The Asian Tropopause Aerosol Layer
through satellite and balloon-borne measurements combined with modeling approaches

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What is ATAL?

The Asian Tropopause Aerosol Layer

- ATAL is a confined area of enhanced aerosol associated Summer Asia Monsoon spanning from the E. Med Sea to W. China
- It essentially extends from top of convective outflow over much of SE Asia
- Existence recognize through CALIPSO observations

*Vernier et al., JGR 2015*
ATAL’s Verification through balloon-borne backscatter measurements

- COBALD backscatter data from Lhasa in August 2013 (Courtesy J. Bian and F. Weinhold)
- Very good agreement between COBALD and CALIPSO in the UTLS

Vernier et al., JGR 2015
ATAL: Intensifies during the 2000s

- SAGE II also observed ATAL after 1999
- Times series of Summer-winter ratios of aerosol AOD between 13 and 18 km over (cloud free) Eastern Med and Asia
- Combined CALIPSO/SAGE II record suggests the intensification of ATAL particularly between 2000 and 2010

Vernier et al., JGR 2015
ATAL’s origin

Trajectory mapping of CALIPSO observations to regions of deep convection (BT<220K from Kalpana);

Map of mean trajectory-mapped CALIPSO SR (AOI) sourced to deep convection, 1-16 Aug., 2008, indicates Northern India as key deep convective source for elevated aerosol in the ATAL.

Vernier et al., JGR 2015
BATAL 2015: Balloon-borne measurements in Asia

5 weeks: July-August 2015: 30 Launches/4 locations/9 Institutes involved

- Banaras Hindu University, Varanasi, India, 15-24 Aug 15
- 7 launches of COBALD backscatter sondes, Optical Particle Counters, Aerosol Impactors, Water Vapor Sensor and Ozonesondes

- King Abdullah University of Science and Technology (KAUST), Thuwal, Saudi Arabia, Aug 15
- 6 launches of COBALD backscatter and meteorological sondes

- Tata Institute for Fundamental Research Balloon facility, Hyderabad, India, 29 July-13 Aug 15
- 11 Launches of large and small aerosol sensors

- National Atmospheric Research Laboratory, Gadanki, India,
- 6 launches of aerosol and chemical sensors 17-25 July 15
BATAL 2015
“ A Scientific endeavor ”

Vanarasi, India, August 2015

Gadanki, India, July 2015

Hyderabad, India, August 15

Thuwal, Saudi-Arabia, August 2015
- ATAL’s thickness increase with latitudes
- Around 2 km (16-18 km)
BATAL-2015 : Comparison CALIPSO/COBALD

AVE CALIPSO :
- Monthly
- +/-30 LON
- +/-2 LAT

Gadanki (13.5N, 79.2E)

Hyderabad, India (17.4N, 78.1E)

Varanasi, India (25.3N, 82.9E)

Thuwal, Saudi Arabia (22.3N, 39.1E)
- Sharp increase of aerosol concentration (r>0.075 micron) near 16.5-18.5 km
- 90% of volatile aerosol
- Coincident increase in Scattering Ratio / Low Color Index (small particles)
- Sharp peak at the Cold Point Tropopause
- Increase in Water Vapor in the same region (Convective moisture)
- Minimum of ozone
Improving representation of UT aerosol and their precursors in GEOS-Chem global CTM

NewSO2: Change to wet scavenging of SO$_2$ - fraction of SO$_2$ dissolved in cloud liquid controlled by Effective Henry’s Law constant

- MIPAS shows SO$_2$ of 50-100 ppt at 14-16 km in seasonal mean maps (2002-2012), filtered for volcanic episodes. from M. Hoepfner et al., MIPAS SO2 in the UTLS, ACPD, 2015.
- SO2 in new scheme, allowed to survive convective storm and be converted into aerosol in the Upper Troposphere (consistent with satellite and a few in situ measurements)
Conclusions

• Satellite observations show ATAL’s intensification since late 90’s

• Indian Sub-continent key place to understand ATA’s nature and related formation mechanism

• BATAL 2015 gives new information about this layer:
  - Made of very small particles of less than 0.25 micron
  - 90 % of volatile particles
  - Strongly correlation with Cold Point Temperature (New Particle formation)
  - Likely influenced by convective moisture
  - Nature

• Improving representation of Sulfur cycle is key to reproduce observations
More slides
In the TTL

- Multiple layers observed near the tropopause by Cobald
- Increase of particle concentration
What is the origin of ATAL?

• Modeling by Neely using WACCM suggests that the aerosol is primarily sulfate with about 30% originating in south Asia

• Similarly, work by Fairlie suggests that it is primarily sulfate but that up to 90% of the sulfur originates in India

• Composition and source remains a matter of debate at this time