Title: Enhancing earthquake location with domain adaptation

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Level: Master-level internship

Working environment: The candidate will work in the Seismology team of the Institut de Physique du Globe de Paris as part of the Université Paris Cité. The project is funded by the Data Intelligence Institute of Paris (https://u-paris.fr/diip/) in collaboration with the Observatoire Volcanologique du Piton de la Fournaise.

Context: Earthquakes express stress release in active geological objects and provide information about the underlying physical processes, such as fluid migrations and stress perturbations [1]. Therefore, our primary motivation is to form accurate seismic catalogs to enable precise monitoring of such active systems. The quality of seismic catalogs involves detection capabilities and location accuracy and depends on the geometry of the seismic station arrays [2] and the background seismic noise [3]. Since the 2000s, seismologists have densified and extended seismic networks in different seismically active areas to build high-quality catalogs [4]. This is the case of the eruption in Mayotte that triggered the deployment of ocean-bottom seismometers and land seismic sensors in the area [see figure and ref. 5]. The earthquake catalogs inferred in those areas prove of high quality, providing a better understanding of the region's dynamics thanks to high-resolution seismic catalogs illuminating the geophysical features. But ocean-bottom seismometers are often deployed temporarily because of their maintenance cost, providing time-limited, high-quality data.

Goal: This work aims to correct the systematically biased hypocenters obtained with a permanent seismic array from the hypocenters inferred with a temporary array with an adequate geometry, as illustrated in the figure below. We consider the case of Mayotte to develop the method and show the potential outcomes on other datasets of interest. We will learn the catalog bias from the events detected with the trusted array over five weeks and test the prediction quality over one week. Once successful, we will deploy the technique over several years of continuous data at Mayotte and other contexts.

Requirements: We seek candidates with a strong taste for programming, seismology, and inverse problem-solving. A motivated candidate for learning about and applying artificial intelligence techniques is strongly preferred. The target programming language is Python, although we are open to other suggestions. We will also use the scikit-learn library or the PyTorch framework to develop the strategy.

References:

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2. Poiata, N., Satriano, C., Vilotte, J. P., Bernard, P., & Obara, K. (2016). Multiband array detection and location of seismic sources recorded by dense seismic networks. Geophysical Journal International, 205(3), 1548-1573.
3. Longuet-Higgins, M. S. (1950). A theory of the origin of microseisms. Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences, 243(857), 1-35.
4. Rost, S., & Thomas, C. (2002). Array seismology: Methods and applications. Reviews of geophysics, 40(3), 2-1.
5. Saurel, J. M., Jacques, E., Aiken, et al. (2022). Mayotte seismic crisis: building knowledge in near real-time by combining land and ocean-bottom seismometers, first results. Geophys. J. Int., 228(2), 1281-1293.