**FINAL REPORT PROGRAM LEFE**

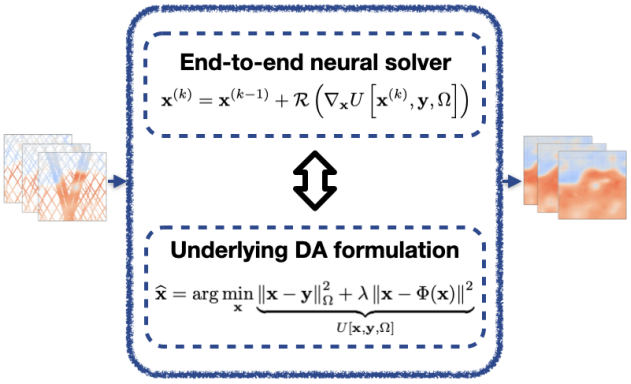
| **Program LEFE/ MANU-GMMC** | **Project Title**<br>*IA-OAC (*Modèles et Stratégies d'Intelligence Artificielle pour l'Océan, l'Atmosphère et le Climat*)* | **Years 2019 – 2022** |
|---|---|---|
| PI: Ronan Fablet, IMT Atlantique, Lab-STICC<br>Participating Laboratories: IGE, INRIA AirSea, INRIA Odyssey, IGE, IPSL, LOPS | Contribution to CNES/NASA SWOT ST and OSTST<br><br>Other funding sources: CNES, ANR | |

***Context:*** *Bridging learning paradigms and model-driven ones in earth science has emerged as a key scientific topic to make the most of available observation and simulation datasets along with the expertise gained over the last decades in the design of earth system models, including at the operational level to address simulation, forecasting and reanalysis issues.*

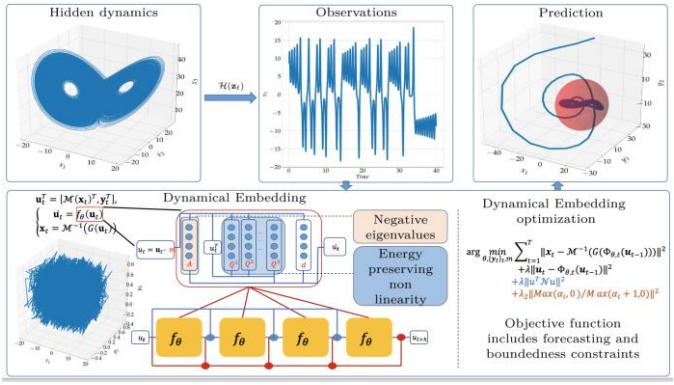
***Objectives / scientific questions*****:** in this context, we have addressed three specific challenges: (i) representation learning for ocean-atmosphere dynamics, (ii) deep learning for data assimilation, (iii) deep learning and uncertainty quantification.

***Main results:*** Beyond specific contributions which support the relevance of AI and more specifically deep learning schemes to advance the state-of-the-art for the modeling, forecasting and monitoring of ocean-atmosphere dynamics both for toy systems (e.g., Lorenz-63/Lorenz-96 dynamics) and real-world case-studies (e.g., sea surface height mapping), key contributions of the project lie in the specifications of experimental testbeds as well as in the participation to the emergence of various collaborative projects, in which AI topics are of strong interest (e.g., ANR Melody, AI chairs OceaniX and AI4CLIM, H2020 EditoModelLab…).

**4DVarNet-SSH**




**Bounded nonlinear forecasts of partially observed**




Illustrations of end-to-end neural schemes for the representation and reconstruction of geophysical dynamics: end-to-end neural 4DVar data assimilation scheme for the space-time interpolation of sea surface height fields from satellite altimeter data (Fablet et al., 2021) (left), physics-constrained deep learning schemes for bounded nonlinear forecasts of partially observed geophysical systems (Ouala et al., 2023) (right).

***Future of the project:*** *Several* national and international projects currently benefit and extend the collaborative framework initiated by IA-OAC project (e.g., ANR Melody, AI chairs OceaniX and AI4CLIM, H2020 EditoModelLab, PPR projects Mediation and Climartic). Besides, initiatives in the context of GDRs "Défis théoriques pour le climat » and « OMER » shall extend the scientific animation developed initially in IA-OAC project.

*Number of publications, communications and theses*

> 10 PhDs defended or in progress co-supervised by IA-OAC participants on topics at the crossroads of AI and ocean-atmosphere-climate science

> 30 journal publications and > 30 communications co-authored by authors from at least two teams involved in the project

*Data availablility*

*Some of the datasets and codes associated with the project are available through open source licenses onto the following two github organisations: https://github.com/CIA-Oceanix and https://github.com/ocean-data-challenges.*