The impact of changes in aerosol loading and surface spectral reflectance observed from space and feedback on Arctic amplification

B02

John P. Burrows, Marco Vountas,
Linlu Mei, Soheila Jafariserajehlou, Luca Lelli

1. Summary

We build on **the heritage of the B02 phase I**, and the goals of phase 2 are:

- to quantify and analyse the change in **Aerosol Optical Thickness (AOT)** and **Surface Spectral Reflectance (SSR),** during the evolving Arctic Amplification, AA;
- to **assess** the relative importance of **local sources** & **transport** of aerosol.

The **key scientific questions** to be addressed in phase 2 are:

Q1: What are the changes in the AOT and SSR observed from space over the past decades? **Quantifying change!**

Q2: Are these changes attributable to natural or anthropogenic origins, i.e. are predicted changes in agreement with the identified changes? **Consequence of change!**

2. Achievements in phase I

Method development for AOT and SSR (12 per-reviewed papers)

Objective: the improvement of the accuracy of AOT/SSR in the Arctic from the observation of reflectance (methods).

Approach: we use a **strategy** , separating three SSR ranges, we have optimised and developed the AOT and SSR retrieval algorithms for:

i) Dark surfaces; ii) Moderately bright surfaces; iii) Bright surfaces.

We use i) the synergetic information from the top of the atmosphere reflectance, in the visible, SWIR and TIR and ii) improved SSR parametrisations to separate better AOT and SSR , and thereby improve quantify cloud free AOT and SSR for moderately bright and bright surfaces.

Analysis of AOT(0.55µm) and SSR:dark and moderately bright surfaces

- **Development** and improvement of Retrieval: eXtensible Bremen Aerosol Retrieval (**XBAER**) (SSR < 0.4) for MERIS/OLCI → used for land and ocean.
- AVHRR AOT retrievals over Arctic ocean have been used. Post-processing to remove potential cloud/ice contamination;
- Creation and analyses of **AOT long term record** over Arctic open waters. Mainly positive regional trends observed:

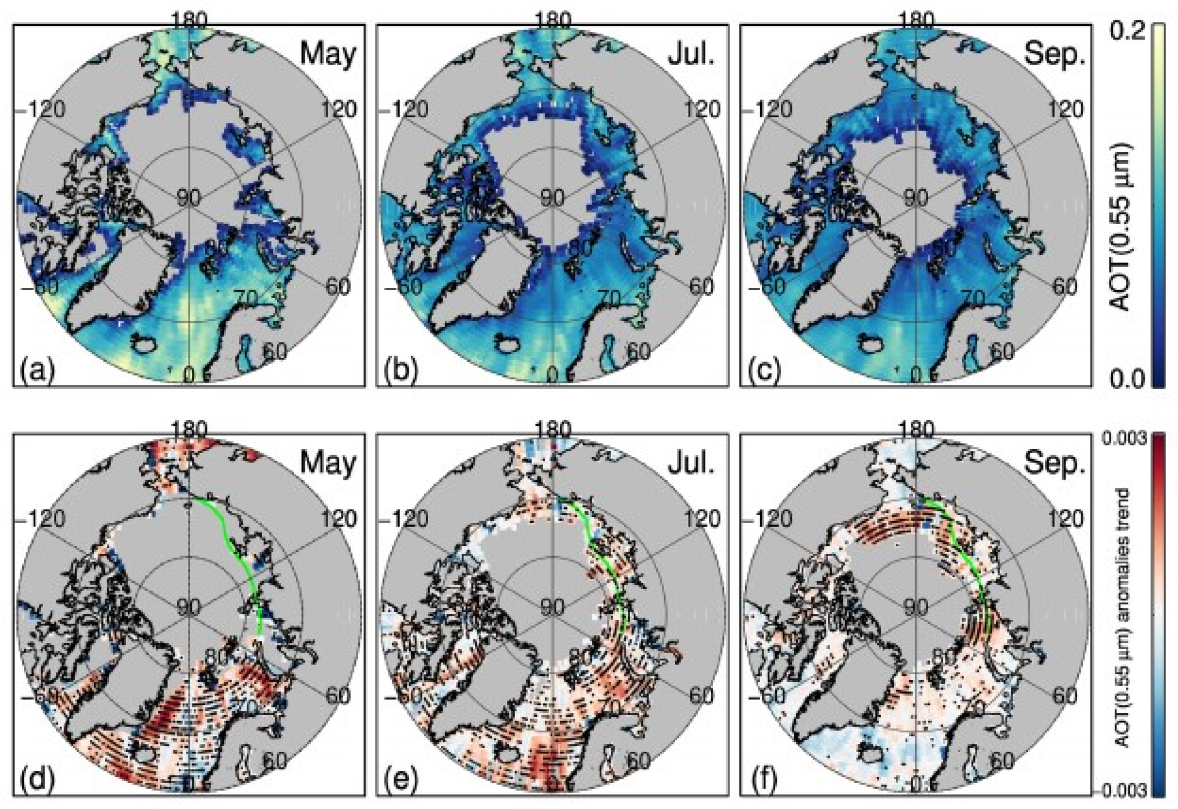


Fig. 1: (upper) Monthly averages of AOT for May, July and Sept. (lower) corresponding anomalies at 95% confidence limit. Green line shows the northeast passage.

Analysis of AOT and SSR: bright surfaces

1. **Development** for use in phase 2, new AOT/SSR retrievals for bright snow and ice scenes (see publications and additionally two new papers are now in review, Mei et al 2019)
2. **Building** on our previous studies (Istomina et al 2011), we further improved **AeroSnow** by optimizing cloud identification (Jafariserajehlou et al., 2019) and by developing improved BRDF (paper in prep., Jafariserajehlou et al 2019/2020).
3. **Validation** of improved AeroSnow using AOT from 10 AERONET sites across the Arctic for 10 years of observations from space.

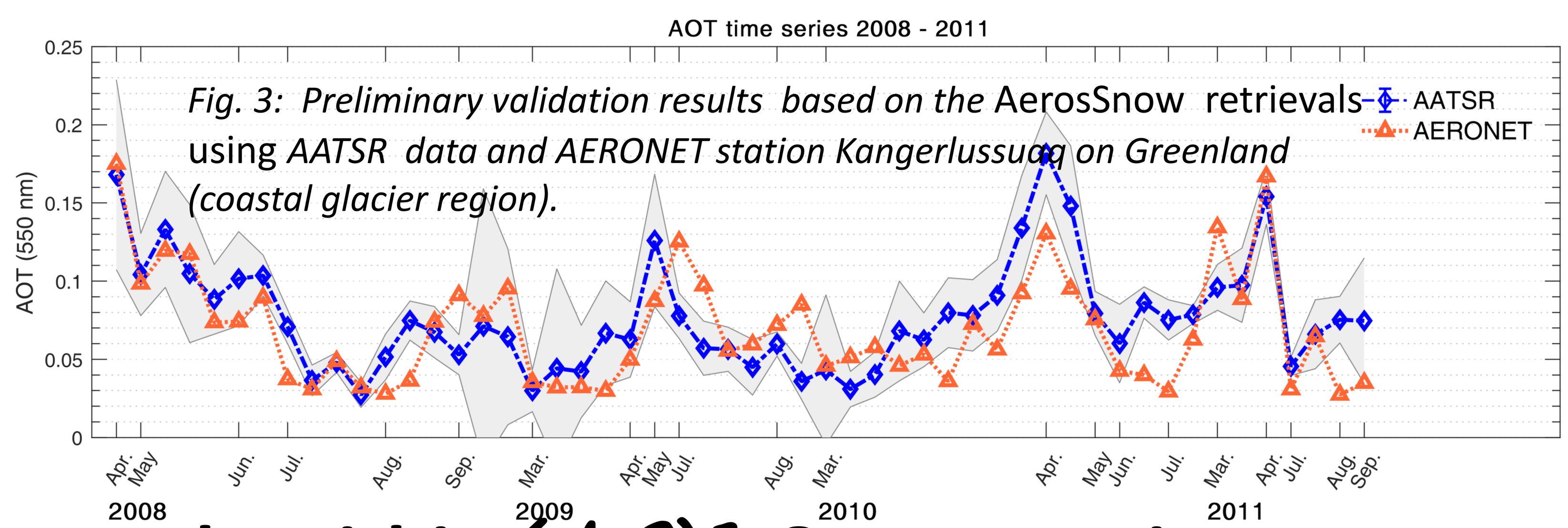
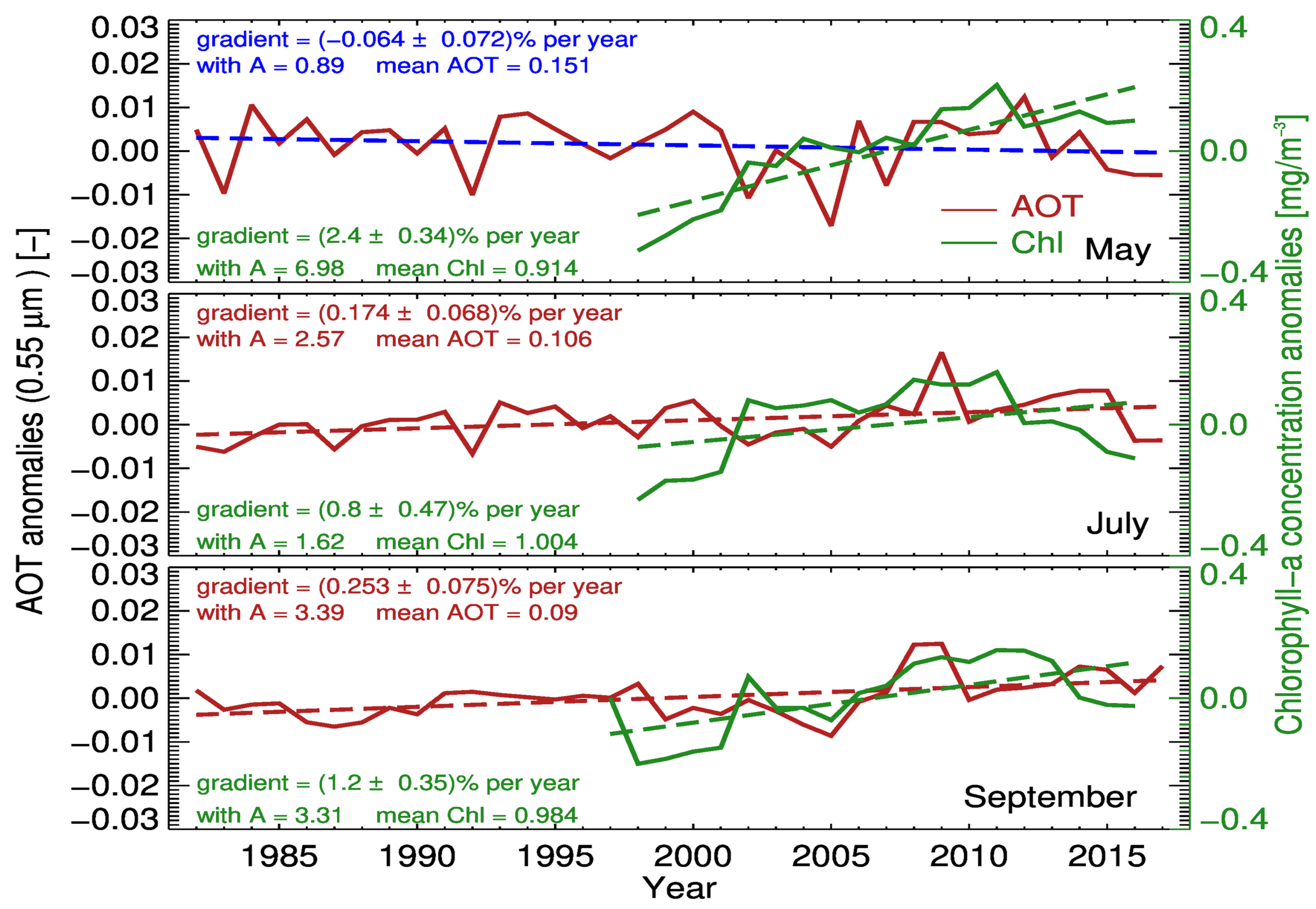


Fig. 3: Preliminary validation results based on the AerosSnow retrievals using AATSR data and AERONET station Kangerlussuaq on Greenland (coastal glacier region).

Hypothesis

Changes in top of the atmosphere reflectance, measured by satellite instruments, yield the changes in aerosol and surface spectral reflectance in the Arctic.

Fig. 2: Monthly spatial averages of AOT(0.55µm) anomalies, AOTa, and Chlorophyll a concentration anomalies for May, July and September and their trends, where the significance parameter A = (d(AOTa)/dt)/ (σ(d(AOTa)/dt), and σ is the standard deviation of d(AOTa)/dt.



3. Research plan phase II

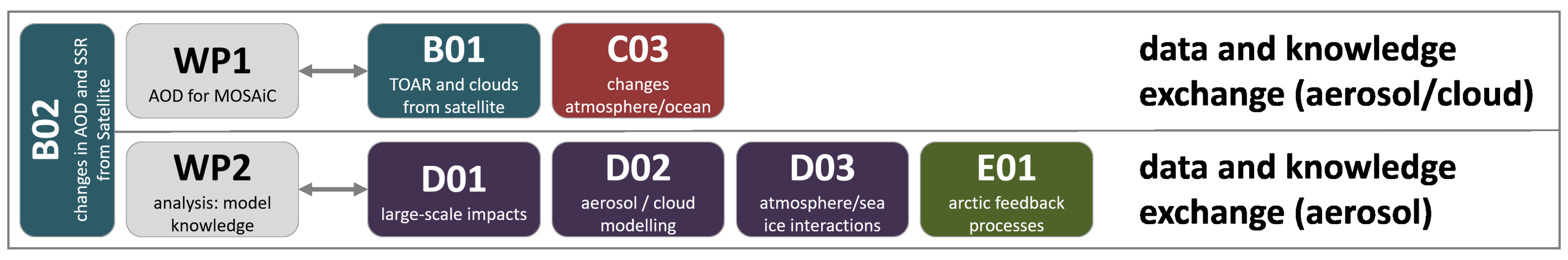
- Contribute to **MOSAiC** using high spatial resolution SLSTR data.
- Extend, consolidate and **harmonize** the **AOT** and **SSR** datasets;
- Analyse statistically the temporal and spatial pattern for AOT and SSR, **compare** with and **evaluate** model **AOT** and **SSR**.

Project Plan

- **WP1: AOT** and **SSR** will be retrieved during **MOSAiC** around the RV Polarstern, using Level 1 data from SLSTR on Sentinel 3. Comparisons with and interpretation of AOT and SSR measurements on Polarstern are planned.
- **WP2: Creation** and **analysis** of long-term **AOT** and **SSR** datasets. Extension of the record over land + temporal extension.
- **WP3: Assessment** of **Trends** in **AOT** and **SSR** using results from **AeroSnow, XBAER, AVHRR/L2** and results from new retrieval algorithms developed in B01 Phase 1.
- **WP4: Collaboration** with modelling groups to **assess trends** in cloud free **AOT** and **SSR** and explain origins, impact and any impact on radiative forcing and feedback.

Year	2020				2021				2022				2023			
Quarter	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
WP1 AOT for MOSAiC																
WP2 Long-term AOT																
WP3 Trend Assessment																
WP4 Collab./Model																

4. Role within (AC)³ & perspectives



Collaborations within (AC)³

Within WP4 collaboration with

a) cluster D and E is envisaged (D02, modelling marine org. aerosol/impact on clouds and E01, Arctic lapse rate feedback)

b) Cluster B an C most importantly B01 and C03, who respectively provide long term data on cloud and use aerosol knowledge.

Perspectives

- The **extension** of the data bases of **AOT** and SSR and their **interpretation** in the **evolving Anthropocene**.
- **Enhance** and intensify the **collaborative research** with model cluster to establish the origins and projections of change.
- **Investigate** of the retrieval of AOT during polar night using passive remotes sensing TIR brightness observations

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(AC)³ ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms

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