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# LINKING INTERACTIVE CONCEPT MODELS INTO THE VISUAL GEOPHYSICAL EXPLORATION ENVIRONMENT (VGEE)

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## 1. INTRODUCTION

The primary goal of the Visual Geophysical Exploration Environment (VGEE) is to use scientific visualization to foster analytical thought in students with little such experience. The El Niño phenomenon was chosen as a prototype topic based on its global scale and awareness as well as its ties to the ocean, atmosphere, and society. Development on the VGEE began on three different fronts: building a curriculum, developing concept models, and constructing a visualization environment. The three would tie together to form a rich experience of discovery and learning.

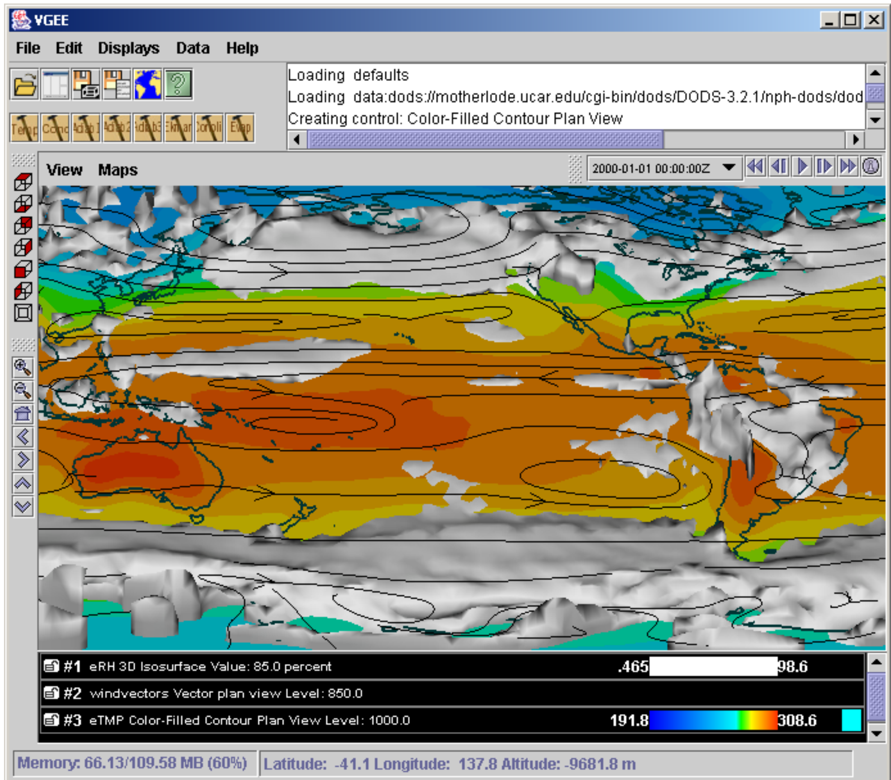


Fig. 1. VGEE interface with surface temperature (color map), relative humidity (white isosurfaces), and streamlines.

Development of the concept models and the visualization tool began independent of each other. However, a critical element to the overall functionality of the VGEE was the integration of these interactive concept models into the visualization tool. This paper outlines this visualization tool as well as the concept models and the linkage between the two.

## 2. VISUALIZATION TOOL

The goal in developing the visualization tool was not simple. It needed to be powerful enough to create a variety of visualization displays (contours, isosurfaces, etc.). However, powerful applications often have complex procedures and steep learning curves – exactly what teachers do not need in an introductory-level science course – meaning this powerful visualization application must be easy to use. Combining power and versatility with ease-of-use was not easy, but did come to fruition with the help of Unidata's Integrated Data Viewer (IDV).

The IDV is a Java-based three-dimensional visualization environment that can be used with a variety of geoscience data, including gridded model data (forecast or research), surface observations, and satellite and radar images. The IDV is a relatively simple application to learn and in many other ways, its design meshes well with the VGEE philosophy.

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The IDV is very flexible to meet the specific needs of its clients. For example, visualization features and the user interface can easily be modified in appearance and functionally to support a variety of audiences. In the VGEE's case, extra one-touch features were added to facilitate both creation and storage of student-created visualizations. An example VGEE-IDV window is shown in Fig. 1. The visualization displays a typical El Niño scenario – especially with the white cloud-like regions of high relative humidity over equatorial South America, which is extremely rare without an El Niño. The white isosurface encapsulates all areas with relative humidity values greater that 85%.

Simple buttons allow users to bypass lengthier menu options in order to open data windows, save visualization images or data, or even get help. Because of this, users of the IDV can range from high school students all the way to university faculty and researchers.

VGEE developers aided in the development of the IDV – creating a mutually beneficial relationship. The VGEE project gained a visualization tool that could be molded into its framework, and the IDV had a strong practical client using its software to its fullest extent.

## 3. CONCEPT MODELS

Concept models are interactive stand-alone modules that allow students to investigate fundamental atmospheric processes. Their production began as a supplemental feature to the VGEE – meaning they would run separate from the VGEE-IDV and the environments they created would be manipulated directly by the user. For example, in the temperature concept model, the user can change the temperature, and in the Moist Rising Air concept model, one can change the temperature, water vapor content, and pressure. Eight such concept models were created and are listed in Table 1.

**VGEE Developed Concept Models**

| | |
|---|---|
| Temperature* | Moist Rising Air (w/ Sounding)* |
| Condensation* | Evaporation |
| Dry Rising Air* | Boundary Layer Winds |
| Moist Rising Air* | Coriolis Force |

* These Concept Models can link to the VGEE data

Table 1: VGEE Developed Concept Models

## 4. LINKING DATA TO CONCEPT MODELS

Despite their ability to work separate from the VGEE-IDV, most of the concept models were constructed so that their environments could also be manipulated by an external source – namely the VGEE data.

The VGEE implementation of the IDV offers extra options to support undergraduate, non-science majors. The key option is the ability to insert special probes into the visualization environment that can extract specific data and send it to a concept model. These concept models illustrate specific fundamental principles of weather (temperature, condensation, etc.). The student is able to either manipulate the probe or elements of the concept model (or both) to discover relevant relationships in the atmosphere and ocean.

### 4.1 *Programming*

Both the IDV and the concept models use the Java™ programming language – allowing them to seamlessly fit together. Also, the extensibility of the language allows for the addition of new resources or concept models to be added to the IDV with minimal impact to the original program.

Their integration into the IDV is an early example of the extensibility of the Java language and the IDV itself.

### 4.2 *Example*

An example of this integration can be seen in Fig. 2. On the right side of this figure is an example IDV window. Loaded in he visualization environment is a student-constructed view of a forecast model. The contours are seal level pressure, while the isosurface – a 3D contour – represents significant positive vertical velocity (rising air).

The student then inserts a Moist Rising Air (w/ Sounding) VGEE probe and places it in a location where both vertical velocity and a surface front exist. The probes location is marked with an interactive stick probe that can be moved around by the user. The probe's readout window, shown on the left side of Fig. 2, reads the sounding data in the column of air where the stick probe is located and creates a simple sounding diagram.

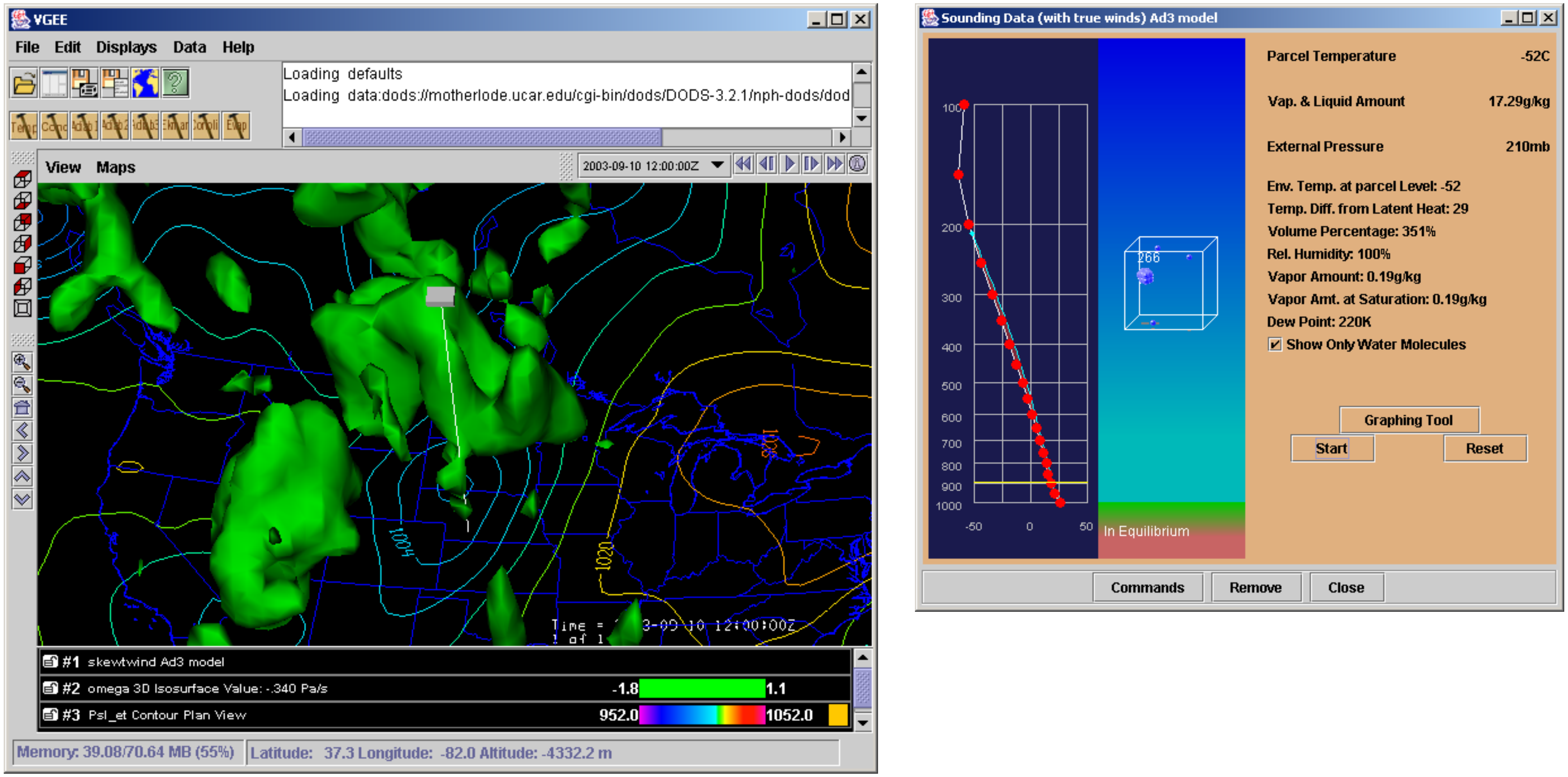


Fig. 2. Illustration of the linkage between the VGEE interface and the Moist Rising Air (w/ Sounding Concept Model. On the left, the VGEE is displaying sea-level pressure (contours) and pressure vertical velocity (green isosurface) for the initialization of a real-time ETA model run. A stick probe has been placed into the data set to read temperature and humidity information about this data. This information is begin transferred to the concept model. The temperature is drawn in white inside the sounding with red circle to denote the levels. In this experiment a student lifts the parcel to 900 millibars (the yellow line in the sounding indicates this) and watches the parcel lift beyond this point all the way to 210 millibars, showing that with adequate forcing, low-level parcels of air can rise very high in this location – which, if you look at the VGEE window, goes right through some rising air just ahead of the cold front. The parcel's path in the sounding is drawn in blue.

The parcel of air, represented by a cube, is located at the surface. It contains both dry air and water vapor molecules that are moving with speeds related directly to the parcel's temperature. The student can then perform a simple experiment: can a parcel of air at this location with these properties become unstable when lifted? By pretending to that they are the lifting mechanism, the student can drag the parcel of air upward into the troposphere and let go. In Fig. 2, the yellow line in the sounding shows that in this case, the parcel was forced to rise to about 900 millibars. After the student lets go of the parcel's lifting level, the parcel slowly rises to that level. Once the parcel reaches the level it was forced to ascend to, its own stability determines whether or not it continues to rise, descends, or remains at the same altitude. In this example, the parcel continued to rise to 210 millibars. This is supported by the data in the visualization because the nearby front could have provided the lift to get the surface air aloft and create precipitation. In fact, on this day, Lincoln, Nebraska experienced thunderstorms and rain totaling 1.6 inches.

## 5. SUMMARY

The ability to link interactive concept models into a fully-interactive data visualization environment gives us a rare opportunity to place powerful visualization tools -- the same tools that researchers and educators use at the university level – into the hands of students who would ordinarily never see such things. The process of interpreting visualizations will continue to be an issue worthy of addressing, but students can use the VGEE to construct simple visualizations and implement useful concept models in order to gain a richer and deeper understanding of the complex atmosphere.

The linked concept models can also serve as a diagnostic tool as in our example. One can look at that visualization and be able to state that if a forcing mechanism can get surface air up to a specific height, that there would most likely be precipitation. This can also prove to build up the confidence of students, and encourage them to ask deeper, more complex questions – and then use the tools at their disposal to answer them.

## 6. WEB SITES

Visual Geophysical Exploration Environment:
*www.dlese.org/vgee/*

Integrated Data Viewer:
*my.unidata.ucar.edu/content/software/IDV/*

Digital Library for Earth Systems Education:
*www.dlese.org/*

VisAD:
*www.ssec.wisc.edu/~billh/visad.html*

## 7. ACKNOWLEDGEMENT

This project is funded by the National Science Foundation Division of Undergraduate Education Grant #DUE-9972491.

## 8. SEE ALSO

Pandya, et al., 2004: Integrating Meteorological Tools and Data into Digital Libraries: A Strategy Used in the Visual Geophysical Exploration Environment (VGEE). Proceedings of the 13th Symposium on Education, Seattle, WA, American Meteorological Society.

Pandya, et al., 2003: The Visual Geophysical Exploration Environment: A Scientific Tool-kit for Learners. Proceedings of the 12th Symposium on Education, Long Beach, CA, American Meteorological Society.

Bramer, et al., 2002: Using an Interactive Java-Based Environment to Facilitate Visualization Comprehension. Proceedings of the 18th Conference on IIPS, Orlando, FL, American Meteorological Society.

Pandya, et al., 2002: An Inquiry-Based Learning Strategy from the Visual Geophysical Exploration Environment (VGEE). Proceedings of the 11th Symposium on Education, Orlando, FL, American Meteorological Society.