# New Particle Formation and the Asian Summer Monsoon
# a partial review of

## *“The ATAL within the 2017 Asian Monsoon Anticyclone: Microphysical aerosol properties derived from aircraft-borne in situ measurements”*

Christoph Mahnke, Ralf Weigel, Francesco Cairo, Jean-Paul Vernier, Armin Afchine, Martina Krämer, Valentin Mitev, Renaud Matthey, Silvia Viciani, Francesco D’Amato, Felix Ploeger, Terry Deshler, and Stephan Borrmann

Christina Williamson

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**The ATAL within the 2017 Asian Monsoon Anticyclone: Microphysical aerosol properties derived from aircraft-borne in situ measurements**

Christoph Mahnke[1,*], Ralf Weigel[2], Francesco Cairo[3], Jean-Paul Vernier[4,5], Armin Afchine[6], Martina Krämer[6], Valentin Mitev[7], Renaud Matthey[8], Silvia Viciani[9], Francesco D'Amato[9], Felix Ploeger[6], Terry Deshler[10], and Stephan Borrmann[1,2]

# Airborne in-situ and remote sensing observation of aerosol microphysical properties

- 2017 StratoClim field campaign within the region of the Asian monsoon anticyclone
- M55 Geophysica - maximum altitude ~ 20.5 km
- modified Ultra High Sensitivity Aerosol Spectrometer Airborne (UHSAS-A) size resolved number concentrations 65 nm - 1 µm
- COndensation PArticle counting System (COPAS), total aerosol concentration 10 nm - 1 µm
- Cloud and Aerosol Spectrometer with Detection of POLarization (NIXE-CAS-DPOL)

**The ATAL within the 2017 Asian Monsoon Anticyclone: Microphysical aerosol properties derived from aircraft-borne in situ measurements**

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# Major Findings

- ATAL layer 15 km ( 370 K) - 18.5 km altitude (420 K).
- Particle concentrations ~ 2x concentrations in other tropical locations at similar potential temperatures and altitudes
- High concentrations of particles with diameters 10-65 nm just below ATAL indicates new particle formation

# New Particle Formation in the UTLS

Clarke and Kasputin 2002
*A Pacific Aerosol Survey. Part I: A Decade of Data on Particle Production, Transport, Evolution, and Mixing in the Troposphere*

Pacific Ocean
3-3000 nm

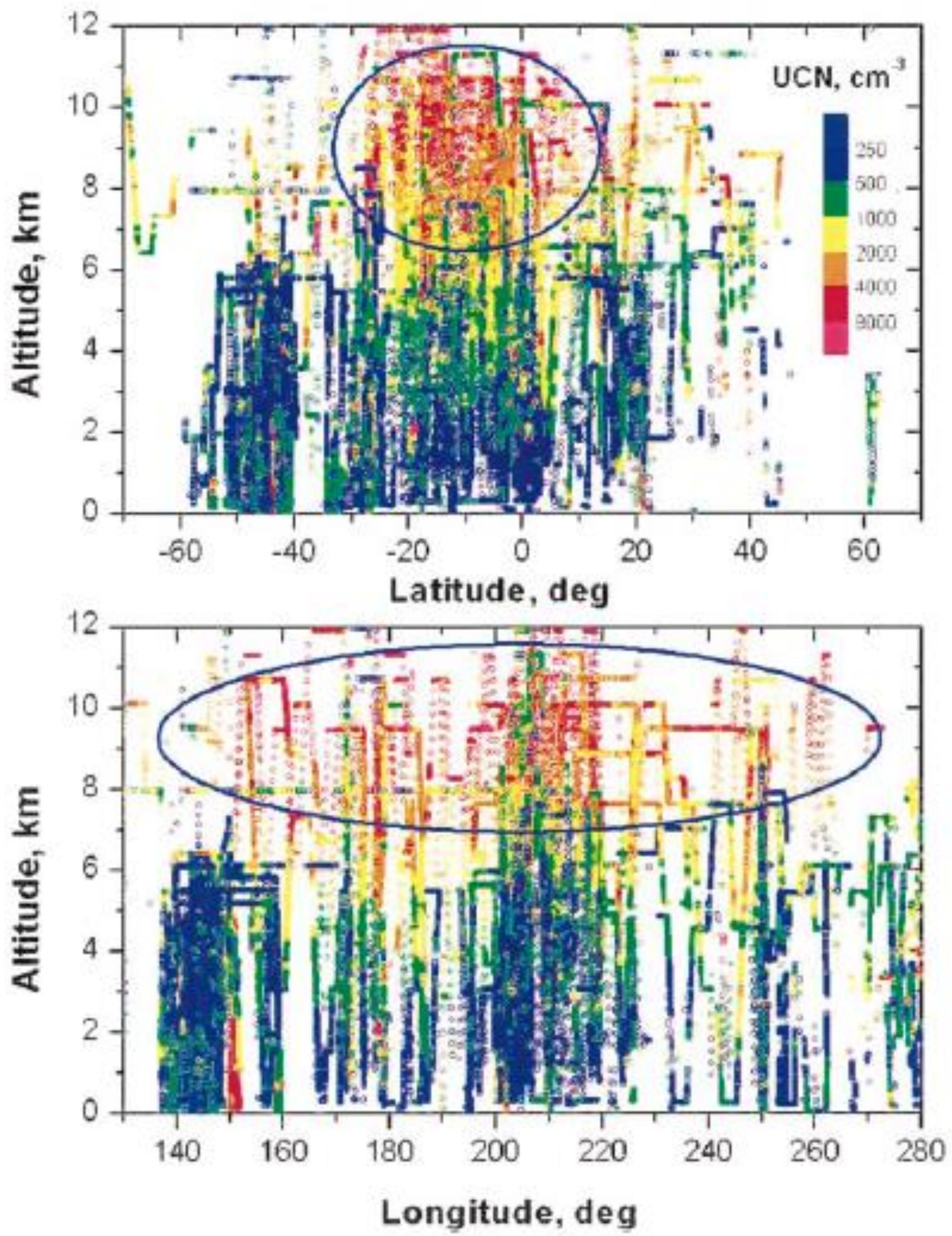
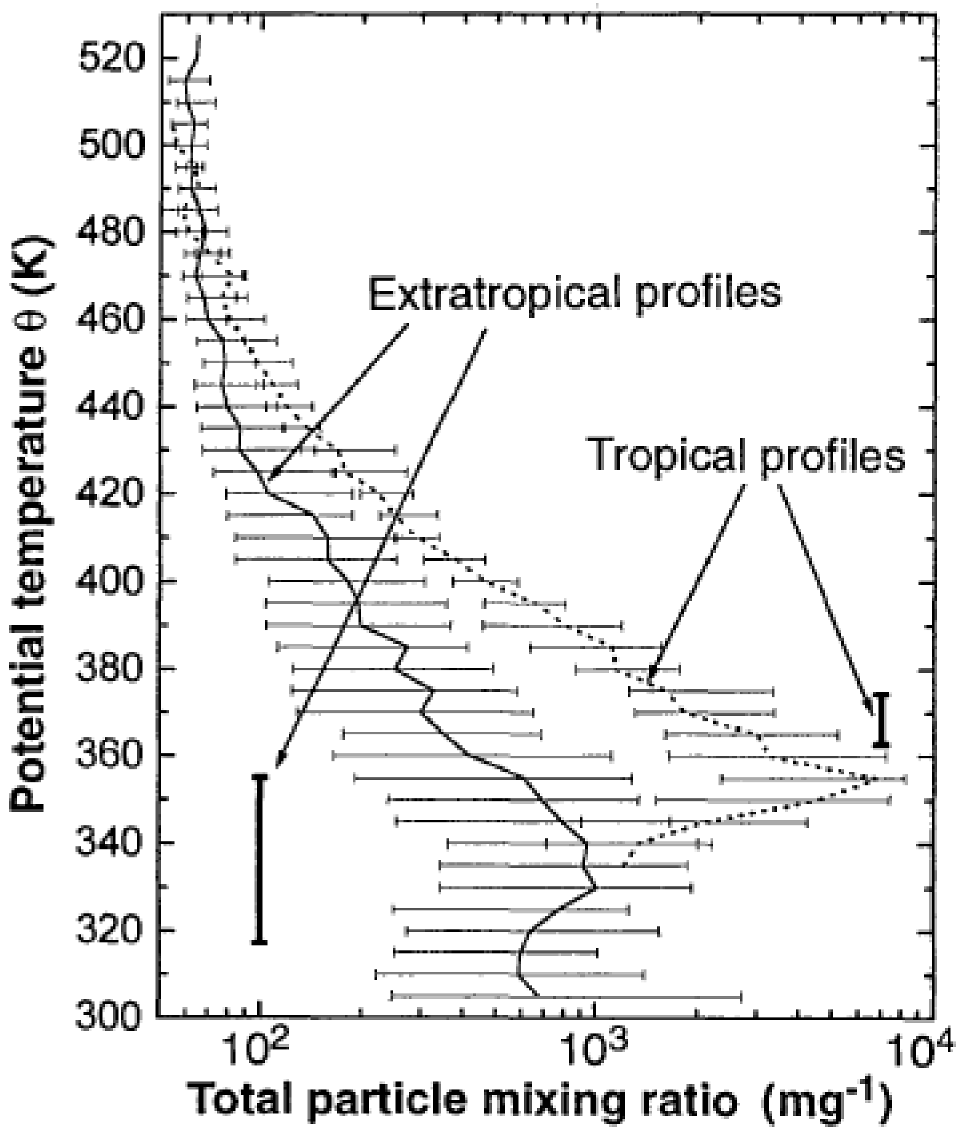



FIG. 7. Color-coded 5-min-average concentrations as a function of altitude and (a) latitude and (b) longitude for all experiments. Highest concentrations are found aloft and distributed over the equatorial zone of deep convection.

# New Particle Formation in the UTLS

Brock et al 1995
*Particle Formation in the Upper Tropical Troposphere: A Source of Nuclei for the Stratospheric Aerosol*

8 nm – 3000 nm

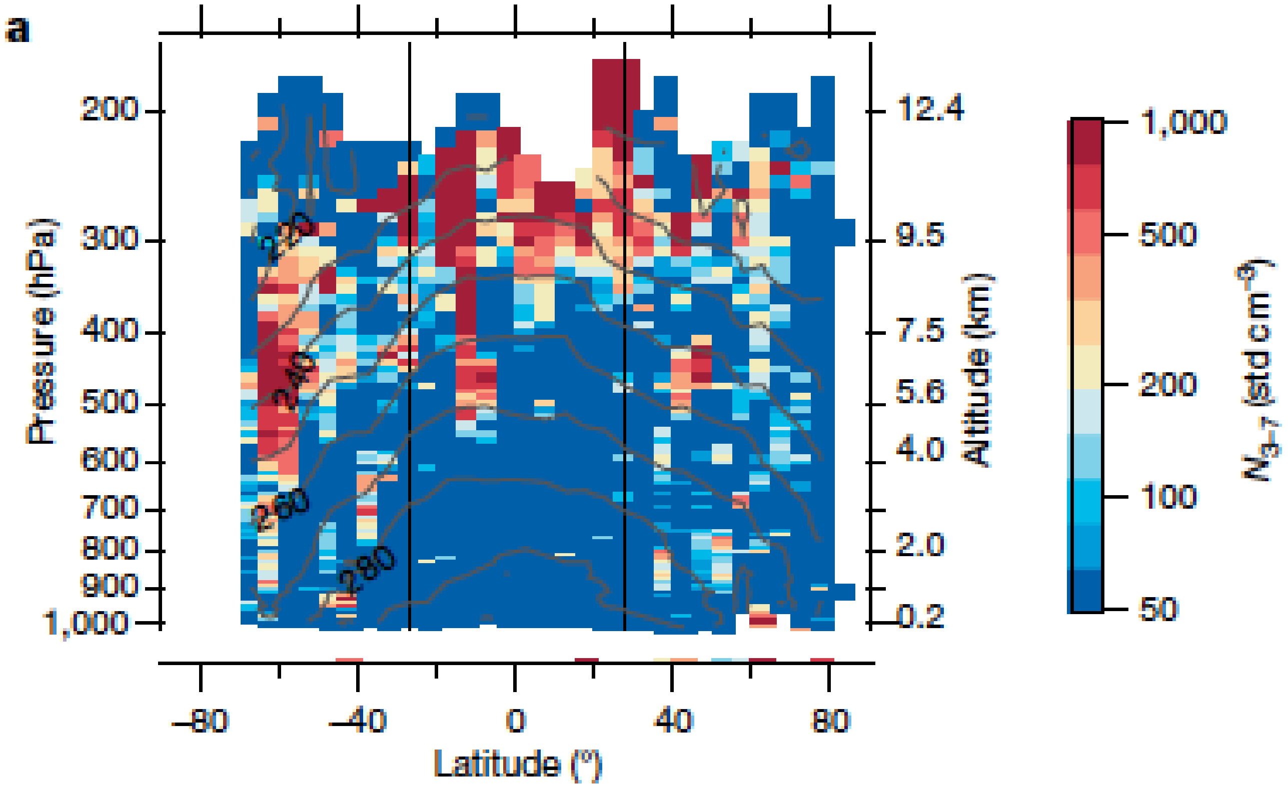


# New Particle Formation in the UTLS

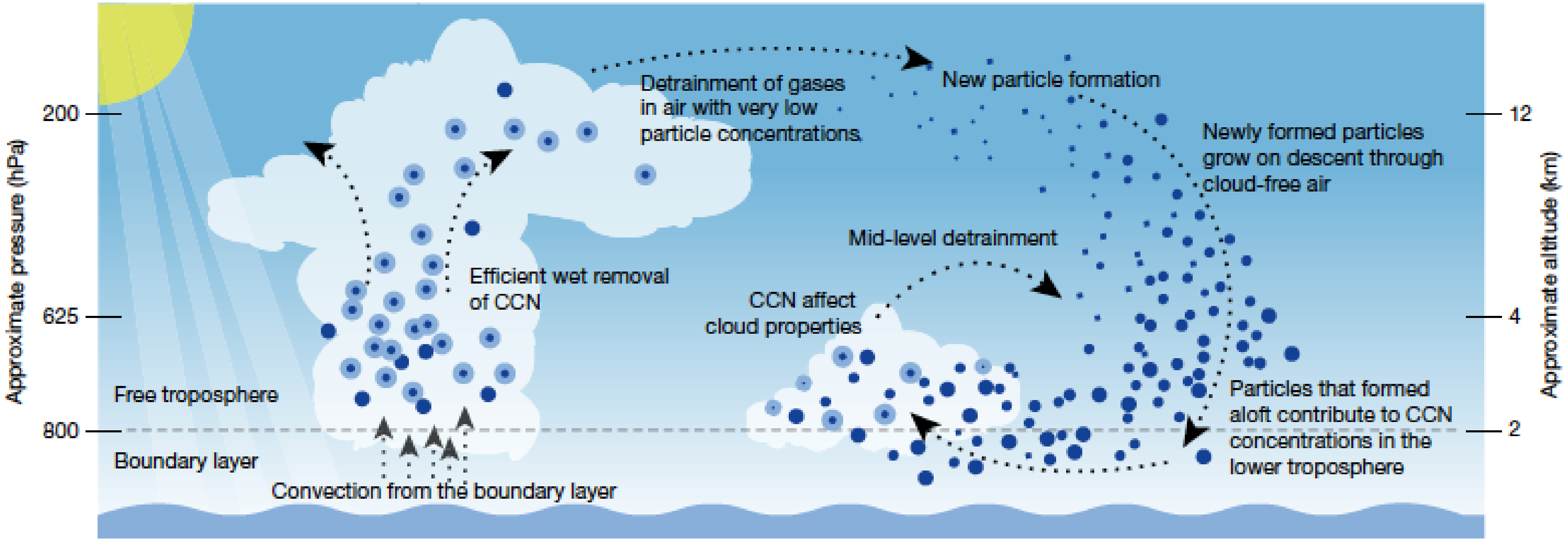
Williamson et al 2019
*A large source of cloud condensation nuclei from new particle formation in the tropics*

Atmospheric Tomography Mission
Remote Pacific and Atlantic

3-7 nm



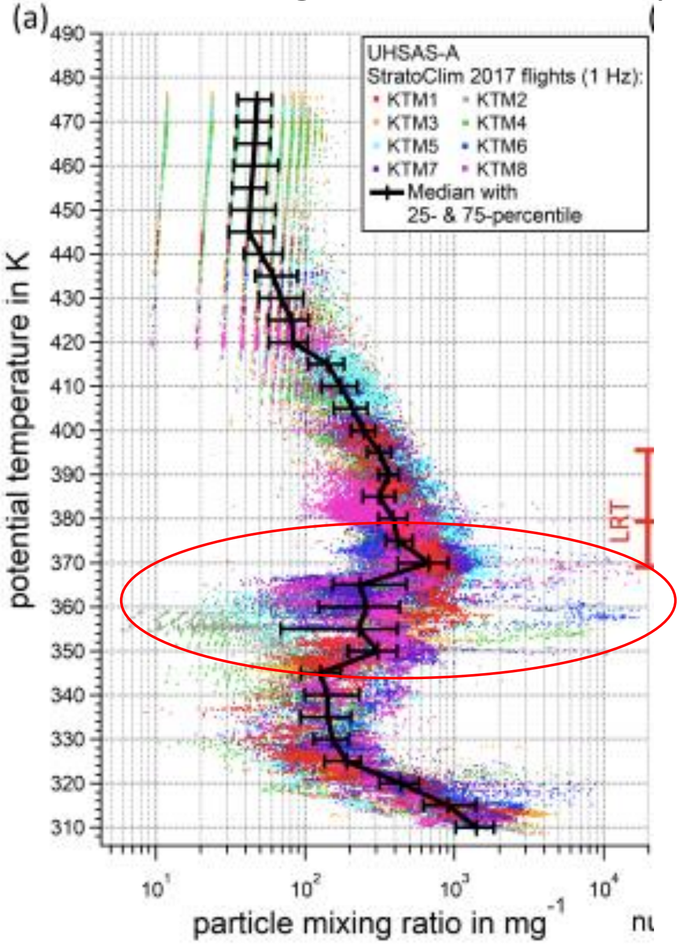
# UTLS new particle formation linked to convection in the tropics and mid latitudes




Williamson et al 2019
*A large source of cloud condensation nuclei from new particle formation in the tropics*
after Clarke et al 1998

# High variability in accumulation mode particles near LRT attributed to AMA

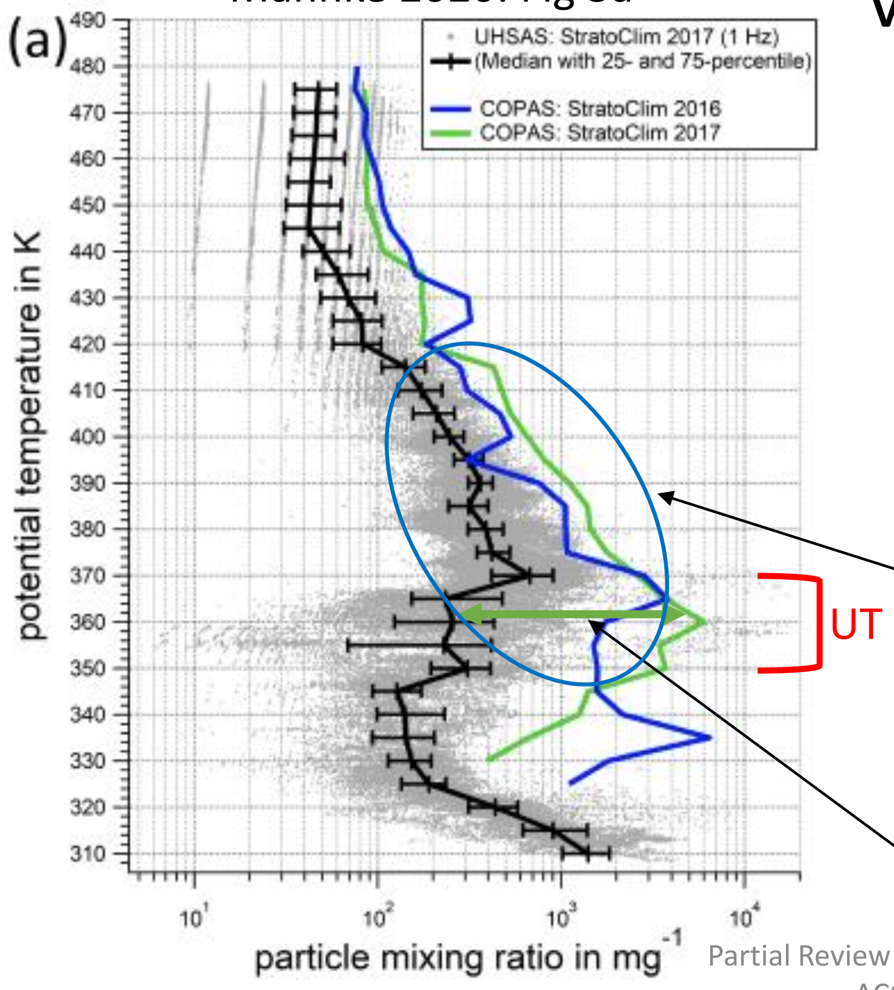
Mahnke 2020: Fig 2a - 65-1000 nm particles




High variability attributed to AMA dynamics, NPF and scavenging from large persistent convective cloud systems

# Large number if 10-65 nm particles in UT during ASM

Mahnke 2020: Fig 3a




Vertical profile of particle mixing ratios:

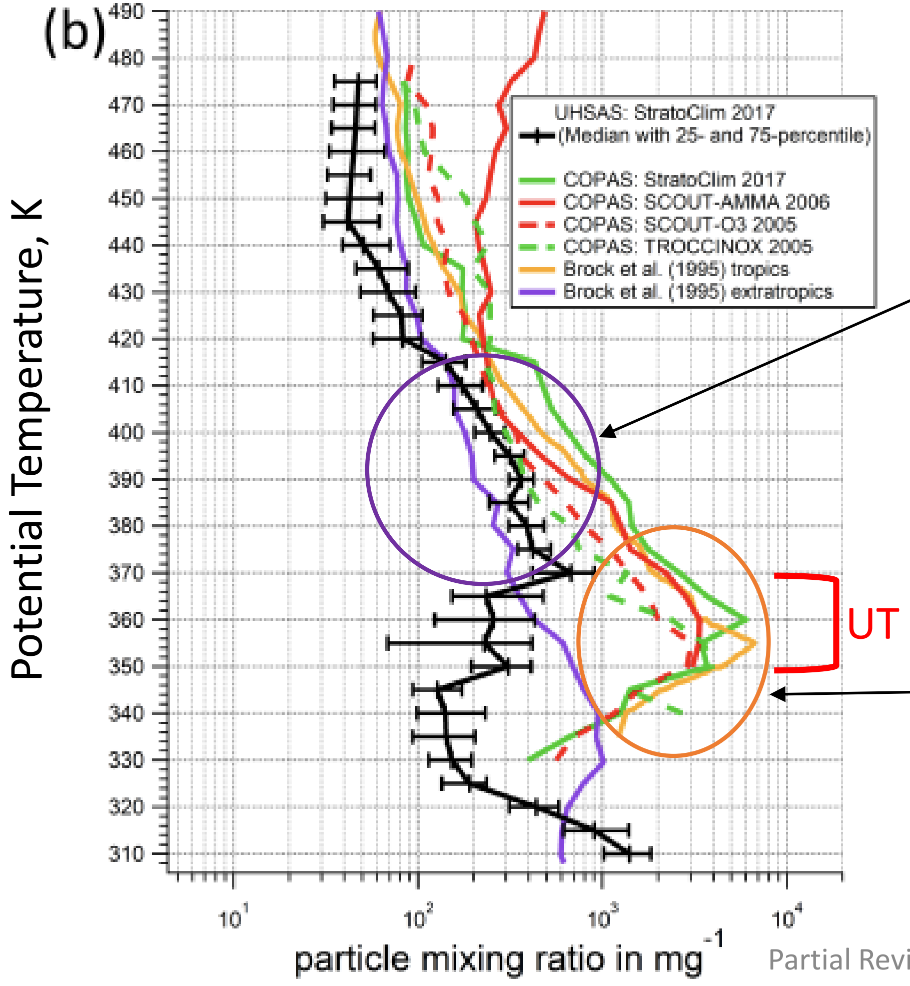
- StratoClim2017 65-1000 nm
- StratoClim 2017 10-1000 nm (tropics, Nepal)
- StratoClim2016 10-1000 nm – extratropics (Greece ~ 37N)

10-1000 nm particles
More in ASM than in extra tropics

~ 6000 mg$^{-1}$ 10-65 nm particles i.e. NPF

# AMA and Tropics in UTLS distinct from extra tropics

Mahnke 2020: Fig 3b



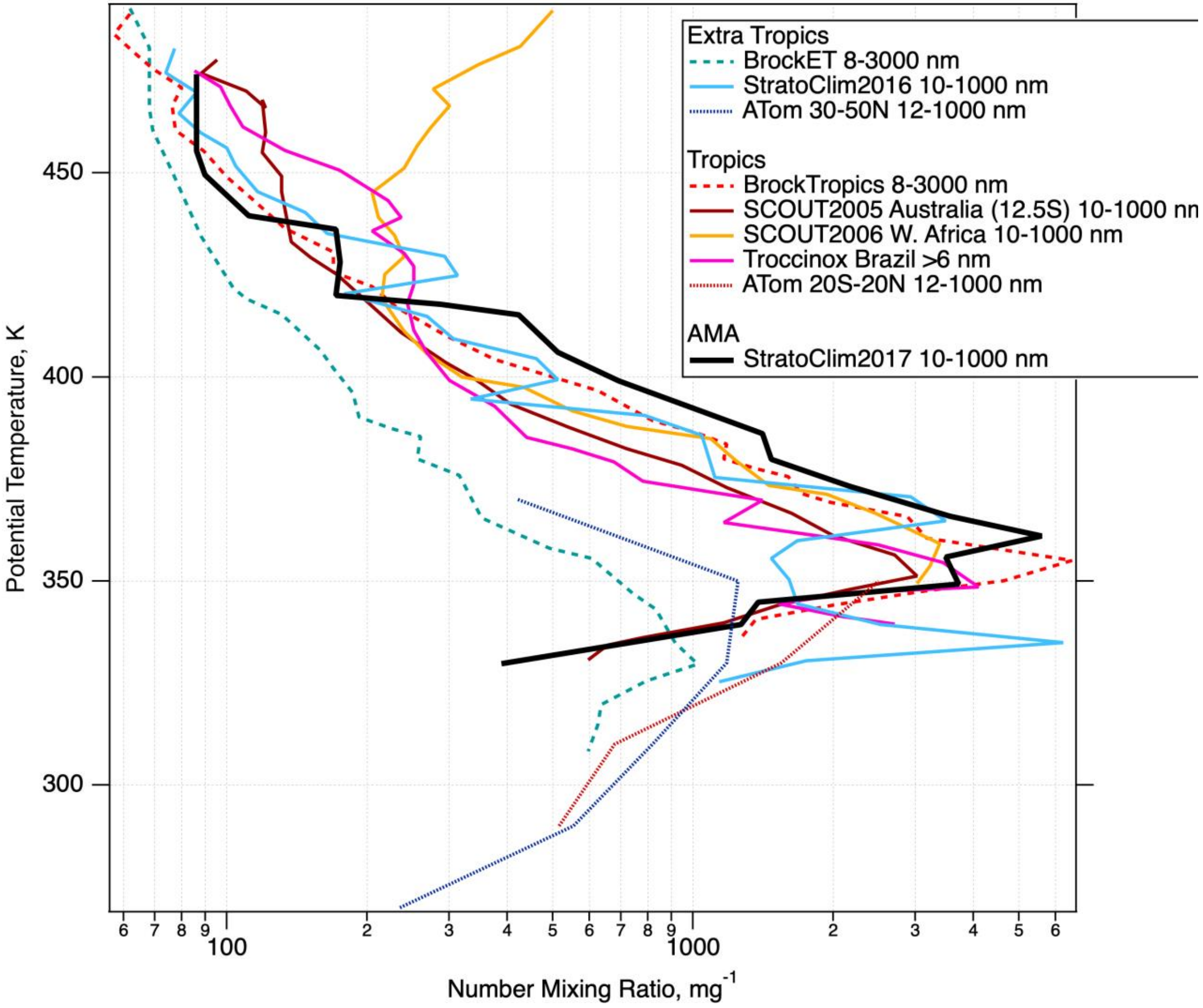

Brock extratropics 8-3000 nm
Stratoclim tropics 65-1000 nm

More particles during ASM

Tropical locations, including particles < 65 nm
Nepal ASM
*Brazil*
W. Africa
*Australia*
Brock 1995 tropics

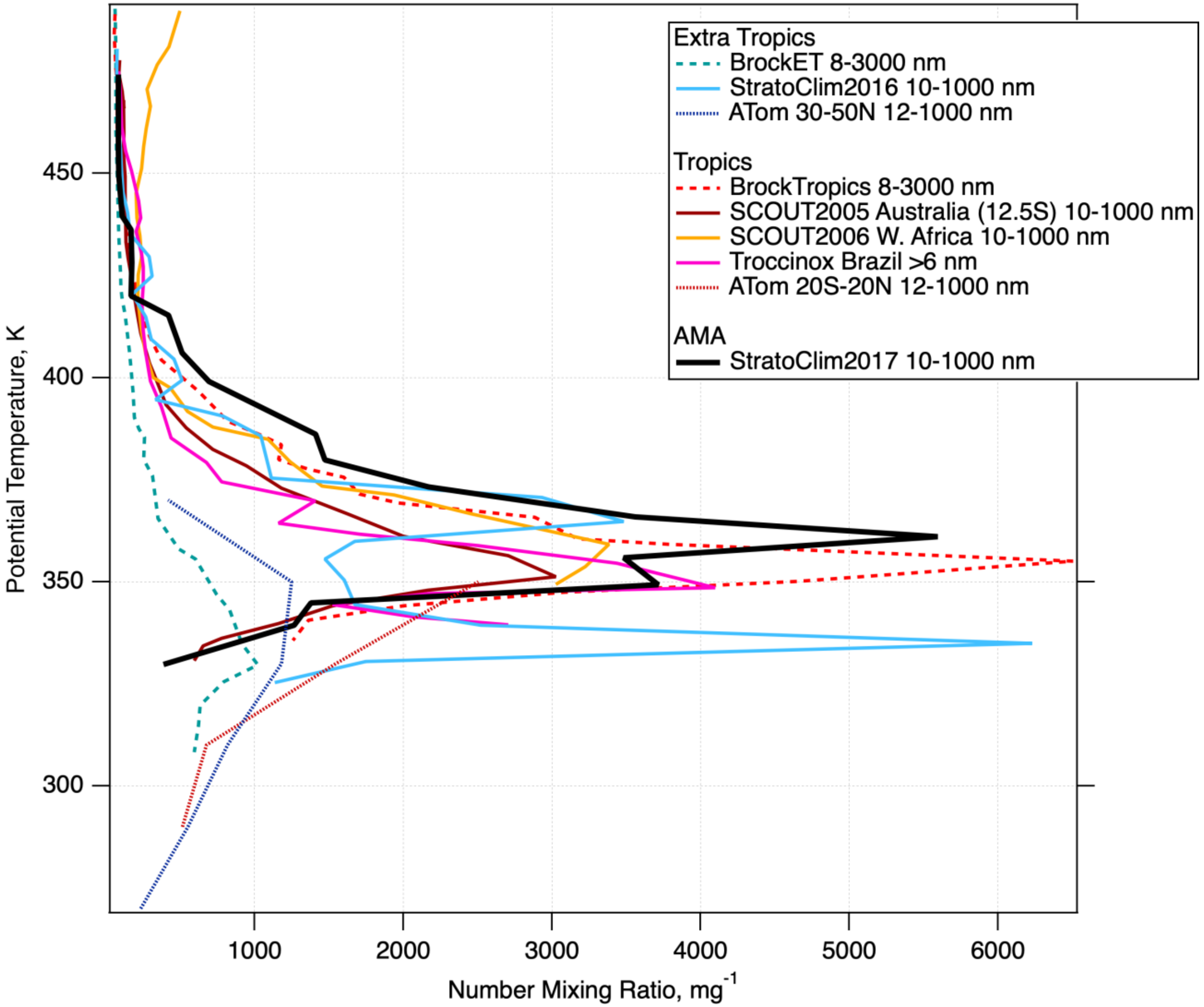
Borrmann et al 2010
*Aerosols in the tropical and subtropical UT/LS: in-situ measurements of submicron particle abundance and volatility*

# Tropics and AMA distinct from Extra-Tropics




Data from Mahnke et al 2020 3a, 3b
Additional data ATom

# Tropics and AMA distinct from Extra-Tropics

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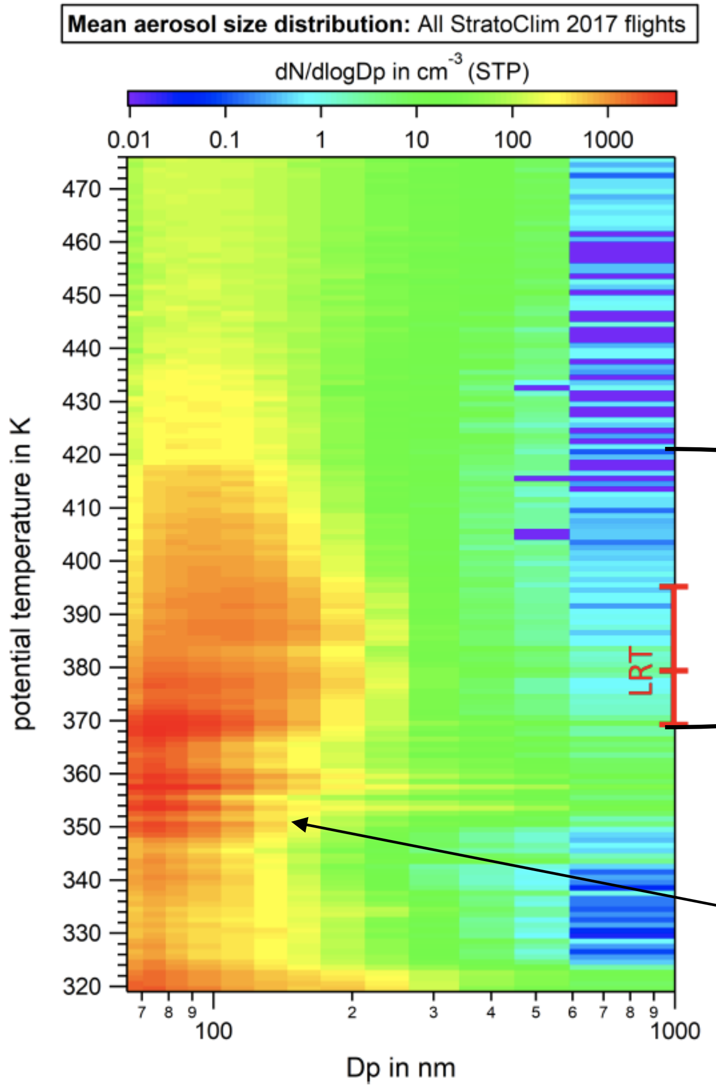
Additional data ATom

# Vertically resolved size distribution in AMA




Mahnke 2020: Fig 5

ATAL feature identified from measurements

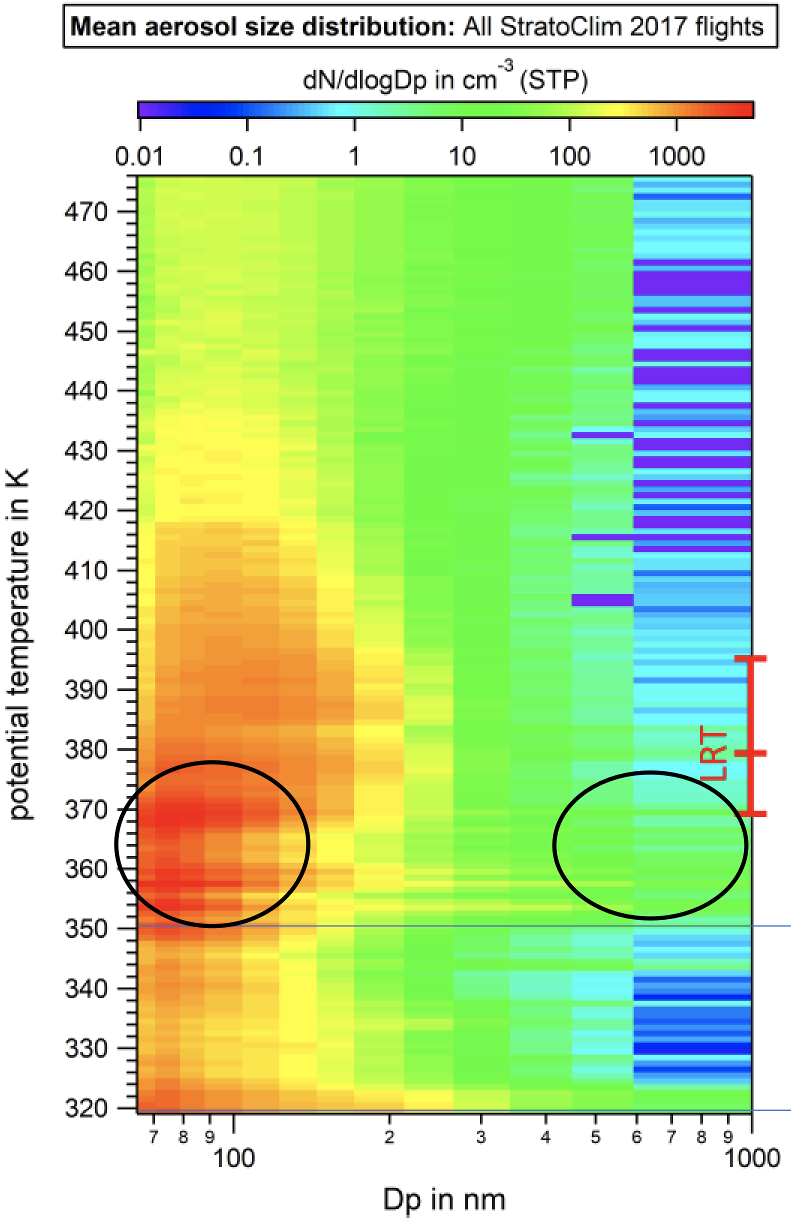
Enhanced numbers of larger particles

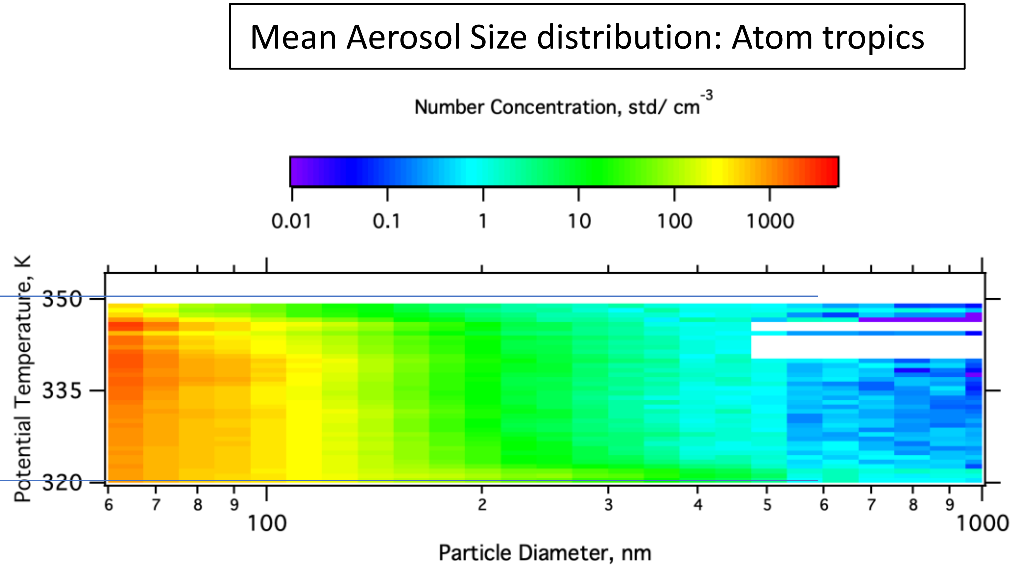
+

Large Aitken mode

# Size Distribution below ATAL fairly similar between StratoClim and mid Atlantic/Pacific

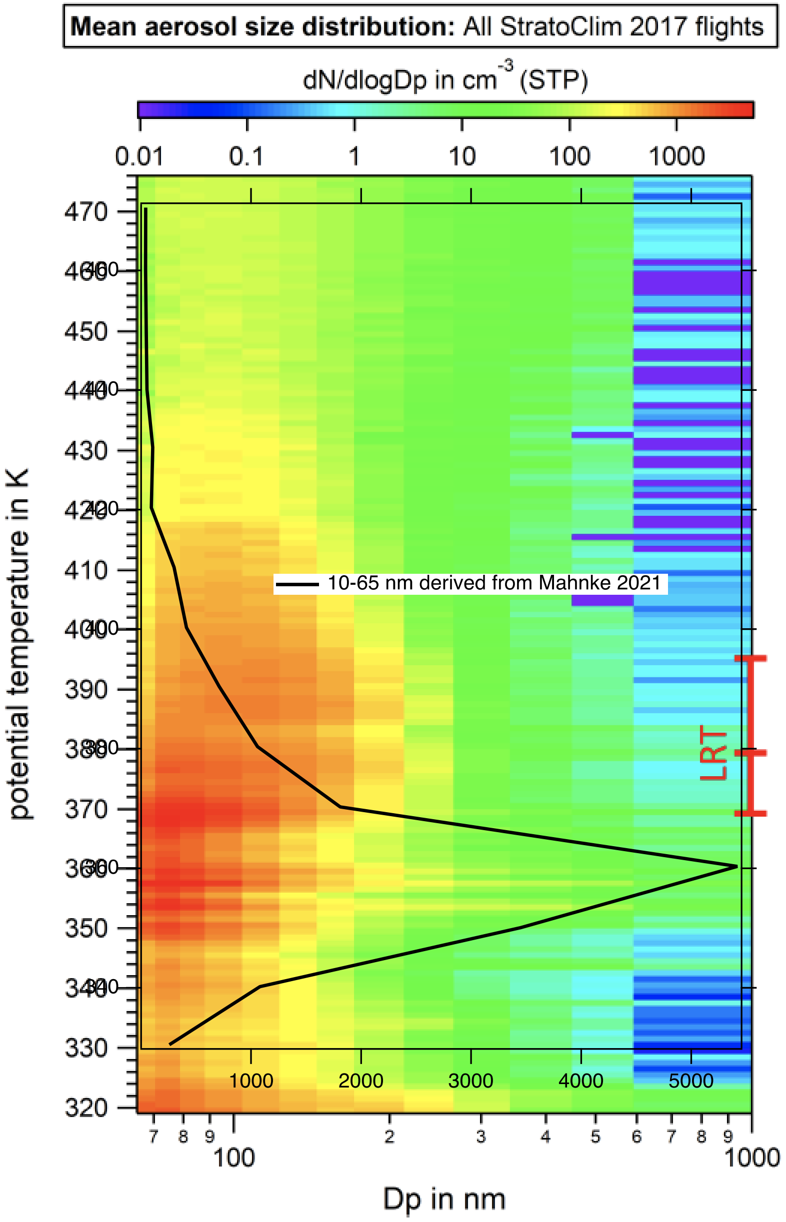
Mahnke 2020: Fig 5

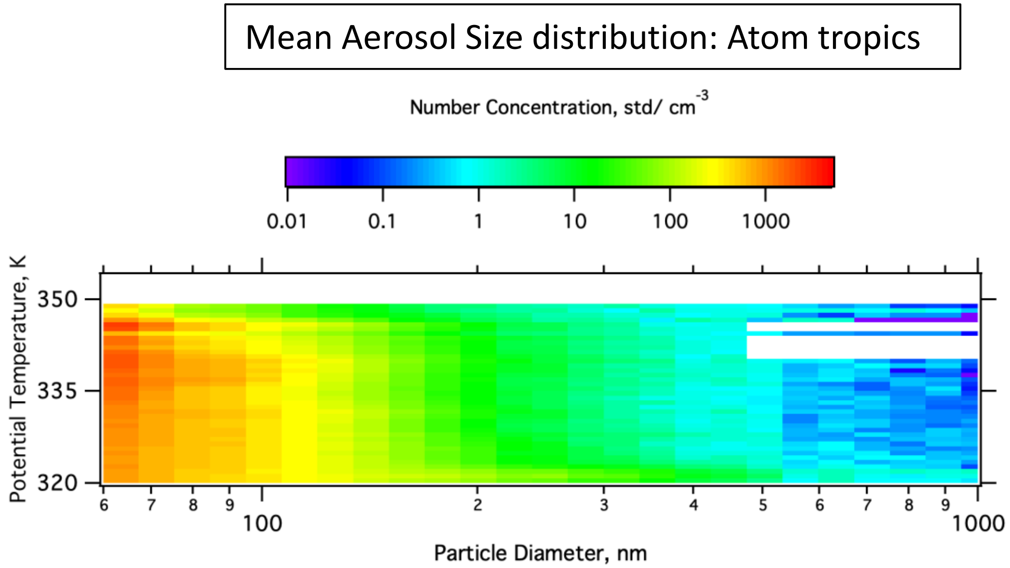


Mahnke 2020: Fig 5
With Aitken mode concentration derived from 3a

# Peak AMA 10-65 nm number concentration at higher sink than Atom remote tropical UT NFP



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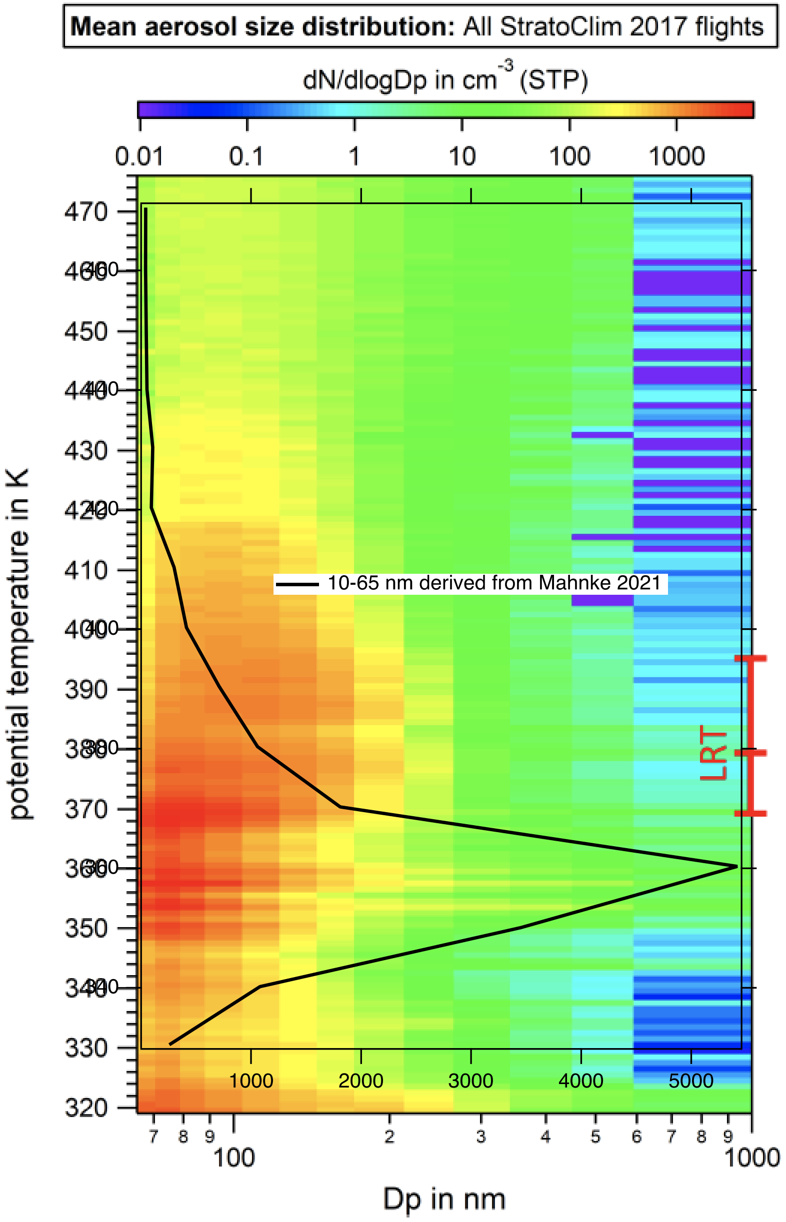
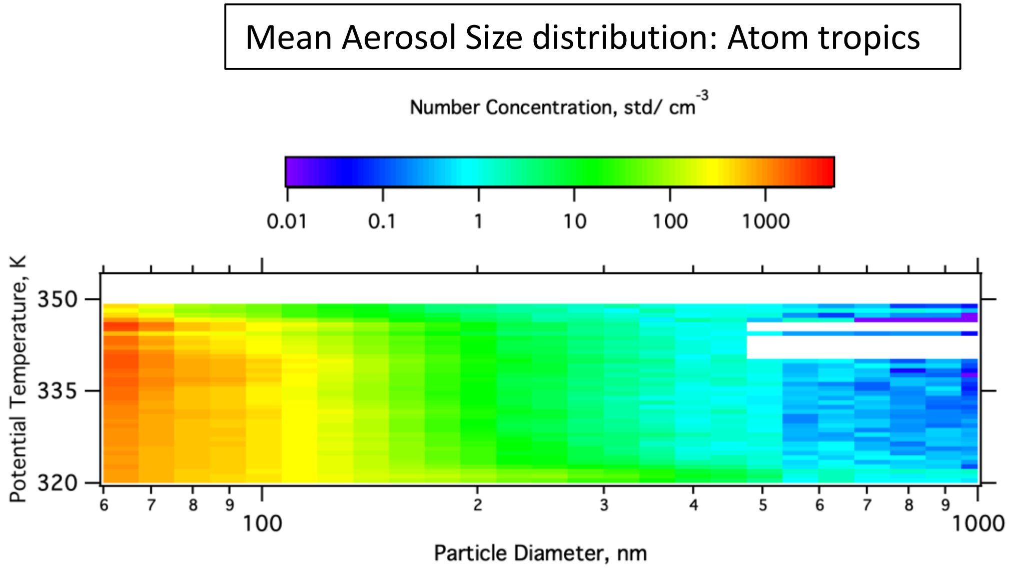



# Peak AMA 10-65 nm number concentration at higher sink than Atom remote tropical UT NFP

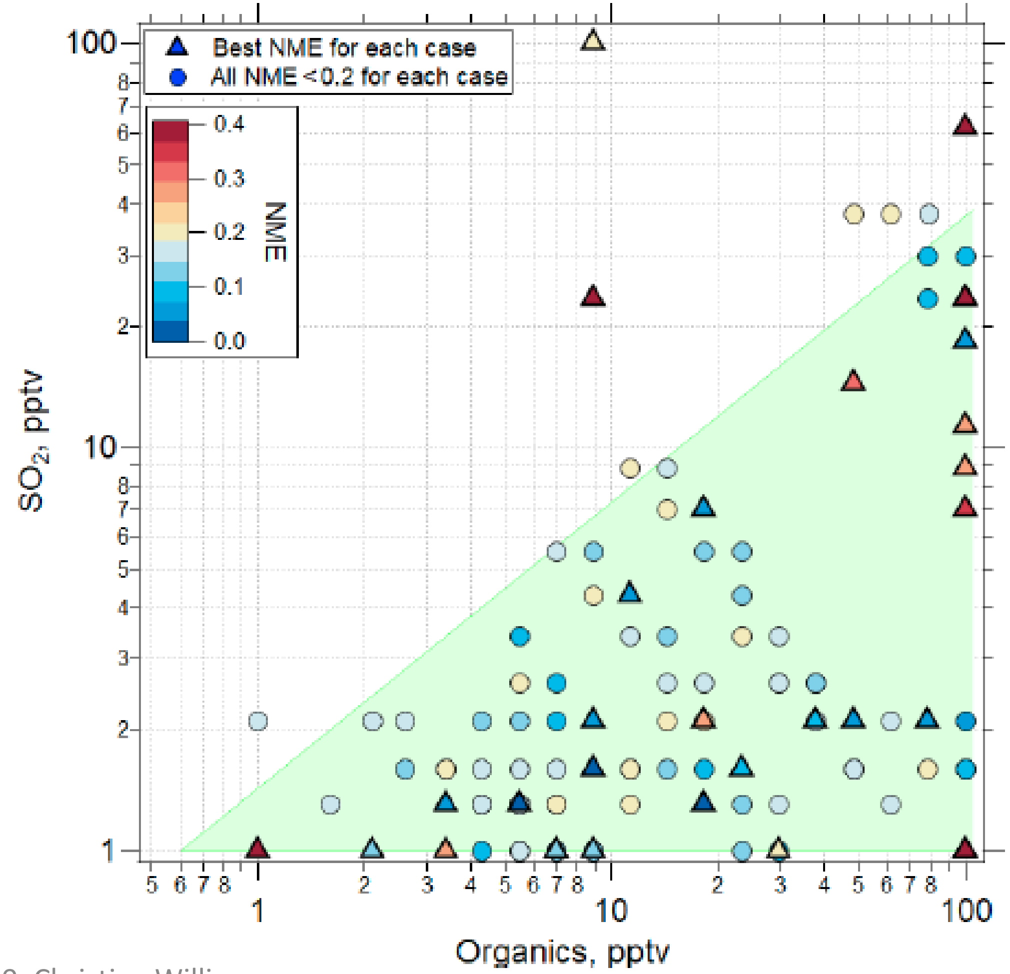
-> causes of NPF may be different in the AMA and remote tropical UT



# Tropical NPF – Sulfuric Acid and Organics??

Kupc et al 2020
*The potential role of organics in new particle formation and initial growth in the remote tropical upper troposphere*

Atmospheric Tomography Mission
Pacific

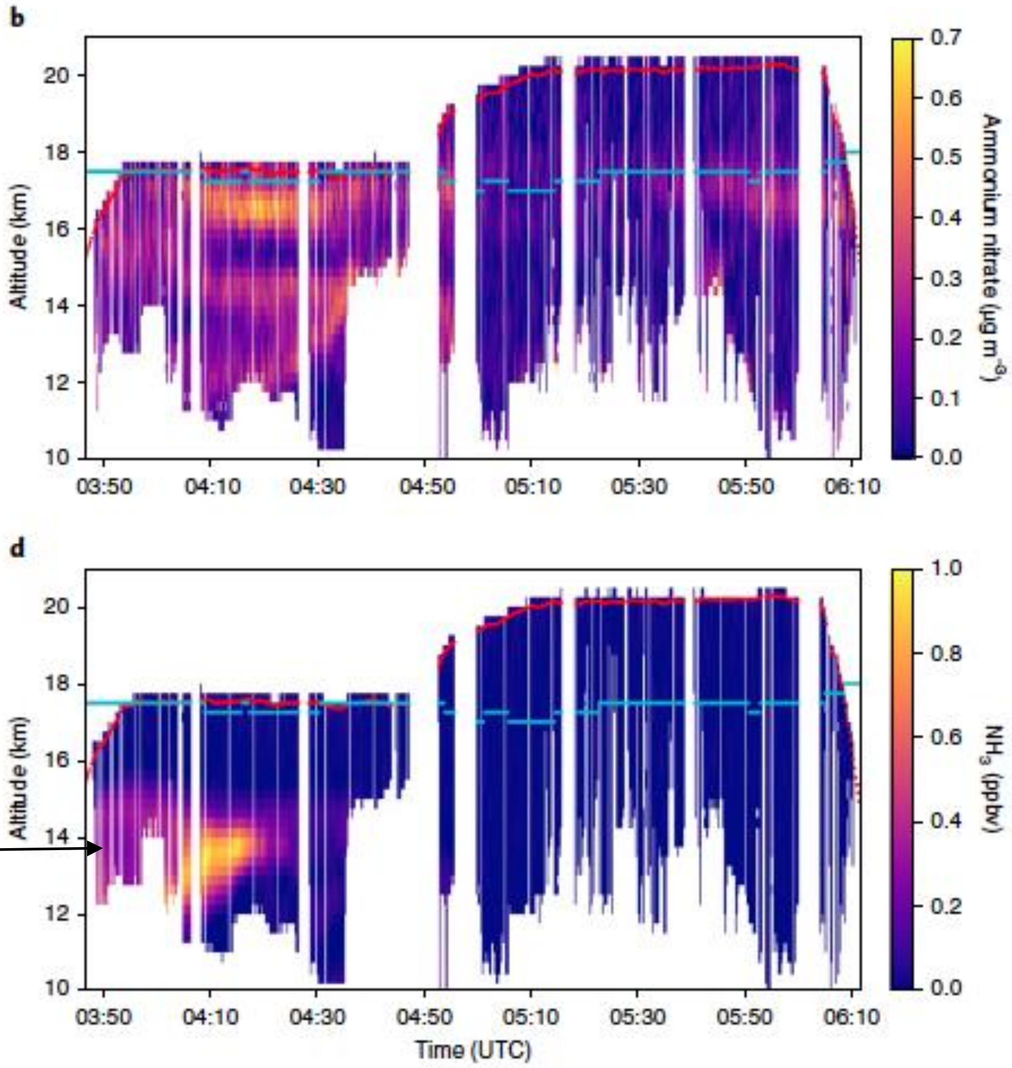


# Ammonia lofted by AMA

Höpfner et al 2019
*Ammonium nitrate particles formed in upper troposphere from ground ammonia sources during Asian monsoons*

StratoClim 2017

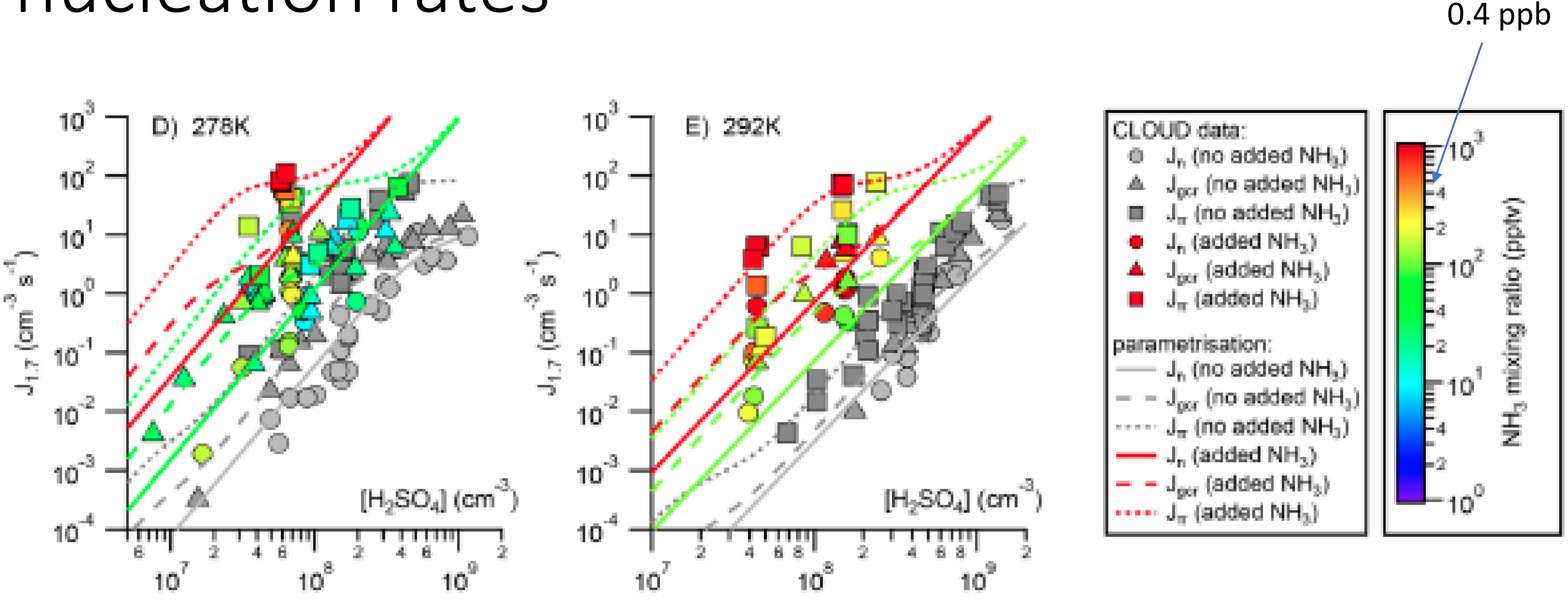
$NH_3$ >= 0.4 ppbv




Aircraft altitude

LRT

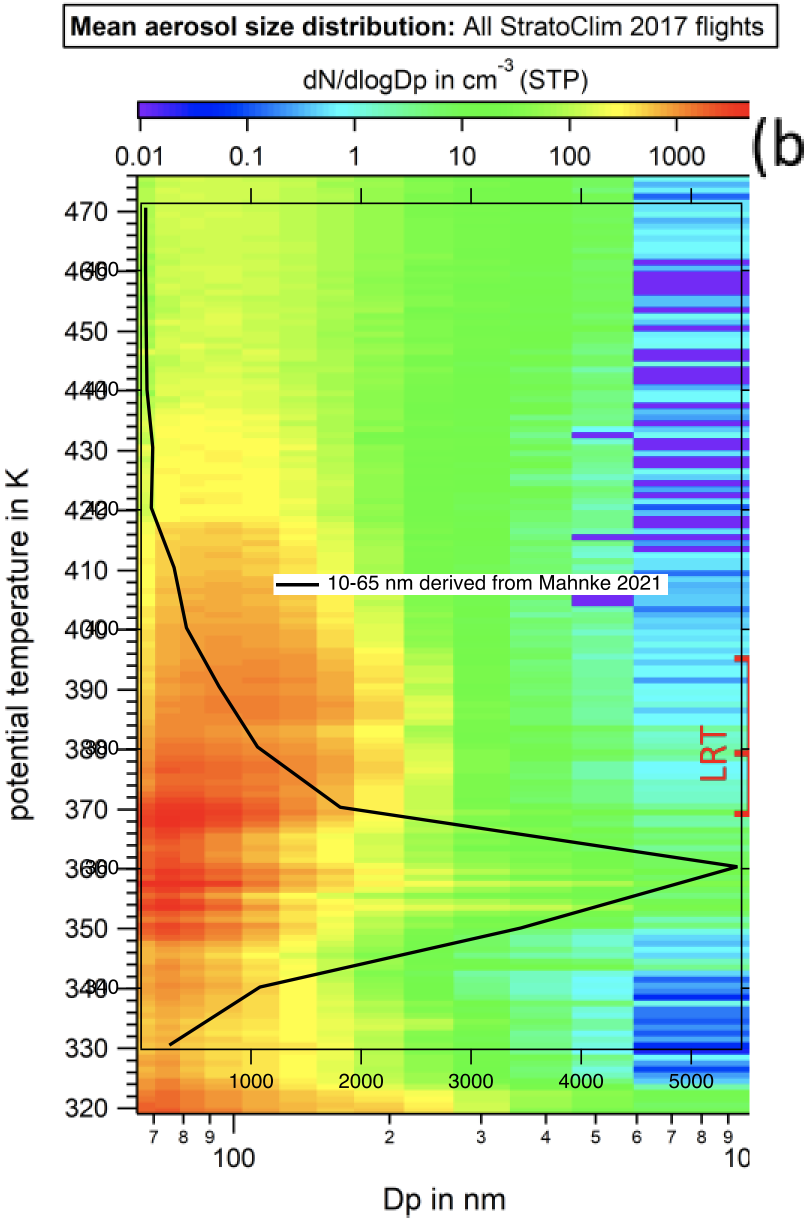
# Ammonia makes a big difference to nucleation rates



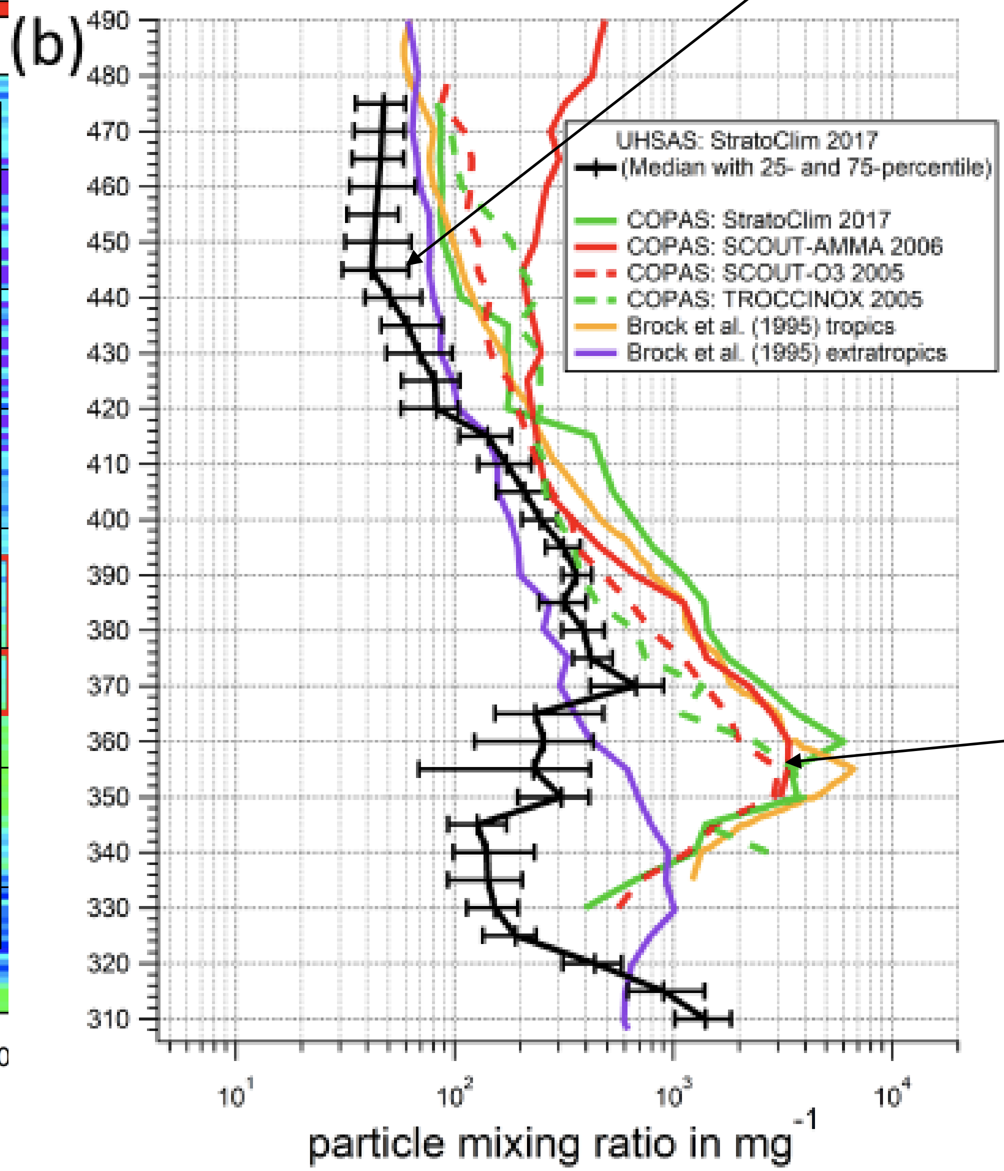

Dunne et al. Science 2016

Mahnke 2020: Fig 5

With Aitken mode concentration derived from 3a




Mahnke 2020: Fig 3b




Brock extratropics 8-3000 nm

Stratoclim tropics 65-1000 nm

Tropical locations, including particles < 65 nm

Nepal ASM

*Brazil*

W. Africa

*Australia*

Brock 1995 tropics

# Summary/Conclusion/Discussion starter

- Mahnke et al. 2020 shows a substantial 10-65 nm aerosol population just below the LRT in the AMA, which is explained well by NPF
- Number concentrations are similar to, or up to a factor of 2 higher than number concentrations over similar sizes ranges measured in the tropical upper troposphere outside of the AMA
- Vertically resolved size distribution from Manhke et al. hints that NPF in the AMA may be working against larger sinks than are generally present in the tropical upper troposphere
- Ammonia lofted by AMA may enable NPF and growth in spite of the larger sinks