Flight Report

HALO-AC3_HALO_20220328_RF09

Cold Air Outbreak over Fram Strait—Day 10

Objectives:

- Sampling airmasses advected along the cold air outbreak and follow them during their southerly track
- Identification/ characterization of low-level cloud streets in the vicinity of the boundary layer and higher reaching cloud and precipitation in the convergence zone (if present)
- Measuring the temporal evolution – by flying twice over flow-perpendicular sections using a spiral flight track.
- Airborne model comparison in terms of cloud forecasts

Mission PI HALO:

HALO Crew	
Mission PI	Henning Dorff
HAMP	Clemantyne Aubry
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SMART/VELOX	Johannes Röttenbacher
specMACS	Anna Weber
Dropsondes	Sebastian Schmidt
Camera	Vera Schemann
Pilots	Roland Welser Thomas Kalfas
Engineer	Alexander Wolf

Flight times:

HALO	
Take off (UTC)	08:37 UTC
Touch down (UTC)	16:06 UTC

<u>Weather situation during the flight:</u>

The 28th of March 2022 was strongly impacted by a large quasi-stationary high-pressure system stretched along the east coast of Greenland. Combined with a low-pressure system located in the south-eastern Barents Sea, this created a weak north-easterly flow at the surface of Fram Strait and accordingly, a rather weak cold air outbreak west and south of Svalbard. While low-level flow had a northerly and northeasterly component (in the eastern entrance of the spiral pattern), slightly moist air was advected from the east (originating from remaining warmer air masses originating from Siberia) in higher levels. At the intersection of both currents, a convergence zone developed. In Fram Strait, mostly low clouds were found which had originated from the north-eastern tip of Greenland and the central Arctic, but became more convective along the convergence zone. While the presence of this convergence zone was clear to several recent forecasts, its actual location was more uncertain before flight.

In contrast, the area between Kiruna and Svalbard additionally sampled by HALO was characterized by some mid and higher level clouds. These were remnants of a dynamic low pressure system that had previously drifted from Iceland towards the Norwegian coast.

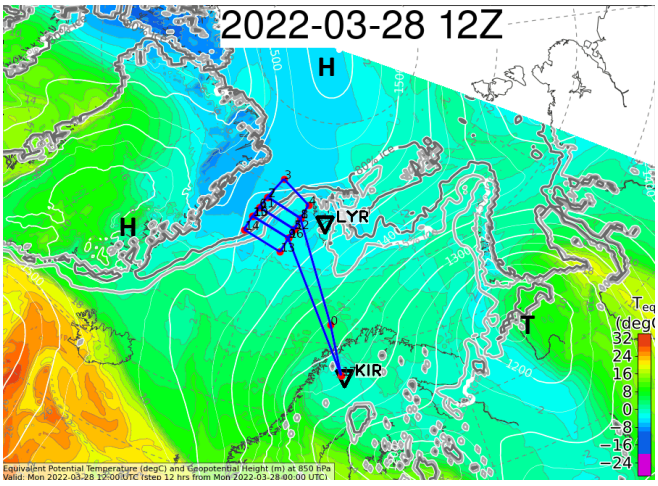
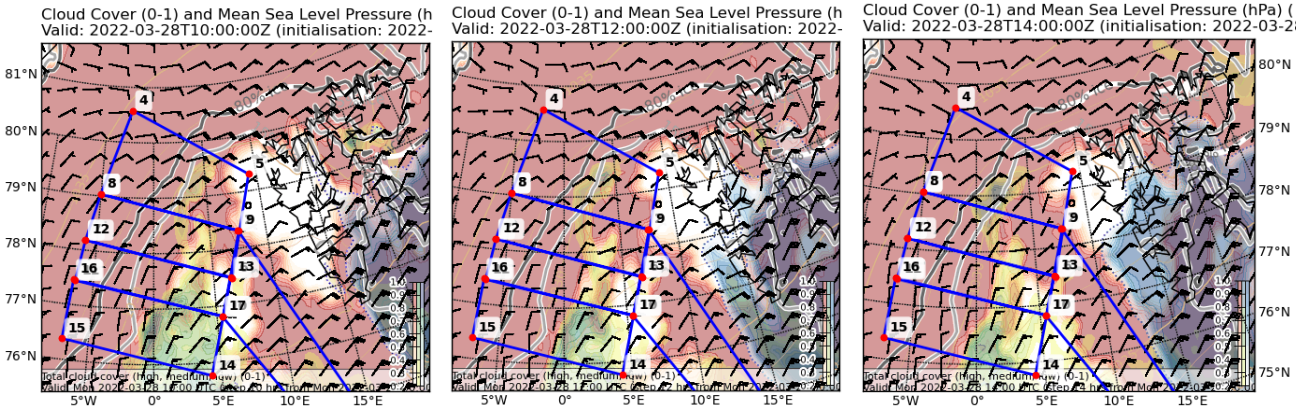
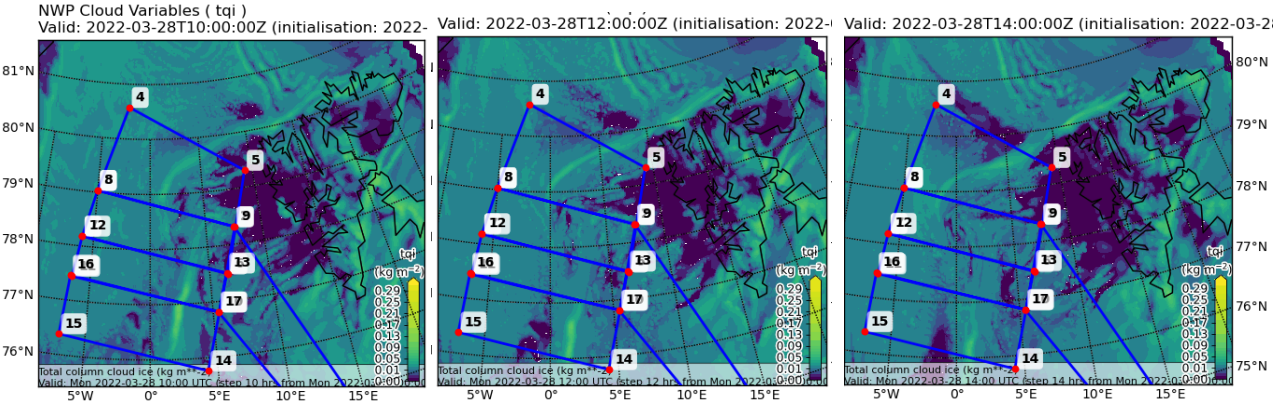


Figure 1: Theta-E at 850hPa for flight day

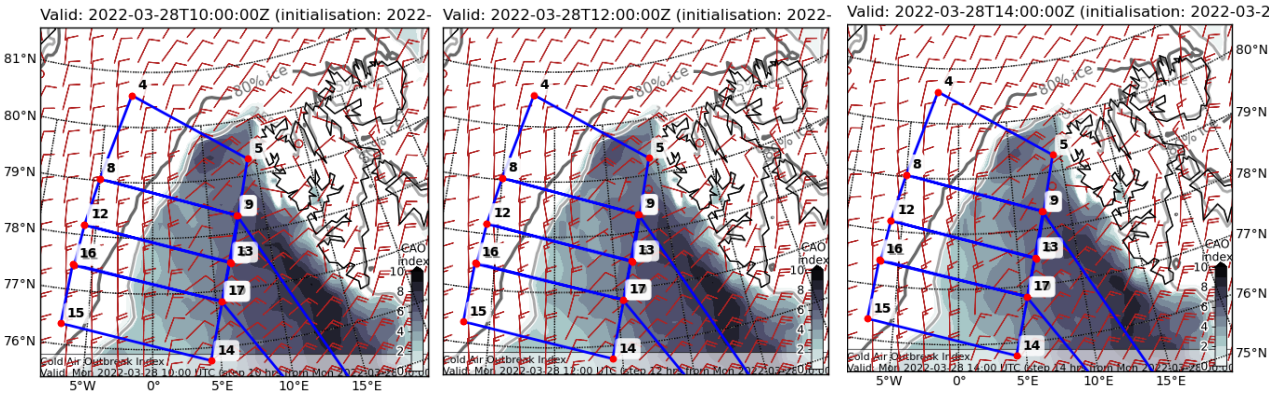
TCC and 925hPa Wind (ECMWF) – 10:00, 12:00 and 14:00 UTC



Total column cloud ice (tqi) in ICON-NWP (2 km) – 10:00, 12:00 and 14:00 UTC



Marine Cold Air Outbreak (MCAO)



Overview of flight:

To achieve an understanding of processes undergoing the converging air masses inside the weak CAO, we have chosen a spiral aligned flight pattern with cross-sections more or less perpendicular to the low-level flow. These legs intend to sample clouds from different parallel cloud streets, which were supposed to show different macrophysics contrasting the converging air masses (more convective in the center, shallower in the edges). Along each leg, three dropsondes were planned to be distributed over the pre-, center- and post convergent zone. While the region of interest was observed by flying the legs from north to south, we achieved a roughly flow following pattern. The spiral-aligned pattern enabled cross-sections to be overflown two times to investigate the Eulerian temporal evolution of the cloud systems. For that additional sondes were placed on the same cross-section positions from before, where not limited by the Danish ATC restriction of maximum sonde number of 5 (Figure 2 left). During

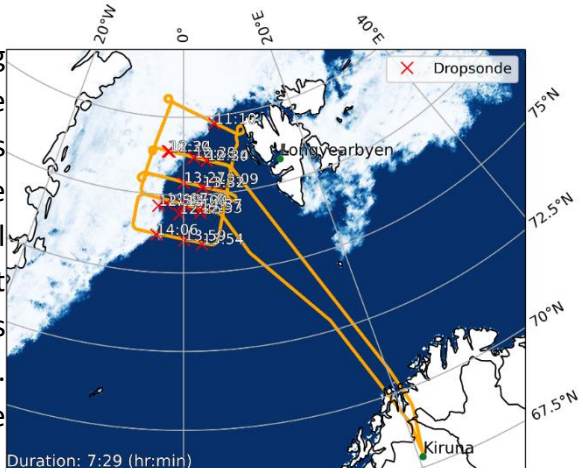


Figure 3 Entire flight track with sea-ice cover and dropsonde locations.

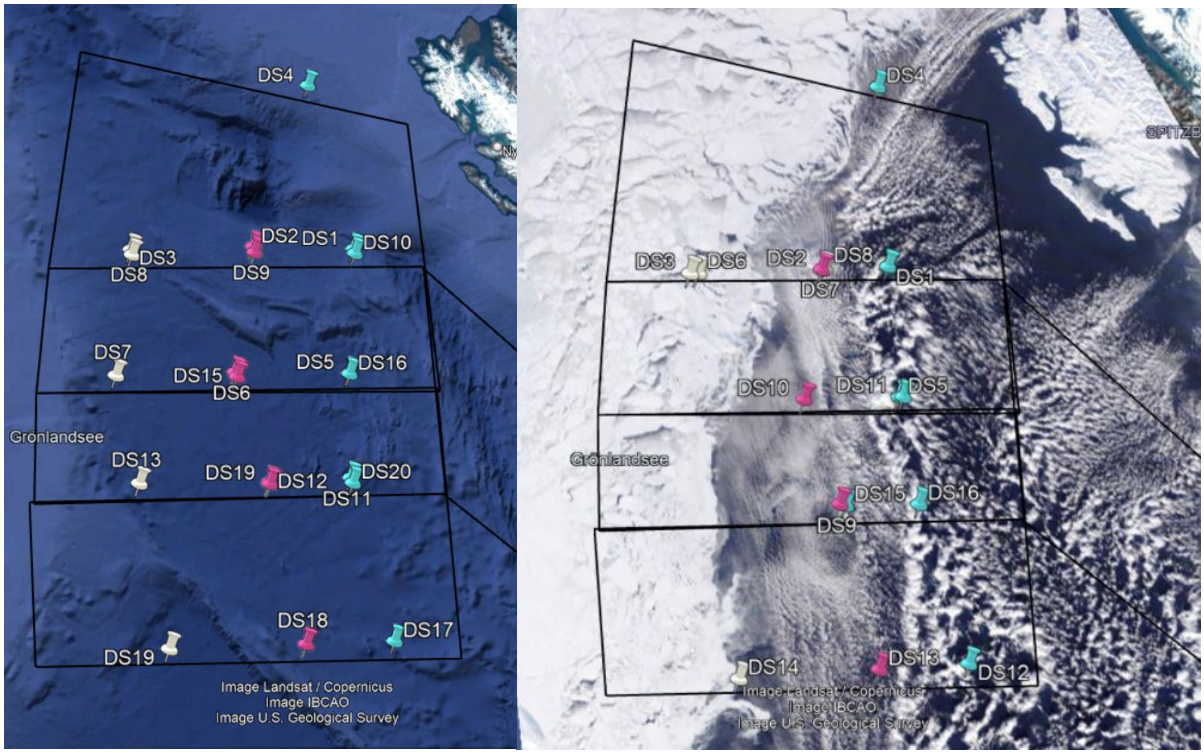


Figure 2 flight track with envisioned dropsonde locations (left) and actual sounding locations (right) with satellite image (TERRA overpass from 12:33 marine clouds, and 14:10 UTC sea-ice region).

the flight performance, six dropsondes were not able to transmit data, as their internal system did not detect launches. Consequently, this concept was not achievable, however still a detailed sonde-based representation of the cold air masses was recorded (Figure 2 right). The northeastern corner of the spiral pattern was slightly adjusted by a radar calibration manoeuver.

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.

Flight Logs (all times in UTC)

08:37 Take off (slight delay due to snowy/icing conditions)
08:50 clear-up of sky towards Norwegian coast
08:55 we have to adjust the flight path due to military exercise – heading further north and later westwards
09:00 over open sea and clear sky
09:10 fluffy clouds tend to increase → more clouds on northward flight leg than expected.

09:24 precipitating cloud overpassed.
09:28 ice fuzzy structures above precipitating cloud decks. Nimbostratus,
09:30 sharp boarder to cumulus clouds.

09:33 Johannes thinks of gravel pattern.
09:41 sky become more overcast with precipitating showers
09:47 end of cloud streets with clusters from eastern CAO ?!
09:52 Svalbard becomes visible.
10:00 open skies close to Svalbard. HAMP-KV module stops measuring

10:10 LIDAR sees 7km high located aerosols showing waving structures (orographic impact on easterly current?)
10:15 entering region of interest
10:18 **DS1*** no launch detected D01/D10 (**stands for originally planned sonde number*)
10:20 new **DS1** slightly shifted sonde
10:24 **DS2** in stratocumulus cloud field.

10:27 ice edge reached with rapidly clearing sky

10:30 **DS3** over sea ice an mostly cloud-free.

10:35 HAMP-KV module back in service

10:55 long cracks in sea ice, clear sky but hazy in lower levels with dirty air.

11:12 **DS4** released at northern top of spiral pattern in much more clouds than expected. Cloud streets are forming further north; south of our flight track they are already changing to convective cells. Regimes of airmasses become clearly visible, cloud streets in convergence zone are deeper.

11:17 rapidly clearing up of sky when approaching Svalbard. Sea ice in Fjords of Svalbard.

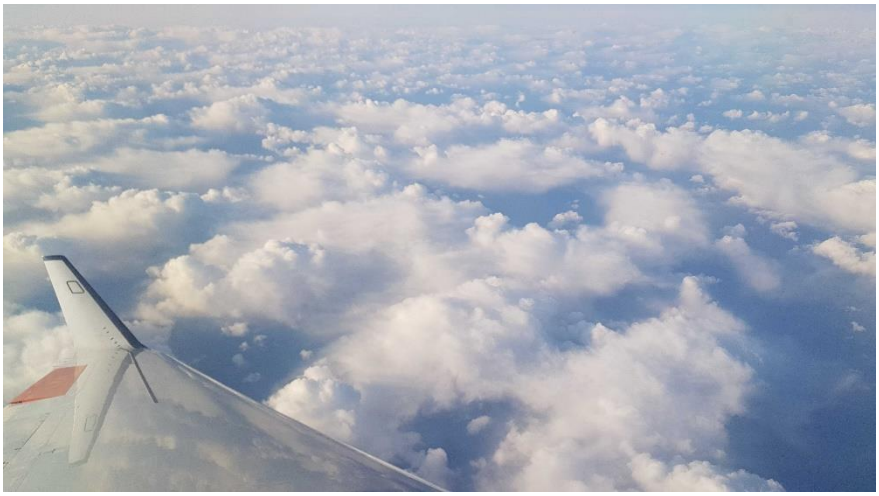
11:21 procedure turn before calibration manoeuver, clear sky during first bank

11:30 re-occurring cloud streets when coming back on flight track.

11:35 very rapidly overcasting clouds visible in radar.

11:36 first signs of precipitation.

11:46 entering second cross-leg with nice fluffy clouds.



11:51 **DS5**

11:52 Stratocumulus with radar-detected precipitation.

11:56 approaching convergence zone


11:58 **DS6*** bad sonde with low power unit as no launch detected

12:02 P6 is airborne.

12:04 **DS7***additional bad sonde in this leg.

12:13 very clear conditions over sea ice. With cracks everywhere but mostly overcast sea ice deck.

12:20 coming to the north the cracks. Thinner ice lakes.

12:22 last procedure turn necessary to coordinate with delayed Polar aircrafts, followings are skipped to head back to KRN earlier.

12:24 **DS6 at location of DS3**, cross-section with inverse flight track. Clear sky

12:27 cloud cover with low-level clouds start to increase.

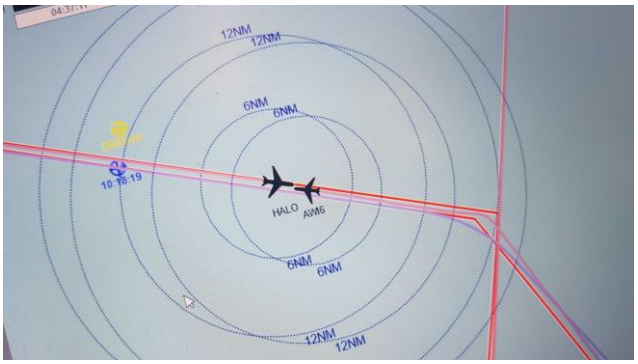
12:30 **DS7,** present cloud conditions below**:**

12:32 stratocumulus ahead of convergence zone

12:34: **DS8**

12:35 fluffy clouds with broken clouds.

12:39 overpass of P6



12:45 quite cloudy in eastern region.

12:50 downstream western leg with nice precipitation, P5 on its way into the research region

12:55 entered next cross-section with a lot of clouds, strong wind shear detectable. As expected south of leg a lot of clouds and shallow clouds in north

12:56 DS12* no launch detect,

12:46 DS12b* now launch detected but lost signal.

12:56 stratocumulus cloud field.

13:00 **DS9** launch detected inside of predicted location of convergence zone

13:06 centered cloud street

13:07 ***DS13** over sea-ice, no launch detected.

13:27 **DS10** launch detected with adapted release method referring to precedent standard procedure

13:32 **DS11**

13:50 less clouds

13:52 entering southern leg, overcasting of clouds and convective cells

13:54 **DS12** with showers

13:57 crossing the convergence zone and entering roll convection again, at least some left overs

14:00 **DS13** over shallow cumulus cloud streets

14:06 more sea ice coverage with decreasing of clouds in thickness, amount and horizontal extension. Initial state of cloud streets **DS14**

14:15 curve and heading northward to close the last rectangle clear sky conditions with some sea-ice leads but overall a very high coverage.

14:18 very low-level cloud are present.

14:26 heading eastward after last turn with clear sky sea-ice

14:29 shallow stratocumulus forming along sea-ice edge, aircrafts quite close

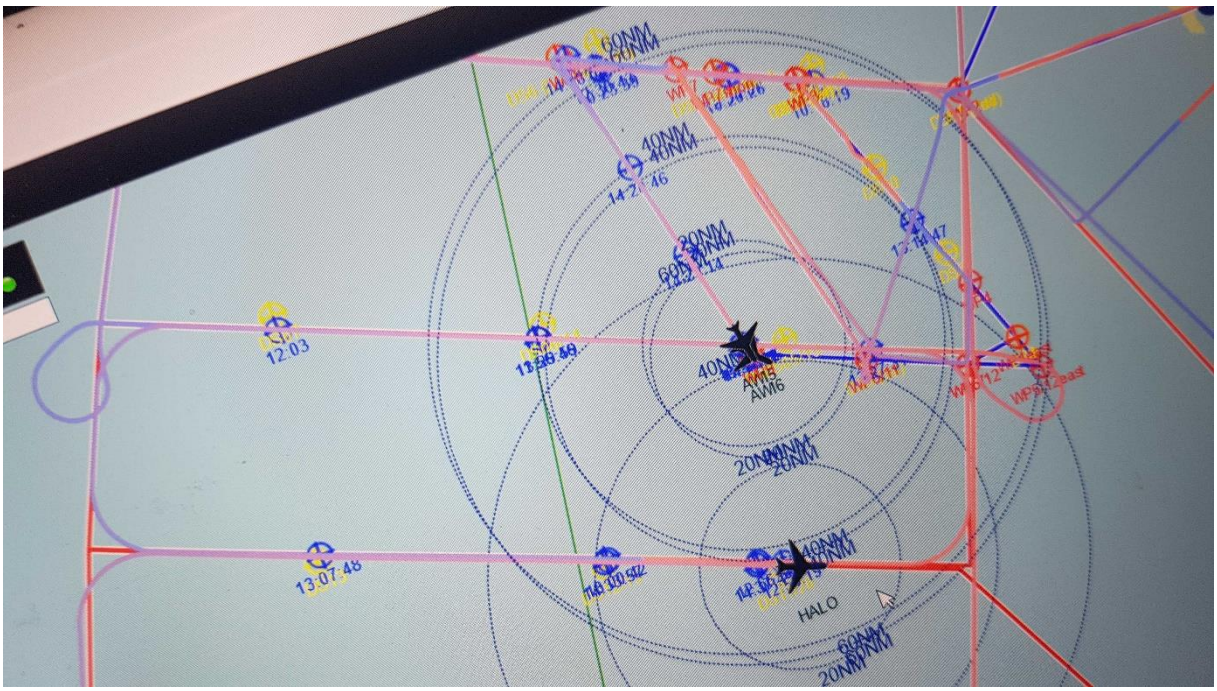
14:32 approaching convergence zone, clouds streets form to overcast stratocumulus conditions.

14:33 **DS15**

14:35 clouds broke before becoming thicker and precipitating. Shallow-cumulus not in radar

14:38 **DS16** precipitating clouds around

14:41 HALO and P5/P6 on parallel legs

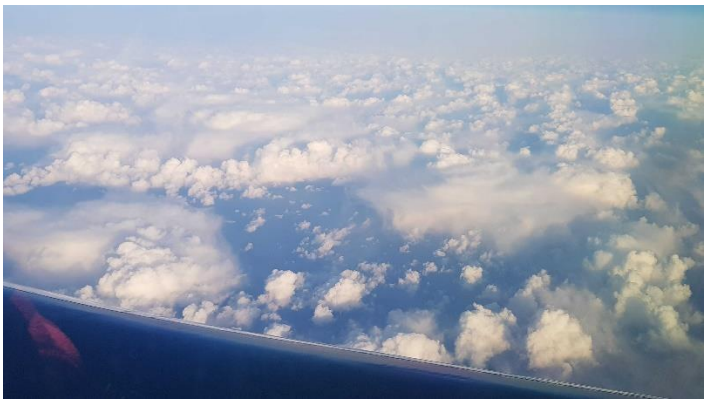


14:44 thicker clouds but not as intense as in the legs before. Leaving research area

14:46 ascent of flight level from FL310 to FL410

14:55 flight level reached

14:57 thick clouds with showers.



15:07 showers with iced cloud top, a lot of precipitation in showers

15:22 still some precipitating clouds with large-scale clusters.

15:25 broken clouds.

15:33 cloud towers having anvils with more than 4 km depth (small thunderstorms?).

15:42 three strong showers detected

15:50 Mountains show very high amounts of snow, presumably also a consequence of previous ARs.

16:07 landing in beautiful evening sunlight

Attached Quicklooks:

Radar CFAD:

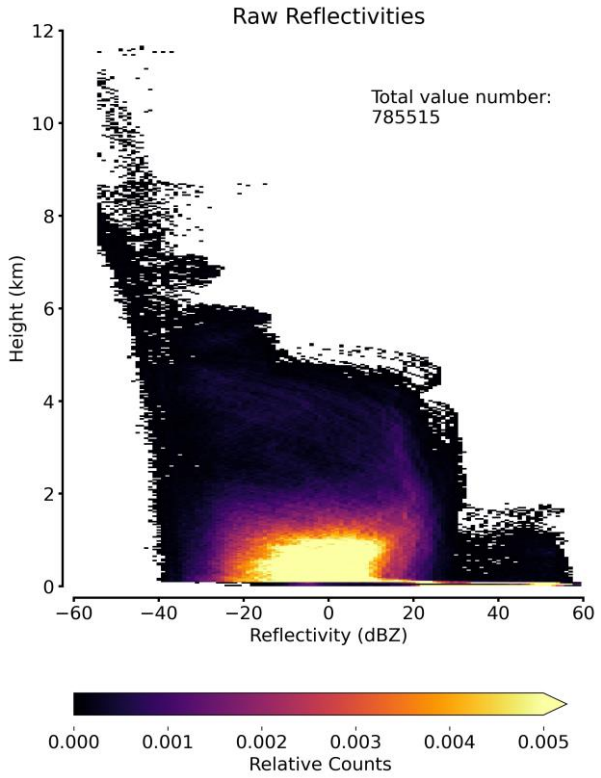


Figure 4: MIRA Radar contoured frequency by altitude diagram (CFAD) showing relative counts of recorded reflectivities

Radar Quicklook of cross-section around nearby TERRA overpass

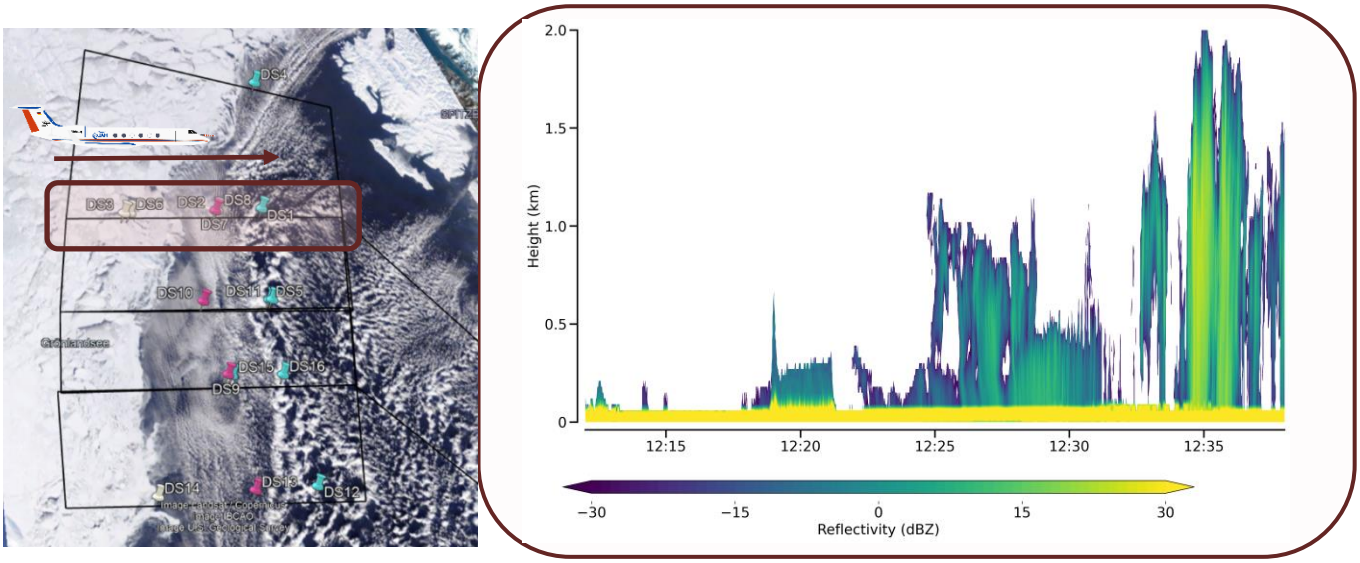


Figure 5: radar reflectivity for cross-section, which is closely located in space and time to TERRA satellite image