Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

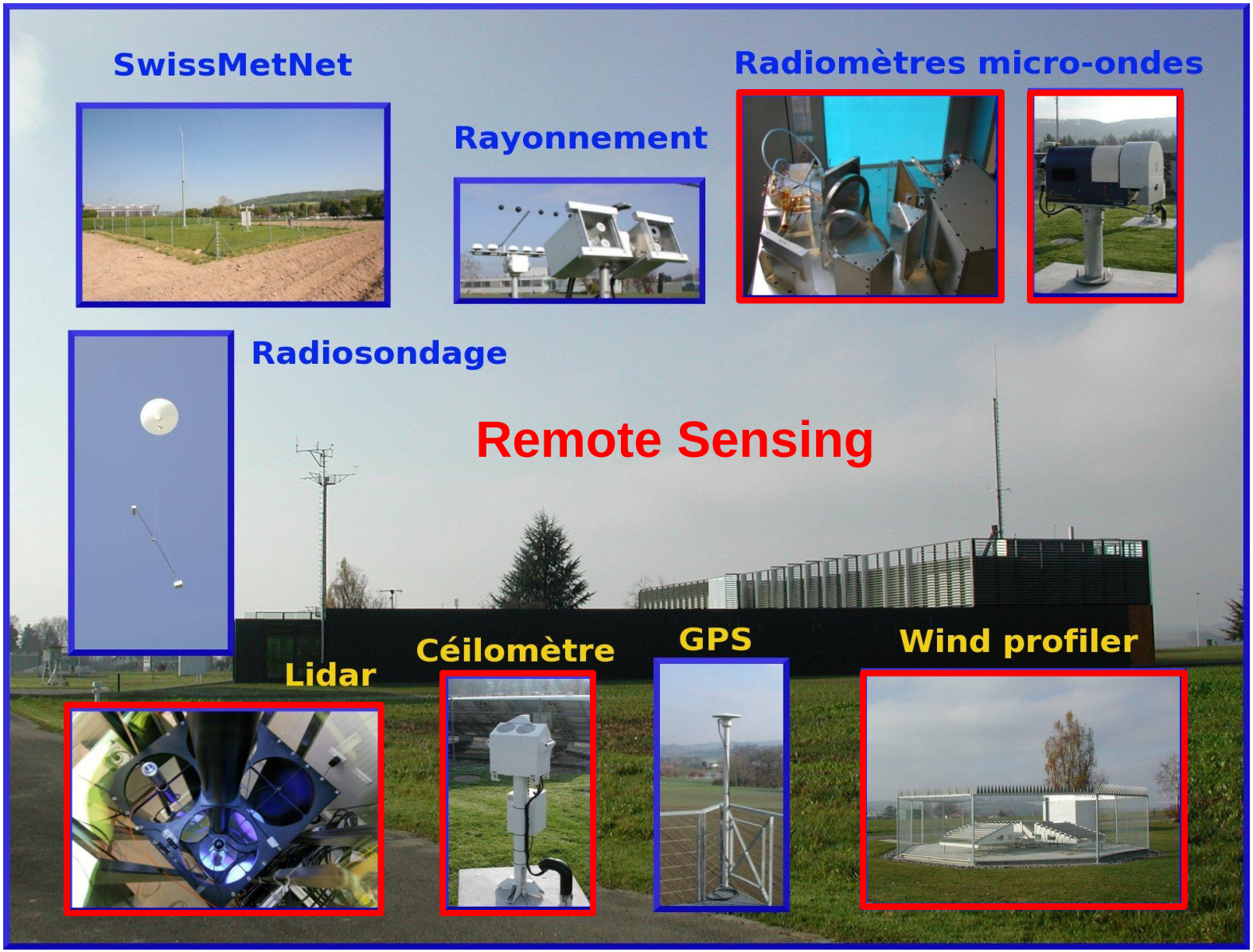
Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

MeteoSwiss Payerne CIMO Testbed report on remote sensing activities and interaction with ET-NRST

Alexander Haefele, Eliane Maillard Barras, Maxime Hervo, Giovanni Martucci, and Dominique Ruffieux

The Aerological Station Payerne



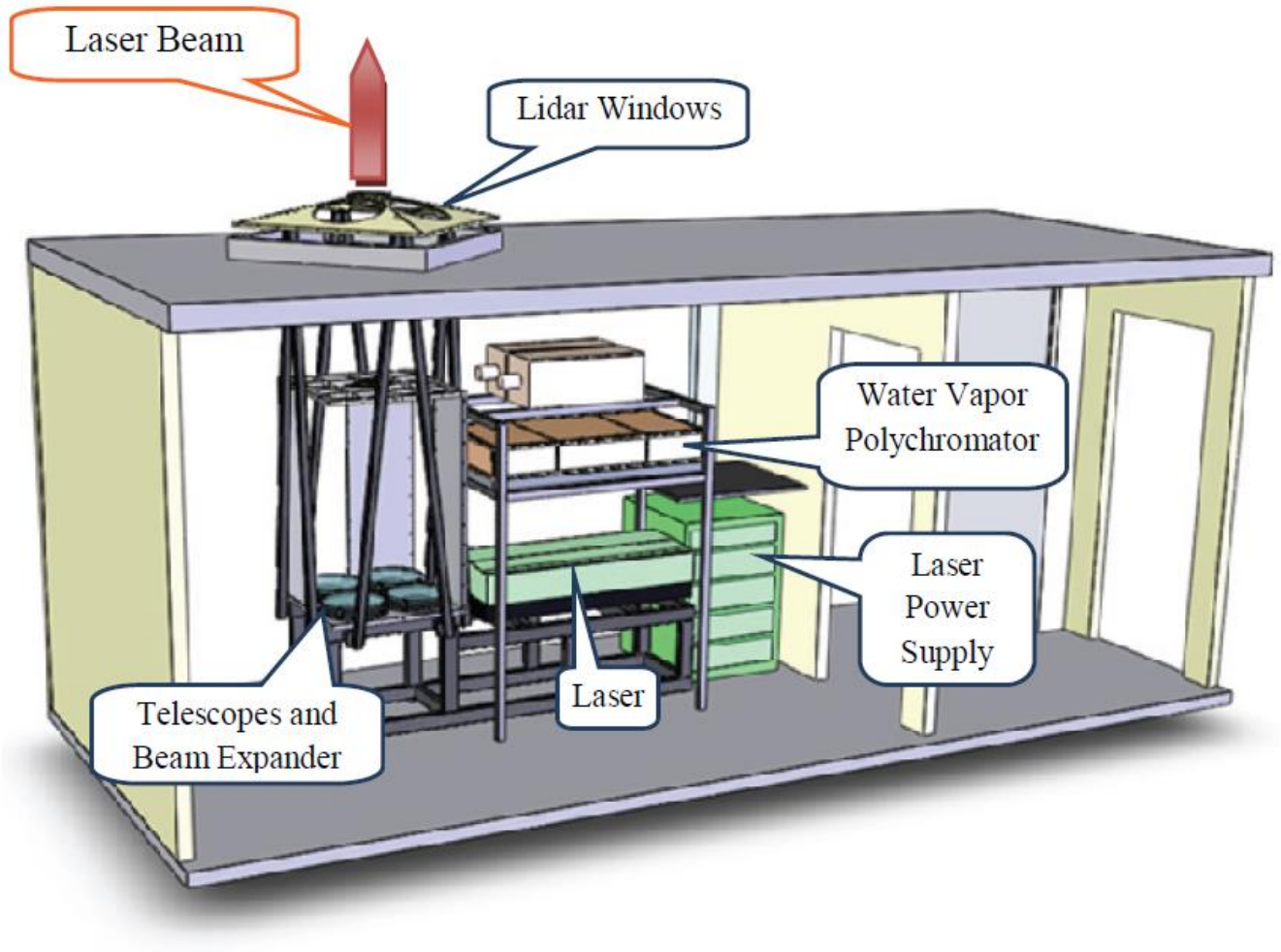
Remote Sensing Activities

- Operational network of radar windprofiler and microwave radiometer (MWR) for surveillance of nuclear power plants
- Operational Raman lidar for water vapor, temperature and aerosols
- Low cost automatic lidars for profiling of aerosols and volcanic ash (EUMETNET/E-PROFILE and COST/TOPROF)
- Operational MWR for stratospheric/mesospheric ozone
- Optimal estimation methods to retrieve information from remotely sensed data
- Assimilation of MWR and Raman lidar into NWP model
- Frequency protection within WMO and EUMETNET
- Metrology for remote sensing (EMPIR environment call, national collaboration with METAS)

For more details see CIMO testbed activity report.

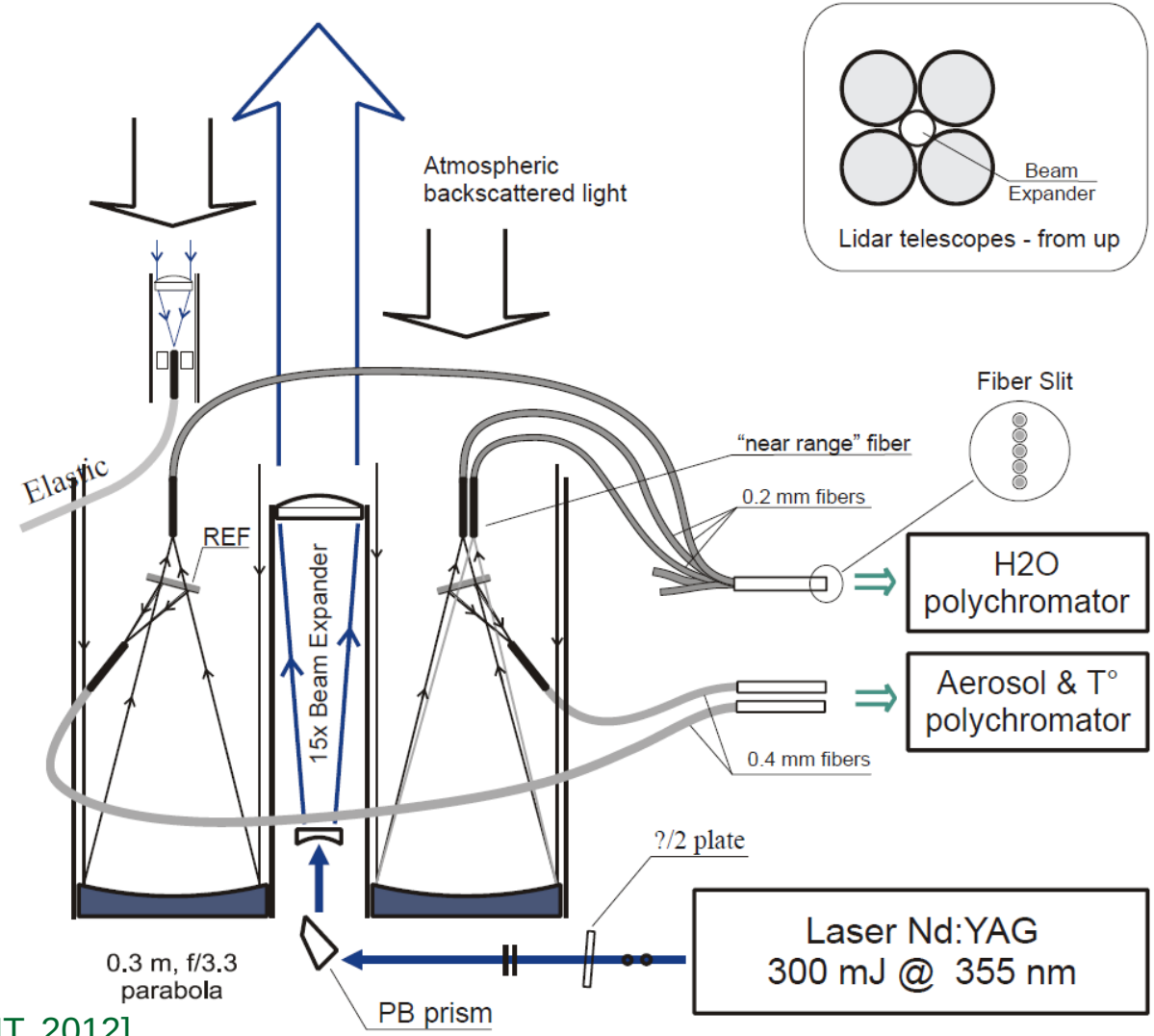
Raman lidar

Instrument Description



Instrument Description

Div. < 0.1 mrad



0.3 nm BW

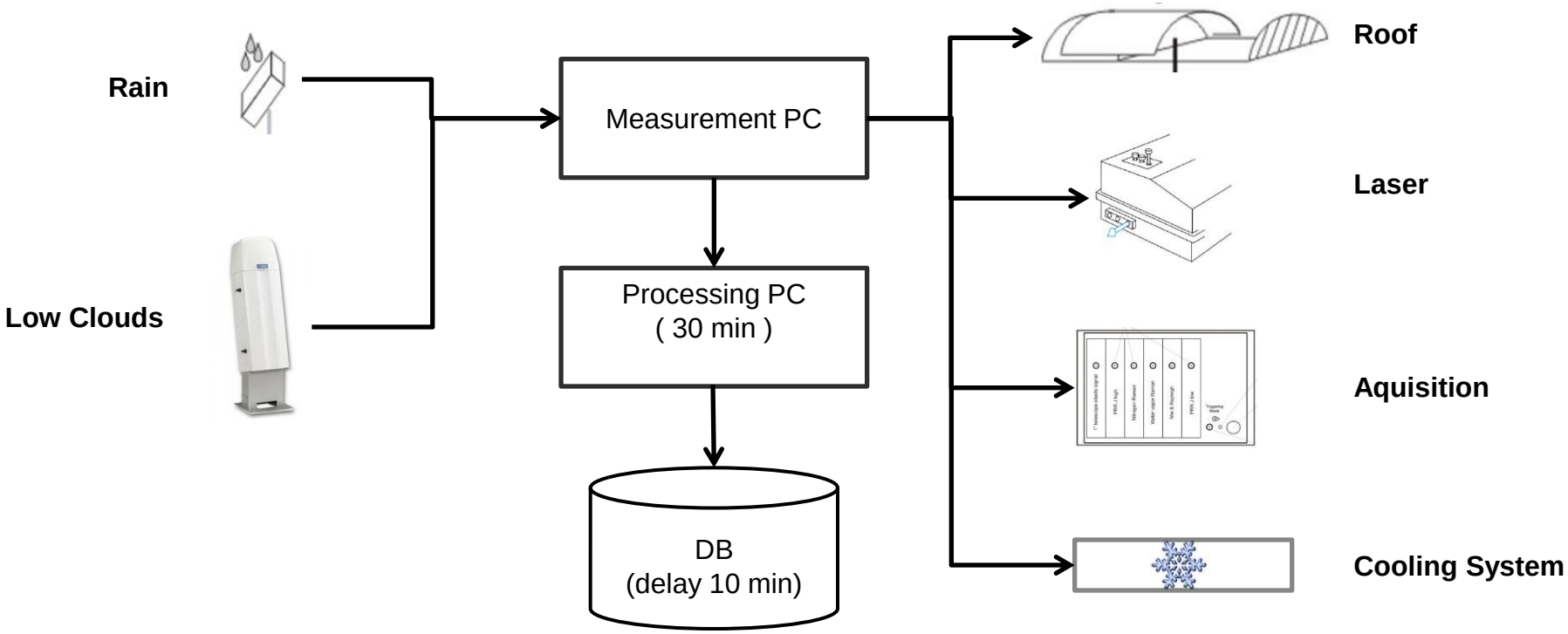
FOV 0.2 mrad

30 Hz / 9 W

[Dinoev et al., AMT, 2012]

Automatic Operation 24/7

http://www.pay.meteoswiss.ch/cgi-bin/rem/remDisplay.pl?timestamp=201608&instrument=LIDAR&measurement=SH&plot=TS&mode=LOW

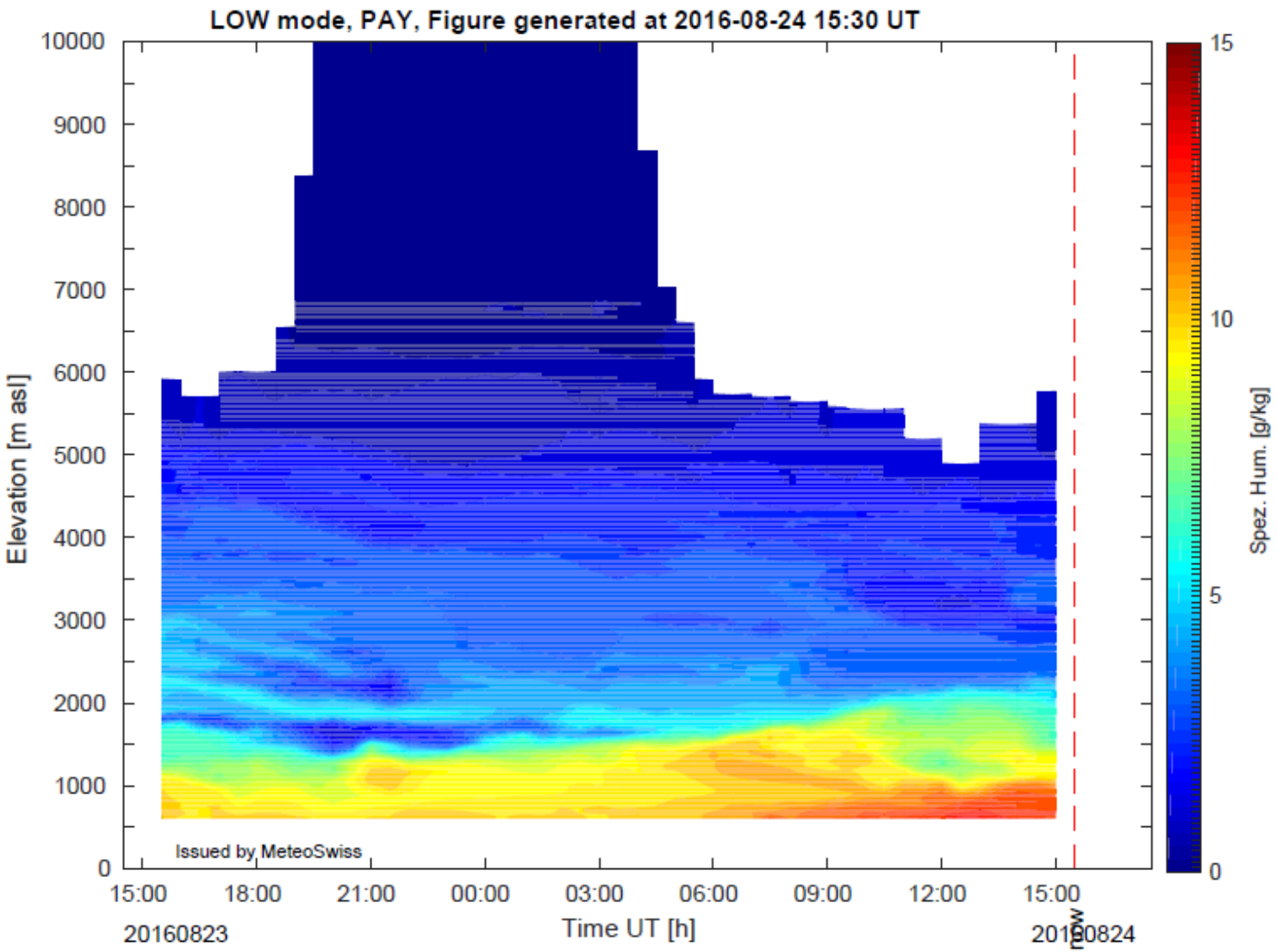


Maintenance

Weekly	Monthly	6 Monthly	Yearly
Cleaning	Flash lamp exchange after 60 M shots	Laser source	Air conditioning
Raw data archiving	Laser & telescope alignment		Cooling system

Interventions
Technician
SLA with Laser Provider
SLA with EPFL

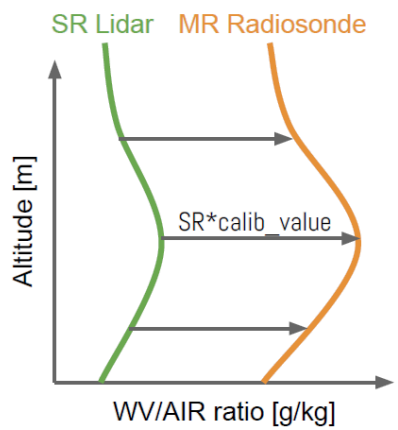
Real Time Example of Water Vpour



Automatic relative calibration of water vapour

SR*calibration_value = MR

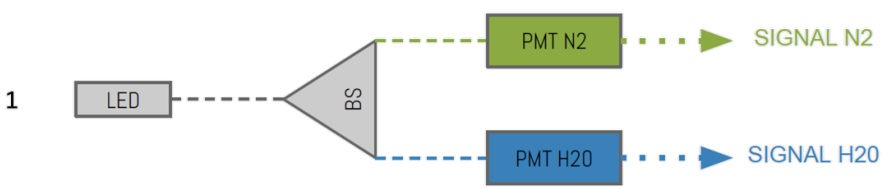
SR = Signal Ratio
MR = Mixing Ratio

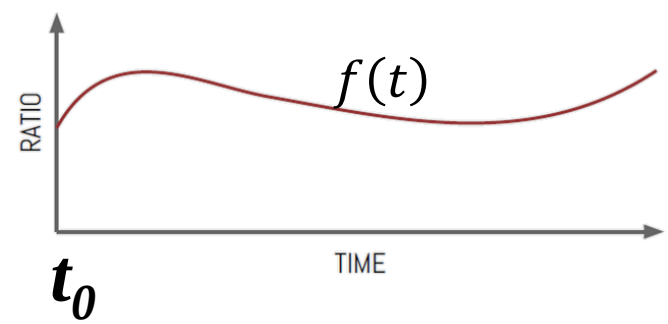


$$\frac{Q_{H2O}}{Q_{N2}} \cdot C(t) = q$$

RATIO = SIGNAL N2/SIGNAL H2O

The photomultipliers are aging but not at the same rate.

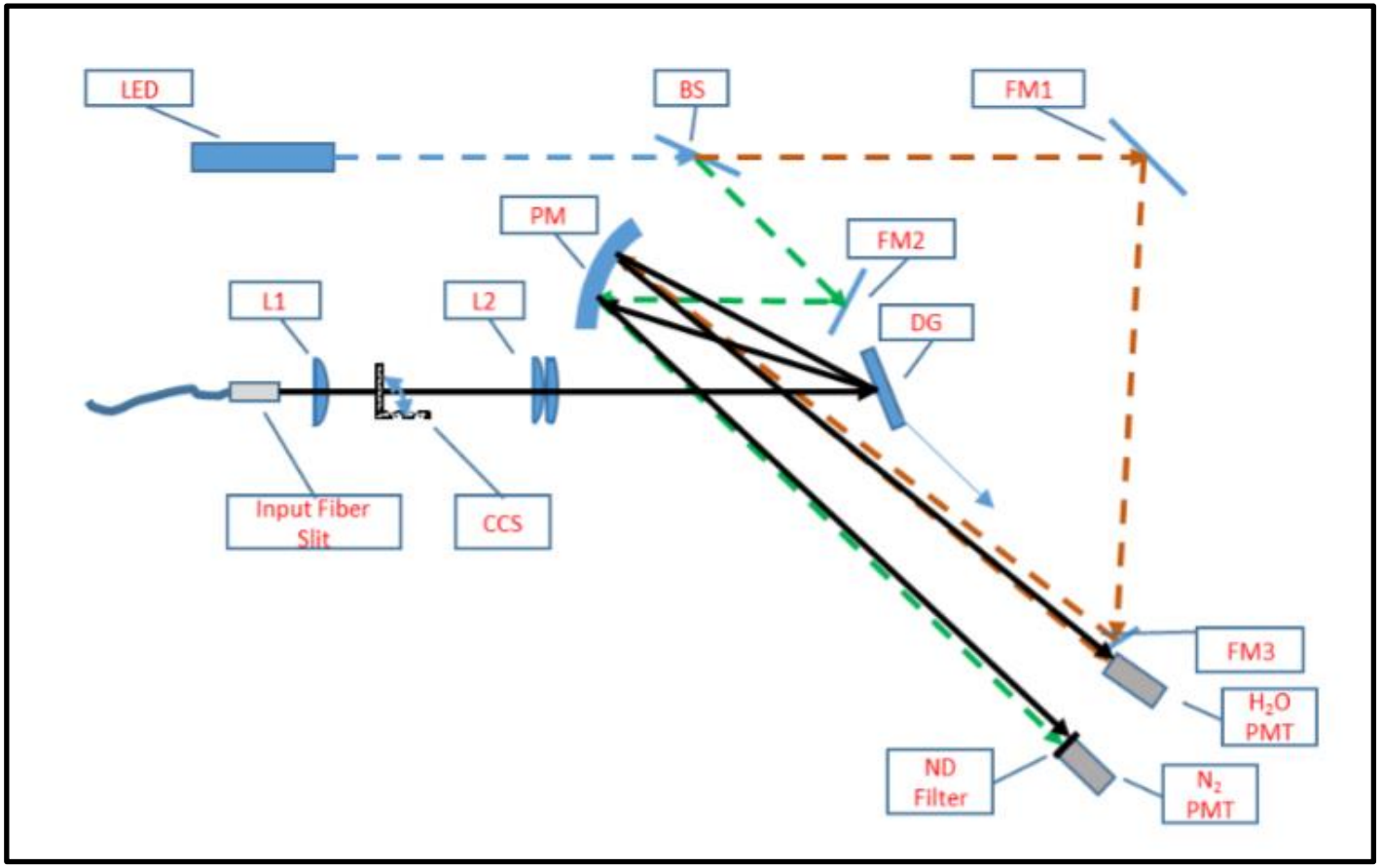




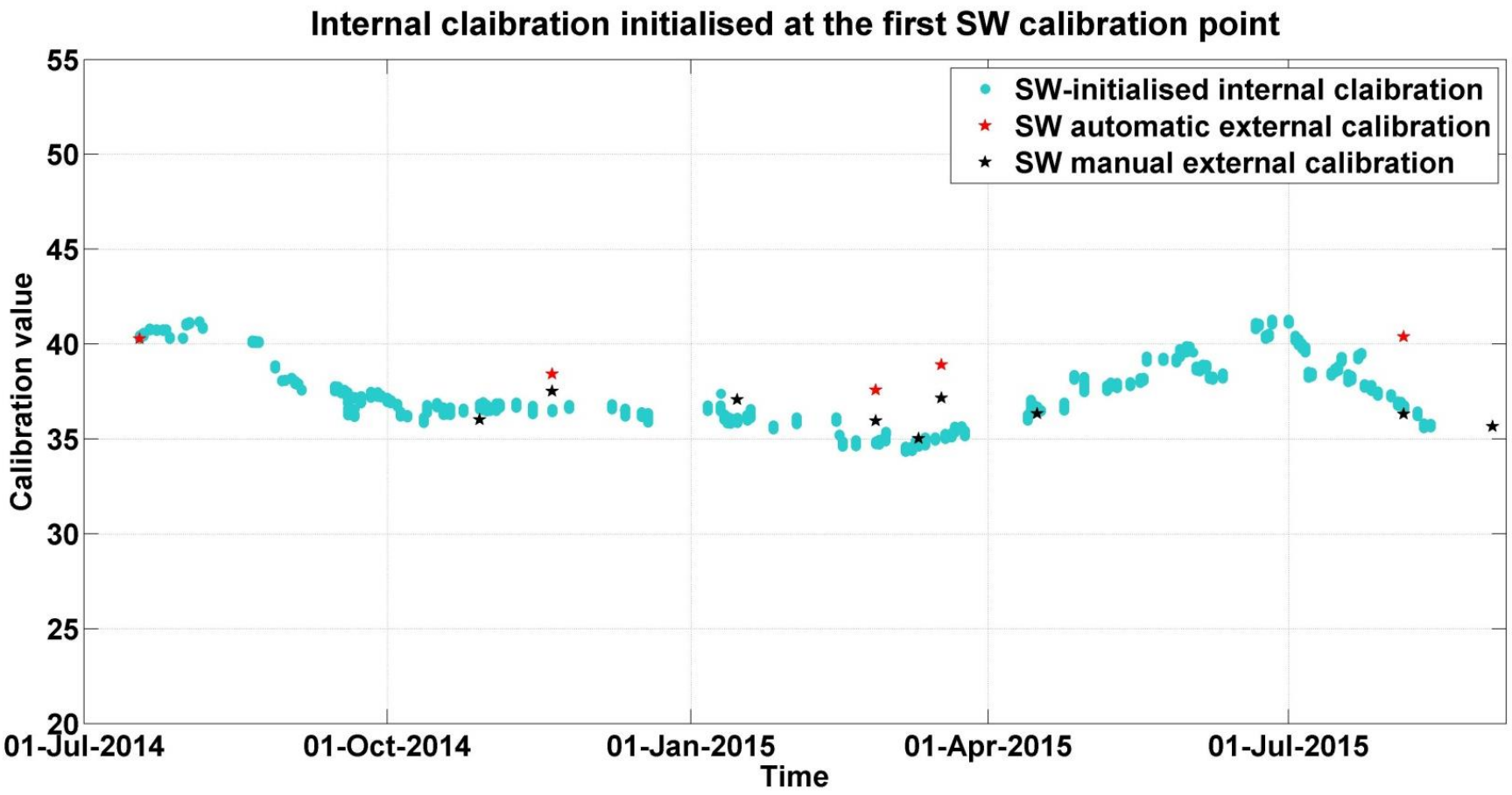
$$f_0 = f(t_0) = R_0 \quad \Rightarrow \quad C_{ext}(t_0) = f_0 C_0 \quad \Rightarrow \quad \boxed{C(t) = C_0 \frac{f(t)}{f_0}}$$

Automatic relative calibration of water vapour

Water vapor polychromator



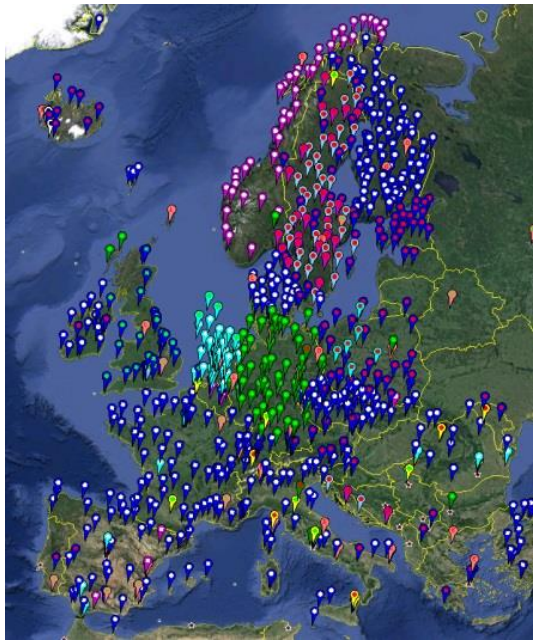
Automatic relative calibration of water vapour



Automatic low cost lidars for profiling of aerosols and volcanic ash

What is a low cost lidar and how can it help?

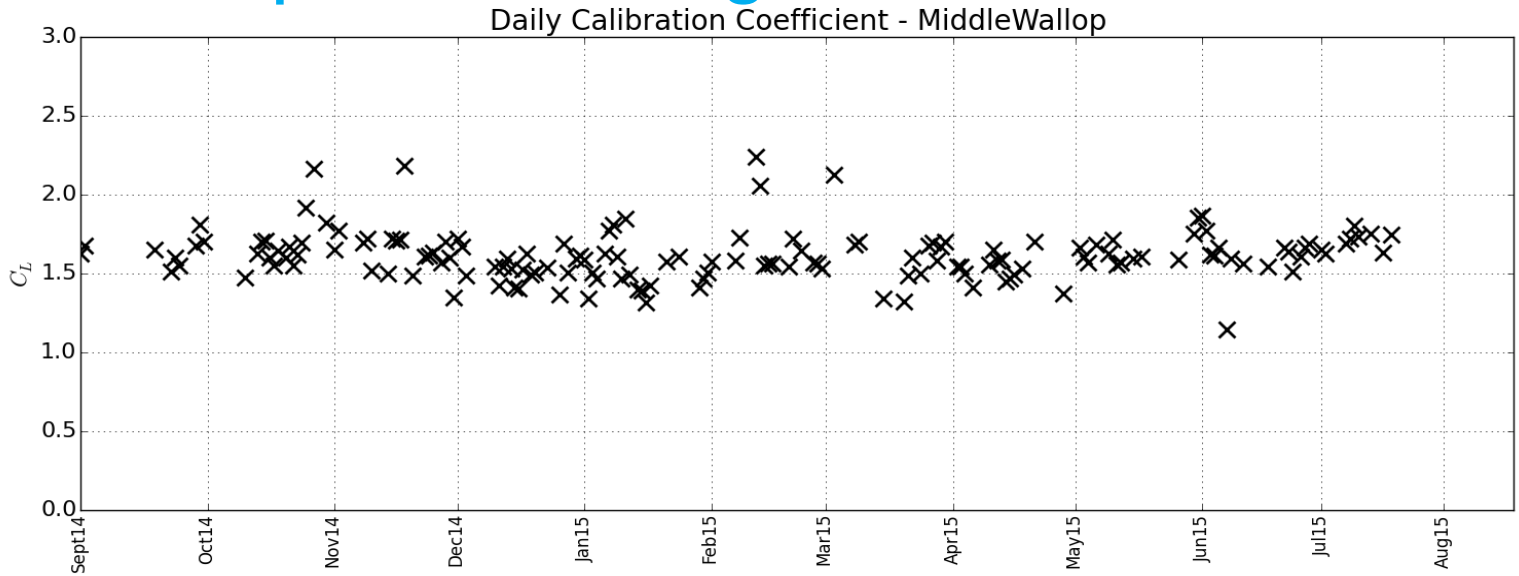
Traditionally referred to as Ceilometers.



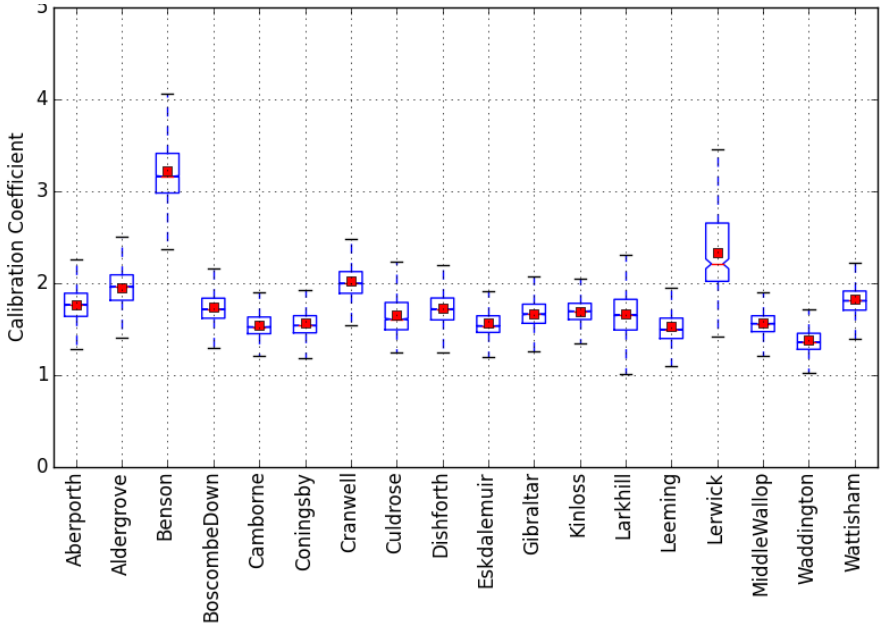
+ Low cost
+ Operational
+ High density

- Limited aerosol capabilites

Calibration: liquid cloud algorithm [O'Connor et al., 2004]



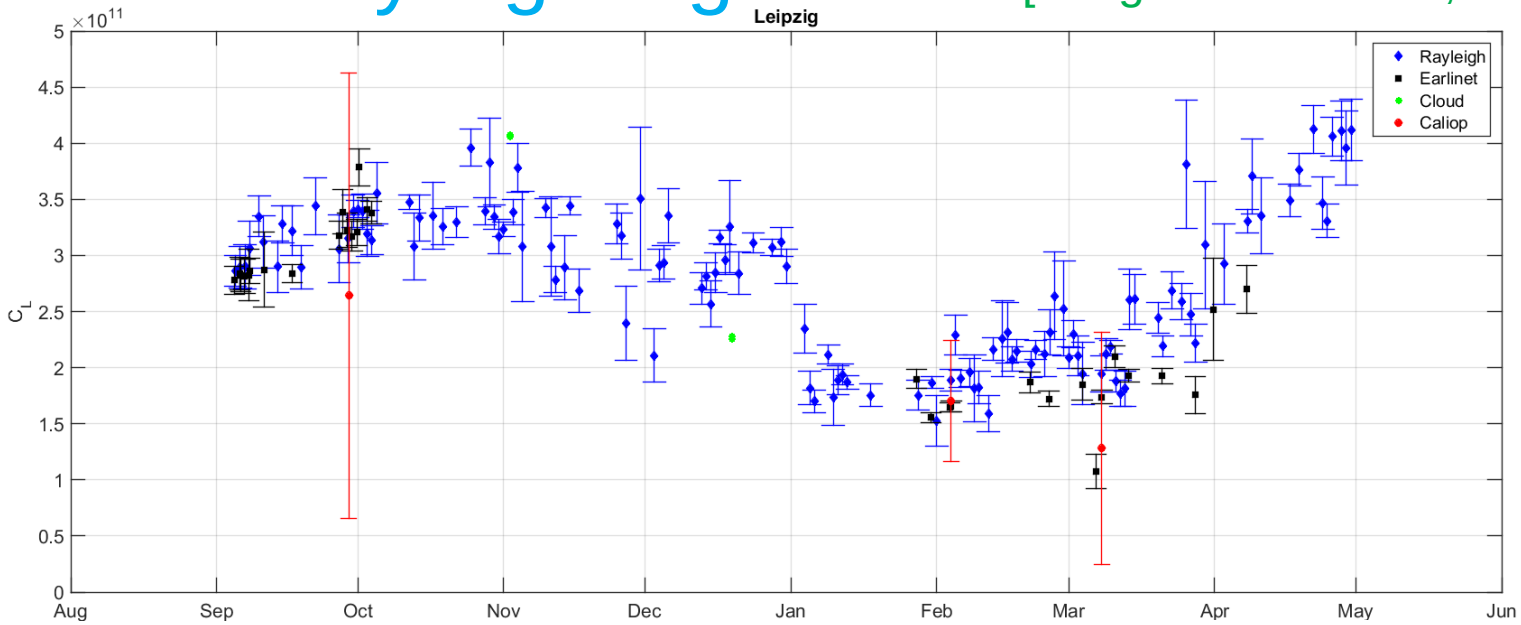
- One year of data – automatic processing
- Stable, no drift, standard deviation less than 10%
- Successful implementation for CL31/51 and CS135



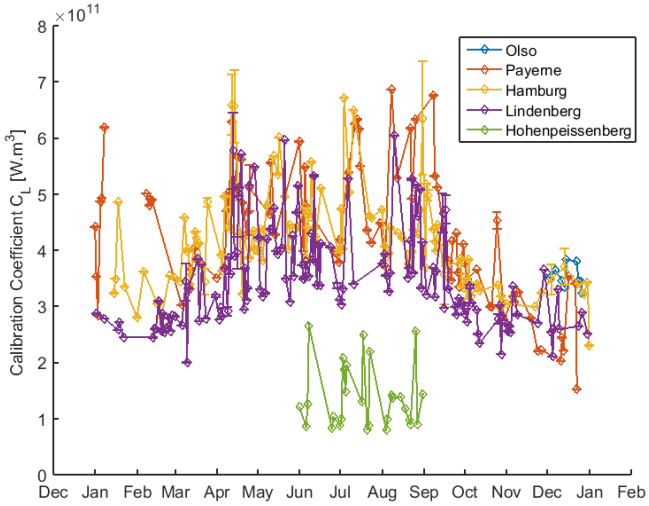
[Plots provided by Emma Hopkin]

Calibration: Rayleigh algorithm

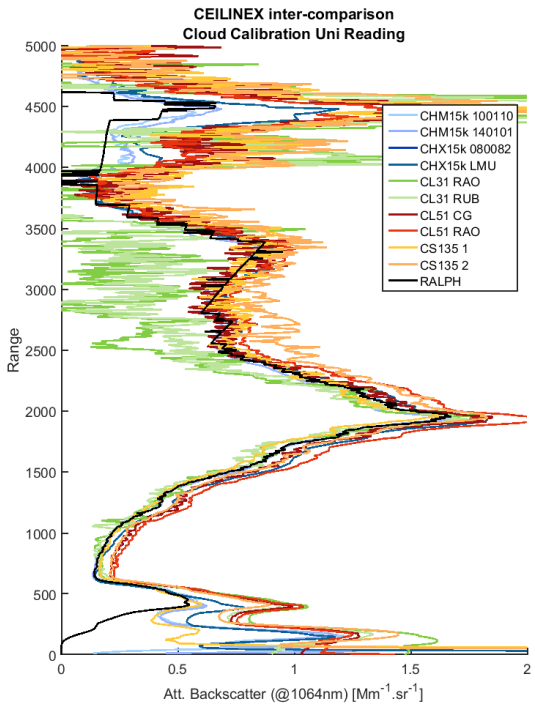
[Wiegner and Geiss, 2012]

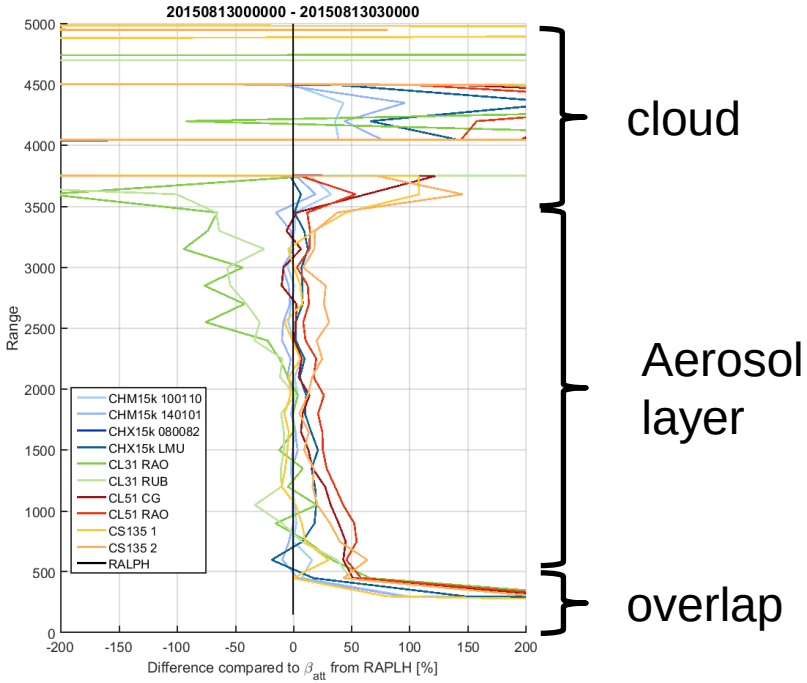


- One year of data, automatic processing
- Seasonal cycle visible, more investigation needed
- Successful implementation for CHM15k



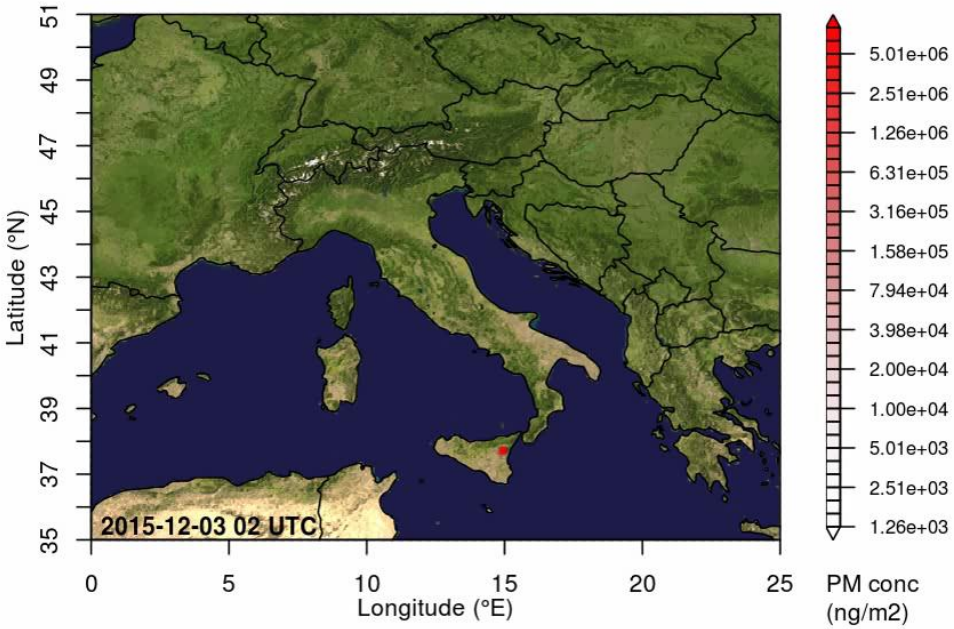
CeiLinEx2015 Results





- Differences in attenuated backscatter @ 1064 nm < 25% within aerosol layer.
- Wavelength correction according to Groß et al. (2013) assuming continental aerosol.
- Water vapor absorption accounted for.

Case study: Etna eruption 2015



- 3 and 4 December 2015
- Up to the tropopause

- Dispersion over Mediterranean sea and Europe

Map of Measurements

- 3 operational ceilometers networks (AliceNet, DWD, MeteoSwiss)
- 6 Ceilometers selected
- In-situ measurements
- Research Lidar

Calculating aerosol mass profile

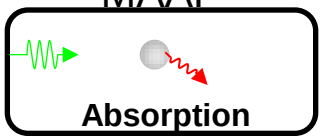
In Situ JFJ (3580m)

Betameter

Mass

Nephelometer

MAAP



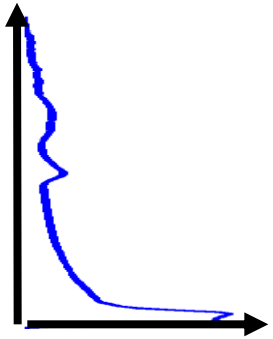
Extinction

$$\mathrm{MEE} = \frac{\sigma_{sca(\lambda)} + \sigma_{abs(\lambda)}}{M}$$

Mass Efficiency

Remote Sensing KSE(2069 m)

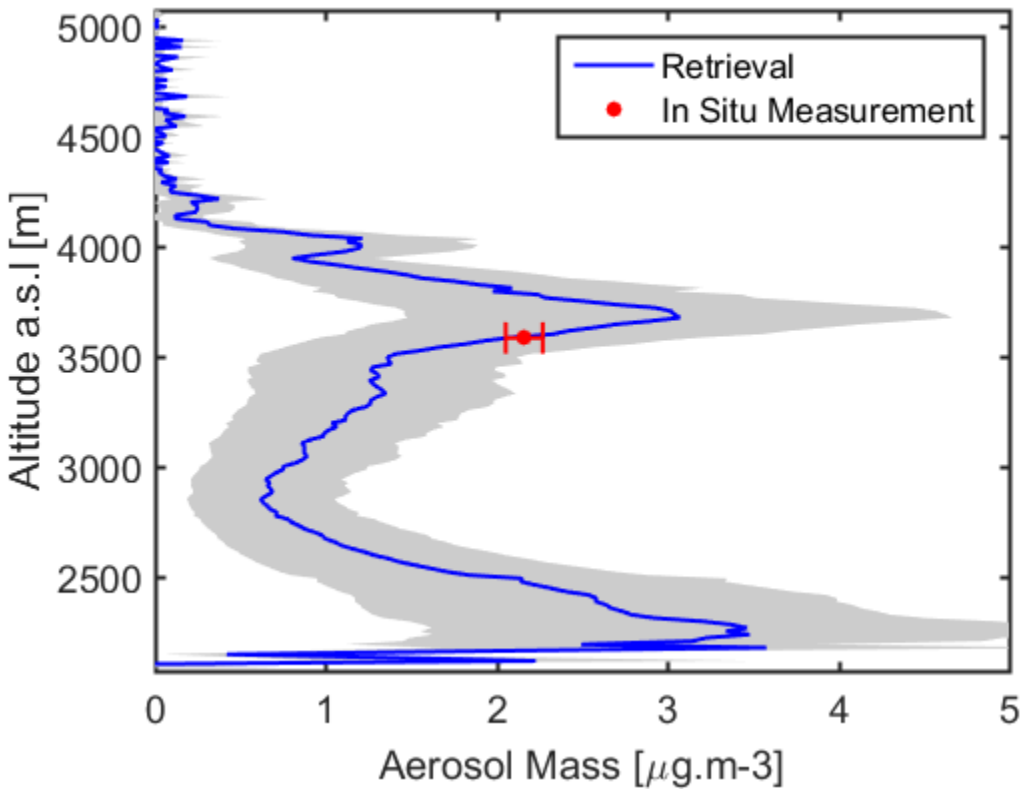
Ceilometer



Extinction vertical profil

Mass Profile

Mass Profile



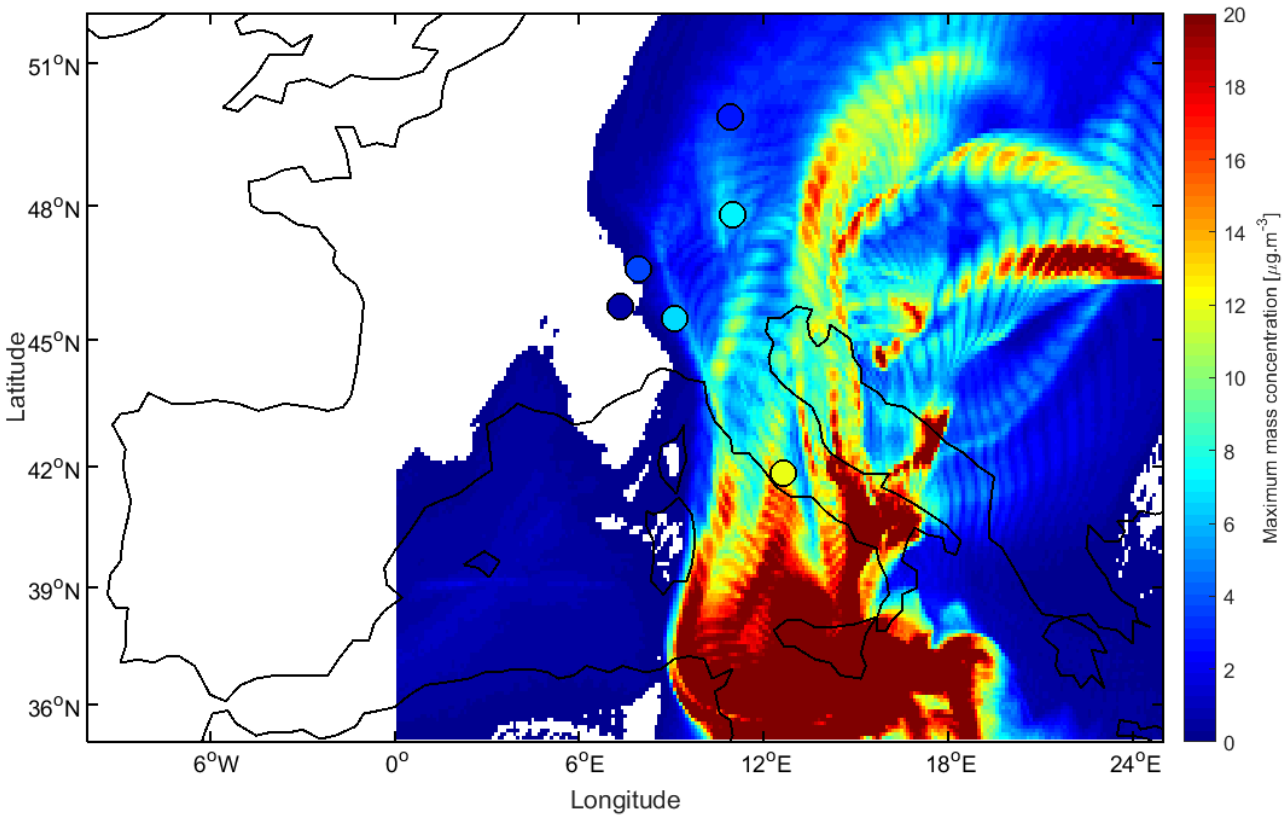
- During maximum of the event (12:00 - 15:00)
- Lidar Ratio 52 Sr [Hervo et al. 2012]
- Mass efficiency of: 0.9 $m^2.g^{-1}$

Eyjafjallajökull:

- 0.68 $m^2.g^{-1}$ Gasteiger et al., 2011

Good agreement Remote sensing / In Situ
Same MEE used for all 6 ceilometers

Spatial distribution



Good agreement between Model dispersion and ceilometers mass retrievals.

Meteo from GFS, dispersion with Hysplit (volcanic ash), source specification from INGV.

Conclusions

- Raman lidar is mature technology and can be used operationally.
- Automatic low cost elastic lidars (ceilometers) provide useful aerosol information and are complementary to coarse high performance lidar networks.

Guidance material and publications

Contributions to guidance material:

- GRUAN lidar and MWR guide
- TOPROF recommendations for MWR operation
- E-PROFILE recommendations for ceilometer operation
- Standardization of representation of vertical resolution and uncertainty for NDACC lidars

Publications

- See report.