have attained "a well-defined component of knowledge or acquired a particular skill" (Stern and Ahlgren, 2002). To determine students' scientific understanding of what causes the Earth's seasons, the SCALE-uP Project focuses on a single Benchmark from Benchmarks for Science Literacy (AAAS, 1993) that include both empirical observations and theoretical statements related to the target concept (Earth's seasons). In the conceptual model guiding our assessment development, we believe the target concept, articulated through the Benchmark (4B,6-8, #4), represents a single coherent knowledge structure and mental model stored in memory that students can recall or access when needed to explain relevant phenomena or solve tasks. Therefore, students that possess the concept of the Earth's seasons would be expected to respond to phenomena related to seasons with consistent and coherent responses to probes and representations related to the Benchmark idea. The instrument development procedure compares assessment outcomes (cognitive model/framework) of about 30 general 7th grade students with little previous classroom exposure to learning about the seasons, to high achieving 8th graders who have studied the seasons, and to introductory astronomy college students, who presumably understand the reasons for Earth's seasons. In this paper, we report on the results of the initial administrations of the instrument for these three groups.

ED31B-1174 0830h POSTER

Student interpretation of space science imagery and representations

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Space science uses a great deal of imagery, such as X-ray pictures of the solar corona, to convey information. It also deals with complex, three-dimensional structures, such as the substorm current wedge, that are generally rendered in two dimensions. In this study we will discuss naive student interpretations of SOHO EIT images of the Sun, and point out broadly-based misconceptions. We will also discuss student interpretation of 2-D renderings of 3-D concepts, and place those findings in the context of research into Expert-Novice differences. This work is an initial investigation in a long-term research program in understanding viewer response to visualizations involving stills, movies, 2-D and 3-D images.

ED31C MCC: Level 2 Wednesday 0830h

Computer Modeling in Earth Science Education Posters *(joint with P, NG)*

Presiding: **K M Menking,** Vassar College**; J T Snow,** University of Oklahoma**; D Bice,** Carleton College

ED31C-1175 0830h INVITED POSTER

Introducing Earth Sciences Students to Modeling Using MATLAB Exercises

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While we subject our students to math and physics and chemistry courses to complement their geological studies, we rarely allow them to experience the joys of modeling earth systems. Given the degree to which modern earth sciences relies upon models of complex systems, it seems appropriate to allow our students to develop some experience with this activity. In addition, as modeling is an unforgivingly logical exercise, it demands the student absorb the fundamental concepts, the assumptions behind them, and the means of constraining the relevant parameters in a problem. These concepts commonly include conservation of some quantity, the fluxes of that quantity, and careful prescription of the boundary and initial conditions. I have used MATLAB as an entrance to this world, and will illustrate the products of the exercises we have worked. This software is platform-independent, and has a wonderful graphics package (including movies) that is embedded intimately as one-to-several line calls. The exercises should follow a progression from simple to complex, and serve to introduce the many discrete tasks within modeling. I advocate full immersion in the first exercise. Example exercises include: growth of spatter cones (summation of parabolic trajectories of lava bombs); response of thermal profiles in the earth to varying surface temperature (thermal conduction); hillslope or fault scarp evolution (topographic diffusion); growth and subsidence of volcanoes (flexure); and coral growth on a subsiding platform in the face of sealevel fluctuations (coral biology and light extinction). These exercises can be motivated by reading a piece in the classical or modern literature that either describes a model, or better yet serves to describe the system well, but does not present a model. I have found that the generation of movies from even the early simulation exercises serves as an additional motivator for students. We discuss the models in each class meeting, and learn that there are many ways to accomplish the exercise, some more efficient than others. One of the more satisfying outcomes of this teaching is that a community of modelers is born, all speaking the same language. The networking among these students well after the end of the class greatly increases the leverage of the class as a learning experience.

ED31C-1176 0830h POSTER

Creation of a Course in Computer Methods and Modeling for Undergraduate Earth Science Programs

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In recent years computer modeling has gained importance in geological research as a means to generate and test hypotheses and to allow simulation of processes in places inaccessible to humans (e.g., outer core fluid dynamics), too slow to permit observation (e.g., erosionally-induced uplift of topography), or too large to facilitate construction of physical models (e.g., faulting on the San Andreas). Entire fields within the Earth sciences now exist in which computer modeling has become the core work of the discipline. Undergraduate geology/Earth science programs have been slow to adapt to this change, and computer science curricular offerings often do not meet geology students' needs. To address these problems, a course in Computer Methods and Modeling in the Earth Sciences is being developed at Vassar College. The course uses the STELLA iconographical box modeling software developed by High Performance Systems, Inc. to teach students the fundamentals of dynamical systems modeling and then builds on the knowledge students have constructed with STELLA to teach introductory computer programming in Fortran. Fully documented and debugged STELLA and Fortran models along with reading lists, answer keys, and course notes are being developed for distribution to anyone interested in teaching a course such as this. Modeling topics include U-Pb concordia/discordia dating techniques, the global phosphorus cycle, Earth's energy balance and temperature, the impact of climate change on a chain of lakes in eastern California, heat flow in permafrost, and flow of ice in glaciers by plastic deformation. The course has been taught twice at Vassar and has been enthusiastically received by students who reported not only that they enjoyed learning the process of modeling, but also that they had a newfound appreciation for the role of mathematics in geology and intended to enroll in more math courses in the future.

ED31C-1177 0830h POSTER

Teaching With Models: A Starting Point Resource Module

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The use of models in entry-level geoscience classes provides an ideal framework for the creation of interactive student-centered learning environments while providing opportunities to introduce students to an important and useful tool. To assist faculty in using models in entry-level courses, we have created a website "Teaching with Models" which is part of "Starting Point", a website aimed at supporting faculty teaching entry-level geoscience with information and materials. The "Teaching with Models" site provides: a definition/clarification of modeling in an introductory geoscience education context; a discussion of when and where different model types are useful and why one would want to use them to promote student learning; a description of how to effectively use models, including pedagogical and technical issues; and specific modeling examples. This basic structure of what, when and why, how, and examples is repeated at various levels throughout the website. We define "model" very broadly to include five model types: conceptual or mental models; physical models; mathematical models; statistical models; and visualization models. We identify three key motivating factors supporting the usefulness of models in introductory geoscience education: 1) The extensive use of models by professional geoscientists suggests that introductory geoscience students should be exposed to the basic philosophy and usefulness of models; 2) Models provide an excellent framework for the creation of interactive student-centered learning environments; and 3) Many concepts from systems thinking and Earth-system science are ideally suited to the use of models. Our presentation will include assessment results based on student surveys for a Fall 2003 introductory Earth's Climate course and a description of several "Teaching with Models" modeling examples available online at: http://serc.carleton.edu/introgeo/models/index.html.

URL: http://serc.carleton.edu/introgeo/

ED31C-1178 0830h POSTER

The NCAR Modeling in the Geosciences Workshop for Middle and High School Educators

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The National Center for Atmospheric Research initiated a new workshop, "Modeling in the Geosciences," in the summer of 2003 with support from the NASA-funded Earth System Modeling Framework Project. This multi-part, multi-year effort, introduced 20 middle and high school educators from across the country to models and the modeling process. The workshop focused on what models are, how scientists use models in their research, and how models can be used for engaging, inquiry-based education in the middle and high school science classroom. Teachers received training on STELLA and ArcView software during the two-week workshop, as well as hands-on activities and demonstrations that illustrate concepts in modeling. Topical areas of emphasis for the workshop included the water cycle, the carbon cycle, population dynamics, and Earth energy balance. Participants are required to develop a unit for use in their own classrooms, based on the resources provided in the workshop, and to report back to the group through extension workshops this fall (facilitated on-line) and in the spring of 2004 (at the National Science Teachers Association Meeting in Atlanta, GA). In addition, participants were provided STELLA and ArcView site licenses for their schools, and are required to provide training to 40 educators per year based on the resources provided to them during the workshop.

URL: http://www.ucar.edu/educ_outreach/mgw/index.html

ED31C-1179 0830h POSTER

A Simple Numerical Model of the Global Carbon Cycle for the Classroom

John T. Snow (405-325-3101; jsnow@ou.edu)

Using the STELLA programming software, a numerical model of the global carbon cycle has been developed for educational purposes. The basic model is a somewhat simplified version of box models developed by researchers in the 1980s to explore the cycling of carbon on time scales of years to centuries. The model contains four reservoirs (or "stocks") of carbon – atmosphere, ocean, and land plants - interconnected by a variety of processes (or "flows"). The presentation will demonstrate the model and cover three topics regarding its use in the classroom. 1) Construction of the model by lower division students, focusing on animating a static diagram of the carbon cycle and emphasizing the importance of the concepts of balance and conservation of carbon to continually check the work in progress. 2) Introduction of students to real-world model tuning to eliminate both starting transients and small imbalances introduced by representing continuous functions in finite difference form.

3) Exploration of model behavior using a variety of perturbations. The perturbations considered include large fires leading to the destruction of the land plants (an internal redistribution of carbon already present in the model) and the burning of fossil fuels (the distribution of "new" carbon added to the model from the outside). The closing discussion will emphasize the importance of developing students' abilities to interpret graphical output in terms of the scenario being played out in the model.

ED31C-1180 0830h POSTER

Integrating Research and Education: A 3D Modeling and Data Visualization Package for Data Assimilation

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Recent advances in the development of integrated models of the Sun-Earth environment are placing increasing emphasis on data assimilation schemes that can maximize the intelligence extracted from our sparse sampling of upwind conditions. One of the schemes proposed is Branch Prediction and Speculative Execution, which consists of making probabilistic estimates of current upstream conditions, and distribute among available machines simulations that assume each of the probabilistically estimated states as initial conditions. As the near-Earth space evolves and near-Earth satellite data are compared with the models, some of the speculatively executed simulations will be proved wrong. At that point the machines that were executing them will be reassigned either to new lines of speculative simulation, or to increase the processing power devoted to more promising simulations already executing. CALCHAS is a 3D visualization package that integrates models and data, and is used in the above data assimilation scheme. The package is written in Java 3D, and has a modular design, so that different models and datasets, both real-time and historical, can be seamlessly compared using a variety of goodness-of-fit measures. The package is used both in research and education at the undergraduate as well as secondary level. Teaching modules use the package to teach Nature of Science (NOS) concepts like modeling and uncertainty, that have been shown particularly difficult to teach with traditional expository instruction. Standard instruments, like the Views About Science Survey (VASS; Halloun and Hesteness, *Science and Education* 7, 1998) and the Views of Nature of Science questionnaire (VNOS; Lederman, Abd-El-Khalick, Bell, and Schwartz, *Journal of Research in Science Teaching*, 39, 2002) are used to track progress in student conceptions of science.

ED31D MCC: Level 2 Wednesday 0830h

The Digital Library for Earth System Education: Opportunities for Collaboration II Posters

Presiding: **R Pandya,** DLESE Program Center/University Corporation for Atmospheric Research**; T Ledley,** TERC

ED31D-1181 0830h POSTER

Immersive Earth: Teaching Earth and Space with inexpensive immersive technology

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In 1995 we pioneered "Space Update", the Digital Library for the rest of us", software that was so simple that a child could use it without a keyboard and yet would allow one-click updating of the daily earth and space science images without the dangers of having an open web browser on display. Thanks to NASA support, it allowed museums and schools to have a powerful exhibit for a tiny price. Over 40,000 disks in our series have been distributed so far to educators and the public. In 2003, with our partners we are again revolutionizing educational technology with a low-cost hardware and software solution to creating and displaying immersive content. Recently selected for funding as part of the REASoN competition, Immersive Earth is a partnership of scientists, museums, educators, and content providers. The hardware consists of a modest projector with a special fisheye lens to be used in an inflatable dome which many schools already have. This, coupled with a modest personal computer, can now easily project images and movies of earth and space, allows training students in 3-D content at a tiny fraction of the cost of a cave or fullscale dome theater. Another low-cost solution is the "Imove" system, where spherical movies can play on a personal computer, with the user changing the viewing direction with a joystick. We were the first to create immersive earth science shows, remain the leader in creating educational content that people want to see. We encourage people with "allsky" images or movies to bring it and see what it looks like inside a dome! Your content could be in our next show!

URL: http://earth.rice.edu

ED31D-1182 0830h POSTER

THREDDS Second Generation (THematic Real-time Environmental Distributed Data Services): Engaging the GIS Community and Tools

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The central mission of the THREDDS (THematic Real-time Environmental Distributed Data Services) project is to make it possible for educators and researchers to publish, locate, analyze, and visualize data in a wide variety educational settings. In the initial phase THREDDS established a solid, working prototype of services and tools to enable data providers to create inventory catalogs of the data holdings at their site and educational module builders to author compound documents with embedded pointers to environmental datasets and analysis tools. These catalogs and data-interactive documents can then be harvested into digital libraries using standard protocols. THREDDS Second Generation (THREDDS2G) will further enhance collaborations among data providers, toolbuilders, researchers and educators. It will do so by expanding the team of contributors and the breadth of data in the collections, taking advantage of recent technological advancements, and integrating THREDDS technologies with emerging standards and related environmental data systems. Since much of this expansion will involve Geographic Information Systems (GIS), THREDDS will actively engage the GIS community with the disciplines and tools that make the end products more useful at all educational levels, for decision makers and for the general public.

URL: http://my.unidata.ucar.edu/content/software/thredds/index.html

ED31D-1183 0830h POSTER

The Earth Exploration Toolbook: An Opportunity to Bring Earth Science Data to the Educational Community

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The Earth Exploration Toolbook (EET) presents step-by-step examples of using Earth science datasets and data analysis tools in educational settings. Each chapter in the EET walks users through a compelling case study in which they use data and analysis tools to explore issues and concepts in Earth system science. Designed for use by K-12 teachers, undergraduate faculty, and their students, each chapter provides enough experience and in-depth knowledge of the resource to enable an educator to use it, apply it to other teaching contexts, or help students use the resource to explore and investigate aspects of the Earth system of interest to them. Using our experience in developing the initial five chapters of the EET we are developing a template for the structure of a chapter. This web-based template will allow those outside the project, who have Earth science datasets and data analysis tools that they would like to be used by the educational community, to contribute a new chapter to the EET. In this presentation we will discuss the currently available chapters and EET chapter template, and describe the opportunities for others to help contribute a chapter to the EET.

URL: http://serc.carleton.edu/eet

ED31D-1184 0830h POSTER

Using Data in the Classroom: Resources for Undergraduate Faculty

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On-line access to geoscience data and tools for data visualization and analysis are creating exciting new opportunities for engaging undergraduate students with data. The National Science Digital Library (NSDL) and DLESE both include access to data and tools as fundamental aspects of their vision and are currently striving to support faculty in using data in their courses. The Using Data in the College/University Classroom Workgroup at the 2003 DLESE Annual meeting brought together data providers, resource developers, and faculty to discuss issues surrounding data access and use in the undergraduate classroom. In order to improve understanding among these diverse viewpoints, workgroup participants created concept maps showing the relationships between data and education. These maps and other highlights of the working group discussion are available at http://swiki.dlese.org/ReportOut2003/26. The working group discussions built on substantial existing resources including: 2001 Report of the DLESE Data Access Working Group bringing together data providers and tool developers (www.dlese.org/documents/reports/meeting/Feb_01/dawg20801_outcomes.html); 2002 Using Data in the Classroom workshop bringing together faculty from across the disciplines (serc.carleton.edu/research_education/usingdata/workshop02/); 2003 Using Data in the Classroom report describing current uses of data in undergraduate science courses and faculty needs for data access and tools (serc.carleton.edu/research_education/usingdata/report.html); NSDL Using Data in the Classroom Portal providing access to data, tools, teaching materials, and a discussion of pedagogic and development issues and opportunites for community contribution to these collections (serc.carleton.edu/research_education/usingdata/); Starting Point "Teaching with Models" site supporting faculty teaching at the entry level in using mathematical, statistical, and other types of models in their courses (serc.carleton.edu/introgeo/);

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