Development of machine learning methods to identify patterns and forecast ocean dynamics using a synergy of remote sensing, in-situ and marine model data

Summary

The PhD candidate shall develop a method that combines in-situ, hydrodynamic models and remote sensing data to identify and forecast patterns of the ocean dynamics (sea level, currents, waves etc.). This development requires: (i) bringing the various data sets to a common vertical reference datum using the geoid; (ii) using machine leaning methods to examine ocean dynamics especially with respect to patterns, spatial and temporal scales and inconsistencies amongst the data sources and (iii) validation (with independent data sources (e.g. field experiments) and sensitivity analysis (e.g. RMS error, and scatter index (SI), error budget) and (iv) using all the sources along with the relevant data on the contributors to perform statistical and machine learning algorithm to forecast the ocean dynamics observed and its associated uncertainty. The candidate is required to perform signal processing, statistical and computing techniques (in terms of RMS error, stand. dev, uncertainty estimates, error budgets, machine learning techniques etc.). From these results a specific model shall be developed that can forecast the sea level and current patterns that is essential for engineering and navigation purposes. The candidate is expected to assist in project related field campaigns.

Research field:	Building and civil engineering and architecture
Supervisors:	Prof. Dr. Artu Ellmann Dr. Nicole Camille Delpeche-Ellmann
Availability:	This position is available.
Offered by:	School of Engineering Department of Civil Engineering and Architecture
Application deadline:	Applications are accepted between June 01, 2023 00:00 and June 30, 2023 23:59 (Europe/Zurich)

Description

Background

Understanding and prediction of marine dynamics (sea level, circulation, waves etc.) is now more important than ever before, especially for navigation, engineering and climate studies. Several sources such as in-situ (tide gauges (TG), marine buoys meters, drifters), hydrodynamic model (HDM), remote sensing techniques (satellite, Airborne Laser Scanning and GNSS) techniques are often utilized. These sources however suffer from: (i) different spatial and temporal resolutions, (ii) difference in technique of measurements, and (iii) dissimilar or unknown vertical reference datum. The utilization of the geoid (equipotential surface of the earth) allows these sources to now all conform to a common vertical reference datum and as a result a quantitative comparison can be analysed. By synergizing these different data set with their strengths and weaknesses it is now possible to obtain a better understanding of the marine processes in terms of identifying patterns and spatial and temporal scales from the offshore to the coastal areas. Advancements made in computing technology and artificial intelligence (machine and deep learning methods) allows a more strategic approach on synergizing the different data sets and a more accurate analysis. The focus of this study is that by combining different sources the development of a method that allows identifying and predicting real-time forecasting of ocean processes both on the coastal and offshore areas. This can be accomplished by the utilization of statistical and machine learning methods.

Tasks

The PhD candidate shall develop a method that combines in-situ, hydrodynamic models and remote sensing data to identify and forecast patterns of the ocean dynamics (sea level, currents, waves etc.). This development requires: (i) bringing the various data sets to a common vertical reference datum using the geoid; (ii) using machine leaning methods to examine ocean dynamics especially with respect to patterns, spatial and temporal scales and inconsistencies amongst the data sources and (iii) validation (with independent data sources (e.g. field experiments) and sensitivity analysis (e.g. RMS error, and scatter index (SI), error budget) and (iv) using all the sources along with

the relevant data on the contributors to perform statistical and machine learning algorithm to forecast the ocean dynamics observed and its associated uncertainty. The candidate is required to perform signal processing, statistical and computing techniques (in terms of RMS error, stand. dev, uncertainty estimates, error budgets, machine learning techniques etc.). From these results a specific model shall be developed that can forecast the sea level and current patterns that is essential for engineering and navigation purposes. The candidate is expected to assist in project related field campaigns.

Requirements

The call is open for candidates that fulfil the following requirements:

- University degree (M.Sc.) in geodesy. Consideration will be given to applicants whose previous degrees are in appropriate related discipline, such as Earth Sciences, Marine Engineering, Mathematics or Physics.
- A clear interest in the research topic are preferred
- Advanced computer literacy and programming skills (e.g. Python, C++, MATLAB etc.).
- Strong and demonstrable writing and analytical skills
- Skills in data analysis, mathematical and statistics (to be trained), machine learning methods (to be trained)
- Ability for independent research as part of a team, interest in the presentation and publication of scientific results.
- Good command of the English language (speaking and writing).

The shortlisted candidate may be required should submit a research plan for the topic. The candidate can expand on the outlined research scope.

We offer:

- 4-year PhD position (full time) in the Civil Engineering and Architecture that has a sound portfolio of ongoing European and national research projects
- An environment to perform excellent research and publications
- Opportunities for training relevant technical and transferable skills aiming academic or industrial careers
- Opportunities for conference visits, research stays and networking with globally leading companies, universities and research centres in the field of research

The candidate is obligated to participate and fulfil the requirements of Tallinn University of Technology PhD programme. Additional funds will be provided (and whence applicable the associated funding can be applied for) for research trainings, conferences and international mobility/stays abroad with durations of up to 3 months. The research group wishes to increase the number of women interested in Geomatics and Engineering. Qualified women are therefore also encouraged to apply. Do not hesitate to contact us for questions regarding the position. We look forward to receiving your application.

About the department

Department of Civil Engineering and Architecture is an interdisciplinary teaching and research center of Tallinn University of Technology that focuses on various actual research issues. The department consists of several research groups. The geodesy research group has mainly been focused on the national geodetic infrastructure related research (modelling the gravity field and geoid, precise height network, GNSS positioning). Currently the TalTech geodesy group is participating in the international collaboration for implementing the Baltic Sea Chart Datum 2000 by improving the marine geoid modeling. Most of the Baltic Sea countries have agreed to adopt this new marine geoid based vertical datum as initial for the nautical charts, hence also for the maritime and offshore industry. The recent European Space Agency sponsored international project Geodetic SAR for Baltic Height System Unification tested potential of the Interferometric Synthetic Aperture Radar (InSAR) of unification of across-ocean vertical datums. The group has relevant contractual research for industry, environmental and governmental agencies, for the details see A. Ellmann's (head of the group) ETIS account, https://www.etis.ee/CV/Artu_Ellmann/eng.

The Laboratory of Waves Engineering is part of the Department of Cybernetics at TalTech, the focus of this lab has been on complex and nonlinear phenomena in wave dynamics and coastal engineering, and the applications of mathematical methods in wave studies. Recent focus has been one the use of Lagrangian transport of different substances in marine environment for marine and maritime spatial planning, adequate description of hydrodynamic (wave and water level) extremes, and preventive methods for mitigation of marine-induced hazards. The geodesy

group has participated in the wave dynamics for coastal engineering and management related large projects, for the details see N. Delpeche-Ellmann's ETIS account https://www.etis.ee/CV/Nicole_Delpeche-Ellmann/eng/. These projects are relevant to the present research since the results and knowledge acquired contribute toward identifying and quantifying ocean dynamic processes.

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