HALO-0211 (11 February 2020)
A Fling to GPM

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1 Objective

The flight FL30 on February 11, 2020 aimed at flying the basic pattern of circles at FL320 to characterize the large-scale environment with 60 sondes and the clouds with remote sensing during daytime with takeoff at 8:30 LT (12:30 UTC). The flight track included 6 circles. 12 dropsondes per circle were deployed in 5 of the circles. Sondes were released every 30° clockwise, starting at the eastern most point of the circle (CE). ATR42 and Twin-Otter sampled the cloud field within the circle with takeoffs at 11:30 and 12:30 UTC, respectively. The excursion was scheduled to the end of the flight in order to underfly the GPM core satellite near the NTAS. This excursion particularly targeted clouds and precipitation. To increase the chances for good data acquisitions, three options for the excursion were prepared (see Fig. 1). An excursion towards TP1 near the NTAS buoy is the preferred track. GPM hosts scanning instruments, therefore crossing the satellite swath allows for more co-locations of airborne and satellite instruments, while staying on a circular flight track. The direct overpass was intended for the return from NTAS and a sonde was released during the overpass time of the satellite. A low level lidar lag through the circle was scheduled for the return to BGI at FL160.

2 Crew

Marek Jacob (Mission PI), Silke Groß (WALES), Jule Radke (HAMP), Kevin Wolf (SpecMACS & SMART & Velox), Antone Wiltshire (Dropsondes), Heike Konow (Dropsondes), Ludovic Touzé-Peiffer (Dropsondes, Meteorological Observer), Stefan Grillenbeck & Roland Welser (Pilots), Sebastian Gerstner (Engineer), Marcus Klingebiel (Ground)

3 Synoptic Situation

The Atlantic high pressure maintained a steep pressure gradient and strong surface winds across the EUREC4A domain. A convective system with strong precipitation signals and stratocumulus on top was the prominent feature of the western circle area (7 to 9 o'clock positions, see Figs. 2

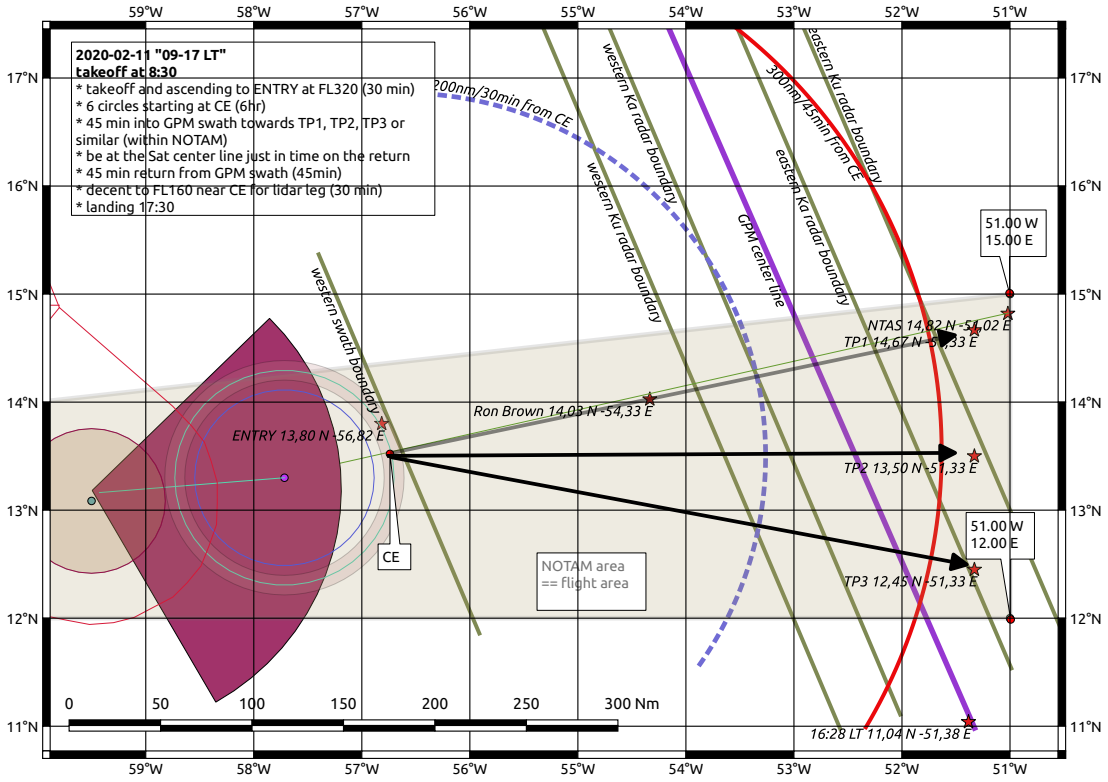

Figure 1: Flight plan schematic.

and 3 c, d) in the morning. Other parts of the circles were covered with small sugar cumuli like depicted in Figs. 3 a and b. The interior of the circle was also characterized by small cumuli in the east and active convection in the west. The latter was also surveyed by the ATR42 and TwinOtter in a coordinated manner.

Meteor did a stationary cloud survey near the 1 o'clock position at L1 such that HALO covered it 6 times. Strong signals in two microwave radiometer channels were seen during the first and sixth overpass of Meteor. Maria S. Merian was close to Meteor, but a few miles closer to circle center. Ron Brown was also near the other vessels at about 30 km out of the circle in 1 o'clock direction according to the reporting in Planet.

The convection in the east reached up to 4.5 km according to WALES in the morning and deepened to 5.0 km during the course of the circles (Fig. 4). The deepening of the clouds is also visible in the HAMP radar. The intensity of radar echos in Poldirad and HAMP radar (Fig. 5) decreased and the whole system moved further to the north west (Fig. 6) such that HALO sampled more of the stratiform outflow. Generally, the total precipitable water in the circle area was high with values up to 45 mm (Fig. 7) and lower near the NTAS with 32 mm.

The excursion inside the GPM swath towards the NTAS buoy was characterized by larger flower-like cloud clusters growing on a sugar cloud field. HALO passed over several precipitating systems with interesting radar signals lasting for over 5 minutes. As HALO was a bit early

for the satellite, a radar calibration was included in the turn at the eastern end of the excursion. The calibration maneuvers included $\pm 20^\circ$ roll wiggles and a 270° turn at 10° bank angle. Less clouds were present in the area of the calibration. However a few clouds, that were also captured by specMACS (Fig. 8), were thick enough to show up in the radar during the maneuver regardless of the additional attenuation, that is required for the calibration. A sonde was launched near NTAS after the calibration maneuver.

The return from the NTAS was in time with a GPM overpass at 20:27 UTC. HALO sampled the same precipitation systems on the inbound leg as well as on the outbound leg. Precipitating and non-precipitating clouds were sampled as desired. The cloud liquid water was also retrieved from the satellite, but the number of rainy pixels looks small in the GPM satellite product in Fig.9 for the line between CE and NTAS. However, more detailed work on the comparison between airborne and space-borne data is needed.

A descent to FL160 was initiated at CE such that a low lidar leg could be flown from CC at 21:07 until the final descent was started 21:21 UTC. Finally the crew happily landed at 21:37 UTC.

4 Flight Elements

Table 1: Overview of main elements of flight

Element	location	Flight Level (FL)	Time (UTC)
Takeoff & Ferry	GAIA	Ascent to 320	12:29
6 Circles	start near CE	320	12:57
Excursion - NTAS-leg outbound	from CE	320	18:56
Radar Calibration turn and wiggles	west of NTAS	320	19:45
Excursion - NTAS-leg Inbound	towards CE	320	20:04
Descent at CE	CE to CC	Descent to 160	20:59
Lidar leg	from CC	160	21:07
Landing	GAIA	n/a	21:37

6 Circles 6 circles were flown clockwise. 5 circles with 12 sondes each were evenly distributed starting at 3, 6, 9, 12 and 3 o'clock.

Excursion After the 5th circle, it was decided to fly the excursion according to the standard plan towards the NTAS buoy as the clouds looked very promising in the GOES images and UK Met Office Model.

Radar Calibration East of NTAS a turn with bank rolling before the turn, constant bank of 10° during the turn and $\pm 20^\circ$ bank rolling after the turn was flown for radar calibration. A sonde was released as soon as HALO returned into the NOTAM area.

NTAS-leg Inbound The inbound leg was flown in close coordination with the satellite overpass to be directly in the central field of view just in time. True air speed was increased to compensate for strong westerlies of about $40\,\mathrm{kn}$.

5 Instrument Status

BACARDI No issues reported.

BAHAMAS No issues reported.

HAMP Radar Functioned well for entire flight. IFAtten1/2 were set to 30 during calibration.

HAMP Radiometer Usual short outages of 183 module. KV outages during takeoff and after the overpass of meteor in the sixth circle. Looks promising otherwise.

KT-19 No problems reported.

SMART No problems reported.

Sondes 60 and 2 dropsondes were launched during 5 circles and the excursion, respectively. 1 failed with no launch detected, four sondes had incomplete measurements with either wind or humidity or both missing.

specMACS No problems reported.

Velox No problems reported.

WALES

6 Figures

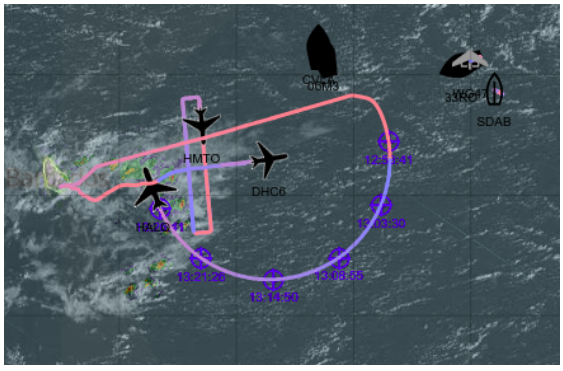

Figure 2: GOES and Poldirad acquisitions during takeoff and the beginning of the circles at 13:28 UTC.

Figure 3: Visual impressions of the flight. Left top to right bottom: a, b cloud streets of shallow cumuli. c 13:20 UTC convective system near 9 o'clock. d 17:34 UTC chaotic cloud layers of a decaying convective system. e thin but dark outflow layer that was inside the circle in the morning and later left the circle at 9 to 11 o'clock. f clouds within radar calibration area.

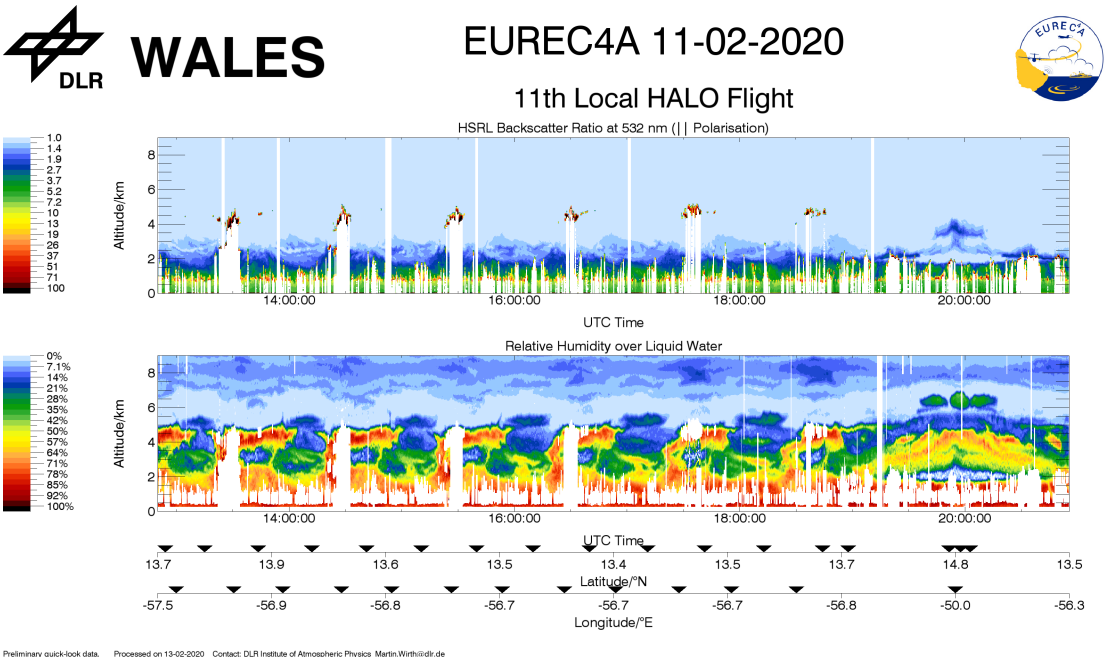

Figure 4: Backscatter and relative Humidity measured by WALES.

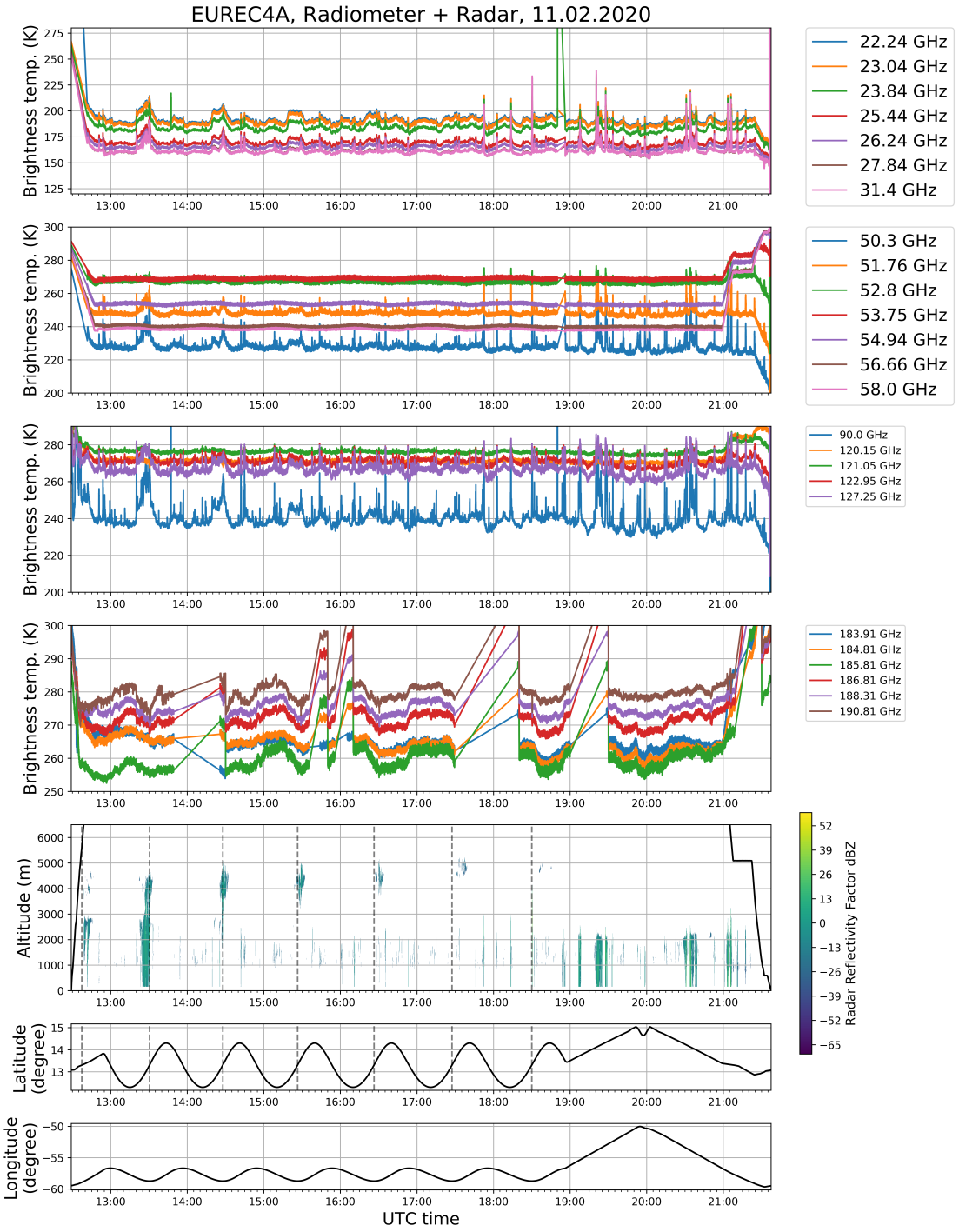

Figure 5: HAMP overview quicklook of microwave brightness temperatures and radar echos.

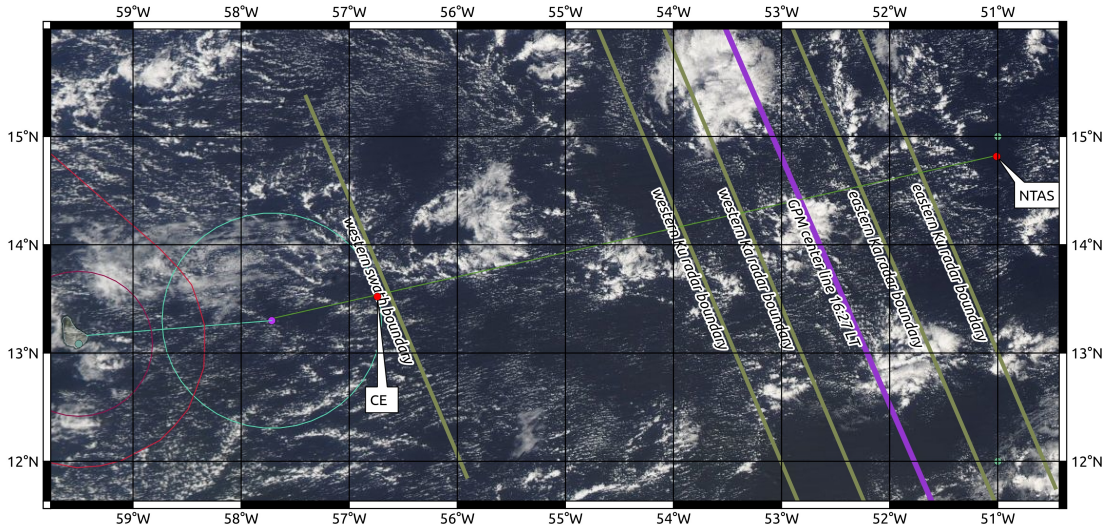

Figure 6: MODIS Aqua Corrected Reflectance at 17:30 UTC (13:30 LT). Source: `https://earthdata.nasa.gov/faq#ed-CRvsSR`

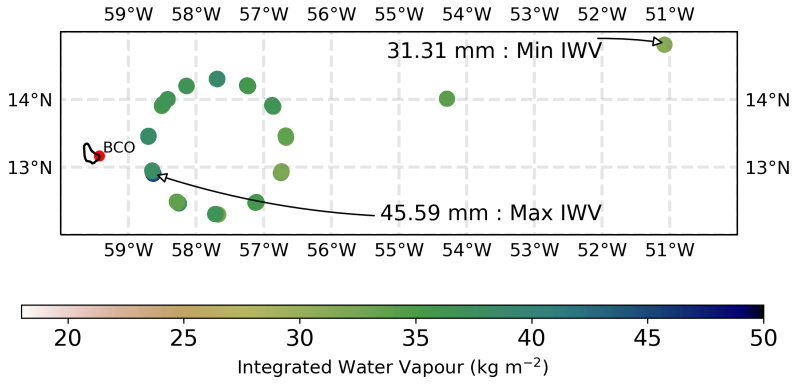

Figure 7: Overview of Dropsonde locations and total precipitable water.

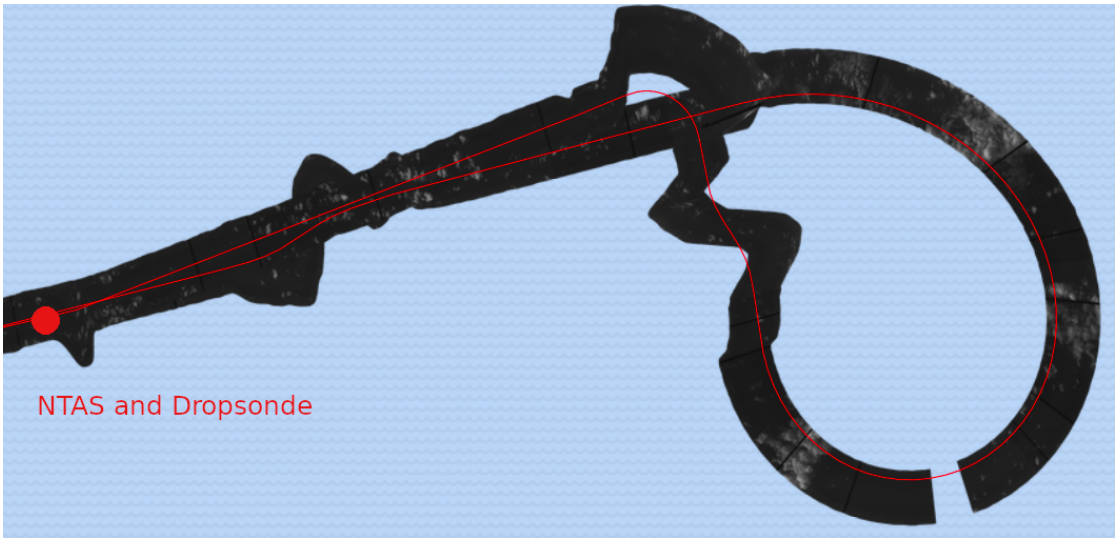

Figure 8: Cloud situation in the radar calibration area as displayed by the specMACS vnir quick-look map.

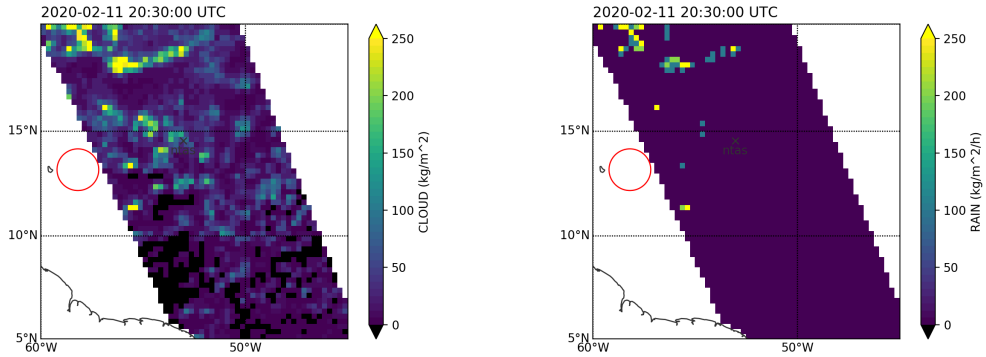

Figure 9: Cloud water path (left) and rain water path (right) as retrieved by REMSS (`http://www.remss.com/`) using the GPM microwave imager (GMI).

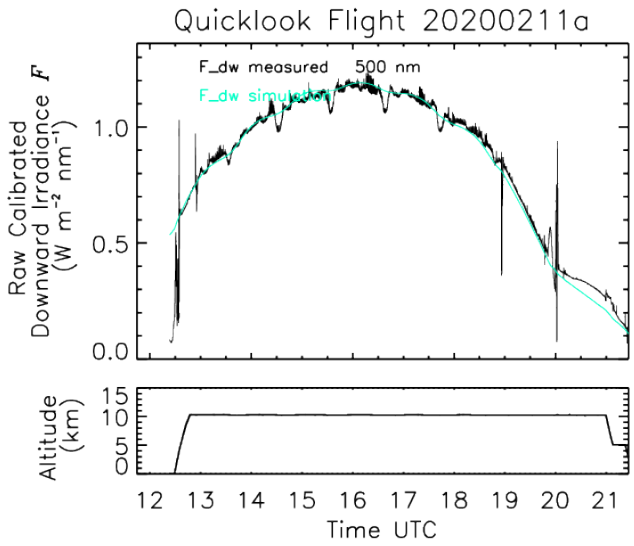

Figure 10: Overview of SMART measured and simulated downward irradiance.

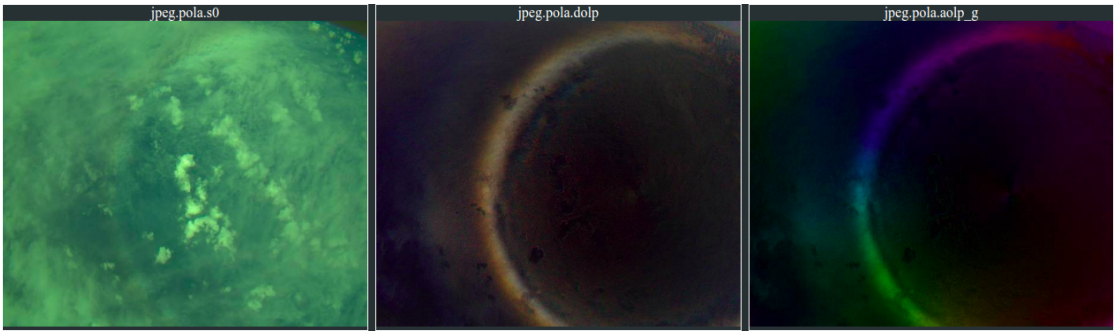

Figure 11: specMACS live image of the outflow status at the 9 o'clock position at 15:30 UTC. Ltr: True color image, uncorrected degree of linear polarization, uncorrected angle of polarization.