Alertness

Observations and simulations from an arctic fjord and valley environment in Svalbard

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+ students and instructors on UNIS courses

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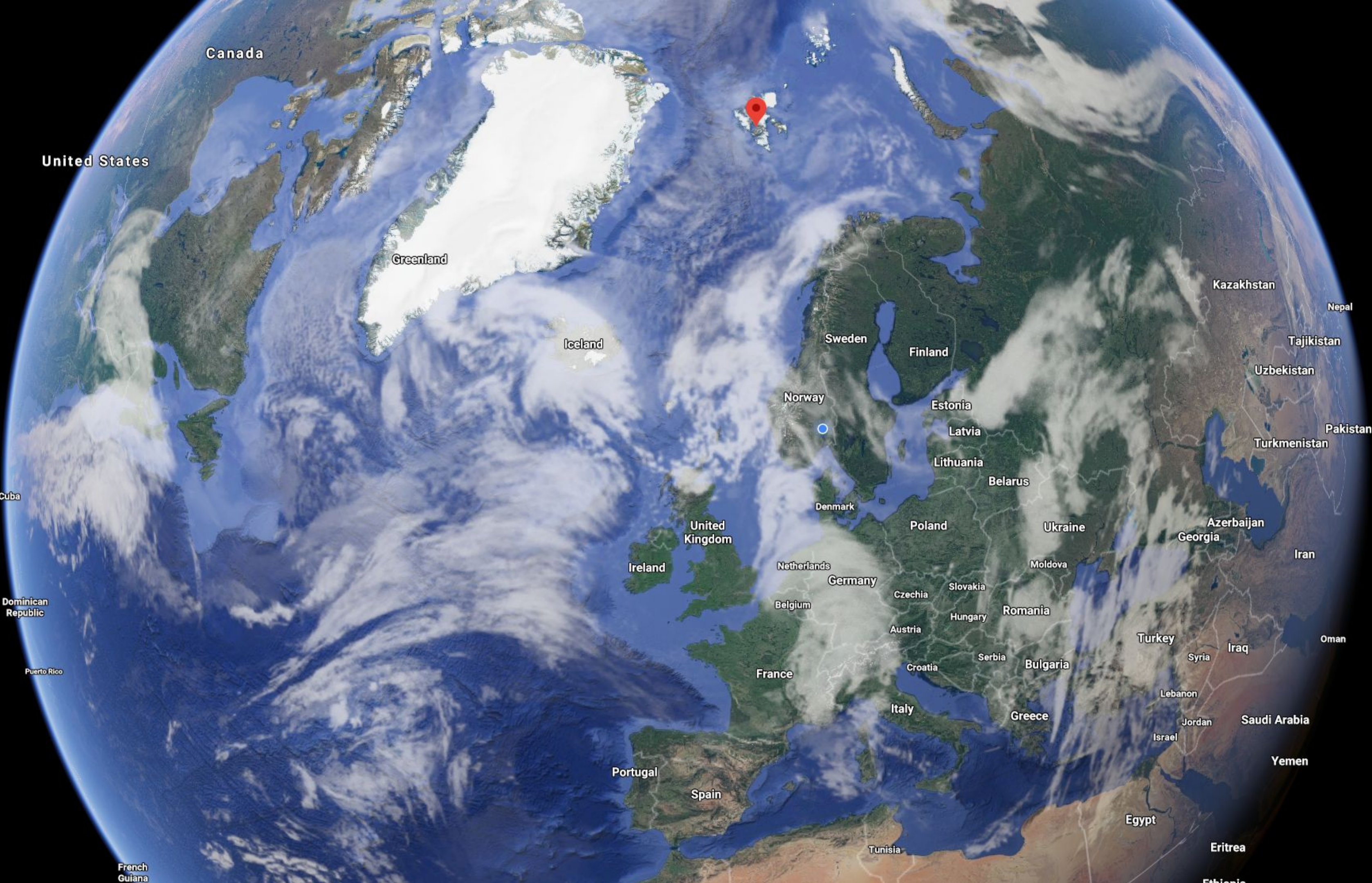
Picture: Ketil Isaksen/MET

Abstract

We present results from a set of field campaigns conducted in an arctic valley and fjord environment in central Spitsbergen, Svalbard. These field campaigns, which are conducted as part of a graduate class at the University Centre in Svalbard (UNIS), address a range of phenomena typical for the arctic atmospheric boundary layer using both observational and numerical means. These phenomena include low-level jets, cold pools, drainage flows, and air-sea interactions, several of which typically are challenging to accurately model. On the observational side, we utilise a range of sensors and instrumentation platforms, such as portable weather stations, a tethersonde (anchored weather balloon), small temperature sensors (TinyTags), sonic anemometers, automatic weather stations, and drones. As of this year, the sensor suite also constitutes a wind lidar and a microwave temperature profiler. The resulting data sets represent unique model-independent data sets from a region where observations are otherwise sparse. On the numerical side, we utilise data from the high-resolution (500 m and 2.5 km horizontal grid spacing) AROME-Arctic weather prediction model. AROME Arctic is run operationally in 2.5 km mode by the Norwegian Meteorological Institute (MET Norway) for a domain covering Northern Fennoscandia, larger parts of the Barents Sea, and Svalbard. We use the model data both to plan our fieldwork and for interpreting our observations. In turn, we use the observations for improving our understanding of the mentioned phenomena and also for validating the model.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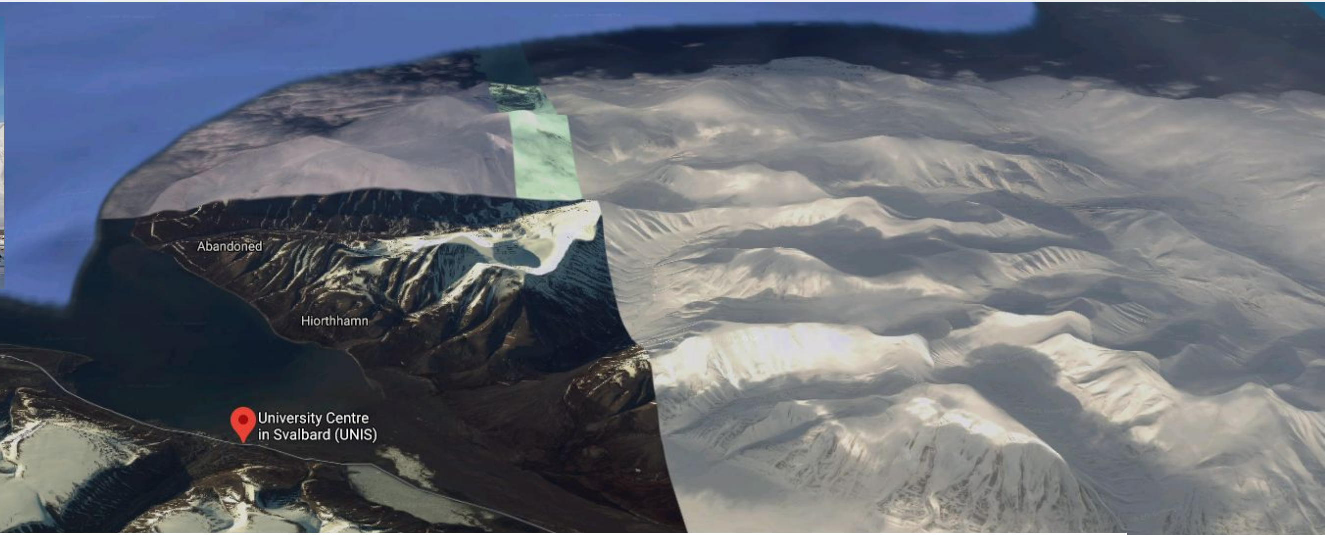
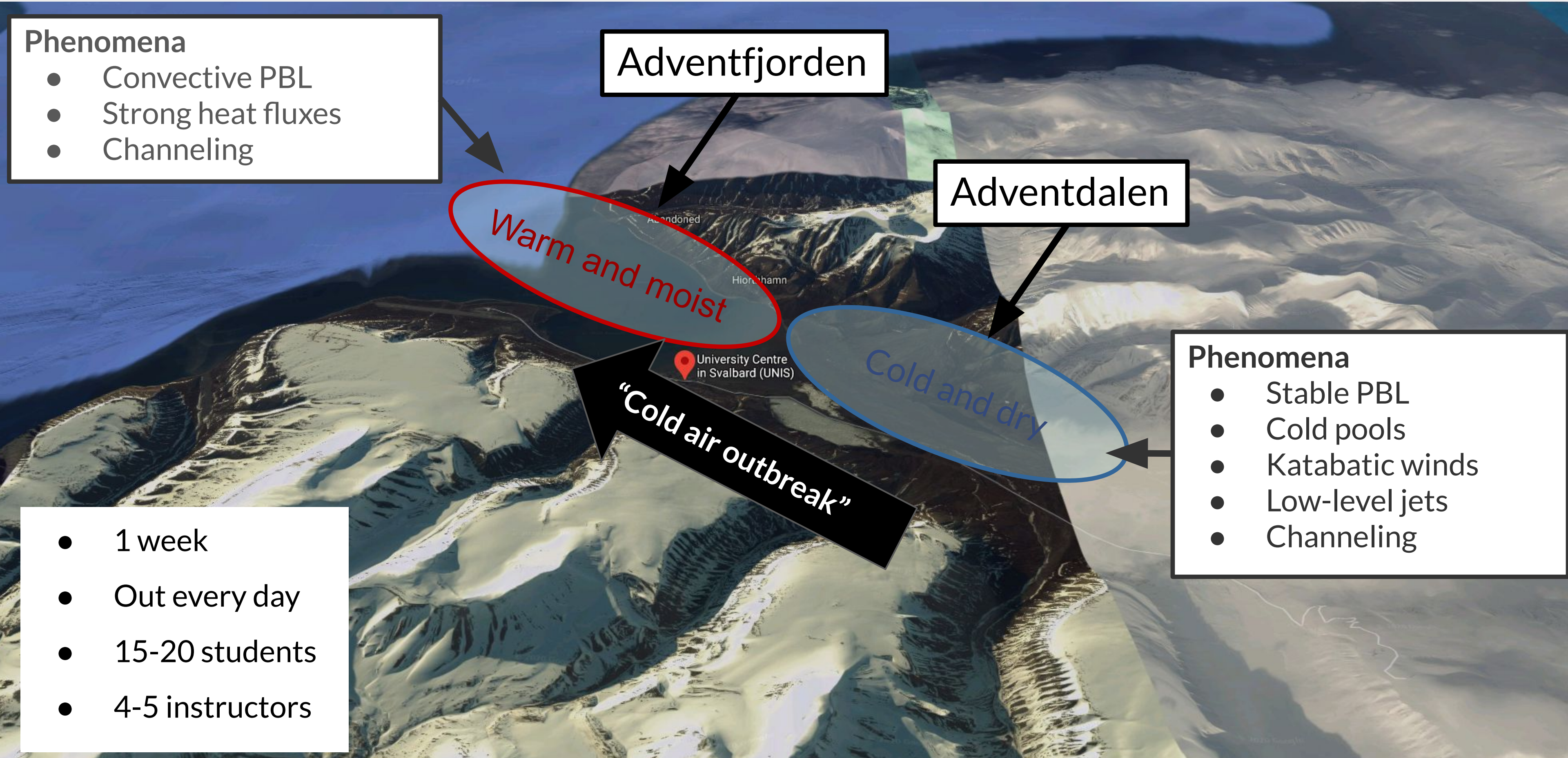


Meteorology courses

- AGF-213: Polar Meteorology and Climate (autumn, 15 ECTS)
- AGF-350/850: The Arctic Atmospheric Boundary Layer and Local Climate Processes (spring, 10 ECTS)

AGF-350/850: The Arctic Atmospheric Boundary Layer and Local Climate Processes

(every second spring, 10 ECTS) fieldwork



Phenomena
- Convective PBL
- Strong heat fluxes
- Channeling

Phenomena
- Stable PBL
- Cold pools
- Katabatic winds
- Low-level jets
- Channeling

- 1 week
- Out every day
- 15-20 students
- 4-5 instructors

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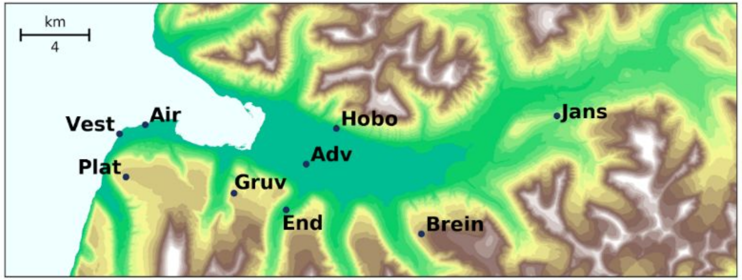
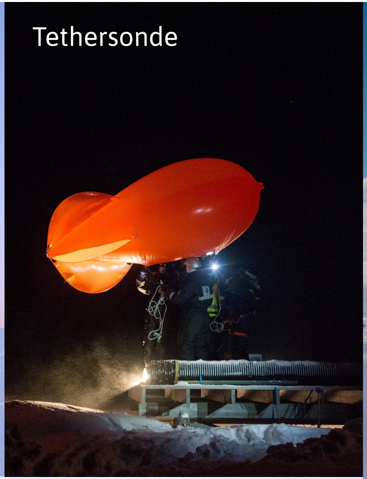
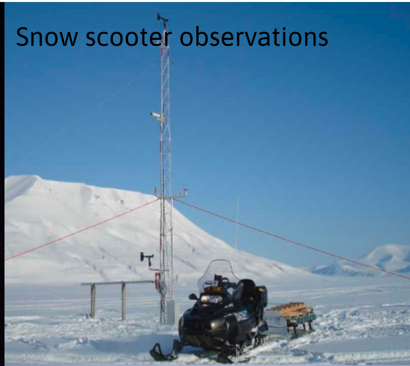
February 2018 campaign

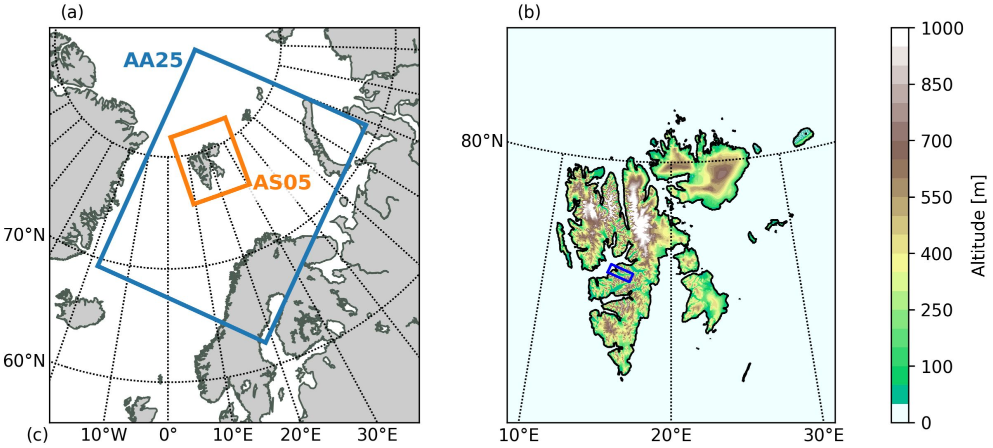


Type of instrumentation	Station	Altitude [m a.s.l.]
Permanent automatic weather stations (temperature, humidity, wind)	Adventdalen (Adv) Janssonhaugen (Jans) Gruvefjellet (Gruv) Breinosa (Brein) Svalbard Airport (Air) Platåfjellet (Plat)	15 251 464 520 28 435
Temporary automatic weather stations (temperature, humidity, wind)	Endalen (End) Vestpynten (Vest) Hobo (Hobo)	78 2 45
Turbulence & radiation measurements	Adventdalen (Adv) Vestpynten (Vest)	15 2
Snowmobile transects (temperature)	Across Adventdalen	0 - 100
Tethersonde balloon (vertical profile of temperature, humidity and wind)	Adventdalen	15





500 m simulations



	AA25	AS05
Horizontal grid spacing (km)	2.5	0.5
Number of vertical levels	65	90
Height of two lowest model level (m)	12, 35	5, 15
Integration time step (s)	60	15
Lateral boundaries	ECMWF-HRES 1-hourly	AA25 1-hourly
Data assimilation atmospheric model	3DVAR 3-hourly, first guess from the operational AROME-Arctic	none
Data assimilation surface model	Optimal interpolation for T2m, RH2m and snow depth	Optimal interpolation for T2m, RH2m and snow depth
Forecast length	24 h starting from 00:00 UTC	24 h starting from 00:00 UTC

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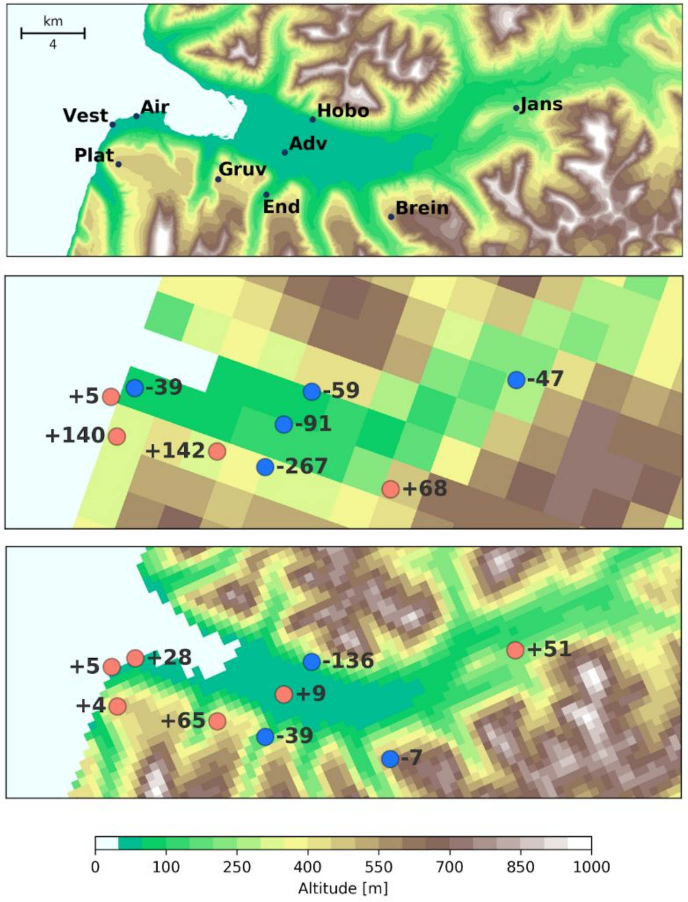
Weather stations
and model topography biases in metres



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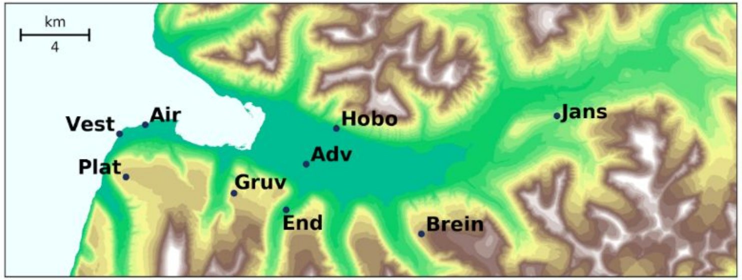
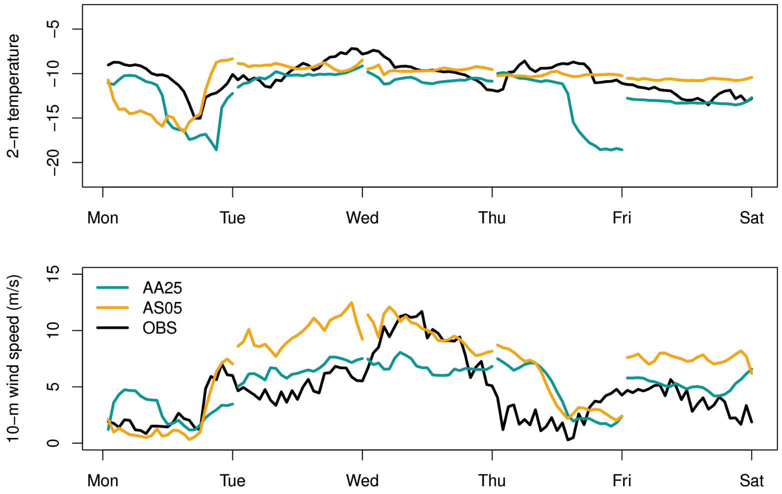
2-m temperature and 10-m wind speed

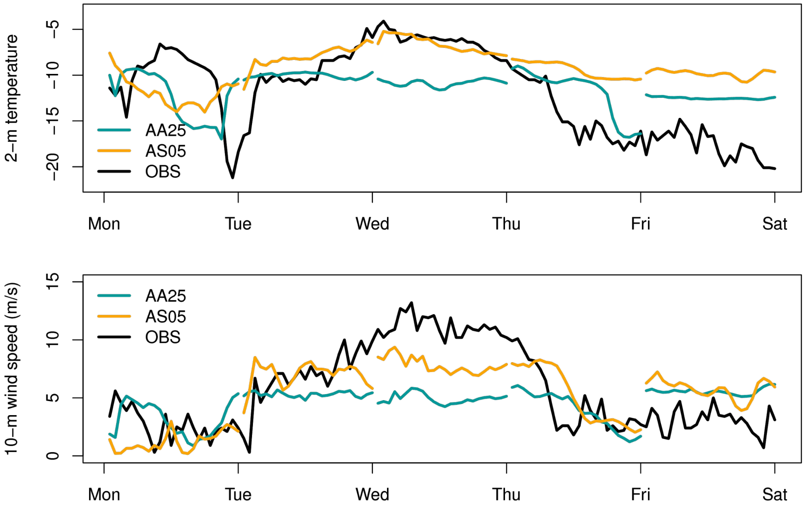
Variable	Experim-ent	Mean error	STD of error
2-m temperature (K)	AA25 AS05	-0.88 0.49	3.86 3.28
10-m wind speed (m/s)	AA25 AS05	1.34 0.44	3.31 2.95



Gruvefjellet (464 m a.s.l.)



Adventdalen (15 m.a.s.l.)



Strong winds, channeling, 14 February 2018

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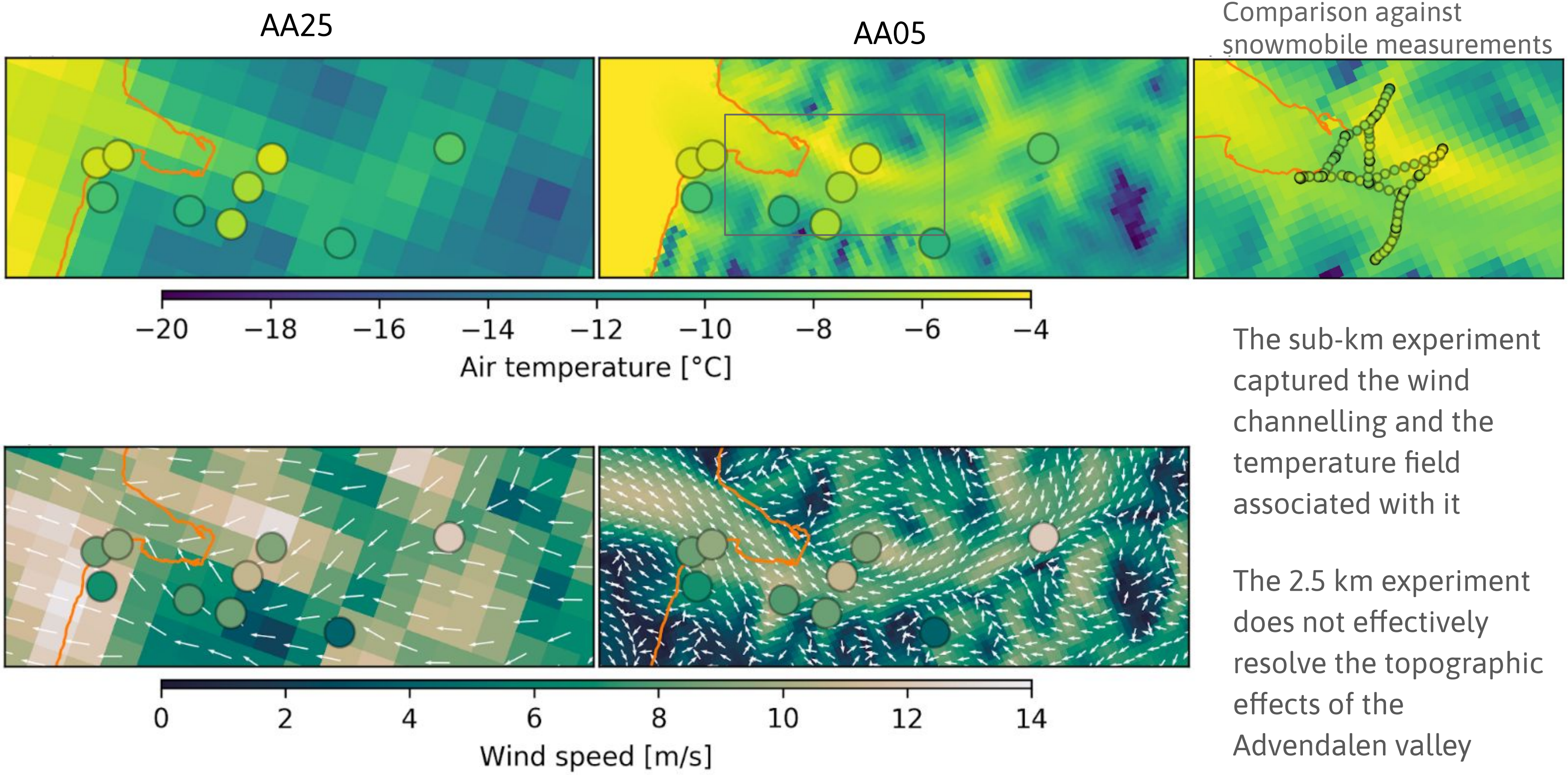
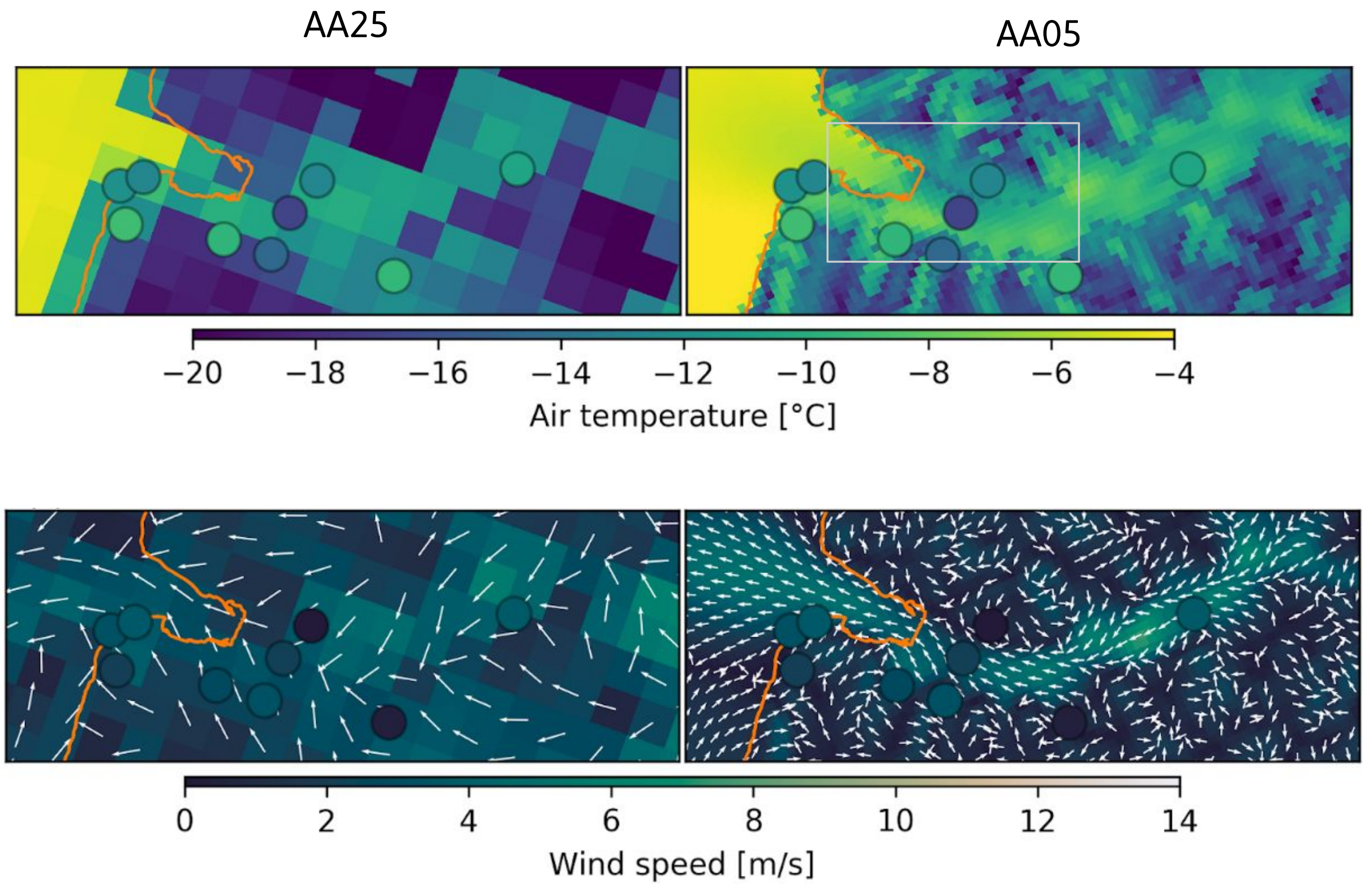


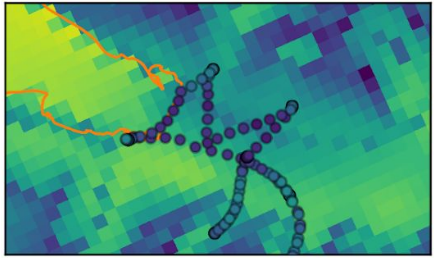
The sub-km experiment captured the wind channelling and the temperature field associated with it

The 2.5 km experiment does not effectively resolve the topographic effects of the Advendalen valley

Weak winds, cold pool, 15 February 2018



Comparison against snowmobile measurements

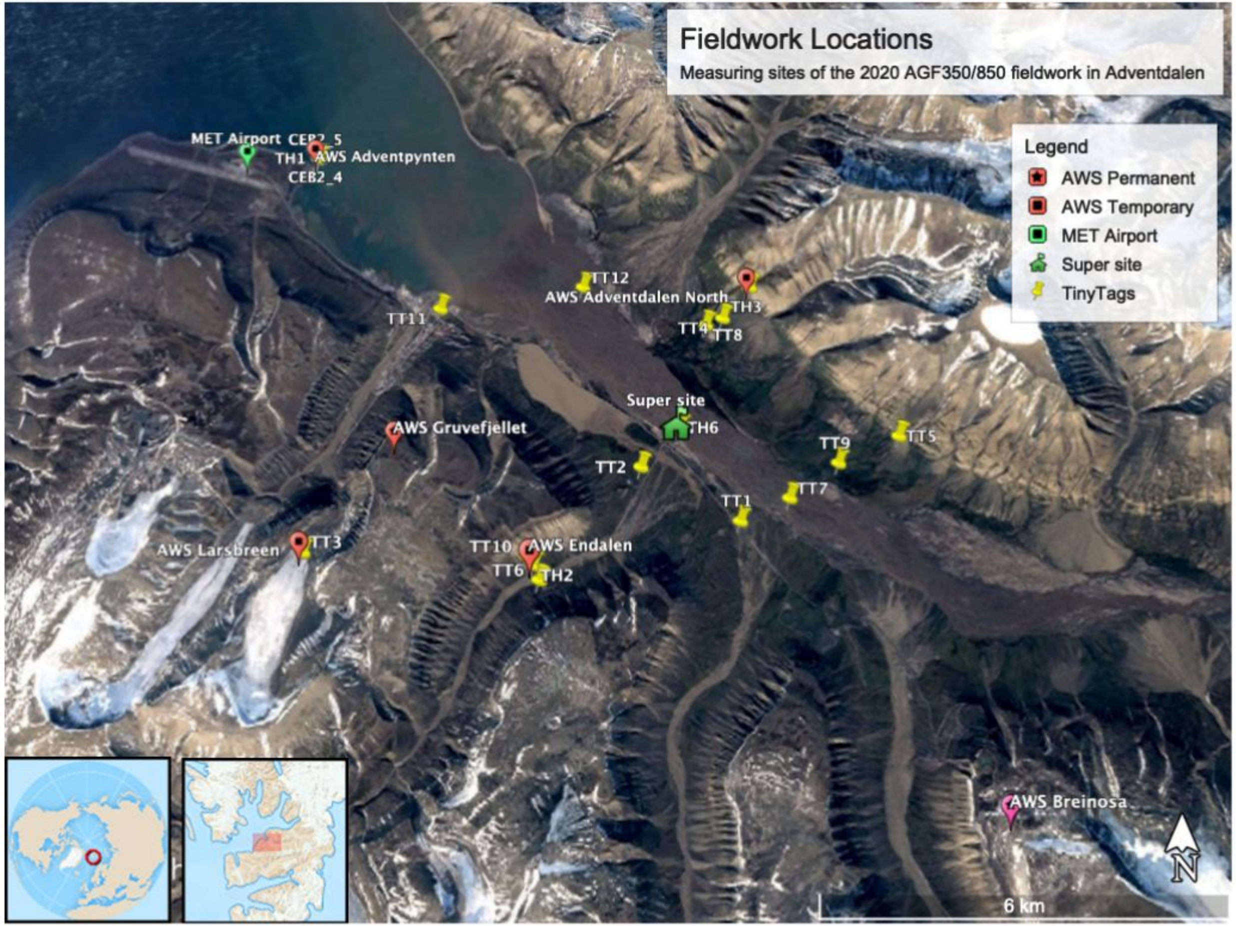


The sub-km experiment resolved the timing of the cold-air pool generation, the spatial variability of temperature and the vertical temperature gradient better than the 2.5 km experiment.

February 2020 campaign

Preliminary results

Pictures by the UNIS AGF-350/850 2020 students



Extended legend

Super site
(Valley site)
2m + 10m AWS
3D sonic anemometer
HATPRO radiometer
Wind lidar
Net-radiometer
Precipitation
Snow height
1m temperature
Surface temperature

AWS Adventpynten
(Fjord site)
2m AWS
3D sonic anemometer
Net-radiometer
1m temperature

TT = 1m temperature sensor

Synoptic weather situation during the fieldwork in 2020

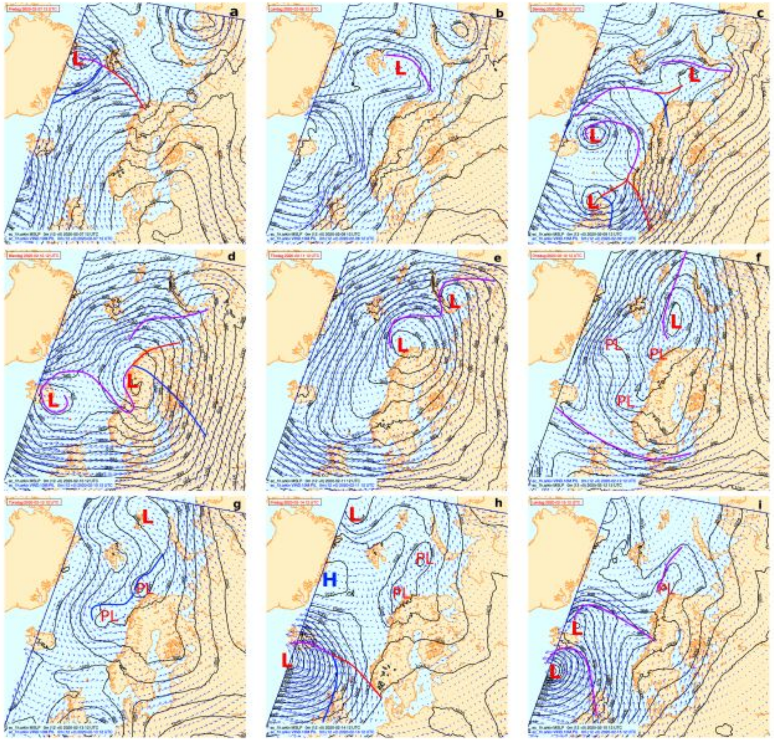


FIG. 2: Daily ECMWF operational analysis between 12 UTC 07 and 12 UTC 15 February 2020 (MET Norway 2020b). Shown are mean sea level pressure (black contour lines with 5-hPA increments) and 10 m wind vectors. Letters indicate cetres of high pressure (blue H) and low pressure (red L). Polar low pressure systems are indicated with red PL. Occluded-, cold- and warm fronts are indicated with purple, blue and red lines, respectively.

*Figure by
Daria Paul and Mathias Tollinger*

Fjord vs. valley temperature stratification

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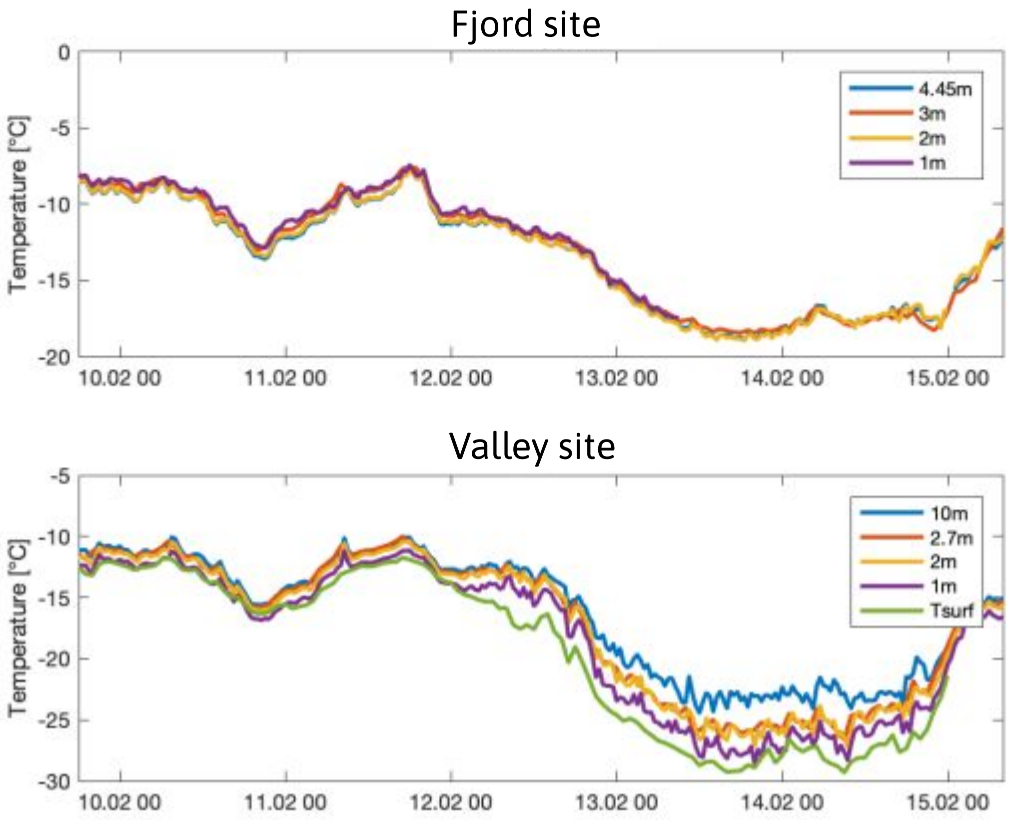

Figure by Cyril Gapp, Florian Lippl and Sonja Wahl

Valley site atmospheric profiles, 14 Feb 2020

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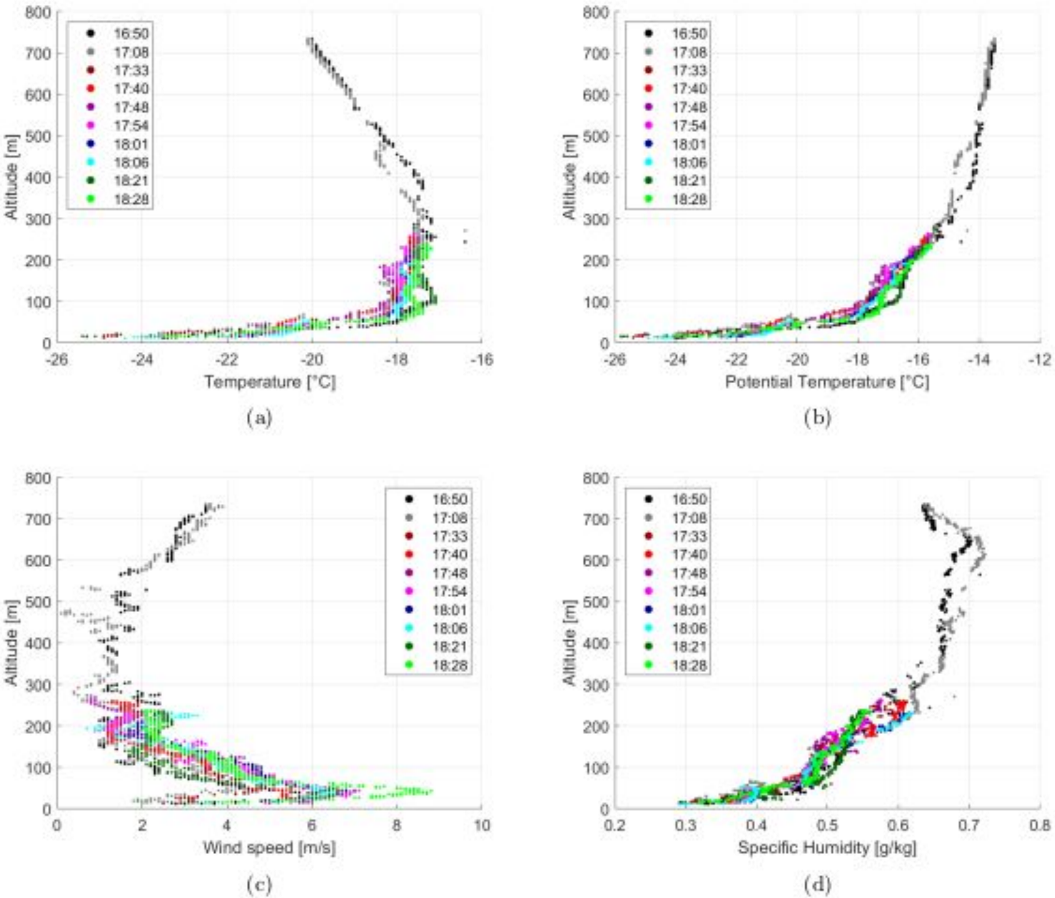

Figure by Cyril Gapp, Florian Lippl and Sonja Wahl

Drone atmospheric profiles, 13 February 2020

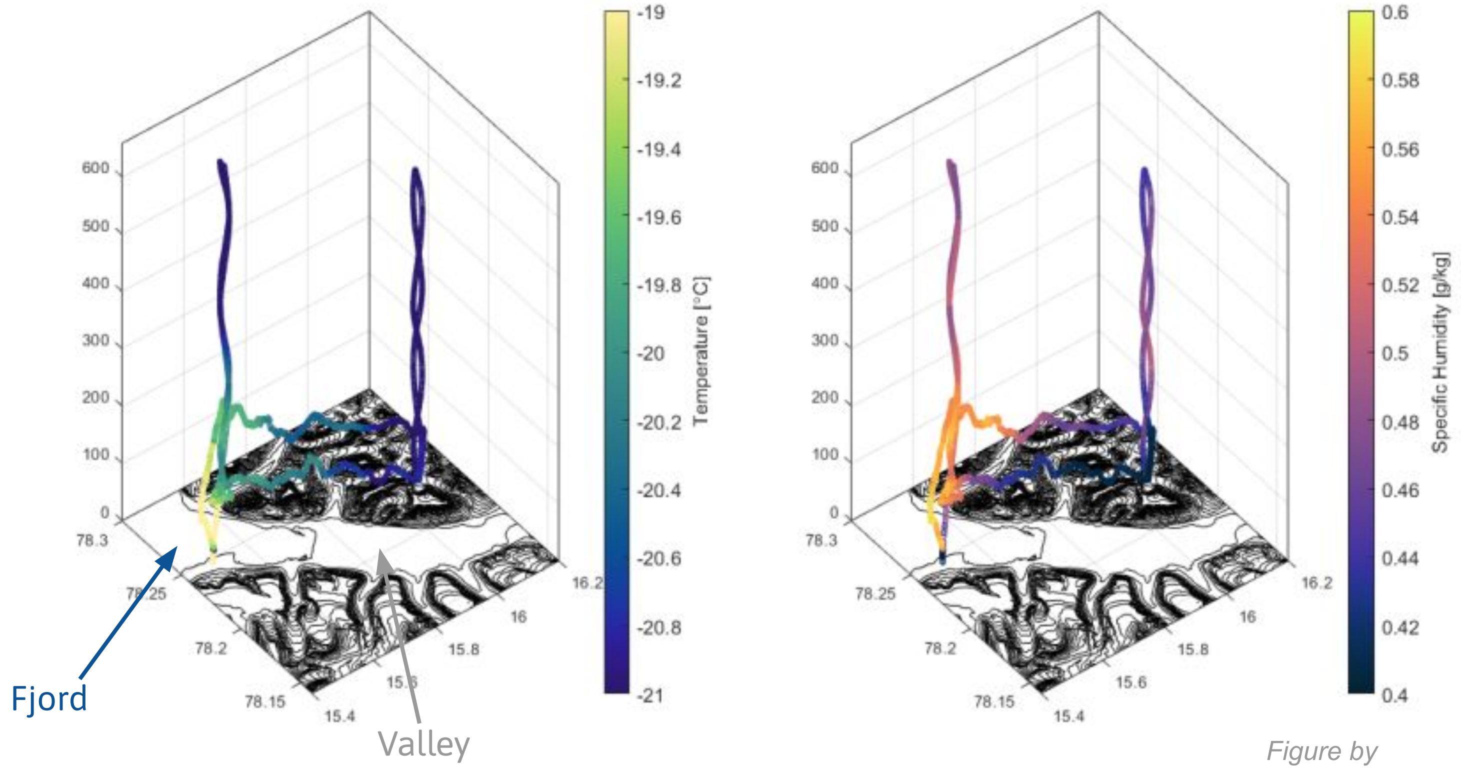

Figure by Cyril Gapp, Florian Lippl and Sonja Wahl

The drone operations were carried out in collaboration with [NORCE]

Mesoscale flow features, as seen by Arome Arctic

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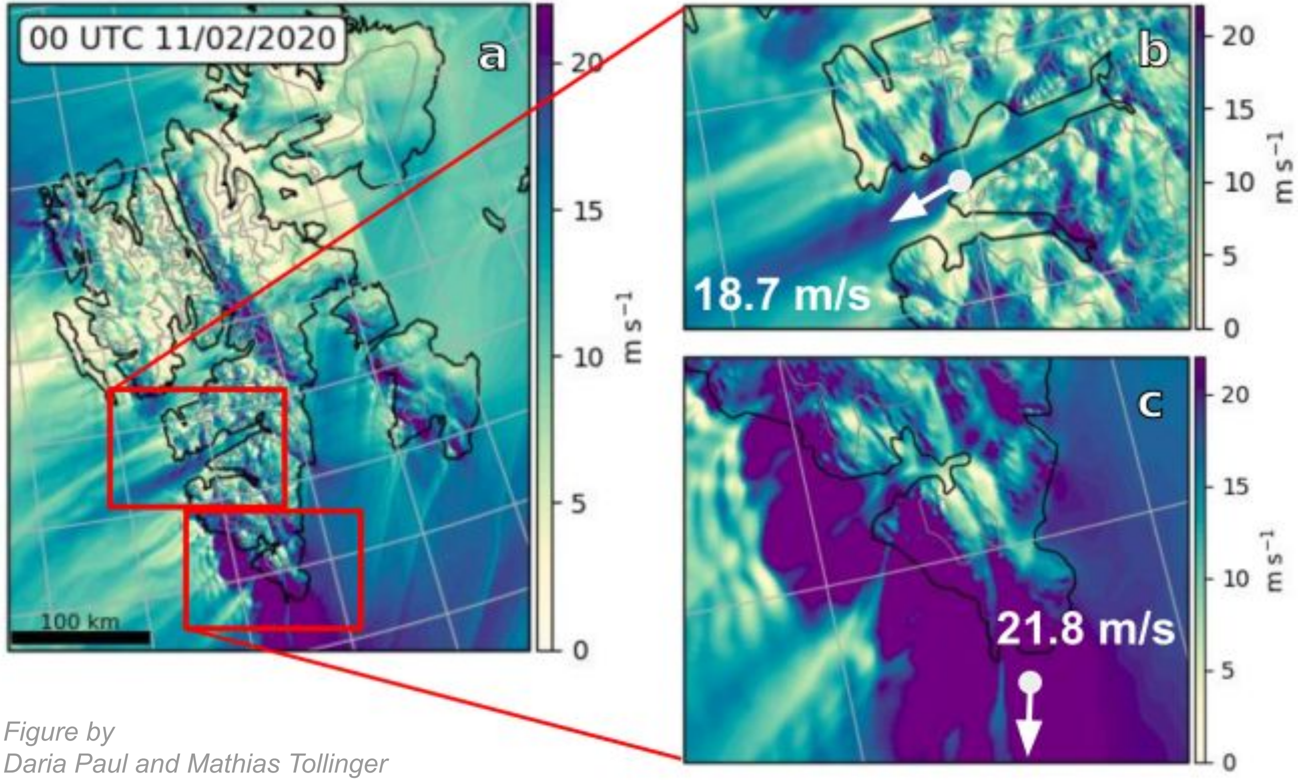

Fjord jet in Van Mijenfjorden

Downslope flow acceleration and tip jet near South Cape

Figure by
Daria Paul and Mathias Tollinger

Summary

- UNIS field courses offer valuable, model-independent observations to be used for model validation.
- The sub-km experiment improved both the spatial structure and overall verifications scores of the near-surface temperature and wind forecasts compared to the 2.5 km experiment.
- The sub-km experiment successfully captured the wind channelling through the Adventdalen valley and the temperature field associated with it. In contrast, the 2.5 km experiment does not effectively resolve the topographic effects of the valley
- In a situation of a cold-pool development, the sub-km experiment better resolved the timing of the cold-air pool generation,the spatial variability of temperature and the vertical temperature gradient than the 2.5 km experiment.
- The sub-km model system for Svalbard is currently being further investigated for longer periods and for an optimal setup

Picture by the UNIS AGF-350/850 2020 students