MSc internship – 6 months

Wave transformation across a barrier reef-lagoon system from wide swath radar altimetry

Context

Atoll reef islands are recognized as highly vulnerable to oceanic climate changes due to their low elevation, geomorphic characteristics (poorly consolidated materials), and high dependency on the sediments supplied by coral reefs (Duvat et al., 2017). The dynamics of barrier reef-lagoon systems, such as atoll reef islands and their inner lagoon, is strongly controlled by the incident wave conditions, which modify the momentum balance across the reef through wave breaking over the reef top (Sous et al., 2020). In the case of extensive lagoon systems, local winds blowing in the direction of maximum fetch are also able to generate significant wind seas that can dominate the sea state conditions in the lagoon (Jouon et al., 2009). To date, the spatial variability of sea states within extensive atolls has been little investigated because of the lack of data in such systems, and the inadequacy of local in situ sensors to characterize spatial patterns. The most comprehensive studies are based on high-resolution modelling systems, coupling atmospheric, circulation and wave models, but the performance of these models are generally assessed only at a few specific locations, where in situ measurements are available.

Satellite altimeters have been monitoring surface ocean waves at global scale for more than three decades, revealing strong interactions with western boundary currents, extreme storm events in the mid-latitudes and intensifying wave conditions in the Arctic and Southern oceans (Ardhuin et al., 2019; Dodet et al., 2020). Yet, the exploitation of radar altimeters in the near-coastal zone (i.e. less than ~10km from the coast) have, until recently, been hindered by the low spatial resolution of conventional altimeters and by the coastal surface heterogeneities impacting radar echoes (Vignudelli et al., 2019). Recent advances in spaceborne radar measurement techniques, such as Syntheric Aperture Radar (SAR) altimetry (e.g. SRAL instrument on board Sentinel-6 mission), and wide-swath altimetry from radar interferometry (e.g. KaRin instrument on board SWOT mission), are now opening new doors for coastal altimetry, with improved resolution and 2D spatial mapping (Morrow et al., 2019).

With this internship, we will investigate the capacity of the recently launched Ka-band radar interferometer (KaRin) instrument on board the SWOT satellite mission to monitor significant wave height (Hs) variability within the Rangiroa atoll, the largest and most populated (~3500 inhabitants) atoll of the Tuamotu archipelago with maximal dimensions of 79 by 32 km and a lagoon surface area of approximately 1500km^2. This atoll reef island is subjected to both remotely generated swell and locally generated wind seas, and can be threatened by wave overwashing during extratropical storms or tropical cyclone events. The “wind and wave” SWOT products will provide new insights on Hs variability both in offshore waters and within the lagoon, in synergy with SSH and sigma0 measurements. The observed gradients will be compared to complementary dataset, such as S3A&B along-track wind and wave records, as well as numerical modelling results, and the physical mechanisms responsibles of these gradients will be investigated to the light of existing knowledge on wind and wave-induced lagoon dynamics.

The results of this internship will be particularly useful to support the deployments strategy of a field campaign in Rangiroa, planned in spring 2024 within PPR FUTURISKs project.

Hosting laboratory

Laboratoire d’Océanographie Physique et Spatiale (LOPS) – IFREMER – Brest, France

Supervision

Guillaume Dodet (researcher at LOPS) – 70%
Fabrice Ardhuin (researcher at LOPS) – 30%

Required skills

- Scientific background in Physical Oceanography or Geoscience and Remote Sensing
- Knowledge on wave physics and coastal dynamics
- Programming skills (Matlab or Python)
- Good communication skills in English

Keywords

Barrier reef-lagoon dynamics, ocean waves, radar altimetry, SWOT

Application

CV and cover letter should be sent to guillaume.dodet@ifremer.fr

Références

Ardhuin, F., Stopa, J.E., Chapron, B., Collard, F., Husson, R., Jensen, R.E., Johannessen, J., Mouche, A., Passaro, M., Quartly, G.D., Swail, V., Young, I., 2019. Observing Sea States. Front. Mar. Sci. 6. https://doi.org/10.3389/fmars.2019.00124

Dodet, G., Piolle, J.-F., Quilfen, Y., Abdalla, S., Accensi, M., Ardhuin, F., Ash, E., Bidlot, J.-R., Gommenginger, C., Marechal, G., Passaro, M., Quartly, G., Stopa, J., Timmermans, B., Young, I., Cipollini, P., Donlon, C., 2020. The Sea State CCI dataset v1: towards a sea state climate data record based on satellite observations. Earth System Science Data 12, 1929–1951. https://doi.org/10.5194/essd-12-1929-2020

Duvat, V.K.E., Salvat, B., Salmon, C., 2017. Drivers of shoreline change in atoll reef islands of the Tuamotu Archipelago, French Polynesia. Global and Planetary Change 158, 134–154. https://doi.org/10.1016/j.gloplacha.2017.09.016

Jouon, A., Lefebvre, J.P., Douillet, P., Ouillon, S., Schmied, L., 2009. Wind wave measurements and modelling in a fetch-limited semi-enclosed lagoon. Coastal Engineering 56, 599–608. https://doi.org/10.1016/j.coastaleng.2008.12.005

Morrow, R., Fu, L.-L., Ardhuin, F., Benkiran, M., Chapron, B., Cosme, E., d'Ovidio, F., Farrar, J.T., Gille, S.T., Lapeyre, G., Le Traon, P.-Y., Pascual, A., Ponte, A., Qiu, B., Rascle, N., Ubelmann, C., Wang, J., Zaron, E.D., 2019. Global Observations of Fine-Scale Ocean Surface Topography With the Surface Water and Ocean Topography (SWOT) Mission. Frontiers in Marine Science 6.

Sous, D., Dodet, G., Bouchette, F., Tissier, M., 2020. Momentum Balance Across a Barrier Reef. Journal of Geophysical Research: Oceans 125, e2019JC015503. https://doi.org/10.1029/2019JC015503

Vignudelli, S., Birol, F., Benveniste, J., Fu, L.-L., Picot, N., Raynal, M., Roinard, H., 2019. Satellite Altimetry Measurements of Sea Level in the Coastal Zone. Surv Geophys 40, 1319–1349. https://doi.org/10.1007/s10712-019-09569-1