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AOD Retrievals using Sentinel-3's SLSTR and OLCI Instruments

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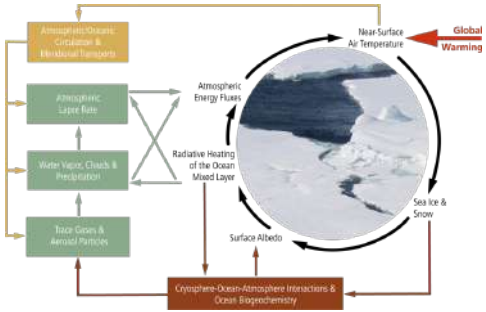
Institute of Environmental Physics, University of Bremen

About me and context

- Cloud Aerosol Surface PArameter Retrieval (CASPAR) group of Marco Vountas
- Institute of Environmental Physics (IUP) — University Bremen, AG Bösch
- Currently pursuing PhD within the DFG funded $(AC)^3$ Project
- Aerosol remote sensing over bright surfaces



Interconnections of the Arctic climate system investigated by $(AC)^3$ (adapted from Wendisch et al. 2023)

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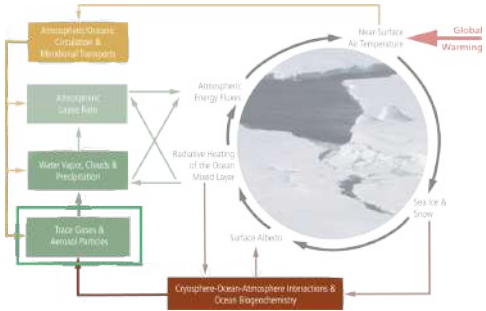

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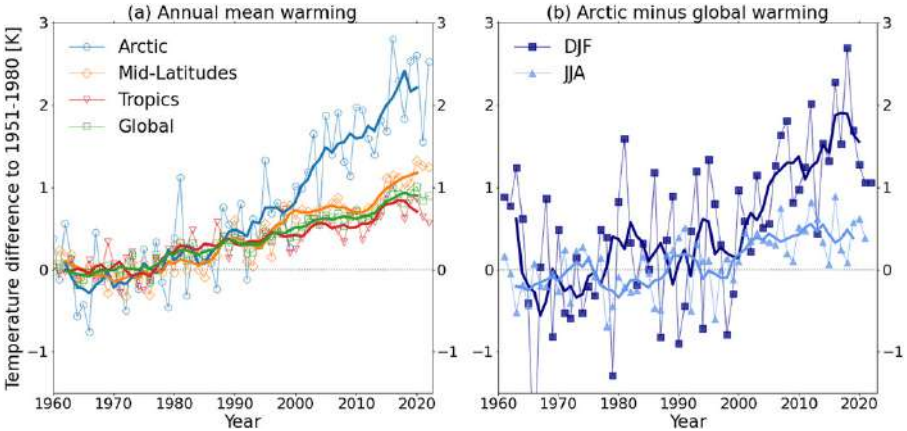
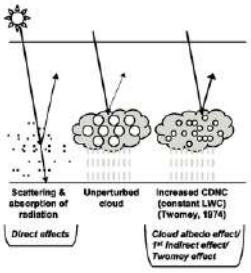


Annual mean warming showing the Arctic amplification phenomena
Wendisch et al. 2023

- Arctic clean atmosphere (low direct effect on radiative forcing)

Aerosol Cloud Interaction
(IPCC AR4, modified from Haywood and Boucher, 2000)

- Arctic clean atmosphere (low direct effect on radiative forcing)
- Event driven high aerosol load



Aerosol Cloud Interaction
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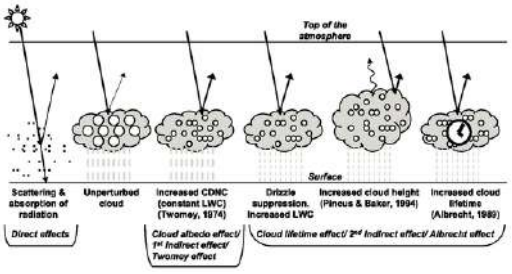
- Event driven high aerosol load
- Complex, badly constrained interaction of aerosol clouds
  Aerosol Cloud Interaction (ACI)



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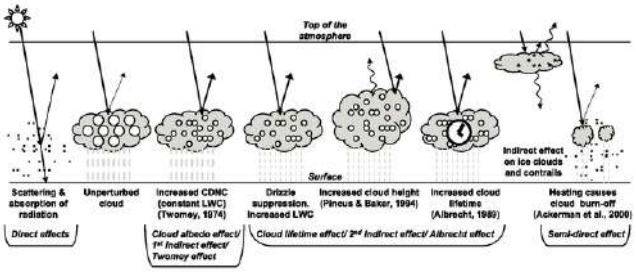


Aerosol Cloud Interaction
(IPCC AR4, modified from Haywood and Boucher, 2000)

What is Aerosol Optical Depth?

Aerosol Optical Depth

Vertical integrated optical thickness of the atmosphere due to aerosol scattering and absorption.

$$\tau(\lambda) = \int_0^{TOA} e(z, \lambda) dz$$

Good indicator for aerosol load

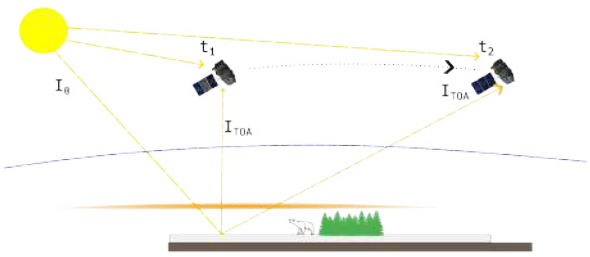
- dark surfaces $\rightarrow$ Aerosol brightens scene
- bright surfaces $\rightarrow$ Aerosol darkens scene
- Arctic $\rightarrow$ bright and low background AOD

(a) Area without a plume (2025–07–08)

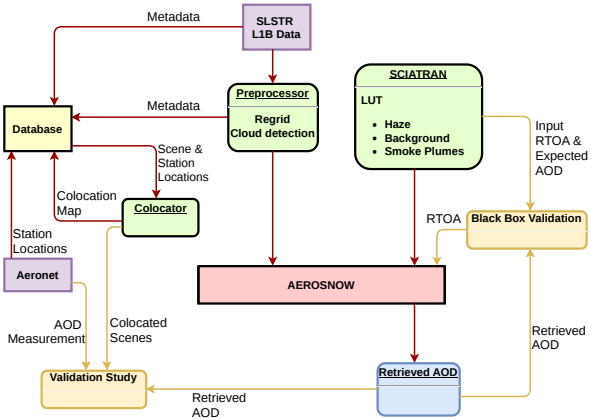
(b) Area with aerosol plume (2025–06–29)

Influence on RTOA of aerosols over Water, Land and Snow
(NASA Worldview Snapshots)

- Adapted to bright surfaces (Arctic / Antarctica)
- Dual View to use BRDF of snow
- 500 m AOD Product
- Validated for AATSR (Swain et al. 2024)
- Approach:
  - Fixed AOD, Surface and SZA per scene
  - Differences in lightpath and viewing geometry
  - Fit measured $RTOA_{meas}$ to $RTOA_{sim}$



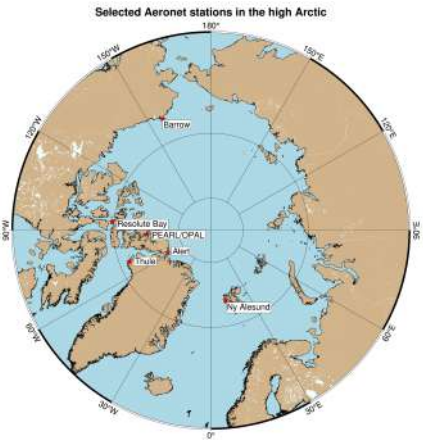
Schematic measurement scheme of AEROSNOW for SLSTR



Dataflow Aerosnow and validation tests

Plan of Comparison, Test and Validation

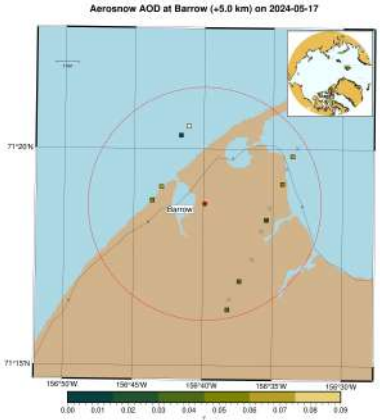
1. SW level unit tests
2. Closed loop tests w/ SCIATRAN
3. Colocation with Aeronet stations
4. Model comparison study with ICON for biomass burning events



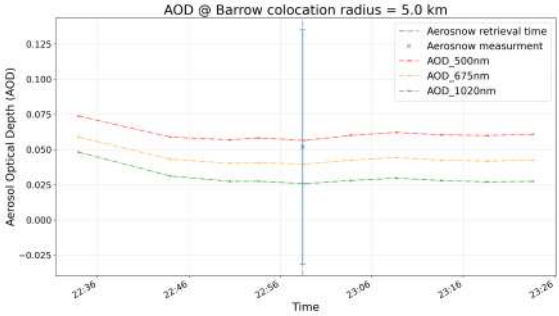
Aeronet (Holben et al. 1998) stations in the Arctic

- AOD sun photometer
- Direct measurement
- Worldwide
- Gap in the Arctic Ocean and no active station in Russia

First validation results



(a) Aerosnow validation data selection



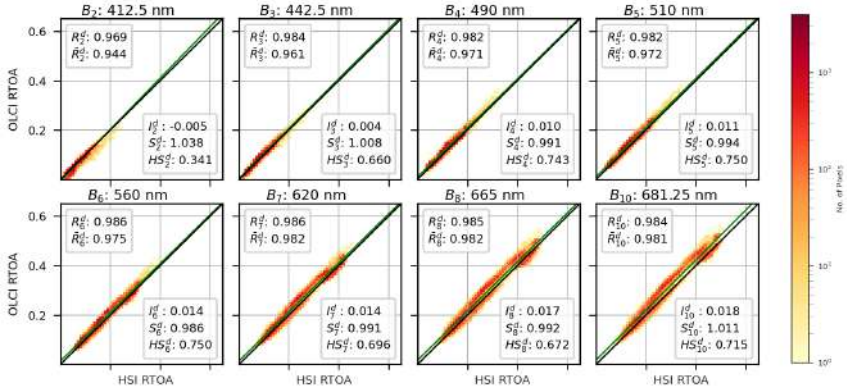
(b) Retrieved AOD

First successful colocation of Sentinel-3A and Barrow AERONET Station

The XBAER Algorithm

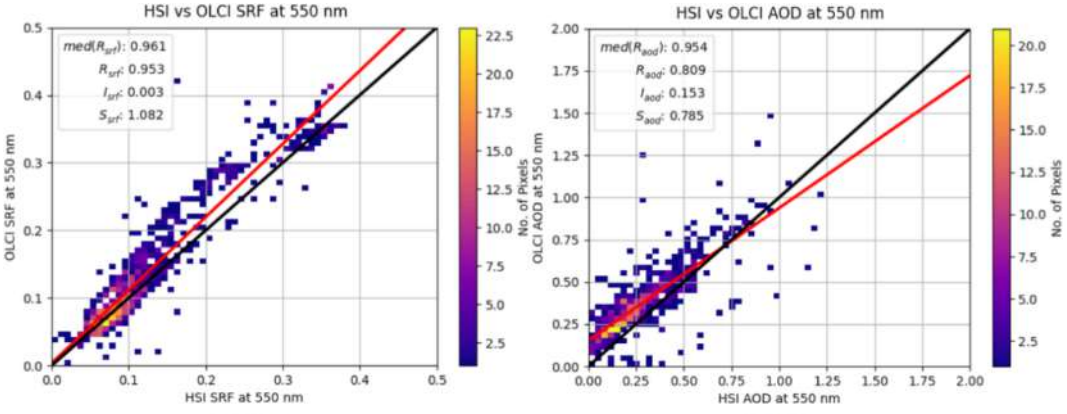
- Work by Simon Laffoy
- eXtensible Bremen AErosol Retrieval (XBAER)
  Retrieves SRF and AOD
  Dark and moderatly bright surfaces
- Developed for MERIS and adapted to OLCI (10km resolution) Mei et al. 2018
  Applied to EnMAP HSI (30m resolution) Laffoy et al. 2026
- Preperation work to be applied to CHIME's HSI
- Comparison of colocated OLCI and EnMap pixels

RTOA Comparison



Comparison of RTOA between HSI (EnMAP) and OLCI Laffoy et al. 2026, Fig. 2

The XBAER Algorithm

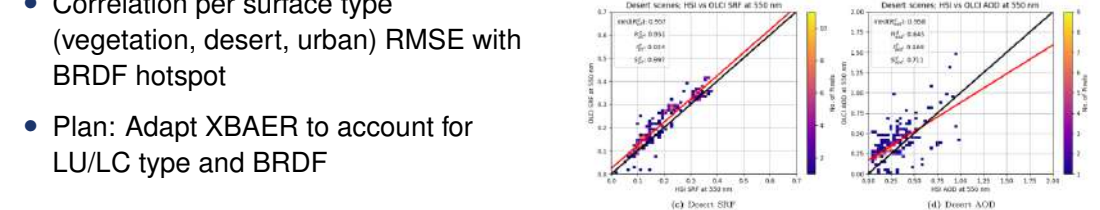


(a) SRF (b) AOD

Comparison of OLCI and EnMAP HSI retrieved SRF and AOD using XBAER for all surface types Laffoy et al. 2026, Fig.6

The XBAER Algorithm

- Correlation per surface type (vegetation, desert, urban) RMSE with BRDF hotspot
- Plan: Adapt XBAER to account for LU/LC type and BRDF



Correlation between EnMAP and OLCI per surface type SRF and AOD Laffoy et al. 2026, Fig.7

Summary

Andrae (SLSTR)

- Promissing first results of validation
- Allows AOD time series staring from 2011–now
- Extendable with ATRS-2 to cover 1995–2011
- Sensitivity study and validation in progress

Laffoy (OLCI / EnMAP)

- Good match of RTOA between instruments
- Good and SRF and AOD results compared with EnMAP

Read the paper

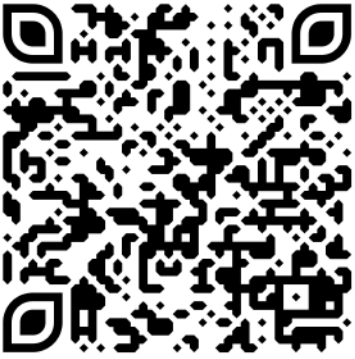
Wishlist

- Colocated oblique and nadir as single L1 product
  Reference implementation for colocating bands
- L1B product hard to introduce to people without a CS background
- Scientific/algorithm development user guide

Colocation Validation

- Colocation of an EnMAP scene (on demand) with tandem would be highly apprechiated
  (probably interessting for CHIME)
- Colocation with 3MI

Questions



Reach out to me

Reach out to Simon

References I

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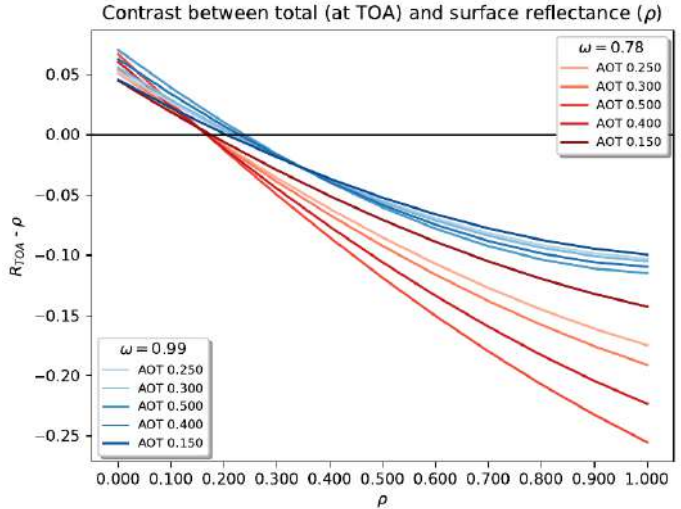

$R_{TOA} - \rho$ for different AOD and wavelength
(adapted from Fraser and Kaufman, 1985)