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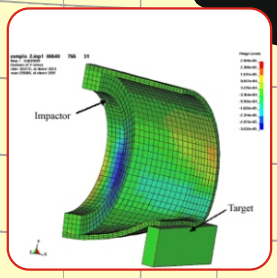
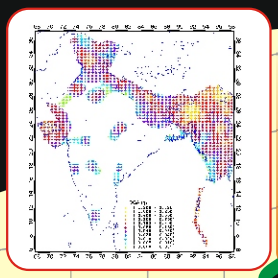
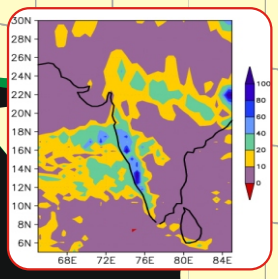
CO_2 Flux

Smart Structure

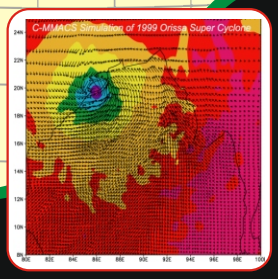




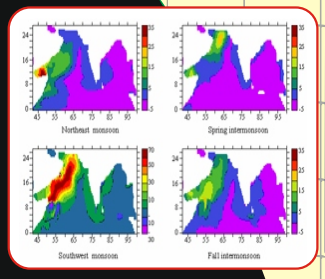
Seismic Hazard



Extreme Weather



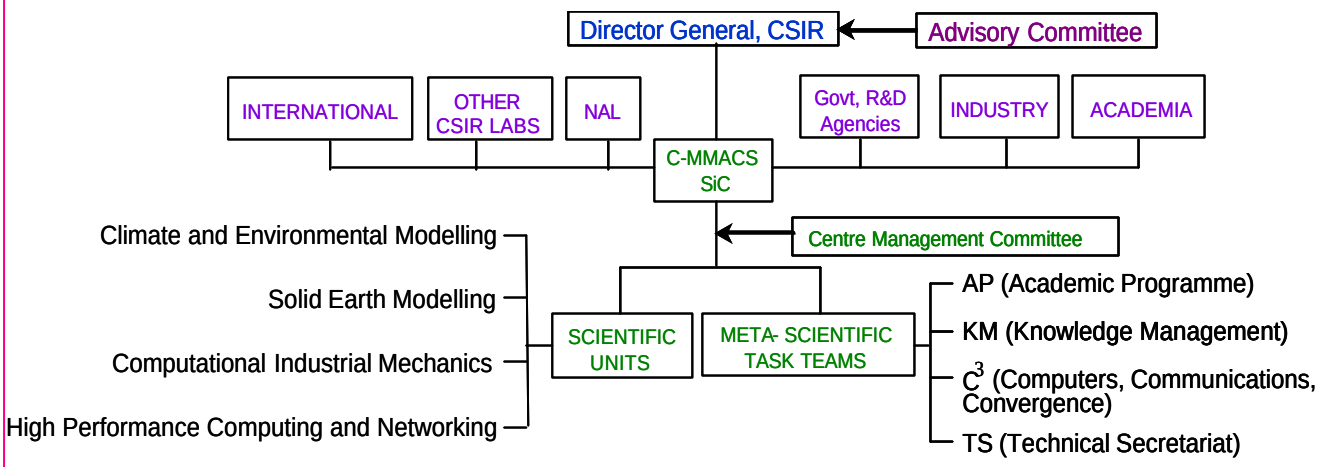
Tropical Cyclone



Marine Ecosystem

CSIR Centre for Mathematical Modelling and Computer Simulation

ORGANISATIONAL STRUCTURE OF C-MMACS



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C-MMACS

Annual Report 2004-2005

CONTENTS

1

Climate and Environmental Modelling Programme (CEMP)

Capacity to model and forecast climate and environmental processes at different spatio-temporal scales has the potential to revolutionize our approach and ability to address many issues that concern us closely. It was to address these issues in an integrated manner and to generate a capability for multi-scale forecasting that CEMP was initiated.

Highlights

The year 2005-20056 had seen a number of significant developments in CEMP. C-MMACS is now a major participant in a national multi-institutional extended -range monsoon prediction (MI-ERMP) programme, which seeks to improve prediction of monsoon rainfall with a multi-model ensemble. C-MMACS has been also involved in a number of national and international programmes and projects.

Inside

1.1 Experimental Forecasts of Monsoon Rainfall for 2005: Post-Forecast Evaluation

A major research programme at C-MMACS is to improve scope and skill of monsoon forecasting. We have developed and employed a new methodology termed Multi-Grid Ensemble (MuGE). Unlike in a conventional multi-lead (ML) ensemble using initial conditions from a number of observations (days); the multi-grid (MG) ensemble uses the variations in the forecasts due to small changes in the grid structure. While ML ensemble forecasting relies on model's response (memory) to differences in initial conditions, the MG ensemble represents a dynamical (and persistent) perturbation, thus providing an alternative and attractive method for enhancing forecast skill.

Traditionally, the day of the onset of monsoon is the day on which coastal Kerala receives it first monsoon rainfall of the season. It is obvious that a unique definition of onset does not (and cannot) exist, as the definition depends on the emphasis. With our focus on rainfall and the users, we have adopted a very functional definition of the onset.

The onset of monsoon is defined as the day in May/ June period on which rainfall occurs with the following characteristics:

(a) Large-scale: should occur more or less simultaneously over a number of stations.

(b) Significant: should be above a threshold value, typically 3 mm/day.

(c) Persistent: should last a few days with characteristics intermittently (day-to-day-variation).

(d) Sustained: The first spell should be followed by another rainfall spell with a gap of no more than 10 days.

While the criteria (a)-(c) have been advocated by others, the criteria (d) is our addition; its implementation requires forecasts for days subsequent to onset.

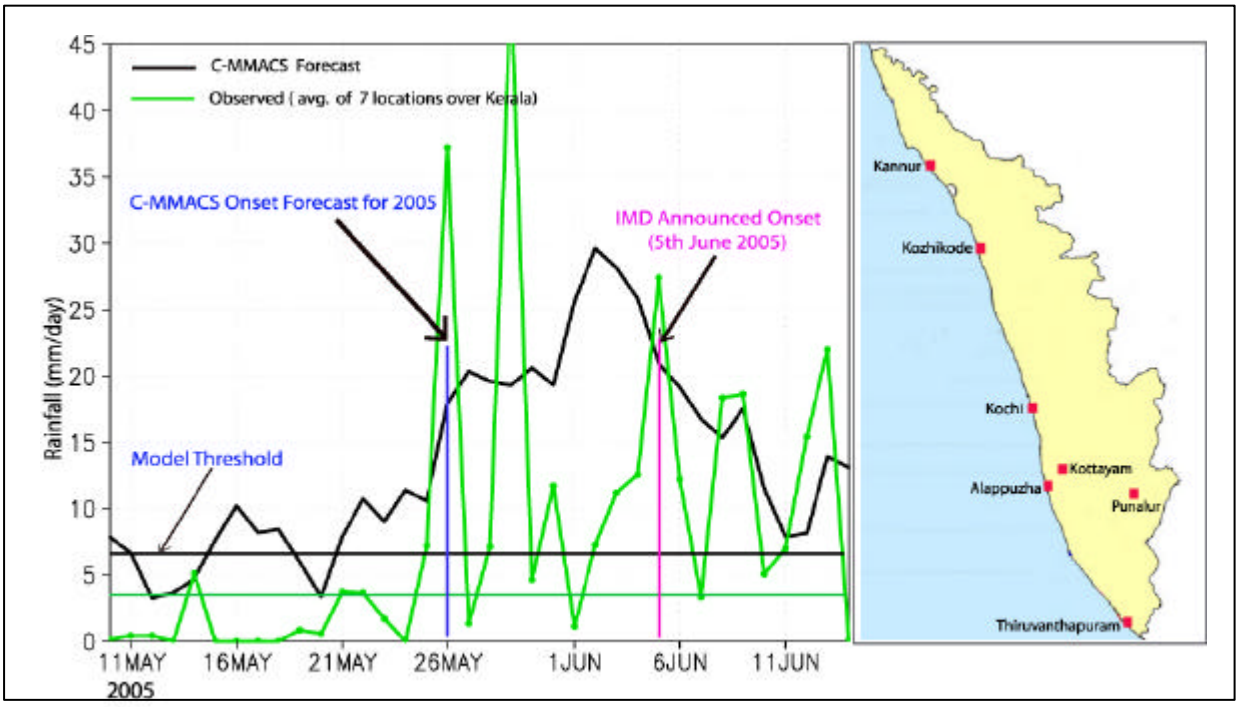

Figure 1.1 Time series of area-averaged (75-77E; 8-12N) daily rainfall over coastal Kerala. Day 1 corresponds to 1st May 2005.

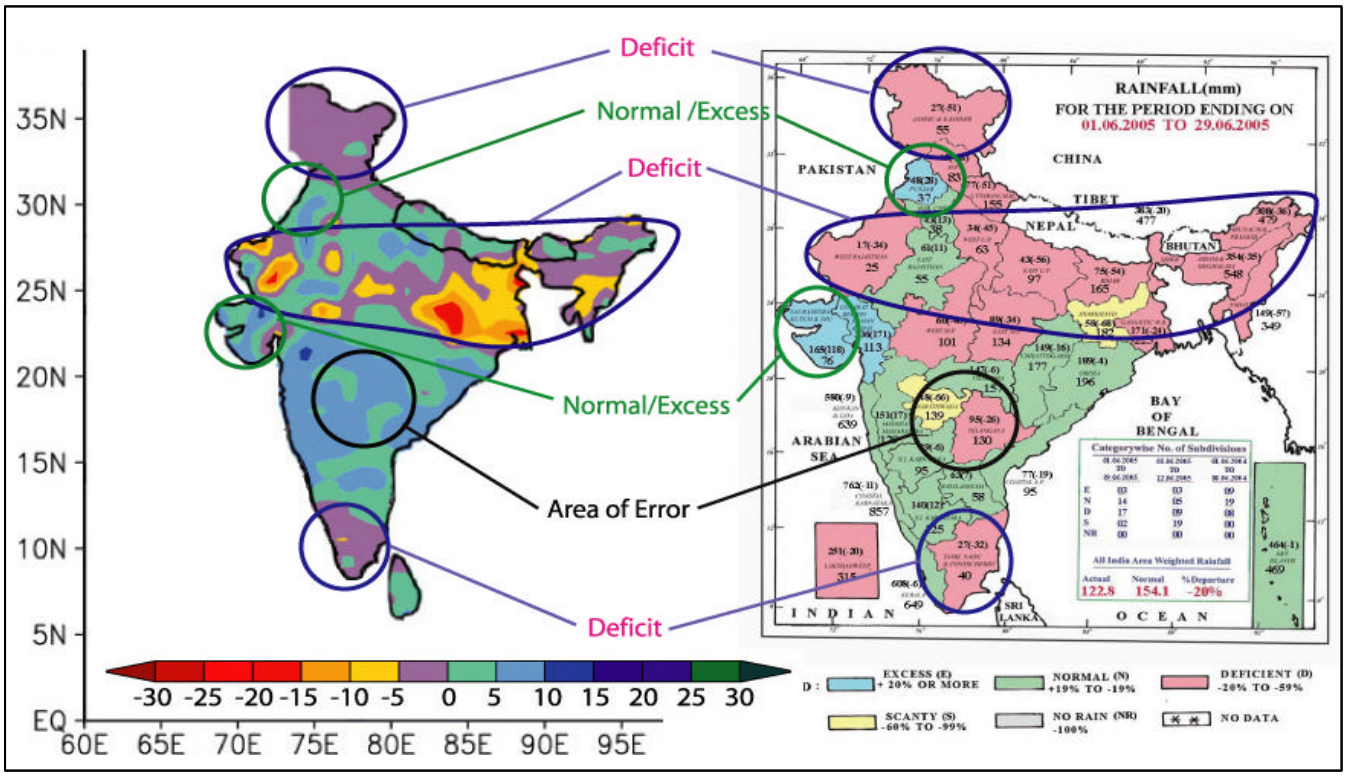

Figure 1.2 Comparison of anomalies in monthly rainfall for June, 2005 from C-MMACS experimental forecasts and observations (www.imd.ernet.in). The forecast anomalies are with respect to 15 year model climatology.

The adopter definition has a number of advantages:

(a) It automatically takes into account a larger time windows, recognizing that nature is not likely to oblige with any fixation of our regarding the likely period of onset.

(b) It is functional; the onset date signifies the beginning of a large-scale, significant, persistent rainfall episode regardless of its mechanism. This is the critical requirement for initiating agricultural activity.

(c) It is holistic: It recognizes that the monsoon is not a monolith in terms of its circulation system but is a composite of many scales: global to local, all of which determine the amount and distribution of rainfall.

In short, our definition somewhat deviates from (or redefines) a pure academic definition. In our definition, a widespread, significant rainfall episode initiated by, say, a tropical cyclone on May 20th and subsequently merging with rainfall due to westerly flow would result in a date of onset as May 20.

With this definition, the onset date for 2005 was predicted as May 26, based on an ensemble of 12 simulations based on initial conditions during the period 01 February to 30 April, 2005.

A quick comparison of anomalies in monthly rainfall from observations and forecasts for June 2005 reveal the following features:

Successes:

a) The north-west part of India was characterized by a strong spatial variation: while Gujrat recorded an excess, the neighboring west Rajasthan experienced a strong deficit, Punjab, neighboring WR on the other hand, experienced an excess rainfall in June. These features are well captured in forecast.

b) The forecasts captured well the belt of severe deficit extending from east to wet, including the severe deficit over ….

c) The forecasts also captured well the normal to excess rainfall over the south-central India.

d) The forecasts indicated deficit rainfall over the north-eastern states as observed.

e) The forecasts correctly indicated deficit rainfall over the peninsular India.

Failures:

a) The amplitudes of the anomalies in the forecasts are smaller than those observed in some cases.

b) The forecasts couldn't capture the severe deficits over Marathawada and Telengana, although they indicated relatively weaker rainfall.

c) The forecasts failed to capture the severe deficits over eastern and western Uttar Pradesh.

K C Gouda and P Goswami

1.2 A Comparison of Interpolated NCEP (I-NCEP) Rainfall with High-Resolution Satellite Observations

Large-scale long-period analyses like NCEP Reanalysis have become invaluable for generating robust statistics for model validation and carrying-out comprehensive diagnostics. This study evaluates daily NCEP rainfall as a high-resolution analysis through comparison with high-resolution rainfall based on satellite and GTS gauge observations. We use daily composite rainfalls over the Indian summer monsoon domain for the period 2001-2005 from satellite observations available at 10-km resolution and 10-km Interpolated NCEP rainfall (I-NCEP). Figure 1 compares all-India daily rainfall values (mm/day) from satellite data (red line) and NCEP (blue line) for five years (2001-2005).

It is clear from both the Figure 1.3 that the I-NCEP rainfall follows the temporal variations in the high-resolution satellite data quite well. As expected, the I-NCEP rainfall does not always match the high amplitudes of certain episodes in the satellite data;

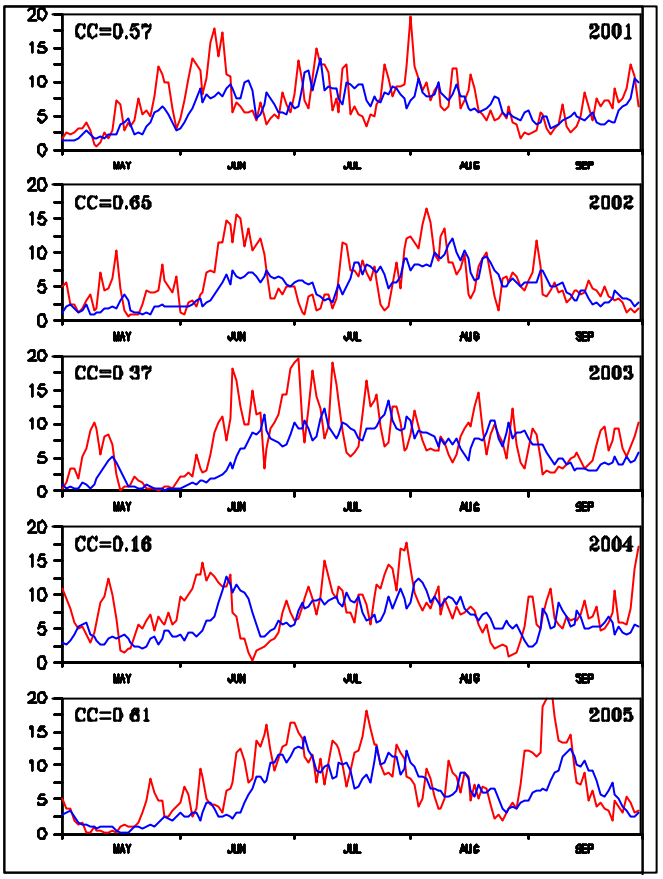

Figure 1.3 All-India daily rainfall values from satellite derived data (red line) and I-NCEP reanalysis (blue line). The x-axis shows time (days) for the June-September period while the y-axis shows rainfall in mm.

however, the broad features of temporal variations are comparable.

The correlation coefficients (Table 1.1) between daily (D) and weekly (W) rainfall values from the two data sets for different domain averages are significant for the degrees of freedom involved, especially at weekly scale. The correlation coefficients, however, show significant variations from domain to domain in the same year from year to year for the same domain, a point that needs further investigation.

The spatial correlation between observed and I-NCEP daily rainfall, reveals three features are discernible: i.e.,

(a) The correlation coefficient is generally non-

Table 1.1 Correlation coefficient between daily (D) and weekly (W) rainfall values for different domain averages

Year	All India		North India		South India		Central India	
	W	D	W	D	W	D	W	D
2001	0.80	0.57	0.79	0.60	0.49	0.32	0.86	0.65
2002	0.81	0.65	0.78	0.61	0.61	0.41	0.68	0.50
2003	0.64	0.37	0.40	0.12	0.58	0.38	0.56	0.28
2004	0.27	0.16	0.59	0.46	0.50	0.31	0.38	0.11
2005	0.82	0.61	0.62	0.51	0.81	0.40	0.79	0.48

negative over the continental Indian domain.

(b) The correlation coefficient is significant (for the degrees of freedom involved) over northern and southern India, while it is insignificant over certain locations, such as parts of eastern India and parts of central India.

(c) The correlation coefficient exhibits significant interannual variations, however; there is no discernible trend in the spatial distribution.

The agreement between rainfall anomalies fromsatellite data and I-NCEP analysis is further quantified in terms of phase synchronization, defined as

$$h = \frac{n - n`}{n}$$

where n is the total number of events (122 in daily scale, 17 for weekly scale) and n` is the number of cases for which the two anomalies have opposite signs (out of phase). Thus η is equal to zero if all the anomalies from the two sets are out of phase while η=1 when all of them are in phase. The values of η (%) for four domains and the five years are given in Table 1. 2. For each domain, and for each of the five years, the phase synchronization is quite high, and considerably higher at weekly (W) scale as expected. Thus the two anomalies are in the same direction most of the time.

The correlation coefficient and phase synchronization, shows that the I-NCEP rainfall provides a good representation of high-resolution observations even at meso-scales and provides a good long-period, high-resolution data set for model

Table1.2 Phase synchronization (%) between daily rainfall anomalies of Satellite and NCEP datasets different domain averages.

Year	All India		North India		South India		Central India	
	W	D	W	D	W	D	W	D
2001	83.3	66.1	83.3	76.9	66.7	67.8	77.8	68.6
2002	83.3	71.1	83.3	76.0	88.9	73.6	77.8	71.1
2003	83.3	64.5	66.7	54.6	83.3	68.6	83.3	62.8
2004	83.3	57.9	83.3	63.6	72.3	57.9	77.8	49.6
2005	72.2	70.2	88.9	68.6	72.3	63.6	71.8	68.6

validation and evaluation. This in turn implies that the I-NCEP Reanalysis can be used for validation and diagnostics of high-resolution rainfall forecasts over a number of years. These conclusions need to be checked for other variables, seasons and other regions. There are, however, certain caveats and issues that need further exploration.

K V Ramesh and P Goswami

1.3 Coupled air-sea interactions in the tropical Indian Ocean and impending monsoon droughts

Monsoon droughts over the Indian subcontinent arise due to failures in the seasonal (June-September) summer monsoon rainfall and rank among the foremost of natural disasters affecting mankind and society. For example, monsoon drought of 2002, which resulted in economic losses of billions of dollars, is a striking example of a large-scale catastrophic event. The question as to how the tropical Indian Ocean and the monsoon circulation dynamically interact on the intraseasonal time-scale still remains unresolved. One of the key issues, in this context, is the role of ocean sub-surface processes in contributing to the maintenance of anomalous atmospheric circulation and convection patterns over the monsoon region. In this study, we demonstrate, from an analysis of a suite of observed datasets, that ocean-atmosphere coupling on the intraseasonal time-scale, in the tropical Indian Ocean, is pivotal in forcing long-lasting breaks in the monsoon rainfall and causing droughts over the subcontinent. The monsoon drought witnessed in 2002 also was related to near equatorial precipitation anomalies; however for the first time advances in the ocean observing system allow characterization of subsurface properties. The striking contrast in the rainfall activity between the equatorial Indian Ocean and the Indian landmass during July 2002 is evident. The suppression of monsoon precipitation over the Indian landmass during July 2002 resulted due to anomalous subsidence over the subcontinent induced by strong upward motions over the equatorial Indian Ocean which weakened the so-called monsoon Hadley circulation.

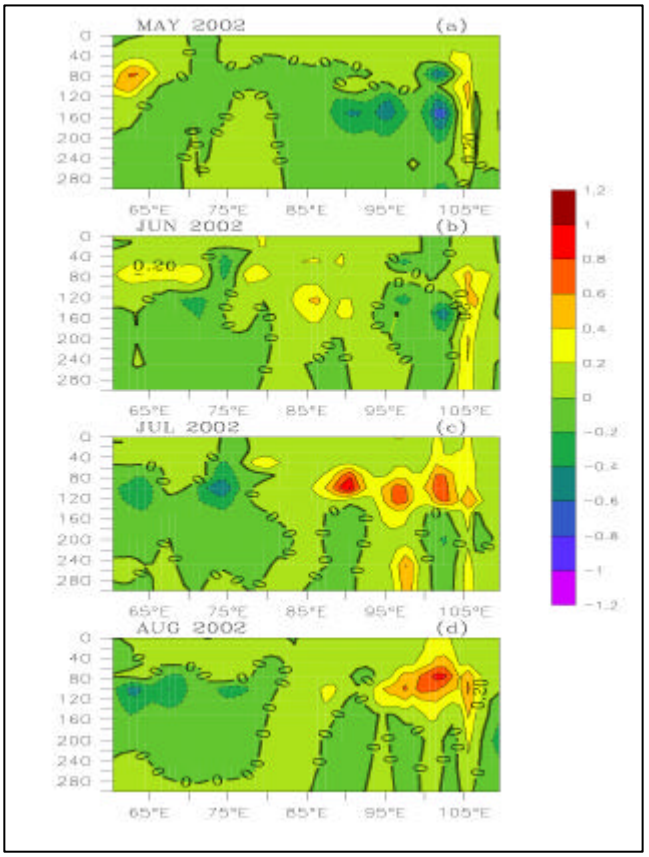

Figure 1.4 Longitude-depth sections of monthly temperature anomalies averaged between 10oS-5oN during May-August, 2002 shown in (a-d). The subsurface temperature anomalies are relative to the climatological World Ocean Atlas 2001 - database.

The dynamical link between the wind field and sea-level anomalies can be interpreted as downwelling Kelvin waves, forced by westerly winds over the equator, which propagate to the eastern boundary (Sumatra) and are reflected as Rossby waves that increase the heat content in the Bay of Bengal, as well as the eastern Indian Ocean as far south as Java. Furthermore, the occurrence of anomalous sub-surface warming, by as much as 0.8oC during July and August 2002, in the EEIO (Figure 1.4 c-d) corroborates the increase in oceanic heat content in the region. The warm sub-surface anomalies in the EEIO together with the cold anomalies of about 0.4oC in the equatorial

western Indian Ocean (Figure1.4b-d) represent an anomalous intensification of the near-equatorial zonal temperature gradient.

Here we demonstrate, from the above analysis of a suite of observed datasets, that ocean-atmosphere coupling on the intraseasonal time-scale, in the tropical Indian Ocean, is pivotal in forcing long-lasting breaks in the monsoon rainfall and causing droughts over the subcontinent. This coupling involves a self-sustaining feedback between the monsoonal flow and the thermocline depth in the equatorial eastern Indian Ocean (EEIO), in which an anomaly of the monsoon circulation induces downwelling in the EEIO and maintains a deeper-than-normal thermocline and higher-than-normal ocean heat content. The warm ocean favours enhanced precipitation locally over the EEIO and weakens the monsoon circulation by inducing subsidence over the subcontinent. The antecedents of an ensuing monsoon drought are evident from ocean heat content evolution starting from the preceding spring season. Our analysis conclusively shows that the intraseasonal evolution of the tropical Indian Ocean coupled system holds the key to unlocking and understanding the dynamics of monsoon droughts.

A question arising at this stage is regarding the termination of the positive feedback process. Our preliminary understanding indicates that the termination can be influenced by processes contributing to SST cooling - such as cloud-radiative effects associated with convective anomalies over the EEIO region; heat loss from the ocean due to increase in latent and sensible heat fluxes over the warm equatorial region. Further studies will be required to resolve this issue. The present findings take on added significance in view of the antecedents that are initiated during the spring months preceding the summer monsoon drought (as in 2002), when enhanced eastward currents in the equatorial Indian Ocean cause accumulation of warm waters in the east. If indeed the coupled interactions among the Indian Ocean dynamics, monsoon circulation and the MJO activity hold the key to the evolution of the tropical intraseasonal oscillations, the implications of these coupled interactions on the regional and global climate warrants careful consideration.

K V Ramesh, R Krishnan, B K Samala, G Meyers, J M Slingo and M J Fennessy

1.4 Mathematical Modelling of Biogeochemical Cycles in the Indian Ocean

A central problem in large-scale biogeochemical modeling is determining how well biological models can simulate observed variability in different ocean environments. The key questions are: Which model formulations work best for a given region? How transferable are models specifically designed for one region to other regions? Answering such questions is one of the central goals of the U.S. JGOFS Synthesis and Modeling Project (SMP). Since biogeochemical models are sensitive to the physical framework in which they are embedded, different models have to be run under the same physical conditions to enable quantitative model intercomparisons. To promote intercomparison studies, the U.S. JGOFS SMP has formed a working group to provide 1-D test beds, which allow researchers to run a variety of biogeochemical models in a specific physical context. This testbed for the central Arabian Sea at 15.5 N, 61.5 E, the site of the WHOI mooring uses environmental fields obtained from a 3-D physical model (McCreary et al., 2000) to run biogeochemical models offline in 1-D.

The objective of this study is to understand the effect of five kinetic relations for ammonium inhibition on nitrate uptake by phytoplankton and two light models on the state variables of a seven-component ecosystem model in the 1-D physical framework given in AS Testbed. This marine ecosystem model is evaluated by using US JGOFS data and buoy data. Figure1.5 shows the profiles of chlorophyll

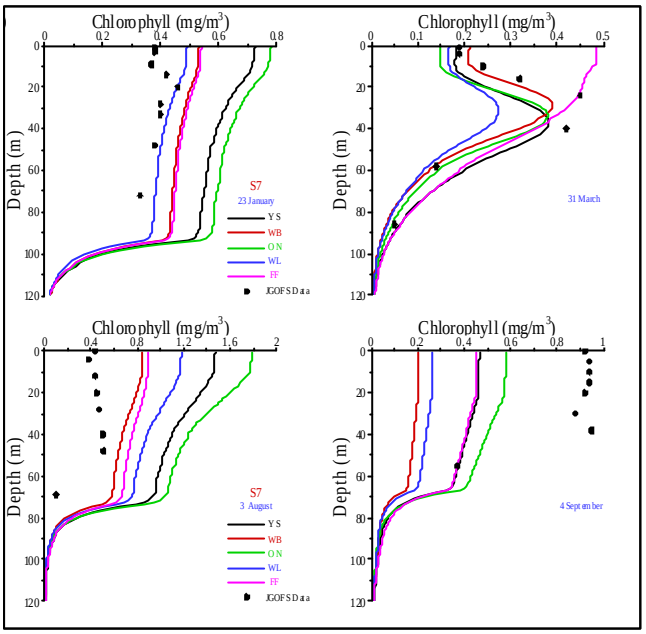

Figure 1.5 Profiles of Chlorophyll (mg Chl/m3) from five simulations of 1-D coupled physical-biological model compared with the US JGOFS data from five cruises at (15.5 N, 61.5 E).

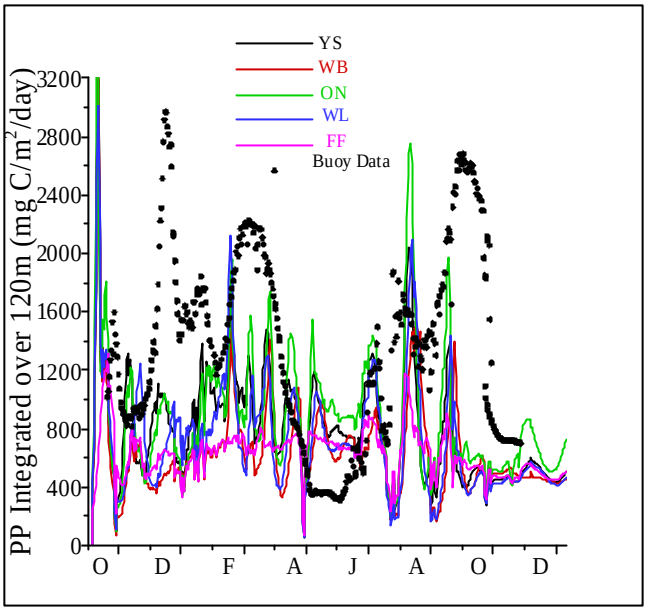

Figure 1. Seaonal variation of depth integrated primary productivity values (mg C/m2/day) from five simulations of 1-D coupled physical-biological model compared with the buoy data at (15.5 N, 61.5 E).

from five model simulations, compared with the data from US JGOFS cruises. It is noticed that deep chlorophyll maximum observed during the spring inter monsoon is captured by the four models and high values of chlorophyll observed during the fall inter monsoon is not obtained from any model simulations. The seasonal variation of depth integrated values of primary productivity is compared with the buoy data **(**Figure 1.6**).** The peak values of depth integrated primary productivity obtained from some model simulations during both monsoons agree well with the buoy data.

This kind of study helps in identifying the appropriate relation(s) for the ammonium inhibition on nitrate uptake and relevant light model to be incorporated in the 3D coupled physical-biological-chemical model used for the study on biogeochemical cycles in the Indian Ocean.

Spatial and temporal variations of carbon flux across the air-sea interface on the regional scale have evoked considerable interest in view of the ocean's capacity to take up anthropogenic carbon. The present models of ocean biogeochemical cycles incorporate several key biological processes whose parameter values are assumed. The major challenges in marine biogeochemical modeling can be addressed by model-data comparisons and data assimilation studies. As a part of these studies, climatological simulations of a 3D coupled physical-biological-chemical model are performed at C-MMACS. We focus on the effect of biology on the carbon cycle in the North Indian Ocean. However, since this effect depends on the assumed values of biological parameters, parameter sensitivity analysis becomes prerequisite. In the present study, simulations were carried out for several sets of values of five parameters governing nutrient recycling. One set of parameter values was selected on the basis of comparison of the simulation results with biological and chemical observations from cruises and satellite. Figure 1.7 shows the profiles of primary productivity obtained from the selected simulation compared with the US JGOFS data from five cruises at S7 (16 N, 62 E). The simulation results agree well with the data during northeast monsoon.

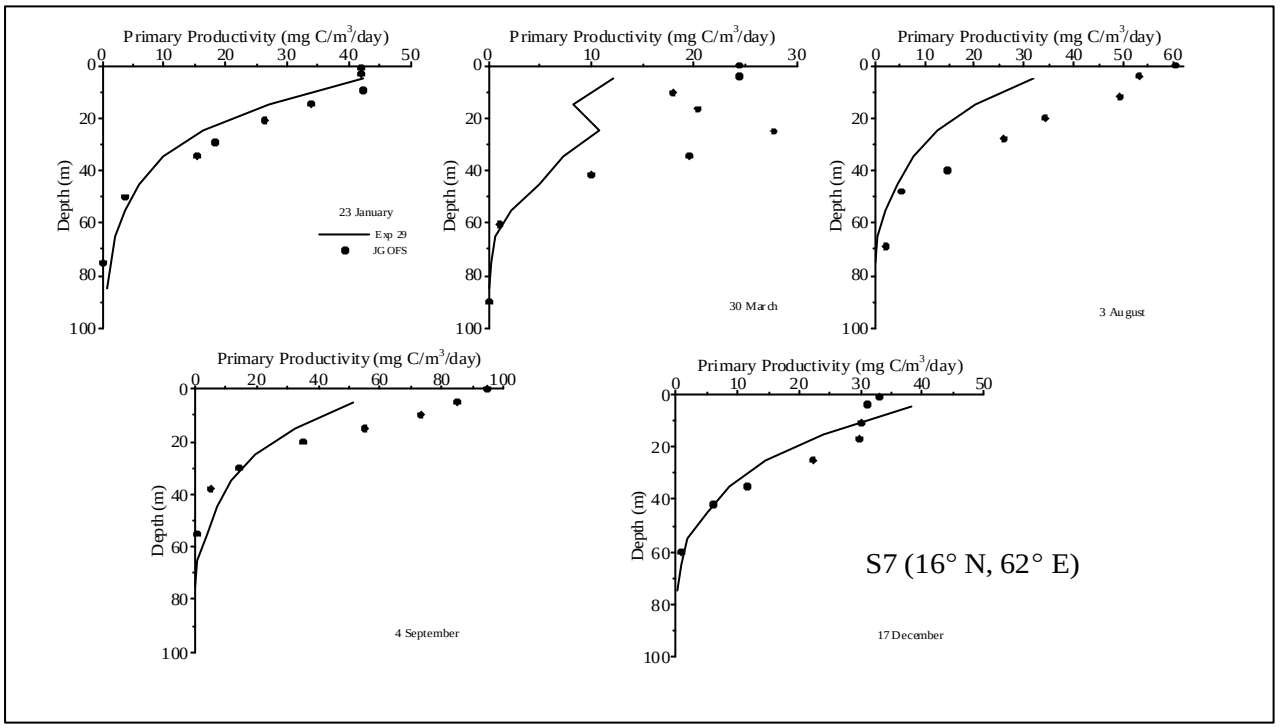

Figure 1.7 Profiles of Primary Productivity (mg C/m3/day) from 3-D coupled physical-biological (Selected experiment) model compared with the US JGOFS data from five cruises at (16 N, 62 E).

The results of the selected simulation give fresh insight into the mechanisms and the extent to which biology contributes to the spatio-temporal variability of pCO2, dissolved inorganic carbon and alkalinity in the upper layers of the Indian Ocean. Comparison of this simulation with the corresponding abiotic simulation reveals the effect of the biological pump. The contribution of the biological pump in north Indian Ocean (above the equator), AS (west of 750 E) and BOB (east of 750 E) in the annual carbon budget is given in Table 1, where carbon flux from the ocean to the atmosphere indicates the magnitude of outgassing over a year. While the biological pump decreases outgassing by 20% in AS, it increases in BOB by 12%, the absolute magnitude of the effect being much smaller in BOB than AS. The effect of the biological pump over the entire north Indian Ocean on a year is decrease of outgassing by 13%. This explains the unexpected effect of biological pump increasing the outgassing which is due to the dominance of regeneration over carbon fixation in large parts of the north Indian Ocean. It is also noteworthy that the carbon flux in AS is nearly two and half times that in BOB.

Table 1 Carbon Flux from Ocean to Atmosphere over an year (Pg C/Year)

Region	Abiotic	Biotic	% Difference	Takahashi
Basin	0.262	0.228	-13	0.119
AS	0.204	0.163	-20	0.0761
BOB	0.058	0.065	12.1	0.0135

M K Sharada and K S yajnik

2

Solid Earth Modelling Programme (SEMP)

Global Positioning System (GPS) based Geodesy had become capable of yielding sub-cm precision in location by the early 1990s and the possibility of it being used to determine crustal strain rates in India was recognised at C-MMACS in 1993 following the Khillari earthquake. Research at C-MMACS has since yielded fairly well constrained figures for the velocity of the Indian plate and partitioning of strain from Kanya-Kumari to Ladakh in the trans-Himalya. Over the years C-MMACS has also taken up the ardous task of setting up GPS stations in remote locations in the country to generate required data base, and to extend application of GPS technology to other areas.

Highlights

The year 2005-06 for SEMP has seen a spectrum of activities in the areas of seismic data analysis, study of tectonics in the Himalayan region and applications and analysis of GPS data. C-MMACS had also carried out a quick response analysis of GPS measurements in Andaman Nicobar Islands following the devastating Sumatra earthquake of 26th December, 2004.

Inside

2.1 Site Response in Ahmedabad City using Microtremor Array Observations: A Preliminary Report

The spate of earthquakes in our country has awakened the sensitivity of administrators, engineers and even the common people to risks due to earthquakes. On January 26, 2001, one of the most destructive earthquakes (Mw=7.7) ever to strike India occurred in the Kutch region of Gujarat. The damage due to this earthquake was spread over a radius of 400 kilometers including major cities like Ahmedabad, Bhawnagar and Surat at distances more than 250 kms. Ahmedabad, a city of historical value and one of the most industrial and economically developed cities in India, is still under seismic threat due to ongoing seismic activities in the Kutch region. Looking into the importance of the subject, Department of Science and Technology, Govt. of India has sponsored a project to C-MMACS for detailed site characterization of Ahmedabad city.

In the present report, a preliminary result is presented on site-effects and shear velocity structure of sub-surface soil using microtremor arrays at twenty different sites in the city. To get the first order response of site characteristics, the most commonly used Nakamura (H/V ratio) technique has been adopted using the ambient noise recorded by an array of seven Lennartz 5 sec seismometers. Most of the sites have shown a fundamental resonance frequency at 0.6 Hz. Very few sites have the peak frequency between 2 - 6 Hz, however, the first peak at 0.6 Hz is also explicit on these sites. This indicates that the thickness of the upper soft soil is very deep (several hundreds of meters) which corresponds to the frequency of 0.6 Hz. The phase velocity dispersion curve is also estimated by frequency-wave number (f-k) and spatial auto correlation (SPAC) methods using microtremor arrays of 7 stations recording ambient noise for at least one hour at each site. Phase velocities have been inverted to obtain the 1-D shear velocity at each site. Generally, the top layers 0.1 to 20 meters show shear velocities between 150-300 m/s and later the velocities vary between 400 to 800 m/s till 100 meters of depth. The estimated shear velocity can be used as an input for the simulation of strong ground motion looking into the influence of source, rupture, propagation path and directivities etc. on the site-effects.

Imtiyaz A Parvez and K Madhukar

3

Computational Industrial Mechanics Programme (CIMP)

Sophisticated mathematical modelling aided by powerful computing and visualization has the potential to provide the cutting-edge to industry; generation of cost-effective solutions, process optimization and product design are some of the areas where modelling and simulation can play critical to enabling role. The C-MMACS Computational Industrial Mechanics Programme (CIMP) seeks to develop and apply tools of mathematical modelling and computer simulation in diverse areas of engineering.

Highlights

The Year 2005-06 for CIMP is characterized by development and refinement of a number of theoretical and conceptual issues in the areas of finite element analysis, elastodynamics, numerical algorithms and non-linear dynamics.

Inside

3.1 Static and Free Vibration Analysis of 6-noded Triangle Element under Mesh Distortion

The classical Lagrangian finite elements will perform poorly under a distorted mesh. Distorted meshes can slow down the convergence of the solutions and may give inaccurate results. The distorted meshes are unavoidable when we do the analysis of complex structures. The distortion sensitivity of the elements is not completely studied in available literatures. A 2-D element can have an angular distortion or a mid-node distortion. The angular distortion will appear in meshes with curved geometries, transition region from coarse mesh to fine mesh and the nonlinear problems with large deformations. Fracture mechanics problems will leads to mid node distortion. To address the 2-D effects of mesh distortion, the 6-noded triangular element with plane stress conditions had been considered. The quadratic displacement is assumed to derive the metric shape functions so that the completeness condition has been satisfied. Depending on the shape function used, the elements are classified into parametric (PP), metric (MM), parametric-metric (PM) and metric-parametric elements (MP). An in-house finite element code had been developed in MATLAB platform to compute the displacements/stresses for the static analysis and to compute the natural frequencies for the free vibration analysis of structural mechanics problems with and without mesh distortion.

Static analysis is carried to assess the behaviour of the proposed PP, MM, PM and MP elements. Two

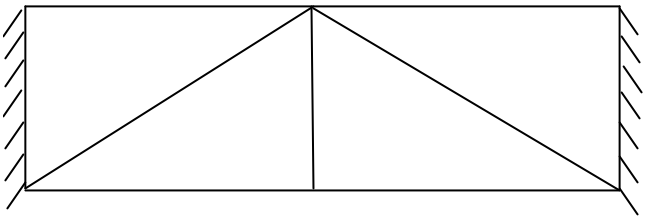

Figure-3.1a - without distortion

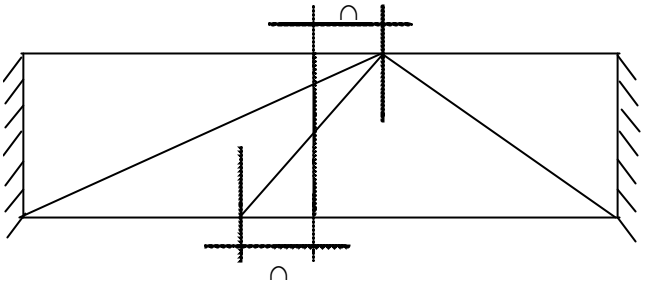

Figure-3.1b - with distortion

types of problems are analyzed, namely a cantilever beam with tip moment and a cantilever beam with a tip shear force under various types of mesh distortions. The numerical test results prove that when there is distortion, only the PM formulation behaved better than the classical finite element. A fixed-fixed bar behaviour had been simulated using 6-noded element for repeated image and mirror image with distortion (Figure 3.1a & 3.1b**)**. This problem had been considered for the free vibration analysis. From the numerical test, it had been seen that the PM element gives more accurate natural frequencies than the conventional PP element. Interestingly, the MP element results are identical with PM element results of the various types of mesh distortions for the free vibration analysis and it will

Table 3.1 First natural frequencies of fixed - fixed bar of 6-noded elements with repeated image

Delta	Exact	PP	PM	MM	MP
0.125	9.86960440	10.91826588	9.97362492	9.93573539	9.97362492
0.100	9.86960440	10.47162887	9.95262833	9.93543675	9.95262833
0.075	9.86960440	10.20699465	9.93723811	9.93076495	9.93723811
0.050	9.86960440	10.04118839	9.92689163	9.92506193	9.92689163
0.000	9.86960440	9.91907349	9.91907349	9.91907349	9.91907349
-0.050	9.86960440	10.04118839	9.92689163	9.92506193	9.92689163
-0.075	9.86960440	10.20699465	9.93723811	9.93076495	9.93723811
-0.100	9.86960440	10.47162887	9.95262833	9.93543675	9.95262833
-0.125	9.86960440	10.91826588	9.97362492	9.93573538	9.97362492

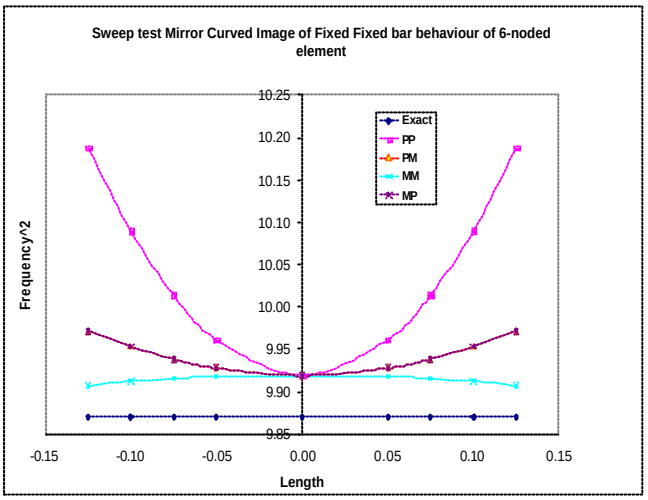

Figure-3.2 Sweep test for 6-noded element with fixed-fixed bar behaviour.

be valid for all the cases with different boundary conditions under admissible distorted geometry shapes. But the MP element behaves poorly in static analysis. Distortion parameter delta had been varied to understand the elements behaviour and the natural frequencies are listed in Table-3.1**.** Also sweep test had been performed to analyze distortion sensitivity for the mirror image element **(**Figure-3.2).

V Senthilkumar and G Prathap

3.2 The Unsymmetric Finite Element Formulation and Variational Incorrectness

The unsymmetric finite element formulation has been proposed recently to improve predictions from distorted finite elements. We examine here whether the unsymmetric formulation is variationally correct. From the weak form in terms of the energy inner product for the exact solution, we ensure that the symmetric formulations, namely the PP and MM versions are both variationally correct, and produce best-fit results. The PM formulation, even though it is practically a very useful device to meet the continuity requirements and the best-fit stress recovery requirements in a distorted element, is not variationally correct. A fixed-fixed bar with single element of an axial load at mid span had been analyzed. Table 3.4 displays the results from a single-element mesh using the PM and MM models described above of the test case when the distortion term Ç is varied. Immediately, we notice that the displacements u_3 from the two FEM models, and for whatever value of distortion, are exact! However, this is not true of the displacement u_2 for all the cases displayed in Table 3.2.

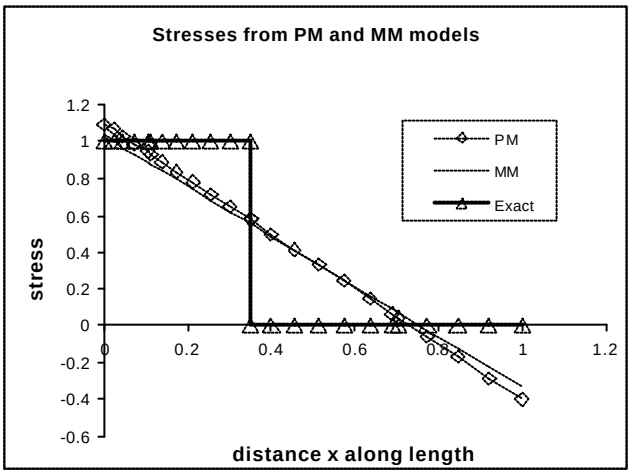

Figure 3.3 Stresses from PM and MM models compared with exact stress when concentrated load is placed at x2 = 0.35

Figure 3.3 shows the variation of stresses computed from the displacements from the PM and MM models as compared to the exact stress in the bar when the concentrated load is placed at x_2 = 0.35 (∩ = -0.15). Both PM and MM, due to the use of the M-trial

Table 3.2 Displacements u_2 and u_3 for a single-element test of fixed-free bar with concentrated load of $P = 1$ at node N_2 as location x_2 is moved by Ç.

Disp.	∩ = 0			∩ = -0.05			∩ = -0.15		
	MM	PM	Exact	MM	PM	Exact	MM	PM	Exact
u_2	0.4375	0.4375	0.500	0.3863	0.3881	0.450	0.2778	0.2931	0.350
u_3	0.500	0.500	0.500	0.450	0.450	0.450	0.350	0.350	0.350

functions, give a linear variation. It can be very easily checked that the stress from MM (shown by the thin solid line) is an exact best-fit of the actual stress variation (thick solid line) whereas the stress from PM (thin broken line) is in error. The geometric representation of the PP, MM and the PM finite element computation from the best-fit and the function space point of view is shown in Figure 3.4.

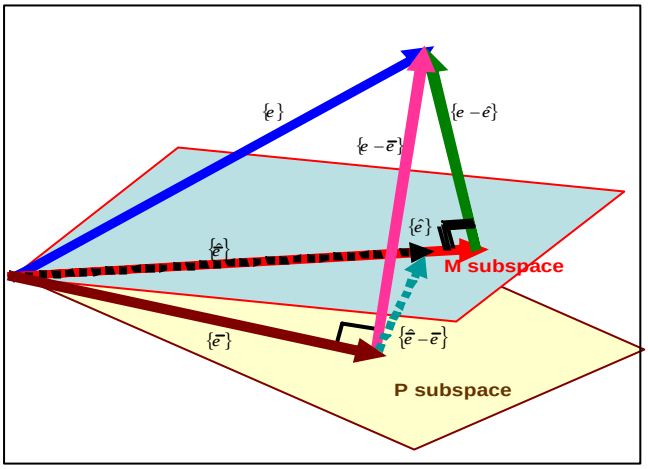

Figure 3.4 The geometric representation of the PP, MM and the PM finite element computation from the best-fit and the function space point of view.

When it comes to a distorted mesh, especially in 2D and 3D modelling, one has to choose between satisfying the continuity condition on the edges of adjoining element and the variational correctness of the correspondence between the actual stress and the approximate stress. We could also succeed in using the best-fit paradigm to predict independently from first principles, the stresses that the unsymmetric PM formulation will produce in an actual finite element computation. The PM formulation is not an exact best-fit of the exact solution u and we are concluding that the stress from the PM formulation will be orthogonal to the stress from the PP formulation. This is seen in Figure 3.4.

G Prathap , S Manju ,V Senthilkumar and P Jafarali

3.3 Effect of linertia on the Dynamics of a Periodically Forced Spherical Particle in a Quiescent Fluid

We have formulated the problem using the formalism of Lovalenti and Brady (1993) for the problem of the motion of a periodically forced spherical particle in a quiescent fluid at low Reynolds Numbers. The formalism of Lovalenti and Brady (1993) for the case of the motion of a spherical particle in a fluid at low Reynolds Numbers is:

$$F^{H}(t)=\frac{4p}{3}\mathrm{Re}\,SlU^{x}(t)-6pU_{s}(t)-\frac{2p}{3}\mathrm{Re}\,SlU_{s}(t)$$
$$+\frac{3}{8}\left(\frac{\mathrm{Re}\,Sl}{p}\right)^{\frac{1}{2}}\left\{\int_{-\infty}^{t}\left[\begin{array}{l}\frac{2}{3}F_{s}^{H_{II}}(t)-\left\{\frac{1}{|A|^{2}}\left(\frac{p^{\frac{1}{2}}}{2|A|}erf\left(|A|^{2}\right)-\exp(-|A|^{2})\right)\right\}F_{s}^{H_{II}}(s)\\+\frac{2}{3}F_{s}^{H_{\perp}}(t)-\left\{\exp\left(-|A|^{2}\right)-\frac{1}{2|A|^{2}}\left(\frac{p^{\frac{1}{2}}}{2|A|}erf\left(|A|-\exp\left(-|A|^{2}\right)\right)\right)\right\}F_{s}^{H_{\perp}}(s)\end{array}\right]\frac{2ds}{(t-s)^{\frac{3}{2}}}\right\}+0(\mathrm{Re}) \quad (1)$$

The various terms in this equation are defined in the original paper of Lovalenti and Brady (1993). We note here that this formalism yields the hydrodynamic force acting on a spherical particle moving with a certain time dependent velocity in a Newtonian fluid which is moving with an arbitrary time dependent uniform velocity. We have used this formalism to develop the equation for the motion of a periodically forced sphere in a quiescent fluid. We note certain features of this equation which need to be kept in mind when we develop numerical solutions to our equation. First we note that the equation is nonlinear

and contains an improper integral which has to be evaluated taking all past values of both the instantaneous position and velocity of the particle. The equation is nonlinear because the variable 'A' in the formalism of Lovalenti and Brady (1993) is a function of both the current value of the position of the particle and its past value. We also note that there is a singularity in the integral which is not bounded at 's', the past time equal to 't', the current time. This singularity has to be treated appropriately in order to evaluate the integral at each time step when we perform a numerical integration of the equation of motion. We checked that our interpretation of the improper integral was reasonable by reproducing a known result, namely, Figure 5 of Lovalenti and Brady (1993).

The equations for a periodically forced spherical particle in a quiescent fluid, as derived, from the formalism of Lovalenti and Brady (1993) are :

$$\frac{dY_p}{dt} = U_p$$

$$\frac{dU_p}{dt} = \frac{6p}{\mathrm{Re}\,St} Sin(t) - \frac{6pU_p}{\mathrm{Re}\,St}\left\{\left(\frac{\mathrm{Re}\,Sl}{p}\right)^{\frac{1}{2}} \frac{1}{2}\int_o^t \frac{ds}{(t-s)^{\frac{3}{2}}} + 1\right\}$$

$$+\frac{9}{2}\left(\frac{\mathrm{Re}\,Slp}{\mathrm{Re}\,St}\right)^{\frac{1}{2}}\int_0^t \left\{\frac{1}{A^2}\left(\frac{p^{\frac{1}{2}}}{2A} erf\,(A)\right) - e^{-A^2}\right\}\left\{\frac{U_p(s)}{(t-s)^{\frac{3}{2}}}\right\} ds \qquad (2)$$

We note that this is a system of two coupled nonlinear non-autonomous equations. In these equations, Yp is the position of the particle, Up is the velocity of the particle, Re is the Reynolds Number, Sl is the Strouhal Number, ReSt is defined as 4 /3 Re + 2 /3 ReSl and is a small positive number; A is defined in terms of the position of the particle at the current time and the position at a past time, 's' as;

$$A = \frac{R_e}{2}\frac{(t-s)^{\frac{1}{2}}}{(\mathrm{Re}\,Sl)^{\frac{1}{2}}}\left(\frac{Y_p(t) - Y_p(s)}{t-s}\right) \qquad (3)$$

We note that velocities are scaled with respect to the product of the size of the spherical particle and the frequency of the periodic force; position is scaled with respect to the size of the spherical particle and time, 't', is scaled with respect to the frequency of the external force field; force is scaled with respect to the product of the size of the particle, the viscosity of the fluid phase and the characteristic velocity. The definitions for Re and Sl then follow from the scaling as mentioned above; 's' is the past time scaled with reference to the frequency of the driving force.

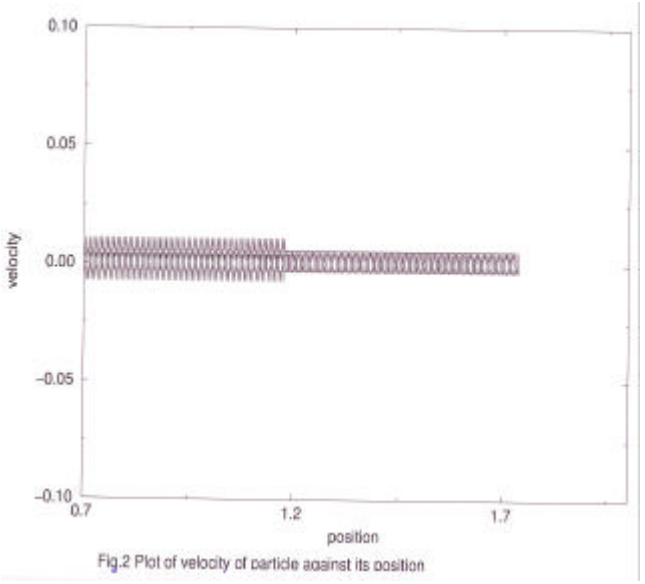

Fig.2 Plot of velocity of particle against its position

When we solved the equation of motion for a selected set of parameters, we noticed certain features of the solution. We observed that the solution for the velocity oscillated about a small positive value. This implied that the position of the spherical particle varied slowly with time. This feature of there being a small non-zero drift velocity of the spherical particle may be considered similar to the presence of a small non-zero drift force in the case of a fluctuating suspension of colloidal spheres as shown by Hinch and Nitsche (1993) upon the inclusion of inertial effects. This is shown in Figure 3.5 for a typical value of the parameters. The value of the small positive velocity around which the velocity of the particle oscillated was a function of the parameters and generally decreased with the value of Re. A qualitative explanation of this behavior may be obtained by averaging the equation of motion over a period of the driving force Upon averaging the equation of motion, we obtain:

$$\frac{d\overline{U}_p}{dt} = \frac{-6p\overline{U}_p}{\mathrm{Re}St}\left\{1+\left(\frac{\mathrm{Re}Sl}{p}\right)^{\frac{1}{2}}\left(\frac{1}{e}\right)^{\frac{1}{2}}\right\}+\frac{6p}{\mathrm{Re}St}\int_0^{2p}\frac{U_p(s)}{s^{\frac{1}{2}}}ds$$

$$+\frac{3}{2}\frac{\mathrm{Re}p^{\frac{1}{2}}}{\mathrm{Re}St}\overline{U}_p^2+\frac{9}{2}\frac{(\mathrm{Re}Slp)^{\frac{1}{2}}}{\mathrm{Re}St}\int_0^{2p}\left(\int_o^{t-e} ds\right)dt \quad (4)$$

When we set the left hand side of the equation to zero indicating that the average velocity changes very slowly with time we see from the above equation that it admits a positive value of the average velocity in addition to the zero average velocity. A more physical explanation might be that the inclusion of inertia which automatically excludes fore-aft symmetry in the flow field around the spherical particle might lead to a small residual positive value of the average velocity. We also note another striking feature of the solutions, namely that there is a qualitative change in the behaviour of the solution at around 500 time units. This might represent the time taken for the flow field induced by the oscillation of the particle to reach an approximate steady state. The resulting plot of the position of the particle with scaled time shows a small change in slope at this time and the phase space plot of the velocity of the particle with the position of the particle shows a sharp reduction in the amplitude of the velocity oscillations. There are some solutions in the literature for the force induced by an oscillatory motion of a spherical particle. However the presence of the non-linearity in our equation makes it difficult to compare our results with those results. Further most of the literature which deals with inertial effects considers the force due to a given imposed velocity of the sphere. Our situation where we consider the effect of a periodic force on the motion of a small spherical particle has received considerably less or no attention to our knowledge.

T R Ramamohan

4

High Performance Computing and Networking (HPCN)

Mathematical modelling and computer simulation in the fields of ocean, atmosphere, earth science and engineering involve computational tasks which can only be provided by High Performance Computing(HPC). The need for computational power, measured in terms of Giga Floating Point Operations per Seconds (FLOPS), grows exponentially with every bit of increase in the complexity of problem. C-MMACS today has one of the best computing facilities in the country.

Highlights

The year 2005-06 has been a year of growth and expansion for HPCN both in terms of computing resource and areas of research. A substantial enhancement of C-MMACS computing platform took place through installation of an ALTIX-350 12-processor system. The two prominent research areas under HPCN: Network Security and Cryptography, provided new results in these important areas.

Inside

4.1 Network Telescope for Malicious Incidents Prevalence Measurement on the Internet

Network Telescope is an emerging concept in network monitoring. It is a viable alternate to distributed network monitoring approach in which a relatively small portion of the Internet is monitored to infer the security dynamics on the rest of the Internet. Various security related phenomena that could be traced and monitored with network telescope are virus spread, automatic worm propagation, occurrence of Denial-of-Service (DoS) and Distributed Denial-of-Service (DDoS) attacks.

Network telescope is based on a key observation that during worm propagation and DoS attacks, the adversary spoofs the source address of the malicious packet with a random source address picked from a list of 232 possible IP address space. Hence, any network connected to the Internet receives unsolicited packets triggered by worms and attacks and these unsolicited packets are called backscatters.

We have developed and deployed a network telescope at C-MMACS network to capture and analyze unsolicited packets. Results for preliminary version of this tools are shown in Figure 4.1. Figure 4.1 (a) shows that total number of unsolicited packet received by our monitoring station during a period of 22 days starting from 3rd November 2005. Figure 4.1(b) gives the cause level breakup of total number of unsolicited packets received. Figure 4.1(c) gives the cumulative number of virus/worm infected machines whose IP address falls into the prefix 202.41 and located in Indian region. Finally, Figure 4.1(d) shows the transmission patterns of three virus/ worm infected machines which top-ranked in our list in terms of number of unsolicited packets received from the infected machines.

V Anil Kumar, G K Patra and R P Thangavelu

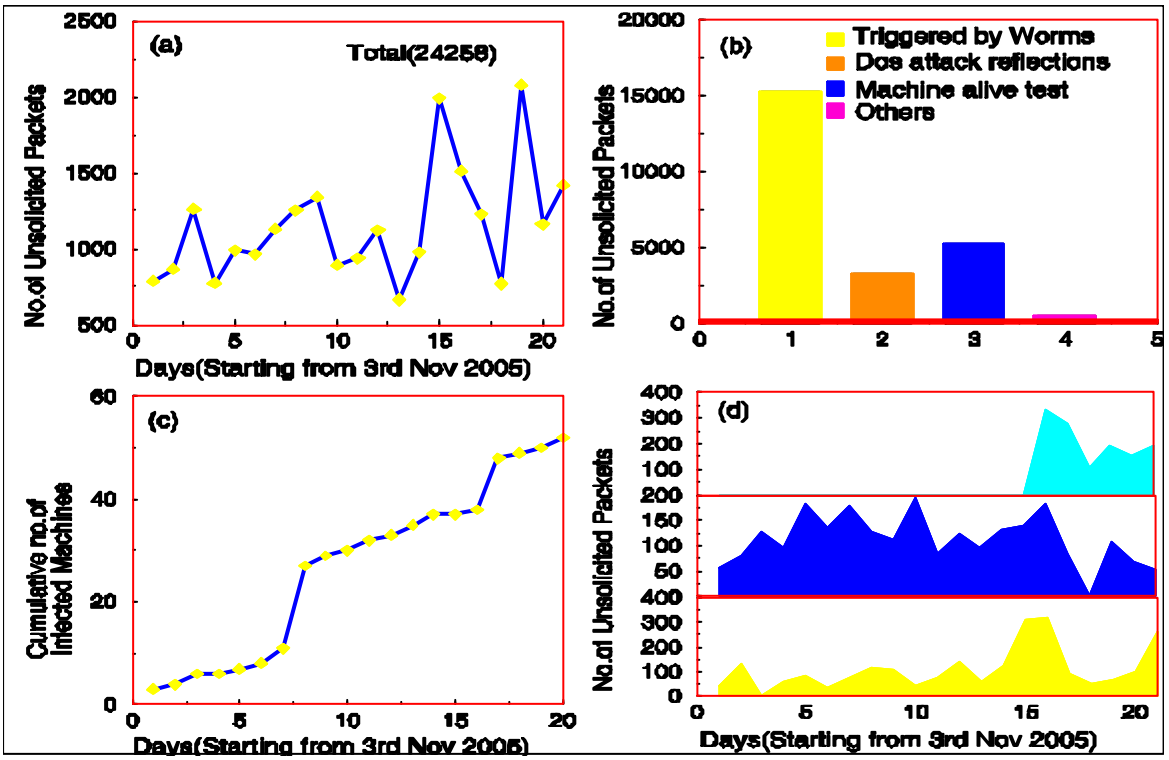

Figure 4.1 Charecterestics of unsolicited packets collected at C-MMACS.

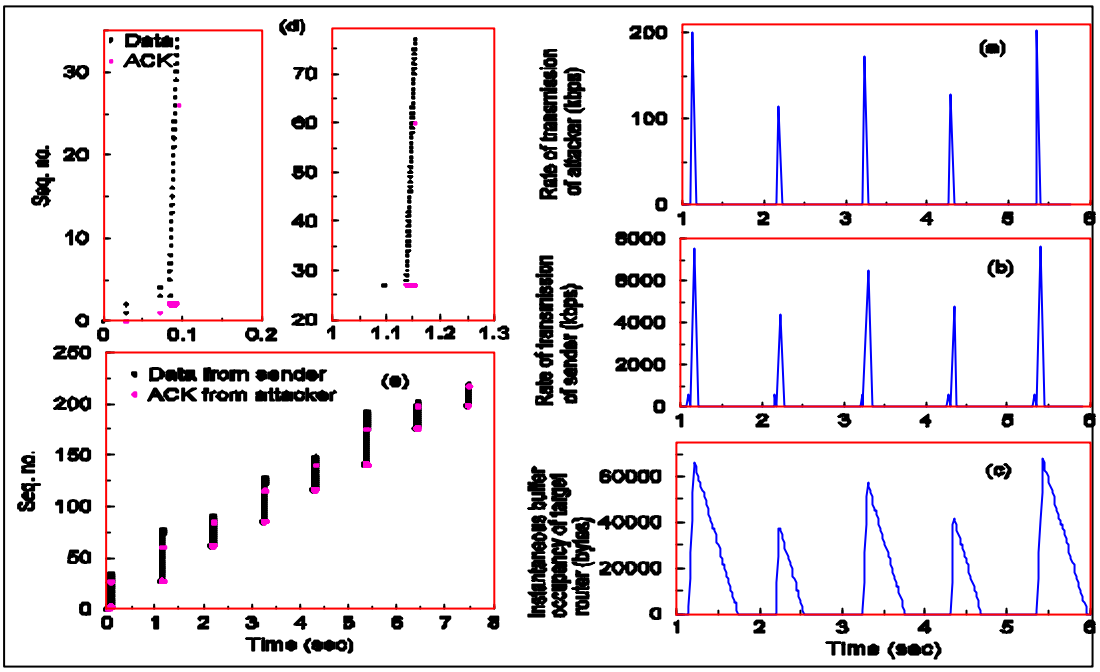

Figure 4.2 (a) Transmission pattern of the attacker, (b) Flood generated by the TCP sender, (c) Instantaneous buffer occupancy of the targeted router, (d) and (e) Time vs. Sequence number plots of the attacker and TCP sender during periodic burst attack at random intensity

4.2 Denial-of-Service Attacks: Analysis and Detection

As part of our ongoing work on analysis and detection of the new class of Denial-of-Service (DoS) attacks, which are constituted by tactically spoofing duplicate and optimistic acknowledgements (ACK), we have identified a number of tactical behaviours of a TCP receiver leading to low-rate DoS attacks. They are burst attacks, sustained attacks and pulse attacks.

Figure 4.2 shows the simulation results of one of the burst attacks, periodic bursts with random intensity. The attacker, in the form of a genuine client, first establishes a TCP connection with the server. It then spoofs several batches of ACKs with each batch having random number of spoofed ACKs and two consecutive batches having constant time gap between them. In response to this, the server ejects periodic bursts of random intensity. Depending on the burst intensity, each burst may completely fill the router buffer resulting in packet drop or partially fill the router buffer leading to high end-to-end delay.

V Anil Kumar, D Sisalem, P S Jayalekshmy

4.3 The Web-based Secure & Automated Online Submission Package

As part of our drive to improve Knowledge Management at C-MMACS the tedious process of submission of inputs to the annual report was simplified by using a "Web-based secure & Automated Online Submission Package". The first module is called "Knowledge Management Online Submission Package", designed to facilitate C-MMACS scientists to submit their technical contribution, reports, publications etc. through a browser. This facility is available through out the year, so that any researcher can use it as an information depository and refers to it whenever required. This has facility to upload files of different formats and preserve it in the server for the publication of annual report, the editor can collect the information and publish it.

This online submission also has another facility of "Online Registration System" for recognizing CSIR scientist as a Ph.D guides of Tezpur University, Osmania University and Cochin University of science and technology, students from various institution also

can register as Ph.D students to carryout their research in the above mentioned Universities, under CSIR University Interface.

These modules are developed using JAVA, JSP, HTML and JavaScript. The "Knowledge Management Online Submission Package" has to be authenticated by using a login name and password which will be created by the administrator, but for "Online Registration System" every user will have to be authenticated using a login name and password, which is created by themselves during the process of registration.

R P Thangavelu, N Prabhu, R Kavita, C Jayalakshmi, Suchanda Ray, Prashant Behara

4.3 High Performance Computing Resources

C-MMACS High Performance Computing was further strengthened after the procurement of two numbers of 24 processors, SGI Altix 3700 server after a detailed technical evaluation based on benchmarking of the possible systems by running LMD GCM and GFDL MOM4. The system is based on Intel Itanium 2 processors and each system is configured with 96 GB of Global memory and software components like Intel Fortran and C++ compilers and MPI libraries.

The 24 processor Origin 3000 server was upgraded to Origin 3900 server by replacing the older 24 processors with 32 numbers of MIPS R16000@1 GHz, 16 MB cache processors. This has enhanced the computing power of the major work horse of the C-MMACS HPC. In addition upgradation of Altix350 servers were done by adding 20 Itanium 2 processors, out of which 16 forms a different system. With this C-MMACS HPC have 112 high performance processors delivering a total computing power more than 550 G flops.

All the high performance servers are maintained with very high uptime efficiency and are efficiently used not only by C-MMACS scientists, but also by other CSIR laboratories. The major applications run on these servers are GFDL MOM, LMD GCM, MM5/ WRF and ABAQUS. In addition commercial application/utilities like Matlab, NISA, GAMIT/GLOBK, IDL, CFD-ACE are extensively used on these servers for designing, processing and visualization.

Storage Area Network

A high performance Storage Area Network (SAN) to cater the ever growing need of data storage is being procured after a detailed technical evaluation of various possible solutions. TP9700 storage solution from SGI is short listed which will provide a three tier solution of about 6 TB of on-line, 20 TB of near-line and 100 TB of off-line storage (archival). This has automatic Data Migration Facility and automatic backup facility. This will provide consolidation and virtualization of the newly procured storage and the already available FC storage. As a result of this all the HPC servers will access the storage as a local file system, which will eliminate the computational time delay arising because of I/O waiting due to Network File Systems (NFS). The SAN is likely to be ready by the end of June 2006.

Other Hardware and Software Enhancements

To improve network services like mail, Webmail, firewall, gateway etc. Intel Pentium based 2U rack servers are procured and are being configured. This is expected to be ready by the end of June 2006. In addition to the HPC servers, to cater the needs of less compute intensive jobs, two numbers of Intel Xeon based servers, one for Linux based applications and other for windows based applications has been procured and installed. The windows server can be access through remote desktop from any PC running both windows and Linux. This has enabled users to access windows applications like Corel Draw, MS-Office from their desktops. This has considerably decreased the financial burden of purchasing individual licensed software for each user.

Software is an integral part of the High

PerformanceComputing. Timely upgradation is essential to keep in pace with the growing requirement. Many new software are purchased and many are upgraded to its newer versions. A complete list of the hardware and software available at C-MMACS can be obtained from the website http://www.cmmacs.ernet.in.

Other Technical services

In addition to providing HPC service for the C-MMACS scientific community, the Computer Communication and Convergence (C3) group also provided various other technical services. This includes supporting students from various institutions of the country to carryout their project work at C-MMACS, and also providing computing facility for Ph.D. scholars from different universities. Computational facilities were provided for various courses and workshops organized at C-MMACS. Further, scientists and researchers from other CSIR and premier institutions use our facility through secure remote login. Technical consultancy is provided to different Government/ CSIR establishment for designing and evaluation of their computing platform. These institutions include INCOIS Hyderabad, DMC Karnataka, SERC Chennai etc.

Last year HPC group was actively involved in restoring the campus wide network from a major cyber attack. Systems affected by various viruses had launched Denial of Service attacks by overloading the campus wide routers and effectively bringing down the total network. The campus network was restored by first analyzing the network at packet level, finding the cause as well as the source and disinfecting them. The analysis showed that almost 50-60% of the systems were infected by some or other kind of viruses. The three campuses were isolated from each other from infection by setting proper need based Access Control List (ACL) at the campus routers.

R P Thangavelu, V Anil Kumar, G K Patra, N Prabhu and Seenappa

5

Knowledge Activities and Products, Publications, Presentations ..

Knowledge creation, knowledge enhancement, knowledge dissemination and knowledge management have been among the core activities of C-MMACS. Ever since its inception, C-MMACS has maintained a high knowledge output in terms of publications and other scientific programmes-knowledge synthesis and exchange through conferences, workshops, brainstorming sessions, etc.

Highlights

In the year 2005-06, C-MMACS has published 19 articles in SCI journals.C-MMACS scientists had participated in a number of national and international scientific events. And, as usual, C-MMACS had a vibrant year with visitors (30), invited talks (16) and other knowledge activities.

Inside

5.1 Publications in Journals

P Goswami, K C Gouda and O Talagrand, Ensemble Initial Conditions Through 4d-var Assimilation, *Geophy. Res. Lett*, Vol 32(21), 2005.

S Mukherjee, **P Jafarali** and **G Prathap**, A Variational Basis for Error Analysis in Finite Element Elastodynamic Problems, *Journal of Sound and Vibration,* 285, 615-635, 2005.

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Supriyo Mitra, Keith Priestley, Anjan Kr Bhattacharyya, and **V K Gaur,** Crustal Structure and Earthquake focal depths beneath northeastern India and the southern Tibetan Plateau, *Geophys Journal Int*, 160, 227-248, 2005.

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R Krishnan, **K V Ramesh,** B K Samala, G Meyers, J M Slingo and M J Fennessy Indian Ocean-Monsoon coupled interactions and impending monsoon droughts, *Geophysical Research Letters*, March, 2006.

A Gnandesikan, R D Slater, **P S Swathi** and G K Vallis, The Energetics of Ocean Heat Transport, *Journal of Climate*, Vol 18, 2604-2616, 2005.

5.2 Publications in Books/Proceedings

K C Gouda, P Goswami and O Talagrand, Dynamically Generated Ensemble Initial Conditions Through 4D-Var Assimilation System, *5th International Scientific Conference on the Global Energy and Water Cycle*, California, 20-24 June 2005.

S Himesh and **P Goswami**, Effect of Hydro-biospheric Processes on Moist Processes over the Monsoonal Region, *5th International Scientific Conference on the Global Energy and Water Cycle*, California, June 20-24, 2005.

G K Patra and **P Goswami**, Pre-monsoon Organization of Dynamics as a Predictor for Monsoon Intensity, *Proceedings 5th International Scientific Conference on the Global Energy and Water Cycle*, 20-24 June 2005, California, USA.

G K Patra and **P Goswami,** Long-range, High Resolution Forecast of Monsoon Rainfall, *International Roundtable on Understanding and Prediction of Summer and Winter Monsoon*, 21-24 November 2005, Jakarata, Indonesia.

G K Patra, Mathematical Model based on Neural Network for High Performance Grid Computing, *Proceedings of*

National Workshop on Mathematical Modeling and High Performance Computing, 28-29 October 2005, Tezpur University, Tezpur.

V Senthilkumar, S Manju and **G Prathap,** Mesh distortion Immunity of Finite Elements and the Best-fit Paradigm, *Proceedings of International Conference on Computational & Experimental Engineering and Sciences*, (ICCES' 05) Dec 2005 , India.

P Rajeevan and **P Goswami**, Effect of Ocean-Atmosphere Coupling on Tropical Cyclone Track: A Case Study with Bay of Bengal Cyclones, *5th International Scientific Conference on the Global Energy and Water Cycle*, California, 20-24 June, 2005.

5.3 Presentations in Conferences/ Symposia/ Workshops/ Meetings

V Anil Kumar, Neural Network Techniques for MI-ERMP, *2nd National Meeting on Multi-Institutional Extended Range Monsoon Prediction*, C-MMACS, Bangalore, 12-13 August 2005.

V Anil Kumar, Analysis and Detection of a New Class of DoS Attacks on the Internet, *Ministry of Communication and Information Technology,* New Delhi, 9 August 2005.

V Anil Kumar, DoS Attacks and Intrusion Detection, C-DAC, Bangalore, 22 July 2005

P Goswami and **A Mandal,** Improved Forecast of Rainfall Through Multi-Grid Ensemble, *5th International Scientific Conference on the Global Energy and Water Cycle*, California, 20-24 June, 2005.

P Goswami, Simulation of Meso-scale Events with a GCM: The Heavy Rainfall Episodes of 2005, *National Workshop on Dynamics and Simulation of Extreme Rainfall*, Bangalore, 16 March 2006.

K C Gouda, An Ensemble Initial Condition from 4 D Var Assimilation, *National Workshop on Dynamics and Simulation of Extreme Rainfall,* Bangalore, 16 March 2006.

K C Gouda, 4D-Var Data Assimilation wit Lorenz model, *International Summer School-2005 on Active Geosphere,* ITB, Bandung, Indonesia, 14-29 August, 2005.

C Acton, S Mitra, **Malay Mukul**, K Priestley and S K Nath, Crustal Structure Beneath the Darjeeling-Sikkim Himalaya from Teleseismic Receiver Functions, EOS Trans. AGU, 86 (53), *Fall Meet Suppl,* Abstract T43A-1377, 2005.

Malay Mukul, Is the Himalayan arc Really Perfect? *Asia Oceania Geosciences Society, 2nd Annual Meeting*, Singapore, 20-24 June, 2005.

Malay Mukul, **Sridevi Jade**, A Matin and **M S M Vijayan**, Global Positioning System (GPS) based Crustal Deformation of the Darjiling-Sikkim Himalaya, *Asia Oceania Geosciences Society, 2nd Annual Meeting*, Singapore, 20-24 June, 2005.

G K Patra, MI-ERMP : Webhosting and Data Management, *2nd National Meeting on Multi-Institutional Extended Range Monsoon Prediction*, 12-13 August, 2005, C-MMACS, Bangalore.

G K Patra, Dynamical Organization Associated with Mumbai Heavy Rainfall Event, *National Workshop on Dynamics and Simulation of Extreme Rainfall*, Bangalore, 16 March 2006.

G K Patra and **P Goswami**, Pre-Monsoon Organization of Dynamics as a Predictor for Monsoon Intensity, *5th International Scientific Conference on the Global Energy and Water Cycle*, California, 20-24 June 2005.

G Prathap, Measurements, Mathematics and Modelling, *Workshop on Mathematical Modelling and High Performance Computing*, Tezpur University, 30 October 2005.

G Prathap, Abductive Logic and the Field Consistency Basis as the Best Explanation for Locking, *International Conference on Computational & Experimental Engineering and Sciences (ICCES' 05),* India, 1-6 Dec 2005,

R Muralikrishna, S Mukherjee and **G Prathap**, Variational Crimes and Finite Element Elastodynamics, *International Conference on Computational & Experimental Engineering and Sciences (ICCES' 05)* India, 1-6 December, 2005.

K V Ramesh, Observed and Diagnostic Features of Different Extreme Weather Events, *National Workshop on Dynamics and Simulation of Extreme Rainfall,* Bangalore, 16 March 2006.

K V Ramesh, Interannual Variability of Upper Ocean Temperature in the Tropical Oceans, *Indo-UK Workshop on Regional Climate Change,* IITM Pune, 23-27 January 2006.

K V Ramesh, Mixed-layer Variability in the North Indian Ocean: Role of Vertical Mixing and Wind Forcing, *International conference Dynamic Planet*, Cairns, Australia, 22-26 August 2005.

K V Ramesh, Seasonal Variability of Heat Content and its Influence on the Thermal Structure of the North Indian Ocean*, IMPA 2006*, IIT Delhi, 14-17 February 2006.

K Sangeeta, S Mukherjee and **G Prathap**, Generalisation of the Projection Theorem for Finite Element Analysis, *International Conference on Computational & Experimental Engineering and Sciences (ICCES' 05)* 1-6 Dec 2005.

V Senthilkumar, G Prathap and S Manju, Mesh Distortion Immunity of Finite Elements and the Best-fit Paradigm, *International Conference on Computational & Experimental Engineering and Sciences (ICCES' 05)* 1-6 December, 2005.

Sridevi Jade, Estimates of Plate Velocity, Crustal Deformation and Precipitable Water Vapor from GPS data in Indian Subcontinent, Participant Lecture, I*AG-IASPEI/ IUGG Joint Capacity Building Workshop on Deformation Measurements and Understanding Natural Hazards in Developing Countries*, ICTP, Trieste, Italy, 17-23 January, 2005.

Sridevi Jade, Advances in GPS/GNSS Data Processing, *GRATICULE-2005*, October 2005, Lead paper.

Sridevi Jade, GPS Derived Deformation in Andaman and Nicobar Islands', *One day Seminar on "GPS aided Crustal Deformation Studies in Andaman & Nicobar Islands" after the Great Tsunami of 26th December, 2004*, 28 July, 2005.

Sridevi Jade, Estimation of Slip and Rupture of the Sumatra Earthquake based on Displacement of the C-MMACS GPS network', *One day Seminar on "GPS Aided Crustal Deformation Studies in Andaman & Nicobar Islands" after the Great Tsunami of 26th December, 2004*, 28 July, 2005.

R P Thangavelu, Towards an IFPReWac Shared HPC Platform for Modelling, *Annual Meeting of the Indo-French Programme for Research in Weather and Climate*, LMD, Paris, 16-18 May, 2005.

5.4 Participation in Conference/Symposia/ Workshops/Training Programme

K C Gouda

One week Workshop on Data Assimilation in Atmospheric and Ocean Modelling, CAOS, Indian Inst. of Science, Bangalore, 2-6 January 2006.

G K Patra & V Anil Kumar

National Seminar on WiMAX- New wave for Broadband Connectivity, MAIT, Bangalore, 7 April 2005.

Two day Workshop on "Wireless LAN", M S Ramaiah School of Advanced Studies, Bangalore, 30 September - 1 October 2005.

SGI Technology Summit 2006, SGI, Bangalore, 1 March 2006.

Voice over IP Seminar 2006, 3-COM, Bangalore, 28 March2006.

V Senthilkumar

ABAQUS Training Programme, C-MMACS, 04 - 08 July 2005

Training on Introduction to NVH using ABAQUS, ABAQUS Engineering India (P) Ltd, Bangalore, 8 Feb 2006.

5.5 Internal Reports

G Prathap, S Manju and **V Senthilkumar**, *The Unsymmetric Finite Element Formulation and Variational Incorrectness,* RR CM 0506, June 2005.

Imtiyaz A Parvez, Franco Vaccari and Giuliano F Panza, *Influence of Source Distance on Site-Effects in Delhi City*, RR CM 0507, June 2005.

Anand Kumar, *An Isotropic Numerical Scheme for Simulation of Turbulence*, RR CM 0508, December 2005.

S O Imoni, F O Otunta and **T R Ramamohan**, *Embedded Implicit Runge-Kutta Nystrum Method for Solving Second Order Differential Equations*, RR CM 0509, June 2005.

S O Imoni, F O Otunta and **T R Ramamohan**, *Multiple Solutions of Order Conditions for Runge-Kutte Nystrom Methods for Second-order differential Equations: Diagonally Implicit Methods*, RR CM 0510, June 2005.

Sridevi Jade, Radhakrishna, **P Dileep Kumar, M S M Vijayan**, Nilof S Pasha and Venkateswaran, *Remeasurement of GPS Locations in the West Southern Peninsular Shield of India (Sept - Oct 2004)*, PD CM 0504.

Anand Kumar, *Directionally Unbiased Numerical Schemes*, PD CM 0506, July 2005.

Malay Mukul, *Industrial Consultancy Phase I: Premier Oil, India: Structural Geology & Neotectonic Signatures in the Dihing River Lead Area, Upper Assam, India,* PD CM 0507, July 2005.

Malay Mukul, I*ndustrial Consultancy Phase I: Premier Oil, India, Structural Geology and Geomorphic Surfaces in the Dirak Footwall Lead Area, Upper Assam, India,* PD CM 0508, July 2005.

P Dileep Kumar, M S M Vijayan and **Sridevi Jade**, *First Remeasurement of GPS Locations in the South-Western Peninsular Shield of India (Sept - Nov 2004)*, PD CM 0509, July 2005.

M B Ananda, P Dileep Kumar and **Sridevi Jade**, *Study of the Seismic Vulnerability and Impact of the Tsunami Effect in Andaman & Nicobar Islands Using GPS*, PD CM 0510, July 2005.

Anand Kumar, *Directional Bias in Numerical Schemes*, PD CM 0511, August 2005.

Anand Kumar, *On the Grid Independence of Numerical Solutions,* PD CM 0512, August 2005.

Imtiyaz A parvez and **G Prathap**, *C-MMACS' Research Performance 1992-2005*, PD CM 0513, October 2005.

A Stella Margaret, *Knowledge Creation and Dissemination during 2005*, PD CM 0601.

Imtiyaz A parvez and **K Madhuker,** *Site response in Ahmedabad Coty using Microtremor Array Observation: A Preliminary Report*, PD CM 0602, April 2006.

M S M Vijayan, P Dileep Kumar, Anil Earnest, Nilof S Pasha and **Sridevi Jade**, *Second Remeasurement of GPS Locations in the South-western Peninsular Shield of India,* PD CM 0603, June 2006.

M B Ananda, P Dileep Kumar and **Sridevi Jade**, *GPS Remeasurements in the Garwal Himalayas (Sept-Oct 2005)*, PD CM 0604, June 2006.

V Anil Kumar, R P Thangavelu and **G K Patra**, *Analysis and Detection of a New Class of Denial-of-Attacks on the Internet* , PP CM 0501.

R P Thangavelu, V Anil Kumar and **G K Patra**, *Ashok Kamath, HNV Dutt, Vidyadhar Mudkavi, Report of the Task Team on Restoration of Campus Computer Network*, NAL Special Publication 0517, Date:Aug,2005 .

5.6 Invited Talks

G Prathap

Management by Stress Model of Finite Element Computation: Lecture at GE, Bangalore, 8 April 2005.
Measurement and Modelling: Science Lecture, Baldwin College, Bangalore, 2 September 2005.

Management by Stress Model of Finite Element Computation, Distinguished Seminar Series, IIT Kanpur, 3 October 2005.

Two minds or three? Role of creativity in Science, NIAS, Bangalore, 26 October 2005.

… the measure of all things, RRL Jorhat, 3 November 2005.

Mesh Distortion Immunity of Finite Elements and the Best-fit Paradigm: Keynote Lecture, SEC-2005, Bangalore, 14-16 December 2005.

Sridevi Jade

Global Navigation Satellite Systems (GNSS), Indian

Institute of Astrophysics, KodaiKanal, Popular talk, 19 August 2005

Tsunami and Sumatra earthquake- Role of GPS, Shri Shankara Vidyalaya, Kodaikanal, 19 August 2005

GPS Technology and its Application in Atmospheric Modelling, Gandhigram Rural University, Gandhigram, Tamilnadu, 20 August 2005

GIS-GPS/GNSS Integration for Navigational and Positional Services, Course on Emerging trends in GIS, CAIR, DRDO, 2 September 2005

Malay Mukul

I*ntegrated Continental Deformation Studies for Active Tectonic Belts: Insights from the Darjiling-Sikkim Himalayas*, Geological Society of India, Bangalore. July 27, 2005.

5.7 Workshop/Conference/ Scientific Meetings

2nd National Meeting on Multi-Institutional Extended Range Monsoon Prediction, C-MMACS, Bangalore, 12-13 August 2005,

National Workshop on Dynamics and Simulation of Extreme Rainfall: Case Study of Recent Events, NAL, Bangalore , Organised by : C-MMACS, Bangalore, Sponsored by : DST, New Delhi , 16-17 March 2006.

Mumbai, India's largest city and financial capital, received a record-high rainfall (944 mm) on Tuesday, July 26, 2005. The related soci-economical impacts are now only too well know; it is reported that 150,000 people were stranded across different railway stations of the Mumbai Suburban Railway, and this unprecedented rainfall produced widespread, massive flooding that was responsible for the deaths of over 1,000, the estimated economic losses were nearly Rs. 1700 cr. While the event of July 26 rainfall in Mumbai is one of the historical record, extreme events today pose a serious threat to a society increasingly dependent on technology, especially in urban areas. Consequent episodes of heavy rainfall events over Bangalore, Chennai and Ahmedabad during 2005 also caused heavy loss in economic and human life.

The purpose of the two day national workshop is to bring together scientists, forecasters and disaster managers to review current status and national requirement for forecasting and managing extreme weather events. Special focus will be on forecasting and understanding the dynamics of the heavy rainfall events of Mumbai (on July 26, 2005), Bangalore, Chennai, Ahmedabad and evaluation of forecasting skill for such events.

5.8 Guest Lectures

Abhishek K Rai, *Seismic Characteristics of the Pan - African High Grade Terranes*, Dept of Earth Sciences, University of Cambridge, UK, 12 May 2005.

R Muralikrishna, *Geometric Nonlinear Finite Element Analysis of Simply Supported Beams*, EACOE & Ph D Scholar, C-MMACS, 24 June 2005.

H K Verma, *Mathematical Modelling in Agriculture for Crop Production*, Head (Retd), Dept of Mathematics & Statistics, Punjab Agricultural University, Ludhiana, 29 June 2005.

S O Imoni, *Embedded Implicit Runge-Kutta Nystrom Method for Solving Second Order Differential Equation*, Dept of Industrial Mathematics, Adekunle Ajasin University, PMB 001, Akungba, Nigeria, 01 June 2005.

R Ramesh, *New Production Measurements in the Northern Indian Ocean,* Physical Research Laboratory, Ahmedabad, 04 July 2005.

D Jagadeesha, *Application of MOZART for CO2 Flux Estimation*, Space Application Centre, Ahmedabad, 11 July 2005.

Micheal Ramonet, *Determination of Regional Co2 Fluxes*, LCSE, CEA Saclay, Gif Sur Yvette Cedex, France, 05 September 2005.

Jonathan Redon, *Unsymmetric Finite Element Formulation of Quadratic Traingular Element for Stress Analysis*, Matmeca, Bordeaux, France, 14 September 2005.

Venkataraman Lakshmi, *Use of Hydrological Modelling and Microwave Remote Sensing for Studies in Ungaged Basins*, Dept of Geological Sciences, University of South Carolina, 26 October 2005.

Gianluigi Liberti, *Satellite Contribution to the Validation and Improvement of Cloud Representation in Numerical*

Climate (NWP) Models : An Overview, Insituto di Science Atmosfera e del Clima - CNR, Via Fosso del Cavaliere, Roma-Tor Vergata, Italy, 17 November 2005.

J**urgen Kurths**, *Synchronization: A Universal Concept in Non-linier Sciences*, Potsdam university, Germany, 2 January 2006.

Thomas R Anderson, *Biogeochemical Modelling of C and N in Marine Systems*, Univ of Southampton, UK, 18 January 2006.

T**homas R Anderson,** *Modelling Dentrification in Arabian Sea,* Univ of Southampton, UK, 20 January 2006.

K N Khattri, *Seismic Gap Theory: A Knowledge born Intelligent Basis for Seismic Risk Reduction*, Dehradun, 20 February 2006.

5.9 In-house Seminar

Mukul M, *Tectonics of the Darjeeling-Sikkim Himalayas-Implications for Himalayan Deformation,* 11 February 2005.

V Senthilkumar, *Mesh Distortion Immunity of Finite Element and the best-fit paradigm*, 24 March 2005.

M K Sharada

(i) *Inhibitory Effect of Ammonium on the Nitrate Uptake by Phytoplankton: A Comparative Study of Six Mathematical Models*
ii) *Mathematical Modelling of Biogeochemical Cycles in Bay of Bengal*, 11 April 2005.

G Prathap, T*he Unsymmetric Finite Element Formulation and Variational Incorrectness*, 17 June 2005.

Kalyani Devasena, *Mixed Layer Variability in the North Indian Ocean : Role of Vertical Mixing and Wind Forcing*, 16 August 2005.

M B Ananda, *GPS Work at Andaman & Nicobar Islands - Post Tsunami Experience*, 20 July 2005.

Sridevi Jade, *Co-Seismic and Post-seismic Displacements in Andaman and Nicobar Islands from GPS Measurements*, 21 July 2005.

Anand Kumar, *Isotropic Numerical Scheme*, 21 December 2005.

5.10 Visitors at C-MMACS

Abhishek K Rai
Dept of Earth Sciences, University of Cambridge, UK
12 May 2005

Bruno Rouot, Scientific Attaché
French Embassy, Bangalore
18 May 2005

Commander M K Singh, Dy Director
Naval Operations Data Processing and Analysis Centre (NODPAC), Kochi
24-25 May 2005

Charlotte Elizabeth Acton
University of Cambridge
01 - 30 June 2005

H K Verma, Head (Retd)
Dept of Mathematics & Statistics
Punjab Agricultural University, Ludhiana
29 June 2005

R Ramesh
Physical Research Laboratory, Ahmedabad
04 July 2005

D Jagadeesha
Space Application Centre, Ahmedabad
11 July 2005

Michel Ramonet
LCSE, CEA Saclay, Gif Sur Yvette Cedex, France
05 September 2005

Jim Poston
Visiting Professor, UK
08 September 2005

Bharathiar University Students
Coimbatore
09 September 2005

Jonathan Redon
Matmeca, Bordeaux, France
14-23 September 2005

Dr Eng Lim Goh, Chief Technology Officer
Silicon Graphics Inc, USA
22 September 2005

Dr Venkatraman Lakshmi
Dep Geological Sciences, University of South Carolina
26 October 2005

Dr G Liberti
ISAC-CNR, Italy
09 - 24 November 2005

Prof Juergen Kurths
Potsdam University, Germany
December 29 - January 5, 2006

Paul Julian Miller
Sr Researcher, DEMOS, UK
10 January 2006

Kristen Elizabeth Bound
Sr Researcher, DEMOS, UK
10 January 2006

Bernard Heulin
Counsiler, French Embassey, Bangalore
25 January 2006

Bruno Rouot
Scientific Attaché, French Embassy, Bangalore
25 January 2006

Bernard Dupre
Toulouse, France
25 January 2006

Jean Riotte
Toulouse, France
25 January 2006

Franco Vaccari
Researcher, Univ of Trieste, Italy
19 - 26 February 2006

Fabio Romanelli
Professor, Univ of Trieste, Italy
19 - 26 February 2006

6

C-MMACS Academic Programme

In keeping with its objective of developing skill and expertise in Mathematical Modelling and Computer Simulation in the country, C-MMACS maintains an active academic programme. The activities span the entire spectram from Ph D guidence to undergraguate/postgraduate student projects to specialized courses. Students and professionals from a wide spectrum of organizations including industries across the country have been benefiting from our various academic programmes over the years.

Highlights:

The year 2005-06 has been an active year in terms of various academic activities at C-MMACS. A number of training and exposure courses were organized for participants cutting across universities, research organizations and industries across the country. The year had also seen, as usual, a large number of students and trainees from various universities and institutions.

Inside

Ph.D Programme

S Raja (Guide: G Prathap, Co-Guide: P K Sinha)

R Muralikrishna (Guide: G Prathap)

P Jafarali (G Prathap, Co-guide: Mohammed Ameen)

K. Asokan (Guide: T R Ramamohan)

K Radhakrishnan (Guide: T R Ramamohan)

S Himash (Guide: P Goswami, Co-guide: S V Goud)

K C Gouda (P Goswami)

Suovik Banerjee (Guide: Malay Mukul)

M S M Vijayan (Guide: Sridevi Jade)

Saigeetha Jagganathan (Guide: Sridevi Jade)

Seminars by Project Trainees (M Tech Thesis/ B E, MCA Project)

V Anil Kumar
Simulation Study on Throughput Variation of TCP under Different Queue Management Schemes, Jayalakshmy P S Noorul Islam College of Engineering, Kumaracoil, 06 June 2005.

Behaviour Analysis of TCP in Context of Acknowledgement Spoofing, A Pradeep, Vellore Institute of Technology, 21 June 2005.

V Anil Kumar & R P Thangavelu
GUI for Bandwidth Utilization of Internet Access Link, B G Ashwini, Kuvempu University, Shimoga, 13 May 2005.

Transport Layer Packet Transfer Visualization System, C G Shubha, S Shilpa Hejmadi, P Sunil, R Sridhar, Dr Ambedkar Institute of Technology, 01 June 2005

P Goswami
Estimation of Sustainable Urbanization : Analysis with a Simulation Model, Ancymol K Thomas & Veena C Jose, Cochin University of Science & Technology, Kochi, 25 August 2005.

Reverse Engineering and Modification of a Meteorological Code using Pseudocode and Parser; Designing, Testing and Analysis, Manna Day, Jyotideep Bhuyan, Jorhat Engineering College, Jorhat, 26 October 2005.

P Goswami & Achintya Mandal
Finding Cyclone Center from Surface Pressure Plot using Image Processing Techniques, Rama Kanta Sinha, Tezpur University, 01 June 2005

P Goswami & V Anil Kumar
A Neural Network Based Rainfall Forecasting System from Multi-model Inputs, T S Aravind, M A L Soumen, S K Ajay Kumar, Dos Bosco Institute of Technology, 24 May 2005

P Goswami & S Himesh
Development of Unix/Linux Compatible Graphic Tool Functions Scientific Data Visualization and Analysis, M G Srinivas Bakkappa, Gulbarga University, 20 April 2005.

River Water Quality Modelling - A Case Study : Tungabhadra River System, G N Anjana, Y G Chaithanya Kumar, Chaitra Seshadri, B S Shalini, Civil Engineering Dept, BMSCE, 27 May 2005.

Imtiyaz A Parvez
One Dimensional Ground Response Analysis, K R Avinash, C Risheej Rajan, S Rohan Kamble, BMS College of Engineering, 14 June 2005

Imtiyaz A Parvez & G K Patra
Prediction of Peak Horizontal Acceleration of Earthquakes Using Artificial Neural Network, P Hari Krishnan, Sathyabama Deemed University, Chennai, 19 April 2005.

G K Patra & Imtiyaz A Parvez
A Neural Network Based System for Assessing Earthquake Peak Horizontal Acceleration with Hypocentral Distance, A K Mohanty, G K Mohanta, Berhampur University, 29 July 2005

Studies on Epoch-Based Artificial Neural Network (Back Propagation Algorithm) for Early Warning of Earthquakes, Sonali Biswal, KIMS Utkal University, Orissa, & Subrat Kumar Nayak, Berhampur University, Orissa, 29 July 2005.

Prediction of Peak Horizontal Acceleration of Earth quakes Using artificial Neural Networks, P Hari Krishna, MCA, Satyabhama Deemed University, Chennai, June 2005.

G K Patra & R P Thangavelu
Cryptanalysis of a Public-Key Encryption Scheme

based on the Polynomial Reconstruction Problem, D Sasikumar & T Suganthi, Gandhigram Deemed University, Dindigul, 19 April 2005.

Hierarchical Authentication System using Proxy Cryptography, N Chithra, S Kshama, Sindhu Madhusudhan, Vemana Institute of Technology, Bangalore, 05 May 2005.

N Prabhu & R P Thangavelu
Development of a Web based Secure & Automatic Online Submission Utilities, C Jayalakshmi, Bharati Institute of Higher Ed. & Research, Chennai, 24 March 2006.

M K Sharada & P S Swathi
Effect of Five Relations for Ammonium Inhibition on Nitrate Uptake on the Dynamics of 1-D Marine Ecosystem Model, Suma, Sumana, Swetha & Sushma, APS College of Engineering, 26 May 2005.

V Senthilkumar & G Prathap
Immunity to Mesh Distortions of Quadratic Plane Triangular Element, Jonathan Redon, Matmeca, France.

Courses at C-MMACS

C-MMACS Course on Mathematical Modelling and Computer Simulation, C-MMACS, Bangalore, 06 - 10 June 2005, Co-ordinator: M K Sharada

The main objective of the course is to impart theoretical knowledge in the principles of Mathematical Modelling, Application of Mathematical Modelling Techniques in Physical, Chemical and Biological Systems. Numerical Techniques for Solving Differential Equations, Software Tools for Solution of Equations and Analysis of the Model Results.

Mesoscale Simulation Training School, C-MMACS, Bangalore, 15 March 2006, Co-ordinator: Dr K V Ramesh

Faculty Participation

C-MMACS Course on Mathematical Modelling and Computer Simulation, C-MMACS, Bangalore, 06-10 June 2005

G Prathap, Inaugural Lecture

K S Yajnik, Introduction to Model Building

V K Gaur, Introduction to Inverse Methods

T R Krishna Mohan, Nonlinear Dynamics

P S Swathi, Numerical Methods

N K Indira, Statistics - Introduction to Methods & Tools

T R Ramamohan, Introduction to Bifurcation Theory

M K Sharada, Modelling of Marine Ecosystem

K Sangeeta, Software Tools used in Mathematical Modelling

C Kalyani Devasena, Software Tools for Data Analysis & Visualization

R P Thangavelu, Scientific Computing at C-MMACS : An Overview

Malay Mukul, Applications of Mathematical Modelling in Geology

Course on Mathematical Modelling and High Performance Computing, Tezpur University, Tezpur, October 30 - November 1, 2005

G K Patra

Introduction to MM5 Modelling System

Message Passing Interface : What, Why and How

Refresher Course on Earth System Science, Indian Academy of Sciences, Bangalore. June 28, 2005

Malay Mukul

Plate Tectonics

First Order Features Resulting from Plate Tectonics

Mesoscale Simulation Training School, C-MMACS, Bangalore, 15 March 2006.

Anil Kumar, Introduction to High Performance Computing

K V Ramesh, Data Analysis and Plotting Techniques

S Himesh, Introduction to MM5 Modelling Systems

G K Patra, Installation and Running of MM5 Modelling system

7

Collaborative Programmes and Projects

Multi-institutional, national and international collaborative research programmes have been the core of C-MMACS overall research. C-MMACS to-day has active collaboration with a number of national and international institutions.

Highlights:

The year 2005-06 had been an active one in terms of multi-institutional collaborative programmes. The long-awaited MoU between CSIR and CNRS, France was finally signed on 28-09-2004 between Dr Mashelkar, DG, CSIR and Bernard Larrouturou, DG, CNRS, France.

A new collaborative research programme under the Global Opportunity Fund, UK was launched in the area of Carbon Cycle Modelling. At national level, C-MMACS is now a major participant in a national programme on Multi-Institutional Extended Range Monsoon Prediction.

Inside

7.1 Sponsored and Collaborative Projects

Scale Interactions in Air, Land, Sea Coupled Environment & North-east Monsoon, USIF ONR - P Goswami, S Himesh.

Evaluation and Validation of Systems of Assimilation, IFCPAR - P Goswami, G K Patra.

Modelling of Atmosphere-Hydrosphere-Biosphere Interaction, ISRO - P Goswami, S Himesh.

Impact of GCM-generated Dynamical Boundary Fields on Meso-scale Simulations, SAC/DOS - P Goswami, S Himesh, A Mandal.

Development of a Commercializable Fog Forecast Platform, CSIR - P Goswami.

High-Resolution Regional Atmospheric Analysis (HiRRAA) through Meso-scale Observation Network for Urban System (MONUS), CSIR - P Goswami, G K Patra, K V Ramesh.

Active Tectonics in the Shillong Plateau using Global Positioning System (GPS) based Geodesy, Department of Science and Technology (India) - Malay Mukul, Sridevi Jade.

A*ctive Tectonics of the Darjeeling-Sikkim Himalayas using Global Positioning System (GPS) based Geodesy,* Department of Science and Technology (India) - A P Krishna, K Kumar, A Matin, Malay Mukul, Sridevi Jade.

Active Tectonics in the Kutch, Cambay and Narmada Rift Systems using Global Positioning System (GPS) Geodesy, Department of Science and Technology (India) - K. C. Tiwari, A. Joshi, Malay Mukul, Sridevi Jade.

Dynamics of Continental Collision and Rheology of Lower Crust based on GPS studies in Indian Sub-Continent, Department of Science and Technology (India) - Sridevi Jade, V K Gaur, Malay Mukul.

Geometry, Kinematics and Deformation Mechanisms in the Gish Transverse Zone in the Darjiling-Sikkim Himalaya, India, Department of Science and Technology (India) - Malay Mukul, Sridevi Jade, V K Gaur, A. P. Krishna, A. Matin.

Assimilation of In-situ and Satellite Altimeter Data into an OGCM, Department of Ocean Development - P S Swathi, Kalyani Devasena.

Modelling Biogeochemical Cycles in Bay of Bengal, Department of Ocean Development - M K Sharada, P S Swathi, Kalyani Devasena, K S Yajnik.

Development of Indian Ocean Community Model, Department of Ocean Development - P S Swathi, C Kalyani Devasena.

Carbon Source and Sinks in Asia and the Indian Ocean, GOF, British High Commission- P S Swathi, M K Sharada, N K Indira, K S Yajnik, R P Thangavelu.

Empirical Modelling and relationship of the primary productivity with other ocean parameters in the Indian Ocean, N K Indira, P S Swathi, M K Sharada.

Microzonation Investigations and Study of Building Parameters in the Anjar (Kutch) area using Microtremor Recordings, Department of Science and Technology (India) - Imtiaz A Parvez.

Site effects in Ahemedabad based on Array Observations of Microtremors, Department of Science and Technology (India) - Imtiaz A Parvez, Sridevi Jade.

Thermal Structure and Mixed Layer Variations of the Indian Ocean in an OGCM and Intercomparison with Institution and Satellite Observations, Department of Science and Technology (India), C Kalyani Devasena, P S Swathi.

A Kinematic Study of Suspected Major Active Shear/ fault Zones in the West Southern Peninsular Shield of India: Implication on Seismogenesis, Department of Science and Technology (India) - M R Radhakrishna, Sridevi Jade.

GPS re-measurements to quantify deformation in Uttaranchal and Ladakh Himalayas, Sridevi Jade, M S M Vijayan

.

Realistic site specific hazard assessment for mega-cities utilizing modeling technique, Imtiaz A Parvez.

Establishment of Continuous recording GPS systems at four sites in North Eastern India. Department of Science and Technology (India) - Sridevi Jade, Malay Mukul, V K Gaur.

Measurement of Accurate Coordinates for ACMI, Gwalior, Airforce (ACMI), Gwaliar, Air HQ - Sridevi Jade, M B Ananda.

Procurement of GPS Receiver Systems for DST National Network, Department of Science and Technology - Sridevi Jade.

GPS Measurements in the Andaman and Nicobar Islands, Department of Science and Technology - Sridevi Jade, M B Ananda, P Dileep Kumar.

Practical Equivalent Continuum Modeling of Jointed rocks and Analysis of Large Scale excavations in rock mass, CSIR, EMR Division- T G Sitharam, Sridevi Jade.

Inertial Effects on Forced particles in Unsteady Flow at Low Reynolds Numbers, Department of Science and Technology - T R Ramamohan.

Analysis and Detection of a new class of Denial-of-Servce attacks on the Internet, Ministry of Information Technology, Govt. of India - V Anil Kumar, G K Patra, R P Thangvelu

8.2 Joint Projects with Laboratories

Director and Concentration Profiles in 2-component Liquid Crystals, RRI, Bangalore - N V Madhusudana, Anand Kumar.

Carbon Fluxes in India and Central Asia, IIAP, Bangalore- N K Indira, P S Swathi, V K Gaur.

Variations in Deformation and Kinematics along and across the Himalayan Arc through Time: Insights from the Darjeeling-Sikkim-Tibet Transect, University of Rhodes, USA-Gautam Mitra, Malay Mukul.

8.3 In house Project

Complex Fluid Flow Modelling and Simulation - Anand Kumar.

Mesoscale Modelling for Monsoon Related Predictions - P Goswami

Coupled Atmospheric - Hydrological Model to forecast Spatio-temporal variability of Water Resource - P Goswami, S Himesh.

Long-range High Resolution Forecast of Monsoon Rainfall, P Goswami, G K Patra, K C Gauda.

Site Specific Ground Motion Modelling and Mocrozonation Studies in Indian Megacities- Imtiaz A Parvez, Sridevi Jade.

GPS Measurements to Determine Time Evolving Surface Strain Field in the Bhuj Region - Sridevi Jade, Malay Mukul.

Maintaining and Monitoring of Continuously Operating CMMACS GPS station located in the IISC campus - Sridevi Jade, R P Thengavelu, M S M Vijayan.

The Dynamics and Rheology of Periodically Forced Particles in Simple Shear Flow at Low to Moderate Reynolds Numbers - T R Ramamohan.

Network security in an inter-networked environment - R P Thangavelu, V Anil Kumar, G K Patra.

8.4 CSIR Network Project

*Sub -Task 1: Computational Mechanics for Modelling, Analysis and Design of High-performance Structures, Materials and Process Applications,*Participating Labs: C-MMACS, SERC-Chennai, RRL-Bhopal, RRL-Trivandrum, NML-Jamshedpur-Nagesh Iyer.

Sub -Task 1: Multi-scale Modelling Platform for Environmental Forecasting and Management, Participating Labs : C-MMACS, NEERI-Nagpur, NIO-Goa, RRL-Bhubaneshpur, CRRI-Roorkee, CBRI-New Delhi-P Goswami.

8

Team C-MMACS - News and Updates

The greatest strength of C-MMACS is 'Team C-MMACS', the dedicated group that takes C-MMACS foreward. One of the smallest of CSIR laboratories, C-MMACS today is a young and vibrant institution of research, with the average age of its scientists less than 35 years.

Highlights:

The year 2005-06 has seen growth of C-MMACS scientific strength through joining of new scientists. A number of C-MMACS scientists have also received recognition for their scientific contribution .

Inside

Team C-MMACS

Scientist-in-Charge
Gangan Prathap

Honorary Emeritus Scientists
Gaur V K
Seshagiri N

Honorary Fellows
Yajnik K S

Scientists
Achintya Mandal
Anand Kumar
Anil Kumar V
Anil Earnest
Goswami P
Himesh S
Indira N K
Krishna Mohan T R
Malay Mukul
Parvez I A
Patra G K
Rajendran K
Ramamohan T R
Ramesh K V
Senthil Kumar V
Sharada M K
Sridevi Jade
Swathi P S
Thangavelu R P

Fellows
Sangeeta K
Imoni S O

Research Associates
Jagadheesha
Kalyani Devasena C
Rajeevan P

Associates
Mukherjee S (NAL, Bangalore)
Raja S (NAL, Bangalore)

Senior Research Fellow
Gouda K C

Junior Research Fellow
Sunaina A N
Swapan Mallick

Technical Officers
Ananda M B
Suchanda Ray
Prabhu N

Controller of Administration
Prabhakaran M

Section Officer
Sailaja Nori

Technical/Administrative Staff
Chandrashekar Bhat
Dileep Kumar P
Seenappa
Sita S
Stella Margaret A
Udaya Kumar M

Project Assistants/Graduate Trainees/ Diploma Trainees

Antaryami Sahu
Balasubramani G
Baby Shakila
Jayalakshmi P S
Geetha M
Kavita
Karthik Kumar M
Madhukar K
Muthu Vijayan M
Nanditha S
Prashanth S Babu
Raghavendra Rao H J
Raghunath Babu
Ronia Andrews
Saigeetha A J
Ujjal Phukan
Vijayareshmi V

Awards/Honours/Recognition

Anand Kumar, Visiting Professor, Raman Research Institute, Bangalore

Services on External Committees/ Membership of Professional Bodies

Anand Kumar
Member, Society of Rheology

Anil Kumar V
Member, Computer Society of India

Goswami P
Life Member, Indian Meteorological Society
Life Member, Indian Complex System Society
Member, Executive Council, Drought Monitoring Cell
Member, Computer Committee, ISRO Regional Climate Modelling Programme
Convener, International Conference on Scale Interaction and Variability of Monsoon
Convener, National Workshop Science and Technology for Regional Development - The Case for the North-East India

Gouda K C
Life Member, Indian Meteorological Society

Himesh S
Life Member, Institution of Engineers, India
Life Member, Indian Society for Technical Education
Life Member, Indian Association for Environmental Management
Life Member, Indian Meteorological Society

Indira N K
Member, Institute of Mathematical Statistics, USA

Krishna Mohan T R
Life Member, Indian Complex Systems Society

Gangan Prathap
Member, Sectional Committee, INSA
Member, Research Council, CMRI, Dhanbad
Member, Research Council, SERC, Chennai
Member, Governing Council, INCOIS, Hyderabad
Member, Management Committee, CFTRI, Mysore
Member, DOD Steering Committee for INDOMOD and SATCORE,
Member, DST Steering Committee on HRD in Earth Sciences
Member, DOD Steering Committee for National Data Buoy Programme
Member-Secretary, Advisory Committee, C-MMACS
Editor, SADHANA - Journal of Engineering Sciences of Indian Academy of Sciences
Member, Editorial Board, Current Science
Member, Editorial Board, Int. J Computational Engineering Science
Member, CSIR Expert Committee for Selection of SRFs and RAs (Engineering)
Member, Special Task Force for Dev. of Indigenous Finite Element Package, ADA
Fellow, Indian Academy of Sciences
Fellow, Indian National Science Academy
Life Member, Indian Society for Theoretical and Applied Mechanics
Member, Current Science Association'
Life Member, Indian Society for Advancement of Materials and Process Engineering
Life Member, Indian Society for Mathematical Modelling and Computer Simulation

Malay Mukul
Life Member, Geological Society of India
Member, Editorial Committee, EQ News - a Biannual Newsletter of Updates on Seismological Programmes, Department of Science and Technology, New Delhi

Imtiyaz A Parvez
Life Member, Indian Society of Earthquake Technology, Roorkee

Patra G K
Life Member, Computer Society of India
Life Member, Indian Meteorological Society
Life Member, Cryptology Research Society of India
Life Member, Orissa Information Technology Society

Prabhu N
Member, Computer Society of India

Sharada M K
Member of the American Geophysical Union

Sridevi Jade
Life Member, International Society of Soil Mechanics and Foundation Engineering Member, Indian Geotechnical Society

Swathi, P S
Member of the American Geophysical Union

Thangavelu R P
Member, Computer Society of India
Member, Cryptology Research Society of India
Invited Member, Computer Committee, ISRO Regional Climate Modelling Programme
Member, Committee on High-Speed Computer System, Tezpur University

Deputation

Anand Kumar
Autumn College on Plasma Physics at the Abdus Salam International Centre for Theoretical Physics, Italy September 5-30, 2005.

Gangan Prathap
Indo-French Programme for Research in Weather and Climate Joint Committee Meeting and Annual Scientific Meeting in Paris, May 16-18, 2005.

Goswami P
Indo-French Programme for Research in Weather and Climate Joint Committee Meeting and Annual Scientific Meeting in Paris, May 16-18, 2005.

Collaborative Research under Indo-US collaborative project on Ocean-Land-Atmosphere Interaction in a Coupled Environment and North-East Monsoon, North Carolina State University, Raleigh, June 6-20, 2005.

5th International Global Energy and Water Cycle Experiment Science Conference, Orange County, California, June 20-24, 2005.

6th WRF User Workshop, Colarado, 27 June - 30 June 2005.

Indo-US Workshop on Joint High Performance Computing for Regional Weather and Climate organized by the Indo-US Forum, Mesa Laboratory, NCAR, Colorado, USA, June 30 - July 2, 2005.

Gopal Krishna Patra
International Roundtable on Understanding and Prediction of Summer and Winter Monsoon and the 11th Governing Council Meeting of NAM S & T Centre, Jakarta and Bandung, Indonesia, November 21-24, 2005.

Gouda K C
2nd KAGI-21 International Summer School on Active Geosphere held at Institute of Technology, Indonesia during August 14-30, 2005.

Himesh S
5th International Scientific Conference on the Global Energy and Water Cycline, Orange Country, California, June 20-24, 2005.

I A Parvez
Visit to the Laboratory of Geophysics and Tectonophysics at Grenoble, France under Indo-French bilateral project of DST during Sept 1 - 30, 2005.

One month visit to the Abdus Salam International Centre for Theoretical Physics, Trieste, Italy under ICTP-CMMACS federation program during October 1-30, 2005.

Kalyani Devasena
Dynamic Planet-2005 for Monitoring and Understanding a Dynamic Planet with Geodetic and Oceanographic Tools, CAIRNS, Australia, 20-26 August 2005.

Krishna Mohan T R
On assignment as a Research Scholar at the Department of Physics, State University of New York at Buffalo, USA , 26 Sept 2005 for one year (EOL).

Malay Mukul
2nd Asia-Oceania Geosciences Society (AOGS) International Conference, Singapore, June 20-24, 2005.

Sridevi Jade
Deputed to ICTP, Trieste, Italy from 17th January to 26th January 2005 for the IAG-IASPEI/IUGG Joint Capacity Building Workshop on Deformation Measurements and Understanding Natural Hazards in Developing Countries. She was invited to participate in the workshop by the Organizers.

Thangavelu R P
Indo-French Programme for Research in Weather and Climate Annual Scientific Meeting in Paris, May 16-18, 2005.

Swathi P S
To Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Paris to work on Carbon Dioxide Measurement and Analysis, and the Global Carbon Cycle, Nov-Dec, 2005.

About C-MMACS

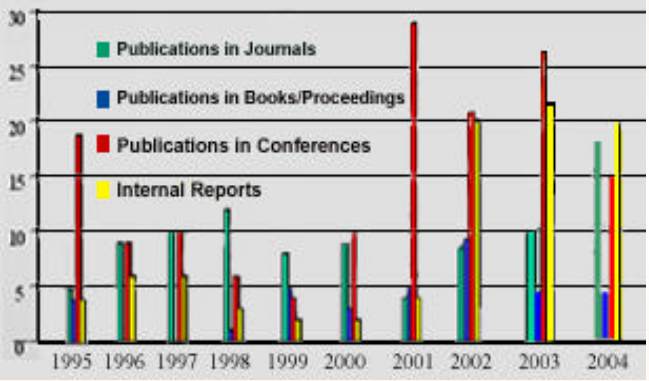
The Mission: To play an enabling role by developing wide-ranging capabilities in mathematical modelling and computer simulation. Specifically, C-MMACS aims to

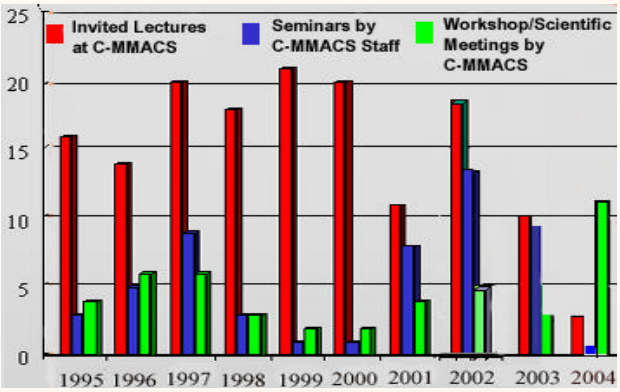
Develop capability for addressing critical issues of scientific significance and societal benefit

Enhance the scope and strength of mathematical modelling through development of new techniques/algorithms etc

Train and develop high-quality man-power in the area of Mathematical Modelling and Computer Simulation

A Profile: One of the youngest and the smallest of CSIR laboratories, C-MMACS today is a vibrant and a premier institution of research. It has successfully blended basic and applied research. In spite of a core scientific strength of less than 20 even now, and much less in the early years, C-MMACS has maintained a high scientific output:





An Invitation: We at C-MMACS believe that synergy through well-developed scientific collaboration is a key to progress in science and technology. C-MMACS is eager to develop such collaboration for sustained effort in a resource-sharing environment

The Vision: The power and scope of mathematical modelling and computing are poised to grow manifold in years to come. C-MMACS would like to play a pivotal role by bringing this emerging technology in its fullest power to the nation

Give me a (Partial) Derivative, I will Invert the World
-Isaac Newton

Modelling for Science
Modelling for a Better Future

An Invitation: We at C-MMACS believe that synergy through well-developed scientific collaboration is a key to progress in science and technology. C-MMACS is eager to develop such collaboration for sustained effort in a resource-sharing environment.

Give me a (Partial) Derivative, I will Invert the World

-Isaac Newton

Modelling for Science
Modelling for a Better Future

Contact :
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