Characterization of volcanic aerosol within EARLINET-ASOS

Ina Mattis

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Volcanic aerosol

- In the tropopause region and stratosphere
  - North Pacific ring of fire 2008-2009
- In the troposphere
  - Etna 2001-2002
  - Eyjafjöll 2010
- EARLINET data for modelling studies

Volcano Eruptions in the North Pacific Region 2008-2009

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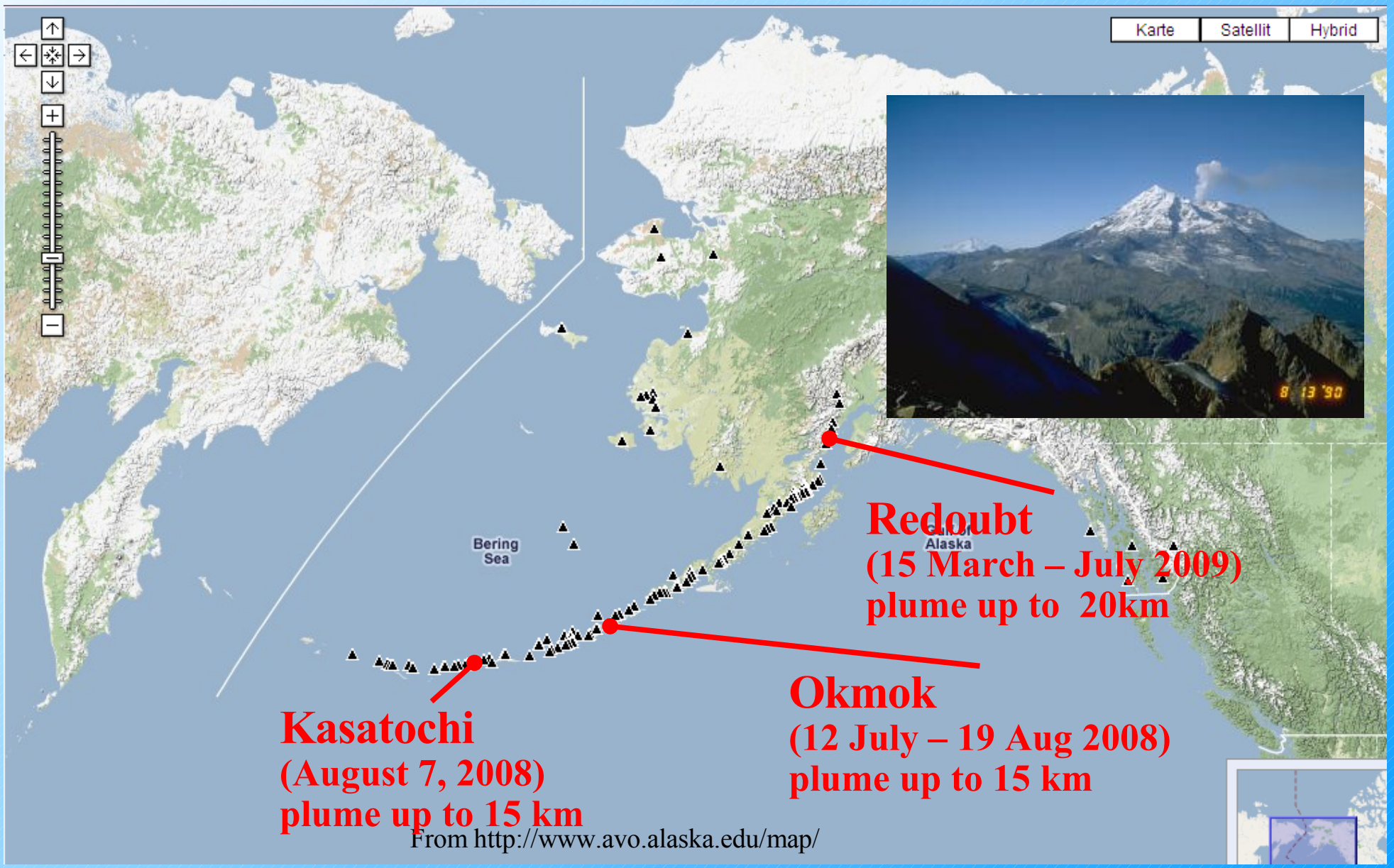
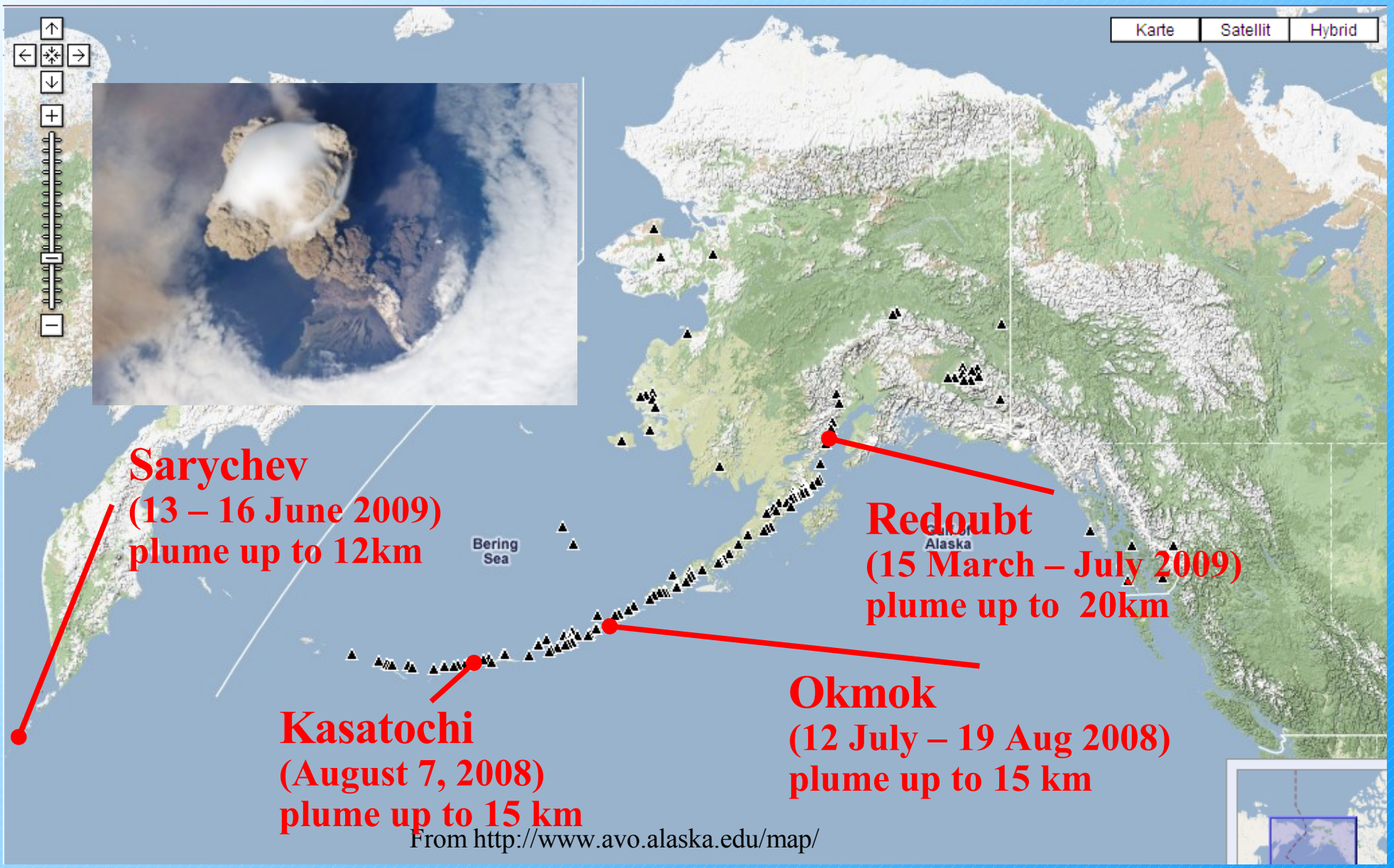
From http://www.avo.alaska.edu/map/

Volcano Eruptions in the North Pacific Region 2008-2009



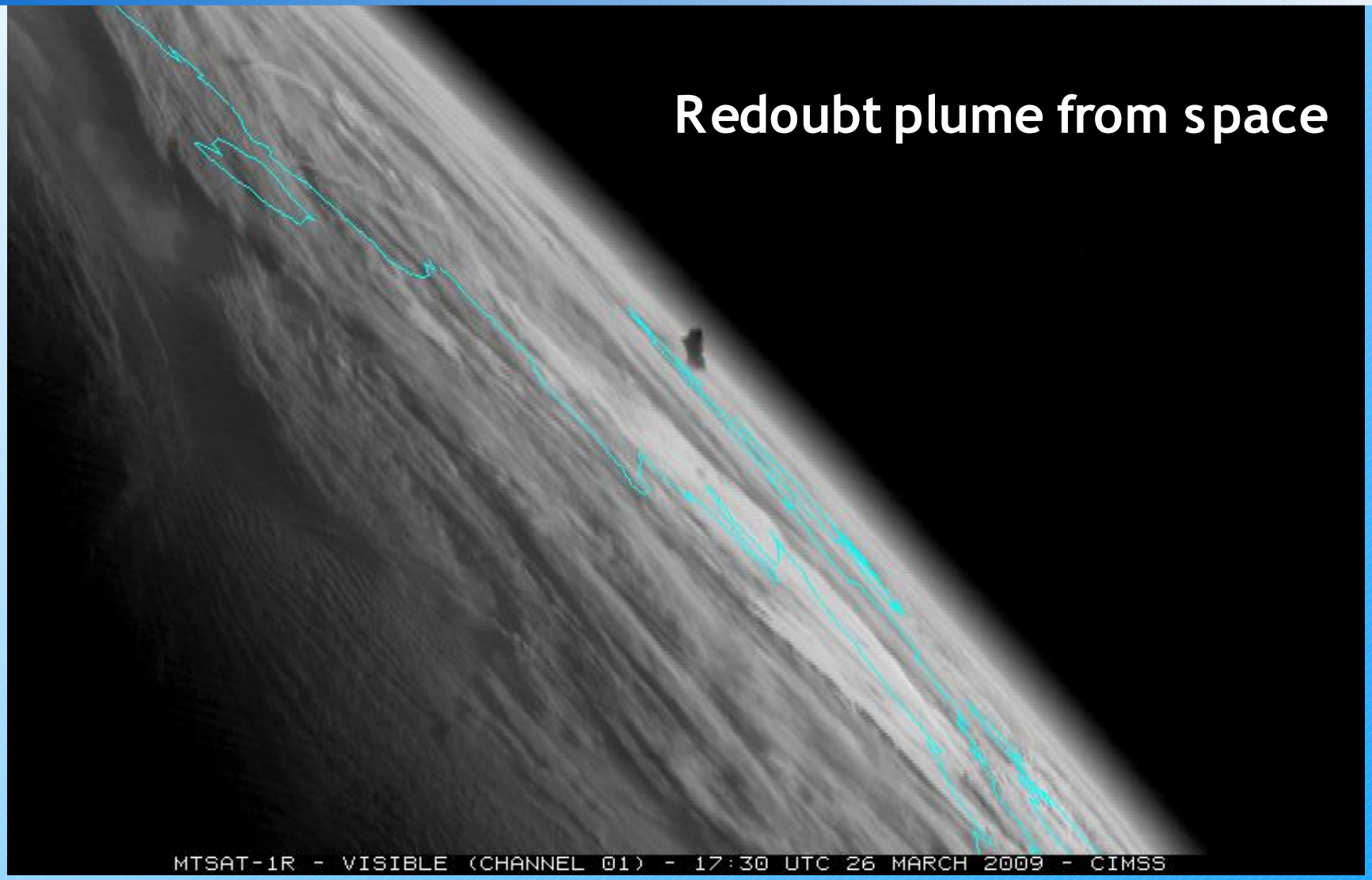
From http://www.avo.alaska.edu/map/

Volcano Eruptions in the North Pacific Region 2008-2009



From http://www.avo.alaska.edu/map/

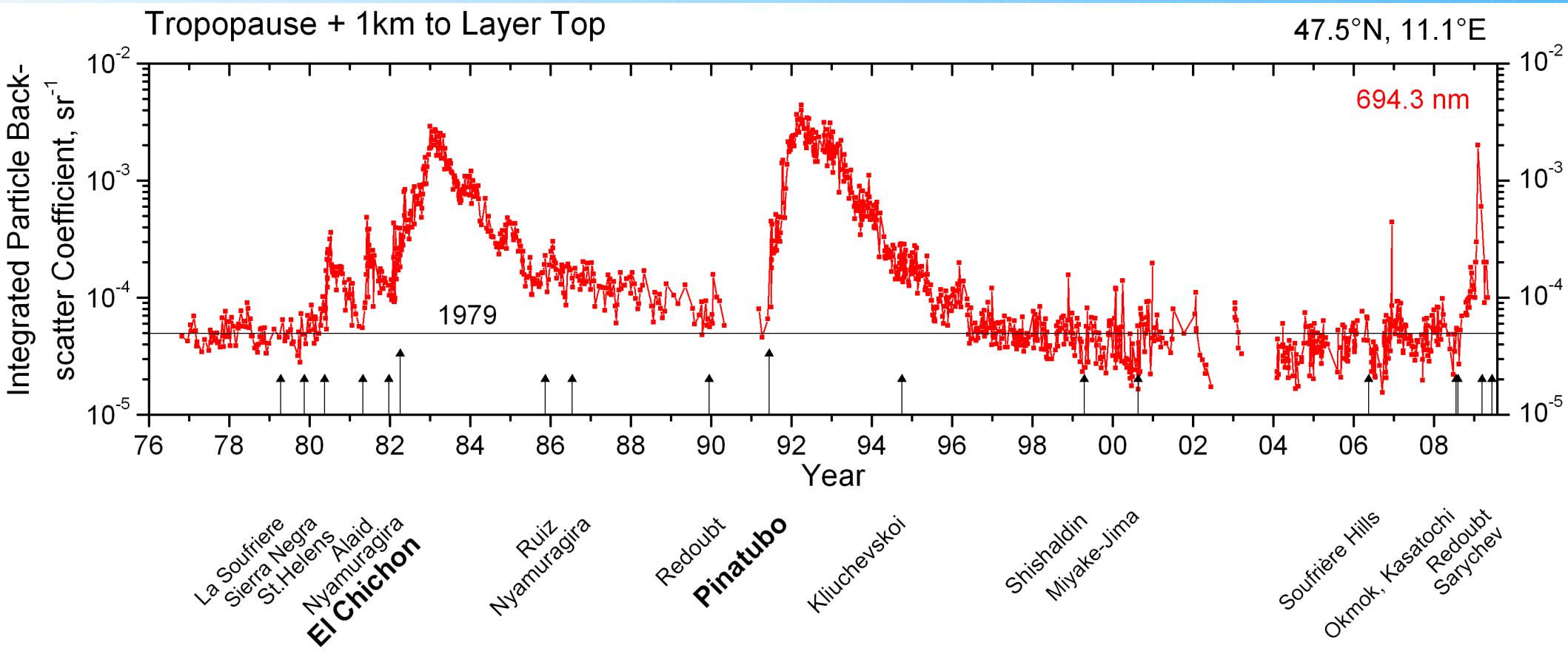
Top height of an volcanic plume



Ash cloud seen in the geostationary MTSAT data, courtesy of the National Weather Service, processed by the Cooperative Institute for Meteorological Satellite Studies at the University of Wisconsin-Madison . We are at the extreme edge of the view for the satellite which is over the equator in Asia.

Picture Date: March 26, 2009 17:30:00 UTC
Image Creator: Dehn, Jonathan; taken from http://www.avo.alaska.edu

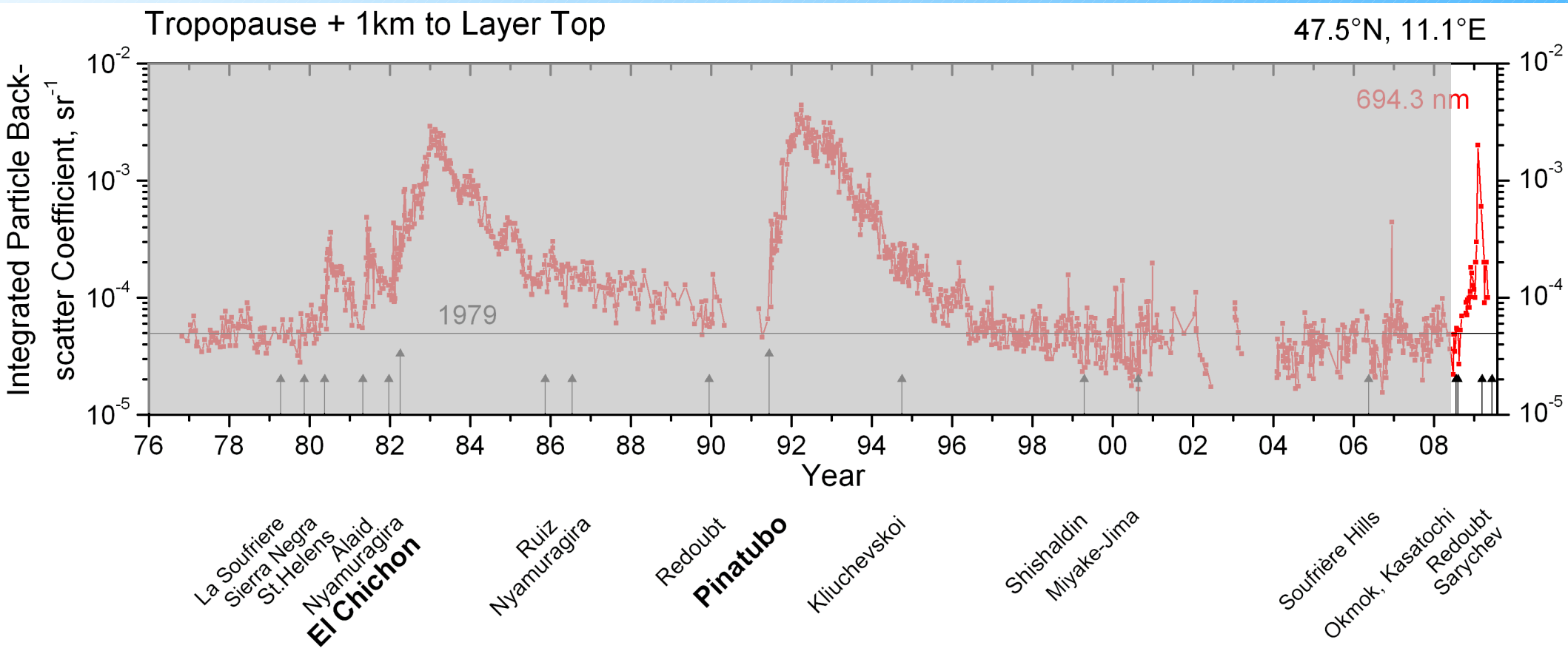
Stratospheric aerosol load



Long-term observations of stratospheric aerosol at Garmisch-Partenkirchen

see: Trickl et al. ILRC 2010

Stratospheric aerosol load



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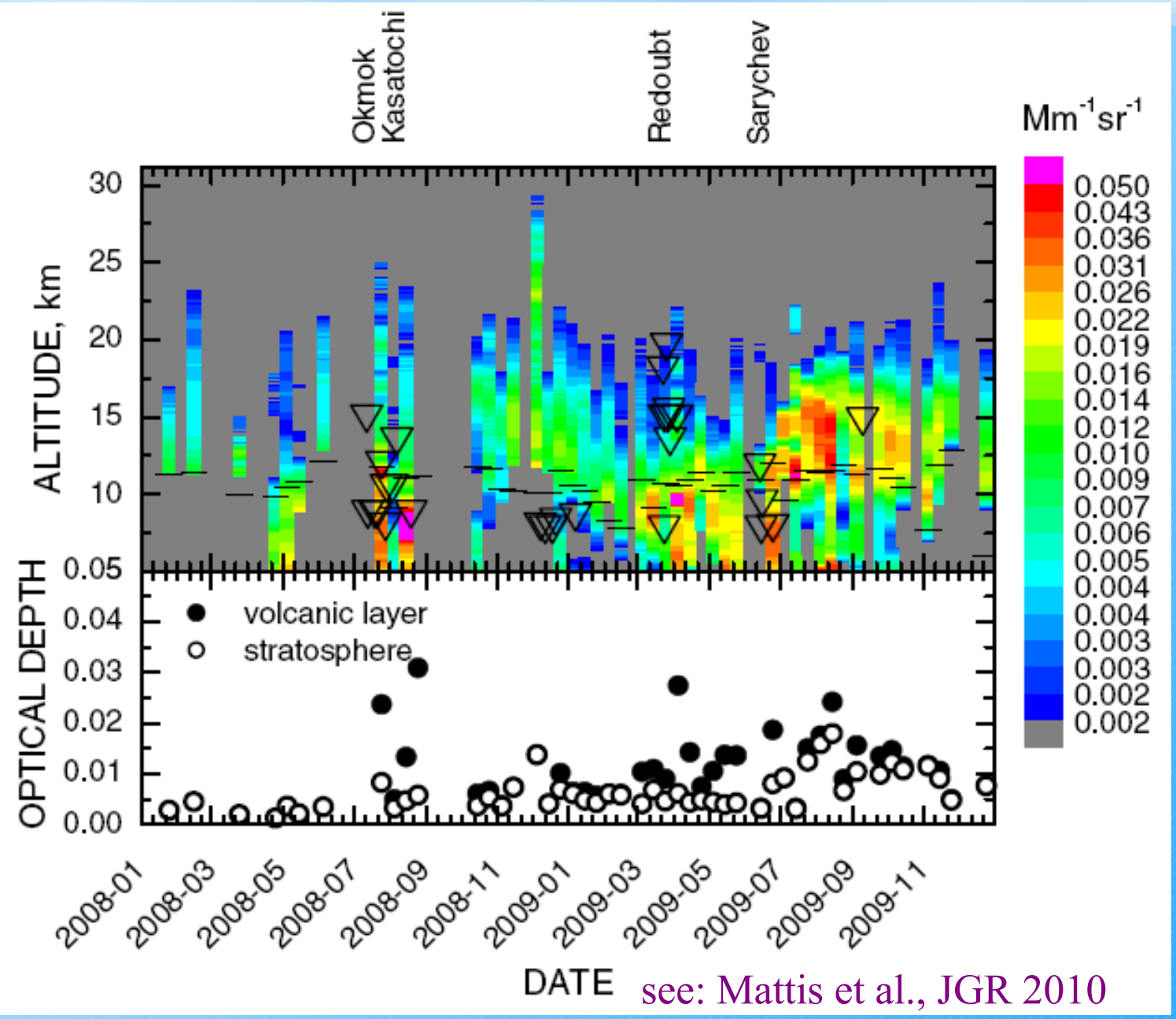
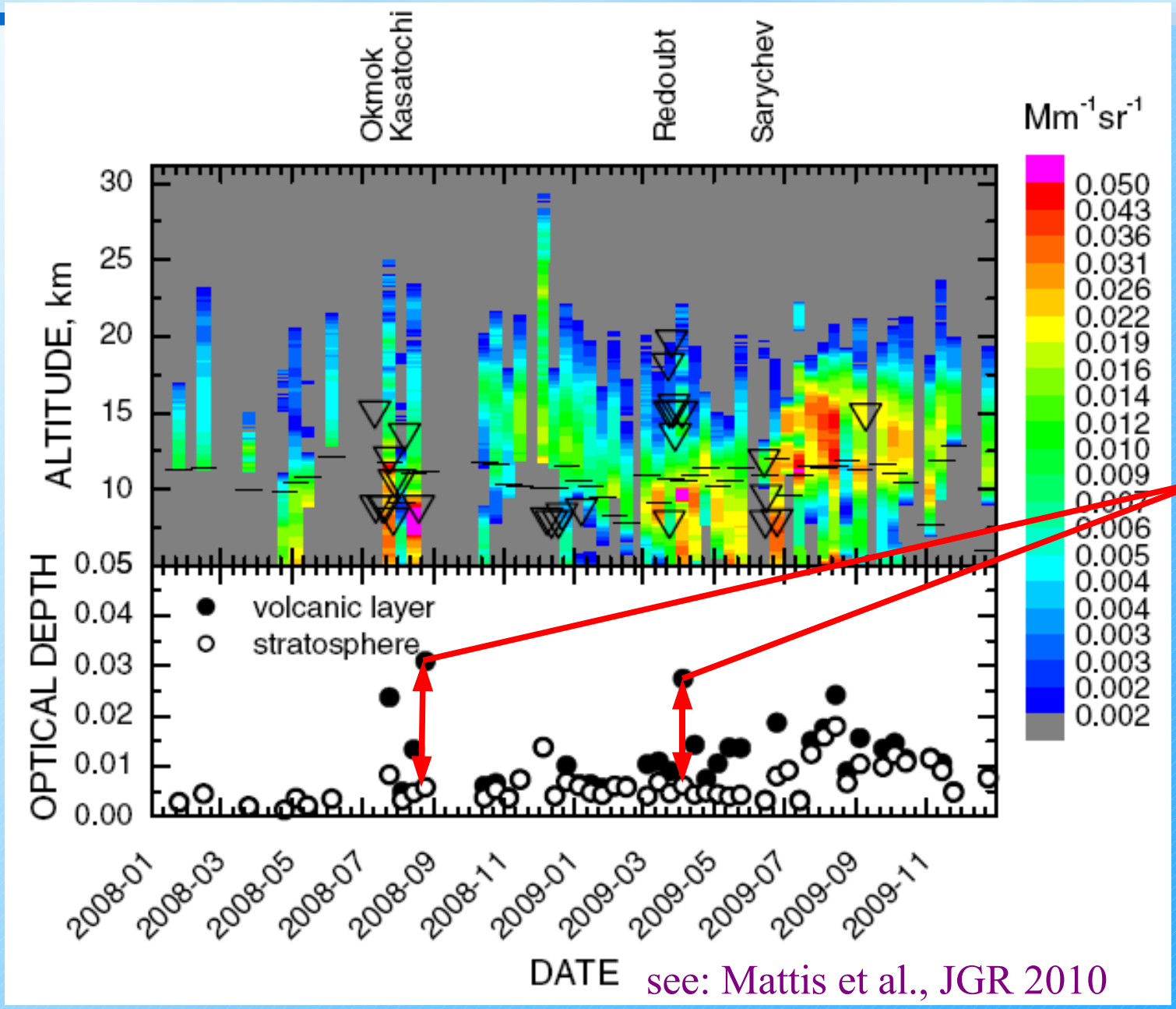
Time Series: backscatter profiles at 1064 nm over Leipzig



see: Mattis et al., JGR 2010

Time Series: backscatter profiles at 1064 nm over Leipzig



maximum OD in tropopause region

see: Mattis et al., JGR 2010

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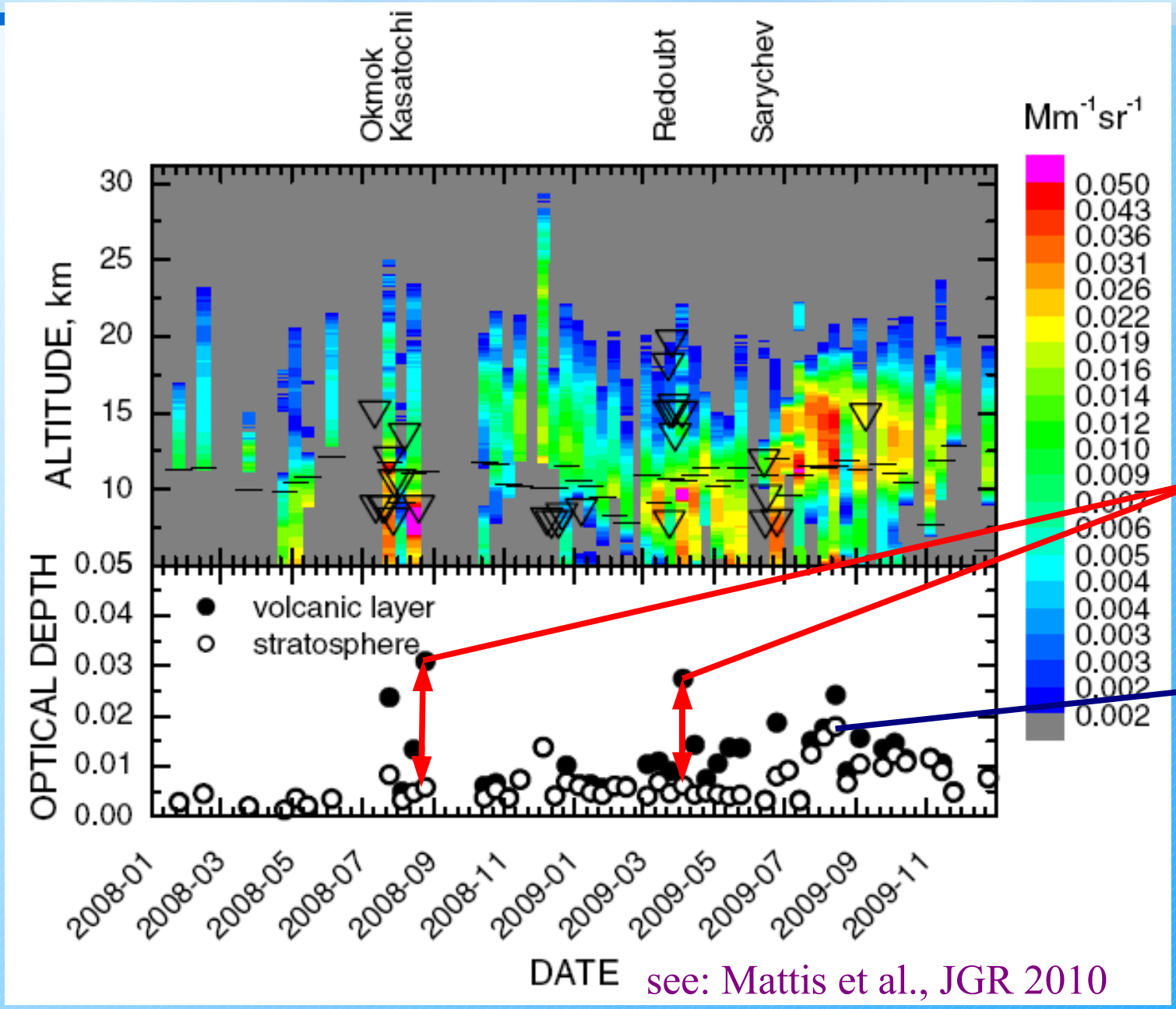


see: Mattis et al., JGR 2010

maximum OD in tropopause region

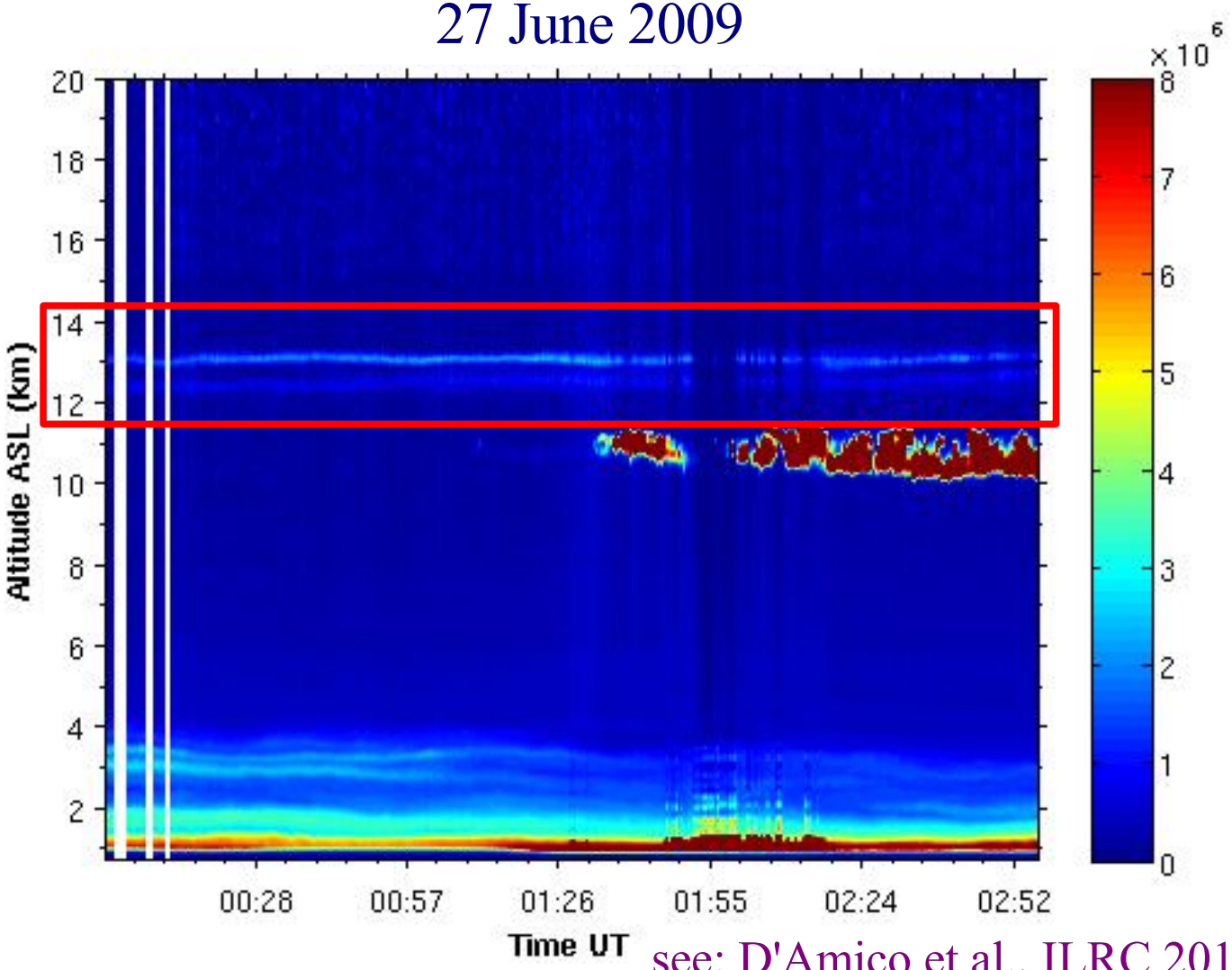
maximum OD in stratosphere ≈ 0.02 (532nm)

↕

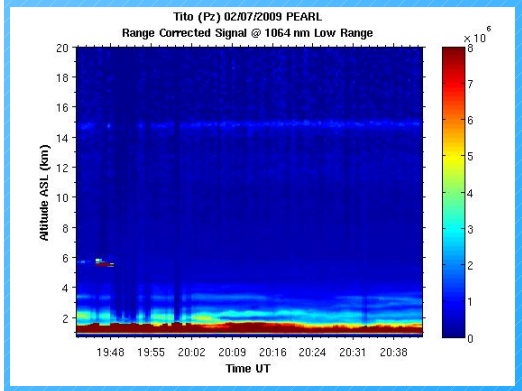
≈ 0.2 (500nm) after Pinatubo

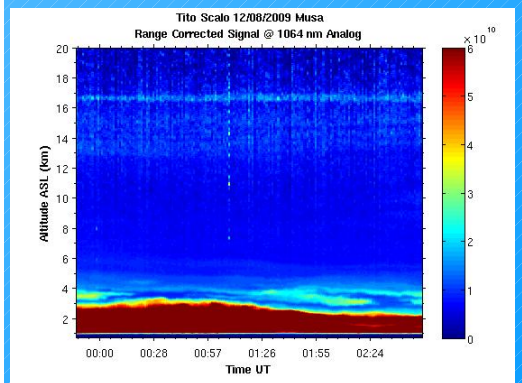
Sarychev plume over Potenza

27 June 2009



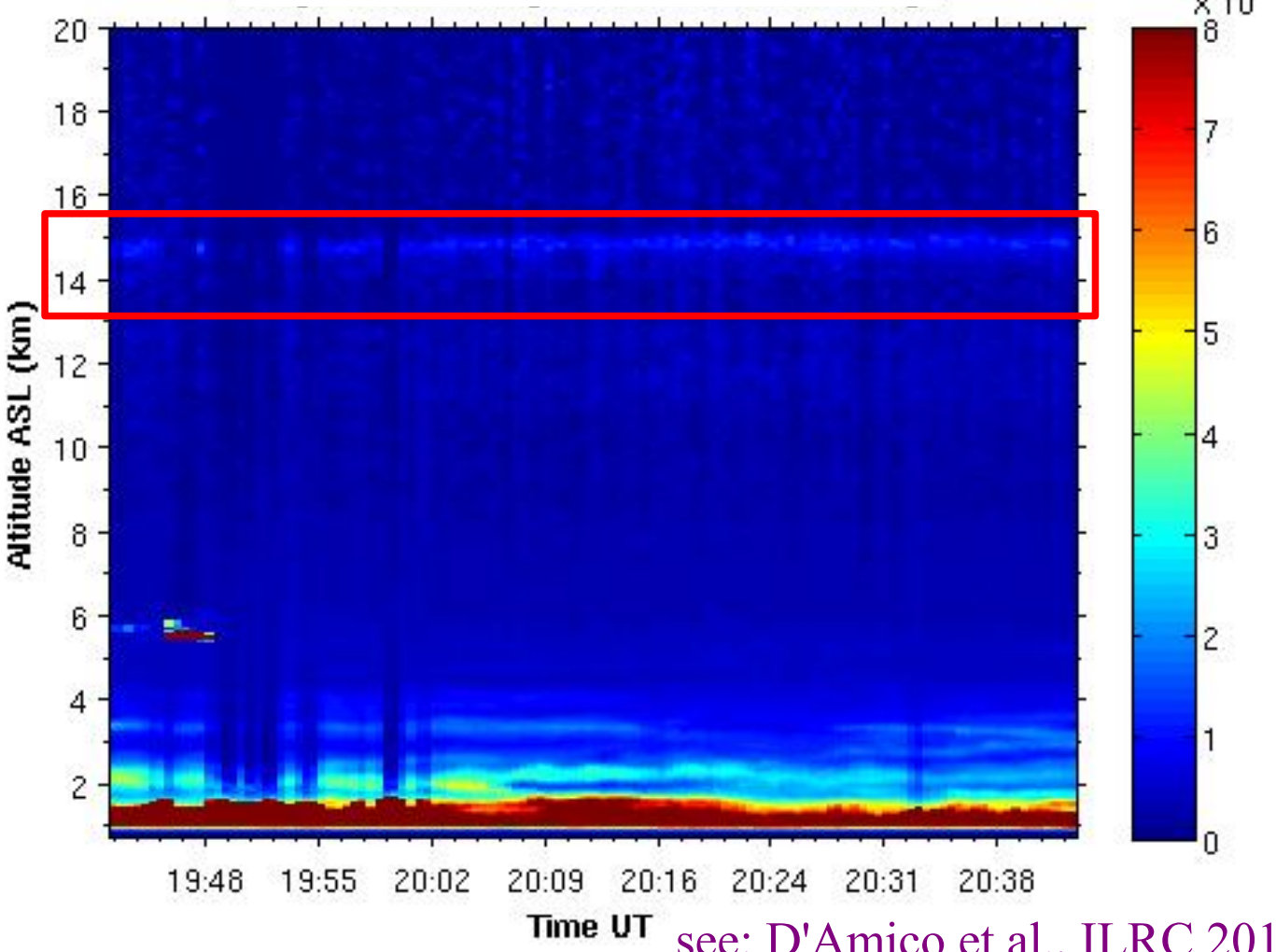
see: D'Amico et al., ILRC 2010



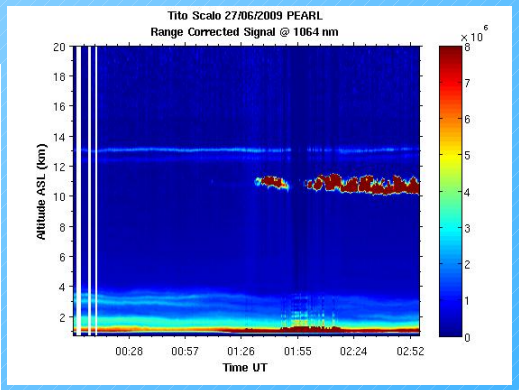


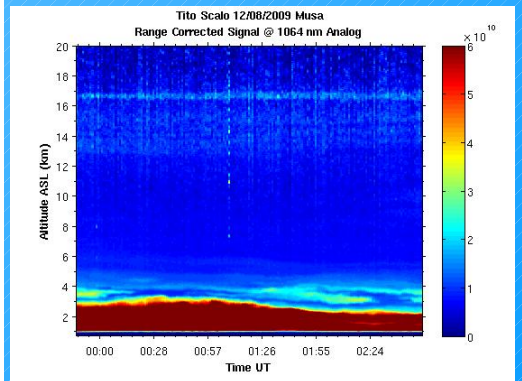
Sarychev plume over Potenza

2 July 2009



see: D'Amico et al., ILRC 2010





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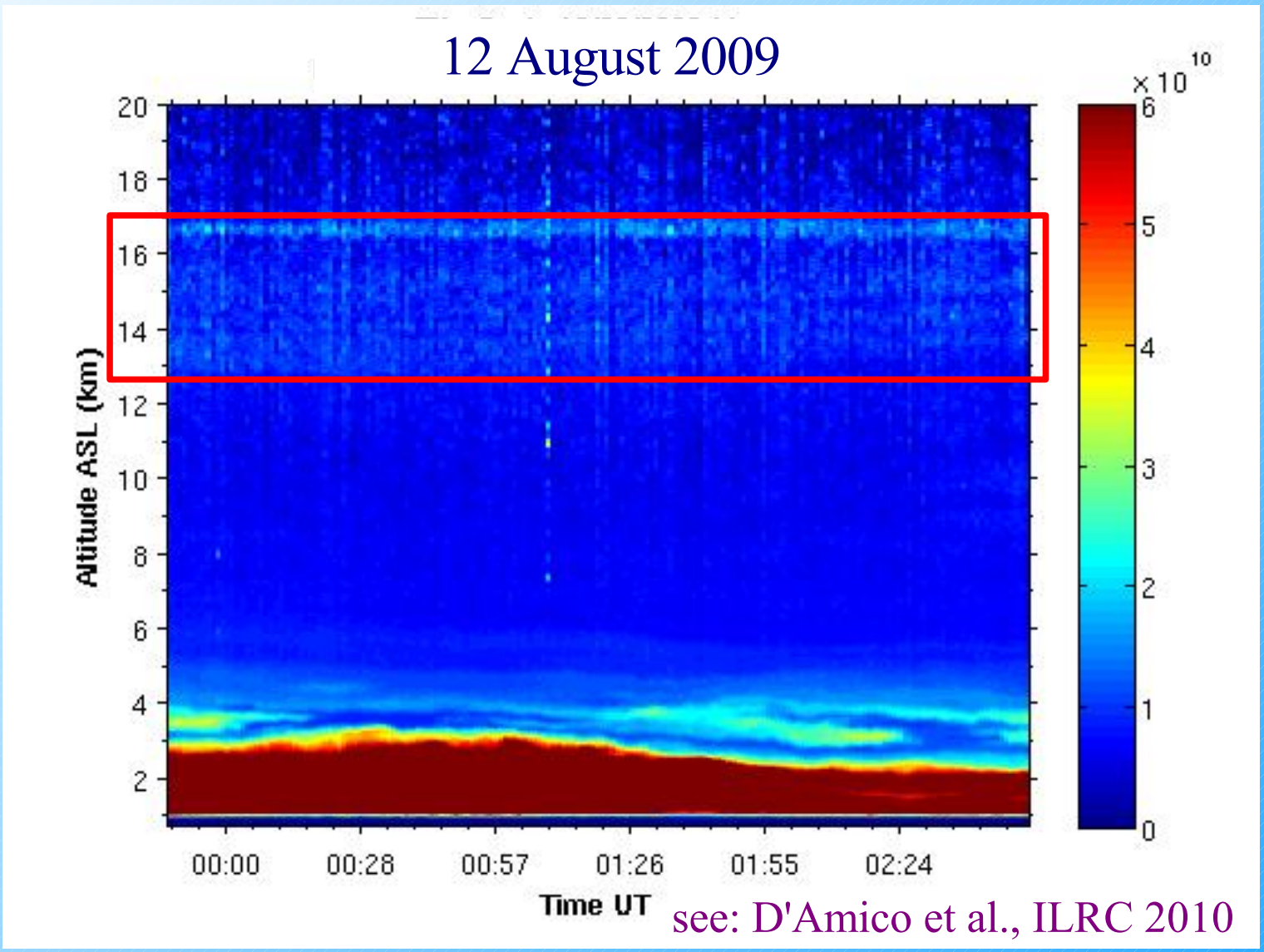

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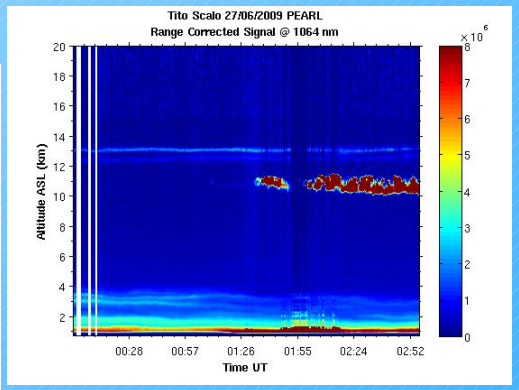
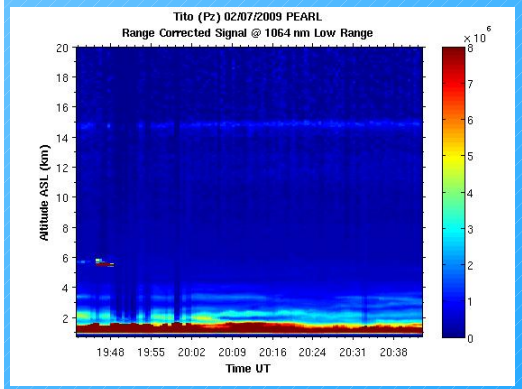
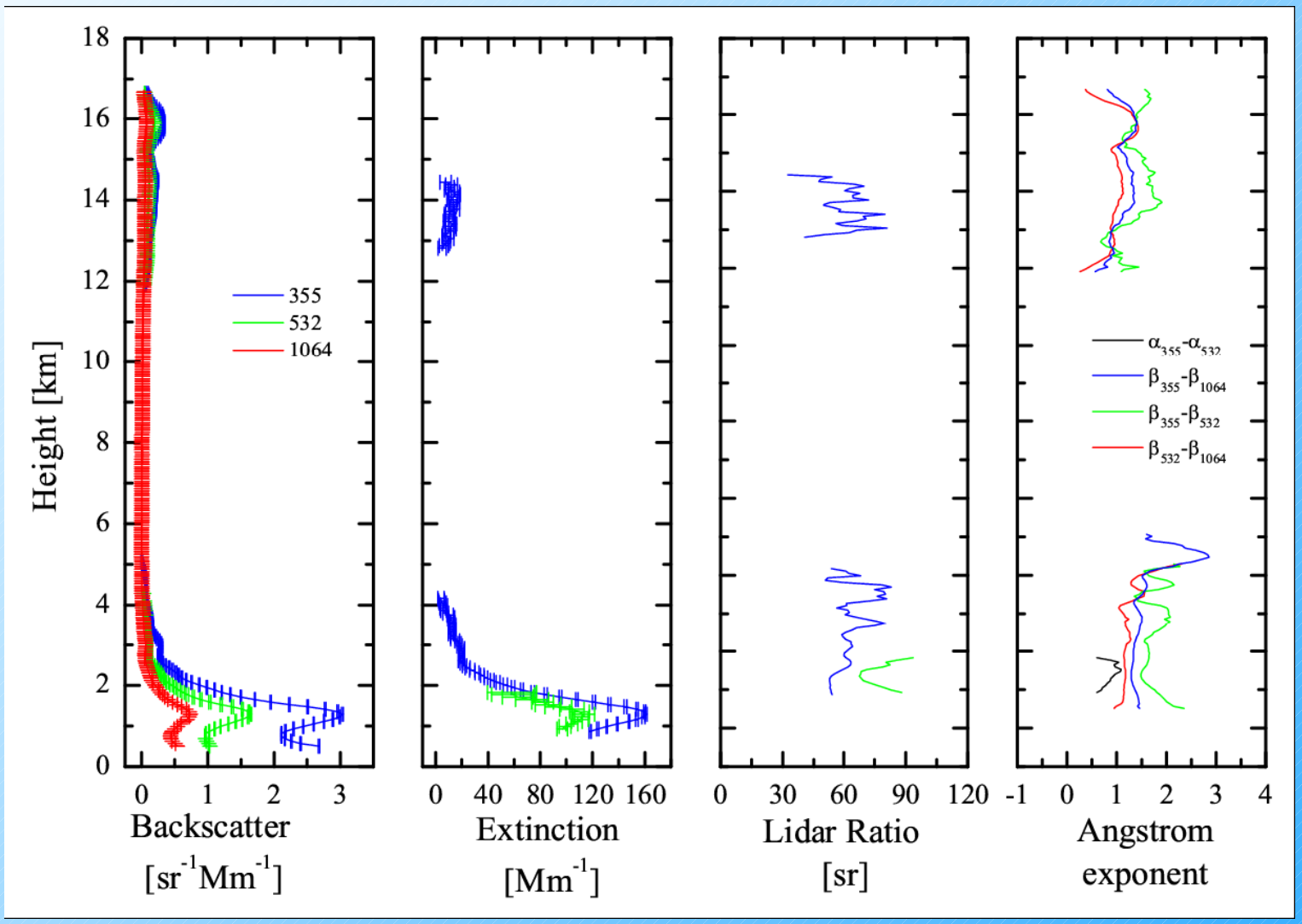
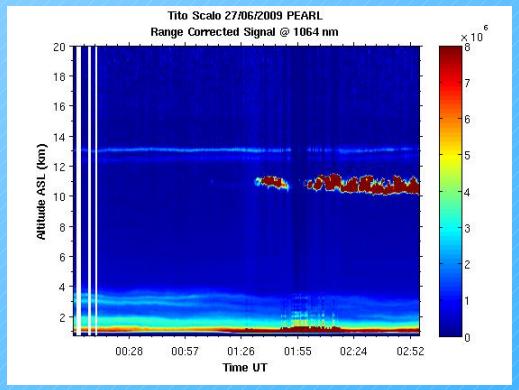
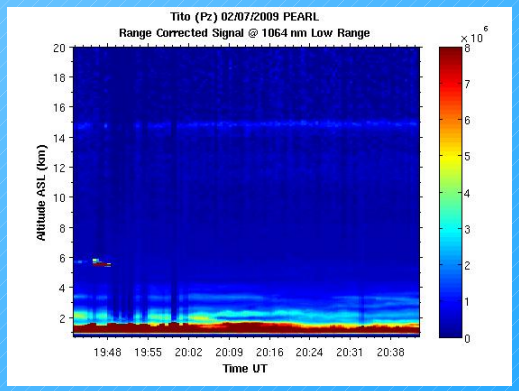


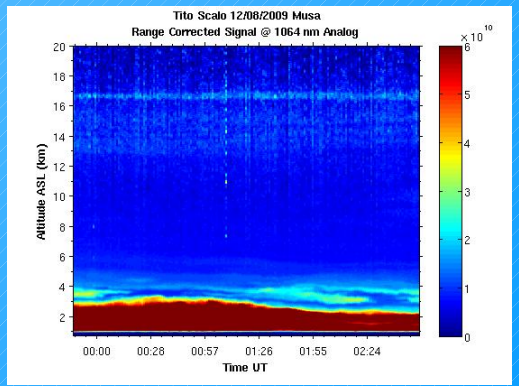


Sarychev plume over Potenza, 12th Aug 09









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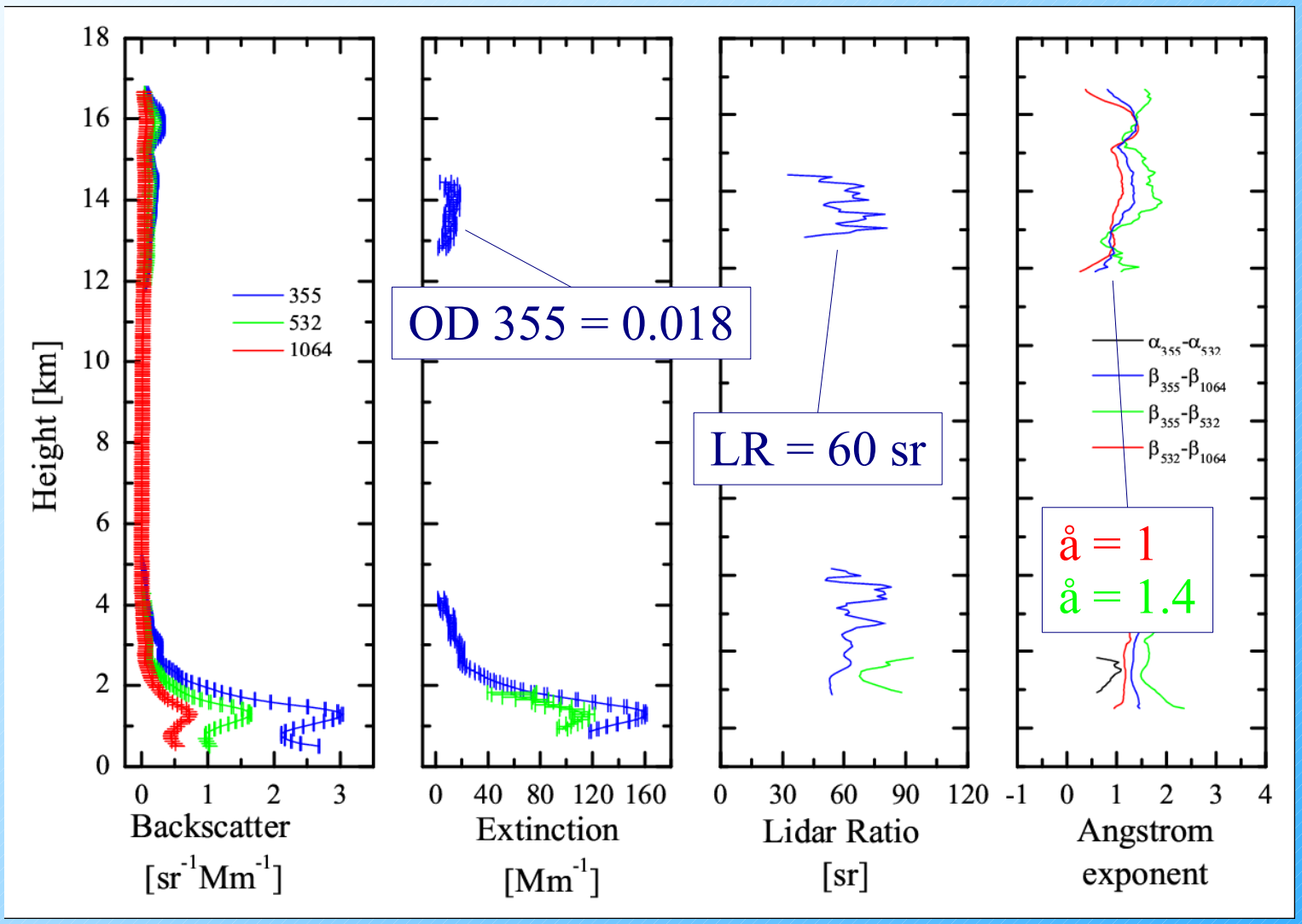
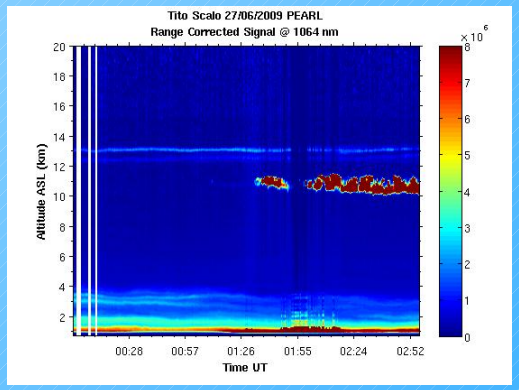
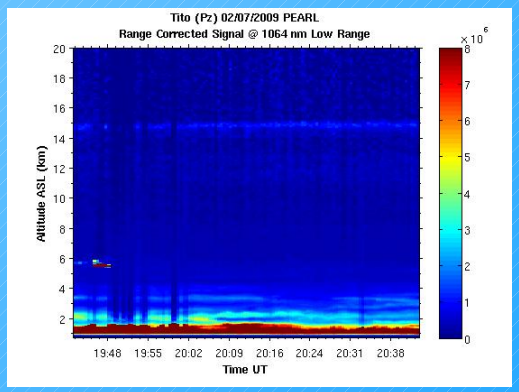
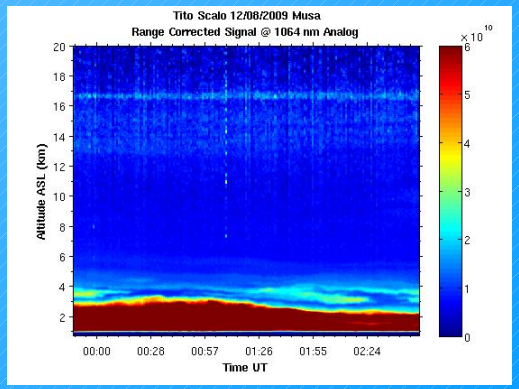


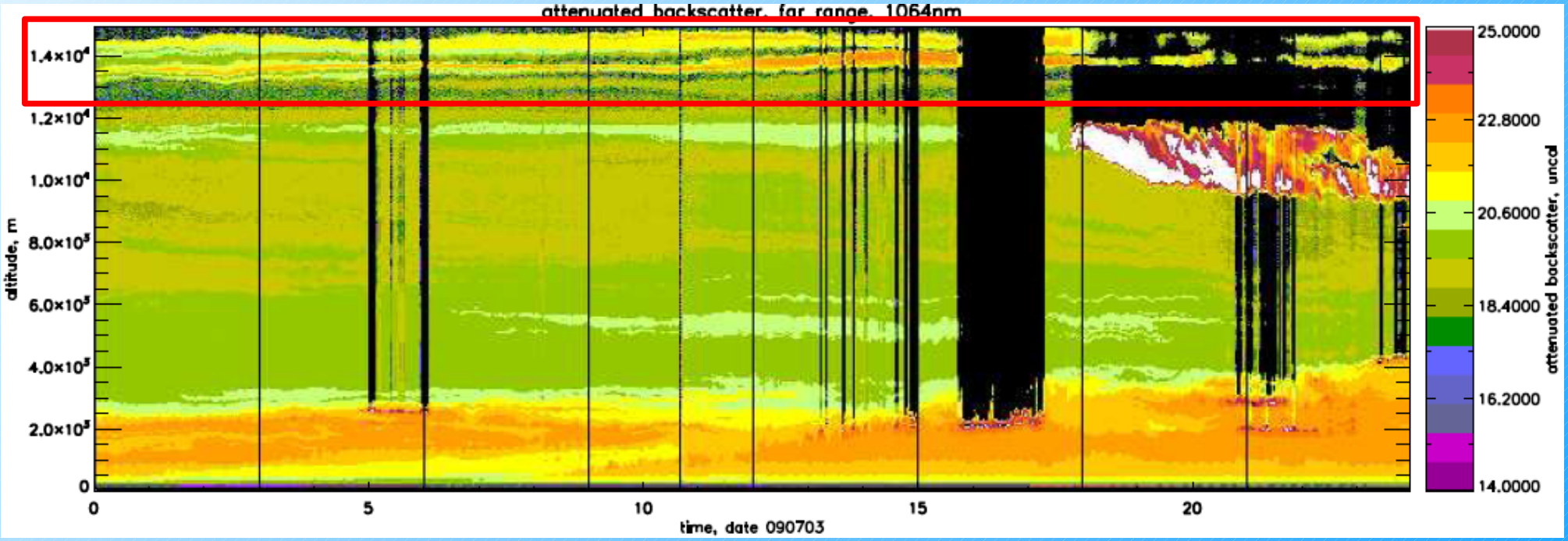






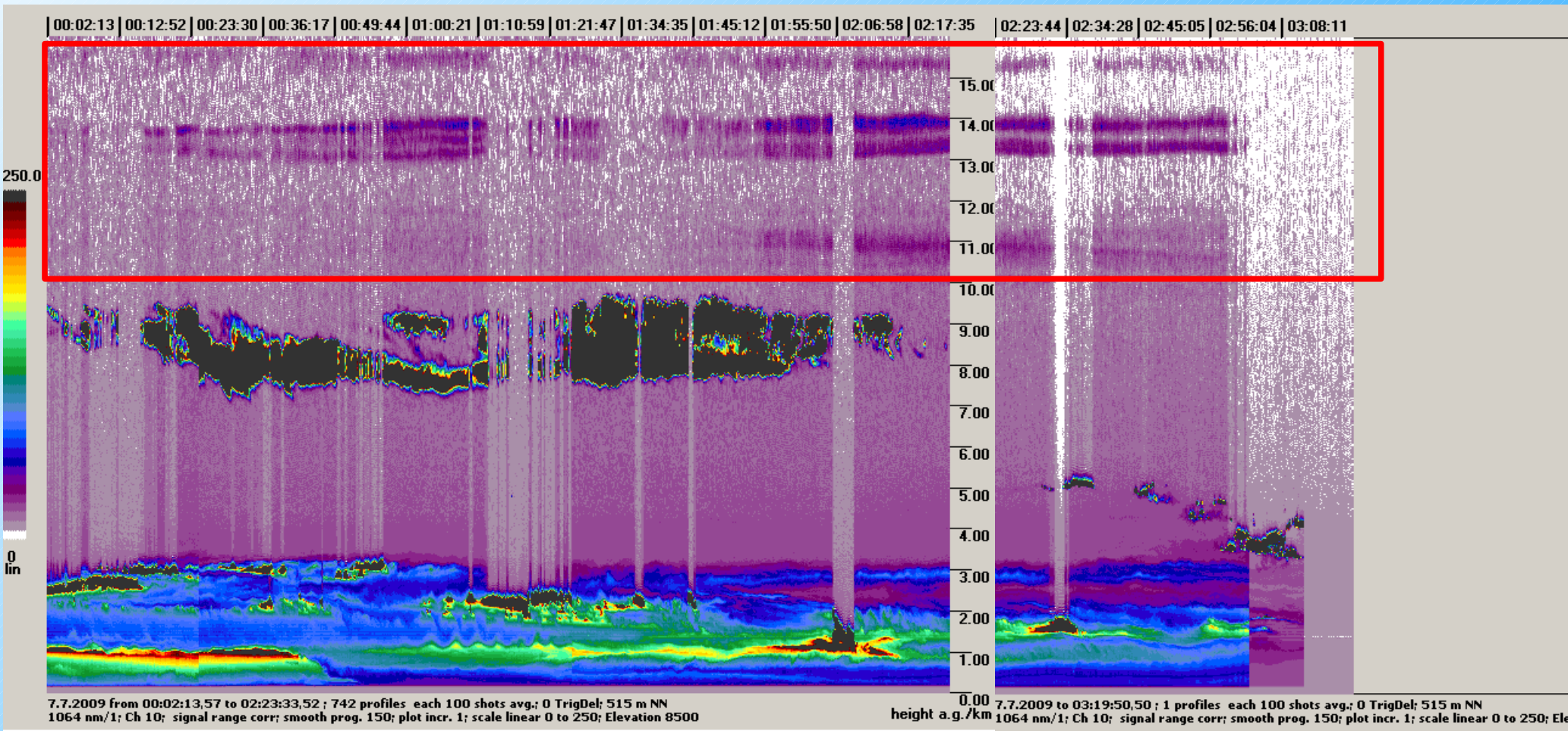
see: D'Amico et al., ILRC 2010

Sarychev plume over Hamburg, 3 July 09



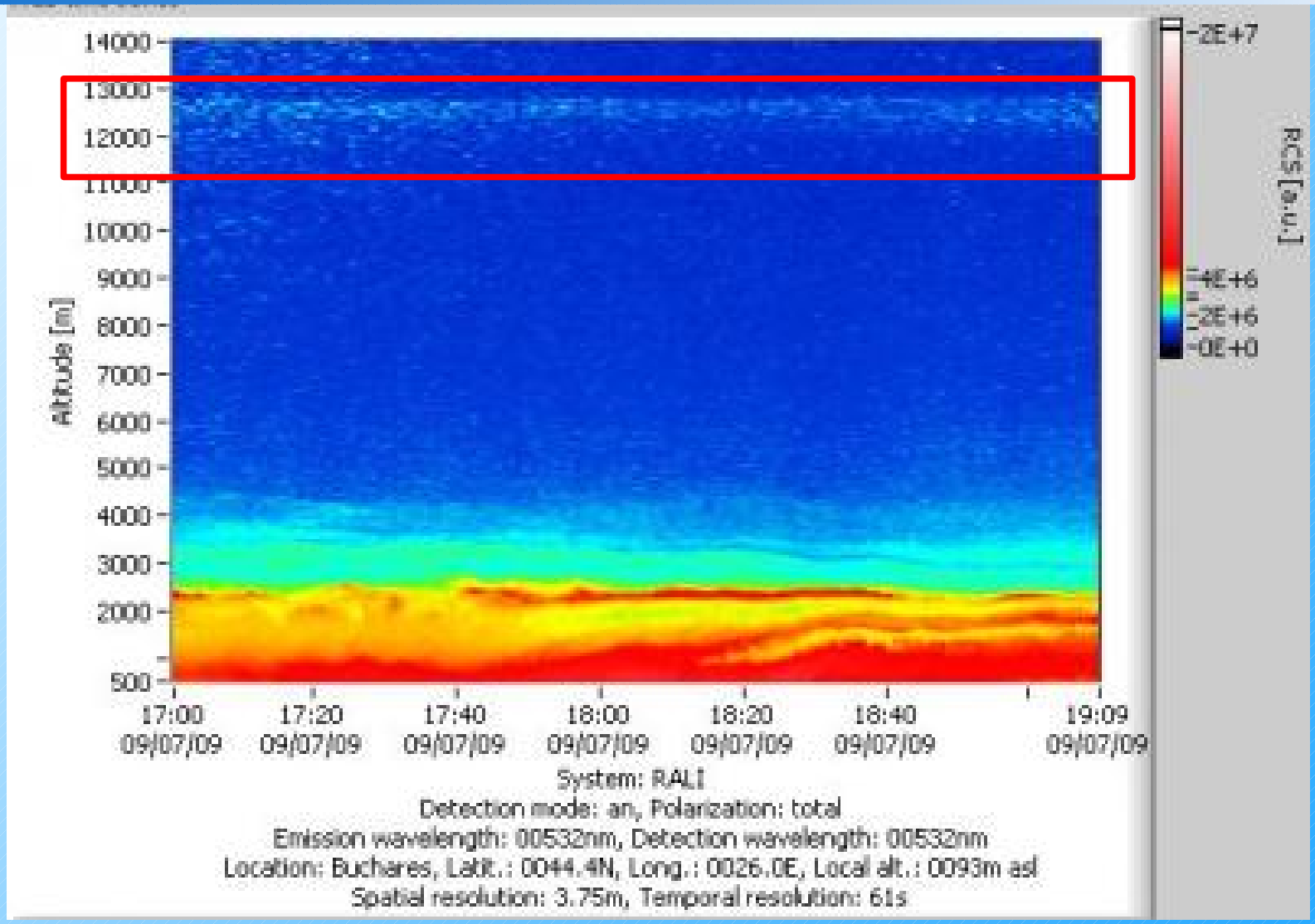
with courtesy from MPI Hamburg, H. Linné and I. Serikov

Sarychev plume over Maisach, 7 July 09



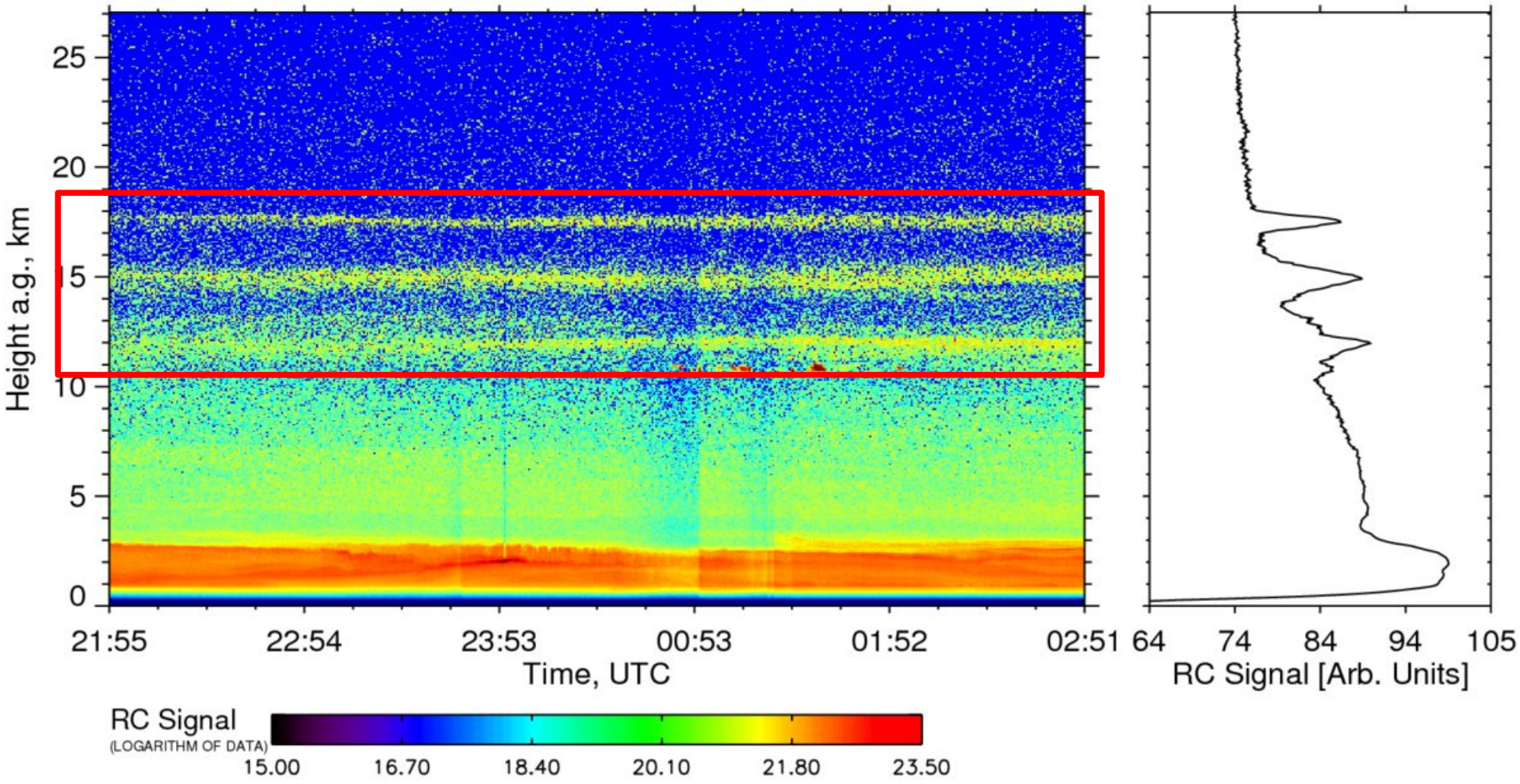
with courtesy from LMU Munich, V. Freudenthaler and S. Groß

Sarychev plume over Bucharest, 9 July 09

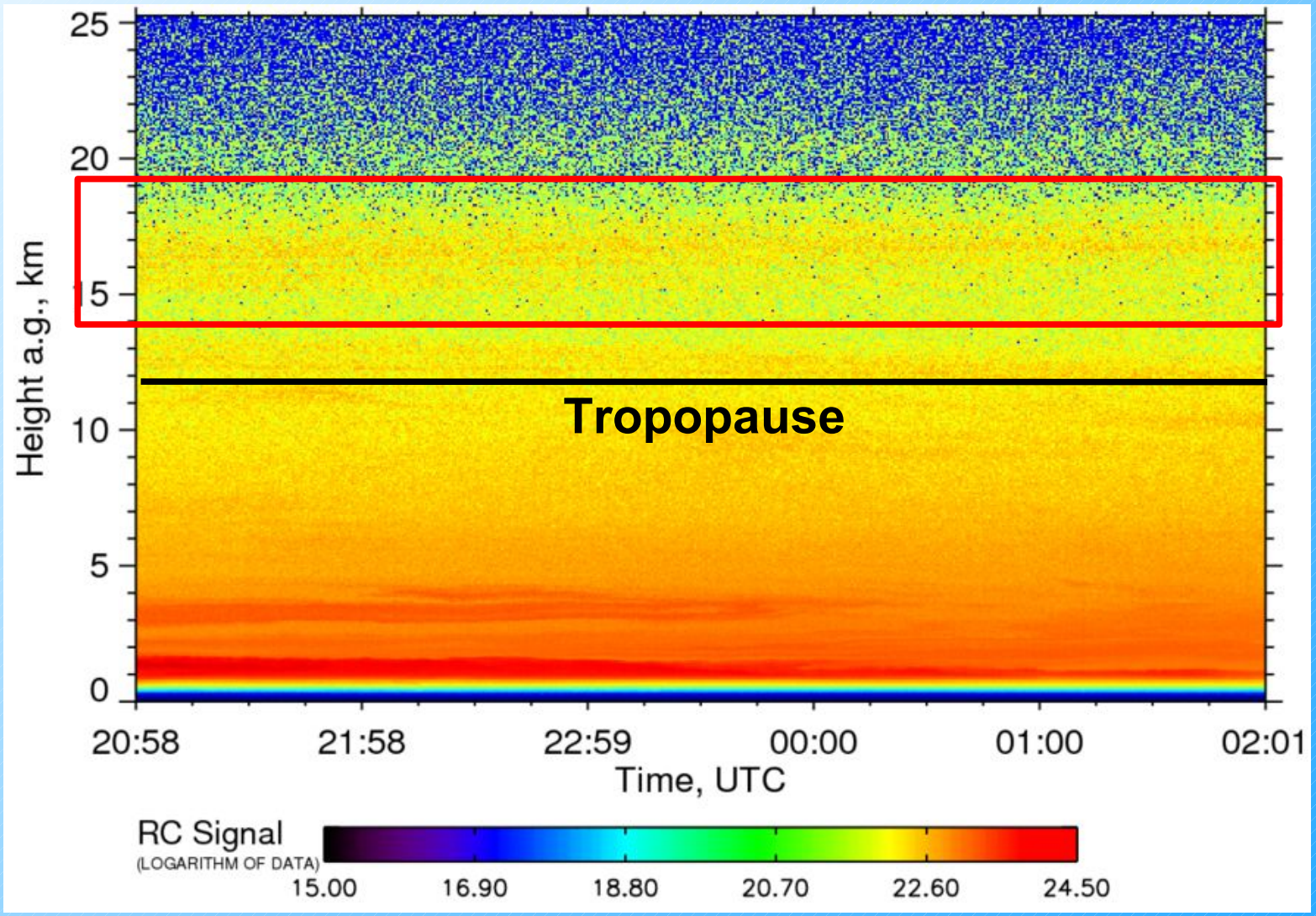


Romanian Atmospheric research 3D Observatory, station bucharest operated by INOE

Sarychev plume over Leipzig, 15 July 09



Volcanic layer in stratosphere over Leipzig 31 August 2009

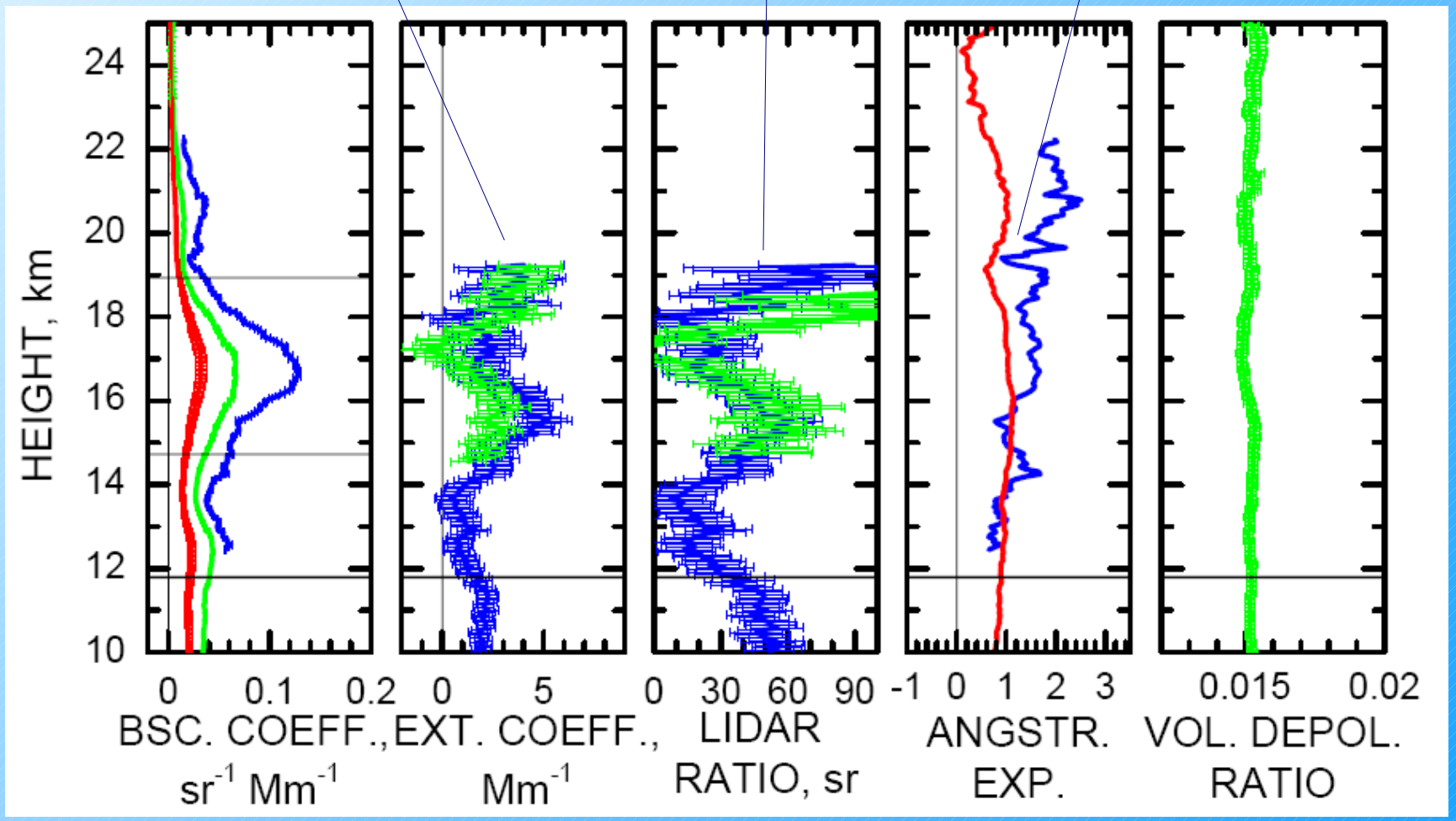


Volcanic layer in stratosphere over Leipzig 31 August 2009

od(532) = 0.015

LR = 30-60 sr
LR = 30-45 sr

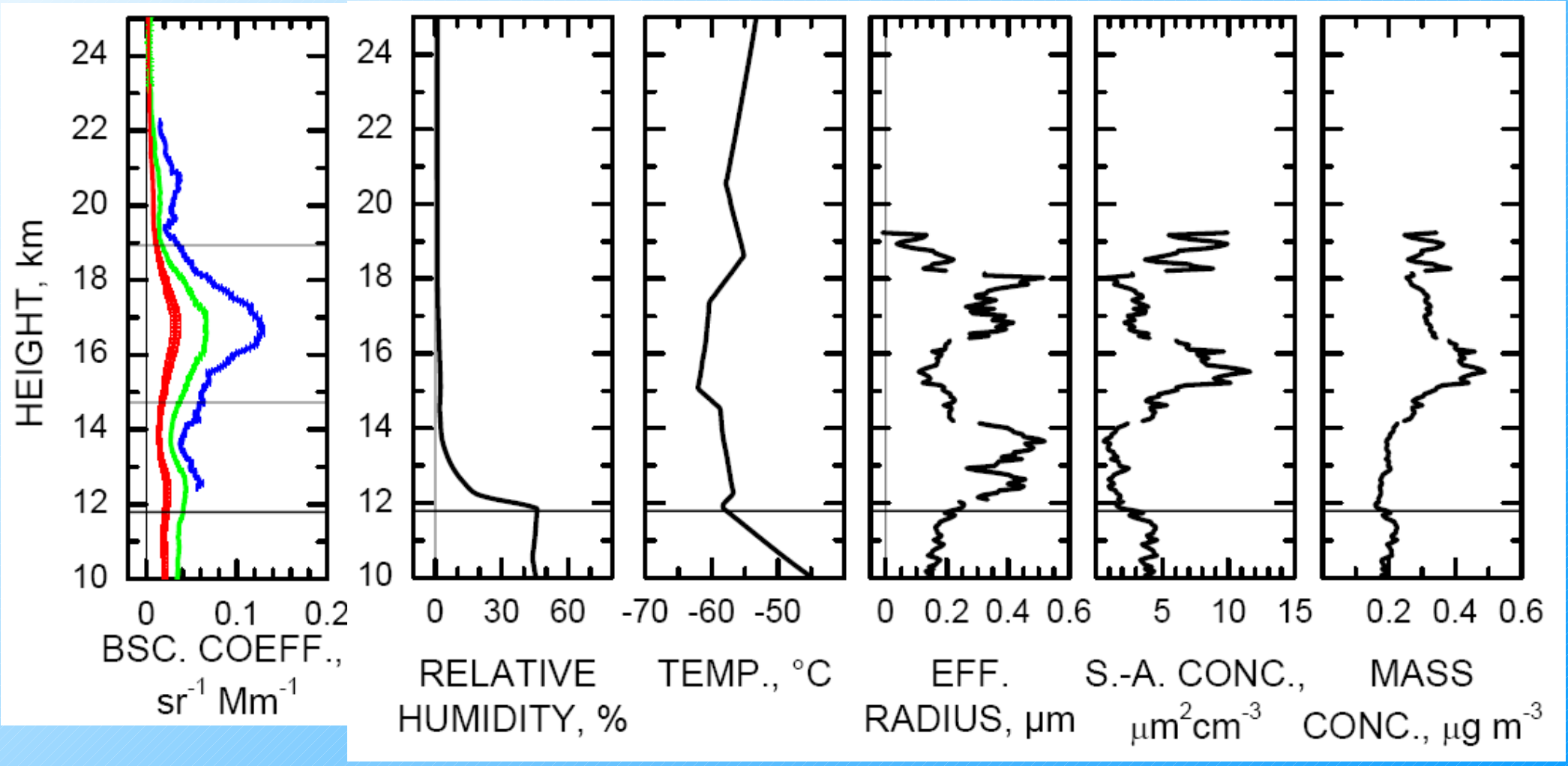
å ≈ 1
å ≈ 1.5



see: Mattis et al., Volcanic aerosol layers observed with..., JGR 2010

Volcanic layer in stratosphere over Leipzig 31 August 2009

Microphysical properties with method from Wandinger et al. 1995



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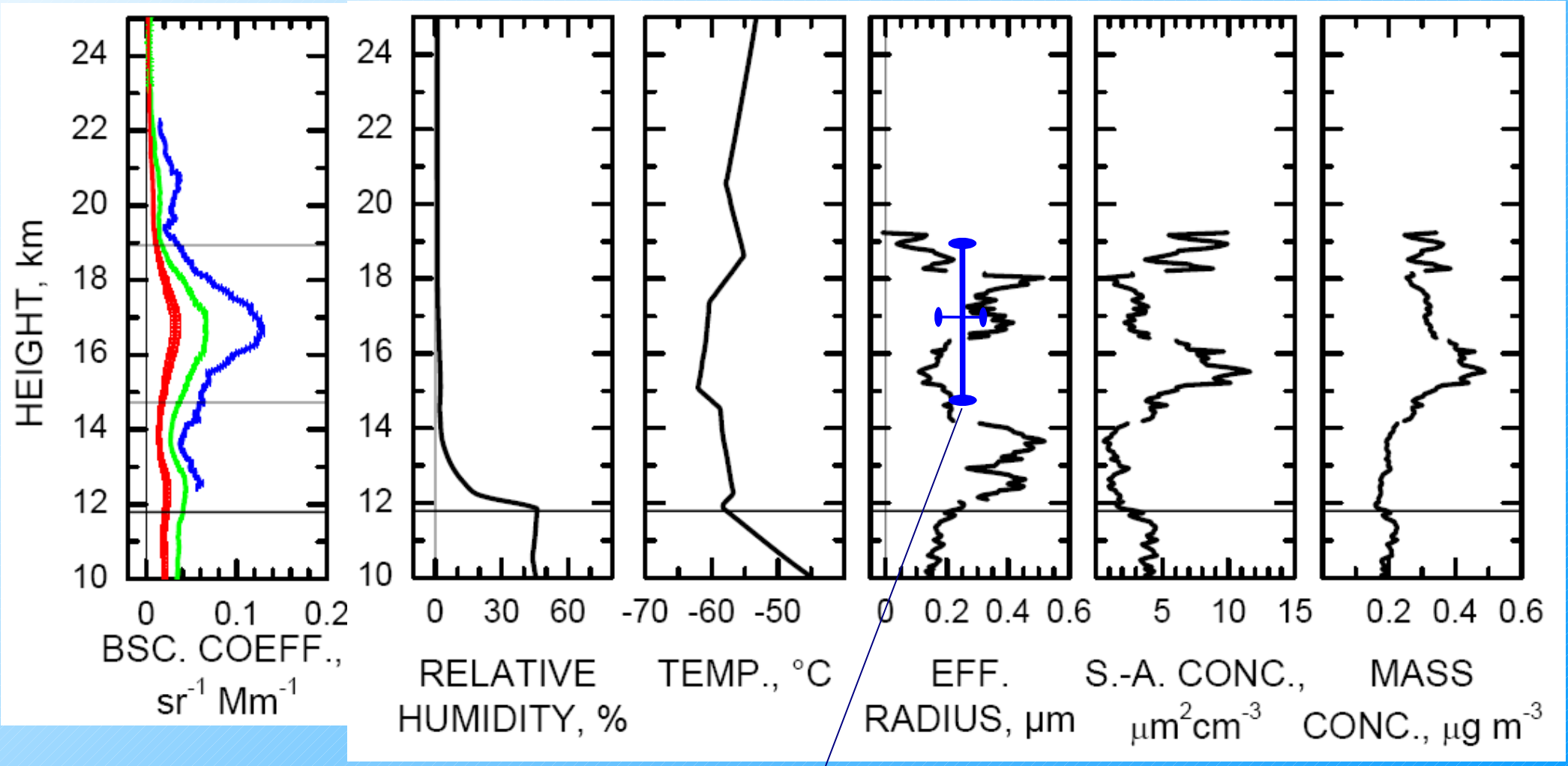

Müller et al. 1999: Inversion with regularization (from „*3+2 data*“) → $r_{eff} \approx 0.25$ µm

Summary: Volcanic aerosols in the tropopause region and stratosphere

- Transport to Europe over long distances
  - mainly sulfuric acid particles
  - layers: 5 – 25 km
  - lidar ratios = 30 – 60sr (355 nm)
    = 30 – 45sr (532 nm)
  - Ångström exponents 1 – 2
  - optical depth (532 nm) $\leq$ 0.02
  - effective radius: 0.1 – 0.25 µm
  - mass concentration: 0.3 – 2µg m^{-3}

Volcanic aerosol

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  - Eyjafjöll 2010
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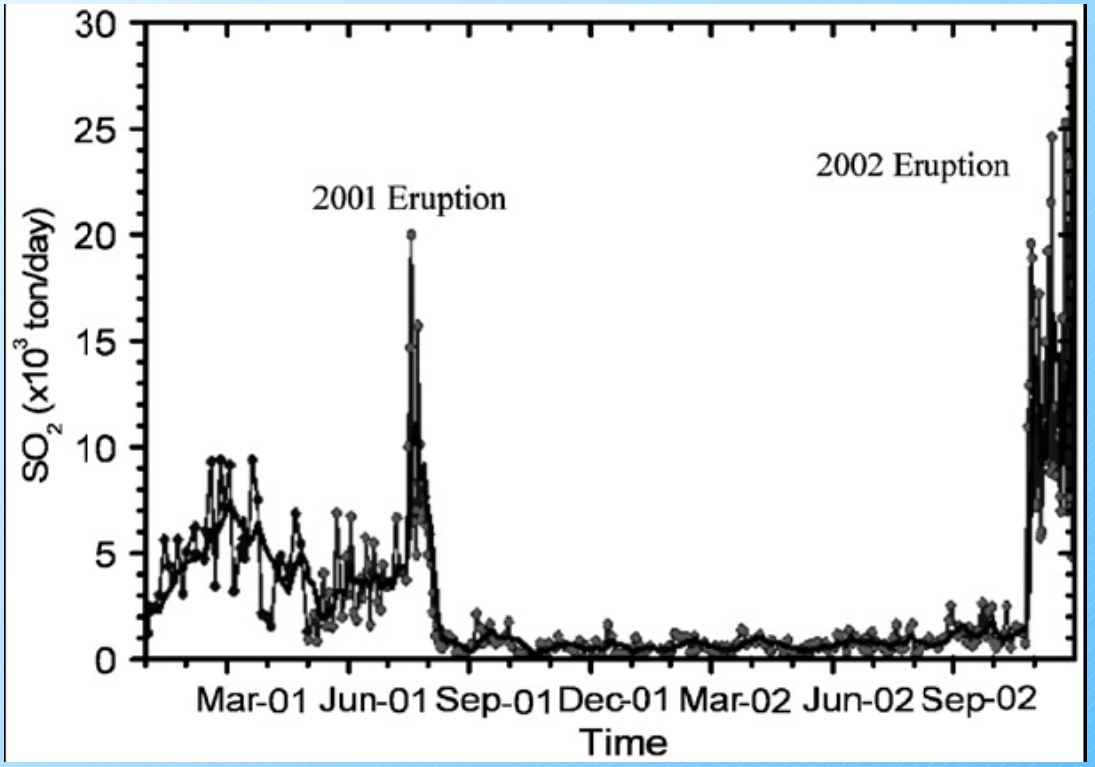
Etna eruptions of 2001 and 2002



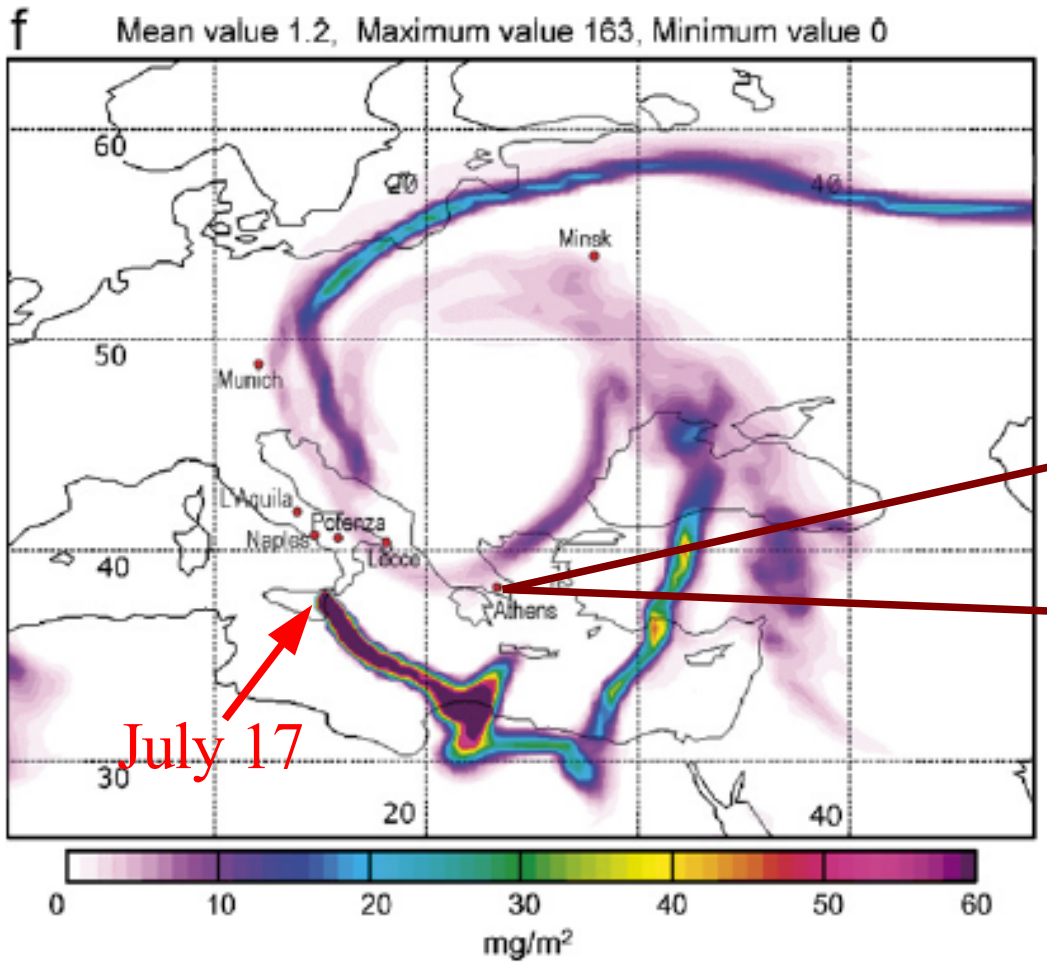
October 28, 2002, Photo by Jean-Claude Tanguy, 2002 (University of Paris).

see: Wang et al., Atmos. Environ. 2008, Fig. 1

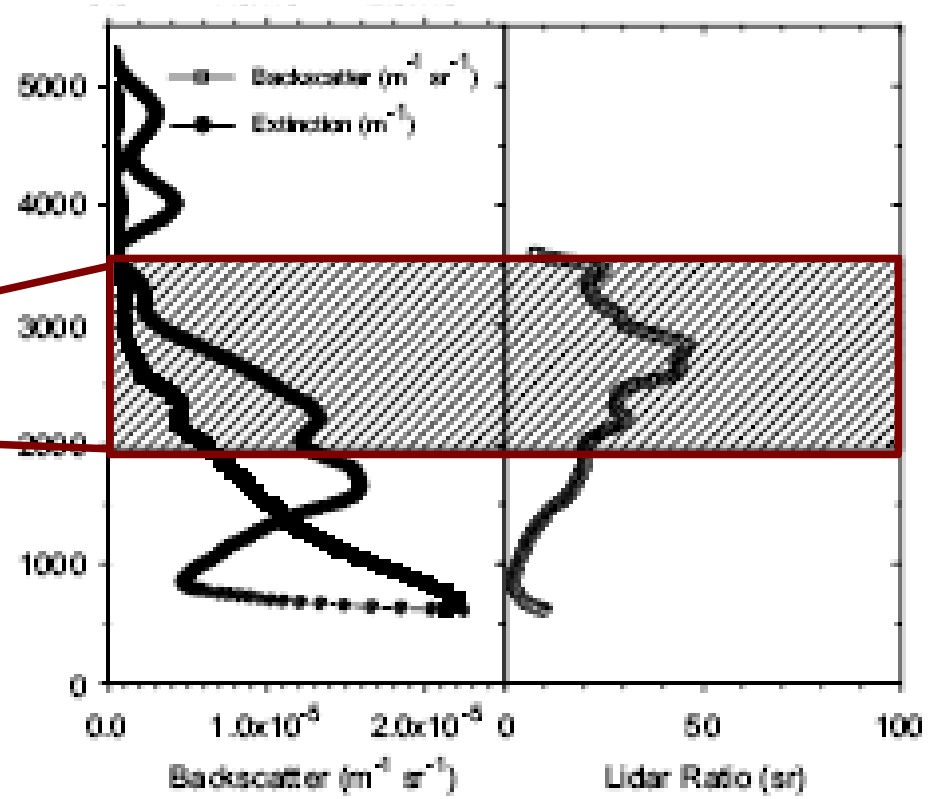
Network observations of the Etna 2001 eruption

FLEXPART simulation

lidar observation



Athens, July 23 2001



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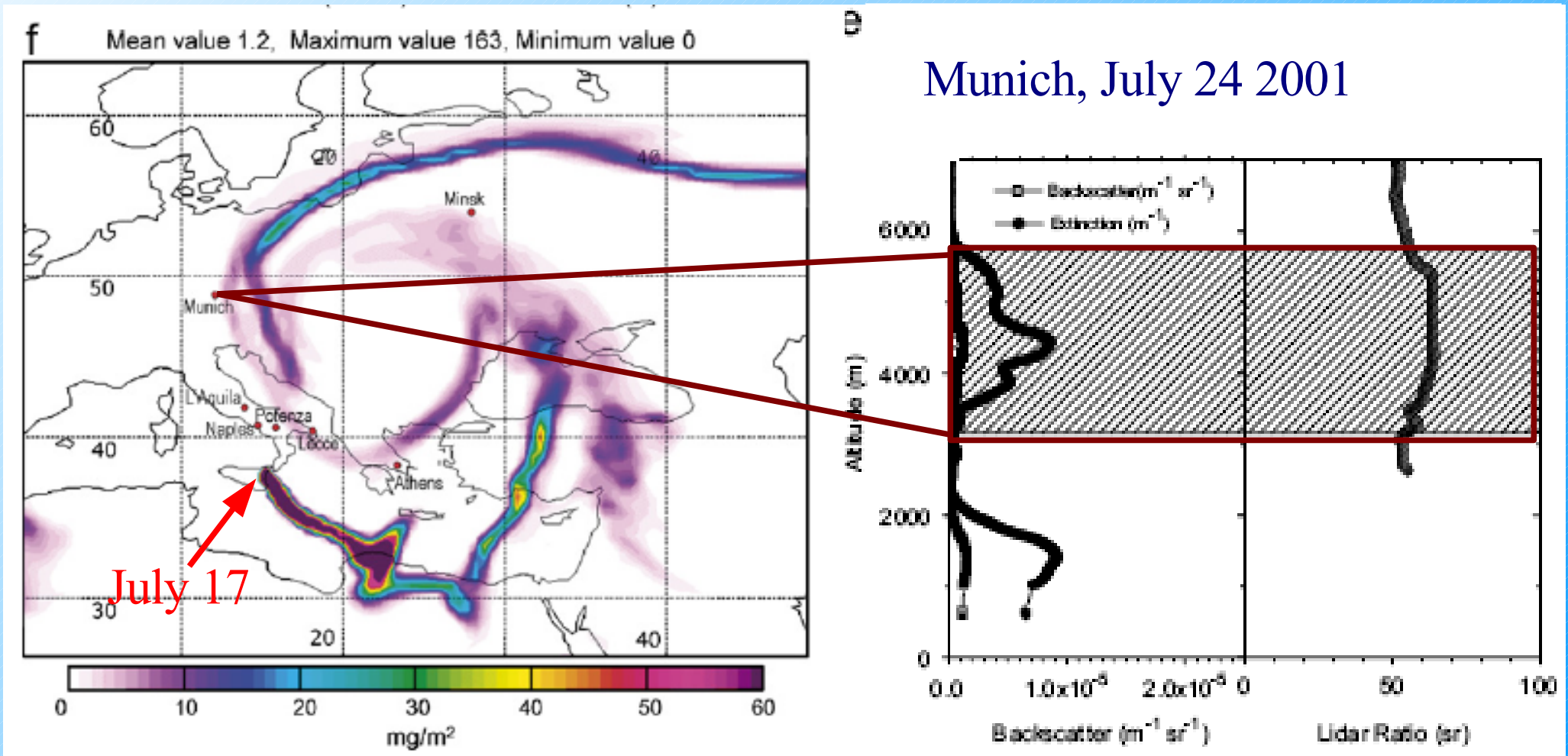

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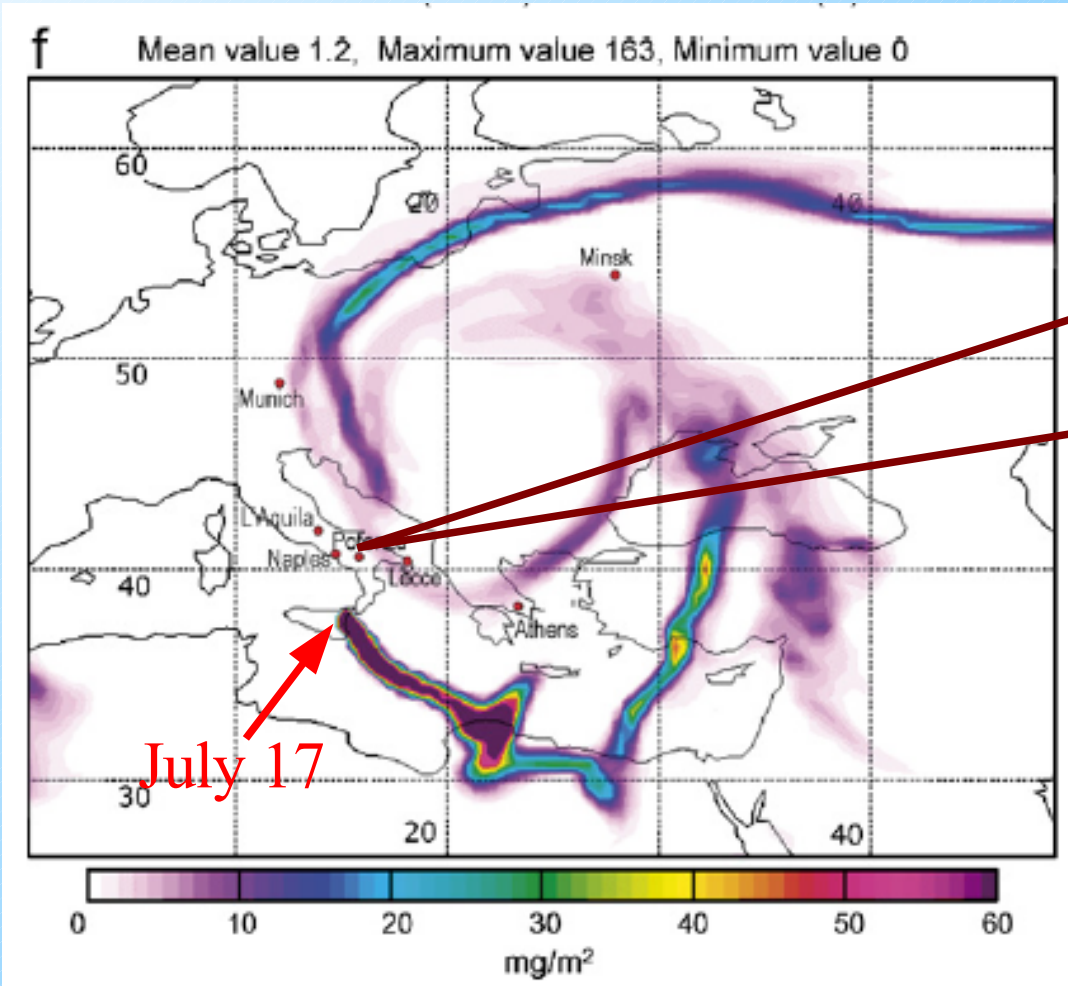

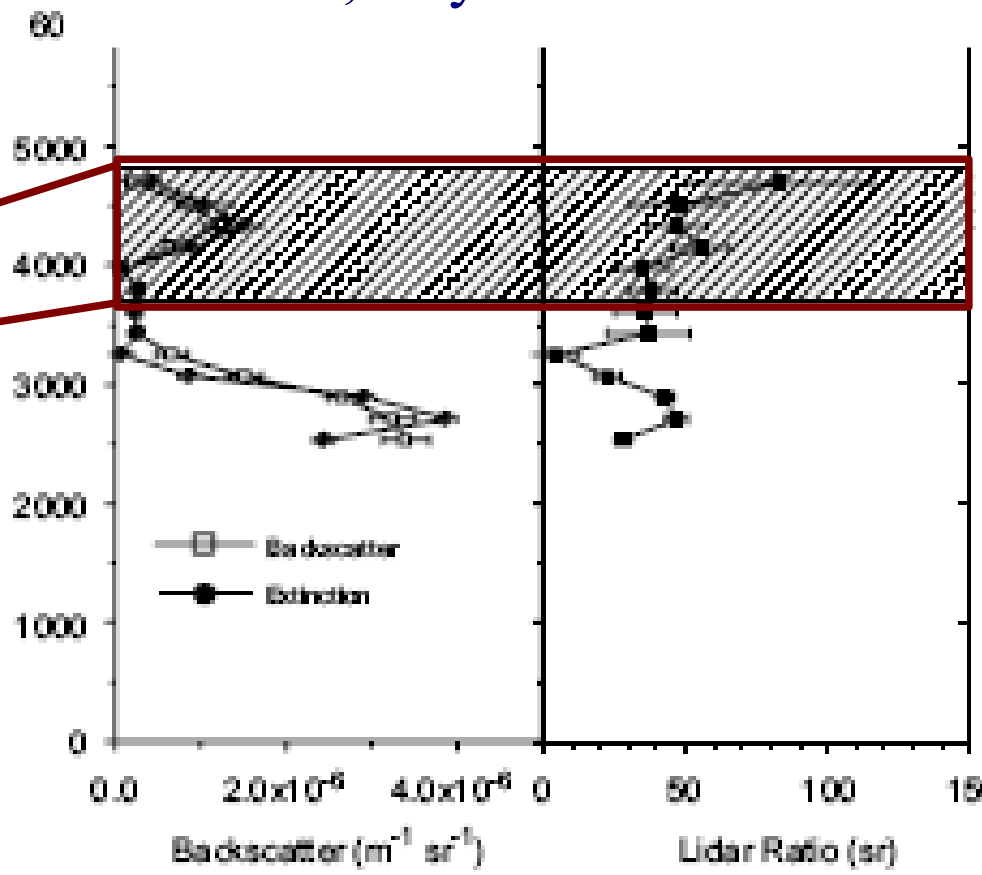

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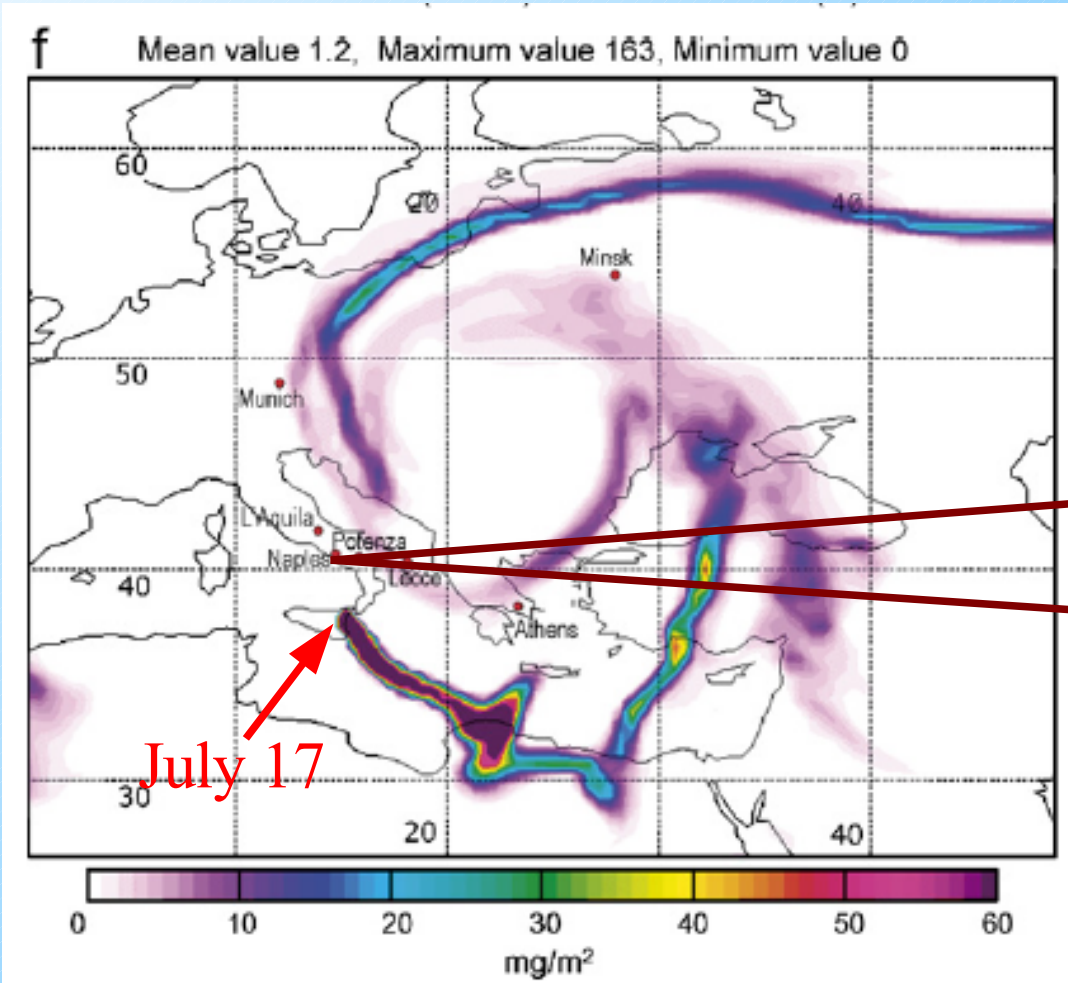

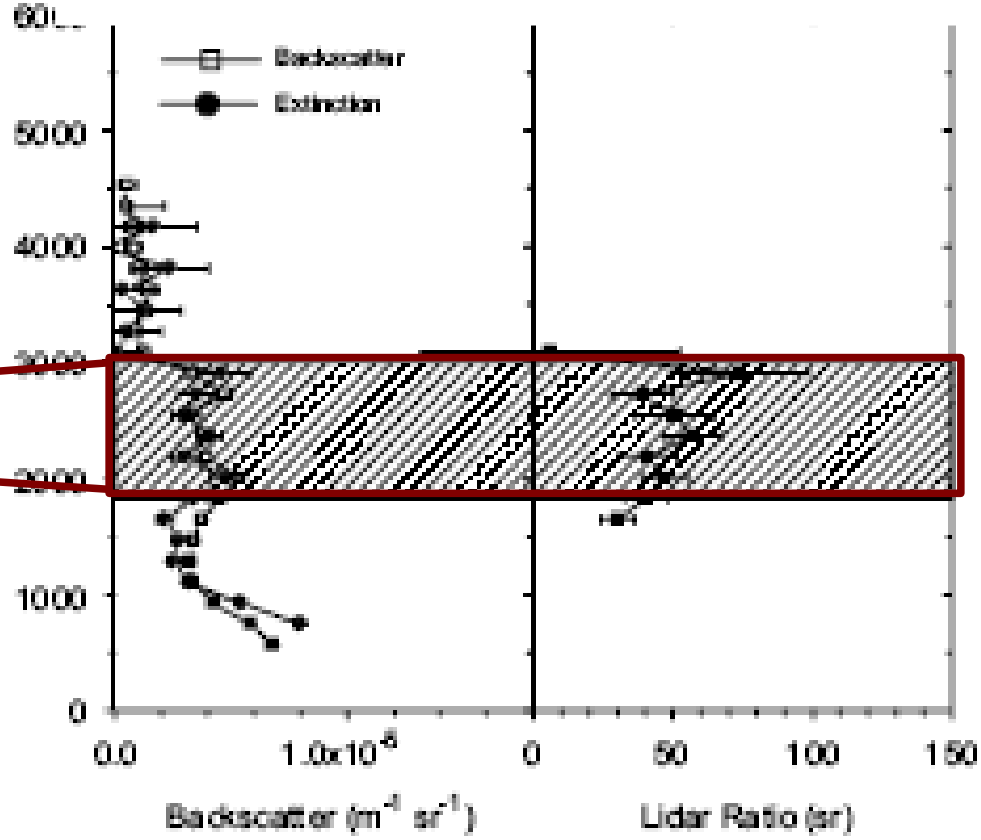

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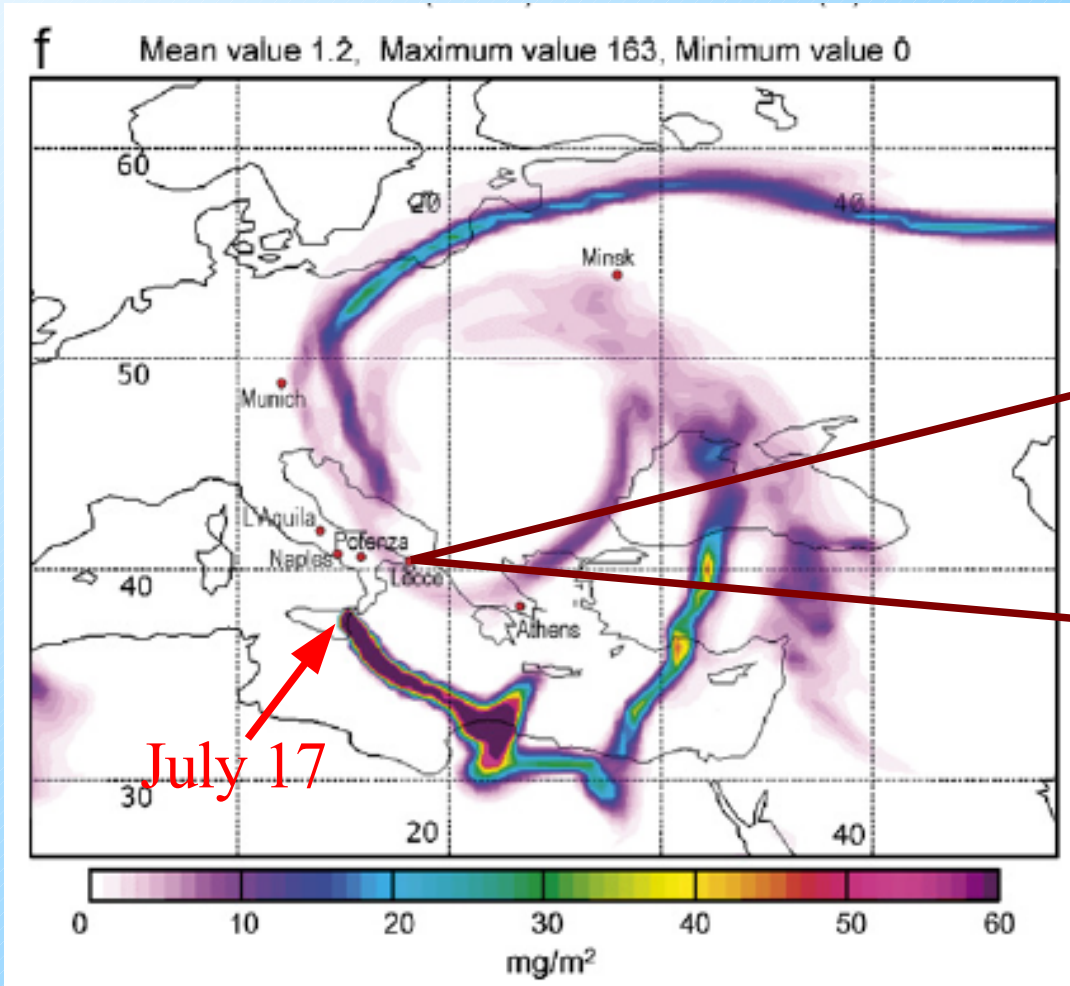
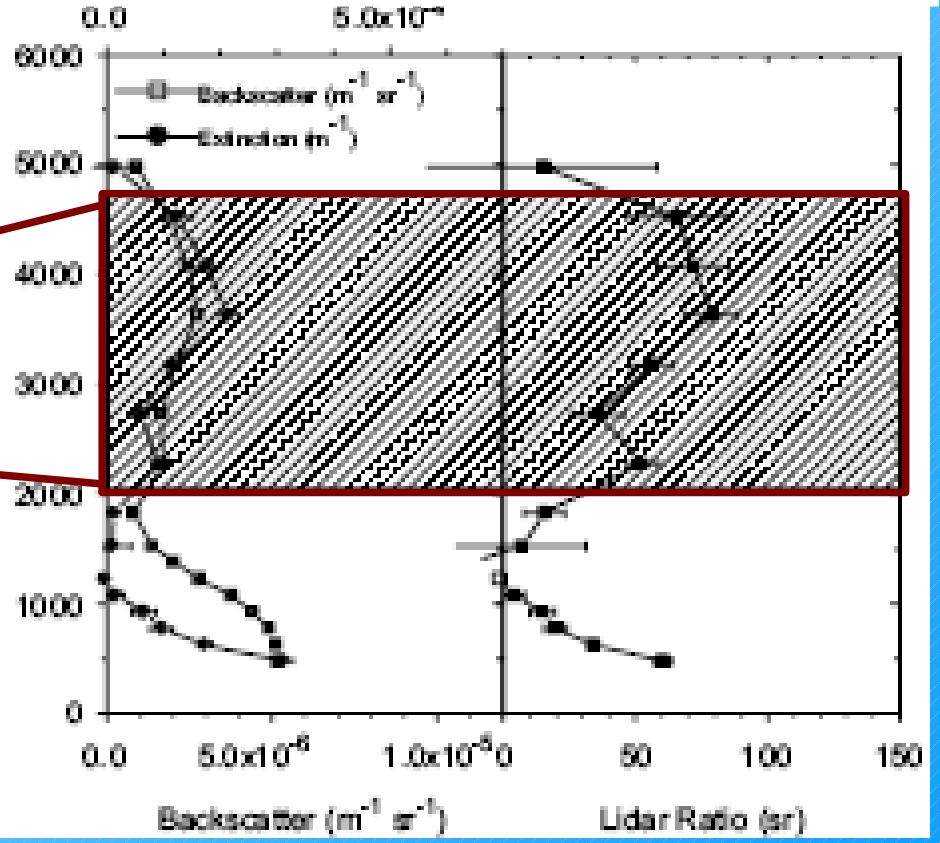
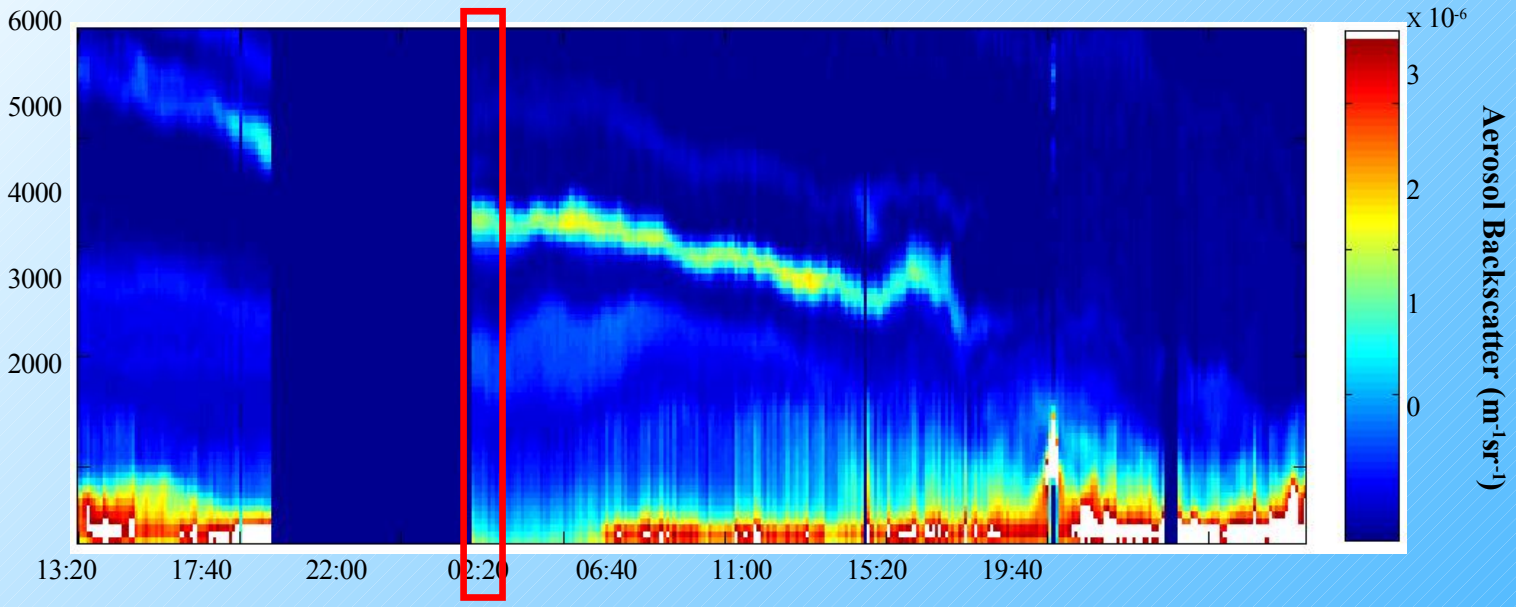


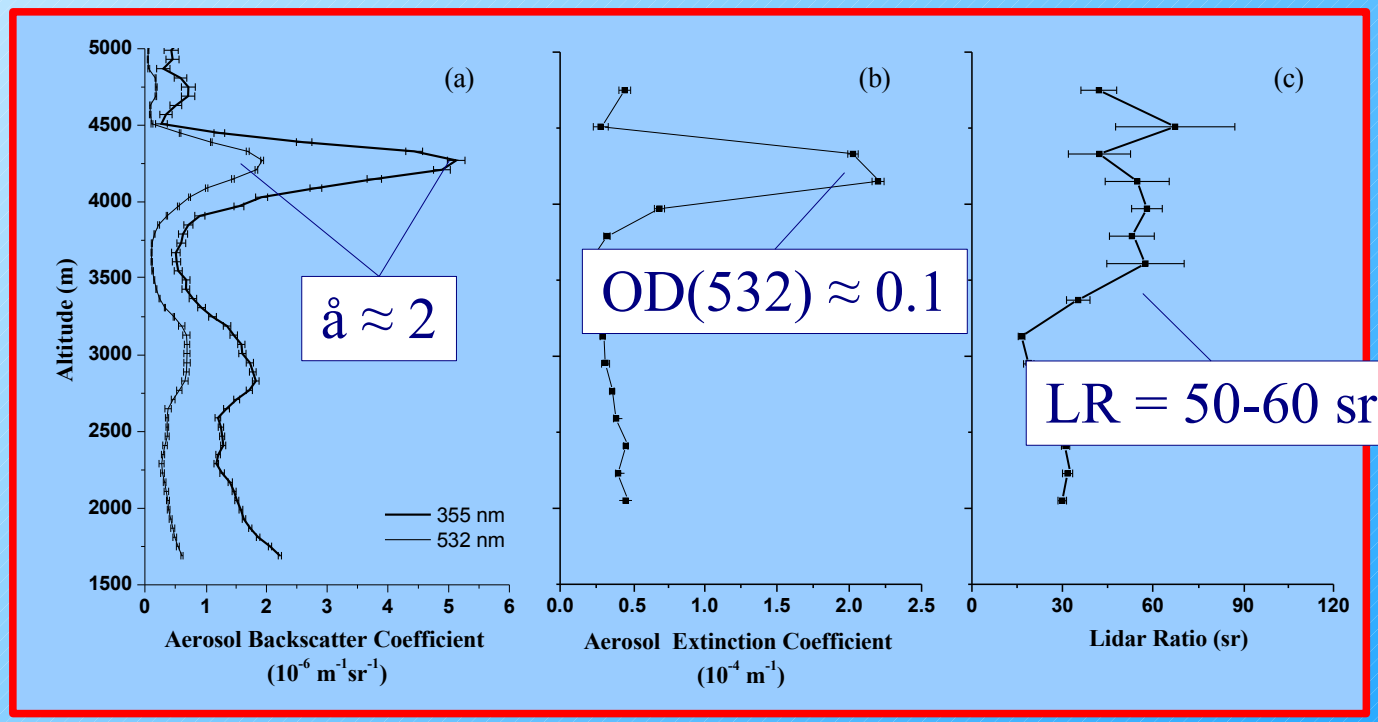


see: Wang et al., Atmos. Environ. 2008, Fig. 1

Etna plume over Potenza, 1-2 November 2002



λ=532nm



young sulfate particles with some absorption

Mona et al., 6th ISTP, Leipzig 2003

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Eruption of the Eyjafjöll volcano, Iceland
14 April 2010

Magnús T. Gudmundsson et al.: ESA/EUMETSAT Workshop on Volcanic Ash Monitoring, ESRIN, Frascati, Italy, May 26-27

Eruption of the Eyjafjöll volcano, Iceland 14 April 2010

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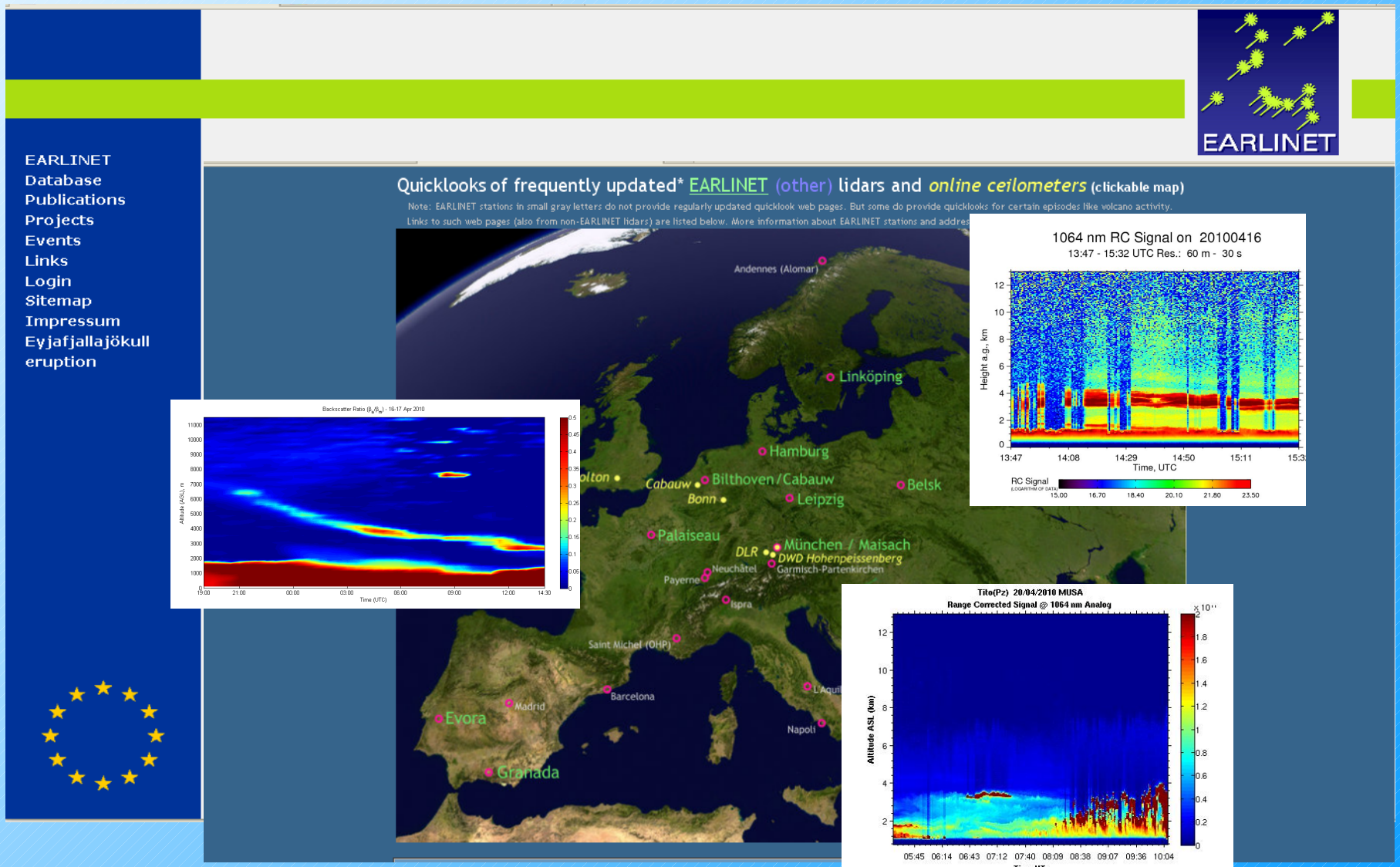

Eruption of the Eyjafjöll volcano, Iceland 14 April 2010

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- daily updated report on the EARLINET website

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Eyjafjallajökull eruption

EARLINET is following the evolution of the volcanic cloud

quicklook avalable at

http://www.meteo.physik.uni-muenchen.de/~stlidar/quicklooks/European-quicklooks.htm

Updated report

EyjafjallajokulEruption_EARLINET_22May2010.pdf 1.3 M

EARLINET talk at EGU 2010

EGU2010-15731_EARLINET.pdf 16.8 M

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)

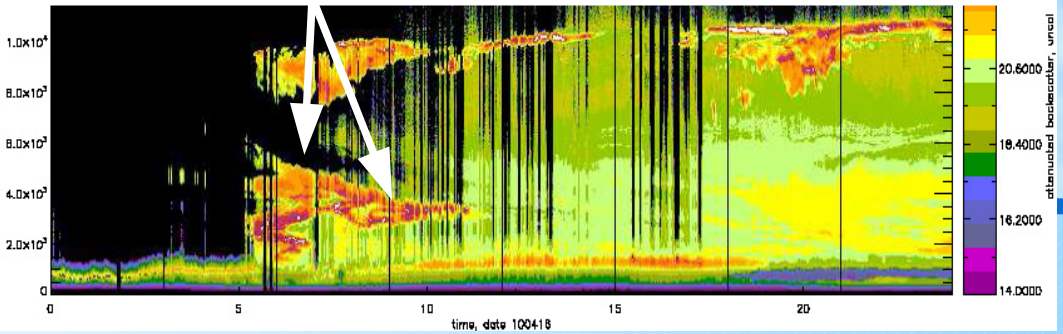
April 16, 2010

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

Arrival of the ash plume over Europe

Hamburg, morning of 16 April



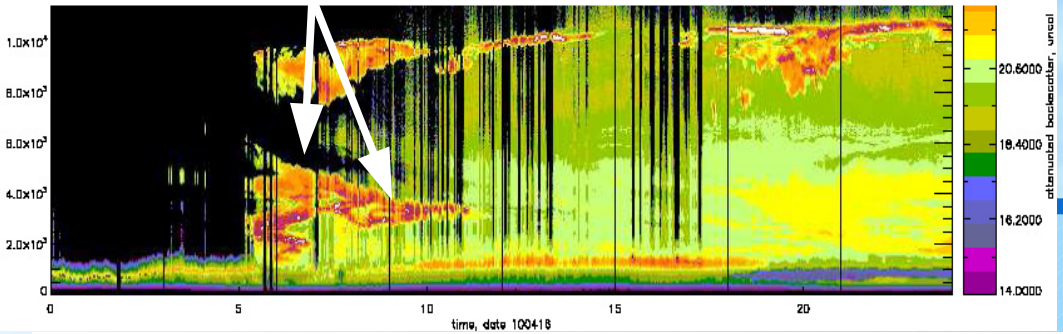
first detection of the ash layer over Hamburg
in the late evening of April 15
at about 10 km height

ash plume crossed central Europe on April 16-17

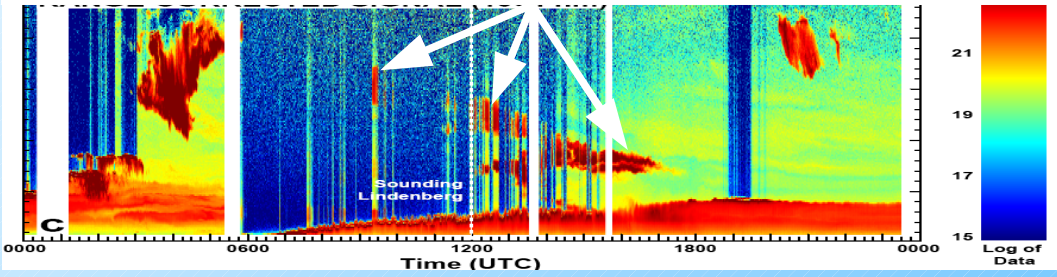
16 April 00 | 1200 | 17 April 00 | 1200 | time

Arrival of the ash plume over Europe

Hamburg, morning of 16 April



Leipzig, late morning of 16 April



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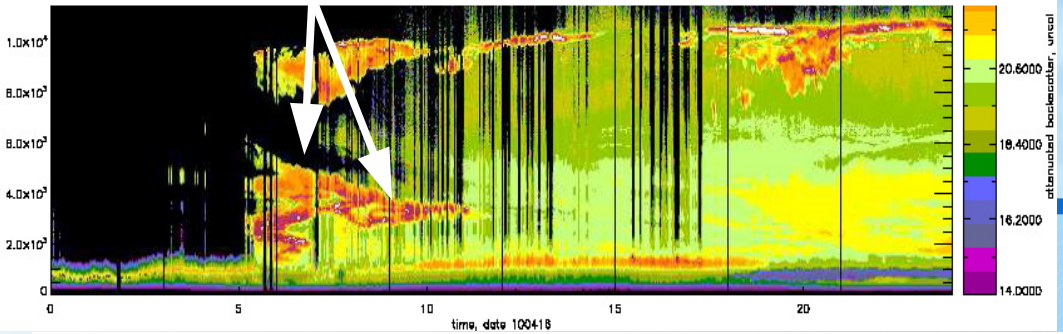

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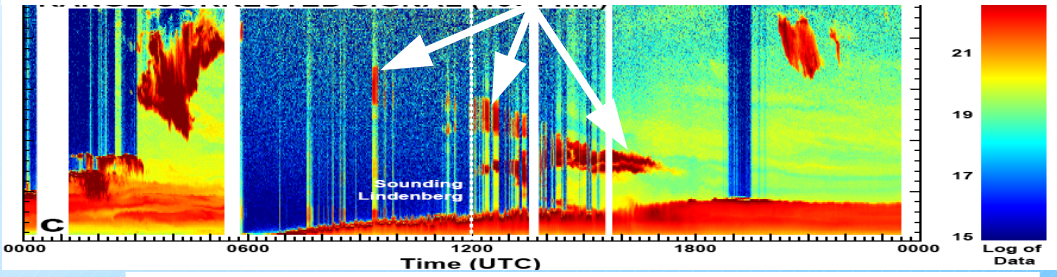
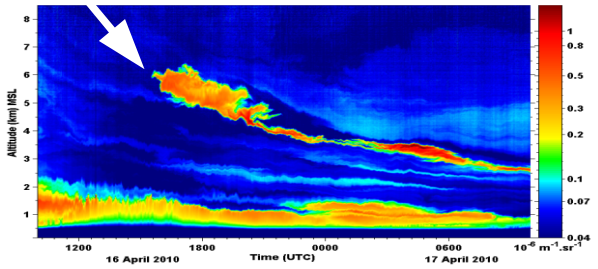


Palaiseau, afternoon of 16 April



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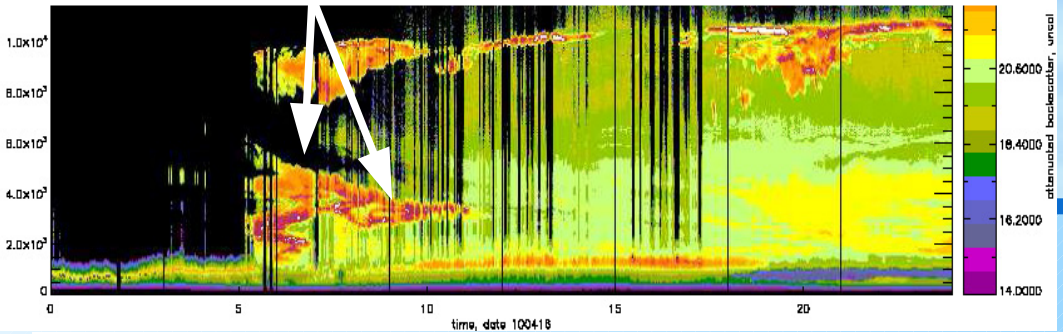

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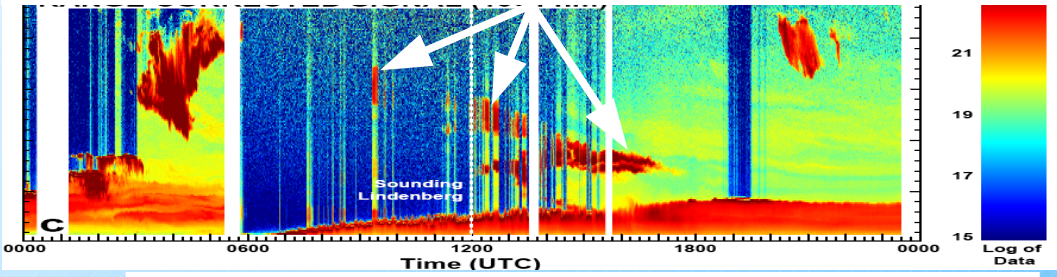

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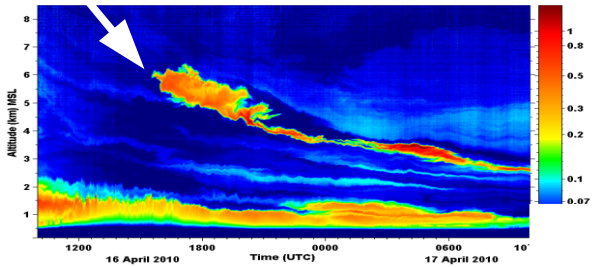
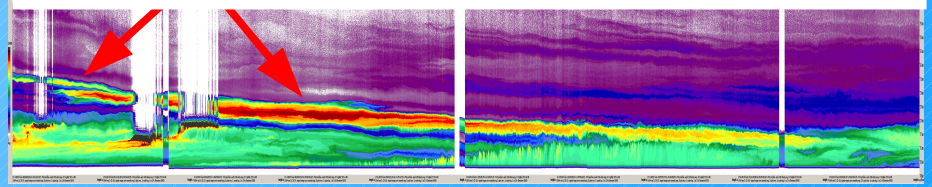


Munich, night 16-17 April



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Arrival of the ash plume over Europe

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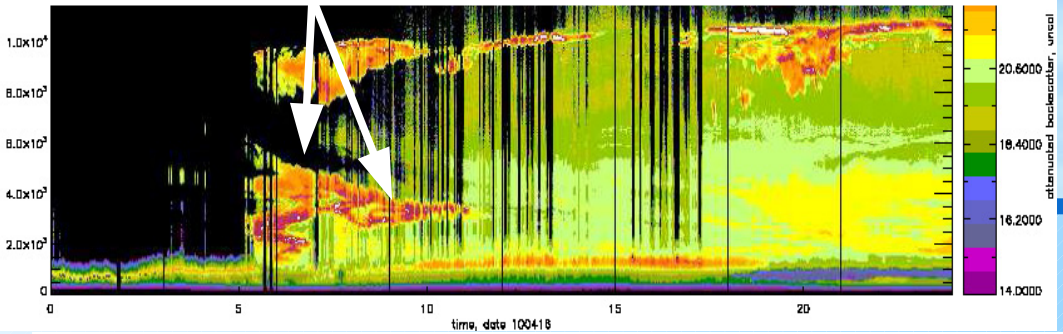

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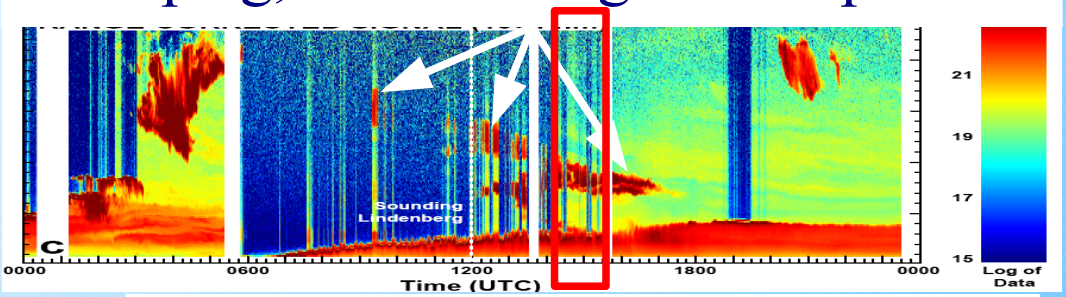
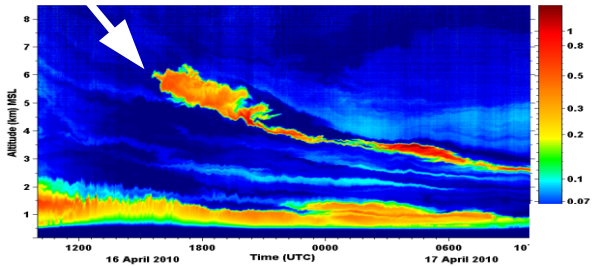


Palaiseau, afternoon of 16 April



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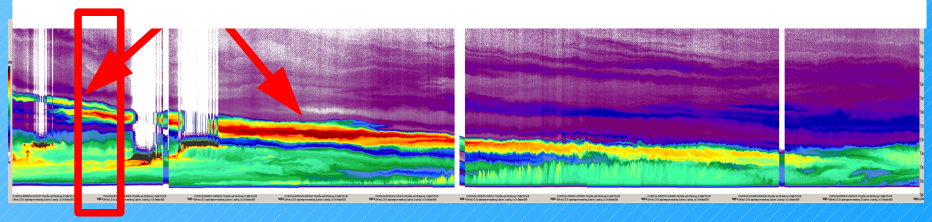

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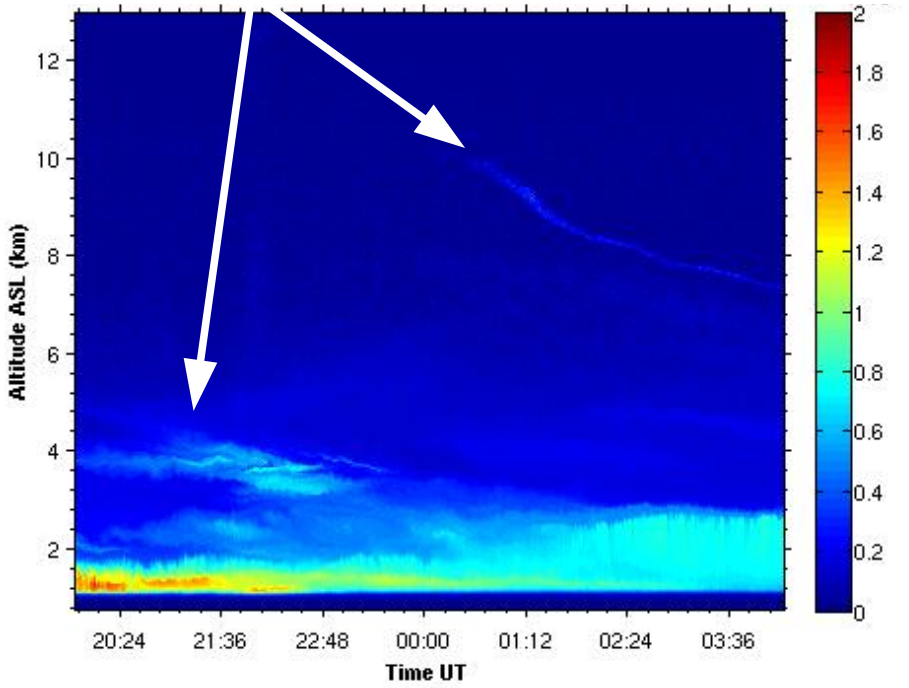
ash plume crossed central Europe on April 16-17

16 April 00 — 1200 — 17 April 00 — 1200 — time

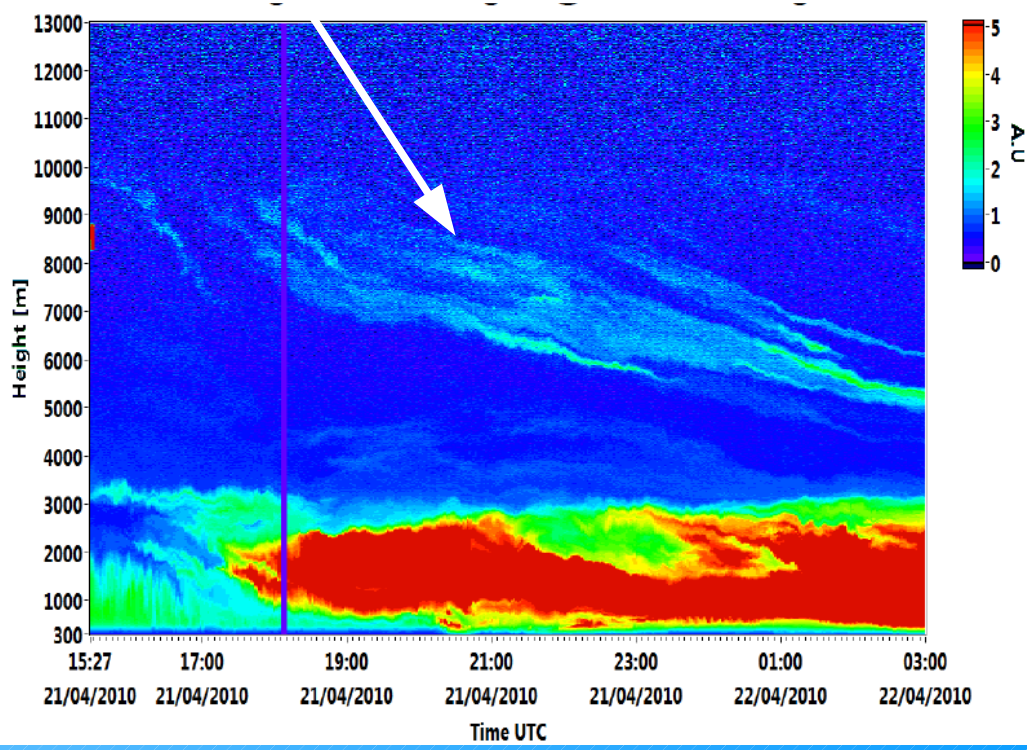
Transport of the ash plume across Europe

Transport over the Alps after April 20

Potenza, 20 April



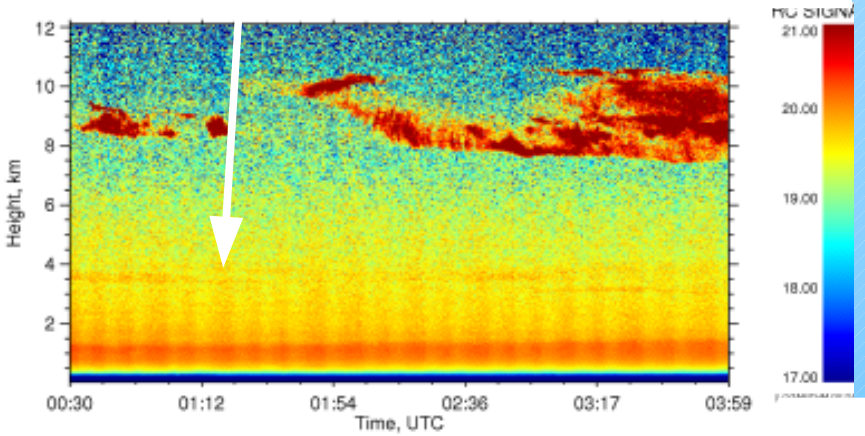
Athens, 21 April



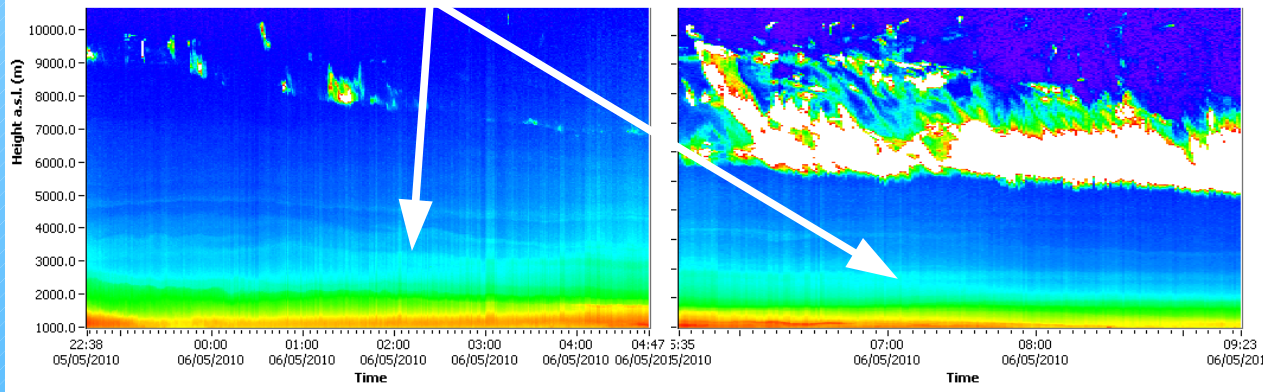
Transport of the ash plume across Europe

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

Evora, 5 May

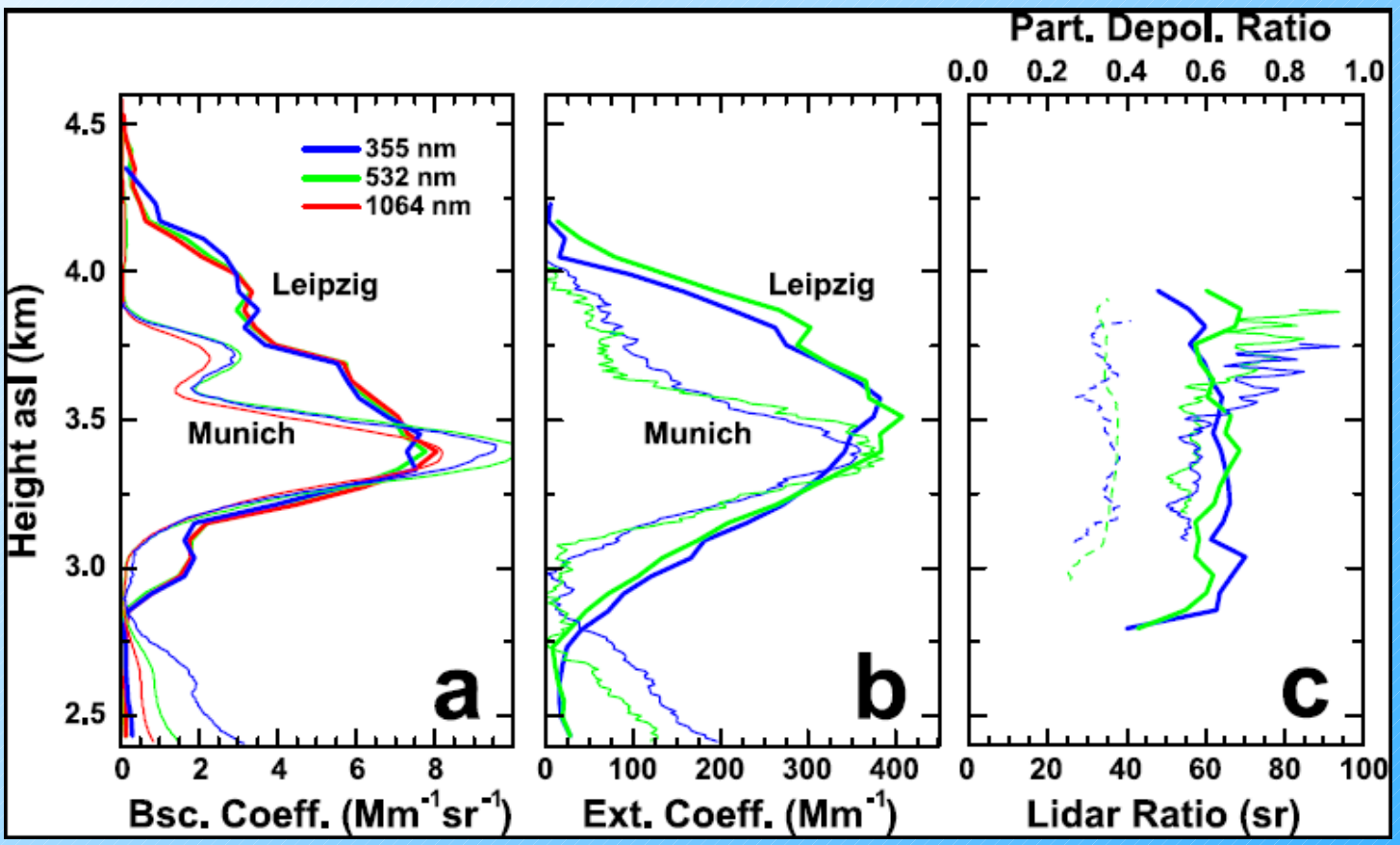


Granada, 6 May



Optical ash properties: April 16-17, 2010

extinction peak values up to 800 Mm^{-1}

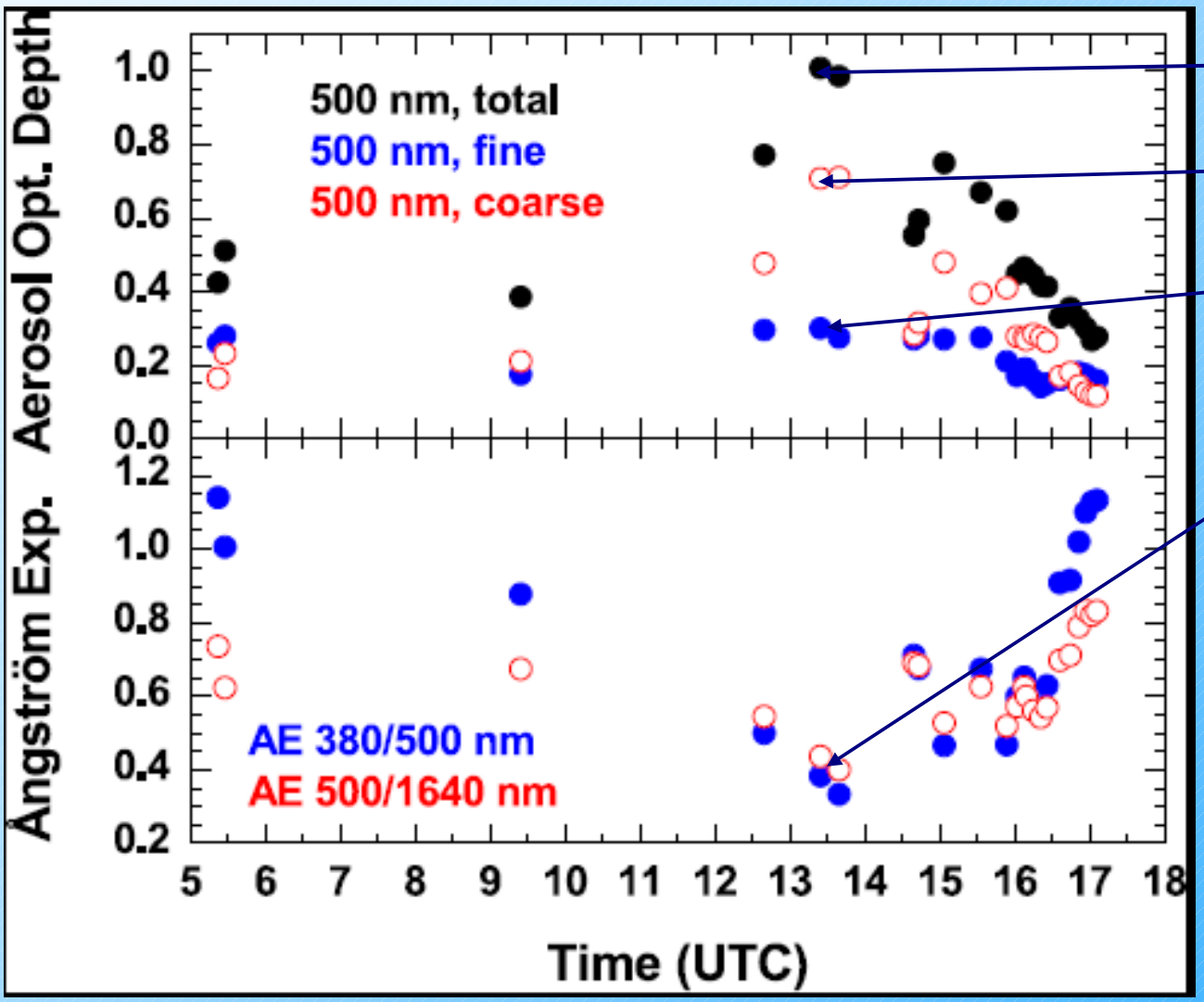


Saharan dust: 25%-35%
ash: 35%-40%

55-65sr at 355 nm
50-60sr at 532 nm

see: Ansmann et al., The 16 April 2010 major volcanic ash plume..., GRL 2010

Optical ash properties: April 16, 2010



total OD = 1

OD of the ash layer = 0.7

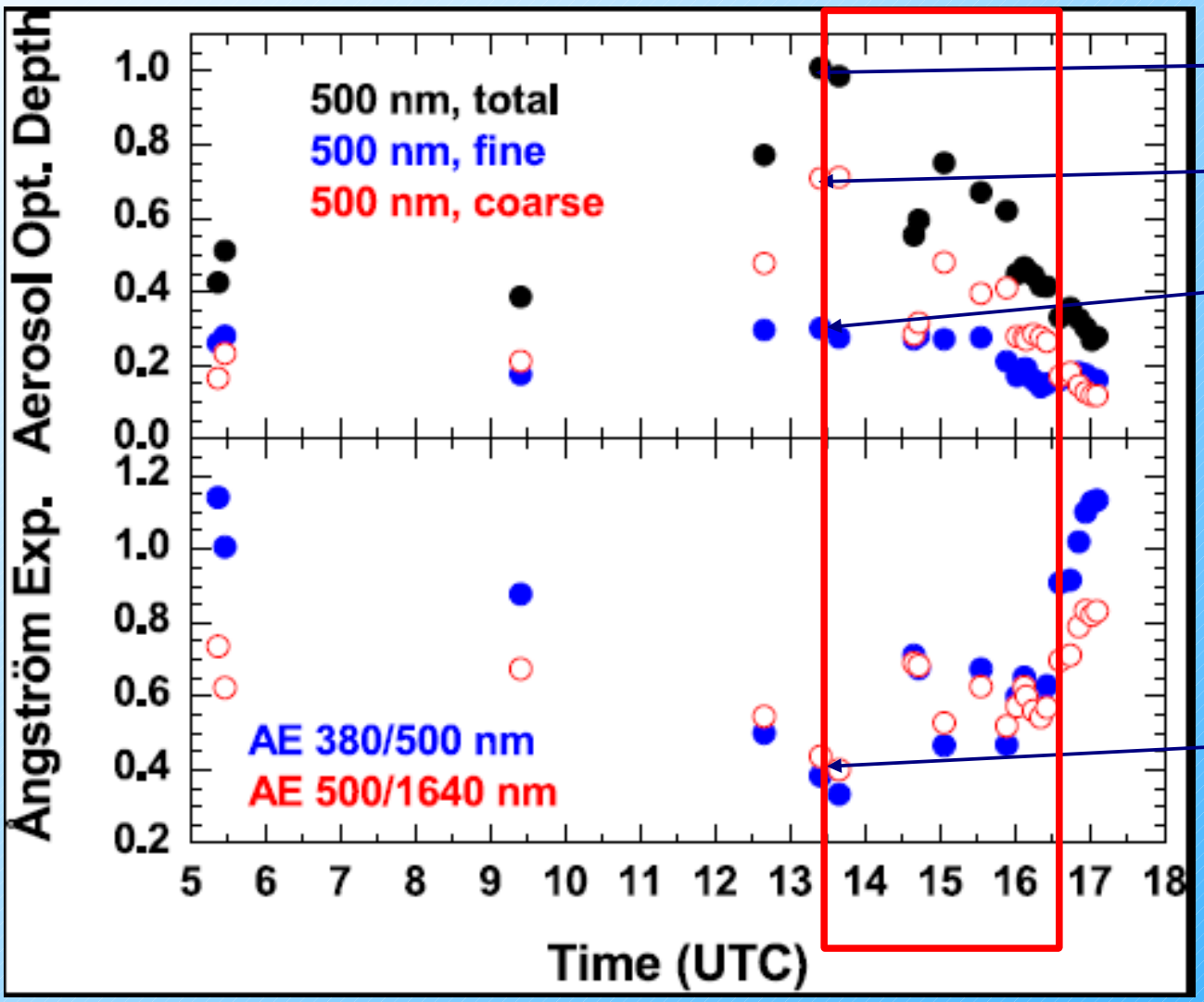
OD in PBL (from lidar) = 0.3

å ≈ 0.35 − 0.4

assumption: å in PBL = 1
→ $å_{ash}$ (380/500) = 0 − 0.1
→ $å_{ash}$ (500/1640) = 0.2 − 0.3
→ similar to Saharan dust (Morocco, 2006)
→ large particles (≥ 20 µm)

see: Ansmann et al., The 16 April 2010 major volcanic ash plume..., GRL 2010

Optical ash properties: April 16, 2010



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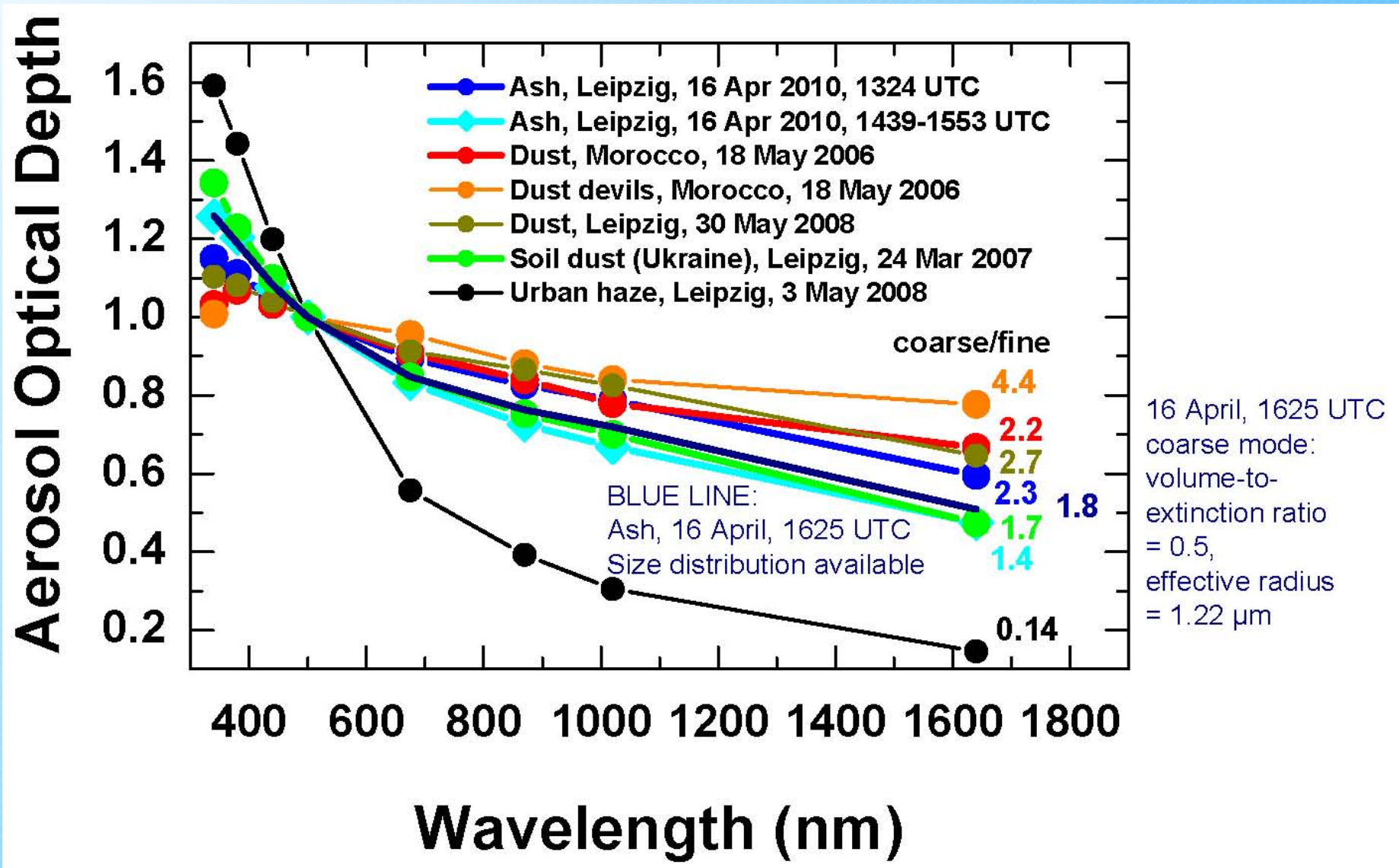


see: Ansmann et al., The 16 April 2010 major volcanic ash plume..., GRL 2010

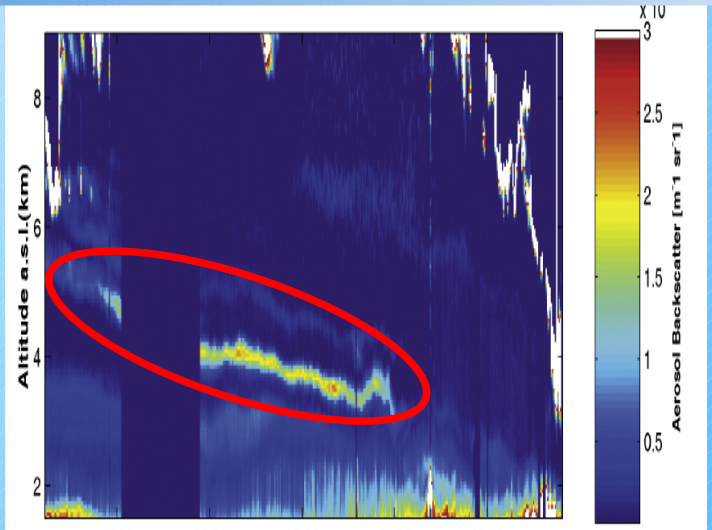
Summary: Eyjaflöll aerosol plume

- inhomogeneous aerosol plumes
  - directly emitted ash particles
  - freshly formed sulfuric acid particles
- layers up to 10 km
- lidar ratios: 50 – 60sr (532 nm)
- Ångström exponents (ash): 0 – 0.5
- linear particle depolarization ratio (ash): 35% – 40%
- estimated effective radius (ash): > 20 µm
- estimated max. mass concentration (ash): 1000 µg m^{-3}

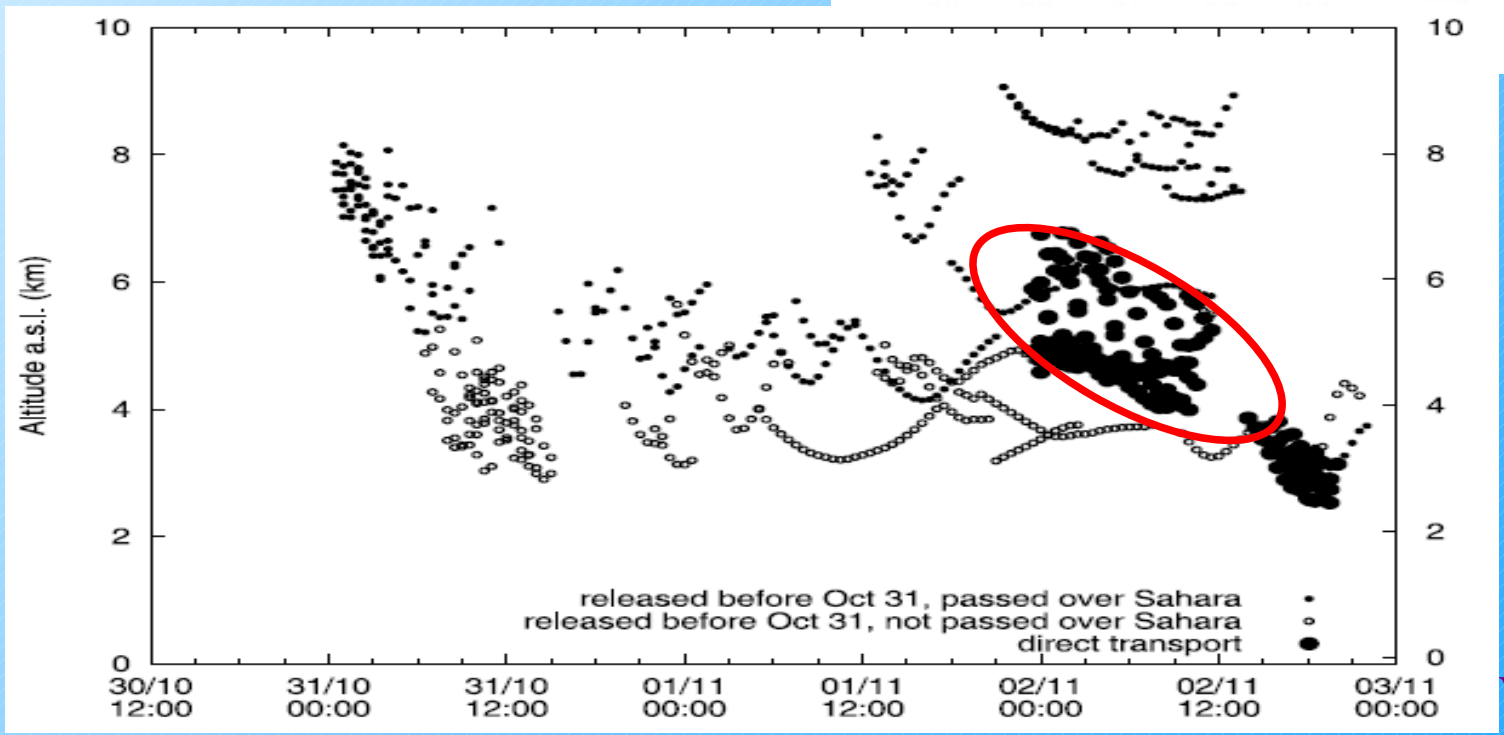
Volcanic aerosol

- In the tropopause region and stratosphere
  - North Pacific ring of fire 2008-2009
- In the troposphere
  - Etna 2001-2002
  - Eyjafjöll 2010
- EARLINET data for modelling studies

Model validation study of the 2002 Etna plume



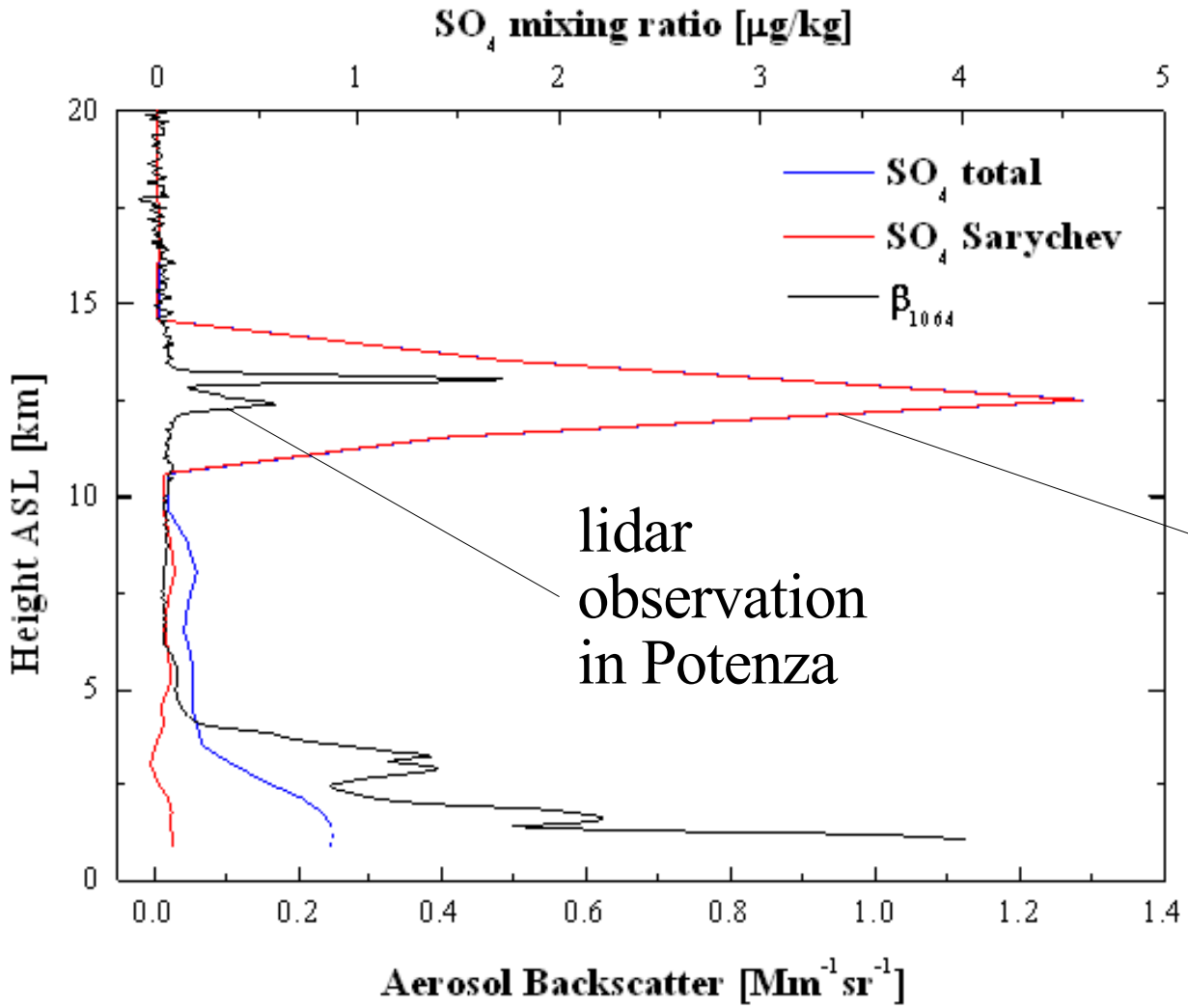
lidar observation in Potenza



BOLAM Model

Villani et al., JGR 2006

Model validation study of the 2009 Sarychev plume



see: D'Amico et al., ILRC 2010

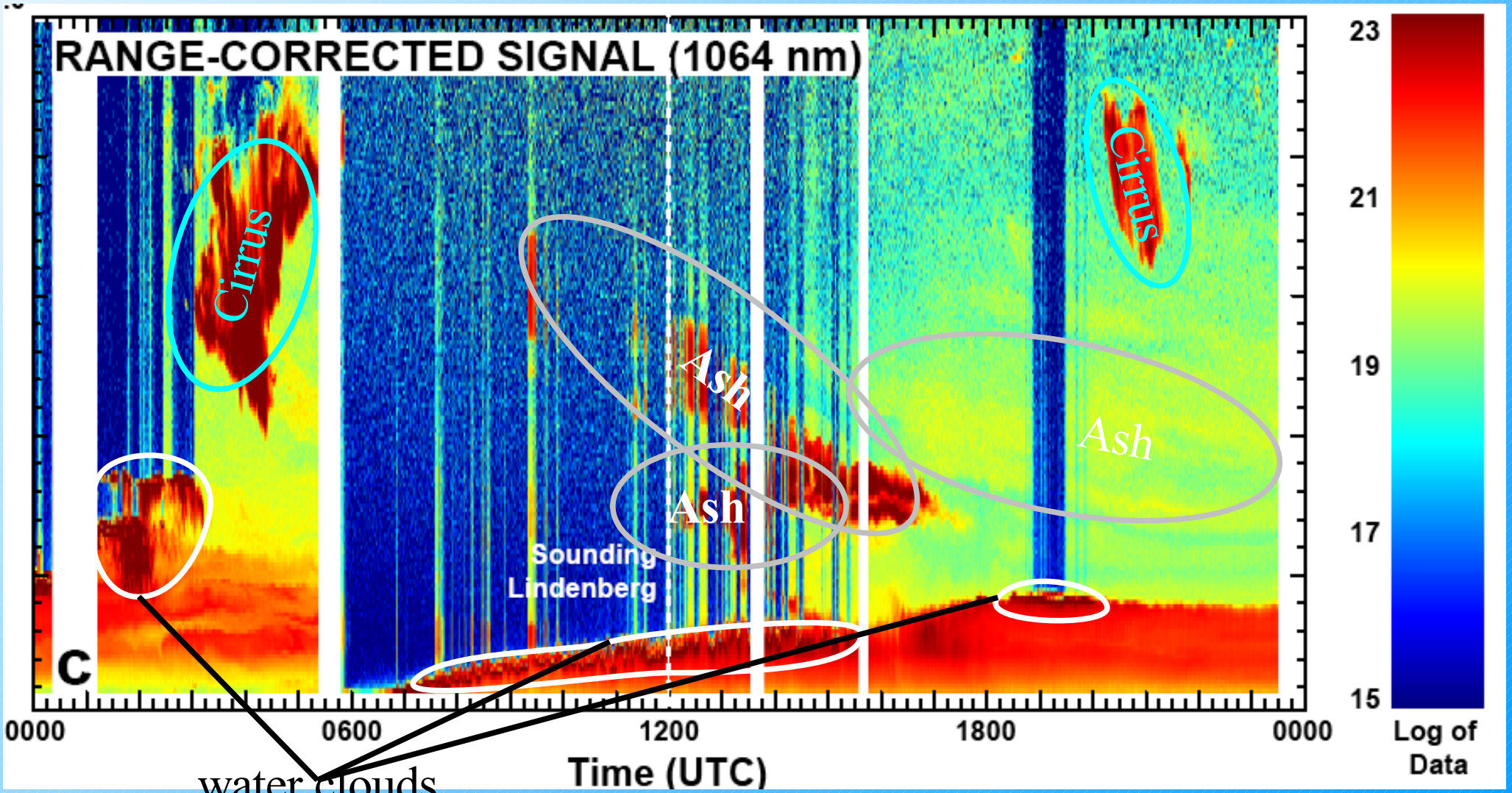
Eyjafjöll data set

Strong need for:

- not only data from individual lidar sites,
  but a homogeneous data set of Eyjafjöll plume observations of all EARLINET sites
- not only backscatter profiles
  but ash mask for non-lidar user

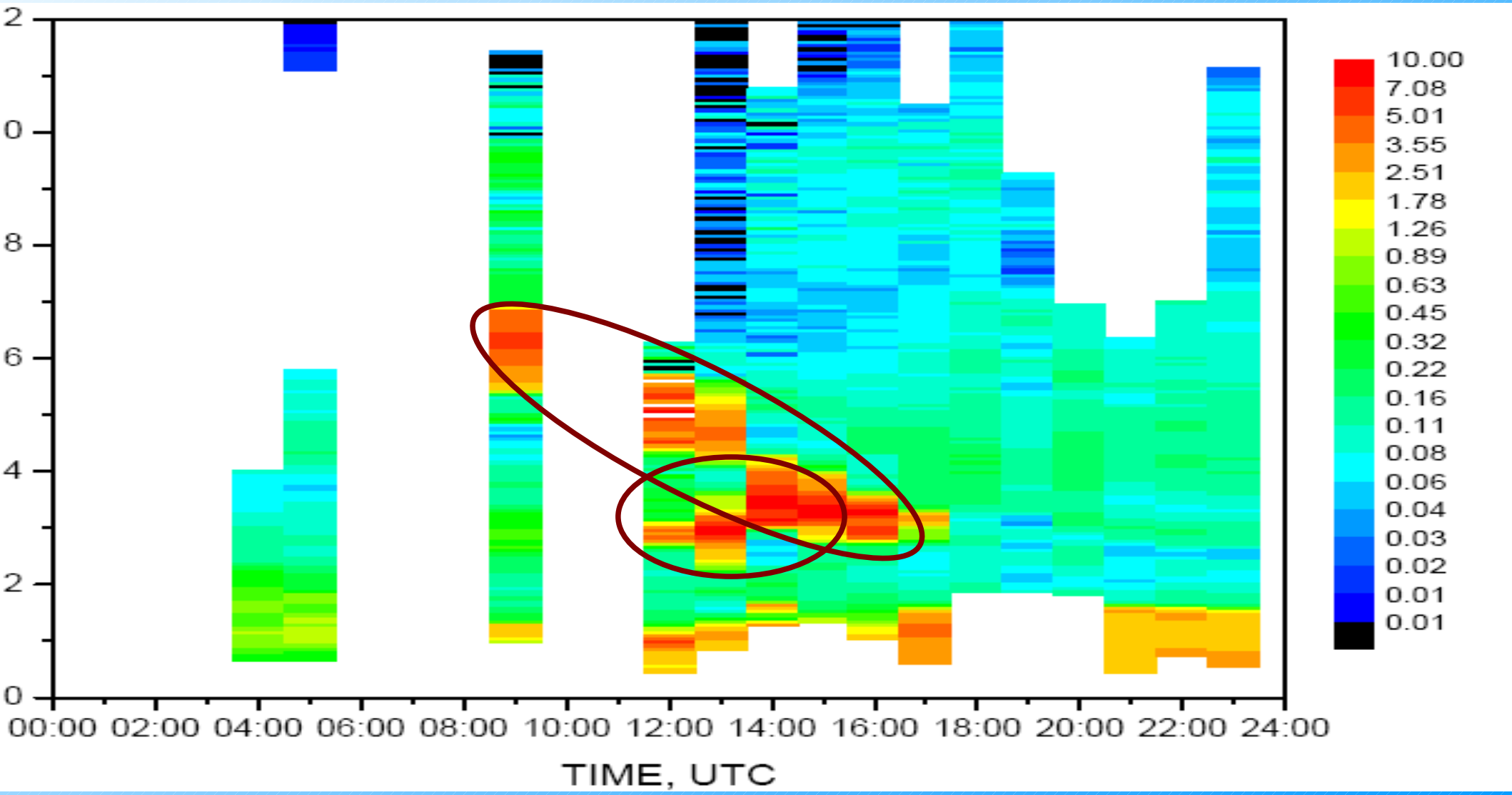
Development of an homogeneous ash mask

1) Quicklooks



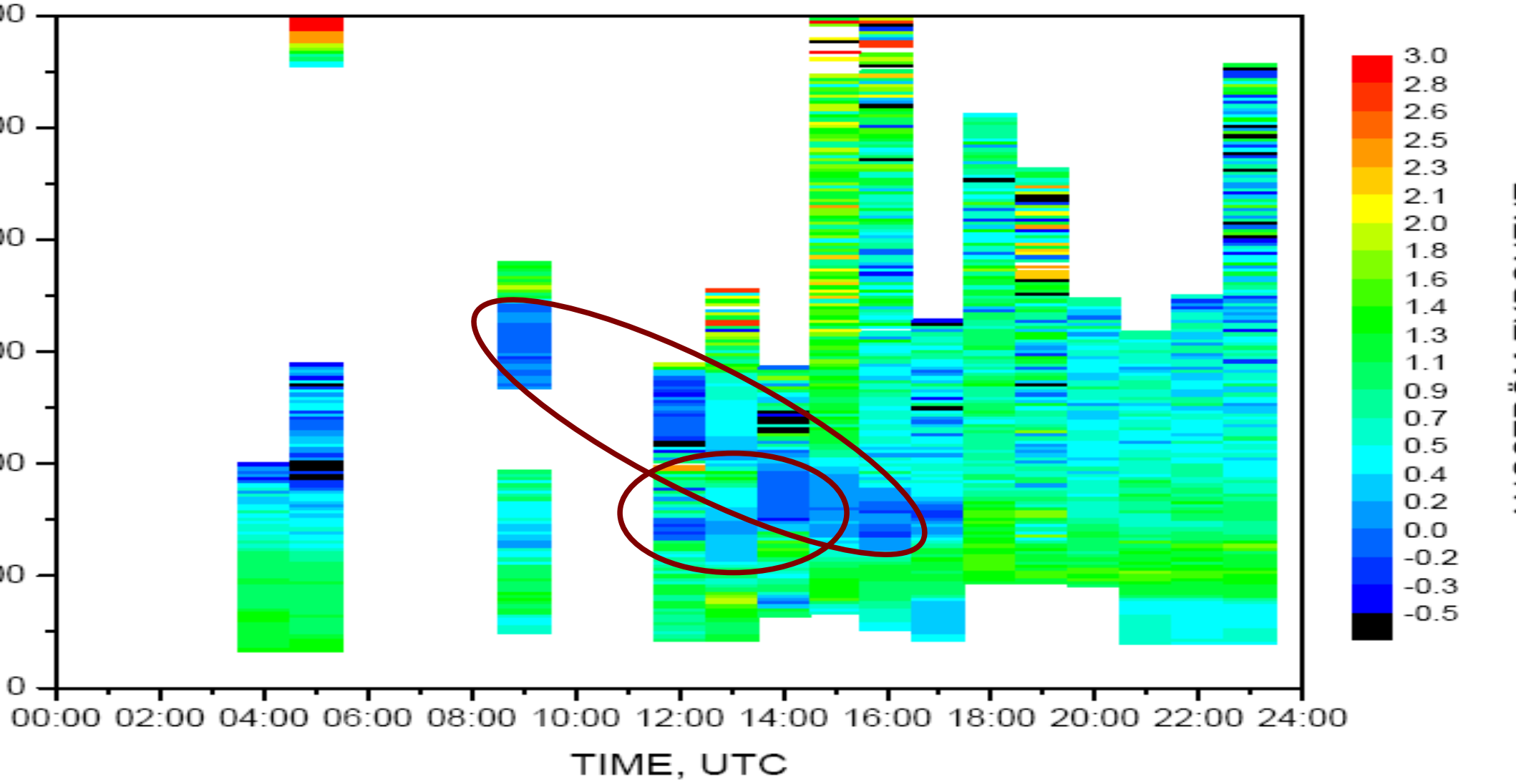
Development of an homogeneous ash mask

2) 1-hour mean values of backscatter profiles



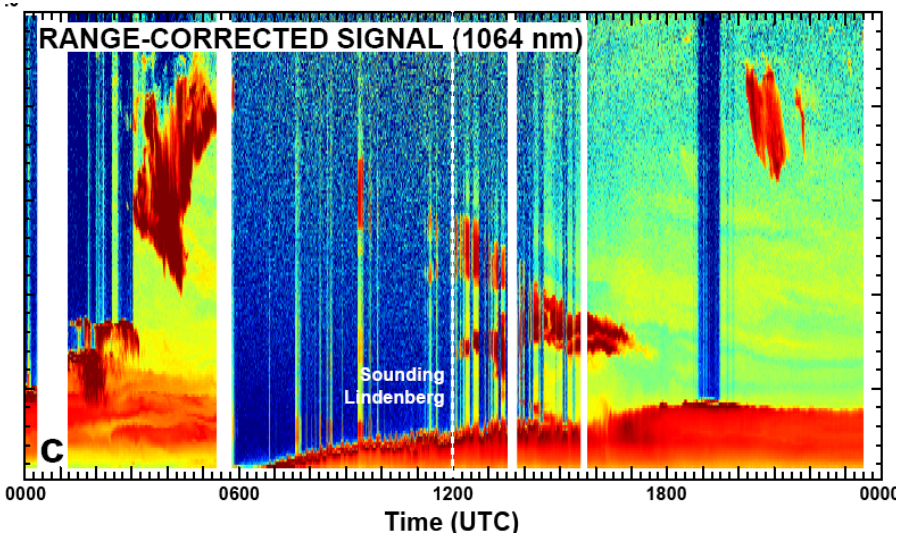
Development of an homogeneous ash mask

3) Angström exponents (if available)

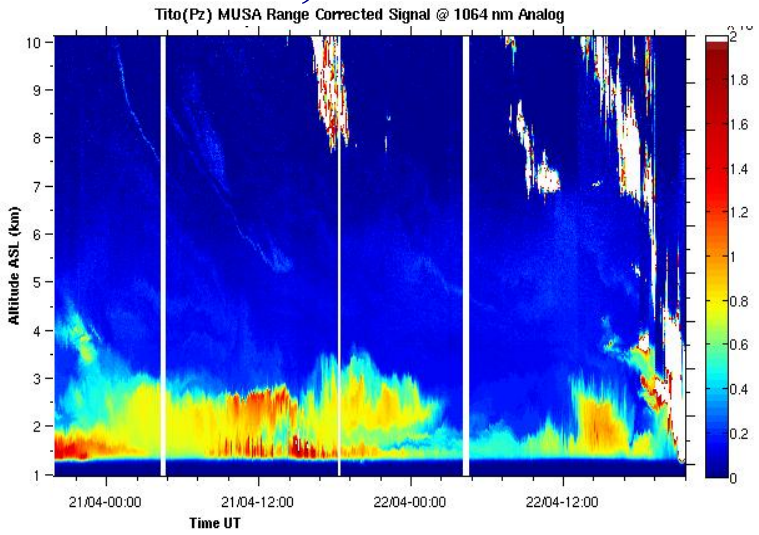


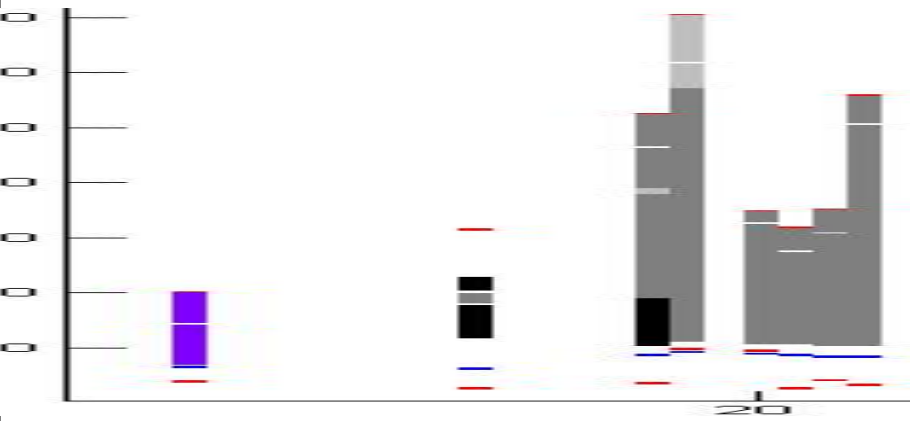
Homogeneous ash mask for all EARLINET stations

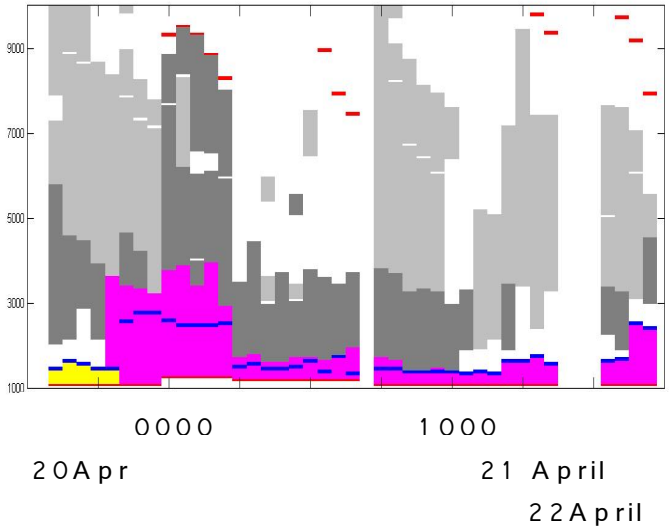
Leipzig, backscatter 1064



Potenza, backscatter 532







- Minimum and maximum investigated altitudes
- PBL top height
- PBLAerosol
- Mixed aerosol

Volcanic aerosol

- b1064>2E-6 m^{-1} sr^{-1}
- 5E-8<b1064<2E-6 m^{-1} sr^{-1}
- b1064<5E-8 m^{-1} sr^{-1}

- Cloud/cirrus
- Desert dust
- Forest Fires Aerosol
- UnknownAerosol

Summary: EARLINET data sets for model validation

- Volcanic aerosols plumes have known sources
  → validation of transport and aerosol transformation in models
- Several model validation studies with data from individual EARLINET stations, e.g.
  - Etna plume 2002
  - Sarychev plume 2009
- New! Eyjafjöll plume measurements will be provided as a homogeneous European ash mask to the community
- Need for homogeneous near-real time data analysis
  → single-calculus chain

Thank you

The EARLINET-ASOS project is funded by the EC under grant RICA-025991.

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M. Adam (30), L. Alados-Arboledas (8), A. Amodeo (1), A. Ansmann (2), A. Apituley (15), D. Balis (13), V. Bellantone (17), C. Böckmann (23), J.A. Bravo-Aranda (8), P. Burlizzi (17), A. Chaikovsky (24), A. Comeron (22), J. Cuesta (19), G. D'Amico (1), M. de Graaf (16), F. de Tomasi (17), D. Donovan (16), V. Freudenthaler (11), J. Gasteiger (11), M. Gausa (4), E. Giannakaki (13), H. Giehl (10), A. Giunta (1), I. Grigorov (28), S. Gross (11), O. Gustavsson (31), M. Haeffelin (20), B. Heese (2), A. Hiebsch (2), M. Iarlori (5), S. Kinne (14), G. Kolarov (28), H. Linne (14), F. Madonna (1), R. Mamouri (12), V. Mitev (25), F. Molero (29), L. Mona (1), D. Müller (2), F. Navas-Guzmán (8), A. Nemuc (6), D. Nicolae (6), L. Osterloh (23), A. Papayannis (12), M.R. Perrone (17), R. Persson (31), A. Pietruczuk (7), G. Pisani (27), J. Podgorsky (7), J. Preißler (18), M. Pujadas (29), J.-P. Putaud (30), F. Ravetta (21), V. Rizi (5), F. Rocadenbosch (22), J. Schmidt (2), P. Seifert (2), I. Serikov (14), M. Sicard (22), A.M. Silva (18), V. Simeonov (26), N. Spinelli (27), K. Stebel (3), D. Stoyanov (28), A. Tafuro (17), M. Tesche (2), T. Trickl (10), F. Wagner (18), U. Wandinger (2), X. Wang (27), M. Wiegner (11), K. Wilson (15)

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