Observations on the Arctic Boundary Layer using the Small Unmanned Meteorological Observer (SUMO) during polar night

Introduction

• **Where:**
  – Svalbard

• **How:**
  – During a graduate course at the University Centre in Svalbard
  – AGF-350/850 *The Arctic Atmospheric Boundary Layer and Climate Processes*
  – 19 international students

• **When:**
  – 8-15 February 2016
Introduction

• Why:
  – Study processes typical for the Polar Atmospheric Boundary Layer
    • Cold pools
    • Katabatic winds
    • Air-sea interactions
    • Cold-air outbreaks
Study Location: Svalbard
Sun returns to Longyearbyen 08.03.2016

Sun above the horizon 16.02.2016
Automatic Weather Stations
with Surface energy balance
Temperature sensors
Tethersonde + SODAR
Automatic Weather Stations
with Surface energy balance
Temperature sensors
Tethersonde + SODAR

Boat
Snowmobiles
RPAS
**SUMO**

*Small Unmanned Meteorological Observer*

**Airframe**

*“Multiplex FunJet”*
- Weight ~800 g
- Wing span 0.8 m
- Battery powered
- Autopilot: Paparazzi

- **Performance:**
  - Ground speed ~15 m/s
  - Endurance ~45 min
  - Range ~35 km
  - Max altitude ~5 km
- “slow” temperature
- “slow” humidity
- pressure
- wind speed
- wind direction
- surface temperature
SUMO
Sensors/Measurements

- “slow” temperature
- “slow” humidity
- pressure
- wind speed
- wind direction
- surface temperature

- \( u' \ v' \ w' \ & T' \)
- Sensible heat flux
- Momentum flux
SUMO
Lighting
Case, 13 February 2016
“cold-air outbreak”
Case, 13 February 2016
“cold-air outbreak”
Case, 13 February 2016
“cold-air outbreak”
Case, 13 February 2016
“cold air outbreak”
Case, 13 February 2016
“cold air outbreak”
Case, 13 February 2016
“cold-air outbreak”
Measurement strategy

- Boat
- Snowmobiles
- RPAS
- Tethersonde
Case, 13 February 2016
“cold-air outbreak”
Measurement strategy
Case, 13 February 2016
“cold-air outbreak”
logistics
Case, 13 February 2016
“cold-air outbreak”

Logistics

RPAS ground base:
BV206 snowcat
Case, 13 February 2016
“cold-air outbreak”

Logistics

RPAS ground base:
BV206 snowcat
Case, 13 February 2016
“cold-air outbreak”

Measurement strategy

![Graph showing measurement strategy for Tethersonde, SUMO, BOAT, and SST on 13 Feb 2016.](image)
Results

temperature and humidity measurements + flux estimates

boat

Courtesy of Haualand et al. 2016
Results

temperature and humidity measurements
+
flux estimates
boat

Courtesy of Hualand et al. 2016
Results

*temperature and humidity measurements*

+ *flux estimates*

*boat*

*Courtesy of Haualand et al. 2016*
Results

*Temperature profiles*

**RPAS**

Boundary layer height *does* increase with distance from the shore

BUT there is no sign of an unstable layer close to the surface

*Courtesy of Hualand et al. 2016*
Results

Temperature profiles

RPAS

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Temperature profiles

RPAS
Results

Numerical model

Figure 8: Potential temperature profiles of four different grid points of the AROME-Arctic model above (a) Isfjorden, (b) Adventfjorden, (c) Adventdalen, (d) Adventdalen up-valley. The colours indicate the forecast time in UTC.

Courtesy of Haukland et al. 2016
Results

Numerical model

Figure 9: (a) Map showing cross-section used in (b). (b) Vertical cross-section of potential temperature from the AROME-Arctic at 18:00 UTC.

Courtesy of Hualand et al. 2016
Results

Numerical model

Figure 9: (a) Map showing cross-section used in (b). (b) Vertical cross-section of potential temperature from the AROME-Arctic at 18:00 UTC.

Courtesy of Hualand et al. 2016
Polar environment

challenges

• High relative humidity:
  – Temperature sensor problem (PT1000)
Polar environment challenges

• High relative humidity:
Polar environment

challenges

• High relative humidity:
Polar environment

challenges

• High relative humidity:
  – Temperature sensor problem
  – Aircraft icing
Polar environment challenges

• Legal issues
  – RPAS operator license from the Norwegian CAA
  – Permission from the Norwegian CAA
  – Permission from the Governor of Svalbard (Sysselmannen)
  – Permission from the Norwegian National Security Authority (NSM)
  – Permission from the local airport:
    • Two-way mobile phone communication
  – A NOTAM was issued
  – Beyond Line of Sight permission within Longyear TIA/TIZ
Future work

• Calculate fluxes using the SUMO profiles
  – *Line Båserud*

• Compare SUMO profiles to the SODAR and tethersonde profiles

• Involve the students more in the operations
  – Separate display with live data and map
Case, 13 February 2016

“cold-air outbreak”

Measurement strategy

- Boat
- Snowmobiles
- RPAS