M2 SOAC : Fiche de stage de recherche en laboratoire

Laboratoire : LEGOS

Titre du stage : Storm surge hazard and compound flooding potential across Madagascar: a historical cyclone hindcast assessment

Nom et statut du (des) responsable (s) de stage : Jamal KHAN, Chargé de recherche

Coordonnées (téléphone et email) du (des) responsable (s) de stage : +33 5 61 33 30 03, jamal.khan@ird.fr

Sujet du stage :

Tropical cyclones and the flooding they trigger are among the most destructive hazards affecting many tropical coastal countries worldwide. Madagascar, located in the Southwest Indian Ocean, is one of the region's most exposed country to tropical cyclones. On average, more than three cyclones make landfall or pass within 200 km of its coastline each season, striking a nation with limited infrastructure to absorb the impacts from extreme wind, storm surges, and flooding. Despite this exposure, the island's storm surge hazard remains poorly characterized, and no systematic multi-event assessment of storm surge hazard exists for this vulnerable island. Furthermore, it has been shown that the cyclone-induced flooding in this region is compound in nature where the oceanic (tides, storm surges, wave setup) and continental (rainfall and riverine discharge) factors interact and exacerbate the impact of flooding (Khan et al., 2025). The potential of such compound flooding events across the island remains poorly quantified and warrants immediate attention towards tackling the ongoing challenge of climate change and sea level rise.

This internship builds on a multi-cyclone hindcast (~80 events, 2002–2025) produced with a high-resolution regional coupled tide-surge-wave model for Madagascar, forced with a bias-corrected merged wind and pressure field that represents cyclone structure typically unresolved by global models such as ERA5. By combining this dedicated hindcast ensemble with publicly available global reanalyses of storm surge (e.g., GTSM) and river discharge (e.g., GloFAS), the student will address three linked objectives:

(1) Water level analysis and comparison : Characterization of total water levels during tropical cyclones from the regional hindcast, and systematically compare against global surge reanalysis dataset(s) to assess the added value of regional modeling.
(2) Extreme value analysis : Application of Extreme Value Analysis (EVA) on water-level extremes to quantify the storm surge hazard levels and associated uncertainty.
(3) Compound flooding potential : Assessment of compound flooding potential through joint analysis of cyclone-induced river discharge from global reanalysis and storm surges from regional hindcasts.

The student will work with different model outputs with varying resolutions; proficiency in Python for geophysical data analysis is strongly encouraged. The internship will be conducted in English. The final report is expected to be written in English as well, reflecting the language of international scientific communication and potential future dissemination of the results to the broader community.

References : Khan, M.J.U., Durand, F., Afroosa, M., Coulet, P., Bertin, X., Mueller, V., Krien, Y., Wainwright, C., 2025. Tropical cyclone induced compound flooding in Madagascar: a coupled modeling approach. Nat. Hazard. 121, 11013–11050. https://doi.org/10.1007/s11069-025-07209-z