Interactions of snow on sea ice with atmospheric constituents including black carbon

C02

Rüdiger Gerdes, André Ehrlich, Andreas Herber

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1 Summary

Black carbon (BC) in the Arctic

- Second most important **anthropogenic emission** (+0.2–2.1 Wm²)
- Interaction within **atmosphere** and **snow surface**
- Increase of **shipping** in the Arctic expected
- Limitations of current BC characterization
  - **Low spatial coverage** → transport path uncertain
  - Satellite retrieval uncertain → surface reflectivity

Hypothesis

BC–containing aerosol particles lead to a surface warming when locally produced/emitted constituents reside at low altitudes and are partly deposited onto snow. Contrarily, long–range transport of BC, remaining in higher atmosphere layers cool the surface.

2 Research rationale

Combine airborne and ground-based observations

- BC and surface properties in **remote Arctic** areas
- Ground-based (Station Nord)
  → **temporal variability**
- Airborne (Polar 5, PAMARCMIP)
  → **spatial variability**

➡ Identical set of instruments

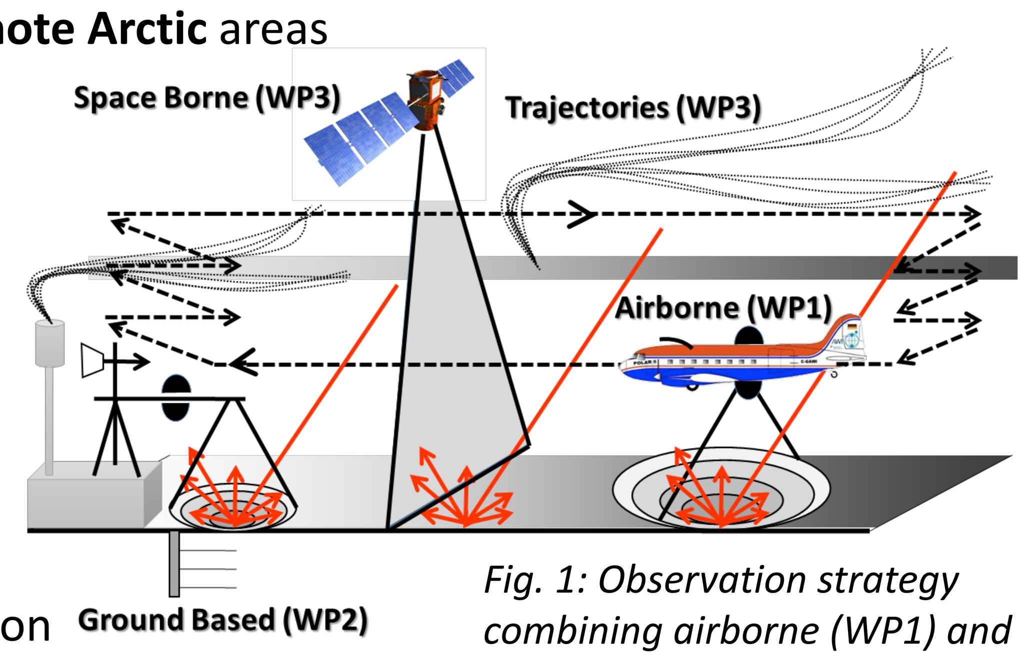


Fig. 1: Observation strategy combining airborne (WP1) and ground–based (WP2) measurements.

Key instrumentation

In Situ
- **SP2, UHSAS, CO, CO2**
  - BC and trace gas concentration
  - In situ snow sampling
- **Villum Research Station** (PSAP, MAAP, Ceilometer)
- **Sun Photometer**

Remote Sensing
- **Eagle/Hawk imaging spectrometer:** - 0.3-2.2 µm, <10 m spatial resolution - Providing maps of BC in snow
- **SMART/CORAS Albedometer:** - 0.3-2.2 µm snow albedo, - Retrieval of BC and snow properties
- **CANON Fish-Eye:** - 180° FOV high resolution - Surface roughness and BRDF
- **AMALi:** - Airborne lidar, vertical profiles of aerosol

Tools: Satellite data, backward trajectories , radiative transfer models

Airborne Data (WP1)		Link	Ground Based Data (WP2)	
Atmospheric BC	In situ	Deposition	Atmospheric BC	In situ
BC in snow	Retrieval	Validation	BC in snow	In situ
Surface albedo	In situ		Surface albedo	In situ
Surface BRDF	In situ		Surface BRDF	In situ
Grain size	Retrieval	Validation	Grain size profile	In situ
Surface roughness	Retrieval	Validation	Surface roughness	In situ
Meteorology	In situ		Meteorology	In situ

Synthesis (WP3)	
Backward trajectories	Model
Surface albedo (Satellite)	Retrieval

Fig. 2: Synthesis and links between individual observations as proposed in WP3.

3 Research plan

Scientific objectives

- Quantify the **horizontal** and **vertical distribution** of BC in atmosphere and snow
- Characterize transport **pathways** and **deposition** of BC in remote Arctic areas
- Quantify the **reduction of snow albedo** by BC in different spatial/temporal scales
- Investigate radiative **forcing** and acceleration of **snow metamorphism** due to BC

WP1: Airborne measurements

Spatial variability
- Atmospheric BC and trace gases
- Remote sensing of snow albedo, BRDF and retrieval of BC

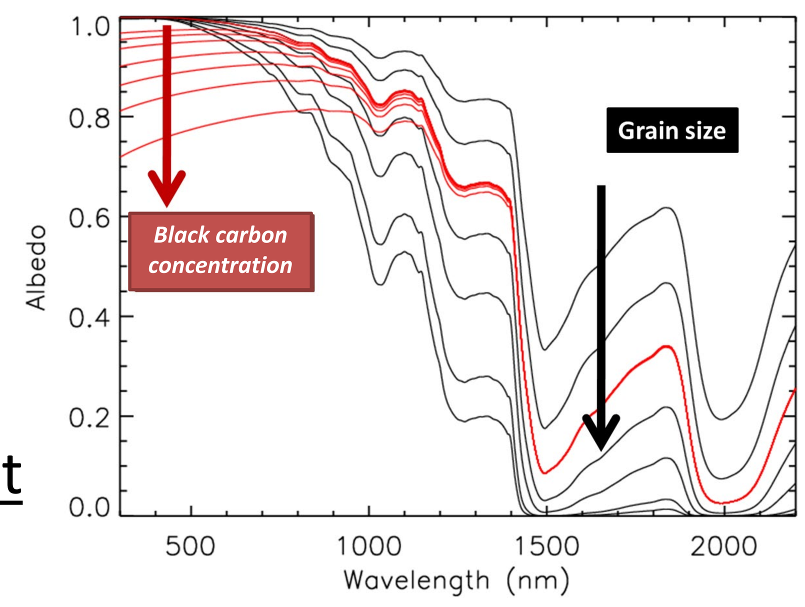


Fig. 3: Spectral snow albedo in dependence of sooth concentration and grain size.

WP2: Ground–based measurement

Temporal variability
- Atmospheric BC and BC in snow
- Snow albedo and BRDF
- Surface radiation budget

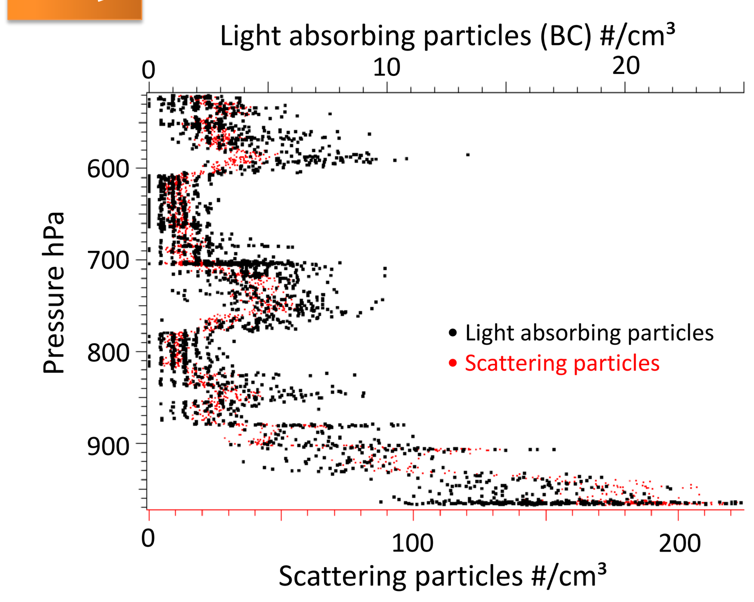


Fig. 4: Example of BC particle profile derived from aircraft.

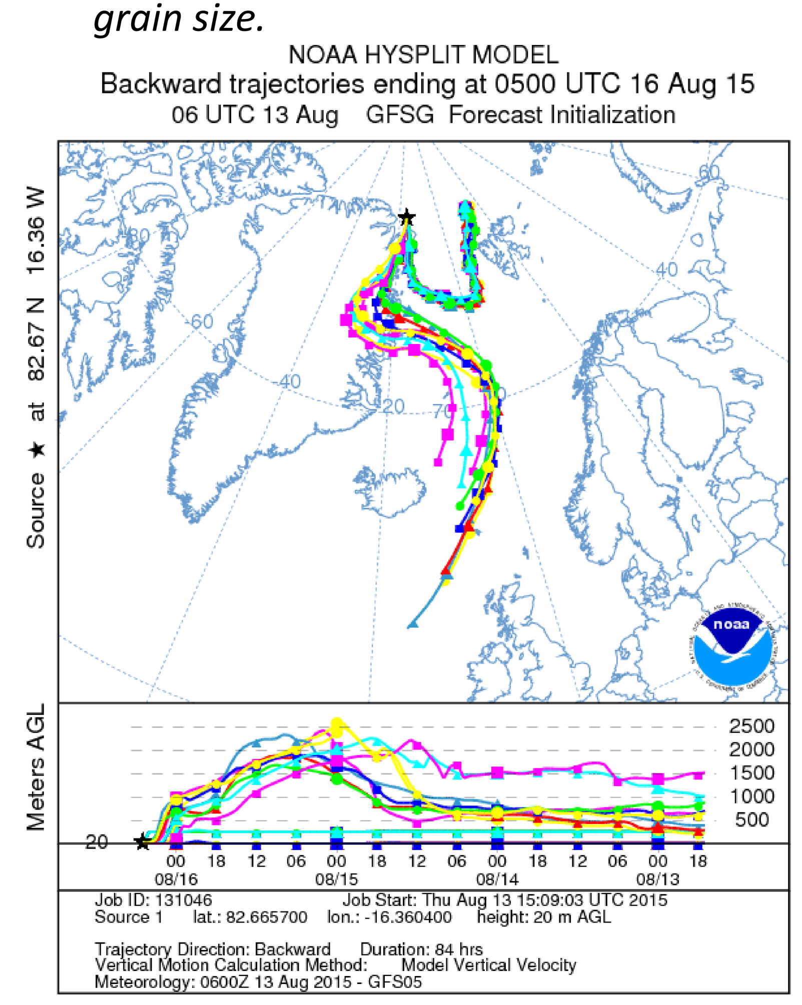
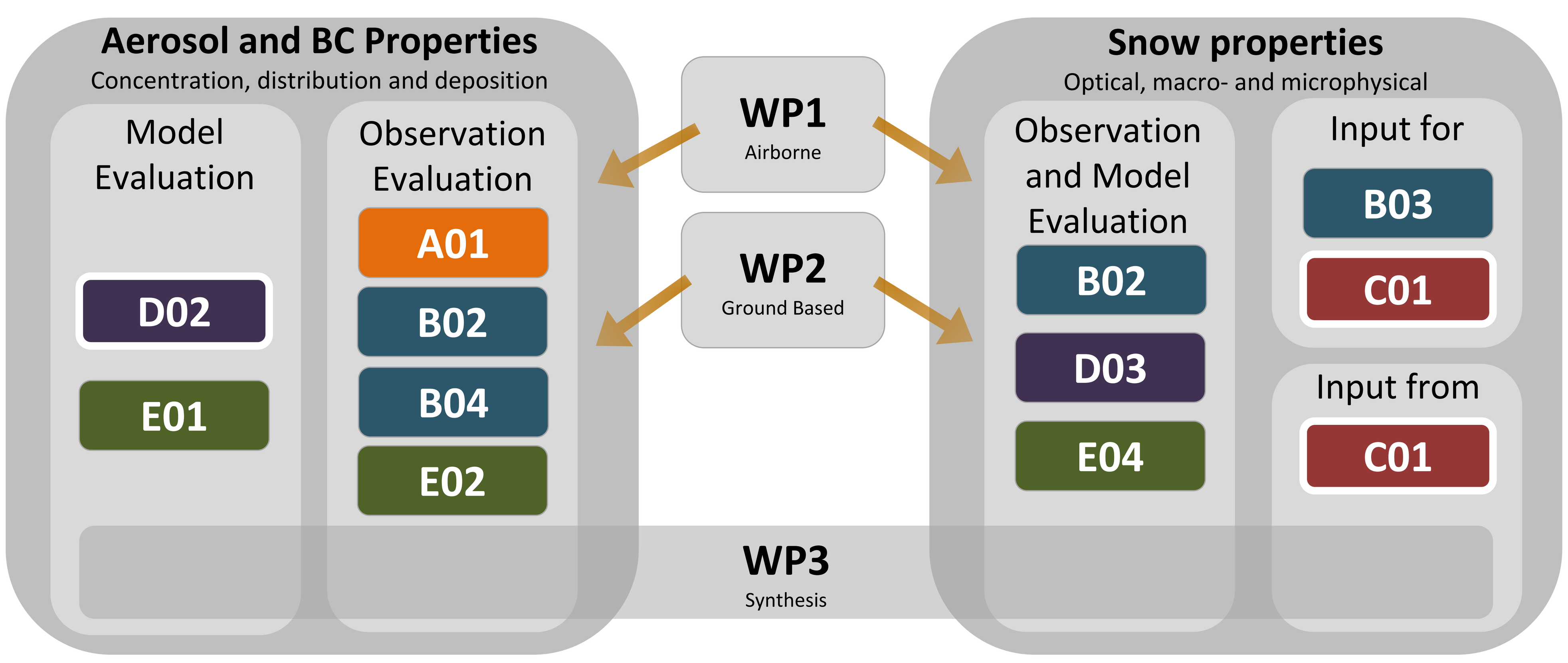


Fig. 5: Example of back trajectory transporting air masses into the suggested observation area.

WP3: Synthesis

- Validation of retrieval for BC in snow
- Horizontal transport and deposition
- Back trajectory analysis
- BC radiative forcing

4 Role within (AC)³ & perspectives



Collaboration within (AC)³

- Airborne albedo measurements jointly processed with **C01**
- Evaluate **satellite products** of aerosol, snow and ice (B02, C01, D03)
- Input for radiative transfer or numerical modelling (B02, B03, E04)
- Evaluate **aerosol transport** in **D02**
- Evaluated snow albedo **feedback mechanisms** in E01

Perspectives

- **PAMARCMIP** will be continued in the next decade
- Target the most relevant BC transport paths
- German research aircraft **HALO:**
  - **Higher altitudes** and **larger area**
  - Extended instrumentation, **wet deposition**
- Connecting airborne and ground–based measurements - **MOSAiC**

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