Constructing the 3D distribution of the global aerosol: *Moving things forward*

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and

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UPMC, Jussieu, 12 Sept 2011

It is well known that aerosol retrievals from backscatter lidar are underdetermined:

- **One measurement, two unknowns**
- **An a priori constraint is required, usually the 'lidar ratio'**

$$P(r) = \frac{C}{r^2}\left[\beta_m(r) + \beta_p(r)\right]\exp\left\{-2\int_0^r\left[\sigma_m(r') + \sigma_p(r')\right]dr'\right\}$$

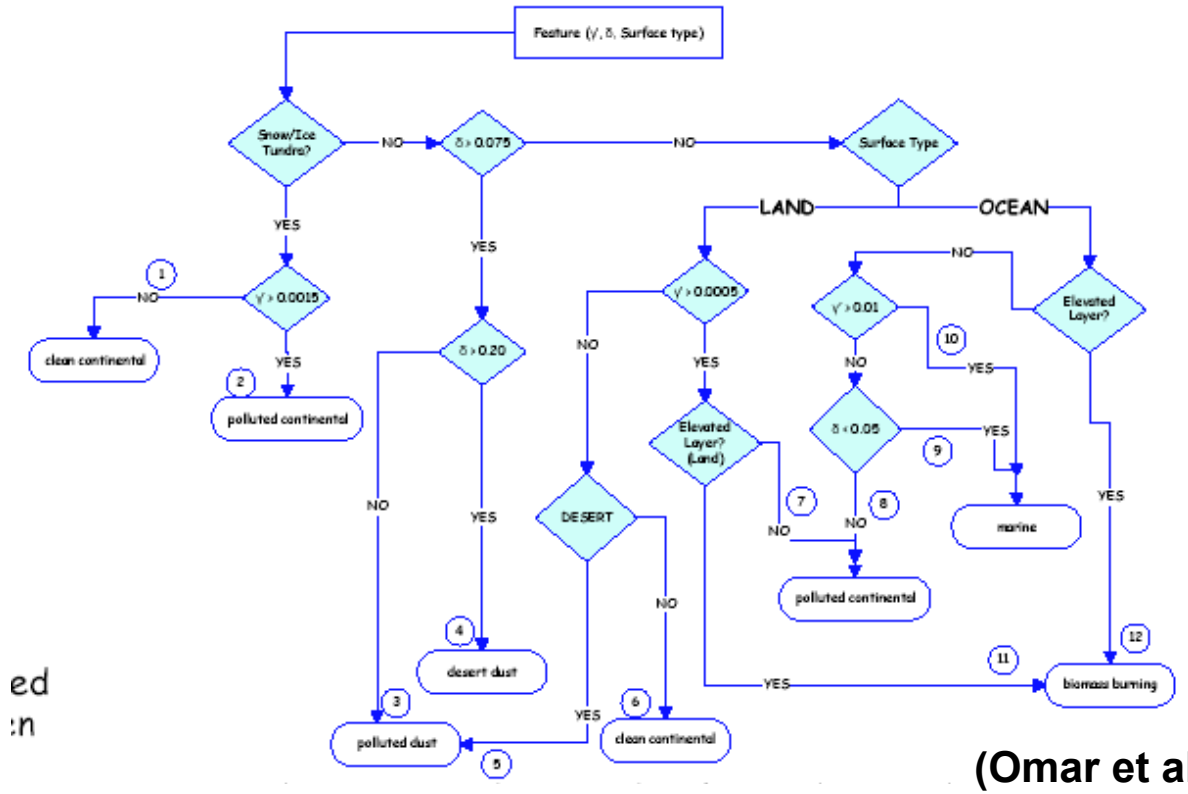
Particulate Backscatter

Particulate Extinction

$$\frac{\sigma_P(r)}{\beta_p(r)} = S_p$$ ← *a priori* value for ratio of extinction and backscatter (S_p) allows aerosol retrieval

CALIOP retrieval approach

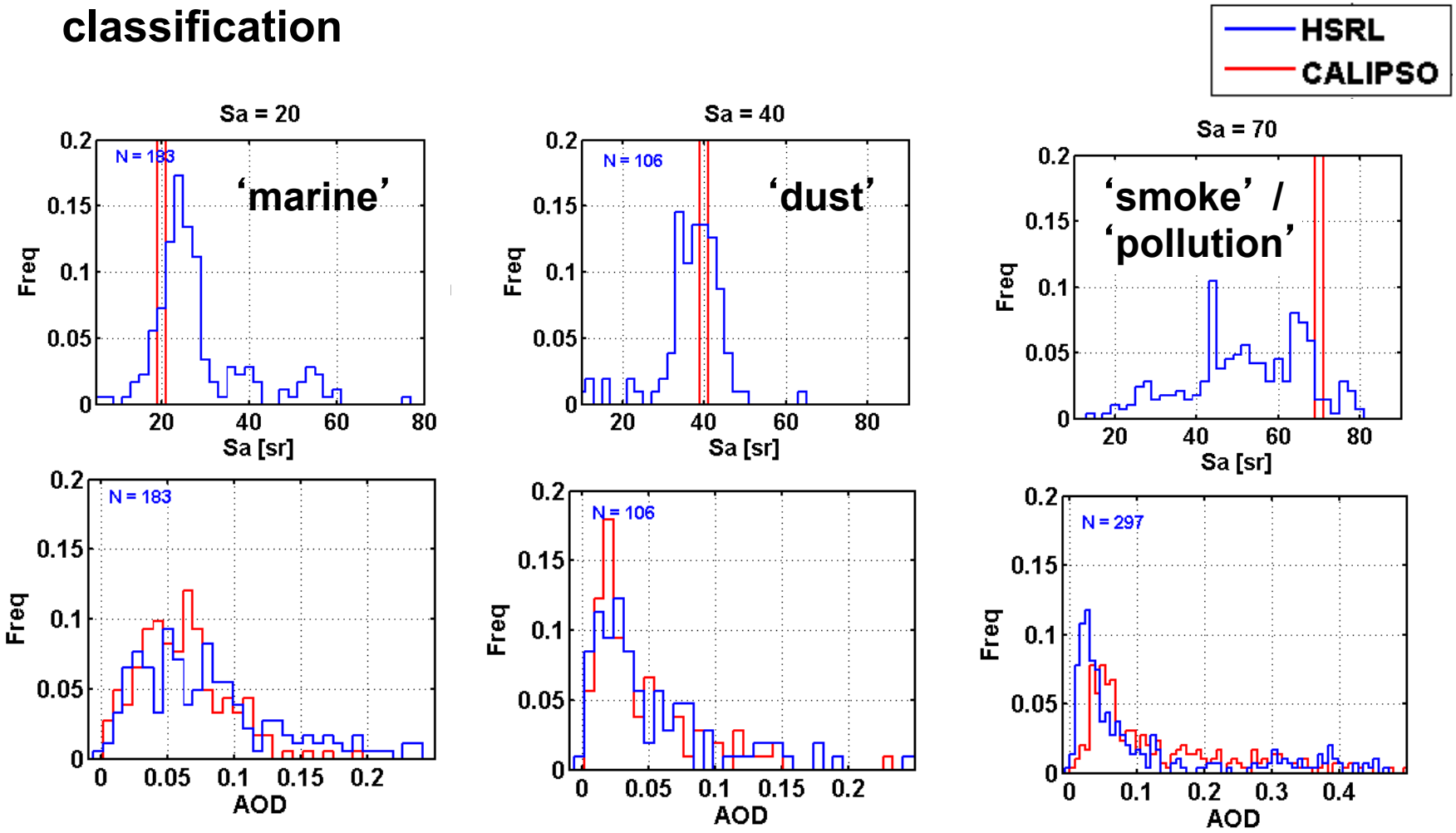
- **Detect aerosol layers**
- **Estimate lidar ratio based on a set of aerosol models relating S_a to measured lidar signals**
- **Limited to detected aerosol layers**
  - **layer-integration required for sufficient SNR**



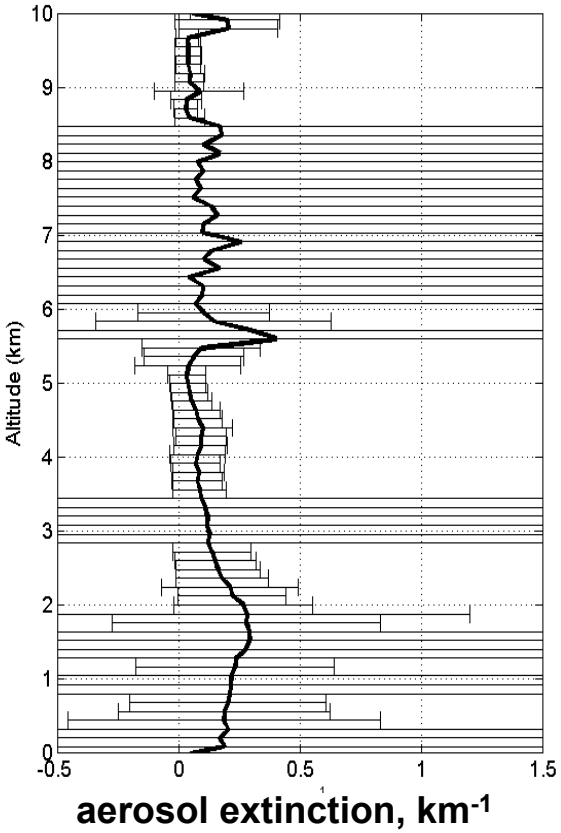
(Omar et al., JTech, 2009)

This approach works, to some extent

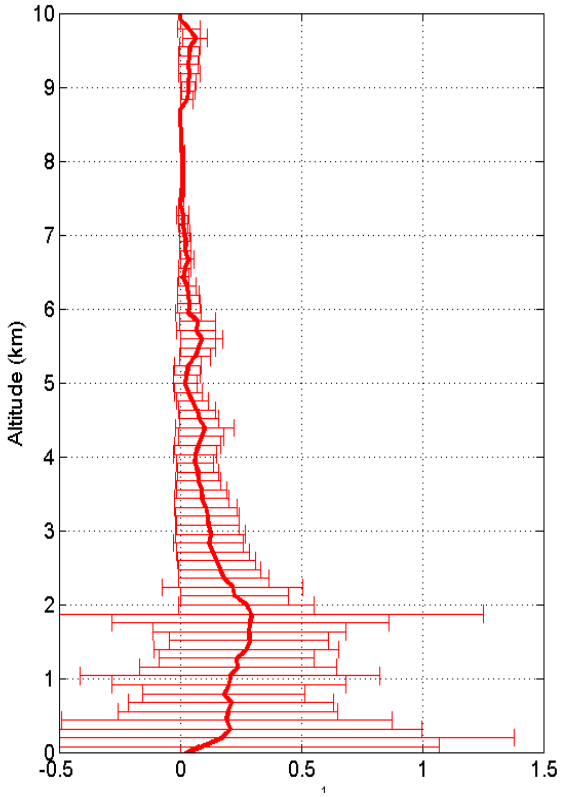
- S_a measured by Langley HSRL
  - > 100 flights over USA, Canada, Caribbean
- HSRL observations partitioned by CALIOP aerosol type classification



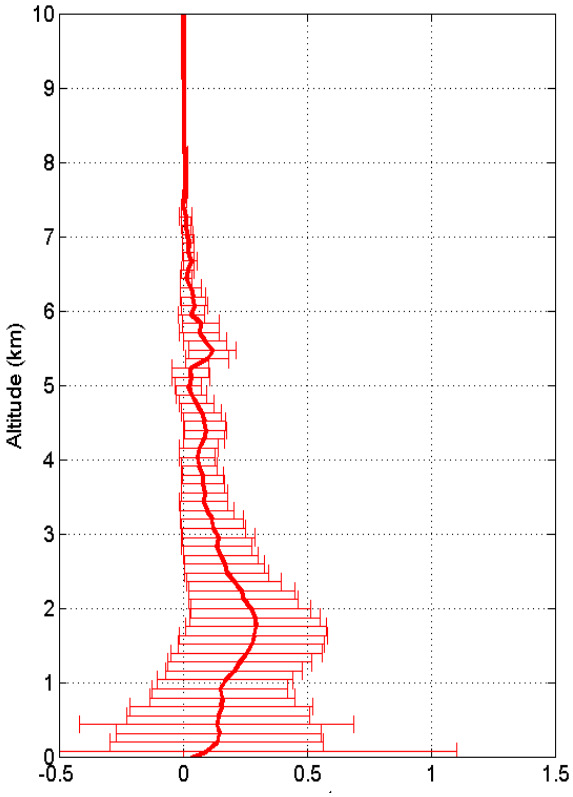
Screening for Level 3
(35N-40N, 75W-80W)



all-sky
no screening



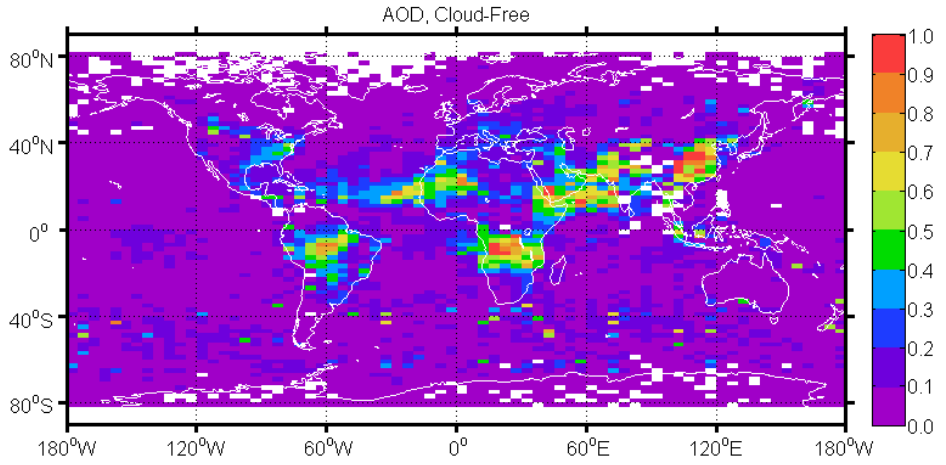
clear-sky
no screening



clear-sky
Screened for:
CAD artifacts
bad retrievals

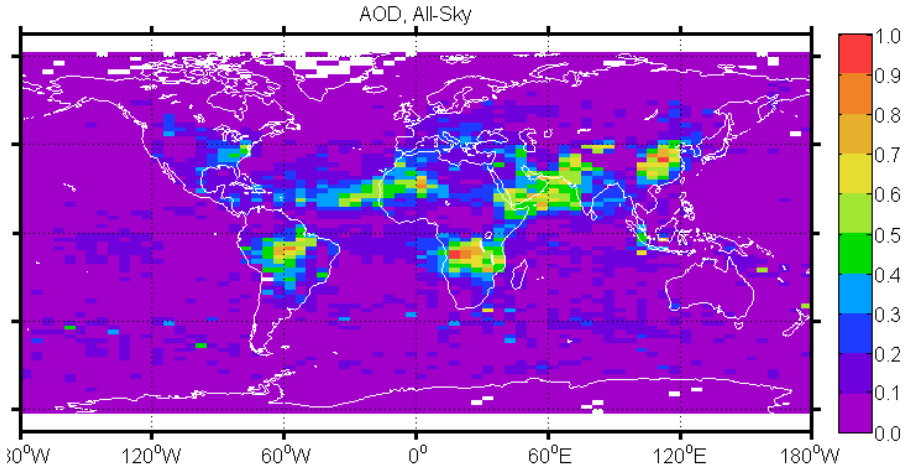
Mean AOD, August 2007, day + night.

Cloud-Free



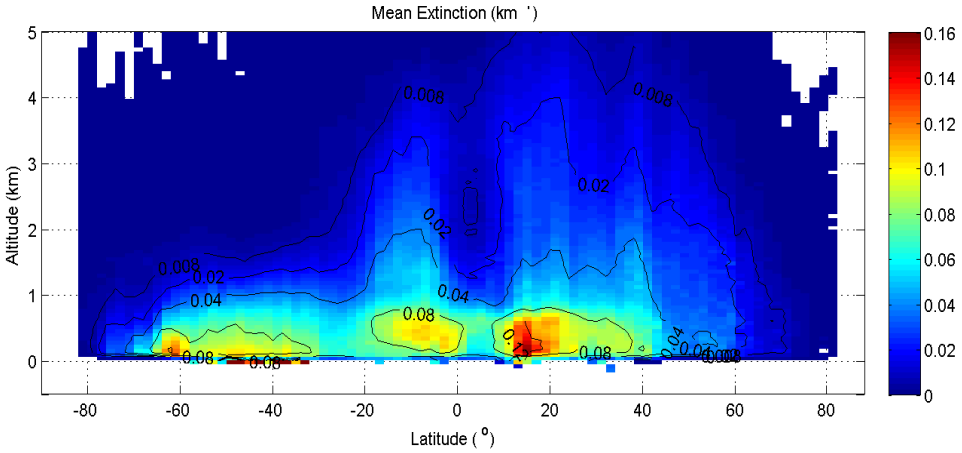
Global mean: 0.092

All-Sky

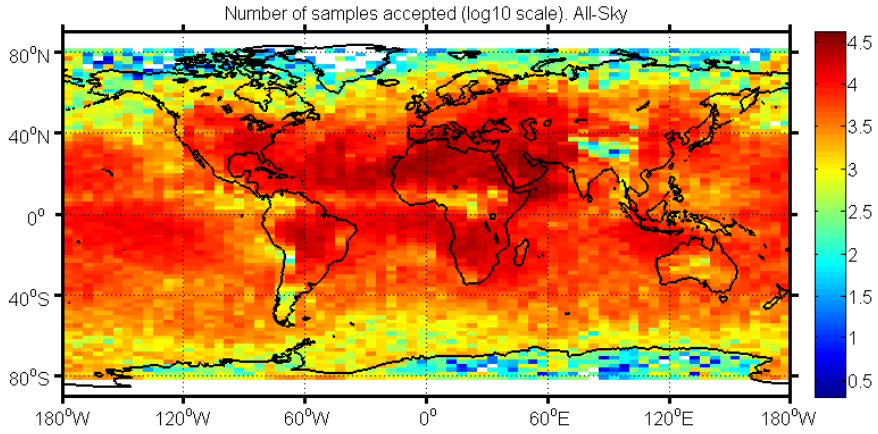


Global mean: 0.086

zonal mean clear-sky extinction:

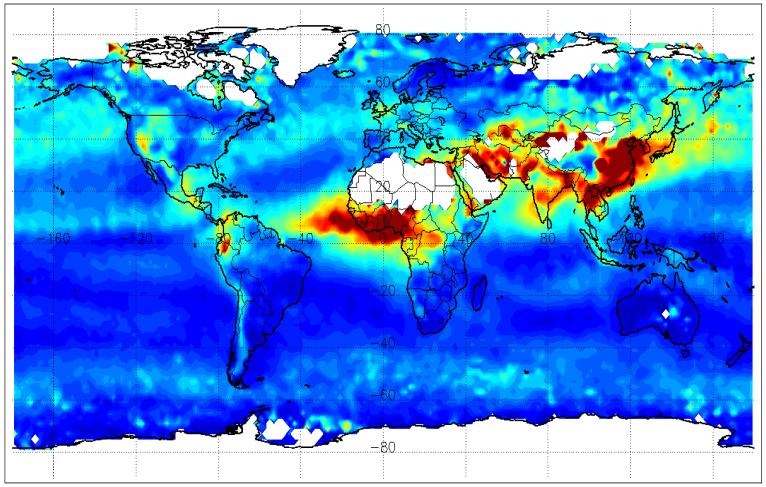


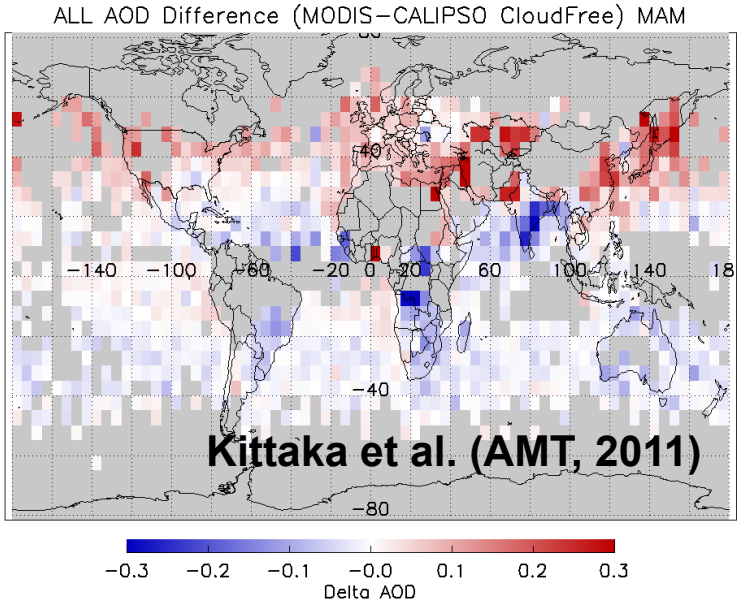
samples (log10):



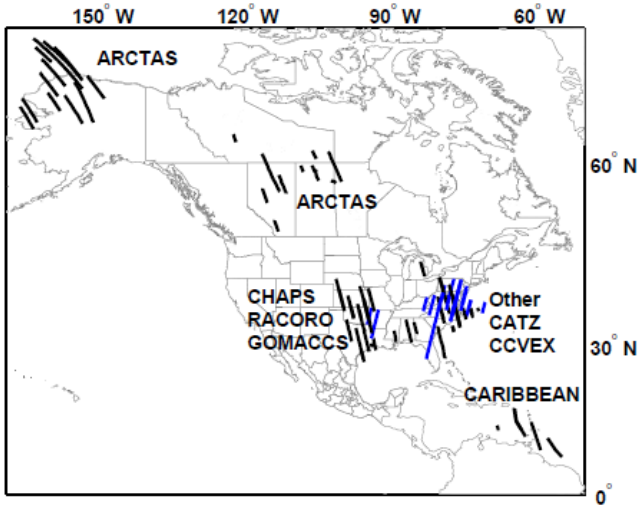
Now, how to validate Level 3?

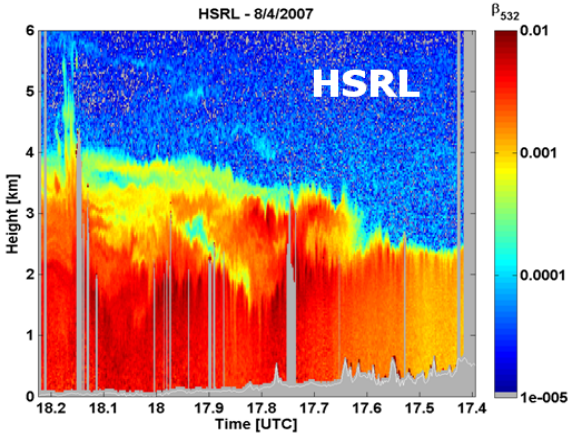
from MODIS



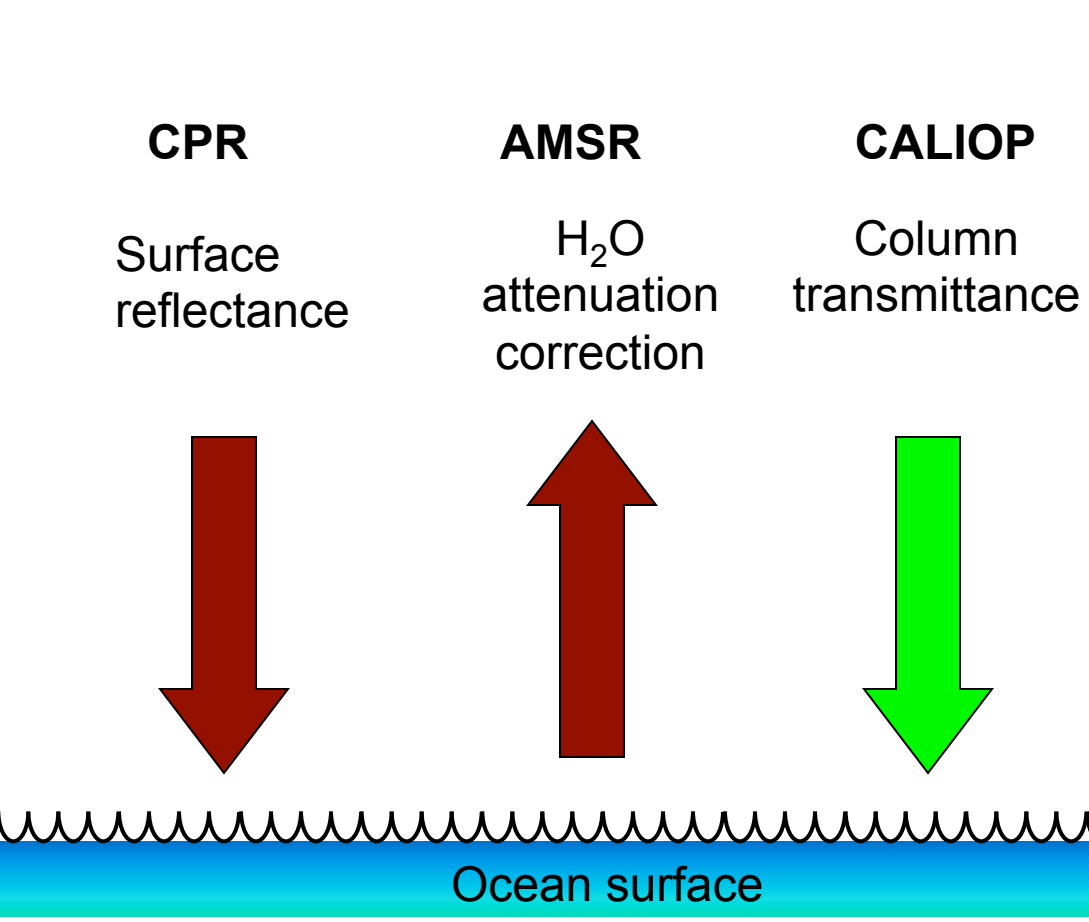


from HSRL:





‘soda’ retrieval: column AOD from lidar surface return
(no microphysical assumptions)



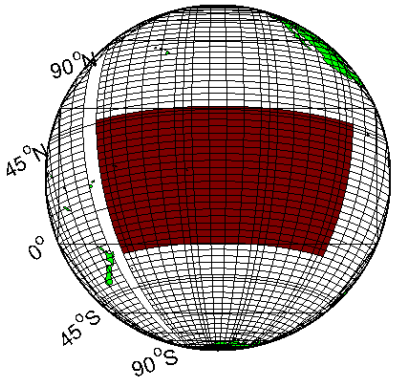
1. Ocean surface reflectance derived from CloudSat CPR
2. Use AMSR-E to correct radar water vapor attenuation
3. Column atmospheric transmittance from lidar ocean surface return
4. Column AOD then used as constraint on profile retrieval

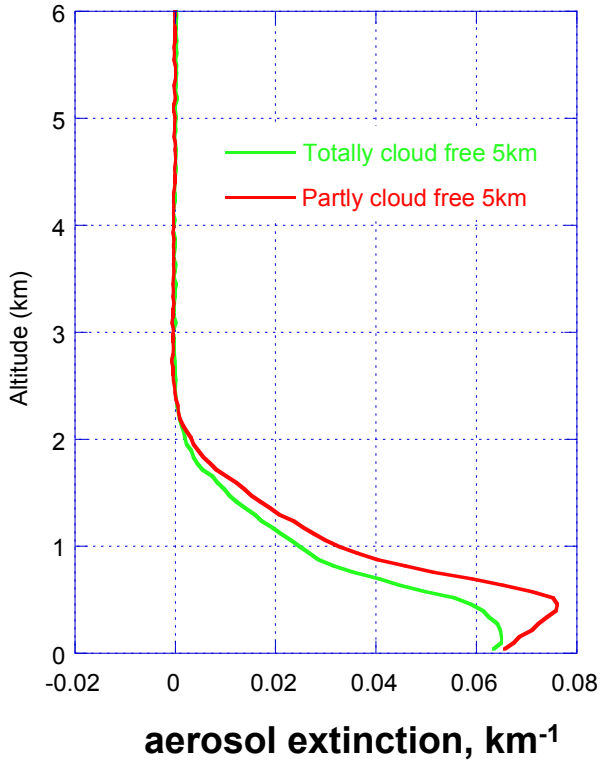
(Josset, Pelon et al, GRL, 2008)

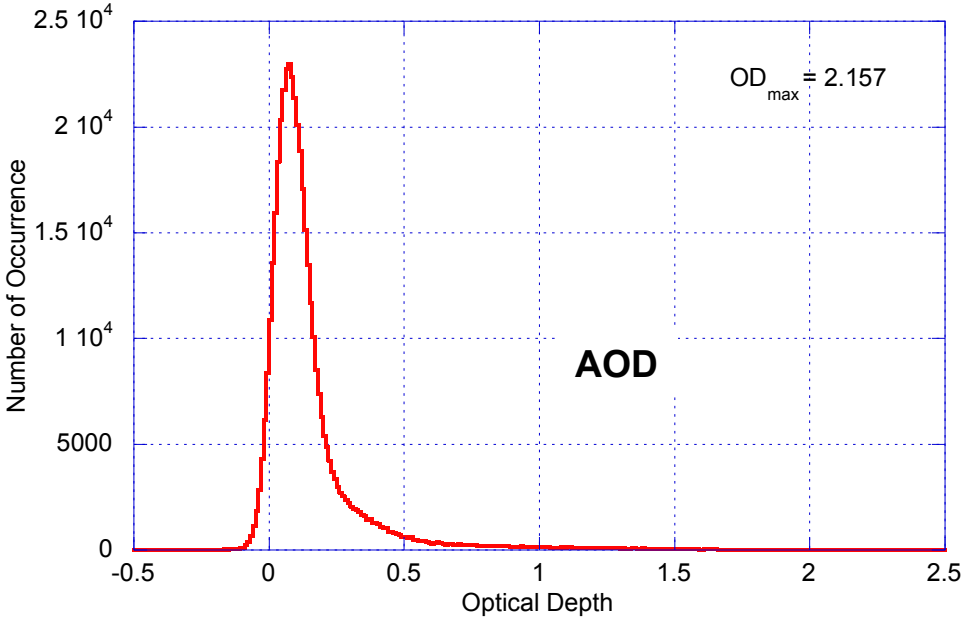
Profile Retrieval Comparison

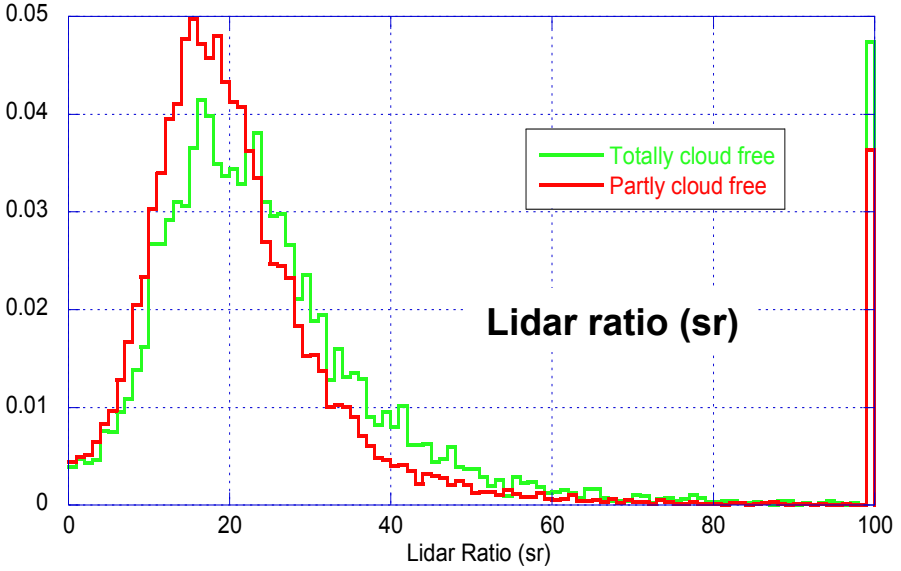
Error sources	Level 2	soda
calibration	√	√
detection sensitivity	√	___
lidar ratio	√	(retrieved)
cloud clearing	√	√
surface reflectance	___	√

Regional monthly distributions: South Pacific







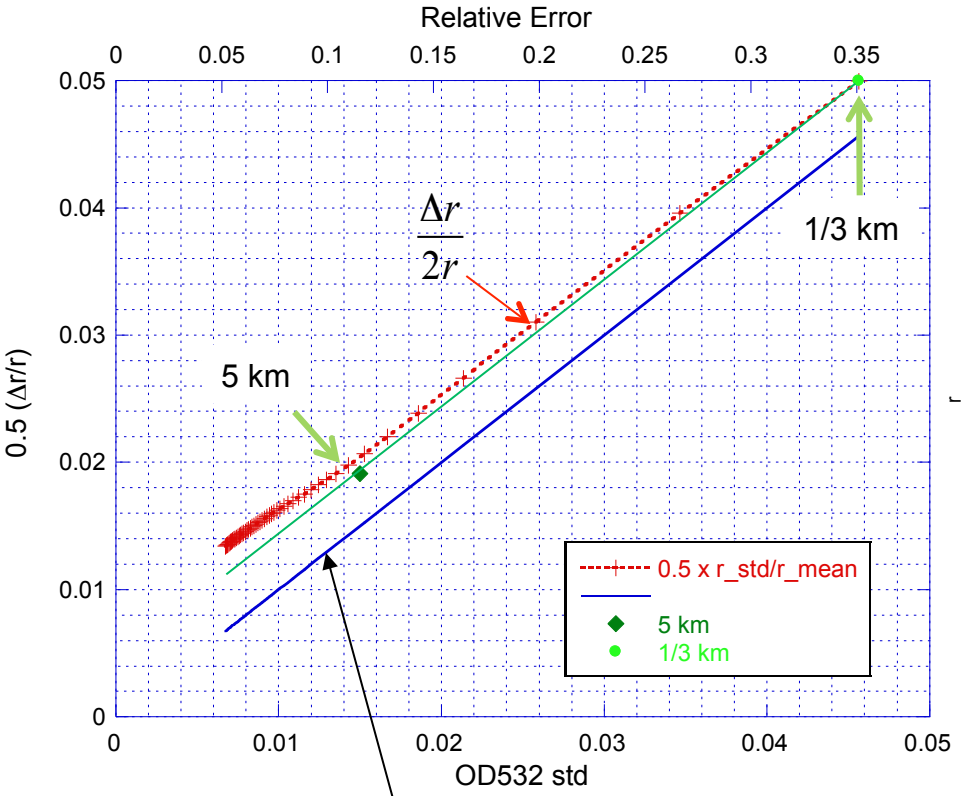


(preliminary) uncertainty analysis

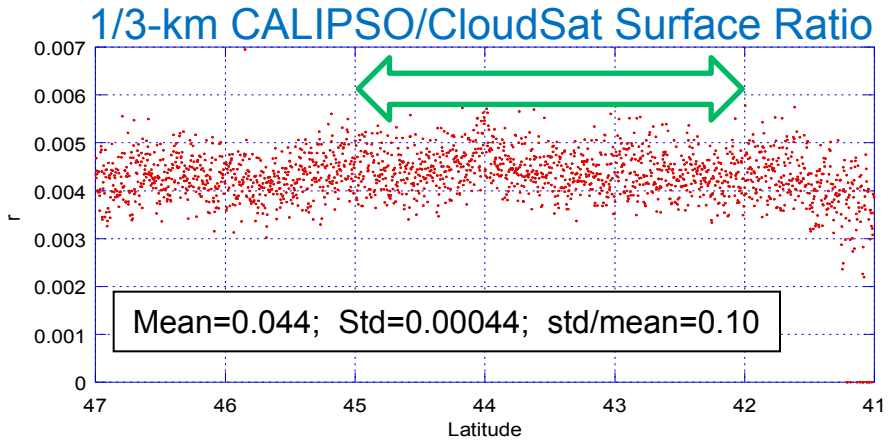
absolute AOD error

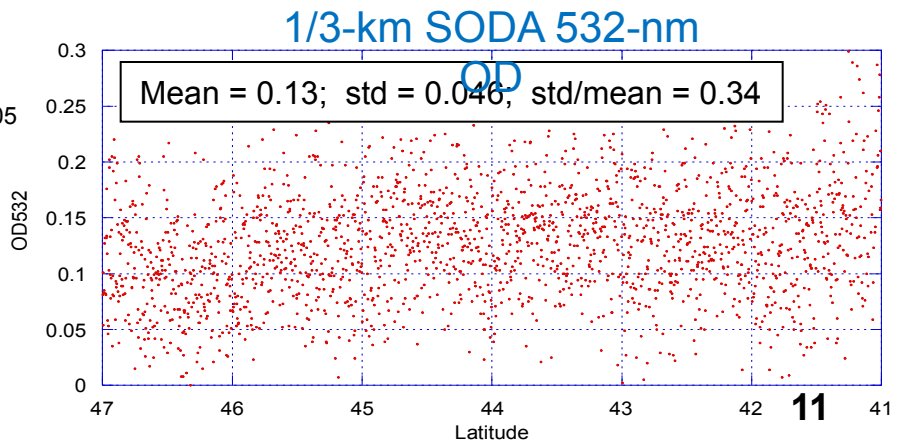
1/3 km: 0.046

5-km avg: 0.015

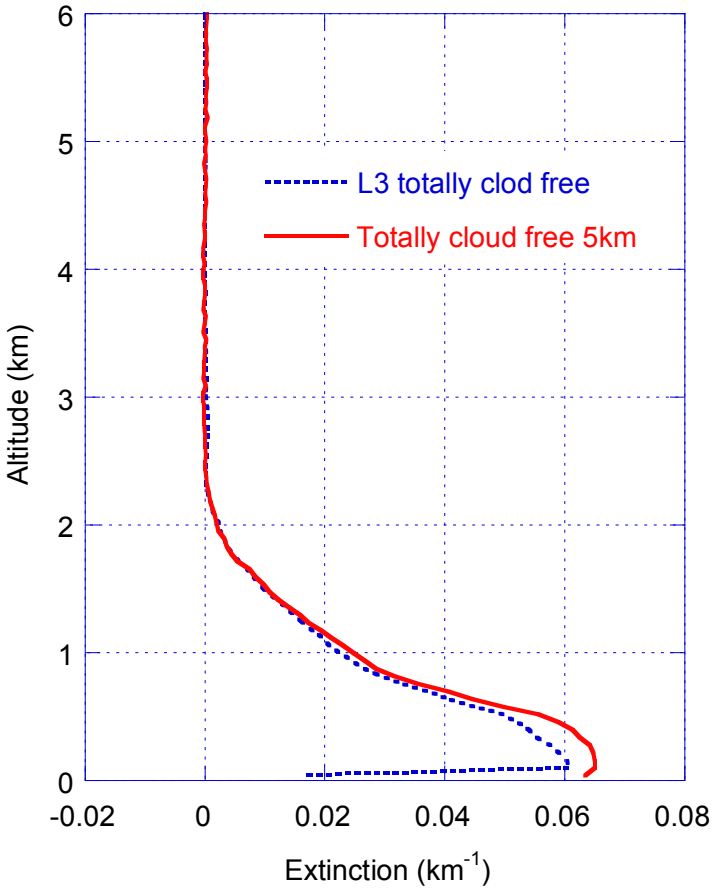


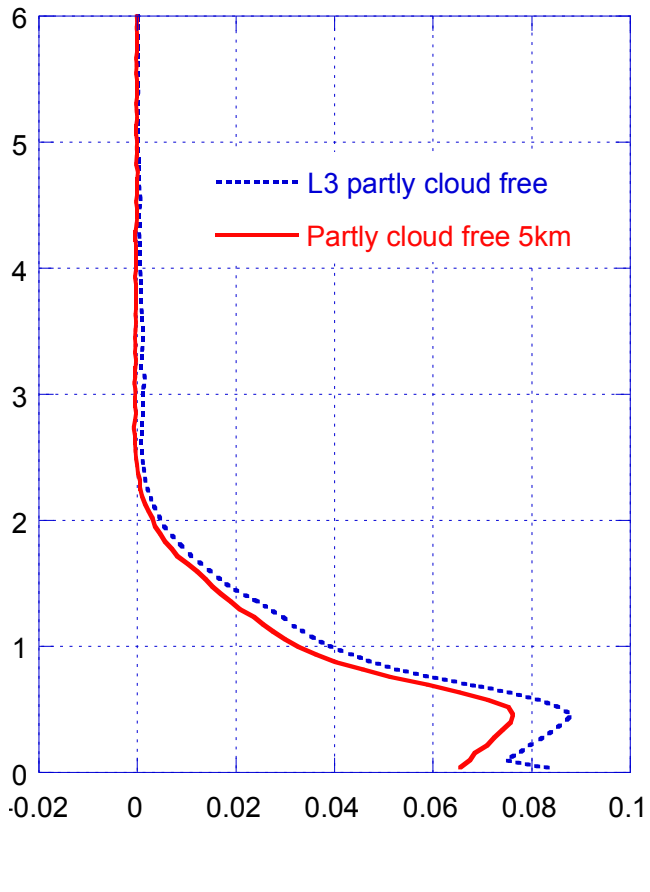
$$\Delta\tau_{p,random} = \frac{\Delta r}{2r}$$

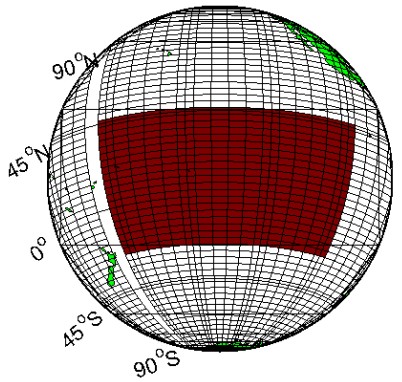




Preliminary extinction comparison: Level 3 vs soda

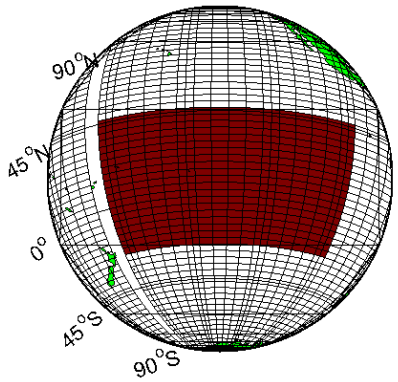




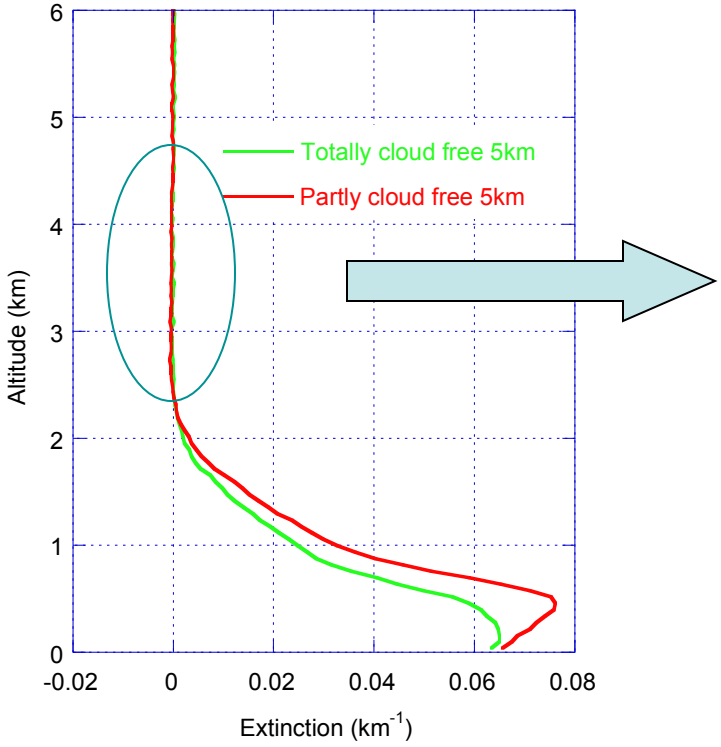


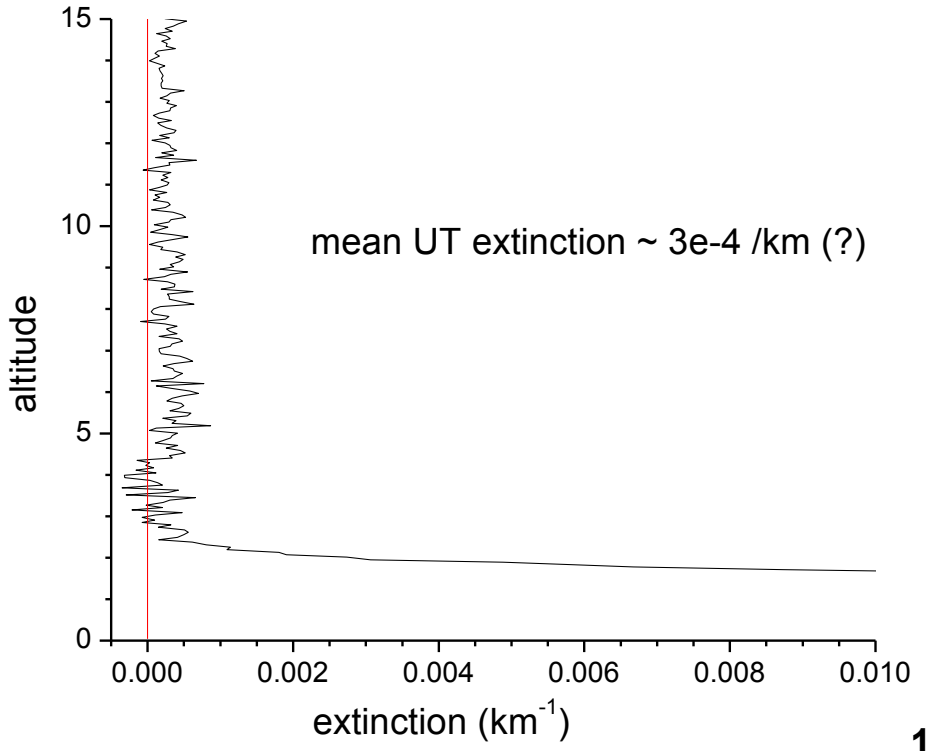
Differences due to:

- **lidar ratios used (derived vs. estimated)**
- **Level 2 detection limits (> 1 k m)**
- **slightly different spatial sampling**
- **slightly different Level 1 calibrations**



Final thought:
We may be able to characterize aerosol in the upper troposphere using soda approach, extinction accuracy limited only by CALIOP calibration





mean UT extinction ~ 3e-4 /km (?)

END