FS METEOR

Expedition M203 "BOWTIE"

10. August 2024 - 24. September 2024 | Mindelo - Bridgetown



3. Weekly Report (19. - 25.08.2024)

In our first full week at sea, we travelled across the ITCZ all the way to 4.6°N, where we crossed the Southern edge of the ITCZ, which we define by the 48 kg/m² contour of columnintegrated water vapor. After reaching the dry tropics, we turned around to head back North. While steaming, we continuously profile the atmosphere and stop to profile the ocean about every degree travelled. During the transect, we performed coordinated measurements with the EarthCARE satellite (on the 20th and 22nd of August) and the German research aircraft HALO (21st and 22nd of August), which is operating from Sal, Cape Verde through our partner project Persistent EarthCARE Underflight Studies of the ITCZ and Organized convection (PERCUSION).

EarthCARE (Earth Clouds, Aerosols and Radiation Explorer) is an earth observation satellite of the European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA). Equipped with four instruments, the EarthCARE satellite mission is designed to make a range of different measurements that together will shed new light on the role that clouds and aerosols play in regulating Earth's climate. It was launched on the 28th of May, 2024 on a SpaceX Falcon 9 rocket. EarthCARE orbits the Earth at an altitude of 390 km and carries a set of four unprecedented instruments on one single satellite. It has a high spectral resolution lidar, a cloud profiling radar, a multi-spectral imager, and a broadband radiometer on board. The satellite will provide larger-scale, and ultimately a longer record of, measurements which complements our ship-based measurements for achieving our scientific goals. In return, the ship-based measurements are valuable for validation and calibration of this new satellite.

The German High Altitude and LOng-range research aircraft (HALO) is a modified Gulfstream G550 operated by the German Aerospace Center (DLR). HALO is equipped with remote sensing instruments and is capable of launching dropsondes. As the aircraft is built for high altitude flight, most of the instrumentation observes the atmosphere (and in particular clouds) from the nadir perspective (i.e., looking straight down). The instrumentation of the HALO aircraft is based on contributions from several universities and research institutions. Each instrument is developed and operated by an individual group, which culminates in a modern instrumentation suite. In particular, HALO's instrumentation includes broadband radiometers, a dropsonde launching system, an active (radar) and passive microwave package, irradiance spectrometers, a thermal imager, an infrared radiometer, a water vapor differential absorption lidar, and spectral and polarization-resolving imagers.



Coordinated measurements in the ITCZ on the 21st of August: The German research aircraft HALO (pink plane and pink track) circling FS METEOR (green arrow) while deploying dropsondes on the blue targets. In the background, the SEA-POL radar reflectivity as measured from the ship (60nm around FS METEOR) and infrared brightness temperature measured from the GOES-East satellite are overlayed.

On the 21st of August, Meteor performed small circles (each taking 20 minutes at 5 knots) about our position at 5.46N, 26.7W, in the northern half of HALO's circle (200km radius, see Figure above). FS METEOR had been experiencing moderate to heavy rain all morning associated with a SW to NE oriented band of convection, and this continued during the HALO circle. The 4 circles that Meteor performed during HALO's 1-hour circle provided us with excellent SEA-POL radar coverage of the convective system. An additional weather balloon – supplemental to the regular 3 hourly launches - was launched while the aircraft was circling us. The measurements from the aircraft will be able to provide the meso-scale (about 200 km) atmospheric state in which the convection over FS METEOR formed and will help in post-campaign analysis to link the local ship-based information to the meso-scale atmospheric dynamics. After meeting HALO on the 21st, we again coordinated with HALO and EarthCARE on the following day.

After the coordinated measurements, FS METEOR steamed south in search of the southern edge of the ITCZ. The ECMWF forecast had called for the 48 kg/m² contour of column-integrated water vapor to be around 5N at our longitude. Measurements of column-integrated water vapor from our microwave radiometer indicated that we passed this threshold at 7:51 UTC, at 5.42N, 24.75W. We continued heading south a bit further to 4.65N, 24.88W, at which point the 15 UTC radiosonde indicated a column-integrated water vapor value of 48.3 kg/m². The 12 UTC radiosonde had measured a value of 49.5 mm. After performing ocean measurement stations, we turned around to head back north into the

ITCZ. The radiometer measurements indicated that we stayed below 48 mm for about 8 hours, until we passed north of 5N.

After days of rough seas with strong ocean currents in the opposite direction to the swell and brisk south-westerly winds, our trip south and the passage of an African Easterly Wave to our west have finally brought us more canonical ITCZ weather conditions, with lighter winds and blissfully calmer seas – the doldrums. On the 24th of August, typical doldrum conditions were observed for the first time, with wind speeds well below 3 m/s and intense convective storms forming within them. We measured strong winds associated with cold and dense air flowing out of the convective systems, causing the observed wind speed to jump from 2 to 10 m/s within 2 minutes.



Convective system in front of FS METEOR within the doldrums – a region of light and variable winds in the inner tropics. The convective system generated a strong gust front passing the ship.

On the 28th of August we will head to Praia, to pick up drones and a repair part for the SEA-POL radar, which will make our suite of measurements for M203 finally complete. This would not be possible without the great support of the German research fleet coordination center in Hamburg and Captain Detlef Korte. After departing Praia, we will recover gliders and drift buoys we deployed on the 18th of August near the Pirata buoy at 11.5°N and 23°W (part of the Prediction and Research Moored Array in the Tropical Atlantic), before heading to the central tropical Atlantic.

Greetings from all participants of M203.

Daniel Klocke (Chief Scientist, M203)