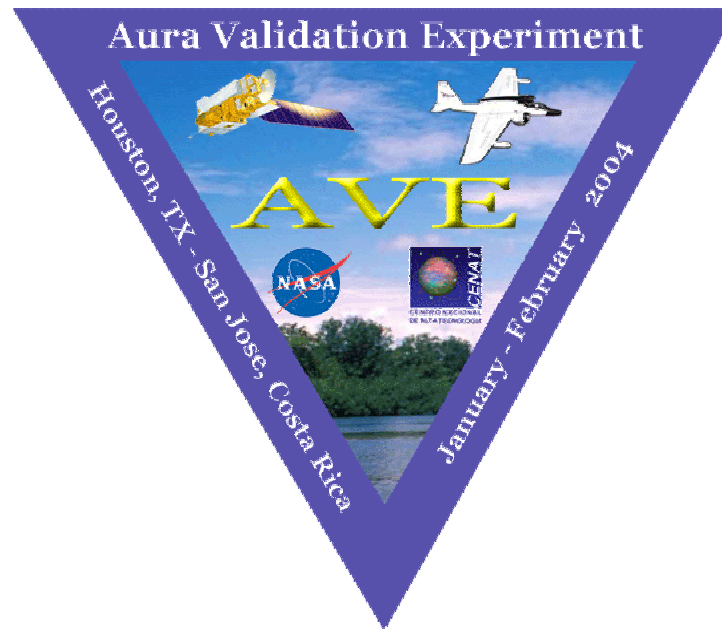
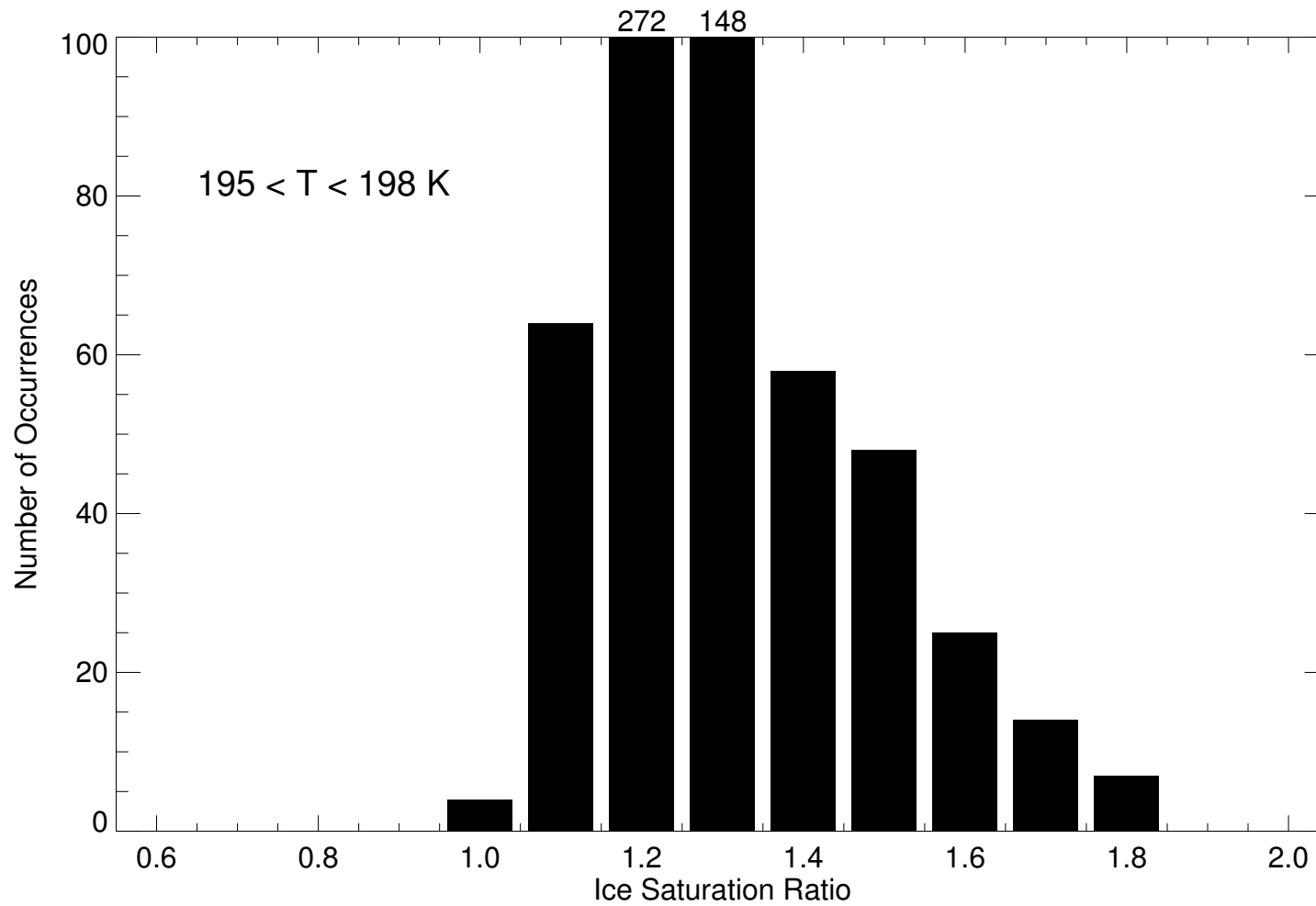


High Supersaturations observed at the Tropical Tropopause: Implications for Ice Nucleation

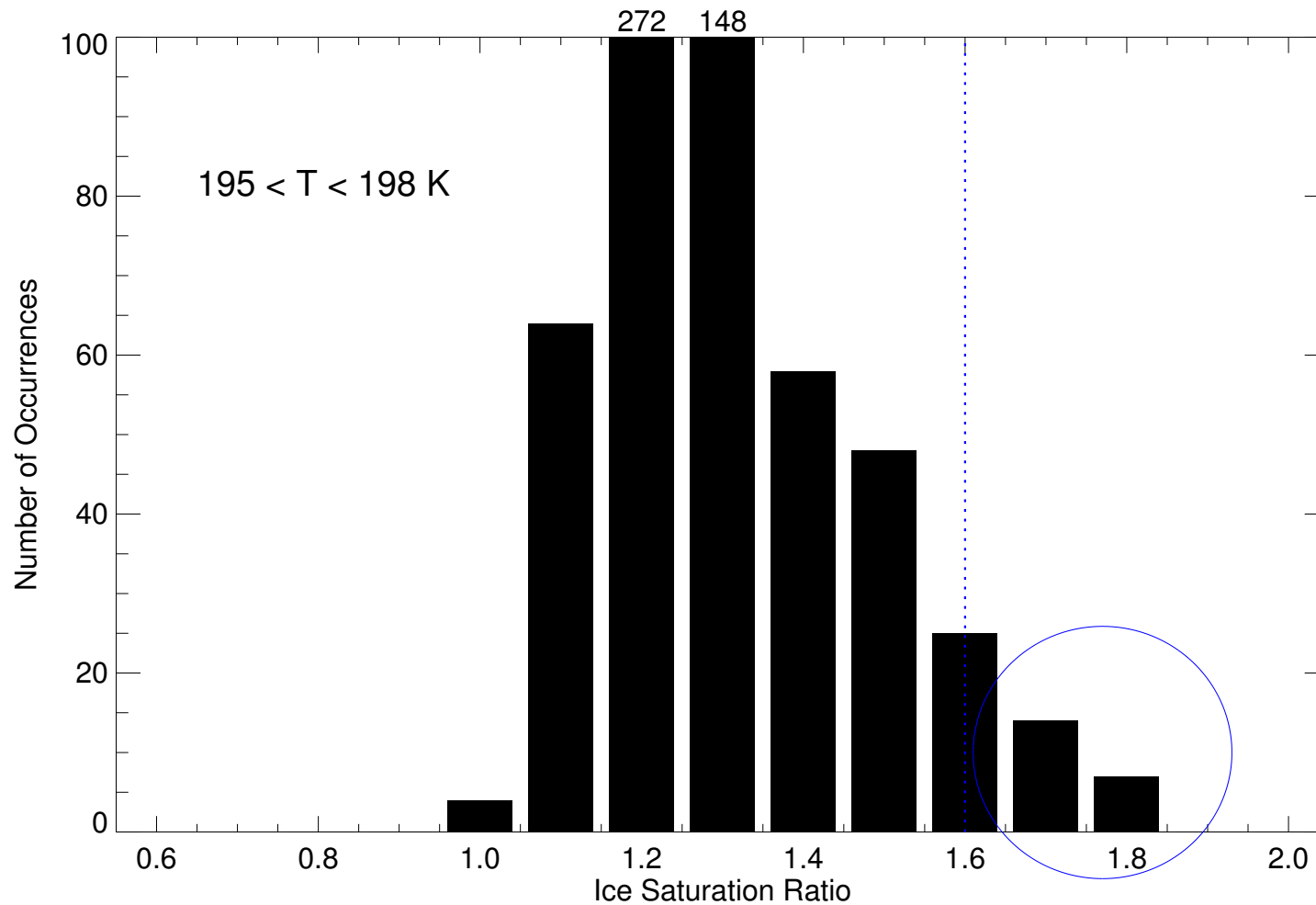


- Surprisingly high supersaturations at low temperatures indicated by in situ measurements
- Ice nucleation simulations are used to evaluate the implications

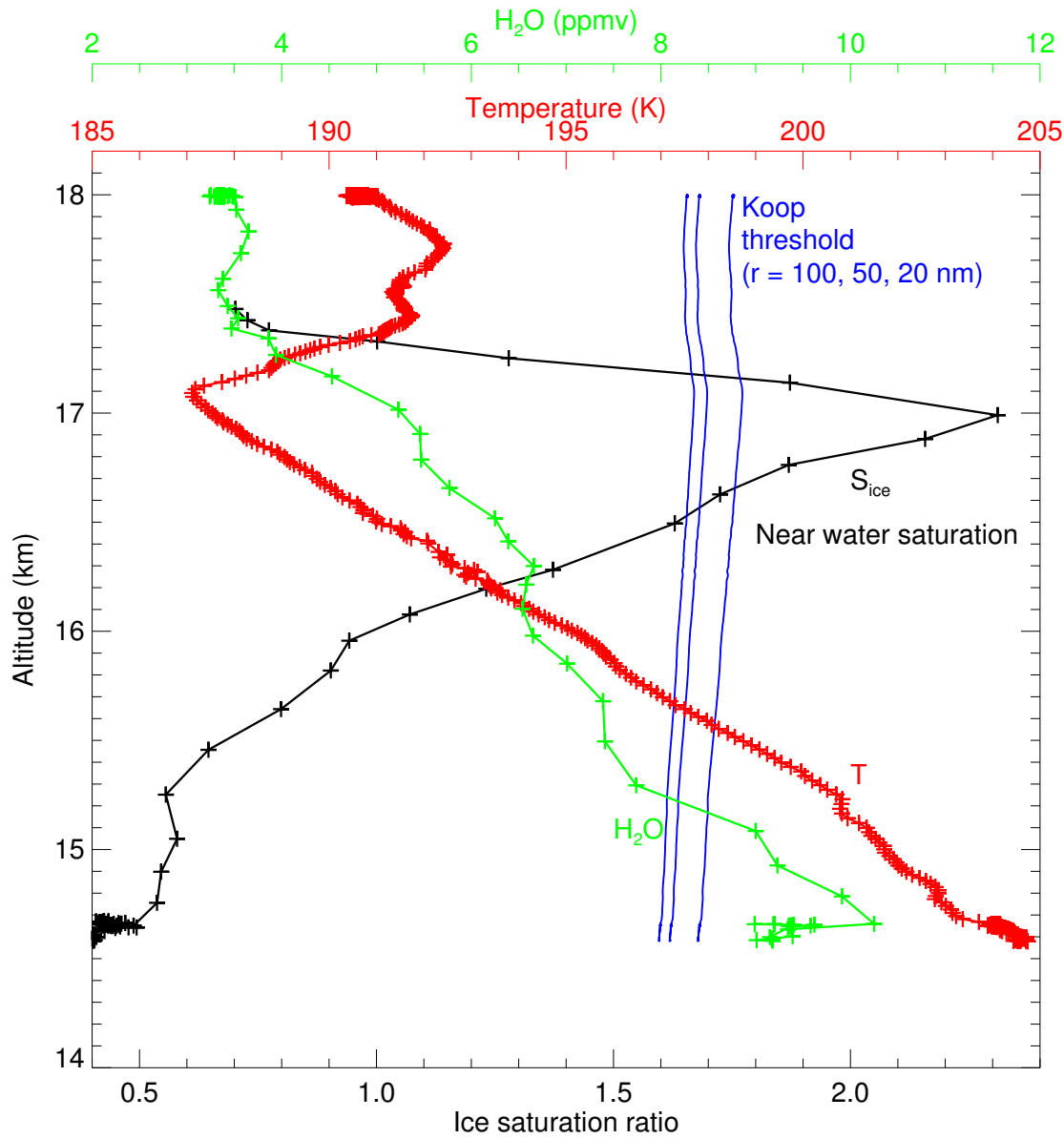
CRYSTAL-FACE July 13, 2002 ice saturation ratio measurements
[E. Weinstock, J. Smith, J. Pitmann, R. Herman, P. Bui]



CRYSTAL-FACE July 13, 2002 ice saturation ratio measurements
[E. Weinstock, J. Smith, J. Pitmann, R. Herman, P. Bui]



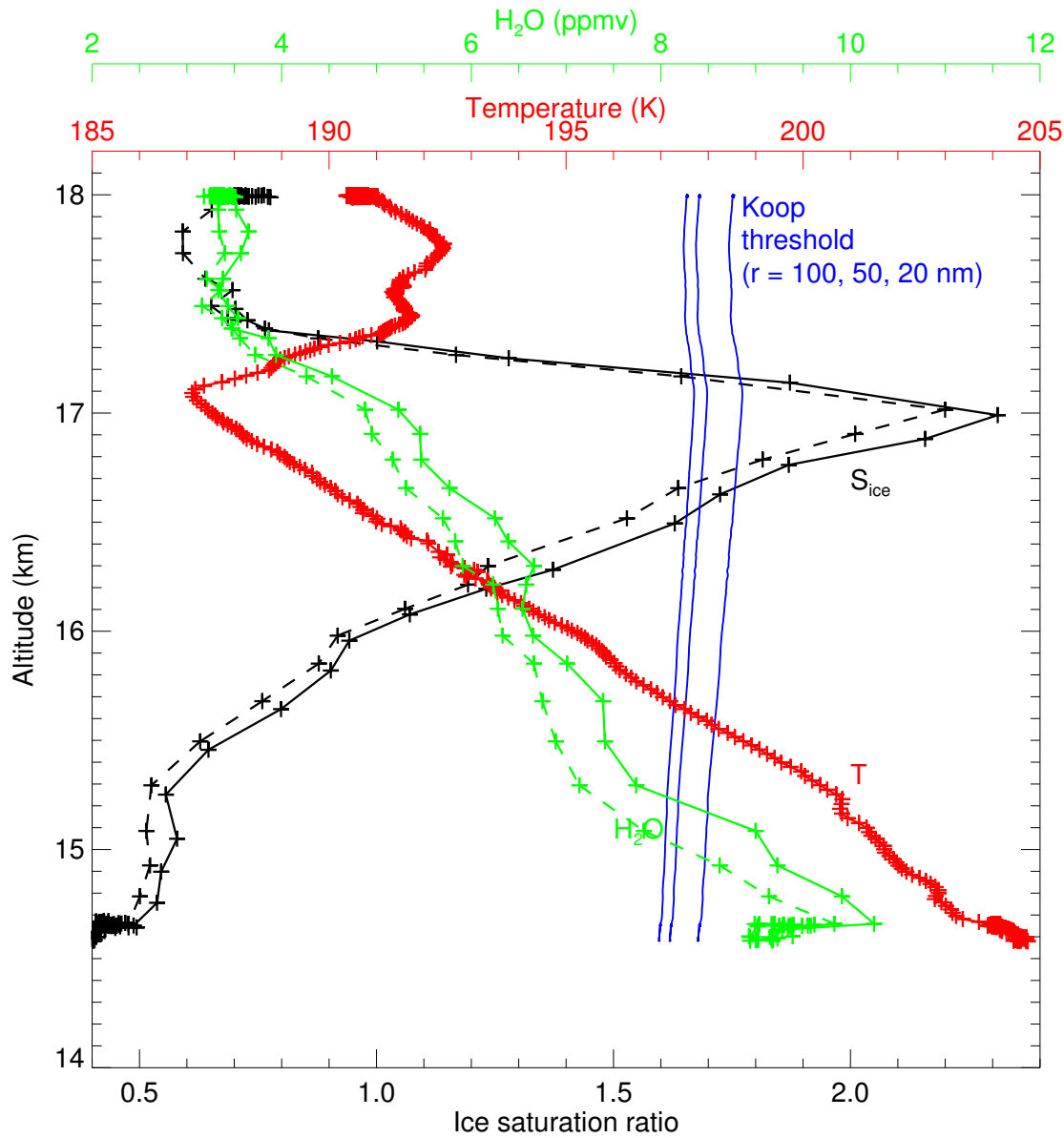
Koop et al. parameterization (based on lab measurements) predicts threshold saturation ratio for sulfate aerosol freezing is about 1.6



Jan. 29, 2004

Temperature: NOAA
[T. Thompson, K. Rosenlof]

Water vapor: Harvard
[E. Weinstock, J. Pittman,
J. Smith]

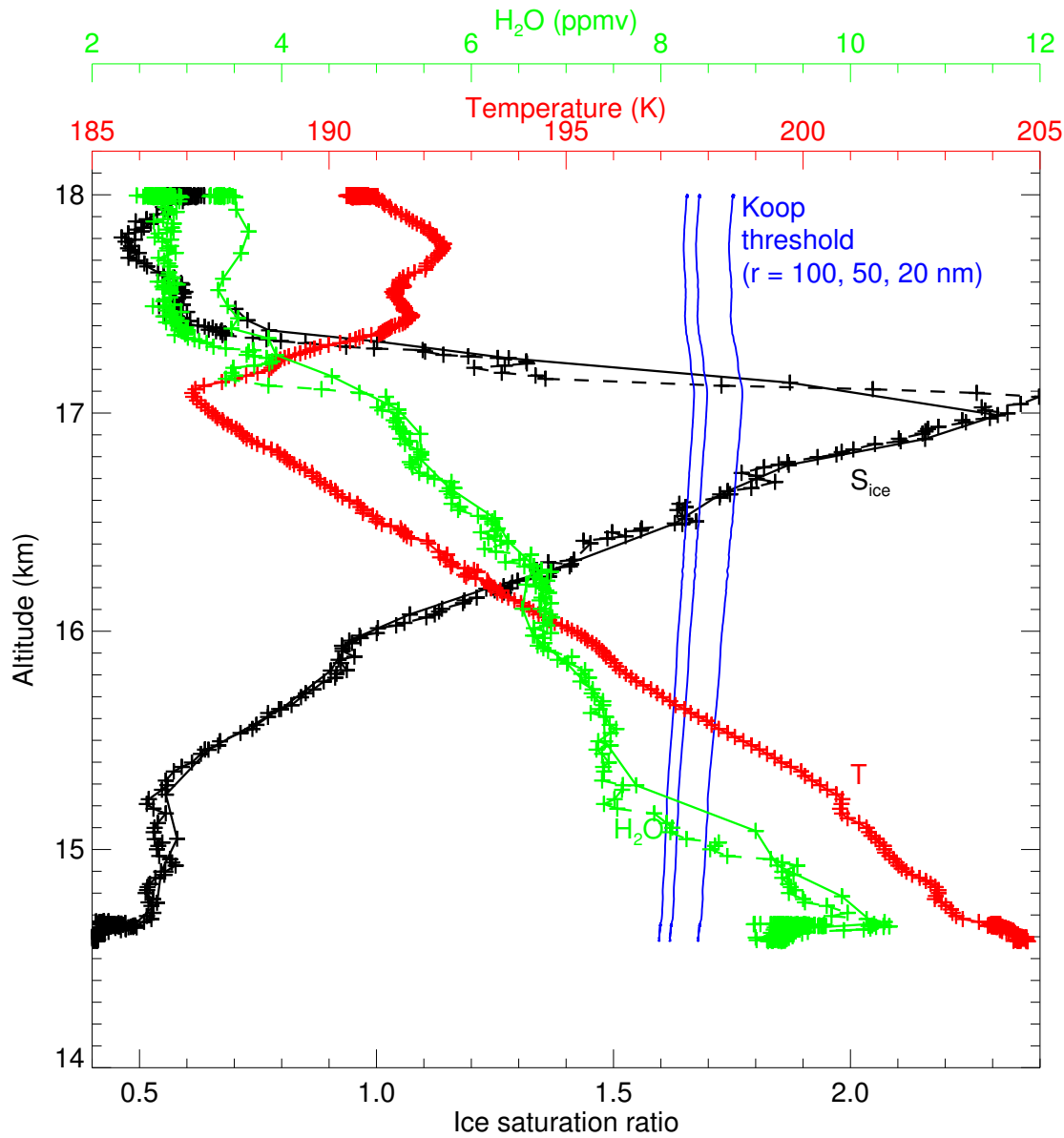


Jan. 29, 2004

Temperature: NOAA
[T. Thompson, K. Rosenlof]

Water vapor: Harvard
[E. Weinstock, J. Pittman,
J. Smith]

Total water: Harvard
[E. Weinstock, J. Smith,
D. Sayres]

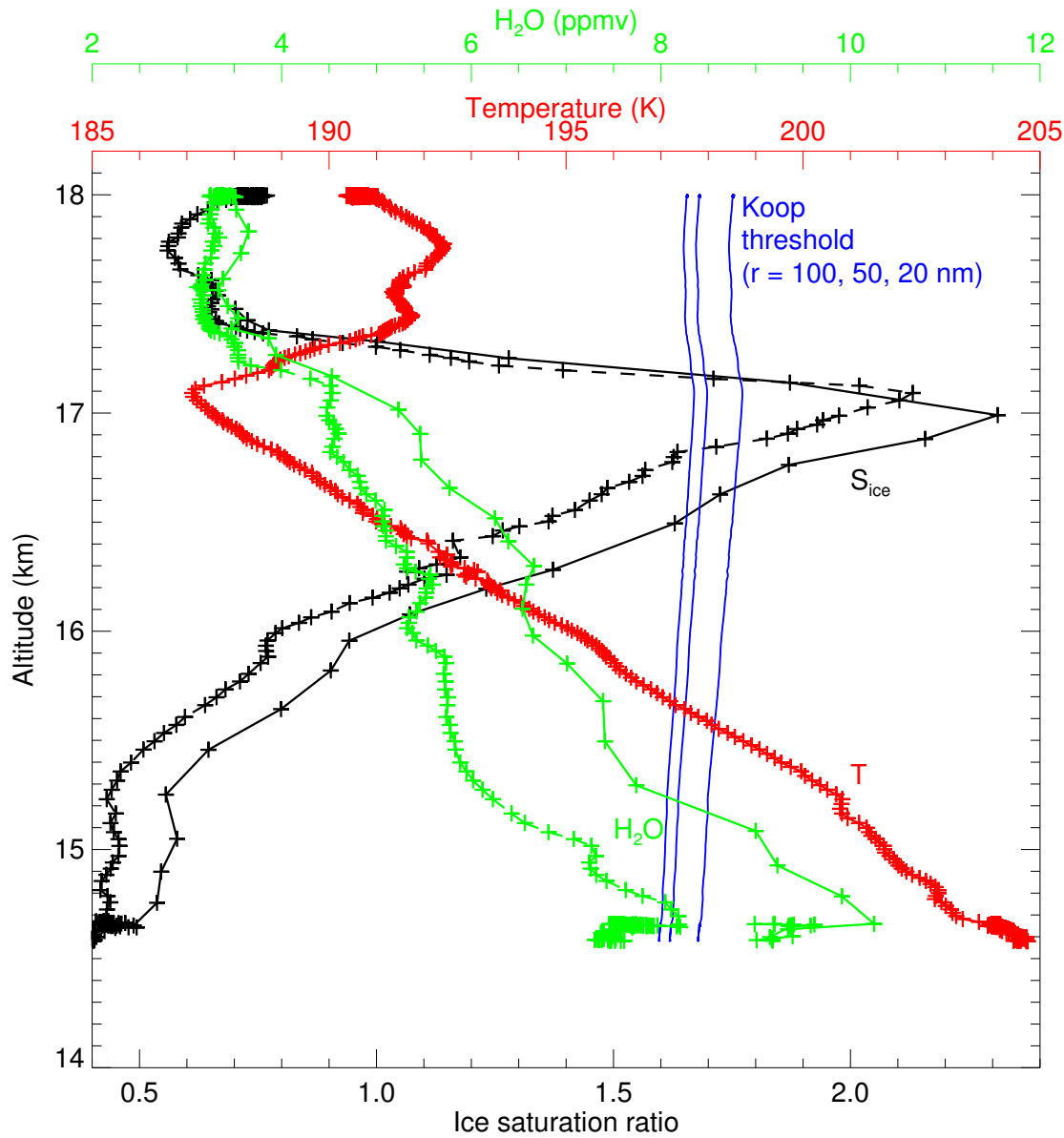


Jan. 29, 2004

Temperature: NOAA
[T. Thompson, K. Rosenlof]

Water vapor: Harvard
[E. Weinstock, J. Pittman,
J. Smith]

Water vapor: JLH
[R. Herman],

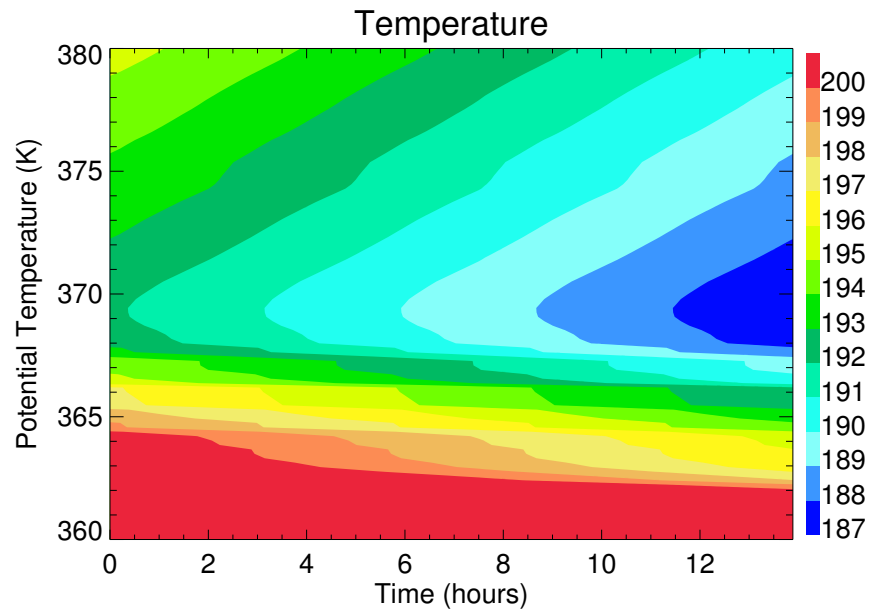


Jan. 29, 2004

Temperature: NOAA
[T. Thompson, K. Rosenlof]

Water vapor: Harvard
[E. Weinstock, J. Pittman,
J. Smith]

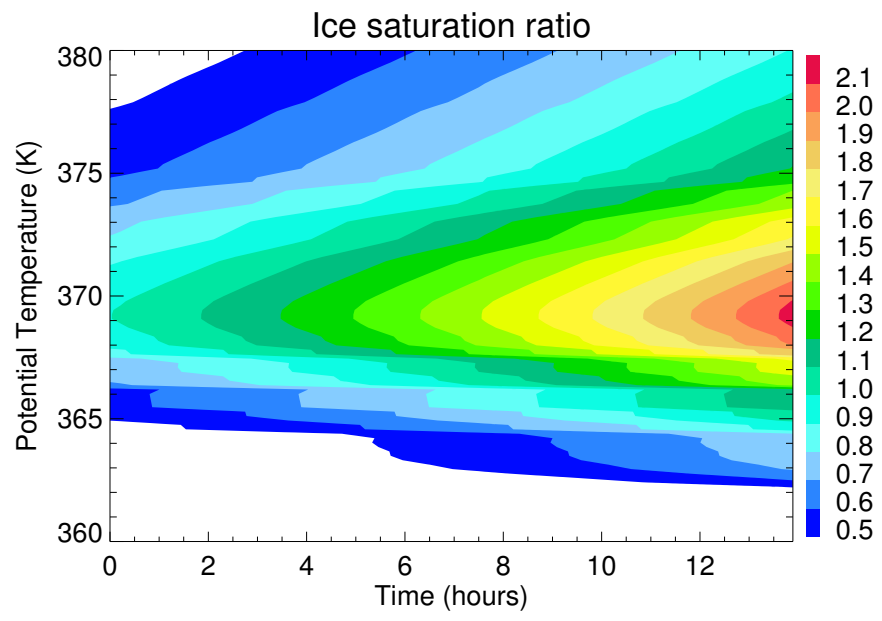
Total water: ALIAS
[C. Webster],

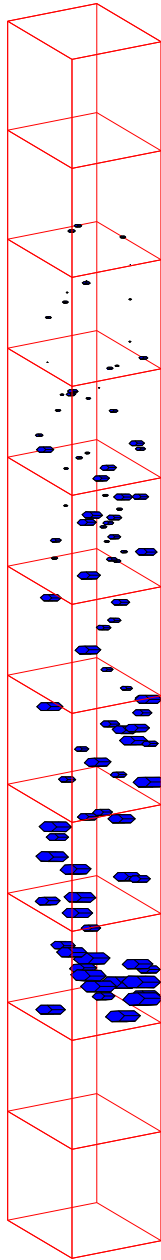


Idealized cloud simulations assuming constant cooling rate

Final temperature profile $T_f(z)$ taken from WB-57 descent

Linear cooling from $T_f - 5$ K to T_f





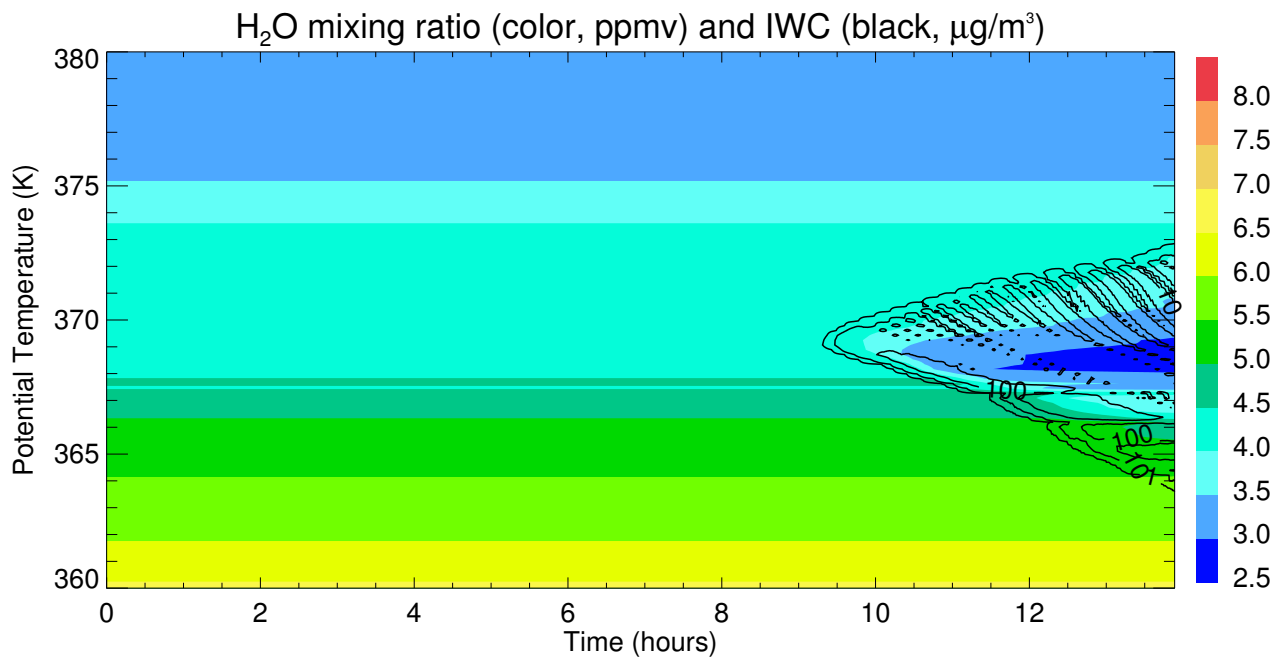
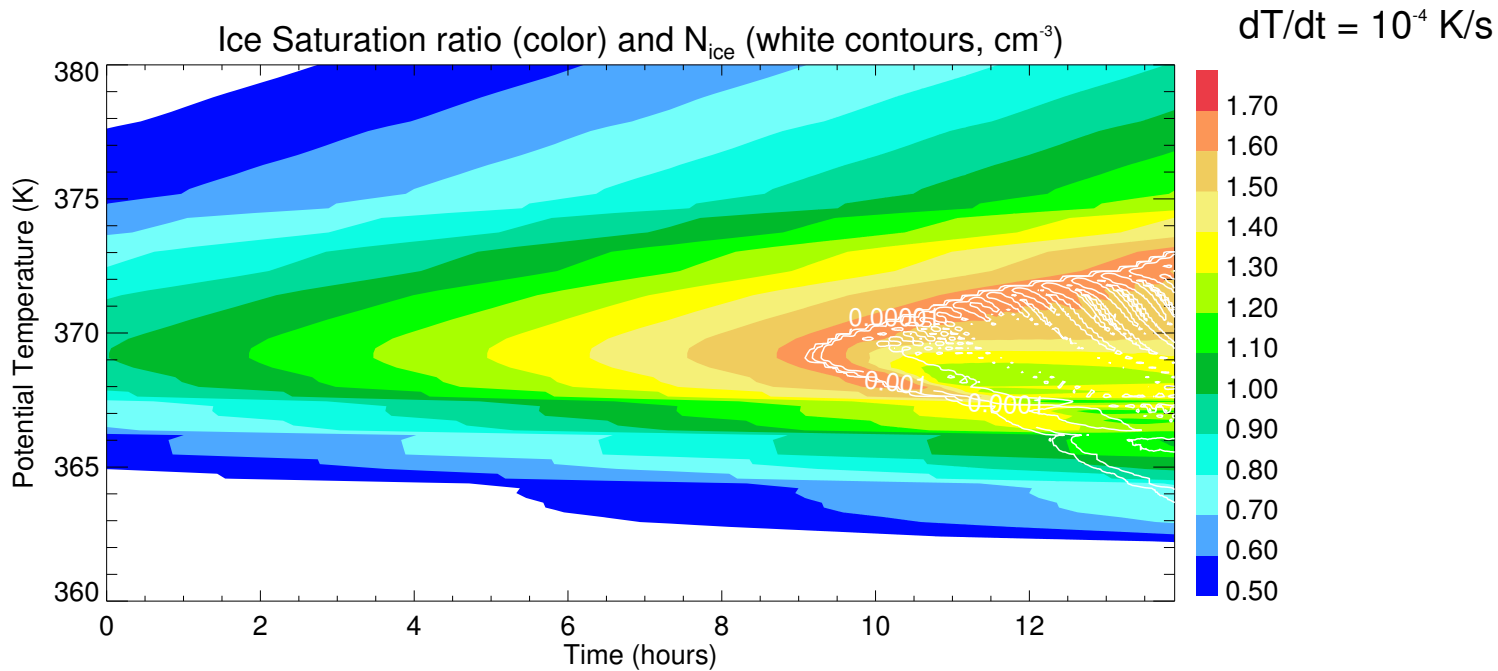
1-D Cloud model

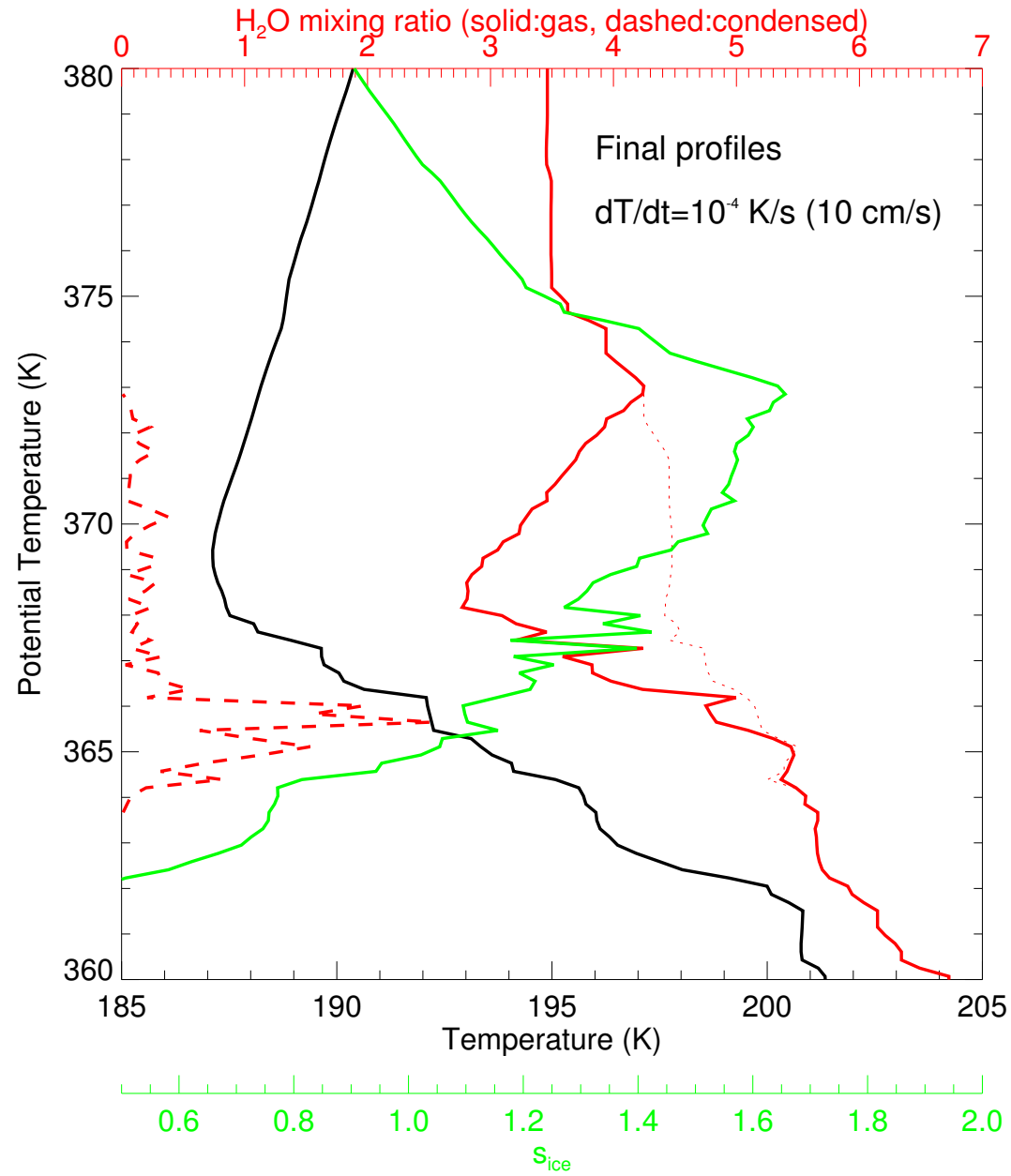
-Cloud formation is simulated in cooling column of air

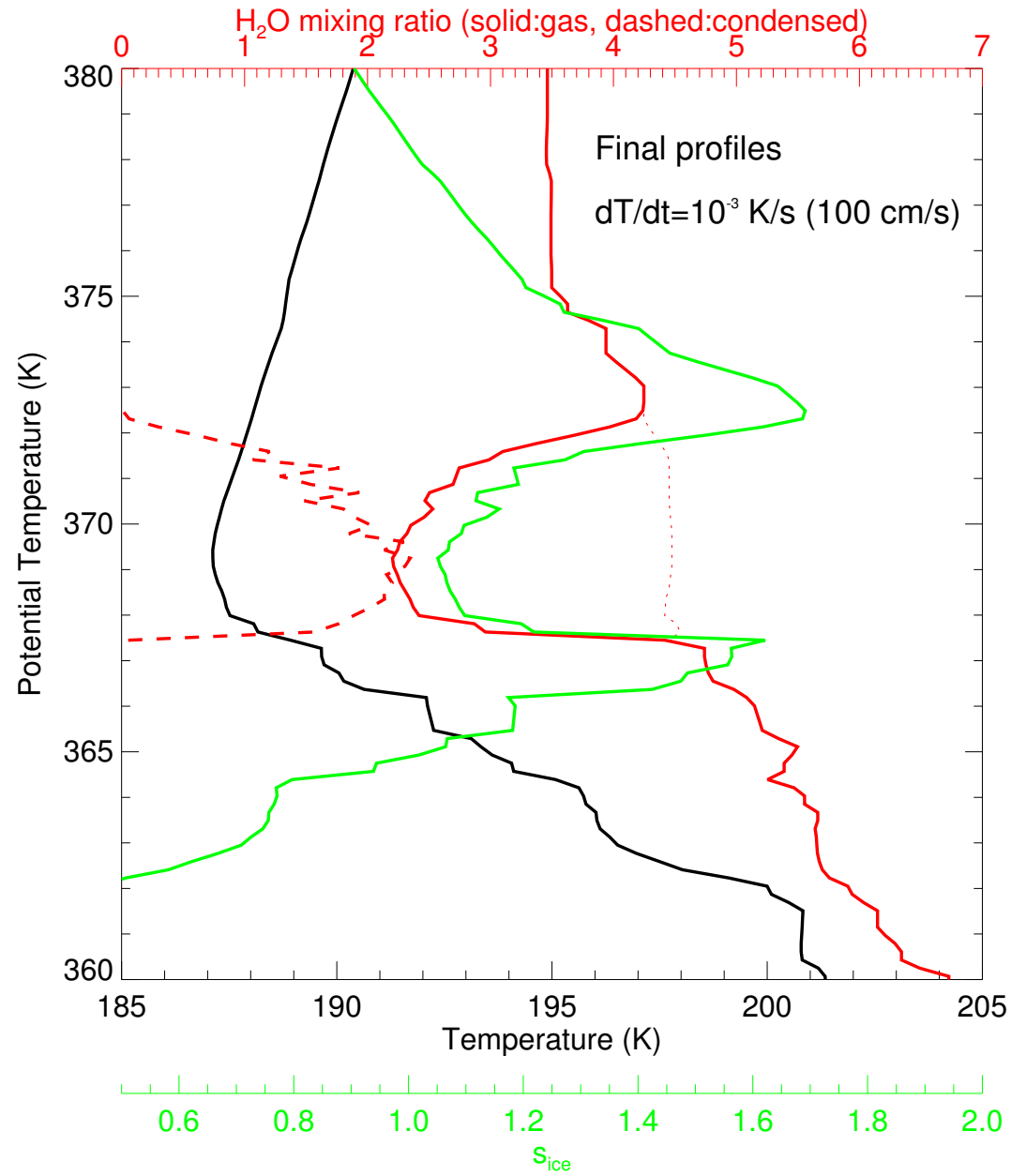
-Thousands of individual ice crystals are tracked

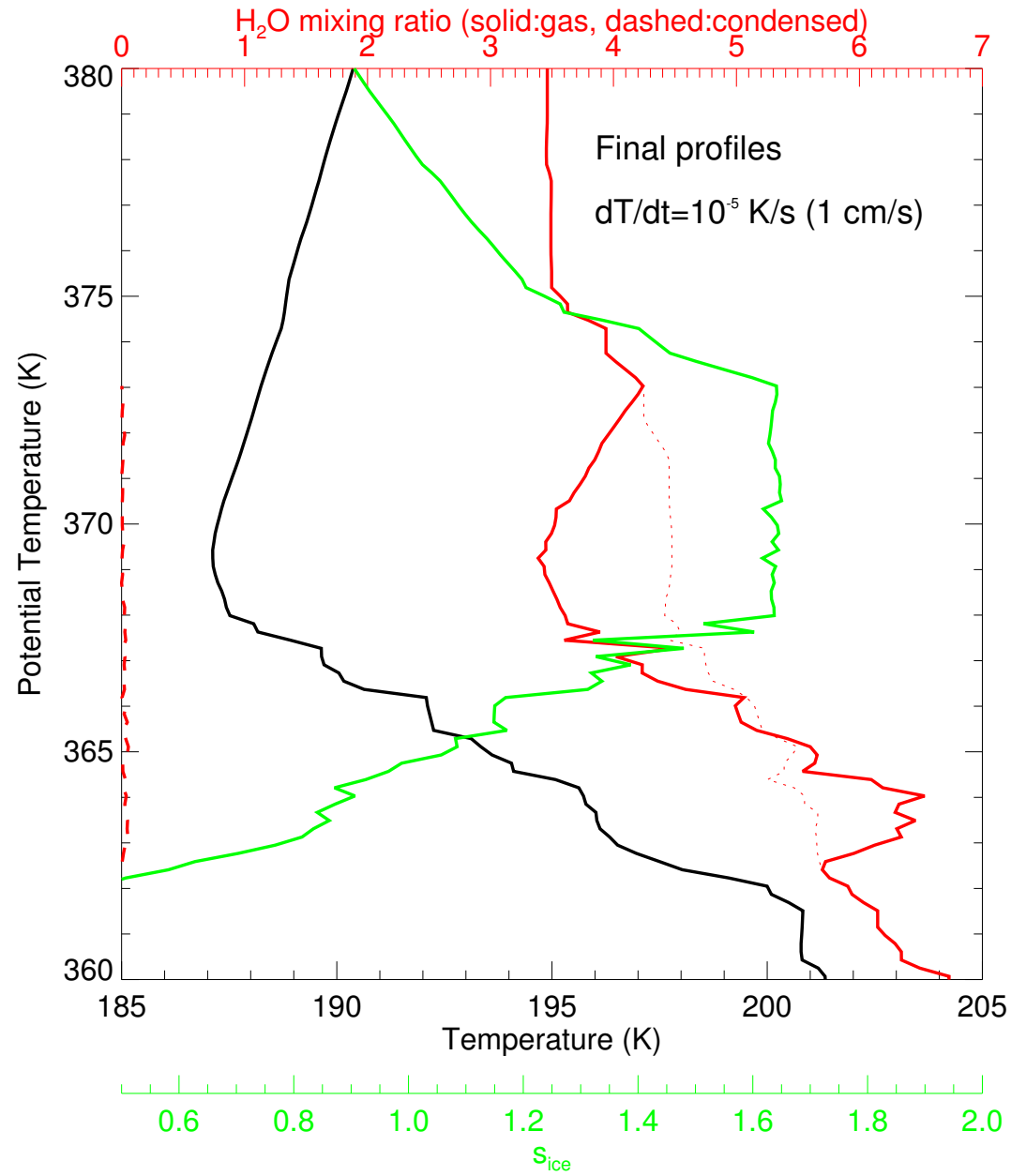
-Processes: crystal nucleation, deposition growth, and sedimentation

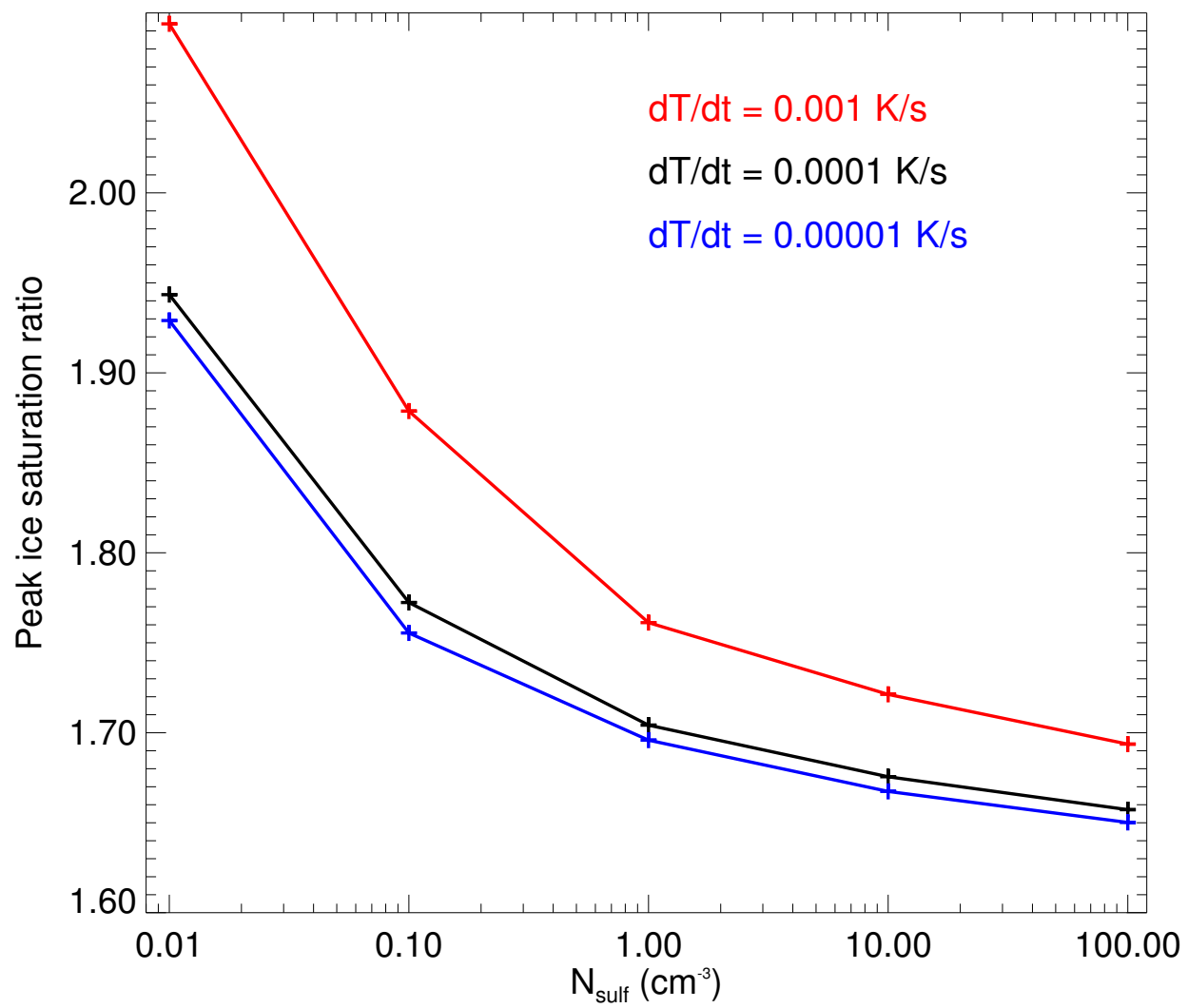
-Initial aerosol size distribution ($r_g=0.1 \mu\text{m}, \sigma=1.5$)
based on NMAS and FCAS measurements
[C. Wilson and J. Reeves]











Implications for ice nucleation

Assuming the high supersaturations cannot be attributed to instrument error, there are only two possibilities:

- The vast majority of the aerosols near the tropical tropopause are somehow different and much harder to freeze than aerosols used in laboratory experiments.
 - DeMott et al. [2003] noted that certain organics in aerosols can delay onset of homogeneous freezing.
- Expressions used to calculate saturation vapor pressure over supercooled liquid at low temperature are off by about 20%.
 - Most laboratory experiments measure the activity (=RH) at which aerosols freeze. Conversion to RHI at freezing point requires use of vapor pressure expressions ($p_{sat,l}$ is not well constrained at low T).
 - Recent AIDA aerosol chamber experiments [Möhler et al., 2003] directly measure vapor pressure and temperature at which aerosols freeze ($p_{sat,l}$ not needed). AIDA experiments: $s_{i,crit} \simeq 1.8$ at 190 K