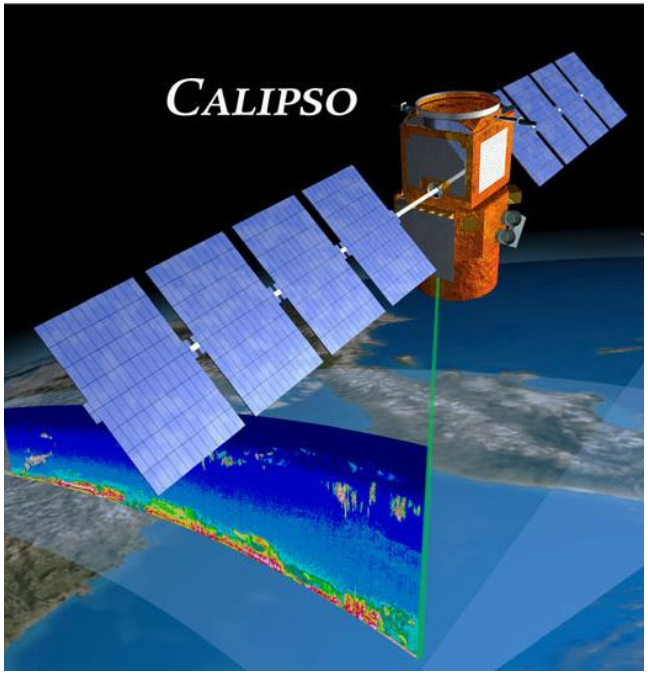
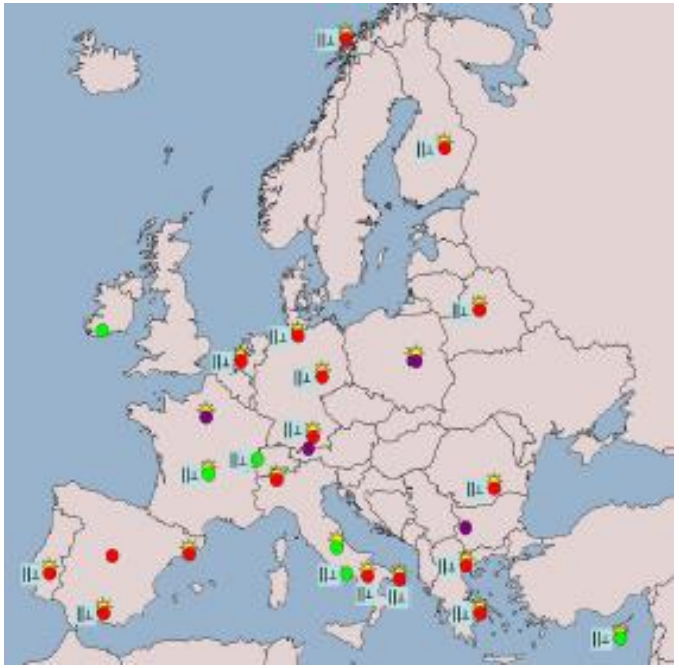
Optimized CALIPSO pure-dust product using EARLINET

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 aerosol classification

CALIPSO L1 product:

- Attenuated backscatter (γ)
- Estimated particle depolarization (δ)

Omar et al., 2009

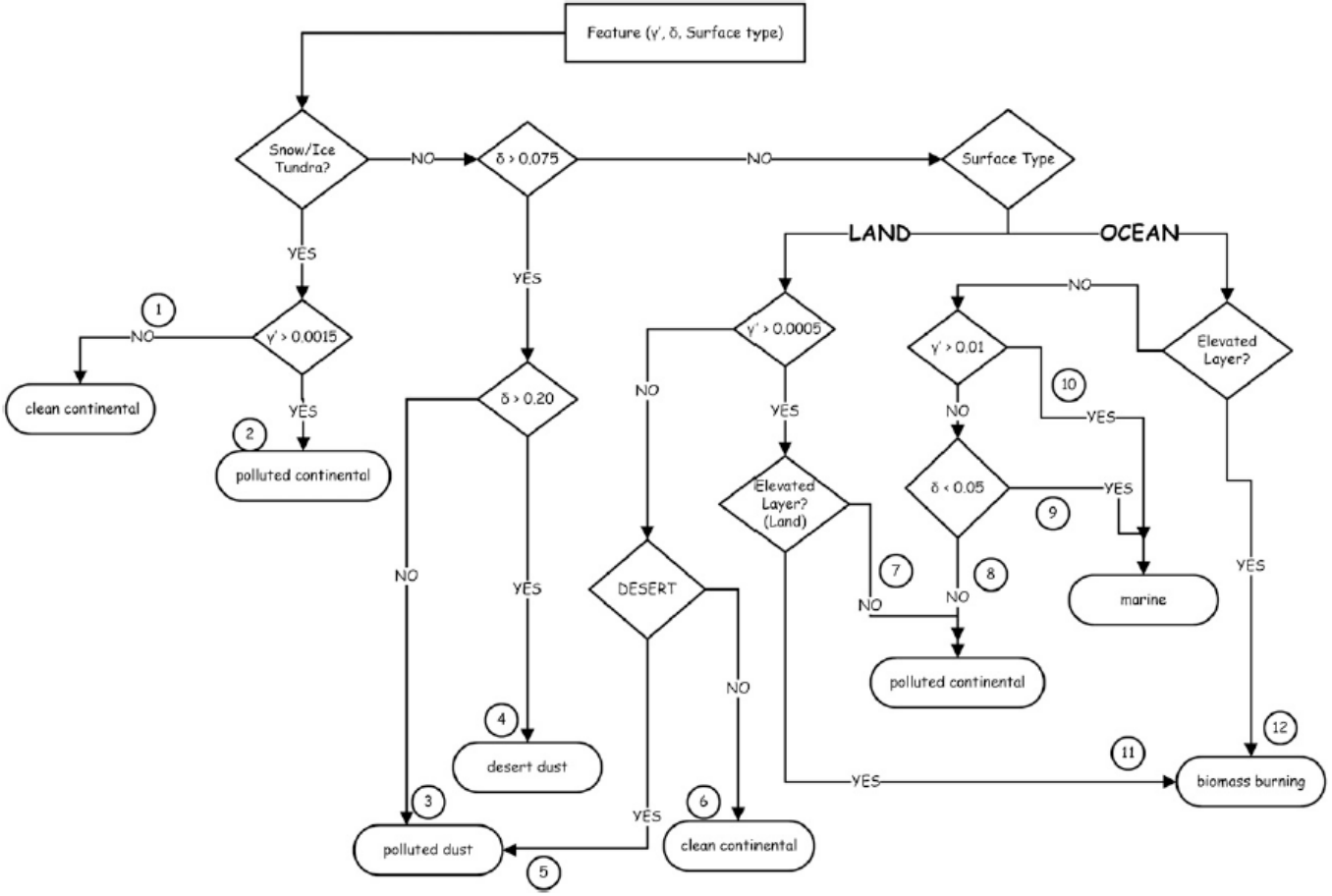
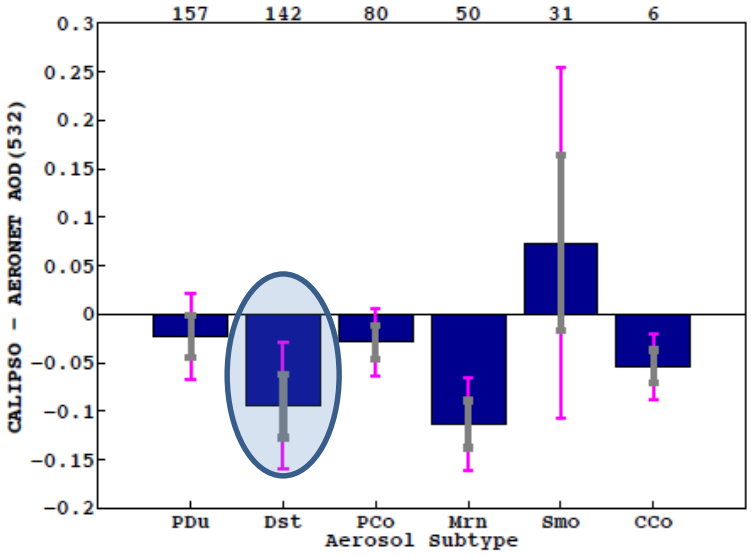


FIG. 2. Flowchart of the CALIPSO S_a selection scheme for tropospheric aerosols.

CALIPSO aerosol classification

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

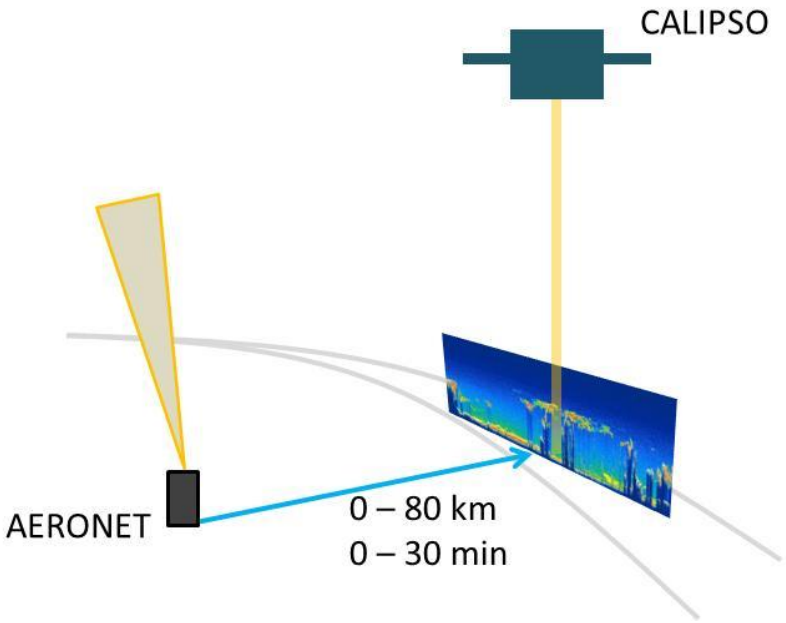
Evaluation of CALIPSO AODs per type



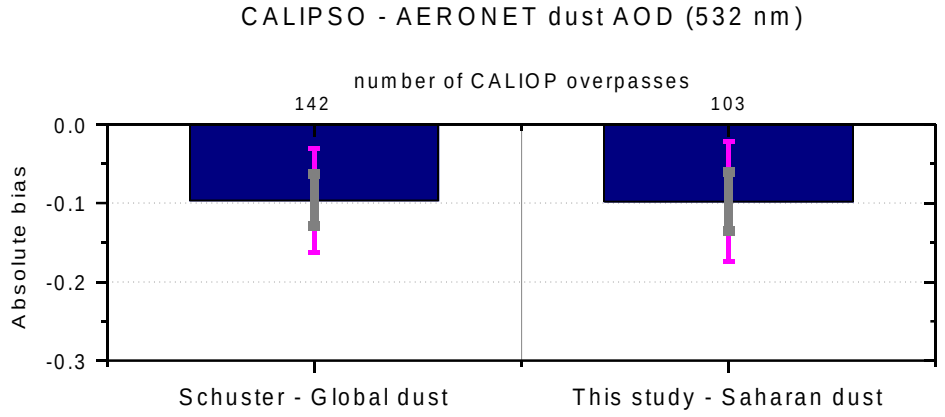
Schuster et al., ACP, 2012

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

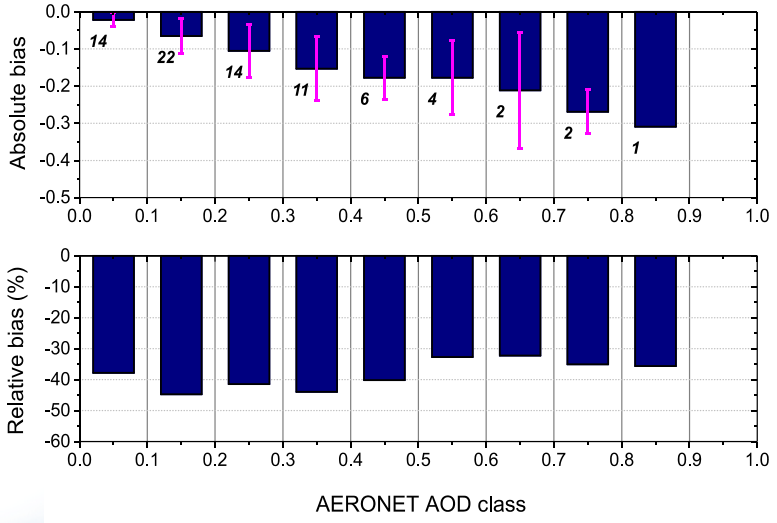
- **-13%** when dust is present
- **-3%** when dust is not included



The dust case

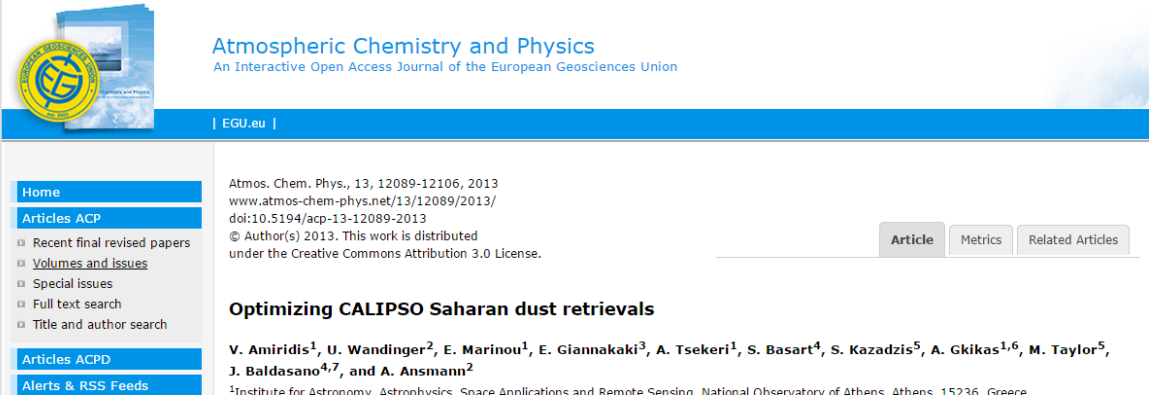


Schuster et al., ACP, 2012



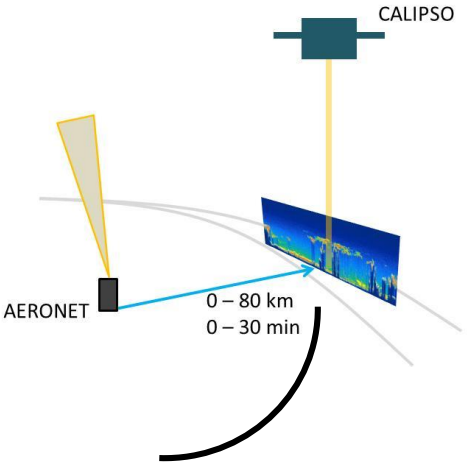
Possible sources of discrepancies:

- Aerosol misclassification
- Lidar ratio

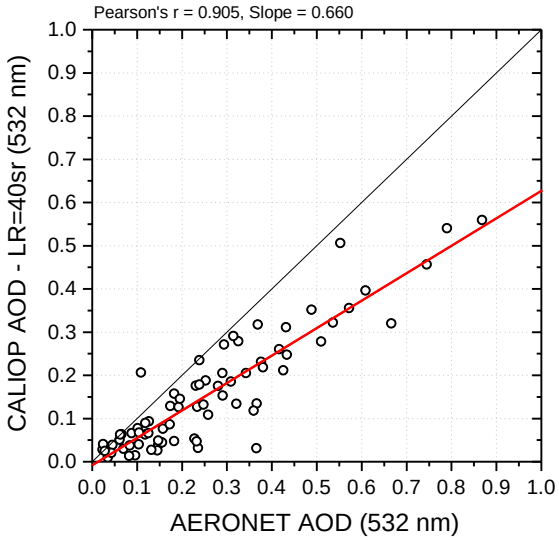


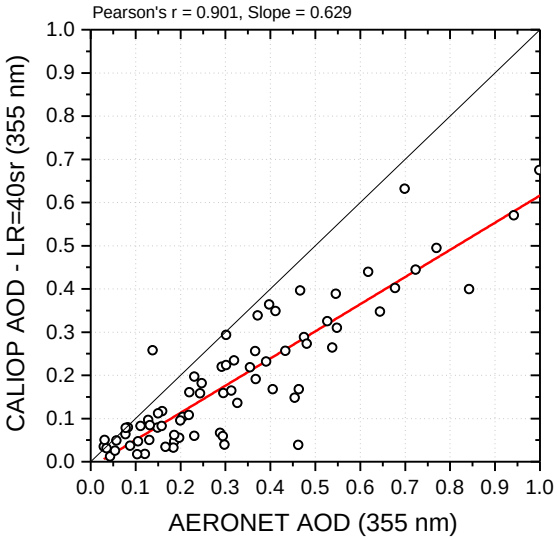
Optimization of the dust product

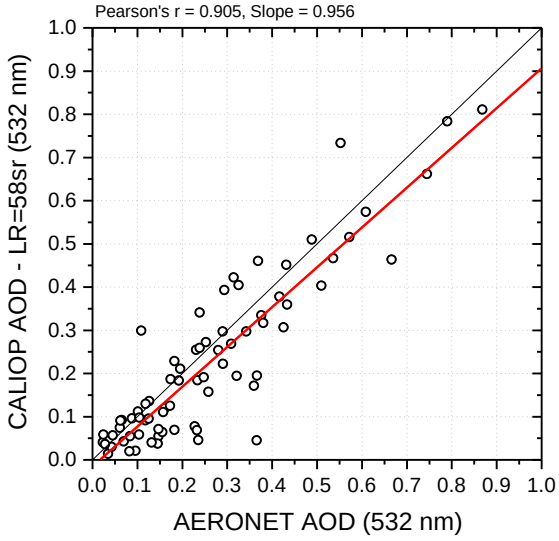
CALIPSO-AERONET Collocation

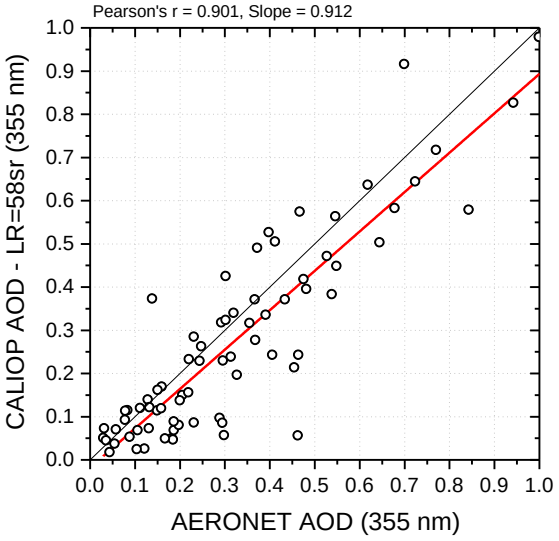


In pure Dust cases from CALIPSO typing



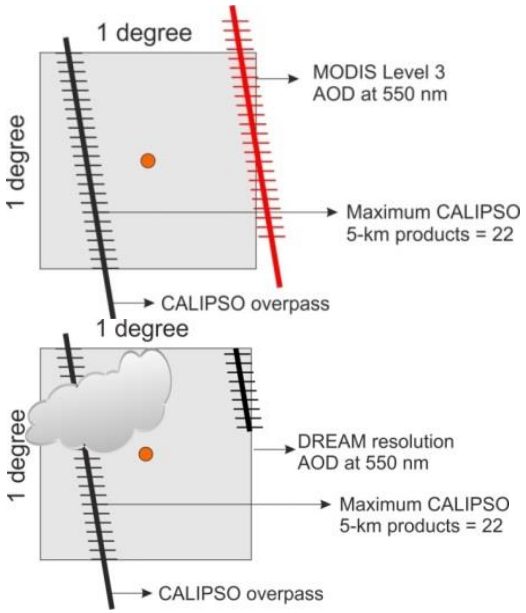




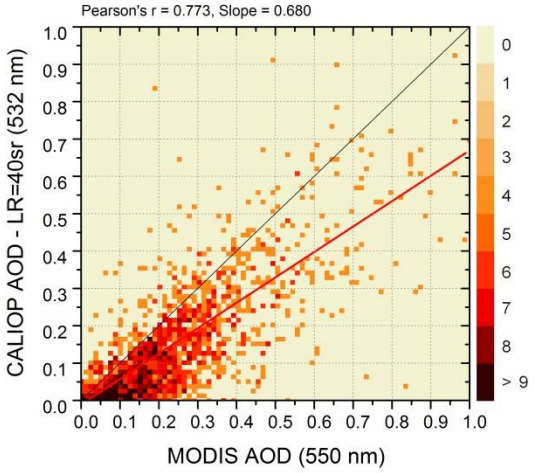


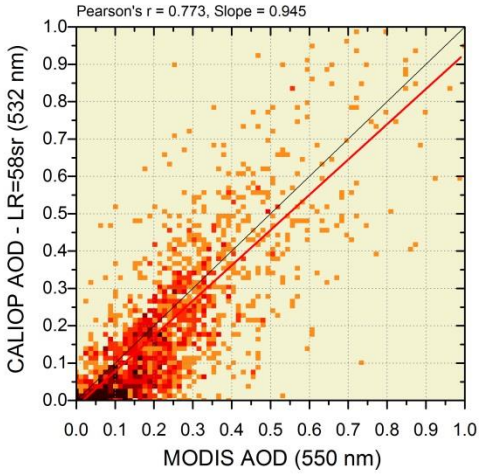
Optimization of the dust product

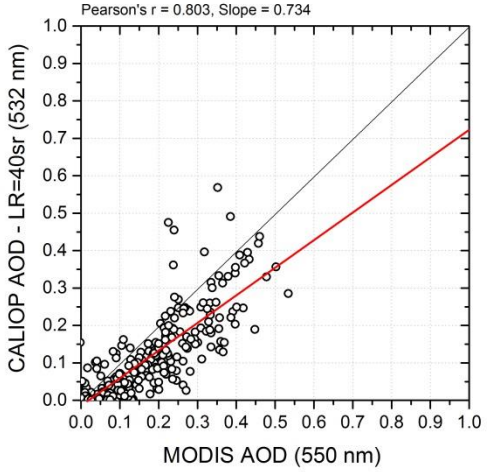
CALIPSO-MODIS Collocation

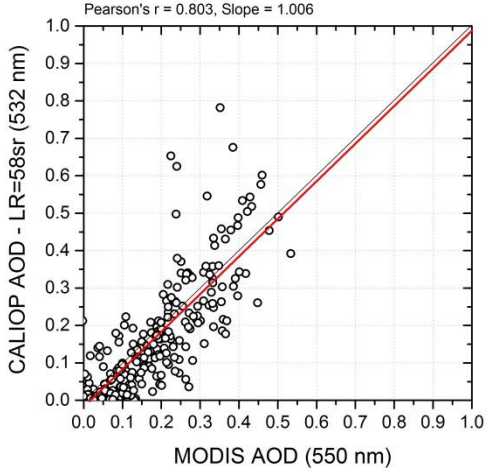


Red overpasses rejected

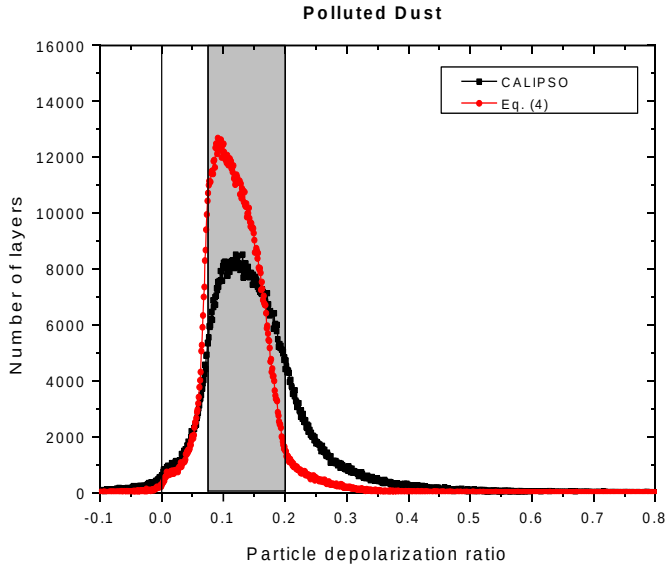


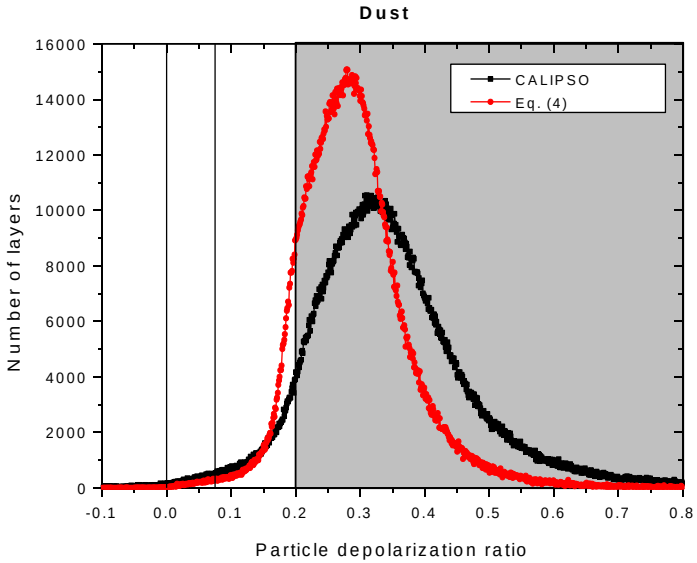






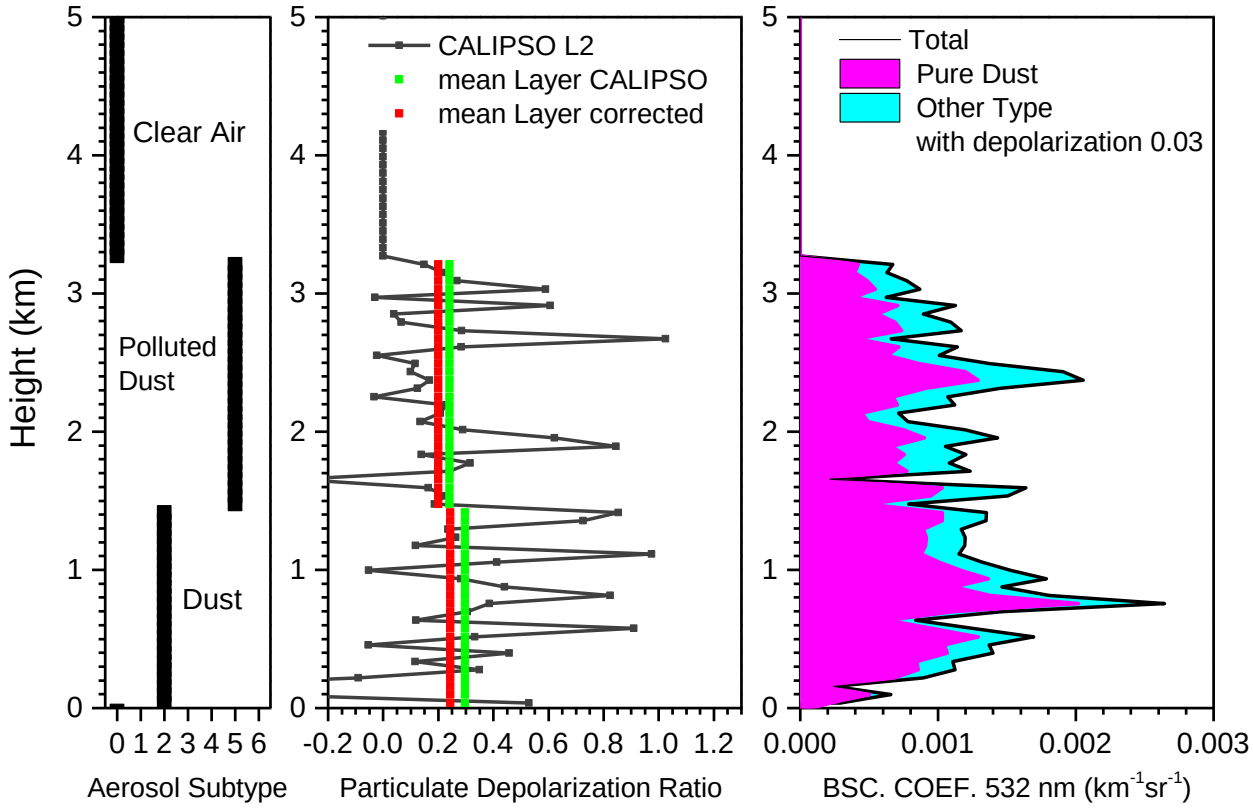
Optimization of the dust product





Amiridis et al., 2013

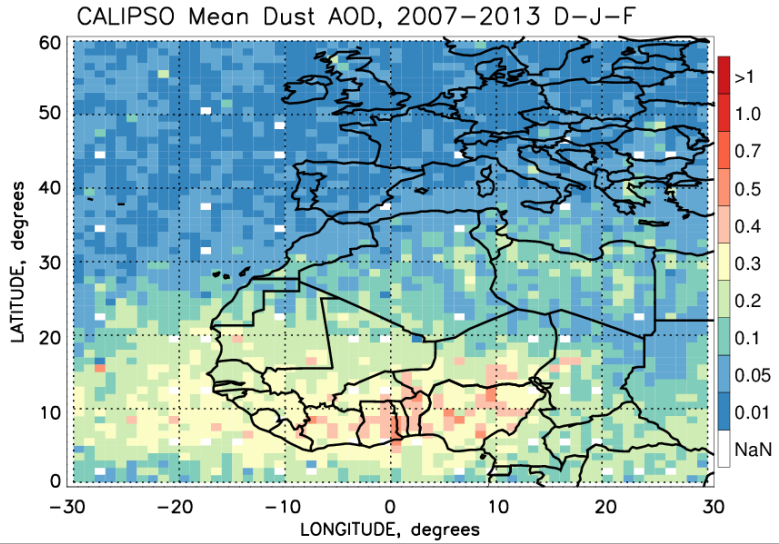
Discrimination of pure dust

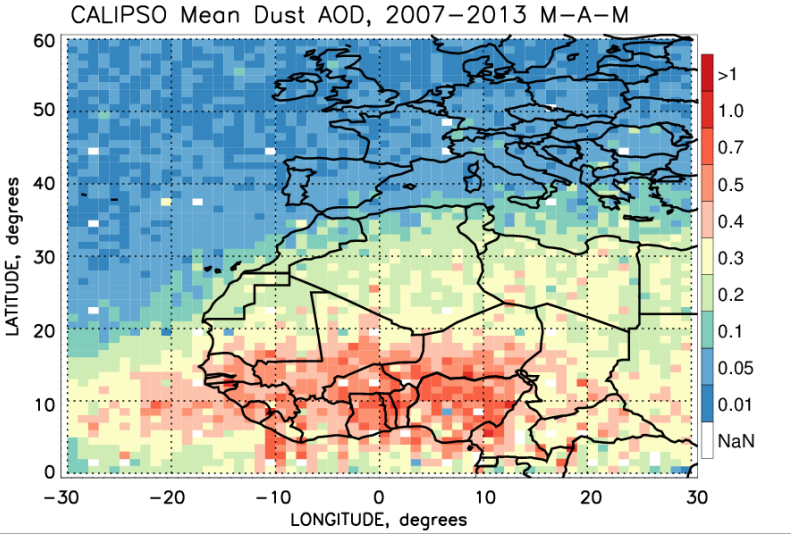


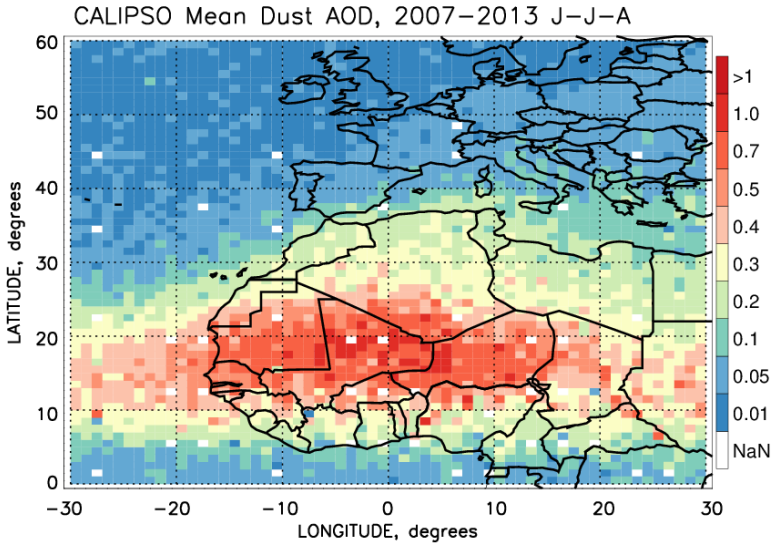
Tesche et al., JGR, 2009

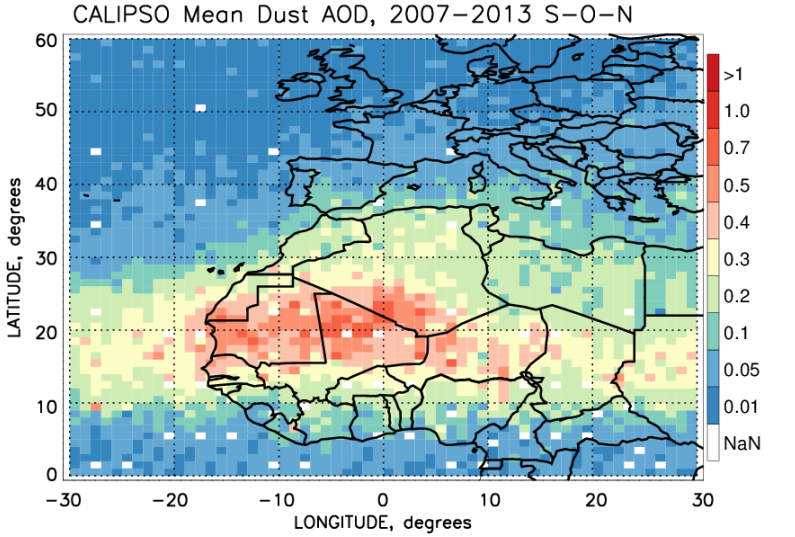
$$\beta_1 = \beta_t \frac{(\delta_p - \delta_2)(1+\delta_1)}{(\delta_1 - \delta_2)(1+\delta_p)}$$

Optimized CALIPSO dust product

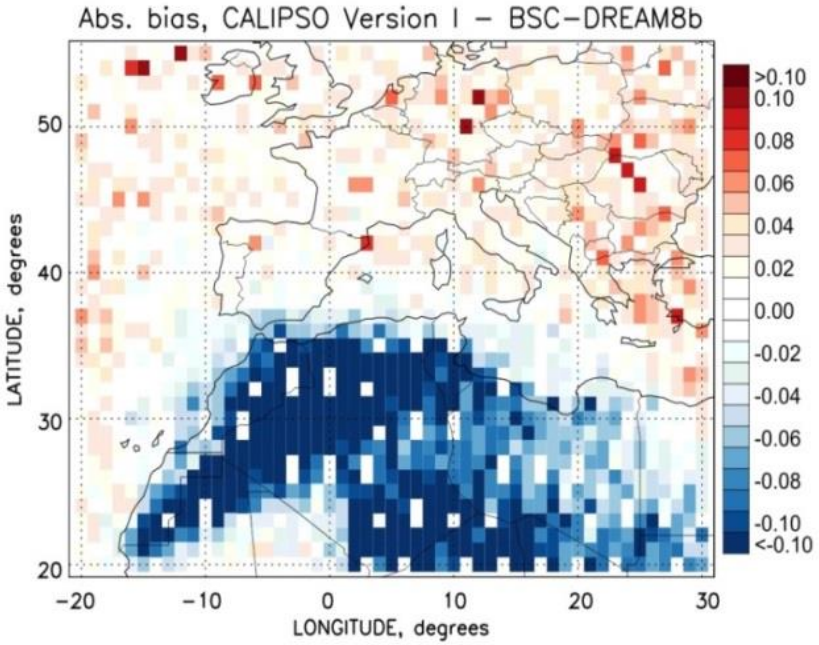


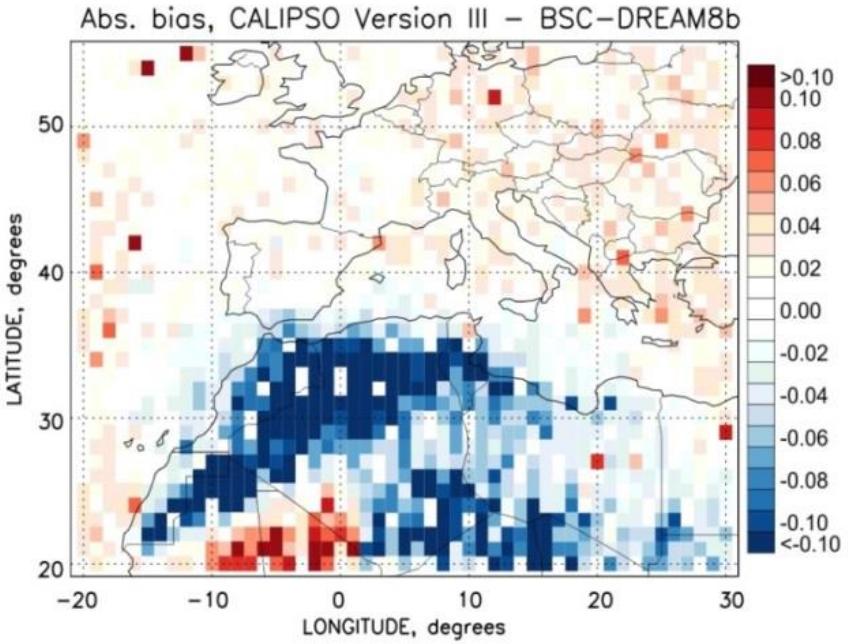




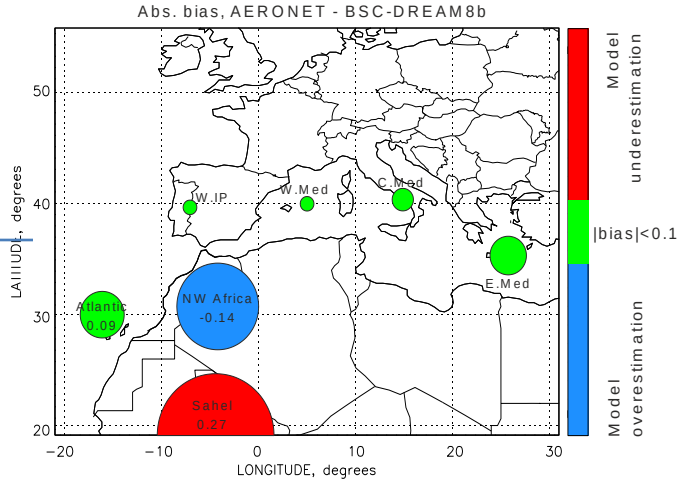


CALIPSO vs BSC-DREAM8b

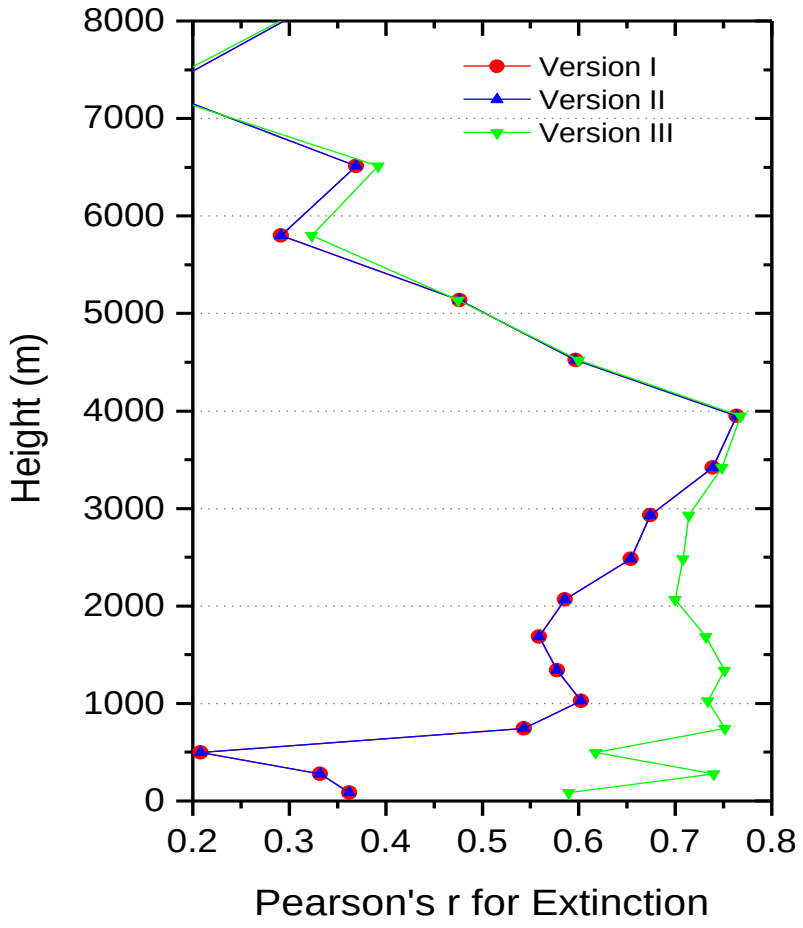




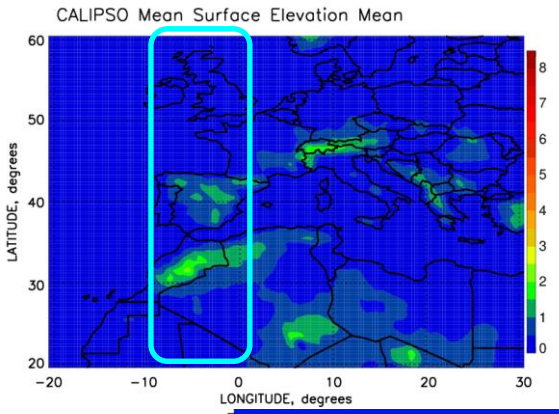
From Basart et al., 2012

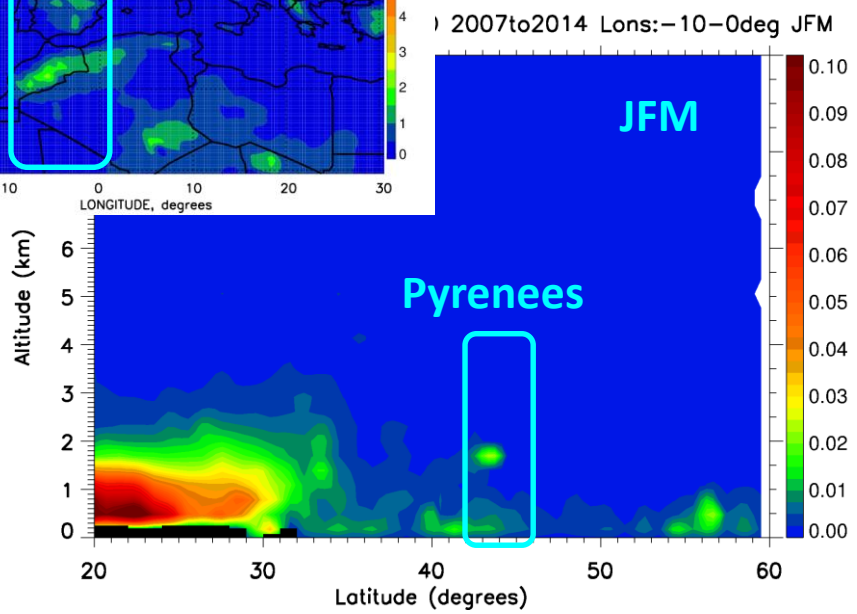


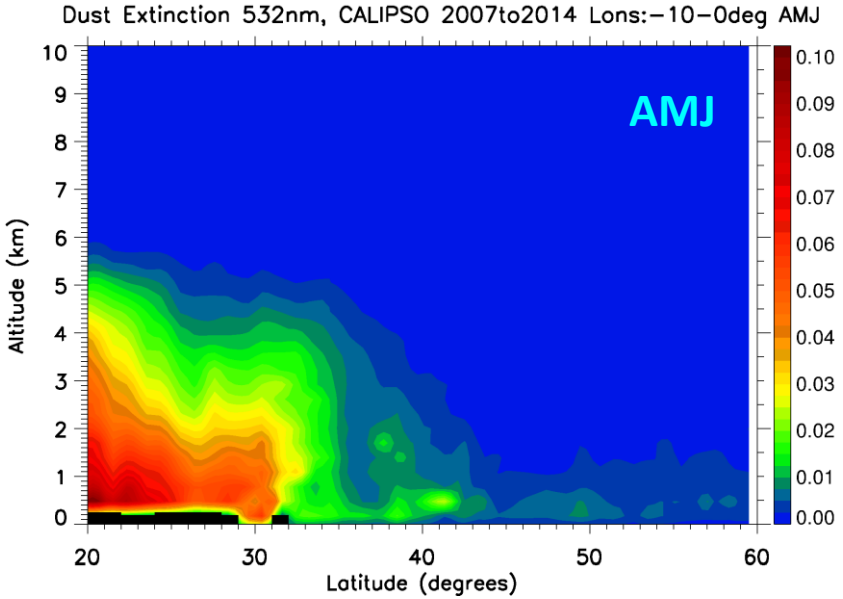
CALIPSO vs BSC-DREAM8b

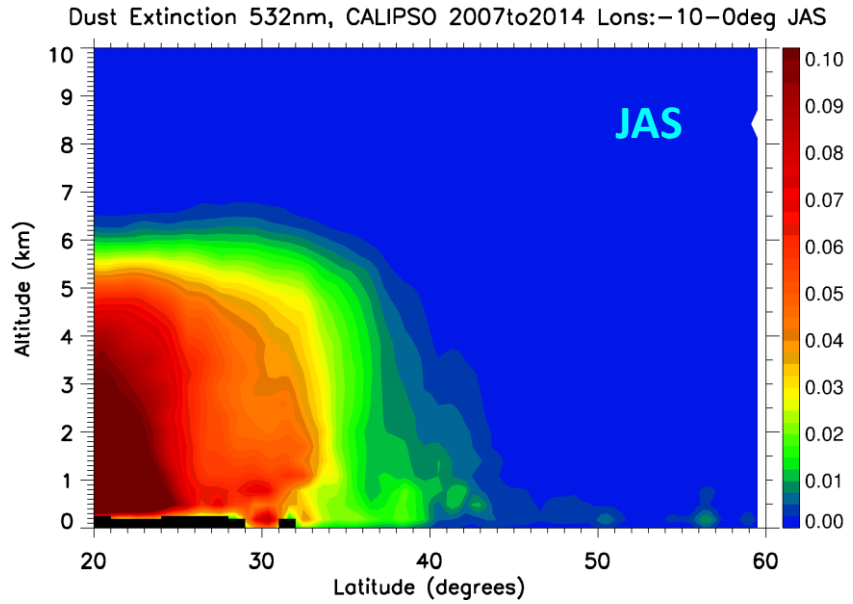


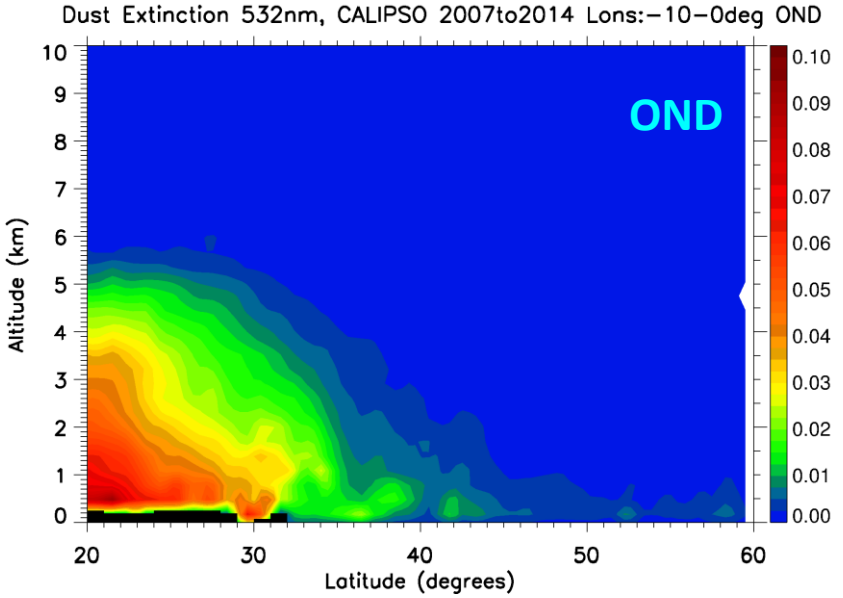
Extinction Coefficient -10-0 deg Longitude



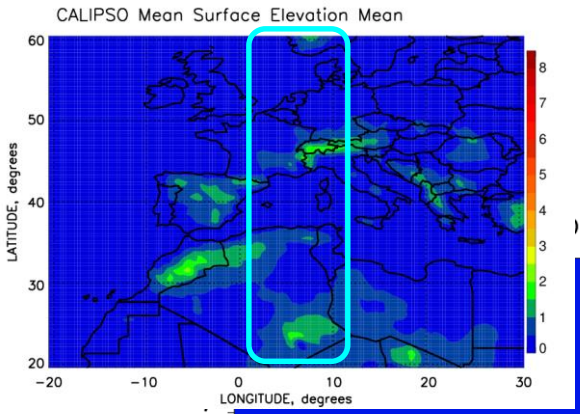


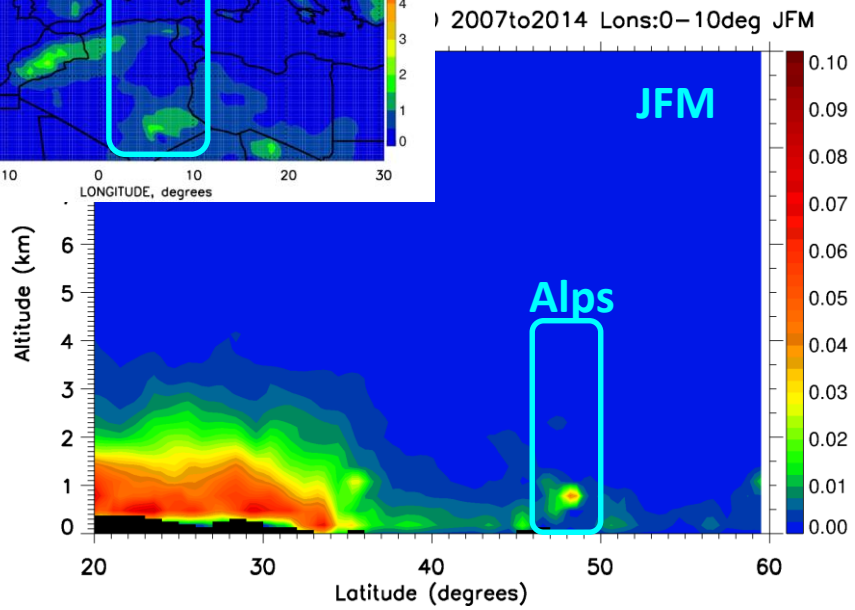


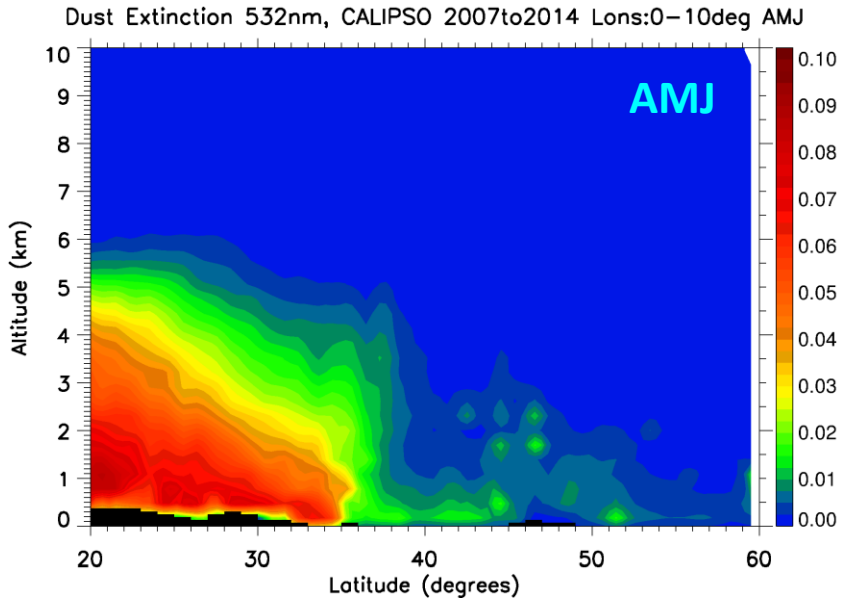


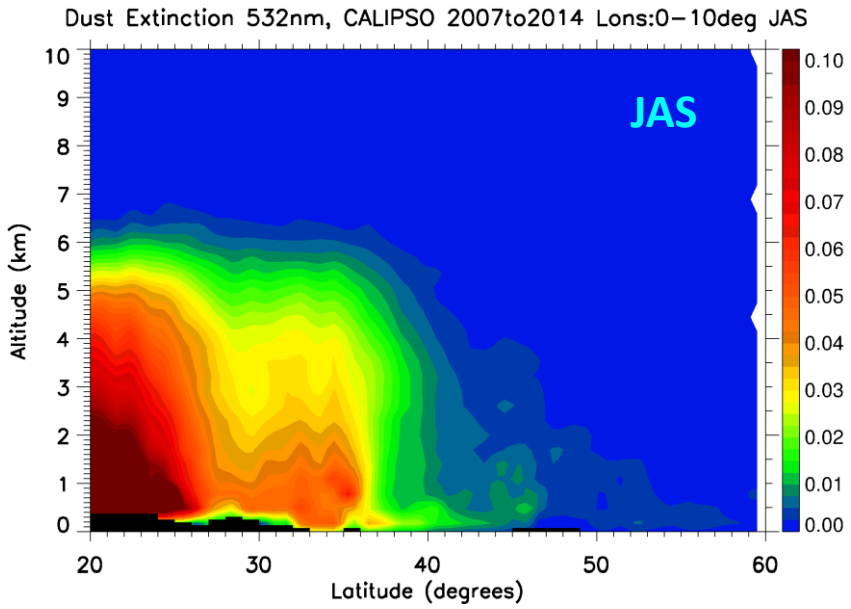


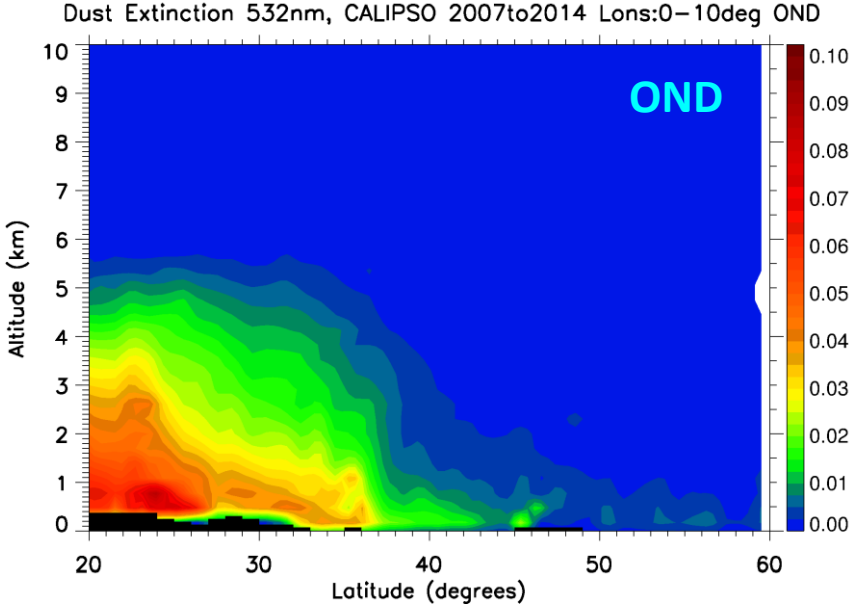
Extinction Coefficient 0-10 deg Longitude



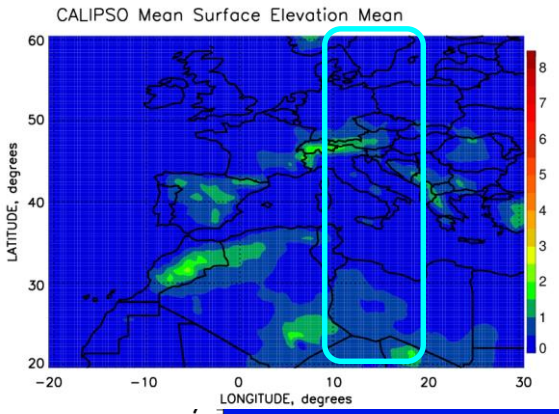


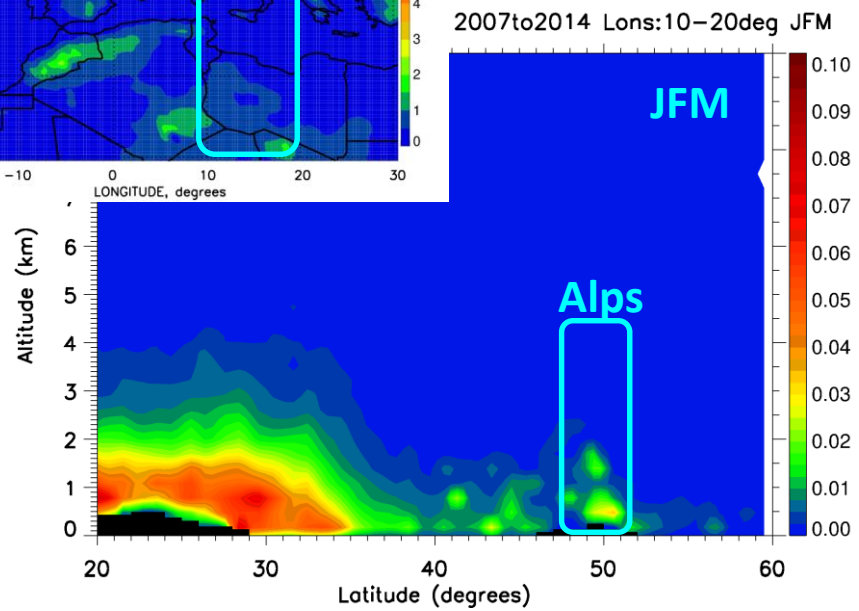


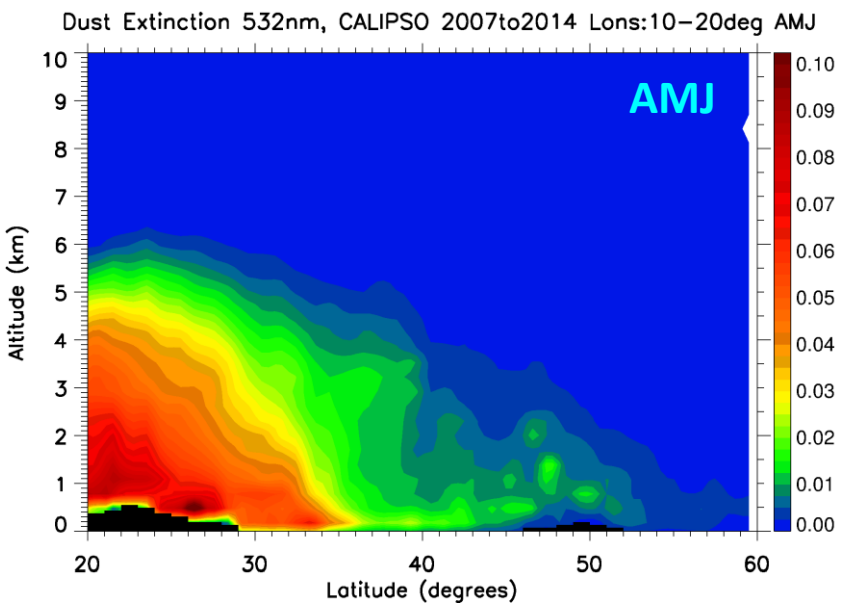


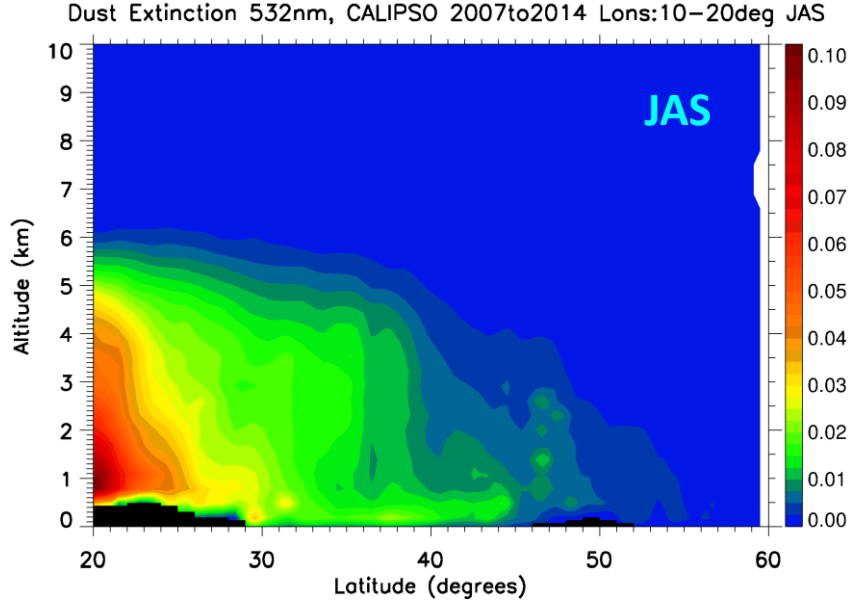


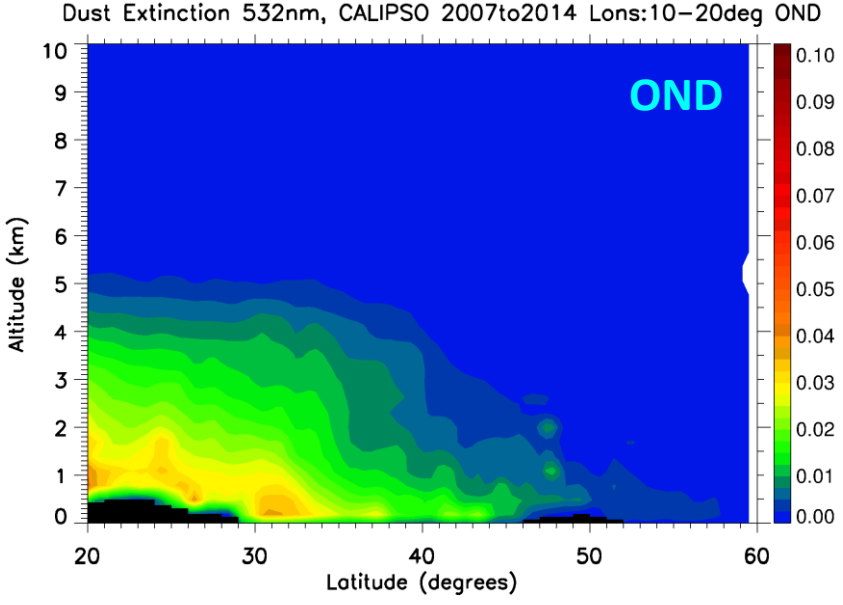
Extinction Coefficient 10-20 deg Longitude



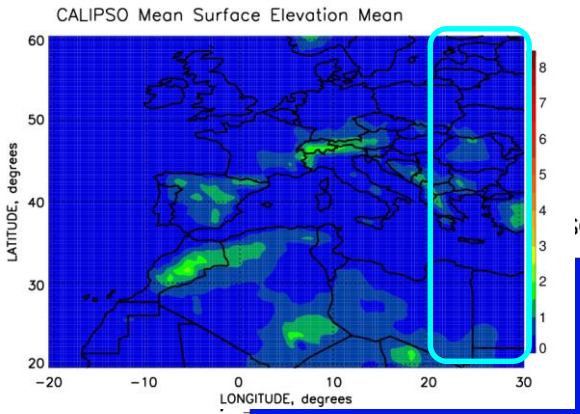


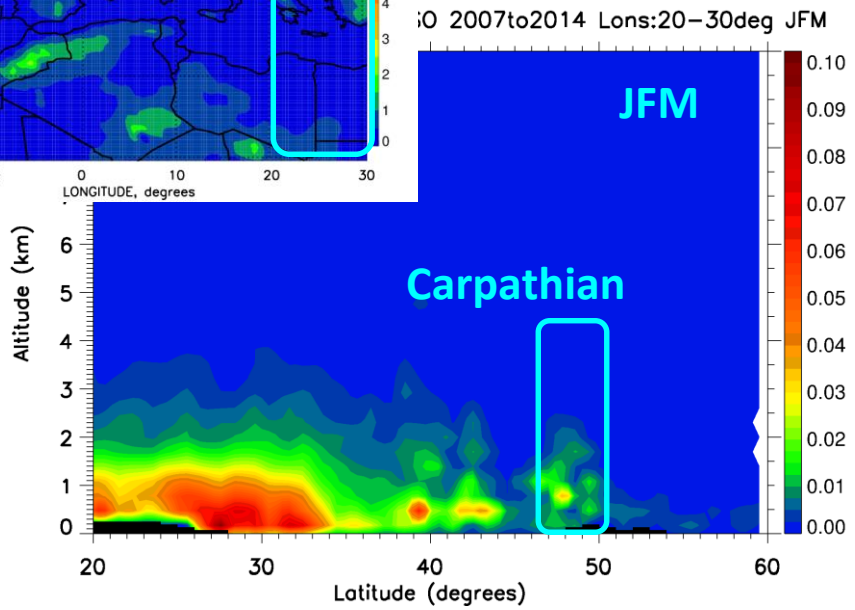


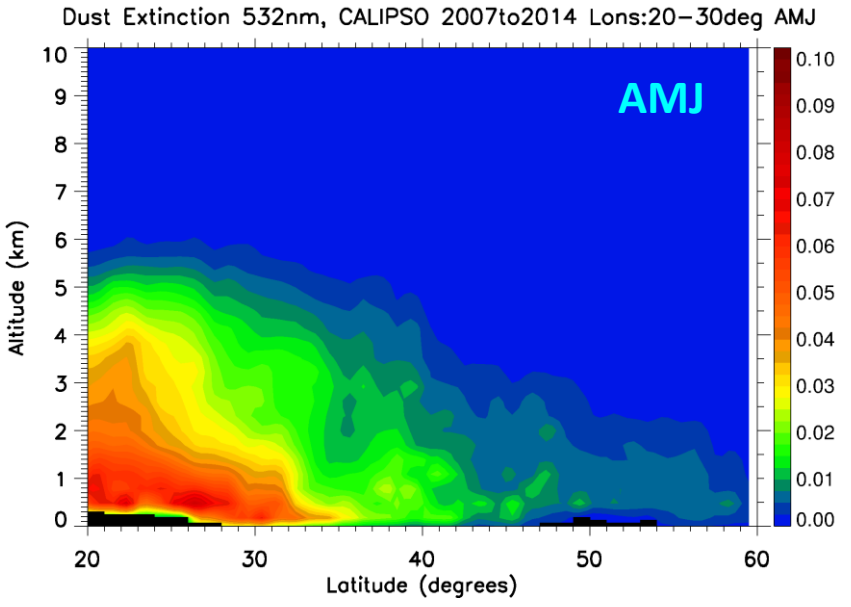


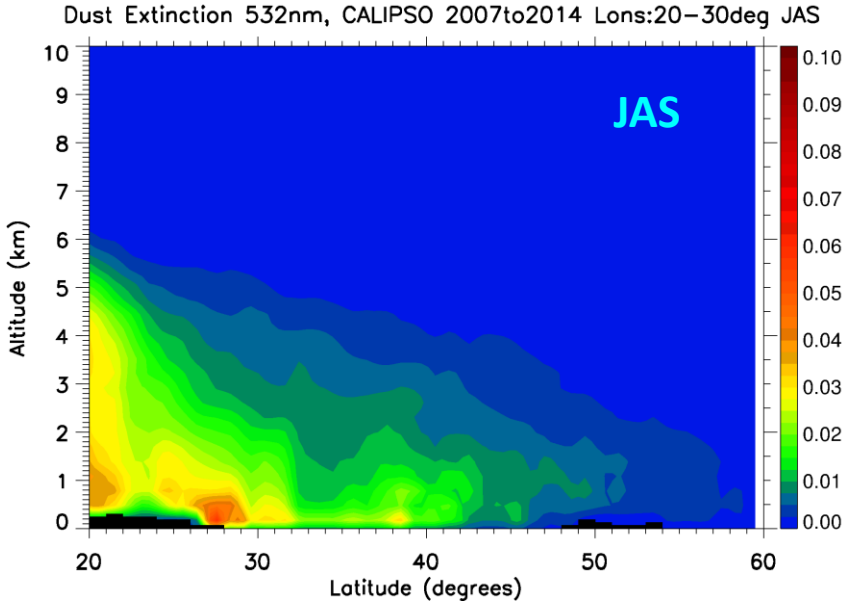


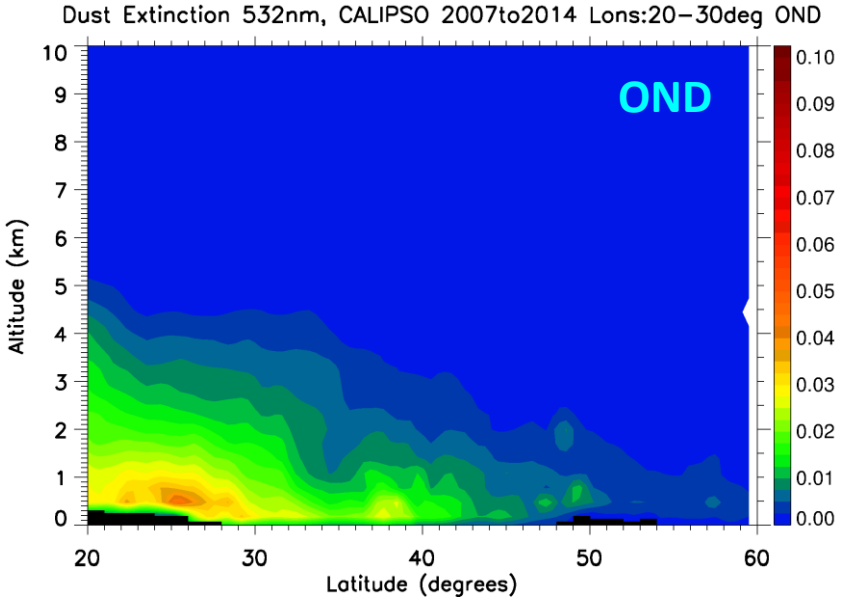
Extinction Coefficient 20-30 deg Longitude



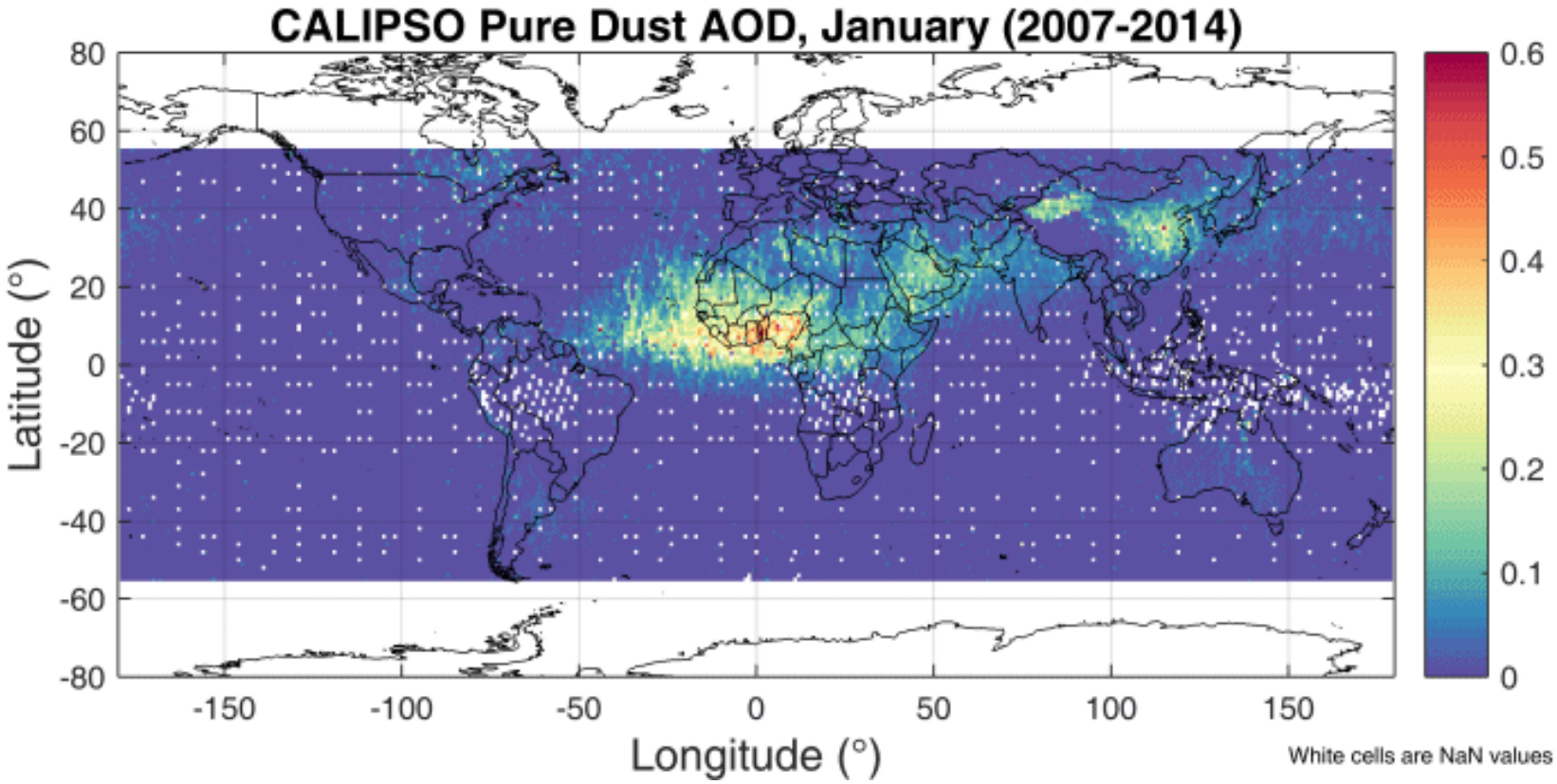




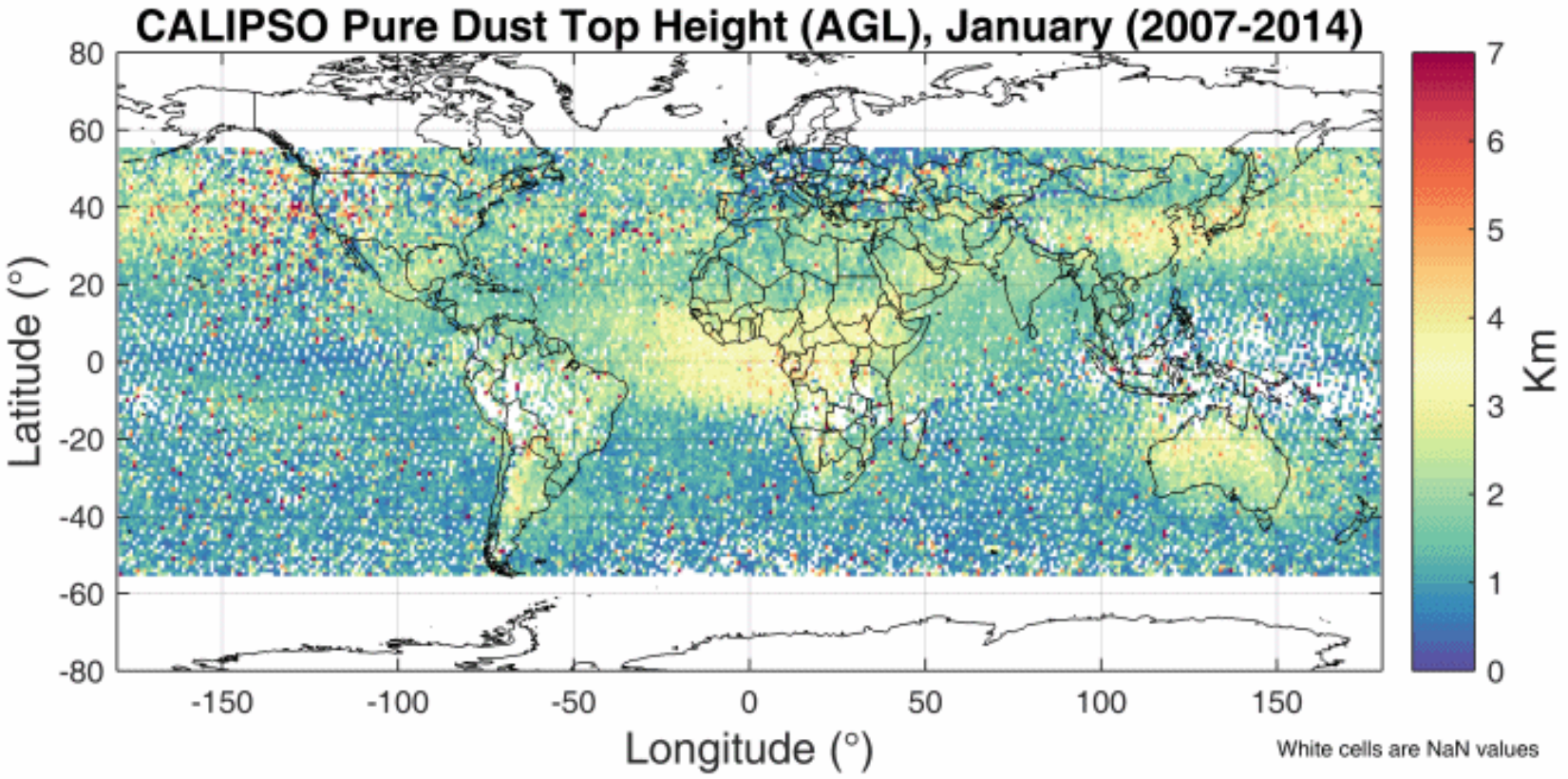




Global LR correction



Top dust layer height



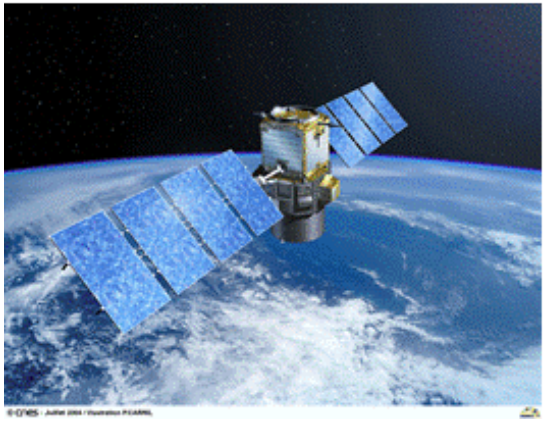
Summary

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

Next steps: climate datasets

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.

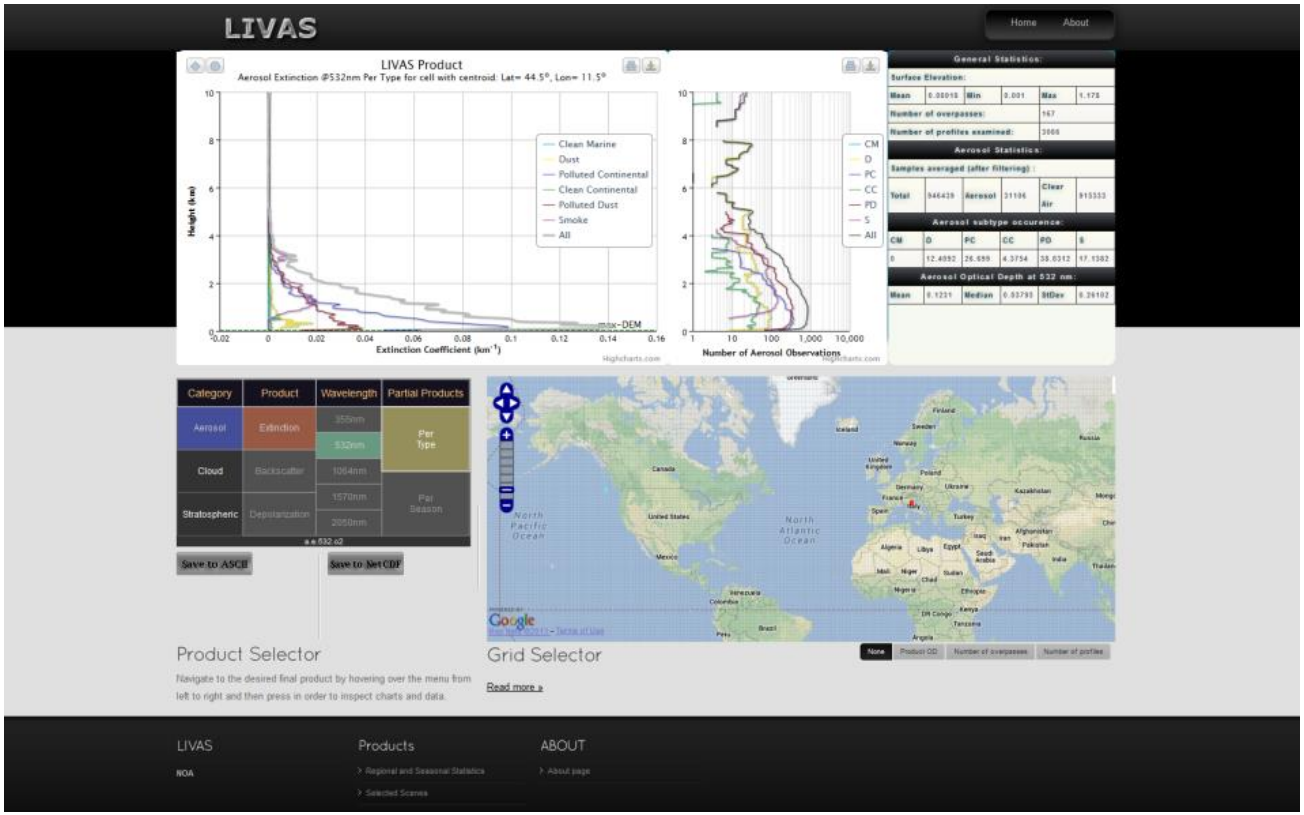
From CALIPSO



EARLINET

To EarthCARE

Next steps: climate datasets

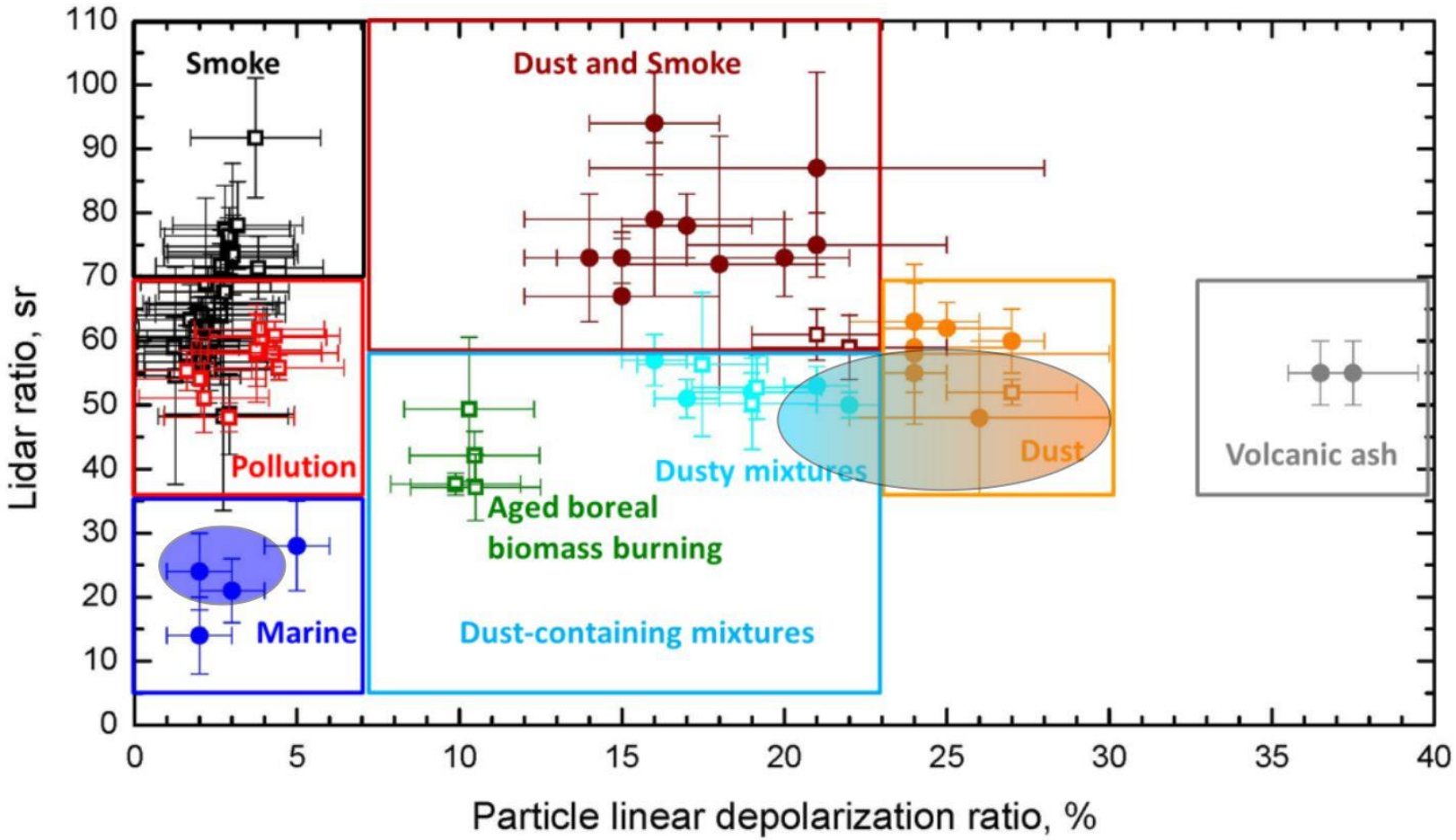


http://lidar.space.noa.gr:8080/livas/

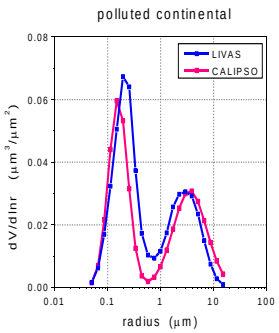
Next steps: Aerosol model improvements

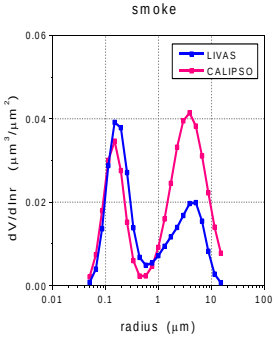
LIVAS AEROSOL TYPE	UV/VIS			VIS/IR				
	approach used	532/355 nm		approach used	532/1570 nm		532/2050 nm	
		BAE	EAE		BAE	EAE	BAE	EAE
Polluted continental	ESA-CALIPSO	1.42	1.24	AERONET-Omar	1.18	1.66	1.32	1.56
Dust	ESA-CALIPSO	0.40	0.55	AERONET-CALIPSO	0.35	0.6	0.43	0.57
Polluted dust	ESA-CALIPSO	0.92	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

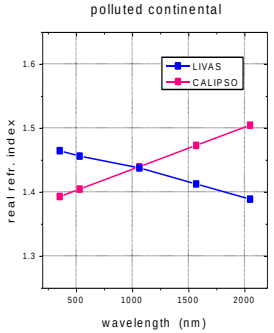
Next steps: Aerosol model improvements

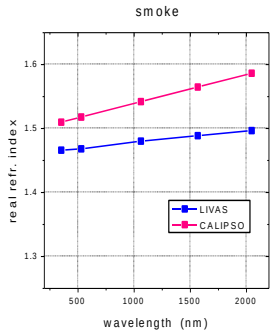


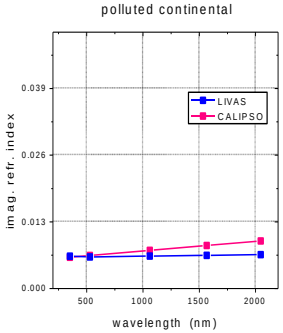
Next steps: Aerosol model improvements

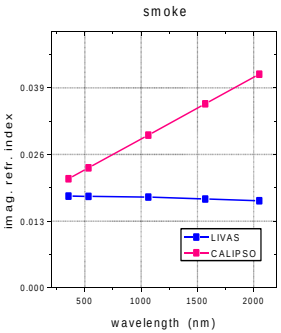


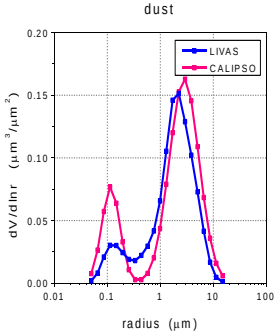


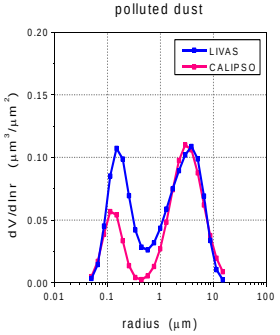


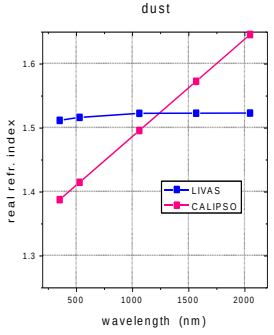


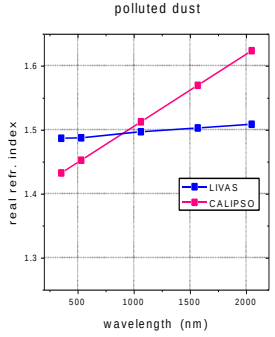


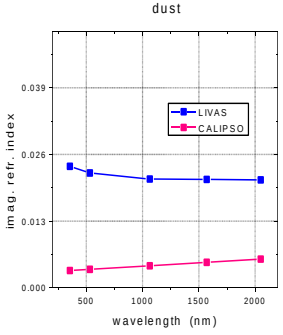


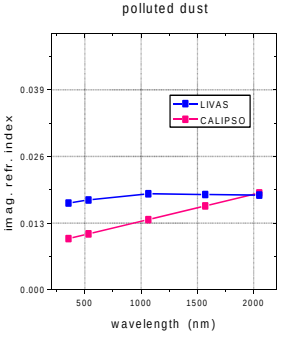


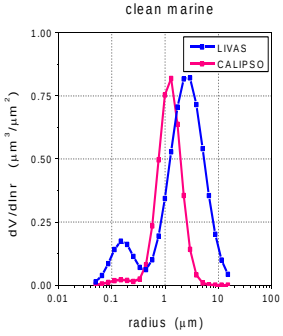


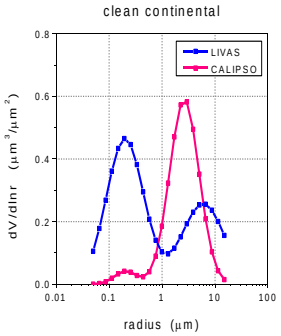


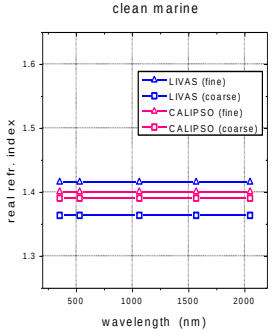


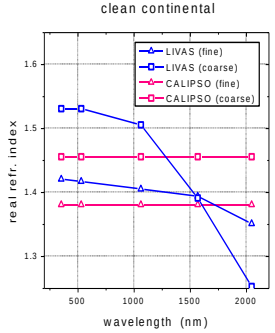


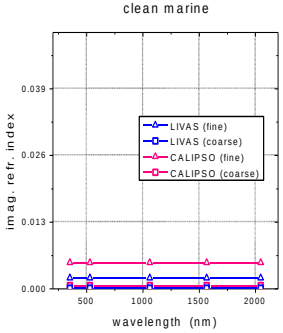


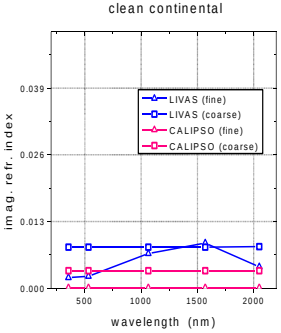




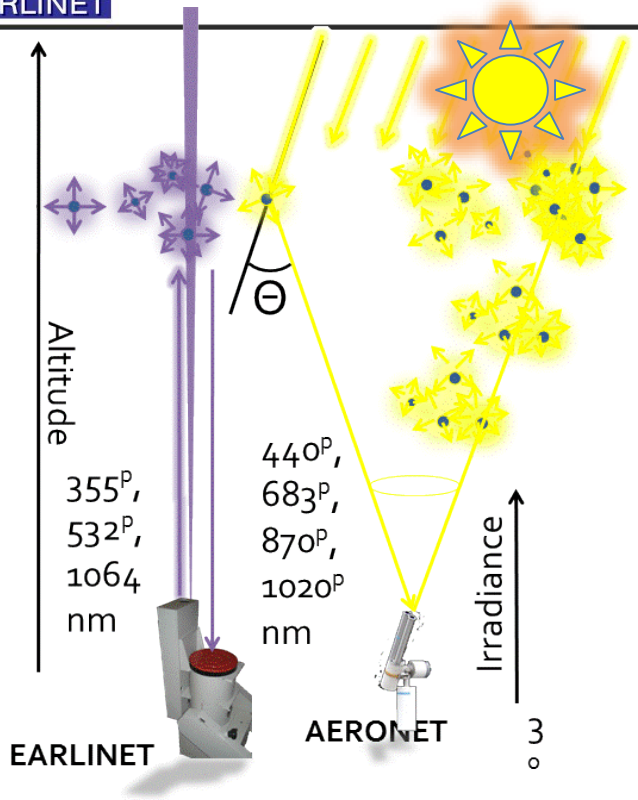


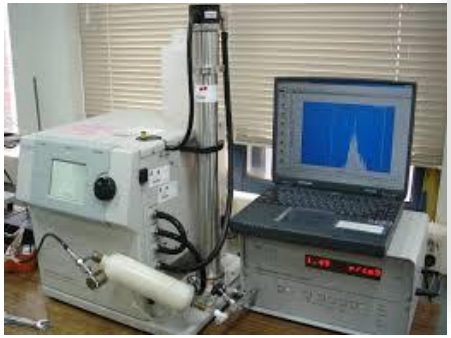


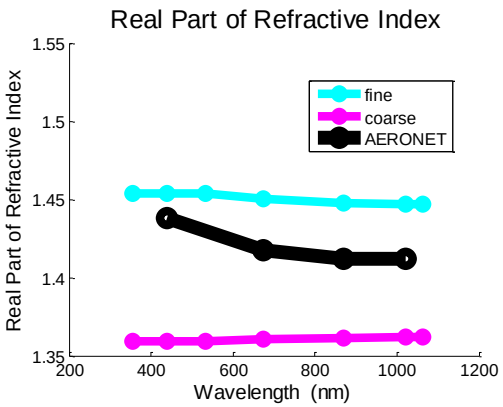


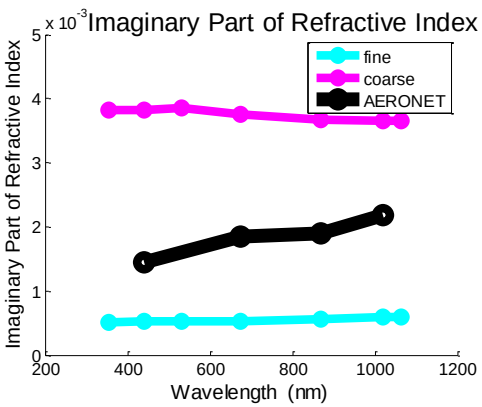


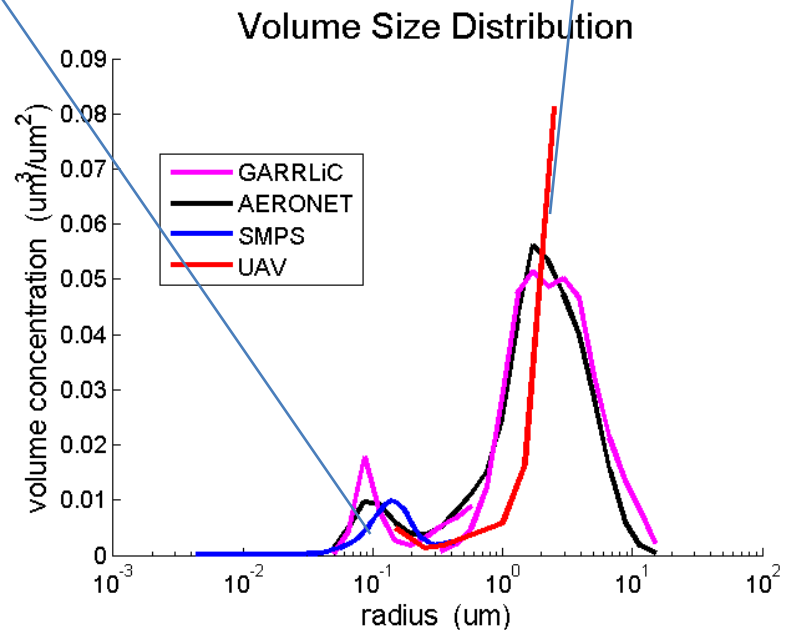
Next steps: Aerosol model improvements











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

Polly^{XT} OCEANET lidar

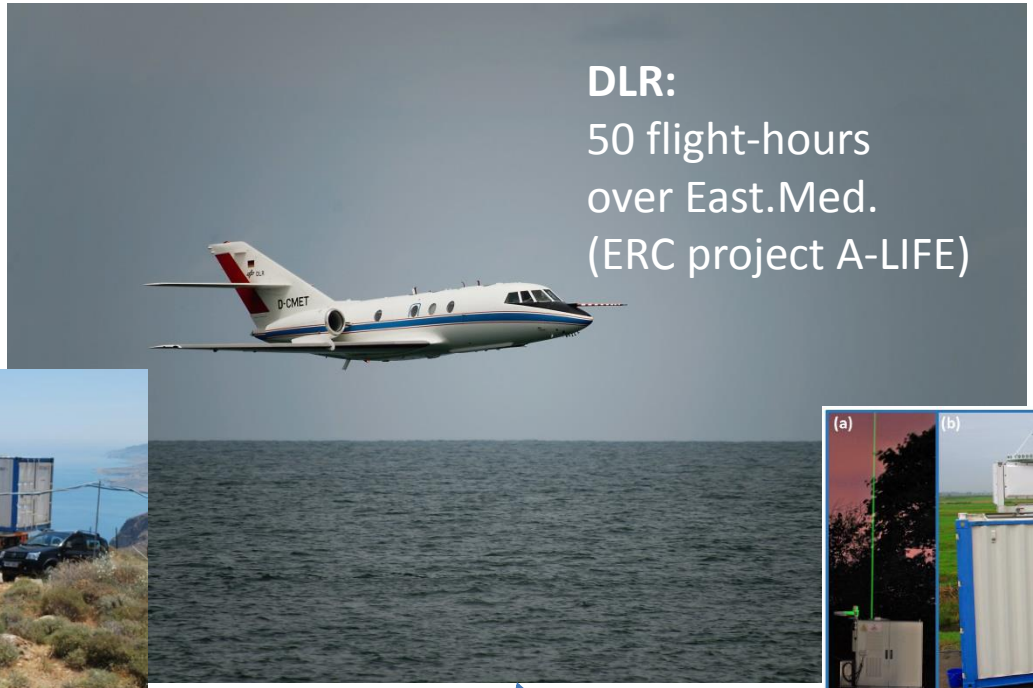
In-situ measurements with Unmanned Aerial Vehicles (UAVs) and/or tethered balloons

Athens and Melpitz campaigns are implemented already

Next steps: Aerosol model improvements

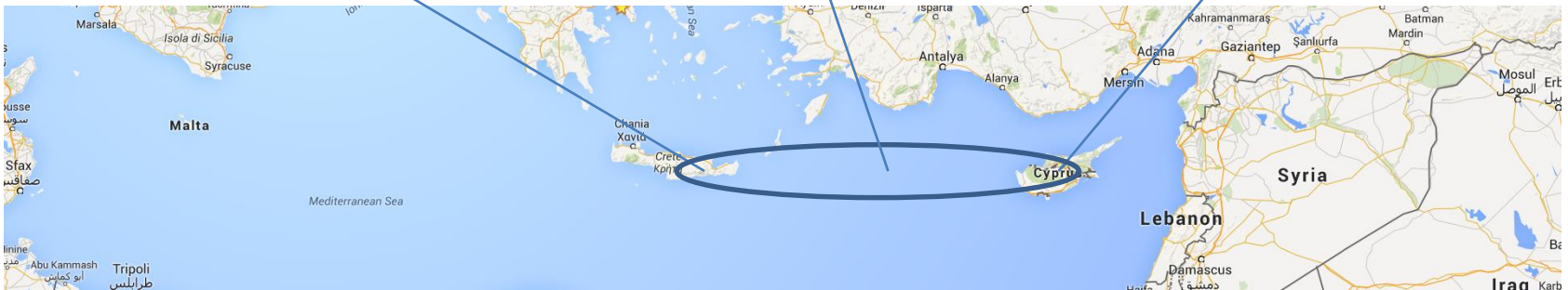
Large scale experimental campaign in Eastern Mediterranean – April 2017

NOA:
Replicate LACROS
@ Crete

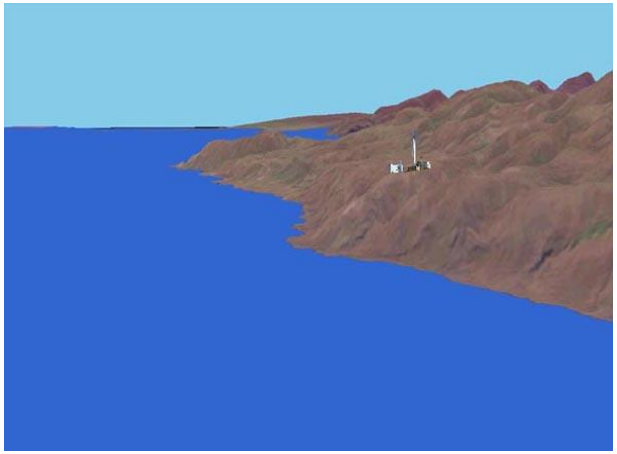


DLR:
50 flight-hours
over East.Med.
(ERC project A-LIFE)

TROPOS:
LACROS @ Cyprus

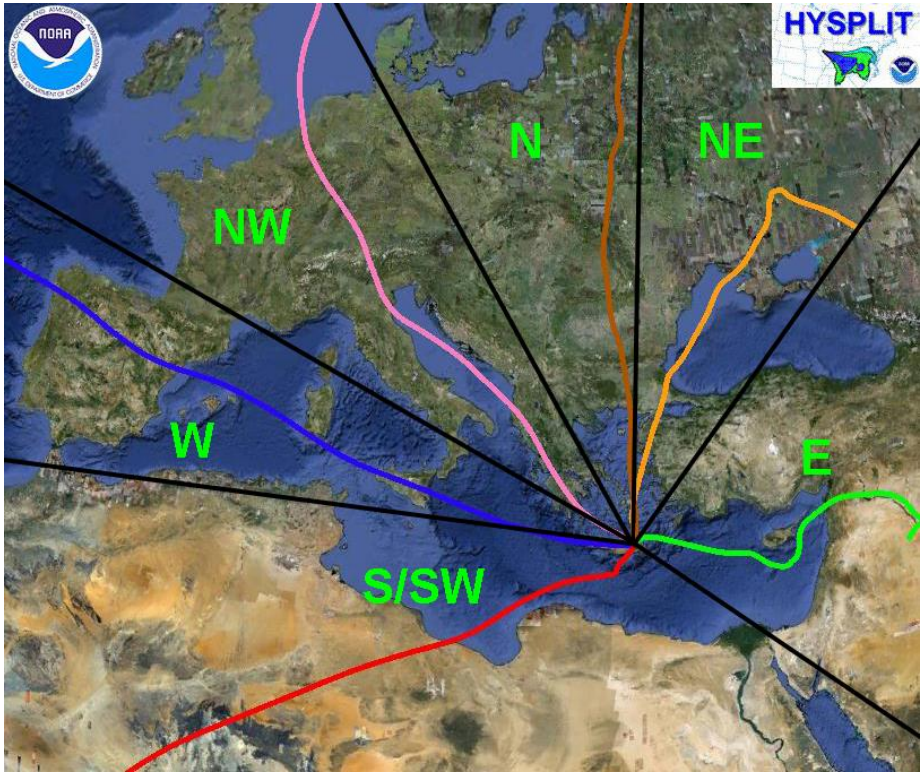


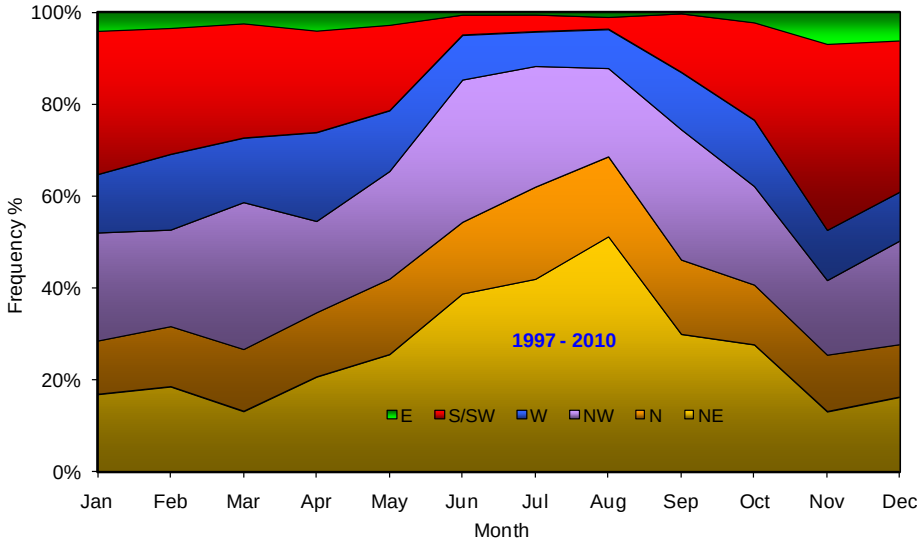
Next steps: Finokalia for near-real time



Latitude = 35.34^{0}N - Longitude = 25.67^{0}E - Elevation = 252 a.s.l.

Next steps: Finokalia for near-real time





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)

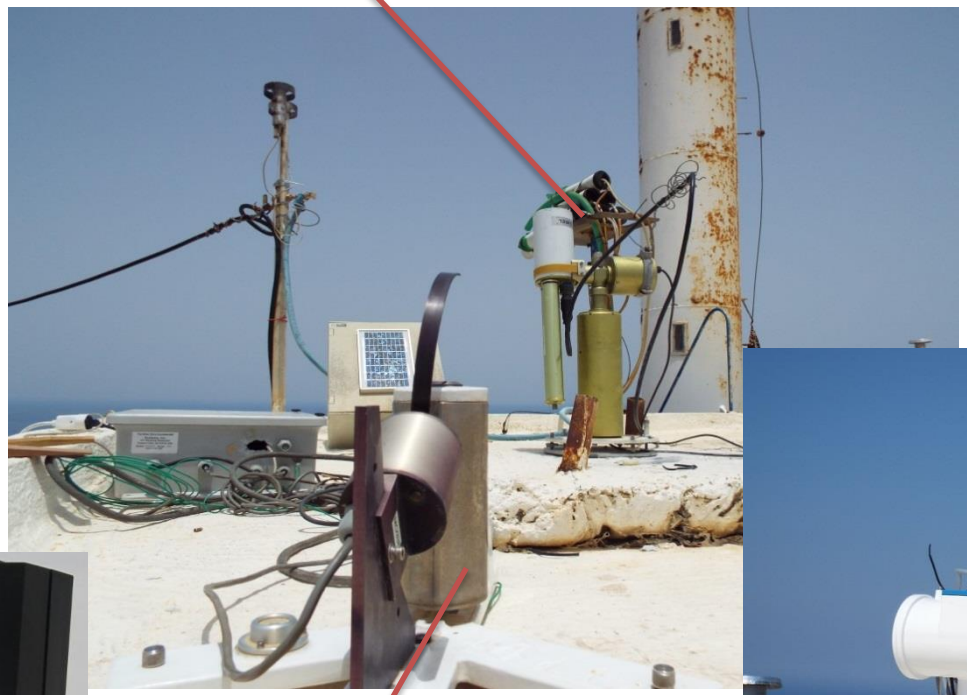

Thermo Environmental Instruments Inc.
PFEIFFER VACUUM
PrismaPlus
PILS
Magee Scientific
Aethalometer™

Next steps: Finokalia for near-real time

- 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

AERONET-CIMEL



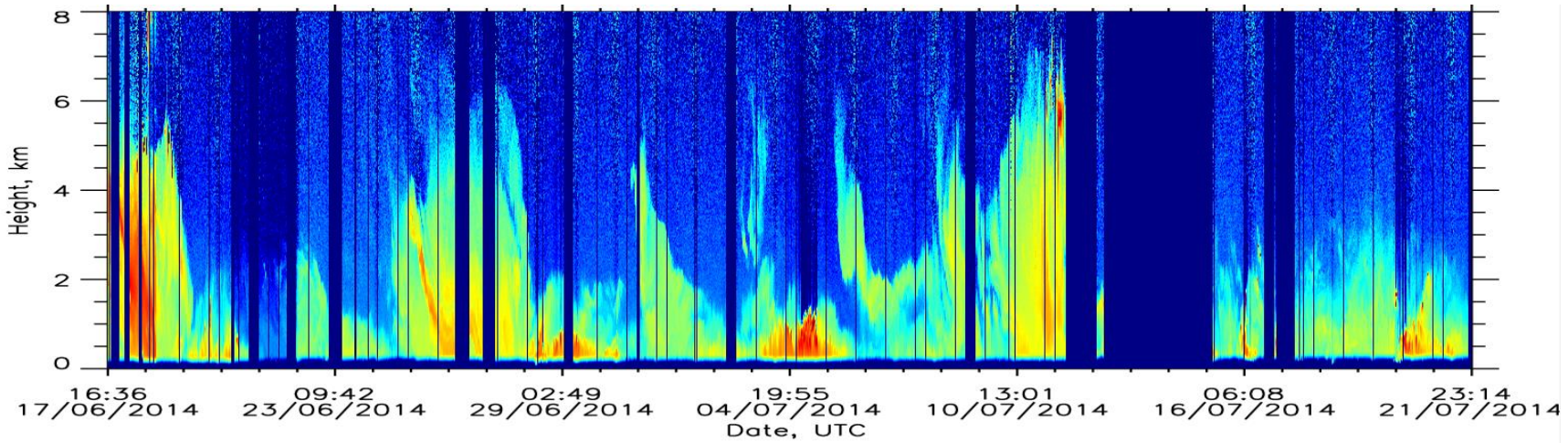
PSR

Microtops II

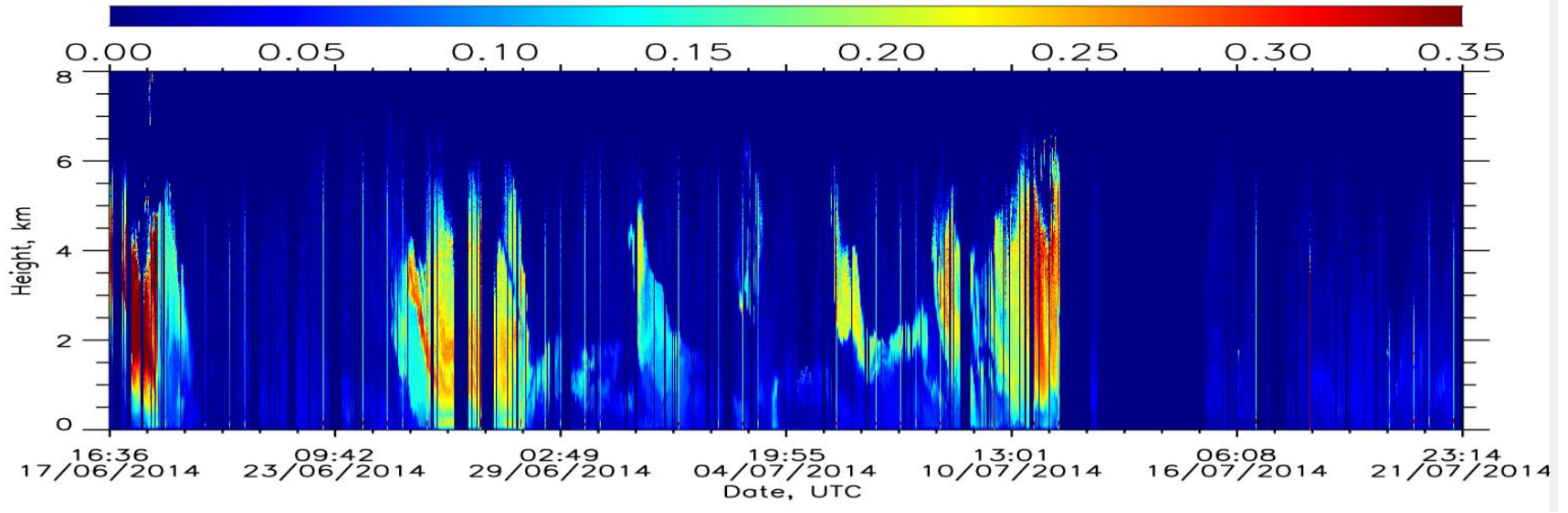
UV-MFR

Next steps: Finokalia for near-real time

Range corrected signal at 1064nm

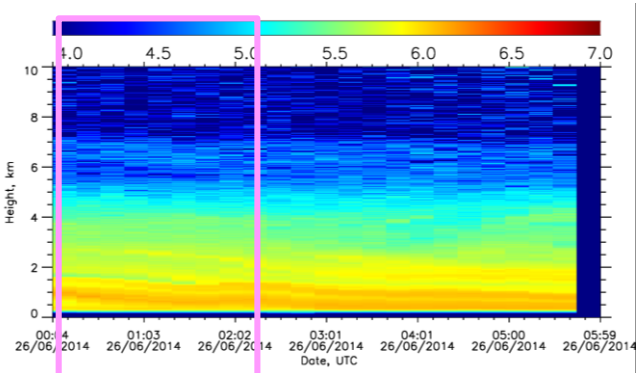


Depolarization: cross/total @532nm

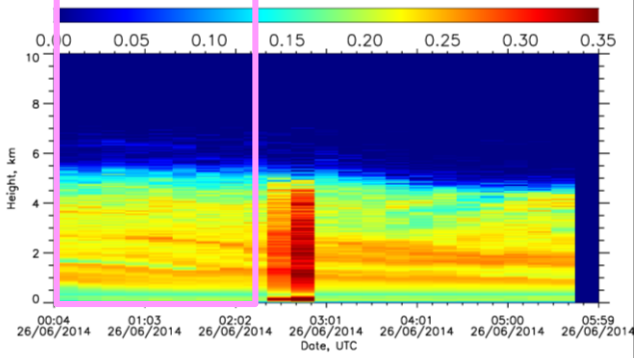


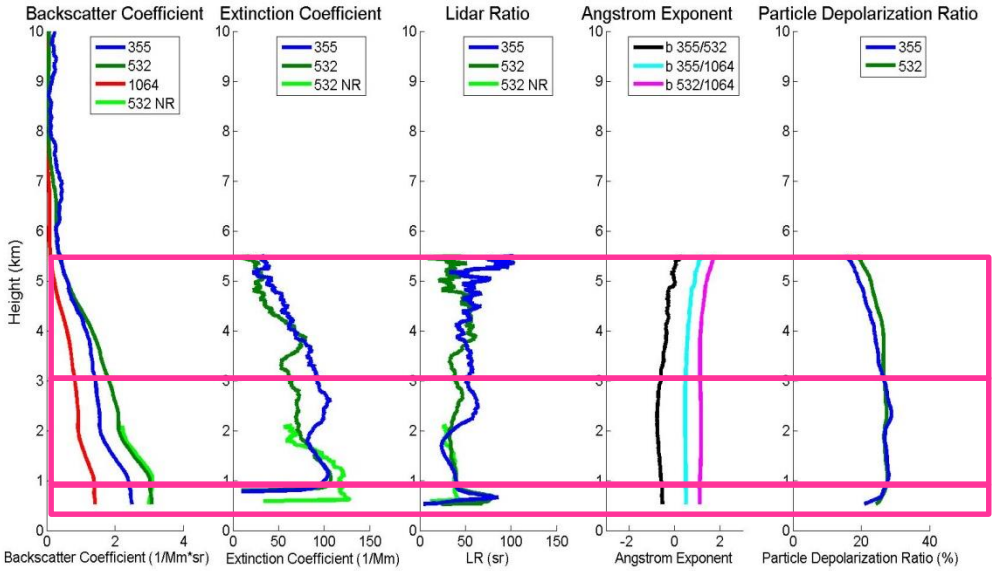
Next steps: Finokalia for near-real time

Range corrected signal @1064nm



Depolarization: cross/total @532nm

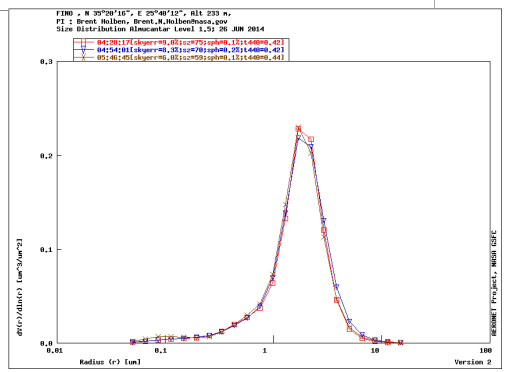




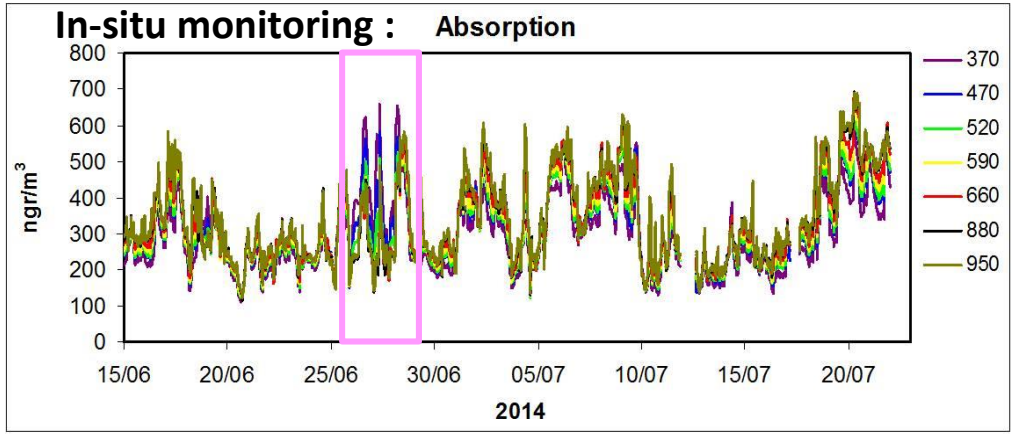
Cimel

AOD_{500}: 0.42

Ang: 0.08



Dominance of coarse mode



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)

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
Uncertainties	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