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## 1. INTRODUCTION

The Operational Multi-scale Environment model with Grid Adaptivity (OMEGA) (Bacon et al., 1993, Bacon et al., 1996, Boybeyi et al., 1996) is an innovative non-hydrostatic primitive equation model developed by SAIC and MESO, Inc. under support from the Defense Special Weapons Agency (DSWA). It is the first atmospheric model to use an unstructured grid system that permits the grid resolution to easily adapt in space and time through the addition, deletion and reconfiguration of grid cells in response to a user-specified set of parameters (e.g. terrain variability, effluent concentrations, deformation of the wind etc.). OMEGA can be used to simulate atmospheric processes including transport and diffusion over a wide range of scales ranging from the planetary scale down to the cloud scale on one continuous grid. Any new model, particularly one as innovative as OMEGA, requires a rigorous evaluation in order to establish it as a viable candidate for use in atmospheric modeling applications. The objective of the project described in this paper is to establish quantitative performance benchmarks for OMEGA's short-term (0-24 hour) forecast skill at the synoptic and meso-a scales and also to compare this forecast skill to skill of standard numerical forecast models run at operational centers such as National Center for Environmental Prediction (NCEP).

## 2. OMEGA MODELING SYSTEM

The OMEGA modeling system is composed of several components: (1) a grid generator; (2) an analysis and initialization module; (3) the numerical-dynamical model; and (4) a suite of post-processing tools. The grid generator is a crucial component of the modeling system due to the fact that the grid system is most unique aspect of the modeling system. The grid is unstructured in the horizontal and composed of a set of triangular prisms. The unstructured attribute of the grid means that there is no pre-defined relationship among the grid cells in the horizontal plane. This allows grid elements to be easily added, deleted or bifurcated and permits the grid cell size distribution to adapt to any horizontally distributed quantity. Additional details of the grid adaptation process can be found in Bacon et al., 1993.

The analysis and initialization module, known as the OMEGA preprocessor, enables a variety of data types to be ingested and processed to generate an initialization dataset

for the numerical-dynamical model. The preprocessor employs a 3-D multivariate optimum interpolation scheme to transform point observations into a 3-D grid point dataset. The modeling system also includes the capability for four dimensional data assimilation through the use of an incremental analysis update (IAU) scheme.

In addition to the basic hydrodynamical equations solved on an unstructured grid the model also incorporates a complete physics package. This includes surface energy and moisture budgets, a atmospheric boundary layer parameterization, a multi-phase bulk parameterization of water microphysics and a cumulus parameterization.

## 3. OMEGA VERIFICATION EXPERIMENT

In order to quantitatively document and analyze the meteorological performance of the OMEGA modeling system a set of real-time simulations were run during the second half of 1997. The simulation domain and horizontal grid structure is shown in Figure 1. This grid has a total of 3279 cells. The size and resolution of the grid domain were chosen to permit 24-hour simulations to be executed in real-time on a single processor Digital Alpha workstation. The simulation domain covers the eastern half of the United States and adjacent areas of the Gulf of Mexico, Atlantic Ocean and Canada. The size of the grid cells varies from 30 km to 102 km. The size of a grid cell is defined as the square root of the area of a triangular cell. Figure 1 indicates that the grid is relatively coarse over most of the domain with an area of high resolution (i.e. small grid cells) over Pennsylvania, New Jersey and New York, Lake Ontario and parts of Canadian Province of Ontario. The size of the grid cells in this area varies from 30 to 44 km. In the coarse region of the grid the cell size varies between 77 and 102 km. The cell sizes vary from 44 km to 77 km in the peripheral areas surrounding the high resolution region. Within the high resolution and low resolution areas the grid cell size is adapted to the terrain field. This adaptation results in smaller grid cells in the regions of greatest horizontal variation in terrain elevation. It is possible for the grid to adapt (i.e. change structure) to dynamical or surface features during the course of a model simulation. However, this capability was not used during the verification experiment in order to provide a "baseline" evaluation which will be used for comparison to future simulations which will employ different grid adaptation strategies.

The verification sample is composed of a series of 24-hour real-time simulations initialized at 0000 UTC over the grid shown in Figure 1. The initialization is based upon a 3-D multivariate optimum interpolation (OI) analysis of rawinsonde and surface data. The first guess for this

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analysis is NCEP's early-Eta 12-hour forecast. Lateral boundary condition data for the simulations is extracted from the Eta 12 to 36 hour forecast data at 6 hour intervals.

#### 4. VERIFICATION PROCEDURE

Due to the variations in grid systems between the models that were to be compared and the horizontal variations in spatial density of observations it was decided to compute verification statistics by interpolating the model output data to the observational sites rather than interpolating (i.e. analyzing) the observations to a grid. Verification statistics were computed for all rawinsonde and first order surface sites within the OMEGA domain (Figure 1). The rawinsonde verification included a computation of root-mean-square (RMS), mean absolute error (MAE) and bias for temperature, pressure height, wind vectors and water vapor mixing ratio at each mandatory pressure level (100 mb, 850 mb, 700 mb, etc.). The surface verification included the same set of statistical parameters for 2 m temperature and dew point, 10 m wind vectors and mean sea level pressure.

The same verification statistics were also computed for real-time Mesoscale Atmospheric Simulation System (MASS) simulations executed over a similar region and the NCEP early-Eta and NGM simulations. In addition, statistics were computed for NGM Model Output Statistics (MOS) forecasts of surface temperature, dew point and winds. Skill scores were also computed to quantify the difference in performance among the models for each parameter.

An effort was also made to stratify the sample according to geographic sub-regions of the OMEGA simulation domain and also according to a synoptic weather regime classification system. The objective of the stratification was to obtain information about how the characteristic errors of the simulations produced by each of the models varied with geography and weather regime. An extensive set of statistical results will be included in the conference presentation.

#### 5. REFERENCES

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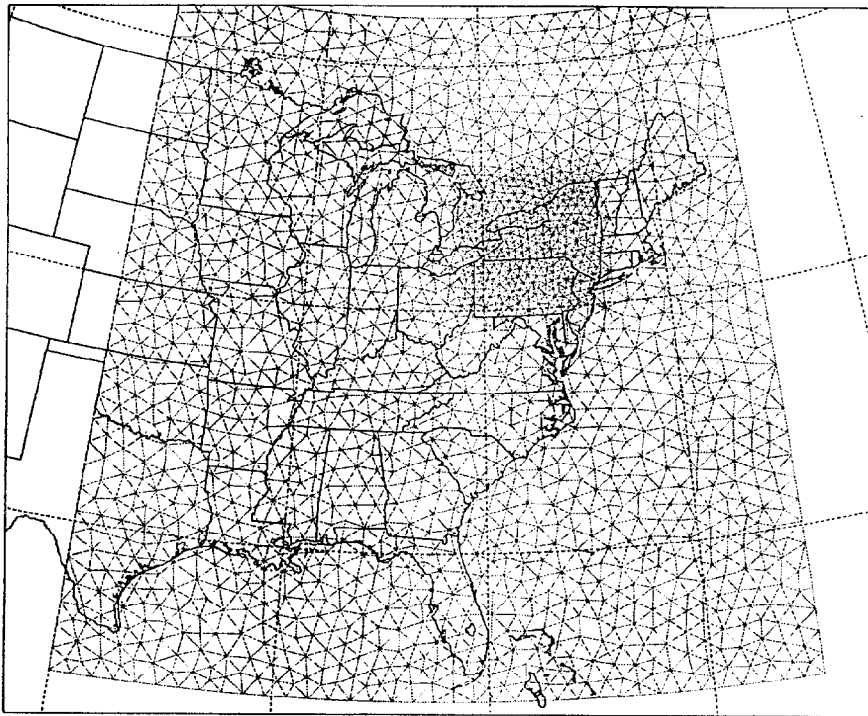


Figure 1. Structure of the horizontal component of the OMEGA grid used for the OMEGA verification experiment. The grid contains 3279 triangular cells which vary in size from 30 km to 102 km.