

# HALO-0209 (09 February 2020)

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## 1 Objective

11th local research flight with standard circle pattern. Take-off was planned for 5 LT, but delayed by 15 minutes due to fueling delays. 7 circles were flown with a total of 72 dropsondes deployed. After 3.5 circles, an excursion leg to the Ron Brown was made, including a dropsonde launched at the Ron Brown. Past the RB, a radar calibration maneuver was performed before returning to the circle on a straight leg, passing the RB again. After getting back on the circle track, 3.5 more circles were performed. Before landing at GAIA, a leg at FL160 was flown for enhanced resolution around cloud edges.

While HALO was circling, the ATR was flying the usual racetrack pattern in the western part of the circle. The Twin Otter was chasing clouds in the western circle area and around CC. The P3 performed its first night flight, landing an hour after HALO's take-off time with the objective of continuous monitoring of the tradewind alley throughout the night. The RSS aircraft joined for a coordinated flight with the ATR for its 2nd flight (14-18:20 UTC), with a high-resolution camera operating from above the ATR. The BOREAL drone performed circles between the HALO circle and Barbados. The Meteor and Maria S. Merian were located in the Eastern half of the circle.

## 2 Crew

Sabrina Schnitt (Mission PI), Timothy Cronin (Scientist), Marc Prange (Dropsondes), Marcus Klingebiel (HAMP), Veronika Pörtge (SpecMACS), Tobias Kölling (Velox & SMART), Andreas Fix (WALES), Roland Welser & Stefan Grillenbeck (Pilots), Sebastian Gerstner (Engineer)

## 3 Synoptic Situation

The circle area was dominated by strong E/ENE surface winds (GALE warning issued) and water vapor amounts varying between 23.9 and 39.7 kg m<sup>-2</sup> (as seen from dropsondes). A rather moist boundary layer was capped by a temperature inversion around 2 - 2.5 km. An elevated moisture layer was located between 3.5 km and 4 km. Throughout the flight, LCL at BCO was located around 700 m to 800 m. Shallow sugar clouds dominated the scene, with

occasional formation of larger, more stratiform cloud aggregations. Throughout the streets of shallow sugar clouds, isolated cumulus towers actively developed with cloud tops bubbling up, pushing through the inversion up to around 4-7 km cloud top heights. Often, these clouds issued precipitating echoes in the POLDIRAD scans. Due to the strong winds, cloud tops were sheared strongly, particularly during the first set of circles; precipitating virgas were observed around the sheared tops that sometimes showed stratiform outflow layers.

During the second set of circles, precipitating clouds moved through the circle area, and dominated the circle particularly in the NW corner and around CC. 2 cold pools passed the SE corner of the circle around the beginning of the second circle set, leading to a more and more cloud-free scenery in the SE corner of the circle towards the end of the flight. Within the 5th and 6th circle, the same precipitating area was first sampled by the ATR and TO, and then passed by HALO in the NW area of the circle (15:25 UTC and 16:29 UTC). This precipitation area reached a cloud top height of 7 km (POLDIRAD), and 6 km (HAMP-radar), and seemed to contain ice as suggested by the HAMP 183 GHz TBs.

## 4 Flight Elements

**Circle 1** Started the circle during sunrise; fresh convective cumulus towers sheared strongly at cloud top; light sugar-clouds in circle area. Dropped twelve sondes with even spacing of 30° heading, starting at 0° (1 sonde failed). All instruments running.

**Circle 2** Sugar clouds in and around circle. Features of a weak cold pool with circular cloud arcs in NE of circle.

**Circle 3** increasing cumulus cloud development with tops pushing through stratiform layers in circle. Cloud tops located up to 3-4 km, strongly sheared by westerly winds. Precipitation development in feature located SE of circle center and at CC; features shown in POLDIRAD; precipitating features close to CC sampled by ATR and TO. Weak sugar clouds with increasing cloud-free areas SE of circle.

**RB excursion** passed sugar-like clouds on the way to RB; dropped sonde at RB position at 13:14 UTC showing enhanced moisture in stratiform patches; clouds organized like on strings with cloud-free areas in between

**radar calibration maneuver** developing cold pools E and SE of circle characterized by cloud arch as visible on GOES images; light sugar cloud conditions during ±20° wobble and 10° bank circle

**Circle 4** crossed cold pool in SE of circle with clouds on rim characterised by precipitation features (POLDIRAD) and large stratiform outflow at top; dropsonde released in center of cold pool. Decreasing cloudiness on S circle track, deeper clouds on W edge circle, also containing precipitation (sampled by ATR on race-track pattern).

**Circle 5** passed precipitation area on W rim of circle characterized by sheared Cu towers with veil around cloud tops. POLDIRAD suggests cloud tops up to 7 km in large field of sugar

Table 1: Overview of main elements of flight

Element	Time (UTC)	Flight Level (FL)	Notes
Takeoff at GAIA	09:15	Ascent to 320	delay of 15 min (fueling delays)
Circle 1 (CW)	09:35 - 10:27	320	started at 0° heading; 1 sonde failed
Circle 2 (CW)	10:50 - 11:43	320	started at 90° heading; 2 sondes failed
Circle 3 (CW)	11:56 - 12:54	320	started at 180° heading; 1 sonde failed
Ron-Brown leg outbound	12:56 - 13:15	320	overpass of Ron Brown (13.85N, 54.9W); 1 dropsonde released at RB at 13:14 UTC
Radar calibration maneuver	13:18 - 13:34	320	after RB overpass: $\pm 20^\circ$ roll angle wobble, then 270° circle cw at 10° bank angle
Ron Brown leg Inbound	13:34 - 13:53	320	
Circle 4 (CW)	13:56 - 14:53	320	started at -150° heading; 1 sonde failed
Circle 5 (CW)	15:07 - 16:05	320	started at -90° heading; complete soundings
Circle 6 (CW)	16:18 - 17:23	320	started at 0° heading; complete soundings
lidar calibration leg	17:25 - 17:50	160	
Landing at GAIA	18:02	ground	

clouds; precipitation sampled by HAMP radar with simultaneous dropsonde launched at 15:25 UTC (0° heading), cloud top located at 6 km. Bubbling, actively developing Cu clouds further W towards Barbados. ATR sampled precipitating features on race track between HALO and CC; E half of circle very light cloudy conditions with many clear air pockets. Cold pool moved towards CC with N rim containing strong precipitation signal, HALO sampled E rim of cold pool; DS show strong humidity gradients around 820 hPa, profiles characterized by 2 T-inversions and distinct cloud layers.

**Circle 6** precipitation pattern sampled in circle 5 at W edge moved out of circle towards W; precipitating clouds on cold pool rim as seen in circle 5 moved towards circle center and developed further, now also containing thin dark layer: now 2 precipitating areas at CC sampled by TO; mix of sugar and gravel clouds on W rim of circle; cloud-free area SE of circle; passed precipitating cloud feature from circle 5 again at 16:29UTC, this time suggesting ice occurrence from the 183 GHz radiometer TBs (see specmacs quicklook and hamp quicklook). HAMP radar suggests cloud top of around 6 km.

**lidar leg** passing through ATR race track pattern at FL160, characterized by active developing

clouds with less shear than in earlier circles.

## **5 Instrument Status**

**Bacardi** No issues.

**Bahamas** No issues.

**Wales** No issues.

**Radiometers** No issues.

**Radar** no issues, successful calibration pattern.

**SpecMACS** vnir camera failed around 13:30 UTC and at 16:30 UTC; missing data for about 5 minutes in total.

**SMART** No issues.

**Velox** No issues.

**Sondes** 5 out of 73 launched sondes failed from which 4 of them did have signal after launching.  
1 sonde lost signal around 325 hPa.

## 6 Figures

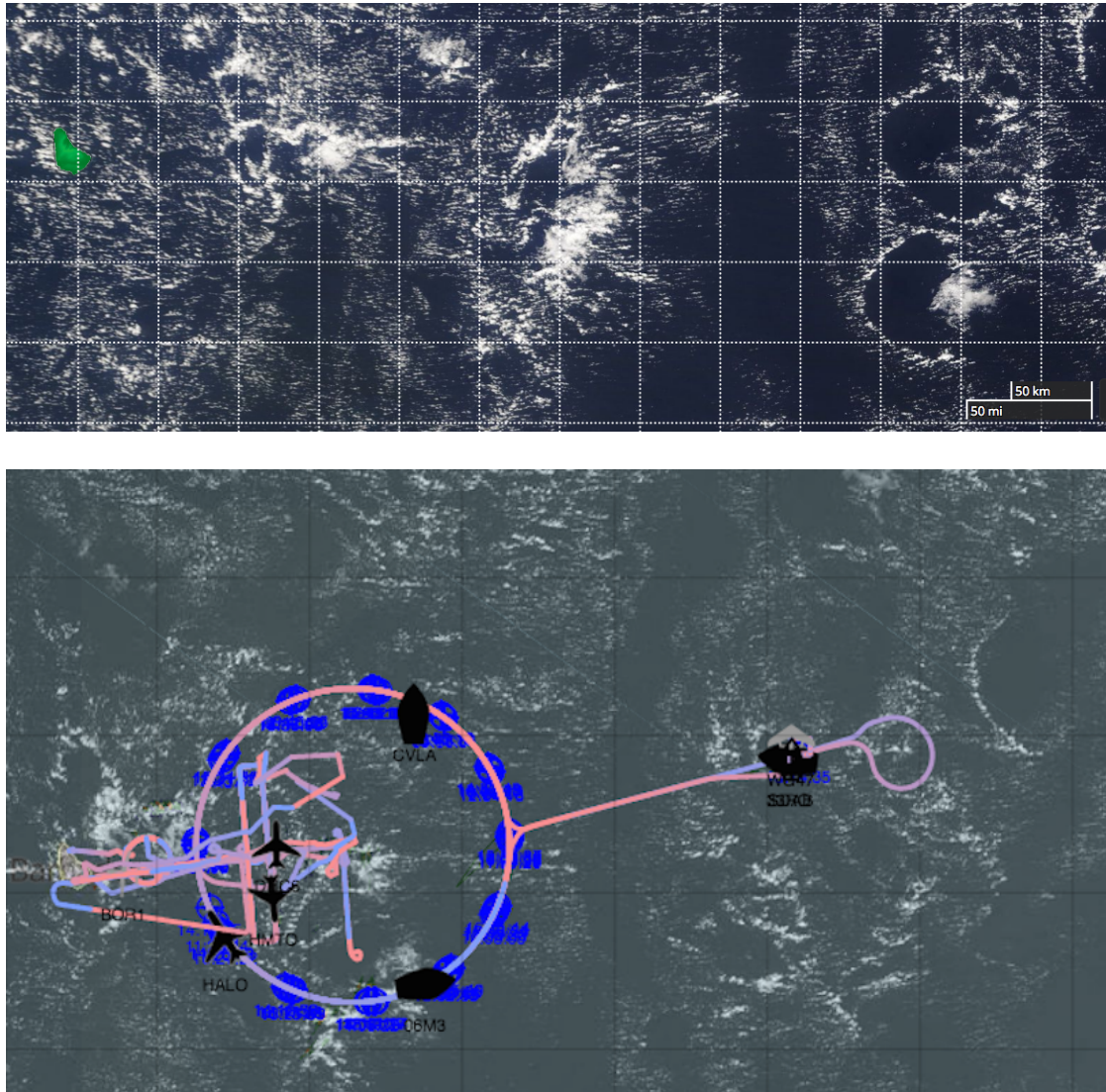


Figure 1: Upper panel shows Terra MODIS RGB, 09.02.2020 ([worldview.earthdata.nasa.gov](http://worldview.earthdata.nasa.gov)), NE corner at (14°N, 53.5°W); SW corner at (11.5°N, 59.5°W). Circle area dominated by sugar/gravel mix with occasional larger stratiform features. The 2 cold pools later moved towards the circle and were crossed in the SE circle during circle 4. Lower panel shows the HALO flight track as screenshot from the PLANET software 30 minutes before landing, also including the ATR and TO flight tracks.

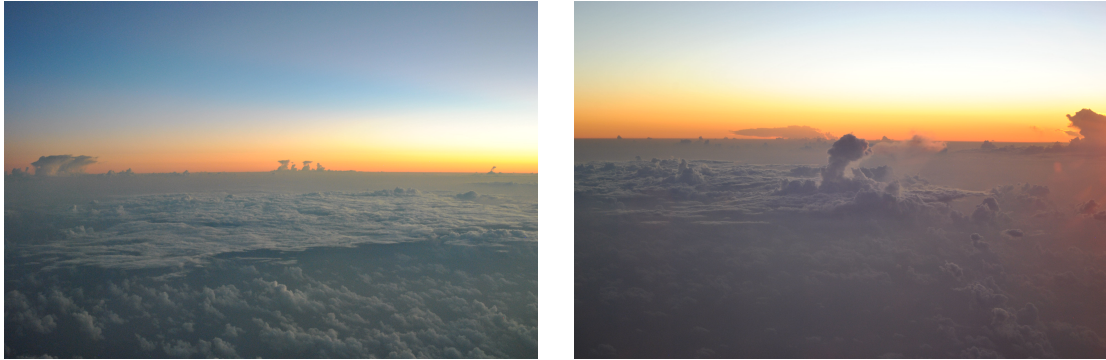


Figure 2: Shallow sugar-like clouds and stratiform layers during sunrise mixed with isolated, actively developing cumulus towers at horizon



Figure 3: strong shear on cloud tops with drizzling virga underneath as seen in beginning of 2nd circle (10:55 UTC); radar cloud tops reaching up to 3 km



(a) cold pool observed at SE of circle (13:21 UTC), later crossed at start of 4th circle (around 14 UTC).



(b) clouds with precipitation features visible in POLDIRAD located NW of CC, sampled by TO at 12:39 UTC.



(c) precipitating features towards CC (15:35 UTC) seen at horizon; area characterized by fresh developing, bubbling Cu



(d) view towards CC with 2 precipitating cloud features sampled by TO (17 UTC); area characterized by sugar/gravel-like conditions with occasional occurrence of stratiform layers.

Figure 4: Cold pool and precipitating cloud features during 2nd circle set

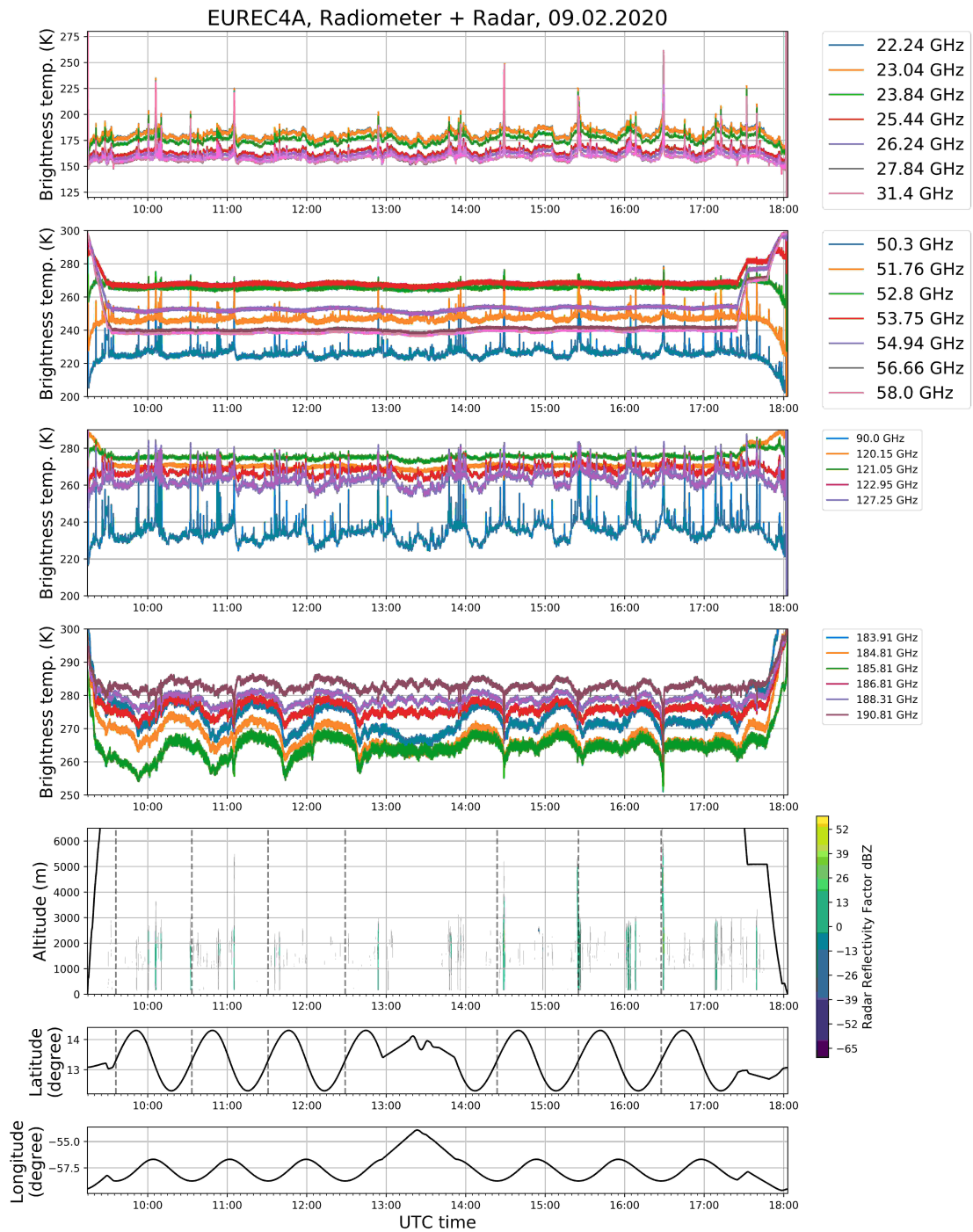


Figure 5: HAMP radiometer and radar quicklook (M. Klingebiel). The TB signal in the 183 GHz channels at 16:29 UTC suggests the occurrence of ice.



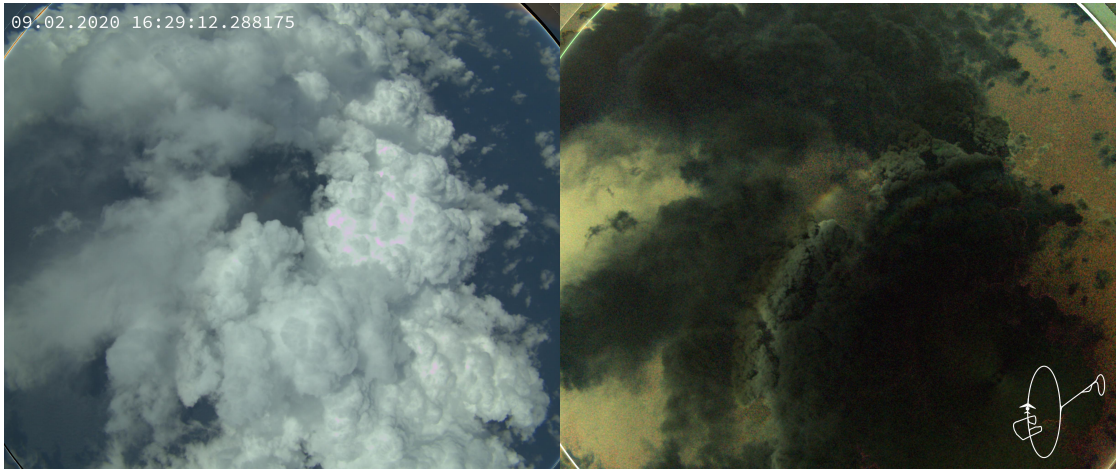


Figure 6: SPECIMACS image (left panel: visible, right panel: polarized) at 16:29 UTC showing signs of a rainbow (courtesy: V. Pörtge)

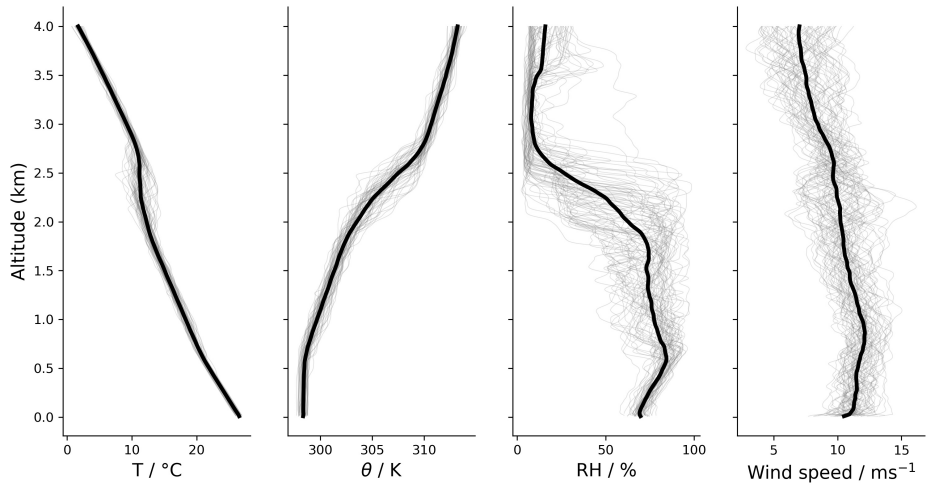
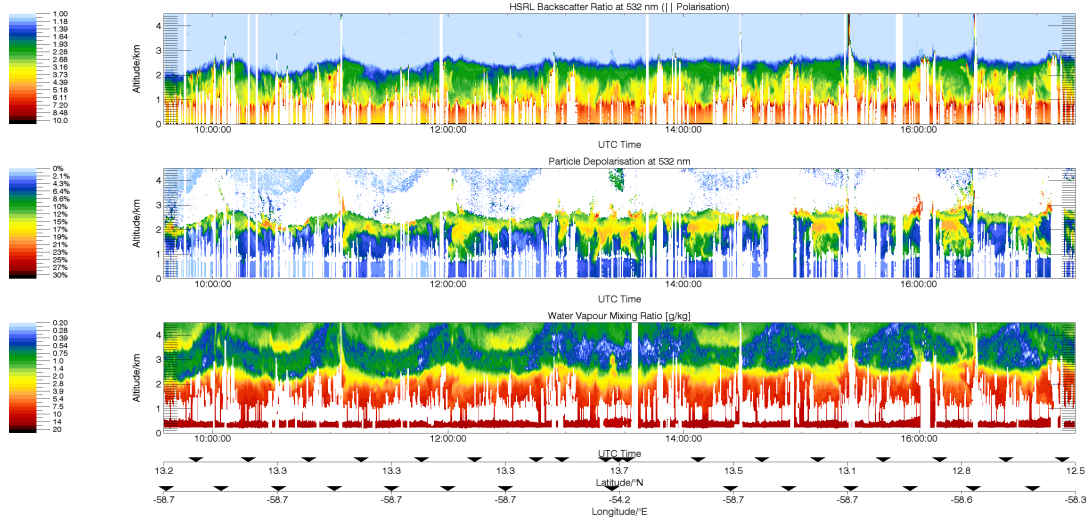


Figure 7: Dropsonde profiles show trade wind inversion located around 2.5 km, strong winds near surface, and distinct moisture decrease around the inversion (courtesy: G. George)

10th Local HALO Flight



Preliminary quick-look data. Processed on 10-02-2020 Contact: DLR Institute of Atmospheric Physics Martin.Wirth@dlr.de

Figure 8: WALES quicklook (M. Wirth); lidar shows stable water vapor conditions throughout the circles with enhanced moisture layers around 3.5 km drying over the course of the flight.

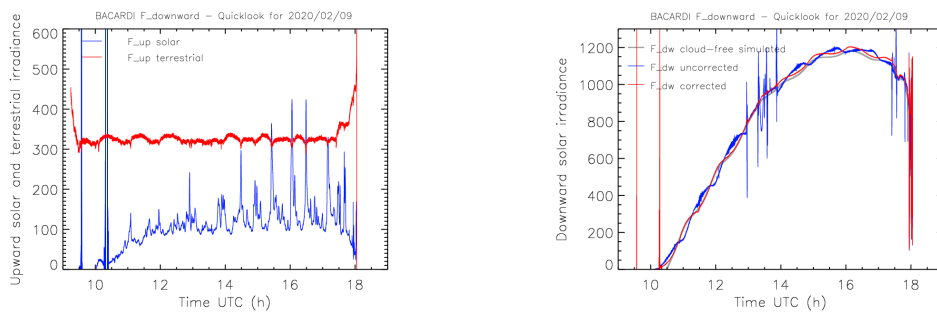


Figure 9: Upward and downward broadband fluxes as measured by BACARDI (courtesy: K. Wolf)

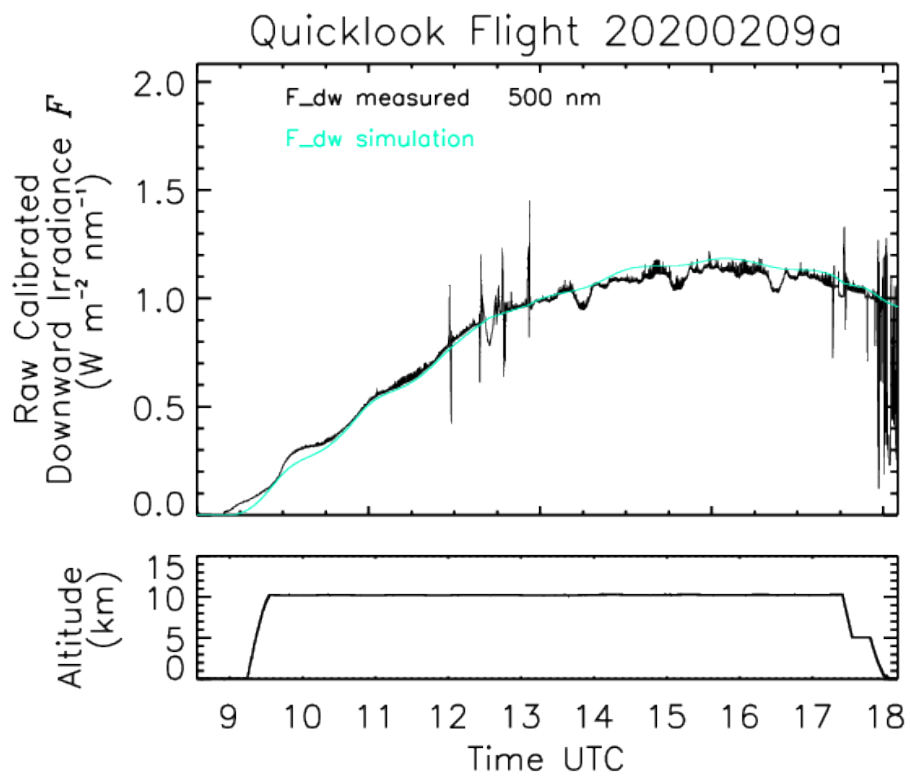


Figure 10: Raw downward irradiance as measured by SMART (courtesy: K. Wolf)