Norwegian Meteorological Institute

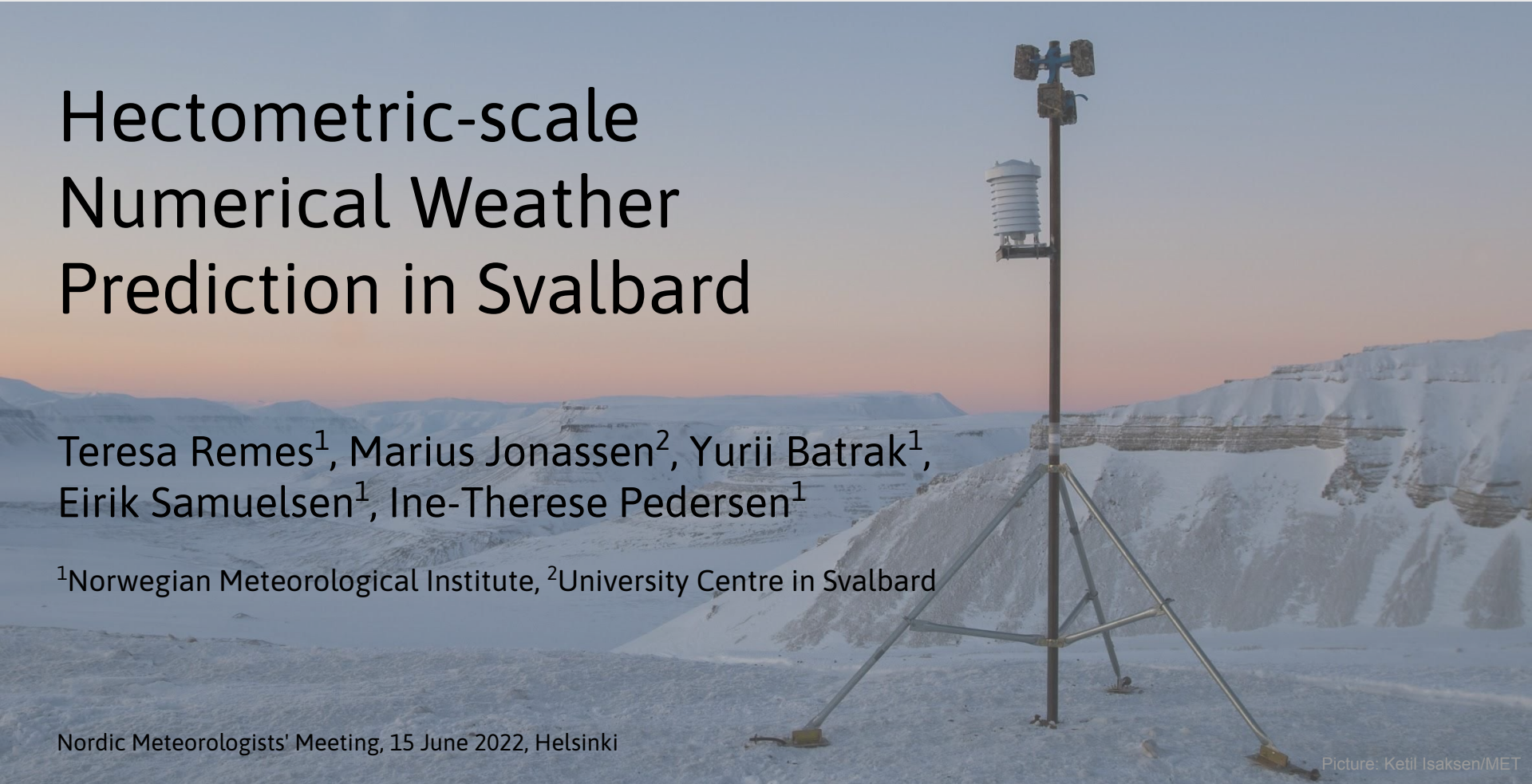
UNIS The University Centre in Svalbard

Hectometric-scale Numerical Weather Prediction in Svalbard

Teresa Remes[1], Marius Jonassen[2], Yurii Batrak[1], Eirik Samuelsen[1], Ine-Therese Pedersen[1]

[1]Norwegian Meteorological Institute, [2]University Centre in Svalbard

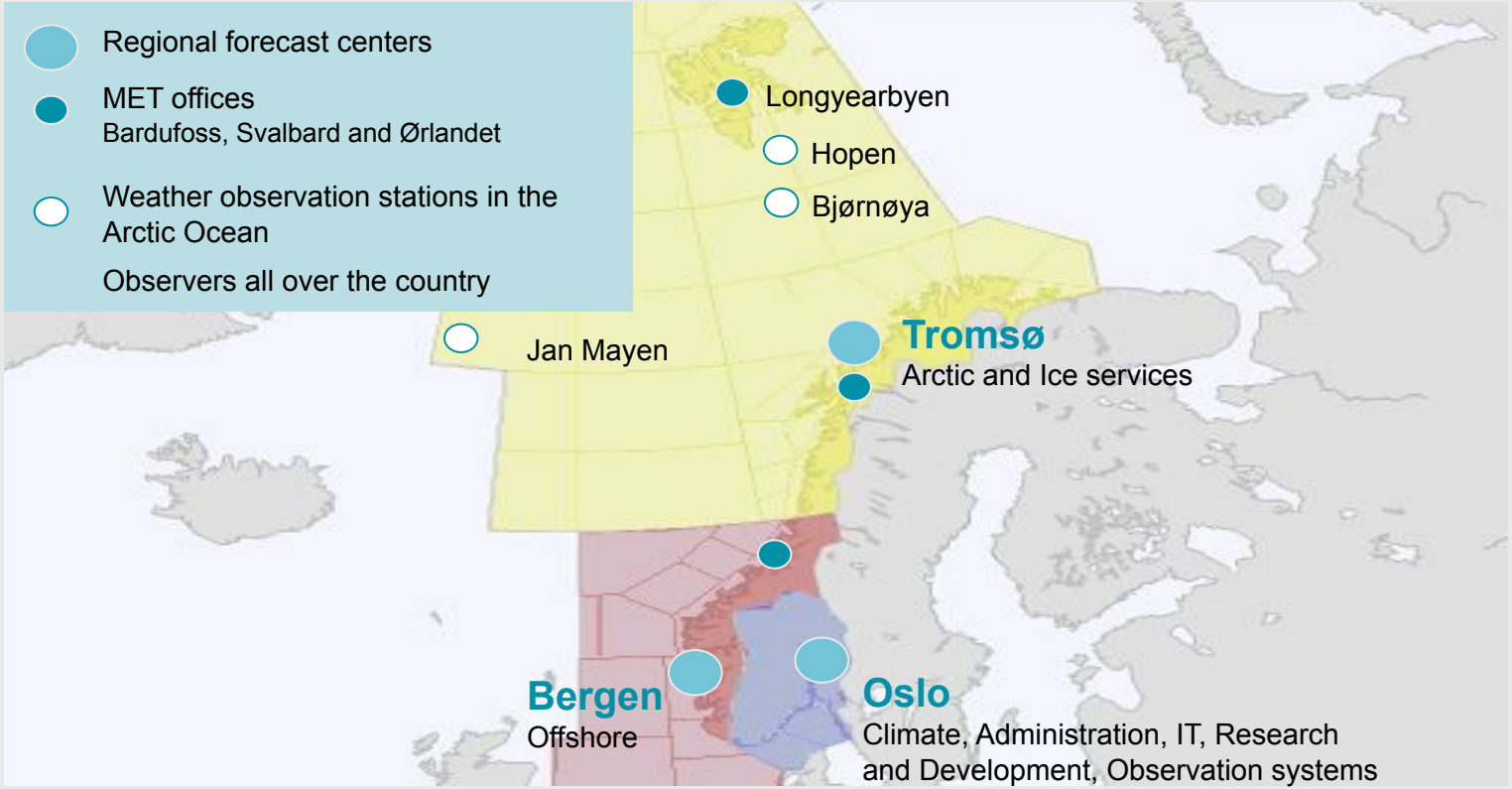
Nordic Meteorologists' Meeting, 15 June 2022, Helsinki



Picture: Ketil Isaksen/MET

Deliver reliable and accurate weather forecasts to safeguard life and property

Geographical responsibility



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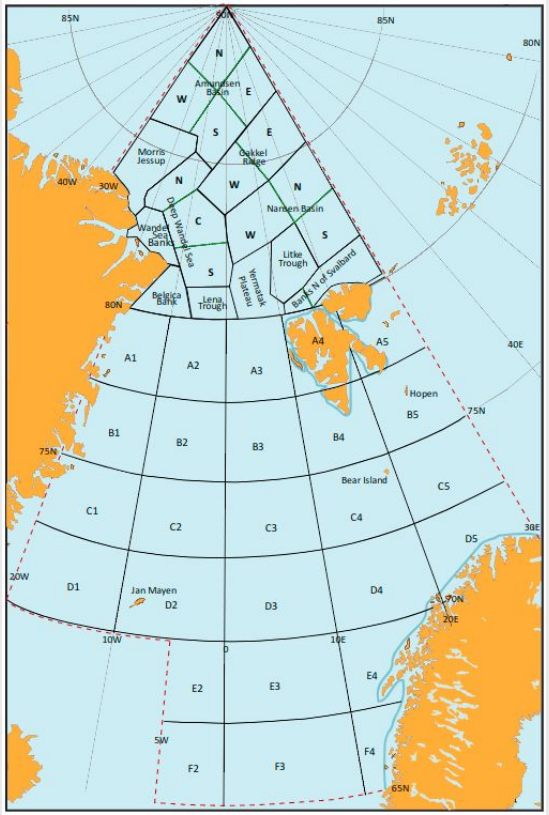
Agreements



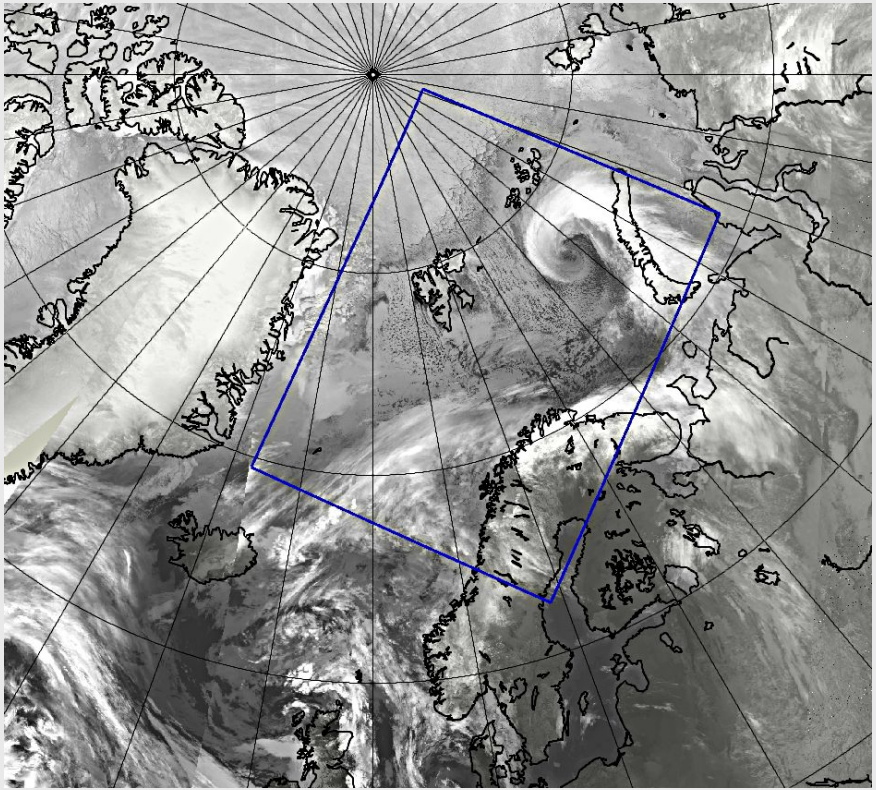
METAREA XIX

Arctic Search and Rescue Agreement

Norwegian Meteorological Institute

AROME-Arctic

- 2.5 km^2 non-hydrostatic operational forecast model for the European Arctic, 65 vertical levels
- 66 hour forecasts 8 times daily, 1:45 h cut-off, one member
- HARMONIE-AROME 43h2.1
- ECMWF IFS-HRES on boundaries
- SURFEX surface model
- 3-hr cycling for DA (3D-VAR and OI)
    - Conventional observations
        - SYNOP, SHIP, BUOY, AMDAR, AIREP, TEMP
    - Satellite radiances
        - AMSU-A, MHS, IASI (Randriamampianina et al., 2019)
    - Satellite retrievals
        - Scatterometer - ocean surface winds (Valkonen et al. 2017)
        - Atmospheric Motion Vectors (AMVs) (Randriamampianina et al. 2017)
    - Dynamic emissivity with microwave assimilation (Karbou et al. 2014)



Forecast challenges unique for the Arctic

1. Limited availability and quality of observations
2. The use of observations challenged by the snow and ice-covered surfaces
3. Large uncertainties in the model representation of physical processes
4. Arctic small-scale processes particularly relevant for the forecast accuracy

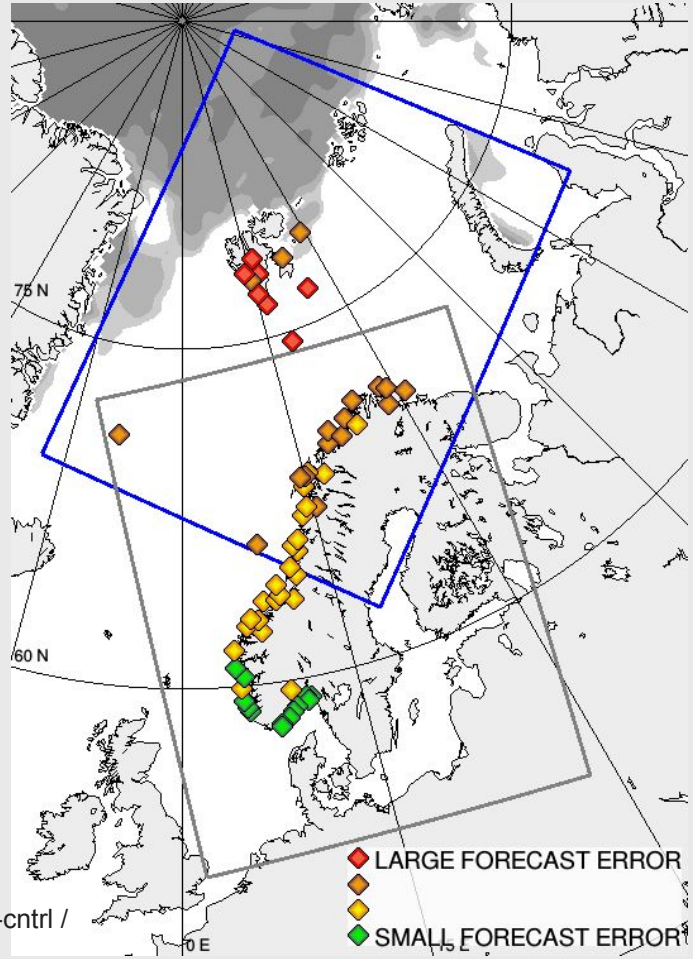
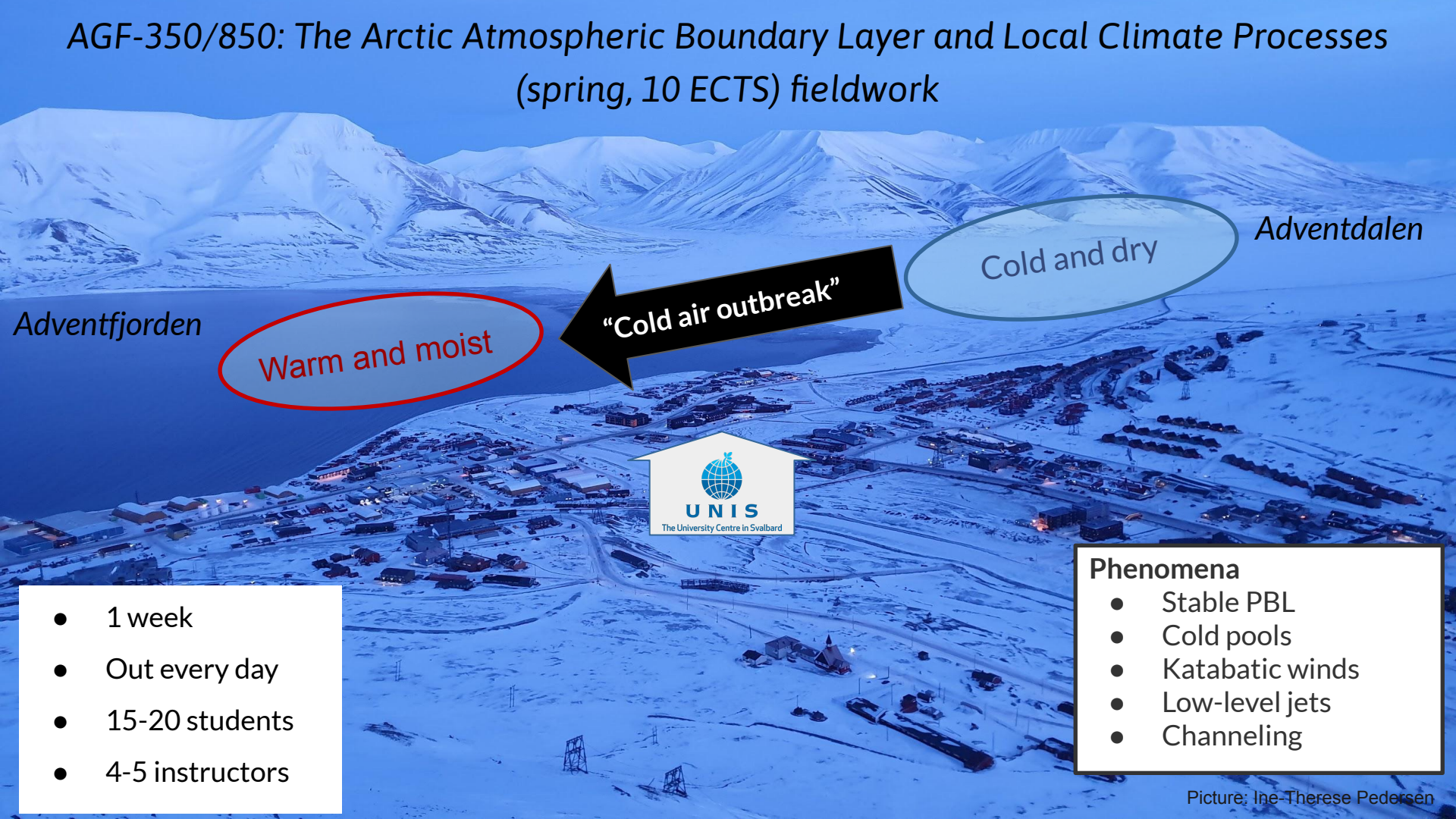


Figure:
RMSE of MSLP forecasts (+24h to +48h, DJF 2016-2017) from AROME-Arctic and MEPS-cntrl / standard deviation of observed MSLP (M. Køltzow, MET Norway)

AGF-350/850: The Arctic Atmospheric Boundary Layer and Local Climate Processes (spring, 10 ECTS) fieldwork



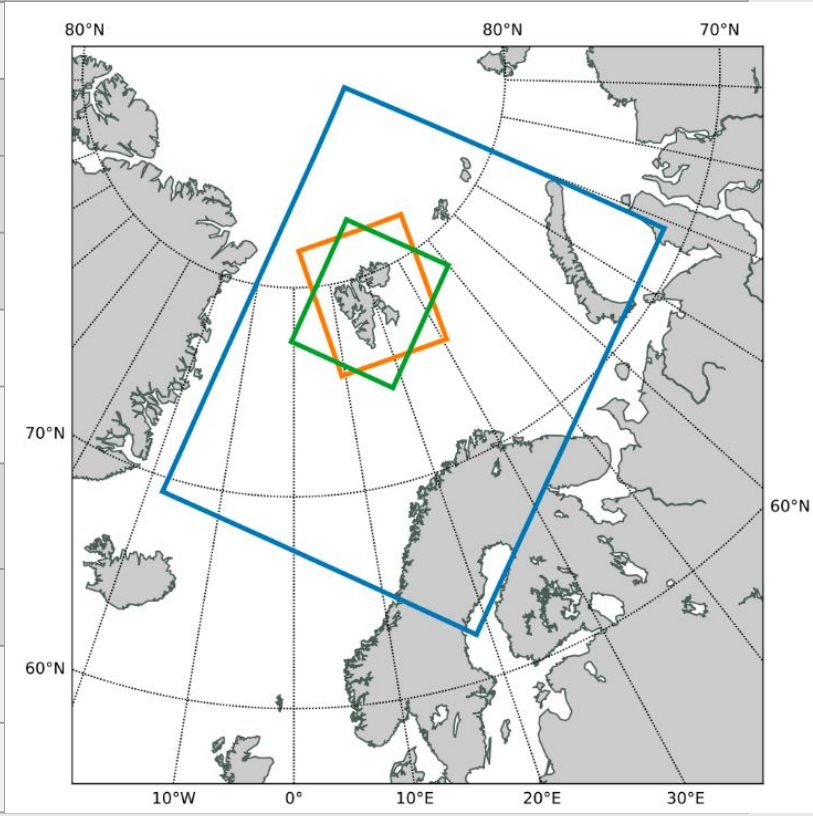
- 1 week
- Out every day
- 15-20 students
- 4-5 instructors

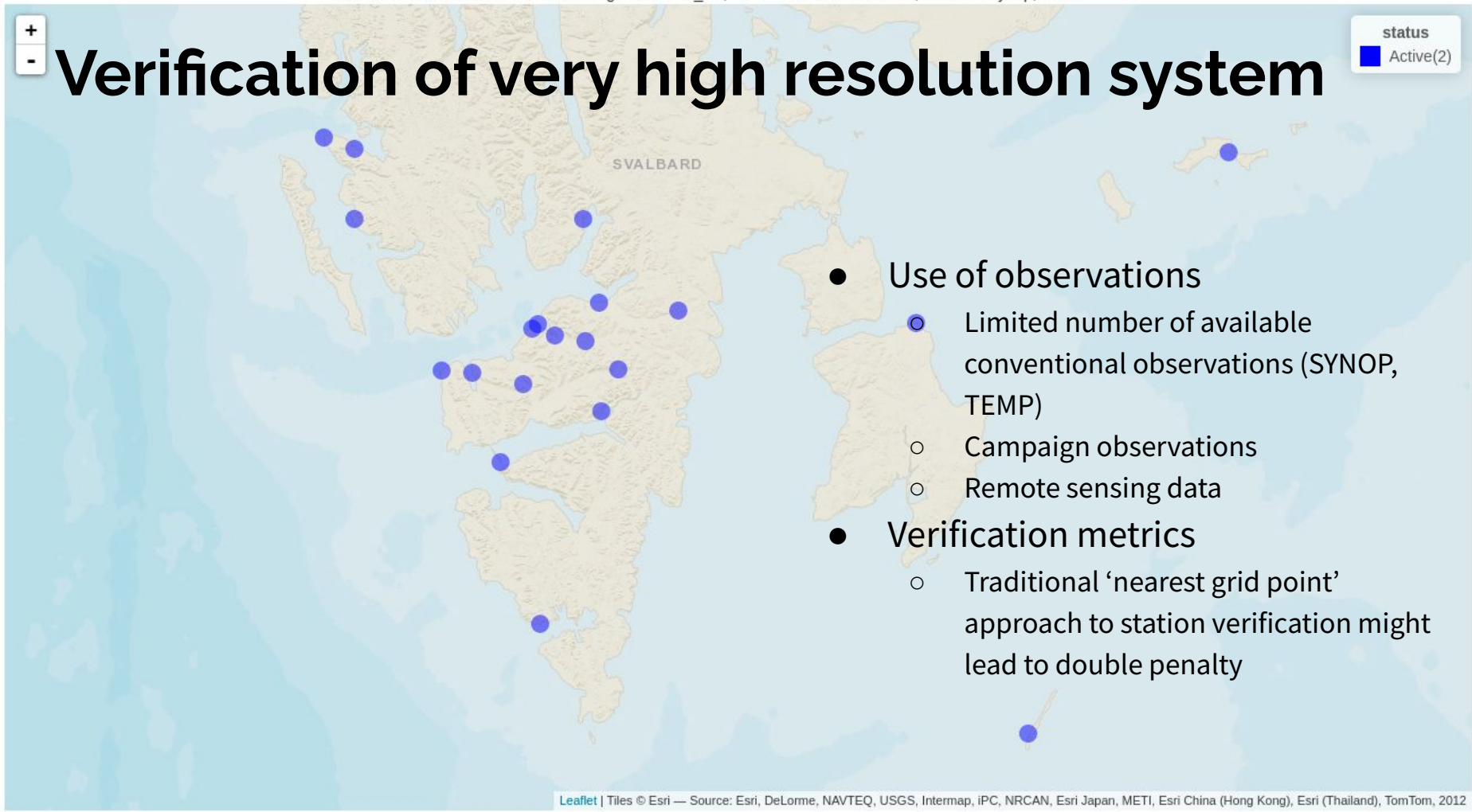
Phenomena

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

Picture: Ine-Therese Pedersen

Hectometric experiments for Svalbard

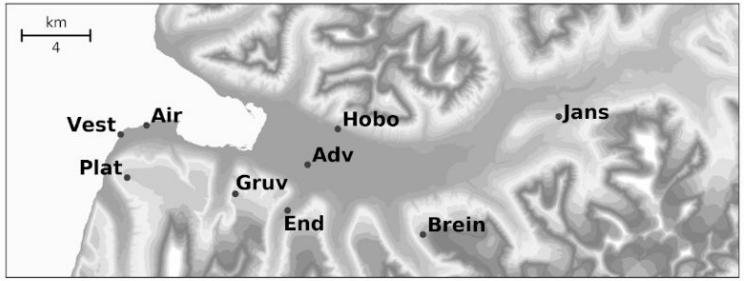
Year	Period	Purpose	Setup
2018	***11-17 February***	***UNIS field campaign 2018***	
2019	1-31 January	Arktis2030	
	17-21 February	Arktis2030	
	Several cases 2019-2020	Arktis2030	
2020	***7 February - 20 April***	***UNIS field campaign 2020***	
	6 February - 17 April	AS <-> ROMS 500m “coupling”	
2021	7-11 November	Impact of boundaries	
	1 case 2021	***Alertness***	
2022	2-18 February	UNIS field campaign 2022	
	Autumn 2022	N-FORCES project/ UNIS field campaign	



Verification of very high resolution system

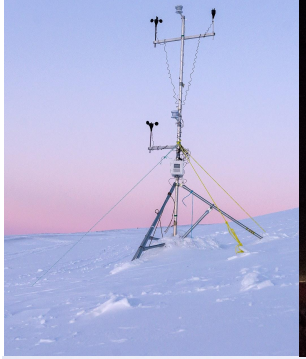
- Use of observations
  - Limited number of available conventional observations (SYNOP, TEMP)
    - Campaign observations
    - Remote sensing data
- Verification metrics
  - Traditional ‘nearest grid point’ approach to station verification might lead to double penalty

February 2018 campaign

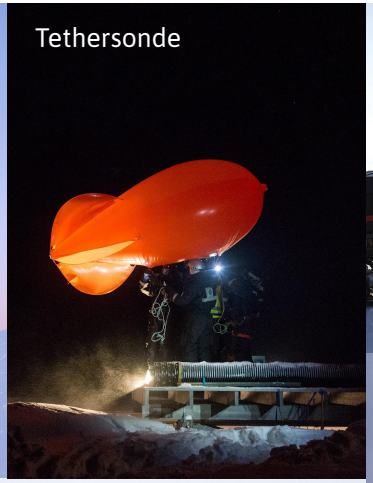


Type of instrumentation	Station	Altitude [m a.s.l.]
Permanent automatic weather stations (temperature, humidity, wind)	Adventdalen Janssonhaugen Gruvefjellet Breinosa Airport Platåfjellet	15 251 464 520 28 435
Temporary automatic weather stations (temperature, humidity, wind)	Endalen Vestpynten Hobo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

Temporary automatic weather station



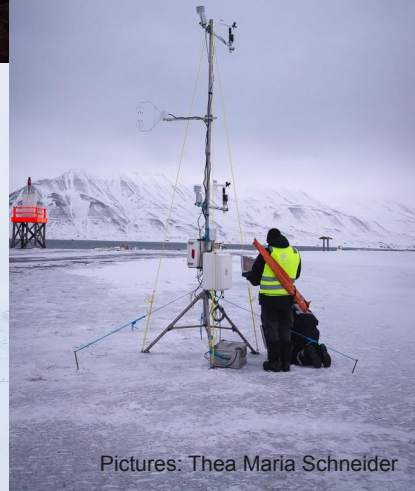
Tethersonde



Snowmobile transects

Permanent automatic weather station including radiometers

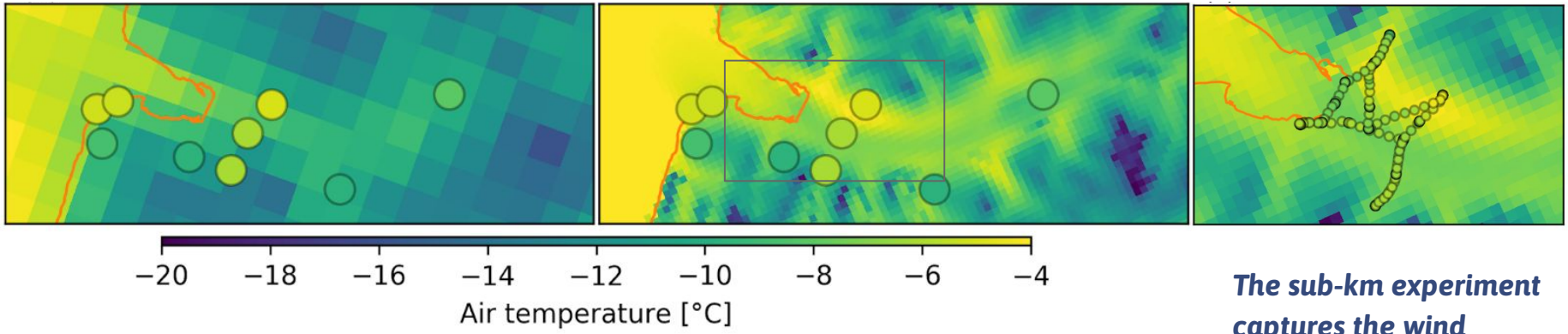
Sonic anemometers

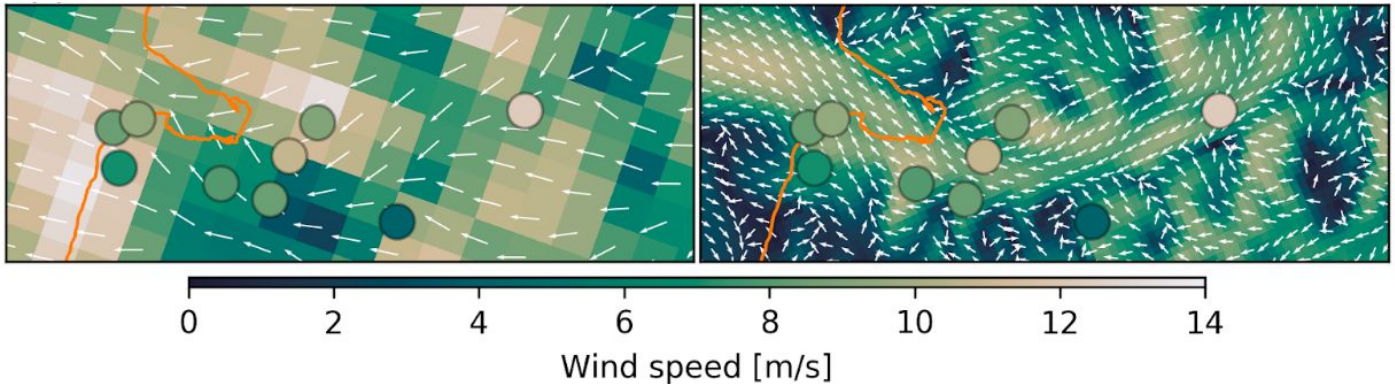


Pictures: Thea Maria Schneider

Situation of valley wind channelling

Alertness



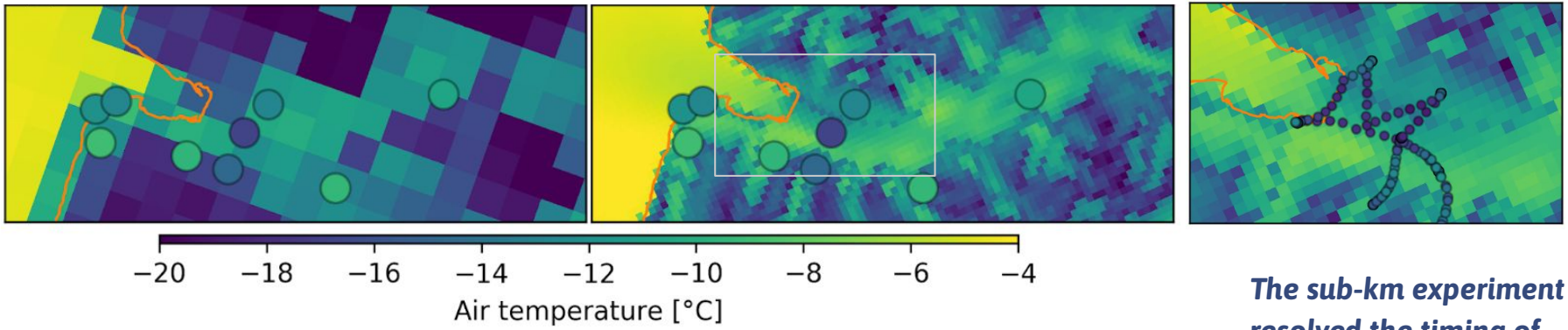


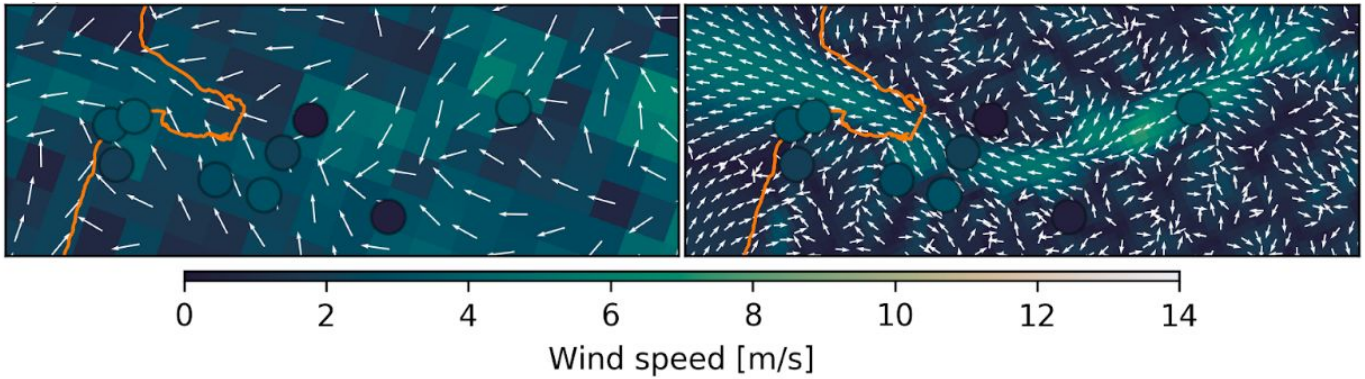
The sub-km experiment captures the wind channelling and the temperature field associated with it

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

Valkonen et al (2020) Evaluation of a sub-kilometre NWP system in an Arctic fjord-valley system in winter, DOI: 10.1080/16000870.2020.1838181

Cold-air pool situation



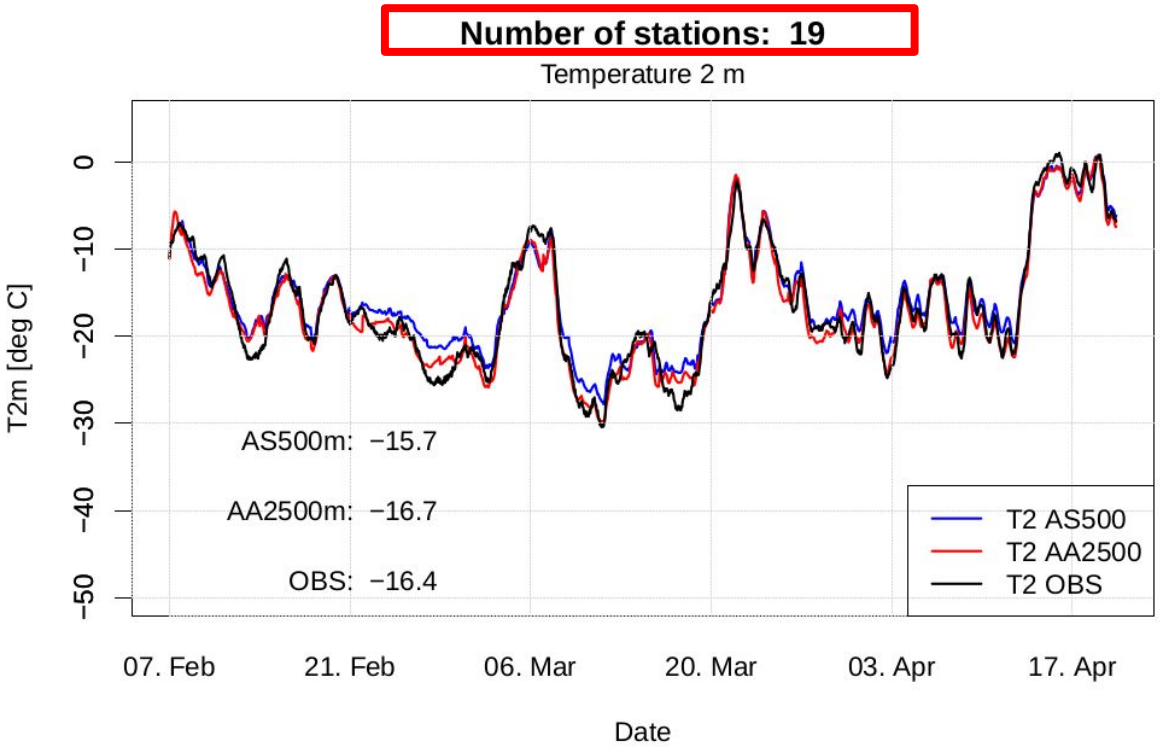


The sub-km experiment resolved the timing of the cold-air pool generation, and the vertical temperature gradient better than the 2.5 km experiment.

Valkonen et al (2020) Evaluation of a sub-kilometre NWP system in an Arctic fjord-valley system in winter, DOI: 10.1080/16000870.2020.1838181

Temperature verification for 2020

Cold period, many days with mean(T) < -20 °C



BLUE: AS500

RED: AA2500

BLACK: OBS

From Eirik Samuelsen

Summary verification scores

7 February - 20 April 2020, 19 stations

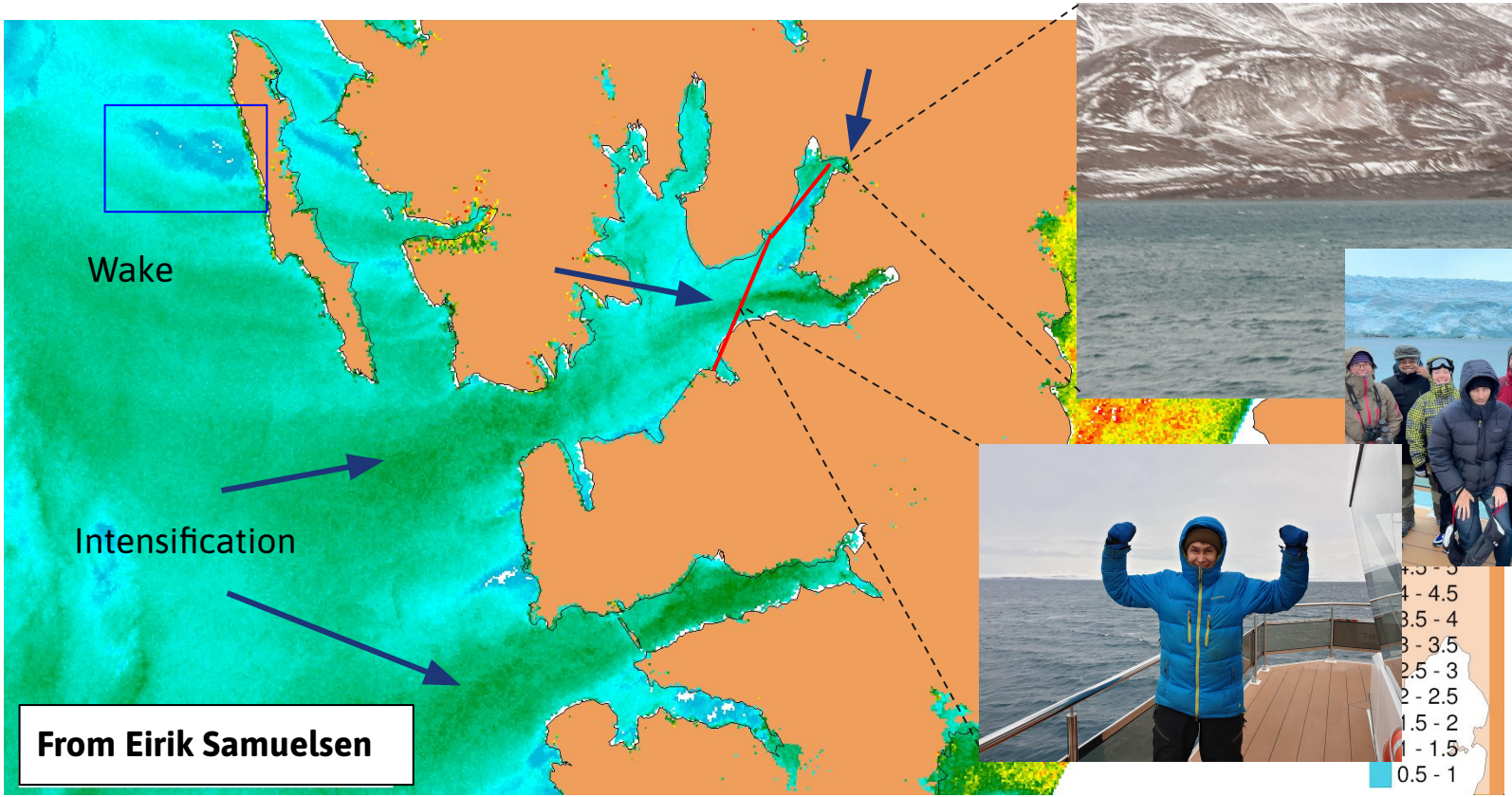
		BIAS	MAE	correlation
2-m temperature (°C)	AA2500	-0.26	2.24	0.93
	AS0500	0.75 👎	2.15 👍	0.94 👍
10-m wind speed (m/s)	AA2500	0.65	2.53	0.69
	AS0500	0.25 👍	2.26 👍	0.74 👍

Higher Bias -
Lower MAE +
Higher correlation +

Lower Bias +
Lower MAE +
Higher correlation +

SAR “observations” 12 November 2021 at 07 UTC

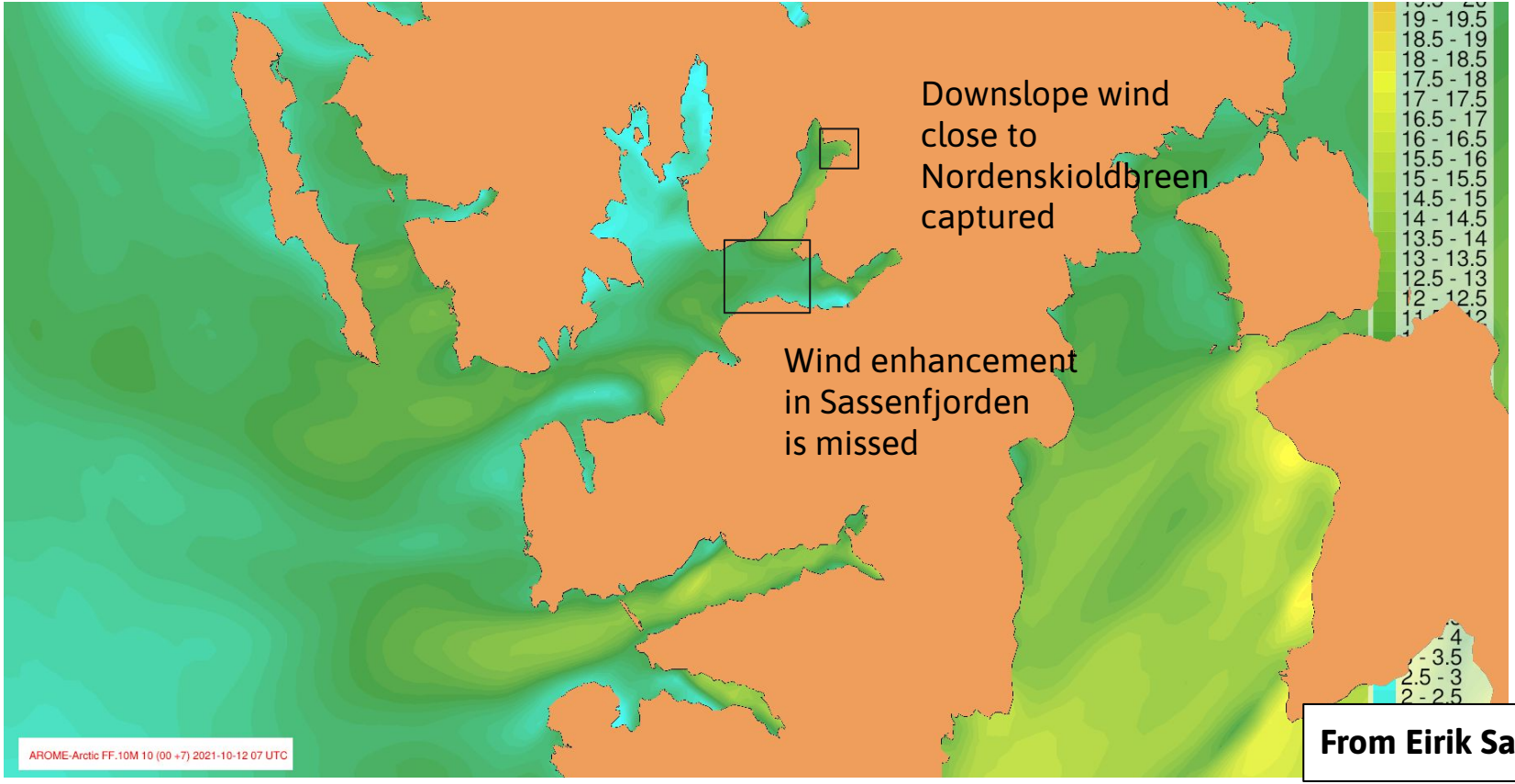
Alertness



There were some temporal changes in wind, particularly in the evening when the front passed

AROME-Arctic (2.5 km) winds

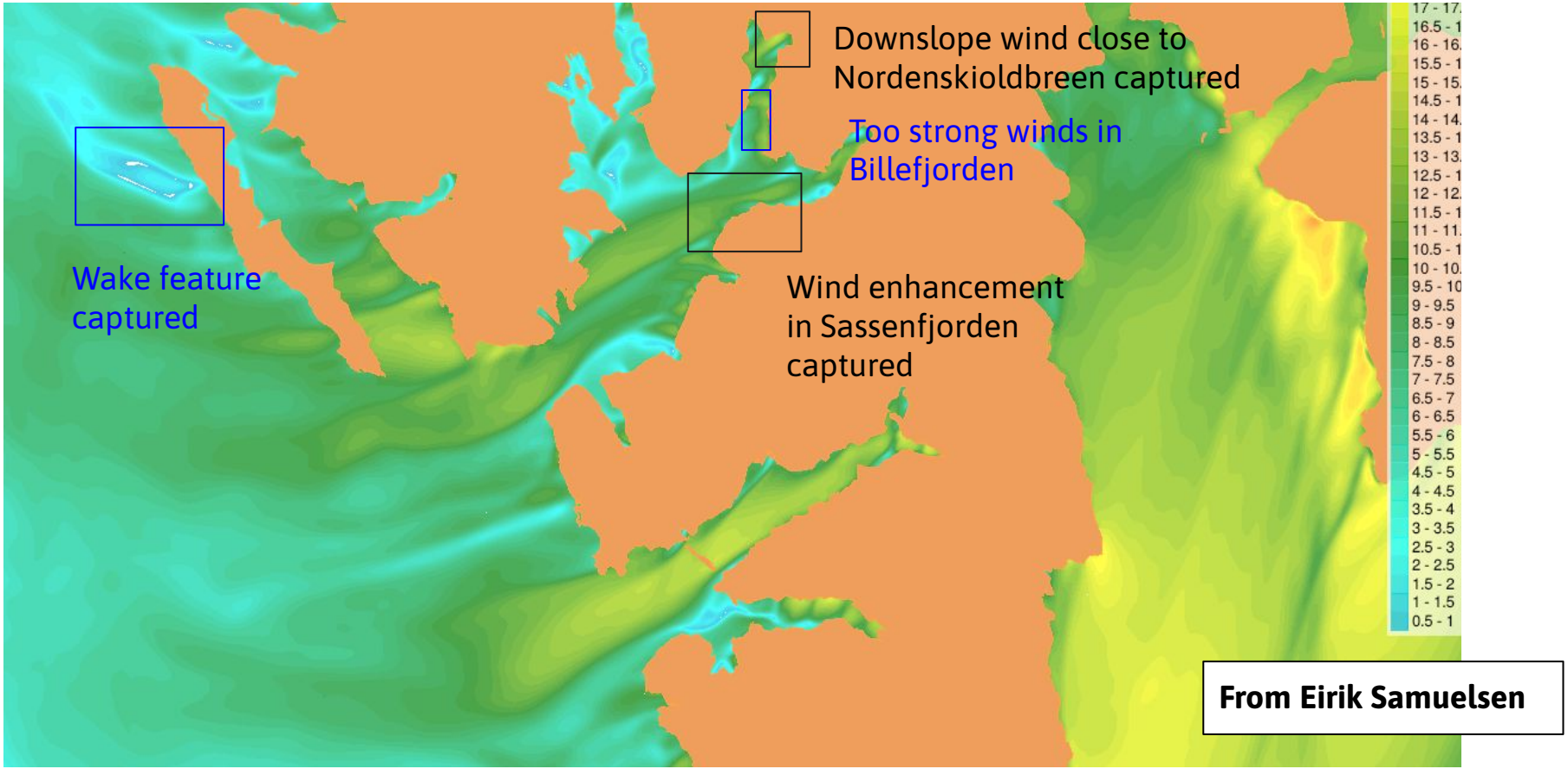
Alertness



From Eirik Samuelsen

AROME-Svalbard (500 m)

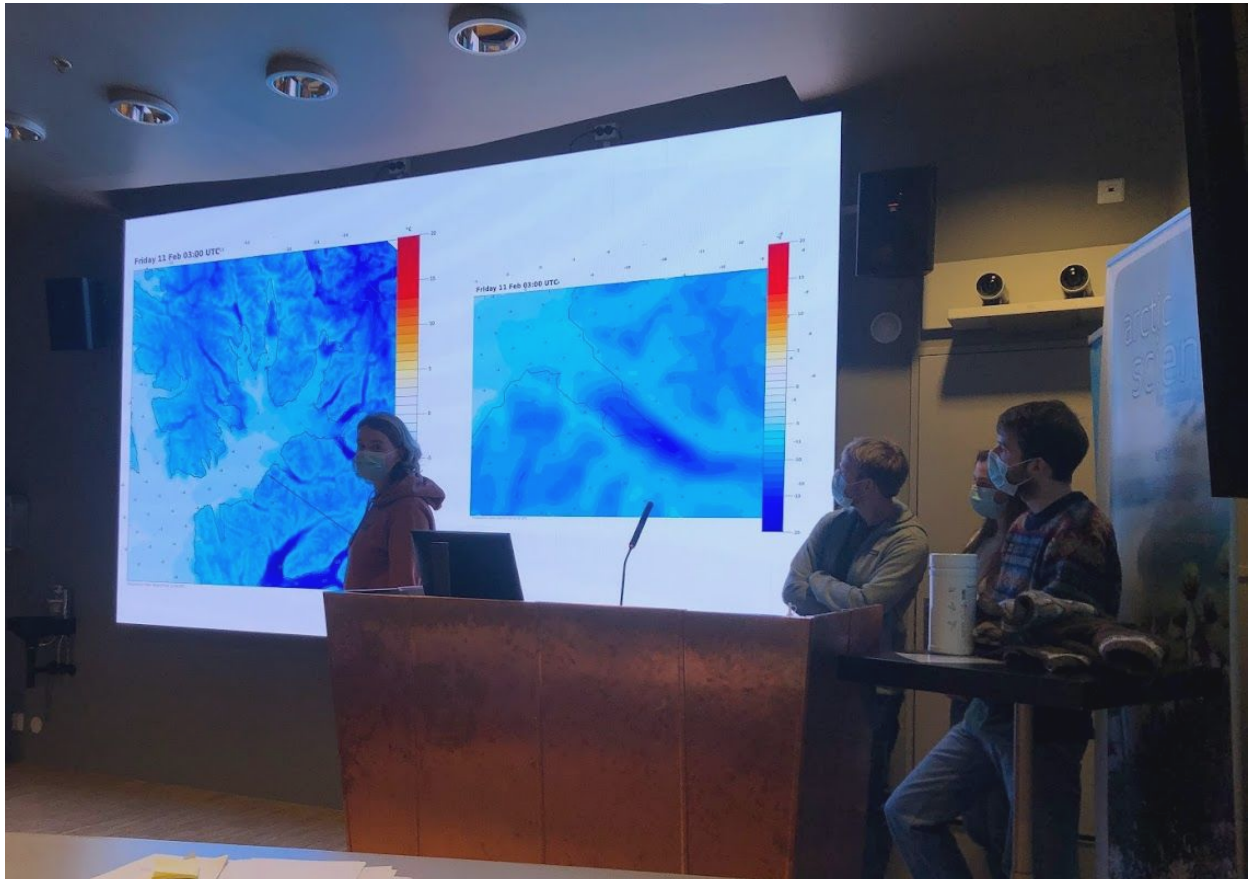
Alertness



From Eirik Samuelsen

Safety: OPEN *forecast data*

Fieldwork planning with students 2022



From Marius Jonassen, UNIS

Conclusions

- Promising results: wind speed forecast is improved!
- Impact on temperature is more complex
- Additional observations and process-based diagnostics are needed to get a full picture of model performance
- Computationally expensive
- The results suggest that the increase in resolution should be done together with further development of other parts of the model system.

Network for meteorological expertise in Svalbard (N-FORCES)

Share meteorological modelling, observational and forecasting expertise to enhance the predictive capacities in the Arctic

The Research Council of Norway

Norwegian Meteorological Institute

UNIS
The University Centre in Svalbard

AWI

Consiglio Nazionale delle Ricerche

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Consiglio Nazionale delle Ricerche

Svalbard Archipelago. Sentinel-2, 29 May 2022.

PROGRAMME OF THE EUROPEAN UNION

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Europe's eyes on Earth

Thank you!

Credit: European Union, Copernicus Sentinel-2 imagery - Processed by @DEFIS_EU.