Aerosol Characterization Through Combined Depolarization and Fluorescence Lidar Observations at CIAO

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Fluorescence measurements at CIAO observatory

ITINERIS TNA Project – “Aerosol Fluorescence Characterization at CIAO Observatory” by Jens Reichard DWD:

Fluorescence Lidar measurements adding a new dimension in aerosol characterization

Offers unique advantages in detecting and analyzing aerosols beyond the capability of conventional lidar methods.

CIAO Observatory:

long-standing expertise in aerosol characterization with advanced Raman lidar operational since 2023, Now POLPO is one of reference systems in ACTRIS (depolarization at 355–532–1064 nm), Now uniquely combining calibrated spectrometric fluorescence with multi-wavelength Raman lidar

Lidar laboratory at CIAO:

enabled system tuning and scientific application

allows for the implementation of various experimental lidar configurations.

Three different gratings are currently available:

(1) 300 gr/mm: this grating provides a bandpass of about 130 nm, e.g., 380 – 510 nm. It is the best choice for fluorescence measurements because it covers a fairly large range of the fluorescence spectrum of atmospheric aerosols.

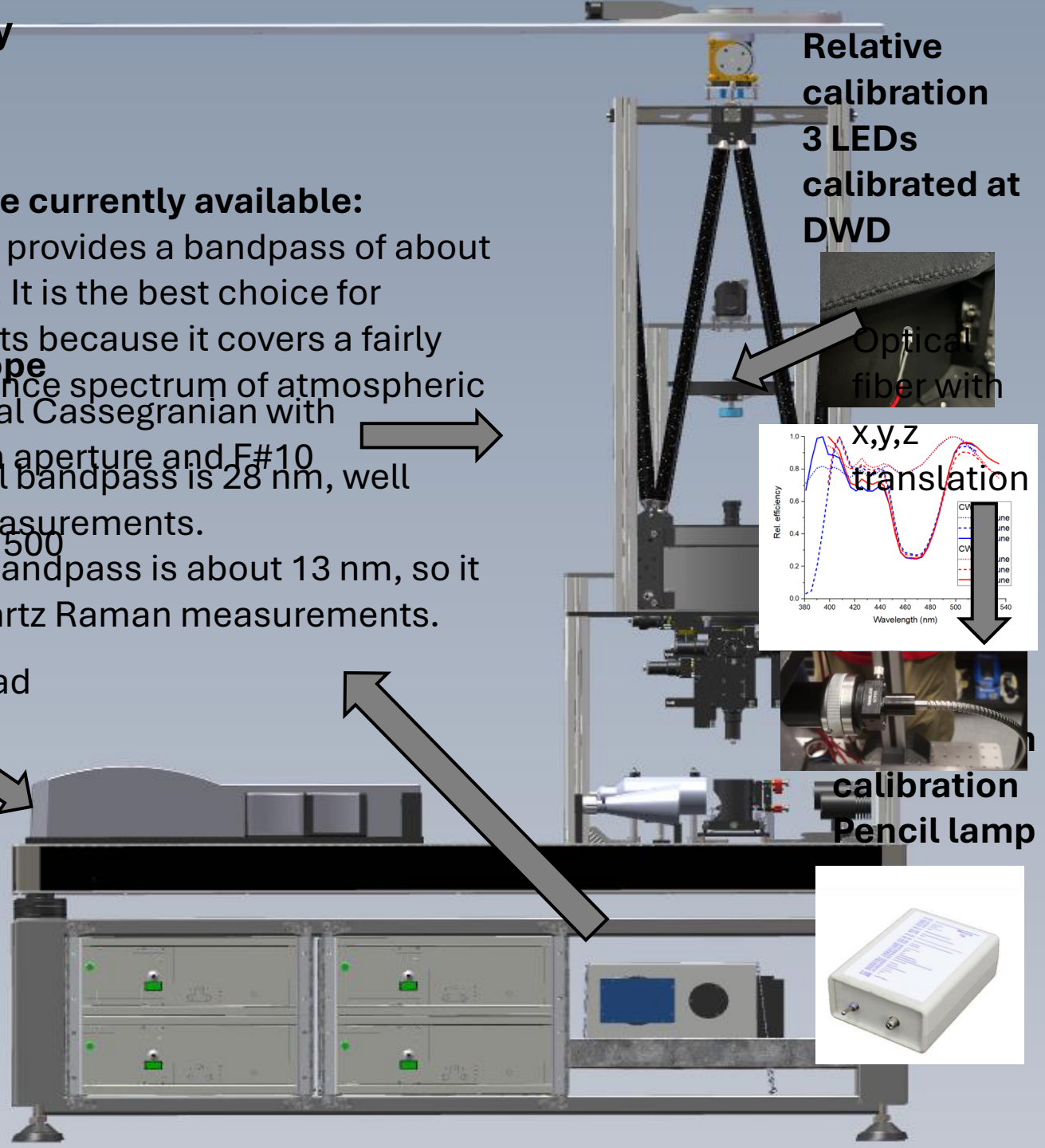
(2) 1200 gr/mm. The overall bandpass is 28 nm, well suited for water Raman measurements.

(3) 2400 gr/mm. Here the bandpass is about 13 nm, so it could be used for, e. g., quartz Raman measurements.

Telescope
Classical Cassegranian with 400 mm aperture and F#10

Laser

Wavelength	Q-smart 1500 355 nm
Pulse energy	> 550 mJ
Beam divergence	< 0.25 mrad



Optical fiber with x,y,z translation

Relative calibration 3 LEDs calibrated at DWD

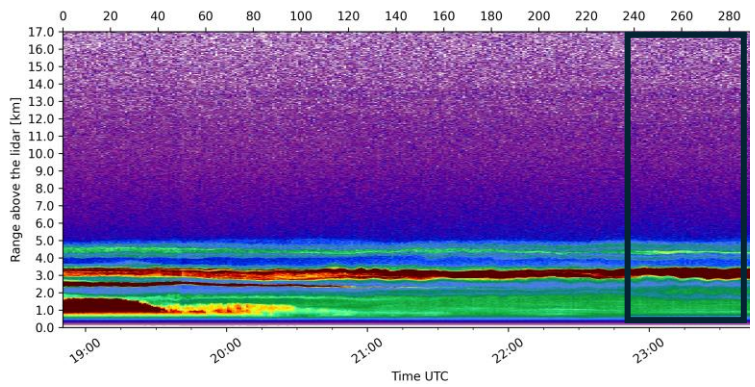
Pencil lamp

Case studies CANADIAN FIRE

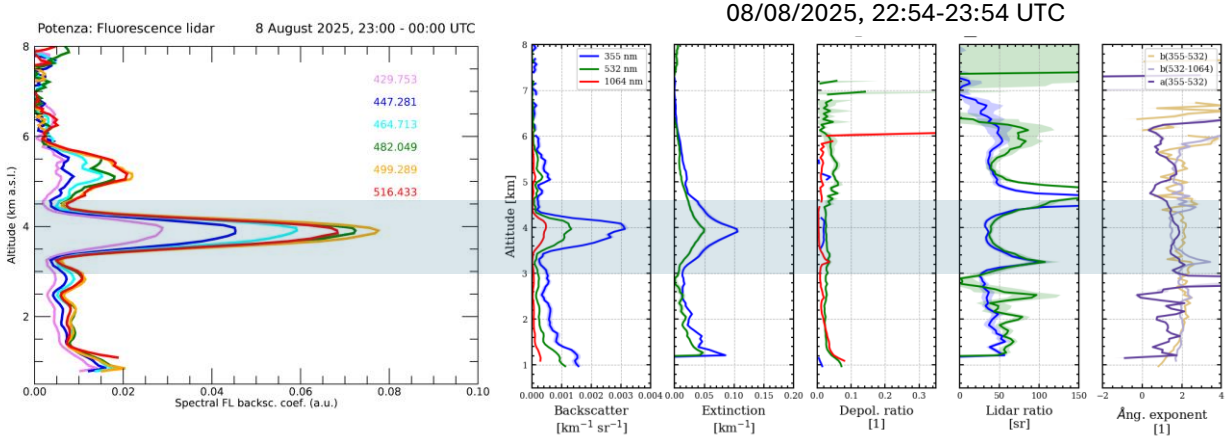
Fluorescence

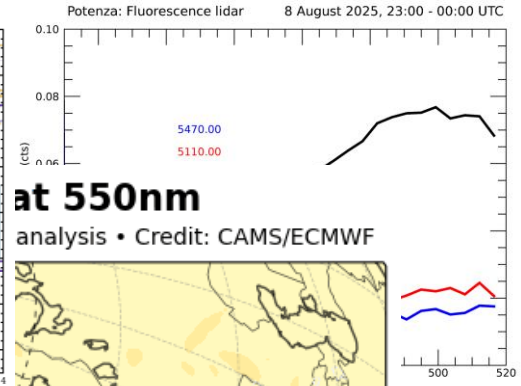
Fluorescence

POLPO 532 par-08/08/2025, 18:50-23:54 UTC

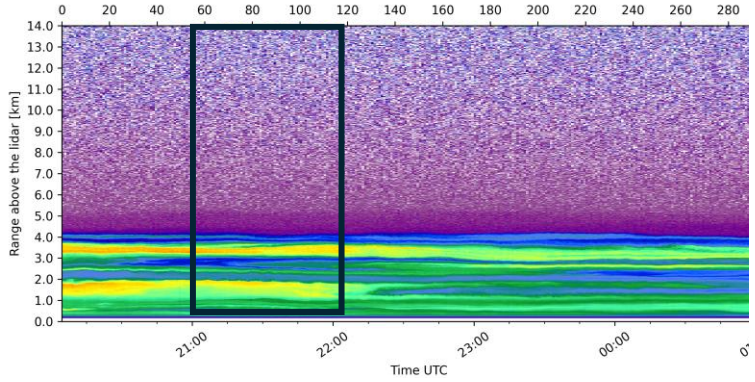


08/08/2025, 22:54-23:54 UTC

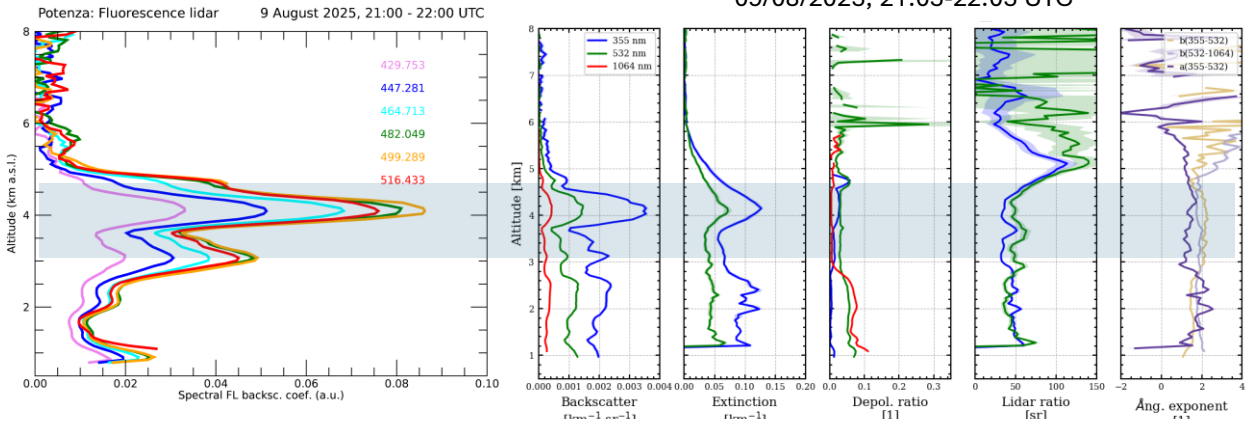




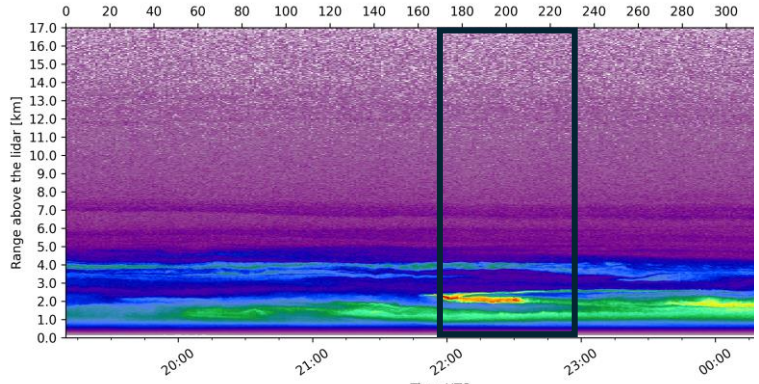
POLPO 1064 par-09/08/2025, 20:05-01:09 UTC



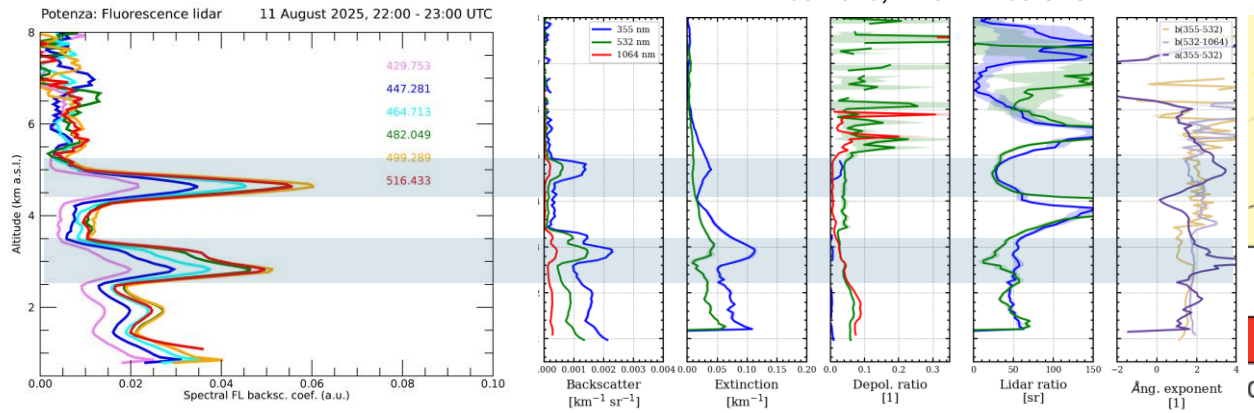
09/08/2025, 21:05-22:05 UTC

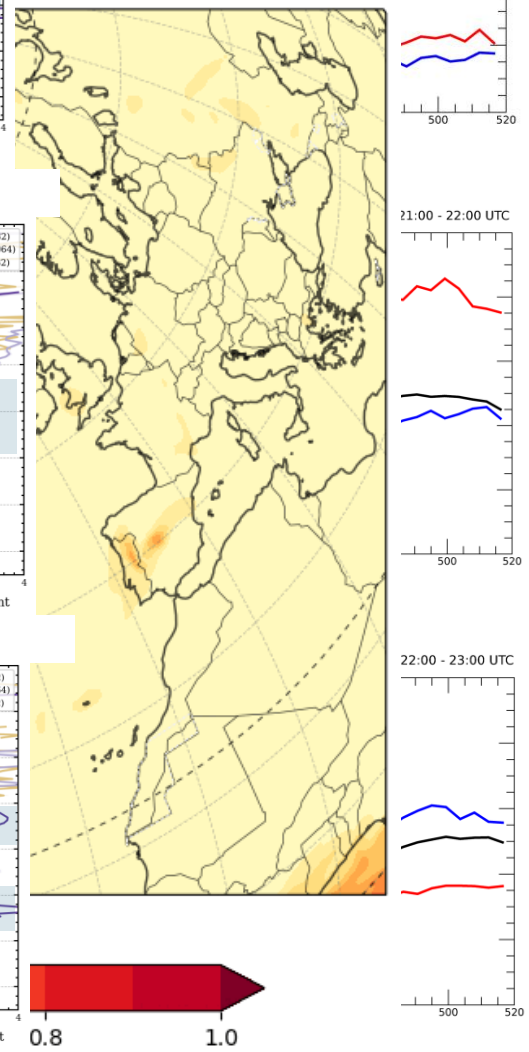


POLPO 1064 par-11/08/2025, 19:10-00:44 UTC



11/08/2025, 21:57-22:53 UTC

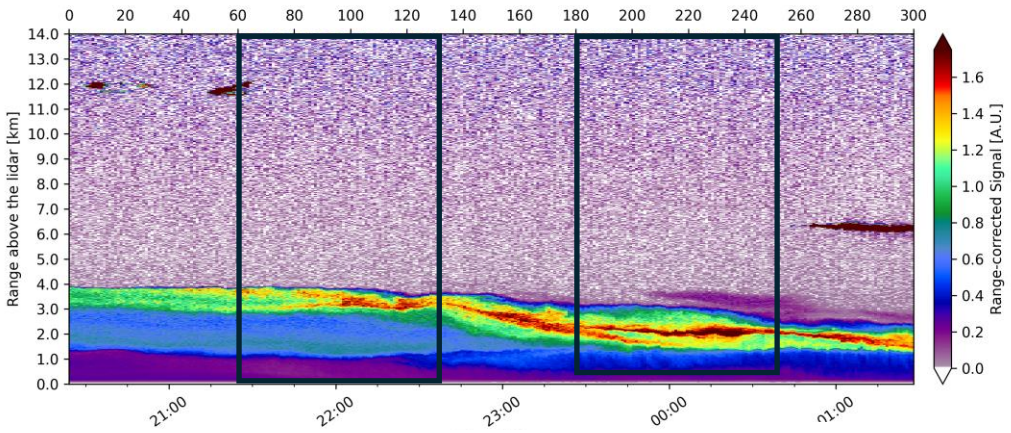


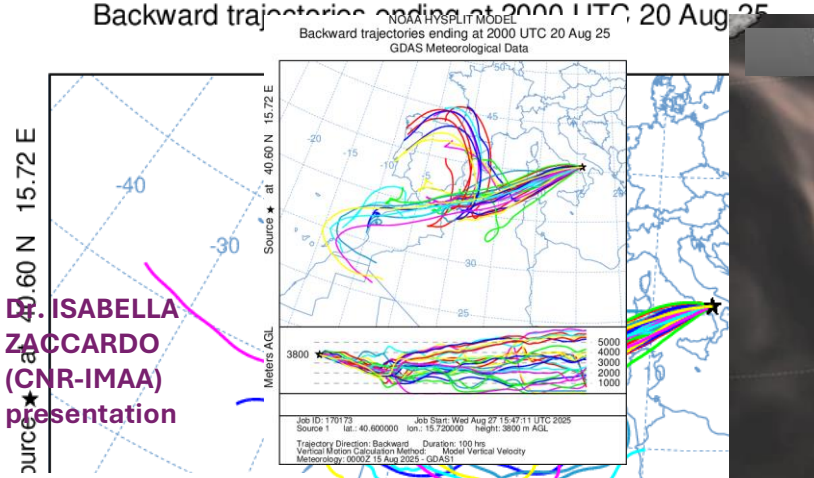


Case studies

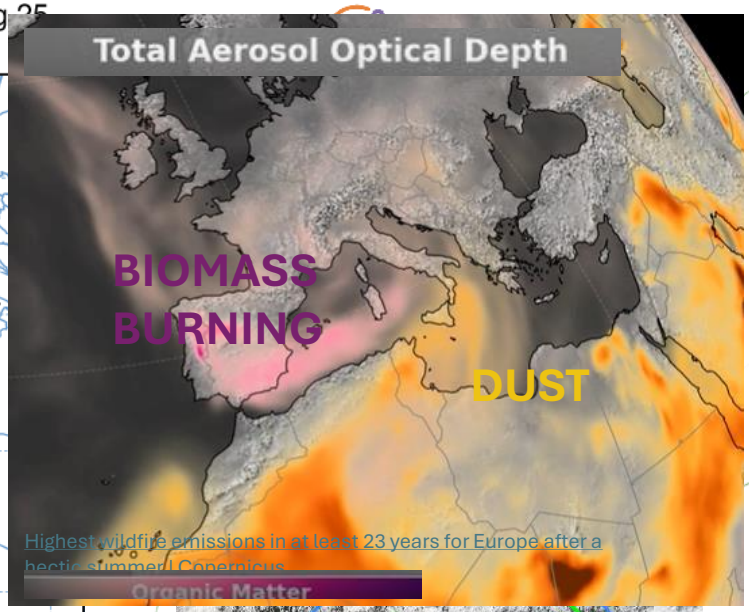
DUST? DUST + BIOMASS BURNING

POLPO 1064 par-20/08/2025, 20:24-01:28 UTC



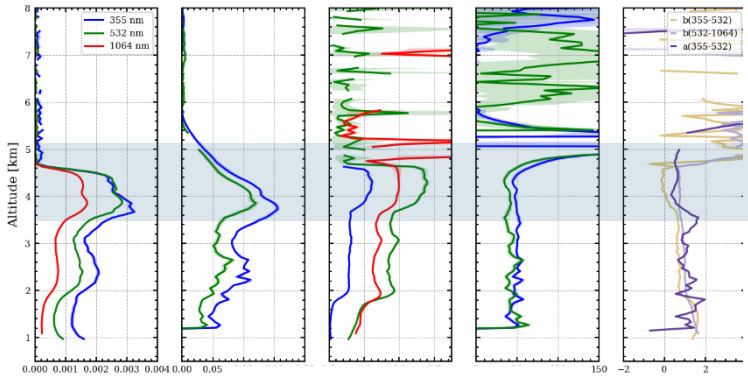


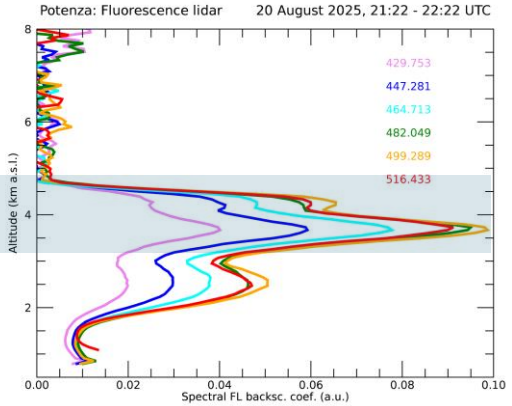
Dr. ISABELLA ZACCARDO (CNR-IMAA) presentation

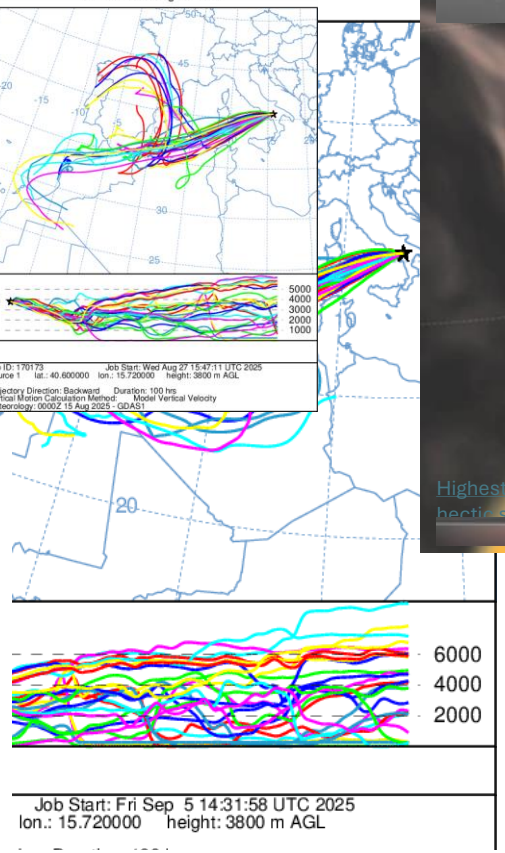


Highest wildfire emissions in at least 23 years for Europe after a hectic summer| Copernicus

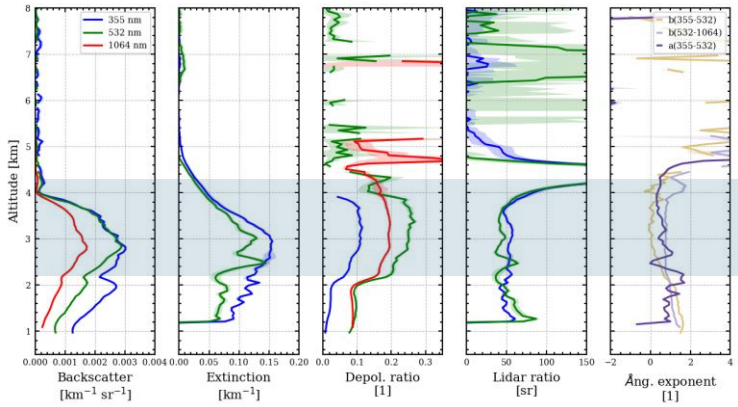
20 /08/2025, 21:21-22:21

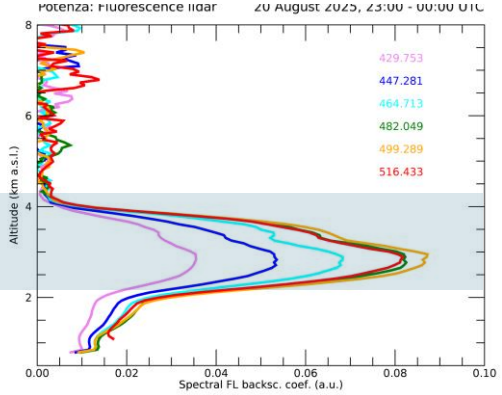


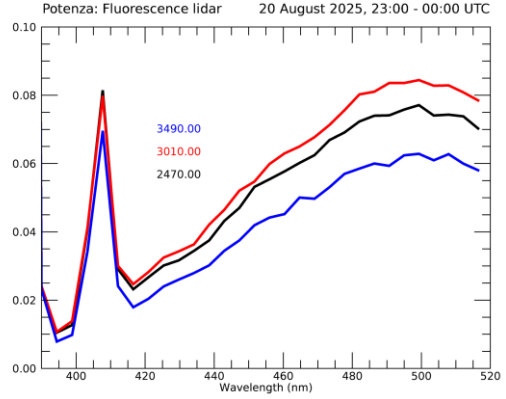


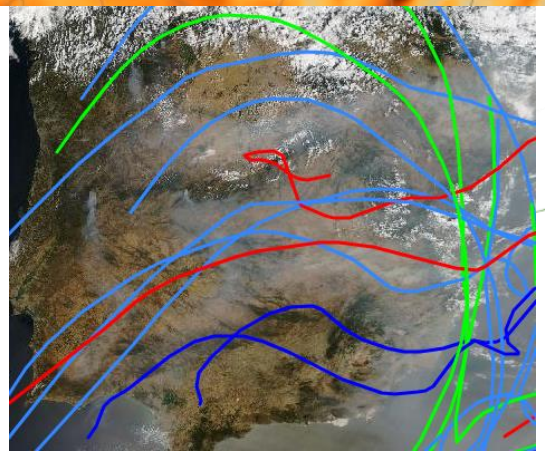


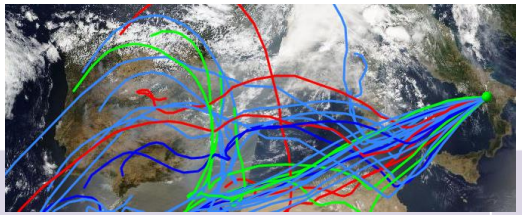
20 /08/2025, 23:26-00:27











Conclusions

•**Emerging technique**: fluorescence has the potential to revolutionize the understanding of atmospheric processes (as shown in the August 20 measurement), providing information not accessible with traditional elastic or Raman lidar.

•**ACTRIS relevance**: fluorescence is of high interest within ACTRIS- A dedicated working group in the National Facility Forum

• **International interest** for aerosol investigaton with fluorescence measurements as demonstrated by a devoted task in the COST Action *EARLIcost CA24135 European Atmospherc Research LIdar COoperation on Science and Technology*.

•**CIAO uniqueness**: the only observatory currently providing both calibrated spectrometric fluorescence lidar and optical parameters from Raman lidar at 355, 532, and 1064 nm (POLPO system).

•**Extraordinary potential**: this unique configuration is especially powerful for aerosol characterization from **wildfires** and **Saharan dust** events at our site.

Future steps

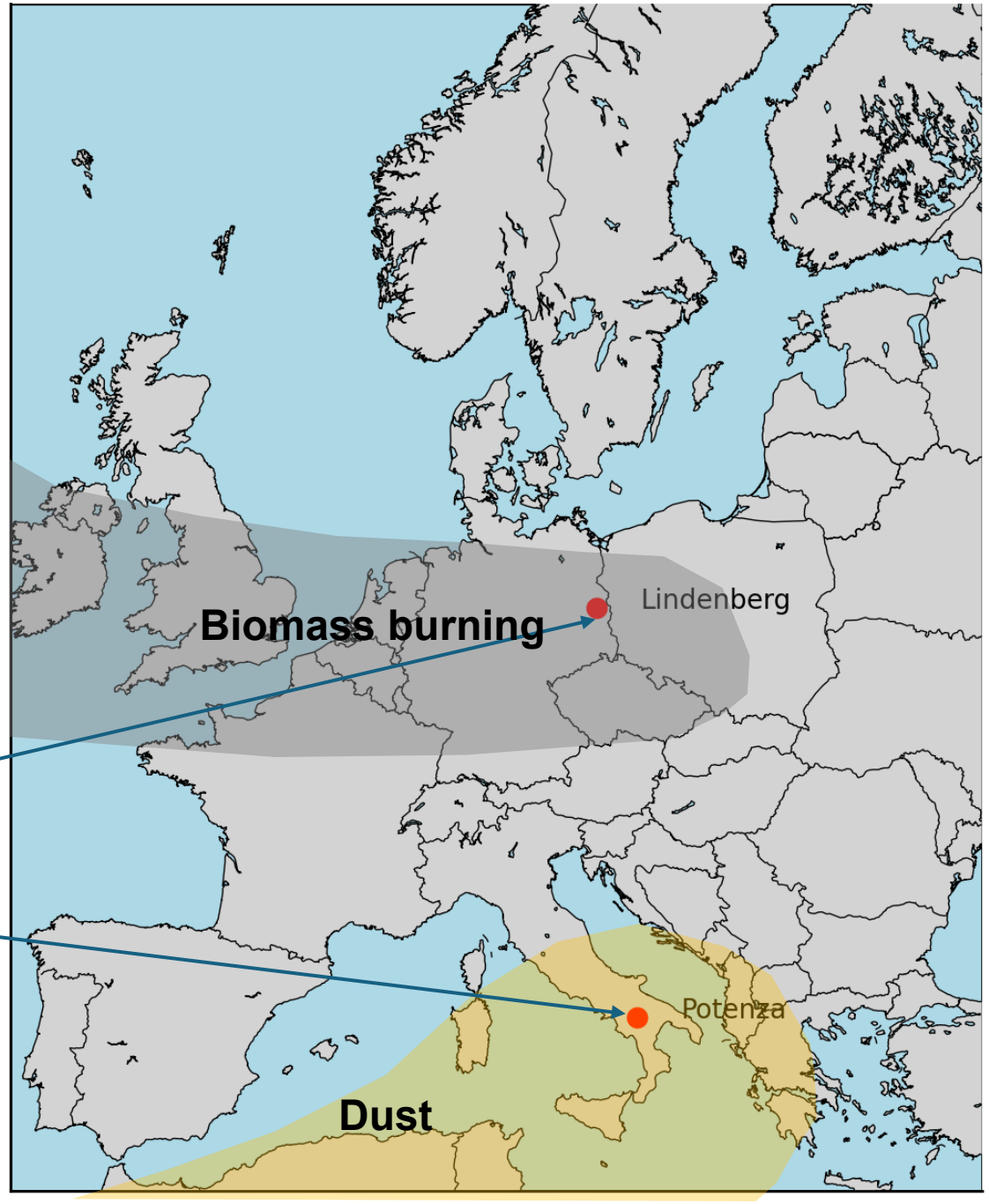
1) Development of dedicated software for advanced data analysis

2) Replace 1200 grating with 150 grating → full spectral coverage

3) Characterization of dust fluorescence spectra
- Compare large dataset with 3 depolarization measurements
- Aim: correlate spectra with dust origin regions
- **Study fluorescence spectra and depolarization (POLPO)**
- Improve aerosol typing (Case 20 August 2025)
- **Focus on local vs. North American wildfire events spectrur**
- Strengthen collaboration with Lindenberg Observatory

4) MEDUSA at Lindenberg → fluorescence + 3 depolarizations for fire studies
- **Potenza site → dust-focused measurements with our system and POLPO**

Key Sites for Measurements



THANKS!

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