Examples of High Resolution Data Produced by a 3-D Mesoscale Atmospheric Model Applied to Problems Impacting the Nuclear Power Industry

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1. INTRODUCTION

There are a variety of problems in which mesoscale models can be used to address power industry data requirements. This paper will present three specific mesoscale modeling efforts of MESO, Inc. that directly relate to the power industry and illustrate the flexibility of mesoscale modeling capabilities. The three examples are: (1) the use of the Mesoscale Atmospheric Simulation System (MASS) model for aiding the forecasting of small scale atmospheric features to improve electric load forecasting, (2) the use of the Operational Multi-scale Environment model with Grid Adaptivity (OMEGA), mesoscale model to improve dispersion forecasting capabilities, and (3) the generation of grids of high resolution climate statistics using CLImate statistics by a dynamical MODel (CLIMOD).

2. MASS FORECASTING CAPABILITIES

Electrical energy consumption is highly correlated with the local distribution of temperature. It is important to properly forecast and weight the temperature distribution as it relates to population density in estimating the power needs. The MASS model can be used as a forecasting aid to capture small scale features that impact the temperature that will occur 6 - 48 hours in the future. The model does an excellent job of capturing localized features which impact temperature, such as the heat island effect and local wind circulations. The MASS also does a very good job of forecasting small scale migratory features such as frontal thunderstorms.

Localized Phenomena

Heat Island Effect

MESO, Inc. has performed several experiments in the Rochester and Albany, New York areas showing that mesoscale models can be used to improve electric load forecasting. The research showed that the resolution and quality of the temperature forecast can be greatly improved for an area impacted by the heat island effect by using a mesoscale model (Waight et al. 1995). Figure 1 shows the location of two sites in a recent example of the heat island effect that occurred under ideal conditions for the MASS model to represent and forecast. The representative location of the urban setting was Saint Louis Missouri (*U*) and the rural setting was Scott Air Force Base, Illinois (*R*).

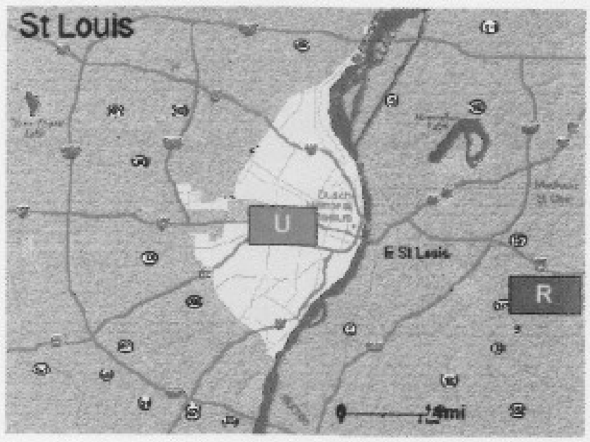

Fig. 1. *R* represents the rural location at Scott Air Force Base, Illinois, *U* represents the urban location, Saint Louis Missouri.

In figure 2, the actual (*observed*) difference in diurnal (*daily*) temperature curves between the rural and urban areas is shown for 16 August 1997.

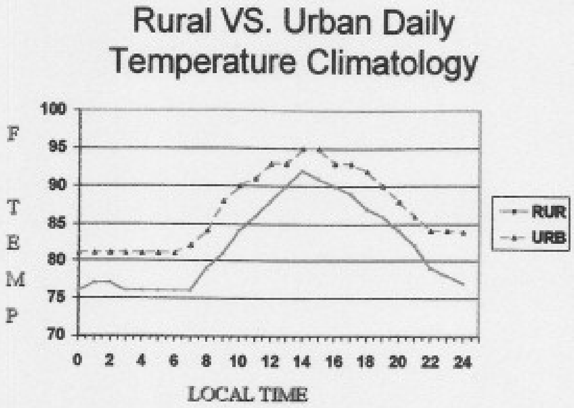

Fig. 2. The difference in the rural versus urban daily temperature cycle can be seen clearly by comparing the rural Scott AFB, IL. (*blue dashed*) and urban (*red triangles*) St. Louis, MO diurnal temperature curves.

The model is capable of capturing the daily temperature differences between the two locations as illustrated by figures 3 and 4. Warmer temperatures tend to be concentrated in the higher population areas. Therefore, the temperature difference between urban and rural areas can make a significant difference in the estimated power consumption compared to that predicted by using just an average regional temperature.

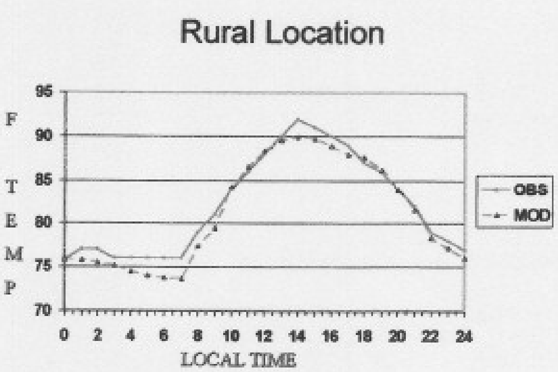

Fig. 3. The rural location (Scott AFB) daily temperature curve comparison between observed (*blue dashed*) and model (*red triangles*).

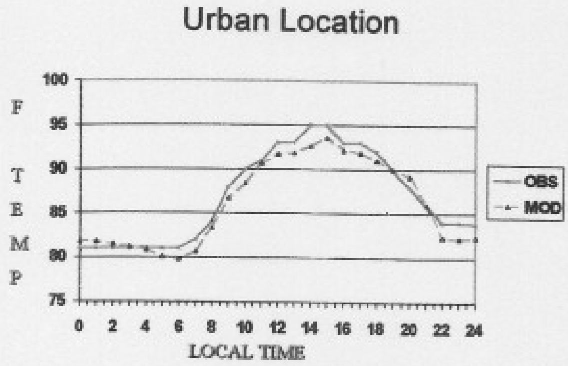

Fig. 4. The urban location (St. Louis) daily temperature curve comparison between observed (*blue dashed*) and model (*red triangles*).

Local Wind Circulations

The MASS model is used to demonstrate the potential that a numerical model has to capture and forecast small scale wind circulations such as land-sea (lake) breeze and mountain-valley breeze. The example shown in figure 5 is for a location (Boston, MA) that was impacted by land-sea breeze circulation. In this case, the model does a good job in depicting the rapid drop in temperatures as the sea breeze front passed through the location in the afternoon.

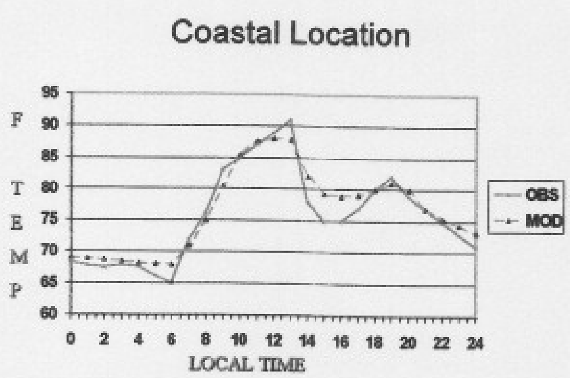

Fig. 5. A comparison of the daily temperature cycle between observations (*blue dashed*) and the model (*red triangles*) for a coastal location (Boston, MA) on 10 August 1997.

Small-scale Migratory Phenomena

Mesoscale models, such as the MASS, are also able to capture small scale migratory features which include thunderstorms, snow bands, and small-scale gust fronts. Figure 6 shows an example of an isolated thunderstorm that passed through central Florida on 19 February 1992. The MASS model, operating in a forecast mode for the Kennedy Space Center, captured the formation and movement of the 19 February thunderstorm (Manobianco et al. 1996). The position of each yellow *O* represents the center of the thunderstorm cell as indicated by radar from 2035 UTC to 2235 UTC. The red *M*'s are the storm center as represented by the output of the MASS model for the same time period. The positions were virtually identical by 2235 UTC (the black dot in the red center).

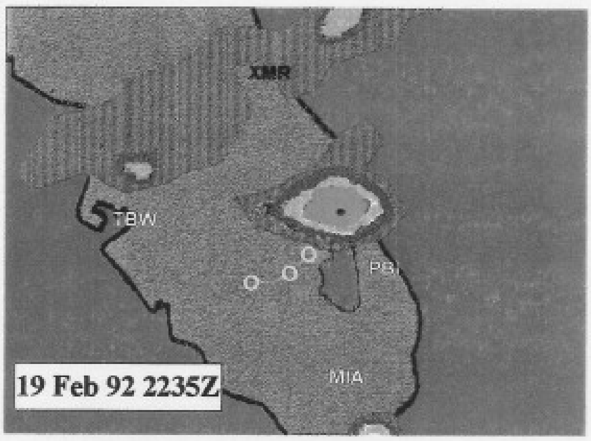

Fig. 6. Example of an isolated thunderstorm captured by the MASS in a forecast mode.

3. DISPERSION MODELING

It has long been determined that improved meteorological forecasts are essential for improving atmospheric transport and dispersion modeling. This is because atmospheric transport and dispersion involve virtually all scales of motion from turbulence to planetary. Science Applications International Corporation (SAIC) and MESO. Inc. have combined efforts to create an atmospheric hazardous material transport model for the Defense Nuclear Agency. The modeling system is called the Operational Multi-scale Environment model with Grid Adaptivity with an embedded Atmospheric Dispersion Model (OMEGA/ADM). The unique features of the OMEGA/ADM modeling system are: (1) the flexibility to change the individual grid element size and shape which allows better representation of areas of interest (such as complex terrain) with a minimum increase in computing requirements and (2) the use of embedded dispersion algorithms. Experiments using this system have shown dramatic improvement in dispersion and transport forecasting (Boybeyi et al. 1996). Figure 7 shows an example of the unique nature of the OMEGA grid system of Italy and the Bosnia-Herzegovina region. The figure shows how OMEGA can create higher resolution grid triangles as needed, which in this example are areas of complex terrain and coastal regions.

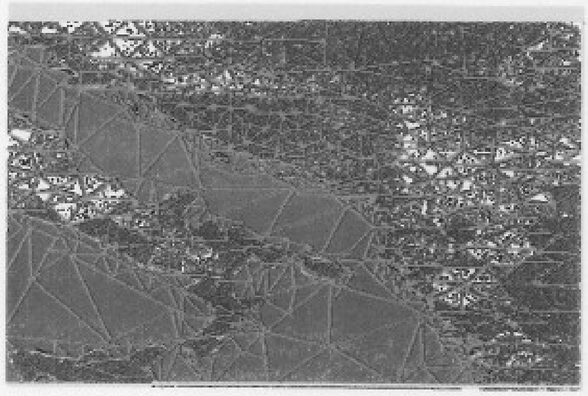

Fig. 7. An example of the OMEGA adaptive grid.

4. HIGH RESOLUTION CLIMATOGIES

There are a multitude of energy industry applications which require values for statistical parameters which describe the local climate. The most obvious and direct way to obtain local climate statistics is to calculate them from long-term point observations. However, the use of long-term observational datasets imposes at least two limitations: (1) long-term point observations are not currently available for many required locations in the United States or have sites with a limited period of record; and (2) the representativeness and quality of observations change in time as observing sites are relocated, the land use around a site is changed, or new instrumentation is used.

MESO, Inc. created CLIMOD which is a system designed to use output from the MASS model to produce high resolution 3-D gridded climatologies for data sparse locations. Data sparse locations are areas with limited direct observation sites. MESO conducted research for the U.S. Air Force and successfully generated hourly 10 Km resolution climate data for several regions around the globe. The pilot study was done for the Eastern Great Lakes Region (Zack et al. 1996) and currently climatologies for Korea and the Middle East are being generated. An example of the quality of temperature climatologies for point locations is seen in figure 8. The daily temperature curve is represented remarkably well by the simulated temperatures. This high quality was obtained for most locations in the domain area.

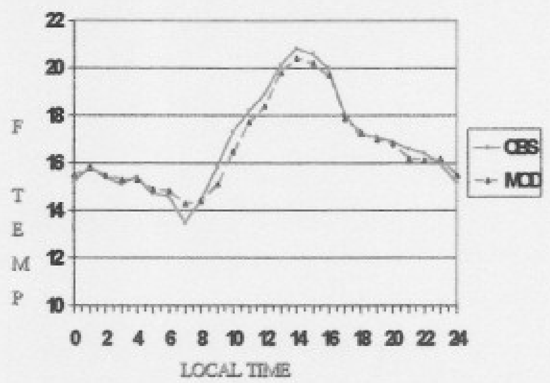

Fig.8. A comparison of the 24 hour 10 year (1985-94) temperature climatology for Watertown, NY. The *blue line* represents the observed climatology and the *red line* the simulated climatology. The temperature is in degrees Fahrenheit, the *Local Time* is Eastern Standard Time.

Figure 9 is an example of a grid of January snowfall climatology. No surface or upper-air station observations were used in creating these climatologies. Observational data was used only to verify the quality of the climate statistics produced by the model.

Fig. 9. Average January snowfall for the period 1985 to 1994 obtained from 310 days of simulations with a 10 Km resolution of the MASS model. The contour interval is 2 inches.

5. SUMMARY

Mesoscale models have the ability to be successfully applied to solve many problems that require knowledge of the environment. The key to successfully solving a specific problem is employing the right methodology and model configuration for a given problem.

6. REFERENCES

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