

WORKSHOP PROPOSAL

Submitted to

INDO-U.S. SCIENCE AND TECHNOLOGY FORUM

A. Title of Activity: Indo-U.S. Workshop on Joint High-Performance Computing for Regional Weather and Climate

B. Executive Summary:

High-performance numerical simulation is a crucial technology for the understanding and ultimately the effective prediction of regional weather and climate and its effects on the economic welfare and physical well-being of large populations in both developed and developing regions of the world. The problems for India and its regional neighbors include prediction of the south-west monsoon circulation that gives rise to vital rainfall patterns with large spatial and temporal variation from June through September. Likewise, in the U.S., climate variation on regional scales has numerous impacts on forests, fisheries, agriculture, energy use, etc. The prediction of track and intensity of severe weather events like the 1999 Bay of Bengal Super-cyclone in India and the hurricanes in the U.S. are of vital importance for both the countries. Similarly, wintertime forecasts of snowfall, its coverage and depth are of vital importance to both the countries. In addition severe weather phenomena for the mountainous regions of India are least understood topics which need collaborative research. Considerable resources have been invested in both the countries on modeling as well as on computational fronts as summarized below:

- Development of new state-of-the-art High Performance Computer (HPC) such as the PARAM Padma in India,
- Development of new national model such as Weather Research and Forecast (WRF) model in U.S.,
- Development of multi-model multi-scale simulation systems such as coupled atmosphere-ocean models for hurricane/cyclone prediction and coupled atmosphere-chemistry models for air-quality simulation,

- Advanced data assimilation techniques such as 3- and 4-dimensional variational assimilation,
- Computational frameworks and software infrastructure for developing modern, flexible, and efficient simulation software, such as the NASA Earth System Modeling Framework (ESMF),
- New high-performance intra- and inter-national network links,
- Grid- and meta-computing middleware such as Globus that enhance sharing of computational resources and data,
- User-oriented problem-solving environments that support and enable use of HPC systems for simulation and data analysis and visualization by non-computer specialists by scientists and educators.

We seek to coordinate these resources and capabilities around a project to develop a joint Indo-U.S. specialized “center of excellence” on climate modeling and global change with emphasis on the importance of regional climate prediction and impacts assessment and severe weather forecasting. In this proposal we request funding from the Indo-U.S. forum to support an international workshop of invited participants comprising scientific experts, technology specialists, and program managers from key institutions and agencies whose mission includes climate and weather.

The main objectives of the workshop are:

- (i) To identify scientific problems of mutual interests and to formulate joint projects for research in regional weather and climate using high performance computers, and
- (ii) To prepare a draft proposal for joint Indo-U.S. specialized center on regional climate studies and global changes.

It is important to mention here that, in the Indo-U.S. Forum Workshop on ‘High Performance Computing and Scientific Applications – Future Trends’ held at Bangalore on 20 December 2002, the field “Weather Forecasting and Climate Modeling” was identified as one of the research areas for collaboration between Indian and U.S. scientists. In the recently held interaction meeting of Indian scientists with visiting

NCAR-UCAR delegation on co-operation in atmospheric research on November 10, 2003 at New Delhi, it was further high lighted that closer collaboration on regional weather/climate modeling as well joint field experiments between the U.S. and India are very essential. It was concluded that in order to achieve those objectives, more bilateral workshops in the U.S. as well as in India should be held with the active support of Indo-U.S. forum. This proposal which originated just after the Bangalore meeting in Dec 2002, is aimed at initiating and strengthening such collaborative activities.

C. Principal Investigators from India and U.S.

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D. Concept and Purpose:

It is well known that the impacts of climate change are region specific. This is especially true for countries such as India and the U.S., which have large and varied geographical areas with complex terrain. All sorts of climate types occur in these subcontinents. The ecosystems, dense forests, medicinal plants, coastal zones and rich bio-diversity areas are most vulnerable to global climate changes. Thus, in order to assess the impacts of climate changes on different sectors such as energy, agriculture, forest and ecosystems, etc. and attendant socio-economical aspects, it is essential to investigate the climate change scenarios at micro levels. Very high resolution (e.g. 2-5km horizontal resolution) regional climate models are the most useful tools for such studies. High resolution models are also very important for improving the accuracy of weather predictions. In India, high resolution weather and climate simulation is essential because the summer monsoon is the dominant quasi-permanent weather system in this region and its prediction presents significant scientific challenges. The Indian Summer Monsoon

occurs every year during June to September and the agriculture and hence the economy of India mostly depends on the rainfall during these four months. The major phases of monsoon are the onset, which varies over different regions of India, the active and break periods and the withdrawal from the land. The summer monsoon over Indian sub-continent is accompanied by a number of synoptic weather systems such as the monsoon trough, Tibetan anticyclone, off-shore trough, low pressure areas, monsoon depressions, tropical cyclones etc. The weather and climate of the region are also characterized by several mesoscale phenomena such as tornadoes, cloud bursts, thunderstorms etc. There are large inter-annual variations of monsoon rainfall over different geographical regions of India. Scientifically, the study of the inter-annual variation of summer monsoon rainfall over India is a challenging problem and area of active research for the scientific community. The role of surface boundary forcing, internal dynamics and intra-seasonal oscillations in the inter-annual variability of summer monsoon can be best investigated with the help of regional weather models nested within global models. Similarly, wintertime forecasts of snowfall coverage and depth are of vital importance to both the countries. In addition severe weather phenomena for the mountainous regions of India are least understood topics which need collaborative research. Joint scientific efforts between the scientists of U.S. and India will contribute to understanding of various problems related to regional weather and climate changes.

The U.S and India each possesses significant expertise in atmospheric science and high-performance computing. NCAR, in the U.S., itself a National Science Foundation supercomputing center, is a major center for atmospheric research including severe weather, climate, atmospheric chemistry, data assimilation, and basic atmospheric research. A large and active regional atmospheric science community uses MM5, developed and maintained at NCAR, and this community will soon transition to the Weather Research and Forecast (WRF) model, under development by a large multi-institutional collaboration that includes NCAR, NOAA laboratories, U.S. Department of Defense operational weather centers and geophysical research laboratories, the National Aeronautic and Space Administration (NASA), U.S. Department of Energy researchers, and many others. Indian institutions such as the Indian Institutes of Technology (IIT), the India Institute of Science(IISc), the India Meteorological Department(IMD), National

Center for Medium Range Weather Forecasting (NCMWRF), the Indian Institute of Tropical Meteorology (IITM), Space Applications Centre (SAC), Centre for Mathematical Modelling and Computer Simulation (CMMACS) and the Andhra University, Cochin University etc. are investigating and applying research into monsoon prediction, tropical storms, regional climate, boundary layer mechanics, and urban air quality. The Centre for the Development of Advanced Computing (CDAC) is on the forefront of high-performance computing technology with its development of the PARAM Padma supercomputer. In addition, several Indian institutions such as CDAC, National Aerospace Laboratory (NAL) and the Bhabha Atomic Research Center (BARC) in collaboration with NCMRWF, IIT-Delhi and IISc and supported by the Department of Science and Technology (DST), Government of India have been working together to parallelize weather codes for their efficient implementation on computers with a number of processors. We seek to bring these scientific and technical communities together for the purpose of exploring specific areas for Indo-U.S. cooperation on the scientific and technical objectives towards improving regional weather and climate research for prediction, impacts assessments, and for advancing scientific understanding of meteorological and climatological processes. By identifying and defining these areas for cooperation, the proposed workshop will foster new active projects for joint numerical simulation of climate and weather between the U.S and India.

E. Specific Need for Bilateral Proposal:

India and the U.S. possess significant intellectual and technical resources that can benefit the earth science research and ultimately the environmental policy and human welfare objectives of the respective countries, provided there is interaction between scientific and technical representatives in the context of projects that focus on problems of mutual interest in the area of regional weather prediction and climate simulation.

**G. Proposed Venue and Date: At NCAR, in Boulder, Colorado
during 23st – 25rd February, 2005**

H. Expected Outcome or Product:

The product of the workshop will be a workshop proceedings booklet, including a conference report describing the specific need and opportunities for joint Indo-U.S. cooperative projects. Ultimately, we expect a successful outcome of this workshop will be the fruition of one or more of these ideas into joint projects as a short-term goal in next 4 -5 years. The joint projects will focus on the use of HPC platforms in both the countries in solving some of the important regional weather and climate issues. One or more regional models will be identified which can be jointly used for conducting sensitivity studies at all the time scales starting from short-range forecasting to climate scenarios. Emphasis may be given on cyclone/hurricane forecasting and impacts study of global climate change on regional scales. As a longer term outcome of this workshop, we expect that within next decade or so a joint Indo-US center for advanced studies on regional weather and climate will be established to facilitate exchange of scientists and know-how between the two countries. The present workshop will help initiating and proposing such a center.

I. List if Indian invitees.

See http://www.mmm.ucar.edu/wrf/WG2/indo-us/india_list.pdf