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MULTI-SCALE MODELLING AND SIMULATION

A fundamental barrier in advancing multiscale weather and climate prediction is the limited capability of contemporary models to represent the multiscale organization of precipitating convection. To overcome this, a multiscale modeling and simulation framework, which replaces the conventional cloud parameterizations with a cloud-resolving model (CRM) in each grid column of a GCM, constitutes a new and promising approach. This can provide for global coverage, two-way interactions between the CRMs and their parent GCM and explicit simulation of cloud processes and their interactions with aerosol, radiation and surface processes. The C-MMACS Multiscale Modeling and Simulation Group (MMSG) seeks to develop and apply this framework for weather and climate predictions and climate change projections.

INSIDE

5.1 High Performance Computing for Meteorological Applications

Computing power has increased enormously in the recent past, but its utilization is limited as the legacy codes are either sequential or first-cut parallel versions which cannot exploit the full power of hardware. Therefore, to make significant break-through in analysis of models and technological problems, it is imperative that the full potential of hardware is exploited. Consider a case in point; one institute may have 10 TFLOPS machines but the legacy code may not permit us to utilize even 1 TFLOPS. Thus, to solve the issues pertaining to our interests, first the models need to be recast both in terms of numerics and programming paradigm which results in deriving the full potential of the hardware. The present scenario is far from satisfactory and an initial step is being made to develop a model which will result in better understanding and forecasting of weather/climate of our country.

U N Sinha

5.2 Global CRM Simulation of Diurnal Variation

Latent heat release associated with rainfall by deep convection (DC) is a main source of energy for general circulation of the atmosphere. Diurnal variation of DC over the tropics has been recognized by observational studies using various data, such as satellite images, rain gauges, and radar. We have studied the diurnal variation of DC rainfall in geostationary satellite data classifying DC cloud by applying Split Window technique on 11 m brightness temperature from METEOSAT data.

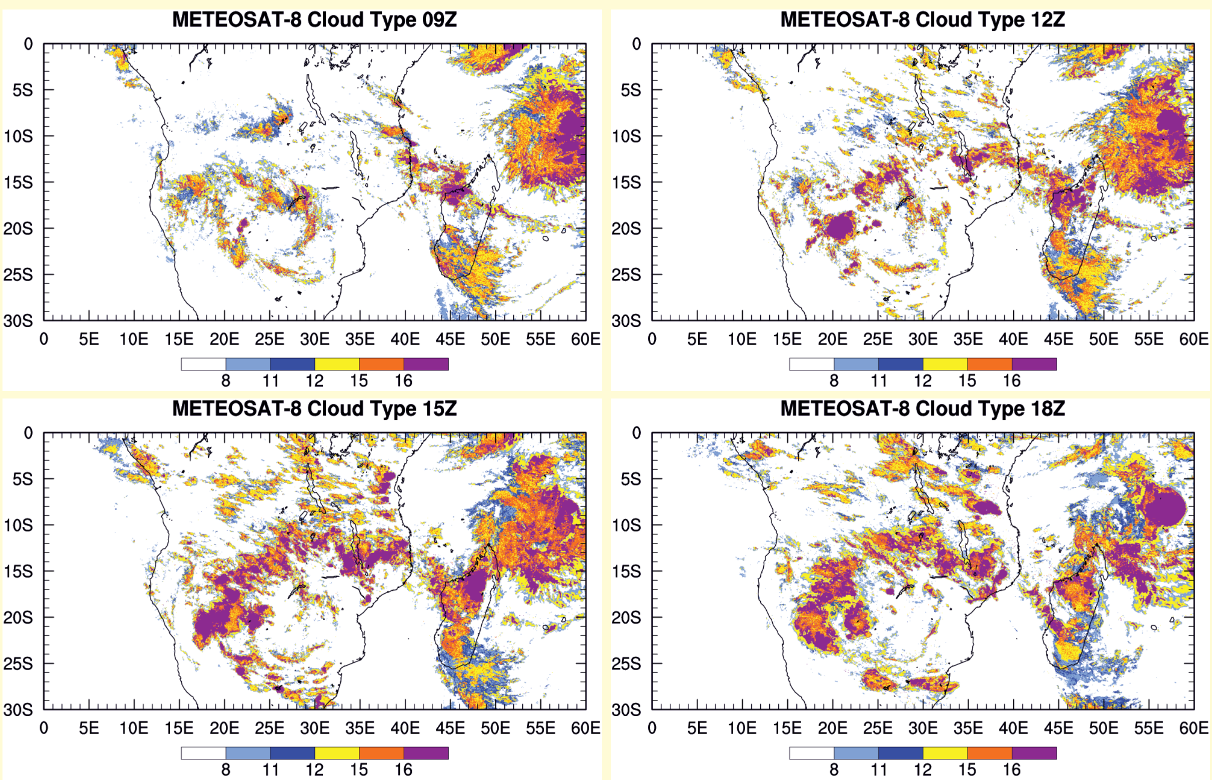

Figure 5.1 Spatial distribution of DC defined by optically thick cloud colder than 253K and classified into different cloud types, for 09, 12, 15, 18 UTC of 26 Dec 2006 from satellite data over the African region.

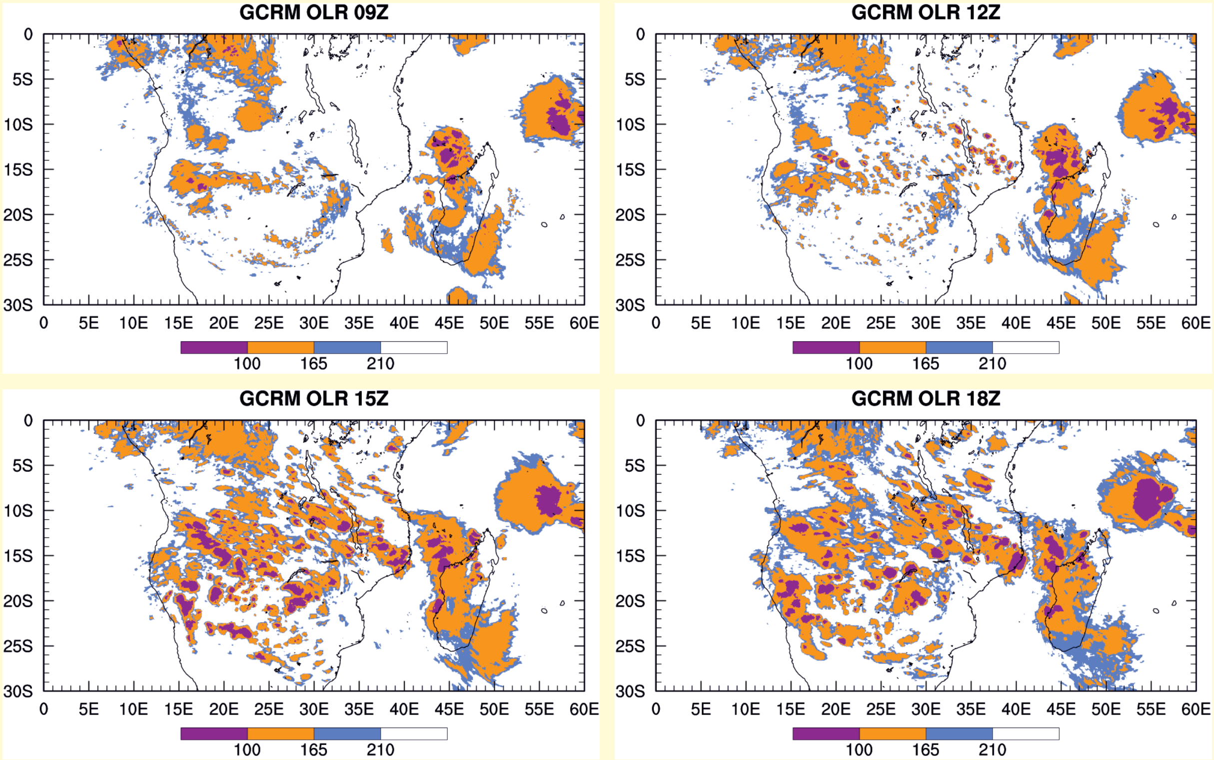

Figure 5.2 Spatial distribution of deep convection defined by OLR less than 210Wm-2 and corresponding to cloud types, for 09, 12, 15, 18 UTC of 26 Dec 2006 from GCRM simulation over the African region. At 12UTC large number of small size deep convections are dominant, while larger size of deep convections are dominant at 18UTC for both GCRM and satellite data.

Realistic representation of DC diurnal variation in the general circulation model (GCM) is one of the essential factors for skillful simulation and prediction of weather/climate. We have verified the simulation of diurnal variation of DC by a GCM embedded with a Cloud-system Resolving Model (GCRM) globally. Results indicate that GCRM successfully captures the characteristics of diurnal variation of DC over the tropics.

K Rajendran and T Inoue

5.3 Climate Impact Mechanism of Aerosol Radiative Forcing

The dominant feedback mechanism responsible for monsoon sensitivity to aerosol direct radiative forcing is analyzed using Atmospheric GCM (AGCM) climate simulations without any aerosol forcing and with three different representations of aerosol direct radiative forcing. Aerosol direct impact due to scattering aerosols causes significant reduction in summer monsoon precipitation over India. Aerosol forcing reduces surface solar absorption over the primary rainbelt region of India and reduces the surface temperature. The simultaneous warming in the south reduces the land-ocean temperature contrast and thereby weakens the circulation and the advection of moisture into the monsoon zone. This increases atmospheric convective stability, and decreases convection, clouds, and precipitation. Aerosol radiative forcing perturbation over Indian region alone is found to have both local and remote climate impacts. Analysis of simulation with climatological aerosol optical depths over the extended

Indian region derived from network of observations merged with MODIS data over India, shows that marked climate sensitivity occurs not only over the region of loading but over remote tropical regions as well.

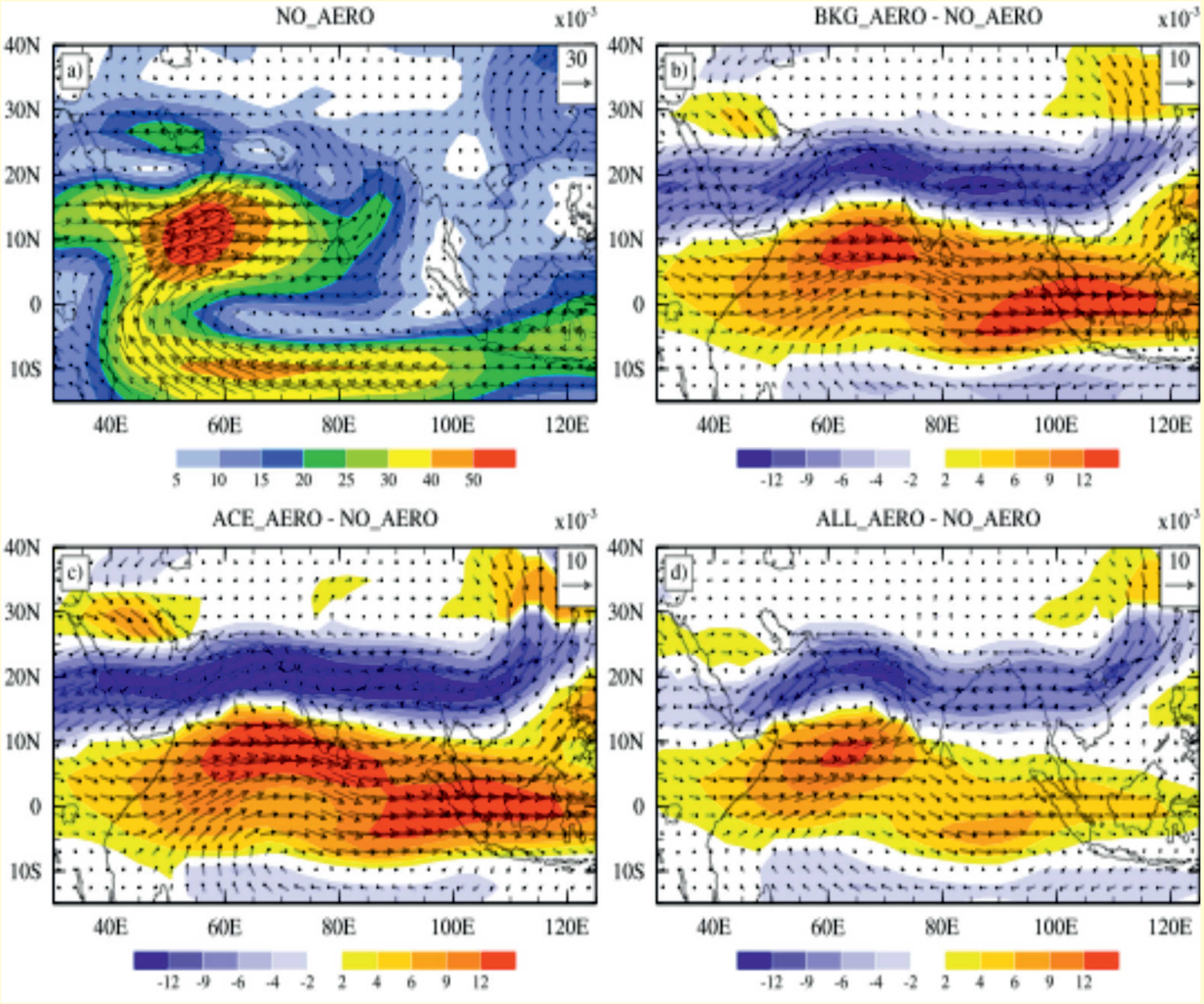

Figure 5.3 Simulated a) climatological JJAS mean moisture transport (in vectors with magnitude10-3 kg/kgms-1 in shading) from NO_AERO (without aerosol radiative forcing) and JJAS mean moisture transport differences (vectors and magnitudes in shading) for the three aerosol simulations with respect to NO_AERO.

This suggests the degree of impact of regional aerosols on climate through circulation changes and warrants the need to prescribe realistic aerosol properties in strategic regions such as India.

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