Raman and elastic lidar techniques for aerosol observation at CIAO

F. Madonna, A. Amodeo, I. Binietoglou, G. D'Amico, A. Giunta, L. Mona, G. Pappalardo

Consiglio Nazionale delle Ricerche, Istituto di Metodologie per l'Analisi Ambientale (CNR-IMAA)

madonna@imaa.cnr.it

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Raman vs Elastic: background

Raman: α+β with no assumption on the lidar ratio S (only angstrom coefficient assumed χ, with low errors)

→ Advanced lidar technique (multi-wavelength)

Elastic: β using Klett or Fernald methods, assumption of S, constant throughout the profile (layer).

→ Basic lidar tecnique (including ceilometers)

Potenza EArlinet Raman Lidar (PEARL)

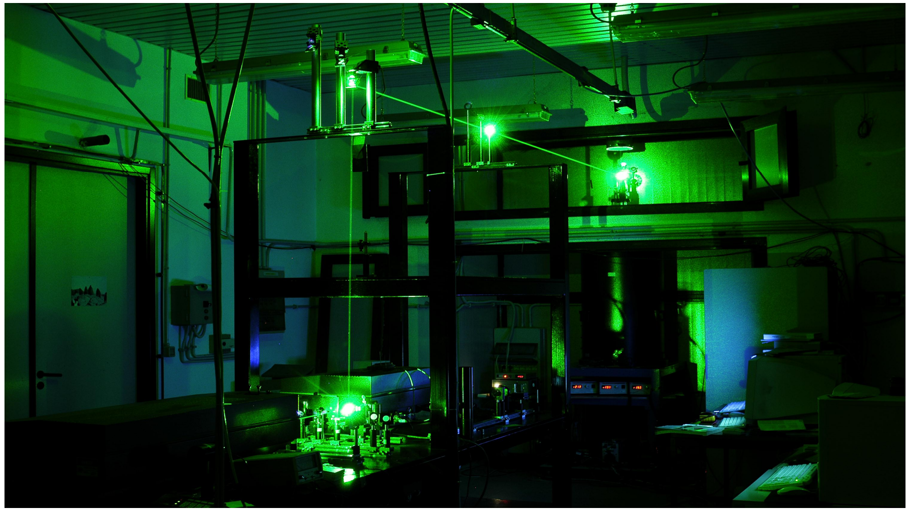
LASER: ND:YAG (Continuum Powerlite Precision II 9050)
Max. pulse energy : 1200mJ @1064nm
600mJ @532nm
350mJ @355nm
Max. repetition rate 50Hz
Beam divergence 0.25 mrad
(beam expander 2X with remixing)

RECEIVER: Cassegrain Telescope
Diameter of the primary mirror 0.5 m
Combined focal length 5 m
Nighttime field of view 1 mrad
Achromatic lens Ø=2", f=50cm

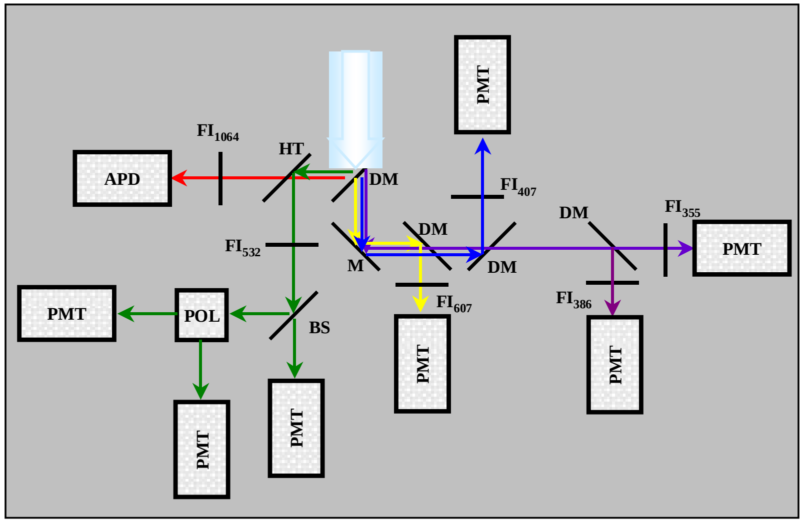
CHANNEL SELECTION
Interference filters (FI), bandwidth 0.5 nm
Polarizer beam splitter (BK7) a 532 nm (POL)
Dichroic mirrors (DM e HT)
Selection of high and low altitude channels

ACQUISITION
Fotomultipliers (PMT) THORN EMI
9202QA 532, 532⊥, 532||, 607 nm
9893/350B 355, 386 nm
EG&G MCS - PCI (100ns min dwell time, 150MHz photon counting)
APD 1064 nm Licel Transient recorder (12bit 20 MHz analogic, 250 MHz photoncounting)

Operational since 2000 (upgrade in 2005 of a pre-existing lidar system)



Madonna et al., Atmos. Meas. Tech. Discuss., 2010



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MUSA: MUltiwavelenght System for Aerosol

LASER: ND:YAG (Continuum Surelite II-20)
Max. pulse energy : 550mJ @1064nm
250mJ @532nm
120mJ @355nm
Max. repetition rate 20Hz
Beam divergence 0.6 mrad

RECEIVER: Cassegrain Telescope

Diameter of the primary mirror	0.3 m
Combined focal length	950 mm
Nighttime field of view	1 mrad
Achromatic lens	Ø=9mm, f=100mm

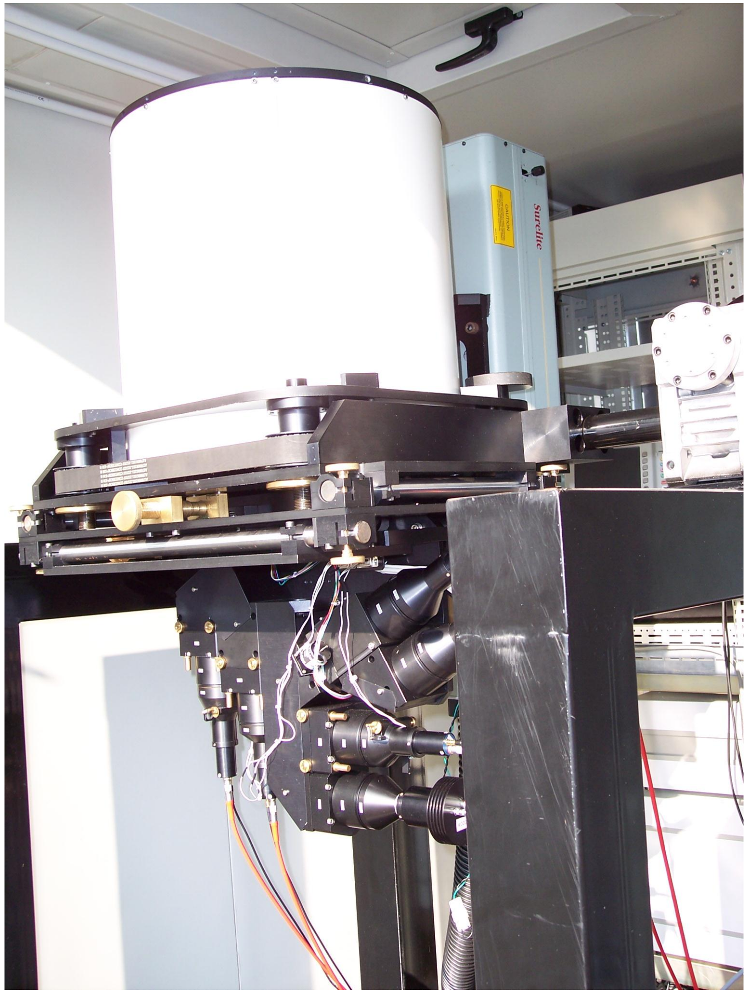
CHANNEL SELECTION
Interference filters (FI), bandwidth 0.5 nm
Polarizer beam splitter (BK7) at 532 nm (POL)
Dichroic mirrors (DM e HT)

ACQUISITION
Fotomultipliers (PMT), Hamamatsu

R7400P-06	355, 387, 532⊥, 532‖ nm
R7400U-20	607nm
APD	1064nm

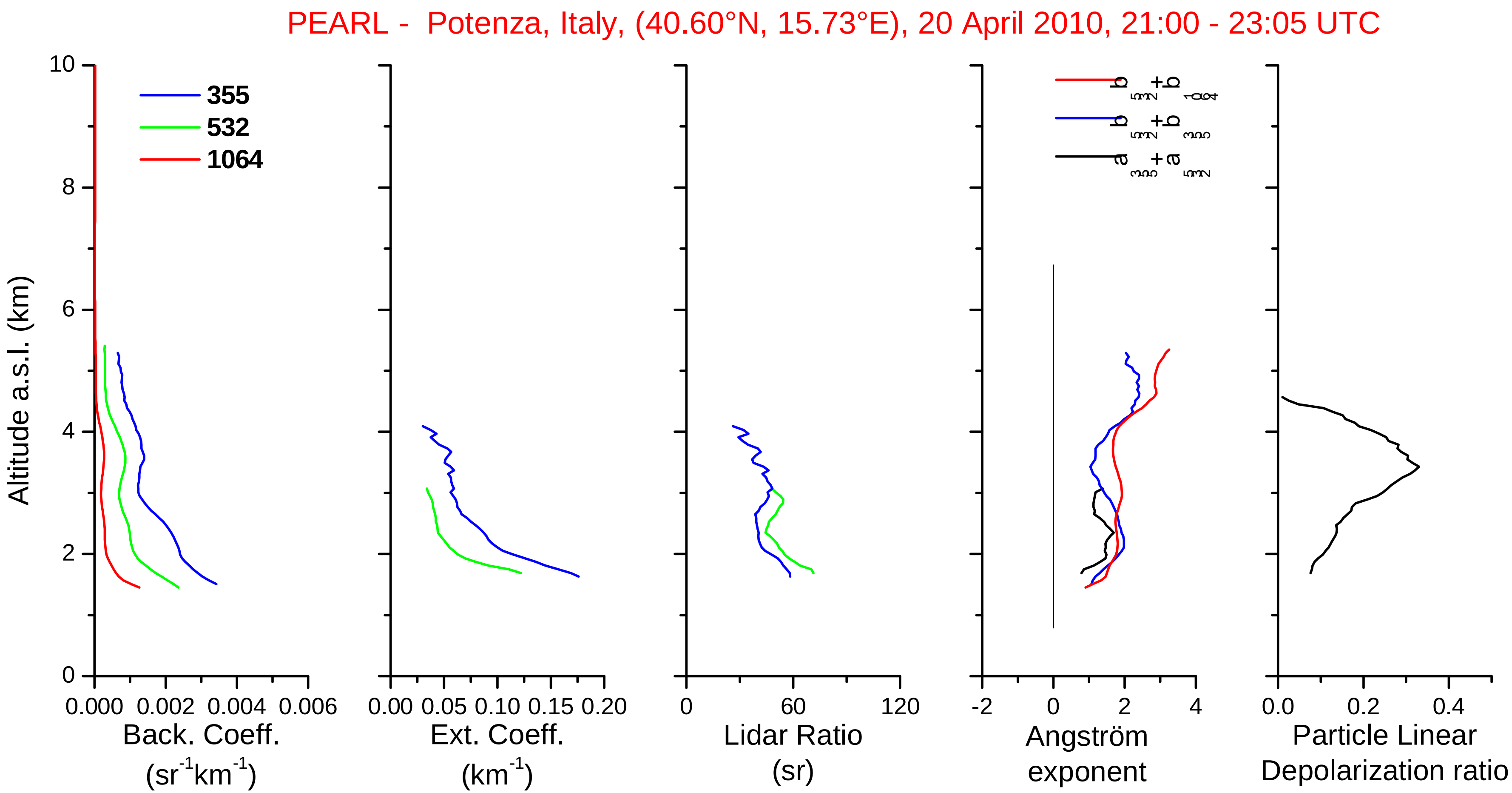
Licel Transient recorder (12bit 40 MHz analogic, 250 MHz photoncounting)

Operational since April 2009



EARLINET Mobile Reference System

3β+2α+δ analysis from Raman lidar



Mona et al., 2011, Atmos. Chem. Phys., submitted

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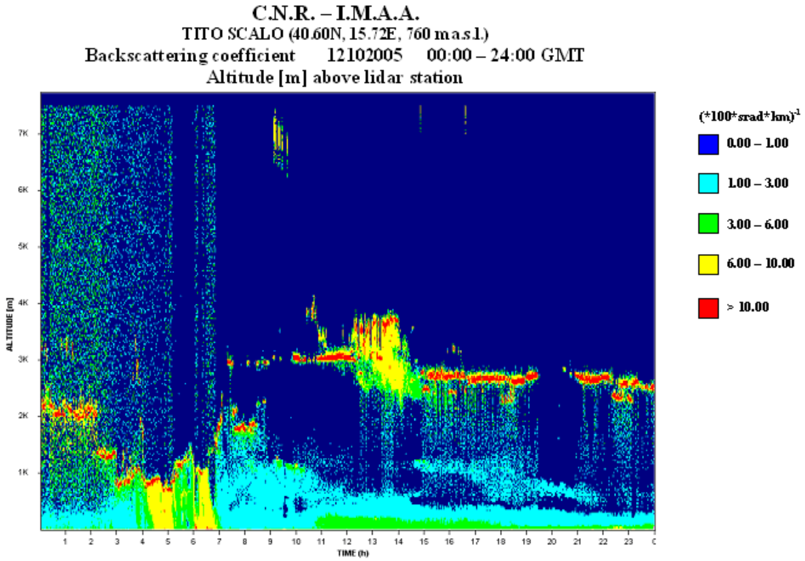
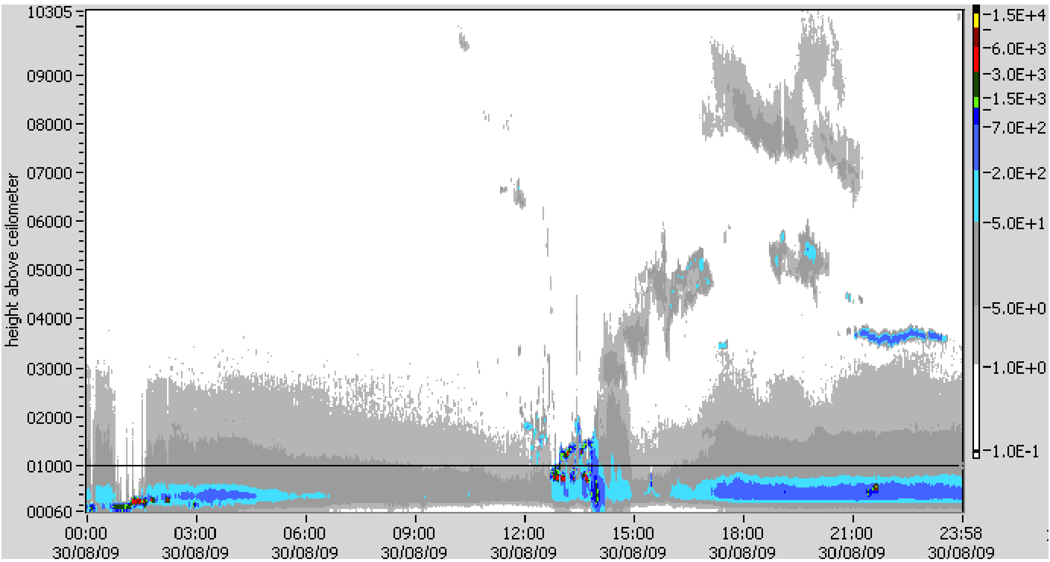
Ceilometers

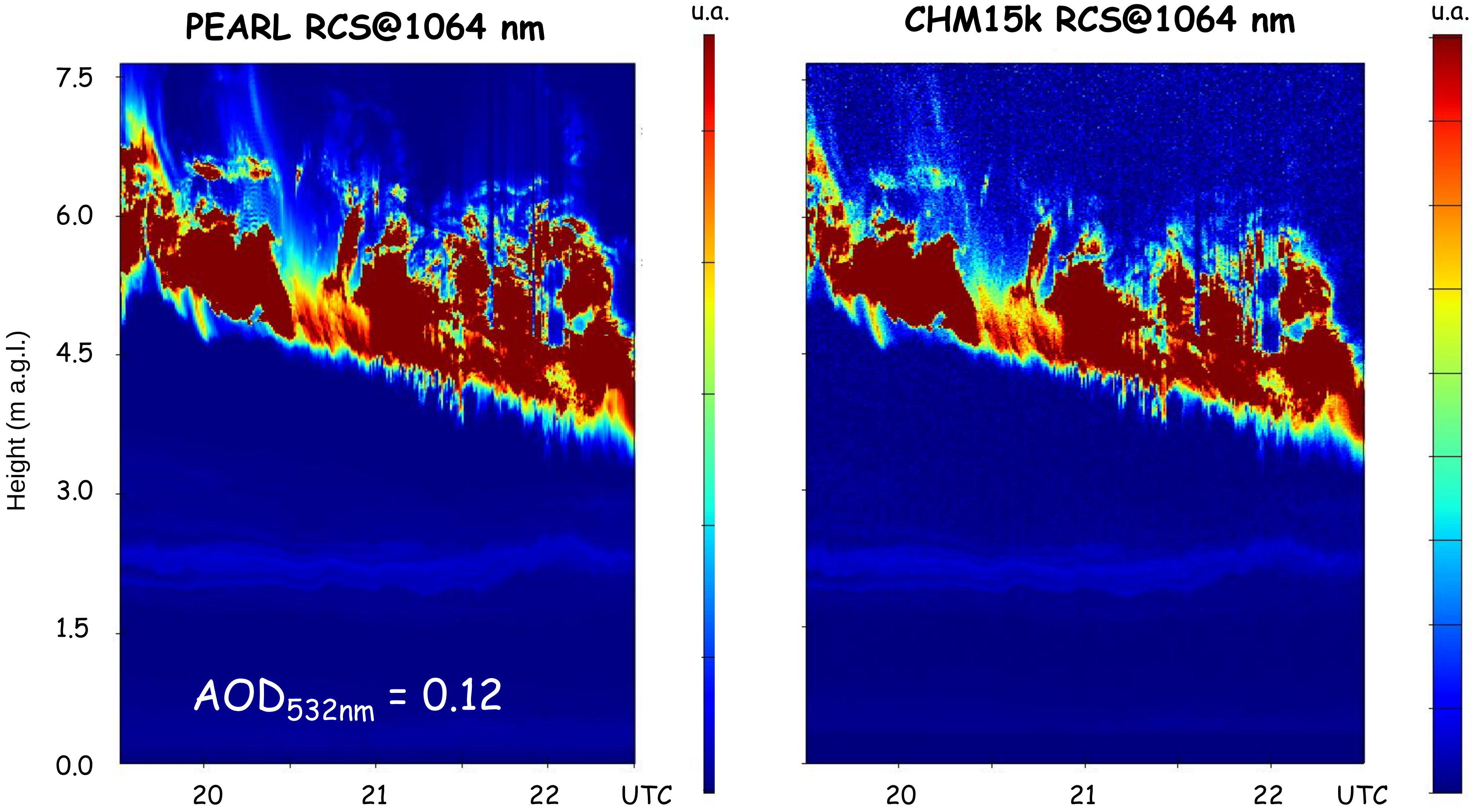
CT25K 905 nm ceilometer
Operational since August 2004





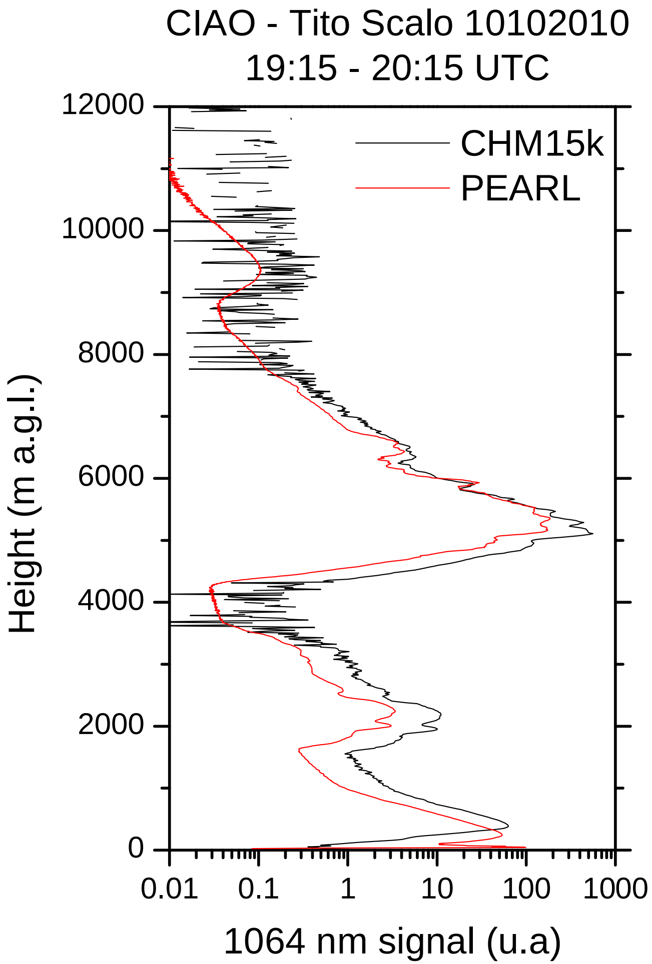
CHM15K 1064 nm ceilometer
Operational since July 2009

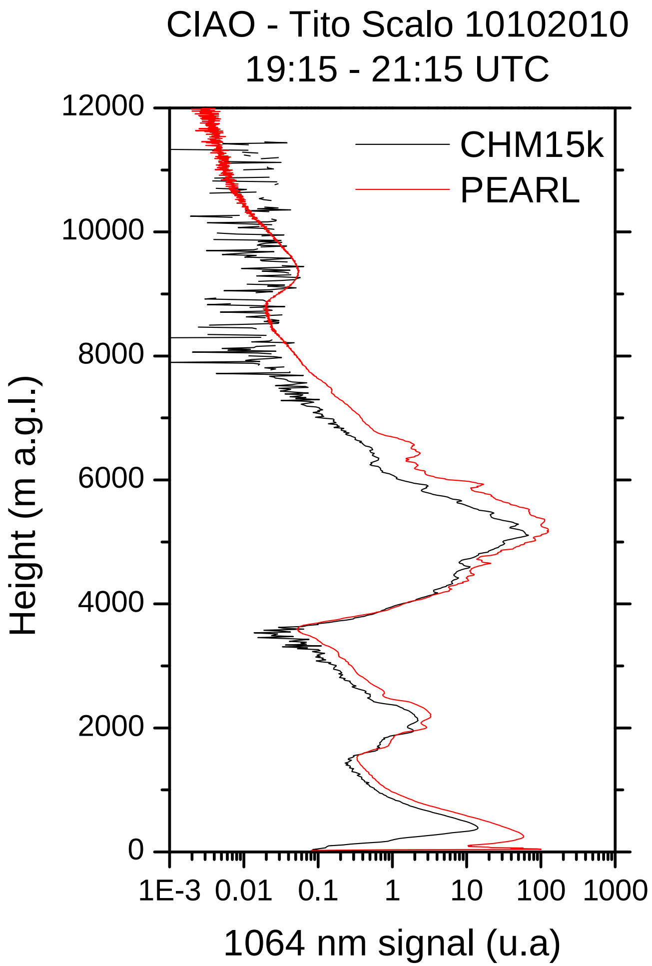
Sensitivity: 10/10/2010



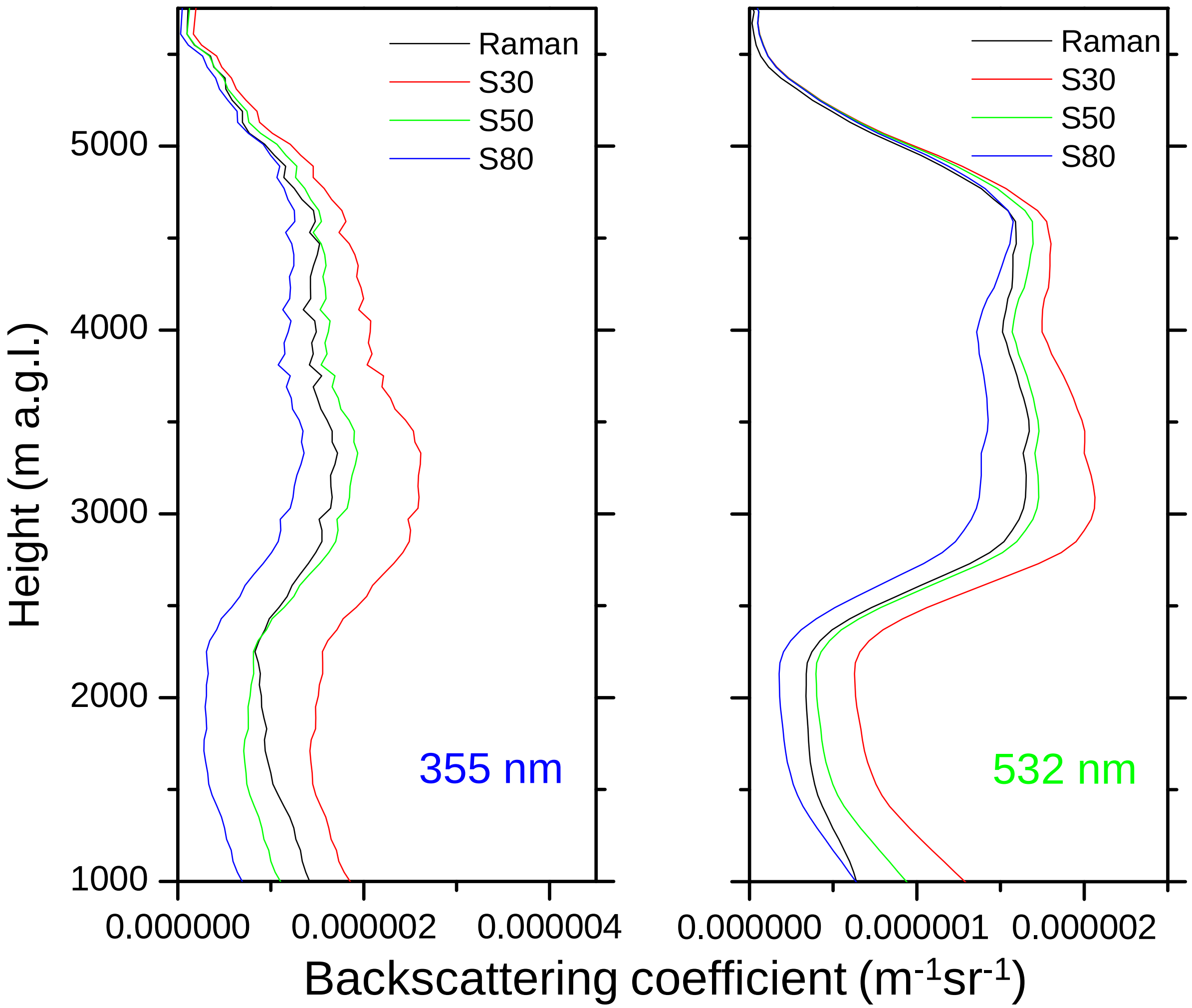
Ceilometer calibration

- CT25K unattenuated backscattering only (Mona et al. 2009)
- CHM15k signal 1064 nm





Influence of the lidar-ratio assumption on backscatter retrievals: 27/05/2008



Böckmann et al., 2004; Pappalardo et al., 2004

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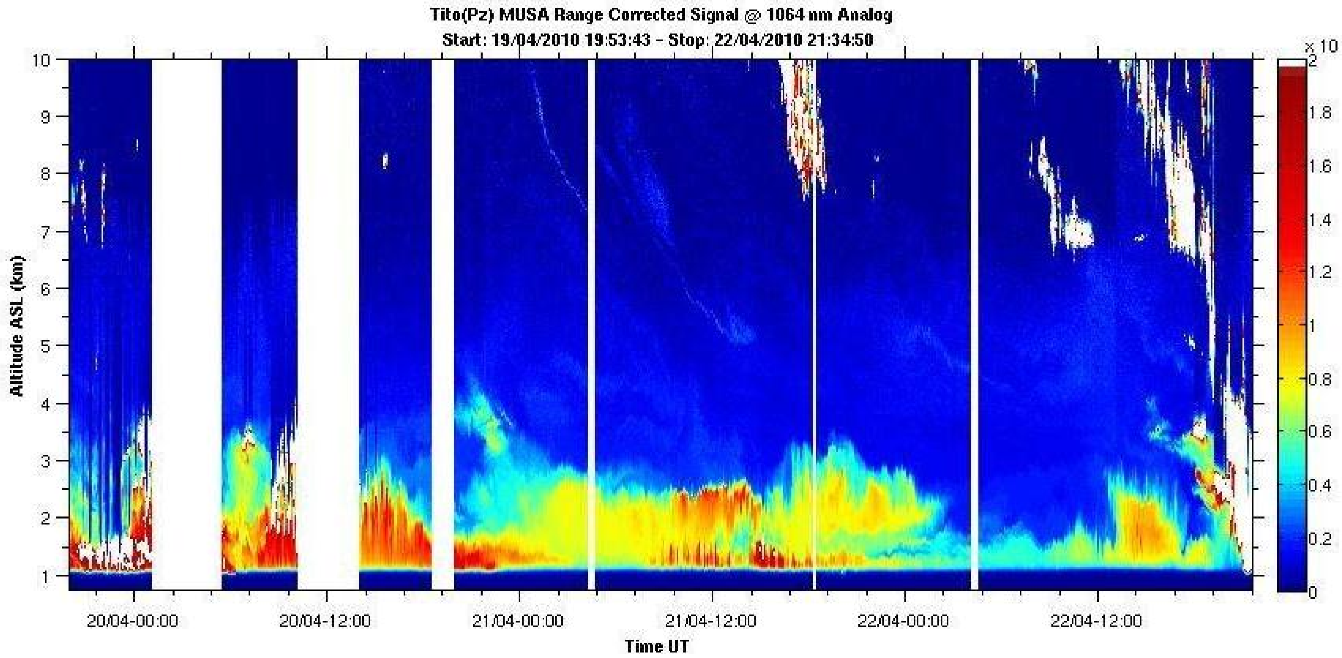
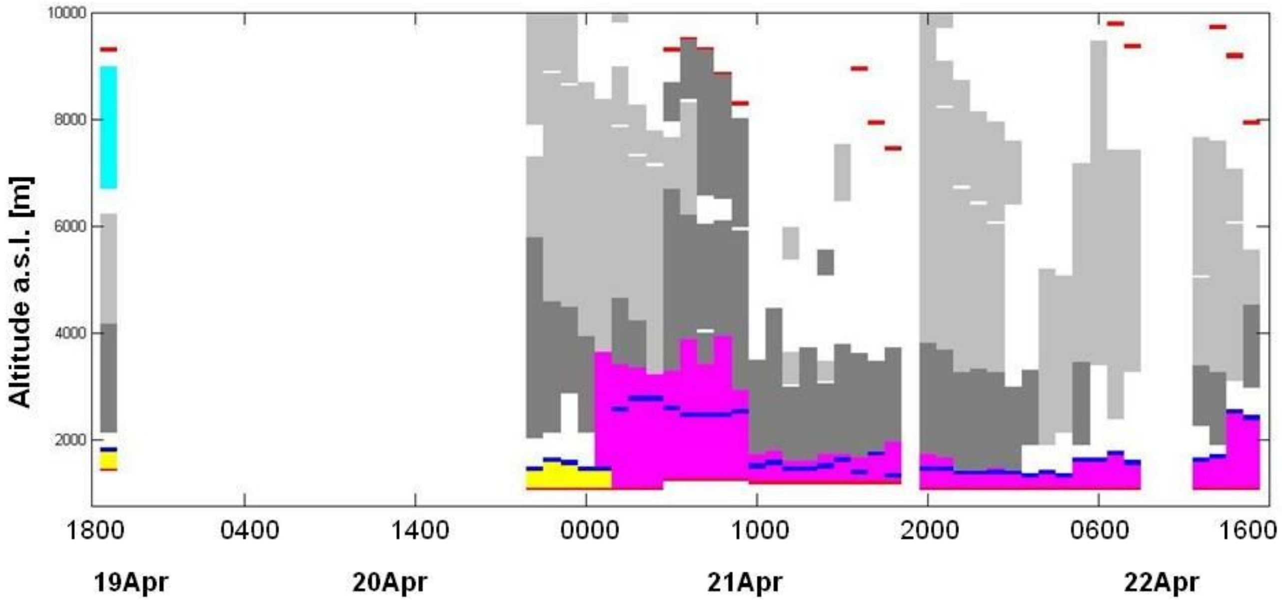


Aerosol mask

Mona et al. ACP special issue, submitted.



Minimum and maximum investigated altitudes

PBL top height

PBL Aerosol

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

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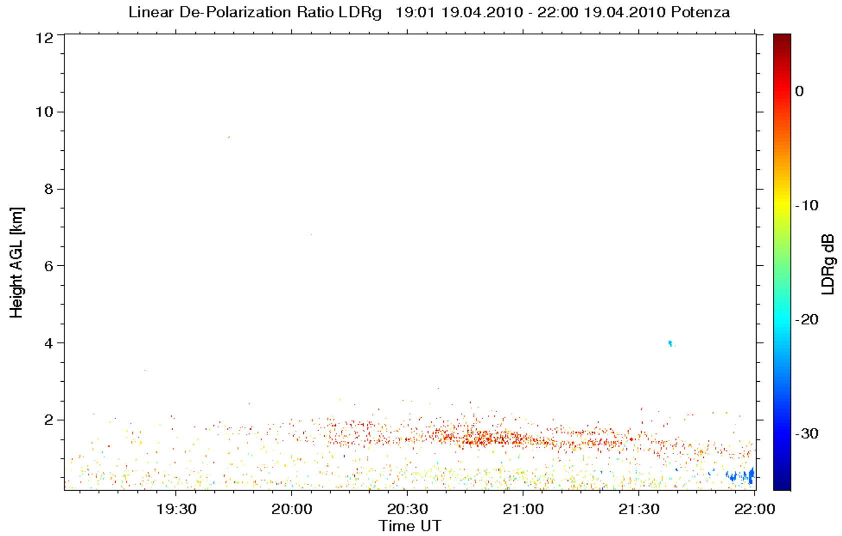
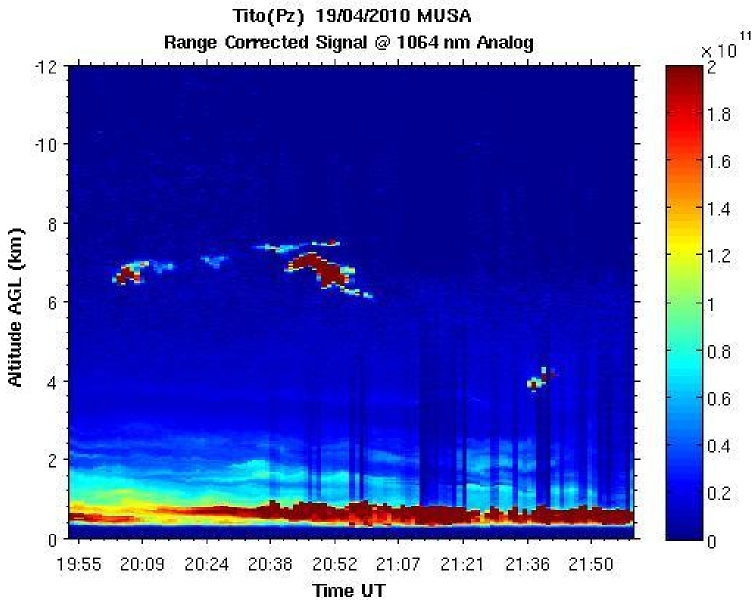
Lidar – Radar synergy



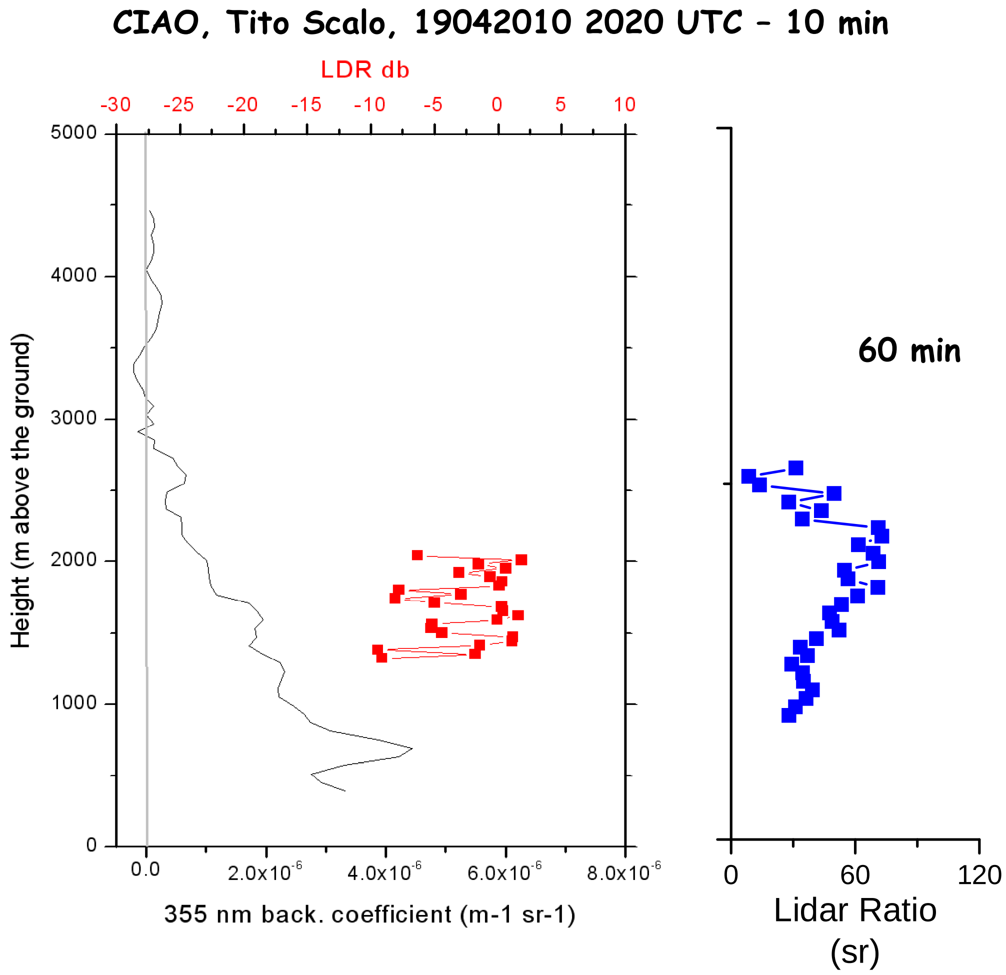


19 April 2010

Lidar start time: 19:47 UT

Radar: 24h operational

Observation of ultragiant aerosol



Integration time: 10 minutes
Lidar vertical resolution: 30 - 300 m

Ultragiant aerosol layer detected by the radar, characterised by high LDR values, is located between about 1.4 and 2.1 km above the ground. This layer is completely included in the lower volcanic aerosol layer observed by the lidar and characterized by a maximum value of the 355 nm volume backscattering coefficient of 2.3 Mm-1 sr-1.

Madonna et al., (2010), Geophys. Res. Lett., 37, L21814, doi:10.1029/2010GL044999.

Summary

- Aerosol layering in the low tropopshere

→ Elastic (sensitivity assessment for ceilometers)

- Alerting system

→ Elastic + backtraj ok in a preliminary phase,
Aerosol masking using advanced Raman lidars

- Aerosol typing, optical and microphysical properties

→ Raman (+depolarization)

- Integrated products

→ Raman

Thanks