Internship: “Analysis of breaking sea surface: Sea state characterization and wave breaking statistics”

O/Ref: FEM-SAS-2021-288

France Energies Marines institute

France Energies Marines is the French Institute for Energy Transition dedicated to offshore renewable energies. Its mission: to define, set-up and apply a scientific and technical framework necessary to remove the obstacles facing this rapidly developing sector. With a multidisciplinary team of 50 employees and a model of public-private collaboration, the Institute has one purpose: R&D, whether collaborative or carried out as part of a service activity. France Energies Marines provides support for the various offshore renewable energy technologies by relying on four cross-disciplinary and complementary R&D programs: site characterization, design and monitoring of systems, environmental integration and farm optimization.

Context

Offshore structures are subjected to numerous stresses due to the physical environment in which they are located. Among these, the forces related to waves, and in particular to breaking waves, are highly dimensioning. Thus, a good knowledge of the sea states, including reliable statistics of breakers, as well as of the resulting forces are necessary to optimize the design of the machines. In addition, breaking waves eject sea spray modifying air-sea momentum and heat fluxes which influence the wind in the marine atmospheric boundary layer. Therefore, characterization of the breaking statistics is necessary, both for the design of the machines and for the evaluation of the resource. However, few wave breaking observations exist and data sets only cover low to moderate sea states. The proposed internship aims at building a database of wave breaking statistics particularly under high wind in storm conditions. This database will then be used in two ongoing projects at France Energies Marines:

- The DIMPACT project, which aims to quantify (occurrence and intensity) the slamming forces for the dimensioning of floating wind turbines;
- The CASSIOWPE project, which aims to develop a coupled numerical model Ocean-Wave-Atmosphere integrating sea-spray impacts on the exchange of heat and momentum at the air-sea interface.

To meet the objectives of these projects, France Energies Marines has deployed various stereo-video systems, allowing stereo triangulation to reconstruct sea surfaces (*Bergamasco et al., 2017. Filipot et al., 2019*). In addition, France Energies Marines has developed an artificial intelligence algorithm to identify breaking waves in video images (*Stringari at al., 2021*). Used together, these two methods allow characterizing the sea state and producing various breaking wave statistics.

The objective of the internship will be to exploit stereo-video databases of breaking waves collected from the lighthouse of La Jument (France), the floating wind turbine Zefyros (Norway), and the oceanographic research vessel Atalante (SUMOS field campaign, France).

The originality of the internship will be to investigate statistics of breaking crest lengths distributions (introduced by *Phillips, 1985*) and of the curling factor (geometry of the breakers which controls the slamming forces) under high-wind conditions. The innovative character of the results could therefore lead to a publication on the generated database.

References:

Bergamasco, F., Torsello, A., Sclavo, M., Barbariol, F., & Benetazzo, A. (2017). WASS: An open-source pipeline for 3D stereo reconstruction of ocean waves. *Computers & Geosciences*, *107*, 28-36.

Filipot, J. F., Guimaraes, P., Leckler, F., Hortsmann, J., Carrasco, R., Leroy, E., ... & Le Dantec, N. (2019). La Jument lighthouse: a real-scale laboratory for the study of giant waves and their loading on marine structures. *Philosophical Transactions of the Royal Society A*, *377*(2155), 20190008.

Stringari, C. E., Guimarães, P. V., Filipot, J. F., Leckler, F., & Duarte, R. (2021). Deep neural networks for active wave breaking classification. *Scientific Reports*, *11*(1), 1-12.

Phillips, O. M. (1985). Spectral and statistical properties of the equilibrium range in wind-generated gravity waves. *Journal of Fluid Mechanics*, *156*, 505-531.

Internship description

The candidate will process the stereo-video images acquired during the aforementioned field campaigns. S/He will set up the processing chain allowing to reconstruct the temporal evolution of the sea surface and implement the method proposed by *Stringari et al (2020)* to identify breaking waves.

The analysis of the data set will then focus on two aspects:

- The characterization of the wave geometry, in particular of the wave front which controls the intensity of the slamming forces;
- The quantification of the breaking statistics, distributed according to the speeds of the breaking fronts (Phillips, 1985).

In practice, the candidate will have to:

- Select the most relevant situations (image quality, sea state severity, etc...).
- Implement the WASS processing chain proposed by *Bergamasco et al. (2017)* for the 3D reconstruction of sea surfaces.
- Apply the algorithm proposed by Stringari et al. (2020) to detect and track breaking fronts:
    - Create a training dataset of wave breaking images;
    - Carry out the training phase;
    - Process the whole dataset.
- Analyze the obtained data to produce:
    - Breaking crest length distributions and derived statistics;
    - Curling factor statistics.

Profile and skills

Initial training

This internship is intended for students in their final year of a master's degree or an engineering program.

Specific knowledge

Required:

- Signal analysis, image analysis,
- Machine Learning" approach (neural network),
- Programming with python or equivalent, (machine learning libraries like *Pytorch,* TensorFlow, …)

Desirable:

- Knowledge of sea states in general, and of wave breaking processes in particular.

Professional Qualities

The student will be required to interact with the various partners (academic and industrial) of the DIMPACT and CASSIOWPE projects. Therefore, the successful candidate will need to have good interpersonal skills. Fluency (reading) in English is essential.

Supervising

- Dr. Fabien Leckler, sea state expert,
- Dr. Sophia Brumer, air-sea flux expert,
- Dr. Jean François Filipot, scientific director of France Energies Marines, sea state expert,
- Dr. Marie Cathelain, atmospheric modeling expert.

Practical information

- **Type of contract:** full time internship contract
- **Duration of the internship:** 5 to 6 months
- **Workplace:** at the head office located at 525 Avenue Alexis de Rochon, 29280 Plouzané, in the Cap Océan building, Totem building of the “Campus Mondial de la Mer”
- **Starting date:** 1 February 2022
- **Deadline for application:** 31 October 31 2021

This position is open to people with disabilities.

How to apply

- Applications must consist of a **CV** and a **cover letter**.
- To apply, please go to the France Energies Marines **website** under the **Join Us** section.