AEROSOL-CLOUD INTERACTIONS AT JOYCE USING ACTRIS DATA

Marcus Müller[1], Ulrich Löhnert[2], Birger Bohn[1]

[1]*Institute for Energy- and Climate Research: Troposphere (IEK-8), Forschungszentrum Jülich GmbH, Germany*

[2]*Institute for Geophysics and Meteorology, University of Cologne, Germany*

contact: *marc.mueller@fz-juelich.de*

Motivation

Today the physical mechanisms of Aerosol-Cloud Interaction (**ACI**) are well known (Twomey, 1977). Nevertheless, the magnitude of ACI and the scales on which it acts in radiative transfer are still reasons of uncertainty in climate models (IPCC, 2022). A method for the calculation of ACI-metrics, using ground-based cloud remote sensing and the backscatter signal of a ceilometer, already exists (Sarna et. al., 2015). A multi-year application and a detailed analysis of this method is still missing. The JOYCE site allows the use of a unique data set of collocated aerosol in-situ and cloud remote sensing observations.

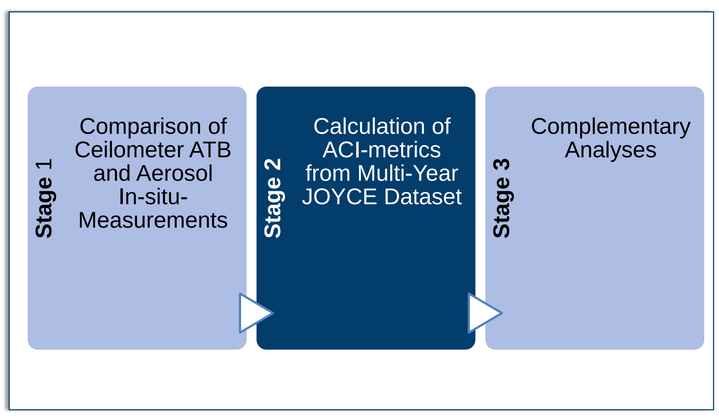
Research Questions

1. Is the attenuated backscatter signal (ATB) of a ceilometer suitable to represent aerosol concentration?
2. Is it possible to confirm and quantify ACI-effects on a long-term JOYCE dataset?

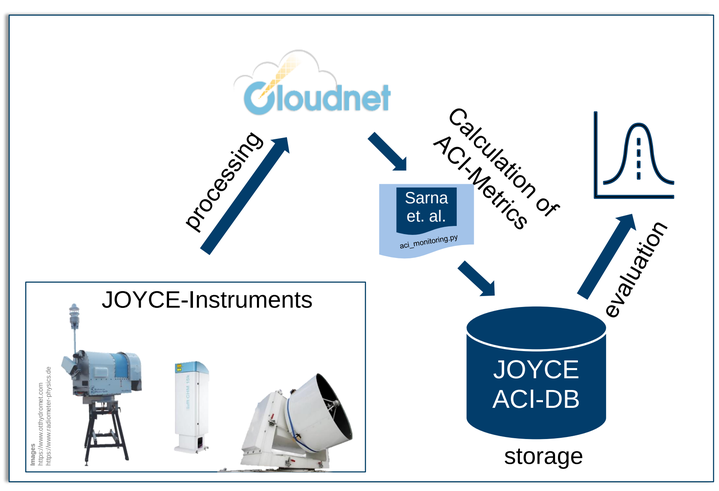
Goals

- Adapt the method (Sarna et. al., 2015) and apply it to long-term JOYCE data.
- Compare the ceilometer attenuated backscatter signal to in-situ aerosol-measurements to verify the applicability of the method.
- Integrate a Planetary Boundary Layer (PBL) classification (Manninen et. al., 2018).
- Set ACI-metrics in context to environmental conditions (temperature, humidity, pressure, weather type classification).

Schedule



Concept



JOYCE

- **J**ülich **O**bservator**Y** for **C**loud **E**volution
- Multi-year tower measurements of aerosol
- Cloud & aerosol remote sensing
  - Ceilometer
  - Cloud Radars
  - Microwave Radiometer
  - Sun Photometer

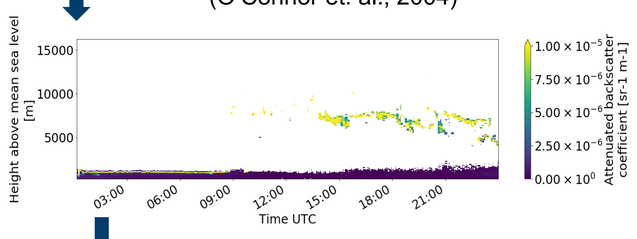
Data Selection

The ACI algorithm (Sarna et. al. 2015) will be applied to data characterized by:

- Low-level liquid water clouds
- Well mixed conditions (Manninen et. al., 2018)
- Cloud base in range 500 m – 2000 m AGL
- Only profiles with liquid cloud droplets and aerosols (based on Cloudnet classification)

ACI Metrics

Calibration is applied to ceilometer signal
(O'Connor et. al., 2004)



vertically integrated attenuated backscatter: **α(t)**

- droplet effective radius: $\boldsymbol{r_e}$
- droplet number concentration: $\boldsymbol{N_d}$
- Liquid Water Path: **LWP**

Calculation of ACI-metrics
Sarna et. al. (2016)

$$ACI_N = \left.\frac{d\ ln(N_d)}{d\ \ln(\alpha)}\right|_{LWP}$$

$$ACI_r = \left.\frac{d\ ln(r_e)}{d\ \ln(\alpha)}\right|_{LWP}$$

$$r_{\alpha,r_e} = \frac{cov(\alpha, r_e)}{s_\alpha s_{r_e}}$$

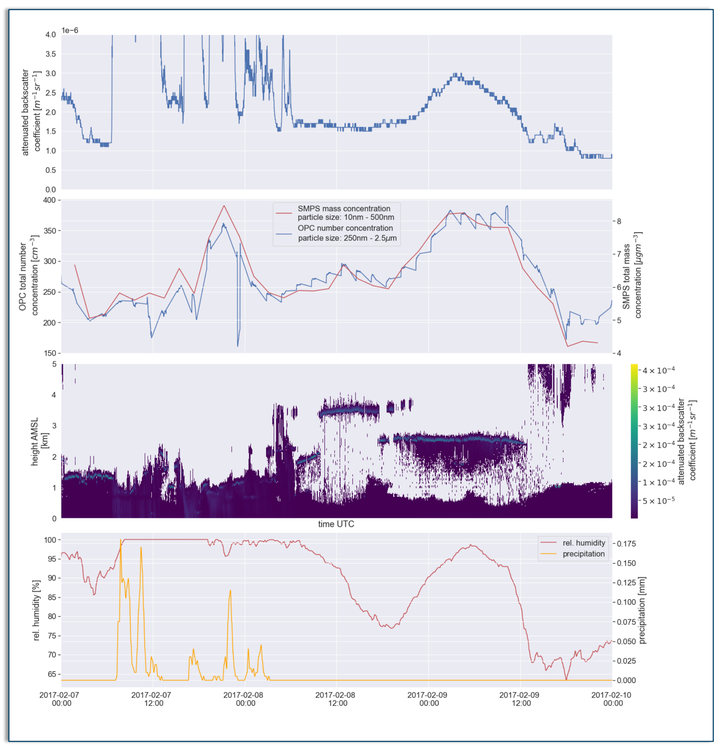
In-situ Observation

Aerosol Number Concentration from Optical Particle Counter[1]	Transmittance from Nephelometer[1]
Aerosol Size Distribution from Scanning Mobility Particle Sizer[2]	CCN-Concentration from Cloud Condensation Nuclei Counter[2]

[1]data by Andreas Petzold and coworkers
[2]data by Caiquin Yan, Defeng Zhao, Jian Xu, and Thomas F. Mentel

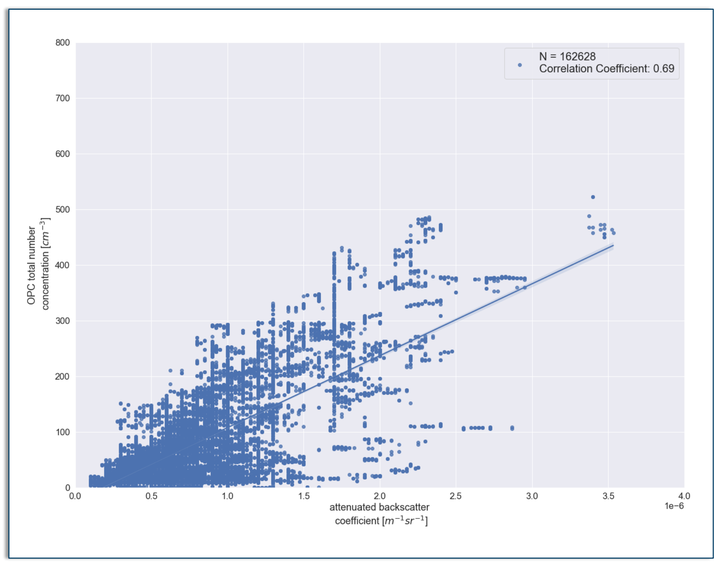
Case Study

Comparison of aerosol in-situ and remote sensing measurements in the period 2017-02-07 to 2017-02-10 at JOYCE (120 m AGL)



OPC Comparison

Comparison of aerosol in-situ (total number concentration) and remote sensing (ATB) measurements in the year 2017 at JOYCE (120 m AGL). Only data, where the rolling STD is smaller $8 \cdot 10^{-8} m^{-1} sr^{-1}$, are shown.



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