HALO-0124 (24 January 2020)

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1 Objective

Second local research flight by HALO. Goal was to fly basic pattern of circles at FL320, with an early morning 05:00LT take-off. The two $210\,\mathrm{min}$ circle segments were to be flow consecutively and would characterize large scale environment with 72 dropsondes and clouds via remote sensing. At the end of the flight a spur toward the NTAS from CE was planned also at FL320, with three sondes. Then we were to return along the same line to CC before turning to align for landing. On the return leg was a planned descent to FL160 at CE for low level radar and lidar operations. The aim of the 'Spur' was to help anticipatie the upstream flow and improve the spatial coverage of the sounding network. Coordination with the ATR-42, Twin Otter and WP-3 was planned, but not with ships, although both the R/V Ron Brown and R/V Meteor were operating in the HALO circle. This was scheduled as a morning flight, which would take off at 05:00 LT, $5\,\mathrm{min}$ after the ATR-42 and fly a super-curtain intercomparison. Coordination with the WP-3 involved the WP-3 flying in the HALO circle after 10:00 LT, and coordination with both platforms dictated a pause in HALO dropsondes as they entered the circle.

Because the ATR-42 instrument integration could not be completed in time, it did not participate in the flight and the super curtain was not flown. Takeoff time was delayed by $30\,\mathrm{min}$ as the fuel truck arrived late. The Spur toward NTAS suffered from poor circle timing as the $420\,\mathrm{min}$ pattern concluded near 30° on the circle compass (i.e., 1 o'clock if the circle denotes a clock with noon being north), so we continued along the circle to the branch point, which slightly fore-shortened the spur. Due to fuel loading the initial 1-2 circles were closer to $55\,\mathrm{min}$ in duration, thereafter the aircraft slowed down to fly $60\,\mathrm{min}$ circles, only speeding up again to cover more distance for the 'spur' and advance the return time on what in the end was anyway a long 9hr 20min flight.

2 Crew

Bjorn Stevens (Mission PI), Linda Foster (specMACS), Manuel Gutleben (WALES), Marcus Klingebiel (Dropsonde), Michael Schäfer (VELOX & SMART), Hauke Schulz (HAMP Radar and Radiometer), Jessica Vial (flight scientist). & Roland Wesler and Marc Puskeiler (Pilots), Alexander Wolf (Engineer)

3 Synoptic Situation

The flight followed two days of unusually wet and rainy weather conditions, and the remnants of what we thought of as a fish were developing into seemingly deeper (tops near zero-degree isotherm) convection to the south-west. A deep ($4\,\mathrm{km}$ moist layer also remained. After take-off, which was delayed to 05:30LT due to the absence of the fuel truck, the coming dawn featured convection overshooting a shallow cloud layer with extensive stratiform cloudiness to the East. Scattered, sheep or sugar like convection was visible to the north, but the day quickly revealed itself to be one of large cold-pools stemming from a region of deeper convection to the South-east of the domain (see snapshots in Fig. 2). The horizon seemed hazy as sun rose. The area of convection gradually moved further into the domain and cold-pools were particularly evident across the north circumference of the circle, with the sources being deeper precipitating convection toward the center, East and South East of the domain. Layers of thin, almost paper, like stratiform layers were associated with convective remnants and often long-lived.

The Meteor was stationed at about $20\,\mathrm{km}$ inside the circle at about 1 o'clock. With the tracking of the Ron Brown toward the BCO and the interior counter-clockwise circle of the Ron Brown gave this the reputation as the Smiley flight (Fig. 3). Along the circles it was possible to track the evolution of the cold pools boundaries, and central stratiform regions each hour as we returned to a specific point. The cold-pools appeared to cross the Meteor's position so that on one circle it appeared at the center of the cold pool, and later the paper clouds (stratiform layers at $4\,\mathrm{km}$) appeared to advect over it from the Southeast. As circle-east (CE) where we left the circles for the spur toward the NTAS, there was a cluster of more vigorous convection which the WP-3 flew lines through, above and under, frequently turning to avoid the more vigorous elements. But on most of the spur the area was remarkable for its absence of clouds. Two sondes were launched along the spur, but only the one near the end was successful. This indicated the emergence of a much shallower moist layer, and an overall much drier atmosphere.

The radar and radiometers worked well on this flight, nicely illustrating the depth and structure of the convective layers (Fig. 4), and some thin stratiform layers were detectable, indicative of large-droplets. The flight is very attractive as one for studying the structure of the stratiform layers (particularly if their microphysics was measured in situ by the Twin Otter) as well as the cold pools. Also on one leg there appeared to be clear evidence of the spreading cold pool through the presence of an arc-like feature in the sea-surface texture, as seen by the aircraft.

Returning on the same track we passed over the region of deeper convection that the WP-3 had been sampling and began descending to FL160 at CE for the short lidar leg that took us back to Barbados. We overflew the Ron Brown. With sightings of the counter-clockwise flying WP-3 during the circles this meant that all the platforms in the 'smiley' image were also visually identified from HALO. On approach Barbados on the low-level (FL160) return leg multi-level convection with a stratiform shelf cloud, and outflow layers at multiple levels was evident to the south (Fig. 2).

Table 1: Overview of main elements of flight, ML denotes 'Meteor Line' at $57.245°$.

Element	Loc.	Alt.	Time (UTC)	Notes
Takeoff	GAIA	↑ 320	9:29	
CW/S1	CW	320	9:48	Sonde failed on channel 3
S2	n/e	”	11:05	
S3	n/e	”	12:15	
S4	n/e	”	13:30	
Note	n/e		13:51	Veil cloud approaching Meteor
Note	n/e	”	14:20	Passed over developing (3 km convection
S5	n/e	”	14:40	
Note	n/e	”	15:47	Arc (cold-pool) feature in surface wave field
S6	n/e	”	15:50	
Spur	CE	”	16:56	Left circle for Buoy
Note	n/e	”	17:24	Sonde
Spur	NTAS	”	17:27	Return
Lidar	CE	↓150	18:06	
Note	CE	”	18:05	Growing cumulus
Note	L1-L2	”	18:11	Sargassum
Note	CW	”	18:22	Theatre of multi-level convection
Note	n/e		18:26	Descent into veil
Landing	GAIA	n/a	18:41	

4 Flight Elements

Circles (first half) We had some troubles with the first circles as two sondes failed, and so we launched a replacement. The faster flying times, and the launch failures also meant a poor sampling of northern line of circles. This improved on second and third sets as we could fly at a lower speed.

Circles (second half) We had some troubles with the first circles as two sondes failed, and so we launched a replacement. The faster flying times, and the launch failures also meant a poor sampling of northern line of circles. This improved on second and third sets.

Spur We stopped sounding near the top of the circle and continued on FL320 along the circle to the Circle East where we turned onto the spur. We increased flight speeds to minimize additional flight time. The final sonde was launched before the turn around to minimize distance to the sonde and maximize reception of its signal. The descent began over the lines of deeper convection also being sampled by the WP-3 at the same time, with a near coincident over flight.

5 Instrument Status

BACARDI: No issues reported.

BAHAMAS: No issues reported.

HAMP Radar: Functioned well for entire flight.

HAMP Radiometer: functioned well for entire flight.

Sondes: 73 sondes launched, four failures, two on first circle, with one replacement, one on penultimate circle, and first drop on 'spur'. All lost signal before reaching $350\,\mathrm{hPa}$.

SMART: No problems reported.

specMACS: No problems reported.

VELOX: No problems reported.

WALES: No problems reported.

6 Figures

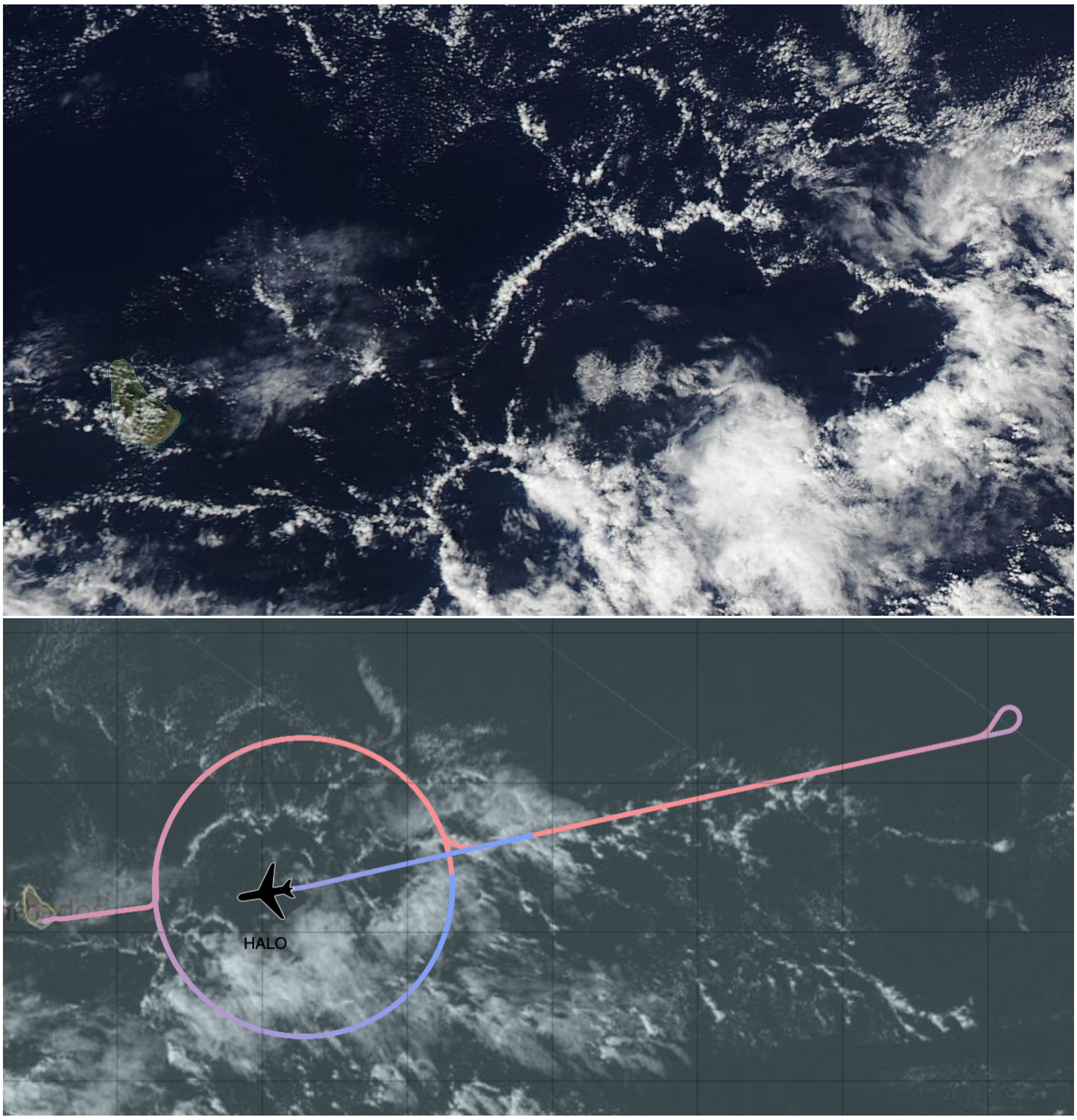

Figure 1: Upper image is from Modis Aqua showing the area of flight circles $12.5°$ to $14.5°$ N, and $56.5°$ to $60°$ W. Flight track from PLANET tracking with superimposed GOES visible imagery over a slightly larger domain. The lower image was taken as HALO was returning to Barbados (about 25 min before landing).

Figure 2: Snapshots from flight. From left to right: 10:43:38 UTC, 10:46:24 UTC (top row), 11:58:51 UTC , 12:59:02 UTC (middle row); 17:32:36 UTC, 18:18:09 UTC. UTC (roughly LT + 4hr)

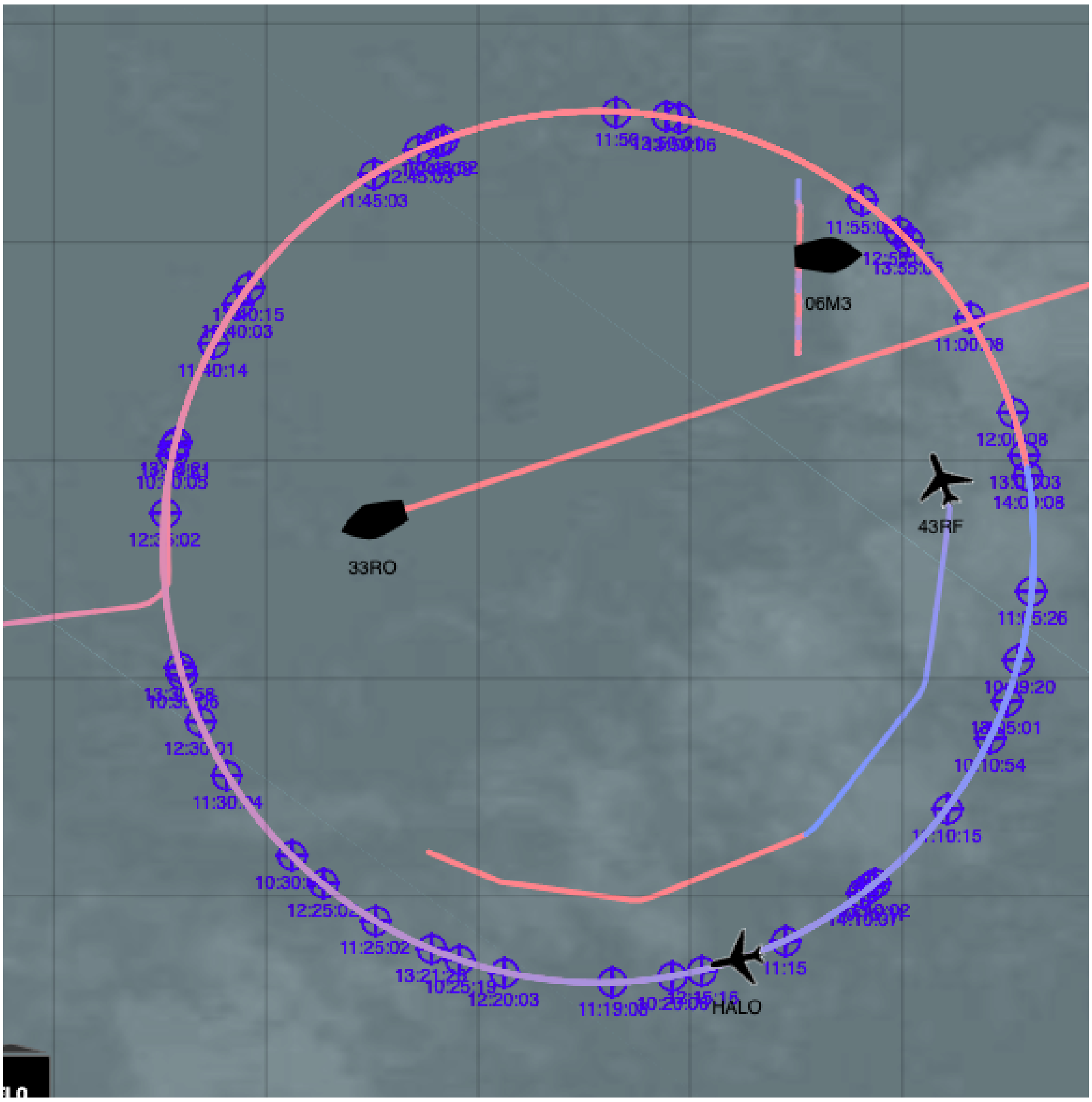

Figure 3: Tracks from PLANET just after the 14:10 dropsonde showing position of WP-3, the Meteor and the Ron-Brown relative to the HALO circles, fortuitously outlining a smiley (something first noticed by Geet George). Dropsonde launches up to that point are also marked on HALO circle.

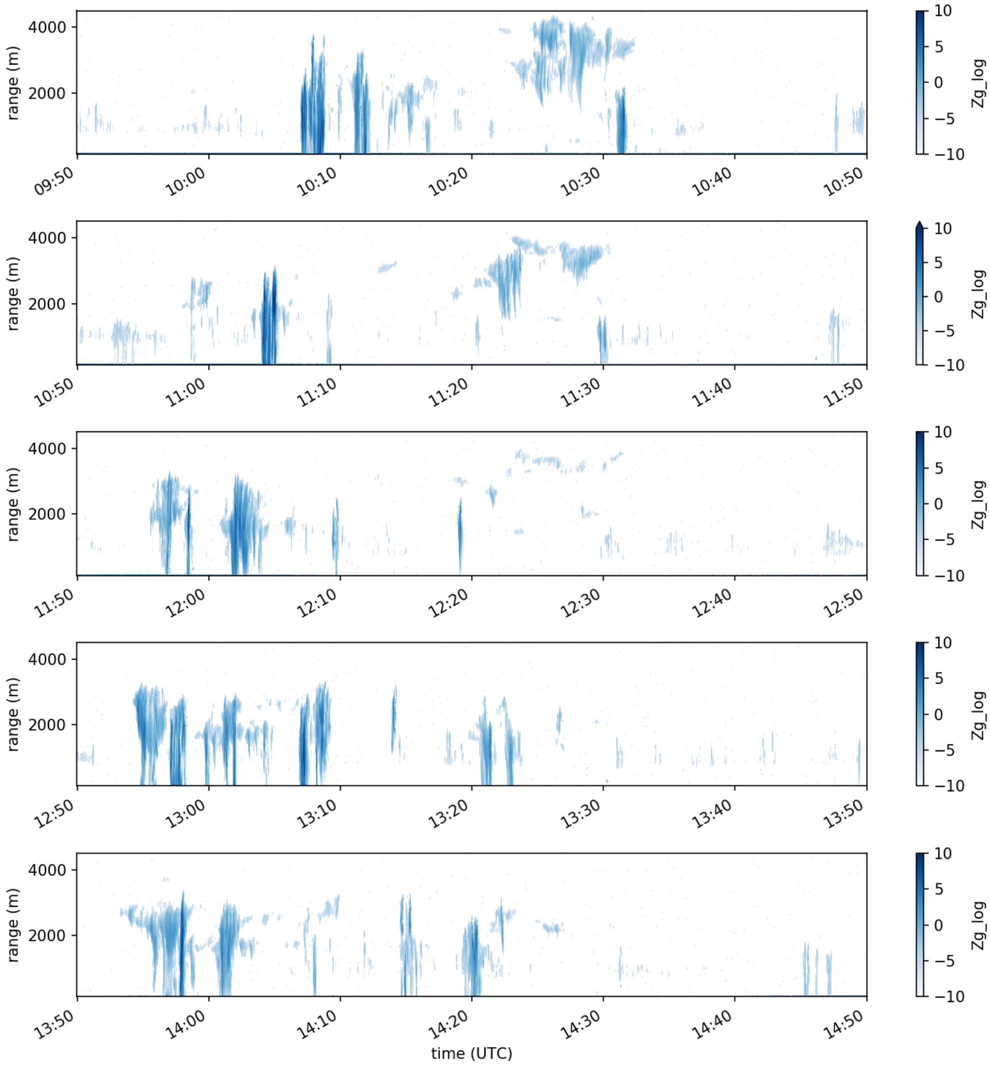

Figure 4: HAMP radar reflectivity from four hours of circles.

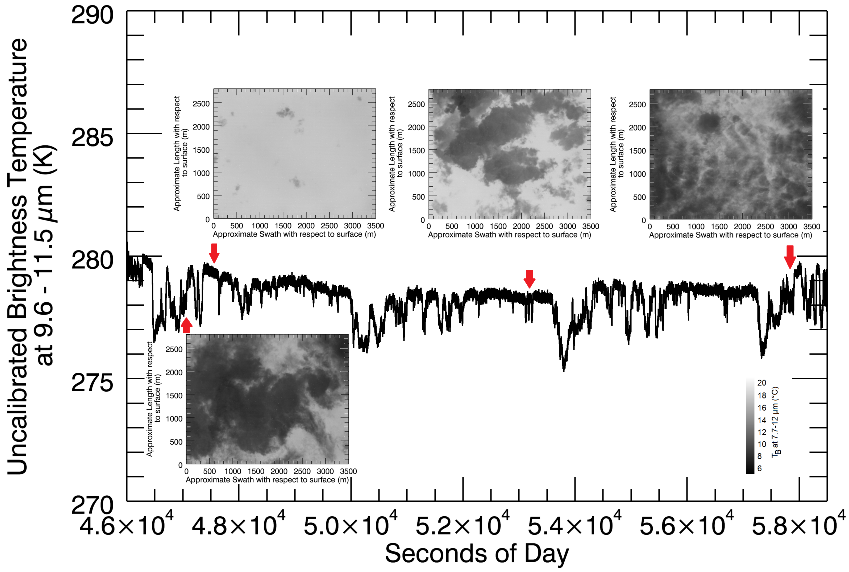

Figure 5: VELOX brightness temperatures (uncalibrated) with inset images (clouds are dark).