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The VAPOR Project at NCAR

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[Overview] VAPOR is the Visualization and Analysis Platform for Ocean, Atmosphere, and Solar Researchers. The VAPOR project is an open-source software project, funded by the NSF-ITR program. Vapor is targeted at improving the ability of earth science researchers to interactively analyze and explore complex dynamics found in massive data sets resulting from high-resolution, 4D (3D space x time) numerical simulations of fluid flow. Vapor is a collaborative effort involving researchers at NCAR, the University of California at Davis, Ohio State University and the University of Colorado.

VAPOR combines a desktop visualization application with a library of IDL access routines. Analysis can be performed in IDL on user-specified portions of the data, and the results of that analysis can be integrated into the visualization. Terabyte data sets can be interactively browsed by user selection of region of interest and resolution.

[technical basis] VAPOR employs a multiresolution data representation to enable users to rapidly access interesting spatial or temporal regions within the data. Users specify the desired data resolution, controlling the tradeoff between accuracy and speed of visualization and analysis. VAPOR provides a library of routines to convert user data to VAPORs multiresolution format.

[capabilities] Functionality and usability features of VAPOR are prioritized by a scientific steering committee consisting of domain experts in numerical simulation. Currently the following are supported:

Direct volume visualization: Recent advances in graphics hardware enable interactive browsing of large (e.g. 512^3) data volumes using inexpensive graphics cards. VAPOR volume rendering exploits this hardware, providing an interface where users can design transfer functions, mapping data values to color and transparency and immediately visualize the results. Regions of interest can be identified and explored in higher detail.

Flow visualization: VAPOR includes a library of integration methods for investigating vector fields. These fields can be explored by specifying a set of points seeding the flow, and advecting flow lines or trajectories from those seeds. Seeds can be interactively positioned using a random or nonrandom rake or specified programmatically in IDL. The resulting flow can be visualized in combination with volume rendering.

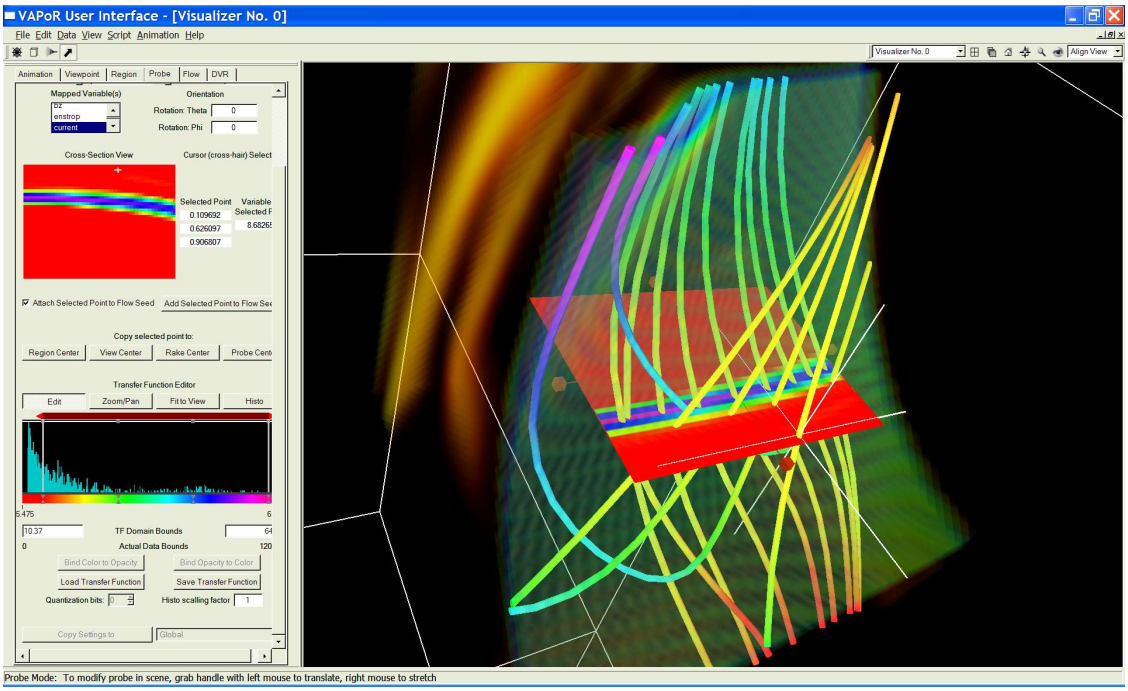
Data probing: A 2D or 3D probe can be positioned within the data volume. Users can histogram data in the probe and color-map the data in the probe. Data values at specific points in the probe can be used for interactive flow seed positioning.

Animation: Time-varying data can be visualized by automatically or manually advancing time steps, enabling an evolving display of flow and volume features.

Analysis: VAPOR supports a tight coupling of visualization with an IDL session. Users can interactively specify a region of interest in the visualization, and that region can be exported to the IDL session. Results of IDL computation are imported back into the visualization.

Adaptive Mesh Refinement: VAPOR supports visualization of block-structured AMR grids. These grids are resampled to uniform grids for analysis and visualization.

The following image, courtesy of Pablo Mininni (NCAR), illustrates a current sheet, visualized using combined flow and volume visualization of a 1536x1536x1536 volume:



[Availability] VAPOR release 1.0 is currently available on (32-bit and 64-bit) Linux, Windows, and Irix. Binary and source for these platforms can be downloaded from http://www.vapor.ucar.edu/download/. Documentation, examples and other information about VAPOR is available at http://www.vapor.ucar.edu/

[Plans] VAPOR is an ongoing software development effort, focused on providing improved understanding of massive scientific data sets. Features being considered for the next release include:

- Use of lossy compression to reduce data size and access time
- Support for spherically gridded data
- Isosurface generation and display
- Enhanced support for AMR grids
- Scripting for batch rendering

[Presentation] At this workshop we shall demonstrate the use of VAPOR to understand simulation results performed at NCAR and elsewhere. These will include the latest capabilities, available in the current release of Vapor:

- Volume rendering
- Animation
- Flow Visualization
- Import and Export to IDL
- Data probing and interactive seed placement

References

[1] J. Clyne, and M. Rast 2005. *A prototype discovery environment for analyzing and visualizing terascale turbulent fluid flow simulations*, *Proceedings of Visualization and Data Analysis 2005*, 284-294.