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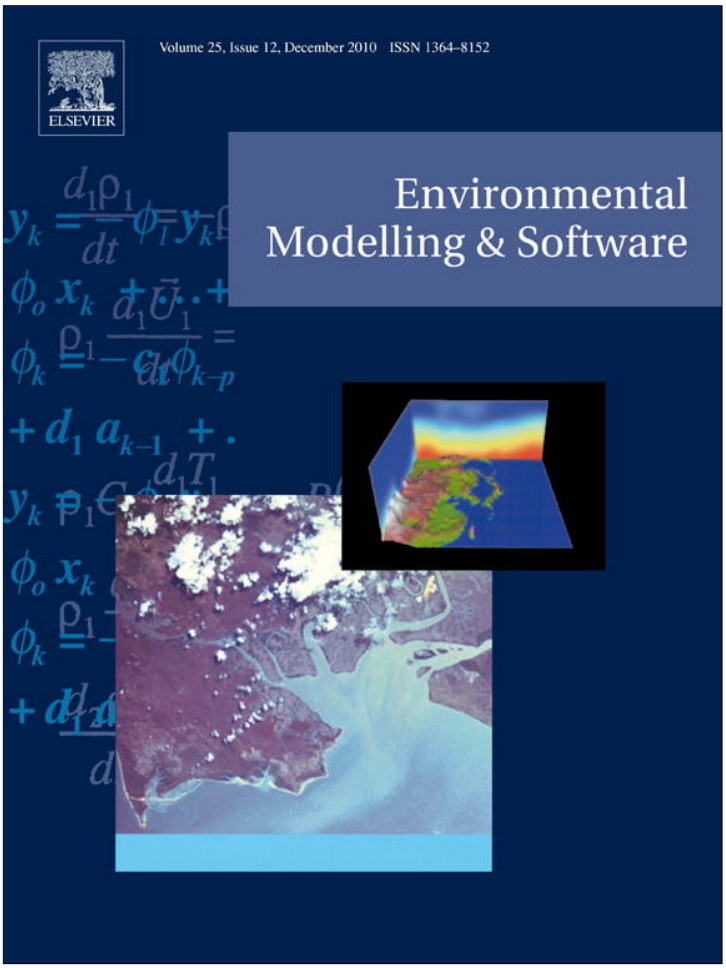

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VGE-CUGrid: An integrated platform for efficient configuration, computation, and visualization of MM5

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ABSTRACT

The platform of VGE-CUGrid integrates a computational grid (CUGrid) and a virtual geographic environment (VGE) to enable an efficient life-cycle process of MM5. The CUGrid is used to speed up MM5 computation. The VGE, which is supported by an underlying GIS system and virtual reality, is adopted as the friendly and efficient interface for initiation, computation, and visualization and analysis of MM5.
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Software availability

Name of software: CUGrid based Virtual Geographic Environment (VGE-CUGrid)
Contact address: Room 615, Esther Lee Building, the Chinese University of Hong Kong, Shatin, N.T., Hong Kong, P.R. China. Tel.: +852 26096010; fax: +852 26037470
Year first available: 2009
Hardware required: tested on Lenovo PC and DELL PC
Software required: MS Windows (tested on Windows XP and Linux)
Programming language: MS visual studio 2003.net C++, Java
Program size: 400 MB
Availability and cost: Contact via e-mail
Maintenance: Contact via e-mail

1. Introduction

The life-cycle of the PSU/NCAR Mesoscale Model version 5 (MM5) includes the steps of initiation, computation, and output visualization and analysis. Large scale simulations with MM5 often require computation that would take days or even months to complete. The time required prohibits timely decision making, especially during emergency situations. Therefore, minimizing the computation time of the MM5 and improving its computation efficiency are needed for decision making. MM5 is developed for the Linux operation system. Windows users are accustomed to installing MM5 on a Linux system and accessing it by some remote accessing tools, such as Secure Shell (SSH). SSH provides a command line interface, and is not user-friendly to non-Linux users. Meanwhile, some of the visualization tools for MM5, such as GrADS and Vis5D, have not been integrated with MM5 for end-to-end processing and analysis support. These tools do not support zooming in/out, information query, nor interactive analysis. To sum up, the challenges of using MM5 are complicated initiation, time consuming computation, and lack of interactive visualization and analysis tools.

We have developed a platform (VGE-CUGrid) integrating a computational grid (CUGrid) and a virtual geographic environment (VGE) (Lin and Zhu, 2005; Xu et al., 2008) to mitigate these challenges. The CUGrid is deployed to reduce the MM5 computation time (Xu et al., 2008). The VGE, which is supported by an underlying GIS system and virtual reality, is adopted as the friendly and efficient interface for simplifying initiation, visualizing computation, and conducting visualization and analysis of MM5 products. The contribution of VGE-CUGrid is supplying an integrated platform for

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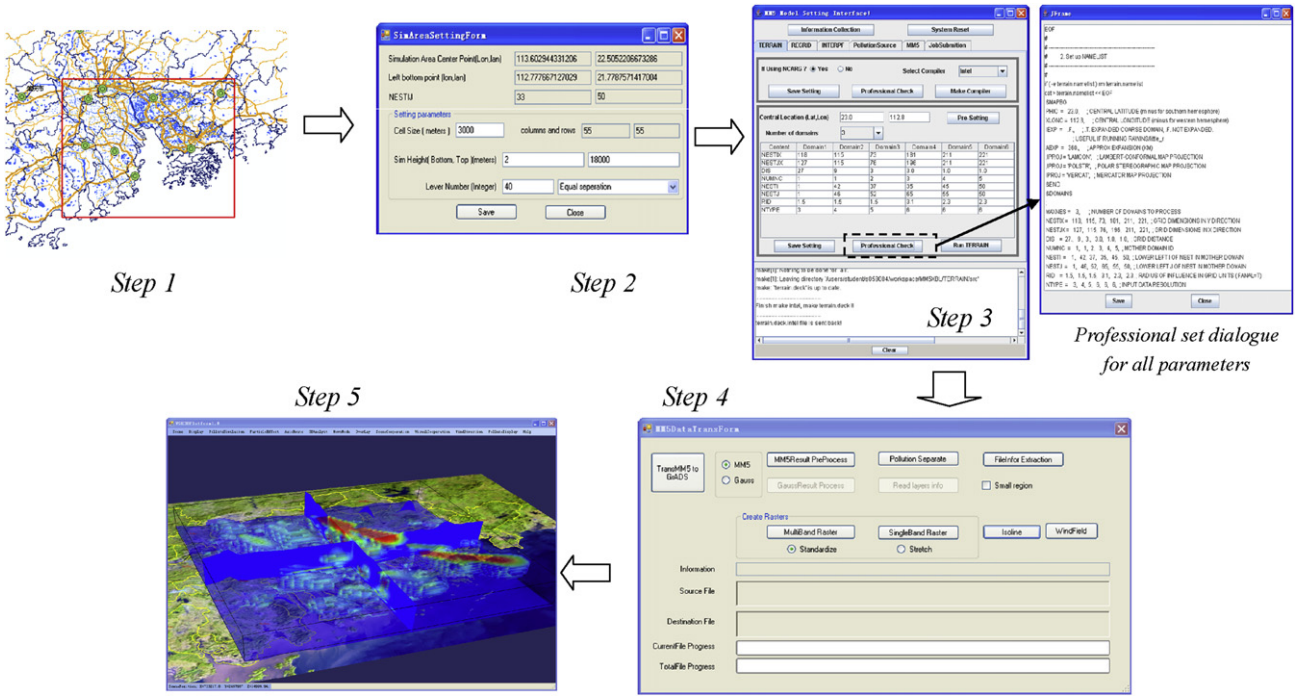


Fig. 1. Working flow of VGE-CUGrid.

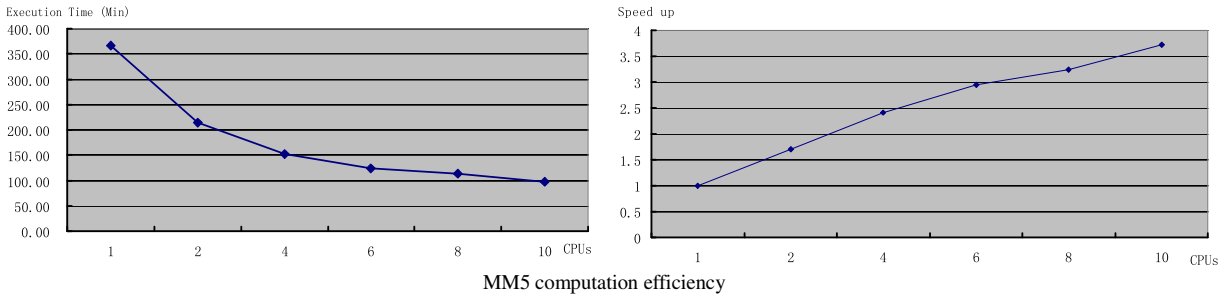
efficient initiation, computation and visualization of MM5. Furthermore, such a platform could feed many MM5 based environmental applications, such as ozone levels prediction (Sokhi et al., 2006), dust storms forecast (Barnum et al., 2004), and PM10 transport pathways identification (Wang et al., 2010).

2. The platform

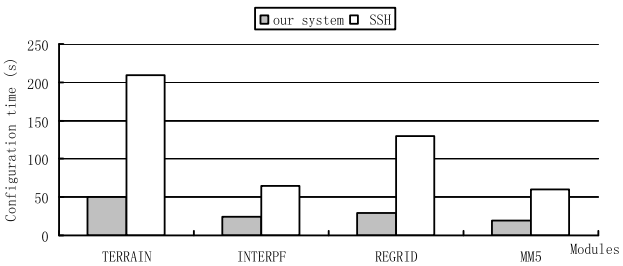
2.1. Platform components and installation

The platform is distributed and composed of three parts: the CUGrid based model server, system management node, and users. The CUGrid is an infrastructure to provide grid computation for MM5. The system management node serves as middleware to relay the commands/messages in two directions. The users are clients who generate commands within VGE and send them to the CUGrid through the management node. The interface of the platform, provided to end users, is VGE, which integrates operations including graphical initiation, grid computation, output processing and conversion, and geographical visualization and analysis of MM5 products.

The software is written in Java and Visual C++. On the server of CUGrid, an agent program written with Java is installed to collect and run commands from users, allocate jobs to computers on



MM5 computation efficiency



MM5 installation efficiency with VGE compared with SSH

Fig. 2. Test results.

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CUGrid, launch grid computation, and send results back to the user. The data to support the running of MM5 is also installed on the server of CUGrid. The system management node has a program also written in Java to relay information in two directions. The software installed in the user client is a virtual geographic environment developed with Visual C++ and Java. The operating system on CUGrid is Linux, while system management is a Window Server and the user client is Windows XP. There is no special requirement for the hardware of this platform except for the display card on the user's computer. To make sure the visualization can be smoothly rendered, the card should have more than 128 MB memory.

2.2. Workflow

The five steps of running MM5 in this system are simplified as follows (Fig. 1).

Step 1: Select the domain (program TERRAIN in MM5) by click and drag of the mouse in VGE. The geographic information is then automatically retrieved from VGE for pre-processing of MM5.
Step 2: A dialog is popped up in VGE to accept the definition of domain resolution, and the sigma height of layers.
Step 3: VGE launches a graphical interface to execute the pre-processing of TERRAIN, INTERPF, REGRID, MM5, and grid computation on CUGrid. On each modules' pane, if a parameter cannot be found, just click the "ProfessionalCheck" button to pop up the dialog, which is filled by the configure file. In the dialog, all of the modules' parameters can be found and defined.
Step 4: MM5 output data are converted to geographically referenced format, which can be read by VGE.
Step 5: The output of MM5 is geographically visualized and analyzed in VGE. The VGE accepts interaction of zoom in/out, roam, measure, layer overlay, information query (such as point profile), analysis (such as transaction analysis), and animation.

3. Efficiency test and results

Simulation of the pollution in the Pearl River Delta is used to test the efficiency of the platform. A group of 10 nodes (Quad core PCs) was used as the computation nodes on the CUGrid. The nested count of MM5 is set to 3. In the Coarse Domain (domain 1), the grid size is 27 km, and the domain dimensions (IX and JX) are 118 × 127. The Nested Domain (domain 2) has dimensions of 115 × 115, and the grid spacing is 9 km. The inner-most domain (domain 3) has dimensions of 121 × 139 with grid spacing of 3 km. Based on this configuration, the computation time decreases with the numbers of CPUs used. Meanwhile, analysis with the data also shows that the visualization is very smooth, even with a total data volume (include Digital Elevation Model (DEM) data, texture data, and the MM5 output data, vector and raster of GIS) of about 5 GB. Compared with SSH, as a new type of GUI interface, VGE significantly improves initiation efficiency of MM5. The test results are shown in Fig. 2.

4. Concluding remarks

Compared with WRFSI (McCaslin et al., 2003), which includes domain selection, data initialization interpolation for WRF, VGE-CUGrid is a life-cycle solution for MM5 in not only initialization, but also high speed computation, and output visualization and analysis. The CUGrid, which currently has more than 300 computing cores, is computing resources scalable on the needs of the institutions in PRAGMA (www.pragmagrid.net). As we are a member of PRAGMA, this capability of scalability guarantees that MM5 can be computed with sufficient computing resources. The VGE not only supports MM5 processing but also has many other features including: (1) compared with SSH, GrADS and Vis5D, the VGE interface is more interactive; (2) GIS data can be directly displayed in VGE; (3) the data of VGE and most 3DGIS are compatible; and (4) the output of VGE can be easily transformed into KML format, which can be read and presented by GoogleEarth.

The VGE-CUGrid platform can serve as a prototype that bridges MM5 based modeling with geographic information and virtual reality, and will facilitate cross- and inter-disciplinary research and application in atmospheric science, environmental science, and geographic information science. The framework of VGE-CUGrid can be easily extended to other disciplines to promote inter-disciplinary research and applications, which will be our next work.

Acknowledgments

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