FINAL REPORT PROGRAM LEFE

Program LEFE/ MANU	Project Title *Nouvelles Approches de Parallélisation pour l'Océan et l'Atmosphère : la dimension temporelle»*	Years 2016 and 2017
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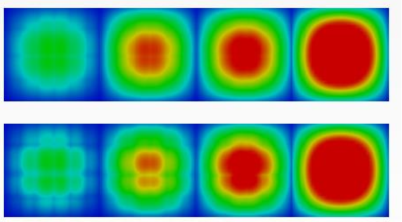
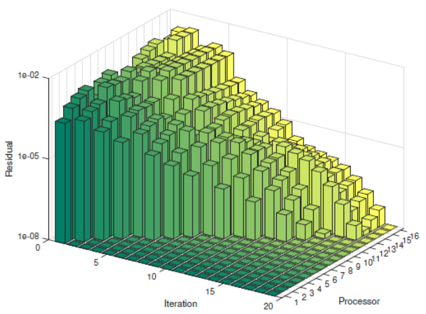
***Context**:*
Supercomputers composed of millions of cores, overall applicability to everyday algorithms unless significant effort is spent to tune the application towards it. Developing new parallel algorithms, like asynchronous time domain decomposition methods might be an alternative for solving complex equations of oceanic models on such large number of cores.

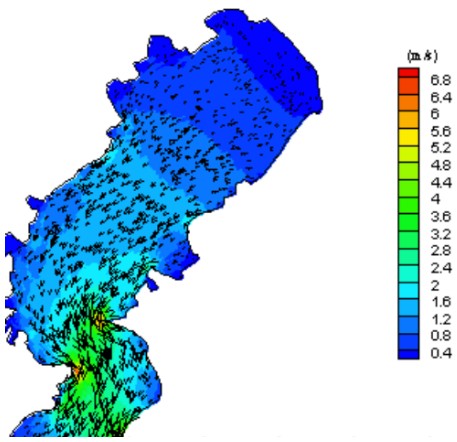
Objectives / scientific questions:
The project is dedicated to the study of asynchronous parallel algorithms for oceanic models. The aim is first to study the constraints related to asynchronous iterations in terms of stability and accuracy for a given application, and then to propose innovative asynchronous alternatives to existing synchronous schemes.

Main results:
The different results investigated during the project are the following:

- it is essential to study the mathematical convergence of the asynchronous model for each application field and to analyze carefully the rate of convergence of the associated synchronous model;
- it is important to define so called asynchronous global residual criteria to get accurate estimate of the asynchronous solution;
- asynchronous-based preconditioning techniques appear fundamental to achieve robust and stable convergence.







(Left top) Comparison of synchronous (first row) and asynchronous (second row) *solutions* at different iteration's number of the algorithm. **(Left bottom)** Example of the evolution of the *global residual criteria* upon the number of asynchronous iterations and the number of processors. Closeup of the first sixteen processors. **(Right)** Example of the water depth elevation in a bay at convergence of the algorithm. The black arrows indicate the speed of the waves.

Future of the project :

Thanks to the project "*Nouvelles Approches de Parallélisation pour l'Océan et l'Atmosphère : la dimension temporelle »* several asynchronous alternatives to existing synchronous have been investigated and thoroughly studied at a theoretical level. Important properties that the numerical algorithm of a given model should satisfy to ensure asynchronous convergence have been emphasized. The next steps are the following:

1. Global convergence criteria can be simplified and generalized to any time dependent problems. This work has been initiated in the framework of a collaboration between CentraleSupélec and other French Universities.
2. Redesigning the numerical kernel of the JACK asynchronous library to deal with complex oceanic models. This redesign will occur in 2018-2021 notably thanks to the project *ANR Asynchronous Domain Decomposition Methods* involving the actual partners of the project "*Nouvelles Approches de Parallélisation pour l'Océan et l'Atmosphère : la dimension temporelle »*.

Nombre de publications, de communications et de thèses
(citer au maximum 5 publications en lien direct avec le projet)

1. Q. Zou and F. Magoulès. *Convergence Detection of Asynchronous Iterations based on Modified Recursive Doubling*, in Proceedings of the 17th International Symposium on Distributed Computing and Applications for Business Engineering and Science, Wuxi, China, October 19-23, 2018. IEEE Conference Publications, 2018.
2. Q. Zou and F. Magoulès. *A New Cyclic Gradient Method Adapted to Large-Scale Linear Systems*, in Proceedings of the 17th International Symposium on Distributed Computing and Applications for Business Engineering and Science, Wuxi, China, October 19-23, 2018. IEEE Conference Publications, 2018.
3. F. Magoulès and Q. Zou. *Asynchronous Time-Parallel Method based on Laplace Transform*. International Journal of Computer Mathematics. Submitted.