

SHORT CRUISE REPORT

R/V L'ATALANTE: Cruise IFM-GEOMAR, Leg 4

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IFM-GEOMAR
Leibniz Institute for Ocean Sciences
Ocean Circulation and Climate Dynamics

IFM-GEOMAR-4 from Mindelo, Cape Verde to Mindelo, Cape Verde
February 23 to March 15, 2008

Participants IFM-GEOMAR-4

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5	Fischer, Jürgen, Dr.	Moorings	IFM-GEOMAR
6	Fischer, Tim	Microstructure/ADCP	IFM-GEOMAR
7	Funk, Andreas, Dr.	CTD/Microstructure/ADCP	IFM-GEOMAR
8	Gülzow, Michael	Film making	MKH
9	Hormann, Verena	Salinometer/CTD	IFM-GEOMAR
10	Hummels, Rebecca	Microstructure /LADCP	IFM-GEOMAR
11	Komander-Hoepner, Sigrun	CTD	IFM-GEOMAR
12	Krahmann, Gerd, Dr.	Glider/CTD/LADCP	IFM-GEOMAR
13	Malien, Frank	O ₂ , nutrients/logistics	IFM-GEOMAR
14	Müller, Mario	Computer/moorings	IFM-GEOMAR
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16	Papenburg, Uwe	Moorings/logistics	IFM-GEOMAR
17	Pinck, Andreas	Moorings/CTD/Glider	IFM-GEOMAR
18	Roth, Christina	CTD	IFM-GEOMAR
19	Sachs, Stephan, Prof. Dr.	Film making	MKH
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Research Program

The research cruise IFM-GEOMAR leg 4 aboard R/V L'ATALANTE is the first cruise of the new Sonderforschungsbereich 754 "Climate-Biogeochemistry Interactions in the Tropical Ocean". Shipboard, glider and moored observations are used to study the temporal and spatial variability within the oxygen minimum zone (OMZ) of the Tropical North Atlantic. This OMZ is located south of the Cape Verde islands and is generated by particularly low ventilation in addition to oxygen consumption due to heterotrophic respiration. At the same time, cruise IFM-GEOMAR-4 represents the main part of the BMBF program "Nordatlantik", subproject "Role of the equatorial Atlantic Ocean for climate variability in the Atlantic sector". Here, the equatorial current system, particularly the Equatorial Undercurrent (EUC), is the focal point of our research. Oceanic Mixing processes were studied in the frame of the DFG Emmy Noether project "Diapycnal mixing processes in the upwelling regions of the tropical Atlantic" as well as in the frame of the BMBF program "SOPRAN", subproject "The role of mixing and transport for the production and sea-to-air flux of N₂O and CH₄".

The research cruise included hydrographic station observations using a CTD/O₂ rosette, including water sampling for helium, oxygen and nutrients. Of particular importance were underway current measurements with both shipboard ADCPs (Narrow Band 75 kHz and 300 kHz). Diapycnal mixing processes were measured on station using a loosely tethered, free-falling microstructure probe. During IFM-GEOMAR-4, an intensive mooring program was carried out with 5 mooring recoveries and 8 mooring deployments. As part of BMBF "Nordatlantik", a mooring array consisting of 5 current meter moorings was installed along 23°W between 2°S and 2°N. This array is aimed at quantifying the variability of the thermocline water supply toward the equatorial cold tongue which develops east of 10°W during boreal summer. Within the framework of SFB 754, two moorings with CTD/O₂ profilers were deployed in the center and at the southern rim of the OMZ of the Tropical North Atlantic. The final mooring of IFM-GEOMAR-4 was deployed near the Cape Verde islands shortly before arrival at the port of Mindelo. During the cruise, one glider was recovered and another glider was deployed near the equator. Both gliders are equipped with CTD/O₂, chlorophyll and turbidity sensors.

Cruise Narrative

R/V L'ATALANTE departed from Mindelo on February 23, 2008 at 10:30L and headed south between the Cape Verdian islands of São Vicente and Santo Antão. South of São Vicente the scientific work commenced with the first CTD/O₂ station. Two gliders had been deployed at this location prior to the cruise and the CTD/O₂ data were needed for calibrating the CTD/O₂ sensors of both gliders. The first glider had been deployed on January 12, 2008 and travelled first along a southeastward track until 14°N, 23°W and then headed further south along the 23°W section. The second glider was deployed a few days before the cruise for a three day test mission. This glider was then loaded aboard R/V L'ATALANTE to be deployed later during the cruise. During the first CTD/O₂ station, several microcats and one newly developed oxygen logger were attached to the rosette. All instruments worked well and

thus allow a proper pre-deployment instrument calibration. During the following day the working deck as well the instruments were prepared for the intense mooring work that will follow within the upcoming week.

On February 25, 2008, after another CTD/O₂ station to calibrate the glider sensor, the first glider mentioned above was recovered without any problems. Using the iridium telephone connection from Kiel/Germany, the dive depth of the glider had been reduced to only 100m, enabling the glider to surface more frequently (about once every 40 minutes). When R/V L'ATALANTE approached the position of the last surfacing, contact with the freewave radio transmitter/receiver system was readily established at a distance of 2-3nm. Over this radio contact the glider transmitted its precise position, and commands were given to keep it at the surface until recovery. Its recovery with the zodiac was a fast operation without any problems despite 2-3 m surface waves. This glider had finished a 45 day mission covering a distance of more than 1200km. All sensors, including temperature, conductivity, pressure, oxygen, turbidity and chlorophyll worked well from beginning to end. Barely any bio-fouling was found on the glider with only some corrosion at the connection between fin-tail and fin.

Following the glider recovery, R/V L'ATALANTE steamed toward the first mooring position at 8°N, 23°W. After a CTD/O₂ station during the night, the microstructure program commenced with the first 6 casts in the early morning on February 26, 2008. During these measurements, carried out at the portside of the aftdeck, R/V L'ATALANTE steamed with 0.5 kn through water during probe deployment while increasing its speed to about 1 kn during descent and recovery of the probe. At 05:00L the microstructure measurements ended and a drift test started with R/V L'ATALANTE steaming with 1.5 kn through water against weak north-easterly winds at almost zero currents. In the mean time, sound speed data from the CTD/O₂ station at the planned mooring position was delivered to the multi-beam echo sounder aboard R/V L'ATALANTE to obtain reliably depth measurements. The survey of the bottom topography revealed a depth of about 4800m at the planned mooring position, with a variation of only a few meters nearby. The mooring deployments started at 06:40L on February 26. The ship moved slowly along the planned track, and after about 3h, all instruments including a McLane moored profiler with an oxygen optode had been launched into the water from the aftdeck. A short steam of about 10min was needed to reach the anchor drop position, and the final mooring position was determined as 8°01.0'N, 22°59.0'W.

The mooring work at 5°N, 23°W started early in the morning on February 27. Communication with the releases was established using the hydrophone board unit of R/V L'ATALANTE, and the release command was sent at 06:30L. The top element of the mooring surfaced within a few minutes, and the zodiac was used to connect it to the ship's A-frame. We noticed numerous scuff marks and cuts to the plastic jacket of the mooring wire during the recovery process. The moored profiler sitting near the lower stopper was entangled in a major and tightly pulled cluster of longline fishing gear, preventing the profiler from climbing the mooring wire as planned. In fact, a first glance at the recorded data showed that the profiler recorded full up and down cycles in all variables for the first 1.5 months only, and a complete failure of the vertical profiles afterwards. Both the Aanderaa current meter below the moored profile and the Microcats above and below the moored profiler indicate an

occasional and sudden “dive” of the instruments of up to 300 m, consistent with being caught up in longline fishing activities.

The next mooring deployment started with a drift test at 12:00L. The ship arrived at the calculated start position at 13:30L, and the top element went into the water, followed by the remaining instruments in short order - a smooth operation without any problems. The anchor was dropped at the exact position, with the final mooring position being the same as the previous one, i.e. 5°00.9'N, 23°00'W. The submergence of the top element was observed, and R/V L'ATALANTE headed toward the next mooring position at 2°N, 23°W. This mooring is part of the equatorial array between 2°S and 2°N. After a deep CTD station and a drift test, the top element including a narrow-band ADCP was deployed at 16:20L. At about 19:55L the anchor was dropped exactly at the planned position, and the final mooring position is 2°02.5'N, 23°02.0'W. Due to darkness, the submergence of the top element could not be observed. Following the mooring deployment, the ship steamed 75nm to the next mooring position 0°45'N, 22°59.5'W. During the night, a shallow CTD station down to 1300m was taken, and upon sunrise on February 29 at 6:20L, the mooring was released, and was completely recovered at 10:40L. R/V L'ATALANTE headed toward the PIRATA buoy at the equator, 23°W. This position was chosen as the start position for a new glider mission using the glider (“Deepy”) that was deployed a few days before the cruise for a test mission south of São Vicente. At 15:00L, the glider went into the water from aboard the zodiac. It was sent first for a 100m test dive. At 15:50L, it was back at the surface, and after checking its engineering and scientific data it was sent for another 800m test dive. It surfaced at 19:30L and we decided to send the glider on its northward path. Its last position at the surface was at 0°01.273N, 22°58.648'W. The plan is to recover the glider during a cruise aboard Maria S. Merian in April 2008 at about 8°N, 23°W.

A series of CTD and microstructure measurements was carried out during the night. The knowledge of captain and officers of R/V L'ATALANTE in handling the ship's drift during microstructure measurements was very helpful and considerably improved the quality of the obtained data, enabling the profiler to reach greater depths without distortion due the tension on the cable. As during the previous day, we released the mooring at the nominal position of 0°00'N, 23°06.8'W at sunrise, and the top element, including the PIRATA workhorse ADCP, was aboard R/V L'ATALANTE at 7:50L. During recovery of the moored profiler wire section, we discovered severe and repeated abrasions throughout the wire length. We decided to use the zodiac to pick up the moored profiler located at its upper stopper during the start of the mooring recovery and slowly moving along the wire while the mooring wire was spooled on the winch. The operation was successful and the remainder of the Benthos floatation elements and the releases were finally recovered at 11:00L. A first check of the moored profiler data showed that the profiler measured within the planned depth range during the first 4 months of the deployment only, with a subsequent continuous decrease of the maximum depth reached during descents.

During our previous mooring deployment at the equator 23°W in June 2006, we had headed into the southeasterly winds, where the mooring wire shifted from its straight position behind the ship and angled strongly toward the port side of the ship, resulting in severe tension on the mooring wire. We believe that parts of the mooring dropped into the depth

range of the very strong EUC and were advected eastward. The current deployment did not feature any long mooring segment without buoyancy, and the problem should be significantly reduced. However, we decided to deploy the mooring headed downwind of the southeasterly wind (instead into it as usually). At the beginning of the deployment, we needed to increase the ship's speed to about 2kn (instead of 1.5kn usually used) to bring about enough tension to pay out the wire. The wire moved slightly to the starboard side during the entire deployment, with only some minor correction of the ship's heading required. The anchor was dropped at the exact position, and the final mooring position is again 0°00'N, 23°06.8'W.

Recovery of our equatorial mooring at 21°30'W was planned for March 1. We were not sure if this mooring was still at its deployment location since, starting on July 10, 2007, we had received ARGOS messages from the transmitter attached to the top element. However, both releases responded to the signal from the board unit and the mooring was released. The first element discovered at the surface was the 45'' flotation with the Longranger ADCP included. After the complete recovery, we had suffered only the loss of the top flotation with the ARGOS transmitter and a temperature/pressure logger. The three Microcats nominally located below the top element dropped down and recorded at unintended depth levels without creating any problems for the Longranger ADCP measurements.

On March 3, we started with the CTD section along 23°W at 2°S. Along the northward cruise track toward Cape Verde, CTD stations will be spaced 15' – 30' of latitude apart, somewhat closer near the equator. Water samples will be taken using the water bottles of the CTD/O₂ rosette. During most of the stations, water samples will be analyzed with respect to their contents of helium and nutrients (nitrate, nitrite, phosphate, silicate) as well as salinity and oxygen to calibrate the sensors of the CTD/O₂ probe. Helium samples are typically taken in the upper 150m mainly in the equatorial region, while nutrient samples are measured in the upper 1000m along the whole section. Along our northward track, the program still allowed for some mooring deployments and recoveries. In the early morning of March 3, we deployed the southernmost mooring of our equatorial current meter array. As the topography appeared to be very rough, the deployment area was surveyed in detail with the multi-beam echo sounder, and a small area of about 1 by 1 nm was found featuring rather smooth topography at a depth of 4840m in between topographic ridges reaching up to 4350m. The mooring went out without problems, and submergence of the top element was observed after the anchor was dropped. The final mooring position is 1°56.4'S and 22°57'W, exactly at the planned position. During the afternoon and the following night, 3 CTD profiles down to 1300m were taken. Early in the morning of March 4, we recovered the last of our moorings deployed in June/July 2006 during M68/2. Both releases responded and the mooring was recovered completely without problems. In summary, we were able to recover all instruments of all moorings except for the top flotation of the equatorial mooring at 21°30'W that was severed on July 10, 2007 as well as one single temperature/pressure logger.

After a CTD station and microstructure measurements, the continuation mooring was deployed at the same position without problems and the final mooring position was calculated, using the positions of the anchor drop and the submerging of the top element, to be 0°44.95'S, 22°59.70'W. During the night, the CTD section was continued toward the equator. In the equatorial mooring deployed 4 days earlier, we had incorporated an additional top

element including a 1200 kHz ADCP with a release attached to the top of the remaining mooring. The ADCP was used to measure within the vertical shear zone between the eastward flowing EUC with a core depth at about 50m and the westward flow above. Before recovering the top element on March 5, its position was exactly triangulated and the position of the upper release was determined to be $0^{\circ}00.22'N$, $23^{\circ}06.76'W$ at a depth of 177m. The 1200 kHz ADCP acquired good data with a vertical and temporal resolution of 50 cm and 2s, respectively, and a vertical range of about 20m showing vertical shears up to 0.07 s^{-1} . The variance of the velocity data will be analyzed in comparison to the microstructure measurements near the mooring to obtain further insight into the mixing processes in the shear zone above the EUC.

The last mooring deployment in the equatorial region started on March 6 at 6:00L. The mooring went into the water without problems. Before the anchor drop at 9:35L, the top element of the mooring was followed by the zodiac to film its submergence - a successful operation. In addition, the submergence position was located exactly, and the resulting mooring position is $0^{\circ}45.17'N$, $22^{\circ}59.28'W$.

During the following days, we continued the CTD/O₂ section along $23^{\circ}W$ northward. South of $2^{\circ}N$ and between $7^{\circ}N$ and $9^{\circ}N$ (the region of the tracer release experiment scheduled for April 2008), each CTD station was followed by a microstructure station consisting of 3 microstructure profiles. North of $9^{\circ}N$, R/V L'ATALANTE headed against quite strong northerly winds and its speed dropped to about 9 kn. To stay within the scheduled program, we decided to cancel further microstructure measurements south of the Cape Verde islands. The meridional section along $23^{\circ}W$ was concluded on March 12 at 11:00 with the last CTD/O₂ station at $14^{\circ}N$.

Before deploying our last mooring north of São Vicente, we had to stop at the port of Mindelo to pick up an Inverted Echo Sounder to be installed near that mooring but was inadvertently left behind at INDP in Mindelo. Using the zodiac of R/V L'ATALANTE, the instrument, as well as the baggage of the crew member which had not arrived in time before the cruise, was brought onboard the vessel without much time delay. On March 13 at 18:00L, we arrived at the planned mooring position at $17^{\circ}36'N$, $24^{\circ}15'W$. During the night we conducted two three hour microstructure stations, separated by one deep CTD station down to the bottom. On March 14 at 4:00L we started the drift test for the mooring deployment, and at 6:00L the top element including a fluorometer, a microcat and an ARGOS watchdog, went into the water. The whole mooring deployment took about 4 hours, and the anchor was dropped at the planned position. Submergence of the top element was observed. Since more than one hour later no ARGOS signal had been received, we deemed the mooring successfully deployed. During lunchtime, microstructure measurements were carried out and at 14:00L, while preparing for the deployment of the Inverted Echo Sounder, we observed the top element of our mooring located right at the surface, at times flushed by the waves. It soon became clear that the top element was still attached to the mooring, but at least 40m shallower than expected. The only option without releasing the mooring again was to cut off the top element. In this case, 34m of mooring, with two Microcats, attached would drop down below the next Benthos group. They would represent no harm for the remainder of the mooring as long as the new top element would stay deep enough below the surface. As there was the

possibility that the top element would re-submerge due to changing currents, we quickly decided to use the zodiac to attach a rope via the ship's A-frame to the top element. In a perfectly executed operation, the captain drove the ship backward to stop exactly in front of the top element. At 16:15L the top element was picked up and heaved out of the water using the ship's capstan. After a haul of only two to three meters, the tension on the mooring wire became very severe. The wire was cut below the top element. From the proximity of the cut position to the actual mooring position we assume that the mooring wire was almost completely stretched and that after cutting the top element, the next Benthos group is about 20m below the surface. The risk for rising to the surface during low current conditions is regarded to be small. As the water depth at the mooring position was exactly determined by independent measures from the CTD, the multi-beam echo sounder during the last R/V METEOR cruise as well as the triangulation of the releases and agreed with expected values of about 3600m, we believe that the only explanation for the surfacing of the top element is a mooring longer than planned. We must check with the manufacturer of the mooring wire if such a mistake is possible and can be prevented for any future deployments. The triangulated mooring position is 17°36.244'N, 24°14.915'W. Note that this location is closer to the anchor drop position than expected, with the backdrop of the anchor only about 9% of the total mooring length.

The inverted echo sounder was then deployed without problems at 17:10L near the mooring at 17°36.031'N, 24°14.604'W. During the night we continued with a 24 h microstructure station near the mooring position. The scientific work of R/V L'ATALANTE cruise IFM-GEOMAR leg 4 ended at 11:30L and the ship headed toward Mindelo where the cruise ended on March 15, 18:00L (Fig. 2.1).

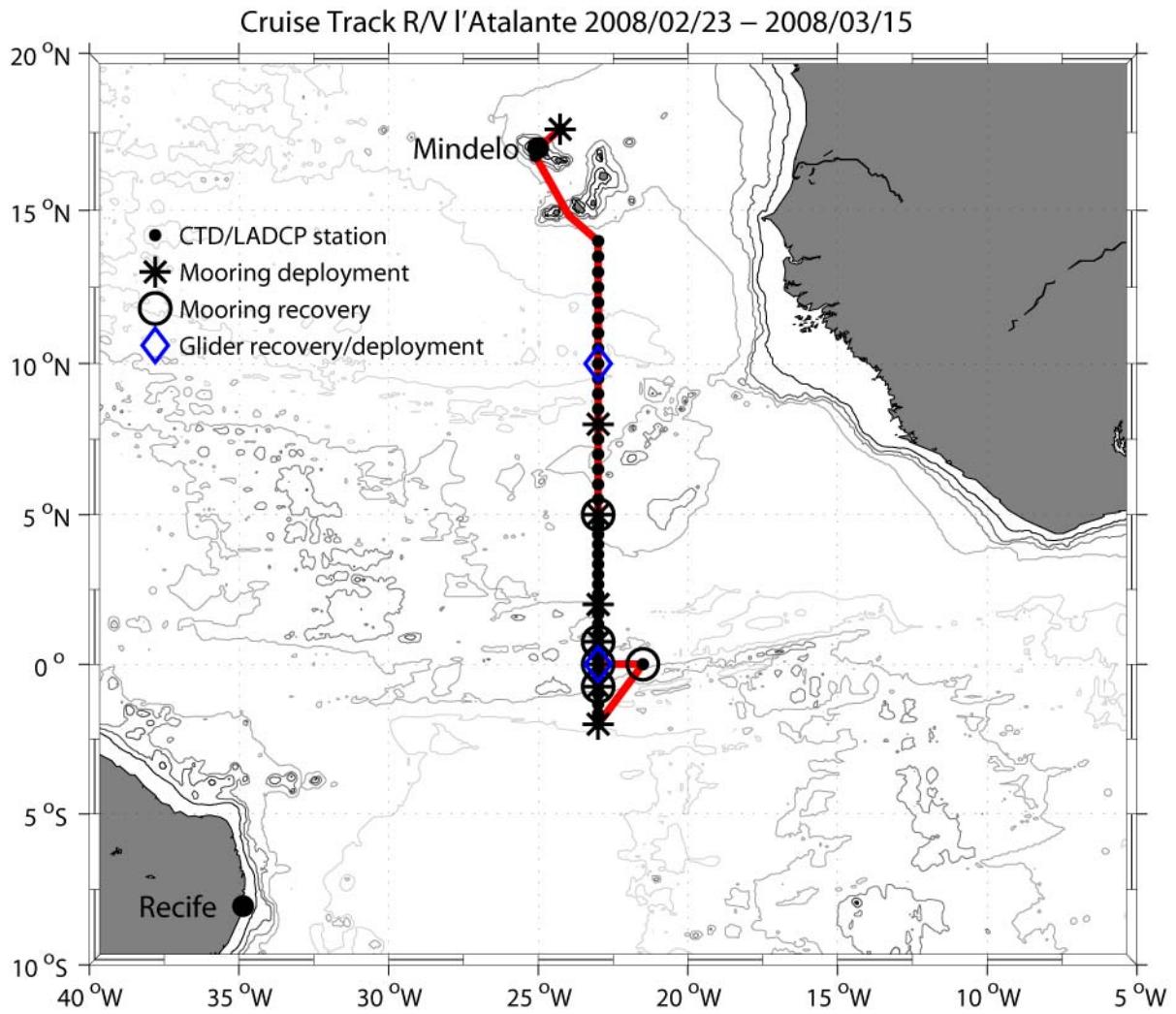


Fig. 2.1: Cruise track of R/V L'ATALANTE cruise IFM-GEOMAR leg 4.