Twin Otter Flight Debrief: Flight TO337 TO338 (31st January 2020)

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TO337 and TO338 double flight

Flight 1: 1335 UTC 1705 UTC 3 hr 30 min [0935 Local to 1305 Local]

Flight 2: 1840 UTC 2240 UTC 4 hr 00 min [1440 Local to 1840 Local]

1. Objective
Sample cumulus "flower" clouds and make measurements of clouds and precipitation along with subcloud aerosol properties in the EUREC4A Joint Operations Area (JOA) in the tropical ocean trade wind region to the east of Barbados, coordinated with the DLR HALO G-V and Saphire ATR42 research sorties. Passes through clouds at all levels. The objective of both flights is the same.

2. Crew:

Pilot: Andy Van Kints
Mission Scientist: Paul Barrett
Instrument operations: Tom Lachlan-Cope
Mission Observer: Leif Denby

3. Synoptic Situation: Please HALO report on this day.

4. Flight Summary
The two flights sampled both cloud and aerosol and thermodynamic properties in the Joint Operating Area circle.

A boundary layer aerosol leg was flown below 300 m, including flybys of Ragged Point observatory at 15 m and 30 m, whilst also taking a filter sample for comparison with the Manchester University aerosol sampling site and BCO

Conditions Overview

Stratus was present in the Joint Operating Area prior to take-off and persisted throughout the day as winds at that level were weak. Solar heating seemed to thin the clouds and convective elements seemed to replenish the layer.
The aircraft sampled the properties of the overnight residual stratus, along with cumulus penetrations at multiple altitudes. The newly formed stratus clouds were also sampled. Above stratus and below stratus radiation legs were flown in the vicinity of the residual overnight stratus clouds on flight TO337

Thermodynamic properties

Lots of structure in thermodynamics with layer boundaries at 550 m, 900m, 1050 m, 1220 m (wind shear), 1920 m and 2200 m. A temperature inversion at 900 m of 2 K, had a drop off in humidity - dry above 1000 m.
Above 2450 m the atmosphere was very dry, and likely to inhibit cumulus penetration from below, with wind shear present at 2375 m. Winds at 1350 m were 100 at 14 m/s, Low level winds 079 at 8 m/s.
Strong updraughts and downdraughts were noted by the crew in and around cumulus clouds, and measurements will be available once quality controlled.

Aerosol Properties
Dust and biomass burning aerosols were noted to be in the region from satellite along with surface observations from Ragged Point. Moist layer at 300 m, with haze layers to this level (visual).

Boundary layer had 400 cm-3 accumulation mode aerosols with large particles, VMD>2 microns, biomodal and more than 550 cm-3 CN concentrations, CNN not working.
At 1500 m CN = 440 cm-3, SMPS monomodal at 200nm, CCN concentrations between clouds were low, close to 40 cm-3. Just below the temperature inversion at 900 m a clean layer was observed with CN concentrations reducing from 500 cm-3 to less than 100 cm-3.

Cloud Properties

Cloud base height, 500 m, Cloud top height: Cumulus >2600 m, stratus to 2200 m

Cloud drop number concentrations: up to 360 cm-3 in cumulus clouds, 50 to 100 cm-3 in stratus clouds. Cumulus had broad drop spectra and precipitation between 1 and 3 mm near cloud tops and 2 to 4 mm slightly lower down. Stratus clouds were often bimodal close 12 and 25 microns, and occasionally with precipitation sized particles.

Cumulus clouds were very active, especially once they were deeper than 2 km. Stratus clouds we often quiescent, especially the newly formed layers, whereas the aged residual stratus clouds showed evidence of cloud scale circulation and appeared to support cellular convection. The vertical distribution of particles was difficult to interpret in flight. The stratus clouds were up to 500 m deep.

Stratus clouds were present above 1800 m, and were observed to have been present in the vicinity for some hours. Wind speeds at this level were very low. Drop concentrations were between 5 and 120 cm-3 with mean volume diameters in the range 15 to 23 microns.
Between clouds the CN concentrations were as low as 30 cm-3 suggesting removal of aerosol through cloud processing.

Cumulus turrets were penetrating the strong thermodynamic boundary at 1900 m, with isolated turrets growing to 400 m containing were large mm sized precipitation particles, and cloud drop number concentrations (CDNC) of 200 cm-3. Strong updraughts were noted.

The cumulus turrets that penetrated to 2300 m were sampled, close to cloud tops (either 50 m or 150 m below). CDNC~100 to 200 cm-3, with a broad spectrum, MVD up to 30 microns, and higher LWC, over 2 g/m3 in the cloud drop size range, and precipitation in the range 2 to 3 mm was measured (300 m below in the cloud turret the precipitation reached 6 mm in diameter).

Close to the turrets the aircraft flew through stratus that looked to have just been formed, which had a sheer appearance, with little evidence of overturning circulations, and bimodal size distributions,

5. Instruments

PCASP has noise in small size channels.
CCN flooded at 1353, returned at 1555, temperamental all day. Not working at start of low level leg on flight TO337
LiCOR Humidity problems,
FFSSP humidity problems,
HVPS required restart on TO338, during sampling of turrets
FILTER #14? is a BLANK
FILTER #9, 330 m, 1408 UTC – 1431 UTC
FILTER #10, 330 m, 1639 UTC – 1653 UTC

CAMERA – PBarrett mobile phone – is correct to 1s, on UTC (GMT)

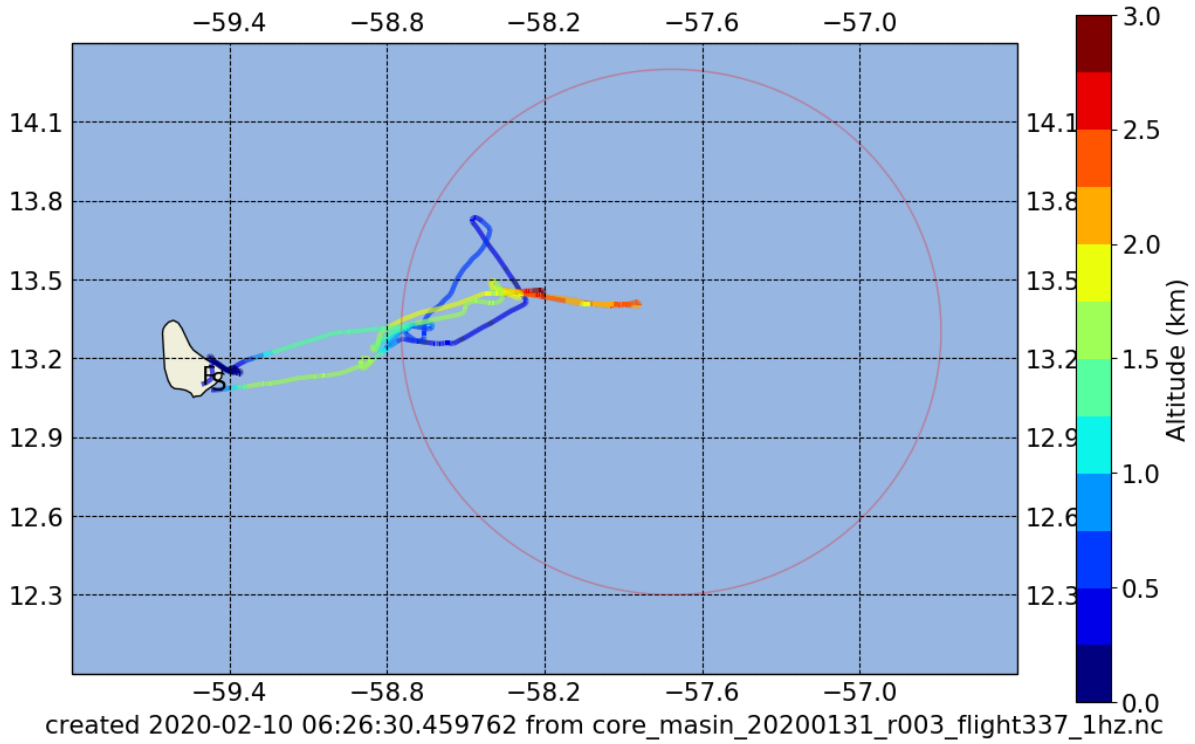

Figure 1: Flight track from 1st flight, TO337

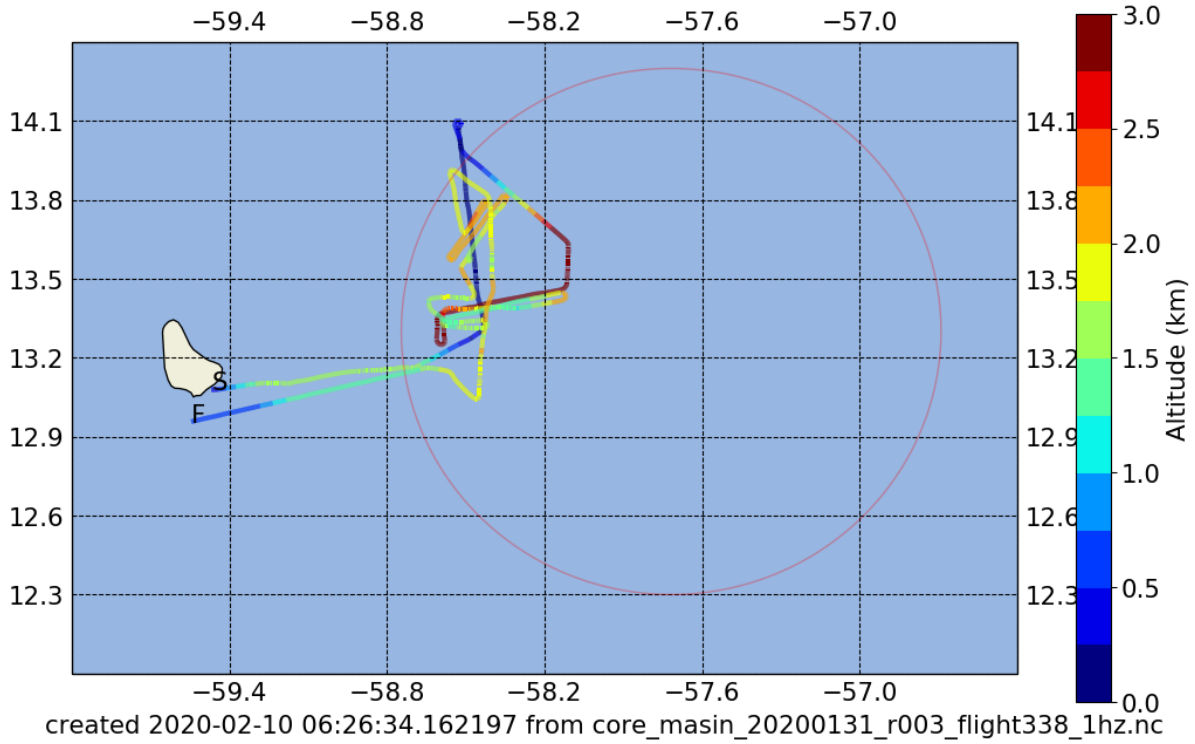

Figure 2: Flight track from flight 2, TO338

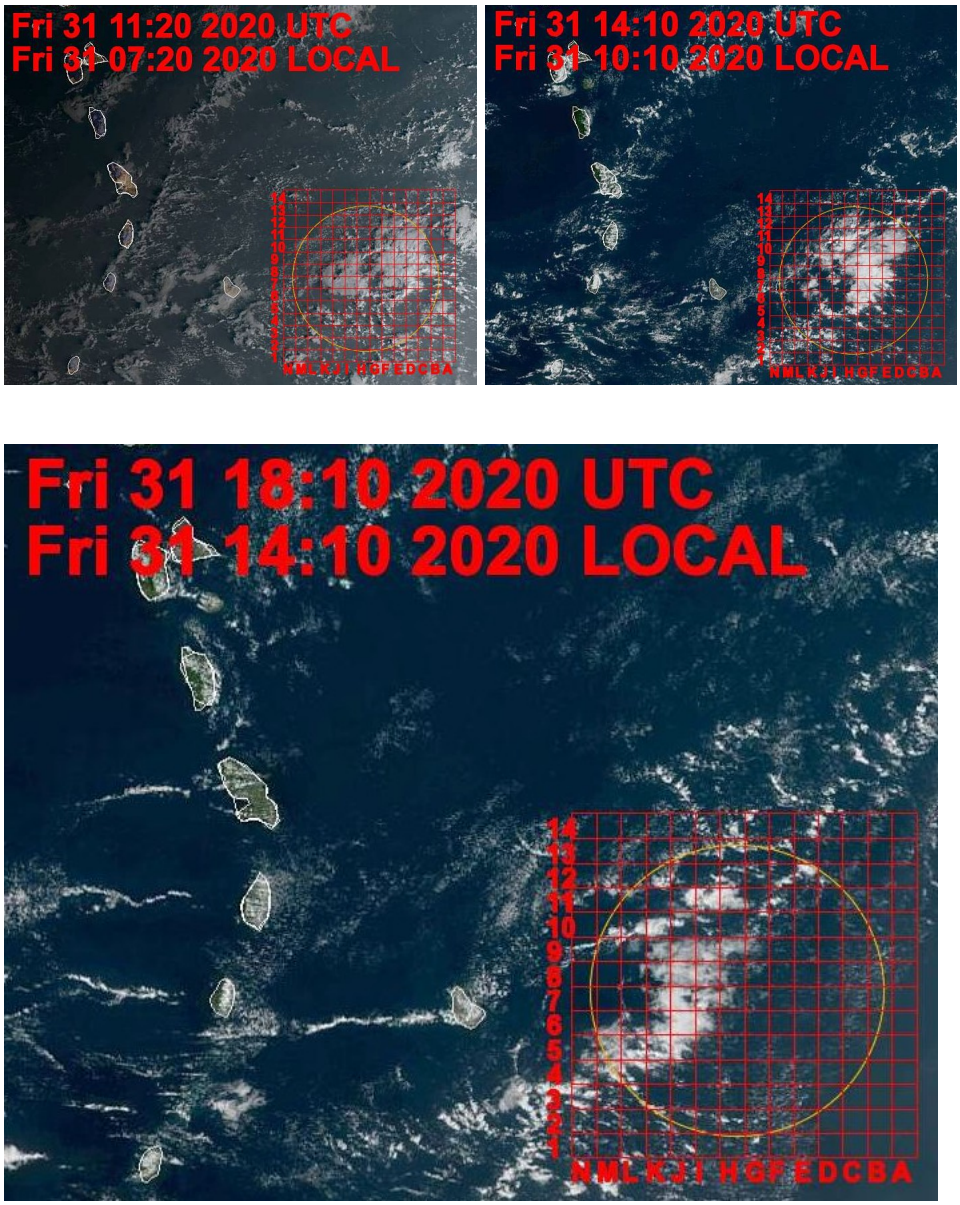

Figure 3 GOES 16 Visible satellite and Joint Operating Area circle for Top left: 0720 Local, Top Right: 1010 Local and Bottom: 1410 Local

Figure 4 Top Left: cumulus penetrating stratus at 2.2 km. Top right: Cumulus cloud growing through residual stratus layer. Bottom Left: cumulus growing to 2.6 km through stratus at 2.2 km with developing cellular circulations. Bottom Right: cumulus clouds with collapsing turrets, generating new stratus clouds with quiescent conditions at 2.2km

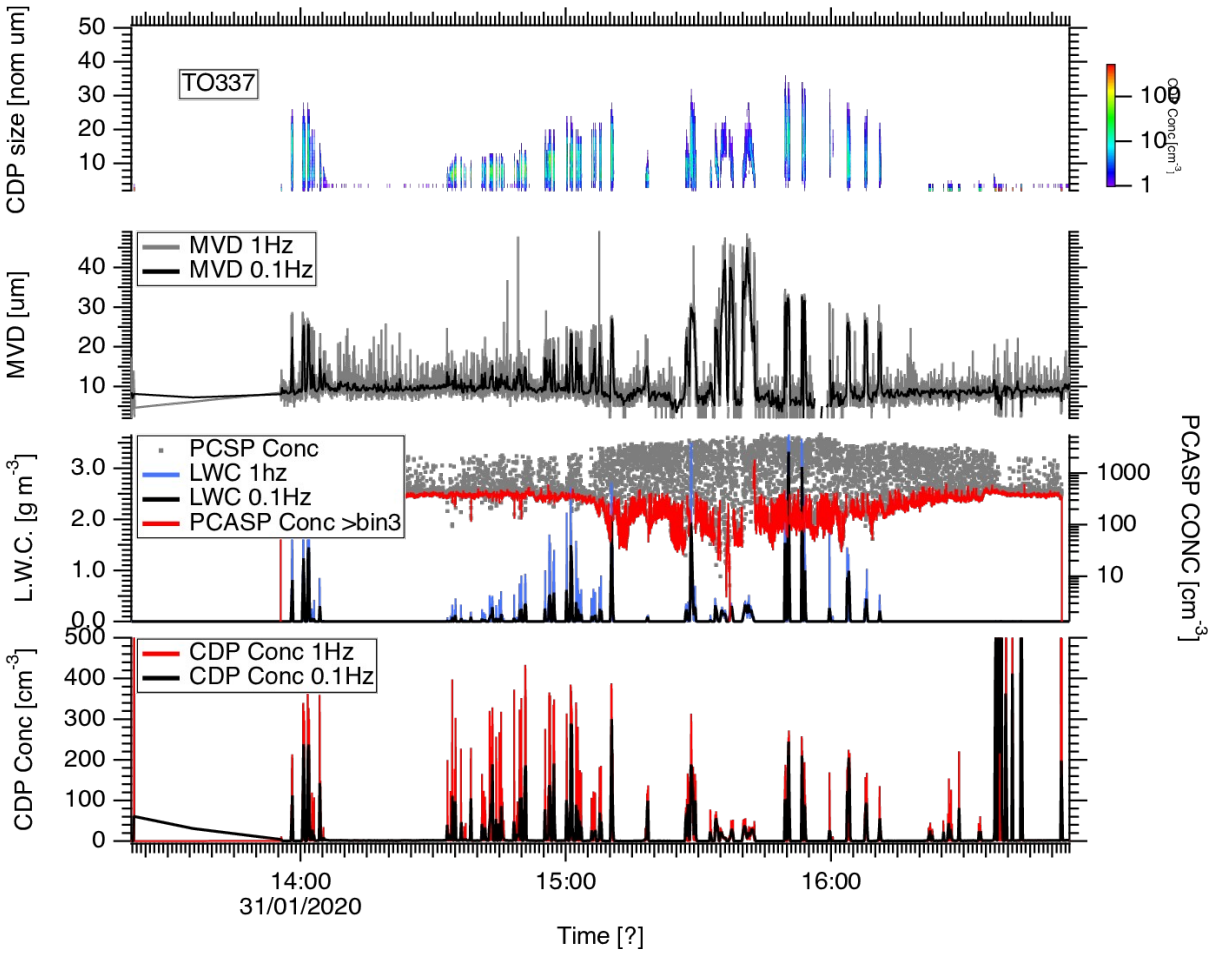

Figure 5 Cloud and aerosol data from Flight 1, TO337

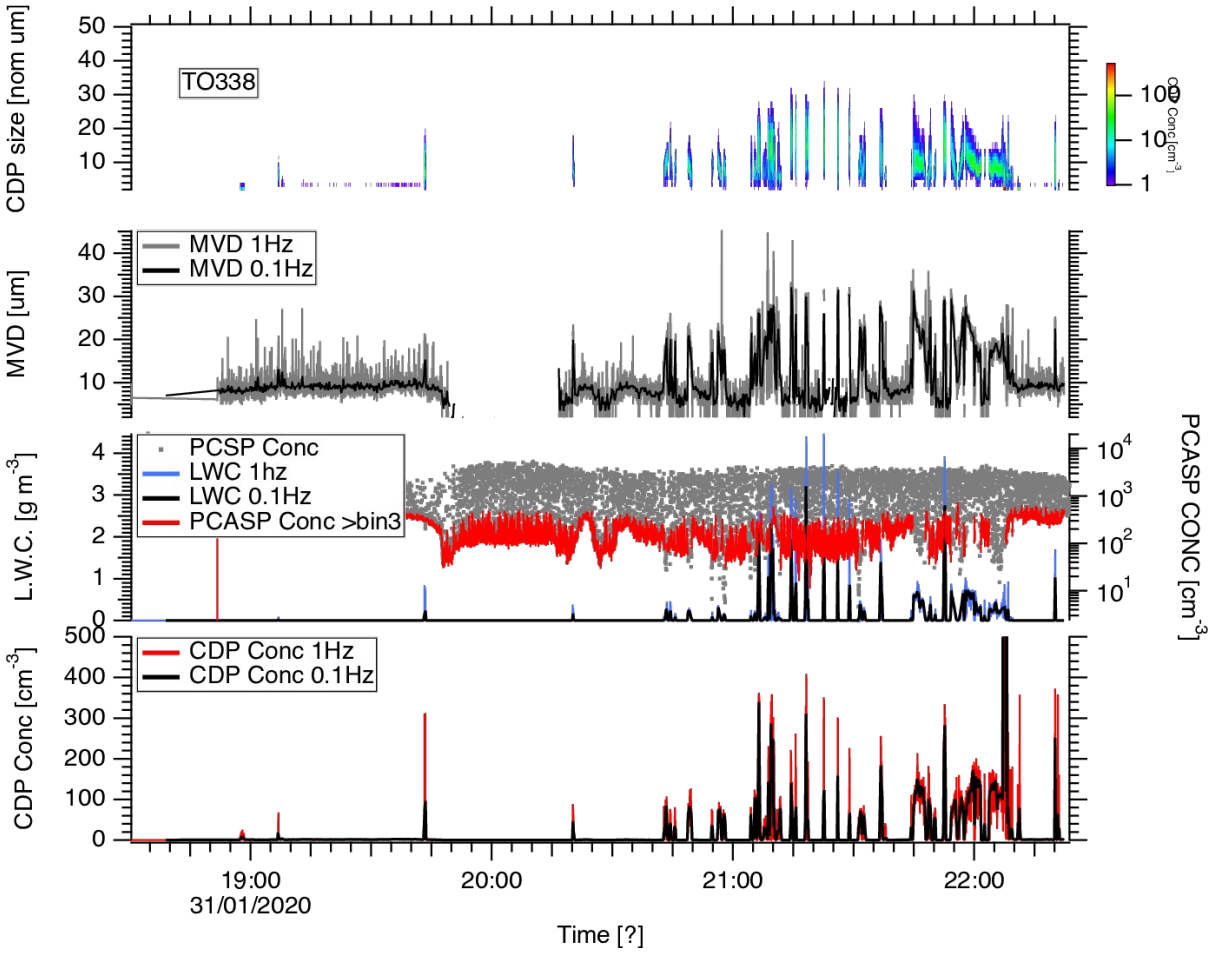

Figure 6 Cloud and aerosol data from Flight 2, TO338