Airborne and in situ ground-based measurements of surface albedo, bidirectional reflectivity BRDF and snow properties on the Antarctic plateau

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1. Motivation and Objectives

**MEASUREMENTS**

- **Broadband and spectral radiation**
  - Irradiance (I), Radiance
  - Atmospheric properties: temperature, humidity, wind, clouds, precipitation, aerosol content

- **Snow radiative properties**
  - surface albedo, BRDF

**RETRIEVAL**

- Microphysical and macroscopic snow properties
  - specific surface area SSA (snow grain size)
  - surface roughness

**Ground-based temporal variability**

**Airborne measurements**

- of the spatial variability of surface albedo, BRDF, SSA and surface roughness
- of the temporal variability of surface albedo, BRDF and SSA to improve prognostic snow models.

2. Campaign ANT-Land 2013/2014 – Kohnen Station

**Kohnen - site conditions**

75° 00' S, 00° 04' E, 2892 m a.s.l.

- Dry, nearly pollutant-free snow
- Calm clear-sky periods
- Episodes with precipitation and wind-induced horizontal transport of snow

**Drifting Maud Land**

- Airborne spatial variability
- Pronounced roughness structures like sastrugi [higher wind speeds]
- Changing type and amount of precipitation

**Scientific work**

2013/12/10 – 2014/01/31: Observations and measurements

**Research flights with Polaris**

16 flights, 60 flight hours

3. Instrumentation

**Figure 3:** Overview of the instrumentation during ANT-Land 2013/2014 on Polaris 6 research aircraft (left) and Kohnen station (right)

**Broadband radiation sensors**

- Pyranometer Kipp & Zonen CM22
  - Measured quantity: Irradiance (I), Wm⁻²
  - Response time: 5s
  - Wavelength range: 305nm - 2.1µm
  - Active range: 3λ, accuracy: 0.2% for 3λ: 2-3nm (0.3-2.1µm) and 0.3% for 0.2λ: 3.6µm

- Corras (Compact Radiation Measurement System)
  - Measured quantity: Spectral irradiance (I(λ)), Wm⁻²sr⁻¹
  - Temporal resolution: 1s
  - Waveband range: 1.2 - 3.6µm
  - Spectral resolution: Full width at half maximum: 2.1-6nm
  - Mount: Kohnen station, radiation rack

**Ground-Based**

- Pyranometer Kipp & Zonen CM02
  - Measured quantity: Irradiance (I), Wm⁻²
  - Response time: 30s
  - Wavelength: 305nm - 2.1µm

- Pyrgeometer Kipp & Zonen GS18
  - Measured quantity: Radiance (T), Wm⁻²sr⁻¹

**Figure 4:** Basic meteorological data
during campaign: temperature (top left), relative humidity w.t.w. (top right) and wind speed (bottom)

**Figure 5:** Illustration of research flights with Polaris, by Daniel Steinhage (AWI)

**Figure 6:** Campaign ANT-Land 2013/2014 on Polar 6 research aircraft (left) and Kohnen station (right)

**Figure 7:** BRDF camera

**Figure 8:** Radiation rack with CORAS and broadband radiation sensors (left), automatic weather station (centre) and BRDF camera (right)

**Instrument status during campaign**

<table>
<thead>
<tr>
<th>Date</th>
<th>Comments</th>
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<tbody>
<tr>
<td>2013/12/24</td>
<td>Radiation squares</td>
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<tr>
<td>2013/12/23</td>
<td>Grid Kohnen</td>
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<tr>
<td>2013/12/27</td>
<td>Triangle Northeast</td>
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<tr>
<td>2013/12/28</td>
<td>Diurnal variations [5 flights]</td>
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<td>Ice divide</td>
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<td>2013/12/30</td>
<td>Jutulstraumen glacier</td>
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<td>2014/01/04</td>
<td>Kohnen-Halley-Kohnen</td>
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<tr>
<td>2014/01/05</td>
<td>North-South lines West</td>
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4. Diurnal cycle of broadband radiation and snow shortwave albedo

**Figure 9:** Temporal variability of broadband and airborne instruments during observation period (2013/12/10-2014/01/31)

- **Ground-based**
  - Principal: Temporal variability

**First interpretation**

- **Clear-sky irradiance**
  - Measurements show almost undisturbed diurnal cycle, during night only shortly modified by CMW

- **Cloud and sky**
  - Cloud event also visible in albedo time series
  - Influence of clouds: depend on cloud optical thickness and cloud cover (2013/12/22)
    - Isolated Cirrus may increase downward shortwave irradiance through increased scattering
    - Thicker clouds decrease downward shortwave irradiance through higher absorption and increase downward longwave irradiance due to cloud temperature
  - Increased snow albedo: a larger solar zenith angle in combination to theoretical behaviour of plane snow surface, may be due to shadow analysis, increased snow roughness

**Figure 10:** Top row: Shortwave irradiance on 2013/12/17 (left) and 2013/12/22 (right) with single images of respective cloud shadow, Middle row: Longwave irradiance on 2013/12/17 (left) and 2013/12/22 (right), Bottom row: Corresponding shortwave albedo on 2013/12/17 (left) and 2013/12/22 (right)

5. Outlook

I. Retrieval of snow properties from remote sensing (SSA, surface roughness)

II. Comparison with in situ measurements of snow properties

III. Simulation and validation of temporal variability of snow optical properties by prognostic snow models (SCIATRAN, SNICAR, Crocos)