HALO-(AC)^3 – 2022/04/12 – HALO research flight #18

Objectives:

Multi objective flight: (a) mesoscale dynamics for cirrus & no-cirrus conditions (b) remote sensing above and below single-layer cirrus

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Mission PI HALO:

Geet George

HALO Crew	
Mission PI	Geet George
HAMP	Friedhelm Jansen
WALES	Georgios Dekoutsidis
SMART/VELOX	Johannes Röttenbacher
specMACS	Lea Volkmer
Dropsondes	Anja Schwarz
Flight Documentation	Manfred Wendisch
Pilots	Roland Welser Stefan Grillenbeck
Engineer	Thomas Leder

Flight times:

HALO	
Take off	**07:25 UTC**
Touch down	**15:30 UTC**

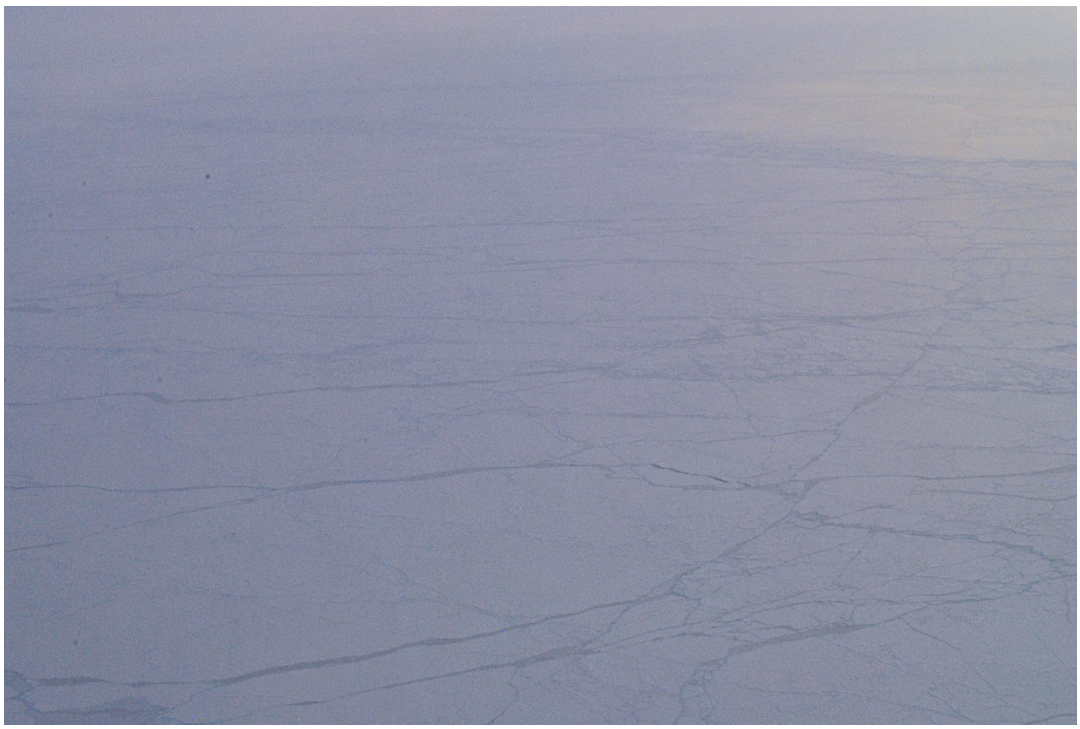


Fig. 1: Photo of sea-ice at the North Pole flying below the cirrus at FL110 (3100 m).

Weather situation as observed during the flight (compare to forecast):

The weather situation was slightly unexpected based on forecast information, but not so much that the sampling strategy had to be changed:

1. We found single-layered cirrus in the northern-most sampling region (albeit with lower cloud bases than the forecast predicted)
2. We expected some cloud-free regions near the western coast of Svalbard to launch a clear-sky dropsonde for radiometer calibrations, but this was not found. Only very small patches a bit away from the flight path towards the west were cloud-free, but the region was mostly blanketed by low clouds
3. The forecast predicted low clouds to the north where the circle for cirrus inhibiting dynamics were to be sampled, but this was mostly found to be cloud-free. Either way, the forecast's prediction of cirrus-free regions was correct and therefore didn't affect the sampling.

Overview:

The general objectives behind RF18 – the last local research flight for HALO-(AC)^3 – were threefold:

(a) Measure the atmospheric mesoscale dynamics and thermodynamics that allowed cirrus formation/maintenance and those that inhibited (dust-layer sampling advantage; see details in text later)
(b) Obtain remote-sensing measurements (especially radiation fluxes) above and below single-layered cirrus to investigate their radiative effects
(c) Perform a radar calibration maneuver

To meet these objectives, the flight plan included (in chronological order):

- Radar calibration maneuver to the west of Svalbard (1 sonde launched to assist calibration of radar and if in clear-sky, radiometers too)
- Circle measurement with 10 sondes in cirrus-free area north of Svalbard
- Pentagon measurements : first pentagon above cirrus with dropsondes launched at each of the vertices; second pentagon below cirrus with the exact same horizontal coordinates as the one above

Regarding the planning of flight strategy: As per the forecast and the information from the RF17 flight on 11.04.2022 (the previous day), the target area of measuring cirrus clouds over sea-ice was planned. Since there was a preference for single-layered cirrus, we planned to fly very close to the pole where forecasts showed them within reach. The flight plan was to fly straight-legged pentagons (mostly thanks to the Danish airspace restrictions) over the cirrus and another exactly at the same horizontal coordinates below the cirrus, to obtain the radiative fluxes above and below the cirrus. We also had the advantage during the flight (as correctly predicted by forecasts) that there were no cloud layers beneath the cirrus.

The cirrus in the north were part of a synoptic system which had been moving northwards since a few days prior. This synoptic system looked initially like a single airmass, but as it moved over Svalbard, it diverged into two systems – one moving east and the other going northwest, which we sampled. This means that the airmass in the wake of Svalbard saw different conditions, thus staying impressively cirrus-free.

These forecast helped us plan another area of measurements – this time to sample the area-averaged divergence (along with the routine thermodynamics and remote-sensing) just north of Svalbard to see the differences in conditions which retained cirrus formation (cirrus in the north) and conditions which inhibited or dissipated the cirrus (in Svalbard's wake). Therefore a circle was planned to be flown just north of Svalbard. Here we had an added advantage with sampling dust layers. The trajectory predictions in forecasts showed that large dust-laden layers sampled in 2-3 flights previously by WALES would be sampled again in the same region where the circle was being planned. Therefore the circle location was restrained by our objective to also capture the dust layer.

During the flight, we encountered weather conditions that were similar to our expectations, but instead of low clouds in Svalbard's wake, the area was almost entirely cloud-free – something that was commonly observed during the campaign for Svalbard's lee effect but mostly on the western side of the island. Since this did not affect the sampling strategy, we continued with the plan of flying the circle at the planned location. Luckily, we did find hazy portions there indicating the presence of dust, but more on this will be learnt after the WALES data has been analyzed.

In the north, we encountered the single layered cirrus we were targeting, but the cloud base was lower than the forecast predicted (FL130) and therefore, we flew at FL110. This didn't change the sampling strategy a lot, since the WALES lidar was planned to be shut for either flight levels.

Instrument Status:

HALO	
BAHAMAS	
BACARDI	
HAMP Radar	
HAMP Radiometer	
WALES	Switched off for lower pentagon
SMART	SMART was not stabilized due to an INS failure
VELOX	
specMACS	VNIR shutter closed
Dropsondes	17/17 worked (1 w/ partial profile)

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

Detailed Flight Logs:

07:19 Taxi

07:24 Take off

07:27 Scattered low-level clouds, closed cloud deck above

07:29 Above clouds, little cirrus above us

07:32 Nice countryside below

07:34 Lidar shutter on

07:38 Scattered clouds below

07:41 Sc below 8/8

07:46 We climb to FL410 to be more than 1.3 km above cloud top (lidar), we will stay at that height for the whole flight except for the time below the cirrus up in the North

07:47 6/8 low level clouds below

07:51 8/8 Sc below

07:55 Reaching FL410

07:57 Extended Sc below us, 8/8, very nice what mother nature creates and displays for us

08:07 No change, just 8/8 extended lower level Sc below us, we stay at FL410 all the time, between flight level and lower level cloud it seems very hazy

08:13 Some gaps appear in the cloud deck below, still 7/8

08:17 6/8 Sc below, hazy/cirrus like clouds between flight level und lower level Sc

08:21 4-5/8 low level clouds, haze/cirrus still atop the Sc but below flight level

08:26 Some sea ice stripes below

08:28 Sea ice flows below, lower cloud deck starts to increase again (coverage increases to 6/8, but quite inhomogeneous

08:32 Spitzbergen appears, 8/8 low level clouds below

08:43 Fly-by Spitzbergen, nice view, unclear inhomogeneous cloud conditions below

08:51 7/8 lower level clouds off the coast of Spitzbergen

08:55 Radar calibration starts: Wiggle maneuver begins

08:56 Wiggle stops

08:57 Circle

09:03 Potentially some dust layer

09:30 circle is mostly cloud-free; a little bit probably sampled in the WNW part of circle but cloud-free inside the circle

10:08 Back from dropping sondes

10:12 Just few clouds below, partly low stuff above he sea ice

10:16 8/8 Sc above the sea ice, cirrus on top of it

10:24 Decent to FL390

10:25 Sea ice becomes visible again

10:29 Just thin cloud stuff below

10:35 We are above nice cirrus flying 4 km above cirrus top, cirrus base is at about 4 km altitude, that is what the radar tells, sometimes we can view to the ground, cirrus has certain gaps

11:30 Back from the drop sonde launch, hexagon finished

11:31 Descending through the cirrus, is optically thin but continuous, we can see the sea ice

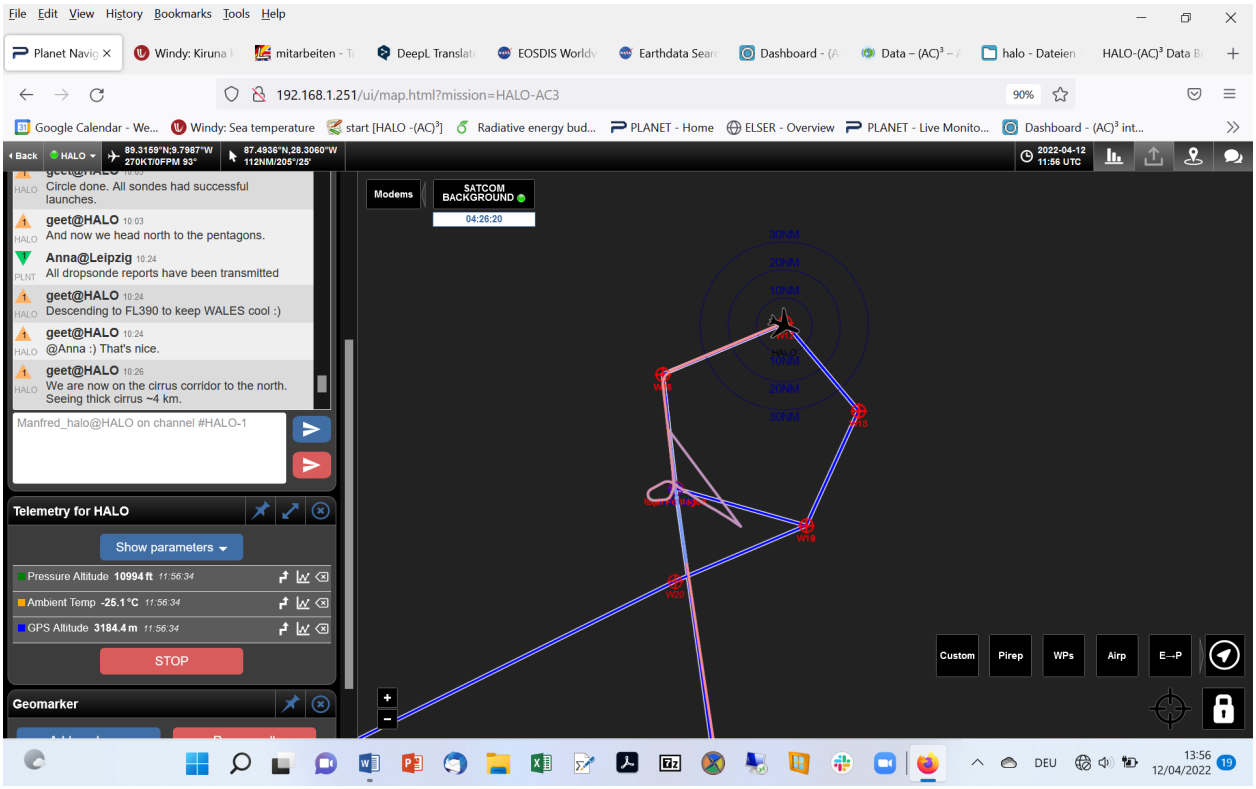
11:36 Sun shines through the cloud

11:40 We are below cloud, FL110, 3100 m altitude

11:40 Start hexagon below the cloud

Maybe on the hexagon we launched the most northern dropsonde ever

11:53 Most northern point of the hexagon: 89.3159°



12:16 Finishing the hexagon below the cloud, start climbing

12:17 Halo visible around the Sun, observed by Lea from Munich

12:25 Again above the cirrus

12:30 Arriving at FL350, well above the cloud, good for the Lidar

12:39 Thick cloud below with 8/8

12:44 Climbing to FL390

12:49 Nice sun dog (Untersonne)

12:53 8/8 cloud cover below, nothing above, cannot see the sea ice through the thick clouds

13:01 Also some aerosol layers can be seen on the horizon, kind of brownish layers

13:17 Still 8/8 cloud cover below, no Sc, but rather St or As, a little bit of a wave structure

13:28 Clouds again turning more into a Sc kind of type

13:50 Last dropsonde of HALO–(AC)³ campaign launched, we had 10 in the most southern circle, another 5 in the northern hexagon above clouds, makes it 16 altogether.

13:52 Fly-by Spitzbergen

13:56 Low clouds more opaque, more convective, over open ocean

14:00 Extended Sc below, nothing above, no cirrus, blue sky

14:16 Blue sky above, extended low level clouds

14:19 Clouds are more scattered now, through holes the open sea is visible, some remaining ice here and there

14:30 No cirrus on our way back

14:44 8/8 Sc below

14:55 Start descent

ETA 15:30 UTC

Quicklooks:

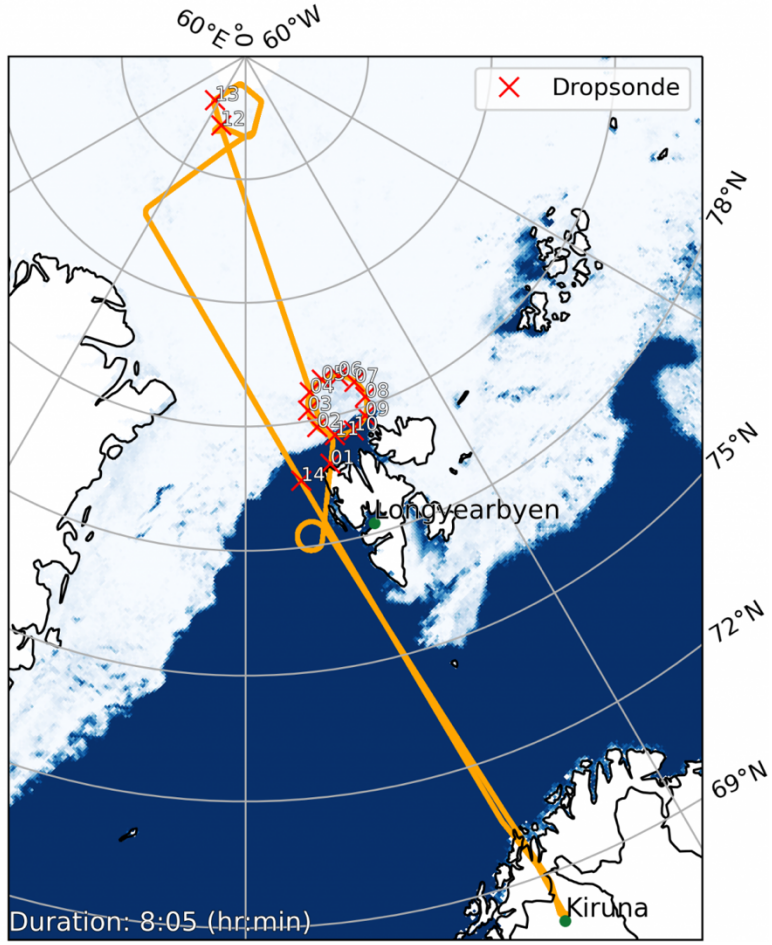


Figure-1 : HALO SMART-INS flight track with red markers showing dropsonde launch locations. Note that three dropsonde markers on the pentagon are missing because they didn't pass initial data quality control – but the data is available

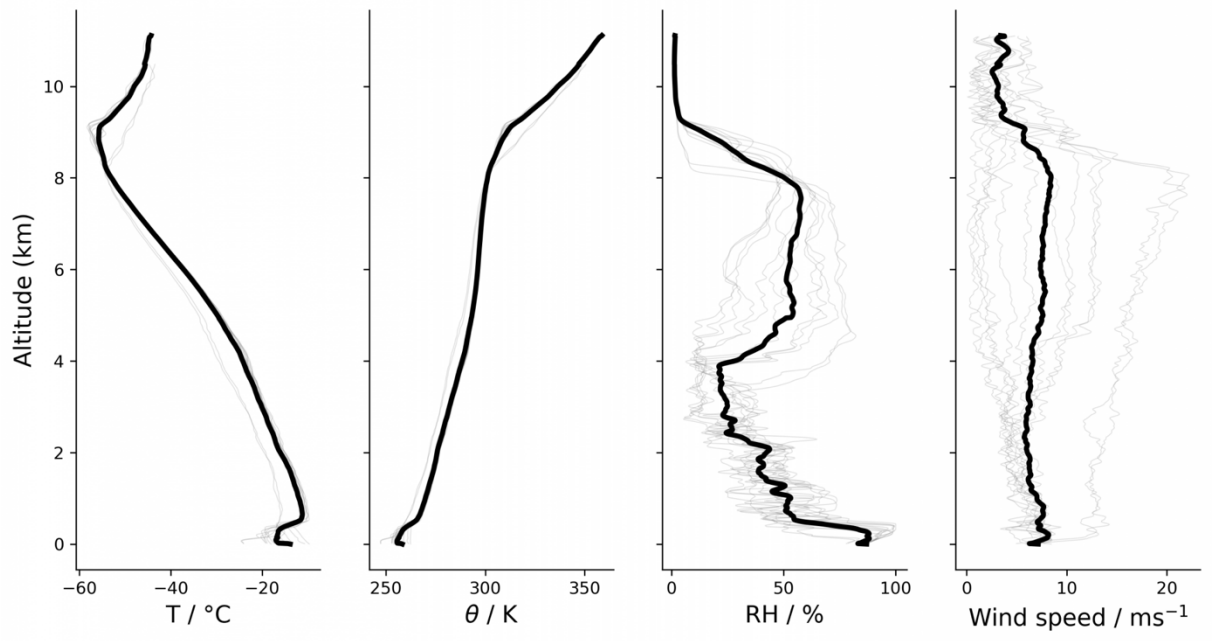


Figure-2 :Dropsonde profiles (dark: mean profile; light: individual launches)

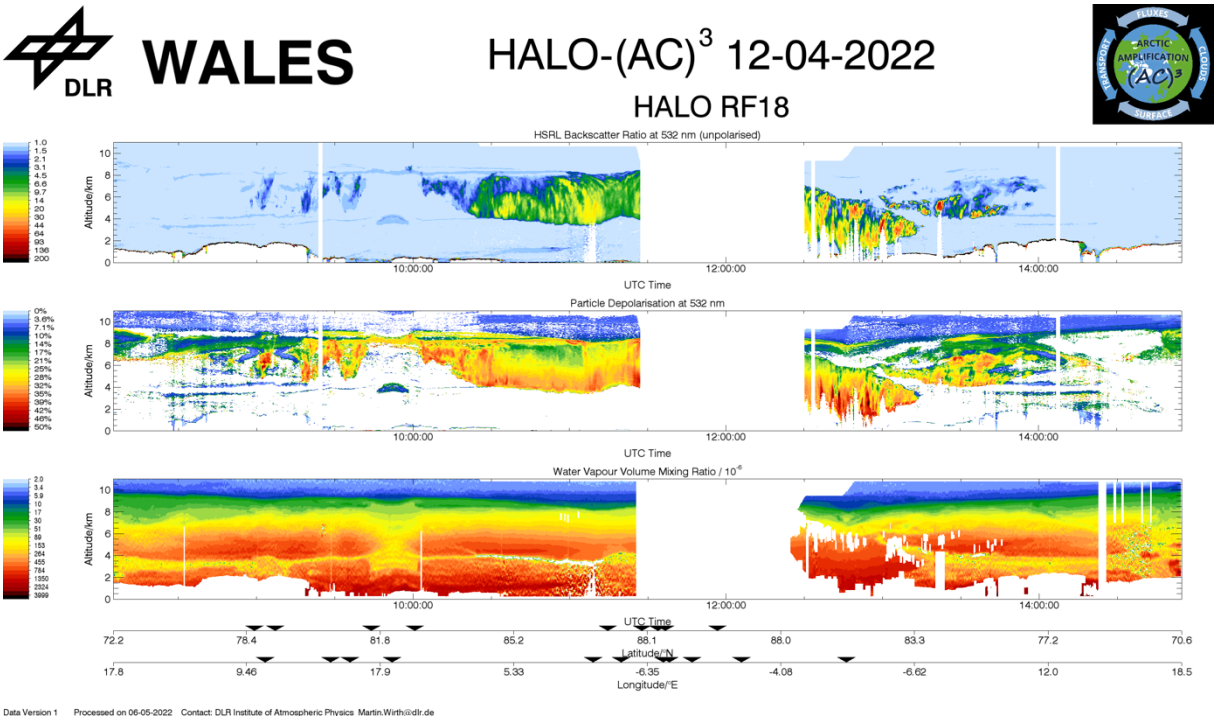


Figure-3: WALES Backscatter Ratio, Particle Depolarization, Water Vapour Volume Mixing Ratio (are there any hints of dust here?) (note that the missing parts around a half-hour around 1200 UTC is because HALO was flying below clouds)

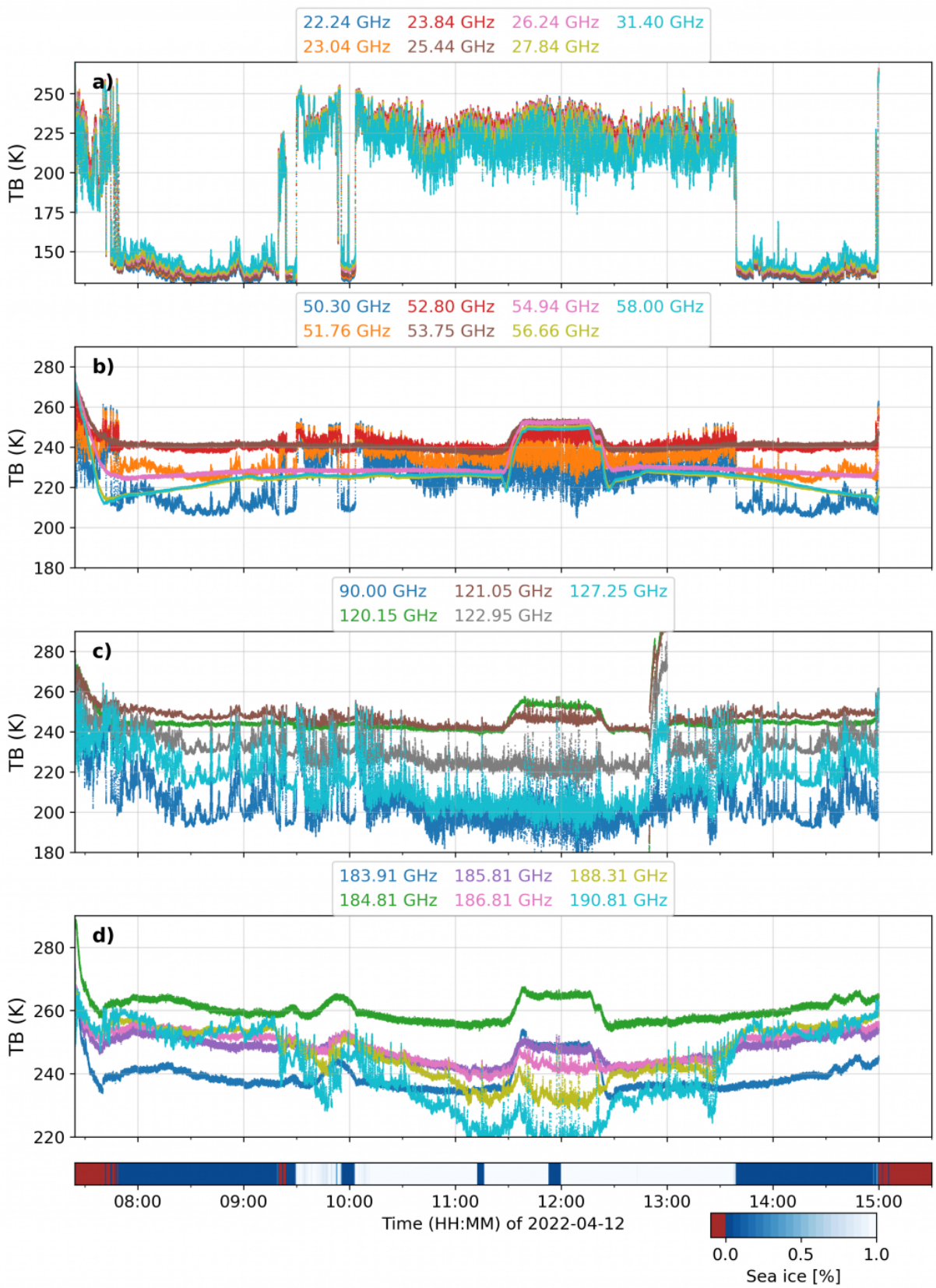


Figure-4: Radiometer brightness temperatures from HAMP (quick reference for sea-ice also available)

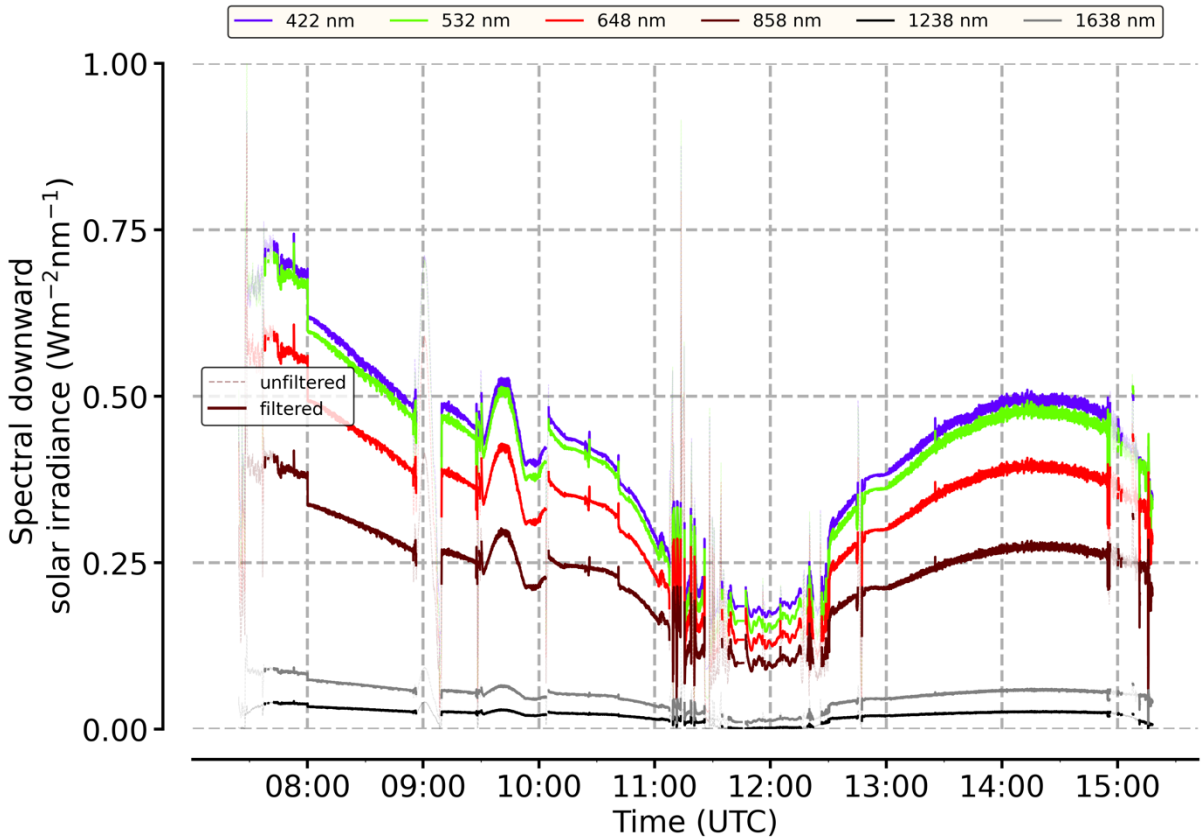


Figure-5: SMART downward irradiance for select wavelengths

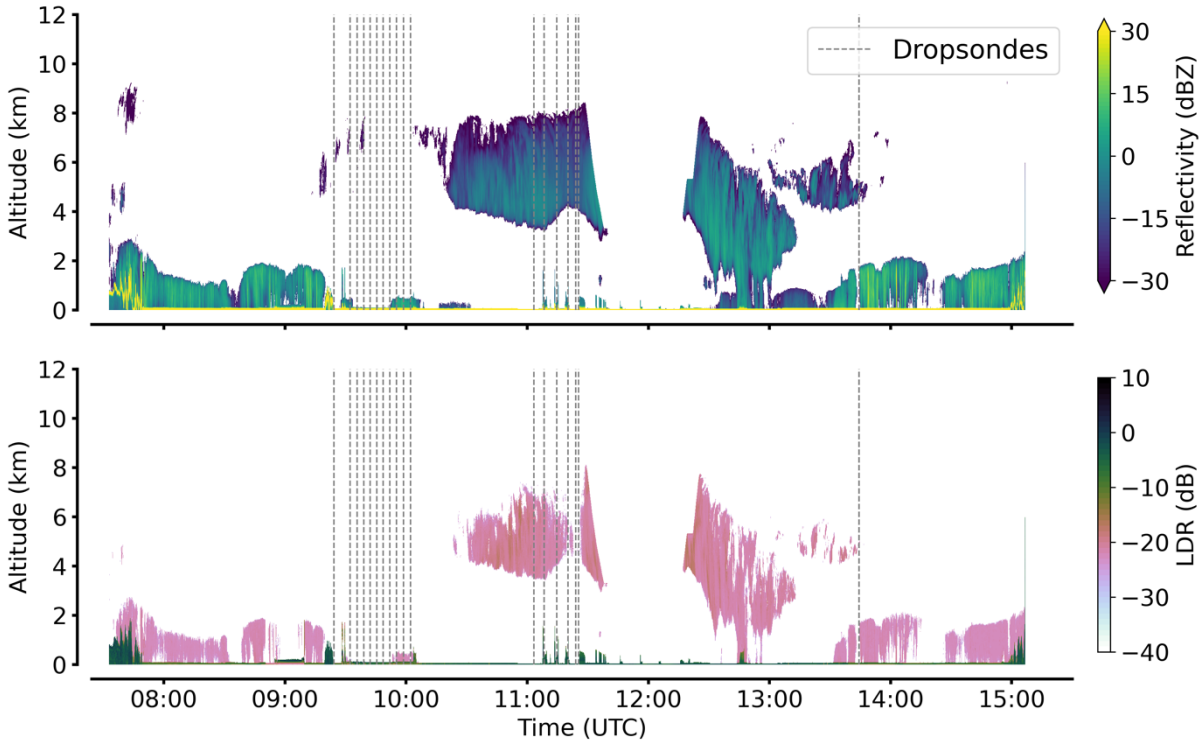


Figure-6: HAMP Radar reflectivity and linear depolarization ratio (note that the missing parts a half-hour around 1200 UTC is because HALO was flying below clouds)