Retrieved vertical distribution of Saharan dust and comparison to models over the northern tropical Atlantic

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Dust Aerosol

- Absorb and scatter visible and infrared radiation
- Act as cloud condensation nuclei

- Single scattering albedo
- Vertical profile

- RF due to dust aerosol is -0.1±0.2 Wm^{-2} (IPCC AR4)
- RF due to dust aerosol is -0.6 - 0.4 Wm^{-2} (IPCC TAR)

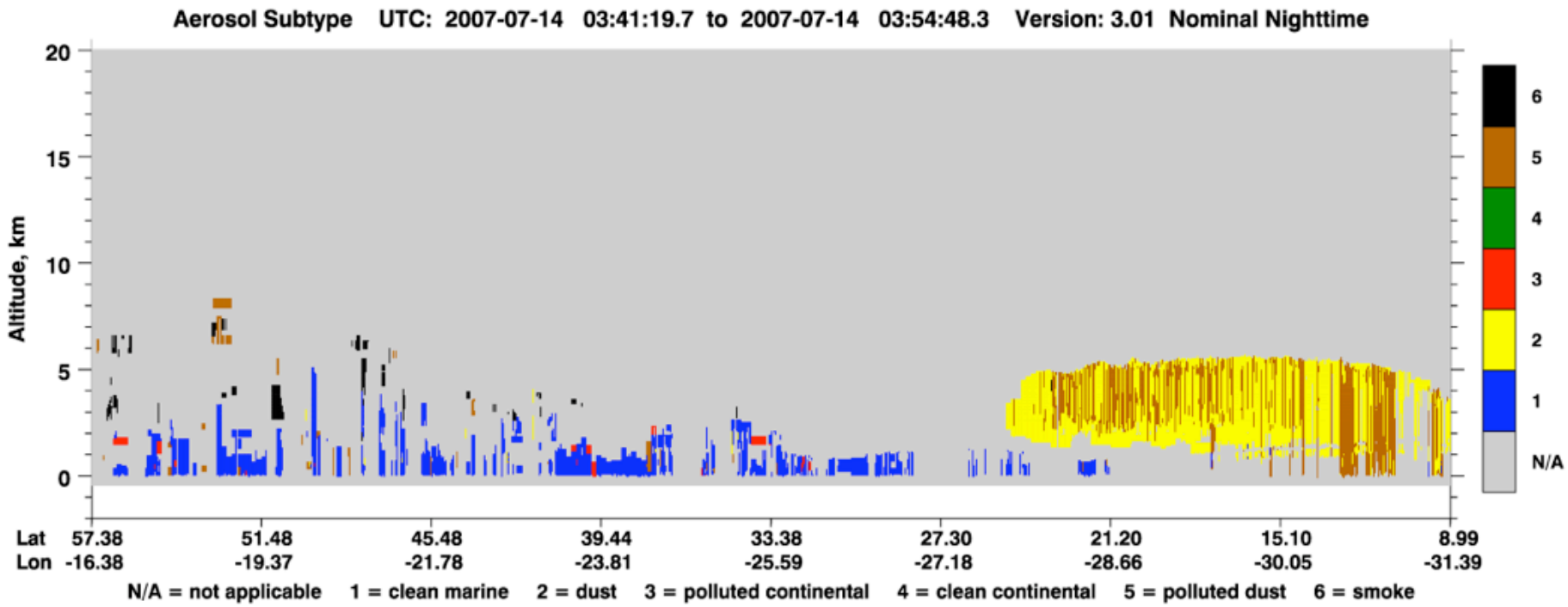
Saharan dust off West Africa over the Atlantic

(Image courtesy Jacques Descloitres, MODIS Rapid Response Team, NASA GSFC)

CALIPSO Level 1b and Level 2 Aerosol Products

	Level 1b	Level2
Vertical resolution	30 m resolution from surface to 8.3 km	8 layers of different resolution from surface to 40 km
Product	βs at 532 nm	βs at 532 nm, layer AOD at 532 nm, vertical feature mask

Aerosol Subtypes



Models

- The atmospheric component of GFDL coupled general circulation model (**AM3**)
- Model of Atmospheric Transport and Chemistry (**MATCH**)
- Goddard Chemistry Aerosol Radiation and Transport (**GOCART**)

Models

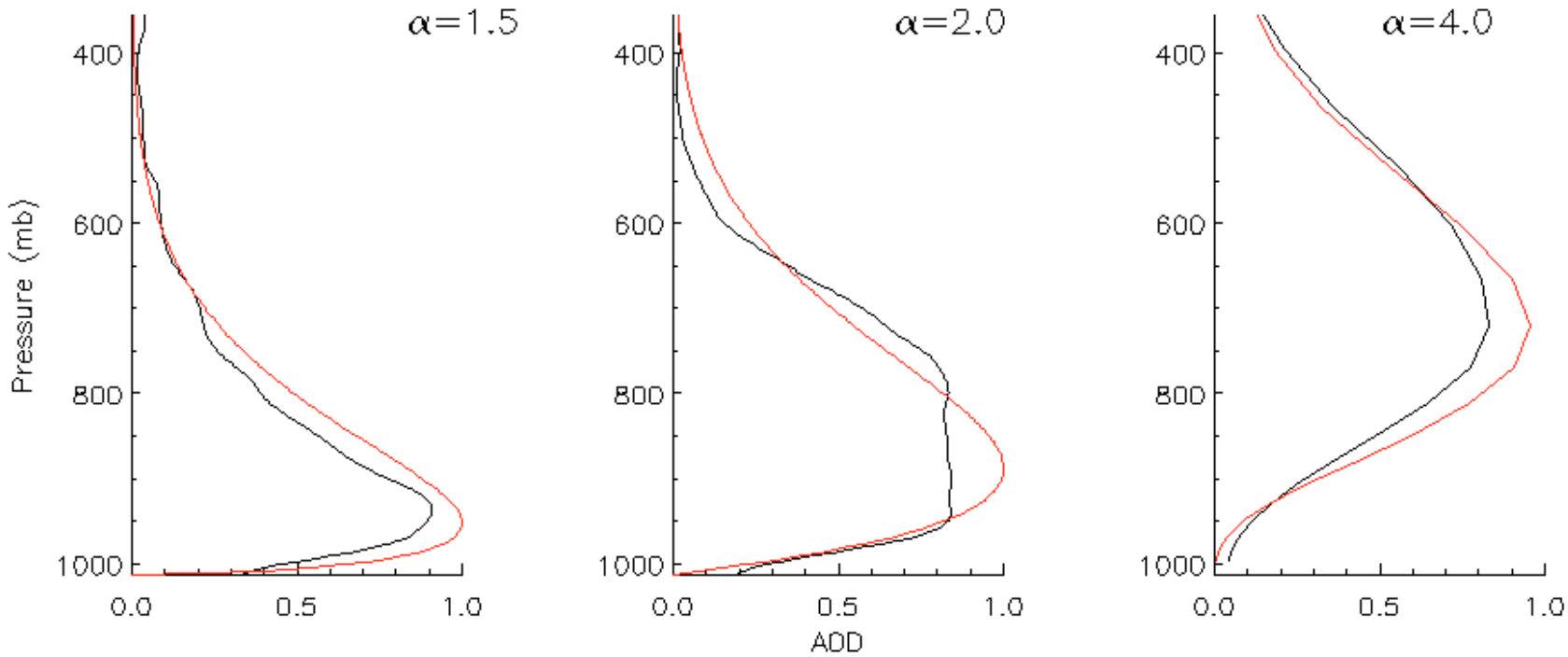
	AM3	MATCH	GOCART
Size distribution (μm)	0.1-10	0.1-10	0.1-6
Resolution (degree)	2.5 lon by 2 lat	1.875 lon by 1.875 lat	2.5 lon by 2 lat
Time period	Jun 06 to Dec 09	Jun 06 to Dec 09	Jun 06 to Dec 07
Driving source	Monthly mean SST	NCEP reanalysis1	GEOS 4

Gamma Distribution

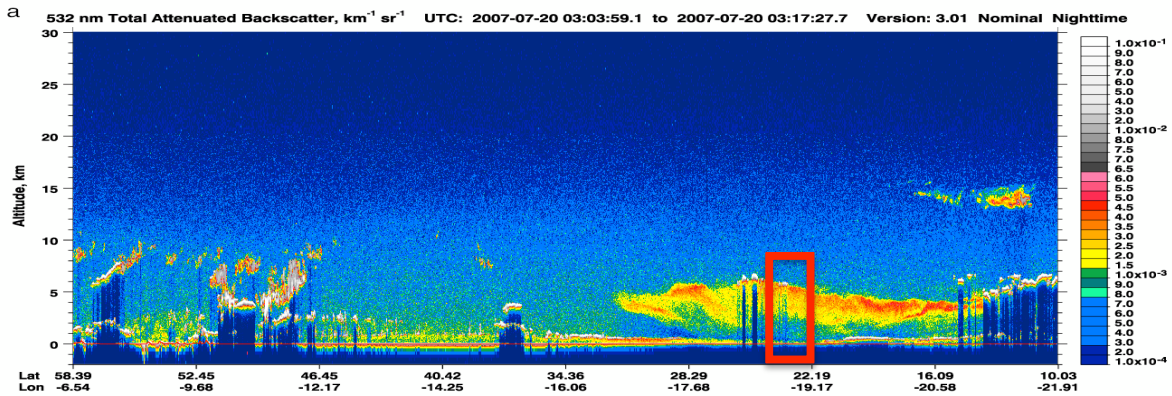
$$y = \frac{(x/\beta)^{\alpha-1}\exp(-x/\beta)}{\beta\Gamma(\alpha)}$$

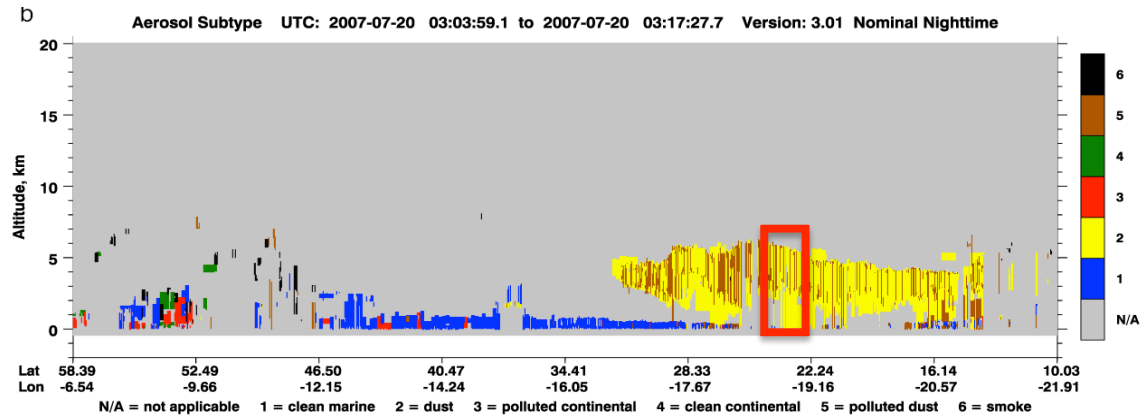
α shape parameter
β scale parameter
x vertical coordinate
y DAOD

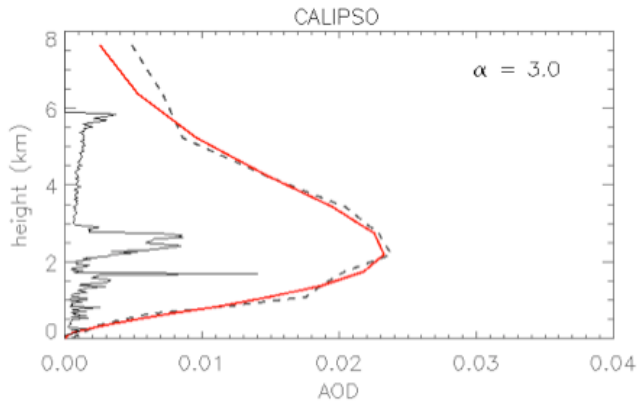
Gamma Distribution Fit to Dust Profiles



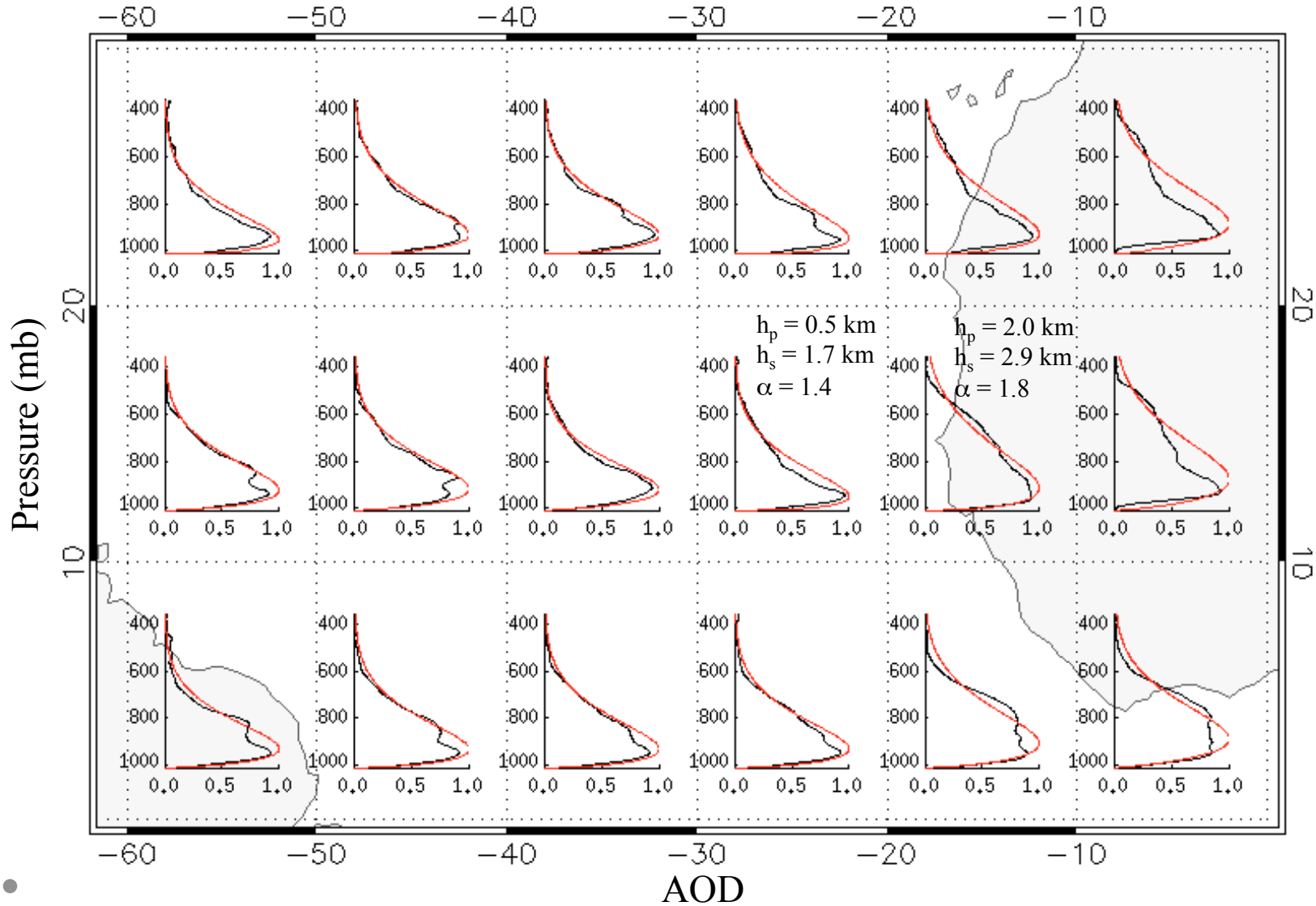
A Case Study


a
532 nm Total Attenuated Backscatter, km-1 sr-1 UTC: 2007-07-20 03:03:59.1 to 2007-07-20 03:17:27.7 Version: 3.01 Nominal Nighttime
Altitude, km
Lat 58.39 52.45 46.45 40.42 34.36 28.29 22.19 16.09 10.03
Lon -6.54 -9.68 -12.17 -14.25 -16.06 -17.68 -19.17 -20.58 -21.91

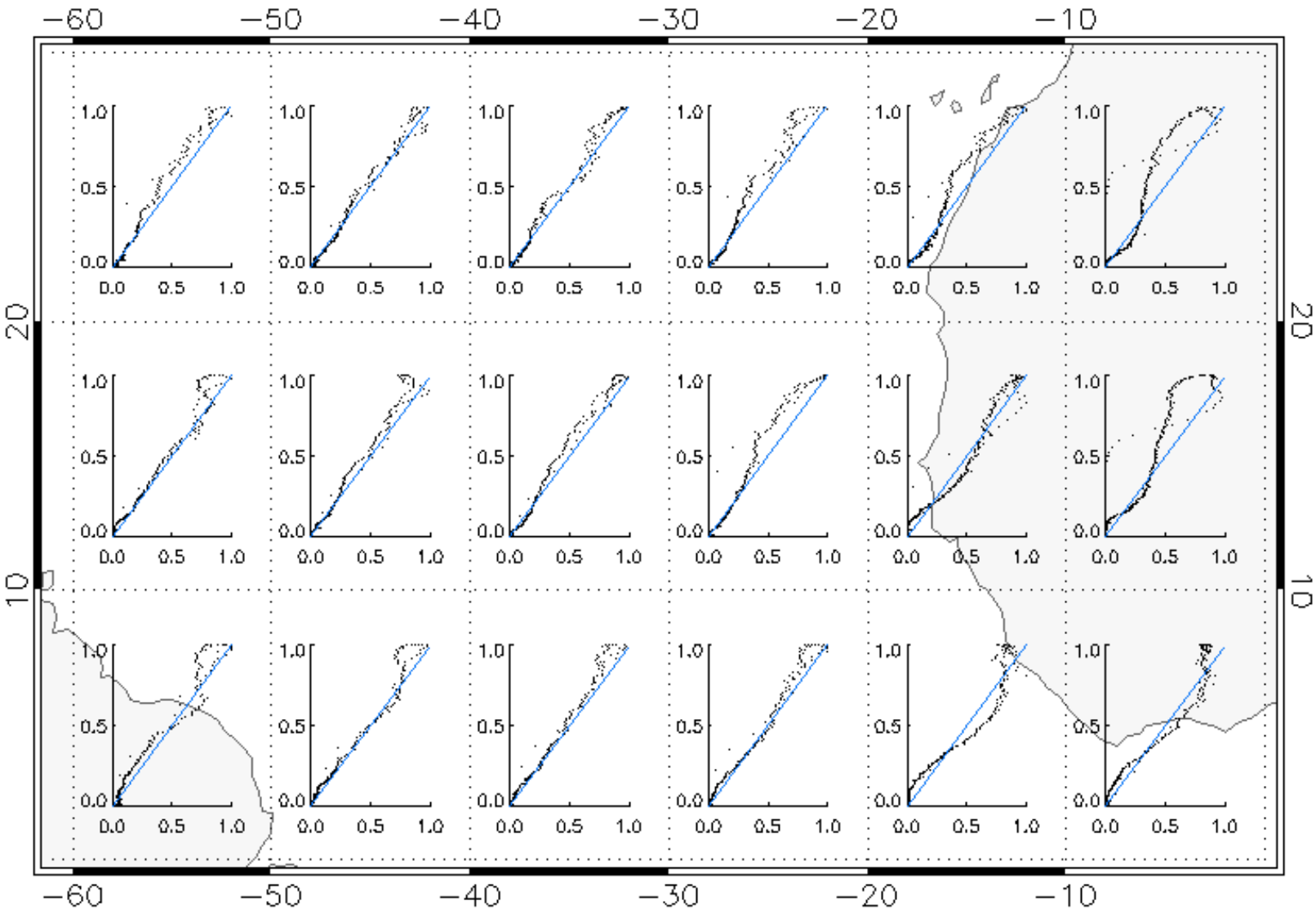

b
Aerosol Subtype UTC: 2007-07-20 03:03:59.1 to 2007-07-20 03:17:27.7 Version: 3.01 Nominal Nighttime
Altitude, km
Lat 58.39 52.49 46.50 40.47 34.41 28.33 22.24 16.14 10.03
Lon -6.54 -9.66 -12.15 -14.24 -16.05 -17.67 -19.16 -20.57 -21.91
N/A = not applicable 1 = clean marine 2 = dust 3 = polluted continental 4 = clean continental 5 = polluted dust 6 = smoke


CALIPSO
α = 3.0
height (km)
AOD

Long-term mean DAOD profiles



Evaluation of Gamma Distribution



$r^2 = 0.90$, bias = 0.03

A First Order Estimate of the Vertical Profile of DAOD

$$\frac{DAOD}{W} = \frac{(h/\beta)^{\alpha-1}\exp(-h/\beta)}{\beta\Gamma(\alpha)}$$

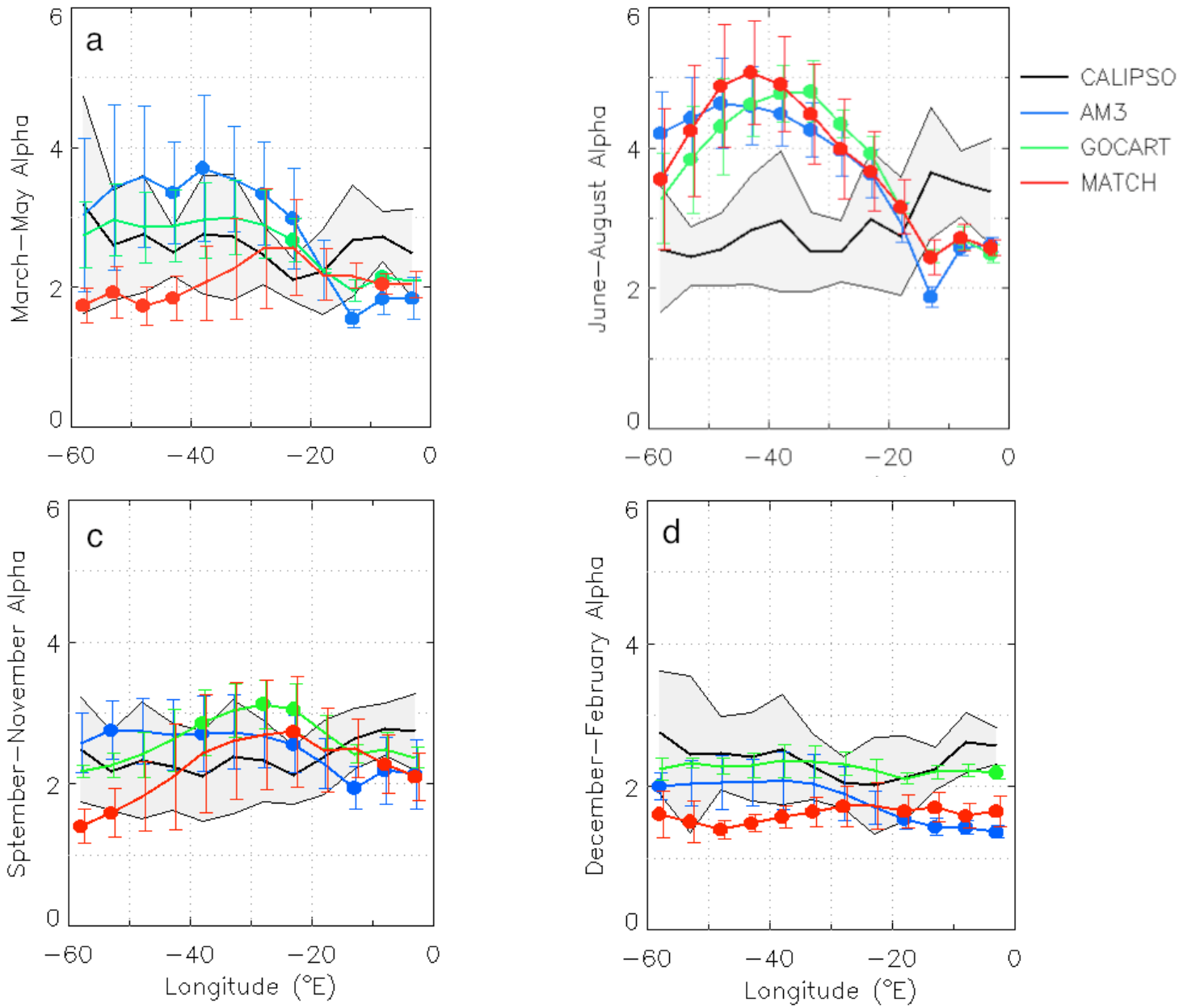
$\alpha = 1.73$

$\beta = 1.13$

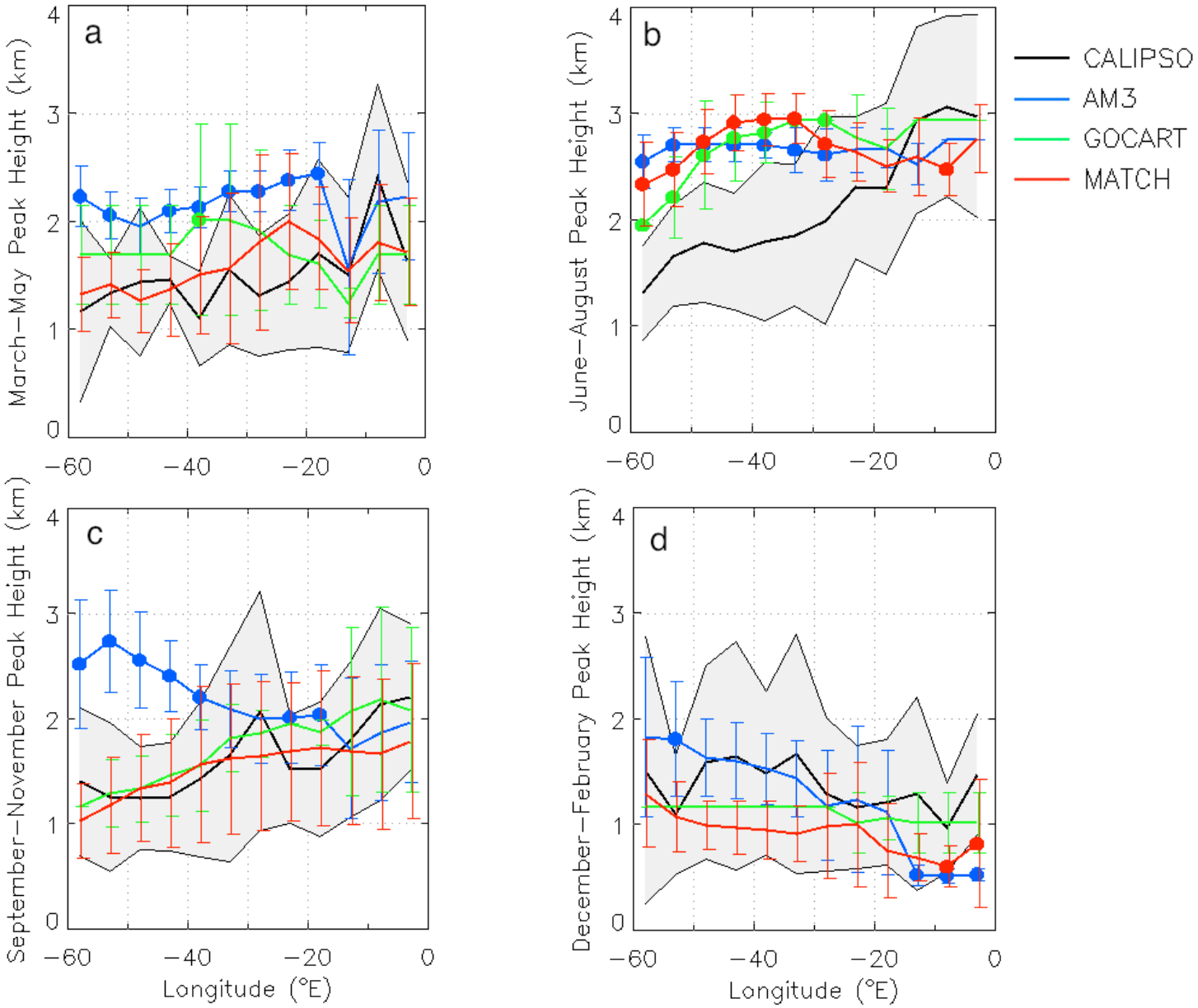
$W = 1.6 \times 10^{-3}$ (regional mean of DAOD)

h: 0 – 8.0 km

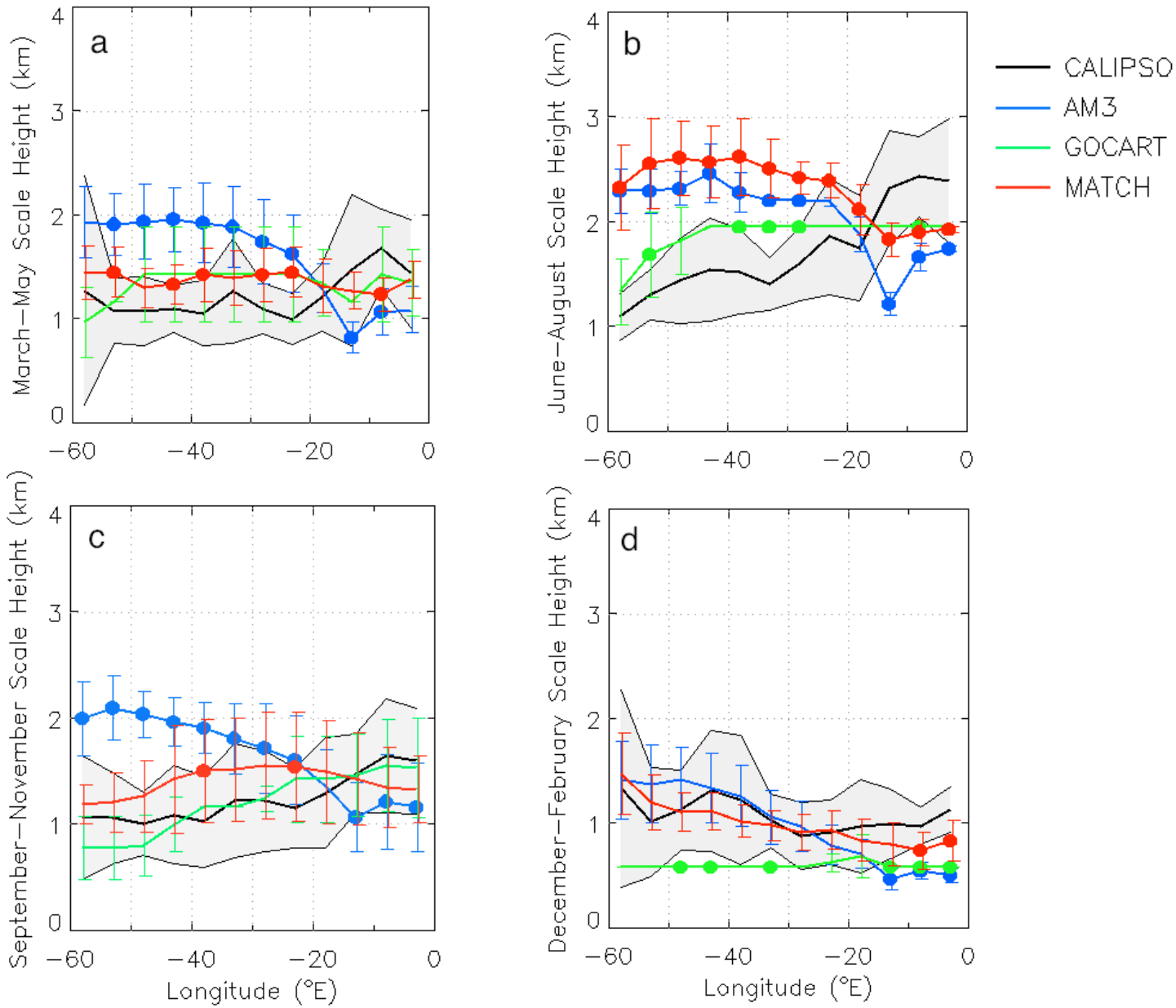
Alpha Values



Peak Height


a
b
c
d
March–May Peak Height (km)
June–August Peak Height (km)
September–November Peak Height (km)
December–February Peak Height (km)
Longitude (°E)
CALIPSO
AM3
GOCART
MATCH

Scale Height



Summary

- Develop a novel method for describing the vertical profile of dust.
- Agreement between the models and observation is within uncertainty estimates in the boreal spring, fall and winter seasons.
- Models have dust at higher altitudes than are in the observations during the summer months.
- During the summer model estimates of dust longwave forcing at the top of the atmosphere may be biased high.