

The Visualization and Computation System (VCS) — Uniquely Versatile Software

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ABSTRACT: *The Program for Climate Model Diagnosis and Intercomparison has developed the Visualization and Computation System (VCS)—computer software for the selection, manipulation and display of scientific data. By specification of the desired data, the graphics method and the display template, the VCS user gains virtually complete control of the appearance of the data display and associated text and animation. In addition to operating in a fully interactive mode, the user can run VCS from a script file, or can alternate between interactive and script modes.*

The principal mission of the Program for Climate Model Diagnosis and Intercomparison (PCMDI) is to develop improved methods for the diagnosis, validation and intercomparison of global climate models. The need for such standards has become increasingly apparent as more complex climate models are developed, while the disagreement among models, and between models and observations, remains significant and poorly documented. The nature and causes of these disagreements must be better understood before these models can be confidently used for climate sensitivity and predictability studies in support of global change research.

The massive amounts (~ gigabytes) of data produced by climate model simulations makes imperative the development of powerful visualization tools. Because no single display technique can elucidate all facets of climate model behavior, the visualization system must possess a wide range of graphics capabilities. In comparing simulations from many different models, it is also necessary to perform grid transformations and computations of additional diagnostic variables.

The PCMDI Visualization and Computation System (VCS) is expressly designed to meet these needs of climate scientists. Because of the breadth of its capabilities, VCS can be a useful tool for other scientific applications as well. VCS allows wide-ranging changes to be made to the data display, provides for hardcopy output and includes a means for recovery of a previous display. VCS also allows the user to browse large amounts of data and obviates the need to create intermediate data files.

In the VCS model (Williams and Mobley, 1994), the data display is defined by a trio of named attribute sets, designated

the “primary elements”. These include: the *data*, which define what is to be displayed; the *graphics method*, which specifies the display technique; and the *picture template*, which determines the appearance of each segment of the display (Fig. 1). Panels for manipulating these primary elements are color-coded in the VCS interface: attributes associated with the *data* are represented in red, those with the *graphics method* in blue, and those with the *picture template* in green (Fig. 2).

In addition, detailed specification of the primary elements’ attributes is provided by eight “secondary elements”:

- *colormap*: specification of combinations of 256 available colors
- *line*: line type, width and color index
- *text*: text font type, character spacing, expansion and color index
- *text orientation*: character height, angle, path, and horizontal/vertical alignment
- *marker*: type, size, and color index
- *fill area*: style, style index, and color index
- *format*: specifications for converting numbers to display strings
- *list*: a sequence of pairs of numerical and character values.

By combining primary and secondary elements in various ways, the VCS user can comprehensively diagnose and intercompare climate model simulations.

VCS provides capabilities to:

- browse data directories and read various data file formats

- quickly display variables via default settings
- view, select and modify attributes of data variables and their dimensions
- create and modify existing template attributes and graphics methods
- save the state of the system as a script to be run interactively or in batch mode
- save a display as a file in Computer Graphics Metafile (CGM), postscript or raster formats
- perform grid transformations and compute new data variables
- create and modify colormaps
- zoom into a specified portion of a display
- change the orientation (portrait vs. landscape) or size (partial vs. full-screen) of a display
- animate single- or multiple-dimensional data variable(s)

Procedures for exercising these capabilities are documented online in VCS (Williams et al., 1995). Especially noteworthy features of VCS are its data representation model and its scripting, computational and animation capabilities.

Data representation in VCS is transparent to the user. Data file formats presently accessible by VCS include: the Data Retrieval and Storage (**DRS**) format, developed by PCMDI (Drach and Mobley, 1994; software is available via anonymous FTP from site sprite.llnl.gov in directory `/pub/drs`); the Network Common Data Form (**netCDF**) format, developed by the Unidata program of the National Science Foundation (NSF) Division of the Atmospheric Sciences (available via FTP site unidata.ucar.edu in directory `/pub/netcdf`); and formats supported by the Grid Analysis and Display System (**GrADS**), developed by the Center for Ocean-Land-Atmosphere Studies (COLA) (available via FTP site grads.iges.org). Within VCS, the user can browse data directories and read variables from combinations of files, perform grid transformations, and compute new variables. A data array's dimensions can be transposed, reversed, sub-selected, randomly selected, and wrapped. The attributes of the dimensions, as well as those of the array data variable, can be modified.

The scripting capability of VCS serves many purposes. It allows the user to save the system state for replay in a later session; to save primary and secondary element attributes for use in later visual presentations; to save a sequence of interactive operations for replay; and to recover from a system failure.

New diagnostic variables can readily be computed in VCS by building mathematical expressions from basic operators and functions. Arithmetic and exponential operators, and functions for computing the statistical mean and standard deviation of a data variable are presently available.

The VCS animation capability allows three-dimensional visualization of one or more data variables (e.g., the temporal progression of a two-dimensional field). The animation control panel (Fig. 3) creates sequences of raster images that may be stored in memory or in an output file; their animation then can be viewed subject to user control. Other VCS animation options include the ability to modify the colormap (Fig. 3), to change the direction of flow, to view each frame in time-delay mode, and to pan or zoom—all while the animation is proceeding.

In the future, PCMDI will continue to enhance the capabilities of VCS. Development priorities include provision of the ability to access data via directories or a database, as well as data written in the Hierarchical Data Format (**HDF**); to save data in **HDF**-, **netCDF**-, and **GrADS**-formatted files; to increase the computational power of VCS; and to augment the types of available graphics methods.

Availability of VCS

VCS is operable on the following computing platforms: Sun, running operating systems SunOS 4.1.3 or Solaris 2.4; Silicon Graphics Incorporated (SGI), running operating systems IRIX 5.2 or 5.3; and Hewlett Packard (HP), running operating system HP-UX 9.0.5. Because VCS is written in ANSI C and utilizes X/Motif, the software should compile on other UNIX-based platforms as well.

VCS is available free of charge to users in nonprofit institutions who sign a PCMDI collaborative agreement stipulating that the software will not be sold to third parties. To obtain a copy of this agreement, contact Dean N. Williams (williams@asia.llnl.gov).

Acknowledgment

Fig. 1 was generated with the help of Chris L. Anderson a member of the National Energy Research Supercomputer Center.

References

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- Williams, D.N., and R.L. Mobley, 1994: The PCMDI Visualization and Computation System (VCS): A workbench for climate data display and analysis. PCMDI Report No. 17, Lawrence Livermore National Laboratory, Livermore, California, 104 pp.
- Williams, D.N., R.L. Mobley, R.S. Drach, and T.J. Phillips, 1995: Hints and examples for the use of the PCMDI Visualization and Computation System (VCS). PCMDI Report No. 23, Lawrence Livermore National Laboratory, Livermore, California, 85 pp.

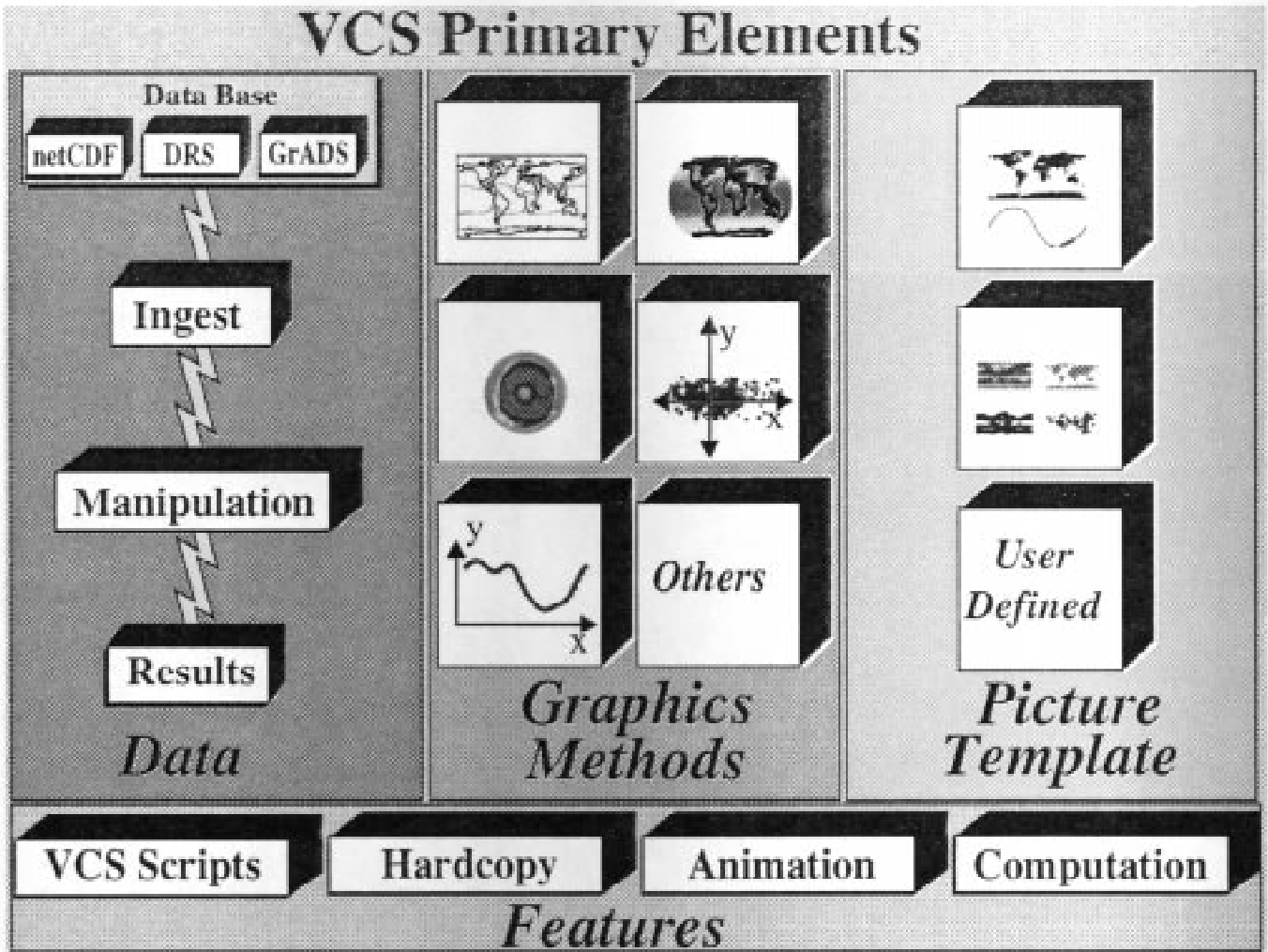


Figure 1: Diagram of the VCS model and capabilities.

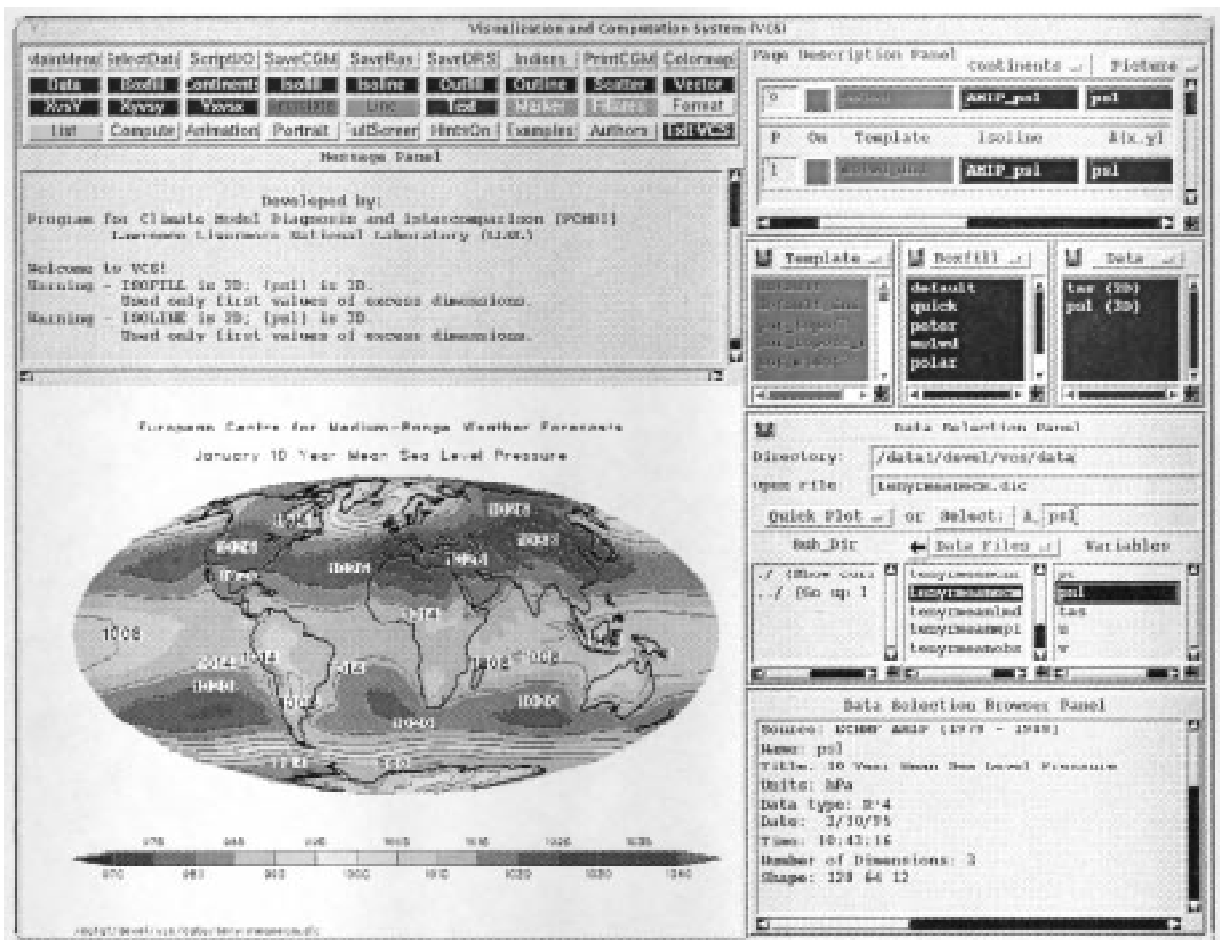


Figure 2: The VCS interface, with a display of January mean sea level pressure simulated by the European Centre for Medium-Range Weather Forecasts (ECMWF) model.

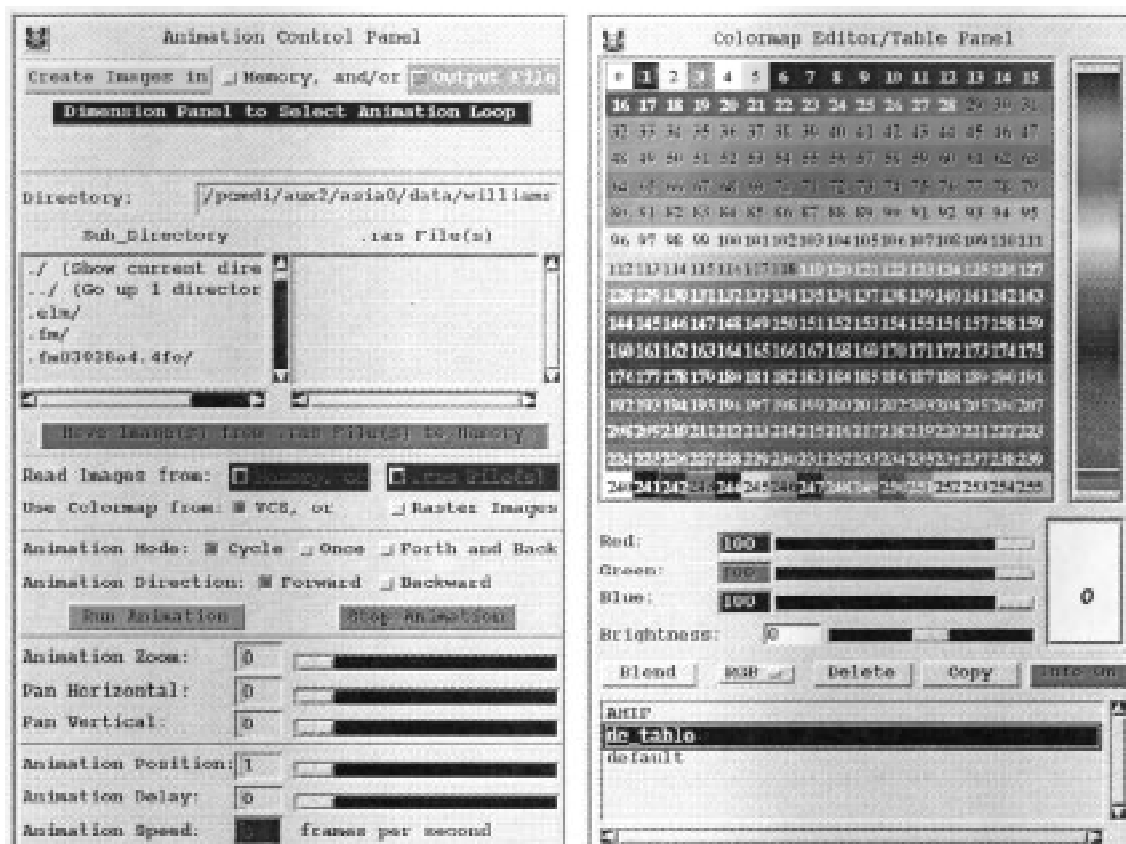


Figure 3: The VCS animation control and colormap panels.