A gentle introduction to data assimilation and HPC Applications on an HPC platform

samedi 15 juin 2024 - samedi 22 juin 2024

Université Française en Arménie

Scientific Programme

The summer school in Armenia, brings together academic expertise from the University Toulouse 3 and the French University in Armenia. The workshop will provide introductory-level courses on Data Assimilation and High-Performance Computing. By providing foundational education and laying the groundwork for a CIMPA school. This project aims to support long-term development in the field of applied data science, benefiting students, faculty, and the broader academic community in Armenia and border countries. The course is designed for students in their first year of the Master's program in mathematics or numerical computing, but we also warmly welcome highly motivated students in their final year of their bachelor's degree.

Lectures 1 Introduction to data assimilation

Jérôme Fehrenbach (IMT Toulouse) and Elisa Gulgulyan (UFAR Yerevan)

This course will provide the main theoretical insights that are behind variational data assimilation. These keys concepts will be illustrated by toy examples during numerical sessions. The mathematical prerequisites are: matrix calculus, elementary Ordinary Differential Equations, gradient and partial derivatives. The hands-on sessions will use the language Python together with the libraries numpy, scipy, matplotlib. It is recommended to have the spyder interface installed www.spyder-ide.org

Course outline
Introduction: examples, variational formulation, Bayesian interpretation
Optimization basics: gradient descent, constrained optimization, Gauss Newton algorithm
Numerical solution of ODEs with Python
Toy optimization examples with Python
Derivation of the tangent model with examples
Derivation of the adjoint model with examples
Implementation of a tangent model
Implementation of an adjoint model
One data assimilation test case

Lectures 2 Introduction to HPC computing

Hrachya Astsatryan (National academy of sciences of Armenia) and Hélène Hénon (INRIA Grenoble)

Course outline
Introduction to High-Performance Computing
Concepts and importance of HPC
Overview of HPC hardware and software
Access and use of HPC resources
Performing basic tasks on an HPC cluster
Introduction to parallel computing
Practical exercises with a simple parallel program
Parallel Programming and Applications
Understanding parallelism and concurrency
Introduction to parallel programming models (e.g. MPI)
Writing parallel code in MPI
Introduction to advanced HPC topics (e.g. GPU computing, distributed computing)

Debugging and profiling parallel programs
Real-life HPC applications
Linking data simulation with HPC