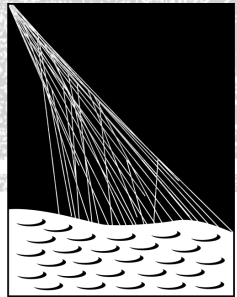


AUGER Raman Lidar



PIERRE
AUGER
OBSERVATORY

Vincenzo Rizi

vincenzo.rizi@univaq.it

Università degli Studi dell'Aquila DSFC & INFN LNGS



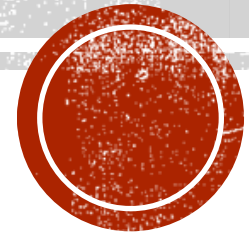
UNIVERSITÀ
DEGLI STUDI
DELL'AQUILA



DSFC
Dipartimento
di Scienze Fisiche
e Chimiche



Istituto Nazionale
di Fisica Nucleare

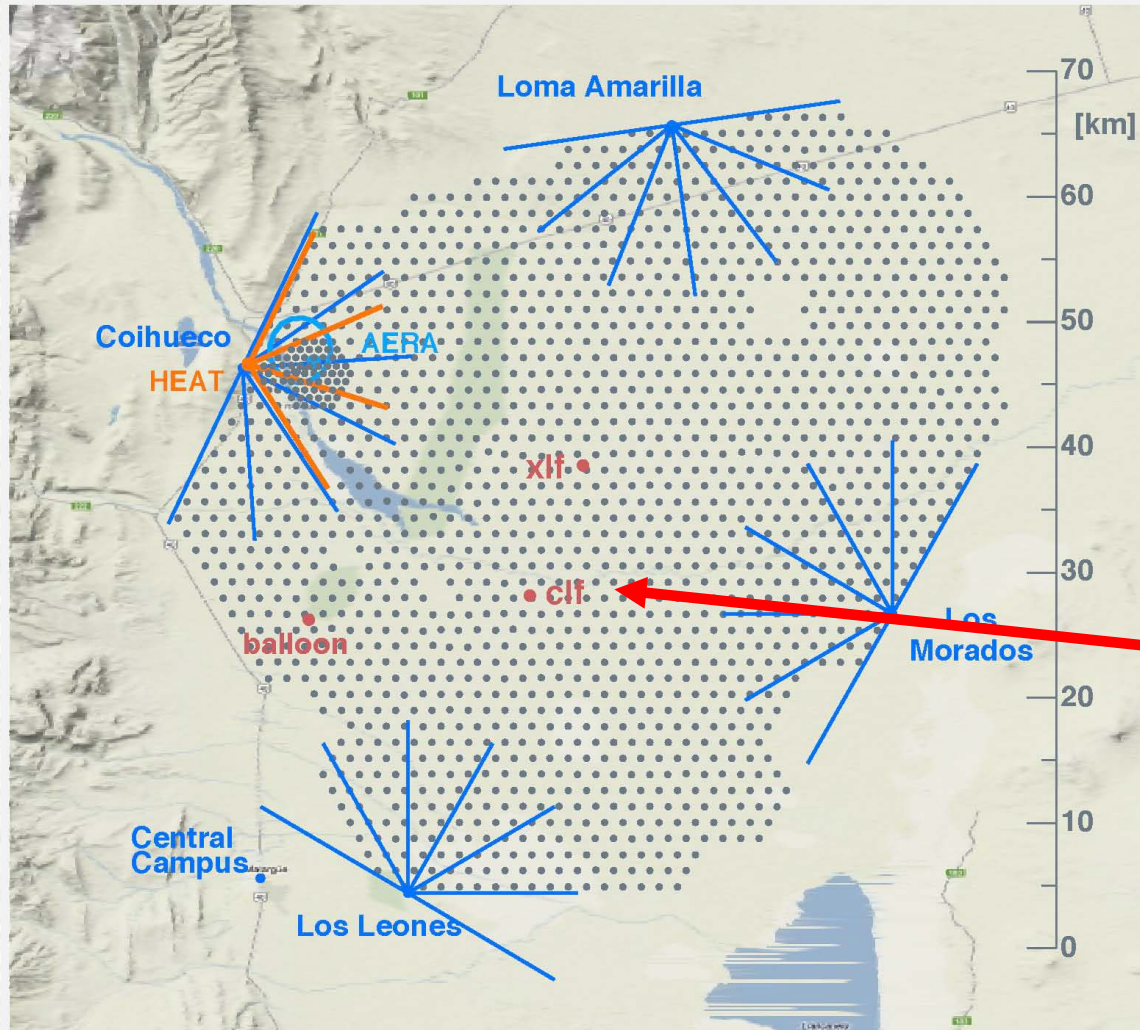


Outline

1. **STATUS** of Auger Raman lidar
2. **Measurements**
3. What's **next**?

STATUS OF AUGER RAMAN LIDAR

The Observatory



C(R)LF



19 November 2024



The Auger Raman lidar (technicalia)

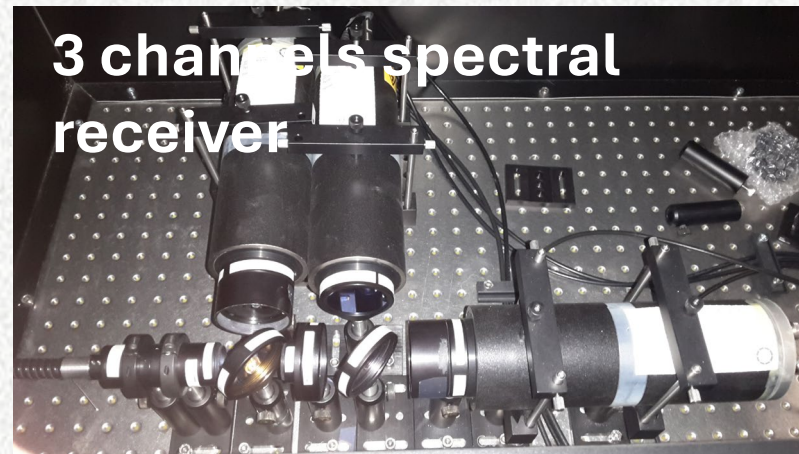
Three channels: 354.7 nm (elastic)
386.7 nm (nitrogen)
407.5 nm (water vapor)

Laser beam: 7 ns width
6 mJ 4.5 mJ/pulse
0.3 mrad divergence
100 Hz

Telescope: parabolic mirror
50 cm, f/3

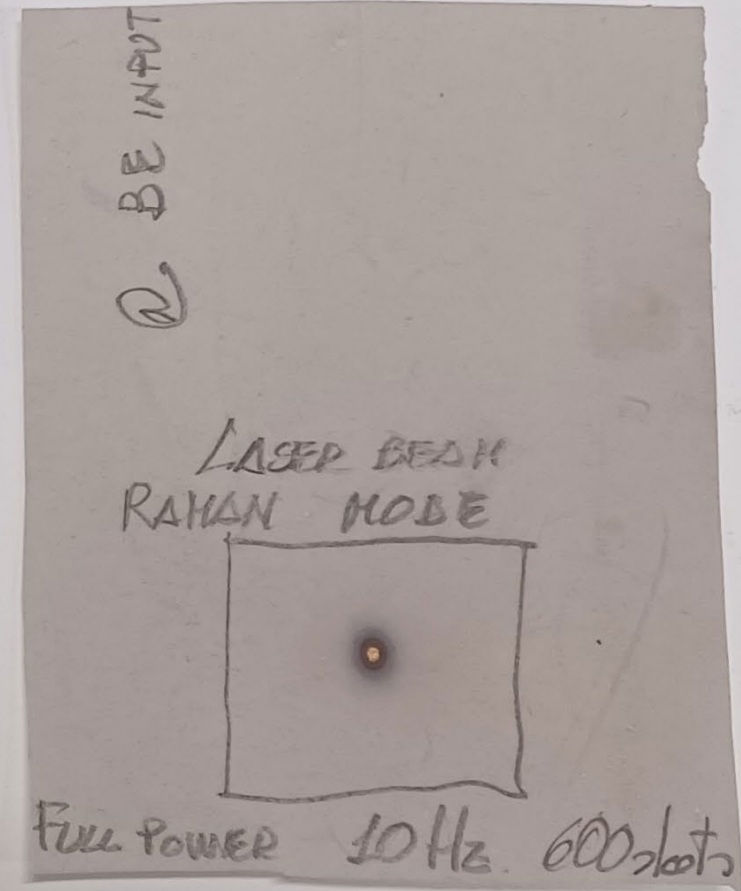
PMT: Electron Tubes 9829QB

DAQ: PC and AD

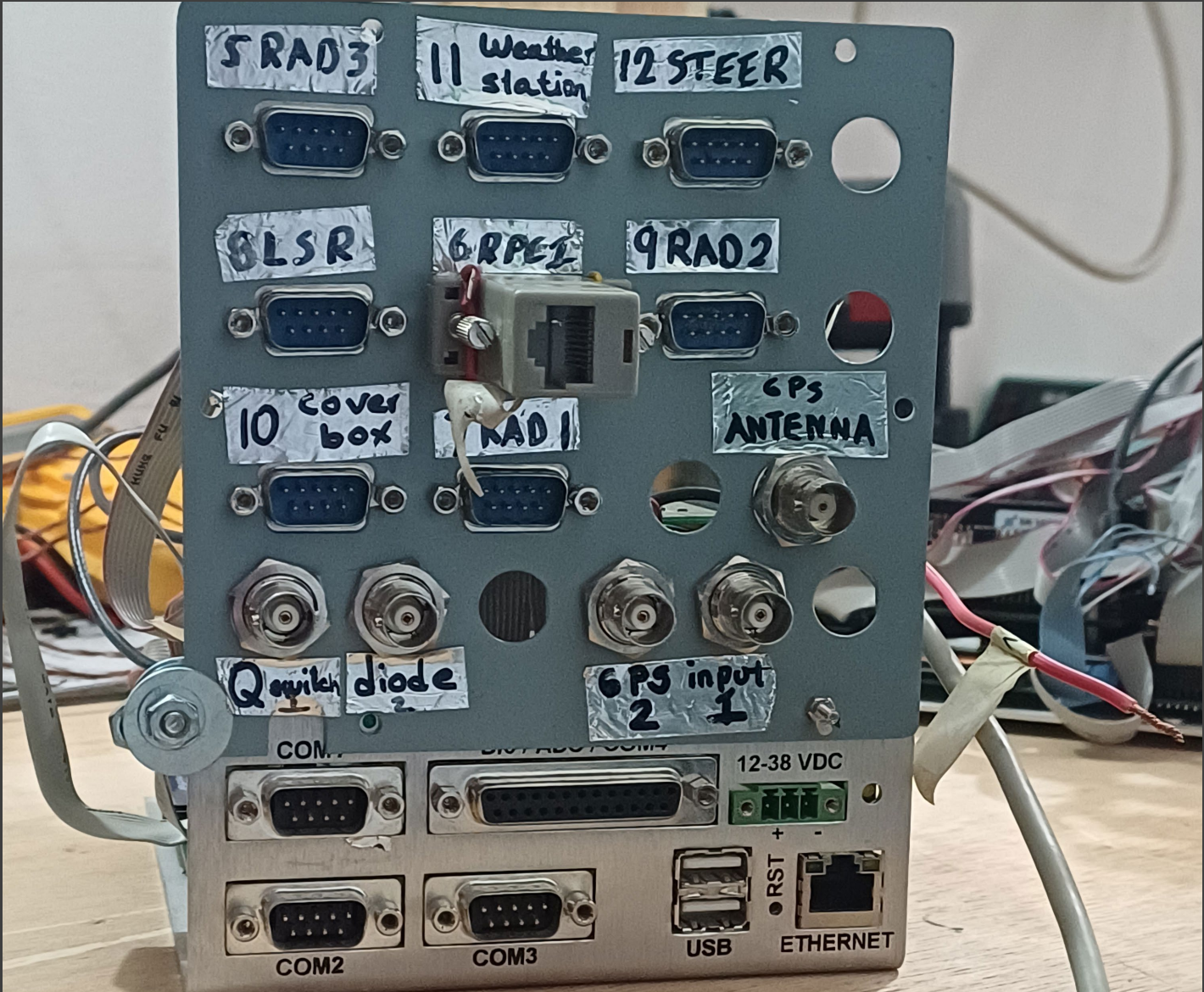
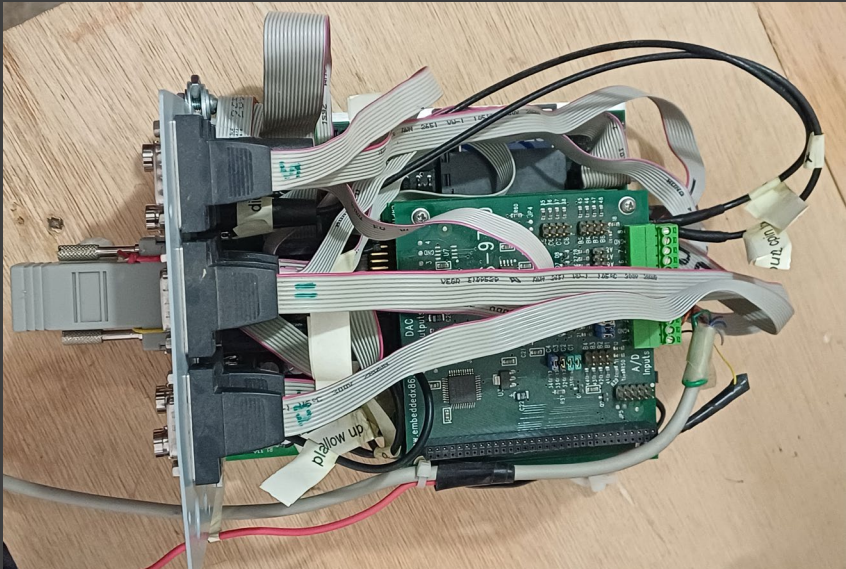


C(R)LF LASER BEAM

4.5 mJ/pulse

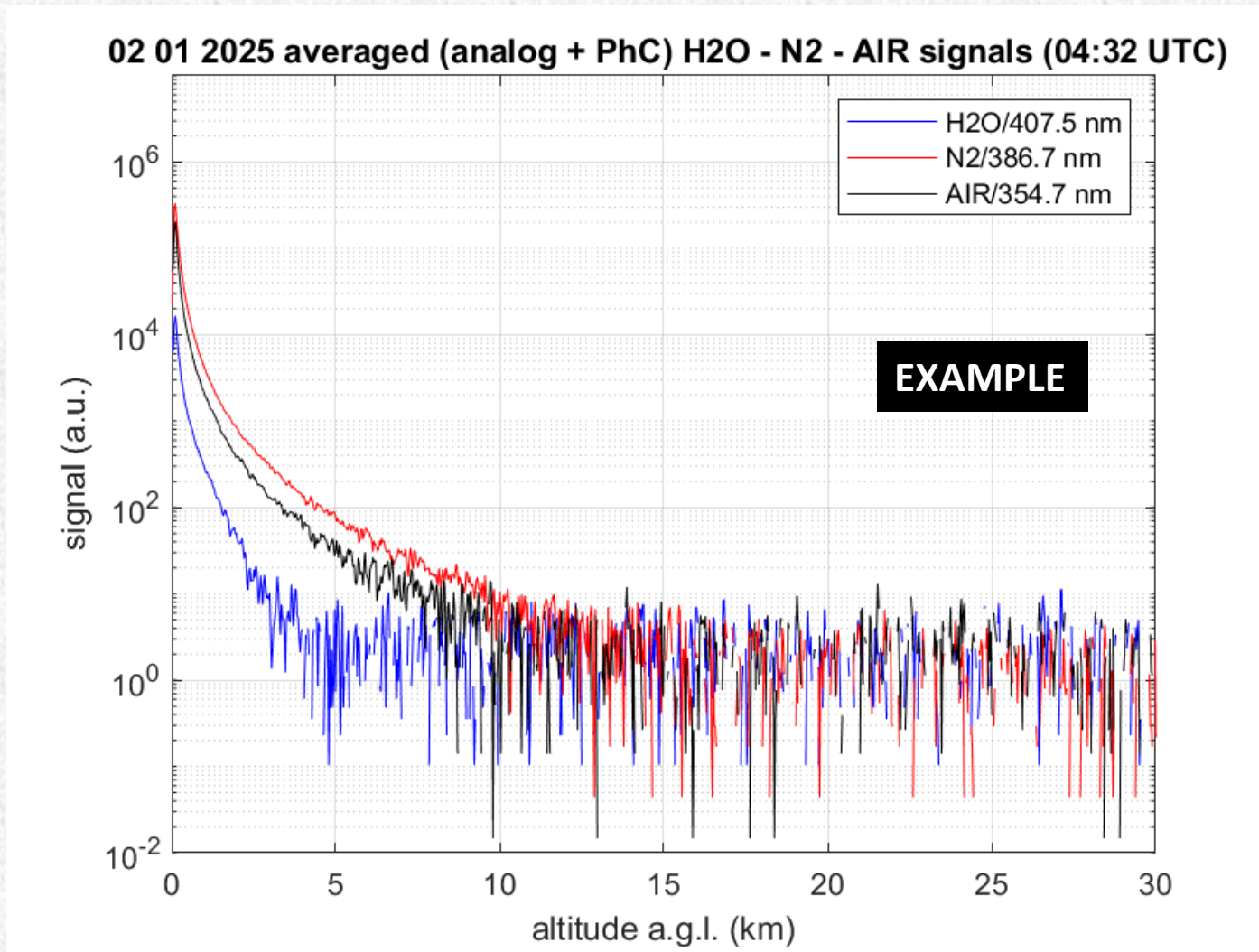


19 November 2024



MEASUREMENTS

Since FD shift 11/2024 back to 'normal operations'



Note that the Raman Lidar samples vertically the part of the atmosphere above the CLF site, and the retrieved VAOD profiles have a representativeness of the aerosol optical transmission in the atmosphere over the Observatory (!).

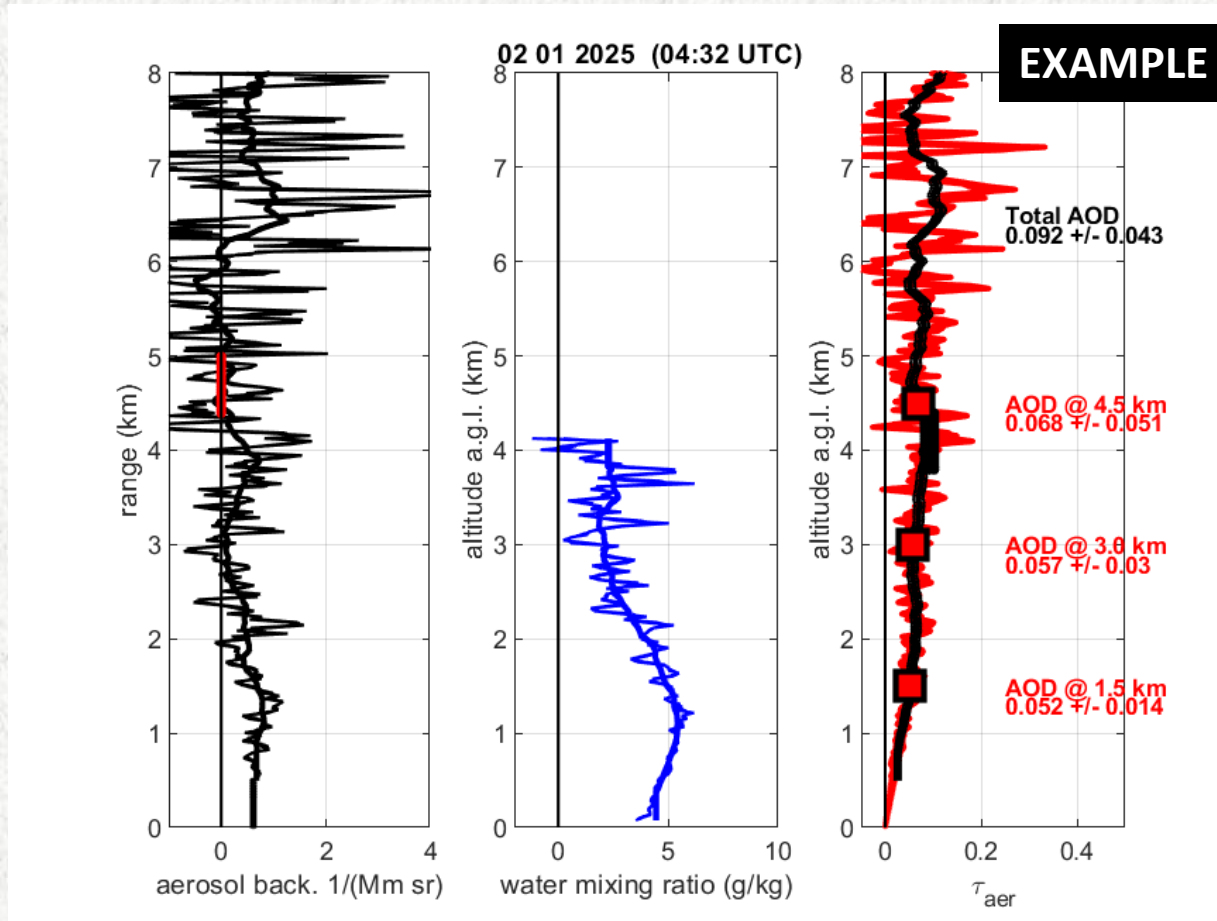
Aerosol optical properties and water vapour vertical profiles

The main products of the Auger Raman lidar are the Vertical Aerosol Optical Depth (or its derivative), the aerosol backscatter coefficient, and the water vapor mixing ratio.

aerosol
backscatter

[H₂O]

VAOD



[V. Rizi - AUGER Raman lidar - Torino 04/02/2025]

Aerosol optical properties

VAOD

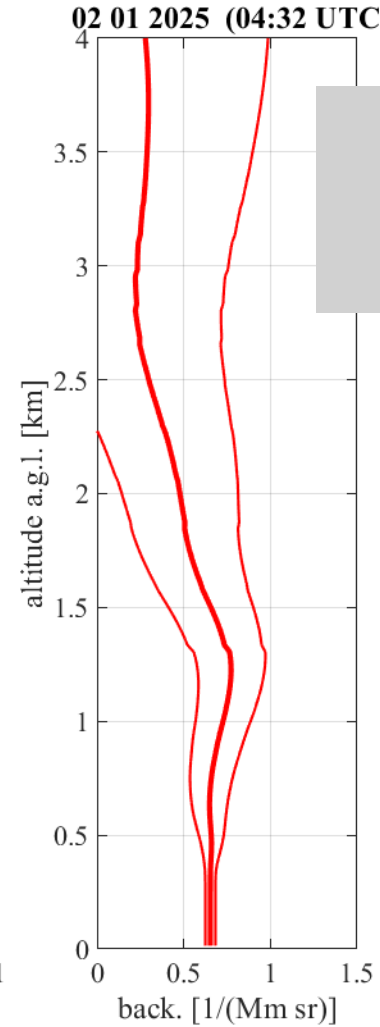
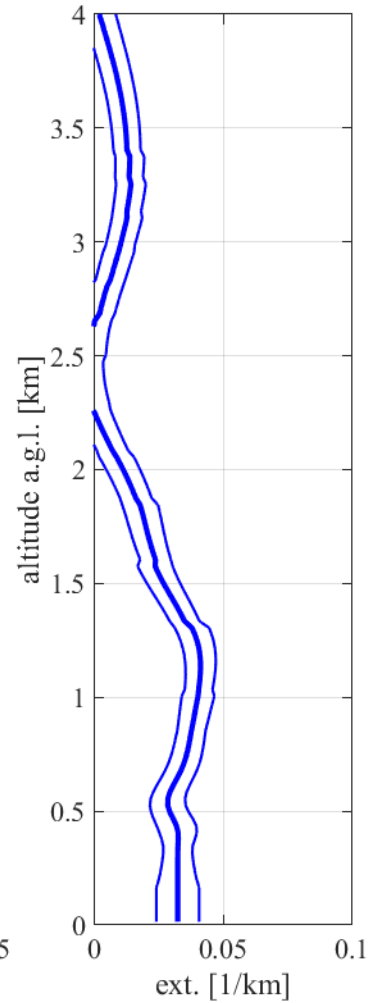
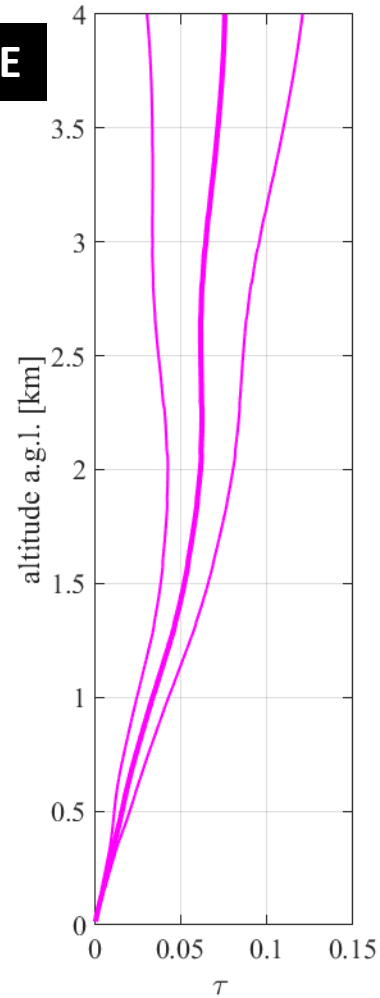
aerosol
extinction

aerosol
backscatter

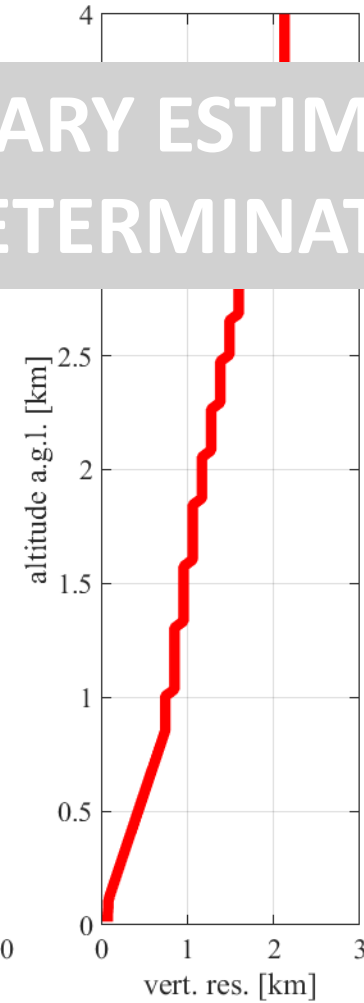
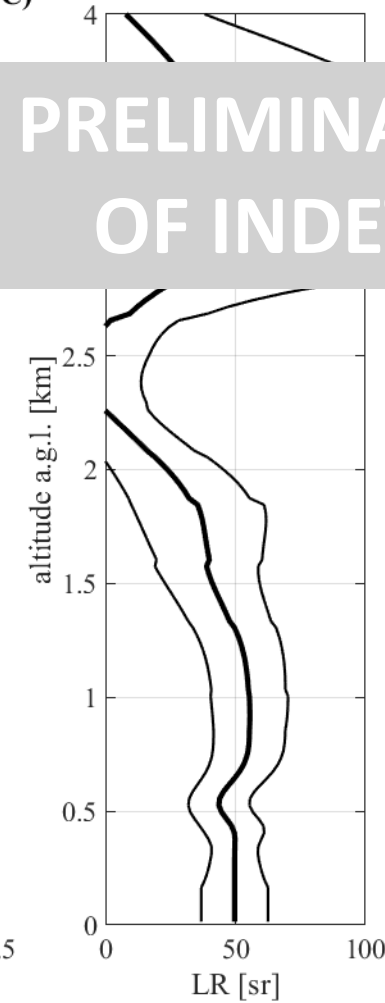
Lidar ratio

Vertical
resolution

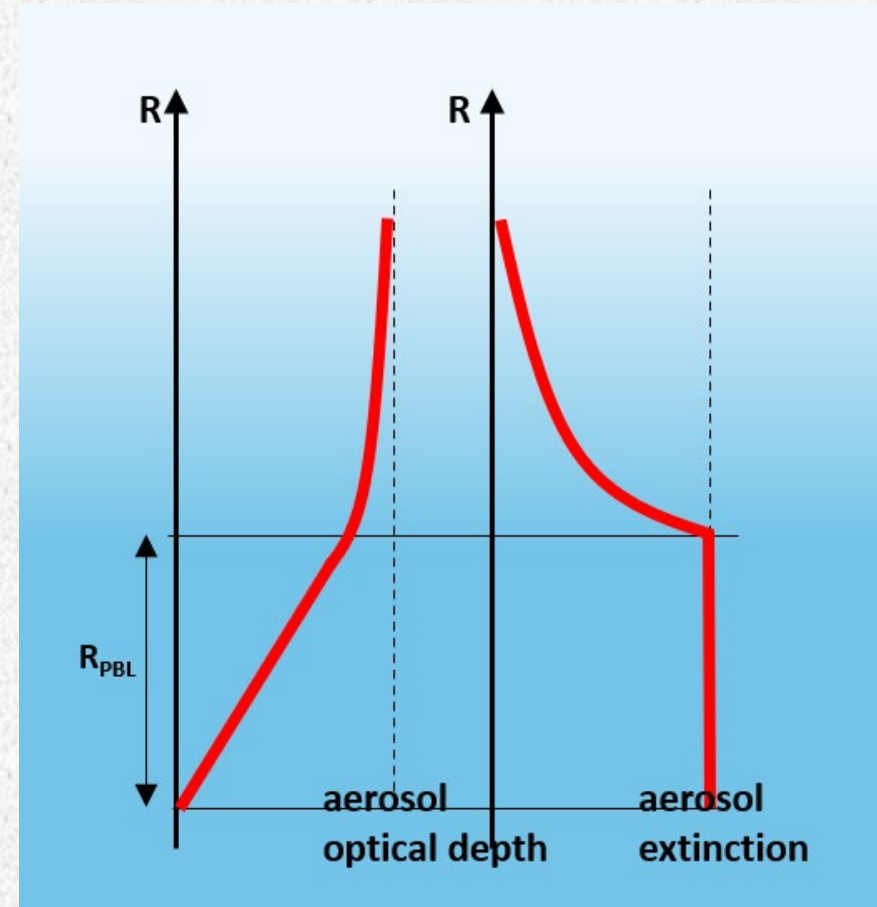
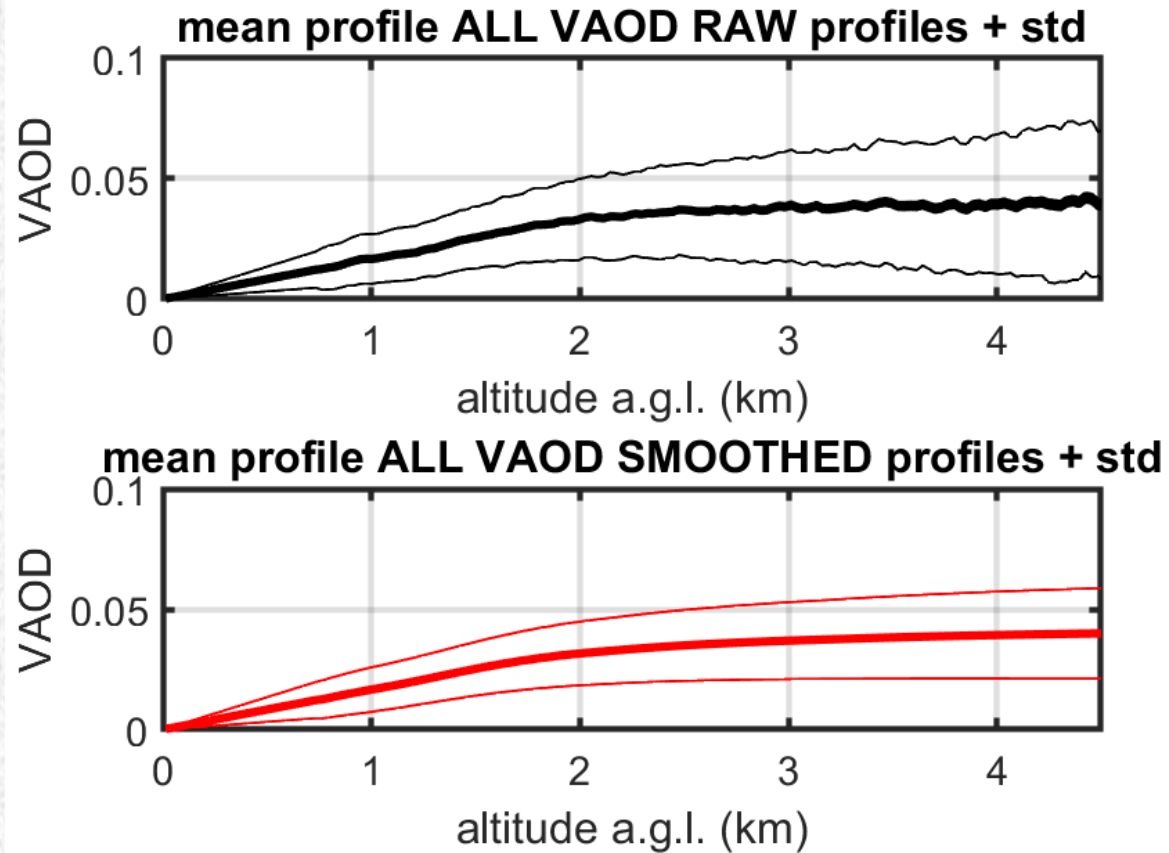
EXAMPLE



PRELIMINARY ESTIMATION
OF INDETERMINATION



Vertical Aerosol Optical Depth – A MODEL



FD shift REPORT

EXAMPLE: FD shift 12 of 2024

1/4

Raman LIDAR at CRLF

Summary report for the period (FD shift 12 of 2024): START 23/12/2024 END 09/01/2025

BEFORE, DURING and AFTER FD shift 12 min - period acquisition Raman runs

Raman LIDAR active channels: Elastic, N2 Raman and H2O Raman backscatterings (50 performed runs of 54 scheduled 93%).

Missing measurements:

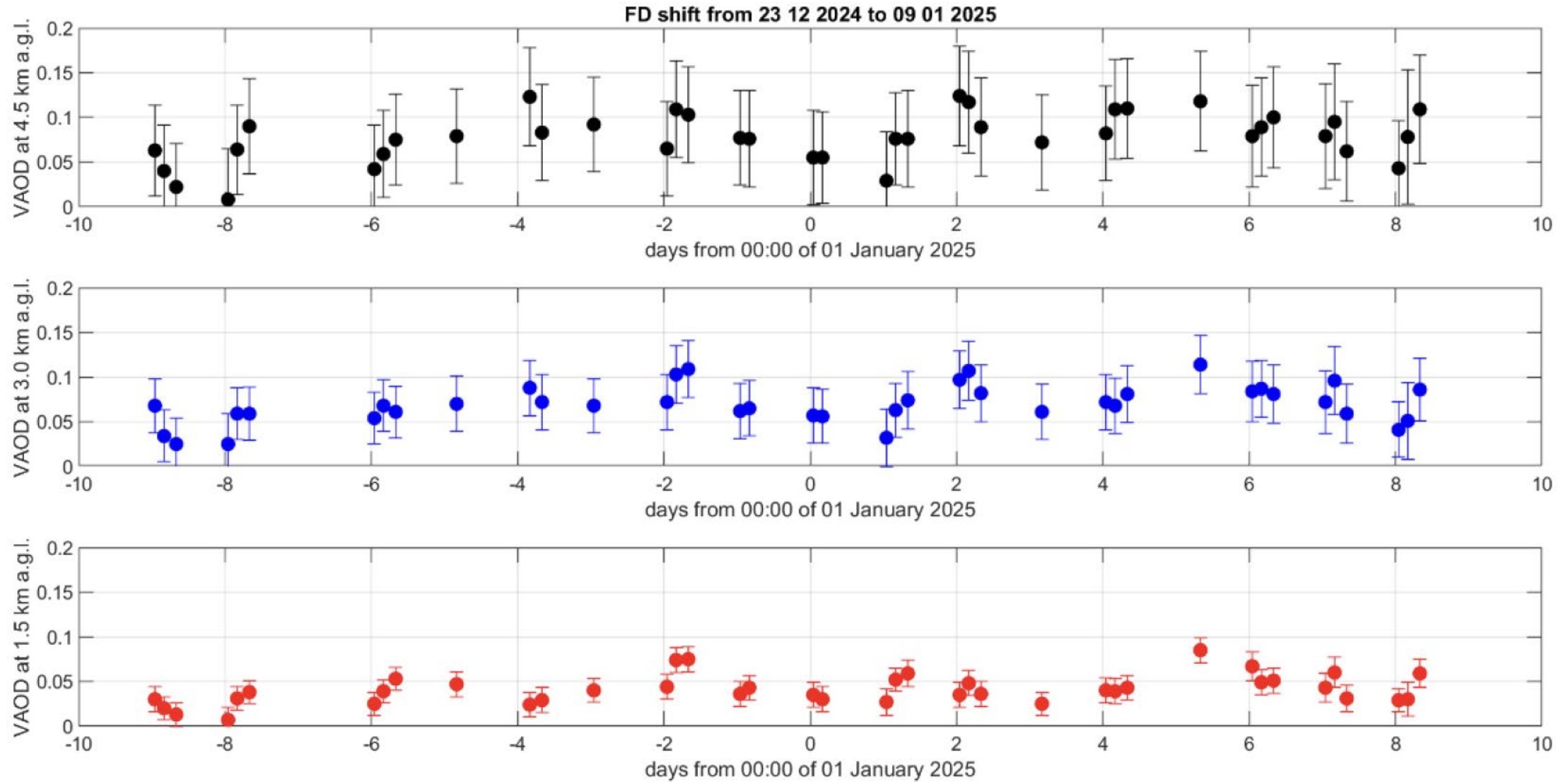
- 4 with software or hardware problems (no laser shots in all cases)

VAOD, H2O mixing ratio and backscatter coefficient profiles: after screening for clouds or high value of VAOD (> 0.15 at 3 km a.g.l.) 40 of 54 scheduled sessions about 67% of clear sky)

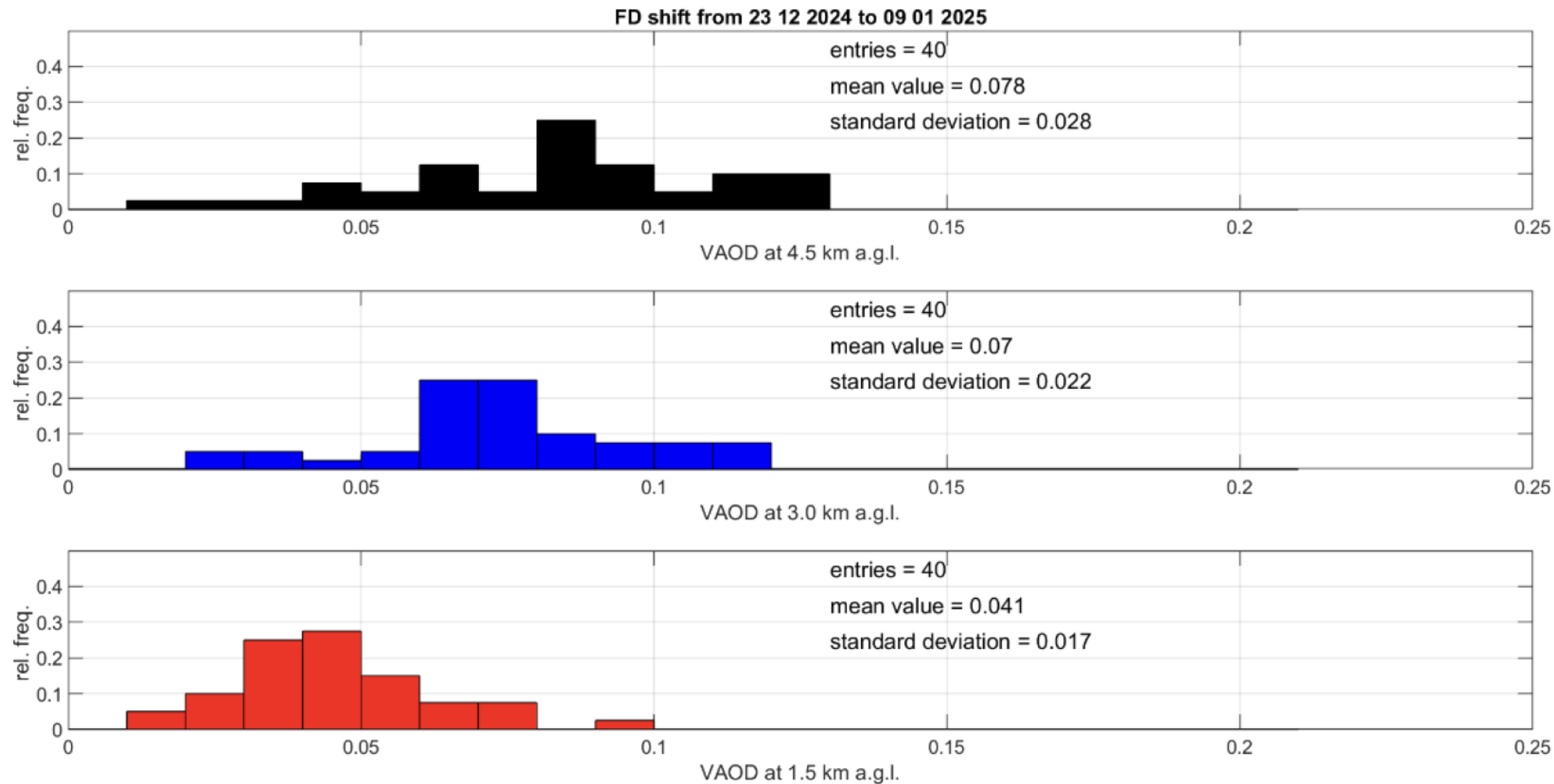
Missing vertical profiles:

- 10 measurements due to low clouds or high value of VAOD (> 0.15 at 3 km a.g.l.) conditions

Timeseries of VAOD values at 1.5, 3.0 and 4.5 km above ground level.



Histograms of VAOD values at 1.5, 3.0 and 4.5 km above ground level



CLEAR NIGHTS

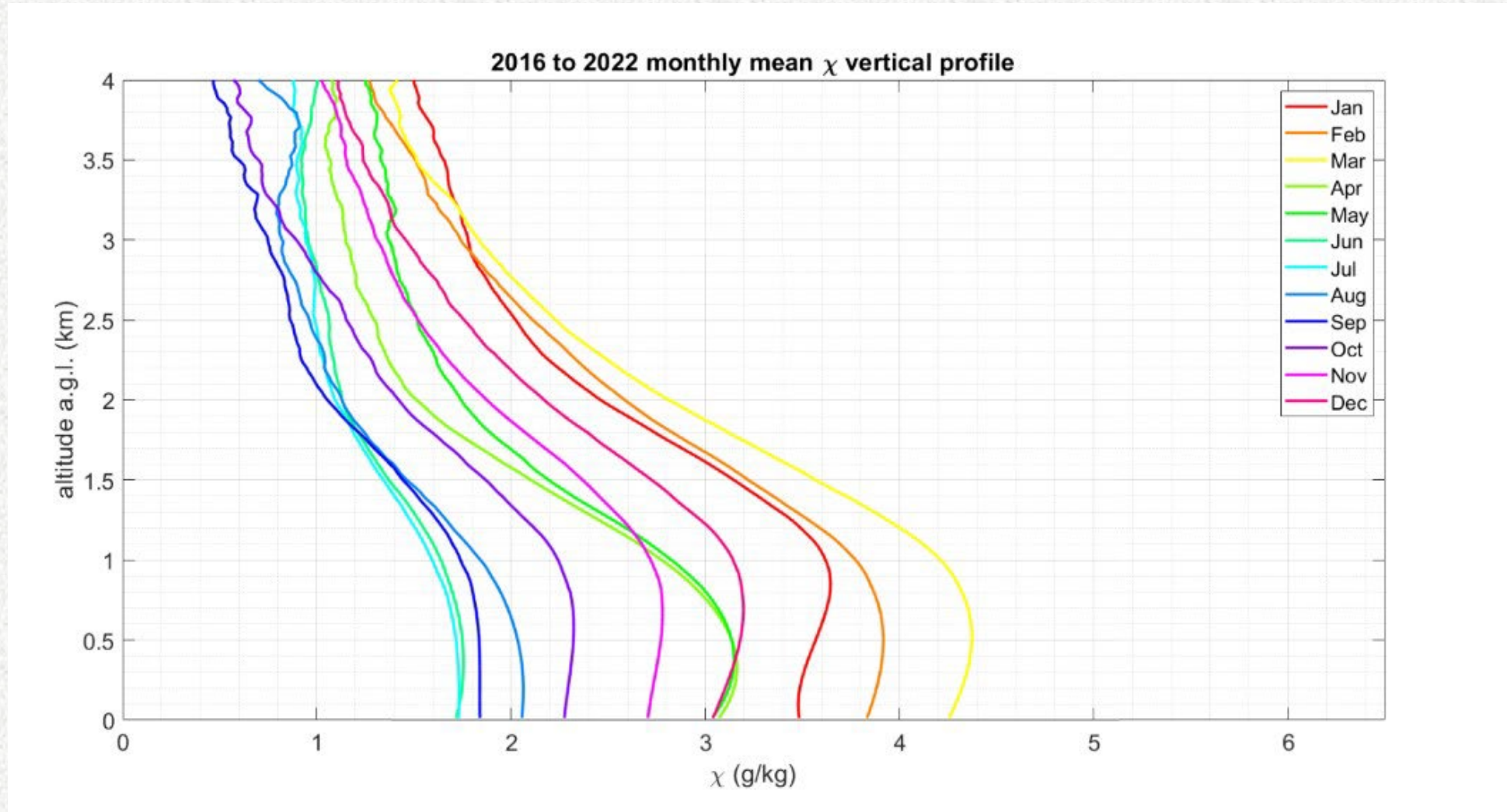
Candidates for clear nights (total VAOD < 0.04):

HH	DD	MM	YYYY	DOY	VAOD@1.5 km	errVAOD@1.5 km	VAOD@1.5 km	errVAOD@1.5 km	VAOD@1.5 km	errVAOD@1.5 km
4	23	12	2024	-8.833	0.020	0.013	0.034	0.029	0.040	0.051
8	23	12	2024	-8.667	0.013	0.013	0.025	0.029	0.022	0.049
1	24	12	2024	-7.958	0.007	0.014	0.025	0.034	0.008	0.057
1	2	1	2025	1.042	0.027	0.015	0.032	0.032	0.029	0.055
1	9	1	2025	8.042	0.029	0.013	0.041	0.031	0.043	0.053

WHAT'S NEXT?

Water vapor mixing ratio measurements on multiannual scale

Credits: L. V. Gomez – UNIVAQ/DSFC Master thesis (2023)



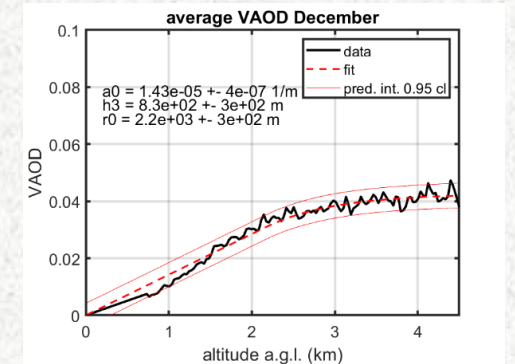
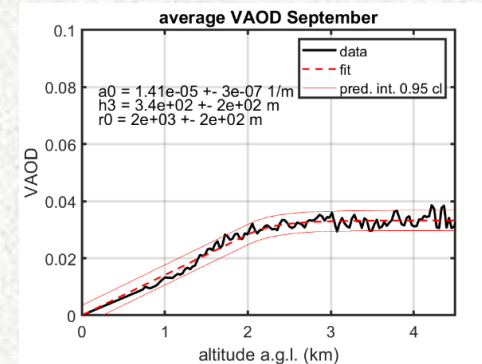
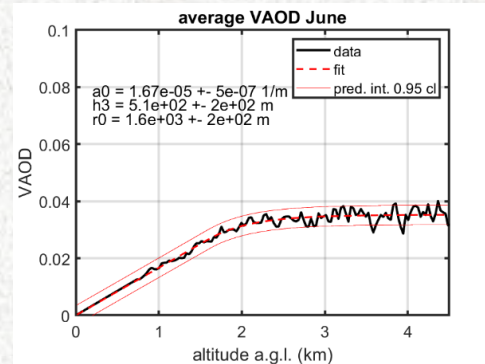
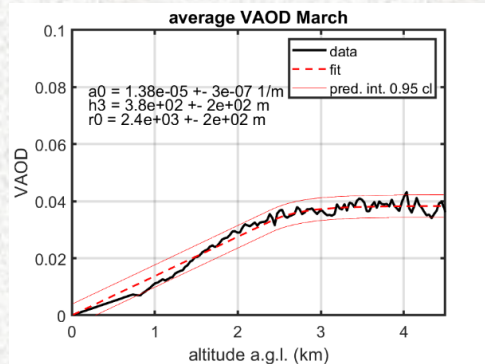
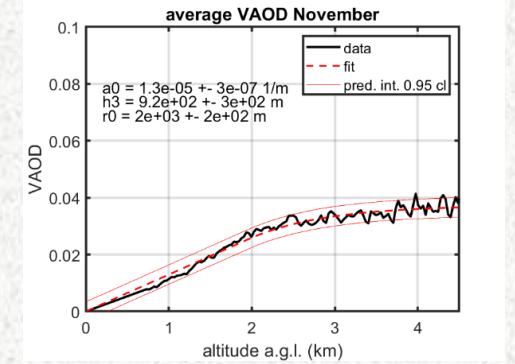
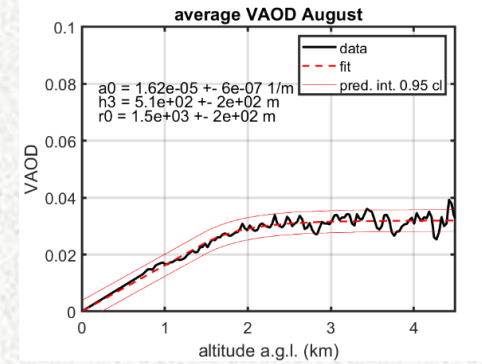
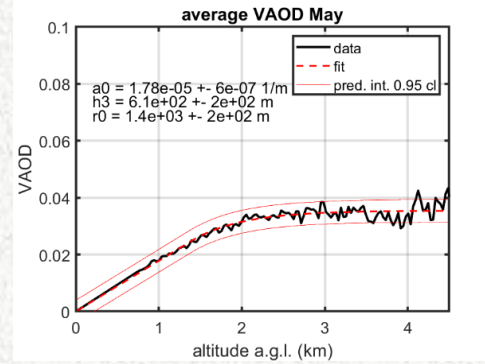
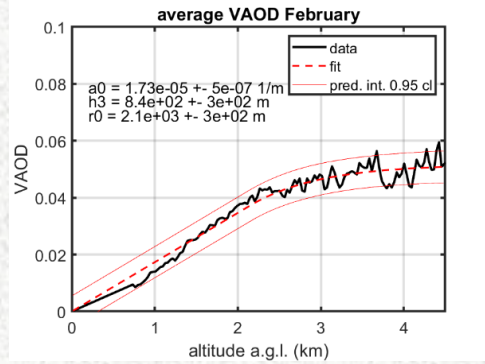
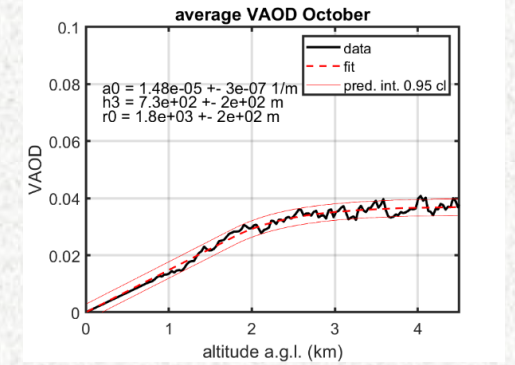
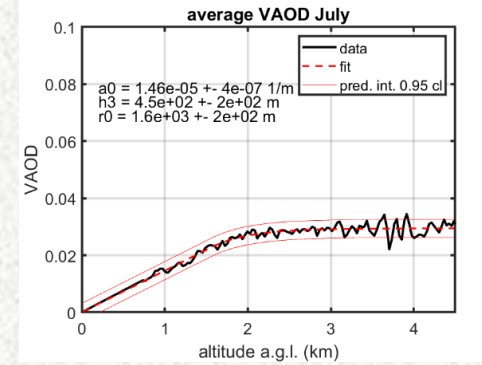
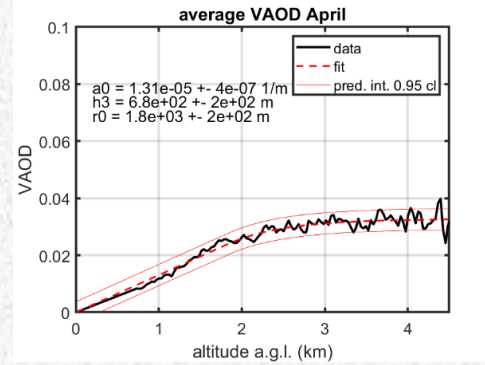
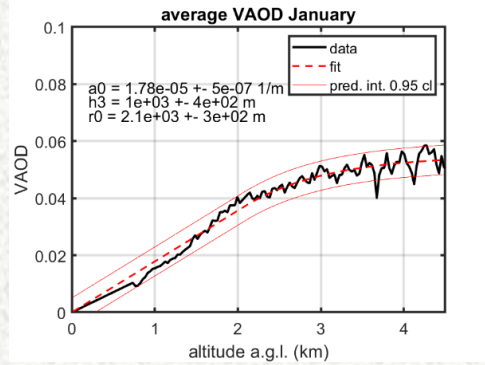
Some conclusions

- The Auger Raman Lidar is measuring the aerosol optical properties @355 nm since November 2013; after a long break January – October 2024 (laser not working), it restarted fully operative on 23 november 2024;
- The measured vertical profiles of the aerosol optical depth, backscatter, and water vapor mixing ratio show a seasonal dependence;
- The shape of the vertical aerosol optical depth can be represented with a 2-parameters model or a 3-parameters model;
- The overall mean/std VAOD at 4.5 km a.g.l. is 0.040 ± 0.019 .

THANK YOU

ADDITIONAL SLIDES

Monthly VAOD



Raman lidar performance

Measurement sensitivity of VAOD at 355 nm ~ 0.005

Sources of Errors: **Random/Statistical**
Systematic

$$VAOD = -\frac{1}{1 + \left(\frac{\lambda_0}{\lambda_{N2}}\right)^k} \log \frac{L_{N2} R^2}{T_{mol}^{\lambda_0} T_{mol}^{\lambda_{N2}} n_{mol}}$$