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Icing in the Arctic

Cases from Svalbard

Ine-Therese Pedersen (MET Norway)
Slides also from Eirik Samulesen (MET Norway)

02.02.2023

Photo: Borealis 360 Weathercam

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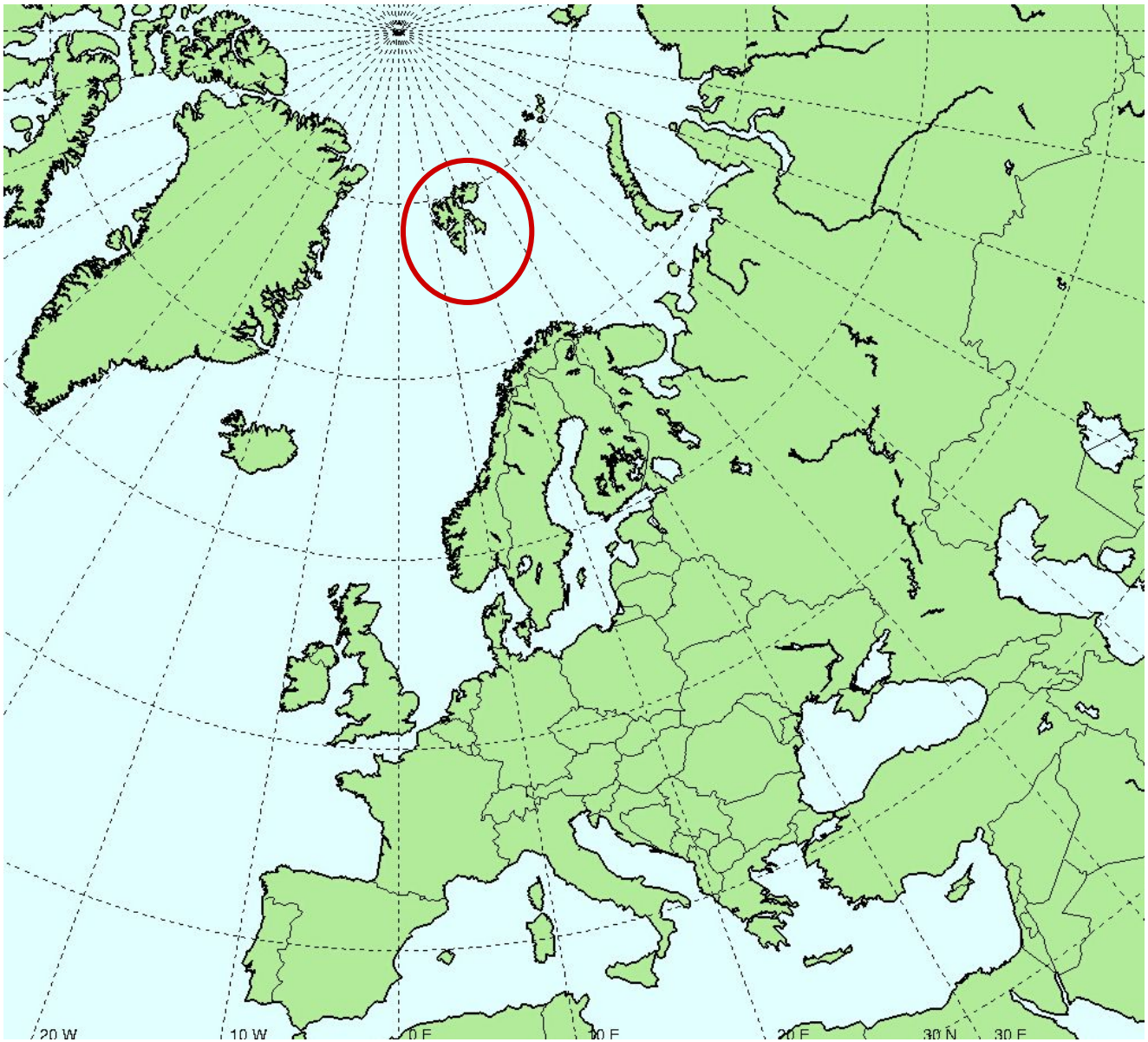
Topics

* Overview of Svalbard
* Air traffic on the airport
* Generally on the subject icing
* Especially on icing in the Arctic
* Cases
* Summary

Svalbard N78 E16



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- The Svalbard Treaty of 1920 recognizes Norwegian Sourvereignty and established Svalbard as a free economic zone and a *demilitarized* zone

- Population:
  - Longyearbyen: ~2700, 55 % Norwegians
  - Ny-Ålesund: 40 (winter), 300 (summer)
  - Barentsburg: 500
  - Pyramiden: 6
  - ~22 000 reindeer
  - ~700 polar bears
  - No cats

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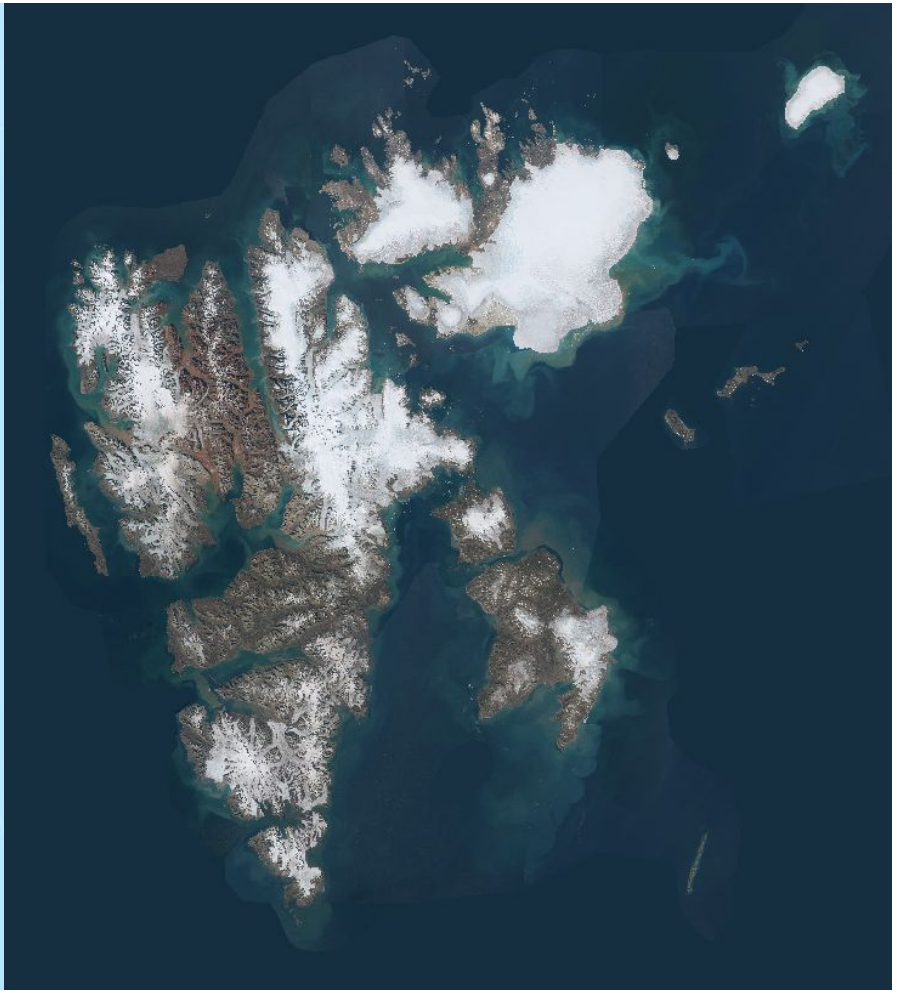
Svalbard: 61 000 km2, 60 % covered with glacier



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Longyearbyen

January

June

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- Meteorologist: Ine-Therese Pedersen
- Aviation forecaster at Svalbard Airport (ENSB) since april 2018.
- Runs the only civil weather office at an airport in Norway.
- Delivers daily (weekdays) weather forecasts to the airport and all aviation traffic there.
- Weather briefs by phone/e-mail to users of the airport, for instance Airbus A320, Boing 737, Dornier, CRJ2, Dakota, Beech 250 and all helicopters.

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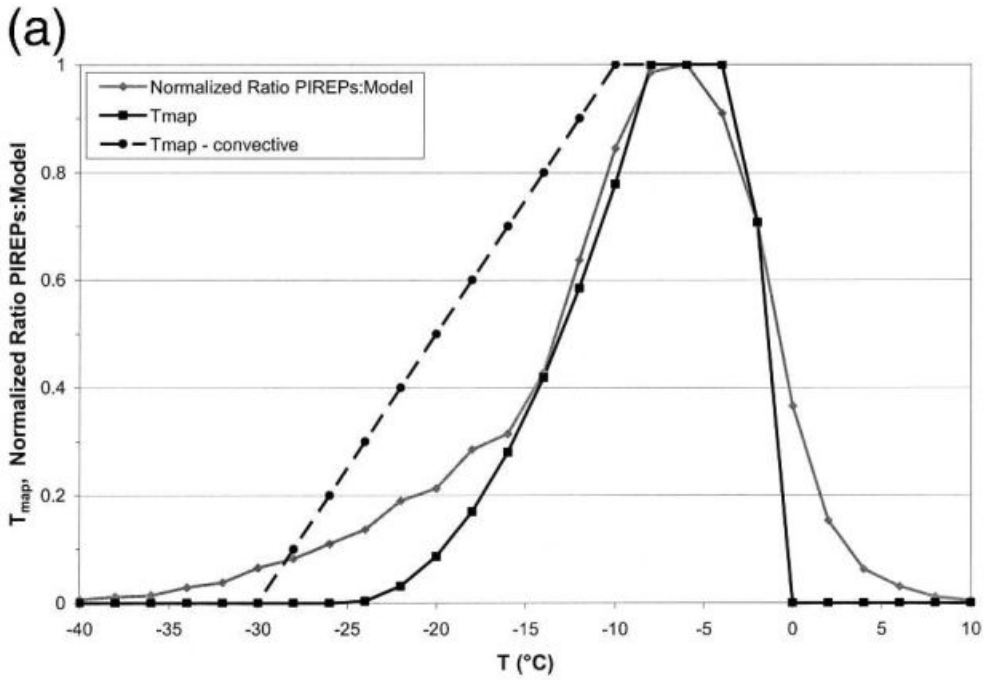
Icing

- Water in minus degrees
- Precipitation under clouds: Supercooling [rain or drizzle]
- Cloud droplets: In-cloud icing
- Theoratically down to -40 deg, but usually not below -20 deg
  - MTW (mountain waves)
  - Convective conditions
- What about just below 0?

Svalbard airport ENSB : SC undulatus opacus



Bernstein et al. (2005)

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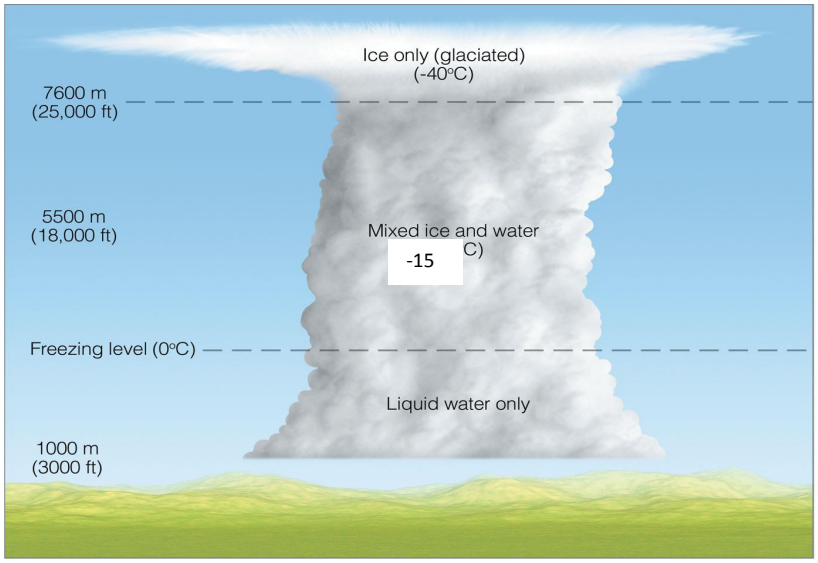
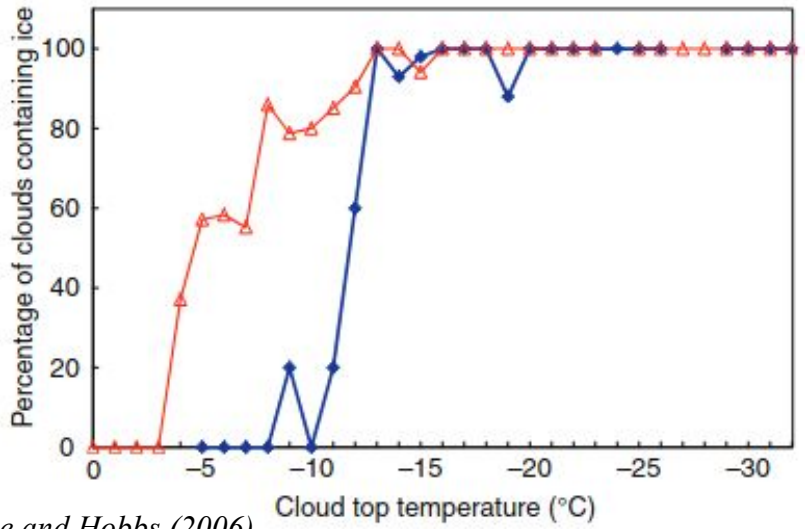
Distribution of water in clouds and in-cloud icing

- Cold clouds: T < 0 deg C
- On middle and high latitudes, all clouds with precipitation are *cold clouds*
- Ice cores: T < -4 deg C
- Ice growth rapidly: T < -12 deg C
- Small chance of "pure" water clouds with T < -20 deg C





Wallace and Hobbs (2006)

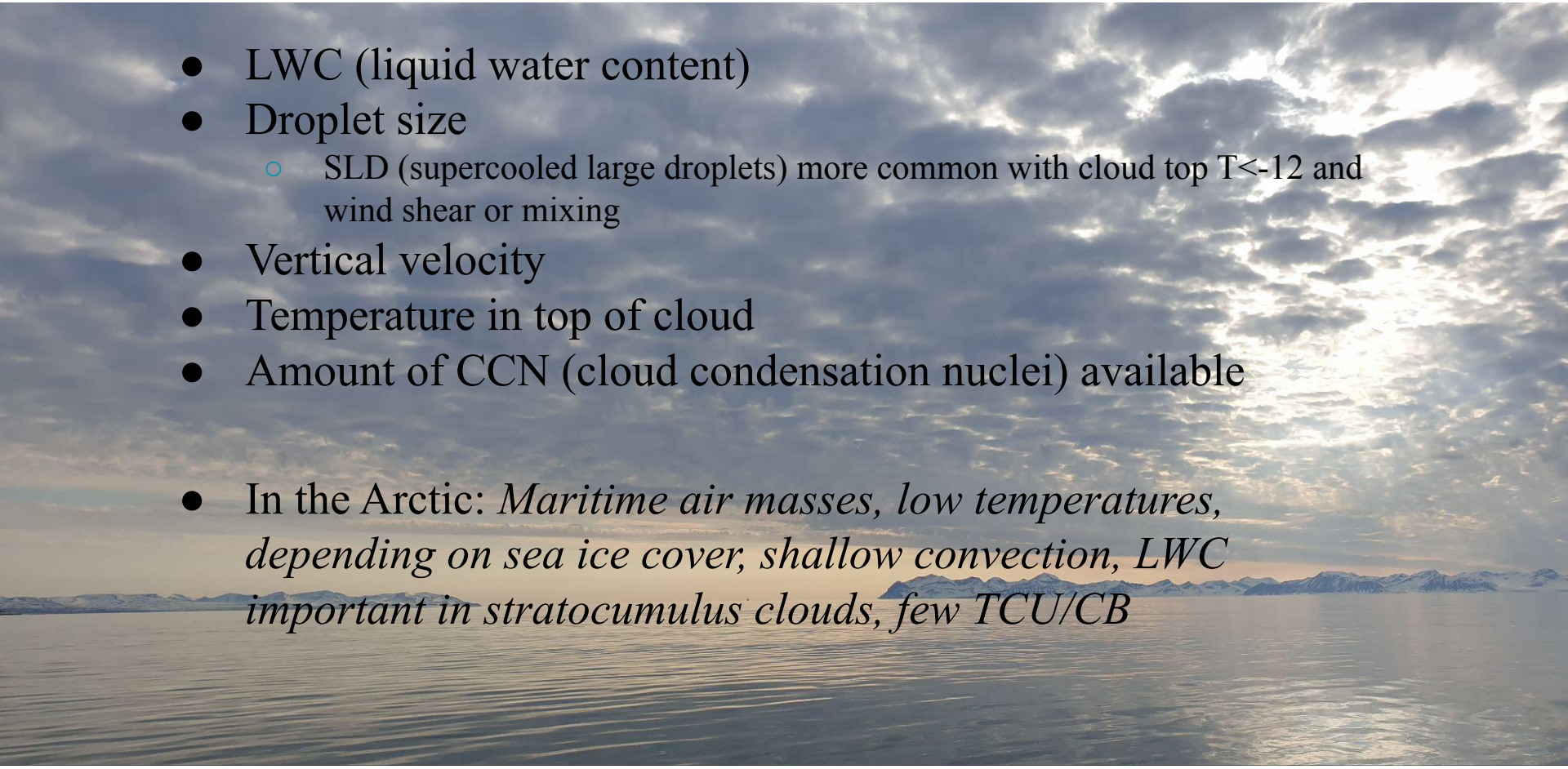
Blue line: Continental CU with -18 to -8 deg, no drizzle or raindropplets before forming ice

Red line: "Pure" maritim CU and "pure" arctic stratiform clouds -25 to -3 deg containing rain or drizzle before forming of ice

Processes that reduces water in clouds

- Bergeron-Findeisen process: Ice crystals grow at the expense of water
- Water freezes on ice crystals (rime)
- Precipitation decrease water content in cloud
- If no production of NEW water droplets→ reduced LWC (liquid water content) in cloud
- Ice crystals falling through the cloud and reducing LWC, will reduce risk of icing
    - EXCEPTION: Thick convective clouds (strong vertical movement) and orographic clouds

Important parameters



- LWC (liquid water content)
- Droplet size
  - SLD (supercooled large droplets) more common with cloud top T<-12 and wind shear or mixing
- Vertical velocity
- Temperature in top of cloud
- Amount of CCN (cloud condensation nuclei) available

- In the Arctic: *Maritime air masses, low temperatures, depending on sea ice cover, shallow convection, LWC important in stratocumulus clouds, few TCU/CB*

Autumn 2022 Svalbard airport, typical icing situations

- Synoptic situations with low pressures from south, tracking west of Svalbard and northward into Fram Strait
  - Increased situations with warm, humid air moved northward to Svalbard
  - Increased situations with southerly winds, that gives gust and crosswind on runway
- Stable high pressure south of Svalbard
  - Often southwesterly/westerly winds "pushing" humid, maritime air masses towards mountains forming stratocumulus clouds with in-cloud icing or supercooled precipitation

Longyearbyen and ENSB 14.04.2022

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Cases from autumn 2022

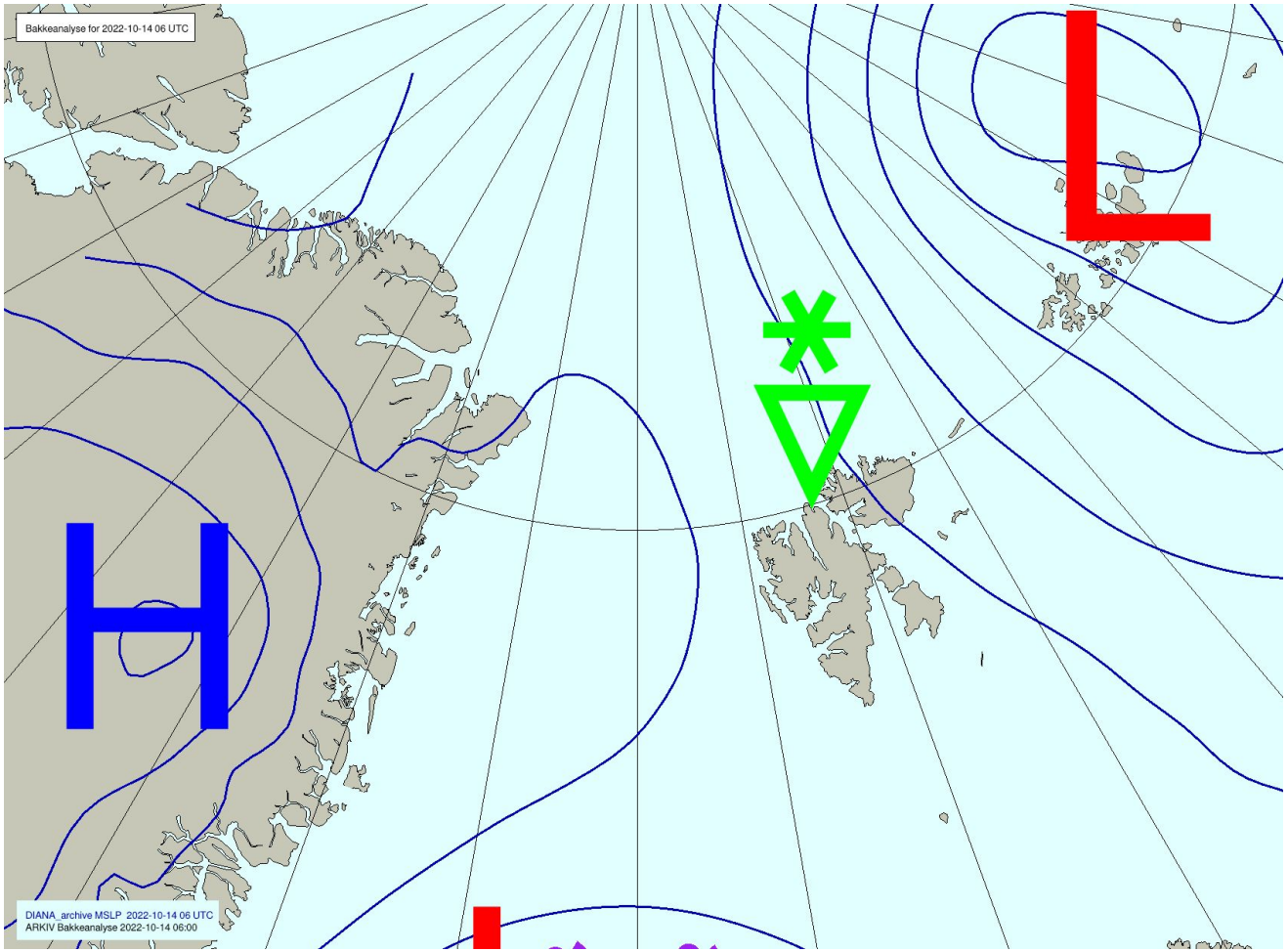
Case 1: 14.10.22

Case 2: 18.10.22

Case 3: 01.11.22

Case 1: 14.10.2022

Surface analysis at 06 UTC



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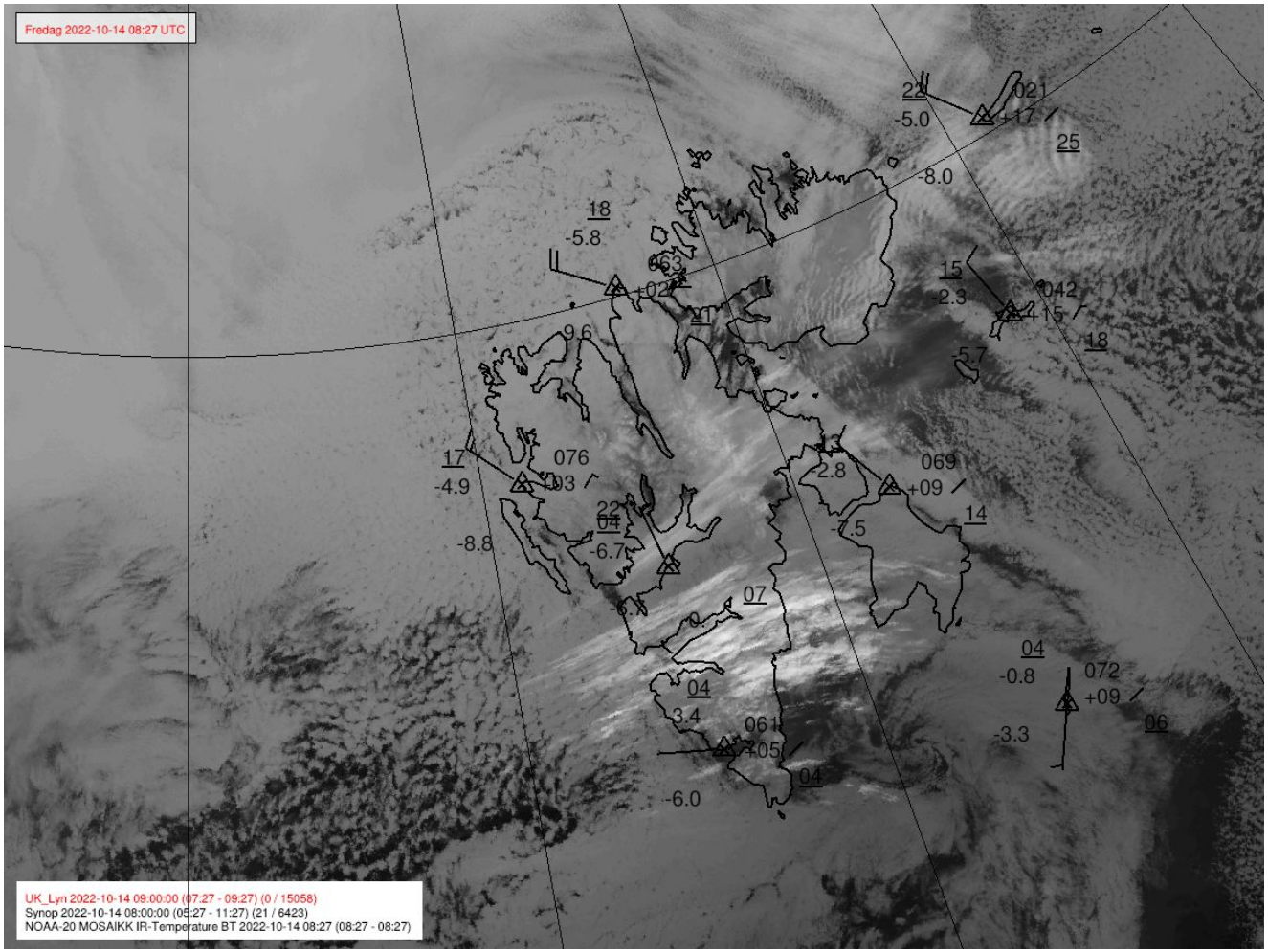
Case 1: 14.10.2022

Satellite picture (IR image) ~08:30 UTC



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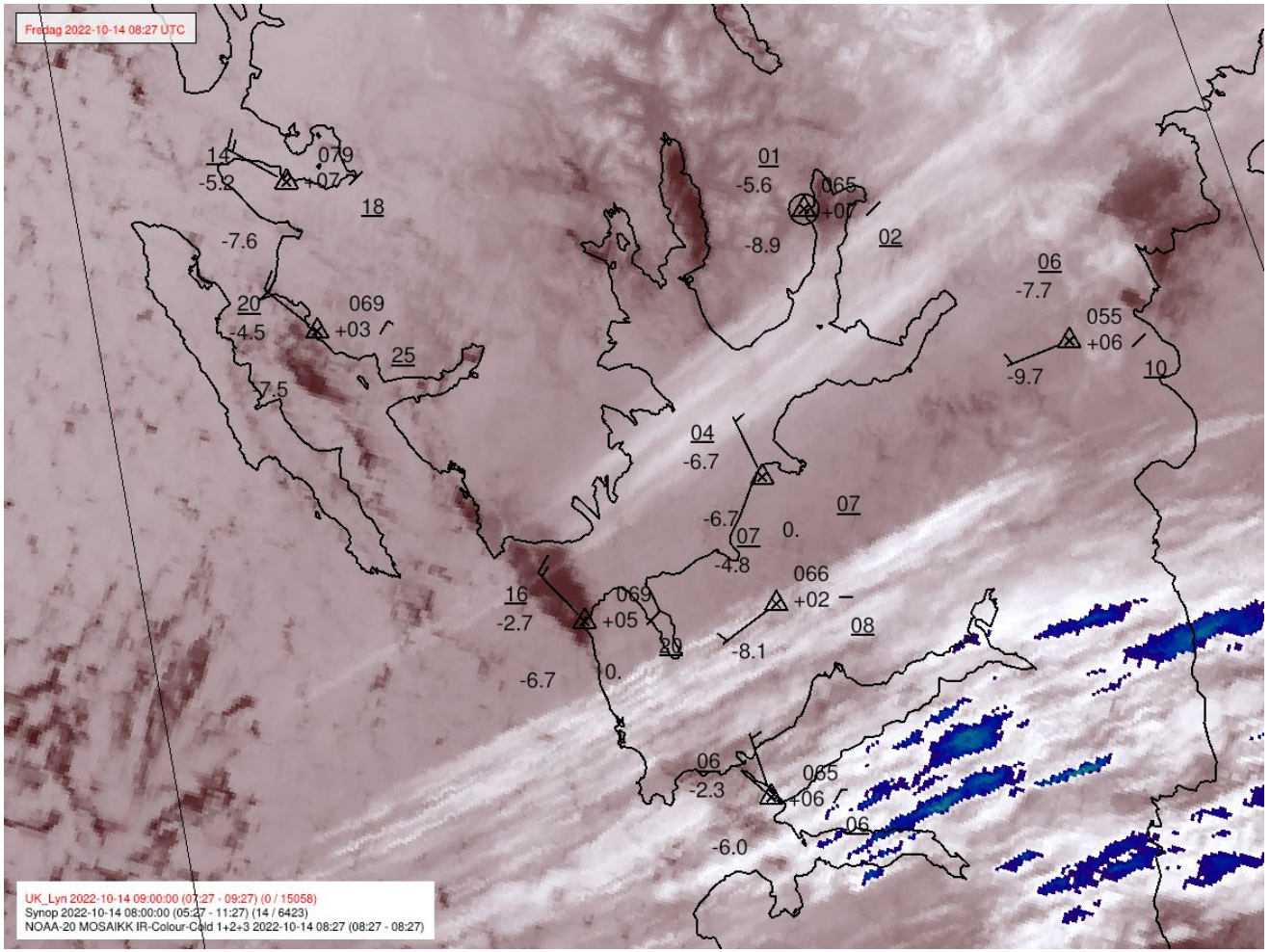
Case 1: 14.10.2022

Satellite picture (IR image) ~08:30 UTC



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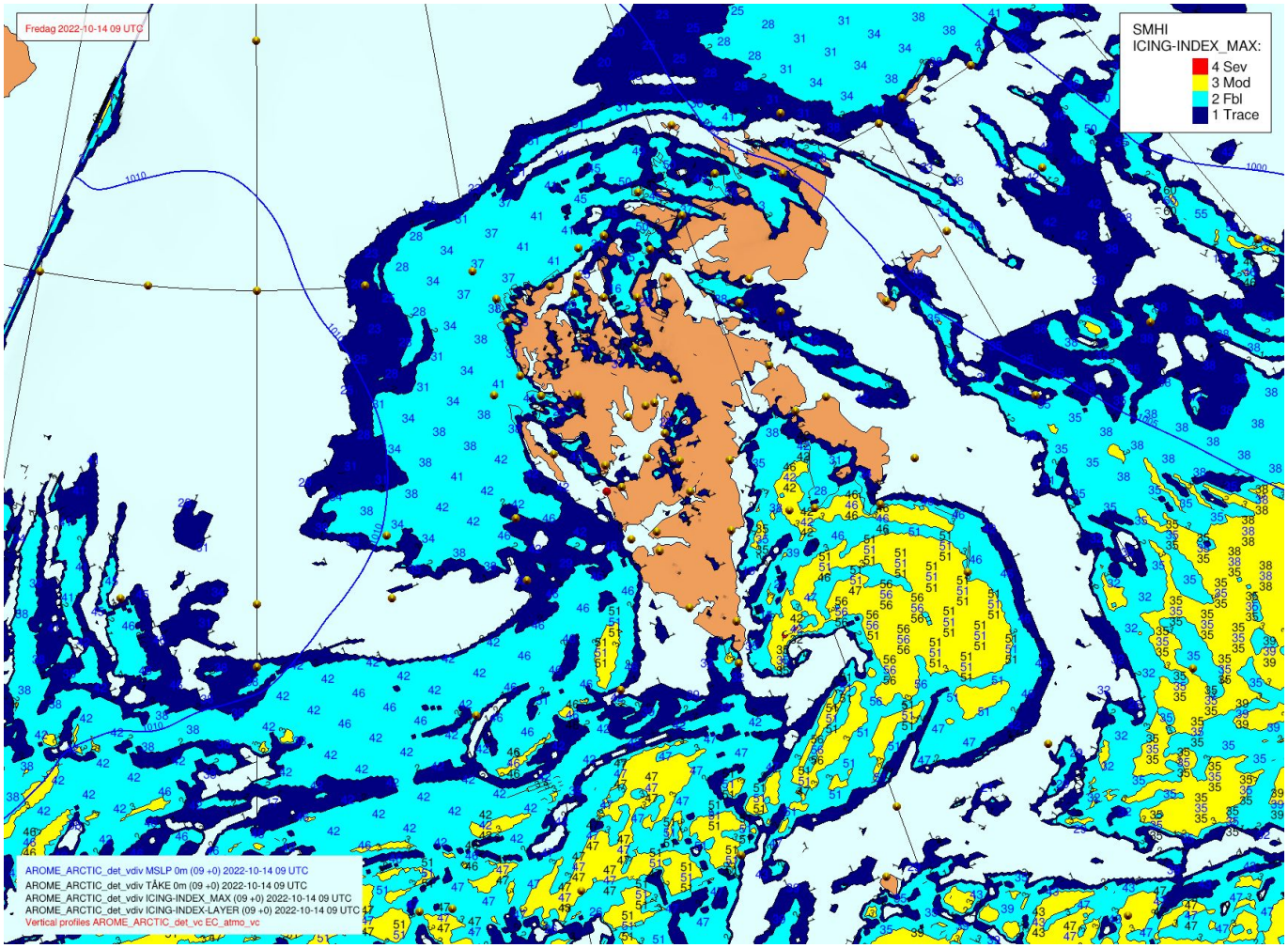
Case 1: 14.10.2022

Icing-index model at 09 UTC



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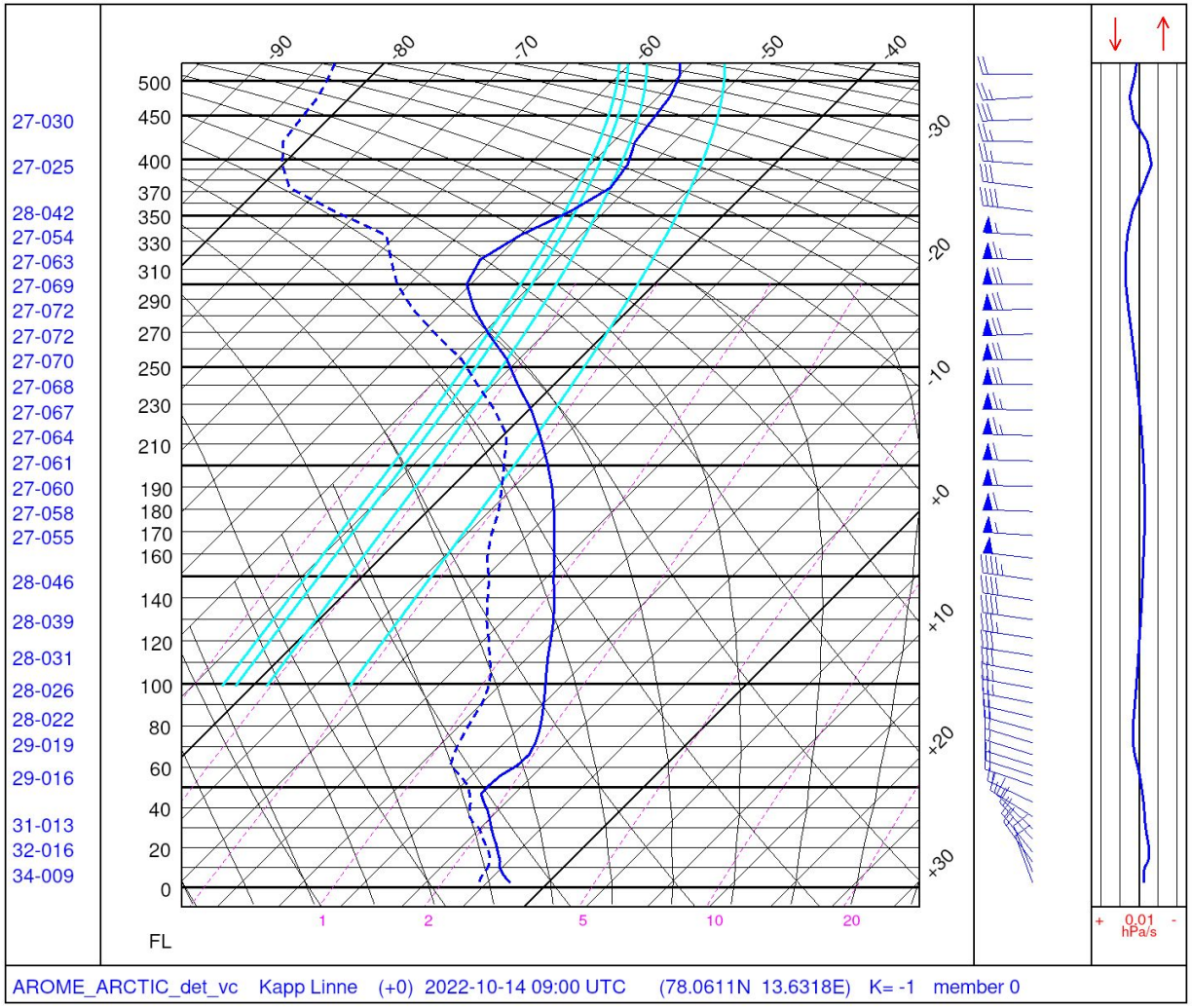
Case 1: 14.10.2022

Skew at Isfjord Radio 09 UTC



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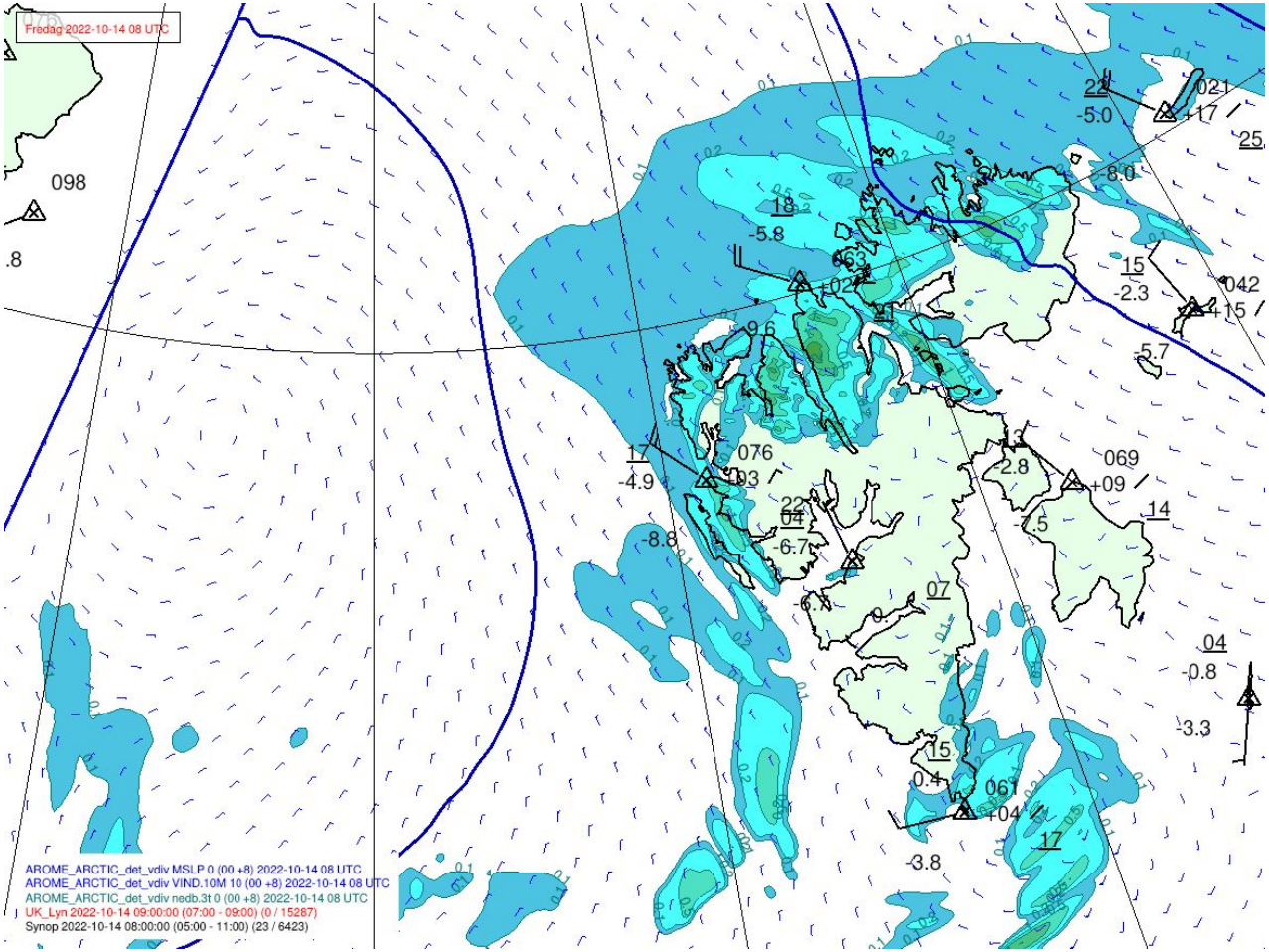
Case 1: 14.10.2022

Surface wind (model and observations) and precipitation with MSLP at 08 UTC



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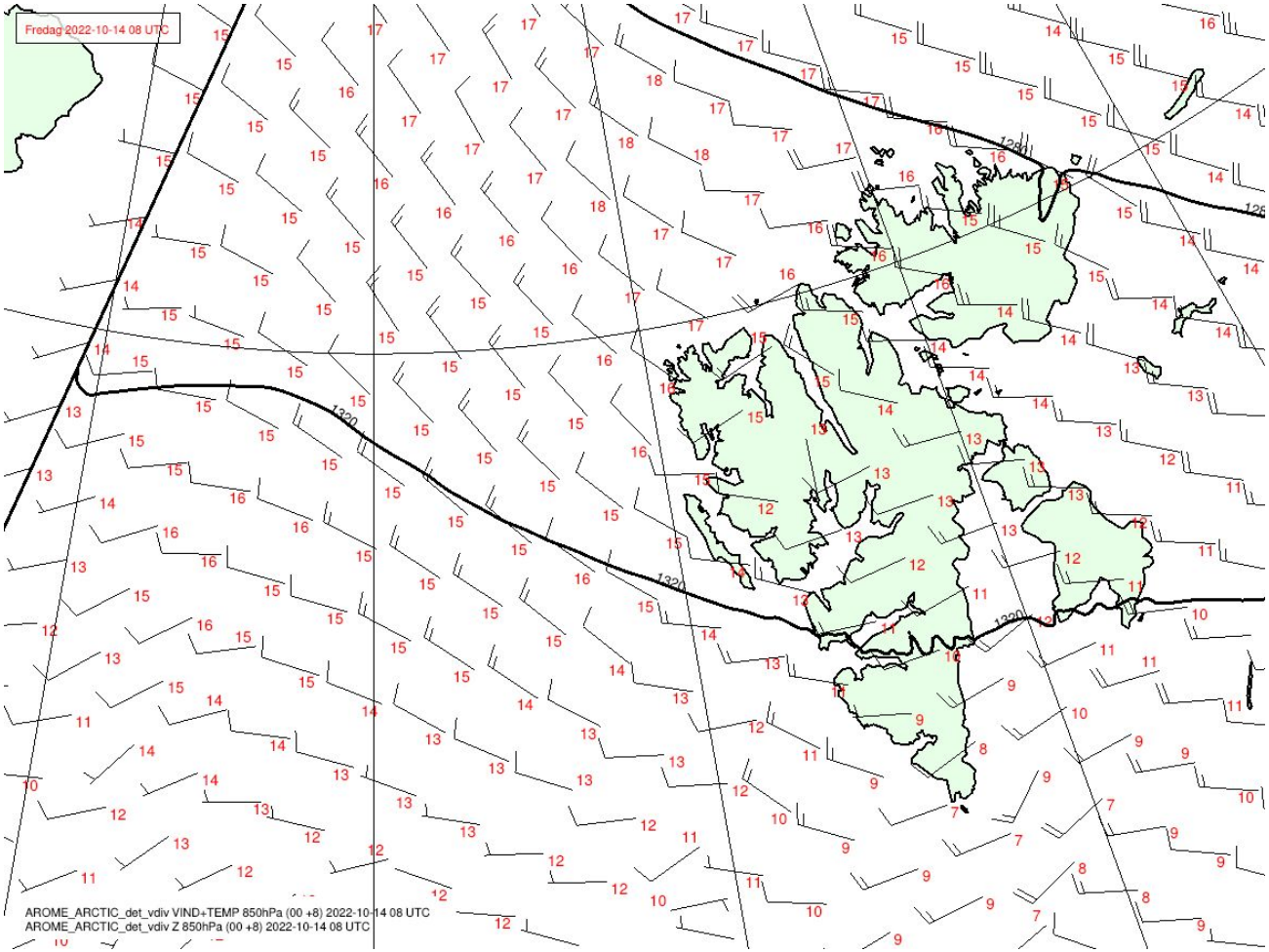
Case 1: 14.10.2022

Wind and temperature ~5000FT at 08 UTC



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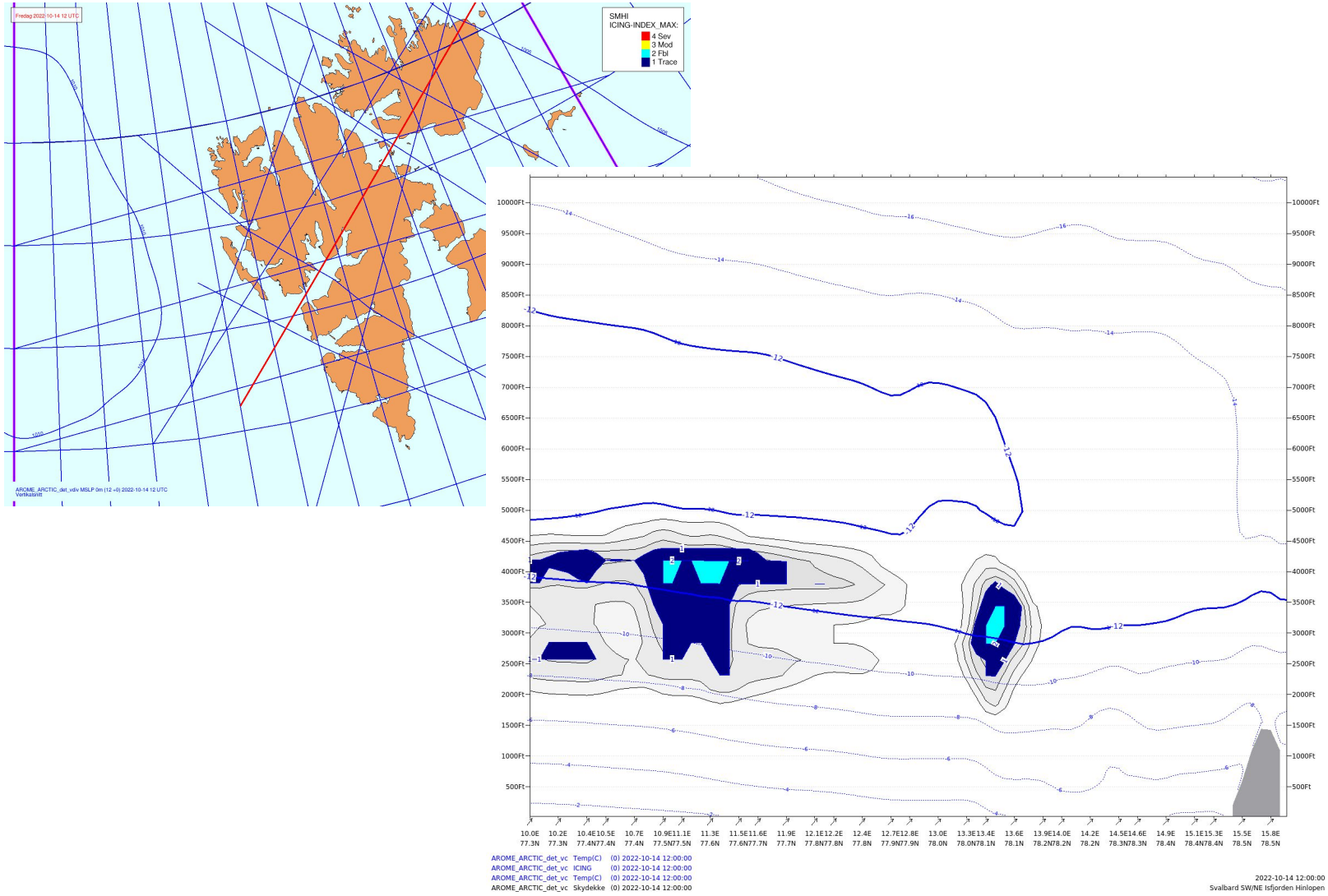
Case 1: 14.10.2022

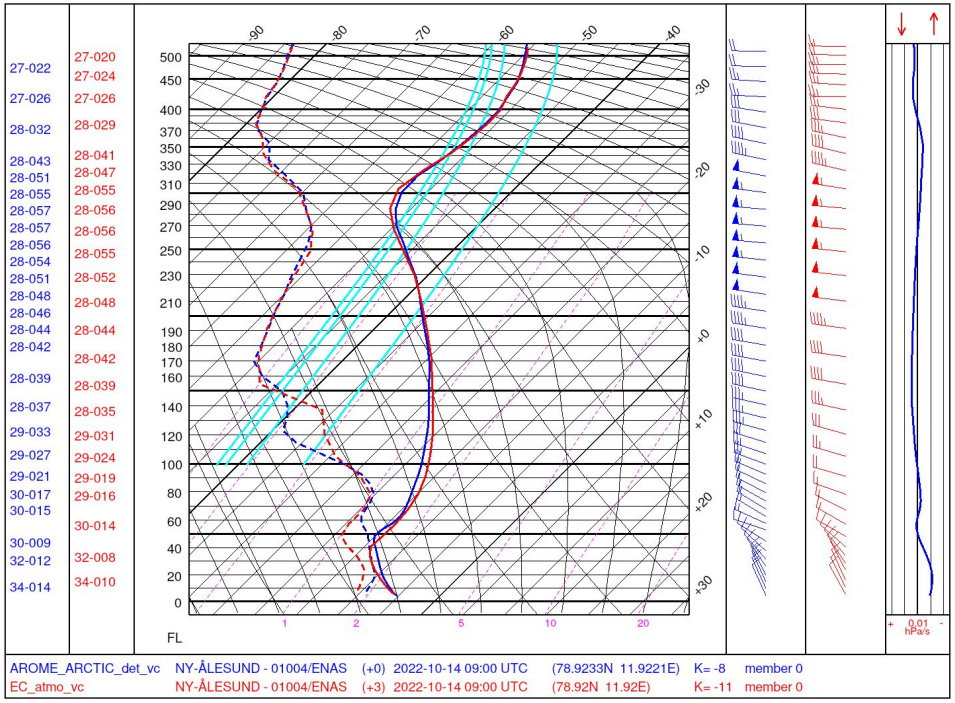
Cross-section with icing 12 UTC



Case 1: 14.10.2022

- Both local and global model indicates shallow stratocumulus layer
- Top around 5000FT with -15 degrees
- The models are probably not humid enough, and clouds probably contains large amount of LWC
- Snow grains observed in Ny-Ålesund is also an indication of icing in-clouds

Skew Ny-Ålesund at 09 UTC



ENAS *(NY-ALESUND/HAMNERABBEN RWY 12/30)*

TAF

TAF ENAS 140725Z 1407/1410 31012KT 9999 -SHSN FEW015 BKN025 TEMPO 1407/1410 2500 SHSN VV008=

METAR

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METAR ENAS 140820Z 30013KT 9999 8000NW -SHSGSN FEW002 SCT018 BKN023 M05/M08 Q1007 RESHSN=

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METAR ENAS 140720Z 30009KT 9999 8000NW -SHSN FEW015 SCT020 BKN026 M05/M10 Q1007=

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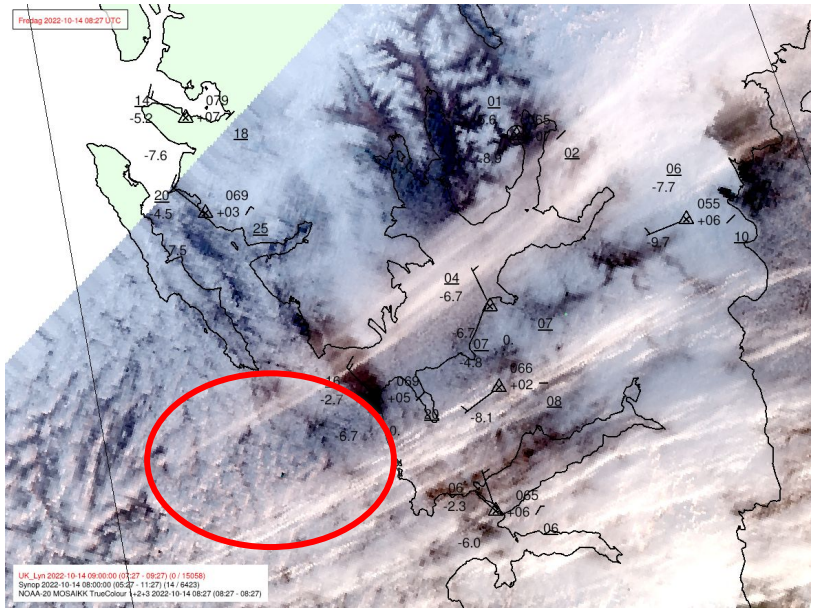
Case 1: 14.10.2022

Satellite image ~08:30 UTC



DC-3 aircraft on campaign on Svalbard:

Name (Registry):Polar 6 (C-G HGF)

Model: Basler BT-67

Year commissioned at the AWI: 2007 || 2011

Length: 20.66 metres

Wingspan: 29 metres

Basic weight: 8.3 t (with ski landing gear 8.9 t)

Engines: 2 x Pratt & Whitney PT6A-67R

Output per engine: 1,281 HP

Fuel consumption: 570 litres / hour

Max. take-off weight: 13 t

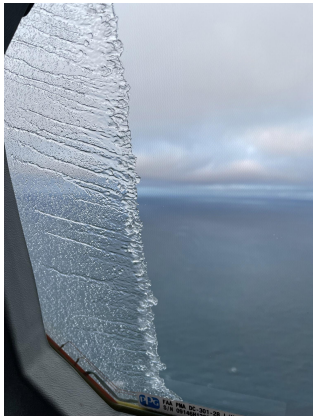
Max. take-off elevation without payload: 4,200 metres

Range without payload: ca. 3,000 kilometres

Max. cruising speed: 315 kilometres / hour (Indicated Air Speed, IAS)

Min. cruising speed: 167 kilometres / hour

- Pilot *Dean Emberley* Polar 6 observed **clear ice** forming on aircraft!
- Below clouds in the area 30-40 NM west/southwest of ENSB.
- Light precipitation under clouds in 1000-1500FT.



Photos: Dean Emberly

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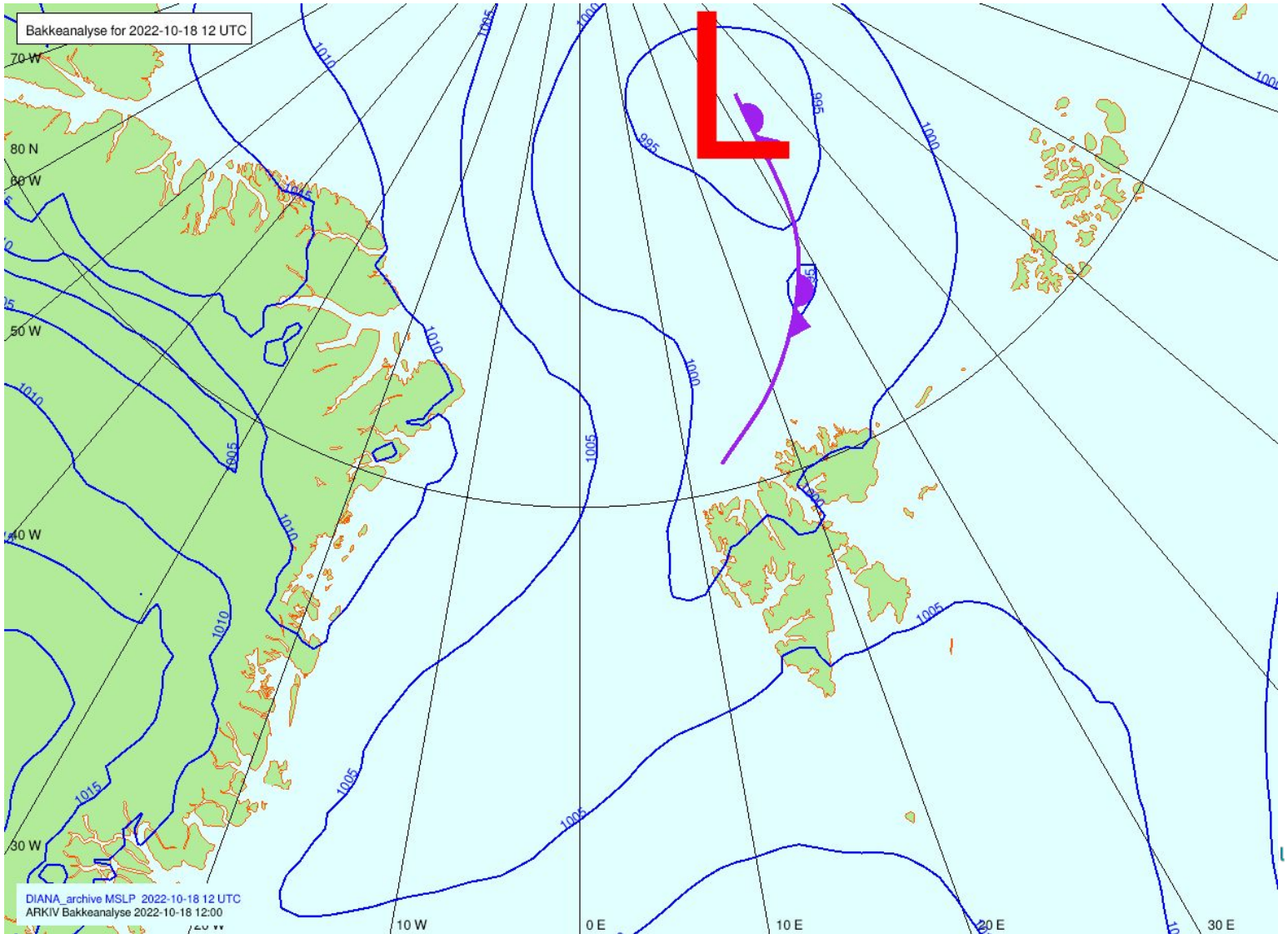
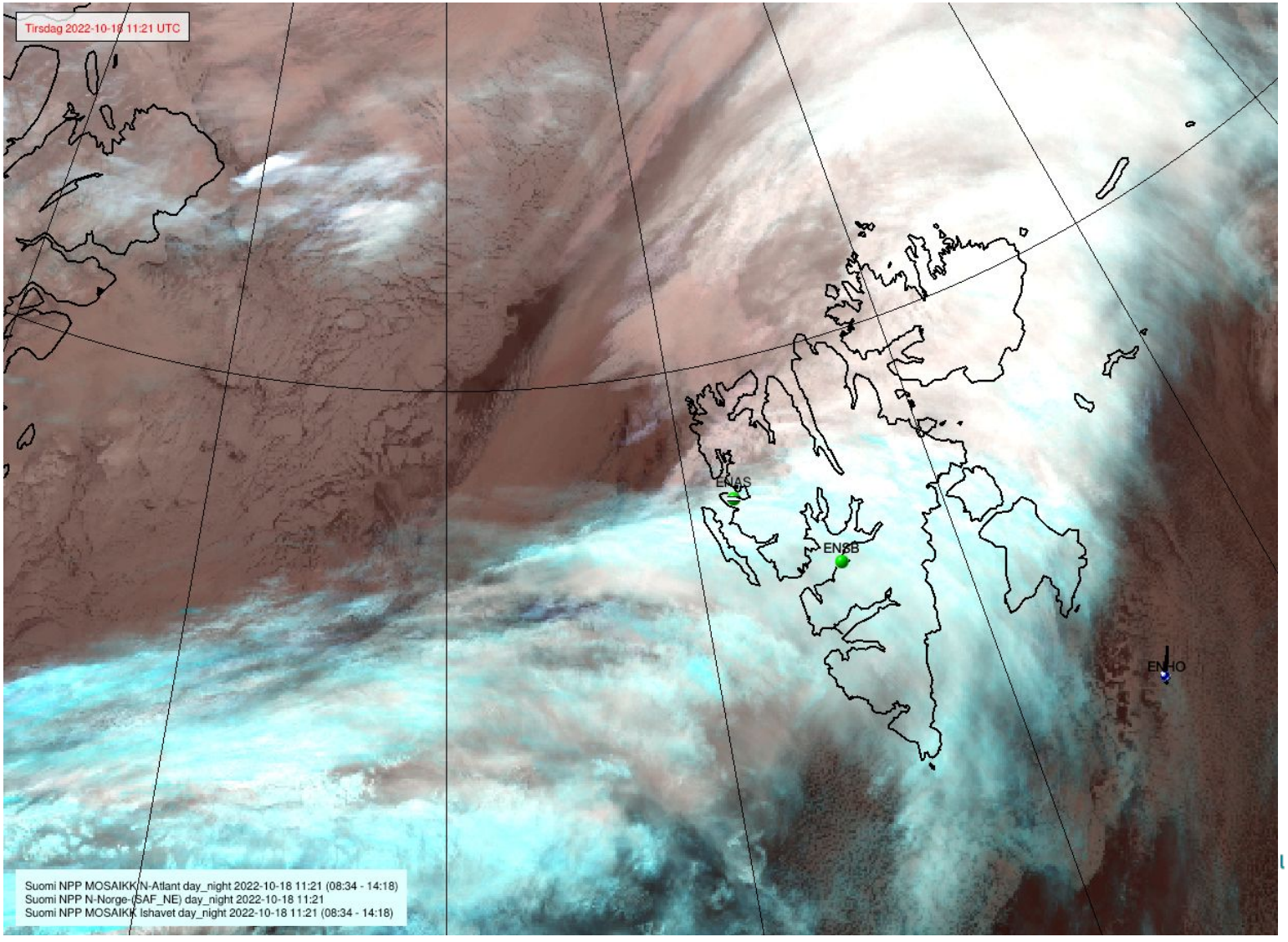
Case 2: 18.10.2022

Surface analysis at 06 UTC



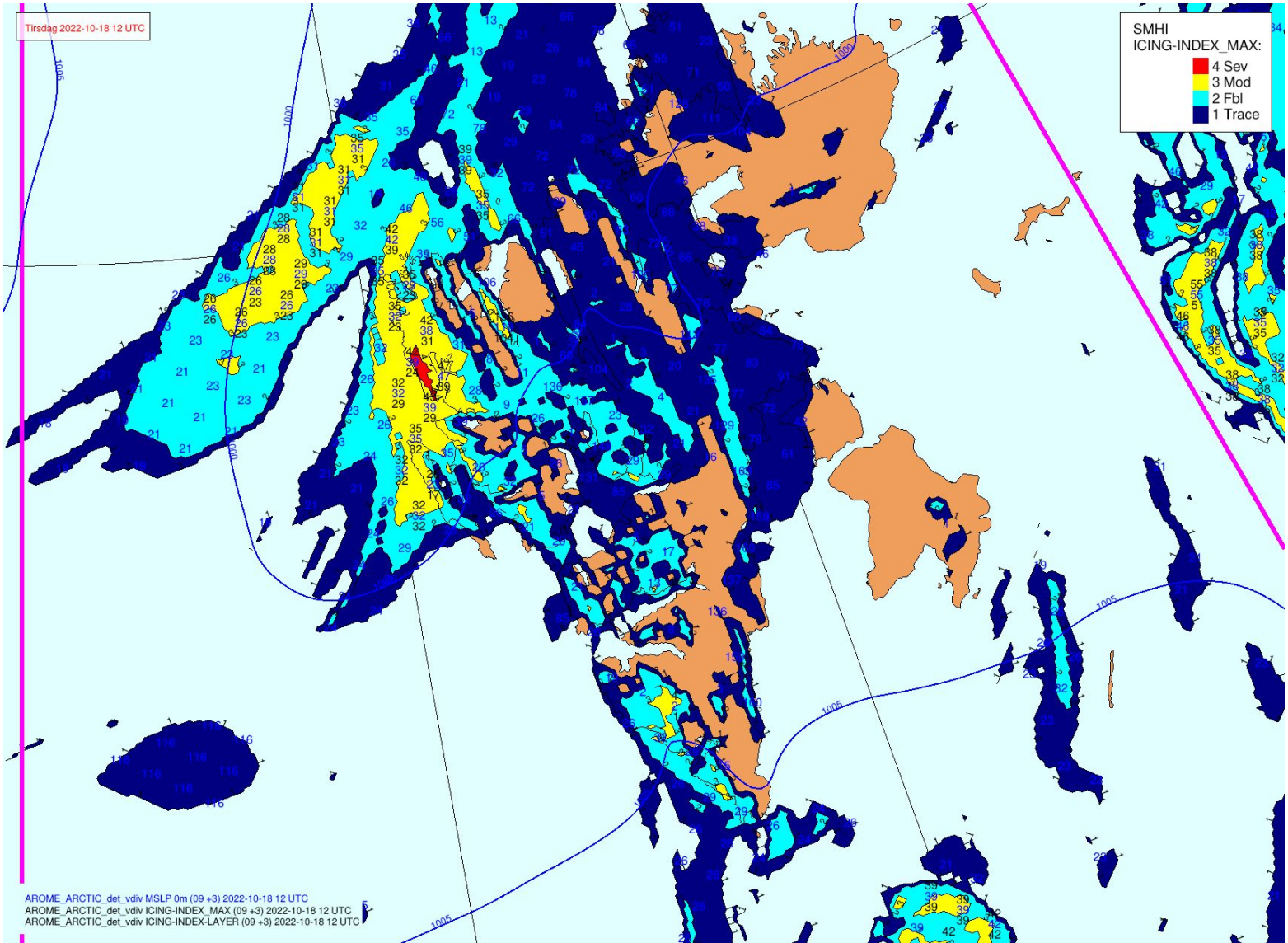
Case 2: 18.10.2022

Satellite picture (IR image) ~11:20 UTC



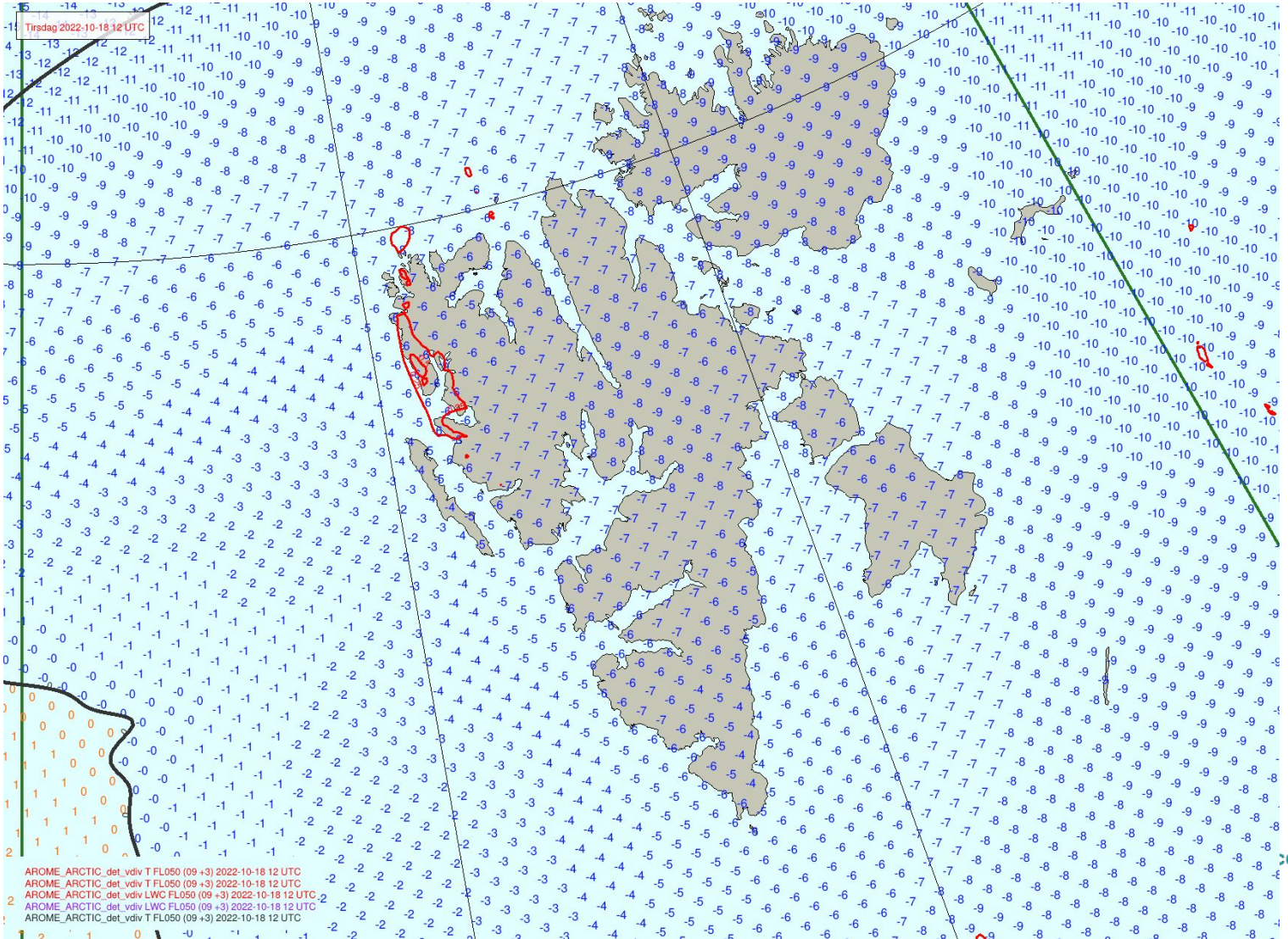
Case 2: 18.10.2022

Icing-index model at 12 UTC



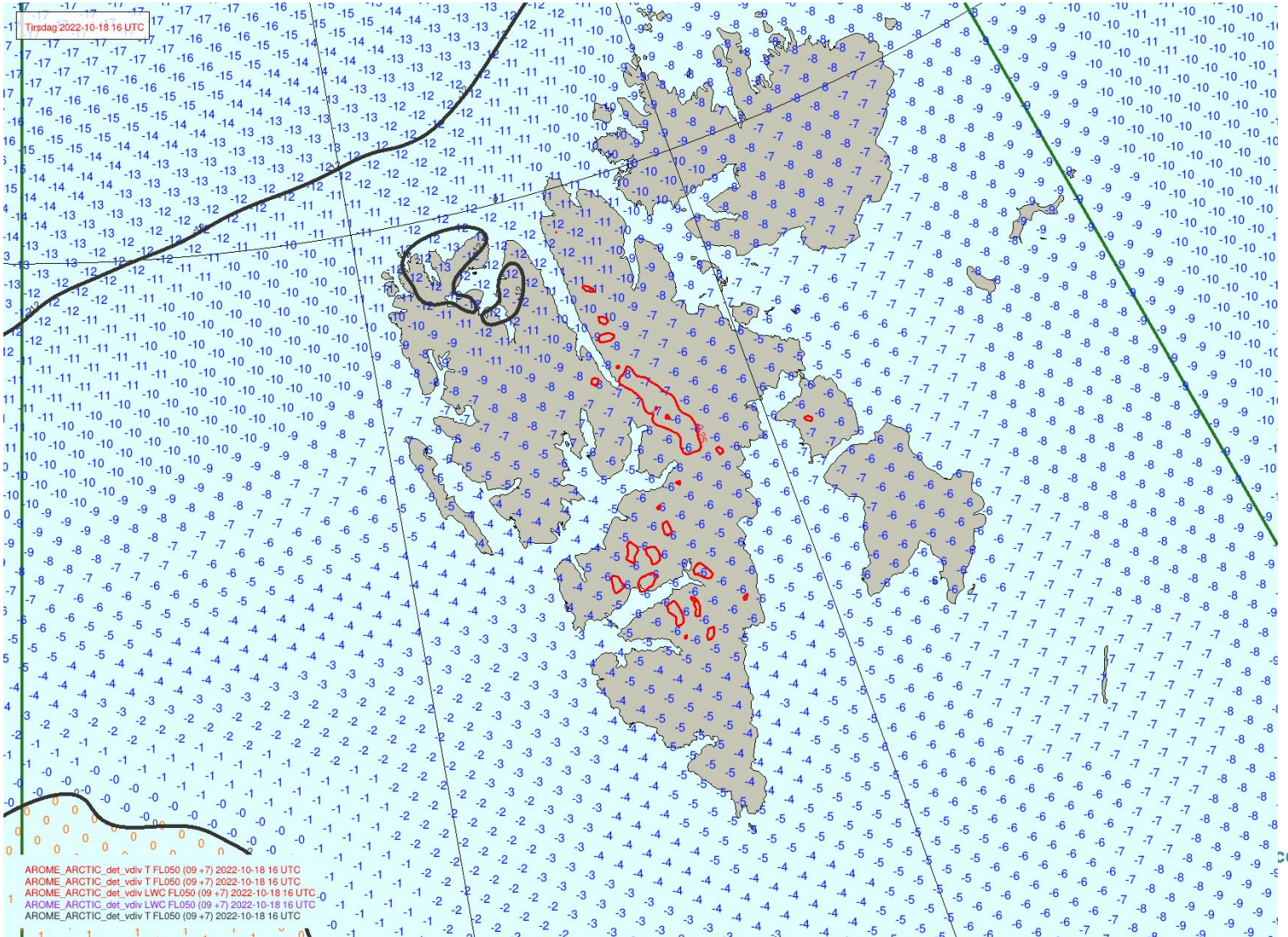
Case 2: 18.10.2022

LWC and temp 12 UTC



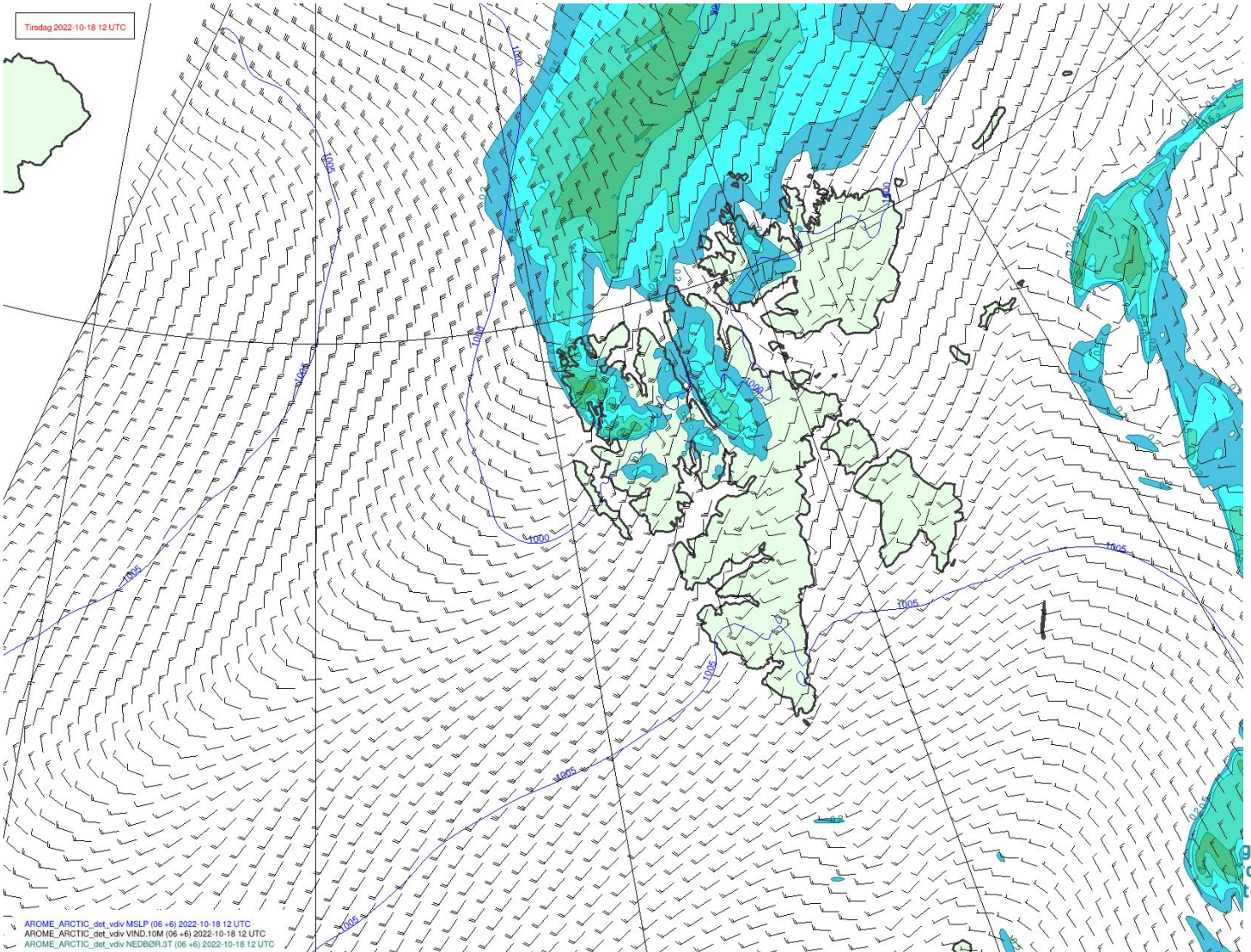
Case 2: 18.10.2022

LWC and temp 16 UTC



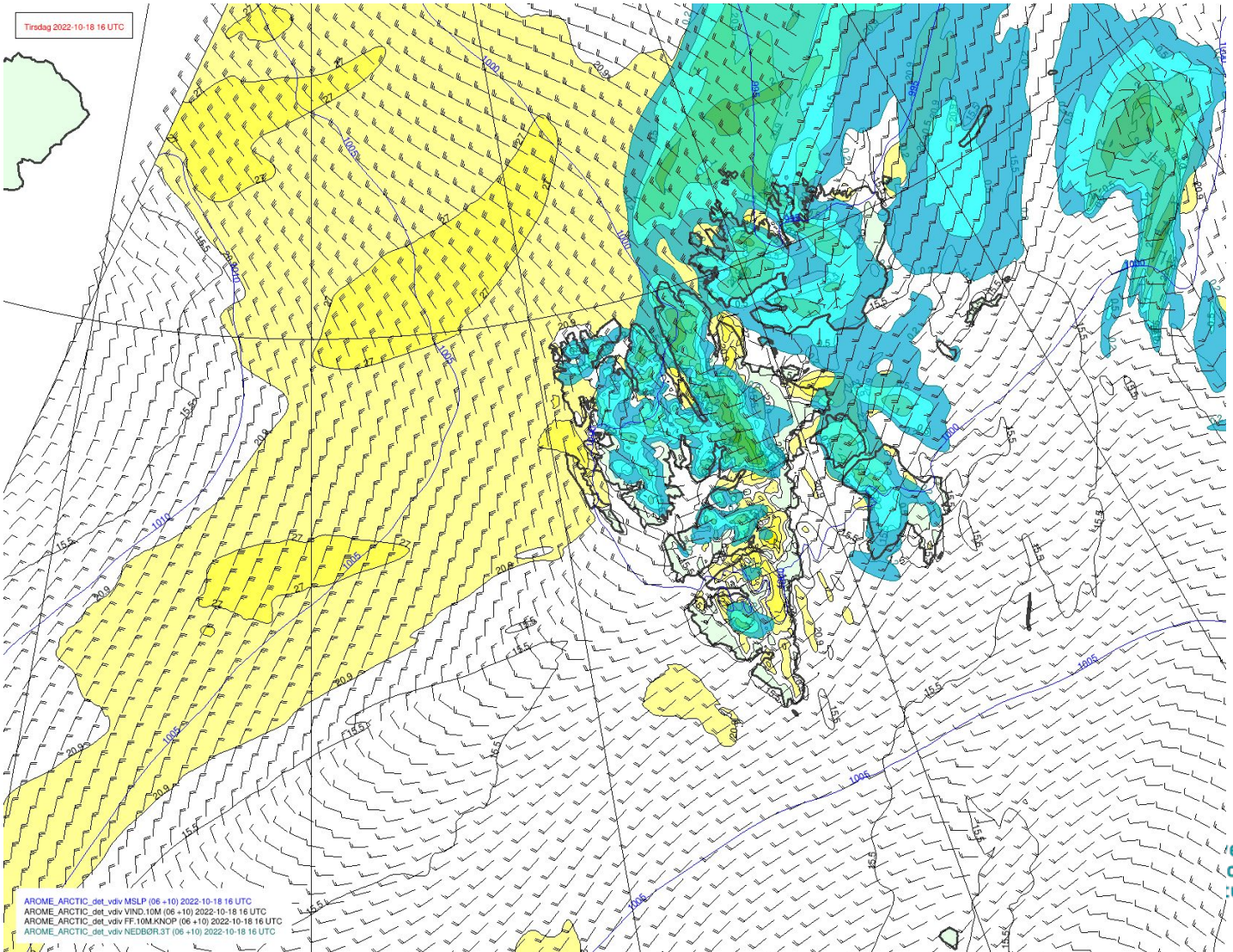
Case 2: 18.10.2022

Surface wind and precipitation with MSLP at 12 UTC



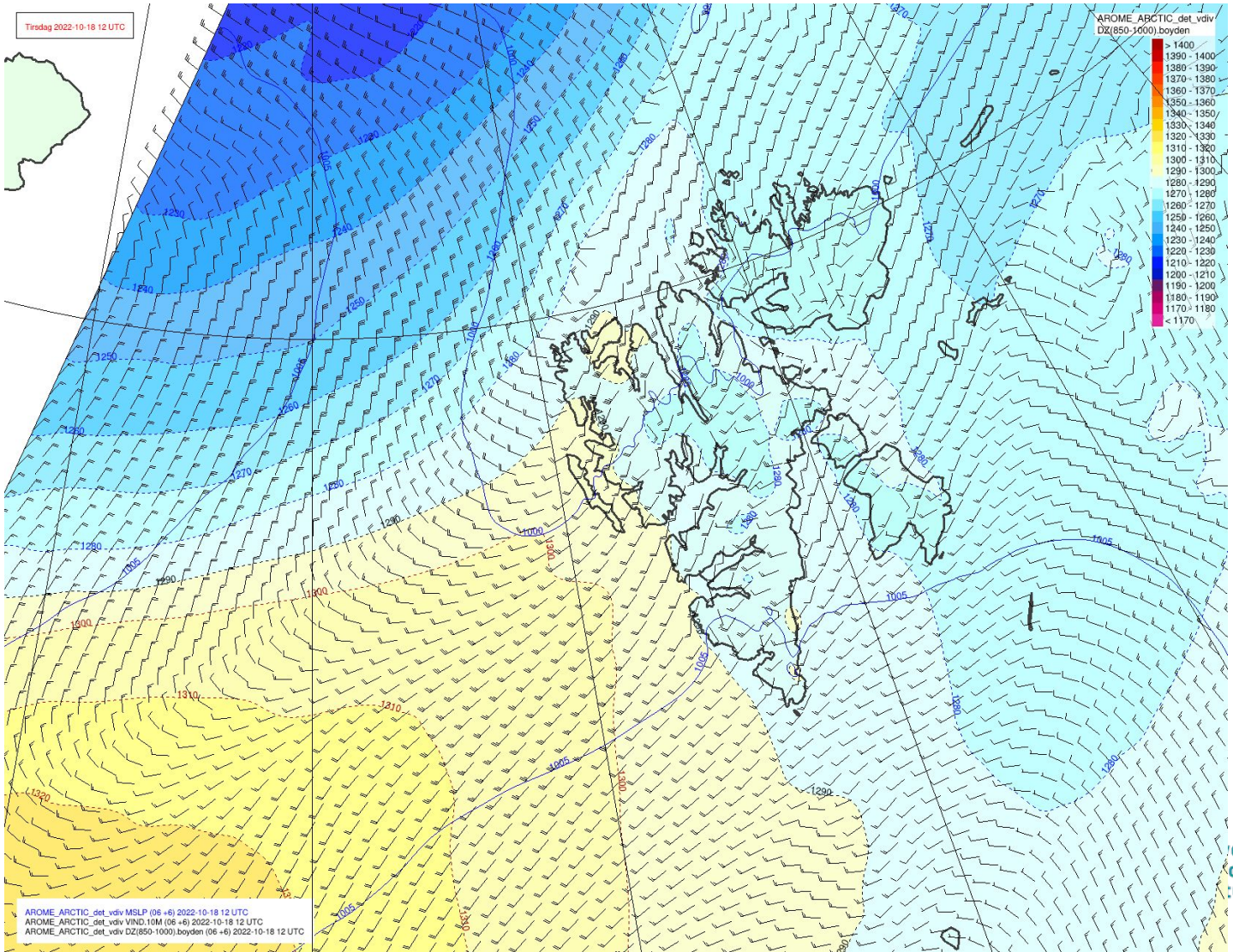
Case 2: 18.10.2022

Surface wind and precipitation with MSLP at 16 UTC



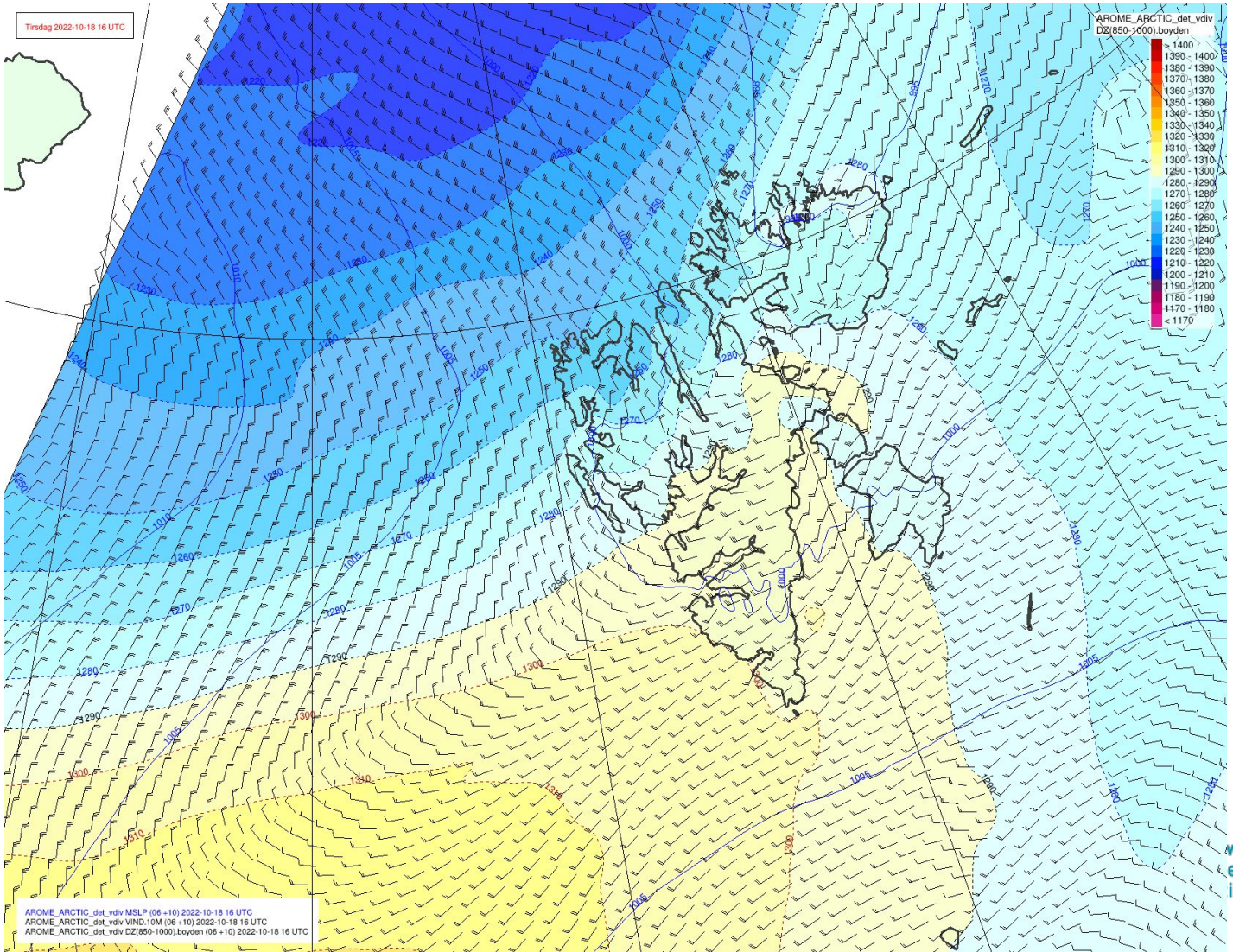
Case 2: 18.10.2022

Airmasses kl 12 UTC



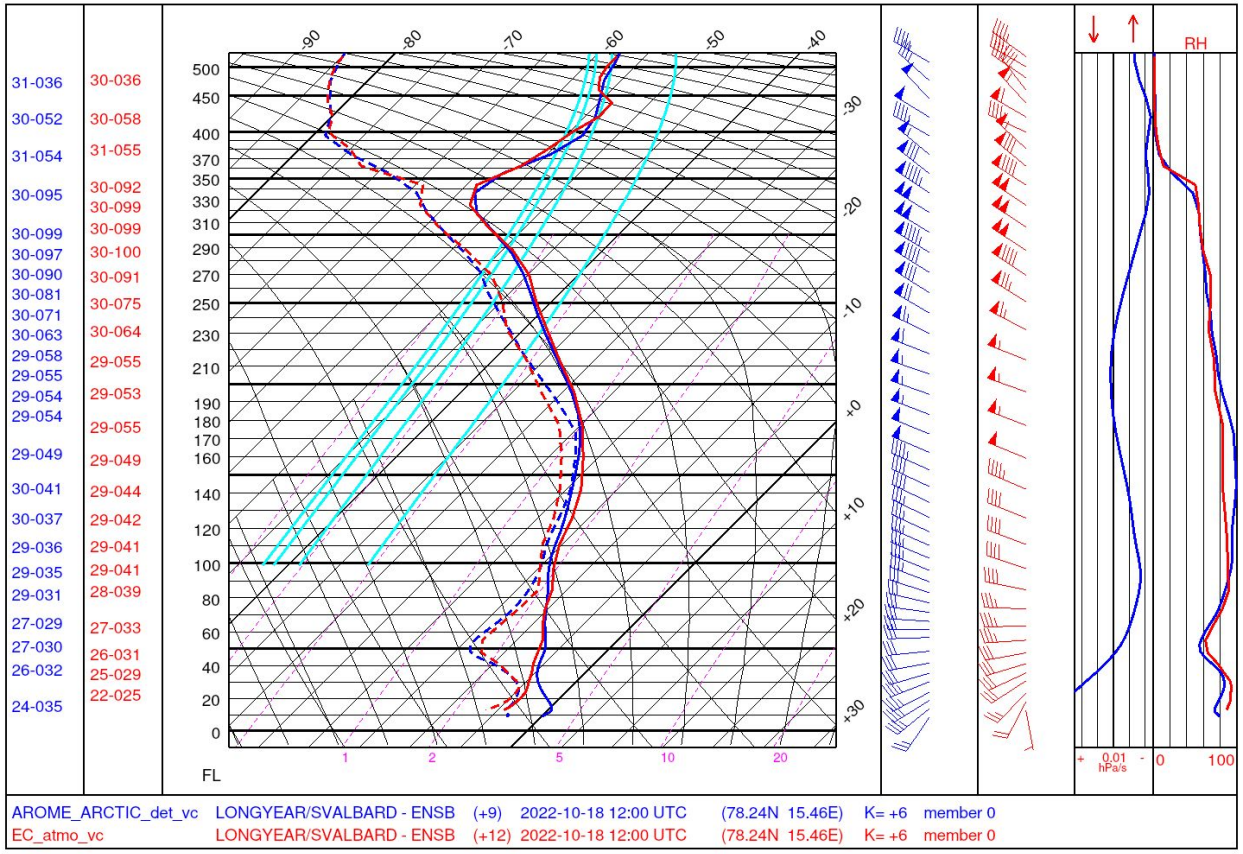
Case 2: 18.10.2022

Airmasses kl 16 UTC



Case 2: 18.10.2022

Skew ENSB 12 UTC



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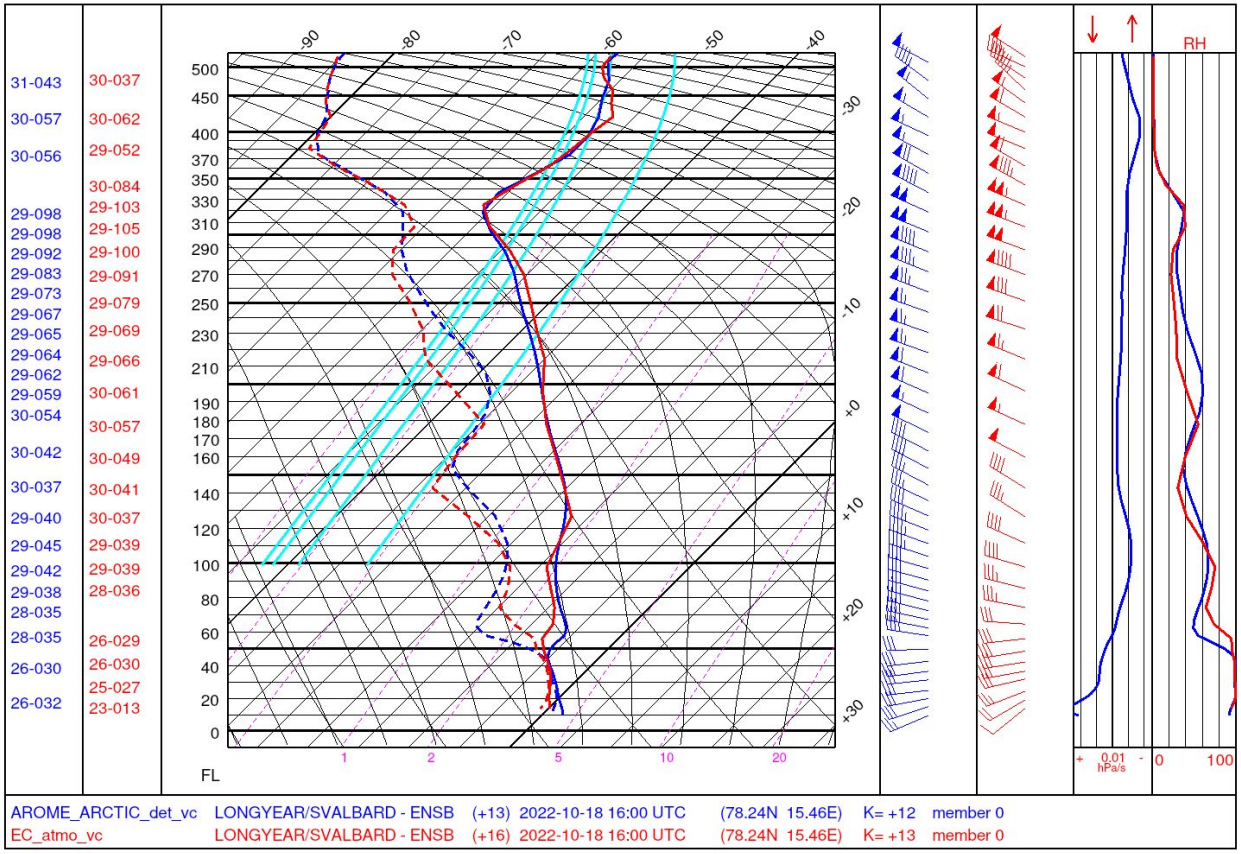
Case 2: 18.10.2022

Skew ENSB 16 UTC



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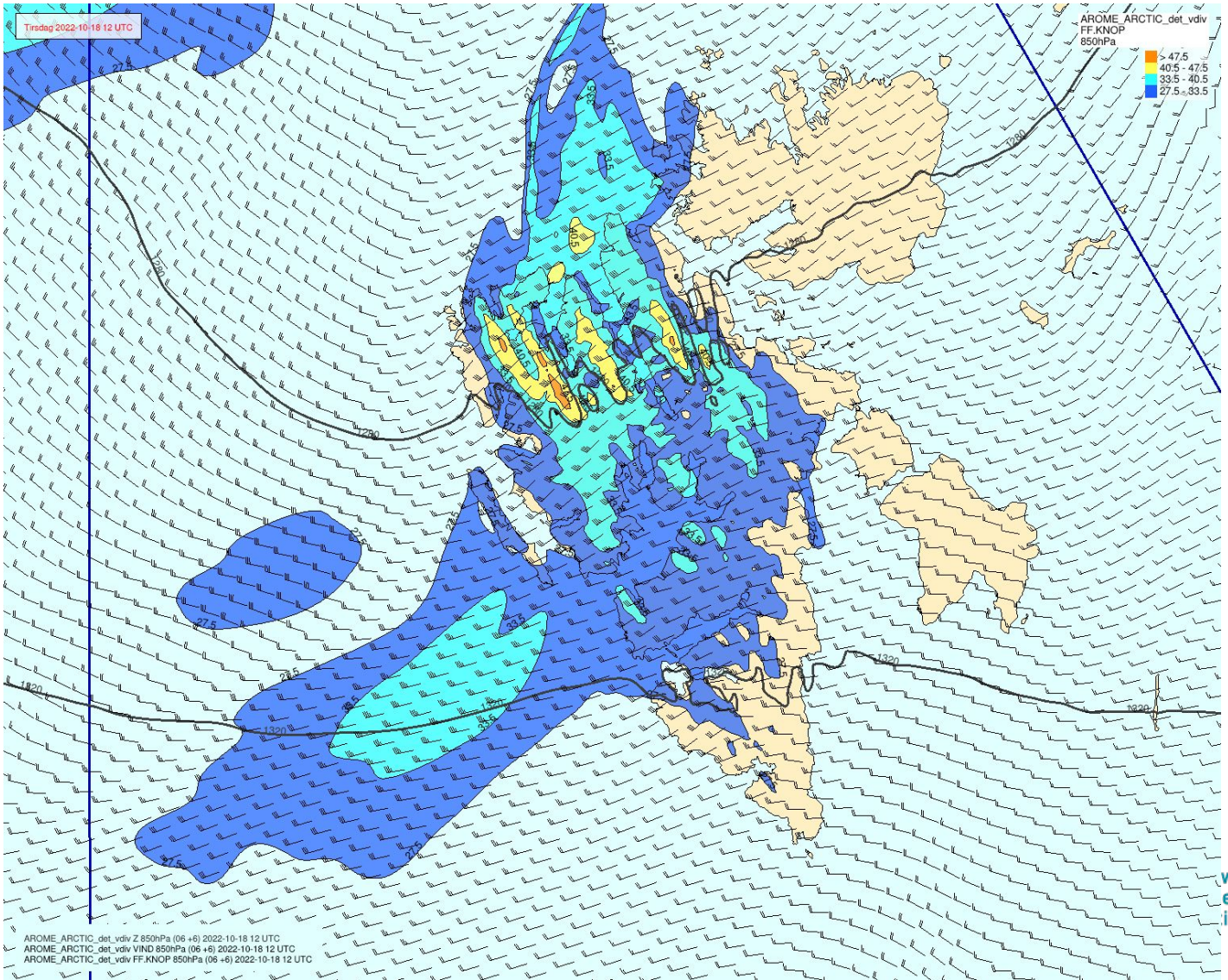
Case 2: 18.10.2022

Wind 850hPa 12 UTC



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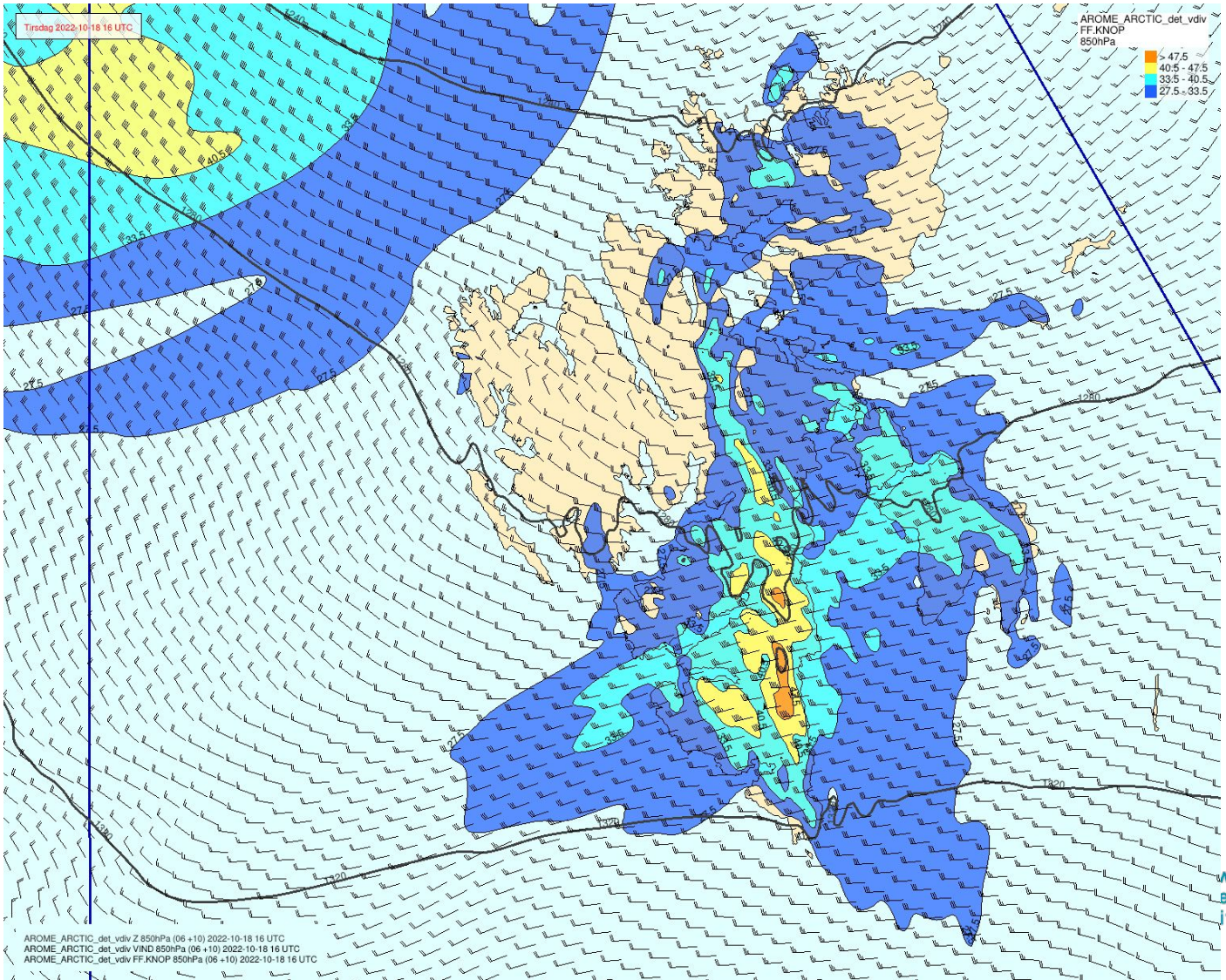
Case 2: 18.10.2022

Wind 850hPa 16 UTC



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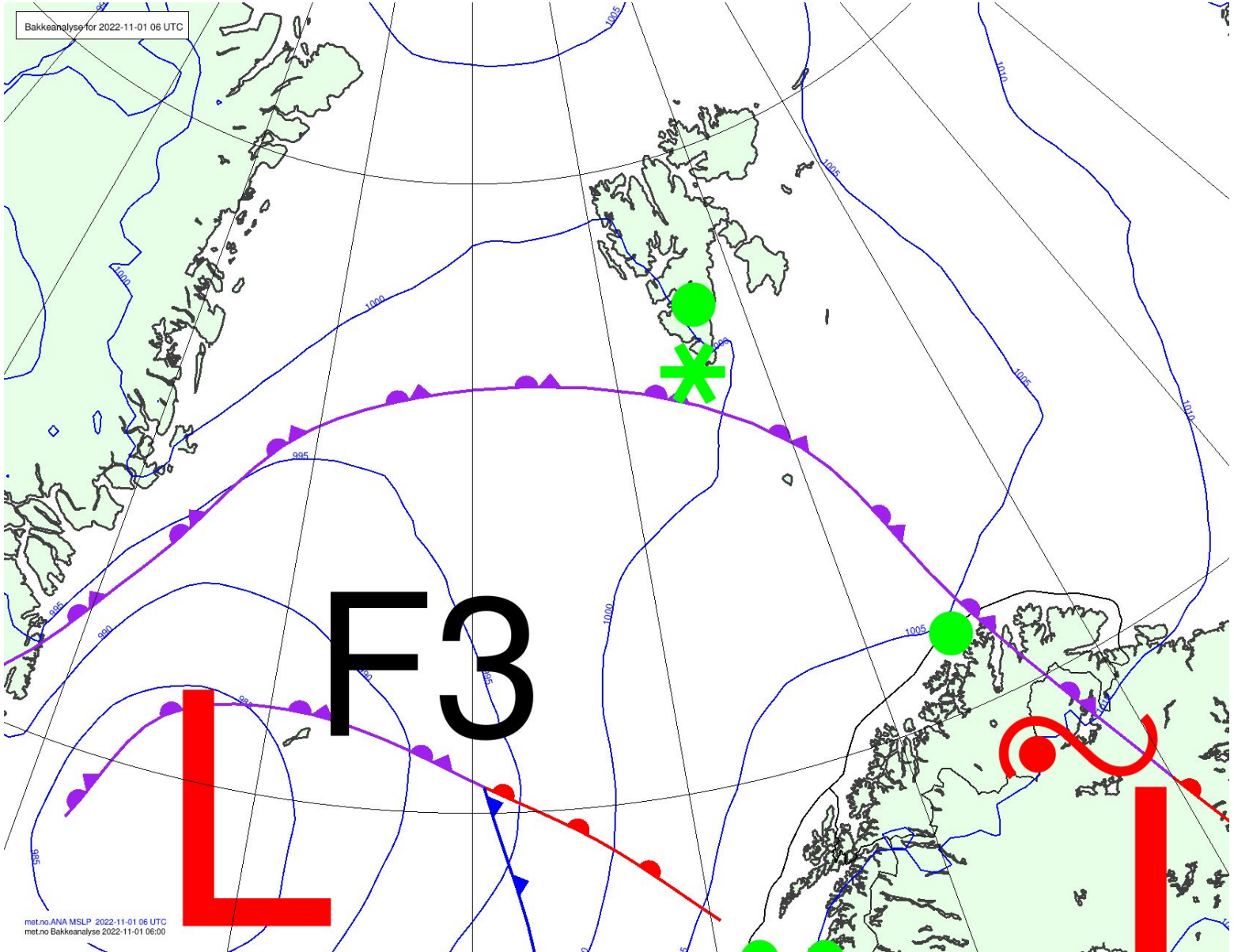
Case 2: 18.10.2022

- Low northeast of Svalbard with frontal zone in northwest part
- Strong wind shear and vertical movements
- Strong winds in height towards mountains
- Large temperature difference in frontal zone
- Large amount of LWC
- Clean, arctic maritime air masses

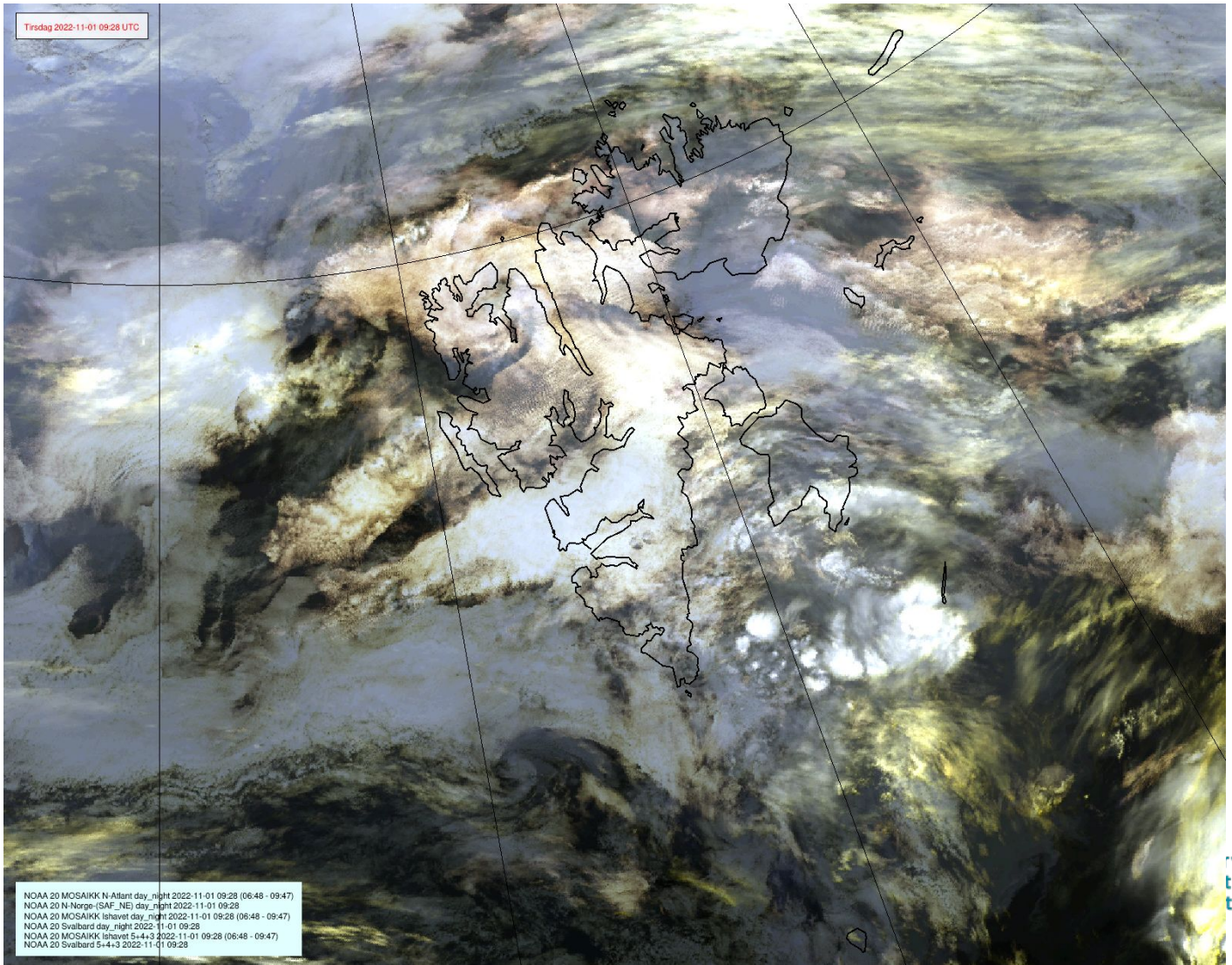
Result: Moderate icing on aircraft

Case 3: 01.11.2022



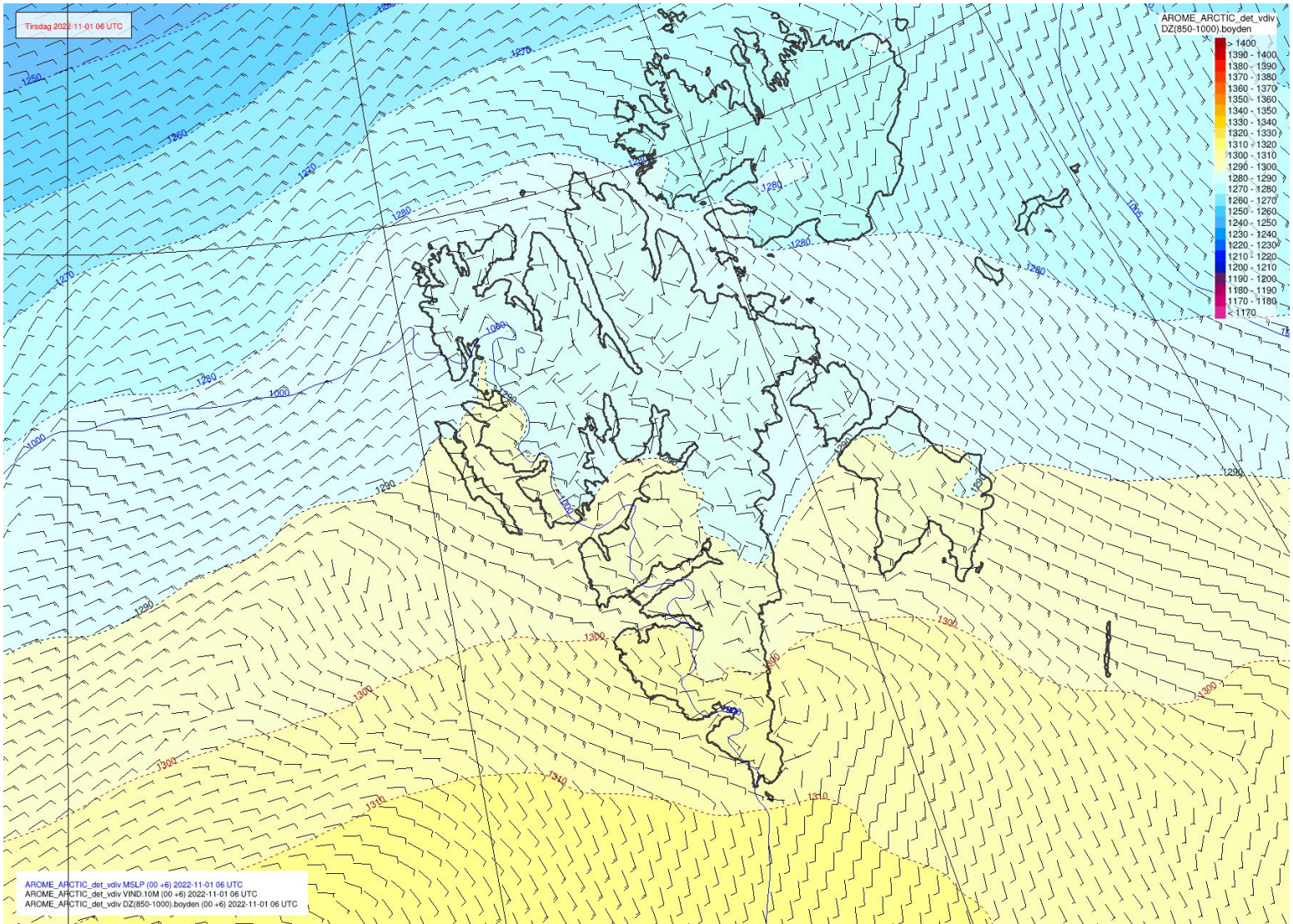
Case 3: 01.11.2022

Satellite picture (IR image) at ~0930 UTC



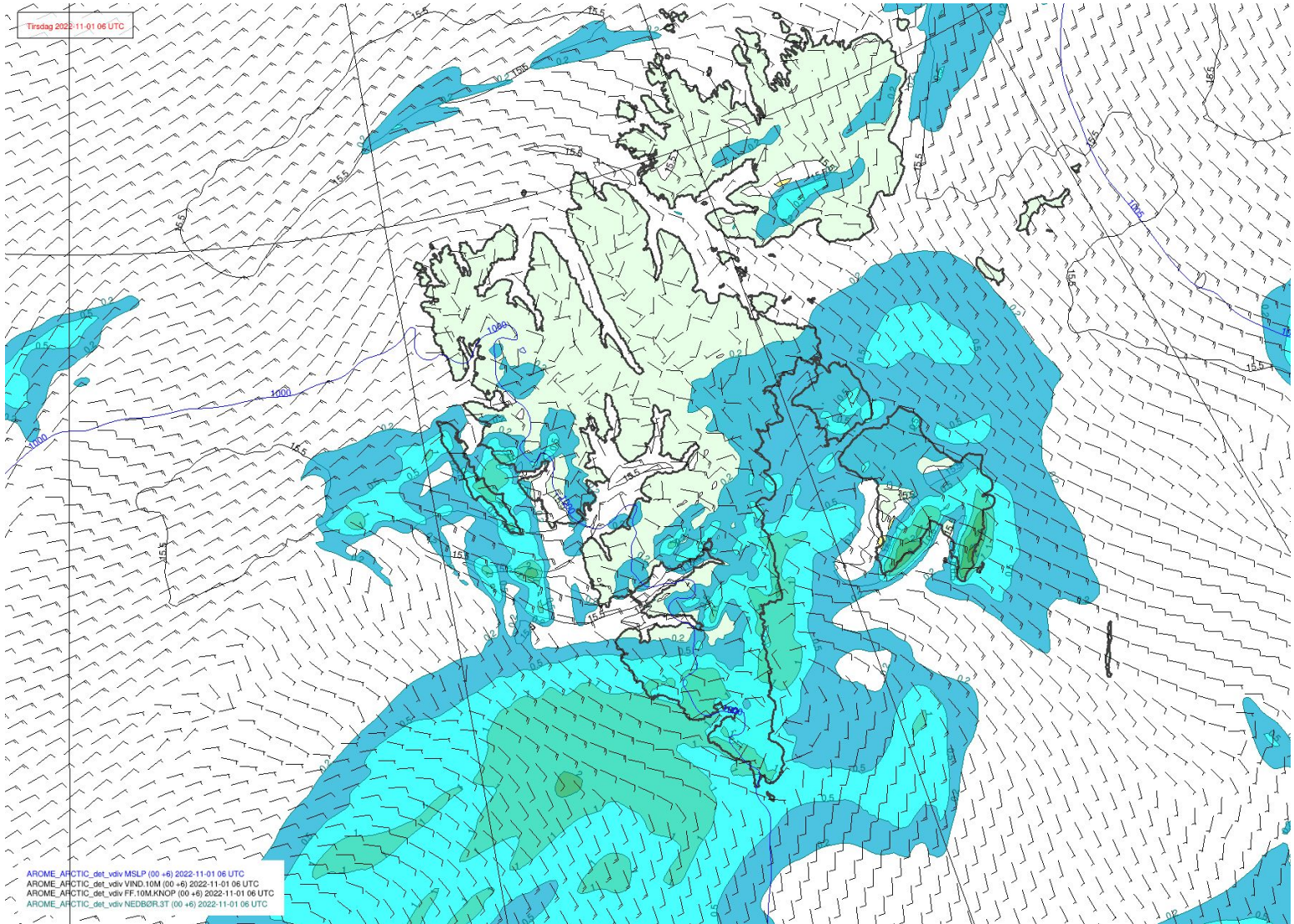
Case 3: 01.11.2022

Wind and airmasses at 06 UTC



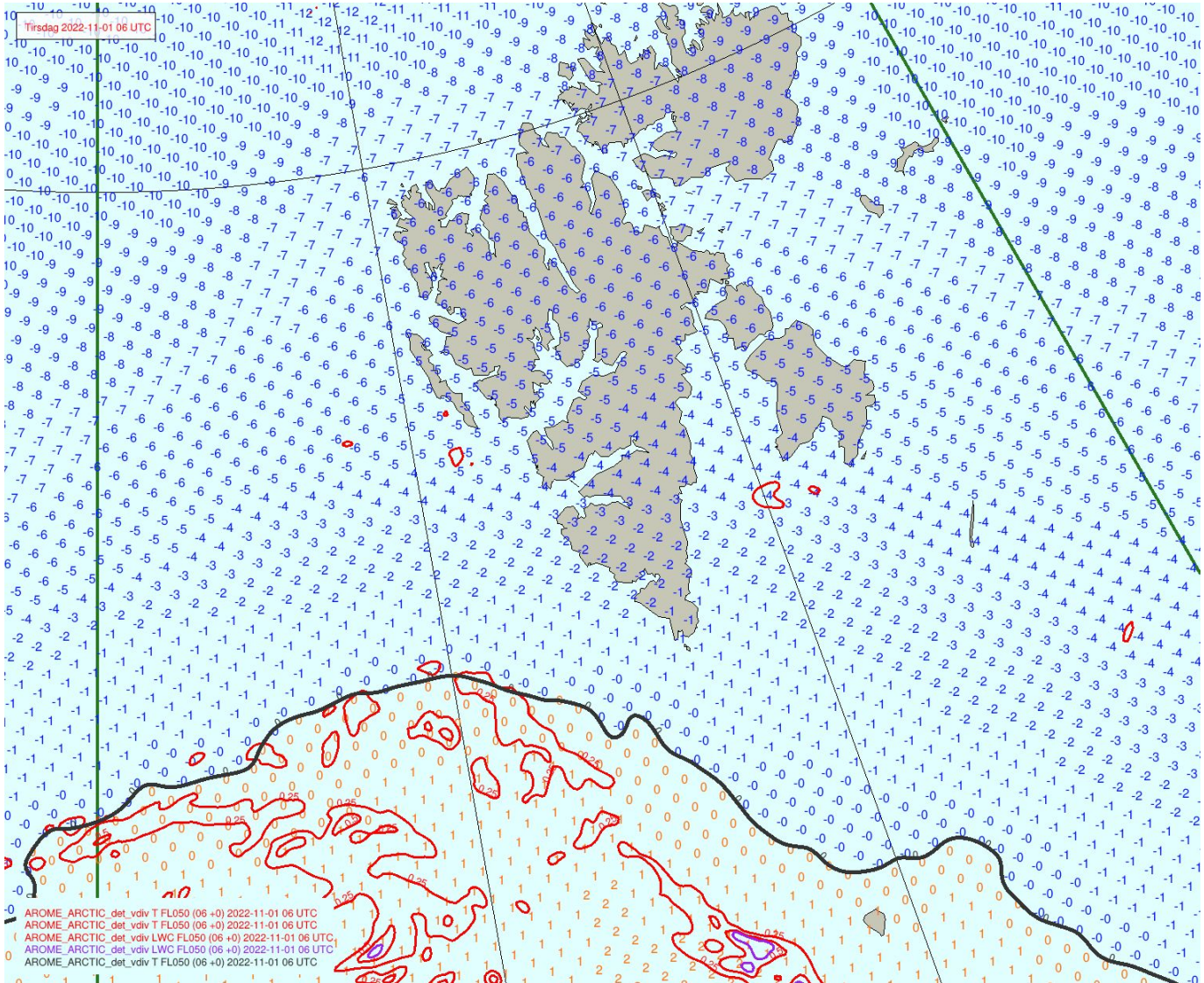
Case 3: 01.11.2022

Wind and precipitation at 06 UTC



Case 3: 01.11.2022

LWC and temp at 06 UTC



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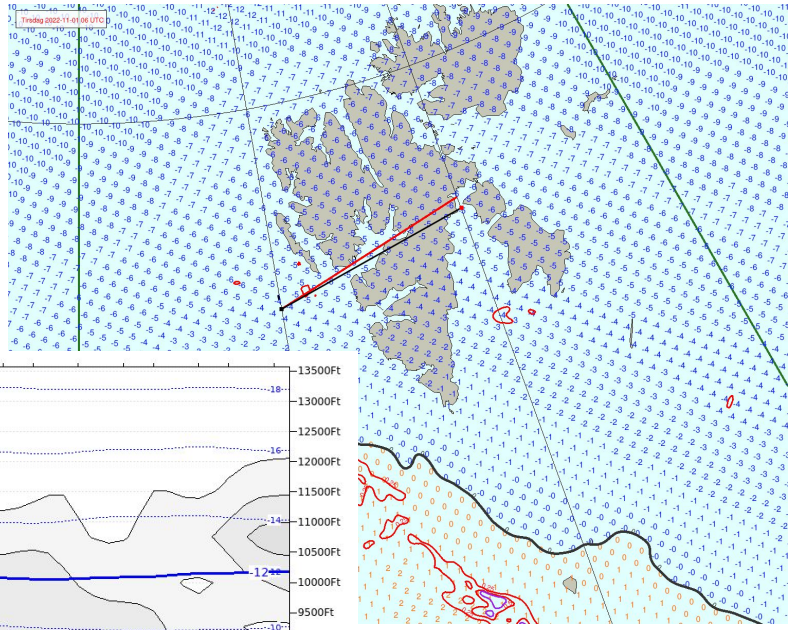
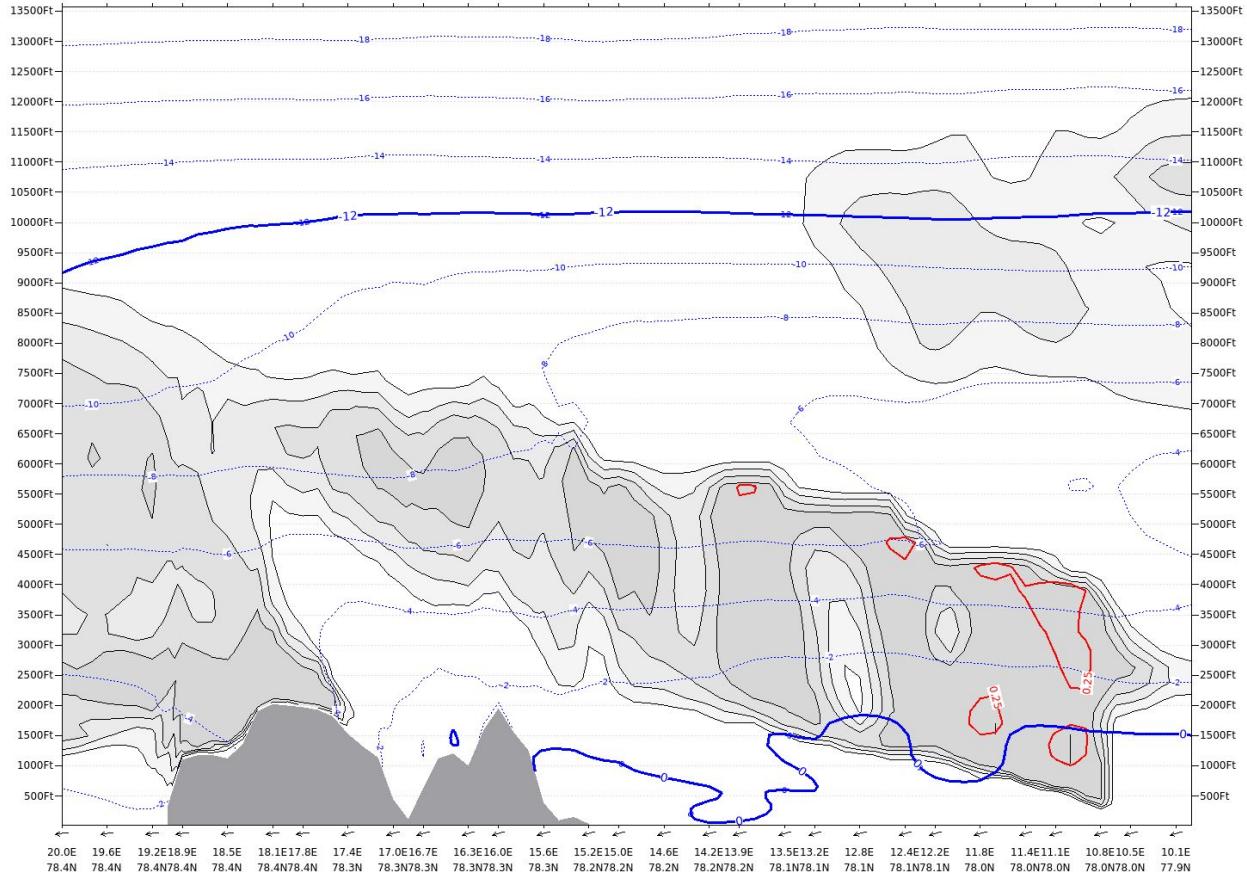
Case 3: 01.11.2022

LWC cross section at 06 UTC





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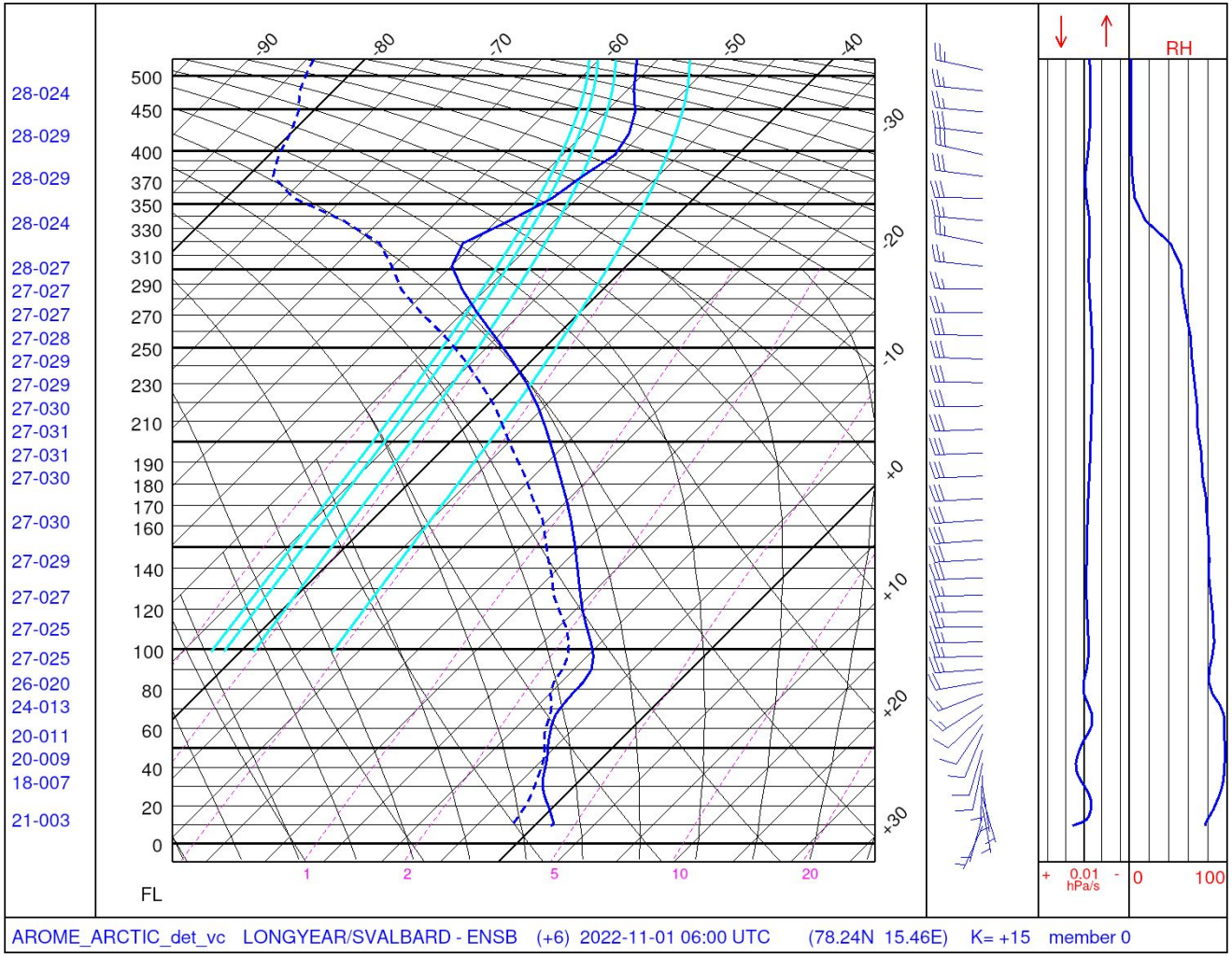
Case 3: 01.11.2022

Skew ENSB at 06 UTC



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Case 3: 01.11.2022

Observations

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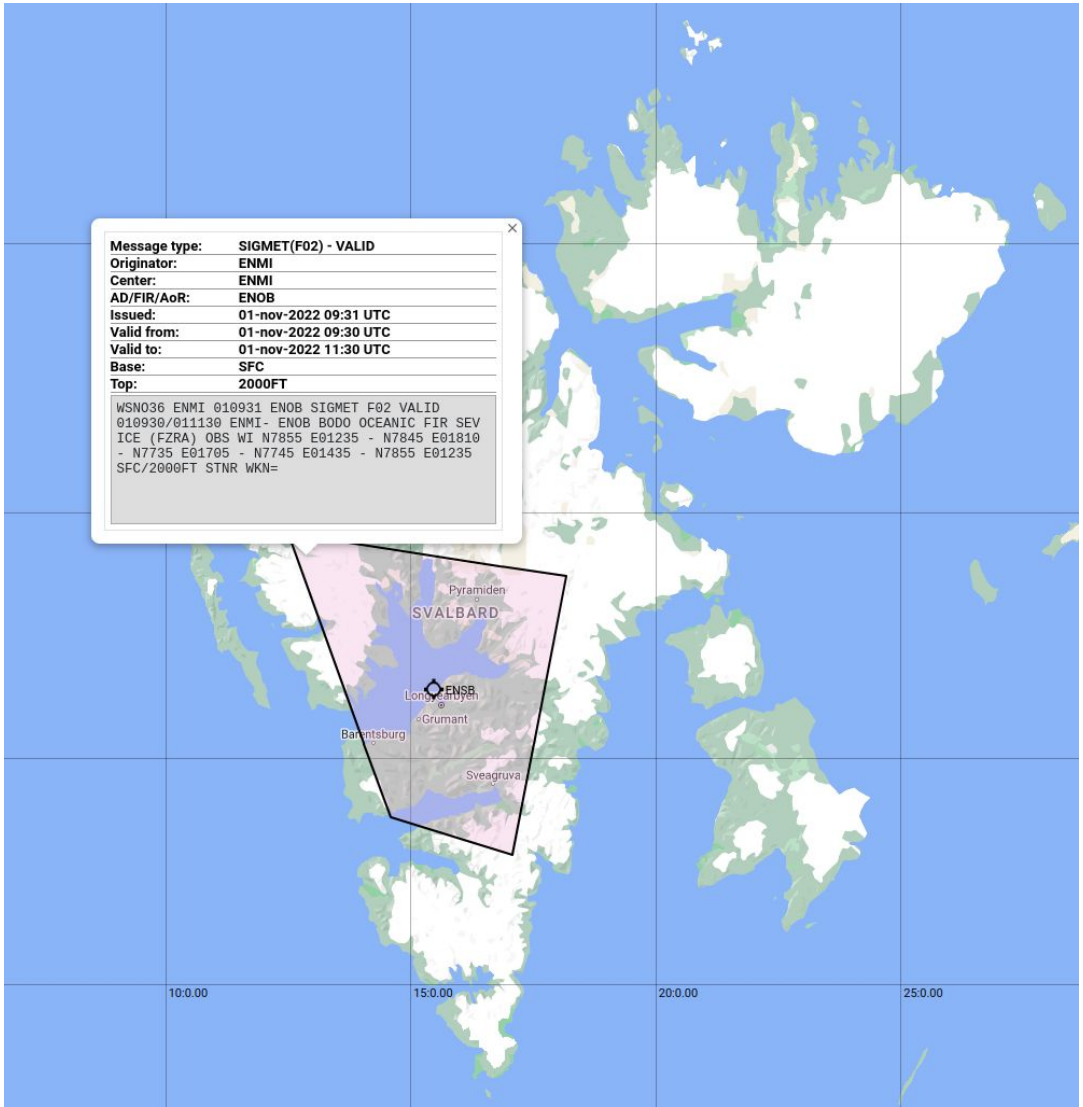
METAR	ENSB 010620Z 19002KT 9[illegible]99 -FZRA BKN[illegible]035 M01/M03 Q0999 RMK WIND 1400FT 11008KT=
METAR	ENSB 010550Z 00000KT 9[illegible]99 SCT031 BK[illegible]N043 M01/M03 Q0999 RMK WIND 1400FT 11009KT=
METAR	ENSB 010520Z 26005KT 9999 SCT031 BKN043 M01/M03 Q1000 RMK WIND 1400FT 10007KT=

Case 3: 01.11.2022

SIGMET



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Thank you for your attention!

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