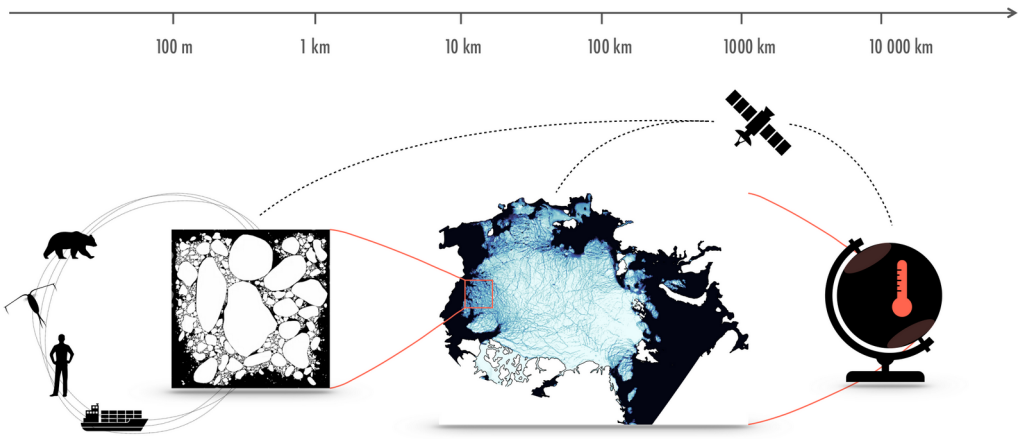
PhD and/or Postdoc positions at École des Ponts ParisTech

Deep learning, data assimilation and sea-ice dynamics

Context:

The Scale-Aware Sea Ice Project (SASIP), aims at developing a truly innovative, scale-aware continuum sea ice model for climate research; one that faithfully represents sea ice dynamics and thermodynamics and that is physically sound, data-adaptive, highly parallelized and computationally efficient. SASIP will use machine learning (ML) and data assimilation (DA) to exploit large datasets obtained from both simulations and remote sensing.



The Scale-Aware Sea Ice Project

Through the further development of existing important state-of-the-art simulators created by some of the investigators, SASIP will build a data-constrained sea ice model that is based on solid-like physics. This model will allow improved high resolution and large scale predictions of Arctic and Antarctic sea ice, and the propagation of sea ice related climate feedback. Employing hybrid DA and ML approaches as a native part of the model architecture will allow for objective combinations of models and data. Ultimately, SASIP will give a better understanding of the impact of amplified warming in polar regions through the development of a model that reduces uncertainties related to global earth systems.

SASIP is an international project funded and supported by the Schmidt Futures foundation:
https://schmidtfutures.com/our-work/scientific-knowledge.
Link to the SASIP website:
https://sasip-climate.github.io

CEREA is a joint laboratory of École des Ponts ParisTech and EdF R&D and a member of Institut Pierre-Simon Laplace (IPSL), and has an internationally recognized expertise in data assimilation and machine learning applied to the geosciences. CEREA will lead Task 4.3 of SASIP WP4, which is entitled *Data Assimilation and Machine Learning*, and will strongly interact with other members of WP4 and of the whole SASIP team.

A **PhD position (3 years)** and/or a **postdoc fellow position (at least 2 years)** is offered at ENPC/CEREA to work on Task 4.3.

Workplan:

The goal of Task 4.3 of the SASIP project is to design sub-grid-scale parameterizations and parameter estimation using ML, to improve sea ice models. Such methods will be based on pure ML techniques, especially deep learning (DL), as well as hybrid ML and DA techniques. In parallel, the international experts of sea ice modeling in SASIP will develop a sea ice model that takes advantage of the physical realism of the Maxwell-Elasto-Brittle (MEB) rheology.

First, in order to build sub-grid-scale parameterizations of MEB physics, we will train deep learning architectures using as data the differences between the MEB model and either granular models or observations. When comparing the MEB model with the granular model, or real data, a challenge arises as ML methods must also learn the hidden relationship between continuum and granular scales.

Second, in the wake of this first work, data-driven parameterizations developed in Task 4.3 will be compared to the physical ones obtained in other Tasks of the SASIP project.

Third, hybrid DA-ML methods formerly proposed by SASIP team members, which are able to use sparse and noisy data to handle model reconstruction will be used in heterogeneous regions such as the Marginal Ice Zone where sea ice meets ocean waves.

Key words:

Sea-ice, Machine learning, Deep learning, Data assimilation, Galerkin discontinuous methods.

Bibliography:

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- Brajard, J., Carrassi, A., Bocquet, M., & Bertino, L. (2021). Combining data assimilation and machine learning to infer unresolved scale parametrisation. *Phil. Trans. R. Soc. A,* 379, 20200086.

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- Bocquet, M., Brajard, J., Carrassi, A., & Bertino, L. (2019). Data assimilation as a learning tool to infer ordinary differential equation representations of dynamical models. *Nonlin. Processes Geophys. 26, 143–162.*

Supervisions:

The PhD and/or the Postdoc fellow will be supervised by Marc Bocquet and Alban Farchi at CEREA, a joint laboratory of École des Ponts ParisTech and EdF R&D.

Collaborations:

A close collaboration will be established with Alberto Carrassi at the University of Reading, United Kingdom as a secondment, with interactions with other members of SASIP WP4, and the rest of the project members at large.
Moreover, the team of WP4 and in particular Task 4.3 will get strong support from data science and computer scientists of the Schmidt Futures foundation for CPU/GPU/TPU computations.

Location:

The PhD candidate and/or Postdoc fellow will be based at École des Ponts ParisTech (Champs-sur-Marne, within 20 mins to Paris Centre, RER A Noisy-Champs). A few-weeks stays in the University of Reading, UK and the NERSC Institute in Bergen, Norway will be planned.

Duration:

3 years, PhD start: fall of 2021.
2 years, Postdoc, start: from April 2021 on.

Skills and profile:

- The PhD candidate must have a master degree in ocean sciences, geosciences, machine learning, computational physics or applied mathematics. Moreover, the candidate should be comfortable with the programming languages Python (mainly) and C/C++. Some knowledge of deep learning tools such as Keras/TensorFlow, PyTorch is desired.
- Additionally, the Postdoc fellow should have a strong background in ML, DL and/or DA, possibly applied to the geosciences.

Contact:

Send an email to Prof. Marc Bocquet (marc.bocquet@enpc.fr) with CV and motivation letter.