

SERVING 3-D RENDERED GRAPHICS OF OCEAN MODEL OUTPUT USING LAS AND VTK

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1. INTRODUCTION

Scientists at NOAA's PMEL laboratory are relying more and more on supercomputing platforms for their modeling efforts. Running ocean models on these large cluster machines poses problems in that domain sizes are increasing and tracking how the model dynamics are developing during a run requires high-bandwidth network time. In an effort to streamline this procedure both server and 3-D rendering technology are utilized.

Intermediate model results saved in netCDF file format can be served remotely to query model progress using the Live Access Server (LAS), and bandwidth can be saved by using a back-end application to serve 3-D rendered geometry in the form of VRML over the web. In our implementation, a crontab script checks for model results and generates an XML data-file descriptor and adds the data set to the list of those available for LAS to serve up. On top of the default product choices (2-D plots, data listings, etc), the user can also chose a VRML isosurface of the variable of interest. LAS then invokes a Visualization Toolkit (VTK) application whose input includes the variable name, region of interest, and netCDF file, and creates a VRML file of the isosurface (as well as topography and surface current vectors). File size can be controlled through the use of topology-preserving polygon mesh decimation algorithms. Animations of the isosurface are obtained through the use of an external prototype node and javascript. Results can be viewed in stereo locally through the use of a VRML-aware internet browser and an inexpensive stereo-capable video card.

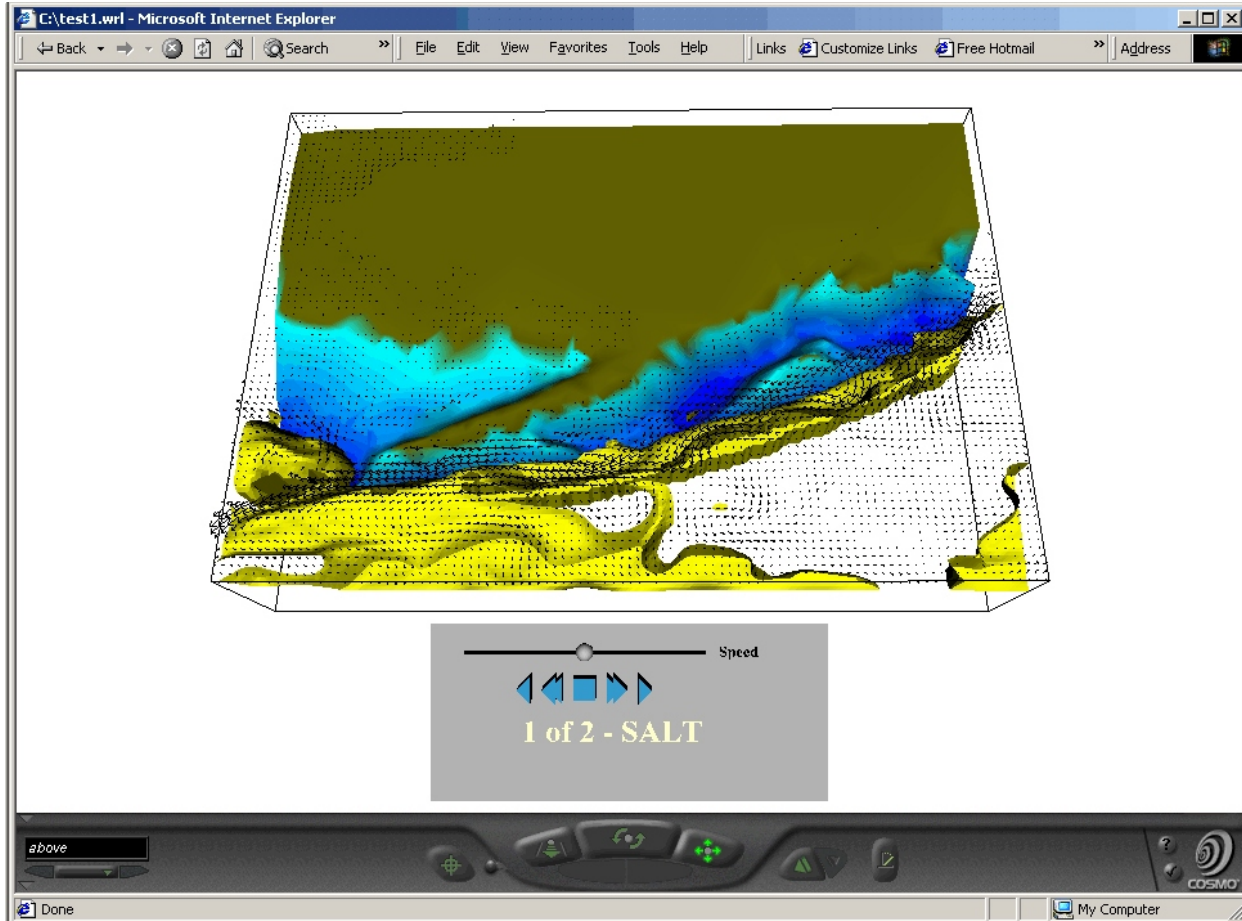
A description of the technique can be found at www.pmel.noaa.gov/~hermann, and a demonstration of the server is available on-line at <http://ferret.wrc.noaa.gov/globec>.

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2. LIVE ACCESS SERVER (LAS)

The Live Access Server (LAS) is a web server for earth science data sets designed at NOAA's Pacific Marine Environmental Lab. LAS uses XML to query a data set as to physical domain to present the user with options pertinent to the data. The user selects the view of interest and is given choices of slices along a plane, a volume, or a time-series. LAS then sets the product choices available to the user, as well as a map of the region over which the data set extends (see fig).

LAS is modular, allowing the developer to serve the data in raw form, or to provide the user with any end product. In our case, we use a back-end to LAS to serve 3-D graphics of prognostic variables from a model running on a remote supercomputer in order to monitor the model's progress without having to FTP large data files to our local machine. The LAS server is run on the remote host with access to the netCDF data files.



A crontab script checks the data subdirectory, and updates the LAS XML file when new files are written and available. We then query LAS, requesting a short 3-D animation consisting of the variable of choice (see figure, above). The VRML is created using the Visualization Toolkit (VTK) and served through LAS.

We can control file size through several means:

- The user can select a subset of the dataset region.
- Only the variable of interest is served.
- An isosurface of the 3-D data is shown, instead of the entire 3-D data.
- The isosurface polygon mesh can be decimated preserving topology.
- The VRML file is gzipped before it is served, as most VRML browsers unzip VRML files on the fly.

3. MAKING VRML OBJECTS: VTK

LAS calls a back-end routine that creates the VRML by issuing a system call that runs a command line program called `ncToVrml`. This routine was written using the VTK API, and takes as input a 3-D netCDF data file, the variable name, the region (lat/lon/depth/time ranges), and a file size compression target for isosurface decimation.

The VTK package is an open-source, freely available API distributed by Kitware at <http://www.kitware.com>. This package for graphics and image processing consists of a C++ class library, with bindings for several other languages including interpreted interface layers such as Tcl/Tk and Java. Advanced algorithms are available for polygon reduction, contouring and Delaunay triangulation.

The `ncToVrml` back-end is written in C++ and uses a Marching Cubes algorithm for creating isosurfaces from 3-D volume data, and gives the user the option of decimating the resulting polygon mesh while preserving topology. The routine looks

for a variable named “depth” or “topography” to add to the visualization, and for variables representing ocean currents to add a vector field representing surface currents (see fig, previous page).

The ncToVrml routine doesn’t take advantage of VTK’s rendering ability, but instead saves the output using a VRML writer class for LAS to serve to the user.

4. VISUALIZATION GENERATION

The VRML objects are grouped together by timestep and written out as one Group node per timestep. The Group nodes are part of an overarching Switch node, and an animation of the results are controlled through an external prototype script node.

The external prototype script node allows access to nodes (objects) in a VRML scene using the VRML event model. This model allows for output events generated by a node to be routed to the input event of another node. The input event is notified so the receiving node can process that event. A script node is a special VRML node containing Java, JavaScript, or any of several other language bindings, and can dynamically change the VRML world in response to user inputs. A script node, when given a reference to a given node, can pass events directly to and from the referenced node and controls the Switch node giving the user the ability to animate forward or backward through time (see VRML specification at http://www.web3d.org/fs_specifications.htm). This external prototype node is served from our web site at <http://www.pmel.noaa.gov/vrml/html/tools>, and can be downloaded, modified, and embedded into the visualization if a free-standing package is needed.

5. CONCLUSIONS

Utilizing the Live Access Server, and writing a small VRML generator with VTK has allowed PMEL scientists to monitor models running on remote supercomputers without having to transfer huge data files over the web to local machines for analysis. Graphics rendering over the internet using VRML and polygon mesh decimation algorithms allow the user to view model results as the model runs, choosing only the variables of

interest. The resulting VRML files can be viewed locally taking advantage of local video card rendering and hardware acceleration. Several stereo VRML viewers are available, allowing the viewing of model results in stereo. These and other remote graphics capabilities are proving themselves to be indispensable tools for the oceanographer as supercomputer advances allow for larger domains and the resulting huge data files.

More information on this technique, as well as source code for ncToVrml and LAS are available at <http://www.pmel.noaa.gov/vrml/las>. For more information on stereo VRML viewers, see <http://www.pmel.noaa.gov/~hermann>.

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