2SC7693 – Optimization of infrasonic wave detection for verification of the Comprehensive Nuclear-Test-Ban Treaty

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Language of instruction: ANGLAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 80
On-site hours (HPE): 48,00

Description

Project topic in partnership with CEA DAM.

Rmk : Project proposed to students of **European Union**

CEA-DAM uses high performance computing resources for its various missions, particularly in the environmental monitoring field (e.g. seismic or acoustic wave propagation phenomena). The “Département d'Ile de France” located in Bruyères-le-Châtel is thus the tsunamis and strong earthquakes french warning center. As part of its missions and based on its skills in the nuclear area as well as in detection and identification technologies, CEA-DAM also brings its expertise for fighting against nuclear proliferation and terrorism. In order to inform national authorities in case of a nuclear test, CEA-DAM thus participates in the implementation of verification means to assess the non-violation of the “Comprehensive Nuclear-Test-Ban Treaty” (CTBT).

The study proposed here concerns the characterization and detection of infrasonic waves at long distances, taking into account the topography and atmospheric conditions (e.g. wind here). A compressible 2D axisymmetric / 3D hydrocode which supports adaptive mesh refinement (AMR) and hybrid parallelism (MPI domain decomposition / OpenMP multithreading) on Cartesian grids is developed in our laboratory. It can simulate the propagation of blast and acoustic waves in the presence of relief and buildings, with or without wind. Judiciously located sensors allow overpressure signals recordings.

Two types of problems which will be solved with this AMR hydrocode are addressed here. The first one consists in localizing an explosion and determining its power on the basis of probes’ recordings located in the scene. The second one consists in defining judicious sensors locations in order to maximize the chances of detection in case of explosions in a given area. In both cases, a "brute force" investigation consisting in simulating all possible configurations before retaining

the best one is unthinkable. It would consume gigantic hours of computations, which would make the design of the solution very long and overpriced.

For these two types of problems, the objective of this study is therefore twofold:

- Propose a solution to characterize the source of acoustic waves.
- Find this solution in a reasonable time on high-performance computers AND with a limited quota of computation hours.

To that end we will develop an optimization loop that uses the hydrocode the most efficiently as possible, by parsimoniously exploring the possible configurations space, to economically find a “good” solution.

Technical details of the studied systems

- **1st topic: characterization of a source at the urban scale, taking into account buildings**

  It consists in locating and determining the power of an explosion, following an accident or a malicious act, knowing only neighboring sensors recordings (whose locations are known). Buildings in the surrounding area will be taken into account. Here, the recordings will come out in practice from a simulation whose fictitious initial conditions (location and power of the source) will not be known by the students.

- **2nd topic: setting up a surveillance network**

  Here, it is question of designing a sensors network allowing the detection of hypothetic explosive experiments around an area that is under surveillance. These sensors - in limited numbers - should be judiciously located in order to maximize chances of detection whatever the weather (we will only consider wind here) and the relief are. Furthermore and for maintenance reasons, the sensors will only be located in so-called "accessible areas”.

Quarter number
ST7

Prerequisites (in terms of CS courses)
First year courses:

- SG1 common course "Systèmes d'Information et Programmation" (1CC1000)
- ST2 common course "Algorithmique et complexité" (1CC2000)

Courses of the ST: