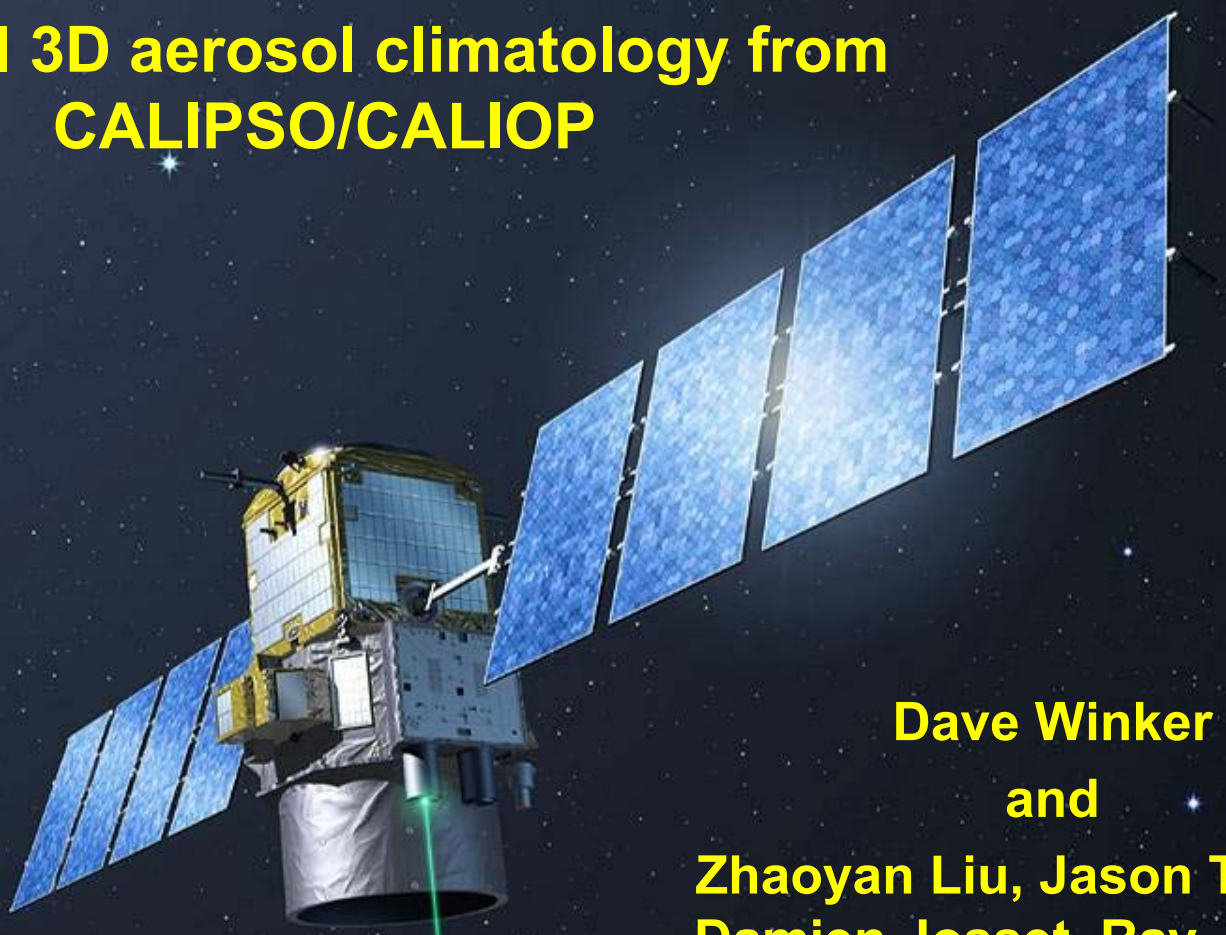
A global 3D aerosol climatology from CALIPSO/CALIOP



Dave Winker
and
Zhaoyan Liu, Jason Tackett,
Damien Josset, Ray Rogers
NASA LaRC

10th Aerocom Workshop, Fukuoka, 3-6 Oct 2011

Status

- **CALIPSO is fine**
  - **Using 2nd laser (of 2) since March 2009**
  - **2nd laser now has as many shots as accumulated on first laser, still healthy and running well**
- **Version 3 products released June 2010**
  - **Better daytime calibration**
  - **Significantly improved aerosol**
    - **Fixed boundary layer cloud-clearing bug**
    - **Better retrievals near surface**
  - **Reprocessed entire dataset (5+ years), ~ 60 TB total**
- **"Level 1.5" product for operational forecast centers**
  - **Near-realtime, cloud-cleared Level 1 profiles**
  - **Product intended for assimilation**
  - **Degraded calibration accuracy due to NRT constraint**
  - **Now being evaluated by ECMWF, NRL, …**
- **Level 3 aerosol profile product now in development**

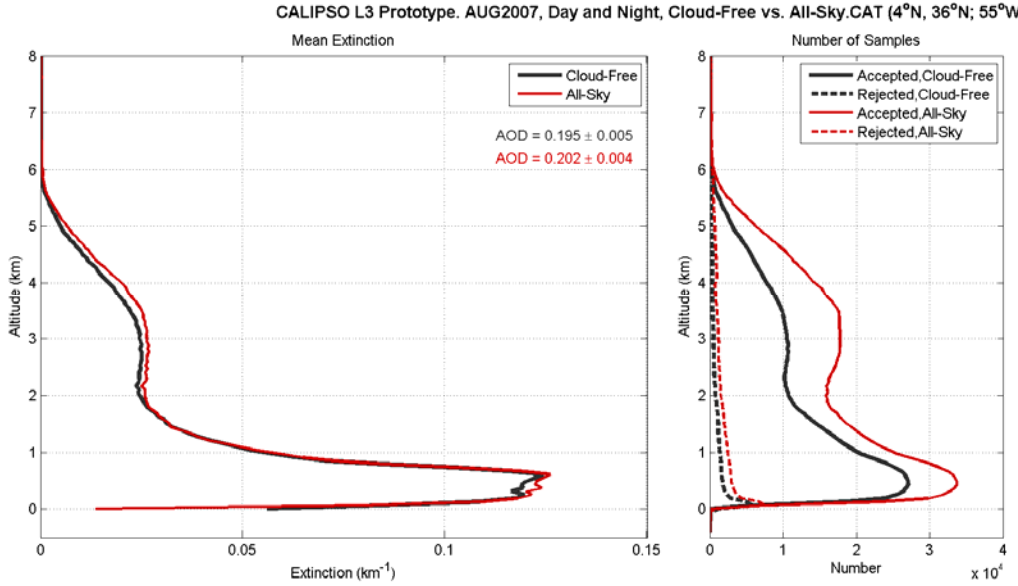
Level 3 Aerosol Product: Basic Contents

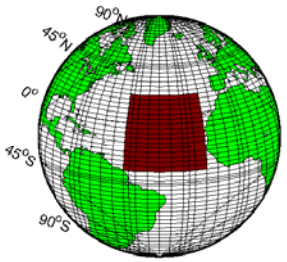
- 532 nm aerosol extinction profiles, from Level 2 profile product
  - Cloudfree (= clear-sky + above-cloud)
  - All-sky
- 532 nm AOD
  - Clear-sky
    - Comparable to MODIS and other sensors
  - All-sky
    - Most comparable to model AOD
  - Above-cloud
  - "Cloudy" (= all-sky – clear-sky)
- Aerosol height metric
  - Options being explored
- Surface height
  - Min, max, median
- Land/water flag

Format

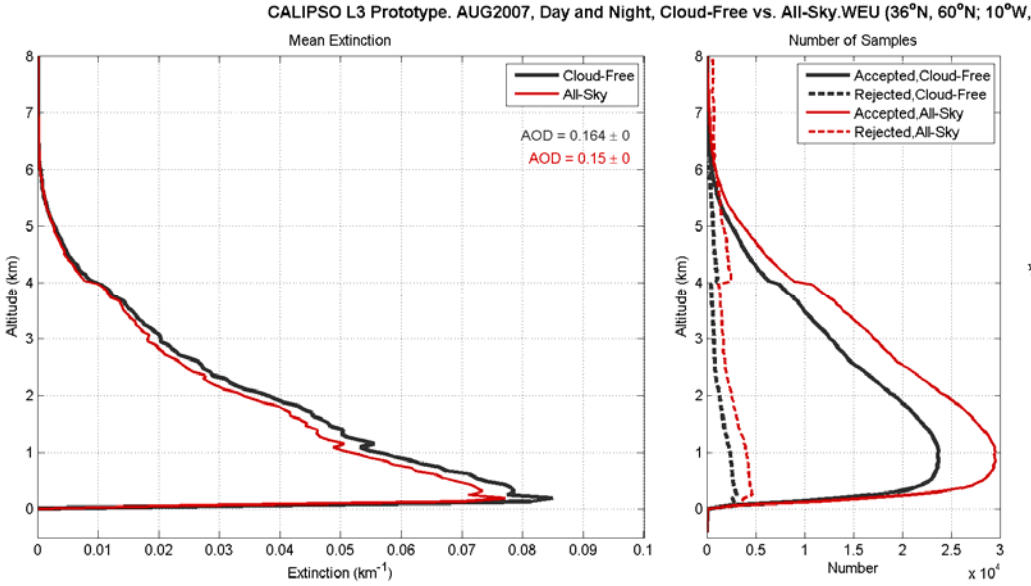
- Monthly gridded extinction profile data
- 60 m vertical resolution, 0-12 km
- Currently: 2x5 degree resolution
  - exploring other options
- Four types of files:
  - Day Cloudfree
  - Day All-sky
  - Night Cloudfree
  - Night All-sky
- Includes sample numbers required for proper time-space averaging
  - Spatial-temporal aggregation will be desirable

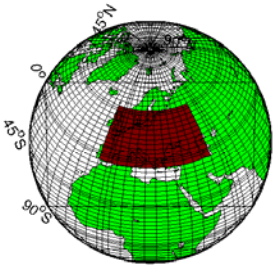
Prototype Level 3 Aerosol Profile Product

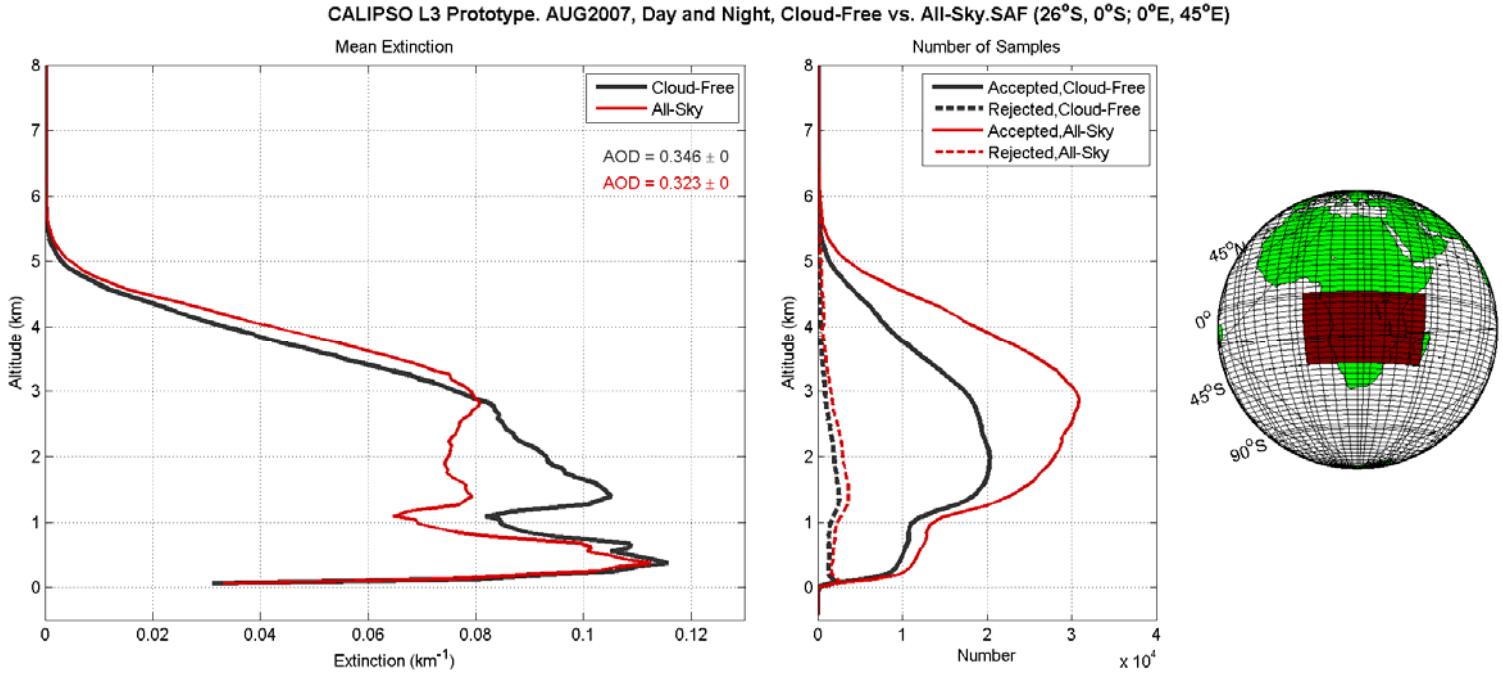




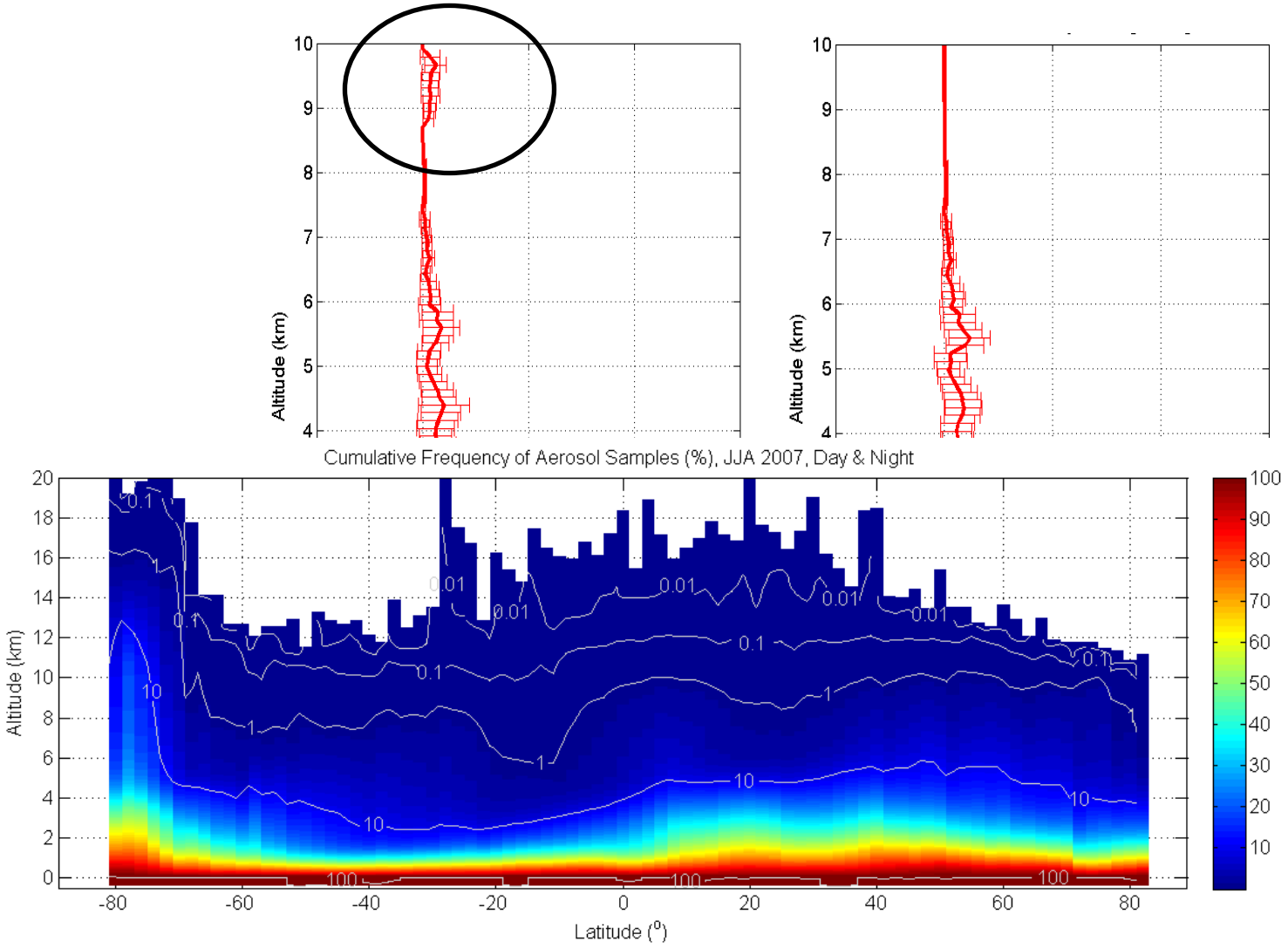
All-sky vs. Clear-sky






CALIPSO L3 Prototype. AUG2007, Day and Night, Cloud-Free vs. All-Sky.SAF (26°S, 0°S; 0°E, 45°E)
Mean Extinction
Cloud-Free
All-Sky
AOD = 0.346 ± 0
AOD = 0.323 ± 0
Altitude (km)
Extinction (km-1)
Number of Samples
Accepted,Cloud-Free
Rejected,Cloud-Free
Accepted,All-Sky
Rejected,All-Sky
Number
x 10^4
45°N
0°
45°S
90°S

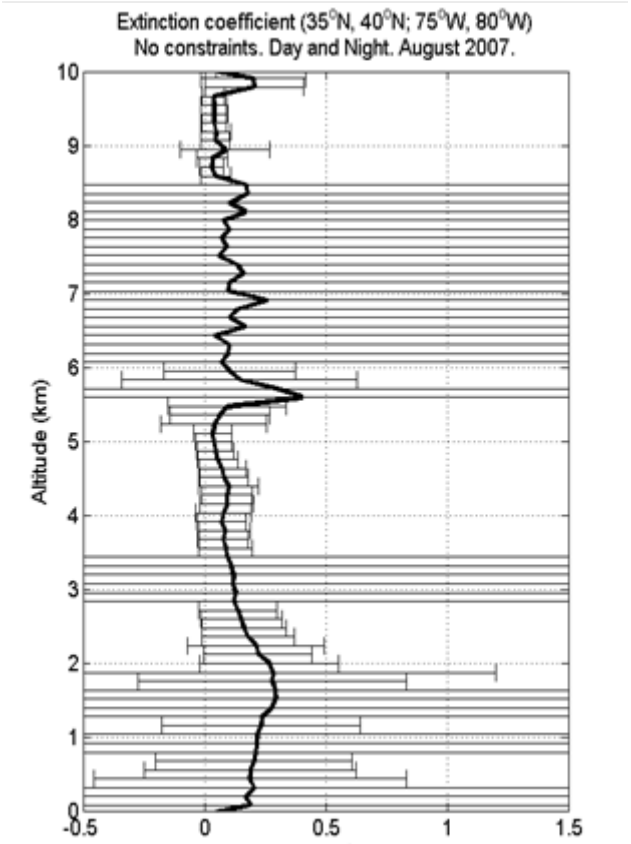
Level 3: Clear-sky Screening
(35N-40N, 75W-80W)



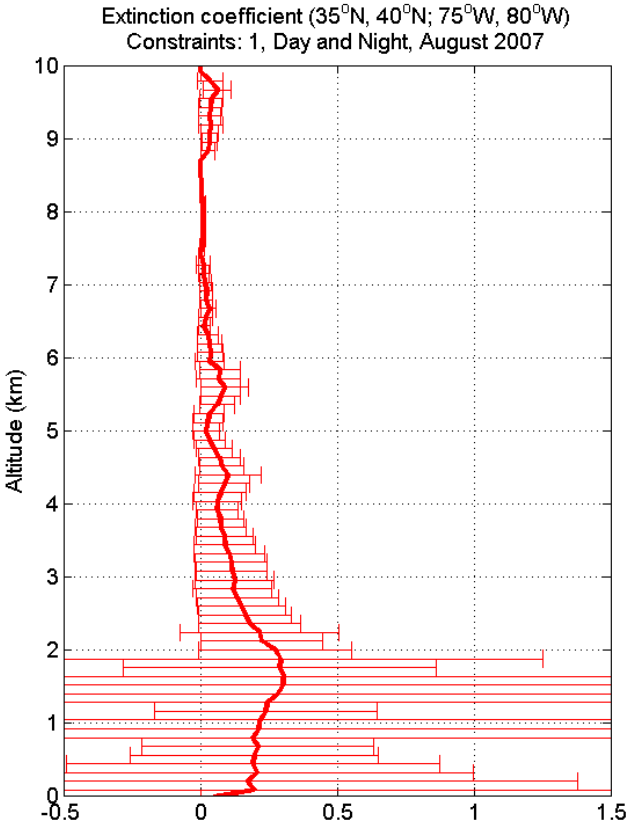
Primary filtering criteria applied

- CAD < -20
- Remove cloud-edge artifacts
- Accept only QC = 0, 1, 18
  - Lidar ratio not adjusted, unless layer is opaque
- Require extinction uncertainty < 99
  - Indicates a failed retrieval
  - Remove profile below any sample with unc = 99
- Several types of artifacts near surface identified, still working to correct or remove them

Higher uncertainties beneath clouds than in clear-sky



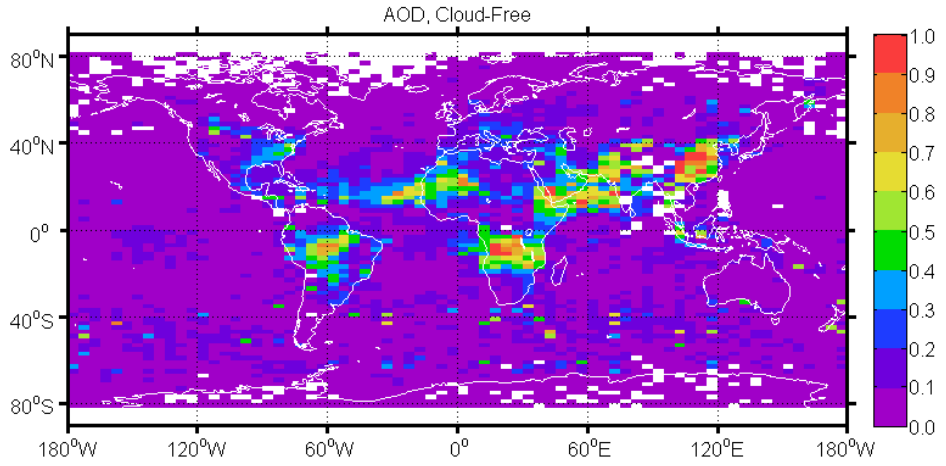
all-sky
no screening



clear-sky
no screening

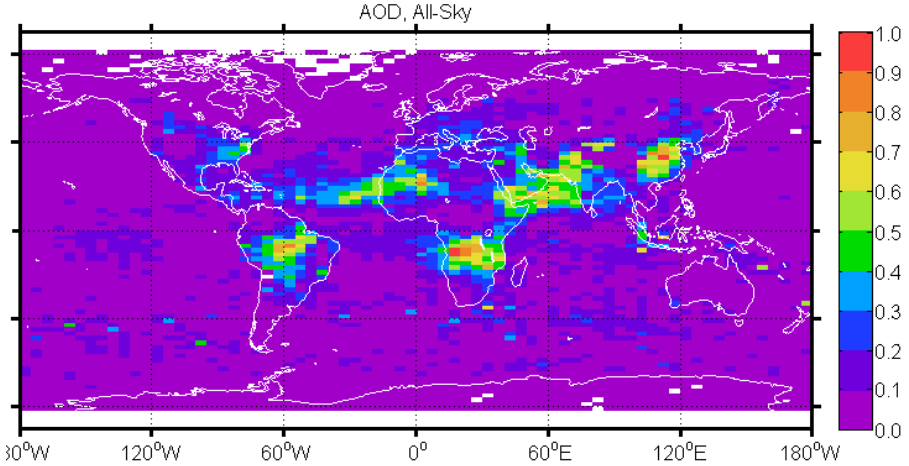
Mean AOD, August 2007, day + night.

Cloud-Free



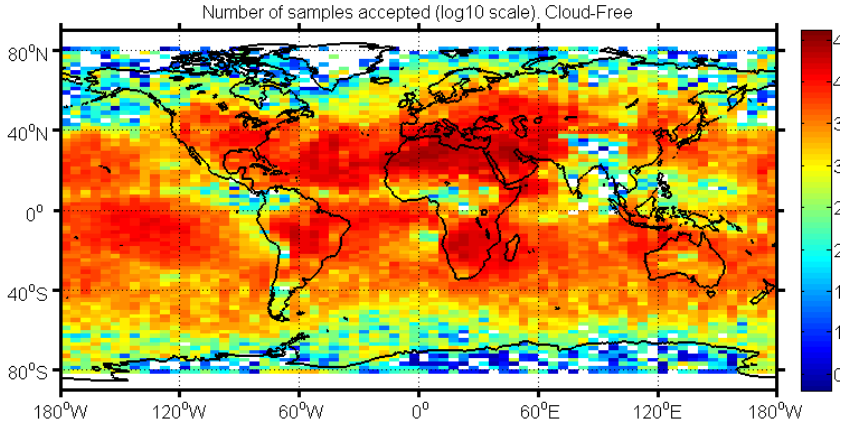
Global mean: 0.092

All-Sky

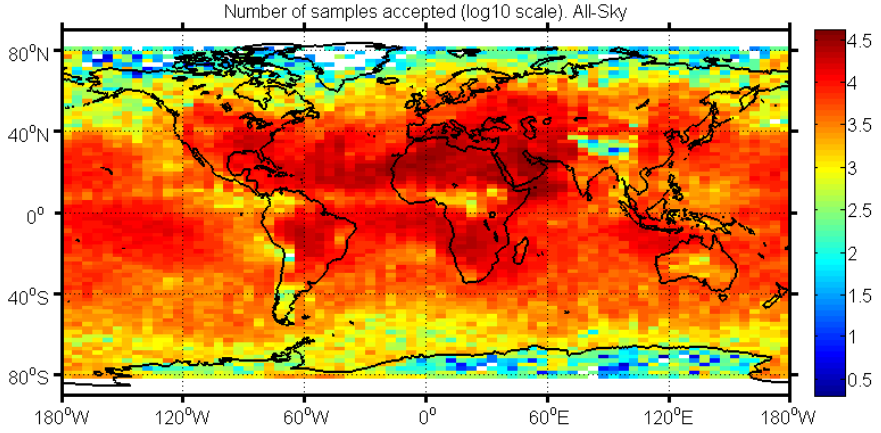


Global mean: 0.086

samples (log10):

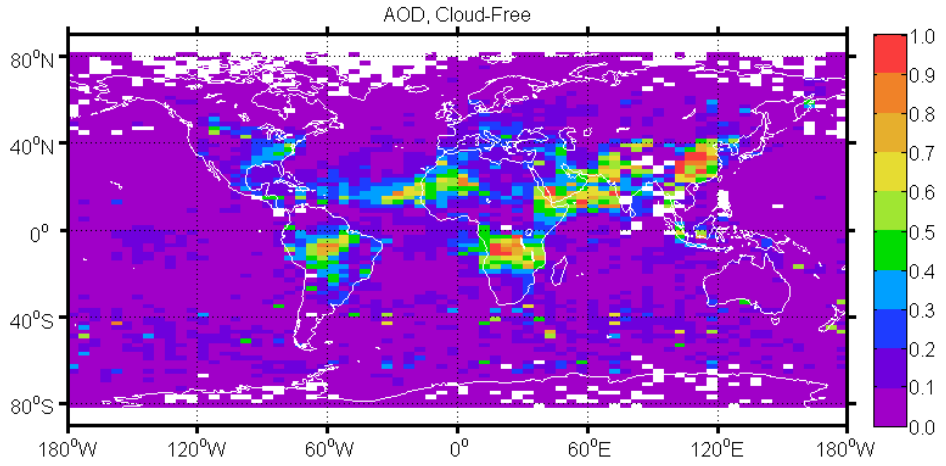


samples (log10):



Mean AOD, August 2007, day + night.

Cloud-Free



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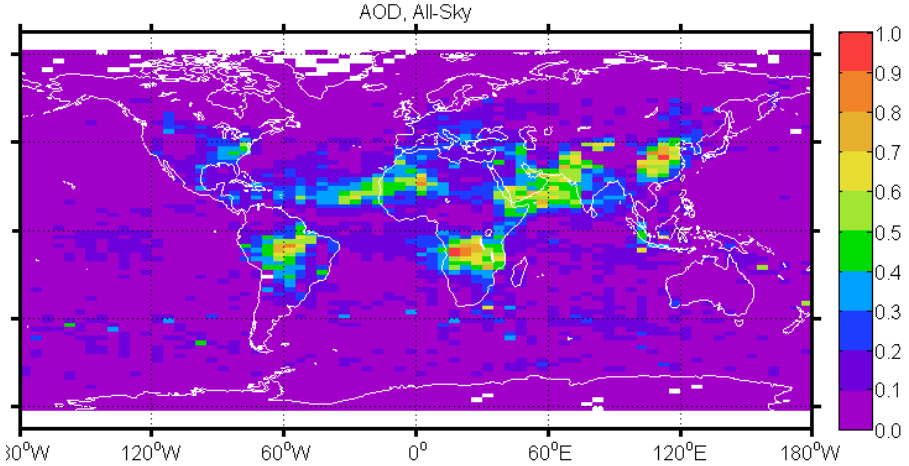

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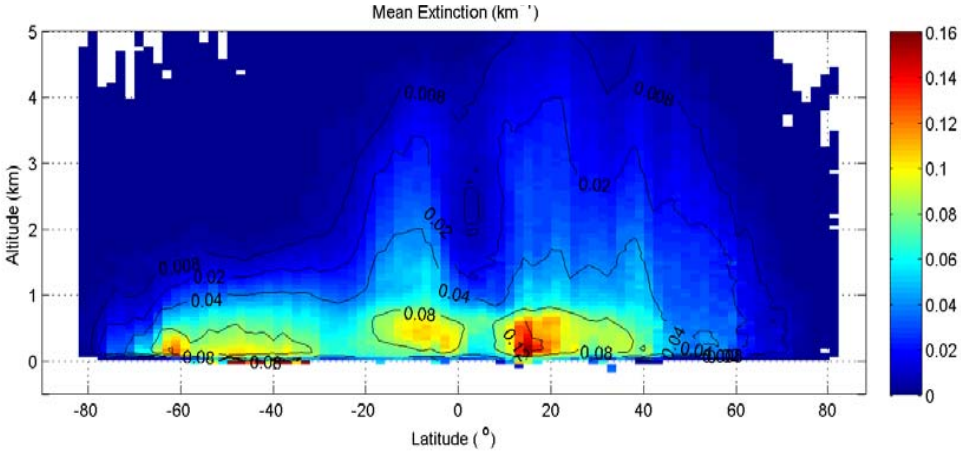
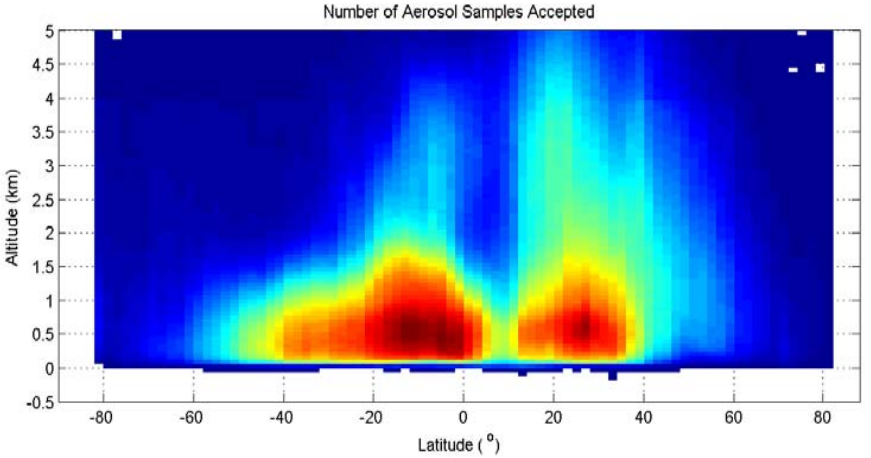
zonal mean clear-sky extinction:



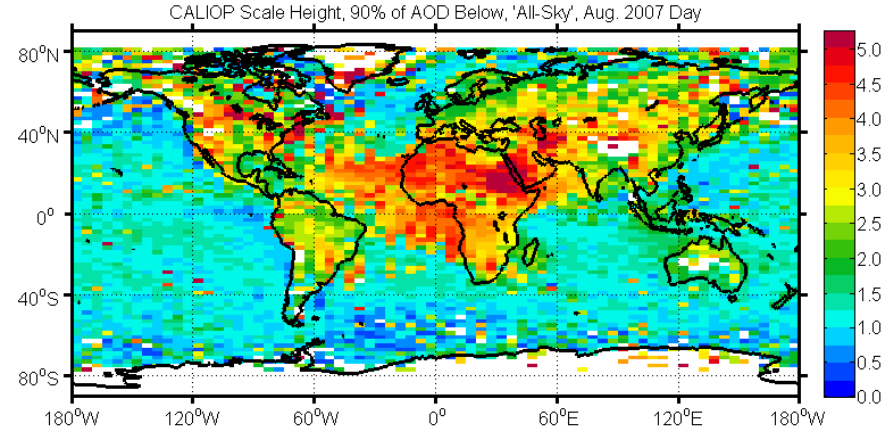
Number clear-sky aerosol samples:



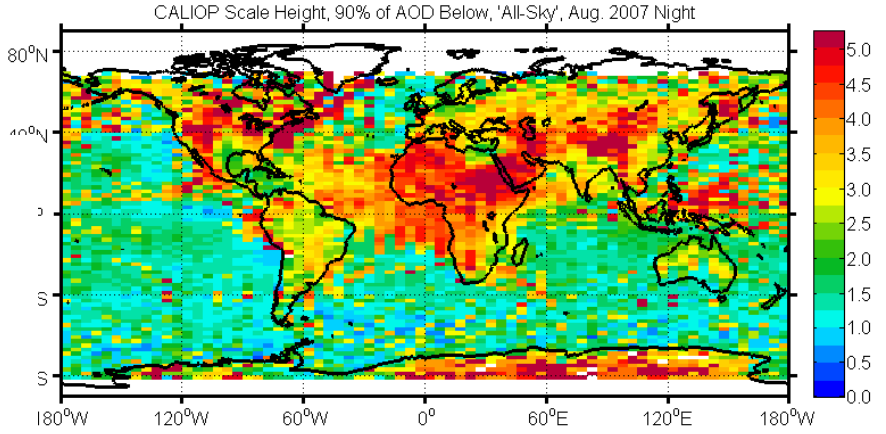
Aerosol height, Aug 2007, All-sky
(x% of AOD below h)

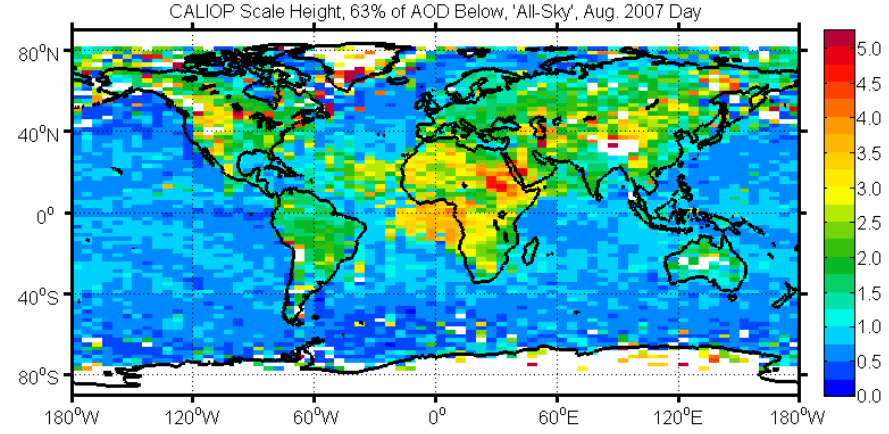
Day

Night

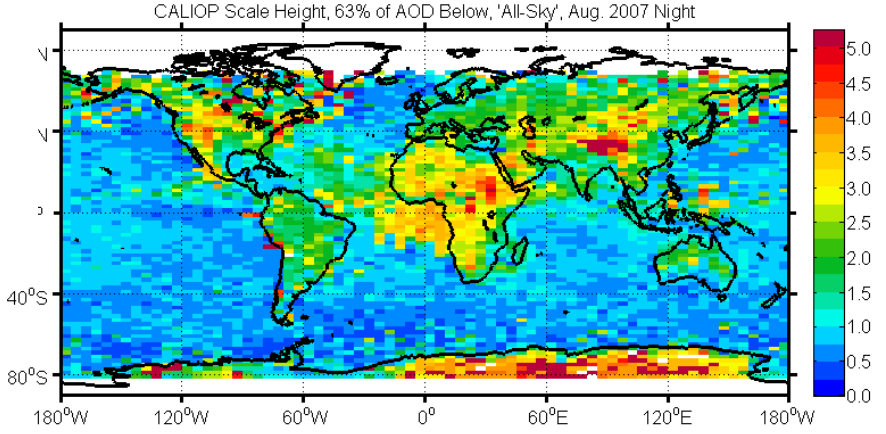


90%



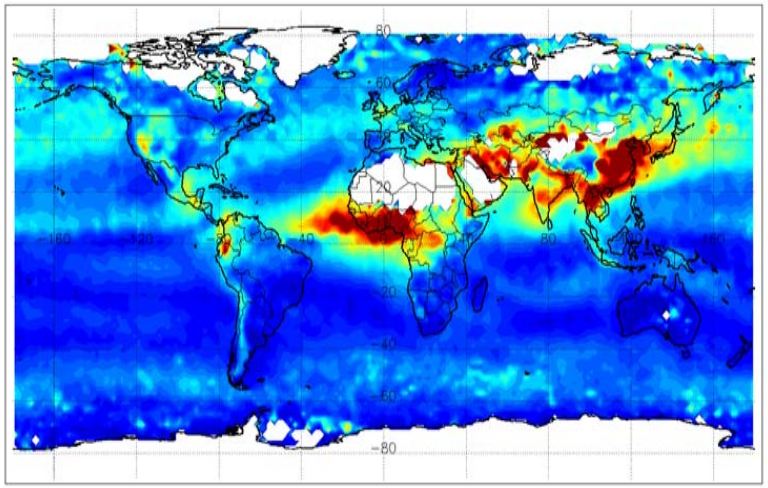


63%



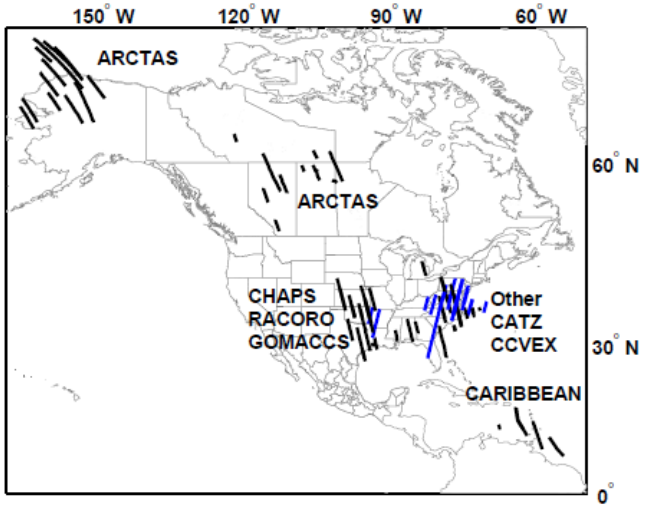
How can we validate Level 3?

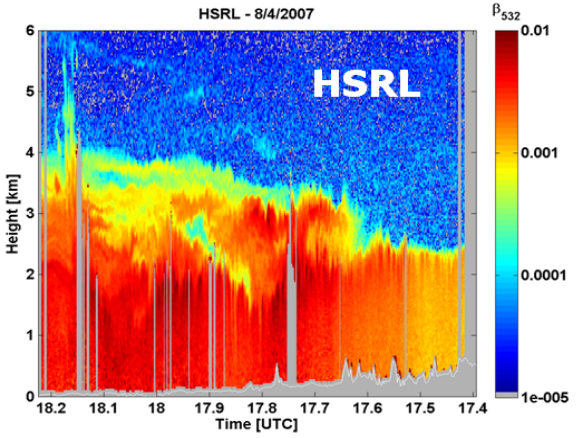
from MODIS



Kittaka et al. (AMT, 2011)

from airborne HSRL:





Two Approaches Being Developed

- **Standard retrieval: retrieve only within detected layers**
- **Alternate #1: Retrieve full column for “highly averaged” profiles**

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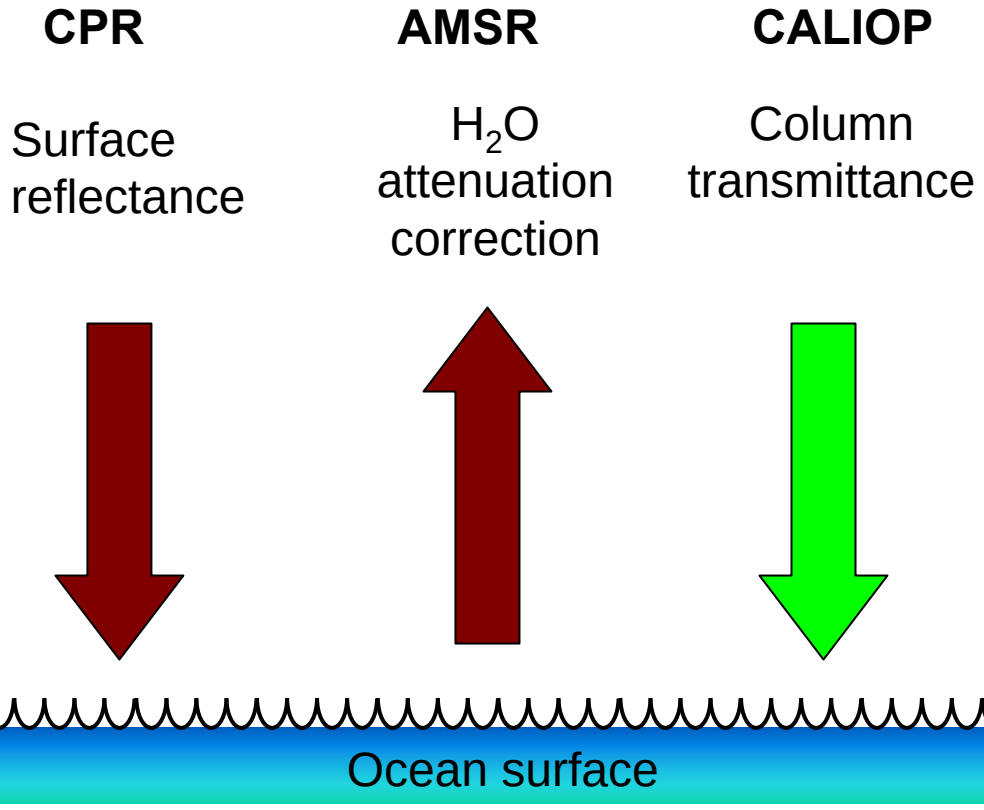
- **Standard retrieval: retrieve only within detected layers**
- **Alternate #1: Retrieve full column for “highly averaged” profiles**
- **Alternate #2: Over ocean, use measured column AOD as a retrieval constraint**

‘soda’ retrieval: column AOD from lidar surface return

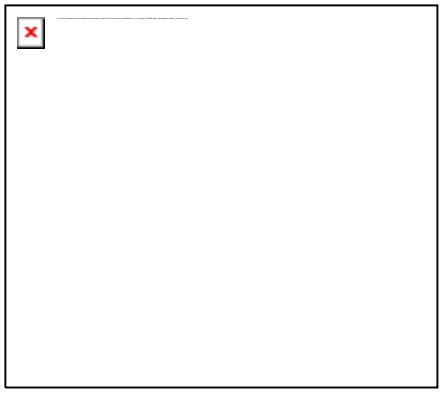
(no microphysical assumptions)

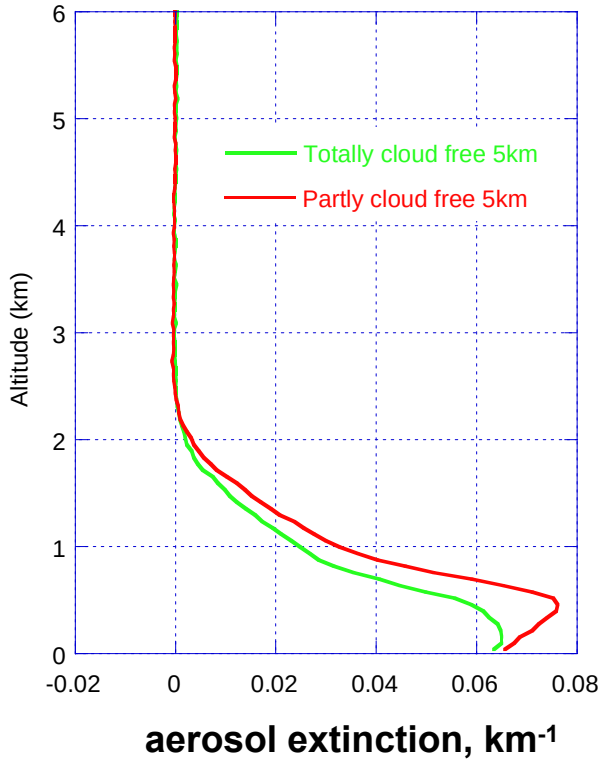


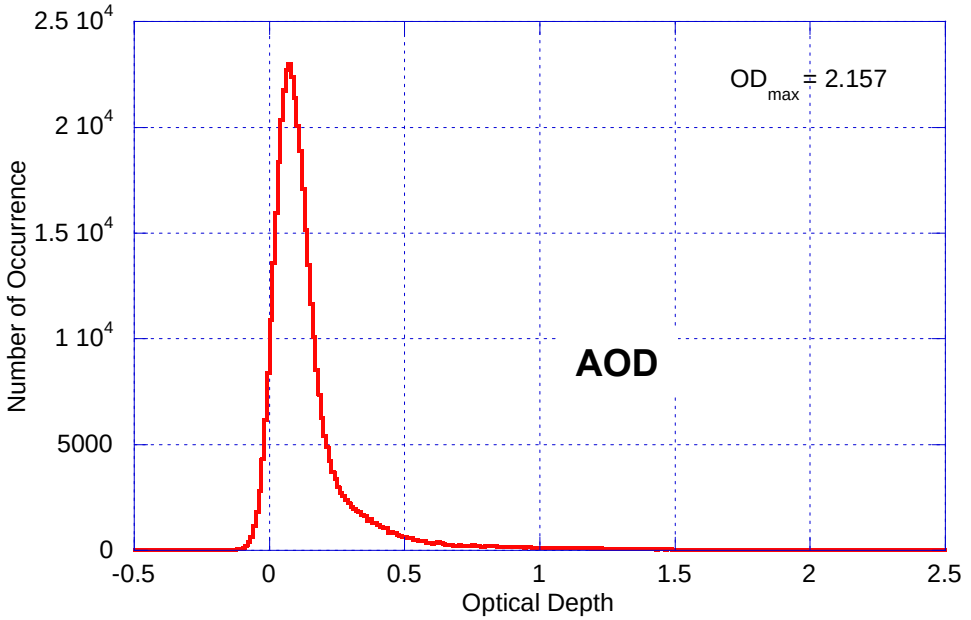
1. Ocean surface reflectance derived from CloudSat CPR
2. Use AMSR-E to correct radar water vapor attenuation
3. Column atmospheric transmittance from lidar ocean surface return
4. Column AOD then used as constraint on profile retrieval

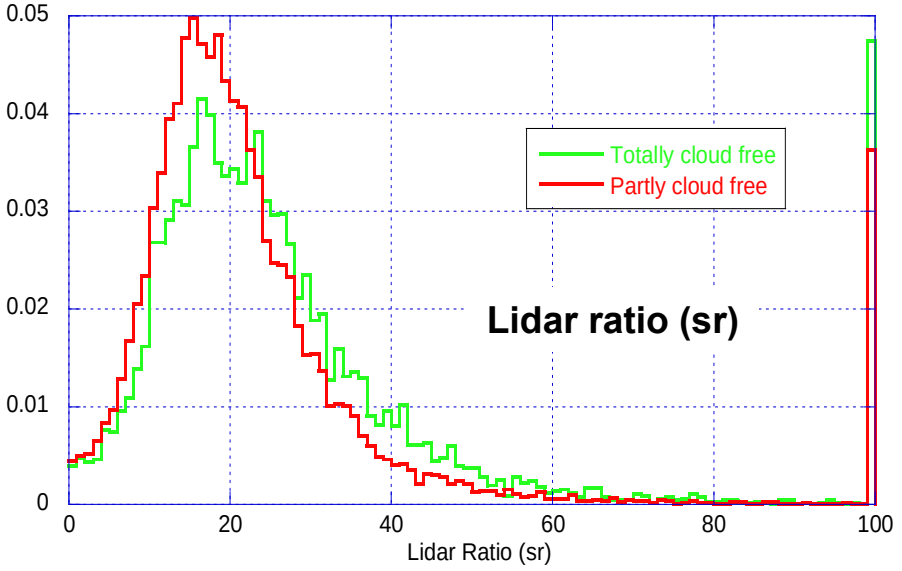
(Josset, Pelon et al, GRL, 2008)

Regional monthly distributions: South Pacific





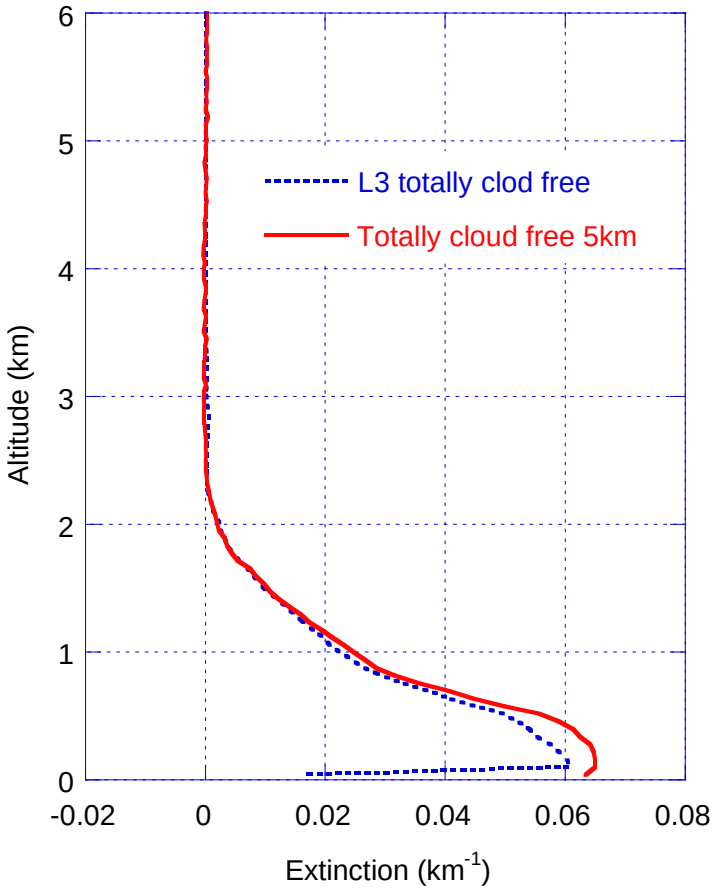


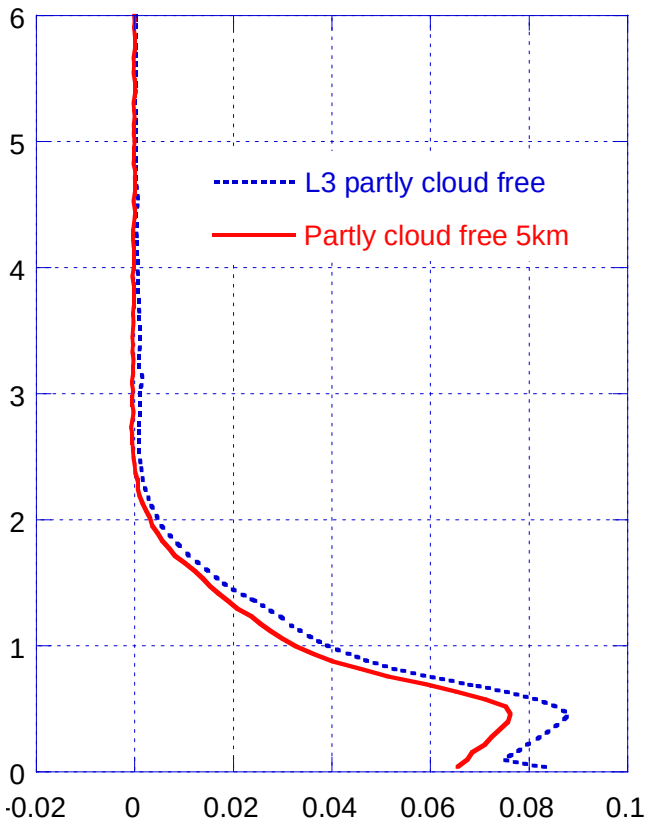


Retrieval Dependencies

Error Source	Level 2	soda (ocean only)	Full-column
Calibration	√	√	√
Detection sensitivity	√	---	---
Lidar ratio	√	retrieved	√
Cloud clearing	√	√	√
Surface reflectance	---	√	---

Preliminary extinction comparison: Level 3 vs soda





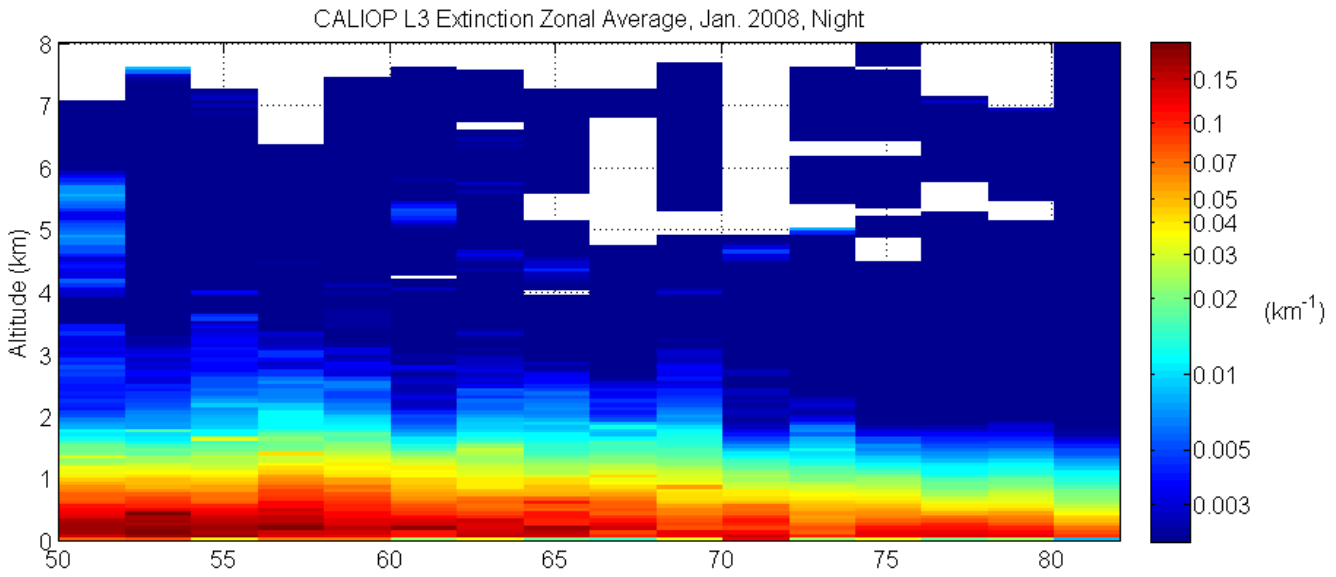
Differences due to:

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

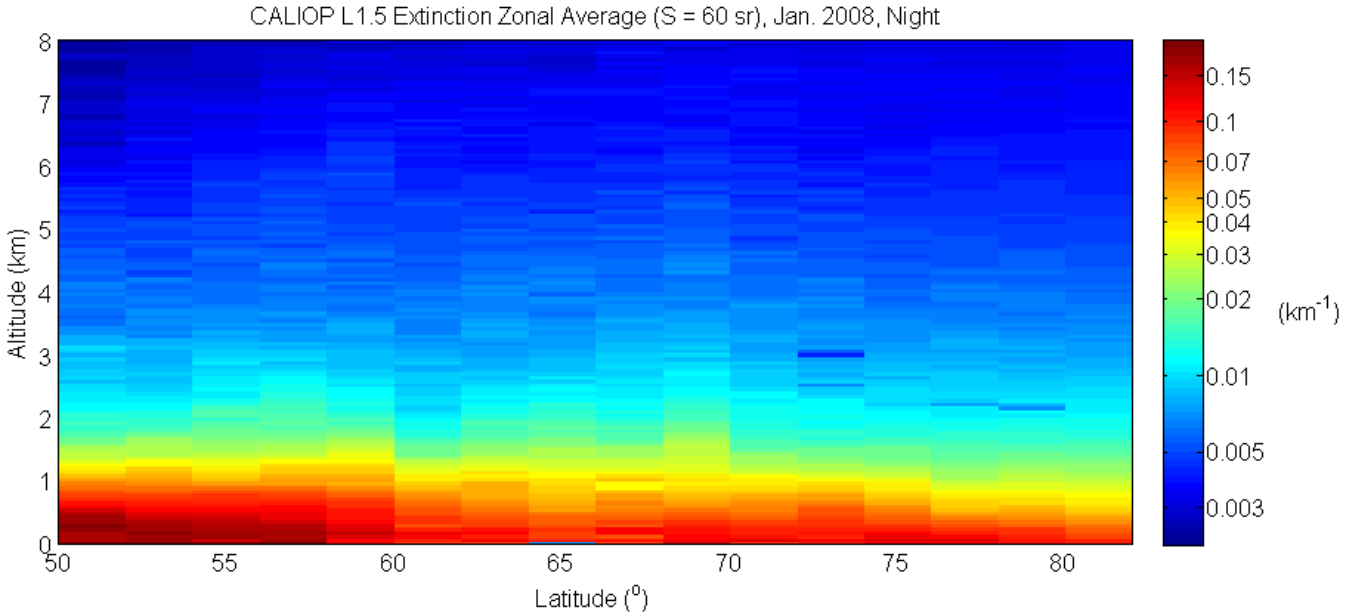
Can characterize what is missed in standard L3

(full column retrieval: zonal mean extinction, Jan 2008)

Level 3 from Level 2



Full-column retrieval



Status/Plans

- Data products catalog produced
- Beta-release – end of this year
  - Will process entire mission
- Revisit format & contents vs. file size
  - 1x1 deg: 60 meters, 0-12 km: ~2.5 GB / file
- Next year
  - Continue validation, improvement of screening
  - Provisional release based on Version 4 Level 2
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- ALSO: Level 3 stratospheric aerosol product in development
  - Vernier et al. (JGR, 2010)
  - Solomon et al. (Science, 2011)