PhD Topic : Seasonal to Multi-decadal forecasting of coastal hazards using machine learning approaches

Supervision :
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Host institutions :
UMR 5110 CEFREM – Université de Perpignan Via Domitia
BRGM – Bureau de Recherches Géologiques et Minières (Orléans)

Duration : 3 yrs (October 2026– October 2029)
Funding : ANR PEPR IRIMA project, IRICOT programme (WP3)

Scientific background : Coastal zones are among the most dynamic and vulnerable environments to natural hazards. Coastal erosion and marine flooding result from complex interactions between meteorological and oceanic forcings (waves, water levels, storms), large-scale climate variability, and coastal morphological characteristics. Research on coastal risks has historically focused on two main temporal scales: 1) short-term extreme events, particularly storms; 2) long-term projections related to climate change, typically by 2100. In contrast, intermediate time scales, from seasonal to multi-decadal, remain largely underexplored, despite their high relevance for spatial planning and the implementation of coastal adaptation strategies.

Research questions and objectives : This PhD aims to go beyond the limitations of "classical" correlation-based approaches by identifying causal relationships between large-scale climate variability modes (e.g., NAO, WEPA), metocean forcings (waves, water levels), and coastal state indicators (shoreline position, dune width, etc.). Traditional statistical approaches often rely on correlations between climate variables and coastal indicators. However, these methods can be limited by autocorrelation in time series and by the difficulty of distinguishing causality from simple correlation. The research will address the following key questions: i) What climatic factors control coastal evolution across different temporal scales? ii) How can we identify, among a large number of environmental variables, those that are truly relevant for predicting coastal hazards? iii) To what extent can the integration of causal information improve the robustness and predictive performance of machine learning models?

Metodological approach : The PhD will rely on a comprehensive environmental dataset covering both the Atlantic and Mediterranean coasts of France, including: i) coastal morphological indicators derived from satellite imagery (shoreline position, beach or dune width); ii) metocean data from observations and hindcast simulations; iii) climate indices describing large-scale atmospheric variability.

First, **causal inference methods applied to time series** will be used to identify cause-effect relationships between climate variables, oceanic forcings, and coastal indicators.

Second, this information will be incorporated into **physics-informed machine learning models to improve their robustness and interpretability**. Time-series-oriented architectures, such as deep neural networks and Transformer-based models, may be explored.

Expected outcomes : The PhD aims to deliver:
1) improved understanding of climate-driven mechanisms controlling coastal dynamics;
2) predictive models capable of forecasting coastal hazard evolution from seasonal to multi-decadal time scales;
3) a methodological framework combining causal analysis and machine learning, potentially transferable to other environmental applications.

Ultimately, this work could contribute to the development of decision-support tools for coastal risk management and adaptation.

Collaborations : In addition to the main supervisors, several IRICOT partners will be involved: Bruno Castelle (University of Bordeaux, EPOC, WP3 coordinator) and Déborah Idier (BRGM) on coastal processes; Didier Swingedouw (University of Bordeaux) and Rémi Thiéblemont (BRGM) on seasonal to multi-decadal climate forecasting; and Isabel Jalon Rojas (University of Bordeaux, EPOC) on estuarine systems and hydroclimatic risks.

Candidate profile : Applicants should have strong skills in applied mathematics (stochastic modelling, optimization, graph theory) and scientific computing (Python or Matlab).

Mandatory requirements: i) MSc degree (or engineering degree) in Earth sciences/oceanography and/or data science; ii) proficiency in at least one scientific programming language (Python, R); iii) good command of English (written and spoken).

Additional desirable skills: i) data analysis, statistical modelling, and machine learning methods; ii) knowledge of coastal physical processes; iii) autonomy, scientific curiosity, open-mindedness, teamwork, and strong writing and presentation skills.

Location : The PhD candidate will be based at the University of Perpignan (CEFREM laboratory), with full access to facilities (office, computer, etc.). Research stays of 1 to 6 months are planned at BRGM in Orléans. Regular meetings with the supervisory team will be held.

Application procedure :

Applicants should send a CV, a cover letter and contact details of three academic referees before **April 30, 2026**, to Sébastien Pinel (sebastien.pinel@univ-perp.fr), Jérémy Rohmer (J.Rohmer@brgm.fr) et Nicolas Robin (nicolas.robin@univ-perp.fr).

Shortlisted candidates will be invited for an oral interview in mid-May 2026.