EARLINET vertically resolved observations of volcanic events

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+ contribution from the whole EARLINET

OUTLINE

- Lidar techniques for aerosol observations
- Lidar network: EARLINET
- EARLINET observations of volcanic events:
  - stratosphere (North Pacific 2008-2009)
  - troposphere (Etna 2001, 2002)
  - continental scale (Eyjafjöll eruption)
- EARLINET data for modelling studies
- Synergies with other observations/platforms
- Summary and future plans

Lidar measurements

Lidar provides excellent information about the vertical structure of aerosol layers.

Advanced lidar methods provide very good information about aerosol optical properties (extinction, backscatter, optical depth).

Advanced lidar plus advanced retrieval methods provide important information about microphysical properties of aerosols.

Lidar Network

Aerosol distribution is highly variable, single point measurements are insufficient for characterization.

At least continental scale coverage is needed for, e.g., climate impact studies, source localization, comparative statistics.

Lidar technologies

- ceilometers
- Backscatter lidar (1 wavelength, multiwavelength)
- Raman lidar (1 wavelength, multiwavelength)
- HSRL (1 wavelength, multiwavelength)
- Doppler lidar

- Lidar products from each technology
  - Direct measured geometrical and optical properties
  - Retrieved aerosol typing/classification, microphysical properties and mass conversion
- Qualitative and quantitative data (i.e. calibrated / not calibrated data)
- Sensitivity/Expected accuracy
- Best location (respect to the volcano source)

Lidar products

- Quicklook (lev 0)

- Geometrical properties

  layer identification (top, bottom and center of mass)

- Optical properties profiles

  Extensive optical parameters (backscatter, extinction)

  Intensive optical parameters (Lidar ratio, depol., color ratio, Ångström exponent)

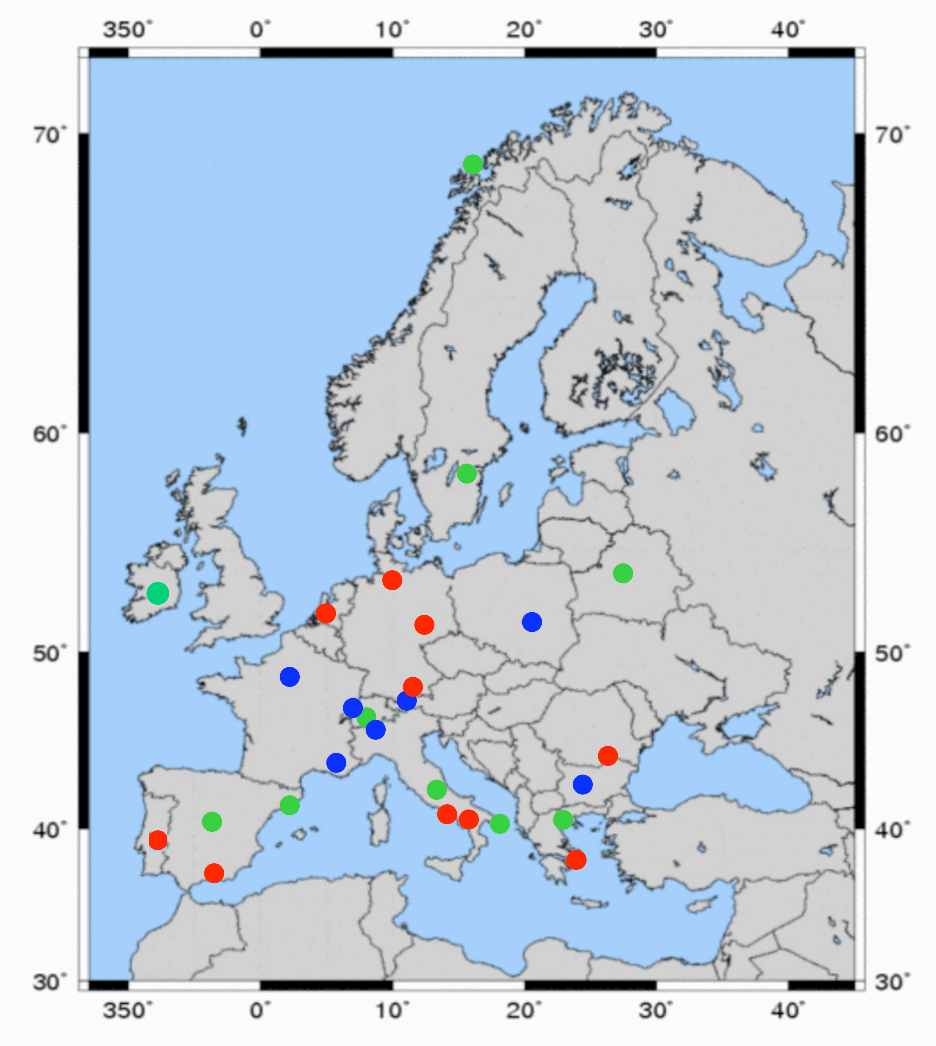
- Optical properties in the identified layer

  Integrated backscatter, AOD

  Mean intensive optical parameters (Lidar ratio, depol., color ratio, Ångström exponent)

- Aerosol Typing classification
- Mass concentration estimate
- Microphysical properties retrieved

European Aerosol Research Lidar Network (2010)



- 27 lidar stations

- 10 multiwavelength Raman lidar stations

backscatter (355, 532 and 1064 nm) + extinction (355 and 532 nm) + depol ratio (532 nm)

- 10 Raman lidar stations

- 7 single backscatter lidar stations

- comprehensive, quantitative, and statistically significant data base

- Continental and long-term scale since 2000

www.earlinet.org

EARLINET: European Aerosol Research Lidar Network

First tool for 4D aerosol measurements on continental scale

- Quality assurance program
  - Instruments
  - Data analysis

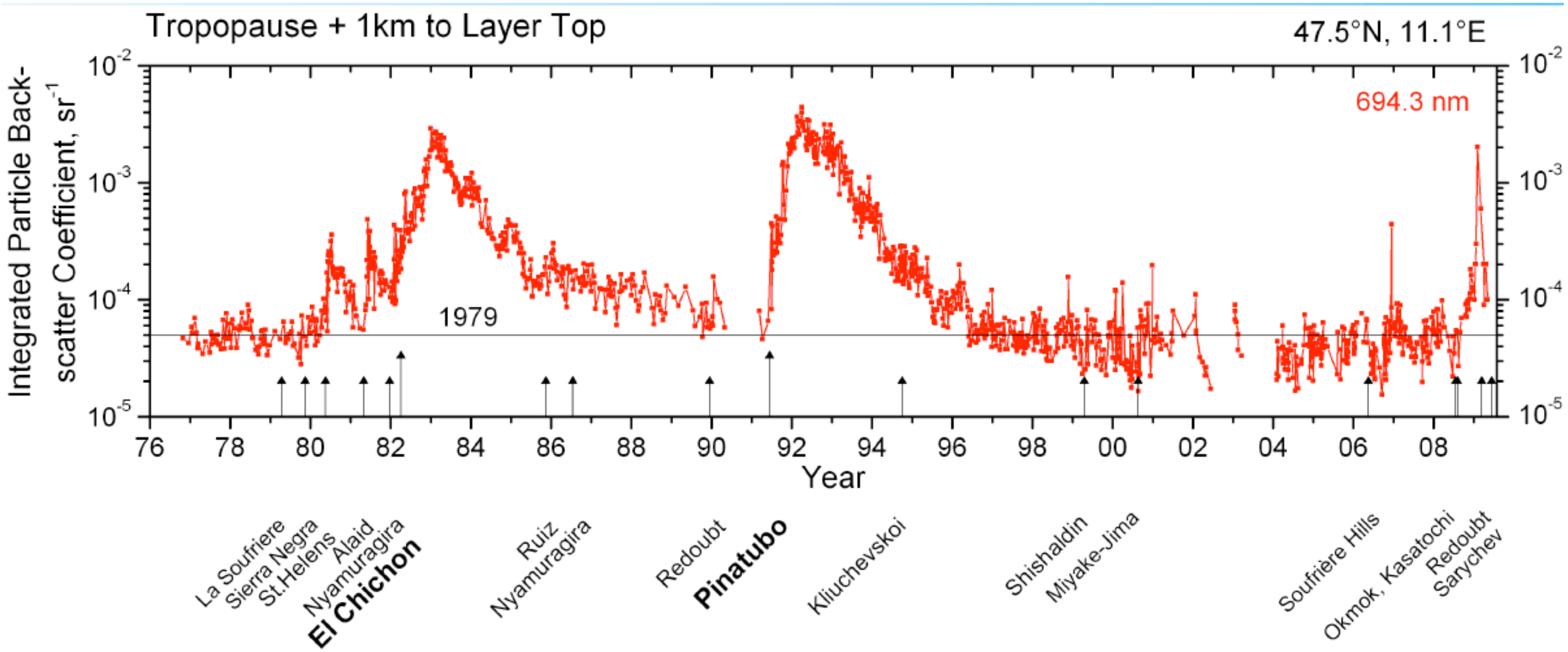
- Predefined measurement schedule (3 per week) → unbiased

- Coordinated network observations for special events (e.g., Saharan dust, forest fires, photochemical smog, diurnal circle, volcanic aerosols)

- Standardized data format

- Access to data via centralized data base

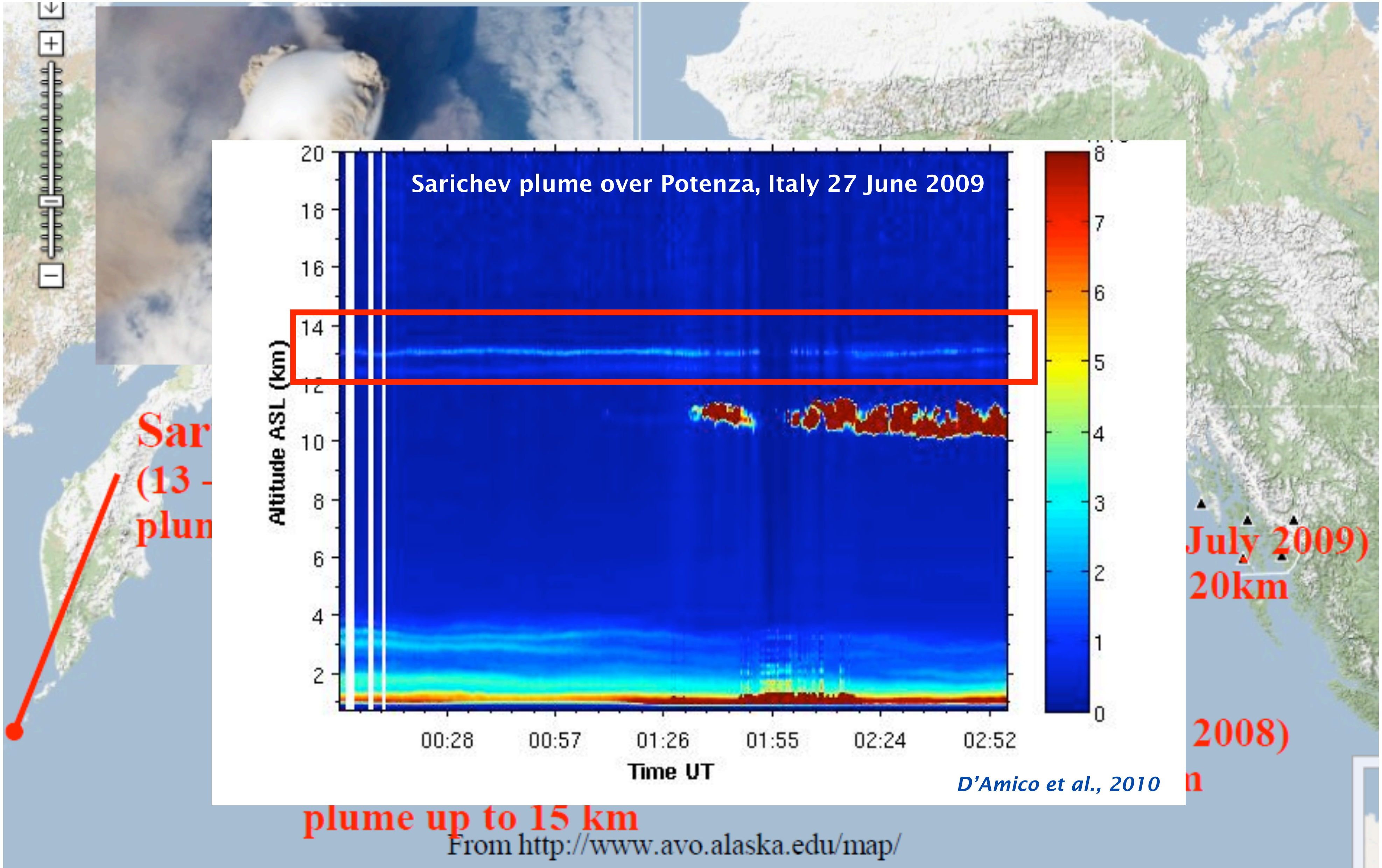
Volcanic eruptions



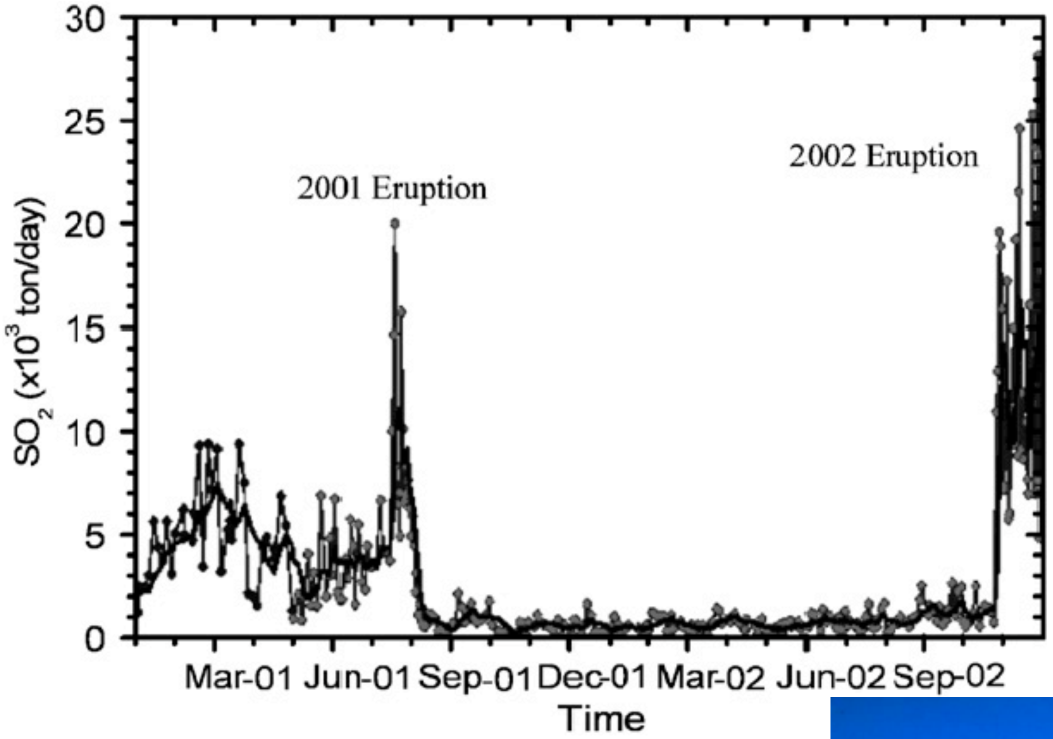
Long-term observations of stratospheric aerosol at Garmisch-Partenkinrken

Trickl et al, ILRC 2010

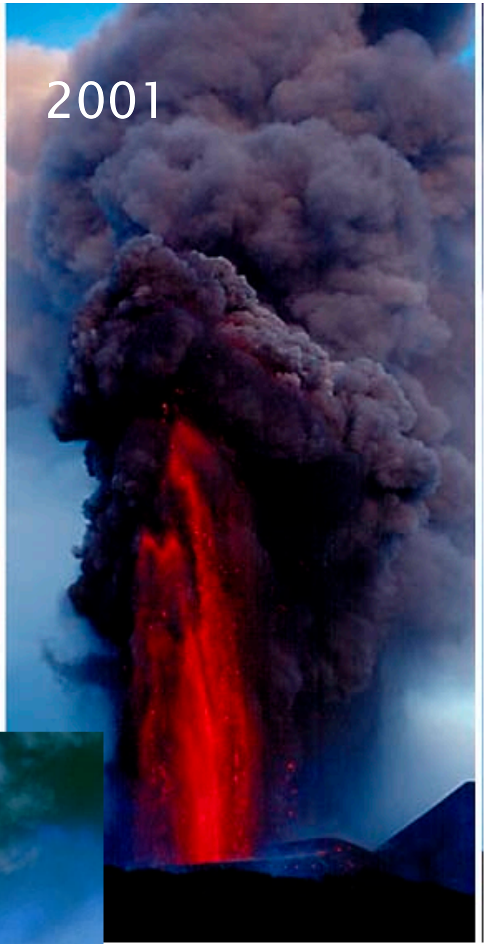
Volcano eruptions in the North Pacific region 2008-2009



Volcanic eruptions (Etna 2001 and 2002)

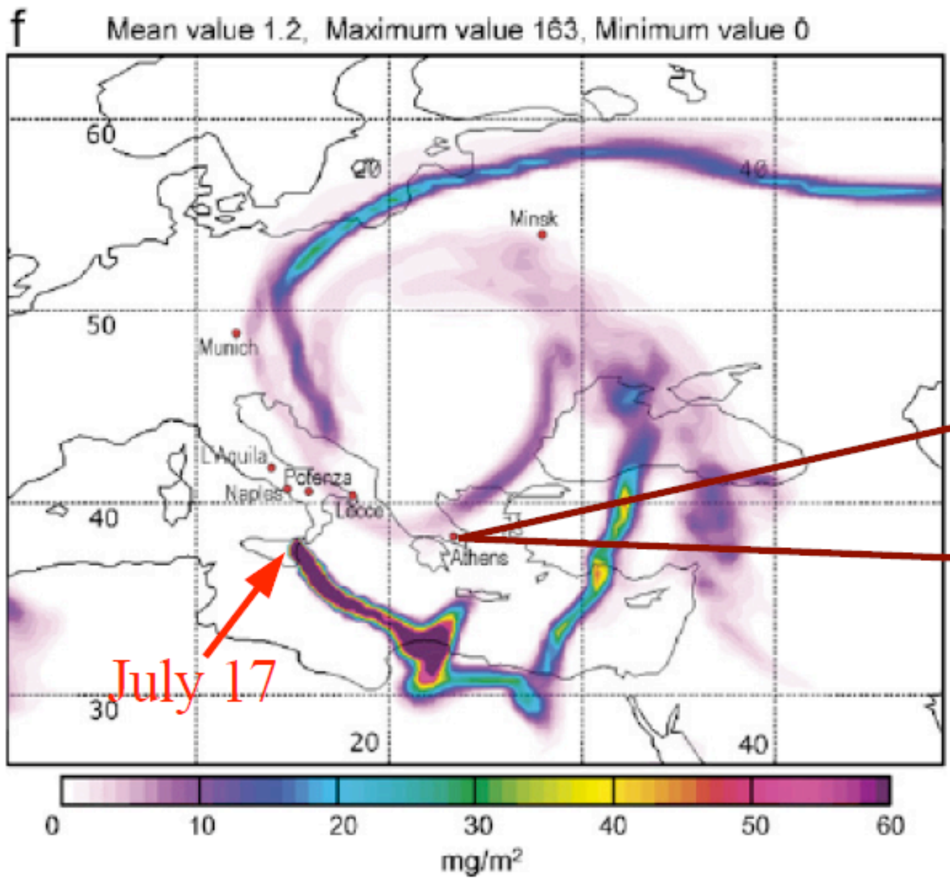


Wang et al., 2008



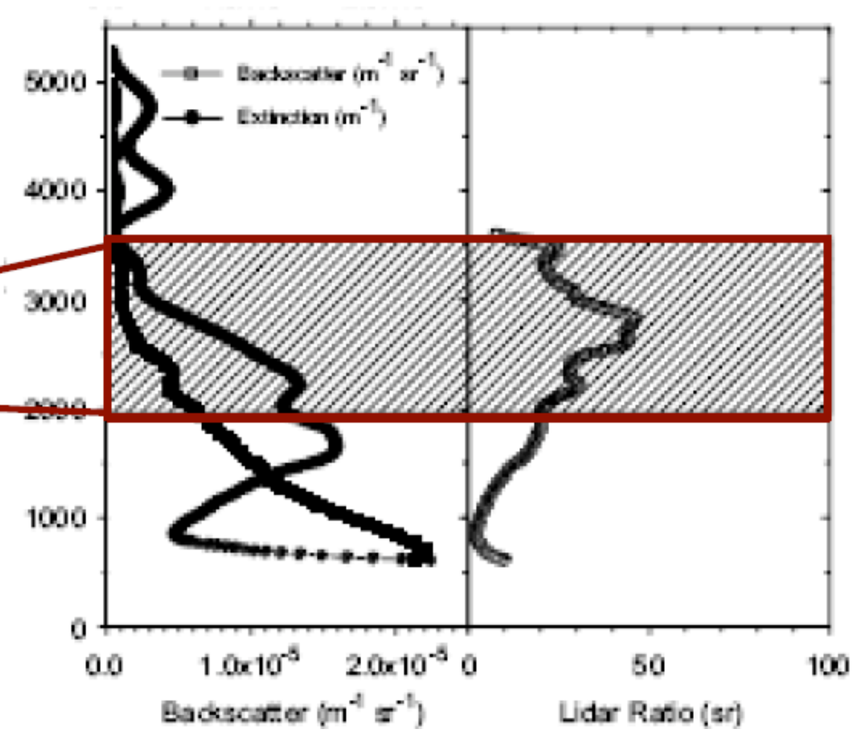
Volcanic eruptions (Etna 2001)

FLEXPART simulation



Lidar observation

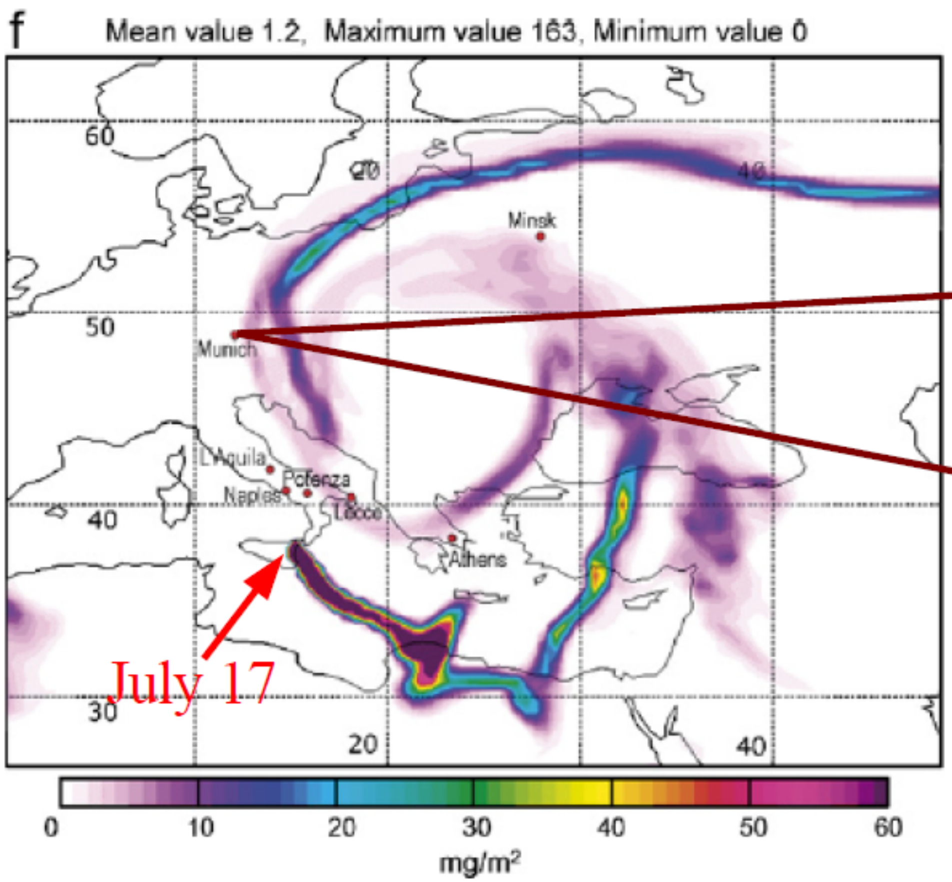
Athens, July 23 2001



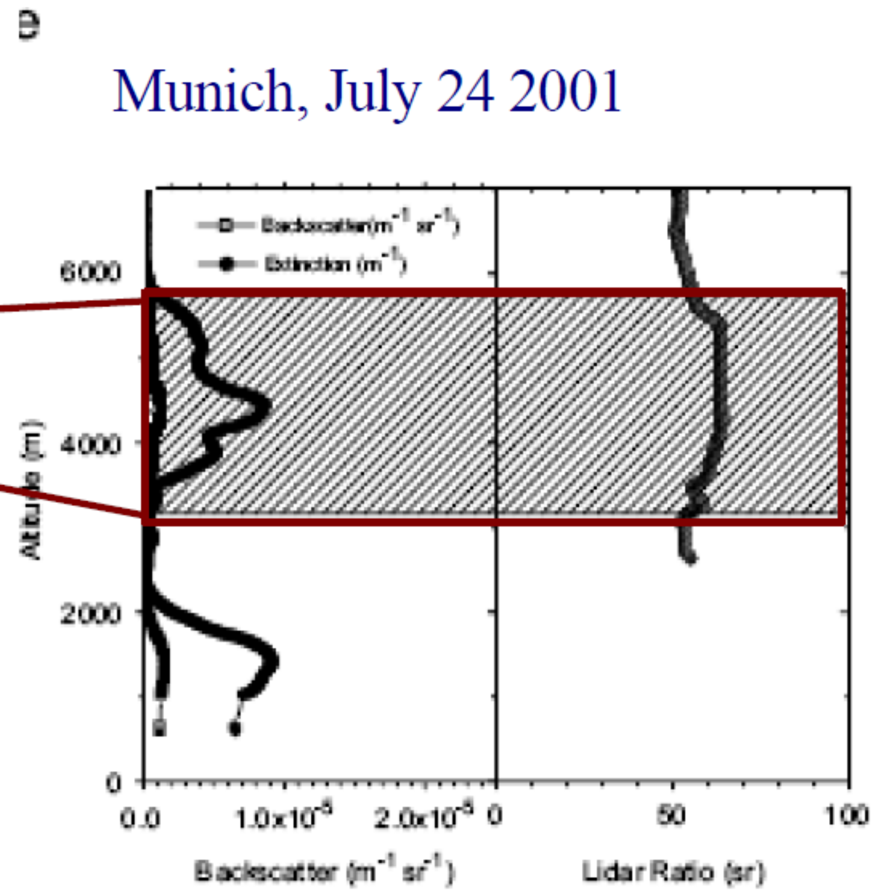
Wang et al., 2008

Volcanic eruptions (Etna 2001)

FLEXPART simulation



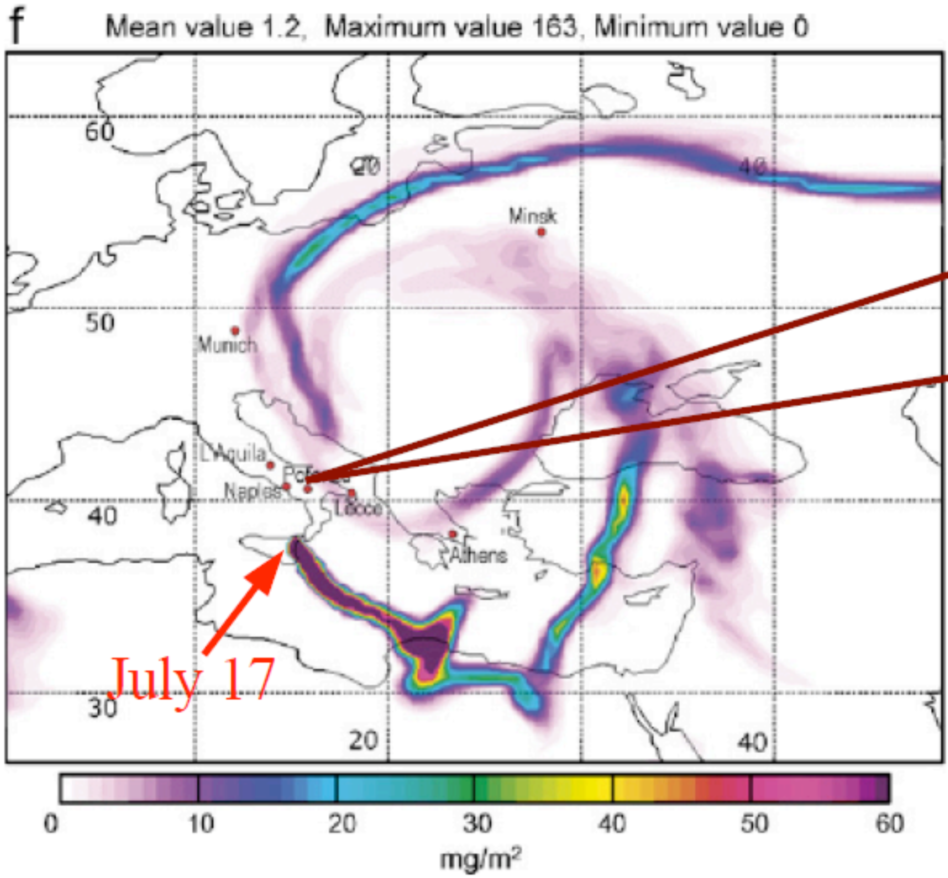
Lidar observation



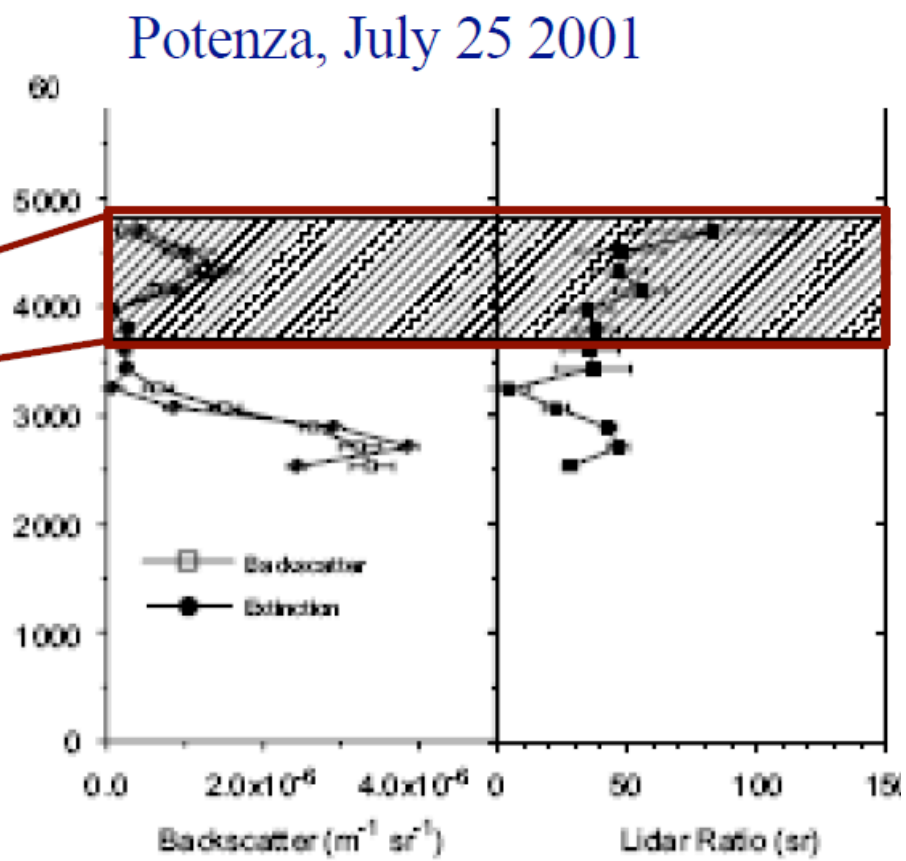
Wang et al., 2008

Volcanic eruptions (Etna 2001)

FLEXPART simulation

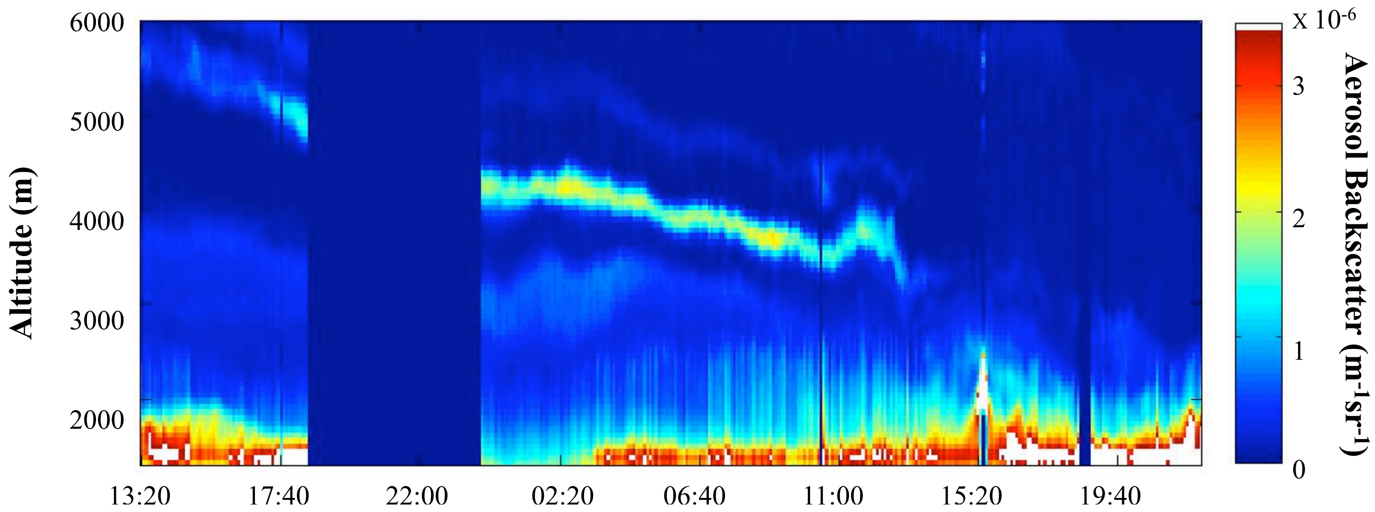


Lidar observation

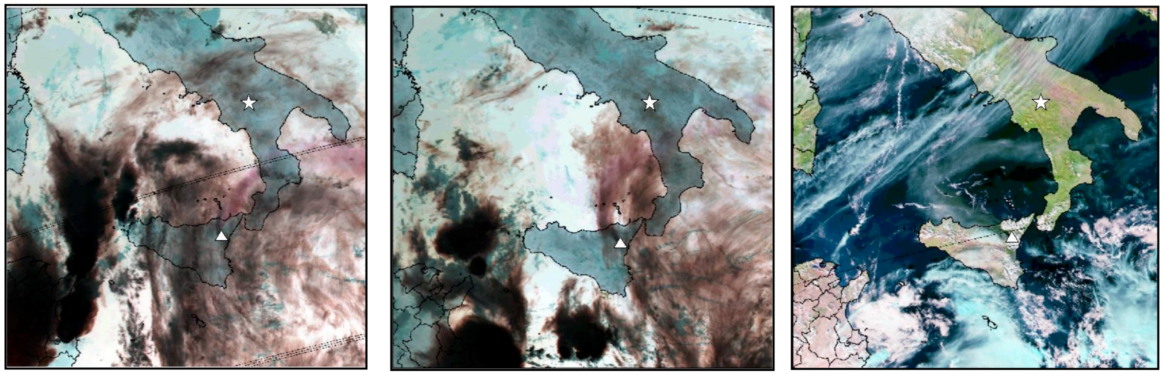


Wang et al., 2008

Volcanic eruptions (Etna 2002)



λ=532nm



1 Nov. 16:58 UT | 2 Nov. 00:50 UT | 2 Nov. 12:16 UT

AVHRR images

Pappalardo et al., 2004

The Eyjafjallajökull eruption

Picture courtesy: Magnús Tumi Guðmundsson

2006-2009 sismic activity in the area

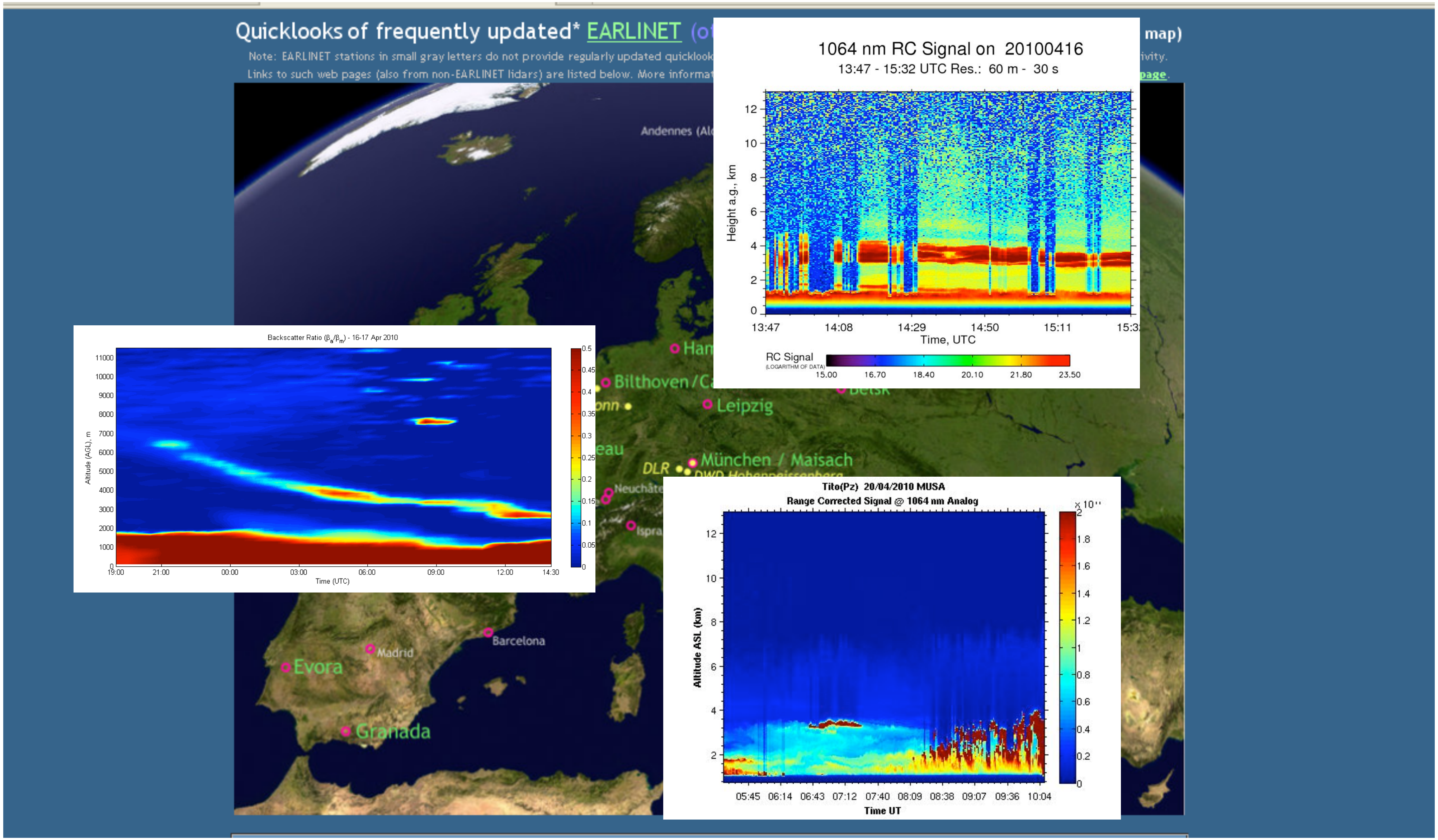
20 March 2010 –a first eruption started

14 April 2010 – explosive eruption with ash injection in the troposphere

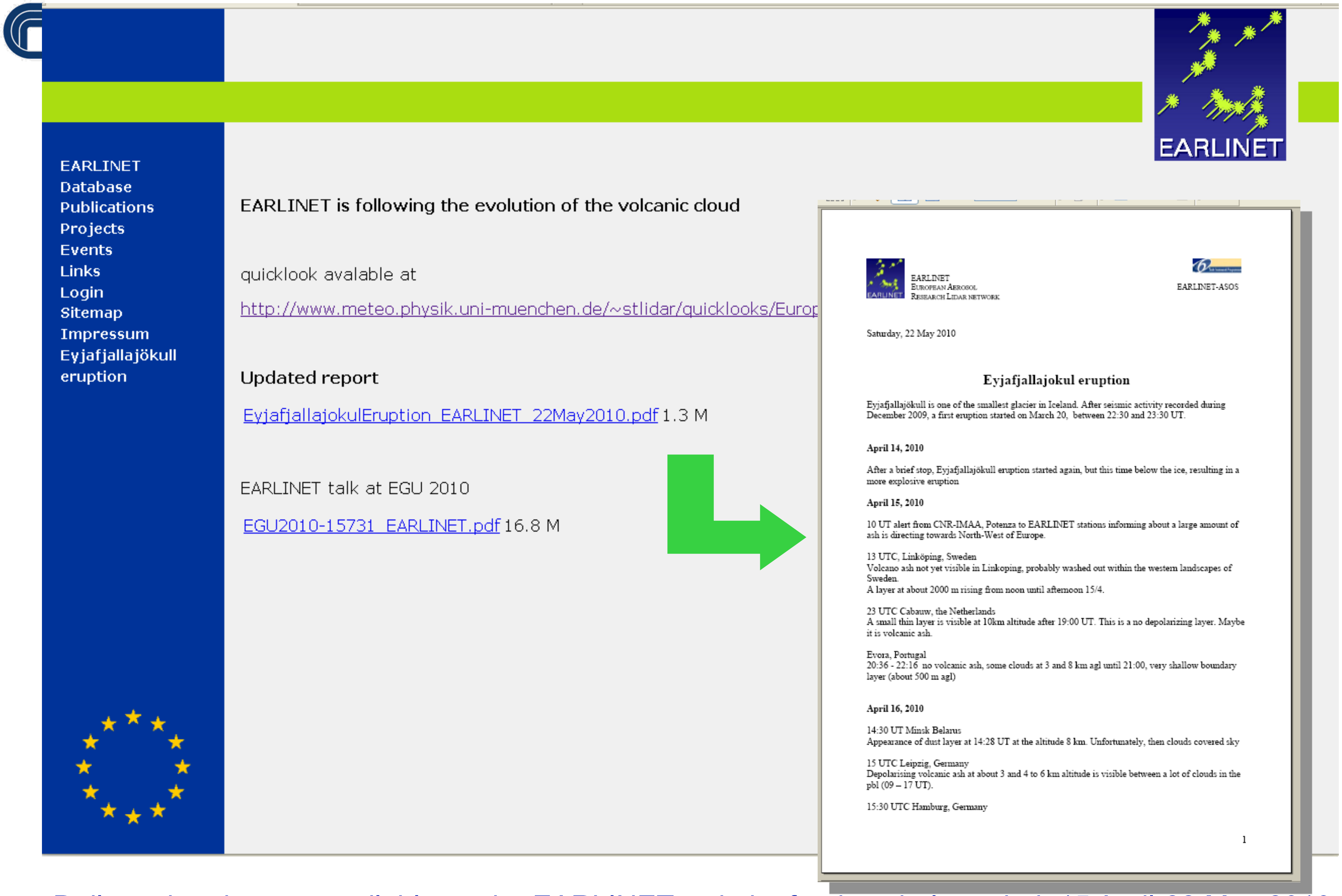
14 April – 23 May eruptive activity continues

24 May 2010 volcanic eruption is over

Almost continuous measurements from April 15 to May 22



Quicklook made available almost in near real time on the EARLINET website



EARLINET
EUROPEAN AEROSOL
RESEARCH LIDAR NETWORK

EARLINET-ASOS

Saturday, 22 May 2010

Eyjafjallajokul eruption

Eyjafjallajökull is one of the smallest glacier in Iceland. After seismic activity recorded during December 2009, a first eruption started on March 20, between 22:30 and 23:30 UT.

April 14, 2010

After a brief stop, Eyjafjallajökull eruption started again, but this time below the ice, resulting in a more explosive eruption

April 15, 2010

10 UT alert from CNR-IMAA, Potenza to EARLINET stations informing about a large amount of ash is directing towards North-West of Europe.

13 UTC, Linköping, Sweden
Volcano ash not yet visible in Linkoping, probably washed out within the western landscapes of Sweden.
A layer at about 2000 m rising from noon until afternoon 15/4.

23 UTC Cabauw, the Netherlands
A small thin layer is visible at 10km altitude after 19:00 UT. This is a no depolarizing layer. Maybe it is volcanic ash.

Evora, Portugal
20:36 - 22:16 no volcanic ash, some clouds at 3 and 8 km agl until 21:00, very shallow boundary layer (about 500 m agl)

April 16, 2010

14:30 UT Minsk Belarus
Appearance of dust layer at 14:28 UT at the altitude 8 km. Unfortunately, then clouds covered sky

15 UTC Leipzig, Germany
Depolarising volcanic ash at about 3 and 4 to 6 km altitude is visible between a lot of clouds in the pbl (09 – 17 UT).

15:30 UTC Hamburg, Germany

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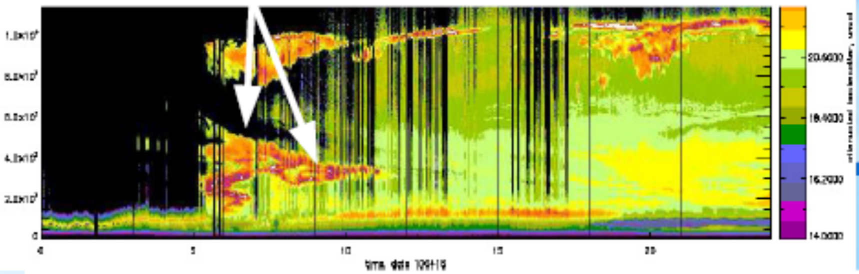
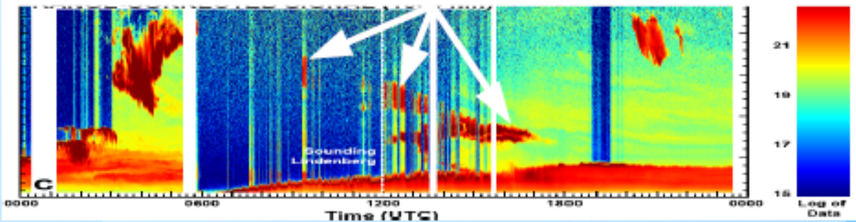
Daily updated report available on the EARLINET website for the whole period 15 April-22 May 2010

Arrival of the ash plume over Europe

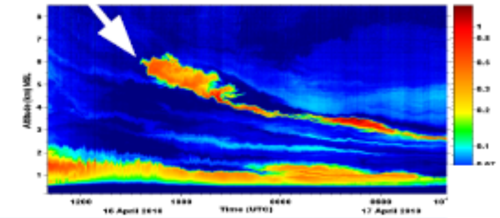
Hamburg, morning of 16 April



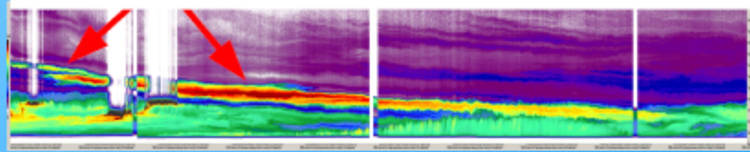
Leipzig, late morning of 16 April



Palaiseau, afternoon of 16 April



Munich, night 16-17 April



first detection of the ash layer over Hamburg in the late evening of April 15 at about 10 km height

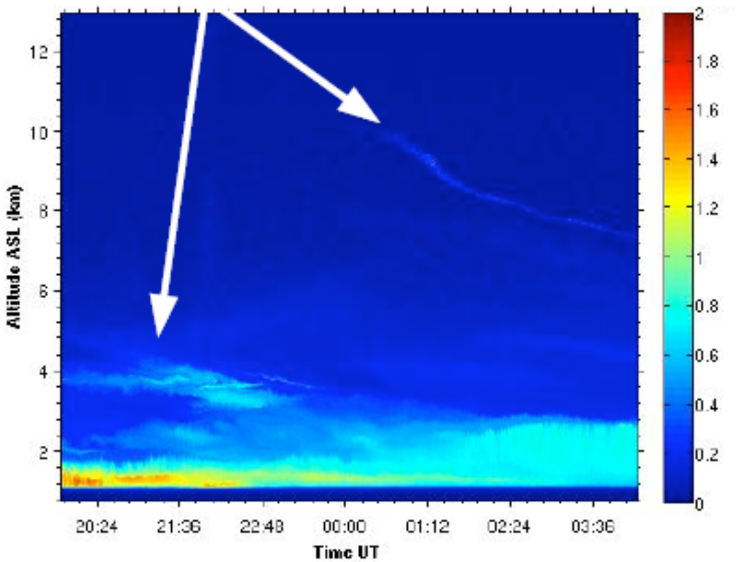
ash plume crossed central Europe on April 16-17

16 April 00 | 1200 | 17 April 00 | 1200 | time

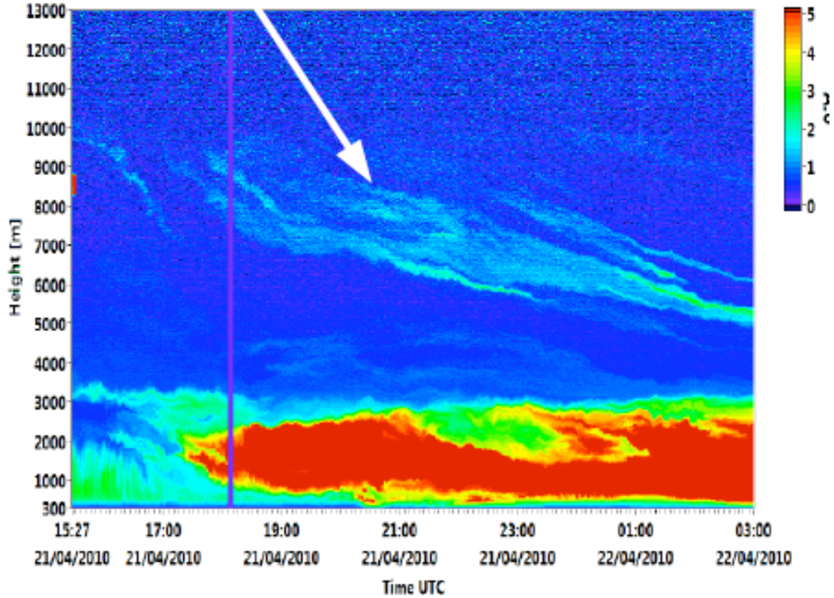
The Eyjafjallajökull eruption – long range transport over Europe

Transport over the Alps

Potenza, 21 April 2010

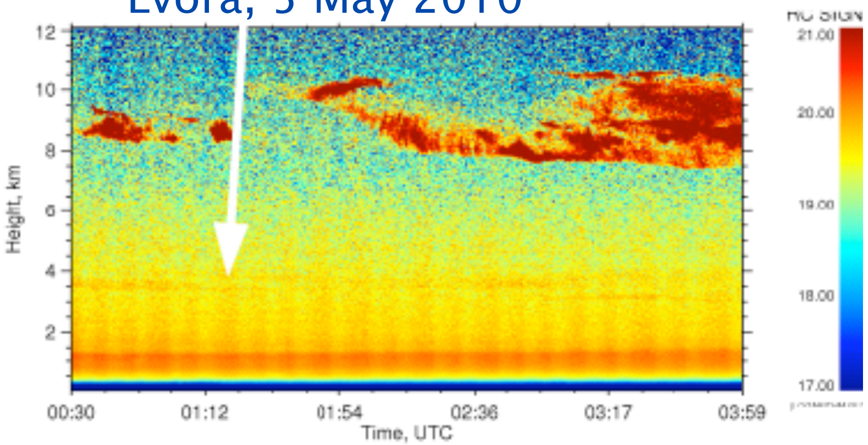


Athens, 21 April 2010



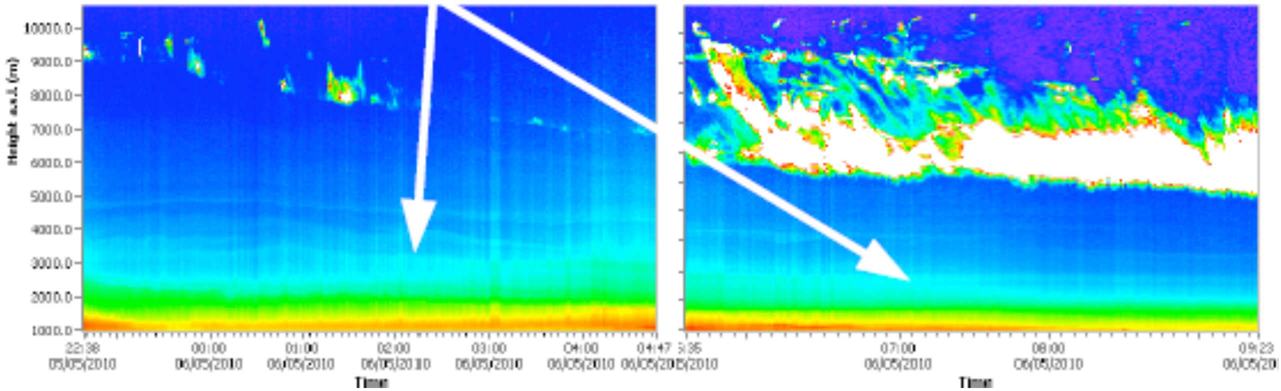
The Eyjafjallajökull eruption – long range transport over Europe

Evora, 5 May 2010



Volcanic plume was observed over Portugal and Spain (6 May) and then over Italy (8 May) and Greece (10 May). Volcanic plume was then observed again over Southern Germany on 11 May.

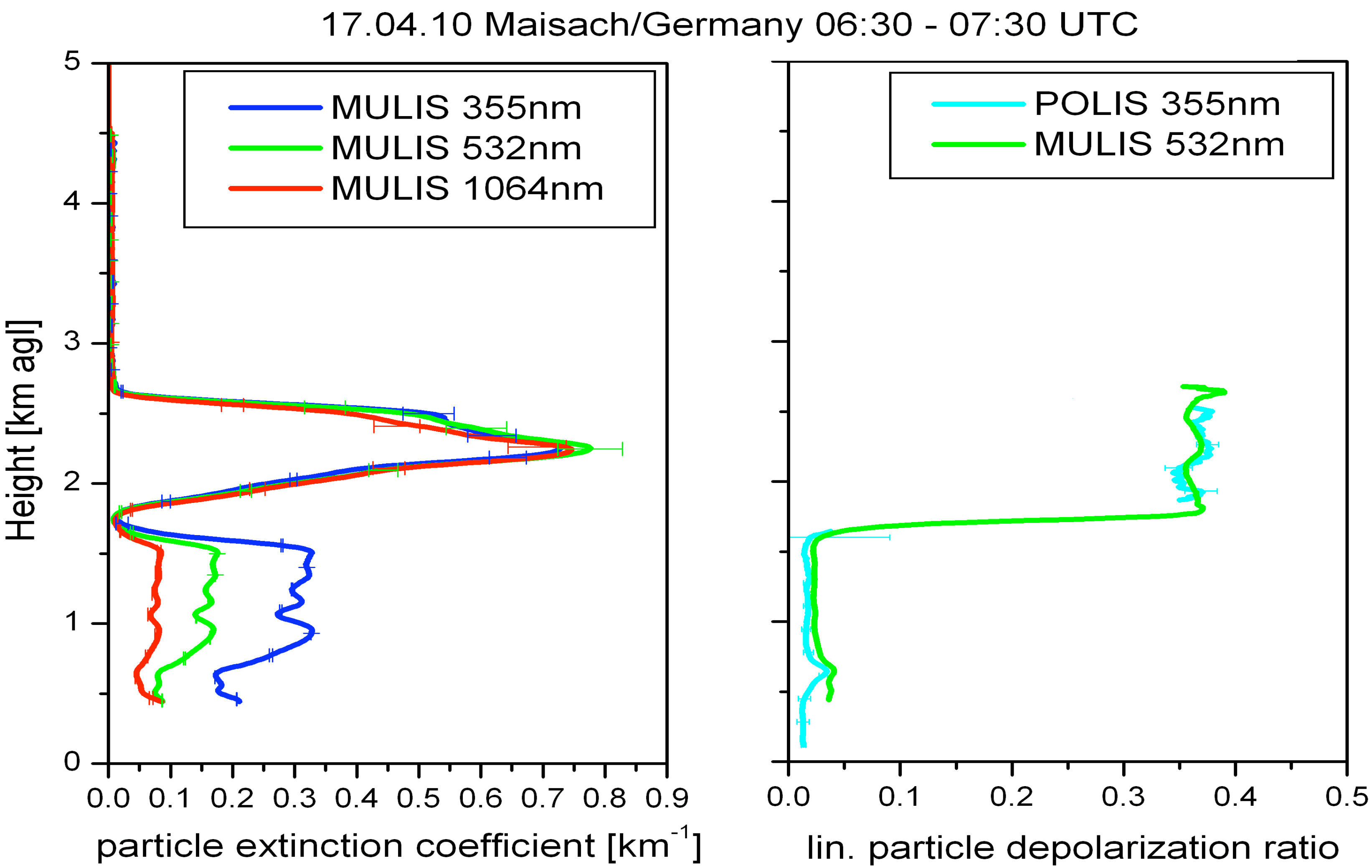
Granada, 6 May 2010



Volcanic layers were observed also in late May: 16 over Spain, Italy and Greece until 20 May.

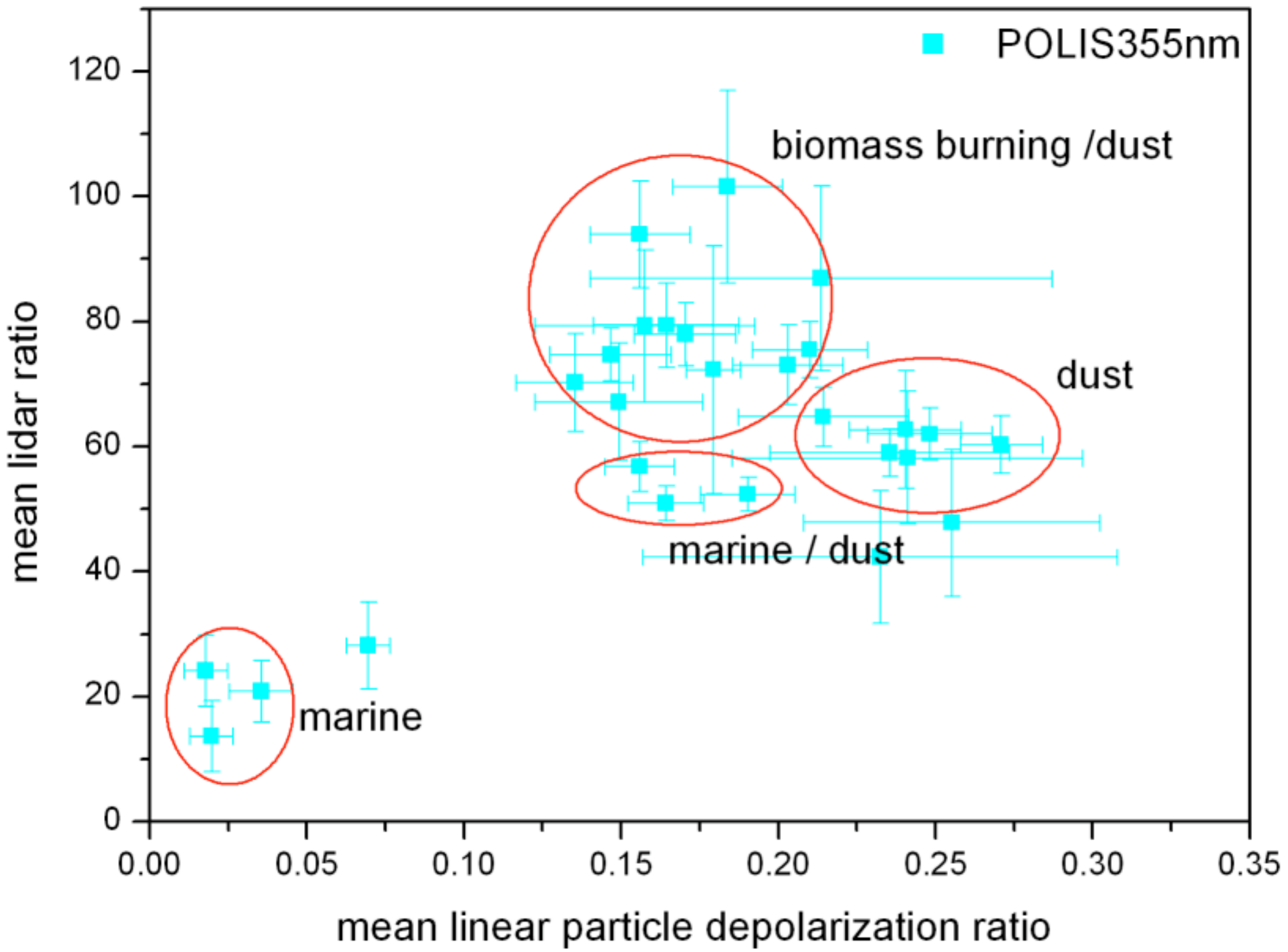
Volcanic layers over Central Europe were observed until 19 May.

Optical characterization



Courtesy of S. Gross et al. (University of Munich)

Aerosol classification



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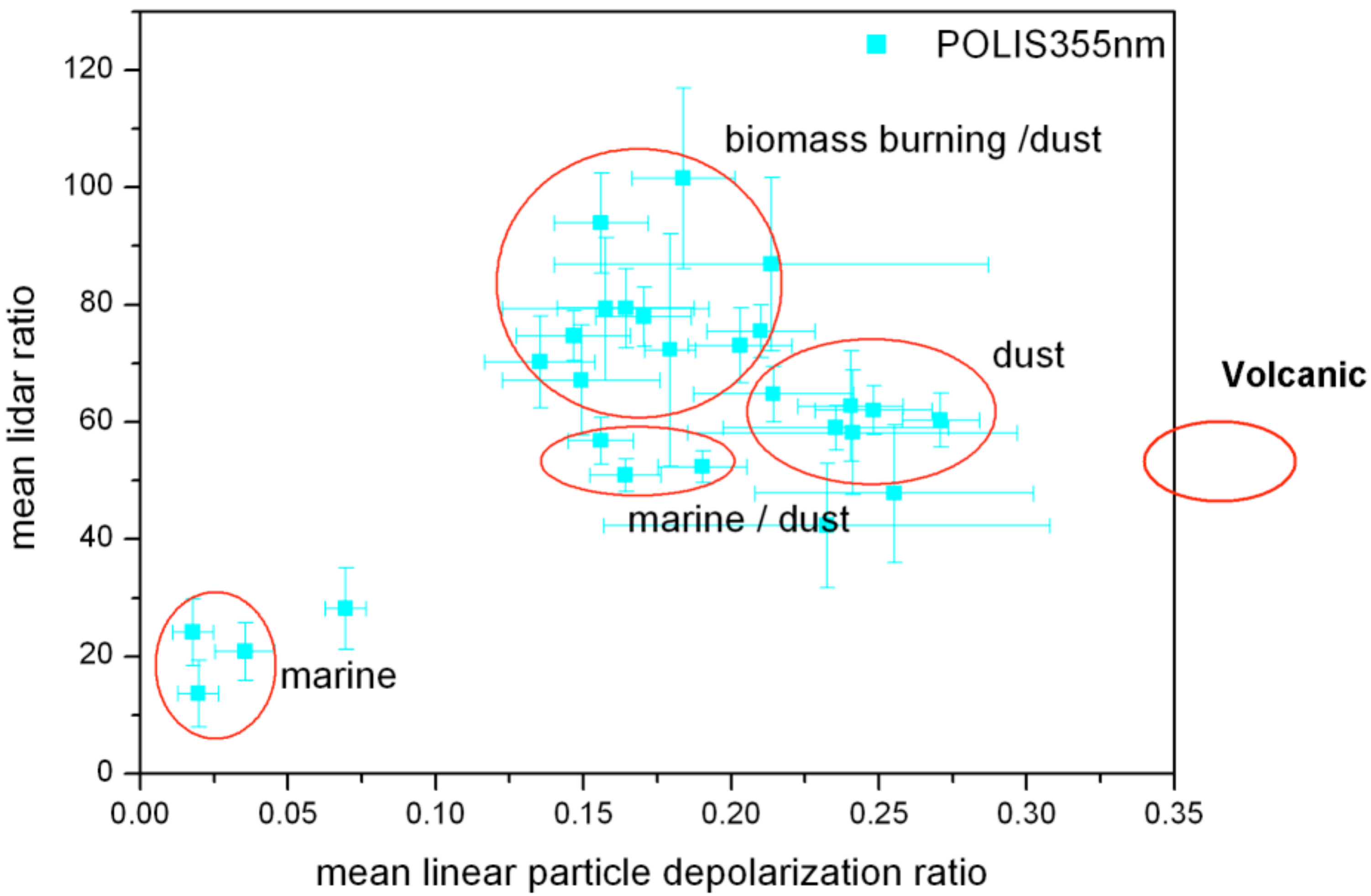
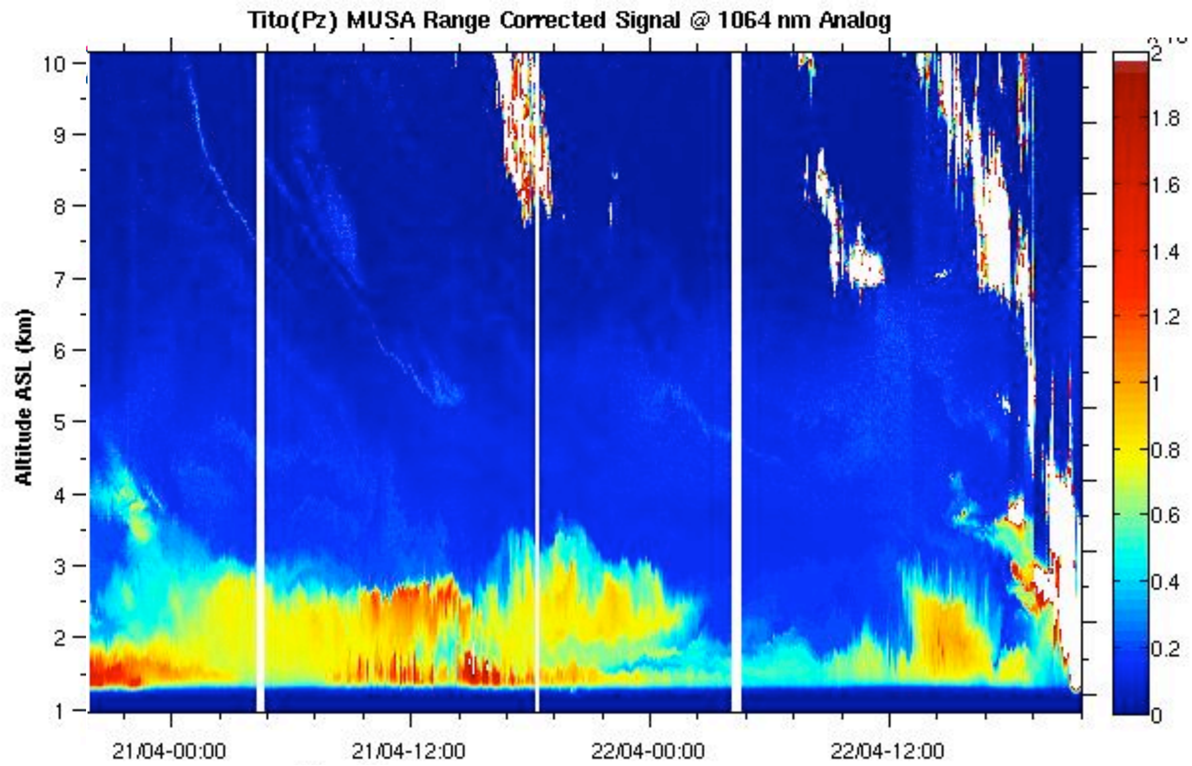
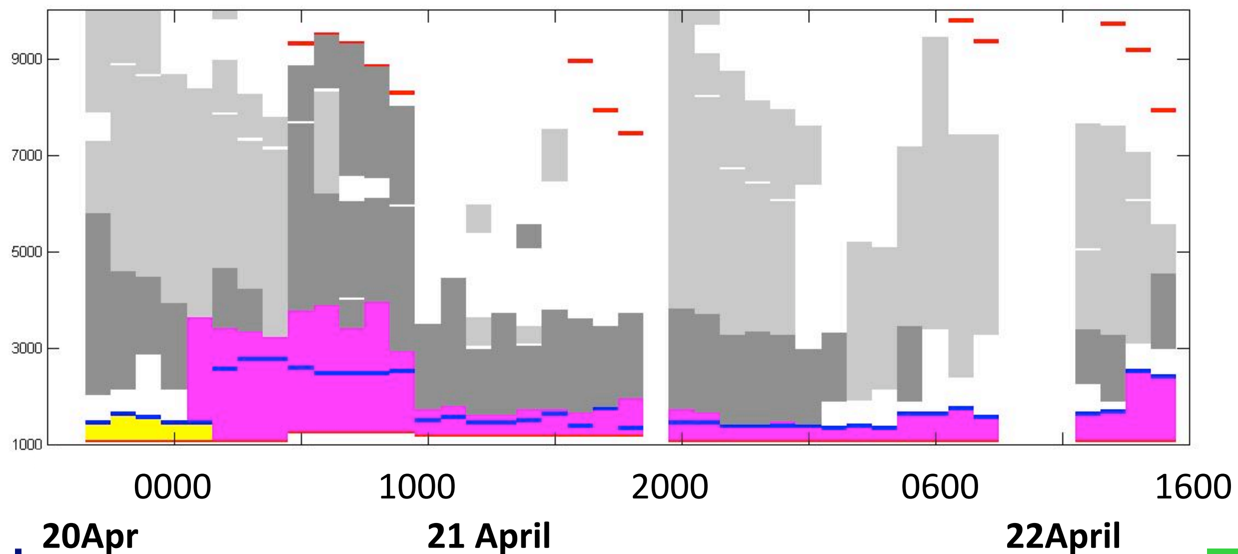
Aerosol classification



Courtesy of S. Gross et al. (University of Munich)

Aerosol mask





Minimum and maximum investigated altitudes

PBL top height

PBLAerosol

Mixed aerosol

Volcanic aerosol

b1064>2 e-6 m-1 sr-1

5e-8<b1064<2 e-6 m-1 sr-1

b1064<5 e-8 m-1 sr-1

Cloud/cirrus

Desert dust

Forest Fires Aerosol

UnknownAerosol

Comparison with models

Etna 2002: BOLAM Model, *Villani et al., JGR 2006*

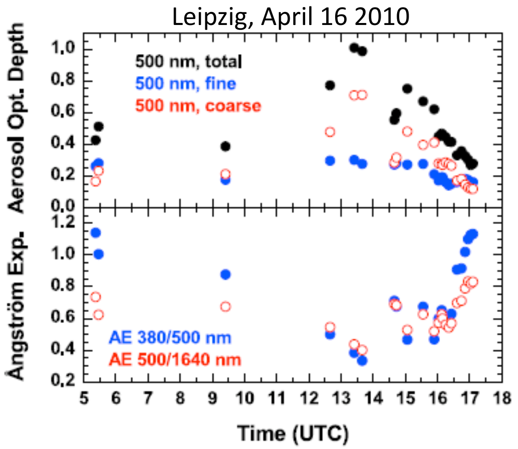
Sarichev 2009: HadGEM2A Model, *D'Amico et al., ILRC 2010*

Eyjafjöll 2010: CMAQ Model, *Matthias et al., IAC 2010*

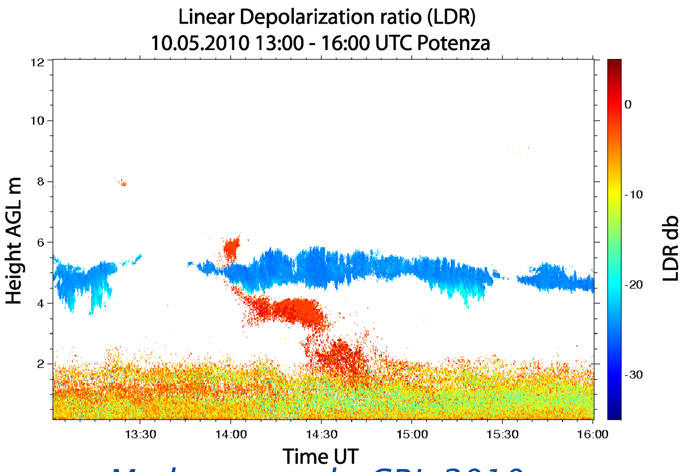
Synergies instruments/platforms

Instruments:

Sunphotometer, in-situ, radar, …



Ansmann et al., GRL 2010



Madonna et al., GRL 2010

Platforms:

Ground-based, airborne, satellite

Hypothesis : ground-based lidar distributed network

Ceilometers or simple backscatter lidar (one wavelength) for qualitative high resolution backscatter, close to the source

Simple backscatter lidar (+ depol) more operational distributed in a dense network (mid - far distance).

Advanced lidar systems (single wavelength Raman lidar + depol) are needed for calibrated optical profiles.

Most advanced multiwavelength Raman lidar as core sites for calibration, aerosol typing and microphysical inversion.

We have to better explore sinergies with ancillary instruments (sun-photometers, radar, in-situ, etc.) and with different platforms

The way forward: action items

Improve information exchange (needs, potential)

Define required quantities (products, resolution, range, accuracy)

Define required infrastructure (specs, operator, quality control)

Collect data from the Eyjafjallajökull event (data sets, models, initiate research)

Strengthen research activities (mass conversion, microphysical inversion, model evaluation, integration with in-situ, airborne, satellite observations)

…. just to name a few