AEROSOL-CLOUD-INTERACTION AT JOYCE

05.07.2022 - BMD SEMINAR

Marcus Müller

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The Influence of Pollution on the Shortwave Albedo of Clouds

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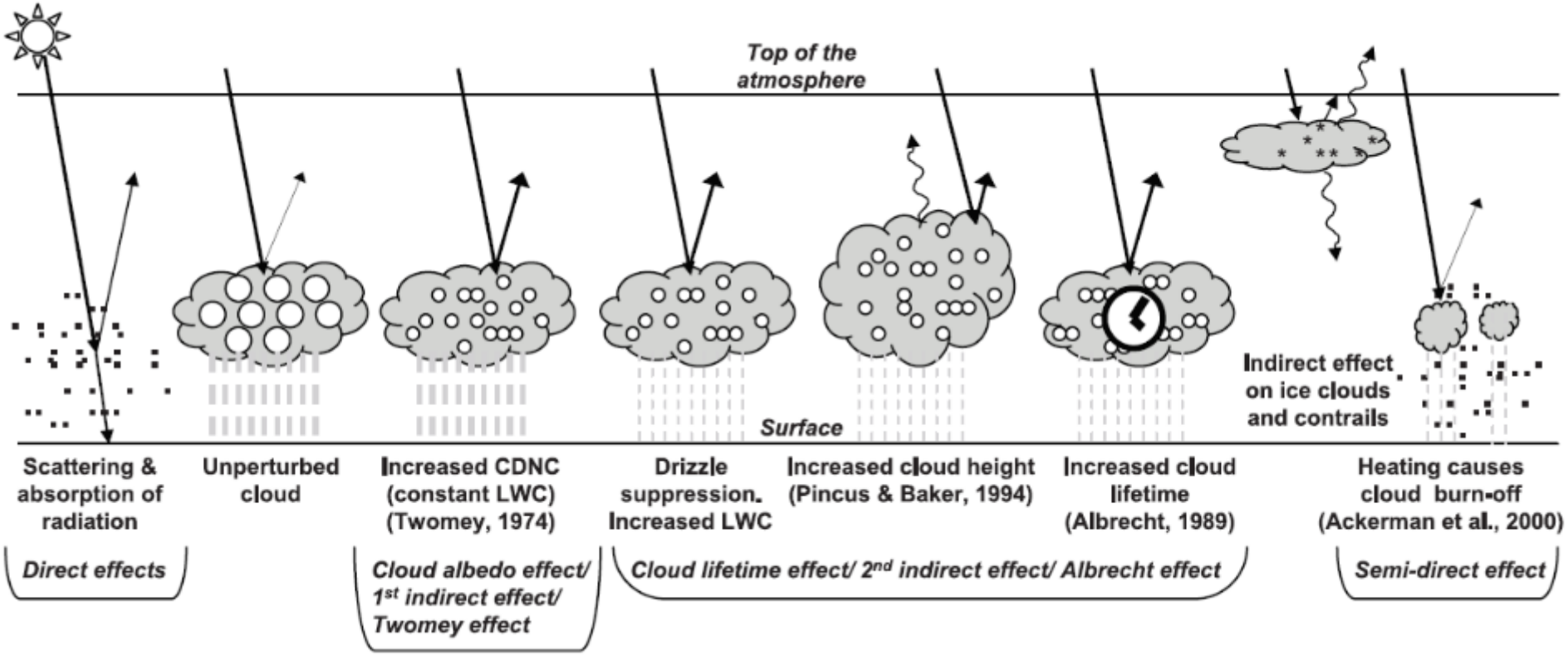
26 October 1976 and 5 April 1977

ABSTRACT

By increasing droplet concentration and thereby the optical thickness of a cloud, pollution acts to increase the reflectance (albedo) of clouds; by increasing the absorption coefficient it acts to decrease the reflectance. Calculations suggest that the former effect (brightening of the clouds in reflection, hence climatically a cooling effect) dominates for thin to moderately thick clouds, whereas for sufficiently thick clouds the latter effect (climatically a warming effect) can become dominant.

AEROSOL-CLOUD-INTERACTION



Source: ECMWF, 2018

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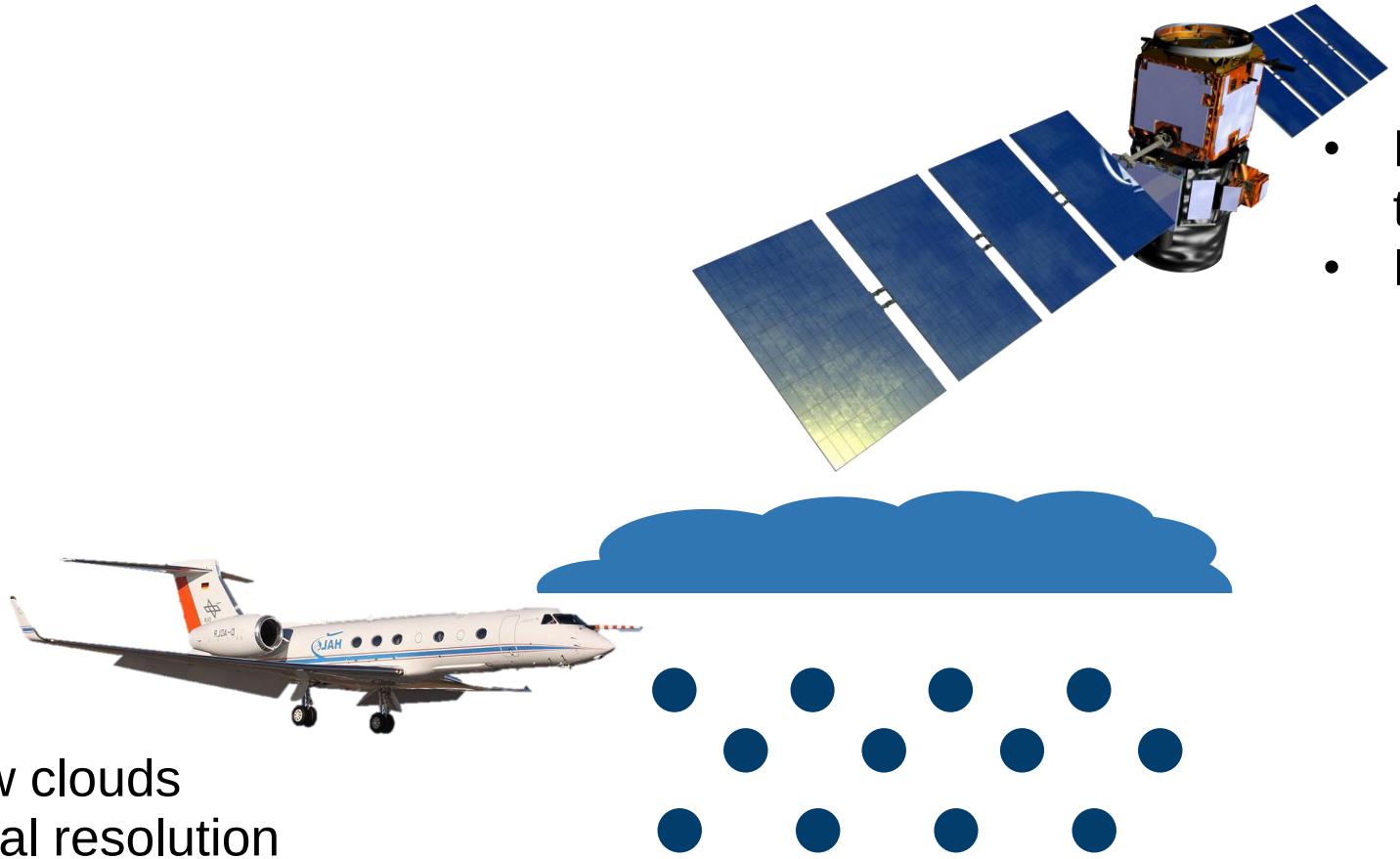
AEROSOL MEASUREMENT



- Hight spatial and temporal resolution
- No data below clouds

- Data below clouds
- No temporal resolution

https://science.nasa.gov/toolkits/spacecraft-icons
https://www.dlr.de/com

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Atmos. Meas. Tech., 9, 1039–1050, 2016
www.atmos-meas-tech.net/9/1039/2016/
doi:10.5194/amt-9-1039-2016

Atmospheric Measurement Techniques
Open Access
EGU

Ground-based remote sensing scheme for monitoring aerosol–cloud interactions

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Received: 13 October 2015 – Published in Atmos. Meas. Tech. Discuss.: 17 November 2015
Revised: 2 March 2016 – Accepted: 2 March 2016 – Published: 14 March 2016

CALCULATION OF ACI-METRICS

Sarna et. al. (2016)

$$ACI_N = \frac{d\ ln(N_d)}{d\ \ln(\alpha)}$$

$$ACI_{r_e} = \frac{d\ ln(r_e)}{d\ \ln(\alpha)}\Bigg|_{LWP}$$

observed proxy of the aerosol concentration α:

- aerosol number concentration
- aerosol optical thickness
- *backscatter of a ceilometer?*

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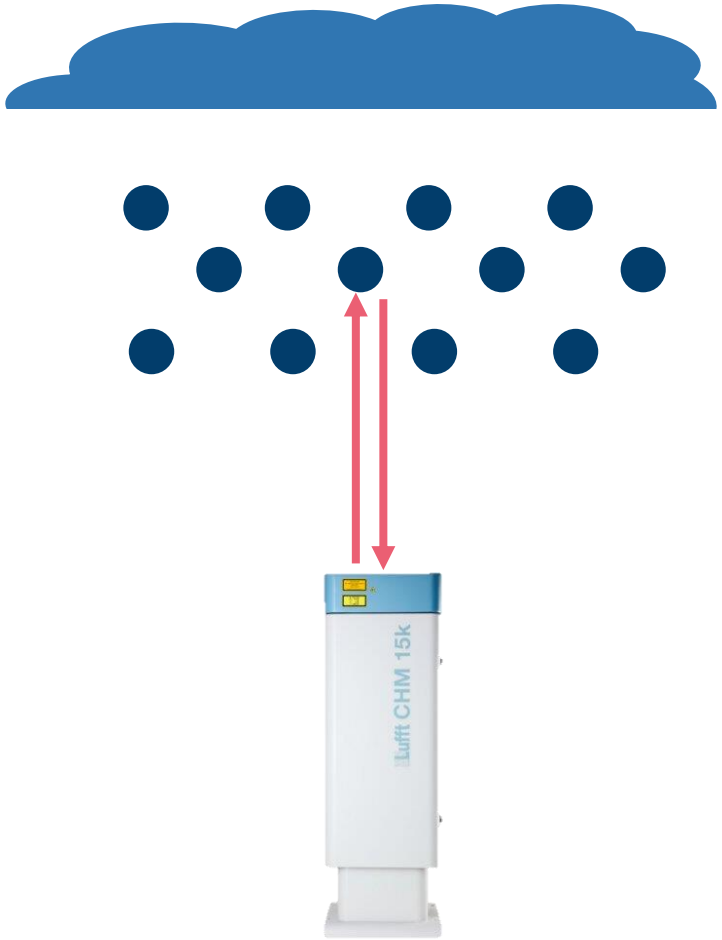
AEROSOL REMOTE SENSING WITH A CEILOMETER



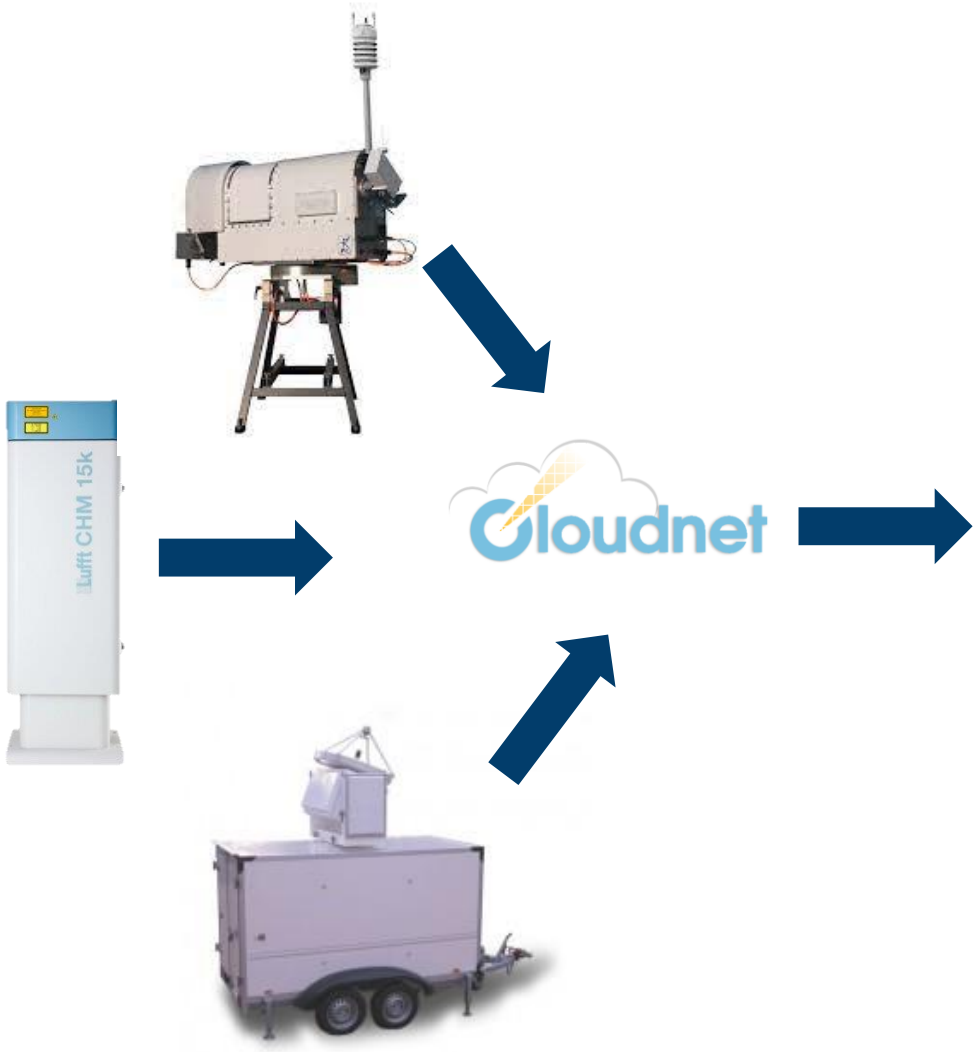
- Lidar technique
- Automated Operation
- Developed to measure cloud base height
- Eye-safe

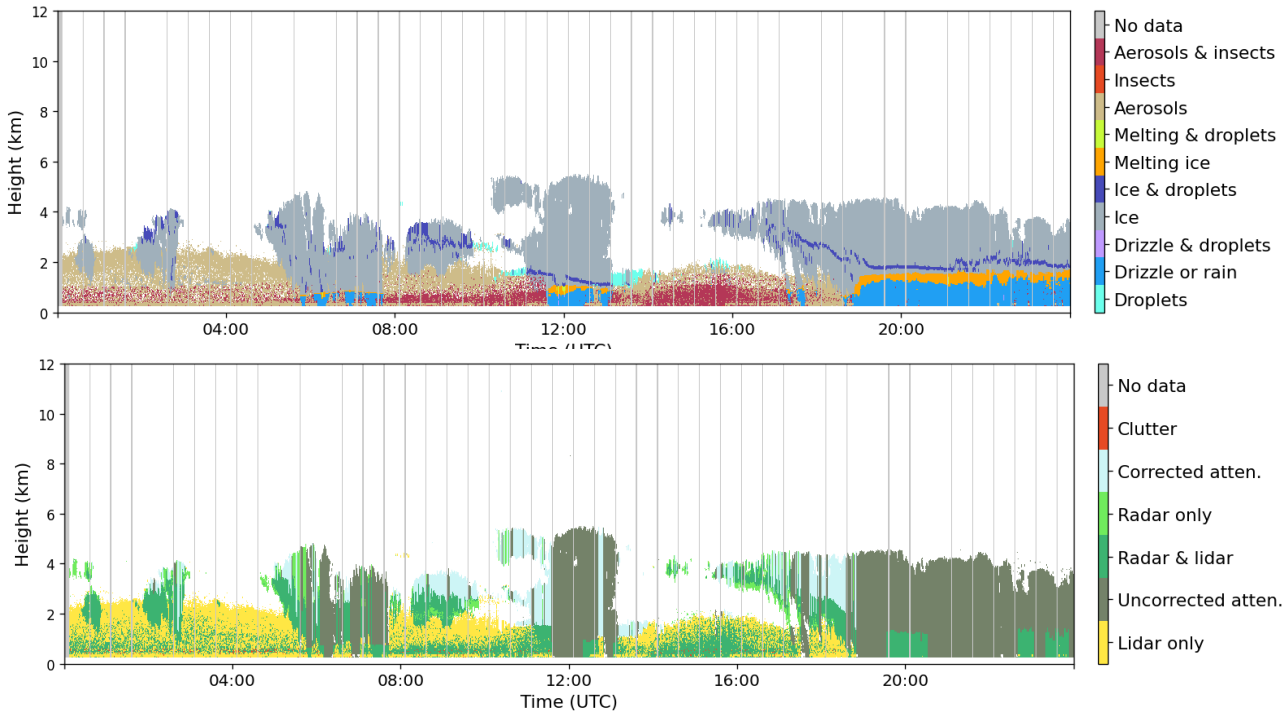
LIDAR EQUATION

$$
\begin{aligned}
P(r) &= C_L \frac{\beta_r}{r^2} \, exp\left\{-2 \int_0^r \alpha(r')dr'\right\} \\
\Leftrightarrow \quad \frac{P(r)r^2}{C_L} &= \beta_r \, exp\left\{-2 \int_0^r \alpha(r')dr'\right\} \\
&:= \beta^*(r)
\end{aligned}
$$

$$
\begin{aligned}
\beta^*(r) &= \beta(r) e^{-2\tau_m(r)} e^{-2\tau_p(r)} \\
&\approx \beta(r) \\
&\approx \sum_j \frac{N_j(r) C_{sca,j}(r) p_j(\pi, r)}{4\pi} \\
&\propto TN(r) \\
&\propto TM(r)
\end{aligned}
$$

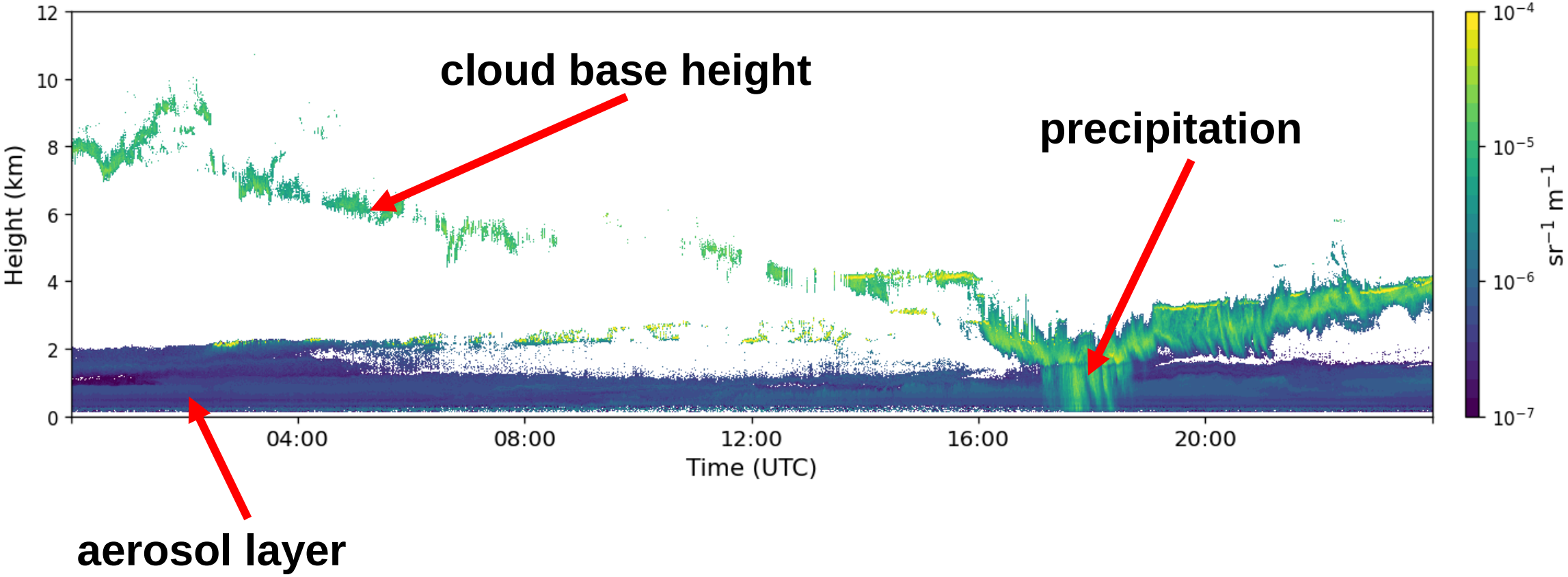
CLOUDNET


Lufft CHM 15k
Cloudnet


Height (km)
04:00
08:00
12:00
16:00
20:00
No data
Aerosols & insects
Insects
Aerosols
Melting & droplets
Melting ice
Ice & droplets
Ice
Drizzle & droplets
Drizzle or rain
Droplets
Time (UTC)
No data
Clutter
Corrected atten.
Radar only
Radar & lidar
Uncorrected atten.
Lidar only

EXAMPLE

2022-04-29



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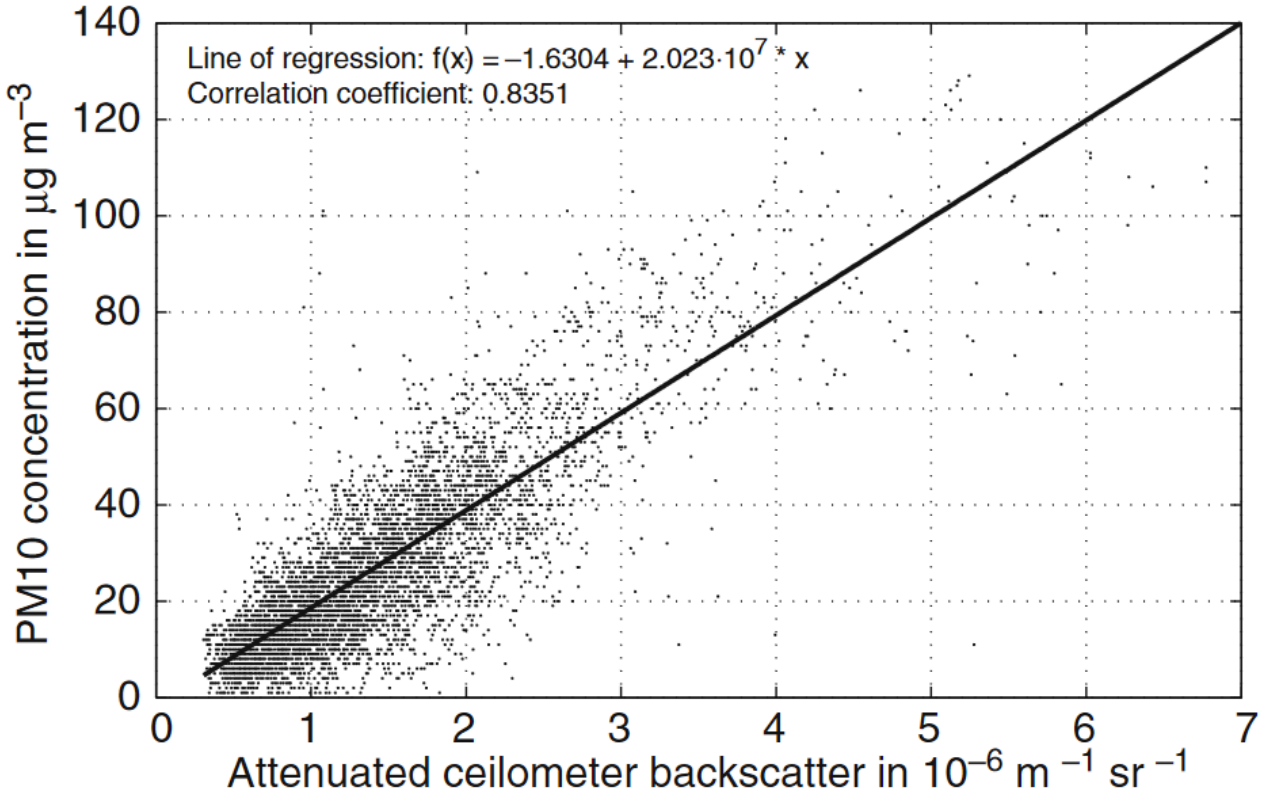
RESEARCH QUESTIONS

Is the backscatter signal of a ceilometer suitable to represent aerosol concentration?

Is it possible to confirm and quantify ACI-effects on a long-term JOYCE dataset?

WHAT HAS BEEN DONE SO FAR?

Münkel et. al., 2006



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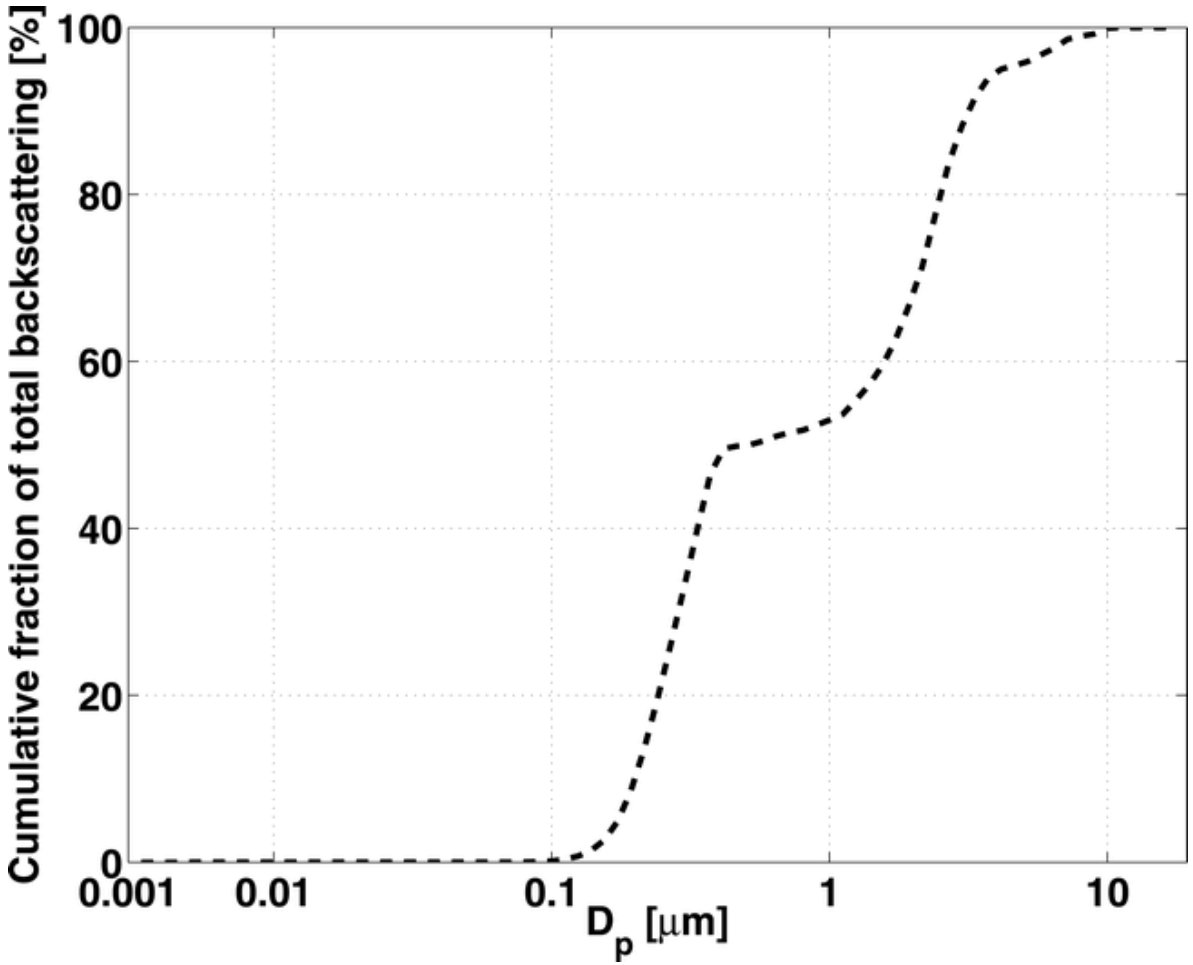
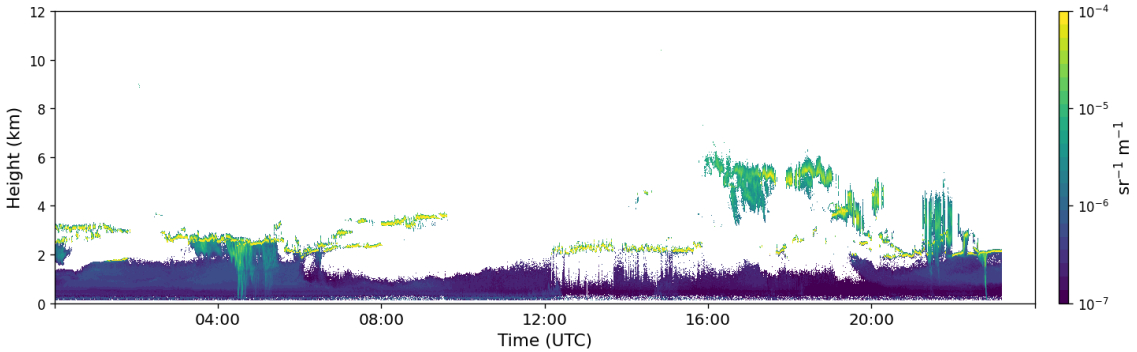
WHAT HAS BEEN DONE SO FAR?

Sundström et. al., 2009



IN-SITU / REMOTE SENSING COMPARISON



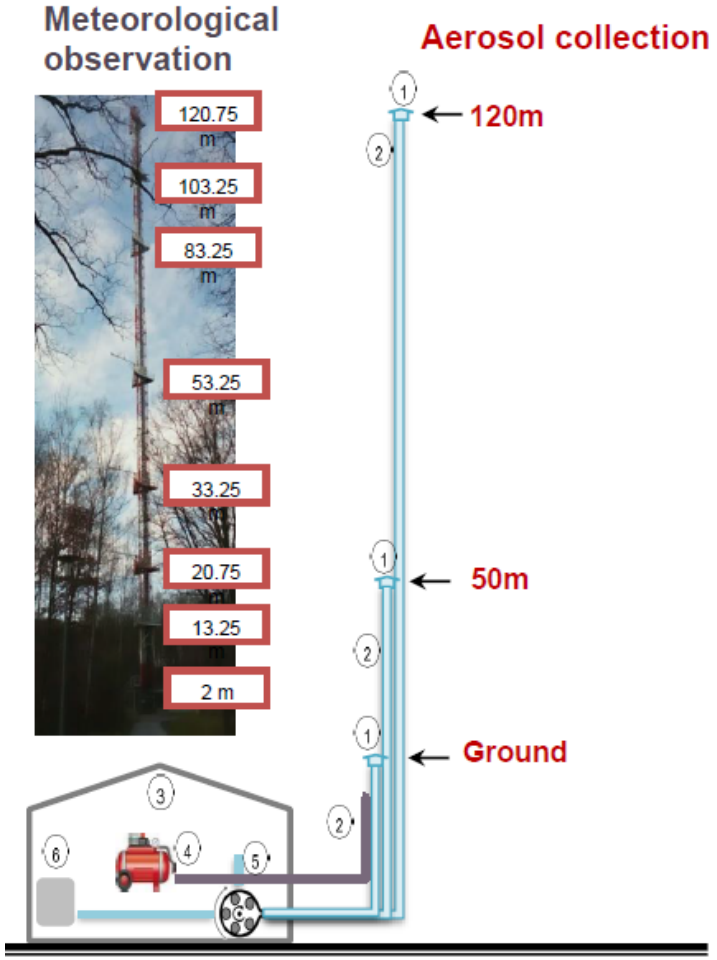


Image: Yan et. al.

OPTICAL PARTICLE COUNTER

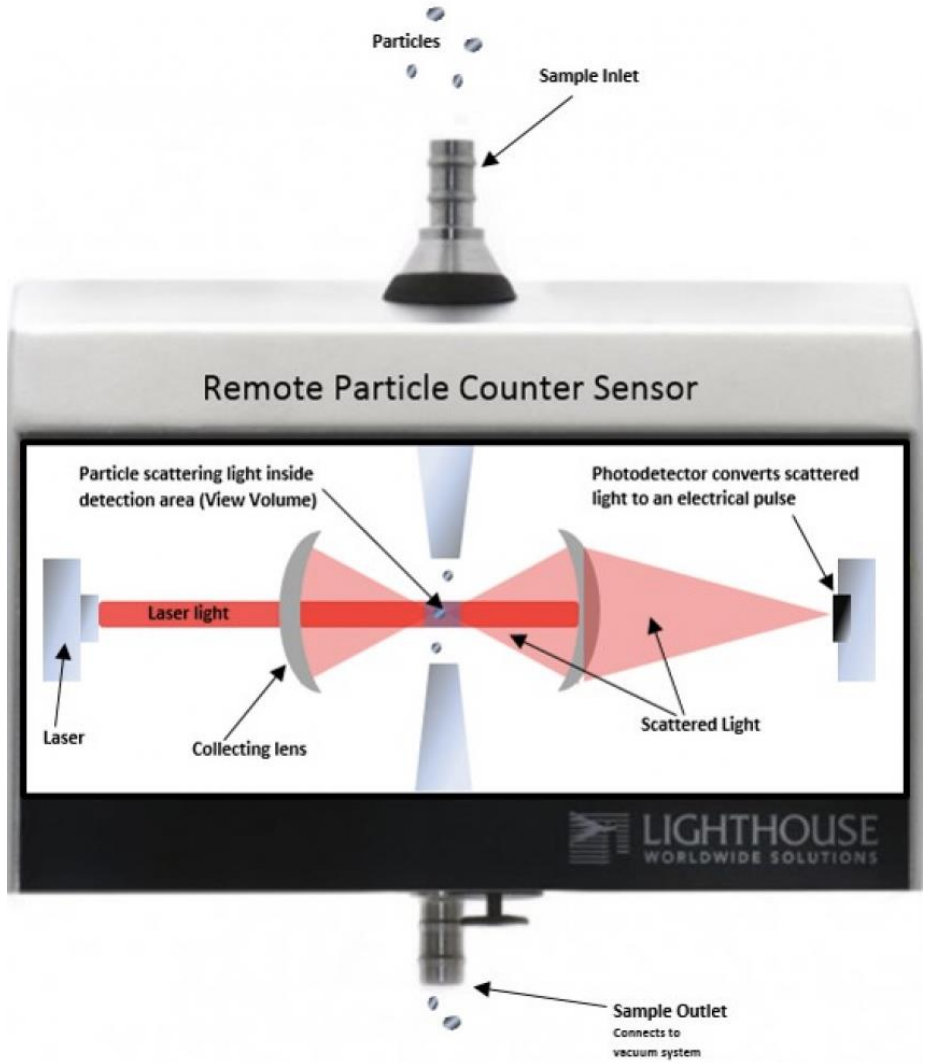


Image: https://www.golighthouse.com

IN-SITU / REMOTE SENSING COMPARISON

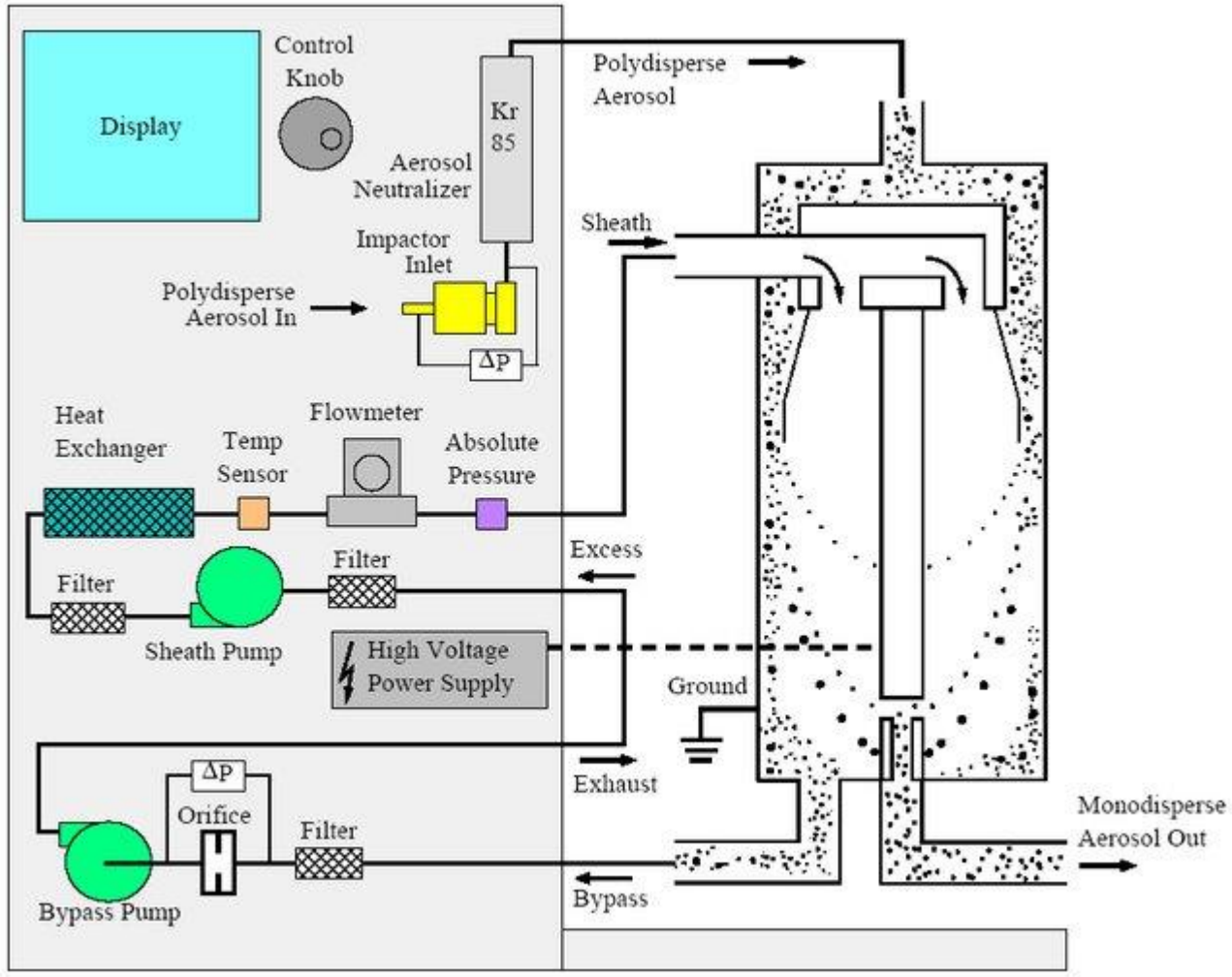


Image: Aggarwal, 2010

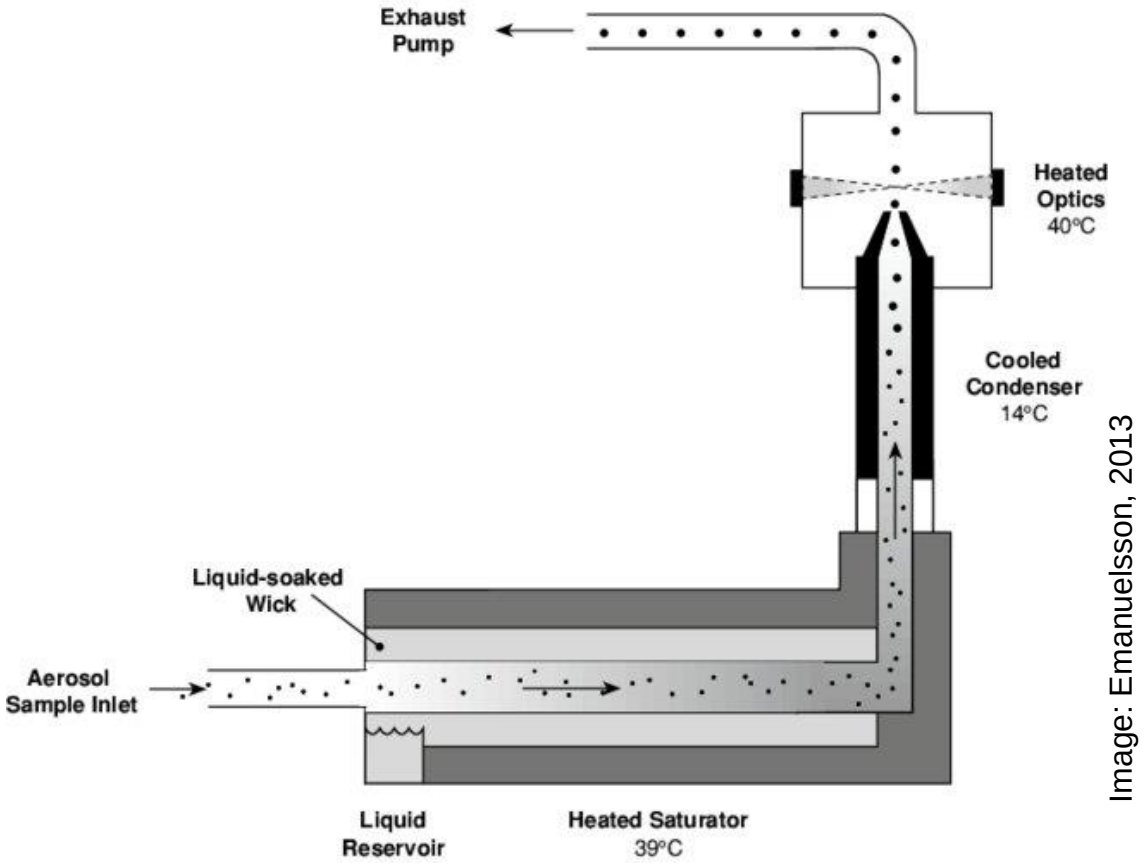


Image: Emanuelsson, 2013

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JOYCE CEILOMETERS

ADDITIONAL DATA

PBL classification

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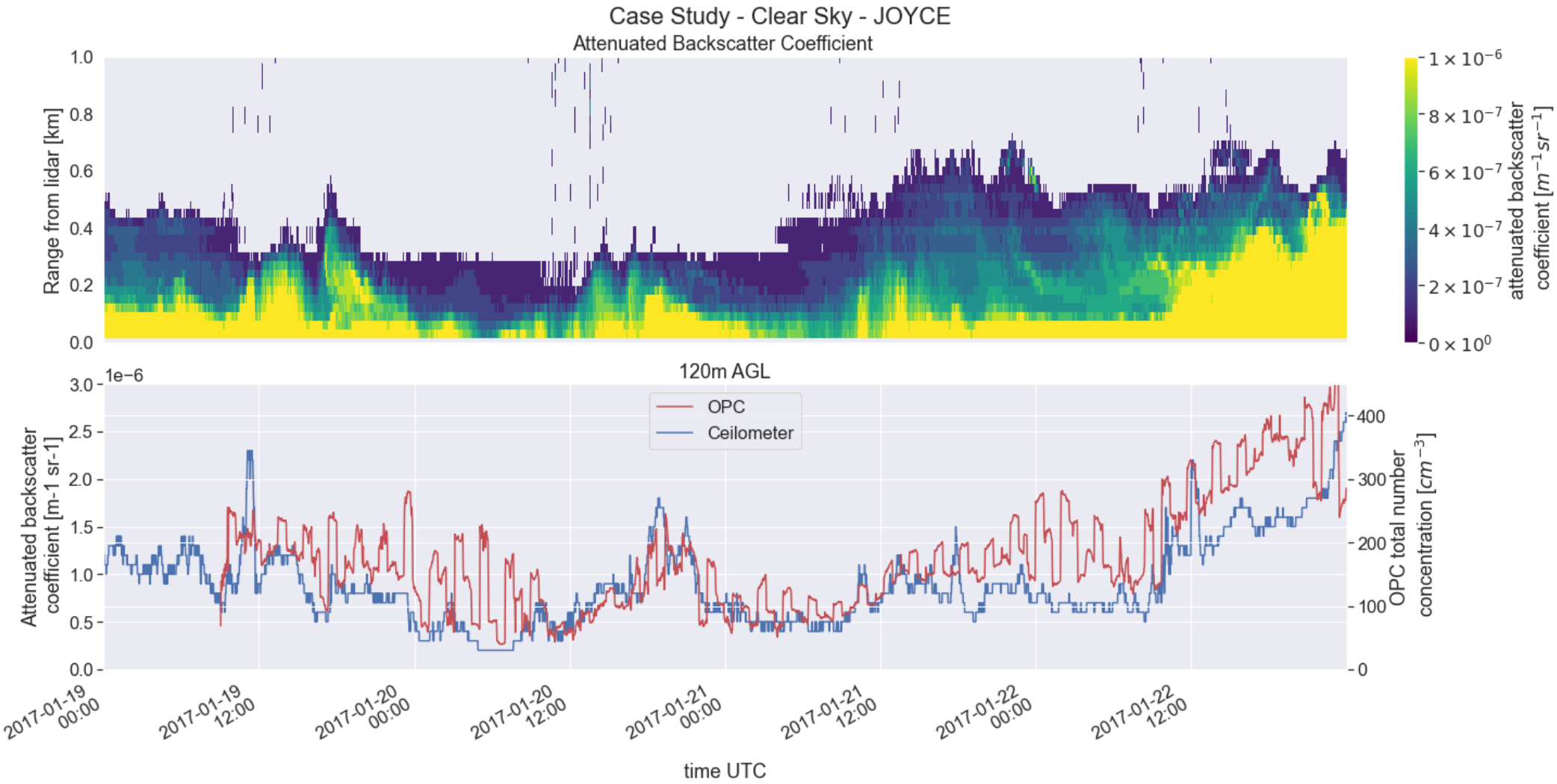
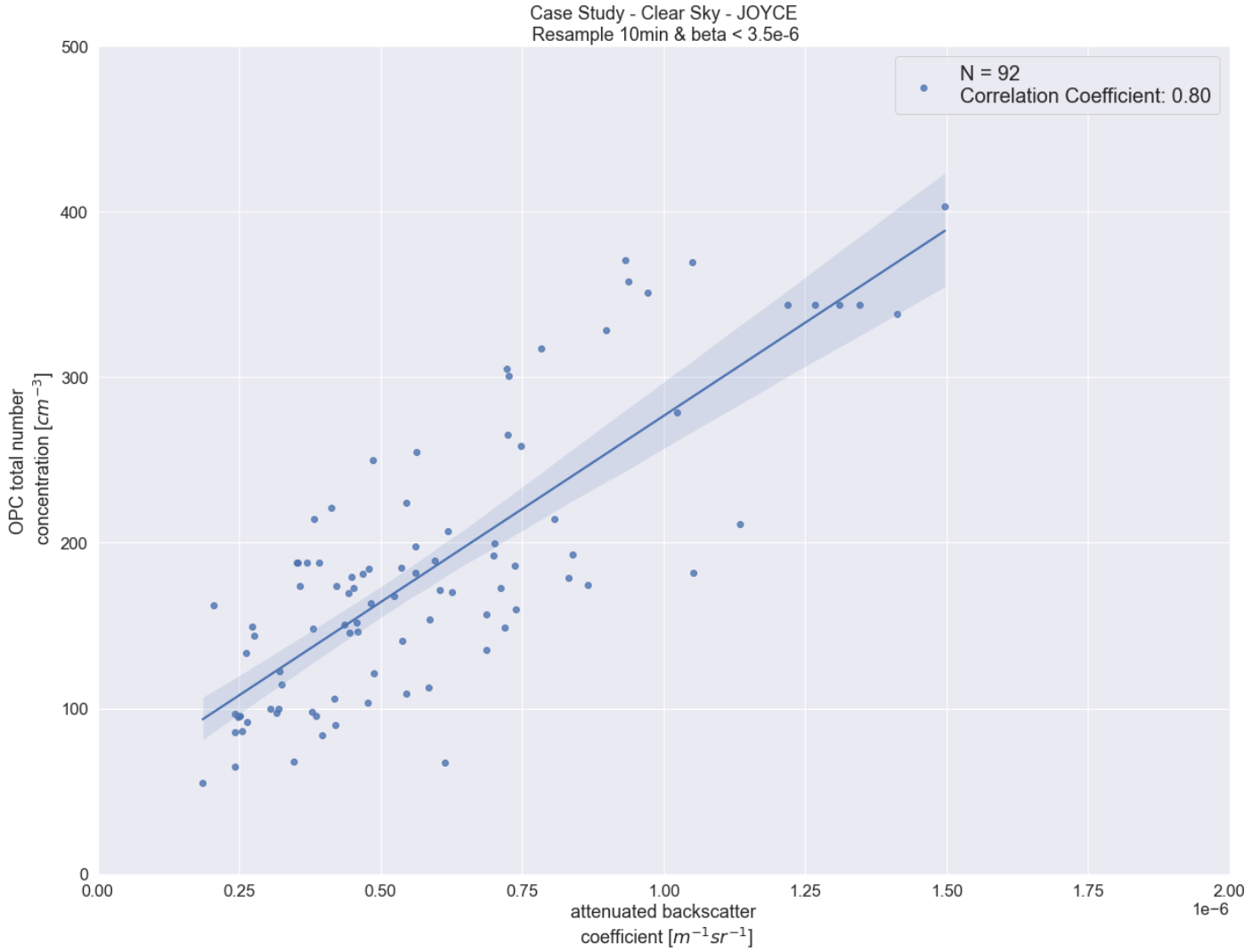
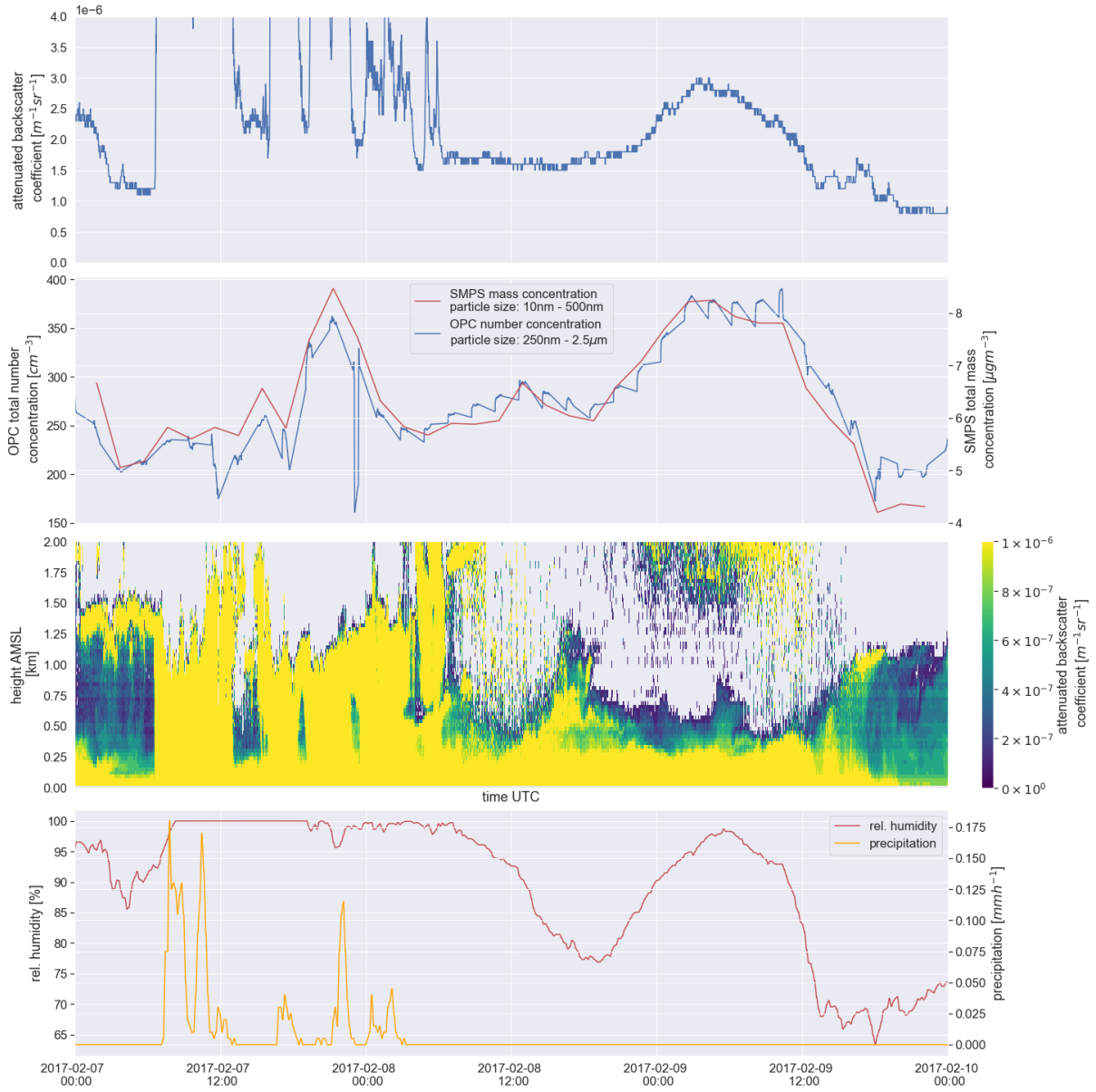
FIRST RESULTS



FIRST RESULTS



FIRST RESULTS



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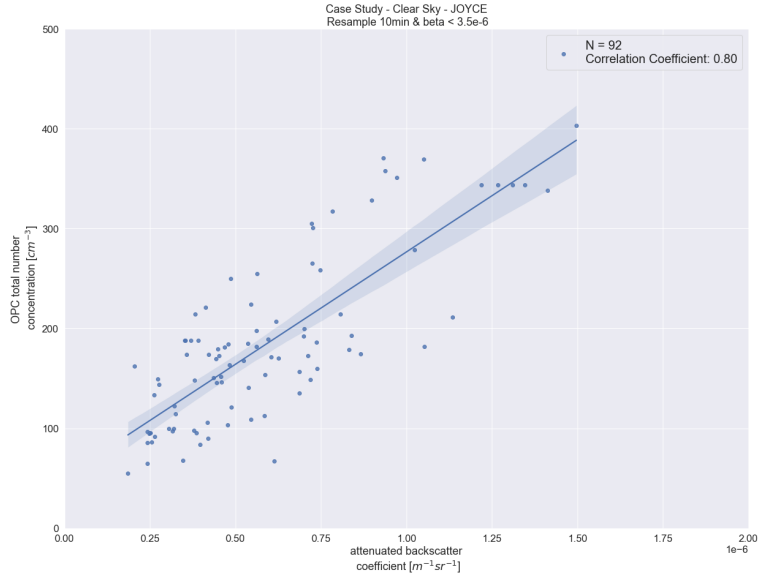
NEXT STEPS

- Aerosol In-Situ Comparison
  - Filter Precipitation
  - Statistical Analysis of 2017
  - Include 50m Height Measurements
- Analysis of Optical Behaviour
  - Compare ATB to In-Situ Nephelometer
  - Compare ATB to Simulated ATB Based on in-situ Measurements

CONCLUSION


Case Study - Clear Sky - JOYCE
Resample 10min & beta < 3.5e-6
N = 92
Correlation Coefficient: 0.80
OPC total number concentration [cm^{-3}]
attenuated backscatter coefficient [$m^{-1}sr^{-1}$]
1e−6