

# Analyzing Large Data using In-Situ Visualization and Computer Vision Techniques

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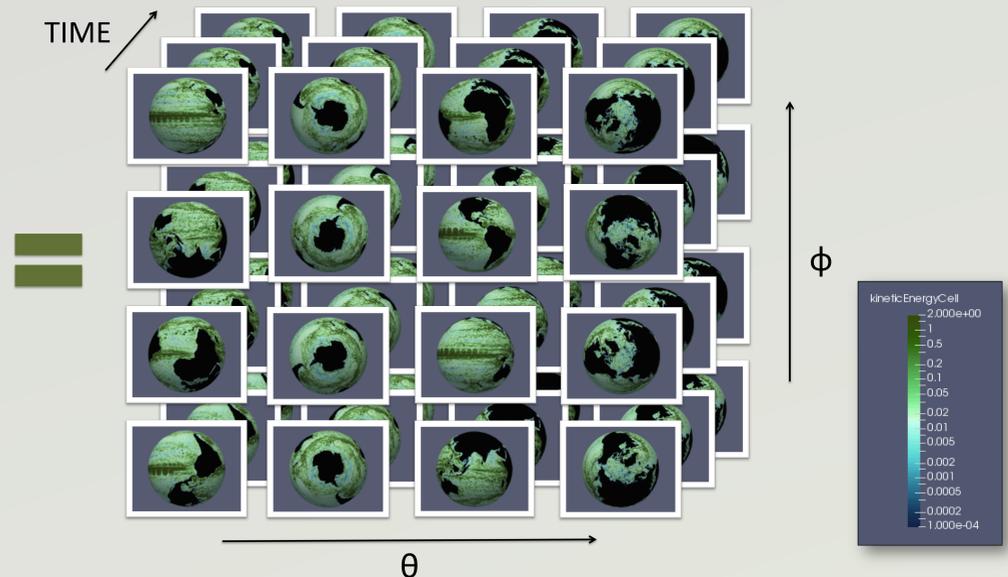
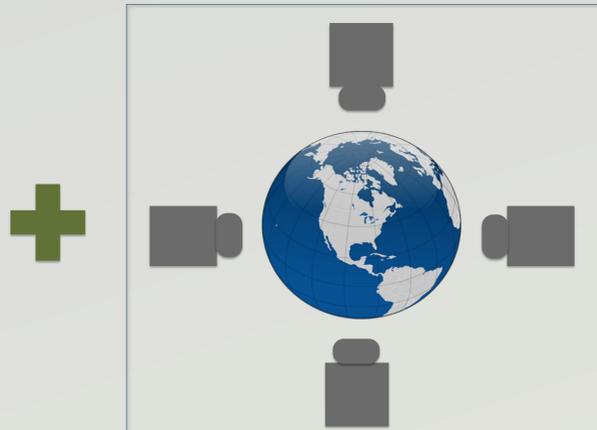
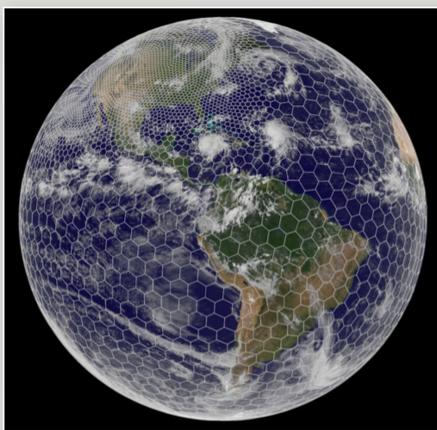
Extreme-scale simulations are essential for scientific progress, but the massive amount of data generated can be an impediment to scientific discovery. In-situ visualization has risen as a necessary solution to this problem, as it allows analysis techniques to be implemented as the simulation is running. This allows the user to save the results of the analysis rather than the entire simulation, which would be cost prohibitive. Cinema, an image-based approach to extreme in-situ visualization, allows the user to save images of the simulation instead of the raw data. The imagery is in the order of  $10^6$  and the data in the order of  $10^{15}$ . Here, we explain Cinema and the set of image processing and computer vision tools that allow the user to further explore their simulation data results.

## MPAS AND CINEMA:

**MPAS** (Model for Prediction Across Scales), is a climate simulation model for atmospheric, ocean and other earth-system components. The images in this paper discuss the results of an MPAS Ocean Simulation showing Kinetic Energy.

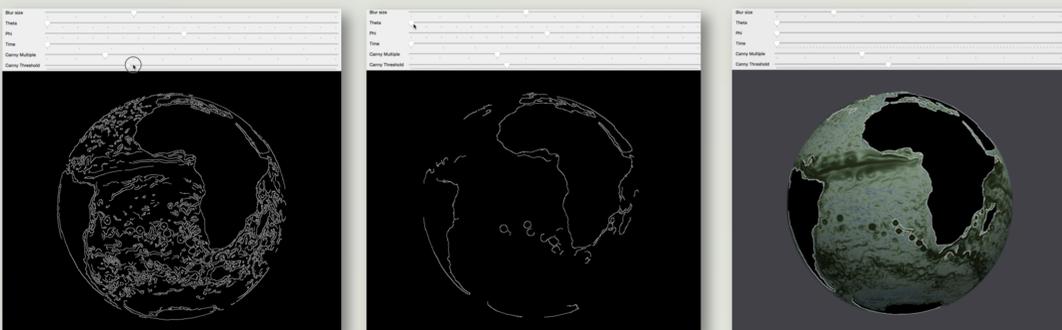
**Cinema** is an in-situ data analysis tool that allows the user to capture, store and explore extreme scale data. This tool allows the user to take snapshots at different angles and at various times steps of the simulation.

**Cinema Databases** are collections of images that represent the simulation, as captured by the Cinema tool. If using a spherical camera setup, this includes the  $\phi$  and  $\theta$  angles around the globe for each image. The database also stores information about the time, simulation parameter, lighting, resolution of the grid, etc. for each image.



## COMPUTER VISION AND IMAGE PROCESSING TOOLS FOR INTERACTION:

### Canny Edge Detection:



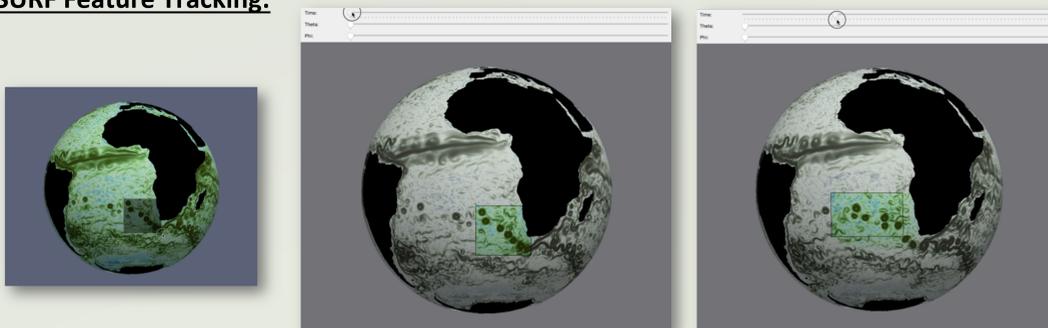
Canny Edge Detection is an image processing algorithm that identifies edges based on changes in hue, lighting and other parameters in an image. This property makes this algorithm especially useful to detect and track major features such as eddies and currents. Here, the user has isolated the eddies near Cape Hope.

### Contour Detection:



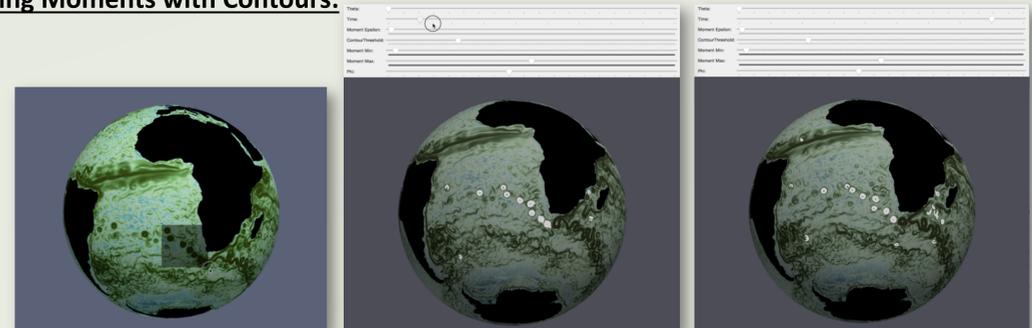
Contour Detection uses Canny Edge Detection as a preliminary step to detect the important regions in an image and then joins adjacent edges to form connected components. Using the interface, the user can separate out areas of interest from the background noise.

### SURF Feature Tracking:



SURF(Speeded Up Robust Features) Feature Detection and Tracking allows the user to select an area of interest and track those features over space and time using SURF detectors and descriptors. In the example above, the user selects the eddies from the Agulhas Current and tracks these features over 30 time steps (30 weeks).

### Using Moments with Contours:



Moments allow the user to define a particular set of features using a mathematical equation. In this example, the user selects the eddies as the features they want to define. The algorithm will then find all eddies similar to the ones defined in the selection. Thus, the user can define moment parameters to track these eddies through time (and space).

#### References:

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