Benchmark Approach for Regional Climate Model in HPC Platforms

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Abstract **— Now a days several models are available for the regional climate studies like Weather Research and Forecasting (WRF) Model, MM5 model, etc. which are designed to serve both atmospheric research and operational forecasting needs. RegCM is a Regional Climate Model Regional climate models (RCMs) are widely used tools to produce high resolution climate simulations at regional scales. In the growing age of HPC and Modelling, Satellite data its very important to use the modelling approaches to understand the weather and climate at regional scale (with very high resolution). The model has the ability to produce simulations reflecting either real data or idealized atmospheric conditions. It provides a flexible and computationally efficient platform for operational forecasting, The model also offers advances in physics, data assimilation and numerics. It can be more precisely defined as knowledge based system development that will provide researchers and atmospheric scientist to choose and designed a more advanced and doctored approach for predicting weather and configuring the system. In this paper an approach of a benchmark of RegCM is studied using the HPC system.**

Keywords— RegCM, Model Dynamics, Model Benchmarking, HPC.

I. INTRODUCTION

Weather is the day-to-day state of the atmosphere in a region, and its short-term variation whereas Climate is defined as statistical weather information that describes the variation of weather at a given place for a specified interval. Both are used interchangeably sometimes but differ in their measure of time, and trends that affect them. To understand the behavior of the atmosphere and predict the hereafter variation various models were used: global or regional. Various organizations and research institutes carryout the research activities to simplify the process with high end technologies and framework by developing sophisticated climate models. Climate models describe several compartments of the climate system, as for instance, the atmosphere, the oceans, the cry sphere, the surface hydrology, the vegetation, or cycles of matter.

The meso-scale weather prediction Model is designed to serve both atmospheric research and operational forecasting needs it is a next-generation meso-scale numerical weather prediction system. For the purpose of parallel computation and system extensibility it features two dynamical cores, Several applications including wide range of meteorological applications across scales ranging from meters to thousands of kilometers. The model has the ability to produce simulations reflecting either real data or idealized atmospheric conditions. It provides a flexible and computationally efficient platform for operational forecasting, The model also offers advances in physics, data assimilation and numerics. The objective of this study is to make aware of various sensitive features and understand the model from insight. Model physics includes understanding the various laws and factors that governs the interaction between model components and the matter of the atmosphere. It includes various convection schemes, boundary layer, radiative transfer, land surface processes etc.

The applications of the weather and climate models include:

- To predict the future atmospheric changes
- To prevent catastrophic storms, cyclones etc
- To understand the rainfall, vegetation, land usage of particular region.
- To help in initiating plan for extreme weather events
- To support city planners and architects.

II. LITERATURE REVIEW

The Regional Climate Model system RegCM ,which is maintained in the Earth System Physics (ESP)which is a section of the ICTP, It was developed originally at the National Center for Atmospheric Research (NCAR). This model provides a flexible, portable and easy to use platform. It can be applied to a large region of the World, with the grid spacing of up to about 10,000mts (hydrostatic limit), and for a wide range of studies, from process studies to paleo-climate and future climate simulation. The history of numerical weather prediction began in the 1920s through the efforts of Lewis Fry Richardson who utilized procedures developed by Vilhelm Bjerknes. Prior to Norwegian scientist Bjerknes, the chapter of meteorology was opened by Cleveland Abbe [1]. It was not until the advent of the computer and computer

simulation that computation time was reduced to less than the forecast period. ENIAC initiated and created the first computer forecasting system in 1950, and more powerful computers later increased the size of initial datasets and included more complicated versions of the equations of motion. In 1966,West Germany and the United States began producing operational forecasts based on primitive-equation models, followed by the United Kingdom in 1972 and Australia in 1977 [1]. The development of global forecasting models led to the first climate models. The development of limited area (regional) models facilitated advances in forecasting the tracks of tropical cyclone as well as air quality in the 1970s and 1980s.

A. Overview of HPC

High Performance Computing (HPC) is the generic name for the most powerful system available at the front line of current processing and simulating capacity, particularly in terms of speed of calculation. The term "SUPERCOMPUTER" is used to denote such class of system that can advance knowledge and generate insight that would not be otherwise be possible or that could not be captured in time to be actionable. They are the indispensable tools for solving the most challenging and complex scientific and engineering problems including the simulation and modeling of physical phenomena. As the technology advances to a new era the core component of any computation i.e., data is not stable and to compete with such petabytes of data's modest computing system is required. However many fast processing systems were developed, yet they are dawdled by scaling, timeliness, architectural design and ability to address important issues. Thanks to the advancement in petascale computing technologies that will overcome the processing and performance constrain of computing resources. One motivation of such computing is to aggregate the power of multiple system in to single system to study the high end calculation intensive task that cannot be possible with single core system. To achieve this goal, proper understanding of system tools, software and underlying hardware is essential.

The development can be traced back to 1960 with the initiation of first supercomputer CDC 6600 by Seymour Roger Cray at Control Data Corporation. With time their developed more such system that can exploit the processing speed and performance, few with thousands of processors and others more than that. Though the market was flourished by European design yet, India was no way out from the challenge, and the development was marked by India's first supercomputer Param 8000 built in 1990 by Center for Development of Advanced Computing (CDAC).

B.Applications of HPC in Weather Forecasting

Supercomputers are the body builders of the computing world. They boost the computing power and cost millions of dollars. The machine can be used in both scientific and business applications, mostly they are used to tackle scientific calculation. It finds its uses from uncovering the origins of the universe to delving into the patterns of protein folding that make life possible. The few classes of applications are listed below. Several studies and projects are being carried out in NASA, MRI Japan, Meteo-France, WMO, NCEP, NCAR, ECMWF in internationaly and MoES, IITM, CSIR C-MMACS, NCMRWF, IMD, ISRO etc in India regarding the Weather prediction and forecasting system for the accurate and advanced prediction of monsoon, disasters like Cyclone, Extreme weather events etc. to avoid the losses of live and money

III. System Model Description

All models share the same objectives: process studies, diagnosis and forecasting. The four major components of modern coupled climate models which includes atmosphere, ocean, land surface, and sea. The development of each component raises important questions as to what is the road map to guide the development of the model architecture and how the physical processes are represented in models. Climate modeling has been steadily improving over the past several decades, but the pace has been uneven because the goal of simulation has several important aspects of the climate system that present severe challenges.

The design of this system consists of two different inputs called as initial and boundary condition. Initial conditions generally taken from different satellites on timely basis and Boundary condition generally taken from the historic or climatological data as well as validate terrain and ungrib dataset. It describes the detailed model configuration needed for the RegCM model. On a long run, statistics can be accumulated that give information on the performance of a particular model or forecast system. On the other hand In climate change simulations, the models can be used for projections of possible future changes over time scales of many decades and for which there are no precise past details

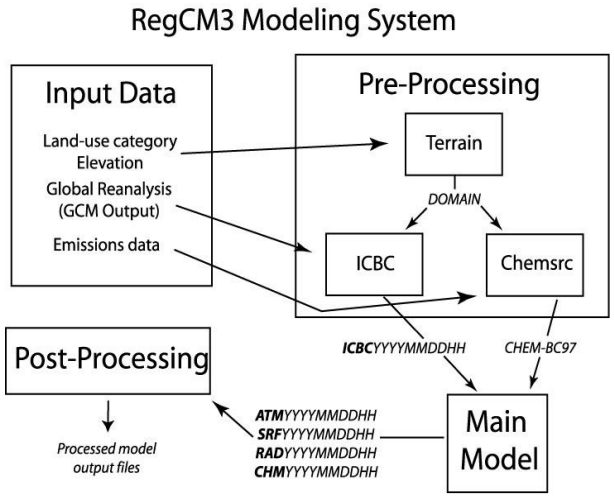

Fig 1 RegCM Flow of Work

The boundary conditions derived from Global Climate Model output can be assimilated into the RegCM3. The Boundary conditions for Regional Climate Models are derived by preprocessing saved GCM fields into a standard format that can be read into the model. The RegCM4 model is a hydrostatic, sigma vertical coordinate, compressible model that runs on different grid structure with various convection scheme in which the atmospheric components like wind, rainfall, temperature etc and thermodynamic variables are staggered horizontally. The use of various scheme help the model customized to different weather and climate parameters like precipitations, sea surface temperature, wind etc.

IV Results and Discussions

The model performance and sensitivity to model physics options are studied using Weather Research and Forecasting model over different region in India for surface and upper air meteorological parameters in different seasons like summer and winter seasons. Generally, the combination of Pleim-Xiu land surface model. The utilization of the Pleim surface layer scheme, and Asymmetric Convective Model will produce the better estimates of temperature and relative humidity for a region wise variations. Several case studies were undertaken in the CMMACS HPC environment for the simulation of weather and climate parameters using the RegCM climate model. Firstly the model is installed and benchmarked in three machines, a comparative evaluation and optimization resources are studied. In the present case the monsoon rainfall is simulated and compared with the IMD observed rainfall climatology. A comparative evaluation of the model execution time on different machines for simulation of 1 month duration has been studied. It is inferred that Altix machine with 12 processor in parallel run is the efficient and optimized.

The main part of the work is to understand the capabilities of the regional climate model to capture the weather and climate parameters accurately, so to study this several sensitivity studies were carried out and it is found that in general, model overestimates and underestimates pre-monsoon and monsoon rainfall, respectively. For sub-annual scale (March-November) and averages from 4 years (1991, 1994, 1996 and 1999), it is found that estimated rainfall by Model and observation is 2432.18 and 2398.30 mm, respectively. More research work is necessary on other model options and other parameters for long term data analysis. Once the option is settled then the RegCM outputs may be useful in real time and high resolution rainfall forecasting over India.

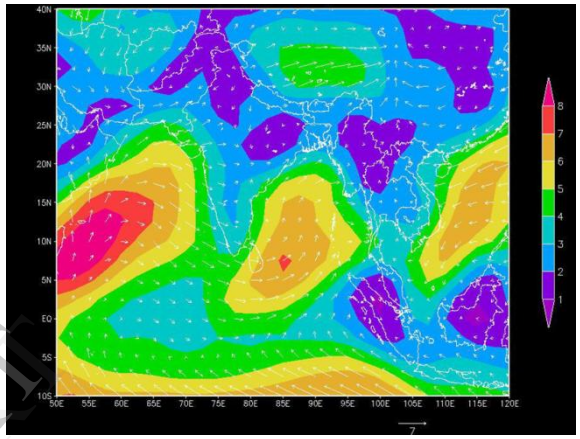

Fig 2: Plotted wind vectors for zonal and meridional components

Conclusions

The model will emphasize on the evaluation of the RegCM in the high performance computing (HPC) and cloud computing environment. Basically the model will be tested in the computing platform, how well the model performs to predict and forecast the weather and climate. Finally the evaluation of high resolution weather model for the climate studies at regional scale will be carried out with different case studies like prediction of a heavy rainfall event or cyclone etc. This model will emphasize on predicting the weather and climate at very high resolution ie at about 25 sq km.

Future Enhancement

This study can further be enhanced to study the different weather phenomena like monsoon rainfall forecasting, cyclone simulation, extreme rainfall events and extreme cold or hot days simulation etc., which in turn can be used by other sectors like agriculture, health, water and disaster sector etc. for a better forecasting assessment and mitigation of the disasters.

ACKNOWLEDGEMENT

The first author Indu B acknowledges to SPARK program of CSIR C-MMACS, HOD Computer Science and Engineering & Principal, SJB Institute of Technology, Bangalore for providing the necessary infrastructures to carry out the work.

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