HALO-0126 (26 January 2020)

Manfred Wendisch

30 January 2020

1. Objective

The flight included three aims:

(a) During a so called “Super-Curtain” pattern, vertically collocated measurements with the Twin Otter and ATR shell be performed, for instrument comparison, closure studies linking microphysical measurements inside clouds (Twin Otter and ATR) with remote sensing observations above clouds (HALO), and irradiance net measurements below and above clouds (ATR and HALO) for estimates of cloud radiative effect.

(b) Two series of 3.5-circle patterns at FL320 with 12 drop sondes released during each circle shell be performed to measure horizontal wind divergence and derive vertical motion.

(c) Coordinated curtain measurements with the Meteor against wind direction shell be combined by flying below cirrus and observe the cirrus using remote sensing means (downward spectral and broadband radiation measurements from HALO), and applying active/passive remote sensing observations from Meteor.

2. Crew

Manfred Wendisch (Mission PI), Tobias Zinner (specMACS), Silke Groß (WALES), Geet George (Dropsonde), Michael Schäfer (VELOX & SMART), Marek Jacob (HAMP Radar and Radiometer), Sabrina Schnitt (flight scientist), Roland Wesler and Marc Puskeiler (Pilots), Thomas Leder (Engineer).

3. Synoptic Situation

There were weak eastern winds at the surface (925 hPa, Fig. 1) turning to southern directions in higher altitudes (500 hPa).

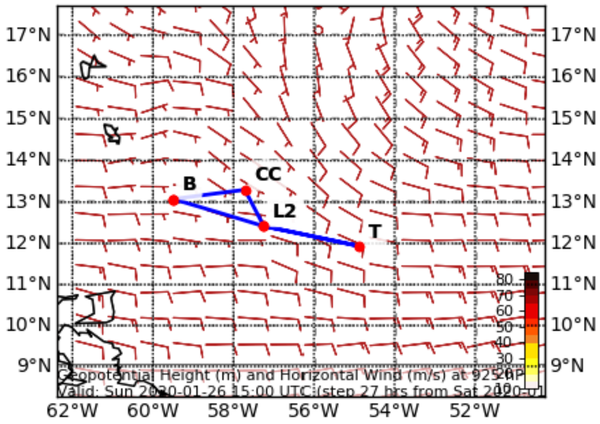

Fig. 1: Top view of the ECMWF wind field forecast (925 hPa) for 26 January 2020, 15:00 UTC (the simulations were initialized 12 UTC on 25 January 2020). The blue lines indicate the flight path, the black letters (red dots) stand for waypoints, given below in Section 4.

With regard to clouds, we observed cirrus almost all the flight. It extended roughly between altitudes of 14-17 km. The cirrus appeared quite often very inhomogeneous. Low level cumuli were observed mostly in the western part of the circle. The cirrus was well captured in the ECMWF forecast (Fig. 2).

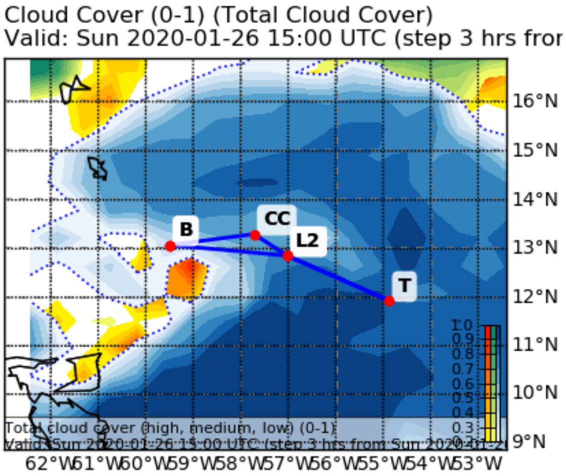

Fig. 2: Top view of the ECMWF cloud cover analysis for 26 January 15:00 UTC. The blue lines indicate the flight path, the black letters (red dots) stand for waypoints, given below in Section 4.

4. Flight Elements

(a) Super-curtain jointly with Twin Otter and ATR at the beginning
(b) 3.5 circles at FL320 releasing drop sondes
(c) Coordinated curtain flight track with Meteor
(d) A second 3.5 circle pattern releasing drop sondes

Waypoints:

-	B (Barbedos):	13.0744 N,	- 59.4925 W
-	CC	13.3 N,	- 57.717 W
-	L2	12.419 N,	- 57.245 W
-	T	11.93 N,	- 54.87 W

A sketch of the flight pattern is presented in Fig. 3.

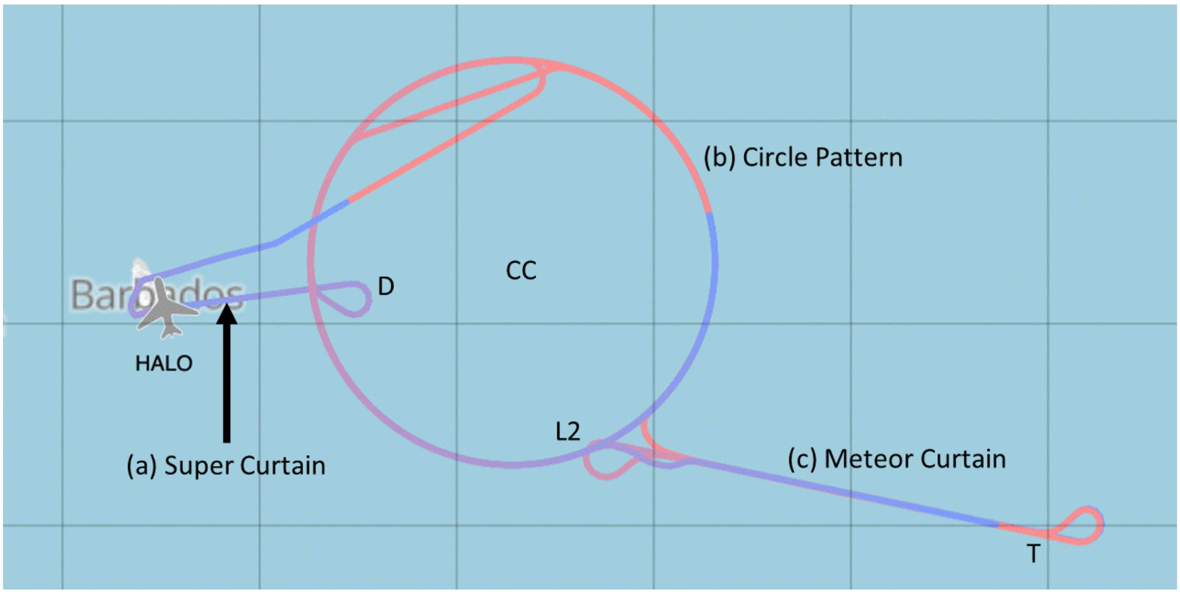

Fig. 3: Sketch of flight path of HALO including waypoints.

The following table summarizes the flight segments.

Element	Flight Track	Flight Level (FL)	Time (UTC)	Notes
Take off			12:05	
(a) Super Curtain	B → D (CC)	Ascent to 320	12:05-12:28	HALO climbed to FL320 and stayed at this altitude, curtain with ATR and Twin Otter (TO) both flying at the same track but at lower altitudes. TO takes off at 11:55, ATR at 12:00. After overtaking TO and ATR, HALO moves into the 110 km circle.
(b) First series of 3.5 circles		320	12:28-15:58	Cirrus above, low-level clouds mainly in the western part of the circle. Drop sondes between 12:29-15:40.
(c) Coordinated curtain flight track with Meteor	L2 ←→ T	320	15:58-17:20	More clouds close to T, less/no clouds close to L2. One drop sonde on the first leg L2 → T, two drop sondes on the last leg from T → L2. First leg (L2 → T) was completed at 16:05. Second leg (T → L2) was finished at 16:32 (L2 → T), third leg ended at 16:58. At the end of the final leg (T → L2) we performed a radar calibration maneuver.
(d) Second series of 3.5 circles		320	17:20-20:50	Always cirrus above, low level clouds (partly cold pools, Fig. 4) mostly in the western part of the circle. During the last circle (northern part, about 19:46-19:51 UTC) we had to deviate from the pattern for a short time because of incoming traffic, we could soon return to the circle without losing any drop sonde measurements. At 20:05 we overfly L2 on the last circle part. The last drop sonde was released at 20:48. At 20:50 we left the circle pattern and headed to Barbados, descending from FL320 to FL160 (reaching at 20:55) for lidar testing.
Touch down			21:21	

Fig. 4: Two cold pools as observed during the second series of circles.

5. Instrument Status

All instruments were operational during the flight, only slight issues were reported.

One microwave channel registered weak spikes when we overflew Meteor.

WALES performed well most of the time. In the first half of the flight the spectral stability of the lasers was not optimal, due to cabin temperature effects. This was solved in the second half. The high temperature sensitivity was partly related to a degradation of the fiber coupling of one of the four seed lasers. This has been realigned after flight.

We have launched 75 sondes all together (72 during the circles and 3 on our L2 → T pattern). 2 sondes lost signal, one did not report humidity, and another one did not transmit pressure, temperature and humidity. For the latter two, we still received all wind measurements. One of the sondes had a weak signal before launch, and we decided to not launch that. It is still with us, with the power plug back in.

The HAMP radiometers worked fine with the exception of the 183 module. The 183 hat some outages leading to some data gaps and jumps due to interrupted heating.

specMACS and VELOX did not report any problems.

6. Figures

Dropsondes:

Figure 5 shows the locations where the drop sondes were launched (the colors show the column moisture). Figure 6 presents the estimated values of omega (preliminary). And Fig. 7 shows the static energy, which gives a good idea of the soundings and what the thermodynamics yesterday were like.

We saw a drier atmosphere throughout, compared to the previous flights, but this seems also typical of the winter trade wind regimes here. We observed an inversion at ~2 km and very dry air above that height. The sub-cloud layer varied from between 600 - 800 m, with the west showing a lower LCL (thus, shallower sub-cloud layer) and moister columns compared to the east.

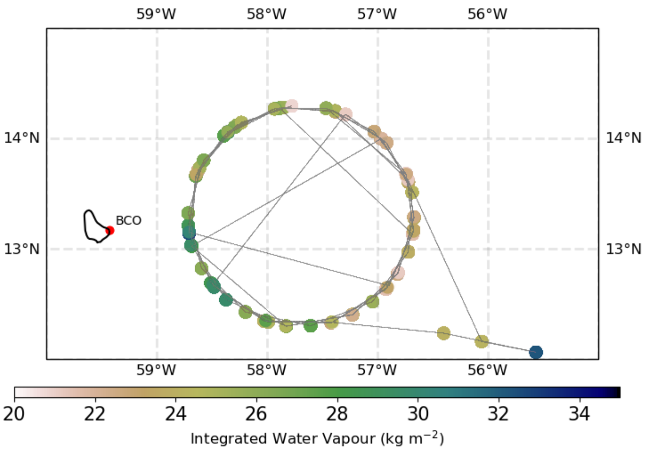

Fig. 5: Location of the drop sonde releases during the two series of circle patterns.

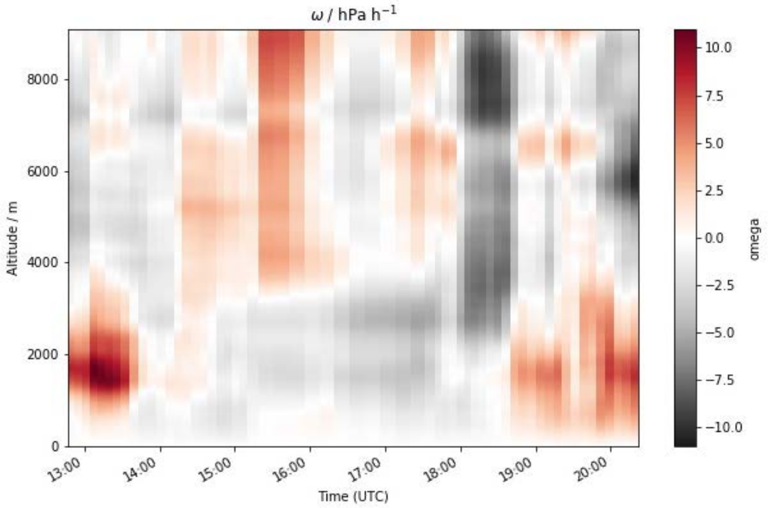

Fig. 6: Estimates of vertical motion (omega = d*p*/d*t*) as derived from the drop sonde releases during the two series of circle patterns.

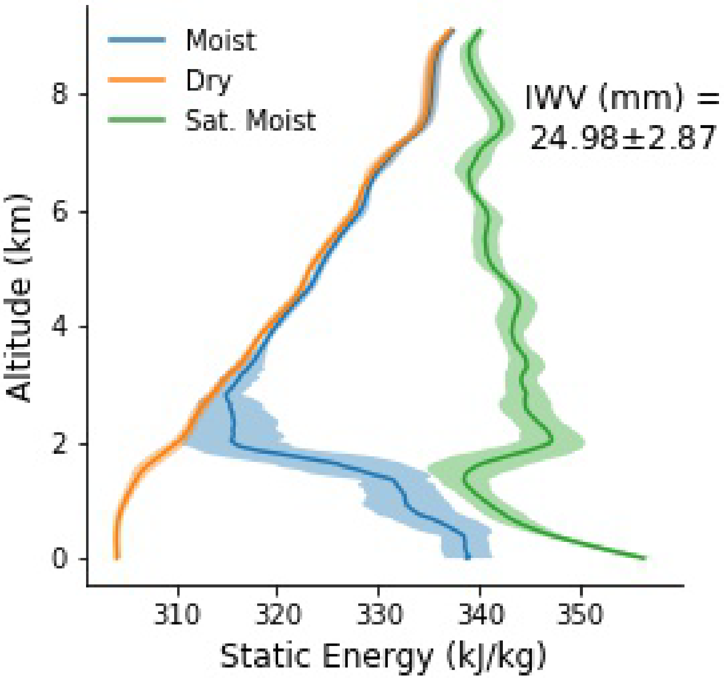

Fig. 7: Static energy as derived from the drop sonde releases during the two series of circle patterns.

WALES:

In Fig. 8 quick look data of the extinction-corrected backscatter ratio at 532 nm along the flight track (upper panel) and of the relative humidity over water are shown from the water vapor data of the WALES DIAL together with temperature data from ECMWF IFS analyses (lower panel).

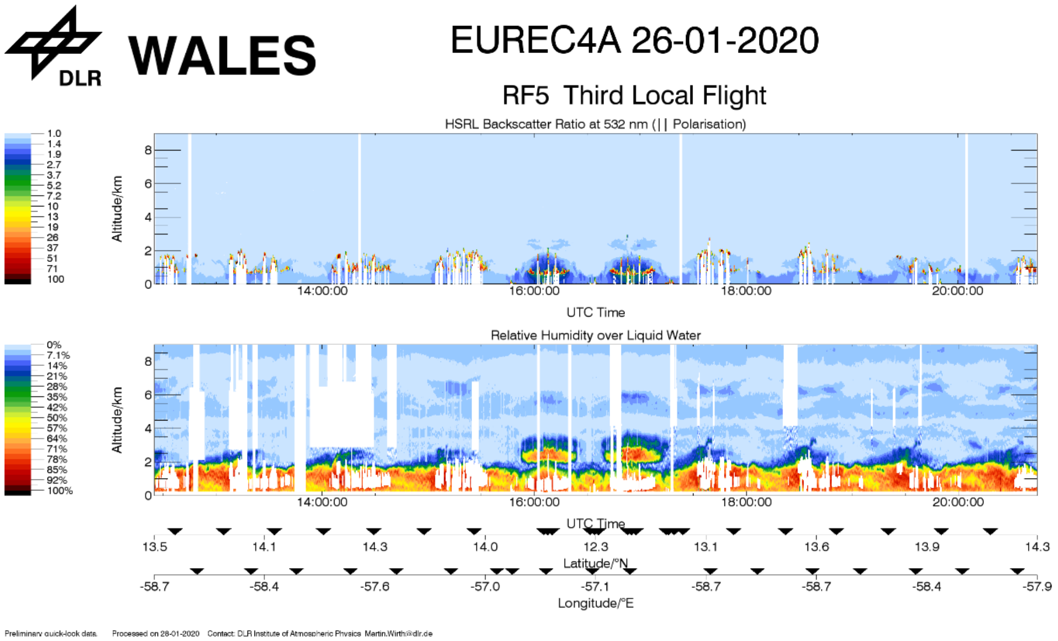

Fig. 8: WALES quicklook of extinction corrected backscatter ratio at 532 nm (upper panel) and relative humidity over water.

VELOX/SMART:

Figure 9 shows an example of VELOX measurements (broad-band, 7.7-12 µm wavelength) of sea surface temperatures (each point representing an averaged over a complete image) during cloud-free conditions below the aircraft (10 minutes, about 130 km, start time at about 20:15 UTC). The sea surface temperature varies in the range of half a Kelvin within 130 km for this selected case.

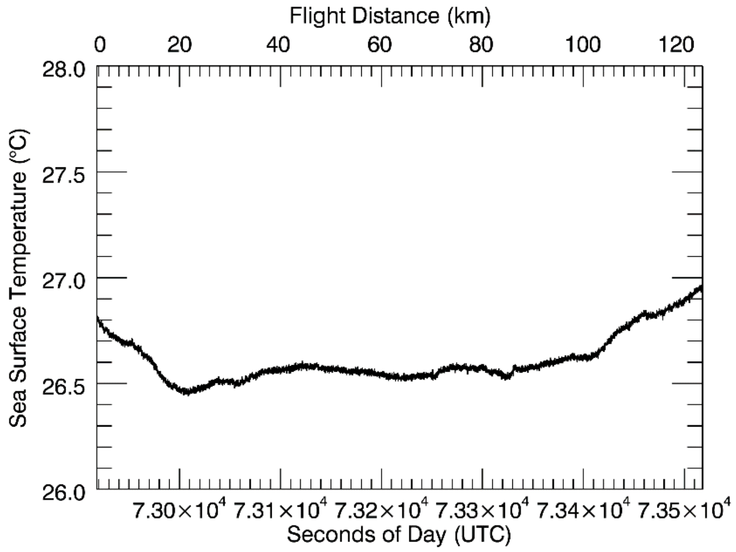

Fig. 9: Time series of sea surface temperatures as measured by VELOX during cloud-free conditions below the aircraft.

The second example (Fig. 10) exemplifies the brightness temperature measurements (uncalibrated) provided by the KT19 instrument including some images of cloudy patches from VELOX (also broadband). The cloudy time periods (seen as fluctuations in the time series) show a decreasing cloud cover and cloud top altitude (increased cloud top temperature) during the second overflight. Less peaks indicate a decreased cloud cover; lower magnitude of fluctuations reveals a reduced cloud top altitude (temperature).

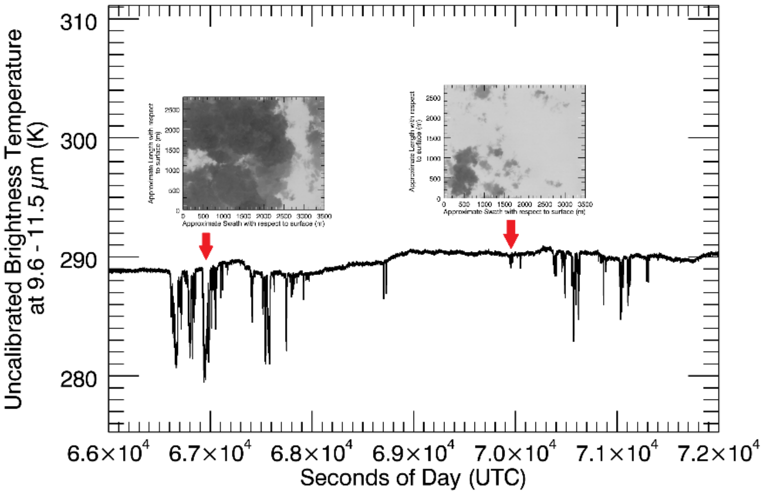

Fig. 10: Time series of brightness temperatures as measured by KT19. Two images from VELOX are included.

specMACS:

specMACS worked without any interruptions from start to landing. All data were stored to hard drives until the evening of January, 27. Low clouds have been rare on that day, high cirrus above the aircraft was present almost all the time. Evaluation of spectral camera data will, therefore, be difficult. Polarisation camera data can nicely by analyzed even in this situation. Attached are two examples of data of this day from the polarization cameras. Figure 11 shows a cloud bow observed at 6:23 UTC. Figure 12 presents the unpolarized observation of a cold pool at 11:41 UTC.

Fig. 11: Observation of a cloud bow (left: radiance unpolarized, middle: degree of linear polarization, right: angle of linear polarization).

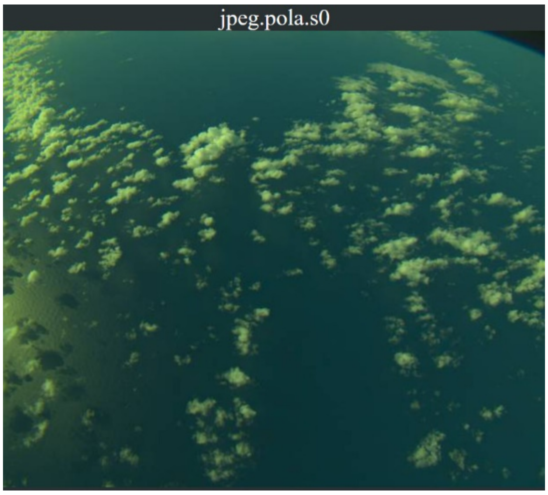

Fig. 11: Observation of a cold pool.

HAMP:

The time series plots in Fig. 12 show periodic features of the circles and the double back-and-forth excursion in most channels. Humidity variation can be retrieved from the slow variation, especially in the K band, with warmer brightness temperatures (TB) indicating more moisture. Positive peaks indicate presence of liquid. It seems like that excursion was more or less cloud free and was directed into moister air masses that were sampled twice. In Fig. 13 a radar curtain shows regular patterns of rain. A shift of the echos in respect to the aircraft location is notable.

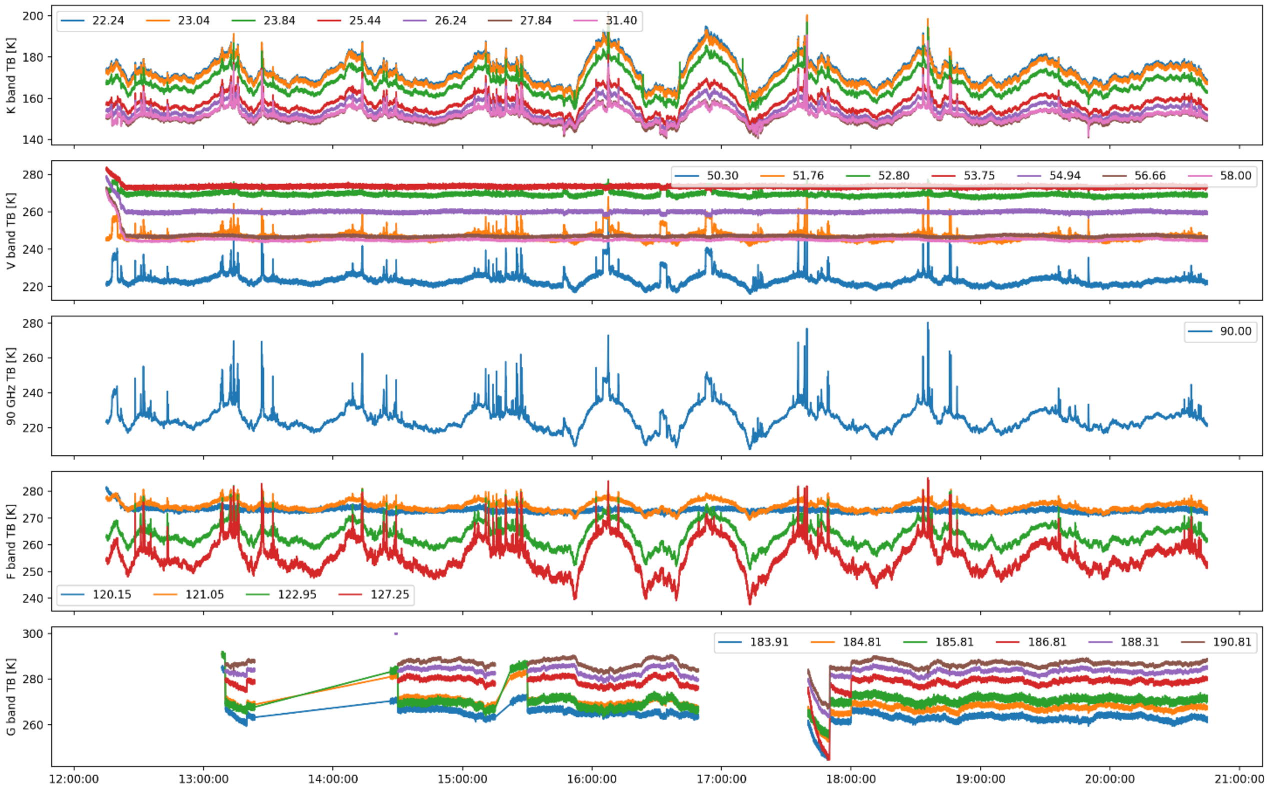

Fig. 12: Time series of HAMP measurements.

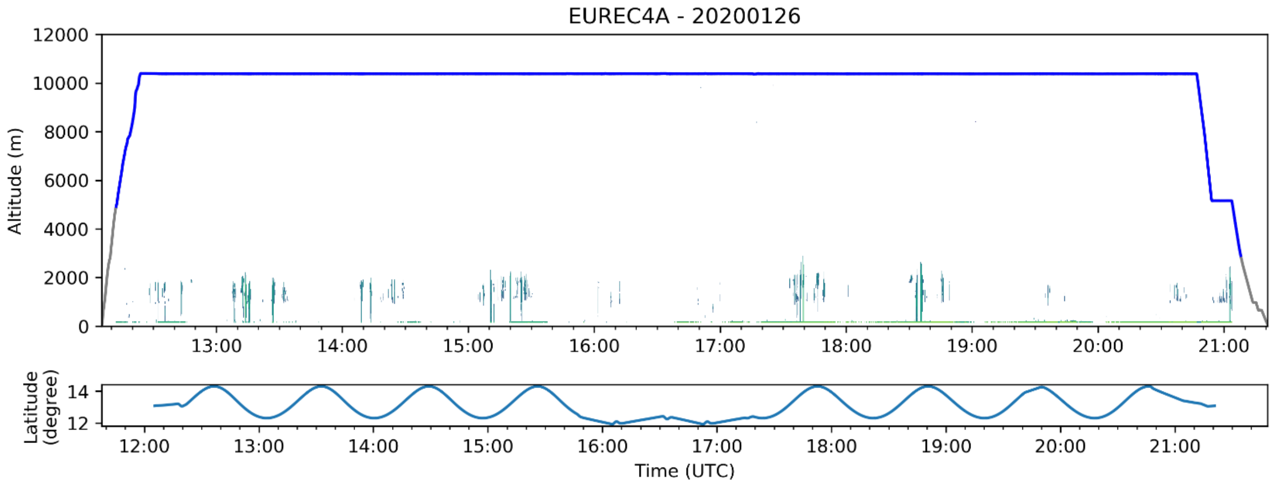

Fig. 13: Time series of radar measurements.

The spirit of the team was great. Thanks to all of you!

Fig. 14: The HALO crew of this flight. From left to right: Sabrina Schnitt (flight scientist), Geet George (Dropsonde), Manfred Wendisch (Mission PI), Michael Schäfer (VELOX & SMART), Marc Puskeiler (Pilot), Thomas Leder (Engineer), Roland Wesler (Pilot), Silke Groß (WALES), Tobias Zinner (specMACS), Marek Jacob (HAMP Radar and Radiometer).