Visualization of ensemble forecasts of the coastal flooding phenomenon.

Post-doctorate offer - ANR ORACLES – 2024/2025

Mots clés :

2D/3D Geovisualization, Visual analytics, heterogeneous and complex data visualization;
Coastal flooding phenomena, Natural hazards ;
Simulated meteo-oceanic data, ensemble forecast data, spatio-temporal data.

Context

The context of strong population growth and increased urbanization in coastal regions tends to increase the risks linked to coastal flooding phenomena in low altitude coastal areas. This phenomenon results from the combination between various processes occuring at different spatial and temporal scales (atmospheric conditions, waves, sea tide, and sometimes rivers flow) and the local configuration of the coastline (bathymetry and topography, protective structures, land use, hydraulic networks, etc.). In addition to prevention and preparation measures, significant work has been devoted to forecasting meteo-oceanic conditions and establishing warning systems in recent decades. There is currently a growing demand for ever more precise and local forecasts, taking into account the uncertainty linked to the models used. To meet this demand, high-performance computing has made it possible to move from a deterministic forecast (based on the generation of one future scenario) to an ensemble forecast (based on the generation of a set of possible future scenarios), allowing a probabilistic forecasting approach. The demand for more precise and local forecasts comes also with a growing demand for more efficient ways to analyze and transmit information related to these forecasts, while taking into account the uncertainties linked to these data (Descamps et al. 2015, Wu et al. 2020, Lecacheux et al. 2020).

The elaboration of visualization approaches allowing better analysis and interpretation of spatio-temporal phenomena is **a long-standing research issue in geovisualization**. Research works carried out at LASTIG laboratory allowed to explore several approaches for the visualization of simulated data related to physical and meteorological phenomena, targeting expert users in order to allow them improving the understanding of the studied phenomena. These works proposed to offer multi-scale visualizations of flood simulation results (Fig. 1-a) (Perrin et al. 2019), and solutions for co-visualization of meteorological and urban topographic data (Fig. 1- b) (Gautier et al. 2020). Allowing the visual analysis of a large number of possible forecast scenarios, their main components and their disparities (Fig1-c) (Jarema et al., 2015), at different spatial and temporal scales, remains a challenge in visualization.

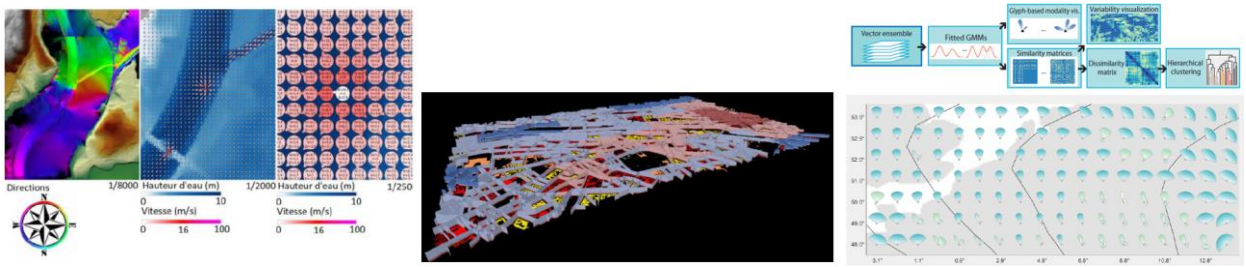

Figure 1: (a) Multi-scale visualization of water height, speed and direction of hydraulic flows (Perrin et al. 2019) ; (b) Co-visualization of simulated temperature data and urban data (Gautier et al. 2020) ; (c) Visualization of the main components of a set of simulated scenarios of wind data (Jarema et al., 2015).

Topic

The ANR ORACLES project “Towards the integration of coastal flooding ensemble forecasts for decision-making under data uncertainty: a journey through the challenges of production, translation and visualization” (LASTIG, BRGM, Météo-France, Keyros) aims to improve the use of probabilistic coastal flooding forecasts for the management of coastal territories. This involves designing new methods for producing and geovisualizing probabilistic forecasts of the coastal floodig phenomenon. In this context, the objective of this **exploratory and interdisciplinary post-doctorate** is to propose visualization approaches allowing scientific experts (Météo-France forecasters, Météo-France and BRGM submersion experts, even territorial officials) to explore and visually analyze massive data from ensemble forecasts integrating flood events and associated forcing conditions. The approaches to be proposed must allow **visualizing the disparities between the different simulated coastal flooding scenarios and the different associated meteo-oceanic conditions, by allowing the simultaneous visualization of different flooding scenarios and the relationships between flooding scenarios and forcing conditions**. Offering this possibility to expert users would help them to refine the understanding of the possible impacts on the concerned areas, and therefore to improve their diagnosis for the Wave Submersion Vigilance system (*Vigilance Vagues Submersion, VVS*) alerting state services and local authorities.

Reaching this objective involves co-visualizing different complex data within the same visualization environment, and proposing interaction modalities allowing the exploration of this data according to several temporal and spatial components, at several scales, and from different points. The intrinsic complexity of the probabilistic dimension of ensemble forecasts, and the strong interdependence between meteo-oceanic forecasts and simulated flooding scenarios, requires focusing on the transmission of uncertainty information, its restitution in the visualization environment, and the level of potential visual complexity induced. Three research axes are thus considered: (1) the visual analysis of the relationships between the outputs of coastal flooding simulation models and the meteo-oceanic forcing conditions used; (2) the visual exploration of disparities and similarities between simulated coastal flooding scenarios, in space and time; (3) the representation of uncertainties according to the type of data and the visualized spatio-temporal scale.

The visualization propositions can involve 2D or 3D representations, using existing 2D/3D frameworks (OpenLayers/Leaflets/D3 or ThreeJS), with the possibility of combining 2D and 3D representations. Interactive 2D maps can be proposed for visual analysis of meteo-oceanic forecasts at a regional scale, while 3D representations can be used to visualize coastal flooding scenarios on a local scale, while highlighting the importance of geospatial context. Throughout the ANR ORACLES project, the needs, interests and visualization choices will be discussed iteratively with the scientific experts from BRGM and Météo-France involved in the project.

Profile

PhD in Geographic Information Science, Computer Science, Geography ou Geosciences, with strong scientific skills in data analysis and visualization, as well as technical skills in prototyping associated methods.

Duration, remuneration, working environment

When ? Soon as possible until end of 2025.

Where ? LASTIG laboratory, GEOVIS Team, IGN, 73 Avenue de Paris, Saint-Mandé (94), France.

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Contacts and application

Candidates must send an application file containing CV, cover letter, possibly outputs of carried out projects, contacts of two referees (names and email addresses), to the following people:

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