PhD proposal: From the parametrization of mesoscale eddies to the ocean's role in climate change

at the National Center for Meteorological and Climate Research (CNRM), Toulouse, France
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Context

We are seeking an outstanding candidate for a **PhD position on the parametrization of mesoscale oceanic eddies to model the ocean's role in climate change.** This PhD is part of the EU-funded Horizon 2020 project "ESM2025— Earth system models for the future" focusing on the development of the next generation of Earth system models. It is open for 3 years, starting September 1st 2021. The recipient will be based at the National Center for Meteorological and Climate Research (CNRM, Toulouse, France), a joint research unit of Météo-France and CNRS. The application deadline is **May 31st**.

Project description

Mesoscale eddies are ubiquitous in the world ocean. They dominate the ocean kinetic energy and the associated dynamic sea level field (Chelton et al., 2011). They have long been known to transport heat, freshwater and biogeochemical matter and to regulate the oceanic heat balance through poleward and upward heat transports (Danabasoglu et al., 1994; Olbers et al., 2004; Griffies et al., 2015). However, in contrast with the atmosphere (von Storch et al., 2012), oceanic eddies remain challenging to represent explicitely in numerical models due to their reduced size (typically tens to hundreds of kilometers (Chelton et al., 2011)). In coupled climate models, the computation constraint is even stronger due to the additional numerical cost of coupling the ocean with other climate components and running long ensemble simulations. Consequently, as of the last Climate Model Intercomparison Program (CMIP6, (Eyring et al., 2016), `https://esgf-node.llnl.gov/projects/cmip6/`), **most coupled climate models still do not resolve the mesoscale eddy spectrum and their role as a regulator of global climate remains a largely open question** (Griffies et al., 2015; Hewitt et al., 2017).

To address this question, the PhD project aims at **1. implementing novel mesoscale eddy parametrizations in the non-eddying and eddy-permitting ocean components of CNRM's climate and Earth System models, and 2. characterizing the role of this improved mesoscale eddy representation on the mean simulated climate and its future response to anthropogenetic forcing.** Regarding objective 1., two aims are pursued: enhancing the explicit resolution of mesoscale eddies and improving the parametrization of unresolved eddies in ocean climate models. To do so, the energically constrained GEOMETRIC parametrization (Mak et al., 2018) will be implemented in global climate models of CNRM (Voldoire et al., 2019; Séférian et al., 2019). The approach is to parametrize the energy of unresolved eddies in order to re-energize the resolved eddy field (backscatter, (Jansen et al., 2019)) and/or to model their effect on the large-scale flow (eddy-induced velocities, (Gent and McWilliams, 1990; Marshall et al., 2012)). Calibration will be performed together with the validation against eddy-resolving simulations and altimetric data.

Objective 2. will be addressed by running long climate simulations with this improved mesoscale eddy parametrization. Impact on the mean climate will be documented in pre-industrial control simulations, whereas historical and future scenario runs will be performed to address the oceanic response to transient anthropogenetic forcings. First, the oceanic general circulation and heat content will be characterized. Then, air-sea coupling will be investigated to characterize the atmospheric and climatic response to the parametrized mesoscale. Finally, we will study the adjustment of biogeochemical tracers to the modified mesoscale advection and the subsequent response of the global climate and carbon cycle.

Expected outcomes of the PhD are: an improved representation of mesoscale ocean eddies in global climate models; and an assessment of their impact on the mean and projected trends in global climate and biogeochemical cycles.

Work environment

This work is part of the ESM2025 project. ESM2025 (6/1/2021 - 5/31/2025) is a multidisciplinary project gathering 21 international partners and aimed at developing the next generation of European Earth System Models. This includes improved representations of climate and Earth system models as well as their response to anthropogenic emissions and land use. Results will feed developments in integrated assessment models and the self-consistency of their coupling with climate components to provide Paris Agreement-compatible pathways to better inform mitigation capacities and potential climate impacts.

The PhD recipient will join the climate modelling group of CNRM-CERFACS which includes some 60 individuals, of which about 35 are researchers, 15 PhD students and 10 technical staff. It is the only research group in the French scientific environment which gathers modelling expertise on all components of the climate and Earth systems. It is a historical contributor to CMIP exercises and is involved in 19 MIPs within the current CMIP6 exercise. Coupled models developed at CNRM include the global climate and Earth system models CNRM-CM6 and CNRM-ESM2 at low and high resolutions, and the regional Euro-Mediterranean climate model CNRM-RCSM6. The CNRM lab benefits from high-performance computing facilities and the scientific environment of the French National Weather Forecast (Météo France) and the European Ocean Forecast (Mercator Ocean) Centers, both located in Toulouse and providing a privileged access to clusters.

Toulouse, "the pink city", is a lively student city with a rich scientific environment, located in southern France. It has a mild climate and affordable costs of living. It is strategically located nearby the Pyrenees mountain range and between the Atlantic Ocean and Mediterranean Sea. Toulouse surely offers a rewarding and memorable experience to its PhD students!

Application

To apply, please first check your eligibility for PhD study at the Université Toulouse 3 Paul Sabatier (http://sdu2e.obs-mip.fr/). Applications should include a letter of intent, CV, academic transcript (degrees and grades of completed courses) and contact details from two references (e.g. former supervisors). They can be sent to: Dr Robin Waldman (robin.waldman(at)meteo.fr).

The successful candidate will have a strong background and an affinity with programming and numerical methods (e.g. Python, Fortran and working in a High Performance Computing environment). He/she is expected to have a good knowledge in geophysical fluid dynamics, physical oceanography and/or climate. In addition, strong written and verbal communication skills in English are essential to a successful PhD and early research career. Finally, expected qualities for a future researcher include curiosity, autonomy, initiative and creativity.

References

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