TRR 181 NEWSLETTER

ENERGY INFLOW

WITH A HO, HO, HO...

...we like to send you into the new year! This newsletter contains many interesting reports: on the retreat, our workshops in October/November and n**ew reports from the scientific front**!

Also: Our TRR book is finally ready!

Furthermore, you find first information on our upcoming Winter School, the annual workshop 2019 and our very own **EGU session**.

So, there is a lot to read and enjoy!

Jennifer and I wish you all a very merry christmas and a happy new year!
Meike

Group picture from the Annual Retreat in Groß Schwansee

BACK TO THE FUTURE: TRR 181 ANNUAL RETREAT

We did not need a time machine to get to our retreat this year, just a large bus for all colleagues from Bremen and Hamburg.

We started a little late in the morning of September 24 to the venue Schlossgut Groß Schwansee but this way we had a warm welcome by our colleagues from Rostock and not the other way around like usually.

After the welcoming by our speaker Carsten Eden, our task groups presented their work. First up was the "Model and Data Management" group. Our postdoc Nils Brüggemann introduced the TRR wiki with all its possibilities. Since the wiki also includes a forum, Nils proposed that we use it for internal discussion and exchange of slides/reports etc. More people signed up after the retreat and the forum is now used e.g. for the planning of the next Winter School.

Next was the Task Group "Gender and Early Career". Meike Ruhnau presented TRR support provided for female scientists or scientists with family obligations. Furthermore, she showed the results of a cartoon project realized by the University of Bremen on female scientists in MINT that the TRR supported.

Last, the "Outreach" task group presented by Jennifer Fandrich and Stephan Juricke showed the new explain video on eddies and pre-

sented a sneak preview into a new and exciting outreach project with the working title "Scrollytelling on Energy transfers in atmosphere and ocean".

In the afternoon, each subproject presented their key results and contributions to the overall goals of our project. First ideas for the next proposal were discussed as well.

The second day started with keynotes by possible new PIs in the next phase. Camilla Nobili, Nedjeljka Zagar, Ralf Bachmeyer, Ulrich Achatz and Peter Korn presented their work and explained how it could contribute to the work done in the TRR in the future.

The whole group split into breakout groups in the afternoon to talk about ideas for the future. First, the groups were build regarding to the research areas in the TRR, but later on split into interdisciplinary discussion groups. On Wednesday, the group discussion were continued and some of the PhDs talked about PhD issues with the project coordination.

The retreat helped everyone to understand more about the work done so far in all the subprojects. It was an excellent start for the upcoming proposal phase and helped bring everyone closer together.

Thanks to everyone for your inspiring input and for creating a warm atmosphere.

You can find the subproject talks and pictures on our internal webpage.

PITCHING AND NETWORKING

In October we organized two workshop days on "Networking and Small-Talk at Conferences" for our PhDs and Postdocs. One day focused on female participants only.

The speakers Karin Bodewits and Peter Kronenberg from natural-science.careers helped improving the scientific pitches of the participants and opened our eyes on how a network is already established even if you send just one email.

We had two interesting days and the feedback from the participants was very positive.

UNUSUAL CONCEPT A GREAT SUCCESS

Many of our project members met on November 14 for a workshop on "Turbulence and Waves" in the Literaturhauscafé Hamburg. The goal was to bridge knowledge gaps between our different disciplines. For this, we decided on an unusual concept: four long talks and an equal amount of time for discussions.

Our postdoc Claus Goetz started the day off with his talk on why analysis matters. This shed light on the different mindsets of our members: While the meteorologists and oceanographers exclude equations when they do not matter for them, the mathematicians are interested to solve them any way. Just because they exist. :)

We continued with talks on waves and turbulence in the ocean and in the atmosphere. First one was held by our postdoc Friederike Pollmann and the second one by our PI Almut Gassmann. We were worried that the discussion time of 45 minutes maybe too long, but it turned out that this time was needed and sometimes was even exceeded. Our postdoc Nils Brüggemann concluded the day with a talk on "Mesoscale turbulence and the ocean energy cycle".

At the end of the day, the participants got together for an early christmas dinner at the restaurant "Hobenköök".

The feedback of our scientists was very positive. They enjoyed the long talks and the extensive discussions. There was no rush for the speakers and we did not have to cut the iscussion off at an interesting point. As a result, we are planning more workshops of this kind for the future.

You can find videos of the talks and pictures on our internal web page!

Impressions from our workshop and the christmas dinner

ALL GOOD THINGS COME TO AN END: OUR TRR BOOK IS READY

We started with the work on the book quite a while ago, but now it is ready and published.

Our book gives a coherent and up-to-date overview over our highly relevant interdisciplinary research activities between applied mathematics, meteorology, and physical oceanography.

You can find more information on the Springer webpage.

We like to thank Armin Iske and Carsten Eden for their editor work and all the authors for their contributions.

UPCOMING EVENTS

January 10-11, 2019
Objective Meeting (for TRR PIs only), Hamburg
This meeting is the first in a long line of meetings to discuss specific ideas for the next phase.

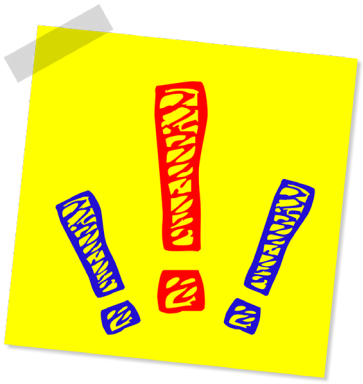
January 17, 2019
Internal Gravity Waves Workshop, Hamburg
This workshop will continue the idea of our November workshop: Have more specific workshops to bridge knowledge gaps between the different disciplines.

January 24, 2019
TRR Seminar "Smagorinsky's travel to the sub-grid scales", Hamburg
The seminar is held by our PhD Bastian Sommerfeld (Leibniz Institute for Atmospheric Physics, PhD in M4)

February 07, 2019
TRR Seminar, Hamburg
The seminar is held by our PhD Thomas Reitz (Max Planck Institute for Meteorology, PhD in L2)

February 11-15, 2019
TRR Winter School, Ratzeburg
Our Winter School will be a combination of carrer development workshops and science. The preliminary program is discussed in our internal wiki.

September 10-12, 2019
TRR 181 Annual Retreat
Our annual retreat follows a workshop day for the PIs on a "Gender bias-free recruiting process"



WORKSHOP ON CONSERVATION PRINCIPLES, DATA, AND UNCERTAINTY IN ATMOSPHERE-OCEAN MODELLING, POTSDAM, APRIL 2-4, 2019

Next years annual workshop is held in collaboration with the SFB 1114 "Scaling cascades in complex systems" and the SFB 1294 "Data Assimilation" in Potsdam, Griebnitzsee Campus, April 2-4 2019.

This three-day workshop will review our state of knowledge on energy budgets and energy transfers in the climate system and how they are represented in current computational models. The physical principles of these transfers and their numerical representation will be discussed. In addition, stochastic modelling and data assimilation schemes will receive particular attention in this context, as these are key to representing and controlling model uncertainties.

Topics touched are:

- Day 1: Energy budgets and energy transfer in climate models and data
- Day 2: Data assimilation
- Day 3: Stochastic modelling in atmosphere-ocean science

Abstract Deadline is February 1, 2019!

You can register or submit an abstract here.

TRR SESSION AT EGU 2019

The TRR 181 has its own session at EGU 2019 in Vienna, April 7-12 2019! You can now submit an abstract!

Energy Transfers in Atmosphere and Ocean

The energy of a closed system is steady. It is not lost but rather converted into other forms, such as when kinetic energy is transferred into thermal energy. However, this fundamental principle of natural science is often still a problem for climate research. For example, in case of the calculation of ocean currents, where small-scale vortices as well as the mixing processes they induce, need to be considered, without fully understanding where the energy for their creation originates from.

Similarly in the atmosphere, the conversion of available potential energy into kinetic energy is the key driver of atmospheric dynamics at a variety of scales, from the zonal-mean general circulation to mesoscale convection. Local turbulent processes can drive larger movements or waves on a larger scale can disintegrate into small structures. All these processes are important for the Earth's climate and determine its evolution in the future.

How exactly the energy transfer between waves, eddies and local turbulences in the ocean and the atmosphere works, often remains unclear. This session wants to discuss this by inviting contributions from oceanographers, meteorologists, climate modelers and mathematicians. We are particularly interested in coupled atmosphere-ocean studies, novel subgrid-scale parameterizations, and energy budget studies of the complex Earth system.

Abstract deadline 10th January 2019.

Please submit your abstracts at: https://meetingorganizer.copernicus.org/EGU2019/session/31257

RESEARCH VISIT TO "THE UNIVERSITY OF NEW SOUTH WALES" IN SYDNEY, AUSTRALIA

Our PhD in M1 Florian Noethen visited Australia in September this year. He wrote about his experience for the MIN Graduate School (MINGS) at Universität Hamburg which financed his trip. He kindly provided us with the report too, so we can share his experience with you.

Being halfway done with my PhD, I felt the need to talk to other mathematicians working on the same topic as me: the analysis of algorithms for covariant Lyapunov vectors. However, with such an exotic topic, it is hard to find experts to discuss with. Thus, I had to search outside of local conferences and workshops. Looking into literature, I found an author whose work is closely related to mine. After speaking to him and my supervisors, we were convinced that a research stay would be perfect. The stay should not only serve as a means to communicate my recent findings, but the primary goal was to obtain new research questions and contacts to help advance the second half of my PhD.

When organizing the trip, I applied for visa well in advance and even got a next-day response. Everything else was planned on more short notice. Hence, I did not find a place to stay near university and ended up booking a hotel a bit farther away but with a good connection via public transport. My hotel was located near Green Square Station, which has a train running to the airport, the central station, and the inner city. The university can be reached by bus in about 15 minutes. Unfortunately, there is no train connection as of yet. However, constructions on a new line stopping at the university are expected to finish in 2019. My relatively short visit of three weeks did not require any prior arrangements with the university itself, although for longer stays I recommend filling out the visit request form online to gain access to special rooms, such as printer rooms. The visitor's room provided basis necessities like desks and computers. After preparing the assigned workspace on my first day, I had lunch with my host at a café on campus.

Following lunch, I presented my recent work as a basis for discussions, which ensued the next weeks. Sadly, one of my host's students, whom I wished to meet, was no longer at the institute. Nevertheless, the discussions were very fruitful. Besides the helpful comments on my presentation, I got to ask questions

that always bugged me and talked about various research ideas. Some turned out to be worth pursuing, while others seemed no more than an interesting thought. This kind of feedback was exactly what I was hoping for. Even more so, we came up with new ideas during the stay. It left me with the impression that there is still much to discover about my topic. Moreover, my host told me of applications that were previously unknown to me. In particular, the computation of long-time coherent sets in ocean dynamics is an application that I find fascinating. One topic we initially planned to collaborate in turned out to be already well-answered. Nevertheless, we agreed upon keeping in touch for further exchange.

Next to the exchange with my host, I was lucky to meet a lot of friendly and interesting people inside and outside of university. For one, a professor staying with me in the visitor's room gave me useful tips on leisure activities. Although in spring the ocean is still a bit cold, a trip to Coogee Beach is a must, as it is only a 15-minute walk from university. A bit farther away, but still reachable with Sydney's Opal card for public transport, is the Blue Mountains National Park. From the heritage center near Blackheath Station there are several hiking trails leading through the beautiful nature. Another nice place is the Royal National Park south of Sydney. It boasts a long walk along the coast that occasionally passes by sandy beaches. However, watch out for blue bottle jellyfish and bring enough sun screen to protect yourself from the strong sun of Australia.

All in all, I had a wonderful time in Sydney that has been enriching on both a professional and personal level. Sydney is a modern city, where people are welcoming and always glad to help. Countless possible activities make it hard deciding on where to spend your free time. The three weeks were over so fast that I still wonder how I managed to explore Sydney and reach my goals. Arriving back in Hamburg, I am filled with new motivation and ideas on how to continue my PhD. Without a doubt, I will always remember the impressions of my research stay in Sydney. Thank you MINGS for making this experience possible!

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.

Iske, A. (2019). **Approximation Theory and Algorithms for Data Analysis.** Texts in Applied Mathematics, 68, Springer.

Iske, A. and C. Eden (Eds., 2019)**. Energy Transfers in Atmosphere and Ocean**, Mathematics of Planet Earth, 1, Springer.

Lembo, V., D. Folini, M. Wild, and P. Lionello (2018). **Inter-hemispheric differences in energy budget and cross-equatorial transport anomalies during the 20th Century**, Climate Dynamics, p. 1-21.

Badin, G., M. Oliver and S. Vasylkevych (2018). **Geometric Lagrangian averaged Euler-Boussinesq and Primitive Equations,** Journal of Physics A: Mathematical and Theoretical, 51, 455501, doi:10.1088/1751-8121/aae1cb

Dräger-Dietel, J., Jochumsen, K., **Griesel, A., and Badin, G.** (2018). **Relative dispersion of surface drifters in the Benguela upwelling region.** Journal of Physical Oceanography.

Koldunov, N., and Cristini, L. (2018). **Programming as a soft skill for project managers: How to have a computer take over some of your work.** Adv. Geosci., 45, 295-303.

Schaefer-Rolffs, U. (2018)**. A comparison of different solutions for the Dynamic Smagorinsky Model applied in a GCM.** Meteor. Z., 27, 249–261, doi:10.1127/metz/2018/0885

Schaefer-Rolffs, U. (2018). **The scale invariance criterion for geophysical fluids.** European Journal of Mechanics-B/Fluids, Vol. 74, 92-98.

Wang, Q., Wekerle, C., **Danilov, S.,** Sidorenko, D., **Koldunov, N.**, Sein, D., ... & **Jung, T.** (2018). **Recent sea ice decline did not significantly increase the total liquid freshwater content of the Arctic Ocean**. Journal of Climate.

HOW THE BACKGROUND MEAN FLOW EFFECTS INTERNAL GRAVITY WAVES

by Rachael Ewins, PhD W4

I am investigating the effect background mean flow has on the propagation of internal gravity waves. From this hopefully general rules may be seen that can be included in parameterisations for internal gravity waves. For this ray tracing is used to follow the positions and properties of wave packets that interact with an idealised current.

"From my work, hopefully general rules may be seen that can be included in parameterisations for internal gravity waves."

The test wave packets are populated randomly over a range of physical positions and also phase space, which allows exploration of the importance to various properties to how the test wave packets interact with the background current. The key property that is being tracked is the energy of the packets and from this the transfer of energy to and from the current can be seen.

Ray tracing simply propagates the position and wave numbers of the wave packets over a series of time steps given that background properties of background flow velocity, the local buoyancy frequency. The energy of the wave packets can be followed due to the conservation of Action. The results means that individual wave packets can be followed to different end conditions namely critical layer absorption, wave capture or refraction away from the current flow. The net energy transfer from the waves to the background flow (or from) can be seen by the end energy of the waves that enter critical layers or are captured by the current.

By varying the properties of the background current the effects of various shears in the current can be seen which will lead to more information about the key properties of both internal wave and background flow that lead to wave captures and critical layer absorption. In addition the background flow can be changed into configuration to simulate eddies, using the same processes.

BALANCE-IMBALANCE DECOMPOSITION OF THE FLOW FIELD

by Gökce Tuba Masur, PhD L2

I am a PhD student in the subproject L2 at Jacobs University Bremen under supervision of Prof. Marcel Oliver.

"We are currently working on application of the optimal balance algortihm to the shallow water model and the primitve equations will follow."

Our role in the subproject can be briefly explained as follows: In large-scale ocean models, the ocean circulations are essentially balanced; however, this balance breaks down in small scales due to spontaneous generation of inertia-gravity waves by quasi-balanced circulations, and waves are maybe re-captured in later times. This spontaneous emission and wave capture is considered to contribute to the energy transfer from the essentially balanced large-scale circulation and mesoscale eddy fields down to smaller scales, which is a route to dissipation.

To analyse the role of inertia-gravity waves in interior dissipation, a reasonable approach is to diagnose the inertia-gravity waves by splitting the flow field into balance and imbalance components, which are the ocean circulation and the inertia-gravity waves, respectively. This balance-imbalance decomposition can be achieved by some diagnostic tools such as linear time filters, balance relations, and optimal potential vorticity balance. In this project, we want to provide a new numerical algorithm to separate spontaneously generated imbalanced flows from the vertical flows depending on a prior work called „optimal balance".

We are currently working on application of the optimal balance algorithm to the shallow water model and the primitive equations will follow. The "optimal balance" algorithm is interesting to us not only for practical aspects but also mathematical features, so that we extensively worked on asymptotics-preserving schemes on a finite dimensional model in the algorithm. There are several other theoretically open questions, which are standing for the algorithm as its existence and uniqueness, to be considered.

THE EARTH'S ENERGY BUDGET AND OTHER FUNNY ASPECTS OF THE THERMODYNAMICS OF THE CLIMATE SYSTEM

by Valerio Lembo, Postdoc S1

My name is Valerio Lembo, and I am a Postdoc in subproject S1, "Diagnosis and Metrics in Climate Models".

The idea of this subproject is assessing the impact of introducing new numerical schemes and physical parametrizations developed in the TRR181 for the energy closure of state-of-the-art climate models. We provide diagnostic tools that allow for evaluation and intercomparison of climate models, starting from their outputted datasets.

It might sound trivial, expecting that the climate system, if in steady state, is also in thermodynamic equilibrium. This is at least what our studies of classical thermodynamics suggest. The problem is that the system constantly exchanges energy with its exterior, i.e. the outer space, and within its interior. In steady state conditions, the net exchange of energy with the exterior has to be null. In other words, the climate system is in thermodynamic equilibrium, once we averaged out the modulation of the solar energy input to an appropriately long timescale and all the energy exchanges occurring in its interior, shaping the solar "reflection" and the thermal energy output. This is a clear example of what is called a "non-equilibrium dissipative steady state thermodynamical system".

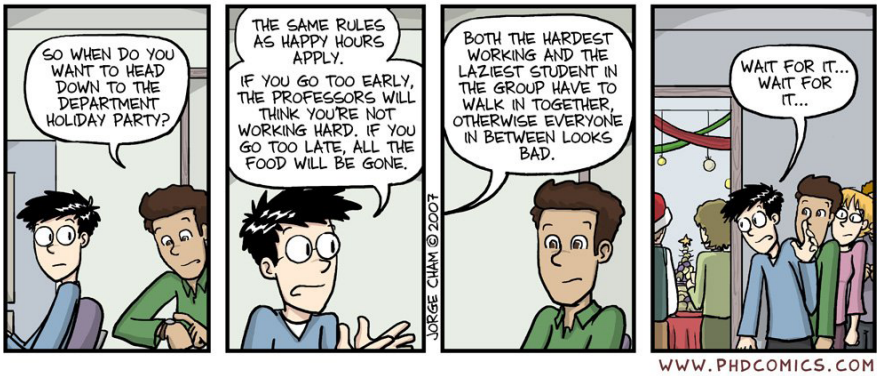
"State-of-the-art climate models still struggle to reproduce a reasonably energetically consistent system, even though outstanding improvements have been achieved in the recent past. "

State-of-the-art climate models still struggle to reproduce a reasonably energetically consistent system, even though outstanding improvements have been achieved in the recent past. This points to the very basic reasons for climate modeling, on one hand reflecting the lack of understanding of some processes involving energy exchanges and the limits of the discretization/truncation of the real world in finite dimension models, on the other hand preventing us from correctly evaluating the impact of the various forcings for reconstructed and projected climate change.

As TRR181, we are participating to the community effort called "ESMValTool", whose aim is providing a set of standardized diagnostics for the evaluation of state-of-the-art and forthcoming multi-model ensembles. In our diagnostics, we try to address specifically the Earth's energy budget and its atmospheric and oceanic components, and the atmospheric energy exchanges, including the Lorenz Energy Cycle, which describes the energy exchanges in the extratropical synoptic eddies. We also provide an estimate of the atmospheric material entropy production, i.e. the entropy production through irreversible processes, and the water mass budget, which is known to be one of the main sources of uncertainty for the modeled energy budget.

The diagnostic tool is currently being ported from version 1 to version 2 of ESMValTool, and will be hopefully soon publicly released. A report for the ESMValTool version 2 is being written, with contributions by all groups in the community, and another paper, focused on potential applications of the tool in various fields of climate science, will be submitted.

SOMETHING FUNNY FOR THE END



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