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
2021/03/30
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

Partial Review of Mahnke et al 2020, Christina Williamson, ACCLIP/NCAR Stratosphere meeting
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

Partial Review of Mahnke et al 2020, Christina Williamson, ACCLIP/NCAR Stratosphere meeting
Large number of 10-65 nm particles in UT during ASM

Vertical profile of particle mixing ratios:
- StratoClim2017 65-1000 nm
- StratoClim 2017 10-1000 nm (tropics, Nepal)
- StratoClim2016 10-1000 nm – extratropics (Greece ~ 37N)

Partial Review of Mahnke et al 2020, Christina Williamson, ACCLIP/NCAR Stratosphere meeting
AMA and Tropics in UTLS distinct from extratropics

Brock extratropics 8-3000 nm
Stratoclim tropics 65-1000 nm
More particles during ASM

Partial Review of Mahnke et al 2020, Christina Williamson, ACCLIP/NCAR Stratosphere meeting
Tropics and AMA distinct from Extra-Tropics

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

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Tropics and AMA distinct from Extra-Tropics

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Vertically resolved size distribution in AMA

Mahnke 2020: Fig 5

Mean aerosol size distribution: All StratoClim 2017 flights

dN/dlogDp in cm\(^{-3}\) (STP)

Partial Review of Mahnke et al 2020, Christina Williamson, ACCLIP/NCAR Stratosphere meeting
Size Distribution below ATAL fairly similar between StratoClim and mid Atlantic/Pacific
Peak AMA 10-65 nm number concentration at higher sink than Atom remote tropical UT NFP

Partial Review of Mahnke et al 2020, Christina Williamson, ACCLIP/NCAR Stratosphere meeting
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

Partial Review of Mahnke et al 2020, Christina Williamson, ACCLIP/NCAR Stratosphere meeting
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

\[
\text{NH}_3 \geq 0.4 \text{ ppbv}
\]
Ammonia makes a big difference to nucleation rates

Dunne et al. Science 2016

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

Mean aerosol size distribution: All StratoClim 2017 flights

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

Mahnke 2020: Fig 3b

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