METEOR-Bericht

Circulation and Variability in the Tropical Atlantic

Cruise No. 68, Leg 2
from Recife, Brazil to Mindelo, Cape Verde
June 6 to July 9, 2006

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2.1.1 Participating Institutions

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2.2 Research Program

The measurement program of M68/2 consisted of station hydrographic observations with a CTD/O_2 rosette including water sampling for tracer, oxygen and nutrient probing. Of particular importance were underway current measurements with both shipboard ADCPs (Ocean Surveyor, 38 kHz und 75 kHz). In addition to horizontal advection by different zonal current bands, diapycnal mixing plays an important role for the heat budget of the mixed layer. In the region between 23°W and 10°W specifically, diapycnal mixing processes were measured on station using a loosely tethered, free-falling microstructure probe and a high-frequency (1200 kHz) LADCP, lowered with the CTD/O_2 rosette at the same station.

During M68/2 an intensive mooring program was carried out. This program particulary consisted of the recovery of two equatorial current meter moorings at 35°W and 23°W. To record changes in the equatorial currents on intraseasonal to interannual time scales, a mooring array was installed at 23°W. This array consists of four current meter moorings and is aimed at quantifying the variability of the thermocline water supply toward the equatorial cold tongue. Another equatorial current meter mooring was installed at 10°W in cooperation with the multi-national PIRATA program. In preparation of a planned new Sonderforschungsbereich [German Special Research Program], a profiling CTD/O_2 was moored at 5°N, 23°W. The goal of this mooring is to observe the transport of oxygen-rich waters toward the oxygen minimum zone in the tropical North Atlantic. The final mooring of M68/2 was deployed near the Cape Verde Islands shortly before arrival at the port of Mindelo.

Helium probes were taken along the meridional sections (23°W and 10°W) and zonal sections (equator and 2°N) in the upper 500m of the water column. Biogeochemical water sampling, including O_2, nutrients, CO_2, CFC, and SF_6 measurements, was carried out during regular CTD/O_2 stations.

In support of the international AMMA program, twice daily radio soundings were taken during M68/2.

2.3 Narrative of the Cruise

R/V METEOR departed from Recife on June 6, 2006 at 10:00L. At that time, some of the instruments (two moored CTD profilers) shipped from Woods Hole, Massachusetts, to Recife should have been delivered to METEOR. Unfortunately, the customs strike in Brazil put a severe damper on these plans, and on-time delivery did not take place. It was decided to ask for permission to take delivery of the instruments upon the ship’s arrival at the island of Fernando de Noronha, where the Brazilian observer was scheduled to disembark from METEOR.

R/V METEOR headed north toward the Brazilian shelf along 35°W where scientific work started with the first CTD/O_2 station early in the morning of June 7. The measurements along this section concentrated on the upper ocean so that the CTD/O_2 profiles were taken to a depth of 1300m only, or near bottom in the shallower waters near the shelf. The CTD/O_2 measurements were accompanied by current measurements with two Workhorse ADCPs attached to the CTD/O_2 rosette, as well as by two shipboard ADCPs, so-called Ocean Surveyors of 38 kHz and 75 kHz, respectively. Both instruments obtain their heading input from the 3D-Ashtech GPS receiver as well as from METEOR’s Fiber Optic Compass (FOG).

Water samples were taken using the water bottles of the CTD/O_2 rosette as part of the intense biogeochemical program during M68/2. During most of the stations, water samples were analyzed with respect to their contents of chlorofluorocarbons (CFC), sulfur hexafluoride (SF_6), helium, oxygen, nutrients (nitrate, nitrite, phosphate, silicate), dissolved inorganic carbon (DIC), total alkalinity (Alk), and hydrogen peroxide (H_2O_2).

Along the northward cruise track, CTD stations were spaced apart by about 20' – 30' of latitude, somewhat denser near the shelf and near the equator. On June 9, 09:00L, METEOR approached the position of our current meter mooring. The mooring had been deployed in August 2004 and contained four current meters, three CTD sensors, two ADCPs, and one RAFOS sound source. The releases were contacted using the hydrophone board unit, and the release command was sent at 09:10L, with the top element surfacing only a few minutes later. The mooring was then recovered without any problems. A first view of the obtained data showed that all instruments worked well, yielding an instrument and data recovery rate of 100%.

At the mooring position, a first test station with our microstructure profiler (MSS) was carried out with the profiler winch attached at the port side stern rail. The ship's course and speed (max of 1 to 1.5 kn suggested) were adjusted in accordance with wind and surface current to ensure that the microstructure profiler would fall free and clear astern on the port side. After adjusting the profiler sink velocity by changing the weights of the MSS, the first data set was obtained. At this position, the strong eastward velocity of the Equatorial Undercurrent advected the profiler eastward, away from the ship steaming with 1 kn through the water while drifting southwestward. Thus there was no risk of losing the profiler by cutting the cable with the ship's propeller.

After the MSS test station, the first APEX float was deployed successfully, and the CTD/O_2 section along 35°W was continued. Water samples were taken at every other station for the full set of biogeochemical analyses. The stations in between were used instead for the calibration of Microcats to be deployed within the mooring array along 23°W.

On June 10, we received information from Mr. Marcos Fonseca (Windrose Serv. Mar.), the ship's agent in Brazil, that the moored profilers were onboard the 53ft sail boat AUSSTEIGER, arriving at Fernando de Noronha in the morning of June 13. The same day, Mr. Fonseca and two customs officers would take an airplane to Fernando de Noronha to facilitate customs clearance and delivery of the moored profilers to METEOR on June 14 at 08:00L.

On June 11, the CTD/O_2 section along 35°W was completed with the last station at 5°N. At this position a sound source mooring had been deployed during METEOR cruise M62/2, however, from the received RAFOS float data we knew that the sound source did not work from the very beginning. After approaching the mooring position at 09:20L, the release responded to the signal from the board unit via hydrophone, and about 10 min after sending the release command, the top element was observed at the sea surface. Recovery went smoothly and was completed at 10:00L. Following the mooring recovery another MSS test station was taken. Due to weak winds and currents, there was no problem in obtaining almost constant sink velocities of 0.6 or 0.7 m/s down to 350m depending on the number of ballasting rings attached to the profiler. The last activity at the 35°W section was a CTD/O_2 test station. During the previous CTD/O_2 casts we observed too strong a tilt of the ADCPs attached to the CTD rosette. We changed the ballast at the CTD rosette, which significantly improved the tilt with smaller pitch and roll angles throughout the CTD test cast. At 13:00L, METEOR began an ADCP section from 35°W, 5°N to

32°30'W, 2°30'N and further to 32°30'W, 3°50'S, the location of the island of Fernando de Noronha. One ARGO float each was deployed at two degrees north and south of the equator, and two CTD stations were carried out to test the performance of our releases to be used for the mooring deployments later during the cruise.

On June 14 at 07:30L we arrived at the island of Fernado de Noronha. After disembarking the Brazilian observer, we contacted the sailboat AUSSTEIGER. They had already arrived one day earlier as did the two customs officer and the ship's agent, Mr. Marcos Fonseca. There were no further complications with customs clearance at the island, and all-in-all we experienced only a minor time delay. All of the shipped equipment was found in good condition, and we felt fortunate to have the profiler available for our two moorings in the central tropical Atlantic. At 11:00L the ship headed toward the position of our next mooring recovery.

On June 15 at 10:00L we arrived at the mooring position. After lowering the hydrophone, we were not able to obtain a clear contact with the single release on the mooring. The release code was submitted nonetheless but without success. It appeared that some noise from the ship interfered with the signal of the hydrophone board unit, and after switching off the Kongsberg EM120 multi-beam echo sounder transmitting at 12kHz, we were able to receive clear signals from the release. The release code was submitted again and we received the message "Release executed". However, the mooring did not come to the surface. Though repeatedly submitting the release code numerous times, nothing happened. As there was no additional time available because of the very tight mooring program, we decided to depart from the mooring position without recovering the sound source mooring. Another ARGO float was deployed at the mooring position, and METEOR headed toward the southern end of the 23°W section beginning at 4°S. Along the cruise track another two ARGO floats were deployed at 27°W and 25°W, respectively.

During the late evening of June 16, the hydrographic section along the 23°W section commenced with a first CTD/O_2 cast at 4°S. Several CTD/O_2 casts and the first set of regular microstructure stations were carried out during the following day. The depth reached by the microstructure profiler strongly depends on the strength of the vertical shear of the horizontal velocity. Near the equator in particular, only very shallow profiles could be obtained because of the very strong Equatorial Undercurrent (EUC) with core velocities above 1m/s at about 70m depth. During the night station on June 17, the acquisition computer of the microstructure profiler did not receive data from the profiler and it soon became evident that the cable was broken. We switched to a different cable, and microstructure measurements commenced after the mooring deployment on June 18.

The deployment of the first mooring of our equatorial array at 23°W began at 1015L with a drift test. The ship headed against the southeasterly winds with a velocity of about 1kn through water. A drift velocity of about 2.5kn to the south resulted due to prevailing wind and currents. After the drift test the bathymetry of the deployment area was surveyed with the multi-beam echo sounder which, during the last METEOR leg, has proven to be a highly accurate instrument. The obtained topographic data showed that the initially chosen mooring position was situated in an almost flat region of about 3680m water depth. The mooring deployment ran very smoothly, and after merely 2h 20min all instruments were in the water. We had to steam an additional hour to reach the anchor drop position. The final mooring position was determined to be at 0°44.95'S, 22°59.60'W. During the night following the mooring deployment, CTD/O_2 and microstructure measurements were continued.

Two mooring operations had been scheduled for the following day, June 19. Recovery of the French mooring located at 0°00.01’N, 23°07.51’W was started early in the morning. This mooring included a PIRATA Workhorse ADCP, an IFM-GEOMAR Longranger ADCP and several Aanderaa current meters (LOCEAN, C. Provost). The release responded accurately, and the first flotation elements surfaced after just a short while. The ship’s Zodiac was used to first recover the release and its flotation package, followed by all other instruments in short order. A first inspection of the ADCP records indicated complete data sets, although located shallower than originally planned, with the upward looking ADCP located right in the core of the EUC which resulted in strong mooring motion and vertical excursions of the top elements. The Aanderaa current meter tapes were not scheduled to be read during this cruise but to be sent to LOCEAN, Paris, to be read and analyzed there. Following the successful mooring recovery, we commenced with a multi-beam echo sounder survey and found the former mooring position was located amidst smooth topography. Water depths within half a mile around the chosen mooring position varied only between 3680m and 3690m. The drift test with 1.5kn through water against the southeasterly wind again yielded a southward drift because of the strong westward flowing SEC. The mooring deployment started very smoothly, all instruments including the moored profiler moved from the aftdeck into the water without any problems. At the end of the long 2.5km long wire segment for the moored profiler, the wire shifted from its straight position behind the ship and moved strongly to the port side of the ship. Severe tension was building on the mooring wire, and the captain decided to turn the ship to the port side to reduce tension on the mooring wire. However, the mooring wire shaved against the ships hull, resulting in some scuffs to its plastic jacket. As the mooring was at risk for being lost, the ship had to turn quickly to the starboard side, thereby leaving the drift track toward the planned anchor drop position.

After submerging the releases into the water and after attaching the mooring wire to the anchor still firmly attached to the ship’s aft deck, the ship made a wide turn for about 2.5h with about 2kn through water to reach the planned mooring position. The anchor was dropped at the proper and intended position. We believe that this very unusual mooring deployment resulted from the fact that the long mooring line segment of the moored profiler dropped into the depth range of the very strong EUC and was advected eastward. For future applications, one must consider alternative strategies to deploy similar moorings in the equatorial region. The submerging of the mooring top was concluded from the disappearance of the ARGO signal from the transmitter at the moorings top element. The mooring position was determined as 0°00.0S and 23°06.8’W.

During the following night, we completed two CTD casts, with the second one already at the next mooring position. After the topographic survey of the mooring area in the morning of June 20, we chose a mooring position at a water depth of 4310m, about 110m deeper than suggested by the 2’ Sandwell topography. The mooring deployment proceeded without any problems, and the anchor was dropped exactly at the planned position. The final mooring position was determined as 0°45.0’N, 22°59.5’W.

Two more CTD casts were taken during the following night. A drift test at the next mooring position showed rather weak surface currents, contrary to the previous deployments. The survey using the multi-beam echo sounder revealed a depth of about 4950m at the planned mooring position, with a variation of only a few meters nearby. The mooring deployments started right after lunch on June 21. The ship drifted along the planned track, and after about 3h, all instruments had been launched from the aftdeck into the water. METEOR had to steam another 45min to reach the anchor drop position, and the final mooring position was determined as 0°00.0'N, 21°29.6'W. This was the last mooring of our equatorial mooring array aimed at studying the role of the equatorial circulation for tropical Atlantic climate variability in the frame of the BMBF Verbundvorhaben "Nordatlantik".

After the successful installation of the mooring array, the zonal section along the equator commenced with combined microstructure und CTD/O_2 observations at 21°W. The distance between successive stations was chosen as 1° in longitude. We completed this section at 12°W during the night of June 24, and METEOR headed toward the southernmost point of the meridional section along 10°W.

Along the 10°W section, nine CTD casts were taken between 1°30'S and 1°30'N. In between, on June 26 at 11:00L, deployment of the French mooring as part of the PIRATA program was started. Following the drift test and topographic survey, the top element, including the PIRATA Workhorse ADCP, was launched smoothly into the water. At the second 2000m length of the parafil rope, the parafil slipped out of the fitting when leaving the capstan. The loose end was captured just before it went into the water (stopped by hand by the bosun and a crew member). We had to cut off about 30m of the parafil rope that were damaged during the rescue action. The 30m of parafil were replaced by 30m of 1/4'' wire. At 16:00L the anchor was dropped, and the final mooring position was estimated as 0°01.28'N, 09°51.23'W. As we were not completely sure that the other fittings would withstand the launch tension, we steamed in the direction of likely drift of the top elements in case of any broken rope, but no sightings were obtained. Thus, we concluded that the mooring had been successfully deployed.

On June 27 at 17:30L the zonal section along 2°N commenced with the first CTD/O_2 cast at 12°W. It was completed on June 30 at 19:30L with the last cast at 22°W. Along this westward cruise track, CTD stations were spaced apart by about 1° of longitude. METEOR headed toward 23°W, 1°N to continue the 23°W section that was interrupted for the eastern box limited by the section along the equator, 10°W, and 2°N. Near the equator, CTD stations were spaced apart by 20' of latitude, and by 30' of latitude starting at 3°N.

The mooring deployment at 5°N started early in the morning of July 1. This mooring contains one of the moored profilers that were delivered to Fernado de Noronha. Equipped with an oxygen sensor, it is aimed at studying the oxygen supply to the oxygen minimum zones in the eastern Tropical Atlantic. After a drift test and a survey with the multi-beam echo sounder, the top element including a Longranger ADCP was deployed at 06:30L. At about 09:30L the anchor was dropped exactly at the planned position, and submergence of the top element was observed about 20 min later. Following the mooring deployment, the section along 23°W was continued with CTD casts spaced apart by 30' of latitude. On July 7, 13:30L the 23°W section was completed at 15°15'N, only a few miles west of the island of Maio, Cape Verde. At this location, a calibration cast for the fluorometer to be moored north of Cape Verde was taken down to 200m with water samples about every 10m.

Early in the morning of June 8, we arrived at the location of our last mooring. After performing microstructure measurements and a CTD cast down to near bottom, the area was surveyed with the multi-beam echo sounder revealing a flat topography at almost exactly the target depth. The mooring operations ran very smoothly, and the anchor was dropped at the planned location. As we had attached a POSIDONIA release at the top element of the mooring, we were able to exactly track the final position of the mooring. It is: 17°35.39N, 24°15.12W. After tracking the top element, the release was activated and it was recovered together with the two Benthos flotation elements. The scientific work of METEOR cruise M68/2 ended at 16:30L and the ship headed toward Mindelo where the cruise ended on July 9, 09:00L (Fig. 2.1).

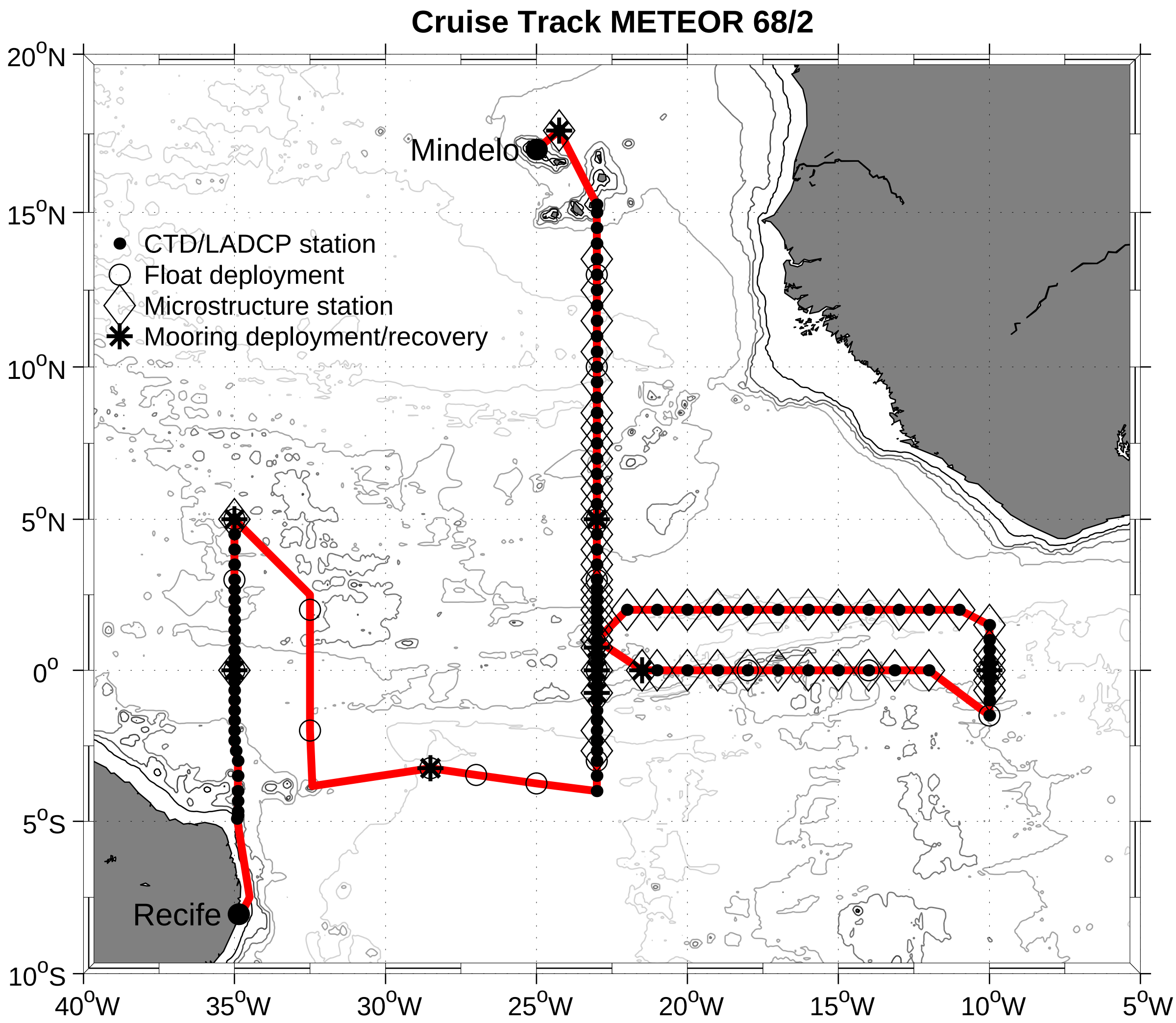

Fig. 2.1: Cruise track of METEOR cruise 68/2.

2.4 Preliminary Results

2.4.1 CTD measurements in the tropical Atlantic

(L. Stramma, A. Funk, V. Hormann)

2.4.1.1 Calibration and Data Quality of CTD and Oxygen Measurements

In total 115 CTD profiles were sampled during cruise M68/2 (Table 2.8). The CTD-system used during the METEOR cruise 68/2 was a Seabird Electronics Inc. of Bellevue, Washington, USA (SBE) 9 plus. The IFM-GEOMAR Kiel SBE-2 with serial number 09p24785-0612 was used. Connected was a pressure sensor (s/n 80024). Two independent sets of temperature, conductivity and oxygen sensors were used. The sensors of the primary set were a temperature sensor (s/n 2826), a conductivity sensor (s/n 2512) and an oxygen sensor, a Seabird SBE-43 sensor (s/n

0194) recording oxygen voltage but no oxygen temperature, as was the case in the former Beckman oxygen sensors. The secondary set of sensors was a temperature sensor (s/n 4547), a conductivity sensor (s/n 2859) and an oxygen sensor (s/n 0992). Starting from profile 51 also a fluorescence (Chlorophyll a) sensor was attached to the CTD but was not calibrated. A second Seabird CTD, IFM-GEOMAR SBE-4, was available as backup system, but was not used.

Routinely, CTD casts were made from surface to about 1300 m depth. Only stations located at a mooring position and two at the Brazilian shelf reached down to the bottom. Sound speed profiles derived from the deep casts were used as input for precise depth sounding at the mooring locations with the multi-beam echo sounder.

The monitor of the pinger used on earlier METEOR cruises to determine the bottom approach of the CTD was removed from the recording lab at the last stay at the shipyard. The only other monitor for the pinger had a broken power supply and was also not usable. The bottom alarm by a ground weight was not working reliably and on all three profiles of the 35°W section reaching to the bottom the CTD touched the bottom. Therefore, the missing monitor of the pinger is a strong limitation for the deep use of our CTD system. At the beginning the primary sensor system was used. At Profile 3 some unstable density layer appeared in the upper ocean. At Profile 16 the primary temperature and conductivity sensors showed large variability below about 2000 dbar while the secondary sensors stayed stable. Therefore, for processing the data only the sensors of the secondary sensor set were used. The pump of the primary sensor set was exchanged after Profile 16, and also the primary sensors worked well afterwards. Problems appeared at the beginning of the stations, as it took up to several minutes until the pump of the seabird system started. Flashing the sensors with salt water just before the start of the CTD solved this problem.

At Profile 24, the pump turned on but went off again during descent in the upper ocean and the upper 90 m of this profile can not be used. However, the upcast profile could be calibrated to replace the downcast CTD Profile 24. On Profile 45 a deep CTD profile was planned as this profile was close to a mooring which was recovered afterwards. Due to a problem with the winch cable the connection broke down at 1940 dbar, and the CTD cast was aborted.

The setup with two independent sensors was ideal to check the sensor behavior. While the older primary thermometer had a recent IFM-GEOMAR lab calibration, the new secondary thermometer had the original Seabird calibration. After applying the two independent calibrations to the sensors the temperature readings differed by less than 0.001°C. In addition recordings with electronic reversing pressure meters and reversing thermometers were made during the first part of the cruise to make sure that no jumps or drifts appeared.

The Seabird bottle release unit used with the rosette connected to the Seabird instrument worked properly and reliable except for 2 or 3 times, when one bottle did not close.

For calibration purposes several water samples were taken from the rosette bottles at most stations. Bottle salinities were determined with a Guildline Autosal salinometer (Guildline Instruments Inc, Smith Falls, Canada). A Guildline Autosal salinometer (Kiel AS7) was installed already at the beginning of leg M68/1. During M68/1 no reliable measurements could be made even after the installation of an additional stabilizer for the power supply. During M68/2 the same salinometer worked very well, although nothing was changed. Presently the only explanation is that during M68/1 electric equipment was used by one of the participating groups that disturbed the salinometer.

The CTD values to be calibrated were chosen from the downcast profiles to avoid hysteresis problems. Calibration of the SBE-2 secondary CTD conductivity sensor was carried out for the 115 profiles using a total of 214 dual samples. First some obviously bad values were tagged and removed. In addition, bad or erroneous data were rejected when exceeding 2.8 times the standard deviation of the conductivity difference. This criterion still includes 98% of the calibration data. After correcting the conductivity with respect to temperature, pressure and conductivity itself as well as for a time trend, the rms difference between the bottle and CTD conductivity samples was 0.0022 mS/cm, corresponding to 0.0020 in salinity.

Oxygen from the bottle samples was determined using the Winkler titration method. The calibration of the secondary oxygen sensor was done with a stronger limitation than for conductivity with a 1.8 rms criterion to place more emphasis on the reliable values. The calibration of oxygen was carried out with 569 samples used which met the 1.8 rms criterion. After correcting with respect to pressure and temperature as well as with respect to a time trend and pressure dependence and a relation to the oxygen values themselves and the oxygen value itself, the rms difference was 0.03 ml/l. As only a few stations reached to depth deeper than 1300 m, the oxygen calibration for the deep profiles was slightly less accurate (but better than 0.04 ml/l). With regard to the investigation of the oxygen minimum zones the CTD oxygen data turned out to be a high quality data set.

2.4.1.2 Oxygen minima distribution in the equatorial Atlantic

In the eastern tropical Atlantic, oxygen minimum zones (OMZs) exist in the depth range 200 to 800 m. The OMZs are a consequence of a combination of ocean ventilation, which supplies oxygen, and respiration, which consumes oxygen (e.g. Karstensen et al. 2007). Although the extrema of the oxygen minimum appear in the Guinea and Angola Dome regions at about 10°N and 10°S, the oxygen minimum at intermediate depth is clearly present near the equator. As the equatorial currents transport either oxygen-rich water to the OMZ or export oxygen-poor water from the OMZs, the circulation of the equatorial Atlantic is of large interest for the observed differences in oxygen distribution.

Cruise M68/2 covered a hydrographic box in the central equatorial Atlantic, with an eastward leg along the equator from 23°W to 10°W, and a westward leg at 2°N, closed by meridional sections at 23°W and 10°W. The meridional CTD-oxygen distributions clearly show a connection between equatorial oxygen minima and the off-equatorial OMZs. The oxygen distribution along the equator (Fig. 2.2) shows two well-separated cores of the oxygen minimum at about 260 m and 450 m depth. The cores stretch along the entire section of more than 1000 km, from 10°W to 23°W. The depth of these oxygen minimum cores corresponds well with the mean current field of the westward oriented Equatorial Intermediate Current (EIC) in Fig. 2.2. The current field derived from a mooring deployed at the equator at 23°W since 2004 shows a stable mean of the EIC, with two cores, however with a strong annual signal at these depths (Brandt et al., 2006). These observations highlight the role of the EIC in the oxygen budget of the OMZs arises from.

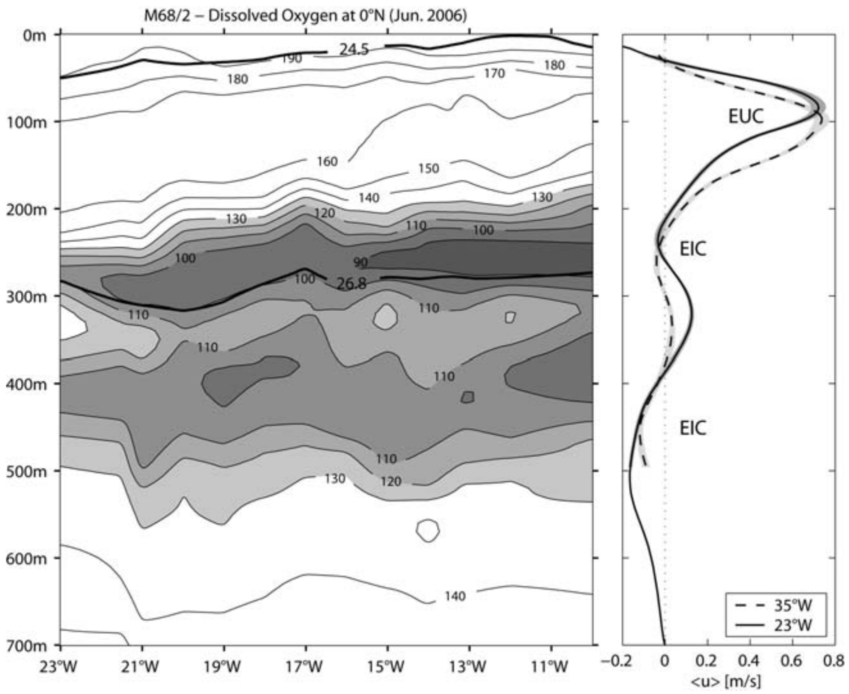

Fig. 2.2: Dissolved oxygen [μmol/kg] along the equator in June 2006. The thick black isolines (left panel) mark potential density surfaces, showing decreasing depth towards the east. The zonal velocity profiles (right panel) at 0°N, 23°W (solid) and 35°W (dashed) with standard error (shaded) were derived from moored instruments for the period March 2004 to February 2005.

In detail there are of course deviations from this mean scenario, for example the velocity distribution derived during June 2006 along the equator from the shipboard ADCP showed the EIC at depths of 450 to 600 m, while at 250 m depth eastward as well as westward currents were observed. The annual cycle calculated from 2 years of data shows a minimum strength of the EIC near June, explaining the difference between the velocity field and the oxygen distribution in June 2006. This further indicates that the water mass characteristics represent an integral part of the annual mean, even when the currents weaken or reverse for a short time period.

The EUC is known to shift from larger depth in the west to shallower depth in the eastern Atlantic. The signature of the upward movement is also visible in the oxygen distribution along the equator. The high oxygen water carried with the EUC eastward becomes slowly less oxygenated to the east as well as the vertical extent of the high oxygen water is reduced. A shallow isopycnal marked in Fig. 2.2 shows also well the upward shift toward east.

2.4.2 Current Observation

(T. Fischer, V. Hormann, A. Funk)

2.4.2.1 Ocean Surveyor: Technical aspects

The cruise saw two vessel-mounted RDI Ocean Surveyor ADCPs in use from June 7th to July 9th. One unit (75 kHz, OS75) is permanently fixed to the ship's hull, the second unit (38 kHz, OS38) was lowered into the well located in mid-ship and fixed hydraulically. Both units worked in narrowband mode, delivering current velocity to depths of up to 750m (OS75) and 1500m

(OS38). There were no interferences with the various acoustic devices on board, except the Doppler-Log (78 kHz) drastically reducing the depth range of Ocean Surveyor 75 to about 200 meters. The Doppler-Log's use was confined to the absolutely necessary minimum during mooring activities.

Both ADCP units were controlled by computers using VMDAS software version 1.40 under MS Windows NT. Pinging was as fast as possible (2.4 seconds for OS75; 2.85 seconds for OS38), single pings recorded in partitions of 100 bins @ 8m (OS75) resp. 50 bins @ 32m (OS38). Navigation information available to ADCP units and control computers were:

Heading from FibreOpticGyro (FOG) via synchro interface, binarily recorded with pings;
Position from ASHTECH GPS via synchro interface, binarily recorded with pings;
Position from ASHTECH GPS and heading, pitch and roll from ASHTECH array, seperately recorded as NMEA textstrings via serial interface.

For best results, ASHTECH heading and position were used to calculate current velocities from ADCP output. As short gaps of 2 to 5 minutes occurred in ASHTECH navigation data about twice or thrice a day, the slightly less accurate FOG heading and TRIMBLE GPS position (recorded by the ship's DVS-system) were used to fill the gaps. Position data from both GPS-sources are sufficiently accurate to recognize the distance between the antennas as well as the swell-induced antenna movement. During post processing, misalignment angle and amplitude factor for both transducers were obtained from water track calibration when the ship accelerated/decelerated. Standard deviations for misalignment angle were 0.46° (OS75) and 0.37° (OS38), for amplitude factor 0.01 (OS75) and 0.006 (OS38). These values match the data quality of previous cruises.

Beginning about June 17th, current velocities calculated from OS38 data exhibited increasingly steplike deviations without any pattern and not related to navigation, reaching their highest level about June 30th during the 2°N-section. These deviations could not be observed with OS75, and were presumably caused by slight movements of the OS38-transducer by less than 1°. After fixing the transducer to the well once more, the problem seemed to be solved.

2.4.2.2 Current sections

The Ocean Surveyor data were mapped on a regular grid, using a Gaussian weighted interpolation scheme, and a best estimate of the currents at 35°W, 32.5°W, 23°W, 10°W, 0°N and 2°N was obtained. The flow across these meridional and zonal sections is described briefly.

a) Meridional Sections

The 35°W section runs from 5°S to 5°N and shows clearly the banded structure of the near-surface zonal flow (Fig. 2.3). The EUC is centered at the equator, with its core at about 80 m depth and a velocity of about 100 cm/s. Below the EUC, there is an indication for the westward EIC. The South Equatorial Undercurrent (SEUC) is found between about 4.5°S and 3°S, with its core at about 200 m depth, and the North Equatorial Undercurrent (NEUC) is present at the northern boundary of the section. In the intermediate depth range, both the Southern and Northern Intermediate Countercurrents (SICC and NICC) are observed between about 1.5° and

3° S and N, respectively. The North Brazil Undercurrent (NBUC), here directed north-westward, shows up near the coast.

Due to time constraints, the first part of the 23°W section, running to 1°N, was limited to 4°S and the SEUC, which seems to have turned more southward compared to 35°W, was missed almost completely. After finishing the eastern equatorial box, the 23°W section was continued up to about 15°N 15' (Fig. 2.4). Both equatorial currents, the EUC and EIC, are still well developed at 23°W and there are clear indications for the SICC and NICC as well. To the north of about 3°N, two bands of the North Equatorial Countercurrent (NECC) are observed. While the first band extends up to about 7°N, the core of the second one is located at about 8°N.

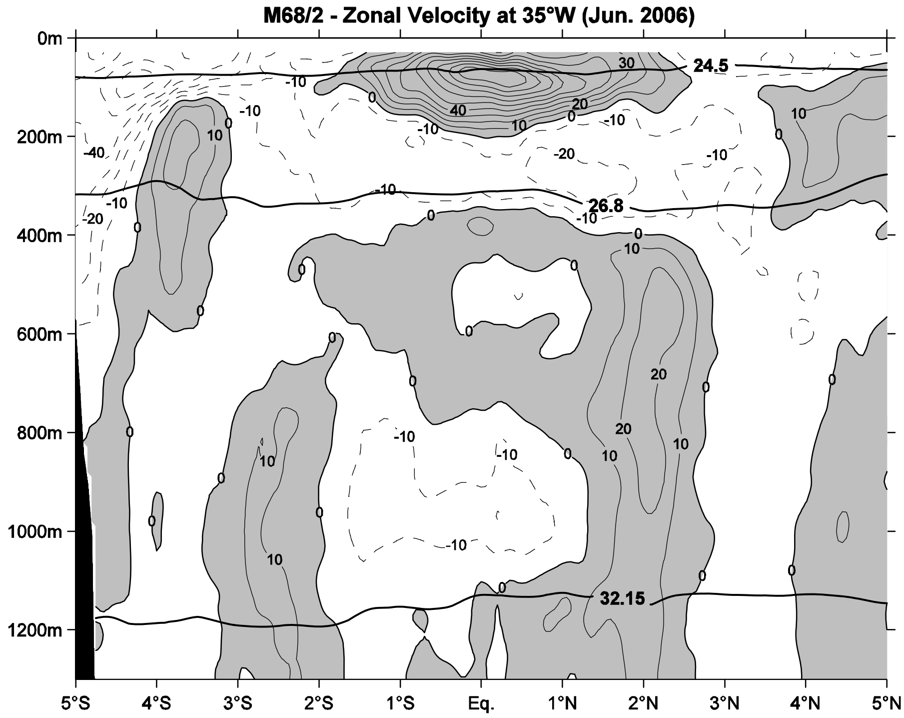

Fig. 2.3: Zonal velocity [cm/s] at 35°W from Ocean Surveyor; eastward currents in grey. Marked are isopycnals σ_θ = 24.5, σ_θ = 26.8 and σ_1 =32.15 [kg/m³] (thick solid lines).

b) Zonal Sections

The meridional sections at 23°W and 10°W show the EUC core shifted to the south of the equator, but nevertheless strong eastward velocities dominate the depth range of the EUC (upper 200 m; Fig. 2.5, upper panel). Underneath the EUC, a band of weak eastward velocities is observed down to about 400 m depth, but there are also indications for westward velocities at about 250 m depth. The prevailing westward velocities between about 400 and 700 m are attributable to the EIC. However, Brandt et al. (2006) showed the existence of two mean westward cores of the EIC below the EUC at 23°W, with a strong annual signal superimposed at these intermediate depths. Near June, the annual cycle reveals a minimum strength of the EIC, explaining the nearly missing upper core of this current at 0°N during June 2006. The alternating eastward and westward current bands below 400m are characterized by small vertical wavelengths typical for equatorial deep jets. These jets show a large zonal coherence along the equator.

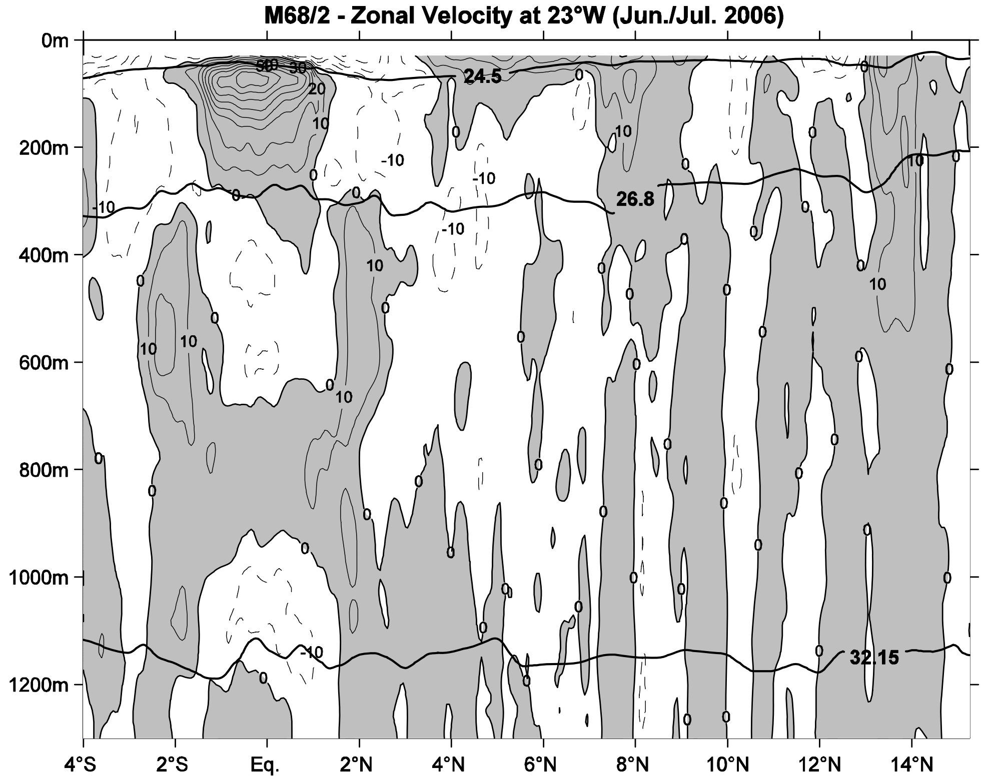

Fig. 2.4: Zonal velocity [cm/s] at 23°W from Ocean Surveyor; eastward currents in grey. Marked are isopycnals $\sigma_\theta = 24.5$, $\sigma_\theta = 26.8$ and $\sigma_1 = 32.15$ [kg/m³] (thick solid lines).

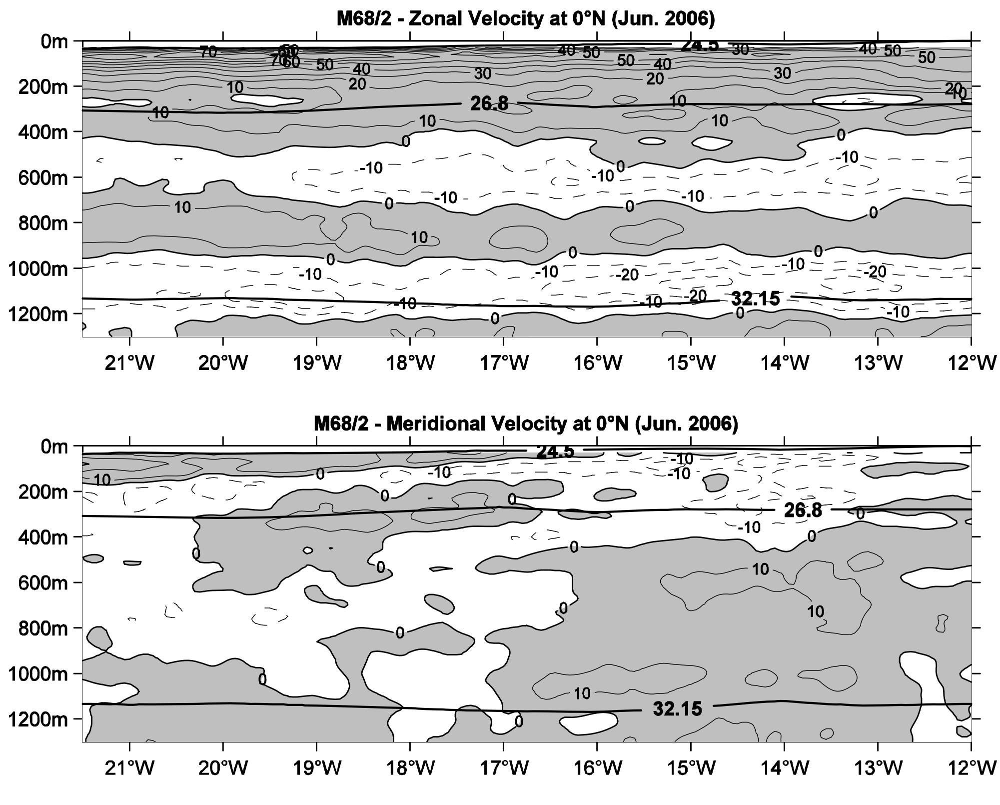

Fig. 2.5: Zonal (upper panel) and meridional (lower panel) velocity [cm/s] at 0°N from Ocean Surveyor; eastward and northward currents in grey. Marked are isopycnals $\sigma_\theta = 24.5$, $\sigma_\theta = 26.8$ and $\sigma_1 = 32.15$ [kg/m³] (thick solid lines).

2.4.2.3. Lowered ADCPs

(J. Schafstall, J. Fischer)

Different from the usual LADCP work the focus during M68/2 was to evaluate whether high frequency ADCPs may be used for turbulent mixing studies. For this purpose a 1200 kHz Workhorse ADCP was attached to the CTD-Rosette working in a downward looking mode. The first trials were with different vertical resolution and with beam velocities.

The first result was that the velocity variances increased in relation to the vertical resolution; short 25cm bins with high variance, and long 100cm bins with significantly lower variance. This is due to longer pulses and higher accuracy of individual pings at large depth cells.

After this first test we decided to use 50cm cells and 0.5s intervals as a compromise between range (larger at large depth cells) and storage required. This setting was used throughout the rest of the cruise at every CTD station except 3, where we used the classic LADCP procedure (2 * 300kHz ADCPs) and instrument tracking with METEOR'S Posidonia. This should enable a comparison of the LADCP estimate of Rosette motion with its measured path.

Inspection of the profiles revealed large tilt angles and consequently we tried to reduce these by appropriate ballasting. However, we got the impression that beside symmetrical ballasting total weight is also important (could not be tested). Remaining tilts were still relatively large (up to 10°).

First data inspection was performed by comparing down- and up-casts with the expectation that the up-cast should show much higher variance, as the ADCP measures within the turbulence field generated by the CTD package. In fact this was observed.

Treating the 4 beams as individual measurements of the turbulent flow field, we performed a statistical analysis of the variance in depth coordinates for comparison with the microstructure measurements. Vertical resolution was 5m depth cells. We inspected many profiles and found no reliable variance enhancement where one would expect these (e.g. in the shear layers of the EUC). There should be some additional analysis with focus on the turbulent layers detected in the microstructure data.

On three stations we tried to track the underwater package by Posidonia. Although undisturbed tracking was not possible, we think it might be feasible to extract valuable data. Remember, the LADCP processing aims at separating ocean currents from package motion in an inverse routine. Inclusion of a first guess of the latter could help to improve the inversion. This might be a step forward in LADCP processing.

2.4.3. Mooring Operations

(R. Zantopp, J. Fischer)

2.4.3.1 Recoveries

Mooring work during M68/2 consisted of the recovery of 4 moorings, and the deployment of seven moorings (Table 2.1). The mooring work began in the morning of June 9 with the recovery of mooring KR4 located just north of the equator at 35°W.

This mooring contained a RAFOS sound source and several current meters, ADCPs and Microcats to study the variability of the equatorial current system (EUC and EIC). After arrival at the mooring position, KR4 was released after successful acoustic ranging. The new digital

MORS deck unit worked well, but is extremely uncomfortable to use. All instruments came aboard in good shape, and all instruments contained full records.

During the morning of June 11 we recovered the sound source at 5°N, 35°W, which had not worked due to some unknown failure. Mooring work was rather routine and uncomplicated.

Several days later on June 15, we had scheduled the recovery of mooring KR2. At the mooring site the response from the Mors release unit was interfered with by another sound source (METEOR's multi-beam echo sounder), but after this was switched off we received a clear response from the single release in that mooring. However, after many release commands with a "receipt and execute" from the release we found the release still locked at its depth. We concluded that the release might be tangled in a wire loop preventing its ascent to the surface. As time did not permit any dredging operation we stopped the procedure and headed to the next CTD station. Hopefully, there will be another opportunity to recover this mooring.

Table 2.1 Mooring and Instrument Recovery during METEOR Cruise 68/2

Mooring KR4				**Notes**
Latitude	0	5.76	N	Combined current meter and sound source
Longitude	35	1.19	W	mooring north of 35W PIRATA mooring.
Water depth	4540			
Mag. Var.	-19.5			100% data recovery!
Deployment	8/13/2004	15:10		
Recovery	6/9/2006	13:10		
Item	Depth	Instr.	s/n	
KR4_01	146	Mini TD	41	good data
	146	RDI-SC	267	
KR4_02		150		good data
KR4_03	149	MicroCat	2249	good data
	151	RDI-SC	393	
KR4_04		150		good data
KR4_05	294	MicroCat	2251	good data
KR4_06	499	Argonaut	D294	good data
KR4_07	650	Mini TD	42	good data
KR4_08	652	Argonaut	D299	good data
	750	RAFOS	22	
KR4_09	809	Argonaut	D304	good data
KR4_10	962	MicroCat	3144	good data
KR4_11	1107	Argonaut	D329	good data

Mooring KR3				**Notes**
Latitude	5	0.00	N	Sound source mooring
Longitude	35	0.00	W	
Water depth	3753			
Mag. Var.	-19			
Deployment	8/11/2004	16:58		
Recovery	6/11/2006	13:20		
Item	Depth	Instr.	s/n	
	804	RAFOS	23	did not work

Mooring KR2				**Notes**
Latitude	3	14.03	S	Sound source mooring
Longitude	28	31.42	W	
Water depth	5100			

Mag. Var.	-19			
Deployment	5/17/2003	19:02		
Recovery	6/11/2006	13:20		Recovery failed
Item	Depth	Instr.	s/n	
	795	RAFOS	13	

French Mooring 23W Equ.				**Notes**
Latitude	0	0.01	S	
Longitude	23	7.51	W	
Water depth	3930			
Mag. Var.	-19.5			
Deployment	5/29/2005	16:55		
Recovery	6/19/2006	8:09		
Item	Depth	Instr.	s/n	
F2_01	49	ADCP WH 300	509	
F2_02	60	Mini TD	68	good data
F2_03	60	ADCP LR 75	2290	good data
F2_04	605	RCM-4	5486	data not read
F2_05	755	RCM-4	4445	data not read
F2_06	905	RCM-4	4587	data not read
F2_07	1055	RCM-4	5891	data not read
F2_08	1205	RCM-4	4588	data not read
F2_09	1355	RCM-4	5897	data not read
F2_10	1505	RCM-4	5899	data not read

2.4.3.2 Deployments

All deployments had a deep CTD cast (for obtaining a precise estimate of the sound speed profile), followed by a bathymetric survey with METEOR's multi-beam echo sounder and a mooring deployment simulation (drift test).

Deployments began with mooring AO_03 during the afternoon of June 18 after a deployment simulation (drift test) and a detailed survey of the topography. We found a well suited area of flat bottom and determined the target location. Mooring work was planned for 3 hours at a deployment speed of about 2.5 kn SOG while METEOR headed against south-easterly winds. Currents appeared to be mainly southwest, and the resulting deployment track was to the south. The actual deployment took a little less than three hours, and we had to tow the mooring to the anchor drop position.

Mooring AO_01, on June 19, was the second and most densely equipped mooring (2 ADCPs, McLane Profiler, current meters and Microcats). During the deployment, which began similar to the previous deployment, some unexpected difficulties arose from a combination of the mooring design and the current field. Apparently the 2500m long wire segment along which the profiler should move, hung down so deep that it was pulled sideways by the EUC. The wire on the stern of the ship moved sharply to the port side and was in danger of being cut by the microstructure winch. It took some time and extreme maneuvering to straighten out the wire behind the ship. However, after a rather long towing operation, we were able to drop the anchor almost as planned. Submergence was determined from the cessation of the ARGOS watchdog data stream.

AO_02 is the second (northern) off-equatorial mooring and was deployed at 0° 45.00’N, 22° 59.50’W on June 20. The deployment followed the usual drift test and a detailed bathymetric survey. The whole deployment procedure took 4.7 h, including an observation of the top element submerging. AO_04 was the second (eastern) equatorial mooring deployed on June 21 at 0° 00.00'N, 21° 29.60'W. The anchor drop position was as planned, and the top element was observed as it went under.

Mooring FR_10W was deployed for our French colleagues in the PIRATA framework. It contained only one WH-ADCP and a MORS rotor current meter. However, during deployment we experienced some accidental shortcomings. Firstly, the ARGOS beacon was apparently not transmitting (either defect, or batteries not connected). Secondly, one wire shot of 25m was put into wrong place (not affecting instrument depth). However, a dramatic event occurred at the last Kevlar termination when the wire separated from the termination, and the deck crew just managed to secure the end before it went into the sea. We had to cut 30m of Kevlar and made a new termination which was tension tested prior to deployment. To compensate for the 30m end we put in a 30m ¼'' wire shot. However, there was some anxiety when the anchor was dropped. We were not able to observe the descent of the mooring top after the anchor drop, and we surveyed the area along the likely surface drift. Nothing was detected and we concluded that the mooring was deployed successfully. An attempt to talk to the release was also non-conclusive, as we received only two acoustic signals within the correct range.

Mooring AO_05 was deployed in the early morning of July 03, 2006. The deployment proceeded extremely well, and after three hours the anchor was dropped as planned (see Table 2.2). We were able to observe the descent of the top element from near by, with the radio signal ceasing at that moment.

Cape Verde Mooring V440 was deployed on the last day of the scientific work during M68/2. Topographic survey and deployment simulation were as during the other deployments. We began to deploy the mooring at 10:00L (11:00 UTC), and the duration was scheduled for 4.5 hours. Already after 3.5h of very smooth operation the anchor was on stand-by, but we had to tow quite a while before anchor drop 17° 35.66'N, 24° 14.98'W at 15:56 UTC. On top of the mooring we mounted a Mors Release with transponder mode for tracking the mooring with METEOR's Posidonia system. Final depth of mooring top was 30 m (designed for 40 m), and its final position was 17° 35.39'N, 24° 15.12'W. After tracking the mooring we released the monitoring element and recovered it a few minutes later. At about 17:30 UTC mooring work was completed.

Table 2.2 Deployment Tables

Mooring Deployment Equatorial Atlantic AO_01					**Notes:**
Vessel:	METEOR				
Deployed:	19-Jun	2006	19:53		
Vessel:					
Recovered:					
Latitude:	0	0.001	S		
Longitude:	23	6.800	W		
Water depth:	3931	Mag Var:	-16.3		
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**	
		Argos WD	11278		
	126	ADCP WH up	508	**x**	
	126	Mini-TD	24		
	130	Microcat	52	**x**	
	234	Microcat	55	**x**	

	399	Microcat	278	**x**			
	621	ADCP LR up	2395	**x**			
	687	RCM-8	9930	**x**			
	842	Argonaut	D182	**x**			
	998	RCM-8	9964	**x**			
	2264	M-CTD MMP	120	**x**			
	3573	Release	174	Code:	9337	**9339**	**A**
	3573	Release	110	Code:	E972	**E974**	**A**
					Interrogate	Release	Mode

Mooring Deployment Equatorial Atlantic AO_02					**Notes:**		
Vessel:	METEOR						
Deployed:	20-Jun		2006 15:25				
Vessel:							
Recovered:							
Latitude:	0	45.000	N				
Longitude:	22	59.500	W				
Water depth:	4310	Mag Var:	-16.0				
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**			
		Argos WD	15172				
	51	Mini-TD	24				
	87	Microcat	381	**x**			
	138	Microcat	780	**x**			
	200	Microcat	921	**x**			
	301	ADCP 150 up	589	**x**			
	301	Mini-TD	11				
	397	RCM-8	9346	**x**			
	552	RCM-8	9932	**x**			
	697	RCM-8	5881	**x**			
	851	Argonaut	D143	**x**			
	1007	RCM-8	8412	**x**			
	3632	Release	188	Code:	8181	**8182**	**B**
	3632	Release	189	Code:	8183	**8184**	**B**
					Interrogate	Release	Mode

Mooring Deployment Equatorial Atlantic AO_03					**Notes:**
Vessel:	METEOR				
Deployed:	18-Jun		2006 18:21		
Vessel:					
Recovered:					
Latitude:	0	44.950	S		
Longitude:	22	59.710	W		
Water depth:	3700	Mag Var:	-16.5		
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**	
		Argos WD	15173		
	47	Mini-TD	22		
	83	Microcat	922	**x**	
	144	Microcat	925	**x**	
	205	Microcat	936	**x**	
	307	ADCP 150 up	267	**x**	
	307	Mini-TD	27		
	403	RCM-8	9816	**x**	
	558	RCM-8	9349	**x**	

	702	RCM-8	9819	**x**			
	857	Argonaut	D145	**x**			
	1013	RCM-8	9820	**x**			
	3132	Release	190	Code:	8185	**8186**	**B**
	3132	Release	220	Code:	9151	**9152**	**B**
					Interrogate	Release	Mode

Mooring Deployment Equatorial Atlantic AO_04					**Notes:**		
Vessel:	METEOR						
Deployed:	21-Jun	2006	18:00				
Vessel:							
Recovered:							
Latitude:	0	0.000	S				
Longitude:	21	29.600	W				
Water depth:	4950	Mag Var:	-15.8				
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**			
		Argos WD	2254				
	48	Mini-TD	73				
	81	Microcat	1281	**x**			
	142	Microcat	1282	**x**			
	204	Microcat	1583	**x**			
	455	ADCP LR up	2627	**x**			
	455	Mini-TD	61				
	459	Microcat	1599	**x**			
	553	RCM-8	10501	**x**			
	708	RCM-8	11621	**x**			
	852	RCM-8	9818	**x**			
	1007	Argonaut	D184	**x**			
	4291	Release	428	Code:	2457	**2459**	**B**
	4291	Release	635	Code:	3A95	**3A96**	**A**
					Interrogate	Release	Mode

Mooring Deployment Equatorial Atlantic AO_05					**Notes:**		
Vessel:	METEOR						
Deployed:	3-Jul	2006	11:36				
Vessel:							
Recovered:							
Latitude:	5	0.900	N				
Longitude:	23	0.000	W				
Water depth:	4210	Mag Var:	-14.5				
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**			
		Argos WD	5461				
	57	ADCP LR dn	3173	**x**			
	57	Mini-TD	62				
	103	Microcat	1682	**x**			
	616	M-CTD MMP	11617	**x**			
	1044	Microcat	2478	**x**			
	1045	RCM-8	10779	**x**			
	3513	Release	441	Code:	8A03	**8A04**	**B**
	3513	Release	633	Code:	3A91	**3A92**	**A**
					Interrogate	Release	Mode

Mooring Deployment Equatorial Atlantic FR_10W					**Notes:**
Vessel:	METEOR				
Deployed:	26-Jun	2006	1:57		
Vessel:					
Recovered:					
Latitude:	0	1.280	S		
Longitude:	9	51.230	W		
Water depth:	5205	Mag Var:	-10.2		
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**	
		Argos WD	66366		
	140	ADCP WH up	509	**x**	
	200	Mors MC3X0	129/92	**x**	
	5150	Release	113		

Mooring Deployment Cape Verde V440-01					**Notes:**
Vessel:	METEOR				
Deployed:	8-Jul	2006	15:56		
Vessel:					
Recovered:					
Latitude:	17	35.390	N		
Longitude:	24	15.120	W		
Water depth:	3601	Mag Var:	-11.2		
ID	**Depth**	**Instr. type**	**s/n**	**Startup log**	
		Argos WD	5510		
	40	Microcat	3753		
	40	Fluorometer	269		
	62	Microcat	3752		
	81	Microcat	1162		
	103	ADCP WH up	1522	**x**	
	103	Microcat	3755		
	127	RCM-11	325	**x**	
	127	Optode	349		
	129	Microcat	2252		
	200	RCM-8	10810	**x**	
	202	Microcat	2255		
	302	Microcat	3754		
	400	Microcat	2256		
	500	Microcat	2254		
	602	RCM-8	11622	**x**	
	603	Microcat	3415		
	753	Microcat	2257		
	899	Watchdog	2265		
	899	Watchdog	11307		
	900	RCM-8	11265	**x**	
	902	Microcat	2279		
	999	Sediment Trap	97150		
	1002	Microcat	3757		
	1151	Microcat	1550		
	1299	RCM-8	11267	**x**	
	1301	Microcat	1269		
	1498	Microcat	2717		
	1749	Mini-TD	63		
	2001	RCM-8	10818	**x**	

	2003	Microcat	1268				
	2249	Mini-TD	64				
	2500	Microcat	2933				
	2748	Mini-TD	65				
	3003	RCM-8	10776	**x**			
	3005	Microcat	2617				
	3250	Mini-TD	72				
	3511	Microcat	2618				
	3563	Microcat	2472				
	3565	Release	108	Code:	E962	**E964**	**A**
	3565	Release	821	Code:	4AA7	**4AA8**	**A**
					Interrogate	Release	Mode

Microcat / CTD calibration:

Six sets of calibrations were performed for Microcats in order to check their factory settings. The instruments were set to a faster sampling rate (10 sec vs. the normal 15 or 30 min) and mounted on the CTD rosette which was lowered to the ocean bottom during a regular CTD cast. Five to six stops of 4 minutes each (2 minutes during first two stations) were made during the upcast to allow for a stabilized equilibrium. A linear fit was performed for temperature, conductivity and pressure data (where available) from the Microcat and CTD instruments, and resulting rms differences are indicated (see Table 2.3). Some Microcats were equipped with pressure sensors. Three instruments (s/n 2249, 2251, 3144) were done post deployment, all others were done in preparation prior to deployment.

Table 2.3 Results of linear fits

CTD	S/N	Temperature			Conductivity			Pressure		
No.		Bias	Slope	RMS	Bias	Slope	RMS	Bias	Slope	RMS
24	52	-0.0004	0.9993	0.0083	0.0939	0.9972	0.0169			
24	55	-0.0048	1.0001	0.0075	0.0838	0.9976	0.0142			
24	925	-0.0044	0.9998	0.0086	0.1485	0.9946	0.0316			
24	936	-0.0025	0.9996	0.0080	0.1789	0.9937	0.0265			
24	1583	0.0004	0.9991	0.0113	0.0527	0.9980	0.0164			
24	1599	-0.0023	0.9995	0.0102	0.0496	0.9985	0.0142			
24	1682	0.0009	0.9988	0.0124	0.0723	0.9978	0.0193			
24	2478	0.0016	0.9992	0.0118	0.0594	0.9982	0.0176			
24	2614	0.0039	0.9988	0.0137	0.0828	0.9976	0.0215			
26	278	-0.0053	0.9997	0.0062	0.0626	0.9972	0.0415			
26	381	0.0046	0.9998	0.0054	0.0095	0.9981	0.0463			
26	780	-0.0054	1.0004	0.0051	0.1164	0.9951	0.0388			
26	921	-0.0031	0.9998	0.0042	0.0392	0.9979	0.0311			
26	922	-0.0065	1.0003	0.0054	0.0494	0.9971	0.0393			
26	1281	-0.0009	0.9994	0.0040	0.0775	0.9963	0.0361			
26	1282	-0.0065	1.0004	0.0053	0.0142	0.9984	0.0368			
26	2249	0.0015	0.9994	0.0034	0.0332	0.9981	0.0110			
26	2251	-0.0039	1.0000	0.0048	-0.0199	1.0000	0.0175			
26	3144	-0.0008	0.9996	0.0039	0.0426	0.9984	0.0128			
53	3754	-0.0010	0.9998	0.0043	-0.0110	1.0000	0.0041	0.4081	0.9992	1.4083
53	3757	-0.0004	0.9997	0.0037	0.0018	0.9995	0.0039	-0.6978	1.0017	1.1569
73	2252	0.0030	0.9992	0.0080	-0.0596	1.0014	0.0197			
73	2255	0.0019	0.9994	0.0076	-0.0639	1.0015	0.0237			
73	3752	0.0029	0.9991	0.0086	-0.0801	1.0019	0.0255	1.5894	0.9999	0.4151

73	3753	0.0042	0.9991	0.0099	-0.0750	1.0018	0.0237	1.7997	0.9996	0.3944
73	3755	0.0034	0.9993	0.0077	-0.0784	0.1002	0.0240	0.5217	0.9976	0.4270
74	1162	0.0091	0.9970	0.0143	0.0599	0.9977	0.0137			
74	2254	0.0086	0.9971	0.0150	0.0804	0.9971	0.0141			
74	2256	0.0089	0.9969	0.0158	0.1081	0.9963	0.0140			
74	2257	0.0085	0.9969	0.0151	0.0943	0.9961	0.0140			
74	2279	0.0060	0.9974	0.0151	0.0769	0.9975	0.0136			
74	3415	0.0062	0.9974	0.0148	0.0456	0.9981	0.0134	0.4664	1.0015	0.7170
91	1268	-0.0015	0.9996	0.0021	0.0845	0.9973	0.0039			
91	1269	-0.0006	0.9997	0.0022	0.0579	0.9982	0.0045			
91	1550	0.0004	0.9995	0.0020	0.2055	0.9936	0.0025			
91	2472	0.0033	0.9996	0.0025	0.2140	0.9933	0.0029			
91	2617	0.0019	0.9997	0.0021	0.2176	0.9932	0.0029			
91	2618	0.0038	0.9995	0.0022	0.2250	0.9930	0.0028			
91	2933	0.0009	0.9993	0.0020	0.2242	0.9929	0.0026			
91	2717	0.0008	1.0002	0.0020	-0.0260	1.0004	0.0020	3.7863	1.0006	0.2834

It is evident that some batches (casts 26 and 73 for conductivity in particular) are worse than others. However, no reason was evident for this abnormal result. As no time was available to perform another set of calibrations prior to the instrument deployment during this cruise, we suggest that a careful post-deployment calibration be done after the instruments are retrieved.

Wetlabs Fluorometer

(N. Gülzow, J. Fischer)

A Wetlabs Fluorometer is installed in the top element of mooring V440. This had to be calibrated versus filtered water samples. These were taken during our approach to the Cape Verde Islands on a separate 200m CTD cast (Station 114). We took twelve water samples centered on the subsurface chlorophyll maximum that was determined during the downward cast – this covers the depth range at which the Fluorometer will be located in the mooring. The Fluorometer was attached to the CTD rosette with a clear downward view of its optics. By this procedure we also get a rough calibration of the SBE fluorescence sensor of the CTD.

By relative scaling (Fig. 2.6) a comparable profile structure is evident and it should be possible to get a good pre-deployment calibration. However, temperature is way off and needs calibration too.

ADCP data treatment

ADCP data from both instruments from the equatorial station at 23°W (continued by AO_01) have been combined to a continuous data set with all gaps eliminated by interpolation. This processing is described as follows:

Horizontal velocities from both ADCP’s are corrected for their compass deviation (location and time correction by mag_dev.m). Data ensembles with less than 20% good pings are eliminated prior to further processing routines. Then data are projected from bins (distance relative to transducer heads) to depth cells by using the pressure sensor information of the ADCPs and an attached Mini-TD-probe. Vertical resolution is 4m for both ADCPs; this corresponds to the original distribution of 4m for up-looking Workhorse ADCP and an oversampling of the 16m bins of the down-looking LongRanger ADCPs.

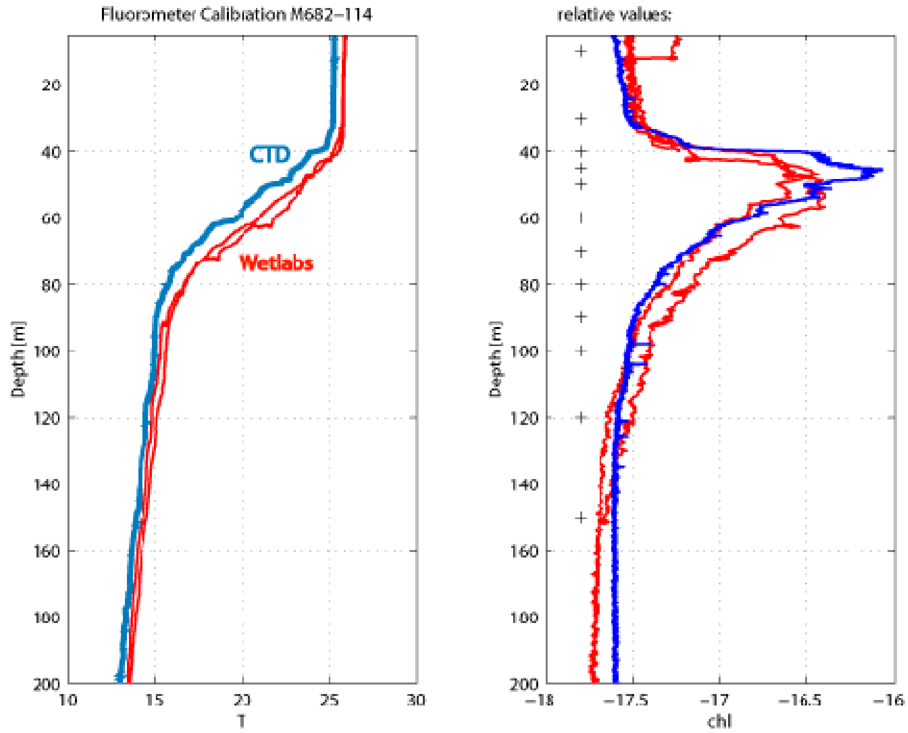

Fig. 2.6: Calibration cast of Wetlabs Fluorometer compared to CTD Station 114. Left: temperature [°C] (sensors close together); right: fluorometer outputs scaled for comparison. Units are relative and need to be calibrated versus filtered water samples. Depths of water samples are marked by plus signs

The data sets are interpolated to an equal time base (necessary due to incorrect times in the Workhorse ADCP), and merged into a combined data set. The combined data set has variable limits due to mooring motion and a gap of some 20m (distance between transducers of 11m plus blanking distance). These gaps were closed by a an advanced Lagrangian interpolation algorithm called **fillmiss.m** available in the Matlab SAGA toolbox. An attempt was made to estimate the accuracy of this procedure by using the end product (interpolated data set as a reference) and introducing a similar gap but with different temporal distribution. This gap was then filled by **fillmiss.m** and the result was compared to the reference. Statistics showed a negligible mean difference (<1cm/s) and a standard deviation of about 3-5cm/s, which appears small relative to the mean speed of the EUC. Another comparison was done with the shipboard ADCP data at times of the mooring recovery. In the next step the gridded data (4m resolution, 1h Intervals) are detided, as there is evidence of substantial tidal flow. Data were low passed at 40h and sub sampled to 12h resolution. Combining the data from the 2004 and 2005 deployments we found the transition from one year to the other suspicious – especially in the meridional component – presumably due to non-perfect compass calibrations of the shallow ADCPs. Several tests were performed with the most stable result from a comparison of the VM-ADCP data and the mooring data. This comparison led to misalignment angles of -6° for the 2004-2005 WH-ADCP and of +6° for the 2005-2006 WH-ADCP. Data from the deeper LongRanger ADCPs seemed to be unaffected (may be masked by the much smaller zonal component), thus no correction was applied to these. – The effect of misalignment is large only when the current speed is large as in the EUC. The effect of this rotation to the mean zonal speed (EUC) is relatively small, of the order of 1cm/s compared to a mean of 70cm/s. WH-ADCP data were corrected accordingly and the whole procedure repeated, yielding the cleaned and sub-sampled final data set suitable for further processing. NB-ADCPs at 35°W also gave the impression of a misalignment angle of -8° compared to OS75 data. However, this appears to be only valid for the relatively short period of the comparison. This leads to unrealistic mean meridional flow structure, and we therefore decided not to rotate the moored ADCP data.

MMP – McLane Moored Profiler

The MMP is a modern observing platform for physical and chemical in-situ measurements over long time intervals. Powered by lithium batteries an electric motor drives a friction wheel for climbing the mooring wire up and down at slow speeds. One million meters is the total range, e.g. 200 profile pairs of 5000m total length (2500m up and down, respectively) can be performed.

During M68/2 we had two of these instruments aboard – we finally got them at Fernando de Noronha – one of them from John Toole (WHOI) and the second one with an additional oxygen sensor (our own). The Toole instrument is used to study equatorial deep jets and is incorporated in our equatorial mooring AO_01 for profiling between 1000m and 3500m on a 4 day profile pair schedule. The position of this mooring is estimated at 0° 00.00'S, 23° 06.80'W. Our own profiler is the core element in mooring AO_05 at 05° 00.90'N, 23° 00.00'W (Fig. 2.7).

The schedule of this instrument calls for paired profiles every 1.6 d. This schedule obtains a full daily cycle every 5 profile pairs or 8 days, and an inertial period of 5.7 days is sampled by 3 to 4 profile pairs. Up- and down profiles follow each other with just a short break in between, and the instrument parks itself in between profile pairs at about 1000m, the lower stop of the profiling range. The LongRanger ADCP serves two purposes, first it will provide an excellent reference for the current measurements of the profiler including tides, and secondly it will give detailed measurements of the NEUC/NECC flow at that location. The Seabird Microcats above and below the profile range as well as the Aanderaa Rotor Current Meter will also be used as references for the CTD and current measurements of the moored profiler.

Fig. 2.7: Mooring AO_05 with full instrumentation, MMP, LongRanger ADCP, Aanderaa Rotor Current Meter, and two Seabird Microcats.

2.4.3.3 Selected Results

The Equatorial Mooring at 35°W had two ADCPs, one up-, and one downward-looking. Both had full, almost two year long data sets that were processed and merged as described under Section "ADCP data treatment".

At both locations the flow in zonal direction is dominated by the intense EUC, reaching about 0.7m/s as a deployment long mean (Fig. 2.8). The most obvious time scale of the zonal variability is the annual cycle, which has maximum flow and is nearest to the surface in northern spring. Beside the intensity of the flow, the EUC core shows significant annual depth variability with its deepest expression around September/October. Below the EUC, the EIC has two stable mean cores at both longitudes – here we expect a clue on the existence of a mean EIC and its seasonal cycle.

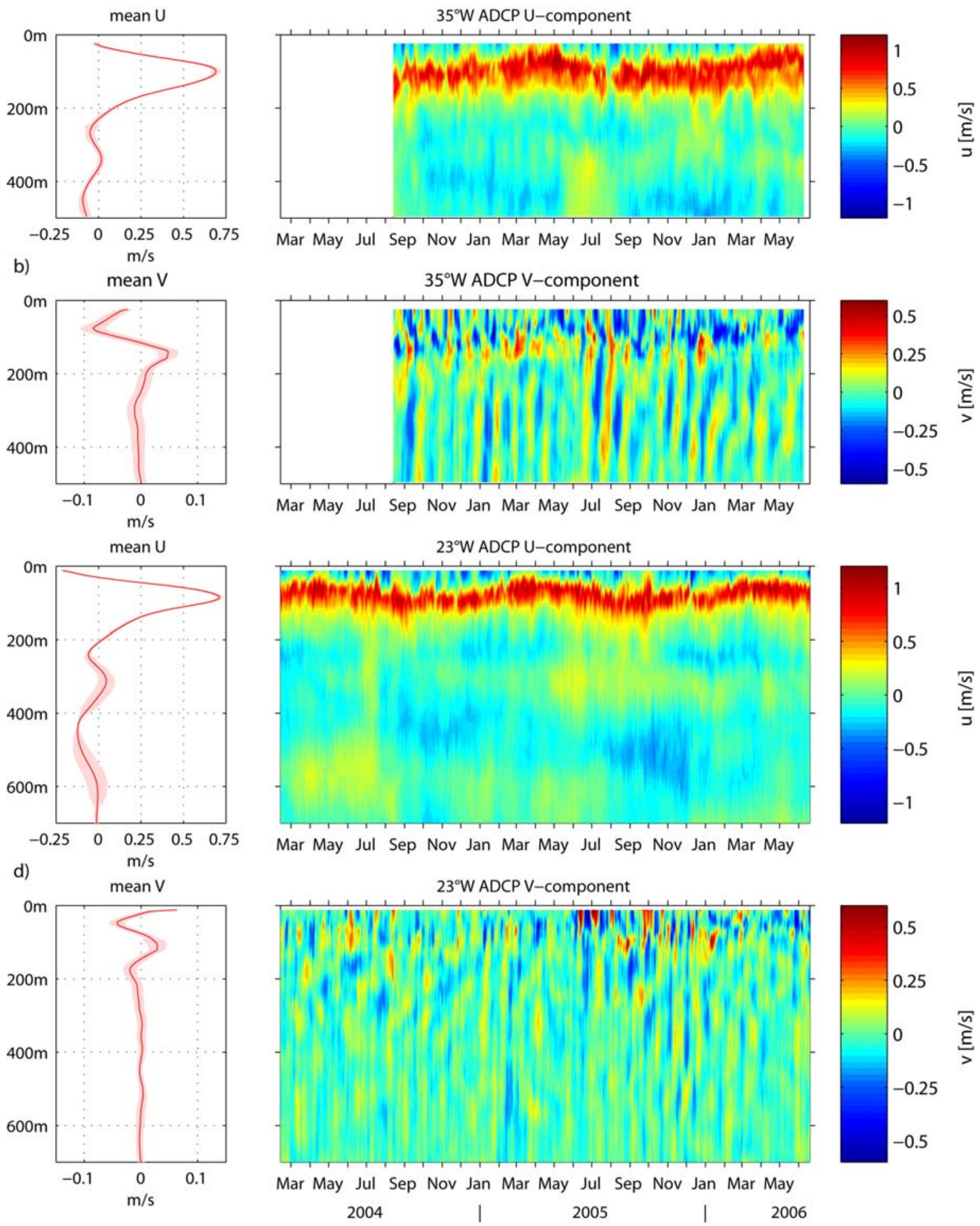

Fig. 2.8: Zonal (a) and meridional (b) velocity at the equator, 35°W from two Narrow-Band 150kHz ADCPs, and zonal (c) and meridional (d) flow at the equator, 23°W from 300kHz WH-ADCP and 75kHz LongRanger ADCP. Data are detided, data gaps in between the instruments were interpolated. The mean flow is calculated by subtracting the annual and semiannual harmonics (solid red line, left panels) with standard error (shaded).

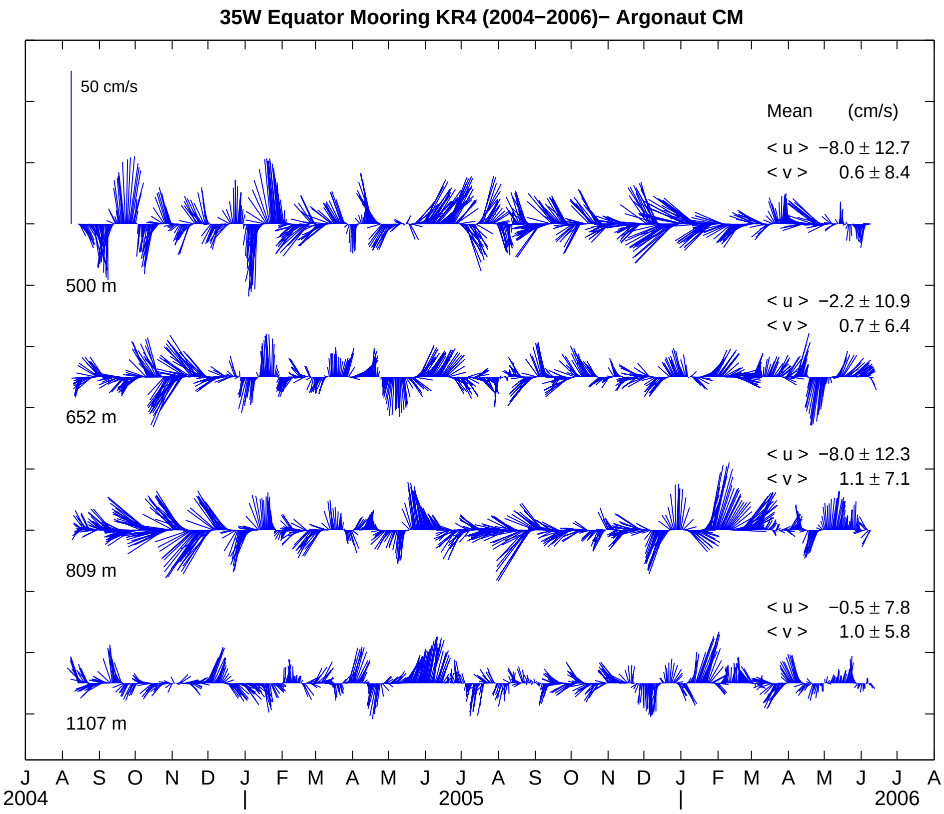

Fig. 2.9: Current vector time series from 4 Argonaut current meters at 35°W. Deployment long means and standard deviations are displayed in graph.

The meridional components look totally different and are dominated by high frequency equatorial wave activity. This extends throughout the measurement range (at 35°W these can be clearly seen in the records of the deep (up to 1000m) current meter records (Fig. 2.9). The wave activity also exhibits seasonality (maximum in northern summer) and interannual variability (much stronger in 2005 than in the year before).

In terms of data quality we were able to compare the downward looking ADCP with data from one of the Argonaut current meters. Both instruments show good agreement in the overlapping range. The zonal and meridional components show no significant differences, indication that current amplitudes and direction are of good quality in both instruments. Especially the compasses of the ADCPs have to be treated with great care when performing a quantitative analysis of the meridional flow of the upper layers (see ADCP data treatment).

2.4.4. ARGO Float Deployments

(B. Rabe)

During M68/2 a total of 18 isobaric profiling drifters (floats) were deployed, as shown in Table 2.4. 15 of these of type APEX are part of the sub-project TROPAT within the German ARGO program. These were placed in order to fill gaps in the existing ARGO profiling array and maintain the almost 2700 floats deployed to date, placing floats a minimum of 3° longitude and latitude apart. The APEX are manufactured by Webb Research, Inc. and are all set to profile

2000m, while the drift depth is set to 1500m or 200m. The shallow floats are meant to give further insight into the shallow tropical-subtropical circulation. In addition to sensors for measuring in-situ temperature, salinity (conductivity) and pressure, using a SeaBird CTD sensor, some also carry an Aandera Optode to measure oxygen concentration in the water.

Further floats were deployed on behalf of other research groups: Two 1000m drifting SOLO floats for Woods Hole Oceanographic Institution and one PROVOR for the chemistry group at IFM-GEOMAR. The latter, equipped with a CTD and an oxygen sensor was deployed around 10°N and 23°W, close to a mooring location, and is meant to capture the supply of oxygen-rich water to the oxygen minimum zones closer to the African coast.

Table 2.4 Profiling float deployment positions during M68/2

Float S/N	*WMO*	*ID (DEC)*	*Date*	*Time*	*Longitude*	*Latitude*	*Sensors*	*Depth Park*	*Depth Profile*
2472	1900653	60444	09.06.06	15:56 UTC	35 ° 01.24 ' W	0 ° 03.44 ' N	T/S/P	200	2000
579	WHOI SOLO		10.06.06	20:30 UTC	34 ° 59.38 ' W	3 ° 01.19 ' N	T/S/P	1000	1100
2484	1900650	56452	11.06.06	14:09 UTC	35 ° 00.26 ' W	4 ° 59.24 ' N	T/S/P/O2	200	2000
2477	1900658	60449	12.06.06	17:24 UTC	32 ° 30.03 ' W	1 ° 59.99 ' N	T/S/P	1500	2000
2478	1900659	60450	13.06.06	22:25 UTC	32 ° 29.96 ' W	2 ° 00.06 ' S	T/S/P	1500	2000
2479	1900660	60451	15.06.06	13:22 UTC	28 ° 30.88 ' W	3 ° 14.73 ' S	T/S/P	1500	2000
2473	1900654	60445	15.06.06	22:42 UTC	27 ° 00.15 ' W	3 ° 27.80 ' S	T/S/P	200	2000
599	WHOI SOLO		16.06.06	09:07 UTC	24 ° 59.52 ' W	3 ° 44.53 ' S	T/S/P	1000	1100
2480	1900661	60452	17.06.06	08:20 UTC	22 ° 59.97 ' W	3 ° 00.09 ' S	T/S/P	1500	2000
2485	1900651	56453	19.06.06	11:15 UTC	23 ° 10.94 ' W	0 ° 01.42 ' S	T/S/P/O2	200	2000
2483	1900664	60455	23.06.06	00:18 UTC	18 ° 00.78 ' W	0 ° 00.53 ' S	T/S/P	1500	2000
2481	1900662	60453	24.06.06	11:34 UTC	14 ° 00.52 ' W	0 ° 00.21 ' N	T/S/P	1500	2000
2475	1900656	60447	25.06.06	19:25 UTC	10 ° 00.00 ' W	1 ° 30.00 ' S	T/S/P	200	2000
2482	1900663	60454	26.06.06	22:32 UTC	9 ° 58.57 ' W	0 ° 01.53 ' N	T/S/P	1500	2000
2476	1900657	60448	02.07.06	05:45 UTC	22 ° 59.55 ' W	2 ° 59.38 ' N	T/S/P	1500	2000
2486	1900652	60443	03.07.06	12:05 UTC	22 ° 59.60 ' W	5 ° 02.20 ' N	T/S/P/O2	200	2000
PROVOR	1900120	52551	05.07.06	14:06 UTC	23 ° 00.85 ' W	9 ° 59.09 ' N	T/S/P/O2	500	2000
2474	1900655	60446	06.07.06	16:00 UTC	23 ° 00.49 ' W	13 ° 00.07 ' N	T/S/P	200	2000

2.4.5. Microstructure mesurements

(U. Koy, J. Schafstall)

In total 202 MSS profiles were sampled during METEOR cruise 68/2 at 60 stations, normally 3 profiles per station (Table 2.5). The microstructure profiling system (MSS) used during the cruise was manufactured by ISW-Messtechnik in collaboration with SEA and Sun Technology (Trappenkamp, Germany) and consists of a profiler, a winch and a data interface. The profiler can operate 16 channels with a very high data transmission rate (1024 Hz) that is sufficient to resolve the small vertical scales of turbulent dissipation in the ocean. It is equipped with two shear sensors (airfoil, 4ms response time), a fast-responding temperature sensor (microthermistor FP07, 12 ms response time), an acceleration sensor, a fast conductivity sensor and typical conductivity, temperature, depths sensors that sample at a lower frequency (24 Hz), in addition we used an oxygen sensor (for details see Table 2.5).

Table 2.5 Microstructure Station overview

MSS Station	METEOR Station	CTD Cast	Date (UTC)	Time (UTC)	Latitude [°N]		Longitude [°W]		Profiles	max. pressure	shear 1	shear 2
Test 1	146	16	6/9/2006	14:57	0	5.04	35	0.59	1-4	175	6052	6054
Test 2	161	30	6/11/2006	13:41	4	59.61	35	0.25	5-8	412	6052	6054
1	173	36	6/17/2006	10:28	-2	40.56	23	0.24	9-11	248	6052	6064
2	175	38	6/17/2006	17:40	-1	59.68	23	0.06	12-14	227	6052	6064
3	177	40	6/18/2006	1:08	-1	20.13	22	59.98	15-17	126	6052	6064
4	178	41	6/18/2006	5:12	-1	0.20	23	0.1	18	10	6052	6064
5	180	42	6/18/2006	18:59	-0	45.40	23	0.15	19-21	58	6052	6064
6	183	45	6/19/2006	2:41	-0	2.40	23	7.5	22-24	66	6052	6064
7	183	45	6/19/2006	5:11	-0	3.17	23	8.92	25-39	76	6052	6064
8	187	48	6/20/2006	7:40	0	45.04	22	59.69	40-42	65	6052	6064
9	189	49	6/20/2006	18:55	1	0.10	23	0.17	43-45	85	6052	6064
10	192	51	6/21/2006	22:06	-0	0.14	21	0.17	46-48	94	6052	6064
11	193	52	6/22/2006	6:28	0	0.09	20	0.07	49-51	202	6052	6064
12	194	53	6/22/2006	14:41	-0	0.00	19	0	52-54	195	6052	6064
13	195	54	6/22/2006	23:25	-0	0.07	17	59.65	55-57	156	6052	6064
14	196	55	6/23/2006	7:58	-0	0.01	17	0.13	58-60	142	6052	6064
15	197	56	6/23/2006	16:30	-0	0.10	16	0.14	61-63	122	6052	6064
16	198	57	6/24/2006	1:08	-0	0.06	14	59.68	64-66	163	6052	6064
17	199	58	6/24/2006	9:25	0	0.01	14	0.01	67-69	223	6052	6064
18	200	59	6/24/2006	18:10	0	7.00	13	7.64	70-72	242	6052	6064
19	201	60	6/25/2006	1:44	-0	0.05	11	59.57	73-75	222	6052	6064
20	204	63	6/25/2006	2:45	-0	0.10	12	0.1	76-78	193	6052	6064
21	205	64	6/26/2006	1:16	-0	39.96	9	59.59	79-81	230	6061	6064
22	206	65	6/26/2006	5:28	0	20.00	10	0	82-84	192	6061	6064
23	207	66	6/27/2006	0:32	0	20.75	9	59.41	85-87	162	6061	6064
24	208	67	6/27/2006	4:37	0	39.87	10	0.36	88-90	153	6061	6064
25	210	69	6/27/2006	12:44	1	30.39	9	59.46	91-93	240	6061	6064
26	211	70	6/27/2006	19:34	2	0.12	11	0.39	94-96	181	6061	6064
27	212	71	6/28/2006	2:06	2	0.40	12	0.1	97-99	177	6061	6064
28	213	72	6/28/2006	8:48	1	59.82	13	0.98	100-102	251	6061	6064
29	214	73	6/28/2006	15:33	1	59.90	14	0.1	103-105	214	6061	6064
30	215	74	6/28/2006	22:22	2	0.13	14	59.74	106-108	216	6061	6064
31	216	75	6/28/2006	5:12	1	59.90	16	0.1	109-111	216	6054	6064
32	217	76	6/29/2006	11:33	2	0.50	16	59.16	112-114	181	6054	6064
33	218	77	6/29/2006	17:47	1	59.90	18	0.2	115-117	162	6054	6064
34	219	78	6/30/2006	0:00	2	0.53	18	58.81	118-120	197	6054	6064
35	220	79	6/30/2006	6:25	2	0.09	20	0.27	121-124	103	6054	6064
36	221	80	6/30/2006	12:53	1	59.92	20	59.67	125-127	273	6054	6064
37	222	81	6/30/2006	19:38	2	0.05	21	59.71	128-130	248	6054	6064
38	223	82	7/1/2006	4:37	0	59.70	23	0.3	131-133	154	6054	6064
39	224	83	7/1/2006	8:35	1	19.98	23	0.1	134-136	243	6054	6064
40	225	84	7/1/2006	12:30	1	39.86	22	59.64	137-139	211	6054	6064
41	226	85	7/1/2006	16:13	1	59.80	23	0.1	140-142	260	6054	6064
42	227	86	7/1/2006	20:12	2	19.93	23	0.04	143-145	280	6054	6064
43	228	87	7/2/2006	0:00	2	39.78	22	59.91	146-148	225	6054	6064
44	229	88	7/2/2006	3:50	2	59.90	22	59.9	149-151	224	6054	6064
45	230	89	7/2/2006	8:24	3	30.01	23	0.05	152-154	283	6054	6064
46	231	90	7/2/2006	12:50	3	57.73	22	59.78	155-157	278	6054	6064
47	232	91	7/2/2006	21:38	4	30.02	22	59.98	158-160	296	6054	6064

48	233	92	7/3/2006	4:37	5	0.80	23	0.5	161-163	265	6054	6064
49	234	93	7/3/2006	16:00	5	29.90	22	59.7	164-166	277	6054	6064
50	235	94	7/3/2006	19:20	6	0.05	22	59.98	167-169	230	6054	6064
51	236	95	7/3/2006	23:53	6	29.88	22	59.86	170-172	249	6054	6064
52	237	96	7/4/2006	4:21	6	59.90	23	0	173-175	244	6052	6064
53	238	97	7/4/2006	8:56	7	29.98	22	5.98	176-178	274	6052	6064
54	239	98	7/4/2006	13:36	7	59.80	23	0.1	179-181	234	6052	6064
55	240	99	7/4/2006	18:30	8	29.92	23	0	182-184	205	6052	6064
56	242	101	6/5/2007	5:20	9	29.95	23	0.04	185-187	236	6052	6064
57	244	103	7/5/2006	16:50	10	29.90	22	59.8	188-190	214	6052	6064
58	246	105	7/6/2006	1:24	11	29.94	22	59.9	191-193	222	6052	6064
59	248	107	7/6/2006	9:54	12	29.83	23	0.04	194-196	273	6052	6064
60	250	109	7/6/2006	18:58	13	29.94	22	59.87	195-199	272	6052	6064
61	255	115	7/8/2006	4:54	17	35.86	24	14.92	200-202	243	6052	6064

The free-falling profiler is optimized to sink at a rate of about 0.6 m/s and is capable of measuring microstructure up to a depth of 500 m. Shear and temperature fluctuations recorded due to vibration of the profiler while sinking can be diagnosed from the spectra of the acceleration sensor time series.

In total, four shear probes (s/n 6052, 6054, 6061, 6064, marked in Table 2.6) were used. A second FP07 fast thermistor was available as backup, but was not used. Routinely, MSS casts were made from the surface to about a depth of 220-260 m. Only stations with excessive vertical velocity shear were stopped when the fall rate of the probe dropped below about 0.3 m/s (see shorter profile in Table 2.5). That was mainly the case at the equator, especially in the western part. First we tried to mount more ballast rings at the probe to increase the depth range, but by using more weight we enhanced mainly the fall rate in the top 30-40 m but did not sufficiently increase the depth. So we decided to use a combination of ballast and buoyancy rings which is optimized for a fall rate of 0.6 m/s above the EUC, or in low shear zones.

Just after putting the probe in the water at Station 234 we experienced a problem with data transmission and got excessive error messages. We decided to cut off the first 20 m of the sea cable, but after fixing the cable the problem was still there. So we switched to our backup cable, which was only 570 m long (instead of the original 800 m), but for most of our measurements the replacement cable was long enough. All other parts of our equipment worked well until the end of the cruise.

Table 2.6 Sensors of MSS system used during METEOR cruise 68/2.

Sensor	Type	Response time	Serial No.
Temperature	PT100	40 ms	
Conductivity	ADM	40 ms	
Pressure	PA-50 Progress	40 ms	
Oxygen	Oxyguard	??	DO522M18
Acceleration	ACC	4 ms	8023
Shear	Airfoil	4 ms	6052
Shear	Airfoil	4 ms	6054
Shear	Airfoil	4 ms	6061
Shear	Airfoil	4 ms	6064
Temperature	NTC; FP07	12 ms	38
Conductivity	Microstructure C-sensor	4 ms	13

2.4.6. Chemical measurements

(T.Tanhua, M. Schütt, A. Schneider, F. Malien, S. Grobe, P. Wiebe, N. Gülzow)

SF_6

Samples for SF_6 measurements were taken on selected CTD stations during the cruise. Due to analytical difficulties, no samples could be analyzed onboard. However, during the cruise samples from a total of 8 profiles were flame-sealed in ampoules and brought back to the laboratory in Kiel for later analysis of CFC-12 and SF_6. The samples were collected in 350 ml glass ampoules with a headspace of about 40 ml of pure nitrogen gas air.

CFC-11 and CFC-12

Samples for CFC measurements were drawn in syringes (first sample to be collected from the Niskin, followed by the SF_6 sampling) and transferred in amounts of 20 ml to a purge and trap gas-chromatographic unit similar to the one described by Bullister and Weiss (1988). Separation of the dissolved gases was performed using a packed column, and detection was done with an Electron Capture Detector (ECD). The CFCs were calibrated against a standard gas, which was re-calibrated against a new gas standard provided by CMDL/NOAA in Boulder, CO. The temporal drift of the ECD was corrected for by applying calibration runs made before and after each station. In total, 1380 water samples (of which 190 were double samples) from 69 stations and 13 air samples were successfully analyzed. The reproducibility was determined by analyzing 190 samples twice and the standard deviation was found to be 1.4 % for CFC-12 and 1.0% for CFC-11. An analytical blank of 0.003 pmol/kg was removed from CFC-12; CFC-11 was free of analytical blank.

Nutrients

Nutrients (nitrate, nitrite, phosphate, silicate) were determined from 1320 water samples at 68 CTD-Stations. The nutrient analysis was made with a Continuous-Flow-Autoanalyzer-(CFA) System developed and built at IFM-GEOMAR according to Grashoff et al. (1999). For the determination of phosphate, the method by Bran and Luebbe (Method No. G-175-96 Rev 8) was used.

The precision for nutrient analysis as determined from 134 double samples from 67 stations was determined as (95 % confidence interval): Nitrite 0.008 μmol kg^{-1}; Nitrate 0.18 μmol kg^{-1}; phosphate 0.016 μmol kg^{-1}, silicate 0.19 μmol kg^{-1}, which was approximately 1 % of the nutrient standards. For precision estimates, two duplicate samples were taken and analyzed at 67 stations. Calibration curves were made with nutrients standards from Ocean Scientific International.

Oxygen

Oxygen was analyzed from 1321 Niskin bottles at 68 CTD-Stations according to a standard titration after Winkler (Grashoff, 1999). Two duplicate samples were taken and analyzed at 67 of the stations, and the precision of the measurement was determined as 0.5 μmol kg^{-1} (95 % confidence interval).

Total Dissolved Inorganic Carbon (DIC) and Total Alkalinity

Direct measurements of DIC were made using a coulometric method according to *Johnson et al.* (1993). The measurements were calibrated independently by regular injections of known amounts of pure CO_2. The accuracy was assessed by regular measurement of Certified Reference Materials (CRM, supplied by Dr. Andrew Dickson, Scripps Institution of Oceanography (SIO), La Jolla, CA.

Stations: 67
Samples analyzed: 1189
Duplicates analyzed: 88

Total alkalinity were determined with a potentiometric titration method according to *Mintrop et al.* (2000). The accuracy was assessed by regular measurement of Certified Reference Materials (CRM, supplied by Dr. Andrew Dickson, Scripps Institution of Oceanography (SIO), La Jolla, CA). During the cruise we found a linear temporal trend in the measurements of CRMs, ranging from +1.93 to 1.42 µmol kg^{-1}, and this was applied to the data set.

Stations: 67
Samples analyzed: 1189
Duplicates analyzed: 88

Table 2.7 Table of analytical precision and information regarding certified reference materials used.

		DIC	A_T
CRM:	analyzed bottles	87	79
	batches used	68 & 74	68 & 74
	Mean deviation from certified CRM-value	-1.42 to 1.93	- 0.65 µmol/kg
	standard deviation	1.85 µmol/kg	± 1.90 µmol/kg
Duplicates:	analyzed pairs	88	88
	mean deviation from duplicate value	0.84 µmol/kg	1.49 µmol/kg
	standard deviation	± 0.94 µmol/kg	± 1.29 µmol/kg

Filtration

Samples for biological filtration were taken with the aim of sampling in, above and below the chlorophyll maximum. The depths, however, varied randomly throughout the cruise. Samples were taken with polycarbonate bottles and a volume of 2L was filtered with a low vacuum pressure onto a 0.22 micron 47 mm filter. After that the filters were removed with clean forceps from the filtration rack, packed in a screw cap cryo-vials and stored in the -80°C freezer.

The collection of filtered seawater samples is important for the detection of nifH genes and serves to get an impression which bacteria can be found in the different depths. To get some information about the size and abundances of bacteria in the seawater, some samples were also taken for Flow Cytometry in the lab in Kiel. A volume of 1.9ml seawater from the same bottles was taken and convicted into a screw cap cryo vials. After that a solution of 20% Glutaraldehyde stock was added to the screw cap cryo vials and stored in a -20°C freezer.

H_2O_2

Samples for H_2O_2 measurements were taken with brown polyethylene bottles at six different depths, typically 10, 20, 40, 60, 80 and 100m. Standard water was taken from the deepest Niskin closed, mostly 1300m. A known concentration of a secondary stock standard was added to the standard (deep) water sampler, after which the standard and samples were immediately measured. The samples were kept as cold as possible and direct sunshine was avoided. The samples were mixed with Luminol in a FIA analytical system were the H_2O_2 concentration could be detected photometrically.

Hydrogen peroxide is one of the strongest oxidants that occurs in natural waters and can be used as a tracer. H_2O_2 is principally produced in the water column by photochemical reactions involving dissolved organic matter O_2. During M68/2, we found more H_2O_2 in the surface and declining concentrations with depth, consistent with the photochemical flux.

2.4.7. DVS meteorological and surface underway data

(B. Rabe)

The central data distributor (DVS) system continuously records a large set of oceanographic and atmospheric parameters from several sensors throughout the cruise. In order to complete the data set obtained from CTD/LADCP measurements and the two vessel-mounted ADCPs, several parameters were post-processed and calibrated. These variables were sea surface temperature (SST) and salinity (SSS) from the thermosalinograph, meteorological parameters including wind speed, wind direction, air temperature, air pressure and humidity as well as bathymetry. The post-processed dataset will be made available to the public by submitting the data to appropriate international data centers.

The METEOR just recently acquired a new database application by Werum Software & Systems. This provides both an “online” database for immediate display as well as web form to download data from an “archive” database by selecting variable names, units and precision. Although the old database was still running during the cruise, previous changes to the ship's hardware during shipyard time meant that some of the data streams were no longer available in the old database while the new one was still in the implementation stage. This concerns the thermosalinograph data and the bathymetric depth from the EM120 multi-beam echosounder. All thermosalinograph data gaps due to outages in the Werum database were filled as best as possible with direct recordings of data from the thermosalinograph.

2.4.7.1 Thermosalinograph data

a) Post-processing and sensor calibration

Sea-surface temperature and salinity were measured by a thermosalinograph with an intake at the ship's hull at 4m depth. The device was a SeaCat SBE 120 manufactured by Sea-Bird Electronics, Inc. The thermosalinograph worked well throughout the cruise. However, there were problems with the data stream into the DVS and the recording via the SeaSave software on a PC directly connected to the thermosalinograph. These two data streams showed inconsistencies in the time offset of salinity and temperature values. Therefore, the DVS thermosalinograph temperature was compared to the ship's surface temperature sensors on both port and starboard. While the DVS data showed very good agreement, the directly recorded data did not. During times where the DVS database was operating, but did not have thermosalinograph data, the available separately recorded data was manually matched to the surface temperature by adjusting the time of the recorded data. The same time adjustment was used for the salinity data.

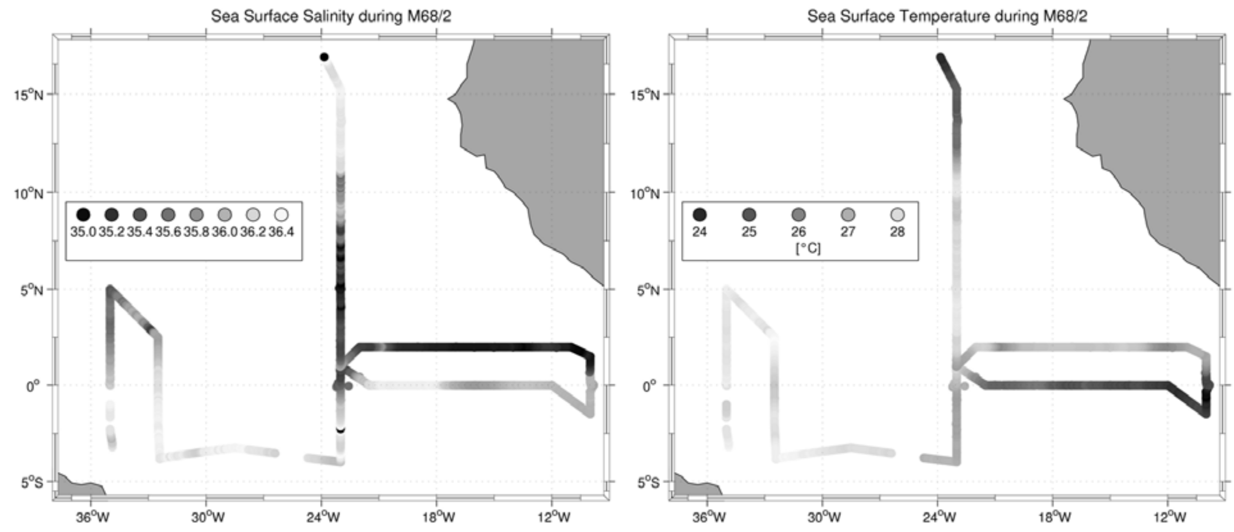

Fig. 2.10: M68/2 thermosalinograph SSS (left) and SST (right), calibrated against CTD data.

In post-processing, the temperature and salinity records were calibrated against CTD temperature and salinity data from 4m depth collected during the cruise. A constant offset in thermosalinograph temperature and salinity was found to be most adequate for calibration, being -0.004 °C for thermosalinograph temperature and -0.075 psu for salinity. The standard deviation of the temperature differences between the CTD and thermosalinograph was 0.014 °C. This value can be viewed as the statistical measurement error of the thermosalinograph SST measurements due to the much higher accuracy of the temperature measurements by the CTD sensors. The standard deviation of the salinity differences was somewhat larger, being 0.023 psu, which again reflects the measurement error of the thermosalinograph salinity. For archiving, the constant offsets in temperature and salinity were removed and the data were averaged to five-minute ensembles. The dataset was submitted to the GOSUD/SISMER project, hosted at IFREMER in Brest, France (http://www.ifremer.fr/sismer/program/gosud/).

b) Observations

During the cruise, sea surface temperatures were higher west of about 24°W, where values are generally above 28°C (Fig. 2.10). East of this, down to 4°C lower temperatures are found along the equator, representing the seasonal cold tongue. Small temperature variations of the order of 1°C, visible for example in the 2°N section, are currently compared to the Vessel Mounted ADCP current velocity data and may be linked to Tropical Instability Waves. The SSS shows the expected large-scale pattern, with a salinity minimum near the African coast, north of the equator. Further south, close to the equator the seasonal cold tongue also brings high salinity water to the surface. In addition, small scale variability can be seen, as in the SST (Fig. 2.10).

2.4.7.2 Meteorological data

a) Data acquisition and post-processing

On R/V METEOR, meteorological parameters are recorded by a weather station from Theodor Friedrichs & Co. The sensors for air temperature, humidity, pressure, wind speed and wind direction are attached to the top platform of the main mast at 40.2 m above sea level. There are wind sensors on both the port and starboard side. The weather station automatically calculates true wind speed and direction from relative wind by using the ship's Doppler log. However, the latter had to be switched off during most of the cruise as it was found to interfere with the vessel mounted ADCPs. Instead, geographical positions from the differential GPS system were used to calculate true wind speed and direction. However, this still did not seem to yield satisfying results when the ship was moving at slow speed, e.g. on-station, so that any wind data collected when the ship had less than 5 kn speed over ground was discarded.

Thus, after removing outliers, the meteorological parameters true wind speed and direction, air temperature, humidity and pressure were averaged into 5-minute ensembles. The meteorological data set will be submitted to the Research Vessel Surface Meteorology Data Center at the Center for Ocean- Atmospheric Prediction Studies, Florida State University (http://www.coaps.fsu.edu/RVSMDC/html/data.shtml).

Radiosoundings were performed twice a day, with real-time data transmission via GTS for ingestion into various mid-range forecast models and to complement the improved African upper air network installed as part of AMMA. After the cruise 64 high-resolution profiles from radiosoundings were delivered to the AMMA database (http://amma-international.org/database/).

b) Observations

Strong northwestward winds were observed in the southeastern part of the cruise (Fig. 2.11). Between 5°N to 10°N, a band of weaker, mainly northward, winds denotes the region of the ITCZ during boreal summer. North of this, winds were dominated by strong southwestward trades. In the west, deviations from the generally expected westward wind are evident. This is likely due to mesoscale variability.

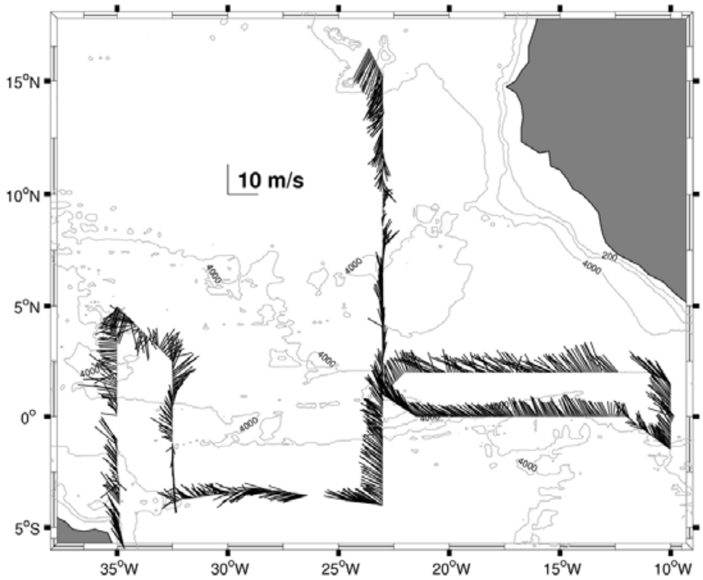

Fig. 2.11: True wind speed at 40m from the METEOR weather station.

2.5 Ship's Meteorological Station

METEOR left the port of Recife on June 06 with south-easterly winds about 4 Bft and isolated showers. Along its northerly course, METEOR encountered the edge of the ITCZ (Intertropical Convergence Zone) near 2°S. At this point a period of heavy shower activity began, associated with squalls up to Bft 8. Outside of the shower area, the mean wind speed range was 3 to 5 Bft.

From June 08 until June 10, a swell from SE reached the vessel, with additional smaller swell from S to SE.

METEOR remained in the ITCZ for the next days with different intensity of the convective clouds. After passing the most northern waypoint near 5°N 35°W on June 11, the cruise continued heading southeast and south en route to Fernando de Noronha. After a short stop an easterly track began until the 23rd degree of longitude. There for the first time the shower activity ceased, and the weather became fair in the region of the SE trades at about 4 Bft. Then METEOR sailed northerly until 1°N. The weather remained fair until METEOR approached the ITCZ on June 20. The clouds became lower and taller, and the wind increased to 4 and 5 Bft from east to southeast. Further along the equator, the ITCZ remained to the north and the weather was mostly sunny with south-easterly winds about 4Bft. The height of the sea (1.5-2m) resulted mainly from the swell from SE to S, sometimes from N.

During the track to the west near 02° N 23° W no significant weather was observed. Along its northerly course, METEOR encountered the ITCZ again near 4°N 23°W. The intensity of the ITCZ was weak at that time. The weather was characterized by southerly winds of Bft 4 and a broken to overcast cloud intensity. Both ITCZ and METEOR moved northward, and the first showers occurred not until July 04. One day later the ITCZ was already crossed, and the clouds became scattered. The light wind veered south-westerly, later northerly. On July 06, METEOR had left the ITCZ far behind and showers were rare. The northerly wind was in a range of 4 to 5 Bft. The voyage ended in the morning of July 09 in the harbour of Mindelo.

2.6 Station List M68/2

Table 2.8 M68/2 CTD/LADCP stations

R/V METEOR cruise M68/2 CTD-stations

SHIP	Station	3.1.1.1	DATE	UTC		POSITION						Uncorr.	MAX	NO. OF	
EXPOCODE	No.	No.	Mmddyy	TIME	CODE	LATITUDE			LONGITUDE			DEPTH	PRESS	BOTTLES	PAR.
06ME68/2	130	1	060706	0722	BE	04	54.96	S	34	55.11	W	828	CTD		
06ME68/2	130	1	060706	0745	BO	04	54.65	S	34	55.17	W		832	21	Bottle test. 8
06ME68/2	130	1	060706	0805	EN	04	54.11	S	34	55.30	W				
06ME68/2	131	2	060706	0924	BE	04	48.47	S	34	52.84	W	983			
06ME68/2	131	2	060706	0953	BO	04	47.85	S	34	53.01	W	1015	1011	21	1.4.5.6.7.8.10
06ME68/2	131	2	060706	1023	EN	04	47.16	S	34	53.15	W				
06ME68/2	132	3	060706	1120	BE	04	40.35	S	34	52.81	W	2426			
06ME68/2	132	3	060706	1159	BO	04	39.69	S	34	52.92	W		1316	2	8
06ME68/2	132	3	060706	1231	EN	04	38.98	S	34	53.00	W				
06ME68/2	133	4	060706	1415	BE	04	20.65	S	34	53.16	W	3520			
06ME68/2	133	4	060706	1450	BO	04	19.95	S	34	53.32	W		1325	2	8
06ME68/2	133	4	060706	1527	EN	04	19.37	S	34	53.62	W				
06ME68/2	134	5	060706	1722	BE	04	00.17	S	34	53.03	W	3460			
06ME68/2	134	5	060706	1755	BO	03	59.78	S	34	53.13	W		1354	21	1.4.5.6.7.8
06ME68/2	134	5	060706	1830	EN	03	59.43	S	34	53.19	W				
06ME68/2	135	6	060706	2104	BE	03	30.57	S	34	52.99	W	2360			
06ME68/2	135	6	060706	2141	BO	03	30.38	S	34	53.08	W		1323	21	--
06ME68/2	135	6	060706	2209	EN	03	30.34	S	34	53.08	W				
06ME68/2	136	7	060806	0113	BE	03	00.35	S	34	53.12	W	3837			
06ME68/2	136	7	060806	0152	BO	02	59.98	S	34	53.46	W		1311	21	1.4.5.6.7.8.10
06ME68/2	136	7	060806	0229	EN	02	59.53	S	34	53.54	W				

06ME68/2	137	8	060806	0429	BE	02	40.00	S	34	56.93	W	3889			
06ME68/2	137	8	060806	0501	BO	02	39.98	S	34	56.98	W		1302	--	--
06ME68/2	137	8	060806	0527	EN	02	40.05	S	34	56.92	W				
06ME68/2	138	9	060806	0735	BE	02	19.95	S	34	59.99	W	3947			
06ME68/2	138	9	060806	0814	BO	02	19.94	S	35	00.02	W		1314	21	1.4.5.7.8
06ME68/2	138	9	060806	0847	EN	02	20.09	S	35	00.03	W				
06ME68/2	139	10	060806	1049	BE	02	00.04	S	35	00.01	W	4053			
06ME68/2	139	10	060806	1128	BO	02	00.39	S	35	00.02	W		1311	Test 2 bottles	
06ME68/2	139	10	060806	1156	EN	02	00.31	S	35	00.03	W				
06ME68/2	140	11	060806	1402	BE	01	40.05	S	34	59.88	W	4080			
06ME68/2	140	11	060806	1439	BO	01	40.06	S	34	59.90	W		1319	21	1.4.5.6.7.8.10
06ME68/2	140	11	060806	1516	EN	01	40.07	S	34	59.88	W				
06ME68/2	141	12	060806	1903	BE	01	20.11	S	34	59.92	W	4345			
06ME68/2	141	12	060806	1943	BO	01	20.25	S	35	00.00	W		1316	Test 3 bottles	
06ME68/2	141	12	060806	2012	EN	01	20.35	S	34	59.98	W				
06ME68/2	142	13	060806	2219	BE	00	59.97	S	34	59.95	W	4373			
06ME68/2	142	13	060806	2251	BO	01	00.00	S	34	59.74	W		1315	21	1.4.5.6.7.8.9
06ME68/2	142	13	060806	2328	EN	01	00.00	S	34	59.72	W				
06ME68/2	143	14	060906	0132	BE	00	39.98	S	34	59:99	W	4460			
06ME68/2	143	14	060906	0204	BO	00	39:97	S	34	59:93	W		1315	--	--
06ME68/2	143	14	060906	0230	EN	00	39:98	S	34	59.83	W				
06ME68/2	144	15	060906	0435	BE	00	19:98	S	34	59:92	W	4515			
06ME68/2	144	15	060906	0508	BO	00	19:96	S	34	59.74	W		1302	--	--
06ME68/2	144	15	060906	0535	EN	00	19.90	S	34	59.45	W				
06ME68/2	145	16	060906	0741	BE	00	00.06	S	34	59.95	W	4543			
06ME68/2	145	16	060906	0919	BO	00	00.43	S	34	59.35	W		4608	20	1.3.4.5.6.7.8.9.12
06ME68/2	145	16	060906	1106	EN	00	00.42	S	34	58.77	W	4543			
06ME68/2	147	17	060906	1804	BE	00	19:95	N	35	00.00	W	4541			
06ME68/2	147	17	060906	1842	BO	00	19.86	N	34	59.61	W		1302	20	1.4.5.6.7.8.9.10
06ME68/2	147	17	060906	1917	EN	00	20.06	N	34	59.224	W				
06ME68/2	148	18	060906	2120	BE	00	39.91	N	34	59.93	W	4544			
06ME68/2	148	18	060906	2156	BO	00	40.00	N	34	59.73	W		1314	4	3
06ME68/2	148	18	060906	2224	EN	00	40.26	N	34	59.70	W				
06ME68/2	149	19	061006	0013	BE	00	59.71	N	34	59.80	W	3620			
06ME68/2	149	19	061006	0102	BO	00	59.70	N	34	59.65	W		1315	20	1.3.4.5.6.7.8.9
06ME68/2	149	19	061006	0138	EN	00	59.63	N	34	59.58	W				
06ME68/2	150	20	061006	0346	BE	01	20.07	N	35	00.00	W	4062			
06ME68/2	150	20	061006	0420	BO	01	20.29	N	34	59.62	W		1303	--	--
06ME68/2	150	20	061006	0448	EN	01	20.44	N	34	59.45	W				
06ME68/2	151	21	061006	0651	BE	01	40.11	N	34	59.97	W	4043			
06ME68/2	151	21	061006	0722	BO	01	40.38	N	34	59.75	W		1320	20	1.4.7.8
06ME68/2	151	21	061006	0759	EN	01	40.61	N	34	59.42	W				
06ME68/2	152	22	061006	0952	BE	02	00.02	N	34	59.99	W	4781			
06ME68/2	152	22	061006	1027	BO	02	00.44	N	34	59.74	W		1314	8	8
06ME68/2	152	22	061006	1127	EN	02	00.63	N	34	59.49	W				
06ME68/2	153	23	061006	1247	BE	02	19.94	N	34	59.91	W				
06ME68/2	153	23	061006	1321	BO	02	20.11	N	34	59.91	W	4140	1337	21	1.4.5.6.7.8.9.10
06ME68/2	153	23	061006	1358	EN	02	20.25	N	34	59.94	W				
06ME68/2	154	24	061006	1600	BE	02	40.20	N	35	00.07	W	3391			
06ME68/2	154	24	061006	1644	BO	02	40.71	N	34	59.91	W		1312	8	--
06ME68/2	154	24	061006	1715	EN	02	40.99	N	34	59.77	W				
06ME68/2	155	25	061006	1909	BE	03	00.11	N	34	59.93	W	3816			
06ME68/2	155	25	061006	1949	BO	03	00.67	N	34	59.92	W		1314	21	1.4.5.6.7.8.9
06ME68/2	155	25	061006	2024	EN	03	00.99	N	34	59.87	W				
06ME68/2	156	26	061006	2303	BE	03	29.99	N	35	00.07	W	3958			
06ME68/2	156	26	061006	2348	BO	03	30.47	N	35	00.09	W		1313	2	calibration

06ME68/2	156	26	061106	0015	EN	03	30.64	N	35	00.14	W				
06ME68/2	157	27	061106	0254	BE	03	59.90	N	34	59.92	W	3487			
06ME68/2	157	27	061106	0325	BO	04	00.08	N	34	59.85	W		1307	21	1.4.5.6.7.8.9.10
06ME68/2	157	27	061106	0403	EN	04	00.29	N	34	59.62	W				
06ME68/2	158	28	061106	0655	BE	04	29.99	N	35	00.07	W	3882			
06ME68/2	158	28	061106	0729	BO	04	30.47	N	34	59.99	W	3896	1318	7	8
06ME68/2	158	28	061106	0758	EN	04	30.75	N	34	59.81	W				
06ME68/2	159	29	061106	1028	BE	04	57.12	N	35	00.02	W	4054			
06ME68/2	159	29	061106	1100	BO	04	57.32	N	34	59.99	W	3997	1315	21	1.4.5.6.7.8.9
06ME68/2	159	29	061106	1140	EN	04	57.68	N	35	00.06	W	3955			
06ME68/2	160	30	061106	1458	BE	04	58.94	N	35	00.13	W	3774			
06ME68/2	160	30	061106	1529	BO	04	59.07	N	35	00.15	W		1308	--	Test
06ME68/2	160	30	061106	1557	EN	04	59.11	N	35	00.09	W				
06ME68/2	163	31	061306	0914	BE	00	39.87	S	32	29.87	W	4559			
06ME68/2	163	31	061306	0947	BO	00	39.48	S	32	29.71	W	4496	1316	21	1.3.4.5.6.7.8
06ME68/2	163	31	061306	1043	EN	00	39.38	S	32	29.26	W				
06ME68/2	164	32	061306	1526	BE	01	19.98	S	32	30.00	W	4360			
06ME68/2	164	32	061306	1555	BO	01	19.97	S	32	29.64	W		1303	21	Test. 9
06ME68/2	164	32	061306	1637	EN	01	15.80	S	32	29.22	W				
06ME68/2	170	33	061606	2255	BE	04	00.01	S	23	00.23	W	5930			
06ME68/2	170	33	061606	2327	BO	03	59.99	S	23	00.30	W	5945	1320	21	1.4.5.6.7.8.9
06ME68/2	170	33	061706	0004	EN	03	59.87	S	23	00.30	W				
06ME68/2	171	34	061706	0256	BE	03	30.14	S	23	00.05	W	5493			
06ME68/2	171	34	061706	0325	BO	03	30.20	S	23	00.06	W		1312	7	9
06ME68/2	171	34	061706	0359	EN	03	30.19	S	23	00.01	W				
06ME68/2	172	35	061706	0706	BE	03	00.02	S	23	00.04	W	5491			
06ME68/2	172	35	061706	0738	BO	03	00.02	S	23	00.07	W		1313	21	1.4.5.6.7.8
06ME68/2	172	35	061706	0815	EN	03	00.09	S	23	00.08	W				
06ME68/2	173	36	061706	1109	BE	02	41.20	S	23	01.00	W				
06ME68/2	173	36	061706	1138	BO	02	41.34	S	23	00.93	W	5577	1316	--	--
06ME68/2	173	36	061706	1209	EN	02	41.31	S	23	00.91	W	5575			
06ME68/2	174	37	061706	1425	BE	02	19.99	S	23	00.03	W	5138			
06ME68/2	174	37	061706	1454	BO	02	00.97	S	23	00.02	W		1303	21	1.4.5.6.7.8.9.10
06ME68/2	174	37	061706	1528	EN	02	19.87	S	22	59.92	W				
06ME68/2	175	38	061706	1836	BE	02	00.64	S	23	01.64	W	5205			
06ME68/2	175	38	061706	1905	BO	02	00.67	S	23	01.60	W	5219	1313	5	8.3
06ME68/2	175	38	061706	1935	EN	02	00.57	S	23	01.52	W	5228			
06ME68/2	176	39	061706	2150	BE	01	40.08	S	23	00.52	W	4949			
06ME68/2	176	39	061706	2219	BO	01	40.11	S	23	00.07	W	4936	1314	21	1.3.4.5.6.7.8.10
06ME68/2	176	39	061706	2257	EN	01	40.07	S	23	00.11	W	4939			
06ME68/2	177	40	061806	0149	BE	01	20.83	S	23	01.21	W	4963			
06ME68/2	177	40	061806	0220	BO	01	20.92	S	23	01.16	W	4966	1312	5	3
06ME68/2	177	40	061806	0248	EN	01	20.80	S	23	01.03	W	4960			
06ME68/2	178	41	061806	0529	BE	01	00.39	S	23	00.60	W	4179			
06ME68/2	178	41	061806	0600	BO	01	00.47	S	23	00.62	W	4186	1315	21	1.3.4.5.6.7.8
06ME68/2	178	41	061806	0637	EN	01	00.57	S	23	00.34	W	4156			
06ME68/2	179	42	061806	0822	BE	00	45.03	S	23	00.00	W	3669			
06ME68/2	179	42	061806	0942	BO	00	44.98	S	22	59.70	W	3680	3654	21	1.3.4.5.6.7.8
06ME68/2	179	42	061806	1106	EN	00	44.99	S	22	59.56	W	3685			
06ME68/2	181	43	061806	2119	BE	00	30.07	S	23	00.06	W	4624			
06ME68/2	181	43	061806	2148	BO	00	30.19	S	22	59.95	W	4622	1313	21	1.3.4.5.6.7.8.9
06ME68/2	181	43	061806	2224	EN	00	30.13	S	22	59.72	W	4628			
06ME68/2	182	44	061906	0004	BE	00	15.22	S	23	00.01	W	4153			
06ME68/2	182	44	061906	0035	BO	00	15.32	S	23	00.00	W	4196	1313	5	3
06ME68/2	182	44	061906	0105	EN	00	15.14	S	22	59.95	W	4147			
06ME68/2	183	45	061906	0330	BE	00	03.33	S	23	09.13	W	3735			

06ME68/2	183	45	061906		BO								1959	--	--
06ME68/2	183	45	061906	0501	EN	00	03.08	S	23	08.72	W	3785			
06ME68/2	185	46	061906	1348	BE	00	07.27	N	23	06.97	W	3792			
06ME68/2	185	46	061906	1411	BO	00	07.30	N	23	06.93	W	3792	701	21	1.3.4.5.6.7.8.9.10
06ME68/2	185	46	061906	1432	EN	00	07.43	N	23	06.75	W	3734			
06ME68/2	186	47	062006	0101	BE	00	24.96	N	23	00.06	W	3868			
06ME68/2	186	47	062006	0133	BO	00	25.06	N	23	00.11	W	3862	1314	21	1.3.4.5.6.7.8.9.10
06ME68/2	186	47	062006	0210	EN	00	25.11	N	23	00.10	W				
06ME68/2	187	48	062006	0418	BE	00	45.07	N	22	59.64	W	4309			
06ME68/2	187	48	062006	0544	BO	00	45.03	N	22	59.50	W	4311	4266	21	1.3.4.5.6.7.8.9
06ME68/2	187	48	062006	0719	EN	00	45.04	N	22	59.49	W	4311			
06ME68/2	189	49	062006	1742	BE	01	00.00	N	23	00.08	W	3239			
06ME68/2	189	49	062006	1812	BO	01	00.06	N	23	00.09	W	3227	1314	21	1.2.3.4.5.6.7.8.9
06ME68/2	189	49	062006	1848	EN	01	00.09	N	23	00.08	W	3227			
06ME68/2	190	50	062106	0756	BE	00	00.01	N	21	30.09	W	4950			
06ME68/2	190	50	062106	0939	BO	00	00.11	N	21	29.44	W	4949	4931	21	1.3.4.5.6.7.8
06ME68/2	190	50	062106	1130	EN	00	00.24	N	21	29.11	W	4950			
06ME68/2	192	51	062106	2239	BE	00	00.45	N	21	00.71	W	5124			
06ME68/2	192	51	062106	2318	BO	00	00.51	N	21	00.62	W	5125	1313	21	1.3.4.5.6.7.8.9.10
06ME68/2	192	51	062106	2356	EN	00	00.69	N	21	00.29	W	5128			
06ME68/2	193	52	062206	0719	BE	00	00.00	N	19	59.98	W	2585			
06ME68/2	193	52	062206	0751	BO	00	00.20	N	19	59.66	W	2543	1314	21	1.3.4.5.6.7
06ME68/2	193	52	062206	0832	EN	00	00.32	N	19	59.20	W	2594			
06ME68/2	194	53	062206	1537	BE	00	00.64	S	19	00.62	W	4163			
06ME68/2	194	53	062206	1608	BO	00	00.36	S	19	00.29	W	4163	1308	21	1.3.4.5.6.7.8.10
06ME68/2	194	53	062206	1715	EN	00	00.18	N	18	59.55	W	4163			
06ME68/2	195	54	062306	0023	BE	00	00.55	S	18	00.78	W	6475			
06ME68/2	195	54	062306	0056	BO	00	00.55	S	18	00.69	W	6467	1312	21	1.3.4.5.6.7.8.10
06ME68/2	195	54	062306	0131	EN	00	00.51	S	18	00.64	W	6468			
06ME68/2	196	55	062306	0853	BE	00	00.21	S	17	01.30	W	4956			
06ME68/2	196	55	062306	0924	BO	00	00.16	S	17	01.16	W	4972	1314	21	1.3.4.5.6.7.8
06ME68/2	196	55	062306	1001	EN	00	00.16	S	17	00.87	W	5041			
06ME68/2	197	56	062306	1725	BE	00	00.11	S	16	01.84	W	3176			
06ME68/2	197	56	062306	1757	BO	00	00.01	S	16	01.91	W	3170	1314	21	1.3.4.5.6.7.8
06ME68/2	197	56	062306	1835	EN	00	00.10	S	16	01.51	W	3217			
06ME68/2	198	57	062406	0159	BE	00	00.03	S	15	01.16	W	3602			
06ME68/2	198	57	062406	0230	BO	00	00.17	N	15	00.85	W	3752	1313	21	1.3.4.5.6.7.8
06ME68/2	198	57	062406	0307	EN	00	00.31	N	15	00.49	W	3775			
06ME68/2	199	58	062406	1018	BE	00	00.03	N	14	00.77	W	3906			
06ME68/2	199	58	062406	1051	BO	00	00.19	N	14	00.68	W	3971	1312	21	1.3.4.5.6.7.8
06ME68/2	199	58	062406		EN										
06ME68/2	200	59	062406	1655	BE	00	00.06	S	13	08.20	W	4457			
06ME68/2	200	59	062406	1726	BO	00	00.02	N	13	07.97	W	4457	1301	21	1.2.3.4.5.6.7.8.10
06ME68/2	200	59	062406	1802	EN	00	00.07	N	13	07.69	W	4423			
06ME68/2	201	60	062506	0240	BE	00	00.18	S	12	00.09	W	3828			
06ME68/2	201	60	062506	0312	BO	00	00.01	N	11	59.72	W	4069	1304	21	1.3.4.5.6.7.8.10
06ME68/2	201	60	062506	0351	EN	00	00.02	N	11	59.45	W	4371			
06ME68/2	202	61	062506	1818	BE	01	29.93	S	10	00.08	W	4808			
06ME68/2	202	61	062506	1848	BO	01	29.92	S	10	00.01	W	4799	1313	21	1.3.4.5.6.7.8.9
06ME68/2	202	61	062506	1923	EN	01	29.99	S	09	59.87	W	4800			
06ME68/2	203	62	062506	2213	BE	01	00.01	S	10	00.00	W	4272			
06ME68/2	203	62	062506	2244	BO	00	59.99	S	09	59.90	W	4275	1314	5	3
06ME68/2	203	62	062506	2315	EN	00	59.99	S	09	59.71	W	4268			
06ME68/2	204	63	062606	0220	BE	00	40.33	S	10	00.44	W	4060			
06ME68/2	204	63	062606	0254	BO	00	40.23	S	10	00.01	W	4031	1307	21	1.3.4.5.6.7.8.9
06ME68/2	204	63	062606	0331	EN	00	40.07	S	09	59.53	W	4042			

06ME68/2	205	64	062606	0630	BE	00	21.18	S	10	00.75	W	4337			
06ME68/2	205	64	062606	0701	BO	00	21.27	S	10	00.64	W	4369	1314	5	3.8
06ME68/2	205	64	062606	0732	EN	00	21.40	S	10	00.38	W	4303			
06ME68/2	206	65	062606	0958	BE	00	00.97	N	09	50.04	W	5203			
06ME68/2	206	65	062606	1120	BO	00	00.89	N	09	49.84	W	5206	4026	21	1.2.3.4.5.6.7.8.9.12
06ME68/2	206	65	062606	1248	EN	00	01.00	N	09	49.53	W	5202			
06ME68/2	207	66	062706	0125	BE	00	20.08	N	10	00.90	W	4745			
06ME68/2	207	66	062706	0157	BO	00	20.13	N	10	00.96	W	4749	1313	21	1.2.3.4.5.6.7.8.9
06ME68/2	207	66	062706	0233	EN	00	20.15	N	10	00.82	W	4750			
06ME68/2	208	67	062706	0533	BE	00	38.76	N	10	02.36	W	4569			
06ME68/2	208	67	062706	0605	BO	00	38.82	N	10	02.29	W	4570	1315	21	3.8
06ME68/2	208	67	062706	0643	EN	00	39.00	N	10	02.18	W	4552			
06ME68/2	209	68	062706	0850	BE	01	00.03	N	10	00.13	W	4667			
06ME68/2	209	68	062706	0922	BO	00	59.98	N	10	00.29	W	4665	1315	21	1.2.3.4.5.6.7.8
06ME68/2	209	68	062706	0958	EN	00	59.98	N	10	00.15	W	4664			
06ME68/2	210	69	062706	1323	BE	01	30.04	N	10	00.22	W	5242			
06ME68/2	210	69	062706	1357	BO	01	30.14	N	10	00.25	W	5241	1301	21	1.3.4.5.6.7.8.9.11
06ME68/2	210	69	062706	1430	EN	01	30.16	N	10	00.33	W	5234			
06ME68/2	211	70	062706	2019	BE	01	59.63	N	11	01.70	W	4420			
06ME68/2	211	70	062706	2059	BO	01	59.61	N	11	02.03	W	4420	1314	21	1.3.4.5.6.7.8.9
06ME68/2	211	70	062706	2133	EN	01	59.51	N	11	02.00	W	4420			
06ME68/2	212	71	062806	0253	BE	02	00.01	N	12	01.54	W	4838			
06ME68/2	212	71	062806	0324	BO	02	00.25	N	12	01.49	W	4841	1307	21	1.3.4.7.8.9.11
06ME68/2	212	71	062806	0404	EN	02	00.44	N	12	01.42	W	4840			
06ME68/2	213	72	062806	0929	BE	01	59.78	N	13	01.04	W	4981			
06ME68/2	213	72	062806	1006	BO	01	59.92	N	13	00.95	W	4984	1312	21	1.2.3.4.5.6.7.8
06ME68/2	213	72	062806	1041	EN	02	00.06	N	13	00.87	W	4991			
06ME68/2	214	73	062806	1615	BE	01	59.26	N	14	01.26	W	5140			
06ME68/2	214	73	062806	1648	BO	01	59.38	N	14	01.16	W	5149	1301	18	1.3.4.5.6.7.8
06ME68/2	214	73	062806	1741	EN	01	59.41	N	14	00.87	W	5149			
06ME68/2	215	74	062806	2308	BE	01	58.92	N	15	00.82	W	5340			
06ME68/2	215	74	062806	2340	BO	01	58.82	N	15	00.89	W	5347	1314	18	1.3.4.5.6.7.8.9.11
06ME68/2	215	74	062906	0036	EN	01	58.82	N	15	00.90	W	5347			
06ME68/2	216	75	062906	0600	BE	01	59.19	N	16	01.82	W	5137			
06ME68/2	216	75	062906	0632	BO	01	59.14	N	16	02.10	W	5159	1313	21	1.3.4.5.6.7.8
06ME68/2	216	75	062906	0709	EN	01	59.14	N	16	02.14	W	5153			
06ME68/2	217	76	062906	1214	BE	02	00.13	N	17	00.51	W	5276			
06ME68/2	217	76	062906	1248	BO	02	00.18	N	17	00.63	W	5284	1314	21	2.3.5.6.8.9.10
06ME68/2	217	76	062906	1325	EN	02	00.23	N	17	00.69	W	5294			
06ME68/2	218	77	062906	1832	BE	01	59.83	N	18	02.04	W	5090			
06ME68/2	218	77	062906	1902	BO	01	59.73	N	18	02.43	W	5162	1314	21	1.3.4.5.6.7.8.9
06ME68/2	218	77	062906	1939	EN	01	59.59	N	18	02.65	W	5179			
06ME68/2	219	78	063006	0048	BE	01	59.91	N	19	00.31	W	5112			
06ME68/2	219	78	063006	0118	BO	01	59.97	N	19	00.44	W	5112	1313	8	3.8.9
06ME68/2	219	78	063006	0152	EN	02	00.00	N	19	00.49	W	5117			
06ME68/2	220	79	063006	0716	BE	01	59.59	N	20	02.43	W	4909			
06ME68/2	220	79	063006	0749	BO	01	59.61	N	20	02.75	W	4947	1314	21	1.2.3.4.5.6.7.8
06ME68/2	220	79	063006	0825	EN	01	59.66	N	20	02.73	W	4934			
06ME68/2	221	80	063006	1333	BE	01	59.94	N	21	00.31	W	4934			
06ME68/2	221	80	063006	1412	BO	02	00.03	N	21	00.00	W	4934	1301	21	3.8.9
06ME68/2	221	80	063006	1441	EN	01	59.93	N	20	59.83	W	4934			
06ME68/2	222	81	063006	2022	BE	01	59.23	N	22	00.82	W	4013			
06ME68/2	222	81	063006	2052	BO	01	59.09	N	22	00.76	W	4024	1313	20	1.3.4.5.6.7.8.9
06ME68/2	222	81	063006	2119	EN	01	59.07	N	22	00.51	W	4055			
06ME68/2	223	82	070106	0520	BE	00	59.02	N	23	01.38	W	3472			
06ME68/2	223	82	070106	0552	BO	00	58.95	N	23	01.33	W	3493	1312	21	1.2.3.4.5.6.7.8

06ME68/2	223	82	070106	0633	EN	00	58.87	N	23	01.05	W	3529			
06ME68/2	224	83	070106	0920	BE	01	19.56	N	23	01.06	W	4571			
06ME68/2	224	83	070106	0952	BO	01	19.46	N	23	01.06	W	4534	1313	21	3.8.11
06ME68/2	224	83	070106	1033	EN	01	19.43	N	23	00.80	W	4600			
06ME68/2	225	84	070106	1314	BE	01	38.80	N	23	00.50	W	4134			
06ME68/2	225	84	070106	1346	BO	01	38.86	N	23	00.39	W	4132	1304	5	3.11
06ME68/2	225	84	070106	1415	EN	01	39.00	N	23	00.25	W	4132			
06ME68/2	226	85	070106	1707	BE	01	59.18	N	23	01.01	W	4324			
06ME68/2	226	85	070106	1739	BO	01	59.29	N	23	00.80	W	4323	1301	21	1.3.4.5.6.7.8
06ME68/2	226	85	070106	1817	EN	01	59.53	N	23	00.66	W	4323			
06ME68/2	227	86	070106	2059	BE	02	19.65	N	23	00.97	W	4270			
06ME68/2	227	86	070106	2130	BO	02	19.52	N	23	01.00	W	4258	1315	8	3.10
06ME68/2	227	86	070106	2204	EN	02	19.54	N	23	00.82	W	4237			
06ME68/2	228	87	070206	0048	BE	02	38.92	N	23	00.75	W	4823			
06ME68/2	228	87	070206	0120	BO	02	38.96	N	23	00.47	W	4819	1315	5	3
06ME68/2	228	87	070206	0152	EN	02	39.04	N	23	00.14	W	4798			
06ME68/2	229	88	070206	0425	BE	02	59.61	N	23	00.06	W	4642			
06ME68/2	229	88	070206	0500	BO	02	59.53	N	22	59.75	W	4642	1312	21	1.3.4.5.6.7.8.9
06ME68/2	229	88	070206	0540	EN	02	59.38	N	22	59.55	W	4647			
06ME68/2	230	89	070206	0906	BE	03	29.85	N	23	00.26	W	4379			
06ME68/2	230	89	070206	0938	BO	03	29.61	N	23	00.02	W	4371	1316	10	3.8
06ME68/2	230	89	070206	1012	EN	03	29.40	N	22	59.82	W	4369			
06ME68/2	231	90	070206	1335	BE	03	57.49	N	22	59.93	W	4217			
06ME68/2	231	90	070206	1404	BO	03	57.35	N	22	59.77	W	4217	1302	21	1.3.4.5.6.7.8
06ME68/2	231	90	070206	1438	EN	03	57.26	N	22	59.59	W	4219			
06ME68/2	232	91	070206	2234	BE	04	30.38	N	22	59.97	W	4115			
06ME68/2	232	91	070306	0000	BO	04	30.22	N	22	59.43	W	4105	4063	18	1.4.5.6.7.8.9.10
06ME68/2	232	91	070306	0151	EN	04	29.60	N	22	59.60	W	4134			
06ME68/2	233	92	070306	0517	BE	05	00.59	N	23	00.34	W	4214			
06ME68/2	233	92	070306	0549	BO	05	00.79	N	22	59.95	W	4208	1313	21	3.8.9
06ME68/2	233	92	070306	0628	EN	05	01.26	N	22	59.34	W	4210			
06ME68/2	234	93	070306	1455	BE	05	29.95	N	23	00.02	W	4231			
06ME68/2	234	93	070306	1525	BO	05	29.94	N	22	59.70	W	4231	1303	7	9.11
06ME68/2	234	93	070306	1556	EN	05	29.86	N	22	59.62	W	4231			
06ME68/2	235	94	070306	2002	BE	06	00.06	N	23	00.01	W	4092			
06ME68/2	235	94	070306	2033	BO	05	59.92	N	22	59.78	W	4099	1315	21	1.4.5.6.7.8.9
06ME68/2	235	94	070306	2110	EN	05	59.74	N	22	59.57	W	4101			
06ME68/2	236	95	070406	0035	BE	06	30.07	N	23	00.12	W	2935			
06ME68/2	236	95	070406	0106	BO	06	29.96	N	22	59.90	W	3119	1314	7	9
06ME68/2	236	95	070406	0138	EN	06	29.71	N	22	59.63	W	2940			
06ME68/2	237	96	070406	0458	BE	06	59.77	N	23	00.08	W	1516			
06ME68/2	237	96	070406	0530	BO	06	59.62	N	22	59.86	W	1452	1316	21	1.4.5.6.7.8
06ME68/2	237	96	070406	0609	EN	06	59.45	N	22	59.94	W	1497			
06ME68/2	238	97	070406	0945	BE	07	29.60	N	23	00.11	W	4390			
06ME68/2	238	97	070406	1017	BO	07	29.41	N	22	59.97	W	4385	1315	6	--
06ME68/2	238	97	070406	1045	EN	07	29.33	N	22	59.68	W	4367			
06ME68/2	239	98	070406	1420	BE	07	59.12	N	23	00.40	W	4422			
06ME68/2	239	98	070406	1450	BO	07	58.91	N	23	00.15	W	4417	1303	21	1.4.5.6.7.8.9.10
06ME68/2	239	98	070406	1527	EN	07	58.59	N	22	59.99	W	4407			
06ME68/2	240	99	070406	2135	BE	08	30.91	N	22	58.98	W	4776			
06ME68/2	240	99	070406	2208	BO	08	30.81	N	22	58.58	W	4777	1314	13	9
06ME68/2	240	99	070406	2238	EN	08	30.82	N	22	58.27	W	4778			
06ME68/2	241	100	070506	0123	BE	09	00.07	N	22	59.74	W	4898			
06ME68/2	241	100	070506	0154	BO	09	00.12	N	22	59.31	W	4894	1313	21	1.2.4.5.6.7.8.9
06ME68/2	241	100	070506	0234	EN	09	00.32	N	22	58.90	W	4898			
06ME68/2	242	101	070506	0601	BE	09	29.65	N	23	00.51	W	4623			

06ME68/2	242	101	070506	0632	BO	09	29.51	N	23	00.07	W	4658	1314	4	8
06ME68/2	242	101	070506	0700	EN	09	29.50	N	22	59.83	W	4673			
06ME68/2	243	102	070506	0958	BE	09	59.95	N	23	00.30	W	5069			
06ME68/2	243	102	070506	1141	BO	09	59.28	N	22	59.73	W	5113	5007	21	1.4.5.6.7.8.9.10
06ME68/2	243	102	070506	1355	EN	09	58.88	N	23	00.80	W	5145			
06ME68/2	244	103	070506	1736	BE	10	29.78	N	22	58.92	W	5186			
06ME68/2	244	103	070506	1807	BO	10	29.98	N	22	59.34	W	5187	1313	7	9
06ME68/2	244	103	070506	1837	EN	10	30.26	N	22	59.47	W	5187			
06ME68/2	245	104	070506	2125	BE	10	59.88	N	22	59.89	W	5146			
06ME68/2	245	104	070506	2157	BO	10	59.96	N	22	59.85	W	5149	1314	21	1.4.5.6.7.8.9.10.11
06ME68/2	245	104	070506	2235	EN	11	00.14	N	23	00.38	W	5149			
06ME68/2	246	105	070606	0205	BE	11	30.08	N	22	59.56	W	5114			
06ME68/2	246	105	070606	0237	BO	11	29.87	N	23	00.02	W	5114	1313	7	9
06ME68/2	246	105	070606	0312	EN	11	29.47	N	23	00.18	W	5115			
06ME68/2	247	106	070606	0603	BE	12	00.08	N	23	00.08	W	5046			
06ME68/2	247	106	070606	0635	BO	12	00.34	N	23	00.23	W	5047	1314	21	1.4.5.6.7.8
06ME68/2	247	106	070606	0711	EN	12	00.56	N	23	00.19	W	5044			
06ME68/2	248	107	070606	1040	BE	12	29.47	N	22	59.86	W	4920			
06ME68/2	248	107	070606	1112	BO	12	29.71	N	23	00.04	W	4917	1312	8	--
06ME68/2	248	107	070606	1145	EN	12	29.98	N	23	00.24	W	4916			
06ME68/2	249	108	070606	1442	BE	12	59.96	N	23	00.05	W	4741			
06ME68/2	249	108	070606	1515	BO	12	59.91	N	23	00.29	W	4739	1302	21	1.4.5.6.7.8.9.11
06ME68/2	249	108	070606	1555	EN	13	00.00	N	23	00.50	W	4737			
06ME68/2	250	109	070606	1941	BE	13	29.21	N	22	59.27	W	4541			
06ME68/2	250	109	070606	2011	BO	13	29.10	N	22	59.27	W	4539	1316	7	9.11
06ME68/2	250	109	070606	2041	EN	13	29.16	N	22	59.16	W	4539			
06ME68/2	251	110	070706	0103	BE	14	00.02	N	22	59.88	W	4322			
06ME68/2	251	110	070706	0135	BO	14	00.08	N	22	59.79	W	4322	1317	21	1.4.5.6.7.9.11
06ME68/2	251	110	070706	0216	EN	14	00.04	N	22	59.75	W	4317			
06ME68/2	252	111	070706	0513	BE	14	29.98	N	23	00.56	W	4088			
06ME68/2	252	111	070706	0545	BO	14	30.09	N	23	00.19	W	4087	1315	--	--
06ME68/2	252	111	070706	0611	EN	14	30.27	N	23	00.25	W	4085			
06ME68/2	253	112	070706	0915	BE	14	59.88	N	23	00.03	W	2672			
06ME68/2	253	112	070706	0948	BO	15	00.09	N	23	00.18	W	2709	1314	21	1.4.5.6.7
06ME68/2	253	112	070706	1027	EN	15	00.43	N	23	00.28	W	2759			
06ME68/2	254	113	070706	1215	BE	15	14.95	N	22	59.59	W	1334			
06ME68/2	254	113	070706	1241	BO	15	15.13	N	22	59.69	W	1315	1013	--	--
06ME68/2	254	113	070706	1302	EN	15	15.20	N	22	59.92	W	1209			
06ME68/2	254	114	070706	1308	BE	15	15.20	N	22	59.92	W	1172			
06ME68/2	254	114	070706	1328	BO	15	15.19	N	23	00.12	W		202	12	Fluorometer
06ME68/2	254	114	070706	1343	EN	15	15.22	N	23	00.19	W				calibration
06ME68/2	255	115	070806	0542	BE	17	35.45	N	24	14.63	W	3592			
06ME68/2	255	115	070806	0655	BO	17	35.97	N	24	14.92	W	3597	3553	21	1.2.4.5.6.7
06ME68/2	255	115	070806	0818	EN	17	36.74	N	24	15.10	W				

Code: BE = begin, BO = bottom, EN = end
Parameters (Par.): 1= CFC, 2=SF_6, 3=He, 4=Oxy, 5=DIC, 6=Alk, 7=Nuts, 8=Sal, 9=H_2O_2, 10=Filtr, 11=Microbiology, 12=PFOS

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