

# Global Remote New Particle Formation: an experiment to compare AeroCom models with observations from the NASA Atmospheric Tomography Mission



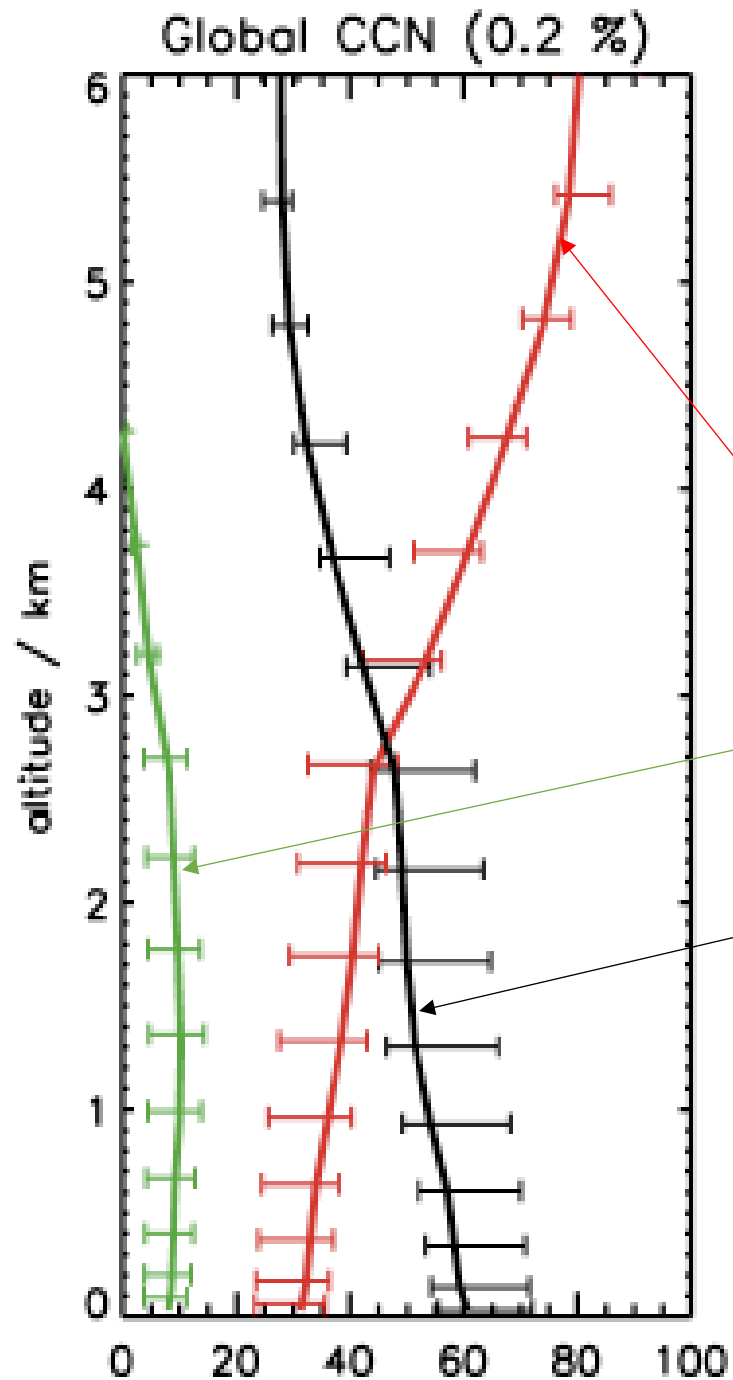
CIRES

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Photograph: Samuel Hall, UCAR



New Particle Formation is an important contributor to global CCN

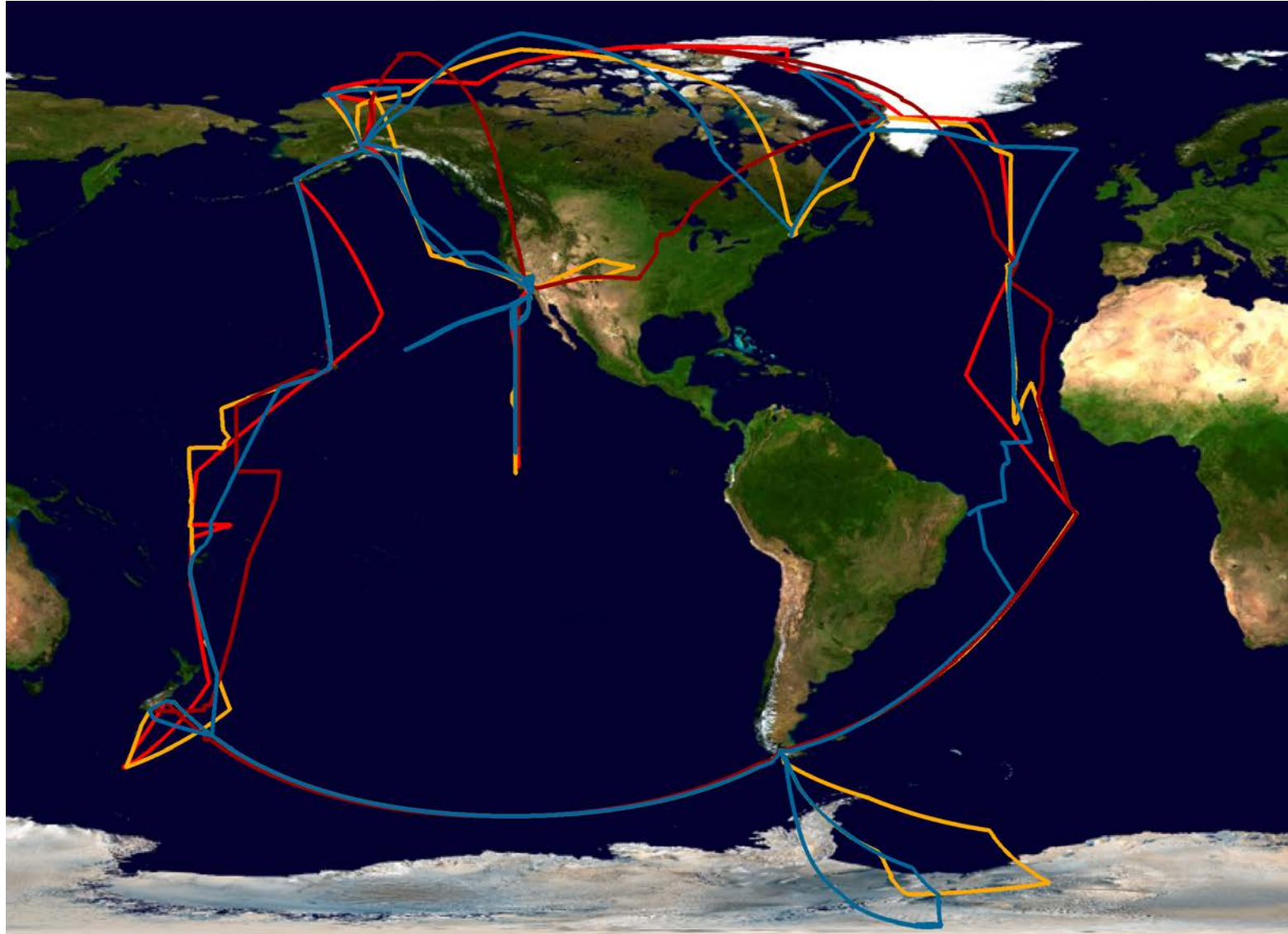
Upper Troposphere NPF

Boundary layer NPF

Primary particles

Vertical contribution of aerosol from different sources to global CCN  
Merikanto et al., 2009 ACP

# The Atmospheric Tomography Mission



■ ATom-1	Aug 2016
■ ATom-2	Feb 2017
■ ATom-3	Oct 2017
■ ATom-4	May 2018



# The Atmospheric Tomography Mission



**Vertical Profiling**

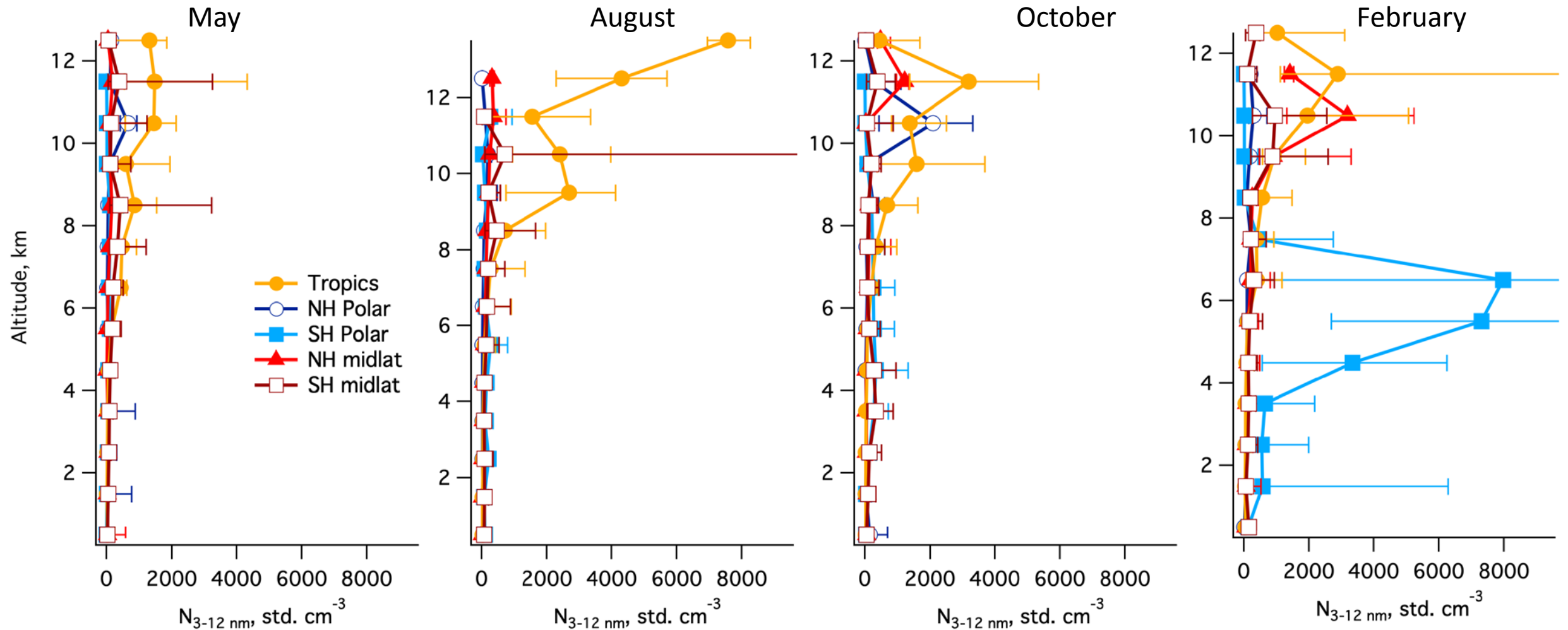
~0.2 – 12km

# AeroCom-ATom New Particle Formation Experiment

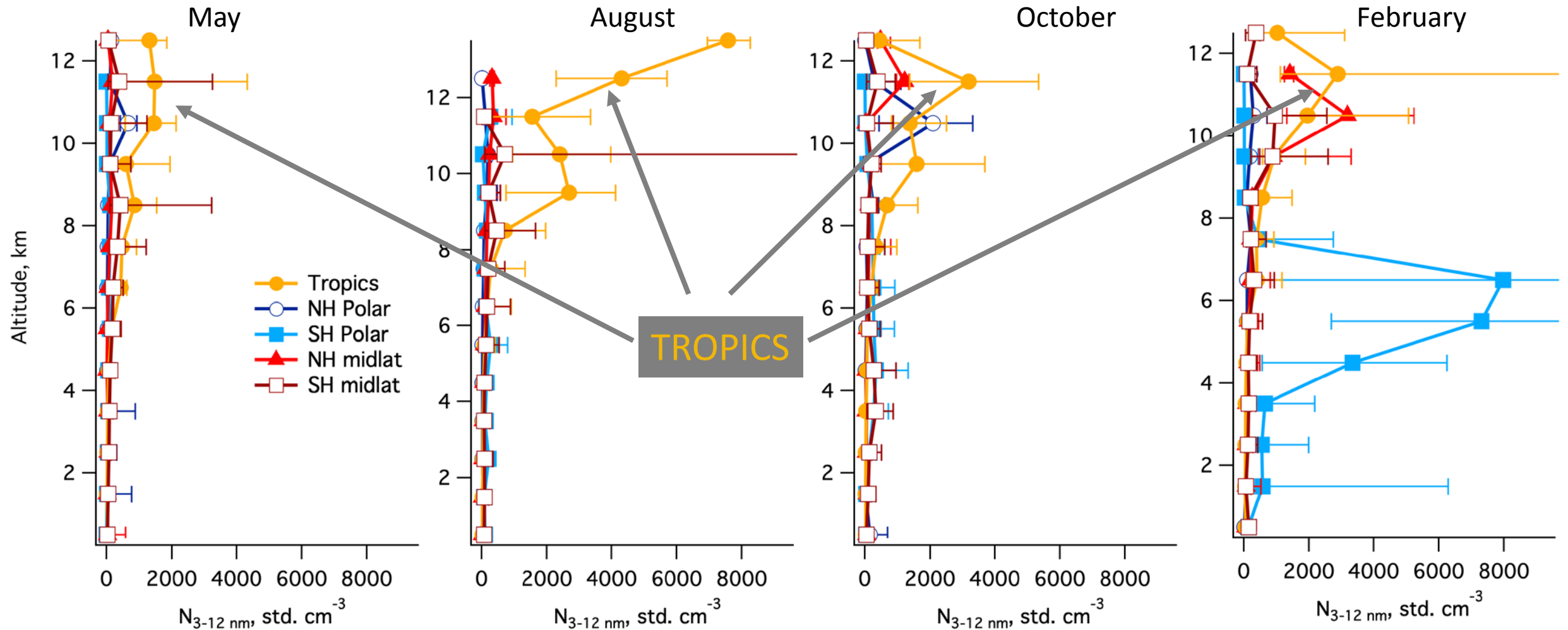
- Impact of nucleation on CCN number concentrations
  - Experiments with nucleation on/off
- Role of different nucleation mechanisms
  - Spatial distribution
  - Seasonal dependence
  - Experiments with different nucleation mechanisms on/off
- Anthropogenic influence on new particle formation

**Wiki: [AeroCom phase III experiments/ATom](#)**

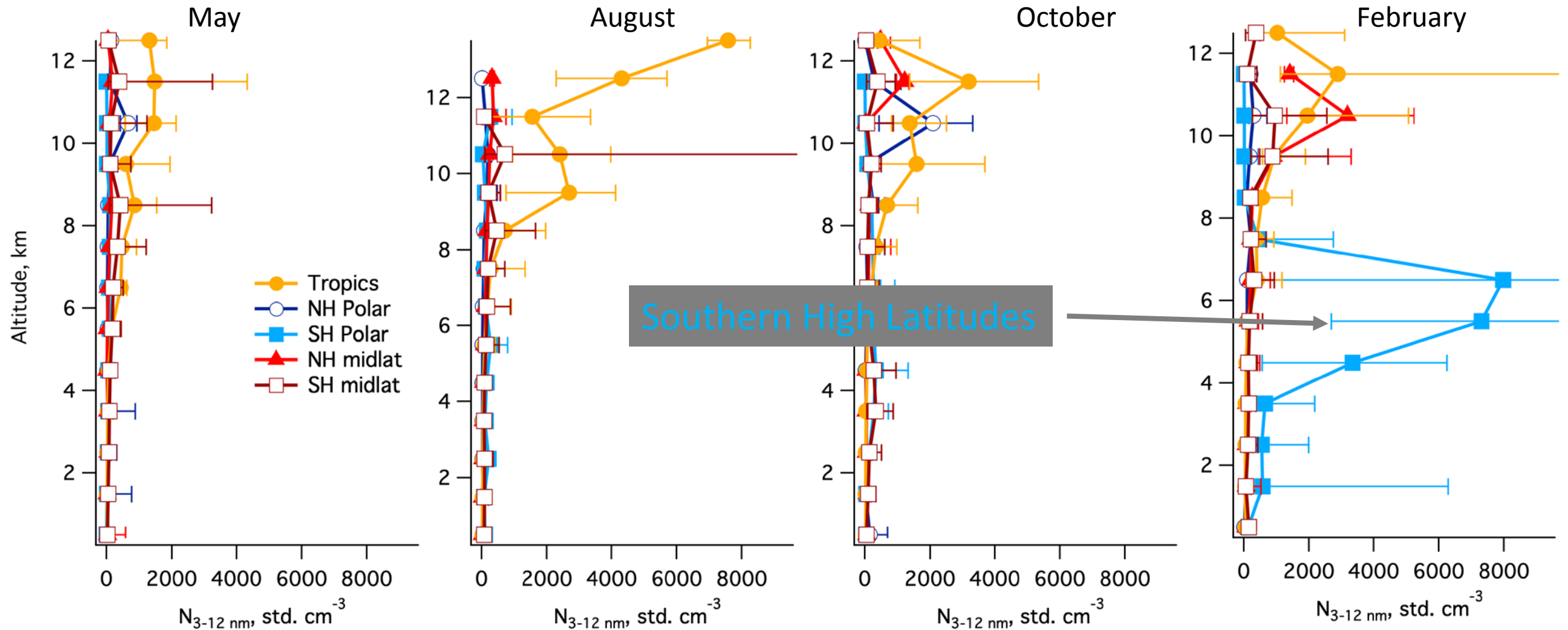
# NPF mostly occurs in tropics and over the Southern Ocean during austral summer



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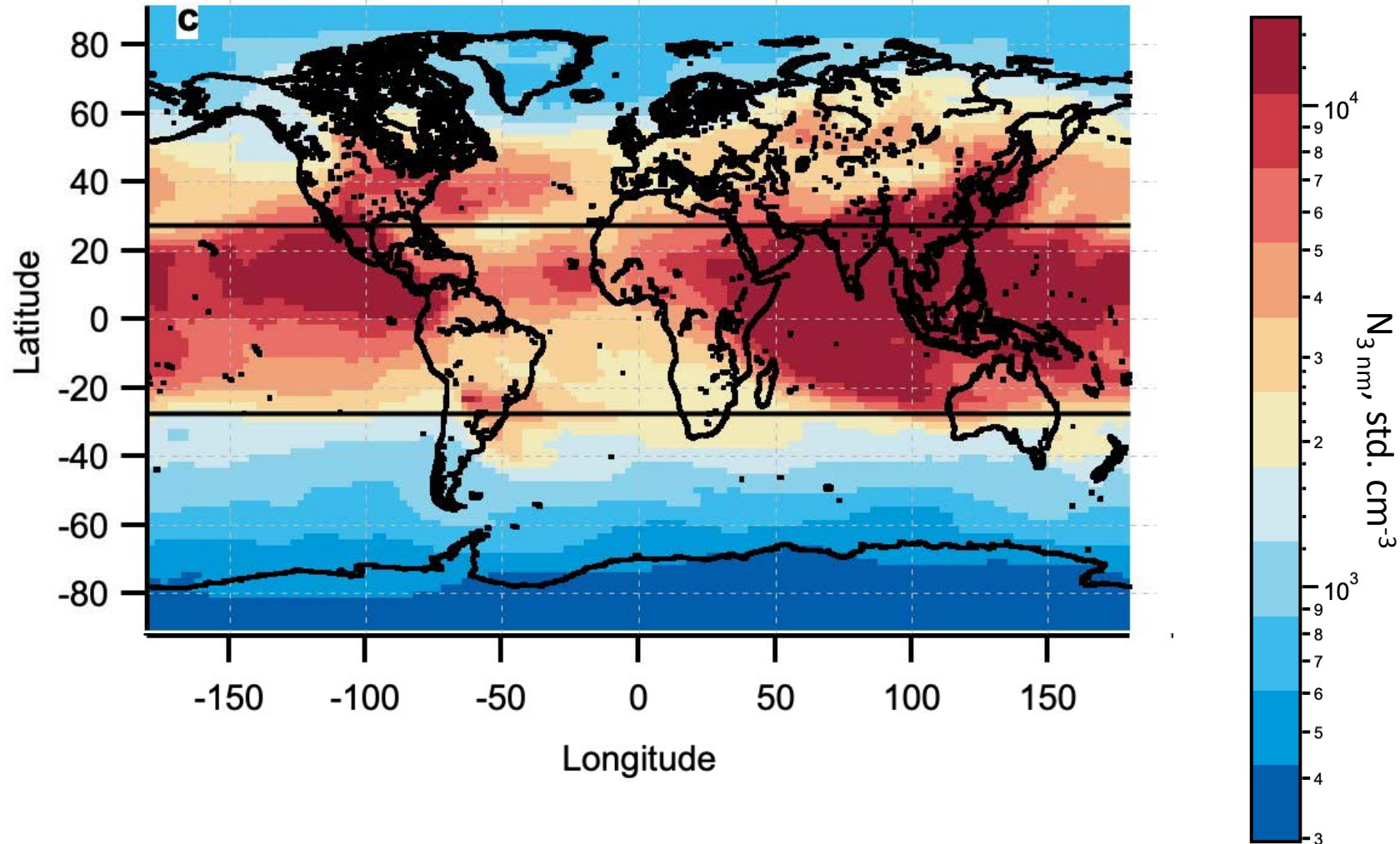


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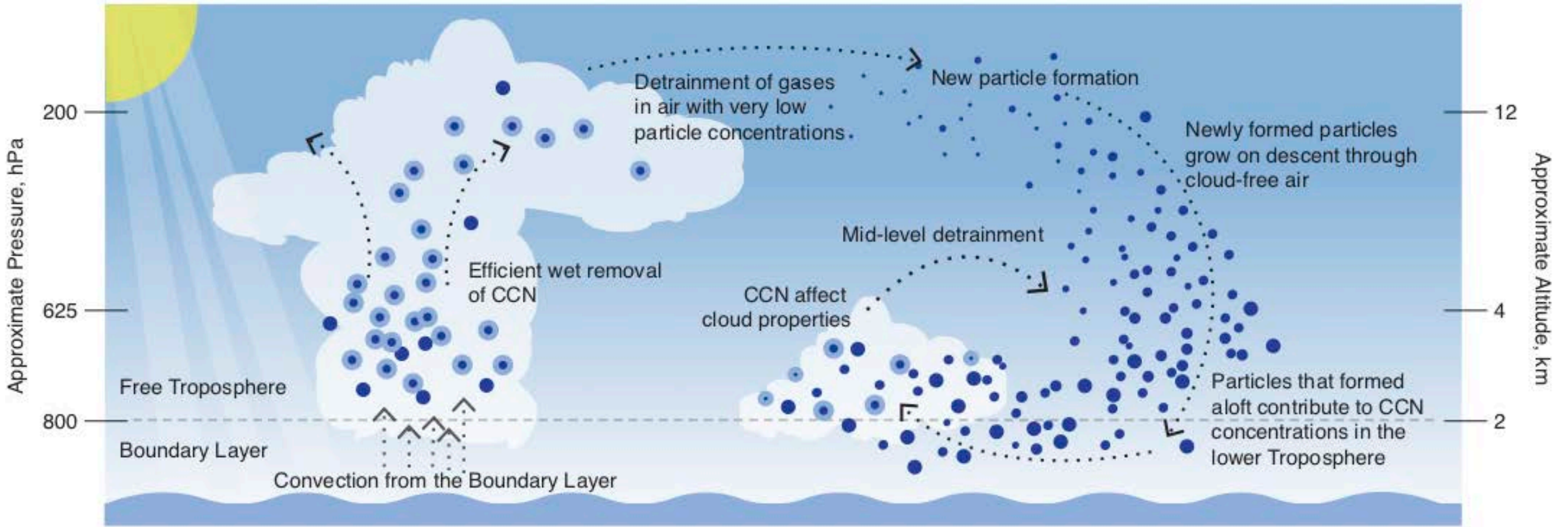


Models and longitudinal spread of observations suggest a continuous band of high altitude NPF in the tropics covering ~40% of the Earth's Surface



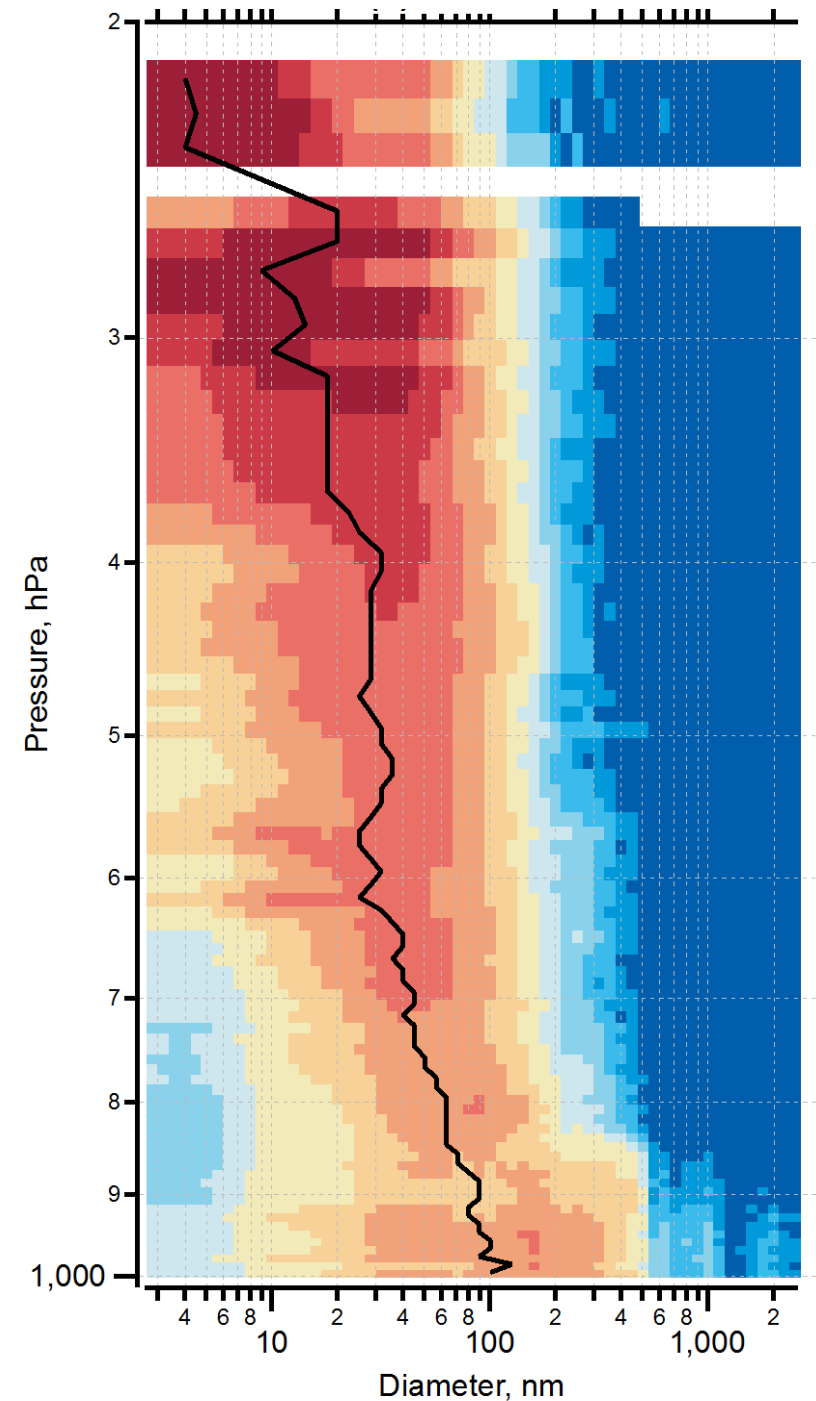
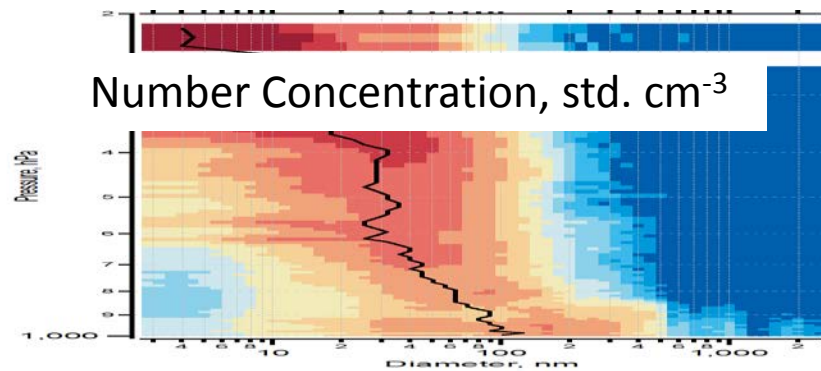
Pressure < 600 hPa

CAM5-APM  
August 2016

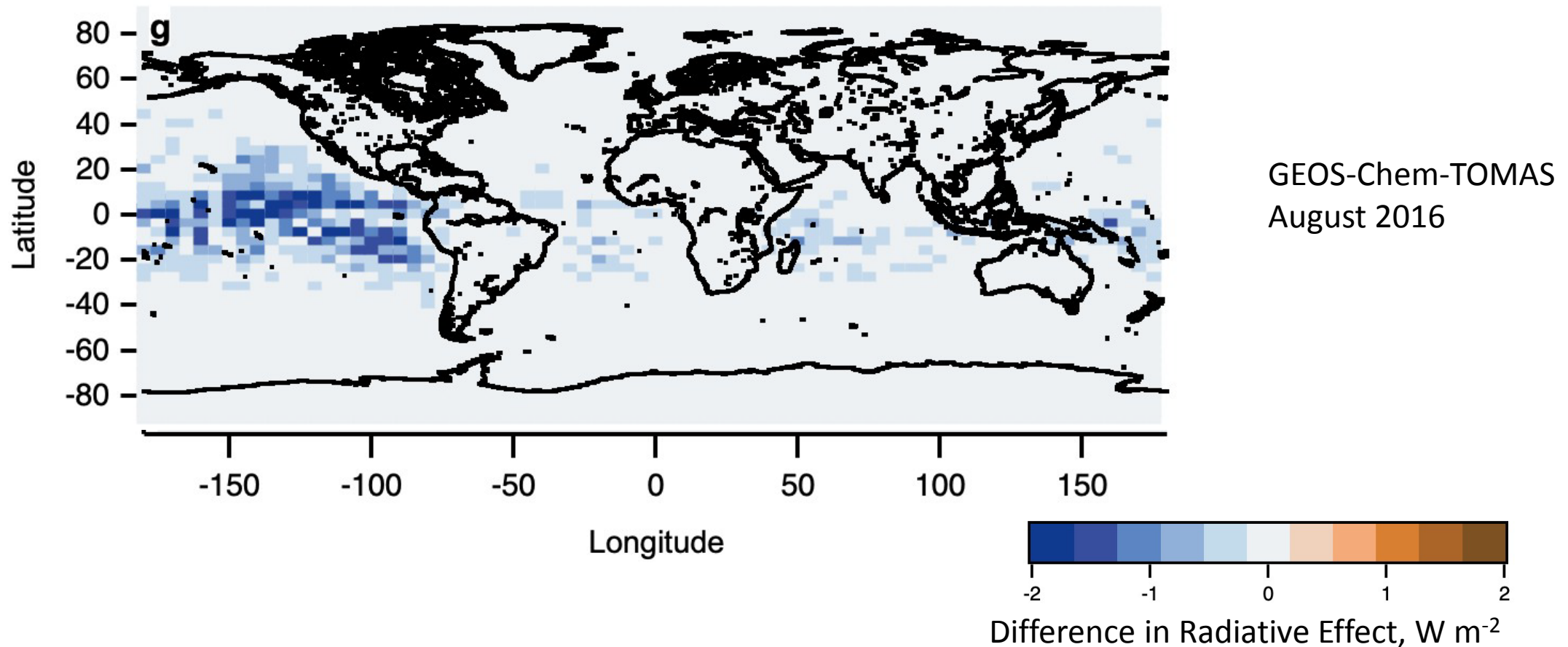


Williamson et al., *A large source of cloud condensation nuclei from new particle formation in the tropics*, 2019 Nature – in press

Newly formed particles grow on descent through cloud-free air to reach CCN-sizes

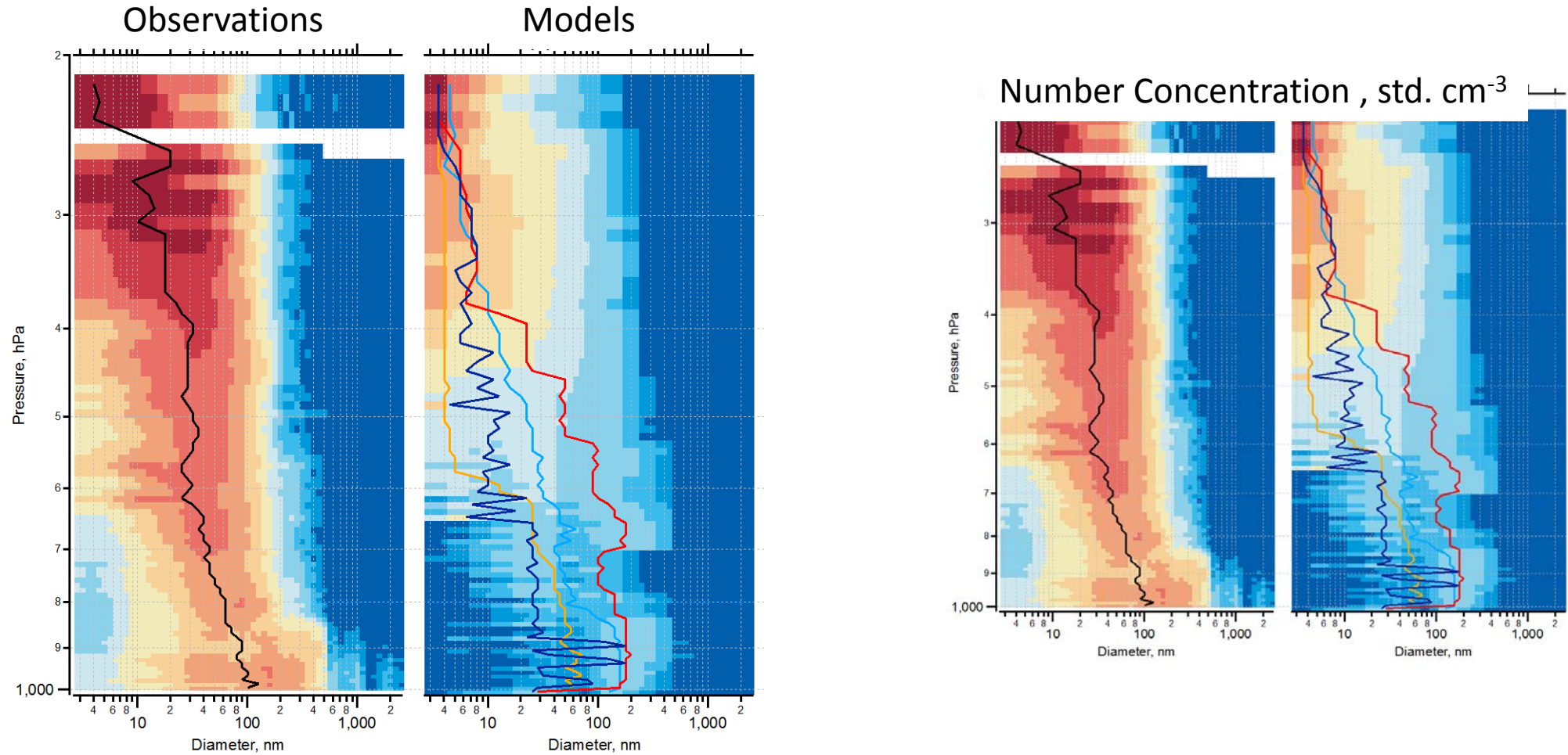


# Tropical new particle formation has a large radiative effect in the tropics

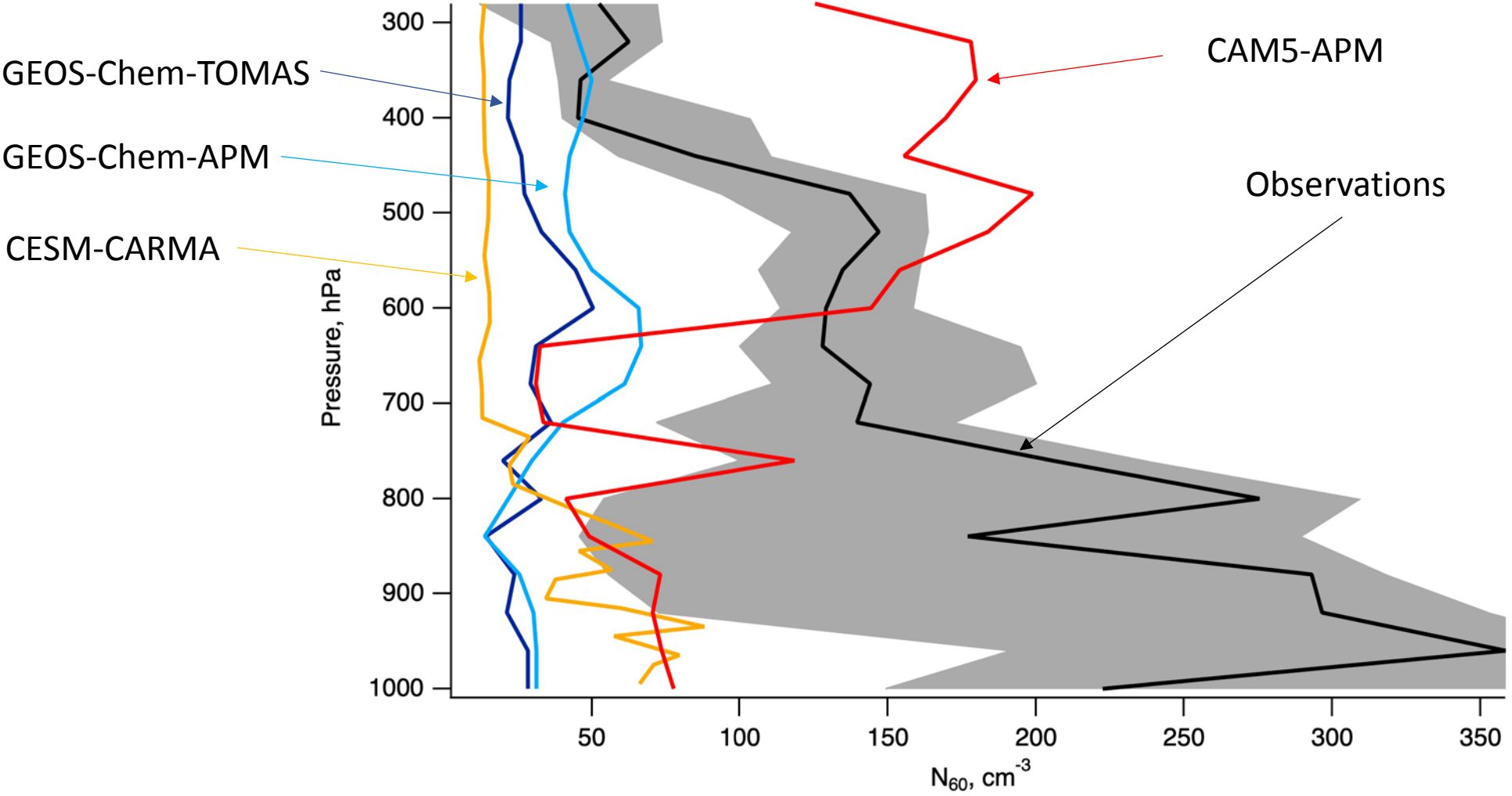




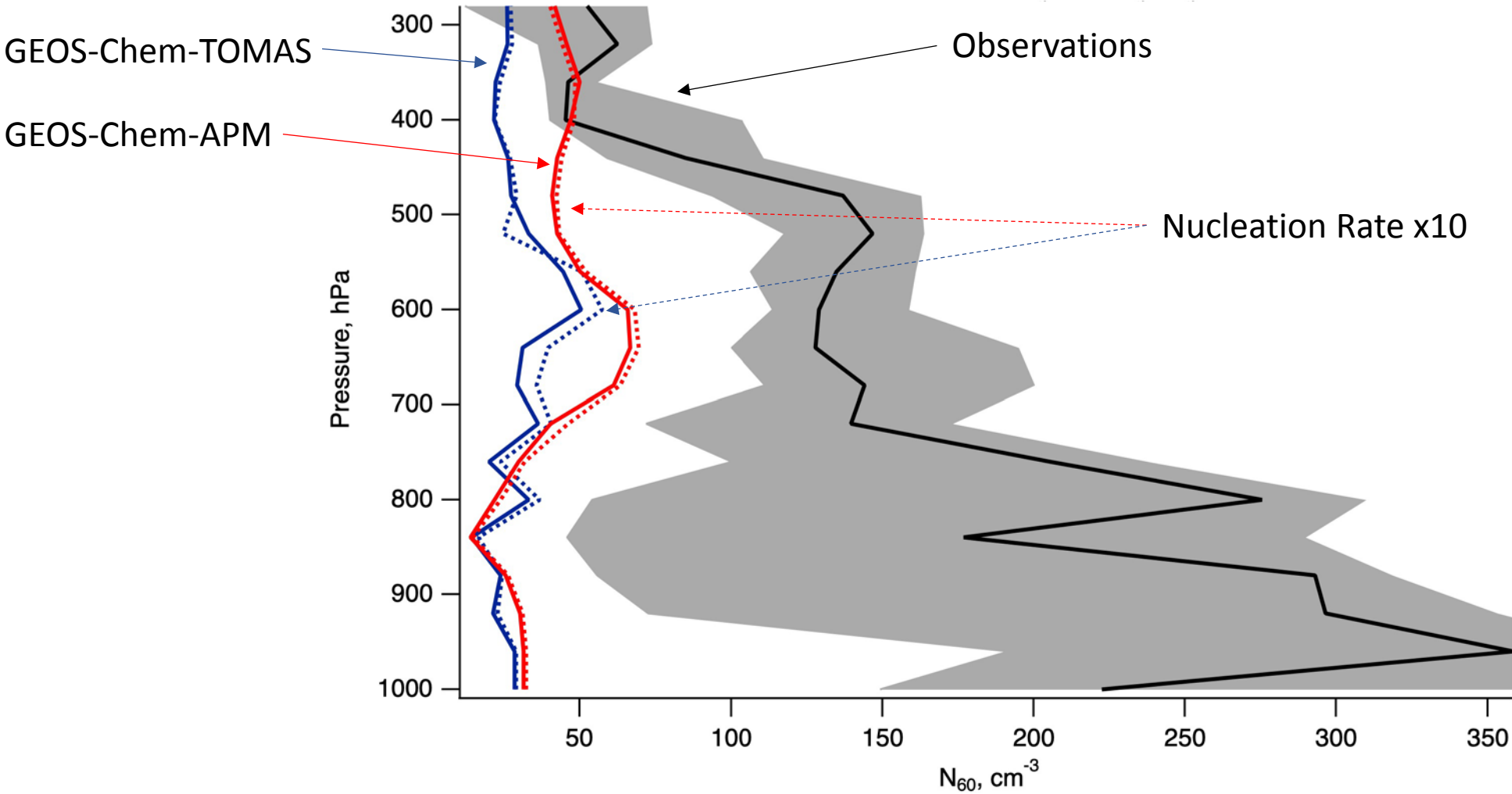
# Chemical-transport models do not reproduce CCN production from Tropical New Particle Formation



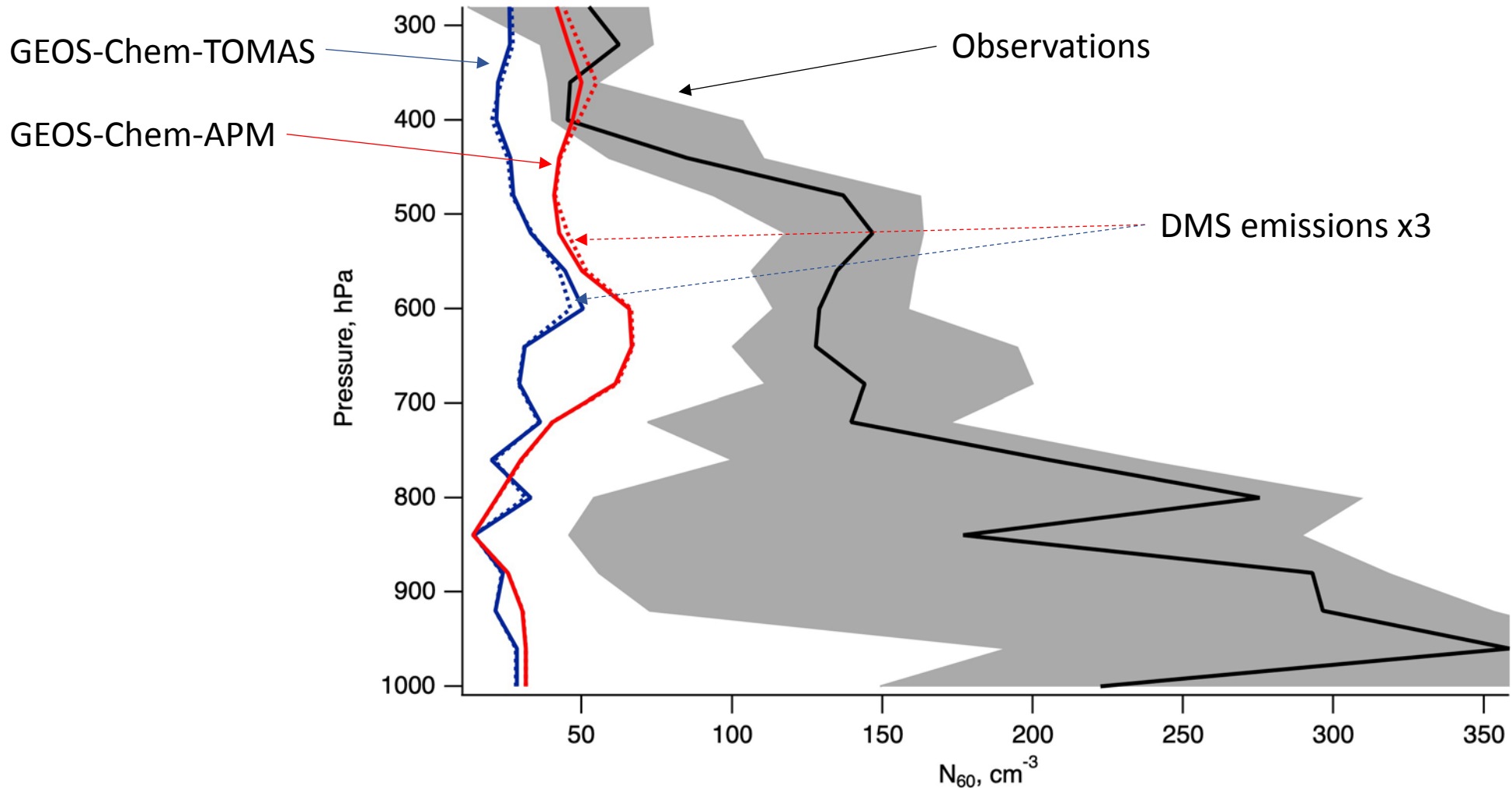
# Chemical-transport models do not reproduce CCN production from Tropical New Particle Formation



# Missing nucleation mechanisms in the models do not explain missing CCN



# Uncertainties in emissions of inorganic vapors do not explain missing CCN







Organics could have a larger effect than DMS on tropical new particle formation and growth ...

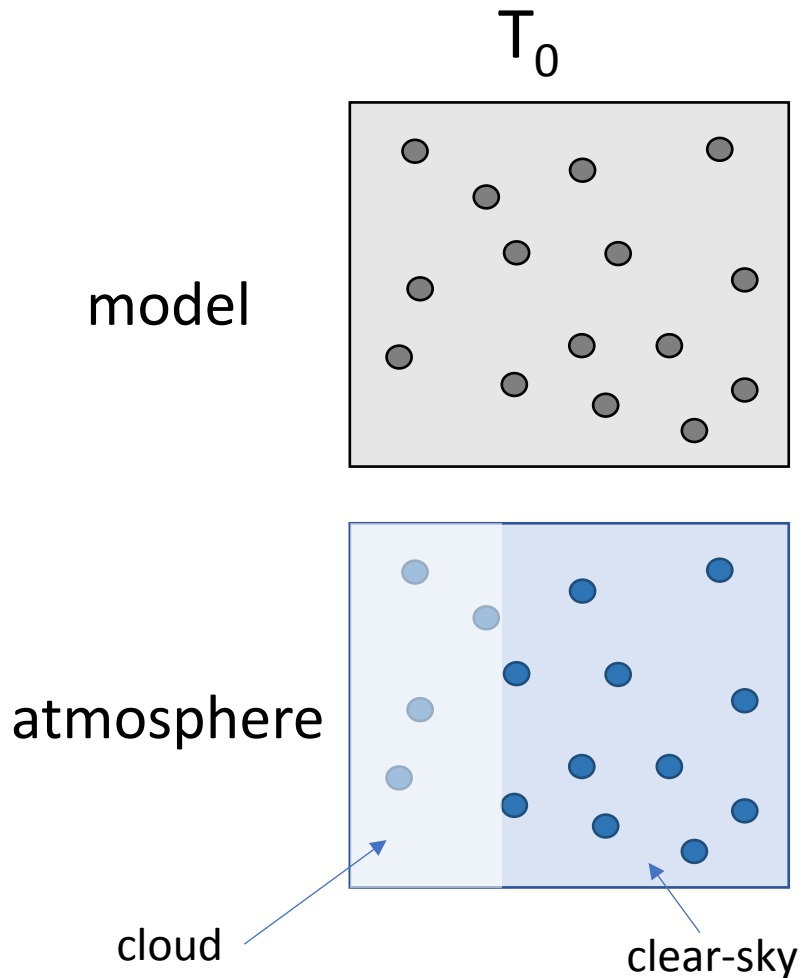
... we're looking into this



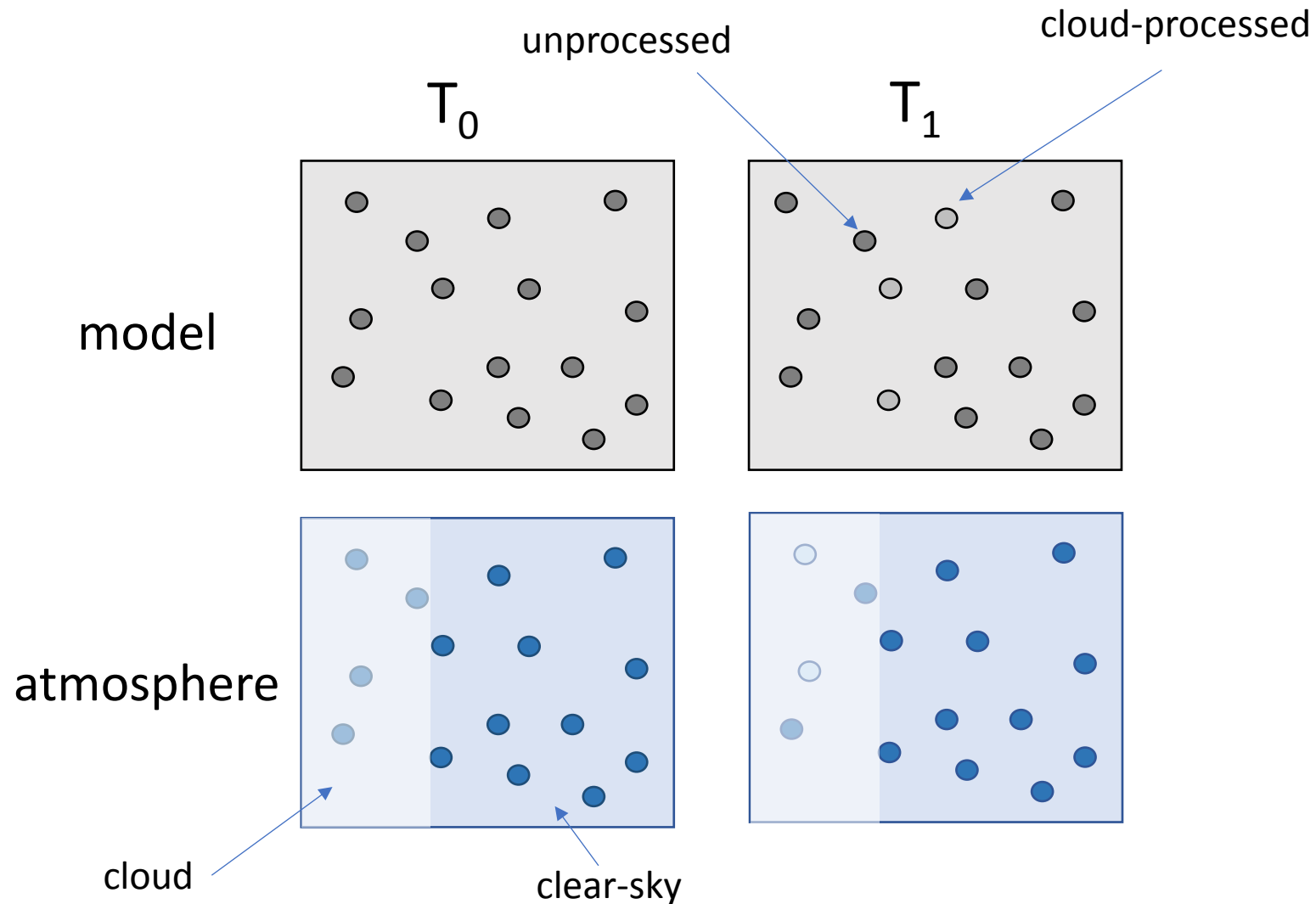
We need to consider the role of cloud processing ...

*Photograph: Samuel Hall, UCAR*

# Too many particles are removed by cloud-processing in models

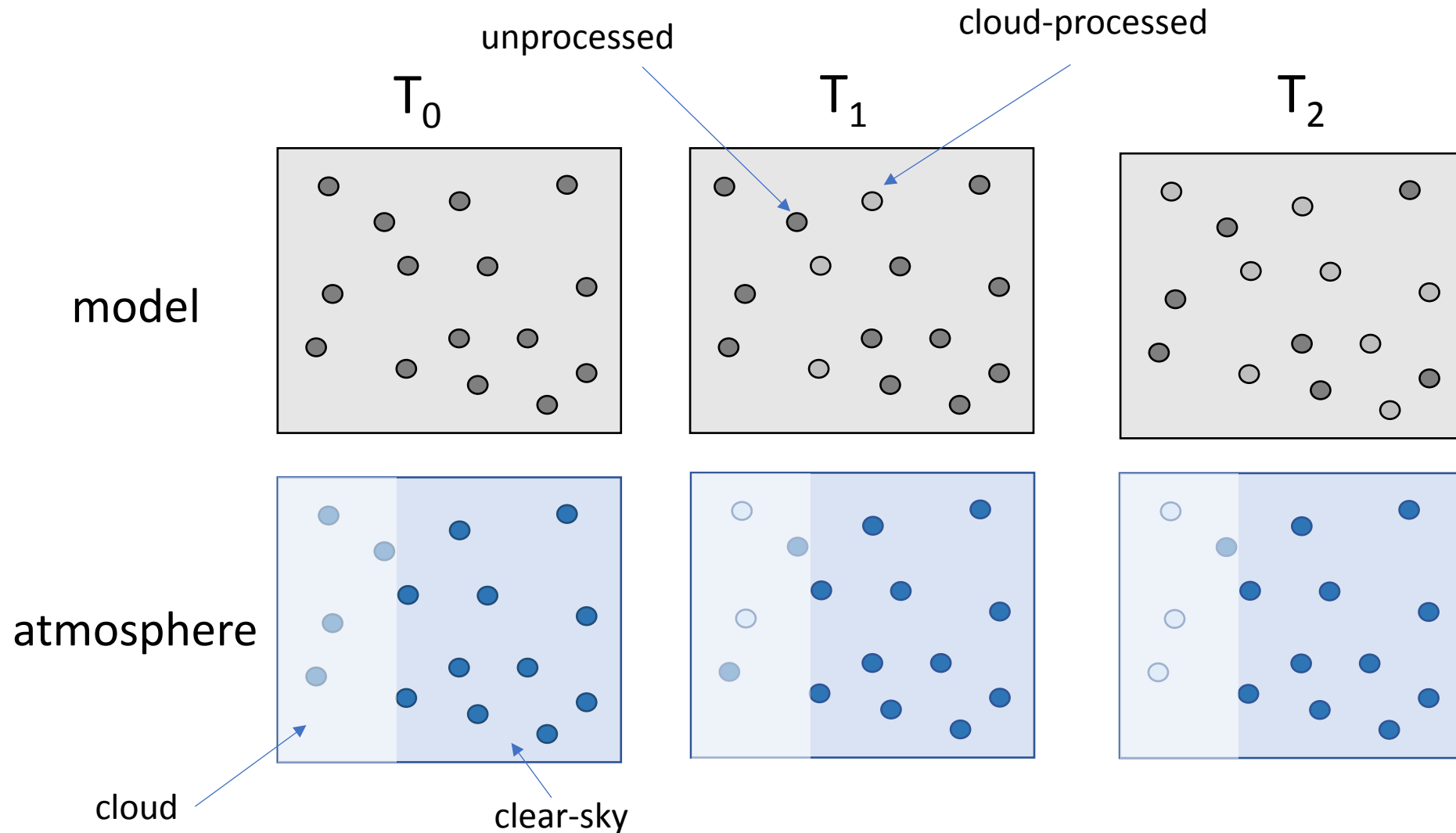


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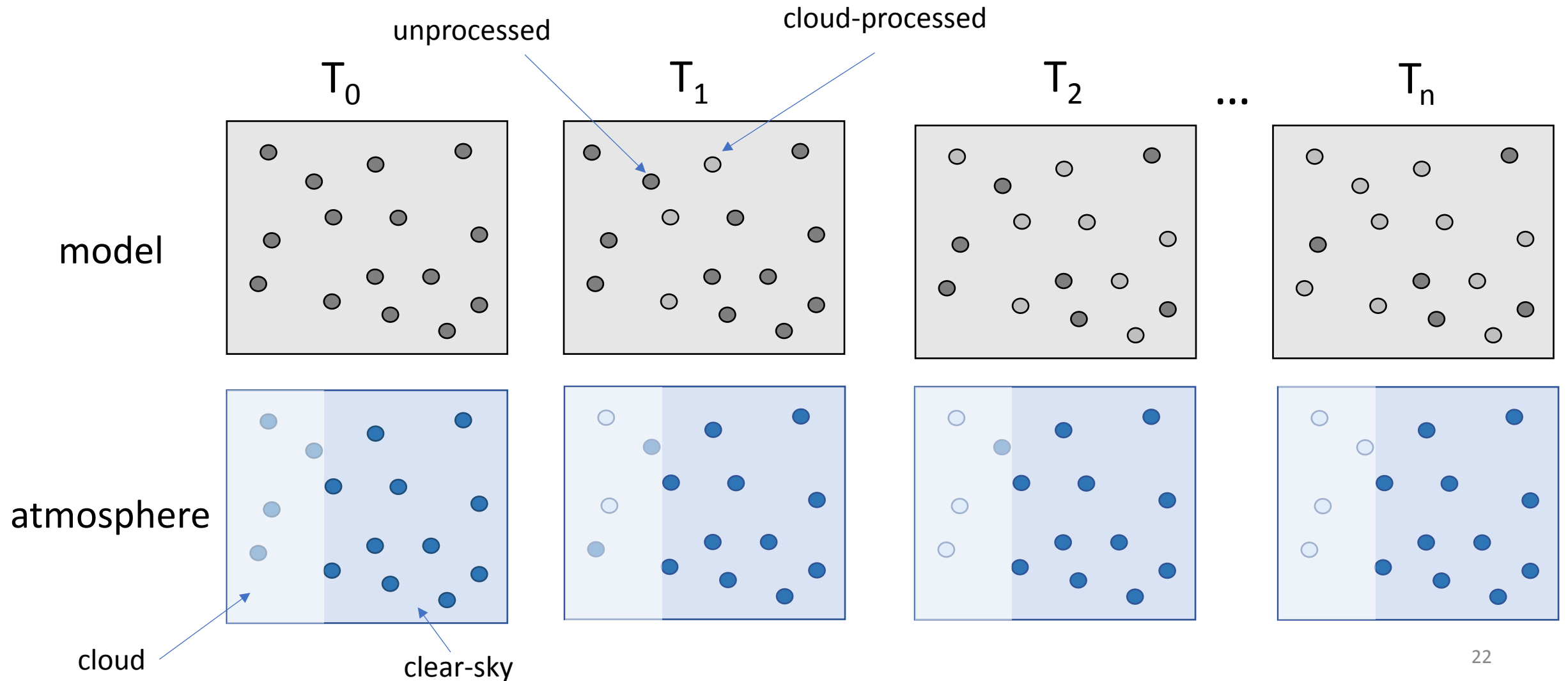




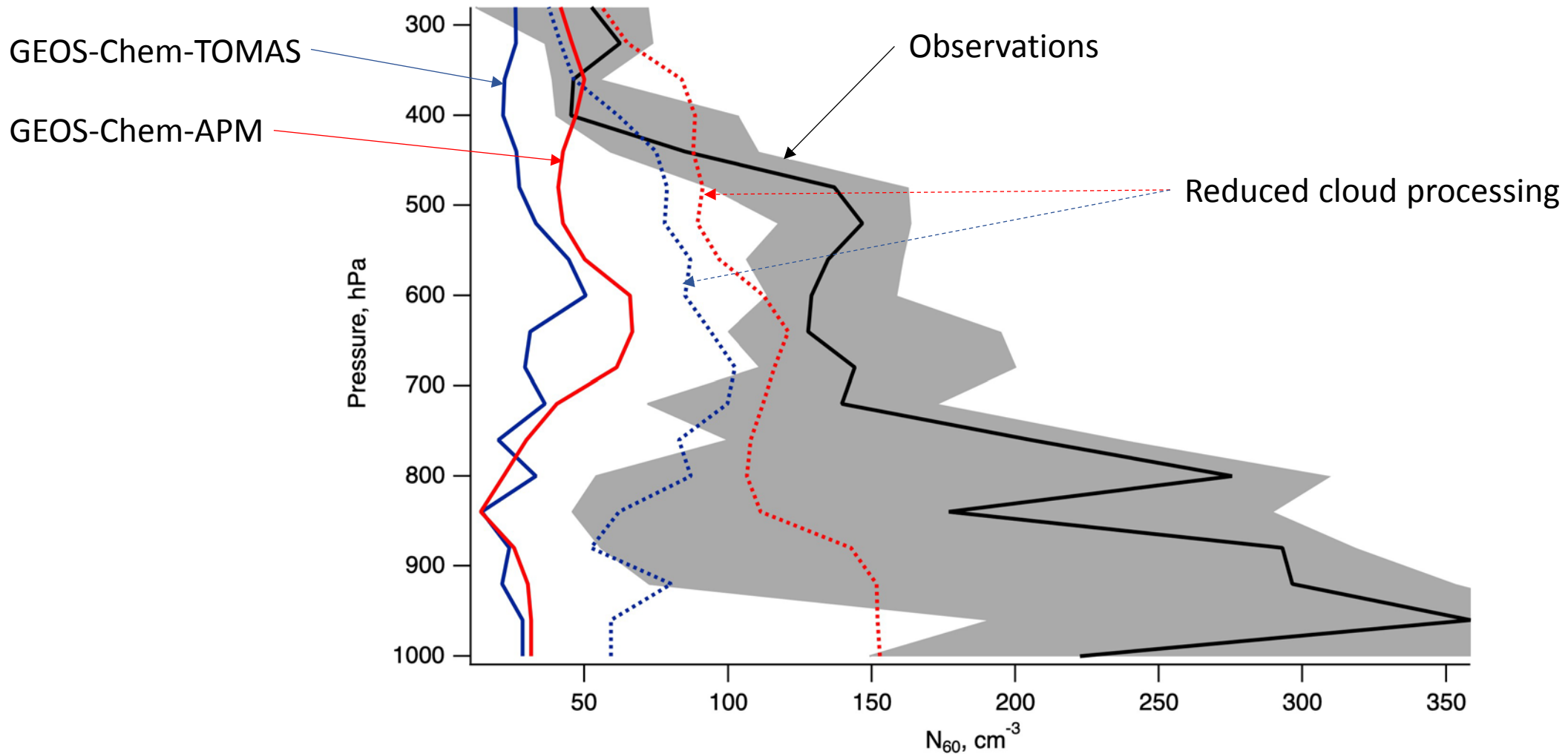
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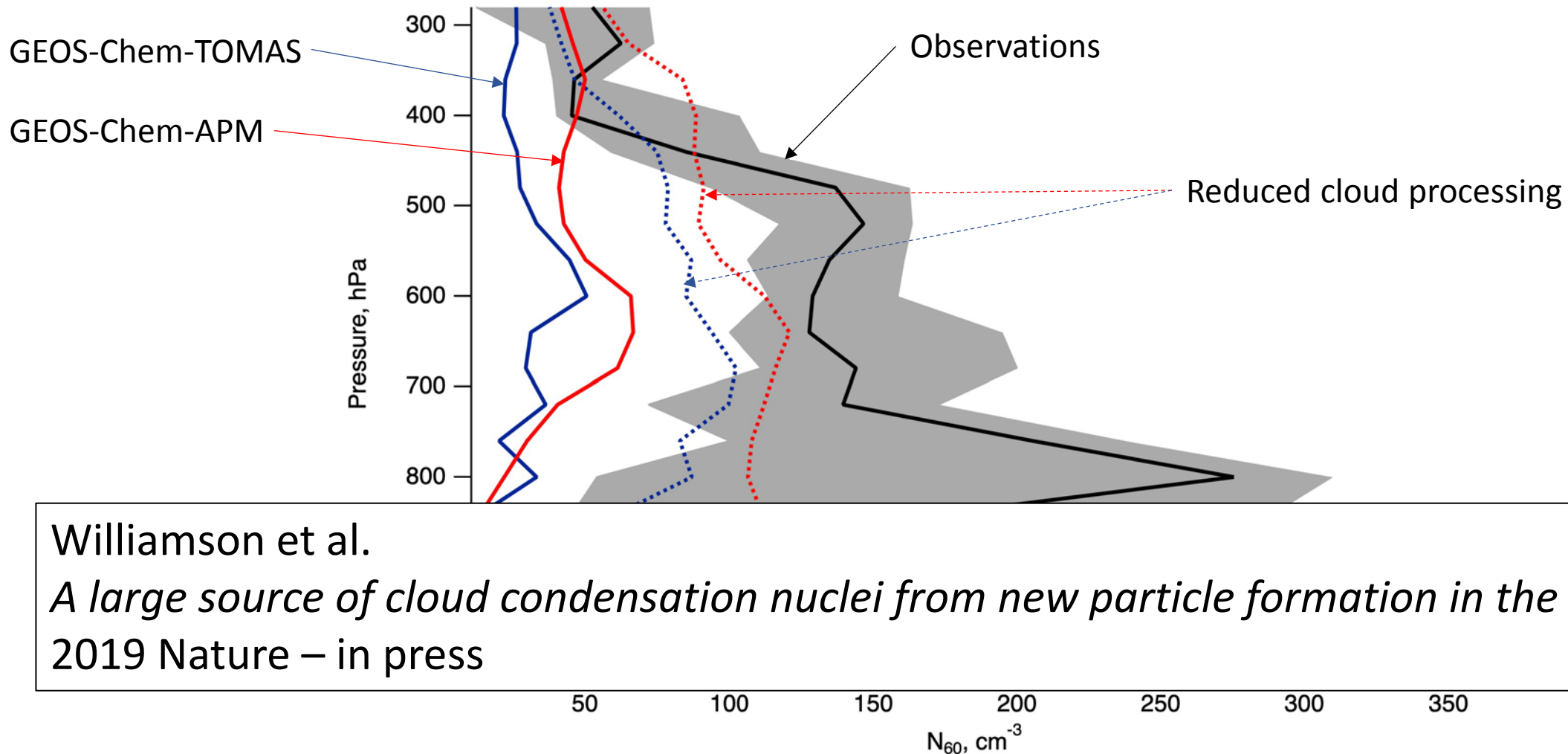
# Too many particles are removed by cloud-processing in models



# Incorrect cloud processing may account for some of the missing CCN



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Williamson et al.

*A large source of cloud condensation nuclei from new particle formation in the tropic*  
2019 Nature – in press

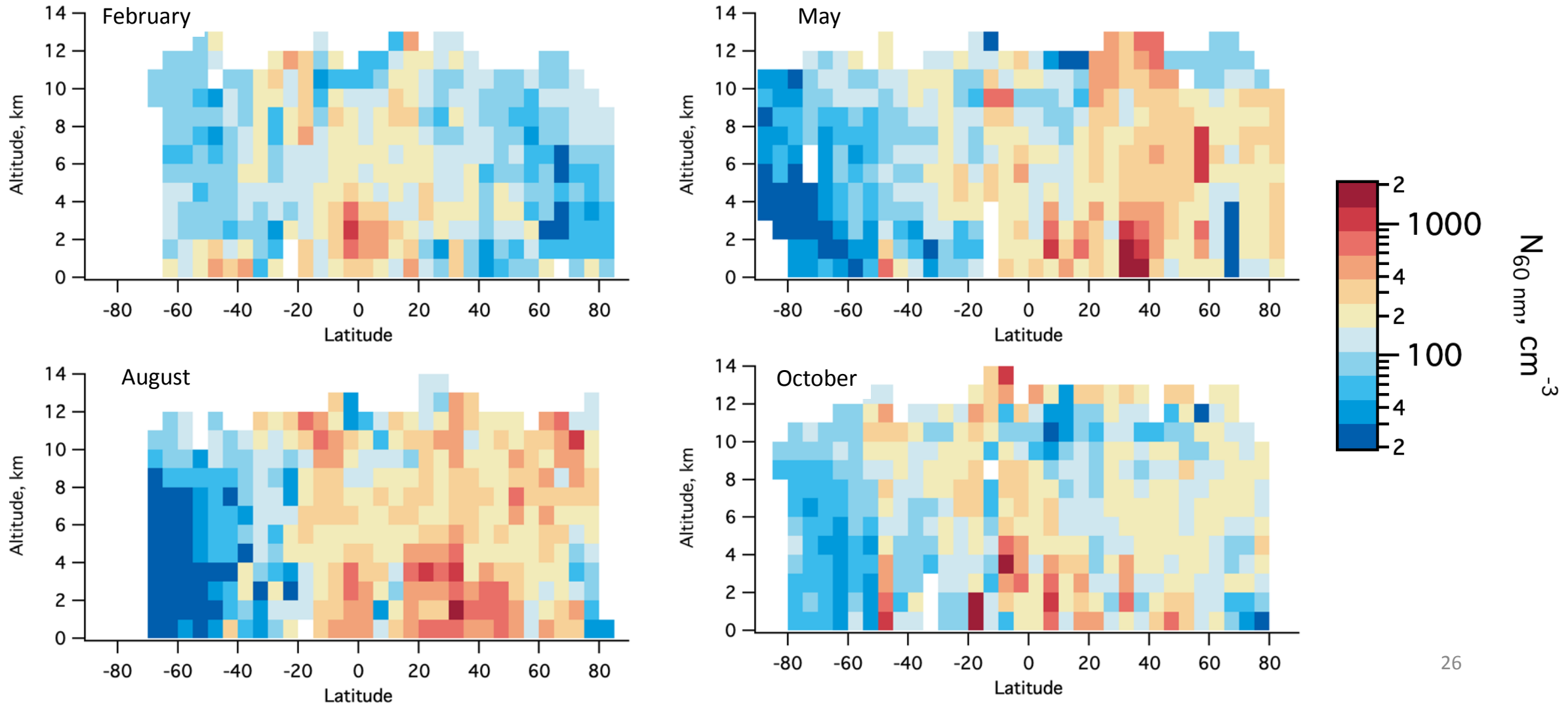


# Southern High Latitudes

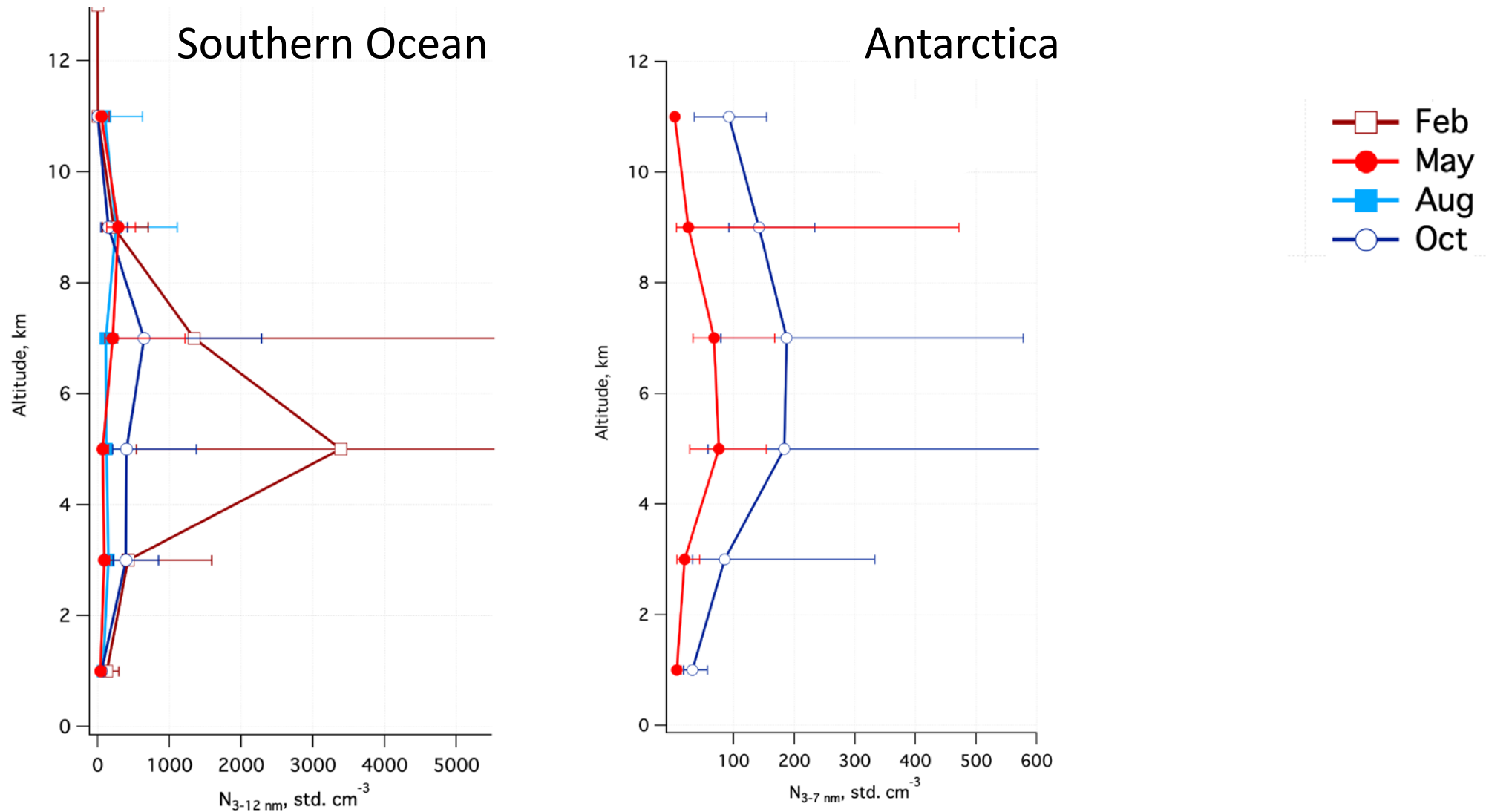


*Photograph: Samuel Hall, NCAR*

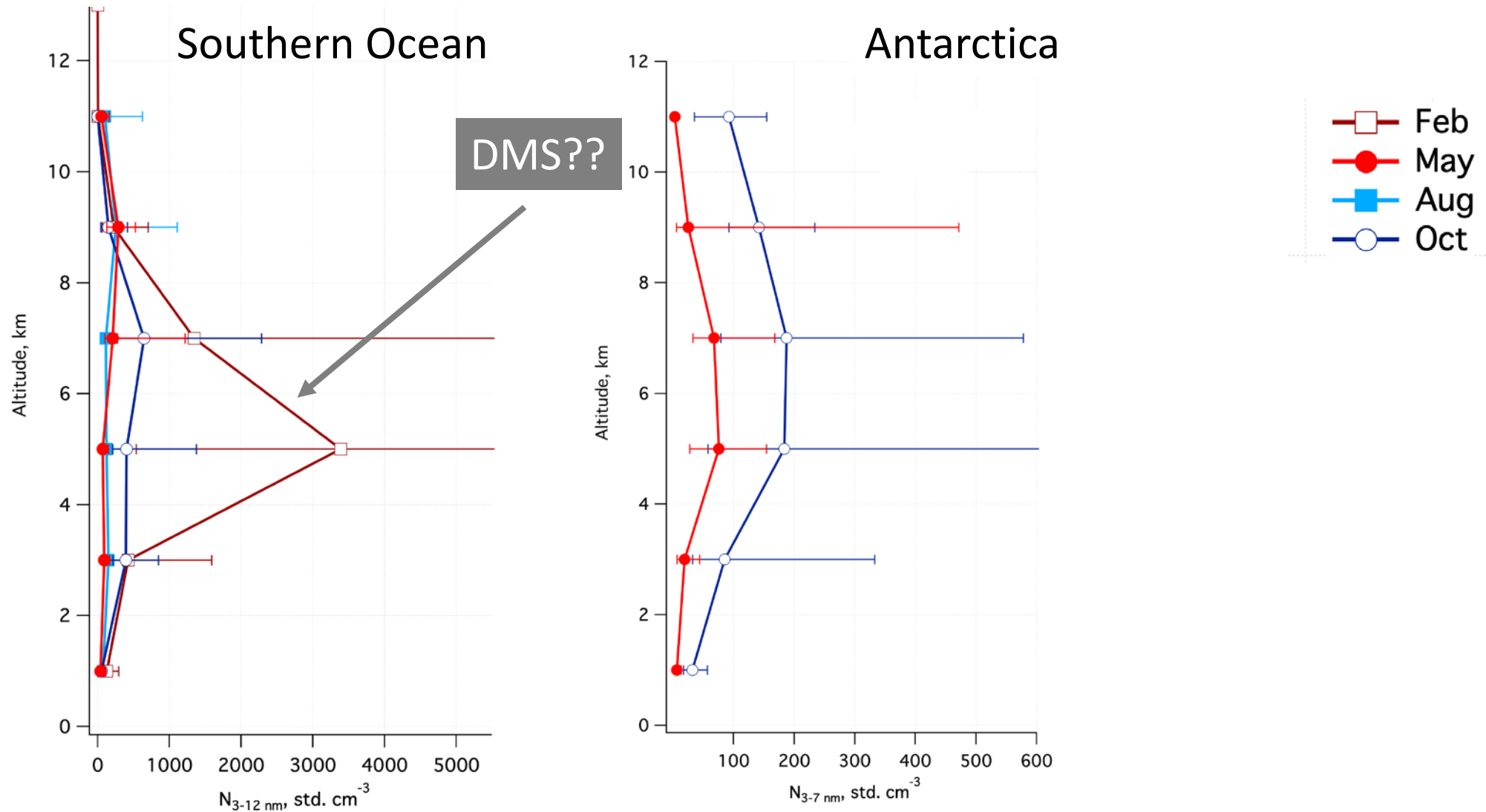
# Few particles from other sources exist at southern high latitudes



# Southern High Latitude NPF has a strong seasonal dependence

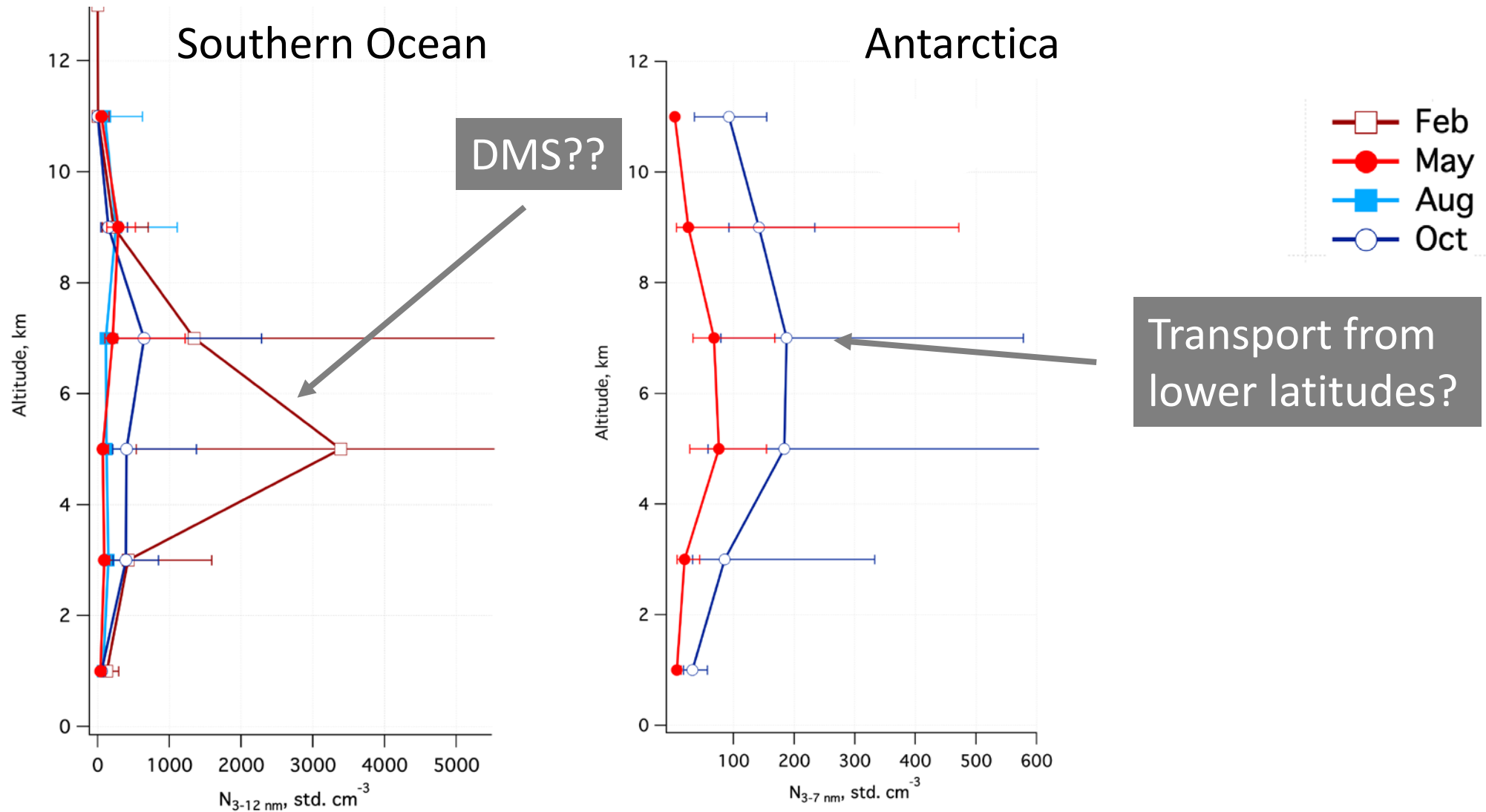


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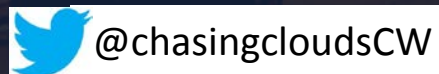
## Summary

- NPF in the tropical upper troposphere is an important source of CCN

*Williamson et al. – Nature, 2019 – in press*

- NPF at southern high latitudes is significant and strongly seasonally dependent
- AeroCom experiment to assessing NPF and it's contribution to CCN in models using ATom observations

*open for submissions!*



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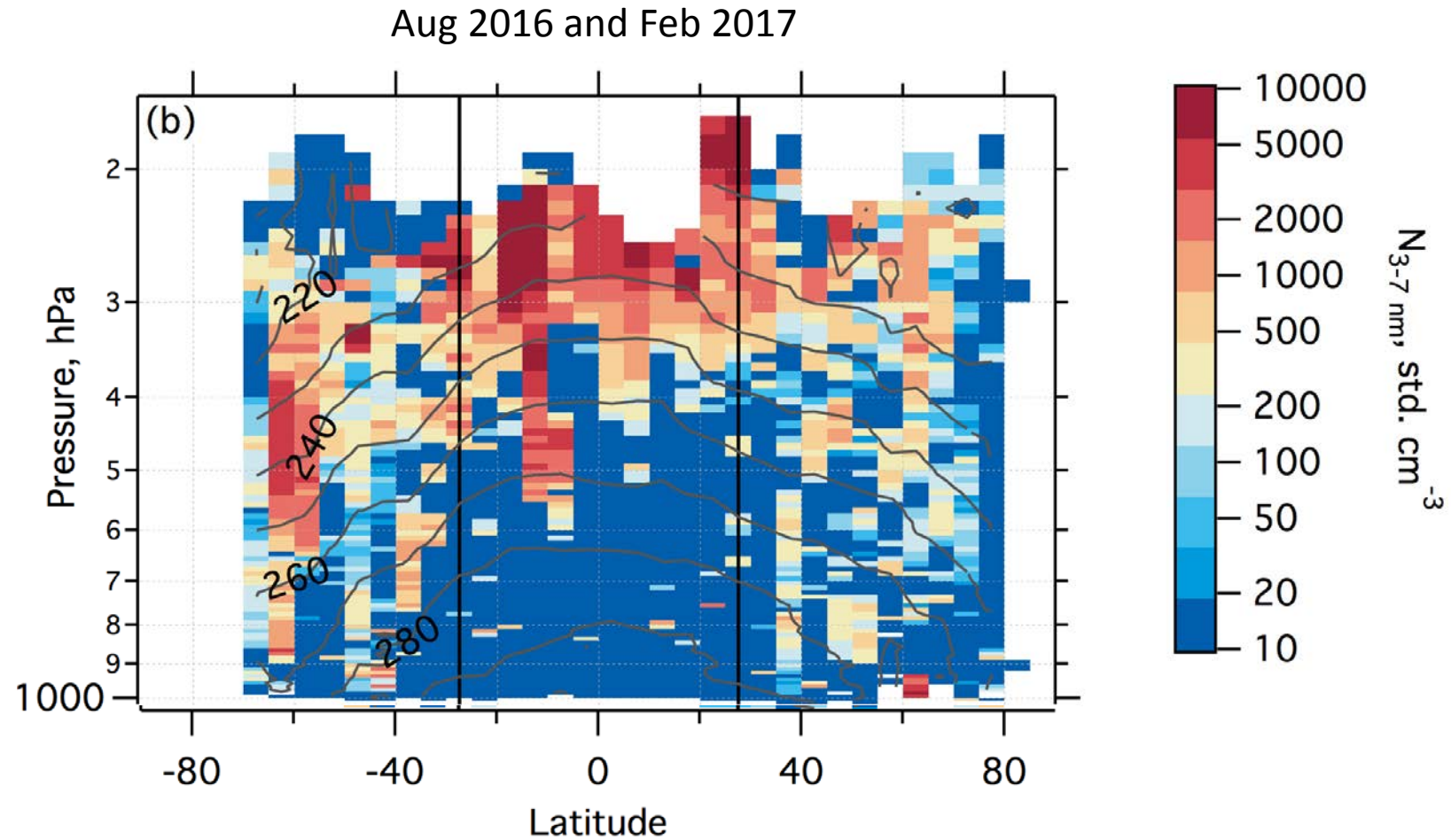
Back-up

# Reduced cloud processing

- rainout and washout in cloud anvils and large-scale cloud systems
- aqueous oxidation of  $\text{SO}_2$
- reduced by a factor of 10 at all altitude between  $28^\circ\text{N}$  and  $28^\circ\text{S}$ .
- proxy for reducing cloud processing of particles and gases in descending air



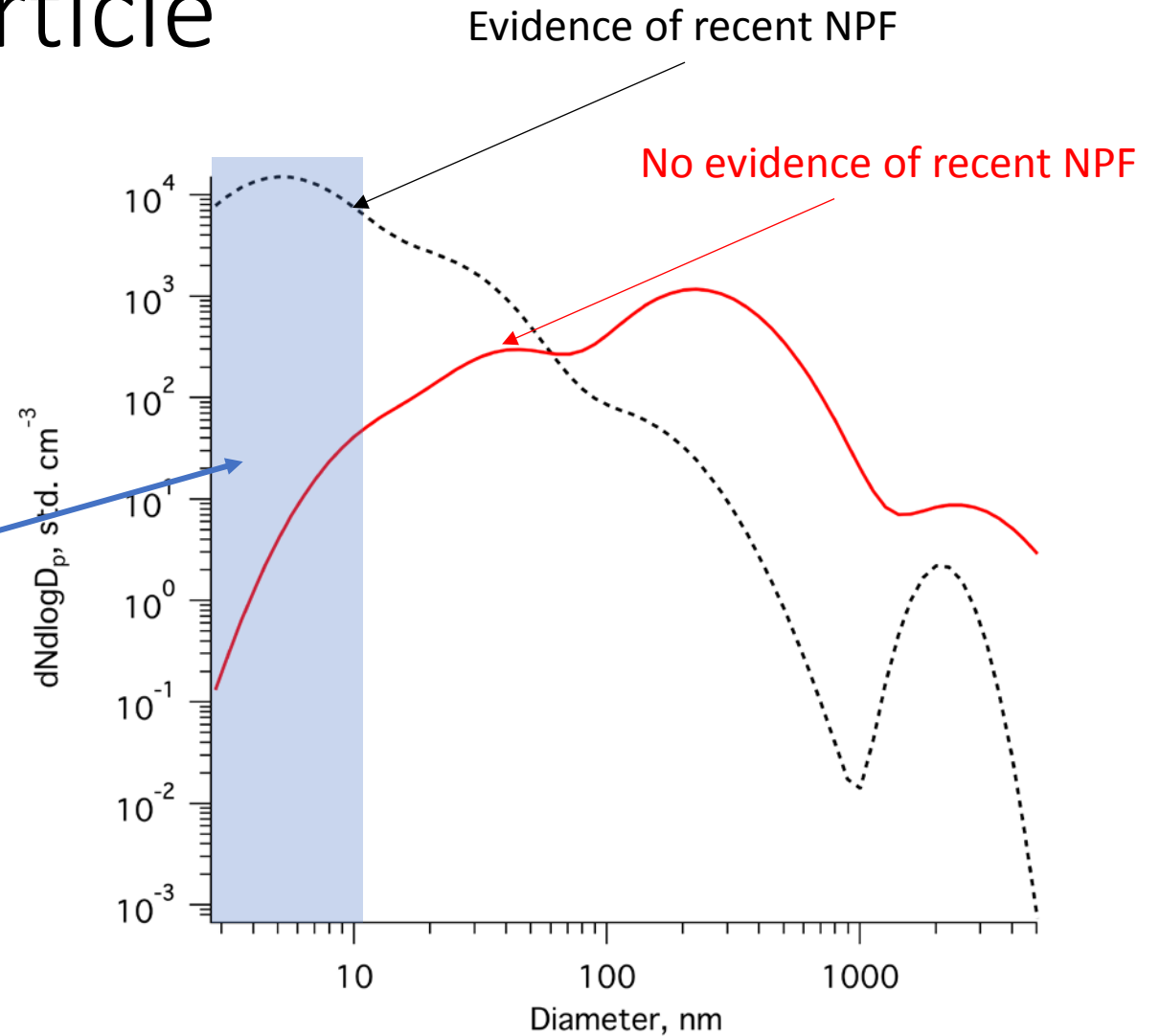
# An abundance of newly formed particles in the tropical upper troposphere



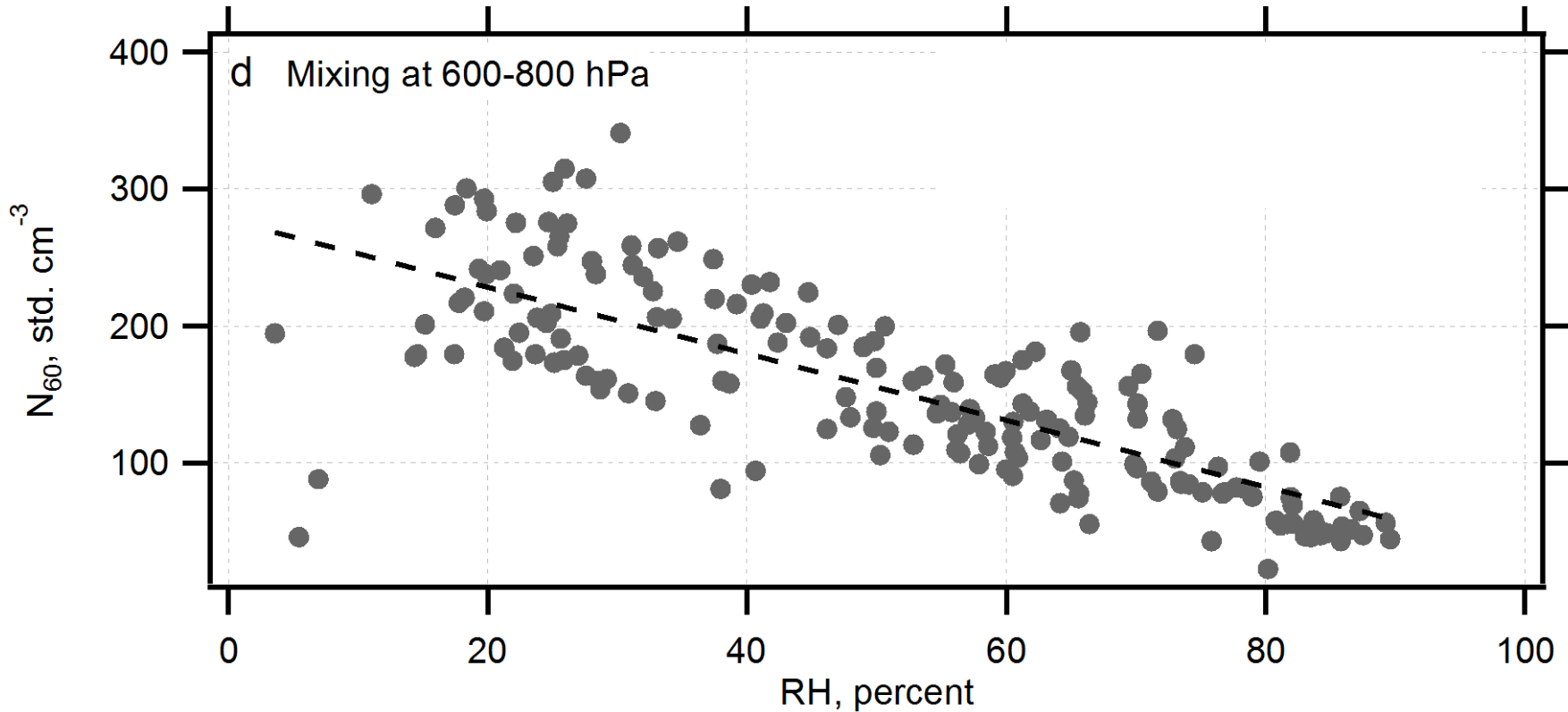
# Observations of particles at the smallest sizes indicate recent new particle

2-12 nm particles

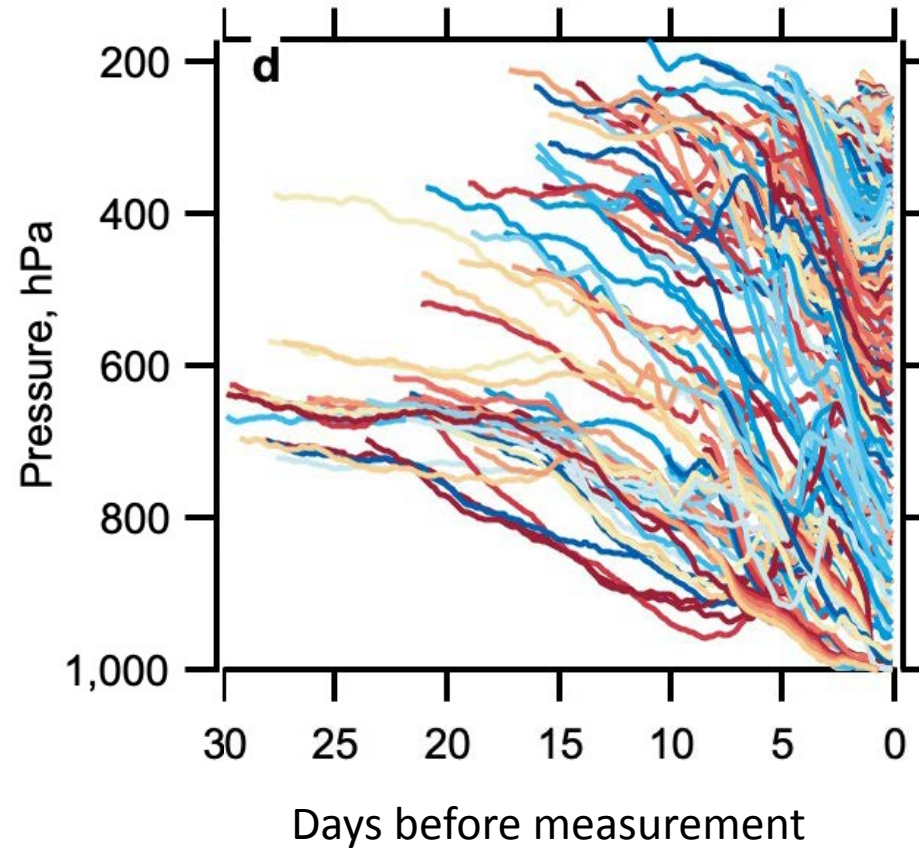
- Only produced by NPF
- Have not had time to grow much



Many CCN-sized particles at lower altitudes  
come from above



Air outside of clouds in the tropics is descending





# Constraining NPF in models is especially important for pre-industrial

