Tethered balloon-borne energy budget measurements in the cloudy central Arctic

A02

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1 Summary

Main goal:
Quantifying vertical profiles of energy fluxes in the cloudy ABL for different stratification and cloud types in the central Arctic

Core of project:
Tethered balloon-borne observations from an ice floe during ABEX (Arctic Balloon-borne profiling EXperiment) in close coordination with PASCAL
(summer 2017). Similar measurements are planned for MOSAiC (2019-2020).

Hypothesis

Cloud macrophysical and microphysical properties influence the profiles of turbulent and radiative energy fluxes, and, therefore the net warming/cooling at the surface.

2 Research rationale

State-of-the-art

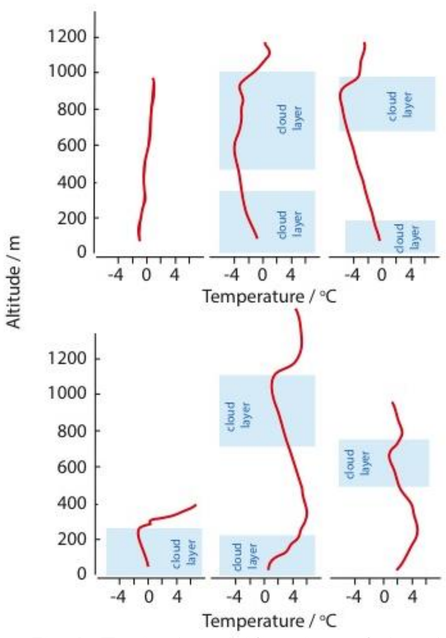


Fig 1: Typical stratification of the cloudy ABL as observed during Arctic summer (redrawn from Fig 1, Curry et al. 1988)

- Complex stratification of Arctic ABL often associated with multi-layer and mixed-phase clouds
- Energy flux observations for such complex situations are rare
- Most observations are not performed in the Central Arctic
- Aicraft observations do not cover ground levels
- Combined broadband and spectral radiation observations are needed to obtain a coherent picture of cloud radiation-interactions, in particular for mixed-phase clouds

Preliminary work

- Small-scale turbulence observations using tethered-balloons in stratocumulus
- Experience from several airborne field campaigns
- Development of tools and sampling strategies
- Collocated turbulence, radiation and microphysical measurements with helicopters

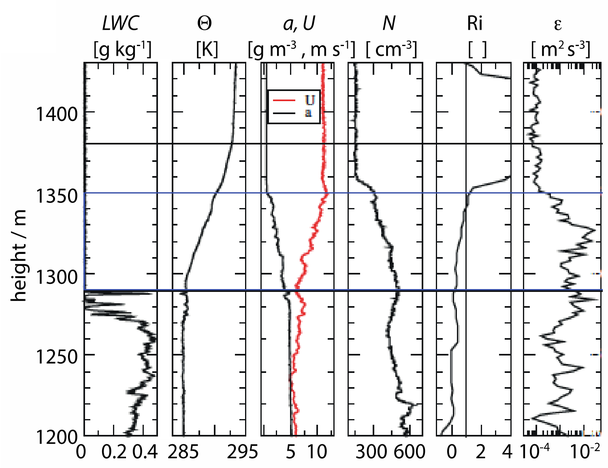


Fig 2: High-resolution observations in a strato-cumulus deck over the Baltic Sea (redrawn from Fig. 2, Katzwinkel et al., 2011)

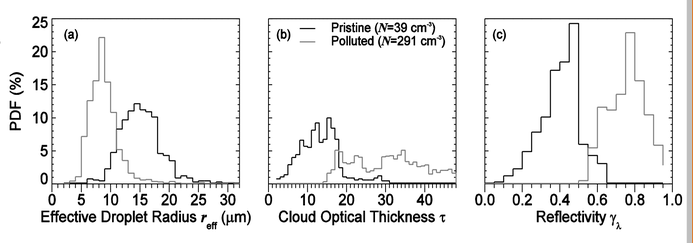


Fig 3: PDFs of (a) effective droplet radius r_{eff}, (b) cloud optical thickness τ, and (c) spectral reflectivity γ_λ at λ = 645 nm (Werner et al., 2014).

3 Research plan

Central research topics

- Profiles of energy fluxes for different clouds and stratification
- Aerosol influence on the energy fluxes in the cloudy ABL
- Evaporative and radiative cooling at cloud top → stability of the ABL
- Surface radiative forcing due to cloud properties

Work packages

1. Probe development and testing
2. Measurements
   - ABL structure
   - Turbulent energy fluxes
   - Aerosol & Cloud Properties
   - Remote Sensing
3. Synthesis
   - Fluxes and clouds vs stability
   - Cloud top cooling vs stability
   - Radiative forcing

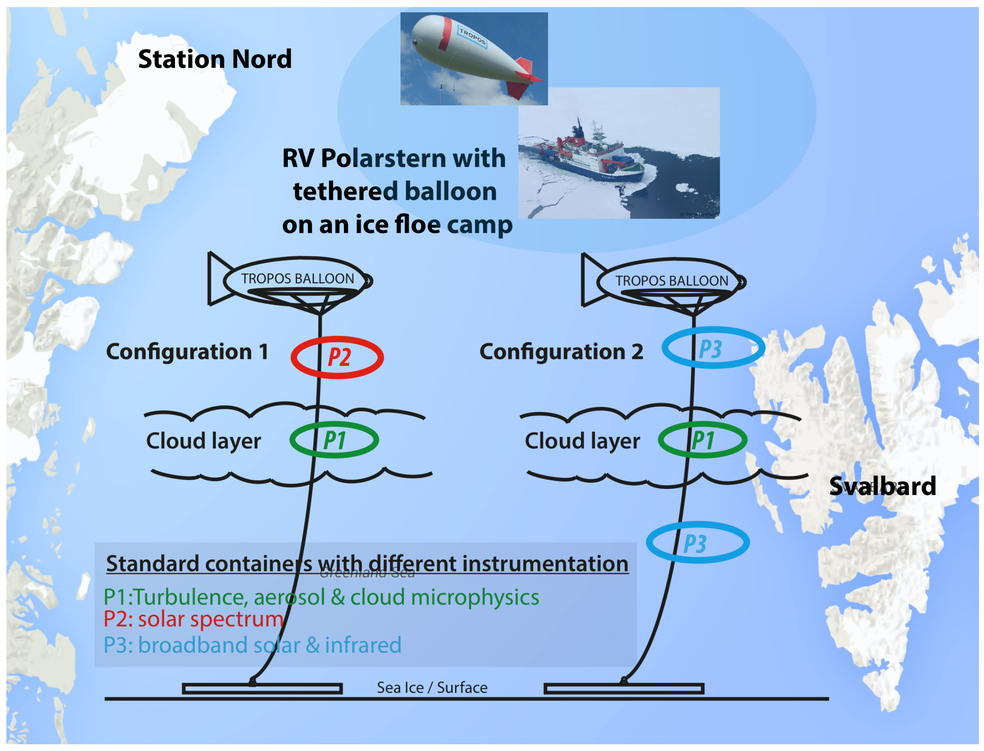
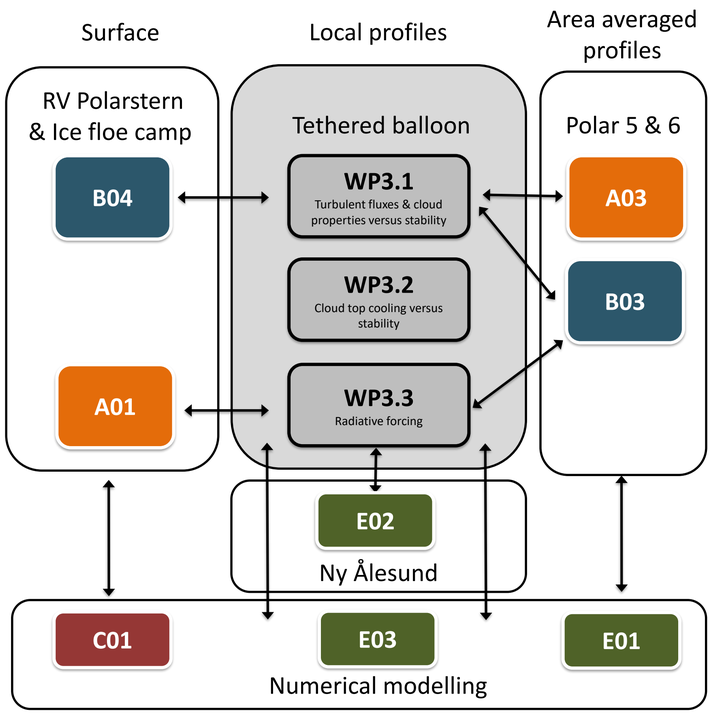


Fig. 4: Proposed tethered balloon observations during ABEX with different sensor packages. The campaign is embedded into the PASCAL project with RV Polarstern in summer 2017 in the Fram Strait.

4 Role within (AC)³ & perspectives

Collaboration within (AC)³



- Strong cooperation between A02 and A03 in terms of methods, data interpretation, and possible parameterization of flux profiles
- B04 with detailed ground-based aerosol characterization will support observed aerosol profiles
- Aircraft measurements of cloud properties (B03) will help to interprete local balloon-borne cloud profiles
- Radiation measurements closely linked to aircraft observations in A03 and B03, and to ship-based studies in A01

Perspectives

- A number of tethered balloon-borne campaigns during the year-round MOSAiC observations are planned.
- Focus will be on seasonal dependence of observations.
- Observations will be used to test and improve models with (AC)³ partners.

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