TRR 181 NEWSLETTER

ENERGY INFLOW

AN INTENSIVE SPRING TIME

It is now almost half a year in the second phase of the TRR - honestly we don´t know how fast the time passed now. Most of the all PhDs and Postdocs have started, that is a huge step.

After the Winter School in March we now had an additional Spring School, you will find a report of the Spring School in this issue. There have already been a few RTG courses and the mentoring programme started - so it is true to say, we tried to give a good scientific start under difficult pandemic circumstances.

The Outreach project kicked off with four artists from different fields. A recap about one meeting with Composer Victor you can find also in this newsletter issue.

We are looking forward to a summer break and hope you can all enjoy it. We hope to meet you in person at the Retreat in Seminaris Hotel in Lüneburg in September, maybe our group picture then will look "normal" without a Zoom frame again.

In this Newsletter you find:

- a **report on the Spring School**
- a **report from the first fundamental RTG course in mathematics**
- a **report of one of the Art&Science meetings**
- **reports** from our new PhD and Postdoc in M5 and W1.

Enjoy!
Jennifer

Outlook Retreat: Will this be possible again in September? (Picture taken at Annual Retreat in 2018)

DIGITAL SPRING SCHOOL 2021

From Monday to Wednesday, June 7-9, the first RTG Spring School of the second phase of the TRR 181 took place. Due to the ongoing pandemic safety measures, the event was held online – hopefully for the last time!

The Spring School 2021 set off on Monday and Tuesday with a workshop on presentation skills, which was held by renowned speaker on communication expertise and teaching skills Jean-Luc Doumont. Despite the format, which allowed little interaction, the participants learned a lot about how to get your message across and why it's useful to view effective communication as optimisation under constraints.

On Tuesday, some science on oceanography was integrated in between workshop and the mentoring programme. Mercator fellow Jacques Vanneste from the University of Edinburgh, who was introduced by the project speaker as the expert in balanced flow decomposition and interpretation, held a talk on 'Coastal Imbalance'. In his science talk, he discussed models and asymptotics on how the ocean responds to atmospheric perturbation. This talk gave some valuable insight into the effects that the coastline has on the business of decomposition between balanced flow and waves. In a separate Zoom breakout session, the speaker and a few scientists had the chance to discuss the topic on ocean imbalances a little further.

Several social activities throughout the event ensured that that the PhDs and Postdocs of the project could get to know each other better. Especially a City Rally and a Speed Networking were much appreciated. The rallies throughout the cities of Bremen and Hamburg were a good opportunity for the PhDs and Postdocs, because everyone was finally able to get to see each other in person. The Speed Networking was in that sense also a welcomed social activity because it offered the PhDs the possibility to talk to all Postdocs one on one and finding out whom they'd like to be their mentor. Although this was organised online, the Speed Networking was perceived very well, thanks to the platform Gather.town, which brought a bit of variety into the online environment that is often dominated by Zoom. Additionally to the Rally and Speed Networking, there was a Game Night and a Lunch Lottery, so that every day of the Spring School was covered with a little bit of entertaining social activities.

Where the first two days focused more on specific topics and the social activities, the Wednesday was fully dedicated to a Q&A format on every subproject of the TRR 181.

"The Speed networking was a welcomed social activity because it offered the PhDs the possibility to talk to all Postdocs."

Although not all of the questions could be answered in the limited amount of time, attendees got on overview of all research areas of the TRR. The session ended with an engaging discussion with Postdocs from the Synthesis area S about the relevance of keeping the overall goal of the TRR in mind when focusing on the work in each subproject: improving climate models.

Although (or because) the pandemic has been with us for more than a year and we already had to organise several events online, the general hope of the participants was that future events will be possible in persona again, for as we all know, video conferences can get tiring at some point. Nevertheless, we are happy to announce that the TRR 181 Spring School 2021 was a success and found a good balance between social activities on the one hand and learning about science and relevant skills on the other hand.

FIRST FUNDAMENTAL COURSE OF RTG: MATHEMATICAL ANALYSIS

Text by Florian Noethen

Organizers: Jens Rademacher and Florian Noethen

From May 4-5, 2021 the first fundamental course of the Research Training Group (RTG) took place via Zoom. Over 20 of our new PhD students attended the 2-half-day course on mathematical analysis and learned about important concepts of mathematics that underlie the different areas of the TRR 181.

Fundamental courses and planning:

The TRR 181 is an interdisciplinary project that contains researchers from very diverse backgrounds. To bridge the gaps between knowledge and languages of different disciplines, we established our own graduate school, the RTG. It provides various benefits to our PhD students and postdocs, such as a mentoring program and different types of courses. Mandatory for all our PhD students are the fundamental courses. They create a basis of knowledge for all main disciplines of our project: mathematics, oceanography, and meteorology. The course on mathematical analysis was the first in the series of fundamental courses.

The organization of the course was not without obstacles. Due to corona, the start of the second phase of the project and the RTG were postponed by half a year. Hence, also the fundamental courses had to be postponed. We decided to wait until the summer semester to have most of our new PhD students on board, but not wait much longer, so that our PhD students can benefit from the fundamental courses early on. The first discipline treated in the fundamental courses was mathematics, as it is needed for the other disciplines as well. Mathematics was split into two parts: analysis and numerics. We began preparing for the courses on mathematics by asking all project leaders about the most important concepts of mathematics needed to understand their subprojects. With these suggestions in mind, a team of project leaders and postdocs organized the course on mathematical analysis. Contentwise, we decided to give an introduction to seven different topics divided among the lecturers, while for the format, we opted for short lecture videos (2h total) and a practical part during a 2-half-day Zoom meeting. The students were tasked to watch the videos before the meeting.

Day 1:
The first day of the course started with some opening words and organizational aspects by Lea Diederichsen and me. Then, Ivan Ovsyannikov took over with the first topic: 'ODE basics'. The students were encouraged to ask questions on his video in which he discussed the existence and uniqueness of solutions to Ordinary Differential Equations (ODEs). After answering the questions, Ivan went through several exercises on solution techniques for ODEs with the students.

Next up was my slot on 'Center manifold'. In the video, center manifolds were introduced as a reduction technique to study local dynamics near stationary states. After a brief recap of the video and questions, the students were divided into small groups and sent into breakout rooms. Each group had the choice between two task in which the knowledge from the lecture video had to be applied.

The last slot of the first day was on 'PDE basics' by Camilla Nobili. She decided to focus on one of the most important Partial Differential Equations (PDEs) for our TRR 181, the Navier-Stokes equations. In her video, she singled out different types of PDEs contained within these equations and discussed their properties. Again, after a recap and questions, the students were sent into breakout rooms in which they recomputed some of the formulas from the video under slightly different assumptions.

Day 2:
With the most fundamental topics out of the way, the second day moved closer to the heart of the TRR 181. Marcel Oliver started with the slot on 'Model reduction'. His video showed the derivation of the 1-layer quasigeostrophic equations from the shallow water equations as a limit of rapid rotation. He demonstrated techniques such as non-dimensionalization, a separation into slow and fast modes in the Fourier representation, and epsilon-expansions to arrive at the first order balance condition. During his slot, the students had to derive the second order balance condition by comparing higher order terms of the epsilon-expansions from his lecture.

The next slot contained two topics that were merged into one: 'Linear waves' by Anton Kutsenko and 'Nonlinear waves' Bing-Ying Lu. Anton Kutsenko highlighted that

linear waves can be obtained analytically if one knows the eigenfunctions of the Laplace operator on the specific domain. Moreover, he showed us properties of linear waves, such as reflection and transmission, analytically and in terms of a simulation. Bing-Ying Lu pointed out the differences between linear and nonlinear waves. While linear waves satisfy a superposition principle, nonlinear waves come from nonlinear PDEs for which the sum of two solutions is in general not a solution anymore. Nevertheless, there are special nonlinear waves, so-called soliton waves, that interact in a similar fashion to linear waves. Furthermore, there are so-called shock waves in nonlinear systems that destroy the classical concept of solutions. During the meeting, both Anton Kutsenko and Bing-Ying Lu gave brief recaps of their videos and showed additional simulations or examples. Various exercises on linear waves were discussed and an example of a nonlinear wave was computed in small groups.

The last slot of the course was by Jeffrey Carpenter on 'Hydrodynamic Instabilities'. For the preparation, he referred to an old, but still great video from the National Committee for Fluid Mechanics Films. The video showed several types of flow instabilities achieved in tank experiments. While the video focused on experiments, Jeffrey Carpenter provided the theoretical background in a lecture during his slot. For the Rayleigh equation, he presented criteria for critical parameters that determine whether the flow is stable or unstable. Central in his talk were Rayleigh's inflection point theorem and Fjortoft's extension theorem, which the students had to apply to example cases.

Overall the lecturers did a great job at introducing the individual topics. However, a 2-half-day course cannot possibly cover all the important details. Thus, for further reading we uploaded a list of references to our internal website. Moreover, for latecomers or RTG members who want to revisit the course, the lecture videos, the lecture notes, and the additional material from the course are also available on our internal website.

CREATING AN "EARTH SYMPHONY" FROM TRR 181 DATA

Text by Colja Vorhoff

Art & Science Meeting June 11, 2021

TRR 181 scientists meet online with composer Victor Cuiza from HfMT Hamburg to discuss music project that aims at translating atmospheric and oceanographic data into sound waves

On Friday, June 11, participants of the TRR 181 outreach project "Art&Science: ENERGY TRANSFERS" met in a virtual meeting to discuss possibilities for the implementation of a music project in this context with music student and composer Víctor Ernesto Gutiérrez Cuiza from Hochschule für Musik und Theater Hamburg.

The idea of the musical project is to create an "Earth Symphony" from Earth System scientific data of the TRR 181. Therefore, the idea is to translate global atmospheric and oceanic data into oscillations, manifesting as frequencies or amplitudes, before these again are translated into sound waves. By applying this process, the project wants to make it possible to hear the state of the atmosphere and the ocean at any given time. Central to the artist´s idea of "music in space" is to feel how waves are moving in space and by this sensual experience learning about the behavior of waves and the interactions between ocean and atmosphere as well as making paramount processes such as climate change experienceable through music.

While during the Kick-off meeting the focus was more on atmospheric data regarding the music project provided by Prof. Nedjeljka Žagar and her PhD student Valentino Neduhal, this meeting also introduced some oceanographic contents provided by TRR 181 scientists Stephan Juricke and Nikolay Koldunov. During the meeting, the participants further discussed ideas on how to translate wave energy motion into music.

One proposal was to associate different melodies, tone keys or dynamics such as crescendo and descrecendo with different parts of the wave and energy spectrum. Therefore, Valentino Neduhal already provided the artist with two two-dimensional atmospheric matrice data sets on Rossby and Inertia-gravity part of energies, that already could be experimented with. While the first data sets were focused on energy of vertical motions, future data sets will also focus on the energy of horizontal motions, before in a further step ocean data that corresponds will then be assimilated. Almut Gassmann brought in the idea, that climate change could be integrated musically as a main theme by creating discords and disharmonies. This way musical elements can directly represent the imbalance of Earth's climate system through global warming.

All in all, a range of ideas on how to "musicize" atmospheric and oceanographic data was introduced, be it by assigning musical dynamics or melodies to the different types of waves or separating data into amplitudes and vibrations in order to transfer it into music. While the meeting gave the participants a chance to discuss on all these ideas and getting familiar with the multiple ways of translating waves into music – we all are excited about the further progress of this project!

ANALYZING DIAPYCNAL MIXING IN OCEAN MODELS

by Erika Henell, PhD M5

Hi! My name is Erika and I work as a PhD student at the Leibniz-Institute for Baltic Sea Research Warnemünde (IOW) in Warnemünde, Rostock. I am supervised by Dr. Knut Klingbeil (IOW) and Prof. Dr. Hans Burchard (IOW) and am part of the TRR subproject M5 entitled "Reducing Spurious Mixing and Energetic Inconsistencies in Realistic Ocean-Modelling Applications".

Before I joined the TRR, I pursued a Bachelor in Physics/Meteorology at the University of Stockholm (Sweden) and a Master in Atmosphere – Climate – Continental surfaces at the University Grenoble Alpes (France). My first connection with physical oceanography was made possible through two internships, during which I worked with the NEMO-eNATL60 model to (a) assess meddies (Mediterranean eddies) and Mediterranean overflow water, and (b) describe the dynamical interaction of internal tides and eddies.

The broad goal of the work in M5 is to implement new methods to reduce errors due to the so called spurious numerical mixing in current ocean models. The part of my supervisors and I in the M5, is to develop analysis tools to evaluate whether the new methods succeed in reducing the spurious mixing. The way we will go about this, is to extend existing tools and ideas about diahaline mixing to diapycnal mixing (mixing across isohalines to mixing across isopycnals).

I will work in particular with the GETM model (https://getm.eu/) which was developed in the working group at IOW that I am a part of. The analysis tools will thus be developed in GETM for idealized cases, extended to the Baltic Sea, and are later to be implemented and applied to global ocean models in collaboration with the Synthesis projects S1 and S2.

INTERNAL GRAVITY WAVE INTERACTION, PROPAGATION, AND BREAKING IN THE ATMOSPHERE

by Georg Sebastian Voelker, Postdoc W1

My name is Georg Sebastian and I am currently a postdoc in the TRR-ENERGYTRANSFERS, working in the project W1: "Gravity Wave Parameterization for the Atmosphere" under the supervision of Prof. Ulrich Achatz at the Goethe University Frankfurt am Main.

I had started out by studying the generation of internal gravity waves below the ocean surface by wind during my PhD under the supervision of Maren Walter. Recently, I moved to working on internal gravity waves in the atmosphere. Thus having studied both physical oceanography and atmospheric dynamics I am keen to investigate internal gravity waves in

both environments considering various aspects of their dynamics.

The W1 Project is concerned with the lateral propagation of internal gravity waves in the atmosphere. In particular we employ the ray-tracing algorithm MS-GWaM to model sub-grid scale gravity waves including their transient propagation characteristics. That is, we model the lifetime of gravity waves including their interaction with the background – such as Doppler shifting or wave modulation by the mean flow. In contrast, current state of the art parameterizations of gravity waves in atmospheric models assume that gravity waves propagate in the vertical instantaneously neglecting their finite vertical group velocity. Moreover these parameterizations do not allow for a horizontal propagation at all. However, it has becomes clear that, even though the vertical propagation of gravity waves may be dominant for

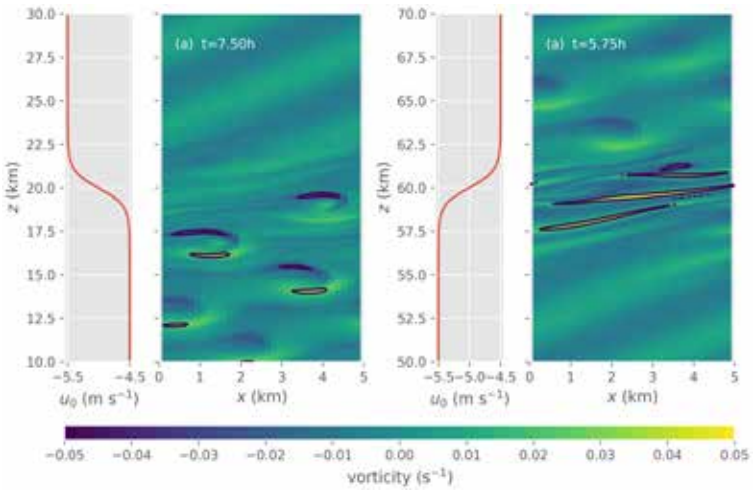
many atmospheric phenomena, the horizontal propagation cannot be neglected. With the implementation of these effects in the numerical weather forecasting code ICON-NWP we hope to support that finding and gain new insight into the net effects and importance of the horizontal propagation.

Propagation is, however, only a part of a gravity wave's life story. On its journey it can undergo a myriad of processes. Of special interest in various contexts are for instance the triad resonant interaction (TRI) and finally its breaking mechanisms.

Recently, we successfully described resonantly interacting gravity wave packets using a ray tracing algorithm utilizing weakly non-linear WBKJ theory in a Boussinesq environment including a slowly varying background flow. While interacting, the triad members are simultaneously modulated by a horizontal jet, leading to a reduction in energy exchange as the waves spectrally pass through the exact resonance conditions.

Moreover we are working on identifying instability mechanisms for strongly non-linear gravity waves in the vicinity of a mean-flow jet. Our theoretical study shows that in contrast to the upper jet edge the lower jet edge can sustain a novel type of modulational instability. New numerical evidence also shows that breaking mechanisms at the jet edges have distinct structures and might be associated to modulational instabilities or TRI (see Fig. 1 a and b).

This ongoing work is- among others–conducted in collaboration with Gergely Bölöni (DWD), Triantaphyllos Akylas (MIT, MA, USA), Mark Schlutow (FU Berlin, GER), and Ulrich Achatz (Goethe Universität Frankfurt).



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.

Lorenz, M., **Klingbeil, K. & Burchard, H.** (2021). **Impact of evaporation and precipitation on estuarine mixing relations.** J. Phys. Oceanogr., doi: https://doi.org/10.1175/JPO-D-20-0158.1.

UPCOMING EVENTS

July 8, 2021
TRR 181 Seminar
The TRR 181 seminar is held by Manita Chouksey (Universität Hamburg) on July 8, 11 am.

July 15, 2021
RTG ENERGY Meeting
Every second Thursday at 3 p.m. the TRR PhDs and Postdocs meet online to discuss their research and talk about current TRR issues.

July 22, 2021
Gender and Diversity to go - an online lecture series at lunchtime
"Gender in STEM: Awareness, Motivation and Reflection" by Dr. Smilla Ebeling, 1 – 2 pm

July 29, 2021
RTG ENERGY Meeting
Every second Thursday at 3 p.m. the TRR PhDs and Postdocs meet online to discuss their research and talk about current TRR issues.

September 22-24, 2021
TRR 181 Retreat
The TRR 181 Annual Retreat is the Annual meeting for all TRR 181 members and held at Seminaris Hotel Lüneburg.

December 5-9, 2021
Warnemünde Turbulence Days
10th Warnemünde Turbulence Days (WTD) on "Interfaces and turbulent boundary layers"

SOMETHING ARTSY FOR THE END

by Manita Choucksey

'A fierce sea and a fiery sky'

A fierce sea and a fiery sky,
Whom waves and whirls mystify!
Serene as a piece of art,
Yet restless as a young heart!

Main content created by Jennifer Fandrich, Lea Diederichsen and Colja Vorhoff
other authors are credited respectively
E-Mail: trr181.cen@uni-hamburg.de
Web: www.trr-energytransfers.de
Twitter: @TRREnergy
Youtube: TRR 181 Energy transfers in Atmosphere and Ocean