Preface

Science with a human touch is more useful than science for the sake of science. This is the main driving force of all of the modelling, simulation and high performance computing activity of the CSIR Fourth Paradigm Institute. The modelling and simulation effort at CSIR-4PI has remained focussed on earthquake hazard, carbon cycle and ocean modelling, atmospheric modelling and climate change projections. Over the years, the modelling tools and technologies have matured enough to take on challenging problems, the previous year being no exception. These activities require the muscle power of high performance computing which is provided by an able team, not only for CSIR-4PI but for all of computational scientific work force of CSIR. As we move towards a more digitally enabled world, we face the challenges of cyber security. Concrete steps have been taken in this direction as well. As we move forward, the much needed competence in data and comptuational science will need to be built to realise the new goals of the institute. In what follows, we summarise the major scientific contributions during 2015-2016.

Several countries have submitted firm plans at the COP 21 meeting of UNFCCC at Paris to mitigate climate change by adopting a variety of strategies. In order to implement these strategies and study their effectiveness, we need robust estimates of the fluxes between atmosphere, land and ocean at good spatial and temporal scales. Lack of accurate measurements of Green House Gas (GHG) concentrations and gaps in modelling the carbon, nitrogen and oxygen cycles, especially the oceanic component have hampered efforts to obtain robust estimates. At CSIR 4PI we have contributed (a) by establishing WMO-standard GHG stations and using this data to obtain robust fluxes by inversion and (b) making fundamental contributions to the processes in the carbon cycle, incorporating these into 3-D ocean circulation and biogeochemistry models to study the interannual variations of the carbon, nitrogen and oxygen cycles.

Climate and environmental modelling is on multidisciplinary and applied research for direct societal benefits. The knowledge products developed under this intiative are geared to be application oriented and provide basis for weather and climate informatics for end-users in the area of agriculture, health and energy. The research on the dynamics of Indian Monsoon, process modeling, high impact weather events and urbanization has continued as they form important components of the ongoing programme.

Climate change is a major concern for the future of humanity as it threatens our very existence. There has been major global thrust and it is only appropriate that we understand the climate change impact from Indian perscpective. Our approach here is to perform advanced simulation of weather and climate, to project future climate change, assess associated vulnerability and provide efficient adaptation and mitigation strategies. Moreover, this is a data intensive paradigm where numerics and computing strategies relevant for different scales in a dynamical system are combined to arrive at an effective computational solution than the one obtained from the strategy dealing with the most relevant single scale. In initial phase of the program, ultra-high resolution weather and climate model framework was developed to address multi-scale processes of the atmosphere and analyze the data from observations and these simulations to effectively arrive at inferences. General Circulation Models (GCMs), coupled ocean-atmosphere climate model and earth system model with emphasis on processes such as multiscale

organization of organized convection and aerosol-cloud-radiation feedbacks, were employed. Recently, multiscale problems ranging from surface processes and climate aspects from surface to ionosphere are being addressed.

Earthquake hazard is another major concern for India. Even small intensity earthquakes result in huge loss of life owing to poor buildings and other emergency infrastructure. The institute has made pioneering efforts in this are over the years. During 2015-16, broadband seismic network in Kashmir Himalayas was augmented to give good spatial coverage which resulted in first crustal shear velocity model of Kashmir valley. Major contributions during the year are quantification of seismic hazard in the Peninsular India, seismic hazard and risk model for Gujarat region, establishment of GNSS observation network in Kashmir Himalaya, modeling of GPS derived landslide deformation, in-depth study of PWV variability at Hanle: high altitude (~ 4500m) site in Trans-Himalaya. Mega project in collaboration with Kashmir University has been awarded by Ministry of Earth Sciences to study the geological characterization of Kashmir valley with the objective of quantifying hazard and risk in the valley.

In the domain of computational mechanics, homotopy analysis method (HMA) was used to study the complex systems like structures containing nanofluid with viscous and thermal effects. The present method captures the behaviour of the structures and results are very well close to the analytical method. The modification of the HMA yielded good results. The wave propagation analysis of granular sphere was simulated using discrete element approach. The effective mechanical properties of nanocomposites are found through continuum models.

One of the main objectives of institute is to provide state-of-the-art high performance computing environment for the whole of CSIR. The 360 TFLOPS Supercomputing facility, Ananta continued to be the centralized computing facility serving this 200 and odd computational scientists across CSIR with the nodes usage reaching its full capacity in most of the days during this year. The usage has been in diverse field of science like Biological, Chemical, Engineering, Earth and Atmosphere, Physical and Information Sciences. This facility is being accessed by CSIR scientists through the high speed National Knowledge Network on a round-the-clock basis.

One of the major milestones achieved this year is the installation of Cyber Security Research and Observation (CySeRO) platform. CySeRO is a sophisticated test-bed for experimental research and data analysis. This facility is certainly going to boost the ongoing research in Cyber Security and Cryptography.

In the years to come, we look towards consolidating some of the modelling efforts the institute has continued to make and bring in the new capability in data and computational science which is now emerging as the new face of science.

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