NEWSLETTER 2015 | 02

Sonderforschungsbereich 754
Climate – Biogeochemistry Interactions in the Tropical Ocean

SFB 754

N_2-fixation Workshop

KIEL, 28TH APRIL 2015

Participants discussed oceanic N_2-fixation in the tropical Atlantic and the Pacific areas. Findings on diversity of N_2-fixers and rate measurements (B4) and benthic N_2-fixation results (B1/B6) were presented. B2 members reported on their observations on controls on N_2-fixation (mesocosms and bioassays). The major goal of this internal SFB 754 workshop was to understand patial patterns of N_2-fixation, its environmental controls and what kind of data is needed to constrain the models (among others A2, B1, B2). The workshop was an initiative by B4 young scientists C. Löscher and J. Dekaezemacker.

Publications

Dale, A.W., L. Nickelsen, F. Scholz, C. Hensen, A. Oschlies and K. Wallmann (2015) A revised global estimate of dissolved iron fluxes from marine sediments. Glob. Biochem. Cy., 29, 691-707, doi: 10.1002/2014GB0050117

Literature data on benthic dissolved iron (DFe) fluxes, bottom water oxygen concentrations (O_{2BW}), and sedimentary carbon oxidation rates (C_{OX}) from water depths ranging from 80 to 3700 m were assembled and analyzed with a diagenetic iron model to derive an empirical function for predicting benthic DFe fluxes. This function unifies previous observations that C_{OX} and O_{2BW} are important controls on DFe fluxes. Upscaling predicts a global DFe flux from continental margin sediments of 109 ± 55 Gmol yr^{-1}, of which 72 Gmol yr^{-1} is contributed by the shelf and 37 Gmol yr^{-1} by slope sediments. The predicted deep-sea flux of 41 ± 21 Gmol yr^{-1} is unsupported by empirical data. Previous estimates of benthic DFe fluxes derived using global iron models are far lower). This can be attributed to (i) inadequate treatment of the role of oxygen on benthic DFe fluxes and (ii) improper consideration of continental shelf processes due to coarse spatial resolution. Globally averaged DFe concentrations in surface waters simulated with the intermediate-complexity University of Victoria Earth System Climate Model were a factor of two higher with the new function. It can be concluded that (i) the DFe flux from marginal sediments has been underestimated in the marine iron cycle and (ii) iron scavenging in the water column is more intense than currently presumed.

Karstensen, J., B. Fiedler, F. Schütte, P. Brandt, A. Körtzinger, G. Fischer, R. Zantopp, J. Hahn, M. Visbeck and D. Wallace (2015) Open ocean dead zones in the tropical North Atlantic Ocean. Biogeosciences, 12, 2597-2605, doi: 10.5194/bg-12-2597-2015

First observations of unexpectedly low (<2 µmol kg^{-1}) oxygen environments in the open waters of the tropical North Atlantic, a region where oxygen concentration does normally not fall much below 40 µmol kg^{-1}, are presented. The low-oxygen zones are created at shallow depth, just below the mixed layer, in the euphotic zone of cyclonic eddies and anticyclonic-modewater eddies. Both types of eddies are prone to high surface productivity and net respiration rates for the eddies are found to be 3 to 5 times higher compared to rates in the surrounding waters. Oxygen was found lowest in the centre of the eddies, in a depth range where the swirl velocity, defining the transition between eddy and surroundings, has its maximum. It is assumed that the strong velocity at the outer rim of the eddies hampers the transport of properties across the eddies boundary and as such isolates their cores. This assumption is supported by a remarkably stable hydrographic structure of the eddies core over periods of several months and propagating over distances of many hundreds of kilometers. The intermittent appearance of an extreme low oxygen environment, created by respiration underneath a high surface productivity area and paired with sluggish exchange across the eddy boundary, resembles very much the creation of coastal "dead zones" but in the open ocean. A direct impact of the dead zone eddy on the marine ecosystem was observed – zooplankton stopped diurnal vertical migration inside the eddies presumably to avoid entering the low oxygen depth range.

Sandel, V., R. Kiko, P. Brandt, M. Dengler, L. Stemmann, P. Vandromme, U. Sommer and H. Hauss (2015) Nitrogen Fuelling of the Pelagic Food Web of the Tropical Atlantic. PLoS ONE, 10 (6), doi: 10.1371/journal.pone.0131258

The relative contribution of atmospheric Nitrogen (N) input (wet and dry deposition and N fixation) to the epipelagic food web were estimated by measuring N isotopes of different functional groups of epipelagic zooplankton along 23°W (17°N-4°S) and 18°N (20-24°W) in the eastern tropical Atlantic. Results were related to water column observations of nutrient distribution and vertical diffusive flux as well as colony abundance of *Trichodesmium* obtained with an Underwater Vision Profiler. The thickness and depth of the nitracline and phosphocline proved to be significant predictors of zooplankton stable N isotope values. Atmospheric N input was highest in the strongly stratified and oligotrophic region between 3 and 7°N, which featured very high depth-integrated *Trichodesmium* abundance, strong thermohaline stratification and low zooplankton $\delta^{15}N$. Relative atmospheric N input was lowest south of the equatorial upwelling between 3 and 5°S (27%). Values in the Guinea Dome region and north of Cape Verde ranged between 45 and 50%, respectively. The microstructure-derived estimate of the vertical diffusive N flux in the equatorial region was about one order of magnitude higher than in any other area. At the same time, this region received considerable atmospheric N input. In general, zooplankton $\delta^{15}N$ and *Trichodesmium* abundance were closely correlated, indicating that N fixation is the major source of atmospheric N input. Although *Trichodesmium* is not the only N fixing organism, its abundance can be used with high confidence to estimate the relative atmospheric N input in the tropical Atlantic. Estimates of absolute N fixation rates are two- to tenfold higher than incubation-derived rates reported for the same regions. The here used approach integrates over large spatial and temporal scales and thus may help to close the gap in oceanic N budgets.

Dutay, J.-C., A. Tagliabue, I. Kriest and M.M.P. van Hulten (2015) Modelling the role of marine particle on large scale 231Pa, 230Th, Iron and Aluminium distributions. Prog. Oceanogr., 133, 66-72, doi: 10.1016/j.pocean.2015.01.010

The distribution of trace elements in the ocean is governed by the combined effects of various processes, and by exchanges with external sources. Modelling these represents an opportunity to better understand and quantify the mechanisms that regulate the oceanic tracer cycles. Observations collected during the GEOTRACES program provide an opportunity to improve the knowledge regarding processes that should be considered in biogeochemical models to adequately represent the distributions of trace elements in the ocean. Here a synthesis about the state of the art for simulating selected trace elements in biogeochemical models is presented: Protactinium, Thorium, Iron and Aluminium. In this contribution particular attention is paid on the role of particles in the cycling of these tracers and how they may provide additional constraints on the transfer of matter in the ocean.

Arévalo-Martínez, D.L., A. Kock, C.R. Löscher, R.A. Schmitz and H.W. Bange (2015) Massive nitrous oxide emissions from the tropical South Pacific Ocean. Nat. Geosci., 8, 530–533, doi: 10.1038/ngeo2469

Nitrous oxide is a potent greenhouse gas and a key compound in stratospheric ozone depletion. In the ocean, nitrous oxide is produced at intermediate depths through nitrification and denitrification, in particular at low oxygen concentrations. Although a third of natural emissions of nitrous oxide to the atmosphere originate from the ocean, considerable uncertainties in the distribution and magnitude of the emissions still exist. Here high-resolution surface measurements and vertical profiles of nitrous oxide that include the highest reported nitrous oxide concentrations in marine surface waters are presented, suggesting that there is a hotspot of nitrous oxide emissions in high-productivity upwelling ecosystems along the Peruvian coast. It is estimated that off Peru, the extremely high nitrous oxide supersaturations that was observed drive a massive efflux of 0.2–0.9 Tg of nitrogen emitted as nitrous oxide per year, equivalent to 5–22% of previous estimates of global marine nitrous oxide emissions. Nutrient and gene abundance data suggest that coupled nitrification–denitrification in the upper oxygen minimum zone and transport of resulting nitrous oxide to the surface by upwelling lead to the high nitrous oxide concentrations. The estimate of nitrous oxide emissions from the Peruvian coast surpasses values from similar, highly productive areas.

Matthießen, J.-D., R.J. Greatbatch, P. Brandt, M. Claus and S.-H. Didwischus (2015) Influence of the equatorial deep jets on the north equatorial countercurrent. Ocean Dynam., doi: 10.1007/s10236-015-0855-5

An ocean circulation model is run using two different idealized equatorial basin configurations under steady wind forcing. Both model versions produce bands of vertically alternating zonal flow at depth, similar to observed Equatorial Deep Jets (EDJs) and with a time scale corresponding to that of the gravest equatorial basin mode for the dominant baroclinic vertical normal mode. Both model runs show evidence for enhanced variability in the surface signature of the North Equatorial Counter Current (NECC) with the same time scale. The same link between the observed NECC and the EDJs in the Atlantic has been found by comparing the signature of the EDJ in moored zonal velocity data at 23° W on the equator with the signature of the NECC in geostrophic velocities from altimeter data. It was argued that the presence of a peak in variability in the NECC associated with the EDJ basin mode period is evidence that the influence at this time scale is upward, from the EDJ to the NECC.

Czeschel, R., L. Stramma, R.A. Weller and T. Fischer (2015) Circulation, eddies, oxygen, and nutrient changes in the eastern tropical South Pacific Ocean. Ocean Sci., 11, 455-470, doi: 10.5194/os-11-455-2015

A large subsurface oxygen deficiency zone is located in the eastern tropical South Pacific Ocean. The large-scale circulation in the eastern equatorial Pacific and off the coast of Peru in November/December 2012 shows the influence of the equatorial current system, the eastern boundary currents, and the northern reaches of the subtropical gyre. In November 2012 the equatorial undercurrent is centered at 250 m depth, deeper than in earlier observations. In December 2012, the equatorial water is transported southeastward near the shelf in the Peru–Chile undercurrent with a mean transport of 1.4 Sv. In the oxygen minimum zone (OMZ), the flow is overlaid with strong eddy activity on the poleward side of the OMZ. Floats with parking depth at 400 m show fast westward flow in the mid-depth equatorial channel and sluggish flow in the OMZ. Floats with oxygen sensors clearly show the passage of eddies with oxygen anomalies. The long-term float observations in the upper ocean lead to a net community production estimate at about 18° S of up to 16.7 mmol C m^{-3} yr^{-1} extrapolated to an annual rate and 7.7 mmol C m^{-3} yr^{-1} for the time period below the mixed layer. Oxygen differences between repeated ship sections are influenced by the Interdecadal Pacific Oscillation, by the phase of El Niño, by seasonal changes, and by eddies, and hence have to be interpreted with care. At and south of the Equator the decrease in oxygen in the upper ocean since 1976 is related to an increase in nitrate, phosphate, and in part silicate.

Conferences

GOLDSCHMIDT - SESSION 02D
16–21 August 2015, Prague (CZ)
What are the unifying principles common to all three oxygen minimum zones (OMZs)?
James Moffett, Aurélien Paulmier

AGU FALL MEETING 2015 - SESSION 8570
14–18 December 2015, San Francisco (USA)
Eastern boundary upwelling systems: Natural laboratories for studying the impacts of multiple stressors on marine ecosystems?
Ivonne Montes, Francisco Chavez, Boris Dewitte and Véronique Camille Garçon

SFB 754 Cruise

METEOR M 119
Tropical Atlantic, Sep. 08 - Oct. 13, 2015
Chief scientist: Peter Brandt

Evaluation

3., 4. & 14. SEPT 2015
Evaluation dry-run (Wissenschafts-Zentrum)
16. & 17. SEPT 2015
Evaluation (Wissenschafts-Zentrum)