Said Ouala
Tenure track associate professor

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Research Interest

Scientific Machine Learning, Numerical models, Hybrid models, Data assimilation, Generative models, Signal processing, Dynamical systems

Current position

Since Jan 2023 — **Tenure track associate professor** *IMT Atlantique, Brest, France.*

Ongoing projects

2024 - 2029 — **Tenure track project, IA for extremes in ocean-atmosphere and climate (AI4Extremes).** *PI of the IA for extremes ocean-atmosphere and climate project funded by IMT Atlantique and the french ANR. The objectives of this project include:*
- Generative data assimilation for probabilistic forecasting of extremes.
- Dynamical description and characterization of extreme events.
- Development of data-driven and hybrid numerical models for the prediction of extremes.
- Learning-based approaches for the control and mitigation of extremes.

2025 - 2029 — **Security enhancement through heterogeneous data fusion and improved AI/ML-powered Copernicus maritime and border surveillance services (AI4COPSEC).**
- Contributor in WP4, WP5, and WP6: Designing heterogeneous training datasets for AI/ML models. Implementation, training, evaluation, and integration of the models to support search and rescue operations, oil spill alerts, and irregular migration and illegal fishing alerts.

2024 - 2029 — **Artificial Intelligence for enhanced representation of processes and extremes in Earth System Models (AI4PEX).**
- Contribution in WP2 and WP3: Design and implementation of hybrid ocean models for accelerated coupled climate simulations and impact of learned parameterizations on the representation of ocean extremes.

2024 - 2026 — **Benchmarking end-to-end neural models for short-term ocean forecasting (OceanBench-STOF).** *Co-PI of the OceanBench-STOF Copernicus Marine Service Evolution project.*
- Contribution in Task 0,1 and 2: Design and implementation of the ocean forecasting benchmarks and implementation of the benchmark models.

2022 - 2024 — **4D-VarNet emulators for Ocean Forecasting and Data Assimilation (4DVarNet-OFDA).** *Co-PI of the 4DVarNet-OFDA Copernicus Marine Service Evolution project.*
- Contribution in Task 1: Study and implementation of the weak constrained 4D-Var as an implicit layer of deep neural networks. Generalization to deep learning-based dynamical priors.

Past professional activities

Jun 2024 — **Co-organization of the Workshop: Using AI for Analyzing Long-Term Marine Data.** *Sorbonne University, Paris, France* Organized within the framework of the LEFE CYBER program. Co-organized with Sabine Schmidt (EPOC, LEFE-CYBER, ODATIS/IR DATA TERRA), Alain Lefebvre (Ifremer, IR ILICO), and Raphaëlle Sauzède (CNRS, IMEV, Argo-France).

Apr 2021 - Jan 2023 — **Research Associate in the Stochastic Transport in Upper Ocean Dynamics (ERC Synergy STUOD) program.** *Brest, France.*
- **Topic**: Modeling upper ocean dynamics from a machine learning point of view: From the data-driven parameterization of physical models to equation discovery.
- **PIs**: Bertrand Chapron (Ifremer).

Apr - Jul 2023 — **Reconstruction of oxygen concentration profiles using physical ARGO and ocean surface observations.** *Visiting Research Collaborator, Arabian Center for Climate and Environmental ScienceS (ACCESS) lab, New York University Abu Dhabi, Abu Dhabi, UAE.*
- BGC ARGO, WOD data, Neural networks, ROMS, Oxygen minimum zones.

Jul - Sep 2021 — **Surface wind estimation from a combination of satellite observations and atmospheric model simulations.** *Research Engineer, Ocean Data Lab, Brest, France*
- SAR data, AROME model correction, Deep neural networks, Surface wind data.

Jun 2019 — **Study and implementation of boundedness constraints in neural network-based surrogate models of upper ocean flows.** *Visiting Scholar, Department of Mechanical Engineering at the University of Washington (UW). Seattle, USA.*
- Neural ODE, Partially observed systems, Schlegel boundedness theorem, Surrogate models.

Mar - Apr, 2019	**Participation in the CALYPSO 2019 Cruise.** *Field Campaign in the Mediterranean Sea.* • Biogeochemical sampling with CTD. Sampling temperature and salinity profiles using an underway CTD.
Sep-Nov 2018, Mar-May 2019	**Development of deep learning techniques for the reconstruction of oceanic fields from highly irregular observations.** *Visiting Scholar, Mediterranean Institute for Advanced Studies (IMEDEA). Esporles, Spain.* • Data assimilation, Ensemble Kalman filter, Data-driven models, Sea surface height.

Education

Dec 2017- Apr 2021	**Ph.D. in Automatic, Signal and Image Processing from IMT-Atlantique.** *Brest, France.* • **Topic**: Data-driven and learning-based approaches for the modeling, forecasting and reconstruction of geophysical dynamics: Application to sea surface dynamics.
Sep 2015- Sep 2017	**MSc. in Signal Processing, Artificial Intelligence from Sorbonne University, Pierre and Marie Curie Campus.** *Paris, France.* • **Coursework includes**: Signal processing, Stochastic processes, Machine learning, Optimization.
2010-2015	**Control Engineering Degree from Ecole Nationale Polytechnique (ENP).** Algiers, Algeria.

Teaching/Supervision

Since Feb. 2024	**Data assimilation, undergraduate students of the European Institute for Marine Studies.**
Since Feb. 2024	**Statistics and Probability, undergraduate students of IMT Atlantique.**
May 2022	**Guest Lecturer, Topics in Machine Learning (IMT-Atlantique).** • *Course title: Deep Learning and Dynamical Systems - graduate level (4h course + 4h research project).*
Nov 2021	**Guest Lecturer, Advanced Course on Deep Learning and Geophysical Dynamics (AI Chair OceaniX).** • *Course title: Deep Learning and Dynamical Systems - graduate level (4h course + 16h research project).*
Sep 2019 -Jan 2020	**Teaching Assistant, Digital Electronics, Université de Bretagne Occidentale (UBO).** • *Practical work on combinational and sequential circuits - undergraduate level (34 hours).*
Jan 2019 -Mar 2020	**Teaching Assistant, Mathematics for Engineers, Université de Bretagne Occidentale (UBO).** • *Tutorial class on Algebra - undergraduate level (18 hours).*

Ph.D. students:
• *Emilio Gonzalez (2024-2027). Reduced order Hybrid Regional Ocean Models.*
• *Gwendal Saliou (2024-2027). Regional weather forecasting using Artificial Intelligence, Data Assimilation and Uncertainity Quantification*

Supervision of several master's students:
• *Louis Laudereau (2024). Dwonscaling surface temperature data.*
• *Oussama Hidaoui (2024). Reconstruction of global trends of oxygen concentration using ML emulators.*
• *Gwendal Saliou (2024). Developement of surrogate regional weather forecasting system.*
• *Thomas AUSSAGUÈS (2021). Derivation of implicit Runge-Kutta schemes using stochastic optimization techniques.*
• *Luc MÉNARD, Tom PÉGEOT, Antoine LEROSEY (2021). Neural Ordinary Differential Equations (NODEs) with trainable solvers.*
• *Audrey GONZALO (2020, 2021). Machine Learning and Biogeochemistry: Study of phytoplankton biomass in the California upwelling using in situ data.*
• *Hubert DELLON (2020). An experimental study of the qualitative properties of solutions of Neural Ordinary Differential Equations under chaotic regimes.*

Academic Services

Reviewer for:
○ Nonlinear Processes in Geophysics,
○ Physica A: Statistical Mechanics and its Applications,
○ IEEE Transactions on Geoscience and Remote Sensing,
○ IEEE Geoscience and Remote Sensing Letters,
○ Proceedings of Stochastic Transport in Upper Ocean Dynamics,
○ Frontiers in Marine Science.
Chair of the Oceanix webinar series.

Selected Publications

Review Papers
○ Camps-Valls, G., Fernández-Torres, M. Á., Cohrs, K. H., Höhl, A., Castelletti, A., Pacal, A., ... Williams, T. (2025).

Artificial intelligence for modeling and understanding extreme weather and climate events. Nature Communications, 16(1), 1919.

○ Cheng, S., Quilodrán-Casas, C., **Ouala, S.**, Farchi, A., Liu, C., Tandeo, P., ... & Arcucci, R. (2023). Machine learning with data assimilation and uncertainty quantification for dynamical systems: a review. IEEE/CAA Journal of Automatica Sinica, 10(6), 1361-1387.

Journal papers

○ **Ouala, S.**, Chapron, B., Collard, F., Gaultier, L., Fablet, R. (2024). Online calibration of deep learning sub-models for hybrid numerical modeling systems. Communications Physics, 7(1), 402.

○ **Ouala, S.**, Chapron, B., Collard, F., Gaultier, L., & Fablet, R. (2023). Extending the extended dynamic mode decomposition with latent observables: the latent EDMD framework. Machine Learning: Science and Technology, 4(2), 025018.

○ **Ouala, S.**, Brunton, S. L., Chapron, B., Pascual, A., Collard, F., Gaultier, L., & Fablet, R. (2023). Bounded nonlinear forecasts of partially observed geophysical systems with physics-constrained deep learning. Physica D: Nonlinear Phenomena, 133630.

○ **Ouala, S.**, Nguyen, D., Drumetz, L., Chapron, B., Pascual, A., Collard, F., ... & Fablet, R. (2020). Learning latent dynamics for partially observed chaotic systems. Chaos: An Interdisciplinary Journal of Nonlinear Science, 30(10), 103121.

○ **Ouala, S.**, Fablet, R., Herzet, C., Chapron, B., Pascual, A., Collard, F., & Gaultier, L. (2018). Neural network based kalman filters for the spatio-temporal interpolation of satellite-derived sea surface temperature. Remote Sensing, 10(12), 1864.

Preprints and submitted papers

○ **Ouala, S.**, & Lachkar, Z. (2025). A novel global gridded ocean oxygen product derived from neural network emulators. In preparation. Submitted to Biogeosciences.

○ **Ouala, S.**, Debreu, L., Pascual, A., Chapron, B., Collard, F., Gaultier, L., & Fablet, R. (2024). Enhanced Computational Complexity in Continuous-Depth Models: Neural Ordinary Differential Equations with Trainable Numerical Schemes. Under review in IEEE Transactions on Pattern Analysis and Machine Intelligence.

○ **Ouala, S.**, Chapron, B., Collard, F., Gaultier, L., & Fablet, R. (2023). Online Calibration of Deep Learning Sub-Models for Hybrid Numerical Modeling Systems. arXiv preprint arXiv:2311.10665 (accepted in Nature Communications Physics).

○ **Ouala, S.**, Debreu, L., Pascual, A., Chapron, B., Collard, F., Gaultier, L., & Fablet, R. (2021). Learning Runge-Kutta integration schemes for ODE simulation and identification. arXiv preprint arXiv:2105.04999.

○ Nguyen, D., **Ouala, S.**, Drumetz, L., & Fablet, R. (2020). Variational deep learning for the identification and reconstruction of chaotic and stochastic dynamical systems from noisy and partial observations. arXiv preprint arXiv:2009.02296.

Conference papers

○ **Ouala, S.**, Debreu, L., Chapron, B., Collard, F., Gaultier, L., & Fablet, R. (2024, April). Neural Ordinary Differential Equations with Trainable Solvers. In ICASSP 2024-2024 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) (pp. 7675-7679). IEEE.

○ **Ouala, S.**, Tandeo, P., Chapron, B., Collard, F., & Fablet, R. (2023). End-to-End Kalman Filter in a High Dimensional Linear Embedding of the Observations. Stochastic Transport in Upper Ocean Dynamics, 211.

○ **Ouala, S.**, Fablet, R., Drumetz, L., Chapron, B., Pascual, A., Collard, F., & Gaultier, L. (2020, September). Physically Informed Neural Networks for the Simulation and Data-Assimilation of Geophysical Dynamics. In IGARSS 2020-2020 IEEE International Geoscience and Remote Sensing Symposium (pp. 3490-3493). IEEE.

○ Nguyen, D., **Ouala, S.**, Drumetz, L., & Fablet, R. (2020, September). Learning Chaotic and Stochastic Dynamics from Noisy and Partial Observation using Variational Deep Learning. In CI'2020: 10th International Conference on Climate Informatics.

○ Nguyen, D., **Ouala, S.**, Drumetz, L., & Fablet, R. (2020, May). Assimilation-based learning of chaotic dynamical systems from noisy and partial data. In ICASSP 2020-2020 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) (pp. 3862-3866). IEEE.

○ **Ouala, S.**, Fablet, R., Herzet, C., Drumetz, L., Chapron, B., Pascual, A., ... & Gaultier, L. (2019, July). Sea surface dynamics reconstruction using neural networks based kalman filter. In IGARSS 2019-2019 IEEE International Geoscience and Remote Sensing Symposium (pp. 10059-10062). IEEE.

○ **Ouala, S.**, Nguyen, D., Herzet, C., Drumetz, L., Chapron, B., Pascual, A., ... & Fablet, R. (2019, July). Learning ocean dynamical priors from noisy data using assimilation-derived neural nets. In IGARSS 2019-2019 IEEE International Geoscience and Remote Sensing Symposium (pp. 9451-9454). IEEE.

○ **Ouala, S.**, Fablet, R., Herzet, C., Chapron, B., Pascual, A., Collard, F., & Gaultier, L. (2019, May). Learning stochastic representations of geophysical dynamics. In ICASSP 2019-2019 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) (pp. 3877-3881). IEEE.

○ **Ouala, S.**, Pascual, A., & Fablet, R. (2019, May). Residual integration neural network. In ICASSP 2019-2019 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) (pp. 3622-3626). IEEE.

○ **Ouala, S.**, Brunton, S. L., Nguyen, D., Drumetz, L., & Fablet, R. (2019). Learning Constrained Dynamical Embeddings for Geophysical Dynamics. In CI 2019: 9th International Workshop on Climate Informatics.

○ Fablet, R., **Ouala, S.**, & Herzet, C. (2018, September). Bilinear residual neural network for the identification and forecasting of geophysical dynamics. In 2018 26th European signal processing conference (EUSIPCO) (pp. 1477-1481). IEEE.

○ **Ouala, S.**, Herzet, C., & Fablet, R. (2018, July). Sea surface temperature prediction and reconstruction using patch-level neural network representations. In IGARSS 2018-2018 IEEE International Geoscience and Remote Sensing Symposium (pp. 5628-5631). IEEE.

Selected invited and conference talks

Selected invited talks

- **Online Learning for Hybrid Numerical Models** Deep Differentiable Emulators (DDEs) in EDITOModelLab. Grenoble, Sep. 30 - Oct. 3, 2024,
- **Artificial Intelligence in Geophysical Data Assimilation: New Methods for Bridging Models and Observations.** Workshop on statistics, data assimilation and machine learning at the IPSL, ENS, Paris, April 2024
- **Modeling upper ocean dynamics from a machine learning point of view.** Arabian Center for Climate and Environmental Sciences. New York University Abu Dhabi. November 2022,
- **Data-driven and learning-based approaches for the modeling, forecasting and reconstruction of geophysical dynamics.** DataLearning Working Group webinars. Imperial College London. November 2021,
- **Constrained neural embedding of partially observed systems.** Data Science and Machine Learning webinars. Florida State University (US). November 2020,

Selected talks in conferences/workshops

- **Machine learning and subgrid scale parameterization: on why and how to learn online.** 23rd International Conference on Computational Science. July 2023.
- Virtual seminar, **Data-driven and learning-based approaches for the modeling of sea surface dynamics.** 20th STUOD Sandbox Workshop, ERC-Synergy STUOD. February 2023,
- **Learning dynamical models from partial observations.** 17th STUOD Sandbox Workshop. ERC-Synergy STUOD. June 2022. Machine learning and uncertainties in climate simulations. Moulin Mer, Logonna-Daoulas, Finistère, France. June 2022,
- Virtual seminar, **Augmented representations for sub grid-scale modeling.** 11th STUOD Sandbox Workshop. ERC-Synergy STUOD. November 2021,
- Virtual seminar, **Approximating the Koopman operator using trainable linear aungmented dynamics.** First OceaniX Annual Assembly. September 2021,
- Virtual seminar, **Learning integration schemes for ODEs: Stability constraints and data-driven identification.** AI chair OceaniX sandbox. May 2021,
- Virtual seminar, **SPDE-based deep neural networks for conditional simulations.** AI chair OceaniX sandbox. February 2021,
- **Data-driven identification of geophysical dynamics: Incorporating stability constraints in neural networks models.** Second IMT-Atlantique & RIKEN Joint Workshop: "Statistical Modeling and Machine Learning in Meteorology and Oceanography". IMT-Atlantique, Brest, France. February 2020,
- **Deep learning models for geophysical spatio-temporal fields reconstruction.** 50èmes Journées de Statistique conference. EDFlab, Paris Saclay. May 2018.