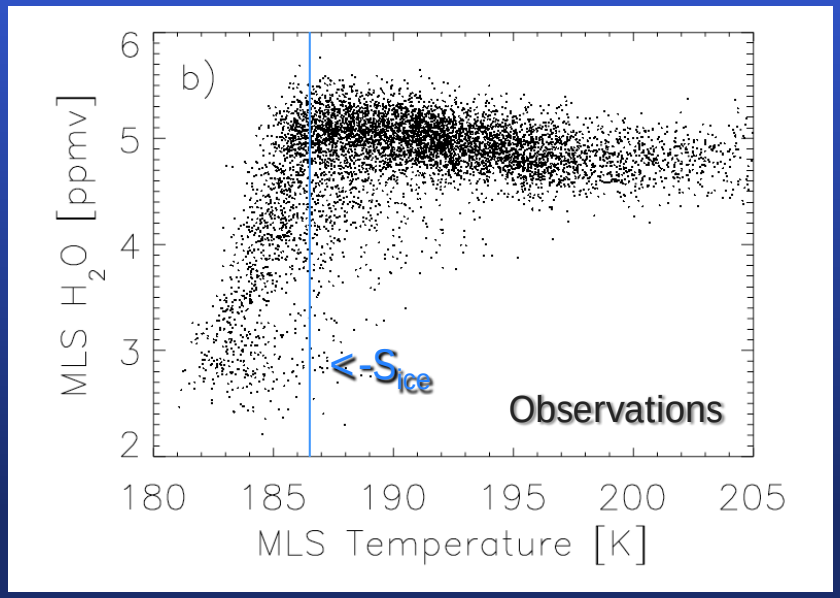


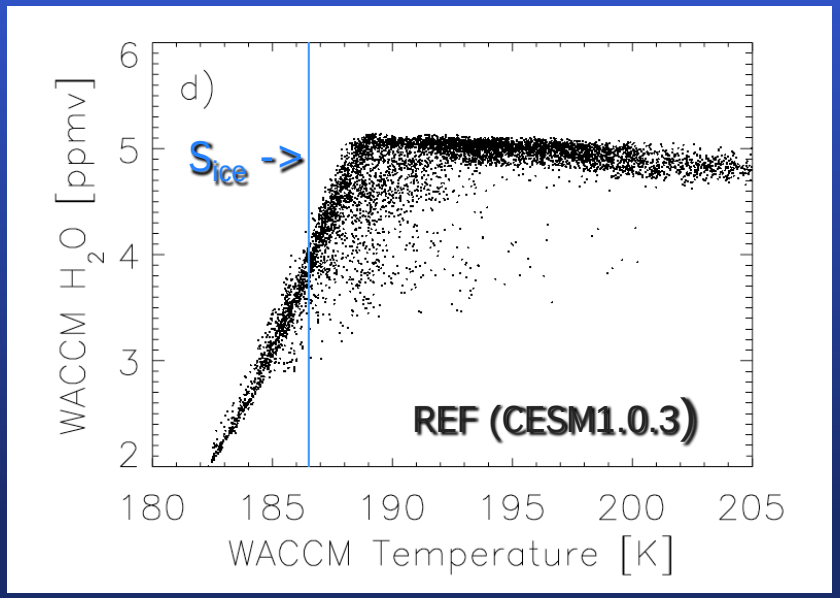
Lowe and MacKenzie, *et al 2008*.

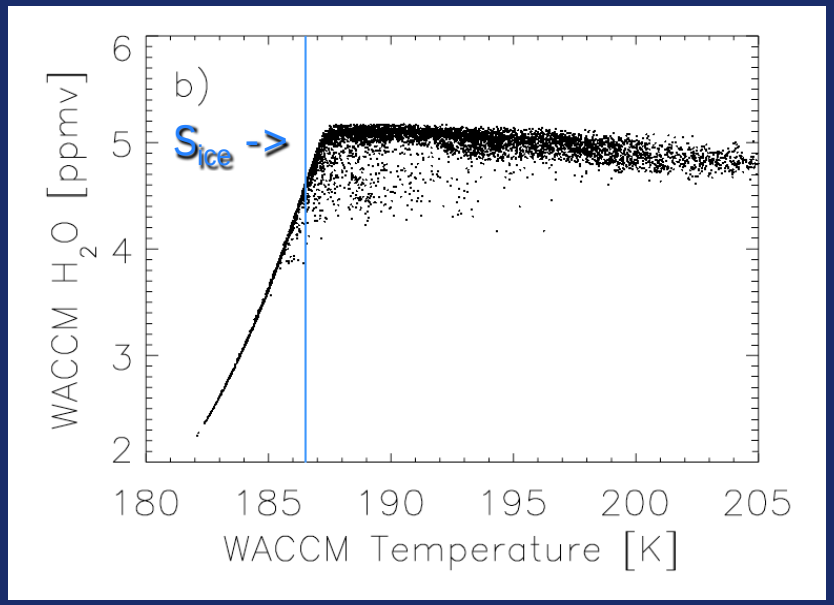
HCl uptake: Dependence on H_2O



H_2O *** 475K, >80S *** May 1st to July 1st 2005



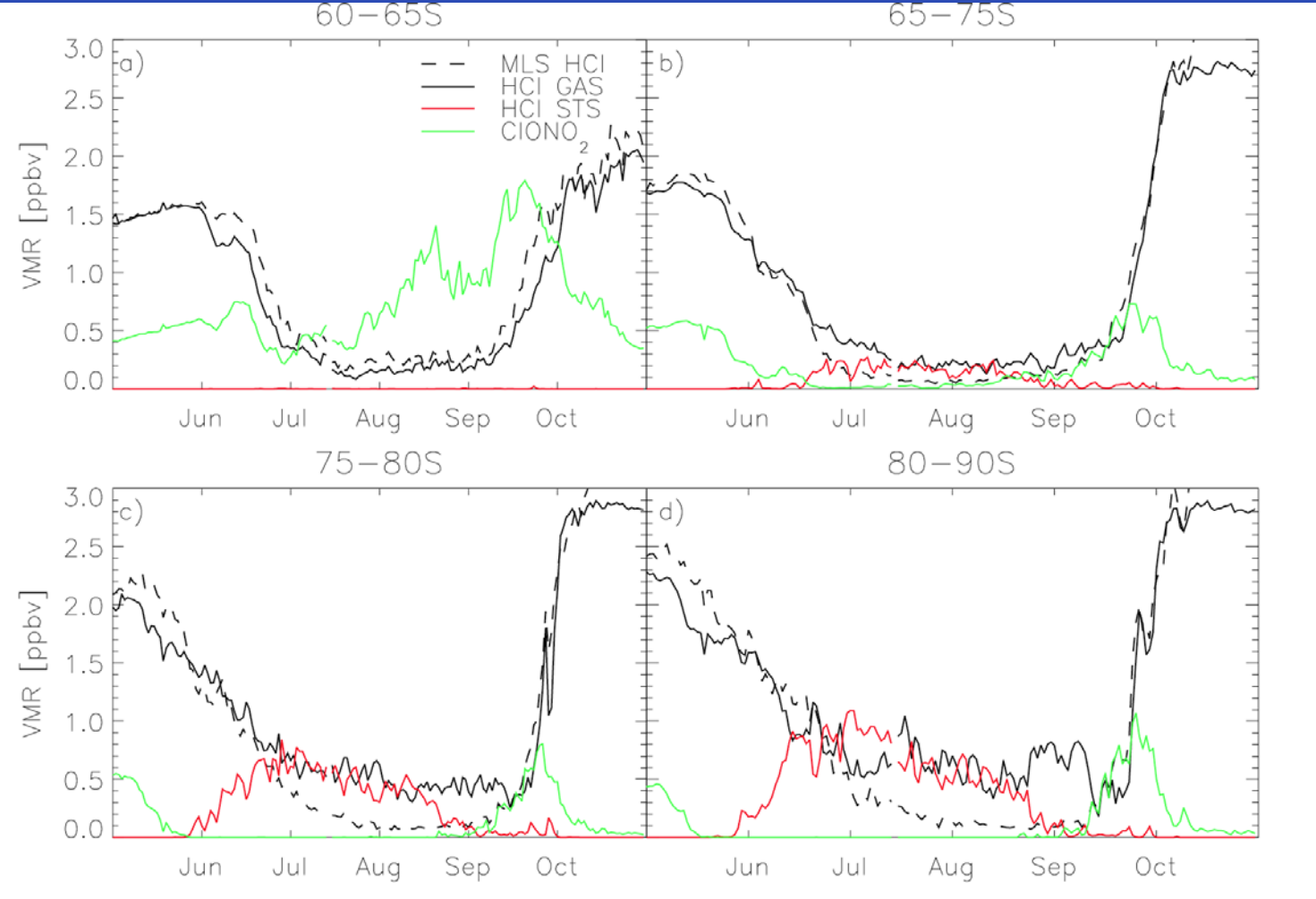




<= Increase cloud_rhminh 0.8->1.2

HCl Evolution *** 475K *** 2005

With H_{HCl} and -2K bias



$ClONO_2 + HCl \Rightarrow Cl_2 + HNO_3$; $K = \frac{1}{4} * V * SAD * \gamma$

HCl (ppbv) *** 475K *** with -2K T_{bias} & H_{HCl}

Summary

- **The base WACCM heterogeneous module was updated and examined using MLS observations. We found:**
  - **Better representation of HNO_3(g) when a 80/20% split in Total HNO_3 is applied to the STS and NAT modules.**
  - **Dehydration starts too early in WACCM. This will not only affect H_2O (g) abundance, but, for a given T, will decrease the solubility of HCl in STS.**
  - **Including the H_{HCl} process better represents winter evolution of HCl (g). Adding a -2K bias to the het module did enhance the HCl uptake.**

What I didn't talk about…

- We have also examined the importance of:
  - NAT particle density (0.1 => 0.01 per cm^{-3}).
  - Condensed phase HNO_3 photolysis (NAT and STS).
    - Both of these processes will not only impact HNO_3 (g), but also ClOx activation, deactivation through formation of $ClONO_2$.
- For comparison of H_2O, HNO_3, and HCl from the Fully Interactive version of WACCM will need to be accurate to <2K in the LS. The bias is currently much larger!

Thank you for your attention!

Impact on Ozone *** >80S