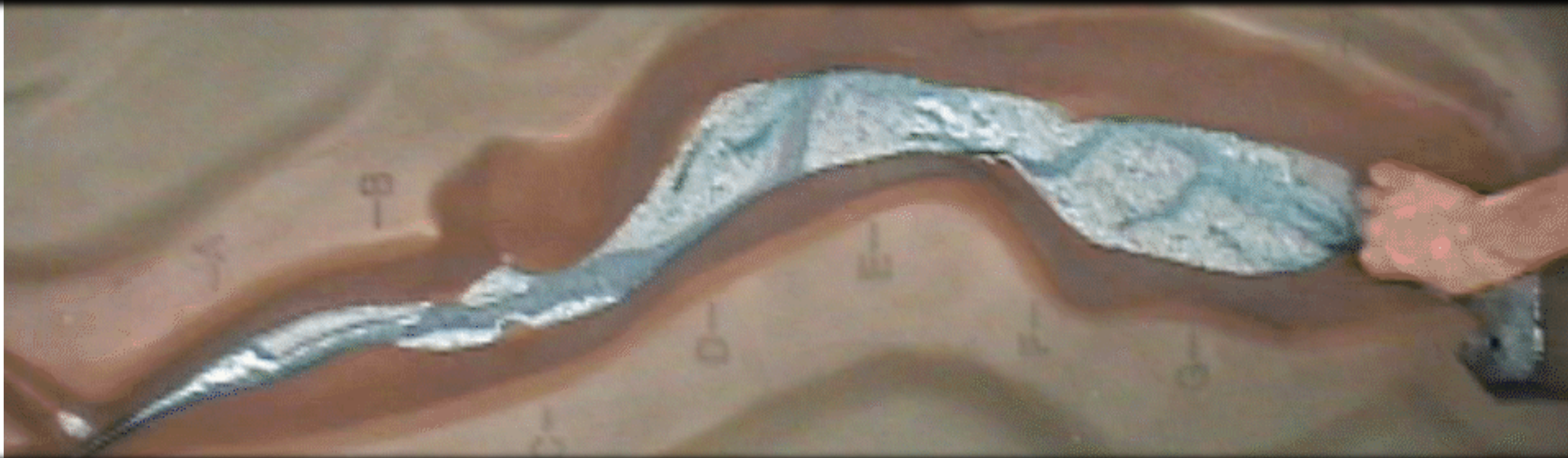


Taking it to the Streets: the case for modeling in the undergraduate curriculum

Karen Campbell, Education Director

Modeling for Environmental Change, CSDMS 2010

October 2010

National Center for Earth-surface Dynamics
A National Science Foundation Science & Technology Center

An NCED Perspective

What we have done: Physical models, teacher professional development, informal science

What NCED and CSDMS share in EKT

Center responsibility

- Center impact: Strength in numbers

Community responsibility

- Lead the community
- Provide opportunities for individuals to doing meaningful Broader Impacts

Civic responsibility

- to future STEM workforce

Demonstrate Better Broader Impacts

"What are the broader impacts of the proposed activity?

- How well does the activity advance discovery and understanding while promoting teaching, training, and learning?
- How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)?
- To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships?
- Will the results be disseminated broadly to enhance scientific and technological understanding?
- What may be the benefits of the proposed activity to society?"

Integrating Diversity into NSF Programs, Projects, and Activities

Broadening opportunities and enabling the participation of:

- all citizens, women and men,
- underrepresented minorities, and
- persons with disabilities,

are essential to the health and vitality of science and engineering.

NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports."

--NSF GPG

Diversity is another whole talk… but please keep in mind:

- modern US demographics
- Community colleges
- HBCUs and Tribal colleges
- Traditional four year liberal arts colleges
- Your colleagues in these schools…

Challege 1: Perceptions
For Majors…

“*Modern geoscience* uses equations, models, and numbers in conjunction with observations, maps, and words as fundamental tools for investigating Earth.

Yet the U.S. public persists in viewing the study of Earth processes as highly qualitative and, in many states, as a remedial science course that is not accepted as appropriate preparation for admission to U.S. colleges and universities…

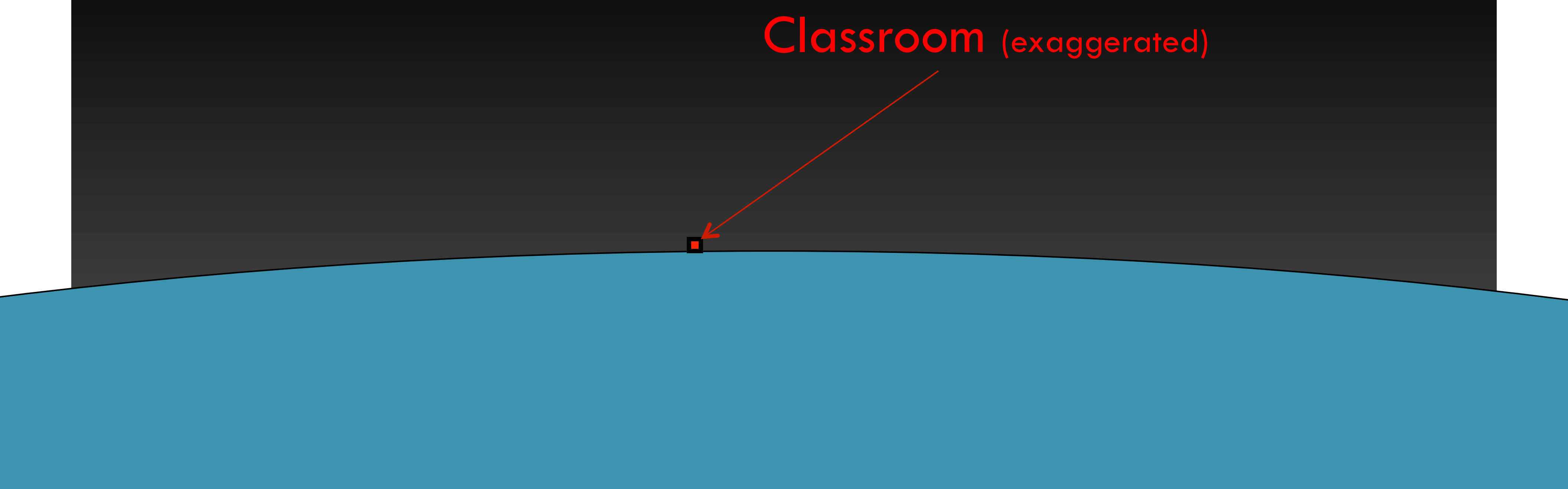
For the terminal science course…

…Quantitative literacy, or numeracy—the ability to use and understand quantitative information in everyday life—is essential for ***citizens*** in a world that bombards us with numbers on a daily basis [*Steen*, 2001]. Because geoscience is perceived by many students as an "easy" science, our ***introductory college courses*** often draw students who seek to avoid quantitative problem solving. Introductory geoscience courses that use quantitative approaches can help students to develop quantitative literacy. In contrast, omission of the quantitative aspects of our science in introductory courses reinforces the notion that quantitative reasoning is not something that citizens need every day.

--Manduca et al, EOS, 2008

Challenge 2: The **Fundamental** Challenge of Geoscience Education:

The Earth is 18 orders of magnitude larger than the classroom.



There are three, and only three, ways to cope with this challenge:

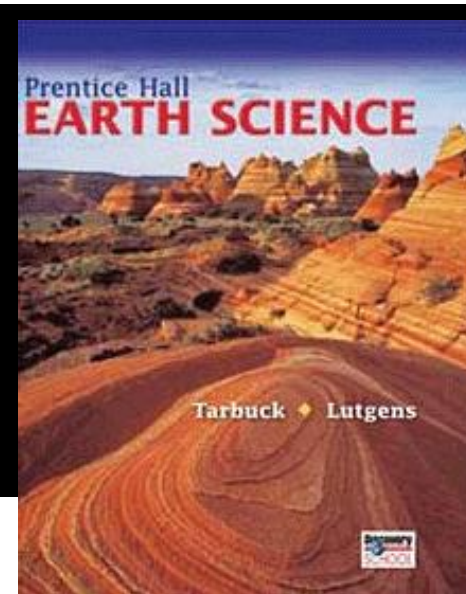
1. Bring small pieces of the Earth into the classroom (e.g. minerals, fossils)

2. Bring students out of the classroom to observe pieces of the Earth in nature.

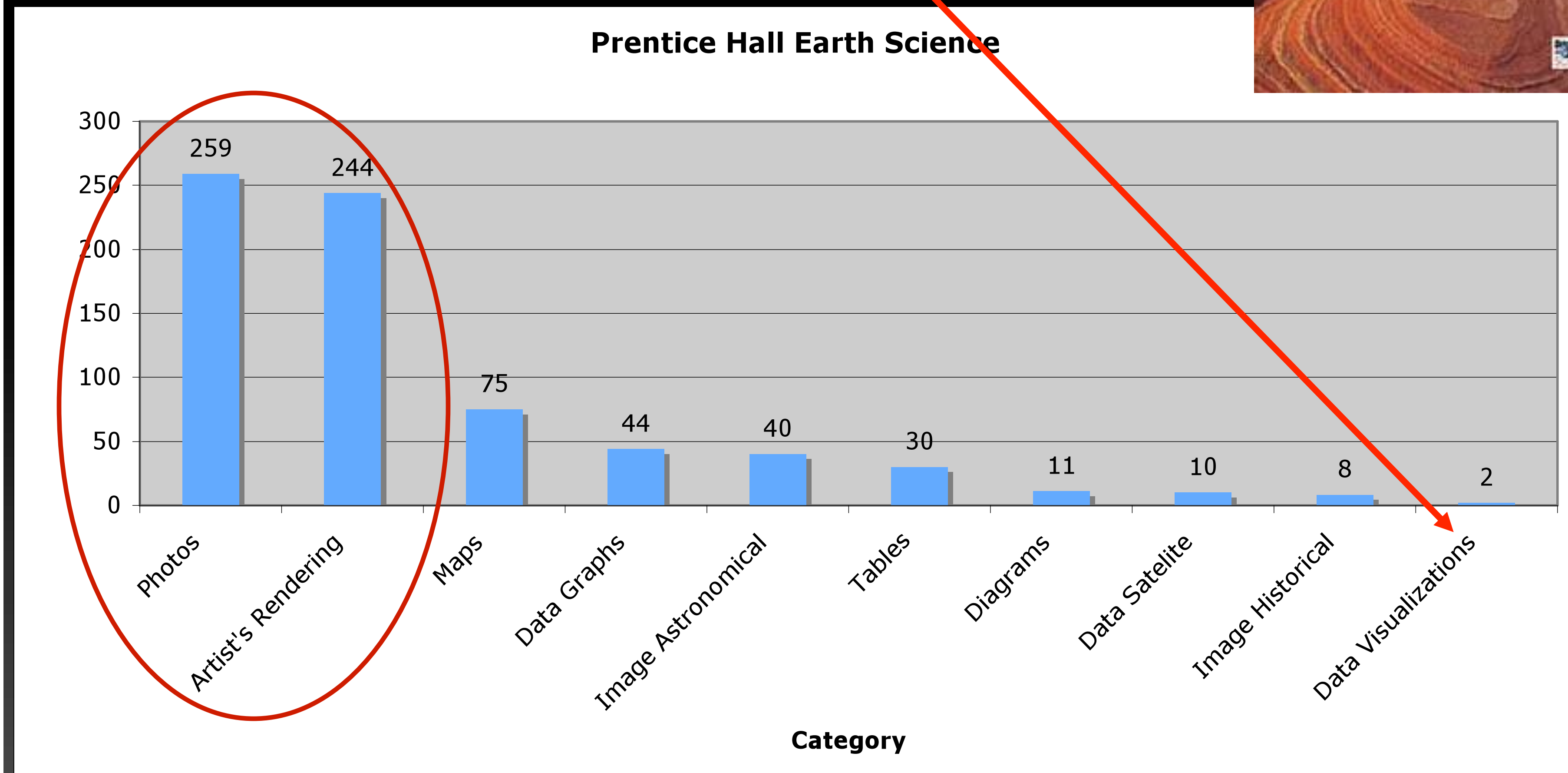
3. Use representations

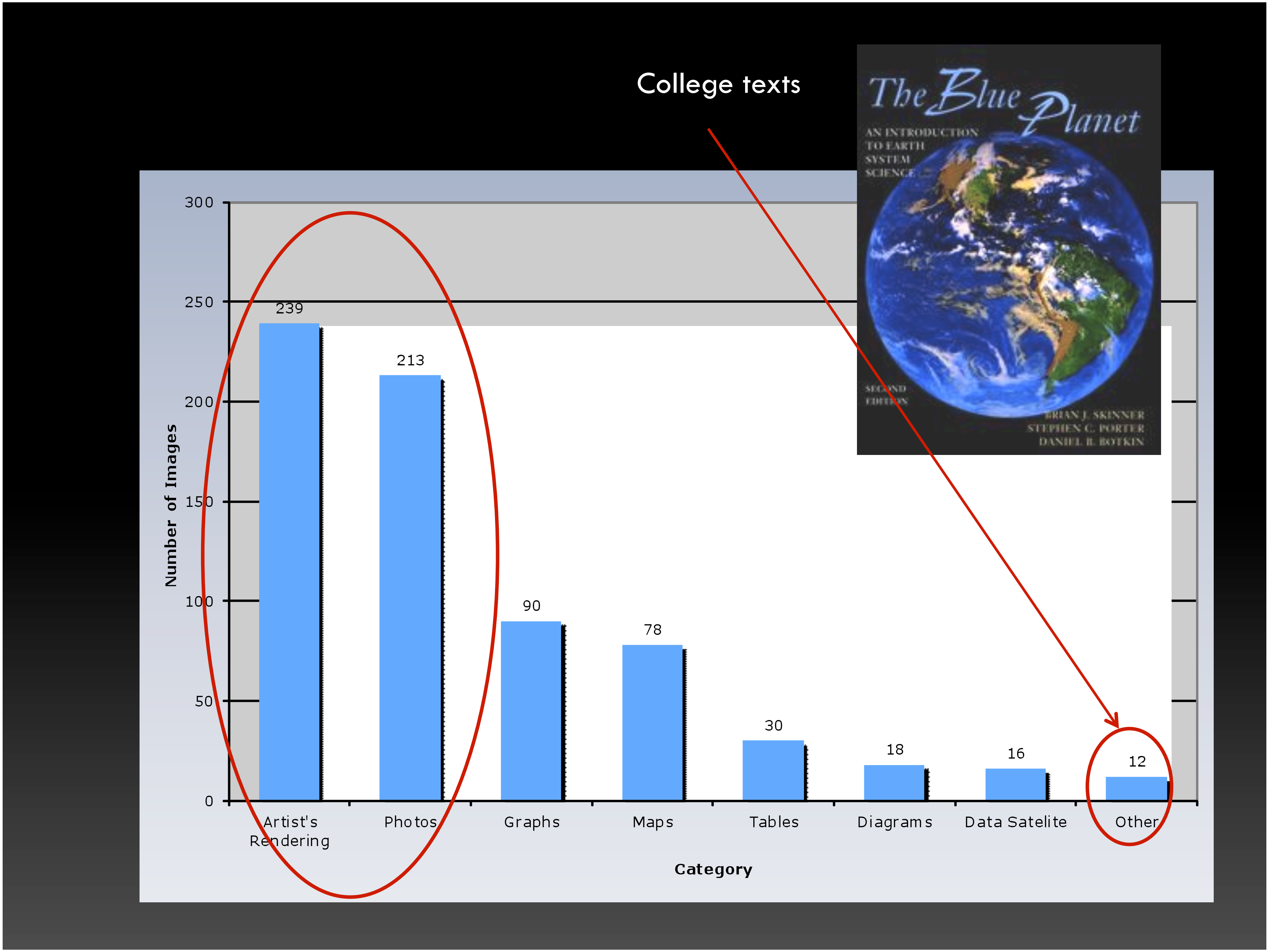
http://eesc.columbia.edu/courses/v1010/index.html http://www.school-assemblies-dinosaur-program.com/arts_in_education.htm

So, what's the problem?



High school texts




College texts
The Blue Planet
AN INTRODUCTION TO EARTH SYSTEM SCIENCE
SECOND EDITION
BRIAN J. SKINNER
STEPHEN C. PORTER
DANIEL B. BOTKIN
Number of Images
300
250
200
150
100
50
0
239
213
90
78
30
18
16
12
Artist's Rendering
Photos
Graphs
Maps
Tables
Diagrams
Data Satelite
Other
Category

Universal Truths

Conditional Truths

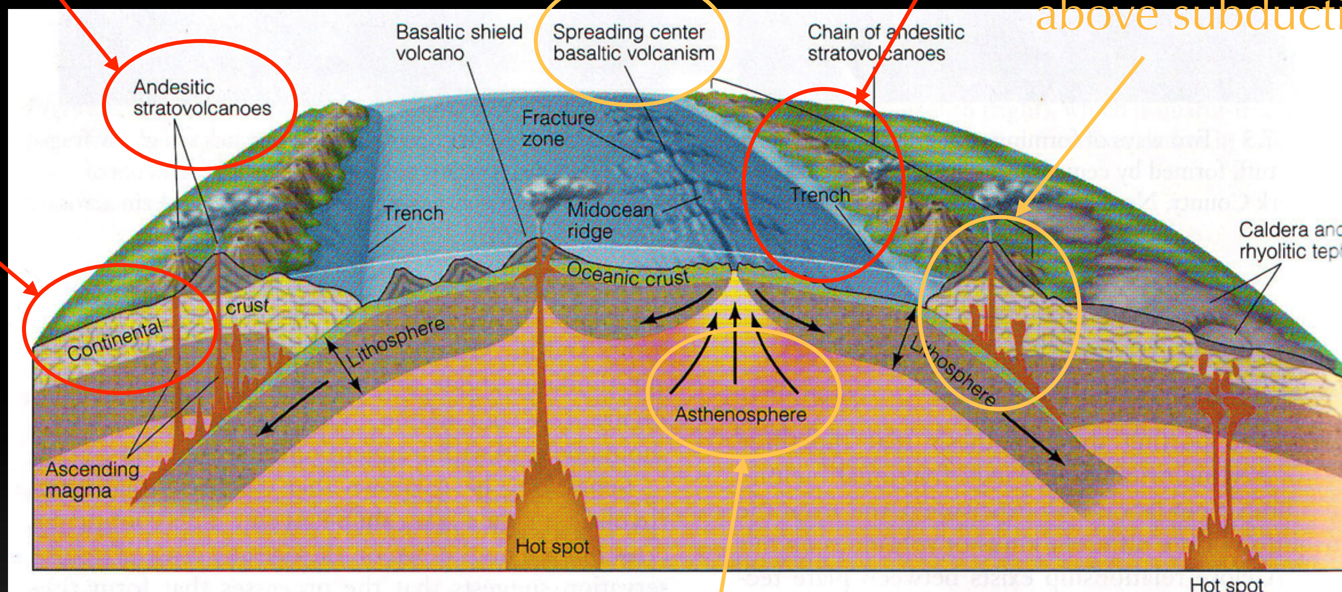
Mid-ocean ridge vulcanism is basaltic

Continent-ocean boundary is only sometimes an active margin (subduction zone).

Arc vulcanism is only sometimes andesitic

Volcanoes occur above subduction zone

Overriding plate is only sometimes continental



The Blue Planet p. 152

Mantle wells up beneath mid-ocean ridge

Challenge 3: static representations are not adequate proxies for a complex, dynamic, variable Earth

(Last 5 slides courtesy Kim Kastens, Lamont-Doherty)

How Research on Learning Can Help,

http://serc.carleton.edu/files/NAGTWorkshops/tools08/kastens_presentation.ppt

Workshop on Teaching with New Geoscience Tools: Visualizations, Models, and Online Data,

February 11, 2008, University of Massachusetts, Amherst.

Challenge 4: Inadequate quantitative preparation

“Geoscience majors, the geoscience workforce of tomorrow, need to be prepared to meet the quantitative demands of industry, research, and education.

In 2006, a group of 20 U.S. graduate and undergraduate faculty and graduate students convened at Carleton College, in Northfield, Minn., to discuss the quantitative preparation of future geoscience graduate students (http://serc.carleton.edu/12980). ..

Participants concluded that

(1) the development of quantitative skills lags well behind other core geoscience skills (geologic interpretation, historical analysis, visualization, data collection, and communication) and

(2) many undergraduate geoscience majors, even those exposed to quantitative material, generally lack the ability to apply quantitative skills to geoscience problems.

As a result, this group perceived a shortage of graduates who have strong backgrounds in both geoscience and quantitative analysis. Similar concern has been expressed by members of industry [*Loudin*, 2004]."

--Manduca et al, EOS, 2008

Challenge 5: Teach majors to do what we do

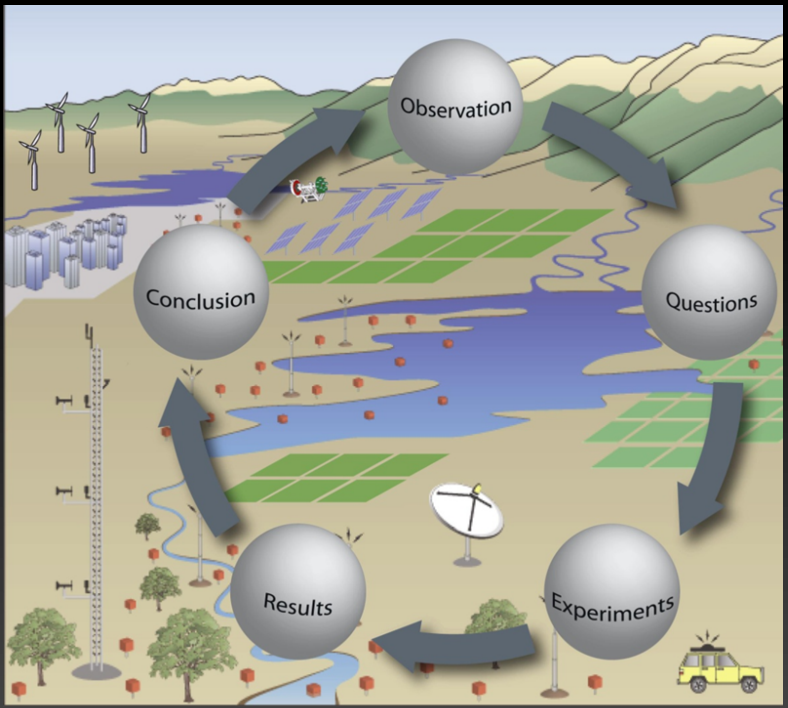
"***Scientific practice*** involves the construction, validation and application of scientific models, so science instruction should be designed to engage students in making and using models."

-- Modeling Methodology for Physics Teachers (1998)

Solution: Modeling in the undergrad classroom

Confronts the challenges of:

- A perception of rigour-LESS-nes
- The fundamental spatial/temporal problem
- The limits of static representations of Earth
- The lack of quantitative preparation
- The need to teach future scientists to do as we do



So what is CSDMS doing: The Survey

How can CSDMS products and tools help supplement existing college courses related to terrestrial, coastal, marine, hydrology, and carbonate topics?

Sample Inventory of Modeling Courses

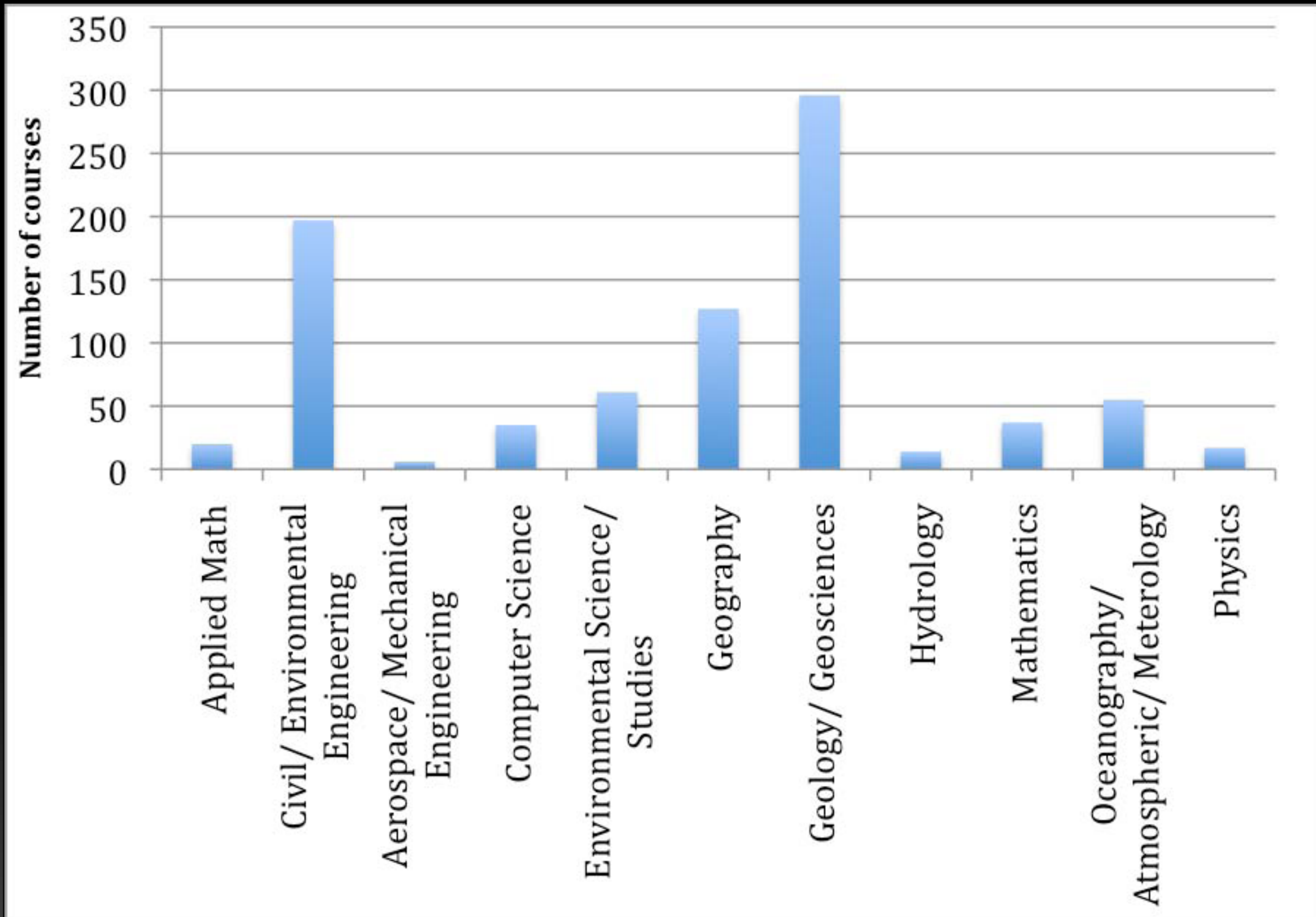
Maureen Berlin and Irina Overeem

July 2010

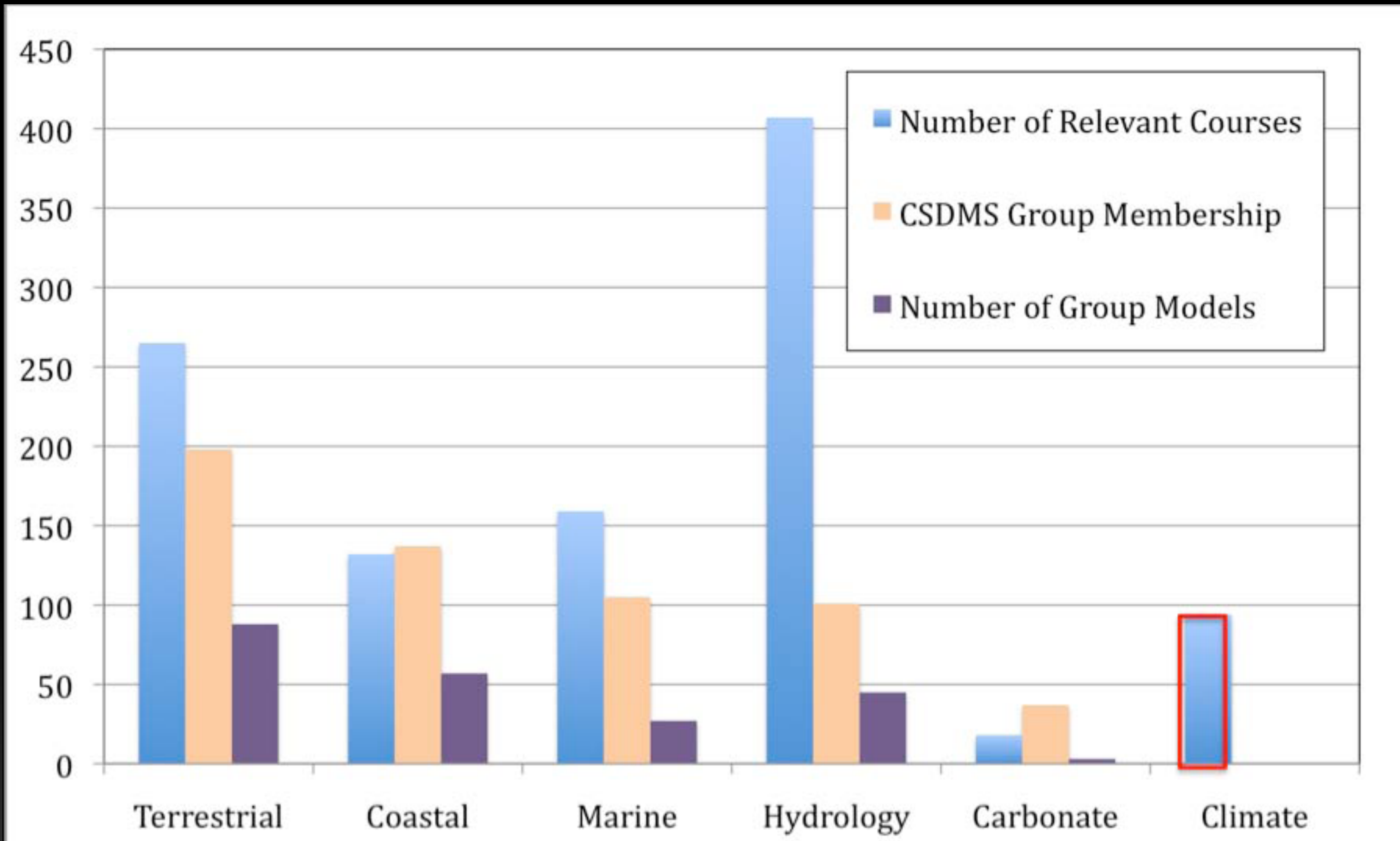
A 2010 survey of university *course catalogs* was conducted to learn how surface process modeling is currently being taught. (Based on a recommendation from the Education and Knowledge Transfer (EKT) Working Group meeting in Fall 2009.)

Survey targeted members of the Association of American Universities (AAU) (http://www.aau.edu/) to gain a representative sample of research-intensive universities. Rather than surveying all 63 AAU members, a representative sample of 36 institutions were chosen. Those chosen had either a geology or

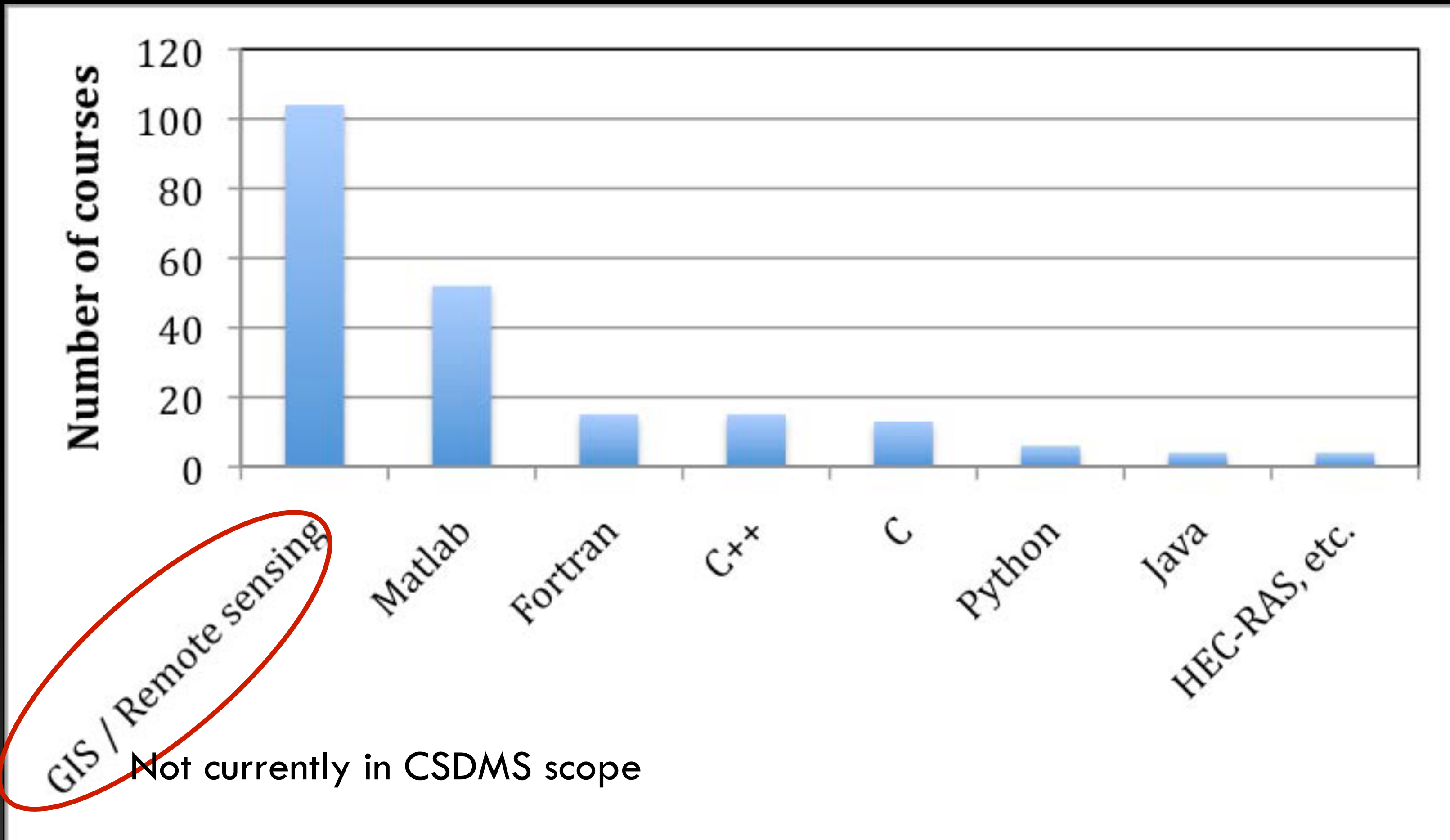
civil engineering department. Of the surveyed universities, 16 are also host institutions of CSDMS members.



Somewhat Relevant courses by department



Frequency of courses relevant to CSDMS Focus Research Groups and Working Groups, membership within those groups, and number of group models as of July 2010.



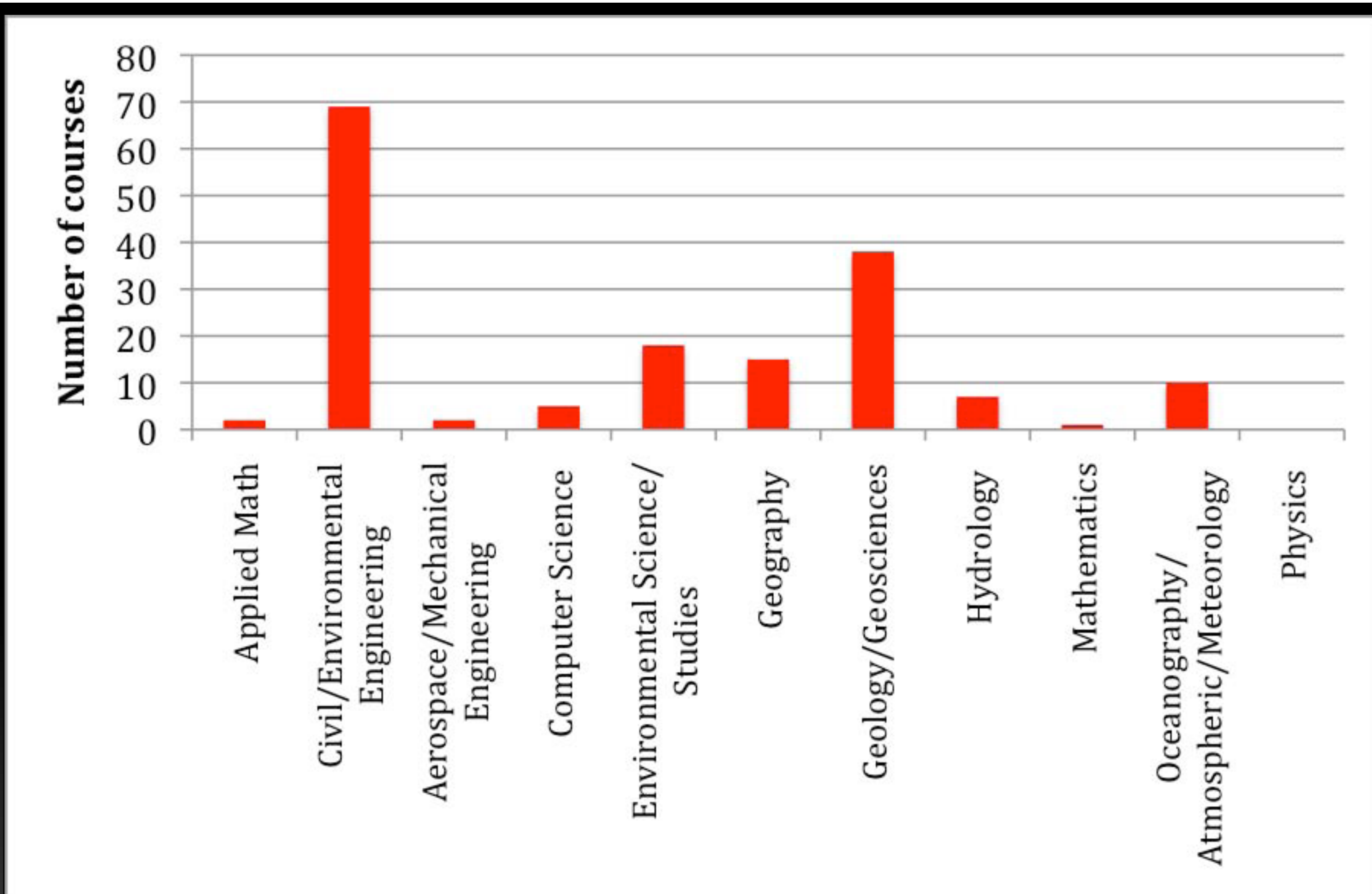
Frequency of courses that specified a software package or programming language.

“High-Relevance” Courses criteria:

- “Modeling” is listed in course description
- Hands-on activities may be emphasized
- Quantitative problem solving using computers
- Courses that could directly use or benefit from CMT/other CSDMS products

167 courses identified as highly relevant to CSDMS, e.g.

- Physical Hydrology
- Coastal and Ocean Modeling
- Groundwater Modeling
- Computer Simulations in Earth and Planetary Sciences
- Geological Modeling
- Sequence Stratigraphy
- Sediment Transport and River Mechanics
- Advanced Watershed Hydrology
- Earth Systems Science
- Marine Sedimentology



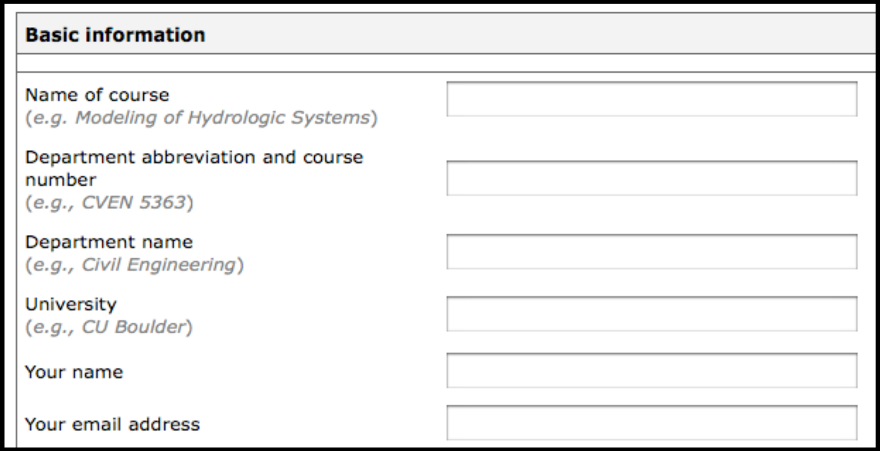
Civil and Environmental Engineering departments had the closest fit, largely due to the presence of groundwater and surface water modeling courses.

(think about this, especially in relation to deep Earth, climate, ocean circulation….)

Next step: CSDMS Modeling Course Questionnaire

Developed as a follow-up to course catalog sampling

Distributed to CSDMS members, sent to Gilbert Club and Geomorph lists, and posted in
Sept. 2010 NAGT eNewsletter


Basic information

Name of course
(*e.g. Modeling of Hydrologic Systems*)

Department abbreviation and course number
(*e.g., CVEN 5363*)

Department name
(*e.g., Civil Engineering*)

University
(*e.g., CU Boulder*)

Your name

Your email address

11 responses as of Oct 6;
Available on meeting thumbdrive and the CSDMS website

Highlights from questionnaire so far

- Offers to share Excel spreadsheets, simple codes for simulations, Matlab GUIs, and other material
- Definite interest in using EKT textbooks in the future (e.g. Pelletier 2008, Parker eBook 2007, Slingerland et al. 1994)

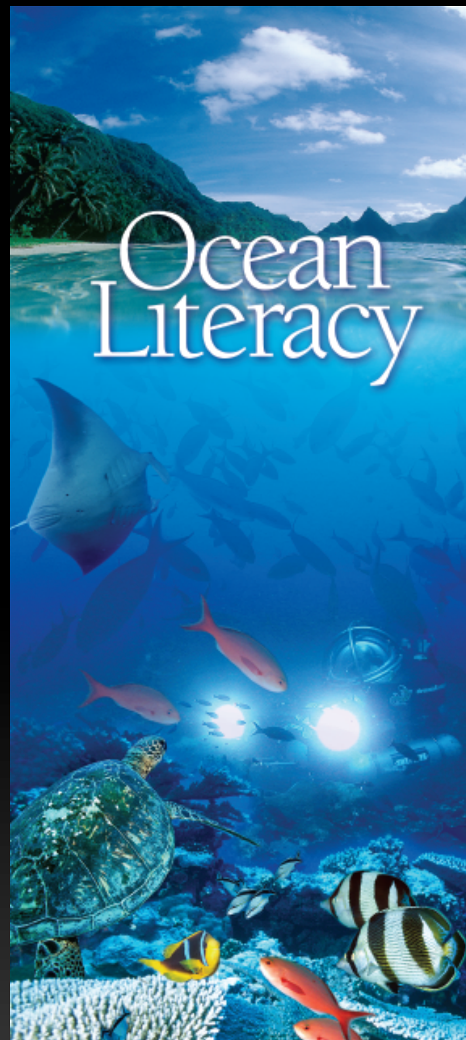
A starting point: a simple modeling tool for faculty and TA's?

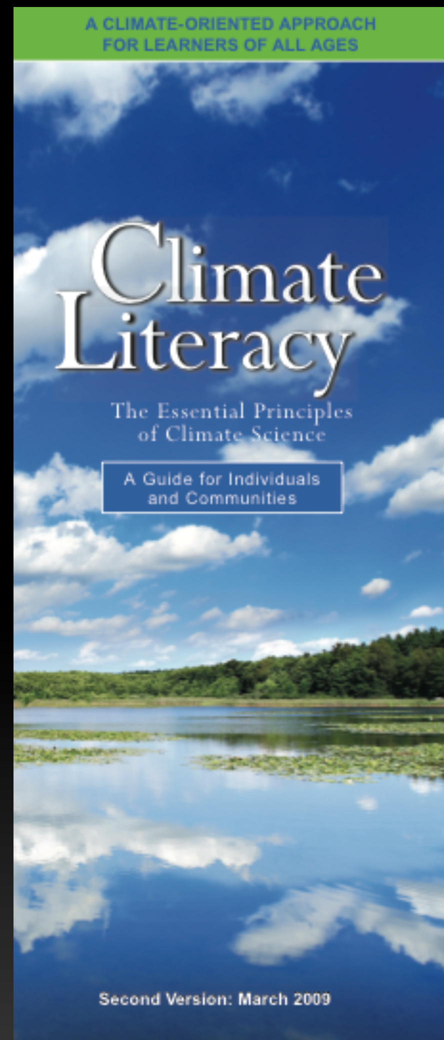
From this survey, we can speculate that hydrology courses represent an opportunity for the immediate or near-term use of CSDMS products, and that civil/environmental engineering departments may be the most logical host of these courses.

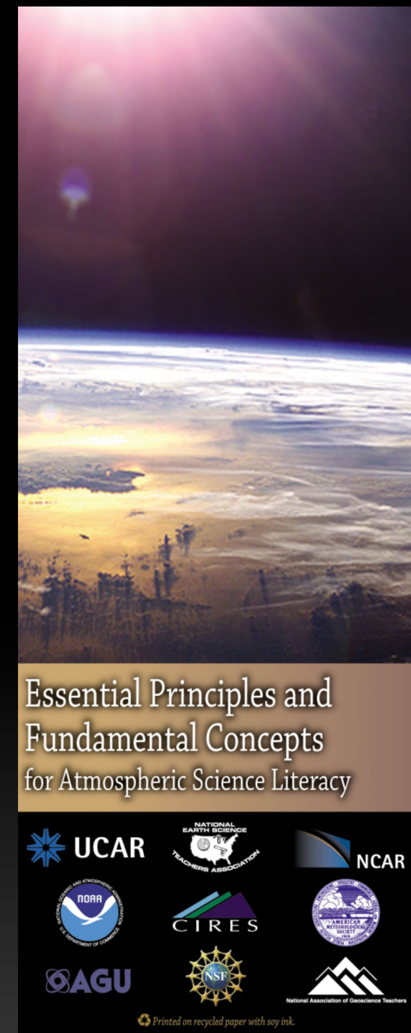
A sample modeling course is included in:

Community surface Dynamics Modeling system Semi-Annual Report 2010, Appendix 2.

Resources: Literacies







Earth Science Literacy: (surface processes throughout)

Big Idea 1. Earth scientists use repeatable observations and testable ideas to understand and explain our planet.

Big Idea 2. Earth is 4.6 billion years old.

Big Idea 3. Earth is a complex system of interacting rock, water, air, and life.

Big Idea 4. Earth is continuously changing.

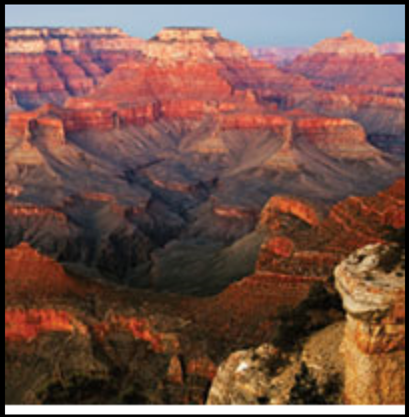
Big Idea 5. Earth is the water planet.

Big Idea 6. Life evolves on a dynamic Earth and continuously modifies Earth.

Big Idea 7. Humans depend on Earth for resources.

Big Idea 8. Natural hazards pose risks to humans.

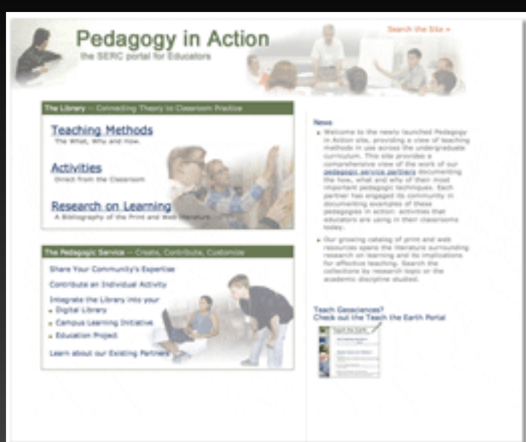
Big Idea 9. Humans significantly alter the Earth.



Resources: SERC (http://serc.carleton.edu)

NSF-funded office of Carleton College

- sponsors workshops
- Hosts resources
- Conducts evaluation research on effective STEM learning, with particular emphasis on undergraduate Earth science.



Past workshops are archived on the website so resources stay available. CSDMS looking into ways to partner, e.g. a modeling workshop in the “Cutting Edge” series.

Resources: CSDMS website Education portal

CSDMS Educational repository

CSDMS Educational Topics

Movies

Model animations as well as real event movies that illustrate earth surface processes.

Labs

CSDMS shares model executables and notes for exercises with students as integrated packages.

Lectures

Various lectures on earth surface modeling.

Textbooks

Source code of published textbooks on modeling are provided

Images

Earth surface images.

1) Animations (*43*)
2) Laboratory movies (*13*)
3) Real event movies (*23*)

3

5

3

~140

Not very big numbers, BUT… research at the Red Stag…

Google analytics

Average # of downloads for EKT movies

Terrestrial animations (~38)

Coastal (~27)

Environmental (~15)

Real event movies (~14)

Marine (~10)

Number of unique page views for EKT lectures

- Surface Dynamics Modeling, Irina Overeem/Scott Peckham: (40)
- Earth Surface Dynamics Modeling, James Syvitski: (28)
- Geological Modeling, Irina Overeem: (26)
- Morphodynamics of Rivers, Gary Parker: (16)
- 1D Sediment Transport, Gary Parker: (12)

Statistics current for August 8 – October 7 2010 (following education page redesign, page views from Google Analytics)

Number of unique page views for EKT textbooks

- Quantitative Modeling of Earth Surface Processes, Jon Pelletier: (17)
- 1D Sediment Transport Morphodynamics with applications to Rivers and Turbidity Currents (E-book), Gary Parker: (18)
- Simulating Clastic Sedimentary Basins/Physical Fundamentals and Computing Procedures, Slingerland et al: (12)

Statistics current for August 8 – October 7 2010 (following education page redesign, page views from Google Analytics)

How you can help

- Take the Survey!
  - On the CSDMS website
  - http://csdms.colorado.edu/wiki/Modeling_course_questionnaire
  - On your complimentary usb key

- Contribute to the CSDMS education website:
  - Movies, animations, models, textbooks, images

- Join the EKT Working Group!

- Partner with a colleague who does primarily undergraduate instruction to develop a model and/or ways to use an existing one in undergraduate instruction, evaluate it's effectiveness and publish the results!

- Contact Irina Overeem or Karen Campbell

Discussion

(SERC/On the Cutting Edge workshop on Visualization)