A New Tool for Analyzing CMAQ Modeling Results: Visualization Environment for Rich Data Interpretation (VERDI)

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1. INTRODUCTION

The Community Multiscale Air Quality Model (CMAQ) produces files of gridded concentration and deposition fields. Users have the need to visualize these data both spatial and temporally. Historically, CMAQ users have used the Package for Analysis and Visualization of Environmental data (PAVE) for visualizing CMAQ output. PAVE was first developed in 1996 and is written in C and Motif. The aging PAVE platform has presented some challenges with current computers and operating systems. The last release of PAVE was in 2004 and no further development is planned. In recent years, there has been a rapid increase in the availability of open source Java libraries for producing graphical output. A development effort was initiated to build a replacement for PAVE that uses these updated software libraries. That effort has resulted in the development of the Visualization Environment for Rich Data Interpretation (VERDI). This new tool is useful for viewing CMAQ files as well as other environmental data.

2. SYSTEM REQUIREMENTS AND INSTALLATION

VERDI requires version 6 of the Java Runtime Environment (JRE). At this time, JRE 6 is available from Sun for Windows XP, Vista and 2000, as well as Linux and Solaris. The full JRE 6 is not currently available for Mac OS X but should appear in the next version of Mac OS X (Leopard) due before the end of 2007.

VERDI's memory and CPU requirements are largely dependant on the size of the datasets to be rendered. Small datasets can be rendered and manipulated in less than 512 megabytes while larger datasets may need considerably more. Similarly, slower CPUs can quickly render and animate smaller datasets whereas larger datasets can take longer. VERDI has been run satisfactorily on older Intel Core Duo and later model Pentium processors as well as on the latest Core 2 Duos and comparable AMD chips using both Windows and Linux operating systems. Three dimensional contour plots require a graphics processor with OpenGL or DirectX capability.

Installation on Windows operating systems is accomplished via a dedicated install program. On Unix based platforms, VERDI is distributed as a gzipped tarball that contains the executable application. When JRE 6 for Mac OS X is available, an application bundle for Mac OS X will be made as well.

3. SOFTWARE DESIGN

One of the goals in the development of VERDI was to use a language that would allow platform independence and eliminate the need for the software bus currently needed when running PAVE. Java was selected as the programming language since it met this requirement and is widely used. Additionally, numerous open-source Java graphical libraries are available which expedited the development. The code is modular in design and well-documented which will facilitate further modifications. A generalized reader was programmed that allows a number of input file formats and is easily extensible to other file types.

In interactive operation, VERDI opens as a single window with data and plot sub-windows accessible as tabs (Figure 1). These windows can be undocked to allow them to be moved into separate windows. Dataset lists and associated formulas may be saved as a project for later reuse. VERDI commands can also be issued directly from the command line or via a script to allow batch processing.

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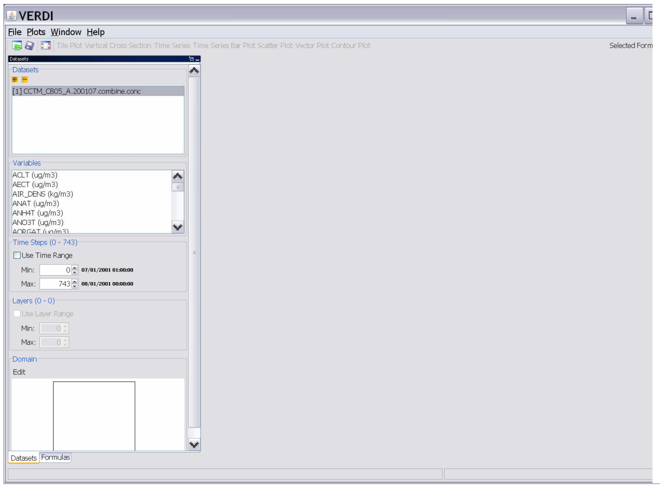

Figure 1. Screen shot showing the VERDI interface with the window open for adding datasets and selecting variables.

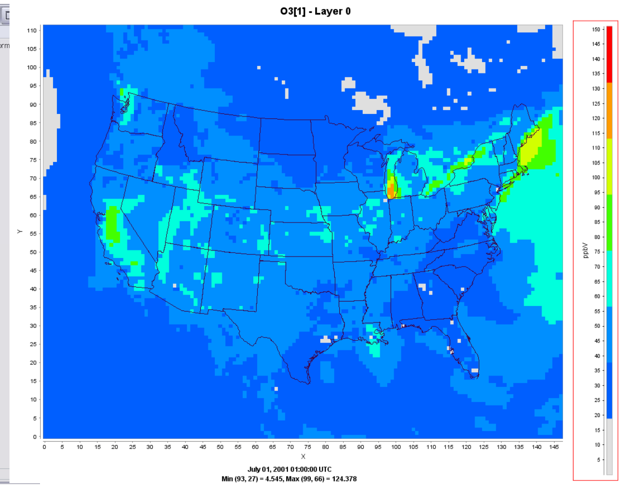

Figure 2. Tile plot exported in PNG format.

4. DATA FORMATS AND PLOT TYPES

VERDI was designed to have all of the functionality of PAVE as well as new features. Currently supported input file formats include Models-3 IOAPI, WRF IOAPI, and netCDF, however additional formats can easily be added to the code. Once a dataset is loaded, users have the option to select variables for plotting and may use formulas to create new variables. Data can also be windowed by selecting a time range and/or layer range and/or domain.

A number of plot types are available including smoothed tile (Figure 2), time series line (Figure 3), time series bar, vertical cross section, scatter, vector, and contour (Figure 4). Plots are full configurable to change scale, color maps, symbols, and text. Plots can be probed to obtain the value of a particular point and can be zoomed to examine an area in detail. Tile and contour plots can be animated to view a time series. Contour plots are displayed in 3-D and may be rotated to achieve different view angles.

A number of output file formats are provided. Results from probing a plot can be saved as a text file. Plots can be saved as a PNG, JPEG, BMP, or TIFF file. Animations can be saved as an animated GIF or a movie.

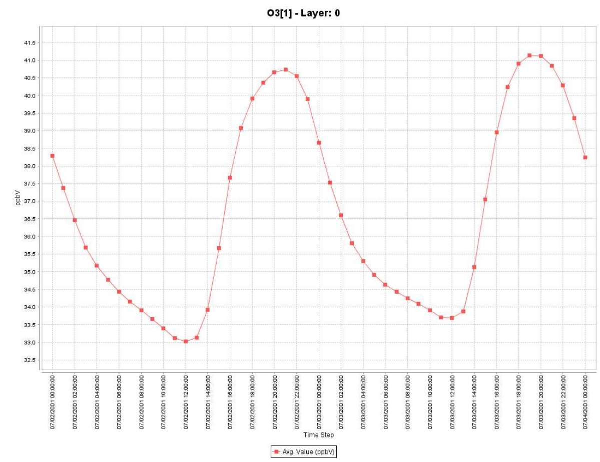

Figure 3. Time series plot exported in PNG format.

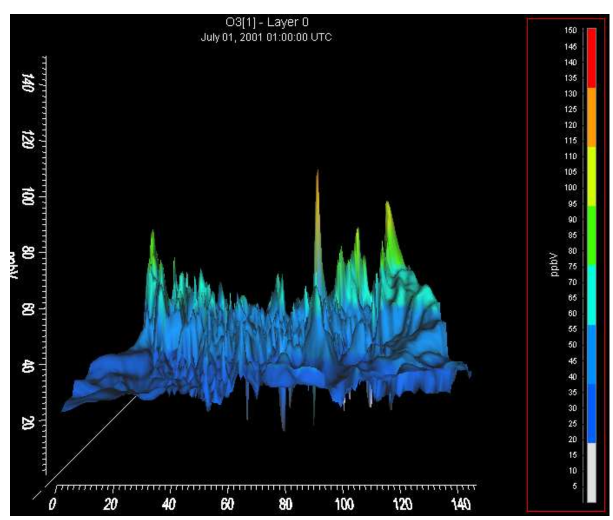

Figure 4. Contour plot exported in PNG format.

5. FUTURE IMPROVEMENTS

VERDI is intended to be a community based visualization tool with strong user involvement. The source code will be made available to the public. Users may contribute modules that they have developed and feel may be useful to the modeling community. Examples include readers for additional file formats and modules for additional plot types. Data analysis routines could be added. The development directions will respond to the needs expressed by the modeling community. EPA is also continuing some limited development of VERDI as resources permit. One targeted area for improvement is speed of operation. In particular, slow rendering speeds have been noted when using Secure Shell. EPA also intends to add the spatial analysis capability found in the Watershed Deposition Tool (Dennis and Schwede, 2006) to VERDI. The Watershed Deposition tool takes gridded atmospheric deposition estimates from CMAQ and allocates them to 8-digit HUC's (hydrologic cataloging units of rivers and streams) within a watershed, State or Region.

6. REFERENCES

Dennis, R., 2006: The Watershed Deposition Tool: A Means to Link Atmospheric Deposition to Watersheds, Proceedings, National Atmospheric Deposition Program, 24-26 October, Norfolk, VA, p 69.

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7. DISCLAIMER

The research presented here was performed under the Memorandum of Understanding between the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) and under agreement number DW13921548. This work constitutes a contribution to the NOAA Air Quality and Global Climate Programs. Although it has been reviewed by EPA and NOAA and approved for publication, it does not necessarily reflect their policies or views. Argonne National Laboratory's work was supported by the U.S. Environmental Protection Agency (EPA) though U.S. Department of Energy contract DE-AC02-06CH11357.