The Asian Summer Monsoon – A Smokestack to the Northern Hemisphere Stratosphere

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and

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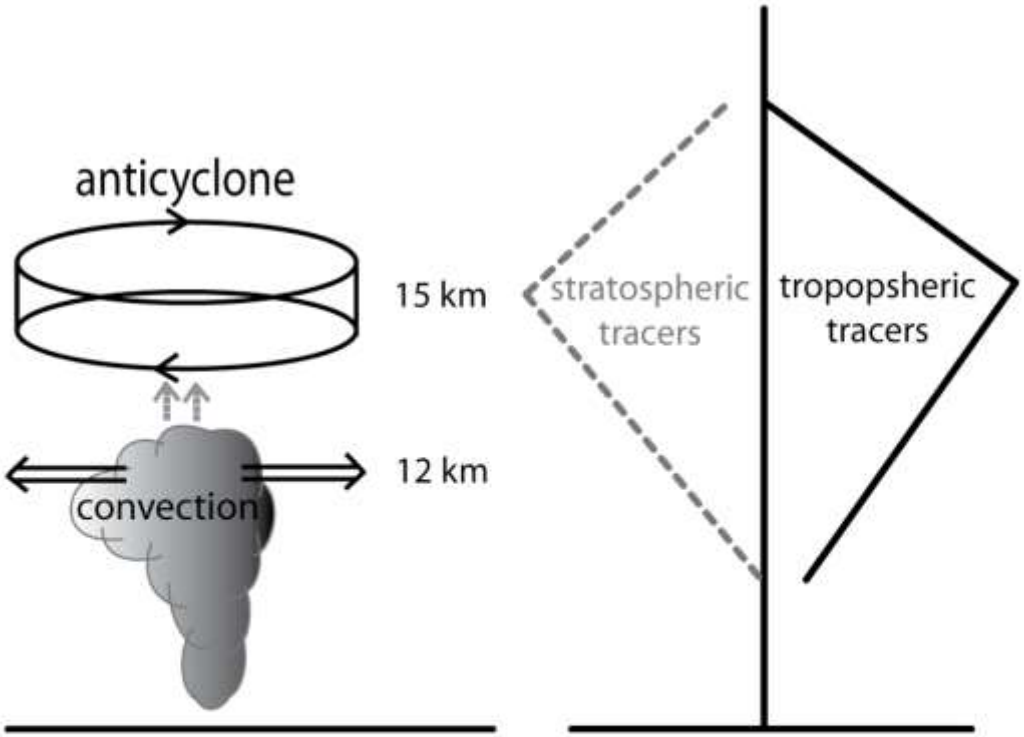
ACAM3, 7 June 2017

A brief introduction to the ASM anticyclone

• The ASM circulation contains a strong anticyclonic vortex in the UTLS.

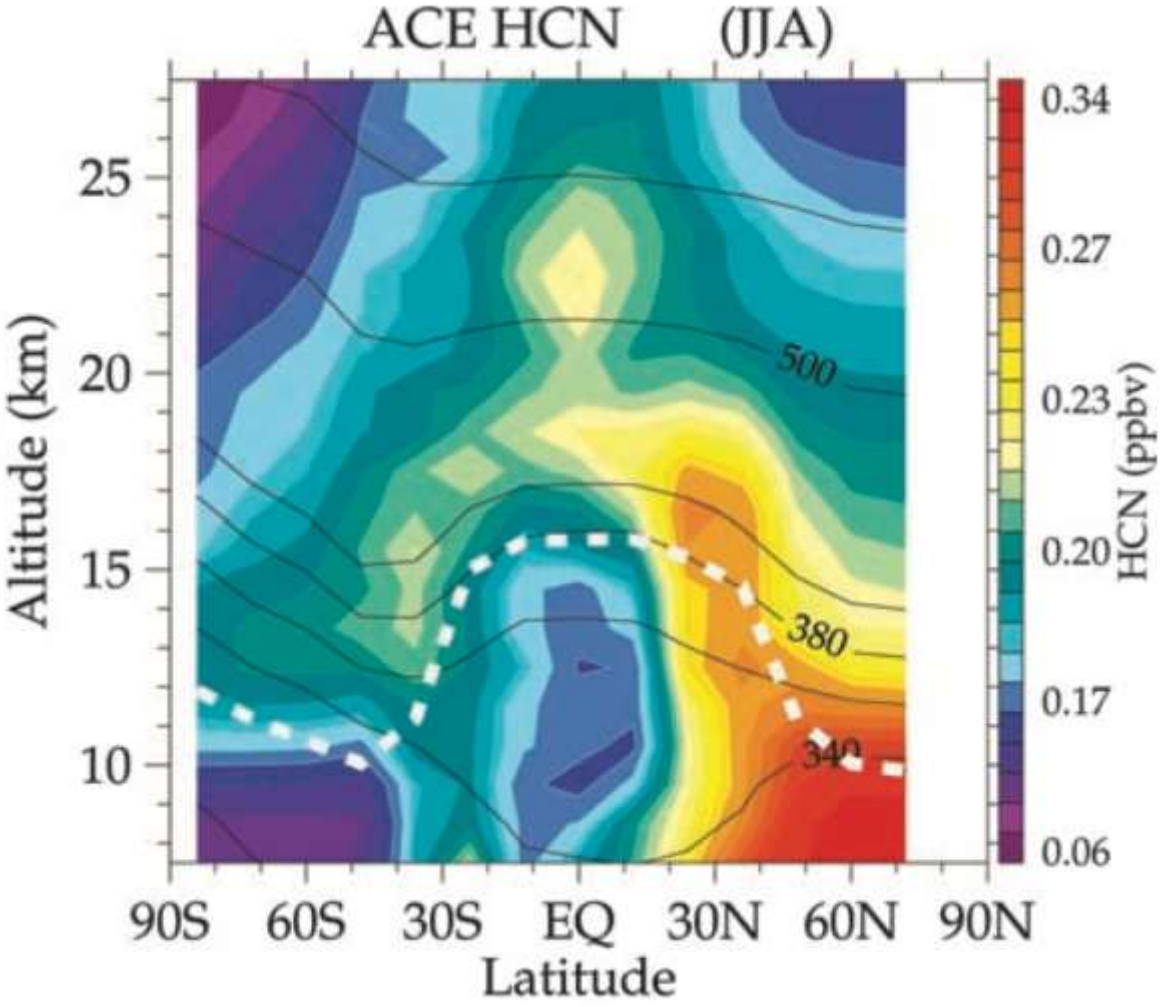


Park et al., ACP 2008

Fig. 9. Schematic diagram showing (left) level of maximum convective outflow (~12 km) versus monsoon anticyclonic circulation (~15 km). (Right) Level of maximum increase (decrease) in the tropospheric (stratospheric) tracers.

A brief introduction to the ASM anticyclone

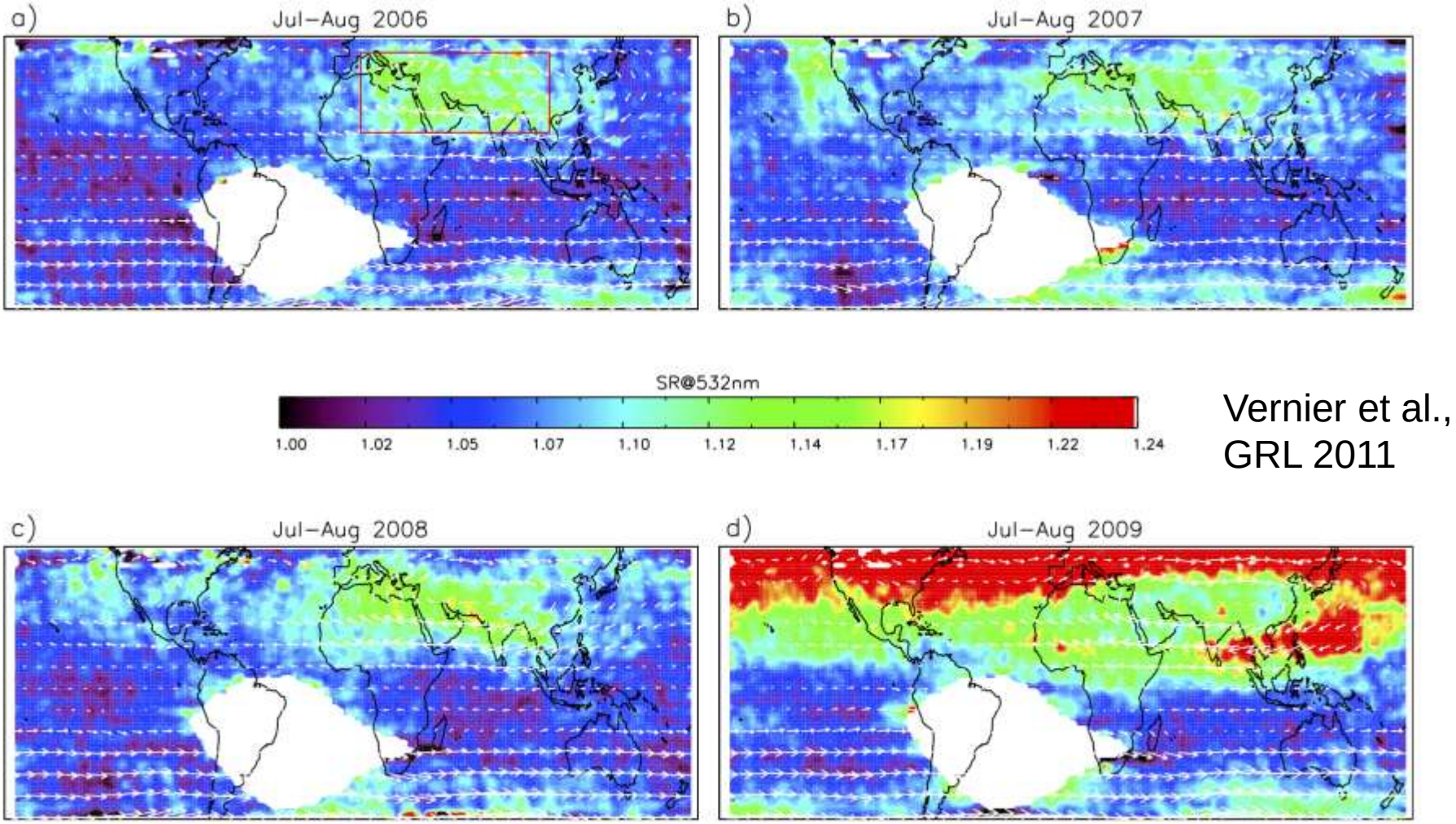
- Tropospheric species can be transported into the stratosphere



Randel et al., Science 2010

A brief introduction to the ASM anticyclone

- ATAL (Asian Tropopause Aerosol Layer) as seen by CALIPSO:



Vernier et al., GRL 2011

A brief introduction to the ASM anticyclone

• Tobo et al. (AR 2007) measured aerosol vertical profiles in Lhasa in 1999 using balloon-borne OPC. With a lower detection limit at 300 nm diameter, the OPC was not sensitive enough.

• Bian et al. (GRL 2012) have performed O_3, water vapor, and backscattering measurements for the past decade.

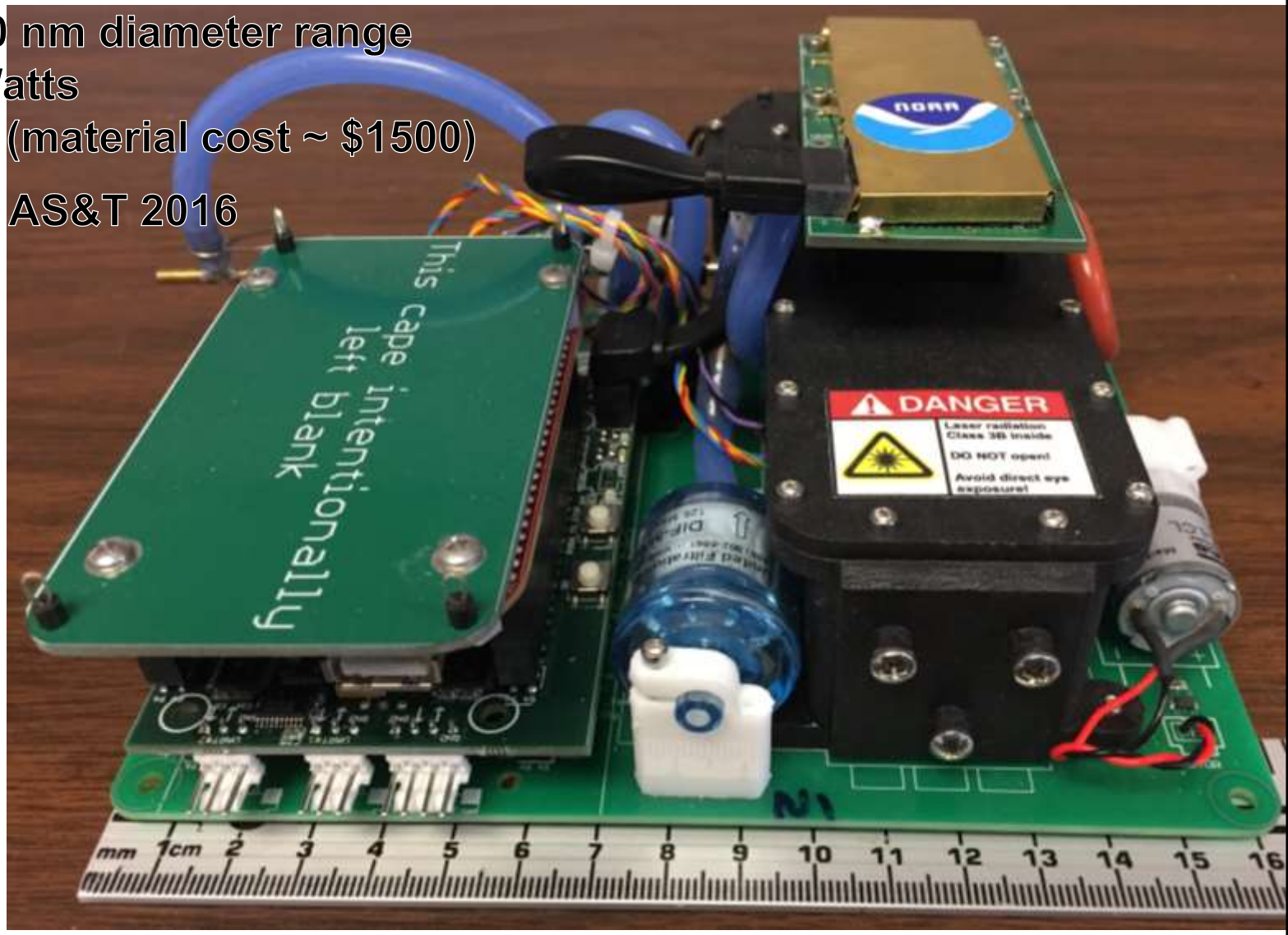
• Santee et al. (JGR 2017) give a comprehensive overview of the climatological composition based on Aura MLS measurements

• Reading material: Fu et al., PNAS 2006; Tobo et al., AR 2007; Park et al., ACP 2008; Randel et al., Science 2010; Vernier et al., GRL 2011; Bian et al., GRL 2012; Pan et al., JGR 2016; Santee et al., JGR 2017

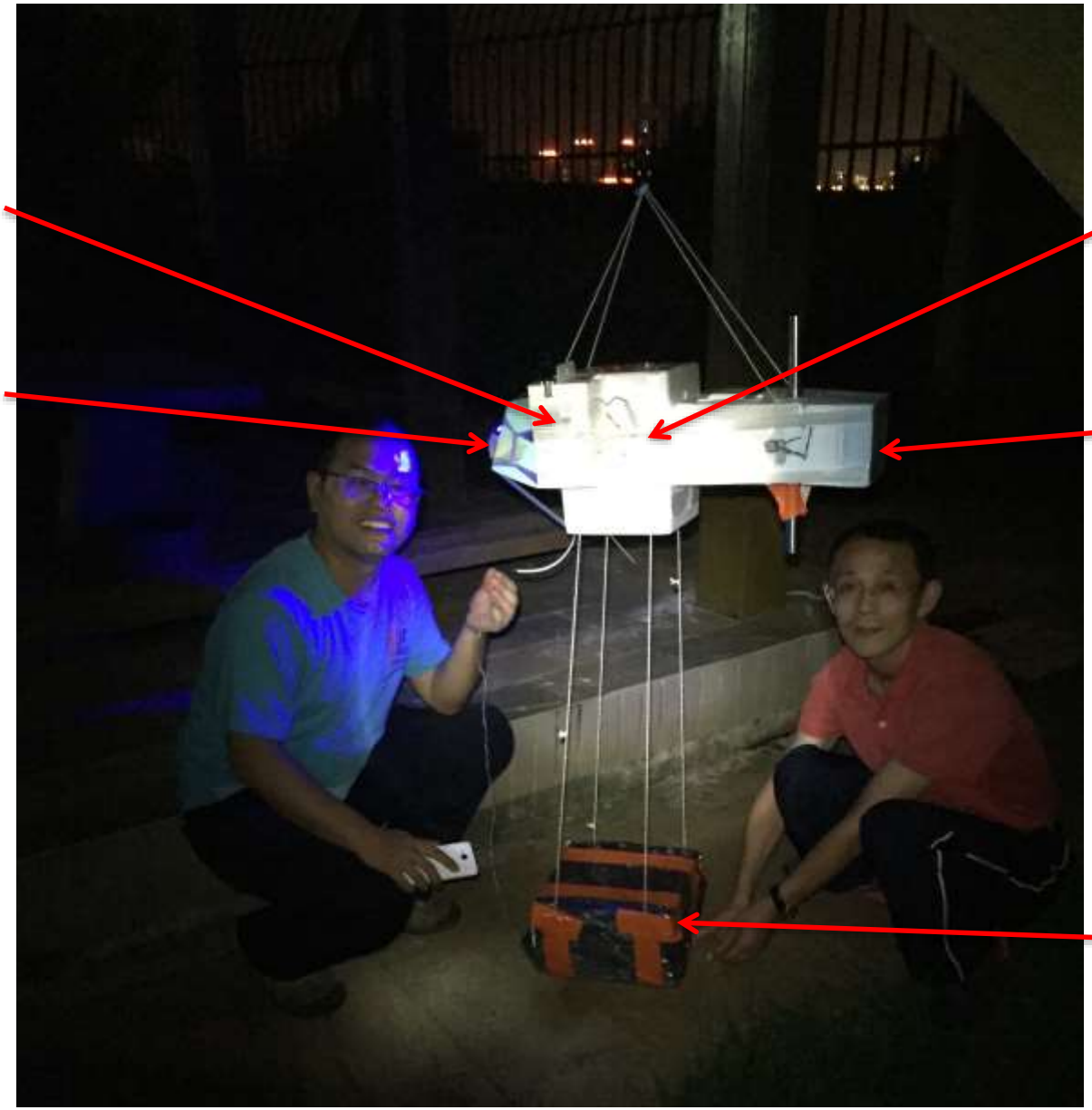
• New balloon-borne measurements were performed in Kunming, China in 2015 with a more sensitive particle spectrometer POPS.

Printed Optical Particle Spectrometer (POPS)

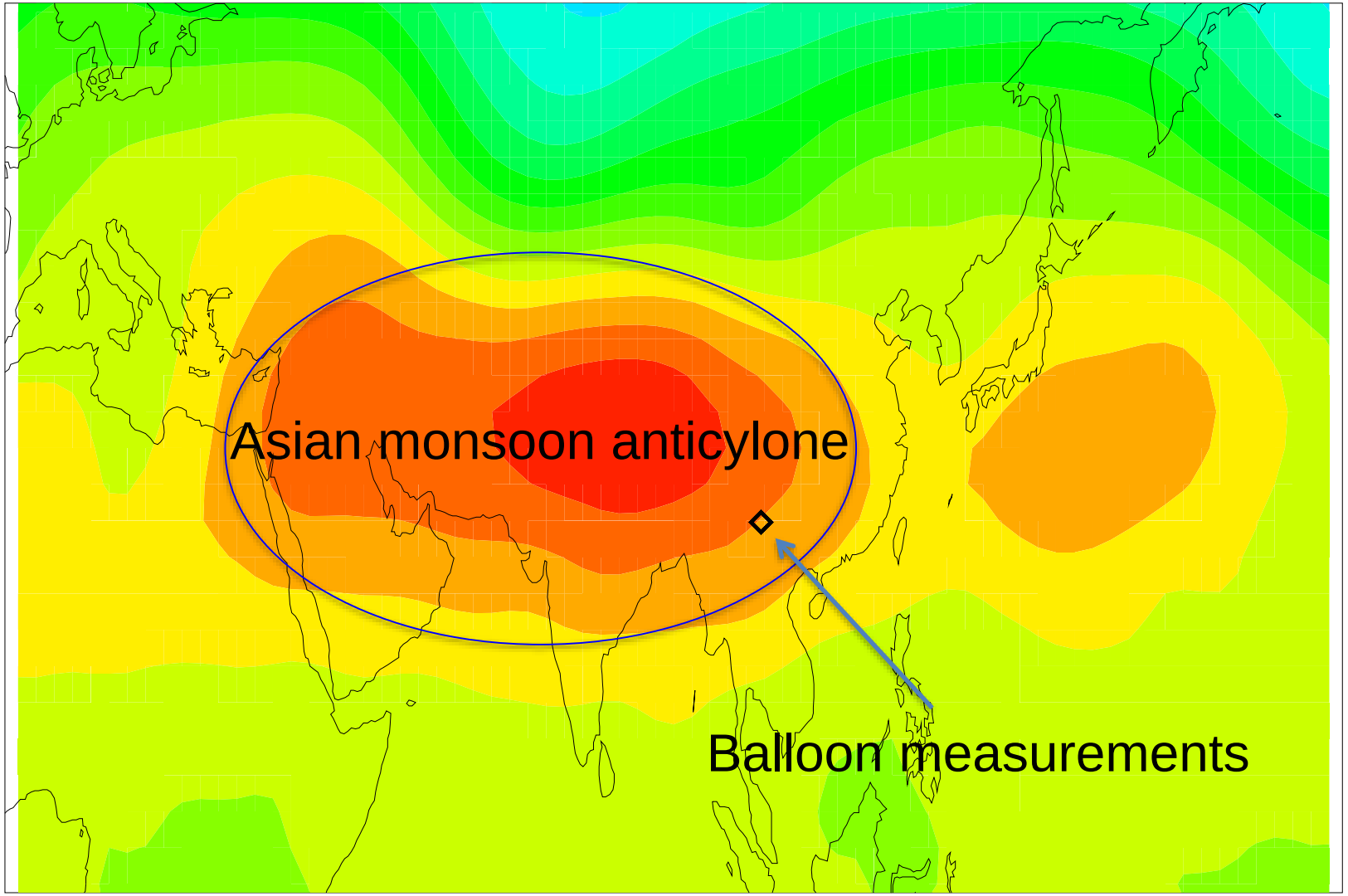
- Single-particle detection
- 140 – 3000 nm diameter range
- 550 g, 5 Watts
- Lose-able (material cost ~ $1500)
- Gao et al., AS&T 2016



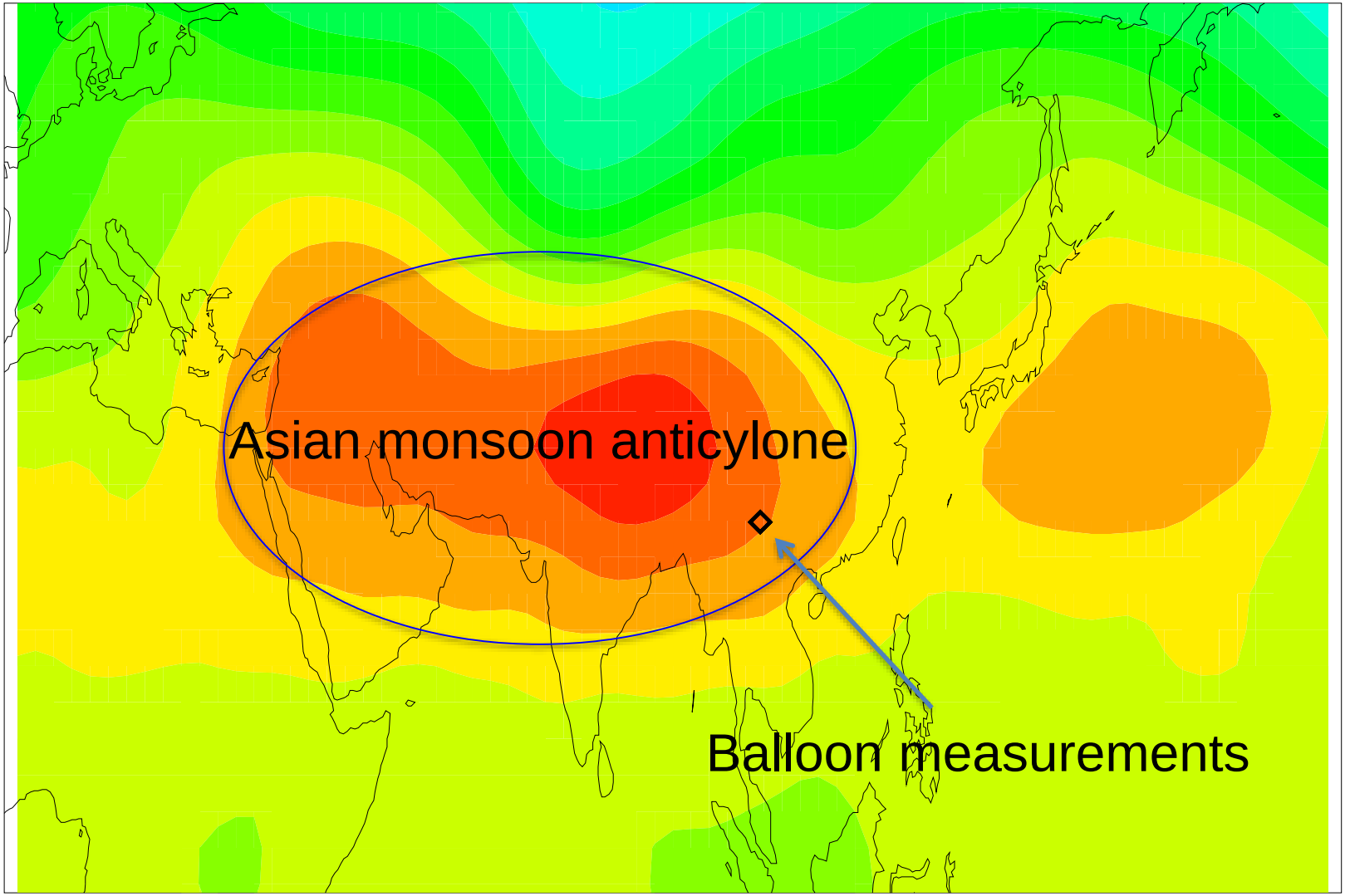
2015 ATAL measurements in Kunming, China



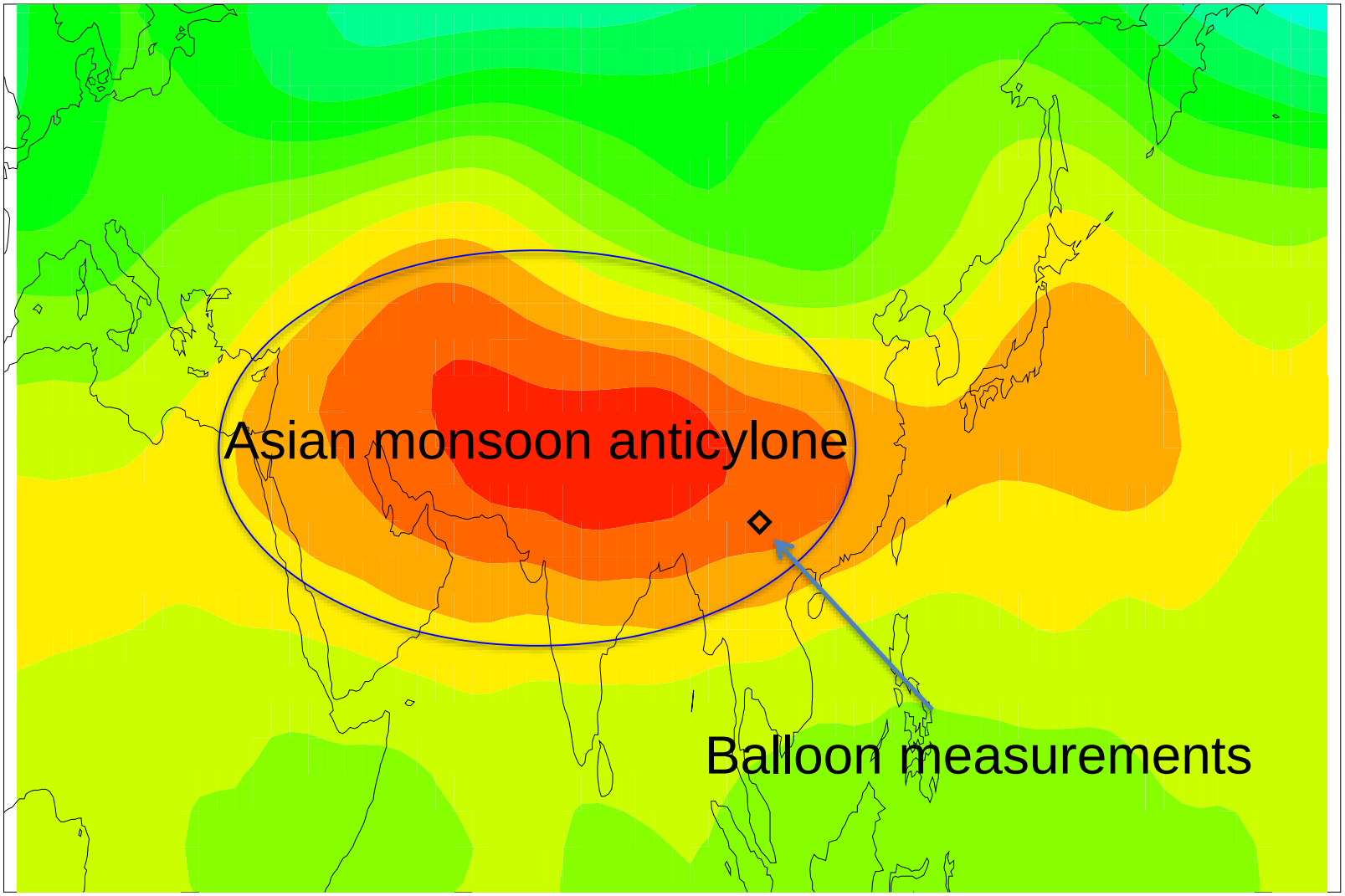
Aug 13, 2015: NCEP 100 mb hgt



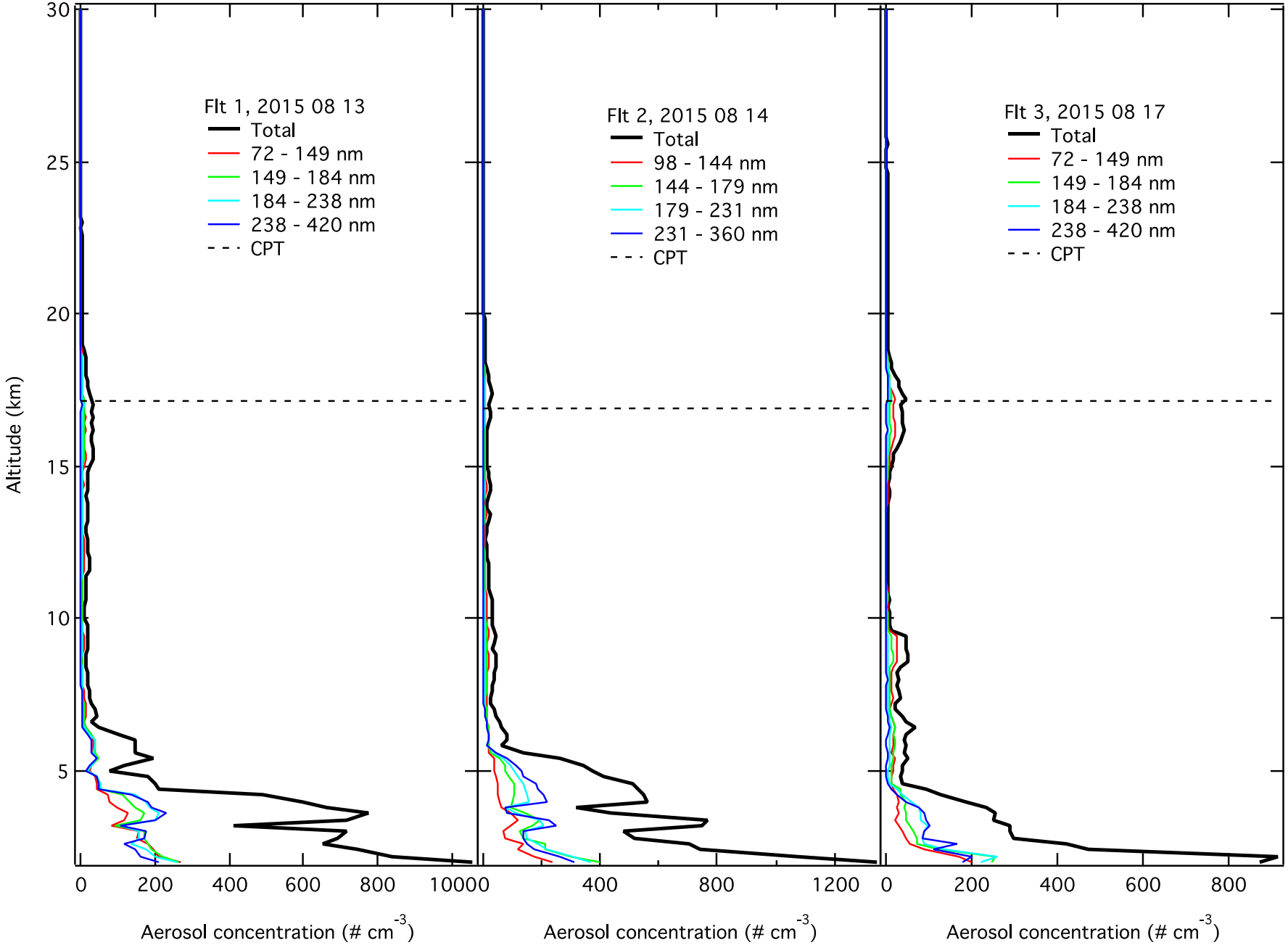
Aug 14, 2015: NCEP 100 mb hgt



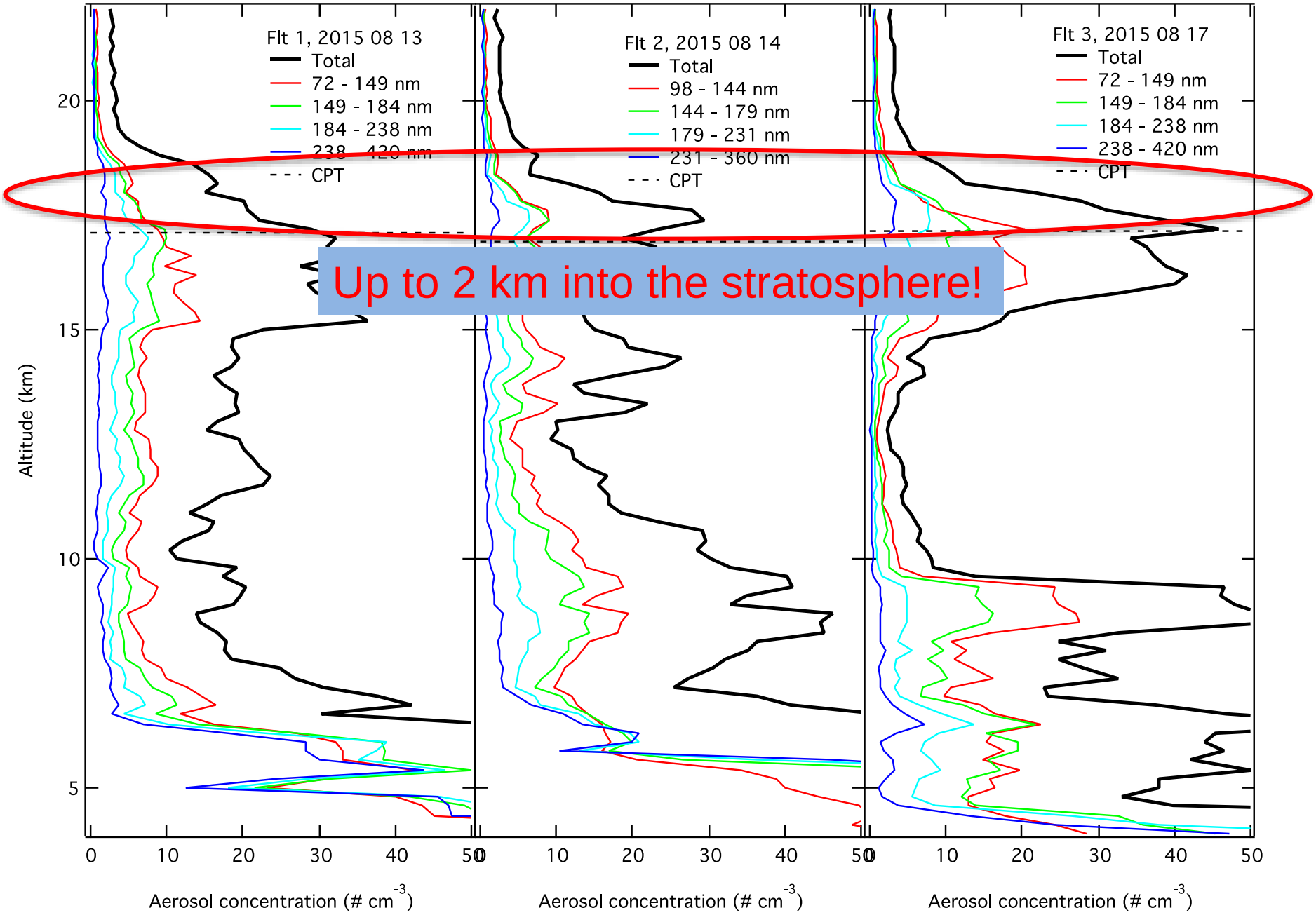
Aug 17, 2015: NCEP 100 mb hgt



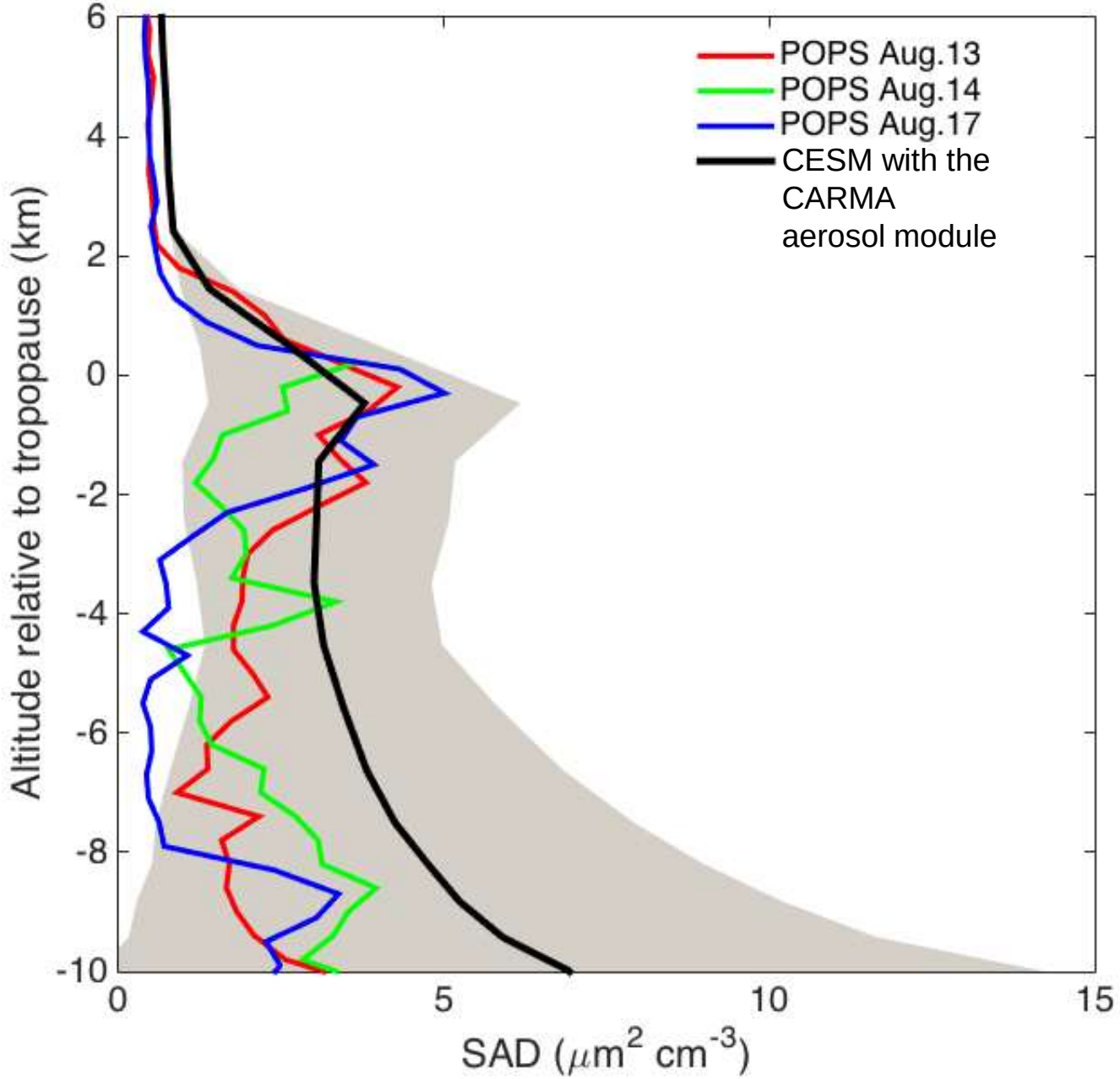
Ascent data, 200-m average



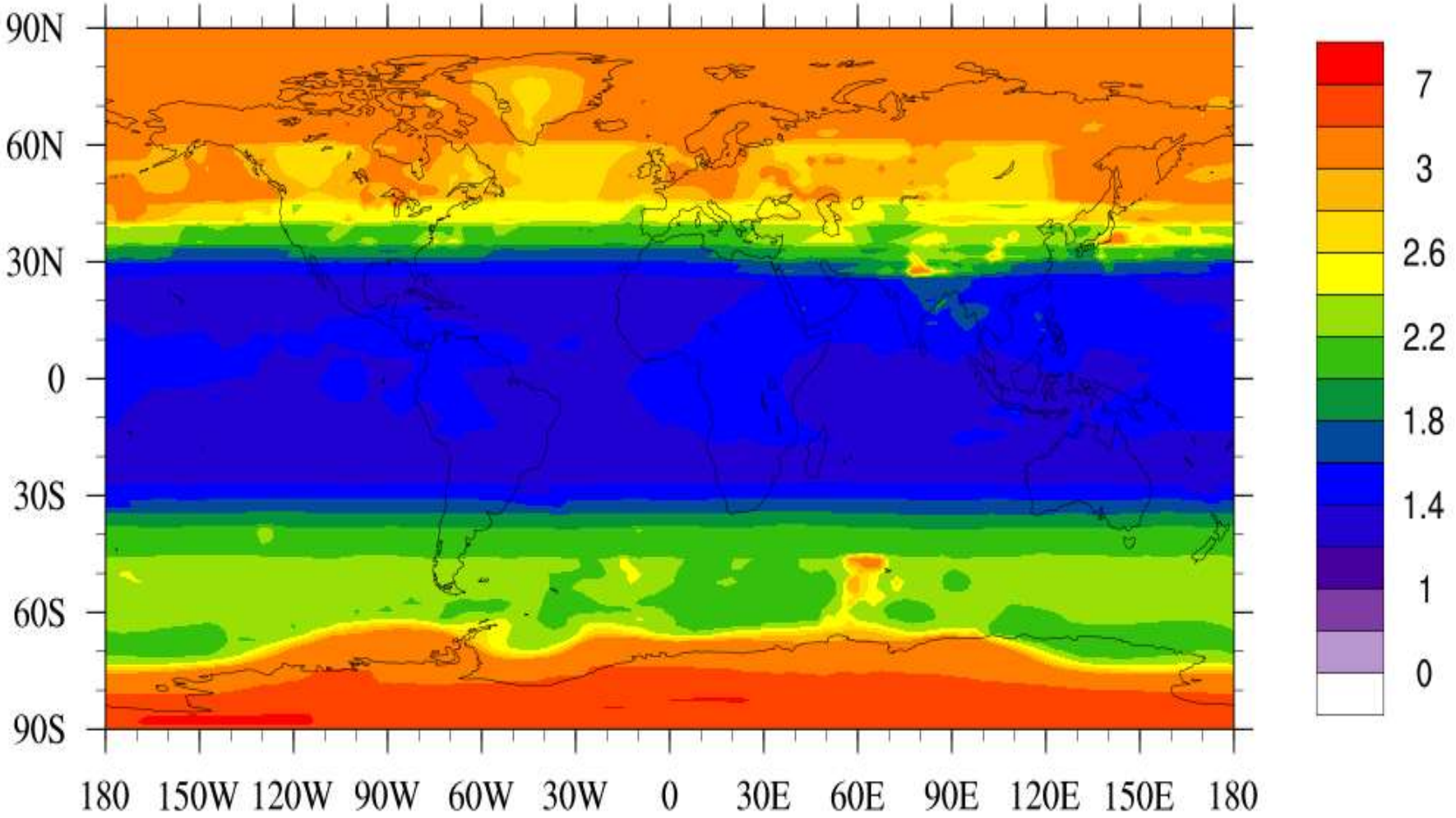
Ascent data, 200-m average



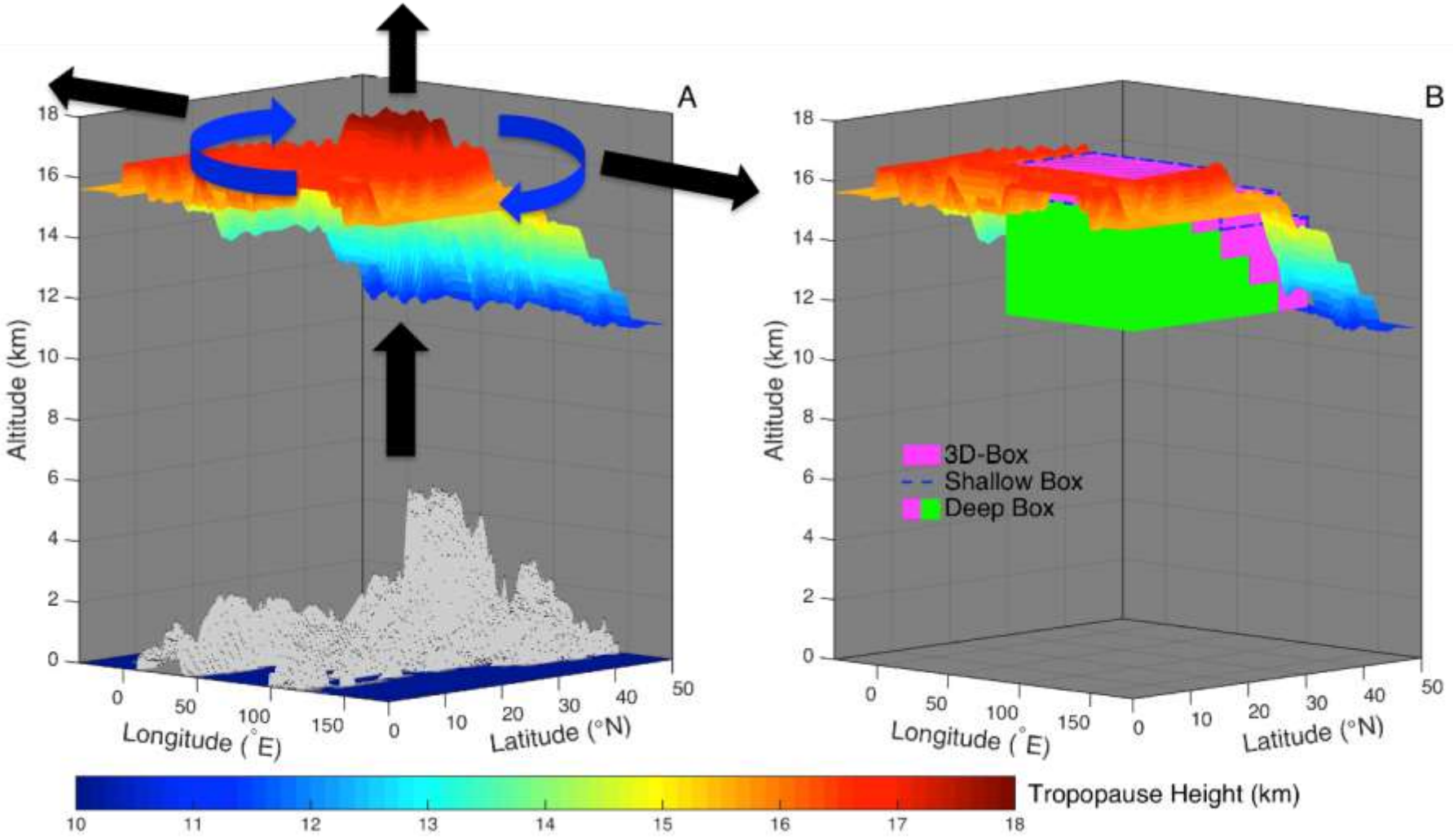
NCAR Community Earth System Model (CESM) – Measurement Comparison



CESM results of the stratospheric column aerosol surface area densities



Tropopause heights and the 3D box



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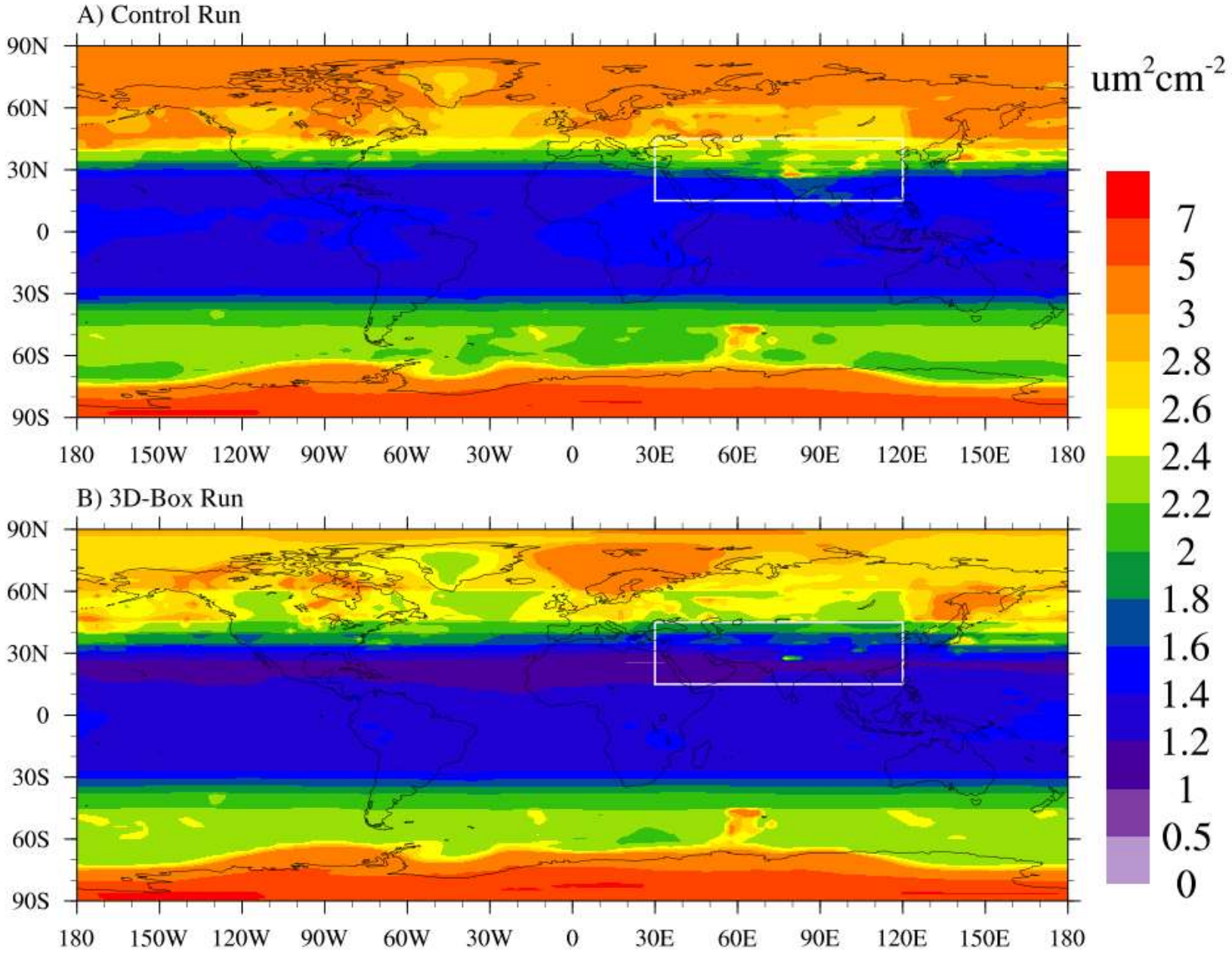
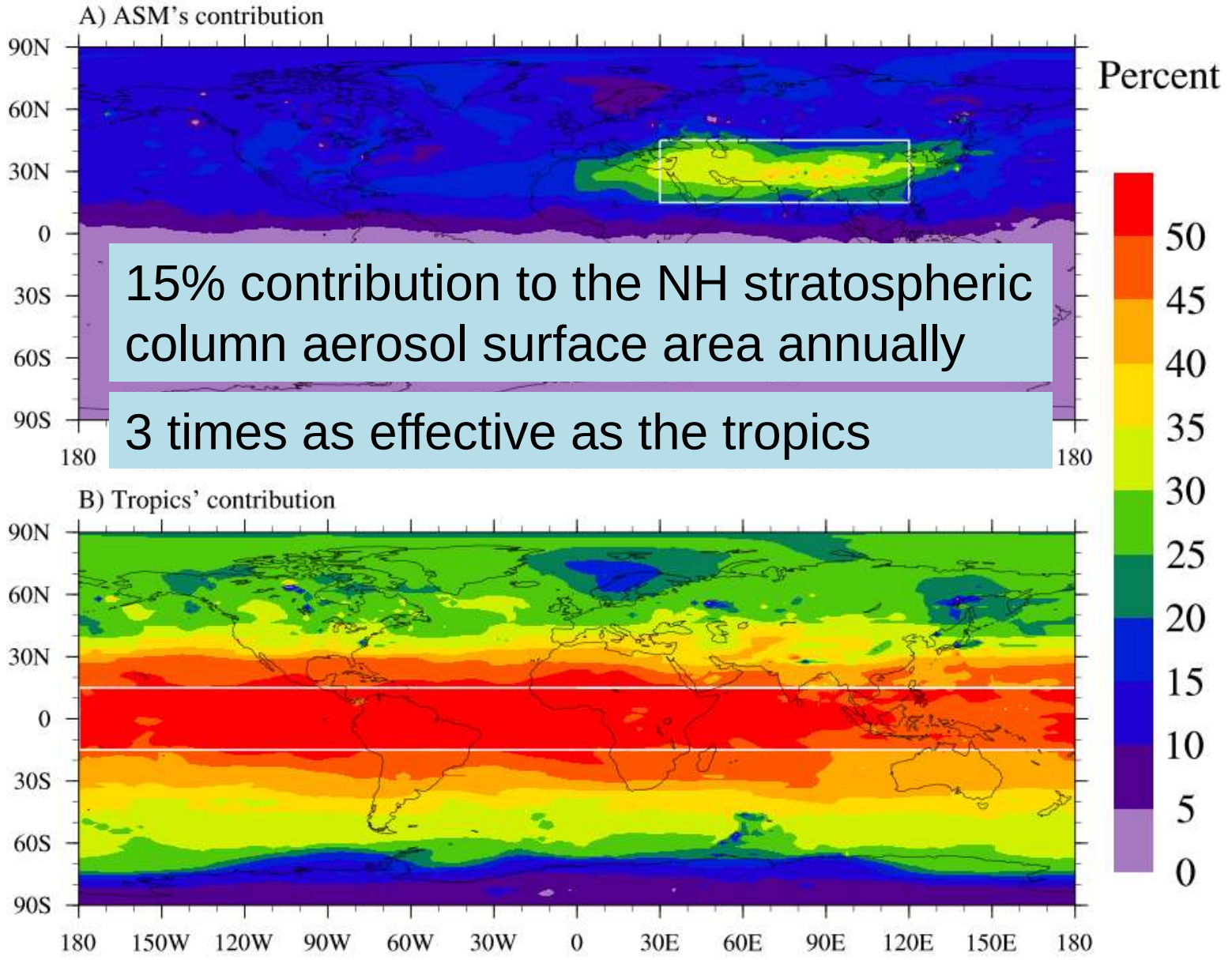


Contributions to the stratospheric column aerosol surface area

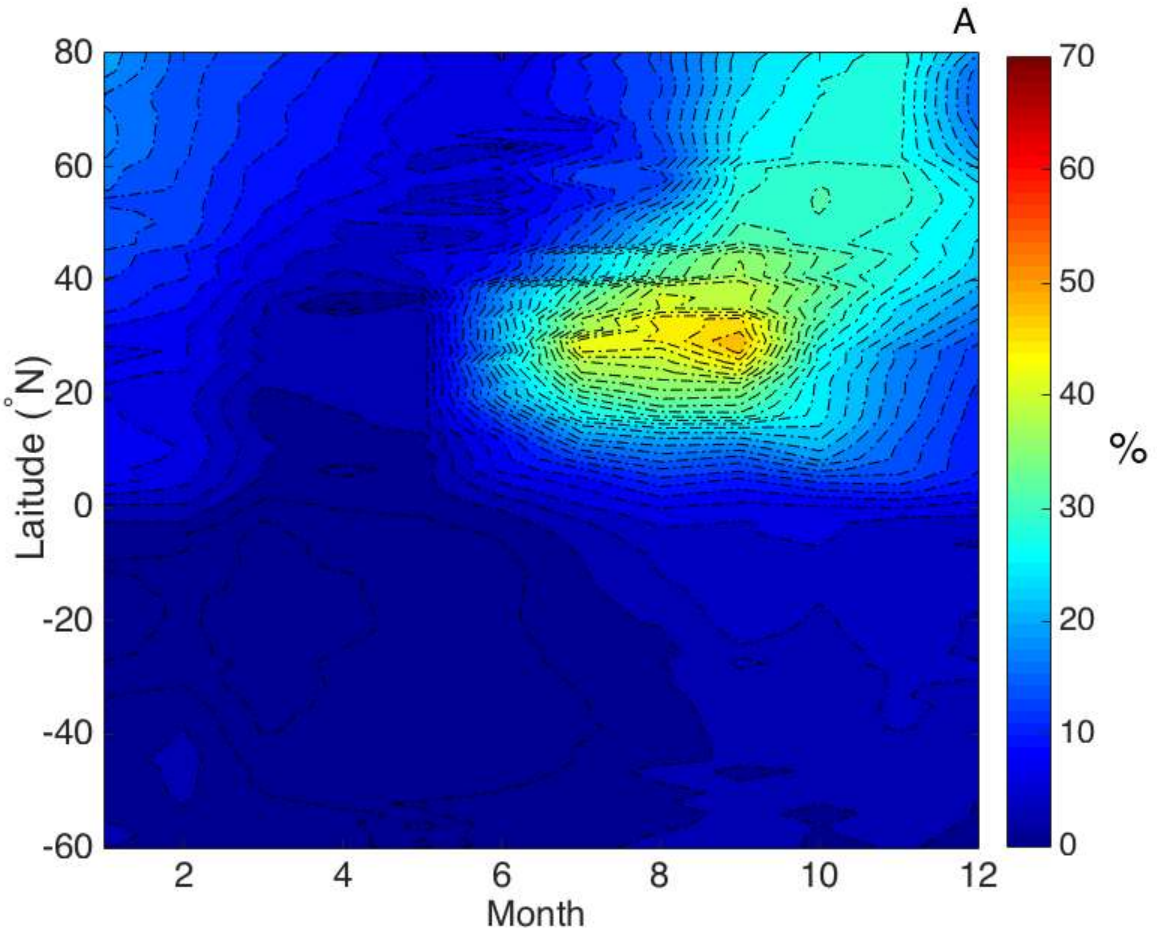


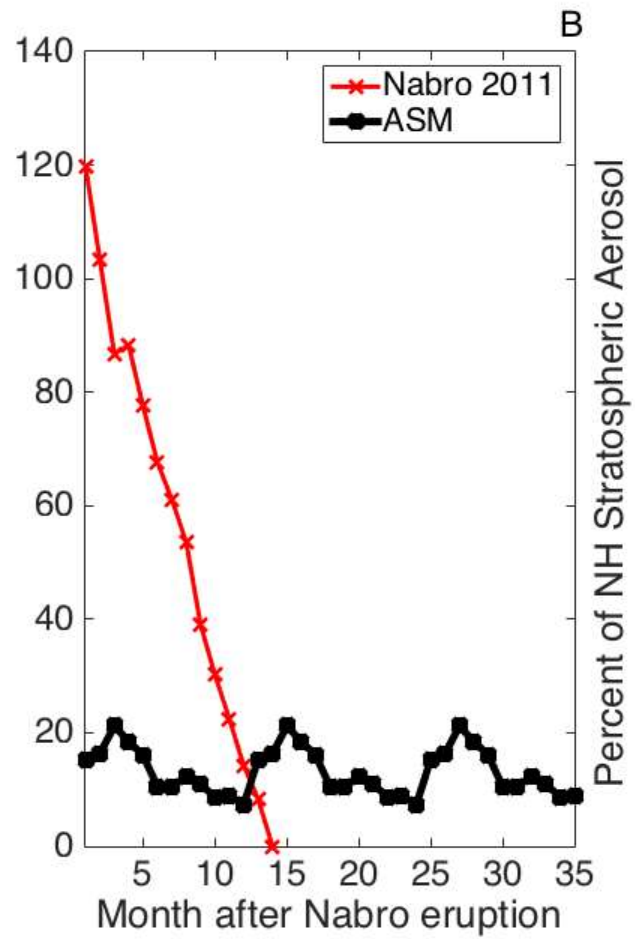
15% contribution to the NH stratospheric column aerosol surface area annually

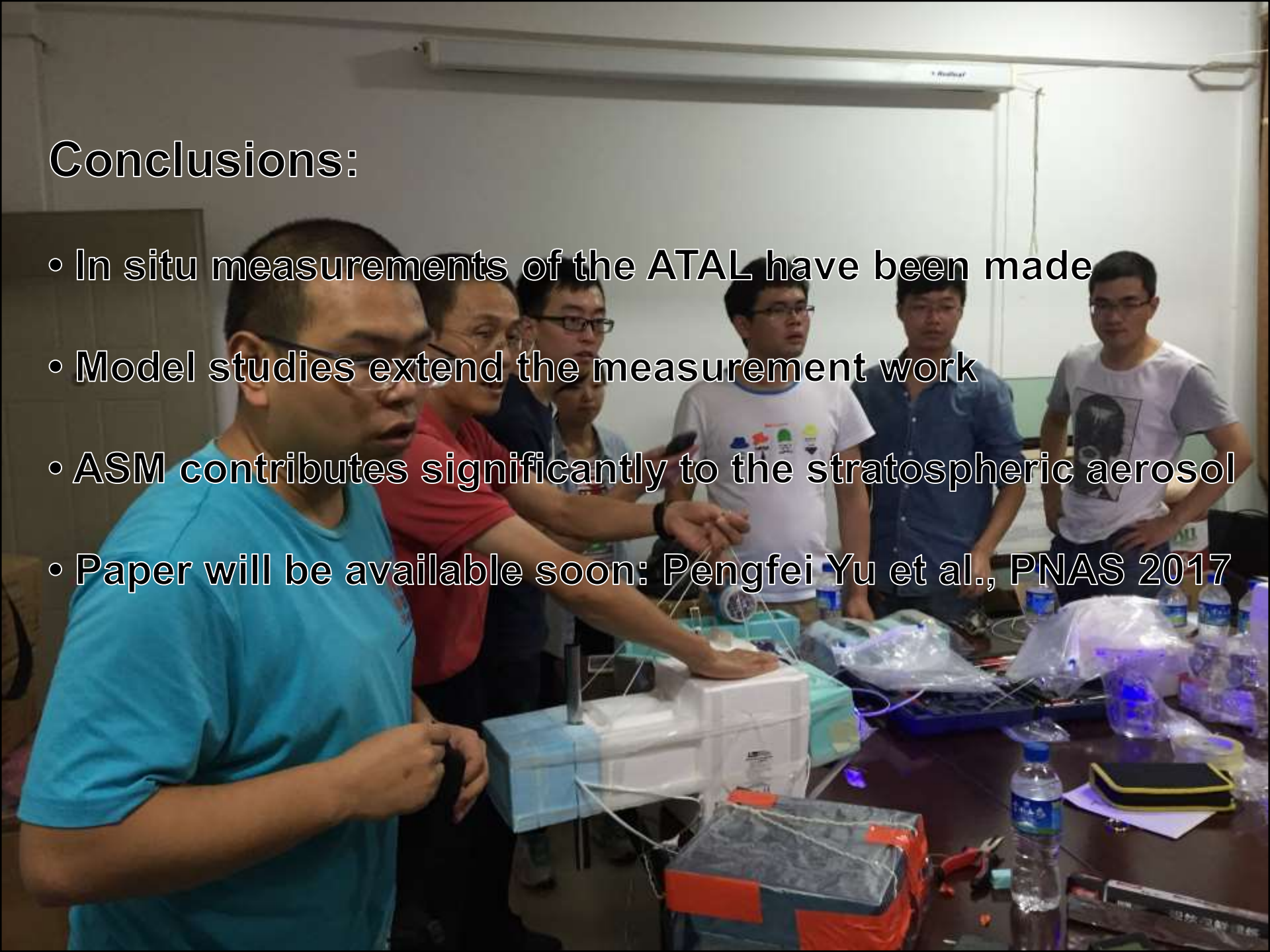
3 times as effective as the tropics

The fate of ATAL aerosol particles

Comparable to a 1.5-Tg-SO_2 Volcano



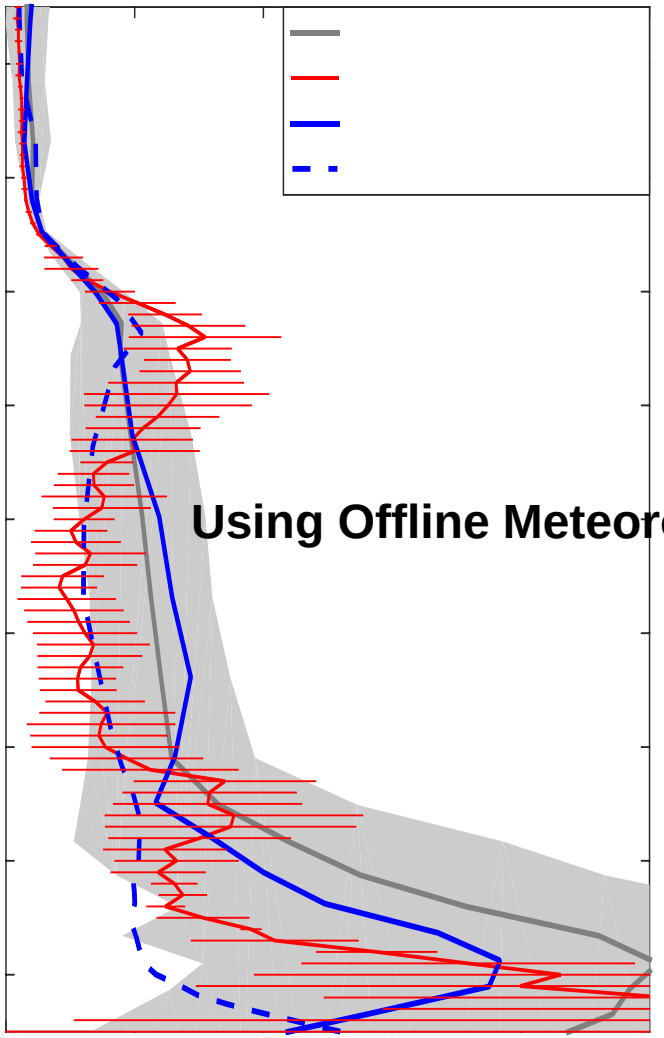


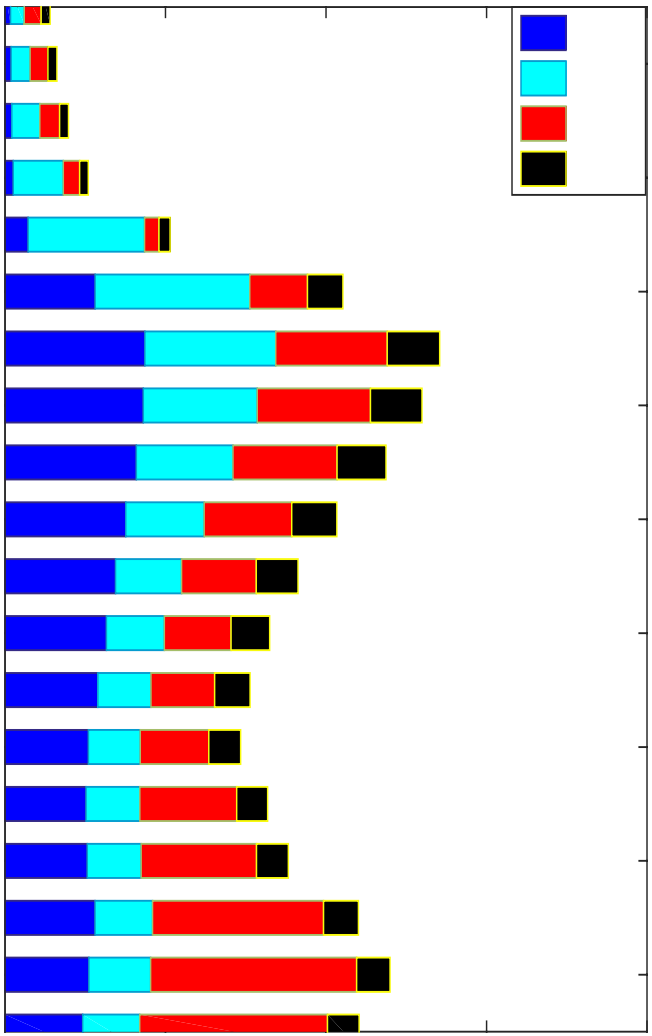


Conclusions:

- In situ measurements of the ATAL have been made
- Model studies extend the measurement work
- ASM contributes significantly to the stratospheric aerosol
- Paper will be available soon: Pengfei Yu et al., PNAS 2017

Model compare well with in-situ measurements at Kunming, Aug. 2015

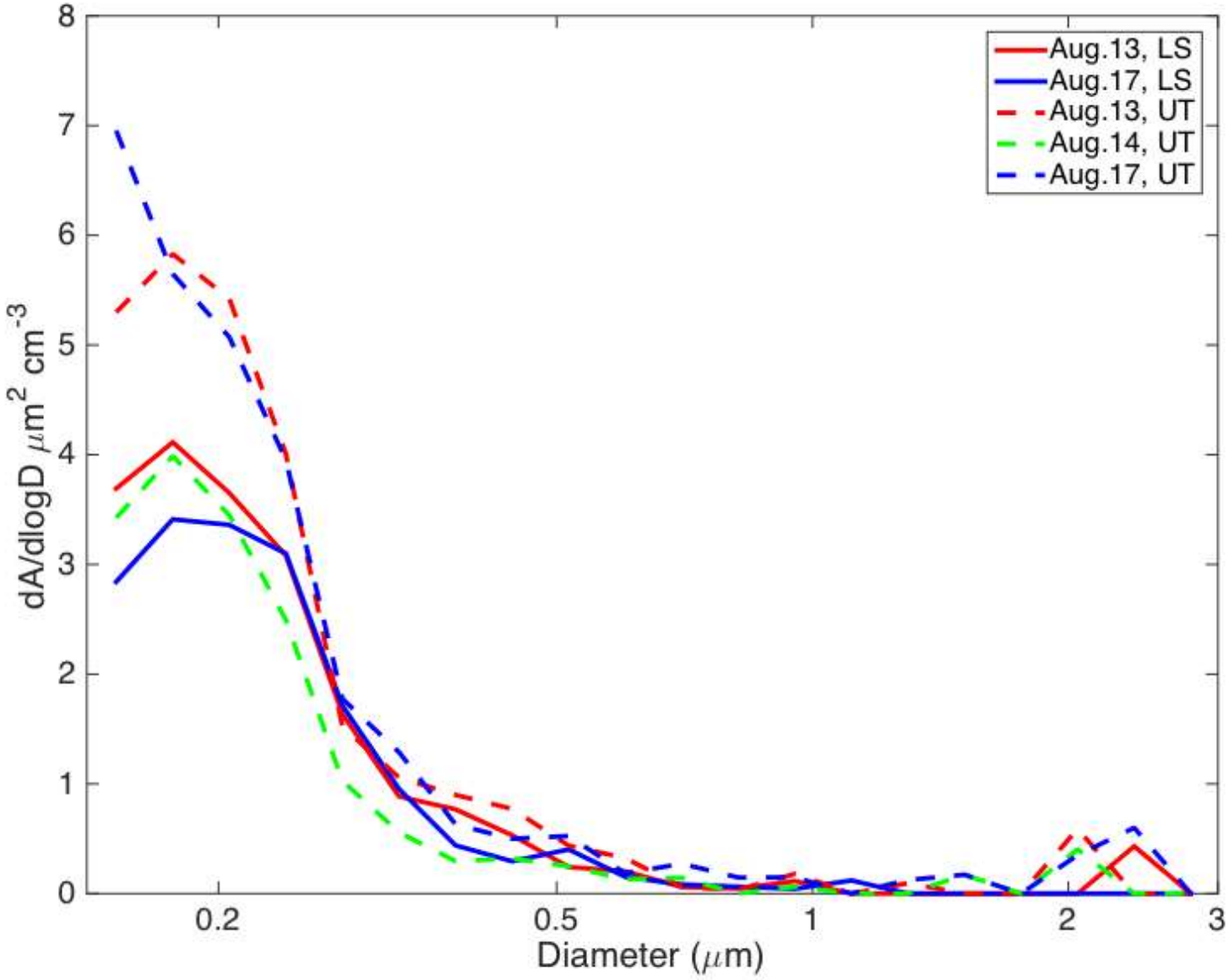




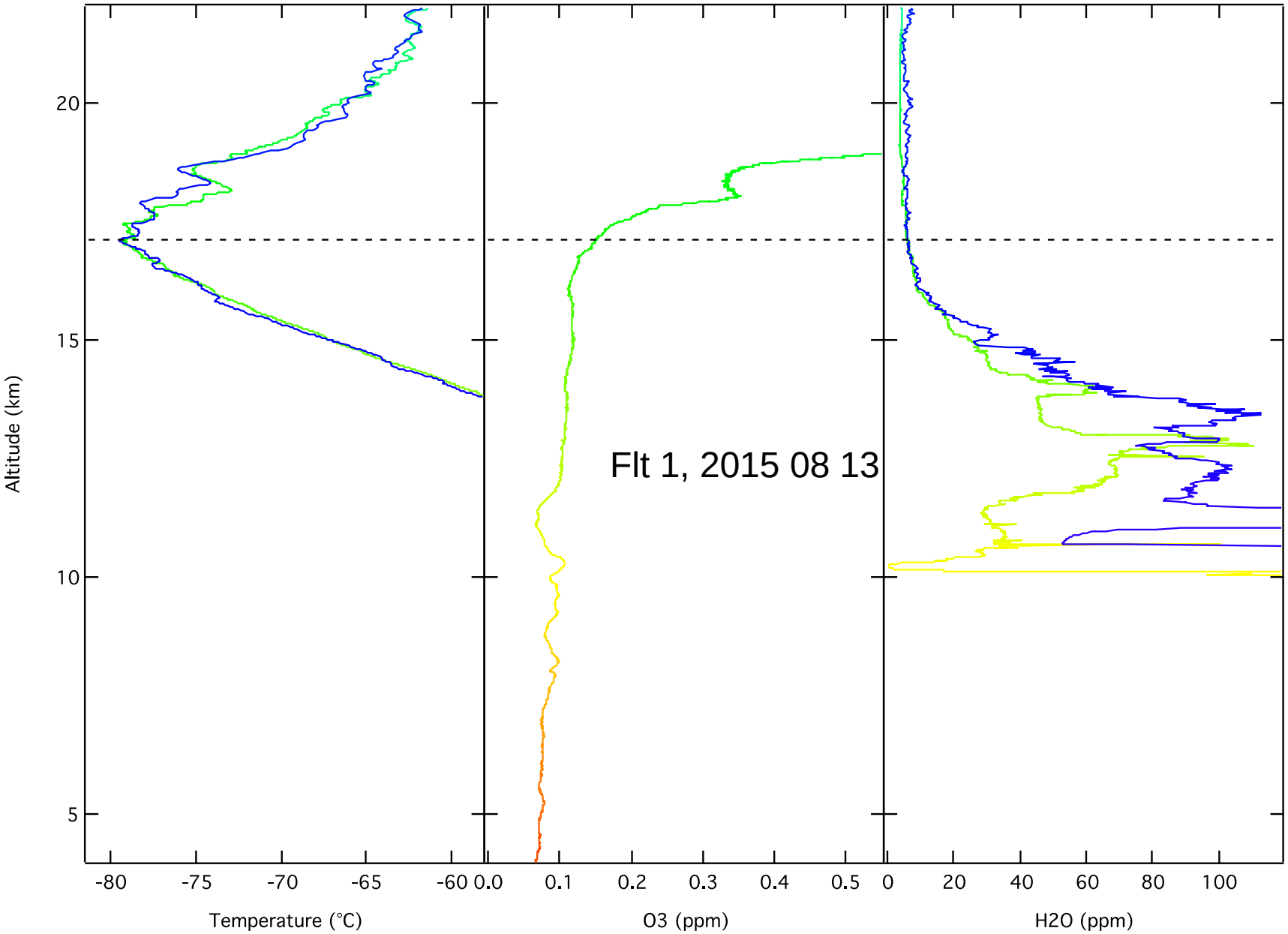
μ

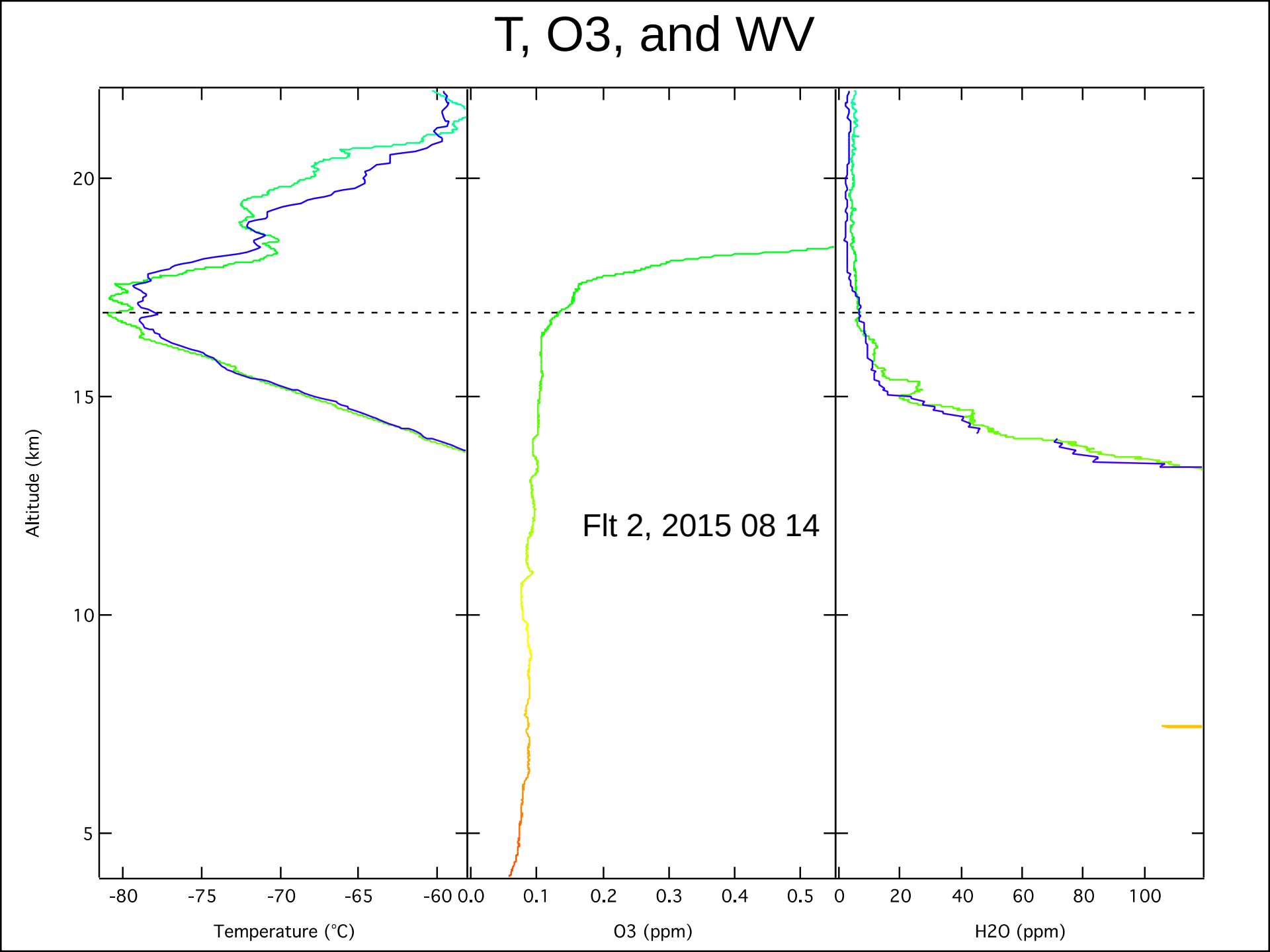
Yu et al., 2016

Aerosol surface area density distributions as functions of particle diameter



T, O3, and WV


Altitude (km)
20
15
10
5
-80
-75
-70
-65
-60
Temperature (°C)
0.0
0.1
0.2
0.3
0.4
0.5
O3 (ppm)
0
20
40
60
80
100
H2O (ppm)
Flt 1, 2015 08 13


T, O3, and WV
Altitude (km)
20
15
10
5
Flt 2, 2015 08 14
-80
-75
-70
-65
-60
Temperature (°C)
0.0
0.1
0.2
0.3
0.4
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O3 (ppm)
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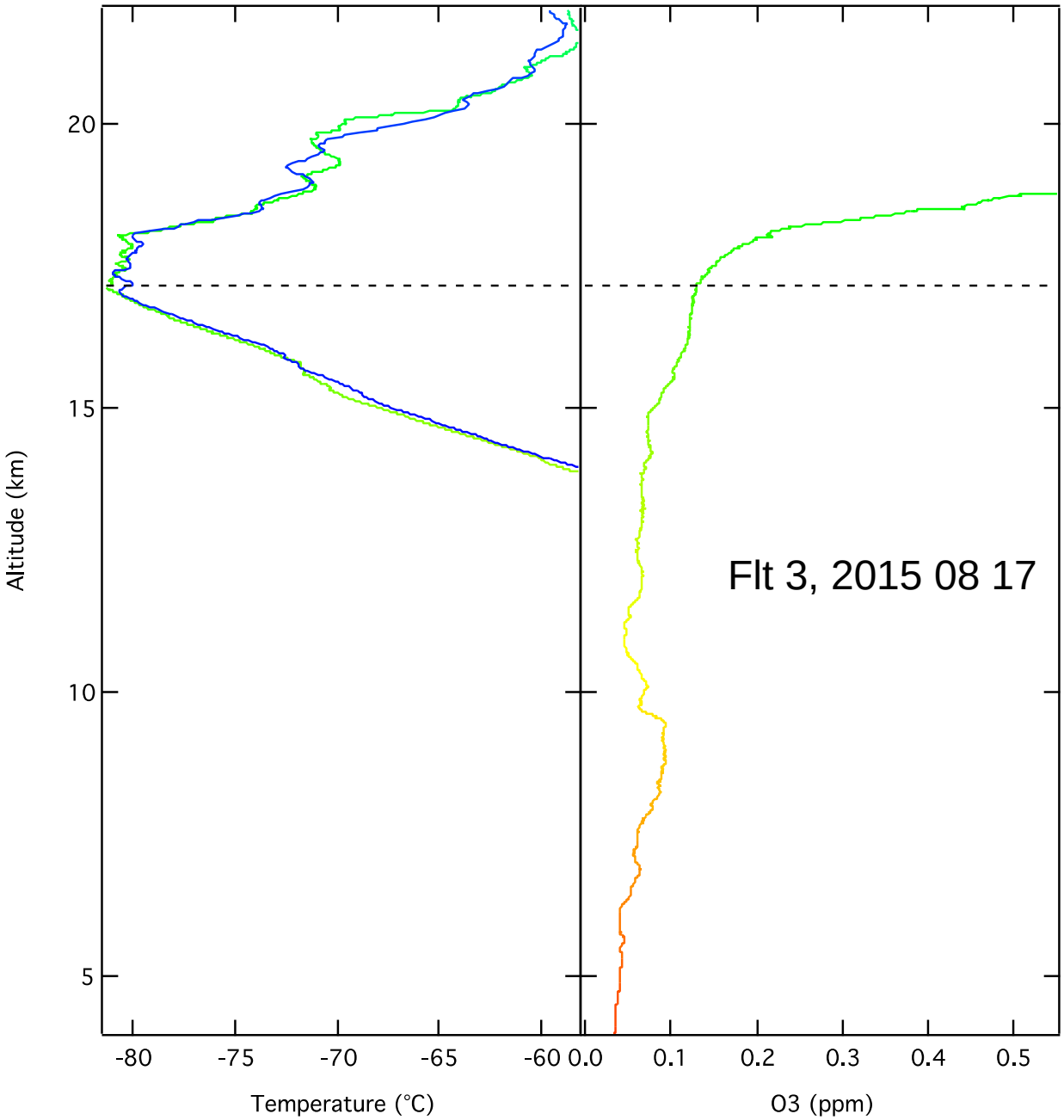
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Flt 3, 2015 08 17