NOAA Climate Testbed Seminar Series

Seamless Weather and Climate Prediction

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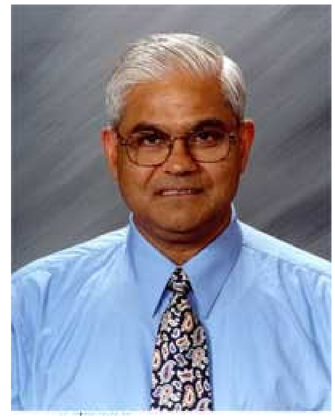
ABSTRACT



The lecture will describe the concept of seamless prediction and its evolution since the establishment of the COPES (Coordinated Observation and Prediction of the Earth System) framework of the World Climate Research Program (WCRP), where the concept was first presented in 2005. The main aim of COPES is to facilitate analysis and prediction of Earth system variability and change for use in an increasing range of practical application of direct relevance, benefit and value to society.

There is no scientific basis to draw artificial boundaries between meso-scale prediction, synoptic scale prediction, seasonal prediction, ENSO prediction, decadal prediction and climate change. However, practical considerations of computing and of model complexity may require different prediction systems for different time scales. The simulation and prediction of meso-scale systems, synoptic scale disturbances, intra-seasonal, seasonal and inter-annual variations are intimately linked, and therefore, it is suggested that future research on prediction of weather and climate be carried out in a unified framework.

For reliable prediction of regional climate change it is essential that climate models accurately simulate the modes of natural variability from diurnal to seasonal and decadal. Utilization of the insights gained from operational weather and seasonal prediction, and of the synergy between the weather and climate prediction communities is essential for the development of next-generation seamless prediction systems.

One of the scientific implications of the seamless framework is that decadal and multi-decadal prediction using IPCC class models should correctly initialize the state of the ocean-land- atmosphere-cryosphere system. Just as the 1 day NWP forecast is critical in determining the 10 day forecast, it is likely that 10-30 year forecasts will be determined by one season to one year forecast. Institutionally the seamless framework requires the weather and climate communities to work as an integral part of a single scientific enterprise.

The lecture will also review the discussion and outcomes of the World Modelling Summit for Climate Prediction held at Reading, UK in May 2008.

(From left to right:) Syukuro Manabe, Jagadish Shukla and Ed Lorenz at the American Meteorological Society meeting in January 2005, when Shukla received the Rossby medal.

When: 2:00 p.m., February 10, 2009

Where: Room 707, NWS/NCEP
World Weather Building
5200 Auth Road
Camp Springs, MD 20746

World Meteorological Organization
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Recent Interview with Prof. J. Shukla

Jagadish Shukla was born in 1944 in a small village in Uttar Pradesh, India. Although science was not on the local school curriculum, he went on to Banaras Hindu University (BHU) and received a B.Sc. and an M.Sc.

After working at the Indian Institute of Tropical Meteorology in Pune, he received a Ph.D. from BHU and then left for the USA, where he received a Ph.D. in Meteorology at the Massachusetts Institute of Technology. Jule Charney, Ed Lorenz, Norman Phillips and Suki Manabe were his research advisers. That led to a career in the atmospheric sciences in the USA, including work at the NASA Goddard Space Flight Center and the University of Maryland.

Prof. Shukla is currently chairman of the Ph.D. Climate Dynamics programme at George Mason University, Fairfax, Virginia, USA, and serves as Ph.D. adviser for five graduate students. He continues to conduct research on seasonal predictability at the Center for Ocean-Land-Atmosphere Studies (COLA). Prof. Shukla has launched a proposal whereby world leaders would commit resources to build world climate laboratories for improved predictions of weather and climate and their uncertainties.

Tell us something about your work concerning "predictability in the midst of chaos".

About 25 years ago, I proposed that, although weather cannot be predicted beyond a few days, space-time averages of the atmosphere should be predictable up to one month due to the dynamical memory of the long waves, and up to a season or beyond (especially in the tropics) due to the influence of the boundary forcings at the Earth's surface (e.g. sea-surface temperature (SST), soil wetness, snow, vegetation, sea ice, etc.). We extended this further to the predictability of monsoons.

These ideas provided a scientific basis for dynamical extended-range forecasting. They became a reality when it was demonstrated that coupled ocean-atmosphere models can skilfully predict one of the most important boundary forcings, namely, SST. These scientific developments led to one of the most successful international research programmes, the Tropical Ocean and Global Atmosphere (TOGA) project of the WMO/International Council for Science/Intergovernmental Oceanographic Commission World Climate Research Programme (WCRP).

I was associated with TOGA from its inception as chairman of the US TOGA panel and as a member of the international science steering group. At the end of the programme, I proposed extending TOGA from the tropical oceans to the global oceans, and to include land-surface processes. This gave rise to the Global Ocean Atmosphere Land System (GOALS) programme in the USA, and the Climate Variability and Predictability (CLIVAR) project programme of the WCRP.

And your work on the influence of land surface processes?

Global vegetation depends on climate and the Earth's mean climate is strongly influenced by vegetation and land-surface processes. Land-atmosphere interactions are also an important factor in influencing the interannual variability of climate.

When we established COLA in 1983, therefore, we made sure we included the word "land" in the title. COLA has made, and continues to make, significant contributions towards understanding the mechanisms of atmosphere-ocean and land-climate interactions, including deforestation and desertification. I believe that, in the not-too-distant future, weather forecasting models will be very-high-resolution coupled ocean-land-atmosphere models with comprehensive assimilation systems for the atmosphere, ocean and land.

Tell us about your ongoing work with the WCRP.

Currently, I am a member of the Joint Scientific Committee (JSC) of the WCRP, and chair of the newly established WCRP Modelling Panel (WMP). The WMP is one of two panels that the JSC has created to implement a new strategic framework for WCRP activities in the decade 2005-2015.

This strategic framework, called Coordinated Observation and Prediction of the Earth System (COPES), is one of the most exciting and significant developments in the history of the WCRP. COPES will integrate and synthesize the activities of all WCRP components to obtain a comprehensive understanding of the predictability of the total climate system and facilitate applications of research for the benefit of society.

The COPES strategy will also enable coordination of the WCRP with other components of the World Climate Programme, WMO's World Weather Research Programme’s THORPEX, the International Geosphere-Biosphere Programme and the International Human Dimensions Programme. It will facilitate the evolution of a unified framework for the prediction of weather, climate variability and climate change. COPES will encourage a common framework for modelling and data analysis and management among centres worldwide.

What are the challenges in extending our skills from operational short-range weather forecasting to longer-range weather forecasting and climate predictions?

The skill of medium-range forecasts has improved steadily during the past 25 years. Current skill is not yet limited by the intrinsic limits of predictability which are due to the chaotic nature of atmospheric flows (the “butterfly effect”). Forecast errors continue to be much larger than would be expected from an idealized predictability experiment. It is thus possible to continue to improve the skill of medium-range forecasts by using more accurate initial conditions (better observations), higher-resolution models and better parameterizations of the physical processes. The potential to improve the predictions of intraseasonal, seasonal and interannual variations, using better models and better observations, is even greater.

To harvest the potential predictability of the coupled ocean-land-atmosphere system, it is necessary to improve observations in the upper ocean and in the upper layers of the land surface. It is also essential to improve the fidelity of coupled models, which, at present, have large systematic errors. As we improve a model’s ability to simulate mean climate, its ability to predict the departures from the mean climate also improves. The deficiency of models is the biggest stumbling block to providing more accurate weather and climate forecasts to society.

How do you see the role of WMO and the National Meteorological and Hydrological Services (NMHSs) in achieving sustainable development?

Weather and climate variations play an important, perhaps crucial, role in the sustainable development of communities worldwide. This is true in both the developed world, where there is rapid population growth in the coastal zones, and in the developing world, because of the prevalence of agrarian economies. The problem is further exacerbated by the impending threat of regional climate change. WMO and the NMHSs therefore have a major role to play.

With the advent of the Internet and other technological advances, it is appropriate for WMO and the NMHSs to examine their respective roles. Twenty years ago, the cost of setting up a supercomputer centre for weather prediction was more than US$ 10 million. Today, any village in the world with an Internet connection and a personal computer can run a high-resolution regional weather forecast model for less than US$ 5 000. WMO should therefore be able to assemble forecasts from all NMHSs and redistribute global data and forecasts with added value to all NMHSs.

It is not unrealistic to plan for a future in which any WMO Member, irrespective of its level of economic prosperity, has access to the latest and best weather and climate information. Likewise, WMO should have the ability to ensure that its Members meet their obligations to maintain the accuracy and reliability of weather and climate observations.

Over the past 55 years, WMO was an important platform to foster international cooperation. I hope that the Organization will now be able to take a more pro-active role in the development of weather and climate services for the benefit of all countries.

What about international research programmes in support of operational weather and climate predictions and related products and services?

COPES and THORPEX are specifically designed to utilize research and development results of the past 25 years in support of operational weather and climate predictions. For example, WCRP and THORPEX have initiated a joint programme in which ensembles of operational medium-range and seasonal forecasts can be assembled and made available to research institutions.

This will provide direct and tangible benefits to Members which support research programmes and observational networks. It should also give additional motivation to Members to maintain and enhance their respective observational and research infrastructure. These developments require WMO and the NMHSs to examine existing procedures for training and for the exchange of data.

When international research programmes were conceived 25 years ago, the support of operational weather and climate prediction was not a central theme. In view of the tremendous advances in the field, it would be appropriate for the WCRP to re-examine its programmes and priorities.

At its inception, the WCRP organized its programmes according to physical processes (atmosphere, land, ocean, cryosphere, etc.) with an emphasis on enhancing understanding of mechanisms of variability and their predictability. In view of the importance of applying research results for socio-economic development, it would now be appropriate to re-organize WCRP components according to functions such as: observations, modelling, data assimilation, prediction and applications.

What advice would you give to a young person considering a career in meteorology?

Our field is both scientifically challenging and of great relevance to society and the health of our planet. Even slight improvements in the accuracy and reliability of forecasts provide direct and immediate benefits to multiple socio-economic sectors. Our work saves lives and property, enhances economic productivity, helps policy-makers be better managers, and improves the quality of life in general.

Weather forecasts for five days are as good as two-day forecasts made 25 years ago; dynamical seasonal predictions are being routinely produced (this was inconceivable 30 years ago); the speed of computers for weather and climate modelling is now measured in teraflops (soon to be petaflops), while it was measured in megaflops 30 years ago; the simple barotropic models of 50 years ago have been replaced by complex general circulation models; and—last but not least—satellites provide high-resolution observations with global coverage.

The opportunities for a young person joining our field today are unprecedented. Enormous amounts of data are available for analysis. We have highly sophisticated models and very fast computers for understanding and predicting weather and climate. From a research perspective, there are unsolved problems of understanding and prediction, especially with regard to the behaviour of the fully coupled ocean-land-atmosphere system. Most importantly, there remains a large gap between what is potentially predictable and what we are able to predict today. Our field offers opportunities of making scientific breakthroughs and helping humanity.

What is your vision for meteorology and related sciences over the next 10-20 years?

We now utilize only 10 per cent of the satellite data that we collect at great cost. We observe the Earth system at a very high resolution (1-10 km), although we know that important functions of society take place at a very fine spatial scale (100 m-1 km) and the models we use for data assimilation and prediction have a coarse resolution of only 50-100 km.

We need to invest in people, high-resolution models and computing capacity if we are to reap the benefits of scientific and technological advances. My vision therefore embraces:

- High-resolution coupled ocean-land-atmosphere models for routine NWP for 1-15 days;
- Development of advanced data assimilation and prediction systems with the high-resolution models described above. This is essential for timely and efficient disaster management and planning for agriculture operations, energy utilization and mitigation of weather-related health problems;
- A globally coordinated “hypothetical perfect model” to simulate the means, variances and co-variances of current climate, to predict future climate and estimate the limits of climate predictability. This may require the establishment of world computing facilities with dedicated scientists and petaflop computers. Without such a scientific effort,however, it will not be possible to provide reliable answers to questions about the habitability and sustainability of human civilization and the future health of our planet;
- A commitment by WMO to support a sustained observing system for weather and climate and to ensure that all NMHSs have access to global observations, analysis, and forecasts;
- A sustained training and education effort by WMO and partners to ensure that all Members achieve the level of scientific and technological capacity that is required to utilize the advanced global analysis and forecast products for the benefit of their populations.

What is your personal vision of the future?

I continue to feel a strong attachment to my village of origin and its people. I have been extremely fortunate, so I do whatever I can do to help alleviate poverty, ignorance and suffering. For example, I set up a college (Gandhi College) in my village for the education of rural women.

I very much want to continue to help my native country achieve its scientific potential. In particular, I hope to help India produce accurate short- and long-range forecasts of the monsoon. As part of this aim, I helped to establish the first modern NWP and data- analysis system in India.

Global socio-economic problems, particularly poverty and the inequality of opportunity interest me. Inequality is a fundamental property of all natural (physical, chemical and biological) systems. Socio-economic inequality is, therefore, inevitable. For long-term socio-economic sustainability, however it should be our shared goal to strive towards a society which maximizes the equality of opportunity—even though we know it can never be fully achieved.

The dynamics of the atmosphere and oceans are perpetually transporting excess heat from the tropical regions to polar regions. Can we imagine a somewhat similar social system, which is perpetually providing “opportunity” to the poor, weak and the disadvantaged? I would like to spend more time and effort in understanding the properties of social systems and, in particular, the causes of inequality.

(From http://www.wmo.int/pages/mediacentre/shukla.html)