2021-03488 - PhD Position F/M [Cordi-S Campaign 2021 Grenoble] Low-dimensional structure of ocean data assimilation problems via gradient information

Type de contrat : CDD
Niveau de diplôme exigé : Bac + 5 ou équivalent
 Fonction : Doctorant

A propos du centre ou de la direction fonctionnelle

Grenoble Rhône-Alpes Research Group centers together a few less than 650 people in 37 research teams and 8 research support departments.

Staff is localized on 5 campuses in Grenoble and Lyon, in close collaboration with labs, research and higher education institutions in Grenoble and Lyon, but also with the economic players in these areas.

Present in the fields of software, high-performance computing, Internet of things, image and data, but also shown in oceanography and biology, it participates at the best level of international scientific achievements and collaborations in both Europe and the rest of the world.

Contexte et atouts du poste

The PhD thesis will take place at the Université Grenoble Alpes in the Inria-AIRSEA team. This work is part of an ongoing collaboration with Monash University and MIT (https://team.inria.fr/unquestionable/).

Mission confiée

One of the many achievements of computer aided simulations has been the sharp improvement in the prediction capabilities of weather and climate, with undeniable benefits for society: extreme weather preparedness, mitigation of climate change effects, agricultural planning etc. The quality of the simulations rely on the ability to acquire data about the present state and the past state and to assimilate these data in the numerical model to make reliable predictions. This task is referred as data assimilation.

There exists a zooology of approaches to solve data assimilation problems: variational methods, particle filter methods, ensemble methods etc [3]. Classical assimilation methods, however, perform poorly when the dimension of the problem is large because the data are not informative enough to make any relevant correction of the high-dimensional state. This phenomenon, called the “curse of dimensionality”, is a major challenge for large-scale assimilation problems [2]. A promising workaround is to detect and exploit the low-dimensional structure that the problem might have. For instance, the gradient-based methods proposed in [3,4] permit to identify a low-dimensional subspace on which the data are informative. Knowing this subspace in advance allows putting the numerical effort in the relevant directions and yields significant computational savings. While these methods have shown they potential on academic problems, their application to large-scale ocean models remains an open challenge.

In this PhD, we aim at developing new algorithms based on transport maps to sample from complex posterior distributions arising in ocean data assimilation problems. To achieve this, the candidate will first extend the methodology [5] to detect the nonlinear manifold that is informed by the data. Compared to [3,4], we expect to obtain a much more efficient dimension reduction, which is the key to efficient sampling strategy. A thorough theoretical analysis and a numerical validation on various benchmarks of increasing complexity will guide the elaboration of the technique. After identifying the low-dimensional structure, the candidate will then apply transport-based techniques to approximate the posterior density. Transport-based techniques have recently shown their potential in machine learning applications see [6,7]. By and large, the standard approaches adopt a density estimation perspective in which one only has access to samples from the target density. In contrast, we plan to adopt a function approximation perspective in which the posterior density is seen as a function to approximate. The low-rank tensor framework proposed in [8] seems particularly relevant in this context. We aim at showing theoretically and numerically that the low-rank tensor approximation benefits from the initial dimension reduction step.

Related literature:

3. [3] Zahm, Cui, Law, Spantini, and Marzouk “Certified dimension reduction in nonlinear Bayesian inverse problems” arxiv 2018

Compétences

This PhD work is at the crossroad between data assimilation and numerical simulations. Candidates must have good knowledge for at least one of these domains and the motivation to quickly acquire the missing complementary skills. This research work will involve both theoretical developments and
practical implementation. Candidates should have demonstrable experience and skill in some of the following topics: scientific creativity, autonomy, writing abilities, oral communication skills (English and possibly French), and taste for teamwork.

Avantages

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking two days per week and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

Rémunération


Monthly salary after taxes: around 1596,05€ for 1st and 2nd year. 1678,99€ for 3rd year (medical insurance included, income tax excluded).