EarthCARE Aerosol products intercomparison with CARO Polly Lidar in Limassol, Cyprus

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ERATOSTHENES Centre of Excellence / Cyprus University of Technology

2nd ESA-JAXA EarthCARE In-Orbit Validation Workshop

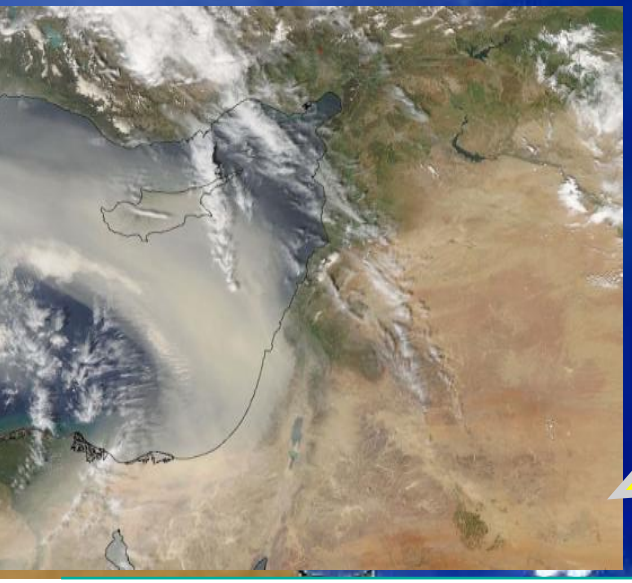
17 – 20 March 2025 | ESA-ESRIN | Frascati (Rome), Italy

Haze and fire smoke

Anthropogenic pollution

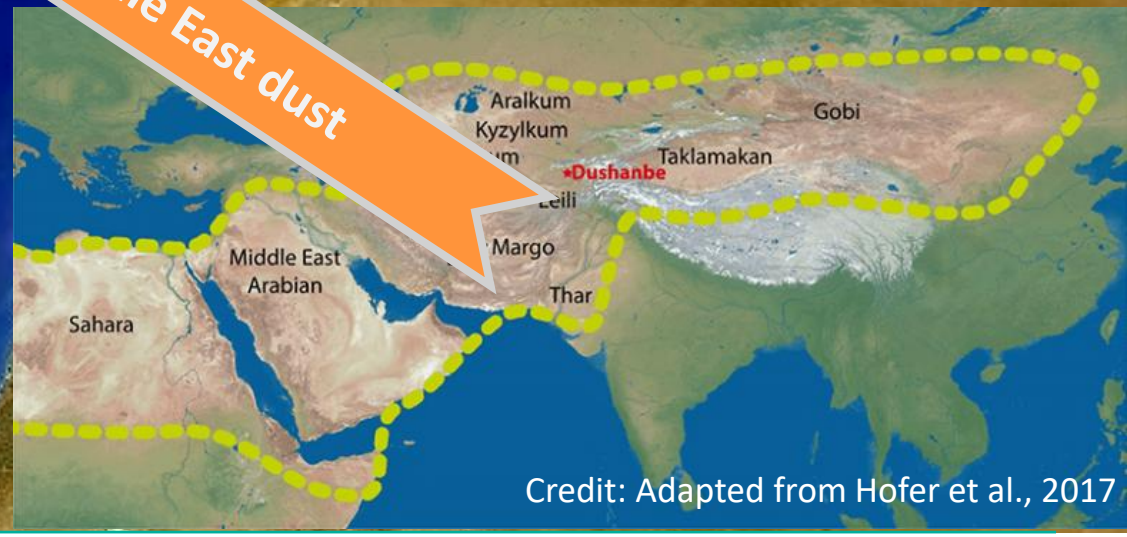
Cyprus

- *Mamouri, R.-E., et al, Atmos. Chem. Phys., 2023*
- *Ansmann, A. et al, Atmos. Chem. Phys., 2019*
- *Mamouri, R.-E., Ansmann, Atmos. Chem. Phys., 2016-2017.*
- *Nisantzi, A. et al, Atmos. Chem. Phys., 2015-2016*



Saharan Dust

Middle East dust



Credit: Adapted from Hofer et al., 2017

EVID39 CORAL Consortium

ERATOSTHENES Center of Excellence:

- **Limassol, coastal area**
- **CARO National Facility**
- **ACTRIS Aerosol and Cloud** Remote Sensing Observational Platforms [under Labeling]
- Solar Radiation observations

CARE-C of the Cyprus Institute

- **Nicosia, urban and inland areas**
- **Cyprus Atmospheric Observatory** (**CAO**)
- ACTRIS aerosol in situ observational platform
- Unmanned Systems Research Laboratory (**USRL**) – ACTRIS exploratory platform

Presentation by Franco Marenco

ERATOSTHENES CARO National Facility

Cyprus Atmospheric Remote Sensing Observatory

Limassol, Cyprus [34.7°N, 33°E]

less than 2 km from the coastline; conditions representative of typical Mediterranean and Middle East region

- **AEROSOL RS OBSERVATIONAL PLATFORM**
  - AERONET Sunphotometer – May 2010
  - **PollyXT [3β+2α+2δ]** October 2020
  - StreamLine **Doppler Lidar** – February 202

CLOUD RS OBSERVATIONAL PLATFORM

- microwave radiometer –July 2024
- ceilometer, **disdrometer** –February 2024
- **35 GHz MIRA** cloud radar –July 2024

Operates since October 2020

Operates Since July 2024

ERATOSTHENES CARO National Facility

Cyprus Atmospheric Remote Sensing Observatory

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- **35 GHz MIRA** cloud radar –July 2024

Operates since October 2020

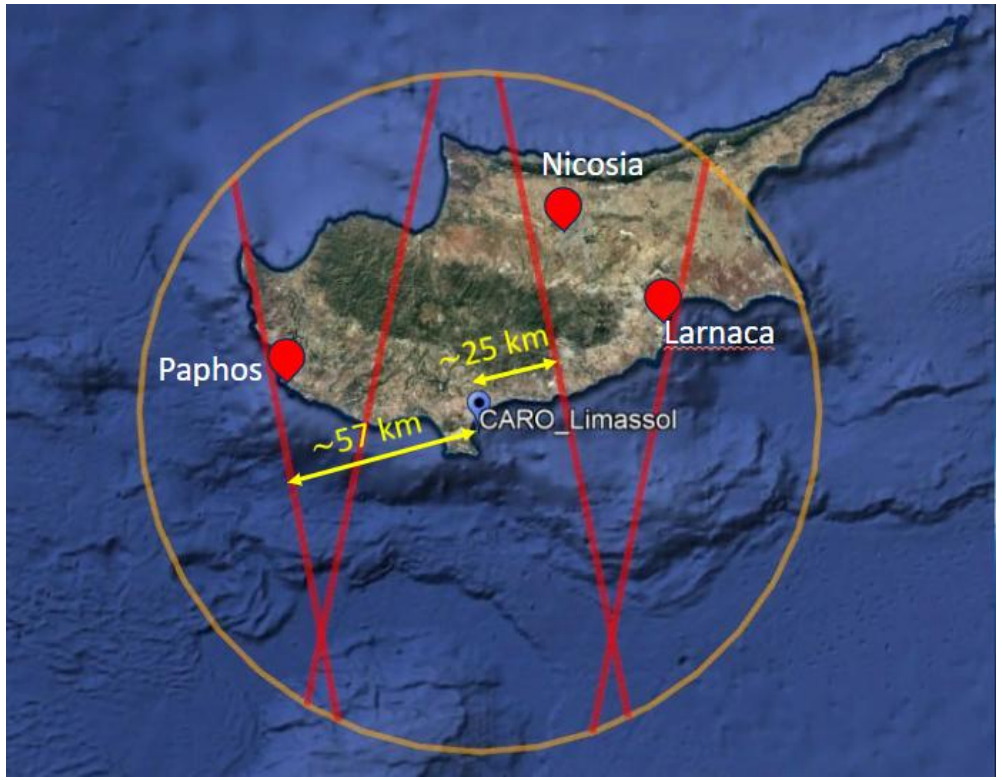
ERATOSTHENES
Cyprus Solar Station

Operates December 2023

Operates Since July 2024

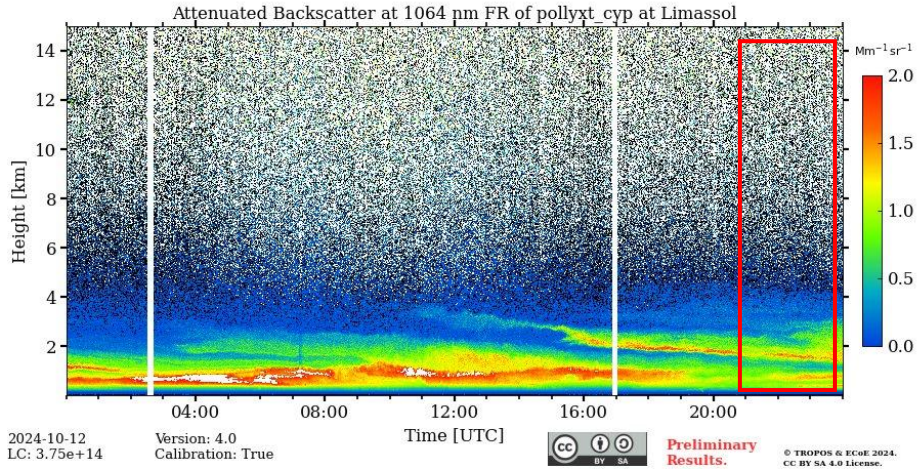
Limassol overpasses

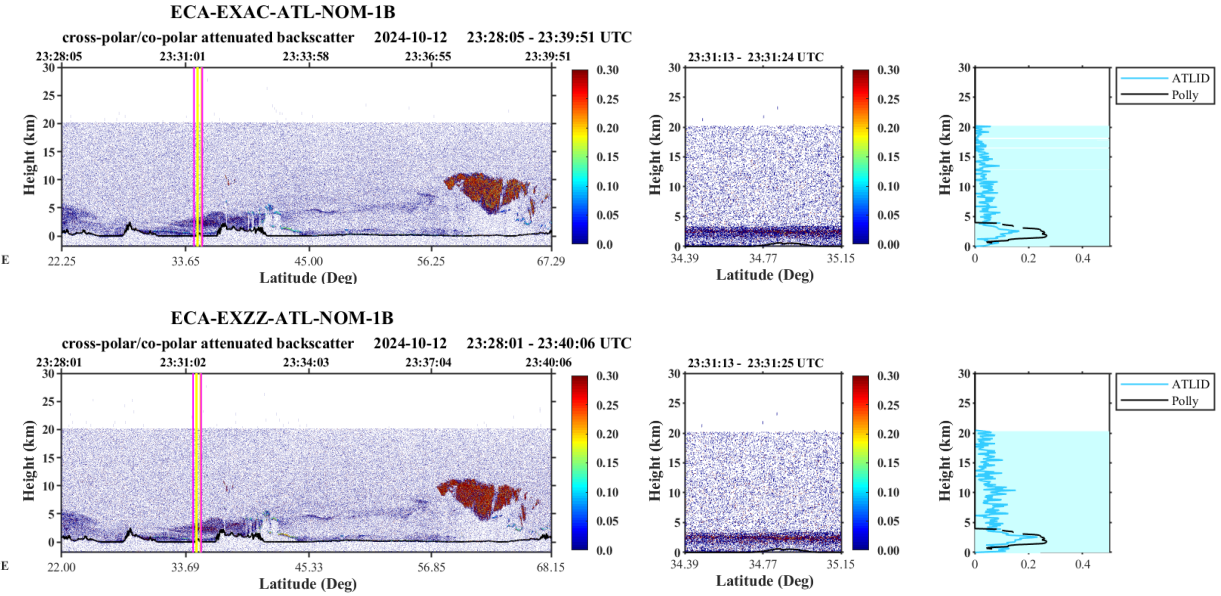
49 overpasses within 100km
32 ATLID-PollyXT-CYP common measurements
29 CPR-MIRA35 common measurements
12 cases of PollyXT+MIRA35
4 cases aerosol+clouds

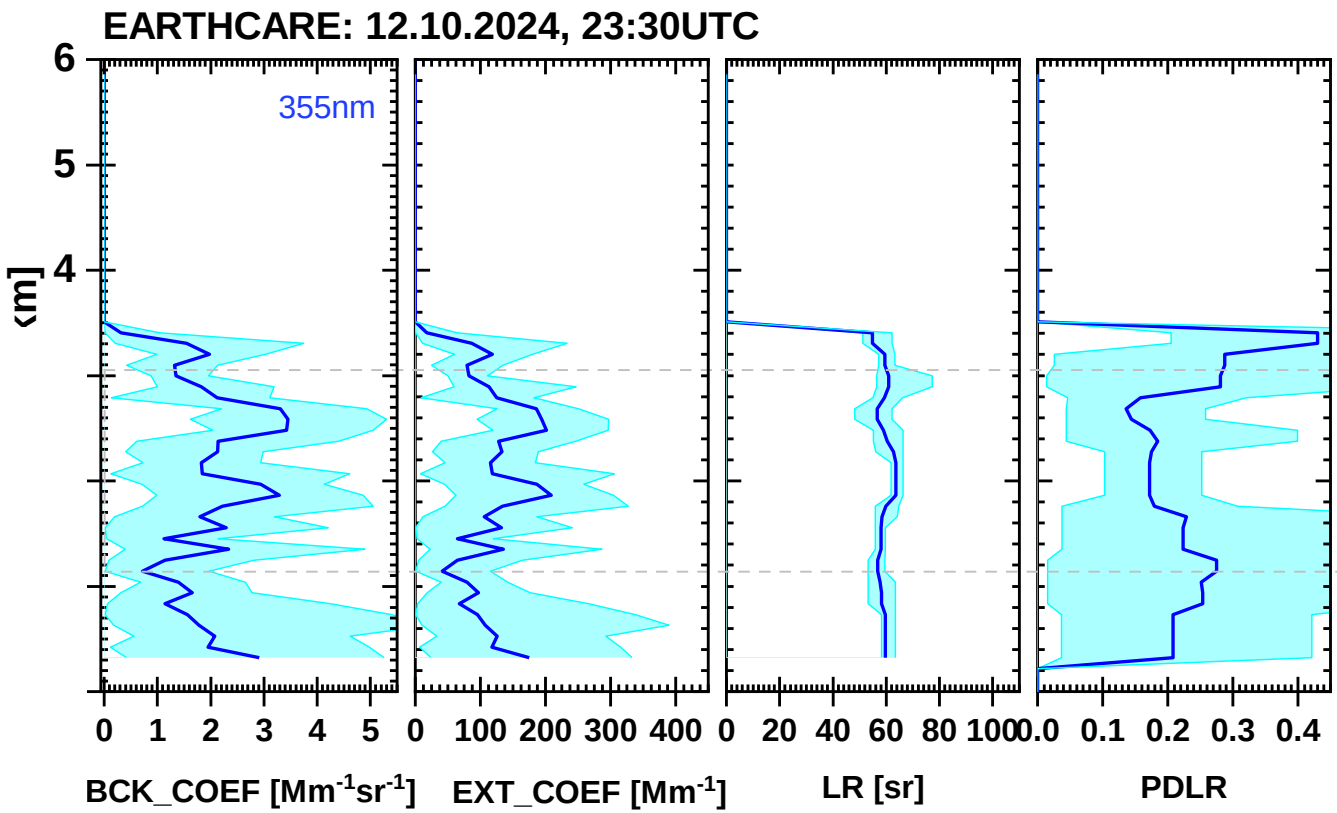


					INSTRUMENT AVAILABILITY		
					Aerosol		Cloud
PASS	DATE	DISTANCE_TO_MID_SWAT	ASCENDING/DESCENDING PA	UTC_TIME_START	PollyXT	Ceilometer	MIRA 35
1	2025-03-23	51.340838	DESC	T12:02:25.101382	☑	☑	☑
2	2025-03-20	25.015134	ASC	T23:24:51.158924	☑	☑	☑
3	2025-03-14	31.794807	DESC	T12:06:13.289602	☑	☑	☑
4	2025-03-11	58.129918	ASC	T23:28:42.718667	☑	☑	☑
5	2025-02-26	51	DESC	T12:03:15.372505	☑	☑	☑
6	2025-02-23	25	ASC	T23:25:44.429443	☑	☑	☑
7	2025-02-17	31	DESC	T12:07:06.037747	☑	☑	☐
8	2025-02-14	58	ASC	T23:29:31.745763	☑	☑	☐
9	2025-02-07				☑	☑	☐
10	2025-02-01	51.34056	DESC	T12:03:18.600752	☑	☑	☐
11	2025-01-29	25.015401	ASC	T23:25:44.658287	☑	☑	☐
12	2025-01-23	31.795086	DESC	T12:07:06.789024	☑	☑	☐
13	2025-01-20	58.129652	ASC	T23:29:36.218002	☑	☑	☐
14	2025-01-07	51.188308	DESC	T12:03:39.491724	☑	☑	☐
15	2025-01-04	25.168217	ASC	T23:26:05.769968	☑	☑	☐
16	2024-12-29	31.947926	DESC	T12:07:28.417129	☑	☑	☐
17	2024-12-26	57.977407	ASC	T23:29:58.029417	☑	☑	☐
18	2024-12-13	51.188325	DESC	T12:04:08.241349	☑	☑	☐
19	2024-12-10	25.168183	ASC	T23:26:34.519587	☑	☑	☐
20	2024-12-04	31.947909	DESC	T12:07:57.166740	☑	☑	☐
21	2024-12-01	57.97744	ASC	T23:30:26.779035	☑	☑	☐
22	2024-11-18	51.188428	DESC	T12:04:36.990949	☑	☑	☐
23	2024-11-15	25.168095	ASC	T23:27:03.269192	☑	☑	☐
24	2024-11-09	32.234191	DESC	T12:08:22.806013	☑	☑	☐
25	2024-11-06	57.692418	ASC	T23:30:52.762151	☑	☑	☐
26	2024-10-24	50.903332	DESC	T12:05:04.998022	☑	☑	☑
27	2024-10-21	25.454125	ASC	T23:27:31.690140	☑	☑	☑
28	2024-10-15	32.234008	DESC	T12:08:55.305474	☑	☑	☑
29	2024-10-12	57.692568	ASC	T23:31:25.261663	☑	☑	☑
30	2024-10-06	31.852081	DESC	T12:09:15.412446	☑	☑	☑
31	2024-10-03	58.072862	ASC	T23:31:44.910254	☑	☑	☑
32	2024-09-29	50.903358	DESC	T12:05:37.497513	☑	☑	☑
33	2024-09-26	25.454087	ASC	T23:28:04.189640	☑	☑	☑
34	2024-09-20	38.265223	DESC	T12:09:43.860276	☐	☑	☑
35	2024-09-17	25.072412	ASC	T23:28:21.016135	☐	☑	☑
36	2024-09-11	42.930503	DESC	T12:10:13.171896	☐	☑	☐
37	2024-09-08	74.788961	ASC	T23:33:00.626293	☐	☑	☑
38	2024-09-04	51.005026	DESC	T12:06:11.190332	☐	☑	☑
39	2024-09-01	74.413799	ASC	T23:26:34.445434	☐	☑	☑
40	2024-08-26	1.258111	DESC	T12:08:34.166997	☐	☑	☑
41	2024-08-25	6.511388	ASC	T23:29:37.044277	☐	☑	☑
42	2024-08-23	16.207973	ASC	T23:30:40.684001	☐	☑	☑
43	2024-08-17	28.45347	DESC	T12:10:04.830126	☐	☑	☑
44	2024-08-14	16.607746	ASC	T23:30:55.311648	☐	☑	☑
45	2024-08-08	58.368392	DESC	T12:06:32.186185	☐	☑	☑
46	2024-08-05	98.484601	ASC	T23:26:18.762820	☐	☑	☑
47	2024-08-03	99.576832	ASC	T23:35:07.655859	☐	☑	☑
48	2024-07-28	15.072982	DESC	T12:08:44.366994	☐	☑	☑
49	2024-07-25	89.796254	ASC	T23:27:01.079948	☐	☑	☑
50	2024-07-23	81.525471	ASC	T23:34:36.753890	☐	☑	☑
51	2024-07-12	38.947596	ASC	T23:29:48.414533	☐	☑	☑

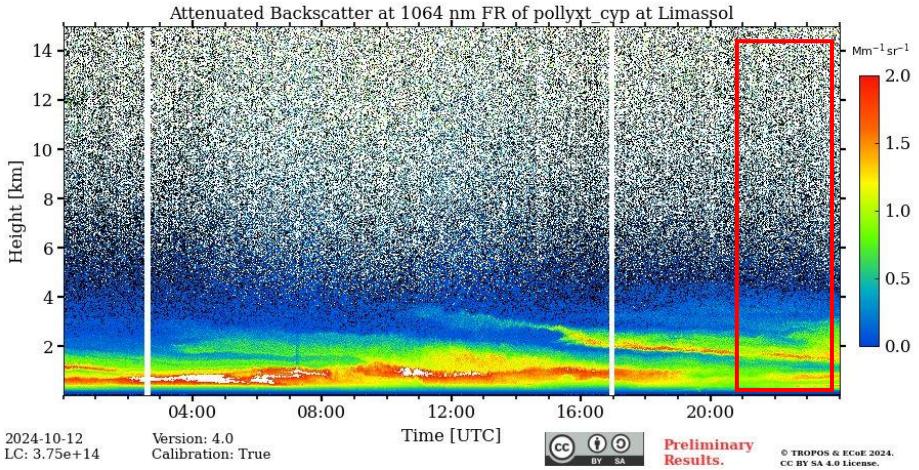
10 October 2024, 23:30, 57km







me), Italy


Attenuated Backscatter at 1064 nm FR of pollyxt_cyp at Limassol
Height [km]
Time [UTC]
Mm⁻¹sr⁻¹
2024-10-12
LC: 3.75e+14
Version: 4.0
Calibration: True
Preliminary Results.
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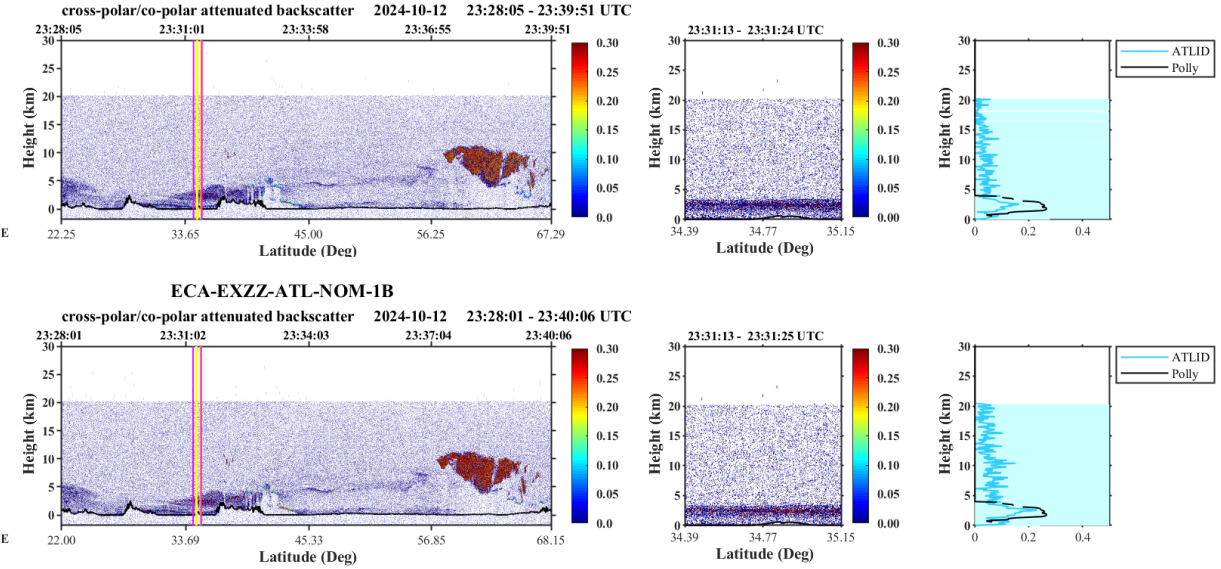
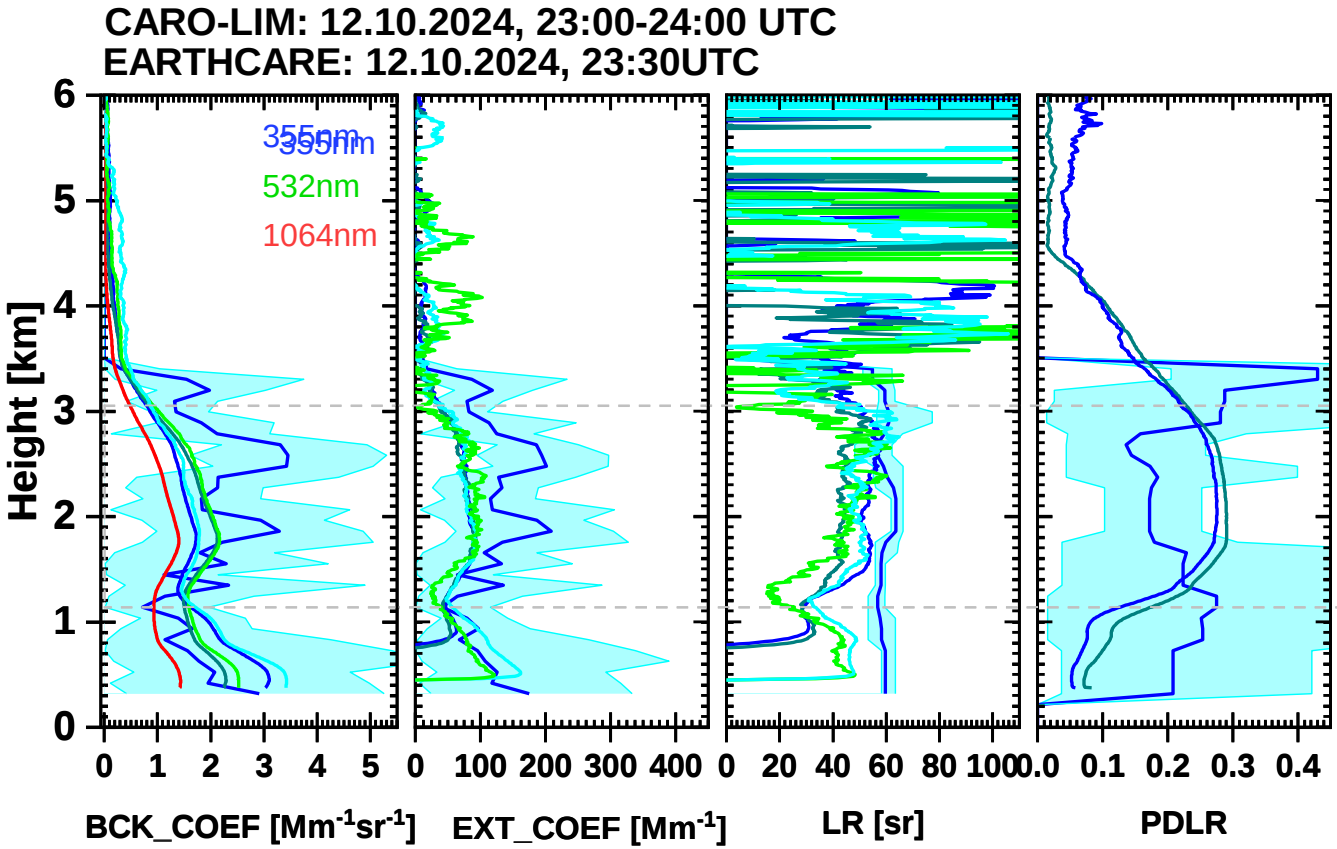
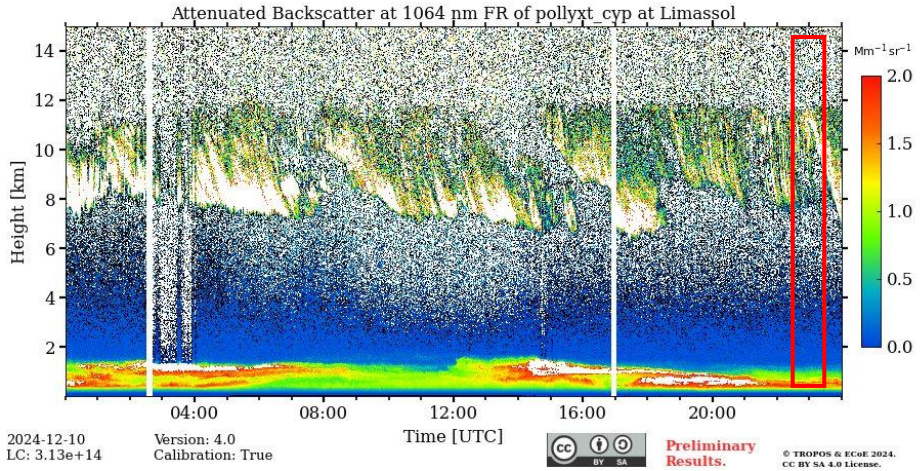

ECA-EXAC-ATL-NOM-1B
cross-polar/co-polar attenuated backscatter 2024-10-12 23:28:05 - 23:39:51 UTC
23:31:13 - 23:31:24 UTC
ATLID
Polly
Height (km)
Latitude (Deg)
ECA-EXZZ-ATL-NOM-1B
cross-polar/co-polar attenuated backscatter 2024-10-12 23:28:01 - 23:40:06 UTC
23:31:13 - 23:31:25 UTC


CARO-LIM: 12.10.2024, 23:00-24:00 UTC
EARTHCARE: 12.10.2024, 23:30UTC
355nm
532nm
1064nm
Height [km]
BCK_COEF [Mm⁻¹sr⁻¹]
EXT_COEF [Mm⁻¹]
LR [sr]
PDLR


Attenuated Backscatter at 1064 nm FR of pollyxt_cyp at Limassol
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Mm⁻¹sr⁻¹
2024-12-10
LC: 3.13e+14
Version: 4.0
Calibration: True
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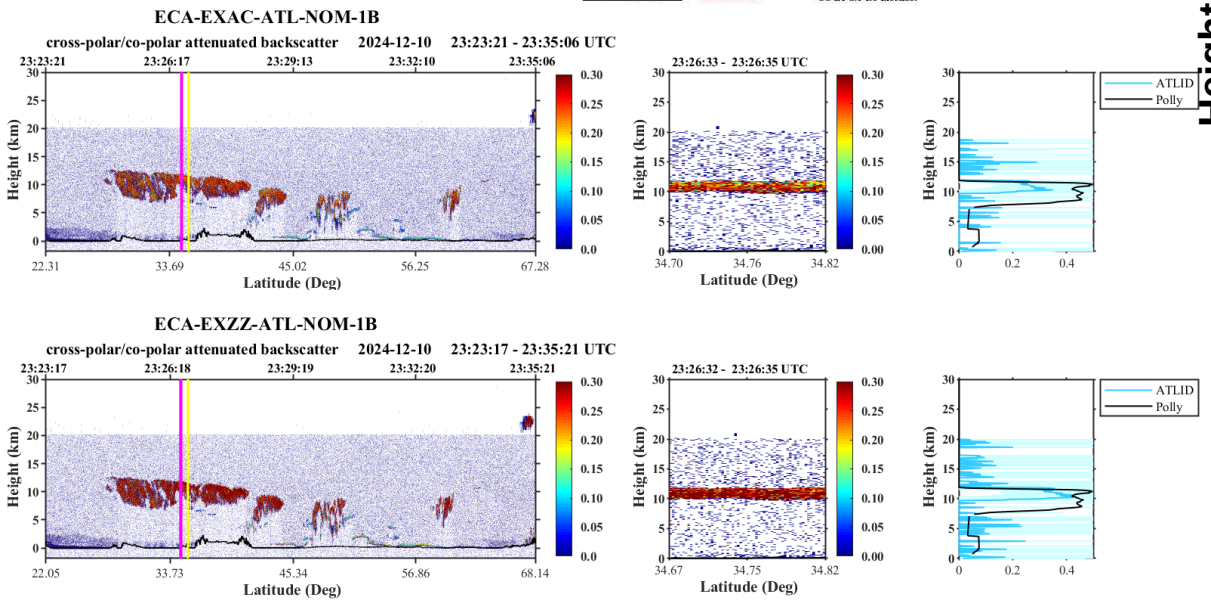
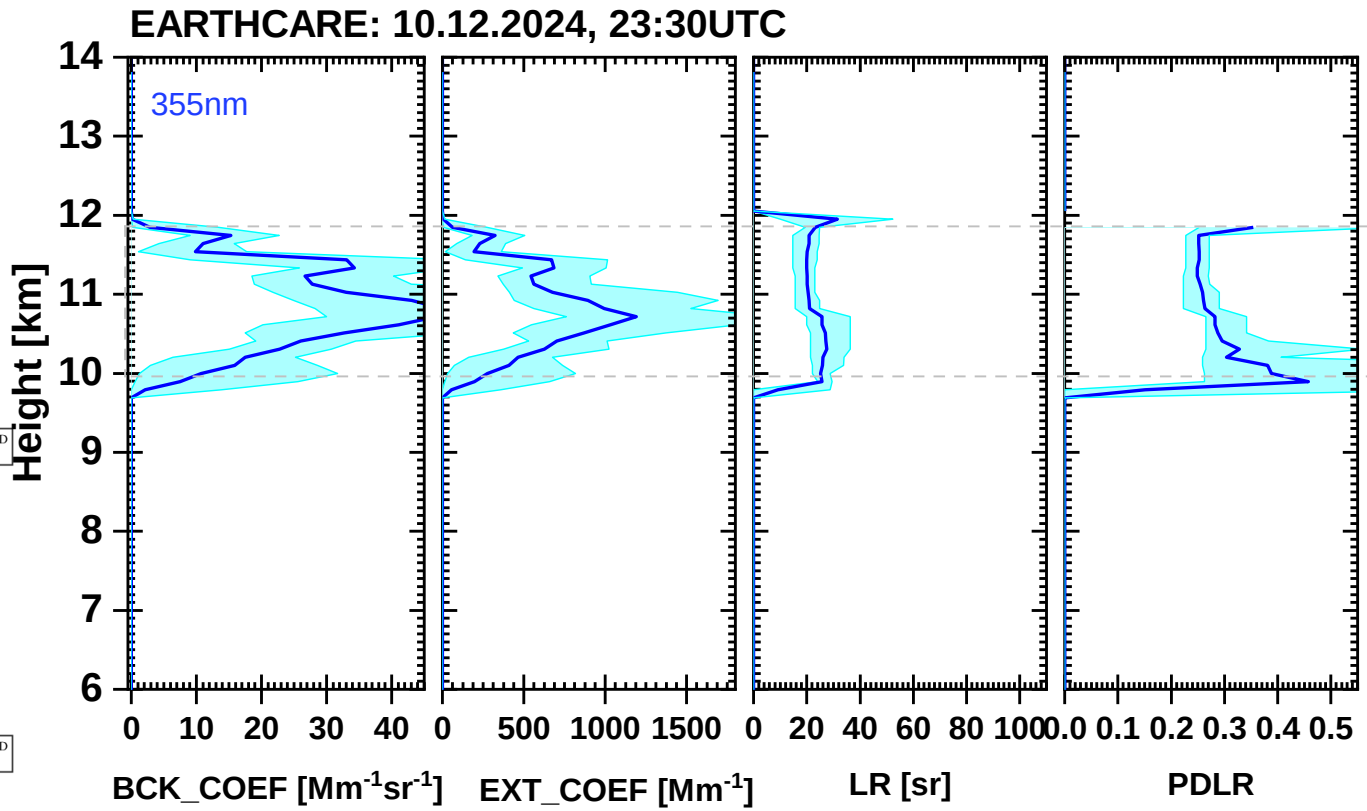
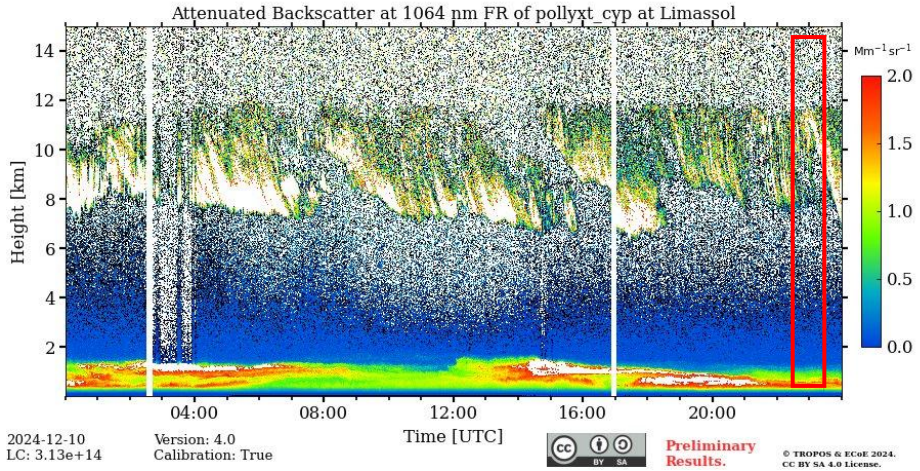

ECA-EXAC-ATL-NOM-1B
cross-polar/co-polar attenuated backscatter 2024-12-10 23:23:21 - 23:35:06 UTC
23:26:33 - 23:26:35 UTC
ATLID
Polly
Height (km)
Latitude (Deg)
ECA-EXZZ-ATL-NOM-1B
cross-polar/co-polar attenuated backscatter 2024-12-10 23:23:17 - 23:35:21 UTC
23:26:32 - 23:26:35 UTC


EARTHCARE: 10.12.2024, 23:30UTC
355nm
Height [km]
BCK_COEF [Mm-1sr-1]
EXT_COEF [Mm-1]
LR [sr]
PDLR


Attenuated Backscatter at 1064 nm FR of pollyxt_cyp at Limassol
Height [km]
Time [UTC]
Mm⁻¹sr⁻¹
2024-12-10
LC: 3.13e+14
Version: 4.0
Calibration: True
Preliminary Results.
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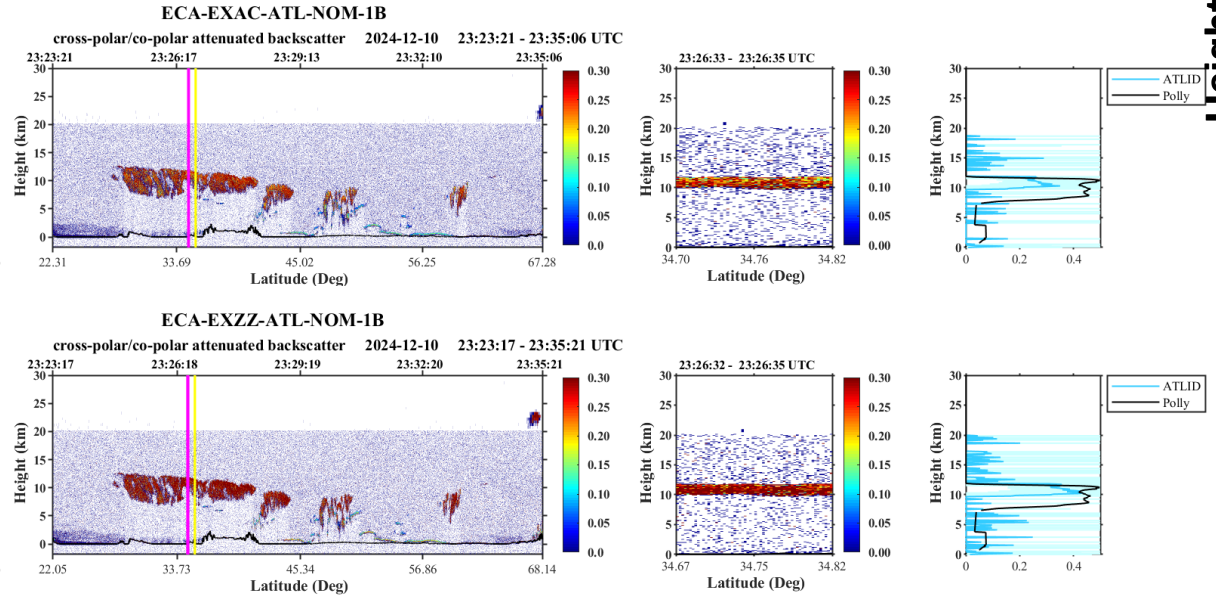
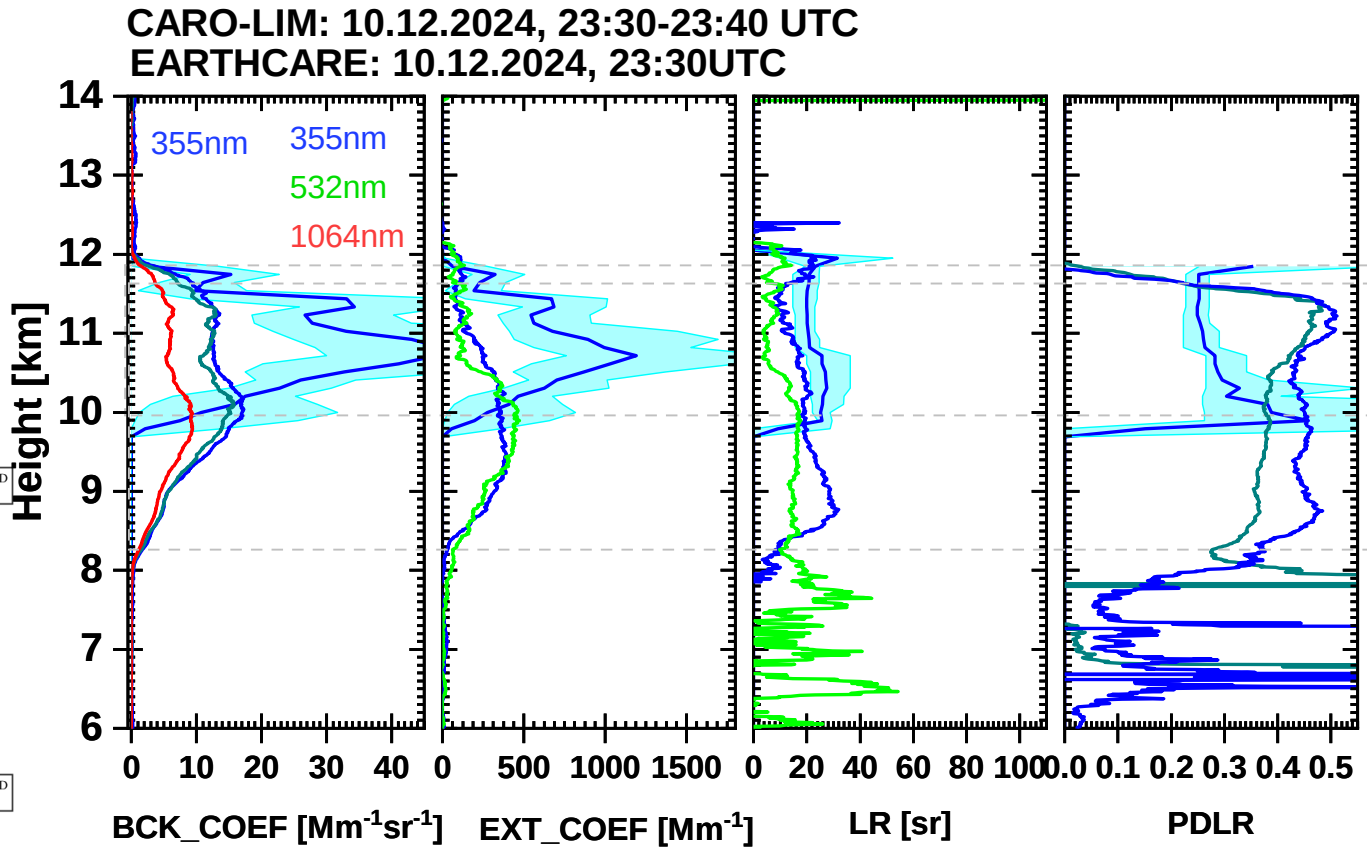
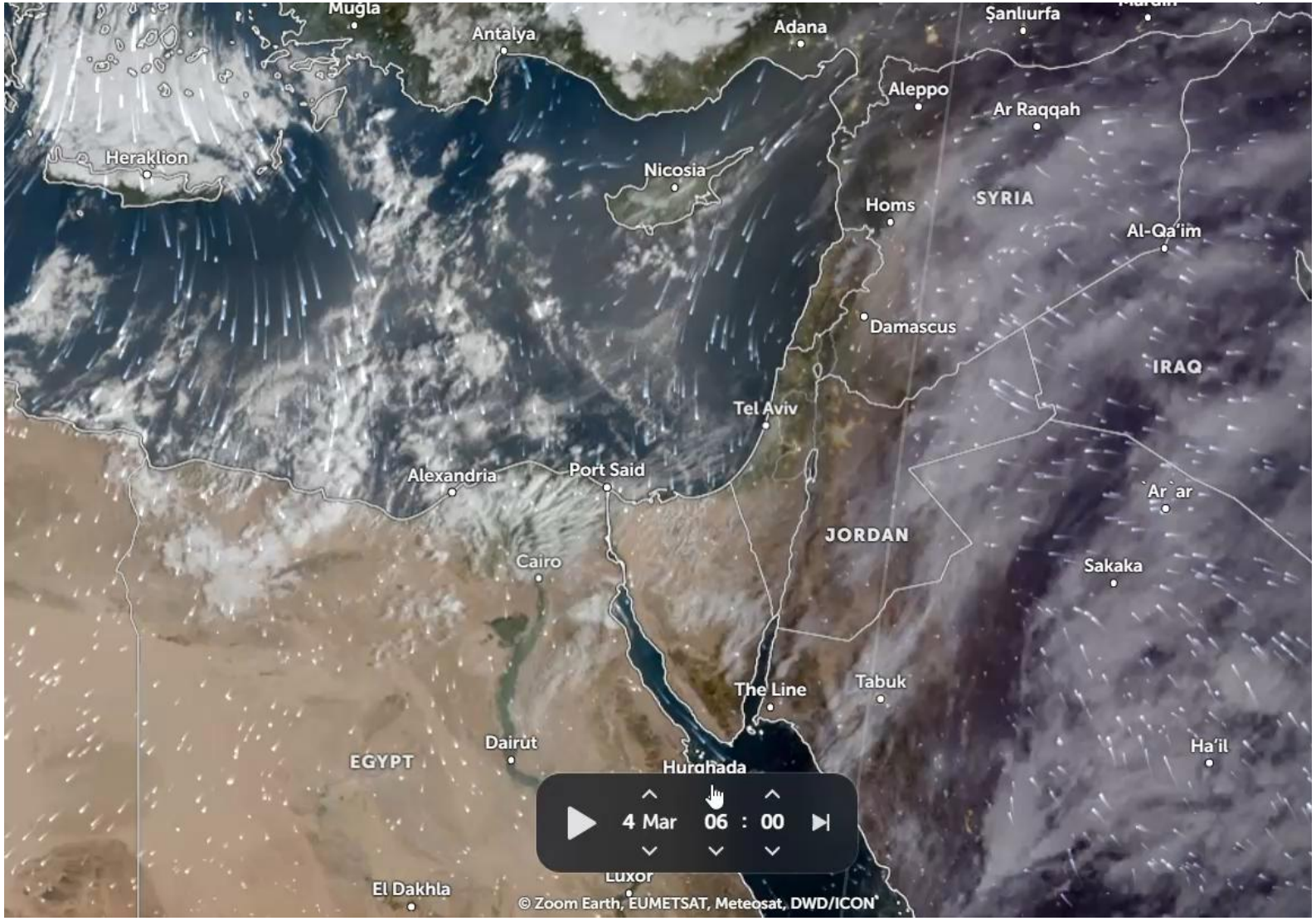
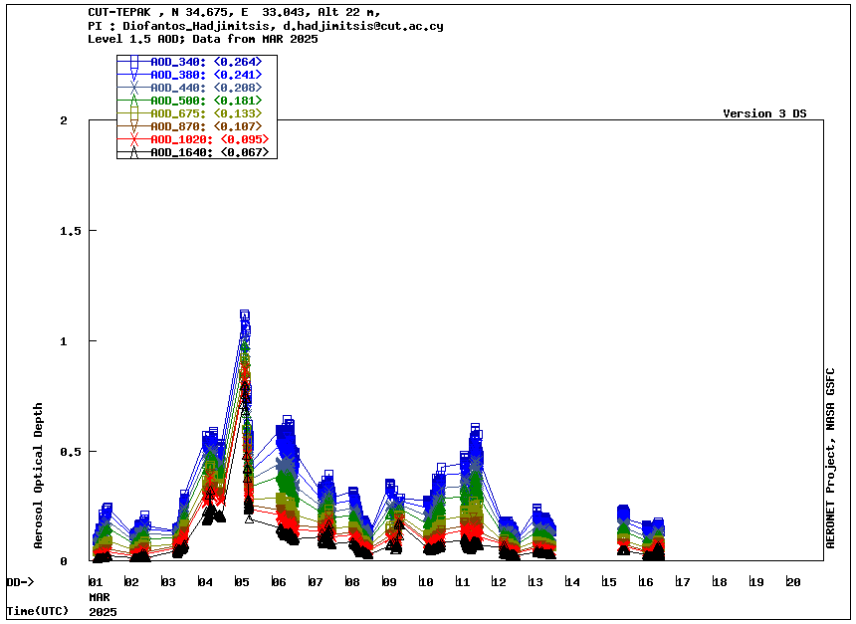

ECA-EXAC-ATL-NOM-1B
cross-polar/co-polar attenuated backscatter 2024-12-10 23:23:21 - 23:35:06 UTC
23:26:33 - 23:26:35 UTC
ECA-EXZZ-ATL-NOM-1B
cross-polar/co-polar attenuated backscatter 2024-12-10 23:23:17 - 23:35:21 UTC
23:26:32 - 23:26:35 UTC
Height (km)
Latitude (Deg)
ATLID
Polly

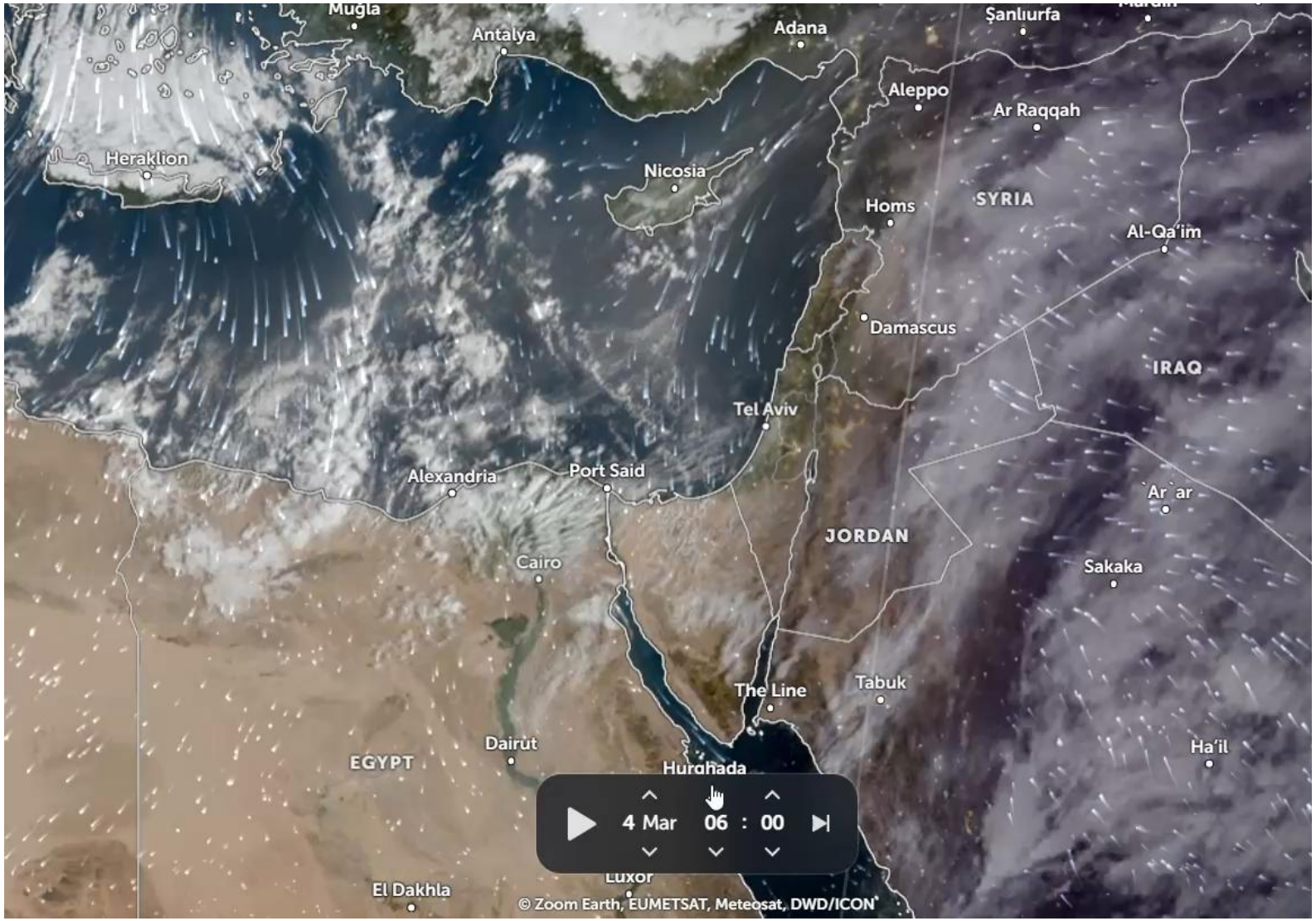

CARO-LIM: 10.12.2024, 23:30-23:40 UTC
EARTHCARE: 10.12.2024, 23:30UTC
355nm
355nm
532nm
1064nm
Height [km]
BCK_COEF [Mm-1sr-1]
EXT_COEF [Mm-1]
LR [sr]
PDLR

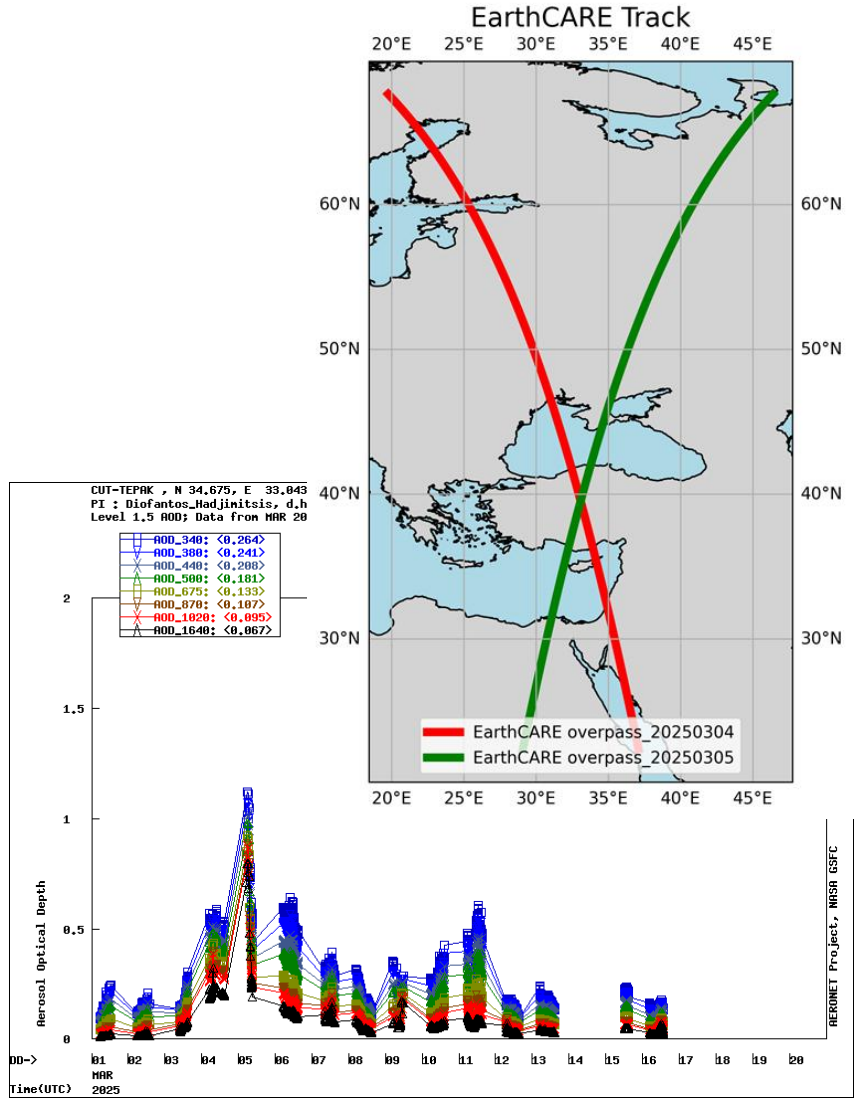
4-5 March 2025: Eastern Mediterranean cross path



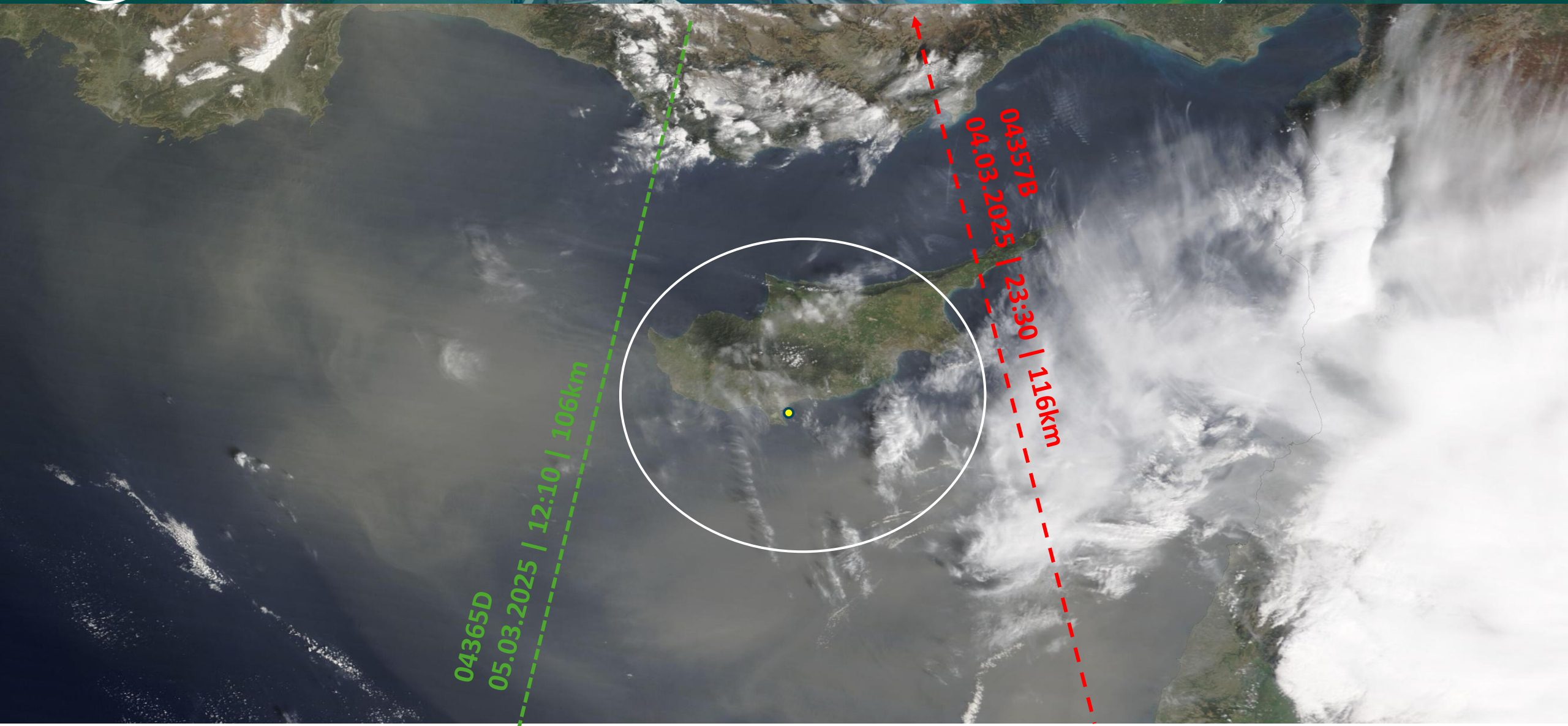


4-5 March 2025: Eastern Mediterranean cross path

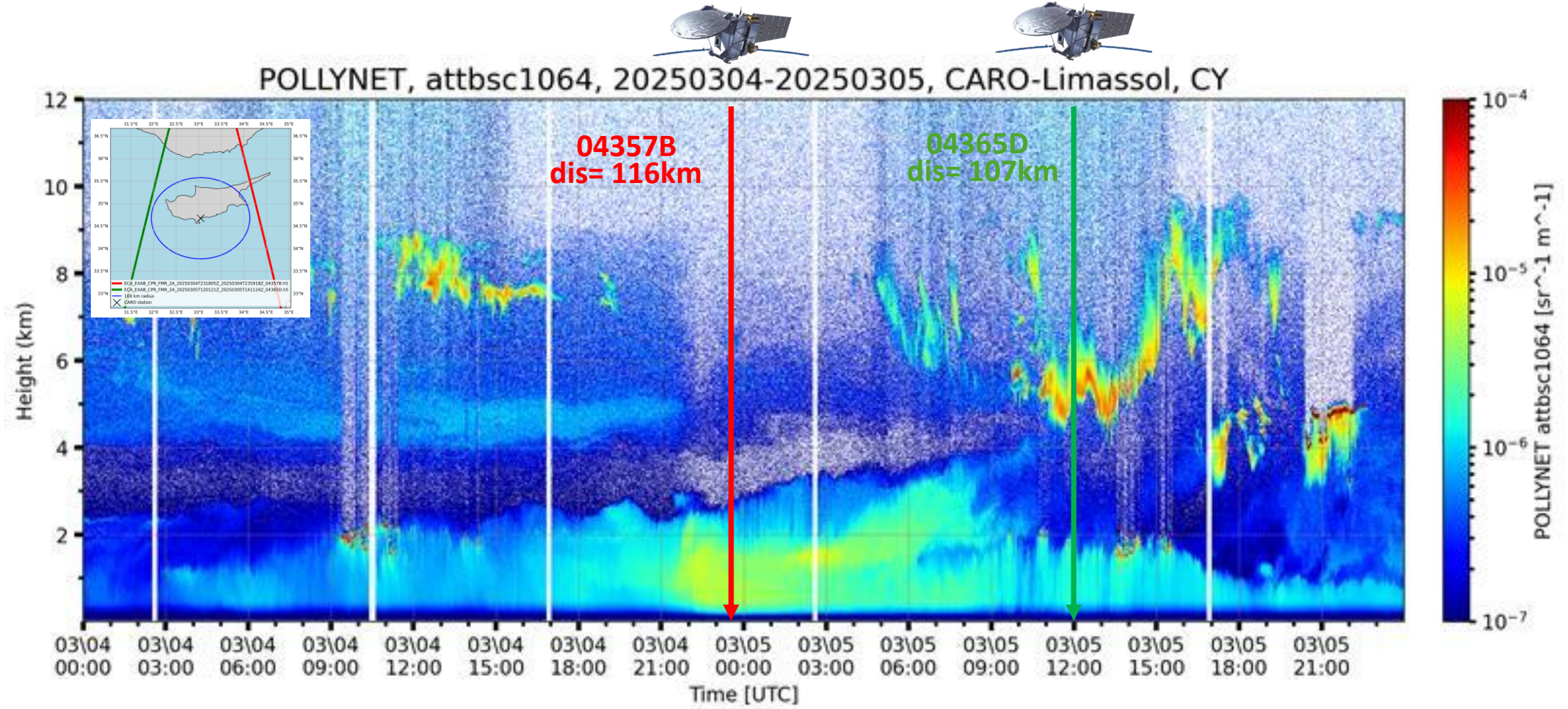


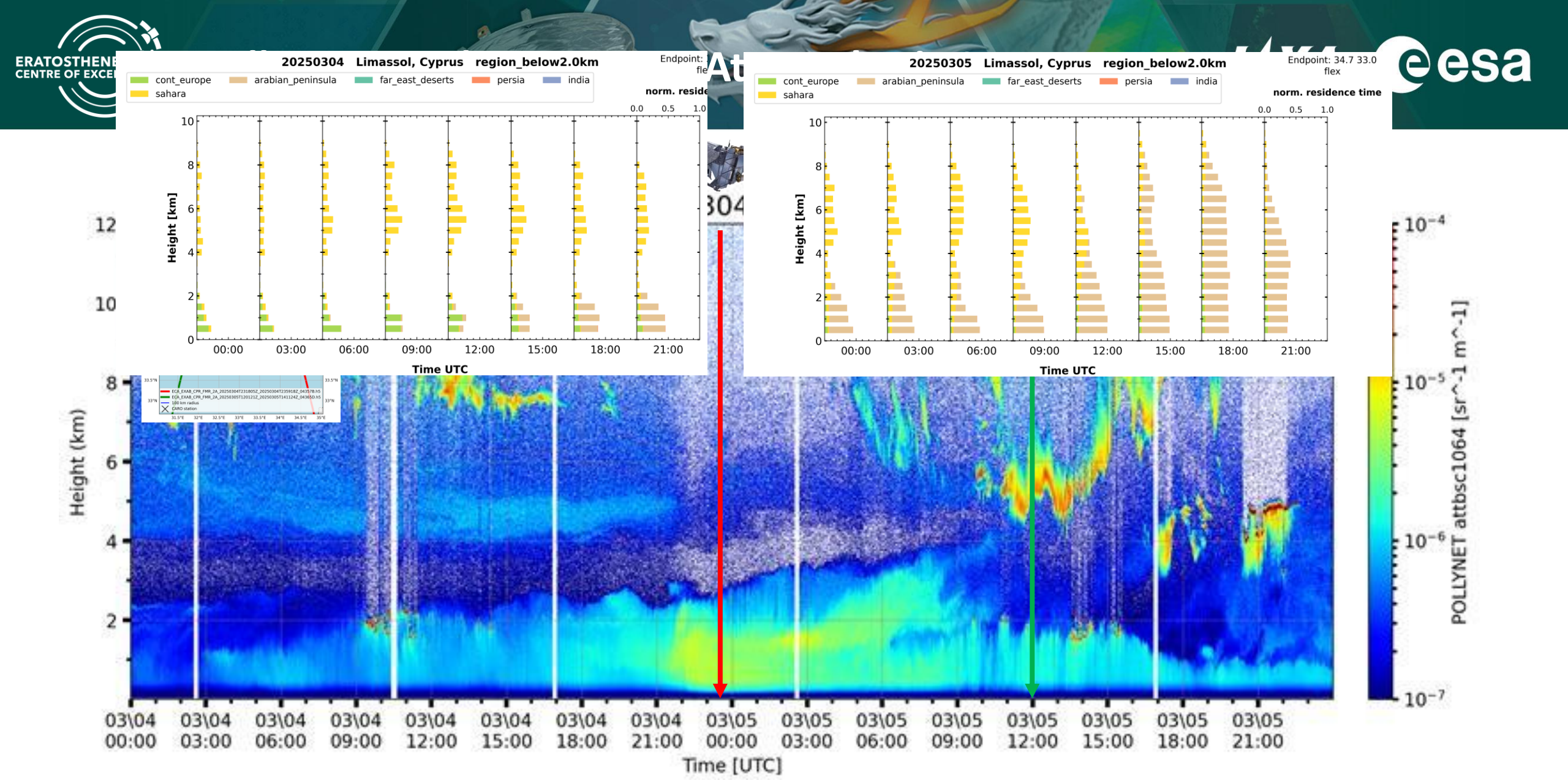


Two “NO” Limassol Overpasses

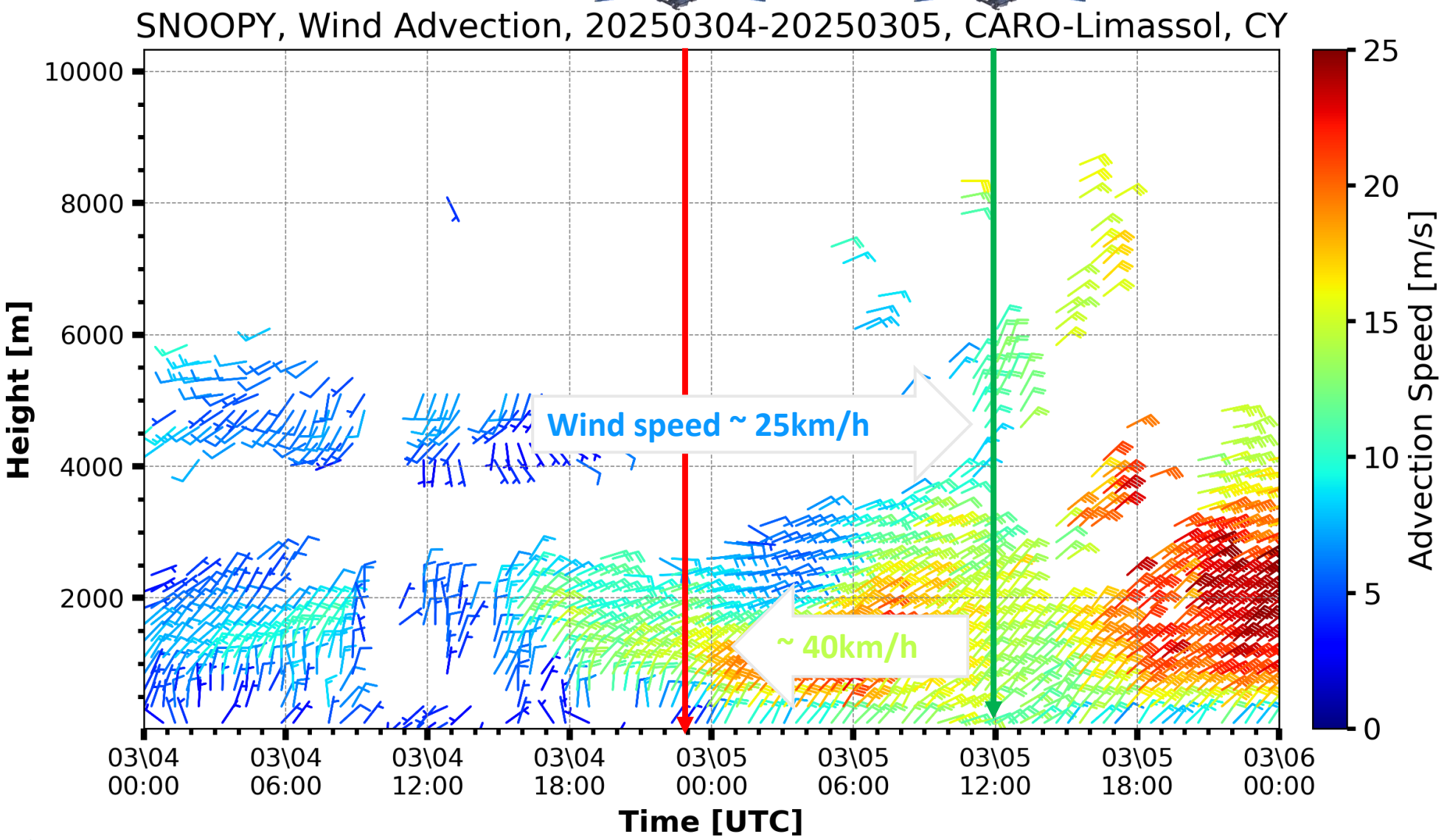


PollyXT-CYP observations: Atmospheric Structure

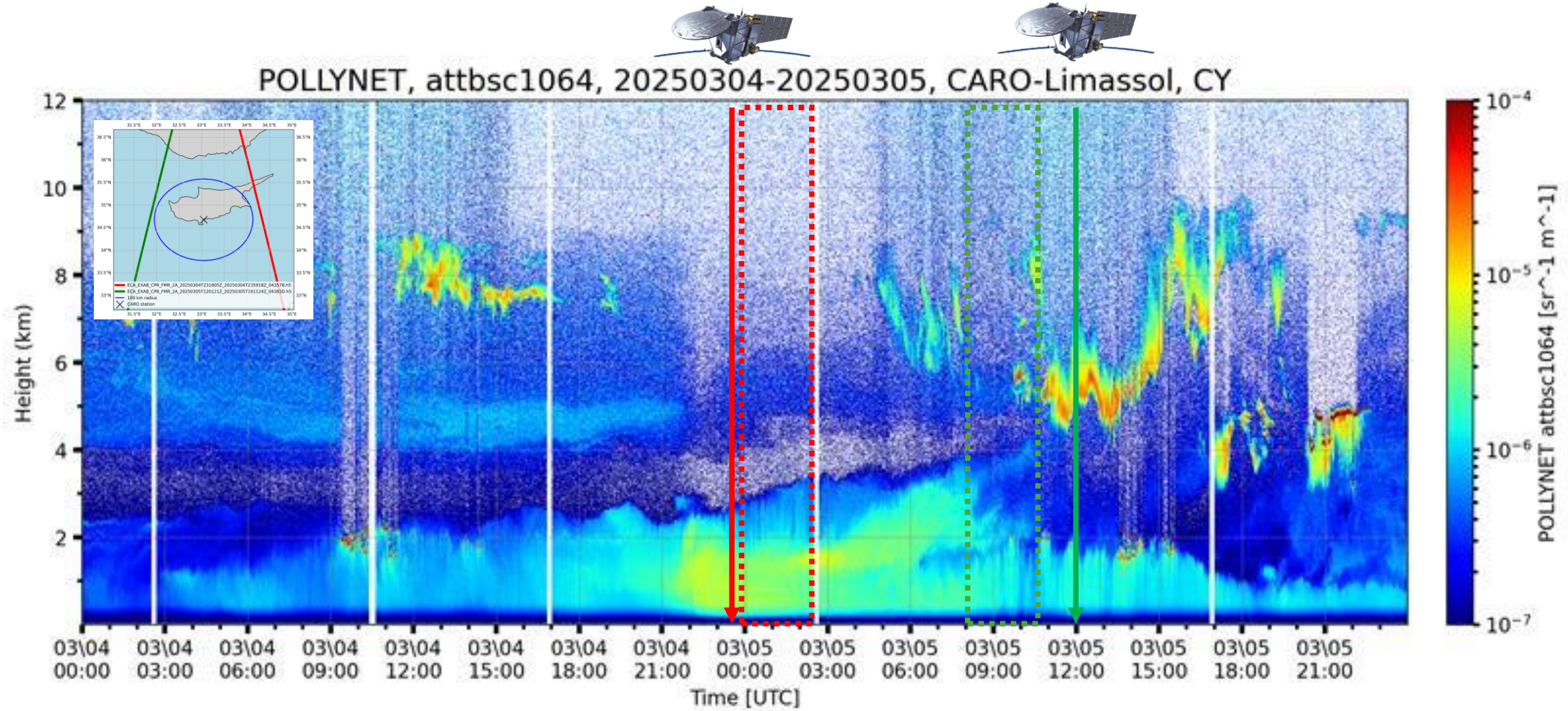



20250304 Limassol, Cyprus region_below2.0km
cont_europe
sahara
arabian_peninsula
far_east_deserts
persia
india
Height [km]
Time UTC
20250305 Limassol, Cyprus region_below2.0km
norm. residence time
Height (km)
Time [UTC]
POLLYNET attbsc1064 [sr^-1 m^-1]
04357B
dis= 116km
04365D
dis= 107km

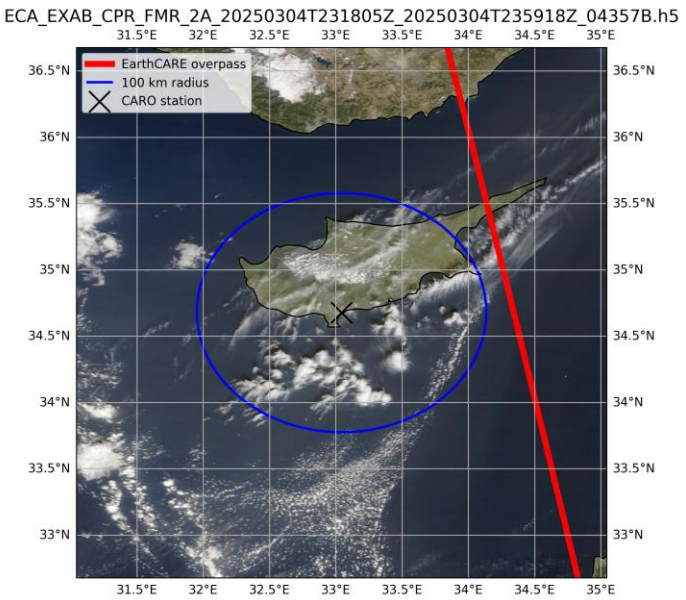
Snoopy Doppler Lidar observations – Wind profiles



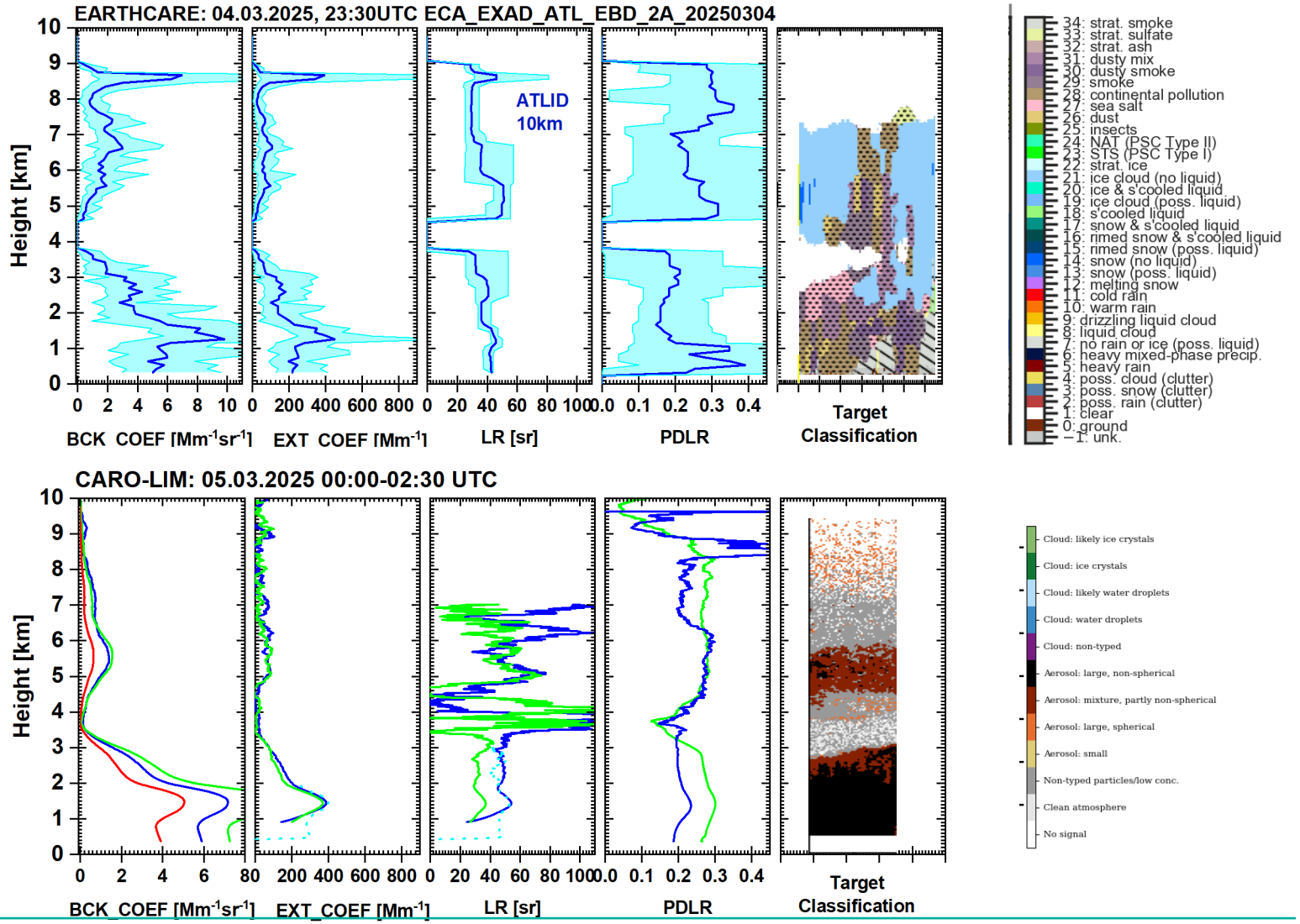
PollyXT-CYP observations: Atmospheric Structure



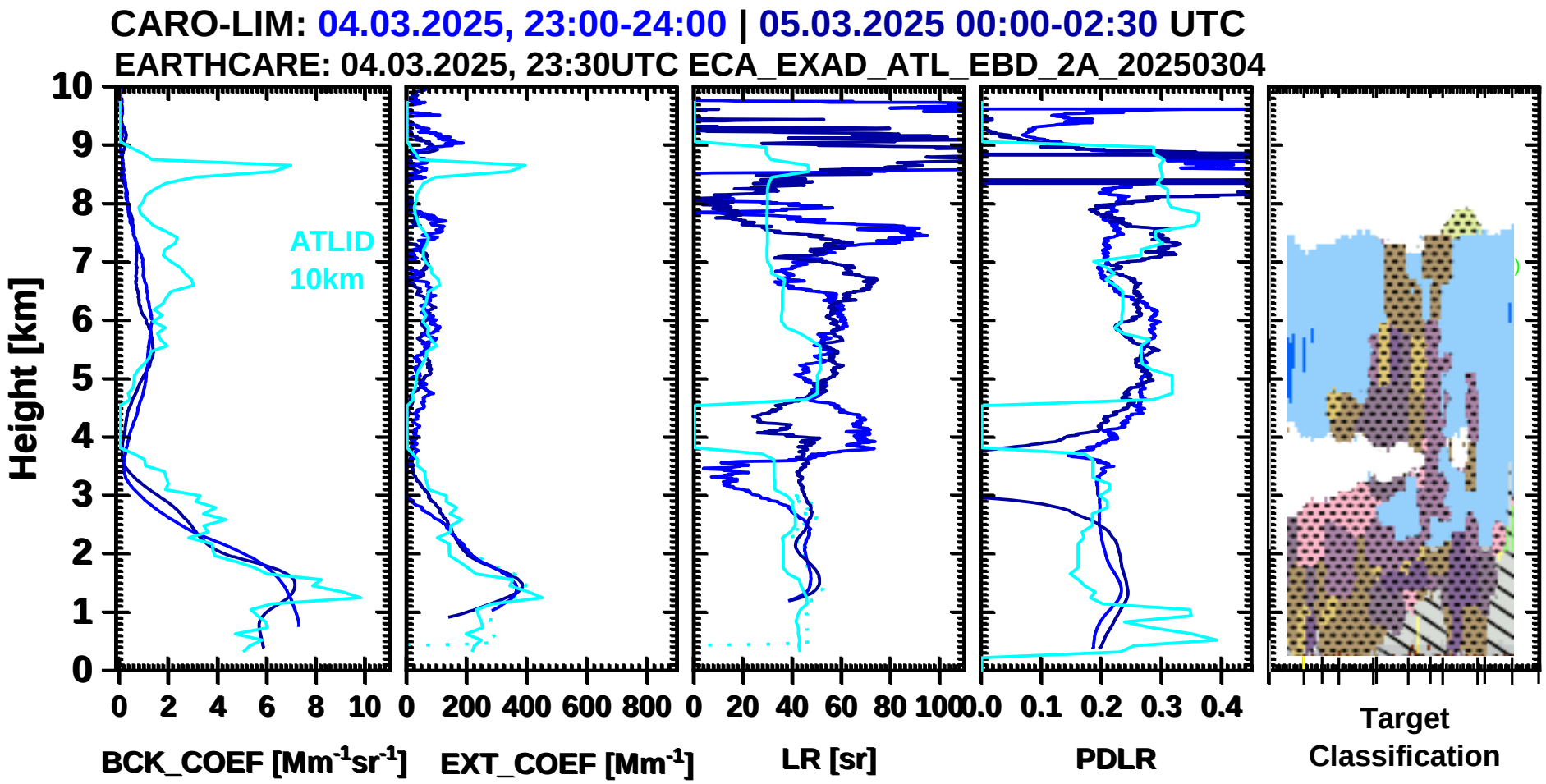
FRAME: 04357B | 4.03.42025 | 23:30 UTC | 106km



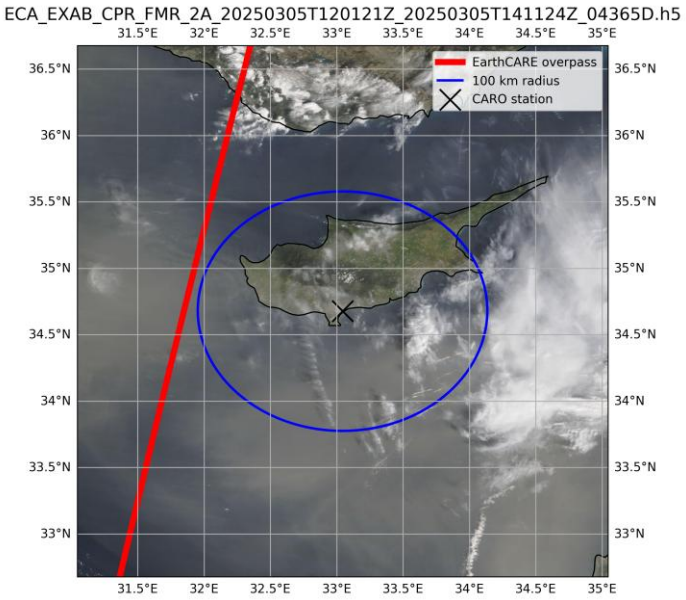
PollyXT_CYP, Limassol, Cyprus,
5 March 2025, 00:00-02:30UTC
+ EarthCARE ATLID A-EBD (AC)
Ascending overpass
Min distance= 116Km
Wind speed= 34-40km/hour
Wind dir = East
2-3 hours delay at GB observations

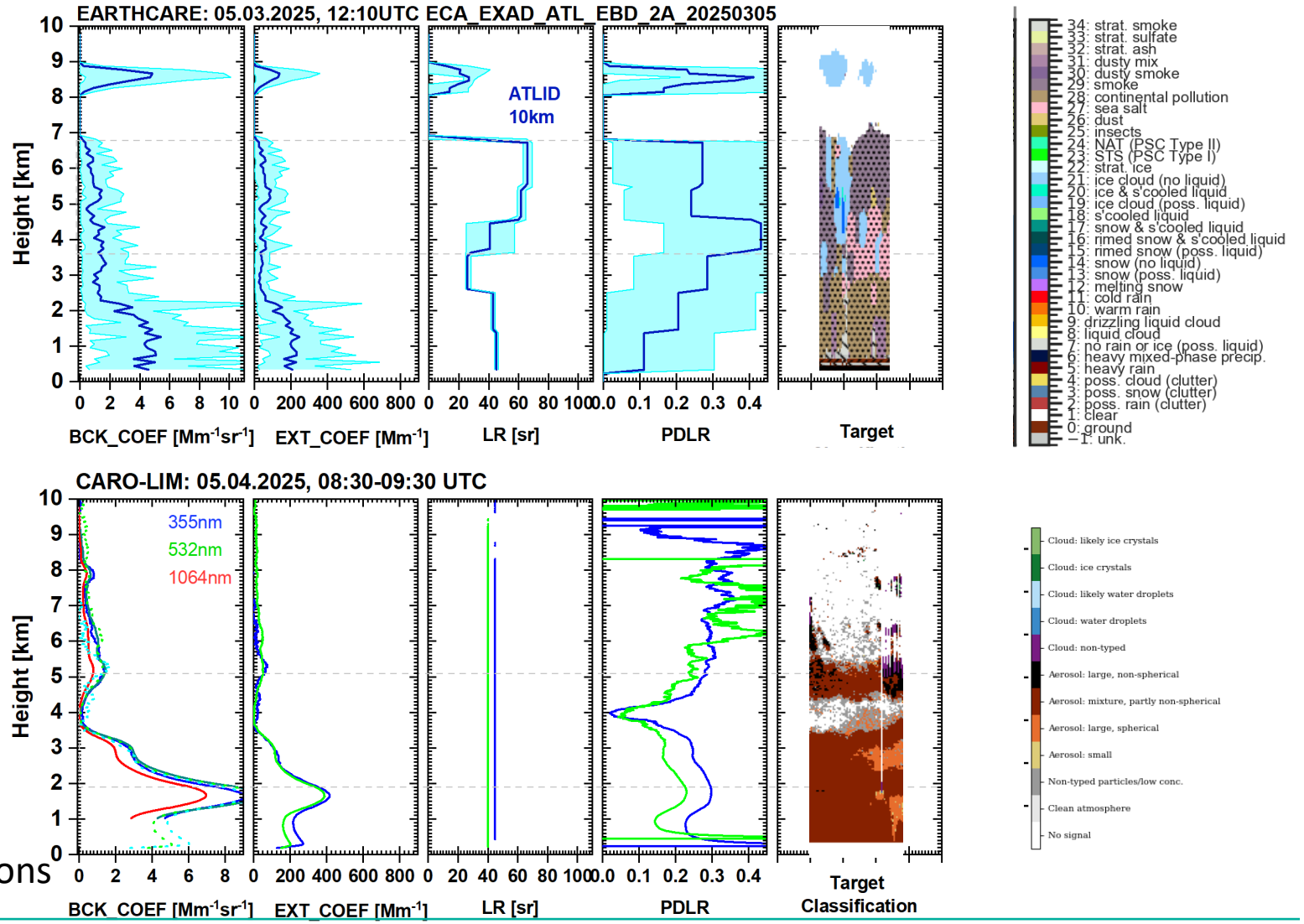


FRAME: 04357B | 4.03.42025 | 23:30 UTC | 106km



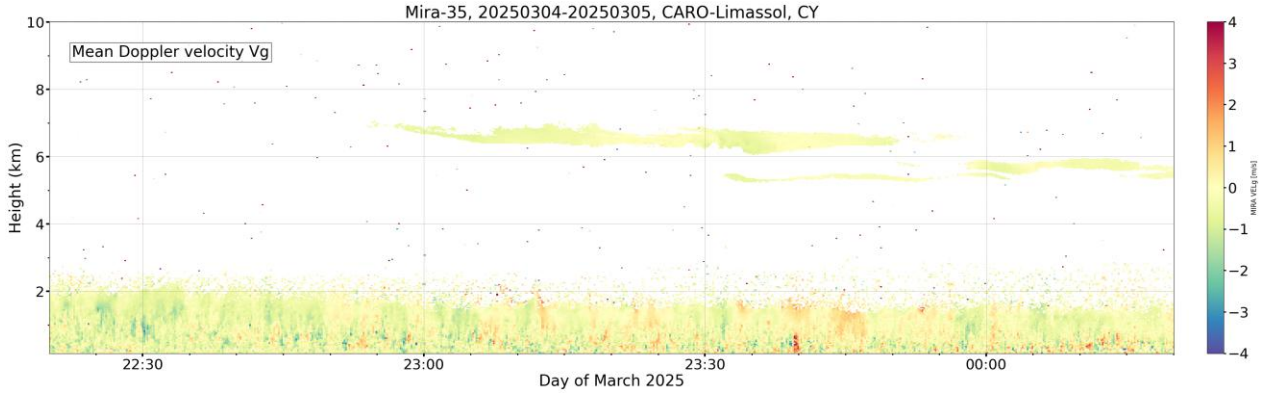
FRAME: 04365D | 05.03.2025 | 12:10 UTC | 108km

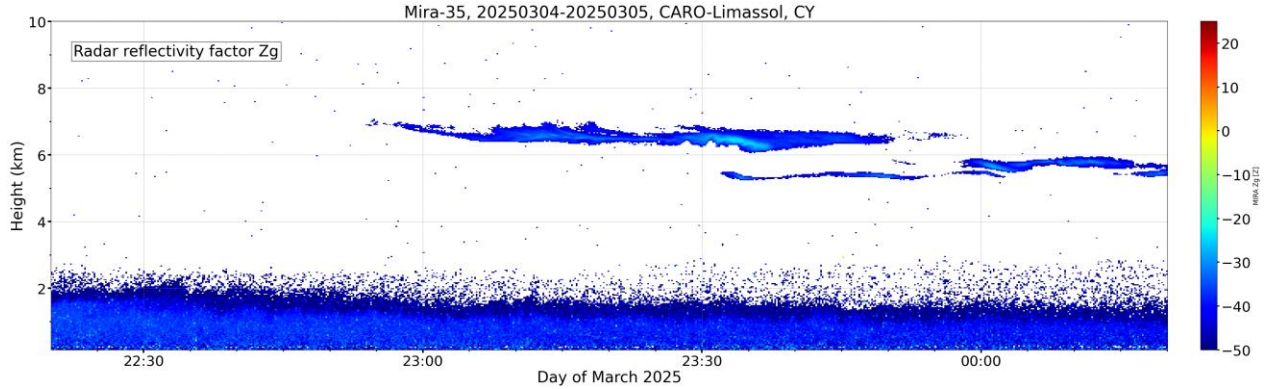


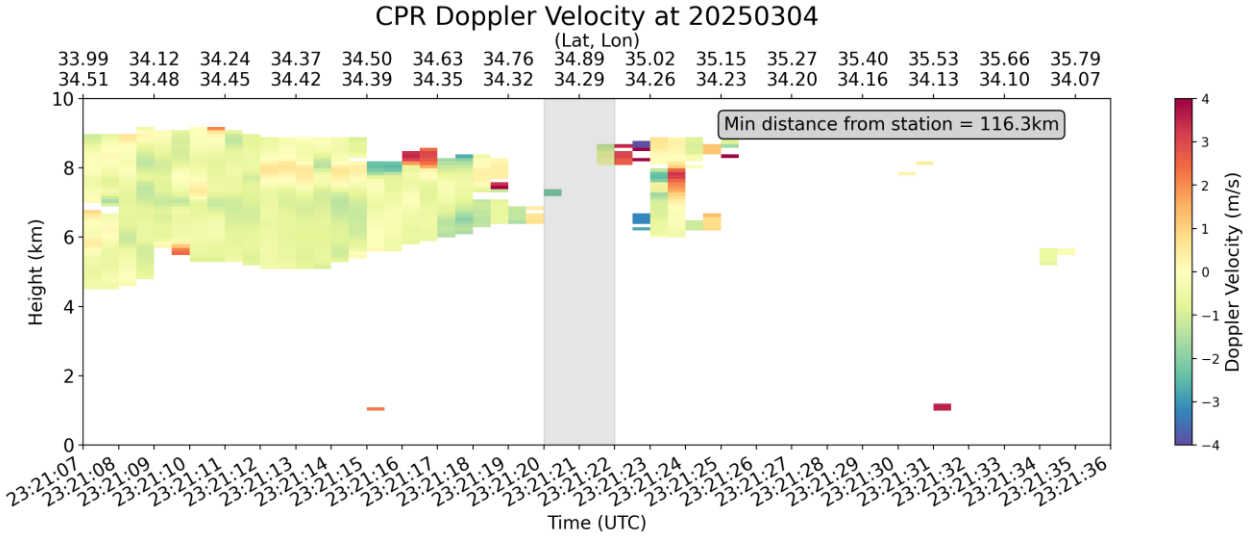


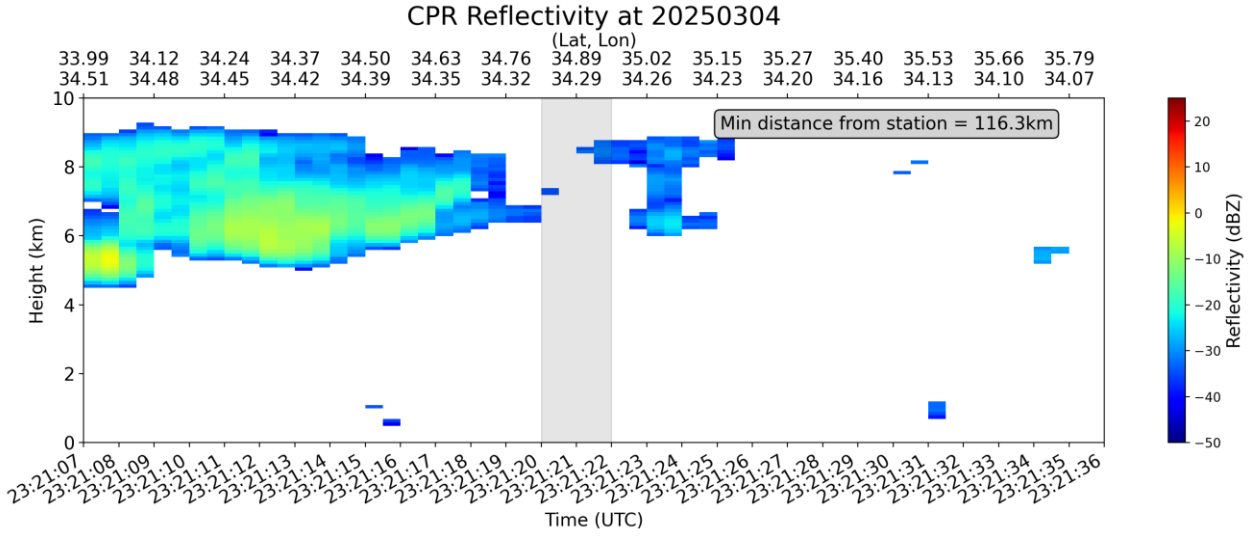
PollyXT_CYP, Limassol, Cyprus,
5 March 2025, 08:30-09:30UTC
+ EarthCARE ATLID A-EBD (AC)
Descending overpass
Min distance= 108Km
Wind speed= 34-40km/hour
Wind dir = East
2-3 hours before overpass time GB observations

Future steps: CPR products









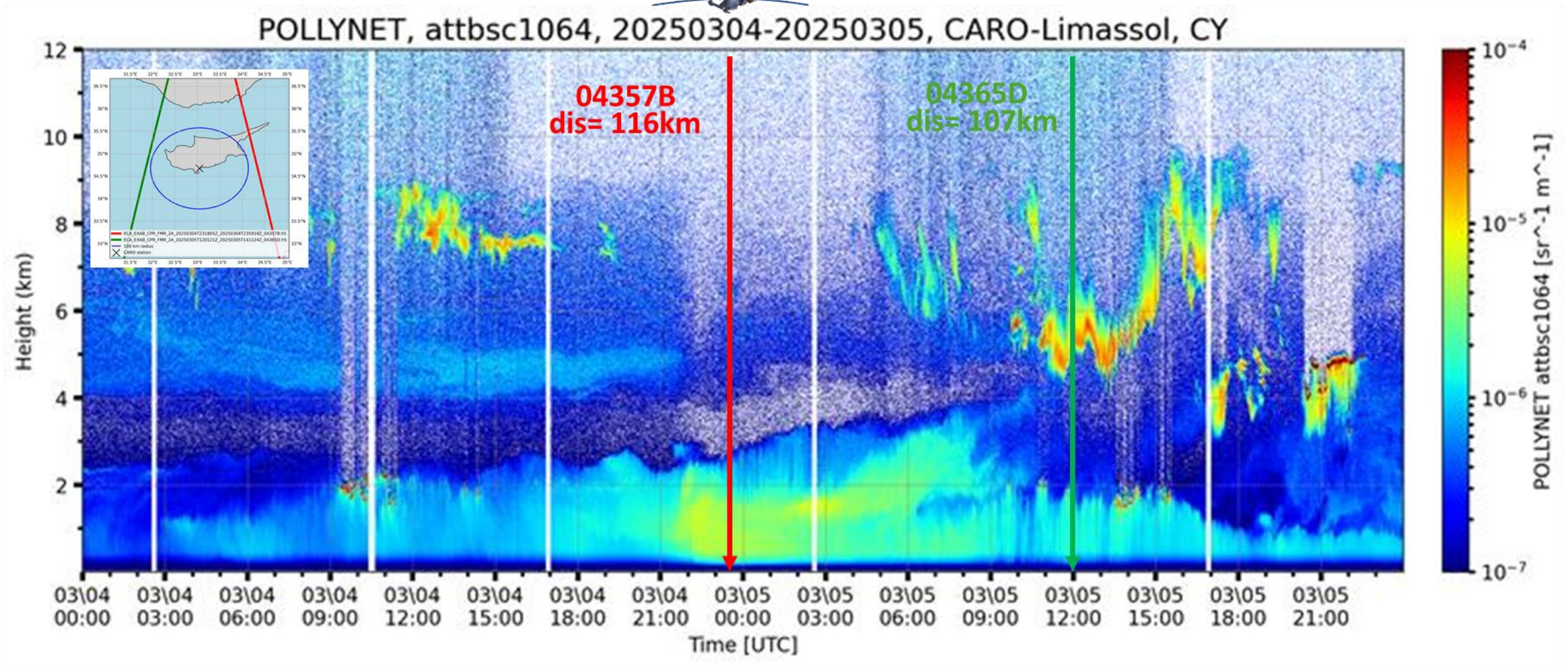
Conclusions and next steps

- **Continuous suborbital measurements with CARO-Limassol Lidar and Radar**

- *L1 A-NOM AC intercomparison:*
- ATLID depolarization ratio significantly improved at ZZ baseline for high depolarizing aerosols
- (Dust and cirrus cases) but still underestimated

- *L2 AC intercomparison with 4 overpasses (3 nighttime & 1 daytime):*
- Accurate classification of ice clouds and dusty cases
- A-EBD: most features bp, ap, LR, dp were within the errors
- **Good to perfect agreement for the case of intense dust plume from Middle East!**

- Future work:
- Continue measurements & quantification of L2 product differences
- Participation to the activities of the RACE and ACROSS community intense operations including
- radiation/cloud/in-situ measurements
- Use of CLOUDNET observations for CPR validation


POLLYNET, attbsc1064, 20250304-20250305, CARO-Limassol, CY
04357B
dis= 116km
04365D
dis= 107km
Height (km)
Time [UTC]
POLLYNET attbsc1064 [sr^-1 m^-1]
12
10
8
6
4
2
10^{-4}
10^{-5}
10^{-6}
10^{-7}
03\04 00:00
03\04 03:00
03\04 06:00
03\04 09:00
03\04 12:00
03\04 15:00
03\04 18:00
03\04 21:00
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