The Asian Tropopause Aerosol Layer

through satellite and balloon-borne measurements combined with modeling approaches

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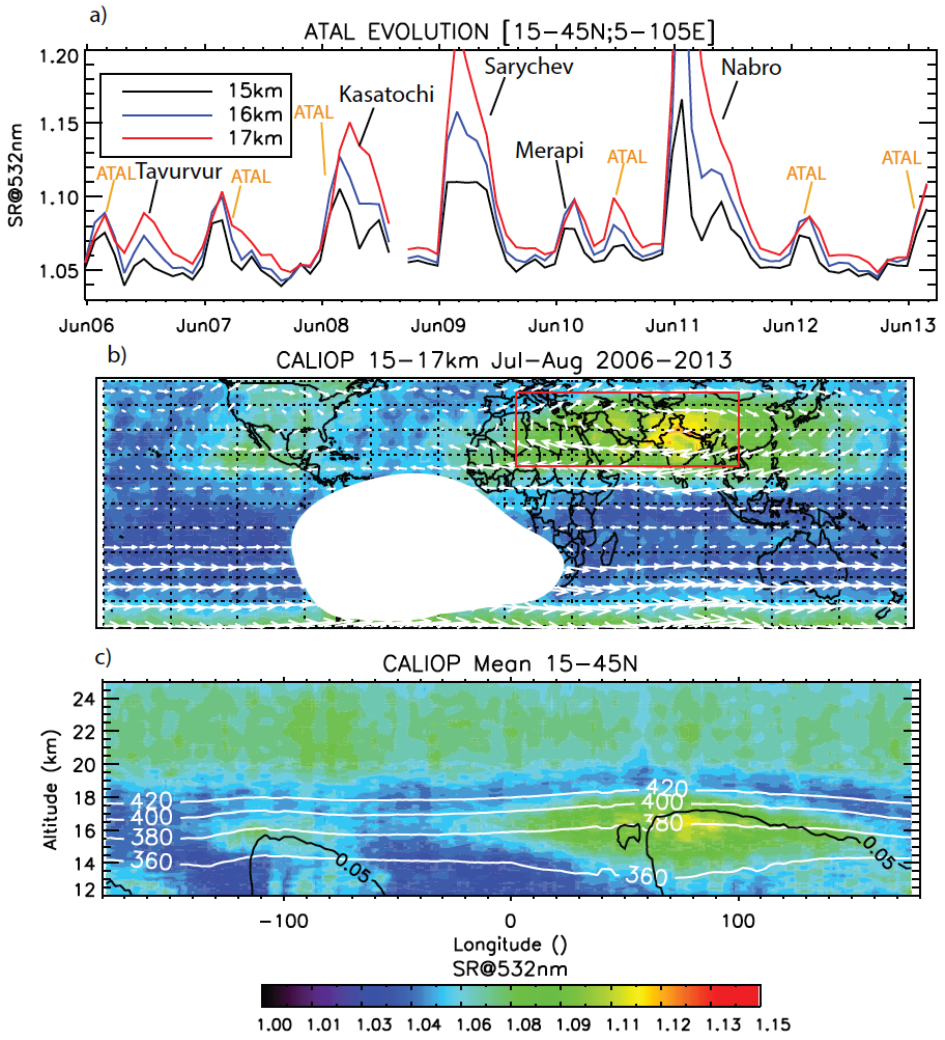
What is ATAL?

The Asian Tropopause Aerosol Layer

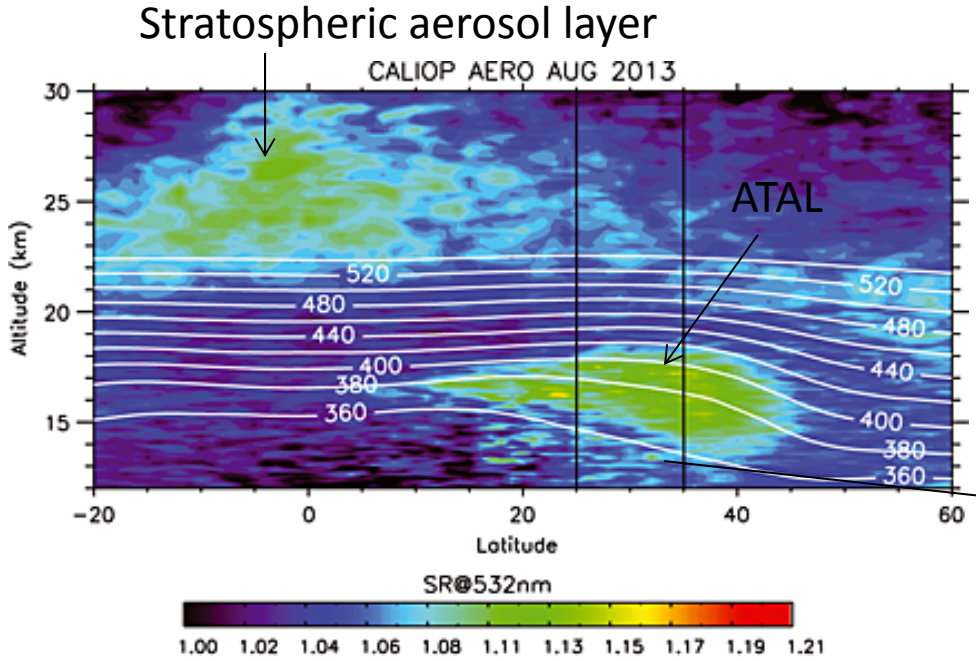
- ATAL is a confined area of enhanced aerosol associated Summer Asia Monsoon spanning from the E. Med Sea to W. China
- It essentially extends from top of convective outflow over much of SE Asia
- Existence recognize through CALIPSO observations

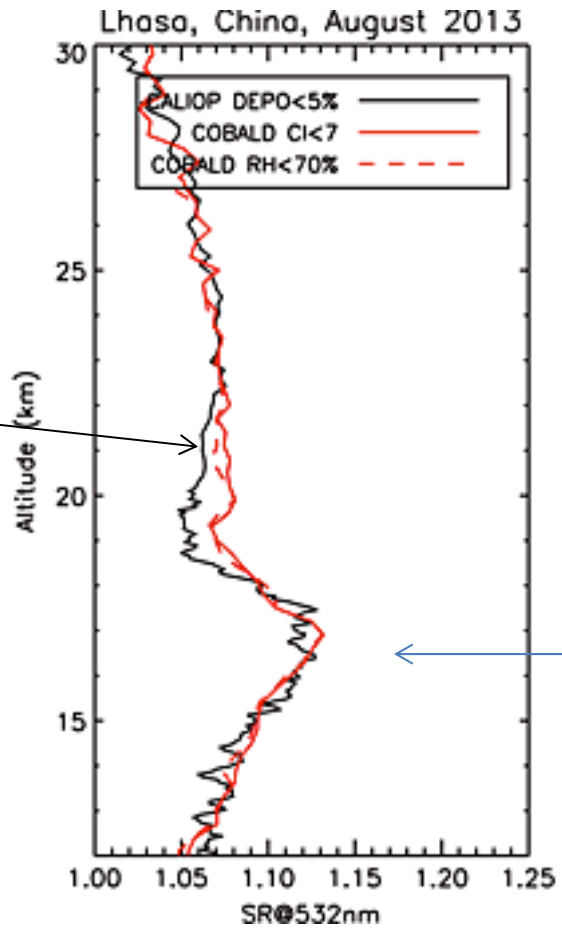


Vernier et al., JGR 2015

ATAL's Verification through

balloon-borne backscatter measurements



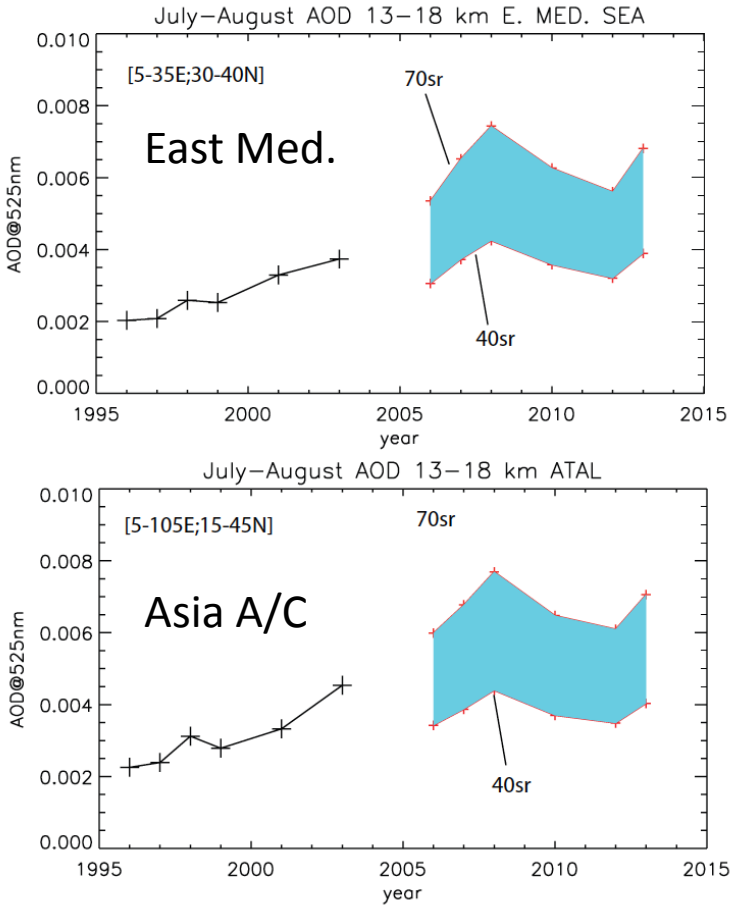


- COBALD backscatter data from Lhasa in August 2013 (Courtesy J. Bian and F. Weinhold)
- Very good agreement between COBALD and CALIPSO in the UTLS

Vernier et al., JGR 2015

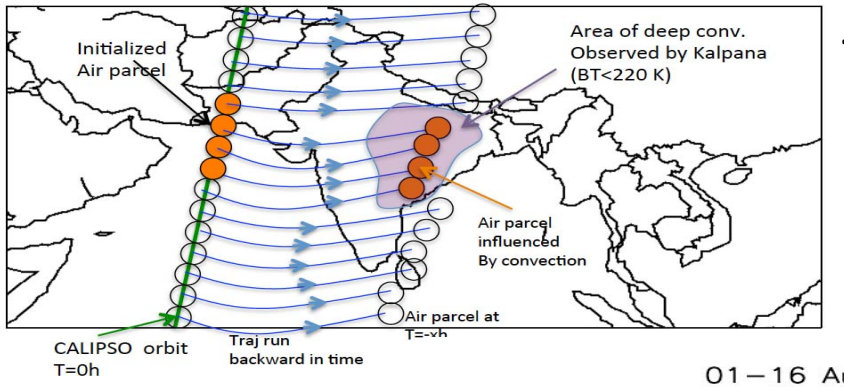
ATAL: Intensifies during the 2000s

- 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**

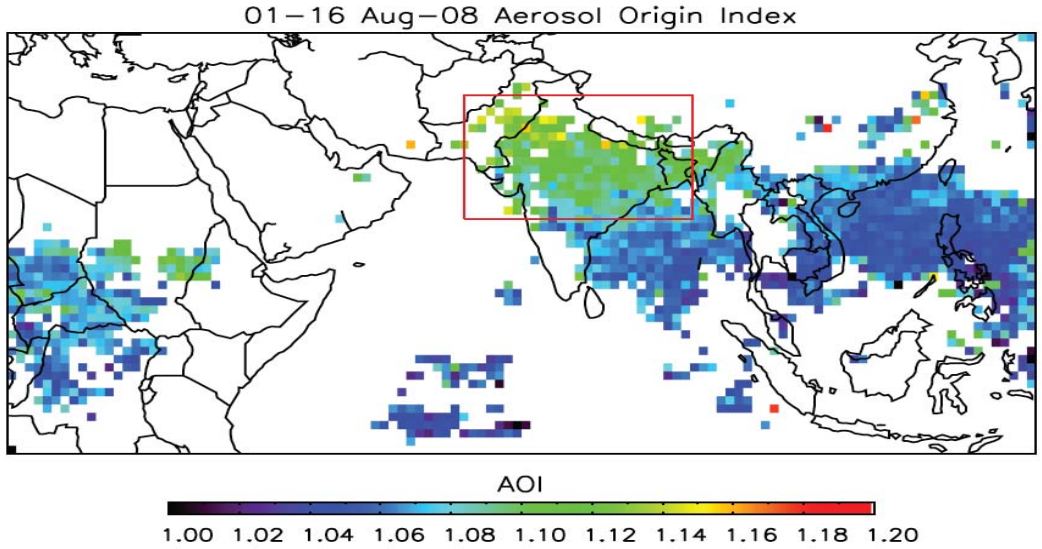


Vernier et al., JGR 2015

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

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

- 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

- 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


Rare Climate Experiment in Collaboration with NASA

National Atmospheric Research Laboratory releases 3-metre balloon with 2.7 kg payload to study Asian Tropopause Aerosol Layer formed over Middle East and other parts of Asia

BATAL 2015

“ A Scientific endeavor ”

Vanarasi, India, August 2015

Gadanki, India, July 2015

Hyderabad, India, August 15

Thuwal, Saudi-Arabia, August 2015

CALIOP/BATAL-2015

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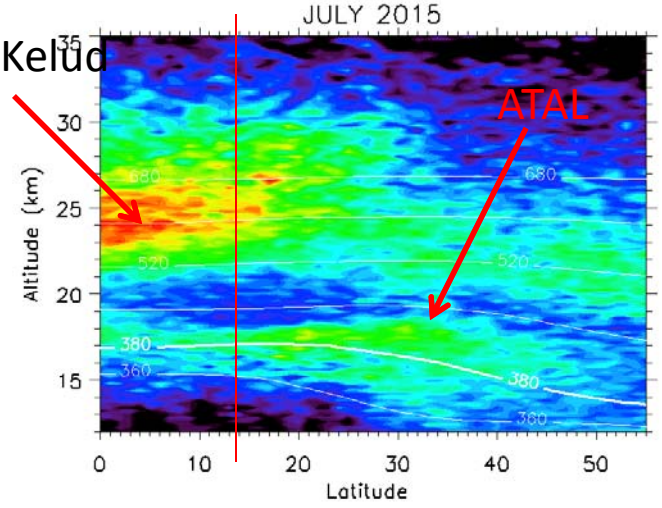
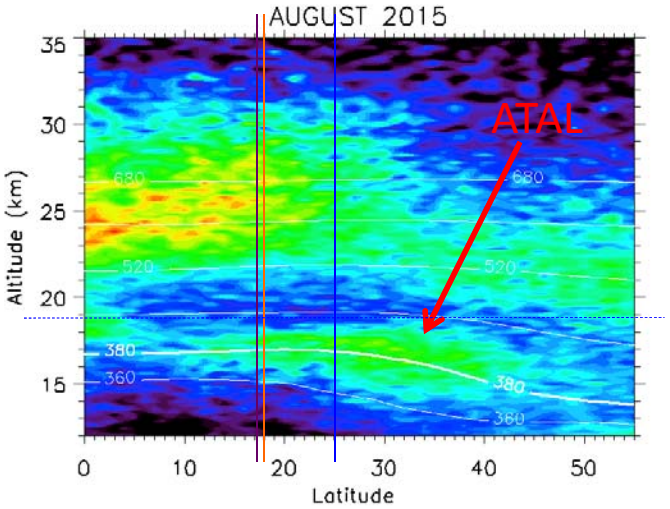
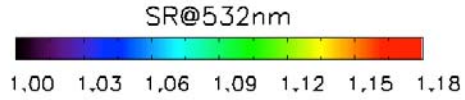
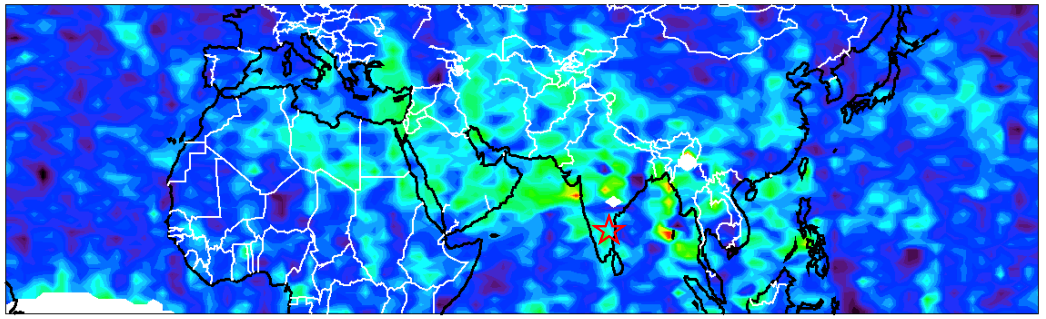


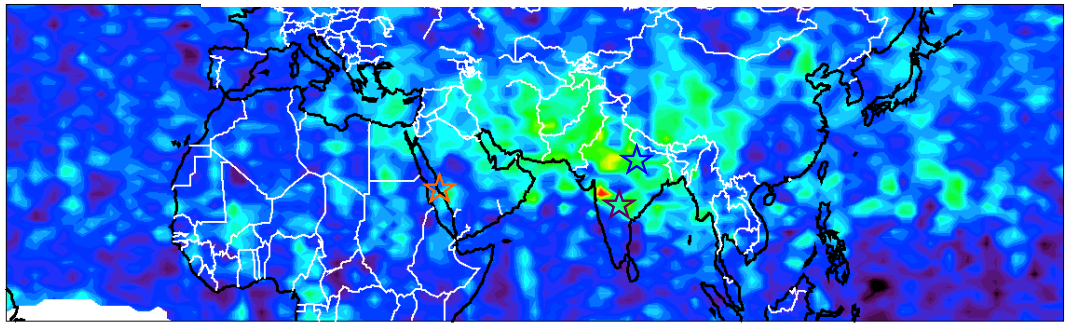


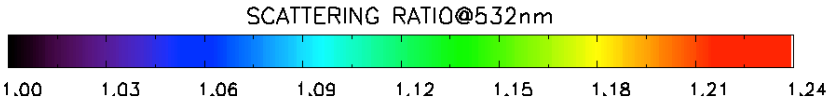


CALIOP July 2015 Average 15-18 km



August 2015





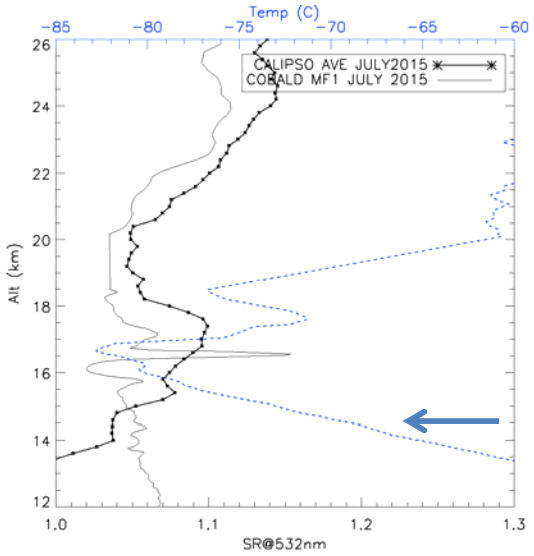
- ATAL's thickness increase with latitudes
- Around 2 km (16-18 km)

BATAL-2015 : Comparison CALIPSO/COBALD

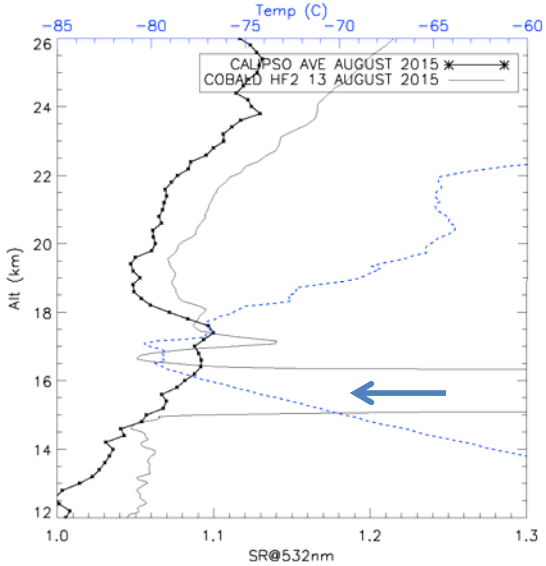
AVE CALIPSO :

- Monthly
- +/-30 LON
- +/-2 LAT

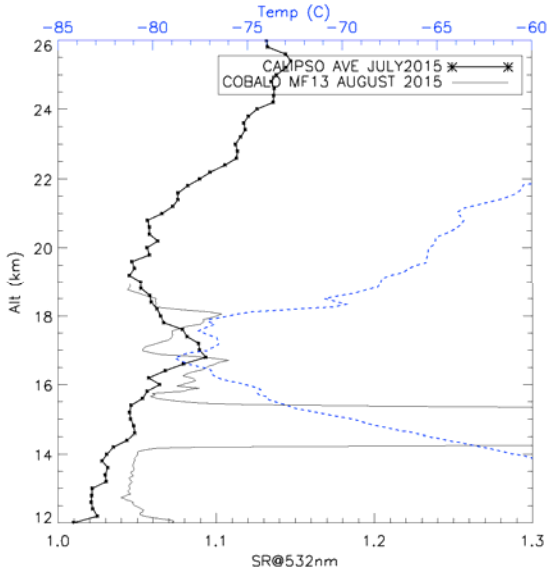
Gadanki (13.5N, 79.2E)



Hyderabad, India (17.4N, 78.1E)



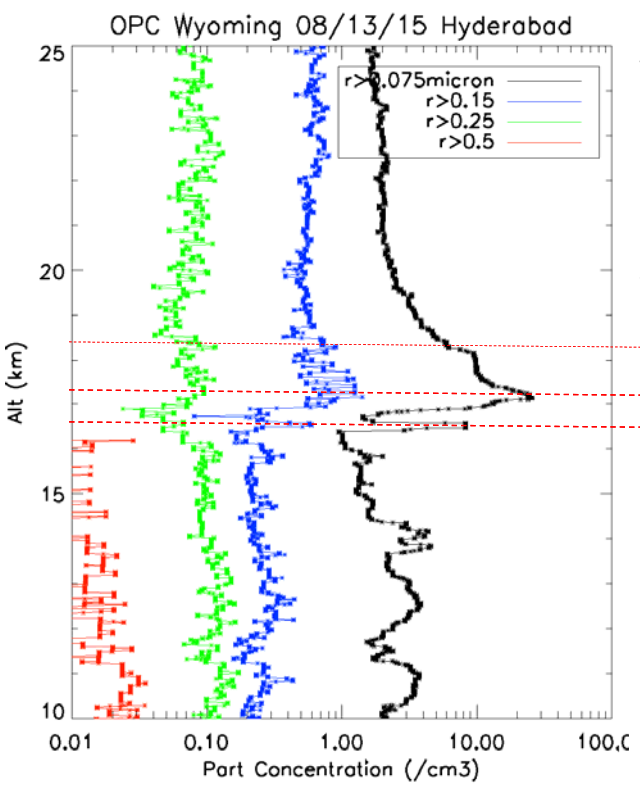
Varanasi, India (25.3N, 82.9E)



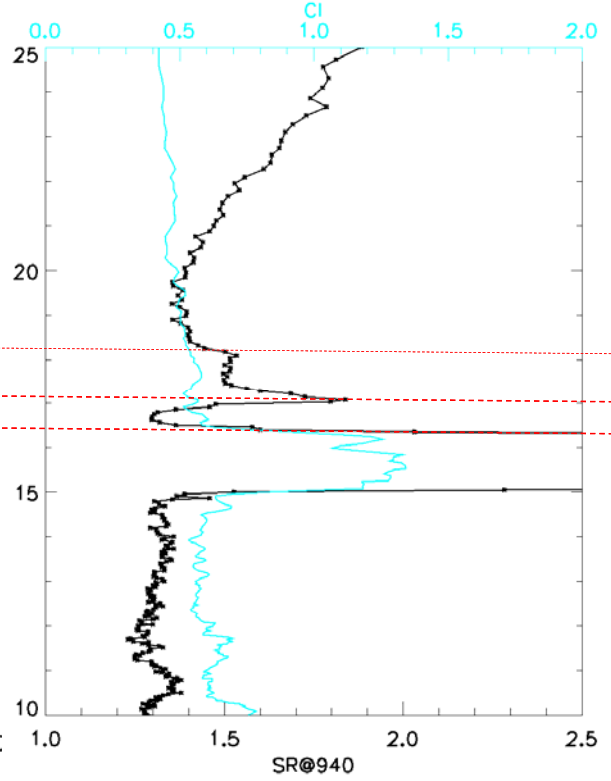
Thuwal, Saudi Arabia (22.3N, 39.1E)

Large balloon flight /Hyderabad/08-13-15

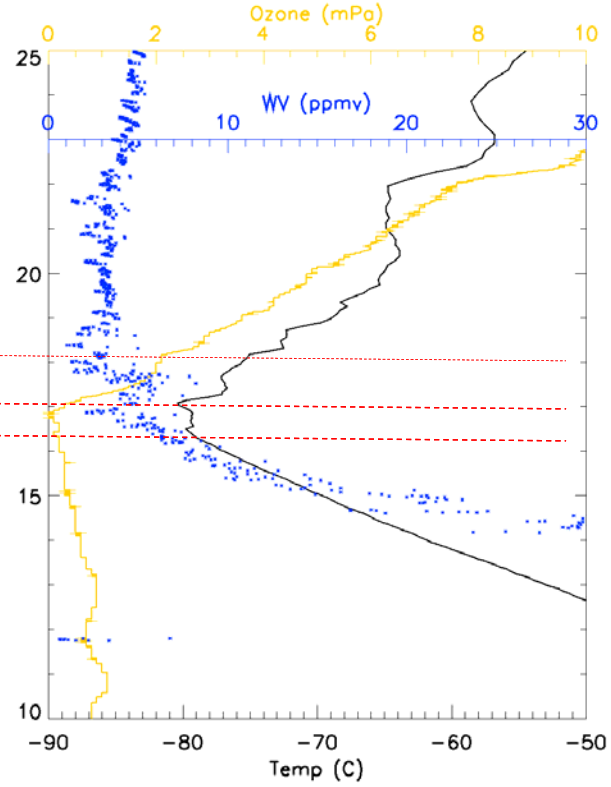
OPC



COBALD



Temp/ozone/WV

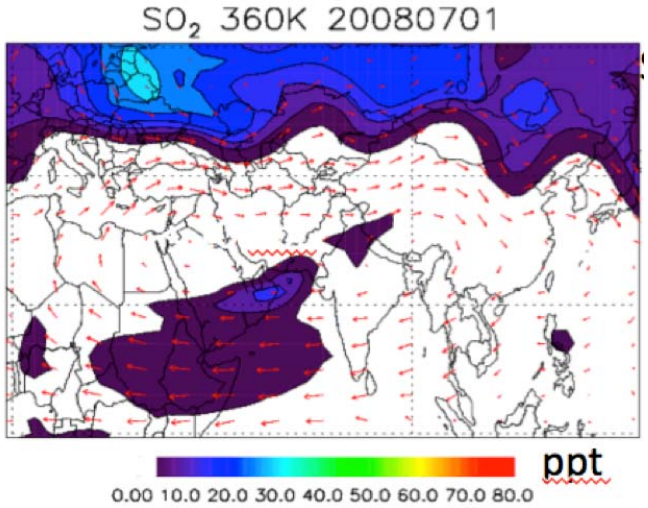


- Sharp increase of aerosol concentration (r>0.075 micron) near 16.5-18.5 km
- 90% of volatile aerosol
- Coincident increase in Scattering Ratio / Low Color Index (small particles)
- Sharp peak at the Cold Point Tropopause
- Increase in Water Vapor in the same region (Convective moisture)
- Minimum of ozone

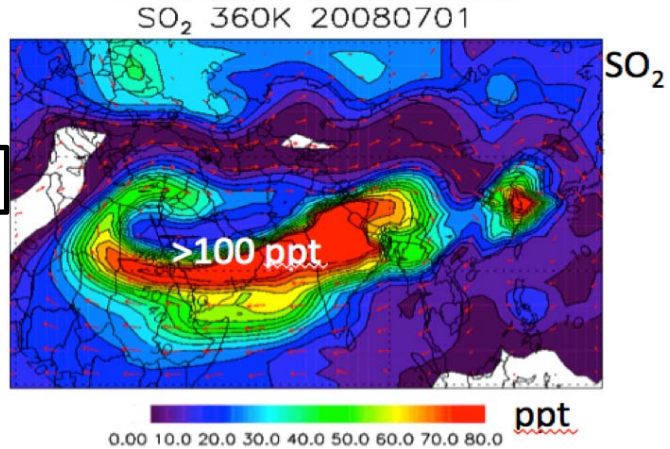
Improving representation of UT aerosol and their precursors in GEOS-Chem global CTM

NewSO2: *Change to wet scavenging of SO_2 - fraction of SO_2 dissolved in cloud liquid controlled by Effective Henry's Law constant*

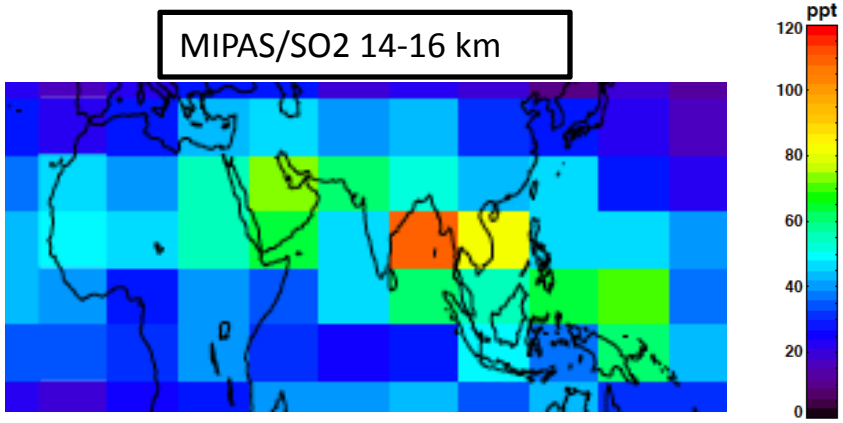
Old scheme



New scheme



MIPAS/SO2 14-16 km

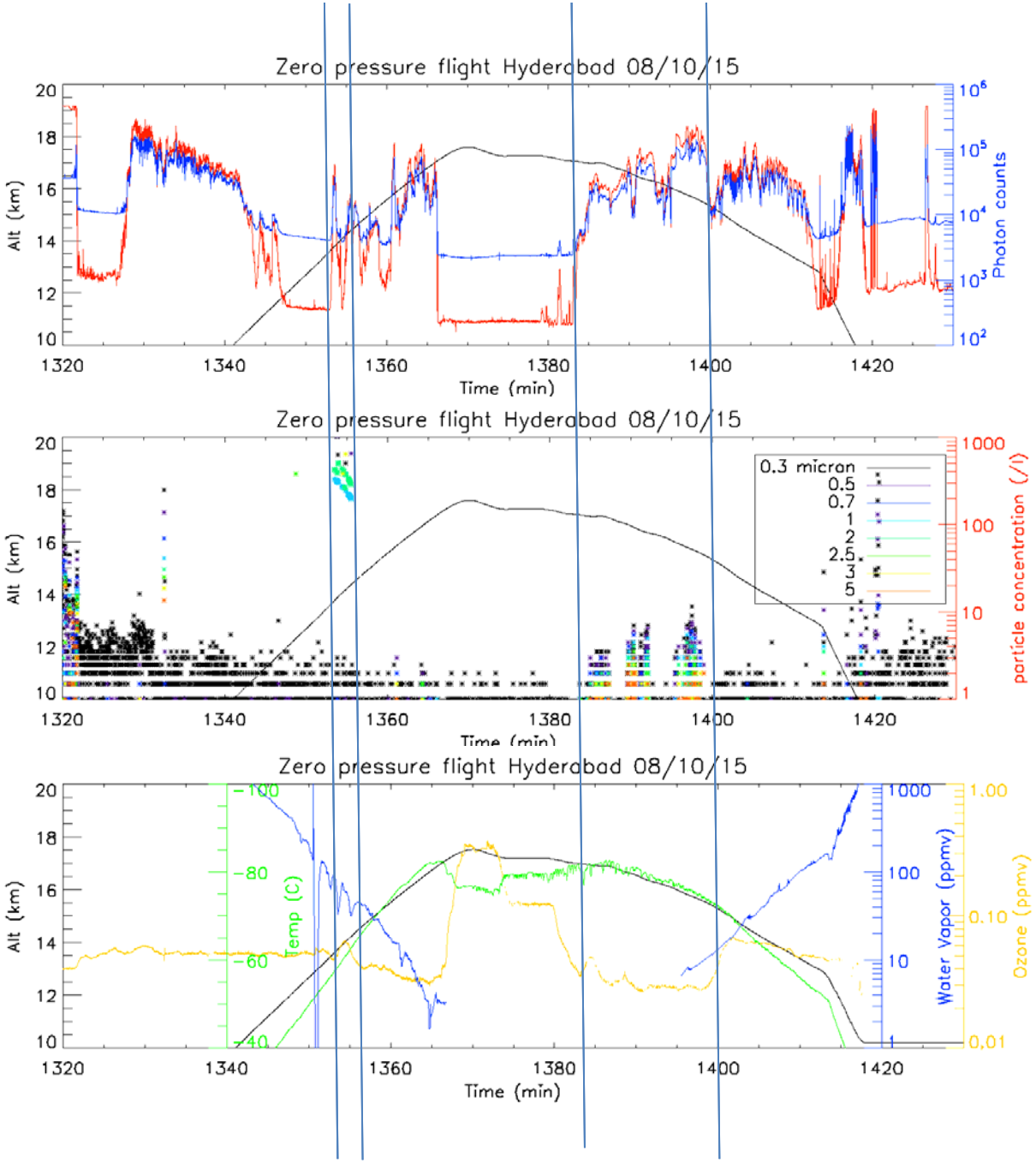


- MIPAS shows SO_2 of 50-100 ppt at 14-16 km in seasonal mean maps (2002-2012), filtered for volcanic episodes. from M. Hoepfner et al., MIPAS SO2 in the UTLS, ACPD, 2015.
- SO2 in new scheme, allowed to survive convective storm and be converted into aerosol in the Upper Troposphere (consistent with 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



ZF1
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