Wind and Turbulence Measurements with RPAS during the ISOBAR Campaign

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ISOBAR (**I**nnovative **S**trategies for **O**bservations in the arctic atmospheric **B**oundary l**A**ye**R**)

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Project Partners:

Geophysical Institute, University of Bergen
Uni Research AS, Bergen
The University Centre in Svalbard, Longyearbyen
Finnish Meteorological Institute, Helsinki
University of Tübingen
University of Applied Sciences Ostwestfalen-Lippe
Leibniz University Hannover
(Marquette University, Milwaukee)
University of Oklahoma, Norman (OU)
University of Colorado, Boulder (CU)
Wageningen University, Netherlands

Outline

- motivation of the project ISOBAR
- characteristics of, and problems with stable atmospheric boundary layers
- methods: remotely piloted aircraft systems (RPAS)
- ISOBAR setup in Hailuoto, Finland in February 2017
- analysis of one exemplary flight during stable conditions
- outlook on analysis of campaign #2 in February 2018

Motivation

- atmospheric boundary layer (ABL) processes in the Arctic
- turbulence within the stable ABL

Goal

- improvement of ABL parameterization schemes

Approach

- observations targeting all relevant processes
  - automatic weather stations (AWS)
  - **profiling with remotely piloted aircraft systems (RPAS)**
  - remote sensing, ground based measurements
- numerical modelling

Characteristics of the Stable ABL

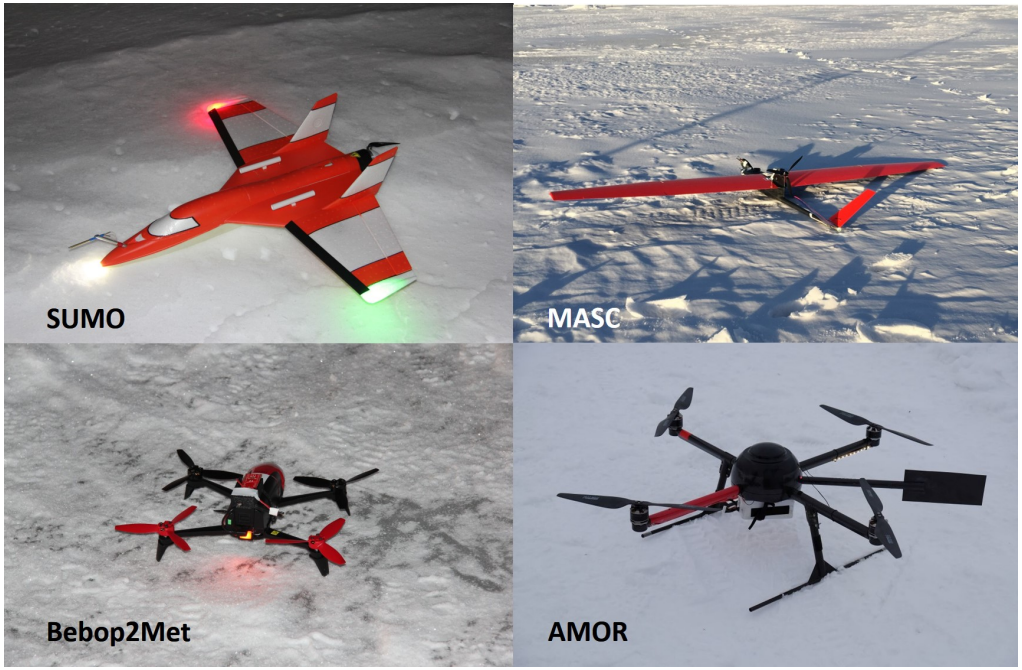
- Weak turbulent fluxes
- Strong gradients
- Inversions
- Shallow ABL height
- Low Level Jets (LLJ)

Problems with Stable ABL in Numerical Models

- poor vertical resolution for shallow ABL
- warm temperature bias in numerical weather prediction and climate models
- overestimation of turbulent mixing rates
- overestimation of the ABL height

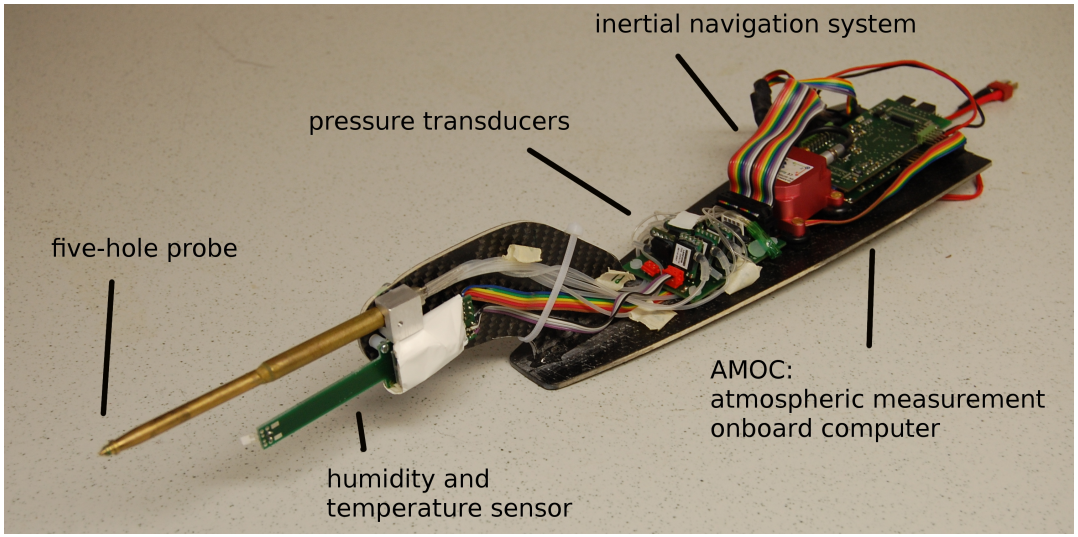
Methods

- measurement strategy
  - ground based flux and met stations
  - ABL remote sensing and profiling systems
  - numerical modeling experiments (SCM, LES, WRF)
  - RPAS



MASC-2: Multi-purpose Airborne Sensor Carrier

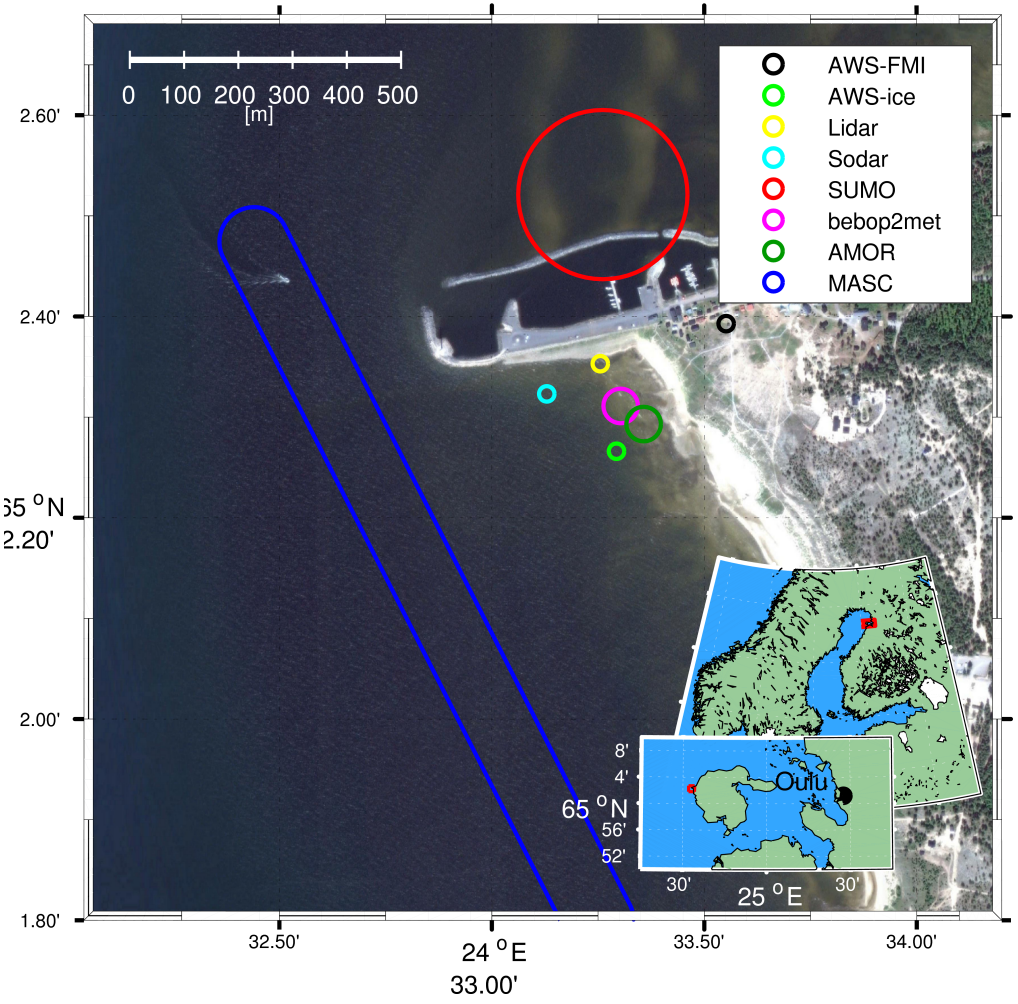
wingspan:	3.5 m
total weight:	< 6 kg
incl. sci. Payload:	1.5 kg
cruising speed:	25 m/s
endurance:	~ 1 hour
electrical engine	pusher
autopilot:	Uni Stuttgart



measurement system:

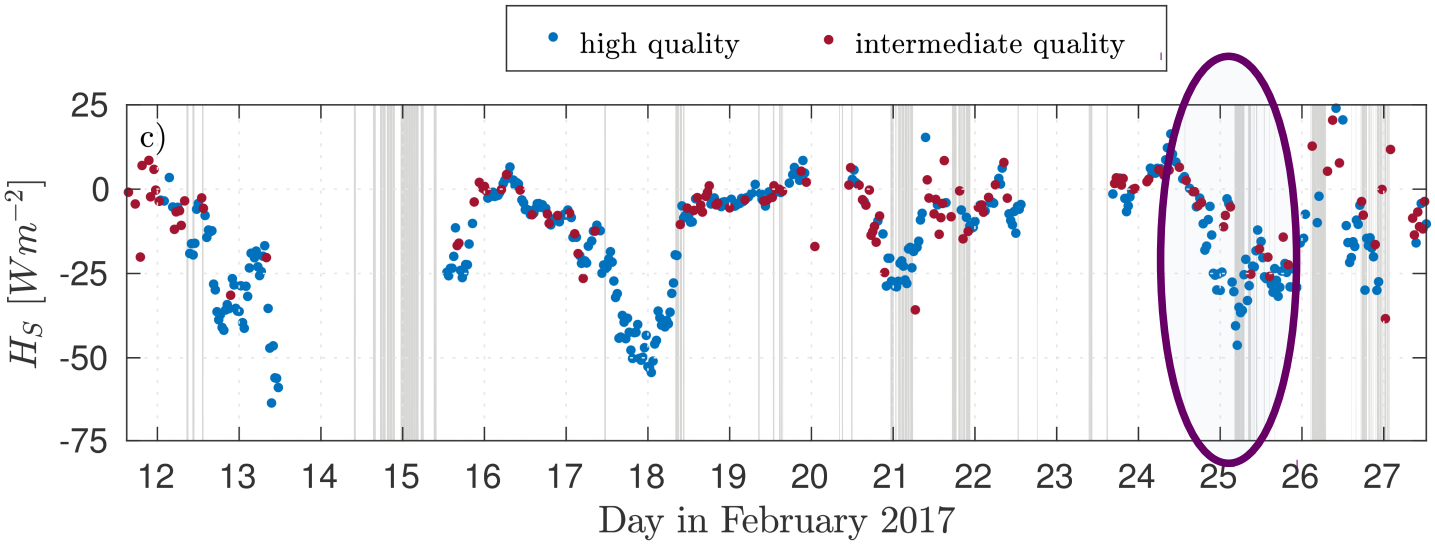
- 3D wind vector (100 Hz)
- air temperature (100 Hz)
- water vapour
- data link to groundstation

ISOBAR Setup 2017

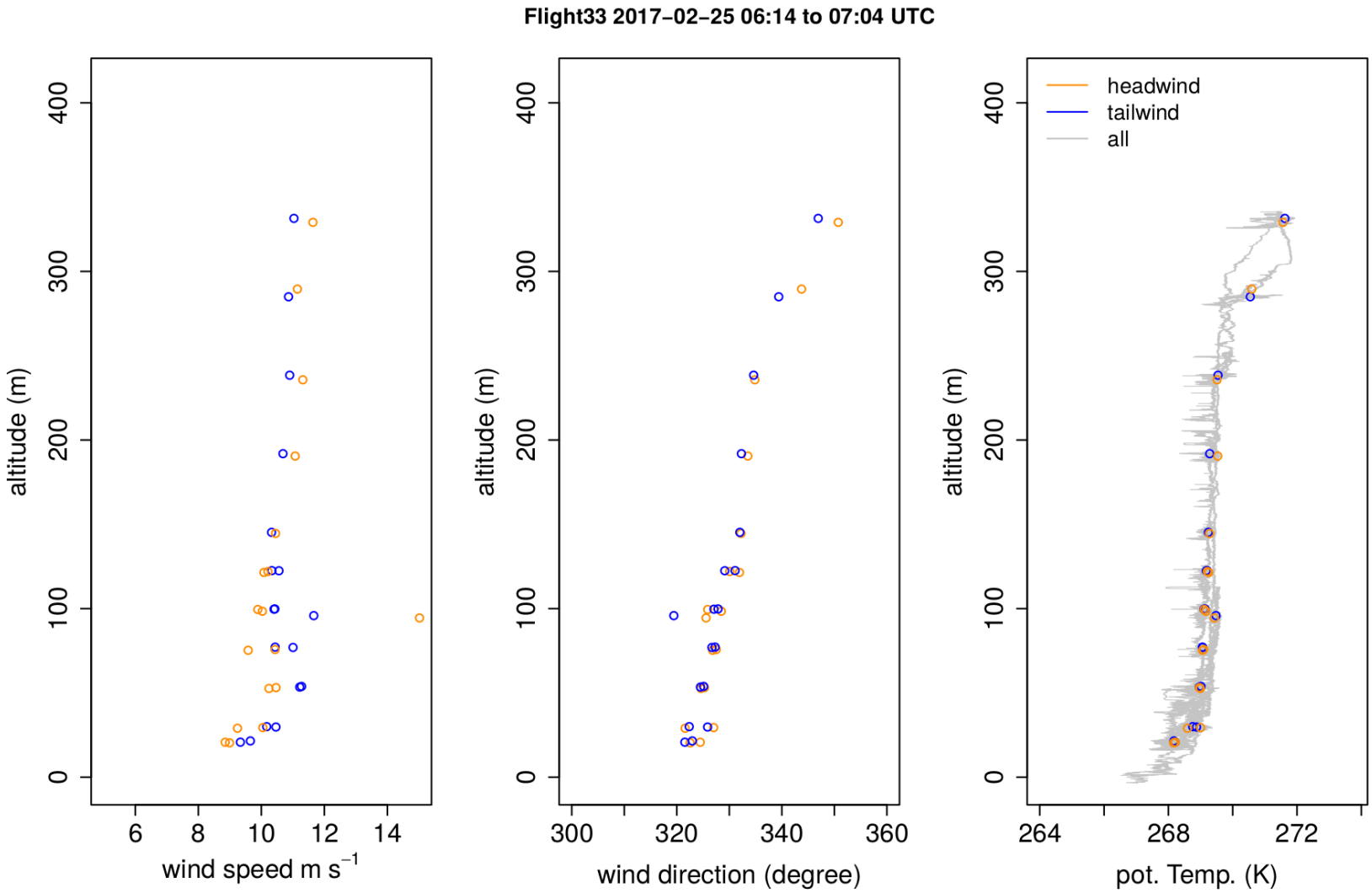


ISOBAR Hailuoto Campaign 2017 – Flight 33

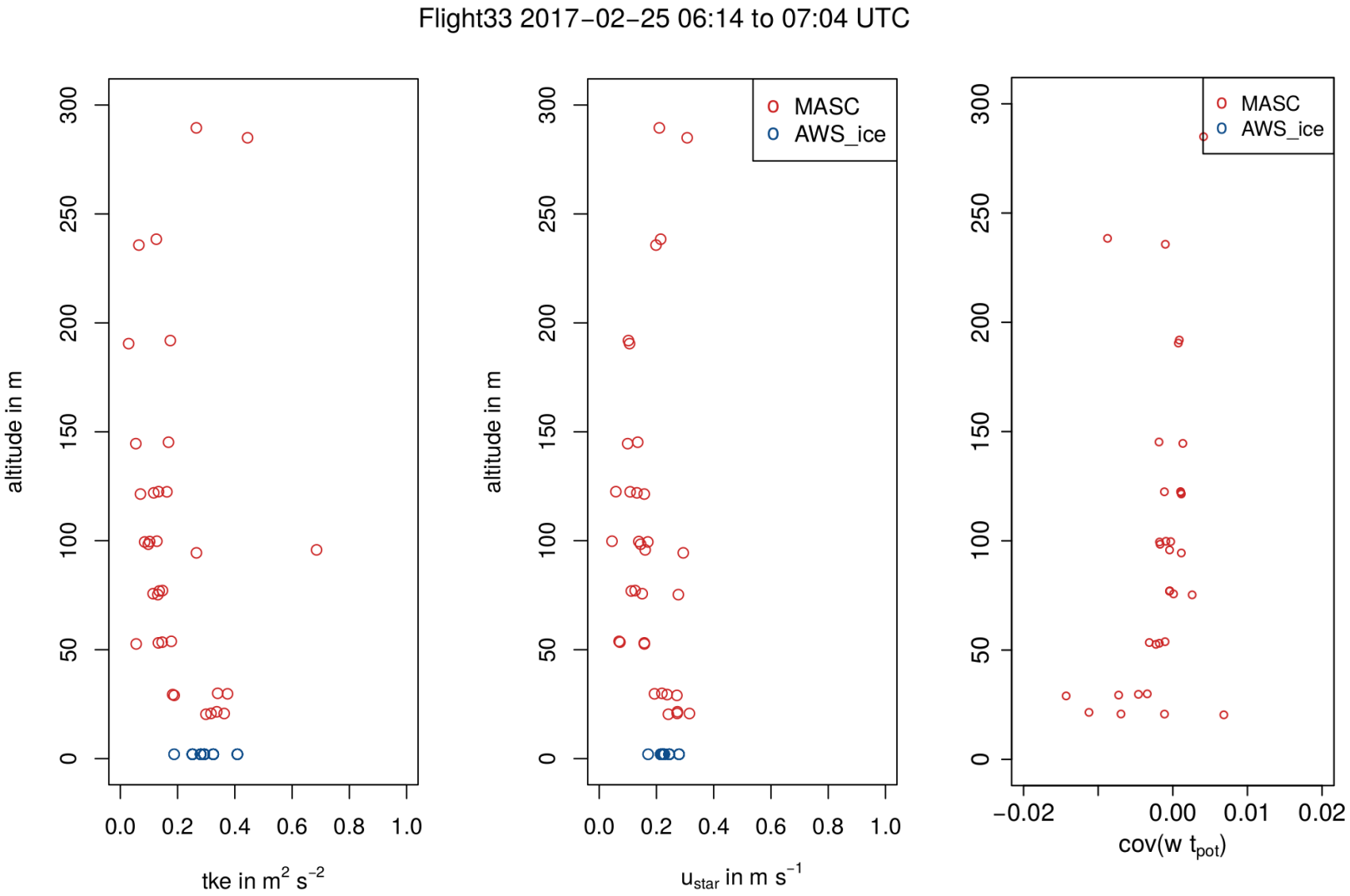
- exemplary analysis of one flight
- case study of a cooling event in the morning of the 25. of February
- profiles of mean quantities and turbulence parameters to derive a complete picture of the ABL



Wind Speed, Wind Direction and Potential Temperature



MASC-2 Turbulence Measurements

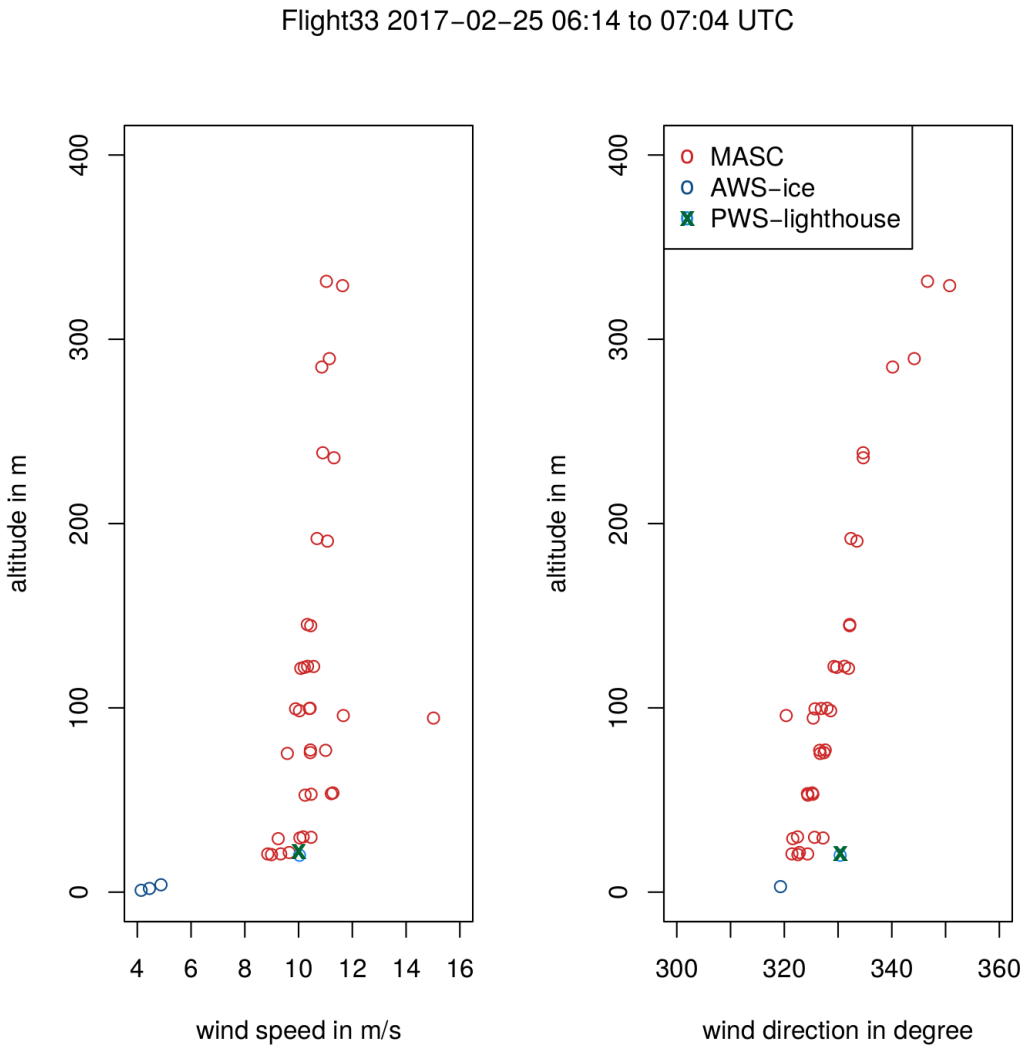


MASC-2: Complete Picture of the ABL

- wind speed
- wind direction
- temperature
- turbulence statistics
- fluxes

<u>Future work:</u>

- normalisation with boundary layer height
- plot flux profiles
- comparison to theory
- process a catalogue of all flights



Outlook: Analysis of Hailuoto Campaign in Feb 2018

- ground stations
  - LIDAR wind profiler (Windcube v1)
  - SODAR (FMI)
  - SODAR (Scintec MFAS, GFI)
  - 10 m mast
  - EC Stations
- MASC-3
- 8 IOP in stable conditions

Thank you!

Webpage ’umphy’ Uni Tübingen: www.geo.uni-tuebingen.de/umphy

MASC-2 Turbulence Measurements

- high resolution temperature and wind speed measurements
  - spectral analysis of the wind speed and temperature measurement
  - Kolmogorov's theory
- long enough sampling to ensure statistical significance of the measurement and reduce errors
  - integral length scale
  - autocorrelation function
- comparison with ground-based measurements