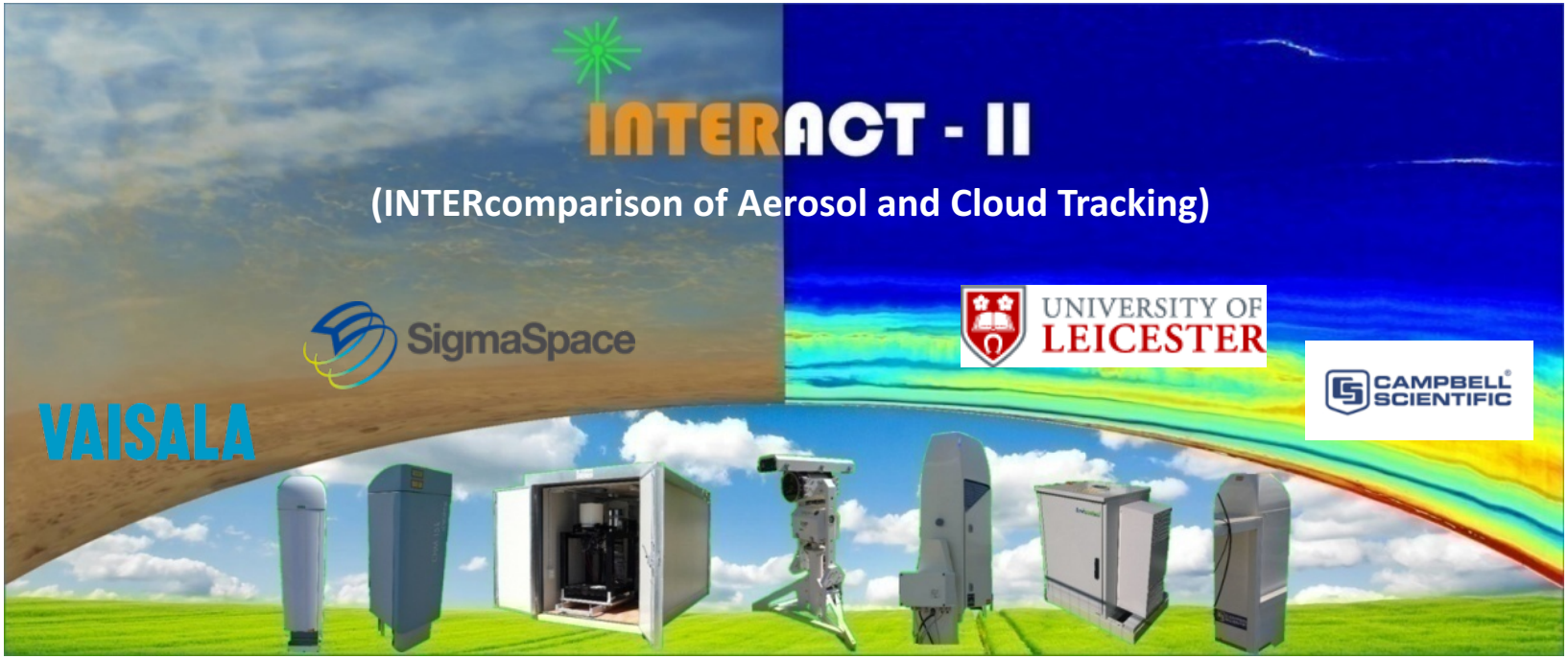

INTERACT-II campaign: comparison of commercial lidars and ceilometers with advanced multi-wavelength Raman lidars

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Objectives

INTERACT-II campaign was carried out at the CNR-IMAA Atmospheric Observatory (760 m a.s.l., 40.60° N, 15.72° E), within the TNA activities of the ACTRIS-2 H2020 Research Infrastructure project.

Period: 01/07/2016 – 10/01/2017

The main objectives of the campaign are:

- Performance evaluation of commercial automatic lidars and ceilometers for aerosol/cloud measurements (in terms of sensitivity to different loads and types of aerosols and clouds);
- Study of instrument SNR and dynamic range (depending on the aerosol extinction coefficient, water vapor content, solar irradiance, ...);
- Study of instrument time stability (e.g. laser, detector, efficiency, thermal drifts,…);
- Assessing the ceilometer's calibration stability and accuracy (using an ACTRIS/EARLINET Raman lidar as a reference).

Involved instruments

In the frame of the campaign, the following instruments have been involved:

- **CIAO multi-wavelength Raman lidars: PEARL (Potenza EArlinet Raman Lidar) and MUSA (MUlti-wavelength System for Aerosol) ACTRIS/EARLINET mobile reference system:**

  Transmission: λ = 355, 532 and 1064nm

  Detection: λ = 355, **532_{tot} , 532p, 532c** and **1064 nm** (elastic backscattering)
  λ = 387 and 607nm (Raman backscattering from N_2)
  λ = 407nm (Raman backscattering from H_2O) only PEARL

  Products: RCS, vertical profiles of multi-wavelength aerosol/cloud optical properties and water vapor content (PEARL)

- **Mini-Micro Pulse Lidar (mini-MPL) provided by Sigma Space Corporation** (since July 2016)

  Transmission: λ = **532 nm**

  Detection: λ = 532_{tot} , 532p , 532c nm (elastic backscattering)

  Products: RCS, vertical profiles of aerosol/cloud optical properties

- **CIAO-VAISALA CT25K ceilometer , VAISALA CL51 ceilometer** (since May 2016) **and Campbell CS135 ceilometer** (since July 2016 due to instability of the power supply unit)

  Transmission/Detection: λ = **905/910 ± 5 nm**

  Products: RCS, attenuated backscattering coefficient, cloud layer heights

- **CIAO-JENOPTIK CHM15k ceilometer** (not operated from July to September because of the laser failure or misalignment between laser and detector; the optical unit is currently in maintenance and has been temporarily replaced by the service one provided by Lufft)

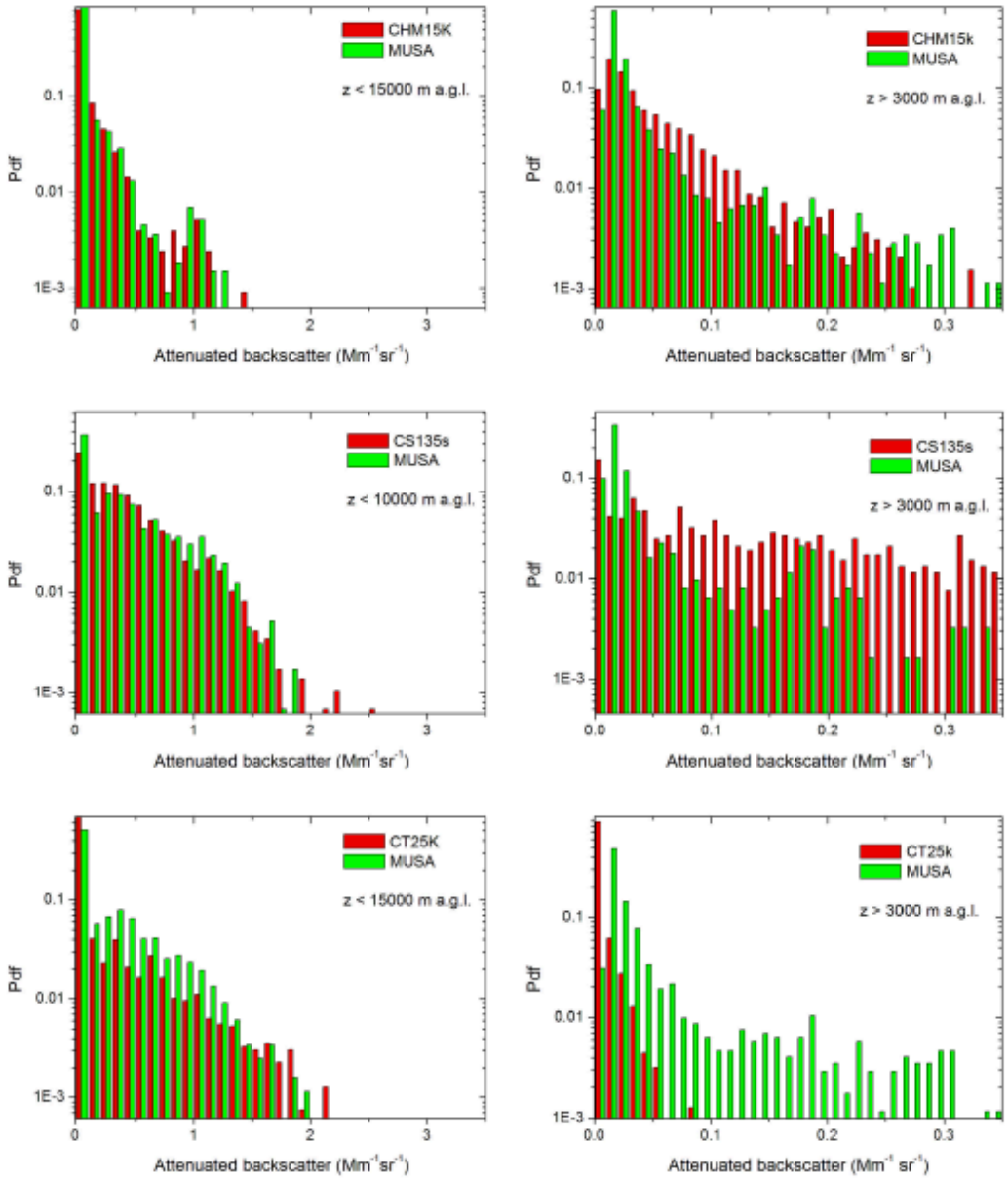
  Transmission/Detection: λ = **1064**nm

  Products: RCS, attenuated backscattering coefficient, cloud layer heights

Maintenance and data evaluation

- Checks of instrument operation: daily.
- Checks of instrument acquisition parameters (laser transmitter, receiver, heater, blower, windows, tilt angle….): 2-3 times per month.
- Cleaning of the windows: two times per month or according to atmospheric conditions (e.g. after precipitation or dust/smoke transport events). Data messages include warnings that inform when windows are contaminated.
- Additional tests have been carried out to assess instrumental stability and dependence on environmental temperature.
- Once the data will be fully assessed (May-June 2017), the dataset may become publicly available (still requires the approval from all the manufacturers). All the data collected by CNR-IMAA instruments (e.g. MUSA, PEARL, CT25k, CHM15k, ….) are publicly available.

.... from INTERACT-I (2014)

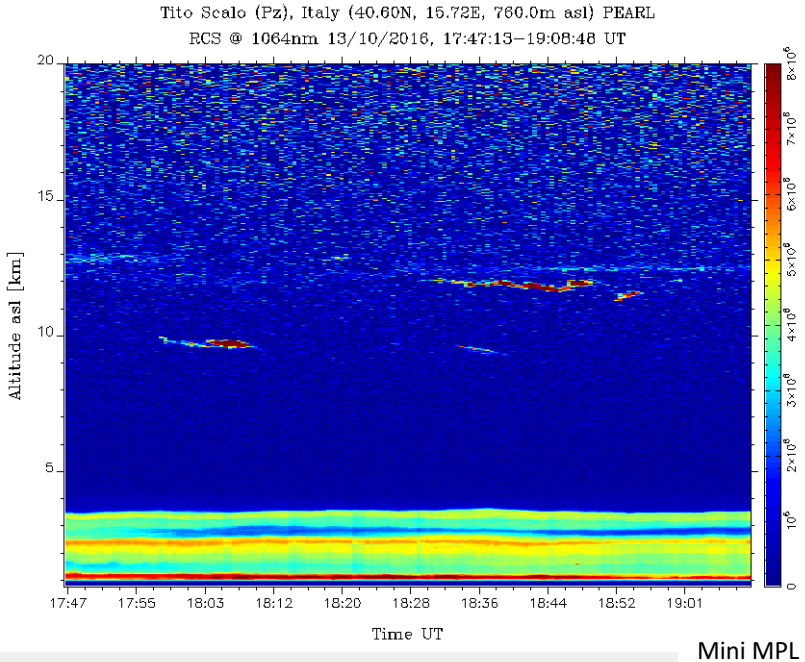


As a whole, ceilometer calibration with MUSA lidar was largely unstable, claiming for frequent check of the calibration values.

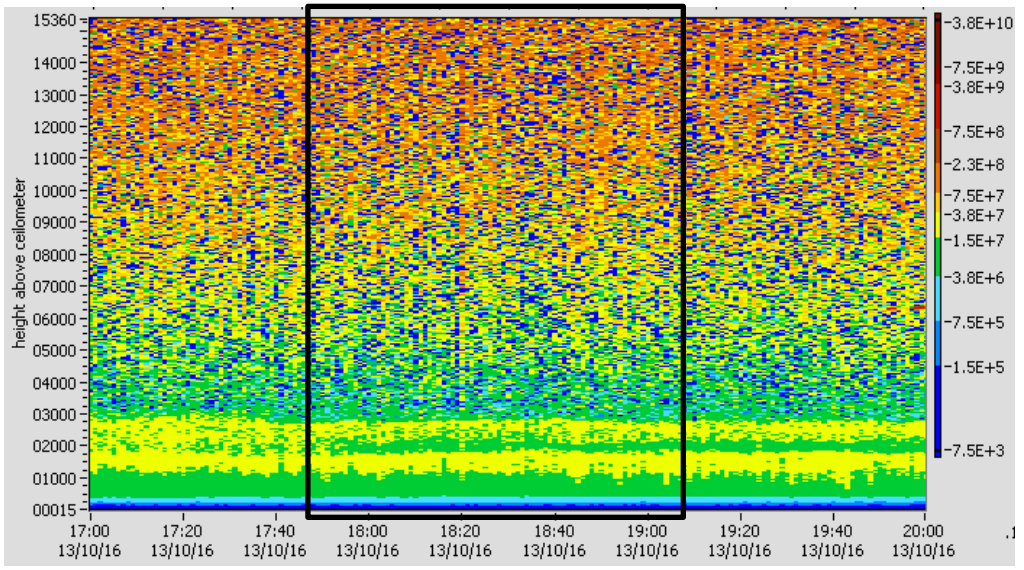
- CHM15: Good performances also in the Free Troposphere (FT)
- CS135s: prototype version, overall good impression, but affected by noise problems, challeging calibration over the lidar
- CT25K: safisfactory in the PBL but affected by several issue (low SNR, dynamic range), cloud calibration the only feasible

Madonna et al., 2015 AMT

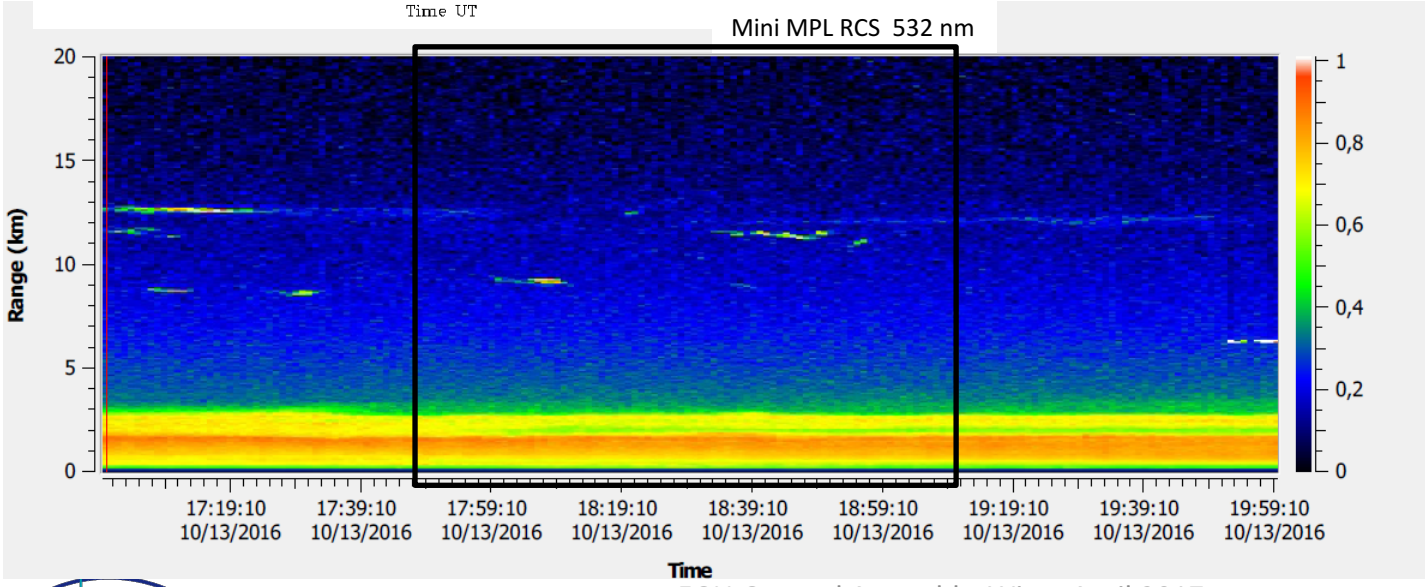
Quicklooks: 13 October 2016



JENOPTIK RCS 1064 nm



Mini MPL RCS 532 nm

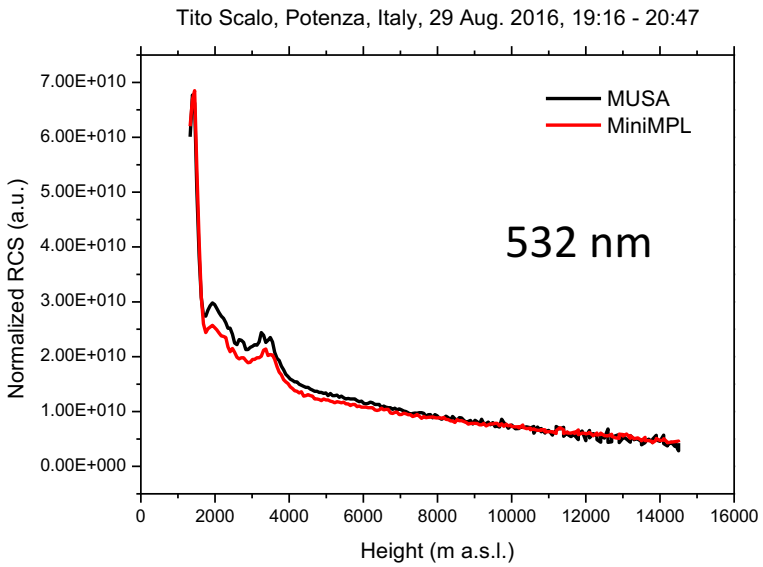


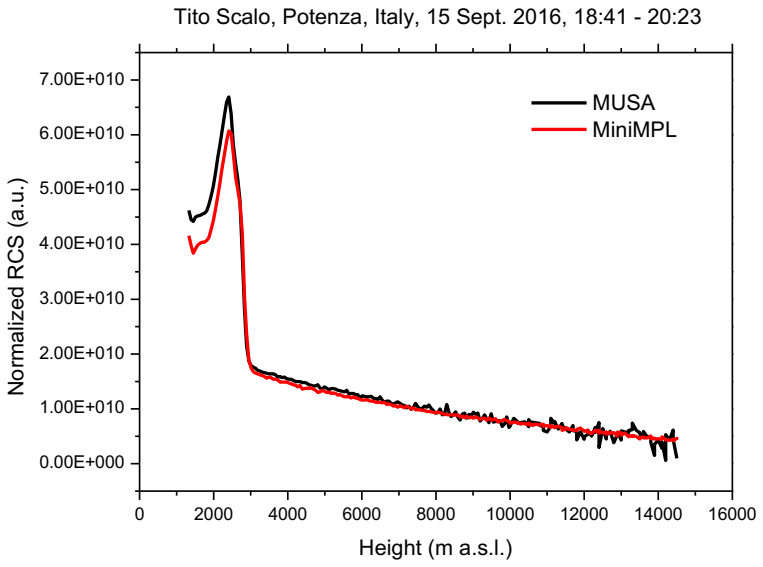
Dust direct transport from Northern Africa

Processing

- **Analysis presented in this work is related to the period July – Sept. 2016**
- Profiles from MiniMPL, and CL51 and CS135 ceilometer have been normalized over the MUSA lidar equivalent profiles (i.e. RCS or attenuated backscatter profiles) at the highest possible altitude level (depending on the instrument SNR).
- Dark currents have been evaluated during the campaign (small contribution).
- For 905-910 nm ceilometers, water vapour correction has been estimated using FLG model and the Potenza GRUAN site (collocated) radiosounding as input (alternative option are the Raman lidar measurements and the RAOB soundings from Brindisi station).
- Signal time integration: 1-2 hours (MUSA data processed using the EARLINET Single Calculus Chain D'Amico et al., 2015 AMT)
- 532 nm signals: retrieved from the gluing of copol and crosspol channels for both MUSA and MiniMPL
- 532/1064 beta related Angstrom coefficient has been used to rescale the 905-910 ceilometers

MiniMPL: examples

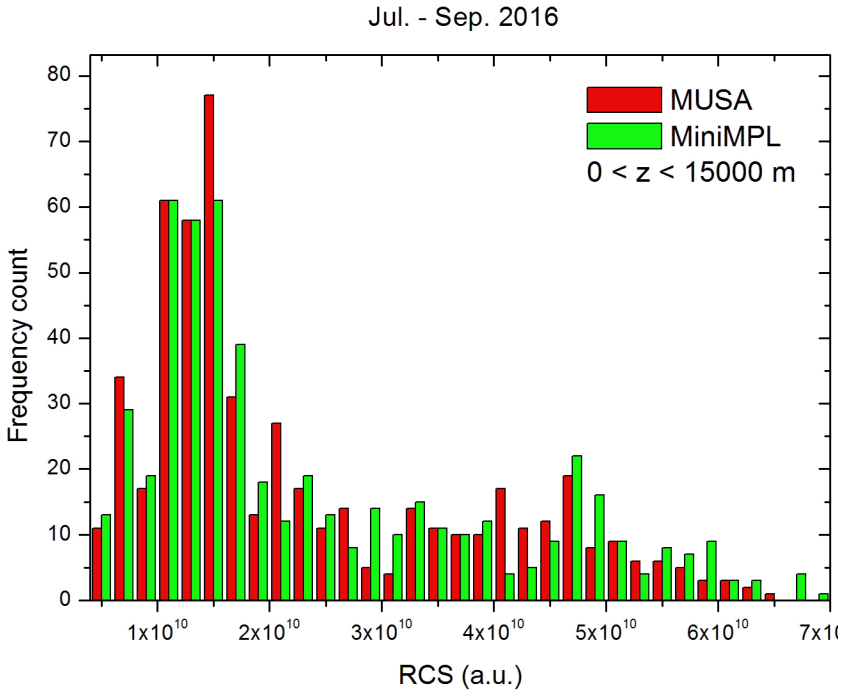


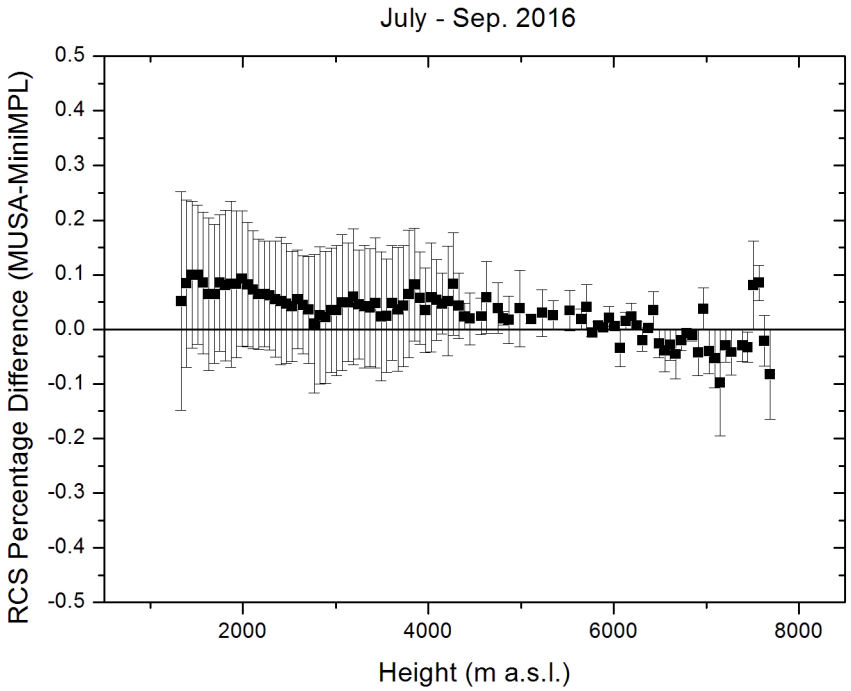


- Profiles starts from the full overlap altitude for MUSA lidar (addressed using the telecover test, performed on EARLINET lidars).
- Two types of differences are pointed out:

1. Incomplete overlap region: MiniMPL overlap function requires a deeper investigation.
2. In free troposheric aerosol layers, MiniMPL underestimates MUSA: wrong MiniMPL dead-time correction? Or after pulses correction? Under investigation.

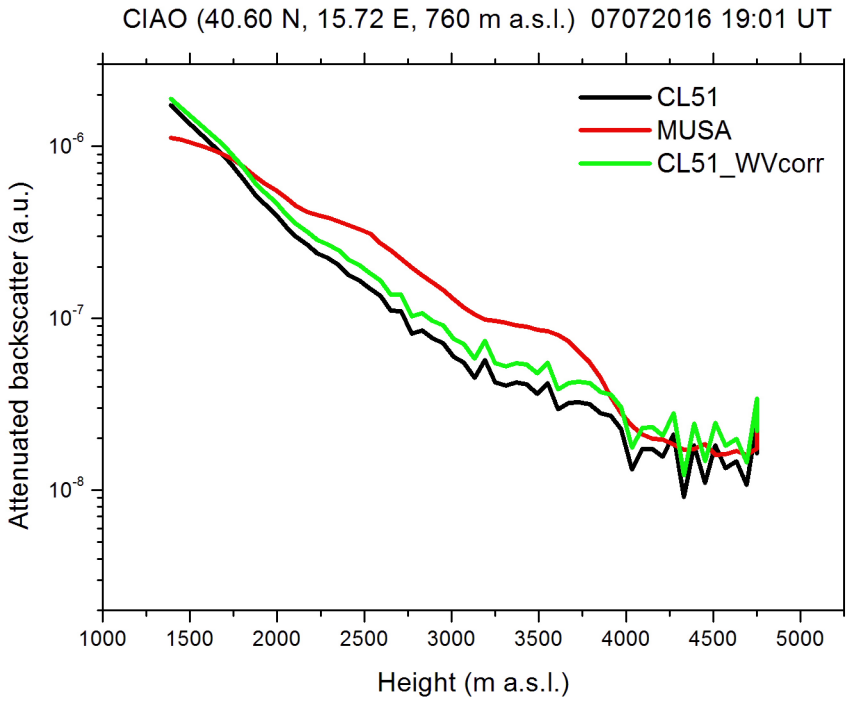
MiniMPL: pdfs vs MUSA

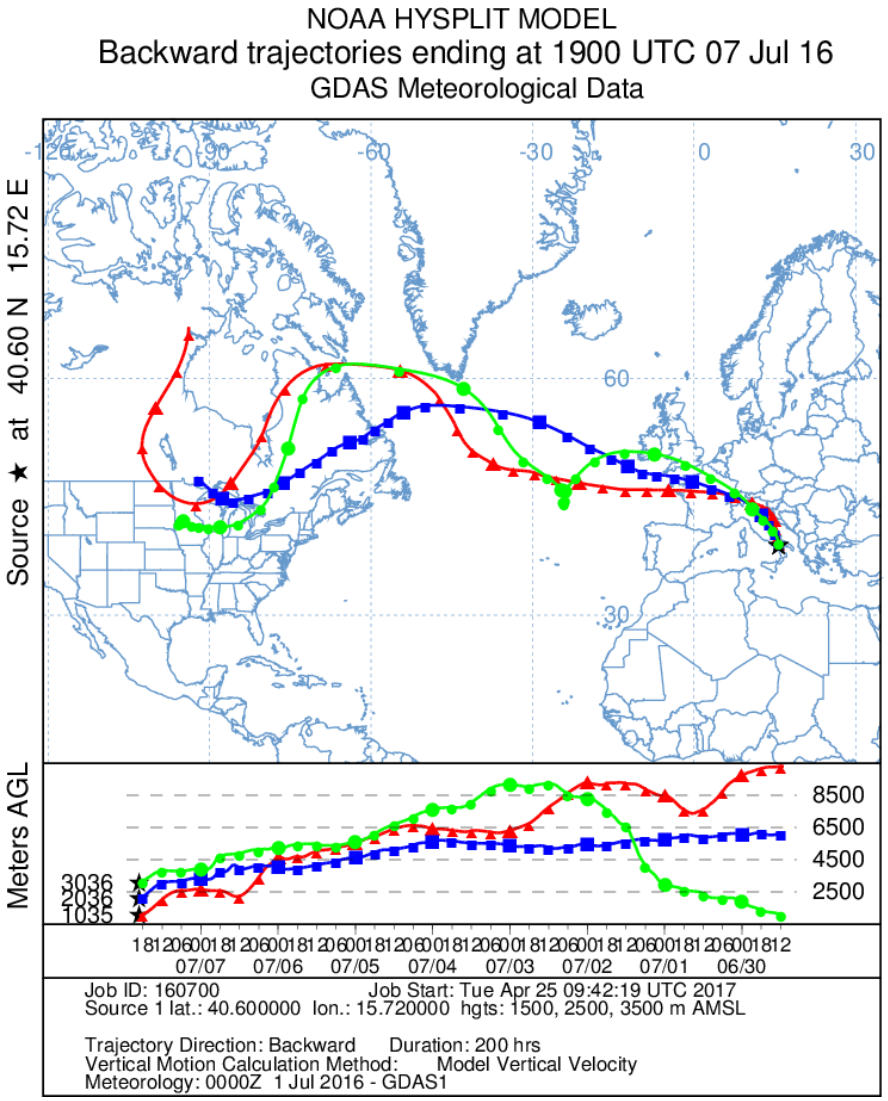




- MiniMPL understimates MUSA on average of 5 % up to 4 km of height a.s.l.
- Good stability of the calibration ("lidar normalization") over the the three months shown by the small percentage variability in the normalization region.

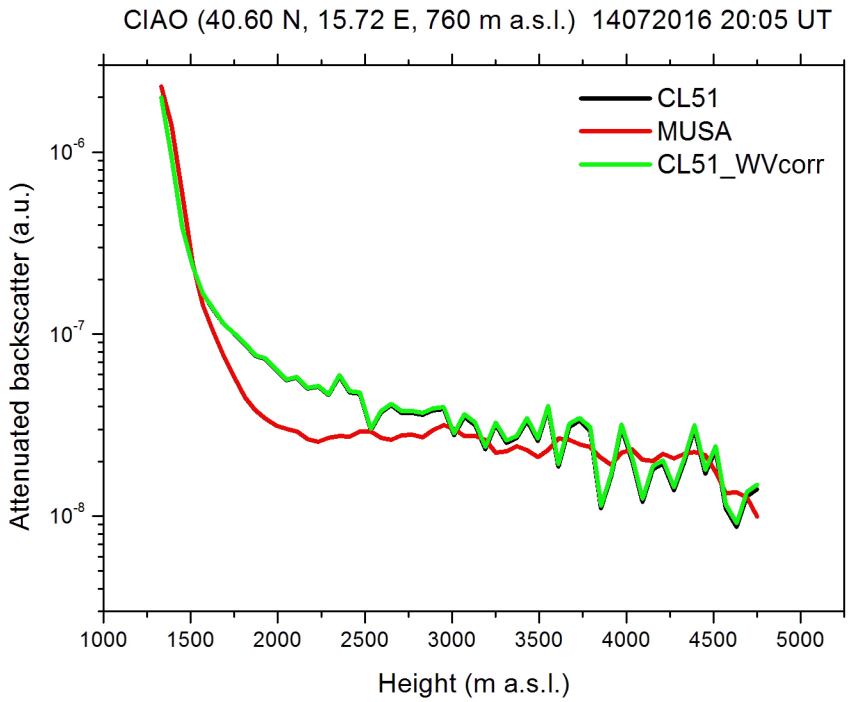
CL51 vs MUSA: 07 July 2016

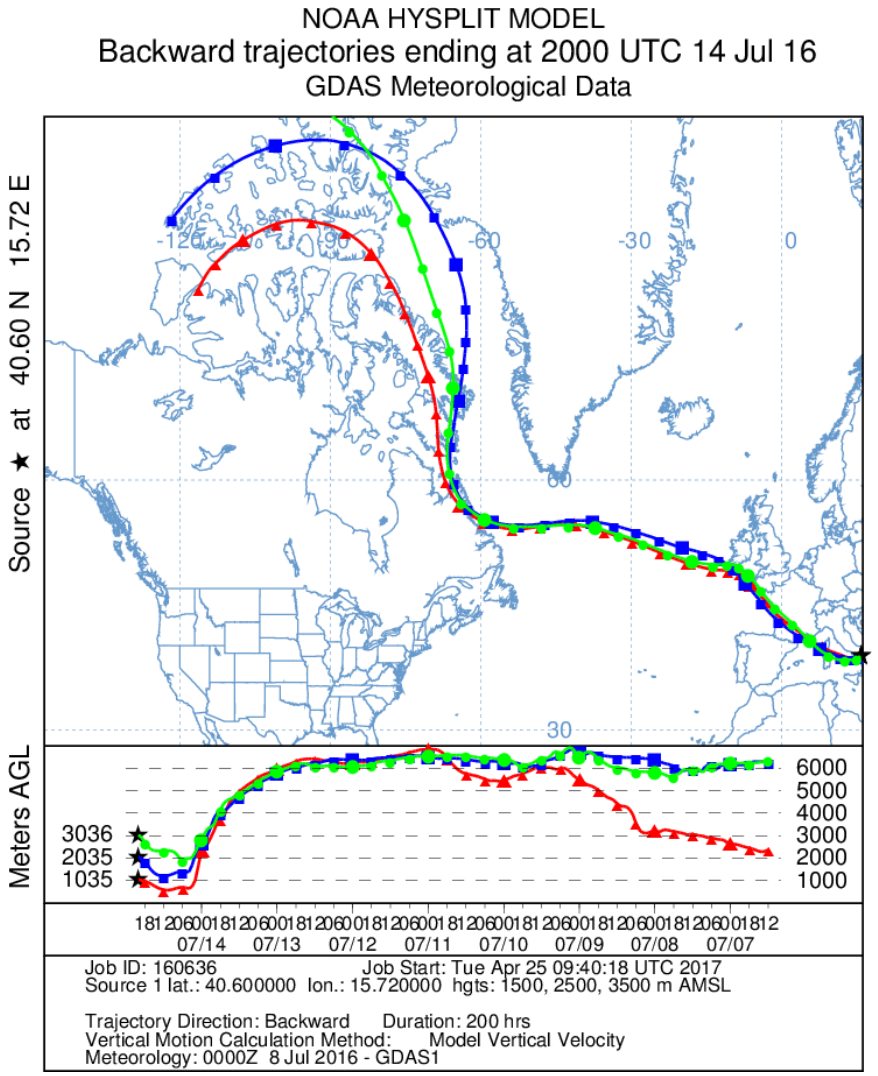




- Differences in both the value of the Attenuated Backscatter but also in the gradients.
- Differences at lower levels due to the CL31 overlap correction function.

CL51 vs MUSA: 14 July 2016

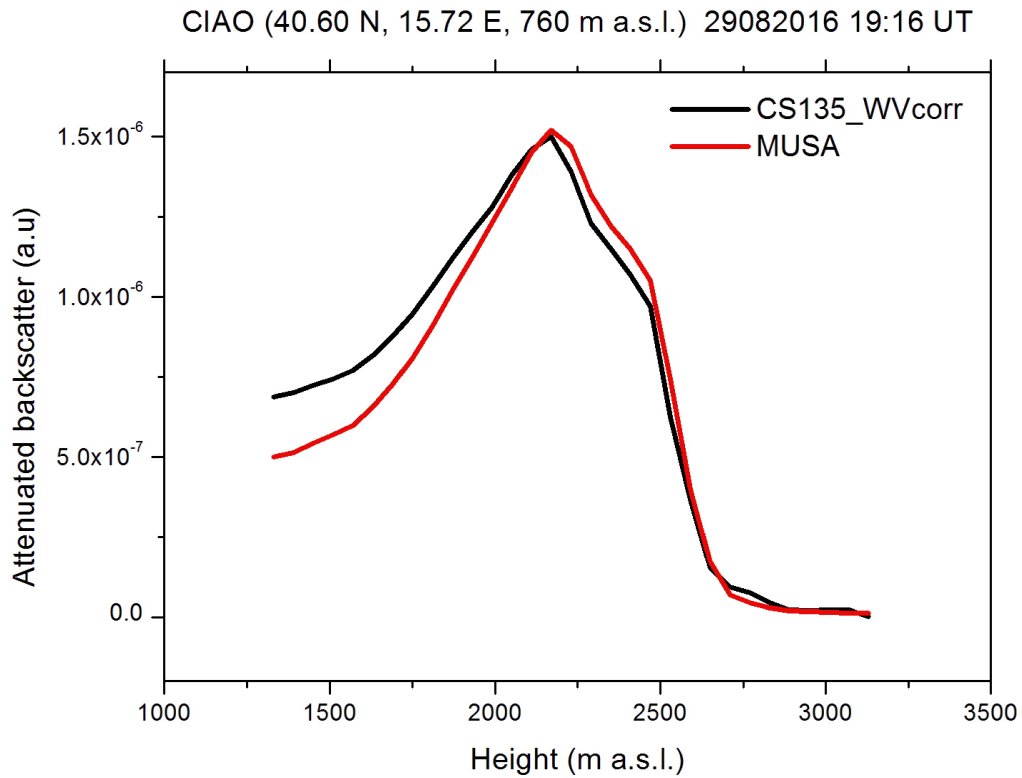




- Better agreement, though differences still exists.
- CL31 overlap correction works better in this case.

CL51: low SNR (better than in older versions) still affect the aerosol retrievals. Also changes in the gain?

CS135: 29 August 2016



Only one case available matching with MUSA time series.

- Very good agreement, promising like pointed out for the prototype in INTERACT-I.
- Plenty of data lost for communication problems: urgent improvements are needed.
- Noisy in the free troposphere like the prototype version, very difficult to normalize on the lidar, molecular calibration looks challenging. To check over more cases.

Outlook

- Use Raman lidar measurements to correct water vapour absorption in the FLG model.
- Check the temperature dependence of the callibration (first test seems to show a certain degree of dependence).
- Compare with the outcome of other international experiments closed or ongoing.

…. and then ….

- Complete the analysis and publish it in peer-reviewed literature (May 2017).
- Make the dataset publicly available (upon agreement with the instrument providers).

Thanks for your attention!