„It is now time to build a modern research infrastructure in Cape Verde to be able to address the future's urgent research needs"

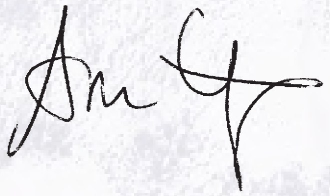
Peter Herzig, Director of GEOMAR

Preface

Arne Körtzinger [1]

The existence of global climate change is scientifically beyond doubt and has become commonplace in public discussion and opinion. Rarely a month goes by without bad climate news reaching us from some place on Earth. Also, in our own perception we do not have to search long for evidence of a changing climate. Nonetheless, our current understanding of the complex interactions of atmosphere, hydrosphere and biosphere is rather limited, particularly with respect to the consequence and feedback potential of global climate change. This is even more the case for the tropics, a key region of the global climate system, in which the ocean and atmosphere are coupled in multiple dynamic ways. The high scientific relevance of the tropics in marine and atmospheric sciences is contrasted, however, with a striking lack of scientific infrastructure and long-term observations. The consortium of research institutions presented in this brochure carries out research at or near the Cape Verde Archipelago, which is a region of high scientific importance in the tropical northeast Atlantic Ocean and has proven to be an excellent research base. The present brochure aims to highlight the region's scientific relevance, present a kaleidoscope of the ongoing multi-facetted research activities at Cape Verde, and spark interest for more. The sustainability of the young Cape Verde Ocean and Atmosphere Observatories depends critically on the development of a modern and versatile local research infrastructure. Better understanding of the complex climate system is a prerequisite for adequate adaptation and mitigation strategies. The research institutions behind this brochure have made a strong commitment to research in the tropics at Cape Verde in an internationally visible way. It is now essential to intensify this and put it on a firm infrastructural footing.

[1] GEOMAR, Kiel, Germany



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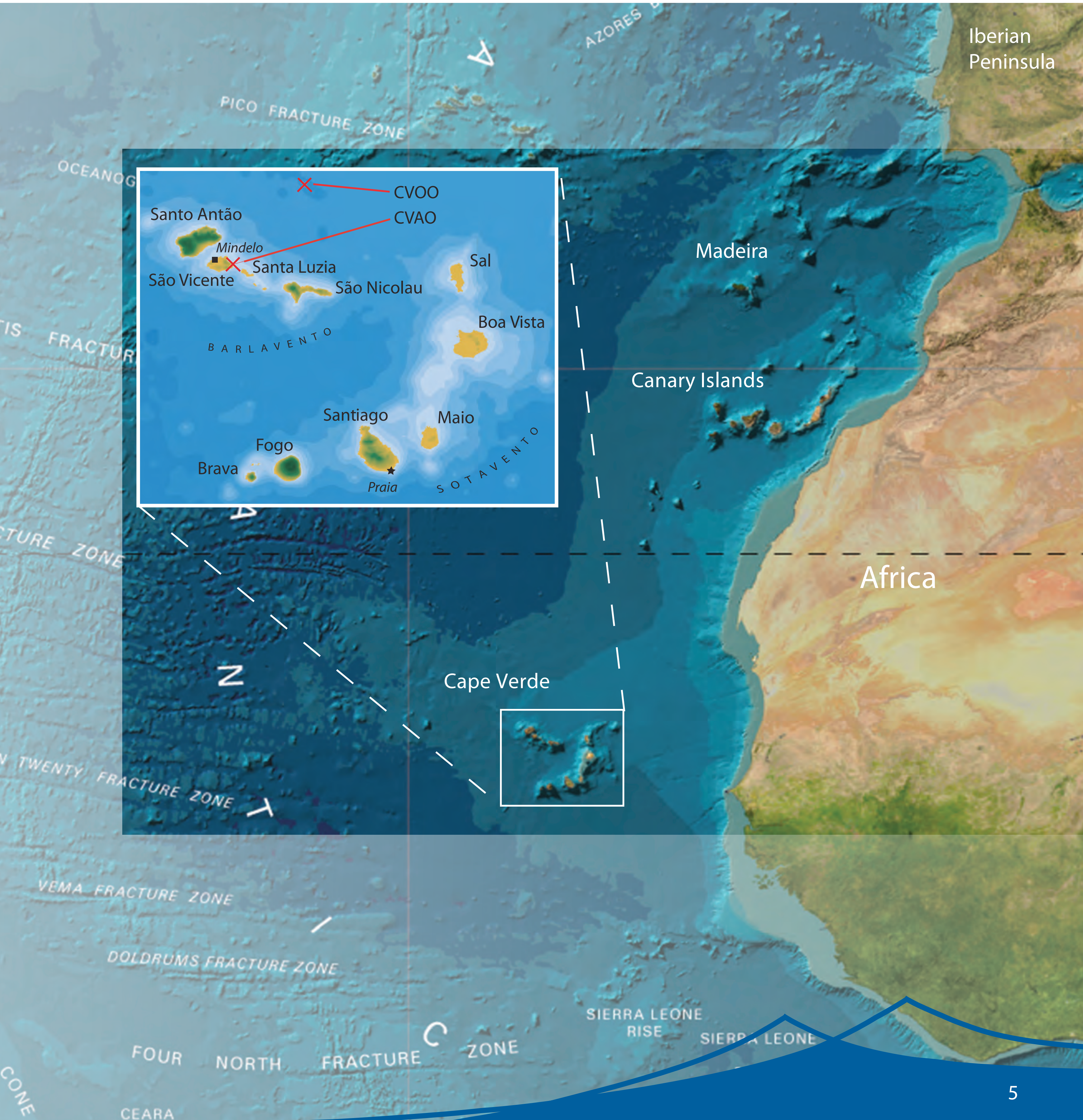
Research Base Cape Verde – A Fascinating Laboratory for Marine and Atmospheric Scientists

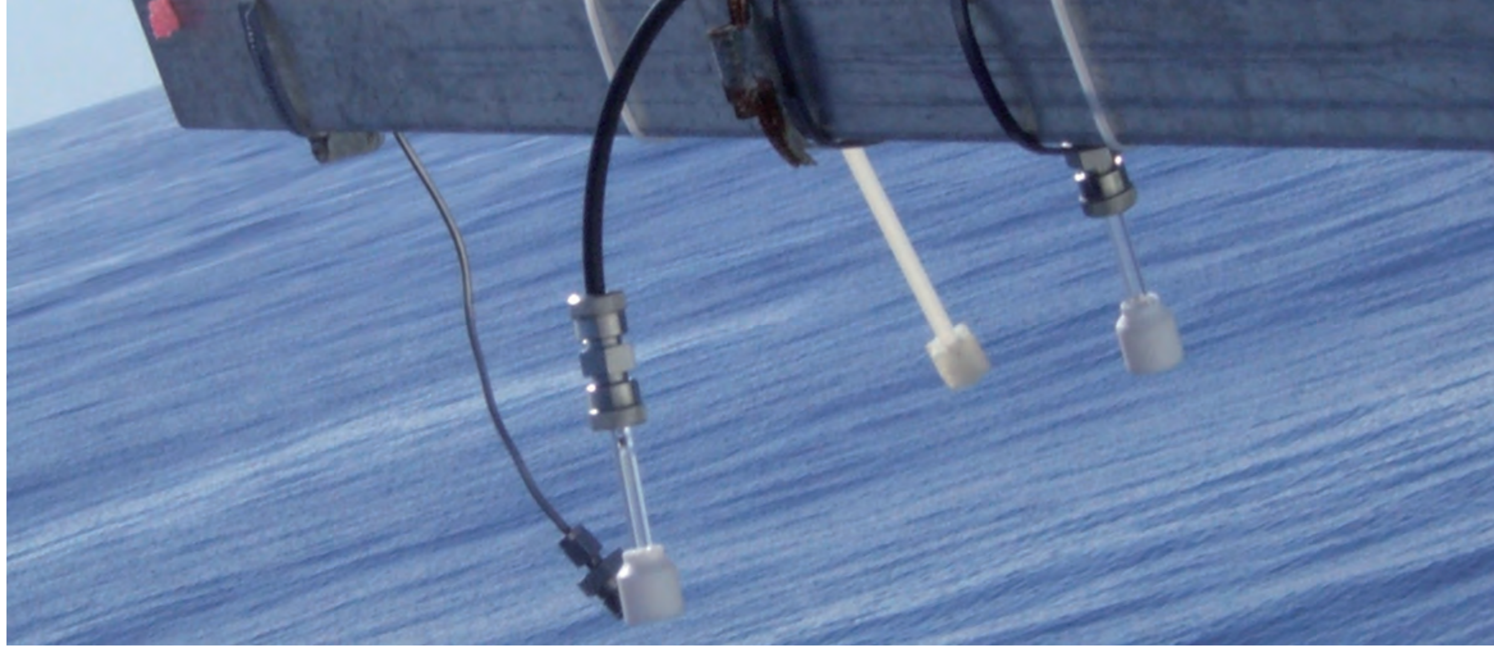
Arne Körtzinger

The tropics are a gigantic weather engine that features phenomena such as energetic thunderstorms, hurricanes, heavy monsoon rain and prominent climate oscillations such as El Niño. In all these, the ocean plays a central role. For example, long-term variations in the West African Monsoon, and hence the vital rainfall over West Africa, are connected to changes in the sea surface temperature of the tropical Atlantic. On the other hand, emissions of halogenated trace gases from the tropical Atlantic can reach up to the stratosphere due to the high tropospheric convection. There they are involed in natural ozone destruction. In the other direction, the atmosphere has a strong influence on the biogeochemistry and biological productivity of the tropical Atlantic by depositing massive amounts of Saharan dust onto the sea. But also within the ocean major processes are at work. The coastal upwelling system of West Africa, for example, feeds a large marine ecosystem that is among the most productive, diverse, and economically important worldwide – a function that is further enhanced by delivery of the essential elements iron and phosphorus via atmospheric dust. In the ocean's interior a natural oxygen minimum zone exists, which in the Atlantic is not (yet) as pronounced as its counterparts in the Pacific and Indian Ocean but in recent decades has shown trends of expansion, as reported from dedicated oceanographic studies from Kiel. The biogeochemical, ecological and socioeconomic consequences of this cannot yet be estimated. Finally, the region is also of high interest from a geoscientific perspective due to its location on a so-called "mantle hot spot" which gives rise to active volcanism, especially at the seafloor near the westernmost islands of the archipelago. Here submarine seamounts are born as the future Cape Verdean islands. Recent studies have even shown for the first time the existence of explosive volcanism in the deep sea.

The region – as the above examples illustrate – bursts with topical scientific questions of high relevance which involve all marine disciplines. To adequately address these questions, modern marine and atmospheric researchers need reliable partners and infrastructure in the region. The conditions for this are ideal in the Republic of Cape Verde, a politically and socially remarkably stable country that has high ambitions particularly in the field of education as well as its marine affairs. The nation is developing quickly and has made all its marine aspects a central policy focus. In marine research and university education the country needs and seeks international partners. The German-Cape Verdean cooperation in marine sciences, which was initiated in 2004 and formalized by a contract between the Instituto Nacional de Desenvolvimento das Pescas de Cabo Verde and the Helmholtz Centre for Ocean Research Kiel, forms an ideal nucleus and basis for future expansion. The next step towards sustainability and high international visibility is the development of adequate research infrastructures and a network of scientific and academic institutions on both sides.

The present brochures aims to present the highly relevant marine and atmospheric research agenda in the tropical northeast Atlantic and advocate for the buildup of long-term research infrastructure in Cape Verde. The following pages provide a kaleidoscope of current research topics, which makes no claim to be complete but rather wants to illustrate thematic breadth and relevance and pique the reader's curiosity.





Tubes for air sampling with pumps at the end lighting air.

Cape Verde: A Natural Laboratory for Investigating Climate Relevant and Chemically Active Trace Gases

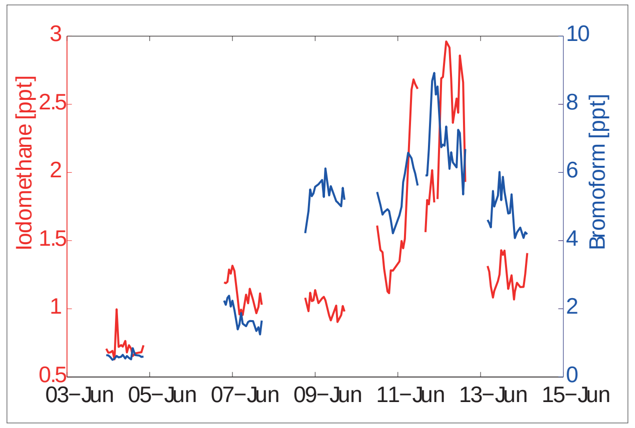
Birgit Quack[1], Douglas W.R. Wallace[2], Christa Marandino[1]

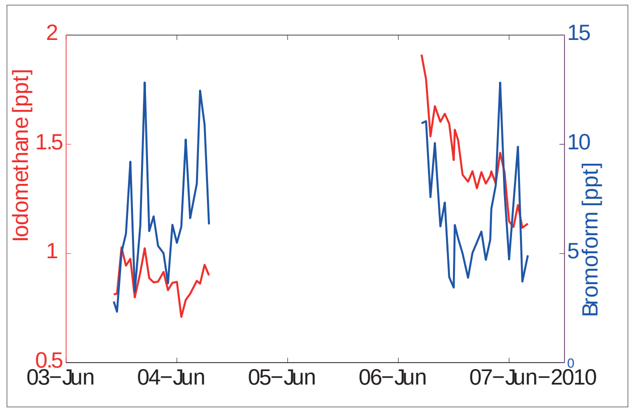
The chemistry of the atmosphere is changing radically. While the most commonly discussed change is increasing CO_2, there are a wide range of other trace gases that are chemically or radiatively active in the atmosphere and which are subject to change. These gases have short atmospheric lifetimes, and hence have regional impacts which may have global consequences. Ocean surface processes can exert critical controls on fluxes of these gases to and from the atmosphere, thus impacting climate and atmospheric chemistry, both regionally and globally. The gases include halogenated volatile organic compounds (e.g. bromoform, $CHBr_3$, iodine-containing gases), sulfur-containing compounds (e.g. dimethyl sulfide, DMS), and oxygenated volatile organic compounds (OVOCs, e.g. acetone and methanol). The impacts range from formation of aerosol affecting cloud cover or radiative transfer, to the destruction of tropospheric and stratospheric ozone, to controls on the atmosphere's ability to rid itself of pollutants.

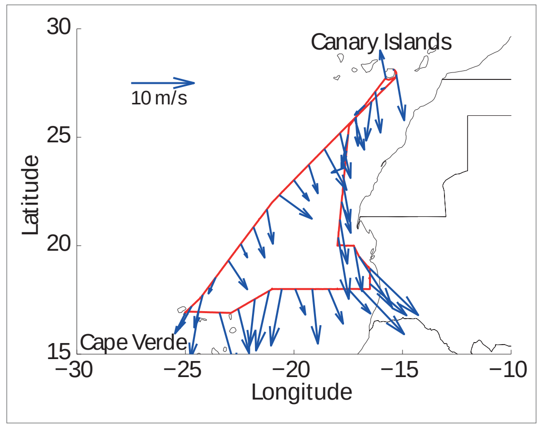
The tropical atmosphere is of special significance with respect to the changing chemistry of the atmosphere. The highest production rates of the hydroxyl radical (OH), which predominantly cleans the atmosphere from biogenic and anthropogenic trace gases, occur in tropical regions. Stratospheric ozone is mainly created in the tropical stratosphere, then transported towards the winter pole by large-scale circulation, sinking downward at higher latitudes. Most long-lived and short-lived trace gases in tropospheric air enter the stratosphere in the tropics, following the same transport pathway, finally descending to the troposphere at mid and high latitudes. Hence, tropical processes impact the chemical composition of the entire atmosphere.

Changes within the tropical surface ocean associated with climate change, changes in surface ocean physics and biology, and ocean acidification can alter the supply of key gases to the critical tropical regions of the atmosphere. However, our ability to predict and quantify such effects is limited, in part because surface seawater sources and sinks of these compounds are often obscure and poorly quantified. For example, despite a number of successfully conducted lab studies that have highlighted production pathways of halocarbon compounds, the importance of these pathways have not to-date been demonstrated in the natural environment. We urgently need the ability to characterise processes and measure rates under natural conditions representative of the Earth's critical tropical regions. These processes include abiotic and biotic production and degradation mechanisms and air-sea exchange. Notably, the kinetics of photochemical, wet chemical and biological processes within the water, in organisms, on particles, and at the sea surface microlayer have yet to be determined.

It is instructive to perform experiments to characterise these processes within a natural laboratory. The tropical ocean is a unique region, because of the warm waters and intense photochemistry that takes place there, as well as the presence of characteristic biota and dissolved organic precursors that support production and emission of specific compounds. It is imperative to study these processes in-situ rather than attempt to extrapolate findings from very different environmental conditions encountered, for example, in coastal or open waters off northern Europe or North America. Such natural laboratories are almost completely missing for tropical latitudes in comparison with facilities located in mid- and high latitude regions.The Cape Verde islands have the potential to serve as a unique in situ natural laboratory for tropical marine and atmospheric chemical studies of these important compounds.







Concentrations of the two halocarbons bromoform and methyl iodide in the atmosphere of the tropical Atlantic around Cape Verde during Poseidon cruise P399/2 (Las Palmas- Las Palmas), June 2010. Fig. top left: Varying atmospheric concentrations during cruise P399/2. Fig. bottom left: Cruise track of RV Poseidon in June 2010, including arrows of wind speed and wind direction at air sampling locations. Fig. above: Varying atmospheric concentrations during cruise P399/2 at the Cap Verde atmospheric observatory 2010.

[1] GEOMAR, Kiel, Germany
[2] HMRI, Halifax Marine Research Institute, Canada

Ocean Atmosphere Interactions - The Importance of Natural Aerosol in Marine Environments

C. Müller[1], K.W. Fomba[1], K. Müller[1], M. van Pinxteren[1], N. Niedermeier[1], T. Müller[1], A. Held[1], I. Tegen[1], A. Wiedensohler[1], H. Herrmann[1]

Due to the large surface exchange area covered by the oceans, interaction processes between the oceans and the atmosphere strongly influence the earth's climate and its further development. Herein, natural aerosols play a significant role due to their impact on the global climate. These particles influence the radiation budget of the earth in a direct and indirect manner through the adsorption and reflection of incident solar radiation on the particle and cloud surfaces (Fig. 1). The behavior of particles towards radiation depends on their physicochemical properties, which again depends on the aging and formation process of the particles. In order to estimate the importance of marine aerosol particles for the global climate, it is necessary to know their exact chemical composition as well as their microphysical and optical properties.

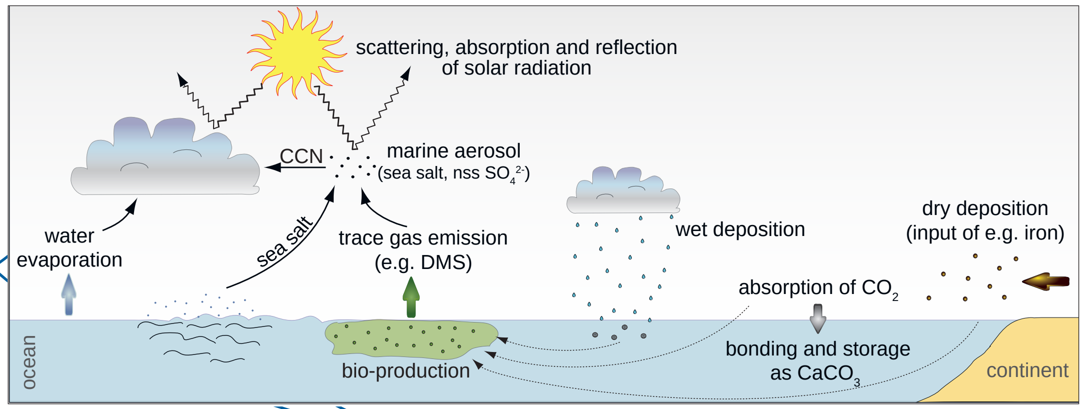
Despite intense research in this area the exact chemical composition of the aerosol particles is still not yet completely understood. The objective of the current studies at the Cape Verde Atmospheric Observatory (CVAO) is, beside the chemical characterization and the determination of microphysical and optical properties, the further understanding of the sources as well as the identification of the formation and transport processes of marine aerosol particles. The geographic location of the station and the different origins of air masses collected at the station allow studying different forms of marine aerosol. In the region around the Cape Verde islands, three dominant types of aerosols can be observed. These are (a) primary, (b) secondary marine aerosols formed from the emission and export of compounds respectively, and (c) dust particles and biomass burning aerosols from the African continent (Fig. 1).

From previous studies it is known that primary and secondary marine aerosols consist to a large extent of inorganic salts like sodium chloride and ammonium sulphate. However, recent results reveal the presence of a significant organic fraction in the particles. Especially very small particles with a diameter less than 0.14 µm consist to about half of their mass of organic carbon (Fig. 2). The organic carbon fraction can be further divided in a water-soluble part (20-40%) whereas the remaining 60-80% is not yet characterized. Moreover, it has been found that particles bigger than 1 µm differ in their microphysical properties compared to pure sea salt particles. This also leads to the conclusion that organic material is accumulated in the particles. The particle composition has a strong variation and is dependent on regional and seasonal parameters as well as on the composition of the ocean surface. Field studies show that the fraction of organic carbon, especially in small particles, is connected to the marine bioactivity.

A similar lack of knowledge exists concerning the chemical composition of the dust particles transported by air masses from the African continent to the Cape Verde islands. Sources and transport pathways of Saharan dust are investigated by means of regional aerosol transport modeling. Since the Saharan desert is the main source of dust in this region, it is expected that the chemical composition of the dust particles at the island should be similar to that in the desert. However, due to atmospheric chemical processes during the transport of dust, there are changes in the composition of the dust particles and thus in their properties. Such changes can have a significant impact on climate relevant processes. Figure 2 b) demonstrates different size fractions of aerosol particles with mainly continental origin. In contrast to particles with marine origin (Fig. 2a), a higher dust fraction especially in the larger particles is evident. The total aerosol dust concentration is determined with optical absorption spectroscopy. Detailed chemical investigations of the dust particles will provide important information regarding the metal composition of the Earth's crust. Furthermore, the measurements will help us to better understand the photochemical formation of iron (II) from iron (III) at the particle's surface during their transportation. Together with the results of regional modeling the investigations will also deliver data on the amount of dust deposition into the Atlantic (Fig. 1). Especially in the active phase of the desert wind Harmattan (October till May) large amounts of dust are transported from the Sahara into the marine boundary layer. Particularly at these times mineral dust is transported to the Atlantic via dry deposition (Fig. 3). These investigations allow an estimating of the input of nutrients like iron and phosphate into the ocean – an important factor for marine biological and geological chemistry.

[1] IfT, Leipzig, Germany

Figure 1. The significance of marine aerosols in the interaction between the ocean and the atmosphere.



CVAO – The Atmospheric Observatory near Calhau, São Vicente, at 16° 51'49 N, 24° 52'02 W.

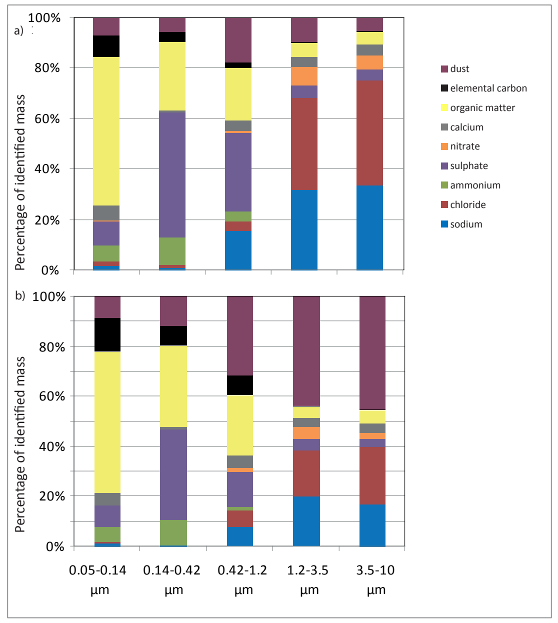


Figure 2: The composition of marine aerosol particles for different size fractions for a) mainly marine influenced particles and b) mainly continental influenced particles on the Cape Verde island São Vicente, measured in spring 2007.

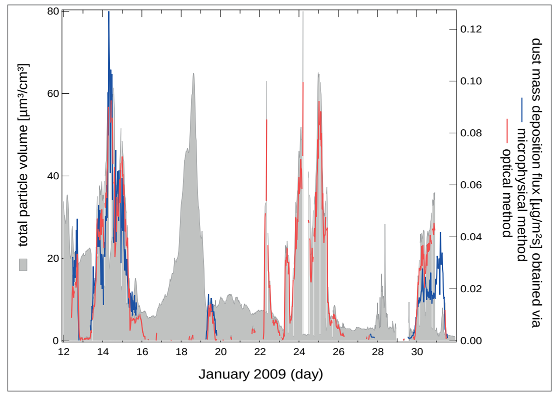
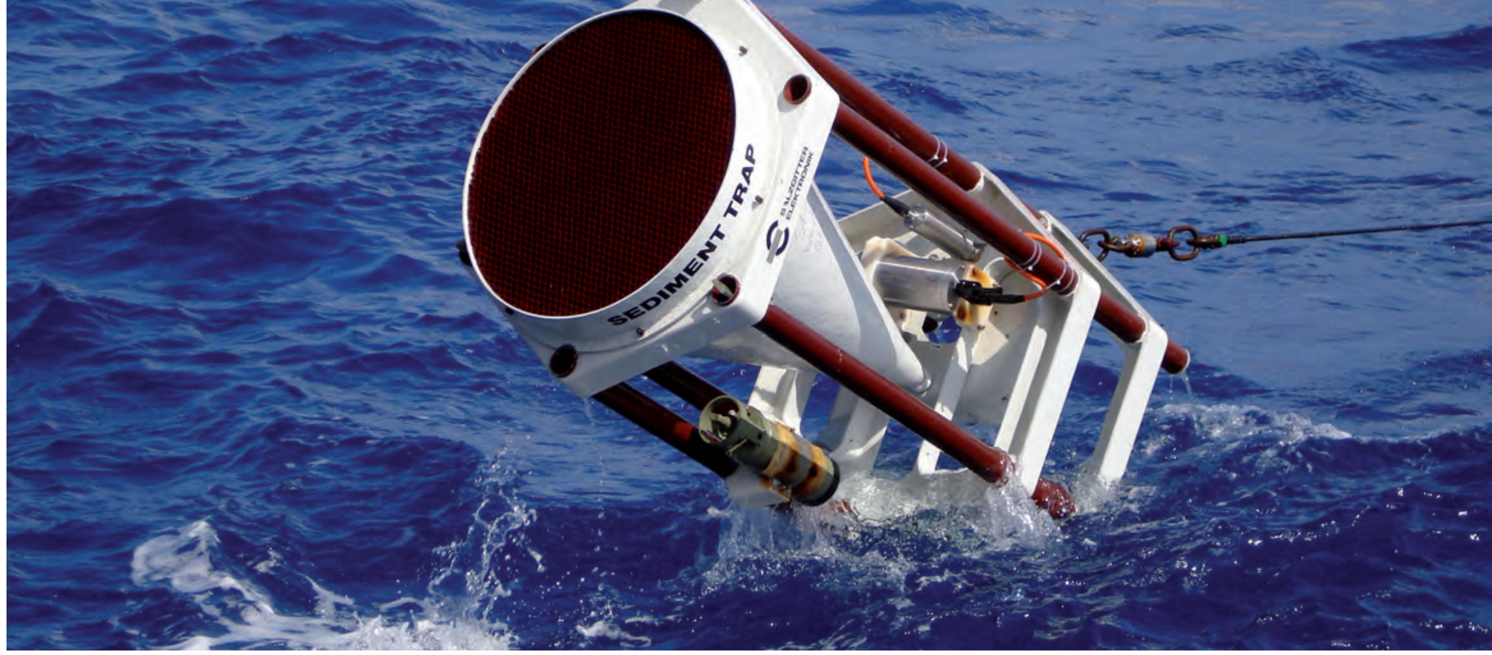


Figure 3: Time series of dust deposition flows (determined with two different methods) and total particle volume.





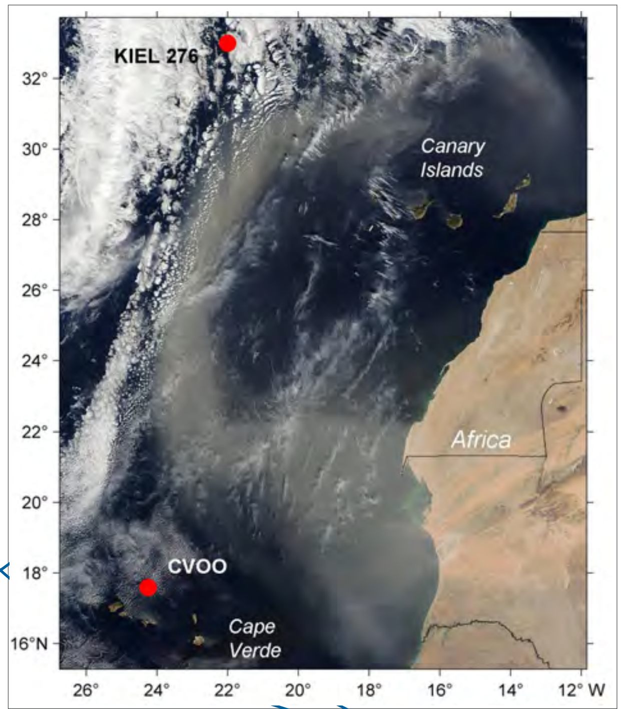
Recovery of a sediment trap designed to collect sinking particles in the water column such as dust particles of the Sahara.

The Interaction between Ocean and Desert

Juliane Brust[1], Joanna Waniek[1], Gerhard Fischer[2]

Important nutrient material, such as nitrogen and phosphorus, as well as iron, copper and zinc are transported by aeolian mineral dust to distant oceanic areas. Aeolian delivered mineral dust interacts in two ways with the particle flux in the ocean. On the one hand, it can stimulate the primary production due to the supply of nutrients. On the other hand, dust acts as „ballast" on organic particles, which carries carbon down, preventing rapid remineralization. Mineral dust is mobilized by the prevailing winds and wind systems in the arid and semiarid areas of the continents and is transported at high altitudes far away from the sources. 26% of the mineral dust is deposited to the world oceans, whereby North Africa is the main supplier for the global dust production and responsible for 2/3 of the global dust mobilization. The eastern North Atlantic is subject to the influence of North African dust outbreaks. Transport paths of the North African dust over the eastern North Atlantic are determined by the Saharan Air Layer, its northern branches and by the trade winds. North African dust is carried far to the west and can even reach the Caribbean region, and North and South America. The maximum distribution of the African dust cloud, usually confined to 5° and 30°N, depends on the position of the Intertropical Convergence Zone and occasionally spreads to higher latitudes. To test the response of primary producers on aeolian dust influx, it is important to conduct continuous studies of the biological production and lithogenic mineral input. The best opportunity, in addition to regular sea voyages, is the deployment of deep-sea moorings and associated sediment traps.

The analysis of particulate sediment-trap material of 2000 m water depth within the Madeira Basin (Kiel 276, 33° N, 22° W, Fig. bottom left) in the framework of Lithflux (DFG, WA2157/2-1) showed the variability of dust inputs from North Africa, the temporal coupling between dust events and lithogenic particle flux, as well as the variability of the source areas and the potential influence of aeolian influx on the ecosystem of the euphotic zone. The mineralogy of the particles is indicative of interannual variability of African source areas, while seasonal changes were not recognized so far. Based on the content of elemental iron in the sediment-trap samples a potential increase in primary production by 20% was estimated. Furthermore, the comparison of satellite data (aerosol optical depth, chlorophyll concentrations) with the biogenic and lithogenic fluxes in the 2000m deep Kiel-276 trap showed a possible response of the biological production to a dust event. Changes in biological production were seen most clearly in summer months in which generally no strong blooms prevail (Fig. right). In the Cape Verde islands region a study of satellite data could also prove that individual dust events can cause an increased primary production.

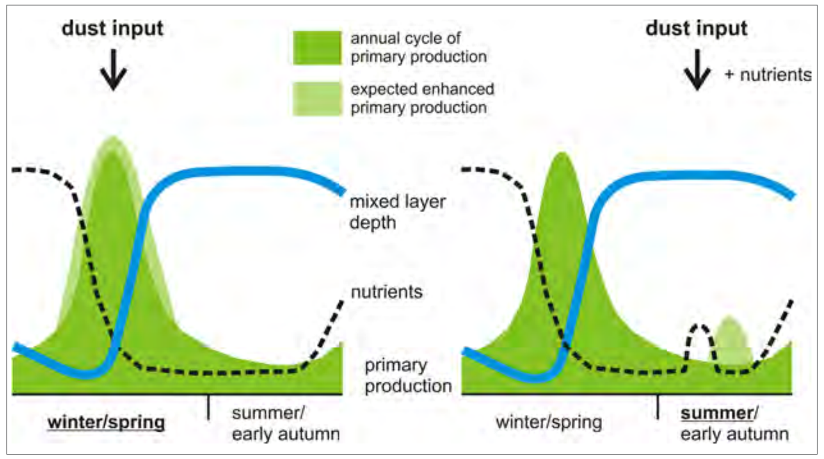


Sahara dust plume over the eastern North Atlantic. Both research stations - in the subtropical (Kiel 276, 33° N, 22° W) and tropical (CVOO, 17.4° N, 24.5° W) North Atlantic - are affected by dust outbreaks. The stations are 960 nautical miles apart from each other.

In the area of the Cape Verde Islands dust outbreaks are more common than over the Madeira Basin. In the coming years, the comparison of the two study areas in cooperation between IOW and MARUM will be at the forefront of activities. The comparison of the Kiel 276, TENATSO (17.4°N, 24.5°W, Fig. bottom left) and two moorings (CB: ca. 21°N, 21°W and CBi: ca. 21°N, 19°W) in the upwelling of Cap Blanc, Mauretania (MARUM) over an overlapping period, will promote the knowledge on the marine biogeochemical processes, and the oceanographic and atmospheric processes affecting them.

Such studies are of importance with regard to the ocean's role in the carbon cycle; about 50% of global primary production and the associated CO_2 fixation take place in the oceans. However, over 90% of the fixed carbon is remineralized within the upper 100 m of the ocean water column and just 0.4% is buried in marine sediments. Nevertheless, in terms of geological time scales the ocean is an important carbon sink. Increased primary production due to the presence of important nutrients in surface waters or a fast and effective transport of organic material towards the sea floor can intensify the „biological carbon pump" and lead to increased carbon burial in marine sediments.

[1] IOW, Rostock-Warnemünde, Germany
[2] MARUM and the Department of Geosciences, University of Bremen, Germany



Potential impact of mineral dust deposition in the subtropical North Eastern Atlantic Ocean on the photosynthetic organisms of the photic zone in the winter/spring (left) and in summer/autumn (right). An increased primary production induced by dust input appears most clearly in the summer months, when the nutrient pool in the surface water is low.

The Avoidable Fate of the Loggerhead Sea Turtle? When Conservation Biology Meets Oceanography

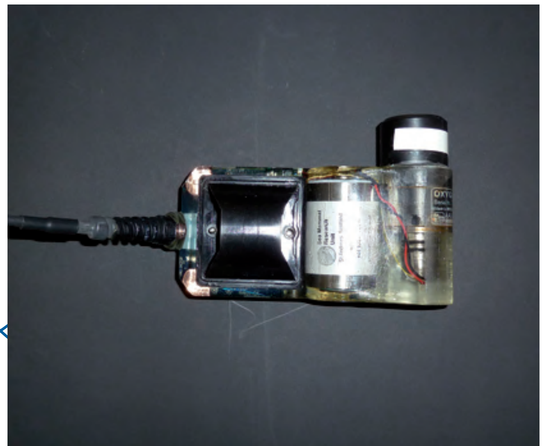
Victor Stiebens[1], Björn Fiedler[1], Torsten Kanzow[1], Sonia Merino[2], Christophe Eizaguirre[1]

The protection of marine species is one of the greatest challenges of our time. The vast oceans cover ~ 70 % of the world's surface and offer unknown natural resources. This project aims at combining conservation needs of the Loggerhead turtles (*Caretta caretta*) from Cape Verde with an innovative collection of oceanographic information from this region.

A striking oceanographic phenomenon near the Cape Verde islands is the occurrence of powerful coastal upwellings. Those water mass movements are primarily the result of the year-round trade winds that push surface waters away from the coast and draw cold, nutrient-rich waters from the deep ocean up to the surface. Those rich waters meet the tropical sun to provide a perfect environment for the growth of phytoplankton - the basis of a productive food web that supports a rich biodiversity. Highly productive areas such as the upwelling system off West Africa are still poorly understood. Thus, the impacts of climate change and its evolutionary consequences on those systems remain unpredictable.

The Loggerhead turtle (*Caretta caretta*) is the most symbolic species of Cape Verde. This archipelago supports the third largest nesting aggregation in the world. Unfortunately, like all Sea Turtles, the loggerhead is listed as endangered in the Red List of the IUCN (International Union for Conservation of Nature) because of poaching and fisheries bycatch. For instance, on the Island of Sal, the second largest breeding colony of Cape Verde, in 2009, as much as one quarter of the turtles recorded were found killed by poachers. On the other hand more indirect menaces through habitat destruction, global warming and increasing risks of disease outbreaks are to be feared. Therefore effective protection measures are urgently needed: a better scientific monitoring, including a better assessment of genetic diversity within the Cape Verde rookery, would be the basis for the development of sound and sustainable conservation programs.

To fill some of the most obvious gaps in our knowledge, we collect tiny skin tissue samples from females which come ashore to lay their eggs. Those skin samples are used for genetic analyses. In particular, we determine the genetic diversity of specific genomic regions of the turtles. We focus on genes involved in disease resistance since the risk of infection is tightly linked to rising temperatures and increased pollution.



New generation data logger incorporating oxygen sensor.

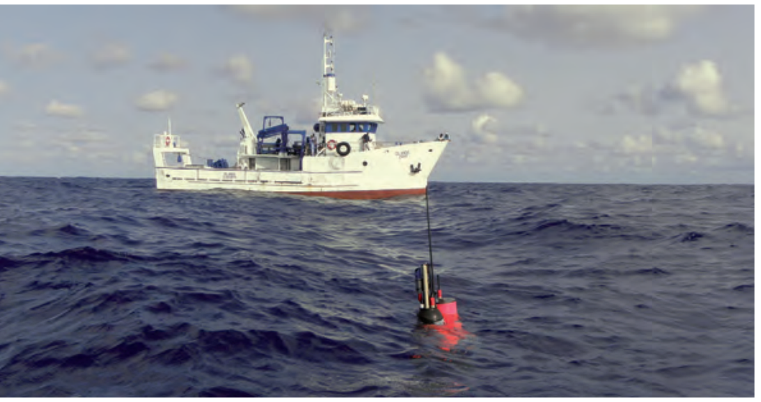
Event organized by INDP to sensitize the population to the endangered loggerhead sea turtle.

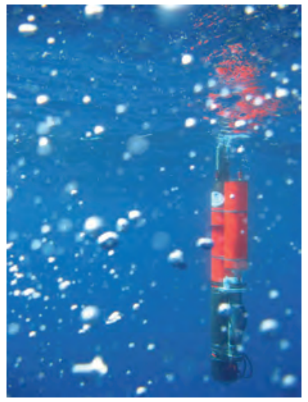
This project is supported by the Insituto Nacional de Desenvolvimento de Pescas (INDP, S. Vicente) and several NGOs such as Turtle Foundation in Boavista. Together with these partners, we have initiated a large sampling program over several islands across Cape Verde. On the long term, we aim to prevent the extinction of this emblematic species.

To improve our understanding of migratory behaviors of the turtles as well as oceanographic environmental parameters of the habitats they use, we have deployed data recorders ("biologger") on the turtles. Those electronic devices are fixed on the carapace and record salinity, temperature, oxygen content and the geographic location of the animals. Each time the turtles come to breathe at the surface a message is sent via satellite to the scientists in Kiel. Such data collection, performed by a large marine species, will deepen our understanding of the evolution of oceanic migration routes and at the same time will help us to gain new insights into the physical and chemical characteristics of water masses in the region of Cape Verde and the West African.

Application of a data recorder on the carapace of the loggerhead sea turtle to register data of its migratory behavior, use of habitat and oceanographic environmental parameters.

[1]GEOMAR, Kiel, Germany
[2]Turtle Foundation, Sal Rei, Cape Verde
[3]INDP, Mindelo, Cape Verde





The Breathing of the Ocean – Autonomous Gas Measurements near Cape Verde

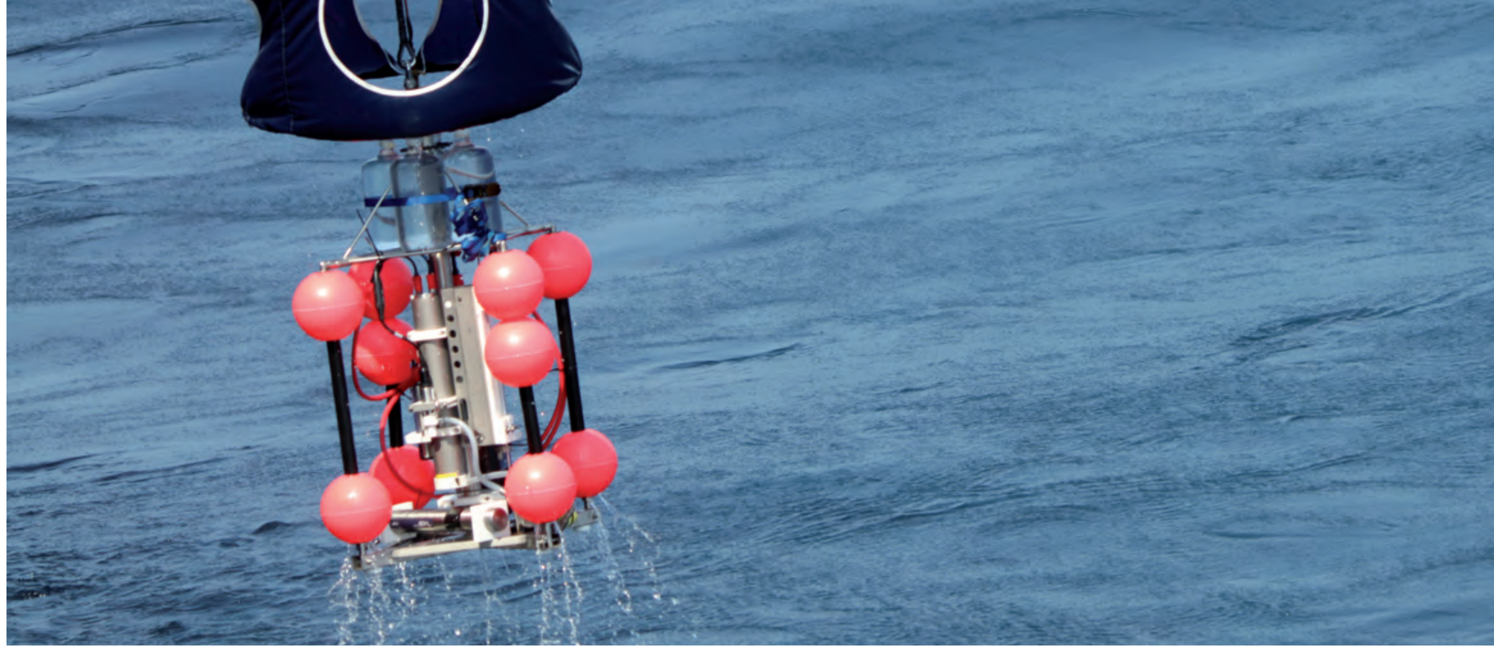
Arne Körtzinger[1], Martin Heimann[2], Nuno Vieira[3], Björn Fiedler[1], Peer Fietzek[1]

Carbon dioxide (CO_2), the basis of all life on earth and at the same time a potent driver of climate change, and oxygen (O_2), the lifeblood of all creatures, are two gases which are intimately linked through photosynthesis and respiration. Both in the atmosphere and in the ocean their distribution patterns and dynamics are thus strongly driven by biological processes on land and in the ocean. Despite their seemingly mirror image behavior the combined observation of CO_2 and O_2 provides information that is not accessible through measurements of one them only. Rather both gases also have a life of their own, which provides important insight into the dynamics of the global carbon cycle. Therefore, the marine oxygen cycle has besides its carbon counterpart recently become a major international focus of marine sciences.

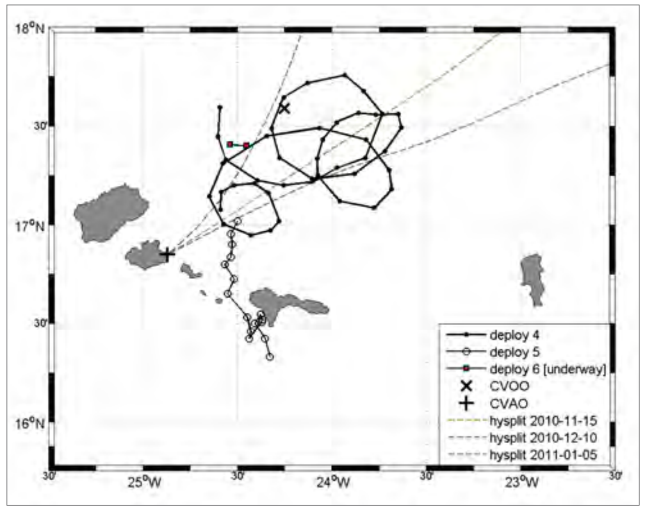
The world ocean acts as a giant sink for human made CO_2 and thereby significantly buffers global climate change. Predictions of possible future changes in this climate stabilizing function of the ocean require robust knowledge of the fate of CO_2. Anthropogenic CO_2 is emitted from fossil fuel burning and land use change. High-precision measurements of atmospheric CO_2 and O_2 have proven to be powerful tools for this purpose. Recent findings of the phenomenon of ocean deoxygenation, however, have not only complicated the interpretation of these atmospheric measurements but at same time provide insight into the reaction of the ocean system on global climate change. The now well-documented small but consistent decline of oxygen concentrations in nearly all ocean basins are indicative of a slow-down in ocean ventilation under ongoing global warming. Furthermore, any climate change driven trends in marine biological productivity would also impact oceanic oxygen. These effects of course are not limited to oxygen but will also impact carbon and are, therefore, of utmost importance for our understanding of the global carbon cycle and its future development.

During recent years, major efforts have been made to intensify and combine the observation of the marine cycles of carbon and oxygen. In this context, new and autonomous observation methods are playing an increasingly important role. At the Cape Verde Ocean Observatory (CVOO) we deploy novel profiling floats – robotic instruments which drift freely with the currents and provide profiling measurements of the upper 250 meters at 30-hour intervals – which in addition to pressure, temperature and salinity sensors for the first time also carry sensors for O_2 and CO_2. These allow continuous observation of surface ocean dynamics and air-sea exchange of the two gases. For short-term process studies aiming at shorter time scales, such as diel cycles, we use a special Lagrangian surface drifter which follows surface current by means of a drogue and carries a sophisticated sensor package for mixed layer measurements of various properties including CO_2 and O_2. The availability of concurrent atmospheric measurements of CO_2 and O_2 at the nearby Cape Verde Atmospheric Observatory (CVAO) allows for the oceanic and atmospheric gas dynamics to be linked. We expect novel insight into the ocean's role in the observed atmospheric trends of the two gases through these combined measurements.

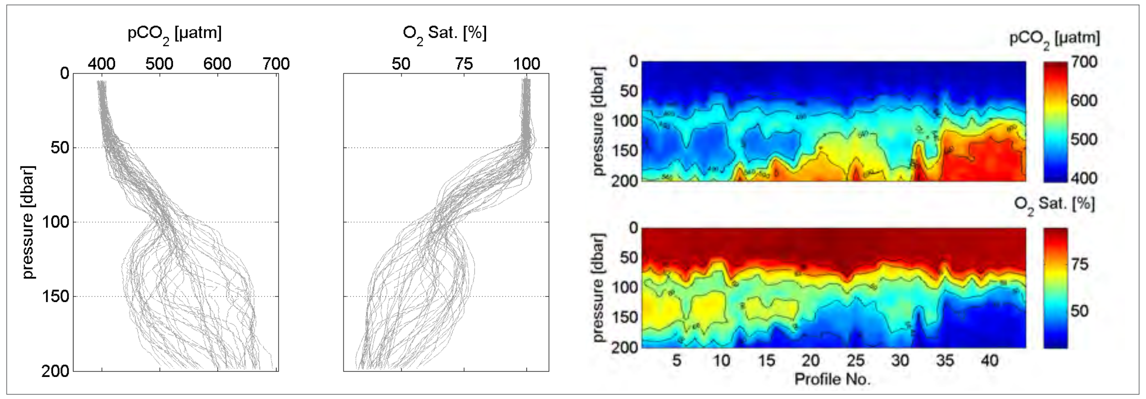
[1] GEOMAR, Kiel
[2] MPI-BGC, Jena
[3] INDP, Mindelo, Cabo Verde



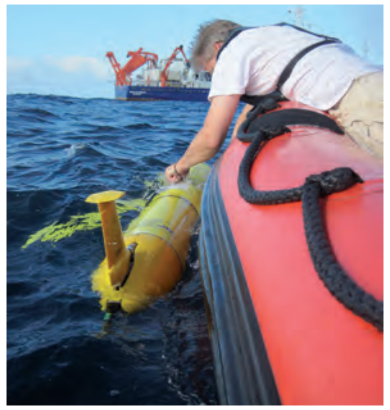
A Lagrangian surface drifter during its recovery. The sensor package is equipped with a large number of biogeochemical sensors.

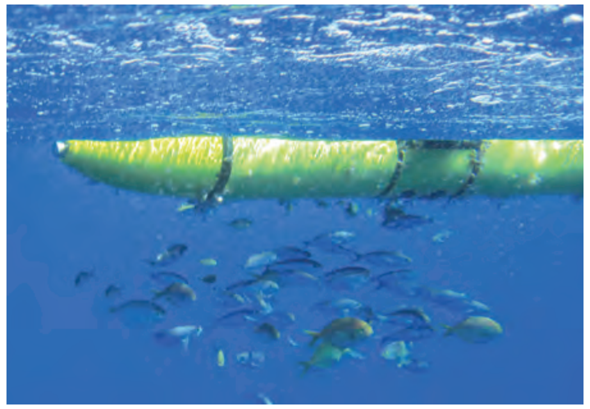


A map demonstrating the oceanic region northeast of the islands of Santo Antão, São Vicente and São Nicolau where measurements of oxygen and carbon dioxide concentrations in the ocean and the atmosphere are performed. The autonomous deep-sea drifter (prototype) used in this area provides high resolution data of the ocean between the oceanic and the atmospheric observatory.



Concentrations of carbon dioxide and oxygen observed between 200 m depth and the ocean surface near the CVOO, registered with the profiling deep-sea drifter for the first time during an autonomous mission of 8 weeks.





Interplay of Small-Scale Physical and Biogeochemical Processes near the Cape Verde Islands

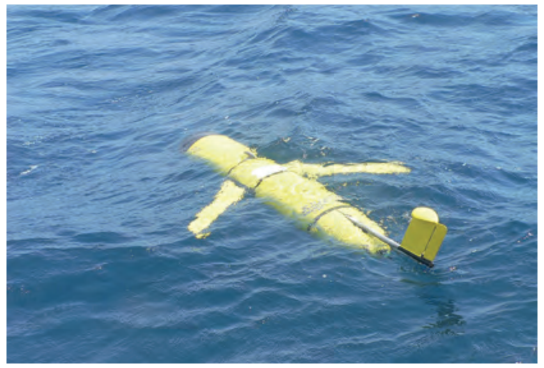
Torsten Kanzow[1], Gerd Krahmann[1], Martin Visbeck[1], Arne Körtzinger[1]

In the sea area around the Cape Verde Islands in water depths of more than 200 meters, a several hundred meter thick layer characterized by very low oxygen concentrations can be found. The water in this region, which is referred to by oceanographers as "shadow zone", is renewed and vented very slowly, because it is isolated from the circulation of the North Atlantic by the Cape Verde frontal zone to the North, and because there is no direct connection to the vigorous equatorial currents. Another environmental feature of the tropical Northeast Atlantic is the recurrent occurrence of storms, carrying huge amounts of Saharan dust, thereby fertilizing the ocean with nutrients such as iron and phosphate.

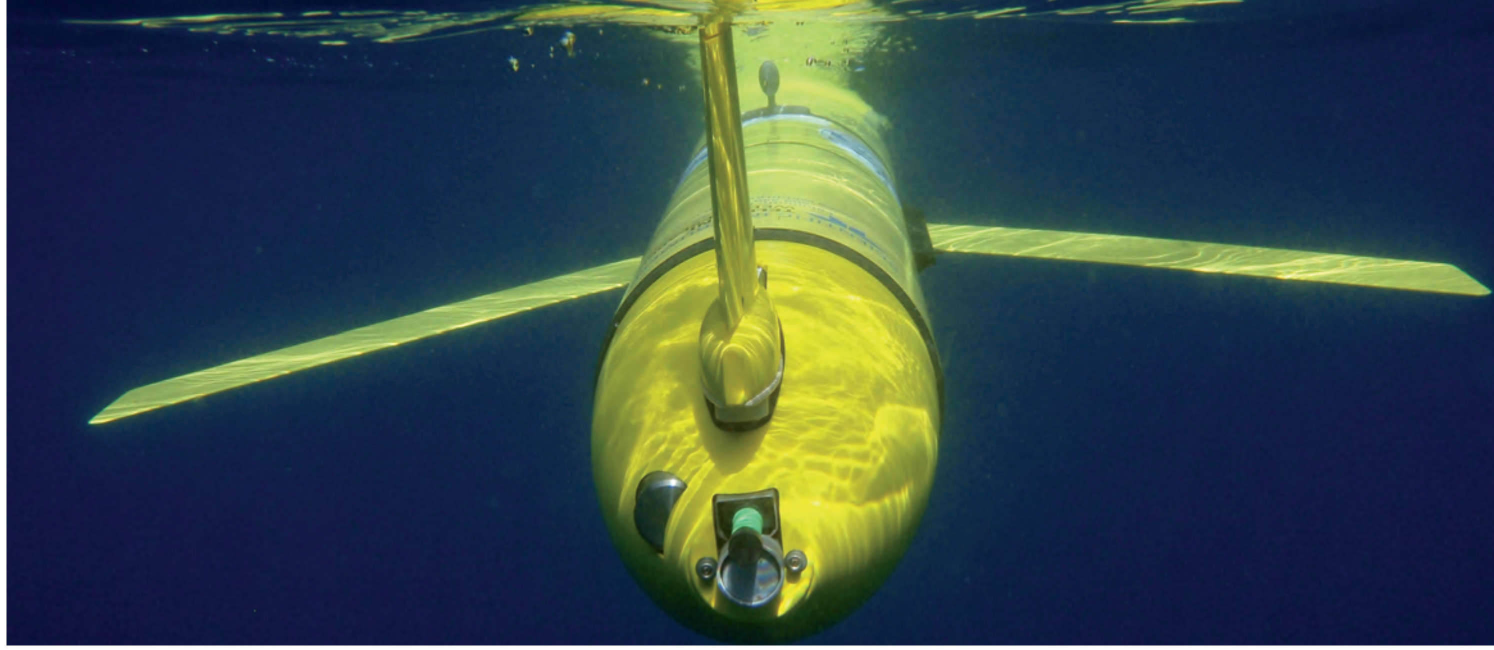
It is thought that small-scale fluctuations of ocean currents play an important role in this region for the redistribution of oxygen and nutrients. For instance, these currents can carry nutrients upward from the dark ocean to the light-flooded zone near the sea surface and thus promote algae growth. At the same time, these currents can supply oxygen from the air-saturated mixed layer to the deeper oxygen-poor zones, making it available for the degradation of organic matter. This combination of physical and biogeochemical processes is subject to strong temporal and spatial variations and takes place within limited geographical areas. Therefore, both physical (temperature, salinity, currents) and biogeochemical parameters (chlorophyll as an indicator of algae growth, oxygen) have to be recorded over a period of several weeks with high spatial resolution in order to allow reliable analyses of physical-biogeochemical coupling.

Based on the above considerations, in the spring of 2010, an experiment was conducted north of Cape Verde, in which instead of a research vessel, a fleet of so-called gliders was used. Gliders (see right Fig.) are autonomously navigating measurement platforms, which travel at about 30 kilometers a day through the water. Although they are not equipped with a propeller, gliders can move forward under water like sailplanes because of their small wings. In a sawtooth-like pattern they descend to a predefined depth and then return again to the sea surface. Upon each arrival at the surface the newly recorded data are transmitted via satellite telephone communication to a shore station and in return new mission parameters such as sampling rate, dive depth, etc. can be transmitted to the glider.

A fleet of gliders was launched in March 2010 south of the island of São Vicente. The platforms then steered autonomously toward the Cape Verde Ocean Observatory (CVOO) located 100 kilometres to the north of the island, where they subsequently sailed along prescribed tracks in a 50 x 50 km wide area for several weeks (Fig. middle right). Thereby, the glider carried out several dives per day up down to a depth of 500 meters below the sea surface, collecting depth profiles of salinity, temperature, pressure, chlorophyll, oxygen and turbidity. Taken together, until their recovery by the research vessel Polarstern in May



A glider at the sea surface. Gliders can descend and ascend in the water column by changing their density. This is associated at a flow against the gliders' wings, by which a forward thrust is generated, enabling the gliders to move forward with about 30 km a day.



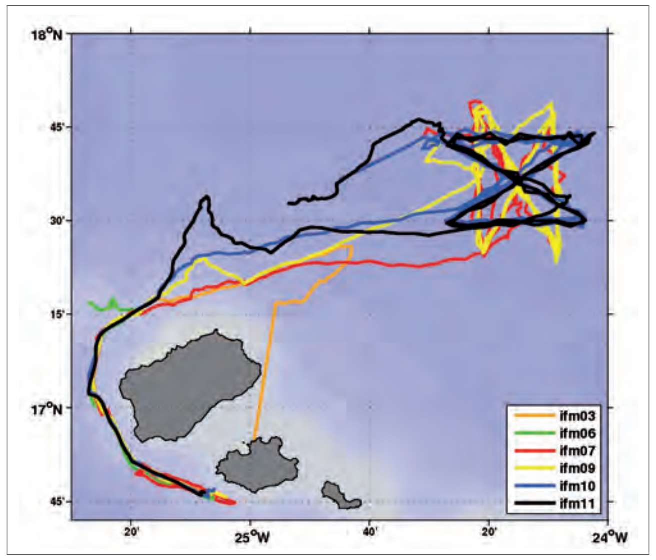
A glider on its way to collect depth profiles of salinity, temperature, pressure, chlorophyll, oxygen and turbidity.

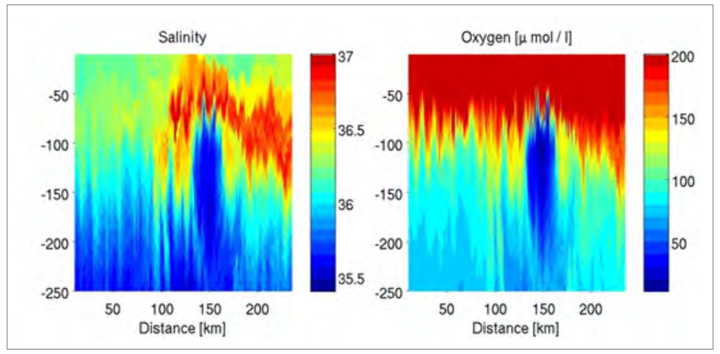
2010, the glider had travelled a distance of 3800 kilometres and completed 3500 dives.

The data clearly show the presence of small-scale circulation changes. They also demonstrate the interplay of physical and biogeochemical fluctuations, including, as shown in the figure below, an eddy containing oxygen-depleted, low-salinity waters. Based on these data we try to understand the spacial and temporal scales and the extent to which ocean currents transport nutrients and oxygen between the different regions and levels of the ocean. Continuous developments make the autonomously navigating underwater robots increasingly powerful and flexible, so they will play an important role in exploring the oceans in the future.

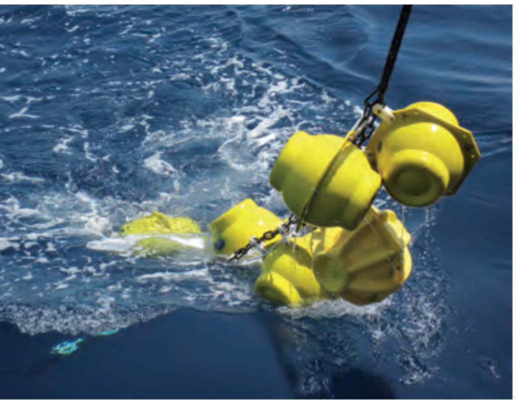
[1] GEOMAR, Kiel, Germany

Example of a small-scale water body (observed about 40 km north of the island of Santo Antão) with very low oxygen concentrations (right), coinciding with an unusually low salt content.





Tracks of the gliders during the measurement campaign in spring 2010. The gliders were launched south of the island of São Vicente, and steered autonomously to the Cape Verde Ocean Observatory. Here they performed measurements along predefined, butterfly-shaped tracks until they were recovered as scheduled on 5th May by the research vessel Polarstern.



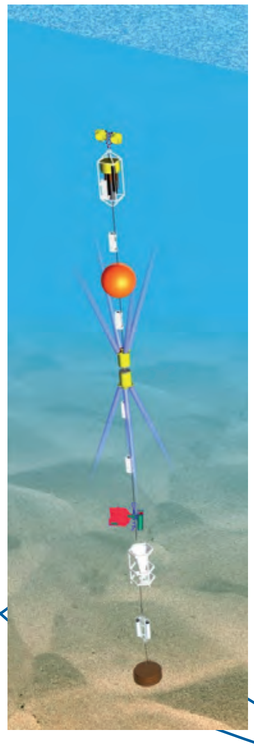
Launch of a mooring anchor dragging along the anchor line. A blue parachute prevents it from sinking too rapidly.

Oceanic Long-Term Observations

Johannes Karstensen[1], Björn Fiedler[1], Arne Körtzinger[1]

About 100 kilometres northeast of the Cape Verde island of São Vicente, a long-term ocean observation station (CVOO) has been established in 2006. The station, at a water depth of about 3600 meters, consists of a mooring which covers the entire water column and is supplemented by repeated ship-based oceanographic measurement campaigns. The autonomous sensors installed on the mooring (Fig. below) record data at very high temporal resolution. The ship-based sampling concentrates on the collection of data that cannot be measured autonomously.

The mooring requires servicing every 1 to 2 years to recover the data and to service the instrumentation (exchange batteries, clean sensors, etc.). This work is typically done from large to medium-sized research vessels and requires only a few days to ensure a sustained sampling scheme. The measurements at CVOO provide time series at selected depths of biogeochemical and biological variables, such as carbon dioxide, dissolved oxygen, particle flux, phytoplankton and zooplankton concentrations. The physical factors of the environment, such as water currents, temperature and salinity, are collected with particularly high resolution in order to accurately quantify the relevant physical processes.



Schematic representation of the CVOO deep-water mooring: A heavy anchor (railroad wheels) is placed on the sea floor, connected to a steel wire with buoyancy spheres and different instrumentation attached to it. Following a 1-2 year deployment, an acoustic signal is used to trigger the release which separates the anchor from the buoyant part. The mooring components rise to the surface and are recovered by the research vessel.

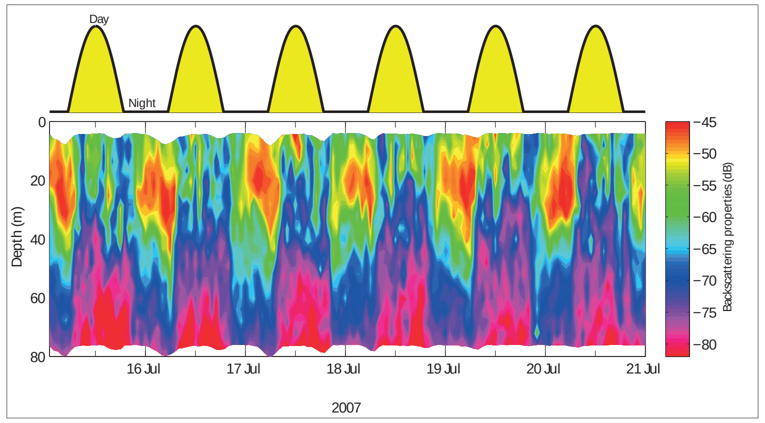
The time series provide a detailed picture of the temporal evolution of oceanic variables at a single geographical location but at different depths. High resolution data are necessary as the oceanic processes occur on time scales of days (diurnal vertical migration of zooplankton) to interannual and eventually long-term changes in the depth of the well-mixed ocean surface layer (Fig. bottom right). Only the simultaneous measurement of biogeochemical, biological and physical parameters allows the identification of various process interactions.

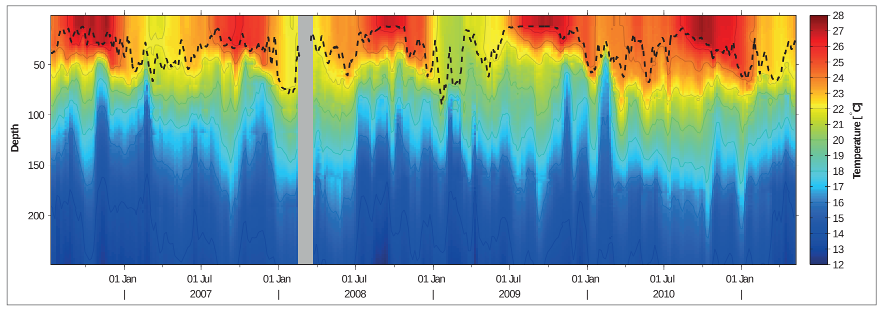
Another feature of the oceanic long-term station is the close link to the Cape Verde Atmospheric observatory (CVAO) on Sao Vicente. The location of the CVOO was carefully chosen to be upwind of the CVAO. With the wind blowing rather consistently at 25 - 30 kilometres an hour from northeasterly directions, the two stations are virtually "atmospherically connected" with each other. Therefore, the probability of a dust event reaching the oceanic CVOO station just a few hours prior to the atmospheric station is rather high. Details of Sahara dust events - such as particle concentration and their chemical composition - can be determined from the measurements at CVAO while the ocean's response is captured at the CVOO. Another example for joint atmosphere/ocean analysis is the ocean/atmosphere gas exchange that impacts both stations.

Exceptionally high data quality standards must be followed in the acquisition of these time series in order to determine any long-term trends which might give a hint of climate-related changes in the region. At CVOO, specific attention has been paid to the quality control of data: Highly accurate and precise reference data are collected whenever possible and used for quality control of the moored instrumentation data.

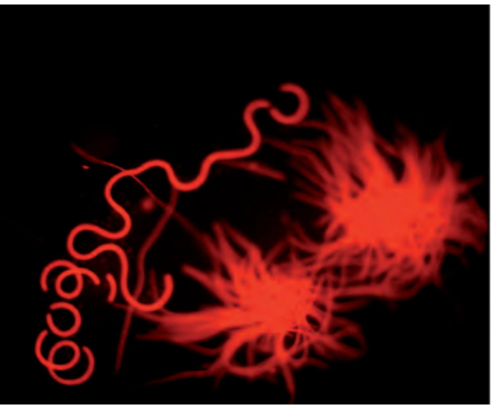
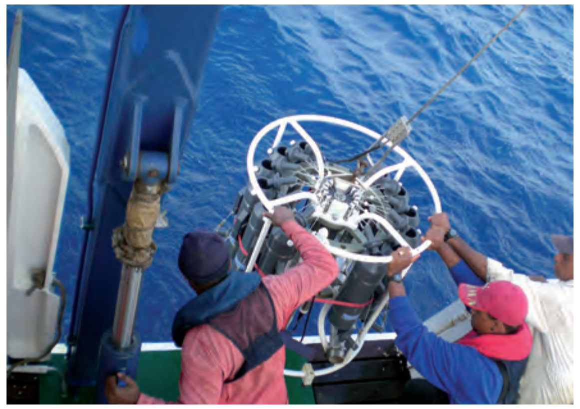
[1] GEOMAR, Kiel, Germany

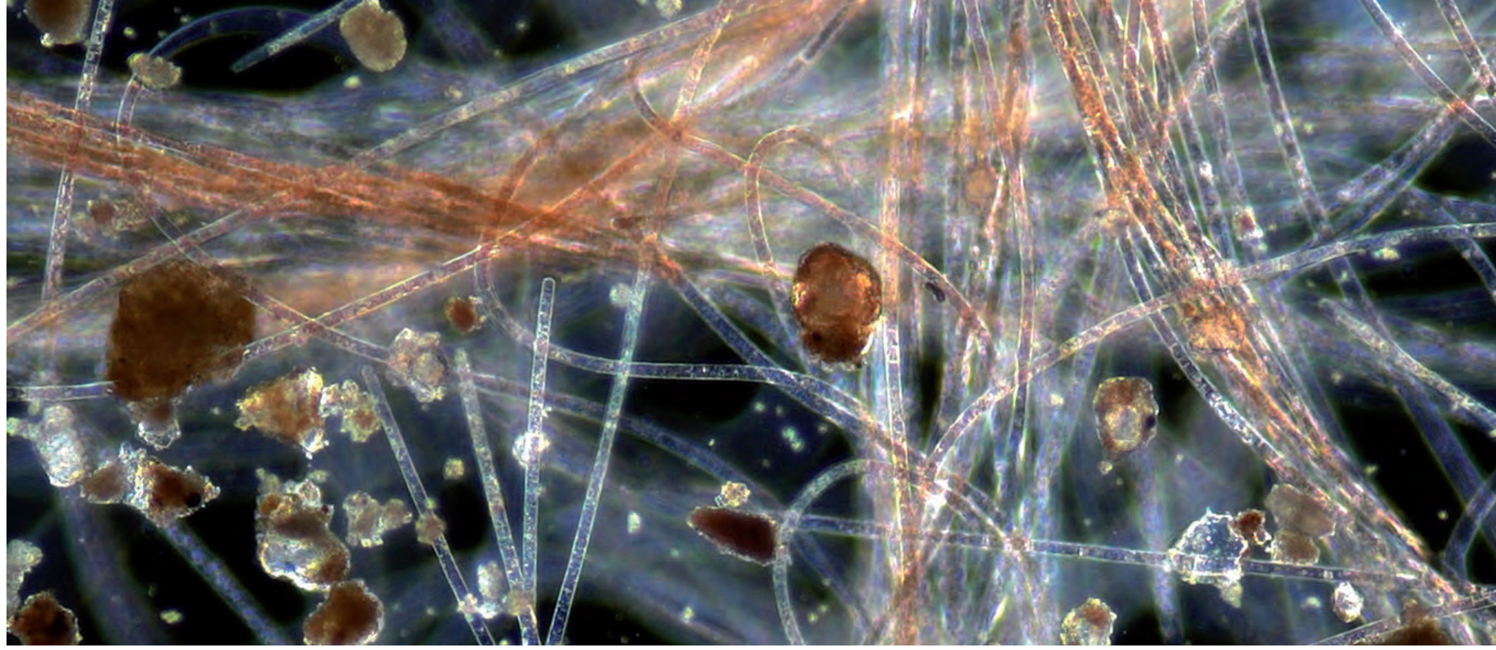
The time series of zooplankton distribution clearly shows that the greatest abundance (-45db) occurs during the night. With increasing daylight the zooplankton escapes to greater depth (not resolved) to hide from predators. The time series also demonstrates that this behaviour is equally linked to the stratification of the water column.





Temporal evolution of the temperature field as observed at CVOO between 2006 and 2011 (see left scale for color coding of temperatures). The black dashed line indicates the maximum depth of the well-mixed surface layer. This mixed-layer depth is an important parameter for the heat exchange between the interior of the ocean and the surface, and it plays a crucial role in climate and marine ecosystems.



Trichodesmium filaments entangled with Saharan dust particles, rich in Fe.

Diversity and Activity of Marine N_2 Fixers in Oligotrophic Waters of the North Atlantic

Julie LaRoche[1], Marcel Kuypers[2]

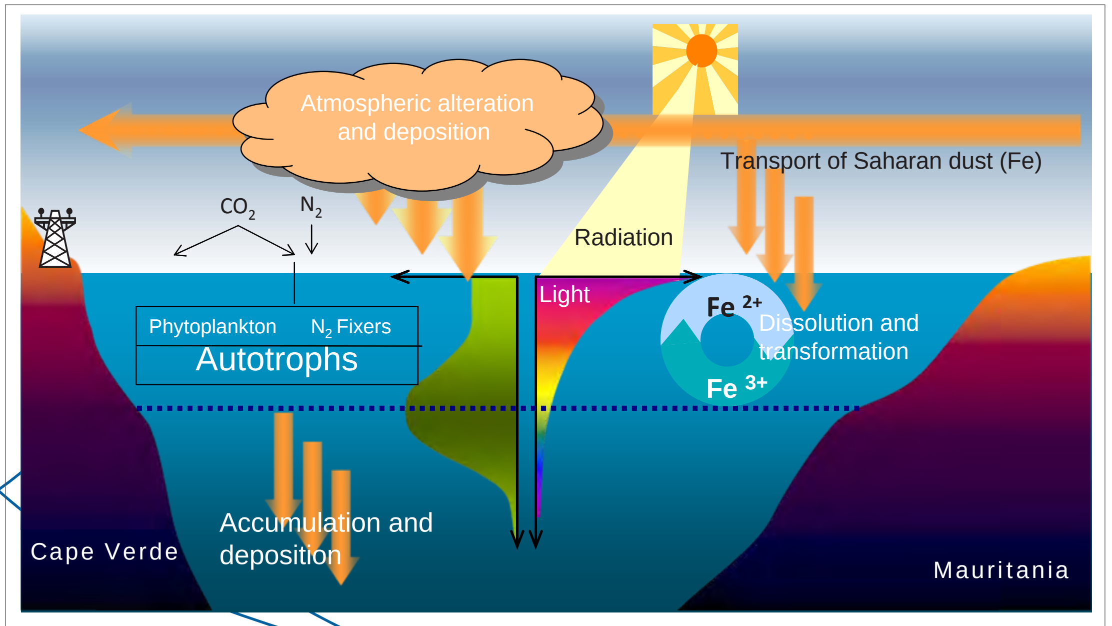
Since 2008, we have been studying primary production and N_2 fixation in the tropical North Atlantic, in and around the Cape Verde Islands. Our aim is to understand the role of Saharan dust deposition on the microbial community, and on N_2 fixers in particular. Microorganisms that are able to fix N_2 gas contain the Fe-rich nitrogenase enzyme complex and as a result N_2 fixers have a high cellular Fe requirement. Fe, although abundant on earth, is very insoluble in seawater, resulting in low bioavailability to the microbial community. Deposition of Fe rich Saharan dust onto the surface of seawater is therefore a major source of Fe in the tropical North Atlantic, promoting the growth of a diverse N_2 fixing community. Assessing the impact of dust in providing essential nutrients for marine microbial communities is an important research direction that can be well studied in the waters around the Cape Verde Islands, especially because of the opportunity to link to long term observations from the atmospheric and oceanic time series that are also located there.

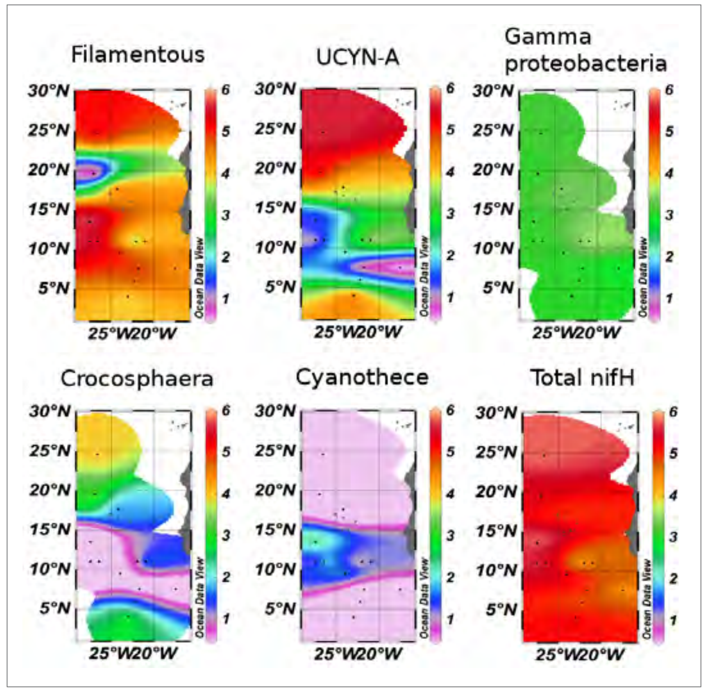
The N_2 fixing microbial community around the Cape Verde Islands is composed of several species that vary in abundance throughout the year, depending on environmental factors such as temperature and Saharan dust deposition. In 2008 and 2009, experiments were conducted with the microbial communities collected near the time-series station and confirmed that primary productivity is limited by the availability of fixed nitrogen, opening an ecological niche for N_2 fixers. *Trichodesmium*, a filamentous non-heterocystous cyanobacteria, often blooms there, especially after a dust storm, reaching cellular abundance of 2-3 milion cells per liter. The uncultured UCYN-A, a unicellular cyanobacterium that appears to lack photosystem II, is also abundant in this region. In addition, a poorly characterized heterotrophic gamma proteobacterium is common in these waters but in lower abundance.

Although *Trichodesmium* has long been recognized as contributing significantly to the input of new fixed nitrogen in the ocean and its physiology well characterized, we know very little about the ecology and physiology of uncultured UCYN-A and gamma proteobacteria. The uncultured N_2 fixers are currently identified from their specific nifH DNA sequence, the functional gene encoding the nitrogenase enzyme, but to date no one has been able to link the nifH signature to a particular cell type for either the UCYN-A or the gamma proteobacterium. Both uncultured groups can be found in waters close to the Tenatso laboratory which is located on São Vincente. In December 2010, a field study was conducted specifically to identify the UCYN-A at the cellular level, by using state of the art methods such as fluorescent in situ hybridization (FISH) and nano-Secondary Ion Mass Spectrometry (nanoSIMS). During this experiment, the UCYN-A group was reliably found in abundance in waters near the CVOO laboratory, demonstrating the importance of this field station for the study of N_2 fixation. We are currently analyzing the samples collected during this experiment and are planning another trip for 2011.

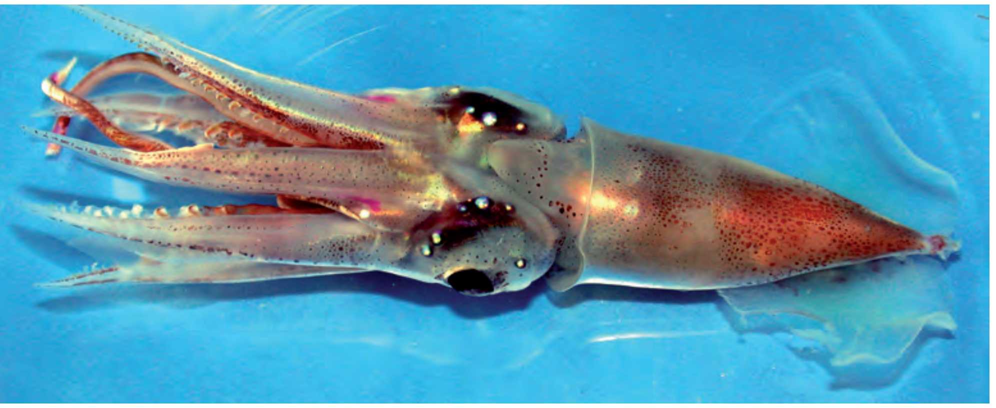
[1] GEOMAR, Kiel
[2] MPI for Marine Microbiology, Bremen

Factors influencing the nitrogen fixation at the Cape Verde time-series station. The nitrogen fixation is the highest entry of bounded nitrogen in the open ocean and is therefore a determining factor for the amount of primary production in the surface waters.





Distribution and relative abundance of the N_2 fixers around the Cape Verde area. Specific molecular genetic sensors for the key gene of nitrogen fixation, the so-called nifH gene, were used to detect various nitrogen fixers.



A living *Keratoisis* sp. taken from 3052 m depth at the Charles Darwin volcanic field during METEOR cruise M80/3.

Life in the Abyss – Fascinating Living Creatures at the Tropical Archipelago

Deep-Sea Corals – Living in the Dark

Jacek Raddatz[1], Wolf-Christian Dullo[1], Andres Rüggeberg[2]

Deep-sea or cold-water corals are widely distributed throughout the world's oceans from the tropics to the polar regions. These fascinating organisms thrive where no light reach the bottom of the ocean, mainly in depths between 200 - 1000 m. They survive in this unfavorable environment by filtering organic matter from the surrounding seawater. These flower-like looking organisms have been recovered by Norwegian fishermen in their fishing nets since the 18th century. In several parts of the ocean, these delicate organisms form unique ecosystems which are increasingly threatened by enhanced ocean acidification, global climate change, and by enhanced bottom trawling due to deep-sea fishing.

On the seamounts around the Cap-Verde islands these cold-water corals occur down to a depth of 3000 m. Here, they occur jointly with sponges, crustaceans, sea cucumbers, molluscs, several specialist fishes, and many other deep-sea organisms. One special distinctive feature among these organisms is bioluminescence just recently discovered in bamboo corals. Bioluminescence is known to occur in many deep-sea organisms, however, it has not been reported from deep-sea corals. The possible functions of this bioluminescence are unknown, so far.

Deep-sea corals are a valuable climate archive, since they record environmental parameters in their skeleton during growth. The element composition and their ratios within the calcified skeleton can be read like letters in a book providing meaningful sentences about past ocean climate history. Radiocarbon or uranium-thorium data provide the age of the corals which allow in concert with the analyses of trace elements to reconstruct past water mass conditions during times in which the analysed coral grew. Such delicate information about the dynamics of the deep-sea environment enhances our knowledge about climate-ocean system interactions, especially with regard to future climate scenarios.

[1] GEOMAR, Kiel, Germany
[2] Katholieke Universiteit Leuven, Belgium

Cephalopod – Fascinating Creatures along (Sub)Tropical Archipelagos

Uwe Piatkowski[1]

Near the Cape Verde frontal zone north of the Cape Verde Islands relatively cold water masses of the Canary Current coming from the north meet the currents of the warmer South Atlantic Central Water. This causes local upwelling and turbulence which form unique hydrographical conditions. They are responsible for the appearance of a variety of marine organisms from temperate waters which show here their most southern distribution. For many tropical species, however, the Cape Verde archipelago forms the most northern distributional range. These circumstances generate an immense species richness – which characterizes this region as a so-called "biodiversity hotspot".

In April 2005 RV Poseidon conducted comprehensive investigations to study the marine life at the Cape Verdes. One major goal was to study cephalopods, an animal group showing a high species diversity in tropical seas. Sampling focused on Senghor Seamount and the waters off the islands Fogo and Brava, where eight and ten, respectively, different species were caught. The cranch squid *Cranchia scabra* (Fig. above right), a jelly-like cephalopod and only several centimetres in size dominated the samples at Senghor Seamount. The enope squid *Abraliopsis pfefferi* which bears dark light organs on the tip of its ventral arms was another typical form. The most abundant species south of Fogo and Brava were the beautiful fire squid *Pyroteuthis margaritifera* (Fig. above left) with light organs located on the eyes and intestine, and the clubhook squid *Onychoteuthis banksi* which develops quite large hooks on the clubs of its tentacles to capture prey. The cephalopod collection taken during the expedition of RV Poseidon illustrates the diverse and impressive cephalopod fauna at the Cape Verde Islands. Unfortunately, we still know very little about the cephalopod community in this region and adjacent waters, although this animal group represents many key species in tropical marine ecosystems.

[1] GEOMAR, Kiel, Germany

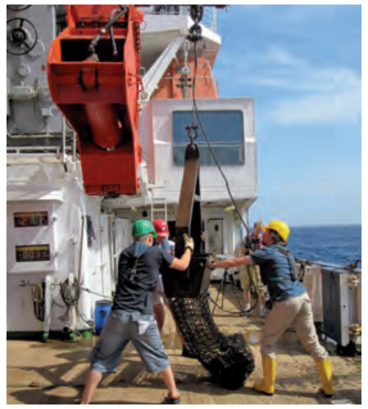
Zooplankton - A Major Hub in Marine Biogeochemical Cycles

Rainer Kiko[1], François Seguin[2], Lena Teuber[2], Holger Auel[2], Frank Melzner[1]

„Zooplankton" is the collective term for small millimeter to centimeter sized, free-living animals that colonize the water column of all oceans. Unlike fish and other large organisms they are unable to avoid sampling nets, but they play a central role in marine food-webs and biogeochemical cycles due to their relatively high abundance and trophic position. They mostly feed on microscopic phytoplankton and themselves are preyed upon by larger predators like fish. Their daily vertical migrations (see pages 18/19) generate a significant export of particulate and dissolved matter into the deep-sea, as they are not feeding at depth, but continue to respire and excrete there. Thus, they release metabolic end products at depth, the precursor molecules of which were consumed at the surface. Copepods - a particular subclass of the subphylum crustacea – represent the major fraction of zooplankton biomass and are therefore of particular interest with regards to fluxes of matter. To characterize the zooplankton of the Cape Verdean Archipelago, several zooplankton samples were taken at different water depths south of São Vicente. These samples were characterized taxonomically and revealed that the Cape Verdean zooplankton is particularly species rich. In total 126 taxonomic categories were identified. As not all categories were identified to the species level, the real species richness even surpasses this number. Within the group of calanoid copepods - a subgroup of the copepoda which we studied intensively - in total 91 species were identified. In particular different species of the genus *Pleuromamma* were found to conduct large diurnal vertical migrations. The high diversity observed is probably mostly a result of the complex hydrographic conditions of the Cape Verde Archipelago (see squids). In future, we will conduct our work at the CVOO, in order to better characterize the role of zooplankton in biogeochemical cycles in the tropical east Atlantic.

[1]GEOMAR, Kiel, Germany
[2] University of Bremen, Germany

The calanoid copepod *Candacia pachydactyla* is a particularly beautiful member of the Cape Verdean zooplankton.



Seamounts at the Cape Verde Archipelago – Volcanism in the Deep Sea

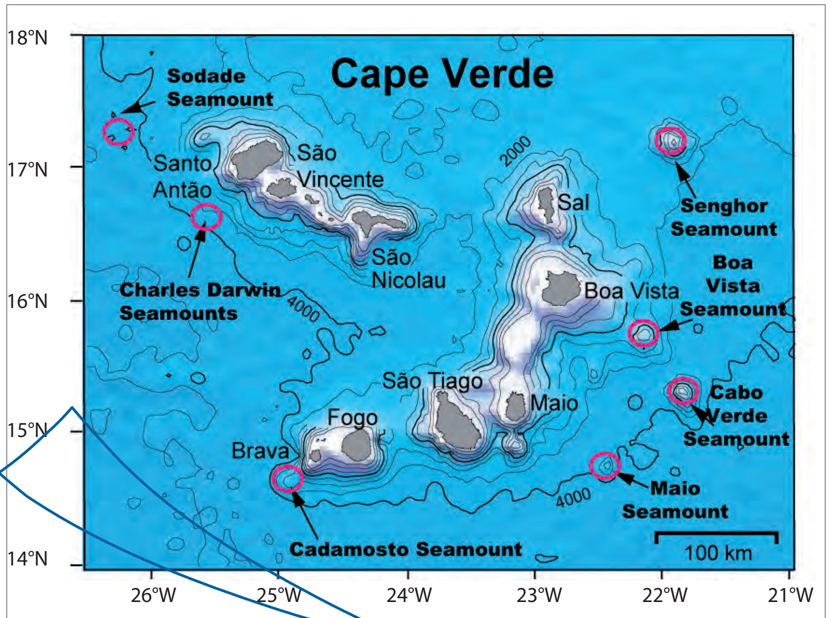
Thor H. Hansteen[1], Ingo Grevemeyer[1]

The Cape Verde archipelago off the West African coast is of volcanic origin - just as the Azores, Madeira and the Canary Islands - and also includes several submarine volcanoes, so-called seamounts. Under water the Cape Verde Islands offer an exciting territory for marine scientists of all disciplines: During a series of several research cruises with the German Research Vessel Meteor the geological and chemical properties of these seamounts have been investigated.

There is a clear age progression of both subaerial and submarine volcanism at Cape Verde, with volcano ages of several million years in the east and active ongoing volcanism in the west. Thus the oldest islands in the east include Sal, Boa Vista and Maio, and the active volcanoes in the west are Fogo, Brava and Santo Antão. Prominent extinct and eroded submarine volcanoes in the east include Senghor[1] Seamount, Boa Vista Seamount, Cabo Verde Seamount and Maio Seamount. Active submarine volcanoes in the west include Cadamosto[2] Seamount, Charles Darwin Seamounts, and the newly discovered Sodade[3] Seamount. We will focus on the latter three active volcanoes, which have quite different properties.

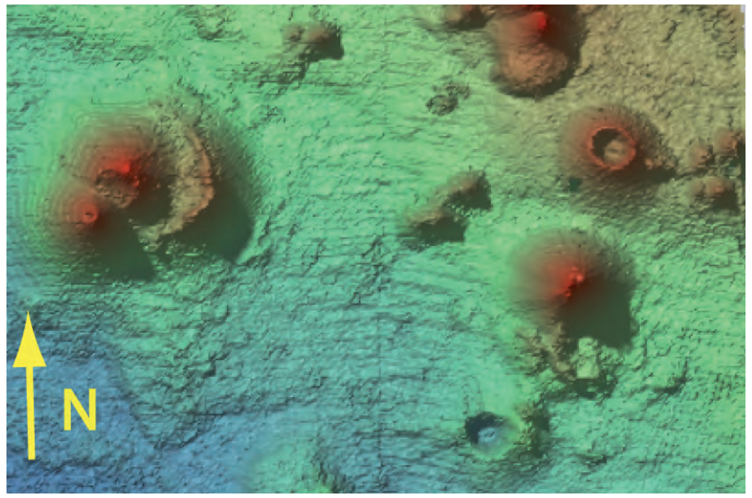
Cadamosto Seamount is a large mountain, rising from about 4000 m to 1400 m below sea level. It has a rather unusual phonolitic composition, suggesting that the magmas responsible for its formation evolved in large magma chambers in the crust. Volcanics rocks from the large explosive Cão Grande[4] eruption on Santo Antão has a very similar chemical composition indicating that Cadamosto also has a potential for violent eruptions. Cadamosto is the seismically most active seamount at Cape Verde, and may grow to become the next Cape Verde Island - which can take roughly 100,000 years.

Charles Darwin Seamounts and Sodade Seamount have considerable morphological similarities, as they comprise several volcanic cones covering a roughly circular area on the sea floor (Fig. bottom right). Both are geologically young, seen morphologically from the several eruption centers that have not yet merged to form a single, large seamount. There is, however, a major difference between the two areas. The most prominent peak at Sodade Seamount is a ca. 1300 m high ridge structure consisting of pillow lavas, suggesting outflow of submarine lavas along a dominant rift zone as the main growth mechanism. The Charles Darwin Seamounts, on the other hand, comprise two large craters with a diameter of about 1 km each, formed by explosive volcanic activity at about 3500 m depth. Thus seamount volcanism at Cape Verde covers an unusually broad spectrum of chemical compositions, eruptive styles and mechanisms.



Location of prominent seamounts at Cape Verde.

Pillow lava frozen under water at a 1300 m high ridge structure of the Sodade Seamount.

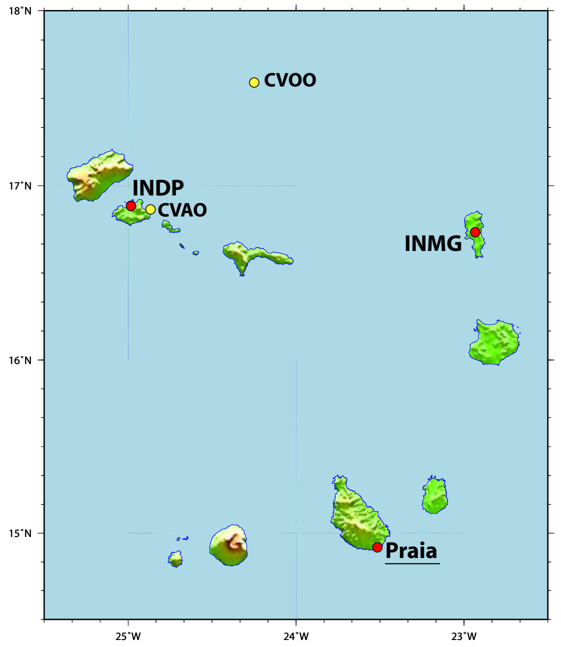


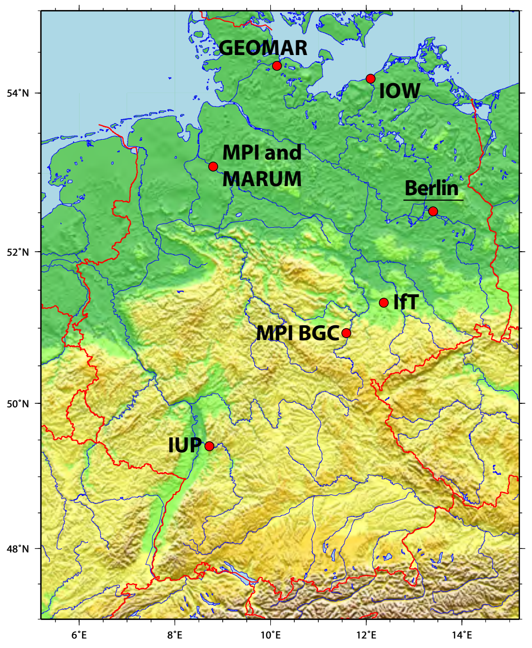
The newly discovered Charles Darwin Seamounts with their characteristic craters.

[1] GEOMAR, Kiel, Germany

[1] Senegalese poet and politician, 1906-2001
[2] Italian explorer serving the Portuguese, 1432-1483
[3] Word expressing "longing"
[4] Large dog

Involved Institutions





GEOMAR - Kiel (www.geomar.de):

The aim of the Helmholtz Centre for Ocean Research Kiel (GEOMAR) is to promote interdisciplinary collaboration in all major areas of modern marine research. The main research areas are divided into four main divisions: Ocean Circulation and Climate Dynamics, Marine Biogeochemistry, Marine Ecology and Dynamics of the Ocean Floor. In 2012 the institute has become a member of the Helmholtz Association and is jointly financed by the Federal Government and the State of Schleswig-Holstein. GEOMAR currently employs 750 people. To investigate the tropical Atlantic Ocean the institute operates the CVOO ocean observatory and a variety of state-of-the-art submarine and deep sea exploration systems.

INDP - Mindelo (www.indp.cv):

The Instituto Nacional de Desenvolvimento the Pescas (INDP) is concerned with studies of the ocean with particular focus on the fishing industry in the tropical Atlantic. The aim is to advise decision makers in politics and economy as regards the fisheries sector. This includes concerted measures to improve the socio-economic impacts caused by the fishery. The INDP, with headquarters in Mindelo on the island of São Vicente together with other regional offices, employs roughly 150 people. The majority of activities of the INDP result from cooperation at both the national and international level. The institute collaborates closely with the Ministry of Infrastructure and Maritime Economy with a major focus on the fisheries sector and the sustainable use of the marine environment.

INMG - Espargos (www.meteo.cv):

The Instituto Nacional de Meteorologiae Geofísica (INMG) based in Espargos on the Island of Sal promotes, coordinates and carries out the government's measurements in the field of meteorology, climatology and geophysics. It ensures meteorological, climatological and geophysical long-term observations, promotes research and technology programs and provides the public and decision makers with information. Currently, approximately 100 people work for the institute. Apart from several meteorological stations, the INMG together with the University of York, the MPI-BGC Jena, GEOMAR and the IfT Leipzig operates the atmospheric observatory at São Vicente. The Global Atmosphere Watch (GAW) and the World Meteorological Organization (WMO) are provided with the collected data on a regular basis.

IOW - Warnemünde (www.io-warnemuende.de):

The Leibniz Institute for Baltic Sea Research in Warnemünde was founded in 1992. Today the IOW is member of the Leibniz Association (WGL). Its basic infrastructure is financed jointly by the Federal Government and the State of Mecklenburg-Western Pomerania. Currently, 218 employees are working at the IOW. The IOW's research program is specializing in coastal and marginal seas with a particular focus on the Baltic Sea's ecosystem. The IOW has a laboratory for scanning electron microscopy and X-ray microanalysis where analysis of biogenic structures and morphological features, reconstruction of transport routes on the basis of terrigenous minerals, and particles regeneration and mineral detection are carried out in sediment samples.

IUP - Heidelberg (www.iup.uni-heidelberg.de):

The Institute of Environmental Physics (IUP) at the University of Heidelberg was founded in 1975 and is currently divided into the areas of Physics and Chemistry of the Atmosphere and Terrestrial and Aquatic systems. It studies the physics of transport and mixing processes as well as the conversion of materials within individual environmental systems and the exchange taking place between them. Specific research aspects are focusing on the atmosphere, soil and the water cycle. Furthermore, the coupling between soil and atmosphere and the greenhouse effect with its impact on the earth system is investigated. The institute currently employs about 150 employees. It is financed by the State of Baden-Wuerttemberg.

IfT - Leipzig (www.tropos.de):

The field of activity of the Leibniz Institute for Tropospheric Research (IfT) includes the study of the state and the properties of the troposphere, especially in anthropogenically influenced regions. The studies are divided into three main topics: 1. Evolution, transport and spatiotemporal distribution of tropospheric aerosol. 2. Influence of tropospheric aerosols on clouds and radiation. 3. Chemical processes in tropospheric multiphase systems. The Leibniz Institute is funded 50 % by the Federal Government and 50% by the State of Saxony. The institute currently employs 140 people. The IfT maintains aerosol filters in Cape Verde and conducts optical aerosol measurements at the atmospheric station CVAO on São Vicente. Furthermore, the IfT chairs the working committee for Africa of the German Climate Consortium.

MARUM - Bremen (www.marum.de):

The Center for Marine Environmental Sciences (MARUM) at the University of Bremen comprises the DFG Research Center and the Cluster of Excellence "The Ocean in the Earth System". Involved in international projects, MARUM aims at understanding the role of the oceans in the Earth's system by employing state-of-the-art methods – with a special focus given to global change. It quantifies the interactions between geological and biological processes in the ocean and provides information on a sustainable use of the same. In addition to the primary research activities, a research infrastructure is made available. MARUM has state-of-the-art technology for exploring the deep ocean, which is continuously being improved. This includes a deep sea drilling unit, remotely operated vehicles, and an autonomous underwater vehicle.

MPI - Bremen (www.mpi-bremen.de):

The Max Planck Institute for Marine Microbiology in Bremen employs over 200 people. Within the departments of biogeochemistry, microbiology and molecular ecology the institute's employees study microorganisms and their habitats in the oceans. The scientists contribute to improving the understanding of microorganisms involved in the nitrogen and carbon cycle. The Cape Verde Islands are ideally located for the institute's research: the microorganisms responsible for the carbon and nitrogen metabolism are nearly always present in the region and the circumstances are similar to niches in the open ocean. The researchers study these processes by using the latest techniques of genetic engineering, microbiology and geochemistry, and NanoSIMS, quantitative molecular genetic analysis, nutrient analysis and stable isotope incubation.

MPI BGC - Jena (www.bgc-jena.mpg.de):

The Max-Planck-Institute for Biogeochemistry (MPI Jena) has been conducting interdisciplinary fundamental research since 1997 on global biogeochemical cycles in the earth system and the biological, chemical and physical processes involved. Currently, about 150 employees are working at the institute. The scientists examine the complex interaction of soil organisms, vegetation and land use with the atmospheric greenhouse gases in order to improve the understanding of the climate's regulatory mechanisms and support the development of forecasts for future climate scenarios. On a 30 m high measurement tower at the atmospheric station CVAO on the Island of São Vicente, the institute has been conducting routine measurements of greenhouse gases for several years.

Projects and Expeditions in the Tropical Atlantic

	Project	Funding	Website
	SOPRAN Surface Ocean Processes in the Anthropocene	BMBF	www.sopran.pangaea.de
	ICOS-D National Implementation of the Integrated Carbon Observation System	BMBF	www.icos-infrastructure.eu
	SFB 754 Climate - Biogeochemistry Interactions in the Tropical Ocean	DFG	www.sfb754.de
	Excellence Cluster Future Ocean	DFG	www.ozean-der-zukunft.de
	SFB 574 Volatiles and Fluids in Subduction Zones - Climate Feedback and Trigger Mechanisms for Natural Disasters	DFG	www.sfb574.ifm-geomar.de
	TENATSO Tropical Eastern North Atlantic Time Series Observations	EU	www.tenatso.com
	EuroSITES European Ocean Observatory Network	EU	www.eurosites.info
	EUR-OCEANS Building scenarios for marine ecosystems under anthropogenic and natural forcings	EU	www.eur-oceans.eu
	SOLAS Surface Ocean Lower Atmosphere Study	SCOR, IGBP, WCRP, ICACGP	www.solas-int.org

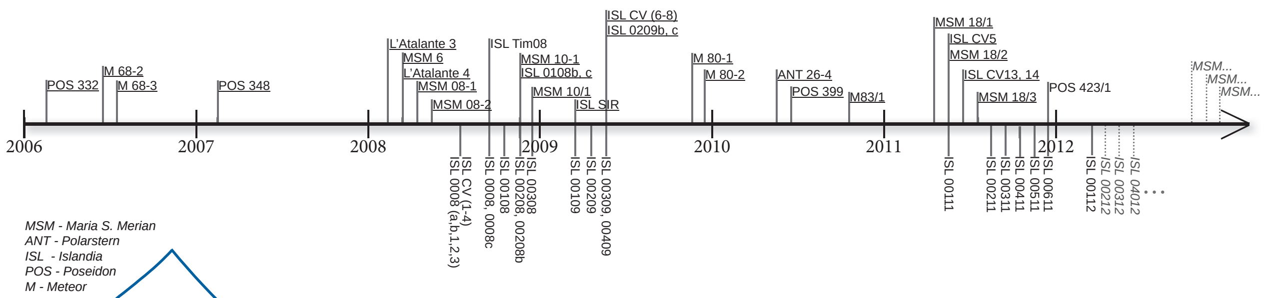

RV METEOR


RV ISLÂNDIA


RV MARIA S. MERIAN


RV POSEIDON


RV POLARSTERN



The Cape Verdean Partner INDP – Science and Logistics on the Site

Nuno Vieira[1], Cordula Zenk[2], Martina Lohmann[2]

When conducting field campaigns and expeditions at sea it is naturally of great advantage to have a regional partner. In the Cape Verde region this partner is represented by the Instituto Nacional de Desenvolvimento das Pescas (INDP).

The INDP, caring primarily about the needs of the fisheries sector, has been placing more and more focus on different areas of international ocean research. Its cooperations with foreign partners have been strengthened increasingly. Particularly noteworthy is the CVOO / CVAO Observatory (www.cvoo.de) being operated in collaboration with GEOMAR, the University of York, the Max Planck Institute for Biogeochemistry in Jena and its national partner the Instituto Nacional de Meteorologia e Geofísica (INMG). The marine component, CVOO, consists of a multidisciplinary long-term instrument mooring in the Atlantic Ocean to observe biogeochemical and physical processes in the water column. Visits by the INDP's research vessel Islândia take place at monthly intervals. A measurement tower at the CVAO station in Calhau / São Vicente serves as the basis for the atmospheric component. Comprehensive meteorological parameters are continuously measured. In addition to the monthly visits carried out by technicians of the INDP, the observatory is visited regularly also by German research vessels. The Port of Mindelo serves as the basis for exchange between scientists and of cargo several times a year.

Taking into account the frequent visits of international scientists and engineers, the INDP with its research infrastructure is a central place and contact point. The research teams not only benefit from the INDP's logistical support but also receive systematic scientific and technical support that is of great benefit and indispensable to conduct the research programs. Some notable examples are the planning and carrying out of cruises on board the Islândia, the deployment and recovery of autonomous devices such as floats and gliders as well as the maintenance of large equipment pools. In addition, water samples are collected and analyzed. Furthermore, researchers benefit from the INDP's help with customs issues and the organization of workshops, and it also provides local mobility. Without the close cooperation with the INDP efficient research would be difficult to carry out.

[1] INDP, Mindelo, Cape Verde
[2] GEOMAR, Kiel, Germany

Capacity Building

Since the beginning of the scientific cooperation with Cape Verde there has been a special focus on capacity building. On the long term a lively co-operation can only succeed if partners operate on the same level. In order to create the preconditions on a broad scale, first school and student projects have been initiated and conducted by GEOMAR, the University of Kiel and the Cape Verdean partners within several of Kiel's projects such as the Nat-Working Marine Sciences Project, the joint Outreach Program of two major collaborative research projects (SFB 574 and SFB 745) and the Future Ocean Excellence Cluster.

School Projects with Cape Verde

Joachim Dengg[1], Ivanice Monteiro[2], Wilfried Wentorf[3], Artemisia Duarte Lopes[4]

In parallel to the close scientific cooperations with the partner institutions of the two SFBs at GEOMAR, links with schools in the respective countries are being established to emphasize the importance of international collaboration in geosciences.

In Cape Verde, INDP (Instituto Nacional de Desenvolvimento das Pescas) has started to invite local schools in Mindelo to initiate joint projects. These concentrate on the distribution and abundance of marine species and the concentrations of nutrients and pollutants in the waters around the island of São Vicente. Similar measurements are carried out in the Kiel Fjord by pupils from Heinrich-Heine Schule in Heikendorf, with the goal of comparing the „Sea in Front of Our Door" at the two locations side-by-side on a common internet site. To get this project started, a small delegation of pupils and a teacher from Heikendorf visited Escola Salesiana in Mindelo in February 2011. Supported by staff from INDP, the University of Cape Verde and GEOMAR, excursions by German and Cape Verdean pupils were undertaken to practice the sampling techniques at different locations on São Vicente and in the laboratory. Measurements are now to be continued on a regular basis both in Mindelo and in Kiel. In November 2009 German and Cape Verdean pupils were able to participate in a research expedition of the R.V. Maria S. Merian to the equatorial Atlantic for the first time.

[1] GEOMAR, Kiel, Germany
[2] INDP, Mindelo, Cape Verde
[3] Heinrich-Heine Schule, Heikendorf, Germany
[4] Escola Salesiana, Mindelo, Cape Verde

Floating University 2008 visits INDP and TENATSO

Joanna Waniek[1]

Modern science needs modern teaching! - A good reason to initiate the "Floating University – Surface ocean properties of different biogeochemical provinces of the Northeast Atlantic".

The MSM08/02 cruise on board the Research Vessel Maria S. Merian provided the scientific framework for the Floating University 2008, which was led by Dr. J. Waniek (IOW). Financing through EUR-OCEANS gave diploma students, doctoral students and young researchers of different scientific disciplines from different European universities the possibility to realize their projects.

To take part, an application including the students' own proposal for a small research project focused on the questions of the EUR-OCEANS initiative was necessary.

During the cruise from Mindelo to Emden the participating students from Poland, Sweden, Portugal, England, Cape Verde and Germany were able to cover the entire scientific spectrum. Instructions and support were given by professional scientists.

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GEOMAR

Research Base Cape Verde

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