



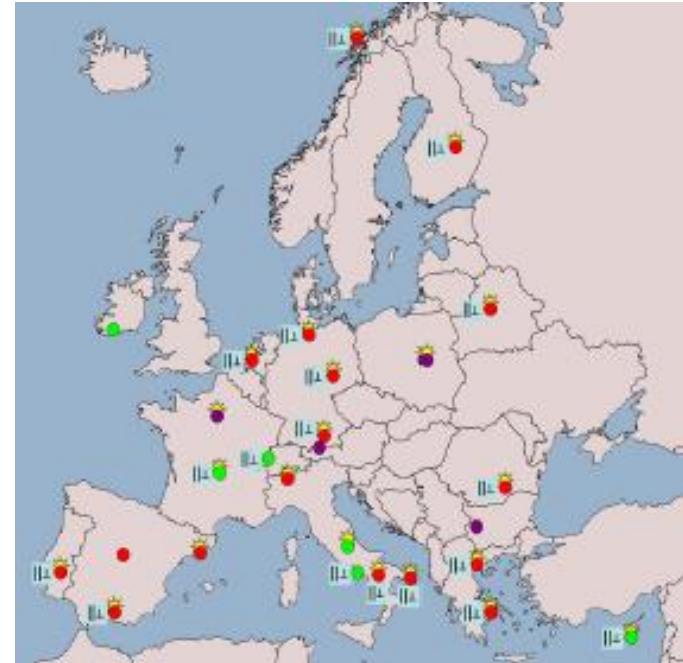
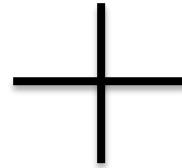
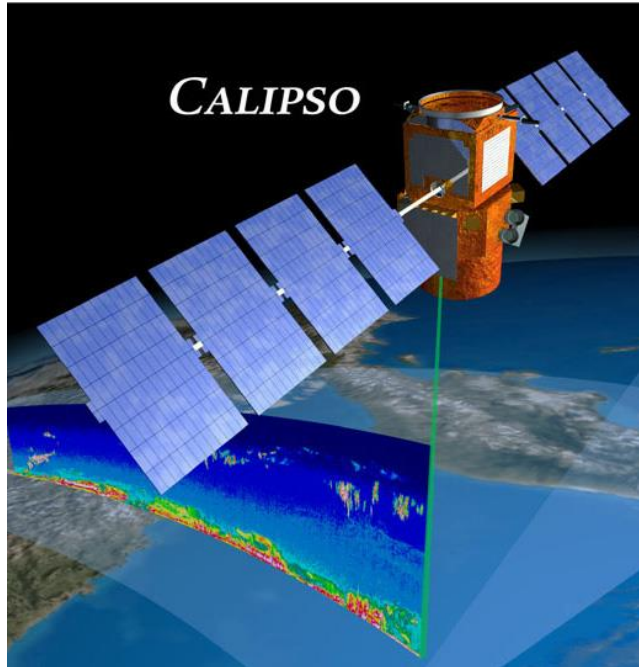
# Optimized CALIPSO pure-dust product using EARLINET

V. Amiridis

NOA - National Observatory of Athens, IAASARS, Athens, Greece



# CALIPSO and EARLINET



**EARLINET** already covers 14 years of homogenized multi-wavelength aerosol lidar measurements and continues upgrading its instruments and methods for the provision of high-quality lidar products.

## CALIPSO L1 product:

- Attenuated backscatter ( $\gamma$ )
- Estimated particle depolarization ( $\delta$ )

Omar et al., 2009

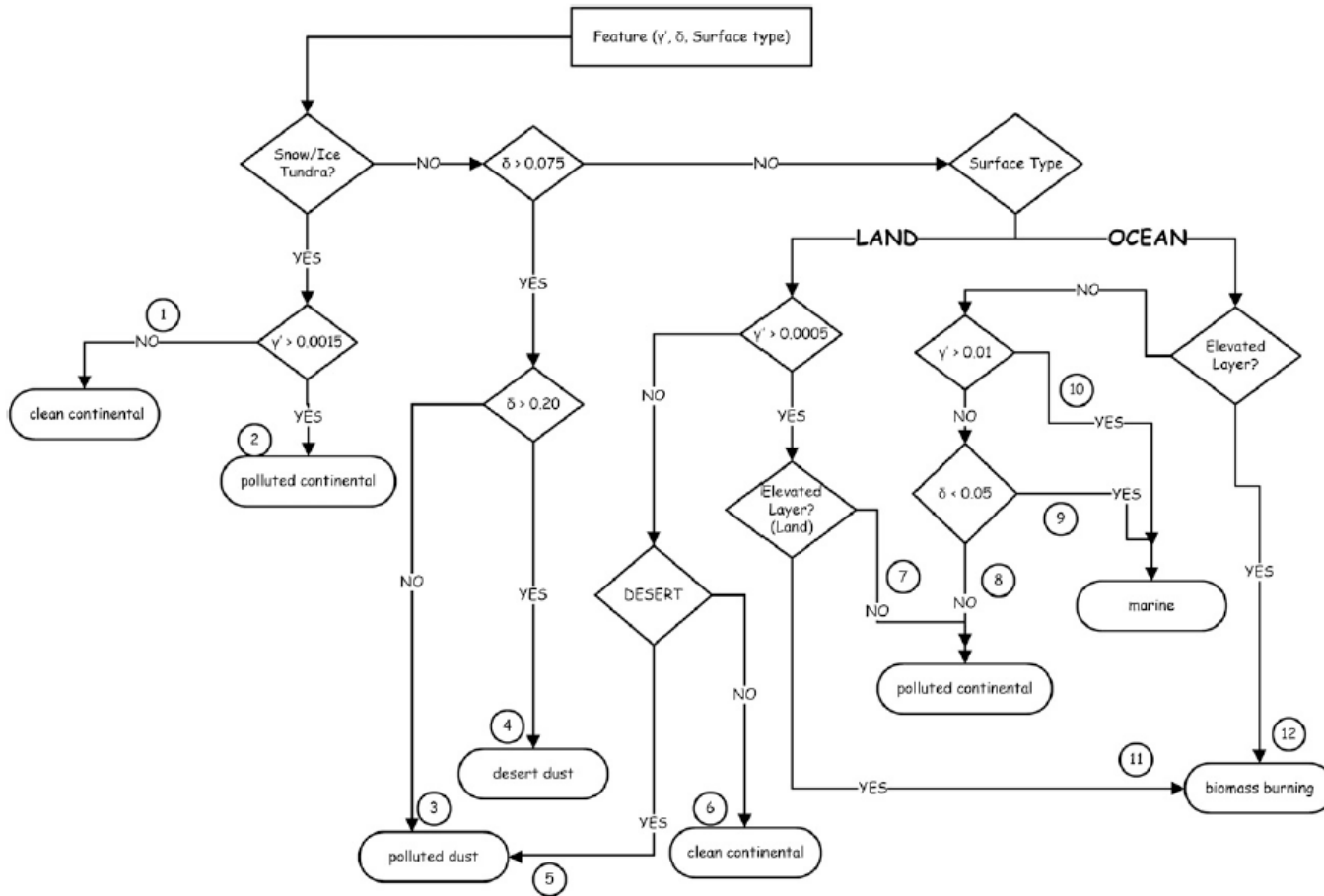


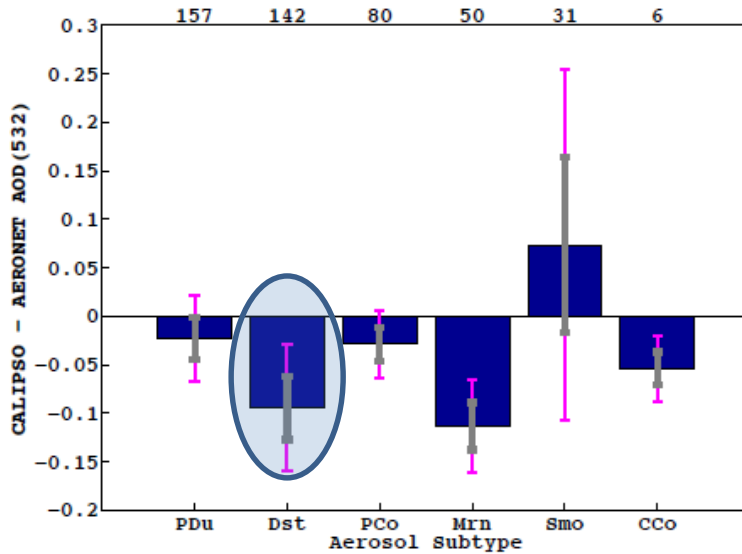
FIG. 2. Flowchart of the CALIPSO  $S_a$  selection scheme for tropospheric aerosols.



# CALIPSO aerosol classification



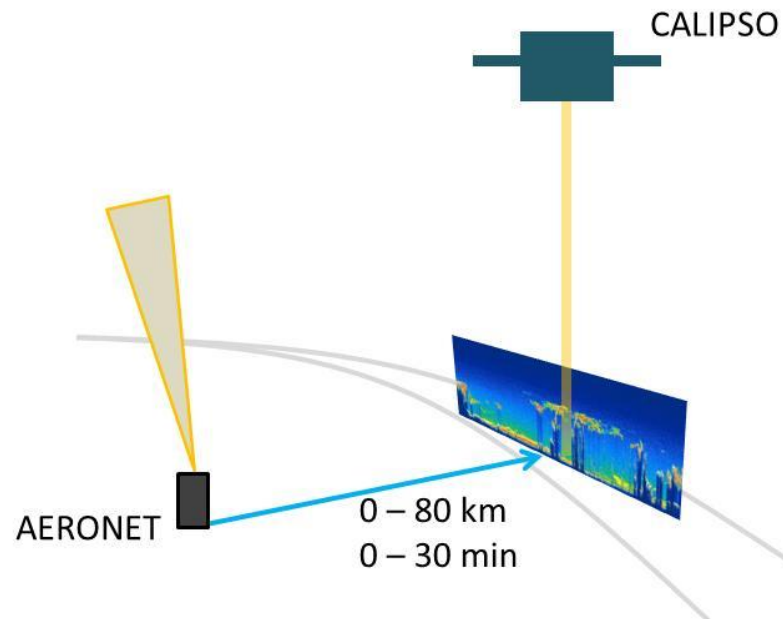
Aerosol Type	Lidar Ratio (sr) (Omar et al., 2009)	Agreement with airborne HSRL (Burton et al., 2013)
Dust	<b>40</b>	<b>80%</b>
Marine	20	62%
Polluted Continental	70	<b>54%</b>
Polluted Dust	65	<b>35%</b>
Smoke	70	<b>13%</b>
Clean Continental	35	-



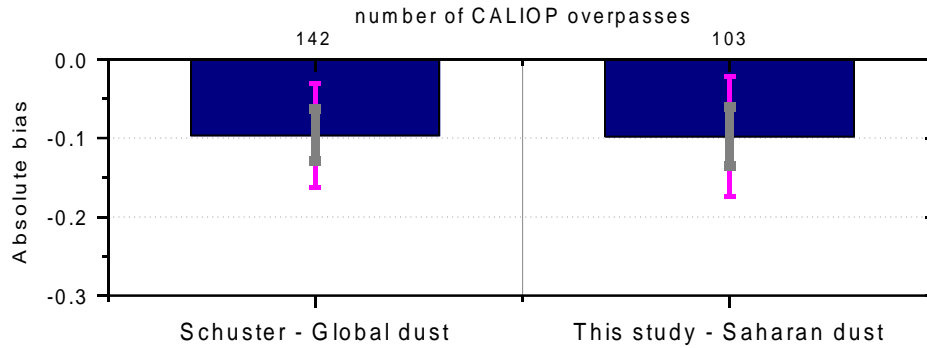
Schuster et al., ACP, 2012

CALIPSO relative bias with respect to 147 AERONET stations in globe:

- **-13%** when dust is present
- **-3%** when dust is not included



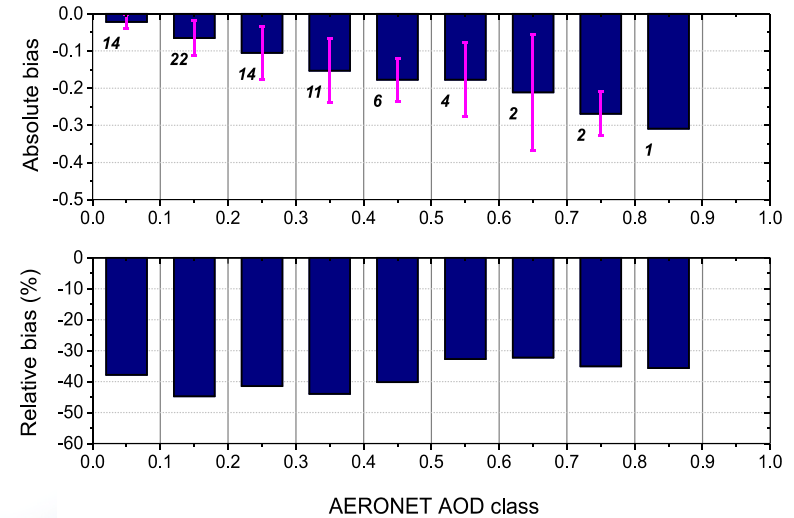
CALIPSO - AERONET dust AOD (532 nm)



## Possible sources of discrepancies:

- Aerosol misclassification
- Lidar ratio

## Schuster et al., ACP, 2012

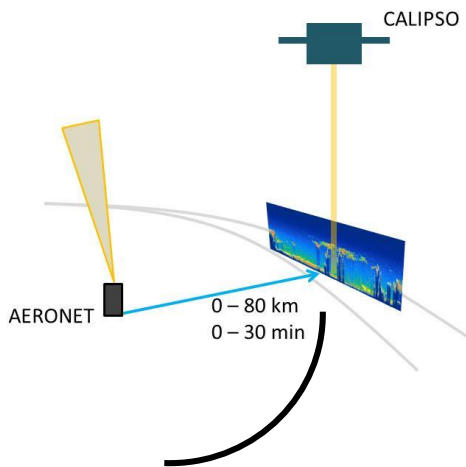


### Optimizing CALIPSO Saharan dust retrievals

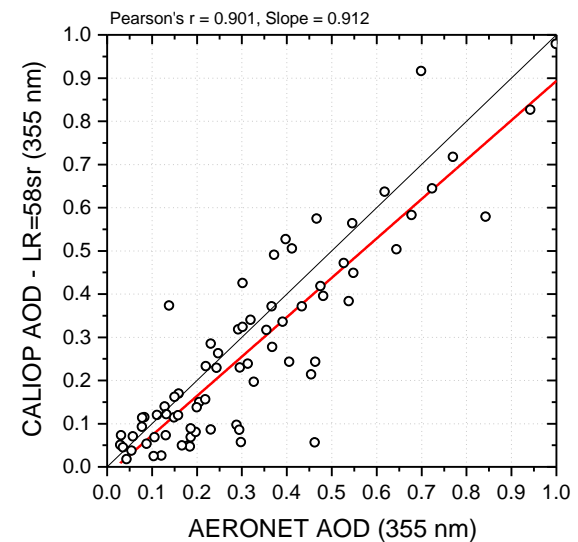
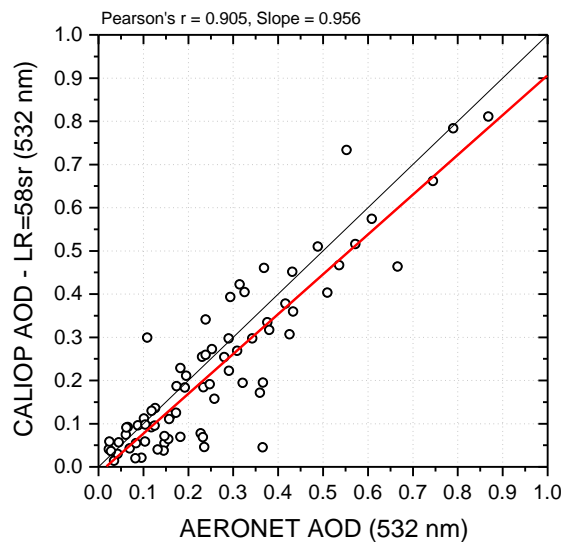
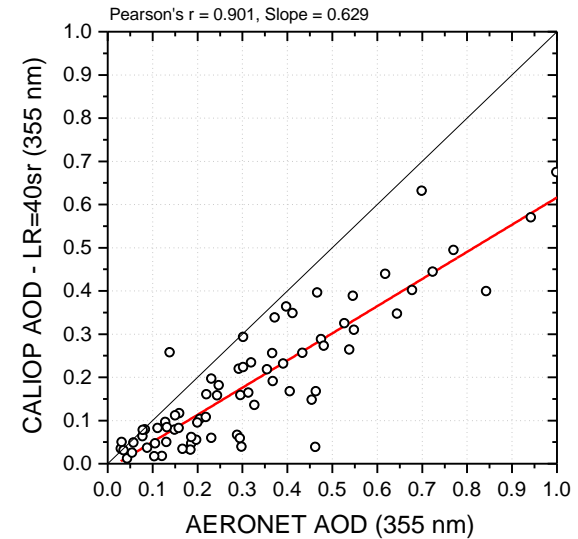
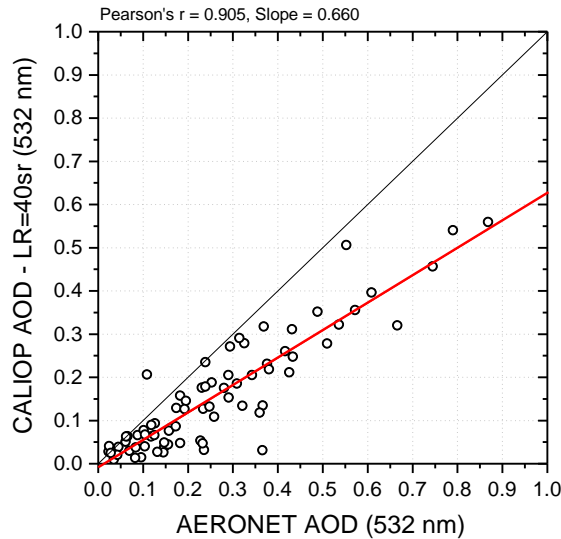
V. Amiridis<sup>1</sup>, U. Wandinger<sup>2</sup>, E. Marinou<sup>1</sup>, E. Giannakaki<sup>3</sup>, A. Tsekeri<sup>1</sup>, S. Basart<sup>4</sup>, S. Kazadzis<sup>5</sup>, A. Gkikas<sup>1,6</sup>, M. Taylor<sup>5</sup>, J. Baldasano<sup>4,7</sup>, and A. Ansmann<sup>2</sup>

<sup>1</sup>Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing, National Observatory of Athens, Athens 15236, Greece

## CALIPSO-AERONET Collocation

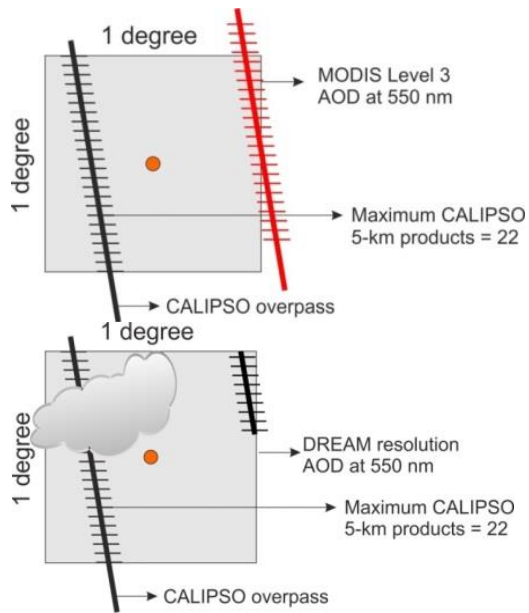


In pure Dust cases from CALIPSO typing

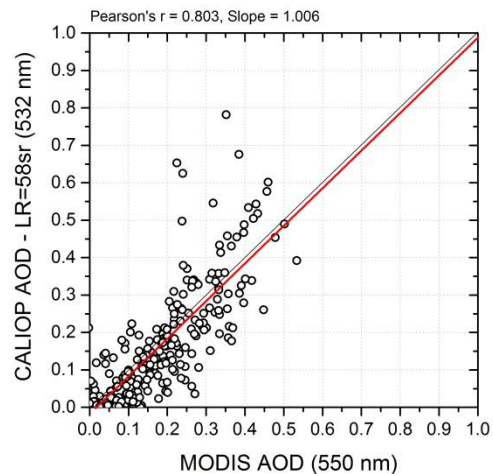
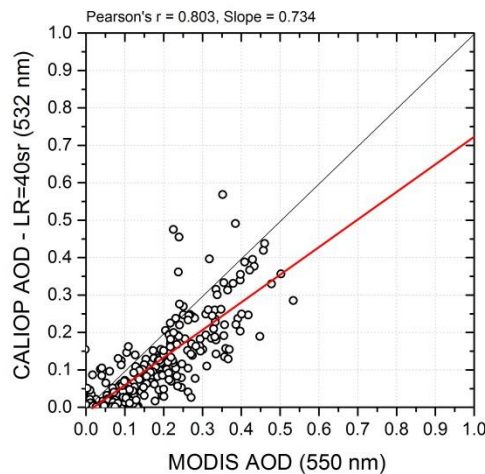
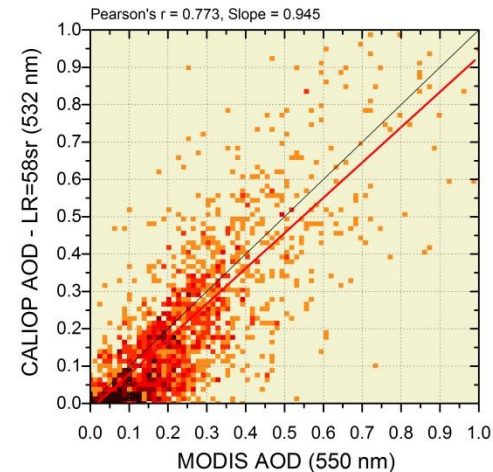
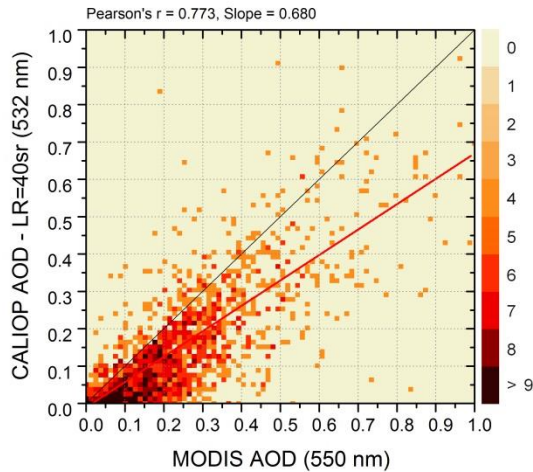




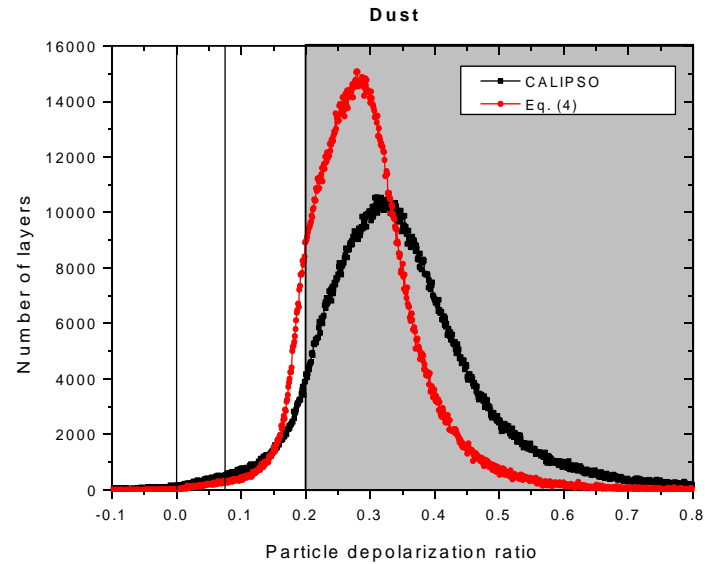
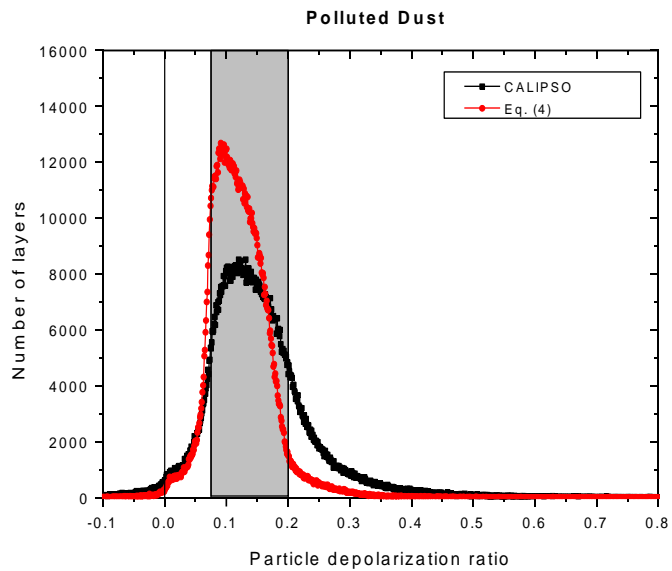
## CALIPSO-MODIS Collocation



Red overpasses rejected

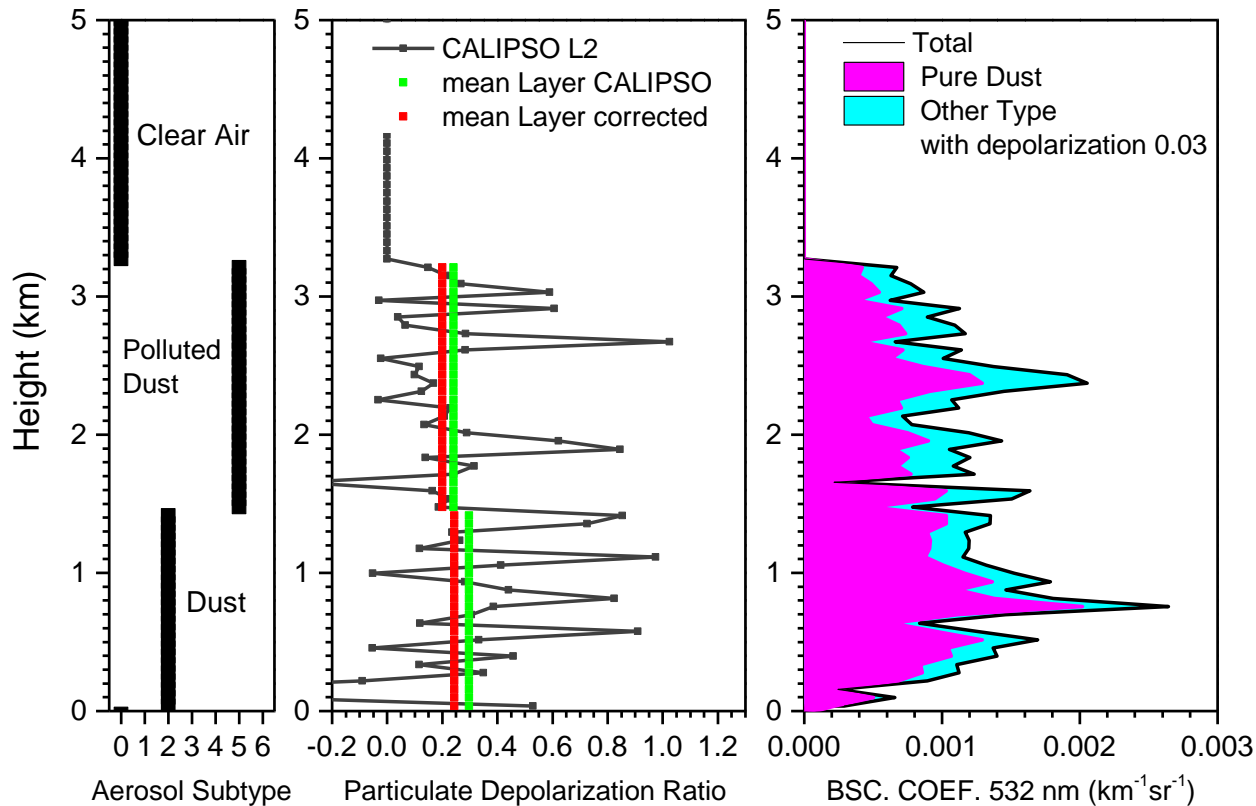






Amiridis et al., 2013

# Discrimination of pure dust



*Tesche et al., JGR, 2009*

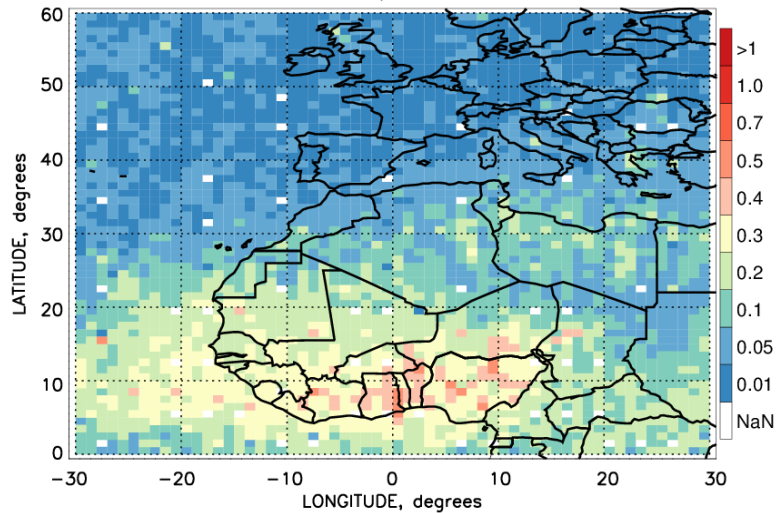
$$\beta_1 = \beta_t \frac{(\delta_p - \delta_2)(1 + \delta_1)}{(\delta_1 - \delta_2)(1 + \delta_p)}$$



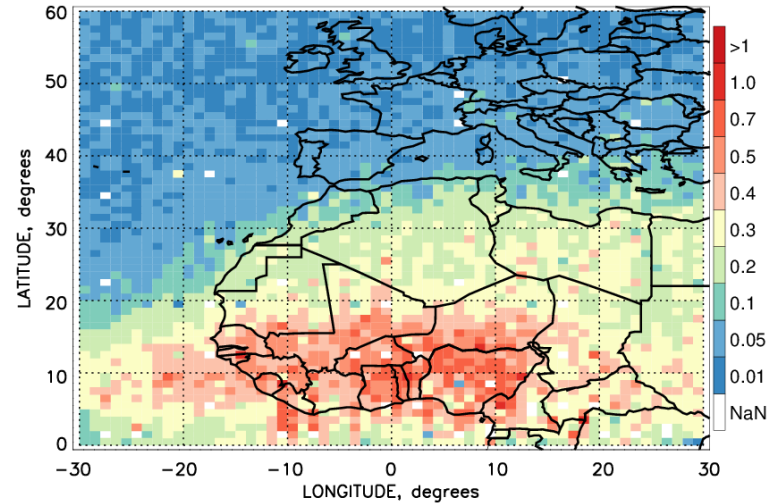
# Optimized CALIPSO dust product



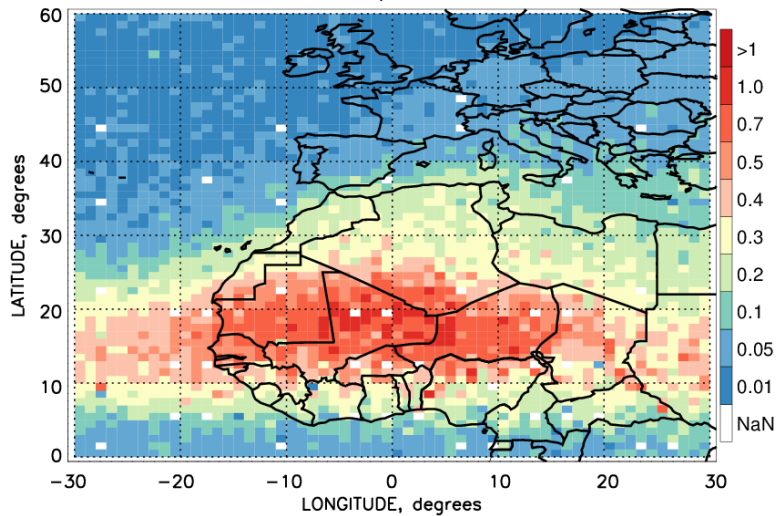
CALIPSO Mean Dust AOD, 2007–2013 D–J–F



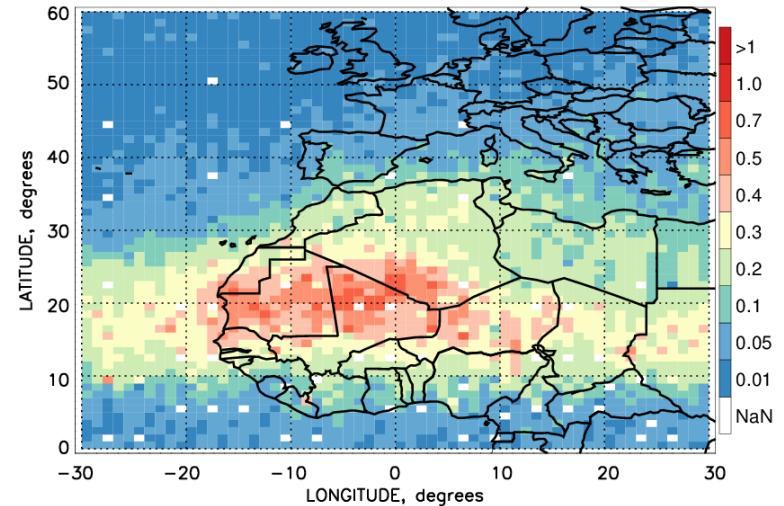
CALIPSO Mean Dust AOD, 2007–2013 M–A–M

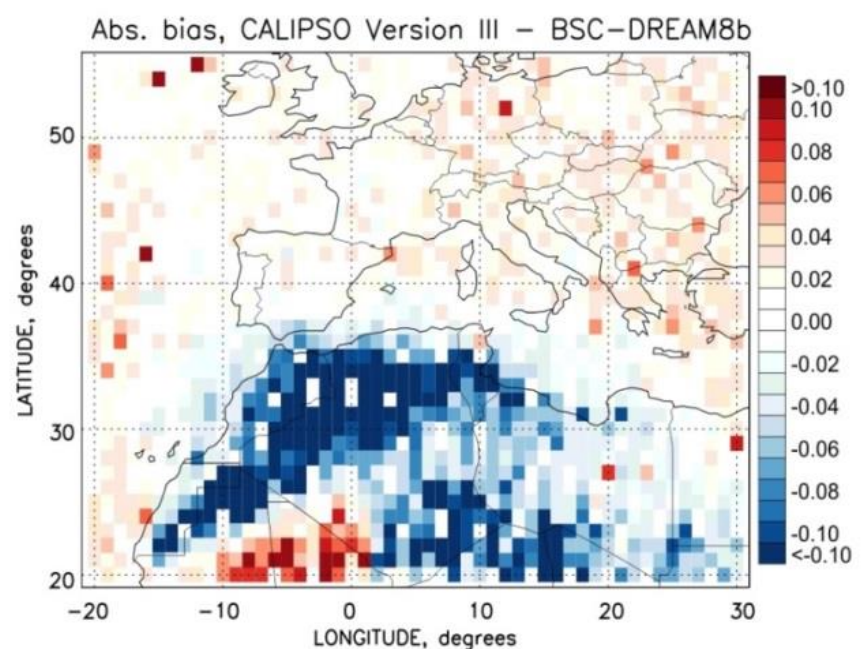
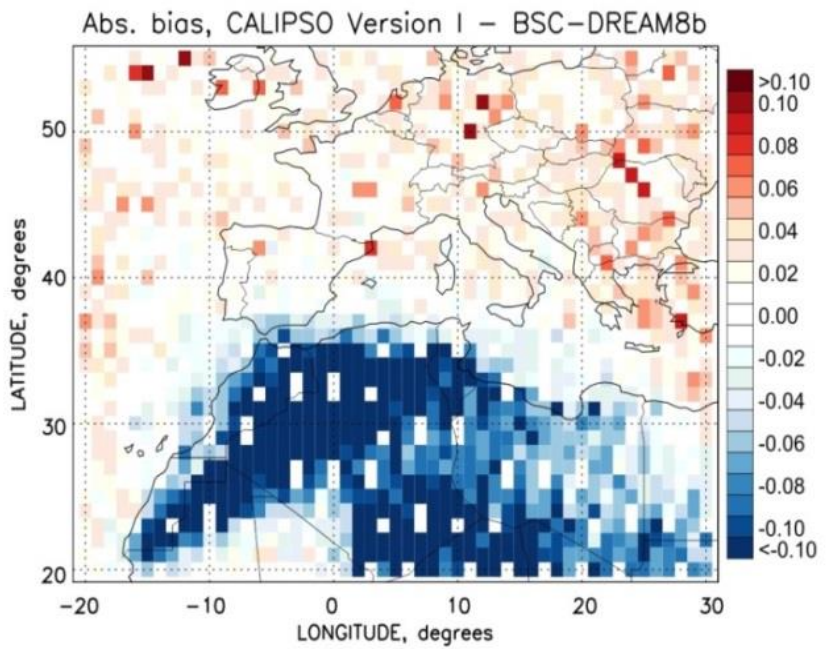


CALIPSO Mean Dust AOD, 2007–2013 J–J–A

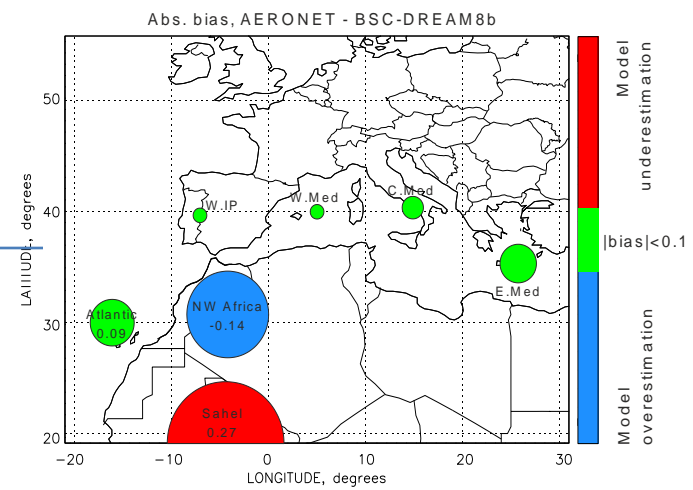


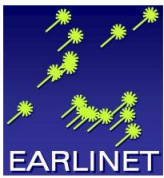
CALIPSO Mean Dust AOD, 2007–2013 S–O–N



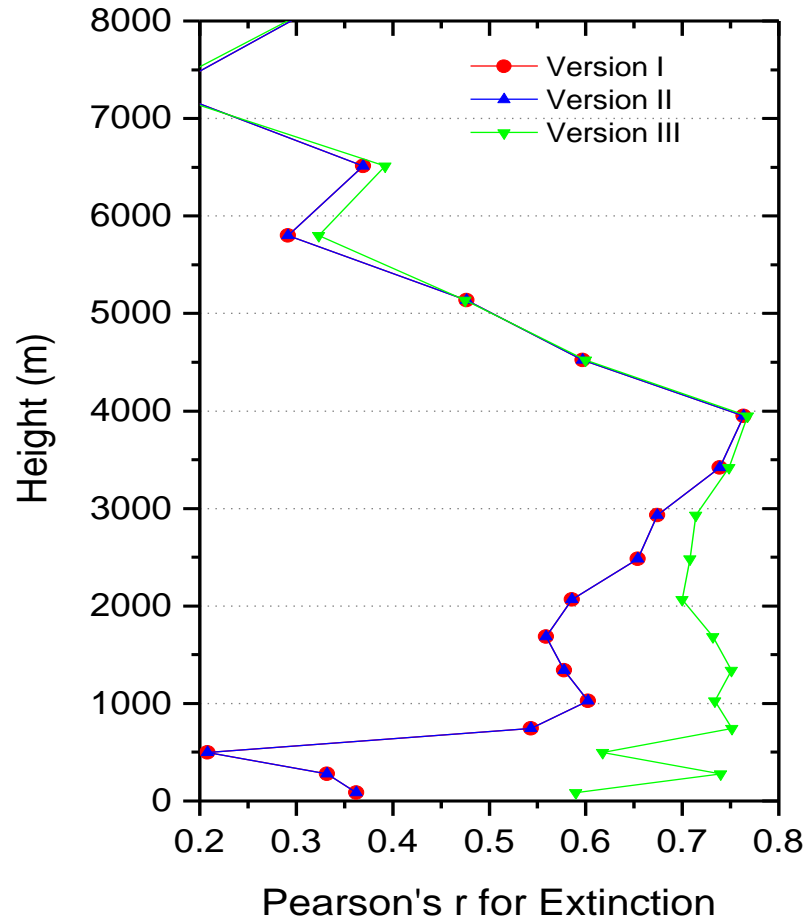


From Basart et al., 2012

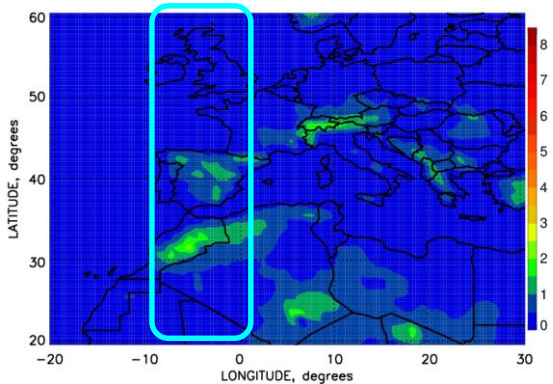




# CALIPSO vs BSC-DREAM8b

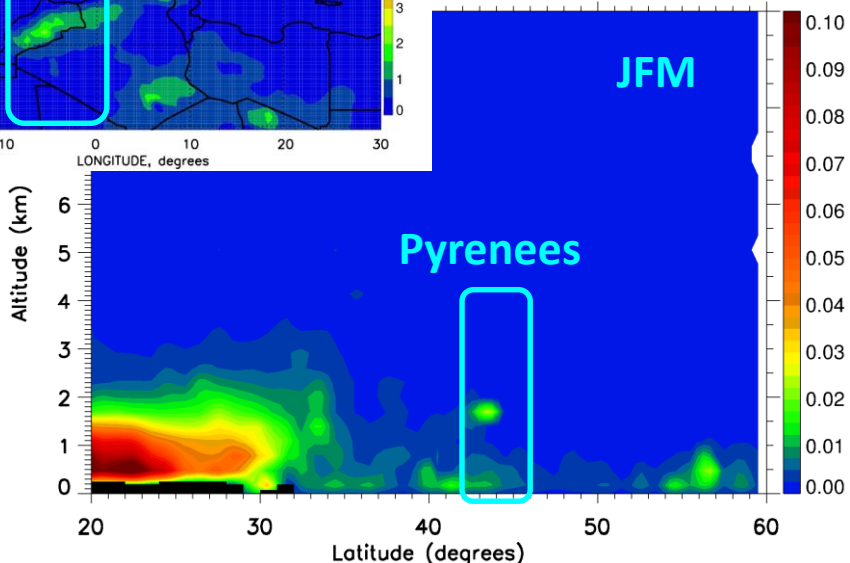




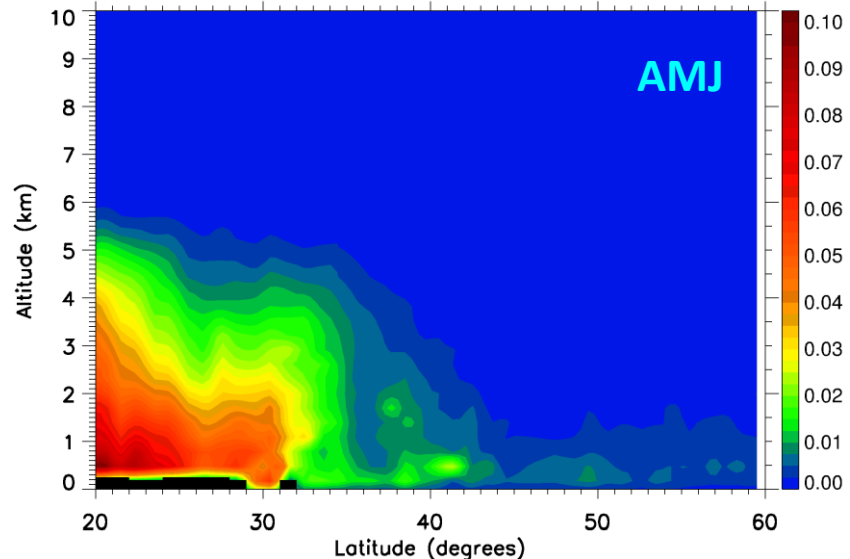


# Extinction Coefficient -10-0 deg Longitude

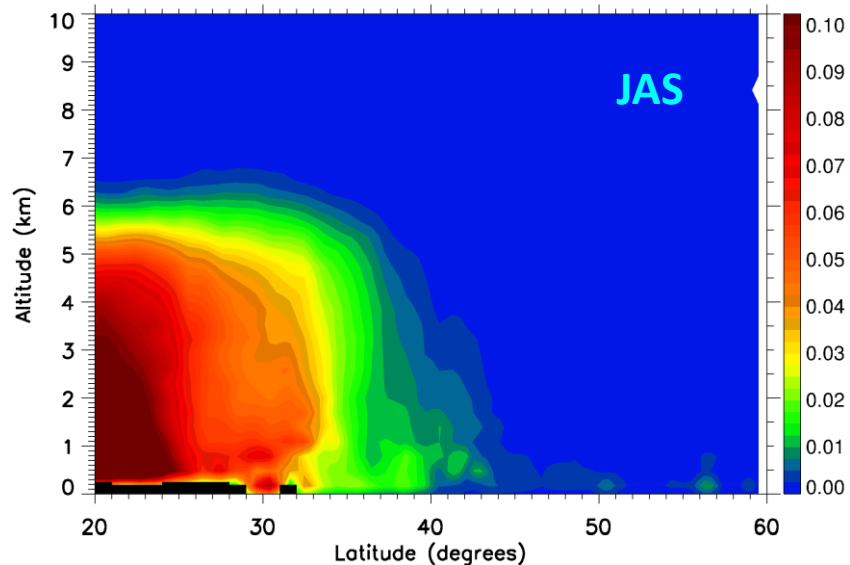
2007to2014 Lons:-10-0deg JFM



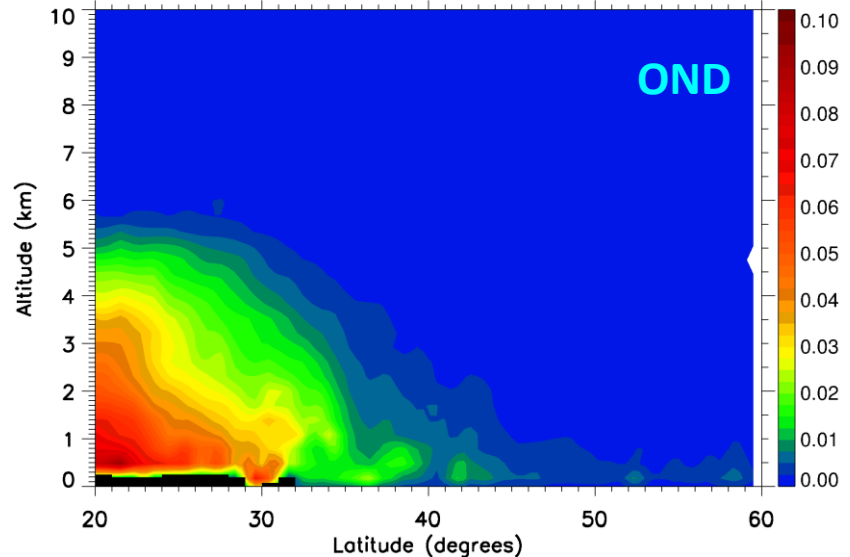
Dust Extinction 532nm, CALIPSO 2007to2014 Lons:-10-0deg AMJ

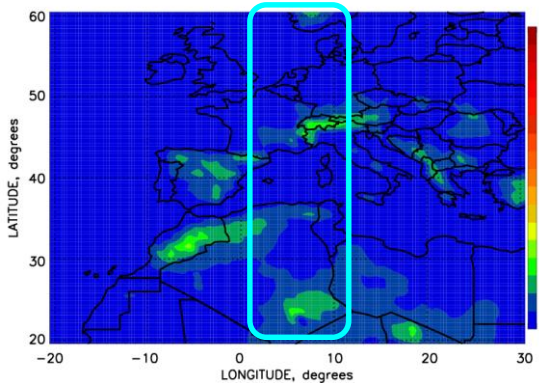


Dust Extinction 532nm, CALIPSO 2007to2014 Lons:-10-0deg JAS



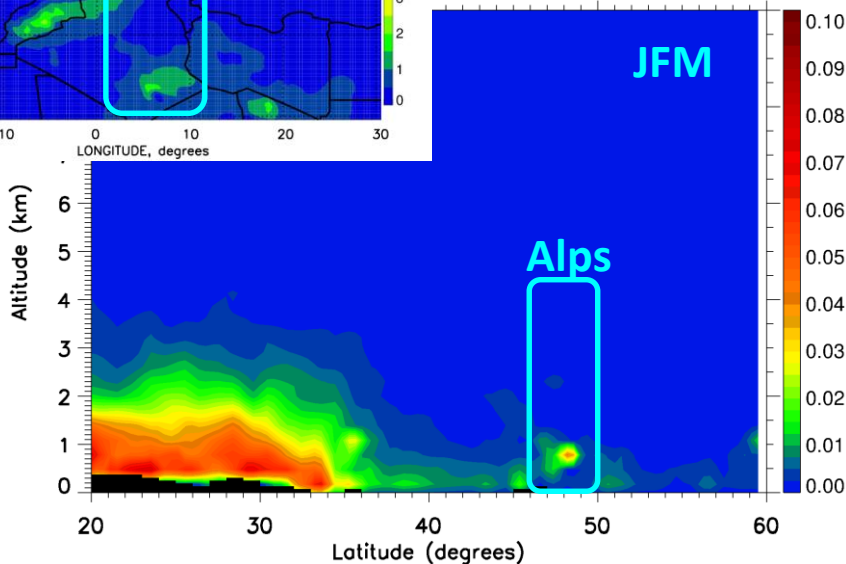
Dust Extinction 532nm, CALIPSO 2007to2014 Lons:-10-0deg OND



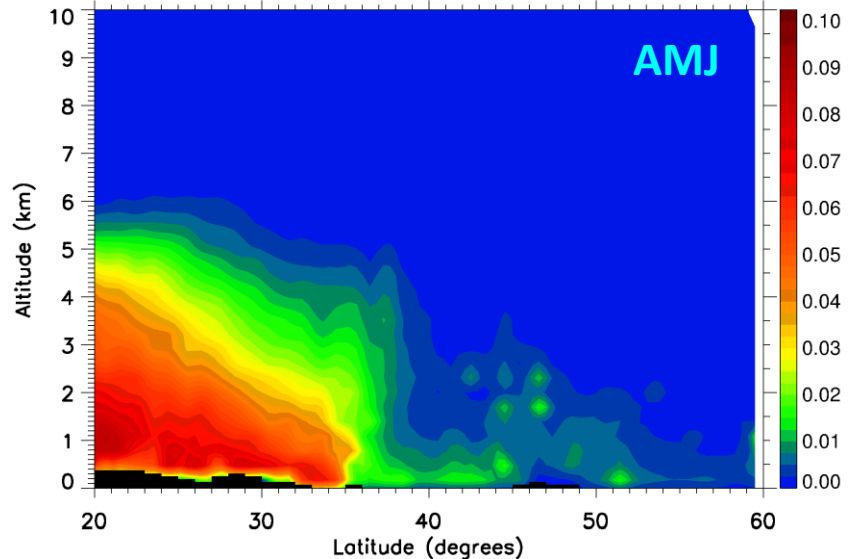


# Extinction Coefficient 0-10 deg Longitude

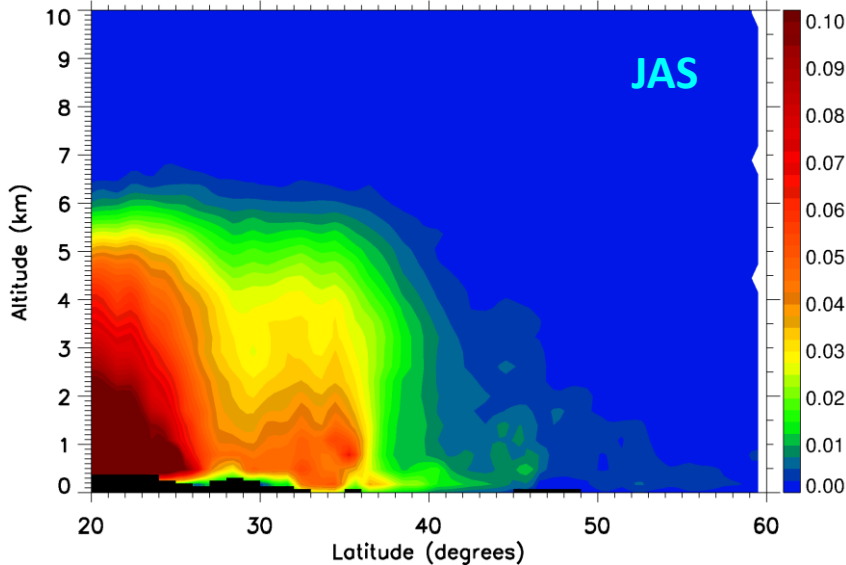
2007to2014 Lons:0-10deg JFM



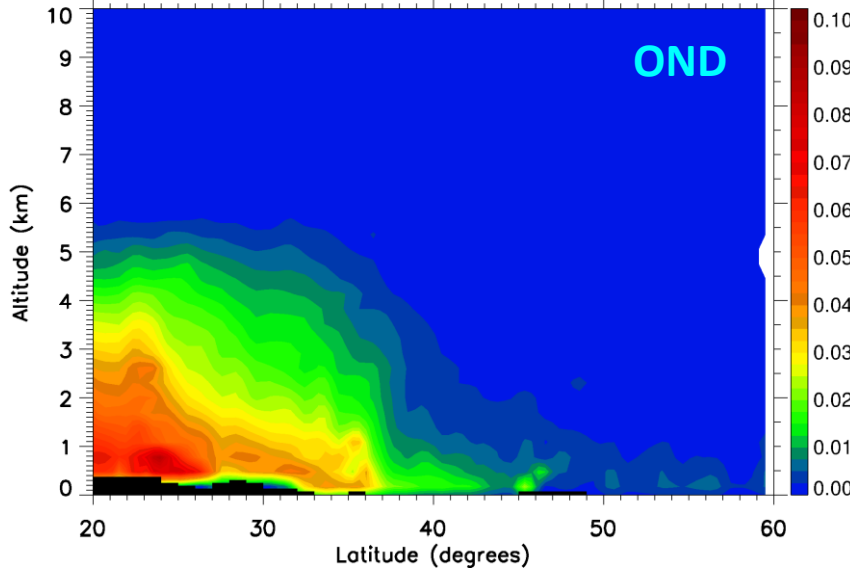
Dust Extinction 532nm, CALIPSO 2007to2014 Lons:0-10deg AMJ



Dust Extinction 532nm, CALIPSO 2007to2014 Lons:0-10deg JAS

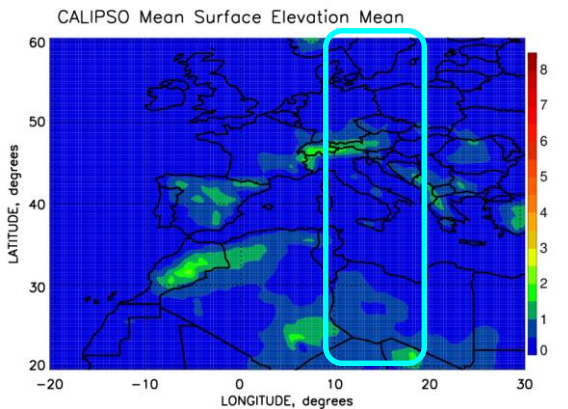


Dust Extinction 532nm, CALIPSO 2007to2014 Lons:0-10deg OND

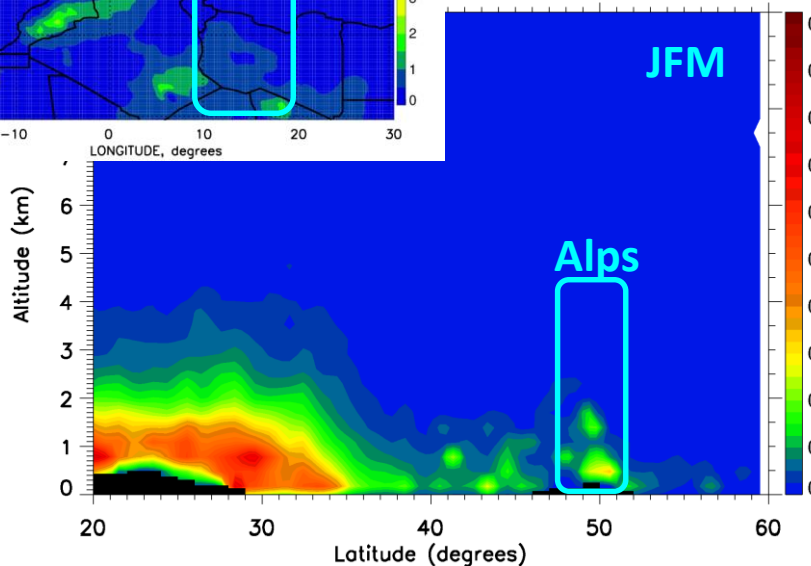




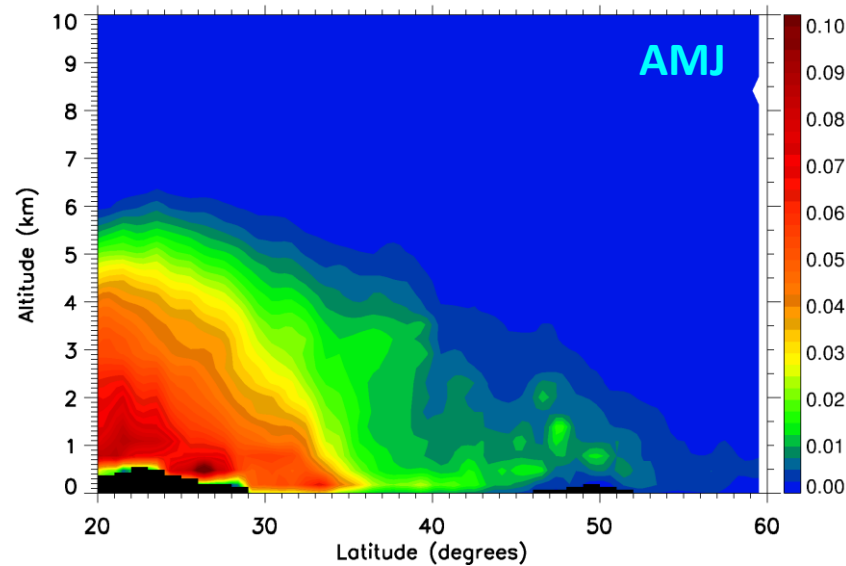
# Extinction Coefficient 10-20 deg Longitude



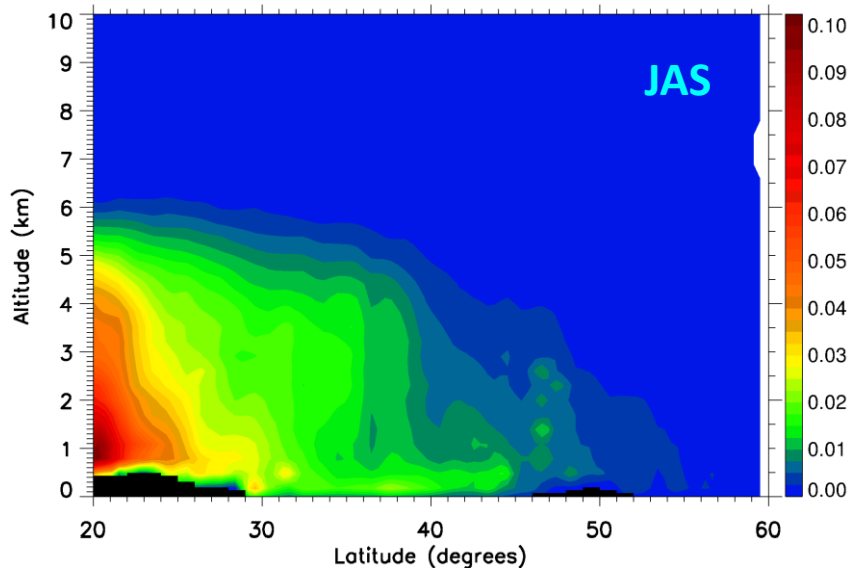
2007to2014 Lons:10-20deg JFM



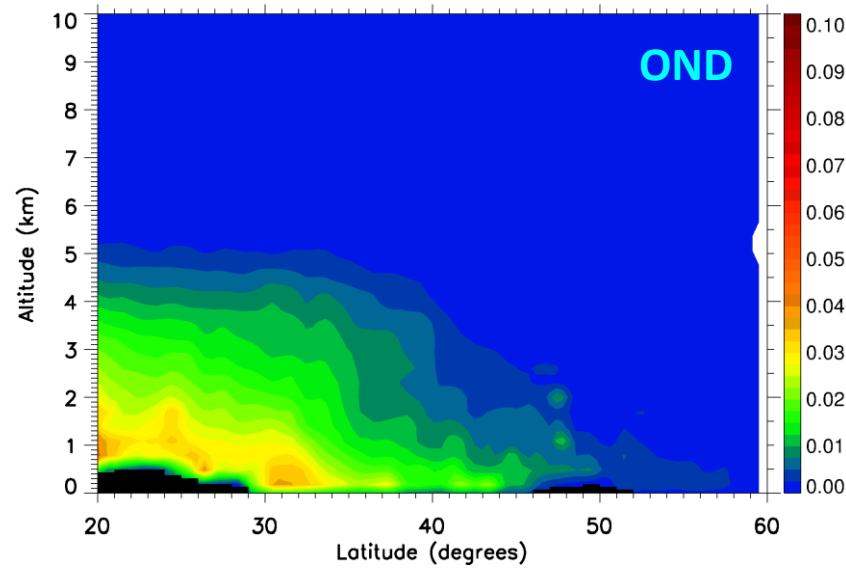
Dust Extinction 532nm, CALIPSO 2007to2014 Lons:10-20deg AMJ

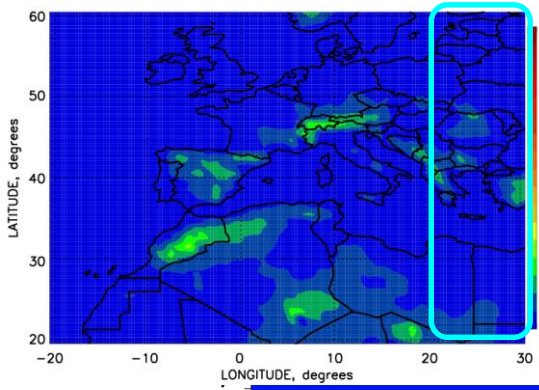


Dust Extinction 532nm, CALIPSO 2007to2014 Lons:10-20deg JAS



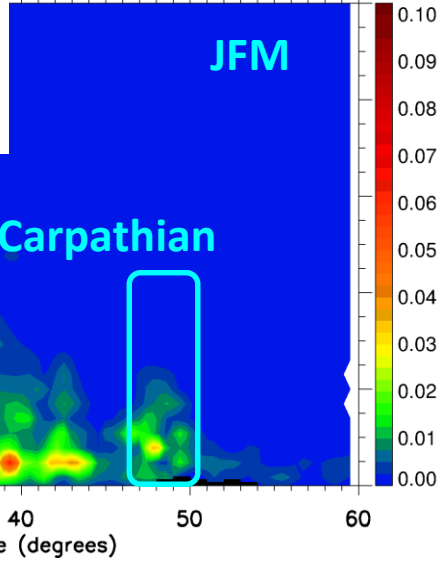
Dust Extinction 532nm, CALIPSO 2007to2014 Lons:10-20deg OND



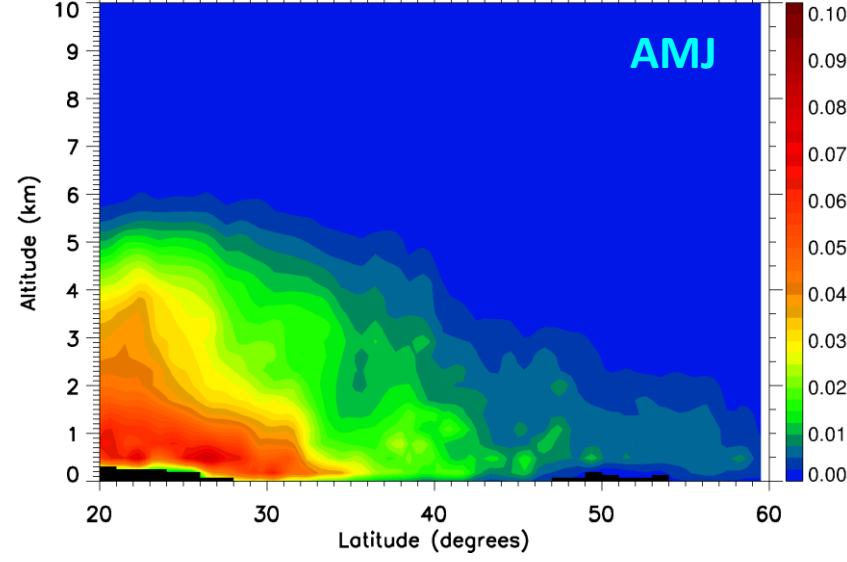


# Extinction Coefficient 20-30 deg Longitude

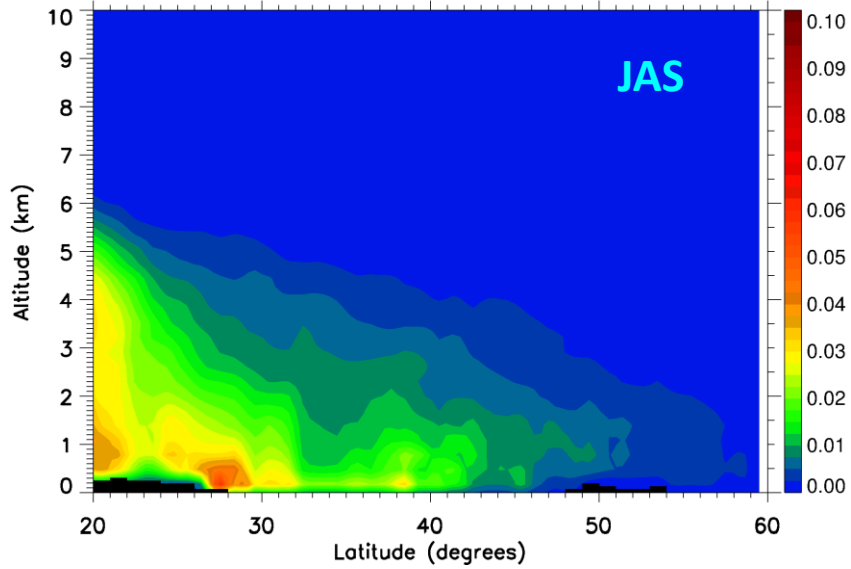
Dust Extinction 532nm, CALIPSO 2007to2014 Lons:20-30deg JFM



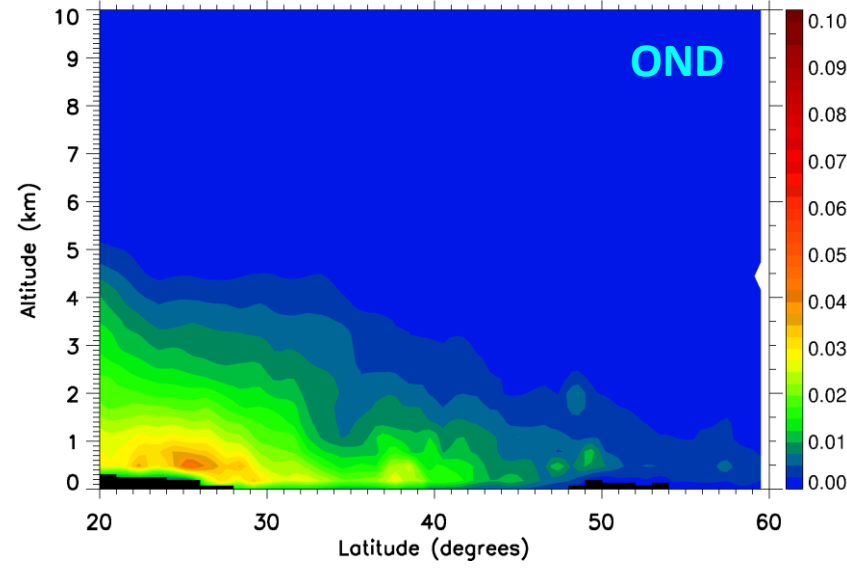
Dust Extinction 532nm, CALIPSO 2007to2014 Lons:20-30deg AMJ

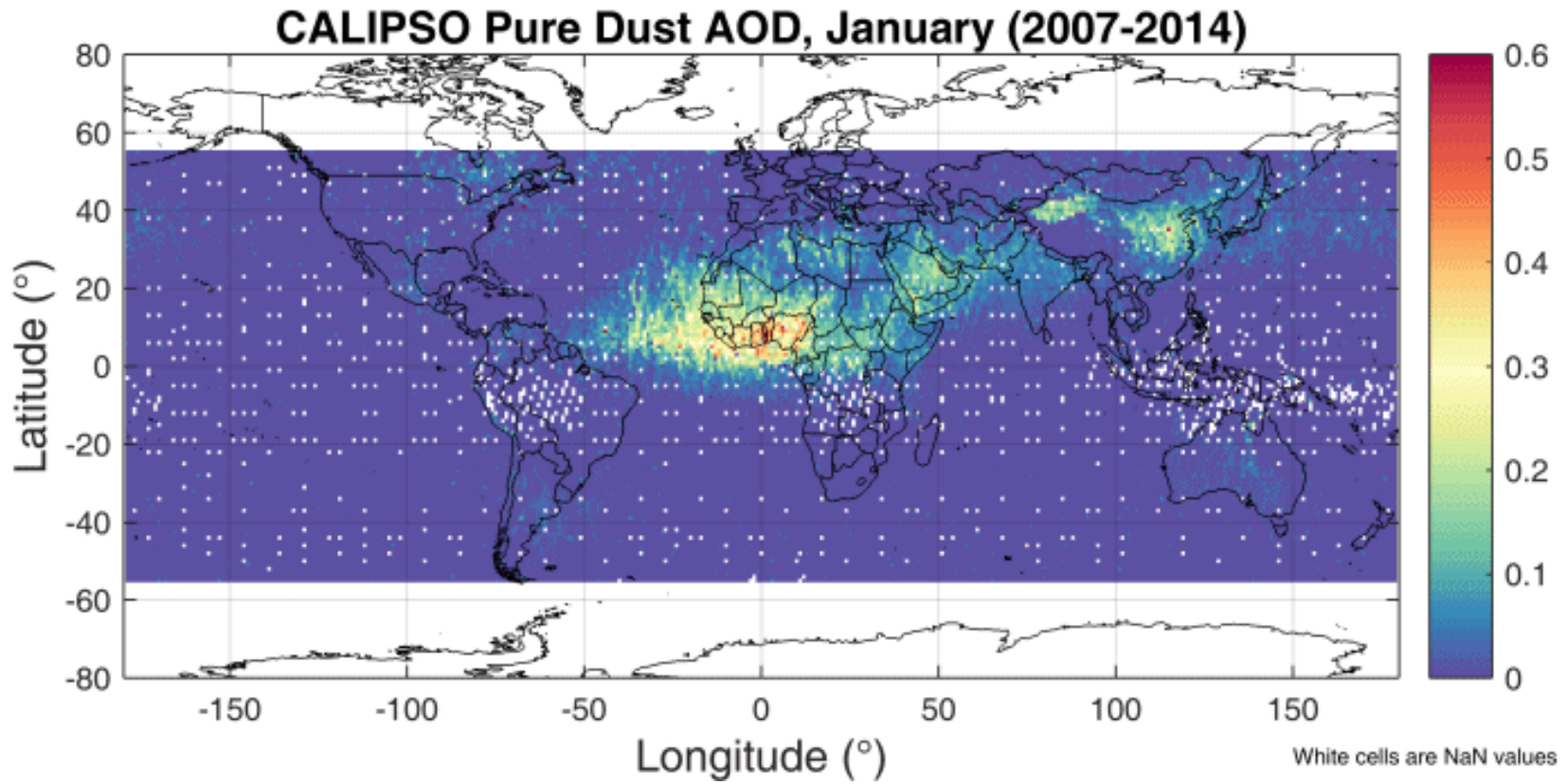


Dust Extinction 532nm, CALIPSO 2007to2014 Lons:20-30deg JAS



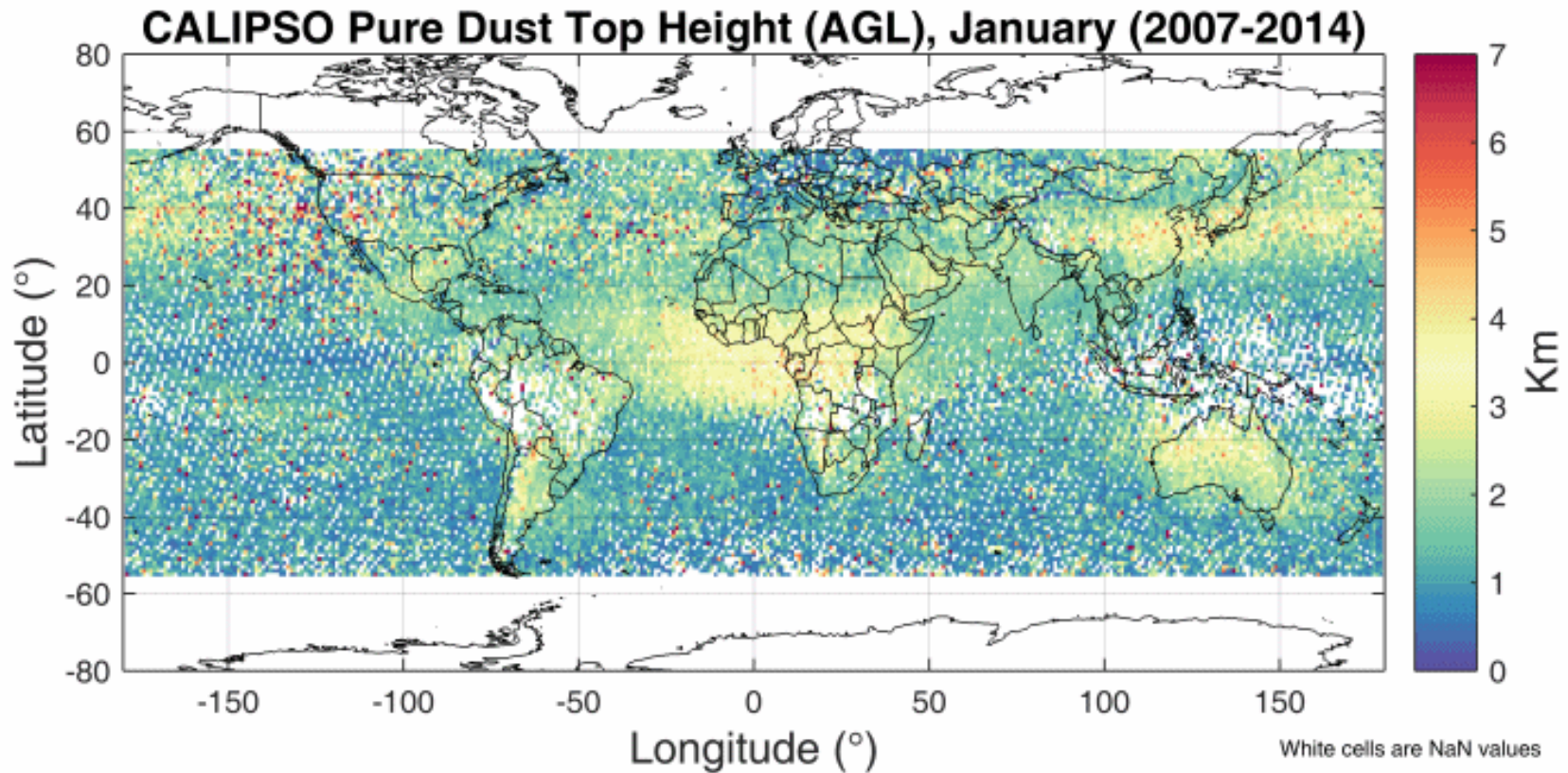
Dust Extinction 532nm, CALIPSO 2007to2014 Lons:20-30deg OND







# Top dust layer height





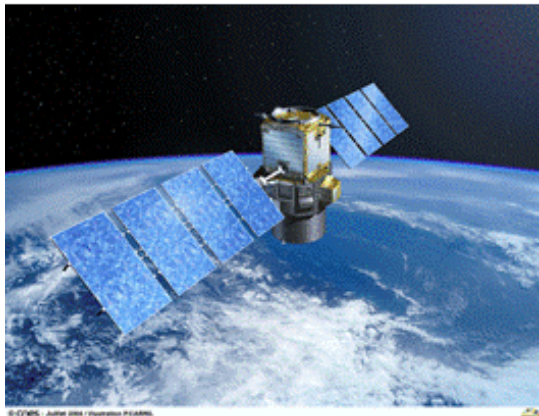
# Summary



1. Due to its polarization sensitivity, CALIPSO is capable of providing pure-dust products
2. The lidar ratio assumption can be optimized through EARLINET ground-based quality assured measurements
3. CALIPSO/EARLINET dust product is provided also over deserts where passive sensors have limitations due to reflectivity assumption
4. The product is provided in monthly averages of 1x1 degree but can be tailored for other applications like assimilation
5. CALIPSO total extinction is now produced including the dust correction. It is expected that CALIPSO underestimations when compared to AERONET and MODIS may be improved

Starting from DUST and expanding to other aerosol types, we aim to optimize CALIPSO and convert to UV. This product is envisioned to serve as the link between CALIPSO and EarthCARE, in order to bridge the missions for the provision of a multi-decadal harmonized climatic record.

**From CALIPSO**



EARLINET



**To EarthCARE**

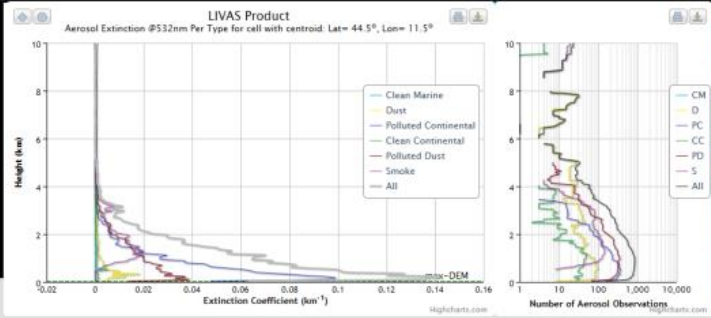


# Next steps: climate datasets

**LIVAS**

Home About

**LIVAS Product**  
Aerosol Extinction @532nm Per Type for cell with centroid: Lat= 44.5°, Lon= 11.5°



General Statistics:

Mean	0.20910	Min	0.001	Max	1.178
Number of overpasses:	167				
Number of profiles examined:	1000				

Aerosol Statistics:

Samples averaged (after filtering):

Total	34643	Aerosol	31196	Clear Air	91533
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Aerosol subtype occurrence:

CM	D	PC	CC	PD	S
0	12.6592	26.699	6.3754	39.6312	97.1382

Aerosol Optical Depth at 633 nm:

Mean	0.1231	Median	0.03791	StdDev	0.24192
------	--------	--------	---------	--------	---------


Category | Product | Wavelength | Partial Products

Aerosol	Extinction	355nm	Per Type
		532nm	
Cloud	Backscatter	1064nm	Per Season
		1570nm	
Stratospheric	Depolarization	2050nm	

Save to ASCII | Save to NetCDF

Product Selector  
Navigate to the desired final product by hovering over the menu from left to right and then press in order to inspect charts and data.

Grid Selector  
Read more »



LIVAS | Products | ABOUT

NOA | > Regional and Seasonal Statistics | > About page | > Selected Science

<http://lidar.space.noa.gr:8080/livas/>

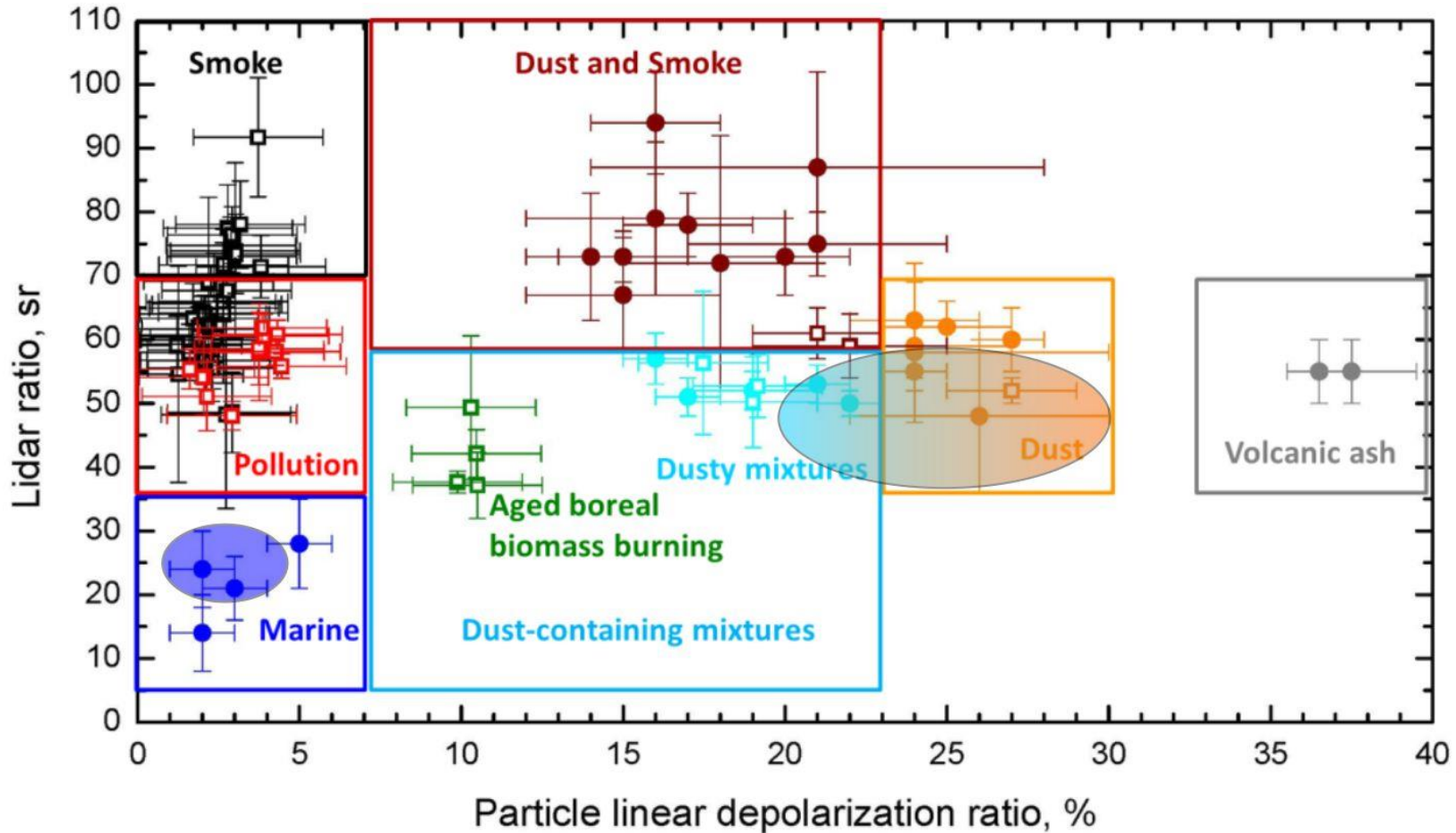




# Next steps: Aerosol model improvements

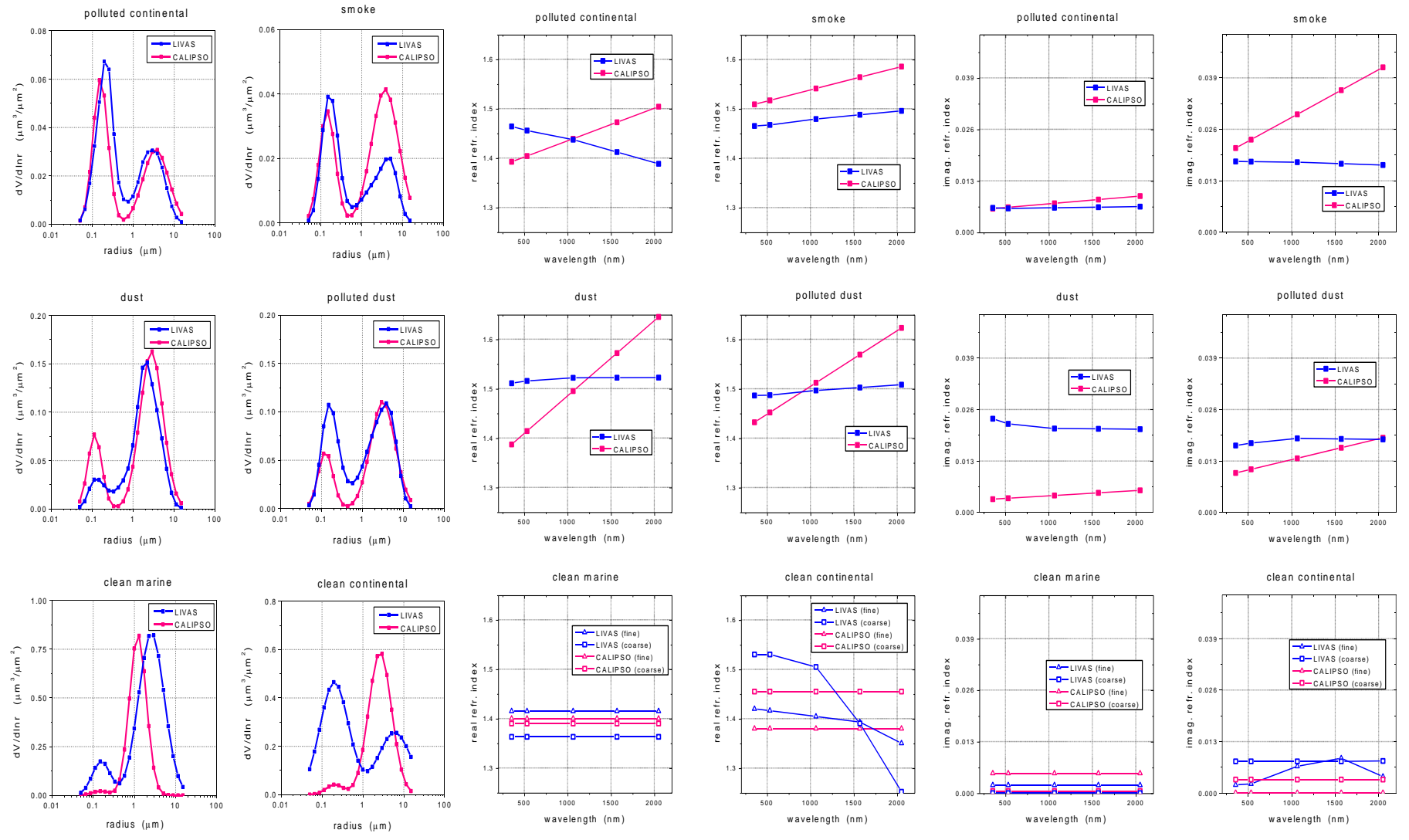


LIVAS AEROSOL TYPE	UV/VIS			VIS/IR				
	approach used	532/355 nm		approach used	532/1570 nm		532/2050 nm	
		BAE	EAE		BAE	EAE	BAE	EAE
Polluted continental	ESA-CALIPSO	1.42	1.24	AERONET-Omar	1.18	1.66	1.32	1.56
Dust	ESA-CALIPSO	0.40	0.55	AERONET-CALIPSO	0.35	0.6	0.43	0.57
Polluted dust	ESA-CALIPSO	0.92	0.71	AERONET-CALIPSO	0.67	1.14	0.71	1.07
Smoke	ESA-CALIPSO	1.46	1.41	AERONET-CALIPSO	0.79	1.42	0.825	1.34
Clean marine	ESA-CALIPSO (bsc) Sayer et al. (2012) (ext)	0.50	0.78	Sayer et al. (2012)	0.74	0.39	0.81	0.38
Clean continental	ESA-CALIPSO (bsc) OPAC (ext)	1.20	1.31	OPAC	1.15	1.28	1.64	1.27
Stratospheric	ESA-CALIPSO (bsc) Deshler et al. (1993), Wandinger et al. (1995) (ext)	0.98	0.48	Deshler et al. (1993), Wandinger et al. (1995)	1.36	1.33	1.38	1.49

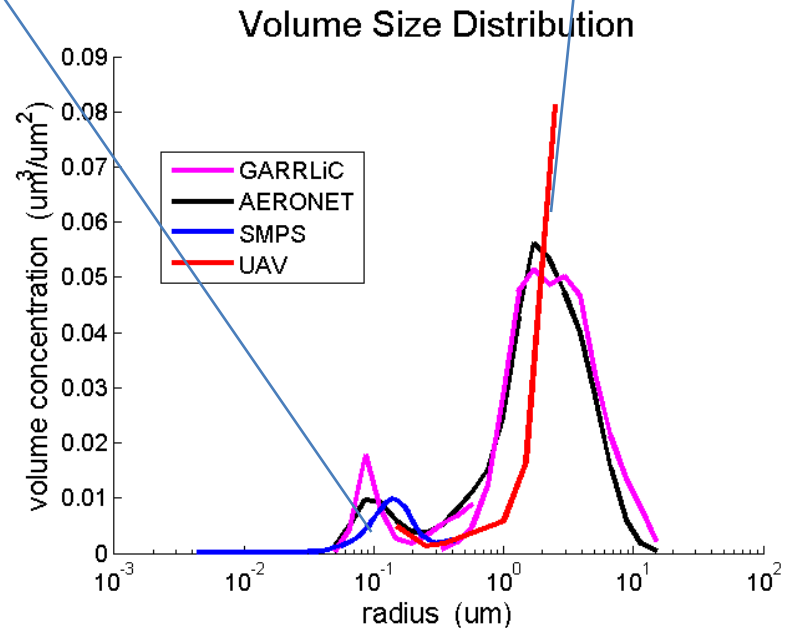
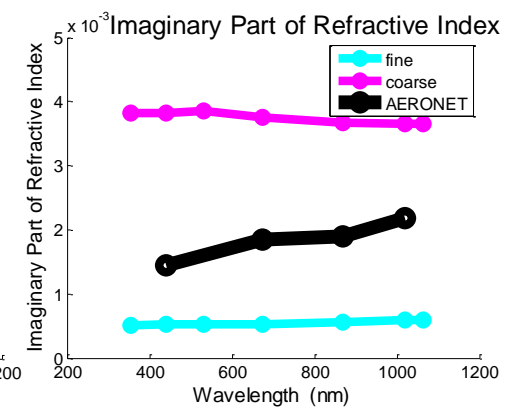
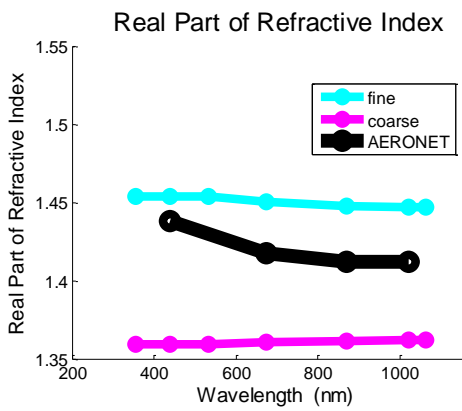
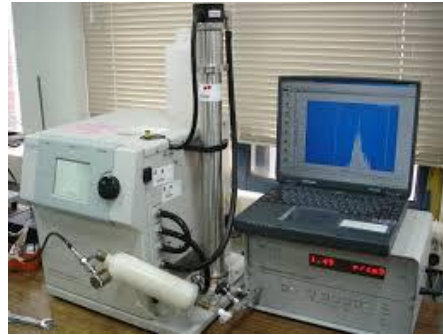
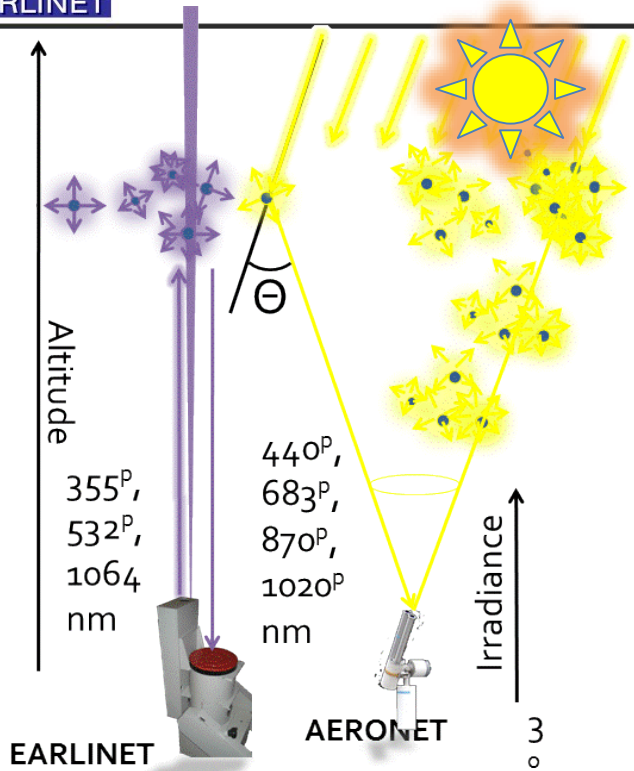




# Next steps: Aerosol model improvements



# Next steps: Aerosol model improvements



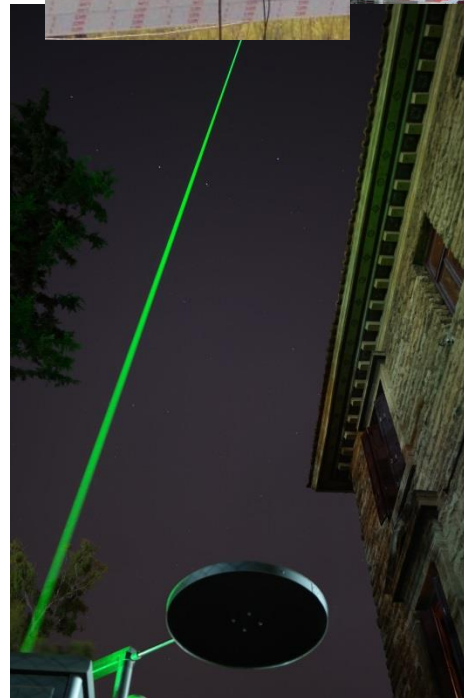
**ACTRIS-2 campaigns: NOA will organize 4 experimental campaigns @ Athens, Crete, Granada, Melpitz**

Night-time retrievals with sun/lunar/star photometer and Raman lidar



CIMEL sunphotometer PollyXT OCEANET lidar

In-situ measurements with Unmanned Aerial Vehicles (UAVs) and/or tethered balloons



Athens and Melpitz campaigns are implemented already



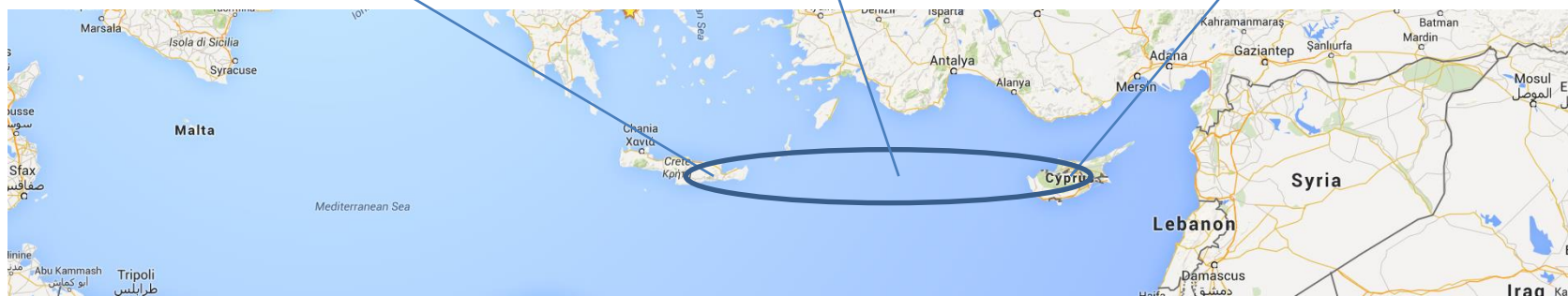
# Next steps: Aerosol model improvements

Large scale experimental campaign in Eastern Mediterranean – April 2017

**NOA:**  
Replicate LACROS  
@ Crete

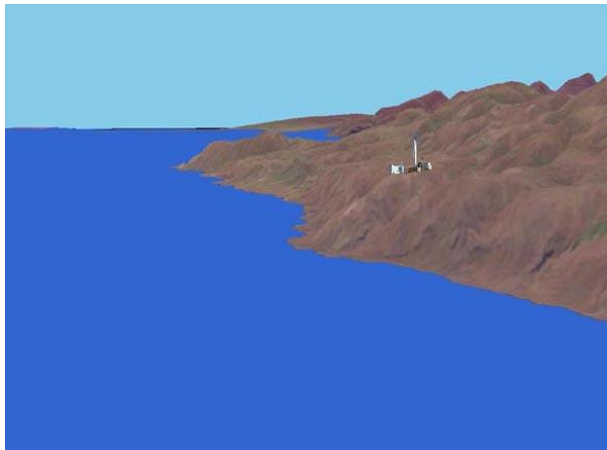


**TROPOS:**  
LACROS @ Cyprus





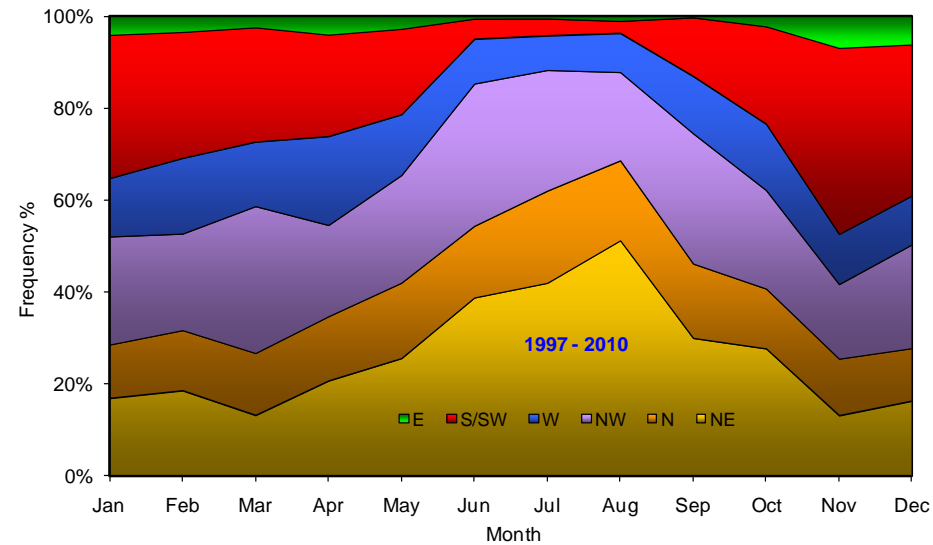
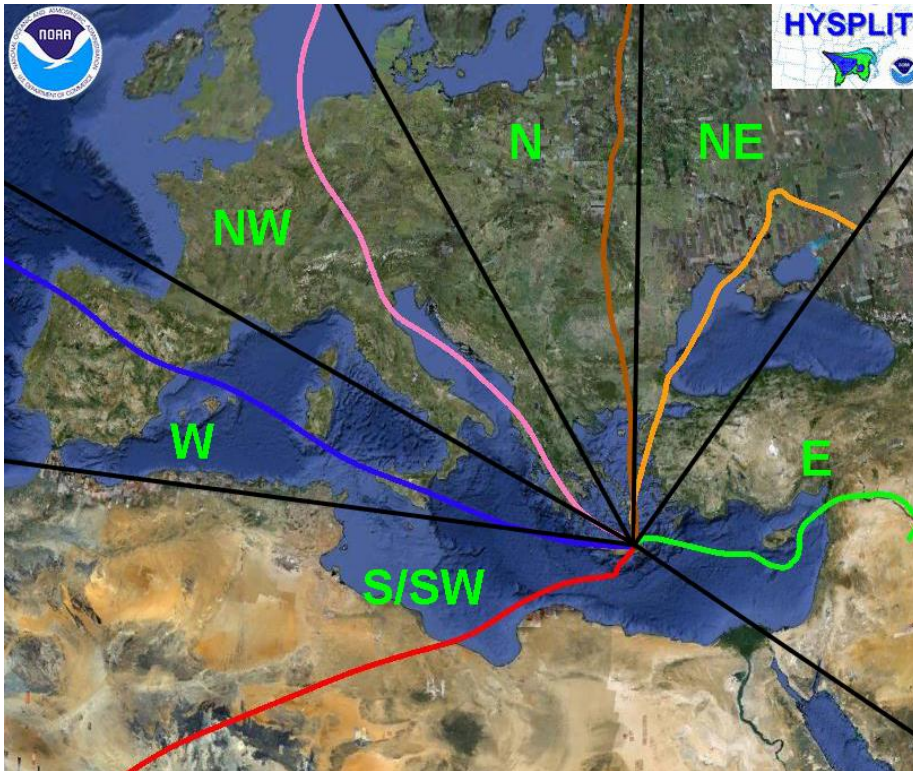
# Next steps: Finokalia for near-real time



Latitude =  $35.34^{\circ}\text{N}$  - Longitude =  $25.67^{\circ}\text{E}$  - Elevation = 252 a.s.l.







In-situ measurements performed during the last 20 years showed that marine and dust particles are present 95% of the time. Smoke from forest fires can be occasionally detected as well as urban pollution from nearby megacities in the Aegean Sea (Athens, Istanbul)





Thermo Environmental Instruments Inc.  
PM10/PM2.5 Analyzer

Thermo Environmental Instruments Inc.  
CO Analyzer

Thermo Environmental Instruments Inc.  
O3 Analyzer

Magor Scientific  
Aethalometer™

Monitor display showing data graphs.

PILS  
Pilsbury Instruments

Thermo  
PM2.5 Monitor

Thermo Scientific  
Instrument with digital display

Main Menu  
Readings  
Data Average  
Report Pref

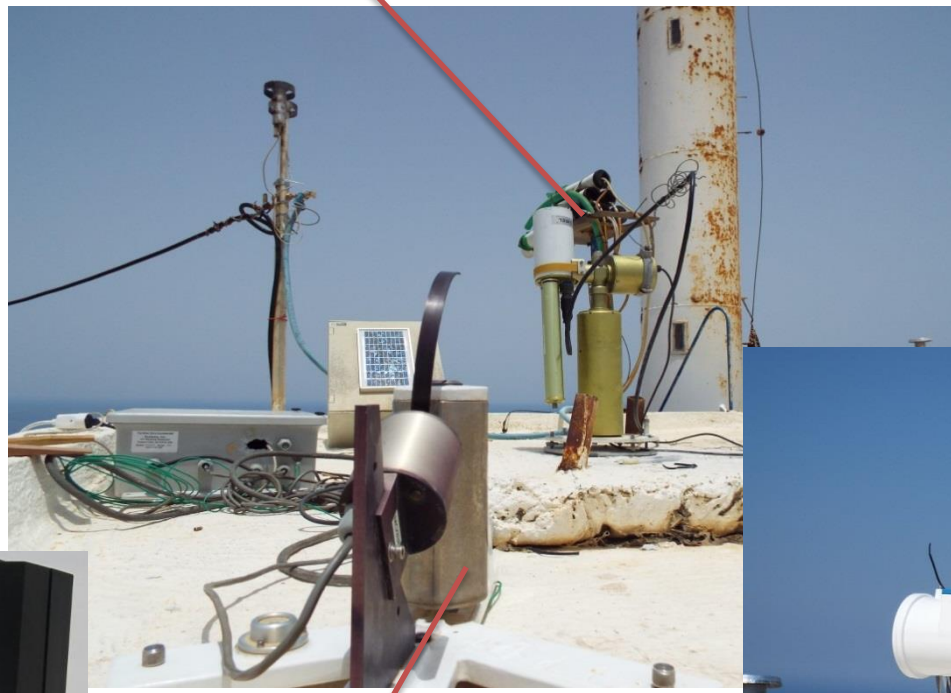




- 3 backscatter channels (355, 532, 1064 nm)
- 2 extinction Raman channels (387, 607 nm)
- 2 depolarization channels (355, 532 nm)
- 1 water vapor channel (407 nm)
- 1 near-range channel (532, 607 nm)



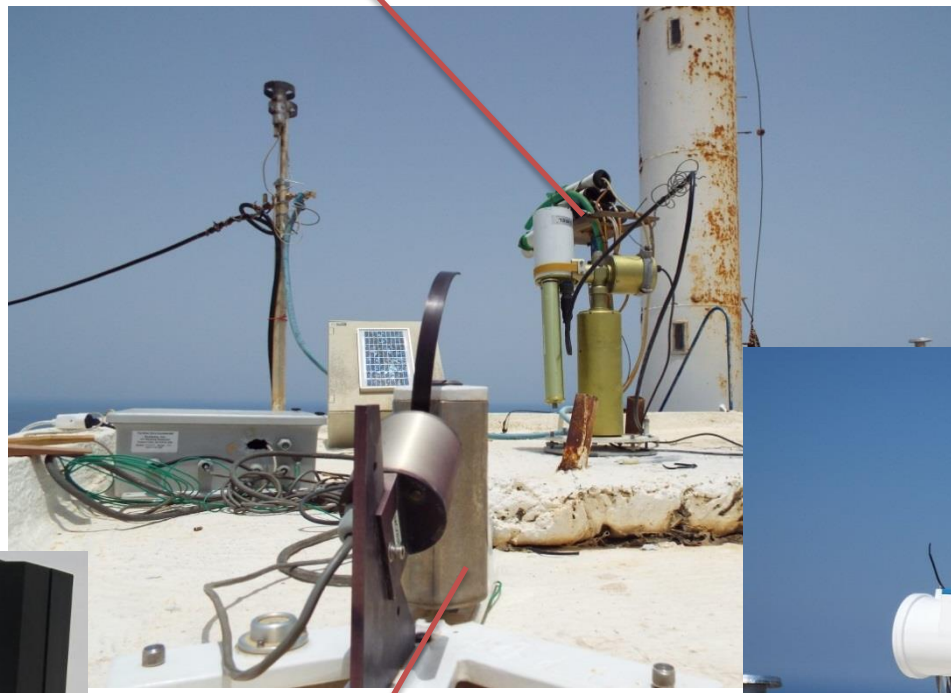
# Next steps: Finokalia for near-real time



Microtops II



UV-MFR



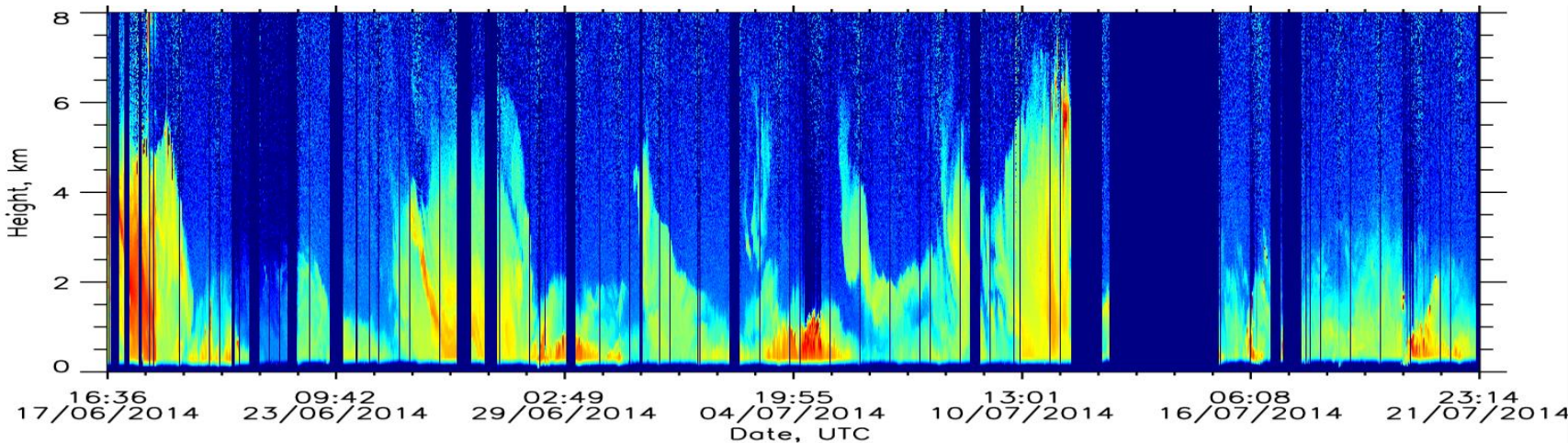




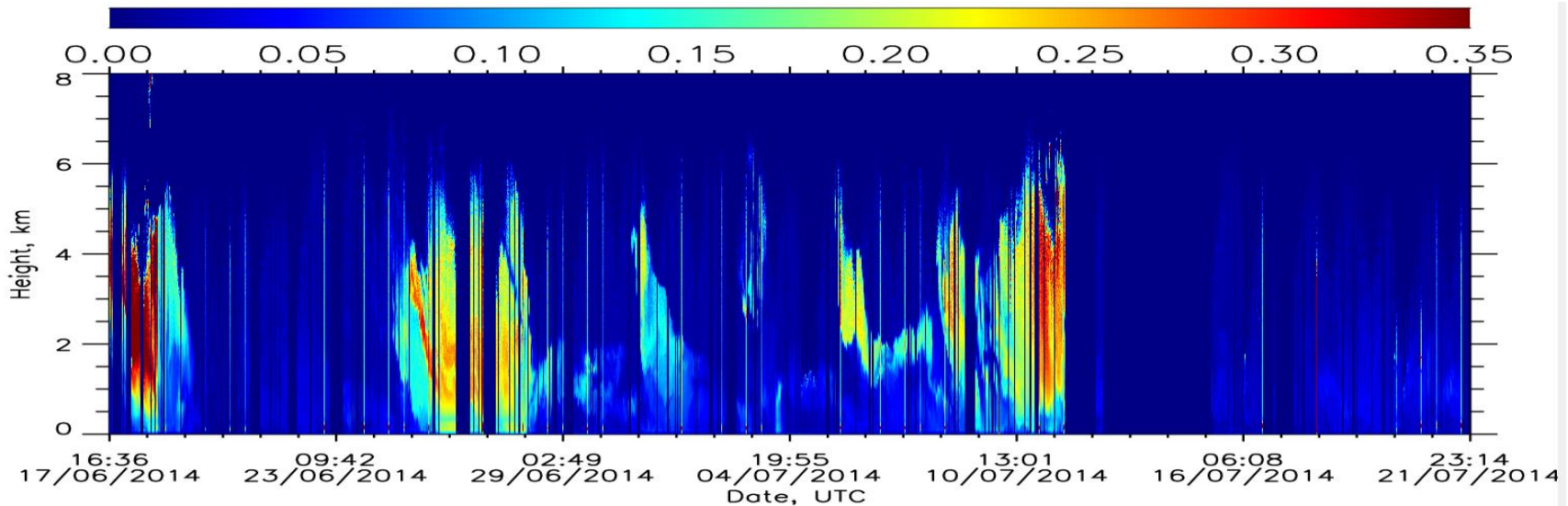
# Next steps: Finokalia for near-real time

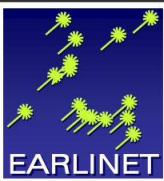


Range corrected signal  
at 1064nm

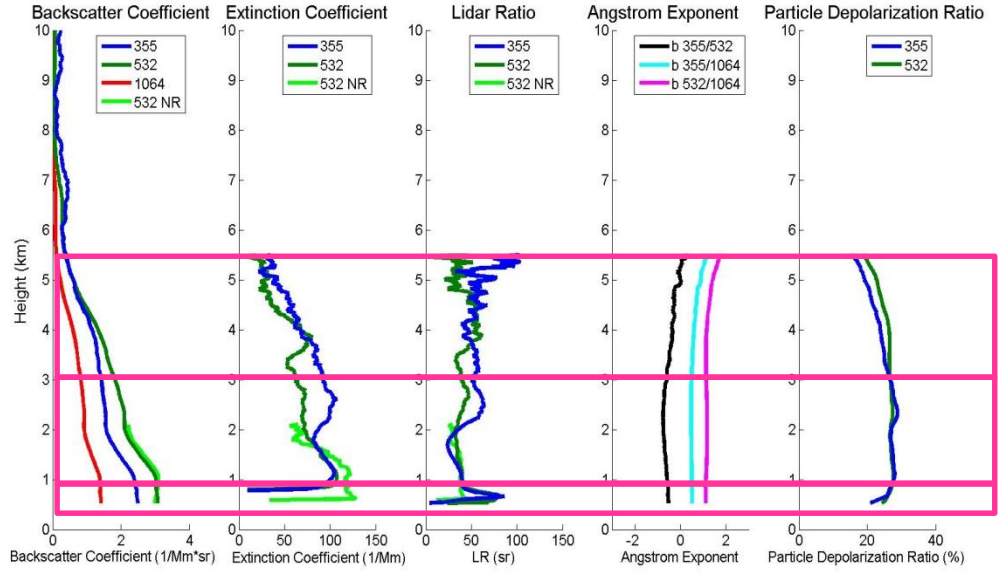
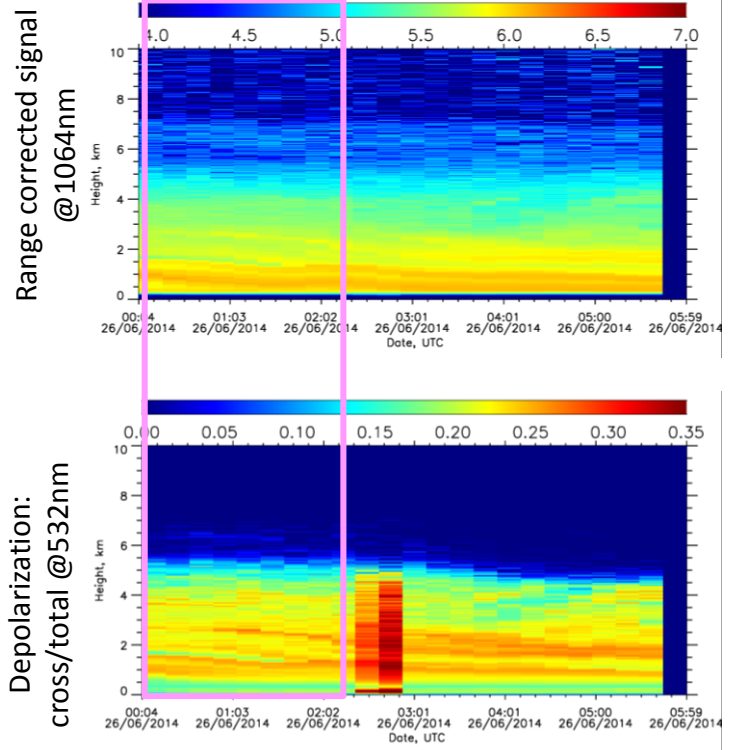


Depolarization:  
cross/total @532nm



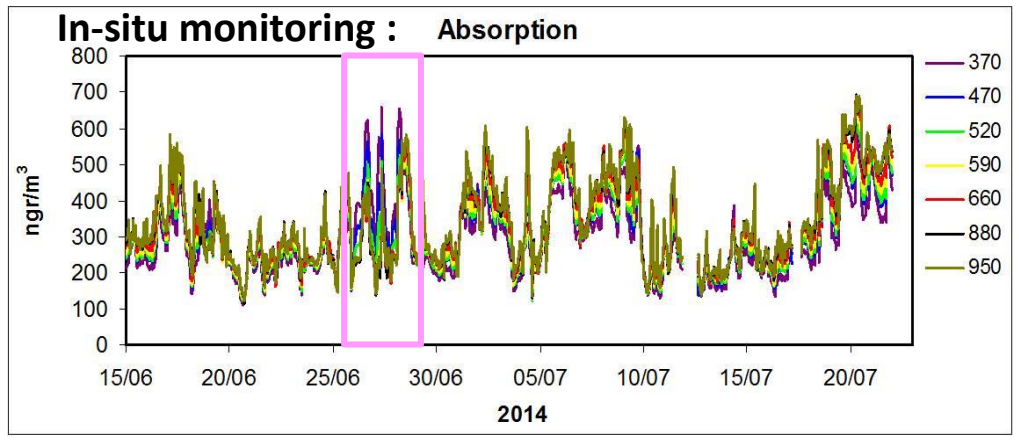
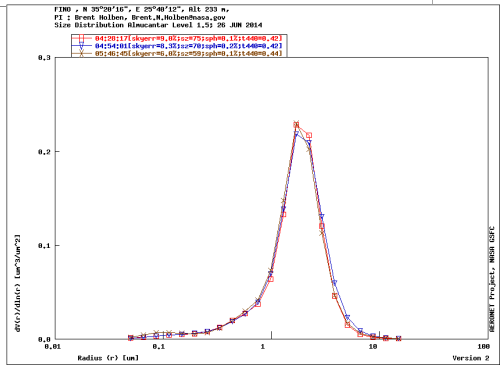


# Next steps: Finokalia for near-real time



**Cimel**  
 AOD<sub>500</sub>: 0.42  
 Ang: 0.08

**Dominance of coarse mode**







## Next steps: input for assimilation



# Expedited CALIPSO Level 1.5 version

Total Attenuated Backscatter 532

Perpendicular Attenuated Backscatter 532

Extinction Coefficient 532 (Mean, Median, stDev & Uncertainty)

Available **6 to 30 hours after downlink.**

Contains all level 1B and level 2 data

Browse images publically available

Data available by subscription only & via FTP


(info here:

[https://eosweb.larc.nasa.gov/sites/default/files/project/calipso/quality\\_summaries/CAL\\_lidar\\_L1-5\\_v3-02.pdf](https://eosweb.larc.nasa.gov/sites/default/files/project/calipso/quality_summaries/CAL_lidar_L1-5_v3-02.pdf))

# Aerosol\_cci Phase 2

## Proposed products 2014/15



Parameter	Sensor (Algorithms)	Coverage (planned) - status
AOD, up to 4 wavelengths	ATSR-2 + AATSR (ADV, SU, ORAC)	1995 – 2012 (available)
	AATSR / MERIS	2003 - 2012
	PARASOL	1996, 1998, 2006 – 2014 (selected land regions)
	SYNAER	2003 - 2012
Dust AOD	IASI	2006 - 2015
AAI	SCIAMACHY/OMI/GOME-2	1995-2015
Stratospheric extinction profiles, AOD, size parameter	GOMOS	1984 - 2005
	SAGE-II, ODIN, OSIRIS, GOMOS	2003 – 2012
Sentinel demo datasets	SLSTR AOD TROPOMI AAI	2015



# Acknowledgments



1. **ACTRIS, ACTRIS-2, EARLINET**
2. Aerosol and cloud **CCI** (Climate Change Initiative)
3. **LIVAS** multi-wavelength 3D aerosol climatology
4. **DEDICAtE** study for dual-depolarization
5. **CHARADMexp** campaign for marine and dust mixtures characterization
6. **ESA-CALIPSO** study for the development of an EARLINET-based aerosol model for space-borne lidar applications

