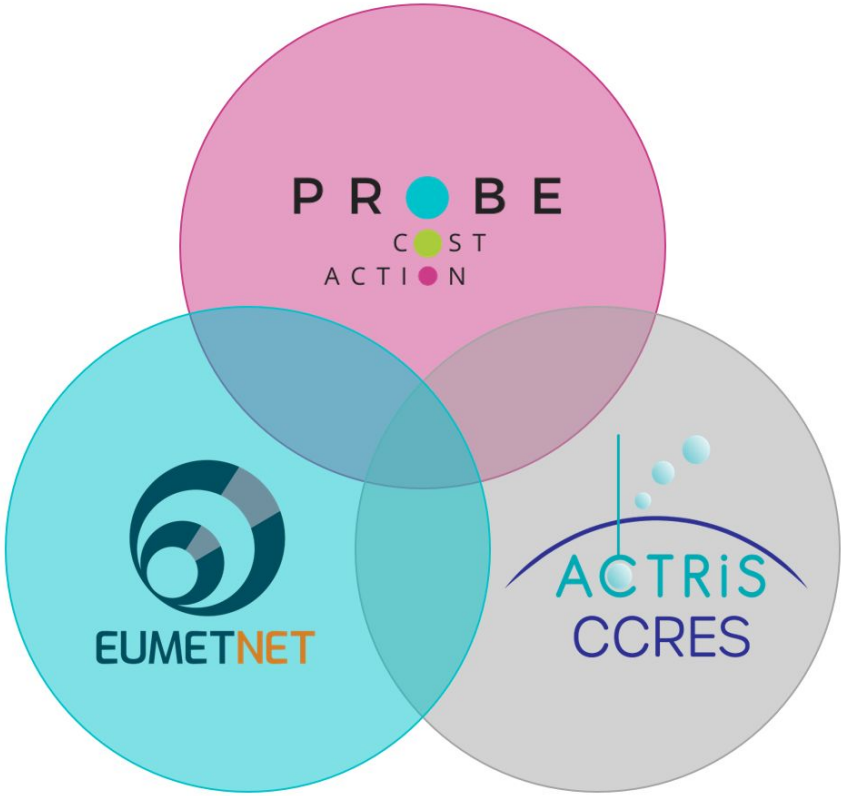
Harmonised processing of ALC data



Updates from collaborations with ACTRIS and E-PROFILE

COST ACTION 1823

Agenda

Agenda		
09:30	ALC processing overview	Simone Kotthaus
09:45	Lufft CHM15k overlap model	Melania Van Hove
10:00	Vaisala CL51 & CL61 overlap	Melania Van Hove
10:05	Instrument background	Frank Wagner
10:20	Calibration status	Ina Mattis, Melania Van Hove, Alexander Geiss
10:40	Rayleigh calibration seasonal cycle	Joelle Buxmann
11:00	Open discussion	Ina Mattis

Important actors

Development support

PROBE COST ACTION

+ research projects such as

RI URBANS

ABL testbed

ACTRiS

EUMETNET
EUROPEAN METEOROLOGICAL SERVICES NETWORK
E-PROFILE

Expert centres

ACTRiS CCRES
Centre for Cloud Remote Sensing

ACTRiS CARS
Centre for Aerosol Remote Sensing

MeteoSwiss
E-PROFILE @ Meteo Swiss

Data centres

ACTRiS CLU
Cloud remote sensing data centre unit

ACTRiS ARES
Aerosol remote sensing data centre unit

AERIS

Met Office
E-PROFILE Hub @ Met Office

V-Profiles
Aerosol products @ Met Norway

PROBE COST ACTION

cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Processing chain

Step 1: Data collection & formatting

Step 2: Corrections & calibrations

Step 3: Advanced products

Processing chain

Step 1: Data collection & formatting

Step 2: Corrections & calibrations

Step 3: Advanced products

Step 1: data collection + formatting

- Numerous models of automatic lidars and ceilometers (ALC)
- Operation of ALC should follow standard operating procedures (SOPs) currently formulated

Collection of 'raw' data & standardisation

- Communicate SOPs and data acquisition protocols to operators
- System for station management (e.g. WIGOS ID in WMO OSCAR)
- Robust data transfer procedures
  - At times not easily matched with instrument output format, (e.g. frequency of file creation)
  - Procedures for missing/duplicated files etc
- Secure and robust data storage
- **Data format standardisation for range of input formats ("raw2L1")**
- Monitoring of firmware versions and hardware
- Quality control and alerts (missing/faulty data etc)
- Housekeeping data

Standard operating procedures

ACTRIS CCRES SOP for ALC:
https://www.actris.eu/sites/default/files/inline-files/CCRES%20SOPs%20-%20ALCs.pdf

PROBE SOPs:
Vaisala CL51 (login to user space):
https://www.probe-cost.eu/images/pdfs/SOPS/PROBE_WG4_ALC_operation_guidelines_VaisalaCL51_20211007.pdf

Vaisala CL31 (login to user space):
https://www.probe-cost.eu/images/pdfs/SOPS/PROBE_WG4_ALC_operation_guidelines_VaisalaCL31_20210915.pdf

Vaisala CL61 (login to user space):

Lufft CHM15k (login to user space):

Updates required?

raw2L1

- Tool to generate a **common file format (NetCDF)** from raw data of different types of ALC
- Developed by Marc-Antoine Drouin (SIRTA) - since COST Action Toprof
- Operationally used by E-PROFILE
- Analysis tools of ACTRIS ALC testbeds (DWD, LMU) (under development) also use raw2L1

New instruments bring

- new information (e.g. depolarization, multiple channels)
- new variables (e.g. housekeeping data)

→ Need to discuss further developments of the tool among developers (and users)

- Naming of new variables
- Introduction of new channel dimension?
- Homogenization of time units
- Moving source code into public repository / package server

Virtual meeting
June 7, 10:00 - 12:00 CEST

*Contact Ina Mattis if you would like to attend

Status of data collection

Current status of ALC data collection

ACTRIS-CLU data centre:
ALC at official CCRES stations

EUMETNET E-PROFILE:
Diverse European ALC network (>400 sites)

independent
Several ALC are **not yet integrated** in any coordinated network
(e.g. urban areas)

- Procedures need to be available to process campaign data locally
- Streamlining of monitoring (missing data, housekeeping data, …)

How to collect ALC data for urban networks?

ACTRIS-CLU data centre?
- Capacity for diverse network?

ACTRIS-ARES
- Suitable for ALC?

E-PROFILE?
- Establish partnership with ACTRIS?

Processing chain

Step 1: Data collection & formatting

Step 2: Corrections & calibrations

Step 3: Advanced products

Status of corrections

- Sensor-specific corrections (instrument background, overlap)
- Absolute calibration to attenuated backscatter

 Both required past time series and near real-time solutions

Calibration and correction, partly implemented at

ACTRIS-CLU:	**E-PROFILE:**	**AERIS-ESPRI**
ALC at official CCRES stations	Diverse European ALC network	ABL testbed sites (~26 sensors)

Status of corrections

	Overlap	Near-range artefacts	background	Water vapour	Calibration
Lufft CHM15k	T-model				Rayleigh
Vaisala CL31		• Climatology method	• Climatology method • cone measurement	To be discussed	Liquid cloud
Vaisala CL51	• Climatology method				
Vaisala CL61	Under investigation	To be checked	Not needed	Necessary?	Rayleigh
Cimel CE376	?	?	?		?
Droplet MT miniMPL	?	?	?		?
Campbell SkyVUE PRO	?	?	?	?	?
Raymetrics	?	?	?		?

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CHM15k Optical overlap

Temperature-dependent overlap

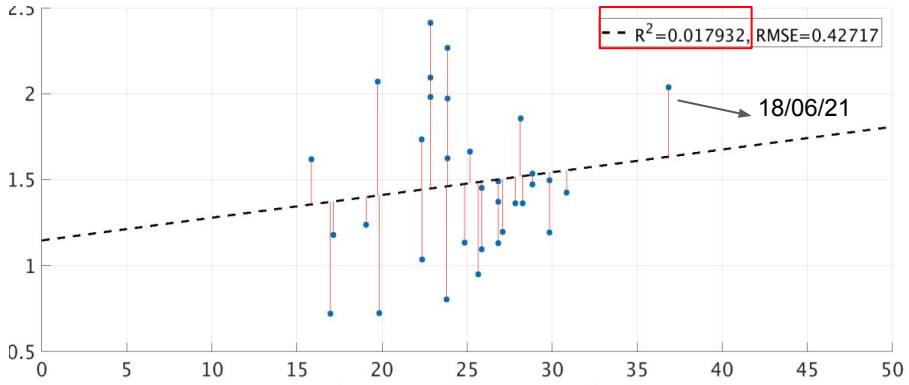
Hervo et al. (2016) (MeteoSwiss) : correction is temperature-dependent

- Production of daily functions (vertical profiles)
  → one final single model based on daily functions **selected manually**
- 1 laser optical module = 1 overlap correction model

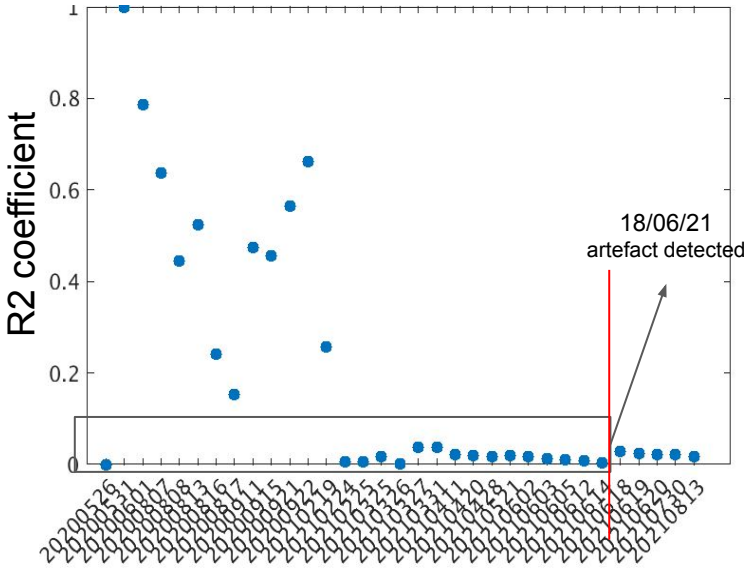
Method to select daily functions automatically

1) Quantification of the impact of each daily function: Δ = mean relative difference between corrected and un-corrected signal
2) Regression Δ vs mean internal temperature → correlation coefficient R^2
3) Time series of $\mathbf{R^2}$, adding daily functions chronologically
4) $\mathbf{R^2}$ become stable after a number of days
5) Stop when $\mathbf{R^2}$ becomes unstable again

Norm of relative difference between corrected and uncorrected signal



Lindenberg - R2 values by adding daily functions

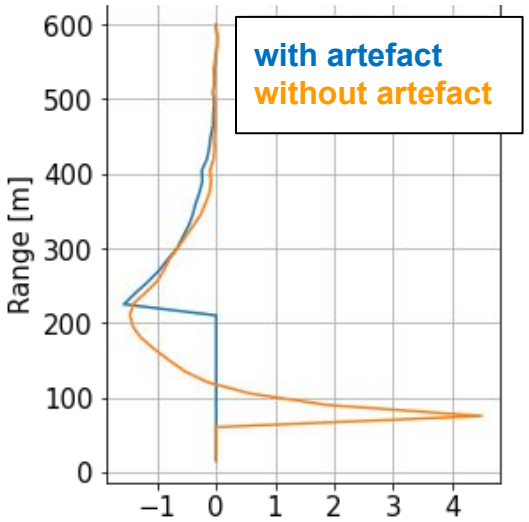


Automatic overlap model creation

Hervo et al (2016)
daily overlap fit

R^2 coefficient time series

Check stable period



≤ 8 stable R^2

Quality control on artifact

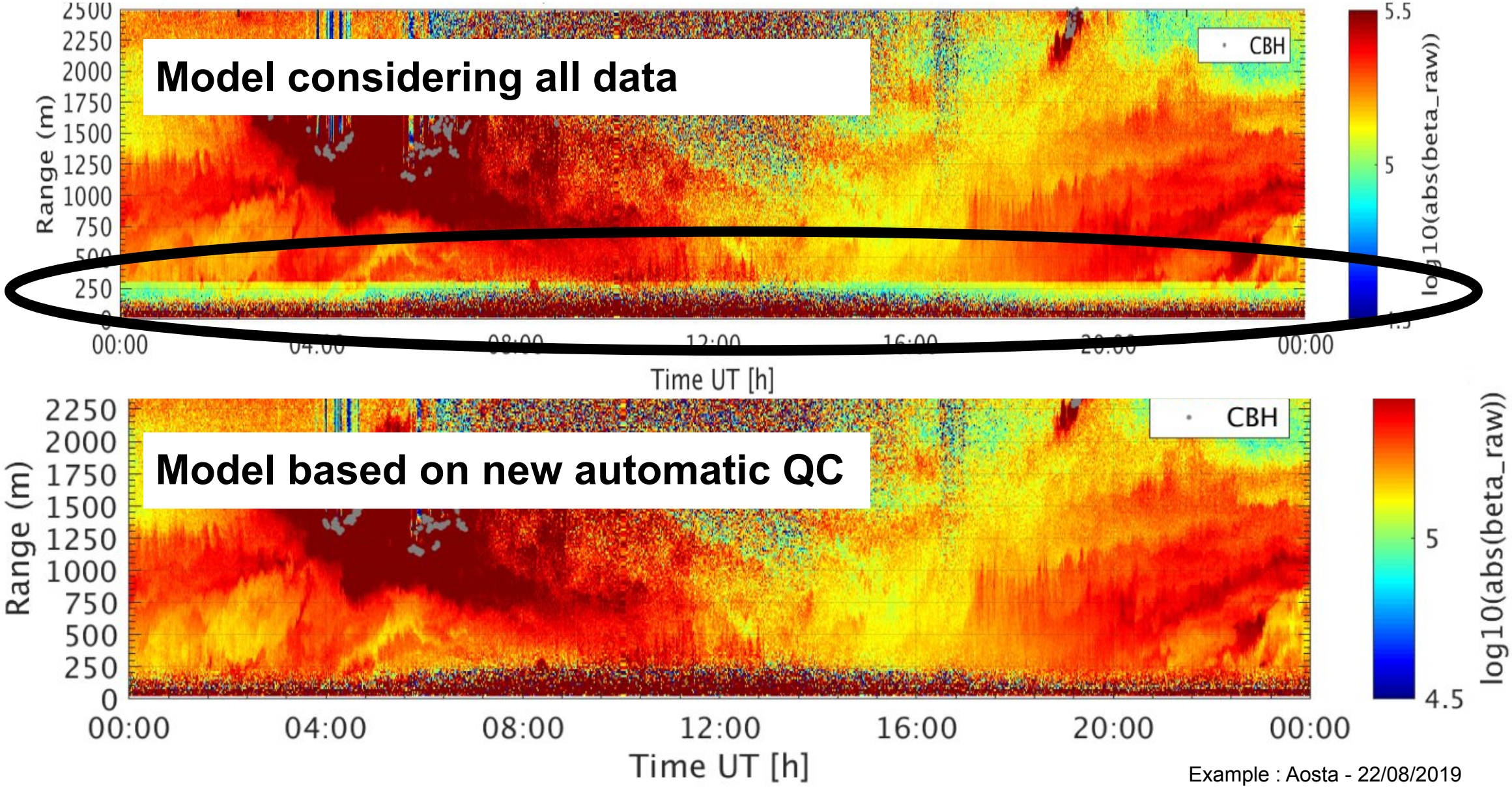
Intermediate model for NRT
temperature-dependant overlap model
a(z)*T + b(z)

> 8 stable R^2

Final model for each optical module
temperature-dependant overlap model
a(z)*T + b(z)

Double-check there is
no artefact in the final model

CHM15k overlap model



Example : Aosta - 22/08/2019

CHM15k overlap model - Conclusion

- Results :
  - Study based on 19 lasers - ABL Testbed
    - 3 improved with detection of raise in R2 coeff
    - 2 where artifacts quality control works (small amount of stable R2)
    - 13 not impacted (all daily functions kept)
    - 1 model not satisfying using R2 method (Magurele-Rado)

      => >90% satisfying models produced
  - R2 coeff and artifact detection show promising result as indicators of the quality of the model but :
    - Not perfect (improvement for 3 out of 4 lasers)
    - Can reduce the amount of daily functions

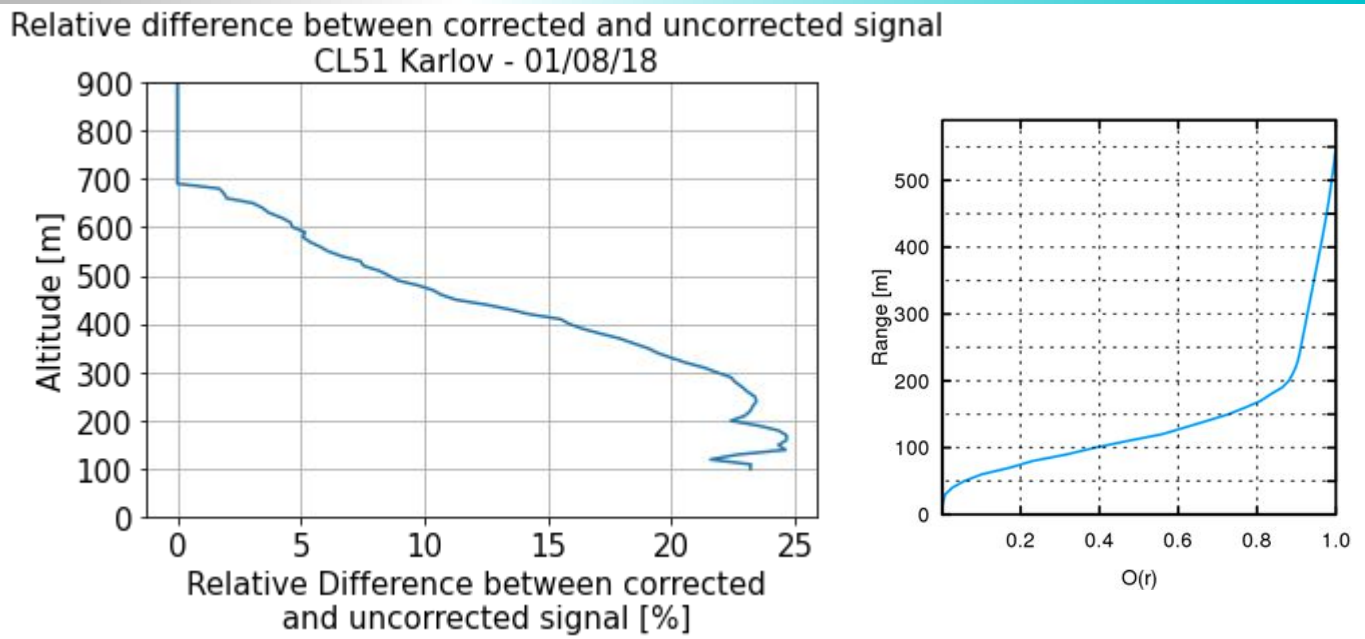
- Current state :
  - Original code in Matlab : more automatic
  - Translation in Python 3 (Martin Osborne (Met Office) + E-PROFILE):
    - promising results for creation of daily functions
    - Expected by end of June 2023
- For future :
  - study artifact detection in daily functions instead of final overlap model
  - thresholds of stability definition are empirical, how to define them?

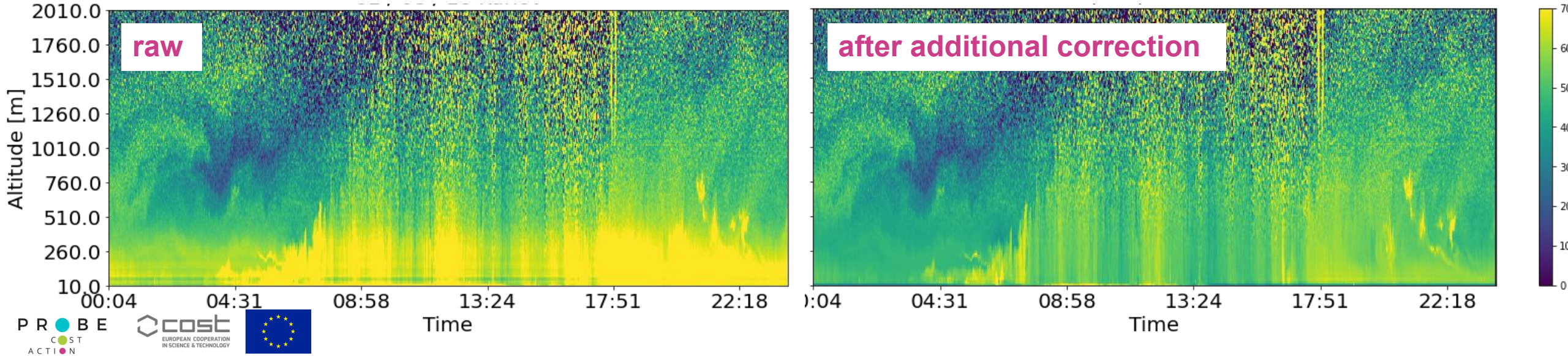
CL51 and CL61 Corrections

CL51 overlap correction bias

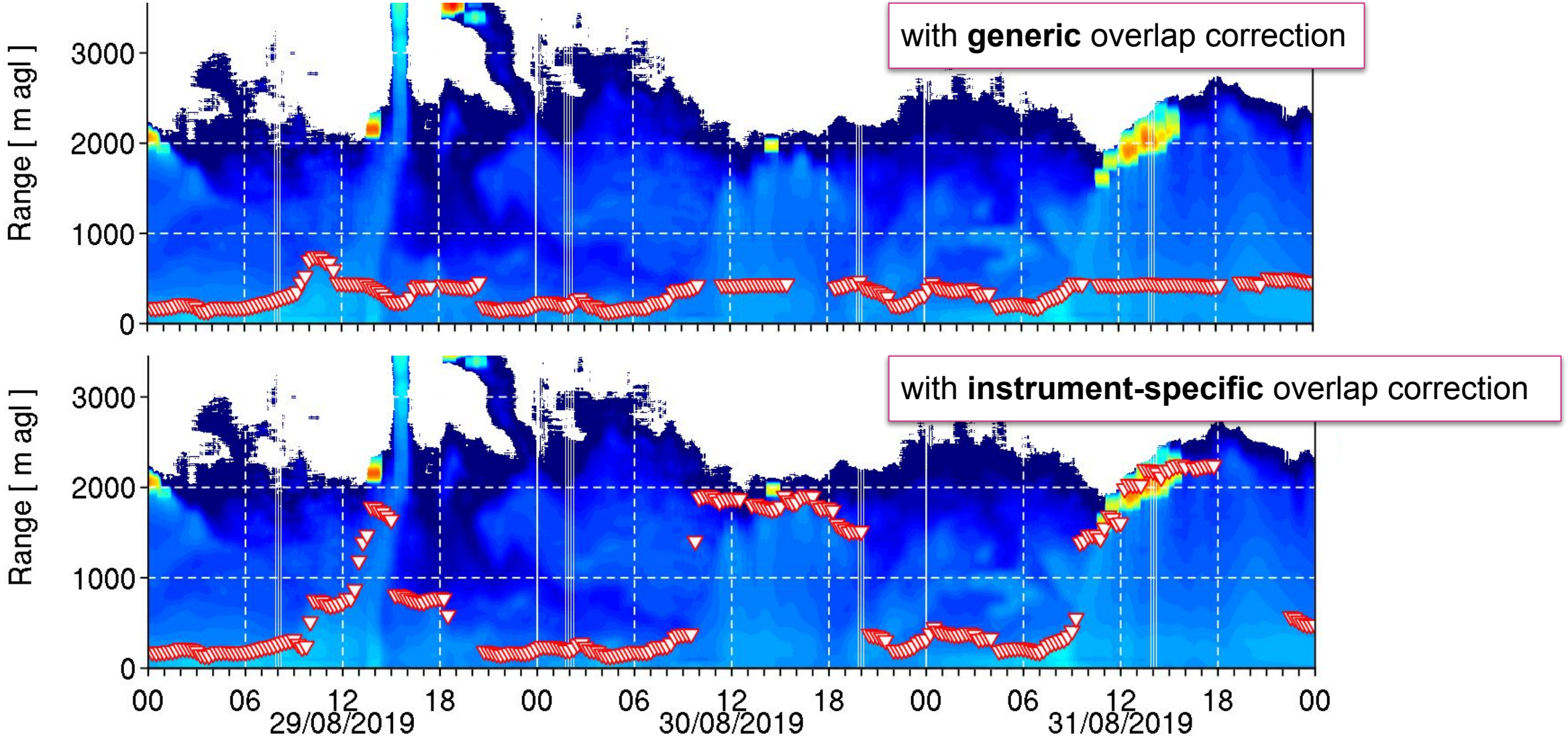
- Systematic overestimation < 500 m
- Not seen by CL31 at same site

- Caused by generic optical overlap correction
- ABL testbed developing **instrument-specific** correction



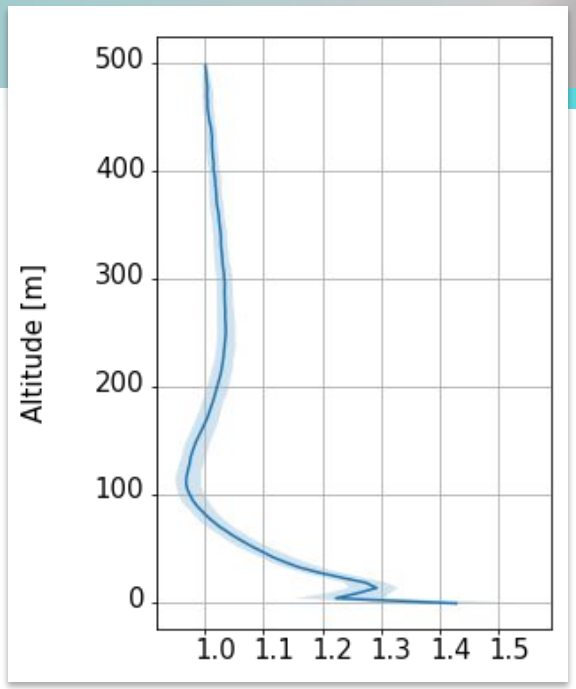


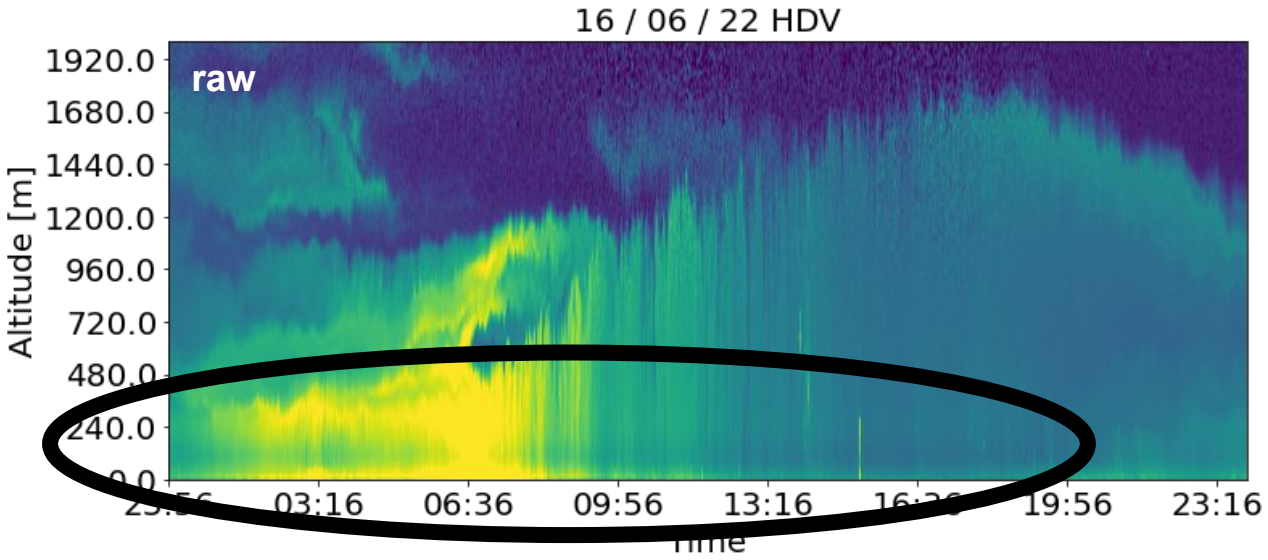
Impact on layer detection

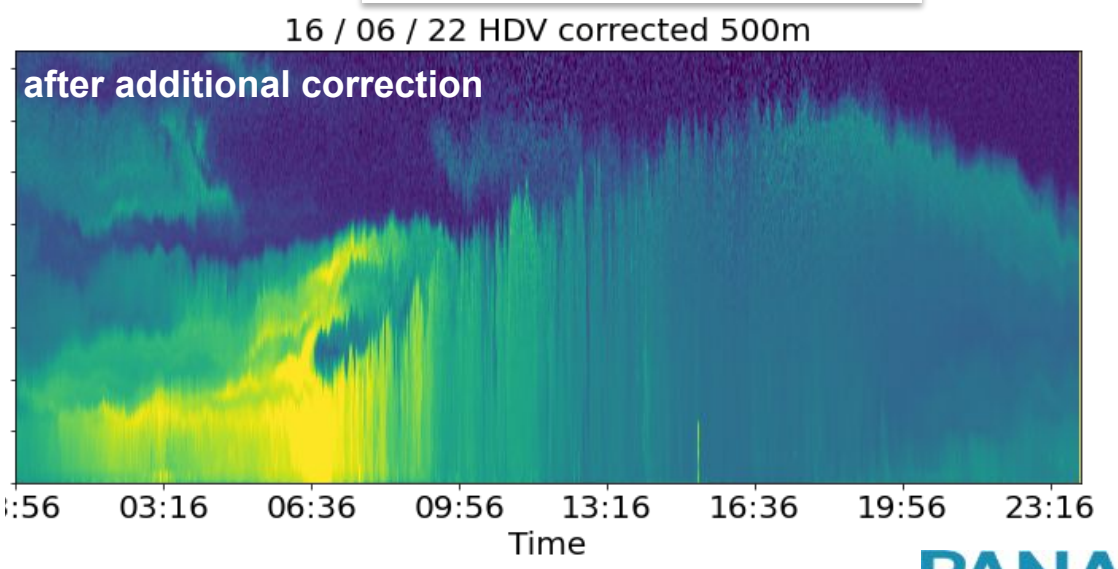


CL61 overlap bias

- Systematic underestimation ~ 80-160 m of about 3 % and overestimation above
- Instrument-specific
- Correction possible? Necessary?







Vaisala CL61 at Paris Hotel de Ville, June 2022

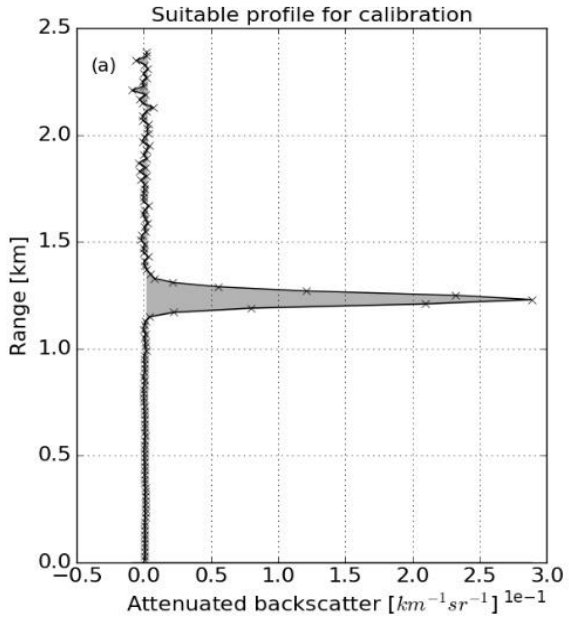
Calibration

Absolute calibration methods

CL31, CL51

Liquid cloud method

- Reference: liquid clouds (lidar ratio 18.8 sr)
- Careful if signal saturates in thick clouds (photon counting sensors)
- Careful selection of profiles is key

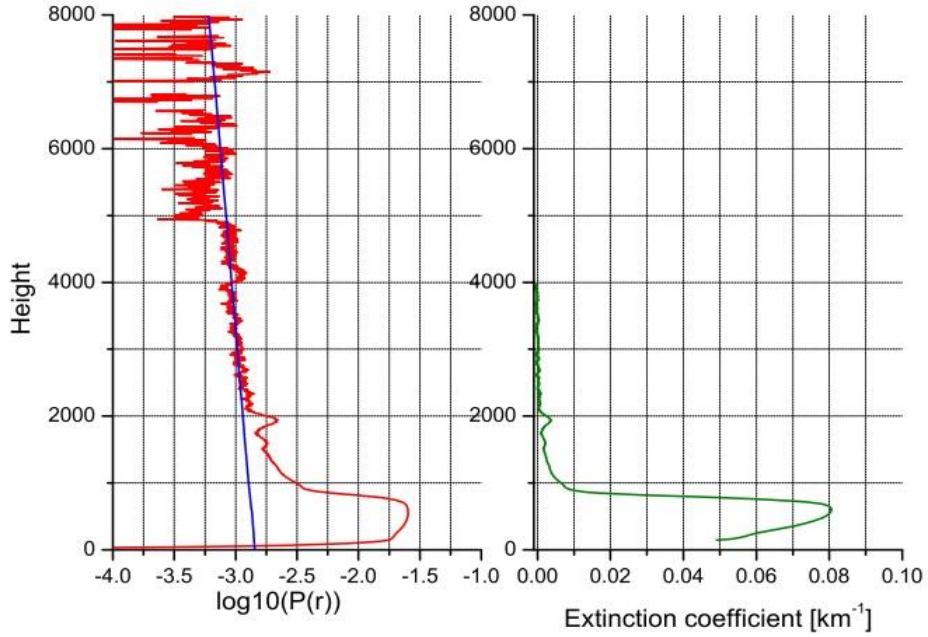


(Hopkin et al. 2019)

CHM15k, CL61

Rayleigh method

- Reference: Rayleigh scattering profile in upper atmosphere
- Sensitivity to molecular scattering required
- **Careful selection of profiles is key**



(Wiegner and Geiß 2012)

Cloud calibration - what is the status?

- Original code from Emma Hopkins (University of Reading / Met Office) in python 2
- Then used by Elliott Warren (University of Reading / Met Office)

- E-PROFILE versions of the code (python 2 and 3) changed by several users
  - Now some conflicts with versioning
  - Significantly different results between original code and E-PROFILE versions
  - Plan: use University of Reading code as a basis

- GitHub repositories available :
  - E-PROFILE (private) containing cloud calibration codes in python 2 and 3
  - Elliott Warren (private) containing “Emma’s original script for LUMO ceilometers”

Rayleigh calibration implementations

(ATLAS & SCC)

- Primary application: **research-grade lidars**
- Detailed steps for selection of molecular zone
- Volker Freudenthaler developed stand-alone python tool (private in EARLINET SCC repository)

☐ Application to ALC possible but requires additional testing (e.g. to determine noise thresholds)

E-PROFILE

V1

@ MeteoSwiss

steps to find molecular zone:
- average ≥ 3h, clear nights
- minimum SNR required
- rolling windows to find the best fit real-synthetic signal
- search zone 2-6 km
- quality controls

V3

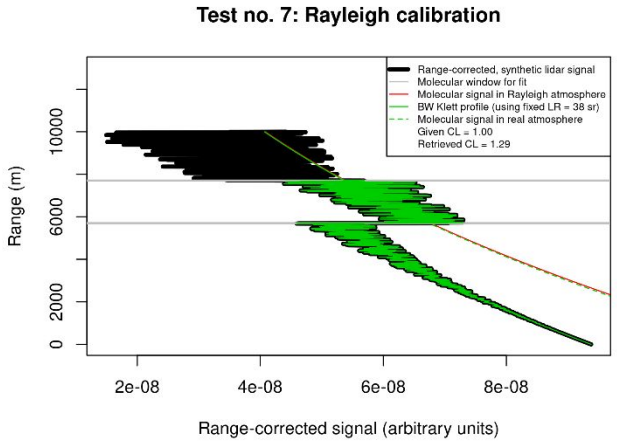
@ ALICEnet (Italy)

steps to find molecular zone:
- average ≥3h in clear nights
- minimum SNR required
- rolling windows to find the best fit real-synthetic signal
- search zone 3-7 km
- improved quality controls: BG test + cumulative sign in residuals to filter aerosol layer

Seasonal cycle CHm15k Rayleigh calibration: instrument or atmosphere?

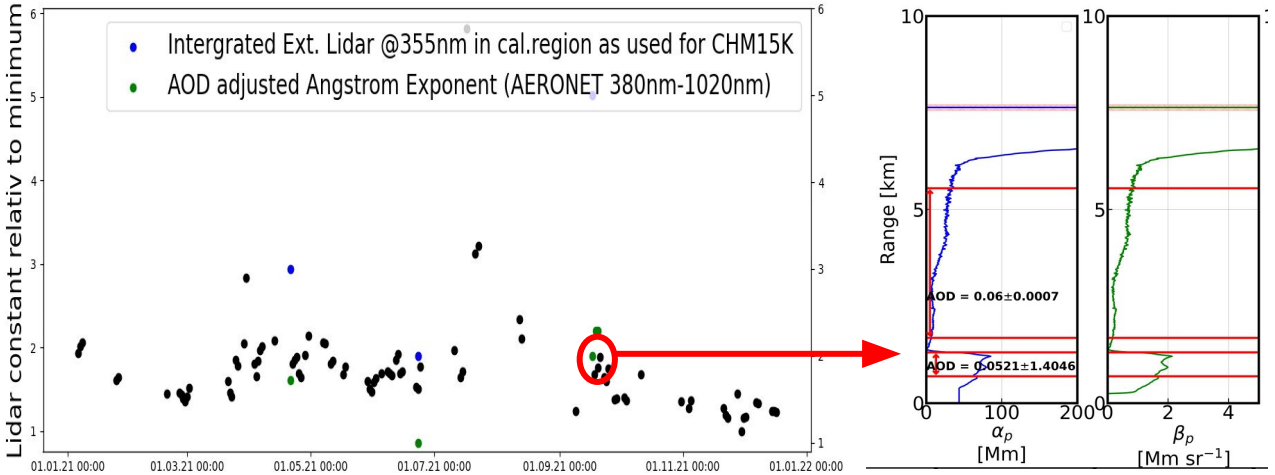
PROBE research study by Joelle Buxmann (Met Office) with Ina Mattis (DWD), Henri Diemoz (ARPA Aosta), Rolf Ruefenacht (Meteo Swiss), Francesca Barnaba (ISAC-CNR), Annachiara Bellini (ISAC-CNR), Martin Osborne (Met Office)

1. Generate synthetic profiles to show theoretical feasibility



- Synthetic profiles show that even very small amounts of aerosol (AOD~0.01) can sufficiently change cal. constant
- Additional influenced by boundary layer aerosols

2. Look at the long-term seasonal variation-comparison between the calibration of the lidar (example Nottingham)



- no clear correlation with lidar constant directly
- Aerosol layers can be detected by the Raymetrics lidar within the calibration window of e-profile CHM15K calibration

 those aerosol layers will artificially increase the calibration constant

Discussion

Virtual mobility and STSM

Recent VMG

- Retrievals of aerosol extinction & mass concentration profiles from Automated Lidars (Annachiara Bellini, CNR-ISAC)
- Investigating the seasonal fluctuations of the CHM15K Ceilometer calibration constant (Joelle Buxmann, Met Office)
- CHM15k optical overlap model (Martin Osborne, Met Office)
-

Report submitted

Report?

Ongoing

Future topics

- Calibration: (Alexander Geiss, Frank Wagner)
  - Rayleigh calibration
  - Rayleigh seasonal cycle (with Joelle, Henri, Rolf, …)
  - Cloud calibration
- Instrument background - cone
- Evaluation of depolarization profile against reference measurements
  (Ina Mattis, Daniel Fenner, Dana, Alkistis - go with CIMEL to another site?)
- Summary of codes and repositories
- SOP updates, compiling existing documents (ACTRIS, E-PROFILE, PROBE, Cloudnet…)

Virtual mobility and STSM

Future topics: PROBE grant period until October 2023

- Testing the overlap model at HPB testbed site
- Calibration: (Alexander Geiss, Frank Wagner)
  - Rayleigh calibration
  - Rayleigh seasonal cycle (with Joelle, Henri, Rolf, …)
  - Cloud calibration – **Jaume Ruiz de Morales (University of Girona) VMG or STSM**
- Instrument background - cone measurements
  - Frank Wagner, Daniel Fenner, …

- Evaluation of depolarization profile against reference obs → CL61 meeting (07/07/2023)
  - Ina Mattis
  - Comparison CL61 to Raymetrics at MetOffice
  - Daniel Fenner, **Dana Looschelders Uni Freiburg VMG**
  - Alkistis - go with CIMEL to another site? Maybe ATMOS-ACCESS in 2024?

- Summary of codes and repositories
- SOP updates
- compiling existing documents (ACTRIS, E-PROFILE, PROBE, Cloudnet…)

Summary

Proposed activities

- SOPS:
  - General updates (Simone)
  - On the use of the cone(s) and Lufft telecover (Frank, Ina)
  - On interpretation of Lufft overlap files (Ina)

D4.1

- Raw2L1
  - Harmonization of developments -> Meeting June 7

D3.1

- Overlap
  - Lufft CHM15k Overlap model – testing new Python version (E-PROFILE?)
  - Correction Vaisala CL51 – new method to be tested with more lasers
  - Assessment of CL61 overlap uncertainty (using cone?) (Frank Wagner, Daniel Fenner)
  - Testing overlap correction methods at CARS testbed

D3.3

D4.2

- Instrument background
  - Comparison to climatology assessment (Simone)
  - CL61, CHM8k, CL51 (Frank Wagner, Daniel Fenner, …)
  - How to apply background correction?

D3.3

D4.2

Proposed activities

- Calibration:
  - Rayleigh calibration (Alexander Geiss)
  - Rayleigh seasonal cycle (Alexander, Joelle, Henri, Rolf, …)
  - Cloud calibration – Alexander with **Jaume Ruiz de Morales (University of Girona) VMG or STSM?**

D3.3
D4.2

- Evaluation of depolarization profile against reference obs → **CL61 meeting (07/07/2023)**
  - Ina Mattis
  - Comparison CL61 to Raymetrics at MetOffice
  - Daniel Fenner, **Dana Looschelders Uni Freiburg VMG**
  - Alkistis - go with CIMEL to another site? Maybe ATMOS-ACCESS in 2024?

D4.3

- Compiling existing documents (ACTRIS, E-PROFILE, PROBE, Cloudnet…)

- Summary of codes and repositories

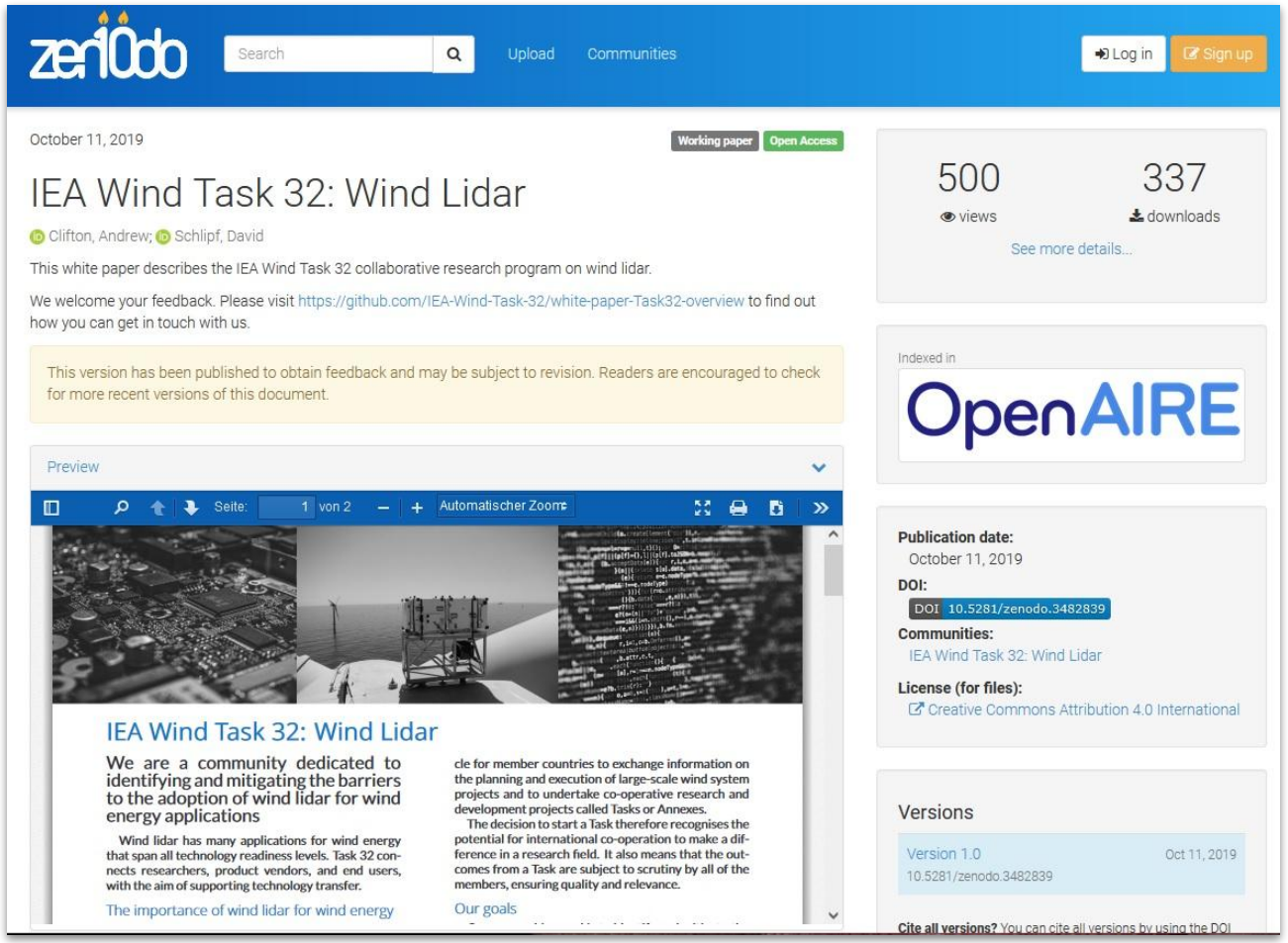
Code repositories

- Where are all the relevant codes?
  - CHM15k Overlap correction
    - Public Matlab code (Melania): https://gitlab.in2p3.fr/ipsl/sirta/chm15k/overlap_corr
    - Public Python code (Martin) https://github.com/martin-obs/OVERLAP_PROBE_EPROFILE
  - raw2L1
    - Public Python code (Marc-Antoine) https://gitlab.in2p3.fr/ipsl/sirta/raw2l1
  - Calibration codes
    - Cloud calibration
      - E-PROFILE (private) containing cloud calibration codes in python 2 and 3
      - Elliott Warren (private) containing “Emma’s original script for LUMO ceilometers”
    - Rayleigh calibration
      - EARLINET (private mercurial) -> ask giuseppe.damico@imaa.cnr.it
      - Meteoswiss -> ask Rolf Rüfenacht
      - ALICENET -> ask

- **A lot of ACTRIS code in Github (backup, automatic testing, …) => shall we all move there?**

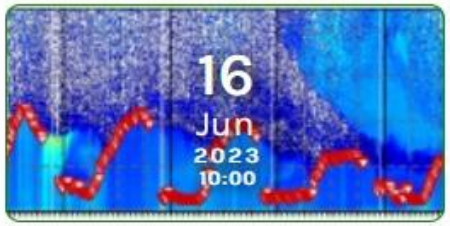
Documents

- ACTRIS documents mainly in intranet :(
- E-PROFILE
  - Glossary
  - File Format description document
  - SOPs
- PROBE documents currently on website
  - Plan to put documents on zenodo (versioning, DOI, …)
  - See e.g. zenodo page from IEA Task 32



Upcoming events

Raw2L1 developer meeting June 7, 10:00 - 12:00 CEST (contact Ina Mattis if would like to attend)



STRATfinder: Automatic detection of mixed layer heights from attenuated backscatter profile observations

SUBGROUP MEETINGS

Friday, 16 June 2023 10:00 - 12:00

zoom

The automatic algorithm STRATfinder is increasingly applied to detect mixed-layer heights from attenuated backscatter profile observations. In this meeting recent developments of the sIgorithm will be summarised and STRATfinder users are invited to share their experience with the tool.

+ INFO

16th June 2023
10-12 CEST

Training school: "Hands-on training on aerosol lidar measurement quality assurance procedures and tools"

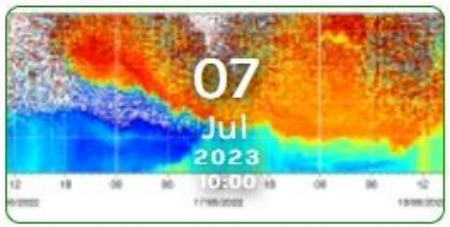
TRAINING SCHOOLS

Tuesday, 27 June 2023 09:00 - **Thursday, 29 June 2023** 18:00

ACTRIS Centre for Aerosol Remote Sensing (CARS) and PROBE CA18235 invite scientists working aerosol high-power lidars to a training school entitled the " Hands-on training on aerosol lidar measurement quality assurance procedures and tools". The event is organized at Magurele center for Atmosphere and Radiation Studies (MARS), 2 Atmosferei Str., Magurele, Ilfov, Romania, 27-29 of June

+ INFO

27-29th June 2023



User experience with the Vaisala CL61

SUBGROUP MEETINGS

Friday, 07 July 2023 10:00 - 12:00

zoom

The Vaisala CL61 is a recent ALC capable also to capture the particle depolarisation. It is increasingly operated by the PROBE community. To better understand its capabilities and [...]

+ INFO

7th July 2023
10-12 CEST