March 27, 2017
Edition 3

ENERGY INFLOW

www.trr-energytransfers.de

New Year, New Progress

Dear colleagues,
The New Year is already three months old and we hope you had a great start into it. Spring is now approaching soon and with this we like to give you some new information on what has happened in the last three months.

What is inside this time?

Our first **Winter School** was held in February and now you can read up on what happened on Sylt.

You can find a direct link to our **new explain video** on overflows and get an update on the progress made with the other videos. Also included is the final draft of our **first info graphic**.

Then we have a big announcement: our **new webpage** is up and running! Have a look now!

As always, you'll find new publications and **new reports from the scientific front**!

Content

At the end of this newsletter you find information on an important cause: the MARCH FOR SCIENCE! Join us in Hamburg on April 22 or march in a city near you!

Winter was coming … but we survived

Our first TRR 181 Winter School took place at the Alfred-Wegener-Institute in List on Sylt starting February 6 to 10. 26 PhDs and postdocs faced the cold winds and snow of the North Sea in February to collaborate and learn about the TRR 181 disciplines.

Day 1: Who are you?
The first day started with a quiet lunch. Most people did not know each other and were still hesitant. To loosen things up, we began the program with two "Get to know" games: scientific speed dating and the triangle of common interests.

During the speed dating, the pairs had 6 minutes to talk quickly about themselves, their work and scientific field. This already helped to break the ice and some pairs did not want to stop after the 6 minutes. ☺ The "triangle of common interests" brought three people together, again to talk about their science. Here, they had to find out what their common scientific or private interests are.

Although most people do not like these kind of "games", the feedback was very positive and more than 60 % of the participants said it helped them get familiar with the other TRR 181 members.

In the afternoon, we introduced the group work for the week: the participants had to get together in groups of three or four to create a realistic proposal or plan what they could work on together, including all the disciplines and different approaches. This task required interdisciplinary thinking and networking. The groups had the whole week for this task and needed to present their results on the last day of the week.

Day 2: It's all about that ocean!

Our speaker Carsten Eden started the second day with an introduction to the TRR 181 and physical oceanography. During the day, talks followed by our PI Dirk Olbers on internal waves, our postdoc Zhuhua Li on her work on internal tides and our PI Hans Burchard on small-scale turbulence and mixing. In between, we had a discussion on scientific outreach and some time for the group work.

In the evening, everyone got together for a dinner at the only open restaurant in February: Gosch. We couldn't believe it either, but it was the only open place.

Day 3: Facing the cold winds of the North Sea

Our postdoc Janna Köhler kicked off the third day with another oceanography talk on the internal wave field. An external guest followed her talk: Hartmut Borth from Universität Hamburg introduced meteorology to us and displayed a fun experiment.

Before lunch, we discussed gender issues in science. It was a lively discussion since most people have an opinion about this topic. The intention of the discussion was to include the PhDs and postdocs in the process on how to spend the TRR 181 gender funds and inform them about the possibilities of support. More than 80 % of the participants thought it is good to be involved in this process and to be able to provide ideas. The Gender Task Group (GTG) uses the outcome of the discussion to create a suitable plan for the next three years. The GTG is open for ideas and suggestions. If you have something in mind, get in touch with me.

Afterwards everyone went out into the cold: We planned a field trip through the dunes with a guide from the "Erlebniszentrum Naturgewalten". They only cancel the trips during thunderstorms, so there was no way out of it. ☺ Facing snow and ice cold winds, the participants learned about the dunes as well as the flora that comes with it. Most people thought it was very interesting but way to cold. So next time we are prepared to offer an alternative. ☺

The field trip was not the last point on the agenda that day. The head of the "School for Integrated Climate System Sciences" (SICSS) Ingo Harms gave an interactive talk on "Good scientific practice". Although it was late, the discussion was quite lively and all participants rated the talk good or very good. The question about what is a good scientific practice or not kept spinning in everyone's head the next few days.

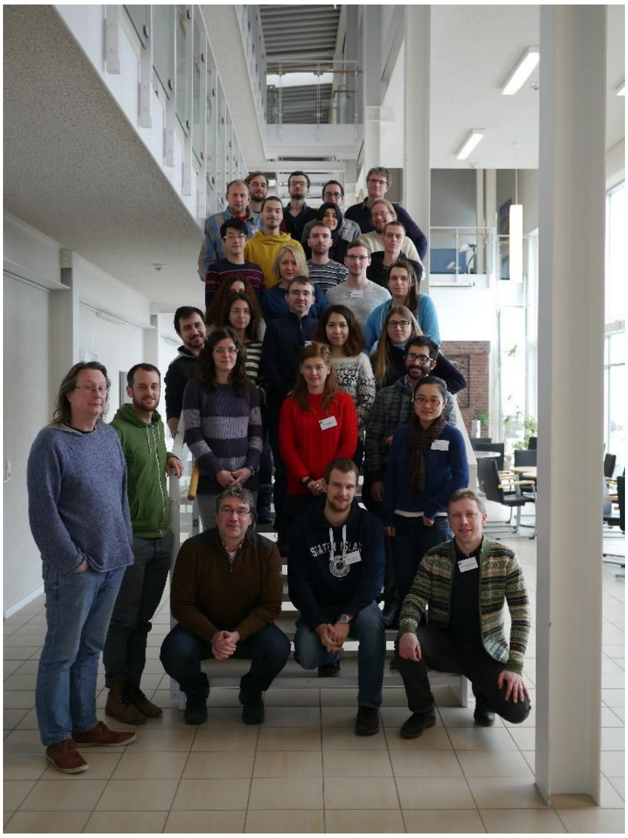
Impressions from the Winter School.

On day four, we started with an introduction on numerics by our external guest Peter Korn from the Max Planck Institute for Meteorology. Afterwards, our PI Marcel Oliver introduced us deeper into mathematics. If the heads were not spinning until then, two more talks followed: our associated member Ivan Ovsyannikov from Universität Bremen talked about chaotic regimes and our postdoc

Sebastian Schubert presented his work with Lyapunov vectors.

The whole afternoon was saved for a soft skill course on “Self-presentation in presentations” by Carolin Pohl, an actress and professional trainer. Her main message was: “You cannot NOT communicate!” indicating that you need to watch your posture, expression and way of talking during presentations. With interactive tasks and group exercises, it was something different from the usual presentations. About 90 % of the PhDs and postdocs enjoyed the course, although only half of them thought it helped them improve their skills.

In the evening the PhDs and postdocs got together in the guesthouse to cook dinner. We like to thank the chefs: Federica Gugole, Bastian Sommerfeld, Valerio Lembo and Florian Noethen for their great cooking! And Rachael Ewins and Ryan North for cleaning afterwards.



All participants together.

Day 5: Final Countdown!

The last day of the week was reserved for the group work presentations. Seven groups presented their scientific ideas that they worked on. Our PIs Carsten Eden and Dirk Olbers as well as the other participants evaluated them. Carsten and Dirk enjoyed the presentations and were impressed by the ideas. Although not all of them are able to be realized in the next few years, the groups put effort in combining their expertise and coming up with something that could be done someday.

It was not easy for Carsten and Dirk to decide on a winner, since all of the groups did so well. However, someone had to win, and so we combined their opinion with the evaluation sheets. The group that won called itself “HOBIIT” and consisted of Stylianos Kritsotalakis (T3, Alfred Wegener Institute), Janna Köhler (W2, Universität Bremen), Federica Gugole (M2, Universität Hamburg) and Anton Kutsenko (M3, Jacobs University). Their idea to investigate “How Boundaries Impact Internal Tides” convinced the PIs and the other participants.

The overall evaluation of the group work was mixed between satisfactory and very good. We however, think that we reached our goal of getting new people together and let them collaborate in a way they may not normally do.

The general evaluation of the week came out very positive. Over 90 % of the participants rated the school good or very good. The comments will help us improve the next events. Although the main problem, we are not able to fix: “Please fix the weather and let the sun shine.” So maybe we do a summer school instead. ☺

We like to thank everyone who participated at the winter school and helped to create a friendly atmosphere. All talks and pictures are stored on the internal web page.

Publications

Have you also published your work, but cannot find it here? Please get in touch with me.

Graves, T., **Franzke, C. L.**, Watkins, N. W., Gramacy, R. B., & Tindale, E. (2017). Systematic inference of the long-range dependence and heavy-tail distribution parameters of ARFIMA models. *Physica A: Statistical Mechanics and its Applications.*

Gonchenko, S. V., and **Ovsyannikov, I. I.** (2017). Homoclinic tangencies to resonant saddles and discrete Lorenz attractors. *Discrete and Continuous Dynamical Systems Series*, Vol 10 (2), p. 273-288, doi: 10.3934/dcdss.2017013.

Blender, R., & **Badin, G.** (2017). Viscous dissipation in 2D fluid dynamics as a symplectic process and its metriplectic representation. The European Physical Journal Plus, 132(3), 137.

Burchard, H., Basdurak, N. B., Gräwe, U., Knoll, M., Mohrholz, V., & **Müller, S.** (2017). Salinity inversions in the thermocline under upwelling favorable winds. *Geophysical Research Letters*, 44, doi:10.1002/2016GL072101.

Franzke, C. L. (2017). Extremes in dynamic-stochastic systems. *Chaos: An Interdisciplinary Journal of Nonlinear Science*, 27(1), 012101.

Franzke, C. L., and O'Kane, T. J. (Eds.). (2017). Nonlinear and Stochastic Climate Dynamics. *Cambridge University Press*.

Upcoming events

March 31, 2017: TRR 181 Seminar "Weak vs. strong solvability of problems in fluid mechanics"

April 23-28, 2017: EGU 2017 in Vienna: TRR 181 at the General Assembly
We are presenting our work together with our colleagues from the SFB 1114 "Scaling cascades in complex systems" (FU Berlin), TR 172 "Arctic Amplification" (Universtität Leipzig) and the research group "Gravity Waves" (Goethe Universität Frankfurt am Main) at a joint booth. Everybody is welcome to come by booth #22!

April 27-28, 2017: Women in PDEs @Karlsruhe

May 3-5, 2017: 3rd Workshop "Energy transfers in Atmosphere and Ocean 2017"
More information and registration

May 22-26, 2017: Marine Turbulence Re^3-visited
The Liège Colloqium and the Warnemünde Turbulence Days are organising their joint colloquium on marine turbulence for a second time, during 22-26 May 2017 in Liège, Belgium. The colloquium is supported by the TRR 181.

Overflow easily explained

Our second explain video is now online in German and English! Together with Kerstin Jochumsen and Martin Losch we created a video about the overflow in the North Atlantic. You are free to use it for talks or public events. The mp4 file is archived on the internal web page.

At the moment we are working on seven additional movies:

- Mathematics in Climate Science (Production phase)
- Climate Models (Storyboard phase)
- Turbulence in the Ocean (Production phase)
- Numerics in Ocean Models (Storyboard phase)
- Internal Waves (Script phase)
- Energy Cycle (first meeting planned)

Reports from the scientific front

Each newsletter will contain short reports from our scientists on their work and the progress they made. So everyone can keep up on the new findings in the project. Enjoy!

Entropy Production in turbulence parameterisations
By Denny Gohlke, PhD M4

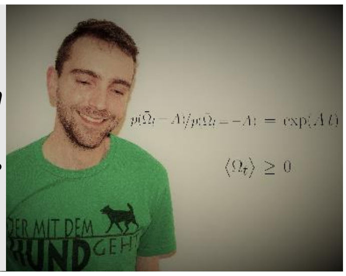
Dear Reader,
Yesterday I dropped my beloved teacup. Viewing the broken fragments from the perspective of an enthusiastic tea addict: hope for occurrence of the backward process called self-repair. From the sober viewpoint of a physicist: second law of thermodynamics and entropy.

Macroscopic (isolated) systems evolve in a one-way direction of time, towards states with increased entropy seeming to be in contradiction to the underlying microscopic equations that are needed for their description. For instance, Newton's law of motion for classical systems is symmetric under time reversal; no preference of a certain time direction; no preference of neither the forward nor backward process. Then why is there a break of time symmetry at macroscopic level (irreversibility)?

The second law of thermodynamics is valid in a statistical sense for large system sizes (average statement in thermodynamic limit) within the frame of equilibrium thermodynamics and can be generalised by the Fluctuation Theorem (FT). Resulting from statistical physics this theorem with its different versions connects microscopic and macroscopic behaviour for time reversal systems of arbitrary size arbitrary far driven out of equilibrium in form of an analytical expression of probability ratio of observing a trajectory of a system (in phase space) to its time reversed counterpart.

The essential quantity of the FT is the dissipation function, an entropy-like quantity in non-equilibrium related to internal entropy production under specific conditions. The latter quantity is especially important in regard to our project M4. Here, 'our' consists of the *Hamburg part*, Richard Blender,

> ***"The idea of M4 is the stochastic or counter-gradient parameterisation of momentum and heat fluxes in forced dissipative systems like the atmosphere and ocean."***



Valerio Lucarini (Reading) and me (since October last year), and of the *Rostock part* (IAP) composed of Almut Gaßmann and Bastian Sommerfeld.

The idea of M4 is the stochastic or counter-gradient parameterisation of momentum and heat fluxes in forced dissipative systems like the atmosphere and ocean. These sub-scale fluxes are related to energy dissipation and backscatter; as well related to positive and negative entropy production. Is it possible to put more physics in these turbulence parameterisation schemes with the usage of the FT? However, it requires the applicability of FT for non-time reversal systems (Navier–Stokes equations). As a representative example for turbulence toy models I use the class of shell models (as a first step) to get a basic notion for the incorporation of the FT with the final aim of modification and improvement of climate prediction models. I am looking forward to this challenge. Thank you for your attention.

Solving equations faster and more accurately
By Claus Götz, Postdoc in M5

Hi, I'm Claus and I am a PostDoc in Project M5. The focus of my research in this project is the development and analysis of high-order advection methods and high-oder flux evaluation techniques for ocean models. Our goal is to reduce spurious diapycnal mixing in ocean models and I'm working on the intersection between mathematical analysis and numerical methods to help with that.

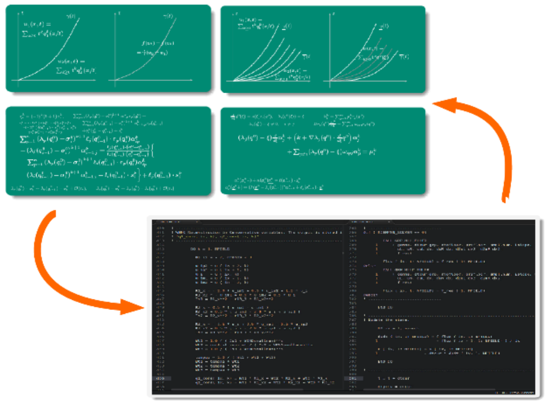
High-order numerical methods for flow computations are becoming increasingly more popular in computational engineering, but may be not as widespread in climate and ocean science. So what's the deal with high and low order?

Classical finite differences and finite volume methods for the discretization of partial differential equations use one piece of information in each cell (say, a function value at the cell-center or an integral average over the cell) and put this information into a discrete version of the PDE. This allows for fast and robust algorithms, but in order to resolve small scale features, we often need very fine grids. On the other hand, the high-order methods we are interested in, use higher degree polynomials or other nonlinear functions in each cell. This extra information allow us resolve more features of the solution, even on coarser girds. In many computational fluid dynamics applications this leads to a smaller overall computational time and we would like to show that this is also true for problems in ocean science.

"Designing high-order numerical methods needs a good understanding of the mathematical equations we want to solve."

However, carelessly throwing high-order polynomials at your problem is a sure recipe for failure. If we want to include more features of the analytical solution in our numerical solution, we need a good understanding of the analytical properties and how they can be translated into our numerical scheme. For our particular application, e.g., we want tight control over diffusion properties and need to tune our methods to avoid artificial diffusion without losing stability properties that numerical diffusion brings.

In short, designing high-order numerical methods needs a good understanding of the mathematical equations we want to solve. I'm happy to be involved with learning more about the equations in ocean science, so that we can solve them faster and more accurately.



The fate of low mode internal tides

By Janna Köhler, Postdoc W2

I am an observational physical oceanographer working as a Postdoc at the University Bremen. Prior to joining the TRR I mainly studied temporal variability of internal waves using time series of moored instruments, and related the observed changes in the internal wave energy to generation processes such as topography-current interaction or energy input into the internal wave field by the wind.

In the TRR I am part of the subproject W2 "Energy transfer through low mode internal waves". Low mode internal waves possess a major part of the entire energy of the internal wave field, which makes them an important component of the oceanic energy pathways.

The major goal of our subproject is to study the fate of low mode internal tides and the processes that operate along their pathways. A seamount south of the Azores provides a good study case for these processes, as it is one of the main generation sites of internal tides in the Atlantic. Here we will conduct shipboard measurements and deploy a mooring for about one year to study spatial and temporal variability of internal tide energy. We will then compare the observed spatial and temporal variability along the tidal beam with output of dedicated runs of the STORMTIDE model carried out by our project partners at the MPI in Hamburg.

"The major goal of our subproject is to study the fate of low mode internal tides and the processes that operate along their pathways."

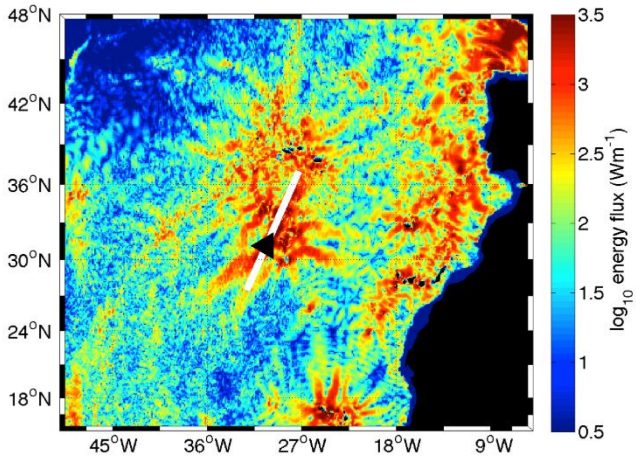


Fig. 1: M_2 internal tide energy flux from the STORMTIDE model (Müller 2013) with the planned cruise track (white line) and mooring position (black triangle).

References: Müller, M. "On the space-and time-dependence of barotropic-to-baroclinic tidal energy conversion." Ocean Modelling 72 (2013): 242-252.

Propagation of long internal waves

By Zhuhua Li, Postdoc W2

I am a postdoc at Max Planck Institute for Meteorology (MPI-M), working with Dr. Jin-Song von Storch. We care about the long internal waves in the ocean's interior, which carry most of the internal wave energy. During their long-range propagation, their energy can be transferred to smaller scales, leading eventually to diapycnal mixing needed for supporting the global overturning circulation. Due to a lack of knowledge about the ultimate location and strength of their dissipation, their effect on mixing is generally parameterized by a spatially uniform diffusion in most ocean general circulation models (OGCMs). It is still a challenge to properly include their effects in OGCMs.

The high-resolution OGCMs, which directly resolve long internal waves (in addition to the general circulation), serve as an indispensable tool for investigating the fate of these waves. They allow us to study long internal waves in a realistic wave environment with realistic stratification and circulation. One such model is the 1/10° STORMTIDE model. This model simulates the long internal waves at tidal frequencies (internal tides) well (Fig. 1), in particular in regions where nonlinear interactions between internal tides and circulation are weak and linear waves predominate. This is reflected by the good agreement of the wavelengths of the most energetic mode simulated by the STORMTIDE model with those derived from linear theory (Fig. 2).

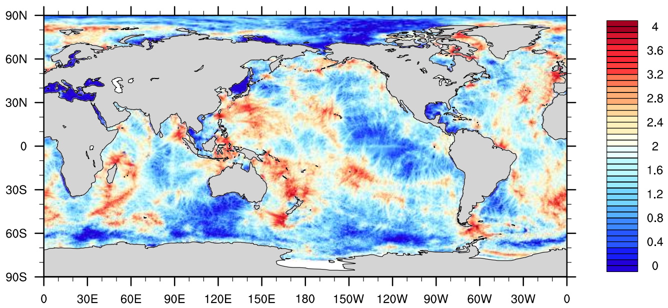


Fig. 1. Vertically integrated kinetic energy (J/m2) of the M2 internal tides in logarithmic scales simulated by the 1/10 STORMTIDE model (Li et al. 2016). The M2 internal tides have a period of about 12.42 hours and they are the most energetic component among internal waves at all tidal frequencies.

"The proper protocol and experiment setup for numerical experiments is crucial."

For the subproject W2, we will investigate the long internal waves generated by surface winds and tides within the same modeling framework. As a starting point, we analyze the global propagation of the long internal tides by using the energy flux simulated by the STORMTIDE model. This is a first step towards a better understanding of the sources and sinks of internal tides.

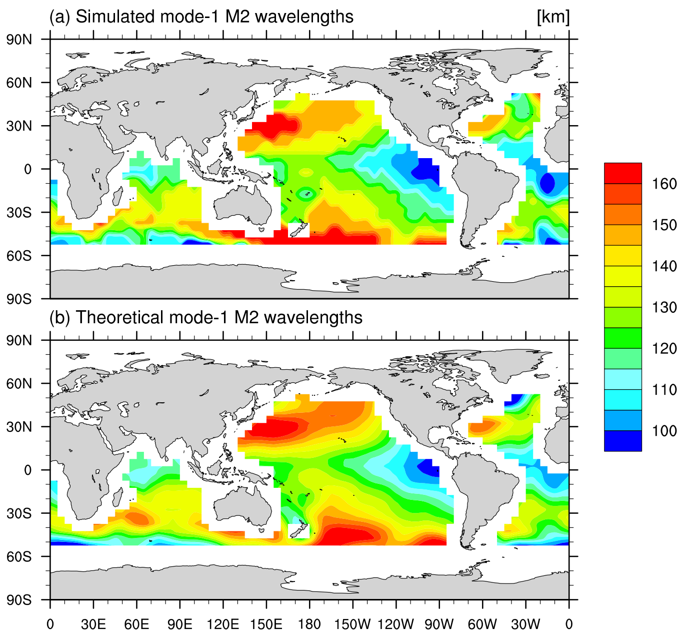


Fig. 2 Wavelengths (km) of the most energetic mode (mode 1) of the M2 internal tides (a) from the STORMTIDE simulation and (b) from linear internal wave theory. In brief: The STORMTIDE model simulates the M2 internal tides well (Li et al. 2016).

Investigating eddy diffusivitites and eddy-mean flow interactions

By Julia Dräger-Dietel, Postdoc L3

In September 2016 I started working as a postdoctoral researcher in the subproject L3 Diagnosing and parameterising the effects of eddies at the Universität Hamburg with Kerstin Jochumsen from Experimental Oceanography and Alexa Griesel from Theoretical Oceanography. Having a background in nonlinear dynamics and statistical physics in application to complex systems, I am strongly attracted by the aim of our research project and by the possibility to work within an inspiring interdisciplinary research network as created by the TRR181 with its great possibilities for exchange with scientists of different fields.

A major link to my former research consists in the analysis of trajectories (derived from in situ experiments or modeled by stochastic processes) and more specifically the analysis of broad (non Gaussian) Langrangian statistics of absolute and relative dispersion. The goal of our research subproject L3 is the quantification of eddy diffusivities and eddy-mean flow interactions by using Langrangian particles statistics in both eddying ocean models and observations. Its aim is to develop and to test energy consistent parameterisations of meso- and sub-mesoscale processes for the global ocean with a focus on 100 km -1 km scales.

At the beginning I developed and tested float deployment strategies by means of the high resolution POP model.
In November/December 2016 our cruise with the RV Meteor took place in the atlantic-sea off the african coast. The cold upwelling front off Namibia's coast in the area of Luderitz has a highly irregular structure due to eddies and filaments, finger-like structures of cold upwelling water pushing west into the warm surface waters offshore (see Figure 1). In our field experiment we explored mesoscale and submesoscale structures within a filament by satellite-tracking 37 surface drifters which we released in groups of triplets. As a first result we find that, due to the underlying rich mesoscale system, the dispersion statistics are very different depending on the location of release. While the drifters of the group

"Our observational data will serve the model as a reference that includes smaller scales that the model is not able to cover."

released at the southern border of the filament separate slower (Figure 2a), the drifters in the group released closer to the upwelling system at the northern border of the filament separate faster from each other and follow distinct paths within the complex surface currents (Figure 2b). Currently our research focuses on the relative dispersion of drifter pairs (and its corresponding probability density function) as its properties depend on the kinetic energy spectrum. The statistical analyzing of single particle dispersion and the comparison of our findings with dispersion statistics of ocean model will be a next step. Here our observational data will serve the model as a reference that includes smaller scales that the model is not able to cover.

More Information about the research cruise on RV Meteor (M132) including reports, posters and videos of the scientific work have a look have a look at our TRR181 homepage.

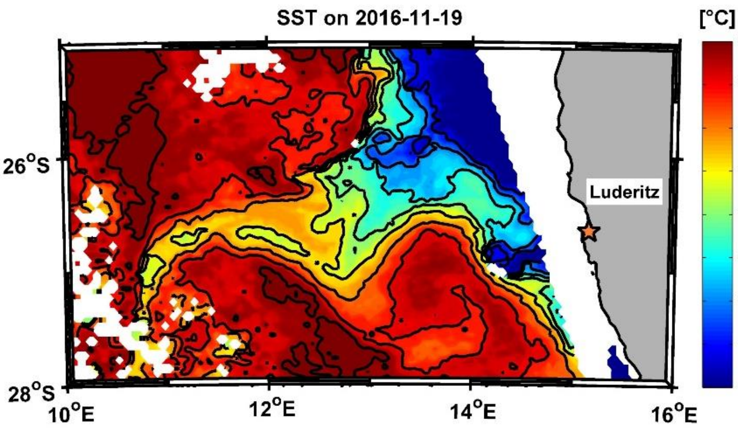
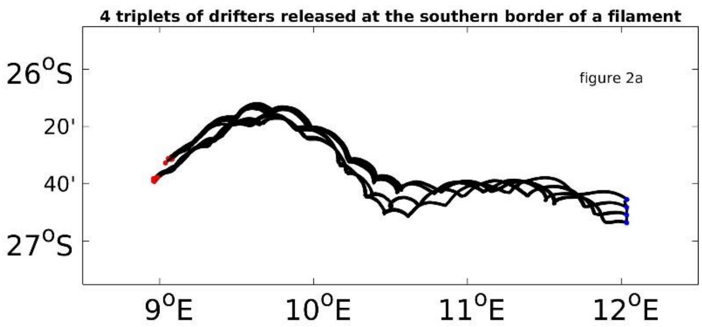


Figure 1. Namibia from satellite. The blue colors show the cold upwelling area off Lüderitz and a cold filament (green and yellow).



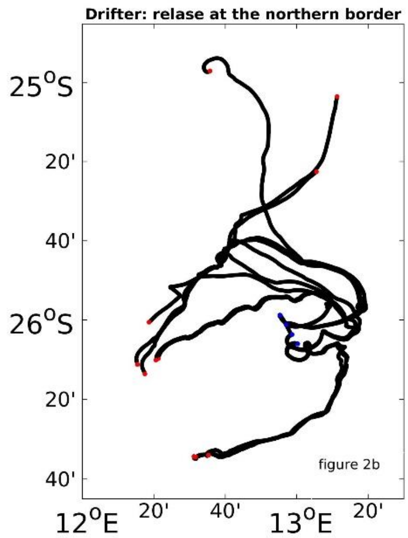


Figure 2a (above), Figure 2b (right)

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ON APRIL 22, 2017, WE WALK OUT OF THE LAB AND INTO THE STREETS.
The March for Science demonstrates our passion for science and sounds a call to support and safeguard the scientific community.

Find a march near your city! The march in Hamburg start at 2 pm at Rathausmarkt. Join us for the cause!

Something funny for the end …