

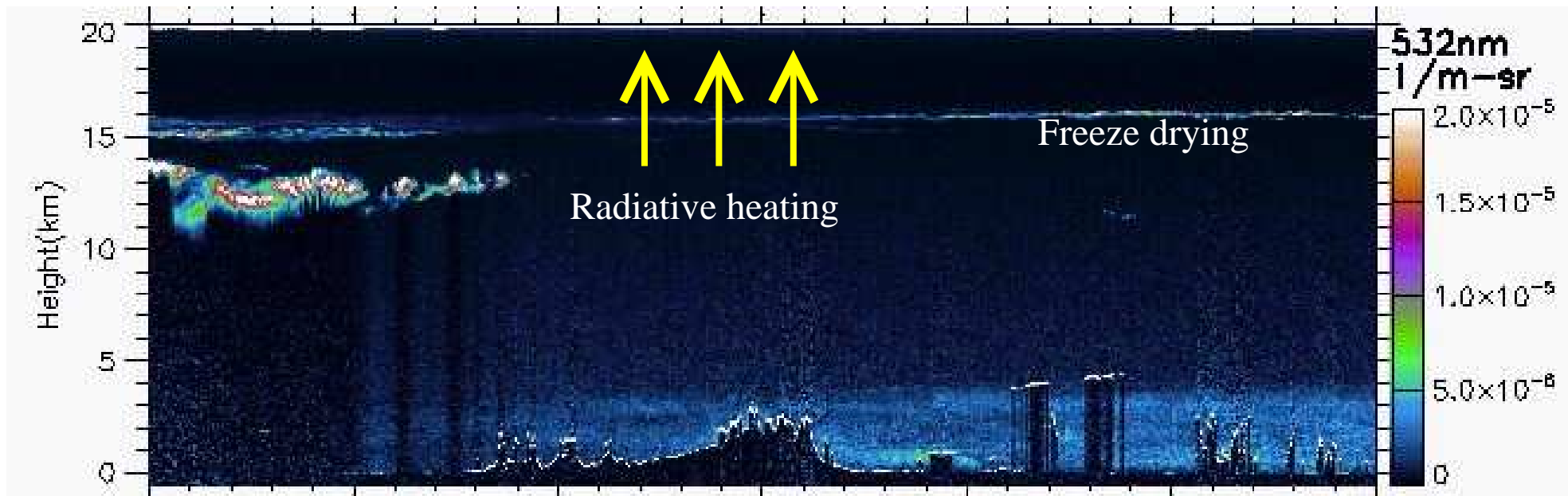
Ice Concentrations and Extinctions in Tropical Tropopause Layer Thin Cirrus

Eric Jensen and Leonhard Pfister

NASA Ames Research Center

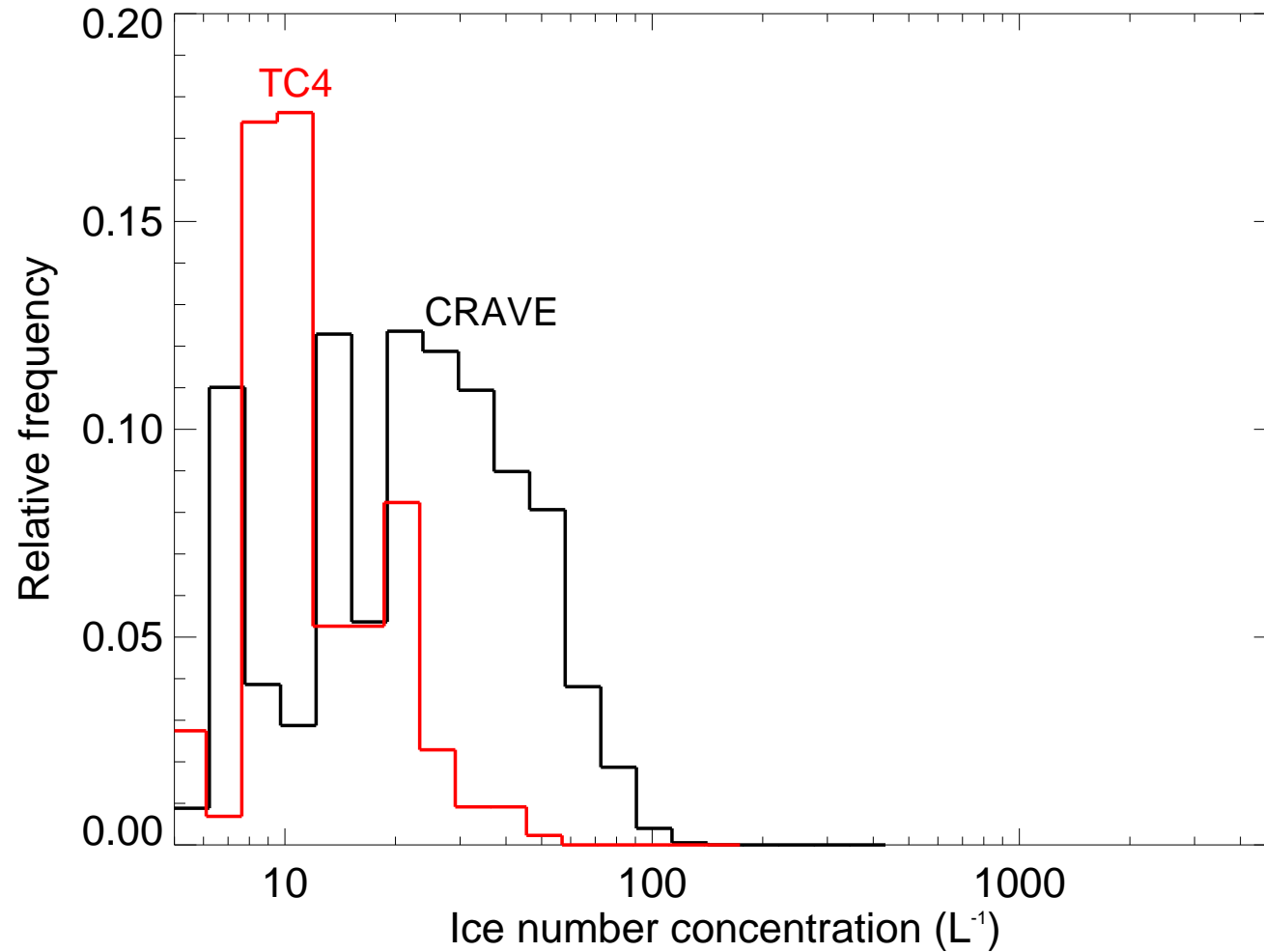
Daniel Murphy

NOAA Earth System Research Laboratory
Chemical Sciences Division



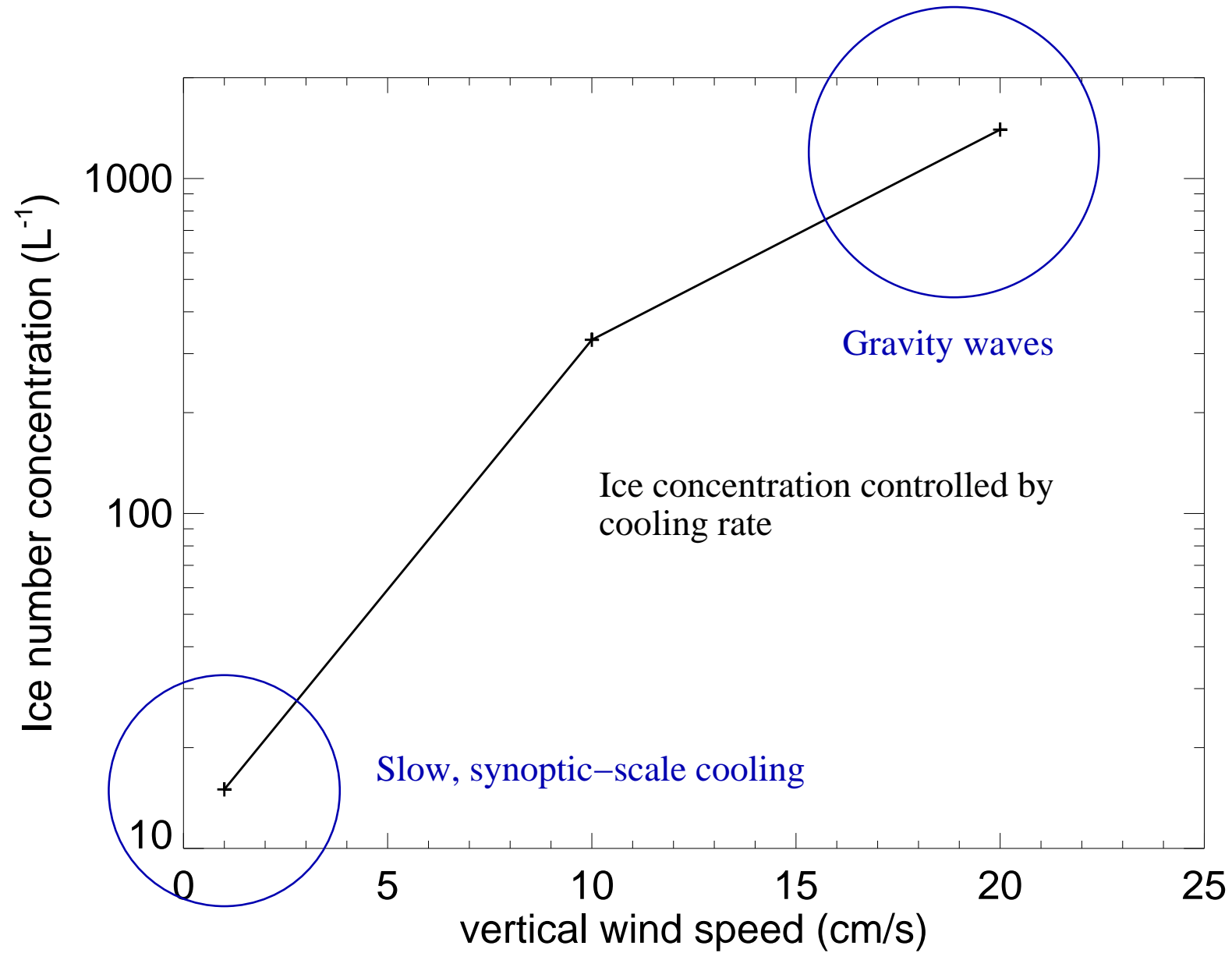
- Measured low ice concentrations, broad size distributions, and low extinctions

Subvisible cirrus ice number concentrations

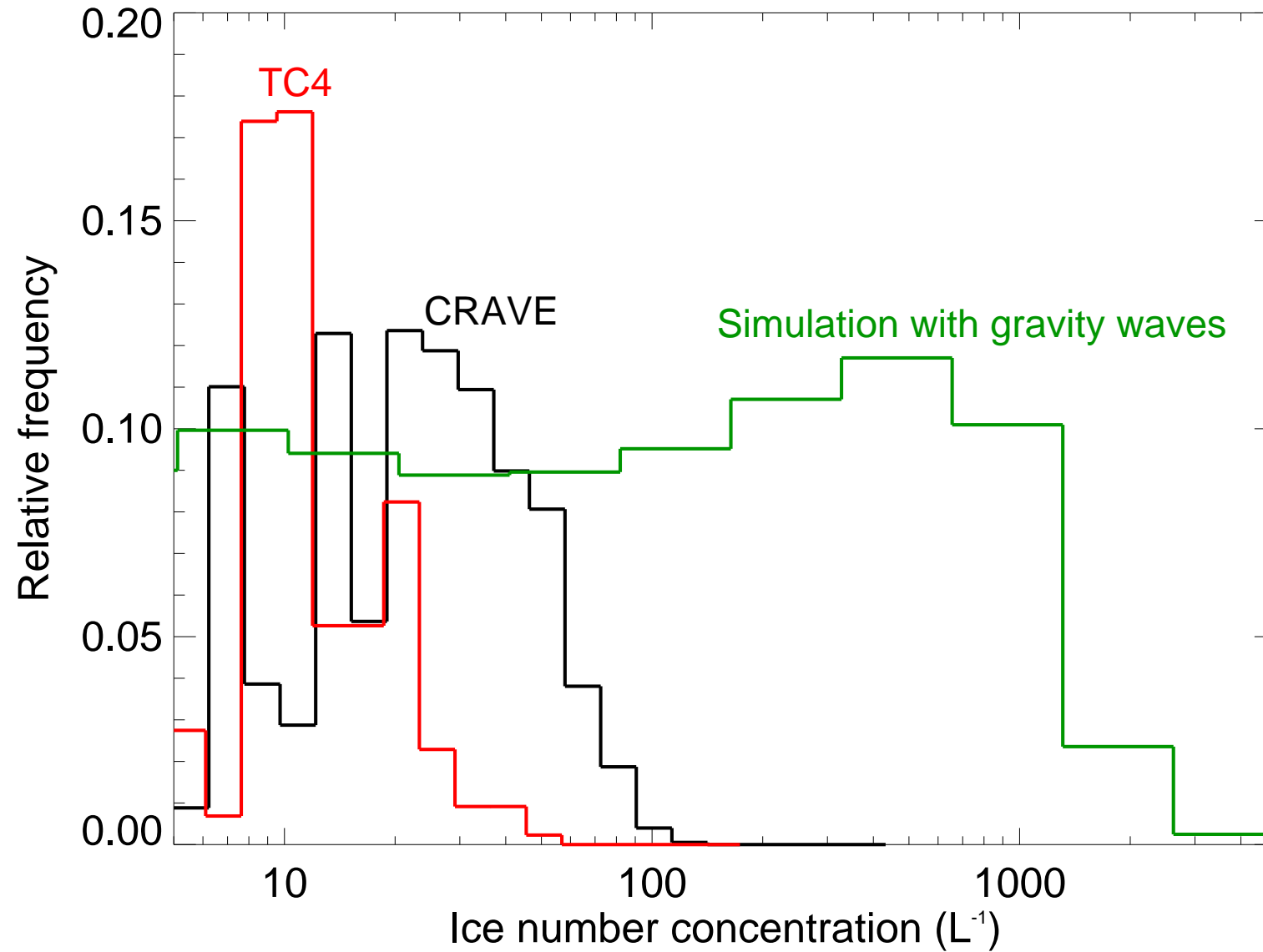


- Consistently low ice concentrations measured in TTL cirrus from multiple campaigns (PreAVE, CRAVE, TC4, AMMA, SCOUT, etc.)
- see M. Krämer poster

Homogeneous freezing



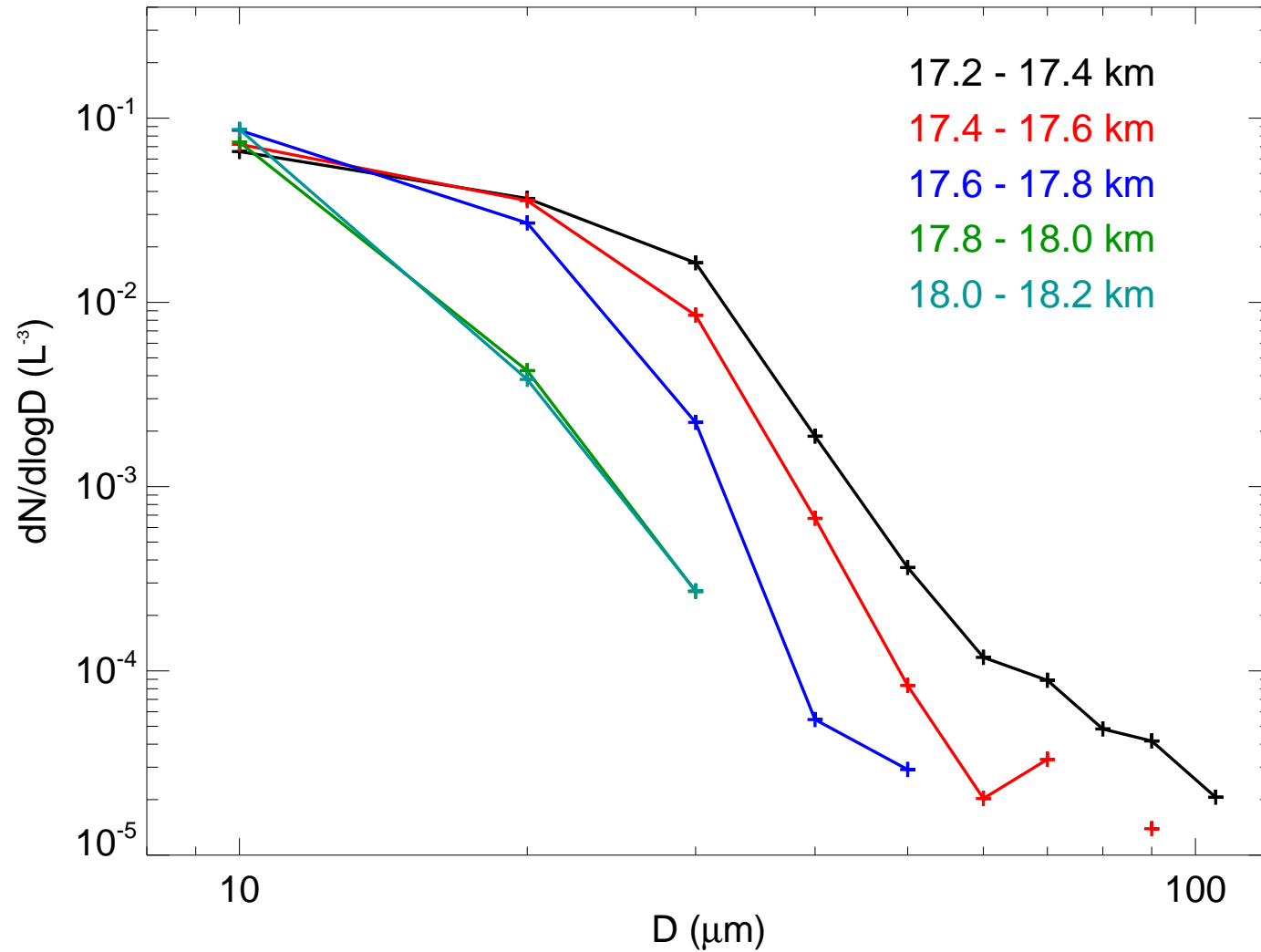
Subvisible cirrus ice number concentrations



- Measured ice concentrations are far lower than theory predicts.

TTL cirrus ice crystal size distributions

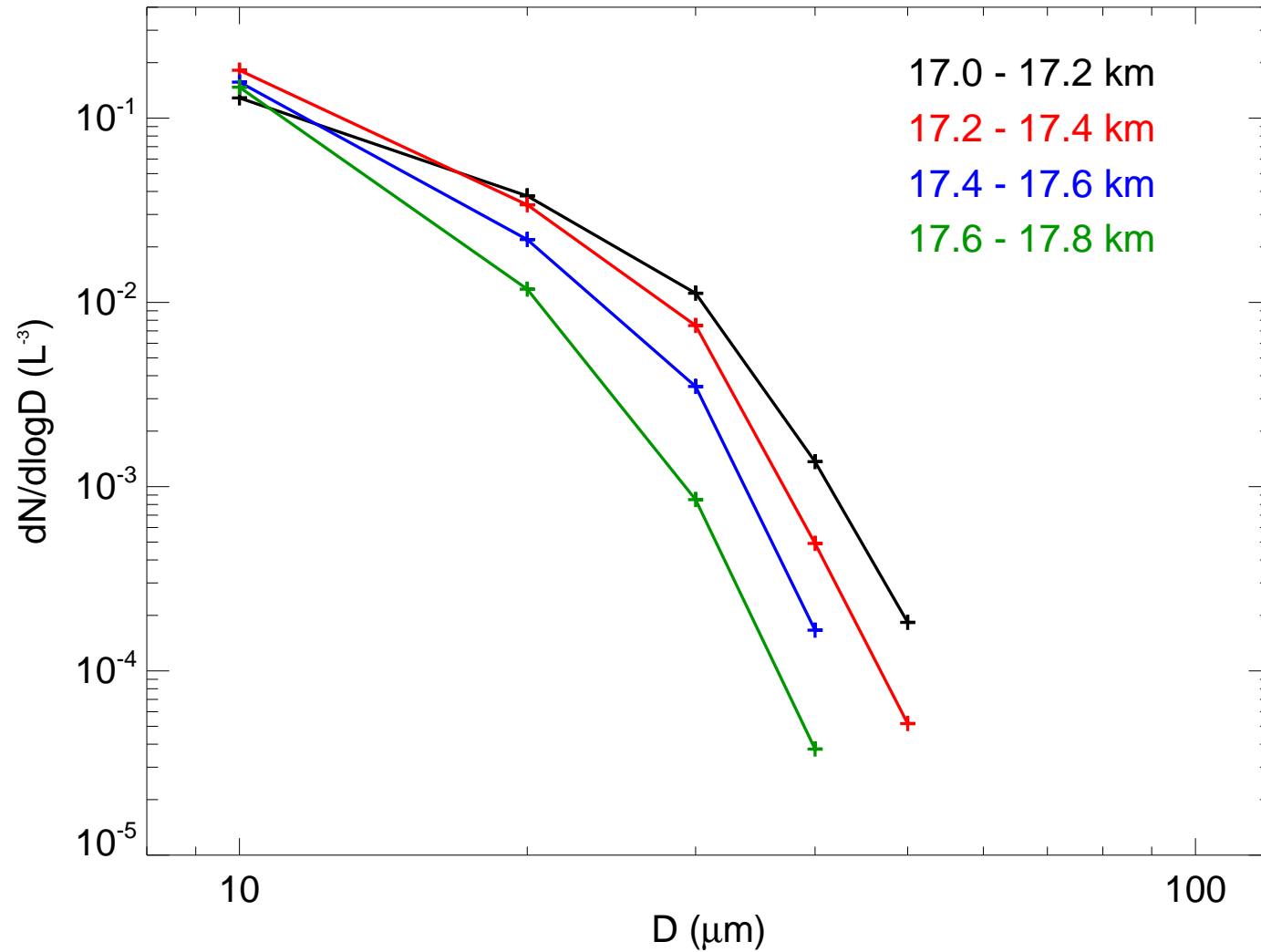
01 Feb SVC 2D-S



- Measured ice crystal size distributions are broad.

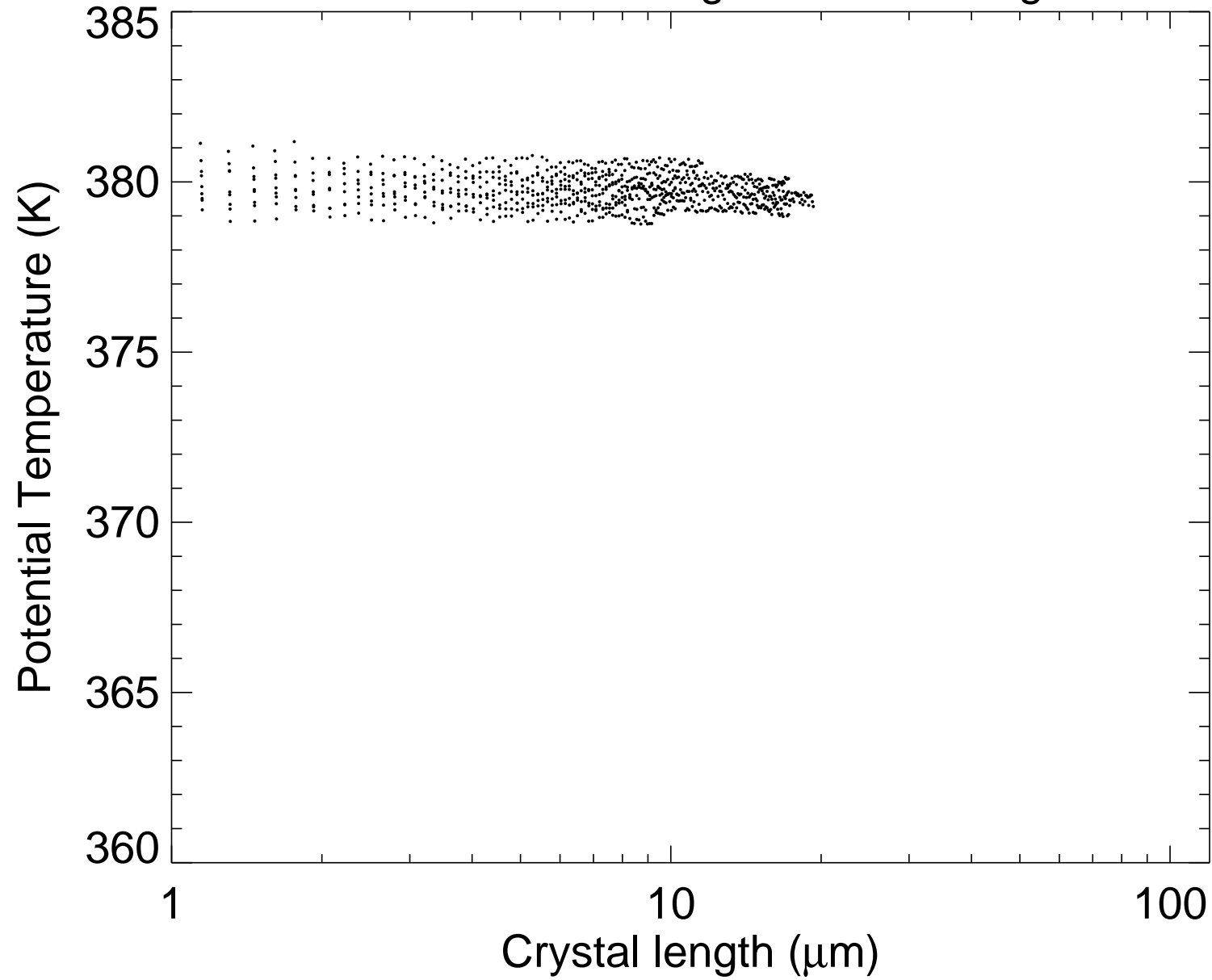
TTL cirrus ice crystal size distributions

02 Feb SVC 2D-S

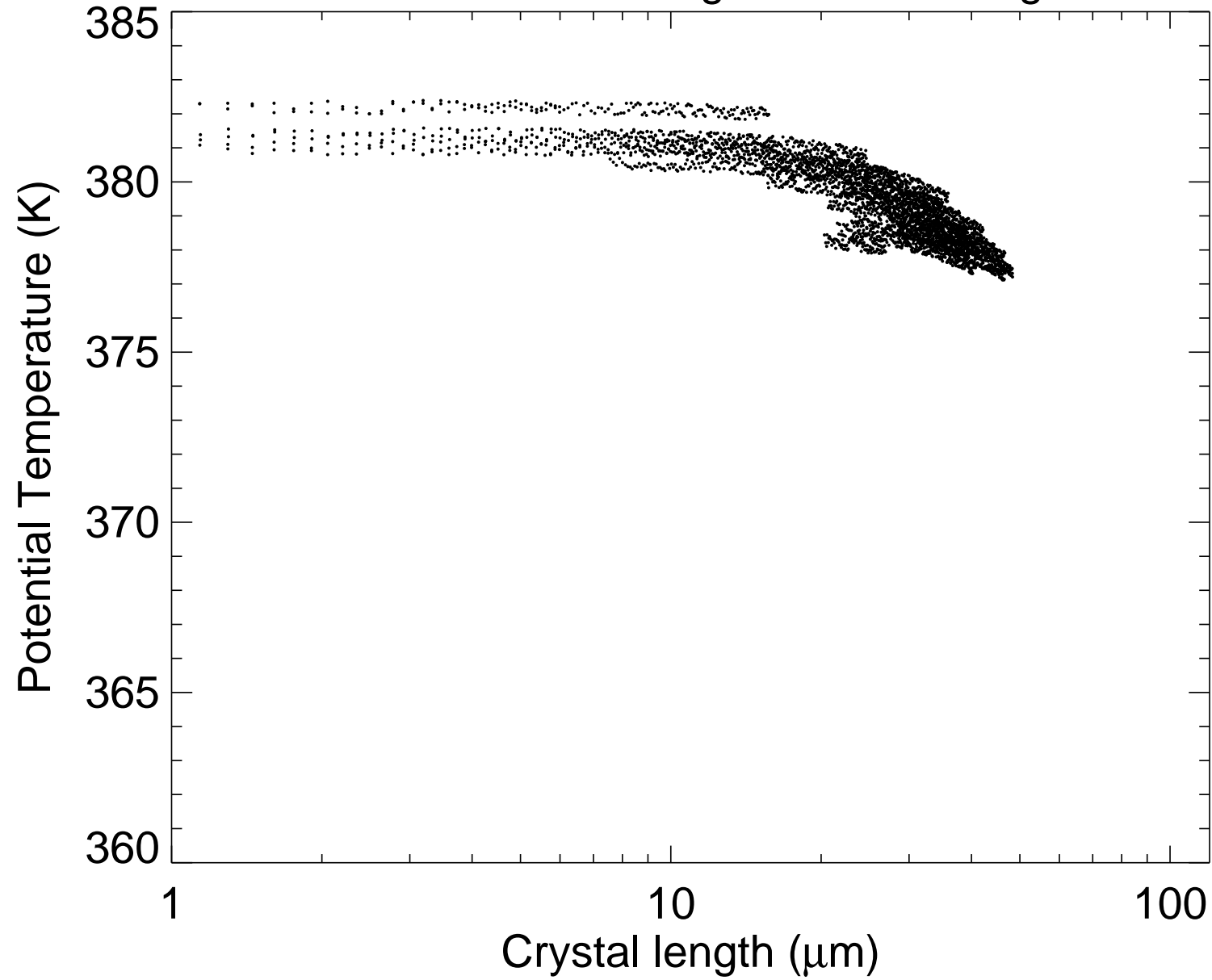


- Measured ice crystal size distributions are broad.

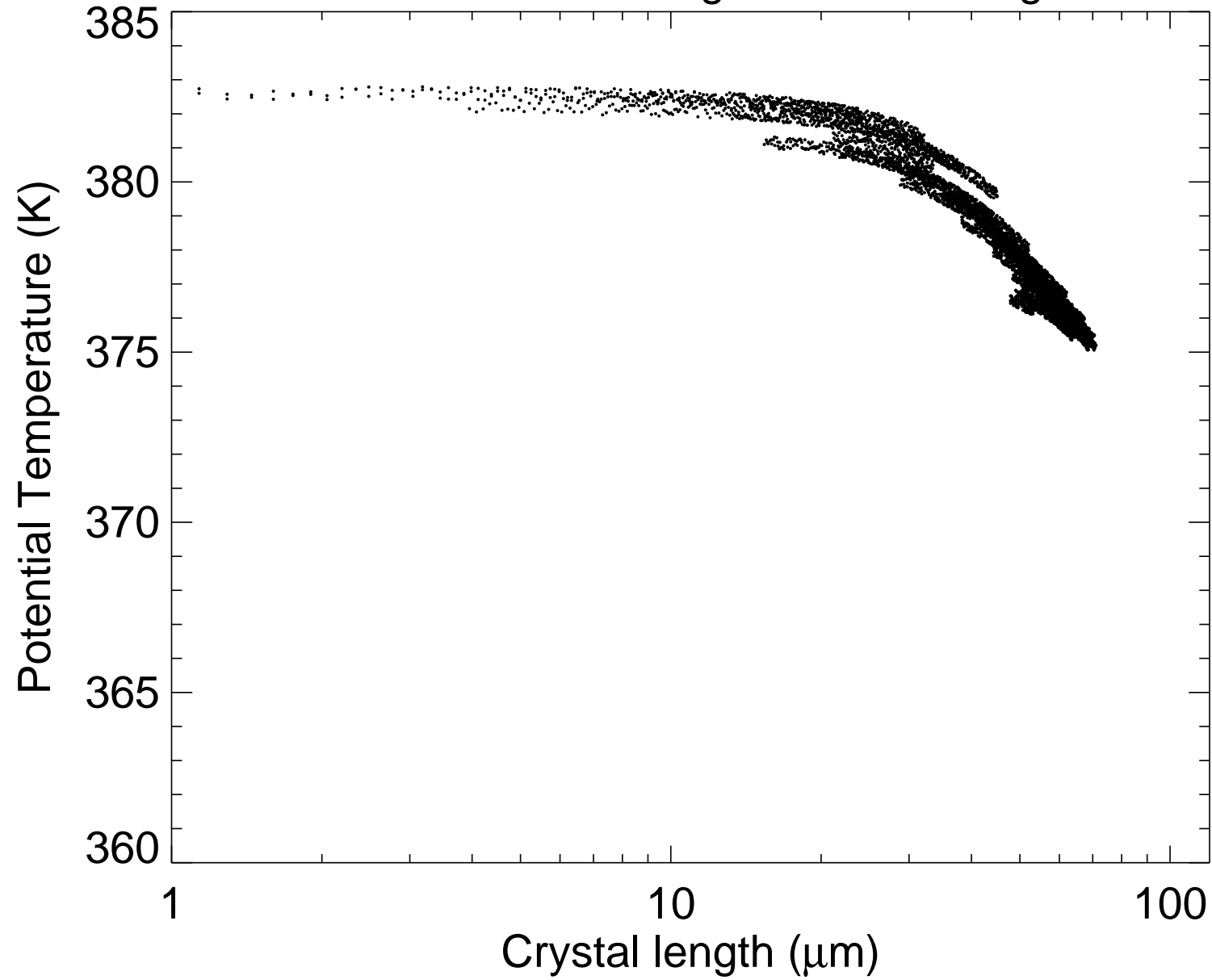
Simulated PSD: homogeneous freezing event



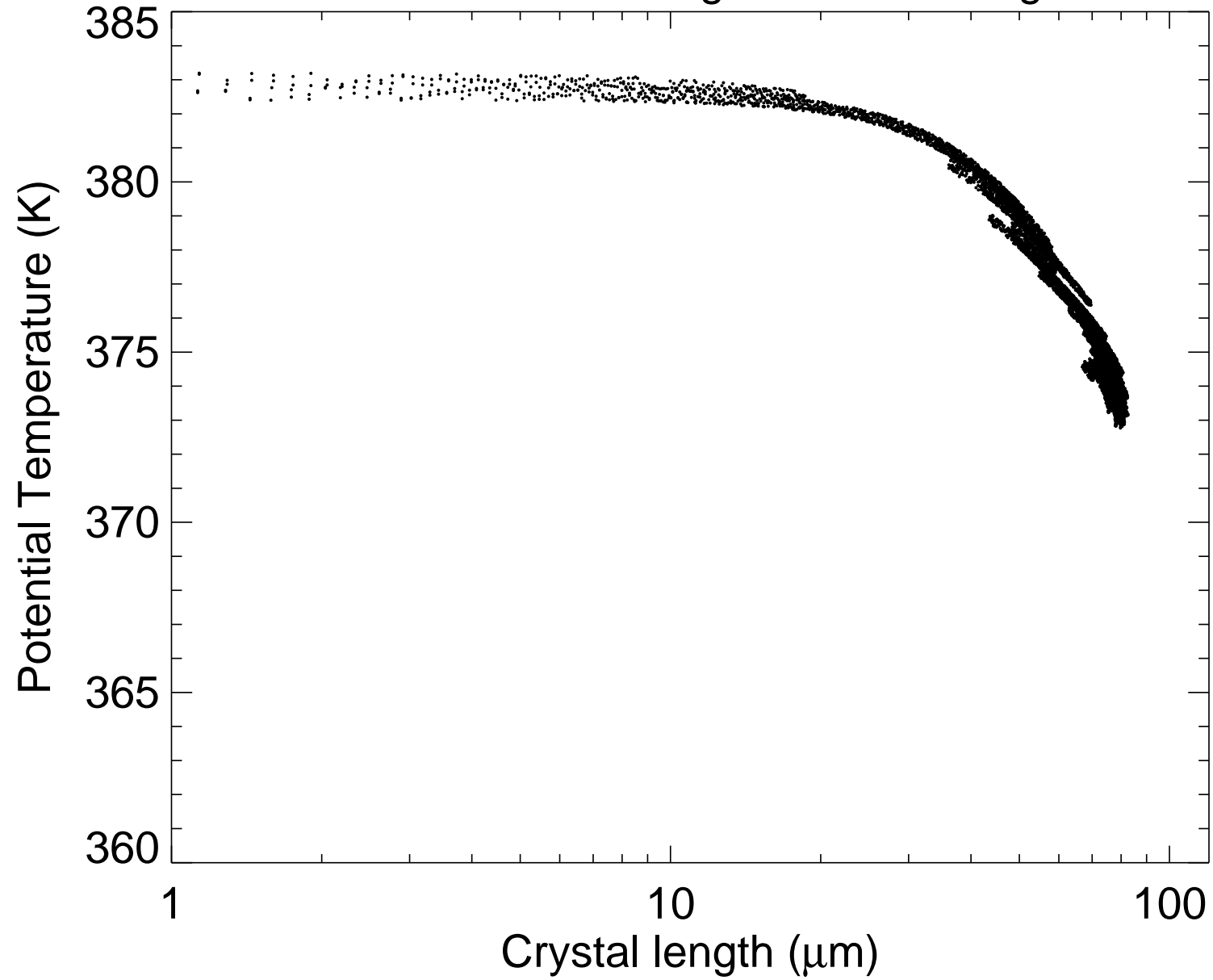
Simulated PSD: homogeneous freezing event



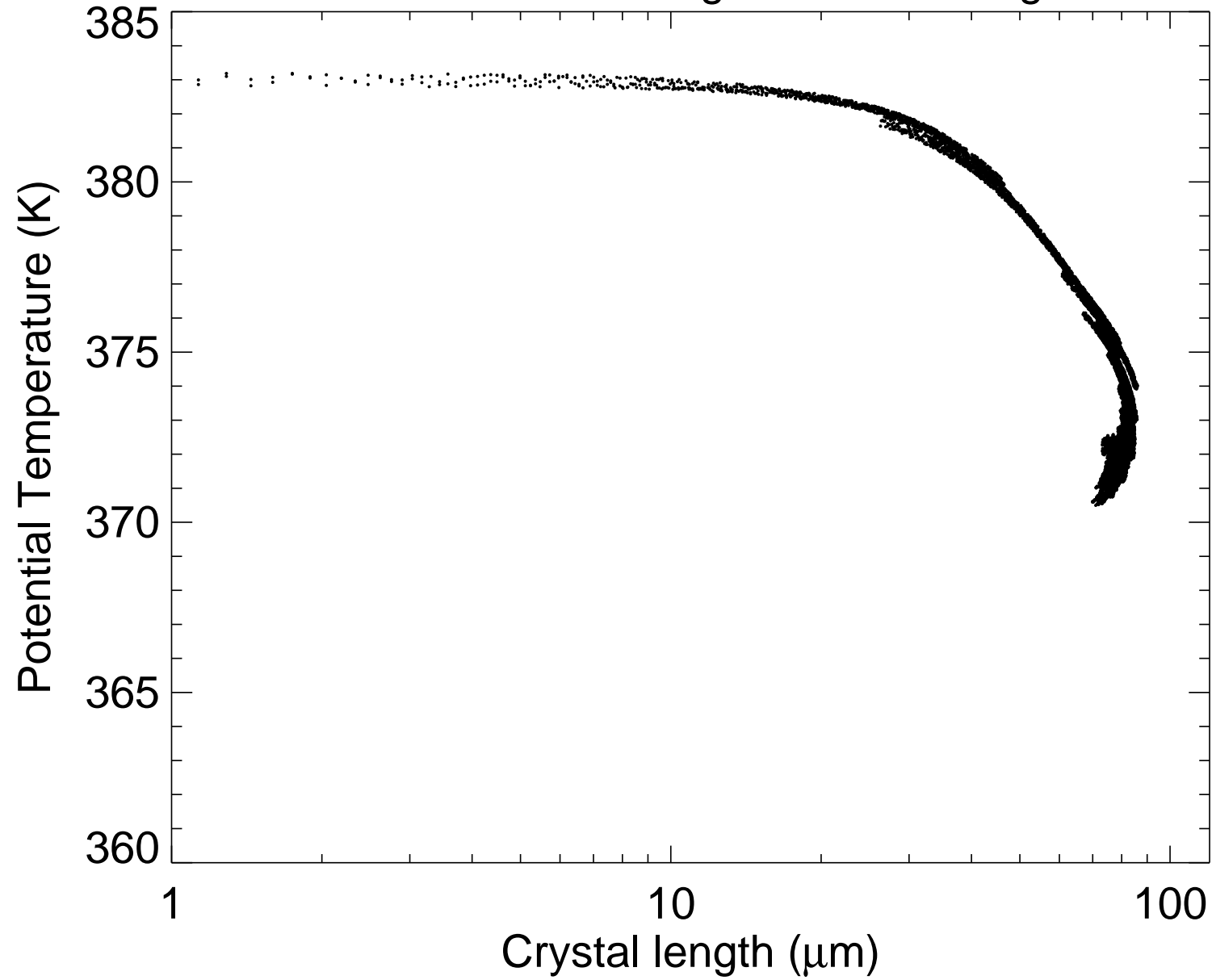
Simulated PSD: homogeneous freezing event



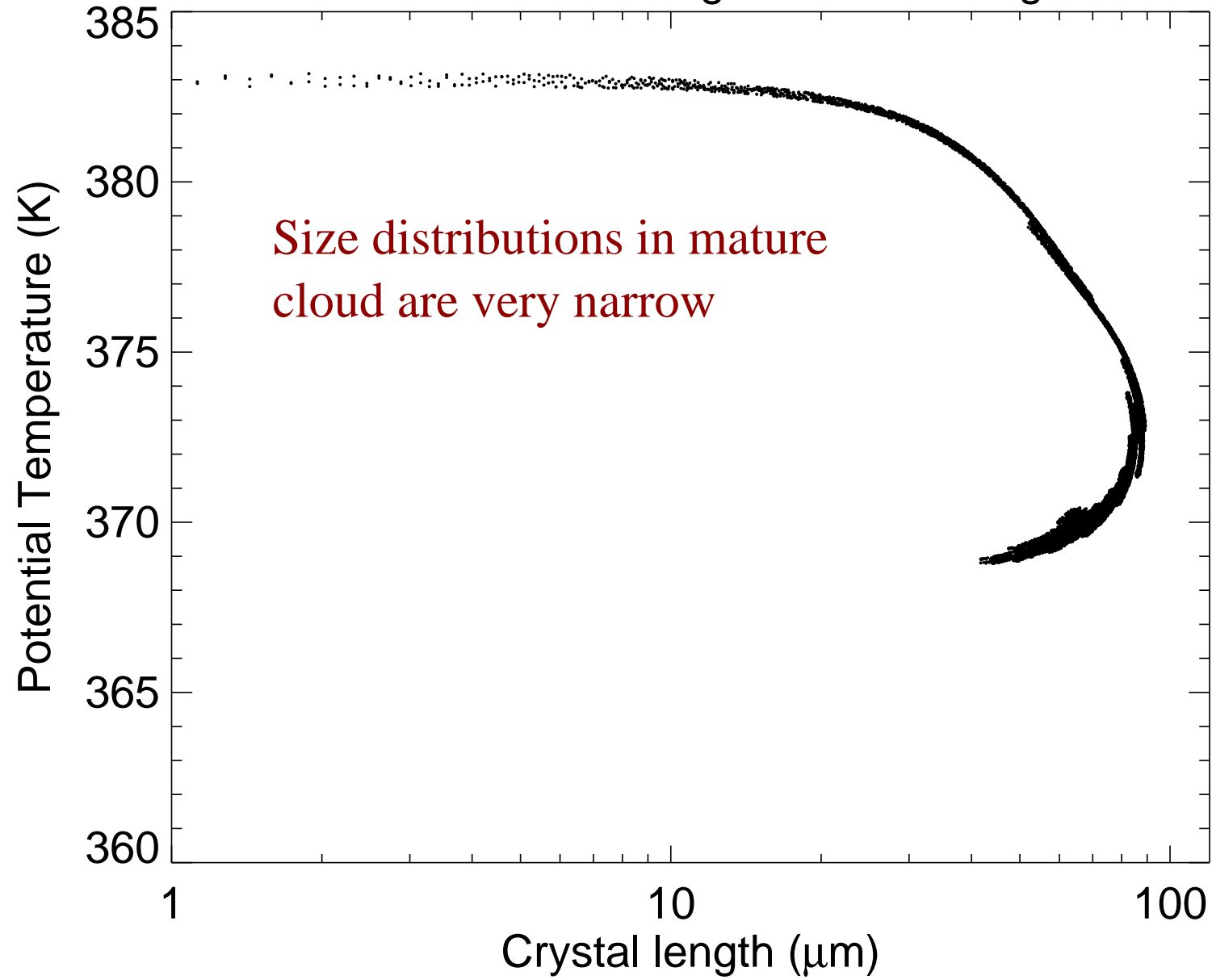
Simulated PSD: homogeneous freezing event



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Simulated PSD: homogeneous freezing event



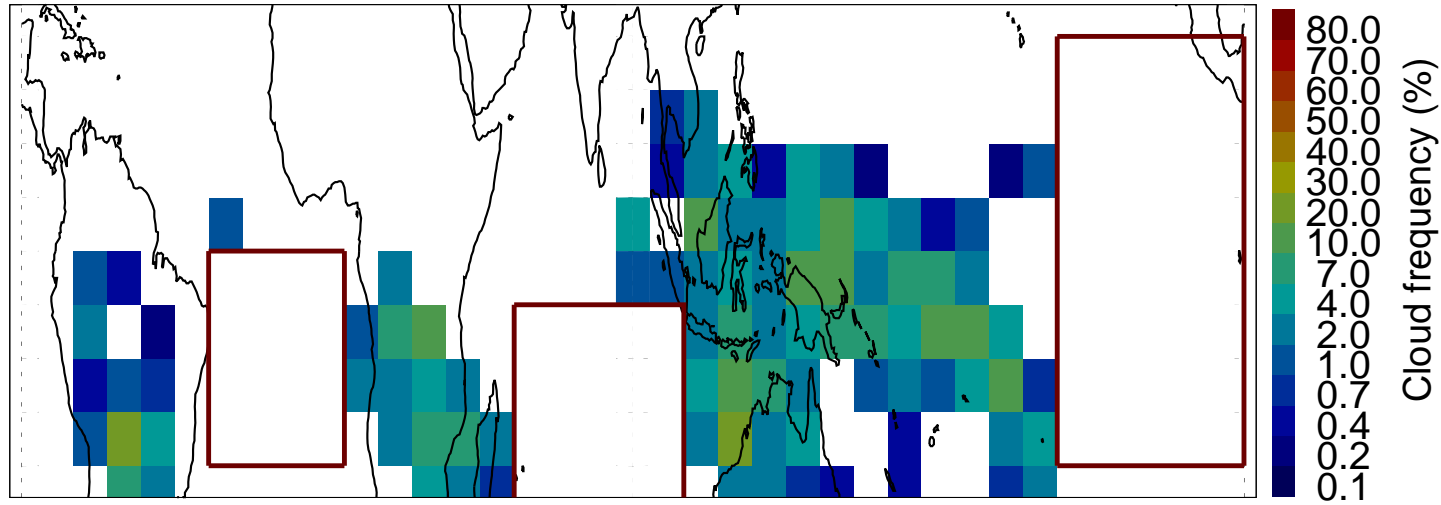
Hypothesis: Numerical models overestimate TTL
cirrus ice concentrations, and they should correspond-
ingly overestimate cloud extinction.... Compare with
CALIPSO

Modeling approach

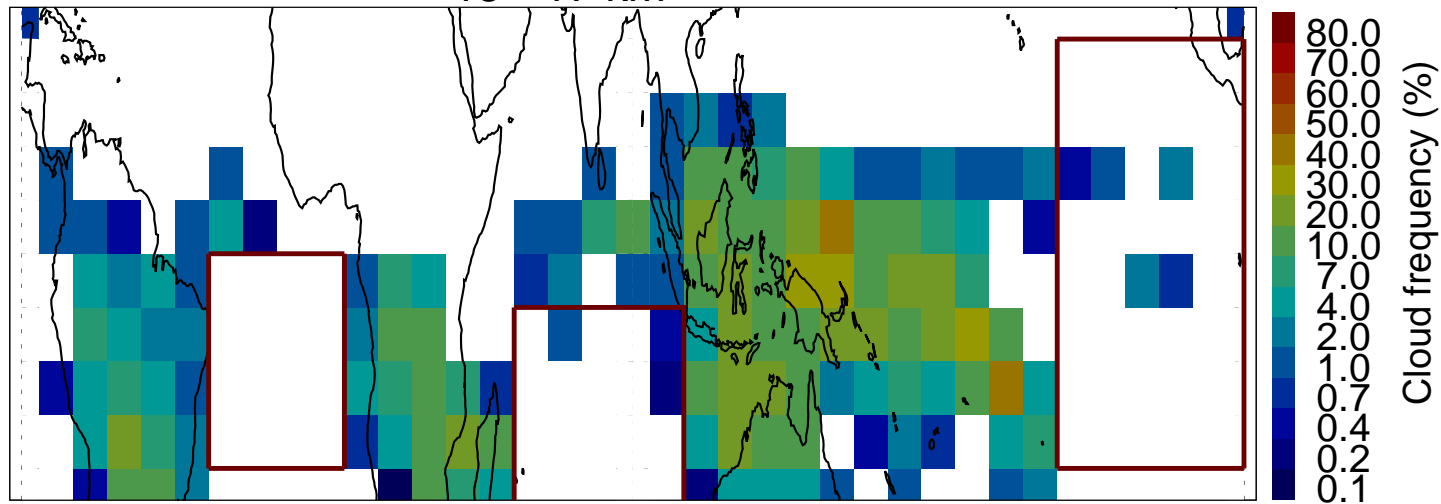
- 40-day diabatic back trajectories from a 5 by 5 grid of points using GEOS-4 analyses and GSFC trajectory model.
- Time-height curtains of T along trajectories. Temperatures adjusted for agreement with radiosondes.
- Include a synthetic spectrum of gravity, Rossby-Gravity, and Kelvin waves.
- Use 1-D (height) full microphysical model with vertical ascent derived from Fu and Yang radiative heating calculations including CALIPSO clouds.
- Convective injection of water included using geostationary satellite imagery.
- see L. Pfister poster for details

Convective cloud frequency

17 - 19 km



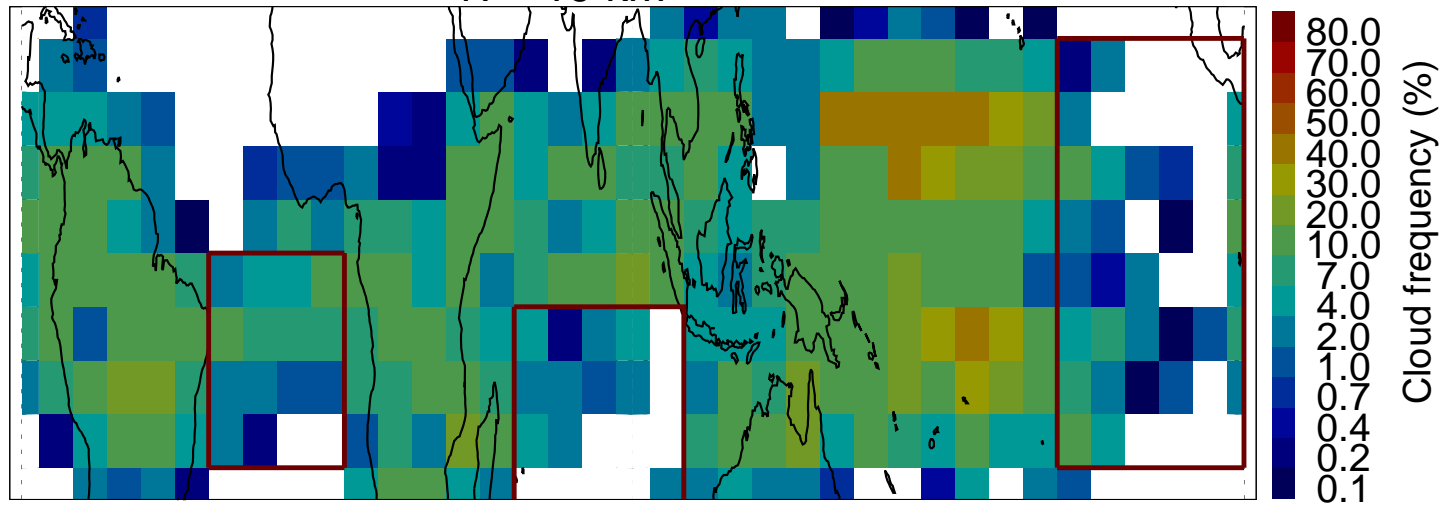
15 - 17 km



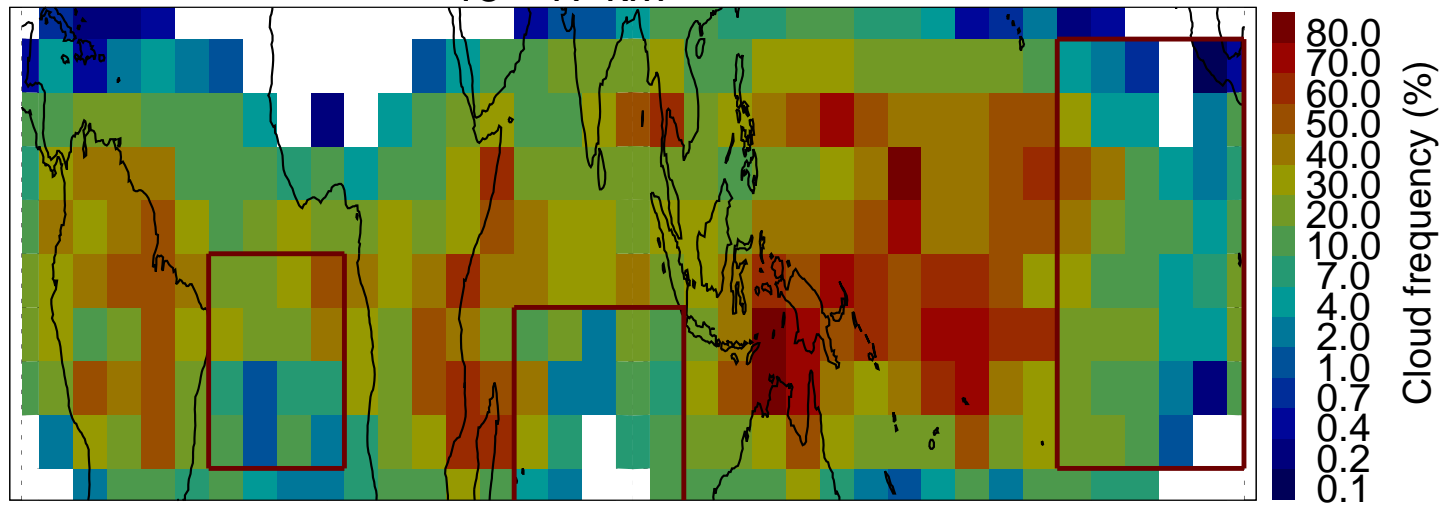
- Focus on regions with only in situ clouds

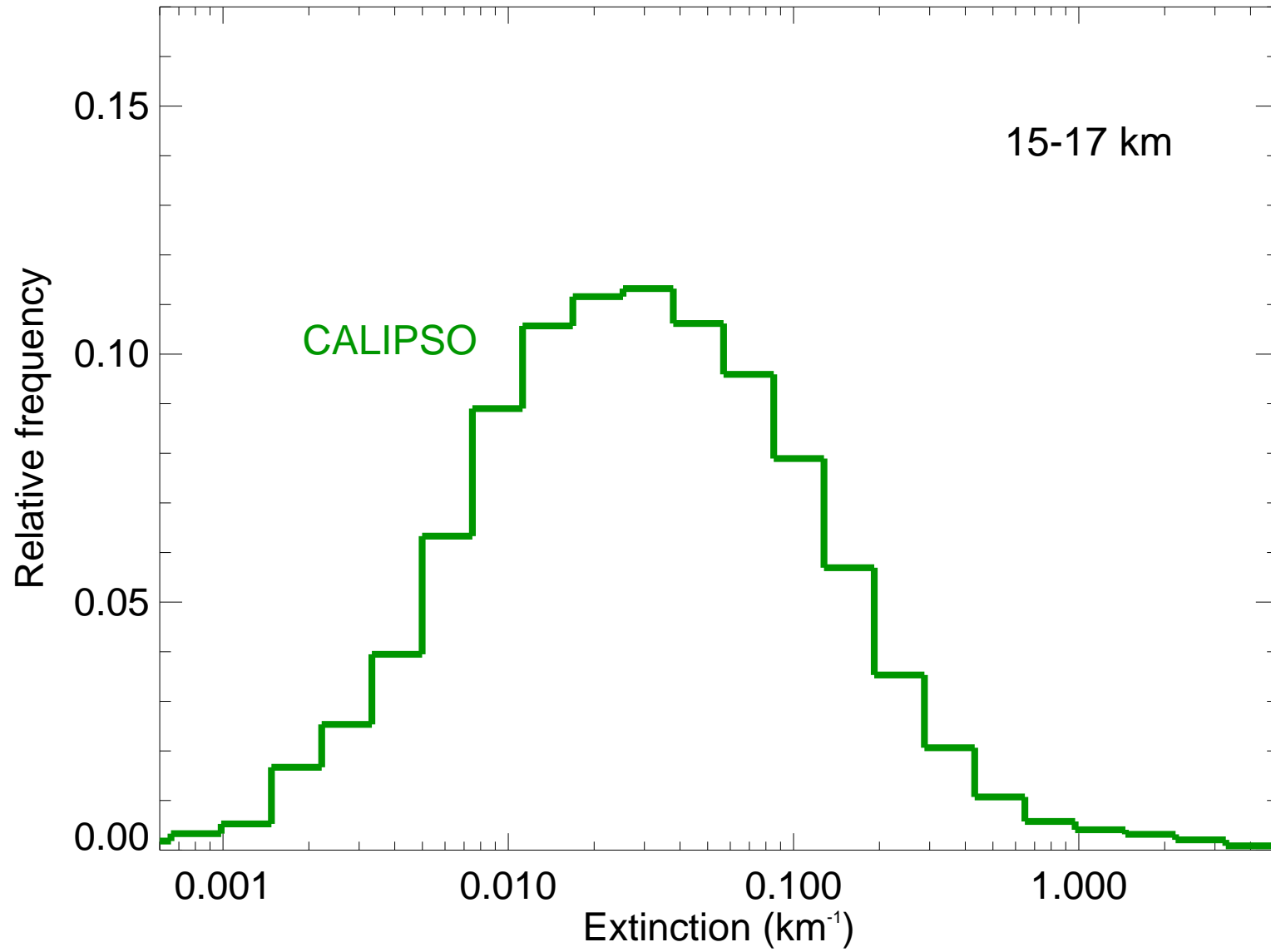
Simulated in situ cloud frequency

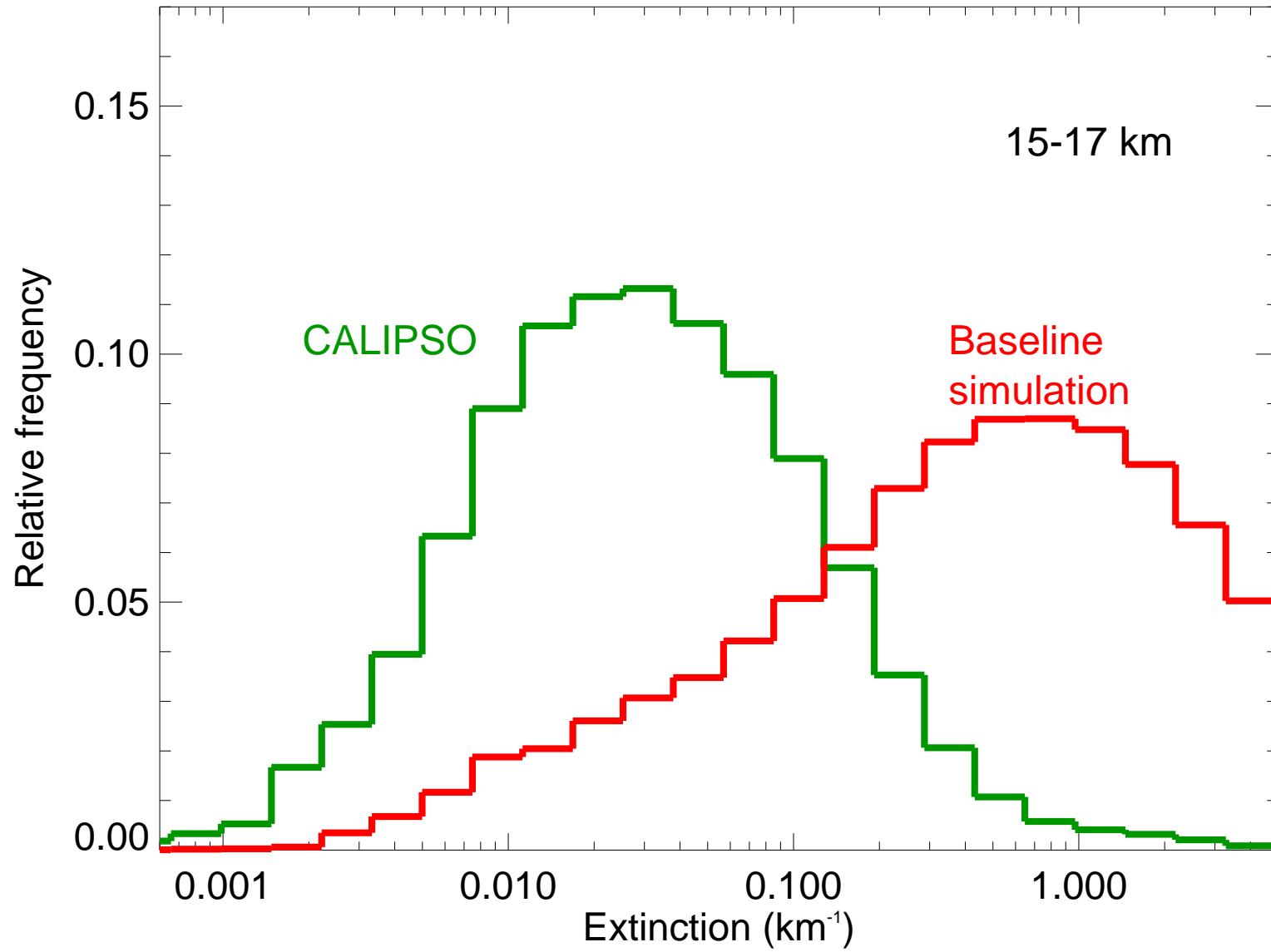
17 - 19 km

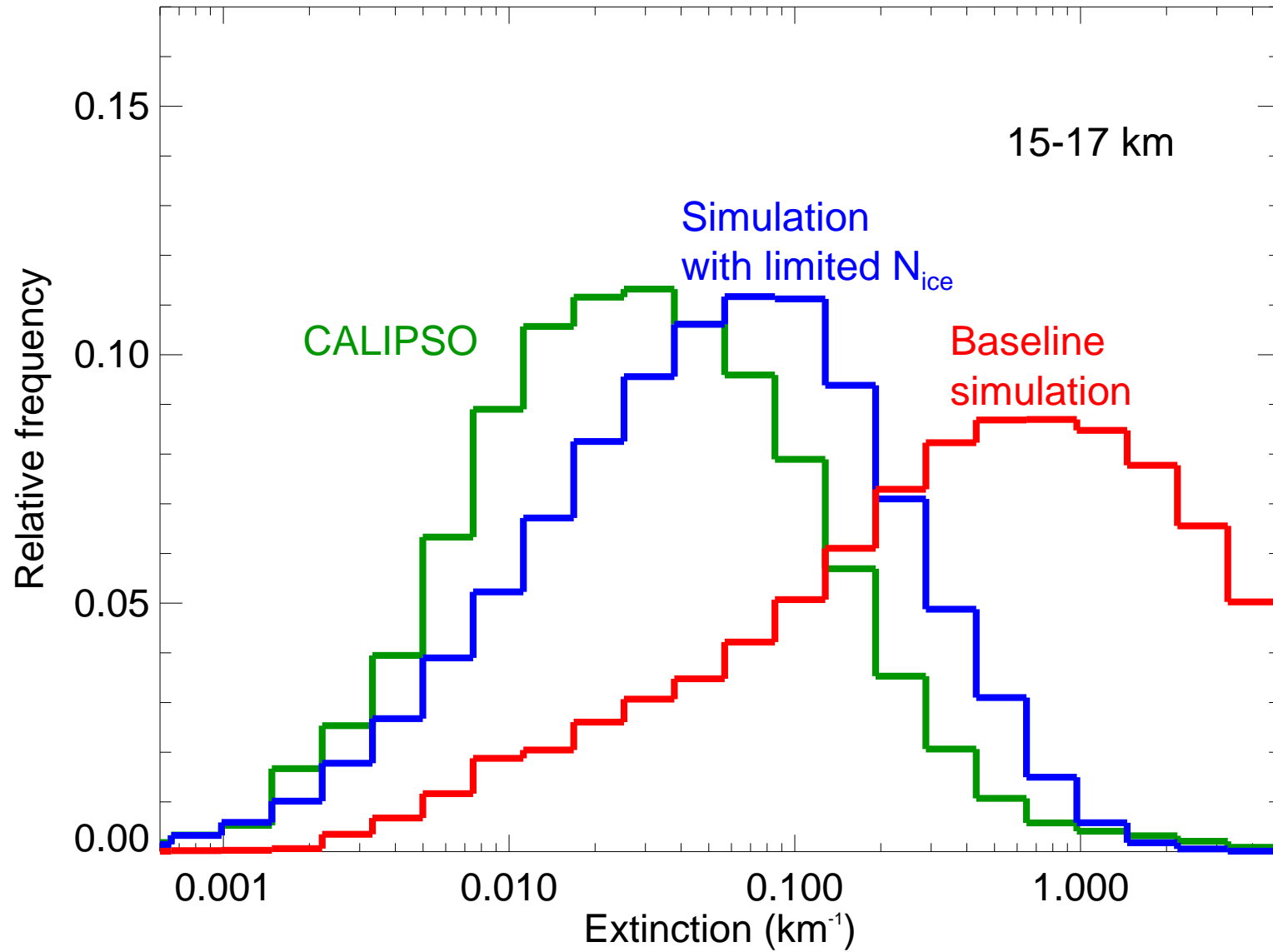


15 - 17 km









To get lower ice concentrations and broader distributions...

- Generate $\simeq 50 \text{ L}^{-1}$ ice crystals first
 - Moderate ice nuclei (**ammonium sulfate**, oxalic acid, ...)
 - However, IN should be scavenged
 - Variable organic content spreads out nucleation over a range of supersaturations
- Differential ice growth
 - Cubic ice
 - Favorable defects/habits
- Only a small fraction of aerosols can freeze
 - Organic-containing aerosols transition to glassy state at low T, preventing nucleation
- Microstructure in humidity field

Summary

- Measured ice concentrations are far lower than nucleation theory predicts.
- Measured ice size distributions are much broader than theory predicts.
- CALIPSO cloud extinctions are much lower than theory predicts.
- Limiting ice nucleation in model improves agreement with CALIPSO extinctions.
- Potential implications for TTL cirrus frequency, radiative properties, and dehydration.