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# Berichte
zur Polar- und Meeresforschung

## Reports on Polar and Marine Research

# The Expedition of the Research Vessel "Polarstern" to the Antarctic in 2003 (ANT-XXI/1)

Edited by
Otto Schrems
with contributions of the participants

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# The Expedition of the Research Vessel "Polarstern" to the Antarctic in 2003 (ANT-XXI/1)

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**ISSN 1866-3192**

# ANT-XXI/1

**22 October 2003 - 15 November 2003**
**Bremerhaven - Cape Town**

**Fahrtleiter / Chief Scientist**
**Otto Schrems**

**Koordinator / Coordinator**
**Hans-Otto Pörtner**

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# 1. ZUSAMMENFASSUNG UND FAHRTVERLAUF

Otto Schrems
Alfred-Wegener-Institut für Polar- und Meeresforschung

Nach einer knapp 10-tägigen Liegezeit in Bremerhaven nach der letzten Arktisexpedition legte die *Polarstern* am Mittwoch, den 22. Oktober 2003, wie vorgesehen pünktlich um 11.00 Uhr (MESZ) zum 1. Fahrtabschnitt ihrer 21. Reise in die Antarktis ab. An Bord des Schiffes waren 44 Besatzungsmitglieder sowie 28 Wissenschaftler aus Deutschland, Großbritannien und den USA. Schwerpunkte der Forschungsaktivitäten an Bord waren Messungen von atmosphärischen Spurengasen und Aerosolen in Troposphäre und Stratosphäre, die z. T. auch zur Validierung von Instrumenten auf dem Umweltsatelliten ENVISAT dienen. Ein weiterer Schwerpunkt war die Erprobung eines Fächerecholots. Der Aufbau der Experimente für die atmosphärenchemischen Untersuchungsprogramme hatte bereits eine Woche vor Auslaufen des Schiffes begonnen, so dass die meisten Probennahme- und Messsysteme schon zu Beginn der Fahrt einsatzfähig waren.

Die Reise führte zunächst über die Nordsee Richtung Ärmelkanal. Nach zwei Tagen Fahrt durch eine ruhige See bei sonnigem, aber sehr kühlem Wetter entlang der südenglischen Küste erreichten wir das Arbeitsgebiet für die Erprobung des Fächerecholots in der nördlichen Biskaya. Das Gebiet am Canyon de Noirmoutier dient seit fast 20 Jahren zur Kalibrierung und Erprobung der Fächerecholotanlage Hydrosweep, die während der Liegezeit in Bremerhaven technisch erweitert wurde. Die stark zerklüfteten Geländeformen des 45 km langen Canyons am französischen Kontinentalhang, der einen Tiefenbereich von 150 m bis 4200 m durchläuft, stellen höchste Anforderungen an die Leistungsfähigkeit der Hydrosweep-Anlage. Während einer 30-stündigen Kalibrierung wurde der Canyon und ein weiteres Testgebiet dann auf vorgegebenen Fahrtprofilen mit großer nautischer Präzision mehrfach durchfahren.

Die 20 Atmosphärenwissenschaftler an Bord bildeten ein internationales Team für ein globales Atmosphärenchemie-Programm und ergänzten sich mit ihren jeweiligen Untersuchungen. Die Messungen, die auf dem Fahrtabschnitt ANT-XXI/1 durchgeführt wurden, dienen der Untersuchung chemischer und dynamischer Prozesse in der Atmosphäre und zur Bestimmung der Verteilung zahlreicher atmosphärischer Spurenstoffe in der Süd- und Nordhemisphäre.

Die Probennahmesysteme für Spurengase und Aerosole der amerikanischen Gruppe von der University of New Hampshire & Mount Washington Observatory und der University of Virginia sowie der Teilnehmer von den englischen Universitäten York und Manchester sowie der Universität Ulm waren auf dem Peildeck und dem Krähennest der *Polarstern* installiert. Die Luftproben wurden überwiegend durch kontinuierlich arbeitende Messsysteme beprobt. Gesammelte Aerosolproben wurden mit den entsprechenden Messinstrumenten in den Labors direkt an Bord analysiert.

Bei diesen Untersuchungen bildeten anorganische und organische Halogenverbindungen einen besonderen Schwerpunkt. Es wurden aber u.a. auch das bodennahe Ozon, Kohlenmonoxid und organische Nitrate gemessen. Zu den Messsystemen an Bord, die mit Hilfe des Sonnenlichtes arbeiteten, zählten ein MAX-DOAS-Spektrometer der Universität Heidelberg, das Sonnenphotometer des AWI zur Messung der aerosoloptischen Dicke und das von AWI und der Universität Bremen gemeinsam betriebene FTIR-Spektrometer. Ein UV-Spektralradiometer und ein Biometer des AWI registrierten kontinuierlich die solare UV-Strahlung. Auf dem Helideck des Schiffes befand sich ein Laborcontainer des AWI mit einem Lidarsystem mit dem Höhenprofile von Zirruswolken und entlang der westafrikanischen Küste die Höhenverteilung von Saharastaub gemessen wurden. Täglich wurde vom Helideck eine Ozonsonde gestartet, welche jeweils Ozonprofile bis in Höhen von ca. 34 km lieferte.

Am Donnerstag, den 30. Oktober wurden die Kanarischen Inseln erreicht und *Polarstern* ging für einen halben Tag vor Las Palmas auf Reede. Von einem Boot wurde zusätzliche Ausrüstung auf *Polarstern* übergesetzt, was bei den bis zu 3 m hohen Wellen nicht ganz ungefährlich war, aber mit größter Vorsicht erfolgreich durchgeführt werden konnte. Außerdem wurden 6 Wissenschaftler ausgebootet und zwei Fahrtteilnehmer wurden aufgenommen. Südlich der kanarischen Inseln wurden dann neben den Hydrosweep-Messungen auch Testmessungen mit dem Parasound-Echsosounder DS-1 durchgeführt und es konnten Messdaten über ein Gebiet von ca. 2000 Seemeilen gewonnen werden.

Der insgesamt sehr erfolgreiche Fahrtabschnitt ANT-XXI/1 endete am 15. November 2003 morgens um 8.00 Uhr nach dem Festmachen der *Polarstern* im Hafen von Kapstadt.

# SUMMARY AND ITINERARY

After about 10 lay days at Bremerhaven following the last expedition to the Arctic *Polarstern* started the first leg of her 21st voyage to Antarctica on Wednesday, 22 October at 11.00 a.m.. Aboard the ship were 44 crew members and 28 scientists from Germany, United Kingdom and the USA. The main focus of the research activities aboard were measurements of atmospheric trace gases and aerosols in the troposphere and stratosphere, which partly also served for validation of instruments aboard the ENVISAT satellite. A further focal point was the test of echosounder systems. Setting up all the experiments for the atmospheric investigations had started already a week prior to sailing. Thus, most sampling devices and measuring systems were ready to operate right at the beginning of the cruise.

At the beginning of the journey we firstly passed the North Sea towards the English Channel. After sailing through a quiet sea at sunny but cold weather along the southern part of the English coast we arrived in the northern part of the Bay of Biscay. The area at the Canyon de Noirmoutier has served for 20 years for the testing and calibration of the echosounder system. The Hydrosweep system was operated there for test and calibration purposes. The echosounder system had been technically upgraded during the lay days in Bremerhaven. The cliffy forms of the 45 km long canyon at the French continental slope, passing through a water depth of 150 m to 4.200 m requires great demands on the performance of the Hydrosweep system. During a 30 hour lasting calibration the canyon and a further testing area were crossed several times at given profiles with high nautical precision.

The 20 atmospheric scientists aboard complemented each other with their measurement programmes and formed an international team for global atmospheric chemistry studies. The measurements which were carried out during the ANT-XXI/1 cruise dealt with the investigation of chemical and dynamical processes in the atmosphere and the determination of the distribution of numerous atmospheric trace substances in the southern and northern hemisphere.

The sampling systems for trace gases and aerosols of the American group from the University of New Hampshire & Mount Washington Observatory and University of Virginia as well as the participants from the English Universities of York and Manchester and the University of Ulm were installed at the observation deck and at the “crow’s nest” of the ship. The air samples had mainly been probed by continuously running measurement systems. Collected aerosol samples were analysed directly aboard the ship with appropriate instruments.

The atmospheric investigations were specially focused on inorganic and organic halogen compounds. However, in addition, near the surface ozone carbon monoxide and organic nitrates were also measured. Among the optical instruments which used solar radiation were the MAX-DOAS spectrometer of the University of Heidelberg, AWI's sunphotometer for the measurement of the optical depth of the atmosphere and a FTIR spectrometer which was jointly operated by AWI and the University of Bremen. AWI's UV spectroradiometer and a biometer continuously registrated solar UV radiation. A laboratory container was placed on the helicopter deck of the ship which contained AWI's LIDAR system MARL. This LIDAR was used for the study of height profiles of cirrus clouds and along the West African coast to study the height distribution of Saharan dust. From the helicopter deck an ozone sonde was launched daily. These sondes provide ozone profiles up to altitudes of 34 km.

On 30 October in the morning we arrived at the Canary Islands and lied in the roads at Las Palmas for half a day. Despite a rough sea a boat supplied *Polarstern* with additional equipment and 6 scientists disembarked and two scientists were taken aboard. In the further course, south of the Canary Islands test measurements not only with the Hydrosweep echosounder but also with the Parasound echosounder DS1 were performed yielding data over a distance of about 2,000 nm.

Altogether, the ANT-XXI/1 voyage was very successful and ended on 15 November 2003, at 8.00 a.m. after the mooring of *Polarstern* in the port of Cape Town.

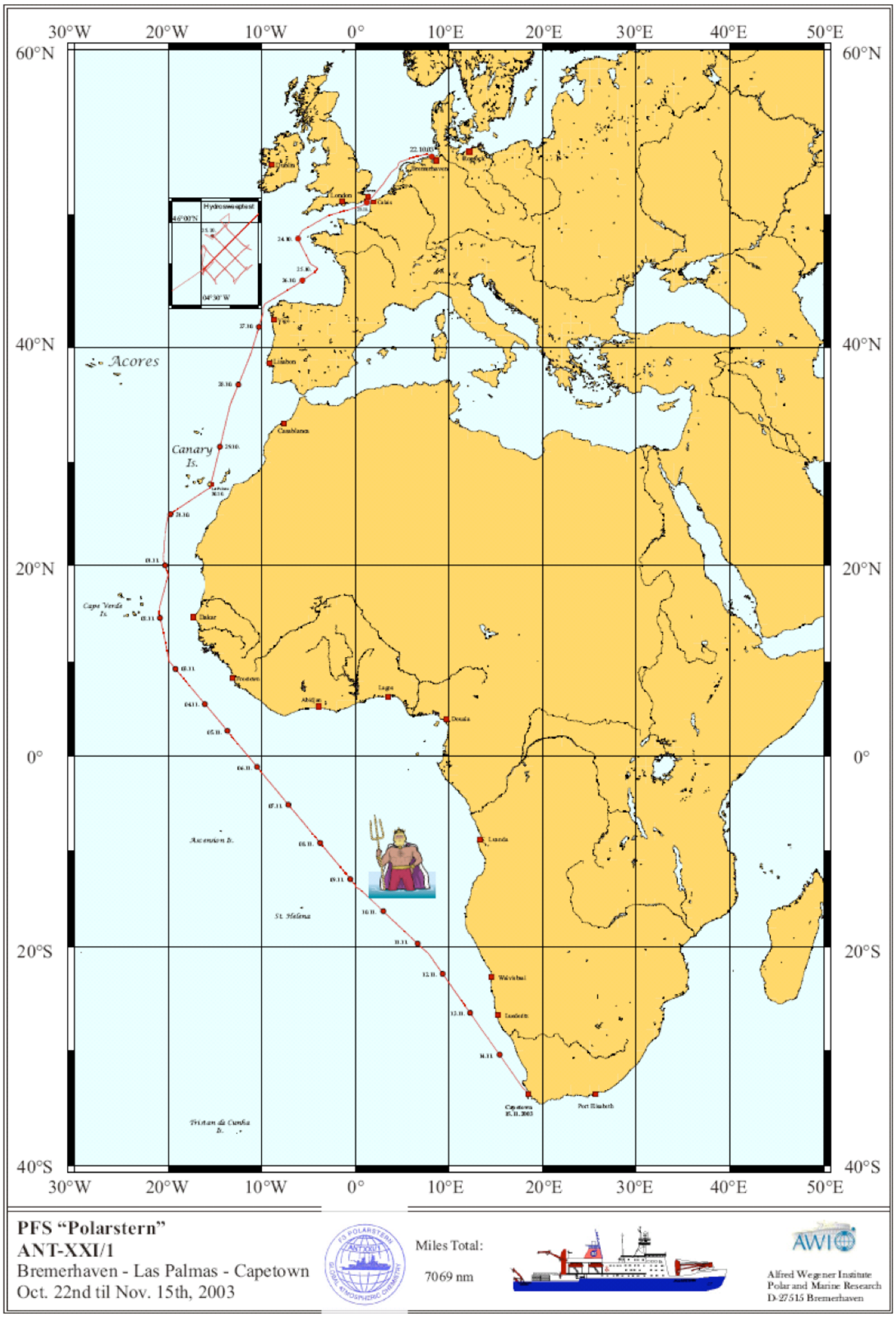


*Abb.1.1: Fahrtverlauf von ANT-XXI/1*
*Fig. 1.1: Cruise track of ANT-XXI/1*

## 2. WEATHER CONDITIONS

Klaus Buldt
Deutscher Wetterdienst

RV *Polarstern* left Bremerhaven on time on 22 October 2003 at 11:00 h local time. A high pressure system reaching from Iceland to central Norway provided sunny but cool weather appropriate for autumn with easterly winds of 5 to 6 Bft. Only during the evening cloud fields of a shallow low pressure system at the western exit of the English Channel affected the conditions on our track. During the night it propagated to Brittany and later to central France. At its northern edge cold air was advected into our area. The orographic conditions in the English Channel induced an additional amplification of the easterly winds so that wind forces of 8 Bft were attained.

The stable high pressure system northwest of the Azores moved until 25 October only little to the east. Simultaneously a small but intensive low developed off the Portuguese coast. The area of the first operations of *Polarstern* was located between the two systems in the Bay of Biscay at 46°N 4°W. Here off-shore airflow from the east with wind forces of 3 to 4 Bft and only a few clouds provided optimal working conditions. The low changed its position and intensity only little during the following days. Along our track it gave rise to easterly to northeasterly winds on average of force 6.

In the early morning hours of the 27 October in the vicinity of Cape Finisterre the winds increased shortly up to 7 Bft. During the day the low shifted slightly to the northwest which induced a significant increase of the wind force and directions veering from southeast to south during the afternoon when the core with a pressure of 998 hPa was reached. Wind forces of 8 Bft and in gusts of 9 Bft were measured. Even in the evening the wind turning now to southwesterly directions relaxed only little.

On 28 October the low moved to southeast first (Fig. 2.1) and then again to east with unchanged core pressure. In consequence the track of *Polarstern* was situated during the whole day in the backside of the wind field with 8 Bft from southwest and with gusts of 9 - 10 Bft. The waves reached 4 m height. Only during the early evening hours the wind calmed slowly down and veered to westerly later to northwesterly directions.

On 29 October the low moved to southwest Portugal were it dissolved during the day. With easterly, later northeasterly winds of about 5 Bft, waves of 2 m and a few clouds Polarstern continued its course to Las Palmas.

On the early morning of the 30 October we reached Las Palmas. With northeasterly winds of 5 to 6 Bft and a swell of 2.5 m, heavy cloud cover and temperatures about 21°C, the transfer of personnel and material by boat lasted until the early afternoon. When we continued our cruise the wind increased due to local effects for a short time to 6 to 7 Bft before it calmed down completely in the lee side of the islands. On 31 October we left the area of the influence of the islands early and from now on the Northeast trade winds kept on with 4 Bft.

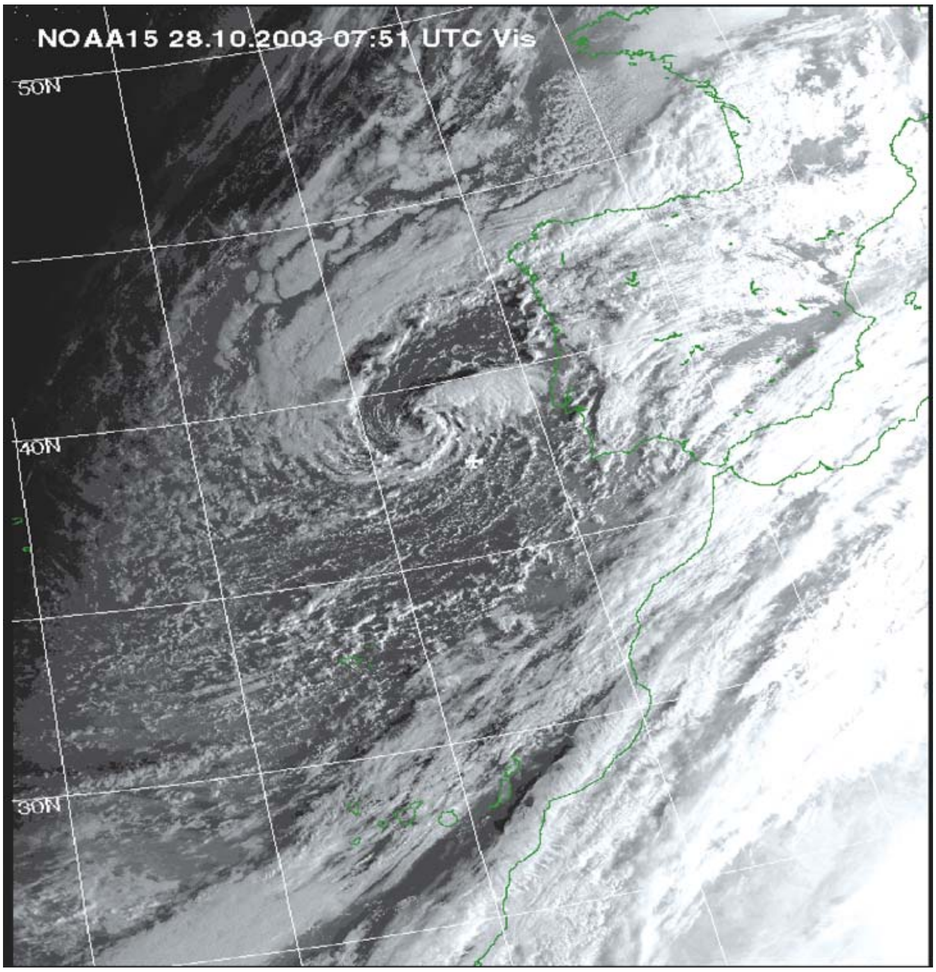


*Fig. 2.1: The low pressure system off the Portuguese coast on 28 October 2003*

In the early morning of the 3 November, almost exactly at 10°N, intensive lightning indicated the edge of the Intertropical Convergence Zone (Fig. 2.2). Already in the late morning we crossed the first tropical shower which provided up to 88 mm/h precipitation and a weak thunder storm. In the vicinity of the shower the wind reached 6 Bft. An intensive cloud cluster separated at 5°N 9°W from the West African coast during the afternoon and the evening and crossed our track in the night to 4 November. However they were not particular weather effective. During the day the over all weak to moderate winds veered to easterly directions and the cloud cover dissolved increasingly during the afternoon. At this day the highest temperatures during the whole cruise were measured with 28.6°C.

In the night from 5 to 6 November we crossed the Equator. The southerly wind blew with 4 to 5 Bft, the temperatures were about 25°C. During the following days we reached the area of influence of the South Atlantic subtropical high. At its northern edge extended fields of stratiform cloud cover determined the weather conditions. In consequence it was mostly cloudy in the morning but already in the early forenoon the clouds cover dispersed. The Southeast trades blew steadily with 4 to 5 Bft and the temperatures were at 24°C. There was no precipitation.

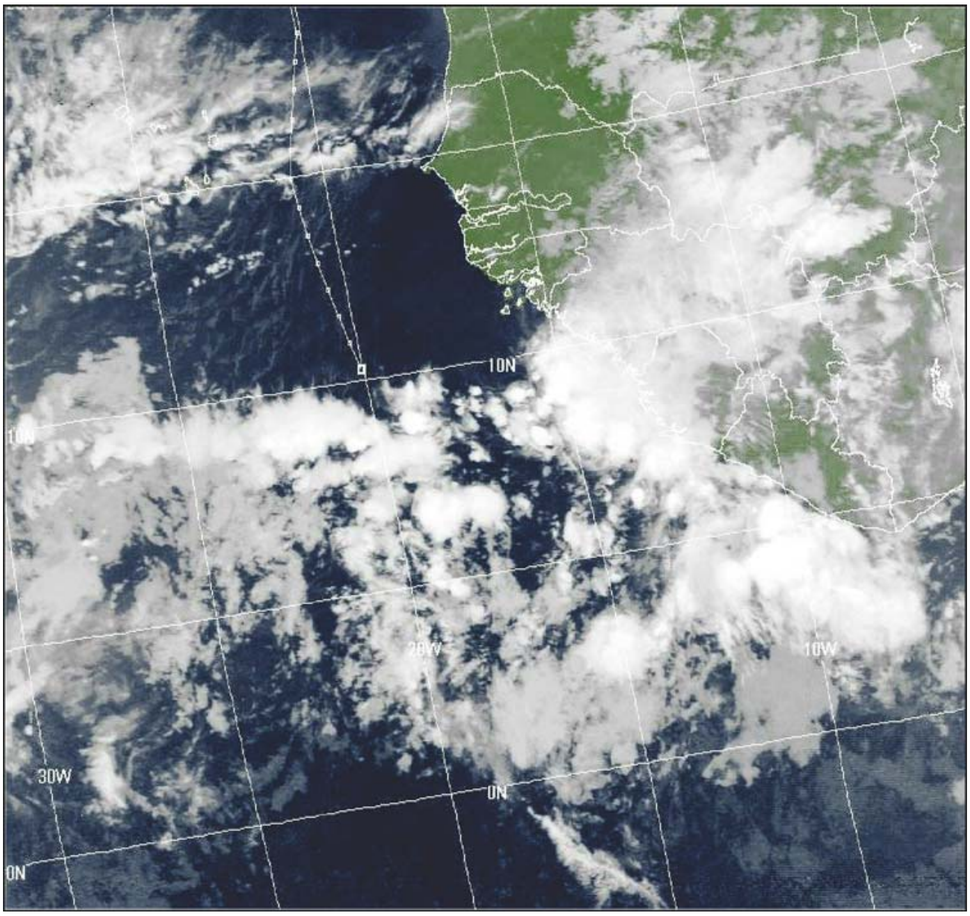


*Fig. 2.2: Approaching the ITC early on 3 November at 10°N – 20°W*

The subtropical high moving to the east and a stable weak low over Angola induced increasing gradients form the evening of the 10 November onwards. In consequence the wind increased to 6 to 7 Bft. The waves reached already 4 m in the morning of the 11 November.

On 12 November the situation did not change significantly. The subtropical high moved to the southern tip of Africa and over Botswana a further low developed which did not change its position at the beginning. On our course between the two pressure systems we experienced southeasterly to southerly air flow of 6 Bft, some clouds and waves of 4 m.

During the 13 November the wind relaxed again, but the sea calmed down only slowly. In the night to the 14 November the outskirts of a low centred at 51°S 2°E influenced the weather on our course with approaching high clouds. But already during the morning the last Cirrus fields had passed our course. With westerly winds of 4 to 5 Bft, a wave height of 2 m and temperatures around 18°C, this last day was one of the sunniest ones of the whole cruise.

*Polarstern* arrived in Cape Town in the morning of 15 November 2003 at 08.00 h local time. The distribution of wind direction and force during ANT-XXI/1 are presented in figs. 2.3 and 2.4.

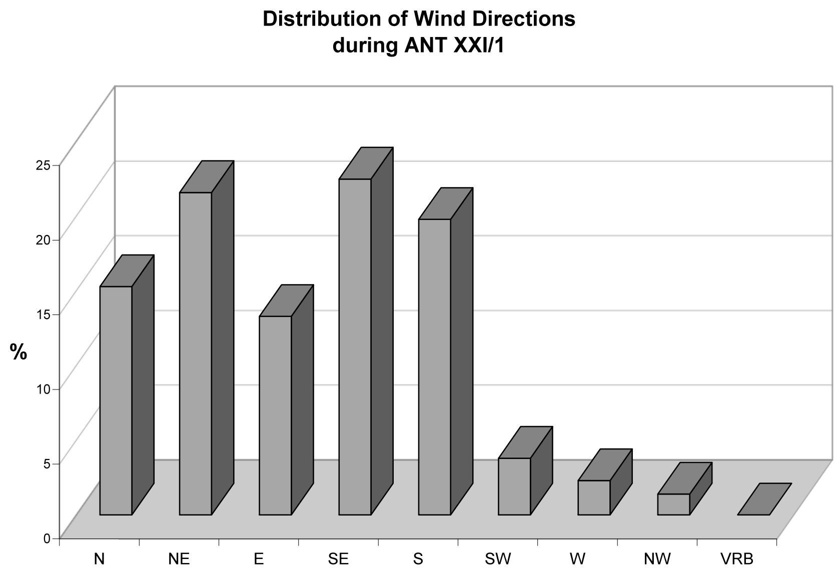


*Fig. 2.3: Distribution of wind directions during ANT-XXI/1*

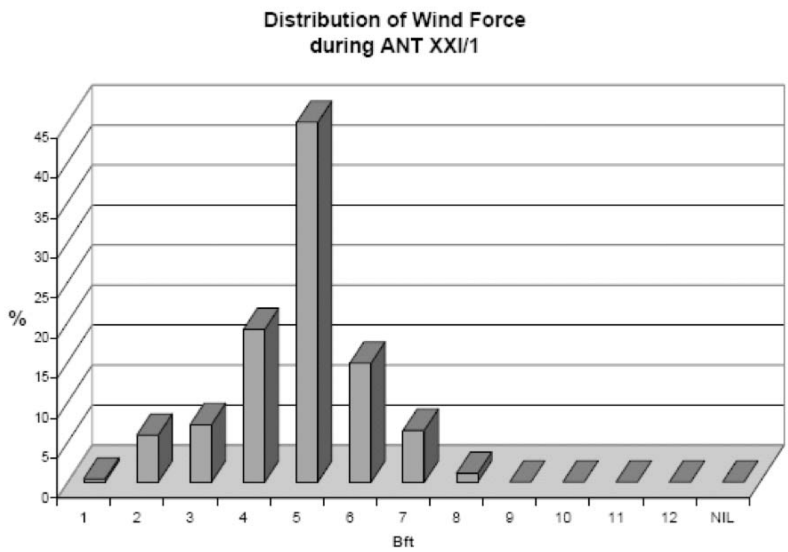


*Fig. 2.4: Distribution of wind force during ANT-XXI/1*

# 3. ATMOSPHERIC CHEMISTRY AND SATELLITE GROUND TRUTHING

## 3.1 Measurements of ozone profiles with ECC sondes on a North (50°N) to South (30°S) transect

Otto Schrems[1], Saad El Naggar[1], Susann Tegtmeier[1], Ingo Beninga[2]

[1]Alfred-Wegener-Institut
[2]Impres GmbH

### Objectives

The main objective of this project was to study the vertical ozone distribution over the Atlantic Ocean by shipborne ozone soundings. We continued measurements performed during earlier ship cruises in order to obtain in combination with our previous soundings a comprehensive picture of the vertical ozone distribution pattern over a wide meridional range in the marine atmosphere over the Atlantic Ocean. Primarily, ozone data are available from vertical ozone profiles measured from ground stations which are either located in the continental northern hemisphere or in polar regions. However, there is still a lack of reliable ozone data from the subtropics and tropics. Thus, the intention of our measurements is to help closing this gap and to provide data for the calibration of satellite-borne instruments and for interpreting spectral UV measurements.

### Work at sea

The ozone soundings aboard *Polarstern* were performed daily in the time period between 24 October 2003 and 14 November 2003. We used electrochemical concentration cells (ECC sondes) together with RS-80-GE and RS-90-AGE radiosondes from Vaisala. The sondes were launched with helium balloons from the helicopter deck of the ship. The balloons reached altitudes between 31 to 35 km, thus the maximum of the stratospheric ozone concentration is well documented. The ECC sondes were prepared according to the detailed instructions given by Komhyr (1986). The equipment allows to simultaneously measure the ECC current which corresponds to the $O_3$ partial pressure, the temperature of the inlet air, and from the meteorological sondes, atmospheric temperature, relative humidity, wind speed and direction, and the pressure of the ambient air. The data string has been modulated on a 403 MHz carrier frequency and transmitted to a DigiCORA radiosonde system (Vaisala) installed in the aerological lab of *Polarstern*. The demodulated signals have been fed into a PC for further evaluation by a special software (Vaisala): the data have been recorded in 10 s intervals. Taking into account the inherent time constant of the ECC sondes of approximately 20 s and the ascent velocity of around 5 m/s, the effective height resolution of the $O_3$ profiles is about 100 m.

## Preliminary results

Altogether 22 ozone profiles were successfully recorded during the cruise. All dates of the ozone sonde launches along with the corresponding latitudes and longitudes and preliminary results for column densities are summarized in table 3.1.1. Figure 3.1.1 shows the preliminary results of the total ozone column. The total ozone column was changing between 350 DU in the North, decreasing in the subtropical and tropical regions and increasing again in the South to about 320 DU. The preliminary analysis of our measurements demonstrates, in connection with comparable data from previous measurements that shipborne ozone soundings are an adequate method to provide particulars of the general $O_3$ distribution pattern on a global scale.

**Tab. 3.1.1 :** Summary of all ozone sounding data collected during ANT-XXI/1 22.10.03 – 15.11.03

| Date | Start Time [UTC] | Latitude [deg] | Longitude [deg] | Max.Height [m] | Ozone Measured [DU] | Ozone Residual [DU] | Ozone Total [DU] | Max. Sun Elevation [°] |
|---|---|---|---|---|---|---|---|---|
| 22.10.2003 | - | | | | | | | |
| 23.10.2003 | - | | | | | | | |
| 24.10.2003 | 09:42 | 48.88 | -5.81 | 33023 | 268.8 | 34.7 | 304 | 30 |
| 25.10.2003 | 13:27 | 45.86 | -4.38 | 31882 | 272.38 | 41.66 | 314 | 32 |
| 26.10.2003 | 13:39 | 45.17 | -5.99 | 35033 | 307.38 | 34.95 | 342 | 32.4 |
| 27.10.2003 | 09:48 | 42.26 | -10.7 | 34208 | 311.79 | 40.79 | 353 | 35.7 |
| 28.10.2003 | 21:42 | 35.09 | -13.4 | 34385 | 297.8 | 39.29 | 337 | 40.1 |
| 29.10.2003 | 09:38 | 32.56 | -14.14 | 32217 | 253.4 | 51.8 | 305 | 44.6 |
| 30.10.2003 | 16:21 | 27.78 | -15.36 | 34760 | 250.35 | 40.63 | 291 | 47.1 |
| 31.10.2003 | 09:40 | 25.51 | -19.18 | 31586 | 210 | 64 | 274 | 51 |
| 01.11.2003 | 16:00 | 18.91 | -20.11 | 33770 | 254.7 | 53.5 | 308 | 56.2 |
| 02.11.2003 | 14:06 | 13.86 | -20.81 | 32087 | 204.3 | 58.7 | 263 | 61.4 |
| 03.11.2003 | 09:30 | 9.74 | -19.78 | 35036 | 226.3 | 40.8 | 267 | 66.1 |
| 04.11.2003 | 09:35 | 5.76 | -16.44 | 31789 | 204.00 | 64.40 | 268 | 68.5 |
| 05.11.2003 | 09:41 | 2.61 | -13.81 | 32981 | 223.7 | 52.31 | 276 | 70.9 |
| 06.11.2003 | 09:50 | -0.98 | -10.83 | 31189 | 240 | 95 | 335 | 72.5 |
| 07.11.2003 | 13:07 | -5.43 | -7.12 | 31326 | 226.40 | 75.80 | 302 | 79.2 |
| 08.11.2003 | 09:56 | -8.68 | -4.4 | 31208 | 207.3 | 71.5 | 279 | 82.4 |
| 09.11.2003 | 09:41 | -12.49 | -1.17 | 31651 | 234.2 | 82 | 316 | 86.1 |
| 10.11.2003 | 09:47 | -16.08 | 2.49 | 32769 | 252.1 | 59.6 | 312 | 89.2 |
| 11.11.2003 | 09:43 | -19.53 | 6.34 | 32752 | 248.6 | 60.7 | 309 | 87.5 |
| 12.11.2003 | 09:51 | -22.52 | 9.15 | 31061 | 242.9 | 83 | 326 | 84.8 |
| 13.11.2003 | 09:47 | -26.5 | 12.2 | 31963 | 259.5 | 65.8 | 325 | 81.1 |
| 14.11.2003 | 09:39 | -30.9 | 15.73 | 33020 | 257 | 50 | 307 | 77 |
| 15.11.2003 | - | | | | | | | |

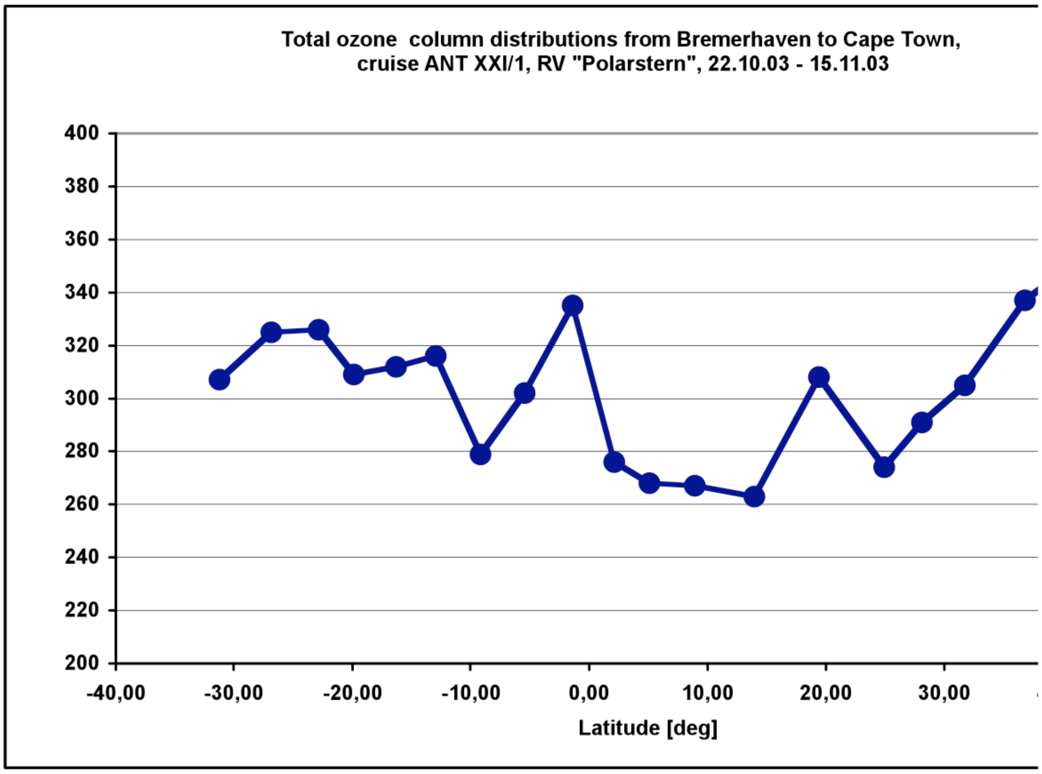


*Fig. 3.1.1: Ozone column distribution between Bremerhaven and Cape Town during ANT-XXI/1*

## References

Weller, R., Lilischkis, R., Schrems, O., Neuber, R., Wessel, S. (1996) "Vertical Ozone distribution in the marine atmosphere over the central Atlantic Ocean (56°S - 50°N)", *J. Geophys. Res*.. 101, D1, 1387-1399.

Komhyr, W.D., Operations handbook - Ozone measurements to 40 km altitude with model 4A-ECC-ozone sondes, /NOAA Techn. Memorandum ERL-ARL-149/, *1986*.

## 3.2 FTIR measurements of atmospheric trace gases for the validation of the SCIAMACHY instrument on board the ENVISAT satellite

Astrid Schulz[1)], Otto Schrems[1)], Thorsten Warneke[2)]
not on board: Justus Notholt, University of Bremen

[1)]Alfred -Wegener -Institut
[2)]University of Bremen

## Objectives

The upper troposphere in the tropical regions act as a reservoir for gases entering the stratosphere, and the UTLS region (Upper Troposphere, Lower Stratosphere) is therefore of high interest for stratospheric research. Our previous ship-based measurements in this region have implied that trace gases originating from biomass burning in the African and the South American continents were enhanced in the upper tropical troposphere. It is thus likely that biomass burning has an influence on the stratospheric air composition. Data of selected trace gases will also be used for the validation of the SCIAMACHY instrument on the ENVISAT satellite.

### Work at sea

Measurements of atmospheric trace gases were conducted aboard the research vessel *Polarstern* during its cruise from Bremerhaven, Germany, to Cape Town, South Africa (ANT-XXI/1). This was accomplished using a Fourier Transform Infrared (FTIR) spectrometer which is mounted inside a custom-made laboratory container and which was located on the observation deck of the ship. Absorption spectra with a maximum resolution of 0.005 $cm^{-1}$ were recorded by using the sun as light source. However, to record such high resolution spectra, very stable weather conditions are necessary. On 15 days of the cruise the conditions were good enough to perform such measurements. The respective days are indicated in table 3.2.1 below. Measurements during the other days were prevented by dense cloud fields, too high windspeeds or rough sea.

**Tab. 3.2.1:** Summary of measurement days, latitude of the measurements and expected data quality

| Date | Approx. Latitude | Expected Data Quality |
|---|---|---|
| 22.10.2003 | 53 N | low |
| 24.10.2003 | 48 N | high |
| 25.10.2003 | 45 N | high |
| 29.10.2003 | 32 N | high |
| 30.10.2003 | 29 N | high |
| 31.10.2003 | 24 N | low |
| 01.11.2003 | 20 N | high |
| 02.11.2003 | 13 N | low |
| 04.11.2003 | 5 N | high |
| 05.11.2003 | 2 N | high |
| 06.11.2003 | 0 | high |
| 07.11.2003 | 4 S | high |
| 08.11.2003 | 8 S | high |
| 10.11.2003 | 16 S | low |
| 13.11.2003 | 26 S | high |

### Status of data and expected results

With the high number of measurements in the tropical regions obtained during this cruise, we were looking forward to providing new insights to the composition of the tropical free troposphere.

Data analysis will be performed after the cruise. Total column densities of more than 20 trace gases, including $O_3$, HCl, HF, $CH_4$, $HCO_3$, $NO_2$, CO, $CO_2$, $C_2H_2$, $C_2H_6$, $CH_2O$, HCN and OCS will be retrieved from the gathered measurements. In addition, it will be possible to retrieve height-resolved information from high-resolution spectra for some trace gases. This would yield concentration profiles with a resolution of 6-8 km.

Data of selected trace gases (e.g. CO, $O_3$, $NO_2$) will be used for the validation of the SCIAMACHY instrument on the ENVISAT satellite. The measurements in the tropical regions are of special interest for the validation since there are only very few measuring sites at these latitudes. The collected data will also be interpreted in comparison with cruise data obtained in October 1996 (Bremerhaven - Punta Quilla) and December 1999 (Bremerhaven - Cape Town), as well as with the date of two recent cruises between Cape Town and Bremerhaven in November 2002 and February 2003, during which the measurements in the tropics were also a major focus of the investigations.

### References

Notholt, J., G. C. Toon, C. P. Rinsland, N.S. Pougatchev, N.B. Jones, B. J. Connor, R. Weller, M. Gautrois, and O. Schrems, (2000). Latitudinal variations of trace gas concentrations in the free troposphere measured by solar absorption spectroscopy during a ship cruise, *J. Geophys. Res.*, 105, 1337-1349

## 3.3 Determination of aerosol optical depth by sunphotometer measurements

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Alfred-Wegener-Institut
not on board: Andreas Herber, Alfred-Wegener-Institut

### Objectives

The primary goal of the sunphotometer measurements is the determination of a meridional distribution of atmospheric aerosol. The values of the aerosol optical depth will be used for the evaluation of the UV irradiation measurements.

### Work at sea

In this study, a multi-channel spectroradiometer SP1A developed by Dr. Schulz and Partner GmbH in Buckow, Germany, was used aboard *Polarstern* for the optical depth measurements. This instrument measures the sun intensity at 17 predetermined wavelengths in a range from 350 nm to 1,100 nm. It takes into account the changing sun elevation and the absorbing and scattering effect from non-aerosol particles, thus enabling it to yield optical properties of atmospheric aerosols, among them the aerosol optical depth.

**Tab. 3.3.1:** Summary of measurement days, geographical positions of the measurements and number of sunphotometer measurements

| Date | Geographical position | Number of measurements |
|---|---|---|
| 22.10.2003 | 53 N, 7 E | 2 |
| 24.10.2003 | 48 N, 5 W | 86 |
| 25.10.2003 | 45 N, 4 W | 70 |
| 29.10.2003 | 32 N, 14 W | 57 |
| 30.10.2003 | 28 N, 21 W | 19 |
| 31.10.2003 | 24 N, 20 W | 28 |
| 01.11.2003 | 20 N, 20 W | 51 |
| 02.11.2003 | 13 N, 20 W | 34 |
| 04.11.2003 | 05 N, 15 W | 28 |
| 05.11.2003 | 02 N, 13 W | 12 |
| 06.11.2003 | 01 S, 10 W | 54 |
| 07.11.2003 | 04 S, 07 W | 10 |
| 08.11.2003 | 09 S, 03 W | 8 |
| 09.11.2003 | 13 S, 00 W | 13 |
| 10.11.2003 | 15 S, 02 E | 36 |

The sunphotometer measurements strongly depend on weather conditions. For the realization of a successful measurement a clear, cloudless sky, especially close to the sun, is needed. Sunphotometer measurements could be performed on 15 days. During the remaining days it was either too cloudy or too stormy for performing measurements.
After the calibration of the instrument in February, 2004, at Izana/Tenerife, Spain, it will be possible to calculate the aerosol optical depth from the measured voltage signals.

## 3.4 Measurements of aerosols and tropical cirrus clouds with an Aerosol Raman LIDAR

Franz Immler[1)], Otto Schrems[1)], Ingo Beninga[2)]

[1)]Alfred-Wegener-Institut
[2)]Impres GmbH

### Objectives

One of the main objectives of this activity was to determine the latitudinal variation of aerosol in the troposphere. Another focus of the project was the detection of tropical cirrus clouds. These clouds form in the tropical tropopause region at altitudes up to 18 km and are generally not visible by the bare eye. Tropical cirrus (TC) play an important role in the exchange between troposphere and stratosphere. As the air moves upward in the tropical tropopause region, these clouds stop the water vapour before it can enter the stratosphere, allowing only very small amounts to reach the stratosphere above 18 km.

## Work at sea

The measurements were performed with our Mobile Aerosol Raman LIDAR system (MARL) which is mounted in a standard 20 ft laboratory container. During the cruise this container was placed at the helicopter deck of *Polarstern*. MARL is a backscatter LIDAR based on a linear polarized Nd:YAG Laser with 30 Hz repetition rate and 200 mJ pulse energy at 532 nm and 355 nm. The 9-channel detector measures elastic backscatter at 355 and 532 nm separated for polarization. Additional $N_2$-Raman channels at 397 and 607 nm provide the opportunity to perform extinction measurements. The system was generally operated with a time resolution of 140 s and a height resolution of 7.5 m. A small field of view and narrowband optical filters allow daytime operation.

## Preliminary results

Data from about 100 hours of measurements could be collected during the cruise by this Mobile Aerosol Raman LIDAR. Dust from the Sahara and other continental sources is often present above the Atlantic in an altitude range from 2 to 6 km. During this cruise, however, we could only detect small amounts of Saharan dust. The highest dust loading was detected on 3 November at about 10°N where the optical depth reached values of about 0.2. Dust is identified by its scattering behaviour, in particular because it depolarises the linearly polarised laser beam. This can be detected with high sensitivity by the LIDAR (see Fig. 3.4.1). Interestingly, weak depolarising layers were present in the altitude range from 2 to 4 km starting from 4 November throughout the ITCZ region and south of the Equator down to about 16°S. The origin of this aerosol needs to be determined back home by means of backward trajectories.

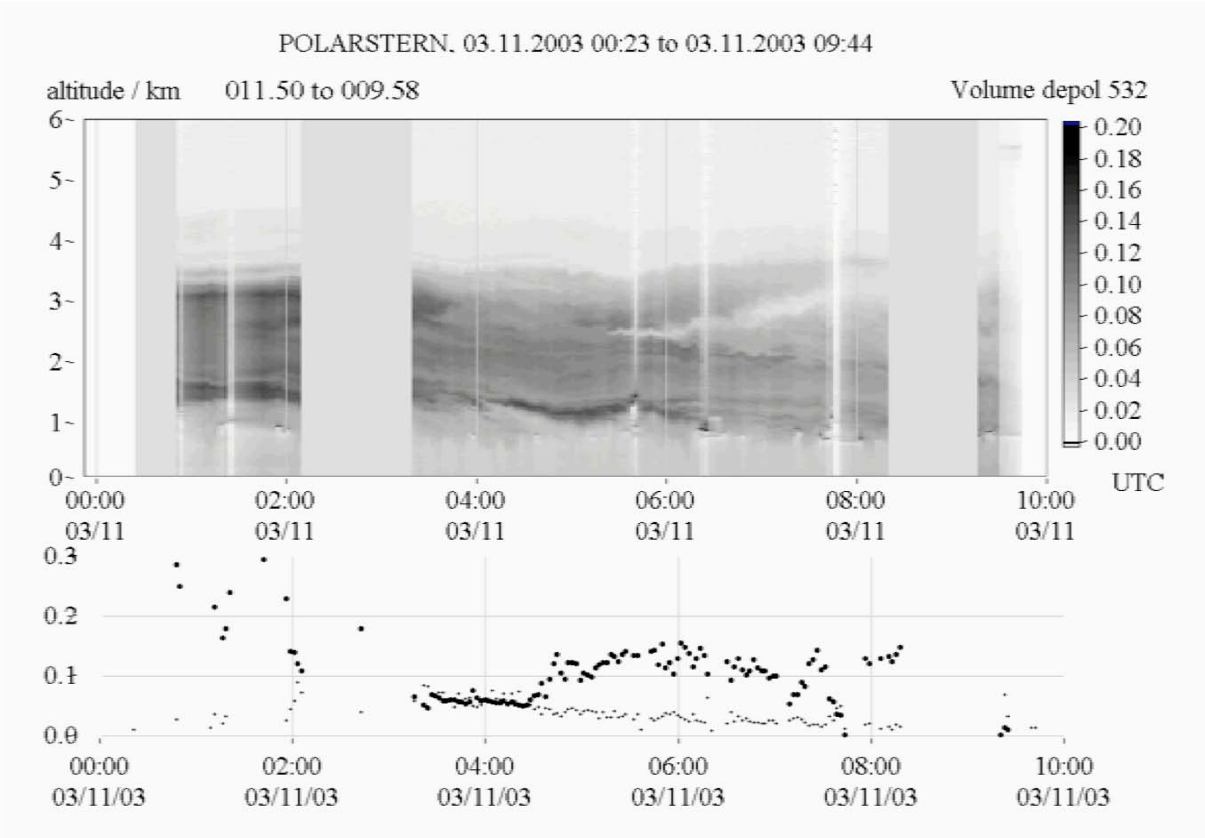


*Fig. 3.4.1: These time series of the depolarisation profiles show a layer of Saharan dust in an altitude range between 1.5 and about 4 km. The lower plot gives the optical depth of the layer (dots) and the mean depolarisation (crosses). These measurements were made between 11.5 and 9.6°N (preliminary data).*

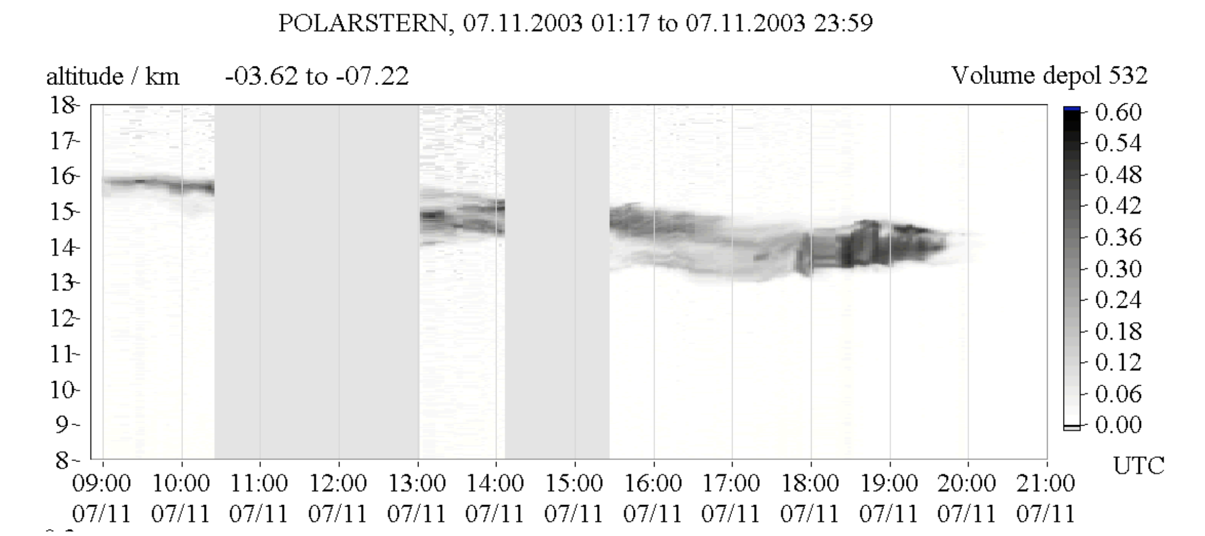


*Fig. 3.4.2: Time series of depolarisation profiles measured aboard Polarstern on 7 November around 4°S. The series shows the occurrence of subvisible tropical cirrus throughout the day. Just about sun-set (18:00 UTC) a stronger, visible cloud developed before the event disappeared. (preliminary data)*

As mentioned above a further focus of the project was the detection of tropical cirrus clouds. During this cruise we observed these types of clouds occasionally (see Fig. 3.4.2). The first event was registered on 1 November, 23:00 UTC, 17°N at 14 km altitude and the last one as far south as 14°S. That last one was of the ultra-thin type which describes clouds with an optical depth below $10^{-3}$. In between there were some high altitude clouds detected in the ITCZ but there was also a large region without the occurrence of TC around the equator. In addition to the daily radiosounding at about noon time we had additional radiosonde launches at night, allowing for a detailed analysis of the temperature in the tropopause region. Based on this data we will be able to determine precisely the conditions under which tropical cirrus do or do not occur.

Based on Raman shifted backscatter, our LIDAR system is also able to determine the water vapour content in the lower and middle troposphere. These data are very useful to study the properties of aerosol in that region as it varies with the relative humidity. Also it gives an interesting insight in synoptic scale airmass variations. On 30 October a thin layer of very dry air was detected just above the planetary boundary (Fig. 3.4.3).

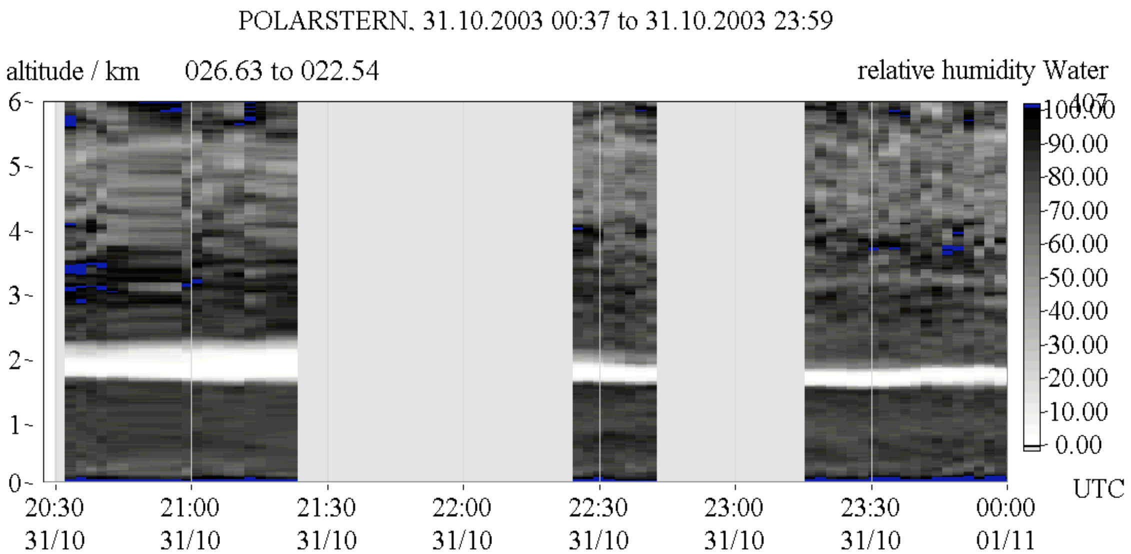


*Fig. 3.4.3: Relative humidity calculated from water vapour Raman measurements by MARL (preliminary data)*

## 3.5 UV-B and UV-A spectral measurements and UV-B dosimetry

Saad El Naggar[1)], Otto Schrems[1)], Heiko Lilienthal[2)]
[1)]Alfred-Wegener-Institut
[2)]ISITEC, Bremerhaven

### Objectives

The aims of this project were to investigate incident UV radiation in dependence of latitude with the focus on the influence of variable ozone content in the atmosphere. In detail the following objectives have been addressed:

- measuring spectral UV-A and UV-B distributions during the cruise using our combined UV-A & UV-B spectroradiometer
- assessing different UV radiation conditions in a variety of climate zones and a large range of solar zenith angles.
- Correlation of meridional ozone column variations with UV-B irradiation
- Determination of global UV-B doses as a function of latitude, sun elevation and total ozone column with different radiation detectors.

### Instruments

Solar spectral UV irradiance has been recorded with a spectroradiometer designed and built at AWI (Groß et al., 2001) This instrument consists of a Bentham 150 DTM double monochromator with a 32 Multi Channel Photomultiplier Plate to measure UV-B irradiance from 290 to 320 nm. The single channels of the UV-B instrument are 1.35 nm apart and the resolution is about 2 nm. For the detection of UV-A irradiance (320 to 400 nm) an Oriel single monochromator with a 256 diode array detector is used. The spectroradiometer has a resolution of 2 nm, but the channels have a step width of only 0.65 nm. Both, the UV-B and UV-A parts of the instrument are operated in a temperature-stabilized box and are controlled by the same software. A complete spectrum is obtained for each part every few seconds (1 sec for the UV-B, 2 to 32 seconds in the UV-A, depending on brightness). Spectra of UV irradiance are stored every minute.

Erythemal irradiance was recorded by two different types of instruments, the personal UV-B dosimeter ELUV-14 and the Solar Light Model 501 Biometer. Both instruments are broadband detectors with a response similar to the erythemal action spectrum. Data are stored in daily files in 1 minute and 5 minute records for the ELUV dosimeters and the Biometer, respectively.

### Work at sea

The spectroradiometer for the measurement of the solar UV irradiance was mounted at the port side of the observation deck. The instrument was in operation during the whole cruise from 22 October to 14 November and had never failed (Tab. 3.5.1). For direct measurements of the erythemal weighted UV-B irradiances and doses, the UV-B- Biometer, type 501 from Solar Light was used and installed nearby the spectrometer.

## Preliminary results

Fig. 3.5.1 shows the irradiance spectra of the UV-B integrated from 280 to 315 nm given with a time resolution of 5 minutes. When the ship crossed the meridian with the sun in the zenith on 10 November the expected maximum was influenced by cloud cover. The irradiance values in the figure obviously are influenced by three parameters, which are the solar zenith angle, cloud cover and ozone.

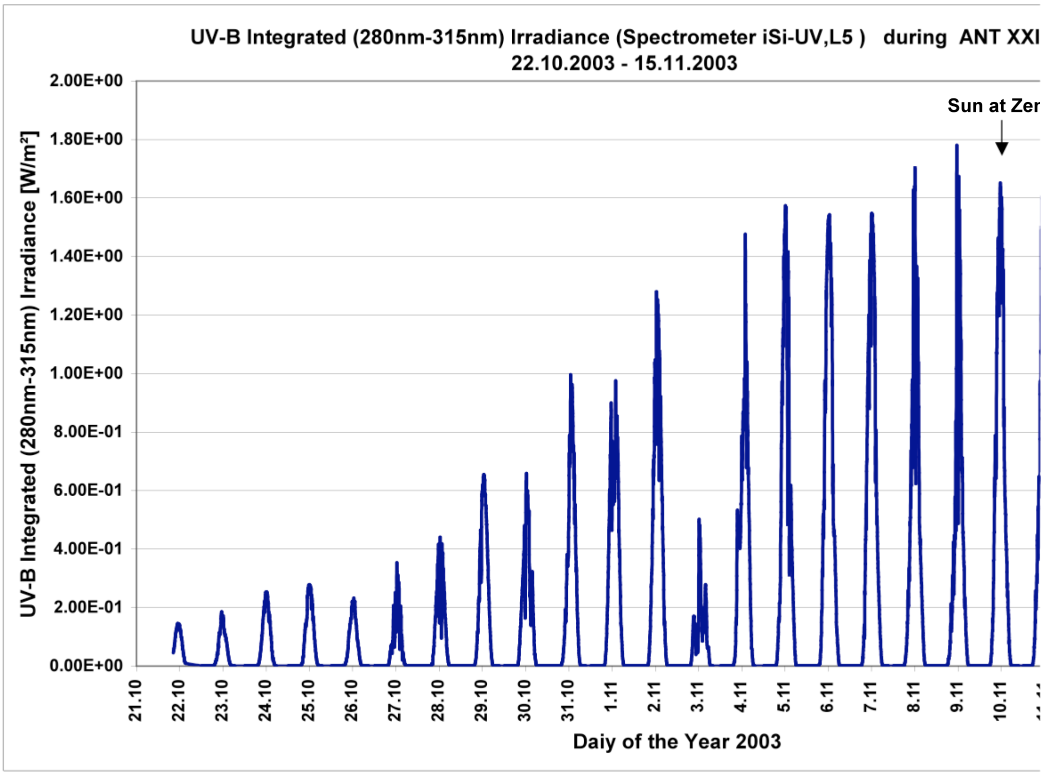


*Fig. 3.5.1: Daily integrated UV-B irradiance during ANT-XXI/1*

The integrated UVB doses retrieved from the integral over a whole day for wavelength between 280 and 315 nm, are shown in Fig. 3.5.2. The influence of cloud cover can be excluded by forming the ratio of two irradiance values of the same spectrum because the absorption of clouds is almost the same for two wavelengths not far separated from each other. The ratio obtained from the irradiance at 300 and 320 nm is called the UVB index. The index is only affected by the solar zenith angle and the ozone column, because the ozone absorption at 300 nm is rather high compared to that at 320 nm.

To calculate the relative ozone variations, the ratio of irradiance at 320/ irradiance at 300 is considered at the same zenith angel for every day. This is shown in Fig. 3.5.3 for airmass 2.3 which corresponds to a solar zenith angle of about 65 degrees. This airmass was chosen with respect to the departure date in Bremerhaven. This also means that for all other days of the cruise we obtained two index values, one in the morning and one in the afternoon. Note, that between both values at a position close to the equator the time gap between both measurements can be more than 8 hours. The average of both measurements is transformed on an absolute scale like in

Fig. 3.5.4. The absolute scale was derived from ozone sonde measurements at the same date. These total ozone values computed by an integral of the tropospheric and stratospheric ozone profile are also shown in figure 3.5.3.

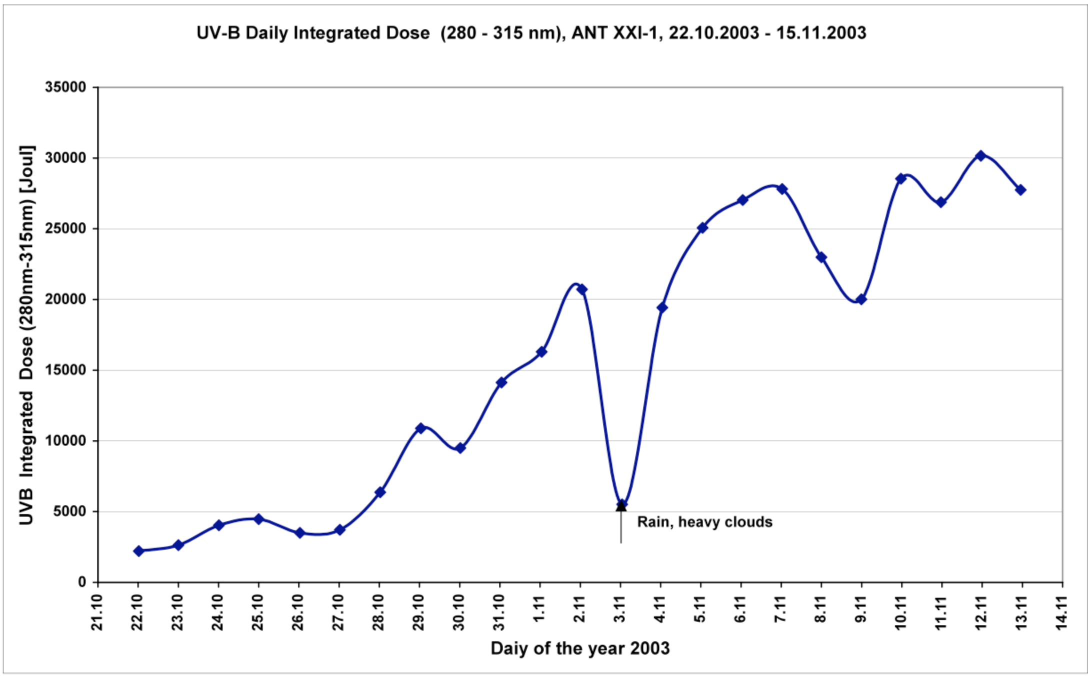


*Fig. 3.5.2: Daily integrated UV-B dose during ANT-XXI/1*

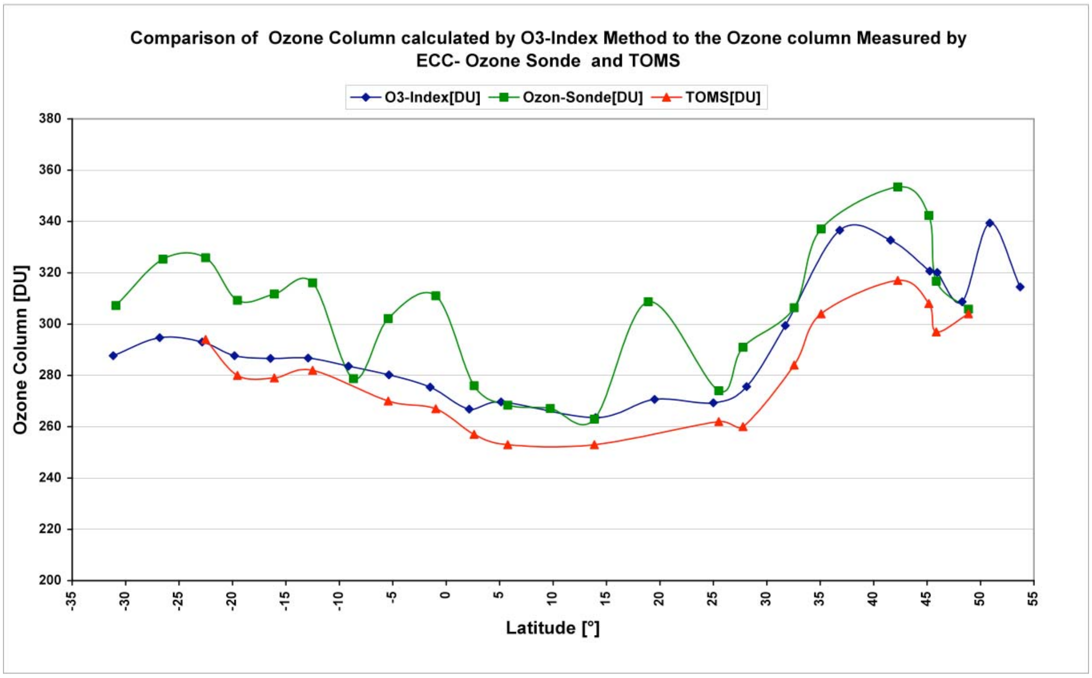


*Fig. 3.5.3: Comparison of Ozone Column calculated by $O_3$-Index Method to the Ozone column measured by ECC- Ozone Sondes and TOMS during ANT-XXI/1*

Figure 3.5.4 shows the UV-B unweighted and erythemal weighted daily doses during the cruise. All measurements were affected by the bad weather conditions. On 3 November heavy cloud coverage occurred and this explains the very low dose for this day. The maximal dose of 60,736 Joule (UV-B) and 3,442 Joule (Erythemal weighted = 16.4 MED, Minimal Erythemal Dose) were recorded on 12 November at sun elevation of 84.8°. The expected maximum should have been observed on 10 November at sun elevation of 89.2°. However, the cloud cover on this day reduced the dose.

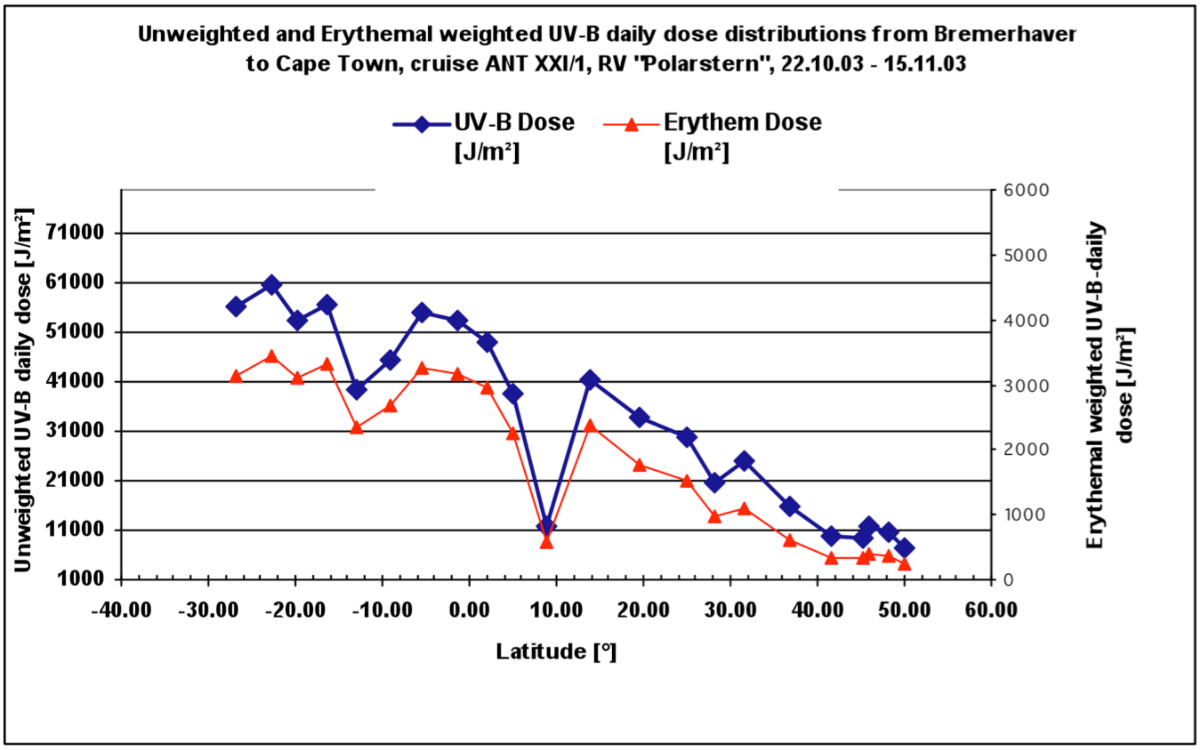


*Fig. 3.5.4: UV-B Dose distributions between Bremerhaven and Cape Town during ARK XXI/1*

**Tab. 3.5.1**: Summary of all relevant data of the UV-B measurement obtained during the cruise

| Date | Zenith Time [UTC] | Latitude [deg] | Longitude [deg] | UV-B Dose [J/m²] | Erythem Dose [J/m²] | Erythem Dose [MED] | Ozone [DU] | Max.Sun Elevation [°] |
|---|---|---|---|---|---|---|---|---|
| 22.10.2003 | | | | | | | | |
| 23.10.2003 | 11:45 | 50.00 | -1.40 | 7561.243 | 237.029 | 1.129 | | 27.6 |
| 24.10.2003 | 12:25 | 48.25 | -6.17 | 10655.266 | 370.615 | 1.765 | 304 | 30 |
| 25.10.2003 | 12:18 | 45.92 | -4.40 | 11728.408 | 410.854 | 1.956 | 314 | 32 |
| 26.10.2003 | 12:23 | 45.23 | -5.85 | 9229.694 | 320.715 | 1.527 | 342 | 32.4 |
| 27.10.2003 | 12:44 | 41.53 | -10.46 | 9651.112 | 344.689 | 1.641 | 353 | 35.7 |
| 28.10.2003 | 12:51 | 36.80 | -12.65 | 15988.919 | 597.644 | 2.846 | 337 | 40.1 |
| 29.10.2003 | 12:57 | 31.70 | -14.38 | 24964.727 | 1085.619 | 5.170 | 305 | 44.6 |
| 30.10.2003 | 13:02 | 28.10 | -15.36 | 20753.651 | 985.880 | 4.695 | 291 | 47.1 |

| Date | Zenith Time [UTC] | Latitude [deg] | Longitude [deg] | UV-B Dose [J/m²] | Erythem Dose [J/m²] | Erythem Dose [MED] | Ozone [DU] | Max.Sun Elevation [°] |
|---|---|---|---|---|---|---|---|---|
| 31.10.2003 | 13:20 | 24.95 | -20.00 | 29785.035 | 1519.073 | 7.234 | 274 | 51 |
| 01.11.2003 | 13:21 | 19.44 | -20.27 | 34081.547 | 1773.546 | 8.445 | 308 | 56.2 |
| 02.11.2003 | 13:23 | 13.92 | -20.82 | 41636.427 | 2374.419 | 11.307 | 263 | 61,4° |
| 03.11.2003 | 13:16 | 8.90 | -19.10 | 11785.206 | 590.405 | 2.811 | 267 | 66.1 |
| 04.11.2003 | 13:04 | 5.10 | -15.90 | 38729.338 | 2247.313 | 10.701 | 268 | 68.5 |
| 05.11.2003 | 12:54 | 2.14 | -13.42 | 49259.385 | 2969.069 | 14.138 | 276 | 70.9 |
| 06.11.2003 | 12:42 | -1.38 | -10.37 | 53338.829 | 3175.600 | 15.122 | 335 | 72.5 |
| 07.11.2003 | 12:29 | -5.42 | -7.13 | 55145.765 | 3248.928 | 15.471 | 302 | 79.2 |
| 08.11.2003 | 12:16 | -9.15 | -3.98 | 45655.588 | 2677.968 | 12.752 | 279 | 82.4 |
| 09.11.2003 | 12:03 | -12.96 | -0.77 | 39642.769 | 2339.440 | 11.140 | 316 | 86.1 |
| 10.11.2003 | 11:48 | -16.32 | 3.00 | 56658.246 | 3322.831 | 15.823 | 312 | 89.2 |
| 11.11.2003 | 11:33 | -19.87 | 6.72 | 53551.800 | 3119.012 | 14.852 | 309 | 87.5 |
| 12.11.2003 | 11:23 | -22.83 | 9.37 | 60736.217 | 3442.406 | 16.392 | 326 | 84.8 |
| 13.11.2003 | 11:10 | -26.85 | 12.47 | 56412.877 | 3130.001 | 14.905 | 325 | 81.1 |
| 14.11.2003 | 10:56 | -31.22 | 15.98 | | | | 307 | 77.0 |

## References

Groß, C., H. Tüg, and O. Schrems, (2001). Three years spectral resolved UV-measurements at Koldewey-Station (1997-1999), *Mem. Natl. Inst. Polar Res., Spec. Issue*, 54, 113-123

## 3.6 MAX-DOAS observation of tropospheric and stratospheric trace gases for validation of the SCIAMACHY instrument

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Universität Heidelberg
not on board: Ulrich Platt, Thomas Wagner, Universität Heidelberg

### Introduction

During the cruise of the research vessel *Polarstern* from Bremerhaven to Cape Town observations of the absorption spectra of the sun light scattered by atmospheric gases were performed daily. These observations were made by the proved DOAS method (Differential Optical Absorption Spectroscopy) in order to identify trace gases in the atmosphere by their characteristic absorption lines in the obtained spectra in different wavelength ranges of the scattered solar light and then to calculate their concentrations through analysis of the obtained data.

These measurements can identify trace gases and determine their concentrations like some mainly tropospheric trace gases as $NO_2$, $H_2O$, HCHO, IO and $SO_2$ and also some other mainly stratospheric trace gases (absorbers) as $O_3$, $NO_2$, BrO, OClO, $H_2O$, HCHO, $O_4$ and IO.

Since some gases have absorptions only in the UV region, as BrO, $SO_2$, HCHO others have absorptions in the visible as $H_2O$ and IO while some gases have absorption in both ranges like $O_3$, $NO_2$, OClO, and $O_4$, the MAX-DOAS (Multi Axis DOAS ) instrument uses 2 separate instrumental setups :

1) The UV unit: covers the spectra range from about 300 to 400 nm and consists of 3 movable telescopes collecting light simultaneously from 3 different directions of sight. Every telescope is connected to an entrance slit with 7 glass fibres to the spectrograph and the resulting 3 spectra are then recorded by a 2-dimensional CCD array with 1,024 x 256 pixels.
2) The unit for the visible covers wavelengths from about 400 to 700 nm. It consists of one movable telescope connected to a spectrograph of 2,048 pixel CCD row by one glass fibre with a diameter 800 micrometer.

The collected scattered sunlight is dispersed by spectrographs and the resulting spectra are recorded by CCD detectors and collected data are saved on PC aboard *Polarstern* for later retrieval and analysis. The concentrations of atmospheric trace gases can be determined by analysis of the collected data.

**Work at sea**

About 4.2 GB of data were collected during ANT-XXI/1. The MAX-DOAS instrument was running continuously and performing measurements during the day and carrying out calibrations at night using Hg-Ne calibration lamps and Halogen lamps. The whole measurements and calibration processes are controlled automatically to a large extent by the measurement software.

**Expected results**

Since similar measurements were also performed by the SCHIAMACHY instrument on board of the ENVISAT satellite launched into a polar orbit in March 2002, it is important to validate the satellite data by making ground-based control measurements at locations beneath the satellite's orbit. The measurements on board of *Polarstern* are best suited for that purpose because during the Antarctica cruise, the ship follows a polar course convenient to the ENVISAT orbit. The validity and the value of SCIAMACHY data will depend on their exactness which is validated by the MAXDOAS ground-based measurements on board of *Polarstern*.

## 3.7 Multiphase halogen chemistry in the Atlantic marine boundary layer

Alex Pszenny[1,2], Bill Keene[3], Astrid Kerkweg[4] John Maben[3], Tom O'Halloran[3], Rolf Sander[4] and Andy Wall[2]

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[2] Mount Washington Observatory, North Conway, USA
[3] University of Virginia, USA,
[4] Max-Planck-Institut für Chemie, Mainz, Germany

### Introduction

Multiphase chemical transformations involving halogenated compounds impact important, interrelated chemical processes in the marine boundary layer (MBL). The phase partitioning of HCl regulates aerosol pH and associated pH-dependent reactions including halogen activation and S(IV) oxidation. Halogen radical chemistry catalytically destroys $O_3$, oxidizes hydrocarbons, dimethylsulfide, and S(IV), and modifies $HO_x$ cycling. However, spatial and temporal variabilities in most reactant and product species and details concerning the nature of some chemical pathways are poorly characterized. Consequently, the global significance of chemical processes involving tropospheric halogens is very uncertain.

Detectable BrO (indicative of significant halogen radical chemistry) was first measured in the open-ocean MBL north of the Canary Islands during a boreal autumn 2000 cruise of *Polarstern* from Germany to South Africa. The present project is part of a more comprehensive follow-up investigation of chemical processes involving halogens along the same transect

### Scientific objectives

- Measure diel variability of principal reactant and product species and related physical parameters relevant to inorganic halogen cycling in the marine boundary layer (MBL) along a latitudinal transect through the North and South Atlantic Oceans.
- Characterize variability in the pH of near-surface marine aerosol as functions of size, day versus night, latitude, and air-mass history (including transport regime) and associated chemical composition.
- Collaborate with other participating scientists in assessing details of halogen activation chemistry and related influences on the cycling, lifetimes, and environmental implications of tropospheric $O_3$ and S(IV).
- Model the relative importance of gaseous- versus particulate- dry deposition for major S and N compounds.

This research addresses the goals of the International Global Atmospheric Chemistry (IGAC) Project and Surface Ocean – Lower Atmosphere Study (SOLAS) elements of the International Geosphere-Biosphere Programme (IGBP).

### Work at sea

Size-segregated aerosols were sampled with cascade impactors. These samples will be analyzed post-cruise for major ionic constituents. Total volatile inorganic Br was sampled with filterpacks, which will also be analyzed post-cruise. HCl* (primarily

HCl), Cl* (including HOCl and $Cl_2$), $HNO_3$, $NH_3$, $SO_2$, HCOOH, and $CH_3COOH$ were sampled with mist chambers; these samples were analyzed onboard by ion chromatography. Aerosol pH as a function of size will be inferred from the measured phase partitioning of the gases and associated thermodynamic properties. Observations will be applied using box model calculations to test specific hypotheses regarding halogen chemistry and sulfur cycling in the marine atmosphere.

Thirty-one sets of aerosol and filter pack samples were collected during the cruise. Samples were transferred into clean centrifuge tubes, sealed in glass mason jars and frozen at –20°C to minimize degradation. Over 175 mist chamber samples were collected and analyzed. Due to failure of one of four ion chromatography systems early during the cruise preliminary data are available now only for HCl* for part of the cruise. These data indicate mixing ratios of 400 to 1200 pptv HCl* during the period 23 - 27 October (English Channel to Bay of Biscay) and 200 to 500 pptv from 30 October to 1 November (track portion from ~33°N to ~21°N).

### Expected results

Once the analyses are complete, the obtained results will provide critical and hitherto unavailable constraints on knowledge concerning multiphase halogen cycling and aerosol pH over a broad range of MBL conditions and the related influences on Earth systems including climate. The study also trains graduate students and strengthen partnerships between European and U.S. scientists. The results of this project will be disseminated through scholarly and public presentations, scientific journals, popular articles, and freely accessible data archives.

## 3.8 Global marine sources of reactive halogen species

Paul I Williams[1], James Hopkins[2], Carl Parlmer[2], Ossama Ibrahim Ahmed[3]
[1]University of Manchester,UK
[2]University of York, UK
[3]Universität Heidelberg, Germany

### Introduction

Over the last decade it has been established that catalytic cycles involving reactive halogen species (RHS) are responsible for ozone depletion events in the troposphere. Active RHS chemistry has so far been demonstrated in regions including (i) the Arctic and around Antarctica where abrupt bromine oxide (BrO) "episodes" completely destroy surface ozone in timescales of hours to days (Barrie et al., 1988; Bottenheim et al., 1990; Tuckermann et al., 1997), (ii) coastal areas where concentrations of the IO radical can be sufficiently high to double the marine boundary layer (MBL) depletion rate of $O_3$ (Alicke et al, 1999; McFiggans et al., 2000) and (iii) the Dead Sea Valley where the highest tropospheric BrO concentrations to date have been observed (Hebestreit et al., 1999). The sources of RHS and/or their precursors in these regions include sea ice, ice algae, salt pans and coastal macroalgae.

It is now emerging that tropospheric bromine and iodine chemistry may not be confined to these specific areas and sources. IO has recently been detected at concentrations of up to 3 pptv (parts per trillion by volume) in air masses with little or no coastal influence (Allan et al., 2000). The most recent measurements of BrO from balloons, aircraft and satellites indicate a free tropospheric background of BrO of about $10^7$-$10^8$ molecules $cm^{-3}$ (e.g., Fitzenberger et al, 2000). The implications of a more widespread abundance of IO and BrO are profound. An important consequence is that the rate of tropospheric ozone destruction may be currently underestimated, which in turn suggests that tropospheric ozone production may also be underestimated.

A detailed understanding of the marine aerosol surface area is vital, as the proposed chemical pathways include the uptake and processing of BrO and IO by-produces by aerosol. As a result, gas phase Br and I maybe enhanced as the aerosol processing can lead to multiplying and subsequent out gassing of these molecules.

Collaboration between UMIST, York University and the University of Heidelberg was set up to study the effects and importance of marine halogen chemistry, away from coastal sources. Participants on the 2003 cruise were Dr. Paul I. Williams (UMIST), Dr. James Hopkins and Carl Parlmer (York) and Ossama Ibrahim Ahmed (Heidelberg). Modelling of the chemical reactions, both in the gas phase and aerosol phase, is to be carried out at UMIST by Dr. Gordon McFiggans once all the data has been collated.

**Work at sea**

Measurements onboard included aerosol size number distribution (in the size range 5nm to 20 µm), carbon monoxide (CO), $O_3$, organo-halogens including $C_nH_{2n+1}I$ (n=1-3), $CH_2XY$ and CHXYZ (X,Y, Z = I, Br, Cl) and BrO and IO.

**Preliminary results**

Preliminary results indicate that there is a good and almost continuous data set for the aerosol size distributions, CO and $O_3$ and that the cruise had been a success. The halogen gas data set is still being validated and some water samples have also been taken.

Some very marked difference between the Northern and Southern hemispheres have been seen and are shown in figure 3.8.1. This shows the total number concentration for aerosol particles with a diameter (Dp) < 1.0 µm for the 2003 and 2002 cruises. There are similarities between the cruises as a function of latitude, the most marked being the drop in total number south of 10°N. Differences between the cruises can be explained by the wind direction and back trajectories. Figure 3.8.2 re-plots the total number concentration on a 2D map and has a sample of the aerosol size distributions from the contrasting regions. The solid curve is data from the UMIST differential mobility particle sizer (DMPS) for sizing and counting particles in the range 5 nm – 820 nm, the dashed from the UMIST optical particle counter (Supplied by Grimm) for the size range 0.3 µm to 20 µm. In the Northern hemisphere, high concentrations of particles are seen in all sizes, extending down to the sub 20 nm size range (ultra fine particles). South of 10°N and on the Southern hemisphere, a different distribution is observed. The distribution is regularly tri-modal with mode diameters around 60 - 100 nm, 200 - 300 nm and 1-2 µm. Furthermore, the total number concentration is two orders of magnitude lower and few, if any, particles exist below 20 nm. The lowest aerosol number concentration of 25 particles per cubic centimetre was recorded on 8 November. The average in the clean Southern hemisphere is about 300 - 450 per cubic centimetre.

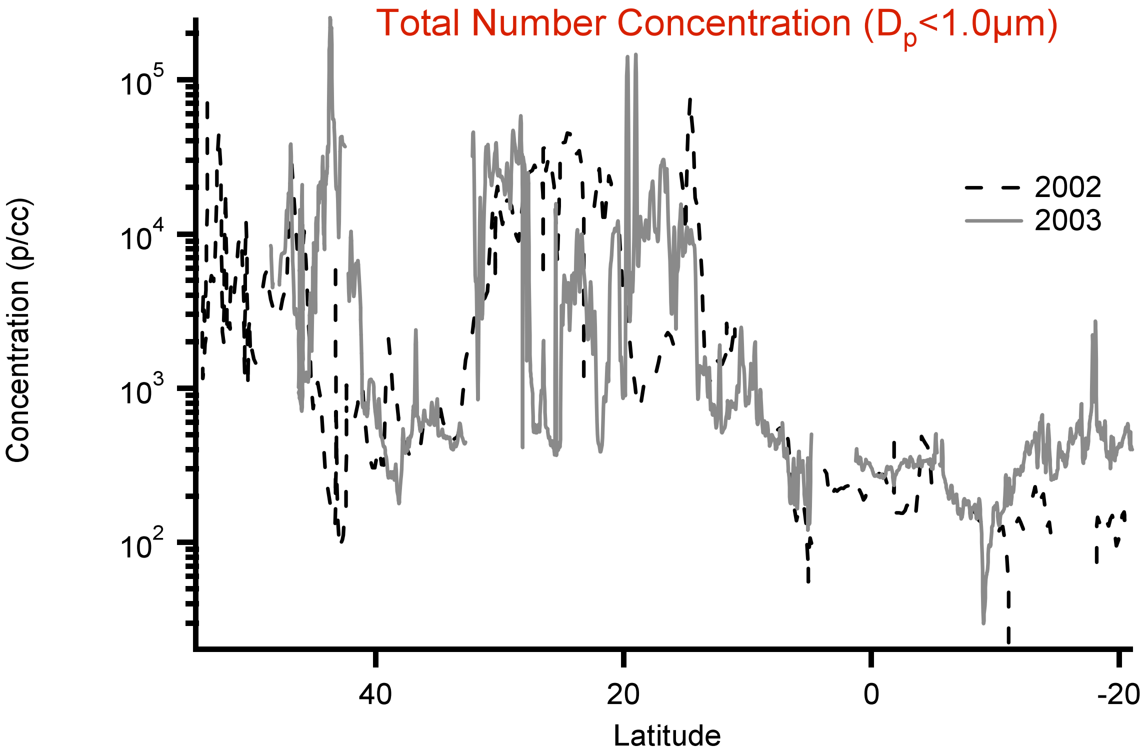


*Fig. 3.8.1: Total number concentration from the UMIST DMPS*

The reason for the lower concentrations is due to the relatively clean air in the Southern Atlantic. The York CO analyser (supplied by Aerolaser) has recorded values of around 60 - 70 parts per billion by volume (ppbv), which suggests that the air masses have not been influenced by any anthropogenic sources. This is further supported by the daily back trajectories which indicated that air masses sampled have not been over land for several days.

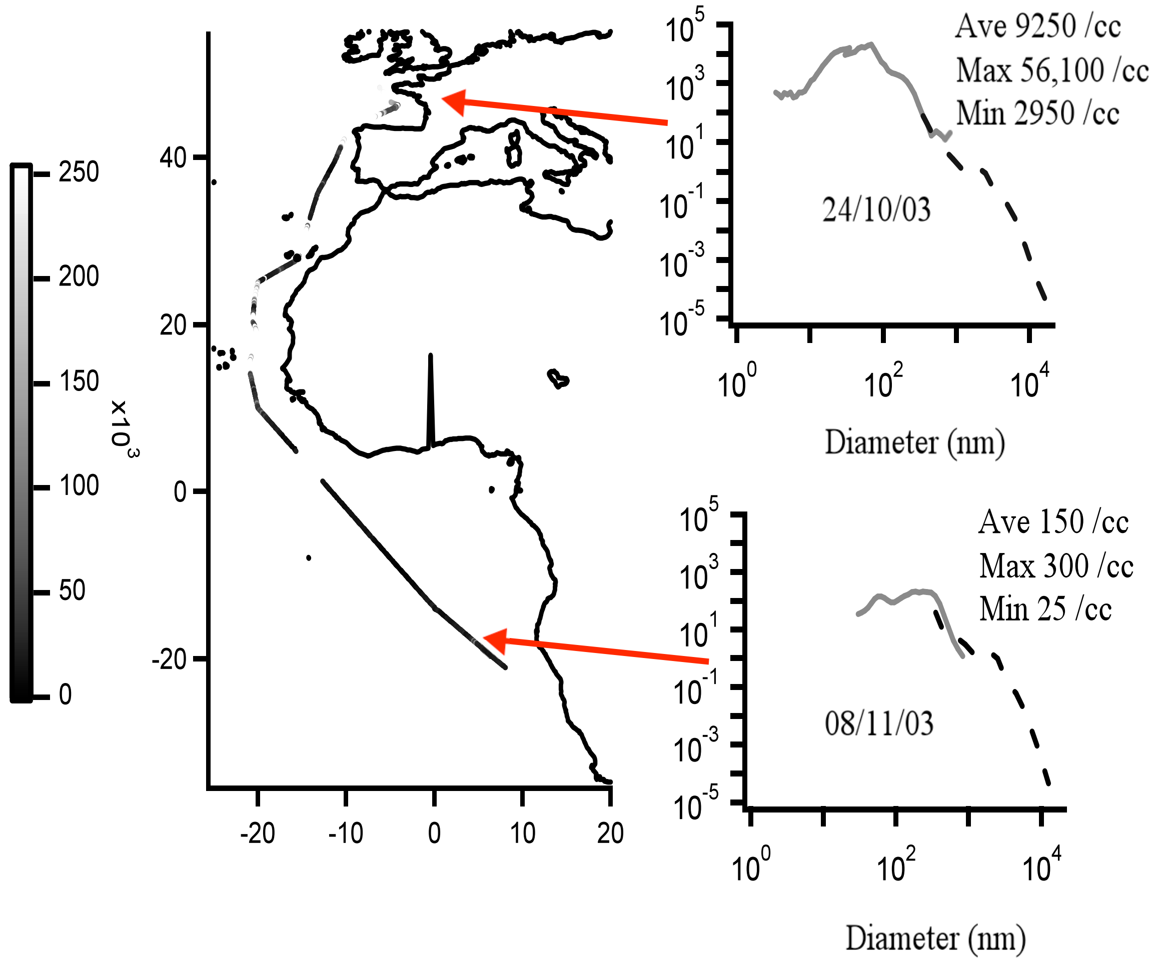


*Fig. 3.8.2 : Total number concentration as a function of the ship's course and examples of the aerosol size distributions*

## References


Alicke B., K. Hebestreit, J. Stutz and U. Platt, Iodine oxide in the marine boundary layer, *Nature*, *397*, 572-573, 1999.

Allan B. J., G. McFiggans, J. M. C. Plane, H. Coe, Observations of iodine monoxide in the remote marine boundary layer, *J. Geophys. Res.*, 105, 14363-14369, 2000.

Barrie, L. A., J. W. Bottenheim, R. C. Schnell, P. J. Crutzen and R. A. Rasmussen, Ozone destruction and photochemical reactions at polar sunrise in the lower Arctic atmosphere, *Nature*, *334*, 138-141, 1988.

Bottenheim, J. W., L. A. Barrie, E. Atlas, L. E Heidt, H. Niki, R. A. Rasmussen, and P. B. Shepson, Depletion of lower tropospheric ozone during Arctic spring: The Polar Sunrise Experiment, *J. Geophys. Res.*, *95*, 18555-18568, 1990.

Fitzenberger R., Bosch H., Camy-Peyret C., Chipperfield M.P., Harder H., Platt U., Sinnhuber B.M., Wagner T., Pfeilsticker K., First profile measurements of tropospheric BrO, *Geophys. Res. Lett.,*, *27*, 2921-2924, 2000.

Hebestreit, K., Stutz J., Rosen D., Mateev V., Pelev M., Luira M., and Platt U., First DOAS Measurements of Tropospheric BrO in Mid Latitudes, *Science*, *283*, 55-57, 1999.

McFiggans, G., B. Allan, H. Coe, J. M. C. Plane, L. J. Carpenter and C. O'Dowd, Observations of IO and a modelling study of iodine chemistry in the marine boundary layer, *J. Geophys. Res*, *105*, 14,371-14,385, 2000.

Tuckermann, M., R. Ackermann, C. Golz, H. Lorenzen-Schmidt, T. Senne, J. Stutz, B. Trost, and U. Platt, DOAS-Observation of Halogen Radical-Catalysed Arctic Boundary Layer Ozone Destruction during the ARCTOC Campaigns 1995 and 1996 in Ny-Alesund, Spitsbergen, *Tellus 49B*, 533-555,

## 3.9 Levels and patterns of organic nitrates in the northern and southern hemisphere

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### Objectives

Global aspects of environmental chemistry – in this case especially of the atmospheric chemistry – become more and more significant. Therefore, a precise knowledge about possible reaction cycles and the involved trace gases is necessary. The aim of this project was to investigate the levels and patterns of organic nitrates in the northern and southern hemisphere. These data will help to identify the sources and sinks of these compounds. As it has been established in investigations of other compounds in our research group, the exchange between the marine boundary layer an the seawater surface seems to play an important role (Schreitmüller, J. et al., 1994 and 1995). Beside the importance of the distribution in the two hemispheres the varying levels and patterns during day and night time chemistry are a main aspect.

### Work at sea

During the expedition ANT-XXI/1 low volume air samples were taken on different adsorbent materials. The amounts of air ranged from 2 l up to 100 l. Because of the extremely high surface area of *Hayesept D* this material was only used for the very low samples (14 samples). Most of the 70 samples were taken on *TENAX TA*. The air samples have extremely low levels of organic nitrates. Thus, it is very important to take care about contamination caused by the ship. After passing the ITCZ all air samples were collected at the "crow’s nest" where the air flow of the south-east trade wind came from the front. Some of the northern hemisphere samples had to be taken at the helideck because the air flow was coming from the north.

### Expected results

The analysis of the air samples will be performed at the University of Ulm with a Chrompack Thermal desorption unit (TCT 4001) coupled with an HP HRGC-ECD-system HP HRGC-MSD, respectively. The obtained results will then be compared with data of former ship expeditions in order to improve the knowledge of the behaviour of organic nitrates in the lower marine atmosphere (Fischer, R. et al., 2000; Ballschmiter, K., 2002).

## References

J. Schreitmüller, K. Ballschmiter, "The Equilibrium Distribution of Semivolatile Organochloro Compounds between Atmosphere and Surface Water in the Atlantic Ocean", *Angew. Chem. Int. Ed. Engl. 33 (1994) 646-649; Angew. Chem. 106 (1994) 688-691.*

J. Schreitmüller, K. Ballschmiter, “Air-Water Equilibrium of Hexachlorocyclo-hexanes and Chloromethoxybenzenes in the North and South Atlantic”, *Environ. Sci. Technol. 29 (1995) 207-215.*

R. G. Fischer, J. Kastler, K. Ballschmiter, „Levels and pattern of alkyl nitrates, multifunctional alkyl nitrates, and halocarbons in the air over the Atlantic Ocean“, *J. Geophys. Res. 105/11 (2000) 14,473-14,494.*

K. Ballschmiter, “A Marine Source of Alkyl Nitrates”, *Science, 297 (2002) 1127-1128.*

# 4. MARINE CHEMISTRY

## 4.1 $^{13}$C-sampling programme during *Polarstern* transits

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### Objectives

The primary goal of the $^{13}$C sampling programme was to study the interannual variability and long term trends in the air-sea $\delta^{13}$C-DIC disequilibrium of surface waters in the Atlantic Ocean. The project is meant to be a long-term study which involves sampling during all *Polarstern* transits to/from the Southern Ocean. It is a joint project of Prof. Dr. Paul Quay of the School of Oceanography, University of Washington, Seattle/WA, U.S.A. and Prof. Dr. Arne Körtzinger of the Institut für Meereskunde, Kiel.

### Work at sea

During each transect, surface samples for $\delta^{13}$C-DIC measurements were taken with regular spacing along the entire cruise track. These samples will be measured at Paul Quay's Stable Isotope Laboratory. For this purpose, the $CO_2$ is extracted to 100 ± 0.5 % using a helium stripping technique, and the $^{13}C/^{12}C$ ratio of the extracted $CO_2$ is later measured on a Finnigan MAT 251 isotope ratio mass spectrometer. The overall precision of $\delta^{13}$C analyses is typically ± 0.02 ‰ based on replicate analyses of standards and seawater samples (Quay et al., 1992).

In order to enhance interpretation of the $\delta^{13}$C data (Körtzinger et al., 2002), parallel sampling for dissolved inorganic carbon (DIC) and total alkalinity ($A_T$) was carried out with a similar number of samples. The water samples were collected from a seawater pumping system at a depth of 11 m at the keel of the vessel. The system works with a "Klaus"-pump, the tube which leads the water into the lab are made of teflon. Temperature- and salinity data were measured by a thermosalinograph nearby the water in-flow. All samples are poisoned with 100 $\mu$L saturated $HgCl_2$-solution. Measurements of DIC and $A_T$ will be carried out in Kiel using the following techniques: DIC is measured by coulometric titration following extraction of the $CO_2$ with an automated system known as SOMMA (Johnson et al., 1993). $A_T$ is determined by potentiometric titration in an open cell (Mintrop et al., 2000 and references therein). DIC and $A_T$ analyses are checked every 10 –15 samples by measuring a certified reference material provided by A. Dickson (Scripps Institution of Oceanography, La Jolla, CA, U.S.A.). The estimated typical accuracy is 1.5 $\mu mol \cdot kg^{-1}$ for DIC and 2.5 $\mu mol \cdot kg^{-1}$ for $A_T$.

The samples are collected during leg 1 and 5 of the *Polarstern* cruise ANT-XXI.

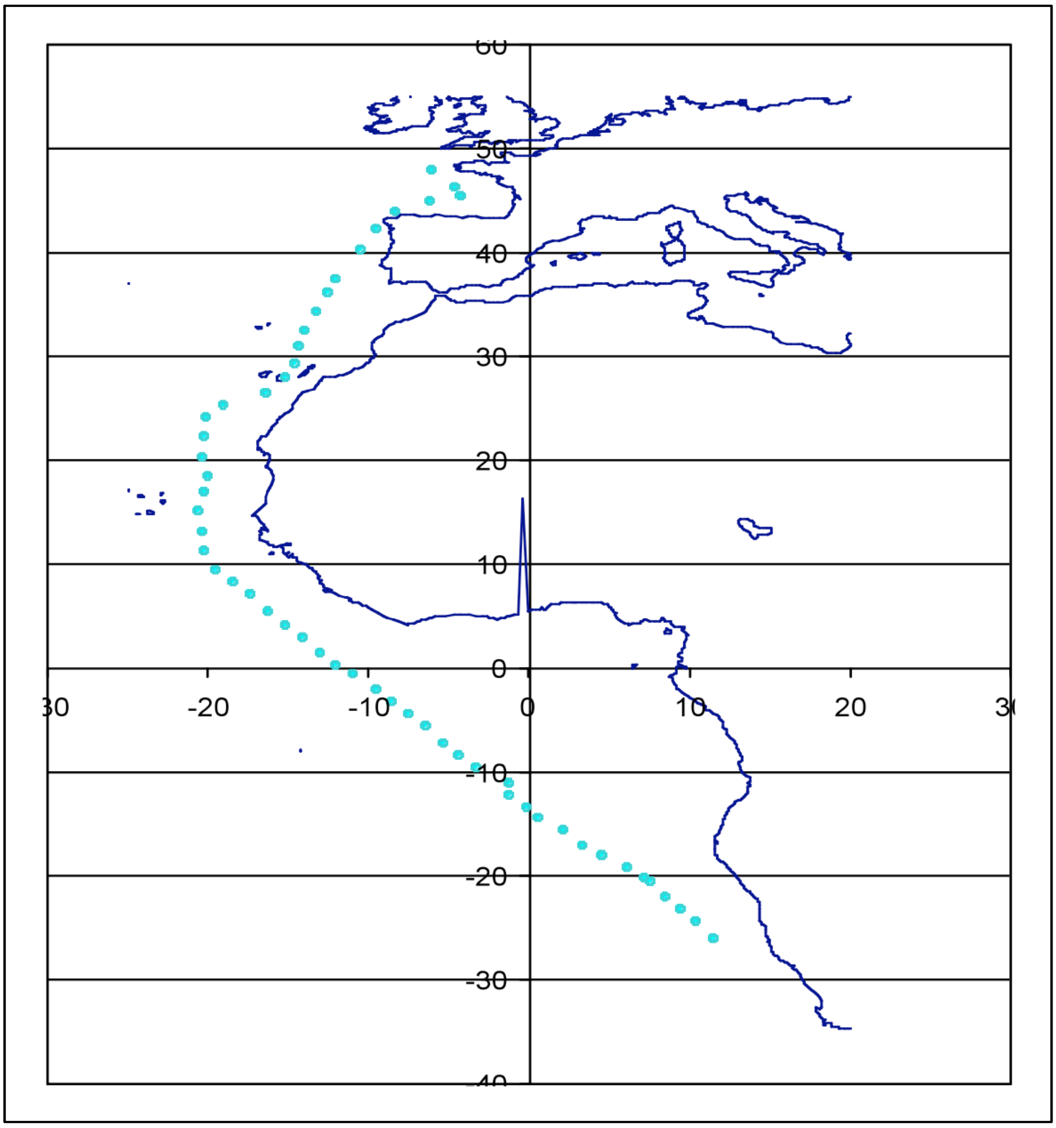


*Fig. 4.1: Overview of the sampling positions*

## References

Johnson, K.M., Wills, K.D., Butler, D.B., Johnson, W.K., Wong, C.S., 1993. Coulometric total carbon dioxide analysis for marine studies: maximizing the performance of an automated gas extraction system and coulometric detector. *Mar. Chem.*, **44**, 167-187.

Körtzinger, A., P.D. Quay, and R.E. Sonnerup, 2003. Relationship between anthropogenic $CO_2$ and the $^{13}C$ Suess effect in the North Atlantic Ocean, *Global Biogeochem. Cycles*, **17**, 1005-1024.

Mintrop, L., Pérez, F.F., Gonzalez-Davila, M., Santana-Casiano, J.M., Körtzinger, A., 2000. Alkalinity determination by potentiometry – intercalibration using three different methods. *Ciencias Marinas*, **26**, 23-37.

Quay, P.D., B. Tilbrook, and C.S. Wong, Oceanic uptake of fossil fuel CO2: Carbon-13 evidence, *Science*, **256**, 74-79, 1992.

# 5. ACOUSTICS

## 5.1 Sea acceptance test of the Hydrosweep multibeam system in the Bay of Biscay

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[2]Atlas Hydrographic GmbH

### Objectives

The software upgrade of the new operating modes "High Definiton Bearing Estimation (HDBE)" and "Automatic Source Level Control (ASLC)" of the Hydrosweep System was evaluated and tested during the first leg of ANT-XXI/1, Bremerhaven to Las Palmas / Gran Canary (Fig. 5.1.1), on the base of the Sea Trial Acceptance Protocol.


*Fig. 5.1.1: ANT-XXI/1 cruise track of the first leg Bremerhaven to Las Palmas*

## Work at sea

Most of the tests were carried out in the French part of the Bay of Biscay at the continental slope by water depths of 200 to 4,000 m. The established test area "Location 2b", in which previous deep sea trials were carried out with Hydrosweep DS-1 and DS-2 (first version), could not be used in full expansion, because of geographic restrictions given in the French research permission. Therefore the region of the Canyon de Noirmoutier (Fig. 5.1.2) of which well known bathymetry is also available, was utilized for the trials. A new test area "Location 2c" (Fig. 5.1.3) was established at the foot of the canyon.

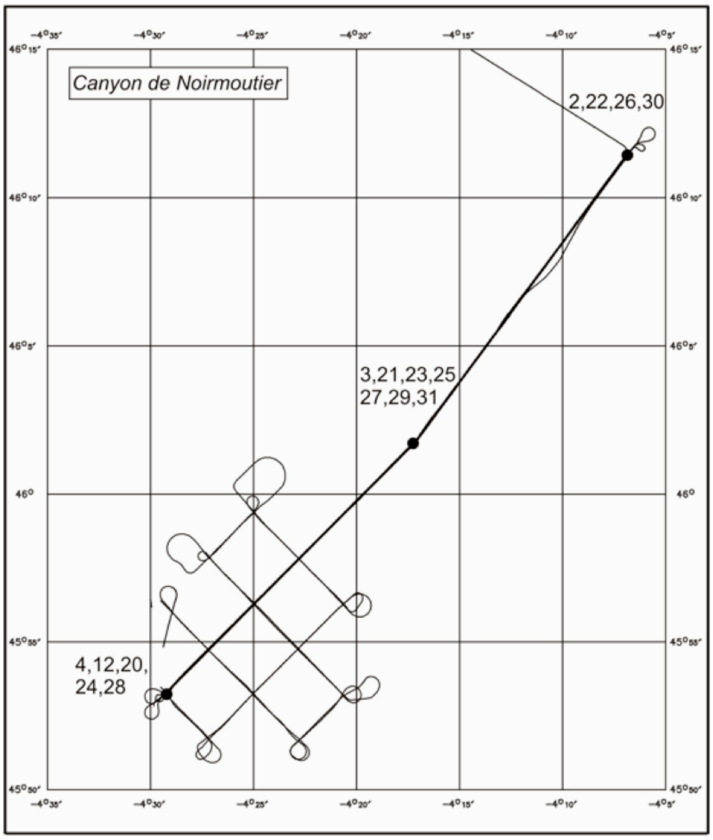


*Fig. 5.1.2: ANT-XXI/1 cruise track and waypoint numbers at the Hydrosweep test site "Canyon de Noirmoutier".*

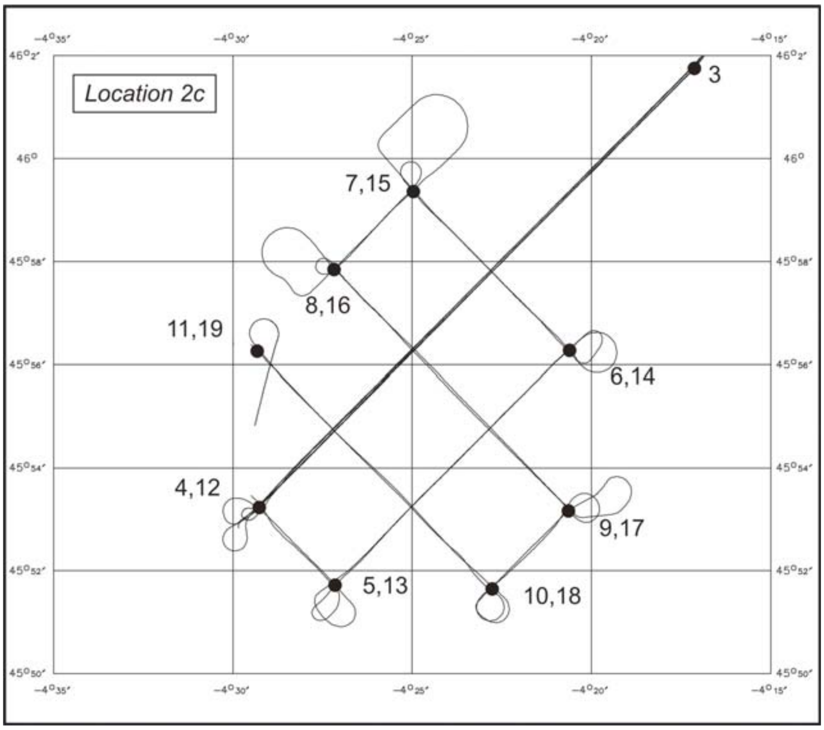


*Fig. 5.1.3: ANT-XXI/1 cruise track and waypoint numbers at the Hydrosweep test site "Location 2c"*

Location 2c is located at the south-west end of the Canyon de Noirmoutier. The test surveys were carried out between 25 and 26 October 2003. During that time the tracks in both areas were sailed and surveyed with Hydrosweep several times with different settings of the new survey modes. Details are shown in table 5.1.1.

**Results**

Programming errors, inherent in the HDBE software upgrade of the Hydrosweep system generated noisy and erroneous data and systematic outliers of the outer beams which were found during the trials. Crashes of the Hydrosweep operating system happened occasionally. Therefore it was not possible to work through all points of the sea acceptance test in detail. In close cooperation with the technician from the manufacturer, efforts were taken to describe the errors, install the software fixes obtained during the trials and test the system again. Shortly before the end of the first part of the cruise in Las Palmas, most of the serious problems were fixed, but there was not enough time left to repeat all required tests a second time.

The ASLC mode depends on a correct estimation of the gain of the received signal. It was shown that this function doesn't work properly which means as a result that the ASLC mode could not be used as desired.

It was agreed that the remaining problems with HDBE and ASLC would have to be solved by Atlas remotely by internet including test measurements carried out with support of the ship's system manager in due time before the subsequent expedition.

**Tab. 5.1.1:** Waypoint list of tracklines for the HDBC/ASLC trials, including geographical coordinates, date and time of the Hydrosweep profiles and variation of the Hydrosw$_{NBS}$

| Waypoint | Date | Time UTC | Latitude | Longitude | WP (end point of profile) | Transmit Angle | Receive Angle | HDBE Mode | Parameter | Calibration Mode | Parasound On/Off | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25.10.03 | 05:53 | 45° 59.33'N | 4° 24.89'W | 7 | 90 | 90 | Standard | | Never | off | End of profile |
| 7 | 25.10.03 | 06:24 | 45° 59.43'N | 4° 24.90'W | | 90 | 90 | Standard | | Never | off | Begin of profile |
| | 25.10.03 | 06:37 | 45° 57.87'N | 4° 27.14'W | 8 | 90 | 90 | Standard | | Never | off | End of profile |
| 8 | 25.10.03 | 07:00 | 45° 57.79'N | 4° 27.07'W | | 90 | 90 | Standard | | Never | off | Begin of profile, RPM of propeller set to 537, 28% pitch |
| | 25.10.03 | 07:39 | 45° 53.14'N | 4° 20.53'W | 9 | 90 | 90 | Standard | | Never | off | End of profile |
| 9 | 25.10.03 | 08:04 | 45° 53.18'N | 4° 20.62'W | | 90 | 90 | Standard | | Never | off | Begin of profile |
| | 25.10.03 | 08:17 | 45° 51.69'N | 4° 22.75'W | 10 | 90 | 90 | Standard | | Never | off | End of profile |
| 10 | 25.10.03 | 08:26 | 45° 51.48'N | 4° 22.43'W | | 90 | 90 | Standard | | Never | off | Begin of profile |
| | 25.10.03 | 09:08 | 45° 56.37'N | 4° 29.46'W | 11 | 90 | 90 | Standard | | Never | off | End of profile, transmission off |
| 12 | 25.10.03 | 09:32 | 45° 53.47'N | 4° 29.50'W | | 90 | 90 | Standard | | Never | off | Begin of profile, transmission on |
| | 25.10.03 | ca. 09:50 | 45° 51.52'N | 4° 27.03'W | 13 | 90 | 90 | **Hardbeam** | | Never | off | End of profile, switch to hardbeam mode |
| 13 | 25.10.03 | 10:01 | 45° 51.81'N | 4° 27.02'W | | 90 | 90 | Hardbeam | | Never | off | Begin of profile |
| | 25.10.03 | 10:40 | 45° 56.27'N | 4° 20.67'W | 14 | 90 | 90 | Hardbeam | | Never | off | End of profile |
| 14 | 25.10.03 | 10:56 | 45° 56.21'N | 4° 20.57'W | | 90 | 90 | Hardbeam | | Never | off | Begin of profile |
| | 25.10.03 | 11:23 | 45° 59.38'N | 4° 25.00'W | 15 | 90 | 90 | Hardbeam | | Never | off | End of profile |
| 15 | 25.10.03 | 11:33 | 45° 59.35'N | 4° 25.06'W | | 90 | 90 | Hardbeam | | Never | off | Begin of profile |
| | 25.10.03 | 11:45 | 45° 57.91'N | 4° 27.06'W | 16 | 90 | 90 | Hardbeam | | Never | off | End of profile, beams 38-48 with wrong depths (to deep) |
| 16 | 25.10.03 | 11:53 | 45° 57.90'N | 4° 27.16'W | | 90 | 90 | Hardbeam | | Never | off | Begin of profile |
| | 25.10.03 | 12:31 | 45° 53.20'N | 4° 20.66'W | 17 | 90 | 90 | Hardbeam | | Never | off | End of profile |
| 17 | 25.10.03 | 12:42 | 45° 53.24'N | 4° 20.67'W | | 90 | 90 | Hardbeam | | Never | off | Begin of profile |
| | 25.10.03 | 12:55 | 45° 51.67'N | 4° 22.80'W | 18 | 90 | 90 | Hardbeam | | Never | off | End of profile |

**Tab. 5.1.1 *continued:*** Waypoint list of tracklines for the HDBC/ASLC trials, including geographical coordinates, date and time of the Hydrosweep profiles and variation of the Hydrosweep parameter settings

| Waypoint | Date | Time UTC | Latitude | Longitude | WP (end point of profile) | Transmit Angle | Receive Angle | HDBE Mode | Parameter | Calibration Mode | Parasound On/Off | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 25.10.03 | 13:07 | 45° 51.66'N | 4° 22.86'W | | 90 | 90 | Hardbeam | | Never | off | Begin of profile |
| | 25.10.03 | 13:46 | 45° 56.18'N | 4° 29.14'W | 19 | 90 | 90 | Hardbeam | | Never | off | End of profile |
| | 25.10.03 | 13:50 | 45° 56.74'N | 4° 29.49'W | | 90 | 90 | Hardbeam | | Never | off | Transmission off, data recording stop |
| | 25.10.03 | 14:30 | | | | | | | | | | For unknown reason system does not start, |
| | 25.10.03 | 15:24 | | | | | | | | | | After several tries system starts operating |
| 20 | 25.10.03 | 15:30 | 45° 53.08'N | 4° 29.58'W | | 90 | 90 | **ASLC** | Max. Source Lev. **239** dB<br>Desired S/N **20** dB<br>Desired Coverage 90°<br>Equal Angle | Never | off | |
| | 25.10.03 | 15:35 | 45° 53.64'N | 4° 28.78'W | | 90 | 90 | ASLC | | Never | off | Outlier on both sides, IP reset, data recording stop |
| | 25.10.03 | 16:42 | 46° 01.71'N | 4° 17.26'W | 21 | 90 | 90 | ASLC | | Never | off | |
| 21 | 25.10.03 | 16:42 | 46° 01.71'N | 4° 17.26'W | | 90 | 90 | ASLC | | Never | off | Continue survey after IP reset |
| | 25.10.03 | 16:55 | 46° 03.51'N | 4° 15.32'W | | 90 | 90 | ASLC | | Never | off | Outlier, 2/3 of data are corrupt |
| | 25.10.03 | 17:09 | 46° 05.42'N | 4° 13.29'W | | 90 | 90 | ASLC | | Never | off | No depth profile visible because of a bug in the "min depth" adjustment |
| | 25.10.03 | 17:21 | 46° 07.01'N | 4° 11.62'W | | 90 | 90 | ASLC | | Never | off | Change to medium depth automatically |
| | 25.10.03 | 17:55 | 46° 11.51'N | 4° 06.79'W | 22 | 90 | 90 | ASLC | Max. Source Lev. 239 dB<br>Desired S/N **10** dB | Never | off | |
| 22 | 25.10.03 | 18:05 | 46° 11.48'N | 4° 06.82'W | | 90 | 90 | ASLC | Max. Source Lev. **233** dB<br>Desired S/N 10 dB | Never | off | Used Source Lev. down to 207 dB, stop survey at ~18:50 |
| | 25.10.03 | 19:00 | 46° 04.32'N | 4° 14.39'W | | 90 | 90 | ASLC | Max. Source Lev. **239** dB<br>Desired S/N 10 dB | Never | off | Factor SLARW changed from 180 dB to 206 dB, IP reset, restart of data recording |
| | 25.10.03 | 19:30 | 46° 00.64'N | 4° 18.72'W | 23 | 90 | 90 | ASLC | | Never | off | WP 23 at 19:20, good data quality since 19:30 |
| 23 | 25.10.03 | 19:30 | 46° 00.64'N | 4° 18.72'W | | 90 | 90 | ASLC | | Never | off | |
| | 25.10.03 | 20:35 | 45° 53.28'N | 4° 29.21'W | 24 | 90 | 90 | ASLC | | Never | off | ASLC uses 239 dB Max. Source Lev. only, factor SLARW changed from 206 dB to 180 dB, |

**Tab. 5.1.1 continued:** Waypoint list of tracklines for the HDBC/ASLC trials, including geographical coordinates, date and time of the Hydrosweep profiles and variation of the Hydrosweep parameter settings

| Waypoint | Date | Time UTC | Latitude | Longitude | WP (end point of profile) | Transmit Angle | Receive Angle | HDBE Mode | Parameter | Calibration Mode | Parasound On/Off | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 25.10.03 | 20:41 | 45° 53.07'N | 4° 29.36'W | | **120** | **120** | ASLC | Max. Source Lev. **239** dB Desired S/N 10 dB | Never | off | Survey speed 10.5 kt |
| | 25.10.03 | 21:18 | 45° 57.66'N | 4° 23.05'W | | 120 | 120 | ASLC | | Never | off | S/N 30 dB, slowly increasing source level to 2 dB. **ASLC control doesn't work** |
| | 25.10.03 | 21:43 | 46° 00.63'N | 4° 18.81'W | | 120 | 120 | ASLC | | Never | off | Switch to equal footprint for a short time -> cross profile looks better |
| | 25.10.03 | 21:54 | 46° 01.90'N | 4° 17.04'W | 25 | 120 | 120 | ASLC | | Never | off | Change of course, evasion manoeuvre |
| 25 | 25.10.03 | 21:54 | 46° 01.90'N | 4° 17.04'W | | 120 | 120 | ASLC | | Never | off | |
| | 25.10.03 | 22:24 | 46° 05.88'N | 4° 12.81'W | | 120 | 120 | ASLC | | Never | off | Water depth 1520 m, some loss of data starboard side |
| | 25.10.03 | 23:06 | 46° 11.69'N | 4° 06.58'W | 26 | 120 | 120 | **Standard** | | Never | off | Medium depth, 227 dB source level indicated |
| 26 | 25.10.03 | 23:20 | 46° 11.70'N | 4° 06.53'W | | 120 | 120 | Standard | | Never | off | Medium depth, 229 dB source level indicated |
| | 26.10.03 | 00:33 | 46° 01.93'N | 4° 16.93'W | 27 | 120 | 120 | Standard | | Never | off | |
| 27 | 26.10.03 | 00:33 | 46° 01.93'N | 4° 16.93'W | | 120 | 120 | Standard | | Never | off | |
| | 26.10.03 | 01:08 | 45° 57.71'N | 4° 22.90'W | | 120 | 120 | Standard | | Never | off | Switch between equal footprint / equal angle because of outlier at port side till 01:10 |
| | 26.10.03 | 01:45 | 45° 53.13'N | 4° 29.45'W | 28 | 120 | 120 | Standard | | Never | off | End of profile |
| 28 | 26.10.03 | 01:59 | 45° 53.20'N | 4° 29.32'W | | **90** | **90** | Standard | | Never | off | Begin of profile |
| | 26.10.03 | 03:10 | 46° 01.74'N | 4° 17.21'W | 29 | 90 | 90 | Standard | | Never | off | End of profile |
| 29 | 26.10.03 | 03:10 | 46° 01.74'N | 4° 17.21'W | | 90 | 90 | Standard | | Never | off | Begin of profile |
| | 26.10.03 | 03:30 | 46° 04.58'N | 4° 14.19'W | | 90 | 90 | Standard | | Never | off | Switch between equal footprint / equal angle because of outlier at outer sides of swath |
| | 26.10.03 | 03:46 | 46° 06.84'N | 4° 11.78'W | | **120** | **120** | Standard | | Never | off | Equal angle |
| | 26.10.03 | 04:21 | 46° 11.49'N | 4° 06.81W | 30 | 120 | 120 | Standard | | Never | off | End of profile |
| 30 | 26.10.03 | 04:31 | 46° 11.37'N | 4° 06.98'W | | 120 | 120 | Standard | | Never | off | Begin of profile |
| | 26.10.03 | 05:08 | 46° 06.59'N | 4° 11.98'W | | **90** | **90** | Standard | | Never | off | Outliers at outer sides of swath after changing the angle |

**Tab. 5.1.1 continued:** Waypoint list of tracklines for the HDBC/ASLC trials, *including* geographical coordinates, date and time of the Hydrosweep profiles and variation of the Hydrosweep parameter settings

| Waypoint | Date | Time UTC | Latitude | Longitude | WP (end point of profile) | Transmit Angle | Receive Angle | HDBE Mode | Parameter | Calibration Mode | Parasound On/Off | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 24.10.03 | 17:17 | 47° 21.11'N | 5° 29.82'W | | 90 | 90 | Standard | Medium Depth | Standard | off | Sea Acceptance Test, checkpoint 4.3.7; **14** |
| | 24.10.03 | 17:32 | 47° 18.19'N | 5° 27.51'W | | 90 | 90 | **ASLC** | Medium Depth<br>Max. Source Lev. **239** dB<br>Desired S/N **20** dB<br>Desired Coverage 90° | Standard | off | Sea Acceptance Test, checkpoint 4.3.7; **18** |
| | 24.10.03 | 17:50 | 47° 14.63'N | 5° 24.52'W | | 90 | **40** | ASLC | Medium Depth<br>Max. Source Lev. **230** dB<br>Desired S/N 20 dB<br>Desired Coverage **40°** | Standard | off | Sea Acceptance Test, checkpoint 4.3.7; **22** until 18:04 |
| | 25.10.03 | 00:35 | 46° 18.15'N | 4° 21.68'W | | 90 | **90** | ASLC | Different Settings | Standard | off | Several tests with ASLC |
| 2 | 25.10.03 | 01:42 | 46° 11.51'N | 4° 06.79 W | | **120** | **120** | **Standard** | | Standard | off | |
| | 25.10.03 | 01:56 | 46° 09.18'N | 4° 09.25'W | | 120 | 120 | Standard | | **Never** | off | Switch to water sound velocity profile |
| | 25.10.03 | 02:15 | 46° 06.64'N | 4° 11.94'W | | **90** | **90** | Standard | | Never | off | |
| | 25.10.03 | 02:50 | 46° 01.88'N | 4° 16.98'W | 3 | 90 | 90 | Standard | | Never | off | |
| 3 | 25.10.03 | 02:50 | 46° 01.88'N | 4° 16.98'W | | 90 | 90 | Standard | | Never | off | |
| | 25.10.03 | 03:39 | 45° 55.88'N | 4° 25.53'W | | 90 | 90 | Standard | | Never | off | Operation stop for IP reset |
| | 25.10.03 | 03:45 | 45° 55.13'N | 4° 26.59'W | | 90 | 90 | Standard | | Never | off | Operation restart |
| | 25.10.03 | 04:00 | 45° 53.28'N | 4° 29.27'W | 4 | 90 | 90 | Standard | | Never | off | End of profile |
| 4 | 25.10.03 | 04:12 | 45° 53.19'N | 4° 29.24'W | | 90 | 90 | Standard | | Never | off | Begin of profile |
| | 25.10.03 | 04:24 | 45° 51.75'N | 4° 27.19'W | 5 | 90 | 90 | Standard | | Never | off | End of profile |
| 5 | 25.10.03 | 04:39 | 45° 51.81'N | 4° 27.15'W | | 90 | 90 | Standard | | Never | off | Begin of profile |
| | 25.10.03 | 05:16 | 45° 56.26'N | 4° 20.66'W | 6 | 90 | 90 | Standard | | Never | off | End of profile |
| 6 | 25.10.03 | 05:29 | 45° 56.38'N | 4° 20.74'W | | 90 | 90 | Standard | | Never | off | Begin of profile |
| | 25.10.03 | 05:33 | | | | 90 | 90 | Standard | | Never | off | Switch to equal footprint because of loss of outer beams |
| | 25.10.03 | 05:36 | | | | 90 | 90 | Standard | | Never | off | Switch back to equal angle because of missing affect |

## 5.2 Sediment acoustics: Software replacement and data collection

Andrea Gerriets[1)], Gerhard Kuhn[2)]
[1)]University of Bremen
[2)]Alfred-Wegener-Institut

### Objectives

Two main goals were achieved during the cruise we had participated after Canary Islands. First the old DOS-based software for data collection of the Parasound sediment echosounder was replaced by a Windows-based software and secondly, approximately 2,000 nm (ca. 8 GBytes) of sub-bottom echosounder data had been collected. In addition to that, data of the swath bathymetric echosounder HYDROSWEEP were recorded, too.

### Parasound / ParaDigMA

### System Description Parasound

The Parasound echosounder DS-2 designed by ATLAS Hydrographic is a permanently installed system on *Polarstern*. It determines the water depth and detects variable frequencies from 2.5 up to 5.5 kHz thereby providing high-resolution information of the sedimentary layers up to a depth of 200 meters below sea floor. For the sub-bottom profiler task, the system uses the parametric effect, which produces additional frequencies through non-linear acoustic interaction of finite amplitude waves. If two sound waves of similar frequencies (18 kHz, 22 kHz) are emitted simultaneously, a signal of the resulting frequency (e.g. 4 kHz) is generated for sufficiently high primary amplitudes. The new component is travelling within the emission cone of the original high frequency waves, which are limited to an angle of 4° for the equipment used. The resulting footprint size of 7 % of the depth is much smaller than for conventional systems and both vertical and lateral resolutions are significantly improved. The Parasound system sends out a burst of pulses at 400 ms intervals until the first echo returns. The coverage of this discontinuous mode depends on the water depth, and produces non-equidistant shot intervals between bursts.

### Replacement of DOS ParaDigMA by Windows ParaDigMA

For about 10 years the ATLAS Parasound system had been equipped with the associated DOS-based data acquisition system ParaDigMA developed by V. Spieß (1993, University of Bremen). The ParaDigMA software offers the visualisation as well as the digitisation and storage of acoustic soundings.

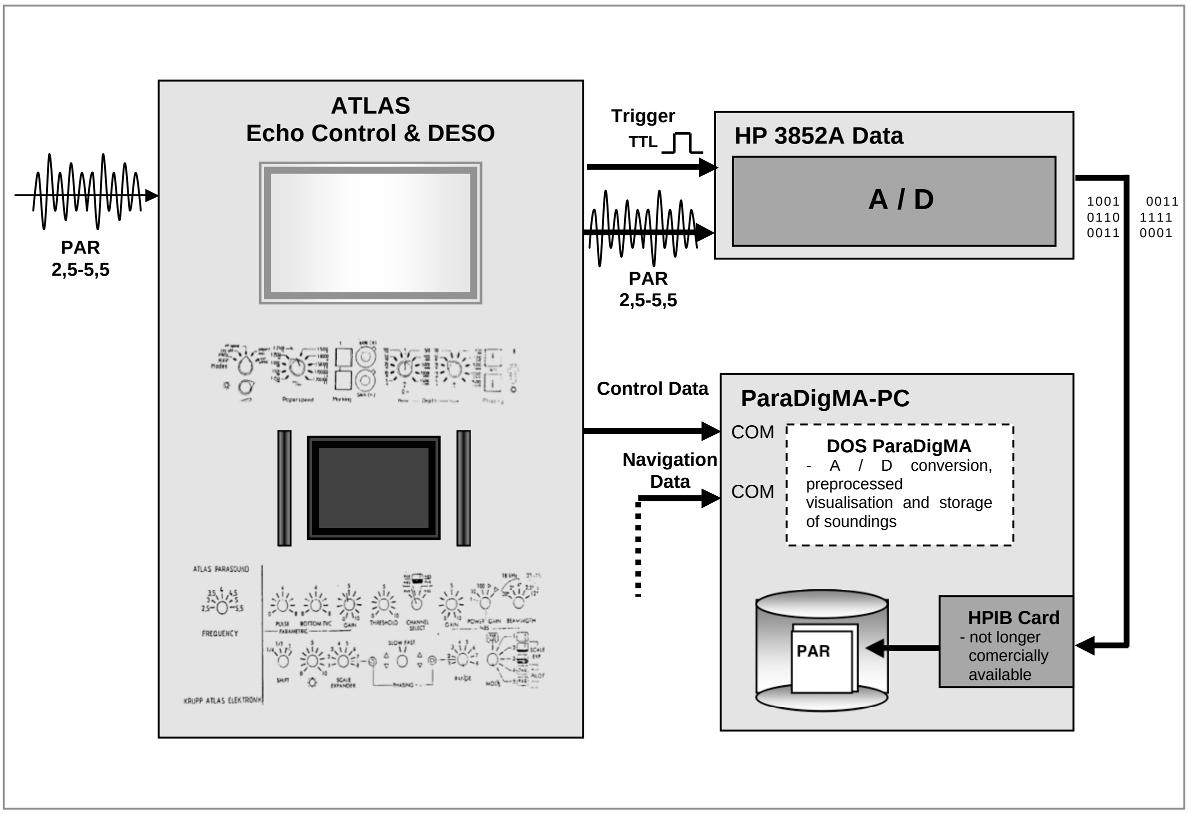


*Fig. 5.2.1: Parasound / ParaDigMA system architecture, since 1993 on Polarstern with communication over hardware interfaces*

Today the combination of Parasound echosounder DS-2 designed by ATLAS Hydrographic and ParaDigMA has accomplished the step from DOS towards Windows platform and network-capability (Fig. 5.2.2). In cooperation with ATLAS Hydrographic and the Department of Earth Sciences, University of Bremen a new release of the Parasound/ParaDigMA system has been developed in order to adapt the system on modern requirements and thereby provide improved features to survey the physical state of the sea floor along the ship's track and a high level data quality.

The new Windows ParaDigMA is commercially available as PARASTORE 3. It is designed for the ATLAS Parasound DS2 system and does not work automatically with the old System on *Polarstern*.

In spite of the fact that this can only be a temporary solution, we decided to make the Windows version of ParaDigMA available for the old Parasound control as it currently exists on *Polarstern* as well as on *Meteor* and *Sonne*. A main reason for that decision is that in general, DOS-based programmes are restricted to a lot of limitations concerning memory management, processing in general and network capability, which would make it worthwhile to improve the measurement quality as soon as possible. Another urgent reason still to invest in a temporary adaptation of the new to the old, had been the fact that a special HPIB controller required by the DOS programme is not commercially available anymore. Crashes of the last card might very soon stop any further digital registration.

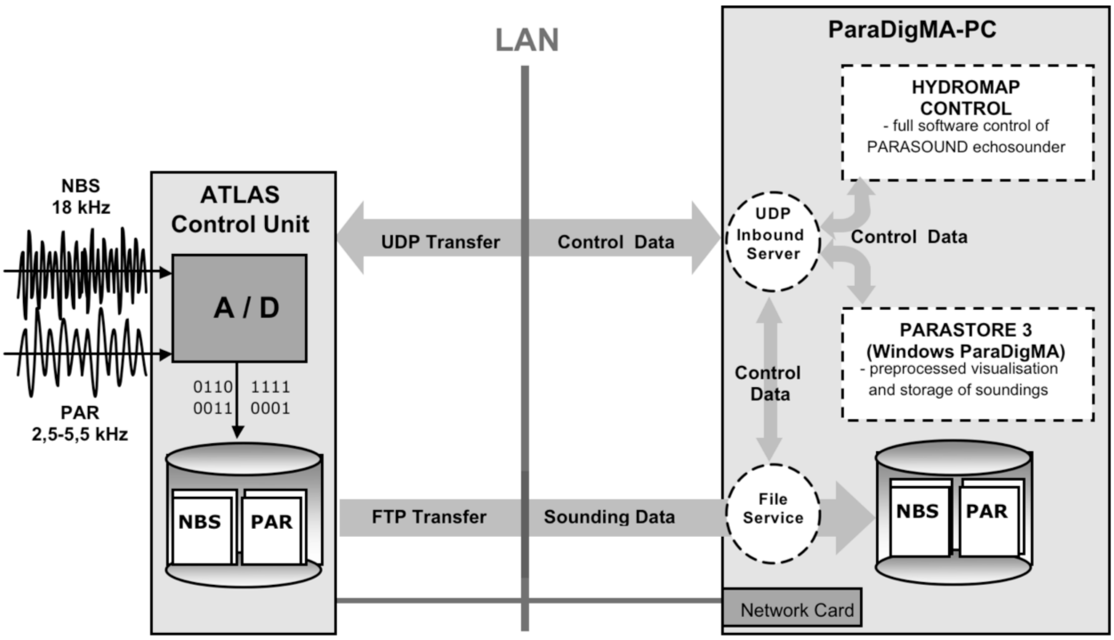


*Fig. 5.2.2: System architecture of new ATLAS Parasound DS2 system (2002) with communication over local area network.*

For making the new Windows ParaDigMA available for the old Parasound control system, a supplemental interface application had to be developed and in a second step adapted to the vessel's special environment. The DAU-Interface application (DAU = Short name of the old HP 3852 Data Acquisition Unit) simulates the new Parasound control system. On the one hand it communicates with and acquires the data from the old Parasound system like the former DOS software did. On the other hand it provides the data to the Windows ParaDigMA software like the new Parasound DS2 control system would do. Concrete advantages of the Windows platform for Parasound watchkeepers and responsibles are the multi-threaded programming structure and the network capability. So, paper jams in the printer do not longer stop the whole registration. The registered data is immediately available now and can be transferred over network to processing computers on any location without stopping the registration. The registration window can be increased up to 400 m without reducing the sampling rate. Finally the improved interactive graphical user interface makes the application more user friendly than before. Also a first step into the direction "Remote PARASOUND" has be done with the installation of remote stations that cannot control the echosounder but visualise online the current soundings on each location with LAN access on the vessel.

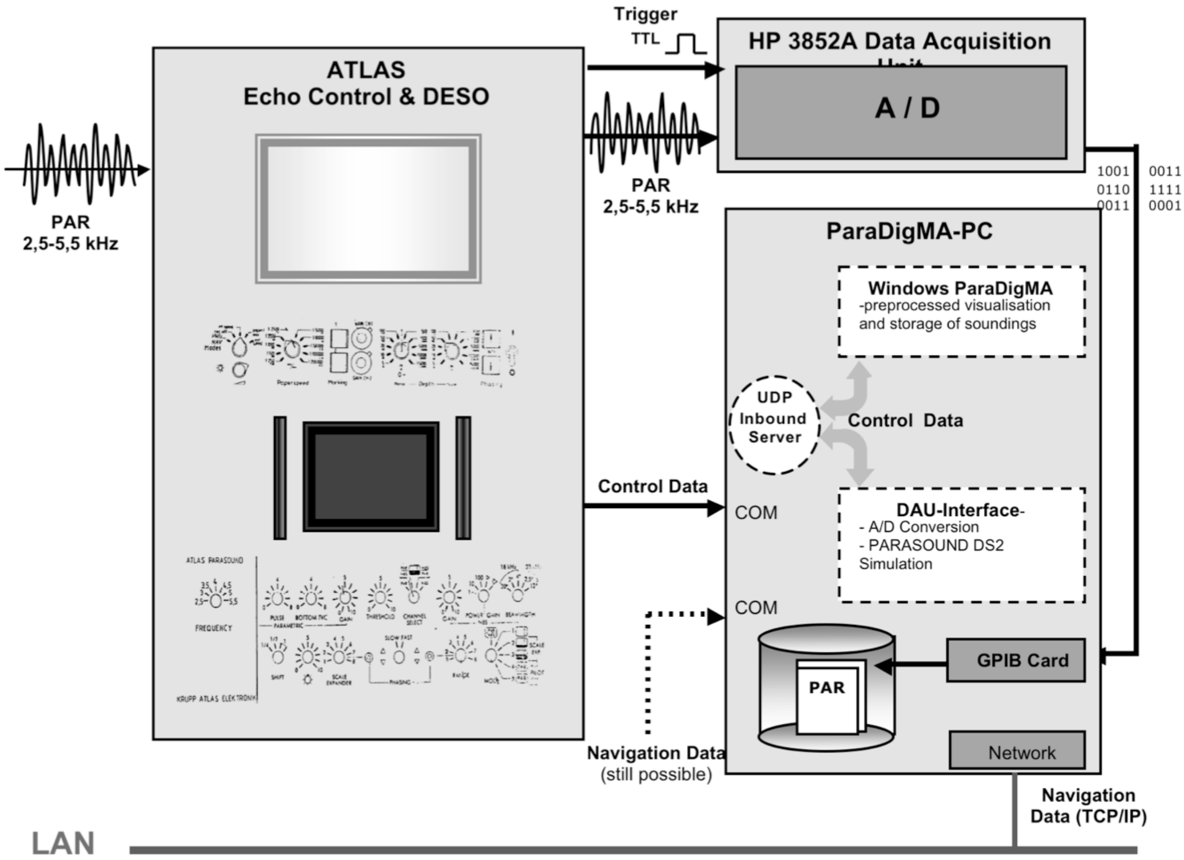


*Fig. 5.2.3: Parasound / ParaDigMA system architecture installed on ANT-XXI/1 with communication over hardware interfaces and network capability*

Some important features of Windows ParaDigMA are still not available in connection to the old analogue control. The registration of the whole water column which allows a watchkeeping free Parasound operation, is only provided by the Parasound DS2, also the two-channel registration of the 2.5 - 5.5 kHz parametric signal (PAR) and the 18 kHz Narrow Single-Beam signal (NBS), which, in combination with the recording of complete sounding profiles, provides the base for evolving scientific research topics, e.g. gas venting. A further exclusively Parasound DS2 capability is the complete software control and the resulting independency of sensor location, A/D location and control location.

Since the programming and adaptation of the DAU-Interface solution had been finished almost a week before *Polarstern* arrived in Cape Town we still had time for operation tests of several days and for ordinary data registration within the transit area (Fig. 5.2.4). A first data quality control had been done already on this cruise. Nevertheless the collected data will be reviewed a second time at the University of Bremen and AWI.

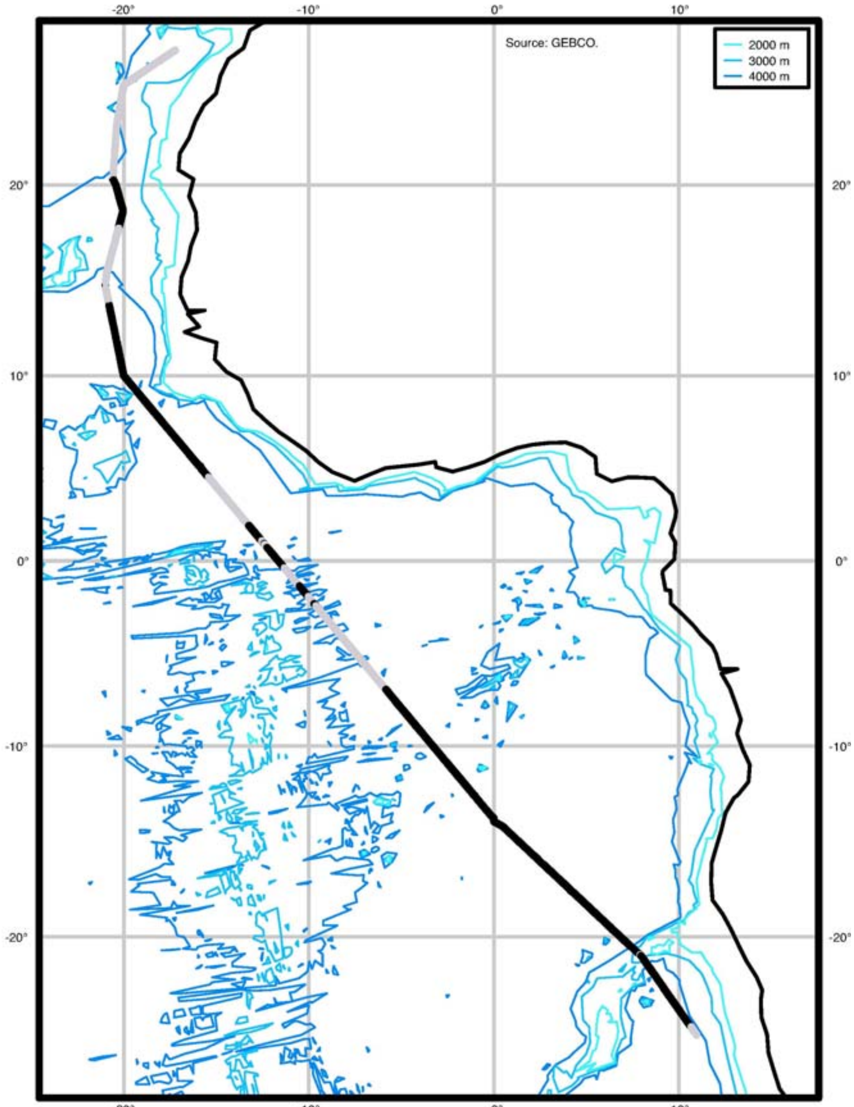


*Fig. 5.2.4: Course track during ANT-XXI/1 (grey) and Parasound / ParaDigMA data registration (black)*

**HYDROSWEEP**

The swath bathymetric system HYDROSWEEP of ATLAS Hydrographic is used for mapping the water depth. 59 beams of well known pre-defined angles sample the seafloor. The total swath width is 90°, giving coverage of 2 times the ocean depth. The system operates at a frequency of 15.5 kHz. The system uses a calibration mode to compare depth values of the central and outer beams in order to calculate a mean sound velocity by producing the best fit between both values. Refraction effects on the outer beams are suppressed by this method and minimize residual errors to values smaller than 0.5 % of water depth.

In cooperation between geosciences at University Bremen and AWI (research center of ocean margins RCOM) we collected Hydrosweep data on the cruise. Data quality must be reviewed, because the system was running in test mode after installation of new software on the cruise between Bremerhaven and Canary Islands. North of Cape Verde Islands we crossed the Cap Timirs Canyon, which was mapped on Meteor-Cruise M58/1 (Fig. 5.2.5). The canyon here still is approximately 100 m deep and more than 1 km broad. The processing of the bathymetric data can be carried out with the public domain software MultiBeam (for Linux, Unix OS) at the university.

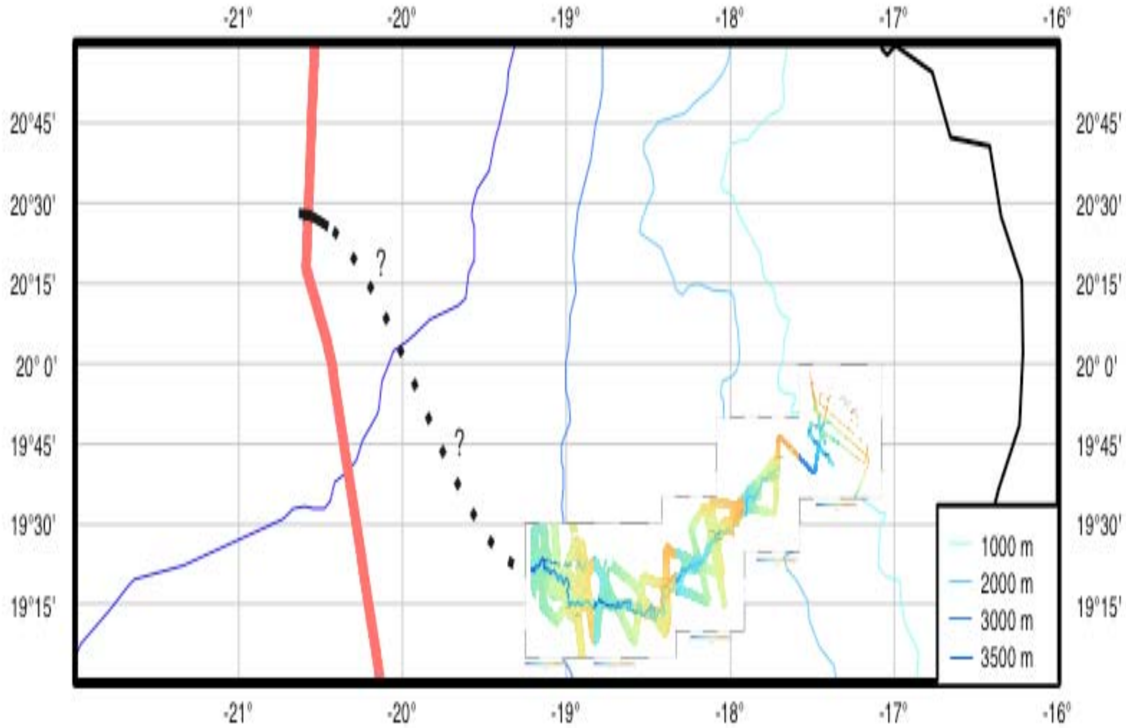


*Fig. 5.2.5: Cruise track (thick grey line) crosses Cap Timiris Canyon (black line) at 20°30'N. The area mapped during Meteor-Cruise M58/1 is more to the south.*

# APPENDIX

## A.1 BETEILIGTE INSTITUTE / PARTICIPATING INSTITUTES

## A.2 FAHRTTEILNEHMER / PARTICIPANTS

## A.3 SCHIFFSBESATZUNG / SHIP'S CREW

## A.4 STATIONSLISTE / STATION LIST PS 28

## A.1 BETEILIGTE INSTITUTE / PARTICIPATING INSTITUTES ANT-XXI/1

| | Adresse / Address | No. of participants |
|---|---|---|
| AWI | Alfred-Wegener-Institut<br>für Polar- und Meeeresforschung<br>Columbusstraße<br>27568 Bremerhaven | 7 |
| AWI-P | Alfred-Wegener-Institut<br>für Polar- und Meeresforschung<br>Forschungsstelle Potsdam<br>14401 Potsdam | 2 |
| CHYORK | University of York<br>Department of Chemistry<br>York, YO10 5DD<br>UK | 2 |
| DWD | Deutscher Wetterdienst<br>Geschäftsbereich Wettervorhersage<br>Seeschifffahrtsberatung<br>Bernhard Nocht Str. 76<br>20359 Hamburg<br>Germany | 2 |
| FIELAX | FIELAX<br>Gesellschaft für wissenschaftliche<br>Datenverarbeitung mbH<br>Schifferstrasse 10-14<br>27568 Bremerhaven | 2 |
| IfM | Institut für Meereskunde<br>Universität Kiel<br>Düsternbrooker Weg 20<br>24105 Kiel | 1 |
| Impres | Impres GmbH<br>Varreler Landstrasse 9<br>28259 Bremen | 1 |
| isitec | ISITEC GmbH<br>Stresemannstr. 46<br>27570 Bremerhaven | 1 |

| | Adresse / Address | No. of participants |
|---|---|---|
| IUPB | Universität Bremen<br>Institut für Umweltphysik<br>Otto-Hahn-Allee 1<br>28359 Bremen | 1 |
| IUPH | Universität Heidelberg<br>Institut für Umweltphysik<br>Im Neuenheimer Feld<br>69120 Heidelberg | 1 |
| MPI-M | Max-Planck-Institut für Chemie<br>Postfach 3060<br>55020 Mainz | 2 |
| U Bremen | Universität Bremen<br>FB 5 Geowissenschaften<br>Klagenfurter Str,<br>28334 Bremen | 1 |
| UMIST | University of Manchester<br>Institute of Science and Technology<br>PO Box 88<br>Manchester M60 1Q<br>UK | 1 |
| UNH | University of New Hampshire<br>Institute for the Study of Earth, Oceans, and Space<br>39 College Road<br>Durham, NH 03824-3525<br>USA | 2 |
| UU | Universität Ulm<br>Abt. Analytische Chemie u. Umweltchemie<br>Albert-Einstein-Allee 11<br>89081 Ulm | 1 |
| UVA | University of Virginia<br>Department of Environmental Science<br>Charlottesville, VA 22904<br>USA | 3 |

## A.2 FAHRTTEILNEHMER / PARTICIPANTS ANT-XXI/1

| Name | Vorname<br>First name | Institut<br>Institute |
|---|---|---|
| Bayer | Uli | FIELAX |
| Beninga | Ingo | Impres/AWI |
| Beyer | Andreas | AWI |
| Buldt | Klaus | DWD |
| El Naggar | Saad | AWI |
| Gebhardt | Sarah | IfM |
| Gerriets | Andreas | UB |
| Grünert | Anke | UU |
| Hopkins | James | CHYORK |
| Ibrahim Ahmed | Ossama | IUPH |
| Immler | Franz | AWI |
| Kahrs | Thomas | FIELAX |
| Keene | William | UVA |
| Kerkweg | Astrid | MPI-M |
| Kuhn | Gerhard | AWI |
| Lilienthal | Heiko | isitec/AWI |
| Maben | John | UVA |
| Niederjasper | Fred | AWI |
| O'Halloran | Thomas | UVA |
| Palmer | Carl | CHYORK |
| Pszenny | Alexander | UNH |
| Sander | Rolf | MPI-M |
| Schrems | Otto | AWI |
| Schulz | Astrid | AWI-P |
| Tegtmeier | Susann | AWI-P |
| Wall | Andrew | UNH |
| Warneke | Thorsten | IUPB |
| Williams | Paul Ivor | UMIST |

## A.3 SCHIFFSPERSONAL / SHIP'S CREW ANT-XXI/1

| No. | Name | | Rank |
|---|---|---|---|
| 01. | Domke | Udo | Master |
| 02. | Grundmann | Uwe | 1.Offc. |
| 03. | Pluder | Andreas | Ch. Eng. |
| 04. | Peine | Lutz G. | 2. Offc. |
| 05. | Spielke | Steffen | 2. Offc. |
| 06. | Szepanski | Nico | 2. Offc. |
| 07. | Krüger | Klaus Jürgen | Doctor |
| 08. | Koch | Georg | R.Offc. |
| 09. | Delff | Wolfgang | 1.Eng. |
| 10. | Kotnik | Herbert | 2. Eng. |
| 11. | Ziemann | Olaf | 2.Eng. |
| 12. | Baier | Ulrich | FielaxElo |
| 13. | Bretfeld | Holger | FielaxElo |
| 14. | Fröb | Martin | FielaxElo |
| 15. | Gerchow | Peter | FielaxElo |
| 16. | Muhle | Heiko | ElecTech. |
| 17. | Piskorzynski | Andreas | FielaxElo |
| 18. | Loidl | Reiner | Boatsw. |
| 19. | Reise | Lutz | Carpenter |
| 20. | Bäcker | Andreas | A.B. |
| 21. | Bastigkeit | Kai | A.B. |
| 22. | Freitag | Patrick | A.B. |
| 23. | Hagemann | Manfred | A.B. |
| 24. | Pousada Martinez | S. | A.B. |
| 25. | Schmidt | Uwe | A.B. |
| 26. | Vehlow | Ringo | A.B. |
| 27. | Winkler | Michael | A.B. |
| 28. | Preußner | Jörg | Storek. |
| 29. | Elsner | Klaus | Mot-man |
| 30. | Grafe | Jens | Mot-man |
| 31. | Hartmann | Ernst-Uwe | Mot-man |
| 32. | Ipsen | Michael | Mot-man |
| 33. | Voy | Bernd | Mot-man |
| 34. | Haubold | Wolfgang | Cook |
| 35. | Silinski | Frank | Cooksmate |
| 36. | Völske | Thomas | Cooksmate |
| 37. | Jürgens | Monika | 1.Stwdess |
| 38. | Wöckener | Martina | Stwdss/KS |
| 39. | Czyborra | Bärbel | 2.Stwdess |
| 40. | Gaude | Hans-Jürgen | 2.Steward |
| 41. | Huang | Wu-Mei | 2.Steward |
| 42. | Möller | Wolfgang | 2.Steward |
| 43. | Silinski | Carmen | 2.Stwdess |
| 44. | Yu Kwok | Yuen | Laundrym |

## A. 4 STATION LIST PS 28

| Station No. | Date/Time | Position Latitude | Position Longitude | Elevation | Elevation end | Device |
|---|---|---|---|---|---|---|
| PS28/1-track | 1993-10-18T08:20 | 5.422.000 | 773.000 | | | Measurements along cruise track |
| PS28/1_2 | 1993-10-21T09:59 | 4.573.330 | -1.276.670 | -4774 | -756 | Expendable bathythermograph |
| PS28/1_3 | 1993-10-21T14:21 | 4.498.330 | -1.388.330 | -3786 | -756 | Expendable bathythermograph |
| PS28/1_4 | 1993-10-21T19:00 | 4.400.000 | -1.373.330 | -4327 | -756 | Expendable bathythermograph |
| PS28/1_5 | 1993-10-21T23:45 | 4.403.330 | -1.391.670 | -5237 | -756 | Expendable bathythermograph |
| PS28/1_7 | 1993-10-22T09:46 | 4.096.670 | -1.426.670 | -5284 | -756 | Expendable bathythermograph |
| PS28/1_9 | 1993-10-22T20:50 | 3.908.330 | -1.415.000 | -4441 | -756 | Expendable bathythermograph |
| PS28/1_10 | 1993-10-23T03:41 | 3.800.000 | -1.383.330 | -4005 | -756 | Expendable bathythermograph |
| PS28/1_11 | 1993-10-23T18:07 | 3.703.330 | -1.400.000 | -1683 | -756 | Expendable bathythermograph |
| PS28/1_12 | 1993-10-23T22:58 | 3.603.330 | -1.441.670 | -3865 | -756 | Expendable bathythermograph |
| PS28/1_13 | 1993-10-24T04:08 | 3.501.670 | -1.471.670 | -3226 | -756 | Expendable bathythermograph |
| PS28/1_14 | 1993-10-24T08:47 | 3.405.000 | -1.521.670 | -3857 | -752 | Expendable bathythermograph |
| PS28/1_15 | 1993-10-24T13:26 | 3.306.670 | -1.561.670 | -3948 | -756 | Expendable bathythermograph |
| PS28/1_16 | 1993-10-24T18:20 | 3.205.000 | -1.601.670 | -4377 | -756 | Expendable bathythermograph |
| PS28/1_17 | 1993-10-24T23:10 | 3.103.330 | -1.640.000 | -4371 | -756 | Expendable bathythermograph |
| PS28/1_18 | 1993-10-25T04:00 | 3.003.330 | -1.680.000 | -3973 | -756 | Expendable bathythermograph |
| PS28/1_19 | 1993-10-25T08:44 | 2.903.330 | -1.716.670 | -3803 | -756 | Expendable bathythermograph |
| PS28/1_20 | 1993-10-26T12:07 | 2.603.330 | -1.886.670 | -3358 | -756 | Expendable bathythermograph |
| PS28/1_21 | 1993-10-26T05:15 | 2.506.670 | -1.960.000 | -3610 | -756 | Expendable bathythermograph |
| PS28/1_22 | 1993-10-26T11:07 | 2.403.330 | -2.038.330 | -3914 | -756 | Expendable bathythermograph |
| PS28/1_23 | 1993-10-27T01:21 | 2.300.000 | -2.095.000 | -4258 | -756 | Expendable bathythermograph |
| PS28/1_24 | 1993-10-27T06:08 | 2.200.000 | -2.100.000 | -4305 | -756 | Expendable bathythermograph |
| PS28/1_25 | 1993-10-27T10:39 | 2.106.670 | -2.108.330 | -4174 | -756 | Expendable bathythermograph |
| PS28/1_26 | 1993-10-27T17:16 | 2.003.330 | -2.118.330 | -3779 | -756 | Expendable bathythermograph |
| PS28/1_27 | 1993-10-27T21:47 | 1.903.330 | -2.146.670 | -3311 | -756 | Expendable bathythermograph |
| PS28/1_28 | 1993-10-28T03:36 | 1.783.330 | -2.181.670 | -3286 | -756 | Expendable bathythermograph |

| Station No. | Date/Time | Position Latitude | Position Longitude | Elevation | Elevation end | Device |
|---|---|---|---|---|---|---|
| PS28/1_29 | 1993-10-28T07:26 | 1.700.000 | -2.205.000 | -3288 | -756 | Expendable bathythermograph |
| PS28/1_30 | 1993-10-28T12:10 | 1.600.000 | -2.231.670 | -1823 | -756 | Expendable bathythermograph |
| PS28/1_31 | 1993-10-28T16:37 | 1.500.000 | -2.261.670 | -3692 | -756 | Expendable bathythermograph |
| PS28/1_32 | 1993-10-28T21:13 | 1.400.000 | -2.288.330 | -4281 | -756 | Expendable bathythermograph |
| PS28/1_33 | 1993-10-29T01:33 | 1.303.330 | -2.315.000 | -4655 | -756 | Expendable bathythermograph |
| PS28/1_34 | 1993-10-29T06:31 | 1.201.670 | -2.343.330 | -5031 | -756 | Expendable bathythermograph |
| PS28/1_35 | 1993-10-29T11:24 | 1.101.670 | -2.370.000 | -5181 | -756 | Expendable bathythermograph |
| PS28/1_36 | 1993-10-29T16:59 | 1.000.000 | -2.400.000 | -5300 | -756 | Expendable bathythermograph |
| PS28/1_37 | 1993-10-29T23:37 | 900.000 | -2.351.670 | -4966 | -756 | Expendable bathythermograph |
| PS28/1_41 | 1993-10-30T11:03 | 700.000 | -2.245.000 | -3984 | -756 | Expendable bathythermograph |
| PS28/1_42 | 1993-10-31T11:42 | 200.000 | -2.016.670 | -4567 | -756 | Expendable bathythermograph |
| PS28/1_43 | 1993-10-31T16:23 | 200.000 | -1.973.330 | -5131 | -756 | Expendable bathythermograph |
| PS28/1_44 | 1993-10-31T22:14 | 100.000 | -1.920.000 | -4663 | -756 | Expendable bathythermograph |
| PS28/1_45 | 1993-11-01T03:52 | 0.00000 | -1.866.670 | -4144 | -756 | Expendable bathythermograph |
| PS28/1_46 | 1993-11-02T10:21 | -0.13330 | -1.483.330 | -2981 | -756 | Expendable bathythermograph |
| PS28/1_47 | 1993-11-03T10:27 | -113.330 | -996.670 | -4333 | -756 | Expendable bathythermograph |
| PS28/1_48 | 1993-11-04T10:18 | -213.330 | -480.000 | -4788 | -756 | Expendable bathythermograph |
| PS28/1_49 | 1993-11-05T09:41 | -315.000 | 0.53330 | -4382 | -756 | Expendable bathythermograph |
| PS28/1_50 | 1993-11-06T08:29 | -500.000 | 563.330 | -4765 | -756 | Expendable bathythermograph |
| PS28/1_51 | 1993-11-07T08:29 | -600.000 | 1.015.000 | -3079 | -756 | Expendable bathythermograph |
| PS28/1_53 | 1993-11-07T18:25 | -800.000 | 963.330 | -4128 | -756 | Expendable bathythermograph |
| PS28/1_54 | 1993-11-07T23:32 | -900.000 | 936.670 | -4346 | -756 | Expendable bathythermograph |
| PS28/1_55 | 1993-11-08T04:34 | -1.000.000 | 911.670 | -4554 | -756 | Expendable bathythermograph |
| PS28/1_56 | 1993-11-08T13:47 | -1.101.670 | 811.670 | -4835 | -756 | Expendable bathythermograph |
| PS28/1_57 | 1993-11-08T21:14 | -1.200.000 | 705.000 | -5140 | -756 | Expendable bathythermograph |
| PS28/1_58 | 1993-11-09T14:31 | -1.300.000 | 625.000 | -5312 | -756 | Expendable bathythermograph |
| PS28/1_59 | 1993-11-09T19:39 | -1.400.000 | 665.000 | -5171 | -756 | Expendable bathythermograph |
| PS28/1_60 | 1993-11-10T12:27 | -1.496.670 | 705.000 | -5050 | -756 | Expendable bathythermograph |

| Station No. | Date/Time | Position Latitude | Position Longitude | Elevation | Elevation end | Device |
|---|---|---|---|---|---|---|
| PS28/1_61 | 1993-11-10T05:48 | -1.600.000 | 746.670 | -5008 | -756 | Expendable bathythermograph |
| PS28/1_62 | 1993-11-10T12:31 | -1.700.000 | 768.330 | -4946 | -756 | Expendable bathythermograph |
| PS28/1_63 | 1993-11-10T17:59 | -1.800.000 | 785.000 | -5002 | -756 | Expendable bathythermograph |
| PS28/1_64 | 1993-11-10T23:20 | -1.900.000 | 803.330 | -5061 | -756 | Expendable bathythermograph |
| PS28/1_65 | 1993-11-11T04:54 | -2.000.000 | 828.330 | -2572 | -756 | Expendable bathythermograph |
| PS28/1_66 | 1993-11-11T11:51 | -2.100.000 | 868.330 | -3436 | -756 | Expendable bathythermograph |
| PS28/1_67 | 1993-11-11T17:32 | -2.200.000 | 906.670 | -4248 | -756 | Expendable bathythermograph |
| PS28/1_68 | 1993-11-11T23:31 | -2.298.330 | 948.330 | -4355 | -756 | Expendable bathythermograph |
| PS28/1_69 | 1993-11-12T05:34 | -2.398.330 | 988.330 | -4279 | -756 | Expendable bathythermograph |
| PS28/1_70 | 1993-11-12T11:27 | -2.500.000 | 1.030.000 | -4319 | -756 | Expendable bathythermograph |
| PS28/1_71 | 1993-11-12T18:10 | -2.596.670 | 1.000.000 | -4600 | -756 | Expendable bathythermograph |
| PS28/1_72 | 1993-11-13T12:06 | -2.700.000 | 963.330 | -4816 | -756 | Expendable bathythermograph |
| PS28/1_73 | 1993-11-13T05:41 | -2.800.000 | 926.670 | -4967 | -756 | Expendable bathythermograph |
| PS28/1_74 | 1993-11-13T10:23 | -2.900.000 | 891.670 | -4980 | -756 | Expendable bathythermograph |
| PS28/1_75 | 1993-11-14T12:02 | -3.000.000 | 868.330 | -4984 | -756 | Expendable bathythermograph |
| PS28/1_76 | 1993-11-14T04:47 | -3.100.000 | 871.670 | -4916 | -756 | Expendable bathythermograph |
| PS28/1_77 | 1993-11-14T09:22 | -3.200.000 | 871.670 | -4823 | -756 | Expendable bathythermograph |
| PS28/1_78 | 1993-11-14T13:27 | -3.300.000 | 861.670 | -5026 | -756 | Expendable bathythermograph |
| PS28/1_79 | 1993-11-14T18:48 | -3.400.000 | 850.000 | -5091 | -756 | Expendable bathythermograph |
| PS28/1_80 | 1993-11-15T07:19 | -3.608.330 | 825.000 | -5041 | -632 | Expendable bathythermograph |
| PS28/1_81 | 1993-11-15T15:05 | -3.731.670 | 813.330 | -4879 | -756 | Expendable bathythermograph |
| PS28/1_82 | 1993-11-15T18:48 | -3.800.000 | 803.330 | -4997 | -756 | Expendable bathythermograph |
| PS28/1_83 | 1993-11-16T12:23 | -3.900.000 | 791.670 | -5347 | -756 | Expendable bathythermograph |
| PS28/1_84 | 1993-11-16T15:12 | -4.000.000 | 795.000 | -5020 | -756 | Expendable bathythermograph |
| PS28/1_85 | 1993-11-16T20:07 | -4.100.000 | 806.670 | -4931 | -756 | Expendable bathythermograph |
| PS28/1_86 | 1993-11-17T01:02 | -4.200.000 | 820.000 | -4580 | -756 | Expendable bathythermograph |
| PS28/1_87 | 1993-11-17T10:31 | -4.400.000 | 850.000 | -4583 | -756 | Expendable bathythermograph |
| PS28/1_88 | 1993-11-17T15:41 | -4.500.000 | 865.000 | -4563 | -756 | Expendable bathythermograph |

| Station No. | Date/Time | Position Latitude | Position Longitude | Elevation | Elevation end | Device |
|---|---|---|---|---|---|---|
| PS28/1_89 | 1993-11-17T20:45 | -4.600.000 | 880.000 | -4513 | -756 | Expendable bathythermograph |
| PS28/1_90 | 1993-11-18T02:11 | -4.708.330 | 896.670 | -3726 | -756 | Expendable bathythermograph |
| PS28/1_91 | 1993-11-18T06:41 | -4.800.000 | 910.000 | -3861 | -756 | Expendable bathythermograph |
| PS28/1_92 | 1993-11-18T11:24 | -4.900.000 | 920.000 | -4317 | -756 | Expendable bathythermograph |
| PS28/1_93 | 1993-11-18T16:32 | -5.000.000 | 876.670 | -4363 | -756 | Expendable bathythermograph |
| PS28/1_94 | 1993-11-18T21:43 | -5.100.000 | 830.000 | -4205 | -756 | Expendable bathythermograph |
| PS28/1_95 | 1993-11-19T02:59 | -5.205.000 | 850.000 | -3784 | -756 | Expendable bathythermograph |
| PS28/1_96 | 1993-11-19T07:17 | -5.300.000 | 883.330 | -2883 | -756 | Expendable bathythermograph |
| PS28/1_97 | 1993-11-19T20:38 | -5.400.000 | 911.670 | -3526 | -756 | Expendable bathythermograph |
| PS28/1_98 | 1993-11-20T01:13 | -5.500.000 | 916.670 | -3483 | -760 | Expendable bathythermograph |
| PS28/1_99 | 1993-11-20T06:45 | -5.606.670 | 920.000 | -5226 | -758 | Expendable bathythermograph |
| PS28/1_100 | 1993-11-20T11:04 | -5.700.000 | 916.670 | -5417 | -756 | Expendable bathythermograph |
| PS28/1_101 | 1993-11-20T15:33 | -5.783.330 | 915.000 | -5177 | -756 | Expendable bathythermograph |
| PS28/10572 | 1993-10-19T10:34 | 5.150.000 | 210.000 | | | Radiosonde |
| PS28/10573 | 1993-10-20T10:35 | 4.910.000 | -610.000 | | | Radiosonde |
| PS28/10574 | 1993-10-20T21:06 | 4.800.000 | -1.000.000 | | | Radiosonde |
| PS28/10575 | 1993-10-21T10:31 | 4.570.000 | -1.280.000 | | | Radiosonde |
| PS28/10576 | 1993-10-21T14:38 | 4.500.000 | -1.350.000 | | | Radiosonde |
| PS28/10577 | 1993-10-21T19:15 | 4.400.000 | -1.380.000 | | | Radiosonde |
| PS28/10578 | 1993-10-21T23:38 | 4.300.000 | -1.390.000 | | | Radiosonde |
| PS28/10579 | 1993-10-22T05:05 | 4.200.000 | -1.410.000 | | | Radiosonde |
| PS28/10580 | 1993-10-22T09:33 | 4.110.000 | -1.430.000 | | | Radiosonde |
| PS28/10581 | 1993-10-22T14:52 | 4.010.000 | -1.440.000 | | | Radiosonde |
| PS28/10582 | 1993-10-22T21:13 | 3.900.000 | -1.420.000 | | | Radiosonde |
| PS28/10583 | 1993-10-23T03:51 | 3.800.000 | -1.390.000 | | | Radiosonde |
| PS28/10584 | 1993-10-23T10:22 | 3.770.000 | -1.380.000 | | | Radiosonde |
| PS28/10585 | 1993-10-23T18:18 | 3.710.000 | -1.400.000 | | | Radiosonde |
| PS28/10586 | 1993-10-23T22:52 | 3.600.000 | -1.440.000 | | | Radiosonde |
| PS28/10587 | 1993-10-24T04:26 | 3.500.000 | -1.480.000 | | | Radiosonde |
| PS28/10588 | 1993-10-24T09:03 | 3.400.000 | -1.520.000 | | | Radiosonde |
| PS28/10589 | 1993-10-24T13:43 | 3.300.000 | -1.560.000 | | | Radiosonde |
| PS28/10590 | 1993-10-24T18:32 | 3.200.000 | -1.610.000 | | | Radiosonde |
| PS28/10591 | 1993-10-24T23:04 | 3.110.000 | -1.640.000 | | | Radiosonde |
| PS28/10592 | 1993-10-25T04:15 | 3.000.000 | -1.680.000 | | | Radiosonde |
| PS28/10593 | 1993-10-25T08:56 | 2.900.000 | -1.720.000 | | | Radiosonde |
| PS28/10594 | 1993-10-26T00:01 | 2.610.000 | -1.880.000 | | | Radiosonde |
| PS28/10595 | 1993-10-26T05:29 | 2.510.000 | -1.960.000 | | | Radiosonde |

| Station No. | Date/Time | Position Latitude | Position Longitude | Elevation | Elevation end | Device |
|---|---|---|---|---|---|---|
| PS28/10596 | 1993-10-26T11:22 | 2.400.000 | -2.040.000 | | | Radiosonde |
| PS28/10597 | 1993-10-27T01:36 | 2.300.000 | -2.090.000 | | | Radiosonde |
| PS28/10598 | 1993-10-27T06:52 | 2.190.000 | -2.100.000 | | | Radiosonde |
| PS28/10599 | 1993-10-27T10:31 | 2.110.000 | -2.110.000 | | | Radiosonde |
| PS28/10600 | 1993-10-27T17:34 | 2.000.000 | -2.120.000 | | | Radiosonde |
| PS28/10601 | 1993-10-27T23:02 | 1.900.000 | -2.150.000 | | | Radiosonde |
| PS28/10602 | 1993-10-28T03:45 | 1.780.000 | -2.180.000 | | | Radiosonde |
| PS28/10603 | 1993-10-28T07:40 | 1.700.000 | -2.210.000 | | | Radiosonde |
| PS28/10604 | 1993-10-28T12:23 | 1.600.000 | -2.230.000 | | | Radiosonde |
| PS28/10605 | 1993-10-28T16:51 | 1.500.000 | -2.260.000 | | | Radiosonde |
| PS28/10606 | 1993-10-28T21:28 | 1.400.000 | -2.290.000 | | | Radiosonde |
| PS28/10607 | 1993-10-29T01:45 | 1.310.000 | -2.310.000 | | | Radiosonde |
| PS28/10608 | 1993-10-29T06:43 | 1.210.000 | -2.340.000 | | | Radiosonde |
| PS28/10609 | 1993-10-29T11:38 | 1.100.000 | -2.370.000 | | | Radiosonde |
| PS28/10610 | 1993-10-29T16:56 | 1.000.000 | -2.400.000 | | | Radiosonde |
| PS28/10611 | 1993-10-29T23:52 | 900.000 | -2.350.000 | | | Radiosonde |
| PS28/10612 | 1993-10-30T05:45 | 800.000 | -2.300.000 | | | Radiosonde |
| PS28/10613 | 1993-10-30T10:31 | 730.000 | -2.250.000 | | | Radiosonde |
| PS28/10614 | 1993-10-30T17:31 | 600.000 | -2.190.000 | | | Radiosonde |
| PS28/10615 | 1993-10-30T22:56 | 500.000 | -2.140.000 | | | Radiosonde |
| PS28/10616 | 1993-10-31T04:40 | 410.000 | -2.080.000 | | | Radiosonde |
| PS28/10617 | 1993-10-31T10:17 | 310.000 | -2.030.000 | | | Radiosonde |
| PS28/10618 | 1993-10-31T16:36 | 200.000 | -1.980.000 | | | Radiosonde |
| PS28/10619 | 1993-10-31T22:10 | 100.000 | -1.920.000 | | | Radiosonde |
| PS28/10620 | 1993-11-01T04:04 | 0.00000 | -1.870.000 | | | Radiosonde |
| PS28/10621 | 1993-11-01T10:10 | -0.20000 | -1.850.000 | | | Radiosonde |
| PS28/10622 | 1993-11-02T10:08 | -100.000 | -1.490.000 | | | Radiosonde |
| PS28/10623 | 1993-11-03T10:14 | -190.000 | -1.000.000 | | | Radiosonde |
| PS28/10624 | 1993-11-04T10:09 | -300.000 | -490.000 | | | Radiosonde |
| PS28/10625 | 1993-11-05T09:54 | -400.000 | 0.50000 | | | Radiosonde |
| PS28/10627 | 1993-11-07T08:25 | -600.000 | 1.020.000 | | | Radiosonde |
| PS28/10629 | 1993-11-07T18:38 | -800.000 | 970.000 | | | Radiosonde |
| PS28/10630 | 1993-11-07T23:25 | -900.000 | 920.000 | | | Radiosonde |
| PS28/10631 | 1993-11-08T04:46 | -1.000.000 | 910.000 | | | Radiosonde |
| PS28/10632 | 1993-11-08T13:37 | -1.100.000 | 820.000 | | | Radiosonde |
| PS28/10633 | 1993-11-08T21:09 | -1.200.000 | 710.000 | | | Radiosonde |
| PS28/10634 | 1993-11-09T10:10 | -1.280.000 | 620.000 | | | Radiosonde |
| PS28/10635 | 1993-11-09T14:41 | -1.300.000 | 670.000 | | | Radiosonde |
| PS28/10636 | 1993-11-09T19:51 | -1.400.000 | 660.000 | | | Radiosonde |
| PS28/10637 | 1993-11-10T00:42 | -1.500.000 | 710.000 | | | Radiosonde |
| PS28/10638 | 1993-11-10T05:56 | -1.600.000 | 750.000 | | | Radiosonde |
| PS28/10640 | 1993-11-10T18:09 | -1.800.000 | 790.000 | | | Radiosonde |
| PS28/10641 | 1993-11-10T23:32 | -1.900.000 | 810.000 | | | Radiosonde |
| PS28/10642 | 1993-11-11T05:14 | -2.000.000 | 830.000 | | | Radiosonde |
| PS28/10643 | 1993-11-11T12:05 | -2.100.000 | 870.000 | | | Radiosonde |

| Station No. | Date/Time | Position Latitude | Position Longitude | Elevation | Elevation end | Device |
|---|---|---|---|---|---|---|
| PS28/10644 | 1993-11-11T17:25 | -2.200.000 | 910.000 | | | Radiosonde |
| PS28/10645 | 1993-11-11T23:42 | -2.300.000 | 950.000 | | | Radiosonde |
| PS28/10646 | 1993-11-12T05:45 | -2.400.000 | 990.000 | | | Radiosonde |
| PS28/10647 | 1993-11-12T11:39 | -2.500.000 | 1.030.000 | | | Radiosonde |
| PS28/10648 | 1993-11-12T18:21 | -2.600.000 | 1.000.000 | | | Radiosonde |
| PS28/10649 | 1993-11-13T00:18 | -2.700.000 | 970.000 | | | Radiosonde |
| PS28/10650 | 1993-11-13T05:55 | -2.800.000 | 930.000 | | | Radiosonde |
| PS28/10651 | 1993-11-13T10:14 | -2.900.000 | 890.000 | | | Radiosonde |
| PS28/10652 | 1993-11-14T00:14 | -3.000.000 | 870.000 | | | Radiosonde |
| PS28/10653 | 1993-11-14T04:57 | -3.100.000 | 870.000 | | | Radiosonde |
| PS28/10654 | 1993-11-14T10:07 | -3.210.000 | 870.000 | | | Radiosonde |
| PS28/10656 | 1993-11-14T19:00 | -3.400.000 | 850.000 | | | Radiosonde |
| PS28/10657 | 1993-11-15T07:31 | -3.600.000 | 830.000 | | | Radiosonde |
| PS28/10658 | 1993-11-15T13:25 | -3.700.000 | 820.000 | | | Radiosonde |
| PS28/10659 | 1993-11-15T18:53 | -3.800.000 | 810.000 | | | Radiosonde |
| PS28/10660 | 1993-11-16T00:28 | -3.900.000 | 790.000 | | | Radiosonde |
| PS28/10661 | 1993-11-16T10:30 | -3.950.000 | 790.000 | | | Radiosonde |
| PS28/10662 | 1993-11-16T15:29 | -4.000.000 | 800.000 | | | Radiosonde |
| PS28/10663 | 1993-11-16T20:12 | -4.100.000 | 810.000 | | | Radiosonde |
| PS28/10664 | 1993-11-17T01:06 | -4.200.000 | 820.000 | | | Radiosonde |
| PS28/10665 | 1993-11-17T06:01 | -4.300.000 | 840.000 | | | Radiosonde |
| PS28/10666 | 1993-11-17T10:27 | -4.300.000 | 850.000 | | | Radiosonde |
| PS28/10667 | 1993-11-17T15:36 | -4.500.000 | 870.000 | | | Radiosonde |
| PS28/10668 | 1993-11-17T20:49 | -4.600.000 | 880.000 | | | Radiosonde |
| PS28/10669 | 1993-11-18T02:15 | -4.710.000 | 900.000 | | | Radiosonde |
| PS28/10670 | 1993-11-18T06:45 | -4.800.000 | 910.000 | | | Radiosonde |
| PS28/10671 | 1993-11-18T11:29 | -4.900.000 | 920.000 | | | Radiosonde |
| PS28/10672 | 1993-11-18T16:38 | -5.000.000 | 880.000 | | | Radiosonde |
| PS28/10673 | 1993-11-18T21:48 | -5.100.000 | 830.000 | | | Radiosonde |
| PS28/10674 | 1993-11-19T03:03 | -5.200.000 | 850.000 | | | Radiosonde |
| PS28/10675 | 1993-11-19T07:20 | -5.300.000 | 860.000 | | | Radiosonde |
| PS28/10677 | 1993-11-20T01:16 | -5.500.000 | 920.000 | | | Radiosonde |
| PS28/10678 | 1993-11-20T06:49 | -5.600.000 | 920.000 | | | Radiosonde |
| PS28/10679 | 1993-11-20T11:09 | -5.700.000 | 920.000 | | | Radiosonde |
| PS28/10680 | 1993-11-20T17:41 | -5.780.000 | 920.000 | | | Radiosonde |
| PS28/10682 | 1993-11-22T10:21 | -5.010.000 | 1.260.000 | | | Radiosonde |
| PS28/10683 | 1993-11-23T10:11 | -4.760.000 | 1.360.000 | | | Radiosonde |
| PS28/10684 | 1993-11-24T10:16 | -4.410.000 | 1.490.000 | | | Radiosonde |
| PS28/10685 | 1993-11-25T10:38 | -4.090.000 | 1.590.000 | | | Radiosonde |
| PS28/11298 | 1993-10-19T15:00 | 5.043.000 | -0.44000 | | | Radiosonde |
| PS28/11299 | 1993-10-20T14:30 | 4.860.000 | -790.000 | | | Radiosonde |
| PS28/11300 | 1993-10-23T12:55 | 3.740.000 | -1.345.000 | | | Radiosonde |
| PS28/11301 | 1993-10-24T10:58 | 3.335.000 | -1.525.000 | | | Radiosonde |
| PS28/11302 | 1993-10-25T21:10 | 2.634.000 | -1.828.000 | | | Radiosonde |
| PS28/11303 | 1993-10-27T13:48 | 2.033.000 | -2.170.000 | | | Radiosonde |

| Station No. | Date/Time | Position Latitude | Position Longitude | Elevation | Elevation end | Device |
|---|---|---|---|---|---|---|
| PS28/11304 | 1993-10-28T21:00 | 1.404.000 | -2.252.000 | | | Radiosonde |
| PS28/11305 | 1993-10-29T13:55 | 1.050.000 | -2.380.000 | | | Radiosonde |
| PS28/11306 | 1993-10-30T13:20 | 670.000 | -2.220.000 | | | Radiosonde |
| PS28/11307 | 1993-10-31T13:46 | 260.000 | -2.000.000 | | | Radiosonde |
| PS28/11308 | 1993-11-01T14:35 | -0.20000 | -1.850.000 | | | Radiosonde |
| PS28/11309 | 1993-11-02T13:30 | -110.000 | -1.410.000 | | | Radiosonde |
| PS28/11310 | 1993-11-03T13:15 | -210.000 | -940.000 | | | Radiosonde |
| PS28/11311 | 1993-11-04T13:20 | -310.000 | -410.000 | | | Radiosonde |
| PS28/11312 | 1993-11-05T13:18 | -410.000 | 130.000 | | | Radiosonde |
| PS28/11313 | 1993-11-06T09:03 | -500.000 | 570.000 | | | Radiosonde |
| PS28/11314 | 1993-11-07T13:25 | -710.000 | 990.000 | | | Radiosonde |
| PS28/11315 | 1993-11-08T12:48 | -1.070.000 | 840.000 | | | Radiosonde |
| PS28/11316 | 1993-11-09T12:22 | -1.260.000 | 615.000 | | | Radiosonde |
| PS28/11317 | 1993-11-10T12:30 | -1.700.000 | 760.000 | | | Radiosonde |
| PS28/11318 | 1993-11-11T12:33 | -2.110.000 | 870.000 | | | Radiosonde |
| PS28/11319 | 1993-11-12T12:14 | -2.510.000 | 1.030.000 | | | Radiosonde |
| PS28/11320 | 1993-11-13T12:27 | -2.940.000 | 870.000 | | | Radiosonde |
| PS28/11321 | 1993-11-14T13:45 | -3.290.000 | 860.000 | | | Radiosonde |
| PS28/11322 | 1993-11-15T12:29 | -3.690.000 | 810.000 | | | Radiosonde |
| PS28/11323 | 1993-11-16T10:27 | -3.950.000 | 790.000 | | | Radiosonde |
| PS28/11324 | 1993-11-17T13:43 | -4.470.000 | 860.000 | | | Radiosonde |
| PS28/11325 | 1993-11-18T08:40 | -4.840.000 | 910.000 | | | Radiosonde |
| PS28/11326 | 1993-11-19T20:44 | -5.400.000 | 910.000 | | | Radiosonde |
| PS28/11327 | 1993-11-20T08:24 | -5.780.000 | 912.000 | | | Radiosonde |
| PS28/11328 | 1993-11-21T10:30 | -5.460.000 | 1.070.000 | | | Radiosonde |
| PS28/11329 | 1993-11-23T18:55 | -4.630.000 | 1.410.000 | | | Radiosonde |
| PS28/11330 | 1993-11-24T18:39 | -4.280.000 | 1.520.000 | | | Radiosonde |
| PS28/11647 | 1993-10-22T12:55 | 4.020.000 | -1.422.000 | | | Radiosonde |

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