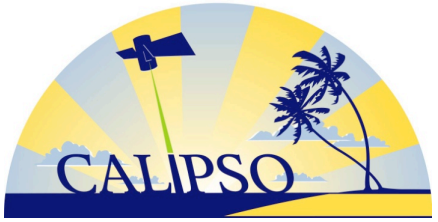


Direct Aerosol Radiative Effect from C3M

Dave Winker[1], Seiji Kato[1], Jason Tackett[2], and Ali Omar[1]

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

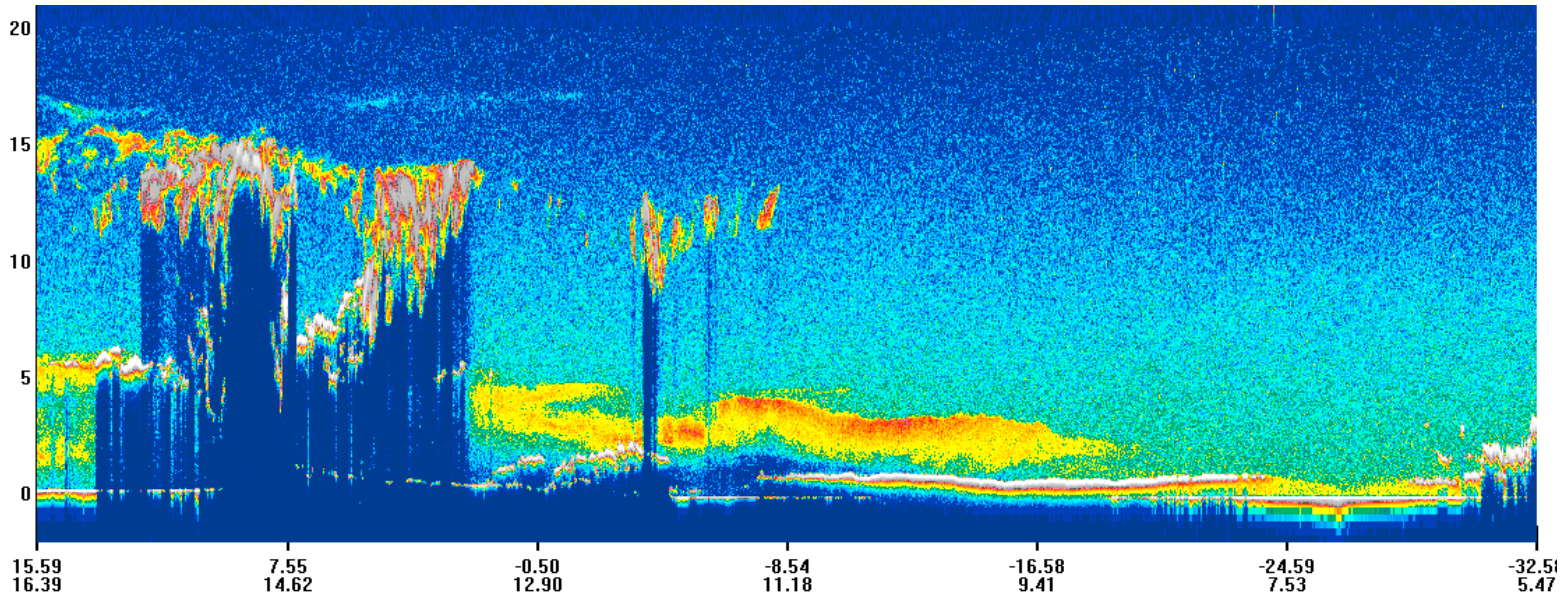
Radiation Budget Workshop, Princeton, 25 Oct 2012

In the past, cloudy-sky direct aerosol RE, RF estimated in various ways

- from model predictions
- cloudy-sky aerosol radiative effects = 0
- etc.

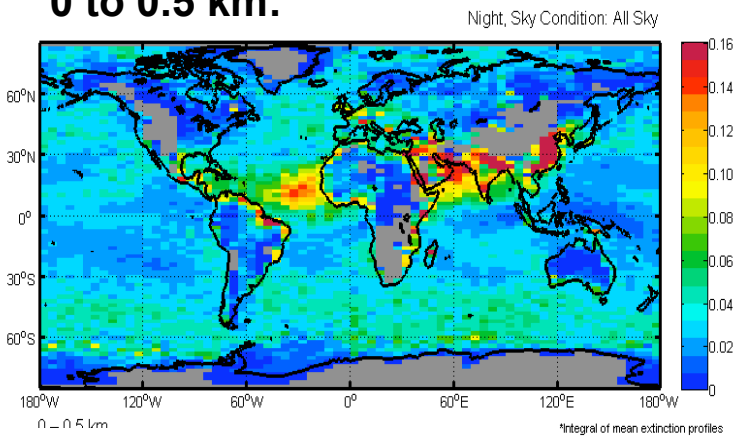
Aerosol profile data from CALIPSO/CALIOP is a new resource for estimating global aerosol effects:

- Aerosol retrievals in cloudy skies
  - Above clouds
  - Beneath thin clouds
- Aerosol retrievals over bright surfaces (deserts)

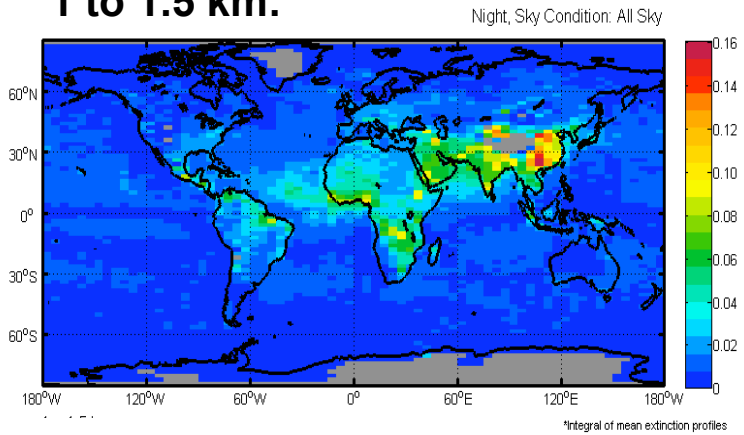


CALIOP Level 3 aerosol product now available
(Winker et al., ACPD, 2012)

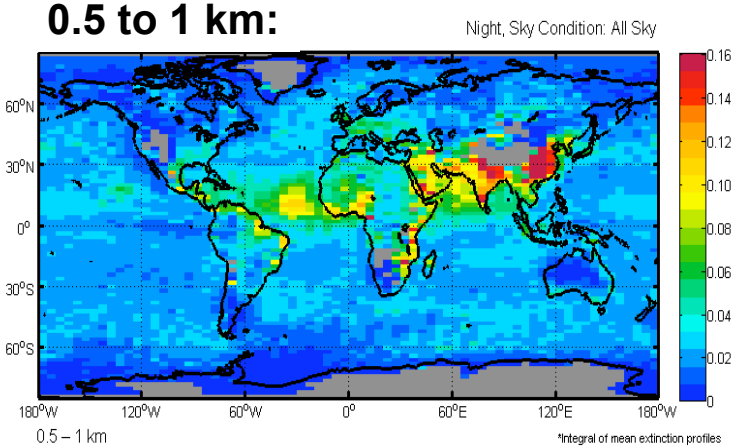
0 to 0.5 km:



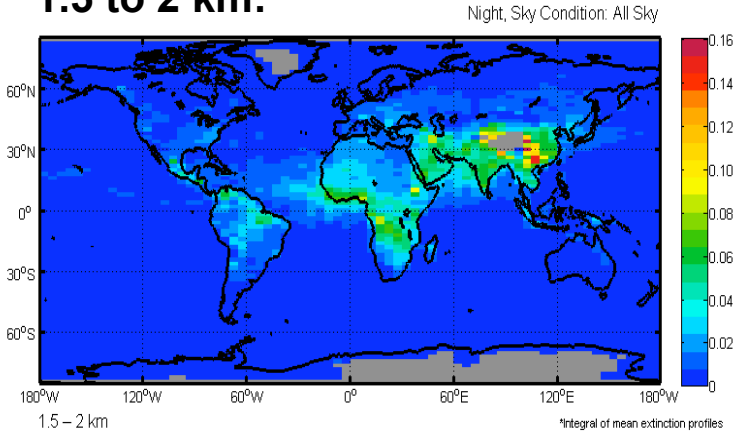
1 to 1.5 km:



0.5 to 1 km:

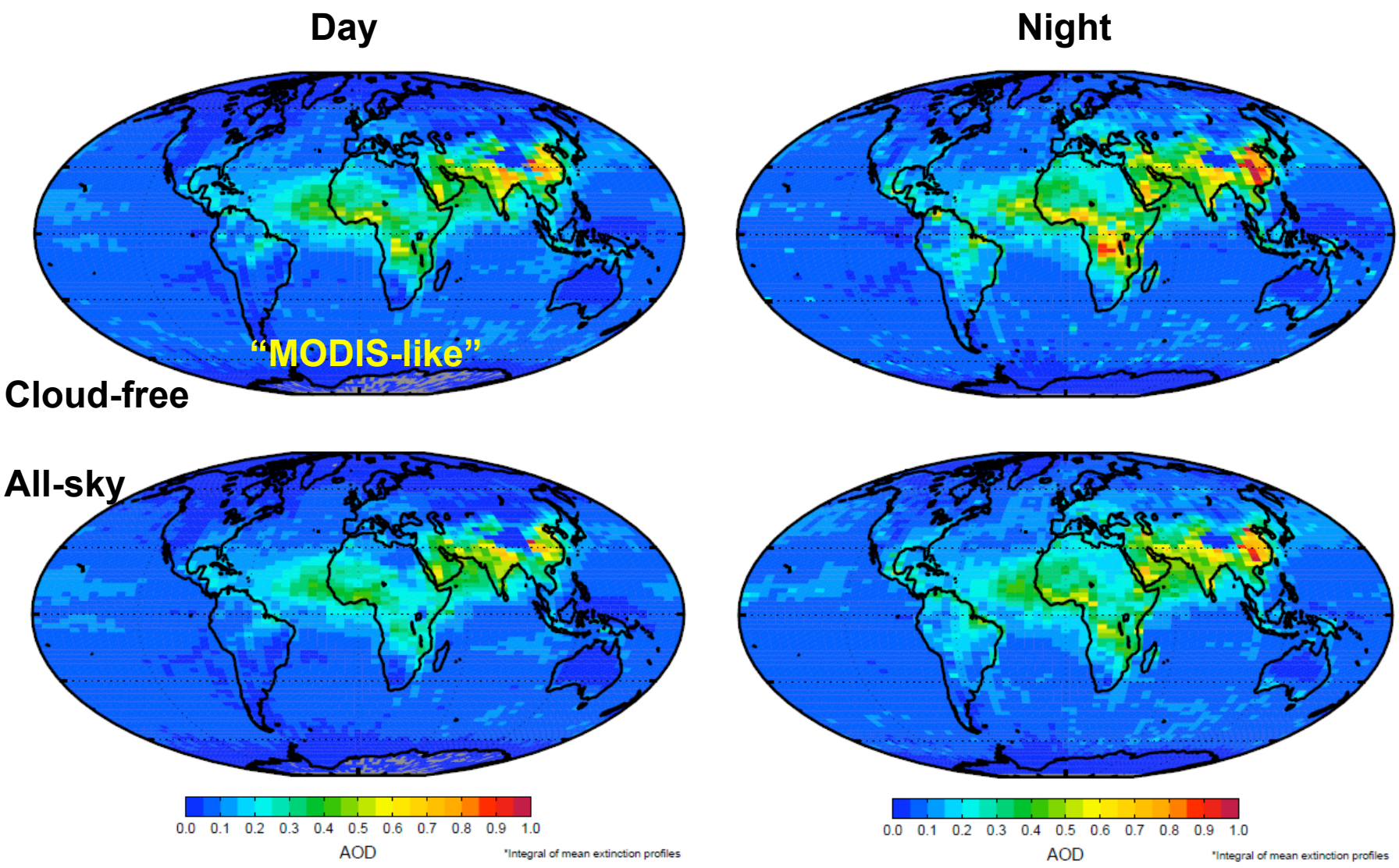


1.5 to 2 km:



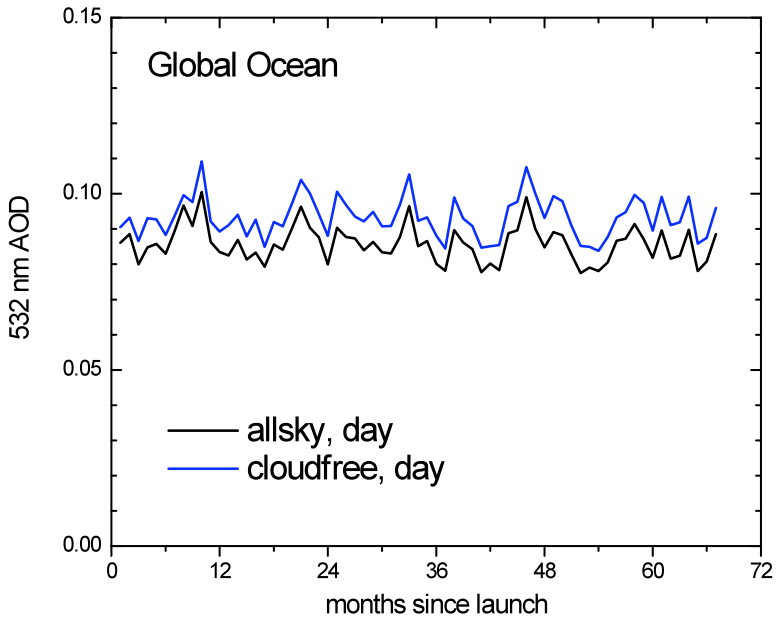
→ **Basis of Aerocom intercomparison (Koffi et al, 2012)**

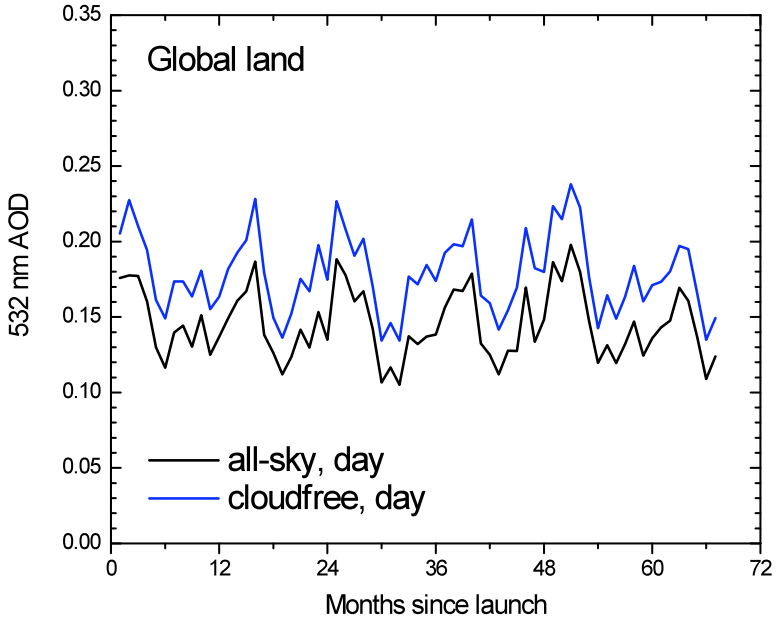
2008 Annual Mean AOD



Daytime AOD

	global ocean		global land	
	CALIOP	MODIS	CALIOP	MODIS
cloud-free	0.093	0.13	0.18	0.19
all-sky	0.086	---	0.15	---

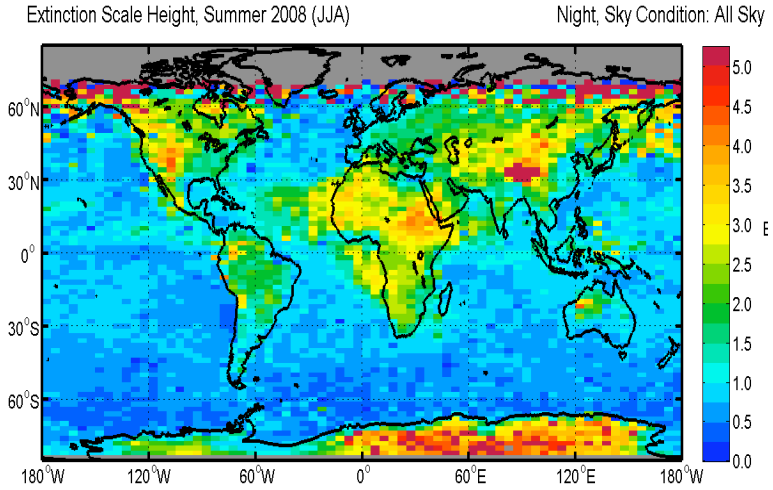


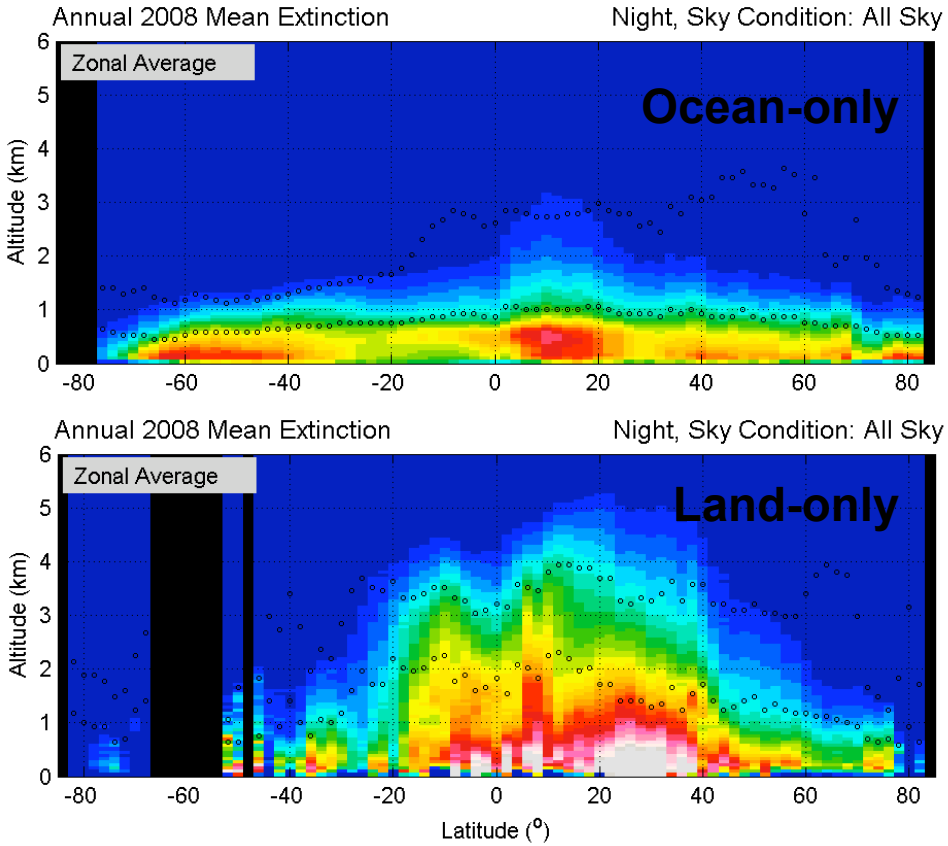


CALIOP aerosol data

- Aerosol radiative effects depend on relative vertical locations of aerosol and cloud
- Now have observed profiles rather than model estimates

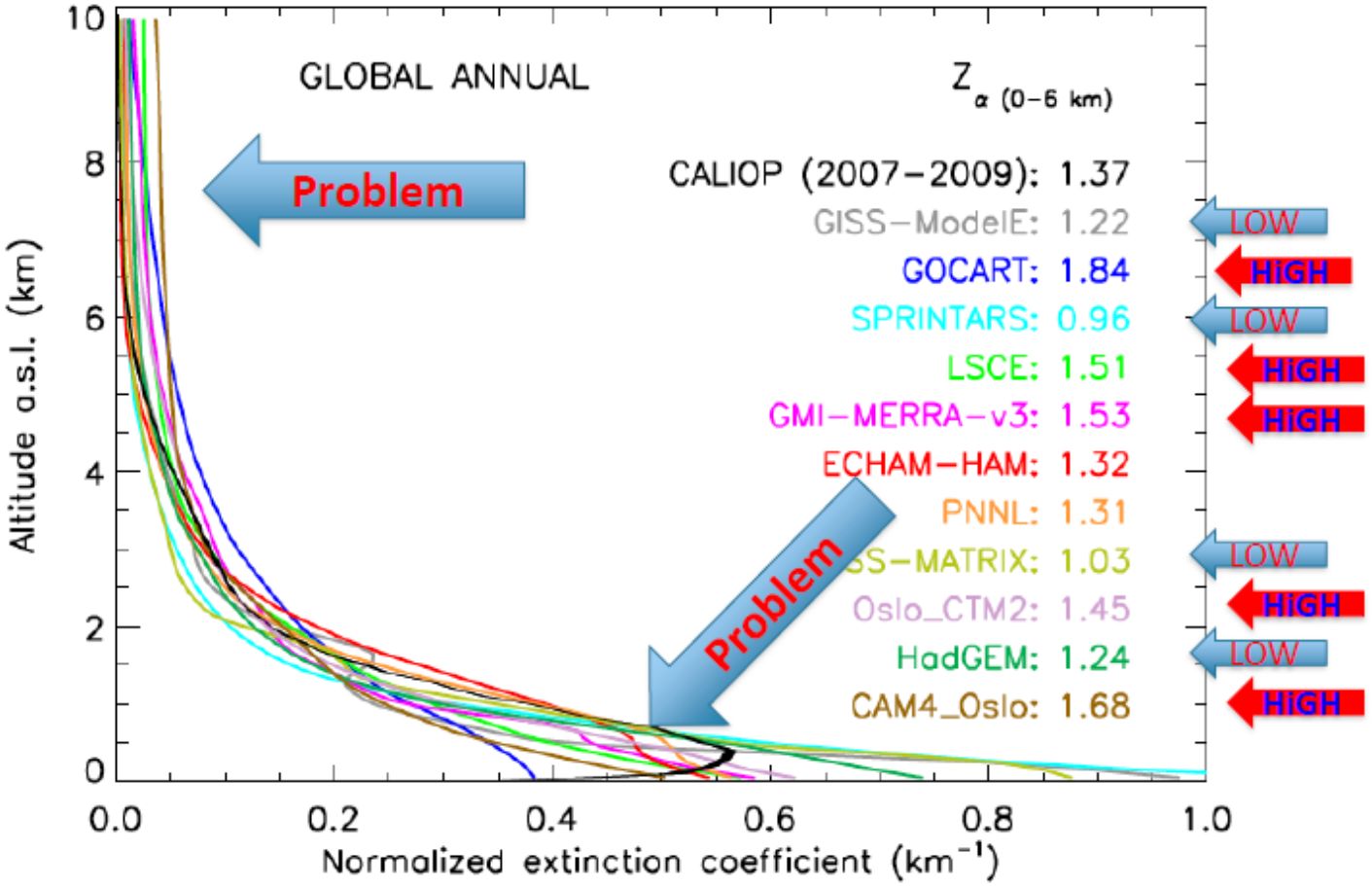
Extinction Scale Height





Aerocom Phase-II Comparison

CALIOP profiles used to evaluate aerosol vertical distributions predicted by 11 global models (Koffi et al., 2012)



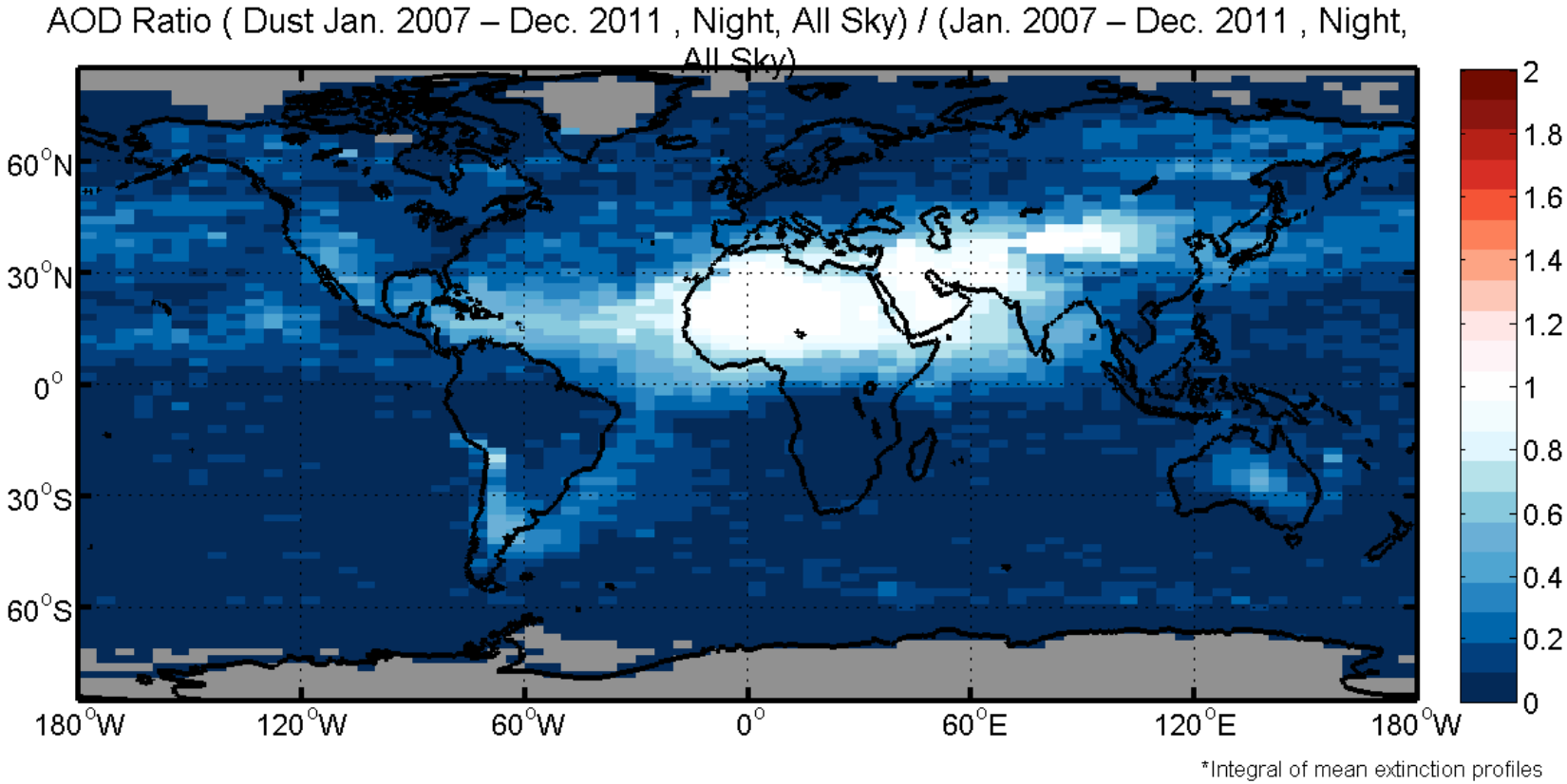
C3M (CCCM) product (Kato et al. 2010)

C3M is a Level 2 product, along the CALIPSO-CloudSat groundtrack

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

- Aerosol extinction profiles from:
  - CALIOP
  - MATCH (assimilates MODIS AOD)
    - MATCH used in columns where there is no CALIOP aerosol
- Cloud profiles and properties from:
  - CALIOP/CloudSat
  - MODIS
    - over the co-located CERES footprint
- Broadband RT calculations simulate up & down LW and SW fluxes using CALIPSO/CloudSat vertical structure above CERES footprints
- Co-located CERES TOA radiative fluxes (SW, LW, and WN)

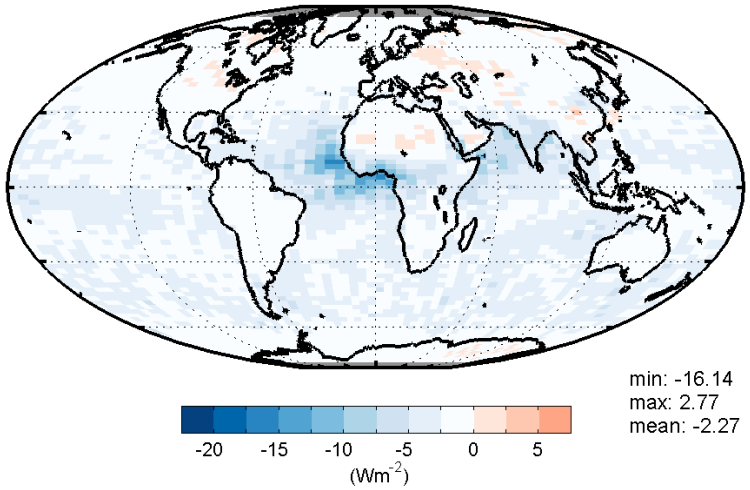
Aerosol type from MATCH, except when CALIOP identifies dust
Broadband aerosol optical properties from OPAC (Hess, 1998)



Dust AOD fraction

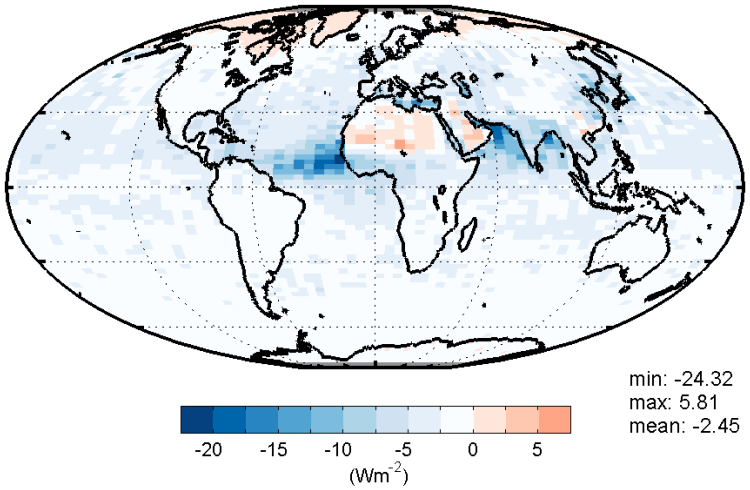
Seasonal All-sky SW DRE

DJF



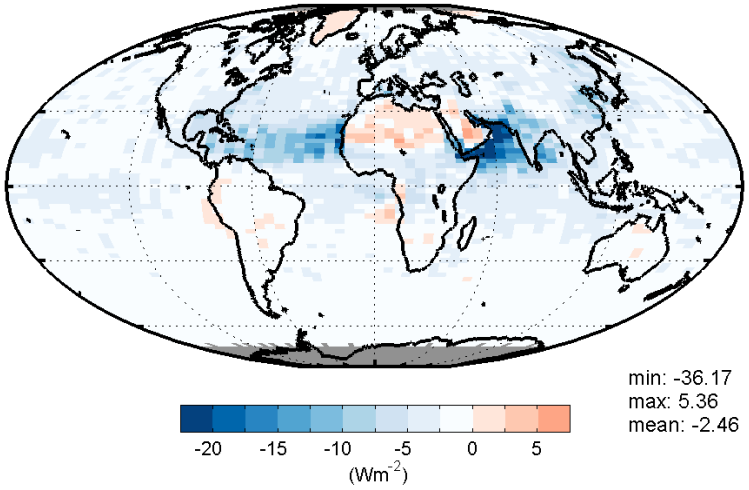
min: -16.14
max: 2.77
mean: -2.27

MAM



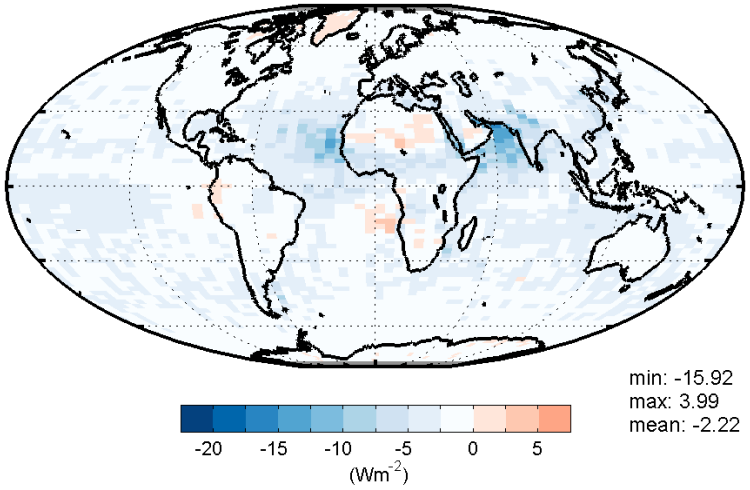
min: -24.32
max: 5.81
mean: -2.45

JJA



min: -36.17
max: 5.36
mean: -2.46

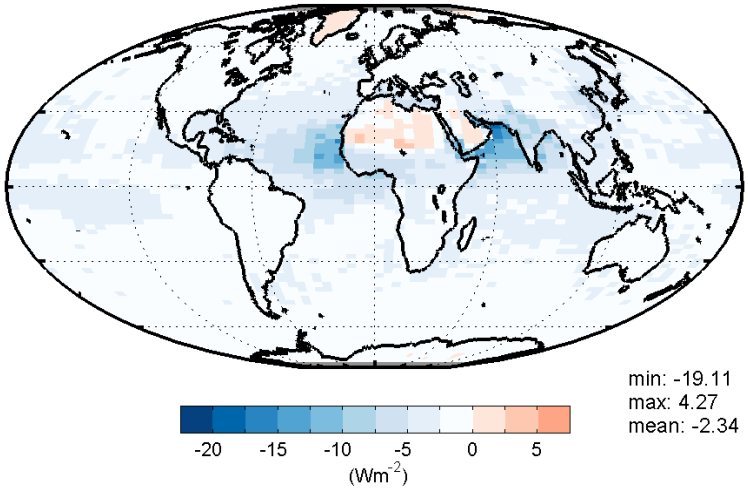
SON



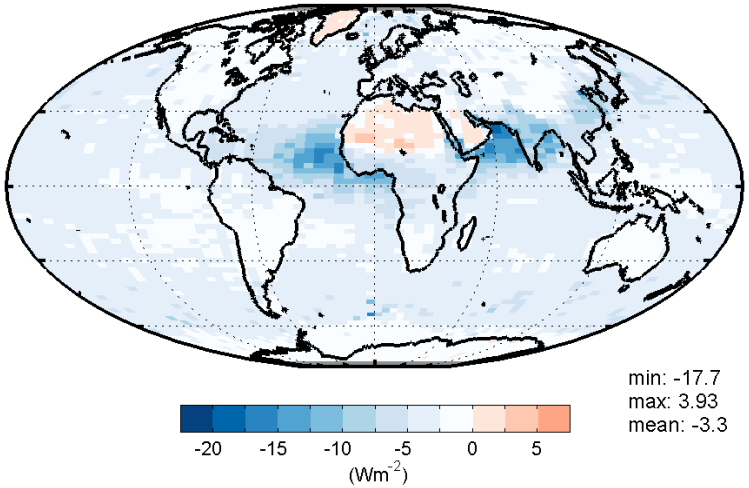
min: -15.92
max: 3.99
mean: -2.22

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 annual mean DRE

clear-sky	- 3.30 W/m^2
cloudy-sky	-1.93 W/m^2
all-sky	- 2.34 W/m^2

DRE smaller in cloudy skies than in clear skies

→ all-sky DRE < clear-sky DRE

C3M vs. Loeb & Smith (2005): clear-sky ocean-only

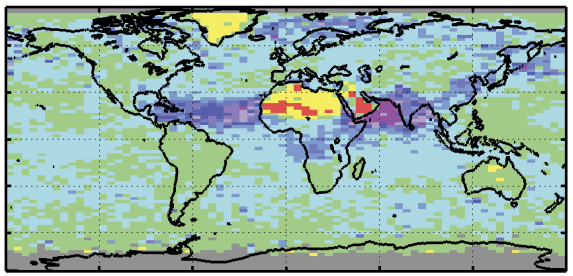
(annual-mean)

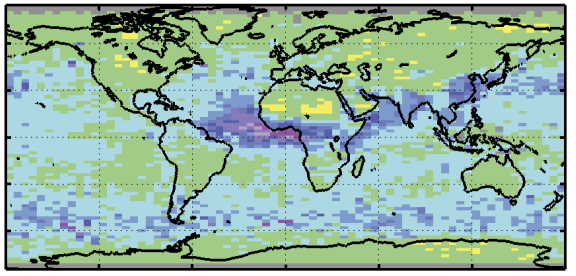
JJA 2008

DJF 2008

C3M

- 3.94 W/m²



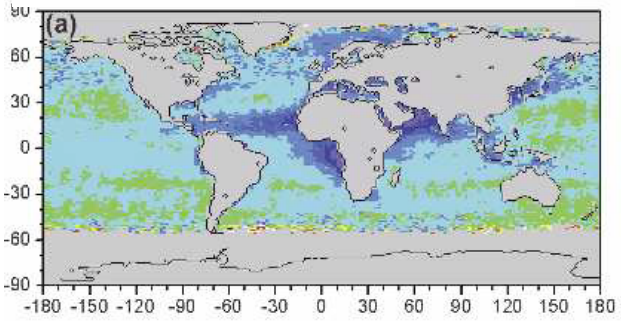


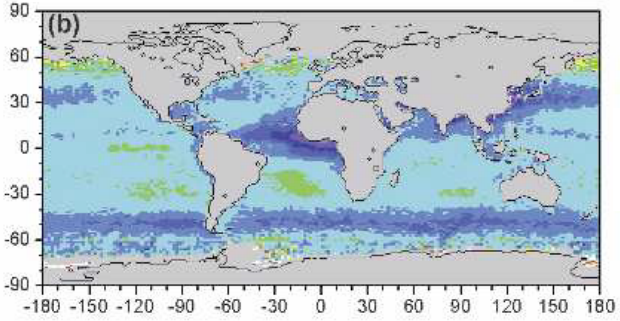
JJA 2000

DJF 2000/01

NOAA SSF cloud mask

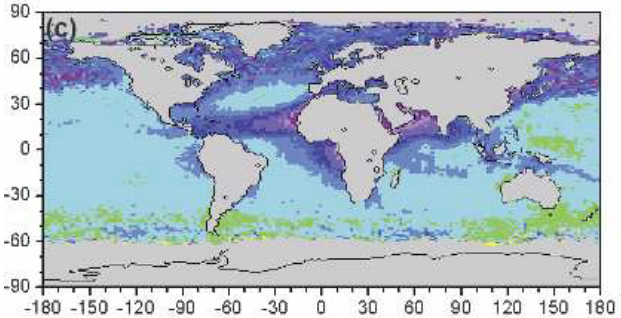
- 3.80 W/m²

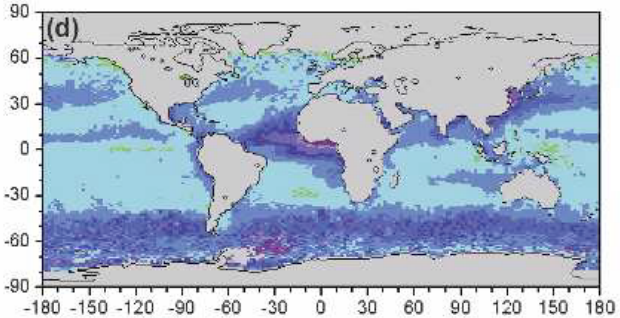


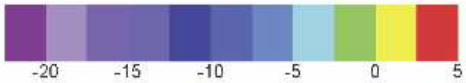


MOD04 cloud mask

- 5.46 W/m²







Aerosol Absorption

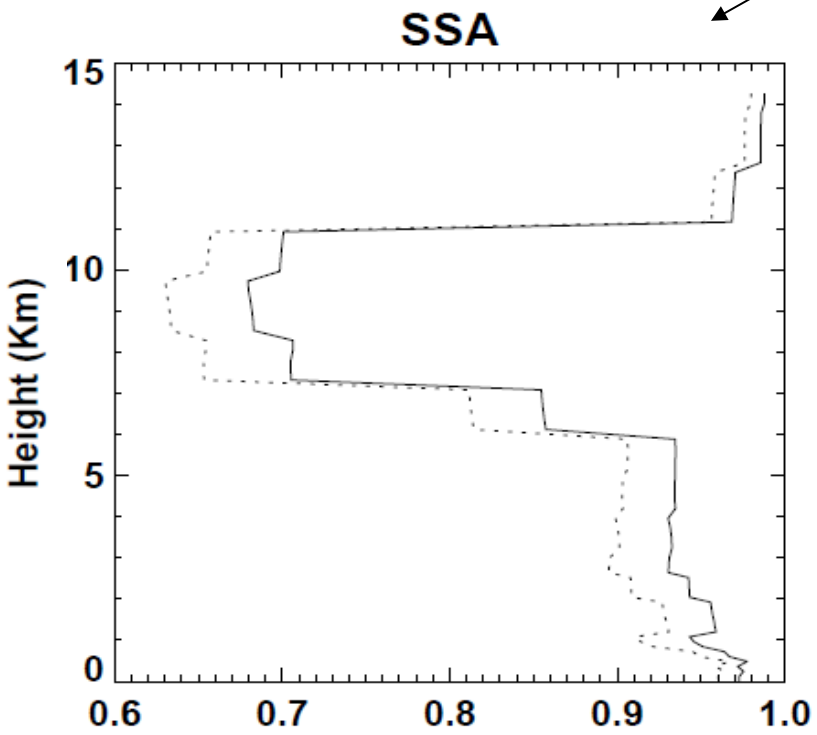
- Clear-sky ocean DRE within the ballpark of other estimates
- Largest uncertainties probably related to:
  - magnitude of AOD
    - C3M AOD somewhat less than MODIS Coll. 5
  - aerosol absorption
    - C3M tends to have too little aerosol absorption

Aerosol Single Scatter Albedo

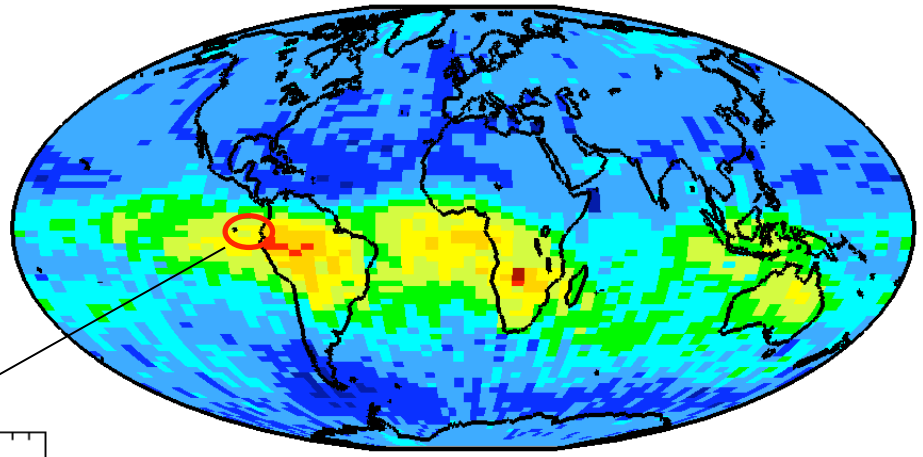
	C3M	Aeronet
Marine	0.98	0.975
Smoke	0.87 – 0.97	0.84 – 0.94
Dust	0.98	0.92 – 0.95
Pollution	0.92 – 0.98	0.93 – 0.98

Sensitivity Study

SSA of OPAC components of smoke are reduced by 0.06 (soot, soluble, insoluble)



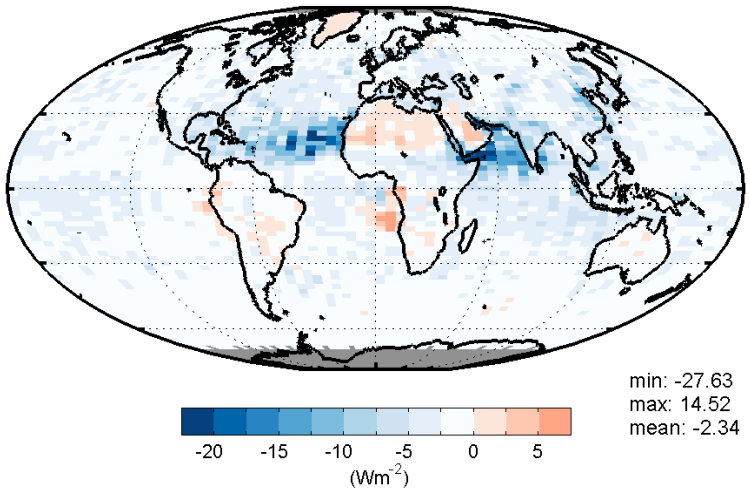
Column-Average Decrease in Single Scattering Albedo, Aug. 2008



% decrease in SSA

TOA Aerosol DRE

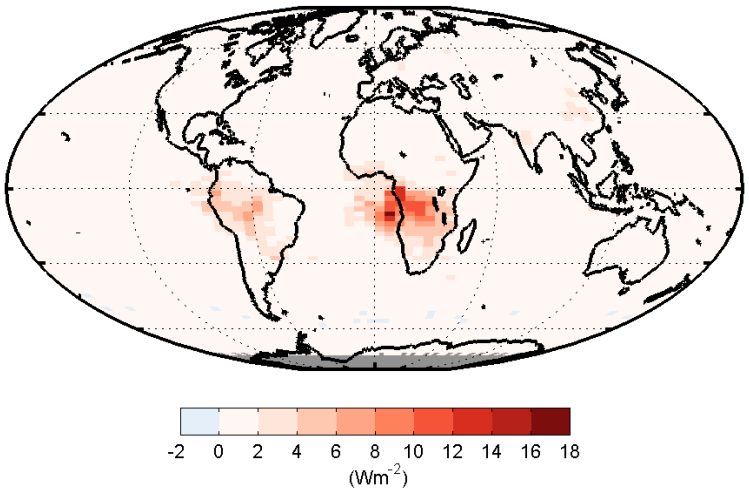
All-Sky, Aug. 2008



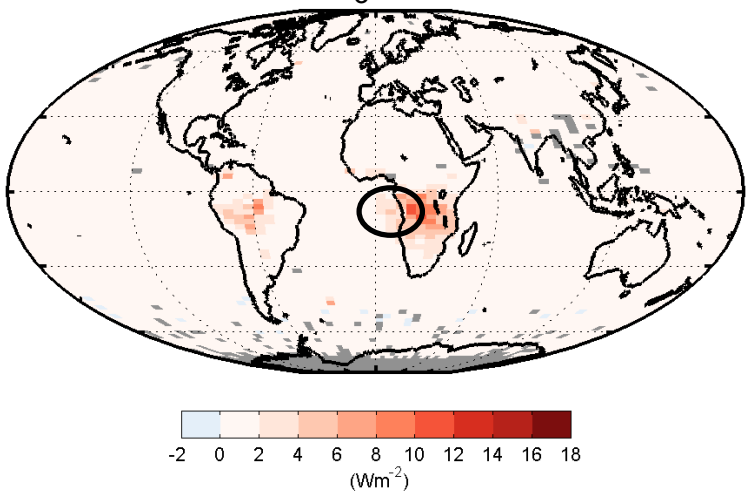
	global DRE (W/m^2) control	reduced ω_o
all-sky	-2.34	-2.06
clear-sky	-3.39	-3.20

	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

- Improved Level 3 aerosol product release next year
- Continue DRE sensitivity studies
  - Estimate uncertainties, measurement requirements
- Compute LW DRE, DRE at surface, atmospheric heating
- Compare with other recent results:
  - Chand et al. (2009): CALIOP + MODIS
  - Oikawa & Nakajima (in press): CALIOP + MODIS, vs SPRINTARS
  - L'Ecuyer: FLXHR-Lidar
  - Redemann: MODIS, PARASOL, OMI, CALIOP
- Longer term: DARF
  - Estimate anthropogenic fraction