High Performance Computing in Ocean Modeling

Presented By

Dr. Zeeshan Ahmed Khan

The Nelson Mandela African Institution of Science and Technology, Arusha

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Introduction

- Ocean economy is large and diverse, accounting for approximately US$1.5 trillion in total global value added. This value is expected to more than double by 2030.
- Apart from traditional maritime sector, there is now wide range of industrial activities like offshore oil and gas exploration, marine renewable energy and aquaculture. Overfishing, pollution, rising sea temperatures and levels, ocean acidification, and biodiversity loss are the greatest impacts on ocean health.
- The foundations upon which much of the worlds well-being and wealth depend is threatened by unsustainable use of ocean resources.

Ocean Modelling

- Ocean models are numerical models of ocean properties and their circulation.
- Numerical ocean models becomes important tools for humans to study ocean activity. As performance of supercomputers has accelerated over decades, application of numerical ocean models in High Performance Computing (HPC) is also rapidly developing.
- They play a large role in our understanding of the ocean's influence on weather and climate.

Ocean Modelling Types

- General circulation models (GCMs)
- Linear, continuously stratified (LCS) model: (barotropic and baroclinic modes)
- Layer ocean models (LOMs)

Importance Ocean Modelling

- The simulation ability and range have improved a lot, through refined spatial discretization, grid configurations, parameterizations, etc. Models are now used for a variety of purposes:
- Simulating the large scale such as the Southern Ocean and the Meridional Overturning Circulation and its variability
- Simulation of submesoscale variability and evaluating parameterizations of submesoscale effects; small-scale process studies including important nonhydrostatic effects. Sea ice, ice shelves and high-resolution atmospheric models are now coupled to ocean circulation models, and the development has driven improvements in ocean and coupled system numerics.

Importance Ocean Modelling

- Modelling and prediction of ocean currents in coastal regions is important for many reasons, including influences on recreation, navigation, algal bloom formation, effluent dispersion, search and rescue operations, and oil spills.
- Information from marine science helps us understand how we are affected, including changes in weather and climate. Insights from ocean research help us understand and respond to earthquakes, tsunami, etc.

Challenges in Ocean Modelling

- In order to understand the mechanism of atmospheric and oceanic turbulence and the climate, it is necessary to simulate properly the interaction mechanism of the atmosphere and the ocean.

- The accuracy and performance of any model simulation is limited by the resolution of the finite difference grid. Increasing the grid resolution increases the computational demands not only by the increase of the number of points in the domain, but also because numerical stability requirements demand a smaller time step on a finer grid.

Regional Ocean Modeling System (ROMS)

- It is a free-surface, terrain-following, primitive equations ocean model widely used by the scientific community for a diverse range of applications.
- ROMS is used to model how a given region of the ocean responds to physical forcings such as heating or wind. It can also be used to model how a given ocean system responds to inputs like sediment, freshwater, ice, or nutrients, requiring coupled models nested within the ROMS framework.
- ROMS is a 4D modeling system. It is a 3-dimensional model (a 2D horizontal grid and a vertical grid) that can be run over a given amount of time, time being the 4th dimension. It is gridded into vertical levels that make up the water column and horizontal cells that make up the coordinates of the 2D cartesian plane of the model region.

Regional Ocean Modeling System (ROMS)

- The implementation of ROMS supports two parallel computing models; a distributed memory model that utilizes Message Passing Interface (MPI), and a shared memory model that utilizes OpenMP. Prior research has shown that portions of ROMS can also be executed on a General Purpose Graphics Processing Unit (GPGPU) to take advantage of the massively parallel architecture available on those systems

High Performance Computing
PARAM KILIMANJARO

CEIT NM-AIST @Tanzania

- The Centre for Development of Advanced Computing (C-DAC), India has developed affordable supercomputer for educational institutes and industry for conducting high-end in-house research work. The supercomputer named PARAM KILIMANJARO has been developed by C-DAC having applications in scientific and engineering domains.

PARAM KILIMANJARO

PARAM KILIMANJARO Specifications:

- Total Computational Speed RPeak: 14.4Teraflops (Pure CPU 10 TF+GPU 4 TF)
- Total Nodes: 7 CPU nodes + 1 GPU node
- Total Cores: 5320 (CPU 160 cores + GPU CUDA cores 5160)
- Total Memory: 480 GB
- Storage: 100 TB + 30 TB Backup

Master's Programs

- Master's in Wireless and Mobile Computing
- Master's in Information System and Network Security

The learning objectives for Wireless and Mobile Computing Program are:

- To develop the concept of systems thinking in the context of mobile and wireless systems
- To develop knowledge of the interplay of concepts and multiple sub-disciplines in mobile and wireless systems
- To develop knowledge and experience in mobile interface and applications design, and development techniques and methodologies set in the context of a research project addressing a real-world application
- To gain knowledge and experience in applying various computation methods and algorithms as a part of software development
- To gain experience in evaluating mobile computing applications, computation methods and algorithms through experiments and simulations
- To read and understand scientific research papers and present them in a seminar talk.

The learning objectives for Information System and Network Security Program are:

- Analyze and resolve security issues in networks and computer systems to secure an IT infrastructure.
- Design, develop, test and evaluate secure software.
- Develop policies and procedures to manage enterprise security risks.
- Evaluate and communicate the human role in security systems with an emphasis on ethics, social engineering vulnerabilities and training.
- Interpret and forensically investigate security incidents.


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