Report for the year 2018 and future activities

SOLAS *'GERMANY'*
compiled by: 'Christa Marandino and Hartmut Herrmann'

This report has two parts:

***- Part 1:** reporting of activities in the period of January 2018 – Jan-Feb 2019*
***- Part 2:** reporting on planned activities for 2019/2020 and 2021.*

The information provided will be used for reporting, fundraising, networking, strategic development and updating of the live web-based implementation plan. As much as possible, please indicate the specific SOLAS 2015-2025 Science Plan Themes addressed by each activity **or specify an overlap between Themes or Cross-Cutting Themes.**

1 Greenhouse gases and the oceans;
2 Air-sea interfaces and fluxes of mass and energy;
3 Atmospheric deposition and ocean biogeochemistry;
4 Interconnections between aerosols, clouds, and marine ecosystems;
5 Ocean biogeochemical control on atmospheric chemistry;
Integrated studies;
Environmental impacts of geoengineering;
Science and society**.**

***IMPORTANT**: This report should reflect the efforts of the SOLAS community in the **entire country** you are representing (all universities, institutes, lab, units, groups, cities).*

PART 1 - Activities from January 2018 to Jan/Feb 2019

1. Scientific highlight

1. **Aliphatic amines at the Cape Verde Atmospheric Observatory: abundance, origins and sea-air fluxes (Theme 5)**

Manuela van Pinxteren, Khanneh Wadinga Fomba, Dominik van Pinxteren, Nadja Triesch, Erik Hans Hoffmann, Charlotte Cree, Mark Fitzsimons, Wolf von Tümpling, Hartmut Herrmann

Aliphatic amines are important constituents of the marine environment. However, their biogenic origins, formation processes and roles in atmospheric chemistry are still not well understood. Within two intensive sampling campaigns at the Cape Verde Atmospheric Observatory (CVAO), a remote marine station in the tropical Atlantic Ocean, amines were measured in all relevant marine compartments, the bulk seawater, the sea surface micro layer (SML), the gas and the submicron aerosol phase. In seawater, the amines were almost exclusively detected in the SML, leaving the question open, if the amines are formed at the ocean surface or transported there due to physical processes (e.g. rising bubbles). Amines in the SML and in the gas phase both showed a positive correlation towards biological (phytoplankton) indicators which suggests their close linkage and indicates that the amine abundance in the atmosphere (gas phase) partly reflects biological processes in seawater. In contrast, particulate amine concentrations did not show such a direct response and might have other significant sources and environmental drivers. Sea to air fluxes of the amines indicated that 2-way transport may be occurring. Overall, these results contribute to reduce the gap of knowledge about amines in the marine environment. Beyond that, it could be shown that aliphatic amines are present as a source of atmospheric base in the remote, often oligotrophic, region of the Cape Verde islands in all marine compartments.

Citation: *Manuela van Pinxteren, Khanneh Wadinga Fomba, Dominik van Pinxteren, Nadja Triesch, Erik Hans Hoffmann, Charlotte Cree, Mark Fitzsimons, Wolf von Tümpling, Hartmut Herrmann*
Atmos. Environ. 2019, *in press*

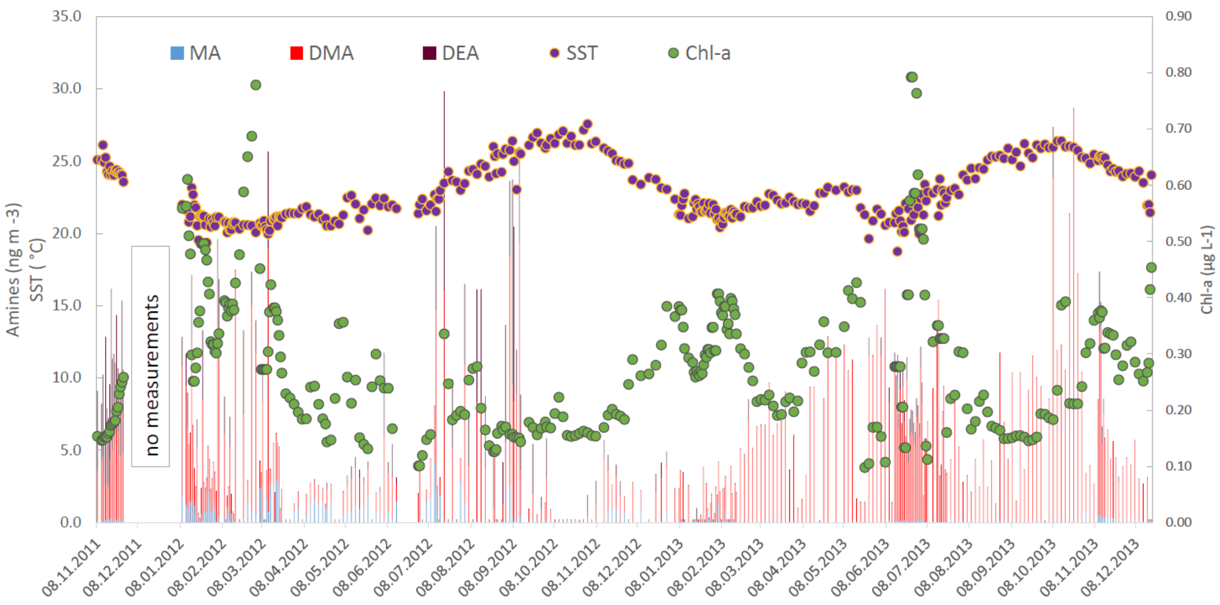
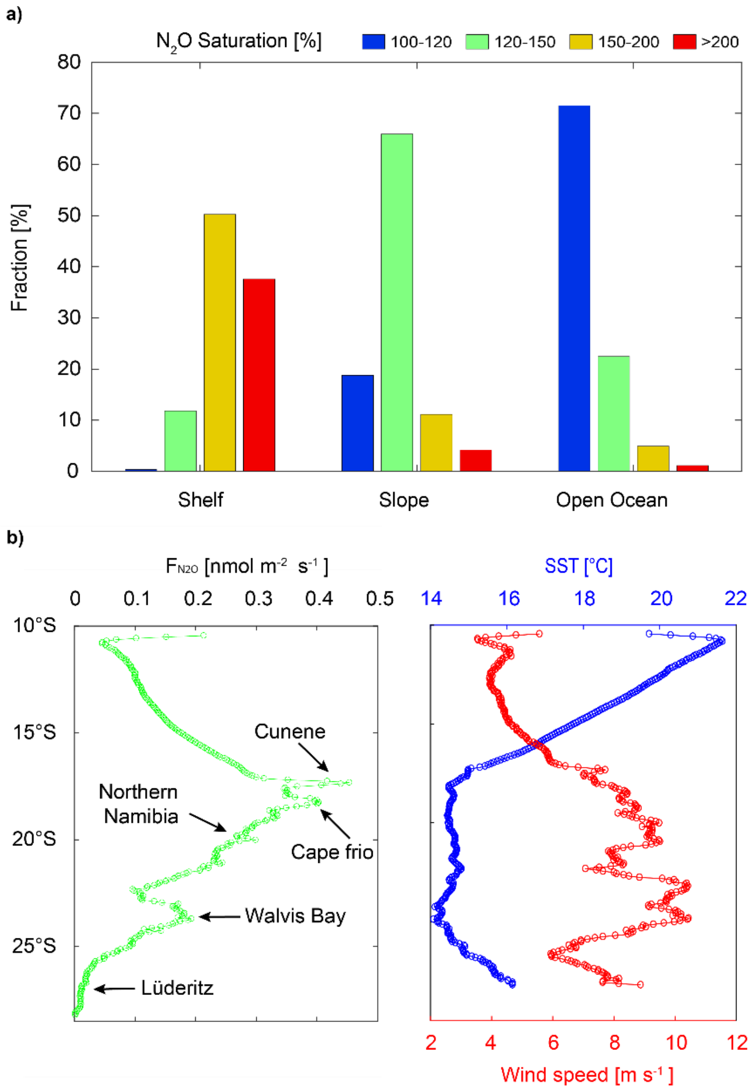


Figure 1: Time series of the particulate amine concentrations, in detail: MA – monomethyl amine, DMA - diethyl amine and DEA - diethyl amine (ng m^{-3}) together with chl-a (µg L^{-1}) and the SST (°C) for the 24-month time series measured at the CVAO.

2. N_2O Emissions from the Benguela upwelling system (Theme 1); Integrated studies)

Nitrous oxide (N_2O) is a potent greenhouse gas that contributes both to Earth's warming and stratospheric ozone depletion. In the marine environment N_2O is produced at mid-depth as a result of microbial decay of organic matter (under low oxygen conditions), and it is transferred to the atmosphere through air-sea gas exchange. The Benguela Upwelling System (BUS) is the most productive of all eastern boundary upwelling ecosystems and it hosts a well-developed oxygen minimum zone. Hence, the BUS is a potential hotspot for production and emissions of N_2O. In order to elucidate the large-scale distribution and variability of air-sea fluxes of this gas, as well as the impact of upwelling filaments on the total emissions, we conducted extensive, high-resolution measurements of dissolved and atmospheric N_2O during three expeditions in 2013. We found strong gradients with a threefold increase in N_2O concentrations near the coast as compared with open ocean waters. Our observations showed enhanced sea-to-air fluxes of N_2O (up to 1.67 $nmol \cdot m^{-2} \cdot s^{-1}$) in association with local upwelling cells. Based on our data we suggest that the high emissions area for the northern BUS is larger than previously thought and that it accounts for 13% of the total coastal upwelling source of N_2O to the atmosphere.



Spatial variability of N_2O in July-September 2013. (a) Histogram showing the variable contribution of different areas to N_2O outgassing (expressed as saturation percentage) from the northern Benguela upwelling system. (b) Latitudinal distribution of N_2O fluxes (F_{N2O}), sea surface temperature (SST), and wind speeds across the Benguela upwelling system (expressed as zonal means at 1/32° spacing; 10.5-15°E). The major upwelling cells are indicated in b (left).

Citation:
Arévalo-Martínez, D.L., Steinhoff, T., Brandt, P., Körtzinger, A., Lamont, T., Rehder, G., and Bange, H. W., 2019, N_2O emissions from the northern Benguela upwelling system, *Geophysical Research Letters*, 46, https://doi.org/10.1029/2018GL081648.

2. Activities/main accomplishments in 2018 (projects, field campaigns, events, model and data intercomparisons, capacity building, international collaborations, contributions to int. assessments such as IPCC, interactions with policy makers or socio-economics circles, social sciences, and media).

- **MarParCloud: Organic Matter in the marine tropical environment: Amino acids**
  Manuela van Pinxteren, Nadja Triesch, Hartmut Herrmann

  The export of organic matter (OM) from the oceans into aerosol particles can establish a significant carbon flux in the Earth system, although the functional relationships of OM in the water column via the SML to the atmosphere are still poorly understood. Within the ocean-atmosphere related project MarParCloud the process chain of biological production of organic matter in the oceans, its export to marine aerosol particles and finally their abilities to act as ice nuclei and cloud condensation nuclei is currently investigated. The project is organized in a network between the TROPOS, the ZMT, the

IOW and the Universities of Oldenburg (ICBM) and Hamburg. Thereby one focus is on the role of the sea surface microlayer (SML) as the direct interface between ocean and atmosphere.
The main event of MarParCloud was a recent intensive field campaign at the Cape Verde Atmospheric Observatory (CVAO), comprising a wide range of sampling and analytical techniques for studying marine aerosol particles as well as sea- and cloud water. As a first step, a detailed characterization of atmospheric relevant organic matter in all marine compartments, e.g. the bulk seawater, the SML, the ground based aerosol particles as well as the aerosol particles at the mountain site (where clouds are present) was conducted. Figure 1 shows the concentrations of amino acids, as important nitrogen containing OM compounds in all relevant marine compartments. Their abundance and varying concentration and composition suggests a selective transfer of the amino acids from the ocean to the atmosphere. Further studies, including biogeochemical parameters will help to reveal sources, fate and effects of OM, such as amino acids in the tropical marine environment. (Themes 2, 4)

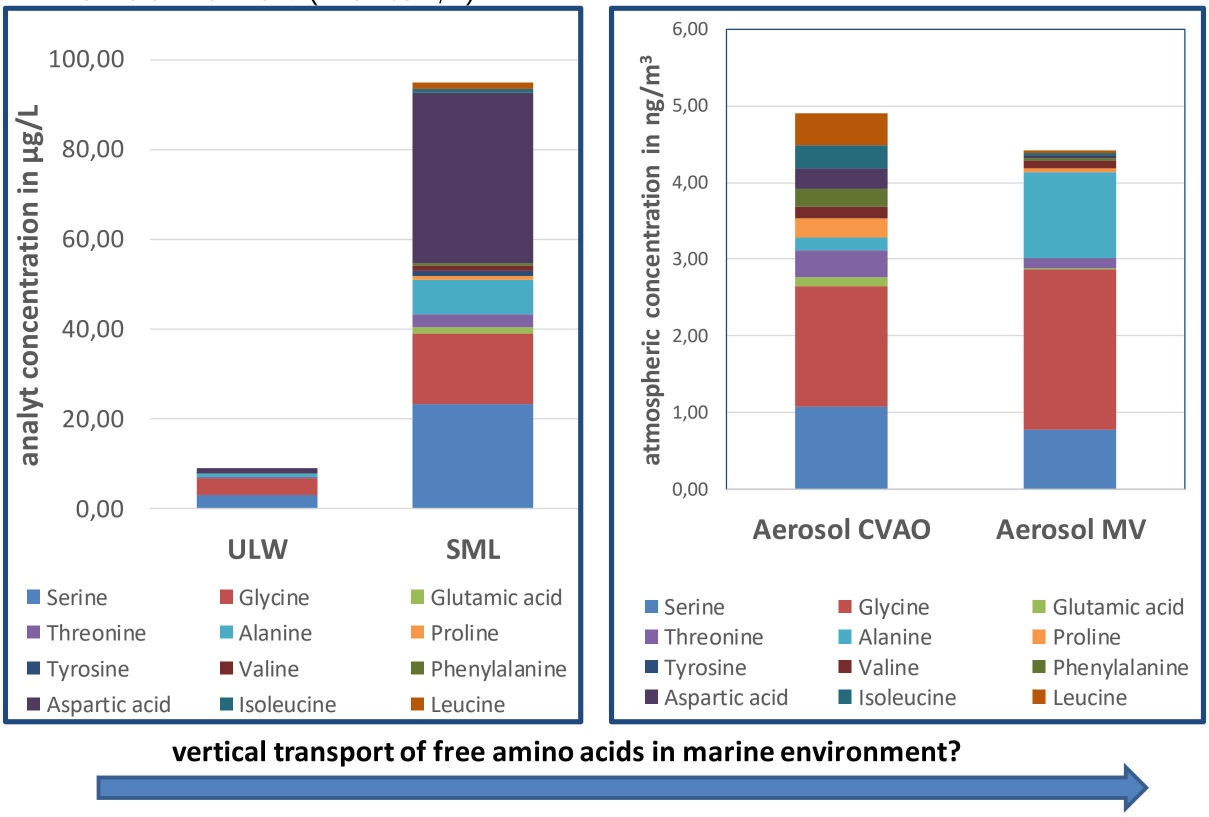


Figure 1: Concentrations of free amino acids in the several marine compartments sampled at the CVAO: in the bulk- or underline water (ULW) , the sea surface microlayer (SML), the ground based aerosol particles sampled at the CVAO and in the aerosol particles at the mountain side during marine conditions.

- Cruise EMB184 (chief scientist: Christian Stolle, IOW; involved institutes: IOW, ICBM, TROPOS, Uni Stockholm) –SML properties, CO_2 gas exchange, aerosol particles (Themes 1, 2, 4)
- Cruise Poseidon POS519 (chief scientist: Tobias Steinhofff, GEOMAR; involved institutes: GEOMAR, Dalhousie Uni) - the cruise POS519 took place between January, 23 and February, 10. We identified a fresh upwelled water mass off the coast of Mauritania and deployed a surface drifter within the water mass. The drifter was equipped with a surface element and a sensor cage at 10 m depth with sensors for temperature, salinity, pCO_2, chlorophyll, oxygen, gas tension and nitrate. Underway measurements of surface water were performed on board for standard variables like temperature and salinity and in addition CO_2, N_2O, COS, Chlorophyll and oxygen while the ship was following the drifter. In addition we installed a “direct flux” instrumentation at the bow of the ship that measured the CO_2 exchange between the ocean and the atmosphere. Furthermore, we sampled the surface micro layer (SML) to observe its development. The overall goal was to determine the variability of such an upwelling patch and to study the impact of the SML on gas exchange. Over 40 stations we sampled the water column for various parameters and conducted microstructure profiles. (Themes 1, 2)
- Cruises Baltic GasEx (chief scientist: Dennis Booge/Christa Marandino, GEOMAR; involved institutes: GEOMAR, University of Hawaii, Kiel University, TROPOS) Air-water gas exchange influences the cycling of biogeochemically important trace gases on global and regional scales (CO_2,

DMS, halocarbons, and non-methane hydrocarbons), and affects water quality on local scales (e.g., oxygen exchange). Wind speed is typically used to parameterize gas transfer and, in the last few decades, advancements in field and analysis techniques have enabled us to narrow the list of reasonable wind speed/gas exchange parameterizations that are applicable in most circumstance over the ocean. However, there are environments and conditions where existing parameterizations might not be applicable. One of these environments is inland seas where surfactants might have a more dominant effect on gas exchange.

All the studies published to date that have investigated the effects of surfactants on air-sea exchange have either used artificial surface active compounds or have only measured surfactant and wave properties under natural conditions, rather than gas transfer or flux directly. Baltic GasEx was conducted in two parts, June and September, during which direct air-sea transfer measurements in the presence of a natural surfactant patch at the Baltic Sea time series station, Boknis Eck (BE), took place. Natural surfactant measurements have been recorded at BE from 2009-2014 using surface-sensitive sum-frequency generation spectroscopy. We used two different methods, simultaneously, to directly measure exchange: 1) $^3He/SF_6$ tracer release experiments and 2) trace gas eddy covariance. In conjunction with gas exchange measurements, the abundance of surface active compounds was quantified and characterized in order to determine the influence of surfactants/microlayer on the air-sea fluxes. Gas transfer parameterizations based on wind speed will be evaluated, both for the influence of surfactants and the difference between the open ocean and inland seas. (Theme 2)

- German Committee for Sustainability group on ship emissions (funded by the DFG, W. Rickells, C. Marandino speakers) (Theme 3; Science and society)
- Blue Carbon (from the SOLAS Science and Society meeting in Brussels/Monaco) presentation at EGU 2018 by Helmuth Thomas (Science and society)
- Participation in OCB workshop on N_2O and CH_4, Lake Arrowhead, USA; 28 – 31 October 2018 (Damian Arévalo-Martínez, Hermann Bange and Annette Kock, GEOMAR). (Theme 1)
- IIOE-2 WG1 'Science and Research' Meeting, Kiel, GEOMAR, 28 – 30 November 2018 (organized by HW Bange, GEOMAR) (All themes)
- H. Bange Lab Group Field campaigns:
- Cruise P519 (Eastern tropical North Atlantic, January-February 2018, SOLAS Theme 1)
- Cruise M148 (Tropical Atlantic, southeast Atlantic, May-June 2018, SOLAS Theme 1)
- Cruise PS114 (Fram Strait, east Greenland, July 2018, SOLAS Theme 1)
- Cruise AI516 (Baltic Sea, September 2018, SOLAS Theme 1)

3. Top 5 publications in 2018 (only PUBLISHED articles) and if any, weblinks to models, datasets, products, etc.

1. Fiehn, A., Quack, B, Marandino, C A, Krüger, K, 2018, Transport Variability of Very Short Lived Substances From the West Indian Ocean to the Stratosphere. *Journal of Geophysical Research: Atmospheres,* 123, 5720-5738, DOI 10.1029/2017JD027563.
2. Lutterbeck, H E, Arévalo-Martínez, D L, Löscher, C R, Bange, H W, 2018, Nitric oxide (NO) in the oxygen minimum zone off Peru, *Deep-Sea Research Part II*, 156, 148-154.
3. Miranda, M L, Mustaffa, N I H, Robinson,T B, Stolle, C, Ribas-Ribas,M, Wurl,O, Zielinski, O, 2018, Influence of solar radiation on biogeochemical parameters and fluorescent dissolved organic matter (FDOM) in the sea surface microlayer of the southern coastal North Sea, *Elementa Science of the Anthropocene*, DOI: 10.1525/elementa.278.
4. Wilson, S T, Bange, H W, Arévalo-Martínez, D L, Barnes, J, Borges, A V, Brown, I, Bullister, J L, Burgos, M, Capelle, D W, Casso, M, de la Paz, M, Farías, L, Fenwick, L, Ferrón, S, Garcia, G, Glockzin, M, Karl, D M, Kock, A, Laperriere, S, Law, C S, Manning, C C, Marriner, A, Myllykangas, J P, Pohlman, J W, Rees, A P, Santoro, A E, Tortell, P D, Upstill-Goddard, R C, Wisegarver, D P, Zhang, G L, Rehder, G, 2018, An intercomparison of oceanic methane and nitrous oxide measurements, *Biogeosciences*, 15, 5891-5907.
5. Zavarsky, A, Goddijn-Murphy, L, Steinhoff, T, Marandino, C A, 2018, Bubble-Mediated Gas Transfer and Gas Transfer Suppression of DMS and CO_2, *Journal of Geophysical Research: Atmospheres,* 123, 6624-6647, DOI 10.1029/2017JD028071.

4. Did you engage any stakeholders/societal partners/external research users in order to co-produce knowledge in 2018? If yes, who? How did you engage?

German Committee for Sustainability group on ship emissions (funded by the DFG, W. Rickells, C. Marandino speakers)– began the planning of an international round table discussion with stakeholders (e.g. Hamburg ports, shipping companies, etc.) to be held in 2019 (Theme 3; Science and society)

PART 2 - Planned activities for 2019/2020 and 2021
1. Planned major field studies and collaborative laboratory and modelling studies, national and international (incl. all information possible, dates, locations, teams, work, etc.).
• PI-ICE campaign, Antarctica: Jan-March 2019: *Polar atmosphere-ice-ocean Interactions: Impact on Climate and Ecology,* Team: Dall´Osto, Berdalet , Vaque , Vidal, van Pinxteren, Šantl-Temkiv, Beddows, Rinaldi • Proposal of an Inter- journal special issue in the journals ACP and OS with the topic: "*Marine organic matter: From biological production in the ocean to organic aerosol particles and marine clouds"* • Field campaigns: - Cruise POS533 (Canary Islands, Cape Verde Islands, February-March 2019, SOLAS Themes 1, 4, 5) - EU BONUS INTEGRAL cruises (Baltic Sea, February-March 2019 and May/June 2019, SOLAS Theme 1) - North Pole 2019 (Barents Sea, March-May 2019, SOLAS Theme 1) - Cruise MSM85 (Eastern coast of Greenland, July-August 2019, SOLAS Theme 1) - GLACE (Circumnavigation around Greenland, July-September 2019, SOLAS Theme 1) - Cruise M158 (Equatorial Atlantic, Benguela region, September-October 2019, SOLAS Theme 1) - ODEN cruise 2019 (Northwest Greenland, June-August 2019, SOLAS Theme 1) - Cruise SO276 (GEOTRACES, Southern Indian Ocean, July-August, 2020, SOLAS Theme 1) - Cruise SO280 (BIOCAN-IIOE2; Arabian Sea, December 2020-January 2021, SOLAS Theme 1) - Meteor/Merian cruise (Equatorial Atlantic, Benguela region, 2021 (proposed), SOLAS Theme 1) - Meteor/Merian cruise (Benguela region, 2021 (proposed), SOLAS Theme 1) - CHINARE 2019 and 2020 (Southern Ocean, SOLAS Themes 1, 4. 5)
2. Events like conferences, workshops, meetings, schools, capacity building etc. (incl. all information possible).
• German Committee for Sustainability group on ship emissions (funded by the DFG, W. Rickells, C. Marandino speakers)– international round table discussion with stakeholders (e.g. Hamburg ports, shipping companies, etc.), March 2019 • International Indian Ocean Conference (H. Bange), at NIO, Goa, India, March 2020 (SCOR, IOGOOS; IOC), planning is ongoing. • SOLAS International Summer School, 2021 (C. Marandino) – planned to be held in Cape Verde
3. Funded national and international projects / activities underway.
• PETRA: Pathways and emissions of climate-relevant trace gases in a changing Arctic Ocean (Integrated projects) • NITROSO: Effects of ocean acidification on the emission and production pathways of NITRous Oxide in the Southern Ocean (Antarctic) (Theme 1) • Integrated carboN and TracE Gas monitoRing for the bALtic sea (EU BONUS INTEGRAL) (Theme 1) • SCOR Working Group 143: *"Dissolved N_2O and CH_4 measurements: Working towards*

a global network of ocean time series measurements of N_2O and CH_4" (Theme 1)

- 2nd International Indian Ocean Expedition: HW Bange is member of the steering committee and co-chairing WG1 'Science and Research' (All themes)
- 3 new upwelling projects funded by the BMBF: REEBUS, CUSCO (A., Körtzinger, U. Riebesell GEOMAR), EVAR (H. Schulz-Vogt IOW) (Integrated projects)

4. Plans / ideas for future projects, programmes, proposals national or international etc. (please indicate the funding agencies and potential submission dates).

- Helmholtz International Ocean Atmosphere Network (HI-OceAN), C. Marandino, A. Engel, A. Körtzinger, Helmholtz Association submitted March 2019, to be located on Cape Verde
- German-Israel Partnership, A. Engel, C. Marandino, DFG submitted March 2019, to study the influence of the sea surface microlayer on air-sea exchange of gases and particles
- Transdisciplinarity in Ocean Research, C. Marandino, E. van Doorn, Belmont Forum submitted January 2019, to study the influence of ship emissions from natural science, legal, and economic perspectives
- Ship proposal for follow up to Baltic GasEX, G. Rehder, C. Marandino, submitted February 2019

5. Engagements with other international projects, organisations, programmes etc.

- Projects
  - 2nd International Indian Ocean Expedition (IIOE-2)
  - RINGO
  - ICOS
  - SCOR
  - Boknis Eck Time Series Station
  - CVOO/CVAO
  - SFB754
  - and many more
- Partner Institutions
  - INDP, Mindelo, Cape Verde
  - Ocean University China, Qingdao, China
  - Third Institute of Oceanography, Xiamen, China
  - York University
  - Dalhousie University
  - and many more
- International Organisations
  - IPCC
  - Future Earth/Belmont Forum
  - and many more

Comments