Numerical Climate Modeling: State-of-the-art, Challenges, and a Program for Latin American and the Caribbean

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Numerical modeling is a mainstay of any modern activity in climate studies and climate prediction. Great progress has been made in those fields since early attempts in the 1950's at 24-hour forecasts for one level in the atmosphere. Modern predictions can be made for tens of levels in the atmosphere and oceans with a high level of detail in the horizontal direction, and cover a wide range of space and time scales. The numerical models of climate currently used include representations of many processes, particularly those that govern the interactions among the atmosphere and underlying surfaces. Thus, some of the resulting products – such as predictions of rainfall and surface evaporation - are directly applicable to the planning of agricultural and energy production, primary contributors to the welfare of human communities. Very long integrations allow for estimates of climate change and sea level rise due to glacier melting. The operation of a contemporary numerical modeling system for climate studies and predictions is complex and requires large national and international centers with powerful supercomputers. These specialized centers distribute their products to a broad range of users that include policy makers, members of the productive sector, and the general public.

Numerical models of climate are not only used for operational predictions, they are also used by basic and applied scientists in support of investigations aimed at increasing understanding of the climate system and the impacts of its variations. The goal of these investigations is to improve the models' performance and thereby enhance the usefulness and reliability of their products. In this regard, numerical models of climate are important teaching tools in university programs on the environment.

The present talk is organized around two major themes. First, numerical models have achieved a great degree of complexity and can provide very detailed

and extraordinarily helpful information; however they are imperfect tools with their own set of challenges and limitations. Second, the full use of information provided by numerical models requires a significant knowledge and in-depth understanding of the power and limitations of model products. This knowledge and understanding must be at a comparable level among users in both countries that produce and countries that use model products. In a region as diverse as Latin American and the Caribbean (LAC), this will require major organized efforts in capacity building.

In addressing the first theme, the talk will give a brief historical overview of numerical modeling as applied to weather and climate prediction ending in state-of-the-art Earth System Models (ESMs) and their products. Special attention will be dedicated to the coupling with hydrology models and to on-going efforts on ecosystems modeling. Next, the presentation will address the many challenges to successful numerical prediction posed by a region such as LAC extending across several climate zones from the northern tropics to the southern polar region with high mountains and major rivers, and affected by remote climates variations such as El Nino/Southern Oscillation. The difficulties in simulating the North and South American monsoons will be taken as examples. Last, the presentation will turn to the essential elements of a program for numerical modeling in the context of linking and applying climate knowledge in the LAC region. Scenarios will be presented to stimulate and guide discussion. It will be argued that the following components should be given serious consideration when designing a program for LAC:

a) Strengthen the operational centers in the region by modernizing methodologies and facilities, and training of scientists and operators as appropriate.

b) Establish close links between operational centers and academic institutions that will provide scientific support and training for personnel.

c) Develop regional centers specialized in the monitoring, numerical simulation, and prediction of weather and climate phenomena of high local relevance.

d) Secure commitments by policy makers as well as members of the productive sector to endorse and participate in the program.