Linking Optical Properties of Dust to Source Regions Over Africa and the Middle East

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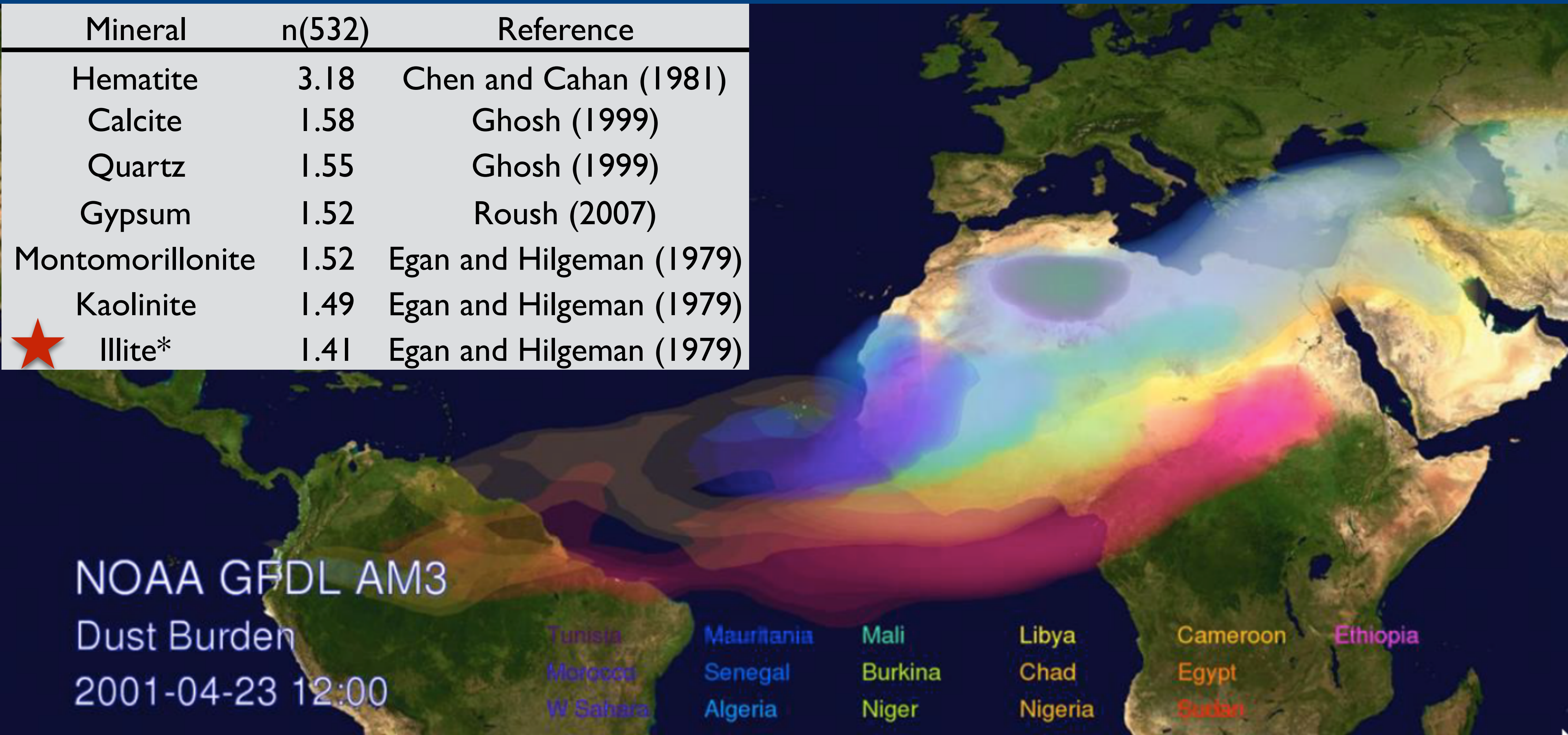
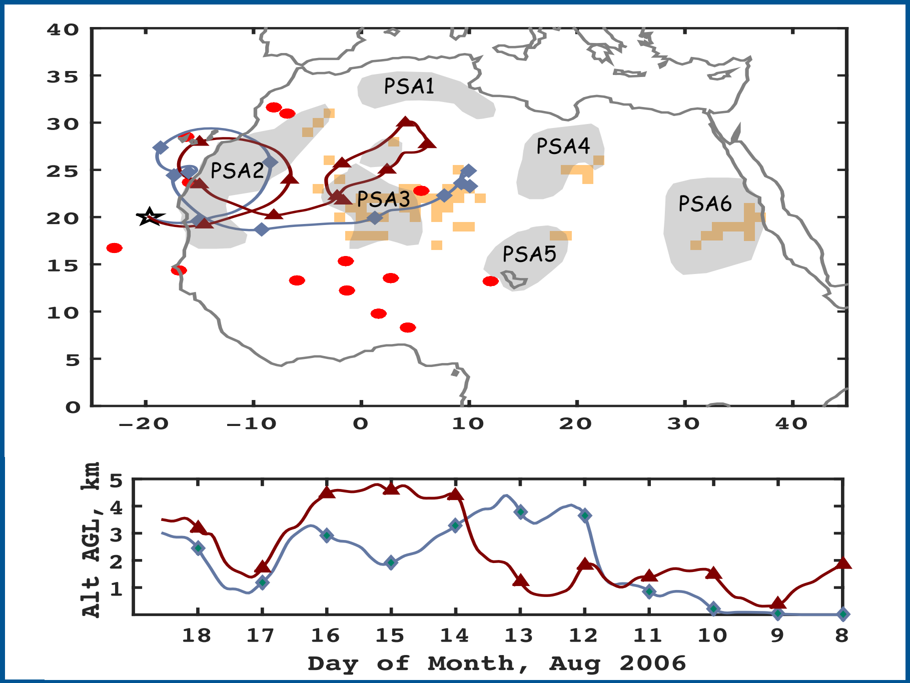
Mineral	n(532)	Reference
Hematite	3.18	Chen and Cahan (1981)
Calcite	1.58	Ghosh (1999)
Quartz	1.55	Ghosh (1999)
Gypsum	1.52	Roush (2007)
Montomorillonite	1.52	Egan and Hilgeman (1979)
Kaolinite	1.49	Egan and Hilgeman (1979)
★ Illite*	1.41	Egan and Hilgeman (1979)



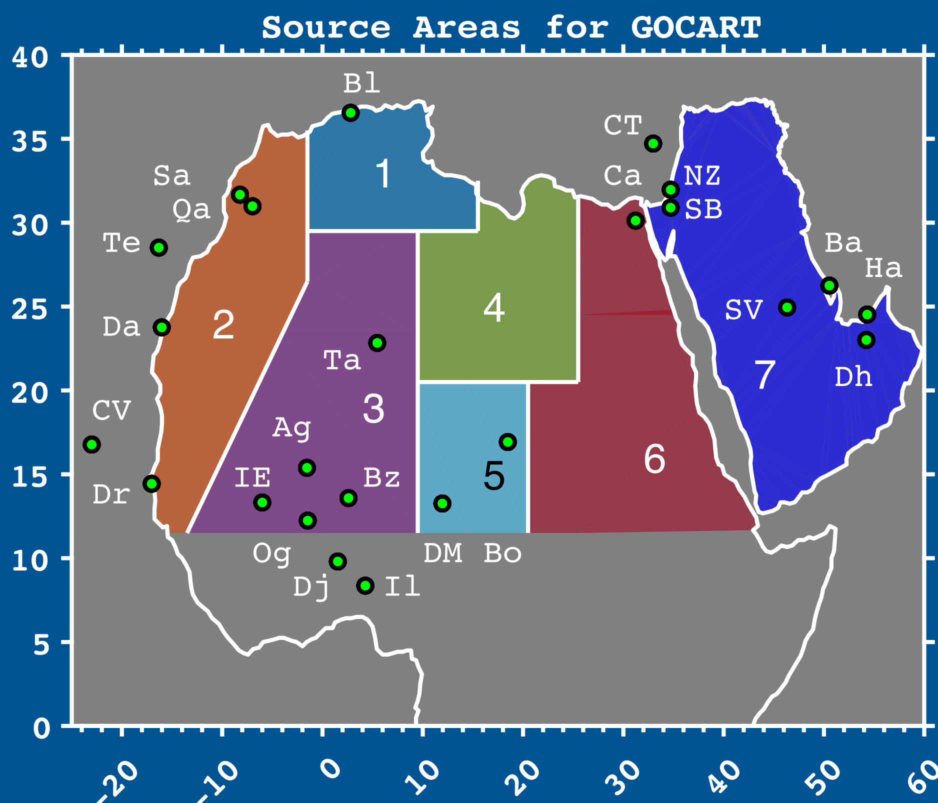
African dust sources presented by Joe Prospero at DUST 2014. Model run by Paul Ginoux

How can we Link Measurements to Potential Source Areas?

- Backtrajectories can not quantify the proportion of dust originating from different Potential Source Areas (PSAs).
- Alternative Approach: "Tag" source regions in a transport model (GOCART).



PSA regions from Formenti (ACP, 2011)



Use Generalized Matrix Inverse (GMI) with AERONET retrievals to assign optical properties to each region

GOCART model runs allow us to write:

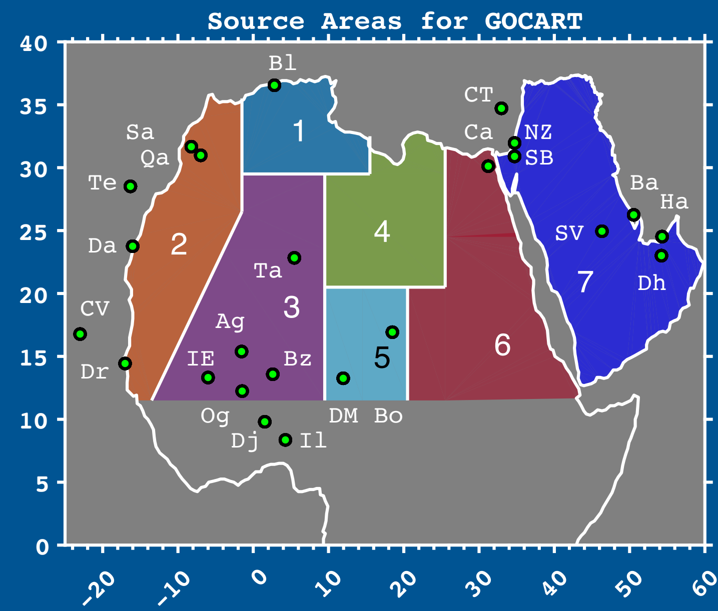
✓ ✓

$$\vec{n}_a = \mathbf{F}\vec{n}_p$$

Real refr index column vector of 7 +1 source regions

M X 8 matrix of PSA fractions at AERONETs (GOCART, 2006-2016)

Real refr index of M AERONET retrievals with $AOT(440) \geq 0.4, dp \geq 0.25, fvf < 0.05$



Have M = 1388, so overconstrained (i.e., M > 8). Solve for $\vec{n}_p$

$$\widehat{n}_p = (\mathbf{F}^t\mathbf{F})^{-1}\mathbf{F}^t\vec{n}_a$$

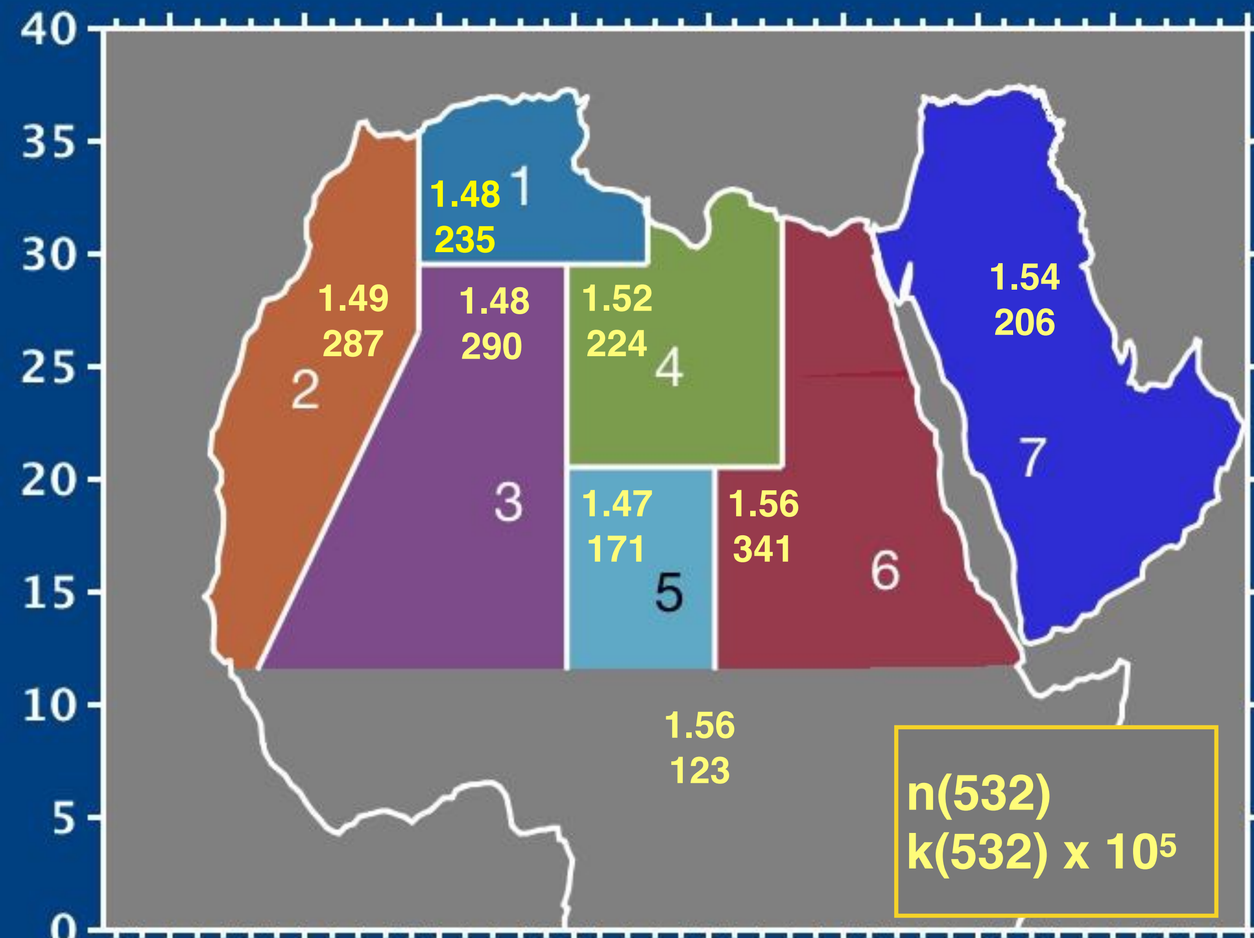
$$\widehat{k}_p = (\mathbf{F}^t\mathbf{F})^{-1}\mathbf{F}^t\,\vec{k}_a$$

Regional Refractive Indices from GMI

$$\widehat{n}_p = (F^t F)^{-1} F^t \overrightarrow{n_a}$$

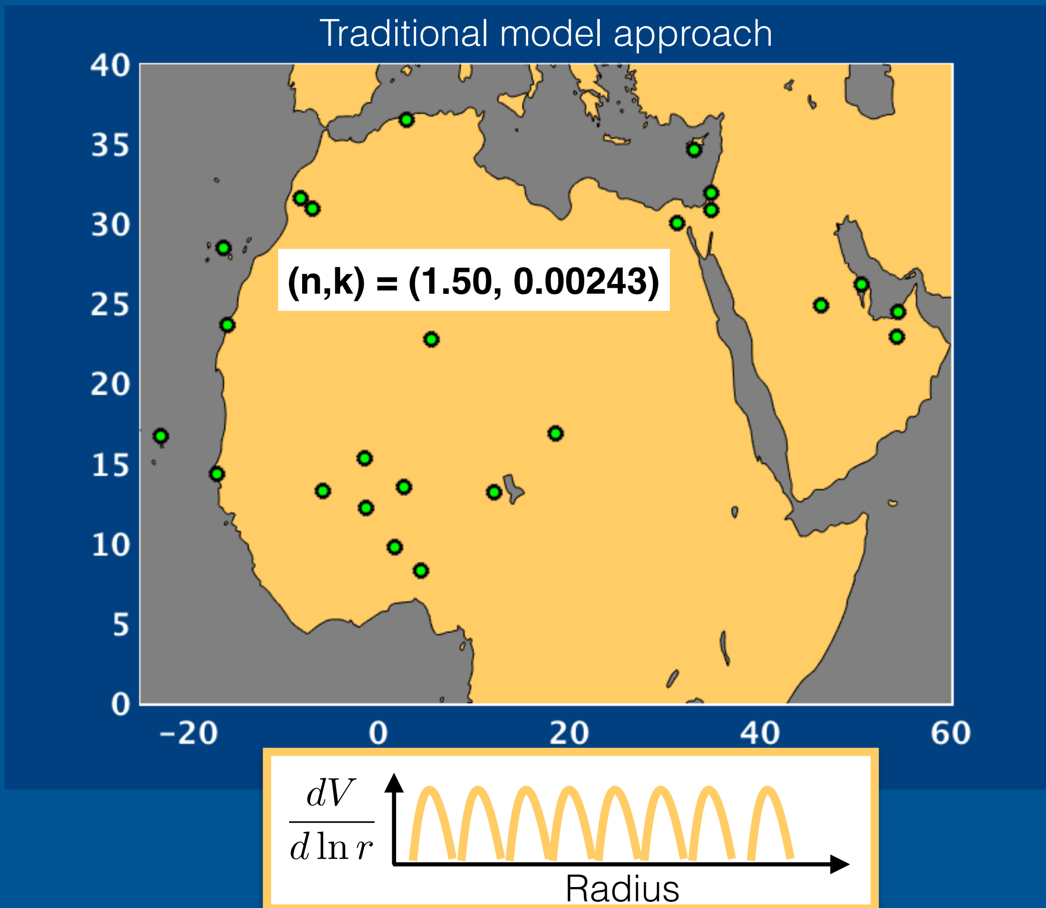
$$\widehat{k}_p = (F^t F)^{-1} F^t \overrightarrow{k_a}$$

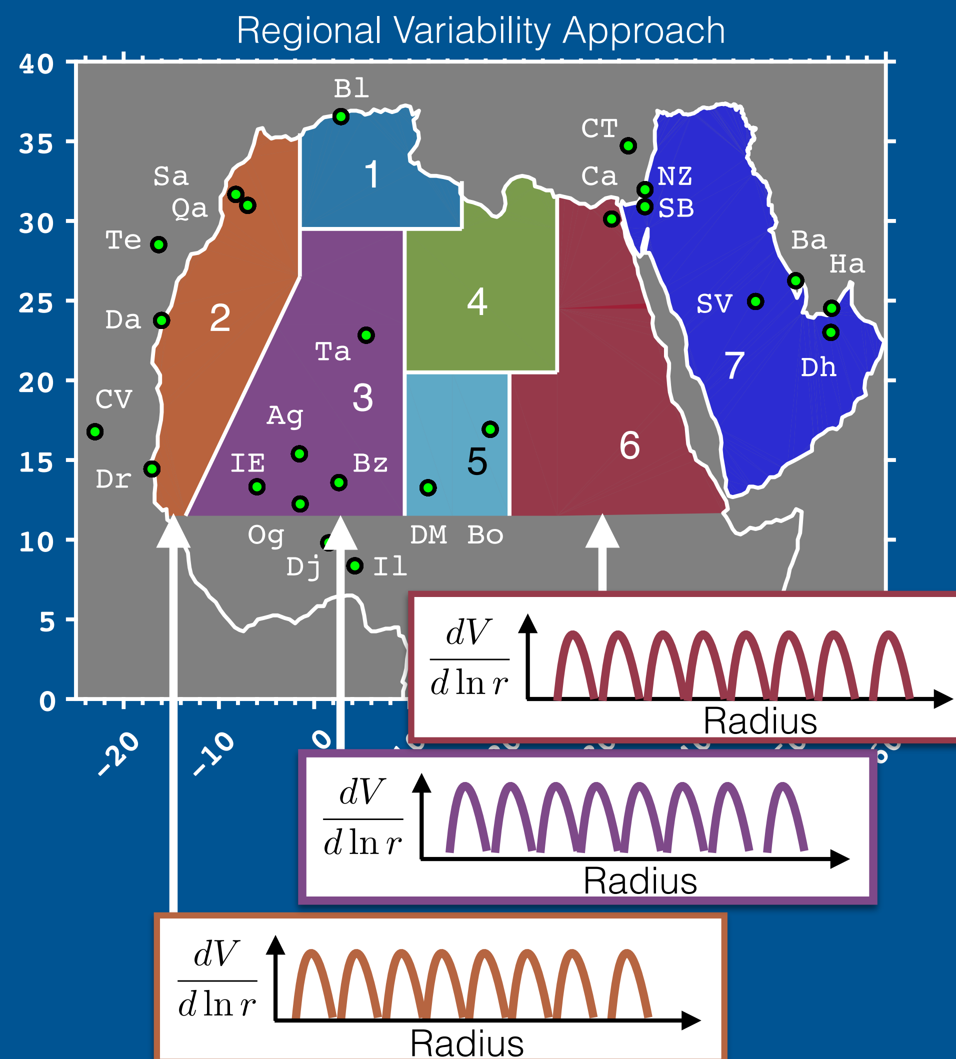
Compute optics
(ext, ssa, lidar ratio, etc.)
from $(\widehat{n}_p, \widehat{k}_p)$ and
modeled size distributions.



	n	k x 10^5
Chin (Ann. Geophys, 2009); GOCART, 550 nm	1.53	550
D. Kim (ACP, 2011), from AERONET, 550 nm	1.50	243
AERONET *minimum*		50

Compute optics using GOCART size modes (extinction, ssa, Sa, etc.)

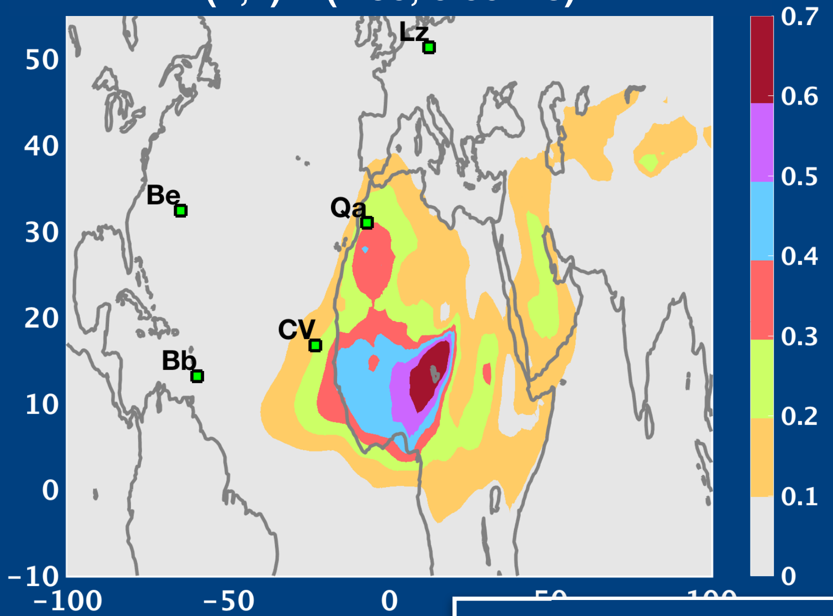


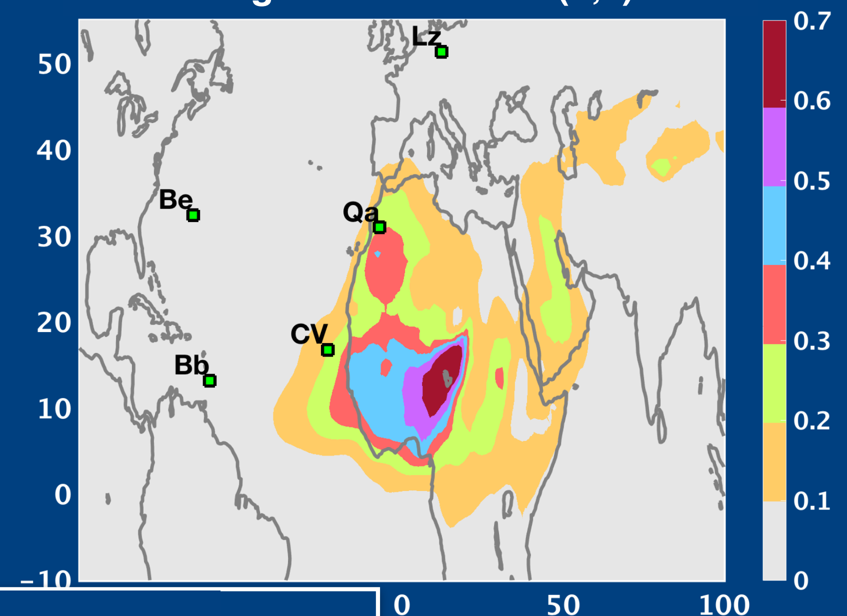


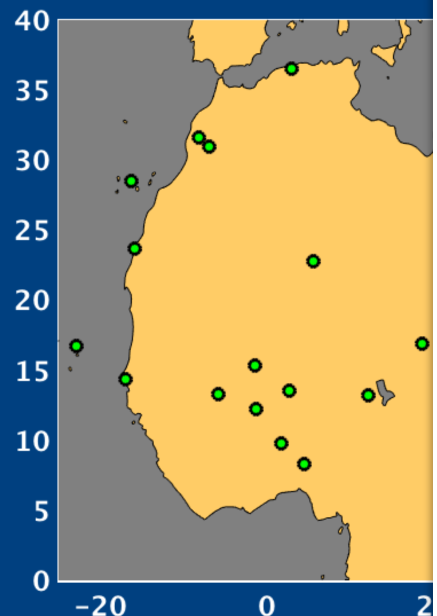
- GOCART's eight lognormal size distributions (Chin, JAS 2002; Ann. Geophys, 2009)
- DLS 2.2 Spheroids (Dubovik, GRL 2002; JGR 2006)
- Regional variability approach requires separate optics computations for each source

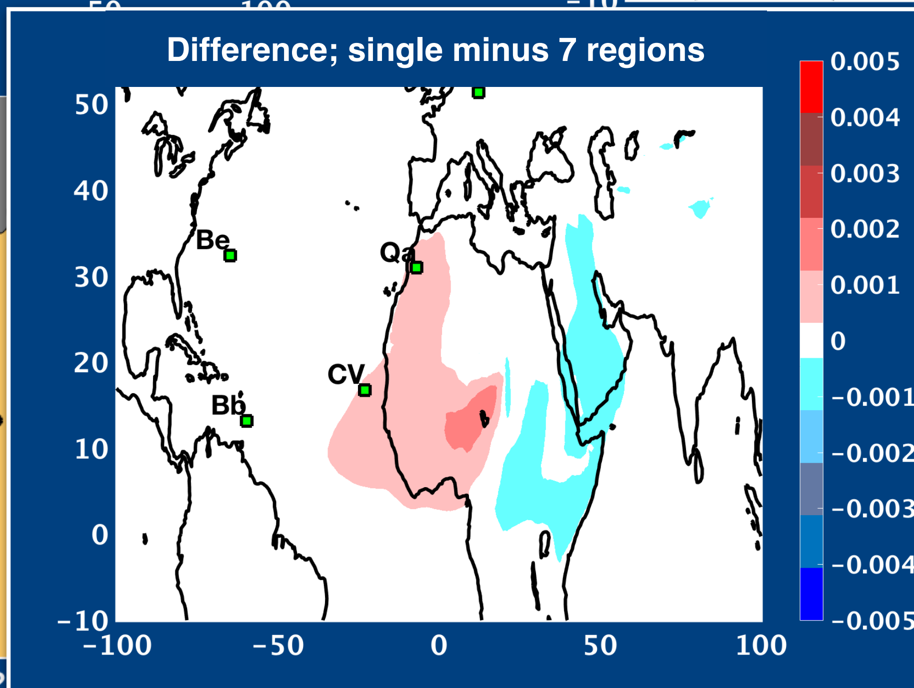
Modeled Extinction (SAMUM 2)

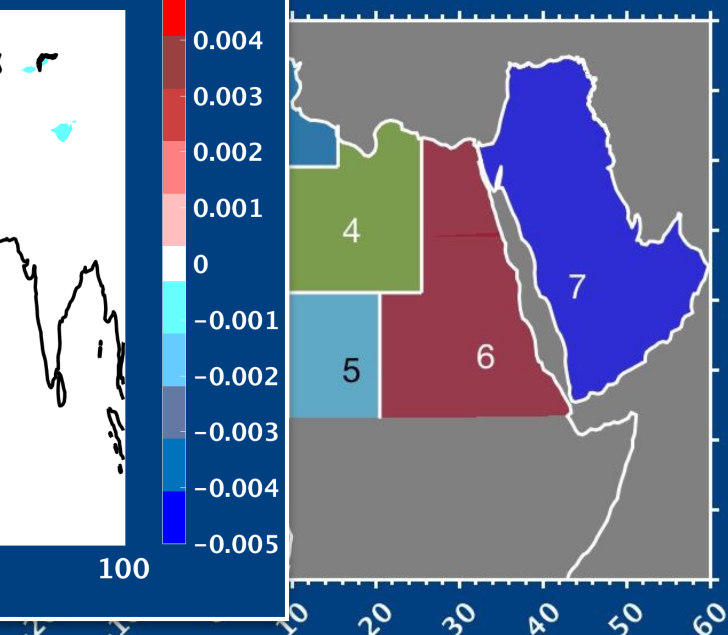
February 2008





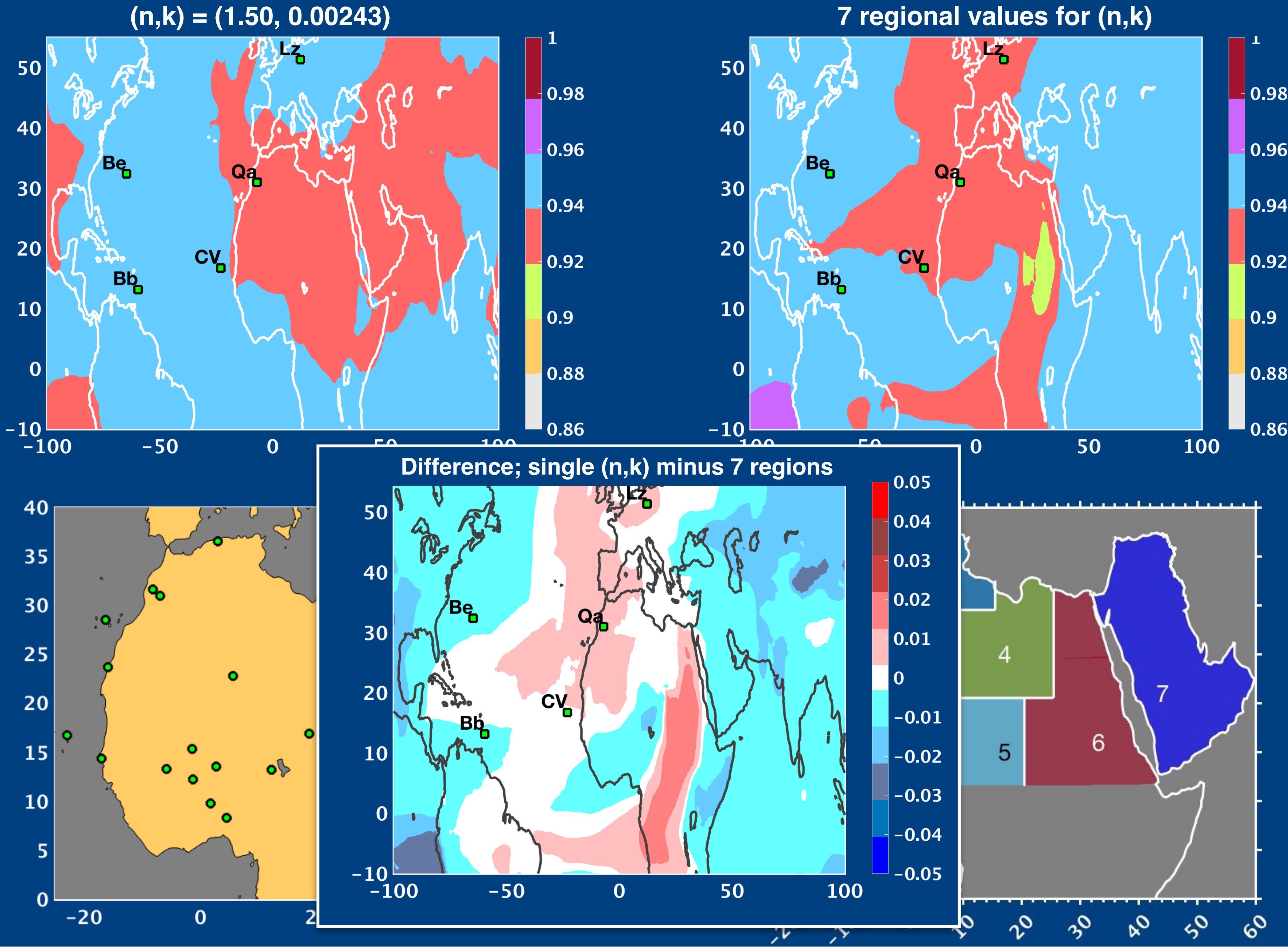






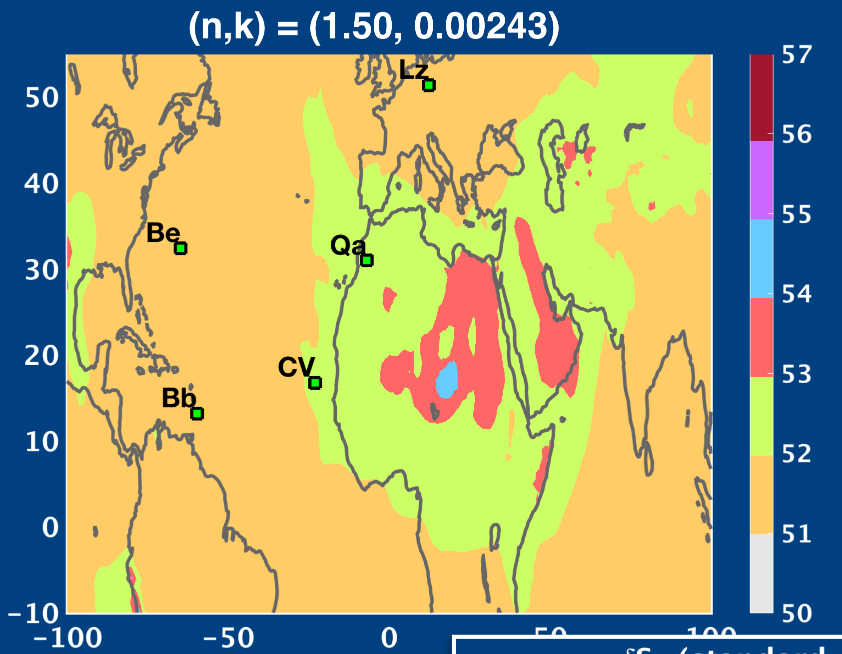
Modeled Single Scatter Albedo (SAMUM 2)

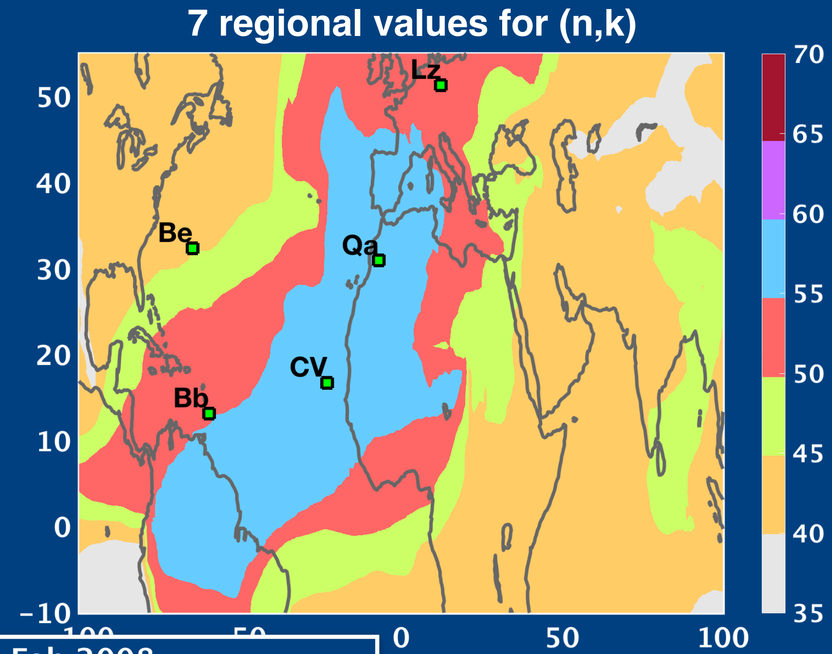
February 2008

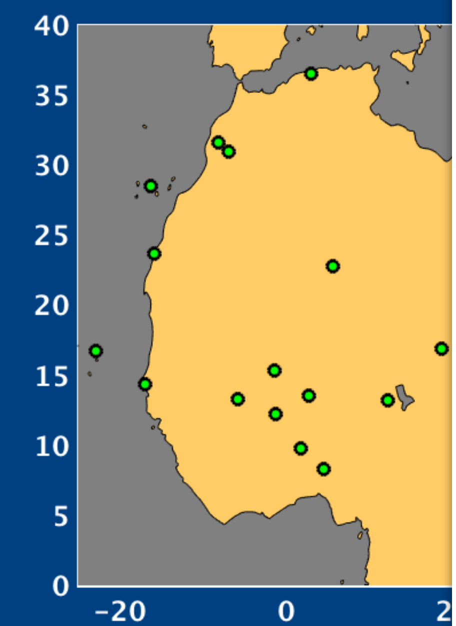


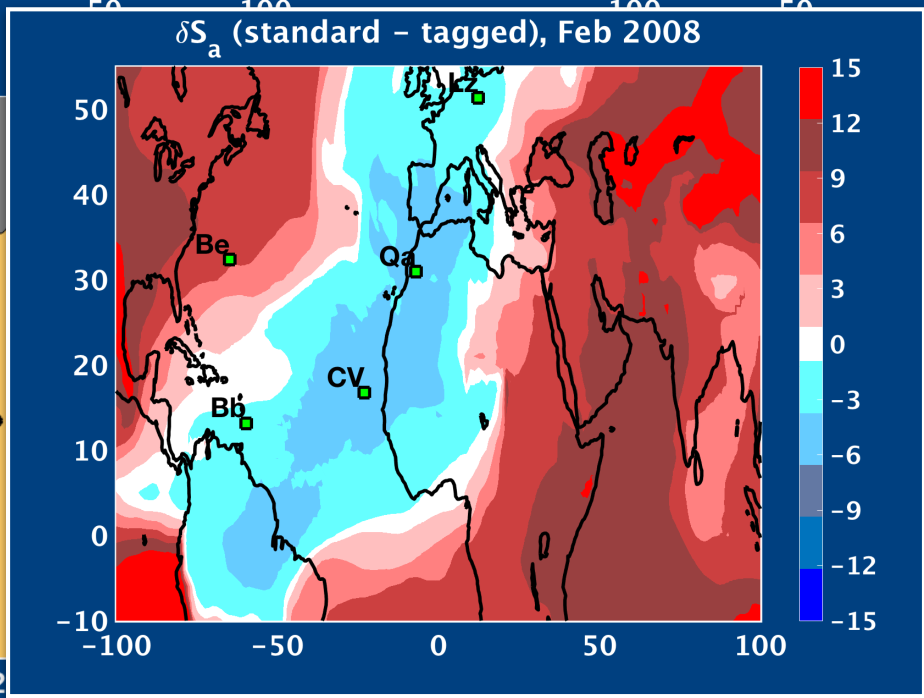
Modeled Lidar Ratio (SAMUM 2)

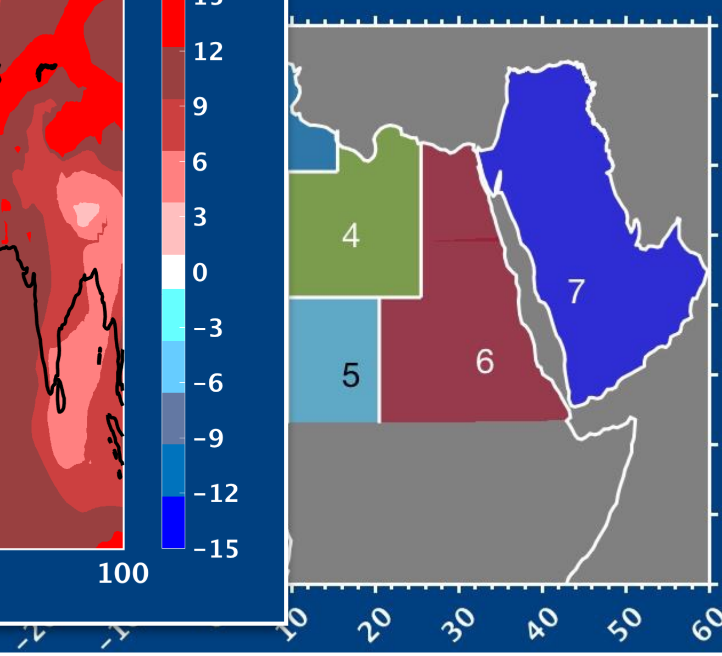
February 2008











Recap

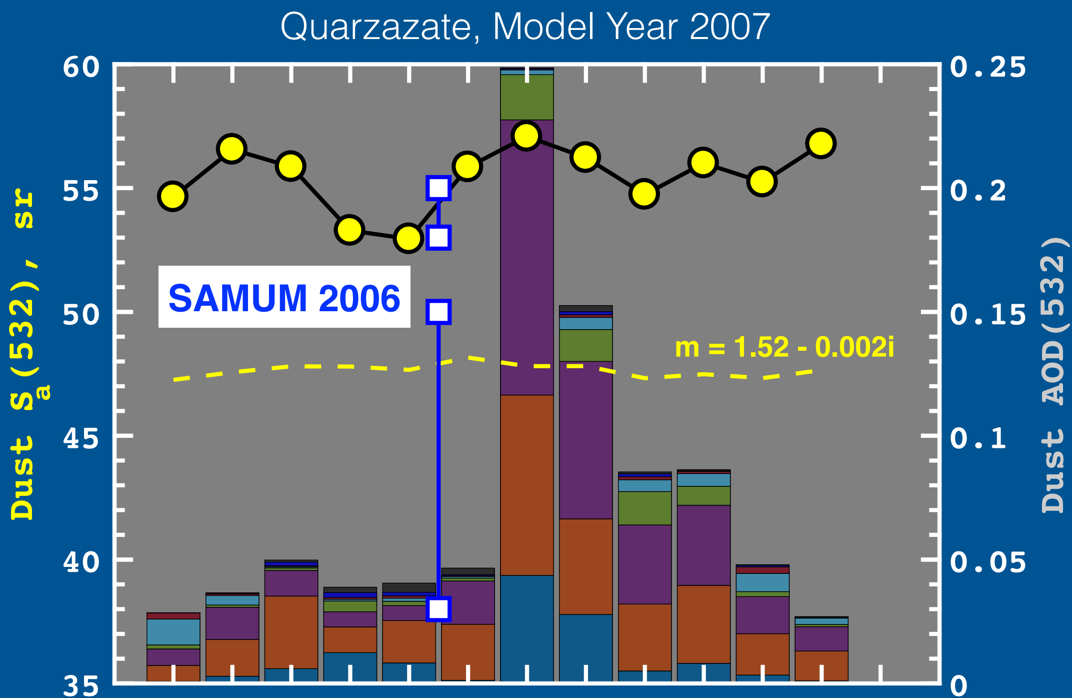
- We used the GOCART aerosol transport model and AERONET with a Generalized Matrix Inverse to assign refractive indices to seven regions in Africa and Middle East.
- Then we re-computed GOCART optics using the seven regionally variable refractive indices and compared optics to using a single "standard" dust everywhere.
- Model output indicates that incorporating regional mineralogy (i.e., regional dust refractive indices) has little effect on dust AOD.
- However, single-scatter albedo changes by up to ~0.03 and lidar ratio changes by up to ~15 sr.

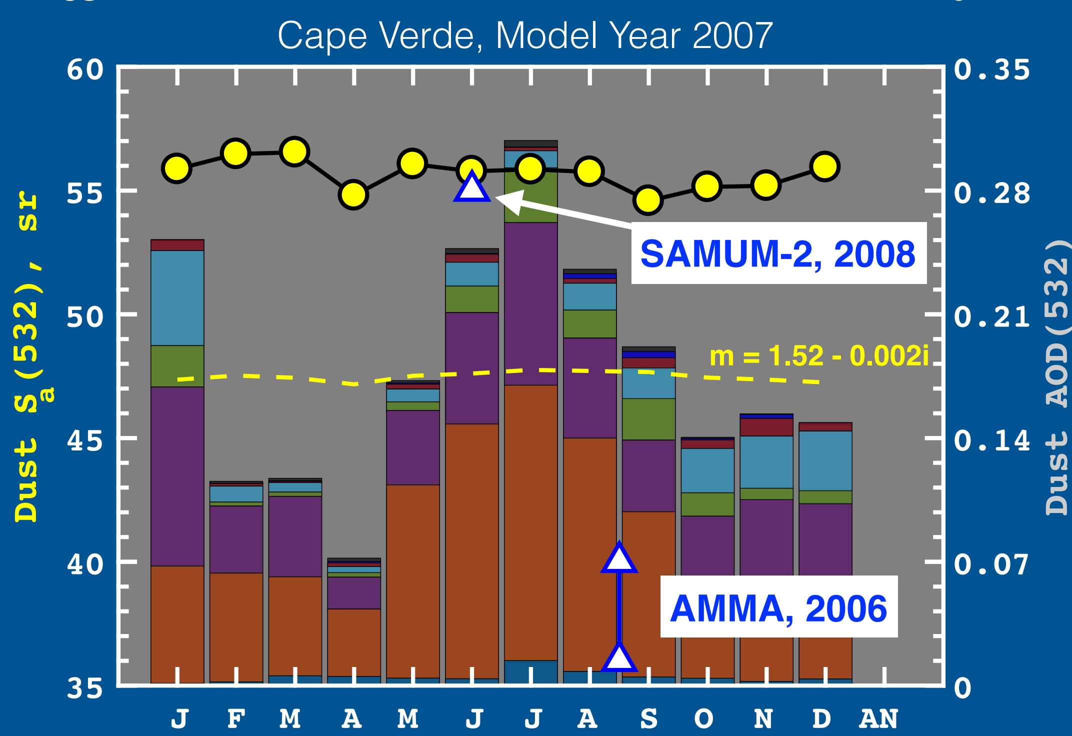
Acknowledgements

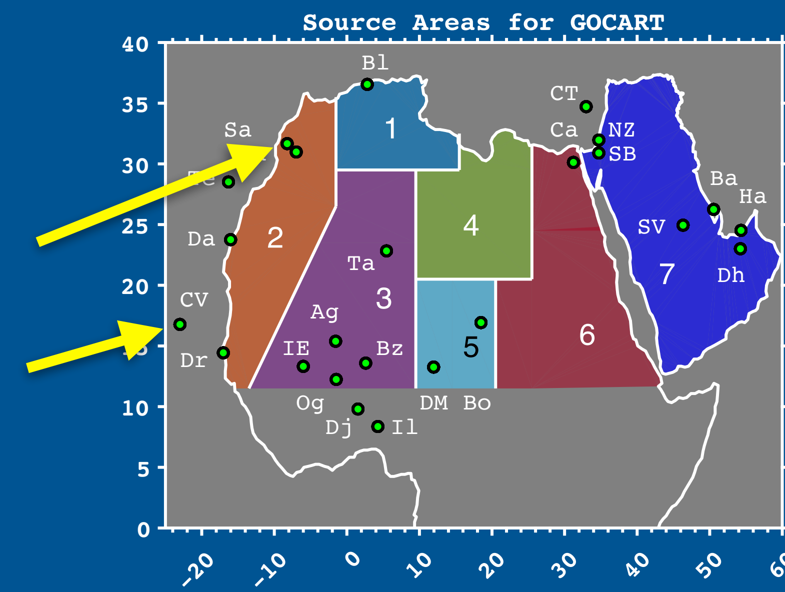
- We appreciate the efforts of the AERONET and PHOTONS (Service d'Observation from LOA/USTL/CNRS) principal investigators, and the entire AERONET, PHOTONS, and CALIPSO teams.
- We thank O. Dubovik and T. Lapyonok for providing the forward scattering code.
- This work is supported by NASA's Earth Science Enterprise through the CALIPSO project.

Appendix

Field Missions with Lidar Ratio Measurements







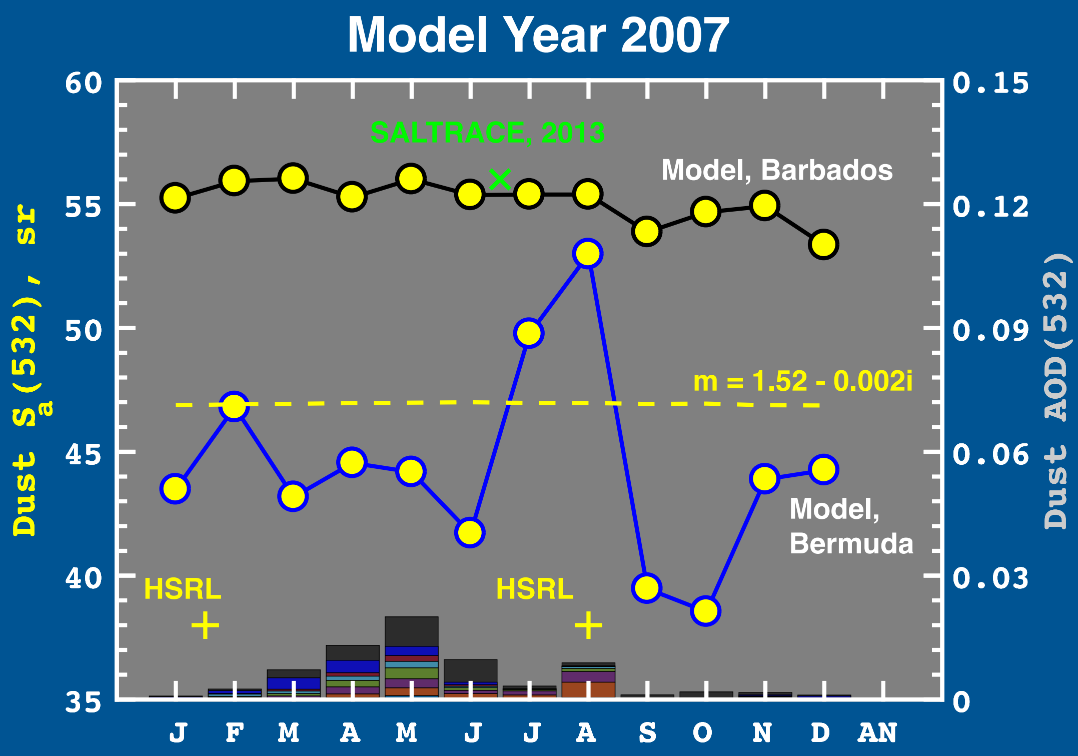
Citations:

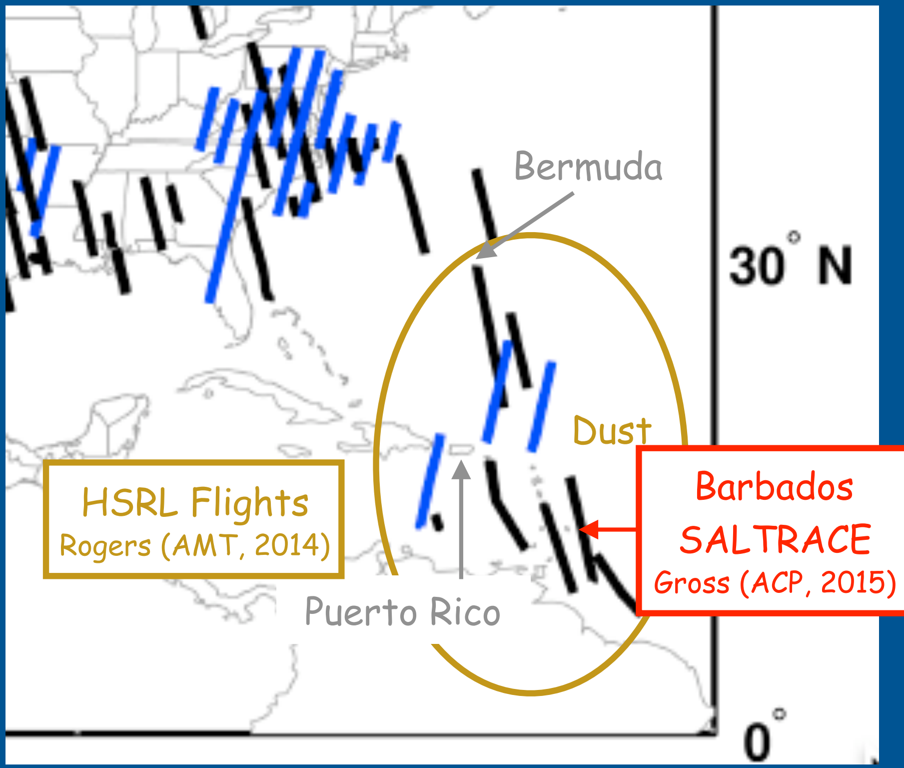
AMMA: Omar (JGR, 2010)

SAMUM: Tesche (Tellus, 2008), Esselborn (Tellus, 2008)

SAMUM-2: Wandinger (GRL, 2010)

Comparison to HSRL and Raman Lidars in West Atlantic

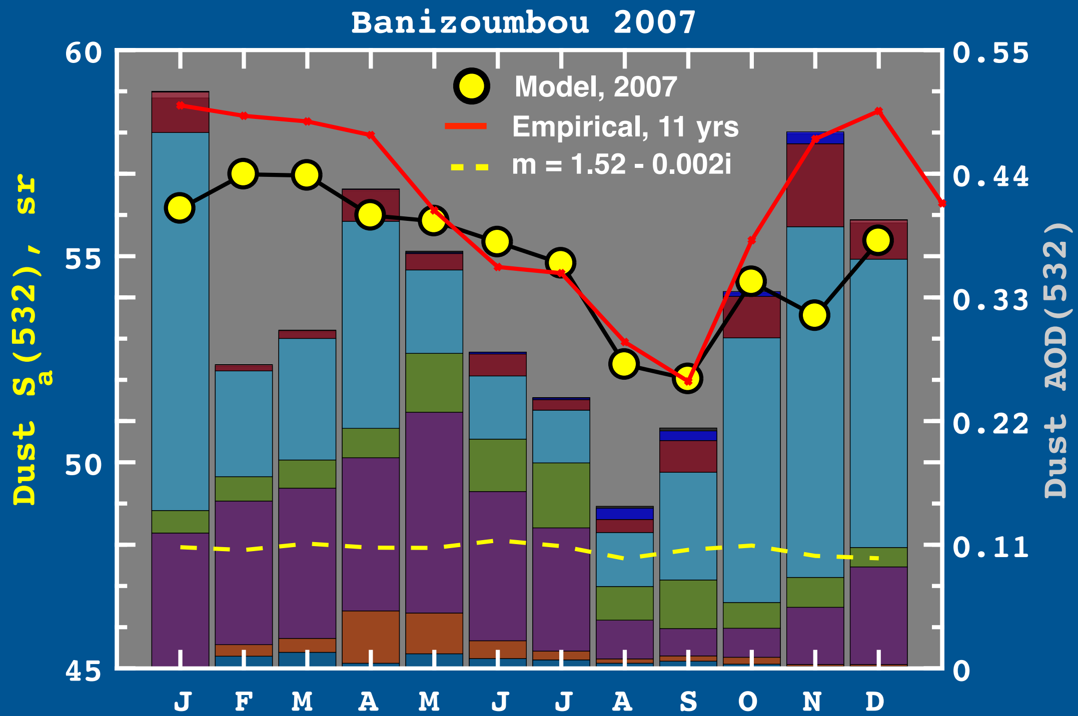


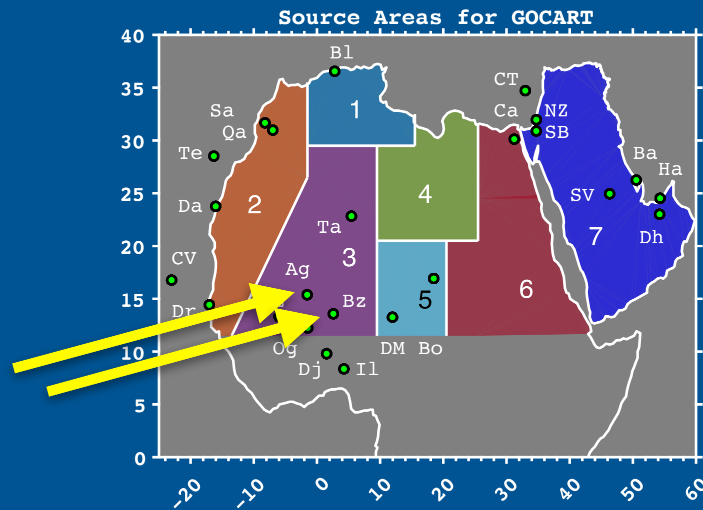


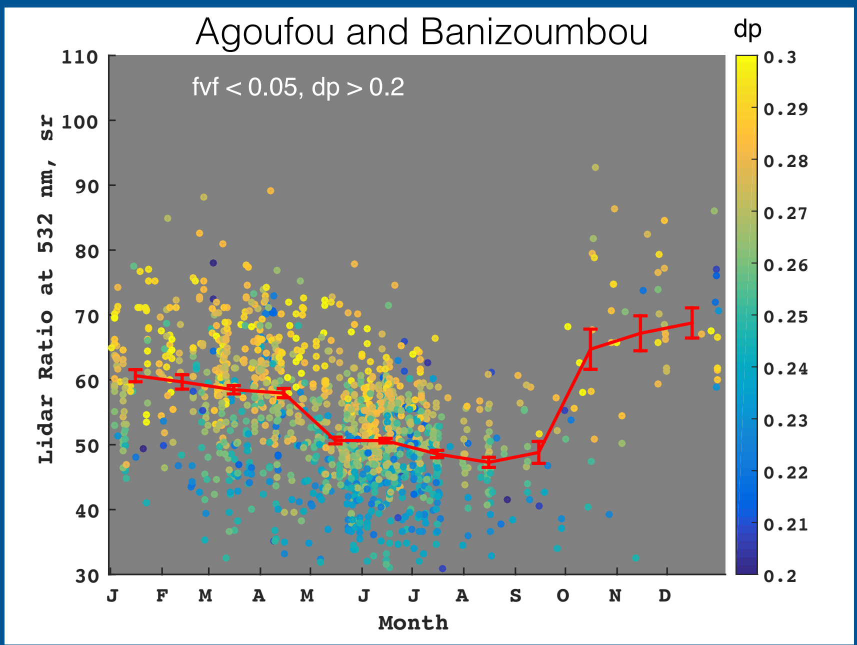
HSRL measurements (Bermuda to Cape San Juan): Rogers AMT 2014

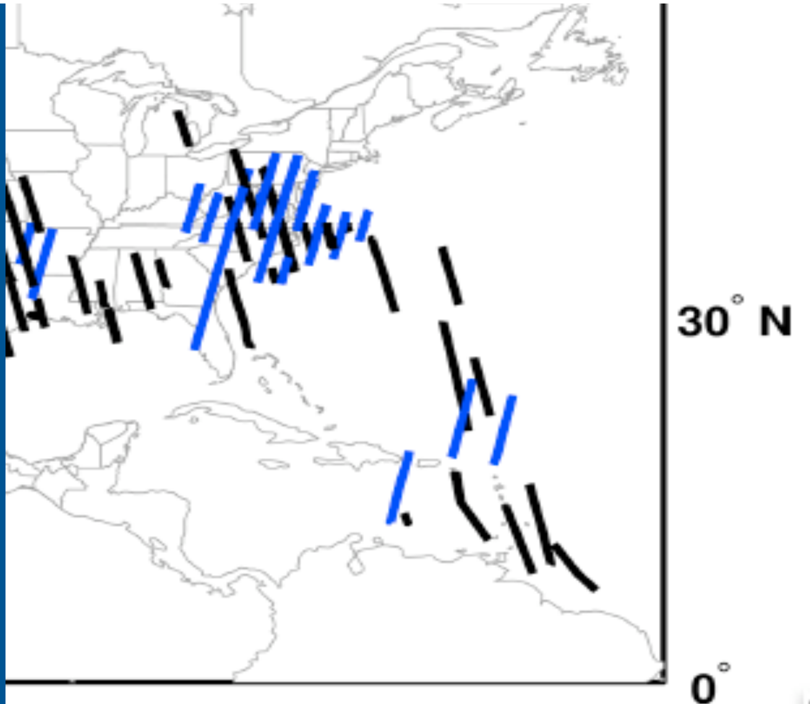
SALTRACE (Barbados): Gross ACP 2015

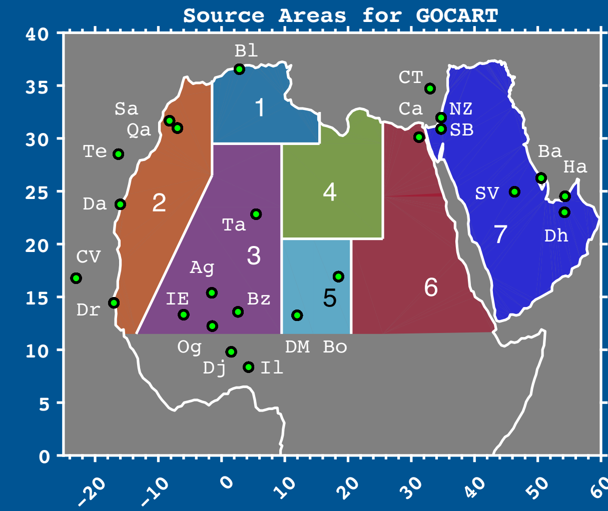
Seasonal Variability at Sede Boker

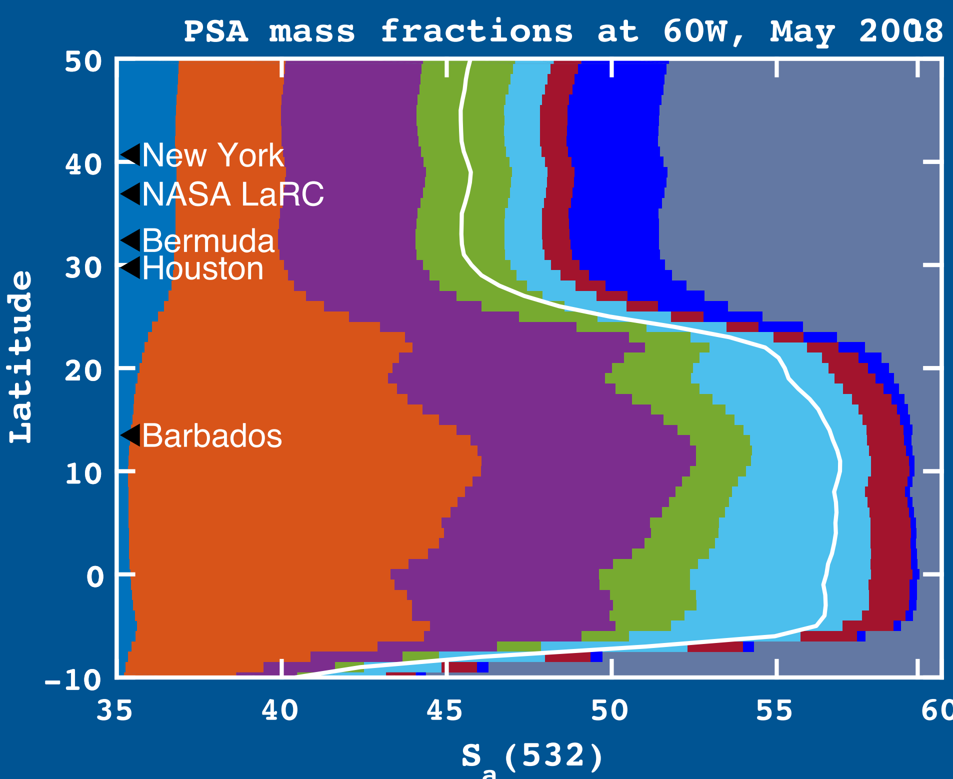


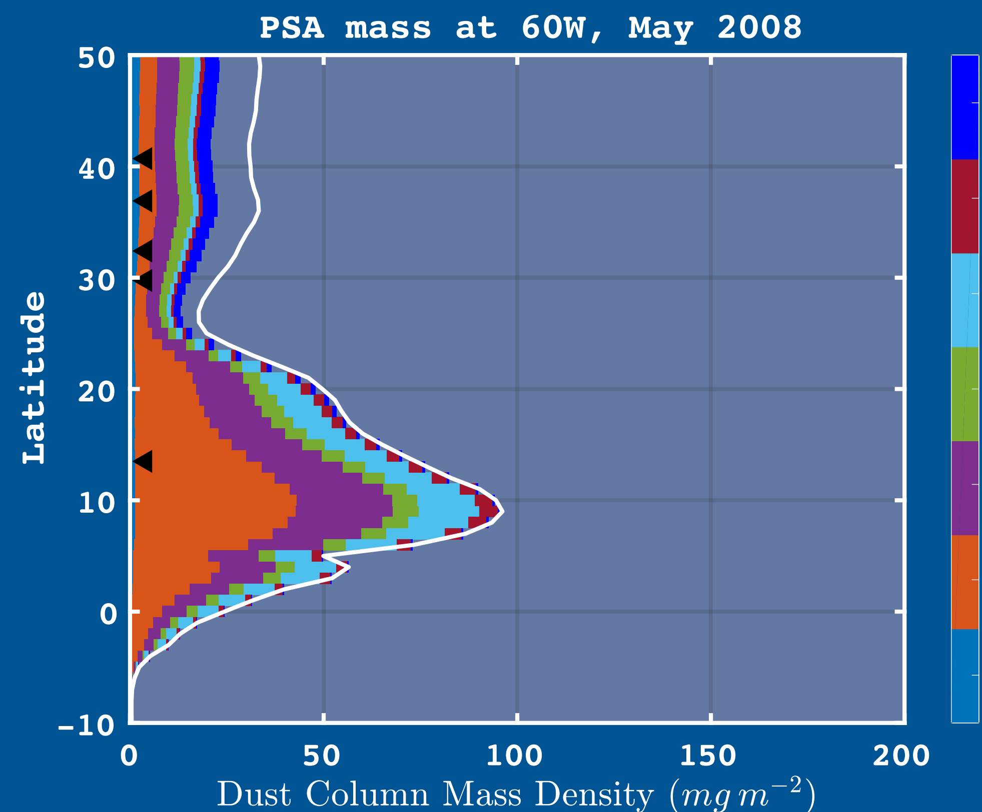




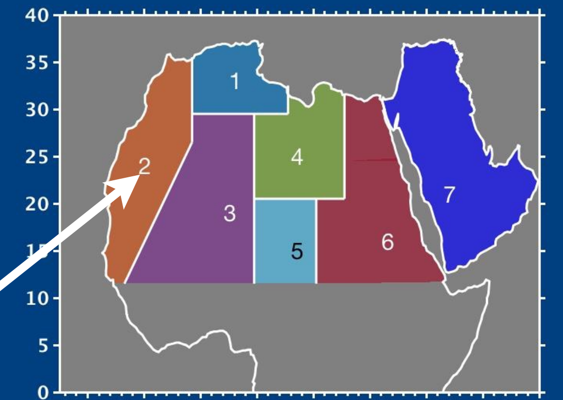

30° N
0°


Source Areas for GOCART
Bl
CT
Sa
Ca
NZ
Qa
SB
Te
Ba
Ha
1
2
4
SV
Da
Ta
7
Dh
3
CV
Ag
5
6
IE
Bz
Dr
Og
DM
Bo
Dj
Il
40
35
30
25
20
15
10
5
0
-20
-10
0
10
20
30
40
50
60

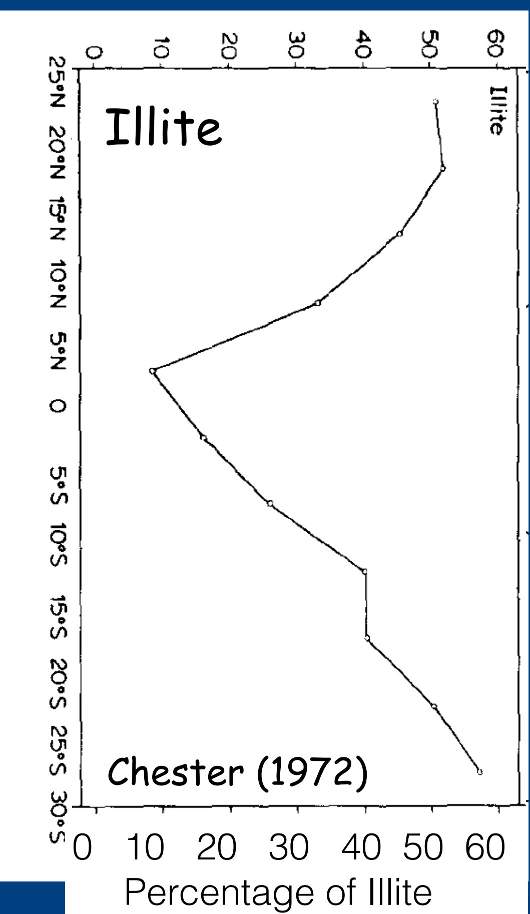

PSA mass fractions at 60W, May 2008
New York
NASA LaRC
Bermuda
Houston
Barbados
Latitude
50
40
30
20
10
0
-10
35
40
45
50
55
60
S_a(532)

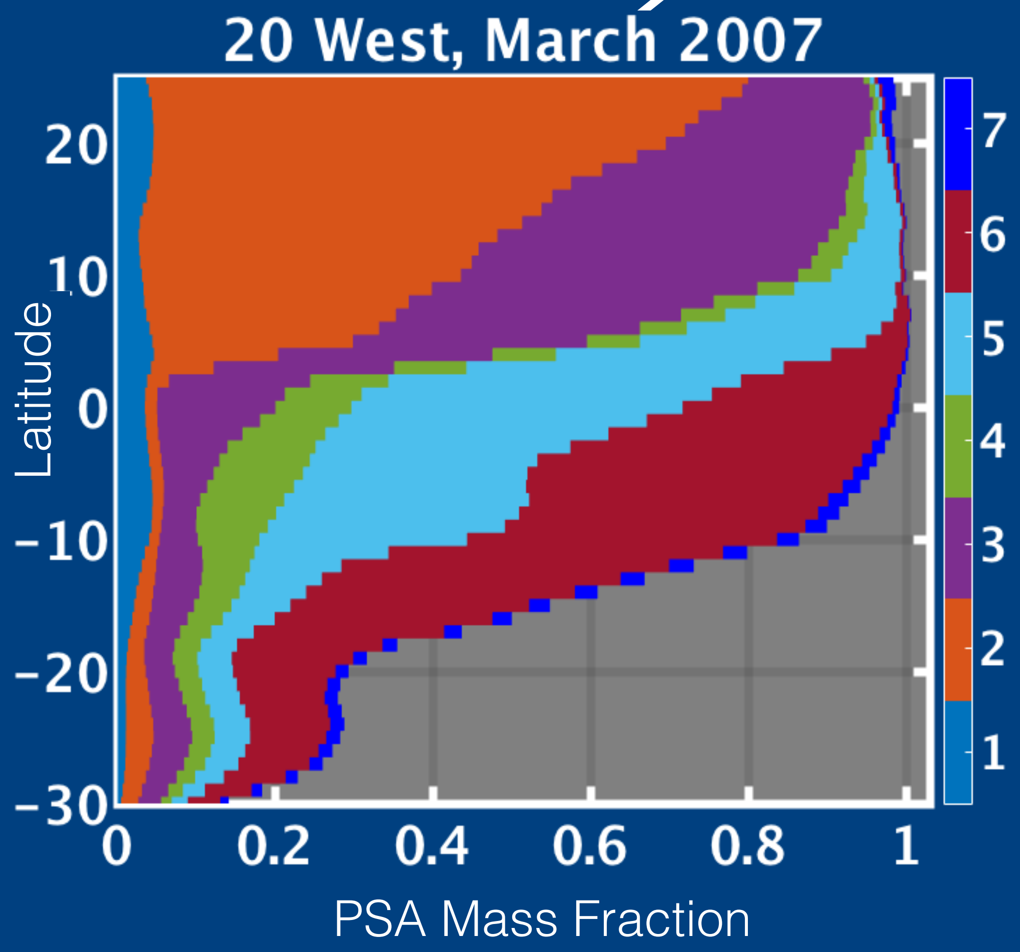

PSA mass at 60W, May 2008
Latitude
50
40
30
20
10
0
-10
0
50
100
150
200
Dust Column Mass Density (mg m^-2)
7
6
5
4
3
2
1

Quantify the Origin of Aeolian Dust Collected over the Atlantic



High concentrations of illite in West Africa
(Caquineau, JGR 2002)





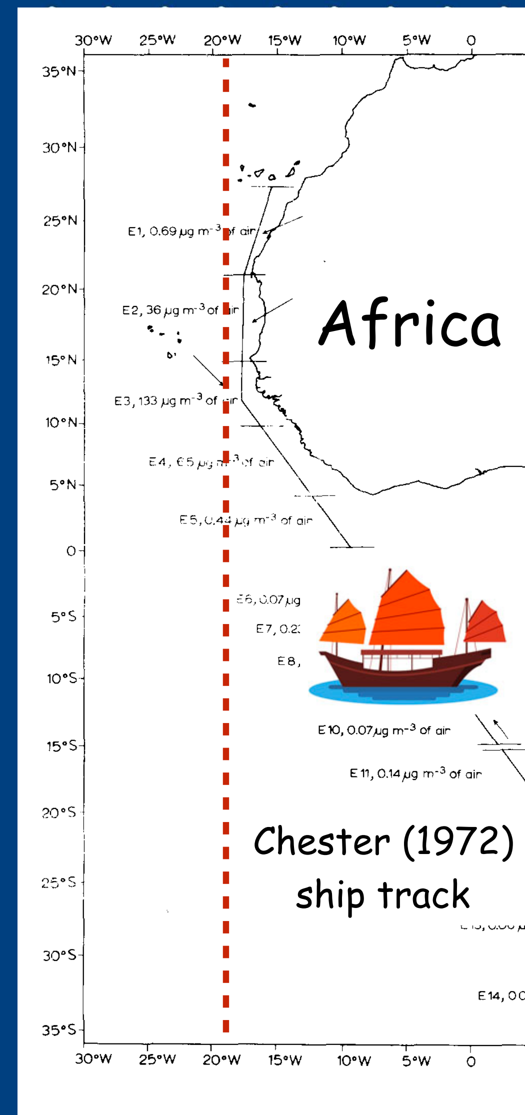
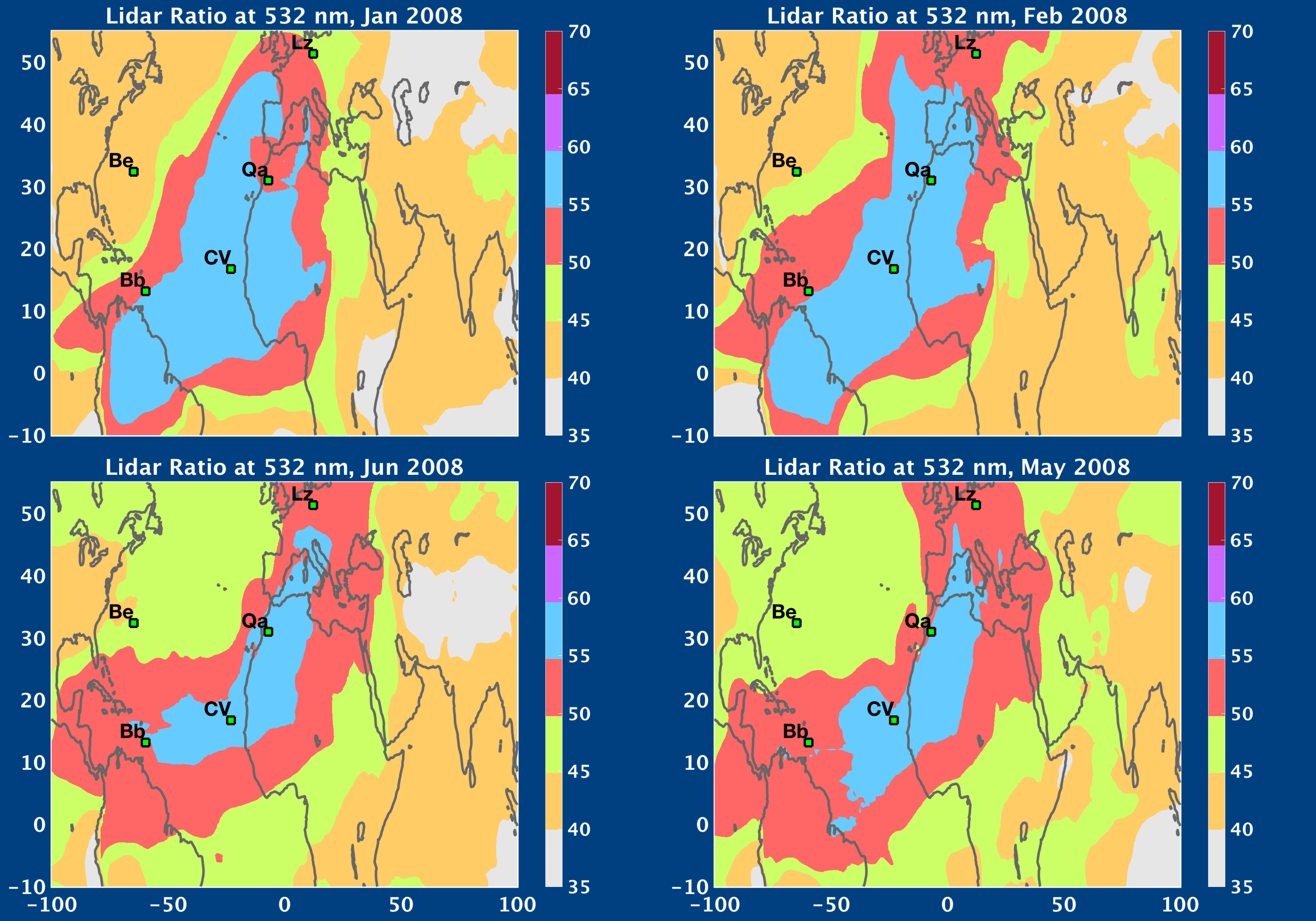
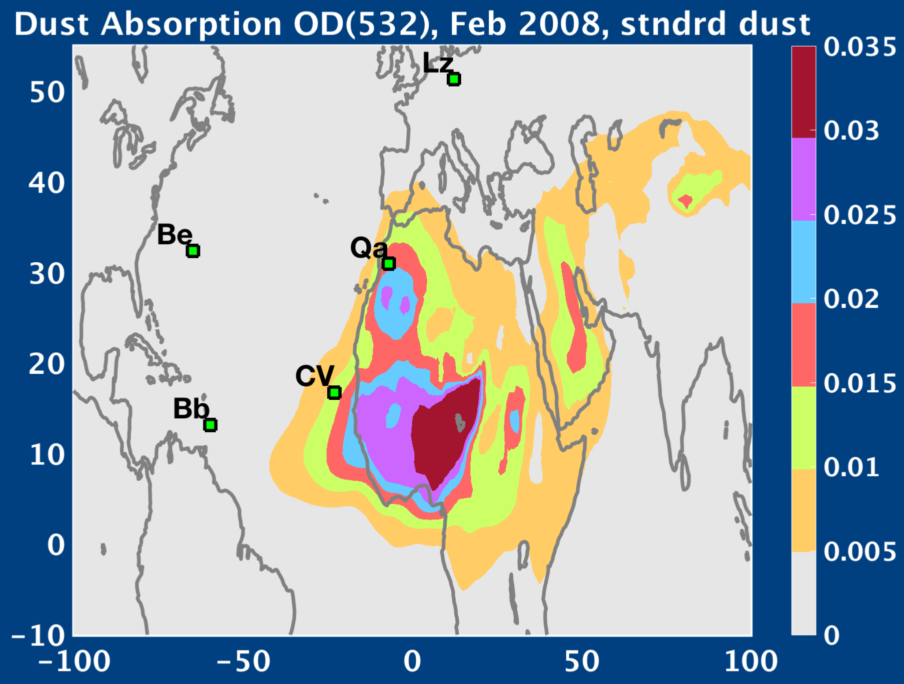


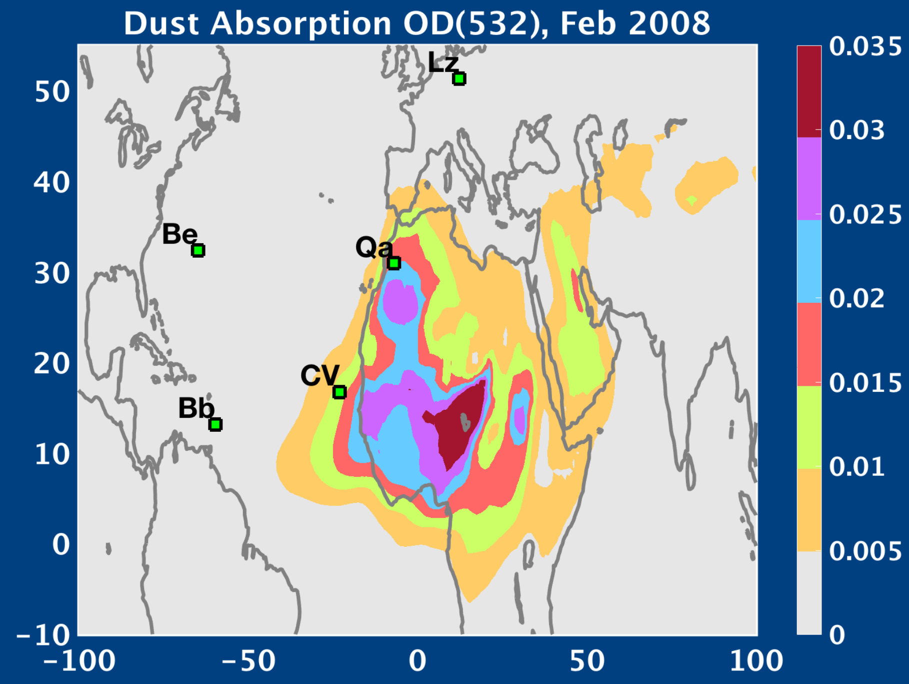
Fig. 1. Collection of atmospheric dust made on board M.V.

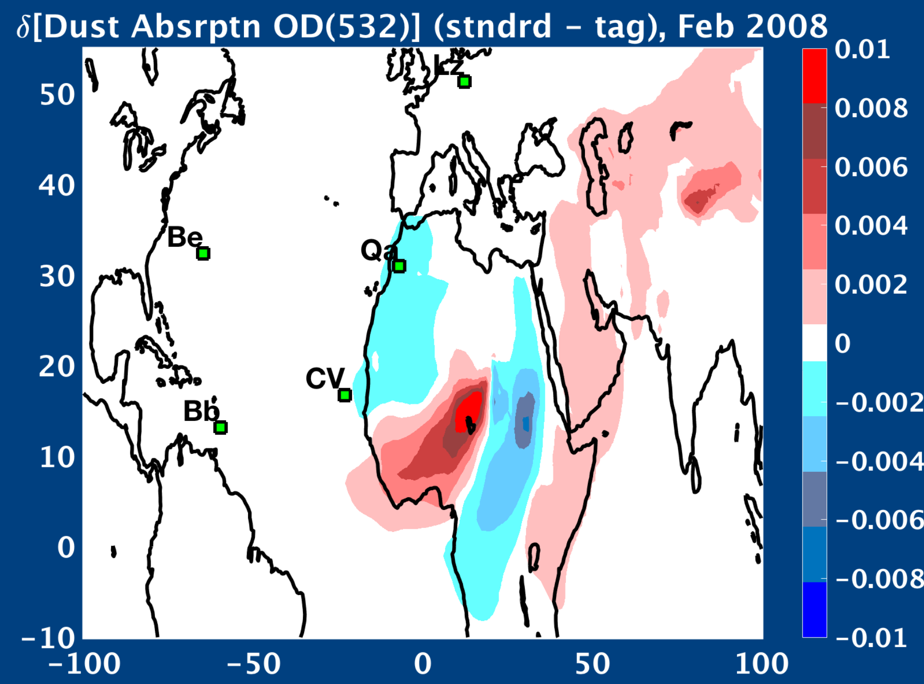
SAMUM 2


Lidar Ratio at 532 nm, Jan 2008
Lidar Ratio at 532 nm, Feb 2008
Lidar Ratio at 532 nm, Jun 2008
Lidar Ratio at 532 nm, May 2008
Lz
Be
Qa
CV
Bb
70
65
60
55
50
45
40
35
50
40
30
20
10
0
−10
−100
−50
0
50
100

Modeled Absorption (SAMUM 2)







Source region impact on dust single-scatter albedo and AOD