HurricaneVis – Geospatial Visualization using Hardware Accelerated Real-Time Volume Rendering

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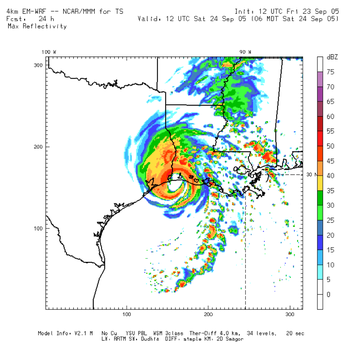
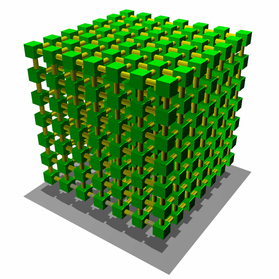
Motivation

- Because of the catastrophic effect of hurricanes, severe tropical storms are studied by weather forecasting agencies and meteorologists.
- A more detailed and more interactive visualization tool will enhance the understanding of hurricanes and answer open questions in weather forecasting.
- Better predictions will save human lives and reduce damage.

Datasets

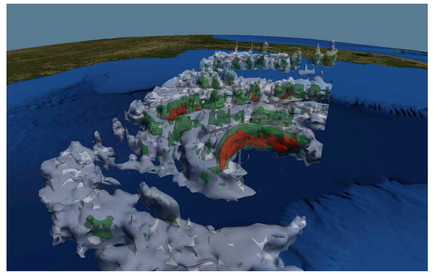


- Weather data are collected by sources such as satellites, airplanes, ships, buoys, balloons or surface weather observatories.
- After the initial data acquisition the data is input into mathematical models of the atmosphere to run a simulation and thereby predict the weather.
- 2D slices are used for forecasting and analysis.

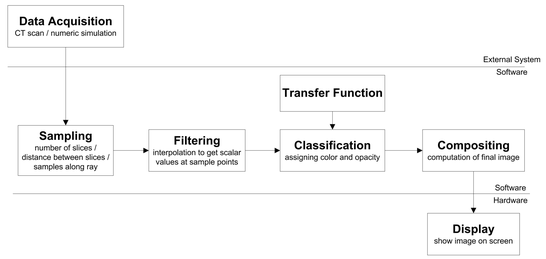


- The output of these simulations are floating point numbers representing a volume of scalar and vector data in 3D space.
- Scalar variables: water vapor mixing ratio, temperature, pressure perturbation, cloud water mixing ratio, rain water mixing ratio, total precipitation mixing ratio, wind velocity components ...
- Hurricane Lili: $84 \times 84 \times 33$ scalars across 9 time steps – fifth generation Penn-State University – National Center for Atmospheric Research Mesoscale Model (MM5).
- Hurricane Isabel: $500 \times 500 \times 100$ scalars across 48 time steps – Weather Research and Forecast (WRF) Model, used in the 2004 IEEE Visualization Conference Contest.

Iso-Surfaces



Volume Rendering



Classification Assigning color and opacity to the scalar values with transfer functions.

Texture Slicing Store volume data in a 3D-texture and render object-aligned or view-aligned quads.

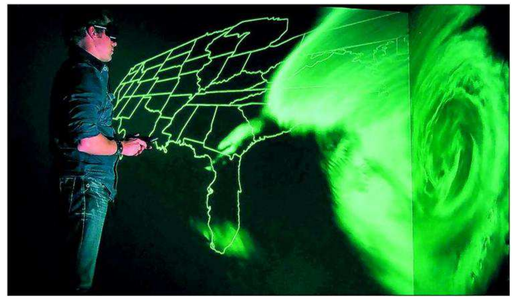
Ray Casting Shoot a light ray through the volume and composite RGBA values along the ray to determine the fragment color.

HurricaneVis

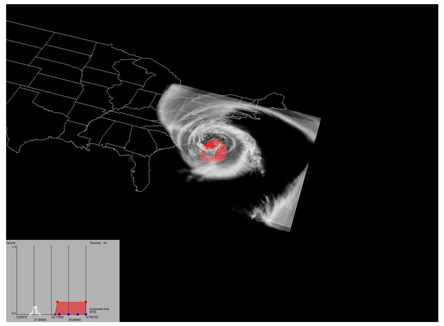
- Extensible and adaptive framework for Hurricane Visualization
- Desktop and immersive visualization
- Real-time performance using GPU
- Post-classification for interactive editing of transfer functions
- Object-aligned and view-aligned texture slicing as a fragment shader
- Ray-casting as a fragment shader

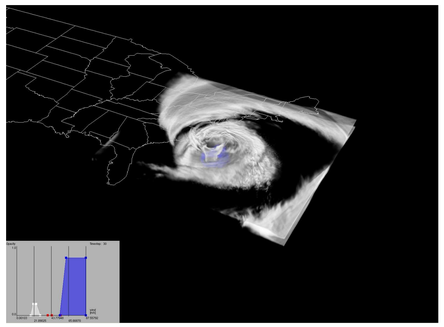
- OpenGL, GLSL
- VTK
- VRJuggler

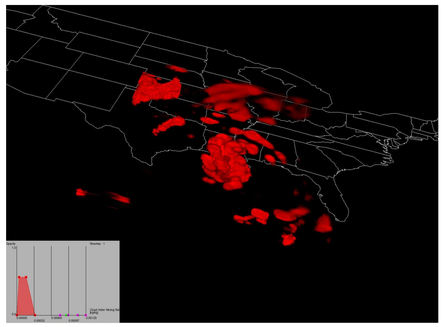
Immersive Visualization



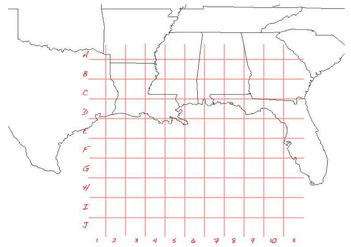
Desktop Visualization







User Study



- Compare iso-surfaces and direct volume rendering for the analysis of hurricanes.
- The subjects: students in the *Dynamic Meteorology II* and *Physical Meteorology* classes at Mississippi State University.
- The results prove that both volume rendering and iso-surfaces visualizations are very useful for the interrogation of hurricanes.
- Because of the higher image quality and the higher frame rates, direct volume rendering using ray-casting or view-aligned texture slicing was preferred.

Future Work

- Ray-Casting leads to the best visual quality, but has to be accelerated.
- Interface for editing transfer functions in an immersive environment.
- User Study comparing the traditional 2D slices and real-time volume visualization techniques for weather forecasting and analysis.

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