4.9 HIGH RESOLUTION REGIONAL WEATHER MODELING: FACTS AND FANTASIES

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1. INTRODUCTION

Regional-to-local scale weather modeling requires high resolution both in horizontal and vertical directions to resolve many critically relevant physical features. However, what is considered "high resolution" for a particular simulation effort largely depends on the type of flow/physical process being modeled. A trial-and-error method may be required to ascertain the required high resolution for acceptable predictive accuracy. Even if computer resources allow for such a high resolution simulation covering a large-enough computational domain, insufficient initial/boundary conditions, limiting nature of representations (parameterizations) of both resolved and unresolved physical processes, types of model paradigms (e.g., a large eddy simulation (LES) method or a Reynolds-averaged Navier-Stokes (RANS) method), model numerics, etc. are some of the many important real hurdles to achieve the fantasies of highly accurate predictions/ forecasts of regional weather variables such as wind speed, temperature, solar radiation, etc. Considerable research efforts are still required to advance numerical weather prediction.

Some of our recent efforts at Regional Earth System Predictability Research, Inc., related to the above mentioned issues, will be presented in the next section. In section 3, a summary and a brief discussion will be given.

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2. RESPR RESEARCH EFFORTS

We approach the regional weather modeling endeavor and the challenges it poses for success from several key standpoints as described below.

2.1 Beowulf parallel computational resource development efforts

First, the all important aspect of weather modeling are the well-tested, stable, and highly reliable computational resources. We have invested the required time and effort to develop our own parallel clusters, simply upon cost comparison between building them ourselves and purchasing from a commercial vendor. For example, by building our own clusters, we could bring the cost down by nearly two-thirds. In other words, we could build a node for ~$1000, whereas a commercial vendor might charge ~$2400 for a node of similar computational processing and peripheral attributes. These dollar amounts are only approximations and they may be falling as we write this note. Needless to say that the cost reduction is unbelievable but what is more amazing is our in-house expertise to troubleshoot such systems.

Our Beowulf cluster, ***Charlotte***, currently has fourteen single-processor nodes with the following key features:

* Fourteen motherboards with built-in fast ethernet network cards.
* Fourteen AMD XP2100+ CPUs.
* 1.5 GB random access memory (RAM) per motherboard.
* Commercial C, C++, Fortran compilers.
* Message passing interface (MPI) software.
* Has been configure to have one master node and thirteen compute nodes.

Figure 1. A fourteen-node Beowulf parallel computing cluster, ***Charlotte***, at RESPR.

With our proven expertise in building reliable Beowulf parallel computer clusters, ***Charlotte*** is slated to grow to a size of well over 500 nodes in the coming few years.

2.2 Computational fluid dynamics (CFD) model development efforts

As part of the multipurpose CFD model development efforts, for example, for applications to engineering and environmental flows, an atmospheric model is being developed at RESPR. A key aspect relevant to geophysical simulations is the "appropriate" vertical coordinate system. Model testing on the available vertical coordinate systems is ongoing in the context of a specific atmospheric phenomenon, to be discussed at the conference, and the insights gained via this model testing are being considered for improvements.

2.3 Weather forecasting efforts

RESPR offers site-specific regional weather forecasts for power companies that have renewable (green) energy sources in their energy portfolios. As an example, a six-hour forecast of wind speed at ~54 m height above ground level is shown in Fig. 2, for a potential wind farm site in Kansas being assessed by Kansas Wind Power, LLC. This forecast was made for 15 April 2003 at 12 Z, using the ~12-km National Center for Environmental Prediction (NCEP) Eta data set. The errors in power production output is below 3.5%. However, this is one of the exceptionally accurate forecasts we have made for this site. On an average, the errors are within 10% for this site.

A three-grid nested model configuration is used for these forecasts, in which the innermost grid (grid 3) has 1-km horizontal resolution. These forecasts are currently being produced using the Regional Atmospheric Modeling System (RAMS version 4.3), which is a parallelized atmospheric model (e.g., Walko et al. 1995). The reader is referred to Pielke et al (1992) for a comprehensive general description of the model, etc. Additionally, RESPR research staff has modeling experience with other popular mesoscale models available today such the fifth-generation Penn State University (PSU)/National Center for Atmospheric Research (NCAR) mesocale model (MM5), described, for example, in Dudhia (1993).

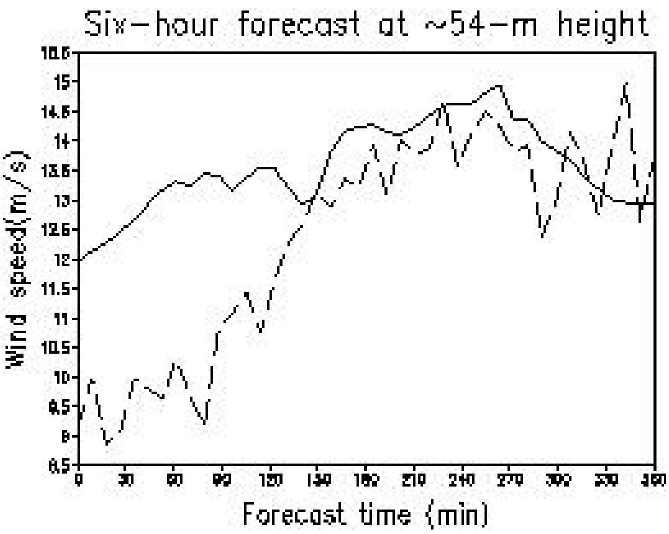

Figure 2. Six-hour forecast for a site in Kansas. Solid line shows forecast wind speed; dashed line shows measured wind speed. RAMS was initialized at 12 Z on 15 April 2003.

Our eventual goal at RESPR is to develop our own atmospheric and other earth-related computer models.

2.4 Research and development efforts

As part of ongoing atmospheric research and development efforts, research on the cell merger process, which was originally initiated within the Department of Atmospheric Science, at the University of Alabama in Huntsville (Stalker 1997), is being undertaken at RESPR using its newly developed parallel computational resources. Additional modeling results of this research, whose baseline modeling results have already been published (Stalker and Knupp 2003), will be presented by the first author of this note at the AMS annual meeting within the joint conference of the Eighteenth Conference on Hydrology, Flash Flood Forecasting in the Urban Environment, and the Symposium on Planning, Nowcasting and Forecasting in the Urban Zone (Stalker 2004).

3. SUMMARY AND DISCUSSION

We have briefly mentioned many of the important aspects of prediction/forecasting for successful regional weather modeling efforts. Computational resource development, computer model development, regional weather modeling (e.g., forecasting wind speed), and research and development efforts into relevant physical processes that take place at RESPR have been described in some detail.

In order to deliver a quantum leap into the future of predictive/forecasting science, one must approach the problem of regional weather modeling from many key standpoints than from just one or two, which is usually the case. For example, having a huge computational resource does not compensate for the lack of understanding into the relevant physical processes in the simulation of an interested phenomenon. Similarly, employing models based on unsuitable paradigms will hinder the advancement of predictive research efforts. It is our primary goal at RESPR to take a concerted approach to regional numerical weather prediction.

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