TRR 181 NEWSLETTER

ENERGY INFLOW

THEY SEE US ROLLIN'...

and working on the new proposal. It is a busy time right now in the project with many meetings regarding the next phase. The pre proposal is nearly done, so the next step is the full proposal. Even more work to come!

In this Newsletter you find a **report on our joint workshop in April**, about our participation at the **"Sommer des Wissens" in Hamburg**, the results from the **DFG survey**, new **publications** as well as a **travel report** and scientific reports from M2, T2, T3 and W2!

Enjoy!
Jennifer and Meike

Group picture from the joint workshop in Potsdam

COLLABORATIVE WORKSHOP ON "CONSERVATION PRINCIPLES, DATA, AND UNCERTAINTY IN ATMOSPHERE-OCEAN MODELLING" A FULL SUCCESS

Our fifth annual workshop was 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.

Over 100 scientists from all over the world gathered in Potsdam for the collaborative annual workshop. The topic of the workshop was "Conservation Principles, Data, and Uncertainty in Atmosphere-Ocean Modelling".

This three-day workshop reviewed 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 have been discussed. In addition, stochastic modelling and data assimilation schemes received particular attention in this context, as these are key to representing and controlling model uncertainties.

Find here the presentations with permission given to upload. Thanks to everyone who made this workshop happen!

"SOMMER DES WISSENS" IN HAMBURG OR HOW TO TEACH (YOUNG) ADULTS ABOUT CLIMATE MODELS

The Universität Hamburg celebrates its 100th anniversary in 2019. Instead of a "Nacht des Wissens" they organized a "Sommer des Wissens" on the town hall square. During the four-day event, we participated with a game and presentation on climate models.

On Thursday June 19, Stephan Juricke (Postdoc, M3) and Friederike Pollmann (Postdoc, S2) got up early to talk about climate models to two ninth grades in the small tents that look like igloos. They prepared a presentation about the difference between weather and climate models before starting with our new educational "climate modeling game".

We got the idea for the game at this year's EGU in Vienna, in the "Games in Geosciences" session. A colleague from Norway created it at the NORCE institute. The goal of the game is to help kids understand the difference between weather and climate models as well as visualizing the problems modeling faces.

With the help of studio ahoi, the agency we create the Scrollytelling with, we created a map of northern Germany with a grid overlay. The kids get large squares of four different color that they need to lay on the map. After finishing this step, they need to discuss what happened: We do not see the small features of the map using the large squares. So, we miss information that might be interesting for us.
The next step is to use smaller squares on the map. Now we can visualize more features, but it takes much more time to lay the grid. This helps kids understand the problem with the time it takes to run climate models and the limited capacities of server.

The young adults at the "Sommer des Wissens" participated nicely during the game, considering that they are teens and it was 9 am in the morning.

Our second time slot on Saturday noon was prominently announced in a Hamburg newspaper so the attendance was good. Almost every seat was taken when we started the presentation. It was announced as a presentation for young adults, instead the audience was heterogenous mixed with adults, students and mainly pensioners.

Stephan Juricke and Jennifer Fandrich showed the first results of the scrollytelling and the interview video that was taken during the research cruise with the POSEIDON in the Subtropical Atlantic. Unfortunately, there were some technical problems with the audio, so we weren't able to show the explainity movies – but Stephan salvaged the situation with talking eloquently about his work instead! He gave an overview about how climate models work and explained that Eddies are the "weather of the ocean". In the end, a discussion started about the importance of scientists informing the public about the impact of society to climate change and Stephan stated that there was always climate change, but now it is very fast climate change – this is a huge difference to the earth's centuries before humanity.

Although we expected a much younger audience to present our digital outreach products, we were happy with the outcome. There was very positive feedback afterwards and some of the listeners asked where to find more information about the project and the outreach products.

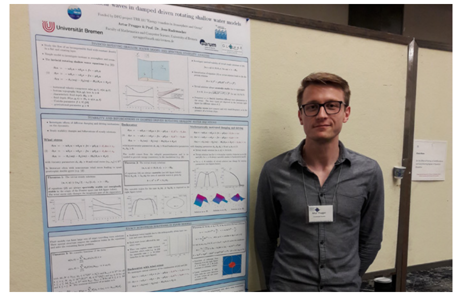
TRAVEL REPORT FROM THE SIAM CONFERENCE ON DYNAMICAL SYSTEMS

Last month we (Artur Prugger, PhD M2 and Florian Noethen, PhD M1) got the opportunity to visit the worldwide biggest conference on applied dynamical systems. The conference was located in Snowbird, a ski resort in the Rocky Mountains, close to Salt Lake City, Utah, USA.

Although it was off-seasons, there was still a lot of snow due to the high altitude of over 2000m. The surrounding mountains offered a beautiful scenery that could be admired from the conference center.

Inside the conference center there was more to admire, namely the mathematics. Tadashi Tokieda kicked off the science part with his talk on chain reactions. After a magic trick of him and some concluding remarks, the audience had a coffee break and split up into smaller groups. Spread throughout the conference were sessions on various topics such as network dynamics, pattern formation, fluid dynamics, mixing and coherent sets, topological data analysis, chaos, bifurcations, mathematical biology, computational mathematics, and many more. The sheer range of interesting topics made it hard to decide for one out of over ten concurrent sessions during each block. With over one thousand participants, we were bound to meet scientists doing similar research as we are. Interesting conversations emerged and new contacts were formed, some of which were already known through literature. Surely, the best place to meet new people was during the poster sessions. A lot of participants came to us and started to discuss at our posters. On Thursday evening Danielle S. Bassett concluded the whole conference with a great talk about neural networks.

Looking back at the conference, we are glad to have made the trip to Snowbird. So much interesting



science was packed into one week, that time flew by very fast. It was a great chance to meet other researchers from around the globe and to get an overview over cutting edge research in the field of applied dynamical systems. We are curious how the mathematics will develop until the next "SIAM Conference on Dynamical Systems", which will take place in May 23-27, 2021 in Portland.

UPCOMING EVENTS

June 28, 2019

TRR 181 Special Colloquium "New aspects of waves in ice – observations and idealized modeling"

The TRR 181 special colloquium is a new seminar for esteemed guests. It is held in Hamburg on announcement and is followed by a small reception.

July 4, 2019

TRR 181 Seminar

The seminar is held by Nicolas Scharmacher (PhD in M6) in Hamburg at 11 am.

July 11, 2019

TRR 181 Seminar

The last seminar of the semester is held by Matthäus Mai (PhD in W1) in Hamburg at 11 am.

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".

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.

Noethen, F. (2019). **Well-separating common complements of a sequence of subspaces of the same codimension in a Hilbert space are generic**, arXiv:1906.08514

Stähler, S. C., M. P. Panning, C. Hadziioannou, R. D. Lorenz, S. Vance, **K. Klingbeil** and S. Kedar (2019). **Seismic signal from waves on Titan's seas**. *Earth and Planetary Science Letters*, 520, 250-259.

Lorenz, M., **K. Klingbeil**, P. MacCready, and H. Burchard (2019). **Numerical issues of the Total Exchange Flow (TEF) analysis framework for quantifying estuarine circulation**, *Ocean Science*, 15, 601-614.

Gugole, F., and C. L. Franzke (2019). **Numerical Development and Evaluation of an Energy Conserving Conceptual Stochastic Climate Model**. *Mathematics of Climate and Weather Forecasting*, 5(1), 45-64.

Gräwe, U., **K. Klingbeil**, J. Kelln, and S. Dangendorf (2019). **Decomposing mean sea level rise in a semi-enclosed basin, the Baltic Sea.** *Journal of Climate*.

Smyth, W. D. and **J. Carpenter** (2019). **Instability in Geophysical Flows**, *Cambridge University Press*.

Klingbeil, K., J. Becherer, E. Schulz, H. E. de Swart, H. M. Schuttelaars, A. Valle-Levinson and **H. Burchard** (2019). **Thickness-weighted averaging in tidal estuaries and the vertical distribution of the Eulerian residual transport.** *Journal of Physical Oceanography*.

Koldunov, N., S. Danilov, D. Sidorenko, N. Hutter, **M. Losch,** H. Goessling, N. Rakowsky, **P. Scholz**, D. Sein, Q. Wang and **T. Jung** (2019). **Fast EVP solutions in a high-resolution sea ice model.** *Adv. Model. Earth Syst.*, 11, https://doi.org/10.1029/2018MS001485

Juricke, S., S. Danilov, A. Kutsenko and M. Oliver (2019). **Ocean kinetic energy backscatter parametrizations on unstructured grids: Impact on mesoscale turbulence in a channel.** *Ocean Modelling.*

Noethen, F. (2019). **A projector-based convergence proof of the Ginelli algorithm for covariant Lyapunov vectors.** *Physica D: Nonlinear Phenomena*, Vol. 396, p. 18-34.

TO RESOLVE OR NOT TO RESOLVE?

by Deniz Aydin, PhD T3

I am Deniz and I work on the T3 'Energy transfers in gravity plumes' project as a PhD candidate at AWI. In particularly we are interested in the Denmark Strait Overflow (DSO) which is between Greenland and

Iceland. This location is special because the DSO carries most of the dense and cold Arctic water entering the North Atlantic. Thus contributing to the deep southward flowing part of the Atlantic meridional overturning circulation.

As soon as the dense water on the sill starts descending, it undergoes a significant amount of mixing and entrainment of ambient water. By 200km downstream of the sill, volume and tracer properties of the overflow water are substantially modified due to combination of different processes. In our subproject we try to understand the interactions of all these different processes at different scales using observational and numerical modeling analysis.

"I'm investigating effects of grid resolution on the modification of overflow and ocean energetics. "

It's difficult to properly represent overflows in a global ocean model with the coarse resolution climate models generally have. For my part in this subproject, I use a general circulation model (MITgcm) in a regional setup with a 1year of simulation period. I'm investigating effects of grid resolution on the modification of overflow and ocean energetics. For this purpose I use 6 different horizontal resolutions ranging from eddy resolving (1km) to coarse resolution (36km). At the moment, I am analyzing the results from higher resolution simulations. Soon coarser resolutions will come into the picture and analysis of eddy parameterization schemes along with them. My research will contribute to a better understanding of consequences of lacking smaller scale processes and better representation of them in coarser models.

ENERGY TRANSFERS IN GRAVITY PLUMES

by Stylianos Kritsotalakis, PhD T3

Hello everyone, my name is Stylianos Kritsotalakis and I am a PhD student in the subproject "Energy transfers in gravity plumes" at AWI/MARUM. The aim of the project is to understand the pathways and

processes by which kinetic energy is transferred from the mesoscale eddy field to submesoscales and dissipative turbulent scales. Using observational and numerical modeling efforts the project focuses in tackling the above problem within the Denmark Strait Overflow plume. I am working , primarily, with

"The next step will be connecting this mesoscale activity with high frequency variability and mixing parameters in the plume."

mooring data aquired ~120km downstream of the Denmark Strait in late summer 2018. I have identified the mesoscale field associated with the plume which consists of eddy pairs with opposing sense of rotation (Fig.1) and at the moment I am comparing these findings with the existing literature. The next step will be connecting this mesoscale activity with high frequency variability and mixing parameters in the plume.

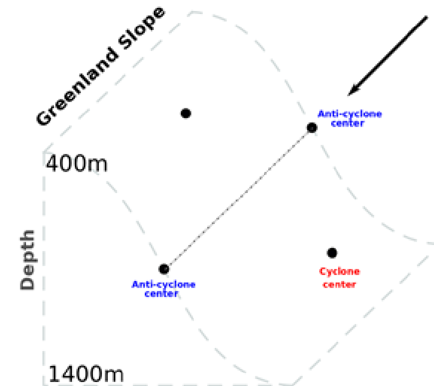


Figure 1: Schematic illustrating the observed mesoscale activity ~120km downstream of the Denmark Strait Sill. The position of the moorings on the Greenland slope is marked with black dots. The direction of the mean flow is indicated with a solid black arrow.

HUNTING FRONTS

by Jen-Ping Peng, PhD T2

Hi, my name is Jen-Ping Peng. I am a PhD student of the subproject T2: "Energy budget of the ocean surface mixed layer" under supervision of Dr. Lars Umlauf at the Leibniz Institute for Baltic Sea Research (IOW) in Warnemünde.

I investigate the oceanic surface mixed layer (SML), typically known to have substantial turbulent mixing driven by vertical surface forcing such as wind stress and surface buoyancy fluxes. However, the processes inside the SML are considerably

complicated by strong horizontal density gradients (e.g., fronts, filaments), which may induce restratification that competes with mixing. SML fronts also host various frontal instabilities which are considered as routes to mixing and energy dissipation in the energy cascade. We address surface-layers fronts and their associated restratification and mixing processes based on the data collected from several cruises in different areas of the ocean.

The analysis of data from research cruises is one of the main tasks of my PhD. The TRR181 cruises took place in the Benguela upwelling system (South-East Atlantic Ocean) in 2016, closely coordinated with subproject L3 using drifters, and in the Central Baltic Sea in 2017 and 2018. These two study areas are characterized by the rich presence of fronts and filaments, ideally suited for the investigation of the processes studied in this subproject. I participated in two research campaigns in the central Baltic Sea. Together with our T2 colleagues from HZG, we were hunting fronts with specialized instrumentations, including turbulence microstructure profilers, a Scanfish, a research catamaran, and ocean gliders.

"SML fronts also host various frontal instabilities which are considered as routes to mixing and energy dissipation in the energy cascade."

I am currently analyzing data obtained from the Benguela upwelling system toward a better understanding of the formation and decay of an upwelling filament, and related instabilities and mixing. I am also involved in the analysis of a related data set that we collected in a frontal region in the central Baltic Sea.

INVESTIGATING INTERNAL WAVE ENERGY FLUXES

by Jonas Löb, PhD W2

My name is Jonas and I am a PhD Student in the subproject W2 “Low mode waves” in the working group Oceanography at the University Bremen. In this project I calculate low mode internal wave energy fluxes from mooring measurements and compare the results with measurements from satellite altimetry and a 1/10° ocean model (STORMTIDE2). Energy flux is an important quantity for these models because its divergence identifies sources and sinks.

Internal gravity waves occur all over the stratified ocean and can be grouped in different categories varying on their generation mechanism. I focus mainly on internal tides in the semidiurnal frequency M2 generated by the barotropic tides over rough topography. Internal tides are a response of the astronomical gravitational forces of the ocean via oscillations in the sea surface elevation with horizontal tidal currents through the entire water column. These waves in the stratified ocean take the form of standing vertical oscillations of horizontal currents, called modes. The “zeroth” (barotropic) mode of horizontal velocity corresponds to horizontal ocean currents that are uniform from top to bottom. The first depth dependent (baroclinic) mode is characterized by flow in one direction at the top and in the opposite direct at the bottom. Higher modes have a more complicated vertical structure and their phase speed decreases with increasing mode number. The vertical structure of a mode can be calculated by the stratification, and velocity profiles can be fitted onto a linear combination of these modes. Low mode motions contain appreciable energy but quickly propagate away laterally. To study these low mode internal waves, we deployed a mooring inside a tidal beam in the eastern North Atlantic, south of the Azores, where a seamount chain stands out as a generation site for internal tides. In our study region the energy flux correlates reasonably well in direction, coherent – uncoherent portioning and mode ratio between mooring and model time series and satellite data. With regard to the total energy flux, the model and satellite observations underestimate the flux compared to the in situ data.

“In my current work, I also look into the impact of mesoscale motion on the energy flux in this dataset.”

In my current work, I also look into the impact of mesoscale motion on the energy flux in this dataset. A surface eddy was crossing the mooring, and in the process dampening the energy flux in the first two modes by about one third, while a passing subsurface eddy dampened the energy mainly in the second mode. These observations support the idea that eddy interactions transfer energy from low modes into higher modes that can lead to increased dissipation. An open question is how much of the energy converted from lower to higher modes result in local dissipation, which is a crucial information in creating energy consistent ocean-climate models.

NONLINEAR WAVES, DISSIPATION AND (QUASI-) GEOSTROPHIC BALANCES

by Artur Prugger, PhD M2

Hi, my name is Artur. I am a PhD student at the University of Bremen and I am a member of the subproject M2 “Systematic multi-scale modelling and analysis for geophysical flow” since April 2017. My supervisor is Professor Jens Rademacher and I work in his research group “Applied Analysis”.

My research is about investigating the effects of various damping and driving realisations on the dynamics of different geophysical fluid models. Waves in linearisations of these models often characterise large scale phenomena in the ocean and atmosphere. I am interested in finding and analysing solutions of the full nonlinear equations. Exact steady solutions for instance can bifurcate from trivial solutions by changing some parameters.

> *“For instance, I can show that for certain type of backscatter there are exact exponentially growing solutions, which shows that energy can get concentrated at some scales, rather than be transferred across scales.”*

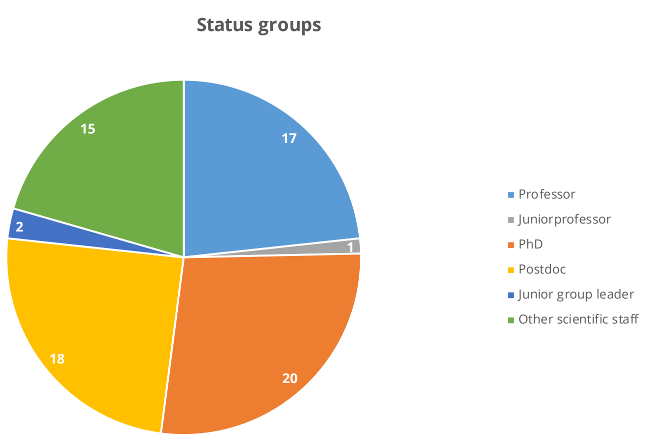
In various cases we can prove analytically when these bifurcating waves occur and we can also determine some of their properties, such as their stability. With numerical tools we can corroborate these results and obtain additional insights into their structure and further properties.

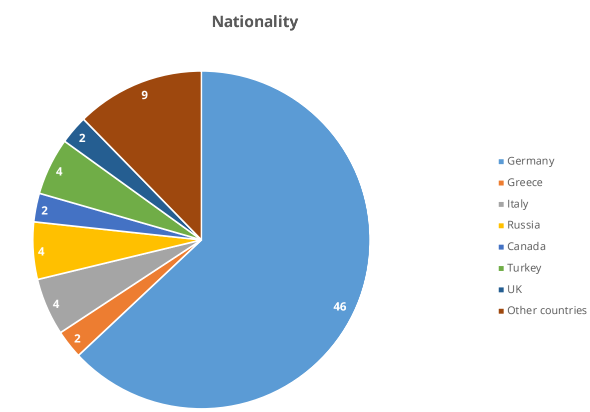
Somewhat surprisingly, there are also linear waves that solve the full nonlinear problem. I was able to extend the class of known solutions of this type and for the first time took into account backscatter. For instance, I can show that for certain type of backscatter there are exact exponentially growing solutions, which shows that energy can get concentrated at some scales, rather than be transferred across scales.
For the investigations I use simple models like the single-layer and two-layer shallow water model as well as more complex ones like the Boussinesq approximation and the Navier–Stokes equations. In order to analyse the dynamics numerically I use the Matlab package "pde2path".

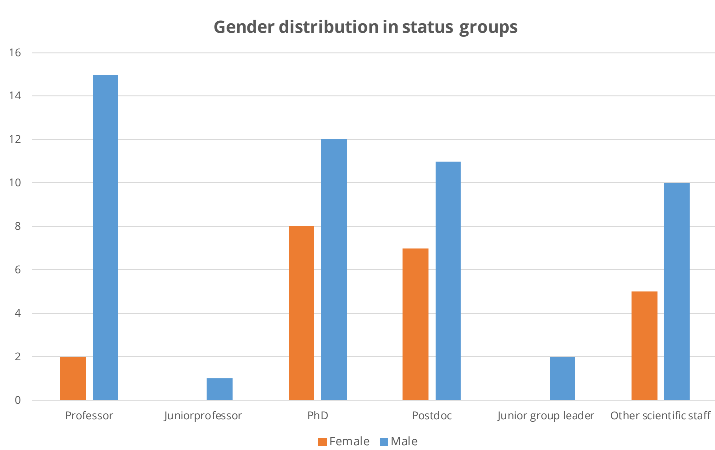
With our investigations of idealised cases we hope to gain a better understanding of the different models used in the ocean and climate research. It is not only important from the mathematical perspective, but also could help to evaluate and improve numerical prediction models for weather and climate.

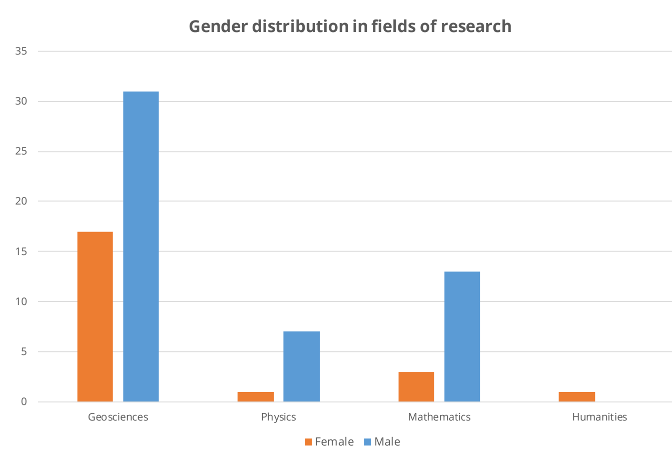
RESULTS OF THE DFG SURVEY 2019

Every year the DFG collects the staff data of the funded projects to create a statistic on the development in different fields. Here are the results for the TRR 181 in 2019.









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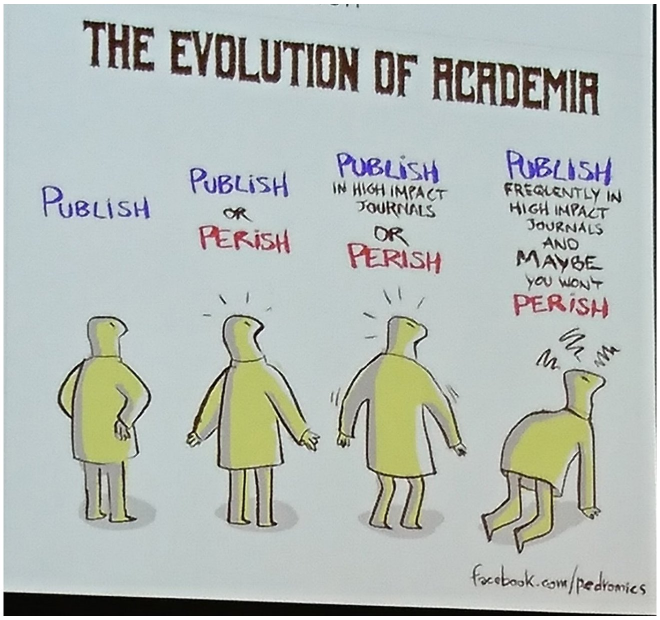

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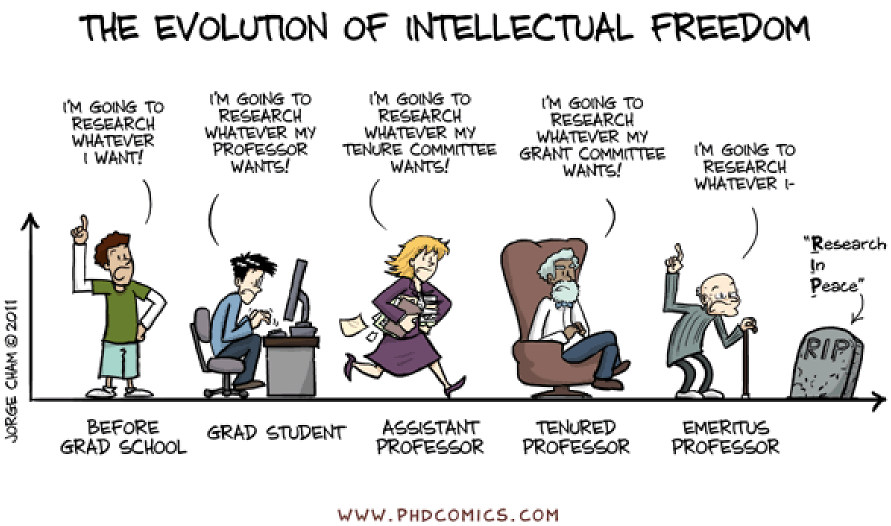

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