IFM-GEOMAR REPORT

IFM-GEOMAR

Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

# FS SONNE
# Fahrtbericht / Cruise Report
# TransBrom SONNE

Tomakomai, Japan - Townsville, Australia
09.10. - 24.10.2009


Berichte aus dem Leibniz-Institut
für Meereswissenschaften an der
Christian-Albrechts-Universität zu Kiel

**Nr. 37**
Februar 2010

IFM-GEOMAR
Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

# FS SONNE
# Fahrtbericht / Cruise Report
# TransBrom SONNE

Tomakomai, Japan - Townsville, Australia
09.10. - 24.10.2009


Berichte aus dem Leibniz-Institut
für Meereswissenschaften an der
Christian-Albrechts-Universität zu Kiel

**Nr. 37**
Februar 2010
ISSN Nr.: 1614-6298

IFM-GEOMAR
Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

Das Leibniz-Institut für Meereswissenschaften ist ein Institut der Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz (WGL)

The Leibniz-Institute of Marine Sciences is a member of the Leibniz Association (Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz).

**Herausgeber / Editor:**
Birgit Quack / Kirstin Krüger

**IFM-GEOMAR Report**
ISSN Nr.: 1614-6298

**Leibniz-Institut für Meereswissenschaften / Leibniz Institute of Marine Sciences**
IFM-GEOMAR
Dienstgebäude Westufer / West Shore Building
Düsternbrooker Weg 20
D-24105 Kiel
Germany

**Leibniz-Institut für Meereswissenschaften / Leibniz Institute of Marine Sciences**
IFM-GEOMAR
Dienstgebäude Ostufer / East Shore Building
Wischhofstr. 1-3
D-24148 Kiel
Germany

Tel.: ++49 431 600-0
Fax: ++49 431 600-2805
www.ifm-geomar.de

# RV SONNE - Cruise report

## Cruise TransBrom Sonne

Tomakomai, Japan to Townsville, Australia
9 to 24 October 2009


Chief Scientist: Dr. Birgit Quack
Leibniz-Institut für Meereswissenschaften
IFM-GEOMAR
Marine Biogeochemie
Düsternbrooker Weg 20
24105 Kiel

Tel : +431 6004206
Fax: +431 6004202
Email: bquack@ifm-geomar.de

Responsible institution: Leibniz-Institut für Meereswissenschaften, IFM-GEOMAR, Kiel
Principle Investigator: Prof. Dr. Kirstin Krüger

Projects: TransBrom Sonne (BMBF 03G0731A, TransBrom (Leibniz Association), SOPRAN BMBF 03F0462A), SHIVA (EU-Project)

Version: 14 January 2010

# Content

# 1 Participants

Dinter, Tilman (scientist), Grossmann, Katja (scientist), Immler, Franz (scientist), Krüger, Kirstin (scientist), Lanatowitz, Arne (technician), Mohr, Victoria (scientist), Müller, Christian (technician), Namkoong, Hansup (technician), Peters, Enno (scientist), Petrick, Gert (technician), Quack, Birgit (chief scientist), Quack, Herbert (technician), Quack, Kim (technician), Rex, Markus (scientist), Ridder, Theo (scientist), Stange, Dörte (technician), Stange, Karen (technician), Tegtmeier, Susann (scientist), Theis, Anja (scientist), Wache, Sebastian (scientist), Weinzierl, Christine (technician), Wittke, Franziska (technician), Wittrock, Folkart (scientist), Zindler, Kathleen (scientist).

**Table 1:** Scientific party during TransBrom Sonne, sorted by research topics into working groups, affiliation is also given.

| | | | | |
|---|---|---|---|---|
| 1 | Quack, Birgit | chief scientist | IFM-GEOMAR | Working group |
| 2 | Petrick , Gert | halocarbons in air-and seawater | IFM-GEOMAR | 1 |
| 3 | Stange , Karen | halocarbons in air-and seawater | IFM-GEOMAR | |
| 4 | Namkoong, Hansup | halocarbons in air-and seawater | IFM-GEOMAR | |
| 5 | Theis, Anja | PHYTO-OPTICS | AWI Bremen | 2 |
| 6 | Dinter , Tilman | PHYTO-OPTICS | AWI Bremen | |
| 7 | Stange , Dörte | PHYTO-OPTICS | IFM-GEOMAR | |
| 8 | Quack, Kim | PHYTO-OPTICS | IFM-GEOMAR | |
| 9 | Zindler, Kathleen | DMS in air-and seawater | IFM-GEOMAR | 3 |
| 10 | Wittke, Franziska | N20, in air-and seawater | IFM-GEOMAR | |
| 11 | Quack, Herbert | CO2, O2 in air-and seawater, gas tension, CTD, ADCP | IFM-GEOMAR | 4 |
| 12 | Krüger, Kirstin | radio and water vapor sondes | IFM-GEOMAR | 5 |
| 13 | Tegtmeier, Susann | radio and water vapor sondes | IFM-GEOMAR | |
| 14 | Mohr, Viktoria | radio and water vapor sondes | IFM-GEOMAR | |
| 15 | Wache, Sebastian | radio and water vapor sondes | IFM-GEOMAR | |
| 16 | Immler, Franz | radio and water vapor sondes | DWD | |
| 17 | Rex, Markus | ozone sondes | AWI Potsdam | |
| 18 | Grossmann, Katja | MAX-DOAS | IUP Heidelberg | 6 |
| 19 | Peters , Enno | MAX-DOAS | IUP Bremen | |
| 20 | Wittrock, Folkart | MAX-DOAS, Aeronet | IUP Bremen | |
| 21 | Müller, Christian | air sampling , aersols, trace gases | IFM-GEOMAR | 7 |
| 22 | Lanatowitz, Arne | air sampling , aersols, trace gases | IFM-GEOMAR | |
| 23 | Ridder, Theo | FTIR-Spectrometer | IUP Bremen | 8 |
| 24 | Weinzierl, Christine | FTIR-Spectrometer | IUP Bremen | |

# 2 Participating institutions

| | |
|---|---|
| AWI BREMERHAVEN | Alfred-Wegener-Institute für Polar und Meeresforschung, Fachbereich. Klima. Bussestraße 24, D- 27570 Bremerhaven.de, email: Astrid.Bracher@awi.de |
| AWI POTSDAM | Alfred Wegener Institute, Telegrafenberg A43, D-14473 Potsdam, email: markus.rex@awi.de |
| DWD | Deutscher Wetterdienst, Richard-Aßmann-Observatorium, D-15848 Lindenberg, email: franz.immler@dwd.de |
| IFM-GEOMAR | Leibniz-Institut für Meereswissenschaften, Düsternbrooker Weg 20, D-24105 Kiel, Tel: +431 6004206, Fax: +431 6004205, email: bquack@ifm-geomar.de |
| IUP BREMEN | Institut für Umweltphysik, Universität Bremen, Otto-Hahn-Allee 1, D-28359 Bremen, Deutschland, folkard@iup.physik.uni-bremen.de |
| IUP HEIDELBERG | Institut für Umweltphysik, Universität Heidelberg, Im Neuenheimer Feld 229, D-69120 Heidelberg, email: katja.grossmann@iup.uni-heidelberg.de |

Other institutions were participating with instruments, being observed by the scientists on board.

| | |
|---|---|
| RSMAS MIAMI | Rosenstiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway,Miami, FL 33149, email: eatlas@rsmas.miami.edu |
| IMAU | Institute for Marine and Atmospheric Research, Department of Physics and Astronomy, Utrecht University, Princetonplein 5, 3584 CC Utrecht, 0031 30 253 2903, email: s.walter@uu.nl |
| UEA | University of East Anglia, Norwich, NR4 7TJ, UK, email: alex.baker@uea.ac.uk |
| UNI FRANKFURT | Institute for Atmosphere and Environment, J.W. Goethe Universität Frankfurt, Altenhöferallee 1, D 60438 Frankfurt/Main, email: an.engel@iau.uni-frankfurt.de |
| HAMBURG | Institute for Biogeochemie und Meereschemie, Universität Hamburg, Bundesstraße 55, 20146 Hamburg, email: enno. bahlmann@zmaw.de |
| CAIRNS | School of Earth and Environmental Sciences, James Cook University, PO Box 6811, Cairns QLD 4870 Australia, email: robin.beaman@jcu.edu.au, web: http://www.deepreef.org/ |

# 3 Scientific background for TransBrom Sonne

**TransBrom-Sonne: Short-lived bromine compounds within the ocean and their route of transport into the stratosphere**

„From ocean into atmosphere' was working title of the expedition „TransBrom-Sonne' which was carried out in October 2009 in the West Pacific by oceanic- and atmospheric chemists as well as biologists and meteorologists. The expedition was funded by the BMBF (German Federal Ministry of Education and Research) as part of the project "TransBrom" (www.ifm-geomar.de/~transbrom), which is funded by the Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz (WGL) since January 2009 at the IFM GEOMAR.

The research mainly focused on a current issue of ozone research, which has obtained high priority in the ozone assessment of 2007 from the World Meteorological Organization (WMO) and concerns the reduction of uncertainties in stratospheric halogen loading and ozone depletion resulting from oceanic emissions and atmospheric transport of ozone depleting substances.

According to new findings, natural, short-lived halocarbons (VSLS – Very Short-Lived Substances) also play a role in the stratospheric ozone budget, besides the anthropogenic emitted, long-lived chlorine- and brominefluorocarbons (FHKW's), well-known for causing the ozone hole within the stratosphere. For example higher concentrations of reactive bromine have been found within the lower stratosphere, than can be explained by the long-lived FHKW's (Dorf et al., 2005, WMO 2007). Increasing scientific evidence suggests that there could be significant contributions from ocean derived short lived substances (Salawitch, 2006). The tropical oceans are a known source of reactive bromine and iodine to the atmosphere in the form of short-lived brominated and iodinated methanes, as e.g. bromoform ($CHBr_3$), dibromomethane ($CH_2Br_2$) and methyl iodide ($CH_3I$). Elevated atmospheric concentrations above the oceans are related to oceanic supersaturations of the compounds, caused by natural photochemical and biological production. Localized emission regions of the brominated compounds have been found near shorelines as well as in upwelling regions of the tropical oceans, while their oceanic production is still mainly unexplored (Quack and Wallace, 2003, Quack et al., 2004, 2007). The tropical Western Pacific is of special interest since it is a largely uncharacterized region for the oceanic compounds and in certain regions a projected hot spot for their emissions and transport pathways into the stratosphere (Butler et al., 2005; Yokouchi et al., 1999). The Tropical Tropopause Layer (TTL) in heights of 14-18 km represents the entrance for trace gases into the stratosphere. Present studies though reflect the uncertainty concerning the transition time of air masses through the TTL (Krüger et al 2009, Plöger et al 2009). The actual contribution of the oceanic bromine emissions of different regions of origin to stratospheric bromine can now be quantified more accurately with a new transport model, which will be used to analyze the campaign data subsequently (Krüger et al., 2008).

The results of the expedition will contribute to comprehension of present and future stratospheric halogen burden and ozone depletion. Beside new insights into emission- and transport controls, we expect to gain new knowledge of oceanic and atmospheric origins of the halogenated compounds (e.g. specific oceanic regions and/or groups of phytoplankton, acting as producers of trace gases) by collecting and analyzing a variety of other parameters. Physical and biological analyses will help to interpret the feedbacks between chemical emissions of marine trace gases, their production and transport. The expedition also contributes to the goals of a new EU - project SHIVA (Stratospheric ozone: Halogen Impacts in a Varying Atmosphere, http://shiva.iup.uni-heidelberg.de/) with participation of IFM-GEOMAR.

This was the first oceanic-middle atmosphere campaign, we are aware of, where the transport of oceanic emission of halogenated trace gases from the surface into the stratosphere was investigated. The impact of the natural ozone depleting substances will be highly sensitive to climate change in terms of their emissions to the atmosphere, their transport, and their chemical processing. Future changes in the mechanisms, that regulate these processes, are largely unknown. Therefore the oceanic emissions have the potential to cause surprises in the future evolution of the ozone layer in the changing climate, unless they are better understood.

## References

Butler, J. H., D. B. King, J. M. Lobert, S. A. Montzka, S. A. Yvon-Lewis, B. D. Hall, N. J. Warwick, D. J. Mondeel, M. Aydin, and J. W. Elkins (2007), Oceanic distributions and emissions of short-lived halocarbons, Global Biogeochem. Cycles, doi:10.1029/2006GB002732.

Dorf, M., J.H. Butler, A. Butz, C. Camy-Peyret, M.P. Chipperfield, L. Kritten, S.A. Montzka, B. Simmes, F. Weidner, and K. Pfeilsticker (2006), Long-term observations of stratospheric bromine reveal slow down in growth, Geophys. Res. Lett., 33, doi: 10.1029/- 2006GL027714.

Krüger, K., S. Tegtmeier, and M. Rex, Long-term climatology of air-mass transport through the Tropical Tropopause Layer (TTL) during NH winter, Atmos. Chem Phys. 8, 813-823, 2008.

Krüger, K., S. Tegtmeier, and M. Rex, Variability of residence time in the TTL during NH winter, Atmos. Chem. Phys., 9, 6717–6725, 2009.

Plöger, F., Konopka, P., Günther, G., Grooß, J.-U., Müller, R., Impact of the vertical velocity scheme on modeling transport in the tropical tropopause layer, J. Geophys. Res., in press, 2009.

Quack, B., and D. W. R. Wallace (2003), Air-sea flux of bromoform: Controls, rates, and implications, Global Biogeochemical Cycles, 17.

Quack, B., E. Atlas, G. Petrick, and D. W. R. Wallace (2007), Bromoform and dibromomethane above the Mauritanian upwelling: Atmospheric distributions and oceanic emissions, J. Geophys. Res., 112, D09312, doi:10.1029/2006JD007614.

Salawitch, R. J.(2006) Atmospheric chemistry - Biogenic bromine, Nature, 439, 275-277.

WMO (2007), Scientific assessment of ozone depletion: Global ozone research and monitoring project, 498 pp, World Meteorological Organization, Geneva.

Yokouchi, Y., H. Li, T. Machida, S. Aoki, and H. Akimoto (1999), Isoprene in the marine boundary layer (Southeast Asian Sea, eastern Indian Ocean, and Southern Ocean): Comparison with dimethyl sulfide and bromoform, J. Geophys. Res., 104(D7), 8067–8076.

# 4 Research program of TransBrom Sonne

Of particular relevance was the characterization of the climate-sensitive oceanic emission strengths of a suite of halogenated gases in various biogeochemical regimes and the investigation of the real contribution of these emissions to stratospheric bromine with a new transport model, being validated by the atmospheric structure determination through intense radio, ozone and water vapor sounding during the cruise. We investigated more marine trace gases as nitrous oxide ($N_2O$), dimethylsulfide (DMS), oxygen ($O_2$) and carbon dioxide ($CO_2$), and possible relationships between these compounds. Further satellite measurements of phytoplankton groups, obtained by special retrieval methods from the SCIAMACHY and GOME-2 instruments gave information about biogeochemical conditions during the cruise. The atmospheric concentration profiles of a variety of long-lived anthropogenic and natural trace gases were also determined. These measurements will help to identify the transport pathways of the tropospheric trace gases to and away from the ship.

The participating groups additionally followed individual research questions. Thus, more specifically, the overall scientific program of TransBrom Sonne included the following themes, which can roughly be assorted to the individual working groups (Table 1):

- 1.) HALOCARBONS: Atmospheric and oceanic concentrations of bromine, iodine and chlorine containing halocarbons, in order to calculate their air-sea fluxes.

- 3.) PHYTO-OPTICS: Phytoplankton pigments, species and size distribution, radiation and absorption spectra of seawater and plankton content in order to characterize the phytoplankton composition and to validate satellite data from the western Pacific.

- 2.) OCEANIC TRACE GASES: Oceanic concentrations of DMS, DMSO, DMSP, nitrous oxide and methane, in order to understand their distribution in the different biogeochemical regimes of the western Pacific and to gain new insights into halocarbon sources.

- 4.) OCEANSENSORS: Identification of carbon dioxide and oxygen sources and sinks, separation of physical and biological factors for observed sources and sinks by CTD data temperature and salinity, joint evaluation with halocarbons, in order to understand more about their sources and sinks

- 5.) RADIOSOUNDING: Identification of meteorological vertical profiles, ozone, water vapor and clouds in order calculate air mass back trajectories to identify origin of sampled air masses and to validate model results and the distribution of ozone in the western Pacific atmosphere

- 6.) MAX-DOAS: Identification of reactive trace gases BrO and IO with Multi-Axis Differential Optical Absorption Spectroscopy in a three dimensional field, as possible decomposition products of organic trace gases and for validation of satellite-data.

- 7.) AIRSAMPLING: Determination of anthropogenic and natural trace gas concentrations by flask sampling for different laboratories, to identify spatial, diurnal and interhemispheric gradients of some compounds and for intercalibration of different instruments. Hydrogen, isotopic composition of compounds and halogens in aerosol samples, in order to quantify the halogen budget in the western Pacific atmosphere.

- 8.) FTIR: Continuous measurements of sunlight spectra with Fourier Transform Infrared Spectroscopy to analyze the vertical distribution of anthropogenic and natural hydrocarbon trace gases. For details of the measured parameters, please revert to Table 2.

- 9.) BATHYMETRY: The water depth of Papua New Guinean and Australian waters were measured with the multibeam echosounder SIMRAD EM 120 of RV Sonne, in order to produce sea floor maps especially from the Great Barrier Reef.

# 5 Work program during the cruise

During the transit of „FS Sonne' along the Western Pacific from Tomakomai/ Hokkaido (Japan: 42°38' N/141°37' E) to Townsville/Queensland (Australia: 19°11' S/146°50' E), a variety of chemical and physical parameters within the surface waters as well as between the atmospheric boundary layer and the stratosphere have been examined.

**Table 2:** Work plan and sampling strategy on board FS Sonne

| UTC-time | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Board-time (UTC-10) | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1 | a/w | a | w | w | st | w | a/w | a | w | w | st | w | a/w | a | w | w | s | w | a/w | a | w | w | st | w |
| 2 | | | w | | | w | | | w | | | w | | | w | | | w | | | w | | | w |
| 3 | | | w | | | w | | | w | | | w | | | w | | | w | | | w | | | w |
| 4 | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c |
| 5 | r | | | | | r | | | | | | r/o | | | | | | | r | | | | | |
| 6 | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c |
| 7 | | | (a) | | | a | | | (a) | | | 2a | | | (a) | | | a | | | (a) | | | 2a |
| 8 | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c | c |

w: water sample
a: air sample (occasional)
c: continuous
r: radio sonde
o:ozone sonde
st: standard

The working schedule during transit included continuous sampling of seawater, a collection of discrete air samples, the installation of optical measuring techniques and the uplift of research balloons. During TransBrom Sonne data and samples have been obtained with 18 instruments

and 14 sampling devices (Table 3). Routinely hourly to three hourly water and - air samples have been taken from pump supplies submersed in the hydrographic shaft, respectively installed on the monkey deck (Work Groups 1,2,3,4,7). Every six hours meteorologists sent weather balloons with trace gas instruments to the stratosphere (up to 30 km height) (Work Group 5). The optical sensors have been installed in the beginning of the cruise on the monkey deck, the bow and in a research container (Work Groups 3, 6, 8).

Ten halogenated hydrocarbons have been analyzed directly on board using a gaschromatography/ mass spectrometry system (Work Group 1). Dimethyl sulfide was also analyzed directly with a gas chromatograph from sea water (Work Group 2), while carbon dioxide and oxygen were also measured immediately with sensors within the upper oceanic layer (Work group 4). Biological sampling included parameters of organic carbon and nitrogen as well as pigments, cell sizes, the amount of small cells and the composition and activity of the phytoplankton (Work Group 3). The optical properties of seawater and its ingredients were measured as reference spectra for the validation of satellite data analysis and models, in order to detect the composition, distribution and productivity of phytoplankton (Work Group 3). Discrete air samples were taken for partners of the Universities of Hamburg, Frankfurt, Norwich and Utrecht as well as the „Rosenstiel School of Marine and Atmospheric Sciences" in Miami (Work Group 7). In the respective home laboratories more than 70 anthropogenic and natural trace gases, isotopes, aerosols and hydrogen within the marine boundary layer shall be analyzed following the cruise. Atmospheric profiles of temperature, humidity and different kinds of trace gases (e.g. ozone, hydrogen, nitric oxide, bromine oxide, carbon monoxide and organic photo oxidation products) are examined on the basis of optical measurements and by rises of research balloons (Work Groups 5, 6, 8).

A lot of samples have been taken during the cruise, some of which only returned to Kiel with the equipment transport container from Australia on January, 6 2010. The majority of samples is currently being analyzed in the respective home laboratories. The analysis of the extensive dataset from the ocean and the atmosphere collected during the TransBrom transit of the „Sonne' through the Western Pacific will bring first results between spring and summer 2010. The new insights into the interaction of ocean and atmosphere, which will be gained in the next months, will be published then in peer reviewed scientific journals.

**Table 3:** Working groups, methods, measured parameters and expected data

| | Working group | Methods and/or parameters | Sampling intervall (approx.) | Expected data |
|---|---|---|---|---|
| in water | 0 | DVS SONNE | 1 min | date, time, latitude, longitude, course speed, water depth, water temp, sal, air temp, pres, rel and true wd, rel and true wd speed, humidity |
| | 1 | HALOCARBONS | 3 h | $CH_3Br$, $CH_3I$, $CH_2Cl_2$, $CHCl_3$, $CCl_4$, ($CH_3CCl_3$), $CH_2Br_2$, ($C_2HCCl_3$), $CHBrCl_2$, $CH_2ClI$, $CH_2BrI$, $C_2Cl_4$, $CHBr_2Cl$, $CHBr_3$,$CH_2I_2$ |
| | 2 | DMS | 3h | DMS, DMSP, DMSO |
| | | N2O,CH4 | 6h | $N_2O$, $CH_4$ |
| | 3 | PIGMENTS | 3h | chlc3, chlc1+2, peridin, 19-but, fuco, 19-hex, viola, neox, diadino, allox, zeax, divchlb, chlb, divchla, chl a, a-caroten, ß-carot, phaeophba, pyrophb a, phaeophy a, pyrophy a, |
| | | FLOWCYTOMETRIE | 3h | size, fluorescence and cell number of small phytoplankton |
| | | MIKROSKOPY | 3h | species composition |
| | | PAB | 3h | particulate absorption |
| | | PSICAM | 3h | particulate and CDOM absorption |
| | | POC | 3h | particulate organic carbon (POC) and particulate organic nitrogen (PON) |
| | | CHLOROPHYLL | 1s | chla fluorescence (~chl-a conc.) and quantum yield (photosynthetic efficiency) |
| | | RADIATION | 1s | water leaving and sky radiance, downwelling irradiance, remote sensing reflectance |
| | 4 | PCO2 | 1min | carbon dioxide ($CO_2$) |
| | | POXYGEN | 1min | oxygen ($O_2$) |
| | | GASTENSION | 1min | pressure of all gases in seawater |
| | | CTD | 1 min | Water temperature and salinity |
| in air | 5 | RADIOSONDE | 6h | air temperature, humidity, pressure, wind vertical structure |
| | | OZONESONDE | 6h | ozone |
| | | WATERVAPOUR | 6h | water |
| | 6 | MAX-DOAS HEIDELBERG | 3min | BrO, IO, |
| | | MAX-DOAS BREMEN | 3min | BrO, IO, HCHO, $CH_3CHO$, $O_3$, $SO_2$, $NO_2$ |
| | 7 | CANISTER MIAMI | 6h | Ethane, Ethene, Propane, Propene, i_Butane, Acetylene, i_$C_5$, n_$C_5$, Benzene F_115, F_13b1, F_134a, OCS, F_22, F_12, $CH_3Cl$, F_142b, F_114, Halon_1211, $CH_3Br$, $C_2H_3Cl$, F_11, F_141b, $CH_3I$, DMS, $CH_2Cl_2$, $MeONO_2$, CFC_113, Halon_2402, $CHCl_3$, $EthONO_2$, 1,2 dichloroethane, $CH_3CCl_3$, $CCl_4$, i_$PropONO_2$, $CH_2Br_2$, $C_2HCl_3$, n_$PropONO_2$, Toluene, 2-$ButylONO_2$, $CHClBr_2$, $C_2Cl_4$, $C_5ONO_2$, 3-$C_5ONO_2$, 2-$C_5ONO_2$, $CHBr_3$, o_xylene, iso_propyl_benzene, $N_2O$, Methane |
| | | CANISTER FRANKFURT | 6h | 34 verschiedene Fluor-, Chlor-, Brom- und Iodkohlenwasserstoffe |
| | | CANISTER KIEL | 6h | $CH_3Br$, $CH_3I$, $CH_2Cl_2$, $CHCl_3$, $CCl_4$, ($CH_3CCl_3$), $CH_2Br_2$, ($C_2HCCl_3$), $CHBrCL_2$, $CH_2ClI$, $CH_2BrI$, $C_2Cl_4$, $CHBr_2Cl$, $CHBr_3$, $CH_2I_2$ |
| | | AEROSOL | 24h | Br, I, nutrients |
| | | HYDROGEN | 6h | $H_2$ |
| | | CARTRIDGE | 24h | unknown iodinated and bromianted compounds |
| | | ISOTOPE | 12h | different halocarbons |
| | | AERONET | 24h | aerosol optical thickness |
| | 8 | FTIR | | $CH_4$, $N_2O$, $CO_2$, CO, OCS, HCN, $C_2H_6$, $C_2H_2$, $CH_2O$,$O_3$, HCl, $NO_2$, $HNO_3$, oder HF,OCS. |

# 6 Narrative of the cruise

The cruise took its participants through various biogeochemical regimes of the northern and southern western Pacific Ocean, which differed in seawater properties, currents, productivity and atmospheric dynamics (e.g. Kuroshio Front, Northern Pacific Gyre, Pacific warm pool and Coral Seas).

The Japanese seaside town of Tomakomai (42°35,4„N/ 141°37,5„E) was starting point of the expedition which took „RV Sonne' 4030 nm (7.500 km) and 60 degrees latitude to Townsville (19°06,6'S/ 146°50,5„E) in Australia ( Figure 1).

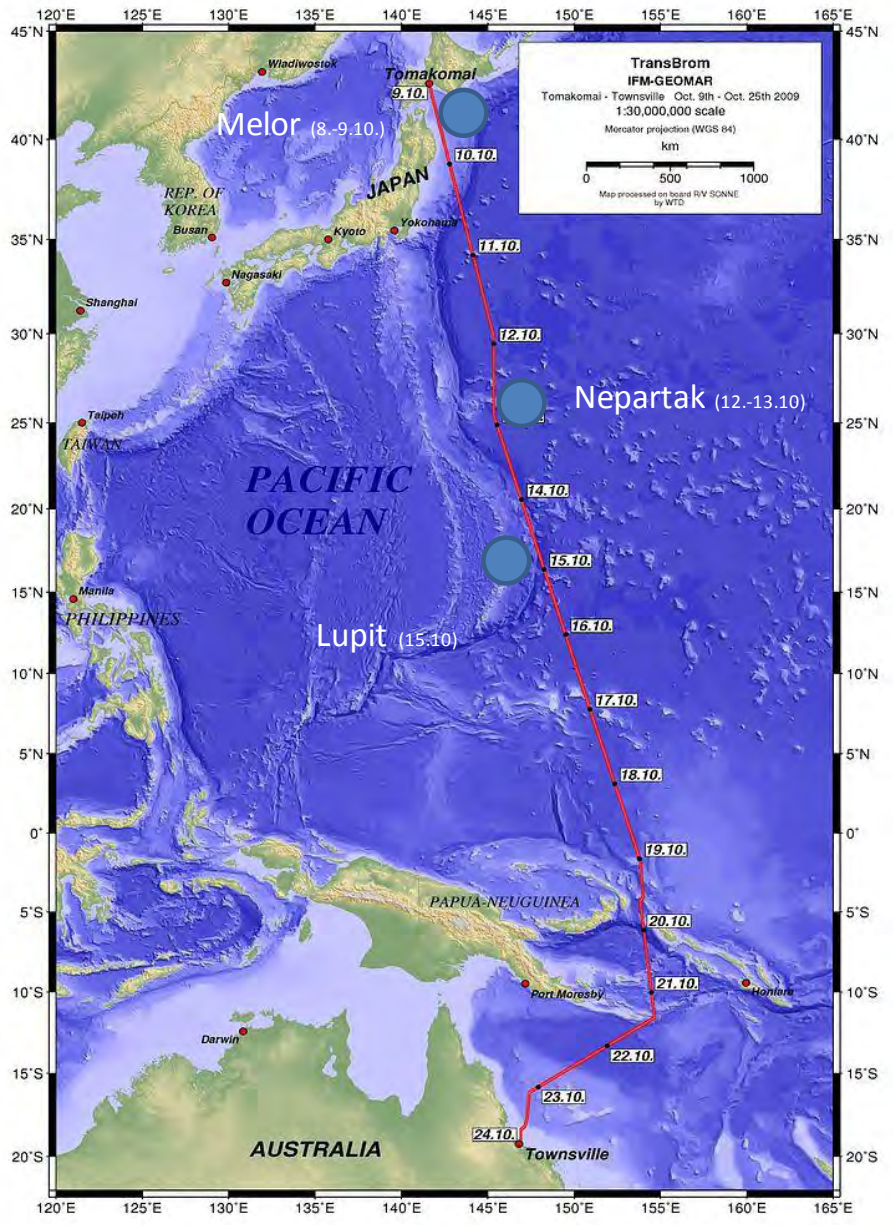



**Figure 1:** Cruise track of RV Sonne from October 9 to October 24, between Tomakomai (Japan) and Townsville (Australia), including the nearest distance of the encountered Typhoon Melor and the tropical depressions Nepartak and Lupit to the ship.

Typhoon “Melor” with a minimum pressure of 910hPa and a maximum speed of 155kn during gusts, a dangerous feature in the Western Pacific several days before, reached the ship on October 9 at 3 pm with rain showers in the safe harbor of Tomakomai, when all scientific equipment from the container had already been stored in the laboratories below deck. Also, the airfreights, the chemicals, the Japanese gases, and the liquid nitrogen reached the ship in time. All scientists immediately found suitable lab space for the 32 analytical devices on board and the first instruments were already operational in the afternoon. As the strong winds of Melor actually reached Sonne during the night of October 9, its strength had decreased to an extra tropical storm system with pressures of 980 hPa, winds of 7 Bft, and 10 Bft during wind gusts. On October 9, after a 4 hour delayed departure due to Melor, Sonne reached Tomakomai’s pilot station at 1 pm, where the plate for the hydrographic shaft, which had been adjusted to our pump systems and sensors was let into the water and the water pumping could start soon beyond the 12-mile-zone. The wind at sea had decreased in strength (5 Bft, north-easterlies) and the ship had an abaft swell of about 2-3 metres. All measuring devices where finally up and running on October 11. Especially the gaschromatography/ mass-spectrometry system took this time for equilibration, which however has been faster than expected.

During the first 2 ½ days 9 radiosondes where launched, measuring the atmosphere up to an altitude of 30 km altitude. The first ozone sonde was launched in the afternoon of October 11 at ~32° N. The sounding showed surprising results, with a massive 2 km thick isothermal stratified inversion at 3-5 km height, revealing already tropical ozone conditions above. Based on these exciting measurements the radiosonde program was expanded at once, which was initially planned for the inner tropics. At 9 pm the first pair of a special water vapor sonde and an additional backscatter instrument, which measures the content of aerosols and cloud particles, were launched, which will give insights into the dehydration processes of air masses transported into the stratosphere.

On the way south, temperatures and air pressure reached more than 28°C (82°F), while the next tropical depression with name „Nepartak’ (Figure 1) reached Sonne during the night of October 13, with a ship’s wind maximum of 20.45 m/s. Wave heights of 2-3 metres allowed to take measurements at night without having further difficulties. During 24 hours the air sampling frequency was increased from 6 to every hour, enabling us to take air samples before, during and after the storm. Possibly these data will allow to quantify the gas transfer of some marine trace gases due to short-term wind velocity changes.

The collected air samples will be analyzed for more than 70 natural occurring and man-made trace gases by the working groups of Elliot Atlas from RSMAS, Miami and of Andreas Engel at the University of Frankfurt. These additional series of measurements will provide an excellent supplement to our on-board in-situ measurements of short-lived halogenated compounds of marine origin.

On October 14 clear skies and intensive solar irradiation provided another special sampling day with perfect conditions for photochemical processes. The air sample and radio sonde frequency were again doubled to be able to distinguish between photochemistry and mixing

processes. The FTIR (Fourier Transformation Infrared Spectrometer) and the PHYTO-OPTICSs group optimized their sun spectra instruments during the only stop of the cruise, which lasted for 30 minutes around 11:30 am.

High resolution sun absorption spectra provide a basis for investigating the total column of more than 20 trace gases and vertical profiles of some of these gases from the Bremen group around Prof. Justus Notholt. An additional FTIR analyzer developed in the working group of Prof. Dr. David Griffith at the University of Wollongong, Australia, measured ground level trace gas concentrations continuously. The carbon monoxide data (CO) showed clear diurnal cycles with maxima being detected around noon. Encountering a constant background atmosphere during the steady north east trade winds the transfer from the ocean into the atmosphere might be quantifiable with these data. The continuous trace gas measurements help to understand the ITCZ (Inner Tropical Convergence Zone) conditions during the cruise, where the transition from northern hemispheric to southern hemispheric air masses took a couple of days, and will be reflected in the trace gas concentrations.

**Figure 2:** Skies in the ITCZ Region from 16 October 2009. (Folkard Wittrock)

In the afternoon of October 15 the third storm during the two-week transit through the tropical western Pacific, Sonne passed only 125 miles east of „Lupit's' point of cyclogenesis, which resulted in short-term intensification of wind speeds and wave heights.

46 balloon launches with differing sonde equipment have been carried out from the radio sonde team until October 16 at ~13° N, where the Sonne has reached the ITCZ, accompanied by a change of wind direction from ENE to WNW. The sky was covered with convective clouds of great vertical dimension, being responsible for a few showers every now and then (Figure 2).

The PHYTO-OPTICS group lead by Astrid Bracher from AWI Bremerhaven and University of Bremen, has continuously taken water samples every three hours for the analysis of phytoplankton. Water samples are filtrated for later pigment analyses in the laboratory in

order to validate daily satellite images. The high sampling frequency also will provide a basis for the detection of biological sources for the halogenated, marine trace gases.

The phytoplanktons fluorescence is being measured in surface waters during the transit by the so-called FRRF (**F**ast **R**epetition **R**ate **F**luorometer) which was, after initial software problems, operating from October 16.

Absorption measurements of sea water were done directly on board with the PSICAM (Point-Source Integrating Cavity Absorption Meter). In addition to the mentioned measuring techniques, the PHYTO-OPTICS group carried out radiation measurements with three radiometers at the ship's bow (Figure 3). The three instruments were installed on top of the bulwark at the ship's bow and measure the incoming global radiation, the diffuse sky radiation and the radiation reflected by the sea surface, between 9am and 16pm local time. The collected data will be analysed after the cruise and provide a basis for satellite validations and reflectance quantifications and therefore the seawater's optical properties.

**Figure 3:** Radiometers of the Phyto-Optics group on the ships bow.

The HALOCARBON group detected a rise in brominated oceanic trace gas concentrations in their surface water samples on October 17 in the vicinity of atolls. By referring to the phytoplankton data it will be possible to differentiate between local phytoplankton producers and a coral source.

The equator was crossed on October 19 at 1:38 (local time).

On October 20 (~6°S), the Sonne encountered strong south-east trade winds, intensified by a low pressure system near Papua New Guinea and a strong high pressure system above Australia. The oceanic currents from behind and the wind from ahead formed a rough sea with wave heights of 3 metres, which lasted for a couple of days.

On Thursday, October 22, the cruise arrived in the Coral Sea, where the concentration of all halogenated hydrocarbons rose slowly, but considerably. The satellite images of the PHYTO-OPTICS group as well as their filtrations showed an increase in phytoplankton levels. More than 300 air samples were collected during the last two weeks which were sent to the respective home labs for analysis upon arrival in Townsville.

On-board measurements of dimethyl sulphide concentrations detected “interesting variations” within the water, but the definitive statements have to await quantitative evaluation of all compounds in Kiel. All three compounds, DMS, DMSP and DMSO, are central constituents of a complex production- and consumption cycle, mainly being influenced by phytoplankton and bacteria within the surface layer. Therefore and because all compounds are measured at once, the dataset collected during the TransBrom cruise is unique up to now. Simultaneously collected data concerning phytoplankton pigments and species assemblage of phytoplankton provide a basis for a comparison with the above mentioned compounds in order to get an overview of the marine plankton’s influence on DMS-, DMSP- and DMSO-production.

Atmospheric DMS-concentrations from air samples will be used for computing possible DMS-emissions from the ocean to the atmosphere. The later quantitative analyses of all samples in the respective home laboratories will yield exciting results from this unique set of about 100 “stations” due to simultaneous sampling of atmospheric as well as marine groups.

To achieve the best synergy among all participating groups, each group presented their work in a daily noon seminar. Despite the 24h shifts, at least 75% of all scientists attended this meeting. This inspiring time of exchange helped to better understand the participating disciplines. The interdisciplinary interpretation of oceanic and atmospheric feedbacks by meteorologists, chemists, biologists and physicists during the transit was surely fostered through the interdisciplinary exchange time.

Heidelberg’s and Bremen’s MAX DOAS group carried out remote sensing measurements during the cruise by making use of the MAX-DOAS method, which uses scattered sunlight as a light source to detect different trace gases in the atmosphere. The focus was on bromine oxide (BrO) and iodine oxide (IO). Initial analysis actually showed a small BrO-Signal within the marine boundary layer on a few days. Both instruments worked throughout the whole campaign without difficulties and the datasets complement one another, since the Heidelberg-system did exclusively portside scans while Bremen’s system made use of different perspectives in order to derive possible horizontal gradients in trace gas distribution.

The Palm Passage through the Great Barrier Reef was reached on Saturday morning October 24 at 1am. Water concentrations of various compounds of interest rose strongly and remained at high levels until Townsville was reached. The marine sources for the measured compounds still need to be identified. However, it was already determined that the Great Barrier Reef is a source for atmospheric bromine trace gases, that might even find their way up to the stratosphere.

Since we were able to obtain research permission for all protective areas within the Great Barrier Reef Marine Park, the TransBrom Sonne scientific party was able to conduct their measurements during the entire transit through the western Pacific. Permissions were granted

for all national exclusive economic zones and protected waters crossed, which were Japan, USA (Marianas), Micronesia, Papua New Guinea and Australia including the Great Barrier Reef National Park (Figure 4).

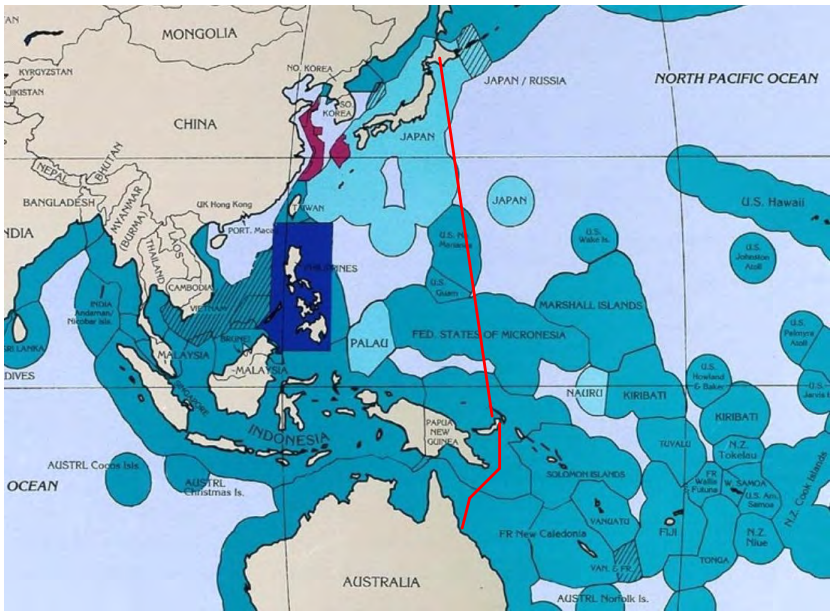



**Figure 4:** Cruise track of TransBrom Sonne and exclusive economic zones (EEZ) of the western Pacific, where research permissions where granted.

The analysis of the extensive dataset from the ocean and the atmosphere collected during the TransBrom transit of the „Sonne' through the Western Pacific is going on. New insights into the interaction of ocean and atmosphere will be gained in the next months and will be published in peer reviewed scientific journals.

# 7 Group reports with preliminary results

## *7.1 HALOCARBONS*

Birgit Quack, Gert Petrick, Karen Stange, Hansup Nam Koong (IFM-GEOMAR)

### Objectives

The halocarbon analytical group investigated oceanic and atmospheric halocarbon concentrations and influences for the observed variations by physics (e.g. winds, currents), phytoplankton, photochemistry, regional specialties as atolls or islands.

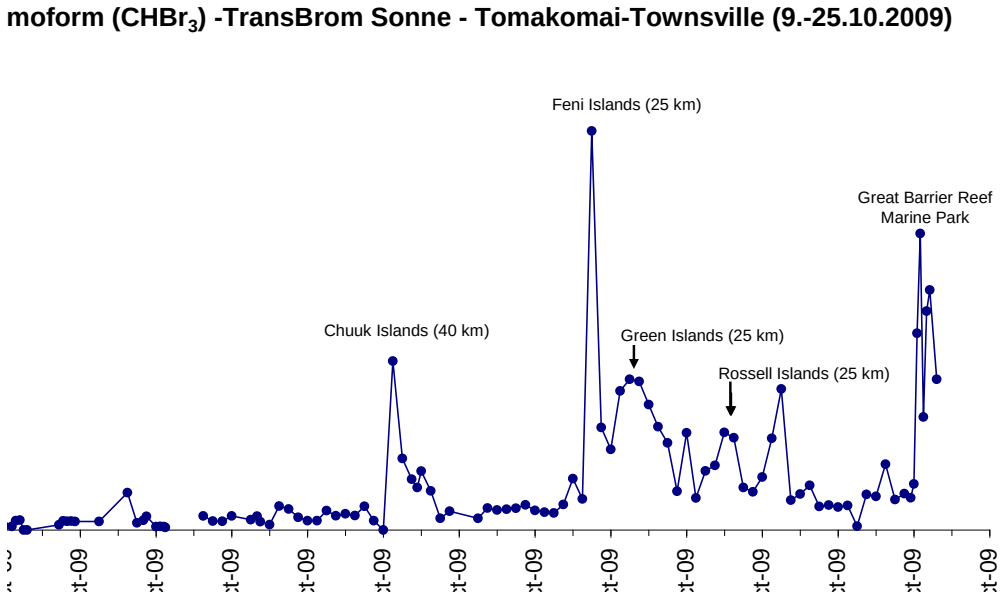
**Figure 5:** Gaschromatographic/ mass spectrometric system for the analysis of halocarbons in seawater and atmosphere.

Water and air samples have been treated with the purge and –trap technique (Nafion dried sample, trapped on glass beads at -130°C ), while subsequently the substances bromomethane, iodomethane, dichlormethane, chloroform, 1,1,1 – trichloroethane, carbon tetrachloride, 1,1,2 – trichloroethene, dibromomethane, dichlorobromomethane, chloroiodomethane,1,1,2 – trichloroethane, dibromochloromethane, bromoiodomethane, bromoform, diiodmethane have been then analyzed with the gaschromatographic/ mass spectrometric system installed on board (Figure 5).

107 water samples (500 ml) have been taken from the continuously running pump system of the hydrographic shaft and 80 ml of these samples have been analyzed, while 42 air samples (1.8 of 3 L in stainless steel canisters) have been analyzed as well.

**Preliminary results**

The first eight days of the cruise showed very low concentrations of all halocarbons in atmosphere and ocean. On passing the island Chuuk a significant increase of e.g. bromoform could be detected in water and atmosphere (Figure 6)




.**Figure 6:** Preliminary concentrations of bromoform in seawater during TransBrom Sonne.

Having seen only small amplitudes of bromoform for several days while being within the blue waters of the North Pacific Gyre, the concentration increase of one order of magnitude occurred while passing atolls and small islands in 20-30 miles distance of the ship. It has still to be analyzed if these increases are related to the islands influence by possibly macroalgae or by phytoplankton, which data however will only be available in spring 2010.

## *7.2 PHYTO-OPTICS*

**Bio-optical measurements: Ground-truthing for satellite observations**

Tilman Dinter, Anja Theis (AWI Bremerhaven), Dörte Stange, Kim Quack (IFM-GEOMAR)

**Objectives**

It has been estimated that marine phytoplankton contributes 30 to 60% to the global primary production. The large uncertainty range is a result of the lack of global information on phytoplankton absorption and light penetration depth, which cannot be supplied by the current ocean colour satellite sensors. The spectral resolution of these sensors is not sufficient to extract the relevant information. The variation of phytoplankton absorption in ocean waters

also affects the retrieval of chlorophyll *a* concentrations (a measure of phytoplankton biomass) derived from satellite data, which are important input data used in primary production models. Results by Bracher et al. (2006) show that specific phytoplankton absorption spectra as well as information on the light penetration depth can be derived by combining information from measurements of the two satellite instruments, MERIS with high spatial, and SCIAMACHY with high spectral resolution (both operating on board of the European environmental satellite ENVISAT).

Besides the analysis of satellite data and applied model studies, field measurements in the open ocean of phytoplankton pigment composition, optical characteristics of phytoplankton and other water constituents, reflectance and underwater light measurements are highly precise input parameters for the validation of results from the analyses of satellite data and modelling.

Thus the aim of this research project was to improve estimates of global marine primary production and the distribution of major phytoplankton functional groups by using remote sensing data in combination with in-situ measurements of ocean optics, phytoplankton productivity and composition and particulate organic carbon (POC). In particular, data were collected during this cruise to improve our understanding of the oceans variability in optical properties and to improve/develop remote sensing algorithms for the investigated research area. Algorithms to retrieve POC from space are still very basic, but are of great importance for studies concerning biogeochemical cycles and the biological pump within the world's oceans because carbon and not chlorophyll are the bases for those studies. Through a better knowledge of the sinks and sources of $CO_2$ in the ocean a contribution will be made to a better understanding of changes in the world's climate as well as to the understanding of the marine food web. In addition the phytoplankton productivity will be linked to the halocarbon concentrations during this cruise.

**Work at sea**

**Water samples**

Water samples were taken frequently (every 3hrs) from beneath the ship in an approximate depth of 5 m. Sampling times were closely coordinated with all other groups to allow analysis of possible correlations between our data in the future. Water samples were processed for various analyses:

Water samples were filtered onto GF/F filters for analysis of pigments, POC and particulate absorption measurements.

Water samples were preserved for flow cytometry measurements later in the laboratory in Bremerhaven.

Particulate absorption in suspension and absorption of Gelbstoff were measured during the cruise using the point-source integrating-cavity absorption meter (PSICAM) (Röttgers et al. 2005).

## Online and in situ optical measurements

A FastTracka Fast Repetition Rate Fluorometer (FRRF) was used in a flow-through system with water continuously pumped from beneath the ship to measure data of chlorophyll fluorescence during the cruise. The observed raw data have to be analysed after the cruise to give actual values on the chlorophyll fluorescence.

Remote sensing reflectance was measured from onboard the ship with a set of three radiometers for at least 6 hours per day, when the sea was relatively calm.

## Satellite images

Satellite images of ESA's GlobColour Chlorophyll-a (case 1 water) product were provided on a daily bases. This product merges data of four different sensors flying on four different satellites (SeaWiFS/Orb-View-2 (*Sea-viewing Wide Field-of-view Sensor*)), MODIS/Terra (*Moderate Resolution Imaging Spectroradiometer*), MODIS/Aqua, MERIS/ENVISAT (*Medium Resolution Imaging Spectrometer*)). The chlorophyll-a concentration is given in mg/cubic meter and is gridded on a spatial resolution of 4 km. To get reasonable coverage, because of excluding measurements which were contaminated by clouds and glint effects, the data were averaged over 5 days. The data were processed in the Institute of Environmental Physics at the University of Bremen and the images were sent to the Sonne ship by mail once a day. An example is shown in Figure 7.

## Preliminary results

*Data from FRRF and PSICAM*

The raw data from FRRF cannot give sufficient information so far and have to be further analysed.

As we know from previous cruises the absorption measurements with the PSICAM corroborate generally with the FRRF data. The chlorophyll absorption of seawater in the PSICAM appeared rather small since the ship left coastal regions from Japan. Only during the last days of the cruise when the ship reached the Solomon Sea chlorophyll absorption seemed to be increased. This can also be seen in the satellite image shown above where higher concentrations are reddish, especially in the coastal region around Japan and lower chlorophyll concentrations are blue as in the centre of the map.

Additionally, water samples were filtered and the frozen or dried filters will be transported to the home laboratories for further analyses of pigments by high-performance liquid chromatography (HPLC) and fluorometry, particulate absorption and particulate organic carbon (POC). Water samples were also preserved for analysis by flow-cytometry and taxonomy.

Combined with satellite pictures of the sampling sites, this range of analyses and in-situ measurements will hopefully give a detailed picture of the surface phytoplankton community along the cruise track in the Pacific.

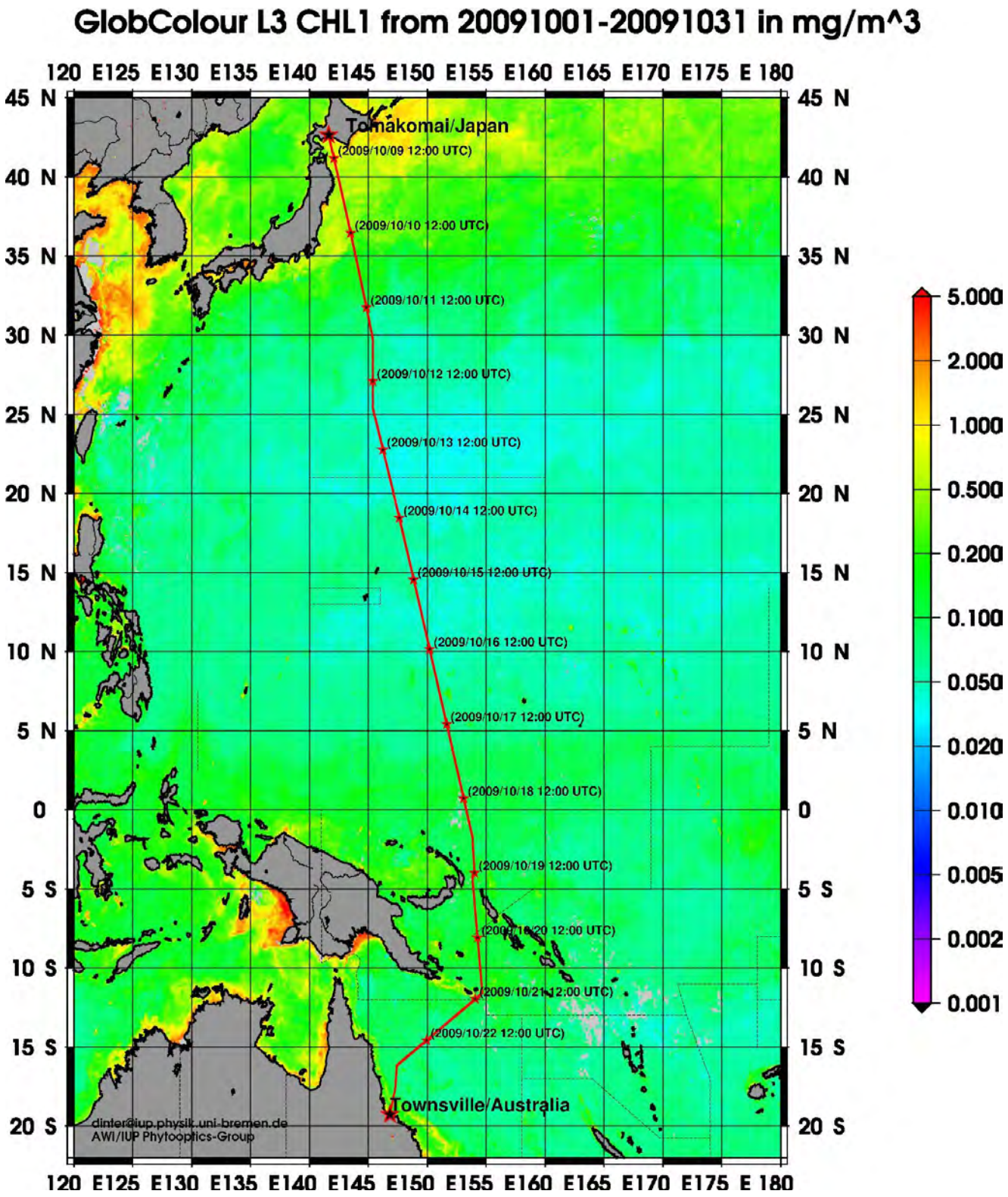



**Figure 7:** Six day average of chlorophyll a concentrations along the cruise track from the merged satellite products.

The in-situ measurements of phytoplankton concentrations give an excellent probability to compare these evaluations with results from satellite retrievals.

### References

Bracher A., Vountas M., Dinter T., Röttgers R., Doerffer R., Burrows J.P. (2006) Retrieval of phytoplankton distribution and light absorption from space borne SCIAMACHY data using Differential Optical Absorption Spectroscopy. Proceedings of the Ocean Optics XVIII, 9-13 Oct 2006, Delta CentreVille, Montreal, Canada

Röttgers R., Schönfeld W., Kipp P.-R., Doerffer R. (2005) Practical test of a point-source integrating cavity absorption meter: the performance of different collector assemblies. Applied Optics 44(26): 5549-5560.

## *7.3 OCEANIC TRACE GASES*

### Measurements of trace gases in the sea surface of the west Pacific Ocean

Cathleen Zindler, Franziska Wittke (IFM-GEOMAR)

### Objectives

Sulphur compounds are of extraordinary interest in the western Pacific, since those waters have not been investigated to date concerning this issue. All three compounds DMS, DMSP and DMSO, measured, are central constituents of a complex production- and consumption cycle, mainly being influenced by phytoplankton and bacteria within the surface layer. Therefore and because all compounds are measured at once, the dataset collected during the TransBrom cruise is unique up to now. Simultaneously collected data concerning phytoplankton pigments and species assemblage of phytoplankton provide a basis for a comparison with the above mentioned compounds in order to get an overview of the marine plankton's influence on DMS-, DMSP- and DMSO-production. Furthermore, the insights into the sulphur cycle, which has already been investigated in detail may reveal possible conclusions for the unknow halocarbon distribution, like the possible involvement of certain phytoplankton groups.

### Objectives and long-term goals for DMS, DMSP and DMSO

Determination of dimethylsulfide (DMS), dissolved dimethylsulfoniopropionate ($DMSP_D$), particulate dimethylsulfoniopropionate ($DMSP_P$), dissolved dimethylsulfoxide ($DMSO_d$) and particulate dimethylsulfoxide ($DMSO_p$) in surface seawater of the west Pacific Ocean

Correlation of the DMS and DMSP distribution with the phytoplankton composition and its density

Determination of DMS flux from the ocean into the atmosphere and comparison with the DMS concentration in the atmosphere

Additionally to sulphur compounds nitrous oxide and methane have joint the measurement programme

## Objectives and long-term goals for dinitroxide ($N_2O$) and methan ($CH_4$)

Determination of $N_2O$ and $CH_4$ in the sea surface of the west Pacific Ocean

Determination of $N_2O$ and $CH_4$ fluxes from the ocean into the atmosphere and comparison with the $N_2O$ and $CH_4$ concentrations in the atmosphere

## Description of sampling programme

Surface seawater was continuously pumped on board and every 3 hours (2, 5, 8, 11, 14, 17, 20, 23 hours in UTC) DMS, DMSP and DMSO samples were taken and analysed directly for DMS, $DMSP_d$ and $DMSP_p$; DMSO will be analysed in the home lab

$N_2O$ were taken every 6 hours (5, 11, 17, 23 hours in UTC) and stored for analyses in the home lab

$CH_4$ was taken every 12 hours (5 and 17 hours in UTC) and every 6 hours like $N_2O$ on the shelf, the samples were also stored for analyses in the home lab

## Description of on board sampling and measurement

DMS/DMSP measurement

DMS was measured on board using a Gas Chromatograph (GC) and Flame Photometric Detector (FPD) system. 250 ml seawater was drawn off the pump system every three hours. For determination of DMS, filtrated (GF/F Filter) triplicates (each 20ml) were directly measured after sampling. For determination of $DMSP_d$ filtrated triplicates of sampled seawater (each 20ml) were alkalized with NaOH pellets in order to convert DMSP into DMS and stored until the measurements were conducted. For determination of DMSP 50ml unfiltered sample water was alkalized and measured later then 24h after sampling.

In order to expel DMS out of the seawater, the seawater sample was purged with helium (He). Gaseous DMS was transported with the helium gas stream into a trap consisting of a Teflon tube submerged into liquid nitrogen in order to pre concentrate DMS. The gas stream was dried using Potassium carbonate. After purging, the trapped DMS is heated up and transferred onto the gas chromatography column where it is separated from other gaseous compounds and burned in the FPD at the end of the column. The emissions of the containing fragments are converted into a signal, which can be analysed. Quantitative analysis will be performed after the cruise.

## *7.4 OCEAN SENSORS*

Christian Müller, Herbert Quack, Björn Fiedler, Arne Koertzinger (IFM-GEOMAR)

### Objective and work at sea

The surface ocean's $CO_2$ source/sink function is maintained by a complex interaction of physical, chemical and biological processes. Therefore its understanding requires measurement of various different parameters.

For this purpose several sensors for underway measurements have been submerged into a thermally insulated flow-through water bath in the laboratory. The container's water volume was 40 L and the water flow was maintained at approximately 10 L/min. This continuous surface seawater supply was provided by a submersible pump installed in the ship's moon pool. A CTD probe was installed next to the intake in 5 m depth in order to provide *in situ* measurements of surface seawater salinity and temperature. Data was recorded with a computer every minute and allocated to ship's UTC timestamp.
The setup includes the following instruments, which worked properly during the entire cruise.

- Continuous $pCO_2$ measurements were performed using a novel submersible sensor with membrane equilibrator (PSI $CO_2$ PRO, Pro-Oceanus Systems Inc., Halifax/Canada), which features an NDIR detector and a pump-driven fast interface (patent pending) that provides an equilibrated gas sample to the detector. Zero-point calibrations were carried out every 6 h.

- Dissolved oxygen was determined continuously via an oxygen Optode (by Aanderaa Instruments, Bergen/Norway). This technique is based on dynamic luminescence quenching.

- Continuous gas tension measurements were performed, using a GTD pro gas tension sensor (by Pro-Oceanus Inc., Halifax/Canada), which measures the sum of partial pressure of all dissolved gases. A membrane interface separates an equilibrated air sample of all dissolved gases from the water and is measured by a high precision pressure sensor

- CTD Probe: Salinity and temperature were logged via PC, from a freshly calibrated (Sea and Sun Technologies, Kiel) ECO-Probe V5 (formerly ME Meerestechnik-Elektronik GmbH).

In order to perform a post calibration and quality control of the obtained $pCO_2$ data discrete water samples (Dissolved Inorganic Carbon and Total Alkalinity) were collected during the entire cruise. Samples will be analyzed in the laboratory at IFM-GEOMAR in early 2010.

### Preliminary results

Most of the instruments have been operated successfully during the entire cruise and obtained data covers the whole cruise track without any gaps in between. Recording of salinity and temperature from the CTD probe caused some problems due to a software problem, which resulted in some data gaps. Post-processing of data is still in progress.

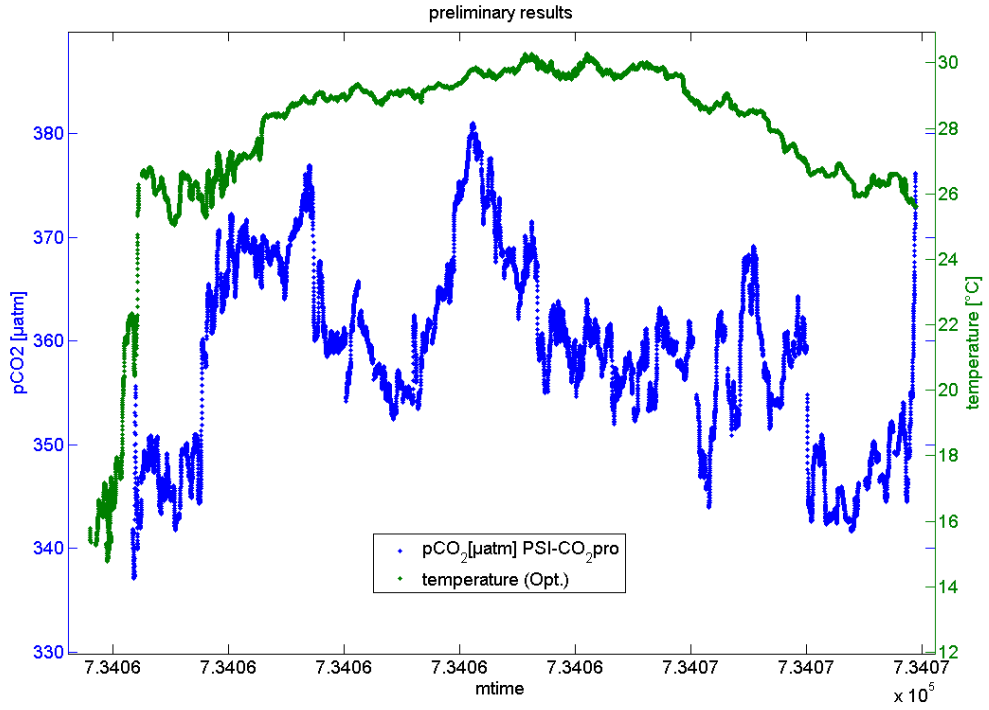



**Figure 8:** Preliminary data for $CO_2$ partial pressure (blue) and sea surface temperature (SST, green).

Preliminary data for $pCO_2$ (Figure 8) and oxygen saturation (Figure 9) show variability on different timescales. Within the tropical pacific region a clear diurnal cycle for oxygen saturation has been observed whereas in higher latitudes this variability has weakened. This pattern seems to be affected by both, physical and biological effects.
The results of the $pCO_2$ sensor show variability on different timescales and physical forcing seems to play less a role. In the vicinity of the Japanese shelf low $pCO_2$ indicates high biological activity in a potential eutrophic environment.

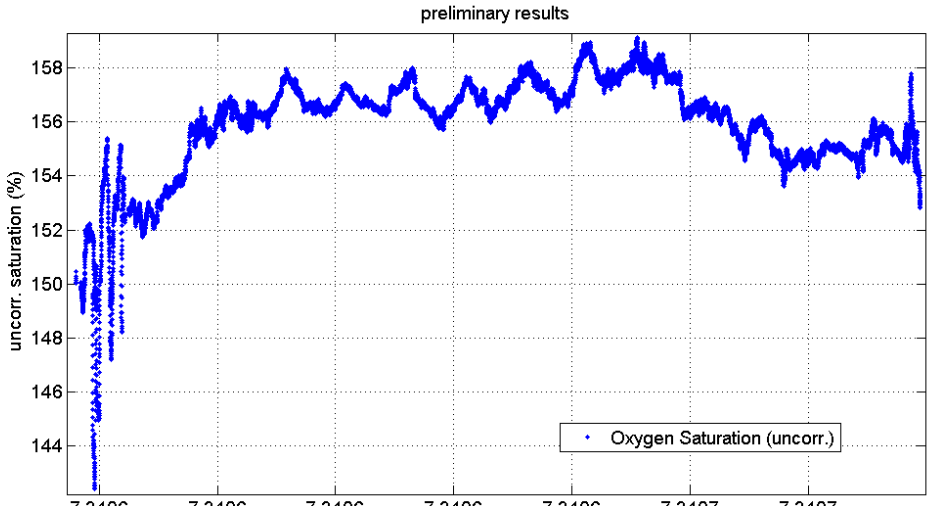



**Figure 9:** Preliminary (non-corrected) data for oxygen saturation measured with an oxygen Optode

## *7.5 RADIOSOUNDING*

GRAW radiosounding: Kirstin Krüger, Susann Tegtmeier, Viktoria Mohr, Sebastian Wache (all IFM-GEOMAR), Franz Immler (DWD)

Snow White/COBALD: Franz Immler (DWD), Kirstin Krüger (IFM-GEOMAR)

Ozone sondes: Markus Rex (AWI)

**Scientific background**

The ozone layer is recovering slowly since the industrial production of chlorofluorocarbons has strongly decreased during the 1990s. However, there is still an unexplained part of chemical ozone loss in mid-latitudes. Very short-lived substances (VSLS) as bromine compounds and other natural trace gases have to be considered for the ozone depletion as well. These chemical species are produced in the ocean, probably through the metabolism processes of microorganisms called phytoplankton. To better understand the relationship between marine biochemistry and atmospheric dynamics and chemistry our Sonne expedition aimed to investigate these relations into more detail. The tropical Western Pacific is especially suitable for these VSLS-transport examinations for two reasons. Firstly, the tropical Western Pacific is known for strong emissions of bromine compounds and has not yet been examined. Secondly, this region belongs to one of the few in which active gas exchange between lower atmospheric layers (i.e., the troposphere, altitudes: 0-15km) and the stratosphere (altitudes: 15-50km) with the protective ozone layer, takes place. Regular (6-hourly) weather balloons are launched to validate trajectory calculations of the “real” transport of air masses starting from the marine boundary layer well into the stratosphere.

**Scientific goals**

Recent publications have shown that spatial and temporal variability does play a role in the transport processes in the Tropical Tropopause Layer (TTL; between 14 and 18 km altitude) (Bonazzola and Haynes 2004, Fueglistaler et al 2004; Fueglistaler et al 2005; Krüger et al 2008). According to available meteorological data and to the best of our knowledge, the fastest and most efficient transport through the TTL takes place during NH winter season, when the wave breaking in the extratropical stratosphere, driving the meridional overturning circulation in the stratosphere, is most pronounced (Krüger et al 2009). That is the reason, why the transition seasons as spring or autumn are investigated rarely. Thus our knowledge for transport processes and variations in the TTL are rather limited during e.g. October, the month of our cruise track through the tropical Western Pacific. This is the region on earth with highest convective activity (“warm pool”) throughout the year.

From the TransBrom-Sonne cruise we will derive new results concerning the meteorology background from the under-investigated autumn season, including convection and transport through the TTL. Given that the transit route is almost along one longitude at 146° E from 44° N to 18° S, we expect clear differences between extratropical and tropical air mass measurements. Within the TTL from 30° S to 30° N (latitudinal extension) moderate cold point temperatures and vertical velocities within the TTL should be measured compared to boreal winter seasons. Although this is also depending on the dynamic activity of the southern

hemisphere (SH) stratosphere during spring (October), the season with highest wave activity in the SH. After the ship cruise we will analyse the air mass pathways (trajectories) from the surface into the stratosphere. The radiosounding of temperature, wind, humidity and ozone will be used to validate the meteorological input data and will serve as a starting point for the trajectory calculations.

**Measurements**

We have carried out 6-hourly radiosoundings of temperature, wind, and humidity, using 350 gr balloons inflated with roughly 1 $m^3$ Helium. This routine observational program was carried out with DFM-06 radiosonde from GRAW. These radiosondes are characterized by their small lightweight package and easy handling which bears great advantage on an expedition that does not provide dedicated balloon filling and launching facilities. Also, the ground receiver equipment (antenna, radio data acquisition) was available at no cost and could be easily installed on the vessel.

Daily ozone sondes were launched usually at 21h LT (12 UTC) together with a GRAW radiosonde, using a TOTEX balloon with 1000 gr weight and about 3 $m^3$ (60 kbar) Helium filling. In total 13 ozone sondes were started during our West Pacific transit as well as 7 Snow White special water vapour sondes optimized to carry out reliable water vapour measurements in the upper troposphere, together with the back scatter instrument COBALD, which detects cloud and aerosol particles. The SnowWhite is an instrument, manufactured by the Swiss company Meteolabor that measures the frostpoint temperature directly by adjusting to a constant frost layer on a chilled mirror. The COBALD instrument was developed at the ETH Zuerich by Frank Wienhold and detects the backscatter from particles at an infrared (940nm) and a visible wavelength (420 nm). The Snow White/COBALD instruments require a dark surrounding and were launched together with the ozone sondes at 21 h LT (12 UTC) with a 1200gr balloon filled with 5$m^3$ (120 kbar) Helium. These large balloons had to be filled on deck. In order to avoid premature burst of the balloons during filling, a special cover („Ballon launcher)' was used for protection. The balloons and the balloon launcher were produced by the Japanese company TOTEX.

The ballon launches were greatly supported by the ship crew by securing the filling and launching staff on deck and by adjusting the ship course and speed for optimized launching conditions.

In total 60 balloons were successfully launched, reaching frequently altitudes above 30km. None of the small balloons bursted during filling or launch even at the wind speeds that sometimes exceeded 20 m/s (8 Bft). The individual starts of the three described instruments are listed in the appendix.

**First results**

Preliminary analysis of our atmospheric profiles reveals several interesting (surprising) aspects:

The transition from the subtropics to the tropics occurred earlier as we expected. Already at 36°N we detected a temperature profile with both an extratropical lower tropopause and a

high cold point tropopause (Figure 10). This might be typical for October season or a specific feature of the Western Pacific during this time of the year. The lowest cold point temperature with -85ºC at 90 hPa was reached at 4º S.

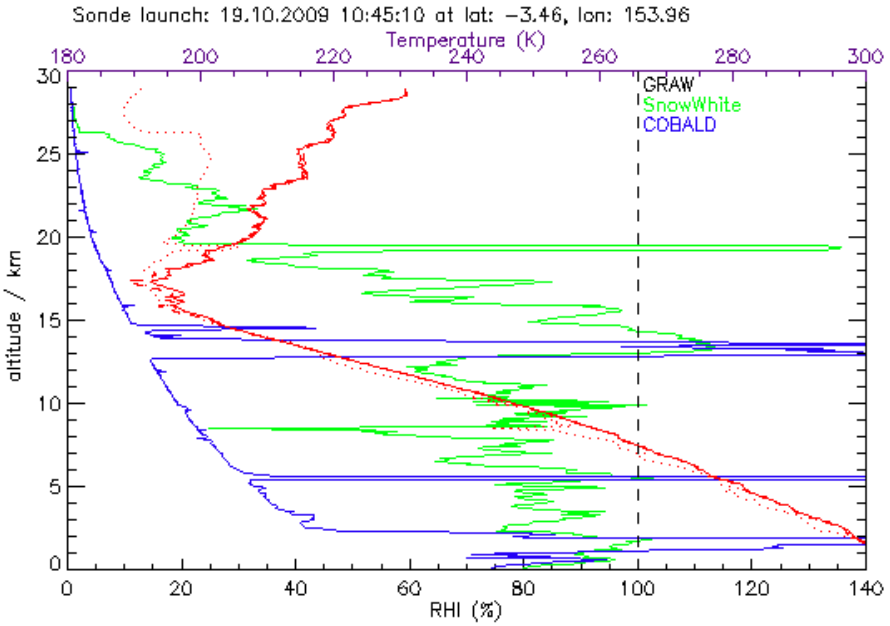



**Figure 10:** Profiles obtained from a radio sounding with a "SnowWhite"-COBALD combination. The red line shows the temperature, the dashed red line indicates the frost point temperature measured by the SnowWhite chilled mirror. From these data the relative humidity above ice can be calculated using an appropriate vapour pressure formula (green line). The blue line shows the backscatter detected by the COBALD instrument. The sharp peaks of the COBALD instrument indicate the presence of clouds.

Within the subtropics (none convective tropical region, NCTR) we recorded regular double tropopauses together with an upper troposphere inversion (UTI) (Immler and Schrems, 2002; Immler et al 2007) as illustrated in Figure 11.

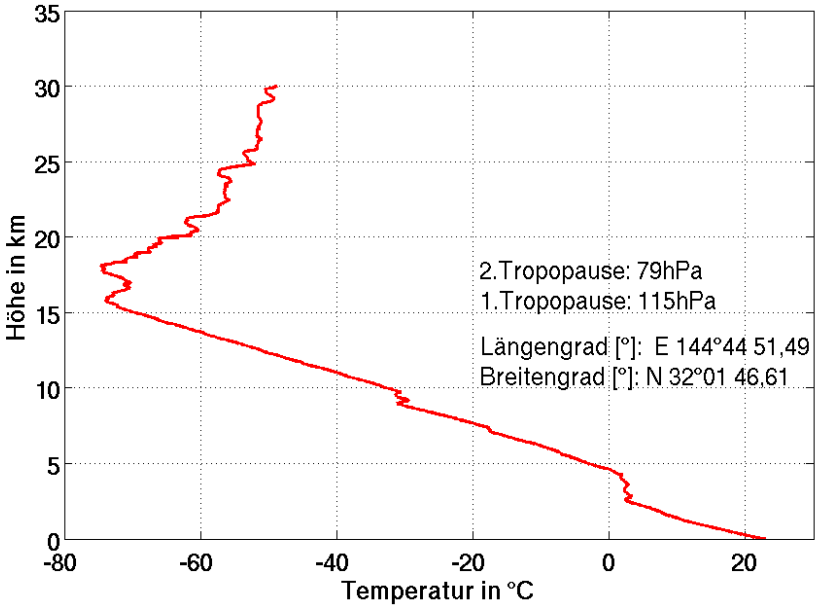



**Figure 11:** Temperature profile obtained from a sounding with a GRAW radiosonde on Oct, 11, 2009, 12 UTC. The double peak between 15 and 18 km indicates the double tropopause.

One highlight are measurements of near zero ozone concentrations throughout the troposphere, observed consistently over vast regions in the inner tropics of the West Pacific. Consistent with a small number of individual previous observations from the central Pacific ozone below or close to the detection limit of the sonde was found in the boundary layer and the tropopause layer in all our tropical observations. But in most observations in the inner tropics these extremely low values were also found throughout the free troposphere (Figure 12), which has not been observed before. These observations suggest an unusually low oxidizing capacity of the troposphere in the West Pacific. The background and implication of this feature has to be investigated in more detail.

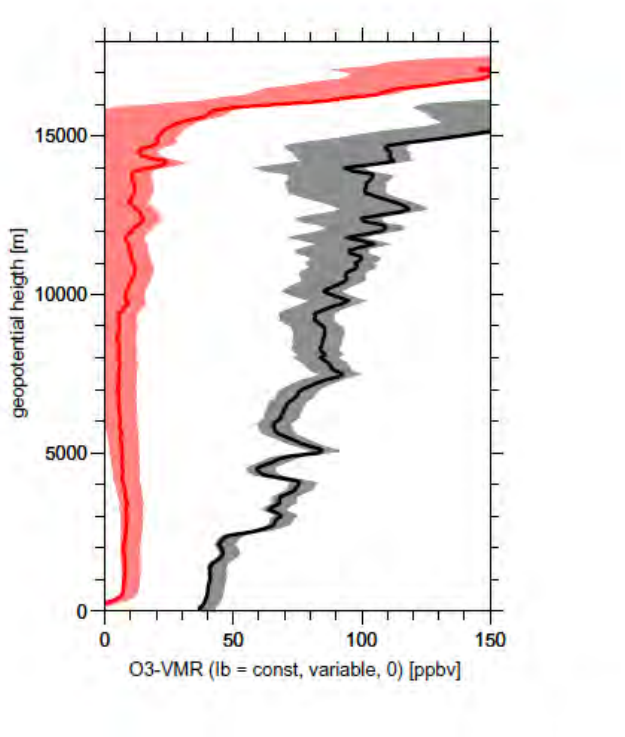



**Figure 12**: Normal (black, 11 Oct. 2009, ~33° N) and unusually low (red, 16 Oct. 2009, ~11° N) tropospheric ozone mixing ratio profile measurements during TransBrom. The shaded areas indicate uncertainty due to background current subtraction and unknown time evolution of the background current. The upper envelop of the uncertainty ranges assume no background current at all and is a robust upper limit for the ozone mixing ratios. Ozone is below the detection limit of the sonde where the lower envelop of the uncertainty range (assumption constant background current) overlaps with zero.

## References

Bonazzola, M., and P. H. Haynes (2004): A trajectory-based study of the tropical tropopause region, J. Geophys. Res., 109, D20112, doi:10.1029/2003JD004356.

Fueglistaler, S., Wernli, H., and Peter, T. (2004): Stratospheric water vapor predicted from the Lagrangian temperature history of air entering the stratosphere in the tropics, J. Geophys. Res., 110, D03108, doi:10.1029/2003JD004069.

Fueglistaler, S., Bonazzola, M., Haynes, P. H., and Peter, T. (2005): Stratospheric water vapor predicted from the Lagrangian temperature history of air entering the stratosphere in the tropics, J. Geophys. Res., 110, D08107, doi:10.1029/2004JD005516.

Immler, F., and O. Schrems (2002): Determination of tropical cirrus properties by simultaneous LIDAR and radiosonde measurements, *Geophys. Res. Lett*., 29(23), 2090, doi:10.1029/2002GL015076.
Immler, F., K. Krüger, S.Tegtmeier, M. Fujiwara, P. Fortuin, G. Verver, O. Schrems (2007): Cirrus clouds, humidity, and dehydration in the tropical tropopause layer observed at Paramaribo/Suriname (5.8°N, 55.2°W), J. Geophys. Res.**,** 112, D03209, doi:10.1029/ 2006JD007440, 2007.

Krüger, K., S. Tegtmeier, and M. Rex (2008): Long-term climatology of air mass transport through the Tropical Tropopause Layer (TTL) during NH winter, Atmos. Chem. Phys.**,** 8, 813-823, 2008.

Krüger, K., S. Tegtmeier, and M. Rex (2009): Variability of residence time in the Tropical Tropopause Layer during Northern Hemisphere winter, *Atmos. Chem. Phys.*, 9, 6717-6725, 2009.

## *7.6 MAX-DOAS*

Folkard Wittrock, Enno Peters (IUP Bremen), Katja Grossmann (IUP Heidelberg)

### Introduction

As part of the TransBrom project two different MAXDOAS (multi-axis differential optical absorption spectroscopy) instruments have been installed on the RV SONNE during the transit from Tomakomai to Townsville, one from the iup Bremen and the other one from the iup Heidelberg. While the Heidelberg setup was mainly focusing on the analysis of bromine oxide (BrO) in the atmosphere with a high temporal resolution, the Bremen instrument has covered a broader wavelength range by using two spectrometers. This in principle allows the retrieval of several other trace gases like e.g. glyoxal (CHOCHO) and ozone in the visible. Furthermore this setup was able to collect light in different azimuthal viewing directions which is useful to study spatial inhomogenities.

In addition to the main objective of the MAXDOAS measurements (analysis of halogen oxides) it is planned to use the data also for the validation of different satellite products (e.g. formaldehyde columns). This is quite important, since measurements over water bodies in general and in the Western Pacific in particular are quite sparse.

### Instrumental set-up (iup Heidelberg)

The telescope unit was fixed on top of the rail at the port side on the Peildeck of the RV Sonne. It includes a Faulhaber stepper motor which allows to adjust the telescope position to any elevation angle between horizon and zenith (see Figure 13). Furthermore an inclinometer was placed in the telescope unit to equalize the rolling of the ship. Scattered sunlight enters the telescope unit through a black metal tube and is focused by a quartz lens onto the entrance of a quartz fibre bundle. By using the filter BG3, light at undesired wavelength is blocked away and the spectrograph stray light is reduced.

The fibre bundle then transmits the light into the ship where the spectrograph, PC and control units are placed (Figure 14).

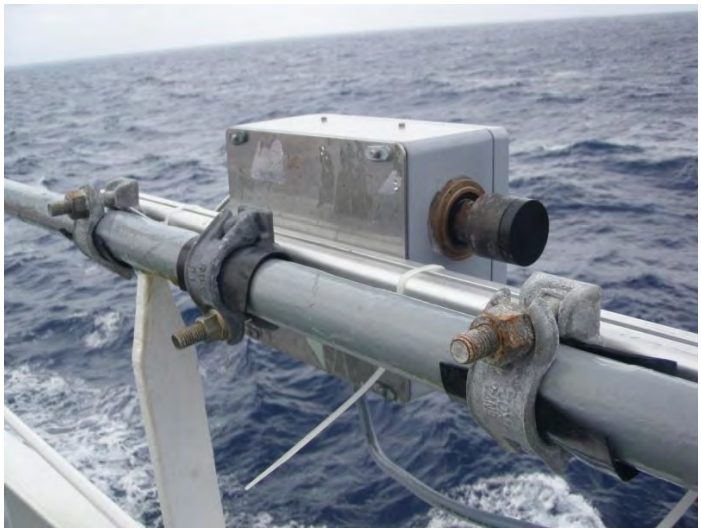


**Figure 13:** MAXDOAS telescope from the iup Heidelberg. An inclinometer is used to correct automatically the roll of the ship.

The instrument consists mainly of an Acton 300i spectrograph which covers a wavelength interval from 327nm to 470 nm. Its functionality is based on the Czerny-Turner principle. The incoming light is focused by an aspheric mirror onto a grating with 600 grooves/mm where it is dispersed. The light is collimated by a second aspheric mirror and detected by a CCD-chip.

To avoid variations in the optical alignment by thermal instabilities, the spectrograph is kept at a constant temperature of 38°C. A heat sensor and a control unit regulate the temperature.

**Figure 14:** MAXDOAS setup of the iup Heidelberg. One spectrograph is used to cover the wavelength range from 327 to 470 nm.

The CCD camera is manufactured by Andor Technology and the chip has 2048 horizontal and 255 vertical channels. The spectrograph contains a shutter at its entrance which closes during read-out of the CCD-chip. To reduce dark current, the CCD-chip is cooled to -30°C using an internal Peltier element. The electronic signal in the camera is digitalized by an internal 16-bit converter, yielding $2^{16} = 65535$ counts at saturation.

The program MS DOAS is used to run the measurement routine. During daylight, scattered sunlight measurements are taken, where a sequence of spectra at the elevation angles α = 90°, 20°, 10°, 7°, 5°, 3°, -45° is recorded repeatedly. During dusk and dawn (SZA > 85°), as well as during noon, only zenith measurements are performed. During night several offset and dark current spectra and from time to time mercury spectra are recorded.

**Instrumental set-up (iup Bremen)**

Similar to the Heidelberg instrument the telescope of the iup Bremen MAXDOAS was mounted on the port side of the ship. Therefore it was possible to select a set of common viewing directions to compare and/or complement measurements of both setups.

The Bremian telescope unit is first of all a stainless steel box containing mainly some optical components and a commercial video camera (see Figure 15). This box is mounted on a pan-tilt-head which is able to turn in almost every direction with high speed (Figure 16, left). It is controlled by the measurement software. For this campaign a scan similar to the Heidelberg setup was chosen but in addition two more sequences, one looking into the water body and another one to different azimuth angles, were added. The duration of a full scan covering all three sequences was about 15 min. This is also the best time resolution for the final data product of the instrument (vertical columns and/or profiles for the different trace gases).

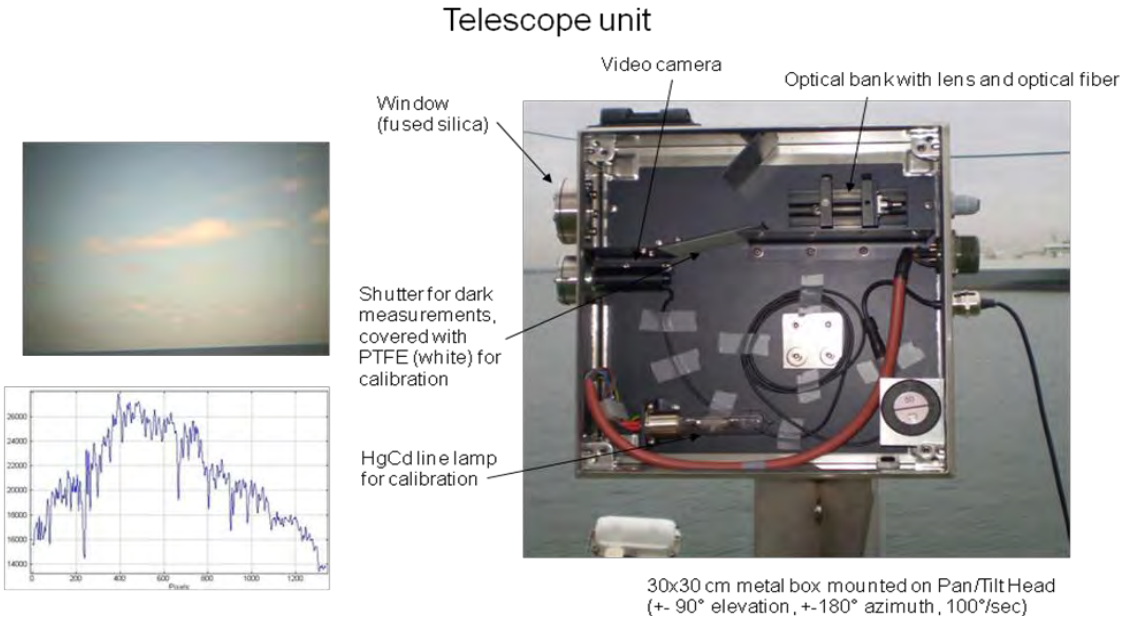



**Figure 15:** New MAXDOAS telescope unit of the iup Bremen. A video camera is used to identify e.g. clouds in the light path (upper left) which is useful for a propper interpretation ot the recorded spectra (lower left).

The Bremen instrument comprises two spectrometers, one covering the UV from 315 to 385 nm and one for the visible including 400 to 570 nm. Other technical features like the temperature control of CCD and spectrograph are quite similar to the Heidelberg setup and therefore not reiterated here.

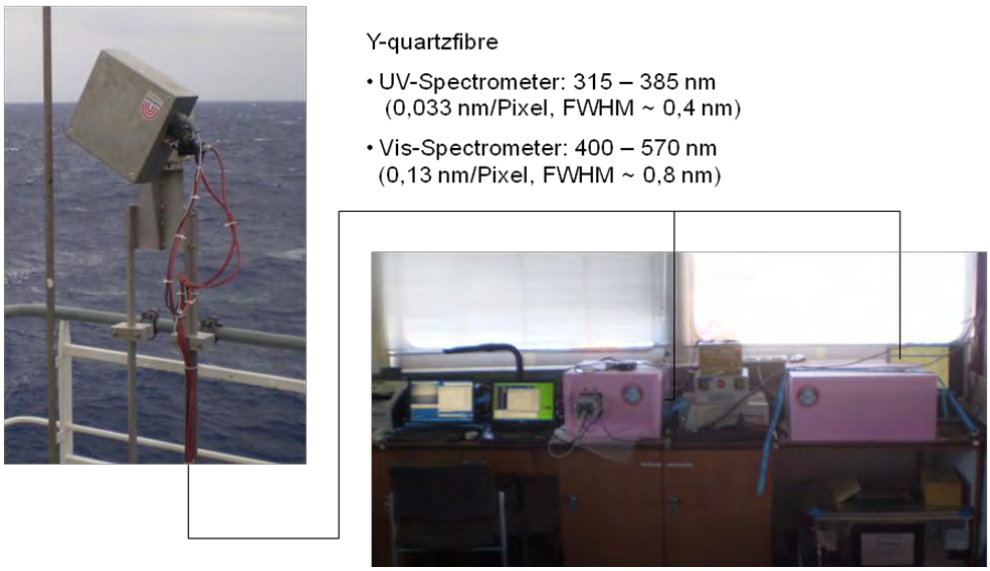



**Figure 16: Bremen telescope on the Peildeck (left) and the Bremen MAXDOAS setup inside the ship (right).**

## Preliminary results

Both instruments have made measurements from scattered sunlight from the beginning of the cruise on October 9 in Tomakomai to the morning of October 24 in Townsville. Up to now all the data have been quality-checked and successfully calibrated. There are no serious data gaps in the time series which means that for each day from sunrise to sunset MAXDOAS data are available. First DOAS retrievals to derive the amount of the trace gases ozone, nitrogen dioxide, formaldehyde and bromine oxide have been carried out and one example is shown here (Figure 17).

## Outlook

Since extensive radiative transfer modelling is needed to interpret the MAXDOAS results the full data set will be available in late spring 2010. This data set includes total vertical columns of ozone, $NO_2$, BrO, HCHO and possibly CHOCHO, IO and $SO_2$. For ozone, $NO_2$, and BrO we suspect to provide in addition some “profile” information.

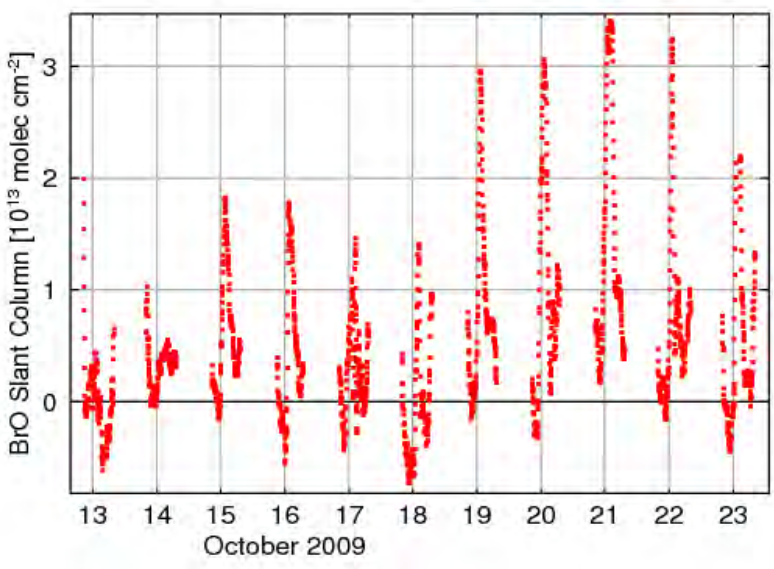



**Figure 17:** Preliminary BrO time series for the 30° elevation angle from Bremen data. On some days in the second half of the cruise the BrO is above the detection limit of about 1 to 2e13 molec/cm$^2$. The calculated mixing ratio is in the order of 1 to 3 ppt.

## *7.7 AIR SAMPLING*

Christian Mueller, Arne Lanatowitz, Herbert Quack, (IFM-GEOMAR); Elliot Atlas (RSMAS-organic trace gases), Andreas Engel (Uni Frankfurt-organic trace gases), Sylvia Walter (IMAU-Hydrogen), Alex Baker (UEA-Norwich), Enno Bahlmann (Uni Hamburg-Isotopes)

### Air sampling

All sampling gear was installed on the monkey deck (Figure 18)

**Figure 18:** Sampling equipment for atmospheric samples (Collage of setup).

## Trace gases -Rosenstiel school of marine and atmospheric sciences- Elliot Atlas- Miami

80 canister samples of air have been collected in 2 L stainless steel tanks, being pressurized to 2 bar for RSMAS with a metal bellows pump and will be analyzed for a variety of trace gases as natural and anthropogenic hydrocarbons and halocarbons, DMS, $N_2O$, alkyl nitrates, CO and others (Table 3) on different instruments (Trace gases-RSMAS-Atlas).
With the help of the trace gases and calculated trajectories oceanic, land-based and anthropogenic sources and possibly source strengths can be determined. Figures 19 and 20 show data of some substances of samples up to the 13th of Oct, which have been analyzed in the laboratory of Elliot Atlas (RSMAS). On 13 October the cruise passed close to the tropical depression Nepartak which had crossed the ships track with its center 12 hours before. The Sonne stayed during travel about 60 km north to north west of the center of Nepartak.

Significant enhancements in methyl iodide and DMS can be seen, roughly six hours after the highest wind speeds have been measured on the ship (Figure 20). This will be an interesting period to study, since the increase in the oceanic trace gases observed in the atmosphere are most likely related to the storm. Also bromoform seems to show a slight increase related to the wind speed. Other gases are either increasing from north to south, or vice versa, or are pretty constant.

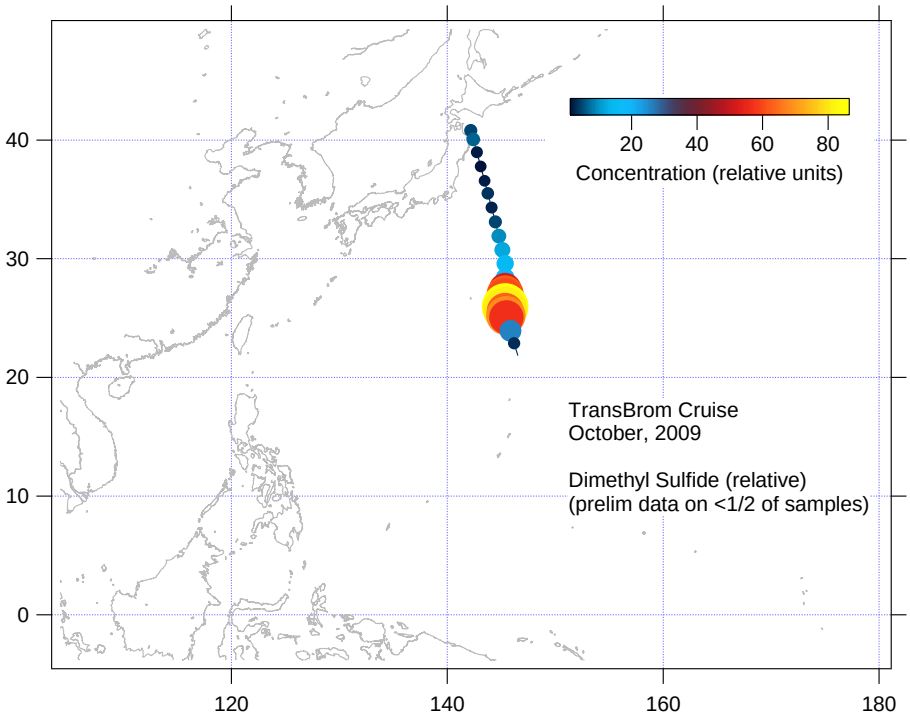



**Figure 19:** DMS concentrations in the atmosphere during TransBrom Sonne.

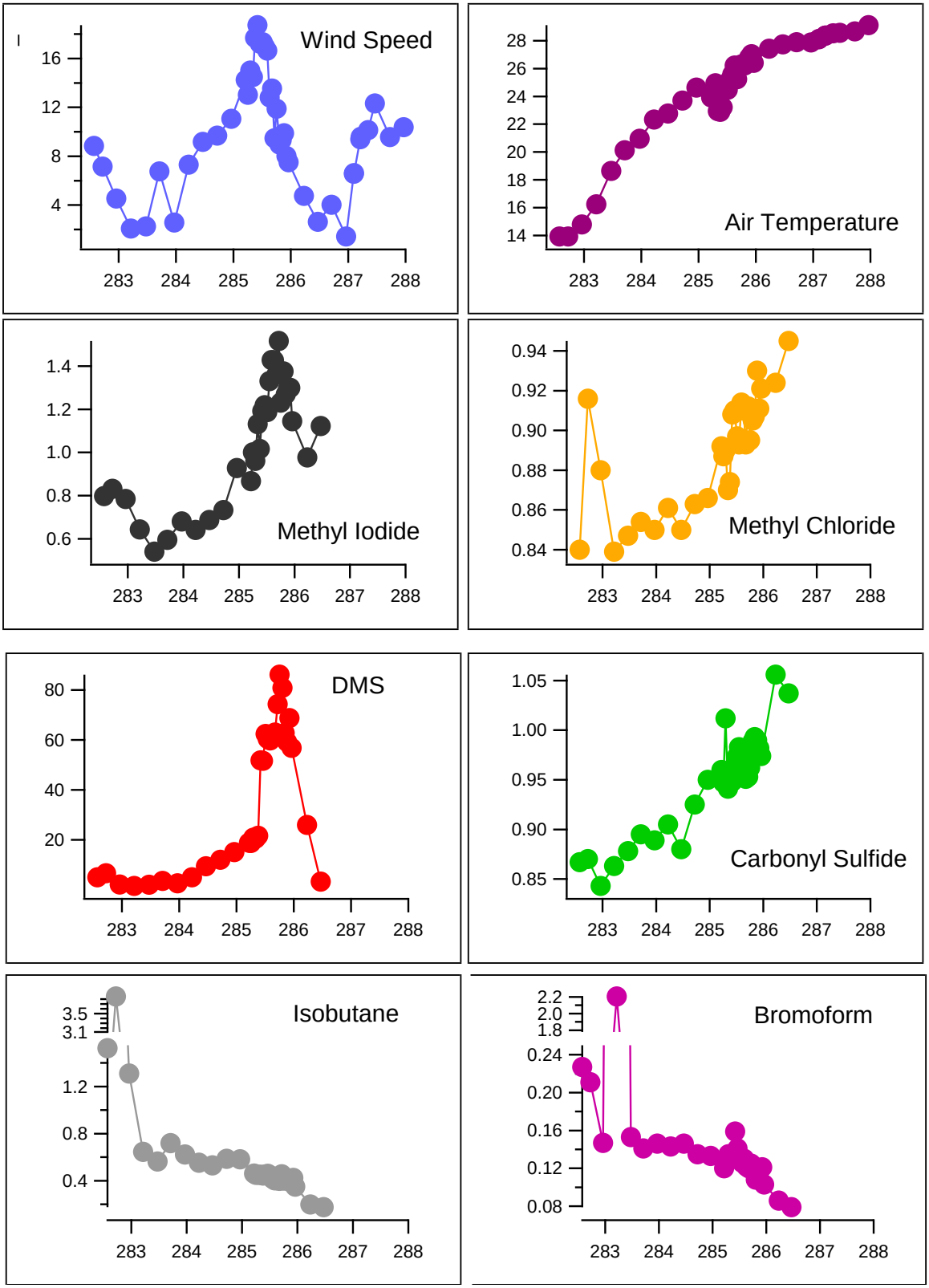



**Figure 20:** Preliminiary results of some trace gases in the atmosphere (RSMAS- canisters and analysis) during the first days of TransBrom Sonne in the north-westen Pacific

## Trace gases - University of Frankfurt- Andreas Engel

23 canister samples of air have been collected in 2 L stainless steel tanks, being pressurized to 2 bar for the University of Frankfurt (Andreas Engel) with the RSMAS metal bellows pump and will be analyzed for a variety of long-lived anthropogenic and natural trace gases by GC/MS with negative chemical ionization(Table3).

It has been recognized for more than two decades that halogen radicals, especially chlorine and bromine can deplete stratospheric ozone. While chlorine is much more abundant then bromine, bromine has a higher potential to destroy stratospheric ozone. Long lived source gases (like the chlorofluorocarbons, halons and some halocarbons) can account for about 3400 ppt of chlorine and about 15-16 ppt of bromine in the stratosphere. The temporal trend of total bromine and chlorine in these source gases is decreasing.

Beyond the input from long-lived source gases, other gases with shorter lifetimes do contribute to stratospheric halogen loading. These so-called very short-lived substances (characterized by chemical lifetimes shorter than 6 months) have recently brought into focus of scientific investigations. Especially brominated substances like bromoform ($CHBr_3$) or dibromomethane ($CH_2Br_2$) might have a significant impact on stratospheric bromine loading. Emissions of these gases are basically attributed to natural sources like seaweed and microalgae (phytoplankton and ice algae). Measurements of brominated short-lived species in marine boundary layer have been performed more frequently within the last years, showing elevated concentrations in coastal areas and certain upwelling regions of the oceans. Deep convection within the tropics could provide a fast pathway for these substances to be transported in significant abundances into the stratosphere. The quantification of this input and its weight in the budget of stratospheric bromine is the major objective. It would give information about natural background halogen loading of the stratosphere and improve the projections of future stratospheric ozone concentrations.

The measurements by University Frankfurt during the TransBrom Sonne cruise therefore serve to quantify the amount of bromine in the long lived source gases and to investigate the variability in short lived source gases. University Frankfurt will measure – next to the complete family of chlorine source gases – many bromocarbons.

These bromocarbons include the following:

| | |
|---|---|
| Brominated hydrocarbons | $CHBr_3$, $CH_2Br_2$, $CH_3Br$ |
| Halons | H1301, H1211, H2402, H1202 |
| Bromochlorcarbons | $CH_2BrCl$, $CHBr_2Cl$, $CHBrCl_2$ |
| Possible further species | $C_2H_5Br$, $C_2H_4Br_2$ |

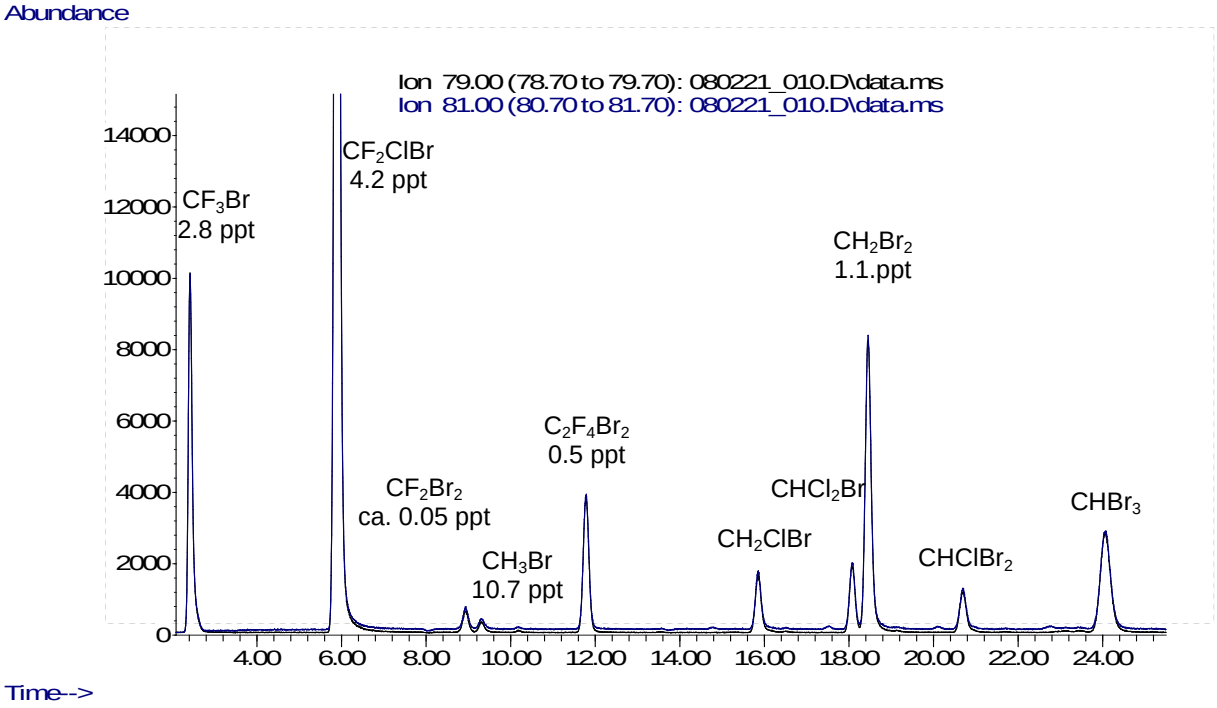



**Figure 21**: typical chromatogram of m/z 79 (black trace) and 81 (blue trace), characteristic of bromine in NICI mode. As the two isotopes in bromine have nearly the same probability, the two ion traces are virtually identical.

The technique we will use is gas chromatopgraphy coupled with mass spectrometry. Especially for the brominated source gases the mass spectrometer will be operated in negative ion chemical ionization (NICI) mode. This technique offers fantastic detection limits. They are below 0.1 ppt for all species with the exception of $CH_3Br$. Reproducibility is typically on the order of 1% or better, with the exception of $CH_3Br$. A typical chromatogram is shown in Figure 21.

First results for the TransBrom Sonne cruise are expected to be available by late February. For some of the minor bromine species only very preliminary calibration values are available. Final values for these species will only be available once firm calibration scales have been established.

18 samples of air (approx. 400l) have been sampled on cooled (-20°) adsorbent traps, and will be analyzed for the isotopic composition of halocarbons (Isotopes-Hamburg-Bahlmann)

**Hydrogen-** IMAU – Sylvia Walter

Concentration and isotopic ratio of molecular hydrogen ($H_2$) along a meridional transect

Sylvia Walter, Institute for Marine and Atmospheric Science, IMAU, Utrecht University
Thomas Röckmann, Institute for Marine and Atmospheric Science, IMAU, Utrecht University

60 samples of hydrogen have been collected in glass flasks and will be analyzed for hydrogen isotopes ( Hydrogen –IMAU-Walter)

**$H_2$ in the future atmosphere.** Hydrogen ($H_2$) is expected to play a significant role in the future global energy economy. Due to the finite nature of fossil fuel resources and the required reduction of greenhouse gas emissions, the use of $H_2$ seems to be an ideal solution: $H_2$ can be used for energy storage, as an energy transport medium, and even as an alternative to fossil fuel burning in the long term perspective. Water is the nearly exclusive combustion product and therefore a $H_2$ based energy economy would come along with almost zero emissions of $CO_2$ and $NO_x$. However, despite the obvious advantages of $H_2$, the environmental impact of a global $H_2$ economy is largely unknown and discussed controversially. It is realistic to expect that an increased economic utilization of $H_2$ will result in a significant increase of $H_2$ mixing ratio in the atmosphere because of leakages during production, storage and transport. This may affect the depletion of stratospheric ozone via an increased formation of stratospheric clouds. Moreover, although $H_2$ is not a greenhouse gas by itself, it contributes indirectly to global warming due to the competitive sink reaction between $H_2$ and methane ($CH_4$) for $OH$[1]. In view of a significant future increase of atmospheric $H_2$ this will result in an unintended increase of $CH_4$ because the reaction of $H_2$ with OH is faster than the reaction of OH with $CH_4$.

**$H_2$ in the ocean.** The role of the oceans for the global atmospheric $H_2$ budget is only poorly understood. Although thought to be a modest but significant net source (approximately 10% of the total sources) estimates of the oceanic $H_2$ emissions are based on only a few measurements of dissolved $H_2$ in the 1970s or have been made from modelled global oceanic $N_2$ fixation processes.
$N_2$ fixation is assumed to be the main source of $H_2$ in the ocean, especially by the filamentous cyanobacterium *Trichodesmium spec*. The application of new methods revealed that also other $N_2$ fixers such as *Synechococcus spec.* or *Anabaena spec.*, also known $H_2$ producer, significantly contribute to the oceanic $N_2$ fixation and subsequently may produce significant amounts of $H_2$. Moreover, besides direct production by oceanic $N_2$ fixation, $H_2$ is indirectly produced by oxidation of atmospheric precursors such as volatile organic compounds (VOC; isoprene, acetaldehyde, formaldehyde etc.) released from the ocean. The emission of VOCs from marine environments is poorly characterized and discussed controversially. Despite the fact that VOCs play a key role in the tropospheric chemistry, the photochemical production of $H_2$ from VOCs is the most uncertain source term in the global $H_2$ budget, which makes it even more difficult to estimate marine $H_2$ emissions. Oceanic $H_2$ emissions show a high temporal and spatial variability, which is probably not solely caused by a highly variable $N_2$ fixation and microbial consumption of $H_2$ but also results from the variable oceanic production and emission of its precursors.

**$H_2$ and the isotopic approach.** $H_2$ sources and sinks have characteristic isotopic signatures. In aquatic solutions hydrogen is in thermodynamic equilibrium with the water. In a biologically relevant temperature range (10°C - 40°C) the isotopic ratio of released hydrogen is approximately -700‰ relative to the water. Due to this very depleted isotopic ratio even small amounts of hydrogen emitted from the ocean to the atmosphere should be detectable and thus offer an excellent tool to identify hotspots of oceanic $H_2$ production. Potential oceanic hotspots with significant $H_2$ emission to the atmosphere are areas with $N_2$ fixation and/or high VOCs emission such as the eastern equatorial Atlantic or the coastal upwelling off Mauritania (Northwest Africa).
Two scenarios are conceivable: 1) $H_2$ is produced in the water and is subsequently emitted to the atmosphere. In this case the released $H_2$ should show a clearly depleted isotopic signal of approximately -700‰ or 2) VOCs originating from the ocean are emitted to the atmosphere and $H_2$ is produced subsequently by photooxidation of the VOCs in the atmosphere over the ocean. In this case it is assumed that $H_2$ originating from photooxidation of VOCs shows similar isotopic signatures to $H_2$ originating from $CH_4$ oxidation, but up to now no data to proof this pathway exist.

During this cruise 60 air samples were taken regularly over the cruise track and in adjustment with the sampling of the other groups. Samples will be analysed after return with an available continuous-flow-isotope-ratio-mass-spectrometer (CFIR-MS) to investigate the D/H isotopic ratio of $H_2$ with main focus on differences between the hemispheres and the different oceanic regimes. Additionally a broad spectrum of VOCs will be measured using a Proton-transfer-reaction-mass-spectrometer (PTR-MS).

**Aerosol- UEA-Baker**

Aerosols play a key role in halogen cycling in the marine atmosphere, with Cl being transferred to the gas phase by acid displacement reactions, Br release being induced by reaction of ozone on sea salt particles and iodine chemistry promoting transfer of Cl, Br and I to the gas phase via halogen activation reactions. Ultimately aerosols appear to be net sources for Cl and supermicron Br and net sinks for I and submicron Br (Baker, 2005).

Although these processes are intimately linked to ozone chemistry, the processes that lead to submicron Br enrichment and those that control aerosol iodine chemistry are very poorly understood at present. In the case of iodine, which has an extremely rich and complex aerosol chemistry, there is a severe lack of field data available, with only one published study in the entire Pacific basin (Lai et al., 2008).

During the TransBrom cruise daily aerosol samples were collected for determination of Cl-, Br- and iodine speciation, as well as a number of other aerosol ionic components which will provide us with useful information on aerosol background chemistry. 11 twenty four hour aerosol samples of about 300 L of air have been collected with a multistage aerosol impactor The data obtained will allow us to examine the potential strength of the aerosol Br source along the transect and investigate the role of iodine chemistry in halogen activation, as well as

providing a unique opportunity to compare atmospheric iodine source (trace gas) and sink (aerosol) strengths.

### References

Baker, A.R., (2005). Marine aerosol iodine chemistry: The importance of soluble organic iodine. Environmental Chemistry, 2(4): 295-298.

Lai, S.C., Hoffmann, T. and Xie, Z.Q. (2008) Iodine speciation in marine aerosols along a 30,000 km round-trip cruise path from Shanghai, China to Prydz Bay, Antarctica. Geophysical Research Letters, 35: L21803, doi:10.1029/2008GL035492.

## *7.8 FTIR*

### Analyzing the transport of trace gases from the troposphere into the stratosphere by solar absorption FTIR spectrometry

Theo Ridder, Christine Weinzierl (IUP Bremen)

### General Background of Research

In the tropics tropospheric trace gases are able to enter permanently the stratosphere. The Western Pacific is the main region where tropospheric trace gases enter the stratosphere. The entry and composition of the tropical tropospheric air determines the composition of the tropopause and stratosphere. However, for several long- and short-lived species this entry is not well known.

We perform solar absorption spectroscopic measurements of atmospheric trace gases in the infrared spectral region in the West Pacific onboard *FS Sonne*. The observations yield the total column concentrations of about 20 different trace gases. For about 10 species the concentration profiles can be retrieved up to 30 km altitude. In addition we perform in situ measurements with a FTIR analyser and a flask sampling system.

The measurements allow studying the transport of tropospheric trace gases through the tropopause, in this way yielding information on the entry of biogenic and anthropogenic tropospheric trace gases into the stratosphere. Throughout the last years we have performed several campaigns of this kind on the *FS Polarstern* in the Atlantic. The suggested observations in the Pacific form an extremely valuable completion of our studies performed so far.

Our observations complement the studies which are performed as part of the TransBrom-campaign (03S0457 and the EU-proposal SHIVA, where the entry of short-short-lived trace species from the surface into the stratosphere is planned to be investigated.

## Work Program

During the TransBrom Sonne campaign we measured solar absorption spectra. Solar absorption FTIR measurements in the infrared spectral region are only possible during direct sunlight conditions. Measurement periods of several minutes are necessary, for example in between clouds.

On board the solar absorption spectra were proven for their quality. The solar absorption spectra will be analysed at the University of Bremen.

We frequently performed cell measurements with an internal light source to prove the internal alignment of the device. In case of misalignment a correction is possible.

In situ measurements were taken by the FTIR analyser continuously. Maintenance of the device was necessary every 24 hours.

Air samples were collected during the cruise. Thereby air is pressurized and filled in sampling flasks. These flasks will be analysed at the Max Planck Institute Jena.

## Preliminary Results

FTIR Spectrometer

During the TransBrom Sonne campaign we have performed solar absorption FTIR spectrometry. Spectra have been collected during sunny weather conditions.

We have performed cell measurements during the campaign to check the alignment of the spectrometer (Figure 22)**.**

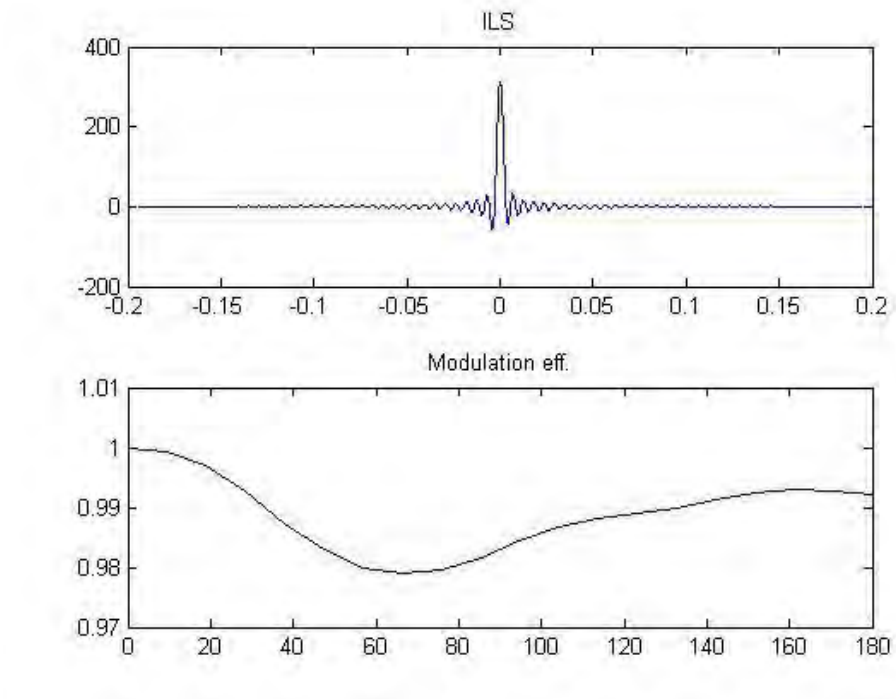



**Figure 22:** Analysis of the cell measurements from 23. Oct. 2009. A symmetric ILS and a deviation of <5% of the Modulation efficiency characterizes good alignment of the spectrometer

The analysis of the solar absorption spectra will be done at the University of Bremen

**FTIR analyser**

During the TransBrom Sonne campaign we have performed in situ measurements with a FTIR analyser. The FTIR analyser detects the concentration of $N_2O$, CO, $CH_4$, del13C in $CO_2$, $13CO_2$, $12CO_2$, $CO_2$ with a sampling rate of 10 minutes. The results shown are not calibrated yet (Figure 23). Calibration of the data will be done at the University of Bremen.

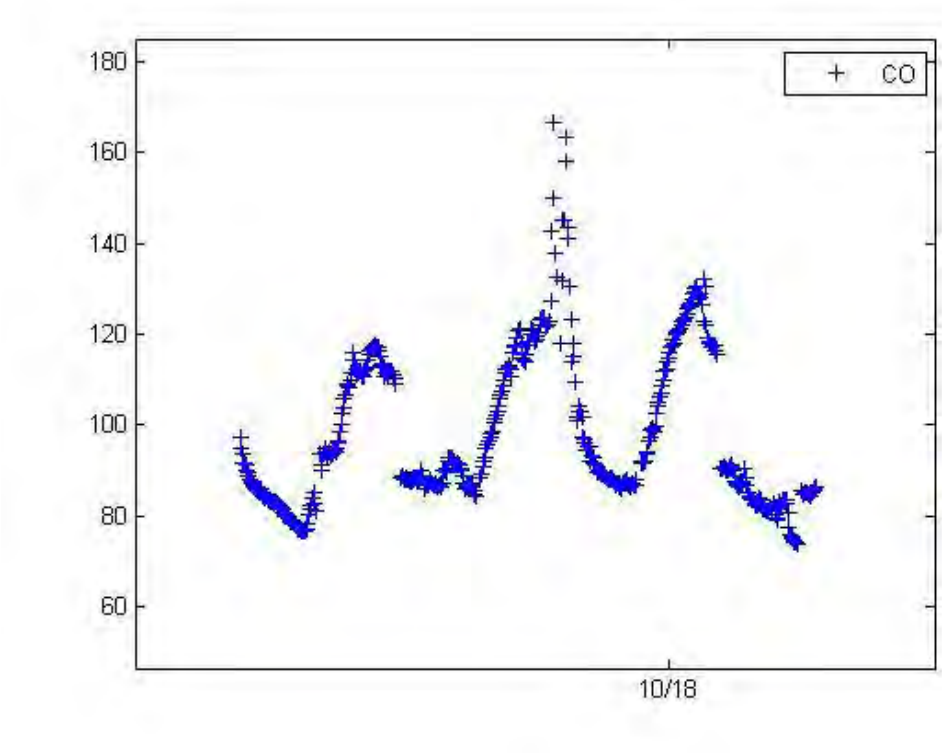



**Abbildung 23:** CO concentration from three sampling days in the remote atmosphere of the western Pacific.

**Flask sampling**

15 Flasks have been collected during the cruise. The analysis of the air samples will be done at the Max Planck Institute Jena, Germany.

## *7.9 BATHYMETRY*

Robin Beaman ( School of Earth and Environmental Sciences at James Cook University in Cairns) Australia, for the Sonne to acquire

The Sonne aquired multibeam swath depth data while in transit across the Coral Sea between PNG and Australia. The multibeam system fitted to the Sonne generates a dense swath of depth data that can be used to map the seafloor in 3D using visualisation software. The 3D images of the seafloor can then be used to help understand detailed seafloor relief and the data incorporated into regional-scale depth models. In this case, the multibeam depth data provided

by the Sonne will be used to map areas of the Coral Sea that have no detailed map data, and so the data collected is most useful to the Australian scientists, who are developing a new high-resolution depth model for the Great Barrier Reef and Coral Sea. The multibeam depth data were provided to Dr Robin Beaman from James Cook University, Australia. Dr Beaman conducted the post-processing required to remove noise and other artifacts from the data. The finalized dataset will then be incorporated into a new high-resolution depth model being developed for the Great Barrier Reef and the Coral Sea. Figure 23 shows a 50 km stretch of data as the Sonne transited from the Coral Sea Basin up onto the Queensland Plateau, showing large submarine canyons.

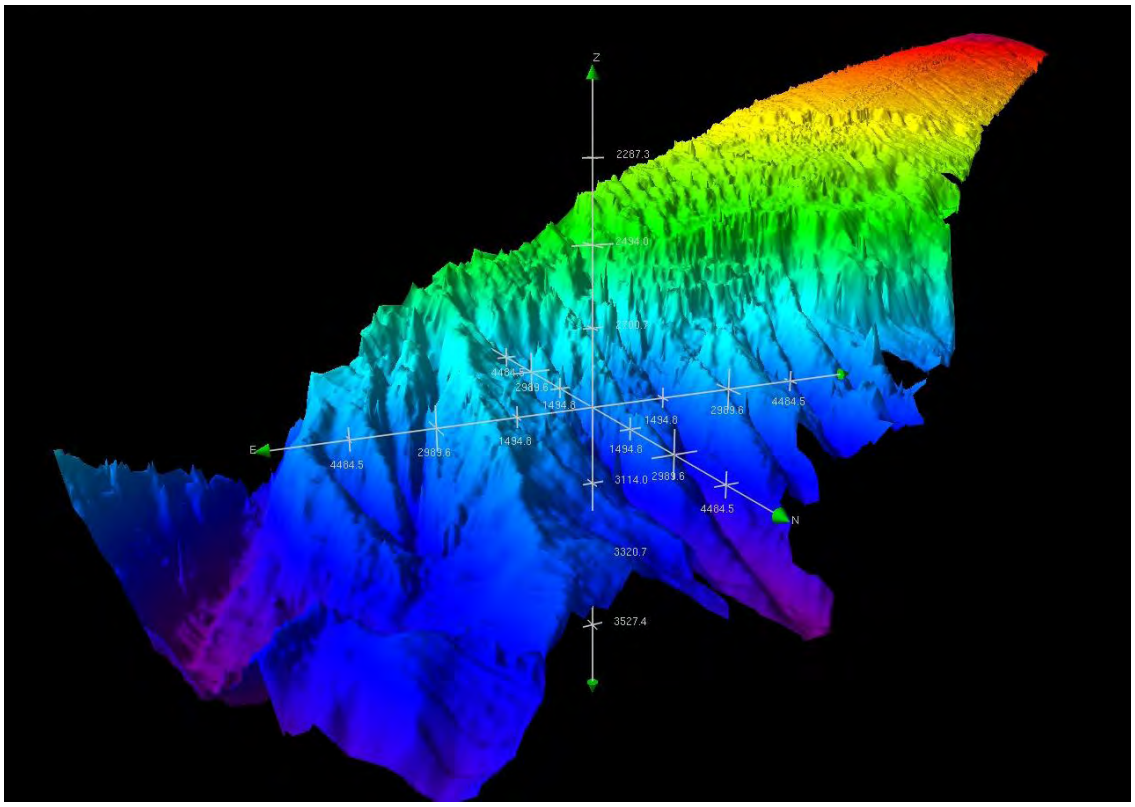



**Figure 23:** 50 km stretch of multibeam data from the Coral Sea Basin up onto the Queensland Plateau.

# 8 Acknowledgements

We would like to express our sincere thanks to the RV Sonne crew for outstanding performance and cooperativeness well beyond the call of duty.

We thank Professors Kimitaka Kawamura from Hokkaido University in Sapporo and Mitsuo Uematsu from the University of Tokyo for their spontaneous, friendly and effective support.

The SONNE expedition, officially titled TransBrom Sonne, has been supported by the Federal Ministry for Education and Research (grants: TransBrom Sonne 03G0731A, SOPRAN: 03F0462A) and by the Leibniz –Association (SAW-project TransBrom; www.ifm-geomar.de/~transbrom; lead by Prof. Dr. Kirstin Krüger, IFM-GEOMAR).

# 9 Measurements

Table 9.1.1. HALOCARBONS: Halocarbon (water samples)

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
|---|---|---|---|---|---|---|---|
| 11.10.2009 | 03:40 | 33.44 | 144.35 | 03:40 | 33.44 | 144.35 | 524 |
| 11.10.2009 | 07:30 | 32.64 | 144.58 | 07:30 | 32.64 | 144.58 | 527 |
| 11.10.2009 | 08:00 | 32.53 | 144.61 | 08:00 | 32.53 | 144.61 | 528 |
| 11.10.2009 | 10:00 | 32.13 | 144.72 | 10:00 | 32.13 | 144.72 | 529 |
| 11.10.2009 | 11:00 | 31.94 | 144.77 | 11:00 | 31.94 | 144.77 | 530 |
| 11.10.2009 | 12:25 | 31.67 | 144.85 | 12:25 | 31.67 | 144.85 | 531 |
| 11.10.2009 | 14:00 | 31.37 | 144.93 | 14:00 | 31.37 | 144.93 | 532 |
| 11.10.2009 | 16:24 | 30.92 | 145.05 | 16:24 | 30.92 | 145.05 | 533 |
| 11.10.2009 | 17:00 | 30.80 | 145.09 | 17:00 | 30.80 | 145.09 | 534 |
| 11.10.2009 | 18:55 | 30.42 | 145.19 | 18:55 | 30.42 | 145.19 | 535 |
| 11.10.2009 | 20:00 | 30.21 | 145.25 | 20:00 | 30.21 | 145.25 | 536 |
| 11.10.2009 | 21:10 | 29.99 | 145.31 | 21:10 | 29.99 | 145.31 | 537 |
| 12.10.2009 | 07:16 | 27.99 | 145.36 | 07:16 | 27.99 | 145.36 | 545 |
| 12.10.2009 | 08:38 | 27.72 | 145.36 | 08:38 | 27.72 | 145.36 | 546 |
| 12.10.2009 | 09:51 | 27.49 | 145.36 | 09:51 | 27.49 | 145.36 | 547 |
| 12.10.2009 | 11:06 | 27.25 | 145.36 | 11:06 | 27.25 | 145.36 | 548 |
| 12.10.2009 | 12:24 | 27.01 | 145.36 | 12:24 | 27.01 | 145.36 | 549 |
| 12.10.2009 | 17:00 | 26.16 | 145.36 | 17:00 | 26.16 | 145.36 | 562 |
| 12.10.2009 | 18:55 | 25.82 | 145.36 | 18:55 | 25.82 | 145.36 | 554 |
| 13.10.2009 | 05:00 | 24.02 | 145.83 | 05:00 | 24.02 | 145.83 | 563 |
| 13.10.2009 | 08:00 | 23.48 | 146.00 | 08:00 | 23.48 | 146.00 | 565 |
| 13.10.2009 | 10:00 | 23.11 | 146.12 | 10:00 | 23.11 | 146.12 | 566 |
| 13.10.2009 | 11:00 | 22.93 | 146.18 | 11:00 | 22.93 | 146.18 | 567 |
| 13.10.2009 | 14:00 | 22.40 | 146.35 | 14:00 | 22.40 | 146.35 | 569 |
| 13.10.2009 | 15:20 | 22.15 | 146.43 | 15:20 | 22.15 | 146.43 | 570 |
| 13.10.2009 | 16:30 | 21.93 | 146.50 | 16:30 | 21.93 | 146.50 | 571 |
| 13.10.2009 | 17:00 | 21.84 | 146.53 | 17:00 | 21.84 | 146.53 | 572 |
| 14.10.2009 | 02:00 | 20.30 | 147.03 | 02:00 | 20.30 | 147.03 | 588 |
| 14.10.2009 | 05:00 | 19.73 | 147.21 | 05:00 | 19.73 | 147.21 | 589 |
| 14.10.2009 | 08:00 | 19.18 | 147.39 | 08:00 | 19.18 | 147.39 | 590 |
| 14.10.2009 | 11:00 | 18.62 | 147.56 | 11:00 | 18.62 | 147.56 | 591 |
| 14.10.2009 | 14:00 | 18.06 | 147.74 | 14:00 | 18.06 | 147.74 | 592 |
| 14.10.2009 | 17:00 | 17.52 | 147.91 | 17:00 | 17.52 | 147.91 | 593 |
| 14.10.2009 | 20:00 | 17.01 | 148.07 | 20:00 | 17.01 | 148.07 | 594 |
| 14.10.2009 | 22:00 | 16.68 | 148.18 | 22:00 | 16.68 | 148.18 | 595 |
| 14.10.2009 | 23:00 | 16.53 | 148.22 | 23:00 | 16.53 | 148.22 | 596 |
| 15.10.2009 | 02:00 | 16.07 | 148.37 | 02:00 | 16.07 | 148.37 | 598 |
| 15.10.2009 | 05:00 | 15.62 | 148.51 | 05:00 | 15.62 | 148.51 | 599 |
| 15.10.2009 | 08:00 | 15.16 | 148.65 | 08:00 | 15.16 | 148.65 | 600 |
| 15.10.2009 | 11:00 | 14.70 | 148.77 | 11:00 | 14.70 | 148.77 | 602 |
| 15.10.2009 | 14:00 | 14.19 | 148.95 | 14:00 | 14.19 | 148.95 | 604 |
| 15.10.2009 | 17:00 | 13.64 | 149.12 | 17:00 | 13.64 | 149.12 | 605 |

| Table 9.1.1. | HALOCARBONS: Halocarbon (water samples) | | | | | | |
|---|---|---|---|---|---|---|---|
| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
| 15.10.2009 | 23:00 | 12.55 | 149.46 | 23:00 | 12.55 | 149.46 | 609 |
| 16.10.2009 | 02:00 | 12.02 | 149.62 | 02:00 | 12.02 | 149.62 | 611 |
| 16.10.2009 | 05:00 | 11.47 | 149.79 | 05:00 | 11.47 | 149.79 | 614 |
| 16.10.2009 | 08:00 | 10.92 | 149.96 | 08:00 | 10.92 | 149.96 | 617 |
| 16.10.2009 | 11:00 | 10.34 | 150.14 | 11:00 | 10.34 | 150.14 | 619 |
| 16.10.2009 | 14:00 | 9.74 | 150.32 | 14:00 | 9.74 | 150.32 | 621 |
| 16.10.2009 | 17:00 | 9.17 | 150.49 | 17:00 | 9.17 | 150.49 | 622 |
| 16.10.2009 | 20:00 | 8.58 | 150.67 | 20:00 | 8.58 | 150.67 | 626 |
| 16.10.2009 | 23:00 | 7.98 | 150.85 | 23:00 | 7.98 | 150.85 | 627 |
| 17.10.2009 | 00:45 | 7.64 | 150.96 | 00:45 | 7.64 | 150.96 | 631 |
| 17.10.2009 | 02:00 | 7.39 | 151.03 | 02:00 | 7.39 | 151.03 | 629 |
| 17.10.2009 | 05:00 | 6.80 | 151.21 | 05:00 | 6.80 | 151.21 | 633 |
| 17.10.2009 | 08:00 | 6.21 | 151.40 | 08:00 | 6.21 | 151.40 | 636 |
| 17.10.2009 | 11:00 | 5.61 | 151.58 | 11:00 | 5.61 | 151.58 | 641 |
| 17.10.2009 | 14:00 | 5.02 | 151.76 | 14:00 | 5.02 | 151.76 | 642 |
| 17.10.2009 | 20:00 | 3.84 | 152.12 | 20:00 | 3.84 | 152.12 | 643 |
| 17.10.2009 | 23:00 | 3.27 | 152.30 | 23:00 | 3.27 | 152.30 | 650 |
| 18.10.2009 | 02:00 | 2.70 | 152.47 | 02:00 | 2.70 | 152.47 | 651 |
| 18.10.2009 | 05:00 | 2.11 | 152.65 | 05:00 | 2.11 | 152.65 | 653 |
| 18.10.2009 | 08:00 | 1.52 | 152.83 | 08:00 | 1.52 | 152.83 | 654 |
| 18.10.2009 | 11:00 | 0.91 | 153.02 | 11:00 | 0.91 | 153.02 | 655 |
| 18.10.2009 | 14:00 | 0.31 | 153.20 | 14:00 | 0.31 | 153.20 | 656 |
| 18.10.2009 | 17:00 | -0.28 | 153.38 | 17:00 | -0.28 | 153.38 | 658 |
| 18.10.2009 | 20:00 | -0.86 | 153.56 | 20:00 | -0.86 | 153.56 | 662 |
| 18.10.2009 | 23:00 | -1.44 | 153.74 | 23:00 | -1.44 | 153.74 | 664 |
| 19.10.2009 | 02:00 | -2.03 | 153.85 | 02:00 | -2.03 | 153.85 | 665 |
| 19.10.2009 | 05:00 | -2.62 | 153.90 | 05:00 | -2.62 | 153.90 | 666 |
| 19.10.2009 | 08:00 | -3.21 | 153.94 | 08:00 | -3.21 | 153.94 | 674 |
| 19.10.2009 | 11:00 | -3.80 | 153.99 | 11:00 | -3.80 | 153.99 | 676 |
| 19.10.2009 | 14:00 | -4.33 | 153.85 | 14:00 | -4.33 | 153.85 | 678 |
| 19.10.2009 | 17:00 | -4.87 | 153.89 | 17:00 | -4.87 | 153.89 | 681 |
| 19.10.2009 | 20:00 | -5.41 | 153.95 | 20:00 | -5.41 | 153.95 | 684 |
| 19.10.2009 | 23:00 | -5.95 | 154.01 | 23:00 | -5.95 | 154.01 | 685 |
| 20.10.2009 | 02:00 | -6.51 | 154.08 | 02:00 | -6.51 | 154.08 | 687 |
| 20.10.2009 | 05:00 | -7.02 | 154.14 | 05:00 | -7.02 | 154.14 | 689 |
| 20.10.2009 | 08:00 | -7.48 | 154.19 | 08:00 | -7.48 | 154.19 | 691 |
| 20.10.2009 | 11:00 | -7.93 | 154.24 | 11:00 | -7.93 | 154.24 | 696 |
| 20.10.2009 | 14:00 | -8.40 | 154.30 | 14:00 | -8.40 | 154.30 | 697 |
| 20.10.2009 | 17:00 | -8.88 | 154.35 | 17:00 | -8.88 | 154.35 | 698 |
| 20.10.2009 | 20:00 | -9.36 | 154.41 | 20:00 | -9.36 | 154.41 | 699 |
| 20.10.2009 | 23:00 | -9.85 | 154.46 | 23:00 | -9.85 | 154.46 | 705 |
| 21.10.2009 | 02:00 | -10.40 | 154.53 | 02:00 | -10.40 | 154.53 | 706 |
| 21.10.2009 | 05:00 | -10.93 | 154.59 | 05:00 | -10.93 | 154.59 | 707 |
| 21.10.2009 | 08:00 | -11.44 | 154.65 | 08:00 | -11.44 | 154.65 | 713 |

Table 9.1.1. HALOCARBONS: Halocarbon (water samples)

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
|---|---|---|---|---|---|---|---|
| 21.10.2009 | 11:00 | -11.84 | 154.26 | 11:00 | -11.84 | 154.26 | 715 |
| 21.10.2009 | 14:00 | -12.20 | 153.70 | 14:00 | -12.20 | 153.70 | 717 |
| 21.10.2009 | 17:00 | -12.53 | 153.18 | 17:00 | -12.53 | 153.18 | 718 |
| 21.10.2009 | 20:00 | -12.87 | 152.64 | 20:00 | -12.87 | 152.64 | 723 |
| 21.10.2009 | 23:00 | -13.23 | 152.08 | 23:00 | -13.23 | 152.08 | 724 |
| 22.10.2009 | 02:00 | -13.54 | 151.58 | 02:00 | -13.54 | 151.58 | 728 |
| 22.10.2009 | 05:00 | -13.86 | 151.08 | 05:00 | -13.86 | 151.08 | 729 |
| 22.10.2009 | 08:00 | -14.17 | 150.58 | 08:00 | -14.17 | 150.58 | 734 |
| 22.10.2009 | 14:00 | -14.78 | 149.62 | 14:00 | -14.78 | 149.62 | 737 |
| 22.10.2009 | 17:00 | -15.10 | 149.11 | 17:00 | -15.10 | 149.11 | 738 |
| 22.10.2009 | 20:00 | -15.43 | 148.58 | 20:00 | -15.43 | 148.58 | 739 |
| 22.10.2009 | 23:00 | -15.73 | 148.10 | 23:00 | -15.73 | 148.10 | 741 |
| 23.10.2009 | 02:00 | -16.05 | 147.59 | 02:00 | -16.05 | 147.59 | 742 |
| 23.10.2009 | 05:00 | -16.51 | 147.37 | 05:00 | -16.51 | 147.37 | 747 |
| 23.10.2009 | 08:00 | -17.03 | 147.33 | 08:00 | -17.03 | 147.33 | 748 |
| 23.10.2009 | 11:00 | -17.51 | 147.30 | 11:00 | -17.51 | 147.30 | 749 |

| Table 9.1.2. | HALOCARBONS: Halocarbon (air samples) | | | | | | |
|---|---|---|---|---|---|---|---|
| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
| 11.10.2009 | 04:55 | 33.18 | 144.43 | 04:55 | 33.18 | 144.43 | 525 |
| 11.10.2009 | 23:30 | 29.52 | 145.36 | 23:30 | 29.52 | 145.36 | 542 |
| 12.10.2009 | 05:23 | 28.37 | 145.36 | 05:23 | 28.37 | 145.36 | 544 |
| 12.10.2009 | 12:08 | 27.06 | 145.36 | 12:08 | 27.06 | 145.36 | 550 |
| 12.10.2009 | 15:20 | 26.47 | 145.36 | 15:20 | 26.47 | 145.36 | 552 |
| 12.10.2009 | 19:24 | 25.73 | 145.36 | 19:24 | 25.73 | 145.36 | 559 |
| 13.10.2009 | 02:35 | 24.42 | 145.69 | 02:35 | 24.42 | 145.69 | 561 |
| 13.10.2009 | 11:25 | 22.86 | 146.20 | 11:25 | 22.86 | 146.20 | 568 |
| 13.10.2009 | 15:30 | 22.12 | 146.44 | 15:30 | 22.12 | 146.44 | 564 |
| 13.10.2009 | 17:22 | 21.78 | 146.55 | 17:22 | 21.78 | 146.55 | 573 |
| 14.10.2009 | 23:21 | 16.47 | 148.24 | 23:21 | 16.47 | 148.24 | 597 |
| 15.10.2009 | 08:41 | 15.06 | 148.68 | 08:41 | 15.06 | 148.68 | 601 |
| 15.10.2009 | 23:08 | 12.53 | 149.47 | 23:08 | 12.53 | 149.47 | 610 |
| 16.10.2009 | 02:31 | 11.93 | 149.65 | 02:31 | 11.93 | 149.65 | 612 |
| 16.10.2009 | 08:29 | 10.82 | 149.99 | 08:29 | 10.82 | 149.99 | 616 |
| 16.10.2009 | 11:33 | 10.23 | 150.17 | 11:33 | 10.23 | 150.17 | 618 |
| 16.10.2009 | 14:10 | 9.70 | 150.33 | 14:10 | 9.70 | 150.33 | 620 |
| 16.10.2009 | 17:26 | 9.08 | 150.52 | 17:26 | 9.08 | 150.52 | 623 |
| 16.10.2009 | 20:00 | 8.58 | 150.67 | 20:00 | 8.58 | 150.67 | 625 |
| 16.10.2009 | 23:42 | 7.84 | 150.90 | 23:42 | 7.84 | 150.90 | 628 |
| 17.10.2009 | 02:11 | 7.36 | 151.04 | 02:11 | 7.36 | 151.04 | 630 |
| 17.10.2009 | 04:57 | 6.81 | 151.21 | 04:57 | 6.81 | 151.21 | 632 |
| 17.10.2009 | 08:20 | 6.14 | 151.42 | 08:20 | 6.14 | 151.42 | 634 |
| 17.10.2009 | 11:27 | 5.52 | 151.61 | 11:27 | 5.52 | 151.61 | 644 |
| 17.10.2009 | 23:06 | 3.25 | 152.30 | 23:06 | 3.25 | 152.30 | 646 |
| 18.10.2009 | 05:20 | 2.05 | 152.67 | 05:20 | 2.05 | 152.67 | 652 |
| 18.10.2009 | 23:09 | -1.47 | 153.75 | 23:09 | -1.47 | 153.75 | 663 |
| 19.10.2009 | 05:45 | -2.76 | 153.91 | 05:45 | -2.76 | 153.91 | 667 |
| 19.10.2009 | 14:15 | -4.37 | 153.84 | 14:15 | -4.37 | 153.84 | 675 |
| 19.10.2009 | 17:09 | -4.90 | 153.89 | 17:09 | -4.90 | 153.89 | 677 |
| 19.10.2009 | 20:07 | -5.43 | 153.95 | 20:07 | -5.43 | 153.95 | 680 |
| 19.10.2009 | 23:30 | -6.04 | 154.03 | 23:30 | -6.04 | 154.03 | 683 |
| 20.10.2009 | 02:15 | -6.55 | 154.08 | 02:15 | -6.55 | 154.08 | 688 |
| 21.10.2009 | 07:23 | -11.34 | 154.64 | 07:23 | -11.34 | 154.64 | 716 |
| 21.10.2009 | 11:00 | -11.84 | 154.26 | 11:00 | -11.84 | 154.26 | 714 |
| 21.10.2009 | 23:10 | -13.25 | 152.05 | 23:10 | -13.25 | 152.05 | 722 |
| 22.10.2009 | 05:31 | -13.91 | 150.99 | 05:31 | -13.91 | 150.99 | 726 |
| 22.10.2009 | 07:30 | -14.12 | 150.66 | 07:30 | -14.12 | 150.66 | 735 |
| 22.10.2009 | 11:17 | -14.51 | 150.05 | 11:17 | -14.51 | 150.05 | 730 |
| 22.10.2009 | 23:36 | -15.79 | 148.00 | 23:36 | -15.79 | 148.00 | 740 |
| 23.10.2009 | 05:39 | -16.63 | 147.36 | 05:39 | -16.63 | 147.36 | 746 |
| 23.10.2009 | 11:20 | -17.57 | 147.29 | 11:20 | -17.57 | 147.29 | 750 |

**Table 9.2.1.** **PHYTOOPTICS: Water samples**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID | Pig-ments (HPLC) | Phyco-billins (PB) | Particulate absorption (PAB) | Particulate organic carbon (POC) | Flow cyto-metry | Micro-scopy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **09.10.2009** | 09:23 | 41.74 | 141.88 | 09:35 | 41.70 | 141.90 | 1_SO_091009_E | x | x | x | x | x | x |
| **09.10.2009** | 22:58 | 39.00 | 142.73 | 23:14 | 38.94 | 142.75 | 2_SO_091009_B | x | x | x | x | x | |
| **10.10.2009** | 04:58 | 37.81 | 143.09 | 05:16 | 37.75 | 143.11 | 3_SO_101009_D | x | x | x | | x | |
| **10.10.2009** | 07:55 | 37.25 | 143.26 | 08:15 | 37.18 | 143.27 | 4_SO_101009_E(1) | x | x | x | | x | |
| **10.10.2009** | 07:55 | 37.25 | 143.26 | 08:15 | 37.18 | 143.27 | 4_SO_101009_E(2) | | | x | | | |
| **10.10.2009** | 11:04 | 36.64 | 143.43 | 11:16 | 36.60 | 143.45 | 5_SO_101009_F | x | x | x | | x | x |
| **10.10.2009** | 13:53 | 36.11 | 143.59 | 14:14 | 36.04 | 143.61 | 6_SO_111009_G | x | x | x | | x | |
| **10.10.2009** | 19:59 | 34.96 | 143.92 | 20:34 | 34.85 | 143.95 | 7_SO_111009_A | x | x | x | | x | |
| **10.10.2009** | 22:59 | 34.38 | 144.09 | 23:18 | 34.31 | 144.11 | 8_SO_111009_B | x | x | x | x | x | x |
| **11.10.2009** | 02:02 | 33.77 | 144.26 | 02:11 | 33.74 | 144.27 | 9_SO_111009_C | x | x | x | | x | |
| **11.10.2009** | 04:59 | 33.17 | 144.43 | 05:12 | 33.12 | 144.44 | 10_SO_111009_D | x | x | x | | x | |
| **11.10.2009** | 07:57 | 32.54 | 144.60 | 08:26 | 32.44 | 144.63 | 11_SO_111009_E | x | x | x | x | x | x |
| **11.10.2009** | 10:55 | 31.96 | 144.77 | 11:08 | 31.92 | 144.78 | 12_SO_111009_F | x | x | x | | x | |
| **11.10.2009** | 13:59 | 31.38 | 144.93 | | | | 13_SO_111009_G | x | x | x | | x | |
| **11.10.2009** | 16:57 | 30.81 | 145.09 | 17:16 | 30.75 | 145.10 | 14_SO_121009_H | x | x | x | x | x | x |
| **11.10.2009** | 20:03 | 30.20 | 145.25 | 20:18 | 30.16 | 145.26 | 15_SO_121009_A | x | x | x | | x | |
| **11.10.2009** | 23:00 | 29.62 | 145.36 | 23:14 | 29.58 | 145.36 | 16_SO_121009_B | x | x | x | | x | |
| **12.10.2009** | 04:54 | 28.47 | 145.36 | 05:08 | 28.42 | 145.36 | 18_SO_121009_D | x | x | x | | x | |
| **12.10.2009** | | | | 08:08 | 27.82 | 145.36 | 19_SO_121009_E | x | x | x | | x | |
| **12.10.2009** | 10:57 | 27.28 | 145.36 | 11:19 | 27.21 | 145.36 | 20_SO_121009_F | x | x | x | | x | |
| **12.10.2009** | 14:01 | 26.72 | 145.36 | 14:16 | 26.67 | 145.36 | 21_SO_131009_G | x | x | x | | x | |
| **12.10.2009** | 17:06 | 26.15 | 145.36 | 17:22 | 26.10 | 145.37 | 22_SO_131009_H | x | x | x | | x | |
| **12.10.2009** | 20:03 | 25.60 | 145.36 | 20:15 | 25.56 | 145.36 | 23_SO_131009_A | x | x | x | | x | |
| **12.10.2009** | 22:55 | 25.08 | 145.47 | 23:13 | 25.03 | 145.49 | 24_SO_131009_B | x | x | x | x | x | x |
| **13.10.2009** | 01:58 | 24.53 | 145.65 | 02:16 | 24.48 | 145.67 | 25_SO_131009_C | x | x | x | | x | |
| **13.10.2009** | | | | 05:18 | 23.97 | 145.84 | 26_SO_131009_D | x | x | x | x | x | x |
| **13.10.2009** | 08:02 | 23.48 | 146.00 | 08:19 | 23.42 | 146.02 | 27_SO_131009_E | x | x | x | | x | |

**Table 9.2.1.** **PHYTOOPTICS: Water samples**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID | Pig-ments (HPLC) | Phyco-billins (PB) | Particulate absorption (PAB) | Particulate organic carbon (POC) | Flow cyto-metry | Micro-scopy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **13.10.2009** | 10:58 | 22.94 | 146.18 | 11:16 | 22.88 | 146.19 | 28_SO_131009_F | x | x | x | | x | |
| **13.10.2009** | 13:58 | 22.40 | 146.35 | 14:31 | 22.30 | 146.38 | 29_SO_141009_G | x | x | x | x | x | x |
| **13.10.2009** | 17:02 | 21.84 | 146.53 | 17:17 | 21.79 | 146.55 | 30_SO_141009_H | x | x | x | | x | |
| **13.10.2009** | 20:00 | 21.29 | 146.71 | 20:13 | 21.25 | 146.72 | 31_SO_141009_A | x | x | x | | x | |
| **13.10.2009** | 23:00 | 20.73 | 146.89 | 23:19 | 20.67 | 146.91 | 32_SO_141009_B | x | x | x | x | x | x |
| **14.10.2009** | 02:01 | 20.30 | 147.03 | 02:24 | 20.22 | 147.05 | 33_SO_141009_C | x | x | x | | x | |
| **14.10.2009** | 05:01 | 19.73 | 147.21 | 05:13 | 19.69 | 147.22 | 34_SO_141009_D | x | x | x | | x | |
| **14.10.2009** | 08:02 | 19.17 | 147.39 | | | | 35_SO_141009_E | x | x | x | x | x | x |
| **14.10.2009** | 10:58 | 18.63 | 147.56 | 11:16 | 18.57 | 147.58 | 36_SO_141009_F | x | x | x | | x | |
| **14.10.2009** | 13:51 | 18.09 | 147.73 | | | | 37_SO_151009_G | x | x | x | | x | |
| **14.10.2009** | 23:00 | 16.53 | 148.22 | 23:26 | 16.46 | 148.24 | 39_SO_151009_B | x | x | x | | x | |
| **15.10.2009** | 02:11 | 16.04 | 148.38 | 02:24 | 16.01 | 148.39 | 40_SO_151009_C | x | x | x | x | x | x |
| **15.10.2009** | 04:57 | 15.62 | 148.51 | 05:11 | 15.59 | 148.52 | 41_SO_151009_D | x | x | x | | x | x |
| **15.10.2009** | 08:04 | 15.15 | 148.65 | 08:14 | 15.13 | 148.66 | 42_SO_151009_E | x | x | x | | x | x |
| **15.10.2009** | 10:58 | 14.71 | 148.77 | 11:18 | 14.66 | 148.79 | 43_SO_151009_F | x | x | x | x | x | x |
| **15.10.2009** | 14:29 | 14.10 | 148.98 | 13:57 | 14.20 | 148.95 | 44_SO_161009_G | x | x | x | | x | |
| **15.10.2009** | 16:59 | 13.64 | 149.12 | 17:17 | 13.59 | 149.14 | 45_SO_161009_H | x | x | x | | x | x |
| **15.10.2009** | 20:01 | 13.08 | 149.29 | 20:11 | 13.05 | 149.30 | 46_SO_161009_A | x | x | x | | x | x |
| **15.10.2009** | 22:55 | 12.57 | 149.45 | 23:16 | 12.50 | 149.47 | 47_SO_161009_B | x | x | x | x | x | x |
| **16.10.2009** | 02:01 | 12.02 | 149.62 | 02:13 | 11.98 | 149.63 | 48_SO_161009_C | x | x | x | | x | x |
| **16.10.2009** | | | | 05:22 | 11.40 | 149.81 | 49_SO_161009_D | x | x | x | x | x | x |
| **16.10.2009** | 08:02 | 10.91 | 149.96 | 08:14 | 10.87 | 149.97 | 50_SO_161009_E | x | x | x | | x | |
| **16.10.2009** | 10:53 | 10.36 | 150.13 | 11:08 | 10.32 | 150.14 | 51_SO_161009_F | x | x | x | | x | x |
| **16.10.2009** | 14:02 | 9.73 | 150.32 | 14:23 | 9.66 | 150.34 | 52_SO_171009_G | x | x | x | x | x | x |
| **16.10.2009** | 16:54 | 9.19 | 150.49 | 17:09 | 9.14 | 150.50 | 53_SO_171009_H | x | x | x | | x | x |
| **16.10.2009** | 19:59 | 8.58 | 150.67 | 20:09 | 8.55 | 150.68 | 54_SO_171009_A | x | x | x | | x | x |
| **16.10.2009** | 22:57 | 7.99 | 150.85 | 23:22 | 7.91 | 150.88 | 55_SO_171009_B | x | x | x | x | x | x |

**Table 9.2.1.** **PHYTOOPTICS: Water samples**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID | Pig-ments (HPLC) | Phyco-billins (PB) | Particulate absorption (PAB) | Particulate organic carbon (POC) | Flow cyto-metry | Micro-scopy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **17.10.2009** | 02:04 | 7.38 | 151.04 | 02:19 | 7.33 | 151.05 | 56_SO_171009_C | x | x | x | | x | |
| **17.10.2009** | 04:56 | 6.82 | 151.21 | 05:08 | 6.78 | 151.22 | 57_SO_171009_D | x | x | x | | x | |
| **17.10.2009** | 08:01 | 6.21 | 151.40 | 08:11 | 6.17 | 151.41 | 58_SO_171009_E | x | x | x | | x | x |
| **17.10.2009** | 10:52 | 5.64 | 151.57 | 11:05 | 5.60 | 151.59 | 59_SO_171009_F | x | x | x | | x | x |
| **17.10.2009** | 13:55 | 5.04 | 151.76 | | | | 60_SO_171009_G | x | x | x | | x | x |
| **17.10.2009** | 17:01 | 4.43 | 151.94 | 17:12 | 4.39 | 151.96 | 61_SO_181009_H | x | x | x | | x | |
| **17.10.2009** | 20:38 | 3.72 | 152.16 | 20:38 | 3.72 | 152.16 | 62_SO_181009_A | x | x | x | x | x | x |
| **17.10.2009** | 22:56 | 3.28 | 152.29 | 23:09 | 3.24 | 152.31 | 63_SO_181009_B | x | x | x | | x | |
| **18.10.2009** | 02:01 | 2.70 | 152.47 | 02:17 | 2.64 | 152.49 | 64_SO_181009_C | x | x | x | | x | x |
| **18.10.2009** | 04:51 | 2.14 | 152.64 | 05:08 | 2.09 | 152.66 | 65_SO_181009_D | x | x | x | x | x | x |
| **18.10.2009** | 07:57 | 1.53 | 152.83 | 08:10 | 1.49 | 152.84 | 66_SO_181009_E | x | x | x | | x | x |
| **18.10.2009** | 10:56 | 0.92 | 153.02 | 11:17 | 0.85 | 153.04 | 67_SO_181009_F | x | x | x | x | x | x |
| **18.10.2009** | 13:57 | 0.32 | 153.20 | 14:14 | 0.26 | 153.22 | 68_SO_191009_G | x | x | x | | x | x |
| **18.10.2009** | 16:56 | -0.27 | 153.38 | 17:12 | -0.32 | 153.40 | 69_SO_191009_H | x | x | x | | x | |
| **18.10.2009** | 19:57 | -0.85 | 153.56 | 20:10 | -0.89 | 153.57 | 70_SO_191009_A | x | x | x | | x | x |
| **18.10.2009** | 22:54 | -1.42 | 153.73 | 23:08 | -1.47 | 153.75 | 71_SO_191009_B | x | x | x | | x | x |
| **19.10.2009** | 01:58 | -2.02 | 153.85 | 02:08 | -2.06 | 153.86 | 72_SO_191009_C | x | x | x | | x | x |
| **19.10.2009** | 04:58 | -2.61 | 153.90 | 05:16 | -2.67 | 153.90 | 73_SO_191009_D | x | x | x | x | x | x |
| **19.10.2009** | 07:57 | -3.20 | 153.94 | 08:11 | -3.25 | 153.94 | 74_SO_191009_E | x | x | x | | x | x |
| **19.10.2009** | 11:02 | -3.81 | 153.99 | 11:25 | -3.88 | 153.99 | 75_SO_191009_F | x | x | x | | x | x |
| **19.10.2009** | 13:54 | -4.31 | 153.86 | 14:04 | -4.34 | 153.85 | 76_SO_201009_G | x | x | x | x | x | x |
| **19.10.2009** | 16:56 | -4.86 | 153.89 | 17:08 | -4.90 | 153.89 | 77_SO_201009_H | x | x | x | | x | x |
| **19.10.2009** | 19:55 | -5.39 | 153.95 | 20:12 | -5.44 | 153.96 | 78_SO_201009_A | x | x | x | | x | x |
| **19.10.2009** | 23:02 | -5.96 | 154.02 | 23:32 | -6.05 | 154.03 | 79_SO_201009_B | x | x | x | x | x | x |
| **20.10.2009** | 01:59 | -6.50 | 154.08 | 02:12 | -6.54 | 154.08 | 80_SO_201009_C | x | x | x | | x | x |
| **20.10.2009** | 05:06 | -7.04 | 154.14 | 05:19 | -7.07 | 154.14 | 81_SO_201009_D | x | x | x | | x | x |
| **20.10.2009** | 07:56 | -7.47 | 154.19 | 08:18 | -7.52 | 154.19 | 82_SO_211009_E | x | x | x | x | x | x |

**Table 9.2.1.** **PHYTOOPTICS: Water samples**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID | Pig-ments (HPLC) | Phyco-billins (PB) | Particulate absorption (PAB) | Particulate organic carbon (POC) | Flow cyto-metry | Micro-scopy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **20.10.2009** | 10:56 | -7.92 | 154.24 | 11:12 | -7.97 | 154.25 | 83_SO_211009_F | x | x | x | | x | x |
| **20.10.2009** | 13:56 | -8.39 | 154.30 | 14:06 | -8.42 | 154.30 | 84_SO_211009_G | x | x | x | | x | x |
| **20.10.2009** | 16:58 | -8.87 | 154.35 | 17:09 | -8.91 | 154.36 | 85_SO_211009_H | x | x | x | | x | x |
| **20.10.2009** | 19:59 | -9.36 | 154.41 | 20:25 | -9.43 | 154.42 | 86_SO_211009_A | x | x | x | x | x | x |
| **20.10.2009** | 22:55 | -9.84 | 154.46 | 23:09 | -9.88 | 154.47 | 87_SO_211009_B | x | x | x | | x | |
| **21.10.2009** | 01:56 | -10.38 | 154.53 | 02:14 | -10.44 | 154.53 | 88_SO_211009_C | x | x | x | x | x | x |
| **21.10.2009** | 05:00 | -10.93 | 154.59 | 05:13 | -10.97 | 154.59 | 89_SO_211009_D | x | x | x | | x | x |
| **21.10.2009** | 07:54 | -11.42 | 154.65 | 08:09 | -11.47 | 154.65 | 90_SO_211009_E | x | x | x | | x | x |
| **21.10.2009** | 10:56 | -11.83 | 154.27 | 11:14 | -11.87 | 154.22 | 91_SO_211009_F | x | x | x | x | x | x |
| **21.10.2009** | 13:55 | -12.19 | 153.72 | 14:06 | -12.21 | 153.68 | 92_SO_221009_G | x | x | x | | x | x |
| **21.10.2009** | 16:56 | -12.52 | 153.20 | 17:24 | -12.57 | 153.12 | 93_SO_221009_H | x | x | x | | x | x |
| **21.10.2009** | 20:01 | -12.87 | 152.64 | 20:12 | -12.89 | 152.60 | 94_SO_221009_A | x | x | x | x | x | x |
| **21.10.2009** | 22:54 | -13.21 | 152.10 | 23:05 | -13.24 | 152.06 | 95_SO_221009_B | x | x | x | | x | x |
| **22.10.2009** | 02:00 | -13.54 | 151.58 | 02:12 | -13.56 | 151.54 | 96_SO_221009_C | x | x | x | | x | x |
| **22.10.2009** | 04:57 | -13.85 | 151.09 | 05:21 | -13.89 | 151.02 | 97_SO_221009_D | x | x | x | x | x | x |
| **22.10.2009** | 07:58 | -14.17 | 150.59 | 08:14 | -14.20 | 150.54 | 98_SO_221009_E | x | x | x | | x | x |
| **22.10.2009** | 10:58 | -14.48 | 150.09 | 11:13 | -14.50 | 150.06 | 99_SO_221009_F | x | x | x | | x | x |
| **22.10.2009** | 14:01 | -14.78 | 149.61 | 14:11 | -14.80 | 149.59 | 100_SO_231009_G | x | x | x | | x | x |
| **22.10.2009** | 16:57 | -15.09 | 149.12 | 17:10 | -15.12 | 149.08 | 101_SO_231009_H | x | x | x | | x | x |
| **22.10.2009** | 19:57 | -15.42 | 148.59 | | | | 102_SO_231009_A | x | x | x | | x | x |
| **23.10.2009** | 01:55 | -16.04 | 147.61 | 02:18 | -16.08 | 147.54 | 103_SO_231009_C | x | x | x | x | x | x |
| **23.10.2009** | 04:58 | -16.50 | 147.37 | 05:12 | -16.54 | 147.37 | 104_SO_231009_D | x | x | x | | x | x |
| **23.10.2009** | 08:00 | -17.03 | 147.33 | 08:16 | -17.07 | 147.33 | 105_SO_231009_E | x | x | x | | x | x |
| **23.10.2009** | 10:56 | -17.50 | 147.30 | 11:12 | -17.55 | 147.29 | 106_SO_231009_F | x | x | x | | x | x |
| **23.10.2009** | 13:54 | -17.97 | 147.21 | 14:15 | -18.02 | 147.20 | 107_SO_231009_G | x | x | x | | x | x |

| Table 9.2.2. | PHYTOOPTICS: PSICAM (point-source integrating-cavity absorption meter) Absorption of Gelbstoff | | | | | | |
|---|---|---|---|---|---|---|---|
| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
| **10.10.2009** | 8:00 | 37.23 | 143.26 | 8:00 | 37.23 | 143.26 | 101009E |
| **10.10.2009** | 11:00 | 36.65 | 143.43 | 11:00 | 36.65 | 143.43 | 101009F |
| **10.10.2009** | 14:00 | 36.09 | 143.60 | 14:00 | 36.09 | 143.60 | 101009G |
| **10.10.2009** | 20:00 | 34.96 | 143.92 | 20:00 | 34.96 | 143.92 | 111009A |
| **10.10.2009** | 23:00 | 34.37 | 144.09 | 23:00 | 34.37 | 144.09 | 111009B |
| **11.10.2009** | 2:00 | 29.04 | 145.36 | 2:00 | 29.04 | 145.36 | 111009C |
| **11.10.2009** | 5:00 | 28.45 | 145.36 | 5:00 | 28.45 | 145.36 | 111009D |
| **11.10.2009** | 8:00 | 27.84 | 145.36 | 8:00 | 27.84 | 145.36 | 111009E |
| **11.10.2009** | 11:00 | 27.27 | 145.36 | 11:00 | 27.27 | 145.36 | 111009F |
| **11.10.2009** | 14:00 | 26.72 | 145.36 | 14:00 | 26.72 | 145.36 | 111009G |
| **11.10.2009** | 17:00 | 26.16 | 145.36 | 17:00 | 26.16 | 145.36 | 121009H |
| **11.10.2009** | 20:00 | 25.61 | 145.36 | 20:00 | 25.61 | 145.36 | 121009A |
| **11.10.2009** | 23:00 | 25.07 | 145.47 | 23:00 | 25.07 | 145.47 | 121009B |
| **12.10.2009** | 2:00 | 20.30 | 147.03 | 2:00 | 20.30 | 147.03 | 121009C |
| **12.10.2009** | 5:00 | 19.73 | 147.21 | 5:00 | 19.73 | 147.21 | 121009D |
| **12.10.2009** | 8:00 | 19.18 | 147.39 | 8:00 | 19.18 | 147.39 | 121009E |
| **12.10.2009** | 11:00 | 18.62 | 147.56 | 11:00 | 18.62 | 147.56 | 121009F |
| **12.10.2009** | 14:00 | 18.06 | 147.74 | 14:00 | 18.06 | 147.74 | 131009G |
| **12.10.2009** | 17:00 | 17.52 | 147.91 | 17:00 | 17.52 | 147.91 | 131009H |
| **12.10.2009** | 23:00 | 16.53 | 148.22 | 23:00 | 16.53 | 148.22 | 131009A |
| **13.10.2009** | 5:00 | 11.47 | 149.79 | 5:00 | 11.47 | 149.79 | 131009C |
| **13.10.2009** | 11:00 | 10.34 | 150.14 | 11:00 | 10.34 | 150.14 | 131009E |
| **13.10.2009** | 14:00 | 9.74 | 150.32 | 14:00 | 9.74 | 150.32 | 131009F |
| **13.10.2009** | 17:00 | 9.17 | 150.49 | 17:00 | 9.17 | 150.49 | 141009G |
| **14.10.2009** | 2:00 | 2.70 | 152.47 | 2:00 | 2.70 | 152.47 | 141009C |
| **14.10.2009** | 8:00 | 1.52 | 152.83 | 8:00 | 1.52 | 152.83 | 141009E |
| **14.10.2009** | 20:00 | -0.86 | 153.56 | 20:00 | -0.86 | 153.56 | 151009A |
| **15.10.2009** | 2:00 | -6.51 | 154.08 | 2:00 | -6.51 | 154.08 | 151009C |
| **15.10.2009** | 5:00 | -7.02 | 154.14 | 5:00 | -7.02 | 154.14 | 151009D |
| **15.10.2009** | 11:00 | -7.93 | 154.24 | 11:00 | -7.93 | 154.24 | 151009F |
| **15.10.2009** | 23:00 | -9.85 | 154.46 | 23:00 | -9.85 | 154.46 | 161009B |
| **16.10.2009** | 5:00 | -13.86 | 151.08 | 5:00 | -13.86 | 151.08 | 161009D |
| **16.10.2009** | 17:00 | -15.10 | 149.11 | 17:00 | -15.10 | 149.11 | 171009H |
| **16.10.2009** | 23:00 | -15.73 | 148.10 | 23:00 | -15.73 | 148.10 | 171009B |
| **17.10.2009** | 11:00 | -19.25 | 146.83 | 11:00 | -19.25 | 146.83 | 171009F |
| **17.10.2009** | 20:00 | -19.25 | 146.83 | 20:00 | -19.25 | 146.83 | 181009A |
| **18.10.2009** | 2:00 | -19.25 | 146.83 | 2:00 | -19.25 | 146.83 | 181009C |
| **18.10.2009** | 5:00 | -19.25 | 146.83 | 5:00 | -19.25 | 146.83 | 181009D |
| **18.10.2009** | 11:00 | -19.25 | 146.83 | 11:00 | -19.25 | 146.83 | 181009F |
| **18.10.2009** | 14:00 | -19.25 | 146.83 | 14:00 | -19.25 | 146.83 | 191009G |
| **18.10.2009** | 23:00 | -19.25 | 146.83 | 23:00 | -19.25 | 146.83 | 191009B |
| **19.10.2009** | 2:00 | -19.25 | 146.83 | 2:00 | -19.25 | 146.83 | 191009C |
| **19.10.2009** | 5:00 | -19.25 | 146.83 | 5:00 | -19.25 | 146.83 | 191009D |

**Table 9.2.2. PHYTOOPTICS: PSICAM (point-source integrating-cavity absorption meter) Absorption of Gelbstoff**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
|---|---|---|---|---|---|---|---|
| **19.10.2009** | 8:00 | -19.25 | 146.83 | 8:00 | -19.25 | 146.83 | 191009E |
| **19.10.2009** | 17:00 | -19.25 | 146.83 | 17:00 | -19.25 | 146.83 | 201009H |
| **19.10.2009** | 23:00 | -19.25 | 146.83 | 23:00 | -19.25 | 146.83 | 201009B |
| **20.10.2009** | 2:00 | -19.25 | 146.83 | 2:00 | -19.25 | 146.83 | 201009C |
| **20.10.2009** | 8:00 | -19.25 | 146.83 | 8:00 | -19.25 | 146.83 | 201009E |
| **20.10.2009** | 11:00 | -19.25 | 146.83 | 11:00 | -19.25 | 146.83 | 201009F |
| **20.10.2009** | 20:00 | -19.25 | 146.83 | 20:00 | -19.25 | 146.83 | 211009A |
| **21.10.2009** | 2:00 | -19.25 | 146.83 | 2:00 | -19.25 | 146.83 | 211009C |
| **21.10.2009** | 8:00 | -19.25 | 146.83 | 8:00 | -19.25 | 146.83 | 211009E |
| **21.10.2009** | 11:00 | -19.25 | 146.83 | 11:00 | -19.25 | 146.83 | 211009F |
| **21.10.2009** | 14:00 | -19.25 | 146.83 | 14:00 | -19.25 | 146.83 | 221009G |
| **21.10.2009** | 23:00 | -19.25 | 146.83 | 23:00 | -19.25 | 146.83 | 221009B |
| **22.10.2009** | 2:00 | -19.25 | 146.83 | 2:00 | -19.25 | 146.83 | 221009C |
| **22.10.2009** | 5:00 | -19.25 | 146.83 | 5:00 | -19.25 | 146.83 | 221009D |
| **22.10.2009** | 8:00 | -19.25 | 146.83 | 8:00 | -19.25 | 146.83 | 221009E |
| **22.10.2009** | 14:00 | -19.25 | 146.83 | 14:00 | -19.25 | 146.83 | 221009G |
| **22.10.2009** | 17:00 | -19.25 | 146.83 | 17:00 | -19.25 | 146.83 | 231009H |

**Table 9.2.3. PHYTOOPTICS: RAMSES (radiation)/chlorophyll**

| Date UTC | RAMSES sampling start | Position lat (North) | Position lon (East) | RAMSES sampling stop | Position lat (North) | Position lon (East) | Chlorophyll fluorescence |
|---|---|---|---|---|---|---|---|
| **11.10.2007** | | | | | | | continuous |
| **12.10.2008** | | | | | | | continuous |
| **13.10.2009** | 22:30 | 20.83 | 146.86 | | | | continuous |
| **14.10.2009** | | | | 07:12 | 19.33 | 147.34 | continuous |
| **14.10.2009** | 22:40 | 16.57 | 148.21 | | | | continuous |
| **15.10.2009** | | | | 06:31 | 15.39 | 148.58 | continuous |
| **15.10.2009** | 22:52 | 12.57 | 149.45 | | | | continuous |
| **16.10.2009** | | | | 06:20 | 11.23 | 149.86 | continuous |
| **16.10.2009** | 21:18 | 8.32 | 150.75 | | | | continuous |
| **17.10.2009** | | | | 07:00 | 6.41 | 151.34 | continuous |
| **17.10.2009** | 23:18 | 3.21 | 152.32 | | | | continuous |
| **18.10.2009** | | | | 06:55 | 1.74 | 152.77 | continuous |
| **18.10.2009** | 22:34 | -1.36 | 153.71 | | | | continuous |
| **19.10.2009** | | | | 06:47 | -2.97 | 153.92 | continuous |
| **19.10.2009** | 21:30 | -5.68 | 153.98 | | | | continuous |
| **20.10.2009** | | | | 02:15 | -6.55 | 154.08 | continuous |
| **21.10.2009** | | | | | | | continuous |
| **22.10.2009** | | | | | | | continuous |
| **23.10.2009** | | | | | | | continuous |

| Table 9.3.1. | OCEANIC TRACE GASES: DMS (water samples) | | | | | | |
|---|---|---|---|---|---|---|---|
| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
| 09.10.2009 | 12:00 | 41.19 | 142.06 | 12:10 | 41.16 | 142.07 | 1 |
| 09.10.2009 | 15:00 | 40.52 | 142.26 | 15:03 | 40.51 | 142.27 | 4 |
| 09.10.2009 | 17:53 | 39.95 | 142.44 | 18:00 | 39.93 | 142.45 | 7 |
| 09.10.2009 | 21:00 | 39.37 | 142.62 | 21:03 | 39.36 | 142.62 | 8 |
| 09.10.2009 | 23:55 | 38.81 | 142.79 | 00:00 | 38.79 | 142.79 | 9 |
| 10.10.2009 | 04:57 | 37.81 | 143.09 | 05:03 | 37.79 | 143.09 | 10 |
| 10.10.2009 | 08:00 | 37.23 | 143.26 | 08:02 | 37.22 | 143.26 | 13 |
| 10.10.2009 | 10:59 | 36.65 | 143.43 | 11:02 | 36.65 | 143.43 | 16 |
| 10.10.2009 | 13:59 | 36.09 | 143.59 | 14:01 | 36.08 | 143.6 | 17 |
| 10.10.2009 | 16:58 | 35.53 | 143.76 | 17:01 | 35.52 | 143.76 | 18 |
| 10.10.2009 | 19:59 | 34.96 | 143.92 | 20:00 | 34.96 | 143.92 | 19 |
| 10.10.2009 | 22:59 | 34.38 | 144.09 | 23:04 | 34.36 | 144.09 | 20 |
| 11.10.2009 | 02:09 | 33.75 | 144.27 | 02:09 | 33.75 | 144.27 | 23 |
| 11.10.2009 | 05:01 | 33.16 | 144.43 | 05:09 | 33.13 | 144.44 | 26 |
| 11.10.2009 | 08:00 | 32.53 | 144.61 | 08:02 | 32.53 | 144.61 | 29 |
| 11.10.2009 | 10:58 | 31.95 | 144.77 | 11:00 | 31.94 | 144.77 | 30 |
| 11.10.2009 | 13:59 | 31.38 | 144.93 | 14:00 | 31.37 | 144.93 | 31 |
| 11.10.2009 | 17:00 | 30.80 | 145.09 | 17:08 | 30.77 | 145.09 | 33 |
| 11.10.2009 | 19:58 | 30.22 | 145.25 | 20:00 | 30.21 | 145.25 | 36 |
| 11.10.2009 | 22:59 | 29.63 | 145.36 | 23:01 | 29.62 | 145.36 | 39 |
| 12.10.2009 | 02:00 | 29.04 | 145.36 | 02:01 | 29.04 | 145.36 | 40 |
| 12.10.2009 | 05:00 | 28.45 | 145.36 | 05:03 | 28.44 | 145.36 | 41 |
| 12.10.2009 | 07:58 | 27.85 | 145.36 | 08:00 | 27.84 | 145.36 | 42 |
| 12.10.2009 | 10:58 | 27.28 | 145.36 | 11:03 | 27.26 | 145.36 | 43 |
| 12.10.2009 | 14:00 | 26.72 | 145.36 | 14:00 | 26.72 | 145.36 | 46 |
| 12.10.2009 | 17:01 | 26.16 | 145.36 | 17:07 | 26.14 | 145.36 | 47 |
| 12.10.2009 | 19:58 | 25.62 | 145.36 | 19:59 | 25.61 | 145.36 | 48 |
| 12.10.2009 | 22:58 | 25.07 | 145.47 | 23:01 | 25.06 | 145.47 | 49 |
| 13.10.2009 | 01:58 | 24.53 | 145.65 | 01:59 | 24.53 | 145.65 | 50 |
| 13.10.2009 | 04:58 | 24.02 | 145.82 | 05:05 | 24 | 145.83 | 51 |
| 13.10.2009 | 08:00 | 23.48 | 146.00 | 08:03 | 23.47 | 146 | 54 |
| 13.10.2009 | 11:04 | 22.92 | 146.18 | 11:07 | 22.91 | 146.18 | 57 |
| 13.10.2009 | 14:00 | 22.40 | 146.35 | 14:01 | 22.39 | 146.35 | 58 |
| 13.10.2009 | 16:58 | 21.85 | 146.53 | 17:04 | 21.83 | 146.54 | 59 |
| 13.10.2009 | 19:58 | 21.30 | 146.71 | 20:00 | 21.29 | 146.71 | 60 |
| 13.10.2009 | 23:00 | 20.73 | 146.89 | 23:03 | 20.73 | 146.89 | 61 |
| 14.10.2009 | 02:00 | 20.30 | 147.03 | 02:02 | 20.29 | 147.03 | 62 |
| 14.10.2009 | 05:00 | 19.73 | 147.21 | 05:05 | 19.72 | 147.21 | 65 |
| 14.10.2009 | 08:00 | 19.18 | 147.39 | 08:01 | 19.18 | 147.39 | 68 |
| 14.10.2009 | 10:59 | 18.63 | 147.56 | 11:02 | 18.61 | 147.57 | 69 |
| 14.10.2009 | 13:59 | 18.07 | 147.74 | 14:01 | 18.06 | 147.74 | 70 |
| 14.10.2009 | 17:00 | 17.52 | 147.91 | 17:04 | 17.51 | 147.92 | 71 |
| 14.10.2009 | 19:56 | 17.02 | 148.07 | 19:58 | 17.01 | 148.07 | 72 |
| 14.10.2009 | 22:56 | 16.54 | 148.22 | 23:00 | 16.53 | 148.22 | 73 |

| Table 9.3.1. | OCEANIC TRACE GASES: DMS (water samples) | | | | | | |
|---|---|---|---|---|---|---|---|
| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
| 15.10.2009 | 02:05 | 16.05 | 148.37 | 02:07 | 16.05 | 148.37 | 74 |
| 15.10.2009 | 04:59 | 15.62 | 148.51 | 05:03 | 15.61 | 148.51 | 75 |
| 15.10.2009 | 07:58 | 15.17 | 148.65 | 08:00 | 15.16 | 148.65 | 76 |
| 15.10.2009 | 11:03 | 14.70 | 148.77 | 11:07 | 14.69 | 148.78 | 77 |
| 15.10.2009 | 13:55 | 14.20 | 148.95 | 13:57 | 14.2 | 148.95 | 80 |
| 15.10.2009 | 17:00 | 13.64 | 149.12 | 17:07 | 13.62 | 149.13 | 81 |
| 15.10.2009 | 19:58 | 13.09 | 149.29 | 20:00 | 13.09 | 149.29 | 82 |
| 15.10.2009 | 22:58 | 12.56 | 149.46 | 23:03 | 12.54 | 149.46 | 83 |
| 16.10.2009 | 01:59 | 12.02 | 149.62 | 02:01 | 12.02 | 149.62 | 84 |
| 16.10.2009 | 04:55 | 11.49 | 149.79 | 05:03 | 11.46 | 149.79 | 85 |
| 16.10.2009 | 08:00 | 10.92 | 149.96 | 08:03 | 10.91 | 149.96 | 88 |
| 16.10.2009 | 11:01 | 10.34 | 150.14 | 11:05 | 10.33 | 150.14 | 89 |
| 16.10.2009 | 13:59 | 9.74 | 150.32 | 14:01 | 9.73 | 150.32 | 90 |
| 16.10.2009 | 17:02 | 9.16 | 150.50 | 17:06 | 9.15 | 150.5 | 91 |
| 16.10.2009 | 20:00 | 8.58 | 150.67 | 20:01 | 8.57 | 150.67 | 92 |
| 16.10.2009 | 23:00 | 7.98 | 150.85 | 23:06 | 7.96 | 150.86 | 93 |
| 17.10.2009 | 01:58 | 7.40 | 151.03 | 02:00 | 7.39 | 151.03 | 96 |
| 17.10.2009 | 05:00 | 6.80 | 151.21 | 05:05 | 6.79 | 151.22 | 97 |
| 17.10.2009 | 07:59 | 6.21 | 151.40 | 08:00 | 6.21 | 151.4 | 98 |
| 17.10.2009 | 11:00 | 5.61 | 151.58 | 11:07 | 5.59 | 151.59 | 99 |
| 17.10.2009 | 14:00 | 5.02 | 151.76 | 14:03 | 5.01 | 151.77 | 100 |
| 17.10.2009 | 17:00 | 4.43 | 151.94 | 17:05 | 4.41 | 151.95 | 101 |
| 17.10.2009 | 20:04 | 3.83 | 152.13 | 20:07 | 3.82 | 152.13 | 102 |
| 17.10.2009 | 22:59 | 3.27 | 152.30 | 23:03 | 3.26 | 152.3 | 104 |
| 18.10.2009 | 02:01 | 2.70 | 152.47 | 02:03 | 2.69 | 152.48 | 105 |
| 18.10.2009 | 05:00 | 2.11 | 152.65 | 05:08 | 2.09 | 152.66 | 106 |
| 18.10.2009 | 07:59 | 1.52 | 152.83 | 08:00 | 1.52 | 152.83 | 107 |
| 18.10.2009 | 11:01 | 0.91 | 153.02 | 11:05 | 0.89 | 153.03 | 108 |
| 18.10.2009 | 14:00 | 0.31 | 153.20 | 14:02 | 0.3 | 153.21 | 109 |
| 18.10.2009 | 16:56 | -0.27 | 153.38 | 17:00 | -0.28 | 153.38 | 110 |
| 18.10.2009 | 20:01 | -0.86 | 153.56 | 20:03 | -0.87 | 153.56 | 111 |
| 18.10.2009 | 23:01 | -1.45 | 153.74 | 23:03 | -1.45 | 153.74 | 112 |
| 19.10.2009 | 02:01 | -2.03 | 153.85 | 02:02 | -2.04 | 153.85 | 113 |
| 19.10.2009 | 05:02 | -2.62 | 153.90 | 05:08 | -2.64 | 153.9 | 114 |
| 19.10.2009 | 07:59 | -3.21 | 153.94 | 08:01 | -3.21 | 153.94 | 115 |
| 19.10.2009 | 11:00 | -3.80 | 153.99 | 11:06 | -3.82 | 153.99 | 118 |
| 19.10.2009 | 14:01 | -4.33 | 153.85 | 14:02 | -4.33 | 153.85 | 119 |
| 19.10.2009 | 17:01 | -4.88 | 153.89 | 17:07 | -4.89 | 153.89 | 120 |
| 19.10.2009 | 19:58 | -5.40 | 153.95 | 19:59 | -5.41 | 153.95 | 121 |
| 19.10.2009 | 23:02 | -5.96 | 154.02 | 23:07 | -5.97 | 154.02 | 122 |
| 20.10.2009 | 02:00 | -6.51 | 154.08 | 02:02 | -6.51 | 154.08 | 125 |
| 20.10.2009 | 05:00 | -7.02 | 154.14 | 05:08 | -7.05 | 154.14 | 126 |
| 20.10.2009 | 07:58 | -7.47 | 154.19 | 08:00 | -7.48 | 154.19 | 127 |
| 20.10.2009 | 10:59 | -7.93 | 154.24 | 11:03 | -7.94 | 154.24 | 128 |

**Table 9.3.1. OCEANIC TRACE GASES: DMS (water samples)**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
|---|---|---|---|---|---|---|---|
| **20.10.2009** | 14:00 | -8.40 | 154.30 | 14:02 | -8.41 | 154.3 | 129 |
| **20.10.2009** | 17:00 | -8.88 | 154.35 | 17:17 | -8.93 | 154.36 | 130 |
| **20.10.2009** | 20:00 | -9.36 | 154.41 | 20:02 | -9.37 | 154.41 | 133 |
| **20.10.2009** | 23:00 | -9.85 | 154.46 | 23:11 | -9.89 | 154.47 | 136 |
| **21.10.2009** | 02:00 | -10.40 | 154.53 | 02:02 | -10.4 | 154.53 | 137 |
| **21.10.2009** | 04:58 | -10.92 | 154.59 | 05:06 | -10.95 | 154.59 | 138 |
| **21.10.2009** | 08:00 | -11.44 | 154.65 | 08:01 | -11.44 | 154.65 | 139 |
| **21.10.2009** | 11:00 | -11.84 | 154.26 | 11:11 | -11.86 | 154.23 | 140 |
| **21.10.2009** | 13:56 | -12.19 | 153.71 | 13:58 | -12.19 | 153.71 | 141 |
| **21.10.2009** | 17:00 | -12.53 | 153.18 | 17:07 | -12.54 | 153.16 | 142 |
| **21.10.2009** | 20:00 | -12.87 | 152.64 | 20:03 | -12.88 | 152.63 | 143 |
| **21.10.2009** | 22:59 | -13.22 | 152.08 | 23:04 | -13.23 | 152.06 | 144 |
| **22.10.2009** | 01:58 | -13.54 | 151.58 | 02:00 | -13.54 | 151.58 | 145 |
| **22.10.2009** | 05:02 | -13.86 | 151.07 | 05:08 | -13.87 | 151.06 | 146 |
| **22.10.2009** | 07:57 | -14.17 | 150.59 | 08:00 | -14.17 | 150.58 | 147 |
| **22.10.2009** | 11:00 | -14.48 | 150.08 | 11:06 | -14.49 | 150.07 | 148 |
| **22.10.2009** | 14:00 | -14.78 | 149.62 | 14:02 | -14.78 | 149.61 | 149 |
| **22.10.2009** | 17:00 | -15.10 | 149.11 | 17:09 | -15.12 | 149.08 | 150 |
| **22.10.2009** | 20:00 | -15.43 | 148.58 | 20:02 | -15.43 | 148.58 | 151 |
| **22.10.2009** | 23:00 | -15.73 | 148.10 | 23:07 | -15.74 | 148.08 | 152 |
| **23.10.2009** | 01:59 | -16.05 | 147.60 | 02:00 | -16.05 | 147.59 | 153 |
| **23.10.2009** | 04:59 | -16.50 | 147.37 | 05:04 | -16.52 | 147.37 | 154 |
| **23.10.2009** | 08:00 | -17.03 | 147.33 | 08:04 | -17.04 | 147.33 | 155 |
| **23.10.2009** | 11:00 | -17.51 | 147.30 | 11:04 | -17.52 | 147.3 | 156 |
| **23.10.2009** | 14:01 | -17.98 | 147.21 | 14:02 | -17.99 | 147.21 | 157 |
| **23.10.2009** | 17:00 | -18.37 | 146.98 | 17:06 | -18.38 | 146.97 | 158 |
| **23.10.2009** | 20:00 | -18.81 | 146.92 | 20:07 | -18.83 | 146.92 | 159 |

**Table 9.3.2. OCEANIC TRACE GASES: $N_2O$ (water samples)**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
|---|---|---|---|---|---|---|---|
| **09.10.2009** | 12:00 | 41.19 | 142.06 | 12:10 | 41.16 | 142.07 | 1 |
| **09.10.2009** | 17:53 | 39.95 | 142.44 | 18:00 | 39.93 | 142.45 | 2 |
| **09.10.2009** | 23:55 | 38.81 | 142.79 | 00:00 | 38.79 | 142.79 | 3 |
| **10.10.2009** | 04:57 | 37.81 | 143.09 | 05:03 | 37.79 | 143.09 | 4 |
| **10.10.2009** | 10:59 | 36.65 | 143.43 | 11:02 | 36.65 | 143.43 | 5 |
| **10.10.2009** | 16:58 | 35.53 | 143.76 | 17:01 | 35.52 | 143.76 | 6 |
| **10.10.2009** | 22:59 | 34.38 | 144.09 | 23:04 | 34.36 | 144.09 | 7 |
| **11.10.2009** | 05:01 | 33.16 | 144.43 | 05:09 | 33.13 | 144.44 | 8 |
| **11.10.2009** | 10:58 | 31.95 | 144.77 | 11:00 | 31.94 | 144.77 | 9 |
| **11.10.2009** | 17:00 | 30.80 | 145.09 | 17:08 | 30.77 | 145.09 | 10 |
| **11.10.2009** | 22:59 | 29.63 | 145.36 | 23:01 | 29.62 | 145.36 | 11 |
| **12.10.2009** | 05:00 | 28.45 | 145.36 | 05:03 | 28.44 | 145.36 | 12 |
| **12.10.2009** | 10:58 | 27.28 | 145.36 | 11:03 | 27.26 | 145.36 | 13 |

| Table 9.3.2. | OCEANIC TRACE GASES: $N_2O$ (water samples) | | | | | | |
|---|---|---|---|---|---|---|---|
| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
| 12.10.2009 | 17:01 | 26.16 | 145.36 | 17:07 | 26.14 | 145.36 | 14 |
| 12.10.2009 | 22:58 | 25.07 | 145.47 | 23:01 | 25.06 | 145.47 | 15 |
| 13.10.2009 | 04:58 | 24.02 | 145.82 | 05:05 | 24.00 | 145.83 | 16 |
| 13.10.2009 | 11:04 | 22.92 | 146.18 | 11:07 | 22.91 | 146.18 | 17 |
| 13.10.2009 | 16:58 | 21.85 | 146.53 | 17:04 | 21.83 | 146.54 | 18 |
| 13.10.2009 | 23:00 | 20.73 | 146.89 | 23:03 | 20.73 | 146.89 | 19 |
| 14.10.2009 | 05:00 | 19.73 | 147.21 | 05:05 | 19.72 | 147.21 | 20 |
| 14.10.2009 | 10:55 | 18.64 | 147.56 | 11:02 | 18.61 | 147.57 | 21 |
| 14.10.2009 | 17:00 | 17.52 | 147.91 | 17:04 | 17.51 | 147.92 | 22 |
| 14.10.2009 | 22:56 | 16.54 | 148.22 | 23:00 | 16.53 | 148.22 | 23 |
| 15.10.2009 | 04:59 | 15.62 | 148.51 | 05:03 | 15.61 | 148.51 | 24 |
| 15.10.2009 | 11:03 | 14.70 | 148.77 | 11:07 | 14.69 | 148.78 | 25 |
| 15.10.2009 | 17:00 | 13.64 | 149.12 | 17:07 | 13.62 | 149.13 | 26 |
| 15.10.2009 | 22:58 | 12.56 | 149.46 | 23:03 | 12.54 | 149.46 | 27 |
| 16.10.2009 | 04:55 | 11.49 | 149.79 | 05:03 | 11.46 | 149.79 | 28 |
| 16.10.2009 | 11:01 | 10.34 | 150.14 | 11:05 | 10.33 | 150.14 | 29 |
| 16.10.2009 | 17:02 | 9.16 | 150.50 | 17:06 | 9.15 | 150.50 | 30 |
| 16.10.2009 | 23:00 | 7.98 | 150.85 | 23:06 | 7.96 | 150.86 | 31 |
| 17.10.2009 | 05:00 | 6.80 | 151.21 | 05:05 | 6.79 | 151.22 | 32 |
| 17.10.2009 | 11:00 | 5.61 | 151.58 | 11:07 | 5.59 | 151.59 | 33 |
| 17.10.2009 | 17:00 | 4.43 | 151.94 | 17:05 | 4.41 | 151.95 | 34 |
| 17.10.2009 | 22:59 | 3.27 | 152.30 | 23:03 | 3.26 | 152.30 | 35 |
| 18.10.2009 | 05:00 | 2.11 | 152.65 | 05:08 | 2.09 | 152.66 | 36 |
| 18.10.2009 | 11:01 | 0.91 | 153.02 | 11:05 | 0.89 | 153.03 | 37 |
| 18.10.2009 | 16:56 | -0.27 | 153.38 | 17:00 | -0.28 | 153.38 | 38 |
| 18.10.2009 | 23:01 | -1.45 | 153.74 | 23:03 | -1.45 | 153.74 | 39 |
| 19.10.2009 | 05:02 | -2.62 | 153.90 | 05:08 | -2.64 | 153.90 | 40 |
| 19.10.2009 | 11:00 | -3.80 | 153.99 | 11:06 | -3.82 | 153.99 | 41 |
| 19.10.2009 | 17:01 | -4.88 | 153.89 | 17:07 | -4.89 | 153.89 | 42 |
| 19.10.2009 | 23:02 | -5.96 | 154.02 | 23:07 | -5.97 | 154.02 | 43 |
| 20.10.2009 | 05:00 | -7.02 | 154.14 | 05:08 | -7.05 | 154.14 | 44 |
| 20.10.2009 | 10:59 | -7.93 | 154.24 | 11:03 | -7.94 | 154.24 | 45 |
| 20.10.2009 | 17:00 | -8.88 | 154.35 | 17:17 | -8.93 | 154.36 | 46 |
| 20.10.2009 | 23:00 | -9.85 | 154.46 | 23:11 | -9.89 | 154.47 | 47 |
| 21.10.2009 | 04:58 | -10.92 | 154.59 | 05:06 | -10.95 | 154.59 | 48 |
| 21.10.2009 | 11:00 | -11.84 | 154.26 | 11:11 | -11.86 | 154.23 | 49 |
| 21.10.2009 | 17:00 | -12.53 | 153.18 | 17:07 | -12.54 | 153.16 | 50 |
| 21.10.2009 | 22:59 | -13.22 | 152.08 | 23:04 | -13.23 | 152.06 | 51 |
| 22.10.2009 | 05:02 | -13.86 | 151.07 | 05:08 | -13.87 | 151.06 | 52 |
| 22.10.2009 | 11:00 | -14.48 | 150.08 | 11:06 | -14.49 | 150.07 | 53 |
| 22.10.2009 | 17:00 | -15.10 | 149.11 | 17:09 | -15.12 | 149.08 | 54 |
| 22.10.2009 | 23:00 | -15.73 | 148.10 | 23:07 | -15.74 | 148.08 | 55 |
| 23.10.2009 | 04:59 | -16.50 | 147.37 | 05:04 | -16.52 | 147.37 | 56 |
| 23.10.2009 | 11:00 | -17.51 | 147.30 | 11:04 | -17.52 | 147.30 | 57 |

**Table 9.3.3.** **OCEANIC TRACE GASES: $CH_4$ (water samples)**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
|---|---|---|---|---|---|---|---|
| **09.10.2009** | 12:00 | 41.19 | 142.06 | 12:10 | 41.16 | 142.07 | 1 |
| **09.10.2009** | 17:53 | 39.95 | 142.44 | 18:00 | 39.93 | 142.45 | 2 |
| **09.10.2009** | 23:55 | 38.81 | 142.79 | 00:00 | 38.79 | 142.79 | 3 |
| **10.10.2009** | 04:57 | 37.81 | 143.09 | 05:03 | 37.79 | 143.09 | 4 |
| **10.10.2009** | 16:58 | 35.53 | 143.76 | 17:01 | 35.52 | 143.76 | 5 |
| **11.10.2009** | 05:01 | 33.16 | 144.43 | 05:09 | 33.13 | 144.44 | 6 |
| **11.10.2009** | 17:00 | 30.80 | 145.09 | 17:08 | 30.77 | 145.09 | 7 |
| **12.10.2009** | 05:00 | 28.45 | 145.36 | 05:03 | 28.44 | 145.36 | 8 |
| **12.10.2009** | 17:01 | 26.16 | 145.36 | 17:07 | 26.14 | 145.36 | 9 |
| **13.10.2009** | 04:58 | 24.02 | 145.82 | 05:05 | 24.00 | 145.83 | 10 |
| **13.10.2009** | 16:58 | 21.85 | 146.53 | 17:04 | 21.83 | 146.54 | 11 |
| **14.10.2009** | 05:00 | 19.73 | 147.21 | 05:05 | 19.72 | 147.21 | 12 |
| **14.10.2009** | 17:00 | 17.52 | 147.91 | 17:04 | 17.51 | 147.92 | 13 |
| **15.10.2009** | 04:59 | 15.62 | 148.51 | 05:03 | 15.61 | 148.51 | 14 |
| **15.10.2009** | 17:00 | 13.64 | 149.12 | 17:07 | 13.62 | 149.13 | 15 |
| **16.10.2009** | 04:55 | 11.49 | 149.79 | 05:03 | 11.46 | 149.79 | 16 |
| **16.10.2009** | 17:02 | 9.16 | 150.50 | 17:06 | 9.15 | 150.50 | 17 |
| **17.10.2009** | 05:00 | 6.80 | 151.21 | 05:05 | 6.79 | 151.22 | 18 |
| **17.10.2009** | 17:00 | 4.43 | 151.94 | 17:05 | 4.41 | 151.95 | 19 |
| **18.10.2009** | 05:00 | 2.11 | 152.65 | 05:08 | 2.09 | 152.66 | 20 |
| **18.10.2009** | 16:56 | -0.27 | 153.38 | 17:00 | -0.28 | 153.38 | 21 |
| **19.10.2009** | 05:02 | -2.62 | 153.90 | 05:08 | -2.64 | 153.90 | 22 |
| **19.10.2009** | 17:01 | -4.88 | 153.89 | 17:07 | -4.89 | 153.89 | 23 |
| **20.10.2009** | 05:00 | -7.02 | 154.14 | 05:08 | -7.05 | 154.14 | 24 |
| **20.10.2009** | 17:00 | -8.88 | 154.35 | 17:17 | -8.93 | 154.36 | 25 |
| **20.10.2009** | 23:00 | -9.85 | 154.46 | 23:11 | -9.89 | 154.47 | 26 |
| **21.10.2009** | 04:48 | -10.89 | 154.59 | 05:06 | -10.95 | 154.59 | 27 |
| **21.10.2009** | 11:00 | -11.84 | 154.26 | 11:11 | -11.86 | 154.23 | 28 |
| **21.10.2009** | 17:00 | -12.53 | 153.18 | 17:07 | -12.54 | 153.16 | 29 |
| **21.10.2009** | 22:59 | -13.22 | 152.08 | 23:04 | -13.23 | 152.06 | 30 |
| **22.10.2009** | 05:02 | -13.86 | 151.07 | 05:08 | -13.87 | 151.06 | 31 |
| **22.10.2009** | 11:00 | -14.48 | 150.08 | 11:06 | -14.49 | 150.07 | 32 |
| **22.10.2009** | 17:00 | -15.10 | 149.11 | 17:09 | -15.12 | 149.08 | 33 |
| **22.10.2009** | 23:00 | -15.73 | 148.10 | 23:07 | -15.74 | 148.08 | 34 |
| **23.10.2009** | 04:59 | -16.50 | 147.37 | 05:04 | -16.52 | 147.37 | 35 |
| **23.10.2009** | 11:00 | -17.51 | 147.30 | 11:04 | -17.52 | 147.30 | 36 |

| Table 9.4.1. | OCEANSENSORS: $pCO_2$ (continuous) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date UTC** | **Sampling start** | **Position lat (North)** | **Position lon (East)** | **Sampling stop** | **Position lat (North)** | **Position lon (East)** | **File-ID** |
| **10.10.2009** | | | | 08:06 | 37.21 | 143.27 | 091009 |
| **10.10.2009** | 08:09 | 37.20 | 143.27 | 10:19 | 36.79 | 143.39 | 091010 |
| **10.10.2009** | 10:28 | 36.76 | 143.40 | 11:41 | 36.52 | 143.47 | 091010-2 |
| **10.10.2009** | 11:45 | 36.51 | 143.47 | | | | |
| **11.10.2009** | | | | 08:04 | 32.52 | 144.61 | 091010-3 |
| **11.10.2009** | 08:04 | 32.52 | 144.61 | | | | |
| **12.10.2009** | | | | 02:50 | 28.88 | 145.36 | 091011 |
| **12.10.2009** | 02:50 | 28.88 | 145.36 | | | | |
| **13.10.2009** | | | | 02:51 | 24.38 | 145.70 | 091012 |
| **13.10.2009** | 02:51 | 24.38 | 145.70 | | | | |
| **14.10.2009** | | | | 02:30 | 20.20 | 147.06 | 091013 |
| **14.10.2009** | 02:30 | 20.20 | 147.06 | | | | |
| **15.10.2009** | | | | 02:24 | 16.01 | 148.39 | 091014 |
| **15.10.2009** | 02:24 | 16.01 | 148.39 | | | | |
| **16.10.2009** | | | | 02:25 | 11.94 | 149.64 | 091015 |
| **16.10.2009** | 02:26 | 11.94 | 149.65 | | | | |
| **17.10.2009** | | | | 02:09 | 7.37 | 151.04 | 091016 |
| **17.10.2009** | 02:09 | 7.37 | 151.04 | | | | |
| **18.10.2009** | | | | 02:41 | 2.57 | 152.51 | 091017 |
| **18.10.2009** | 02:41 | 2.57 | 152.51 | 10:45 | 0.96 | 153.00 | 091018 |
| **18.10.2009** | 10:45 | 0.96 | 153.00 | | | | |
| **19.10.2009** | | | | 02:22 | -2.10 | 153.86 | 091018-2 |
| **19.10.2009** | 02:22 | -2.10 | 153.86 | | | | |
| **20.10.2009** | | | | 02:21 | -6.57 | 154.09 | 091019 |
| **20.10.2009** | 02:21 | -6.57 | 154.09 | | | | |
| **21.10.2009** | | | | 02:02 | -10.40 | 154.53 | 091020 |
| **21.10.2009** | 02:02 | -10.40 | 154.53 | | | | |
| **22.10.2009** | | | | 02:07 | -13.56 | 151.56 | 091021 |
| **22.10.2009** | 02:07 | -13.56 | 151.56 | | | | |
| **23.10.2009** | | | | 02:27 | -16.10 | 147.51 | 091022 |
| **23.10.2009** | 02:27 | -16.10 | 147.51 | 21:19 | -19.03 | 146.93 | 091023 |

**Table 9.4.2.** **OCEANSENSORS: Optode ($pO_2$, temperature)/ CTD (salinity, temperature)**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Optode(cont) File-ID | CTD salinity | CTD temperature |
|---|---|---|---|---|---|---|---|---|---|
| **10.10.2009** | | | | 08:17 | 37.18 | 143.28 | 091009 | continuous | continuous |
| **10.10.2009** | 08:18 | 37.17 | 143.28 | 10:11 | 36.81 | 143.38 | 091010 | continuous | continuous |
| **10.10.2009** | 10:16 | 36.80 | 143.39 | 10:36 | 36.73 | 143.41 | 091010-2 | continuous | continuous |
| **10.10.2009** | 12:06 | 36.44 | 143.49 | | | | | continuous | continuous |
| **11.10.2009** | | | | 08:08 | 32.51 | 144.62 | 091010-3 | continuous | continuous |
| **11.10.2009** | 08:08 | 32.51 | 144.62 | | | | | continuous | continuous |
| **12.10.2009** | | | | 02:52 | 28.87 | 145.36 | 091011 | continuous | continuous |
| **12.10.2009** | 02:53 | 28.87 | 145.36 | | | | | continuous | continuous |
| **13.10.2009** | | | | 02:52 | 24.37 | 145.70 | 091012 | continuous | continuous |
| **13.10.2009** | 02:53 | 24.37 | 145.70 | | | | | continuous | continuous |
| **14.10.2009** | | | | 02:32 | 20.20 | 147.06 | 091013 | continuous | continuous |
| **14.10.2009** | 02:32 | 20.20 | 147.06 | | | | | continuous | continuous |
| **15.10.2009** | | | | 02:26 | 16.00 | 148.39 | 091014 | continuous | continuous |
| **15.10.2009** | 02:26 | 16.00 | 148.39 | | | | | continuous | continuous |
| **16.10.2009** | | | | 02:27 | 11.94 | 149.65 | 091015 | continuous | continuous |
| **16.10.2009** | 02:28 | 11.94 | 149.65 | | | | | continuous | continuous |
| **17.10.2009** | | | | 02:10 | 7.36 | 151.04 | 091016 | continuous | continuous |
| **17.10.2009** | 02:11 | 7.36 | 151.04 | | | | | continuous | continuous |
| **18.10.2009** | | | | 02:42 | 2.56 | 152.51 | 091017 | continuous | continuous |
| **18.10.2009** | 02:43 | 2.56 | 152.52 | | | | | continuous | continuous |
| **19.10.2009** | | | | 02:24 | -2.11 | 153.86 | 091018 | continuous | continuous |
| **19.10.2009** | 02:24 | -2.11 | 153.86 | | | | | continuous | continuous |
| **20.10.2009** | | | | 02:22 | -6.57 | 154.09 | 091019 | continuous | continuous |
| **20.10.2009** | 02:22 | -6.57 | 154.09 | | | | | continuous | continuous |
| **21.10.2009** | | | | 02:04 | -10.41 | 154.53 | 091020 | continuous | continuous |
| **21.10.2009** | 02:04 | -10.41 | 154.53 | | | | | continuous | continuous |
| **22.10.2009** | | | | 02:08 | -13.56 | 151.55 | 091021 | continuous | continuous |
| **22.10.2009** | 02:08 | -13.56 | 151.55 | | | | | continuous | continuous |
| **23.10.2009** | | | | 02:29 | -16.10 | 147.51 | 091022 | continuous | continuous |
| **23.10.2009** | 02:29 | -16.10 | 147.51 | 21:20 | -19.04 | 146.93 | 091023 | continuous | continuous |

| Table 9.4.3. | OCEANSENSORS: Gastension (continuous) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date UTC** | **Sampling start** | **Position lat (North)** | **Position lon (East)** | **Sampling stop** | **Position lat (North)** | **Position lon (East)** | **File-ID** |
| **10.10.2009** | | | | 08:13 | 37.19 | 143.27 | 091009 |
| **10.10.2009** | 08:14 | 37.19 | 143.27 | 10:17 | 36.79 | 143.39 | 091010 |
| **10.10.2009** | 10:18 | 36.79 | 143.39 | 11:41 | 36.52 | 143.47 | 091010-2 |
| **10.10.2009** | 11:46 | 36.50 | 143.47 | | | | |
| **11.10.2009** | | | | 08:06 | 32.51 | 144.61 | 091010-3 |
| **11.10.2009** | 08:07 | 32.51 | 144.62 | | | | |
| **12.10.2009** | | | | 02:51 | 28.88 | 145.36 | 091011 |
| **12.10.2009** | 02:52 | 28.87 | 145.36 | | | | |
| **13.10.2009** | | | | 02:51 | 24.38 | 145.70 | 091012 |
| **13.10.2009** | 02:52 | 24.37 | 145.70 | | | | |
| **14.10.2009** | | | | 02:31 | 20.20 | 147.06 | 091013 |
| **14.10.2009** | 02:31 | 20.20 | 147.06 | | | | |
| **15.10.2009** | | | | 02:25 | 16.00 | 148.39 | 091014 |
| **15.10.2009** | 02:25 | 16.00 | 148.39 | | | | |
| **16.10.2009** | | | | 02:26 | 11.94 | 149.65 | 091015 |
| **16.10.2009** | 02:27 | 11.94 | 149.65 | | | | |
| **17.10.2009** | | | | 02:09 | 7.37 | 151.04 | 091016 |
| **17.10.2009** | 02:10 | 7.36 | 151.04 | | | | |
| **18.10.2009** | | | | 02:41 | 2.57 | 152.51 | 091017 |
| **18.10.2009** | 02:42 | 2.56 | 152.51 | | | | |
| **19.10.2009** | | | | 02:23 | -2.11 | 153.86 | 091018 |
| **19.10.2009** | 02:23 | -2.11 | 153.86 | | | | |
| **20.10.2009** | | | | 02:21 | -6.57 | 154.09 | 091019 |
| **20.10.2009** | 02:22 | -6.57 | 154.09 | | | | |
| **21.10.2009** | | | | 02:03 | -10.41 | 154.53 | 091020 |
| **21.10.2009** | 02:03 | -10.41 | 154.53 | | | | |
| **22.10.2009** | | | | 02:07 | -13.56 | 151.56 | 091021 |
| **22.10.2009** | 02:07 | -13.56 | 151.56 | | | | |
| **23.10.2009** | | | | 02:28 | -16.10 | 147.51 | 091022 |
| **23.10.2009** | 02:29 | -16.10 | 147.51 | 21:20 | -19.04 | 146.93 | 091023 |

| Table 9.4.4. | OCEANSENSORS: $CO_2$ (water samples) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date UTC** | **Sampling start** | **Position lat (North)** | **Position lon (East)** | **Sampling stop** | **Position lat (North)** | **Position lon (East)** | **Sample-ID** |
| **10.10.2009** | 03:54 | 38.01 | 143.03 | 03:54 | 38.01 | 143.03 | 01/1 |
| **10.10.2009** | 09:16 | 36.99 | 143.33 | 09:16 | 36.99 | 143.33 | 01/2 |
| **11.10.2009** | 02:38 | 33.65 | 144.29 | 02:38 | 33.65 | 144.29 | 02 |
| **12.10.2009** | 02:45 | 28.90 | 145.36 | 02:45 | 28.90 | 145.36 | 03 |
| **12.10.2009** | 22:25 | 25.17 | 145.44 | 22:25 | 25.17 | 145.44 | 04/1 |
| **13.10.2009** | 08:11 | 23.45 | 146.01 | 08:11 | 23.45 | 146.01 | 04/2 |
| **14.10.2009** | 02:52 | 20.13 | 147.08 | 02:52 | 20.13 | 147.08 | 05 |
| **15.10.2009** | 02:37 | 15.97 | 148.40 | 02:37 | 15.97 | 148.40 | 06 |
| **16.10.2009** | 02:20 | 11.96 | 149.64 | 02:20 | 11.96 | 149.64 | 07 |
| **17.10.2009** | 02:20 | 7.33 | 151.05 | 02:20 | 7.33 | 151.05 | 08 |
| **18.10.2009** | 05:16 | 2.06 | 152.67 | 05:16 | 2.06 | 152.67 | 09/1 |
| **18.10.2009** | 11:38 | 0.78 | 153.06 | 11:38 | 0.78 | 153.06 | 09/2 |
| **19.10.2009** | 02:18 | -2.09 | 153.86 | 02:18 | -2.09 | 153.86 | 10 |
| **20.10.2009** | 02:36 | -6.61 | 154.09 | 02:36 | -6.61 | 154.09 | 11 |
| **21.10.2009** | 02:12 | -10.43 | 154.53 | 02:12 | -10.43 | 154.53 | 12/1 |
| **21.10.2009** | 11:30 | -11.90 | 154.17 | 11:30 | -11.90 | 154.17 | 12/2 |
| **22.10.2009** | 02:46 | -13.62 | 151.45 | 02:46 | -13.62 | 151.45 | 13 |
| **23.10.2009** | 02:37 | -16.11 | 147.49 | 02:37 | -16.11 | 147.49 | 14/1 |
| **23.10.2009** | 11:44 | -17.63 | 147.29 | 11:44 | -17.63 | 147.29 | 14/2 |
| **23.10.2009** | 20:27 | -18.88 | 146.92 | 20:27 | -18.88 | 146.92 | 14/3 |

**Table 9.5.1.**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Radiosonde-ID | Ozone-sonde | Frost-point temperature (Snow White *SW*) | Particle backscatter (COBALD) |
|---|---|---|---|---|---|---|---|
| **09.10.2009** | 10:55 | 39.01 | 142.73 | 904608 | | | |
| **09.10.2009** | 17:04 | 36.64 | 143.43 | 904603 | | | |
| **09.10.2009** | 22:46 | 35.57 | 143.75 | 904594 | | | |
| **10.10.2009** | 04:40 | 36.72 | 143.41 | 904657 | | | |
| **10.10.2009** | 11:02 | 34.37 | 144.09 | 904605 | | | |
| **10.10.2009** | 17:09 | 31.92 | 144.78 | 904733 | | | |
| **10.10.2009** | 22:56 | 30.81 | 145.08 | 904585 | | | |
| **11.10.2009** | 5:03 | 31.93 | 144.77 | 910084 | x | | |
| **11.10.2009** | 11:06 | 29.60 | 145.36 | 904607 | | | |
| **11.10.2009** | 16:54 | 27.29 | 145.36 | 904687 | | | |
| **11.10.2009** | 22:54 | 26.18 | 145.36 | 904719 | | | |
| **12.10.2009** | 7:57 | 26.17 | 145.36 | 904664 | | | |
| **12.10.2009** | 10:58 | 25.07 | 145.47 | 904016 | | | |
| **12.10.2009** | 17:21 | 22.87 | 146.20 | 842010 | x | | |
| **12.10.2009** | 22:52 | 21.87 | 146.52 | 904595 | | | |
| **13.10.2009** | 4:56 | 22.94 | 146.17 | 904773 | | | |
| **13.10.2009** | 11:38 | 20.61 | 146.93 | | x | x | x |
| **13.10.2009** | 17:16 | 18.57 | 147.58 | 903847 | | | |
| **13.10.2009** | 22:57 | 17.53 | 147.91 | 904593 | | | |
| **14.10.2009** | 1:55 | 19.75 | 147.21 | 903468 | | | |
| **14.10.2009** | 4:58 | 18.63 | 147.56 | 904763 | | | |
| **14.10.2009** | 7:50 | 17.55 | 147.90 | 904688 | | | |
| **14.10.2009** | 11:06 | 16.51 | 148.23 | | x | x | x |
| **14.10.2009** | 18:03 | 14.53 | 148.85 | 903571 | | | |
| **14.10.2009** | 23:11 | 16.04 | 148.38 | 904160 | | | |
| **15.10.2009** | 5:13 | 14.67 | 148.79 | 903549 | | | |
| **15.10.2009** | 10:56 | 12.56 | 149.45 | 846030 | x | | |
| **15.10.2009** | 17:02 | 10.33 | 150.14 | 903651 | | | |
| **15.10.2009** | 22:50 | 11.50 | 149.78 | 904684 | | | |
| **16.10.2009** | 5:00 | 10.34 | 150.14 | 903775 | | | |
| **16.10.2009** | 11:01 | 7.98 | 150.86 | 842006 | x | | |
| **16.10.2009** | 17:02 | 5.61 | 151.58 | 904713 | | | |
| **16.10.2009** | 23:04 | 6.79 | 151.22 | 904758/904666 | | | |
| **17.10.2009** | 4:59 | 5.62 | 151.58 | 846018 | x | | |
| **17.10.2009** | 10:59 | 3.27 | 152.30 | 904652 | | | |
| **17.10.2009** | 16:50 | 0.95 | 153.01 | 904707 | | | |
| **17.10.2009** | 22:56 | 2.13 | 152.65 | 904675 | | | |
| **18.10.2009** | 5:00 | 0.91 | 153.02 | 902934 | | | |
| **18.10.2009** | 12:26 | -1.73 | 153.83 | | x | | |
| **18.10.2009** | 16:51 | -3.77 | 153.98 | 903610 | | | |
| **18.10.2009** | 22:57 | -2.61 | 153.90 | 904672 | | | |
| **19.10.2009** | 4:55 | -3.78 | 153.98 | 904749 | | | |
| **19.10.2009** | 10:57 | -5.95 | 154.01 | 910066 | x | x | x |
| **19.10.2009** | 17:02 | -7.94 | 154.24 | 904654 | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **19.10.2009** | 23:02 | -7.03 | 154.14 | 904020 | | | |
| **20.10.2009** | 5:01 | -7.94 | 154.24 | 903515 | | | |
| **20.10.2009** | 11:03 | -9.86 | 154.47 | 846009 | x | | |
| **20.10.2009** | 17:09 | -11.86 | 154.23 | 904762 | | | |
| **20.10.2009** | 22:56 | -10.92 | 154.59 | 904710/904714 | | | |
| **21.10.2009** | 5:01 | -11.84 | 154.26 | 904674 | | | |
| **21.10.2009** | 10:52 | -13.21 | 152.10 | 846045 | x | | |
| **21.10.2009** | 17:04 | -14.49 | 150.07 | 904483 | | | |
| **21.10.2009** | 22:57 | -13.85 | 151.09 | 904754 | | | |
| **22.10.2009** | 5:04 | -14.49 | 150.07 | 903740 | | | |
| **22.10.2009** | 11:06 | -15.74 | 148.08 | 842012 | x | x | x |
| **22.10.2009** | 16:57 | -17.50 | 147.30 | 904738 | | | |
| **22.10.2009** | 23:02 | -16.51 | 147.37 | 904764 | | | |
| **23.10.2009** | 4:55 | -17.50 | 147.30 | 904755 | | | |

**Table 9.6.** **MAX-DOAS (multi-axis differential optical absorption spectroscopy) (3-minutes data)**

| **Date UTC** | **BrO, IO** | **HCHO, $CH_3CHO$, $O_3$, $SO_2$, NO2** |
|---|---|---|
| **09.10.2009** | continuous | continuous |
| **10.10.2009** | continuous | continuous |
| **11.10.2009** | continuous | continuous |
| **12.10.2009** | continuous | continuous |
| **13.10.2009** | continuous | continuous |
| **14.10.2009** | continuous | continuous |
| **15.10.2009** | continuous | continuous |
| **16.10.2009** | continuous | continuous |
| **17.10.2009** | continuous | continuous |
| **18.10.2009** | continuous | continuous |
| **19.10.2009** | continuous | continuous |
| **20.10.2009** | continuous | continuous |
| **21.10.2009** | continuous | continuous |
| **22.10.2009** | continuous | continuous |
| **23.10.2009** | continuous | continuous |

| Table 9.7.1. | AIRSAMPLING: Canisters Miami | | | | | | |
|---|---|---|---|---|---|---|---|
| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
| 09.10.2009 | 13:40 | 40.81 | 142.17 | 13:45 | 40.79 | 142.18 | So01 |
| 09.10.2009 | 17:20 | 40.06 | 142.41 | 17:24 | 40.05 | 142.41 | So02 |
| 09.10.2009 | 23:02 | 38.98 | 142.74 | 23:07 | 38.97 | 142.74 | So03 |
| 10.10.2009 | 05:06 | 37.78 | 143.10 | 05:11 | 37.77 | 143.10 | So04 |
| 10.10.2009 | 11:23 | 36.58 | 143.45 | 11:28 | 36.56 | 143.46 | So05 |
| 10.10.2009 | 17:01 | 35.52 | 143.76 | 17:06 | 35.50 | 143.76 | So06 |
| 10.10.2009 | 23:15 | 34.32 | 144.10 | 23:20 | 34.31 | 144.11 | So07 |
| 11.10.2009 | 05:15 | 33.11 | 144.45 | 05:20 | 33.09 | 144.45 | So08 |
| 11.10.2009 | 11:08 | 31.92 | 144.78 | 11:16 | 31.89 | 144.79 | So09 |
| 11.10.2009 | 17:03 | 30.79 | 145.09 | 17:18 | 30.74 | 145.10 | So10 |
| 11.10.2009 | 23:05 | 29.61 | 145.36 | 23:10 | 29.59 | 145.36 | So11 |
| 12.10.2009 | 05:09 | 28.42 | 145.36 | 05:11 | 28.41 | 145.36 | So12 |
| 12.10.2009 | 06:01 | 28.24 | 145.36 | 06:04 | 28.23 | 145.36 | So13 |
| 12.10.2009 | 07:03 | 28.03 | 145.36 | 07:06 | 28.02 | 145.36 | So14 |
| 12.10.2009 | 08:04 | 27.83 | 145.36 | 08:16 | 27.79 | 145.36 | So15 |
| 12.10.2009 | 08:58 | 27.66 | 145.36 | 09:10 | 27.62 | 145.36 | So16 |
| 12.10.2009 | 10:02 | 27.45 | 145.36 | 10:04 | 27.45 | 145.36 | So17 |
| 12.10.2009 | 11:03 | 27.26 | 145.36 | 11:08 | 27.25 | 145.36 | So18 |
| 12.10.2009 | 12:12 | 27.05 | 145.36 | 12:17 | 27.03 | 145.36 | So19 |
| 12.10.2009 | 13:06 | 26.89 | 145.36 | 13:11 | 26.87 | 145.36 | So20 |
| 12.10.2009 | 14:06 | 26.70 | 145.36 | 14:11 | 26.69 | 145.36 | So21 |
| 12.10.2009 | 15:06 | 26.51 | 145.36 | 15:11 | 26.50 | 145.36 | So22 |
| 12.10.2009 | 16:07 | 26.33 | 145.36 | 16:12 | 26.31 | 145.36 | So23 |
| 12.10.2009 | 17:11 | 26.13 | 145.36 | 17:13 | 26.12 | 145.36 | So24 |
| 12.10.2009 | 18:03 | 25.98 | 145.36 | 18:05 | 25.97 | 145.36 | So25 |
| 12.10.2009 | 19:13 | 25.76 | 145.36 | 19:15 | 25.76 | 145.36 | So26 |
| 12.10.2009 | 20:08 | 25.59 | 145.36 | 20:10 | 25.58 | 145.36 | So27 |
| 12.10.2009 | 21:05 | 25.41 | 145.36 | 21:07 | 25.40 | 145.36 | So28 |
| 12.10.2009 | 22:08 | 25.22 | 145.42 | 22:10 | 25.21 | 145.42 | So29 |
| 12.10.2009 | 23:00 | 25.07 | 145.47 | 23:05 | 25.05 | 145.48 | So30 |
| 13.10.2009 | 05:30 | 23.93 | 145.85 | 05:32 | 23.93 | 145.85 | So31 |
| 13.10.2009 | 11:15 | 22.89 | 146.19 | 11:17 | 22.88 | 146.19 | So32 |
| 13.10.2009 | 17:01 | 21.84 | 146.53 | 17:03 | 21.83 | 146.53 | So33 |
| 13.10.2009 | 23:05 | 20.72 | 146.89 | 23:07 | 20.71 | 146.90 | So34 |
| 14.10.2009 | 02:16 | 20.25 | 147.04 | 02:18 | 20.24 | 147.05 | So35 |
| 14.10.2009 | 02:26 | 20.21 | 147.06 | 02:28 | 20.21 | 147.06 | So36 |
| 14.10.2009 | 05:01 | 19.73 | 147.21 | 05:06 | 19.71 | 147.22 | So37 |
| 14.10.2009 | 05:12 | 19.69 | 147.22 | 05:17 | 19.68 | 147.23 | So38 |
| 14.10.2009 | 08:20 | 19.12 | 147.41 | 08:25 | 19.10 | 147.41 | So39 |
| 14.10.2009 | 11:10 | 18.59 | 147.57 | 11:15 | 18.57 | 147.58 | So40 |
| 14.10.2009 | 17:27 | 17.44 | 147.94 | 17:29 | 17.43 | 147.94 | So41 |
| 14.10.2009 | 23:10 | 16.50 | 148.23 | 23:12 | 16.50 | 148.23 | So42 |
| 15.10.2009 | 05:06 | 15.60 | 148.51 | 05:11 | 15.59 | 148.52 | So43 |
| 15.10.2009 | 11:27 | 14.63 | 148.81 | 11:29 | 14.63 | 148.81 | So44 |
| 15.10.2009 | 17:05 | 13.62 | 149.13 | 17:10 | 13.61 | 149.13 | So45 |

| Table 9.7.1. | AIRSAMPLING: Canisters Miami | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date UTC** | **Sampling start** | **Position lat (North)** | **Position lon (East)** | **Sampling stop** | **Position lat (North)** | **Position lon (East)** | **Sample-ID** |
| **15.10.2009** | 23:27 | 12.47 | 149.48 | 23:29 | 12.47 | 149.48 | So46 |
| **16.10.2009** | 05:16 | 11.42 | 149.81 | 05:18 | 11.42 | 149.81 | So47 |
| **16.10.2009** | 11:07 | 10.32 | 150.14 | 11:12 | 10.30 | 150.15 | So48 |
| **16.10.2009** | 17:17 | 9.11 | 150.51 | 17:19 | 9.11 | 150.51 | So49 |
| **16.10.2009** | 23:33 | 7.87 | 150.89 | 23:25 | 7.90 | 150.88 | So50 |
| **17.10.2009** | 04:51 | 6.83 | 151.21 | 04:53 | 6.83 | 151.21 | So51 |
| **17.10.2009** | 11:08 | 5.59 | 151.59 | 11:13 | 5.57 | 151.59 | So52 |
| **17.10.2009** | 17:12 | 4.39 | 151.96 | 17:17 | 4.37 | 151.96 | So53 |
| **17.10.2009** | 23:18 | 3.21 | 152.32 | 23:20 | 3.21 | 152.32 | So54 |
| **18.10.2009** | 05:26 | 2.03 | 152.68 | 05:28 | 2.02 | 152.68 | So55 |
| **18.10.2009** | 11:23 | 0.83 | 153.04 | 11:25 | 0.83 | 153.05 | So56 |
| **18.10.2009** | 17:00 | -0.28 | 153.38 | 17:05 | -0.29 | 153.39 | So57 |
| **18.10.2009** | 23:30 | -1.54 | 153.77 | 23:32 | -1.55 | 153.77 | So58 |
| **19.10.2009** | 05:25 | -2.69 | 153.90 | 05:30 | -2.71 | 153.90 | So59 |
| **19.10.2009** | 11:06 | -3.82 | 153.99 | 11:11 | -3.84 | 153.99 | So60 |
| **19.10.2009** | 17:19 | -4.93 | 153.90 | 17:21 | -4.94 | 153.90 | So61 |
| **19.10.2009** | 23:09 | -5.98 | 154.02 | 23:09 | -5.98 | 154.02 | So62 |
| **20.10.2009** | 05:08 | -7.05 | 154.14 | 05:10 | -7.05 | 154.14 | So63 |
| **20.10.2009** | 11:07 | -7.95 | 154.25 | 11:09 | -7.96 | 154.25 | So64 |
| **20.10.2009** | 17:11 | -8.91 | 154.36 | 17:13 | -8.92 | 154.36 | So65 |
| **20.10.2009** | 23:05 | -9.87 | 154.47 | 23:07 | -9.87 | 154.47 | So66 |
| **21.10.2009** | 05:12 | -10.96 | 154.59 | 05:14 | -10.97 | 154.60 | So67 |
| **21.10.2009** | 11:08 | -11.86 | 154.24 | 11:10 | -11.86 | 154.23 | So68 |
| **21.10.2009** | 17:08 | -12.54 | 153.16 | 17:13 | -12.55 | 153.15 | So69 |
| **21.10.2009** | 23:32 | -13.28 | 151.99 | 23:34 | -13.29 | 151.98 | So70 |
| **22.10.2009** | 05:42 | -13.93 | 150.96 | 05:44 | -13.93 | 150.96 | So71 |
| **22.10.2009** | 11:08 | -14.50 | 150.07 | 11:10 | -14.50 | 150.07 | So72 |
| **22.10.2009** | 17:41 | -15.17 | 148.98 | 17:43 | -15.18 | 148.98 | So73 |
| **22.10.2009** | 23:23 | -15.77 | 148.04 | 23:28 | -15.78 | 148.02 | So74 |
| **23.10.2009** | 05:30 | -16.60 | 147.37 | 05:32 | -16.61 | 147.37 | So75 |
| **23.10.2009** | 11:11 | -17.54 | 147.29 | 11:13 | -17.55 | 147.29 | So76 |
| **23.10.2009** | 17:12 | -18.39 | 146.96 | 17:14 | -18.39 | 146.95 | So77 |
| **23.10.2009** | 20:06 | -18.82 | 146.92 | 20:08 | -18.83 | 146.92 | So78 |

| Table 9.7.2. | AIRSAMPLING: Canisters Frankfurt | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date UTC** | **Sampling start** | **Position lat (North)** | **Position lon (East)** | **Sampling stop** | **Position lat (North)** | **Position lon (East)** | **Sample-ID** |
| **09.10.2009** | 13:45 | 40.79 | 142.18 | 13:50 | 40.77 | 142.18 | So01 |
| **09.10.2009** | 23:19 | 38.93 | 142.75 | 23:24 | 38.91 | 142.76 | So02 |
| **10.10.2009** | 11:07 | 36.63 | 143.44 | 11:12 | 36.61 | 143.44 | So03 |
| **10.10.2009** | 23:25 | 34.29 | 144.11 | 23:30 | 34.28 | 144.12 | So04 |
| **11.10.2009** | 10:50 | 31.97 | 144.76 | 11:08 | 31.92 | 144.78 | So05 |
| **11.10.2009** | 23:14 | 29.58 | 145.36 | 23:19 | 29.56 | 145.36 | So06 |
| **12.10.2009** | 11:16 | 27.22 | 145.36 | 11:21 | 27.21 | 145.36 | So07 |
| **12.10.2009** | 23:10 | 25.04 | 145.48 | 23:17 | 25.02 | 145.49 | So08 |
| **13.10.2009** | 11:35 | 22.83 | 146.21 | 11:37 | 22.82 | 146.21 | So09 |
| **13.10.2009** | 23:13 | 20.69 | 146.90 | 23:15 | 20.69 | 146.90 | So10 |
| **14.10.2009** | 11:20 | 18.56 | 147.58 | 11:25 | 18.54 | 147.59 | So11 |
| **14.10.2009** | 23:00 | 16.53 | 148.22 | 23:02 | 16.52 | 148.23 | So12 |
| **15.10.2009** | 11:15 | 14.66 | 148.79 | 11:17 | 14.66 | 148.79 | So13 |
| **15.10.2009** | 23:17 | 12.50 | 149.47 | 23:19 | 12.50 | 149.47 | So14 |
| **16.10.2009** | 11:17 | 10.29 | 150.15 | 11:23 | 10.27 | 150.16 | So15 |
| **16.10.2009** | 23:21 | 7.91 | 150.88 | 23:23 | 7.90 | 150.88 | So16 |
| **17.10.2009** | 11:31 | 5.51 | 151.61 | 11:36 | 5.49 | 151.62 | So17 |
| **17.10.2009** | 23:09 | 3.24 | 152.31 | 23:11 | 3.24 | 152.31 | So18 |
| **18.10.2009** | 11:13 | 0.87 | 153.03 | 11:15 | 0.86 | 153.04 | So19 |
| **18.10.2009** | 23:20 | -1.51 | 153.76 | 23:22 | -1.52 | 153.76 | So20 |
| **19.10.2009** | 23:15 | -6.00 | 154.02 | 23:20 | -6.01 | 154.02 | So21 |
| **20.10.2009** | 23:15 | -9.90 | 154.47 | 23:17 | -9.90 | 154.47 | So22 |
| **21.10.2009** | 23:21 | -13.26 | 152.02 | 23:23 | -13.27 | 152.01 | So23 |

**Table 9.7.3.** **AIRSAMPLING: Aerosol**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
|---|---|---|---|---|---|---|---|
| **10.10.2009** | 00:05 | 38.77 | 142.80 | | | | |
| **11.10.2009** | | | | 03:03 | 33.57 | 144.32 | SN09I01 |
| **11.10.2009** | 04:30 | 33.27 | 144.40 | | | | |
| **12.10.2009** | | | | 00:04 | 29.41 | 145.36 | SN09I02 |
| **12.10.2009** | 00:42 | 29.29 | 145.36 | | | | |
| **13.10.2009** | | | | 02:31 | 24.43 | 145.68 | SN09I03 |
| **13.10.2009** | 03:22 | 24.29 | 145.73 | 23:57 | 20.55 | 146.95 | SN09I04 |
| **14.10.2009** | 00:27 | 20.46 | 146.98 | 23:00 | 16.53 | 148.22 | SN09I05 |
| **15.10.2009** | 00:04 | 16.36 | 148.27 | 23:04 | 12.54 | 149.46 | SN09I06 |
| **15.10.2009** | 23:50 | 12.40 | 149.50 | | | | |
| **16.10.2009** | | | | 23:10 | 7.95 | 150.86 | SN09I07 |
| **17.10.2009** | 00:20 | 7.72 | 150.93 | | | | |
| **18.10.2009** | | | | 00:30 | 2.98 | 152.39 | SN09I08 |
| **18.10.2009** | 00:01 | 3.08 | 152.36 | 23:16 | -1.50 | 153.76 | SN09I09 |
| **18.10.2009** | 23:50 | -1.61 | 153.79 | | | | |
| **19.10.2009** | | | | 22:57 | -5.95 | 154.01 | SN09I10 |
| **19.10.2009** | 23:45 | -6.09 | 154.03 | | | | |
| **20.10.2009** | | | | 23:02 | -9.86 | 154.47 | SN09I11 |
| **20.10.2009** | 23:35 | -9.96 | 154.48 | | | | |
| **21.10.2009** | | | | 23:10 | -13.25 | 152.05 | SN09I12 |
| **22.10.2009** | 00:00 | -13.33 | 151.91 | 23:20 | -15.76 | 148.04 | SN09I13 |
| **22.10.2009** | 23:59 | -15.83 | 147.94 | 23:59 | -15.83 | 147.94 | MOTOR BLANK |
| **23.10.2009** | 00:10 | -15.85 | 147.91 | 11:33 | -17.60 | 147.29 | CASSETTE BLANK |
| **23.10.2009** | 11:36 | -17.61 | 147.29 | 20:10 | -18.83 | 146.91 | EXPOSURE BLANK |

| Table 9.7.4. | AIRSAMPLING: Hydrogen | | | | | | |
|---|---|---|---|---|---|---|---|
| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
| 09.10.2009 | 23:29 | 38.89 | 142.76 | 23:29 | 38.89 | 142.76 | 107440 |
| 10.10.2009 | 05:11 | 37.77 | 143.10 | 05:11 | 37.77 | 143.10 | 107441 |
| 10.10.2009 | 11:00 | 36.65 | 143.43 | 11:00 | 36.65 | 143.43 | 107442 |
| 10.10.2009 | 17:22 | 35.46 | 143.78 | 17:22 | 35.46 | 143.78 | 107443 |
| 10.10.2009 | 23:02 | 34.37 | 144.09 | 23:02 | 34.37 | 144.09 | 107444 |
| 11.10.2009 | 05:30 | 33.06 | 144.46 | 05:30 | 33.06 | 144.46 | 107445 |
| 11.10.2009 | 11:00 | 31.94 | 144.77 | 11:00 | 31.94 | 144.77 | 107446 |
| 11.10.2009 | 17:23 | 30.72 | 145.11 | 17:23 | 30.72 | 145.11 | 107447 |
| 11.10.2009 | 23:00 | 29.62 | 145.36 | 23:00 | 29.62 | 145.36 | 107448 |
| 12.10.2009 | 05:10 | 28.42 | 145.36 | 05:10 | 28.42 | 145.36 | 107449 |
| 12.10.2009 | 11:13 | 27.23 | 145.36 | 11:13 | 27.23 | 145.36 | 107450 |
| 12.10.2009 | 17:15 | 26.12 | 145.36 | 17:15 | 26.12 | 145.36 | 107451 |
| 12.10.2009 | 23:15 | 25.02 | 145.49 | 23:15 | 25.02 | 145.49 | 107452 |
| 13.10.2009 | 05:20 | 23.96 | 145.84 | 05:20 | 23.96 | 145.84 | 107453 |
| 13.10.2009 | 11:20 | 22.87 | 146.20 | 11:20 | 22.87 | 146.20 | 107454 |
| 13.10.2009 | 17:25 | 21.77 | 146.56 | 17:25 | 21.77 | 146.56 | 107455 |
| 13.10.2009 | 23:20 | 20.67 | 146.91 | 23:20 | 20.67 | 146.91 | 107456 |
| 14.10.2009 | 05:09 | 19.70 | 147.22 | 05:09 | 19.70 | 147.22 | 107457 |
| 14.10.2009 | 11:20 | 18.56 | 147.58 | 11:20 | 18.56 | 147.58 | 107458 |
| 14.10.2009 | 17:12 | 17.48 | 147.92 | 17:12 | 17.48 | 147.92 | 107459 |
| 14.10.2009 | 23:10 | 16.50 | 148.23 | 23:10 | 16.50 | 148.23 | 107460 |
| 15.10.2009 | 05:08 | 15.60 | 148.51 | 05:08 | 15.60 | 148.51 | 107461 |
| 15.10.2009 | 11:21 | 14.65 | 148.80 | 11:21 | 14.65 | 148.80 | 107462 |
| 15.10.2009 | 17:25 | 13.56 | 149.15 | 17:25 | 13.56 | 149.15 | 107463 |
| 15.10.2009 | 23:11 | 12.52 | 149.47 | 23:11 | 12.52 | 149.47 | 107464 |
| 16.10.2009 | 05:10 | 11.44 | 149.80 | 05:10 | 11.44 | 149.80 | 107465 |
| 16.10.2009 | 11:10 | 10.31 | 150.15 | 11:10 | 10.31 | 150.15 | 107466 |
| 16.10.2009 | 17:29 | 9.07 | 150.52 | 17:29 | 9.07 | 150.52 | 107467 |
| 16.10.2009 | 23:21 | 7.91 | 150.88 | 23:21 | 7.91 | 150.88 | 107468 |
| 17.10.2009 | 04:57 | 6.81 | 151.21 | 04:57 | 6.81 | 151.21 | 107469 |
| 17.10.2009 | 11:16 | 5.56 | 151.60 | 11:16 | 5.56 | 151.60 | 107470 |
| 17.10.2009 | 17:30 | 4.33 | 151.97 | 17:30 | 4.33 | 151.97 | 107471 |
| 17.10.2009 | 23:24 | 3.20 | 152.32 | 23:24 | 3.20 | 152.32 | 107472 |
| 18.10.2009 | 05:30 | 2.02 | 152.68 | 05:30 | 2.02 | 152.68 | 107473 |
| 18.10.2009 | 11:21 | 0.84 | 153.04 | 11:21 | 0.84 | 153.04 | 107474 |
| 18.10.2009 | 17:12 | -0.32 | 153.40 | 17:12 | -0.32 | 153.40 | 107475 |
| 18.10.2009 | 23:21 | -1.51 | 153.76 | 23:21 | -1.51 | 153.76 | 107476 |
| 19.10.2009 | 05:30 | -2.71 | 153.90 | 05:30 | -2.71 | 153.90 | 107477 |
| 19.10.2009 | 11:07 | -3.82 | 153.99 | 11:07 | -3.82 | 153.99 | 107478 |
| 19.10.2009 | 17:22 | -4.94 | 153.90 | 17:22 | -4.94 | 153.90 | 107479 |
| 19.10.2009 | 23:05 | -5.97 | 154.02 | 23:05 | -5.97 | 154.02 | 107480 |
| 20.10.2009 | 05:08 | -7.05 | 154.14 | 05:08 | -7.05 | 154.14 | 107481 |
| 20.10.2009 | 11:05 | -7.95 | 154.25 | 11:05 | -7.95 | 154.25 | 107482 |
| 20.10.2009 | 17:25 | -8.95 | 154.36 | 17:25 | -8.95 | 154.36 | 107483 |
| 20.10.2009 | 23:10 | -9.88 | 154.47 | 23:10 | -9.88 | 154.47 | 107484 |

**Table 9.7.4. AIRSAMPLING: Hydrogen**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
|---|---|---|---|---|---|---|---|
| **21.10.2009** | 05:18 | -10.98 | 154.60 | 05:18 | -10.98 | 154.60 | 107485 |
| **21.10.2009** | 11:07 | -11.86 | 154.24 | 11:07 | -11.86 | 154.24 | 107486 |
| **21.10.2009** | 17:13 | -12.55 | 153.15 | 17:13 | -12.55 | 153.15 | 107487 |
| **21.10.2009** | 23:15 | -13.25 | 152.04 | 23:15 | -13.25 | 152.04 | 107488 |
| **22.10.2009** | 05:35 | -13.92 | 150.98 | 05:35 | -13.92 | 150.98 | 107489 |
| **22.10.2009** | 11:11 | -14.50 | 150.07 | 11:11 | -14.50 | 150.07 | 107490 |
| **22.10.2009** | 17:43 | -15.18 | 148.98 | 17:43 | -15.18 | 148.98 | 107491 |
| **22.10.2009** | 23:15 | -15.76 | 148.06 | 23:15 | -15.76 | 148.06 | 107492 |
| **23.10.2009** | 05:25 | -16.59 | 147.37 | 05:25 | -16.59 | 147.37 | 107493 |

**Table 9.7.5. AIRSAMPLING: Adsorbed HVC (high volatile compounds)**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Sampling stop | Position lat (North) | Position lon (East) | Sample-ID |
|---|---|---|---|---|---|---|---|
| **11.10.2009** | 08:37 | 32.41 | 144.64 | | | | |
| **12.10.2009** | | | | 05:21 | 28.38 | 145.36 | SoC01/SoC02 |
| **12.10.2009** | 05:35 | 28.33 | 145.36 | | | | |
| **13.10.2009** | | | | 05:20 | 23.96 | 145.84 | SoC03/SoC04 |
| **13.10.2009** | 05:40 | 23.90 | 145.86 | | | | |
| **14.10.2009** | | | | 11:08 | 18.60 | 147.57 | SoC05/SoC06 |
| **14.10.2009** | 11:11 | 18.59 | 147.57 | | | | |
| **15.10.2009** | | | | 05:33 | 15.53 | 148.53 | SoCo7/SoC08 |
| **15.10.2009** | 05:39 | 15.52 | 148.54 | | | | |
| **16.10.2009** | | | | 08:10 | 10.88 | 149.97 | SoC09/SoC10 |
| **16.10.2009** | 08:20 | 10.85 | 149.98 | | | | |
| **17.10.2009** | | | | 04:56 | 6.82 | 151.21 | SoC11/SoC12 |
| **17.10.2009** | 10:20 | 5.74 | 151.54 | | | | |
| **18.10.2009** | | | | 11:20 | 0.84 | 153.04 | SoC13/SoC14 |
| **18.10.2009** | 11:23 | 0.83 | 153.04 | | | | |
| **19.10.2009** | | | | 05:22 | -2.69 | 153.90 | SoC15/SoC16 |
| **19.10.2009** | 05:24 | -2.69 | 153.90 | | | | |
| **20.10.2009** | | | | 05:15 | -7.06 | 154.14 | SoC17/SoC18 |
| **20.10.2009** | 05:20 | -7.08 | 154.14 | | | | |
| **21.10.2009** | | | | 05:22 | -10.99 | 154.60 | SoC19/SoC20 |
| **21.10.2009** | 05:22 | -10.99 | 154.60 | | | | |
| **22.10.2009** | | | | 05:24 | -13.90 | 151.01 | SoC21/SoC22 |
| **22.10.2009** | 05:26 | -13.90 | 151.01 | | | | |
| **23.10.2009** | | | | 05:18 | -16.56 | 147.37 | SoC23/SoC24 |
| **23.10.2009** | 05:20 | -16.57 | 147.37 | 20:00 | -18.81 | 146.92 | SoC25/SoC26 |

| Table 9.7.6. | AIRSAMPLING: Isotopes | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date UTC** | **Sampling start** | **Position lat (North)** | **Position lon (East)** | **Sampling stop** | **Position lat (North)** | **Position lon (East)** | **Sample-ID** |
| **11.10.2009** | 10:05 | 32.12 | 144.72 | 10:20 | 32.07 | 144.74 | 01 |
| **11.10.2009** | 22:32 | 29.72 | 145.36 | | | | |
| **12.10.2009** | | | | 00:45 | 29.28 | 145.36 | 02 |
| **17.10.2009** | 01:00 | 7.59 | 150.97 | | | | |
| **18.10.2009** | | | | 03:00 | 2.51 | 152.53 | 03 |
| **18.10.2009** | 03:00 | 2.51 | 152.53 | 11:25 | 0.83 | 153.05 | 04 |
| **18.10.2009** | 11:30 | 0.81 | 153.05 | 23:23 | -1.52 | 153.76 | 05 |
| **18.10.2009** | 23:24 | -1.52 | 153.76 | | | | |
| **19.10.2009** | | | | 11:05 | -3.82 | 153.99 | 06 |
| **19.10.2009** | 11:06 | -3.82 | 153.99 | 23:26 | -6.03 | 154.02 | 07 |
| **19.10.2009** | 23:27 | -6.03 | 154.02 | | | | |
| **20.10.2009** | | | | 10:52 | -7.91 | 154.24 | 08 |
| **20.10.2009** | 23:08 | -9.88 | 154.47 | | | | |
| **21.10.2009** | | | | 11:00 | -11.84 | 154.26 | 09 |
| **21.10.2009** | 23:15 | -13.25 | 152.04 | | | | |
| **22.10.2009** | | | | 11:05 | -14.49 | 150.07 | 10 |
| **22.10.2009** | 23:20 | -15.76 | 148.04 | | | | |
| **23.10.2009** | | | | 11:05 | -17.53 | 147.30 | 11 |

**Table 9.8.1.** **FTIR-SPECTROMETRY: Solar absorption (* filename)**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Range[cm$^{-1}$] 500-1350 | 1900-2750 | 2300-3400 | 2700-4000 | 3900-4500 | 4000-11000 |
|---|---|---|---|---|---|---|---|---|---|
| **10.10.2009** | 02:24 | 38.31 | 142.94 | | | 00-01.4 | | | |
| **10.10.2009** | 02:46 | 38.23 | 142.96 | 01.1 | | | | | |
| **10.10.2009** | 04:06 | 37.97 | 143.04 | | | | | | 000-009.7 |
| **11.10.2009** | 02:41 | 33.64 | 144.30 | | | 00.4 | | | |
| **11.10.2009** | 06:19 | 32.89 | 144.51 | | | 06-09.4 | | | |
| **11.10.2009** | 06:30 | 32.85 | 144.52 | 01.1 | | | | | |
| **13.10.2009** | 06:22 | 23.78 | 145.90 | | | *.4 | | | |
| **13.10.2009** | 21:16 | 21.06 | 146.79 | | | *.4 | | | |
| **13.10.2009** | 21:36 | 20.99 | 146.80 | *.1 | | | | | |
| **13.10.2009** | 21:41 | 20.98 | 146.81 | *.1 | | | | | |
| **13.10.2009** | 22:51 | 20.76 | 146.88 | | | | | *.6 | |
| **13.10.2009** | 23:07 | 20.71 | 146.90 | | | | *.5 | | |
| **13.10.2009** | 23:20 | 20.67 | 146.91 | | | | | | *.7 |
| **13.10.2009** | 23:32 | 20.63 | 146.92 | | | *.4 | | | |
| **13.10.2009** | 23:44 | 20.60 | 146.93 | *.1 | | | | | |
| **13.10.2009** | 23:54 | 20.56 | 146.94 | | | | | *.6 | |
| **14.10.2009** | 00:21 | 20.48 | 146.97 | | | | | | *.7 |
| **14.10.2009** | 00:43 | 20.45 | 146.98 | | | *.4 | | | |
| **14.10.2009** | 01:22 | 20.42 | 146.99 | | *.3 | | | | |
| **14.10.2009** | 02:16 | 20.25 | 147.04 | | | *.4 | | | |
| **14.10.2009** | 02:24 | 20.22 | 147.05 | *.1 | | | | | |
| **14.10.2009** | 02:43 | 20.16 | 147.07 | | | | | *.6 | |
| **14.10.2009** | 02:58 | 20.11 | 147.09 | | | | *.5 | | |
| **14.10.2009** | 03:06 | 20.08 | 147.10 | | *.3 | | | | |
| **14.10.2009** | | | | | | | | | *.7 |
| **14.10.2009** | 04:07 | 19.89 | 147.16 | | | *.4 | | | |
| **14.10.2009** | 05:10 | 19.70 | 147.22 | | | 06.4 | | | |
| **14.10.2009** | 05:29 | 19.64 | 147.24 | 01.1 | | | | | |
| **14.10.2009** | 05:55 | 19.56 | 147.26 | | | | | 02.6 | |
| **14.10.2009** | 06:03 | 19.54 | 147.27 | | | | 02.5 | | |
| **14.10.2009** | 06:14 | 19.51 | 147.28 | | | | | | *.7 |
| **15.10.2009** | 22:52 | 12.57 | 149.45 | | | *.4 | | | |
| **15.10.2009** | 23:07 | 12.53 | 149.46 | *.1 | | | | | |
| **15.10.2009** | 23:18 | 12.50 | 149.47 | | | | | *.6 | |
| **16.10.2009** | 06:03 | 11.28 | 149.85 | | | *.4 | | | |
| **16.10.2009** | 06:18 | 11.23 | 149.86 | *.1 | | | | | |
| **16.10.2009** | 06:29 | 11.20 | 149.87 | | | | | *.6 | |
| **16.10.2009** | 20:46 | 8.42 | 150.72 | | | *.4 | | | |
| **16.10.2009** | 21:02 | 8.37 | 150.74 | *.1 | | | | | |
| **16.10.2009** | 21:27 | 8.29 | 150.76 | | | | | *.6 | |
| **16.10.2009** | 22:07 | 8.15 | 150.80 | | | | *.5 | | |
| **16.10.2009** | 22:21 | 8.11 | 150.82 | | *.3 | | | | |
| **16.10.2009** | 22:32 | 8.07 | 150.83 | | | *.4 | | | |
| **16.10.2009** | 22:47 | 8.02 | 150.84 | *.1 | | | | | |

**Table 9.8.1.** **FTIR-SPECTROMETRY: Solar absorption (* filename)**

| | | | | Range[$cm^{-1}$] | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Date UTC** | **Sampling start** | **Position lat (North)** | **Position lon (East)** | **500-1350** | **1900-2750** | **2300-3400** | **2700-4000** | **3900-4500** | **4000-11000** |
| **16.10.2009** | 22:58 | 7.99 | 150.85 | | | | | *.6 | |
| **16.10.2009** | 23:35 | 7.86 | 150.89 | | | | *.5 | | |
| **16.10.2009** | 23:43 | 7.84 | 150.90 | | *.3 | | | | |
| **17.10.2009** | 00:40 | 7.65 | 150.95 | | | *.4 | | | |
| **17.10.2009** | 01:18 | 7.53 | 150.99 | | | *.4 | | | |
| **17.10.2009** | 01:31 | 7.49 | 151.00 | *.1 | | | | | |
| **17.10.2009** | 03:20 | 7.13 | 151.11 | | | | | *.6 | |
| **17.10.2009** | 04:16 | 6.95 | 151.17 | | | | *.5 | | |
| **17.10.2009** | 04:22 | 6.93 | 151.18 | | *.3 | | | | |
| **17.10.2009** | 04:40 | 6.87 | 151.19 | | | *.4 | | | |
| **17.10.2009** | 04:54 | 6.82 | 151.21 | *.1 | | | | | |
| **17.10.2009** | 05:02 | 6.80 | 151.22 | | | | | *.6 | |
| **17.10.2009** | 05:09 | 6.77 | 151.22 | | | | *.5 | | |
| **17.10.2009** | 05:15 | 6.75 | 151.23 | | *.3 | | | | |
| **17.10.2009** | 05:22 | 6.73 | 151.24 | | | *.4 | | | |
| **17.10.2009** | 05:37 | 6.68 | 151.25 | *.1 | | | | | |
| **17.10.2009** | 05:42 | 6.67 | 151.26 | *.1 | | | | | |
| **17.10.2009** | 06:07 | 6.58 | 151.28 | | | *.4 | | | |
| **17.10.2009** | 06:15 | 6.56 | 151.29 | | | | *.5 | | |
| **17.10.2009** | 06:25 | 6.52 | 151.30 | | *.3 | | | | |
| **17.10.2009** | 06:38 | 6.48 | 151.31 | | | *.4 | | | |
| **17.10.2009** | 21:08 | 3.63 | 152.19 | | | *.4 | | | |
| **17.10.2009** | 22:30 | 3.36 | 152.27 | | | *.4 | | | |
| **17.10.2009** | 22:47 | 3.31 | 152.29 | *.1 | | | | | |
| **17.10.2009** | 22:56 | 3.28 | 152.29 | | | | | *.6 | |
| **17.10.2009** | 23:10 | 3.24 | 152.31 | | | | | *.6 | |
| **17.10.2009** | 23:23 | 3.20 | 152.32 | | | | *.5 | | |
| **17.10.2009** | 23:36 | 3.16 | 152.33 | | | | *.5 | | |
| **17.10.2009** | 23:48 | 3.12 | 152.34 | | *.3 | | | | |
| **17.10.2009** | 23:56 | 3.09 | 152.35 | | *.3 | | | | |
| **18.10.2009** | 00:03 | 3.07 | 152.36 | | | *.4 | | | |
| **18.10.2009** | 00:38 | 2.96 | 152.39 | | | *.4 | | | |
| **18.10.2009** | 01:30 | 2.79 | 152.44 | *.1 | | | | | |
| **18.10.2009** | 02:40 | 2.57 | 152.51 | | | | | *.6 | |
| **18.10.2009** | 02:46 | 2.55 | 152.52 | | | | *.5 | | |
| **18.10.2009** | 02:53 | 2.53 | 152.53 | | *.3 | | | | |
| **18.10.2009** | 03:01 | 2.50 | 152.53 | | | *.4 | | | |
| **18.10.2009** | 04:00 | 2.31 | 152.59 | | | *.4 | | | |
| **21.10.2009** | 23:09 | -13.24 | 152.05 | | | *.4 | | | |
| **21.10.2009** | 23:21 | -13.26 | 152.02 | | | *.4 | | | |
| **22.10.2009** | 00:01 | -13.34 | 151.90 | | | *.4 | | | |
| **22.10.2009** | 00:17 | -13.37 | 151.86 | *.1 | | | | | |
| **22.10.2009** | 00:38 | -13.40 | 151.80 | *.1 | | | | | |
| **22.10.2009** | 02:44 | -13.62 | 151.46 | | | *.4 | | | |
| **22.10.2009** | 03:00 | -13.65 | 151.41 | *.1 | | | | | |

**Table 9.8.1.** **FTIR-SPECTROMETRY: Solar absorption (* filename)**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Range[cm$^{-1}$] 500-1350 | 1900-2750 | 2300-3400 | 2700-4000 | 3900-4500 | 4000-11000 |
|---|---|---|---|---|---|---|---|---|---|
| **22.10.2009** | 03:20 | -13.68 | 151.36 | *.1 | | | | | |
| **22.10.2009** | 03:34 | -13.71 | 151.32 | *.1 | | | | | |
| **22.10.2009** | 03:45 | -13.73 | 151.29 | | | | | *.6 | |
| **22.10.2009** | 04:06 | -13.76 | 151.23 | | | | | *.6 | |
| **22.10.2009** | 21:16 | -15.55 | 148.38 | | | *.4 | | | |
| **22.10.2009** | 21:30 | -15.58 | 148.34 | *.1 | | | | | |
| **22.10.2009** | 21:37 | -15.59 | 148.32 | | | | | *.6 | |
| **22.10.2009** | 21:43 | -15.60 | 148.31 | | | | *.5 | | |
| **22.10.2009** | 22:00 | -15.63 | 148.26 | | *.3 | | | | |
| **22.10.2009** | 22:08 | -15.64 | 148.24 | | | *.4 | | | |
| **22.10.2009** | 22:22 | -15.67 | 148.20 | *.1 | | | | | |
| **22.10.2009** | 22:30 | -15.68 | 148.18 | | | | | *.6 | |
| **22.10.2009** | 22:38 | -15.69 | 148.16 | | | | *.5 | | |
| **22.10.2009** | 22:46 | -15.71 | 148.14 | | *.3 | | | | |
| **22.10.2009** | 23:18 | -15.76 | 148.05 | | | *.4 | | | |
| **22.10.2009** | 23:28 | -15.78 | 148.02 | *.1 | | | | | |
| **22.10.2009** | 23:38 | -15.79 | 148.00 | | | | | *.6 | |
| **22.10.2009** | 23:45 | -15.81 | 147.98 | | | | *.5 | | |

**Table 9.8.2.** **FTIR-SPECTROMETRY: Air samples**

| Date UTC | Sampling start | Position lat (North) | Position lon (East) | Flask-ID |
|---|---|---|---|---|
| **17.10.2009** | 05:03 | 6.79 | 151.22 | J1032 |
| **18.10.2009** | 05:22 | 2.04 | 152.67 | J0973 |
| **19.10.2009** | 05:03 | -2.62 | 153.90 | J0954 |
| **19.10.2009** | 22:59 | -5.95 | 154.01 | J0805 |
| **20.10.2009** | 12:48 | -8.22 | 154.27 | J0589 |
| **20.10.2009** | 23:01 | -9.85 | 154.46 | J488-01 |
| **21.10.2009** | 11:05 | -11.85 | 154.25 | J0339 |
| **22.10.2009** | 01:04 | -13.45 | 151.73 | J0266 |
| **22.10.2009** | 11:16 | -14.51 | 150.05 | J0259 |
| **23.10.2009** | 01:11 | -15.96 | 147.73 | J0148 |
| **23.10.2009** | 11:29 | -17.59 | 147.29 | J0155 |
| **23.10.2009** | 21:34 | -19.08 | 146.92 | J0160 |

**Table 9.8.3.** **FTIR-SPECTROMETRY: $CO_2$, $N_2O$, CO, $CH_4$, $H_2O$ samples (10-minutes data)**

| Date UTC | Sampling | Sample-ID |
|---|---|---|
| **09.10.2009** | continuous | 091009Sample |
| **10.10.2009** | continuous | 091010Sample |
| **11.10.2009** | continuous | 091011aSample |
| **11.10.2009** | continuous | 091011bSample |
| **12.10.2009** | continuous | 091012Sample |
| **13.10.2009** | continuous | 091013Sample |
| **14.10.2009** | continuous | 091014Sample |
| **15.10.2009** | continuous | 091015Sample |
| **16.10.2009** | continuous | 091016Sample |
| **17.10.2009** | continuous | 091017Sample |
| **18.10.2009** | continuous | 091018Sample |
| **19.10.2009** | continuous | 091019Sample |
| **20.10.2009** | continuous | 091020aSample |
| **20.10.2009** | continuous | 091020bSample |
| **21.10.2009** | continuous | 091021Sample |
| **22.10.2009** | continuous | 091022Sample |
| **23.10.2009** | continuous | 091023Sample |

IFM-GEOMAR
Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

# IFM-GEOMAR Reports

| No. | Title |
|---|---|
| 1 | RV Sonne Fahrtbericht / Cruise Report SO 176 & 179 MERAMEX I & II (Merapi Amphibious Experiment) 18.05.-01.06.04 & 16.09.-07.10.04. Ed. by Heidrun Kopp & Ernst R. Flueh, 2004, 206 pp. In English |
| 2 | RV Sonne Fahrtbericht / Cruise Report SO 181 TIPTEQ (from The Incoming Plate to mega Thrust EarthQuakes) 06.12.2004.-26.02.2005. Ed. by Ernst R. Flueh & Ingo Grevemeyer, 2005, 533 pp. In English |
| 3 | RV Poseidon Fahrtbericht / Cruise Report POS 316 Carbonate Mounds and Aphotic Corals in the NE-Atlantic 03.08.–17.08.2004. Ed. by Olaf Pfannkuche & Christine Utecht, 2005, 64 pp. In English |
| 4 | RV Sonne Fahrtbericht / Cruise Report SO 177 - (Sino-German Cooperative Project, South China Sea: Distribution, Formation and Effect of Methane & Gas Hydrate on the Environment) 02.06.-20.07.2004. Ed. by Erwin Suess, Yongyang Huang, Nengyou Wu, Xiqiu Han & Xin Su, 2005, 154 pp. In English and Chinese |
| 5 | RV Sonne Fahrtbericht / Cruise Report SO 186 – GITEWS (German Indonesian Tsunami Early Warning System 28.10.-13.1.2005 & 15.11.-28.11.2005 & 07.01.-20.01.2006. Ed. by Ernst R. Flueh, Tilo Schoene & Wilhelm Weinrebe, 2006, 169 pp. In English |
| 6 | RV Sonne Fahrtbericht / Cruise Report SO 186 -3 – SeaCause II, 26.02.-16.03.2006. Ed. by Heidrun Kopp & Ernst R. Flueh, 2006, 174 pp. In English |
| 7 | RV Meteor, Fahrtbericht / Cruise Report M67/1 CHILE-MARGIN-SURVEY 20.02.-13.03.2006. Ed. by Wilhelm Weinrebe und Silke Schenk, 2006, 112 pp. In English |
| 8 | RV Sonne Fahrtbericht / Cruise Report SO 190 - SINDBAD (Seismic and Geoacoustic Investigations Along The Sunda-Banda Arc Transition) 10.11.2006 - 24.12.2006. Ed. by Heidrun Kopp & Ernst R. Flueh, 2006, 193 pp. In English |
| 9 | RV Sonne Fahrtbericht / Cruise Report SO 191 - New Vents "Puaretanga Hou" 11.01. - 23.03.2007. Ed. by Jörg Bialas, Jens Greinert, Peter Linke, Olaf Pfannkuche, 2007, 190 pp. In English |
| 10 | FS ALKOR Fahrtbericht / Cruise Report AL 275 - Geobiological investigations and sampling of aphotic coral reef ecosystems in the NE-Skagerrak, 24.03. - 30.03.2006, Eds.: Andres Rüggeberg & Armin Form, 39 pp. In English |

IFM-GEOMAR
Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

| No. | Title |
|---|---|
| 11 | FS Sonne / Fahrtbericht / Cruise Report SO 192-1: MANGO: Marine Geoscientific Investigations on the Input and Output of the Kermadec Subduction Zone, 24.03. - 22.04.2007, Ernst Flüh & Heidrun Kopp, 127 pp.<br>In English |
| 12 | FS Maria S. Merian / Fahrtbericht / Cruise Report MSM 04-2: Seismic Wide-Angle Profiles, Fort-de-France – Fort-de-France, 03.01. - 19.01.2007, Ed.: Ernst Flüh, 45 pp.<br>In English |
| 13 | FS Sonne / Fahrtbericht / Cruise Report SO 193: MANIHIKI Temporal, Spatial, and Tectonic Evolution of Oceanic Plateaus, Suva/Fiji – Apia/Samoa 19.05. - 30.06.2007, Eds.: Reinhard Werner and Folkmar Hauff, 201 pp.<br>In English |
| 14 | FS Sonne / Fahrtbericht / Cruise Report SO195: TOTAL TOnga Thrust earthquake Asperity at Louisville Ridge, Suva/Fiji – Suva/Fiji 07.01. - 16.02.2008, Eds.: Ingo Grevemeyer & Ernst R. Flüh, 106 pp.<br>In English |
| 15 | RV Poseidon Fahrtbericht / Cruise Report P362-2: West Nile Delta Mud Volcanoes**,** Piräus – Heraklion 09.02. - 25.02.2008, Ed.: Thomas Feseker, 63 pp.<br>In English |
| 16 | RV Poseidon Fahrtbericht / Cruise Report P347: Mauritanian Upwelling and Mixing Process Study (MUMP), Las-Palmas - Las Palmas, 18.01. - 05.02.2007, Ed.: Marcus Dengler et al., 34 pp.<br>In English |
| 17 | FS Maria S. Merian Fahrtbericht / Cruise Report MSM 04-1: Meridional Overturning Variability Experiment (MOVE 2006), Fort de France – Fort de France, 02.12. – 21.12.2006, Ed.: Thomas J. Müller, 41 pp.<br>In English |
| 18 | FS Poseidon Fahrtbericht /Cruise Report P348: SOPRAN: Mauritanian Upwelling Study 2007**,** Las Palmas - Las Palmas**,** 08.02. - 26.02.2007, Ed.: Hermann W. Bange, 42 pp.<br>In English |
| 19 | R/V L'ATALANTE Fahrtbericht / Cruise Report IFM-GEOMAR-4: Circulation and Oxygen Distribution in the Tropical Atlantic, Mindelo/Cape Verde - Mindelo/Cape Verde, 23.02. - 15. 03.2008, Ed.: Peter Brandt, 65 pp.<br>In English |
| 20 | RRS JAMES COOK Fahrtbericht / Cruise Report JC23-A & B: CHILE-MARGIN-SURVEY, OFEG Barter Cruise with SFB 574, 03.03.-25.03. 2008 Valparaiso – Valparaiso, 26.03.-18.04.2008 Valparaiso - Valparaiso, Eds.: Ernst Flüh & Jörg Bialas, 242 pp.<br>In English |
| 21 | FS Poseidon Fahrtbericht / Cruise Report P340 – TYMAS "Tyrrhenische Massivsulfide"**,** Messina – Messina**,** 06.07.-17.07.2006, Eds.: Sven Petersen and Thomas Monecke, 77 pp.<br>In English |

IFM-GEOMAR
Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

| No. | Title |
|---|---|
| 22 | RV Atalante Fahrtbericht / Cruise Report HYDROMAR V (replacement of cruise MSM06/2), Toulon, France - Recife, Brazil, 04.12.2007 - 02.01.2008, Ed.: Sven Petersen, 103 pp. In English |
| 23 | RV Atalante Fahrtbericht / Cruise Report MARSUED IV (replacement of MSM06/3), Recife, Brazil - Dakar, Senegal, 07.01. - 31.01.2008, Ed.: Colin Devey, 126 pp. In English |
| 24 | RV Poseidon Fahrtbericht / Cruise Report P376 ABYSS Test, Las Palmas - Las Palmas, 10.11. - 03.12.2008, Eds.: Colin Devey and Sven Petersen, 36 pp, In English |
| 25 | RV SONNE Fahrtbericht / Cruise Report SO 199 CHRISP Christmas Island Seamount Province and the Investigator Ridge: Age and Causes of Intraplate Volcanism and Geodynamic Evolution of the south-eastern Indian Ocean, Merak/Indonesia – Singapore, 02.08.2008 - 22.09.2008, Eds.: Reinhard Werner, Folkmar Hauff and Kaj Hoernle, 210 pp. In English |
| 26 | RV POSEIDON Fahrtbericht / Cruise Report P350: Internal wave and mixing processes studied by contemporaneous hydrographic, current, and seismic measurements, Funchal – Lissabon, 26.04.-10.05.2007 Ed.: Gerd Krahmann, 32 pp. In English |
| 27 | RV PELAGIA Fahrtbericht / Cruise Report Cruise 64PE298: West Nile Delta Project Cruise - WND-3, Heraklion - Port Said, 07.11.-25.11.2008, Eds.: Jörg Bialas & Warner Brueckmann, 64 pp. In English |
| 28 | FS POSEIDON Fahrtbericht / Cruise Report P379/1: Vulkanismus im Karibik-Kanaren-Korridor (ViKKi), Las Palmas – Mindelo, 25.01.-12.02.2009, Ed.: Svend Duggen, 74 pp. In English |
| 29 | FS POSEIDON Fahrtbericht / Cruise Report P379/2: Mid-Atlantic-Researcher Ridge Volcanism (MARRVi), Mindelo- Fort-de-France, 15.02.-08.03.2009, Ed.: Svend Duggen, 80 pp. In English |
| 30 | FS METEOR Fahrtbericht / Cruise Report M73/2: Shallow drilling of hydrothermal sites in the Tyrrhenian Sea (PALINDRILL), Genoa – Heraklion, 14.08.2007 – 30.08.2007, Eds.: Sven Petersen & Thomas Monecke, 235 pp. In English |
| 31 | FS POSEIDON Fahrtbericht / Cruise Report P388: West Nile Delta Project - WND-4, Valetta – Valetta, 13.07. - 04.08.2009, Eds.: Jörg Bialas & Warner Brückmann, 65 pp. In English |
| 32 | FS SONNE Fahrtbericht / Cruise Report SO201-1b: KALMAR (Kurile-Kamchatka and ALeutian MARginal Sea-Island Arc Systems): Geodynamic and Climate Interaction in Space and Time, Yokohama, Japan - Tomakomai, Japan, 10.06. - 06.07.2009, Eds.: Reinhard Werner & Folkmar Hauff, 105 pp. In English |
| 33 | FS SONNE Fahrtbericht / Cruise Report SO203: WOODLARK Magma genesis, tectonics and hydrothermalism in the Woodlark Basin, Townsville, Australia - Auckland, New Zealand 27.10. - 06.12.2009, Ed.: Colin Devey, 177 pp. In English |

IFM-GEOMAR
Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

| No. | Title |
|---|---|
| 34 | FS MARIA S. MERIAN Fahrtbericht / Cruise Report MSM 03-2: HYDROMAR IV: The 3rd dimension of the Logatchev hydrothermal field, Fort-de-France - Fort-de-France, 08.11. - 30.11.2006, Ed.: Sven Petersen, 98 pp. In English |
| 35 | FS SONNE Fahrtbericht / Cruise Report SO201-2 **KALMAR: K**urile-Kamchatka and **AL**eutian **MAR**ginal Sea-Island Arc Systems: Geodynamic and Climate Interaction in Space and Time Busan/Korea – Tomakomai/Japan, 30.08. - 08.10.2009, Eds.: Wolf-Christian Dullo, Boris Baranov, and Christel van den Bogaard, 233 pp. In English |
| 36 | RV CELTIC EXPLORER Fahrtbericht / Cruise Report CE0913: Fluid and gas seepage in the North Sea, Bremerhaven – Bremerhaven 26.07. - 14.08.2009, Eds.: Peter Linke, Mark Schmidt, CE0913 cruise participants, 90 pp. In English |
| 37 | FS SONNE Fahrtbericht / Cruise Report: TransBrom SONNE, Tomakomai, Japan - Townsville, Australia, 09.10. - 24.10.2009, Eds.: Birgit Quack & Kirstin Krüger, 84 pp. In English |


Das Leibniz-Institut für Meereswissenschaften ist ein Institut der Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz (WGL)

The Leibniz-Institute of Marine Sciences is a member of the Leibniz Association (Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz).

**Leibniz-Institut für Meereswissenschaften / Leibniz-Institute of Marine Sciences**
IFM-GEOMAR
Dienstgebäude Westufer / West Shore Building
Düsternbrooker Weg 20
D-24105 Kiel
Germany

**Leibniz-Institut für Meereswissenschaften / Leibniz-Institute of Marine Sciences**
IFM-GEOMAR
Dienstgebäude Ostufer / East Shore Building
Wischhofstr. 1-3
D-24148 Kiel
Germany

Tel.: ++49 431 600-0
Fax: ++49 431 600-2805
www.ifm-geomar.de