Major Achievements

Carbon Cycle and Ocean Modelling

A comprehensive simulation and analysis of marine biogeochemical cycles was performed with TOPAZ and MOM4P1. A 150-year climatology run followed by a 60 year (1948-2007) interannual run were performed and these simulations have been able to reproduce a few of the observational features of the marine carbon cycle well.

Data from CO2 measurement stations at Hanle and Pondicherry have been used in carbon flux estimation for the first time. There is considerable reduction in posteriori uncertainties due to the use of this new data.

The existing Factor Analysis algorithms crucially depend on the positive-definiteness of a correlation matrix estimated from a set of input time series. However, noise in the time series could make a correlation matrix non-positive definite some time. Therefore, an important issue is how to extract the fundamental modes from a noisy data whose correlation matrix is non-positive definite. The present algorithm successfully addressed this issue in a novel way.

Climate & Environment Modelling

Significant progress has been made under the C-MMACS supra-institutional project Multi-scale Analysis of Sustainability and Vulnerability, with active participation from the research groups: Climate and Environmental Modelling, Solid Earth Modelling and Carbon Flux and Ocean Modelling, ably supported by the C-MMACS HPC group. One of the important developments is an algorithm for long-range forecasting of monsoon based on a novel ensemble methodology.

The year 2010-11 is the second year of the CSIR Network project Integrated Analysis for Impact, Mitigation and Sustainability (IAIMS), and it gives a sense of achievement to recordhere a number of results that were made possible through the Networking. A major achievement is the model of malaria epidemiology over Arunachal Pradesh validated using data provided by the Network partners from CSIR IICT. Significant progress has been also made in the area of arsenic toxicity (with CSIR IICB) and land-based carbon sequestration (with CIMAP).

The CSIR Outreach Programme in Environment and Climate (COPEC), a part of IAIMS, has seen active participation of eminent research groups from Indian Institute of Science, India Institute of Technology-Delhi, India Institute of Technology-Kharagpur and CSIR laboratorie. There is also active interest from other university and research organizations.

The CSIR Climate Observation and Modelling Network (CSIR COMoN), implemented through a multi-agency research alliance in a resource-sharing environment, has seen another year of efficient functioning as well as further expansion. The data from COMoN has enabled novel

analysis as well as calibration of model over India as outlined in the Report.

C-MMACS has embarked upon development of a ground-based cloud seeding technology as an effective and eco-friendly mitigation solution for water stress. The first prototype, codeveloped with industrial partner, was a part of the Water Pavilion (Gold Medal winner) in CSIR Technofest, 2010 at Pragati Maidan, Delhi. Three-dimensional dynamical cloud modelling, critical for making cloud seeding a precision scientific exercise, has been developed at C-MMACS; some of the results are outlined in this Report. The other critical components, like seeding material, are being developed and tested in collaboration with the Network partner, CSIR NAL.

Advance and accurate forecasts of rainfall can aid many sectors, from agriculture to disaster mitigation. However, for effective application, such forecasts must be at relevant spatial scales. Recognizing dynamical meso-scale forecasting as an emerging but promising technology, C-MMACS, in collaboration with Karnataka State Natural Disaster Monitoring Centre (KSNDMC), has initiated a pioneering project to usher in dynamical hobli-level rainfall forecasts using concepts and formalisms developed at C-MMACS.

M/S EID Parry, pioneer and leader in sugar production in India, has agricultural activities over multiple locations in Tamil Nadu. Recognizing that accurate and advance forecasts as well as agro-meteorological informatics for these regions can significantly aid the local farmers, M/S EID Parry has initiated a collaborative program in a resource-sharing environment with C-MMACS to develop a multi-scale forecast platform for precision agricultural planning combining observations, forecasting and analysis.

The collaboration between C-MMACS and academia has been active with exchanges and interactions. Dr Sanjeev Mahanta has obtained his Ph D under joint guidance of C-MMACS and Tezpur University this year.

Solid Earth Modelling

Solid Earth Modelling group has niche expertise in GNSS geodesy and Computational seismology with scientists from Engineering, seismology, geology, geophysics and physics background. Major achievements of the group during 2010 -2011 is quantification of inter, co and post seismic regional deformation in tectonically complex regions like Indian Himalayas, northeast , Andaman and Nicobar islands . The interseismic deformation is used to model the slip along the buried dislocations (Karakoram Fault) in Indian Himalayas, coseismic deformation in A and N island is used to model the geometry of rupture and slip due to Sumatra earthquake where as the post seismic deformation is used to model the progression of rupture and after slip in this region. The research contribution of computational seismology is to determine the ground motion parameters from scenario earthquakes using modeling and simulations in Delhi, Ahmadabad and Anjar. In addition to this we have given the deterministic hazard map of Indian subcontinent and also seismic hazard map using Bayesian approach. The Delay suffered by

GNSS signal when it passes through atmosphere has been used to estimate the precipitable water vapor(PWV) and Total Electron content (TEC) in Indian subcontinent. These estimates of TEC and PWV are being modeled to give their spatio-temporal variability over the Indian subcontinent

For the first time, finite source model of extended source has been used to simulate the ground motion time histories and the hazard parameters in terms of displacement, velocity, acceleration and response spectra related to earthquake engineering interest are estimated for Delhi city. It can be used reliably to formulate the building codes with a great impact on the effective reduction of their seismic vulnerability. The broadband seismic array has been established in Dharwar craton with 5 seismic stations. The array is fully operational and recorded more than 500 teleseismic events including the mega earthquake of Japan followed by hundreds of aftershocks. These events are being used to image a high resolution crustal and mantle structure.

Computational Mechanics

The effects of both convective and unsteady inertia have been studied on the dynamics and rheology of a dilute suspension of periodically forced neutrally buoyant spherical particles, at low Reynolds numbers, in a quiescent Newtonian fluid when the amplitude of the periodic forcing is low. A program based on Lattice Boltzmann method has been developed to address similar situations at higher Reynolds number with a point force approximation. Work on a Homotopy analysis method has been initiated to solve nonlinear ordinary differential equations by introducing a non-homogeneous auxiliary linear operator. This has been demonstrated by solving some standard nonlinear ODEs. The critical buckling load and fundamental frequency of carbon nanotubes have been evaluated using a simple, robust and powerful semi-analytical approach called the transformation technique, which has performed well with all types of boundary conditions.

High Performance Computing & Cyber Security

During the year 2010-2011, significant enhancement has been made to both the supercomputing and communication infrastructure at CSIR C-MMACS. The most significant among them was the installation and commissioning of the 6th fastest supercomputer in the country. The system consists of 1152 processor cores distributed over 96 nodes, which are interconnected in the form of an enhanced hypercube using 4XQDR Infiniband technology. The peak performance of the system is 13.5 TFLOPS, and the sustained performance measured by the High Performance LINPACK (HPL) is about 11.83 TFLOPS. With this system in place, C-MMASC currently has a total compute power of about 16 TFLOPS (peak) across 7 High Performance Computing Systems

As on end of March 2011, C-MMACS is in the final stage of getting connected to the National Knowledge Network (NKN) with a 1 Gbps Optical Fiber Link. Further, all network servers

namely DNS (Domain Name Server), NIS (Network Information Services), WWW (World Wide Web) and Internet gateway have been redesigned and migrated to new servers to provides secure, faster and reliable access to the computing facility.

The supercomputing facility, which includes the largest shared memory system in the country, was made operational on a round-the-clock basis with an uptime efficiency of more than 99%. Several CSIR laboratories have been remotely accessing the compute facility to solve challenging computational problems across various scientific disciplines.

The team has also taken up a new R & D project on cyber security under the CSIR EMPOWER scheme. As part of this activity, a detailed characterization of the nature and prevalence of IP spoofed Denial-of-Service Attacks is being done.

Laying of Foundation Stone for the Climate Simulation Building

Laying of Foundation Stone for the Cloud Chamber Building