TRR 181 NEWSLETTER

ENERGY INFLOW

LET THE GAMES BEGIN!

The new year is already three months old and they have been busy months for our project! 2019 is a proposal writing year so we started it with a workshop on new ideas for the next TRR 181 phase. This was quickly followed by a workshop in "Internal Gravity Waves" and our annual Winter School.

In this Newsletter you find a **report on the Winter School**, important dates in the next months, new publications as well as **travel and scientific reports** from our PhDs and Postdocs!

Enjoy!
Jennifer and Meike

Group picture from the Winter School in Ratzeburg

THE FUTURE IS STILL UNKNOWN: OUR WINTER SCHOOL IN RATZEBURG

We held our annual Winter School for our early career scientists at the Youth Hostel in Ratzeburg this year. We focused on career development workshops during the first half of the week and on science during the second half.

We started the week with a focus on the research landscape Germany. How does the German system work? What is the WissZeit-VG? And how do I get funding, if I like to stay in science? Those were the questions tackled in the presentation by Meike Ruhnau. Key message was: although it looks grim, there is always hope.

After lunch, Liz Elvidge and Rachel Herries from the Imperial College London took over with their career development workshop. The PhDs and Postdocs had time to reflect on their personal path that led them to their current position and learned about how important CV writing is. On the second day, the group split into PhDs and Postdocs. Here, the focus lay on writing of cover letters and interview skills.

The participants enjoyed the workshop although some topics could have needed a little bit more time. For some, the workshop could have happened sooner, but for most, it was just the right time. The future however, is still unknown for most of our young scientists.

On Wednesday, the focus shifted to the scientific part of the project.

In the morning, the participants had two more workshops on “How to pitch your science” and “How to give effective feedback”. Both workshops were held in preparation for the poster sessions, since the participants needed to pitch their science to three randomly assigned feedback givers.

We held two poster sessions, one on Wednesday, one on Thursday. The participants regarded these as very helpful. Especially the feedback process was seen as beneficial, although there could have been even more time for the poster session. Some of our PIs - Carsten Eden, Christian Franzke and Marcel Oliver- attended the poster session to get an overview about Scientific work.

On Wednesday there was another outreach task group meeting. It was a lively discussion about the current status of the scrollytelling, how to spread the explainity movies and the next big event, the Sommer des Wissens in Hamburg in June.

Thursday and Friday morning, some of our Postdocs held talks on their work. The participants especially like the effort the speakers took to make sure everyone understood what they are doing. We like to thank Anton Kutsenko, Claus Goetz, Janna Köhler and Urs Schaeffer-Rolffs for their contributions.

During the evenings, most of the group gathered in the foyer to play table tennis, “Kicker” or pool. Also the Wi-Fi was strongest there.

On Wednesday evening, we all went out to dinner were we decided to plan a TRR 181 movie, but only if we can get Meryl Streep and Jessica Alba to participate. Still working on that.

You can find the talks, workshop notes and pictures on our internal webpage.

DO YOU COME FROM A LAND DOWN UNDER?

At the end of 2018, our PhD Federica Gugole (M2) did a research stay in Australia. She provided us with a short report, so that we can participate in her experience.

My research visit at the University of Sidney (yes guys, I feel for you, another report about Sydney... what a lack of fantasy, but koalas are really sweet) started mostly out of curiosity. After discussing at conferences and schools with scientists with different backgrounds, I got interested in exploring a broader circle then just TRR and German research. Of course I read a lot of papers of scientists from all over the world, but that still leaves a feeling of incompleteness. Discussion on the other side is much more engaging, and a constructive exchange of ideas and questions is probably the best part of this work. So it happened that one day my supervisor got the idea of a research stay.

As an applied mathematician to geophysical fluids, it made sense to visit another scientist with a similar experience. After digging into the literature I came up with a name and with an idea of what I would like to investigate further during my doctorate study. We first got in contact via email, and then we had the chance to meet at the EGU2018 and hence have a first impression and discussion. Once the collaboration was settled, I had to find funds. I first applied for a grant at the DAAD but got unlucky and subsequently, thanks also to Meike’s help, I managed to be financed by TRR, however for a shorter period. At this point not much was left: I only had to book the tickets, arrange for an accommodation and apply for the visa.

After a never ending travel I finally arrived in Sydney. I’m not going to talk about what to do in the free time, it will be enough to mention that nobody will believe you are in

Sydney until you show a picture of the Opera House. Nevertheless, for how exotic the environment might be, the tourist attraction I visited the most was the UniCampus. Discussions with my host revealed to be very fruitful and we managed to get a broader overview of the topic and hence to define a clear structure of the upcoming work that will hopefully lead to the closure of my PhD. Aside from that I met also other PhDs, postdocs, lecturers and professors with whom I could exchange experiences and confabulations not just about mathematics but also about research in general.

Five weeks passed quickly, especially when summer is approaching, and when I was getting used to my new sunlit office, it was time to come back to the old cloudy one.
This is a demanding experience, not just in terms of money, but if anyone is a minimum curious about it, I would recommend it independently of the research point of view and of the location.

UPCOMING EVENTS

April 07-12, 2019
EGU, Vienna
Our project has its own session this year! Have a look at the program here.

April-July, 2019
TRR Seminar
Our next seminar series mainly focuses on ur PhD students. Each PhD has to present their work in the upcoming sumer semester or the following winter semester. Have a look on our webpage to see the dates.

May 02, 2019
TRR Seminar, Hamburg
The seminar is held by Annette Müller (Freie Universität Berlin).

September 17-19, 2019
TRR 181 Annual Retreat
Our annual retreat follows a workshop day for the PIs on a "Gender bias-free recruiting process".

January 28-31, 2020
COMMODORE Conference
The conference is organized by the TRR 181 and held at the MARKK Museum in Hamburg.

February 03-07, 2020
TRR 181 Winter School
Our annual Winter School is held at the DJH Ratzeburg again.

PUBLICATIONS

Have you also published your work, but cannot find it here? Please get in touch with the project coordination. Members of the TRR 181 are printed in bold.

Voelker, G. S., P. G. Myers, **M. Walter** and B. R. Sutherland (2019). **Generation of Oceanic Internal Gravity Waves by a Cyclonic Surface Stress Disturbance.** Dynamics of Atmospheres and Oceans.

Kutsenko, A. A. (2019). **A note on sharp spectral estimates for periodic Jacobi matrices.** Journal of Approximation Theory, Vol. 242, p. 58-63.

Merckelbach, L., A. Berger, G. Krahmann, M. Dengler and **J. R. Carpenter** (2019). **A dynamic flight model for Slocum gliders and implications for turbulence microstructure measurements.** Journal of Atmospheric and Oceanic Technology, Vol. 36 (2), 281-296.

Conti, G. and **G. Badin** (2019). **Velocity statistics for point vortices in the local α-models of turbulence**, Geophysical and Astrophysical Fluid Dynamics, doi:10.1080/03091929.2019.1572750

Pollmann, F., J. Nycander, **C. Eden and D. Olbers** (2019). **Resolving the horizontal direction of internal tide generation**, Journal of Fluid Mechanics, Vol. 864, pp. 381-407.

Franzke, C. L., D. Jelic, S. Lee, and S. B. Feldstein (2019). **Systematic Decomposition of the MJO and its Northern Hemispheric Extra-Tropical Response into Rossby and Inertio-Gravity Components.** Quarterly Journal of the Royal Meteorological Society.

Mohamad, H., and **M. Oliver** (2019). **A direct construction of a slow manifold for a semilinear wave equation of Klein–Gordon type.** Journal of Differential Equations.

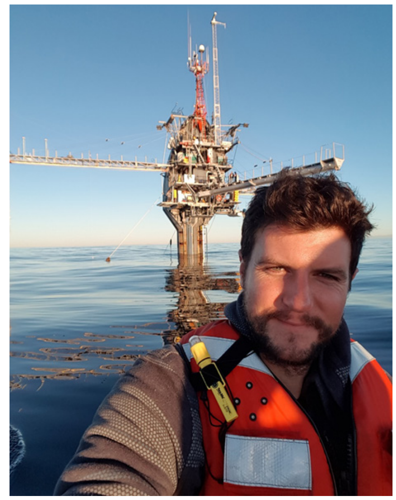
NOVEL MEASUREMENTS FOR SURFACE WAVES

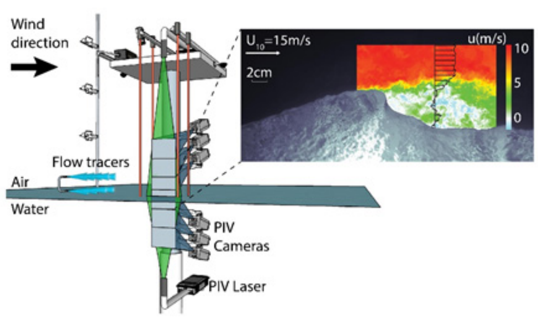
by Marc Buckley, Postdoc M6

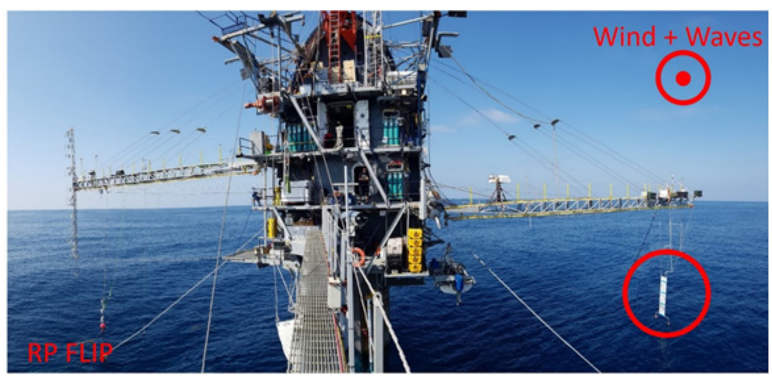
I'm Marc Buckley, a Postdoc in the Techniques subproject. My objective to measure and understand small-scale physics within the first few meters above and below the wavy ocean surface, and how they influence fluxes of energy between the atmosphere and the ocean. My main experimental approach is Particle Image Velocimetry (PIV), which consists in seeding a turbulent flow with particles and tracking the particles to retrieve information about the turbulent motions in the flow. I recently developed such a system to measure both ocean wave dynamics and turbulent motions in the airflow above the waves. I deployed it first from R/P FLIP in October 2017 off the coast of California, and more recently (September-October 2018) from a small platform in the Oder Lagoon (Baltic Sea lagoon).

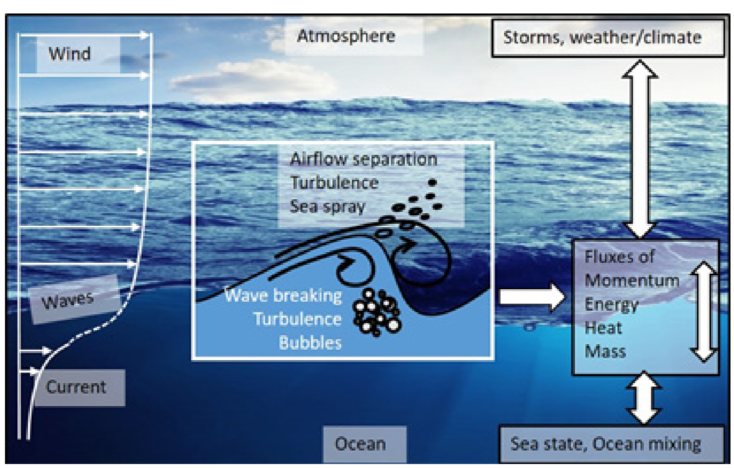
> ***"I recently developed a system to measure both ocean wave dynamics and turbulent motions in the airflow above the waves."***

We plan to use these novel measurments alongside laboratory wave tank measurements to test and validate a wind-wave coupling model developed at University of Hamburg by Michael Hinze and Nicolas Scharmacher. Additionally, we plan to use these high resolution measurements to better understand the complex physical processes that control air-sea energy fluxes, including airflow separation past steep surface waves, wave breaking, wave and current generation through the action of viscous and form (pressure) stresses. This will possibly lead to a novel physics-based air-sea energy and momentum flux parameterization, that may go beyond existing bulk parametrizations that are used in current atmospheric and oceanic models.









PARAMETERISING GRAVITY WAVE EFFECTS IN THE ATMOSPHERE

by Brenda Quinn, Postdoc W1

I am a postdoctoral researcher working on adapting the IDEMIX internal gravity wave model for the atmosphere in subproject W1 together with Carsten Eden, Dirk Olbers, Matthäus Mai and Erich Becker.

Internal gravity waves in the atmosphere have a profound effect on the large-scale circulation in the atmosphere and contribute significantly to the mesoscale wind and temperature variance. Since their scales are too small to be represented in general circulation models, their effects must be included via sub-grid scale parameterisations. Most climate and numerical weather prediction models now include some form of gravity wave parameterisation in order to accurately simulate large-scale middle-atmospheric phenomena such as the Brewer-Dobson circulation, the seasonal zonal-mean wind reversal and the quasi-biennial oscillation. Without the gravity wave parameterisations the models do not simulate these large scale reversals so the inclusion of gravity wave parameterisations are essential to Earth system models for future climate change predictions.

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However current gravity wave parameterisations have a major drawback in that they use much too simplified physics to determine the feedback of the waves on the large scale flow. They are steady state and use separate parameterisations for terrain-generated and convectively-generated gravity waves. The main goal of this project is to include more sophisticated physics in atmospheric gravity wave parameterisations by use of IDEMIX which simulates the evolution in time of the wave field, its energy exchange interaction with the background flow (shown in Figure 1) and can accommodate multiple wave sources at once, allowing for wave-wave interactions. IDEMIX can easily incorporate the effect of critical layers which occur frequently in the atmosphere since the gravity waves have similar phase speeds to the background flow, typically tens of metres per second. A dynamically-determined dissipation is calculated when the waves break, to keep the wave field within convective stability limits. The wave energetics from IDEMIX are used to calculate the gravity wave drag which feeds back onto the largescale circulation to either accelerate or decelerate it.

Compared to traditional parameterisations which tend to provide the drag around the mesopause, IDEMIX exhibits a better vertical distribution of gravity wave drag throughout the middle atmosphere which is more fitting to observations. The basic IDEMIX for the atmosphere is now being implemented into the ICON-A component of the ICON Earth System Model.

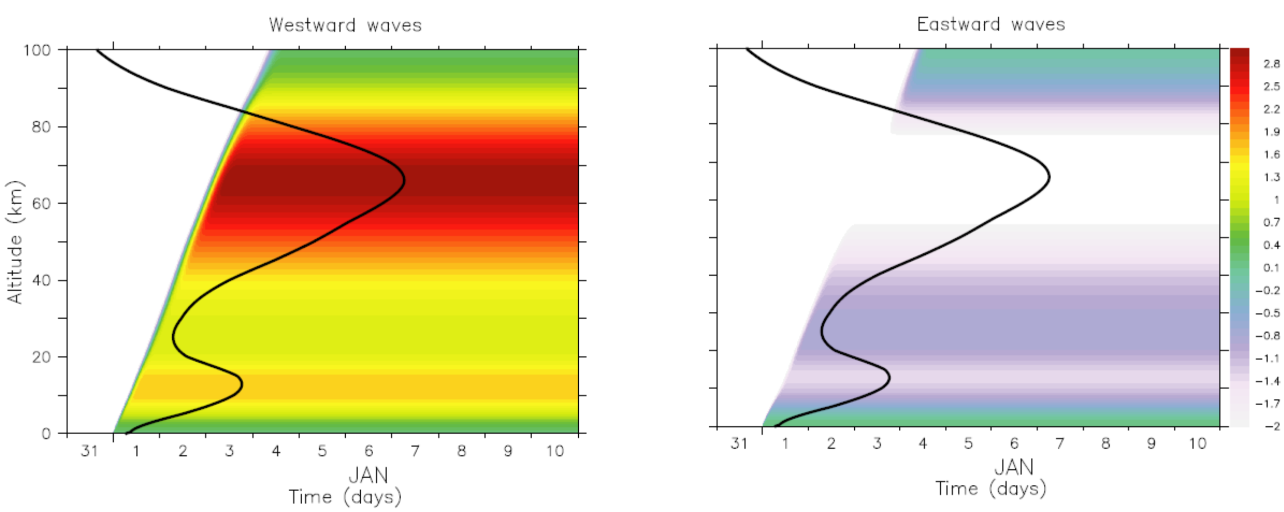

Figure 1 (below): The westward waves gain energy from the eastward jets while the eastward waves lose their energy to the background flow.

MODELS, RESPECTING THE CONSERVATION LAWS

by Sergiy Vasylkevych, Postdoc L2

Ideal (i.e. non-dissipative) fluids are characterized by a number of conservation laws, which are the defining features of the motion, such as

1) energy conservation;
2) mass conservation;
3) material conservation of generalized vorticity, e.g. potential vorticity,
4) model specific advected quantities, for instance, potential temperature in inviscid primitive equations.

In many applications the dissipation can not be ignored, whereupon all of the above laws must be modified appropriately. However, in order to establish the ideas, it is useful to stick to the non-dissipative case initially. My work in TRR 181 is focused on developing "simplified" models that inherit the conservation laws from their parent system. This branches into two distinct sub-projects.

1. Lagrangian turbulence models. Common approach to turbulence modeling is based upon averaging the equations of motion at each spatial location (e.g. Reynolds averaging). While very natural, this approach destroys material conservation laws. This can be remedied by using more elaborate procedures, known as Lagrangian averaging, based on averaging fluid parcels' trajectories. Combining the recently introduced concept of geometric generalized Lagrangian mean (geometric GLM) with averaging of the variational principles, we developed a turbulence framework, which guarantees the inheritance of the above conservation laws by the model.

Using this framework, we derived a number of idealized turbulence models, namely for the primitive and Euler-Boussinesq equations, Euler's equations of ideal fluid flow, and the multi-dimensional Burgers' equations. While working on these models, we found that our framework is highly adaptable to different physical contexts (compressible and incompressible flows, manifolds, various boundary conditions, anisotropy are all treatable within the framework) and leads to models with desirable mathematical properties (well-posedness, filtering of small scales). Another advantage is that the framework is not bound to a particular choice of scalar-averaging (e.g. time-averaging or statistical averaging). Recently we have learned how to combine the framework with stochastic turbulent closures, thereby making another step towards realistic turbulence models.

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The bulk of work done up to now provides a proof of concept for our methodology. Several steps still need to be taken, in order to make the concept attractive to applied scientists. One is the inclusion of dissipation. Another avenue is further adapting the framework to a specific physical context (for instance, incorporating the concept of isopycnal averaging for the ocean models) and developing corresponding parametrizations in the closure.

Three papers so far were written for this sub-project: one is published, one is submitted, and one is in preparation.

2. Variational approximations for rescaled fluid models. A powerful method of studying equations of mathematical physics is rescaling of equations of motion followed by their asymptotic analysis. However, when applied to Lagrangian system, this approach has an important drawback as it potentially destroys the variational structure of the problem and associated conservation laws.

How to construct asymptotic approximations to the rescaled equations that yield models inheriting conservation laws 1)-4) from the parent system then? The answer is fairly straightforward for an isotropic scaling and is based on first approximating the rescaled variational structure, then computing the equations of motion. However, for anisotropic scaling, the rescaled variational structure becomes more complex and not all its approximations have the desired property.

We completely resolved the question for inviscid homogeneous fluids, thereby developing a systematic procedure for constructing conservation laws-preserving approximations to the rescaled systems. It turns out that many known models are trivial to derive using our framework. For instance, the inviscid primitive equations fall within the framework as an approximation to Euler-Boussinesq system.

The problem that initiated this project comes from equatorial dynamics. There is much theoretical interest in the dynamics of planetary-scale Kelvin waves for the purpose of atmospheric and oceanic data assimilation. This calls for a geophysical balance model, which retains equatorial Rossby waves in addition to Kelvin waves. The work on deriving the required balanced model is about to begin. Another direction of our research is to obtain

models of front-formation in atmosphere and ocean due to strong meridional temperature gradients. Further applications are likely as the framework should prove useful whenever approximate models are sought in an anisotropic setting.
The theoretical paper for this sub-project will be submitted for publication in the nearest future. Two further papers on equatorial balance models and front-formation models are planned.

SPONTANEOUS WAVES AND DISSIPATION

by Thomas Reitz, PhD L2

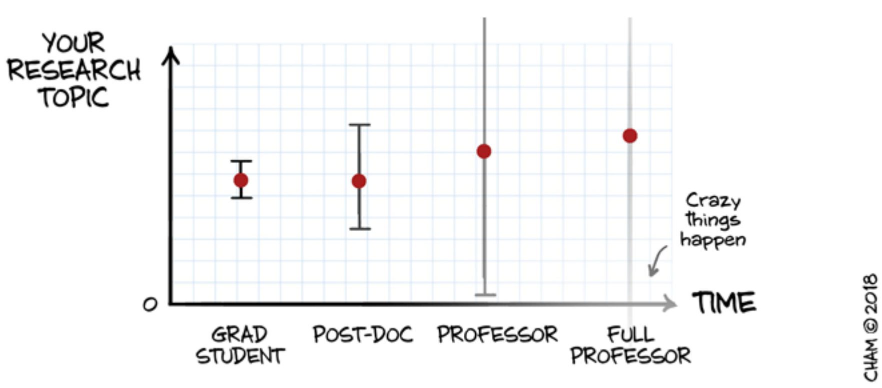
Hi, my name is Thomas, I am a PhD Student in subproject L2 “The interior energy pathway: internal wave emission by quasi-balanced flows” at the Max-Planck-Institute for Meteorology. This project tries to answer the question to what extend spontaneous wave generation contributes to the ocean’s route to dissipation.

The ocean’s route to dissipation is not yet fully understood. Both the large-scale currents and the meso-scale eddies in the ocean are essentially balanced. Moreover, those eddies tend to transfer energy upward towards larger scales. So the question arises how the energy is transported from the large scales to the small scales, where the energy can be dissipated. Spontaneously emitted waves can be refracted by the eddying flow and captured later. Wave capture is a possible way to transfer energy to smaller scales. I am contributing to this question by identifying spontaneously emitted waves in an OGCM.

> ***“To identify spontaneously emitted waves in a more or less realistic setting I use a high resolution global ocean model.”***

To identify spontaneously emitted waves in a more or less realistic setting I use a high resolution global ocean model. The model runs in two configurations: One is a realistic setting forced by 6-hourly atmospheric fluxes obtained by reanalysis data and a second one with temporally constant forcing. By comparing the two simulations I found wavelike structures which are not generated by external forcing but by the eddying flows itself. The properties of these structures identify them as gravity waves which are likely to be generated by spontaneous emission. Further analysis may show to what extend these waves contribute to the ocean’s route to dissipation.

SOMETHING FUNNY FOR THE END



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