A study on the performance of a triple nested mesoscale model over tropical Indian Ocean during INDOEX

Orbita Roswintiarti*, Sethu Raman*, U. C. Mohanty† and Devdutta S. Niyogi*

*State Climate Office of North Carolina and Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC 27695, USA
†Center for Atmospheric Sciences, Indian Institute of Technology, New Delhi 111 016, India

A triple nested version of the fifth generation PSU–NCAR Mesoscale Model (MM5) was used over the INDOEX domain. A 3-dimensional model study over the tropical Indian Ocean was performed. The domain extended from 40.12°N–32.04°S; 32.10°E–117.90°E for the outermost grid (horizontal resolution of 180 km), while the inner most grid (20 km horizontal resolution) extended from 19.81°N–13.92S; 56.20°E–91.64°E, with 17 vertical *s* levels. The model was integrated for 48 h starting from 00 UTC 5 March 1999. The model results were validated against analysis for large-scale characteristics (circulation pattern, ITCZ location and rainfall). MM5 was able to realistically simulate these large-scale features. In addition to this validation, objective evaluation of the model performance was undertaken by comparing GPS sonde vertical soundings obtained from RV *Ronald H. Brown* for the times of model integration. MM5 results were in good agreement with both dynamical (wind components) and thermodynamical (temperature and humidity) fields over the INDOEX domain.

THE Indian Ocean Experiment (INDOEX) is a multidisciplinary international field experiment directed towards studying the transport of continental air masses from the Northern Hemisphere towards the Inter Tropical Convergence Zone (ITCZ). The principal hypothesis was that the aerosol loaded continental air could alter the radiative properties of the ITCZ, leading to higher uncertainties in the radiation balance over tropical Indian Ocean. To study this phenomenon, ship and air-based observations were conducted over the Arabian Sea and equatorial Indian Ocean extending up to 20°S (ref. 1). The study period was chosen during northeasterly monsoon (January to March) over the Indian subcontinent. The field phase of the INDOEX was conducted in 1999. During the field phase, emphasis was on identifying the lower troposheric meteorology and air chemistry related to the transport and the corresponding boundary layer processes, along with ship-based physio-chemical measurements. The measurements composed of six-hourly vertical profiles and continuous meteorological observations of the mean state of the marine atmosphere. These observations by their very nature are point measurements and several studies[2–5] have identified distinct inhomogeneities and variations in the boundary layer as well as physiochemical characteristics over the INDOEX domain. For these reasons there was an immediate need to develop a more comprehensive understanding of the temporal and spatial variability of the marine environment during the INDOEX. Such an understanding can be achieved using a three-dimensional modeling approach in conjunction with the observations. However, to have confidence on any comprehensive simulations of a model, it is important that the model results are validated over the region. The INDOEX domain is traditionally a data-sparse region and the analysis is greatly biased on the first-guess (six-hourly forecast) from the general circulation models (GCM). Hence one of the first steps in applying atmospheric models for INDOEX, is validation through evaluations using special observations made during the Intensive Field Phase (IFP). This study reports the validation exercise undertaken for one such state-of-the-art atmospheric model over the INDOEX domain.

The mesoscale model used is the fifth generation PSU-NCAR-Mesoscale Model (MM5) of Pennsylvania State University-National Center for Atmospheric Research Mesoscale Model (MM5)[6]. It is a non-hydrostatic, primitive equation limited-area model. The model has been extensively tested and validated over various regions for different applications. However, no validation exists for the INDOEX domain. The aim of this study is hence to validate the performance of MM5 over the tropical Indian Ocean environment with large scale analysis and observations (sounding) made during the INDOEX IFP from RV *Ronald H. Brown*.

Model description and design of experiment

Model description

The mesoscale model used in this study is the three-dimensional, non-hydrostatic version of the fifth generation

†For correspondence. (e-mail: mohanty@cas.iitd.ernet.in)