Impact of low-level clouds on Arctic boundary layer turbulence and radiation

A03

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1 Summary

- Main goal: Quantify impact of Arctic low-level clouds on vertical profiles of turbulent and radiative energy fluxes as a function of:
  (i) sea ice, (ii) large scale forcing, and (iii) season.
- Data base: Previous measurements and two aircraft campaigns
- Modelling: Mesoscale and radiative transfer
- Quantify drawbacks / improve flux parameterizations (near-surface and entire ABL)
- Identify major properties to represent the cloud impact on radiative flux profiles

Hypothesis

The net effect (warming/cooling) of Arctic low-level clouds varies regionally and seasonally, and exhibits a major dependence of sea ice cover

2 Research rationale

State-of-the-art

- ABL structure highly variable
- Cloud impact on flux profiles not well characterized
- Humidity inversions influence clouds
- Surface and cloud governed ABL, decoupling of the surface layer

→ Flux parameterizations need to be validated and further developed

→ More in-situ measurements needed, coordinated with modelling

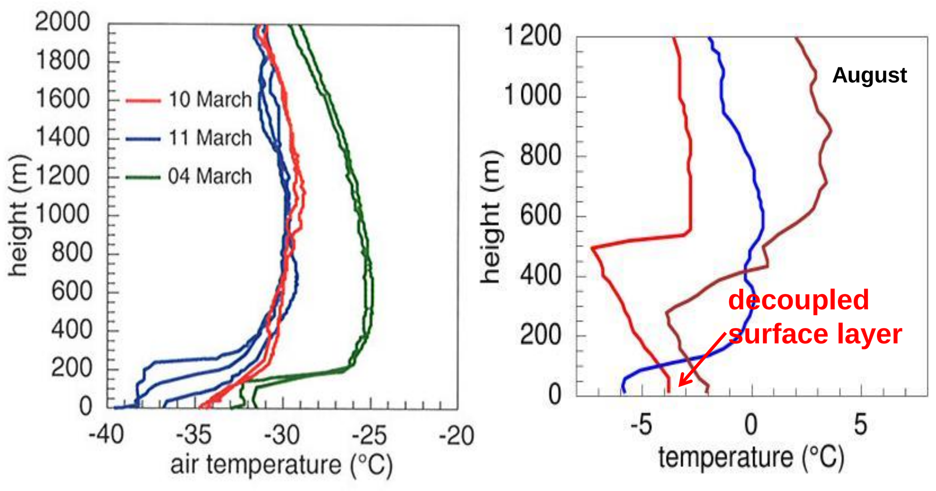


Fig 1: Typical temperature profiles over sea ice

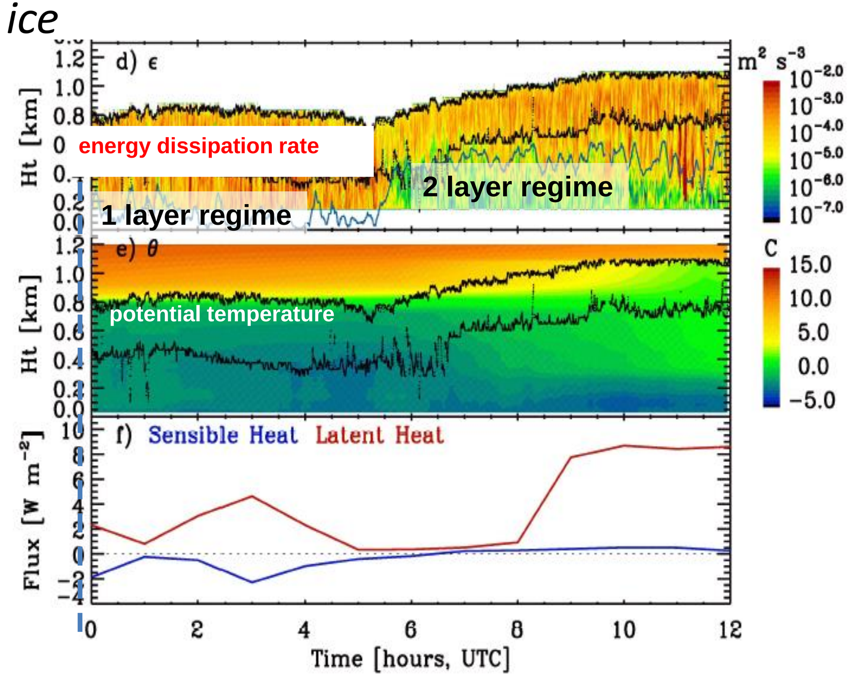


Fig 2: Regime change from two decoupled layers (left part) to an ABL with a coupled surface layer (right). From Shupe et al. 2013 Atm. Chem. Phys.

Preliminary work

- Airborne measurements (turbulence and spectral radiation)
- Meso-scale and radiative transfer modelling
- Turbulence parameterization (e.g., surface fluxes, non-local closures)

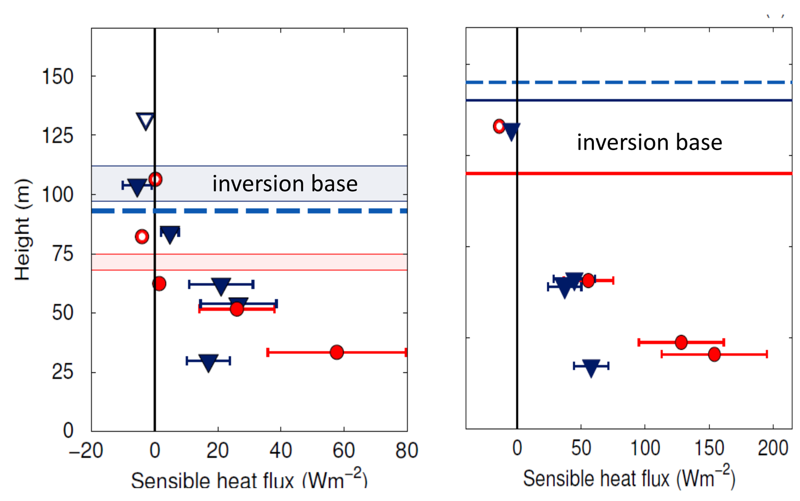


Fig. 3: Examples of aircraft measured linear and nonlinear flux profiles in the vicinity of leads (Tetzlaff et al. 2015,QJRMS).

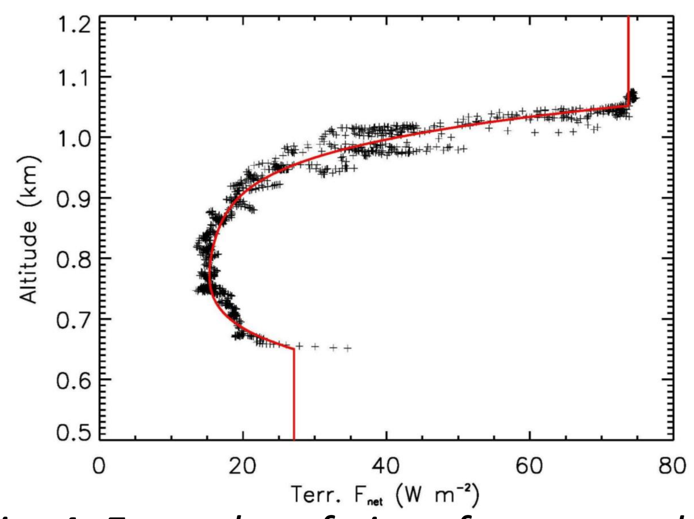


Fig. 4: Examples of aircraft measured net irradiances collected during the VERDI campaign using Polar 5.

3 Research plan

Central Research Topics

- Profiles of turbulent and radiative fluxes: Cloudy versus cloudless conditions
- Seasonal dependence of cloud impact on turbulent and radiative characteristics
- Relative importance: sea ice, large scale forcing, clouds on the ABL energy budget, and dependence on season?
- Improvement of turbulence parameterizations in the cloudy and cloudless ABL
- Realistic representation of cloud impact on radiative flux profiles

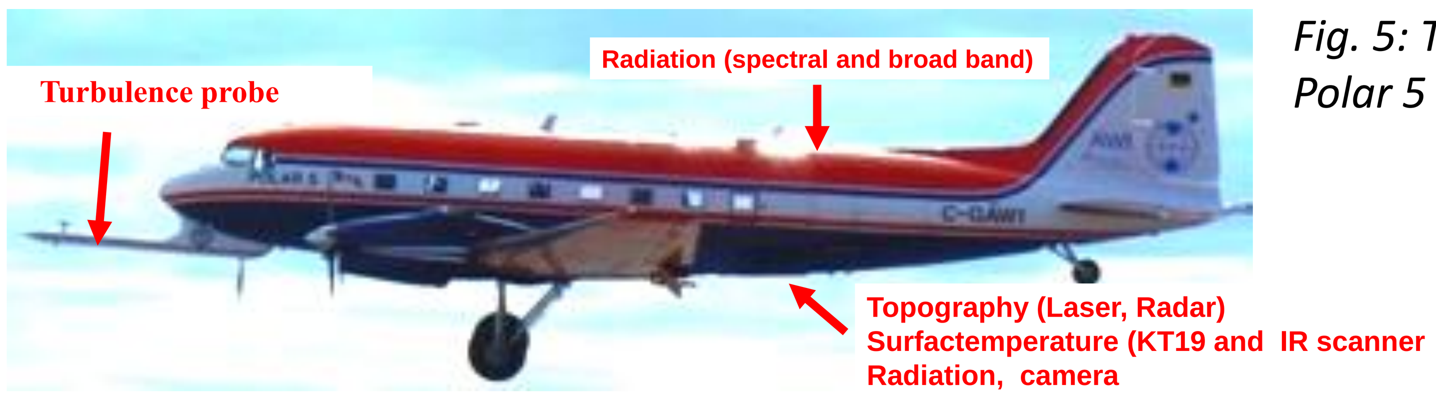


Fig. 5: The aircraft Polar 5 of AWI

WP1: Observations

New and previous observations are evaluated

Two new campaigns:

Summer 2017: ACLOUD (2 aircraft + RV)

Winter 2019: AFLUX (1 aircraft)

Flight patterns: staggered flights in different vertical levels.

Fig. 6: Domain of combined aircraft and ship campaign.

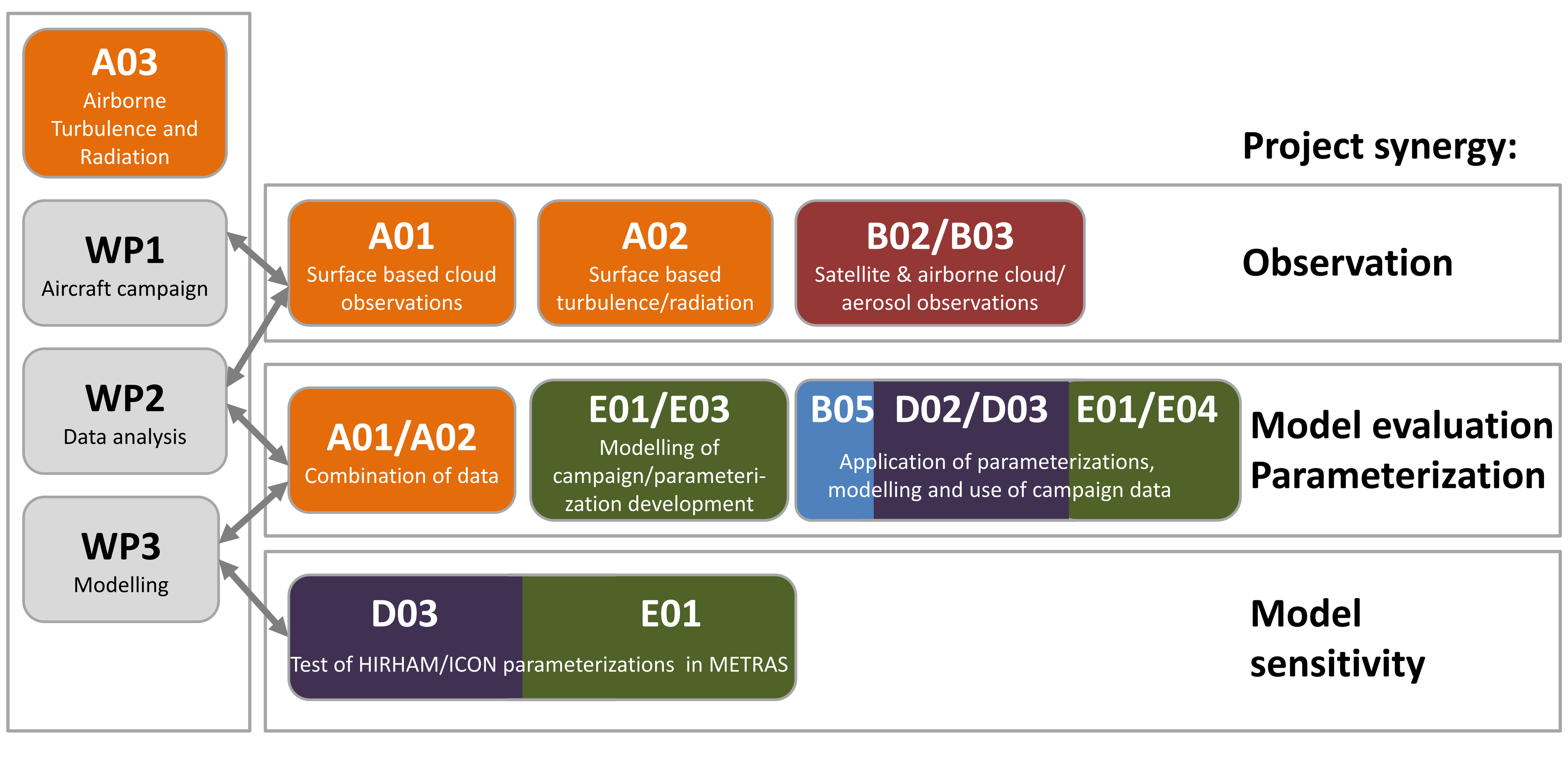
WP2: Data Analysis and Parameterizations

ABL characterization: coupled and uncoupled layers, flux profiles, temperature and humidity inversions, large scale flow conditions, turbulence statistics (fluxes, higher order moments) as function of height, cloud and sea ice parameters. Observations will be used for the validation of turbulence parameterizations.

WP3: Modelling

Mesoscale modelling: focus on idealized scenarios, grid dependence of turbulent fluxes, their relation to sea ice cover using different types of parameterizations. Model: METRAS (University Hamburg), radiative transfer modelling with libRadtran

4 Role within (AC)³ & perspectives



Collaboration within (AC)³

- Aircraft data form the core of cooperations
- A03 parameterizations developed on the basis of observations and modeling (projects in A03 and B/D/E) will be made available

Perspectives

- Measurements in different seasons
- Leading contribution to year-round observations (2019-2020) from an Arctic drifting station

MOSAiC – Multidisciplinary drifting Observatory for the Study of Arctic Climate – IASC

www.mosaicobservatory.org

- Icebreaker RV Polarstern constitutes the main basis
- Supported by observations from AWI aircraft (Polar 5 and 6).

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