Aerosols – Remote sensing and transport models

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Workshop "Atmospheric Aerosol Science in Vienna"
November 16, 2017

About myself

Education

PhD in Physics, Optical Technologies

PhD Thesis: “Computational methods for lidar signal optimisation, processing and validation” (Politehnica University of Bucharest, 2008)

MSc, Mathematics and Informatics, University of Craiova

Position

Senior scientist, National Institute of Research and Development for Optoelectronics Remote Sensing Department, Bucharest-Magurele, Romania (1997 – present)

FWF Lise Meitner Project M2031, BOKU-Met (Aug. 2016 – Jul. 2018)

Expertise

Experimental and theoretical atmospheric researches using remote sensing techniques (lidar, sunphotometer, microwave radiometer)

Founding member of the development team of the Romanian Atmospheric Research 3D Observatory, RADO, Bucharest

Aerosols – Remote Sensing and Transport Modelling
FWF Lise Meitner M2031

Host: BOKU-Met, Prof. Petra Seibert
Aug. 2016 – Jul. 2018

Short overview of the project

Objectives and methodology

To use active remote sensing measurements together with satellite imagery and in situ data and new analysis methods in order to improve the identification of the aerosols types and the determination of their optical, microphysics and chemical properties

To improve the aerosol classification for complex mixtures of aerosol types

To improve the capabilities of aerosol transport modelling in FLEXPART using data from remote sensing measurements

To show the benefits of including a hypothetical lidar station in the Austrian atmospheric research infrastructure, station eventually integrated in EARLINET, for Austria and for Europe.

5 work packages, see list and description in backup slides.

Combine the ground-based remote sensing, in situ and satellite measurements with aerosol transport model (FLEXPART) to provide more precise information about the vertical distribution of aerosols in the atmosphere and about their interactions with other atmospheric components (gaseous precursors, water vapor, and ozone) over a larger region from Central-Eastern Europe, centered on Austria.

Observational remote sensing data from EARLINET and AERONET stations from Romania (Bucharest, Timisoara, Cluj-Napoca), and three Germany stations (Garmisch-Partenkirchen, Munich, Leipzig), and AERONET Austrian stations are used to provide a detailed characterization of aerosol types – network of stations closest to Austria, centered on Austria

MACC products (integrating satellite data) from the European Copernicus Atmosphere Service, and CALIOP data are used to cover a large area and to improve the aerosol profiles properties

In situ data as complementary instruments are used to make a comprehensive analysis of aerosol types and their properties

FLEXPART model is used to compute source-receptor sensitivity and trajectories analysis

Some results from the project

- "Characterization of Long-Range Transports of Aerosols over Austria"

  EGU General Assembly, Apr. 2017, Vienna, Austria

- "Analysis of a case of sulfate aerosols over Austria"

  10th International Symposium on Tropospheric Profiling (ISTP10), May 2017, Fort Collins, Colorado, US

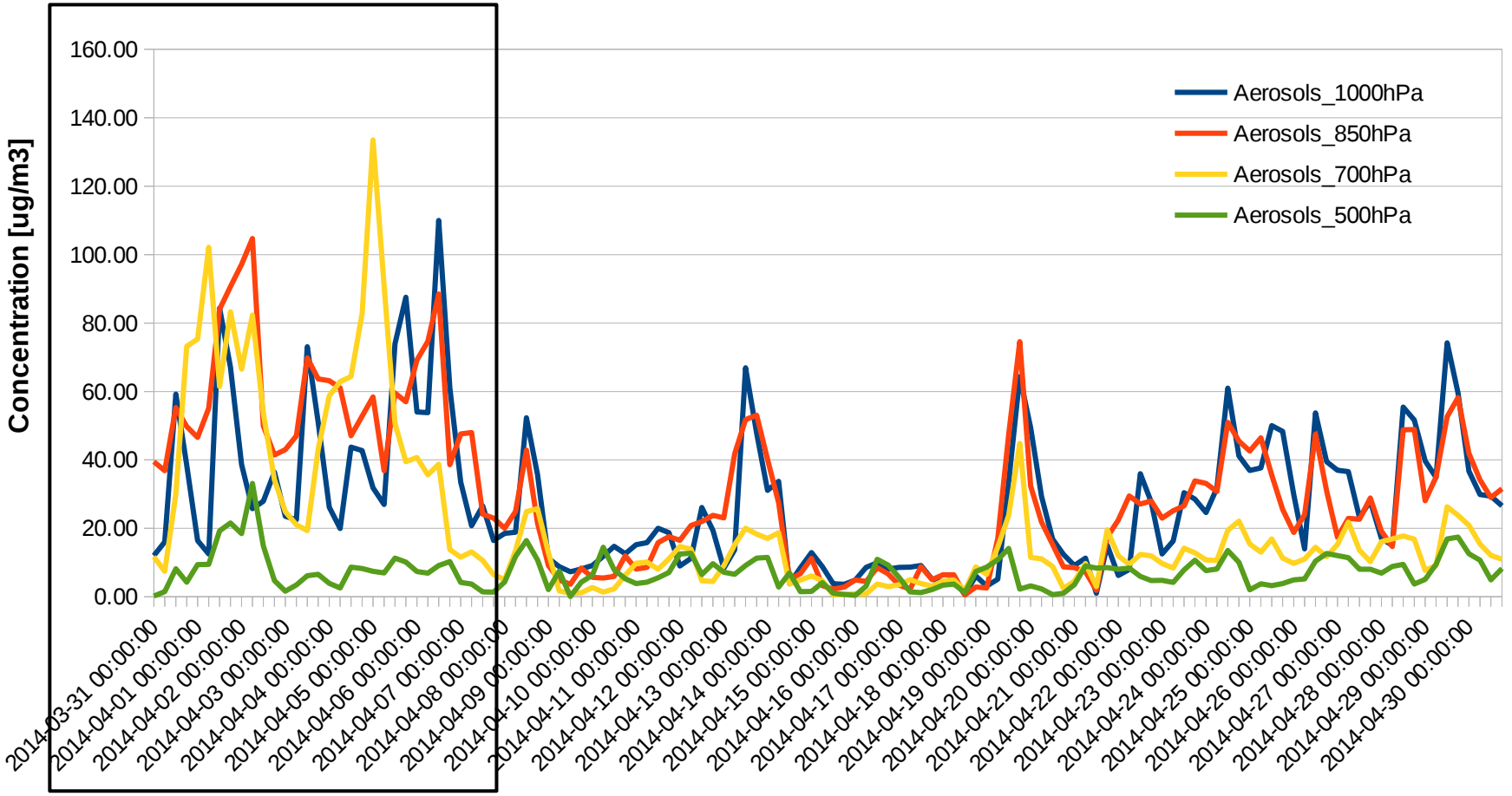
- "Identification of long-range transport of aerosols over Austria using EARLINET lidar measurements"

  International Laser Radar Conference (ILRC28), Jun. 2017, Bucharest, Romania

- "Characterization of the aging process of smoke observed over Austria using organic carbon mixing ratio"

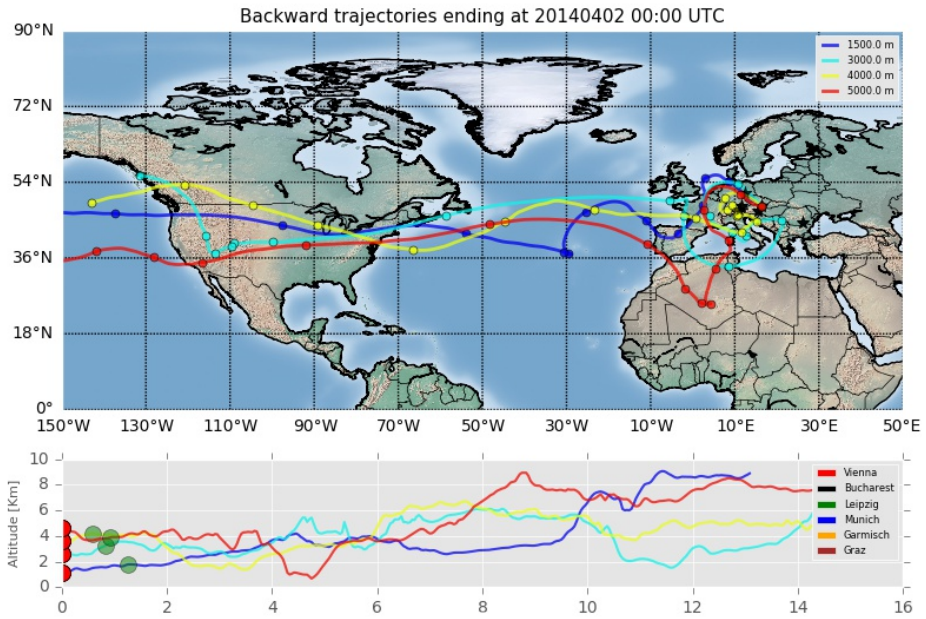
  European Aerosol Conference (EAC 2017), Aug. 2017, Zurich, Switzerland

Aerosol profiles from CAMS reanalysis
Vienna, April 2014

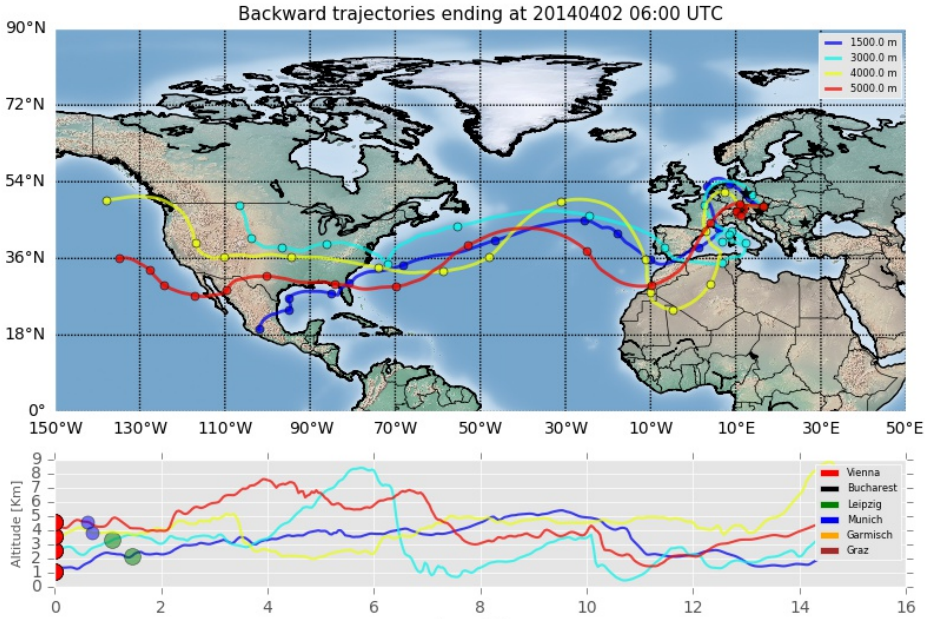


Back-trajectories analysis
Vienna, 02.04.2014

00:00 UTC



06:00 UTC



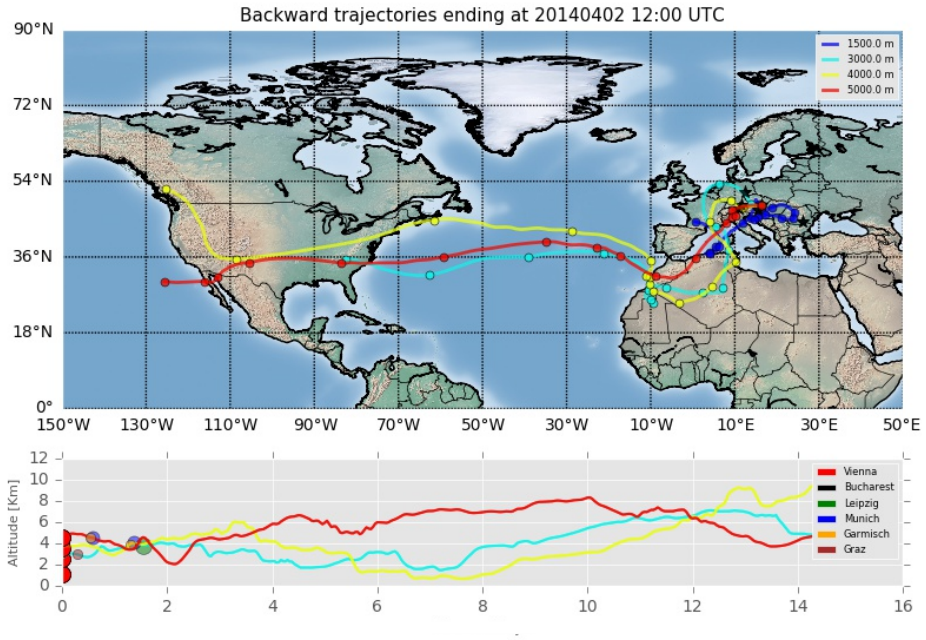
Trajectory color
- blue: 1500 m
- cyan: 3000 m
- yellow: 4000 m
- red: 5000 m

Lidar station color
- black: Bucharest
- green: Leipzig
- blue: Munich
- orange: Garmisch

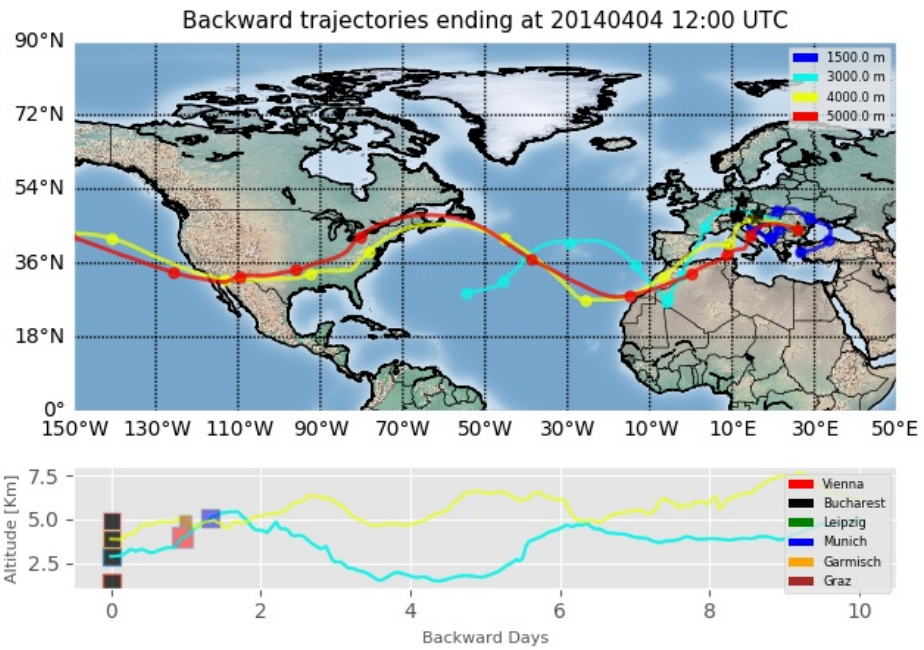
In-situ station color
- red: Vienna
- brown: Graz

Back-trajectories analysis
Vienna, 02.04.2014 & Bucharest, 04.04.2014

Vienna, 12:00 UTC



Bucharest, 12:00 UTC



Trajectory color
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Lidar station color
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- green: Leipzig
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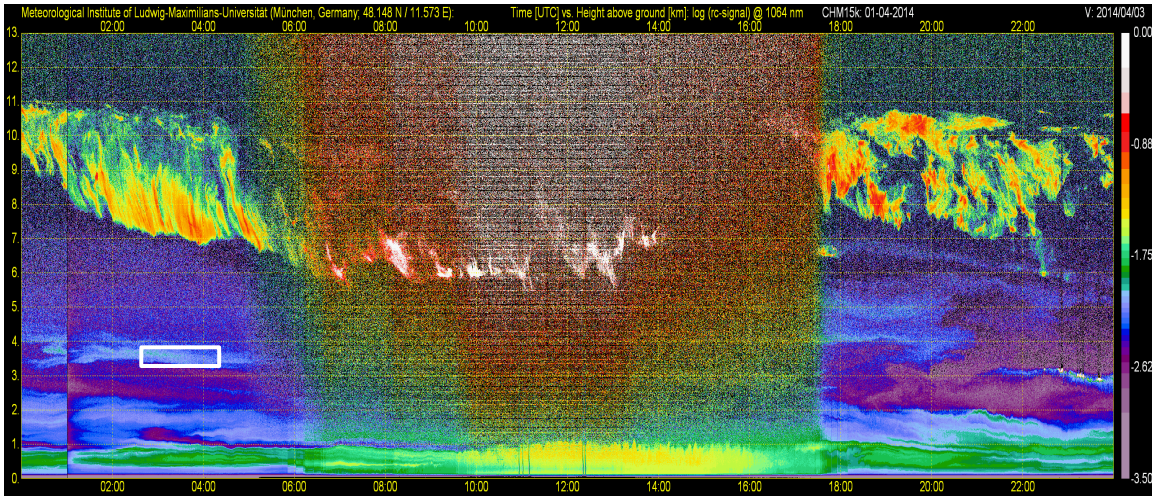
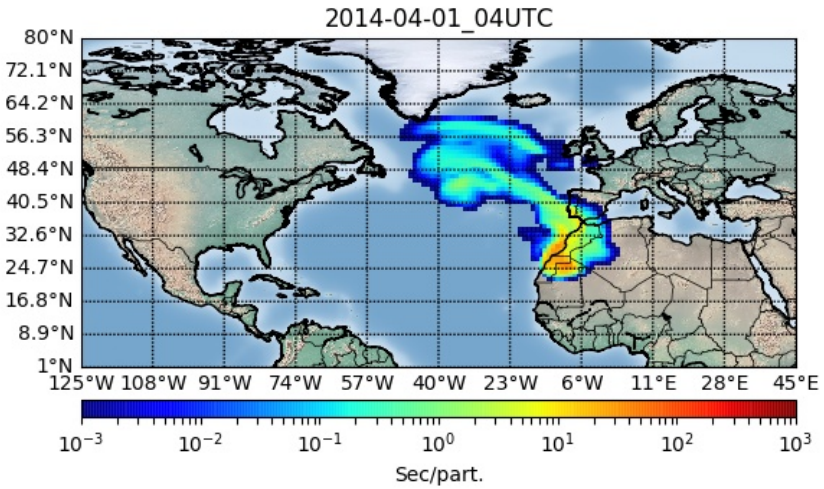
In-situ station color
- red: Vienna
- brown: Graz

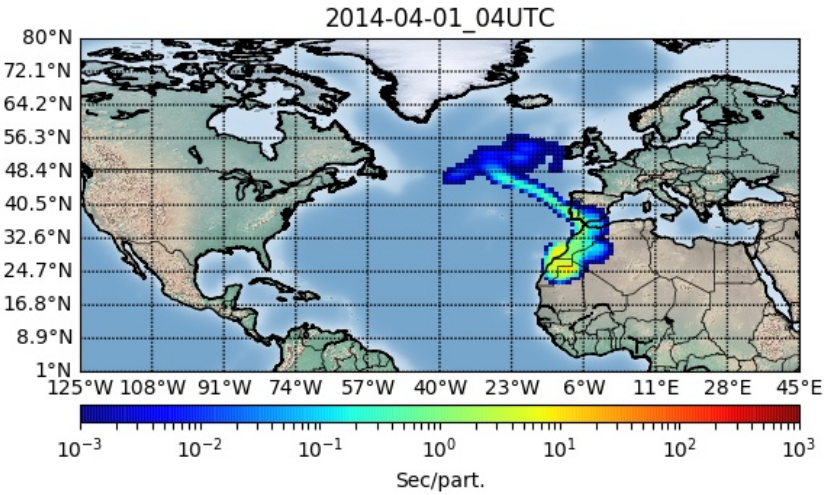
Results: Munich 01.04.2014, 03:00 – 04:00 UTC



Logarithm of range corrected signal, channel 1064 nm
Layer analyzed: 3500 m – 4000 m
Ceilometer YALIS, 24h measurements

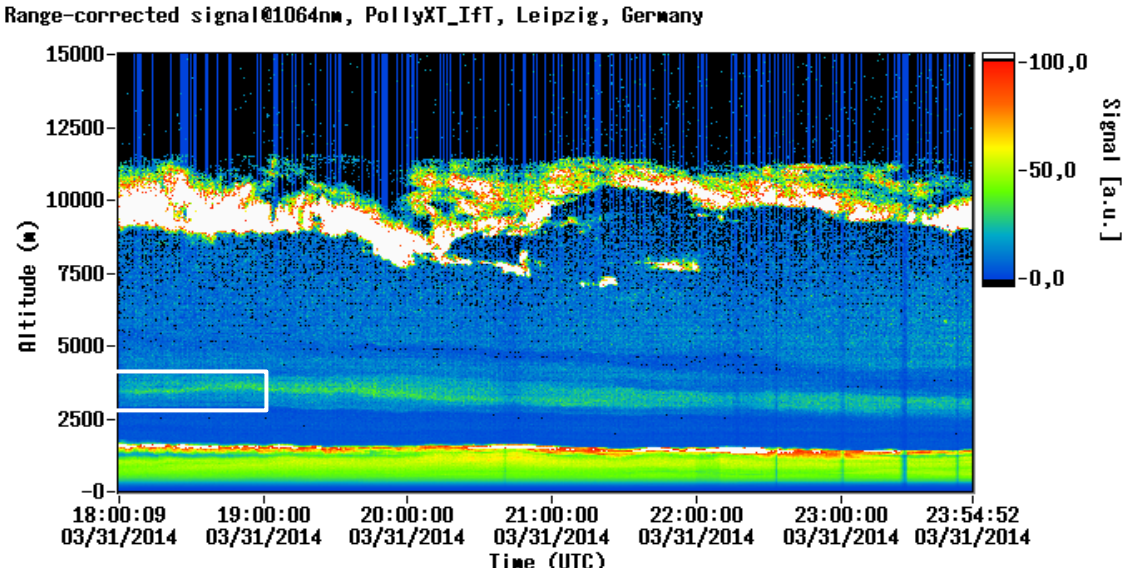


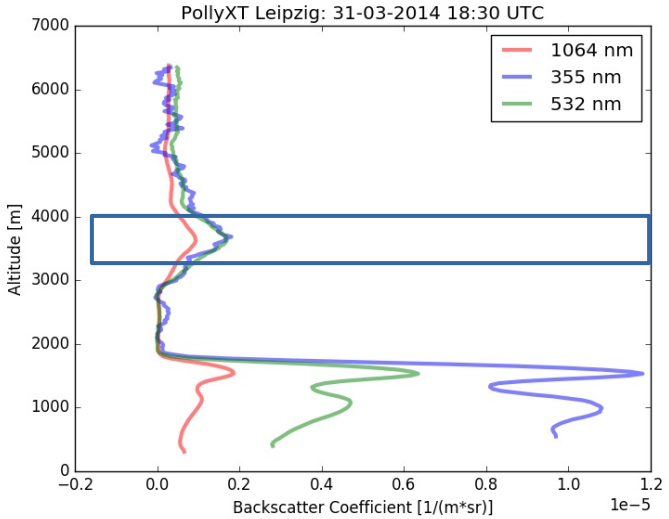
Total column sensitivity for the aerosol layer sampled over Munich at 03:00 – 04:00 UTC on 1 April between 3500 m and 4000 m.

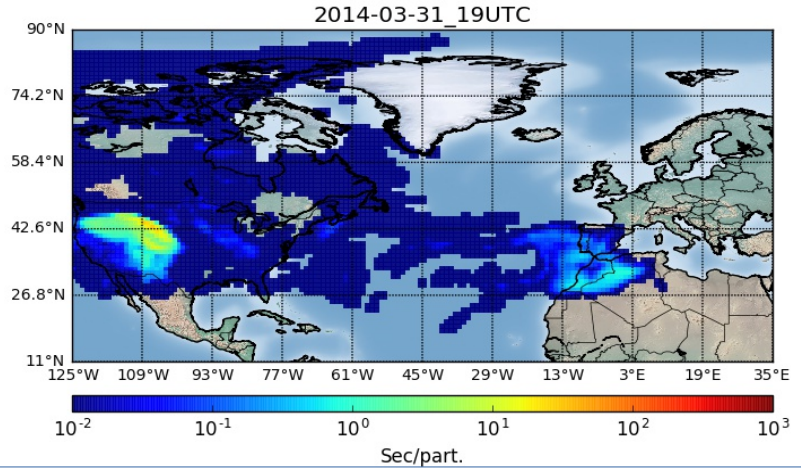


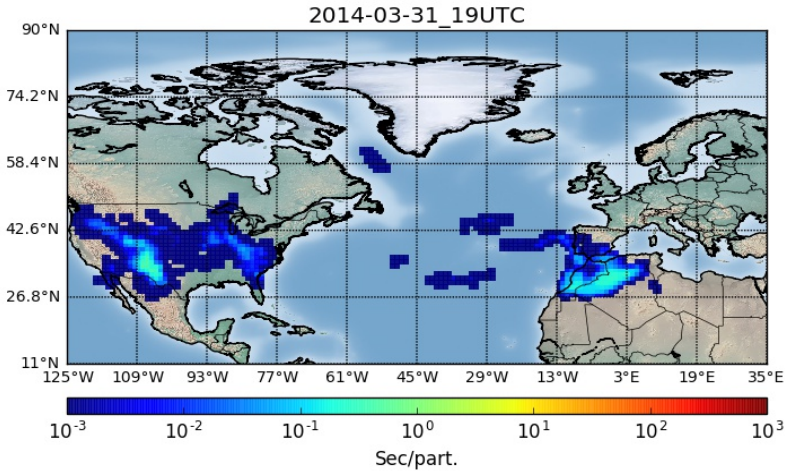
Aerosol layer sensitivity for the aerosol layer sampled over Munich at 03:00 -04:00 UTC on 1 April between 3500 m and 4000 m.

Results: Leipzig 31.03.2014, 18:00 – 19:00 UTC





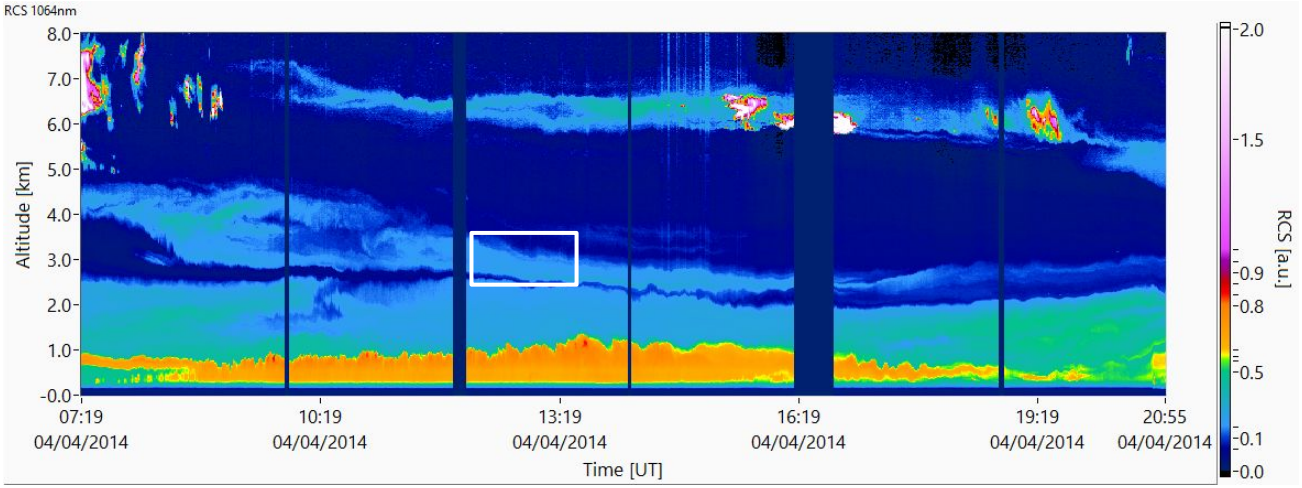




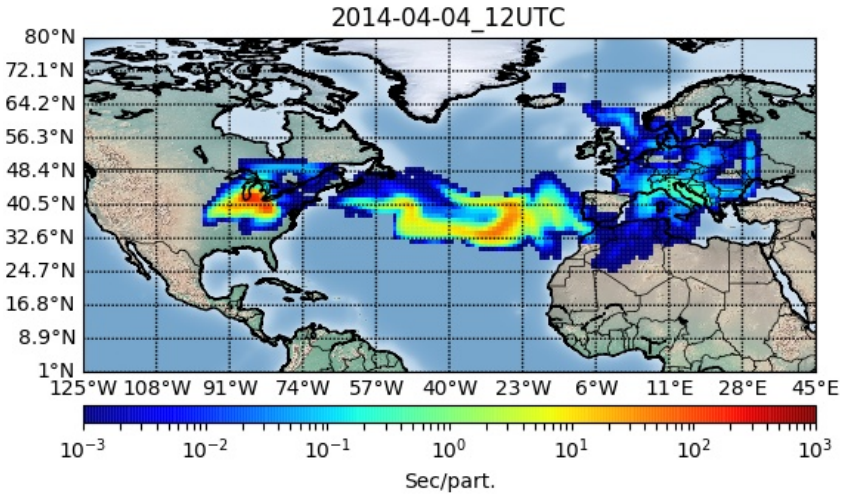
Total column sensitivity for the aerosol layer sampled over Leipzig at 19:00 – 20:00 UTC on 31 March between 3200 m and 3700 m.

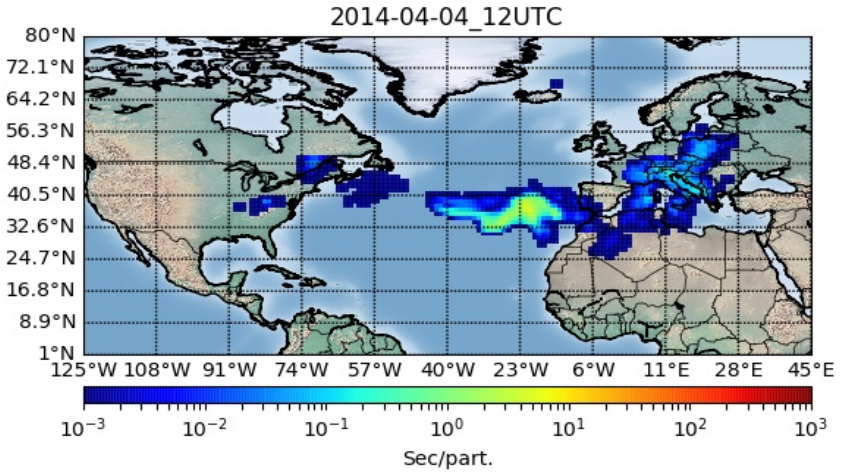
Aerosol layer sensitivity for the aerosol layer sampled over Leipzig at 19:00 – 20:00 UTC on 31 March between 3200 m and 3700 m.

Results: Bucharest 04.04.2014



Range corrected signal, channel 1064 nm
Layer analyzed:
3500 m – 3500 m
Lidar RALI, continuous measurements from:
07:00 – 21:00 UTC





Total column sensitivity for the aerosol layer sampled over Bucharest at 12:00 – 13:00 UTC on 4 April between 3000 m and 3500 m.

Aerosol layer sensitivity for the aerosol layer sampled over Bucharest at 12:00 – 13:00 UTC on 4 April between 3000 m and 3500 m.

Aerosol properties

Site	Date	Time [UTC]	Layer [km]	AOD 550	Dep532 [%]	LR532 [sr]	Conc. [μ/m^3]	Type
Munich	2014-04-01	04:00	3.5 – 4.0	0.24	23	55± 3	70.6 ± 5	Dust
Garmisch	2014-04-01	12:30	3.5 – 4.0	0.21	N/A	58 ± 6	62.1 ± 4	Dust
Leipzig	2014-03-31	18:30	3.2 - 3.7	0.37	22	56 ± 6	94.6 ± 11	Dust Polluted
Bucharest	2014-04-04	12:00	3.0 - 3.5	0.34	13	67 ± 3	40.3 ± 9	Dust Polluted
Vienna	2014-04-02	12:00	3.0	0.24	18	71 ± 7	53.7 ± 5	Dust Polluted
Vienna	2014-04-02	06:00	3.0	0.21	13	76 ± 5	82.4 ± 6	Dust Polluted
Vienna	2014-04-02	06:00	5.0	0.17	17	72 ± 7	33.2 ± 2	Dust Polluted
Vienna	2014-04-03	18:00	3.0	0.20	14	61 ± 6	43.8 ± 3	Dust Polluted

Observations

Higher values of lidar ratio and smaller values of linear particle depolarization for Vienna and Bucharest compared to German lidar stations show the presence of sulfate particles in the aerosols.

Dust polluted defines the mixing of non-spherical (dust) particles with continental polluted and/or smoke, during different transport paths to Leipzig, Vienna and Bucharest (see in backup slides)

Analysis of including a hypothetical lidar station for atmospheric studies in Vienna (WP5)

A quick analysis of the distribution of lidar stations used for aerosol measurements over Europe, reveals a striking measuring gap in the southeastern part of Central Europe (Austria, Hungary, Czech Republic, Slovakia) between the four stations in Germany, the five stations in Southeast Europe (Romania, Bulgaria, Greece, Cyprus) and the five stations in Italy.

A lidar system in Vienna would provide local measurements of aerosols, allowing a precise determination of their properties and vertical profiles of their distribution, all in near real time – to fill the gap in EARLINET infrastructure

The presence of Austria in the European lidar network would significantly improve the results and consequently the importance of the network, as the absence of data for the Austrian territory is notable in the European lidar network due to its geographical position and terrain characteristics.

Based on the quality of the existing research infrastructure, the world-renowned expertise and scientific results of Austrian atmospheric research, the Austria infrastructure could be an ideal candidate for an atmospheric remote sensing centre in ACTRIS – ESFRI

A Proposal for Collaboration: Austrian Remote Sensing Network

Scope ARS-net:

Infrastructure

start building a lidar station in Vienna
integrate it with the existing infrastructure:
sunphotometers (BOKU, UniVie), MAX-DOAS (BOKU),
ceilometer (ZAMG), trace-gases instruments (TU, UniVie, etc)

eventually, extend the network to Innsbruck and Graz
and develop the stations

Common aerosol research activities using network data

all interested aerosol research groups in Vienna, Innsbruck, Graz

Target: join ACTRIS

Possible funding:

FWF SFB project
EU Horizon 2020
ESA

Such a project requires extensive collaboration of more (all?) aerosol research groups from Austria.

I have the experience of building from scratch the RADO 3D Observatory, see backup slides for observatory description

Aerosol Lidar

Applications:

Aerosol loading / layering

Volcanic ash / dust / biomass burning identification

PBL structure / mixing height

Weather model forecast validation

Air quality / pollution model remote data

Humidity profiling

Cloud / precipitation measurement

Specifications (min. request):

1 depolarization channel (355 / 550nm)

1 elastic channel (355 / 532 nm)

1 Raman channel (387 / 607 nm)

1 water vapor Raman channel (408 nm)

Estimated costs:

150k – 500k EUR (depend on the lidar configuration)

Delivery time:

At less 6 months

Human resources:

Technical maintenance: 0.2 FTE (2 technicians)

Operating the system: 0.2 – 0.4 FTE

Increased requirements during:

- campaigns
- alerts of special events (volcanic eruption, massive dust, large fires)

Additional:

Environmental tolerance: -20C to +45C

Weight approx 250 kg

Power 110 – 240V (25 kW consumption), 50 – 60 Hz, 25A (peak current)

Location agreed by aviation authorities

Why lidar?

Higher quality data, increased capabilities and greater range than ceilometers!

Backup slides

Work packages

WP1: Analysis of aerosols over Austria - seasonal analysis and selected past periods

Analysis of aerosols over Austria: (a) air-flow dynamics and known aerosol sources in the last five years, (b) analysis of two periods, March - August 2010 and March - August 2014, characterized by some special events

WP2: Elaboration of an aerosol classification scheme based on optical and microphysics parameters

Expand and improve the aerosol classification scheme using in situ, remote sensing, modelling products

WP3: Improving numerical modelling of aerosols in FLEXPART using remote sensing products

Use the cases studied in WP1 to validate and improve FLEXPART

WP4: Analysis of aerosols over Austria during a selected project period with improved FLEXPART

Quasi-real time analysis of aerosols over Austria, using the products from lidar, sunphotometer, satellite and in situ monitors, for a period of around half an year, based on WP1, WP2 and WP3 experience and results.

WP5: Analysis of including a hypothetical lidar station for atmospheric studies in Vienna

EARLINET - European Aerosol Research Lidar Network

EARLINET – European network of ground-base lidars

39 stations distributed over Europe (28 permanent stations, 9 joining stations, 2 not permanent stations)

Network provide:

a long-term systematic observation of the vertically resolved aerosol distribution over Europe

a quantitative comprehensive statistical database of the horizontal, vertical, and temporal distribution of aerosols

Quality assurance program for instrument performance and evaluation of algorithms

Lidars systems inter-comparisons

Scientific campaigns

Handbook of instruments

Single calculus chain

Standard operation procedures

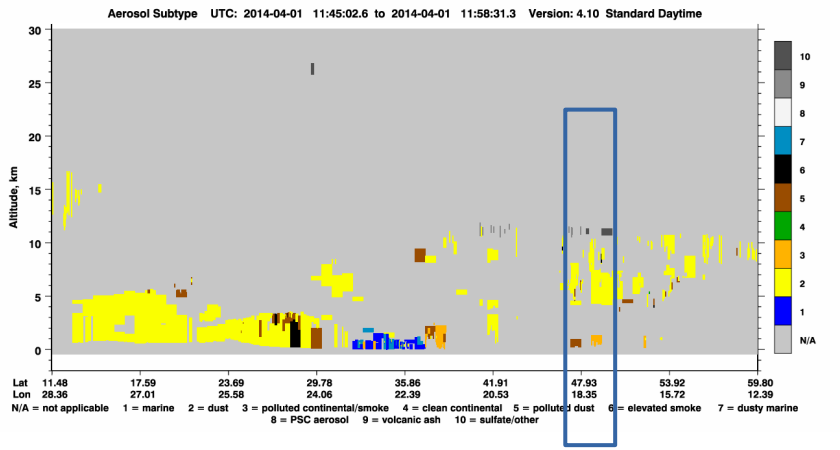
Lidar calibration centre

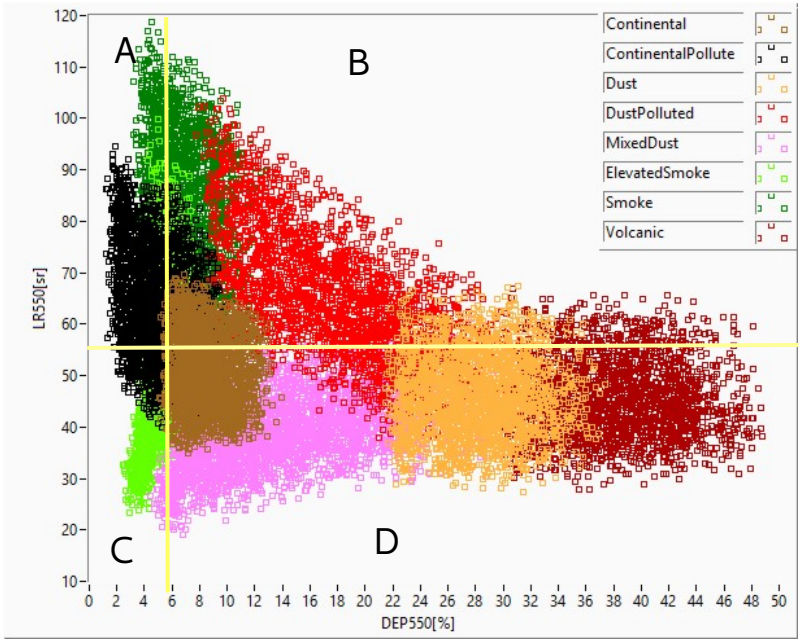
services for characterization, testing, calibration, comparison of instruments, operator training, etc

operated by: Romania (INOE), Germany (LMU), and Italy (CNR-IMAA)

https://earlinet.org

Aerosol types





CALIPSO, 1.04.2014 11:40 UTC

3 layers of aerosols:

- 1.0 – 2.0 km: polluted dust
- 4.0 – 10.0 km: dust
- 10 .0 – 11.0 km: sulfate

Aerosol typing

Depolarization ratio vs lidar ratio diagram

- A – Spherical particles, high absorbing
- B – Non-spherical particles, high absorbing
- C – Spherical particles, less absorbing
- D – Non-spherical particles, less absorbing

ACTRIS - Aerosols, Clouds, and Trace gases Research Infrastructure Network

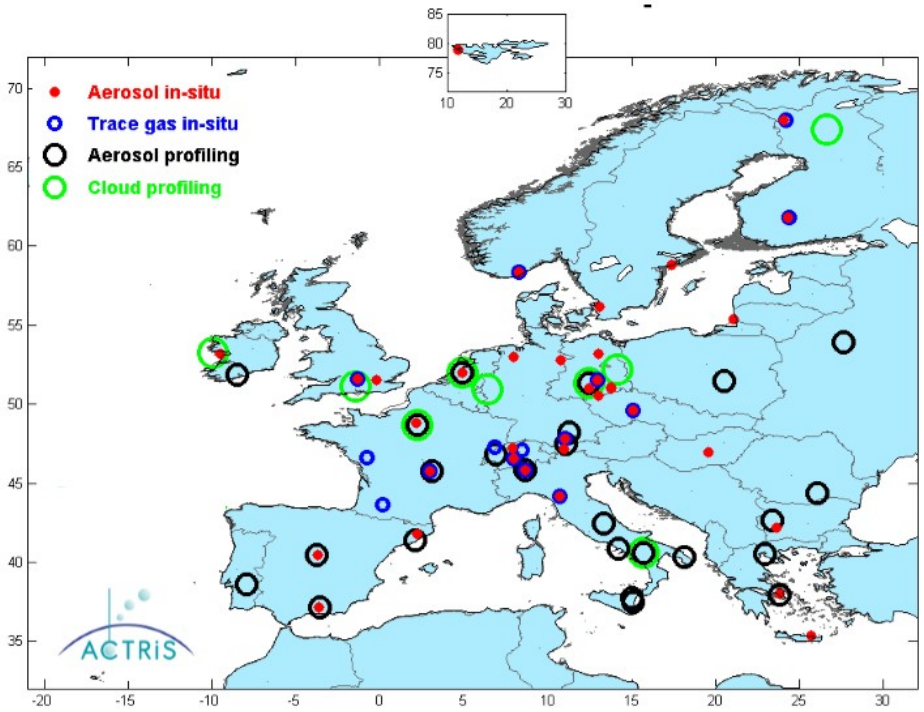
ACTRIS - coordination of European ground-based network for aerosols, clouds and short-lived trace gases

- trans-national access (TNA) to infrastructure
- networking (EARLINET , CLOUDNET, AERONET-EU, EUSAAR)
- automation of the QA (remote) tests
- coupling AMS and lidar for absorbing aerosols

ACTRIS-ESFRI

ACTRIS on the European roadmap

- hosting the Lidar calibration centre
- operation of the research infrastructures, provides trans-national access and training
- services (data collection, submission, advanced products, CAL/VALs)



http://www.actris.eu

Joint Research → New knowledge, innovation → Implementation → Trans-national access → Services


Romanian Atmospheric 3D Research Observatory
RADO
Bucharest (Magurele) station

RADO overview