Flight Report

HALO-AC3_HALO_20220411_RF17

Arctic Cirrus #2 Day 2 (The Arctic Dragon)

Objectives:

- Remote sensing above and below single layer Arctic cirrus
- Cross section along the flow (northward) of cirrus field over sea ice
- Overflight of “Golden Leg” in front of Spitzbergen -> Extensively sampled section crossing from open ocean to sea ice

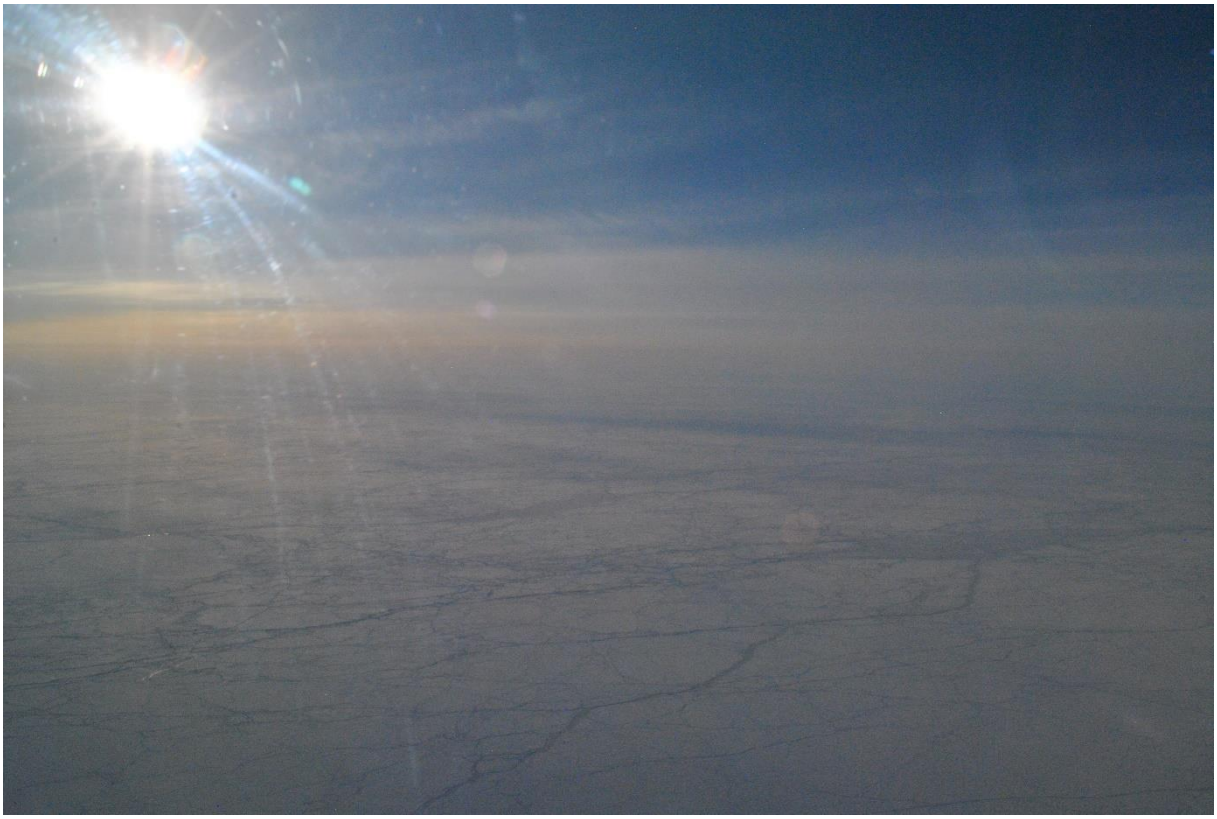


Figure 1: Photo from below the Arctic cirrus.

Mission PI HALO:

HALO Crew	
Mission PI	Johannes Röttenbacher
HAMP	Davide Ori
WALES	Georgios Dekoutsidis
SMART/VELOX	Michael Schäfer
specMACS	Anna Weber
Dropsondes	Irina Gorodetskaya
Camera	André Ehrlich
Pilots	Stefan Grillenbeck Thomas Kalfas
Engineer	Alexander Wolf

Flight times:

HALO	
Take off (UTC)	07:55:53 UTC
Touch down (UTC)	15:55:48 UTC

Weather situation the day before:

The 10th and 11th April 2022 were characterized by a low pressure system above northern Norway, which has been a consistent feature for the last couple of days. On the 10th April it transported moist air through the Barents sea to the south of Spitzbergen. The airmass featured extensive low, mid and high level clouds, with the high level clouds already reaching far into the Fram straight and over to the sea ice edge (TCC 04-10 12Z). The flow split at around 500 hPa with the lower flow showing a southwesterly direction, whereas the upper flow showed a northerly direction. This upper level northerly flow transported the cirrus further over the sea ice along the coast of Greenland and into the central Arctic.

Weather situation during the flight day:

The low pressure system over northern Norway was still present today and dominated the weather in the Barents sea. West of Svalbard a upper level high pressure system, which was accompanied by a surface high pressure system over Greenland and one in the central Arctic, caused a upper level northward flow along the coast of Greenland and into the central Arctic (GFS Modell, wind maps). The cirrus from yesterday was travelling along this flow and sustained through large scale lifting at the Greenland coast.

At 500 hPa altitude a strong wind band was present over the Greenland coast during the whole day. At the surface over the sea ice easterly winds prevailed.

Cloud situation

Over the open ocean the thick cirrus from the mainland thinned out and patches of low level stratocumulus became visible. There were some small convective cells present. Further towards the north the Sc became more closed. Close to Svalbard the Sc started to show holes until cloud streets appeared which started to the south of Svalbard. Once over the sea ice optically thin cirrus with very small low level clouds dominated the scene. Far up in the North the cirrus reached down to around 5.5 km. Towards the south and the west the cirrus layer deepened. No low level clouds were present below. Towards the end of the flight low level clouds were present over the sea ice.

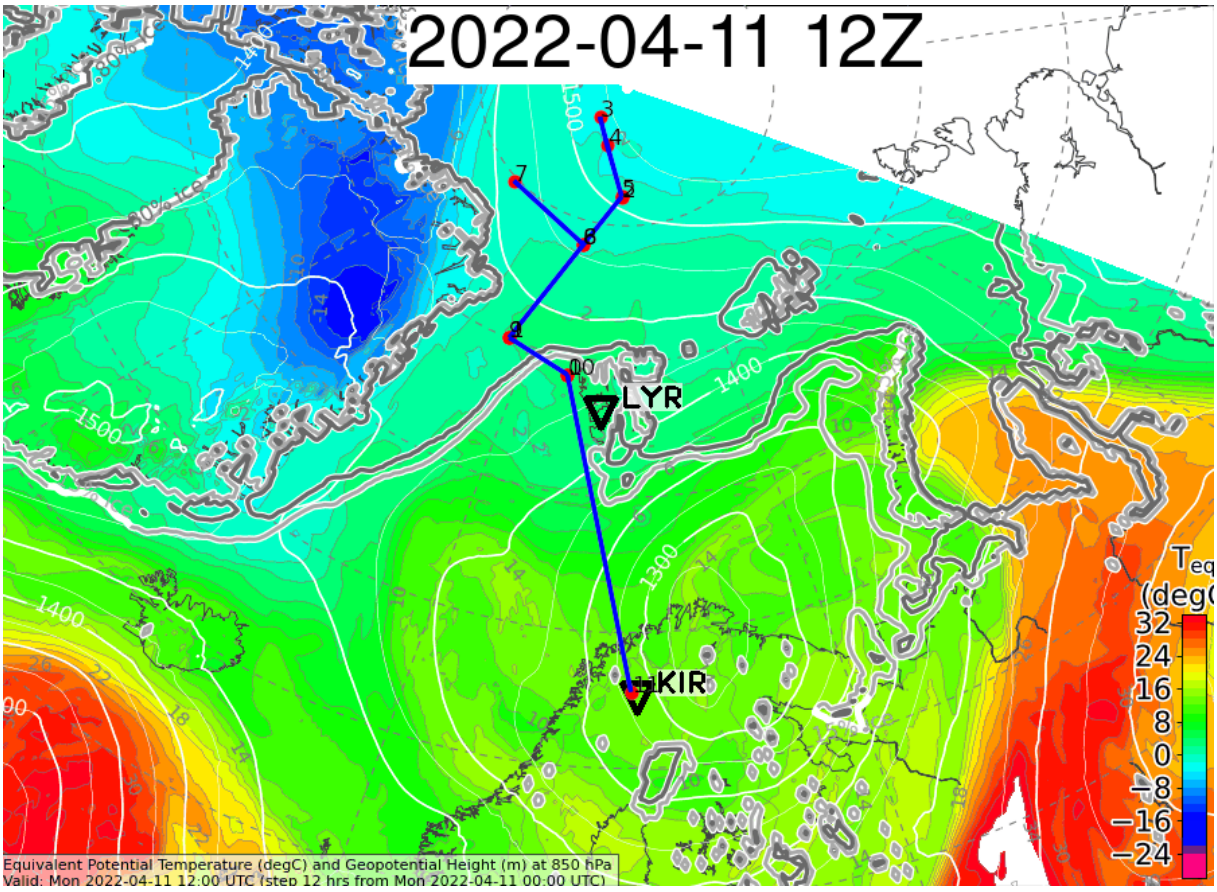


Figure 2: ECMWF 850 hPa Theta-E

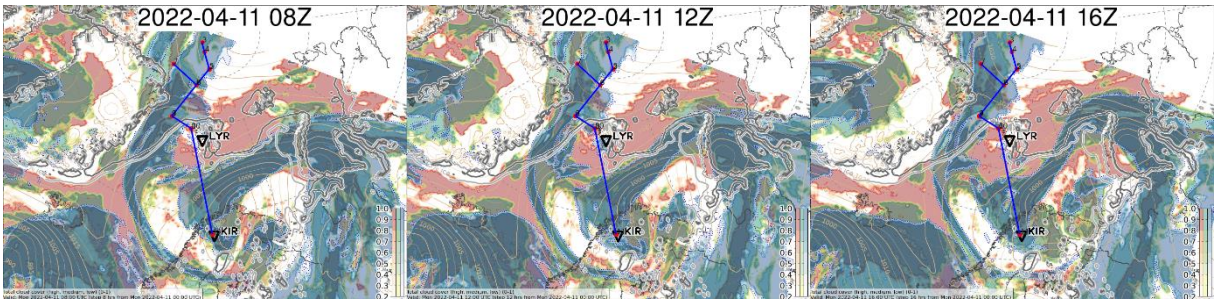


Figure 3: ECMWF total cloud cover 08, 12 and 16 UTC

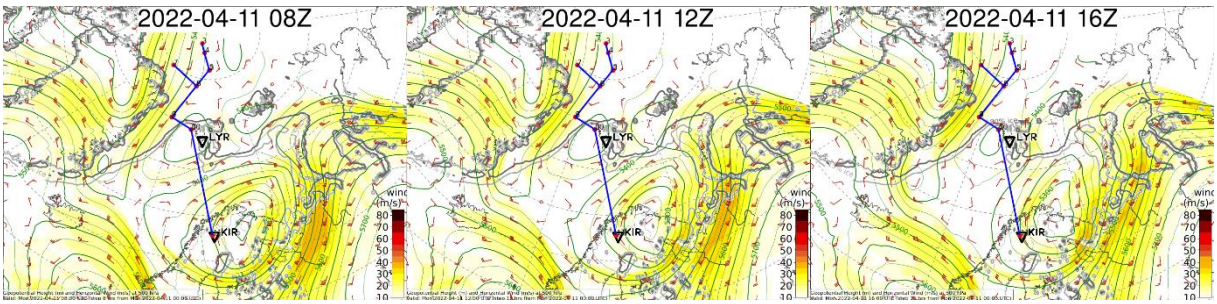


Figure 4: ECMWF 500 hPa wind and geopotential height

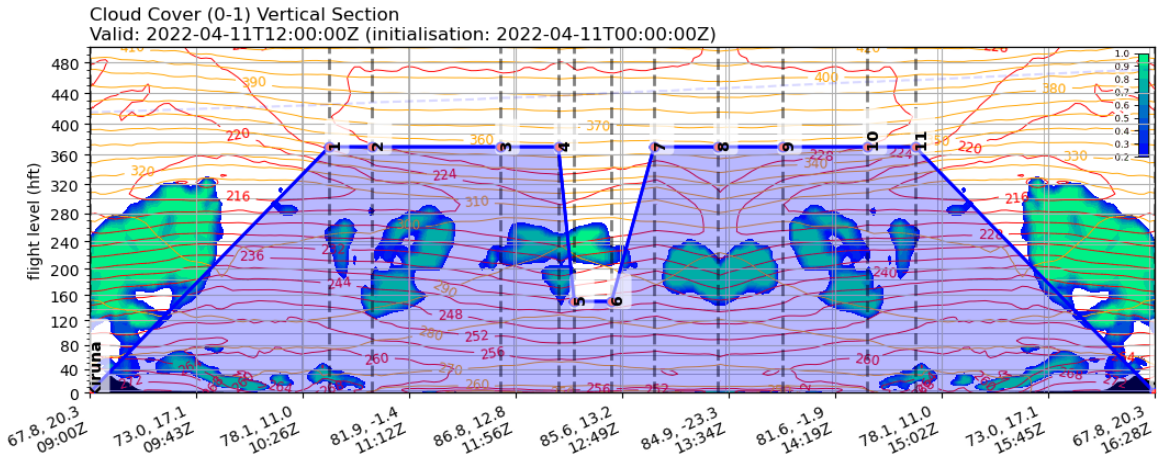


Figure 5: ECMWF side view of flight track 12 UTC

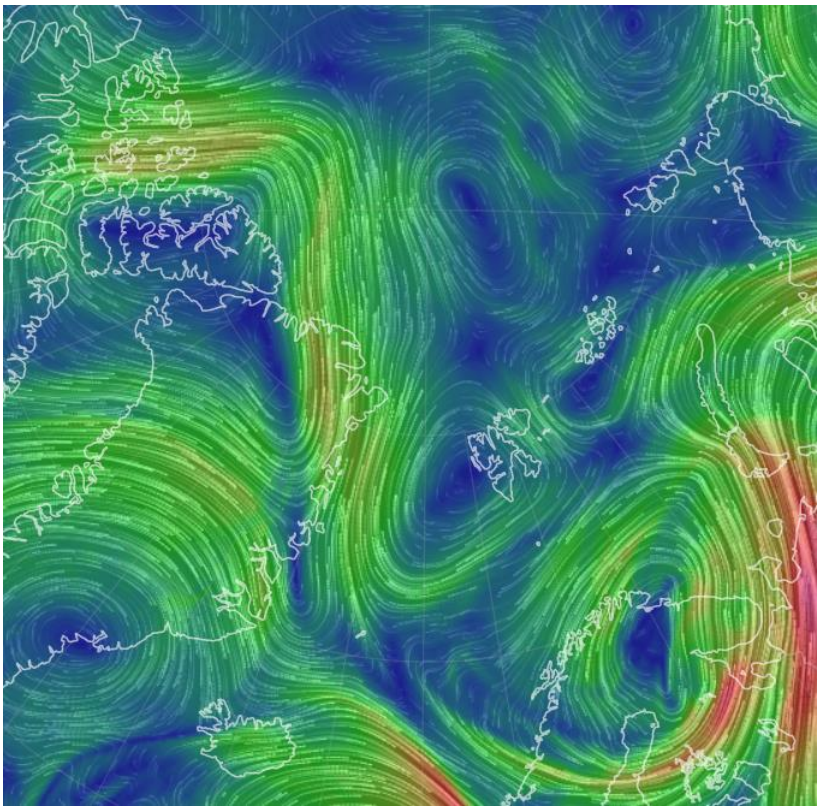


Figure 6: GFS 500 hPa wind showing the upper level high over the Fram straight and the high pressure system in the central Arctic (www.earth.nullschool.net).

Overview of flight:

The flight pattern was designed to sample the Arctic cirrus from a radiative point of view. At first, however, we had to make our way to the north. We used this to sample the so called “Golden Leg”, an area we extensively sampled in other flights before and which captures the transition from open ocean to sea ice. Here we also released our first dropsonde.

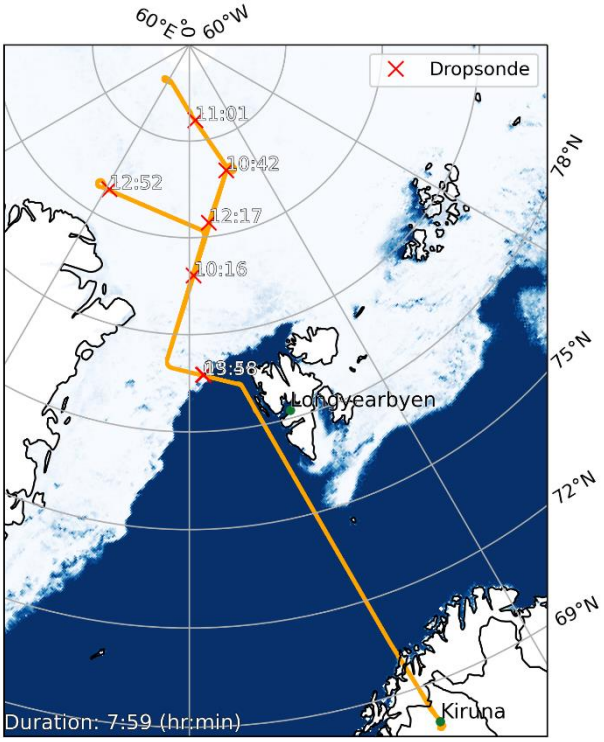


Figure 7: Entire flight track with sea-ice cover and dropsonde locations

Once over the sea ice we turned northward to sample the cirrus band along the flow. We headed North and turned to the west to sample a cross section of the cirrus which we also used to determine the cloud base height from the Lidar. Using this we then descended below the cirrus to get the complete radiative budget of the cirrus. The model prediction did not disappoint us and we were able to stay below the cirrus for the whole time we also were above it.

At the end of the leg we ascended again and headed south. We turned to the west closer- to the Greenland coast to sample another cross section of the cirrus further south. We then returned the same way we had entered the cirrus field to get a sense of the temporal evolution of it.

We used the two cross sections to drop four dropsondes after we already dropped one our way along the flow and thus had reached our maximum amount of dropsondes in the Danish airspace. On our second time on the “Golden Leg” we dropped our seventh sonde.

Instrument Status:

Table 1: Instrument status as reported after the flight by the instrument PIs on HALO.

HALO	
BAHAMAS	
BACARDI	
HAMP Radar	
HAMP Radiometer	
WALES	
SMART	
VELOX	
specMACS	dirty window
Dropsondes	7/7

Dropsonde locations:

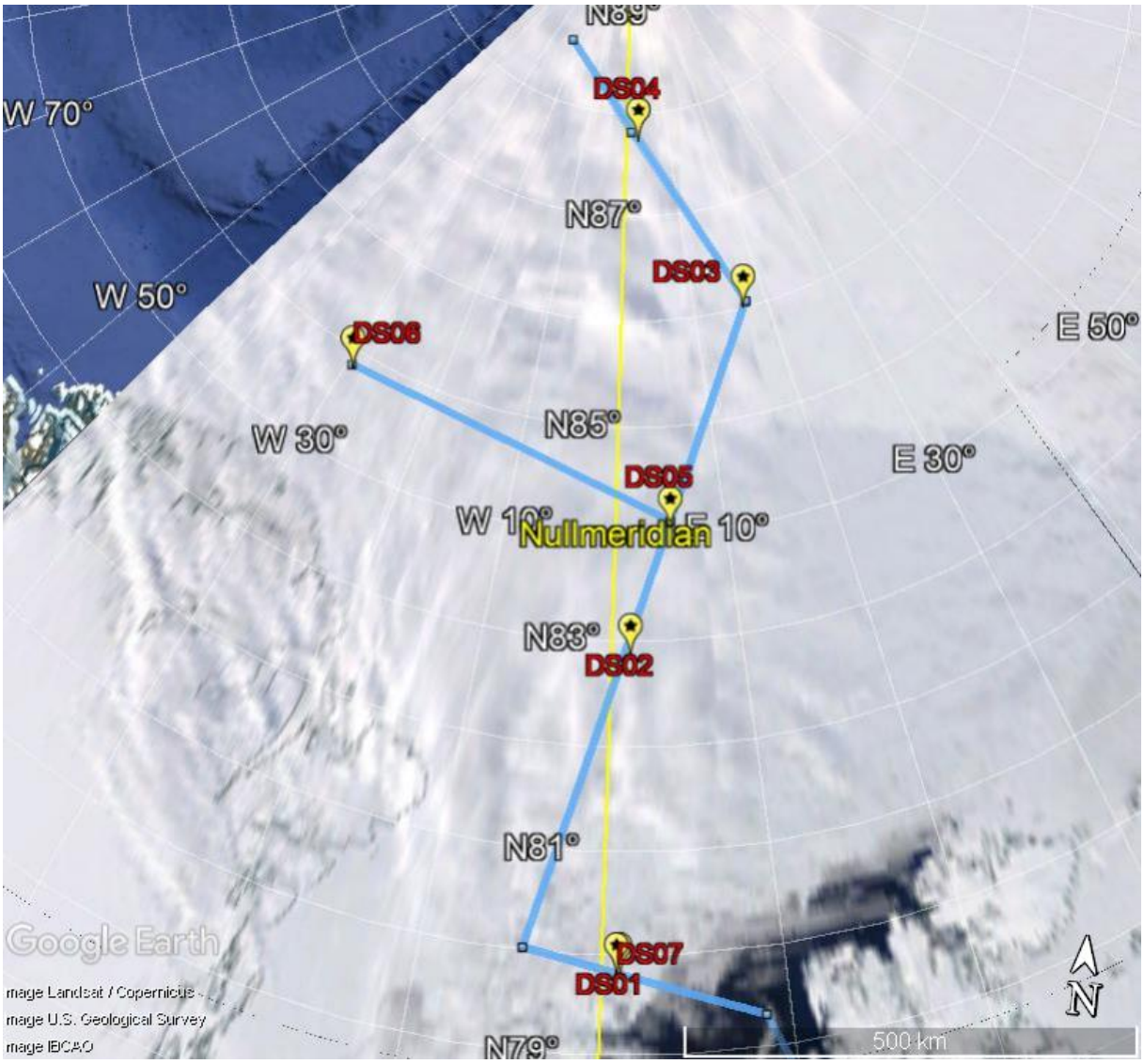
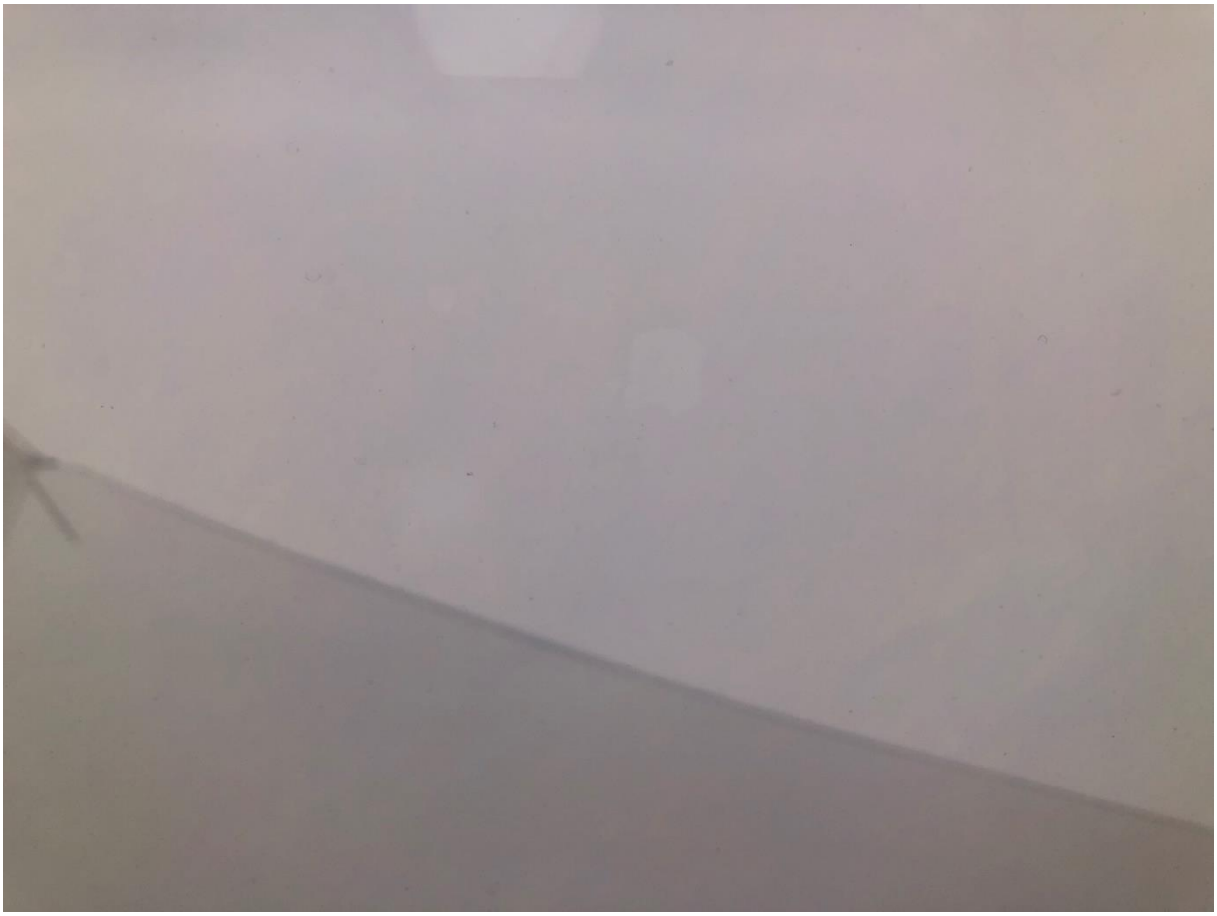


Figure 8: MODIS satellite composite with dropsonde locations (www.worldview.earthdata.nasa.gov).

Flight Logs (all times in UTC)

07:20 All systems up and running
07:32 METAR 06:50, T -1C, DewPoint -5C, QNH 993hPa, Wind 12kt, 330°
07:51 Taxi
07:55:50 TO
07:59 Ascend through clouds (picture 08:02)



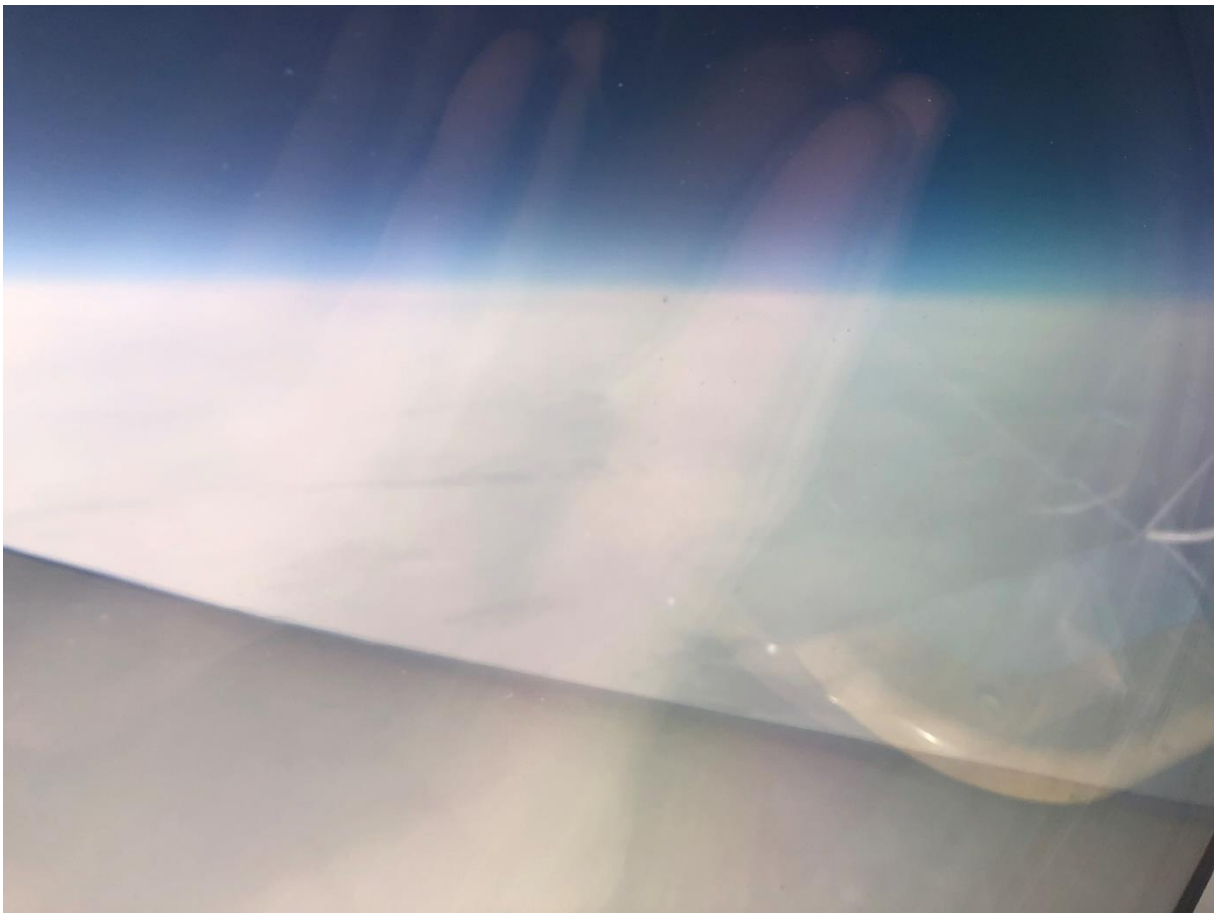
08:04 Sun at FL200 -> in Cirrus tops
08:05 Above clouds FL240
08:07 Opened Laser shutter
08:09 Laser shutter completely open
08:14 Thick cirrus below, with some holes and low clouds
08:18 Kite like cloud structures -> cumulus (picture 08:17)

08:17:49 FL370
08:18 crossing the coast, some turbulence
08:21 thin cirrus now with low level convective cloud patches (picture 08:21)

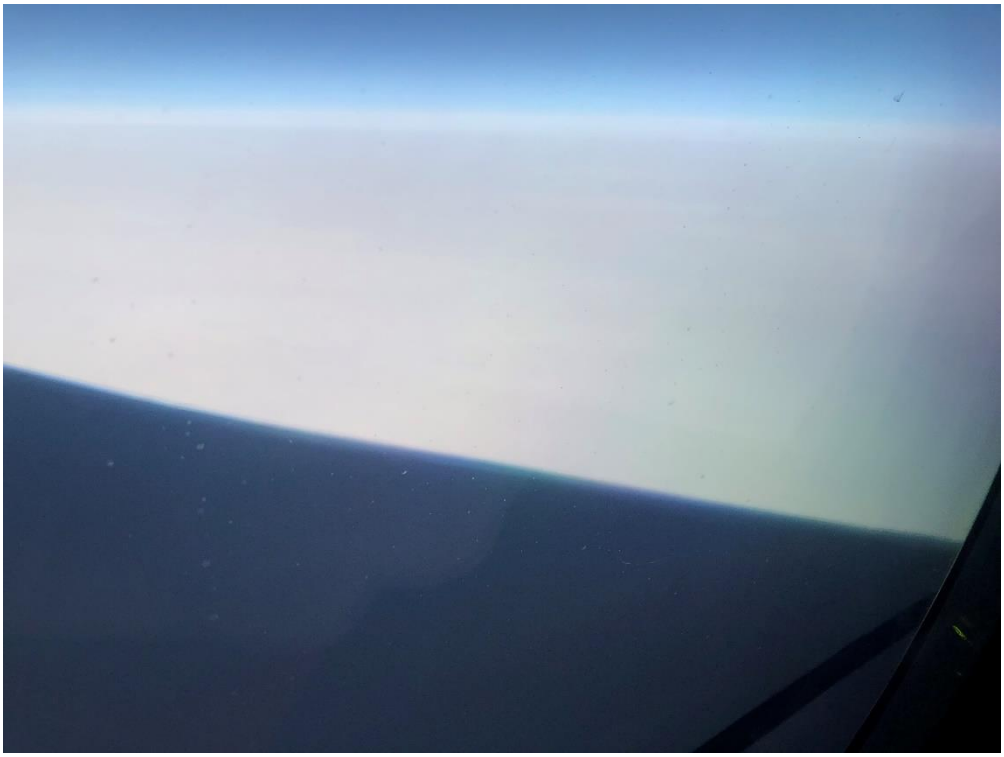
08:24 small turn
08:33 multilayer cloud below -> Cirrus and Stratus
08:35 Cloud tops about 1.5km away -> ask for FL390
08:37 rising to FL390 for Lidar

08:38 precipitating clouds below with 4.5-5km thick cirrus above
08:43 extensive stratocumulus clouds with embedded convection (picture 08:43)

08:50 Cirrus optically thin (picture 08:51)
08:56 more wavey structure in the stratocumulus (picture 08:57), with mid level clouds above
09:00 dark cirrus to the left -> shadow
09:01 turbulent structure in the Sc
09:04 fine dark filaments on the horizon -> dust/aerosol?
09:05 Sc starts to show holes
09:06 Svalbard ahead to the right
09:09 cloud streets below starting south of Svalbard
09:15 no clouds below, Svalbard to the right
09:19 lone ice floe (picture 9:19)
09:28 Radar calibration
09:46 DS01
09:49 already over sea ice for a while
09:51 optically thin cirrus (picture 09:51)



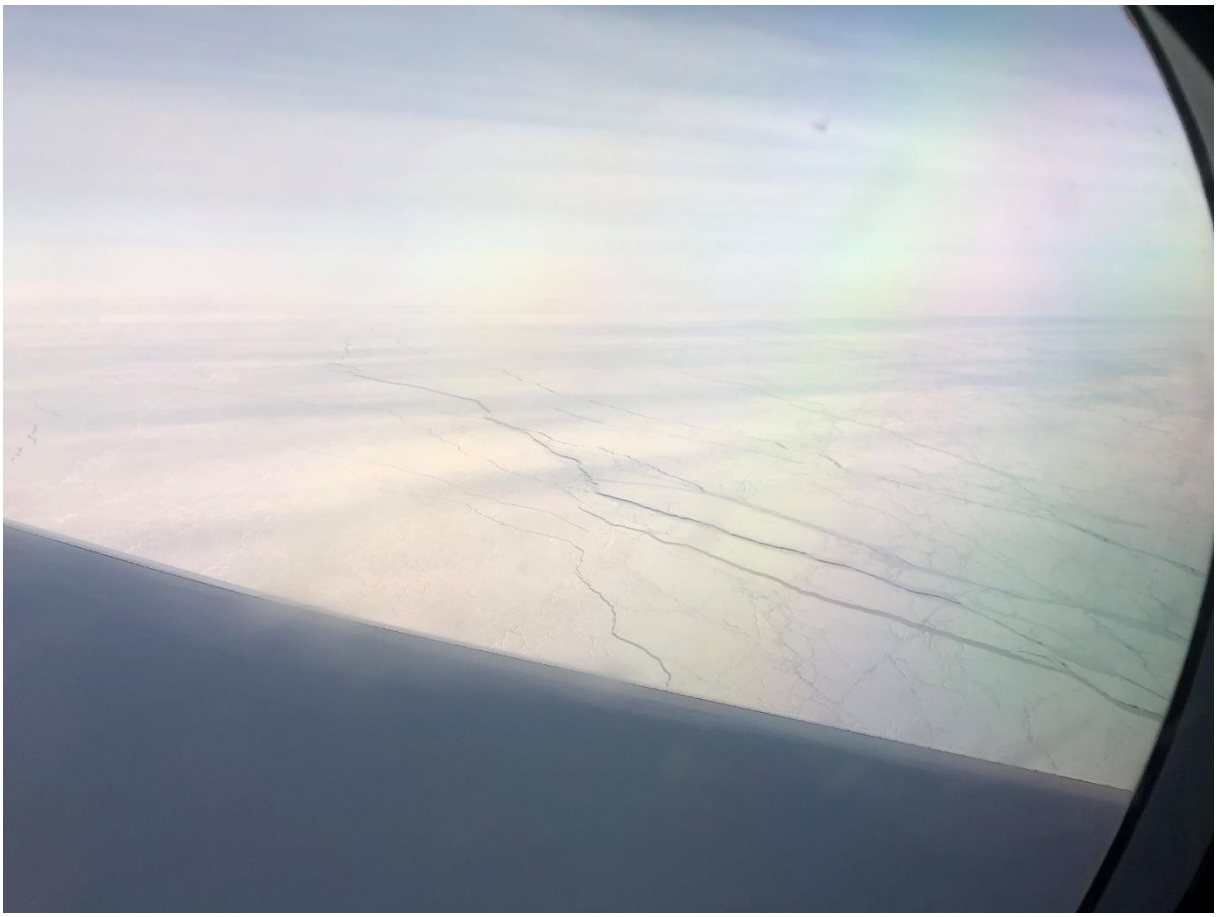
09:53 small turn
10:00 Ice clouds with very thin low level clouds below
10:16 DS02
10:17 Thick 3-3.5km cirrus, sea ice visible (picture 10:17)



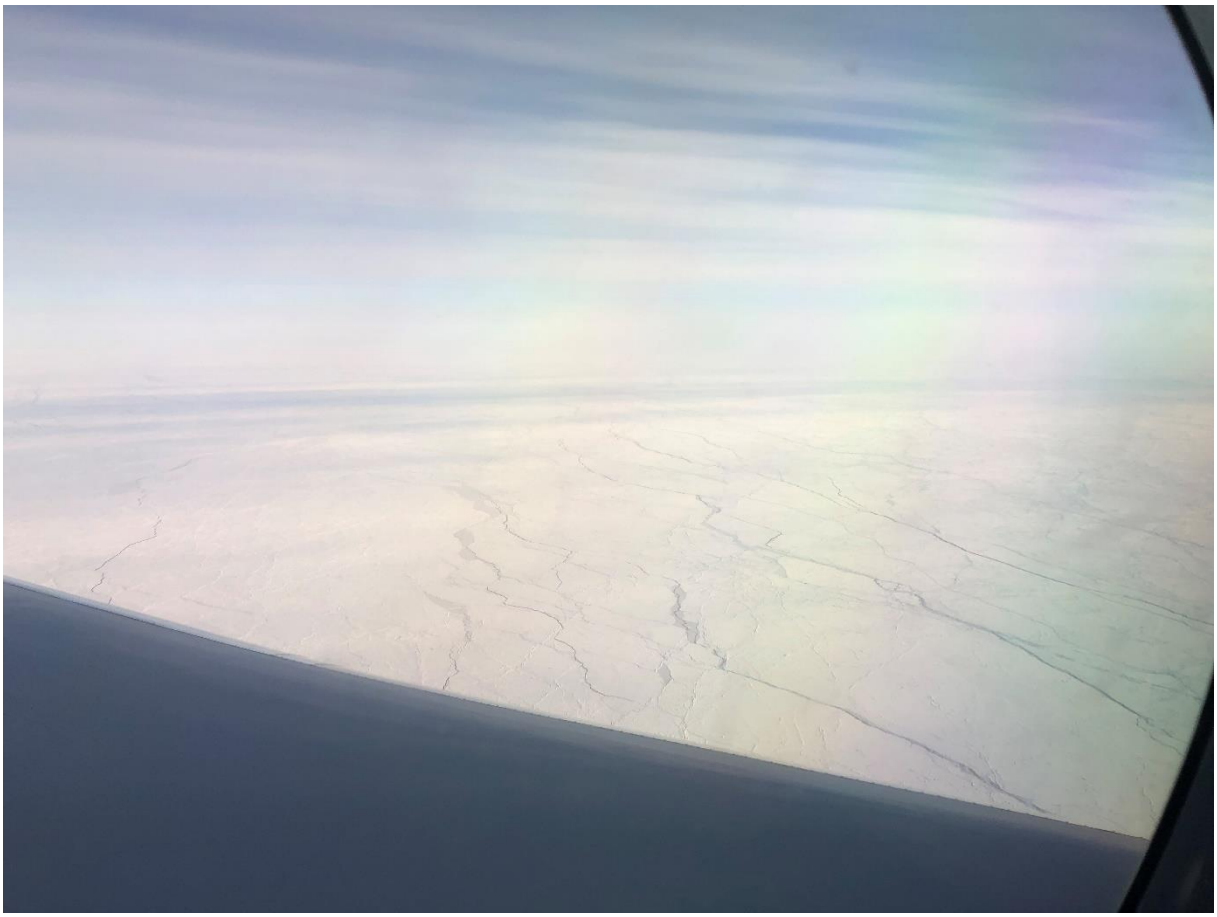
10:23 Cirrus shows less dense parts, shadows visible on the sea ice sometimes, sometimes not

10:26 cloud base of cirrus is higher in the second sonde 400mb before now 500mb
10:40 Cirrus getting more patchy
10:42 DS03
10:43 procedure turn
10:50 stable cirrus cloud base at 5500m
11:01 DS04
11:07 start descend to FL150
11:15 procedure turn
11:18 FL150
11:22 inside cirrus with ice particles (picture 11:22)

11:28 still inside cloud -32C
11:35 small turn with unexpected roll
11:38 below cirrus cloud, individual shadow visible showing the stripey nature of the cirrus above (picture 11:38)

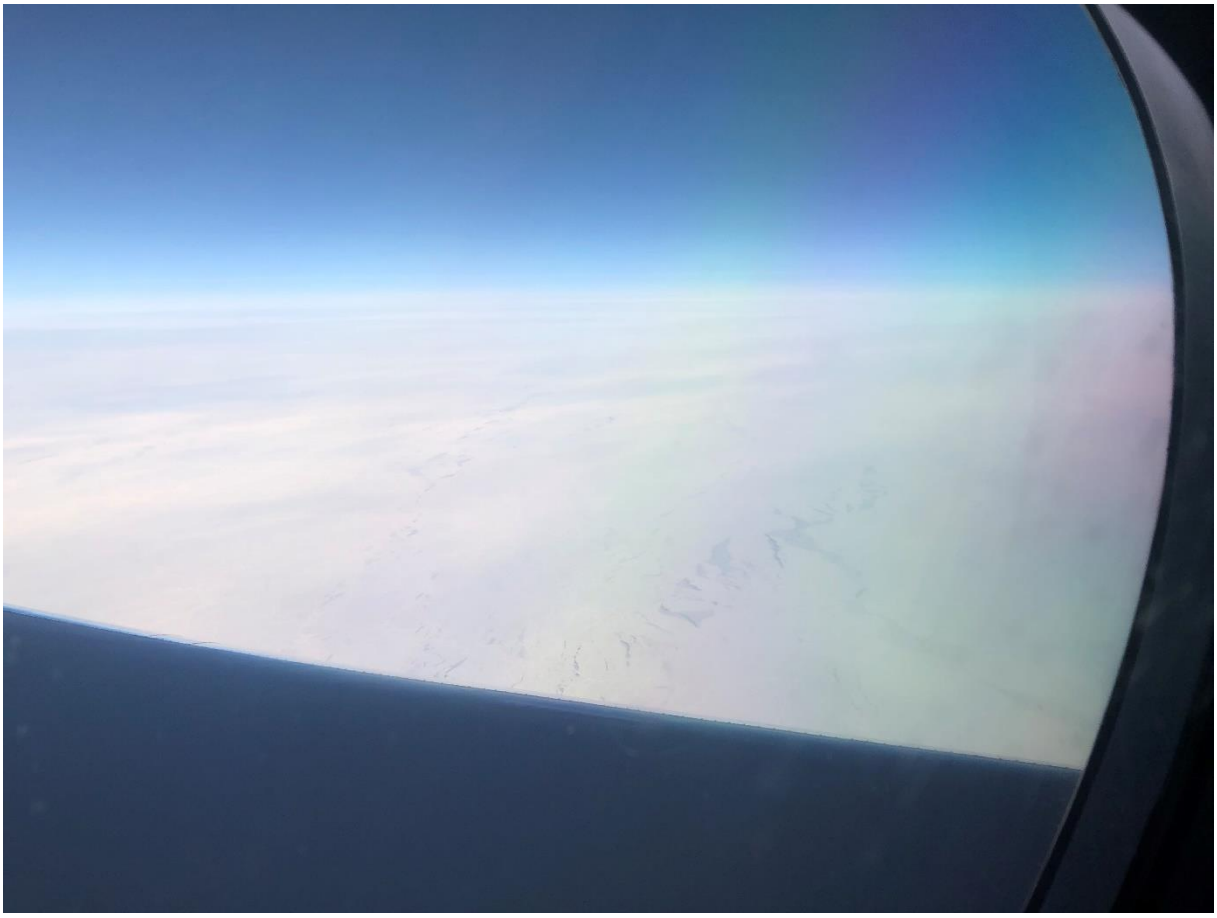


11:45 open leads and cracks below (picture 11:45)

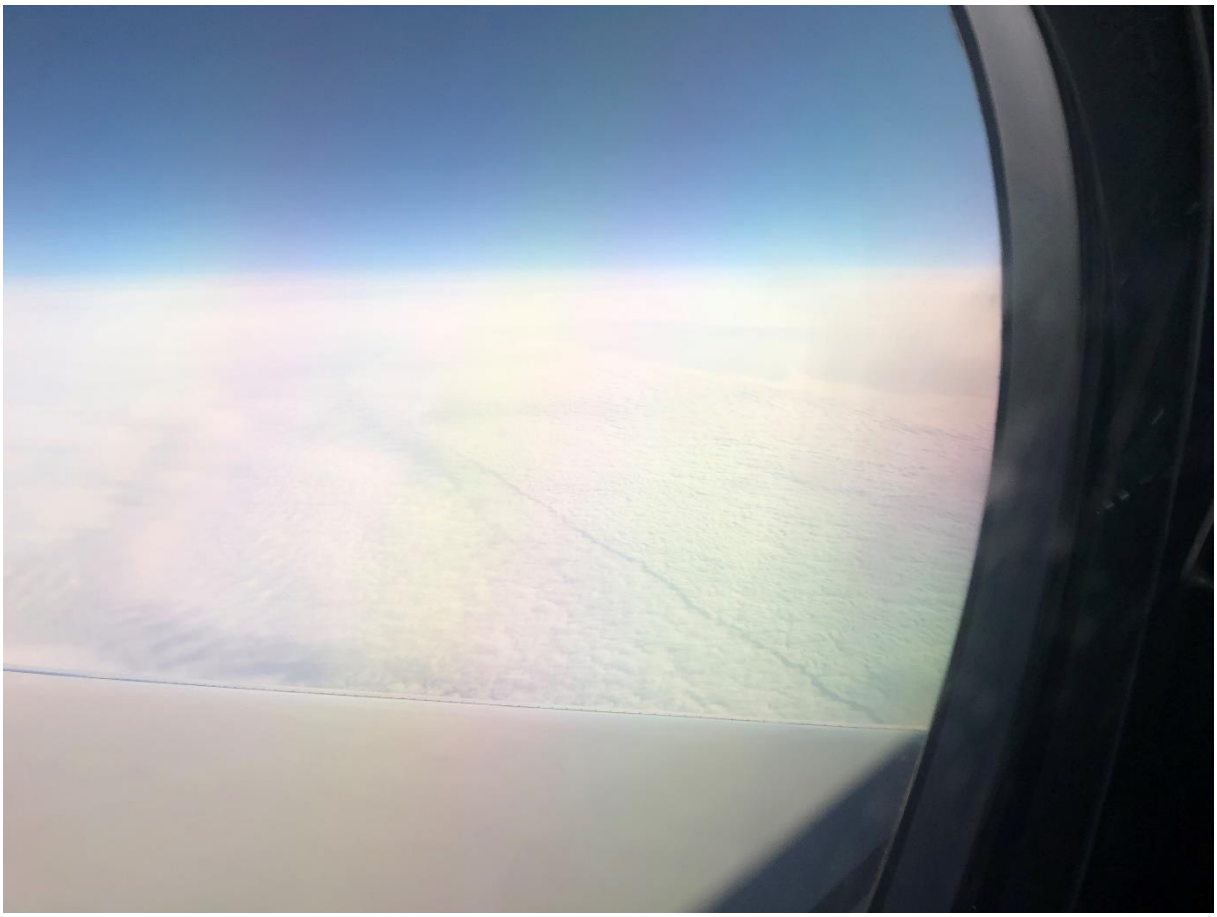


11:46 refreezing leads

11:49 rough sea ice pattern to the left
11:50 Double reflection of HALO visible in the Radar return -> Davide thinks he can filter it out
12:00 Turn and ascend to FL390
12:14 FL390
12:14 thickening cirrus
12:17 DS05
12:18 small turn
12:39 Fallstreaks to the left
12:40 single layer cirrus rather inhomogeneous
12:44 procedure turn
12:52 DS06
12:55 sea ice visible in some parts of the cirrus
12:56 cirrus is thicker to the south
13:10 Cirrus thinning again, sea ice visible with some leads and refreezing fractures (picture 13:10)



13:16 small turn
13:26 Cirrus is optically thicker now, André can still see sea ice and leads, CTH 8km, CBH 3.5km, nothing seems to be below
13:36 Cirrus has reached optical thickness of 3 -> no more sea ice visible below
13:37 weak signal from close to the ground -> clouds due to leads maybe
13:38 stratiform clouds now visible, cirrus less optically thick
13:43 Cirrus getting thinner, more structure in the Sc (picture 13:44)
13:46 some sort of border visible in the Sc (picture 13:46)



13:53 big hole visible below Sc (picture 13:53)
13:58 DS07
13:59 Sea ice border
13:59 Sc getting more line like with bigger gaps in between (picture 13:59)

14:01 Approaching Svalbard and cloud free Lee area

14:03 cloud free now
14:07 small turn
14:50 stratiform low clouds with a second layer below, patchy cirrus above -> three layers
15:01 more convective cells in the Sc
15:07 Cirrus optically thickening
15:18 unexpected Roll
15:20 start descend
15:55:42 TD
THANKS to the amazing flight crew!

Flight Log André Ehrlich (Flight Documentation)

07:43:40	thick cirrus @Kiruna
	INS/BAHAMAS had run-up problems, worked after some tries
07:50:00	INS/SMART does only show high drift values
07:52:00	taxi
07:55:44	TO
07:57:05	cloud base
07:58:30	cloud top, some patchy stratus below = low cloud layer?
07:59:45	next cloud layer
08:04:20	reaching cloud top --> Sun above
08:05:30	cloud top, some wavy structure at cloud top
08:18:00	westwards = convective clouds present, less cirrus
	eastwards = homogeneous cirrus, multilayer
08:24:00	cirrus + stratus below , cirrus=transparent
08:34:00	nice homogeneous cirrus + stratus
08:40:00	inhomog. cirrus + more convective low clouds
	also some fall streaks
08:44:00	embedded convection in stratus field
08:46:50	now very stratiform, sharp boundary/transition
08:50:00	change of stratus structure, cirrus very thin above
08:56:00	change of stratus structure + 2nd layer
09:09:00	end of low clouds / cloud streets from easterly flow
09:14:00	cirrus and haze also over Svalbard, west of Svalbard = lee hole
09:16:00	thin clouds below
	VELOX = sees surface temperature gradient

09:20:00	end of thin low clouds
09:33:00	nothing than sightseeing weather at Svalbard
09:50:00	cirrus started with the sea ice, also low clouds
09:53:00	haze layer in all directions
09:58:00	cirrus becomes thicker, low clouds? at least they changed
10:03:00	partly low clouds
10:09:00	thicker stratus again + cirrus thick
10:17:00	no stratus, sea ice visible
10:30:00	cirrus becomes thinner, no stratus
10:35:00	stratus far eastwards
10:51:00	patchy shadows from cirrus
11:05:00	cirrus is optically thick but still transparent, no low clouds
11:30:00	since descent = nice halo visible --> see foto docu
11:31:00	HALO getting brighter, shadows
11:56:00	nice leg below the cirrus, cirrus above very thin or not present?
	backboard = cirrus
	starboard = no cirrus + sun
	take care for geometry
12:11:00	thick cirrus ahead / shadows
12:54:00	southern leg, thick cirrus, no sea ice visible, different types of cirrus (virga,...)
12:56:00	cloud glint --> upper layer in South
13:05:00	smells like fresh coffee
13:06:00	for flight documentation look into WALES quicklooks
13:18:00	very homogeneous cirrus now
13:40:00	stratus below, cirrus visible
13:47:00	cirrus gone? only stratus left??
13:52:00	still thin cirrus --> cloud glint from cirrus + glory from stratus
14:30:00	over ocean, fields of stratus, different structures,
	further south closed stratus fields
14:55:00	change to cirrus layer above stratiform clouds
15:10:00	cirrus above stratus

Attached Quicklooks:

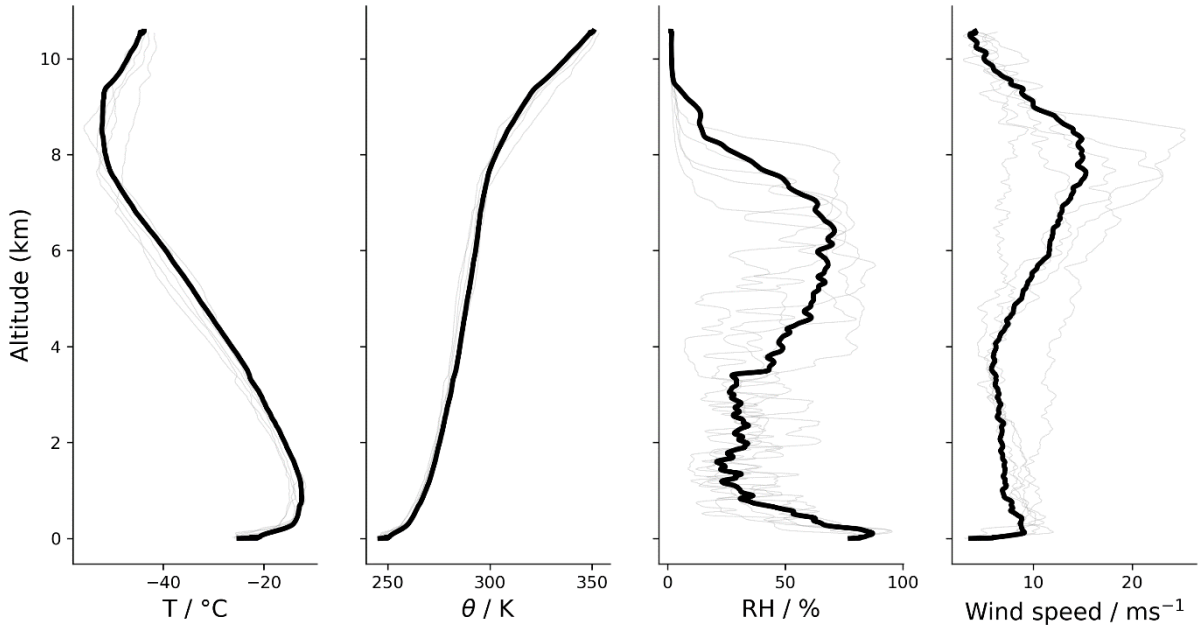


Figure 9: Dropsondes vertical profiles.

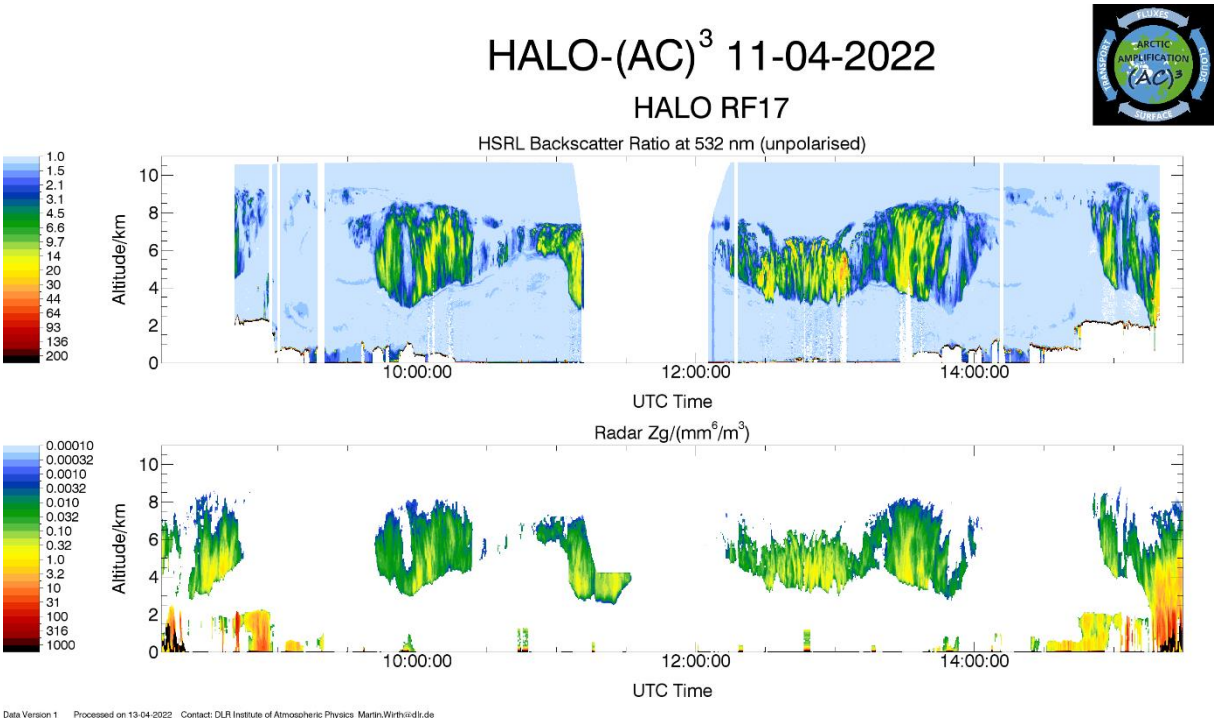


Figure 10: WALES HSLR backscatter ratio and radar reflectivity factor.

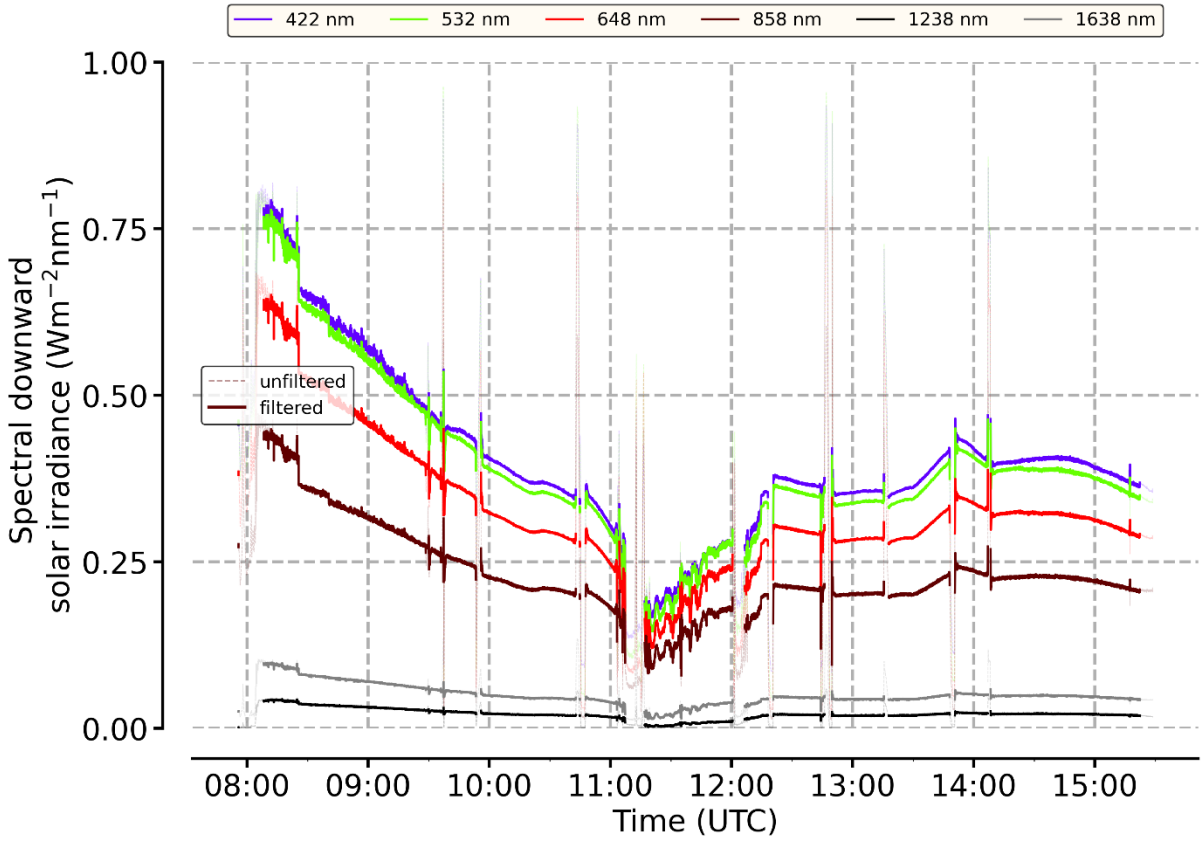


Figure 11: SMART downward irradiance for selected wavelengths, filtered for high motion angles. Note the below cirrus section between 11 and 12 UTC.