HALO-(AC)^3 – 2022/04/04 – HALO research flight RF13

Objectives:

1. Sample an ice cloud / cirrus north of Greenland and observe on the transfer to this location the humidity field, the skin surface temperature and aerosol structure over the cloud free sea ice north of the Fram Strait.
2. Extend the cloud field statistics obtained on RF12 (1. April) both over the sea ice and open water in the Fram Strait during less forced or even calm wind situations.
3. Analysis the formation of precipitation at the convergence zone located over the ice edge in the Fram Strait and along the air mass transported to the Southeast between Svalbard and the Norwegian Coast

HALO Crew	
Mission PI	Felix Ament
HAMP	Clémantyne Aubry
WALES	Manuel Gutleben
SMART/VELOX	Johannes Röttenbacher
specMACS	Anna Weber
Dropsondes	Lutz Hirsch
Documentation	Jörg Schmidt
Pilots	Roland Welser, Thomas Kalfas
Engineer	Alexander Wolf

Flight times:

HALO	
Take off	**7:26 UTC**
Touch down	**16:18 UTC**

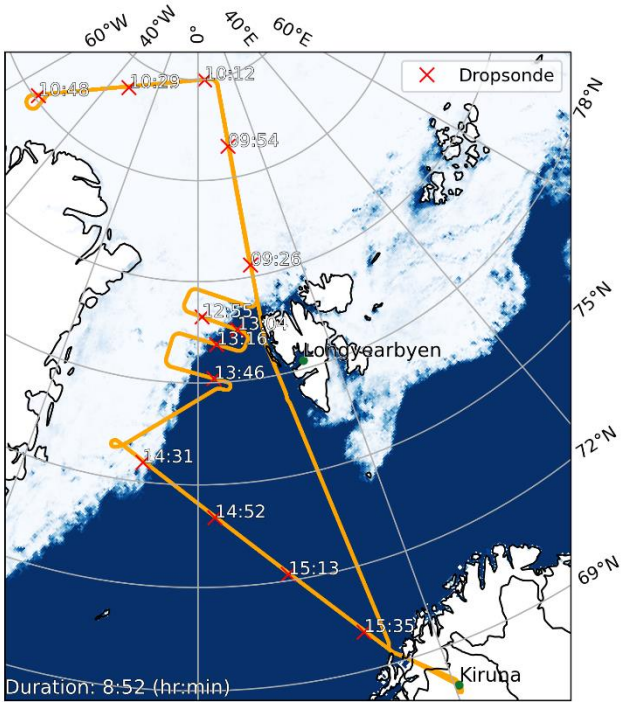


Fig. 1: Flight track and drop sonde launch times (UTC) and locations (red crosses) on top of climatological sea ice fraction (Spreen et al., 2008).

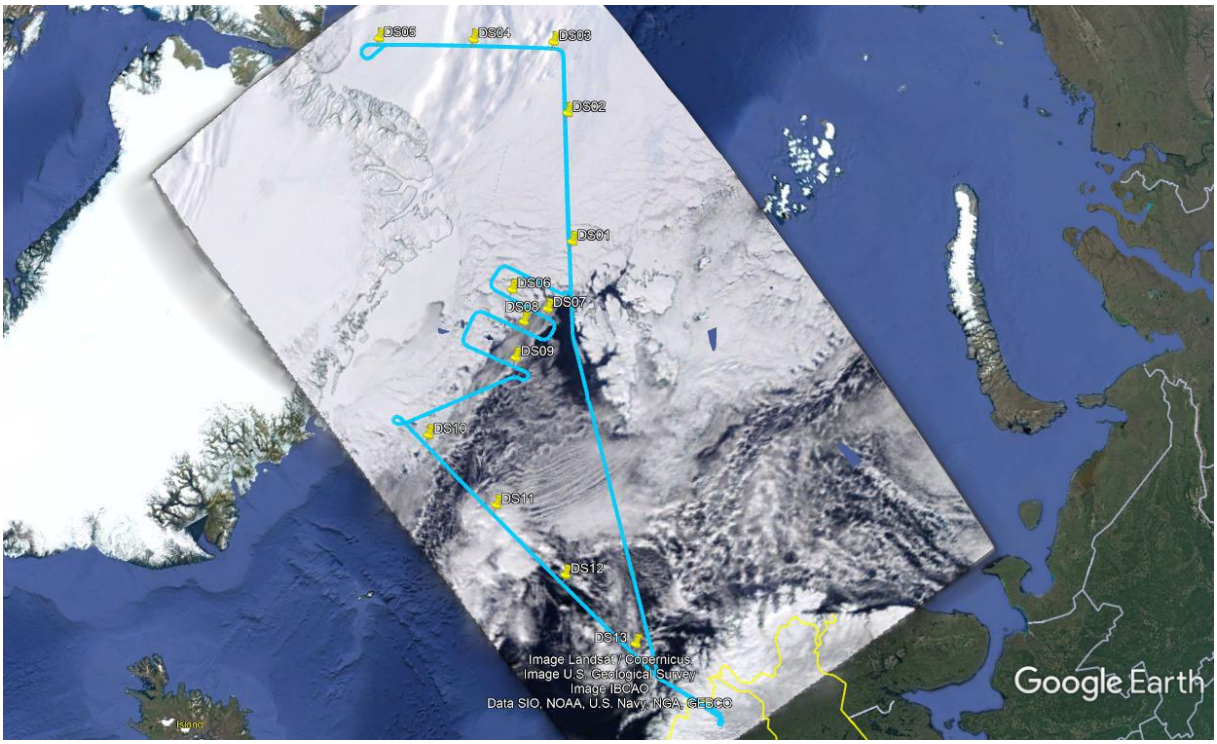


Fig. 2: Flight track and drop sonde launches times (UTC) on top of TERRA visible composite at the flight day.

Weather situation as observed during the flight

The flow in the region between Kiruna and Svalbard was determined by a persistent low-pressure system over Scandinavia advecting slightly warmer and moisture air masses westwards from Siberia towards the Fram Strait. Next to the Norwegian Coast intense precipitating convection reaching up to 4km height evolved. This convection was partly topped by cirrus clouds at 6 km height with potentially some seeder-feeder-interaction with precipitating clouds below. The cloud tops lowered towards Svalbard and the cloud cover decreased. West of Svalbard we flew through cloud free areas as consequence of lee effect.

All clouds vanished at the ice edge and the leg up to the most Northern way point was cloud free – in contrast to model forecast indicated a complete coverage with low clouds. The dropsondes detected a weak northly flow. The region north of 80° was under weak high-pressure influence without strong gradients or wind. A thick ice cloud (cloud top at 7km height and a cloud base rising from 700m up to almost 3km at the western edge) covered most parts of the westward leg towards the turning point close to the coast of Greenland. The turning point – as predicted by the models – was cloud free.

The weak cold air outflow west of Svalbard generated a characteristic west-east sequence of cloud conditions: no clouds over the sea-ice, uprising convective clouds at the well predicted convergence line close to the sea-ice edge, shallow convective cloud streets east of the ice edge over open water and dissipating clouds close to the coast of Svalbard. The cloud top height of the uprising clouds at the convergence increased while flying more southerly legs. Likewise, we observed the most intense convection and precipitation at the final most southerly leg flying home. This leg features segments with all stages of convection: pure boundary layer convection; boundary layer convection with outflow of ice clouds aloft and residual layers of cirrus clouds without boundary layer convection.

The model forecasts predicted the location of the clouds system very precisely. Only the forecasted lo-level cloud cover over the sea-ice north of Svalbard was wrong.

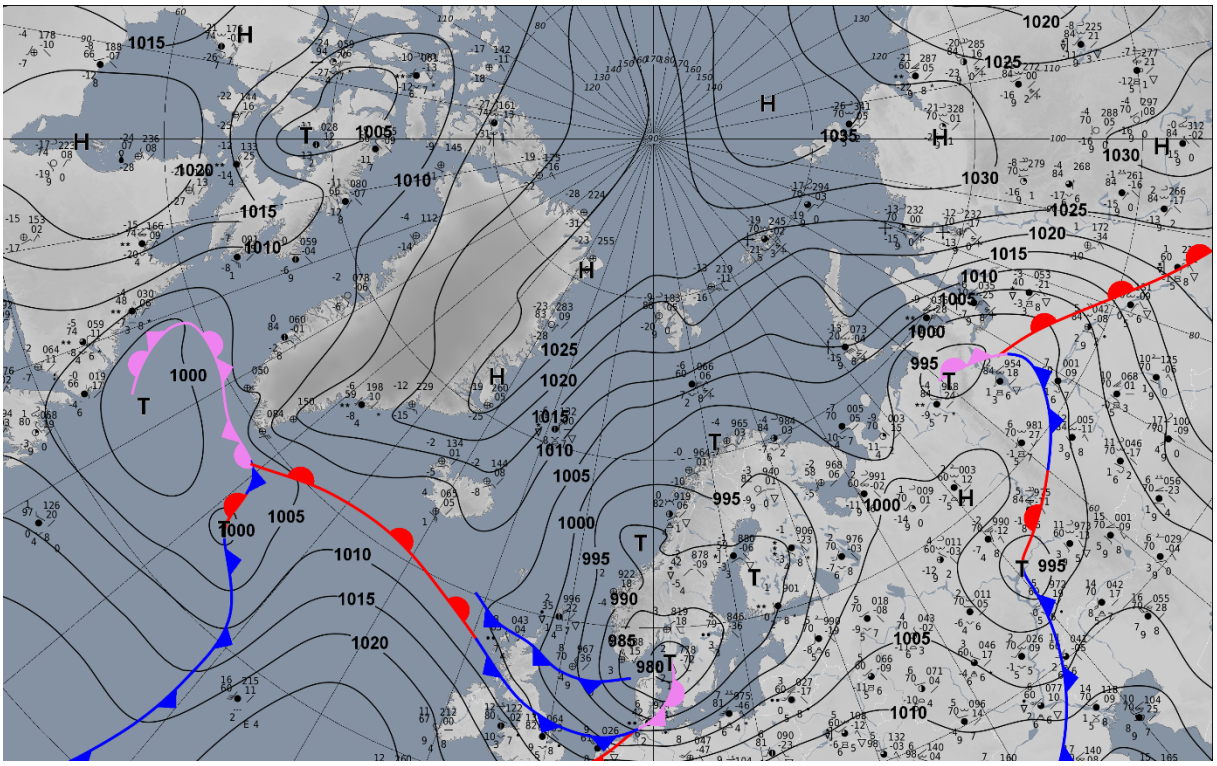


Figure 3: Surface pressure analysis by DWD valid at 12 UTC, 4. April 2022.

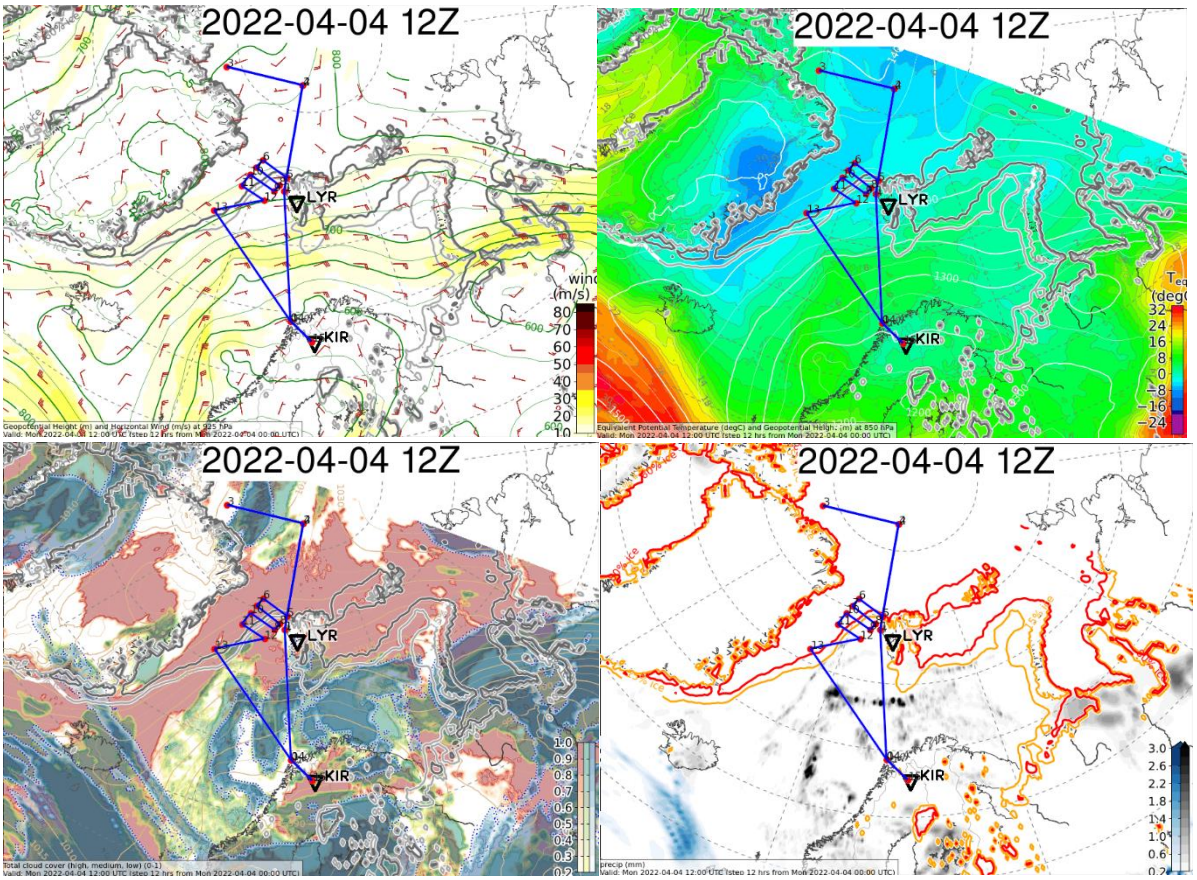


Figure 4: ECMWF forecasts with 12 hours lead time of wind at 850hPa height (top left), equivalent potential temperature (top right), cloud cover (bottom right; red colors for low-level, green colors for mid-level and blue color for high-level clouds) and instantaneous precipitation (bottom right; blue rainfall & black snowfall).

Overview:

The three objectives of RF13 are addressed by the following segments of the flight:
"High up north" (9:07 – 12:29 UTC): The original plan to fly below the cirrus cloud was impossible due to the low cloud base of this cloud. Therefore, we stayed at FL 410 and just descended to FL 370 as technical maneuver to stabilize the laser cooling of WALES in colder air layers close to the tropopause. The goals to falsify the model predicted low cloud cover, to sample an arctic ice-cloud or cirrus and to dropsondes at latitudes higher than 85° N were all reached.
"Cloud field statistic at the sea ice edge" (12:29 -13:52 UTC): We repeated exactly the four southern legs of RF12 (skipping just the most northern leg over sea ice, as the "High up North" segment has already sampled a lot of sea-ice conditions) at FL 370. We met the Polar aircraft on the third leg. To give context to this "golden leg" of the we dropped two sondes north on the second leg and one south at the final leg. A fourth sonde was dropped in the center of this triangle shortly after the meeting point with P5 and P6.
"Precipitation formation and convergence line" (13:52- 15:43 UTC): The convergence line was a remarkably feature which was also sampled in the previous segment. We again passed it two times in this segment. We climbed again at FL410 to save time by flying faster. The long leg home features a multitude of different convective states. Precipitation signals were detected at the convergence line as well as occasionally at deeper convection on the leg towards Kiruna.
In addition, RF13 provides to overflights over the Andenes measuring site after take-off and before landing as well as transect between Kiruna and Svalbard at beginning of the flight.

Instrument Status:

HALO	
BAHAMAS	
BACARDI	
HAMP Radar	
HAMP Radiometer	
WALES	
SMART	
VELOX	
specMACS	
Dropsondes	

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

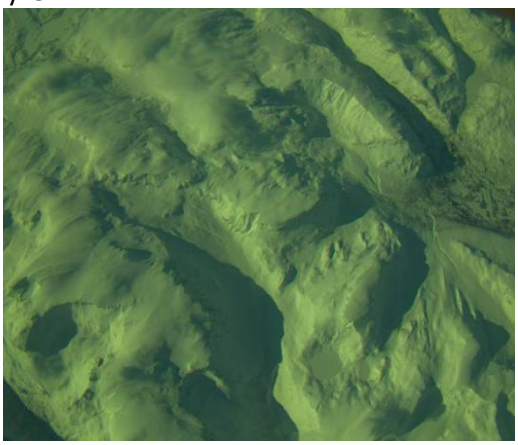
All 13 dropsondes were successful! Just few additional minor issues:

- HAMP: no issues during the flight – after the calibration one channel of the 183 GHz radiometer featured high positive Bias (common effect during the campaign)
- WALES: three short (a few minutes) laser shutdowns at the northern leg because of insufficient cooling by too warm stratospheric air
- SMART: minor issues with stabilization

Detailed Flight Logs:

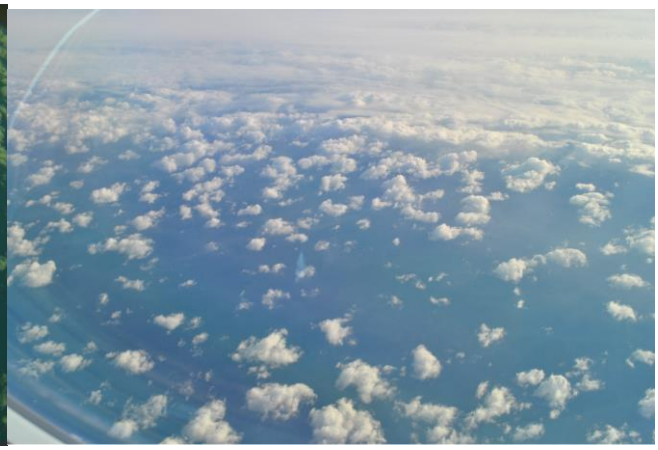
slightly adapted from the notes kindly provided by the “Flight documentation” operator Jörg Schmidt – all time in UTC

7:05	DSC_5496	Time Check
7:22	-	Take Off
7:36	DSC_5519 - DSC_5523	Cloud free, Nice Scenery ☺

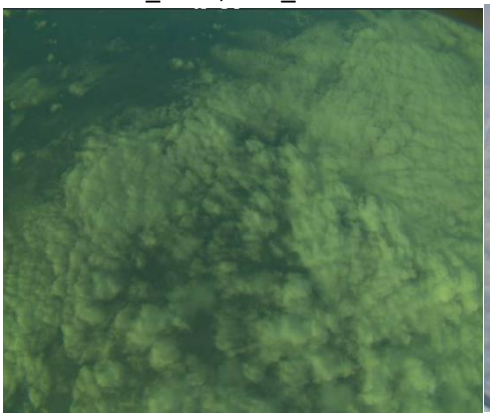
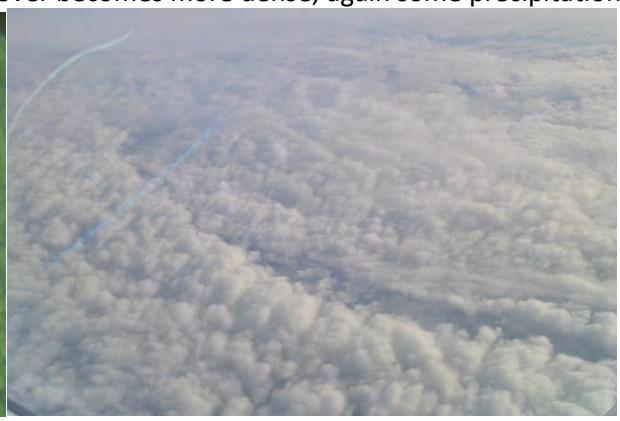



7:49	-	WP 1 – Overpassing Supersite Andenes – no clouds
7:51	DSC_5544, DSC_5545	Some low and midlevel clouds


7:55		some precipitation
8:05	DSC_5546	Shallow Cumuli

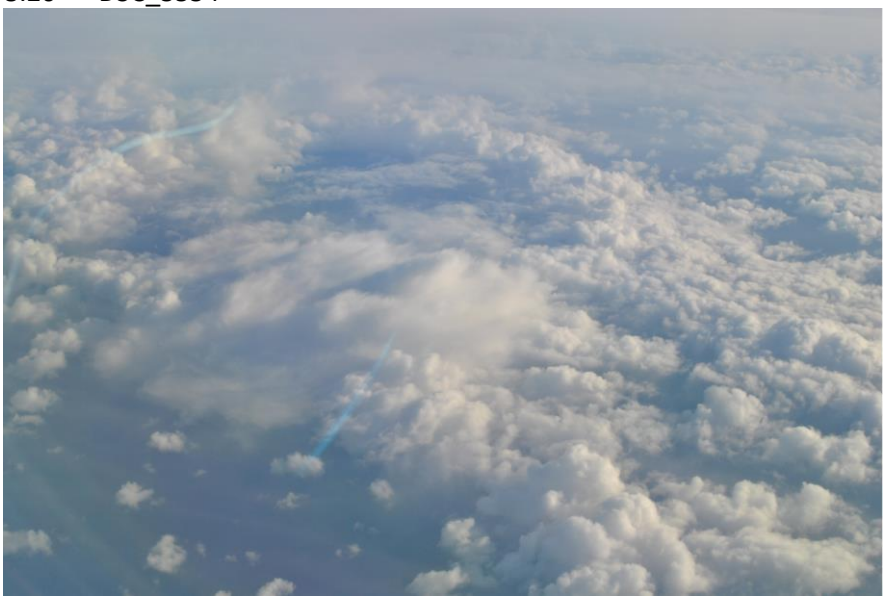



8:12 DSC_5550, DSC_5551 Cloud Cover becomes more dense; again some precipitation

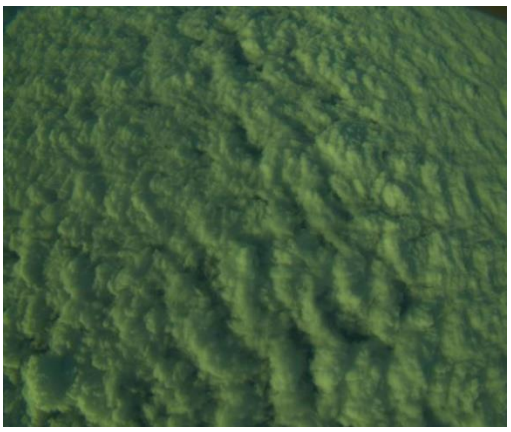
8:15 DSC_5552 More breaks in cloud cover

8:20 DSC_5554



8:20 Summary at Planet by Felix “We fly most of the time over cellular shallow convection. Lidar sees also elevated (~6km) layer of aerosol / ice crystal. Occasionally this becomes also visible by the radar - especially at times when we see snowfall with some liquid at the radar”

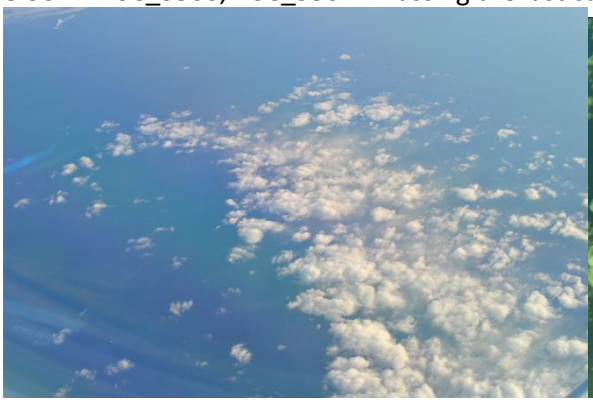
8:25 DSC_5555 Dense cloud cover, cloud streets




8:42 Felix: “Suprises of this leg so far: thick but thin cirrus layer at 5-8km height - hardy visible by eye + shallow boundray layer convection, which rarely clusters into penetrating convection with snowfall. And Specmacs is happy with cloud bows :-)”

8:44 DSC_5563, DSC_5564 Decreased cloud cover, still shallow cumuli


8:50 DSC_5566, DSC_5567 Passing the last cumuli, from now onwards cloud-free




8:52-8:55 Radar calibration pattern

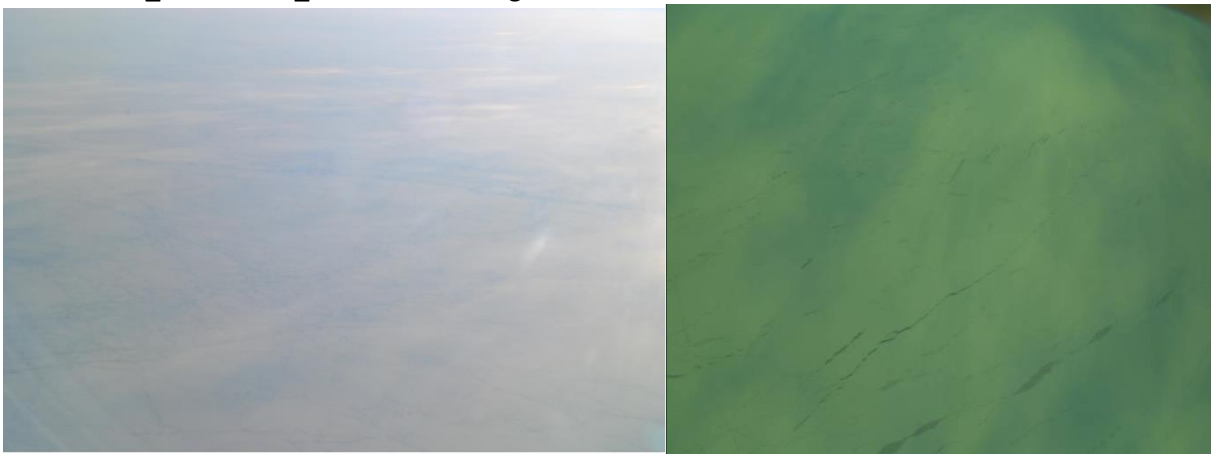
9:01 no clouds – lee effect of Svalbard

9:07 WP2 reached – now turned to the NORTH. Beautiful view of Svalbard! Still cloud free

9:13 ice edge to the left, some cloud streets visible

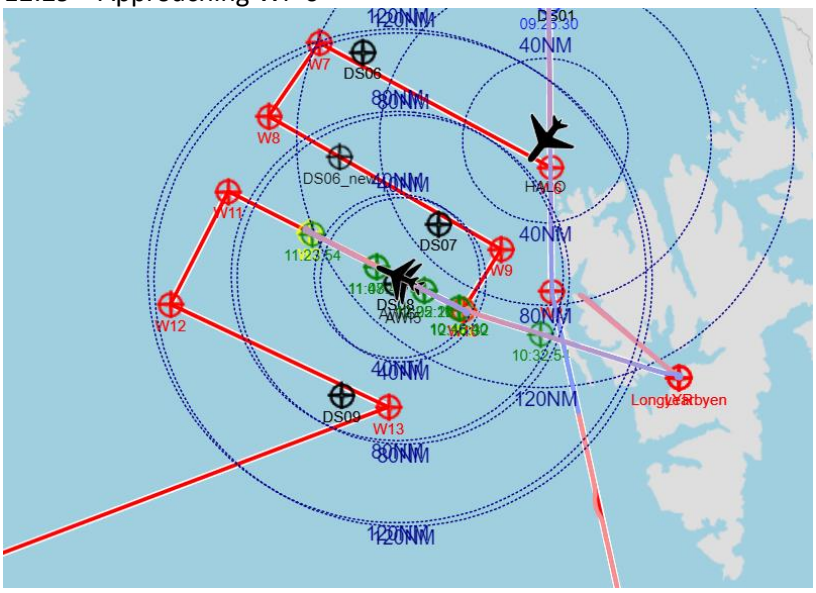
9:15 DSC_5585 – DSC_5590 Passing the ice edge

9:26 Launch of DS 1
9:40 Still cloud-free, still over ice
9:55 Launch of DS 2
10:12 Passing WP 3
10:13 Launch of DS 3
10:15 Very thick Cirrus; but semi-transparent (s. photo below)
10:29 Launch of DS 4
10:40 Cirrus dissolves / leaving the Cirrus
10:49 Launch of DS 5
11:03 DSC_5604 – DSC_5614 Re-entering the Cirrus



11:23 DSC_5615 - DSC_5618 Leaving the Cirrus
11:38 Descend from FL 410 to FL 370 because Velox and Wales have heat problems
12:07 Calm flight over the sea ice – no clouds

12:29 Approaching WP 6



12:33 Summary from the excursion "high up North": “No cloud on the outbound North leg, one cloud at the inbound leg. But the East-West-leg in the North revealed a nice cirrus system.”

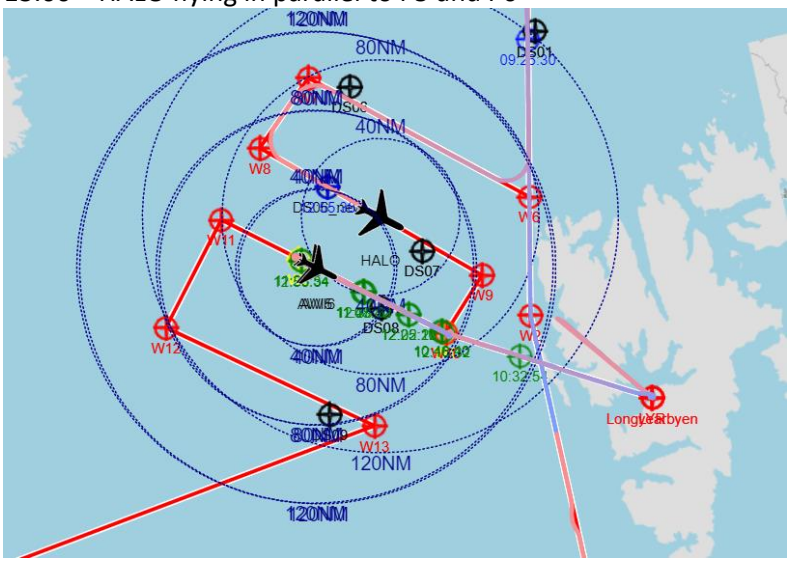
12:35 DSC_5728, DSC_5729 Shallow cumuli on the left of HALO. No clouds on its right.

12:45 WP 7, cloud-free

12:50 WP 8, cloud-free

12:55 Dropsonde 6

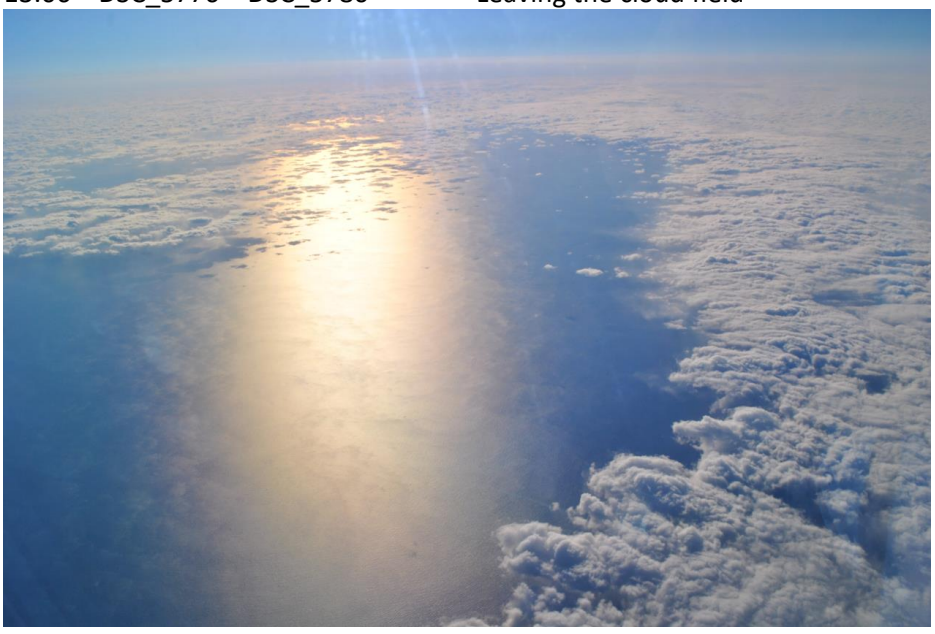
13:00 HALO flying in parallel to P5 and P6



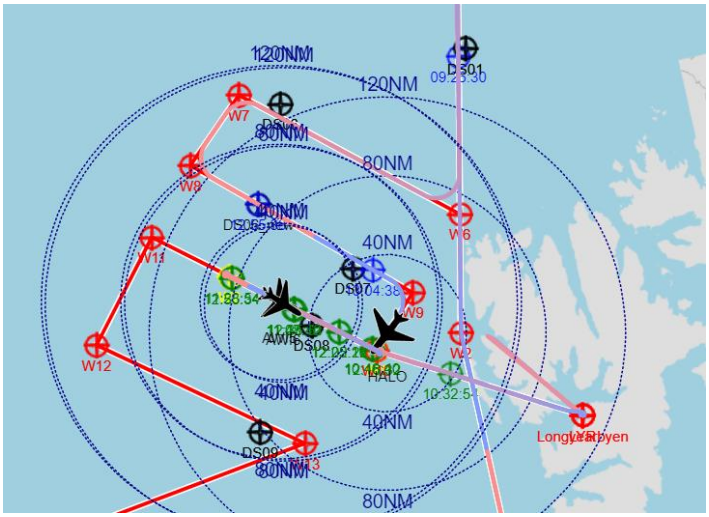
13:02 DSC_5766 – DSC_5775 Fields of shallow cumuli appear as soon as we leave the ice and enter the sea

13:04 Dropsonde 7

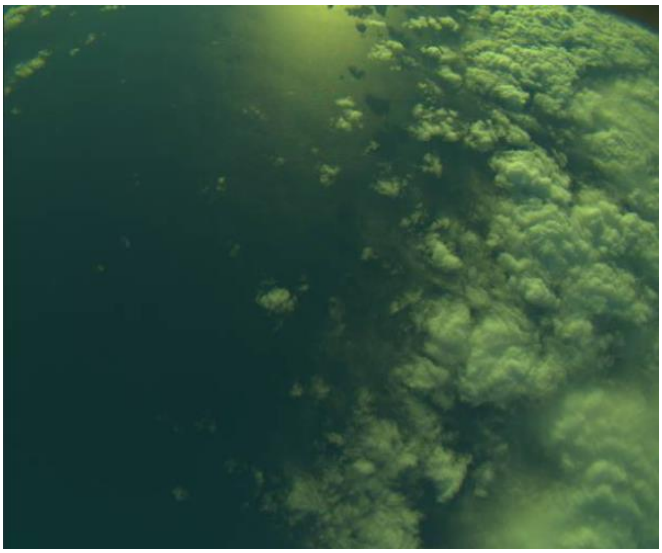
13:06 DSC_5776 – DSC_5780 Leaving the cloud field



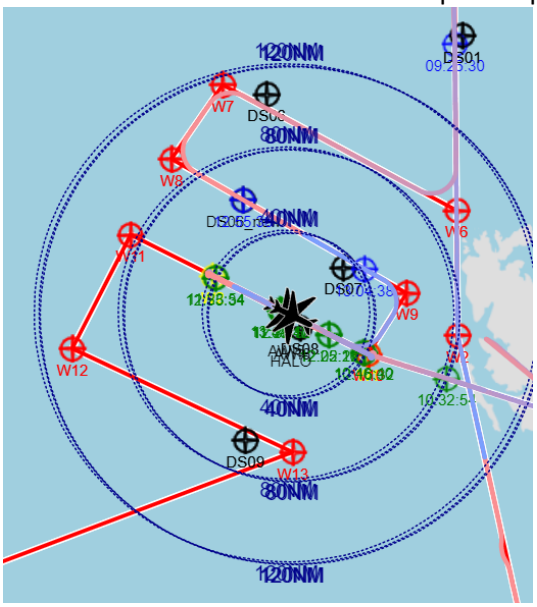
13:09 WP 10



13:12 Back into the cumulus clouds

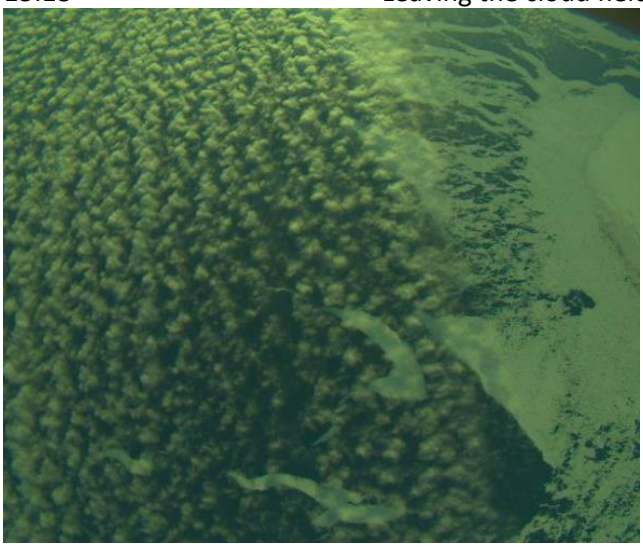


13:16 Overpass of polar aircrafts



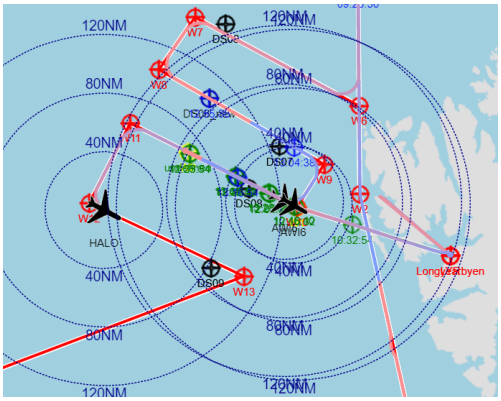
13:16 Dropsonde 8

13:18 Leaving the cloud field



13:26 WP 11

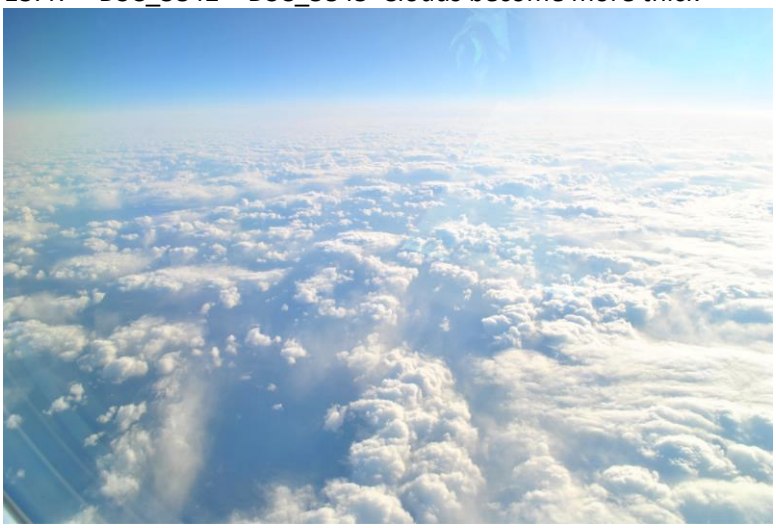
13:34 WP 12



13:39 DSC_5840, DSC_5841 Leaving the ice, flying over cumuli again

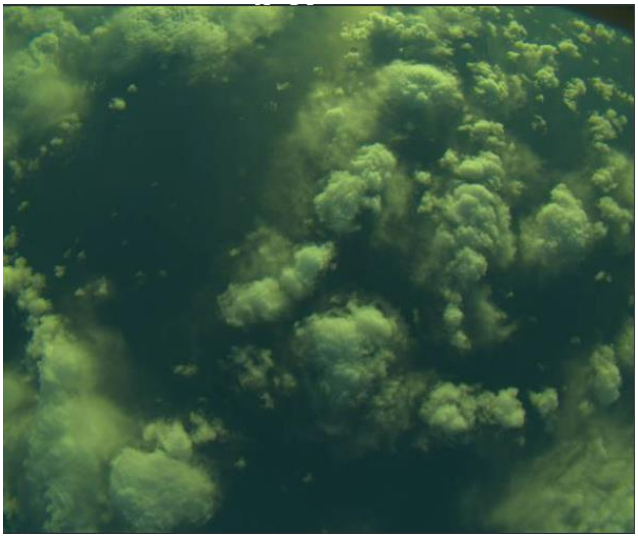
13:46 Dropsonde 9

13:47 DSC_5842 – DSC_5845 Clouds become more thick

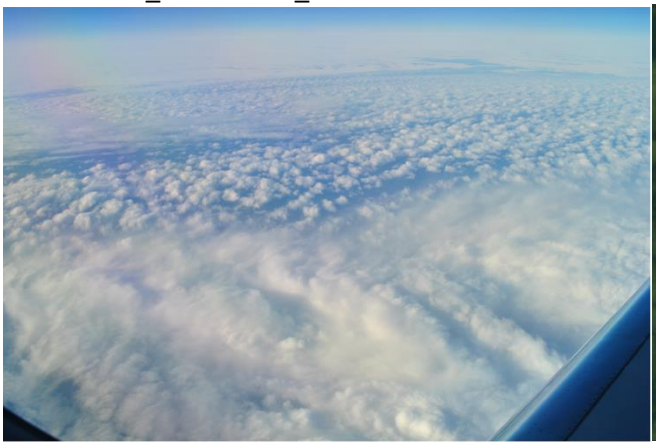


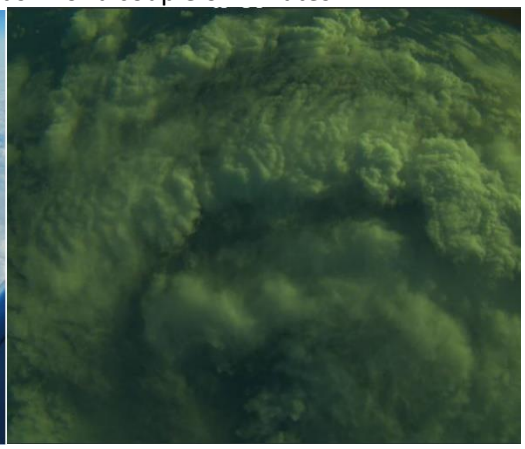
13:51 WP 13

13:52 More breaks in cloud cover

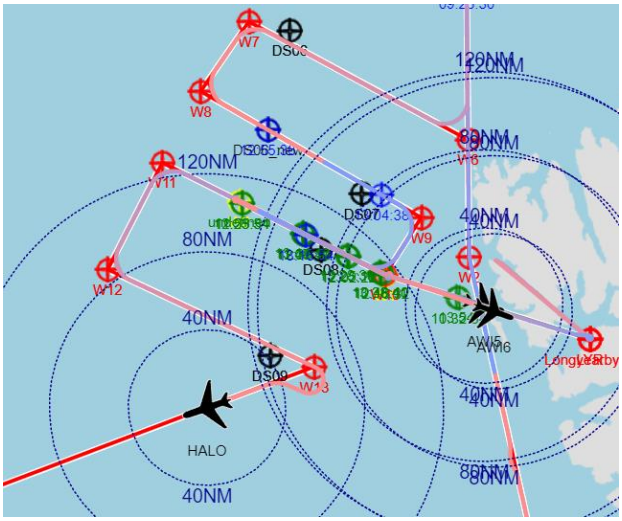


13:55 DSC_5849 – DSC_5852 Rather stratiform clouds – for a couple of minutes





13:59 HALO and Polar aircrafts leave the common area of operation



14:02 As we come closer to the ice edge (diagonally, slowly), cloud types vary very quickly, partly cloud ice aoutflow at the top

14:04 No clouds

14:07 Above sea ice. Thin cirrus layer visible – no PBL clouds any more

14:12 filaments of cirrus clouds at midlevel

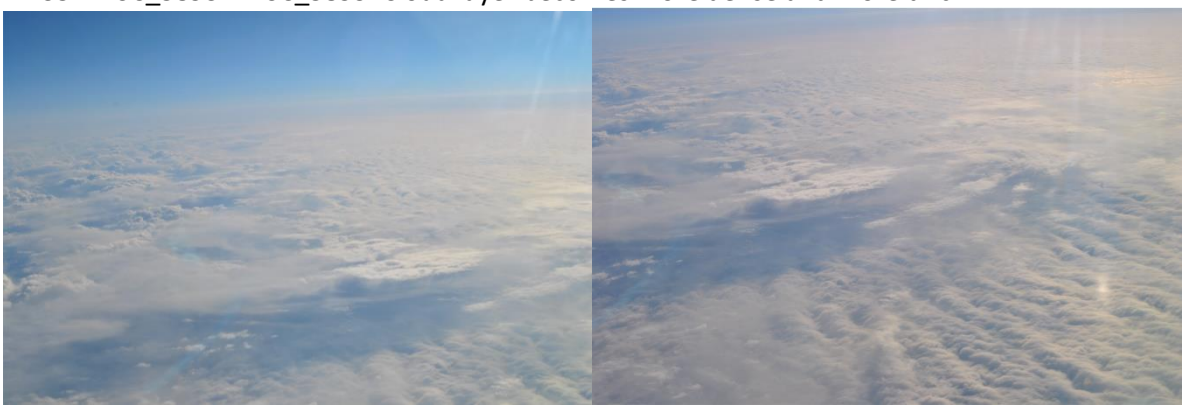
14:14 Cloud-free, flying over ice

14:20 WP 14

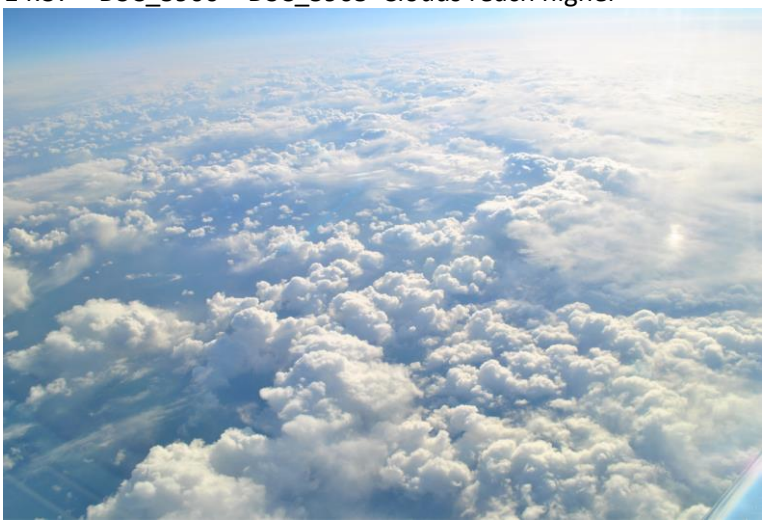
14:31 Dropsonde 10

14:33 DSC_5886 – DSC_5892 Leaving the ice, flying over cumuli

14:35 DSC_5893 – DSC_5899 Cloud layer becomes more dense and more thick

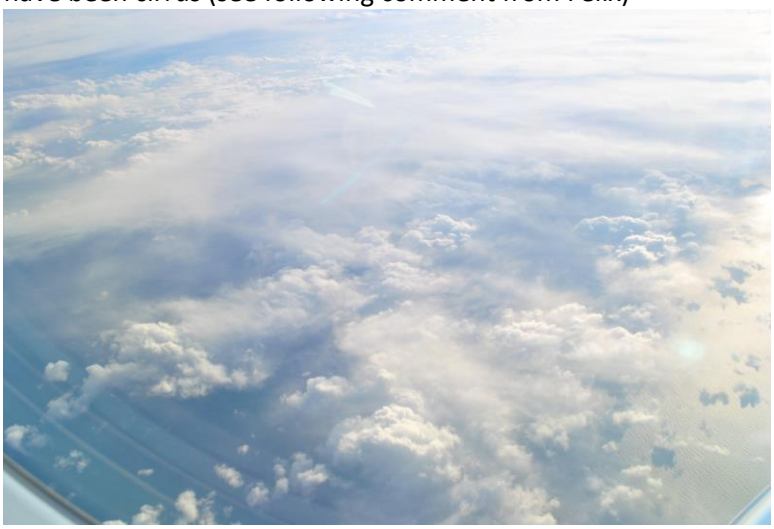


14:37 DSC_5900 – DSC_5905 Clouds reach higher



14:39 Decrease in cloud cover, shallow cumuli

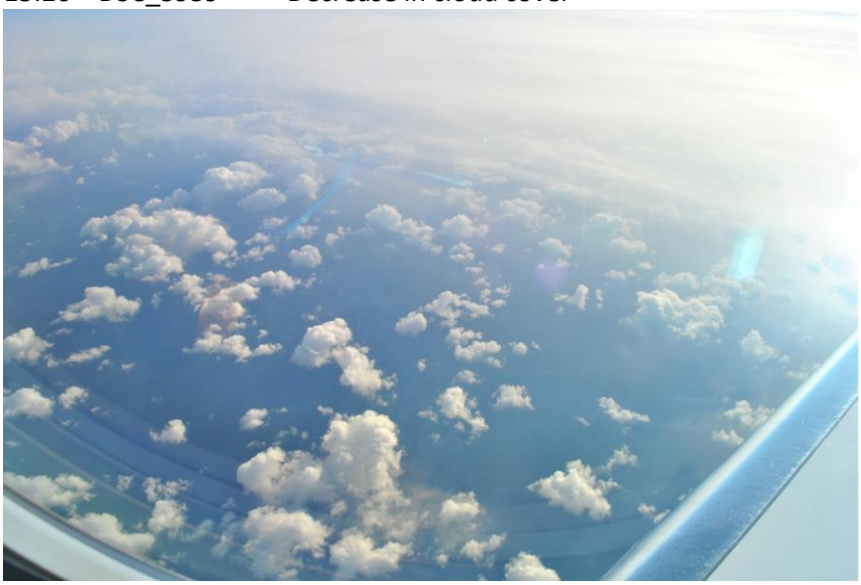
14:43 DSC_5909 – DSC_5911 Increased cloud cover, cumuli with increased cloud depths, some stratiform clouds mixing in; maybe I misinterpreted the cloud top height, somewhere here should have been cirrus (see following comment from Felix)



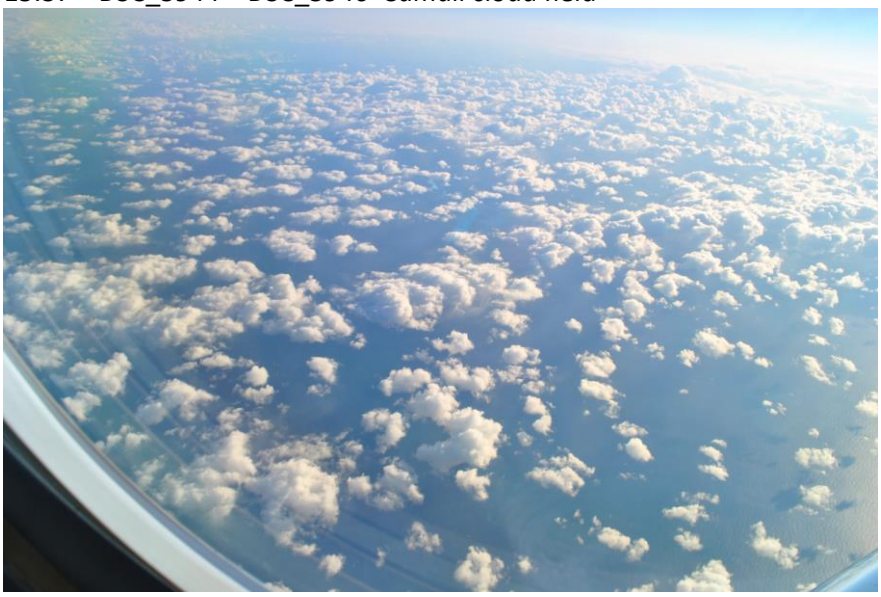
14:47 Precipitating convection below. But capped at 2-3km heigh

14:48 DSC_5916 – DSC_5918 Stratiform clouds

14:52 Dropsonde 11
14:56 homogeneous cirrus with embedded convection – cloud top at ~7.5km
15:00 Felix: “Our final leg is nice trip trhough different cloud regimes: starting with no clouds or just scattered cirrus filaments over the sea ice close to WP14, then some isolated convective cells with snowfall and now at the center of the leg a cirrus fills almost the entire troposphere with internally embedded convection.”
15:02 cirrus is gone – PBL convection with some snowfall remains.
15:08 Convective clouds
15:13 Dropsonde 12
15:16 Deeper clouds
15:26 DSC_5939 Decrease in cloud cover

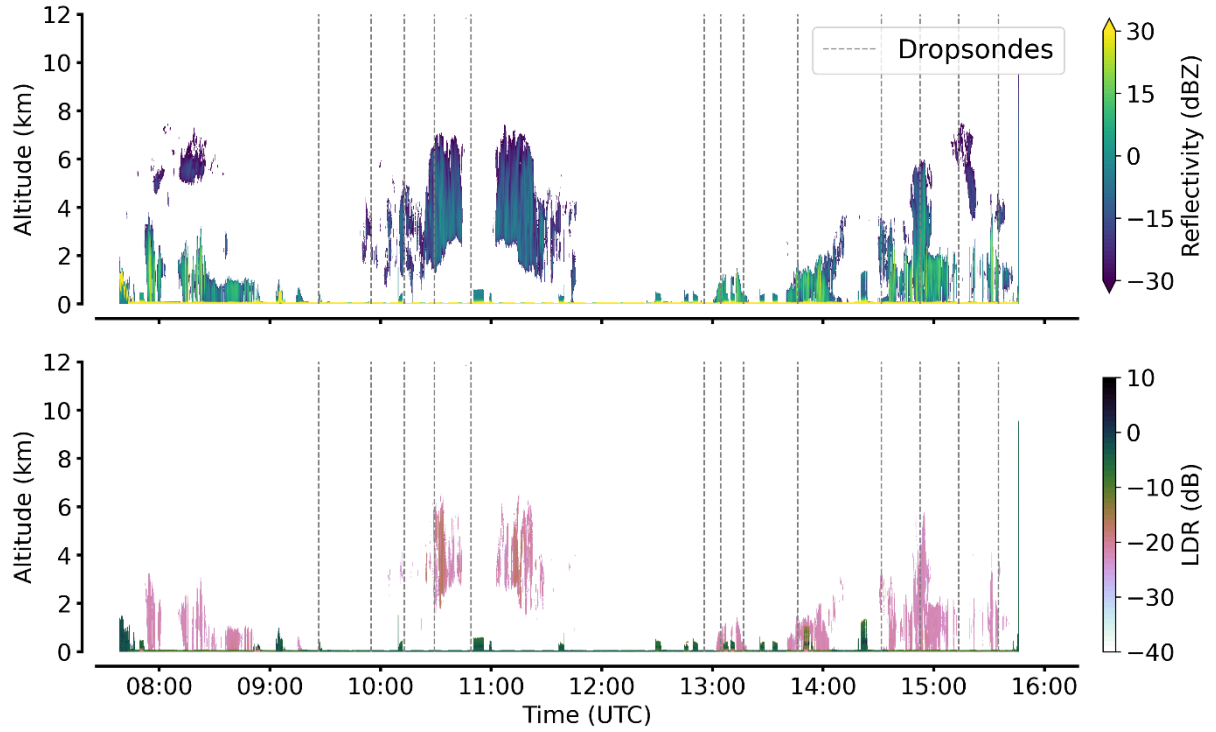


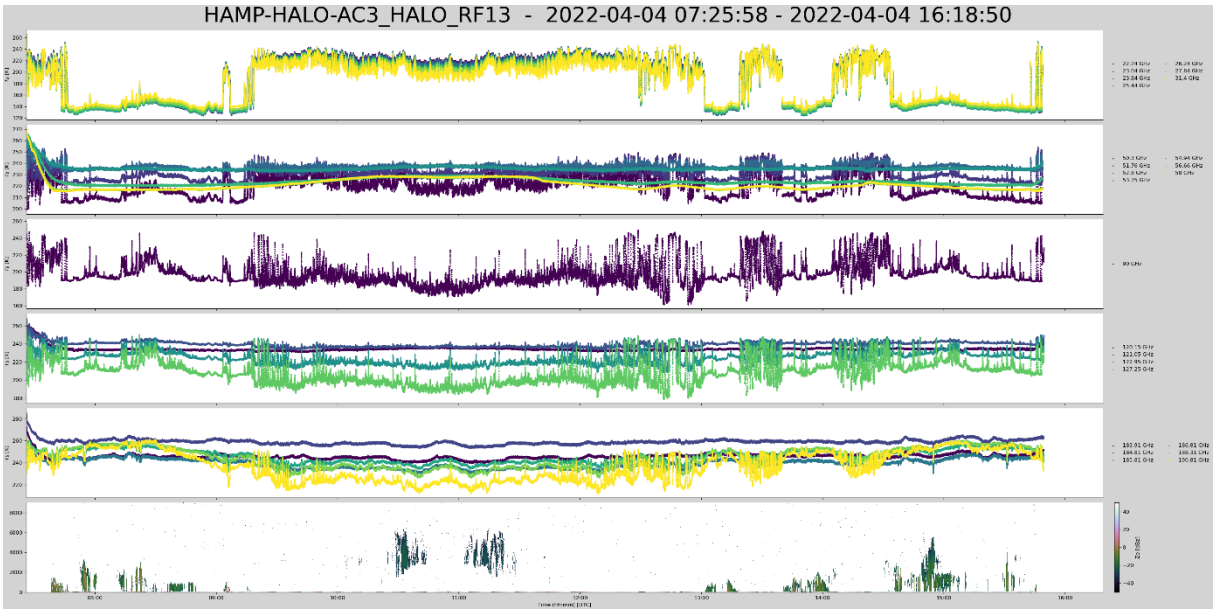
15:29 DSC_5941 – DSC_5943 Deeper clouds
15:35 Dropsonde 13
15:37 DSC_5944 – DSC_5946 Cumuli cloud field



15:43 Approaching the Scandinavian Coast, cloud-free
16:18 Landing

Quicklooks:


Dropsondes
Altitude (km)
Reflectivity (dBZ)
LDR (dB)
Time (UTC)
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00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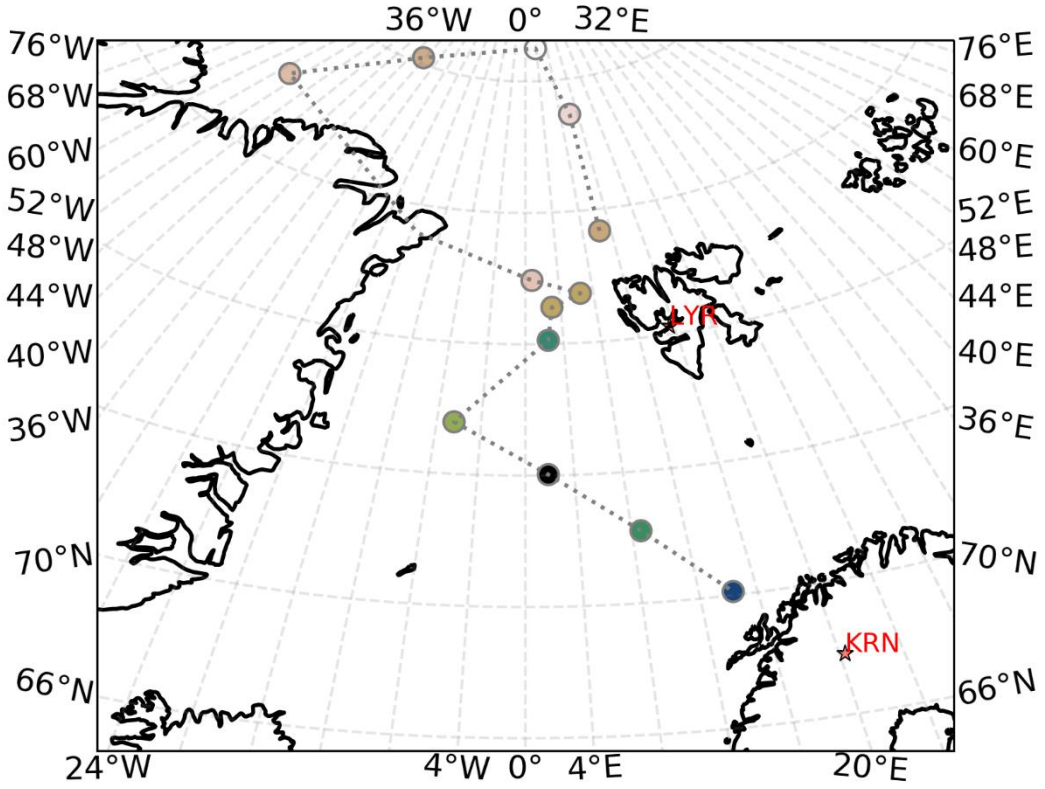
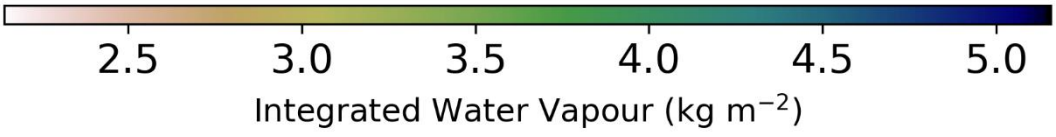
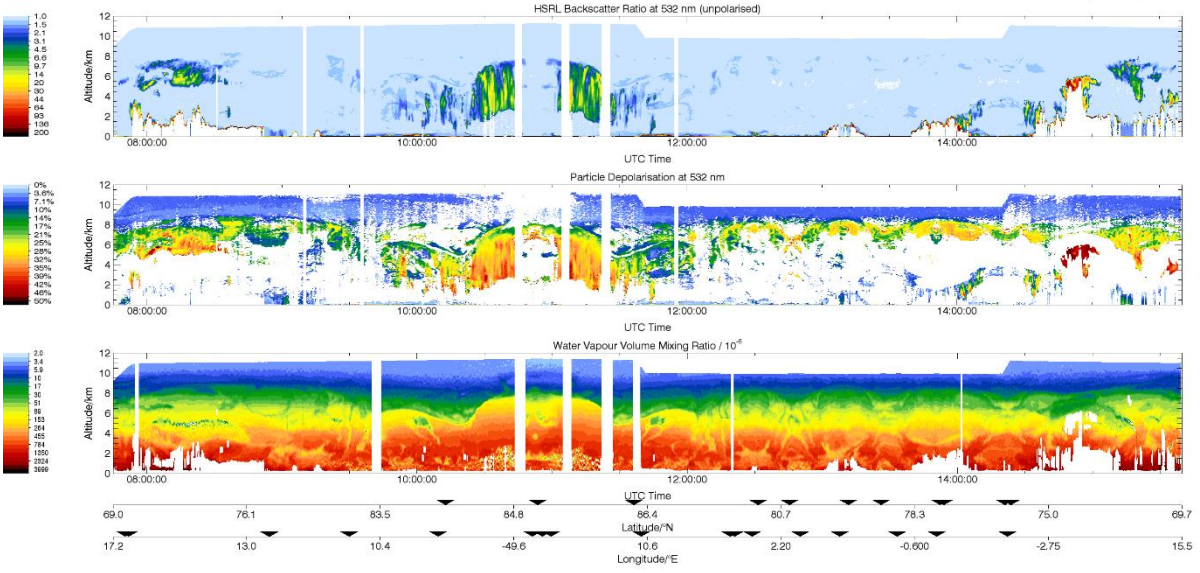




DLR **WALES**

HALO-(AC)^3 04-04-2022

HALO RF13



Data Version 1 Processed on 06-04-2022 Contact: DLR Institute of Atmospheric Physics Martin.Wirth@dlr.de