June 15, 2017
Edition 4

ENERGY INFLOW

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So much news, so little time

Dear colleagues,
Another three months have passed and now we are heading already into summer. A lot of things have happened since March and we hope you enjoy reading about them in our new issue of "Energy Inflow".

What is inside this time?

You find reports on the EGU, the third annual workshop "Energy transfers in Atmosphere and Ocean", the international Family Day and Schülerkongress in Hamburg.

Furthermore, we present you the results from the DFG survey.

And as always, you'll find new publications and **new reports from the scientific front**! This time by our PhDs and Postdocs from M2, M3 and T2.

But let's start off with an announcement! As most of you know I will start my maternity break on July 5. Jennifer Fandrich takes over the project coordination, during my 12 months parental leave. She starts on June 16, so that we can ensure a good transition.

Maternity leave substitute Jennifer Fandrich.

Content

EGU 2017: A week of science and networking in Vienna

The European Geophysical Union General Assembly was held in Vienna April 23.-28. With over 14.000 attendants it is the largest conference of its kind in Europe. TRR 181 scientists presented their work and collaborated with three other projects in a joint exhibition booth.

Several project members attended the EGU and presented their scientific work with talks and posters (you can find a list of contributions online). Not many of our PhDs attended this year's conference, but this is normal since most of them just started.

The EGU exhibition opened from Monday to Friday and our booth was maintained by scientists from the TRR 181, TR 172 "Arctic Amplification" (Manfred Wendisch, Universität Leipzig), SFB 1114 "Scaling Cascades in complex systems" (Rupert Klein, Freie Universität Berlin) and the research group "MS-Gwaves" (Ulrich Achatz, Goethe Universität Frankfurt am Main). We used the booth to inform other conference participants about the work we do in our projects, but also used the time to get to know our collaborators and their work.

Booth at the EGU 2017.

Due to the changing composition of the team, there were always new people to meet. Furthermore, the booth was used as a meeting place for our scientists to meet with other colleagues or to relax a bit.

It was a busy week. Many people were interested in our projects and the work we do in Germany. In the end we think the collaboration was fruitful and a success. Hence, there are plans to repeat this kind of collaboration in the future.

Interested conference participants at the "Ocean – Atmosphere Dynamics" booth.

Workshop a full success!

On May 3.-5. over 100 scientists from all over the world gathered in Hamburg at "Haus des Sports" for our third annual workshop on "Energy transfers in Atmosphere and Ocean".

The topic of the workshop was the energy cycle in atmosphere and ocean. This included the interaction of different dynamical regimes such as gravity waves, small-scale turbulence and geostrophic flow, new parameterisations, the formulation of consistent models, but extended also to new numerical methods, and other aspects of geophysical fluid dynamics and the climate system.

Impressions from the workshop.

It was our biggest workshop yet with 35 talks and 21 poster. Invited keynotes were given by David Marshall (University of Oxford), Malte Jansen (University of Chicago), Claudia Pasquero (University of Milano-Bicocca), Florian Lemarié (INRIA), Geoffrey Vallis (University of Exeter), Beth Wingate (University of Exeter), Jörn Callies (Massachusetts Institute of Technology) and Remi Tailleux (University of Reading).

The program was a nice mixture of oceanographic, atmospheric and mathematical talks and the breaks were used for intensive networking between the different disciplines. The poster session was held on Thursday afternoon and was accompanied with a dinner buffet. Several young researchers had the opportunity to present their work to a larger audience with a talk or poster and received insightful questions or remarks.

Many of our project scientists attended the workshop and presented their first results. Contributions included talks by our postdocs Julia Dräger-Dietel, Janna Köhler, Sergiy Vasylkevych and Knut Klingbeil as well as poster by our PhDs Denny Gohlke, Federica Gugole and Thomas Reitz and Postdocs Zhuhua Li and Valerio Lembo.

We like to thank all participants again for their attendance and their contribution to a successful workshop. We are looking forward to meeting you in 2018!

International Family Day

May 15 is the official International Family Day. This was celebrated by Universität Hamburg and collaborating universities with a diverse program.

Information booth for the International Family Day.

TRR 181 participated with an information booth and a discussion panel on "Getting back to science - How to return after parental leave?" organized in collaboration with the cluster of excellence CliSAP. Two TRR 181 scientists were part of the panel: Kerstin Jochumsen (PI T3/L3) and Knut Klingbeil (Postdoc, M5). Thank you again for your commitment.

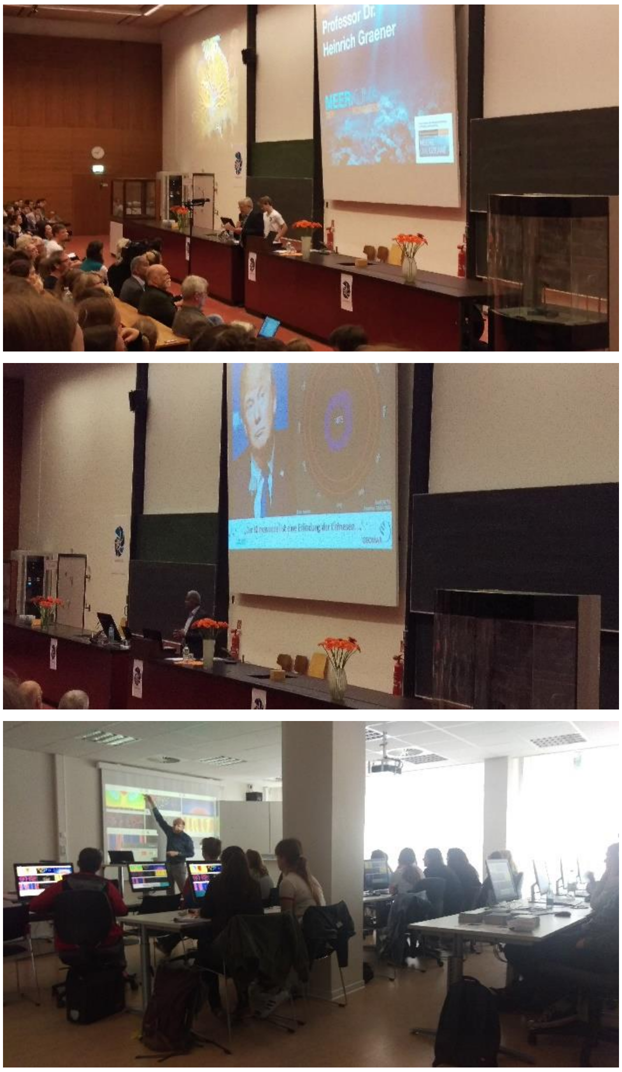
Many people were interested and came by the information booth during their lunch break. The discussion panel gave an interesting insight into different career paths and how to combine family and science. The attending scientists (although few) thought it was an insightful event.

Teaching school kids about climate

Last week a conference for pupils was held at Universität Hamburg on the topic of ocean and climate. The conference was organized by the pupils themselves and had a large attendance of over 600 participants.

The program included scientific talks on all kind of scientific fields working with the ocean as well as workshops. The kids could choose between different sessions that were running simultaneously. The event is supposed to introduce scientific work to young people as well as to provide the opportunity to get in touch with real scientists.

The opening keynote was held by Prof. Mojib Latif from GEOMAR, who is also one of the TRR 181 reviewers. Our own PI Christian Franzke held a workshop on climate modelling, which drew a large crowd. The pupils had the opportunity to work on the PUMA model and learn why climate modelling isn't always that easy.

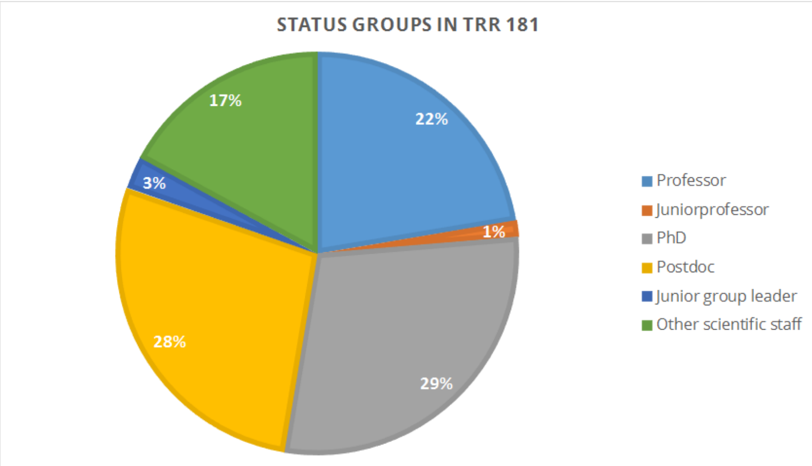


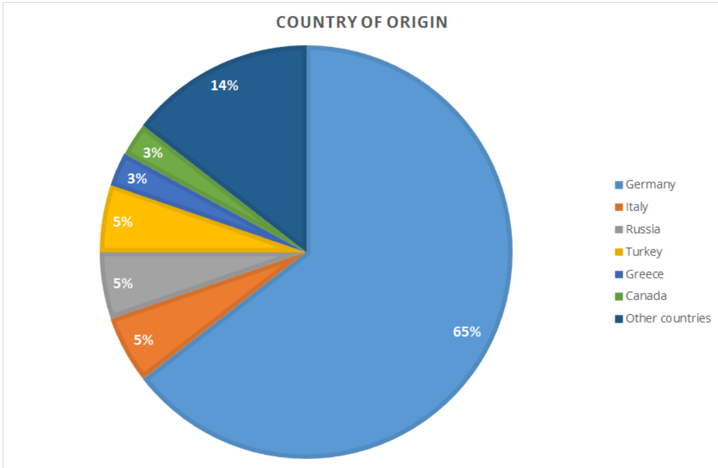
Impressions from the "Schülerkongress".

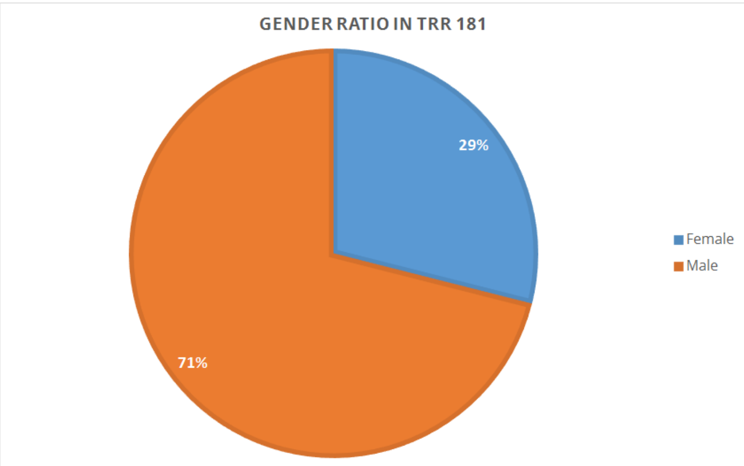
Where do we stand? –Results of the DFG survey

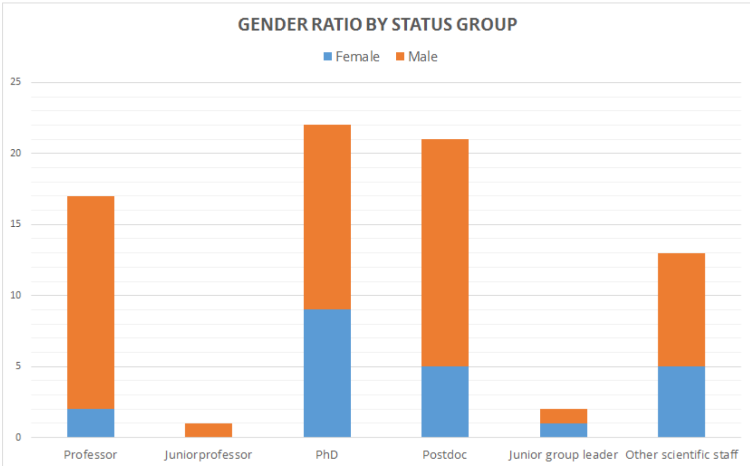
Annually, the DFG asks who contributed scientifically to their large collaboration projects. This includes not only financed staff but also participating researchers and guests.

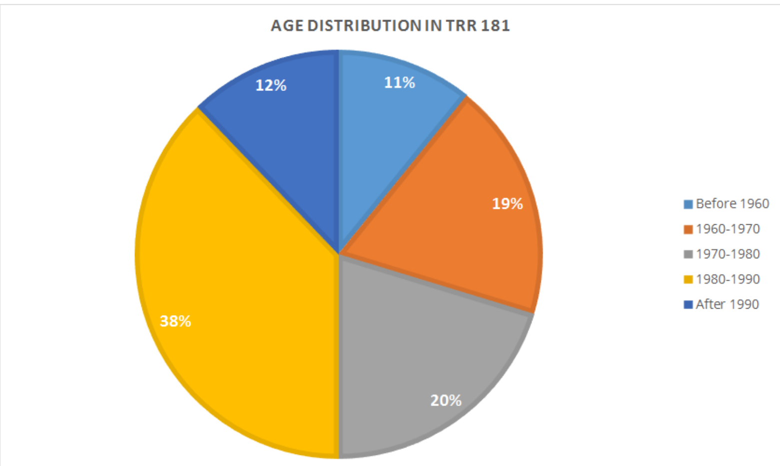
We like to thank you all for your cooperation in this matter and present to you the results of this year's survey regarding the TRR 181.

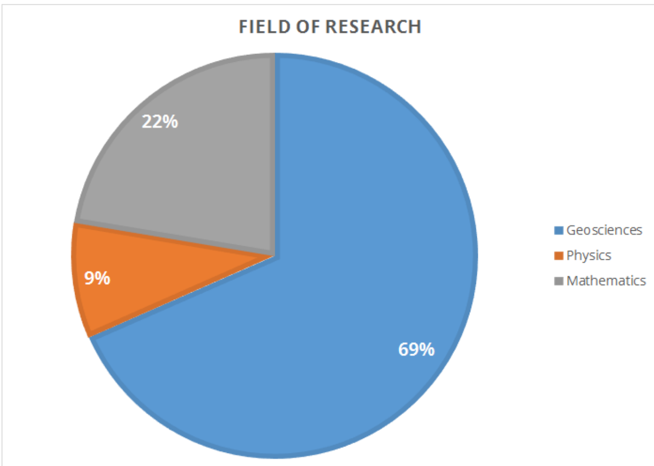












Publications

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

Blender, R., & Badin, G. (2017).Construction of Hamiltonian and Nambu Forms for the Shallow Water Equations. *Fluids 2017*, 2 (2), doi:10.3390/fluids2020024.

Eden, C., & Olbers, D. (2017). A closure for eddy-mean flow effects based on the Rossby wave energy equation. *Ocean Modelling*, *114*, 59-71.

Olbers, D., & Eden, C. (2017). A closure for internal wave-mean flow interaction. Part A: Energy conversion. *Journal of Physical Oceanography*, (2017).

Carpenter, J. R., Guha, A., & Heifetz, E. (2017). A physical interpretation of the wind-wave instability as interacting waves. *Journal of Physical Oceanography*.

Eden, C., & Olbers, D. (2017). A closure for internal wave-mean flow interaction. Part B: Wave drag. *Journal of Physical Oceanography*, (2017).

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.

Upcoming events

June 29, 2017: TRR 181 seminar by Dr. Ivan Ovsyannikov (Universität Bremen)

July 6, 2017: TRR 181 seminar by Stamen Dolaptchiev (Goethe Universität Frankfurt am Main)

July 11, 2017: Workshop: Waves, internal waves and ocean mixing - Bangor (Wales)
This is an informal workshop aimed at bringing together those with an interest ocean mixing and its parameterisation.

July 13, 2017: TRR 181 seminar by Dr. Claus Goetz (Universität Hamburg, TP M5)

July 30, 2017: Summer School on "Ocean Waves and Models" in Bornö
The school is co-organized by the Universities of Copenhagen, Oslo, Stockholm and Hamburg. The summer school is supported by the TRR 181.

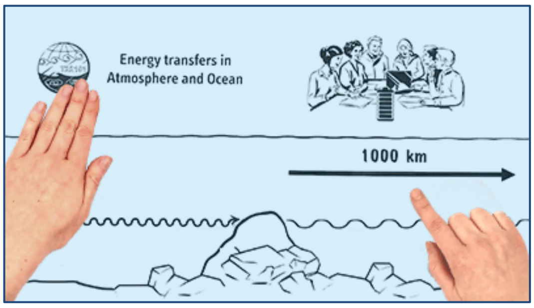
July 31, 2017: Summer School "Turbulent Flows in Climate Dynamics"
The school has a focus on fundamental aspects of turbulent flows in climate dynamics, July 31–August 25, 2017, Les Houches, France

September 11, 2017: SIAM Conference on Mathematical and Computational Issues in the Geosciences
The conference has a long tradition in subsurface modeling as well as atmospheric / ocean / climate and general hydrologic modeling and is held in Erlangen, September 11-14.

September 11, 2017: TRR 181 Annual Retreat

Many things easily explained

Several explain videos have been finished since March! We created videos about turbulence in the ocean, mathematics in climate sciences and internal waves. You can watch them online or download them on the internal web page.



We are nearly done with all planned videos. Here is an update on the progress:

- Climate Models (Production phase)
- Numerics in ocean models (Storyboard 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!

Developing stochastic parameterisations for different flow regimes
By Federica Gugole, PhD M2

Hi, I am Federica and I am a PhD student in project M2. I studied mathematics and now I am working at the Meteorologic Institute of the University of Hamburg. Mathematics and physics are very intertwined one with the other: improvements in understanding the mathematics leads to physics advances to new realizations which in turn help developing more accurate mathematical models. The invention of the computer and the improvement of this technology, allowed more and more mathematical theories to find useful applications and one field for those applications is also climate (and ocean) modeling. Even though a lot has already been accomplished in this field, there is still room for development. There are material limitations (as computer processors, memory storage, computer precision, etc…) as well as theory limitations (not all the phenomena taking place are fully understood at the moment and the techniques used to model them are not always accurate enough) that have to be overcome.

This is where my work takes place. To be more specific most climate models include only the slow and most energetic modes since including also the fast modes would require too much computational time. However, in real atmosphere and ocean there is energy, enstrophy and momentum transfer between the resolved and the unresolved scales. Most current deterministic parameterisation schemes do not re-inject energy into the resolved scales; instead they are effectively an energy drain. Similarly, current stochastic parameterisations are operated mainly ad hoc without consideration of energy and momentum consistency. Recent studies showed that neglecting the fast unresolved modes induce also error growth, uncertainty and biases in the model therefore they should be included somehow. My work is focused on developing a stochastic parameterisation for the interaction between different flow regimes that will still preserve the total energy of the system and require not too much computational time.

"My work is focused on developing a stochastic parameterisation for the interaction between different flow regimes that will still preserve the total energy of the system and require not too much computational time."

Stochastic processes have some nice features that make them suitable in climate and ocean modeling. However, when dealing with stochastic processes, extra care should be employed. Their main feature is to have different realizations with same initial conditions. Therefore, if you find something worked fine once, you should be sure it was not just luck!

Working on fundamental mathematical questions
By Gözde Özden, PhD in M2

Hi, I am Gözde. I am a PhD student in the subproject M2 Systematic multi-scale modeling and analysis for geophysical flow at the Jacobs University with Marcel Oliver. This subproject is splitted into three parts. Our part is variational model reduction. The purpose is to look at balance, multi-scale phenomena and variational approaches.

We mainly focus on foundational aspects of the problem. Then, we expect to encounter a variety of models where fundamental mathematical questions, such as well-posedness, regularity of solutions, validity of limits, and the analysis of associated numerical schemes is open and possibly nontrivial to resolve. It is important to understand them for evaluating and improving numerical weather and climate prediction models.

We started to examine the well-posedness for balance models for stratified flow. We will compare some models such as L1 balance and classical semigeostrophic model from shocks. Both models are formally derived in the same distinguished scaling limit and to the same order of expansion. The shocks in semigeostrophic theory are thought to be representative of the frontal dynamics regime, but this has not been tested in direct comparison.

I am really happy to be part of this project. The best advantage of it is to contribute with the other groups.

"It is important to understand fundamental mathematical questions for evaluating and improving numerical weather and climate prediction models."

Stochastic superparametrization (SSP) for ocean models

By Anton Kutsenko, Postdoc M3

"We are working on adapting SSP for applying it to ocean primitive equations (PE)."

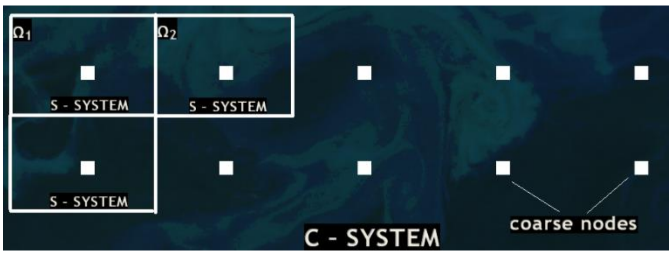
Due to the coarse resolution, ocean circulation models cannot resolve all important effects of mesoscale eddies. There are different ways to parameterize these effects without making expensive simulations on a fine grid. We will focus on SSP proposed in, e.g., [1-3] for quasi-geostrophic ocean models (QG). We found a straightforward way [4] to explain the main idea. Assume a simple single layer model

$$\partial_t \zeta + [\psi, \zeta] + \beta \partial_x \psi = F, \quad \zeta = \Delta\psi, \qquad (1)$$

where ζ, ψ are the related vorticity and the stream function, $[\psi, \zeta]$ is the Jacobian operator, and, for simplicity we omit a dissipation operator $D\zeta$. Let us decompose ζ, ψ on the coarse mesh and subscale variables $\zeta = \zeta^c + \zeta^s, \quad \psi = \psi^c + \psi^s$, and $F = F^c + F^s$ on the physical and stochastic forcing. The stochastic source F^s emulates various uncertainties of subscales. Substituting them into (1) we obtain

$$\partial_t \zeta^c + \partial_t \zeta^s + [\psi^c, \zeta^c] + [\psi^c, \zeta^s] + [\psi^s, \zeta^c] + [\psi^s, \zeta^s] + \beta \partial_x \psi^c + \beta \partial_x \psi^s = F^c + F^s \quad (2)$$

and $\zeta^c + \zeta^s = \Delta\psi^c + \Delta\psi^s$. Now let us split the equation into two systems describing the evolution of coarse and subscale mesh variables (c-system and s-system).



This spitting is non-rigorous, so we have some freedom of choice. Nevertheless, we need to take into account the arguments: 1) c-system should contain all coarse mesh variables and some terms (CT) connecting c-system with s-system, otherwise c-system will be uncoupled from s-system; 2) s-system should be linear, otherwise the combined computational cost would be higher than the cost of simulating of the entire system on the fine grid; 3) the linear combinations of fine mesh variables have little effect on c-system because they are fast and their linear combinations are also fast. Hence, we obtain exact two systems from (2):

c-system $\partial_t \zeta^c + [\psi^c, \zeta^c] + [\psi^s, \zeta^s] + \beta \partial_x \psi^c = F^c, \quad \zeta^c = \Delta\psi^c$;

s-system $\partial_t \zeta^f + [\psi^c, \zeta^s] + [\psi^s, \zeta^c] + \beta \partial_x \psi^s = F^s, \quad \zeta^s = \Delta\psi^s$.

S-system is linear with constant coefficients since all coarse mesh variables are constants in the local boxes Ω_n, see Fig. Hence, s-system admits an explicit solution. Taking this solution, we compute $CT = [\psi^s, \zeta^s]$and substitute it into c-system at each coarse time step. For solving s-system we also need to know the initial data. These data can be selected to be satisfying some a-priori statistical information taken from independent fine-grid simulations (or physical predictions, or real-world observations, or simply random). In any case, the initial data and F^s are parameters for tuning the systems. Now we are working on adapting SSP for applying it to ocean primitive equations (PE). We have already obtained c-system and s-system for PE, and the explicit solution of s-system which is more complicated than for QG. We are working also on simulations. Because PE are written in terms of the velocities, there are some possibilities for improving s-system which can make the coefficients not only constant or introduce other non-homogeneous defects. We expect that in this case some recent methods of homogenization of non-uniform media [5] or fast algorithms of solving non-uniform systems, based on integral continued fractions [6], can be helpful.

[1] Efficient stochastic superparameterization for geophysical turbulence; I. Grooms, A.J. Majda; Proceedings of the National Academy of Sciences, 2013, 110 (12), 4464-4469
[2] Stochastic superparameterization in quasigeostrophic turbulence; I. Grooms, A.J. Majda; Journal of Computational Physics, 2014, 271, 78-98
[3] Stochastic superparameterization in a quasigeostrophic model of the Antarctic Circumpolar Current; I. Grooms, A.J. Majda, K.S. Smith; Ocean Modeling, 2015, 85, 1-15
[4] Toward consistent subgrid momentum closures in ocean models; S. Danilov, A. Kutsenko, M. Oliver; book chapter; in preparation
[5] Wave Propagation and Homogenization in 2d and 3d Lattices: A Semi-Analytical Approach; A.A. Kutsenko, A.J. Nagy,
X. Su, A.L. Shuvalov, A.N. Norris; Q J Mechanics Appl Math, 2017, 70, 131-151
[6] Application of matrix-valued integral continued fractions to spectral problems on periodic graphs with defects; A.A. Kutsenko; submitted

Focussing on the ocean surface mixed layer

By Evridiki Chrysagi, PhD T2

My name is Evridiki and I'm PhD candidate working with Prof. Dr. Hans Burchard, in subproject T2. Our research will be focused mainly on the ocean surface mixed layer which is a highly complex and energetic region. The upper ocean is characterized by a relative shallow mixing layer with weak stratification due to turbulent mixing. Our scope is to investigate the sub-mesoscale structures and the surface mixed layer instabilities in order to develop new parameterisations of energy consistent pathways, associated with these motions. For that we will use the General Estuarine Transport Model (GETM) which includes turbulence closure models provided by GOTM, diagnostic tools for the numerical mixing and dissipation but also adaptive vertical coordinates that can resolve the sub-mesoscale features. The configurations will include idealized high resolution simulations as well as hindcast simulations of the Central Baltic Sea. In order to validate the model, the results will be combined with field observations.

"Our scope is to investigate the sub-mesoscale structures and the surface mixed layer instabilities in order to develop new parameterisations of energy consistent pathways."

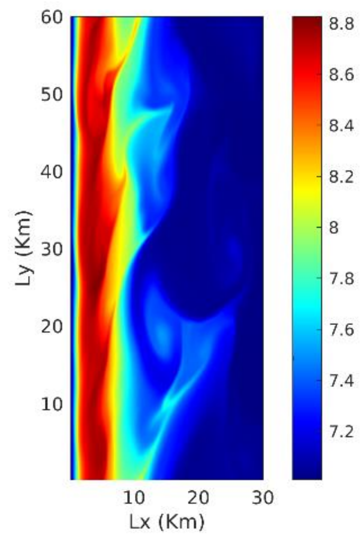


Fig: Surface salinity field and eddy formation in an idealized high resolution upwelling simulation. The model domain is a re-entrant channel with periodic boundary conditions forced by wind stress.

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Something funny for the end ...