2010 Update

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Outline

- VAPOR overview and status
- VAPOR capabilities
- Work in progress
- Research directions
- Demo: Using VAPOR multi-resolution data in VisIt

VAPOR project overview

- **VAPOR** is the **V**isualization and **A**nalysis **P**latform for **O**ceanic, atmospheric and solar **R**esearch
- **Motivation**: Scientific datasets have become too large to interactively apply current analysis and visualization resources. VAPOR's multi-resolution approach enables scientists to interactively analyze and visualize massive datasets resulting from fluid dynamics simulation.
- **Narrow domain focus**: 2D and 3D, gridded, time-varying turbulence datasets, especially earth-science simulation output.
- **VAPOR** is a free desktop application, widely distributed. Exploits latest GPU capabilities

VAPOR Capabilities

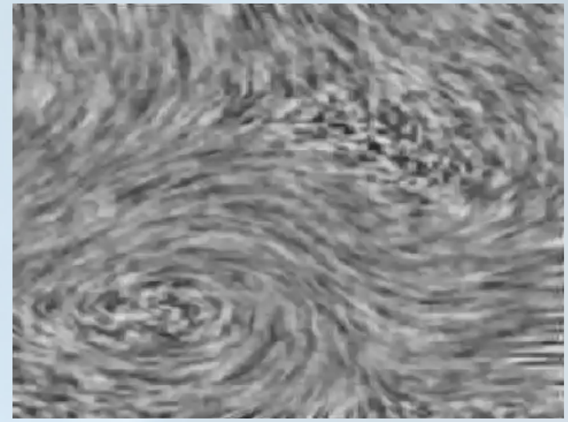
Emphasis on ease-of-use in scientific research

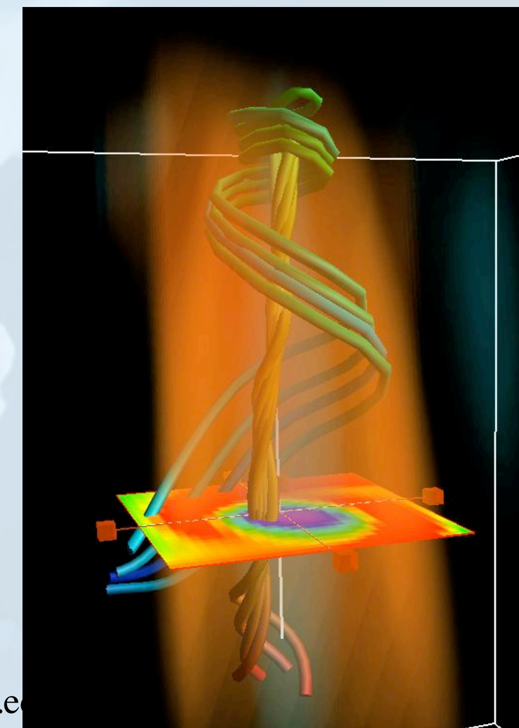
- Multi-resolution data representation
  - Enables interactive visualization of massive datasets
- Volume rendering and isosurfaces on the GPU
  - Interactive color/transparency editor
- Steady and unsteady flow integration
- Field line advection
  - Combination of steady and unsteady flow integration
- IBFV (Image-Based Flow Visualization)
- Data probing and contour planes
  - Interactive flow seed placement
- Supports WRF-ARW (Weather Research Forecast Model) visualization

VAPOR flow analysis capabilities

A variety of techniques developed in response to science needs

- Steady and unsteady flow integration uses adaptive integration developed by Han-Wei Shen, OSU.
- Texture-based visualization (IBFV) animates 2D slices of flow, using techniques of Jarke Van Wijk
- Physically-based field line advection (Aake Nordlund, Pablo Mininni), originally for MHD, now of more general use
- Analytic and visual seed placement techniques



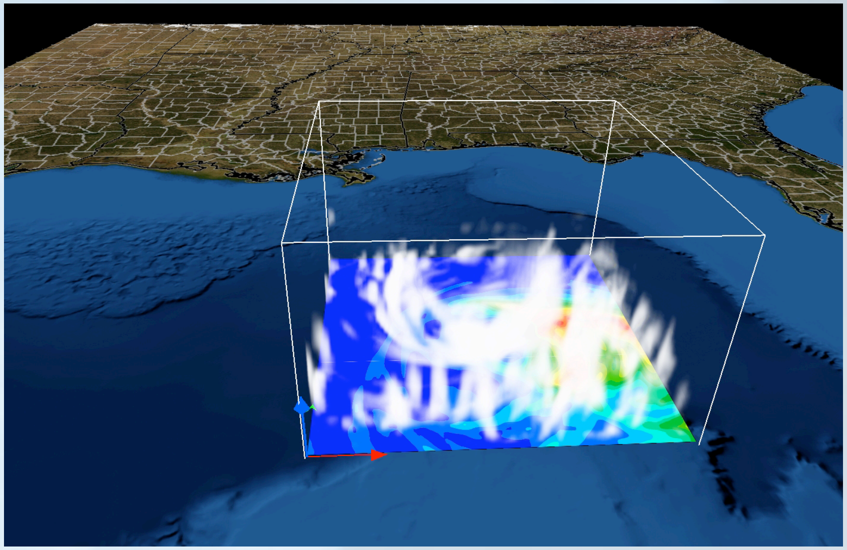


Visualization & Analysis Platform

New features (Release 1.5.2, Nov 2009)

Geo-referencing support

- Support mapping projections used by WRF:
  - Lambert conformal conic
  - Mercator
  - Longitude/latitude
  - Polar stereographic



- Support for geo-referenced images obtained from Web Mapping Services (satellite imagery, political boundaries, rivers, etc.)
- NCL data plots are geo-referenced and inserted in scene
- Track moving WRF nests
- Terrain displayed as elevation grid

Feature plans

Preparing for the next VAPOR release:

- Qt UI upgrade (to 4.6)
  – Native Mac support
- Mac 64-bit support
- Accelerated flow rendering
  – 10-fold improvement with many thousands of streamlines
- Extensibility improvements
  – Initial restructuring to facilitate 3rd-party development
- Interfaces to VisIt and ParaView
  – Enable VisIt and Paraview to load VAPOR multi-resolution datasets (More later)

Features under development

Being developed for upcoming releases

- Web-based training modules
- Full extensibility API
  - Third-parties can add new renderers and other capabilities with customized user interface
- Built-in expression evaluator
  - Possibly based on Python/NumPy
- Improved data model
  - Support for wavelet compression
  - Parallel I/O library

VAPOR Extensibility API

Objective is to make VAPOR a community platform, by facilitating extension development by 3rd parties

Third-party developers will be able to customize

- Data models
- Renderers
- UI components

Support transparent integration with existing VAPOR capabilities such as:

- Undo/Redo
- Session save/restore
- Multi-resolution data access

VAPOR Research

- Improved data model
  - Support lossy compression as well as resolution control
  - Needed for petascale
- Feature identification
  - Combine statistics and multi-dimensional transfer functions to identify and classify features
- Feature tracking
  - field line advection provides physically-based prediction of feature position

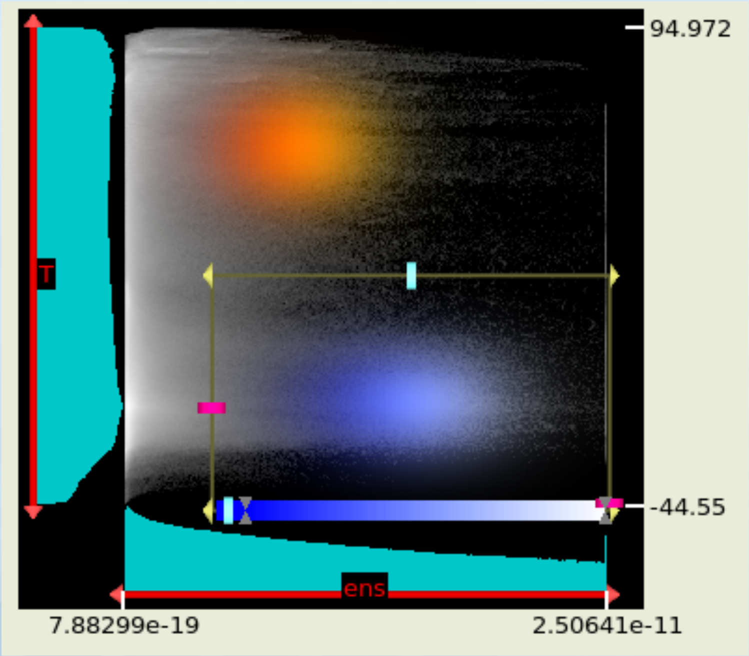
Data compression for Petascale computation

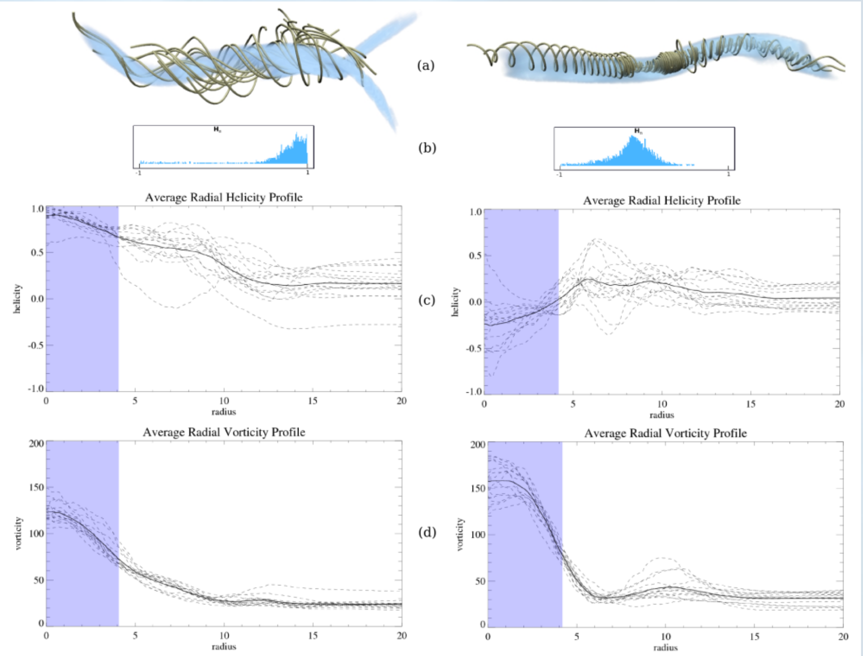
NCAR

- Existing VAPOR data model supports data navigation with control over resolution (refinement level)
- But current model is insufficient to permit interactive visualization of petascale data volumes.
- J. Clyne: Developing an improved data model in VAPOR to support:
  - Parallel wavelet transform of full and partial datasets, callable from parallel applications
  - Efficient random retrieval in massive repository of wavelet coefficients
  - Wavelet compression/decompression using wavelet families known to efficiently compress earth science data

Feature Identification (K. Gruchalla)

- Use a multidimensional transfer function to identify and select structures of interest
- Connected component analysis isolates these structures.
- Local statistical measures used to classify dynamics





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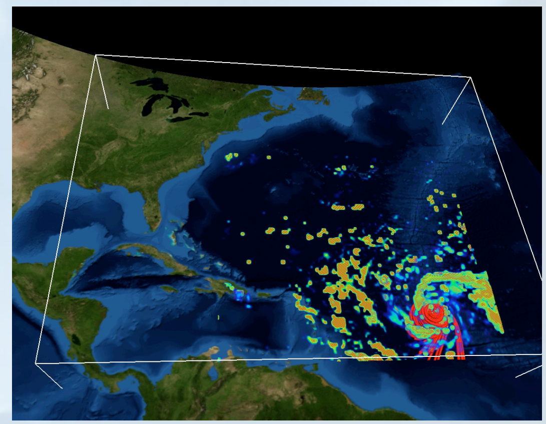
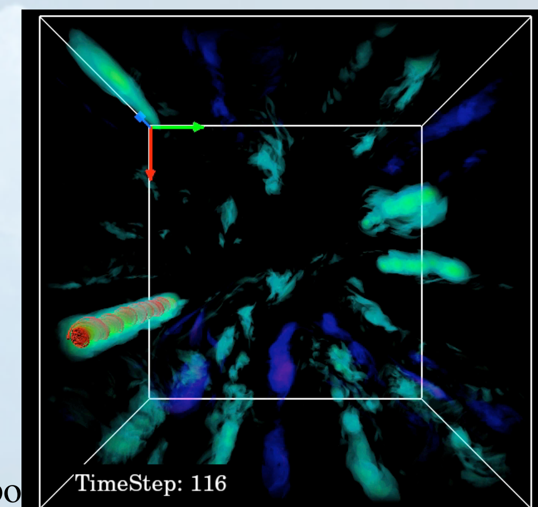
Use of field line advection for feature tracking

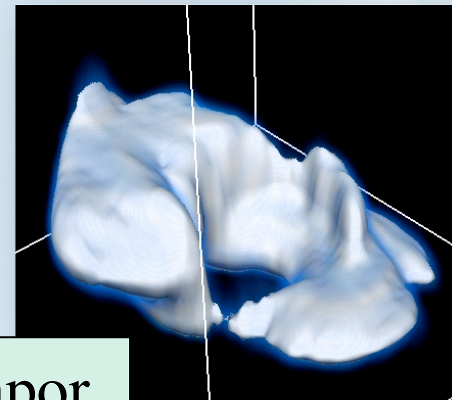
- Problem: Simulation output can only be infrequently saved. Impossible to track by retrieval and examination of full data at multiple time steps
- Proposed approach:
  - Identify feature of interest in small region
  - Determine motion of feature, using field line advection
  - Retrieve data at other time-steps, restricted to the time-varying volume associated with the advected feature.



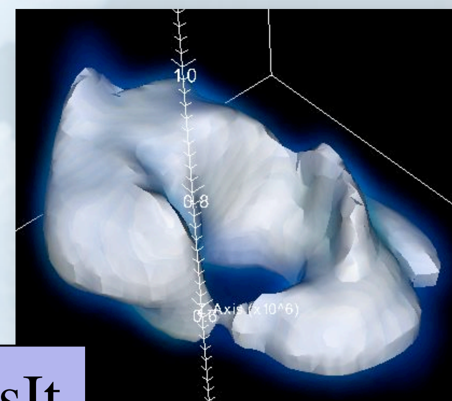


VAPOR data in VisIt and ParaView

- Apply the unique features and parallel scalability of VisIt and ParaView to Vapor Datasets
- VisIt Plug-in:
  - Single or multi domain.
  - Reports time steps to VisIt for animation.
  - Uses Vapor data manager to handle metadata and scalar data access.
- ParaView Plug-in:
  - Still in early development.
  - Similar features to VisIt plug-in.



Vapor



VisIt

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VAPOR Availability

- Version 1.5.2 software released in November 2009
  - Next version planned for mid-2010
- Runs on Linux, Irix, Windows, Mac
- System requirements:
  - a modern (nVidia or ATI) graphics card (available for about $200)
  - ~1GB of memory
- Software dependencies
  - IDL® http://www.ittvis.com/ (only for interactive analysis)
- Executables, documentation available (free) at http://www.vapor.ucar.edu/
- Source code, feature requests, etc. at http://sourceforge.net/projects/vapor

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