Offer #2025-08985

PhD Position F/M Reduced-order modelling of internal tide for altimetry data assimilation

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

Level of experience : Recently graduated

About the research centre or Inria department

The Inria Rennes - Bretagne Atlantique Centre is one of Inria's eight centres and has more than thirty research teams. The Inria Center is a major and recognized player in the field of digital sciences. It is at the heart of a rich R&D and innovation ecosystem: highly innovative PMEs, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute, etc.

Context

The thesis will be directed by Etienne Mémin and supervised by Noé Lahaye and Gilles Tissot, at Inria in Rennes.

The "Odyssey" inter-institute team involves members of Ifremer, Laboratoire d'Océanographie Physique et Spatiale (UMR 6523), IMT Atlantique in Brest and the Inria centre at the University of Rennes. It will provide an extremely rich working environment and collaborations for the candidate. The main aim of this team is to develop innovative, cross-disciplinary research areas (satellite observation / physical modelling / applied mathematics / numerical methods) based on the analysis of observation data and numerical modelling, in order to improve our understanding and knowledge of ocean dynamics.

The candidate will also benefit from the intense research activity around the stochastic modelling of surface dynamics (ERC STUOD).

Assignment

Internal tide waves are disturbances in currents and densities that propagate in the ocean, and are generated by the interaction of the astronomical tide and the underwater topography. They play a major role in ocean dynamics, as they contribute to the transfer and dissipation of energy and to mixing in the ocean, affecting global ocean circulation and its climatic role.

Despite their importance, however, they remain poorly represented in general circulation models, due to the wide range of spatial and temporal scales they cover and their complex and intrinsically non-linear dynamics. In addition, their estimation using observation methods such as satellite altimetry is currently imperfect, mainly because of the temporal variability of the waves and the temporal sampling of the satellites. Among the main dynamic processes involved, the interactions between internal waves and “balanced” turbulence (eddies and jets) are a major source of uncertainty in our understanding of ocean dynamics.

In this thesis, we will seek to develop approaches for modelling the internal tide that take account of these interactions with balanced turbulence and provide a basis for estimating the internal tidal wave field from satellite observations. This thesis is connected with the ‘SWOT’ wide swath oceanographic mission, operational since December 2023, and for which the separation between internal waves and equilibrated flows is crucial.

Main activities

The methodology used in this thesis will be based on resolvent analysis. This method, derived from fluid mechanics, consists of investigating the spectrum associated with realisations of a non-linear flow by searching for the response/forcing pairs of the linearised system (the resolvent operator), in which the forcing represents the non-linear terms. By constructing a modified formulation of this formalism, we can extract the incoherent part of the wave as being a response to the interaction between the coherent part, assumed to be regular in time, and fluctuations in the balanced dynamics, the latter then appearing in the forcing term. The idea is to identify two bases: one associated with currents and one associated with waves, where each of the modes of one base is dynamically linked to the corresponding mode of the other base.

First, the candidate will implement this formulation in an idealised context, the reference for which will be provided by simulations in the (non-linear) rotating shallow water model. Then, he/she will extend this formulation to a more realistic context, in particular by allowing the multi-frequential character of the coherent part of the internal tide to be taken into account. Another advantage of the proposed formulation, compared with so-called a posteriori strategies, is that it avoids problems of convergence of the basis, which is a fundamental obstacle in the realistic framework.

Secondly, the candidate will formulate a reduced model based on a Galerkin projection of the dynamic equations (linearised shallow water equations) on the basis of resolved modes. The aim will then be to set up a data assimilation model using this reduced model and a variational formalism (4Dvar) to estimate the internal tide from a set of sea level observations. Again, this assimilation system

will first be deployed and tested in an idealised configuration, but it is expected that the thesis will include the application of this methodology to realistic configurations: first on realistic numerical simulations (which give access to a reference solution, or “ground truth”) and then on data from the wide-swath satellite “SWOT”.

Skills

The thesis project is at the interface between geophysical fluid dynamics and applied mathematics. Either a background in physics, fluid mechanics or physical oceanography with strong mathematical skills and an interest in numerical simulation, or a background in applied mathematics with a strong interest in fluid mechanics modelling and numerical simulation is sought.

Basic programming skills in Python or Julia and Fortran or C++ will be appreciated.

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking (after 6 months of employment) and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

Remuneration

Salary gross : 2200€

General Information

- **Theme/Domain :** Earth, Environmental and Energy Sciences
  Scientific computing (BAP E)
- **Town/city :** Rennes
- **Inria Center :** Centre Inria de l'Université de Rennes
- **Starting date :** 2025-10-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2025-08-05

Contacts

- **Inria Team :** ODYSSEY
- **PhD Supervisor :**
  Tissot Gilles / gilles.tissot@inria.fr

About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

Warning : you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

Instruction to apply

Please submit online : your resume, cover letter and letters of recommendation eventually

Defence Security :
This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST).Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :
As part of its diversity policy, all Inria positions are accessible to people with disabilities.