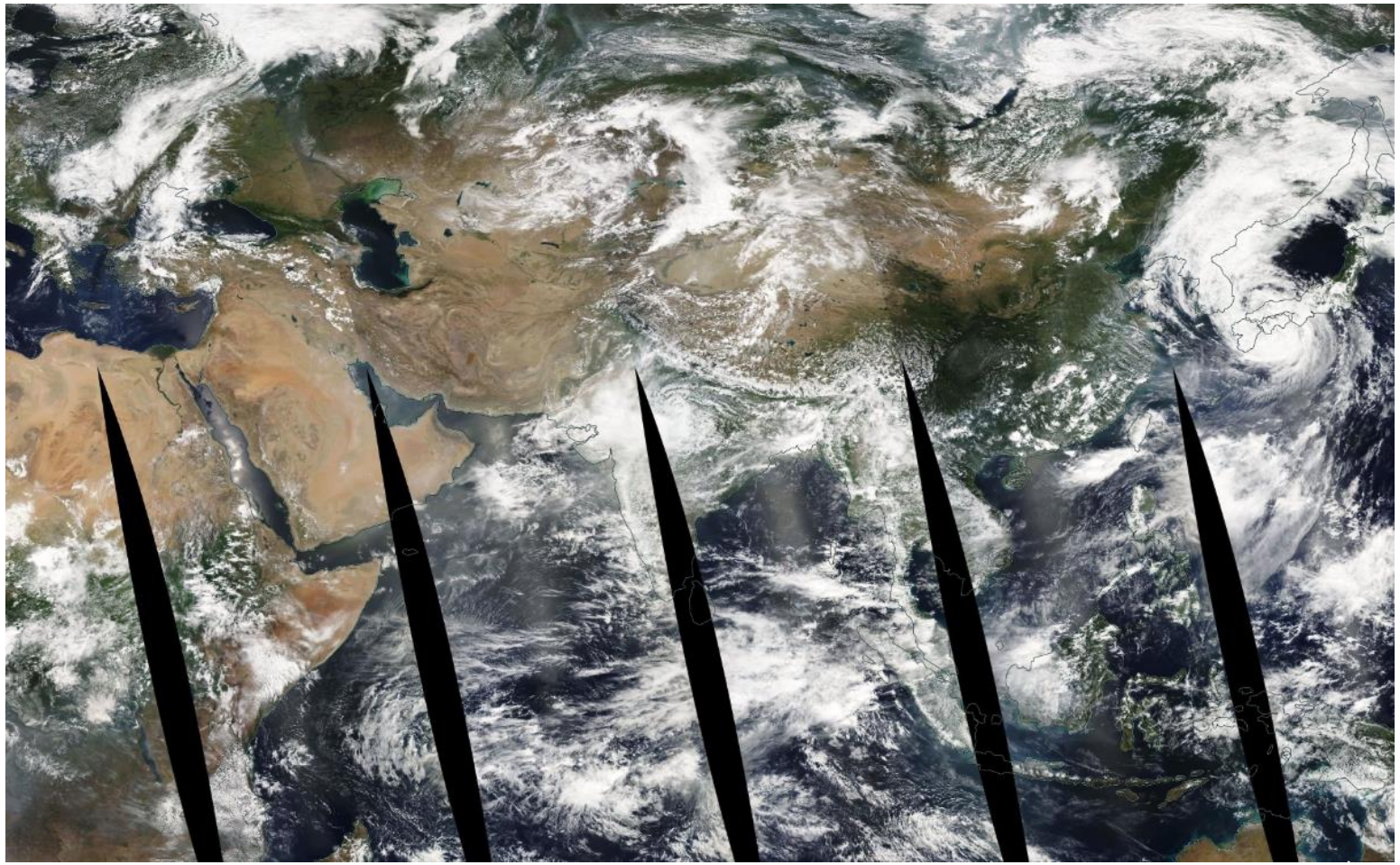
Aerosol Discrimination in the Asian Monsoon Region: Is it a cloud? Depolarizing Aerosol? Non-depolarizing aerosol?



Melody Avery, NASA Langley; With a whole lot of help from colleagues and friends:

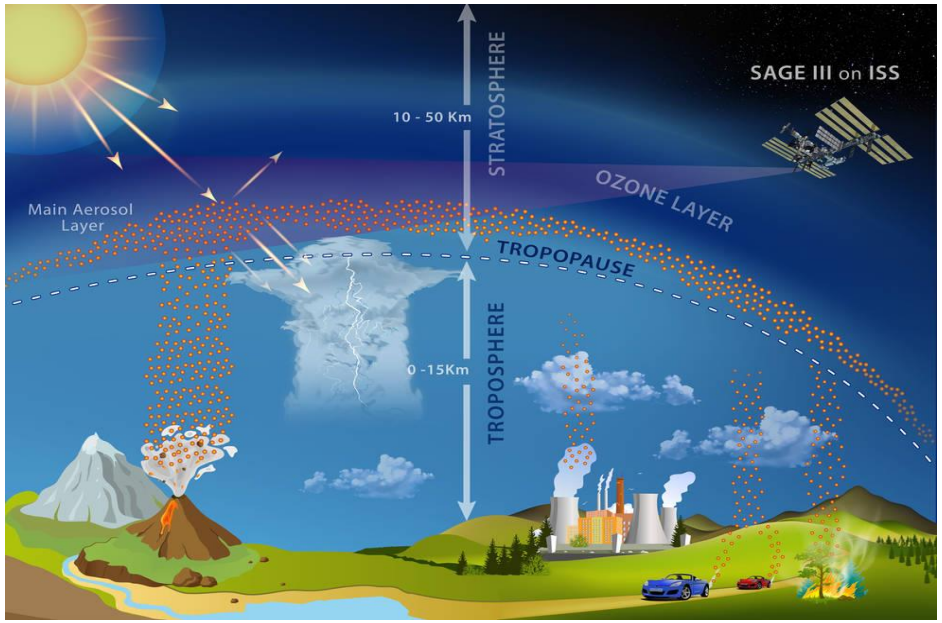
John Kummer, Mark Schoeberl, Kris Bedka, Jean-Paul Vernier, Hongyu Liu, Duncan Fairlie, Bo Zhang, Amit Pandit, Karen Rosenlof, Sean Davis, Jason Tackett, Jayanta Kar, Zhaoyan Liu, Mark Vaughan

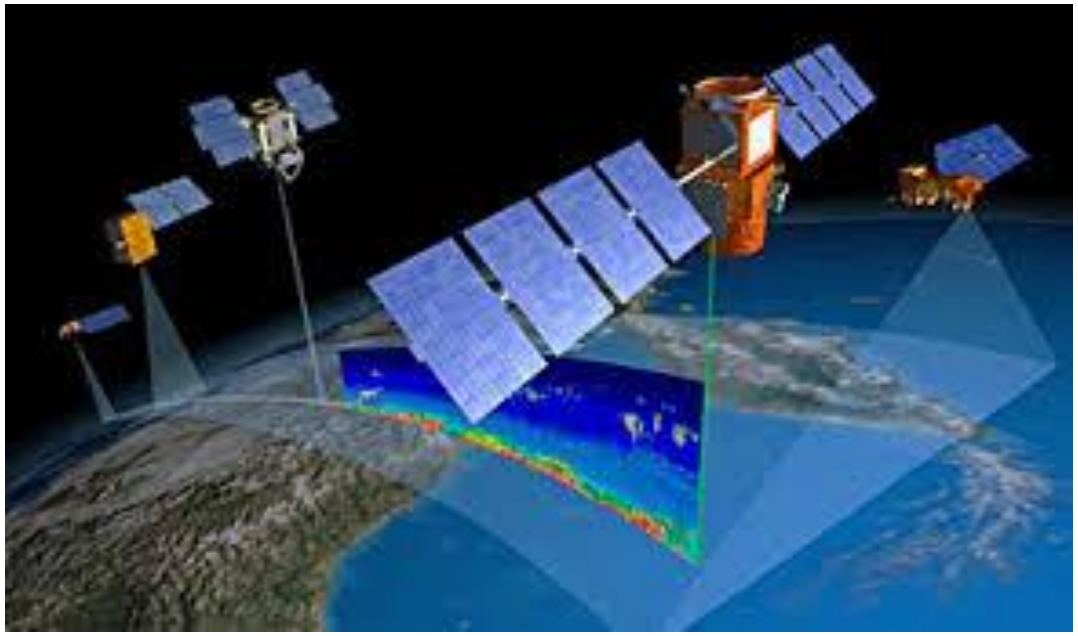
Science questions/Talk Outline

- Top of Aerosol layers > top of convective parameterization in models. What happens to loft aerosols in the ATAL?
- Hypotheses:
  - Modeled convection is too low.
  - Intermittent very deep convective events contribute long-lasting aerosols by injection.
  - Cloud radiative effects create lofting that elevates small particles.
  - All of these things could be true.
- Measurement Challenges:
  - Imperfect data, always missing something in space or in time.
  - Particles are detected. Aerosols or Clouds? Or both!
  - Where is the local tropopause?
- This talk:
  - Focus on observations by CALIOP, SAGE-III/ISS and some geostationary for context.

Goal: A regional comparison of cloud/aerosol discrimination in CALIOP and SAGE-III data, with an atmospheric process context.

SAGE-III vs CALIOP Cloud and Aerosol Detection

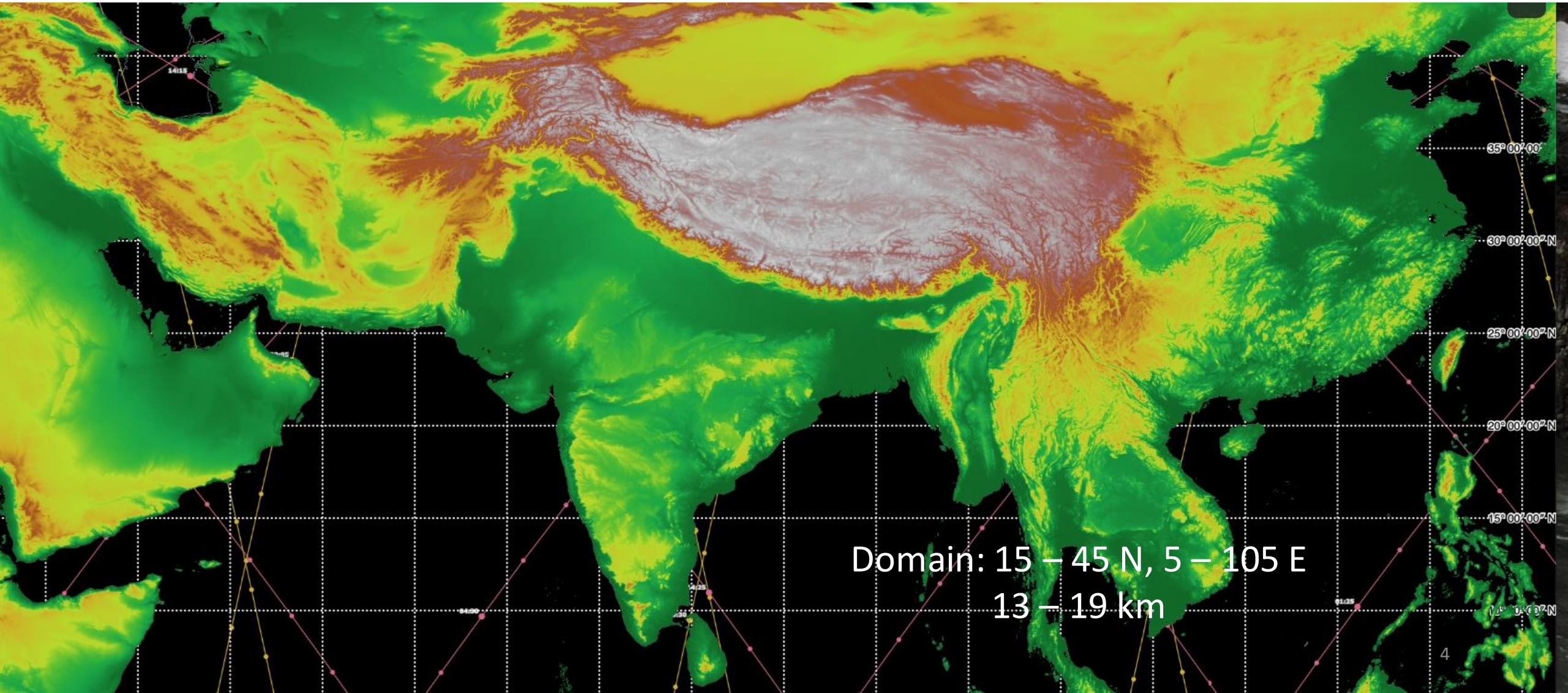




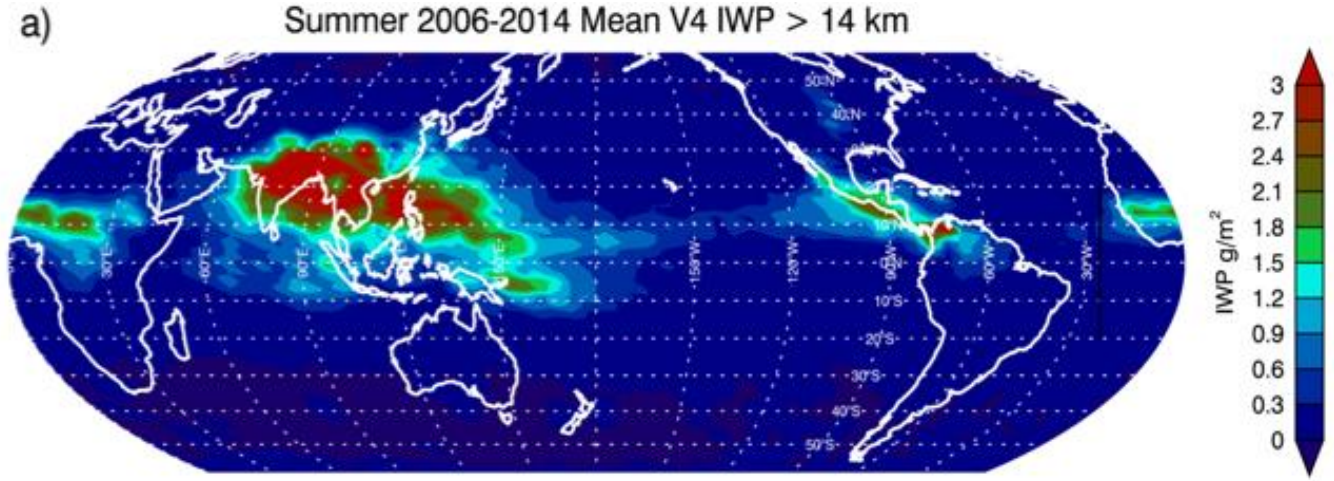
- 200 km path, 500 m vertical resolution
- 9 wavelengths (nm): 384, 449, 521, 602, 676, 756, 869, 1022, 1544
- Extinction observations at solar occultations
- Chemical observations as well
- *Detects cumulative extinction by aerosols and cloud ice particles along the sample path.*

- Features detected at 5, 20, 80 km
- Mode of transparent layer thickness distribution in the tropopause region is ~ 500 m, like SAGE bins
- Two 532 nm Channels with linear polarization plus 1064 nm
- Continuous measurements but no swath
- *Detects atmospheric features in a profile that have elevated backscatter and sorts them into aerosols and clouds.*

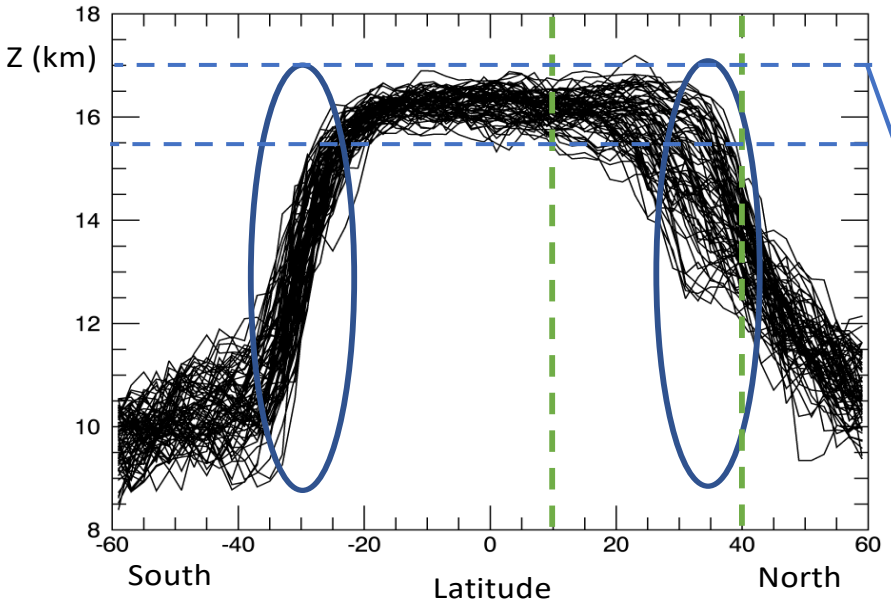
Domain: Asian Monsoon, Tropopause Region
Peak Monsoon Season; July and August 2017-2018



In the NH Summertime UT/LS, the Asian Monsoon is the biggest, baddest game in town.



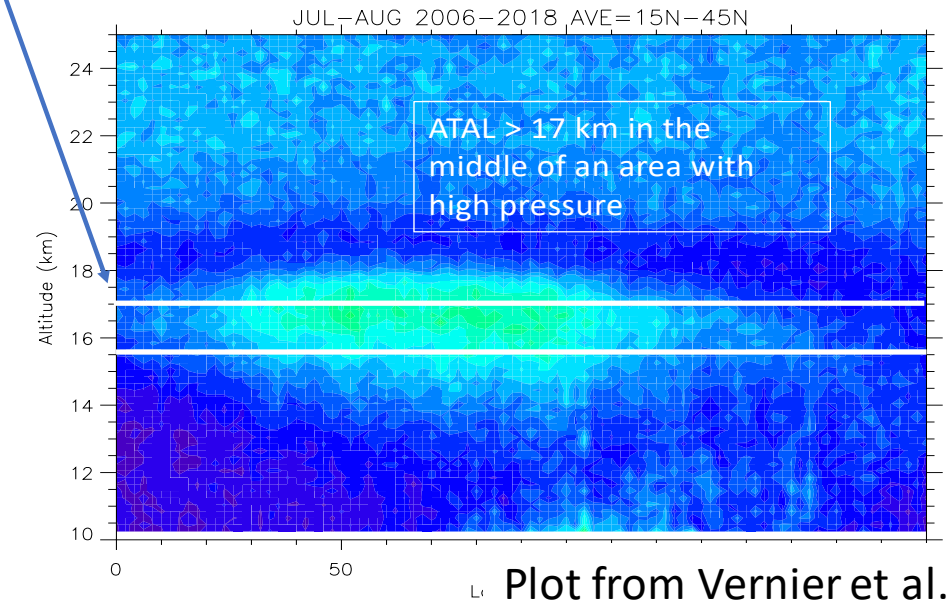
MERRA-2 tropopause height vs latitude



Hemispheric asymmetry in the Boreal Summer due to the Asian Monsoon in the Northern Hemisphere.
The NH tropopause break at the subtropical jet is much less well-defined due to deep convection.

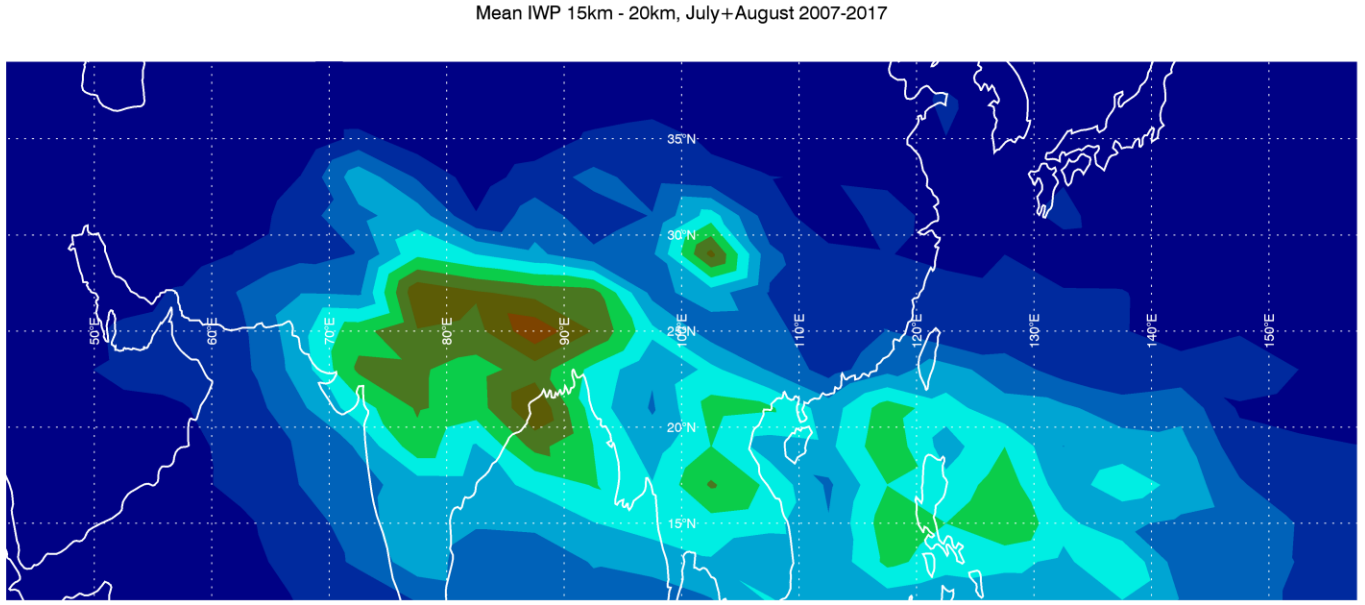
Asian Monsoon:

1 – Convective transport of tropospheric chemicals to the Stratosphere.
2 – More Subtropical, overshooting convection more likely to contribute water vapor to the Stratosphere (Schoeberl et al., 2019)
3 – Asian Tropopause Aerosol Layer (ATAL – Vernier et al.)

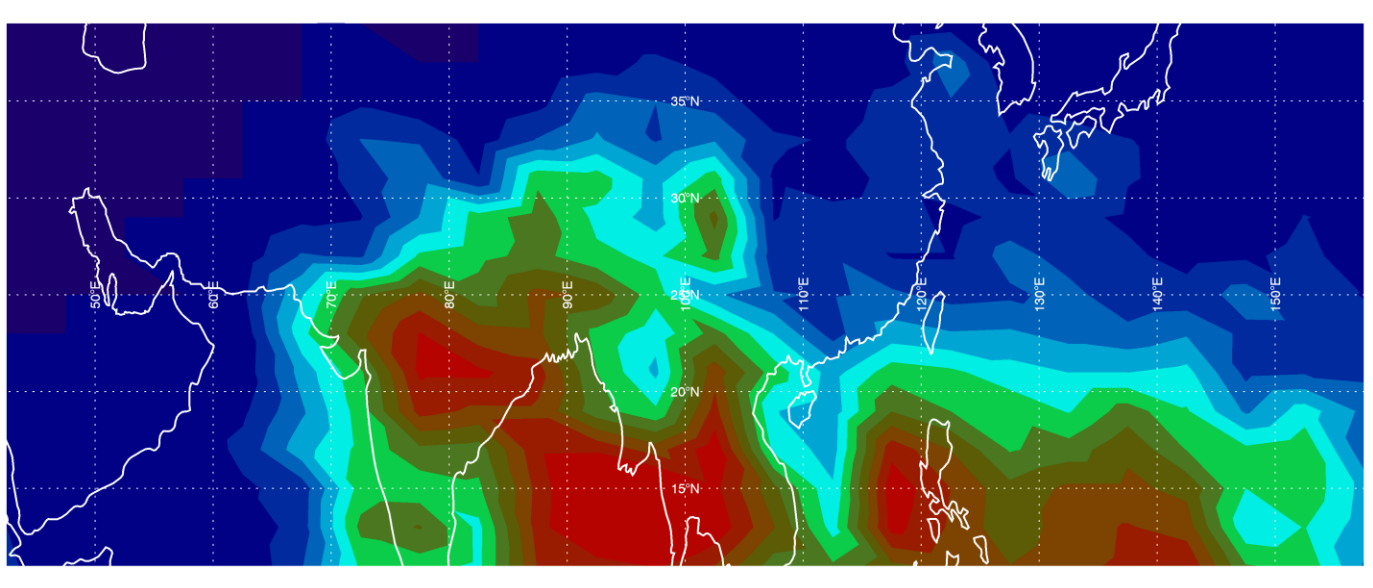


Plot from Vernier et al., 2020

CALIOP Nighttime Cloud Distribution “Climatology”

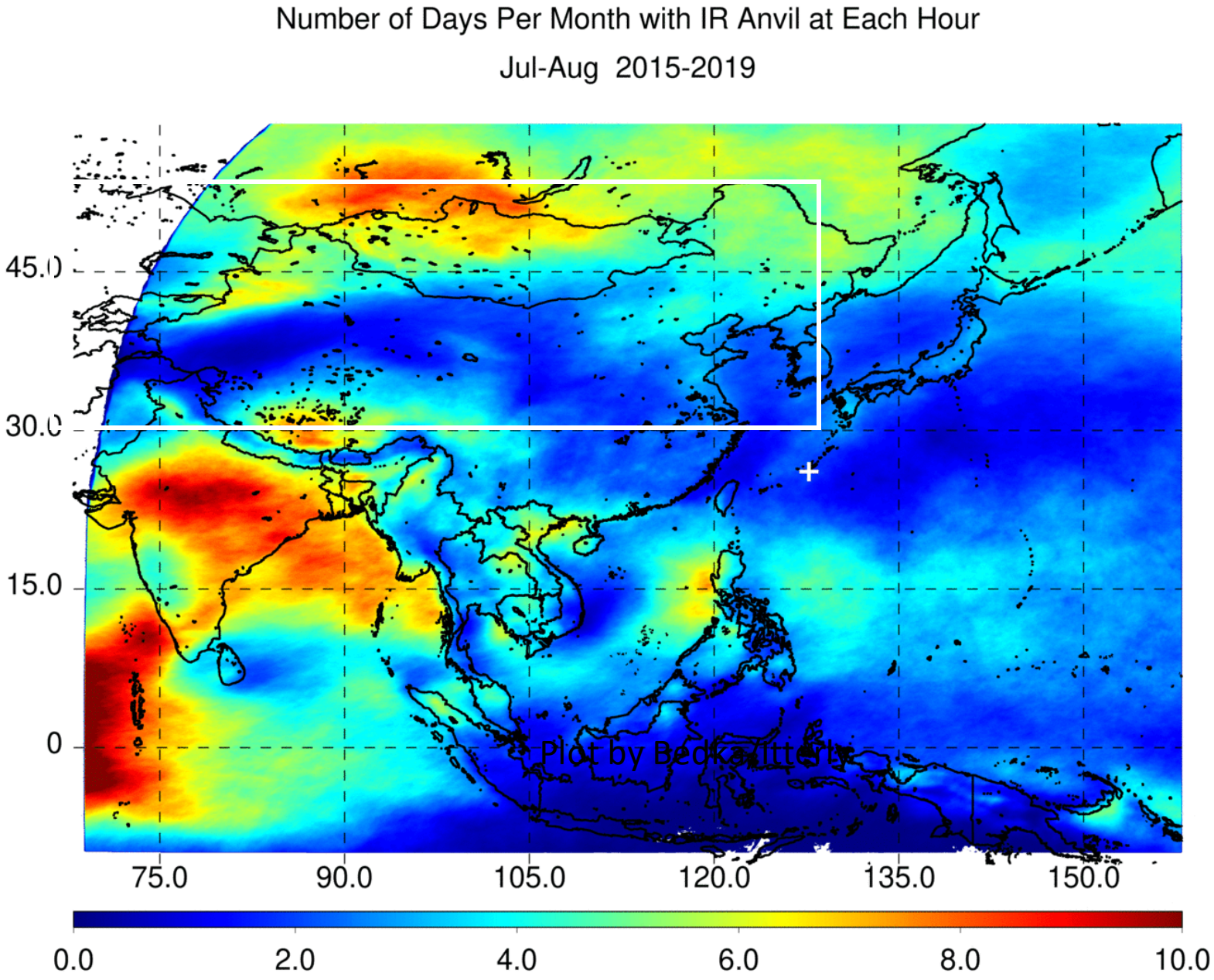


Cloud Ice Water Path, 15-20 km July and August 2007 - 2017 CALIOP Nighttime



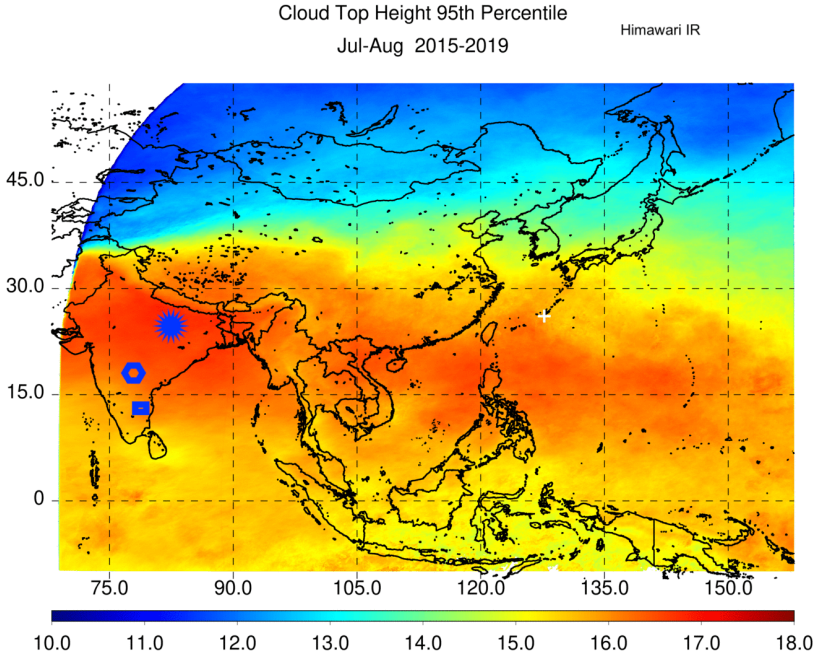
Convective Cloud Fraction > 15 km July and August 2007 - 2017 – CALIOP Nighttime

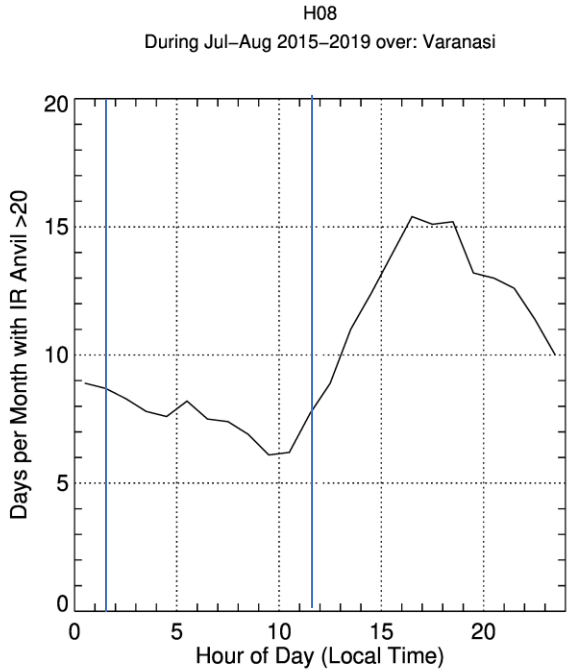
Compare Geostationary (IR) with LIDAR (vis) – “All-Times” vs Nighttime



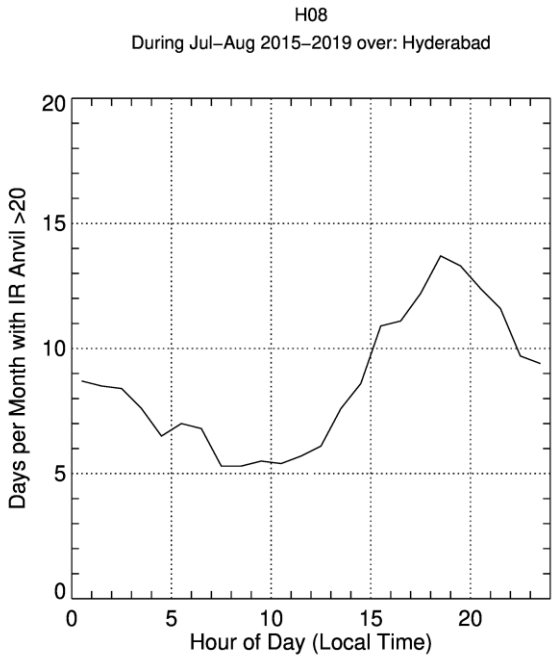
From Himawari IR, Anvil counts using the method of Scarino et al. (2020, in preparation) on a 4x4 degree grid.
Mean for Julys and Augusts, 2015 - 2019

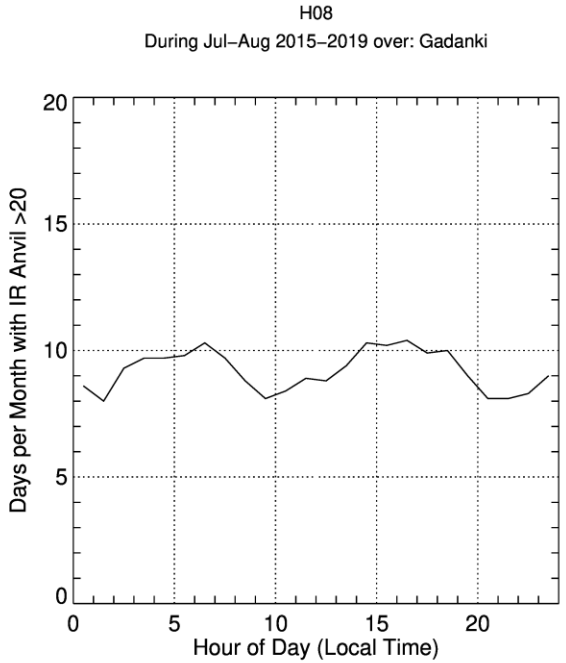
Plot by Bedka/Itterly





For land convection, apparently A-Train crossing times would be about the same.





Plots by Bedka, Itterly

SAGE-III Cloud/Aerosol Categorization

SAGE-II

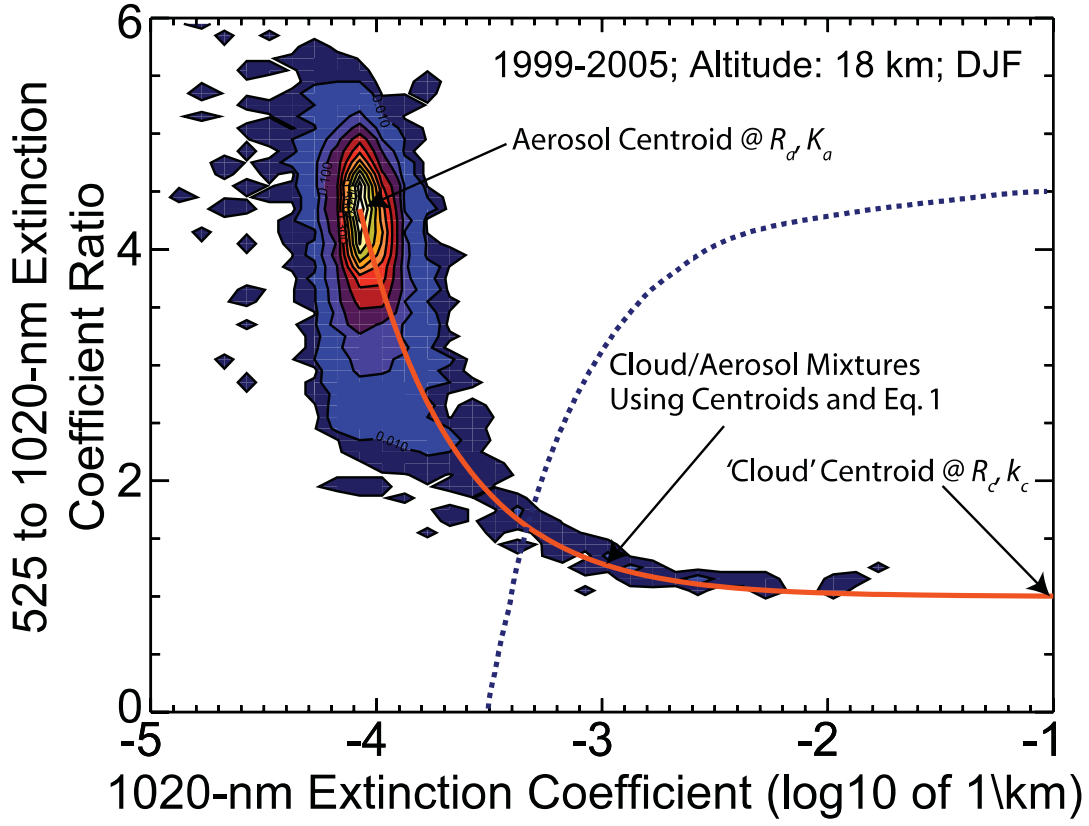
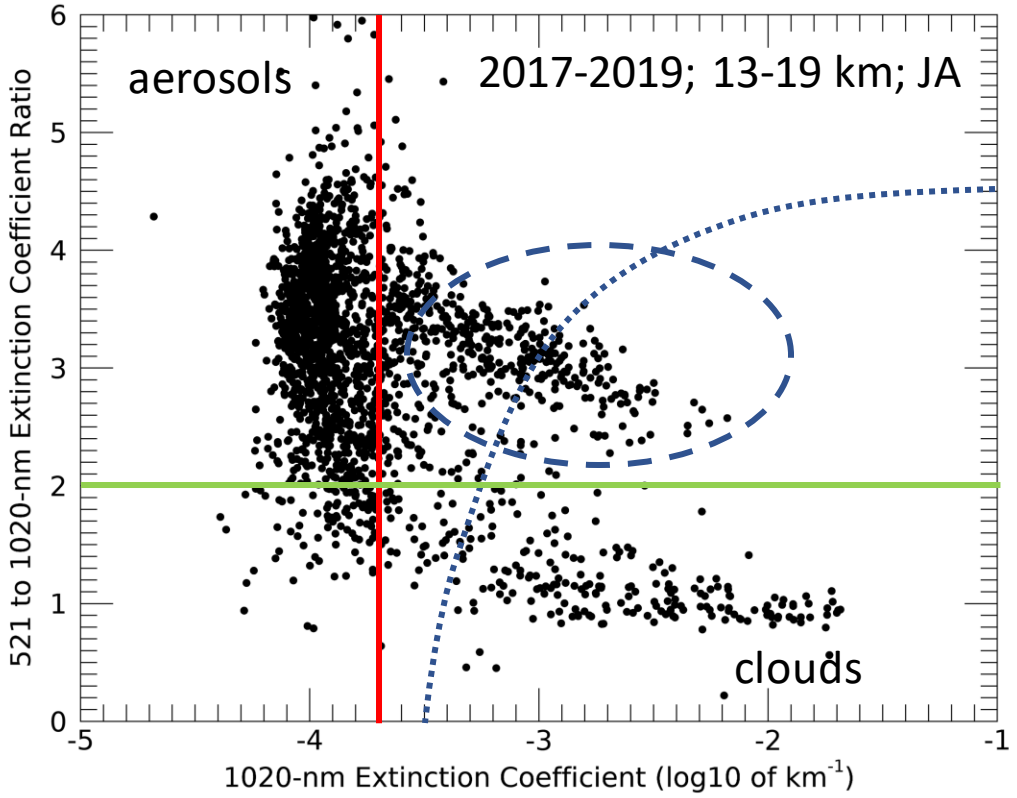


Figure 4, Thomason and Vernier, ACP 2013

SAGE-III/ISS

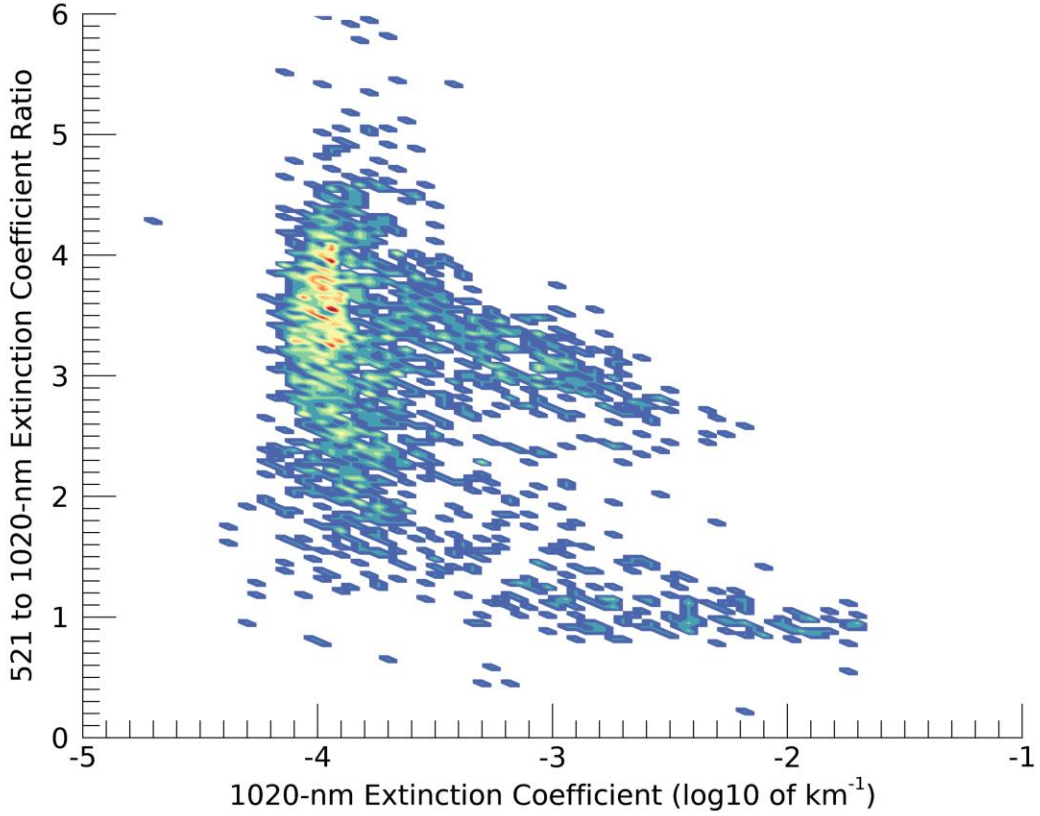


Solar (sunrise, sunset), 179 events, 500 m bins

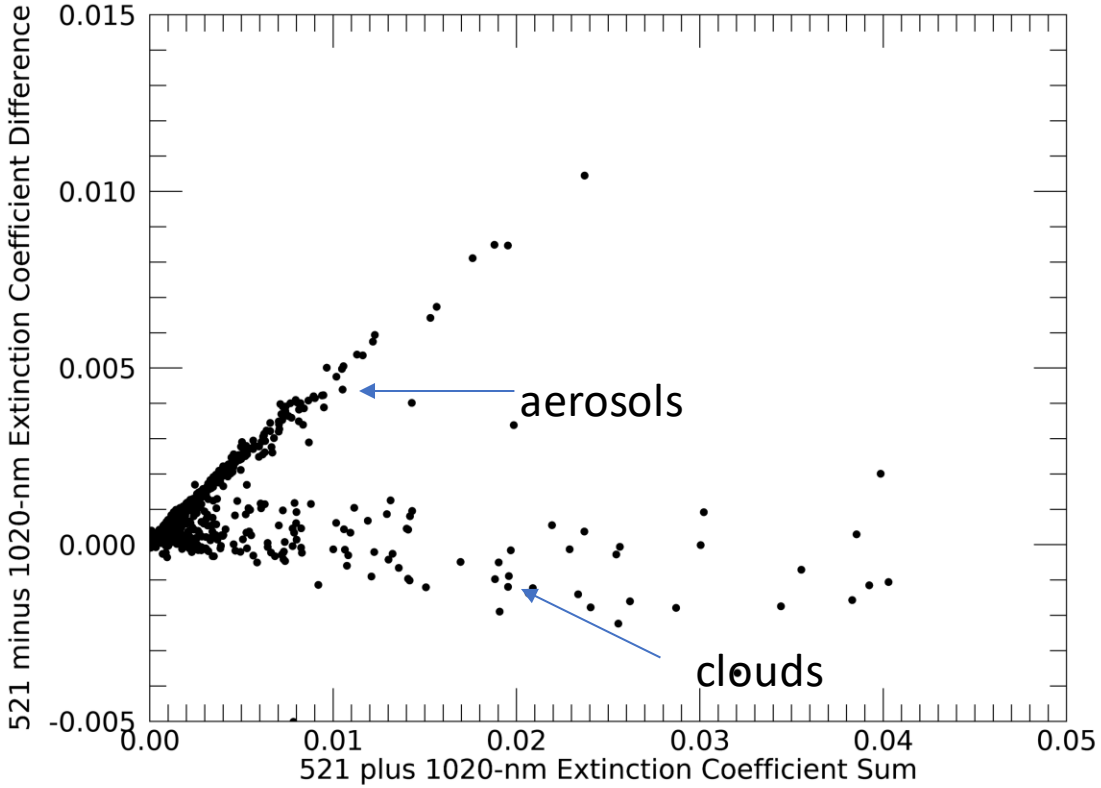
2-λ (Thomason algorithm) – red and green lines

Alternative View: Spectral Radiative Signature (SRS) algorithm

521/1020 Ratio vs log10 of 1020 – same as last plot with some distribution information

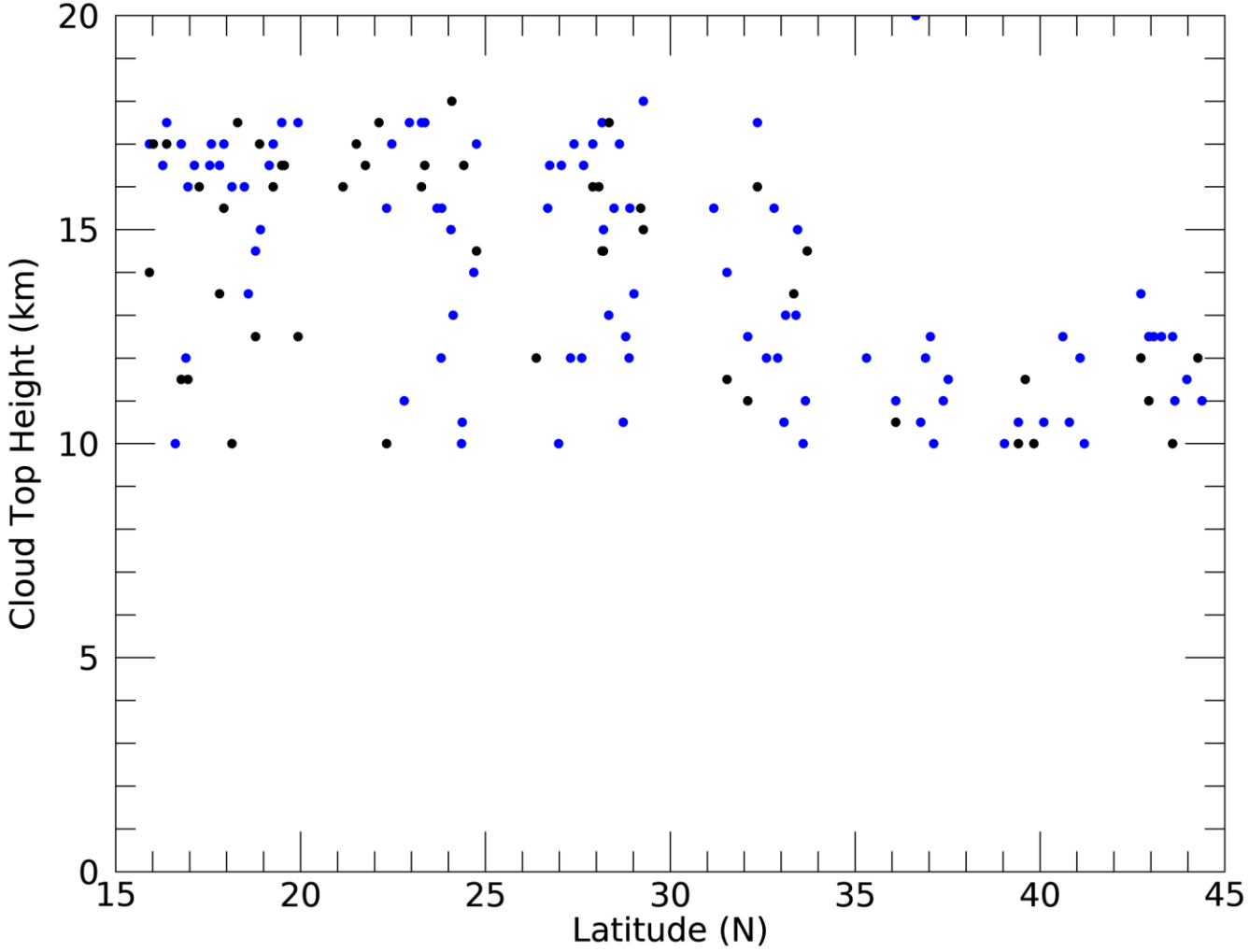


521 - 1020 nm Extinction Coefficient Difference vs 521 + 1020 nm Extinction Coefficient Sum



SRS technique from Chiu et al. (2009)

SAGEIII-ISS Cloud Tops –July, August 2017-2019

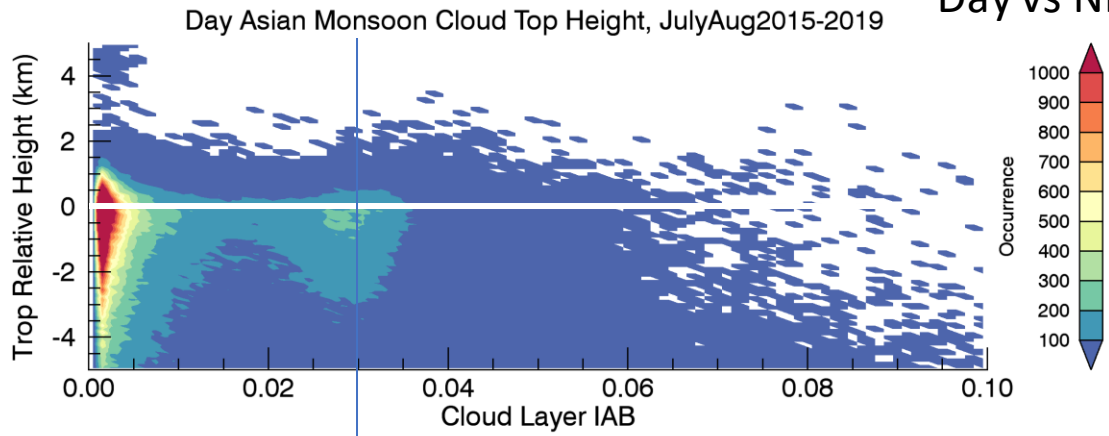


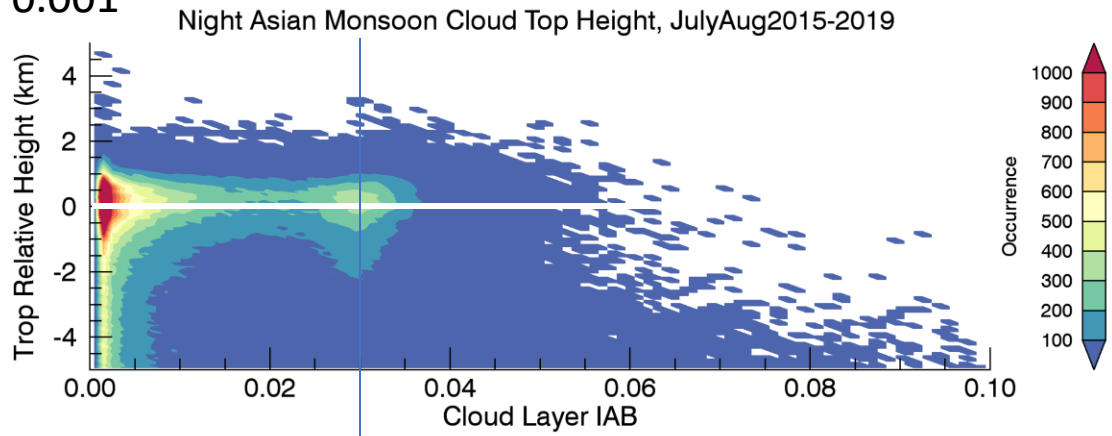
Clouds Detected by John Kummer using the 2-wavelength method of Thomason and Vernier (2013).

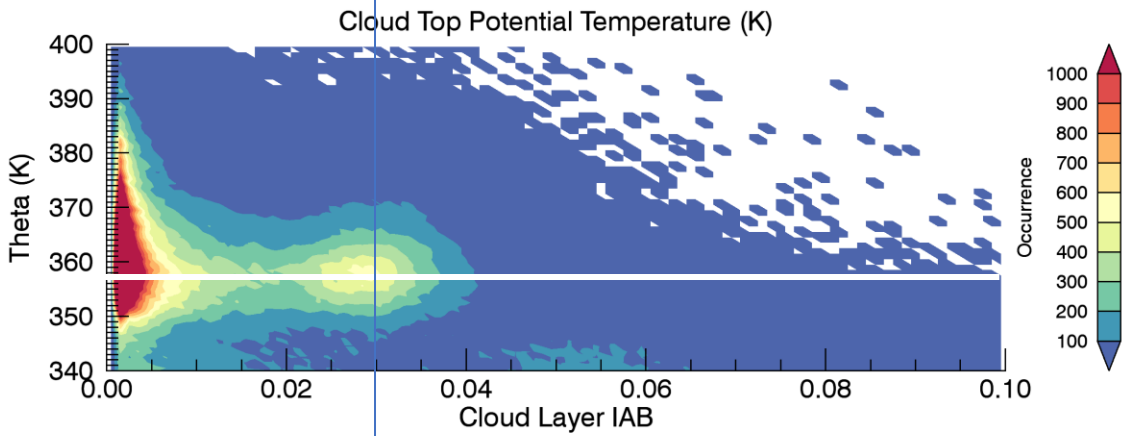
SAGE-III Clouds

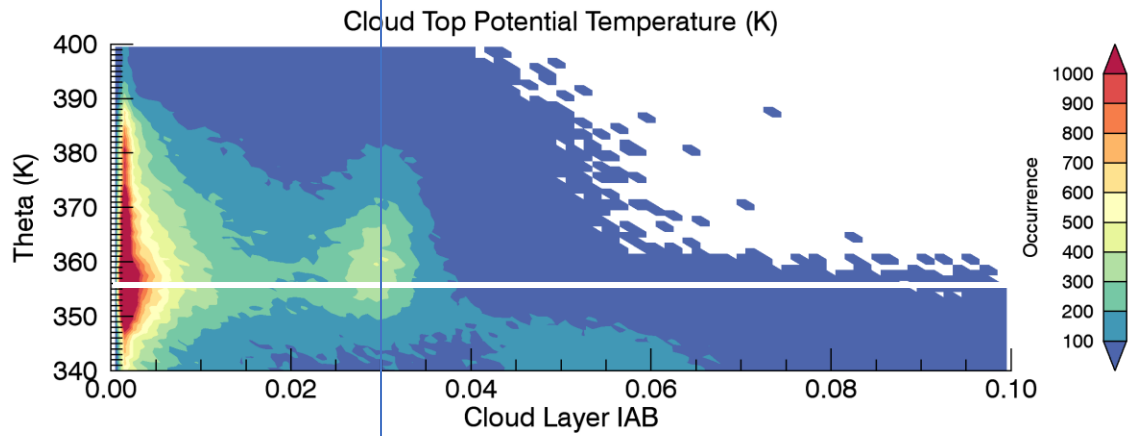
Opaque to SAGE-III at 1020 nm

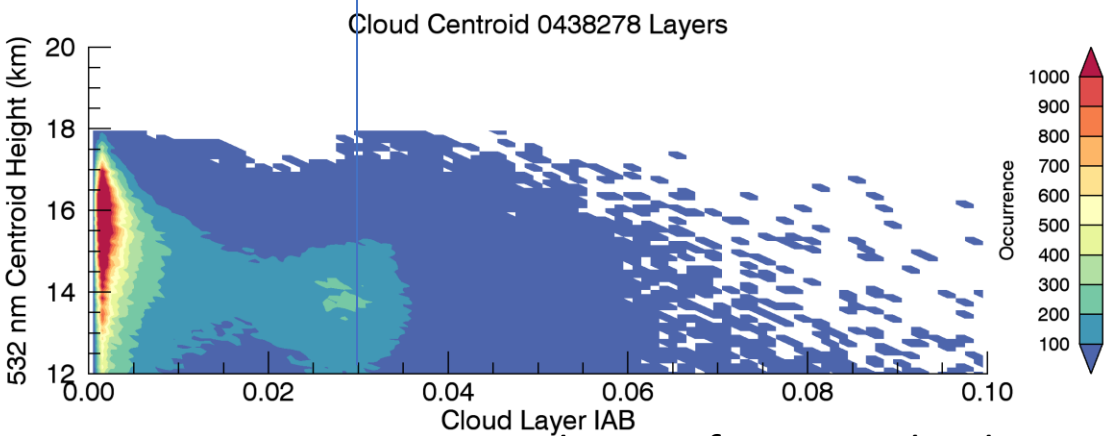
Day vs Night, IAB > 0.001

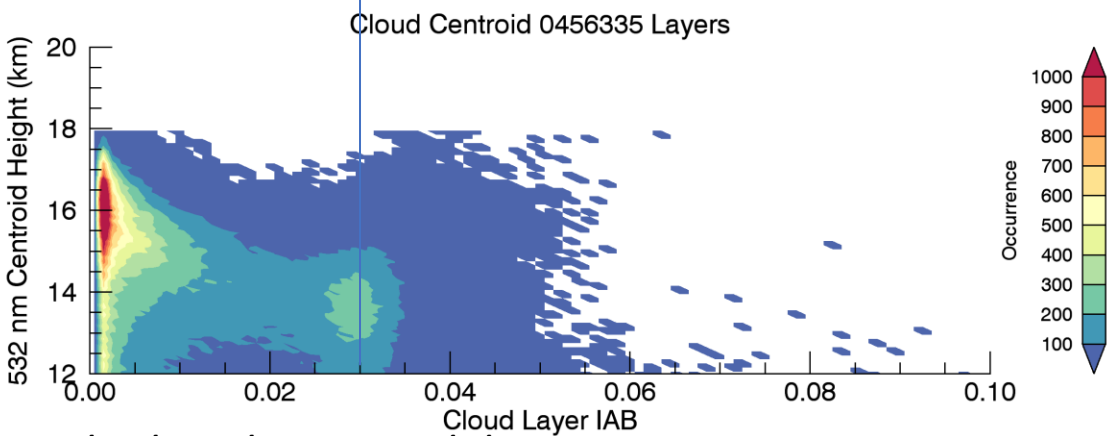








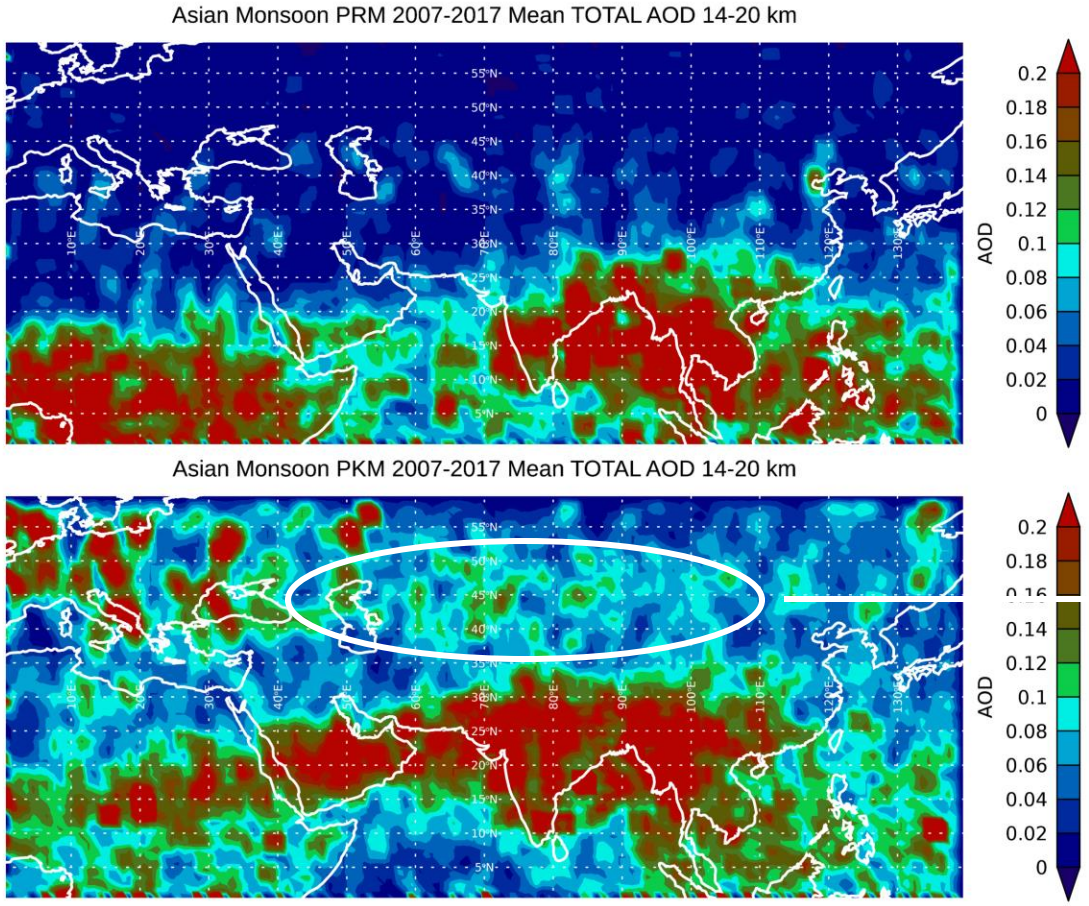




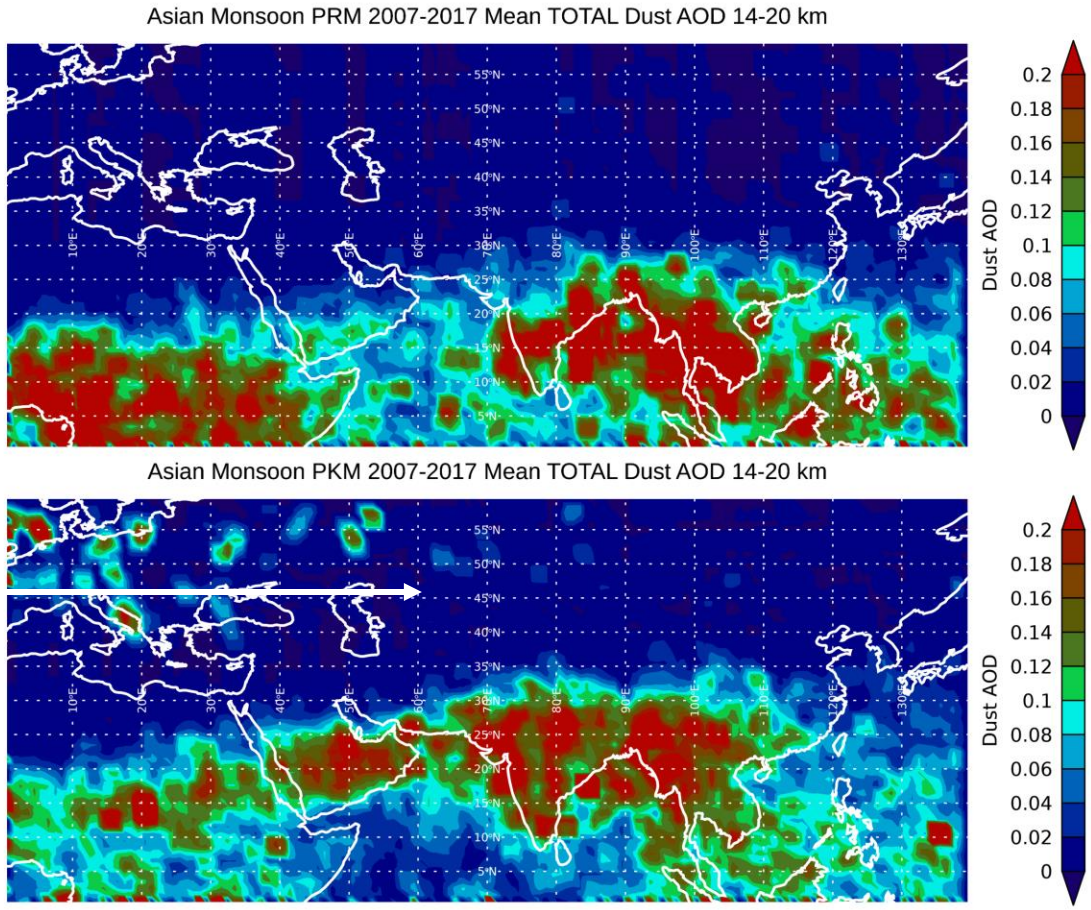
Population of opaque clouds maximizes at 0.03 both nighttime and daytime

CALIOP Aerosols – Total AOD vs Dust AOD

Total AOD: Top = May, June
Bottom = July, August



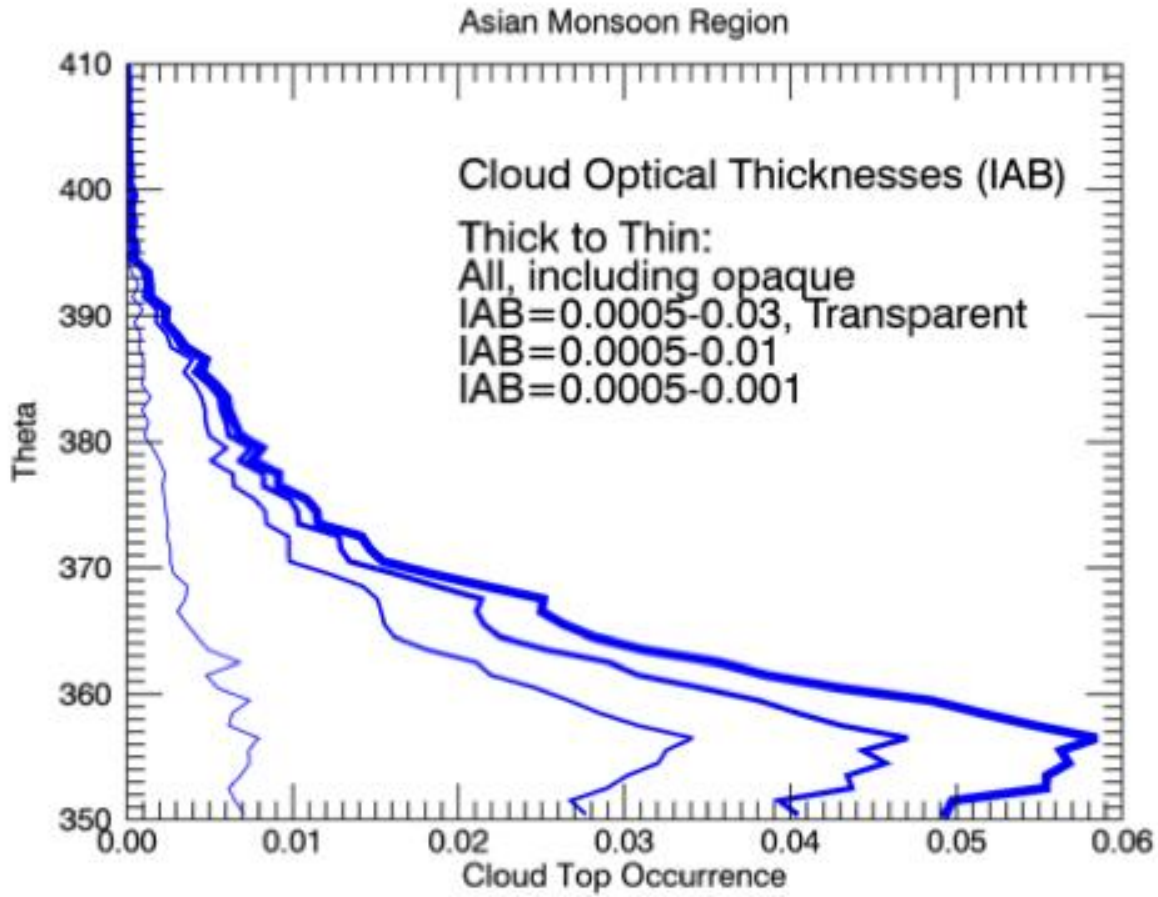
Dust AOD: Top = May, June
Bottom = July, August



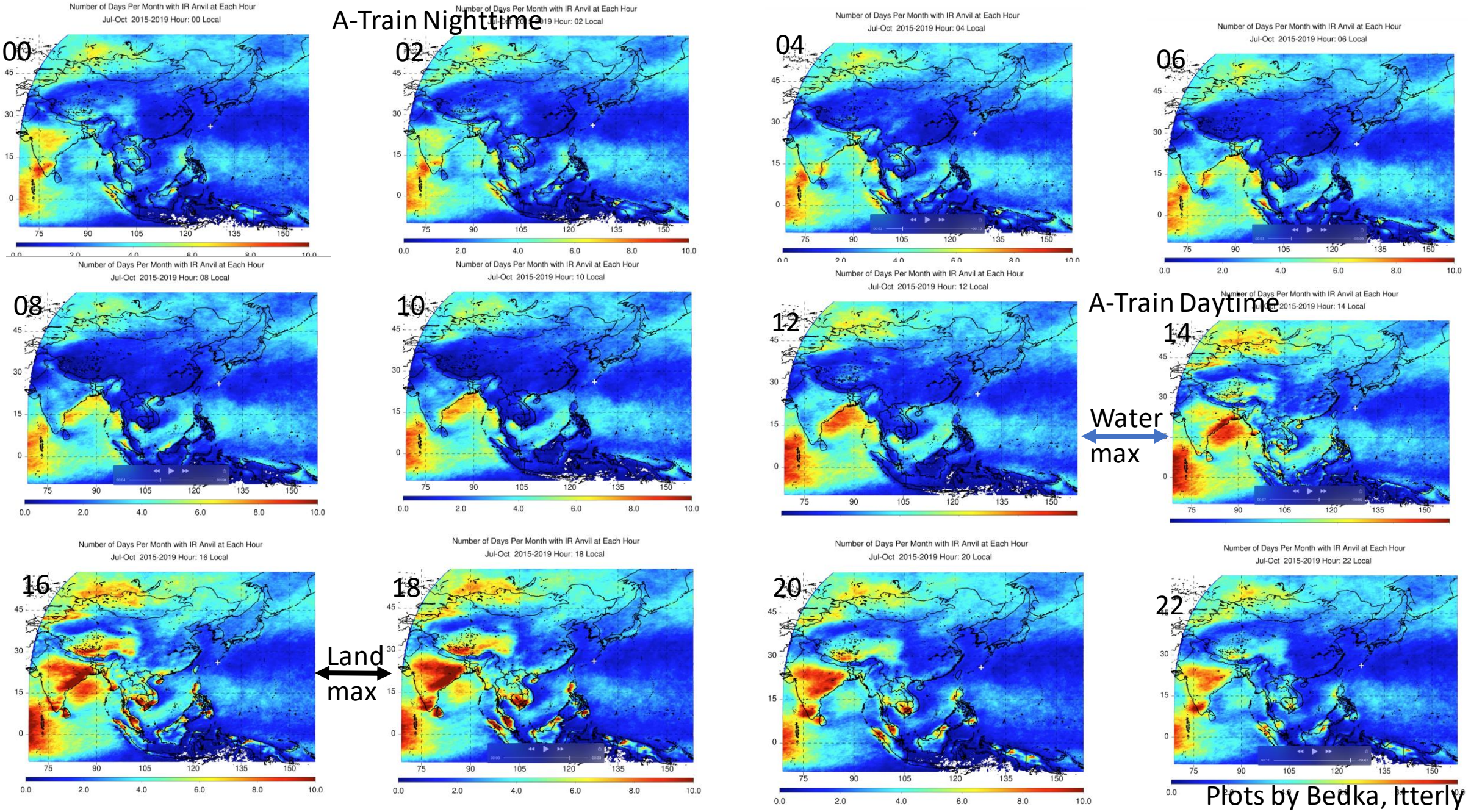
Take-Away Messages

- In the UT/LS, detecting polarizing aerosol layers is complicated.
- There is ample evidence of mixed cloud and aerosol sampling in the Asian Monsoon UT/LS.
- While SAGE-III cloud tops might be expected to be lower than CALIOP cloud tops due to the tangent height location (Kent et al., 1997), they appear to be comparable, or higher.
- Cloud top heights might be higher partly due to real diurnal variability and a different sampling time.
- More work to do: CALIOP thin cloud layers and depolarizing layers can be compared with SAGE-III – more to come!
- Finding 1:1 sampling isn't likely to produce much.

Extras


Asian Monsoon Region
Cloud Optical Thicknesses (IAB)
Thick to Thin:
All, including opaque
IAB=0.0005-0.03, Transparent
IAB=0.0005-0.01
IAB=0.0005-0.001
Theta
410
400
390
380
370
360
350
0.00
0.01
0.02
0.03
0.04
0.05
0.06
Cloud Top Occurrence

Mean Anvil Counts by Local Time from Himawari IR, Scarino et al., 2020 in prep.; July – Oct. 2015 - 2019



Day vs Night, OD > 0.3