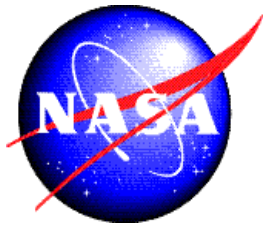
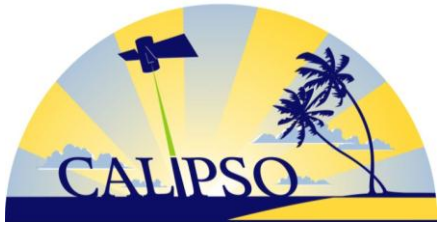




Global Distribution of Aerosol *and Aerosol Forcing* from CALIOP Observations

Dave Winker[1], Jason Tackett[2], Brian Getzewich[2], and Seiji Kato[1]

1) NASA LaRC, 2) SSAI, Hampton, VA

Aerocom Workshop, Seattle, 10-13 Sept 2012

Summary

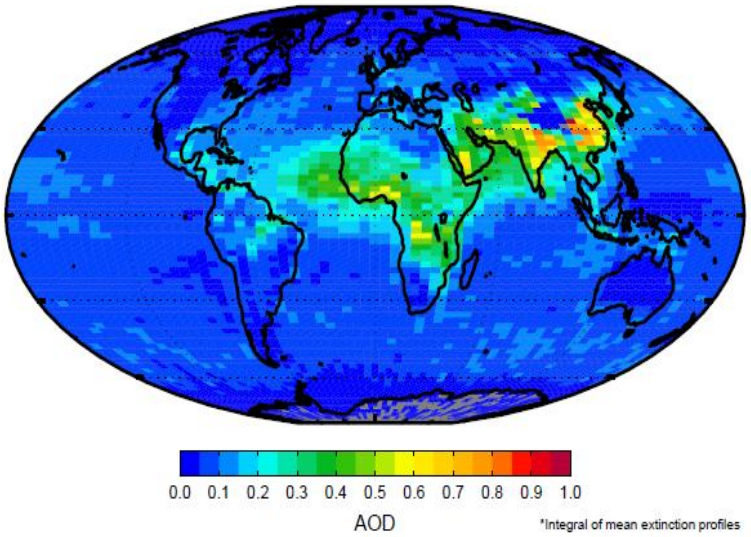
- A monthly, gridded, global aerosol profile product has been produced from CALIOP Level 2 aerosol data
  - June 2006 – Dec 2011
  - 60 m vertical resolution, 0 – 12 km
  - Beta-version product currently available from ASDC
- Initial characterization/validation performed
- Manuscript submitted to ACP (Winker et al, 2012)
- Optimization studies now underway
- Initial aerosol direct radiative effect calculations
- Release of improved profile product planned for 2013

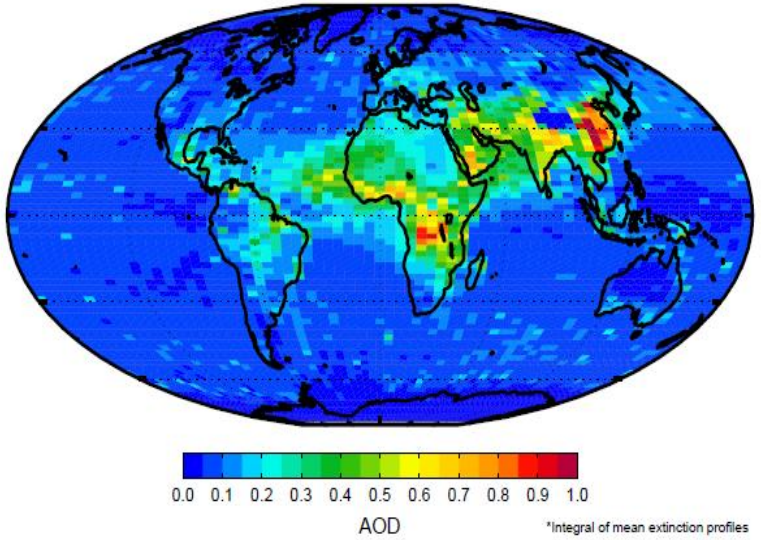
Four types of extinction profiles, 2008 annual mean

Day

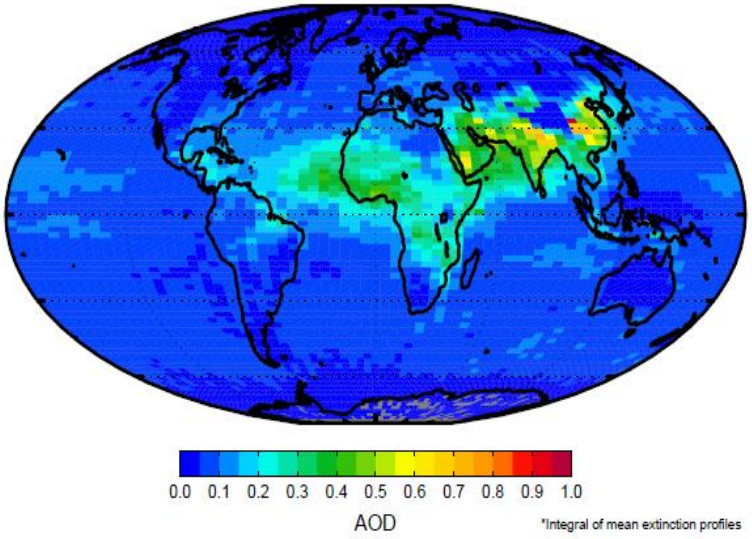
Night

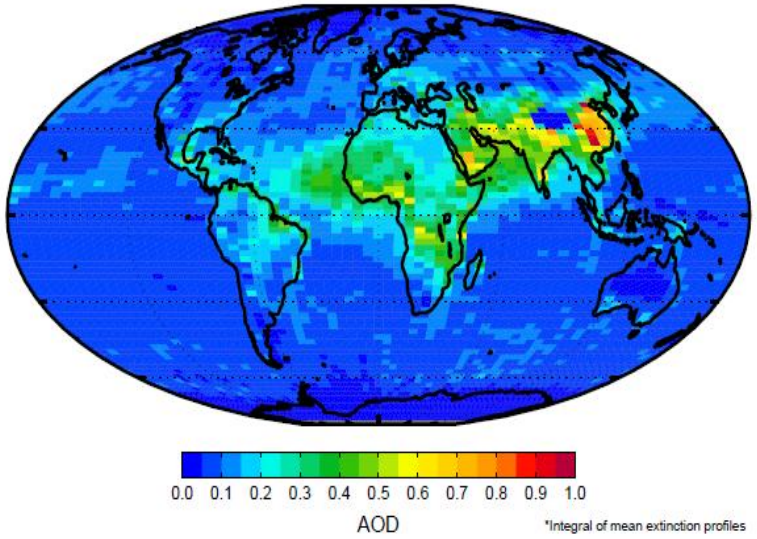
Cloud-free



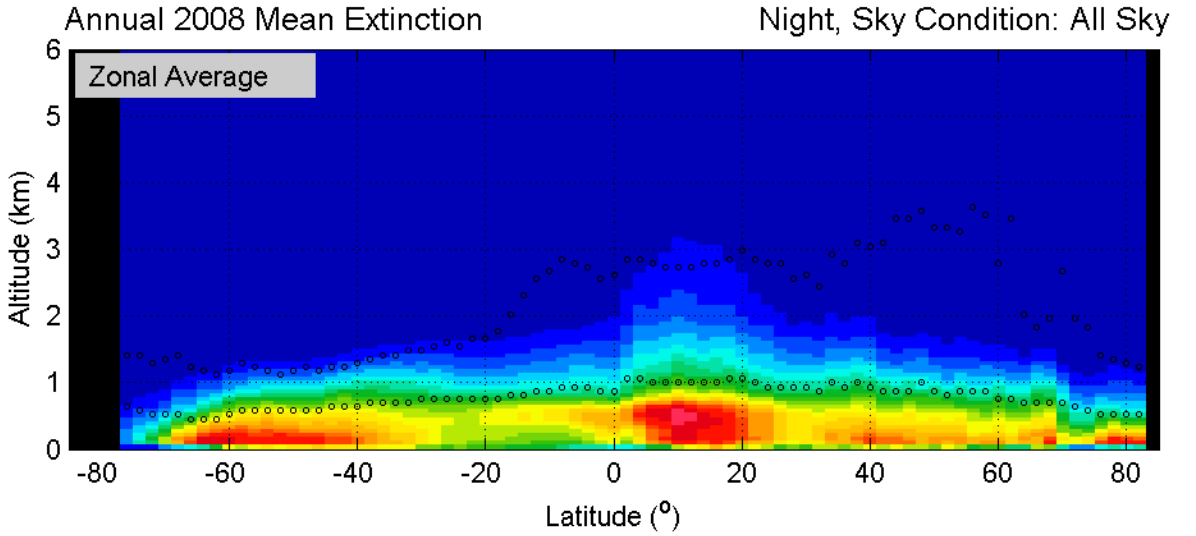


All-sky

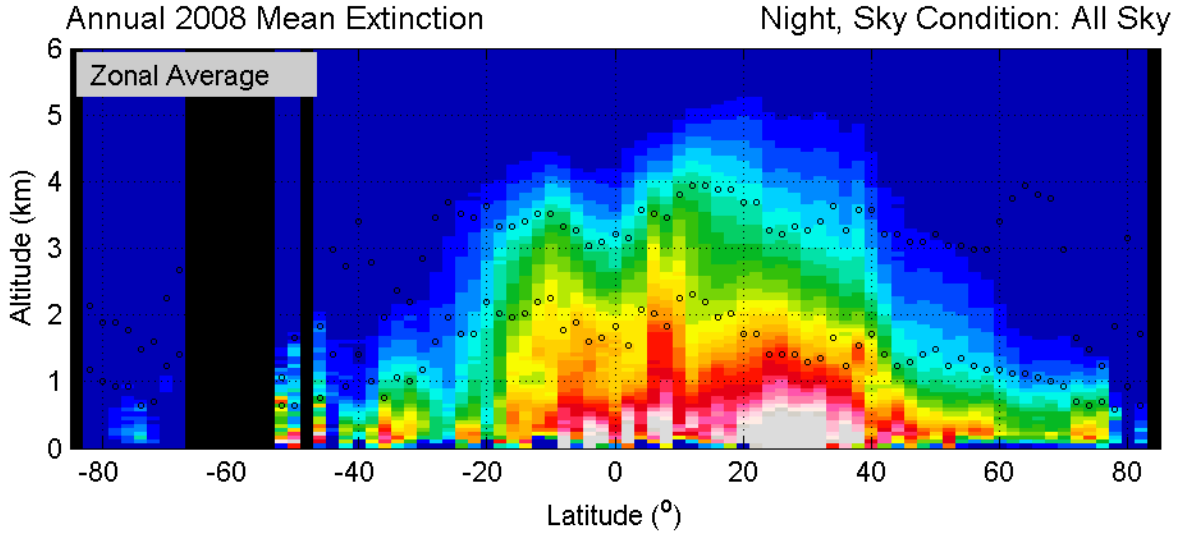




2008 annual: night, all-sky

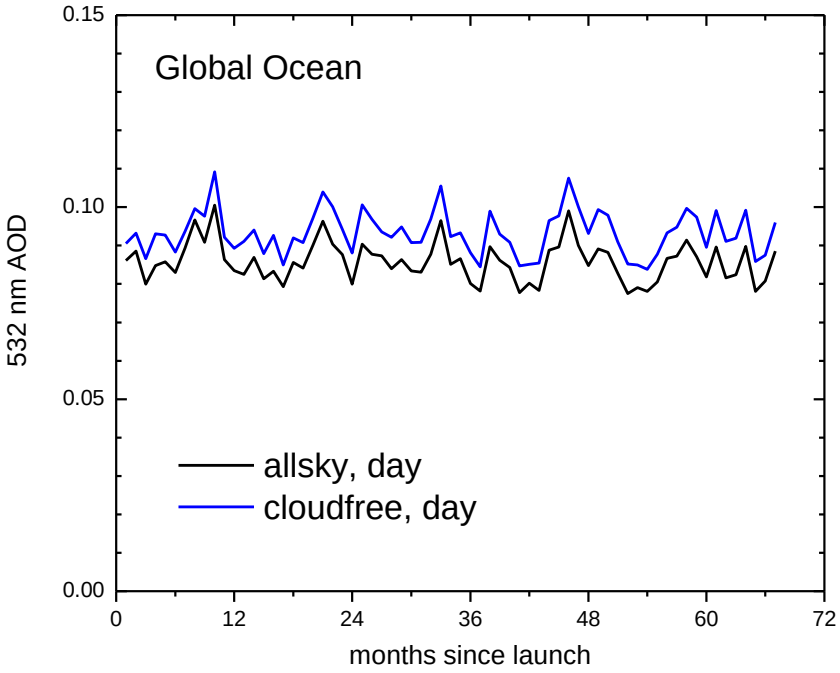


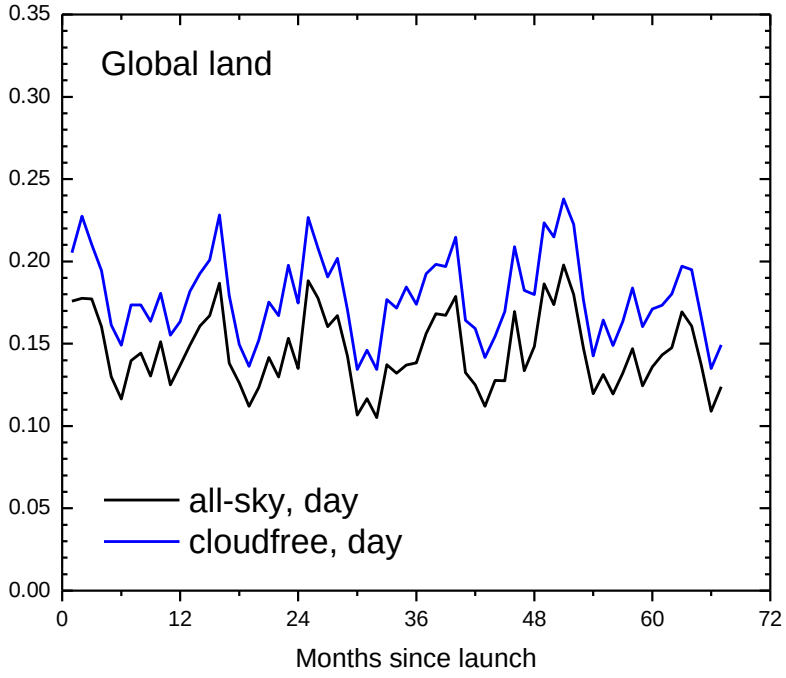
Ocean-only



Land-only

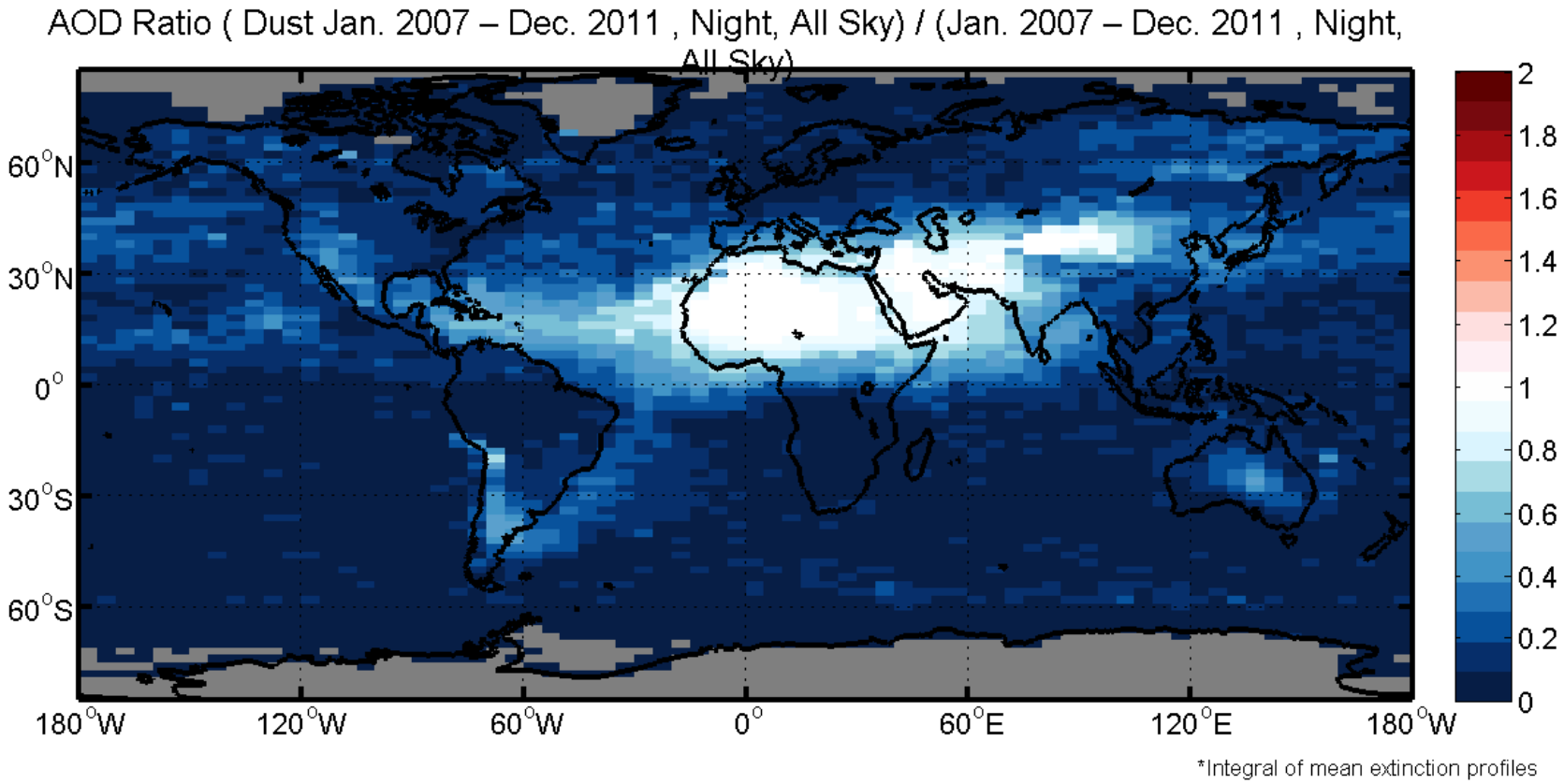
AOD:	global ocean			global land		
	CALIOP		MODIS	CALIOP		MODIS
	night	day		night	day	
cloud-free	0.087	0.093	0.13	0.21	0.18	0.19
all-sky	0.098	0.086	---	0.19	0.15	---





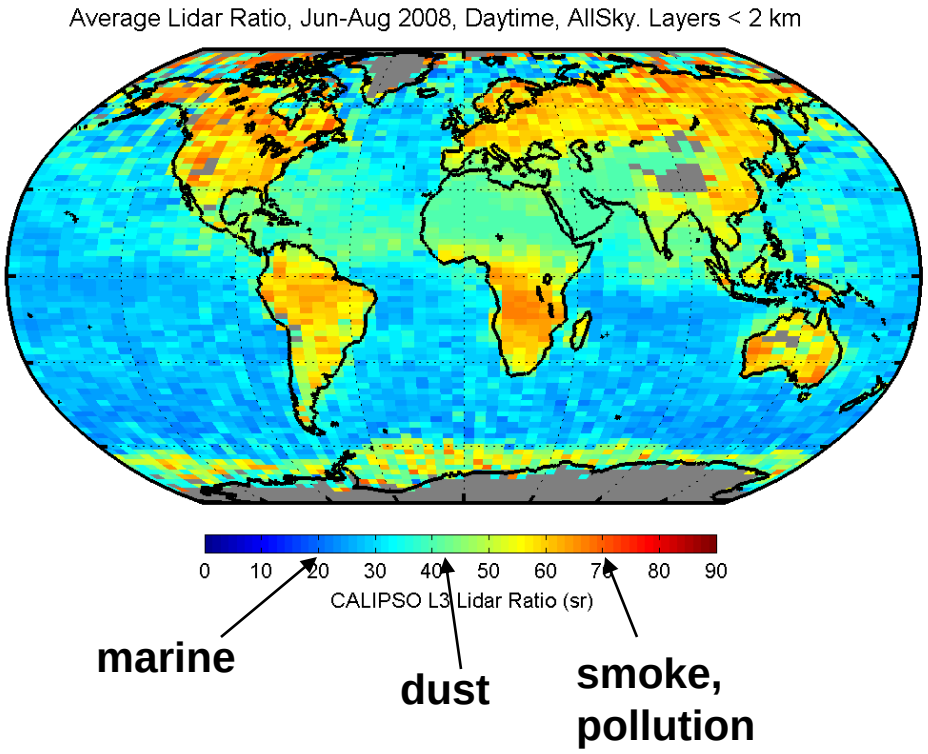
CALIOP employs an algorithm to estimate aerosol type based on measured lidar signals

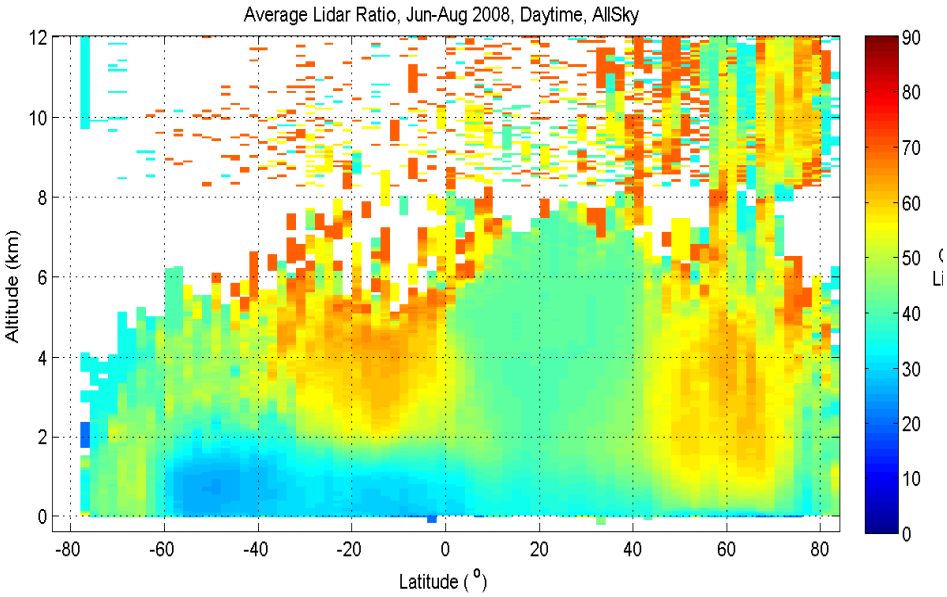
- depolarization provides robust identification of dust



Dust AOD fraction

Average Aerosol Type, JJA 2008





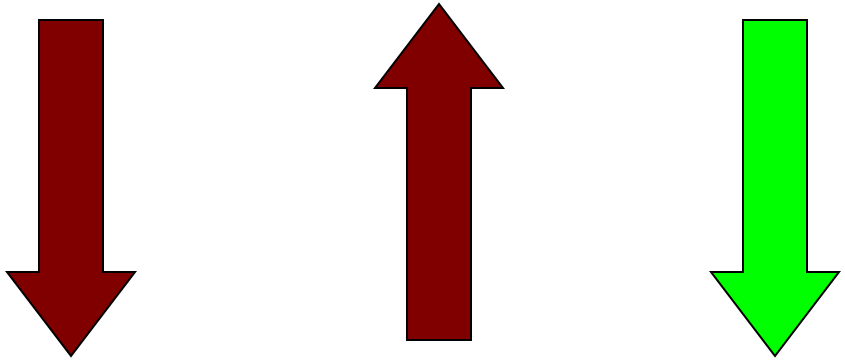
Validation of Global Aerosol Profiles

'SODA' retrieval:
column AOD from ocean surface returns
(no microphysical assumptions)

CloudSat
Surface reflectance

AMSR-E
H_2O attenuation correction

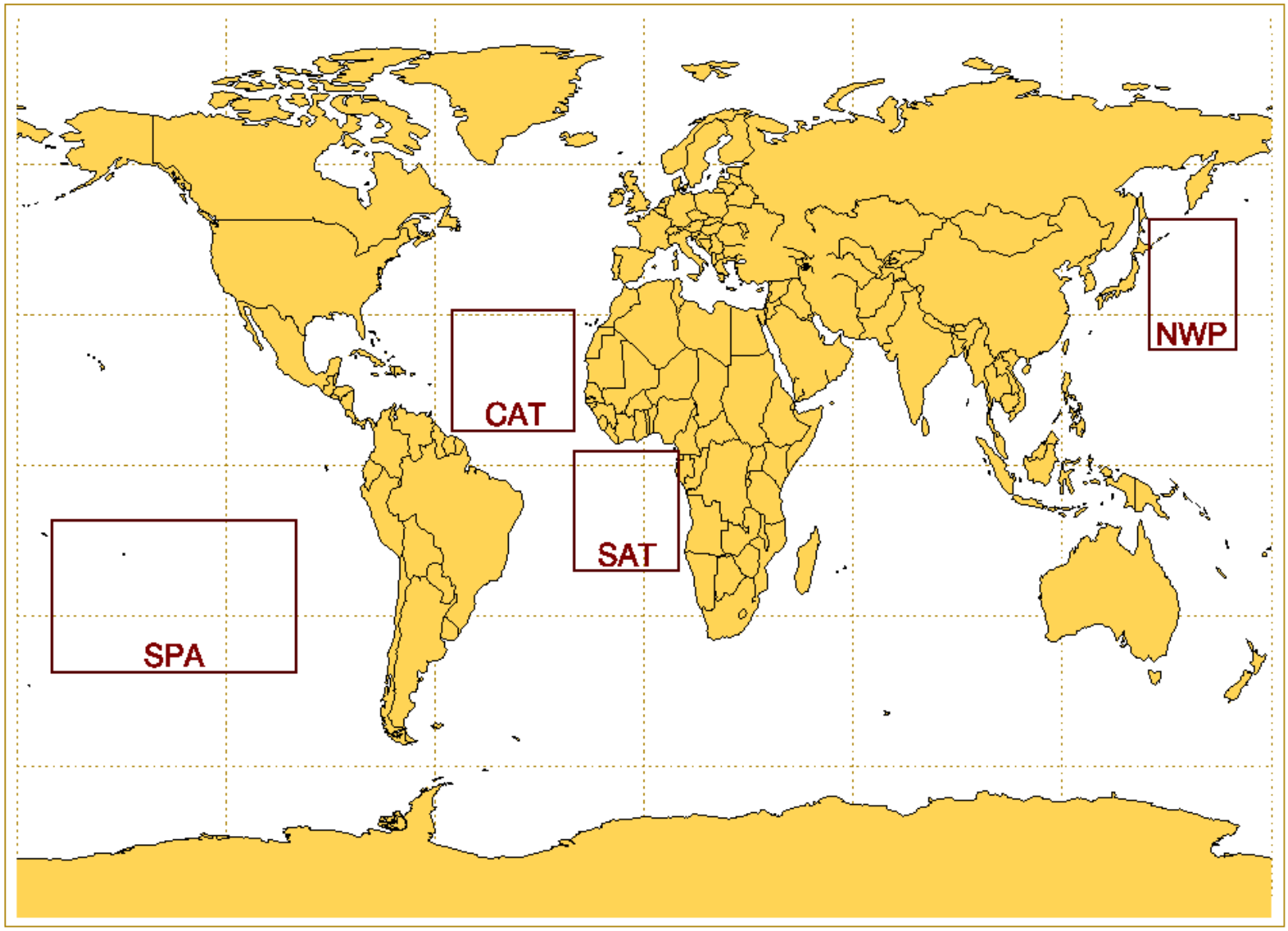
CALIOP
Column transmittance

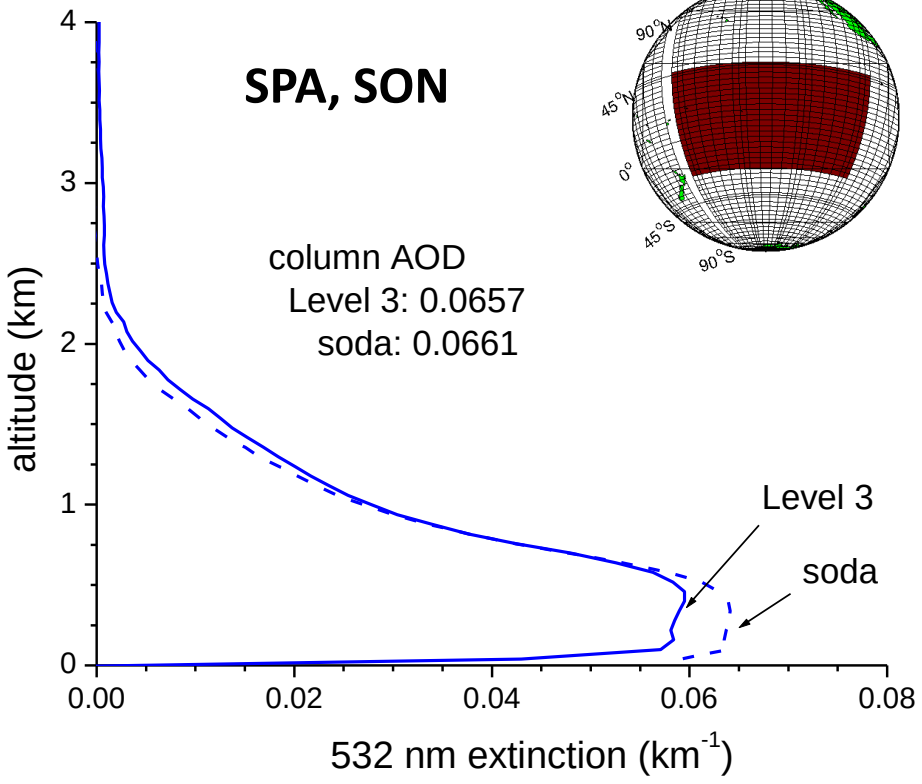


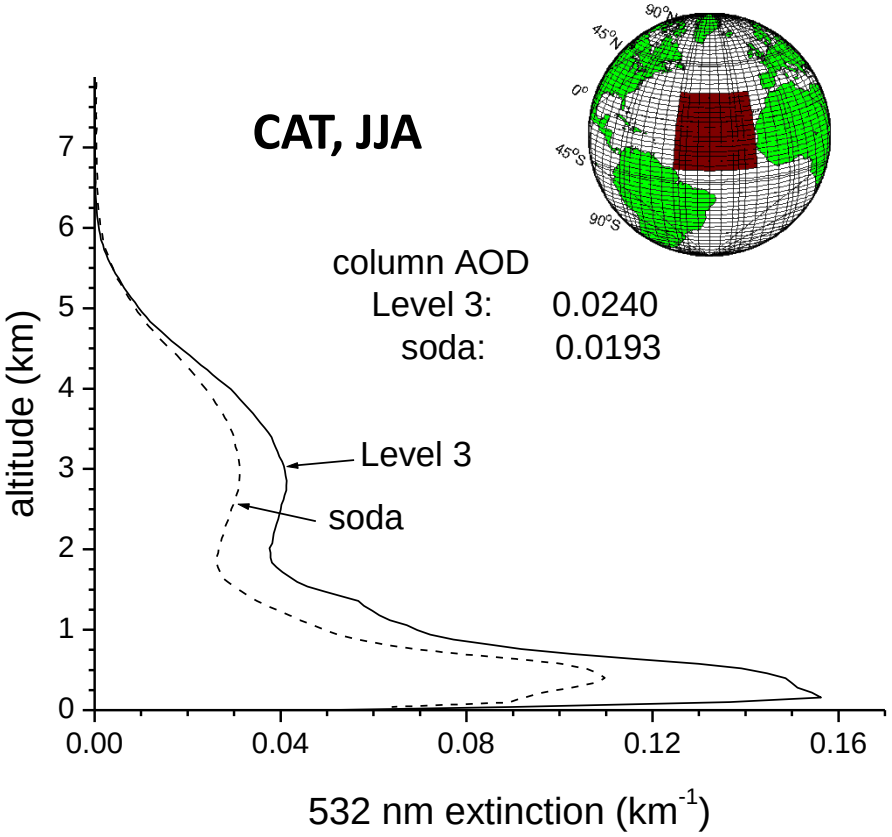
Ocean surface

error source	CALIOP	"SODA"
calibration	√	√
cloud clearing	√	√
detection sensitivity	√	
lidar ratio	√	
H2O attenuation		√
surface reflectance		√

(Josset, Pelon et al, GRL, 2008)

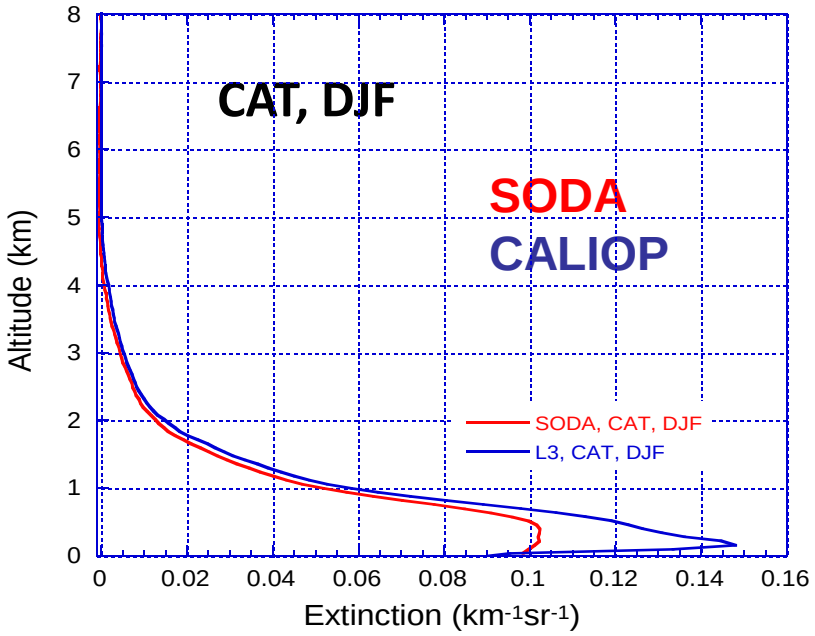

NWP
CAT
SAT
SPA

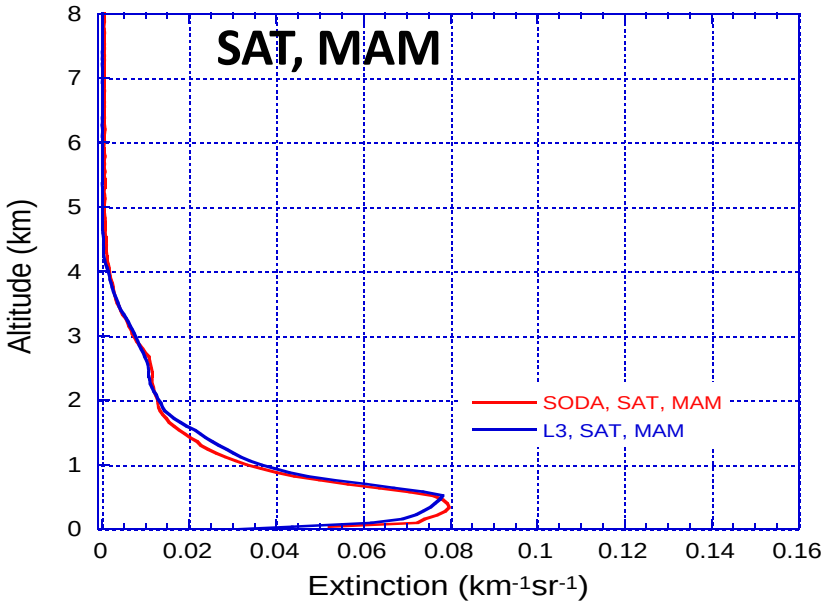


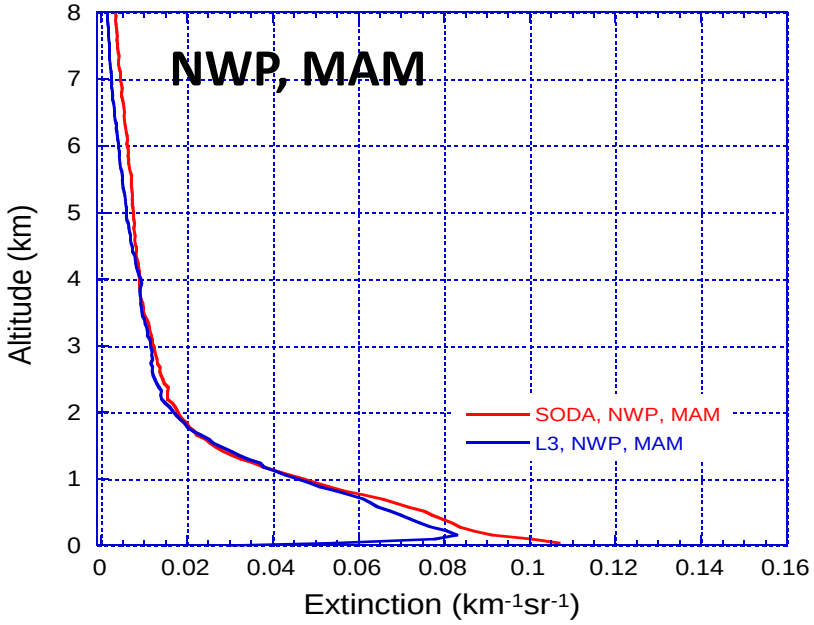


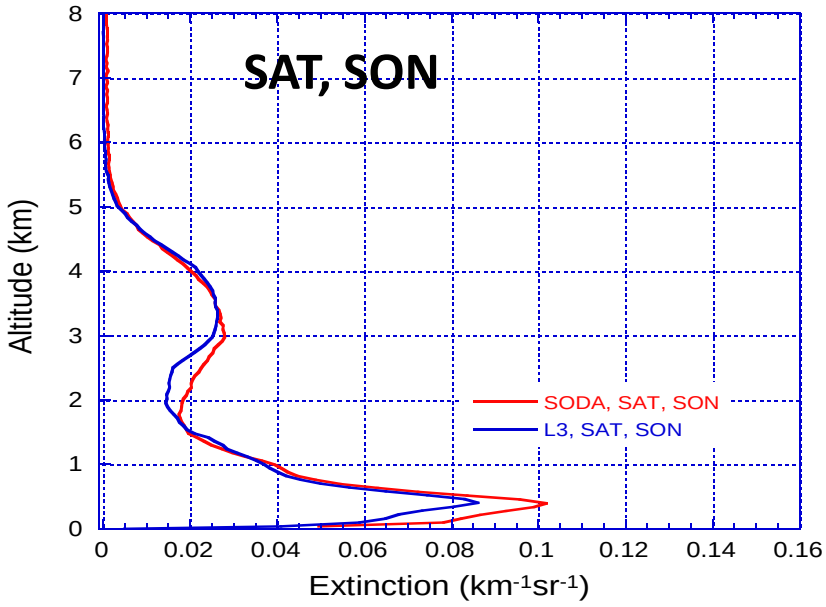
Differences due to:

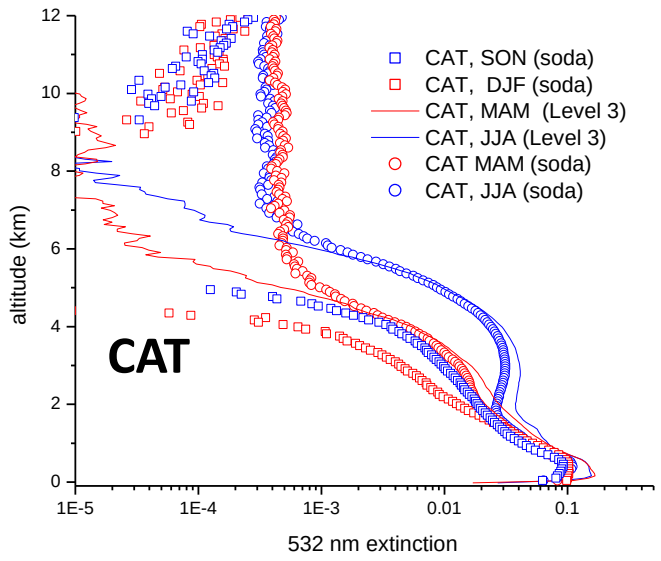
- **lidar ratios used (derived vs. estimated)**
- **Level 2 detection limits (> 1 k m)**
- **potential AOD error in SODA**

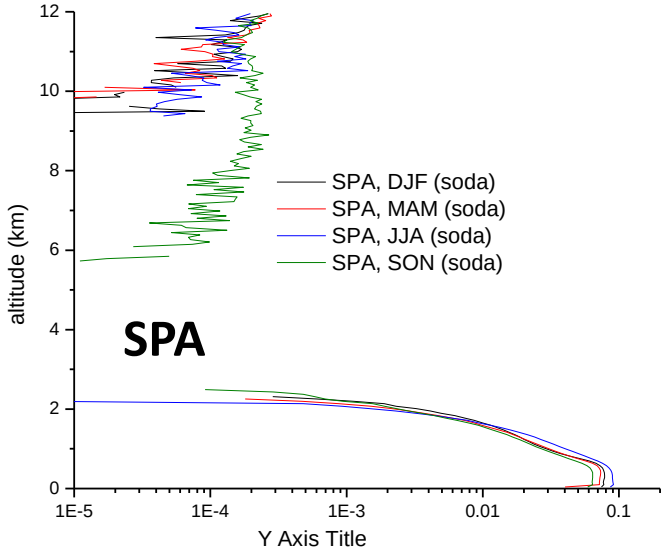

CAT, DJF
SODA
CALIOP
SODA, CAT, DJF
L3, CAT, DJF
Altitude (km)
Extinction (km-1sr-1)
0
1
2
3
4
5
6
7
8
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16

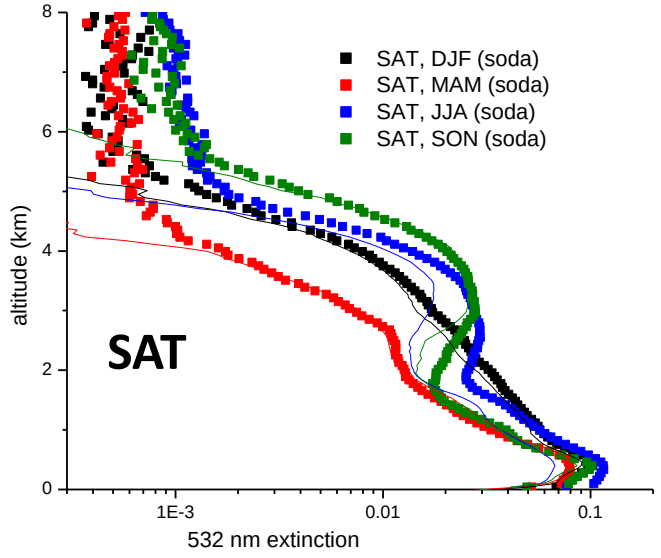

SAT, MAM
SODA, SAT, MAM
L3, SAT, MAM
Altitude (km)
Extinction (km-1sr-1)
0
1
2
3
4
5
6
7
8
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16

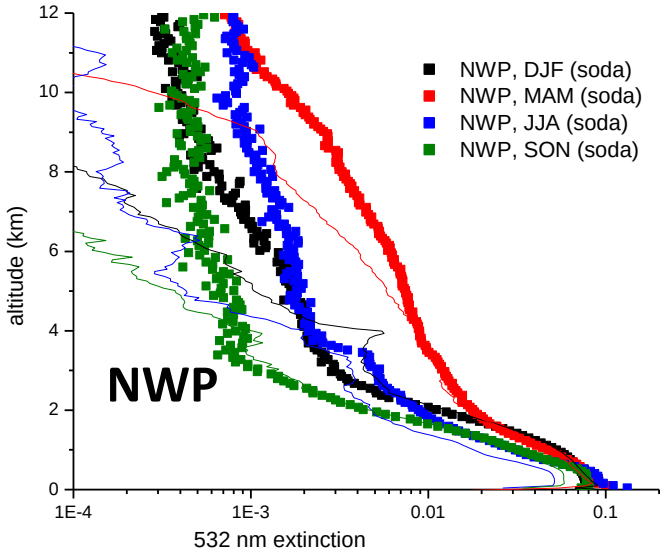

NWP, MAM
SODA, NWP, MAM
L3, NWP, MAM
Altitude (km)
Extinction (km-1sr-1)
0
1
2
3
4
5
6
7
8
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16


SAT, SON
SODA, SAT, SON
L3, SAT, SON
Altitude (km)
Extinction (km-1sr-1)
0
1
2
3
4
5
6
7
8
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16


CAT, SON (soda)
CAT, DJF (soda)
CAT, MAM (Level 3)
CAT, JJA (Level 3)
CAT MAM (soda)
CAT, JJA (soda)
CAT
altitude (km)
532 nm extinction
12
10
8
6
4
2
0
1E-5
1E-4
1E-3
0.01
0.1


SPA, DJF (soda)
SPA, MAM (soda)
SPA, JJA (soda)
SPA, SON (soda)
SPA
altitude (km)
Y Axis Title
12
10
8
6
4
2
0
1E-5
1E-4
1E-3
0.01
0.1


SAT, DJF (soda)
SAT, MAM (soda)
SAT, JJA (soda)
SAT, SON (soda)
SAT
altitude (km)
532 nm extinction
8
6
4
2
0
1E-3
0.01
0.1


NWP, DJF (soda)
NWP, MAM (soda)
NWP, JJA (soda)
NWP, SON (soda)
NWP
altitude (km)
532 nm extinction
12
10
8
6
4
2
0
1E-4
1E-3
0.01
0.1

Summary of initial profile evaluations

- Level 3 profiles appear to be representative:
  - up to altitudes of 4-6 km
  - for extinction greater than 0.001 km^{-1} (in most regions)
- Comparisons against HSRL and in situ measurements are generally consistent with SODA comparisons
- Even where CALIOP extinction is biased low, bias is no greater than about 0.001 km^{-1}
- Accuracy of full-column retrievals limited by calibration to about 0.001 km^{-1} at best
- Extinction in lowest 120 meters or so is significantly underestimated

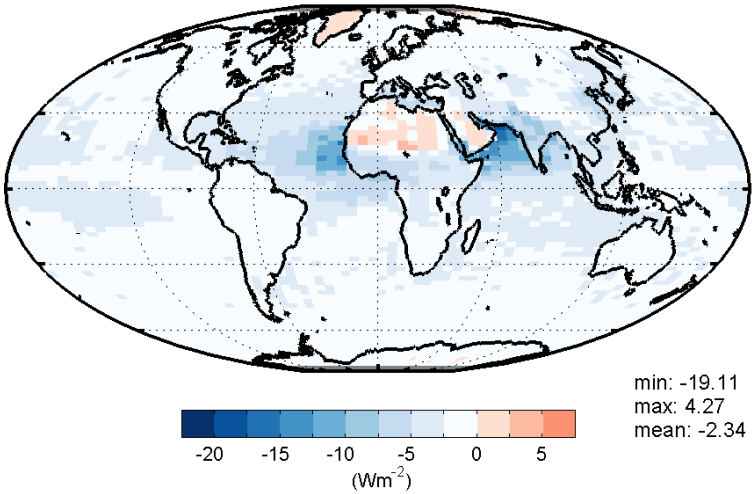
Aerosol DRE, based on C3M product (Kato et al. 2010)

Co-located, merged CALIPSO, CloudSat, CERES, and MODIS data

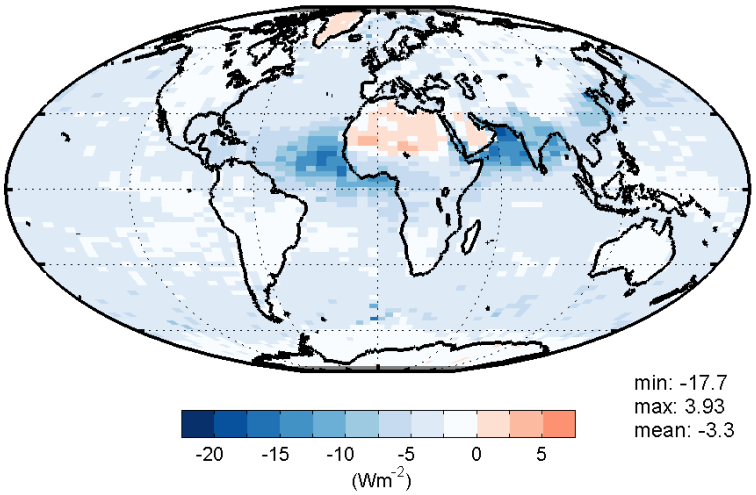
- Aerosol extinction profiles
  - CALIOP
  - MATCH
    - using assimilated MODIS AOD
    - MATCH used in columns where there is no CALIOP aerosol
- Aerosol type from MATCH, except when CALIOP identifies dust, broadband aerosol optical properties from OPAC (Hess, 1998)
- Cloud profiles and properties
  - CALIOP/CloudSat
  - MODIS
- Broadband RT calculations: up & down LW and SW fluxes using CALIPSO/CloudSat vertical structure above CERES footprints

Diurnally-averaged SW aerosol DRE

All-Sky Aerosol SW DRF



Clear-Sky Aerosol SW DRF



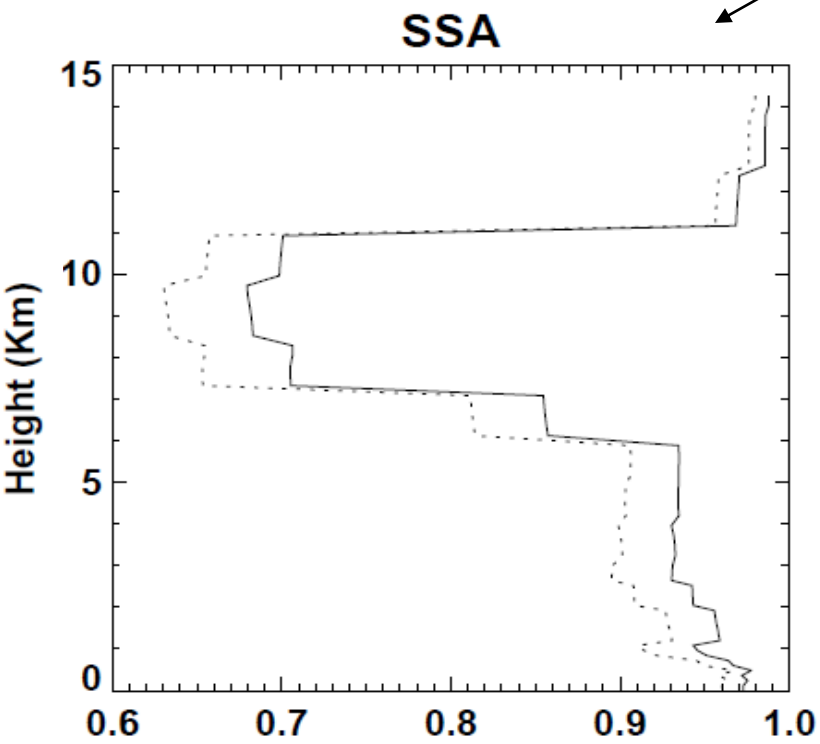
$$DRE_{total} = (1 - A_c)\, DRE_{clr} + A_c\, DRE_{cldy}$$

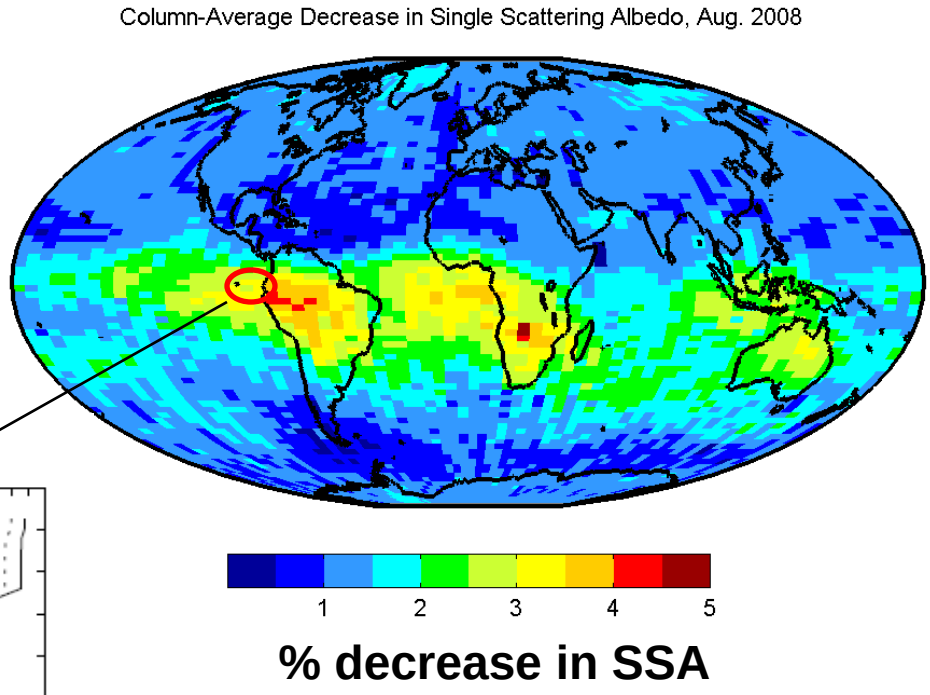
2008 global mean DRE

all-sky	- 2.34 W/m^2
clear-sky	- 3.30 W/m^2
cloudy-sky	-2.27 W/m^2

Sensitivity Study

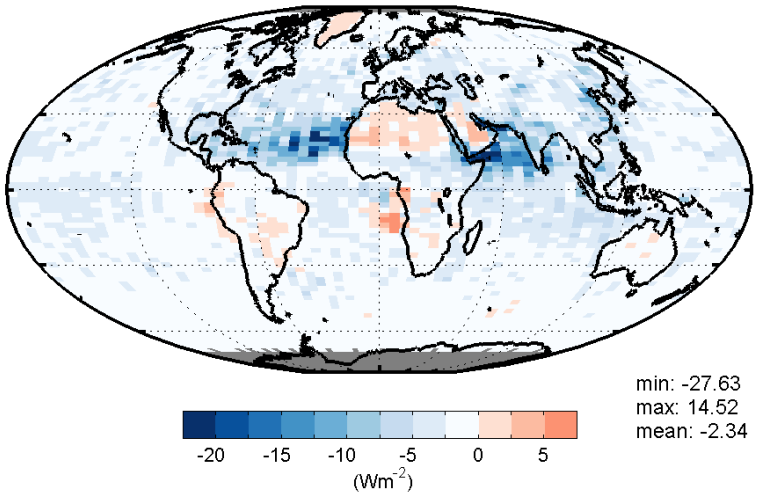
- **C3M tends to have too little aerosol absorption**
- **reduce SSA of OPAC smoke components by 0.06 (soot, soluble, insoluble)**





TOA Aerosol DRE

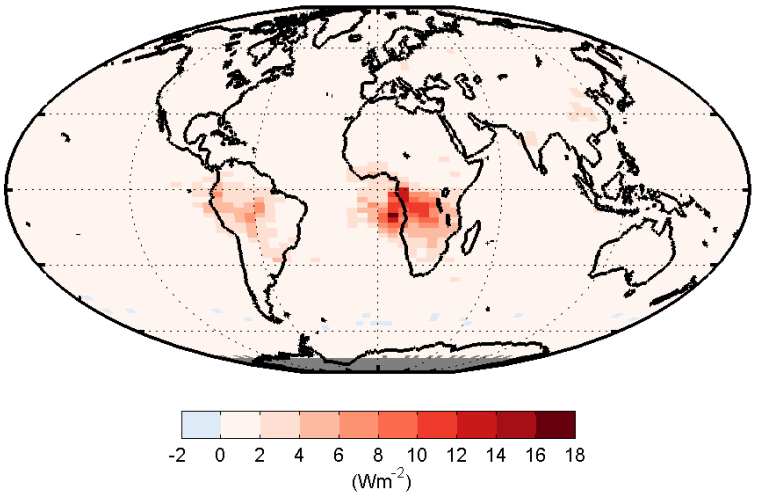
All-Sky, Aug. 2008



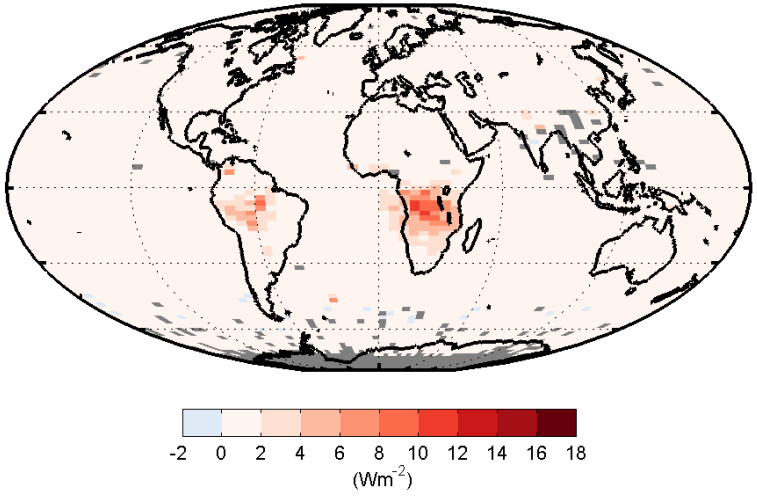
	global DRE (W/m^2) control	reduced ω_o
all-sky	-2.34	-2.06
clear-sky	-3.39	-3.20

	global ocean control	reduced ω_o
all-sky	-2.78	-2.57
clear-sky	-3.99	-3.88

Difference: ω_o reduced − control



Difference: ω_o reduced − control



Next Steps

- Issue improved ("provisional") Level 3 aerosol dataset
  - Early next year?
- Longer term: improvements to aerosol typing
- Continue DRE sensitivity studies
- Compare standard C3M with CALIOP-only aerosol
- Compute surface radiative effects, atmospheric heating
- Compare with other studies using CALIOP:
  - **Chand et al. (Nat GeoSci, 2009)**
  - **Oikawa & Nakajima (JGR, in review)**
  - **L'Ecuyer (using CloudSat FLXHR-lidar product)**
  - **Redemann (MODIS, PARASOL, OMI, CALIOP)**