Visualizing NetCDF Files by Using the EverVIEW Data Viewer

Background

Over the past few years, modelers in South Florida have started using Network Common Data Form (NetCDF) as the standard data container format for storing hydrologic and ecologic modeling inputs and outputs. With its origins in the meteorological discipline, NetCDF was created by the Unidata Program Center at the University Corporation for Atmospheric Research (UCAR), in conjunction with the National Aeronautics and Space Administration (NASA) and other organizations (Unidata Program Center, 2009). NetCDF is a portable, scalable, self-describing, binary file format optimized for storing array-based scientific data. Despite attributes which make NetCDF desirable to the modeling community, many natural resource managers have few desktop software packages which can consume NetCDF and unlock the valuable data contained within. The U.S. Geological Survey (USGS) and the Joint Ecosystem Modeling (JEM) group, an ecological modeling community of practice, are working to address this need with the EverVIEW Data Viewer. Available for several operating systems, this desktop software currently supports graphical displays of NetCDF data as spatial overlays on a three-dimensional globe and views of grid-cell values in tabular form. An included Open Geospatial Consortium (OGC) compliant, Web-mapping service (WMS) client and charting interface allows the user to view Web-available spatial data as additional map overlays and provides simple charting visualizations of NetCDF grid values (Open Geospatial Consortium, 2010).

Using the Tool

The spatially enabled NetCDF outputs produced by hydrologic and ecologic models can be viewed on a three-dimensional globe by using the EverVIEW Data Viewer (fig. 1). Because NetCDF files can contain multivariate time-series data, users opening a NetCDF data file will be prompted to choose a single variable: a start date and an end date range from the respective drop-down lists in the File>Open dialog window. It is common practice to divide the range of values of a NetCDF dataset into ecologically significant classes or groups represented as various colors. These classes correspond to a color ramp that shows which color corresponds to each range of values. Users have the option of allowing EverVIEW to automatically generate a color ramp used to display values on the globe, or they can define a custom color ramp and choose which colors are associated with each defined class (see "User Example," center spread, top left). When color ramps are automatically generated, the entire range of data values is divided into equal-sized bins, rather than on any inferred characteristics of the dataset. Custom color ramps allow the user to override this default setting, and the user-defined settings can be saved to a configuration file. This file can be used in subsequent data-loading events to ensure consistent color representation of cell values across multiple maps.

Once the modeling output has been loaded onto the globe, the user can zoom in and out or navigate the map with both the mouse and keyboard. To make analyzing data easier, EverVIEW allows the user to import and display data from WMS servers. An example of WMS data might include annotations, stream networks, or roads networks. The user can choose from provided WMS sources or enter custom WMS sources and turn these sources on or off. Users want to be able to track model outputs for specific cells by selecting either a point on the globe or a particular cell in the table or by importing existing coordinates from a text file. Known as "identify points," these coordinates allow the user to precisely monitor a cell's value over the entire time range of the data. This feature is reflected by a callout bubble placed on the globe, highlighted cells in the table, and in XY line plots. The user can name these points and can have the globe view zoom to them. Additionally, a widget in the corner of each globe, table, and charting tab allows the user to track the values of the identify points regardless of which view is being used. To make comparisons between similar datasets easier, users can save the identify points to a file for later use with a similar dataset.

As with most time-series data, visualization on a chart helps the user identify extremes or trends which lead to a better understanding of the data. Charting capabilities of the application currently include a line graph showing all identified points through time, a histogram of the data values for the selected days, and a pie chart showing the relative distribution of values defined by the color ramp classes. Users can zoom in or out of the generated charts for more detailed inspection, and all charts can be saved to image files for use in other applications. To aid the visual comparison
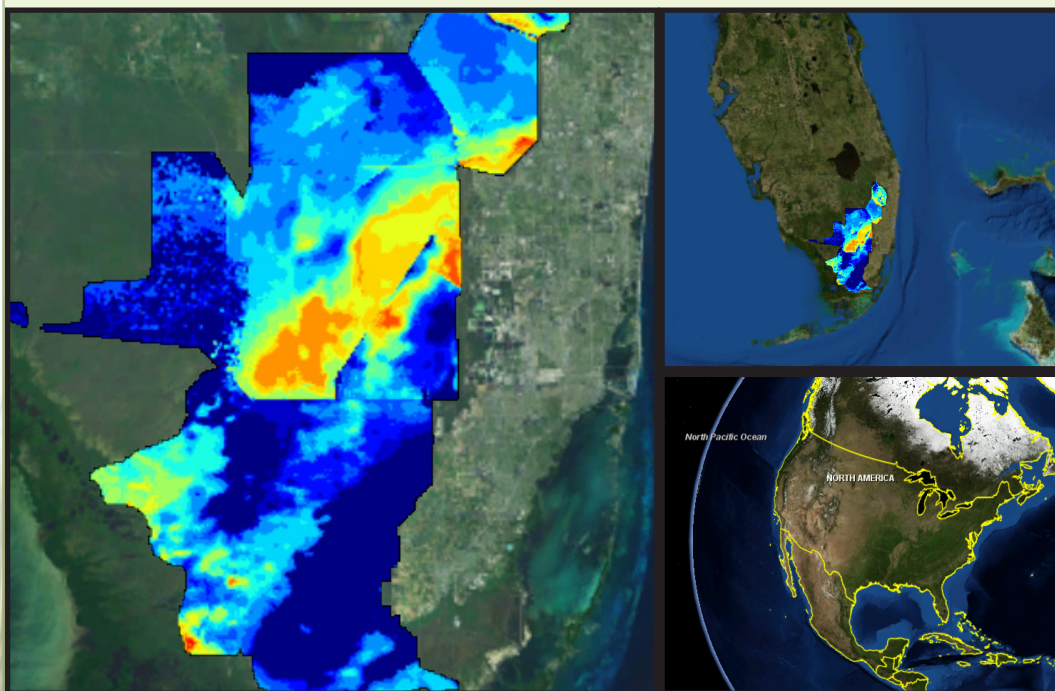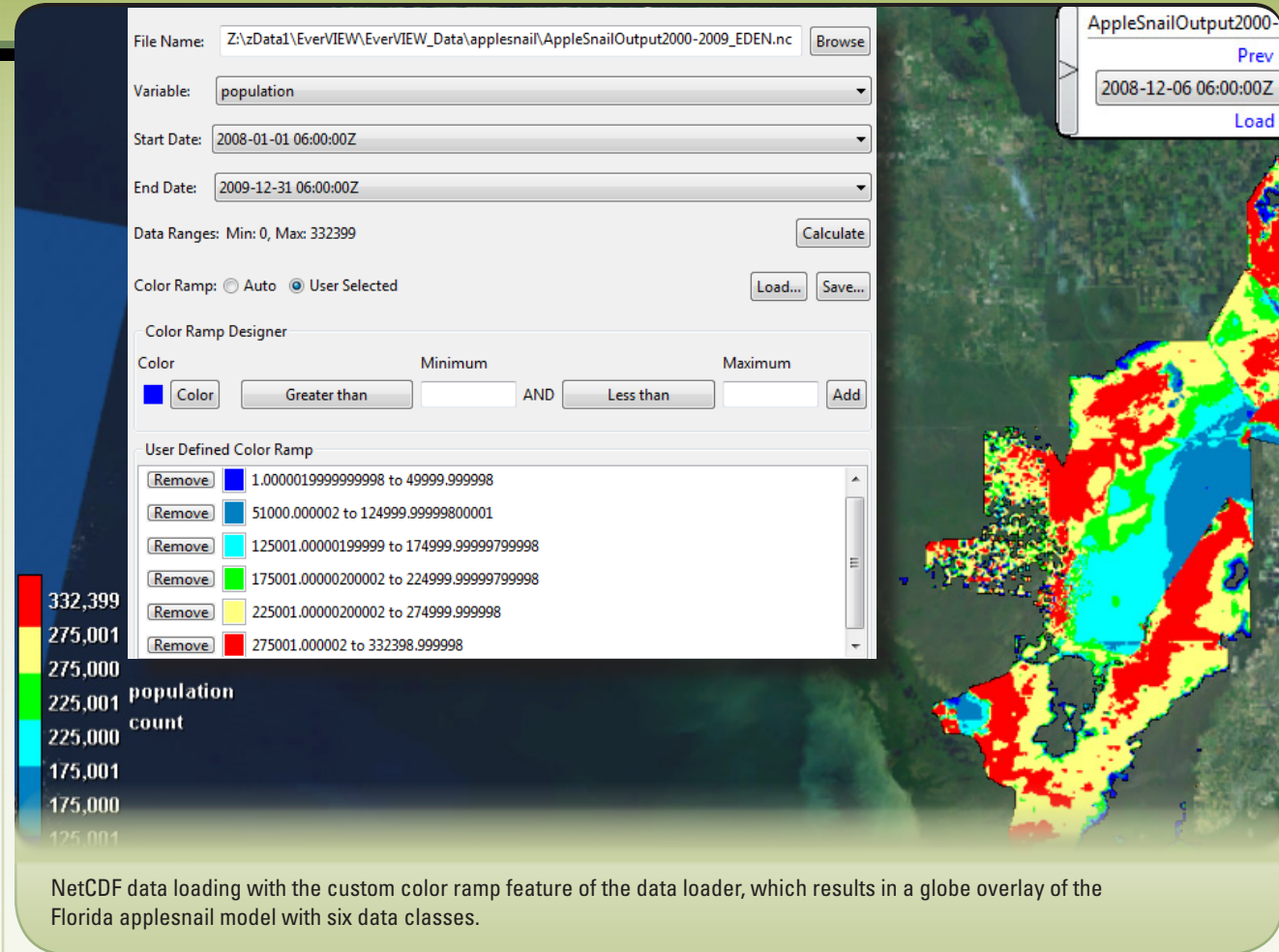

Figure 1. The Florida applesnail model output as an EverVIEW globe overlay at various spatial scales.

NetCDF data loading with the custom color ramp feature of the data loader, which results in a globe overlay of the Florida applesnail model with six data classes.

EverVIEW Usage Example

The EverVIEW Data Viewer was recently used to verify the logic behind the JEM Florida applesnail (Pomacea paludosa) population model. The multiglobe capabilities of EverVIEW were leveraged to analyze the input and output datasets simultaneously, allowing the modelers to view changes in the input data and correlate them to changes in the output data without having to leave the EverVIEW application. To give an overview of the data, multiple globes were loaded with input water level and temperature data and output Florida applesnail population data. The views of the three globe sections were then locked by using the view-lock tool so that each globe section showed the same location while the user zoomed and panned the globe. The animation tool was then used to play back the dates of all three datasets simultaneously to visually observe the changes in the data over time. Using the identify-points feature, the modelers were able to focus on key areas of interest and view the exact data values for a chosen date to verify their accuracy. The ability of the identify points to synchronize across-globe sections proved to be key in correlating input and output data because it allowed data from the same location to be shown from multiple datasets. The WMS capabilities were also an important part of the process because they were used to load layers onto the globe to provide reference information, such as annotated water management units, which were much more recognizable than GPS coordinates.

Once several identify points were carefully chosen and inspected, the need arose to inspect adjacent cells for spatial trends. The tabular view of the data provided an ideal way to inspect the cell values geographically surrounding the identify points. This view displayed the data from the three globes in a spreadsheet layout with the cells colored according to the classes defined in the map color ramp, allowing users to quickly recognize cells of interest. With the click of a button, the identify points could be centered in the table views to give the modelers a view of the same location in all the datasets, while also showing the data surrounding the identify point. This view made it easy to quickly jump to different regions of interest in the dataset. After several individual dates were inspected, the chart view was opened to give a better view of how the data changed over the entire time period of the model. The identify points, which were chosen by the modelers as areas of interest, were then automatically plotted on a line chart that spanned the model's period of record. Subsequently, the modelers were able to visualize climate trends from the input data and the effect those trends had upon the model output for the Florida applesnail population growth. The modelers could also quickly compare the identify line plots against the histogram and pie charts of the dataset to determine if those regions were representative of the landscape as a whole. Lastly, the modelers exported the EverVIEW charts for use in a report.
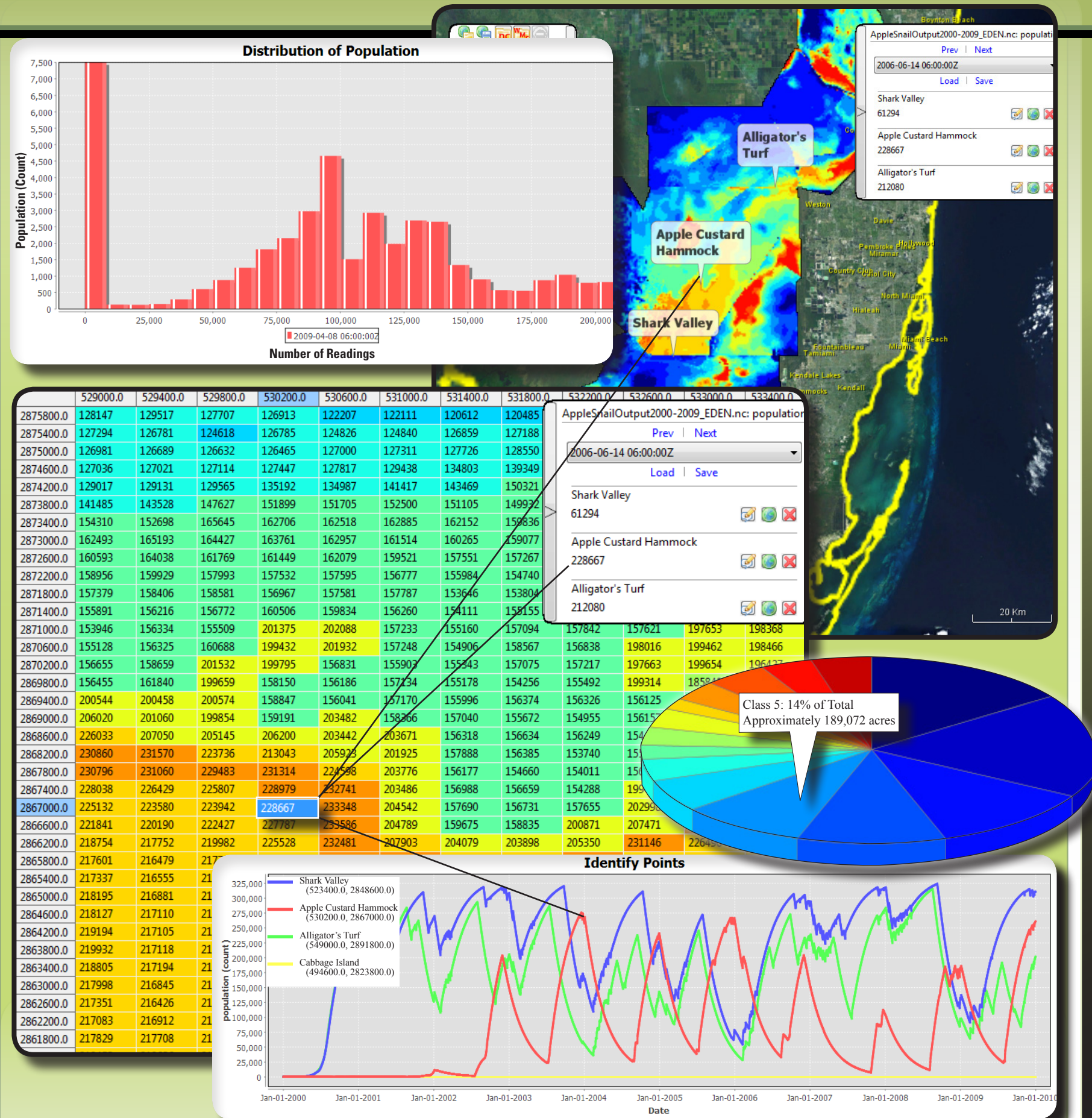
EverVIEW's ability to display NetCDF data simultaneously as a globe overlay and as a tabular grid with the user's identify points represented by call-out windows on the map and highlighted cells in the table. Note that the EverVIEW table viewer inherits the color scheme used on the map overlay to paint table cells, emphasizing the linkage between the spatial and tabular data. Charting capabilities include a histogram of the data values for the selected days, a pie chart showing the relative distribution of values defined by the color ramp classes, and a line graph showing all identified points through time.
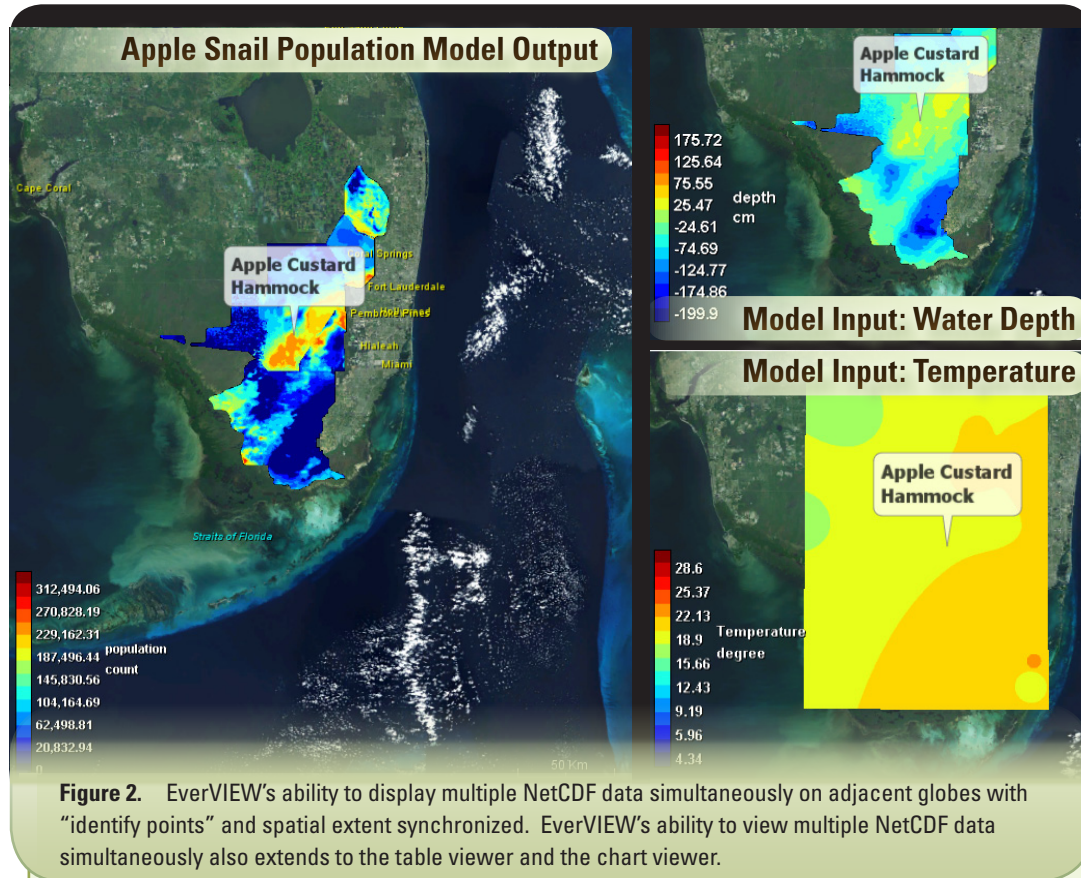
Apple Snail Population Model Output

population count

312,494.06
270,828.19
229,162.31
187,496.44
145,830.56
104,164.69
62,498.81
20,832.94

Apple Custard Hammock

Model Input: Water Depth

depth cm

175.72
125.64
75.55
25.47
-24.61
-74.69
-124.77
-174.86
-199.9

Apple Custard Hammock

Model Input: Temperature

Temperature degree

28.6
25.37
22.13
18.9
15.66
12.43
9.19
5.96
4.34

Apple Custard Hammock

Figure 2. EverVIEW's ability to display multiple NetCDF data simultaneously on adjacent globes with "identify points" and spatial extent synchronized. EverVIEW's ability to view multiple NetCDF data simultaneously also extends to the table viewer and the chart viewer.

having to download a new copy of EverVIEW.

Summary

As modelers who study the Everglades increase their use of NetCDF for storing data, the need for powerful visualization software grows. Applications such as the EverVIEW Data Viewer meet that need by enabling users to inspect model output values in tabular form, understand the characteristics of the dataset with charts, and view modeling data spatially on a three-dimensional earth model. The USGS and JEM are committed to working with natural resource managers and the modeling community to produce powerful visualization tools that help decision makers and scientists better manage and restore the complex systems placed in their care.

of data values between days, a variable-rate animation feature has been included. The user may click the "play" button to start the animation, which will cause the current date of the displayed dataset to change incrementally. The feature automatically loops around to the start date in the dataset, allowing continuous animation. A slider is included to allow the user to speed up or slow down the animation as desired.
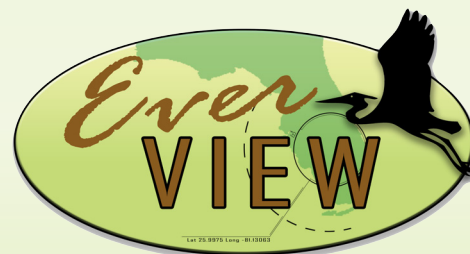
Because users often need to view the output from multiple models simultaneously, EverVIEW allows the user to view up to four data files simultaneously, with one data file per open globe (fig. 2). The visualization and time-series animation capabilities act upon all open globes simultaneously. The viewpoints for each globe can be synchronized across globe sections, allowing the user to visually compare the same spatial region with different data. When the user has more than one NetCDF data file open, the default setting results in each data-viewing panel operating independent of the others, each having its respective tabs for globe view, table view, and charting view. Users also have the option of "locking" multiple data-viewing panels together, in essence synchronizing the viewing experience. When two or more data-viewing panels are locked together, EverVIEW synchronizes their maps so that panning and zooming actions on the globe view occur simultaneously across all sections that have been locked. Any identify points on the maps are also synchronized along with the underlying table viewer and chart viewer.

To allow more user flexibility in the synchronization of each section, two synchronization channels may be used. For example, the user may synchronize the first and second sections in the first channel and then synchronize the third and fourth sections in the second channel. When a section is added to a synchronization channel, it takes on the view characteristics of the sections already in that channel. If the user wants to preserve the configuration for a specific section, the current data file in use, its defined color ramp, and any identify points can be saved to a file to be loaded later. Lastly, to support the anticipated needs of incremental software improvements by USGS and JEM, EverVIEW was built with a simple software update functionality that allows the user to install updates and fixes without

For More Information

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Reference

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[1]Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.