HALO-(AC)^3 – 2022/04/01 – HALO research flight #12

Objectives:

- Capturing spatial and temporal evolution of cold air outbreak West of Svalbard
- Coordinated flight leg with the Polar 5 and 6
- Capturing low pressure system between Kiruna and Svalbard

Mission PI HALO:

Veronika Pörtge

HALO Crew	
Mission PI	Veronika Pörtge
HAMP	Andreas Walbröl
WALES	Georgios Dekoutsidis
SMART/VELOX	Michael Schäfer
specMACS	Anna Weber
Dropsondes	Geet George
Optional	Michail Karalis
Pilots	Roland Welser and Thomas Kalfas
Engineer	Thomas Leder

Flight times:

HALO	
Take off	**07:30 UTC**
Touch down	**15:41 UTC**

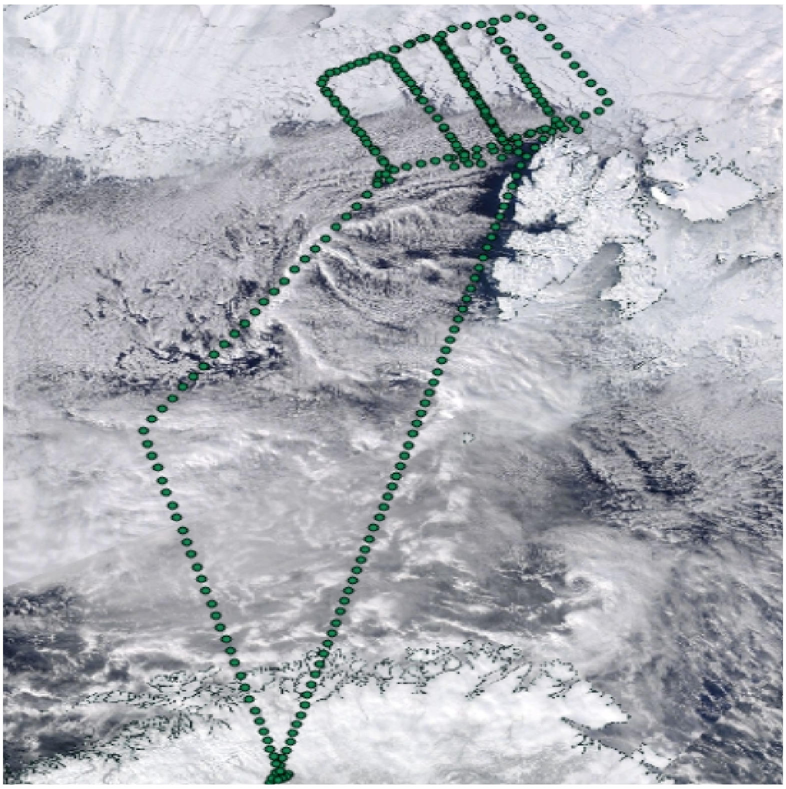


Figure 1: MODIS Terra image from 2022-04-01 with HALO flight path. Remark: No Aqua measurements available on this day!

Weather situation as observed during the flight:

The region between Kiruna and Svalbard was dominated by a low pressure system. This led to high clouds reaching up to 8 km near Kiruna. On the way to Svalbard, the high reaching clouds disappeared and only low level clouds remained. The main measurement region was located to the West of Svalbard. Here, a north-easterly flow was present, responsible for the cold air advection (CAA). We measured the spatial evolution of this CAA by 5 legs perpendicular to the flow from North to South. Furthermore we measured the temporal evolution of the CAA by measuring the legs at least 2 times, except for the northernmost leg which was flown only once.

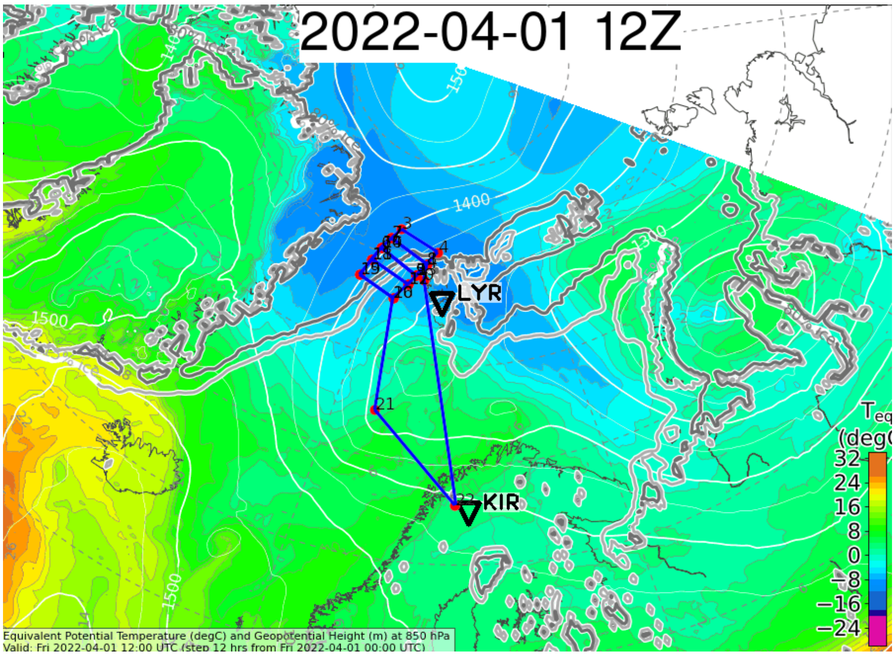


Figure 2: ECMWF Equivalent Potential Temperature (degC) and Geopotential Height (m) at 850 hPa

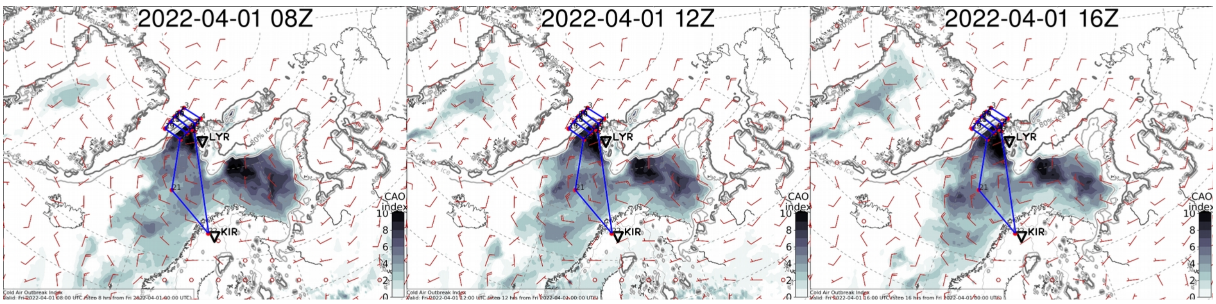


Figure 3: ECMWF: Cold Air Outbreak Index

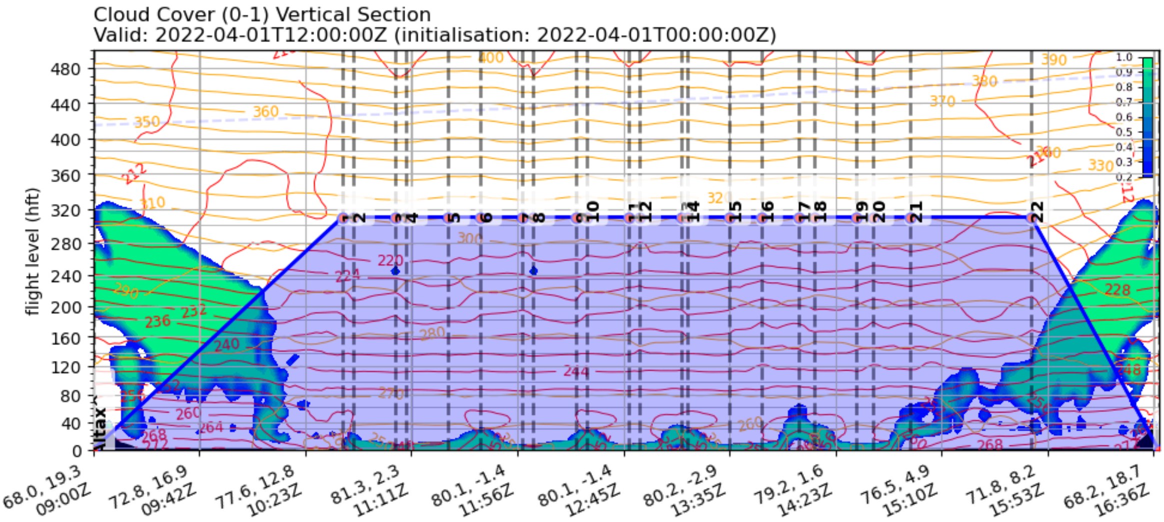


Figure 4: ECMWF: Vertical Cross Section of Cloud Cover

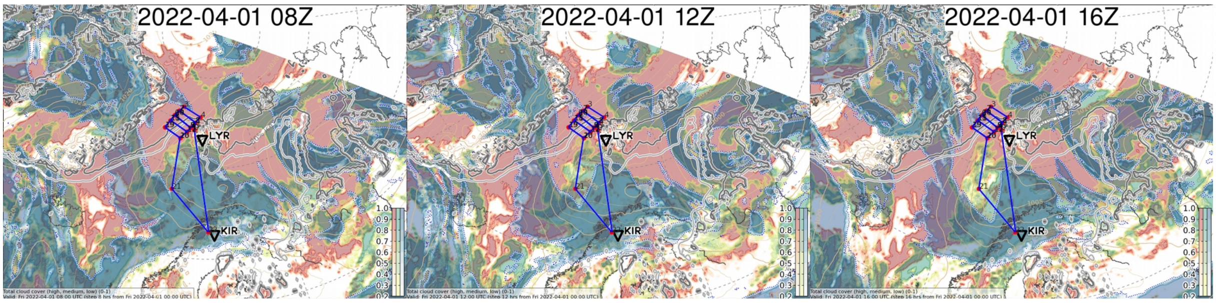


Figure 5: ECMWF: Total Cloud Cover

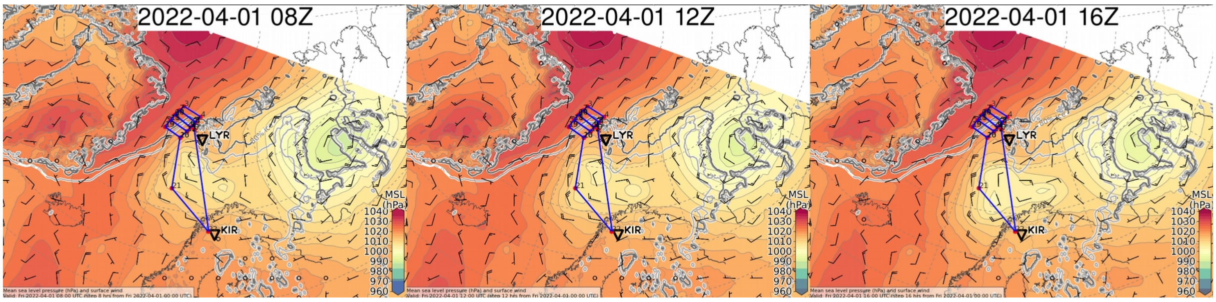


Figure 6: ECMWF: Mean Sea Level Pressure and Surface Winds

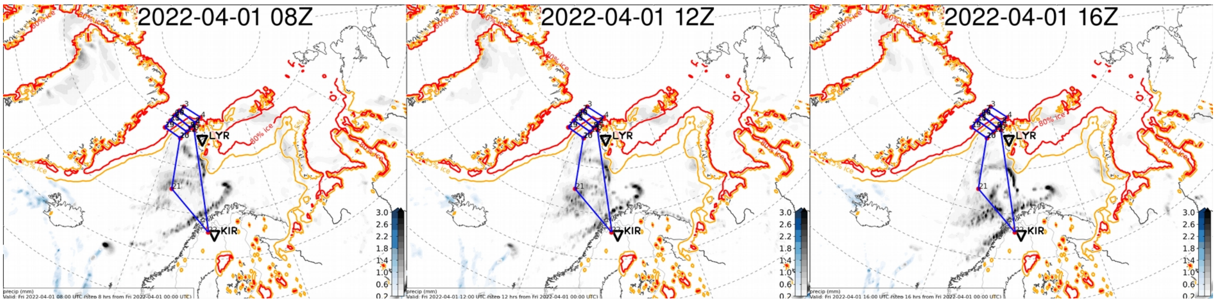


Figure 7: ECMWF: Precipitation (mm)

Overview:

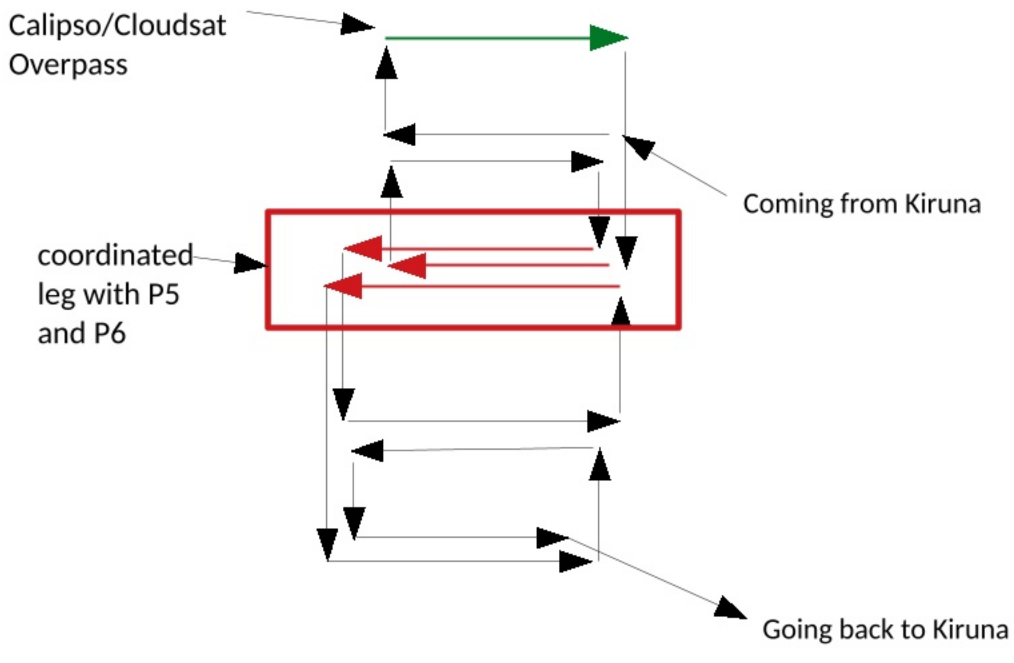
The flight plan was arranged to capture the CAA to the West of Svalbard. On the way to Svalbard we were first passing the low pressure system between Norway and Svalbard at FL 400. As a cloud-free area near Ny-Ålesund was predicted, we planned to do the radar calibration pattern and launch one dropsonde in this clearsky region. The forecast was correct and we were able to carry out this plan. As soon as we entered the main measurement region, we were descending to FL 310. In this region five legs perpendicular to the north-easterly flow were carried out:

- Leg 1 was located above the sea ice and was flown only once. The Cloudsat satellite was overpassing us at almost the same time (at about 09:43 UTC). We entered the leg at 09:45 UTC and left it at 10:01 UTC.
- Leg 2 was mainly also over sea ice, but approaching the sea ice edge. This leg was flown two times.
- Leg 3 was a coordinated leg with the Polar aircraft. The Polar aircraft were flying on a part of this leg back and forth for the whole flight. After their first leg, they decided to shorten the leg a bit, as there were no clouds over the sea ice. We had three direct overpasses: The first one at 10:22 UTC, the second at 11:17 UTC and the third at 12:15 UTC. Half of our leg was over sea ice and half of it was over ocean. The coordination worked very well.
- Leg 4 was mainly over the ocean and was flown two times.
- Leg 5 was mainly over the ocean and was also flown two times.

We nicely captured the cloud streets forming just at the sea ice edge. The clouds were low level clouds (as predicted). The forecast has also predicted low level clouds above the sea ice which has not occured. On these five legs we planned to drop 43 Dropsondes to calculate the divergence pattern of the different regions (ice, ocean, sea ice edge, North vs. South). 5 of the sondes were not working correctly, which is why we dropped 3 replacement sondes.

On the way back to Kiruna we changed the FL to 430 and measured the western side of the low pressure system with high reaching clouds.

Detailed plan for the CAA region:



Instrument Status:

HALO	
BAHAMAS	
BACARDI	
HAMP Radar	
HAMP Radiometer	
WALES	2 short failures. In total around 20 minutes.
SMART	
VELOX	
specMACS	VNIR off
Dropsondes	5 failed, three replacement sondes

Table 1: Instrument status as reported after the flight for all instruments on HALO.

Detailed Flight Logs:

07:25 UTC: Taxi

07:29:54 UTC: Takeoff

07:36 UTC: Asked for FL Change to FL 400

07:48 UTC: Stratus below

07:57 UTC: Broken stratus, cumulus clouds below visible

08:05 UTC: Cirrus becoming less

08:06 UTC: Thick cloud deck, extensive and uniform structure

08:17 UTC: Still thin layer between us and Cumulus clouds below us

08:35 UTC: Radar and lidar see that cloud top height decreases. Just as expected from the forecast.

08:35 UTC: Approaching position of predicted low (74.6° latitude)

08:43 UTC: Cloud remains thick -- only few discontinuities and appears to be more turbulent; less uniform structure

08:45 UTC: Seeing more Cumulus from outside the window

08:48 UTC: Layer disappears

08:57 UTC: very nice view to Svalbard

09:01 UTC: Cu formation close to surface as cold air is advected over the ocean (East of the airplane) and more cellular structure downstream (west)

09:13 UTC: Radar calibration pattern

09:15 UTC: First dropsonde launch in (almost) clear sky for calibration purposes

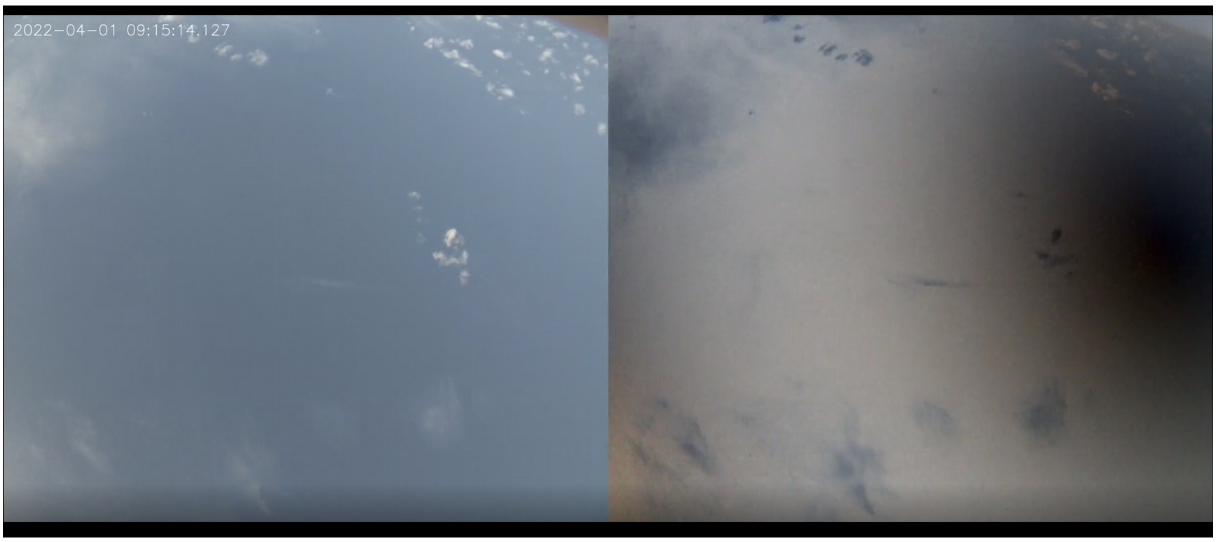


Figure 8: specMACS Polarization Camera at 09:15:14 UTC. Almost clear sky.

09:17 UTC: Descending to FL 310

09:22 UTC: Sea ice edge visible

09:24 UTC: Cloud streets that merge into Sc sheets downstream

09:25 UTC: Flying over sea ice; big breaks

09:45 UTC: Northernmost leg; high ice concentration; gaps refreezing

09:54 UTC: Still flying over ice; Same image

Figure 9: specMACS Polarization Camera at 09:45:40 UTC. Sea ice with some cracks.

09:59 UTC: Thin cloud layers over ice; finishing leg; stayed over ice the entire time just as planned

10:03 UTC: Ice thinning again, heading South

10:03 UTC: Cloud streets visible

10:07 UTC: Flying over sea

10:14 UTC: Starting first coordinated leg with P5 and P6

10:19 UTC: Over sea ice again

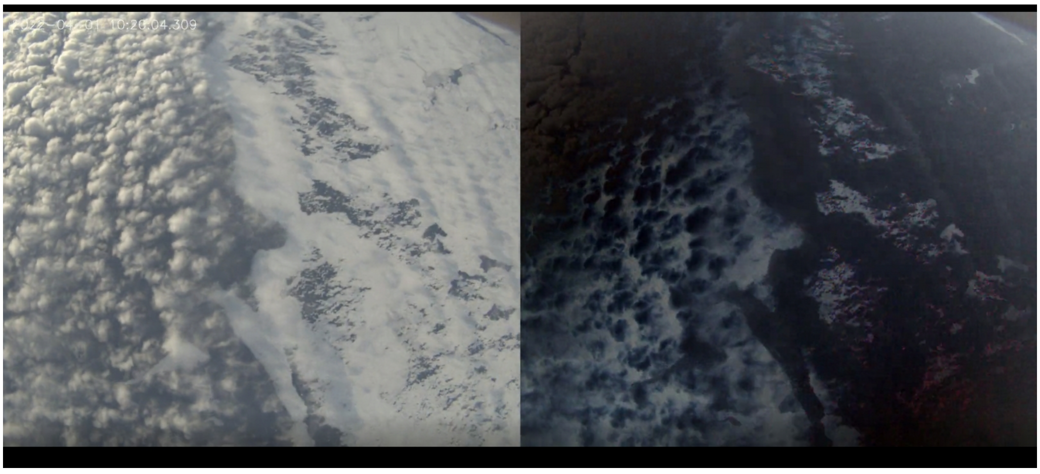


Figure 10: specMACS Polarization Camera at 10:20:04 UTC. Cloud streets perpendicular to the flight direction (= to the right). Clouds start to disappear as soon as the ice edge is reached.

10:22 UTC: Directly above P5/P6

10:25 UTC: Gaps in ice covered area later seen refreezing

10:26 UTC: Still over sea ice, but no more clouds

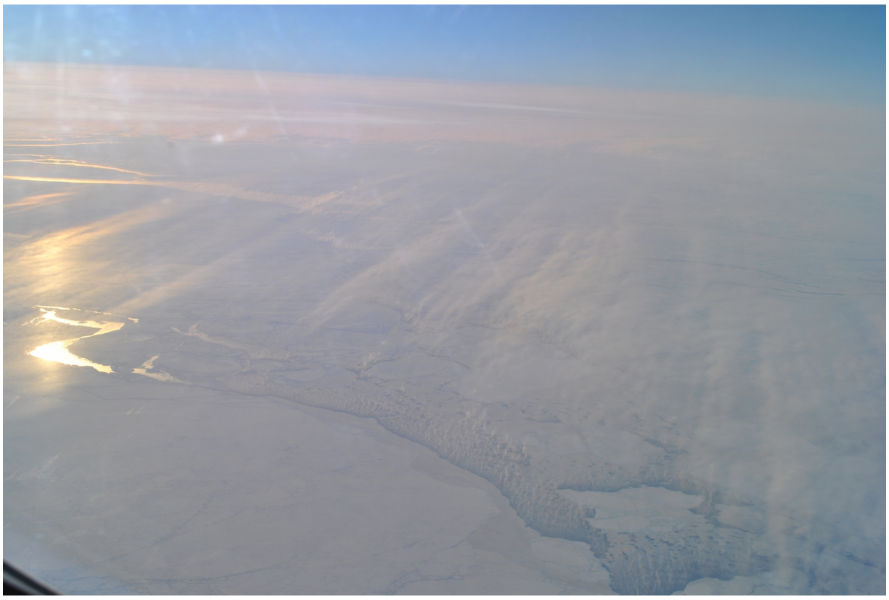


Figure 11: Camera: 10:42:36 UTC. Clouds forming above sea ice leads

10:47 UTC: Thin streaks of condensed vapor hovering over sea ice leads

10:52 UTC: Formation of cloud streets starting again. Sea ice edge visible

10:57 UTC: Procedure Turn (duration: 7 minutes), Clouds above Sea/Sea Ice edge

11:14 UTC: Starting second coordinated leg with P5/P6

11:16 UTC: Flying parallel to ice edge

11:17 UTC: directly above Polar 5/6

11:19 UTC: Clouds disappear directly at sea ice edge

11:43 UTC: Still over ice, no clouds

11:47 UTC: Clouds start forming as soon as we reach the sea ice edge

12:13 UTC: Starting third coordinated leg with P5/P6

12:15 UTC: Directly above Polar 5/6

12:21 UTC: Cloud streets above ice but disappearing quite fast as soon as sea ice begins

12:42 UTC: Climb to FL 330 (Cirrus too close for WALES). Still no thick clouds above ice

12:51 UTC: Pictures of transition from cloud free, ice-covered surface to thick low clouds extending over open sea

12:53 UTC: most Southern Leg. Clouds start forming just after the sea ice edge. More dense, less cloud street like

12:55 UTC: Launching one replacement dropsonde, as one was not working

13:03 UTC: Distinct cumulus tops rising above cumulus deck

13:11 UTC: Entering Leg 4

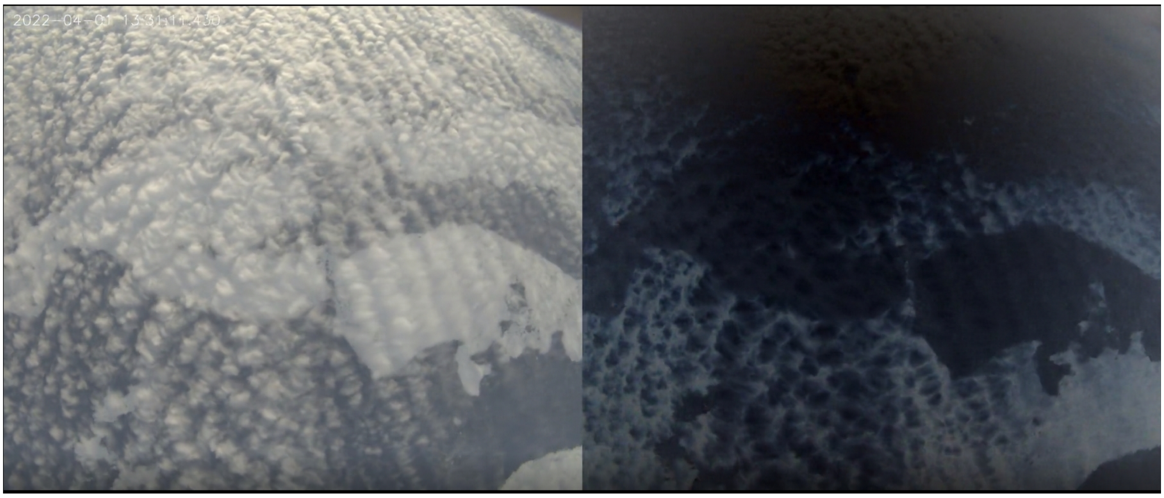


Figure 12: specMACS Polarization Camera at 13:31:11 UTC. Cloud streets over sea ice edge.

13:58 UTC: very large backscatter glory (= small droplet radius + liquid water) together with snowfall in the radar

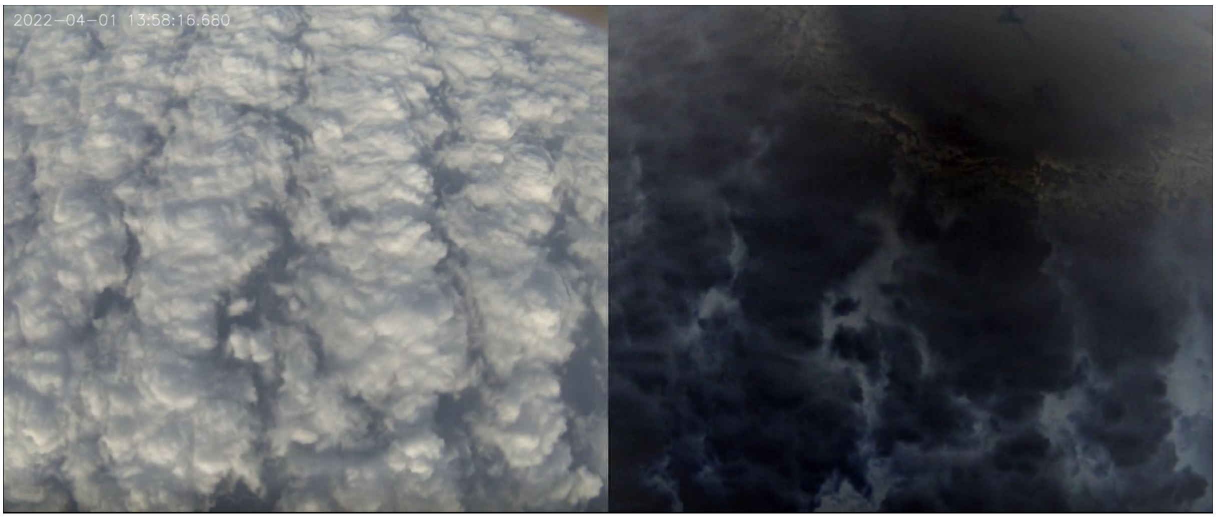


Figure 13: specMACS Polarization Camera at 13:58:16 UTC. Clouds larger and more dense.

14:07 UTC: Ascending to FL 430 for our way back

14:08 UTC: Extensive Sc looking cloud sheets displaying a few discrepancies through the gaps, multilevel cloud vertical structure can be observed (tiny cumulus near the surface under the Sc layer)

14:12 UTC: more convective conditions; higher clouds and big breaks

Figure 14: Camera: 14:23:17 UTC. Higher clouds.

14:28 UTC: Clouds start to disappear

14:32 UTC: High reaching clouds

14:39 UTC: Heading South; Clouds keep getting higher along the flight track

15:16 UTC: We slowly start to descend for landing

15:25 UTC: We are flying through the clouds. Low visibility from window.

15:40:41 UTC: Landing

Quicklooks:

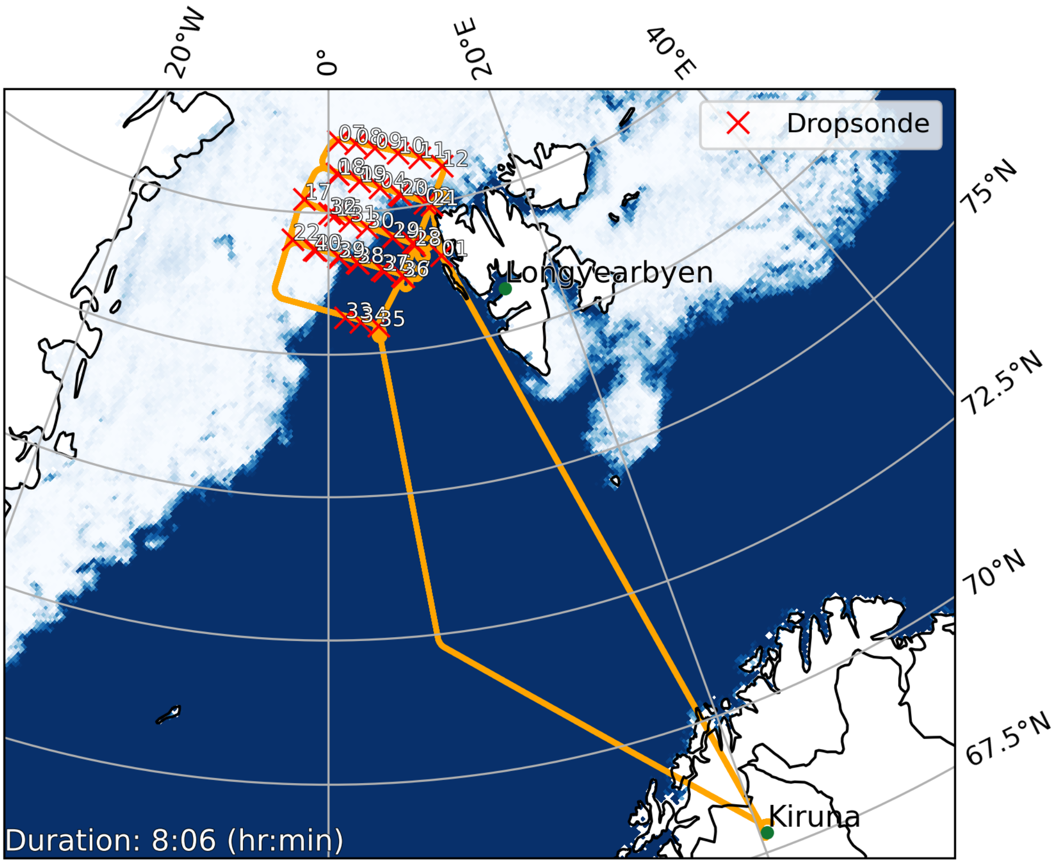


Figure 15: HALO SMART-INS Track with dropsonde locations

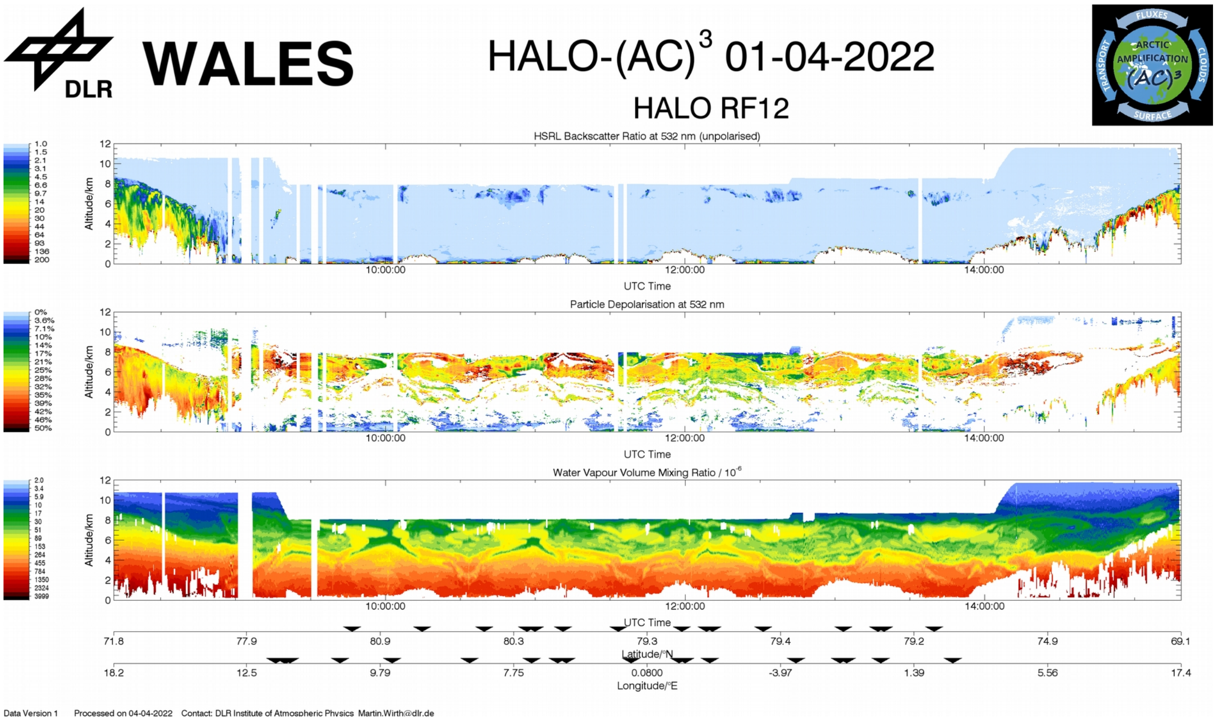


Figure 16: WALES Backscatter Ratio, Particle Depolarisation, Water Vapour Volume Mixing Ratio

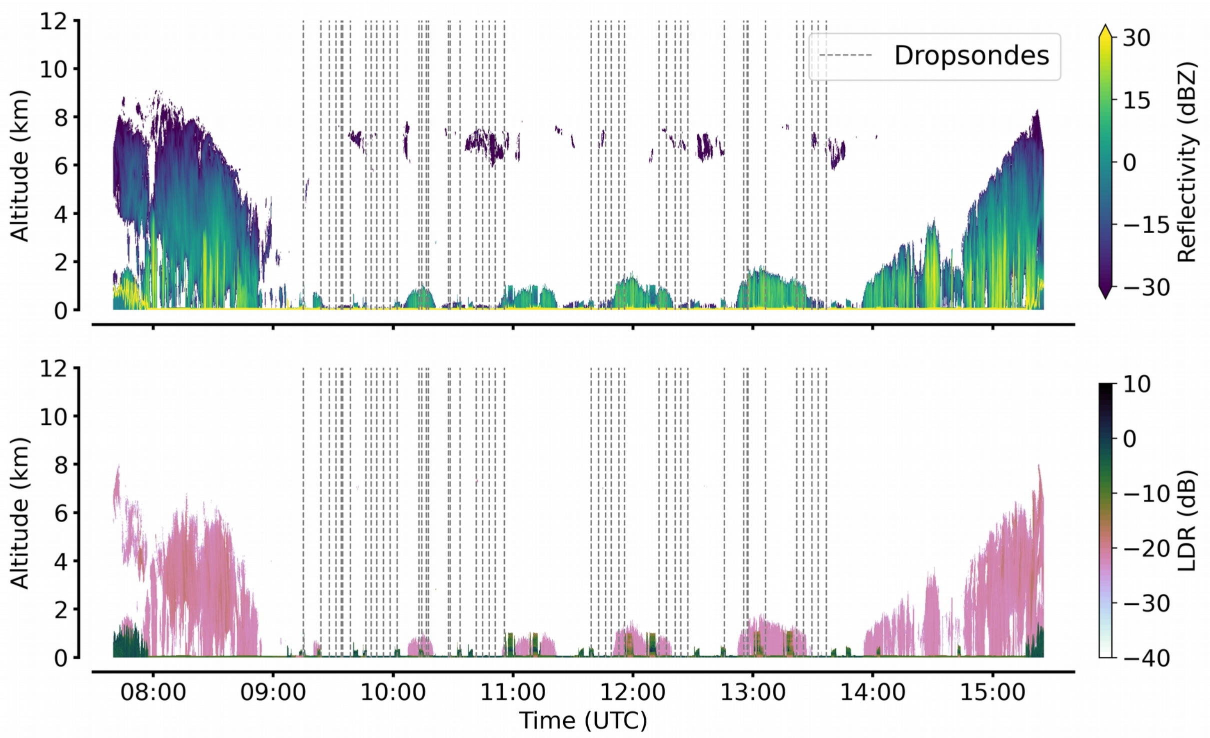


Figure 17: HAMP Radar Reflectivity

Figure 18: Thomas Kalfas, Michail Karalis, Andreas Walbröl, Georgios Dekoutsidis, Veronika Pörtge, Michael Schäfer, Roland Welser, Geet George und Anna Weber