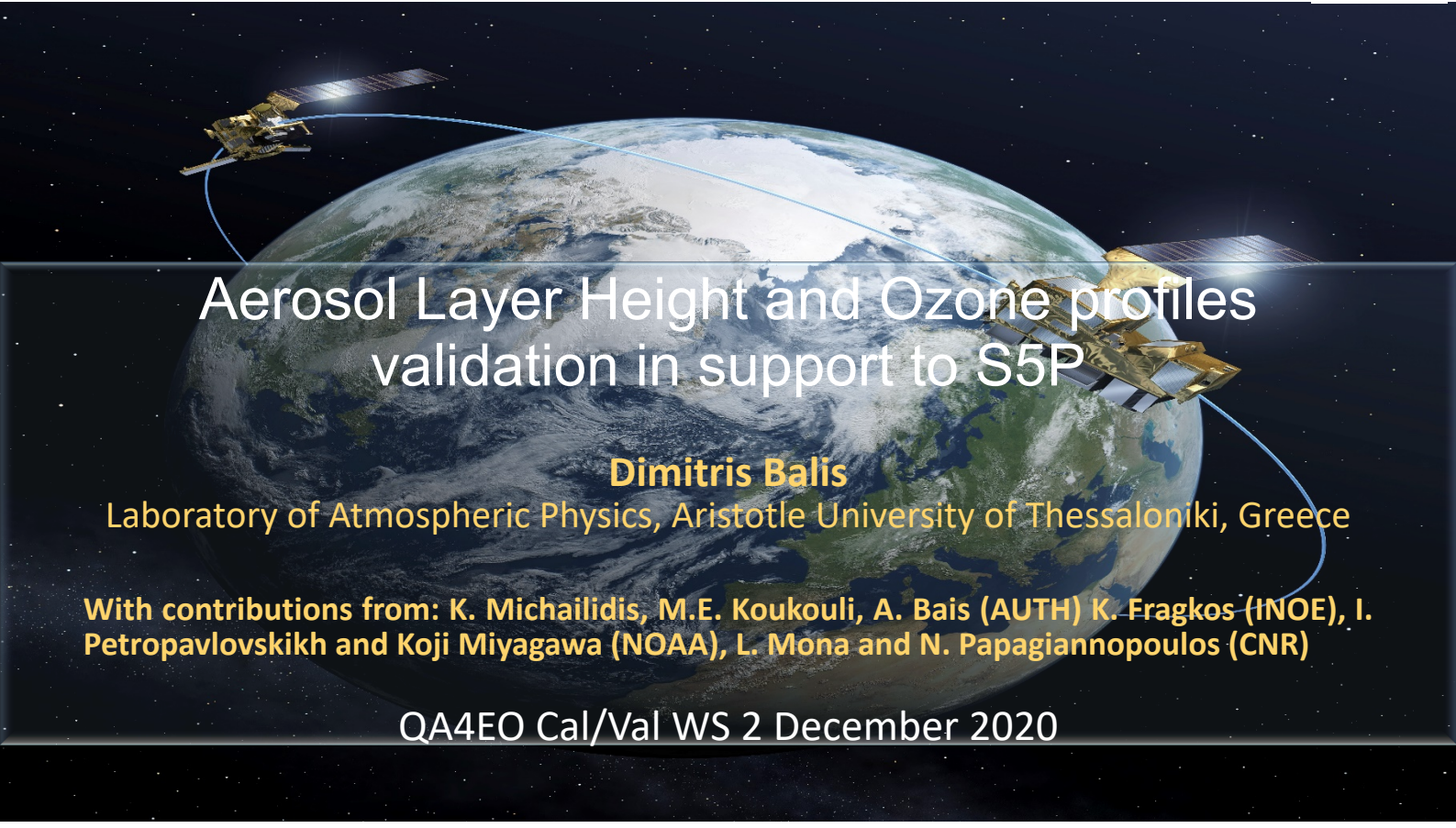


Aerosol Layer Height and Ozone profiles validation in support to S5P

Dimitris Balis
Laboratory of Atmospheric Physics, Aristotle University of Thessaloniki, Greece

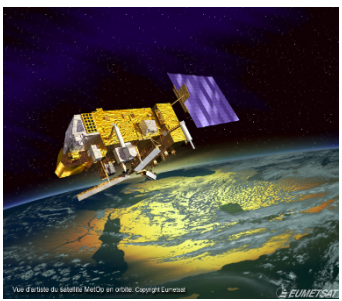
With contributions from: K. Michailidis, M.E. Koukouli, A. Bais (AUTH) K. Fragkos (INOE), I. Petropavlovskikh and Koji Miyagawa (NOAA), L. Mona and N. Papagiannopoulos (CNR)

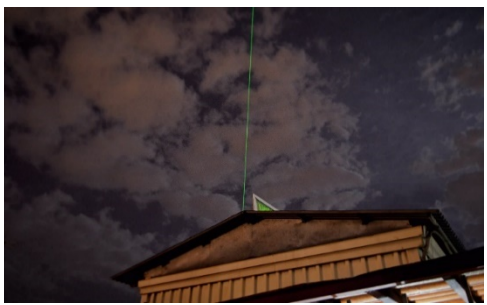
QA4EO Cal/Val WS 2 December 2020

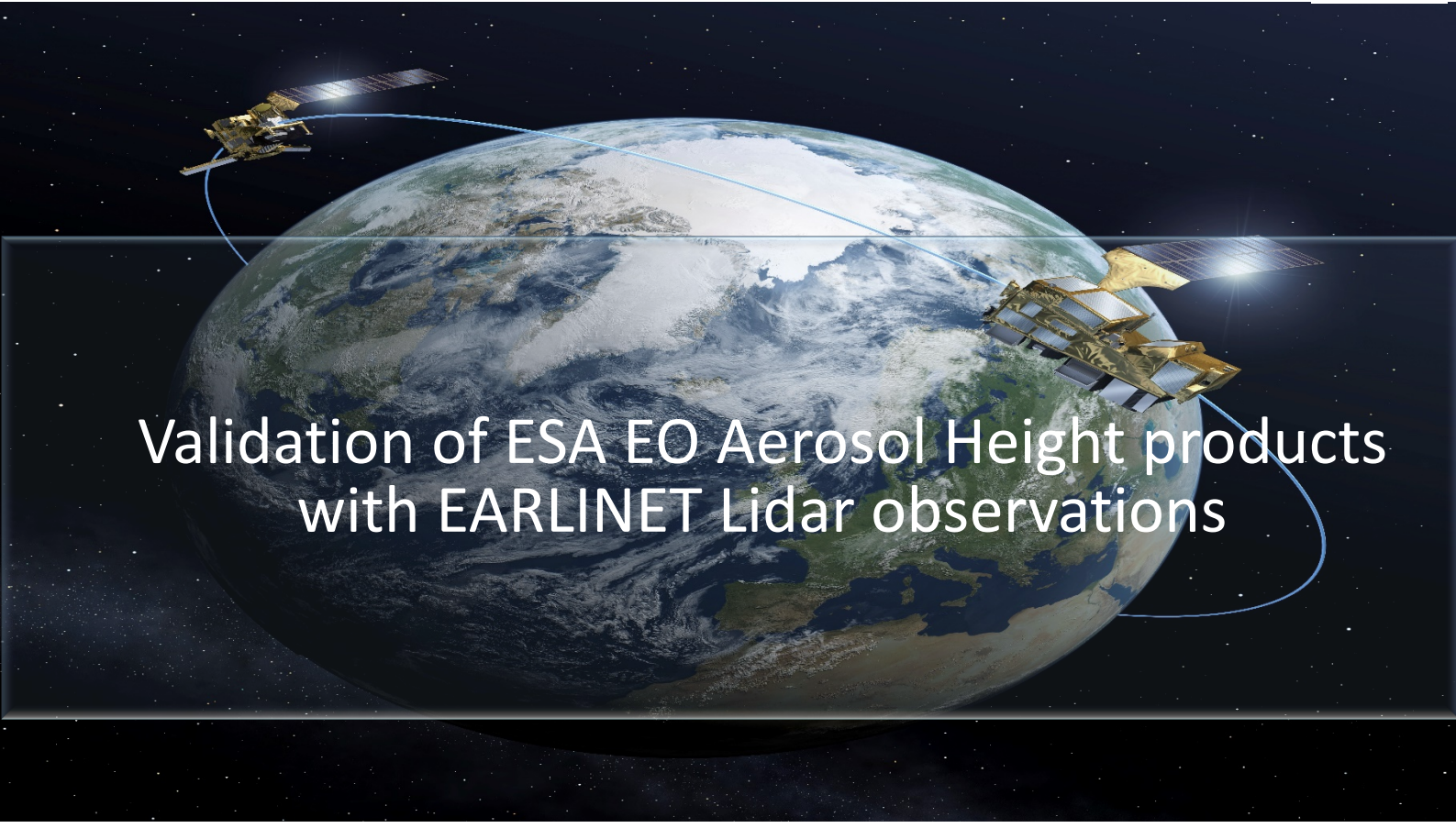
Involvement of AUTH in QA4EO

WP1 Validation of ESA EO Aerosol Height products with EARLINET Lidar observations

WP2 Umkehr Ozone Profile Analysis and Satellite Validation for the time period 2007-2020





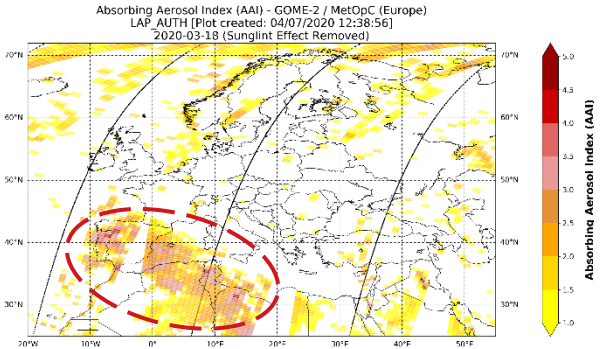


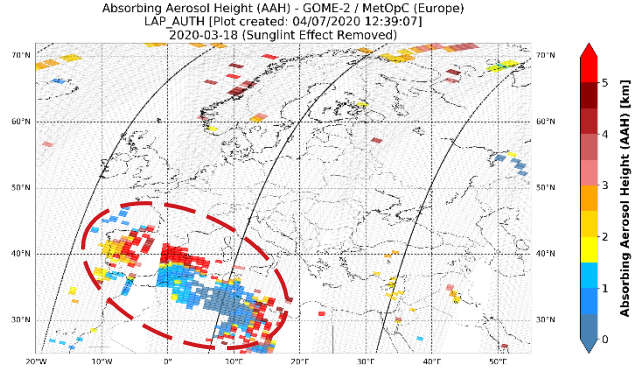
Validation of ESA EO Aerosol Height products with EARLINET Lidar observations

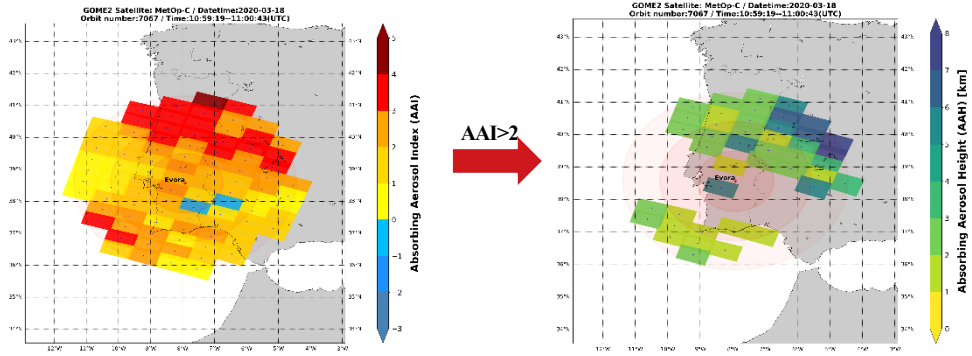
WP layout

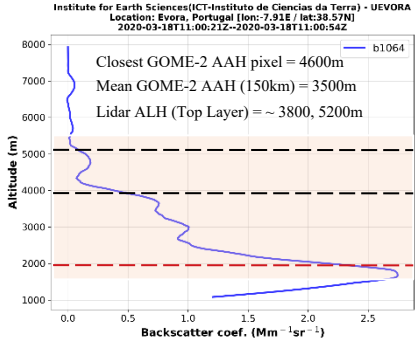
- Acquire lidar EARLINET records for the period 2007 to 2020.
- Post-process the lidar profiles with the LAP/Auth dedicated software in order to identify lofted aerosol layers and exclude all cases of cloud presence contamination.
- Acquire S5P/TROPOMI and GOME2/Metop products for the applied period. The latter dataset will be used as demonstrational product for the validation capabilities of the validation chain.
- Post-process the TROPOMI/GOME2 profiles and study the possible effects of other geophysical parameters of the satellite L2 algorithm in order to clearly identify aerosol layers.
- Acquire auxiliary information for the dates of common valid measurements, such as CALIOP/CALIPSO or DREAM dust modelling which will further assist in identifying the provenance of the aerosol layer.
- Perform the validation activity via the dedicated LAP/Auth Aerosol Validation Chain.

Application of GOME-2 Tool (Evora case, 18-03-2020)









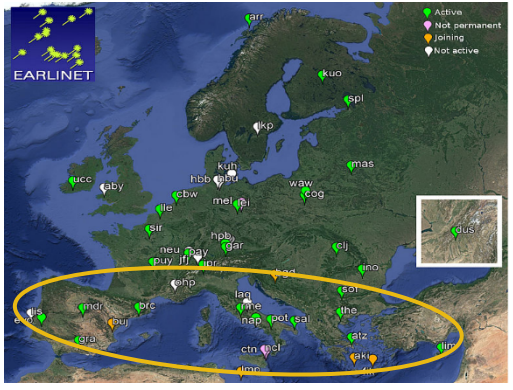
Wavelet Covariance Transform method

Aerosol Layering (Siomos et al., 2018)

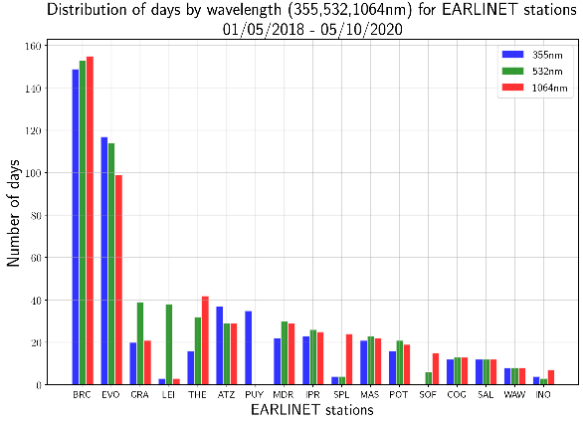
Michailidis, K., et al., First validation of GOME-2/MetOp Absorbing Aerosol Height using EARLINET lidar observations, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-601, in review, 2020.

Adjustments for EARLINET- TROPOMI comparisons

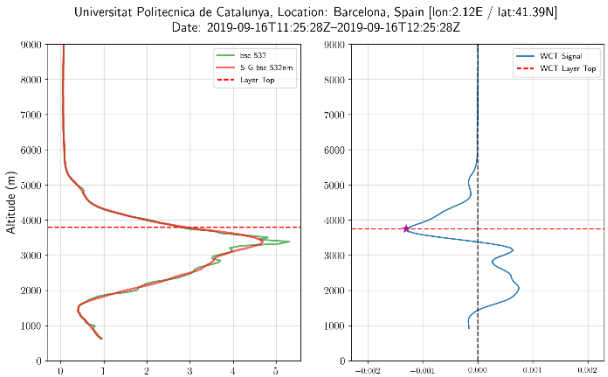
- The study is focused on selected desert dust cases, fires plumes and occasional volcanic eruptions.
- We use an optimal "tool" for aerosol monitoring using EARLINET and TROPOMI aerosol products
- **Currently, the number of collocated cases with TROPOMI during suitable aerosol events is very limited.**
- **Over land, TROPOMI ALH becomes unreliable (measured signal is influenced from the surface reflectance). We select stations near the sea.**

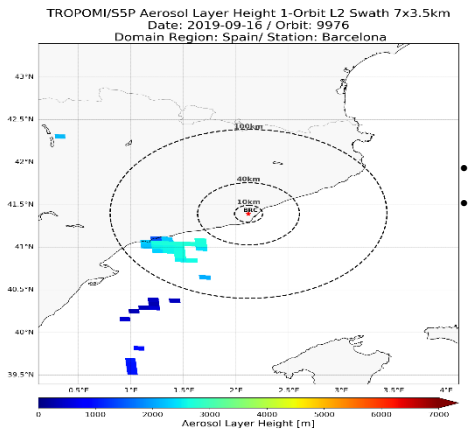


- ✓ Selected study period: **01-05-2018** to **05-10-2020**
- ✓ Temporal window: **08:00 -16:00 UTC**

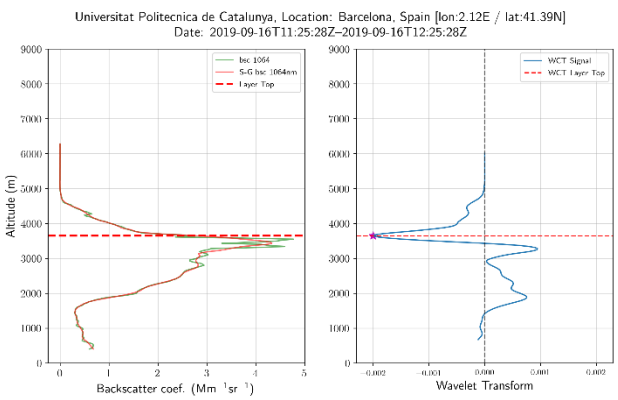


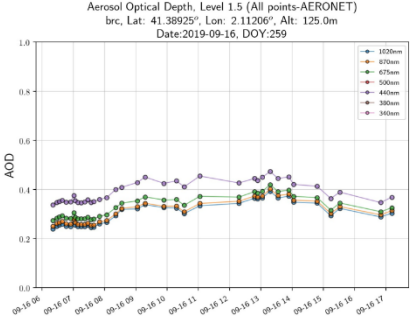
Case study for Barcelona station (16-09-2019)

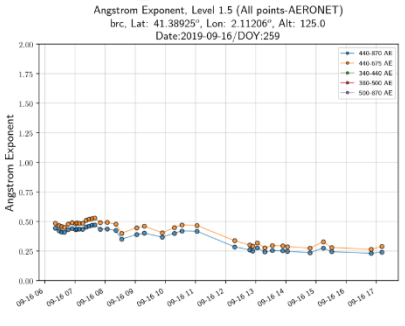




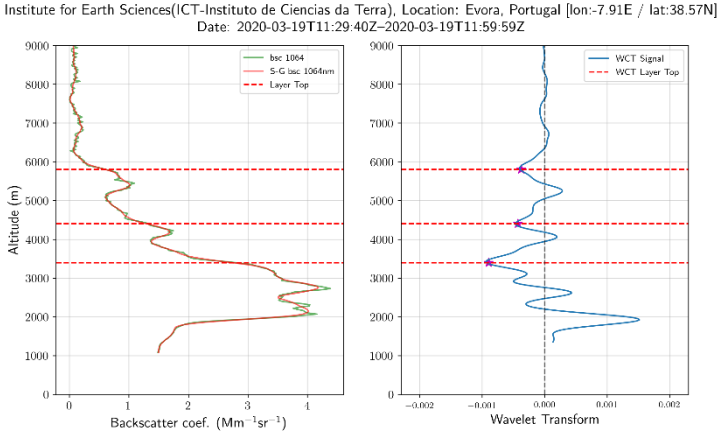
- **TROPOMI Mean value (<100km) = ~ 3000m**
- **Lidar ALH (Top Layer) = 3700m**

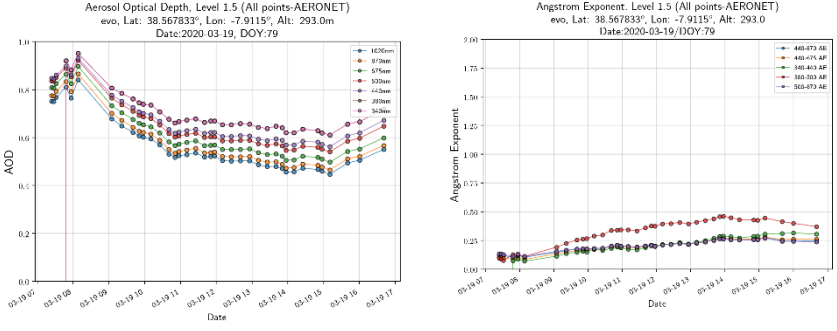


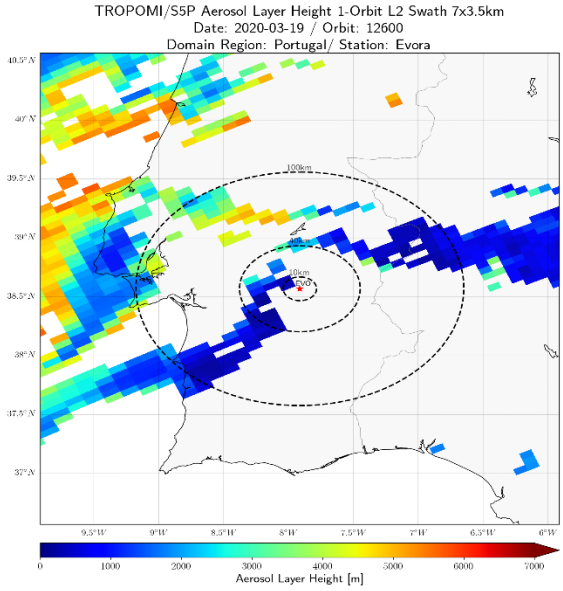




Case study for Evora station (19-03-2020)







- **Mean TROPOMI ALH (150km) = ~ 3500m**
- **Lidar ALH (Layer top) = ~ 3400m, 4200m, 5800m**

Summary and Outlook

- We have developed a optimal "tool" for aerosol monitoring using EARLINET and TROPOMI aerosol products
- **Few TROPOMI data, we focus on selected desert dust cases and fires plumes**
- The results of the GOME-2 AAH against EARLINET data, encourages the operational usage of the WCT - based algorithms based algorithms in validation processes.
- **Currently we test the automated tools for the comparison of the TROPOMI products with EARLINET datasets, case by case for time period 2018-2020. Promising first results**

Ongoing work:

- **Calculate aerosol layer center of mass (COM) and Aerosol optical depth (AOD) for for each lidar backscatter profile. It provides additional information on the height where the majority of the particles are located.**
- Investigate the optimum search radius around an EARLINET station for TROPOMI, considering the high spatial resolution of instrument.
- **Use data from the COVID-19 lidar campaign that took place in May 2020**

Umkehr Ozone Profile Analysis and Satellite Validation for the time period 2007-2020.

WP Layout

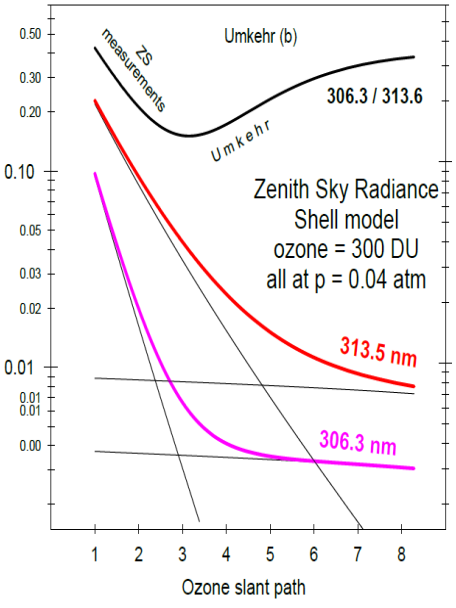
- Acquire Umkehr records for selected stations from the WOUDC archive for the period 2007 to 2020.
- Investigate the EuBrewNet database for possible Umkehr measurements that could be analyzed.
- Collect and ingest information about instrument calibrations and reports on inter-comparisons for selected station record so as to identify instrumental artefacts in the data record.
- Reprocess the for selected stations the full 2007-2020 dataset and reduce a large part of the bias currently existing between satellite and Umkehr ozone profiles for e.g. due to stray light entering the spectrometer.

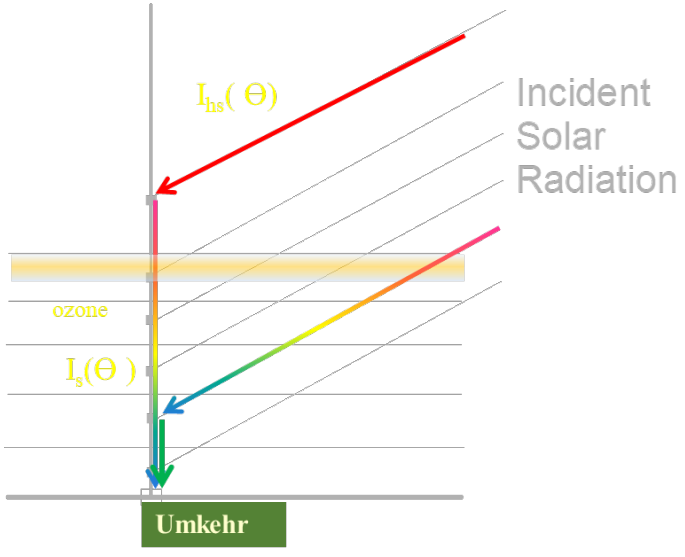
Umkehr method observations (wavelength ratio: Dobson 332/311 or Brewer 326/310 nm)

The (logarithmic) plot of the ratio of intensities at two wavelengths against the ozone slant path shows a turn-around or Umkehr where the short wavelength begins, paradoxically, to lose intensity more slowly than the longer wavelength which has the smaller absorption coefficient.

This model Umkehr depends on the height of the ozone.

Therefore, information on the ozone profile can be retrieved from measured zenith sky radiance ratios.





Scattering Geometry:
information is weighted by different layers as sun sets/rises

Dobson Ozone Profile Data- 18 stations identified

UMKEHR (UMK)

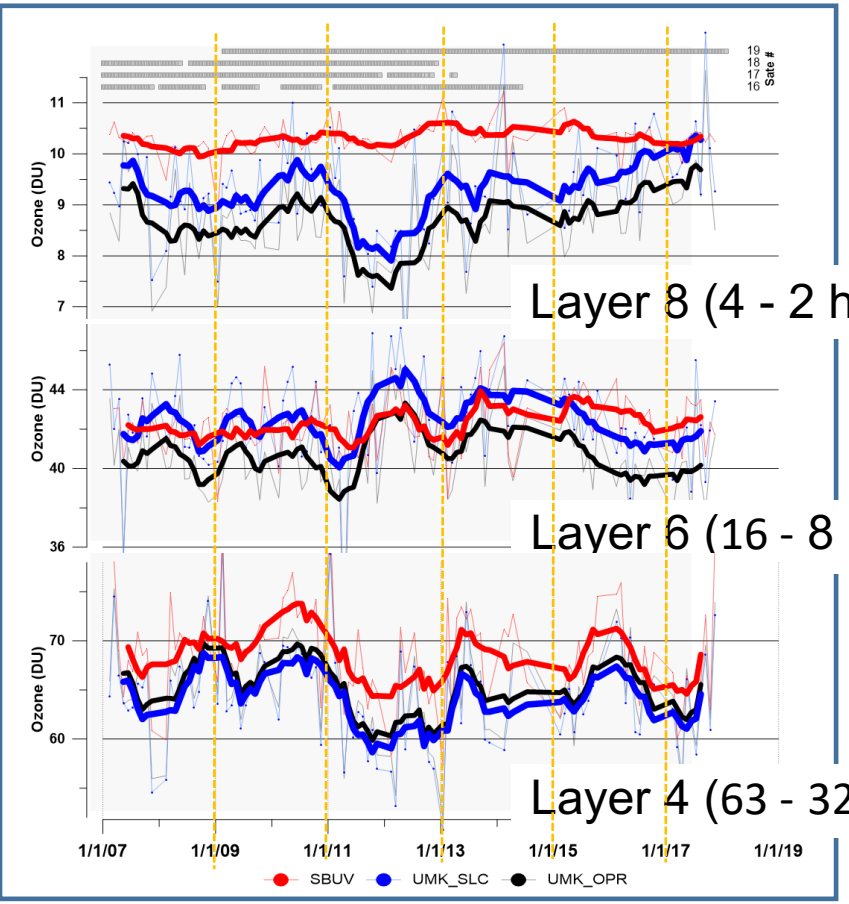
- Boulder, MLO and Lauder records :
  - applied Stray light correction and Optimized records (OPT).
- Arosa: applied Stray light correction (SLC).
  - Umkehr observations need QA.
  - Corrections from N-value residuals Retrieval of the ozone profile used UMK04rev and a priori fstguess.11b.
- Apply AK to Umkehr (61 layers) for satellite comparisons

- Satellite comparisons:
  - i.e. NASA SBUV Aggregated overpass.

Table 1. These are the stations since 2007 deposited on WOUDC. List date shows the newest data.

Lat	Lon	instance_datetime	agency	platform_id	platform_name	gaw_id	instrument	instrument	# instrumer	# of month
46.78	9.68	2007/12/01 00:00:00+00	MeteoSwiss	35	Arosa	ARO	dobson	BECK	51	36
23.967	32.78	2011/10/06 00:00:00+00	EMA	245	Aswan	ASW	dobson	BECK	69	57
39.99	-105.3	2020/07/01 00:00:00+00	NOAA-CMDL	67	Boulder ESRL HQ ((	BLD	dobson	BECK	61	174
-27.39	153.13	2019/03/13 00:00:00+00	ABM	27	Brisbane	BBN	dobson	BECK	111	117
30.08	31.283	2009/06/03 00:00:00+00	EMA	152	Cairo	CAI	dobson	BECK	96	4
-12.42	130.89	2018/09/11 00:00:00+00	ABM	84	Darwin	DWN	dobson	BECK	78	58
64.817	-147.867	2020/07/10 00:00:00+00	NOAA-CMDL	105	Fairbanks (AK)	FBK	dobson	BECK	63	115
43.933	5.7	2019/12/02 00:00:00+00	NOAA-CMDL	40	Haute Provence	OHP	dobson	BECK	85	158
27.28	33.75	2011/10/08 00:00:00+00	EMA	409	Hurghada	HUR	dobson	BECK	59	54
-45.04	169.68	2017/12/07 00:00:00+00	NIWA-LAU	256	LAUDER	LAU	dobson	BECK	72	152
19.53	-155.58	2020/07/01 00:00:00+00	NOAA-MLO	31	Mauna Loa (HI)	MLO	dobson	BECK	76	181
26.2	127.683	2014/03/10 00:00:00+00	JMA	190	Naha	NAH	dobson	BECK	127	104
28.65	77.217	2008/04/09 00:00:00+00	IMD	10	New Delhi	NDL	dobson	BECK	112	6
-31.917	115.95	2012/12/06 00:00:00+00	NOAA-CMDL	159	Perth	PTH	dobson	BECK	81	81
43.05	141.333	2014/03/02 00:00:00+00	JMA	12	Sapporo	SAP	dobson	BECK	126	104
1.333	103.883	2012/05/22 00:00:00+00	MSS	214	Singapore	SIN	dobson	BECK	7	83
-69	39.58	2013/01/14 00:00:00+00	JMA	101	Syowa	SYO	dobson	BECK	122	61
36.05	140.1	2014/03/04 00:00:00+00	JMA	14	Tateno (Tsukuba)	TKB	dobson	BECK	125	106

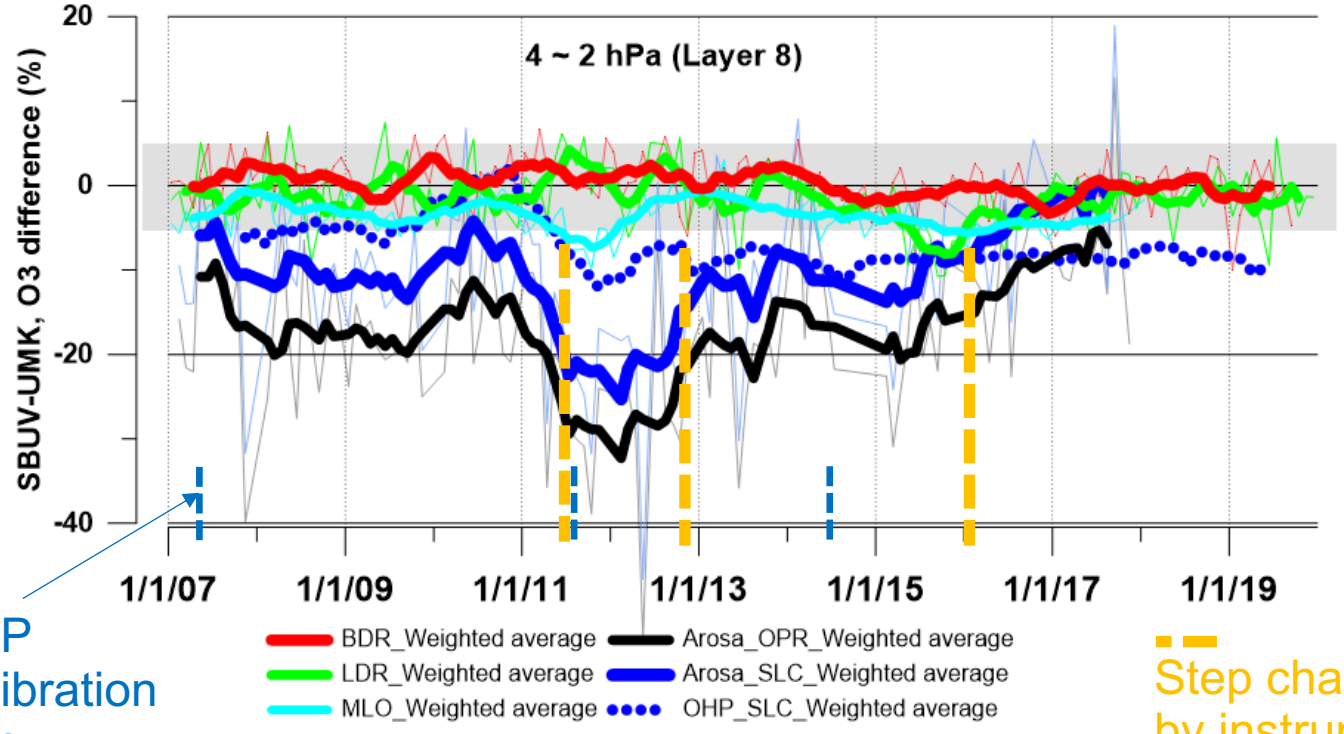
10 stations have long enough records



AROSA station

The ozone time series plot in the layer 4, 6 and 8. Matched time with SBUV in +/- 24 hours.

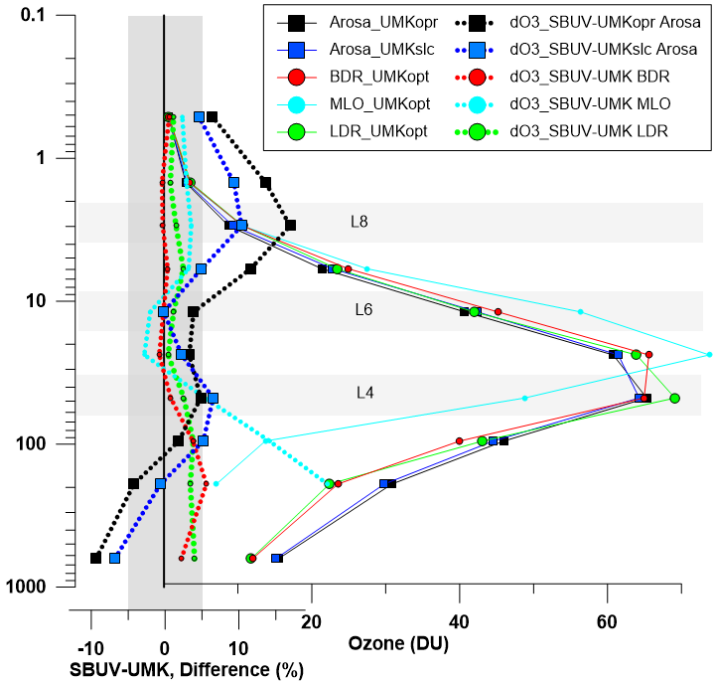
Ozone difference with SBUV in the layer 8.



OHP Calibration date

Step change by instrument calibration?

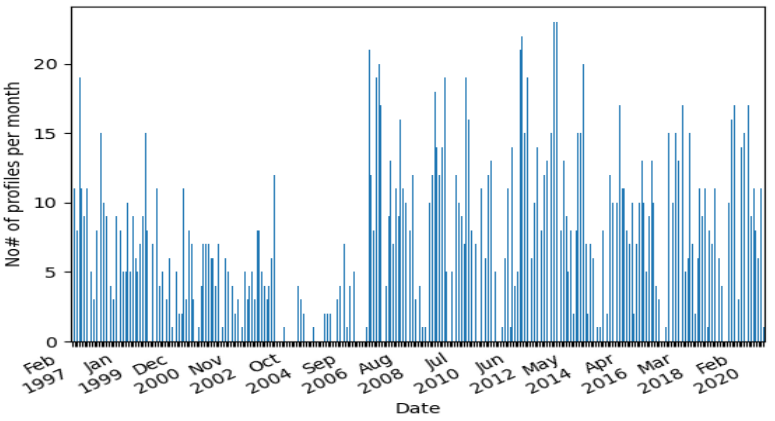
UMKEHR and SBUV (2007-2019)



Summary

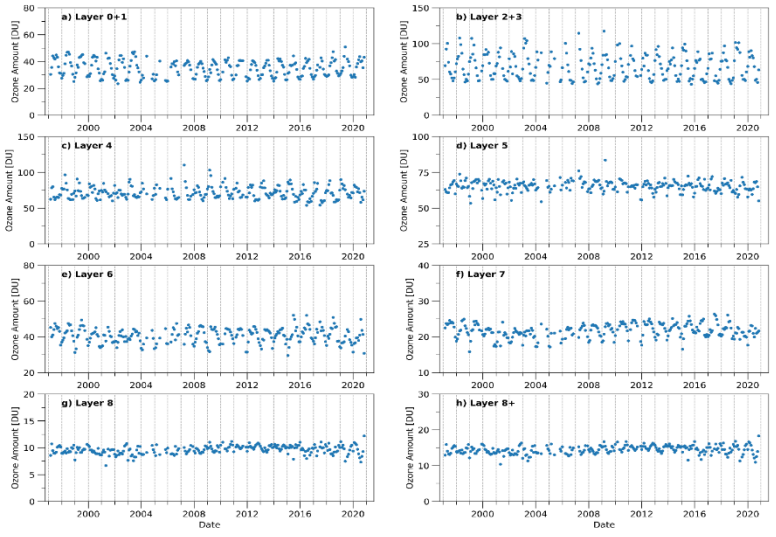
- 10 stations a have adequate frequency of observations
- SLC correction is not always enough. Optimization is needed. Aggregated SBUV profiles used as reference
- History of instrument's calibration is needed (ongoing work)
- SLC and optimized data have biases within 5%

Brewer Ozone Profile Data



Update Thessaloniki's time series (2120 profiles)

- Umkehr measurements at Thessaloniki only during sunset
- Number of profiles depend on the weather conditions (clouds) and the schedule of the instrument
- Higher number during summer months



0+1

2+3

8+

Layer	Layer Boundary (km)	Pressure limits (hPa)
0	0 – 5.5	1013 – 506.5
1	5.5 – 10.3	506.5 – 253.25
2	10.3 – 14.7	253.25 – 126.63
3	14.7 – 19.1	126.63 – 63.31
4	19.1 – 23.5	63.31 – 31.66
5	23.5 – 28	31.66 – 15.83
6	28 – 32.6	15.83 – 7.91
7	32.6 – 37.5	7.91 – 3.96
8	37.5 – 42.6	3.96 – 1.98
9	42.6 – 47.9	1.98 – 0.99
10	47.9 – 53.2	0.99 – 0.49
11	53.2 – 58.3	0.49 – 0.25
12	58.3 – 63.1	0.25 – 0.12
13	63.1 – 67.8	0.12 – 0.06
14	67.8 – 72.2	0.06 – 0.03
15	72.2– top of the atmosphere	0.03 – 0

EUBREWNET stations with Umkehr measurements

Station ID	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Location	Type
1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Athens/Greece	MKIV
5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Thessaloniki/Greece	MKII
9	x	x			x	x	x	x	x						Mauna Loa/USA	MKIV
15	x	x	x	x	x	x	x	x	x	x	x	x			Toronto/Canada	MKII
17	x	x	x	x	x		x				x				Toronto/Canada	MKII
33	x	x	x	x	x	x	x	x	x	x	x	x	x		Santa Cruz	MKII
37	x	x	x	x	x	x	x	x	x						Sodankyla/Finland	MKII
40	x	x	x	x	x	x	x	x	x	x		x	x	x	Arosa/Swiss	MKII
67	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Rome/Italy	MKIV
70	x		x	x	x		x	x	x	x	x	x	x		La coruna/Spain	MKIV
72	x	x		x		x	x	x	x	x	x	x	x	x	Davos/Swiss	MKII
75	x	x	x			x	x	x	x	x	x	x	x	x	Reading/UK	MKIV
97					x		x	x	x	x	x	x	x	x	Poprad-Ganovce/Slovakia	MKIV
117	x		x		x		x	x	x	x	x	x	x		Murcia/Spain	MKIVe
119		x			x	x	x	x	x	x	x				Mauna Loa/USA	MKIII
145	x		x		x	x	x	x	x	x	x	x			Toronto/Canada	MKIII
150	x		x		x	x	x	x	x	x			x		El Arenosilo/Spain	MKIII
151	x		x	x	x		x	x	x		x	x	x	x	Madrid/Spain	MKIVe
156	x	x	x	x	x	x	x	x	x	x		x	x	x	Arosa/Swiss	MKIII
166	x		x		x		x	x	x		x	x	x		Zaragoza/Spain	MKIVe
172	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Manchester/UK	MKIII
180					x	x	x	x	x	x	x	x	x	x	Punta Arenas/Chile	MKIII
184								x	x	x	x	x	x	x	Hradec Kralovı/Czech	MKIII
186	x		x			x	x	x	x	x	x	x	x	x	Madrid/Spain	MKIII
207											x	x	x	x	Warsaw/Poland	MKIII
214							x	x	x	x	x	x	x	x	Sodankyla/Finland	MKIII
217								x	x	x	x	x	x	x	Abu Dabi/UAE	MKIII
225								x	x	x	x	x	x		Poprad-Ganovce/Slovakia	MKIII
229										x	x	x	x		Rio Gallegos	MKIII
232										x			x	x	Singapore	MKIII

Thank you for your attention!