GNSS Interferometric Reflectometry for sea surface monitoring

2-year postdoctoral or research engineer position at ENSTA, IP Paris (Brest Campus)

Keywords: GNSS, GNSS interferometric reflectometry, Sea surface, Sea state, Sea level

Project

Research context

The RINGOS project is being conducted in partnership with Shom (French naval hydrographic and oceanographic service) and is funded by the Defense Innovation Agency (AID) within the framework of the Interdisciplinary Center Seas and Ocean (CIMO) of IP Paris over a period of 3 years. It focuses on the analysis and utilization of sea surface monitoring using GNSS Interferometric Reflectometry.

Understanding and describing the physical marine environment requires accurate sea surface observations. This project aims to complement current measurement methods (such as tide gauges, wave buoys, and altimetry satellites), which can be challenging to deploy, provide localized observations, and require regular maintenance and ongoing calibration/validation operations. To this end, we aim to use a technology based on the measurement of GNSS signals reflected by an antenna's environment, known as GNSS Interferometric Reflectometry (GNSS-IR). The advantage of the GNSS-IR technique lies in its ability to provide absolute measurements of sea level and sea state (including significant wave height, period, and direction). It requires minimal effort to implement and is already accessible via all existing GNSS antennas (such as those in permanent reference network and on ships or Unmanned Surface Vehicles – USVs) or low-cost systems, thus eliminating the need for additional instrumentation. It can be easily deployed on the coast, including in areas where traditional techniques cannot be installed. Our efforts will focus on developing a robust method for analyzing GNSS-IR data, to enable the quantification of measurement uncertainty using interval-based ensemble calculations. The technique will be extended to marine carriers and applied to sea state monitoring. The limitations of the method, particularly those associated with extreme sea states, will be examined to define its applicability.

Objectives

The objective of this project is to develop and evaluate methods for monitoring the sea surface (water height, sea state) using GNSS-IR measurements, either from a fixed

terrestrial antenna or one mounted on a ship or USVs. GNSS-IR uses the signal-to-noise ratio of signals received by any GNSS receiver to extract the signature of interference caused by reflections from a surrounding surface (Larson et al., 2013). From this interference, it is possible to deduce the characteristics of the reflecting surface, such as its height relative to the antenna and its roughness. These methods are intended to contribute to the development of new tools for measuring sea level and sea state and for monitoring the draught of marine vessels, as part of the CHOF (*Capacité Hydro-Océanographique Future*) program. They are also intended to complement existing measurement methods to increase the density of the Shom's observation networks, thereby contributing to navigation safety and monitoring coastal infrastructures. They will also provide new data that can be assimilated into ocean forecasting models.

To achieve this objective, three tasks have been identified:

1. Developing a procedure for measuring sea surface height using GNSS-IR, based on a robust estimate derived from interval analysis with tools developed at ENSTA (Rohou et al., 2024). This estimate will be accompanied by a metrological characterization. A GNSS-IR analysis using the inverse method will be preferred, as it provides a better representation of the phenomenon's physics (Standberg et al., 2016; Pira et al., 2024).

2. Transposing this method to marine vessels (ships or USVs) for air draught monitoring. This will contribute to extending the algorithmic developments carried out at Shom for the Direction Générale de l'Armement (DGA), which are intended for the operational use of onboard GNSS measurements, for monitoring marine surfaces and validating altimetry missions' measurements (Chupin et al., 2023; Tanguy et al., 2014).

3. Monitoring the sea state from a terrestrial antenna or on a marine carrier. The physical parameters will be estimated using an inverse method to characterize the reflecting surface. This characterization will be evaluated with the aim of compiling new sea state data that can be assimilated into ocean forecasting models.

Application

Expected degree and skills

Applicants should have a background (PhD or science degree) in marine sciences and/or geodesy and/or GNSS technologies and good programming skills (Python).

An interest in teamwork, scientific curiosity and rigour will be welcome.

Application procedure

Curriculum + cover letter to be sent to pierre.bosser@ensta.fr and gael.andre@shom.fr. The application must be submitted by 10 July.

Collaboration

Université de la Rochelle / LIENSs, CNES / GET.

Practical information

- Localization: ENSTA, IP Paris / Lab-STICC UMR CNRS 6285 - 2 rue François Verny, 29806 Brest
- Expected net monthly salary: salary depends on professional experience
- Duration: 24 months
- Start date: from 1 October

References

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