

<PROPOSITION DE SUJET DE THESE

Formulaire demande de financement : ARED - ISblue - ETABLISSEMENTS - ...

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Identification du projet

Acronyme du projet (8 caractères maximum) : IACOUSA

Intitulé du projet en langue anglaise : Using artificial intelligence for event detection in hydroacoustic observatories

Présentation de l'établissement porteur (bénéficiaire de l'aide régionale)

Établissement porteur du projet : Université de Brest

Ecole Doctorale : EDSML SPI ou MATHSTIC pour les projets ISblue

Identification du responsable du projet (futur directeur de thèse)

Nom du laboratoire d'accueil : [Laboratoire Geo-Ocean](#)

Code du laboratoire (U/UMR/USR/EA/IE/...) : UMR 6538

Directeur¹ du Laboratoire : Marc-André GUTSCHER

Nom de l'équipe de recherche : ALMA

Nombre HDR dans le laboratoire : 41 Nombre de thèses en cours : 29 Nombre de post-docs en cours : 10

Nom et prénom du directeur* de thèse (HDR), porteur du projet : BAZIN Sara

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- Téléphone : +33 2 98 49 87 18

- Publications récentes du directeur de thèse (nb total et 5 références max au cours des 5 dernières années) :

In total : 36 papers (high rank) plus 3 submitted or in press. Score Research Gate : 29.66, h-index: 20, citations : 1337

Bazin, S., Royer, J.-Y., Dubost, F., Paquet, F., Loubrieu, B., Lavayssière, A., Sukhovich, A., Bonnet, R., Deplus, C., Jacques, E., Retailleau, L., Saurel, J.-M., Feuillet, N., Rinnert, E., Thinon, I., Lebas, E., et le groupe REVOSIMA. First attempt of an hydroacoustic network to monitor submarine lava flows near Mayotte island. *C. R. Geoscience*, submitted.El Houssein, A., Bazin, S., Chazot, G., Bertrand, H., Le Gall, B., Youbi, N., Salem Sabar, M., Khalil Bensalah, M., Boumehd, M.A. Geophysical modelling of the deep structure of the Richat magmatic intrusion (northern Mauritania): insights into its kinematics of emplacement. *Arabian Journal of Geosciences*, <https://doi.org/10.1007/s12517-021-08734-4>, 2021Ingale, V.V., Bazin, S., Royer, J.-Y. Hydroacoustic observations of Two Contrasted Seismic Swarms along the Southwest Indian Ridge in 2018. Special Issue Earthquake swarms, *Geosciences*, doi:10.3390/geosciences11060225, 2021Skurdal, G., Pfaffhuber, A.A., Davis, A., Bazin, S. Improved near-surface resolution in geotechnical applications using very early AEM time gates. *Exploration Geophysics*. doi: 10.1080/08123985.2019.1691441, 2019.Bazin, S., Lysdahl, A.K., Viezzoli, A., Günther, T., Anschutz, H., Scheibz, J., Pfaffhuber, A.A., Radic, T., Fjermestad, H. Resistivity and chargeability survey for tunnel investigation: a case study on toxic black shale in Norway. *Journal of Near Surface Geophysics*,¹ Ce formulaire est rédigé en style épïcène

- Expériences d'encadrement et co-encadrement de doctorants (passées et en cours)

(nom des doctorants dirigés et en cours et antérieurement, sur les 6 années passées : sujet, financement, date de soutenance, et situation professionnelle actuelle si connue)

INGALE Vaihab : Oct. 2020-present. Dynamic of seafloor spreading viewed through the analysis of seismic swarms detected in the last decade along three mid-oceanic ridges with contrasted spreading rates. Brest Univ. Thesis on going - Funding 50% ARED + 50% Isblue - Co-advisor : Jean-Yves Royer (LGO)

Co-encadrant scientifique : CAZAU Dorian

Laboratoire de recherche co-encadrant (nom + code U/UMR/USR/EA/JE/...) [Lab-STICC - UMR 6285](#)

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- Téléphone : +33 6 72 55 34 94

- Expériences d'encadrement et co-encadrement de doctorants (passées et en cours)

(nom des doctorants dirigés et en cours et antérieurement, sur les 6 années passées : sujet, financement, date de soutenance, et situation professionnelle actuelle si connue)

NGUYEN HONG DUC Paul : Development of artificial intelligence methods for marine mammal detection and classification of underwater sounds in a weak supervision (but) Big Data-Expert context. Thesis on going. Funding French (DGA)-UK. Defended on 17/12/2020 at Sorbonne University. Now postdoc at Dalhousie Univ. (Halifax, Canada) - Co-advisor

ZAMBRA Matteo : Nov. 2020-present. Méthodes IA multimodales dans des contextes d'observation océanographiques et de surveillance maritime multi-capteurs hétérogènes.

Thesis on going - CIFRE funding and Naval Group within the OceaniX Chair- Co-advisor

DUBUS Gabriel : Nov. 2021-present. Using artificial intelligence for the development of an Oceanic Acoustic Soundscape Identification System (OASIS).

Thesis on going – Funding from Sorbonne University - Co-advisor

Co-encadrant scientifique : CLORENNEC Dominique

Laboratoire de recherche co-encadrant (nom + code U/UMR/USR/EA/JE/...) SME [Quiet-Oceans](#)

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- Téléphone : +33 9 82 28 21 23

- Expériences d'encadrement et co-encadrement de doctorants (passées et en cours)

Head of the acoustics and bioacoustics department. In charge of impact studies taking into account acoustic propagation. In-situ measurements in shallow water environments to assess the sound levels as well as the frequentation of marine fauna on a large time scale.

Supervision of ENSTA internships (2nd or 3rd year), Master2 in Acoustics, University of Le Mans.

Financement du projet de thèse

En cas de financement à 50 %, le cofinancement est-il déjà identifié (oui/non) : non

Si oui, préciser la nature du cofinancement (ANR, partenaire privé, Ademe, etc.) :

Si le cofinancement n'est pas encore confirmé, date prévue de réponse du cofinancier :

En cas de non-obtention du cofinancement demandé, une autre source de cofinancement est-elle identifiée (oui/non) :

Si oui, laquelle :

Sollicitez-vous un co-financement Is-Blue (y compris ARED Is-Blue) (oui/non) ? oui

Important : Veillez à bien compléter les différents co financements sollicités sur le serveur Thèses en Bretagne Loire lors du dépôt de votre dossier.

Projet de thèse en cotutelle internationale

S'agit-il d'un projet de thèse en cotutelle internationale dans le cadre d'une convention (oui/non) : **non**

Si oui, préciser l'établissement pressenti (et le pays de rattachement) :

Ce projet de thèse fera-t-il l'objet d'un cofinancement international (oui/non) : **non**

(Rémunération du doctorant par l'établissement implanté sur le territoire régional (18 mois sur 36 mois), et l'établissement étranger, qui s'engage également à rémunérer le doctorant dans le cadre de son séjour à l'étranger, soit durant 18 mois -a minima-)

En cas de cofinancement international, préciser -si vous en avez connaissance- l'organisation du calendrier des périodes de séjour :

Préciser quel est le stade du projet international (joindre une lettre d'engagement du partenaire)

Présentation du projet (en langue française ou anglaise, 2 à 3 pages)

merci de respecter ce format maxi compatible avec extranet région

Résumé du projet (4000 caractères maxi espaces compris) :

Mooring networks of autonomous hydrophones is an effective way to monitor the ocean soundscape and its sources: underwater earthquakes and volcanic eruptions, marine mammals, icequakes, sea-state, ship noise... For more than 10 years, the Laboratory Geo-Ocean has been maintaining hydroacoustic networks in the open ocean, composed of a few hydrophones moored in the sound channel, which acts as an acoustic waveguide, carrying acoustic waves over thousands of kilometers. In the Indian Ocean, the OHASISBIO network comprises 7 to 9 distant hydrophones continuously recording low-frequency sounds (0-120Hz) since 2010 (Royer et al., 2015). Near Mayotte island, the MAHY network has been monitoring the activity of the new underwater volcano since 2020 thanks to 4 moored hydrophones (Bazin et al., in review). Their objectives are to monitor the seismic and volcanic activity but also the presence and migration patterns of large whales, and the oceanic ambient noise in general. Over the years, passive acoustic monitoring of the ocean has resulted in very large data sets. The preliminary, but indispensable and time-consuming step in the data analysis consists in manually identifying the different types of acoustic events. To achieve a more complete and efficient analysis, we wish to develop artificial intelligence (AI) applications for event detection and signal discrimination in our acoustic database. The novelty is to employ modern deep learning techniques to efficiently discriminate the broad variety of signals present in the soundscapes. The student will build on some preliminary experience from the supervisors (Cazau et al., 2021; Torterotot, 2020). Available hydrophone data will be used to design the detection method: parts of the OHASISBIO and MAHY datasets have already been manually processed and classified, and will serve for training of the machine learning model. Other hydroacoustic datasets collected by Lab-Sticc and by the start-up Quiet-Oceans will also be analyzed. They are usually shorter but encompass a wider range of environments and sources. They also use different types of acoustic sensors with higher frequency-bands, and will therefore generate different types of false-alarms. The student will have the opportunity to participate to maintenance oceanographic cruises in the Indian Ocean and instrument deployments in several French coastal regions for industrial projects.

The originality of the PhD project lies in the collaboration of supervisors specialized in geoscience, in marine

acoustics, and in AI.

Key words: hydroacoustics, deep learning, event detection, marine mammals, seismicity, submarine volcano

References:

Bazin et al. (in review). First attempt of an hydroacoustic network to monitor submarine lava flows near Mayotte island. *Comptes rendus Géosciences*.

Cazau et al. (2021) Multimodal deep learning for cetacean distribution modeling of fin whales (*Balaenoptera physalus*) in the western Mediterranean Sea. *Machine Learning, Springer Verlag*. doi:10.1007/s10994-021-06029-z

Royer et al. (2015). Seafloor seismicity, Antarctic ice-sounds, cetacean vocalizations and long-term ambient sound in the Indian Ocean basin, *Geophys. J. Int.*, doi: 10.1093/gji/ggv178

Torterotot, M. (2020). Traitement et analyse de signaux bioacoustiques dans l'océan Indien austral. *UBO doctoral thesis*.

Présentation détaillée du projet :

1 - Hypothèse et questions posées, état de l'art, identification des points de blocages scientifiques (4000 caractères maxi espaces compris)

Understanding the context and relative contributions of the different sound sources provides key insights into how anthropogenic changes to ocean soundscape may affect marine life and the overall health of the ocean. Marine mammals use vocal communication to aid in mating, rearing of young, group cohesion and feeding. Weather conditions, anthropogenic noise and geological processes also make important contributions to marine soundscape. The Global Ocean Observing System (GOOS) recently adopted ocean sound as an Essential Ocean Variable (EOV) necessary to characterize sound sources and potential impacts on marine life.

Acoustic specialists now face a scientific challenge due to the diversity of sound sources and the difficulty to efficiently process the very-large time series data. In the current situation, each community focuses on one type of sound while there is a need for detection and processing techniques that are able to grasp the wide diversity of soundscape in time and spatial scales. Our PhD project aims at developing new automatic methods to detect, classify and locate the different sound sources in our existing hydroacoustic databases.

2 - Approche méthodologique et techniques envisagées : (4000 caractères maxi espaces compris)

The novelty is to employ machine learning techniques to efficiently discriminate the broad variety of signals present in the soundscapes. The LGO and the Lab-Sticc supervisors propose to team-up to help the PhD student develop artificial intelligence (AI) techniques in the hydroacoustic context. The student will develop an automatic detection and classification tool for acoustic signals recorded in the ocean, based on machine learning techniques. She/he will benefit the proximity to a commercial company (Quiet-Oceans) and will therefore be familiar with practical applications for the offshore industry. Among the wide range of approaches for intelligent classification, we seek for the implementation that would best extract information from our growing acoustic database. Available hydrophone data can be used to design the detection method: parts of the datasets (OHASISBIO and MAHY at LGO and other datasets collected by Lab-Sticc and Quiet-Oceans) have already been manually processed and classified, and will serve for training of the machine learning model. The student will select events representative of each species (marine mammals, dolphins, benthic etc), different type of geo-events (volcano-tectonic seismic events, long-period seismic events, teleseisms, volcano degassing events, submarine landslides, explosions), as well as anthropogenic sounds (air-guns from seismic surveys, ship noise, etc), and define their characteristics (duration, amplitude, frequencies, waveform).

Bioacoustic catalogs will be used to establish statistics on the presence of marine mammals and its evolution over the years, a key to developing conservation measures for biodiversity. Furthermore, ocean noise pollution by anthropogenic noise is becoming a major issue and its evolution has yet to be characterized in the long term.

Once the geo-events are detected and classified on several hydrophones, their source can be localized based on their arrival times, the geometry of the network, and the sound-speed in the ocean. Ultimately, the seismic catalogs will depict the spatial and temporal seismicity that will help understand the dynamics of seafloor spreading. Lava eruption and explosion catalogs will characterize the Mayotte volcano activity and will help quantify the risk for the Mayotte population and for the local ship activity.

3 - Positionnement et environnement scientifique dans le contexte régional, national et international :

At the regional level, this project participates in the work of a group formed in Brest on underwater acoustics, particularly on the interpretation and modelling of acoustic waves. This group brings together researchers from IMT Atlantic, ENSTA Bretagne, SHOM, LGO, École Navale, and Quiet-Oceans. This work focuses on the processing and interpretation of noise of biological (large whales, dolphins, benthic), geological (earthquakes, volcanic eruptions), cryogenic (icequakes), oceanic (sea state), and anthropogenic (ships) origin.

The LGO is the only French academic laboratory that maintains long-term hydro-acoustic networks. It is well established in the international scientific community and has a good publishing record. Jean-Yves Royer started this endeavor in 2000 and has since initiated several collaborations with scientists in marine biology (including at ENSTA) and oceanography. Thanks to a Region Bretagne financial support, the LGO has developed a monitoring strategy employing cost-effective and resilient instruments to acquire long-term hydroacoustic datasets over large marine regions. LGO will also hosts the future national pool of advanced hydrophones within the MARMOR project financed by the PIA3/EQUIPEX.

The NOAA's Pacific Marine Environment Laboratory is the only academic team to deploy high-sea hydrophone networks to monitor ocean seismicity. Some collaborations are on-going. Internationally, our results are of interest to the Vienna-based Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), which maintains real-time hydroacoustic stations in different parts of the world ocean. The objective of the CTBTO is to detect suspicious explosions in the water column in real time and at great distances.

Founded in Brest in 2010 and based on a recognized expertise in marine acoustics and oceanography mainly developed in the defense research, Quiet-Oceans has become the French leader in environmental studies specialized in the underwater noise issue. Expert in passive acoustics, underwater noise prediction, monitoring and mitigation, Quiet-Oceans provides state-of-the-art risk assessment tools and management capabilities to help the offshore industry to secure their projects. Quiet-Oceans is involved in French and international offshore projects such as offshore windfarm developments, coastal infrastructure developments, seismic surveys, conservation projects, etc. Quiet-Oceans is member of the Technical Group Noise (TG Noise) appointed by the European Commission to provide advice and recommendations the governments about the implementation of the Marine Strategic Framework Directive (MSFD). Quiet-Oceans is involved in a number of European collaborative projects (FP7/AQUO, INTERREG/BIAS, LIFE/AGESCIC, LIFE/PIAQUO, INTERREG/JONAS, H2020/SATURN) and international projects, especially in the Western Indian Ocean (FFEM/QWIO).

4 - Contexte scientifique et partenarial : éléments généraux (ERC, CPER, FEDER, Breizhcop ...) (4000 caractères maxi espaces compris)

The PhD student will analyze data collected by a pool of instruments financed by Région Bretagne/FEDER within the CPER project ODO-3D.

The PhD student will work in collaboration with Quiet-Oceans, a start-up company specialized in the emerging issue of underwater noise. Its expertise covers underwater noise forecasting, risk assessment and consulting services to reduce the impact of noise on biodiversity. The company carries out research focused on ensuring Good Environmental Status regarding noise level in European waters in accordance with the Marine Strategy Framework Directive (MSFD) and its implementation within the respective domestic laws of European countries. Their team has more than 15 years of combined experience in management, project planning, oceanographic engineering and scientific marine acoustic research in manufacturing, the military and academia. Their wide range of customers and partners gives QO a global and objective perspective on the issue of underwater noise.

Vous sollicitez un financement ISblue, ou une ARED ISblue :

Précisez le lien du sujet avec les thèmes ISblue

Thème ISblue	Thème principal	Thème secondaire (si nécessaire)	Autre (si nécessaire)
la régulation du climat par l'océan			

les interactions entre la Terre et l'océan		x	
la durabilité des systèmes côtiers			
l'océan vivant et les services écosystémiques		x	
les systèmes d'observation à long terme	x		

Expliquez/précisez en quelques lignes dans quelle mesure votre demande correspond à l'un ou plusieurs des critères ISblue ci-dessous :

The project corresponds to 3 of the ISblue themes:

- Ocean-Earth interactions: monitor submarine earthquakes and volcanoes
- Living ocean: detect migration patterns of large whales, measure impact of noise on ecosystems
- Long-term monitoring: take advantage of continuous and temporary monitoring hydrophone networks

1- Originalité, impact potentiel du projet (4 lignes maxi)

The goal of hydrophone networks is to acquire time series of the sound of large whales, seismic and volcanic activity, and environmental noise. The advantage of long time-series is to be able to follow the evolution of these acoustic sources and to analyze the interactions between bioacoustic activity and ambient noise. The originality of the project is to efficiently analyze these large databases with new AI tools.

2- Positionnement international du sujet, cotutelle ou co-encadrement international (4 lignes maxi)

The supervising team has on-going collaboration with Prof Stan Matwin, Director of the Institute for Big Data Analysis at the Dalhousie Univ (Canada), Pierre Cauchy involved in the MARS project developing a cutting-edge acoustic observatory in the Saint-Laurent estuary at ISMER (Québec), and also with Julien Bonnel who works on signal processing and passive acoustic monitoring at the Woods Hole Oceanographic Inst. Exchanges are expected.

3- Effet intégrateur entre unités de recherche et / ou interdisciplinarités (4 lignes maxi)

This project participates in the work of a group of Brest researchers (from IMT, ENSTA, LOPS, LGO, École Navale, Quiet-Oceans) working on underwater acoustics. Some of them focus on the analysis of the acoustic sources, other on the wave propagation, or on events detection. Together they contribute to a better understanding of the soundspace and the potential interactions between sources. All contributions are necessary for the DIS 1-2.

4- Potentiel d'insertion à un haut niveau dans la communauté académique ou non académique du docteur (4 lignes maxi)

This doctoral work will provide a solid background in hydroacoustics for the candidate to pursue in the academy. Competences in IA, Big Data and data processing will allow him/her to postulate for jobs in the industrial sector such as in acoustic monitoring for example within the DCSMM context.

Le candidat

Profil souhaité du candidat (spécialité/discipline principale, compétences scientifiques et techniques requises) :

The candidate must have a solid background in programming and AI skills, and eventually in maths and physics (signal processing and wave propagation).

ATTENTION :

Tout dossier non déposé sur le serveur dans les délais indiqués, ne pourra être pris en compte notamment par les instances ISblue, conseil de l'EDSML.