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1. INTRODUCTION

For years, instructors have been trying to incorporate emerging computer and Internet technologies into their classroom. Succeeding in this task, however, is more challenging than developing a couple of web pages or showing a movie – a quickly crafted web page can't be expected to be more powerful than the same thing on paper. The true advantage of using computers and the Internet for education is realized when students are allowed to view information in a way impossible to duplicate in a textbook.

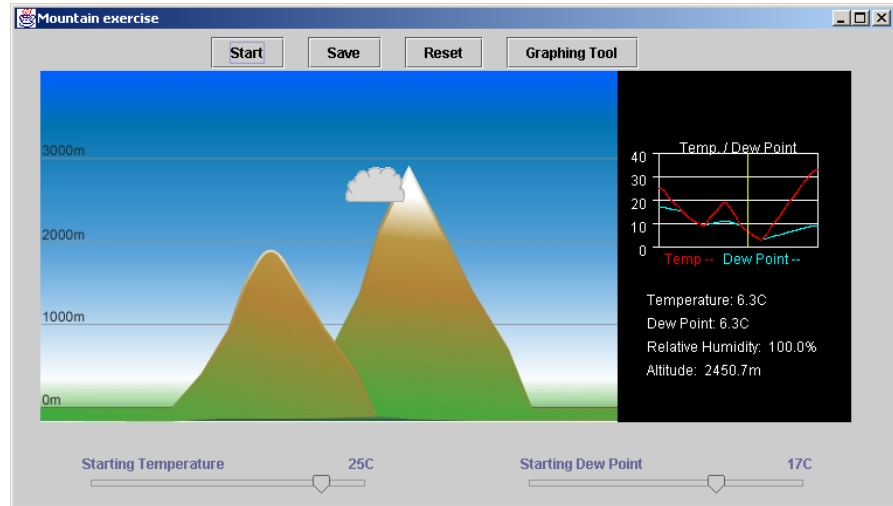


Fig. 1. Mountain Winds Concept Model

One commonly used method to utilize this advantage is to introduce interactivity to web pages and computer programs. This gives the student an active role to play in discovering conceptual relationships. They become more engaged, and can manipulate a scenario or environment and dynamically view the consequences – something impossible to do outside an expensive and difficult-to-maintain traditional laboratory.

2. ATMOS 100 HANDS-ON METEOROLOGY

In 2002, the University of Illinois at Urbana-Champaign (UIUC) implemented additional general education requirements. Every student who enrolled at UIUC beginning fall semester of 2002 is required to take two courses that utilize quantitative reasoning.

In the spring and summer of 2002, faculty, students, and staff from the Department of Atmospheric Sciences (DAS) at UIUC collaborated to retool the Introduction to Meteorology course (ATMOS 100) to meet the new “Quant. 2” standards. The three one-hour lecture course was modified to two one-hour lectures and a one-hour hands-on session.

In this new hands-on session, students learn by performing exercises in conjunction with interactive concept models using real data (real weather maps or

climate data). Designing only computer programs and web pages for students to use in class is not an effective teaching method. These programs needed to be hooked to exercises that can guide the students through the use of thought-provoking questions. DAS-UIUC instructors and teaching assistants developed these exercises, and they are discussed further in Charlevoix *et al.* (2003b).

3. INTERACTIVE CONCEPT MODELS

A major part of developing the hands-on session was creating a pseudo-laboratory Internet environment called Hands-On Meteorology. The Hands-On Meteorology environment would consist of various interactive Java applications – concept models – that the students can operate and manipulate themselves.

The idea of concept models first came from the Visual Geophysical Exploration Environment (VGEE) a NSF-funded project to develop a 3D visualization environment for use in introductory undergraduate geoscience courses. A large part of this project was to design a suite of concept models that allowed the students to probe the dataset to learn more. This is discussed further in Pandya *et al.* (2003).

All of the concept models listed in Table 1 were developed within DAS-UIUC. Eight were developed under the VGEE project, with the remaining twenty developed for the Hands-On Meteorology sessions. They are simple-yet-effective Java™ applications that empower students to manipulate a specific aspect or

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process of nature (greenhouse gases, agricultural growing seasons, air pollution, etc.) or illustrate basic course elements (contouring, sounding analysis, etc.).

Condensation*	Lifting Air (Dry)*
Contour (3)	Lifting Air (Moist)*
Coriolis*	Lifting Air (w/Sounding)*
Coriolis (L)	Mountains (3)
Controls of Temperature	Pollution
Cyclone	Radar
Ekman*	RadSat
Evaporation*	Slide Viewer
Fronts	Temperature*
Growing Seasons	Temperature (L)
Humidity	Thunderstorm
Jet Stream	Tornado
* VGE developed; (L) lecture sized; (#) versions	

Table 1. Available Concept Models

Applications were chosen instead of applets for this project. While applets are more universally used in situations where online interactivity is desired, the advantages to using applications over applets are numerous. This project required being able to save information (graphs, images, text) to local files for insertion into homework assignments. Applications greatly facilitate file input/output. Also, applications can take advantage of advanced API, allowing for enhanced look and feel, better image manipulation (transparency, rotation), and other conveniences. Delivery, a common concern for applications, is discussed later.

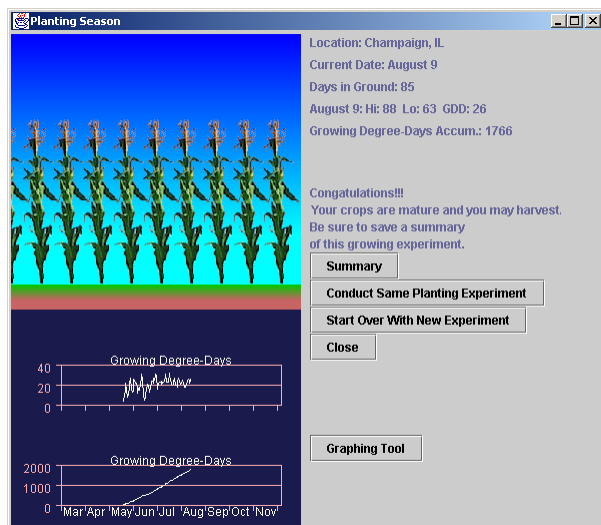


Fig. 2. Growing Seasons Concept Model

Each figure shown here illustrates different interactive concept models. For example in Fig. 1, the mountain winds concept model, students can change an air parcel's initial temperature and humidity. They then move that parcel over mountains and observe the ensuing changes. Fig. 2 shows the Growing Season concept model, where students select crop-type, city,

and plant date – choosing each based on climate data to avoid frosts. In Fig. 3, the RadSat concept model, the student can annotate a feature in one window, and the other window is also annotated to help identify specific areas in satellite or radar (not shown) images. Fig. 4 illustrates the air pollution concept model. Here, the properties of a smokestack, the location of the observer, and the atmosphere can all be changed to help understand their relationship to pollution concentrations.

These concept models can graph acquired data and save it as an image. They can also open a notepad that can be used to log journal entries or import acquired data that can be saved and exported to a separate spreadsheet application for further analysis. The students can either use the concept models in free-discovery or as directed by the supporting exercises.

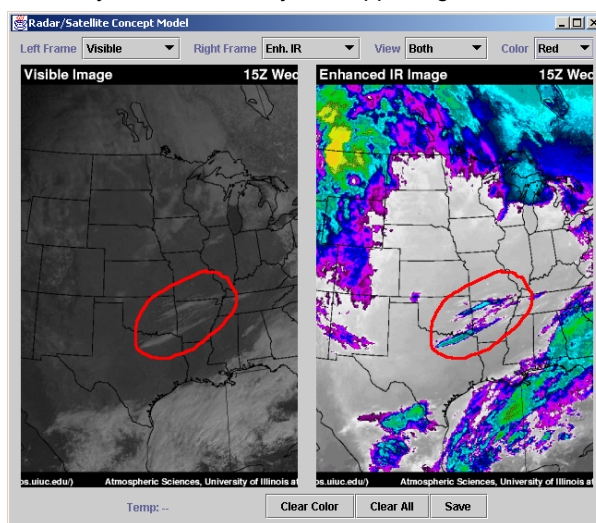


Fig. 3. RadSat Concept Model

4. DIGITAL LIBRARIES AND COLLECTIONS

The exercises (in electronic format), concept models, and real data combine to form a digital collection and can be submitted to one or more digital libraries for reference.

Digital Libraries such as the Digital Library for Earth System Education (DLESE) or the National Science Digital Library (NSDL) are ideal locations to facilitate sharing this collection with other institutions. They do not have to house the collection, but simply point to the resources – a service that digital libraries provide.

This collection will be submitted to the DLESE Collections Review System and made available to the earth science education community; widening the exposure of the collection and allowing future work elsewhere to concentrate on alternative goals (avoid re-inventing the wheel). Also, as most digital collections are capable of doing, other instructors can develop exercises, program new concept models, or submit their data to the overall collection – enhancing the project and potentially taking it beyond its original audience.

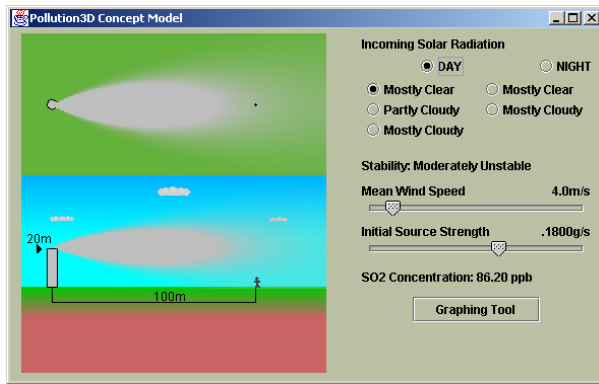


Fig. 4. Air Pollution Concept Model

5. USE CASE: ATMOS 100

The first use case for this collection is ATMOS 100: Introduction to Meteorology, a general education course provided by DAS-UIUC. It is a course taken by many first and second year students (fall 2002 enrollment: 300) – many with little experience in scientific thought and some with little knowledge of computers. The collection was beta-tested in the summer 2002 term, and fully implemented in the fall semester of 2002. Students accessing the collection spend one hour per week in a computer lab with 30 Pentium IV class machines with 1.4GHz processor speed and 512MB of memory. (Minimum required about 700MHz and 256MB, respectively.). The sections are divided into 30 students per section, so each student has their own computer. The remaining two hours are in a lecture setting.

6. OTHER SCENARIOS

The collection can also be used in part or in whole for other use cases. For example, the entire collection can be moved into another meteorology class. Some concept models (and possibly their respective exercises) can be brought in as an occasional resource. Instructors could also tailor their own exercises to the original concept models. Another possible use is to illustrate a concept with a concept model in a lecture setting. To avoid appearing outdated, teachers can also easily update the data used in the concept models by switching in newer maps and charts.

Also, because of the open-source/Java framework of the concept models, they could be integrated with the Integrated Data Viewer (IDV). The IDV is a Java™-based interactive 3D visualization environment that can access real-time data. This could potentially provide a seamless integration with datasets, visualization tools, and interactive educational concept models.

7. DELIVERY

Delivery is a very important feature to any digital collection, and is especially so in this circumstance because DAS-UIUC will house the information. In early stages, the collection undergoes frequent changes, and

just allowing the 'current' set of concept models to be downloaded creates a problem where many versions of the same program exist simultaneously.

As a solution, delivery is being handled through an application called Java™ Web Start (JWS) developed Sun Microsystems. Compatible with Linux, Windows, Mac, OSX, and Solaris operating systems, this new technology allows users to execute Java™ applications over the Internet. When a concept model is launched, the JWS program checks to see if the local computer has the most current version of it. If so, it starts the model. If not, it quickly downloads the necessary files and then runs it – ensuring the version running is the most current.

With JWS, Java™ applications are as easy to run as Java™ applets. Instructors and students can also download JWS to their home computer and run the concept models from home.

The web site is also a critical component to the delivery of the collection. It must contain all the necessary content for both students and instructors from links to the exercises and programs to how best to use the collection. It must also be composed in an easy-to-use manner to avoid user confusion.

8. WEB SITES

DAS-UIUC ATMOS 100 Hands-On Meteorology:
<http://www.atmos.uiuc.edu/courses/atmos100/>
 DLESE: <http://www.dlese.org/>
 Java™ Web Start:
<http://java.sun.com/products/javawebstart/>
 VGEE: <http://www.dlese.org/vgee>

9. ACKNOWLEDGEMENT

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10. SEE ALSO

Charlevoix, *et al.*, 2003a: Assessment of Interactive, Hands-On Meteorology Exercises in a course for Undergraduate Non-Majors. Proceedings of the 12th Symposium on Education, Long Beach, CA, American Meteorological Society.

Charlevoix, *et al.*, 2003b: Development of In-Class Exercises to Accompany Interactive, Hands-On Meteorology for Undergraduate Non-Majors. Proceedings of the 12th Symposium on Education, Long Beach, CA, 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.