NEWSLETTER 2014 | 03

Sonderforschungsbereich 754

Climate – Biogeochemistry Interactions in the Tropical Ocean

SFB 754

Young Scientists Retreat

25 – 29 August 2014 | Lotseninsel, Schleimünde | Also in its 2nd phase, the SFB 754 can be very proud of its strong young scientists cohort. More than 20 PhD candidates and postdocs participated in this year's annual young scientists retreat that took place at the picturesque Lotseninsel. The 5-days programme included presentations on inter-/intradisciplinary research and communication skills across various research fields given by guest scientists and science managers (Dr. K. Schäfer (University of Cologne), PD Dr. A. Antia (ISOS, Kiel), Dr. H. Dietze (GEOMAR)). Several poster sessions and discussion-slots complemented the programme. In addition, a workshop on "Gender Matters?! Gender Awareness in Science" led by M. Schoop (University of Cologne) fostered critical and constructive dealing with the topic of gender equality and diversity. One of the highlights was the trial course "self-assertiveness and self-defence for females" organised by two policemen from Kiel. This course has been conducted successfully before for female members of the SFB 754 only and was offered this time to both, the male and female retreat participants. Finally, Prof. A. Oschlies, the speaker of the SFB 754, spent a day with the young scientists to gather their ideas on interdisciplinary research topics for a 3rd phase of the SFB 754. The young scientists presented their results to the SFB 754 subproject leaders and major contributors of the 3rd phase proposal preparation at the SFB 754 mid-retreat in Hohwacht (15th – 16th Sept 2014).

Publications

Arteaga, L., Pahlow, M., and Oschlies , A. (2014), Global patterns of phytoplankton nutrient and light colimitation inferred from an optimality-based model, Global Biogeochem. Cycles, 28, 648–661, doi: 10.1002/2013GB004668

The widely used concept of constant "Redfield" phytoplankton stoichiometry is often applied for estimating which nutrient limits phytoplankton growth in the surface ocean. We investigated to what extent both views agree by analyzing remote sensing and in situ data with an optimality-based model of non-diazotrophic phytoplankton growth in order to infer seasonally varying patterns of colimitation by light, nitrogen (N), and phosphorus (P) in the global ocean. The eastern equatorial Pacific appears as the only ocean area that is essentially not limited by N, P, or light. Even though our optimality-based approach specifically accounts for flexible stoichiometry, inferred patterns of N and P limitation are to some extent consistent with those obtained from an analysis of surface inorganic nutrients with respect to the Redfield N:P ratio. Iron is not part of our analysis, implying that we cannot accurately predict N cell quotas in high-nutrient, low-chlorophyll regions. The relative importance of N, P, and light in limiting phytoplankton growth diagnosed here by combining observations and an optimal growth model provides a useful constraint for models used to predict future marine biological production under changing environmental conditions.

Bittig, H.C., Fiedler, B., Scholz, R., Krahmann, G. and Körtzinger, A. (2014) Time response of oxygen optodes on profiling platforms: Dependence on flow speed and temperature. Limnol. Oceanogr. Methods 12, 617–636. doi: 10.4319/lom.2014.12.617

The time response behavior of Aanderaa optodes model 3830, 4330, and 4330F, as well as a Sea-Bird SBE63 optode and a JFE Alec Co. Rinko dissolved oxygen sensor was analyzed both in the laboratory and in the field. The main factor is the dynamic regime, i.e., the water flow around the sensor that influences the boundary layer's dynamics. Response times can be drastically reduced if the sensors are pumped. Application of a diffusion model including a stagnant boundary layer revealed that molecular diffusion determines the temperature behavior, and that the boundary layer thickness was temperature independent. The time response was characterized for typical deployments on shipboard CTDs, gliders and floats, and tools are presented to predict the response time. Finally, the problem of inverse filtering optode data to recover some of the information lost by their time response is addressed.

Boyle, R.A., Dahl, T.W., Dale, A.W., Shields-Zhou, G.A., Zhu, M., Brasier, M.D., Canfield, D.E. and Lenton, T.M. (2014) Stabilization of the coupled oxygen and phosphorus cycles by the evolution of bioturbation. Nature Geoscience 7. 671–676. (2014). doi: 10.1038/ngeo2213

Animal burrowing and sediment-mixing (bioturbation) started during the run up to the Ediacaran/Cambrian boundary, initiating a transition between the stratified Precambrian and more well-mixed Phanerozoic sedimentary records, against the backdrop of a variable global oxygen reservoir probably smaller in size than present. Phosphorus is the long term limiting nutrient for oxygen production via burial of organic carbon, and its retention (relative to carbon) within organic matter in marine sediments is enhanced by bioturbation. Here we explore the biogeochemical implications of a bioturbation-induced organic phosphorus sink in a simple model. We show that increased bioturbation robustly triggers a net decrease in the size of the global oxygen reservoir – the magnitude of which is contingent upon the prescribed difference in carbon to phosphorus ratios between bioturbated and laminated sediments. Bioturbation reduces steady-state marine phosphate levels, but this effect is offset by the decline in iron-

adsorbed phosphate burial that results from a decrease in oxygen concentrations. The introduction of oxygen-sensitive bioturbation to dynamical model runs is sufficient to trigger a negative feedback loop: the intensity of bioturbation is limited by the oxygen decrease it initially causes. The onset of this feedback is consistent with redox variations observed during the early Cambrian rise of bioturbation, leading us to suggest that bioturbation helped to regulate early oxygen and phosphorus cycles.

Claus, M., Greatbatch, R.J. and Brandt, P. (2014) Influence of the Barotropic Mean Flow on the Width and the Structure of the Atlantic Equatorial Deep Jets. J. Phys. Oceanogr., 44, 2485–2497. doi: 10.1175/JPO-D-14-0056.1

A representation of an equatorial basin mode excited in a shallow-water model for a single high-order baroclinic vertical normal mode is used as a simple model for the equatorial deep jets. The model is linearized about both a state of rest and a barotropic mean flow corresponding to the observed Atlantic Equatorial Intermediate Current System. It was found that the eastward mean flow associated with the North and South Intermediate Counter Currents (NICC and SICC, respectively) effectively shields the equator from off-equatorial Rossby waves. The westward propagation of these waves is blocked, and focusing on the equator due to beta dispersion is prevented. This leads to less energetic jets along the equator. Independent of the presence of the mean flow, the application of sufficient lateral mixing also hinders the focusing of off-equatorial Rossby waves, which is hence an unlikely feature of a low-frequency basin mode in the real ocean.

Dale, A. W., Sommer, S., Lomnitz, U., Montes, I., Treude, T., Gier, J., Hensen, C., Dengler, M., Stolpovsky, K., Bryant, L. D., and Wallmann, K. (2014) Organic carbon production, mineralization and preservation on the Peruvian margin. Biogeosciences Discuss., 11, 13067-13126, doi: 10.5194/bgd-11-13067-2014

Carbon cycling in Peruvian margin sediments (11° S and 12° S) was examined at 16 stations from 74 m on the inner shelf down to 1024 m water depth by means of in situ flux measurements, sedimentary geochemistry and modeling. Sediment accumulation rates and benthic dissolved inorganic carbon fluxes decreased rapidly with water depth. Particulate organic carbon (POC) content was lowest on the inner shelf and at the deep oxygenated stations (< 5%) and highest between 200 and 400 m in the oxygen minimum zone (OMZ, 15 – 20%). The organic carbon burial efficiency (CBE) was unexpectedly low on the inner shelf (< 20%) when compared to a global database, for reasons which may be linked to the frequent ventilation of the shelf by oceanographic anomalies. Organic carbon rain rates calculated from the benthic fluxes alluded to a very efficient mineralization of organic matter in the water column, with a Martin curve exponent typical of normal oxic waters (0.88 ± 0.09). Mean POC burial rates were 2–5 times higher than the global average for continental margins. The observations at the Peruvian margin suggest that a lack of oxygen does not affect the degradation of organic matter in the water column but promotes the preservation of organic matter in marine sediments.

Dietze, H., Löptien, U. and Getzlaff, K. (2014) MOMBA 1.1 – a high-resolution Baltic Sea configuration of GFDL's modular ocean model. Geoscientific Model Development, 7. p. 1731. doi: 10.5194/gmd-7-1713-2014

Even though substantial progress has been made, current state-of-the-art coupled ocean circulation biogeochemical models still struggle to retrace OMZ dynamics. This showcases an inadequate quantitative understanding of processes involved. Some of the deficient processes have been identified already by flyspecking models with observations in the last phases of the SFB (c.f. Dietze & Loeptien, 2013). However, the wealth of particularly spatially highly resolved observations has led to new conundrums – conundrums that call for model-based hypothesis testing. To this end we configured an ultra-high resolution (approximately one nautical mile) ocean circulation model of the Baltic Sea dubbed MOMBA 1.1. This pilot study was aimed to explore (and resolve) technical issues associated with ultra-high resolution models. As a byproduct, we have now a peer-reviewed ocean-circulation model of the Baltic Sea. This model is well suited to serve as a nucleus of a fully fledged coupled ocean-circulation–biogeochemical model that may be used to test generic ideas of how biogeochemical cycles are affected by low oxygen concentrations.

Montes, I., Dewitte, B., Gutknecht, E., Paulmier, A., Dadou, I., Oschlies, A. and Garçon, V. (2014) High-resolution modeling of the Eastern Tropical Pacific oxygen minimum zone: Sensitivity to the tropical oceanic circulation. J. of Geophys. Res.-Oceans. n/a-n/a. doi: 10.1002/2014JC009858

The connection between the equatorial mean circulation and the oxygen minimum zone (OMZ) in the Eastern Tropical Pacific is investigated through sensitivity experiments with a high-resolution coupled physical-biogeochemical model. A validation against in situ observations indicates a realistic simulation of the vertical and horizontal oxygen distribution by the model. From a Lagrangian perspective, the mean differences near the coast originate to a large extent from the different transport of deoxygenated waters by the secondary Tsuchiya Jet (secondary Southern Subsurface countercurrent, sSSCC). At regional scale, we also find that the variability of the physical contribution to the rate of O_2 change is one order of magnitude larger than the variability associated with the biogeochemical contribution, which originates from internal high-frequency variability. Overall our study illustrates the large sensitivity of the OMZ dynamics to the equatorial circulation.

Conferences

2ND INTERNATIONAL OCEAN RESEARCH CONFERENCE "ONE PLANET, ONE OCEAN"
November 17 – 21, 2014, Barcelona, Spain
Session: Low oxygen and low pH environments in coastal and ocean waters

AGU FALL MEETING
December, 15 – 19, 2014, San Francisco, USA

AQUATIC SCIENCE MEETING (ASLO)
February, 22 – 27, 2015, Granada, Spain
Session: Eastern Boundary Upwelling Systems

SFB 754 Cruises

METEOR M 116
Atlantic, May 2, 2015 – June 3, 2015
Chief scientist: Toste Tanhua

METEOR
Atlantic, Autumn, 2015
Chief scientist: Peter Brandt

SFB 754 Intern

HOHWACHT FOLLOW-UP MEETING "PROPOSAL PREPARATION 3RD PHASE"
November 3, 2014, GEOMAR westshore

SFB 754 ANNUAL RETREAT 2015
February 16 – 17, 2015, Kieler Yacht Club

TEST RUNS DFG EVALUATION
September 3, 4 & 14, 2015,
Wissenschaftspark, Kiel

DFG EVALUATION:
September 16 – 17, 2015
Wissenschaftspark, Kiel

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