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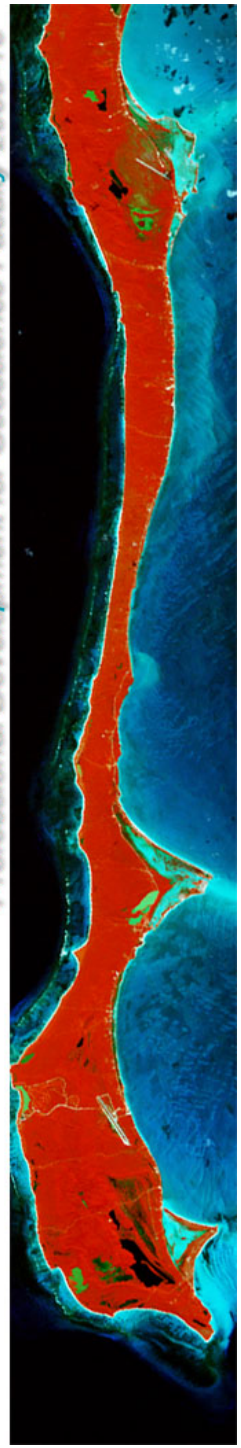

Resources for Designing, Selecting, and Teaching with Visualizations in the Geoscience Classroom

Karin Kirk, Cathryn Manduca, Carol Ormand, and John McDaris

Science Education Resource Center

Carleton College

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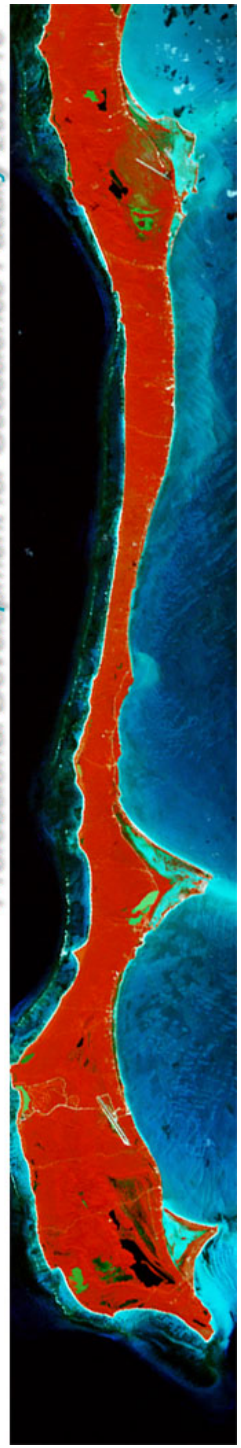

Outline

- Why use visualizations?
- The take-home message:
  - Choose or construct your visualizations carefully. Students don't always see what we see!
- What makes an effective visualization?
- Affective impacts of visualizations
- Resources on the SERC website:
  - Visualizations and tools for educators

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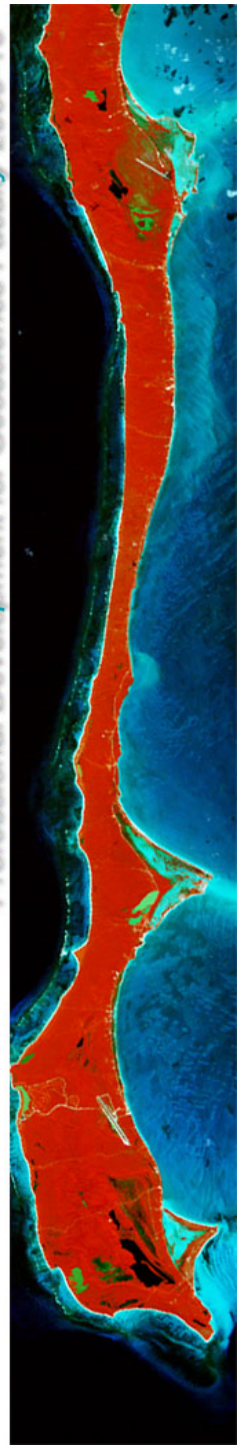

Why use visualizations?

- Geoscience is a highly visual field
- ***Effective*** use of visual tools can
  - enhance student learning,
  - motivate students to learn, and
  - help them acquire skills for interpreting visual information.

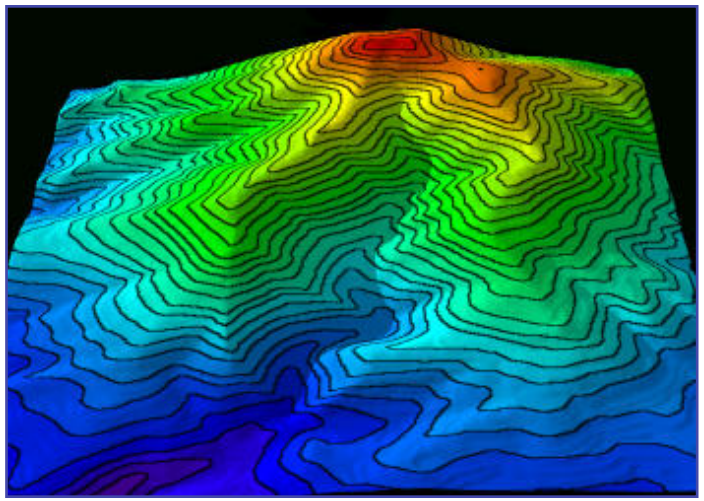

Image credit: Steve Reynolds

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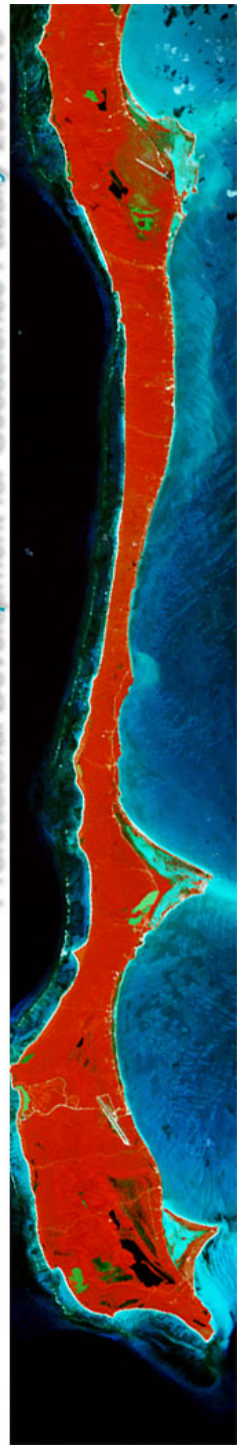
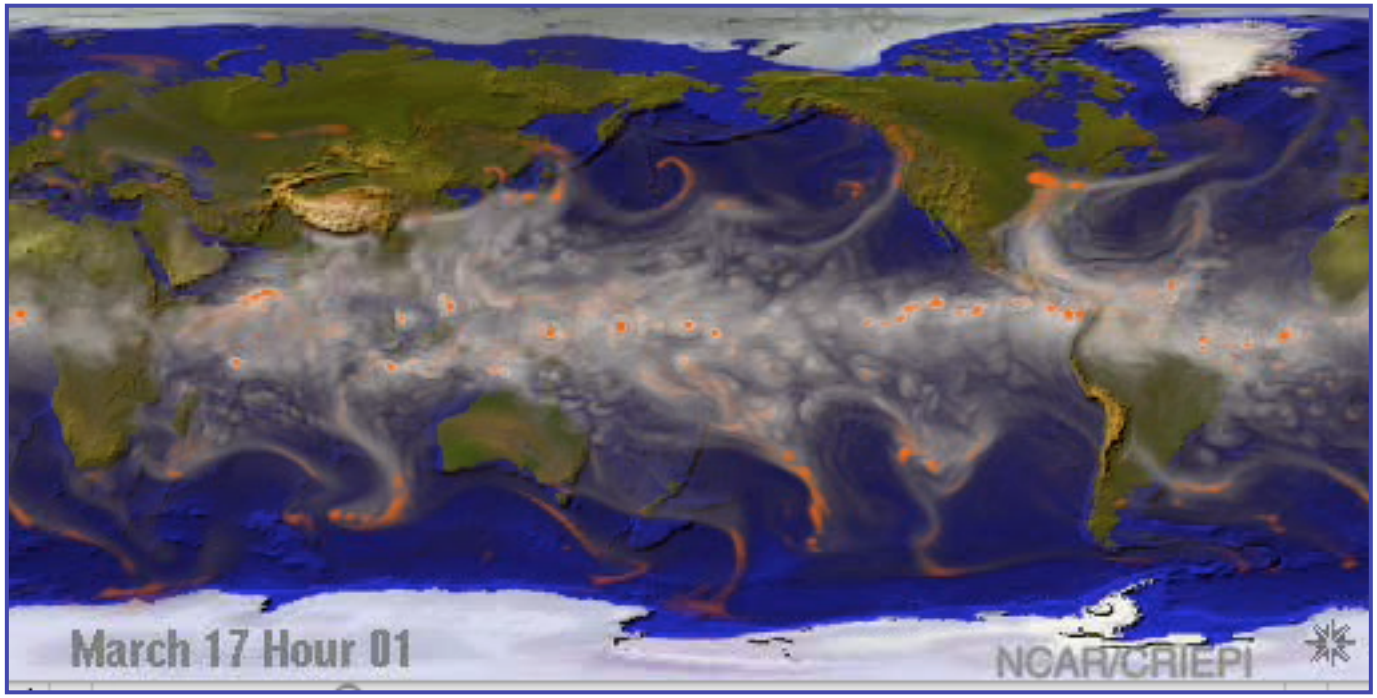


Enhancing student learning



http://www.vets.ucar.edu/vg/CCM3T170/movies/ccm3_all_512.mpg

- Observing the unobservable
- Renderings showing 3 dimensions or changes over time make complex processes much easier to understand (reduces cognitive load)
- Visualizations allow students to construct their own mental images that stick with them

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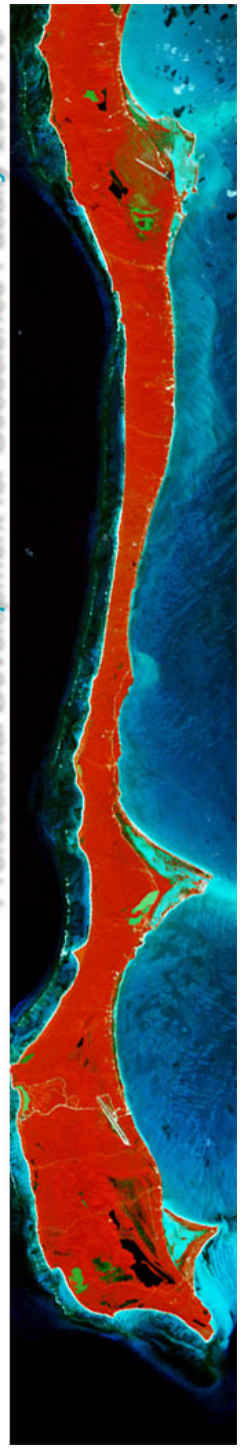
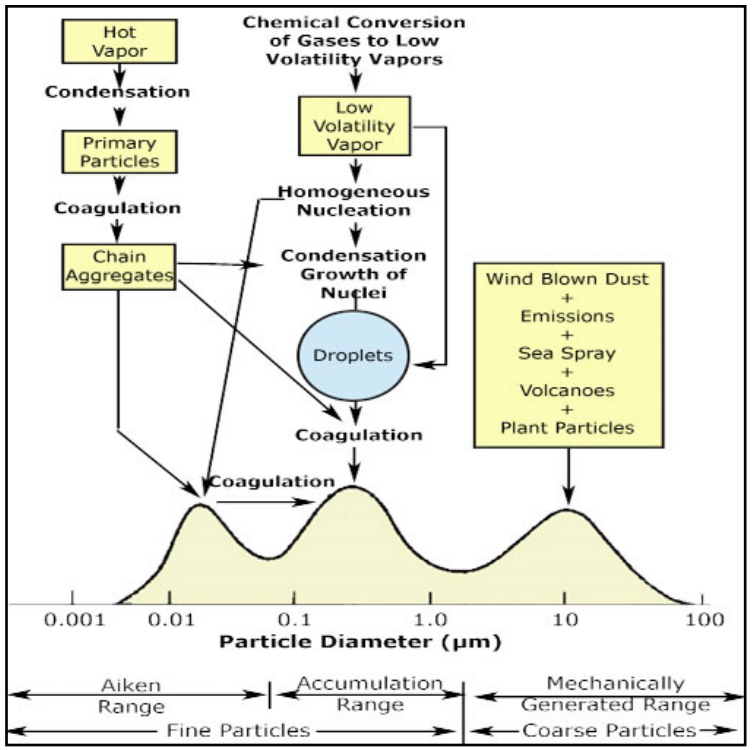


BUT: Students don't (always) see what we see

- Geoscientists have sophisticated spatial reasoning skills
  - Mental models of processes
  - Familiarity with reading maps, contours, scales
  - Geographic knowledge
- Looking and seeing are learned skills
- These skills improve with guided practice
- The knowledge you bring to the image affects what you see



Frequency distribution of particles in the atmosphere by size as developed by Whitby (1978). Classroom scenario described by Perry Samson, University of Michigan: *"I see the three mountains in the picture, but I don't understand which way the wind is blowing."*

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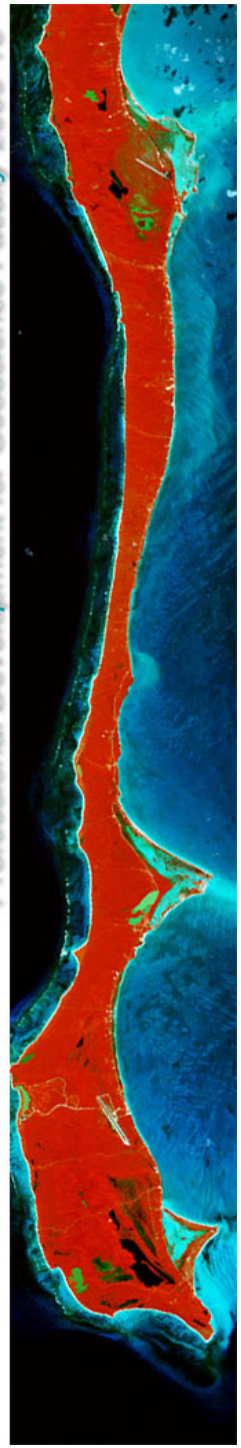

Using visual data in the classroom

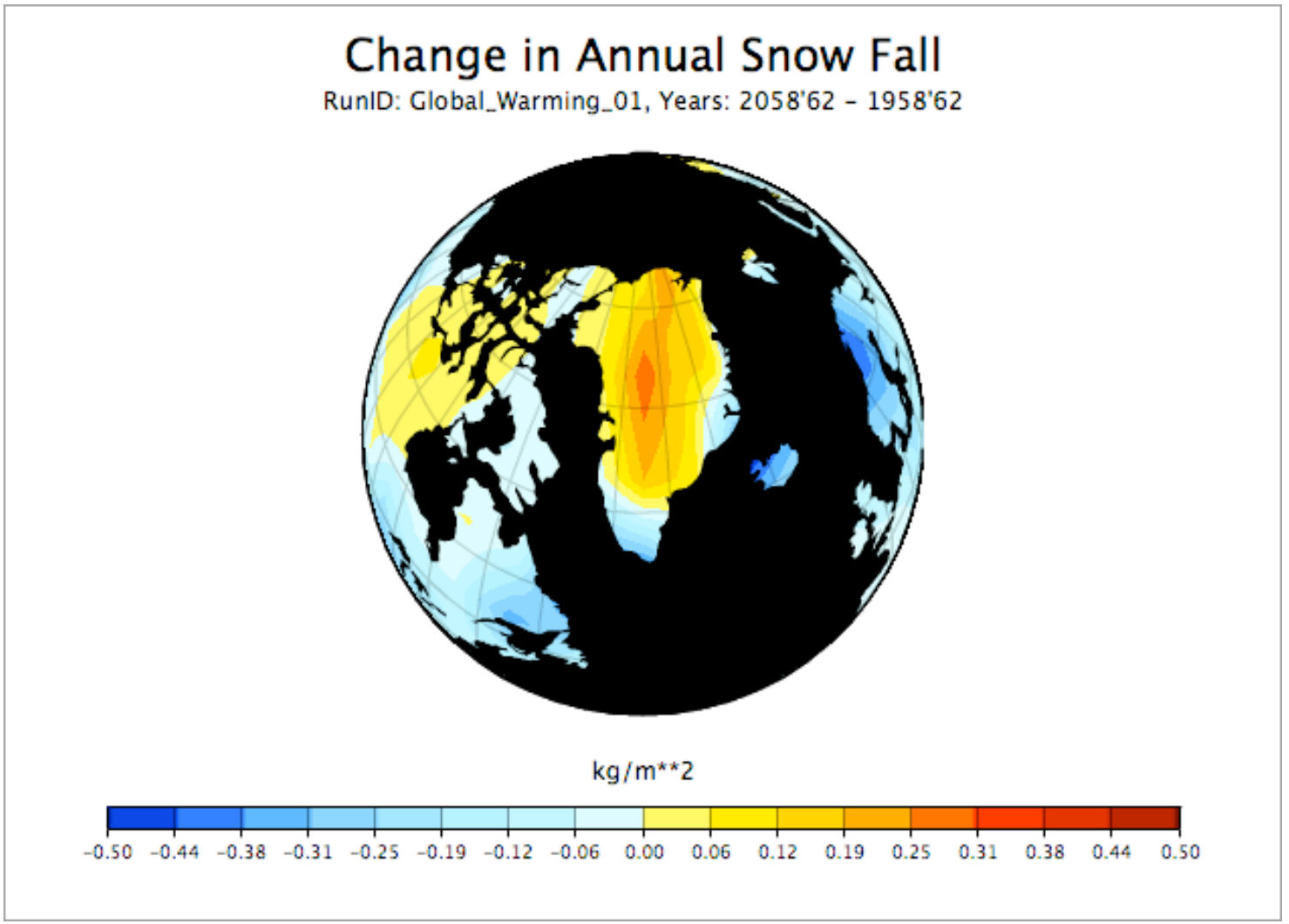

Image from EdGCM

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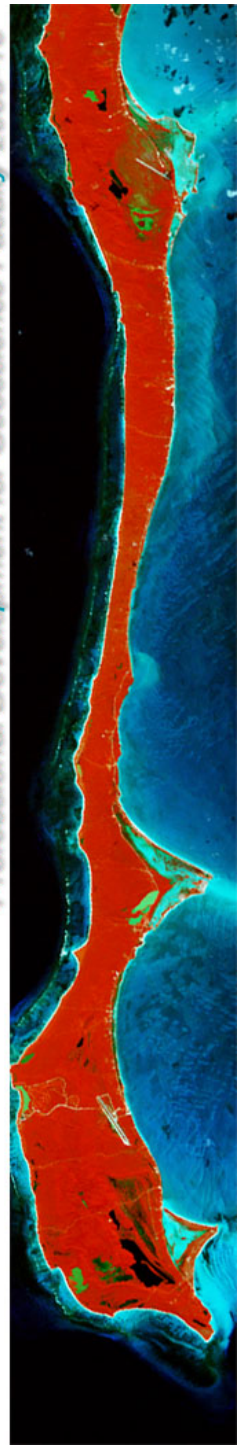

How can we align what students see with what we want them to see?

- Map the structure and content of the information to be conveyed on the structure and content of the diagram
- Use extra-pictorial devices like arrows and guidelines unambiguously
- Craft diagrams to explain, not just show
- Check to see if students learn what is intended

(Tversky, 2004)

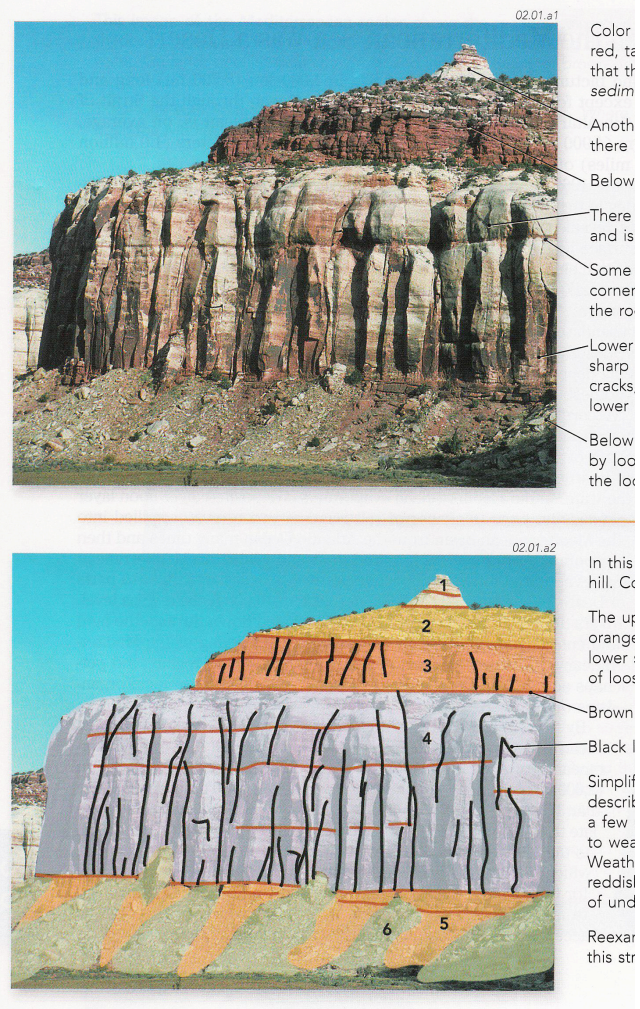

Diagram from *Exploring Geology* (Reynolds et al.)

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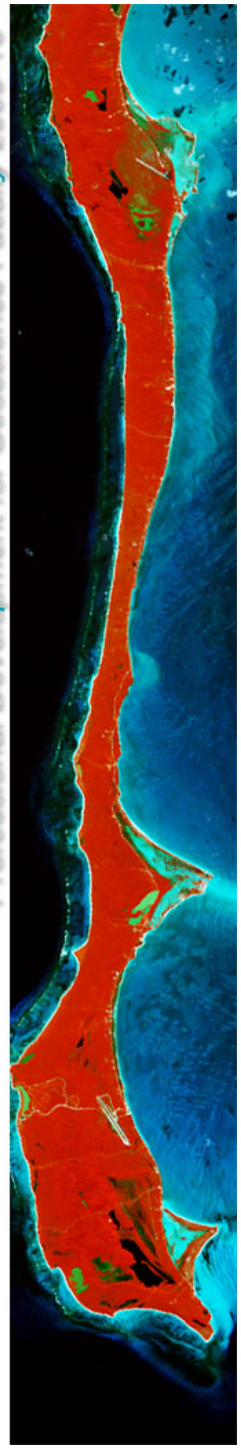
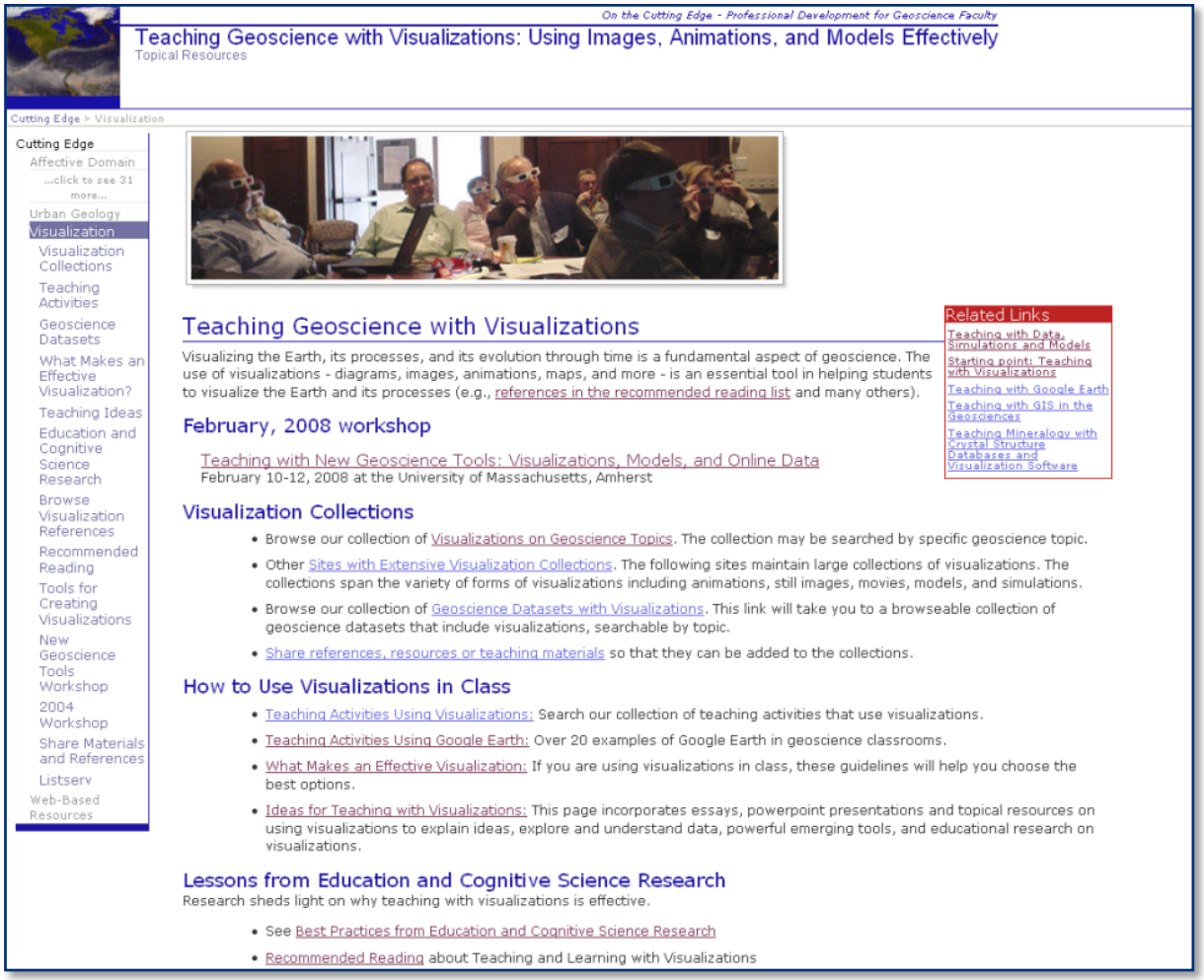


What makes an effective visualization for teaching?



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Teaching Geoscience with Visualizations: Using Images, Animations, and Models Effectively

Topical Resources

Cutting Edge > Visualization

Cutting Edge
Affective Domain
...click to see 31 more...
Urban Geology
Visualization
Visualization Collections
Teaching Activities
Geoscience Datasets
What Makes an Effective Visualization?
Teaching Ideas
Education and Cognitive Science Research
Browse Visualization References
Recommended Reading
Tools for Creating Visualizations
New Geoscience Tools Workshop
2004 Workshop
Share Materials and References
Listserv
Web-Based Resources

Related Links
Teaching with Data, Simulations and Models
Starting point: Teaching with Visualizations
Teaching with Google Earth
Teaching with GIS in the Geosciences
Teaching Mineralogy with Crystal Structure Databases and Visualization Software

Teaching Geoscience with Visualizations

Visualizing the Earth, its processes, and its evolution through time is a fundamental aspect of geoscience. The use of visualizations - diagrams, images, animations, maps, and more - is an essential tool in helping students to visualize the Earth and its processes (e.g., references in the recommended reading list and many others).

February, 2008 workshop

Teaching with New Geoscience Tools: Visualizations, Models, and Online Data
February 10-12, 2008 at the University of Massachusetts, Amherst

Visualization Collections

- Browse our collection of Visualizations on Geoscience Topics. The collection may be searched by specific geoscience topic.
- Other Sites with Extensive Visualization Collections. The following sites maintain large collections of visualizations. The collections span the variety of forms of visualizations including animations, still images, movies, models, and simulations.
- Browse our collection of Geoscience Datasets with Visualizations. This link will take you to a browseable collection of geoscience datasets that include visualizations, searchable by topic.
- Share references, resources or teaching materials so that they can be added to the collections.

How to Use Visualizations in Class

- Teaching Activities Using Visualizations: Search our collection of teaching activities that use visualizations.
- Teaching Activities Using Google Earth: Over 20 examples of Google Earth in geoscience classrooms.
- What Makes an Effective Visualization: If you are using visualizations in class, these guidelines will help you choose the best options.
- Ideas for Teaching with Visualizations: This page incorporates essays, powerpoint presentations and topical resources on using visualizations to explain ideas, explore and understand data, powerful emerging tools, and educational research on visualizations.

Lessons from Education and Cognitive Science Research

Research sheds light on why teaching with visualizations is effective.

- See Best Practices from Education and Cognitive Science Research
- Recommended Reading about Teaching and Learning with Visualizations

http://serc.carleton.edu/NAGTWorkshops/visualization

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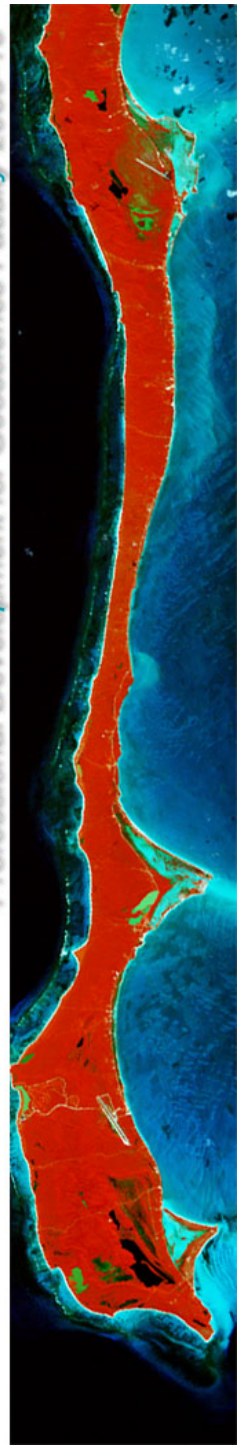

1. The same things that make any educational activity effective

- Start with your goals
  - What do you want the students to learn?
  - What are you trying to accomplish with the visualization?

Kalutara Beach, Sri Lanka; images from Tony Demark:
http://homepage.mac.com/demark/tsunami/

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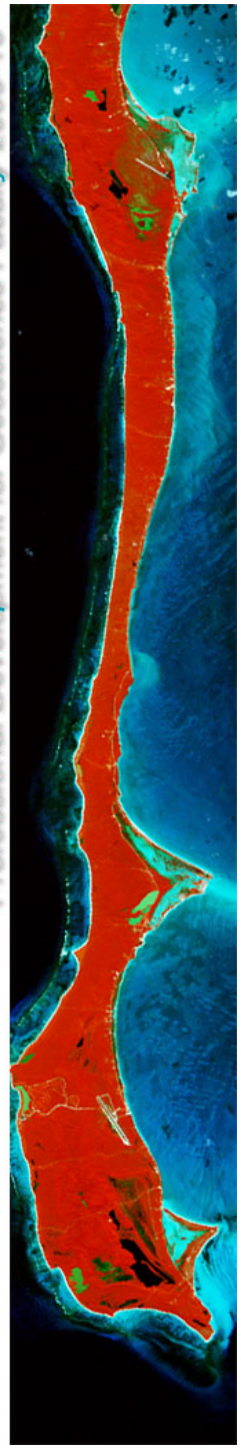

2. Choose visualizations to build on student knowledge

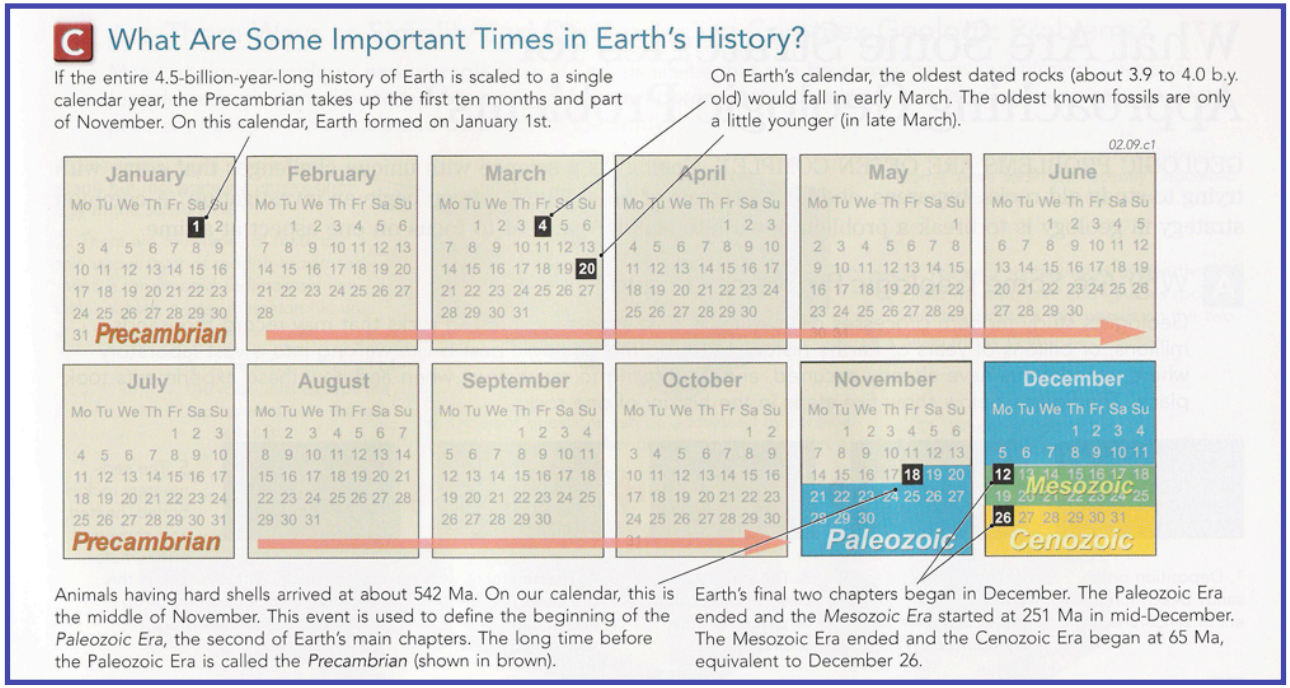

Diagram from *Exploring Geology* (Reynolds et al.)

- Just as in other aspects of learning, what students see and learn is built on what they already know.

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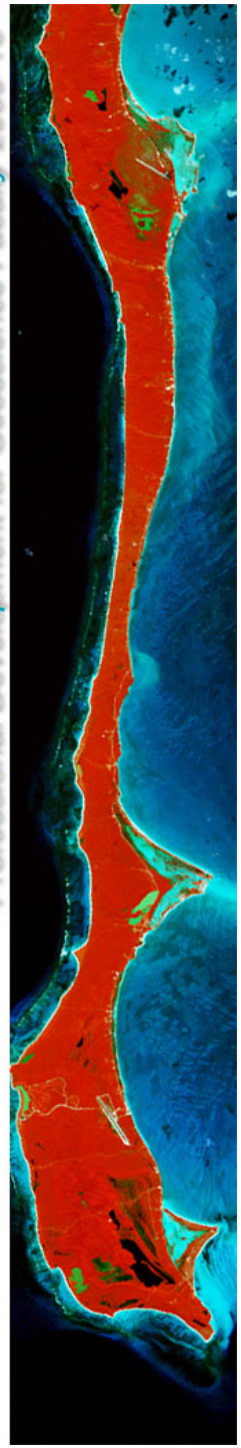
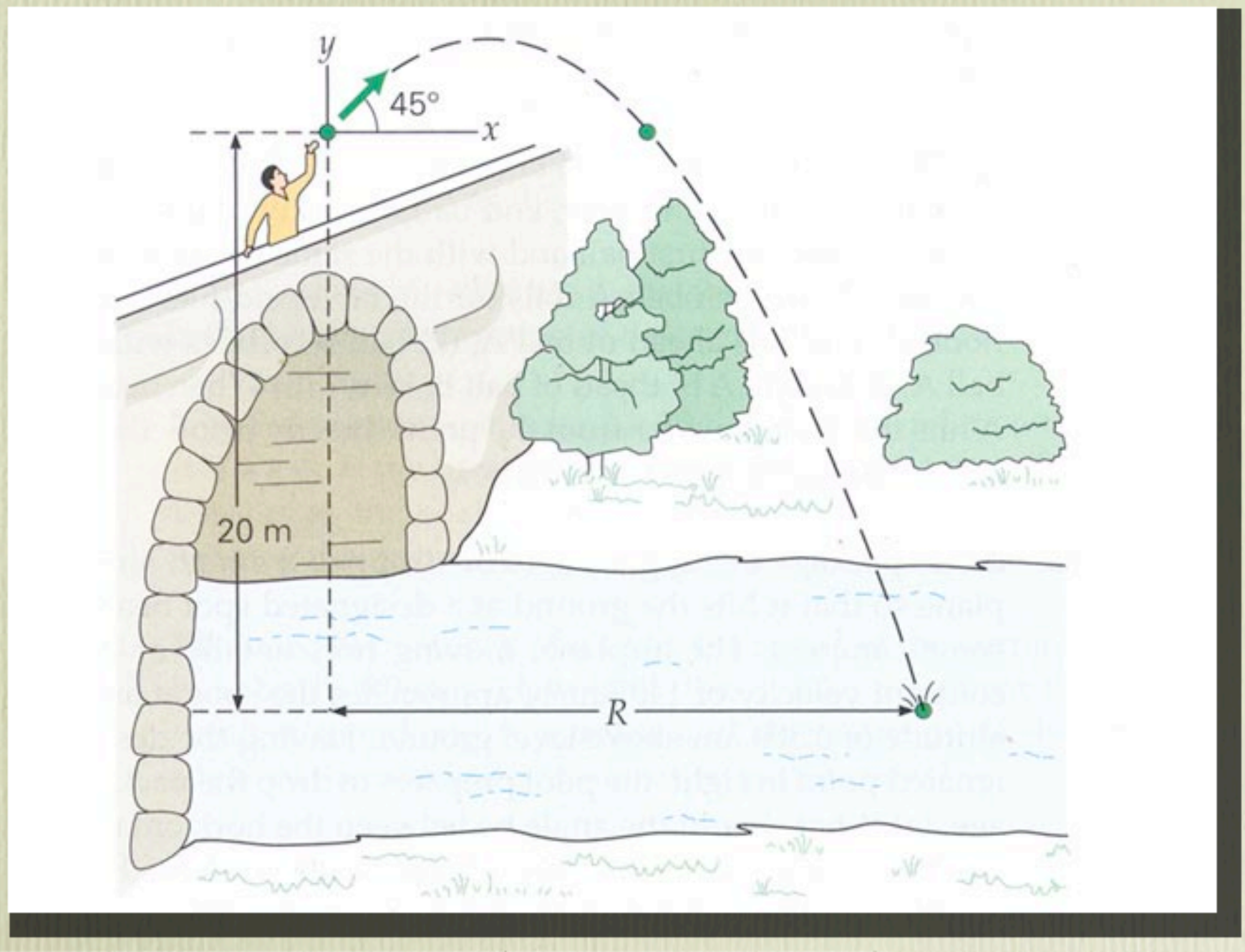


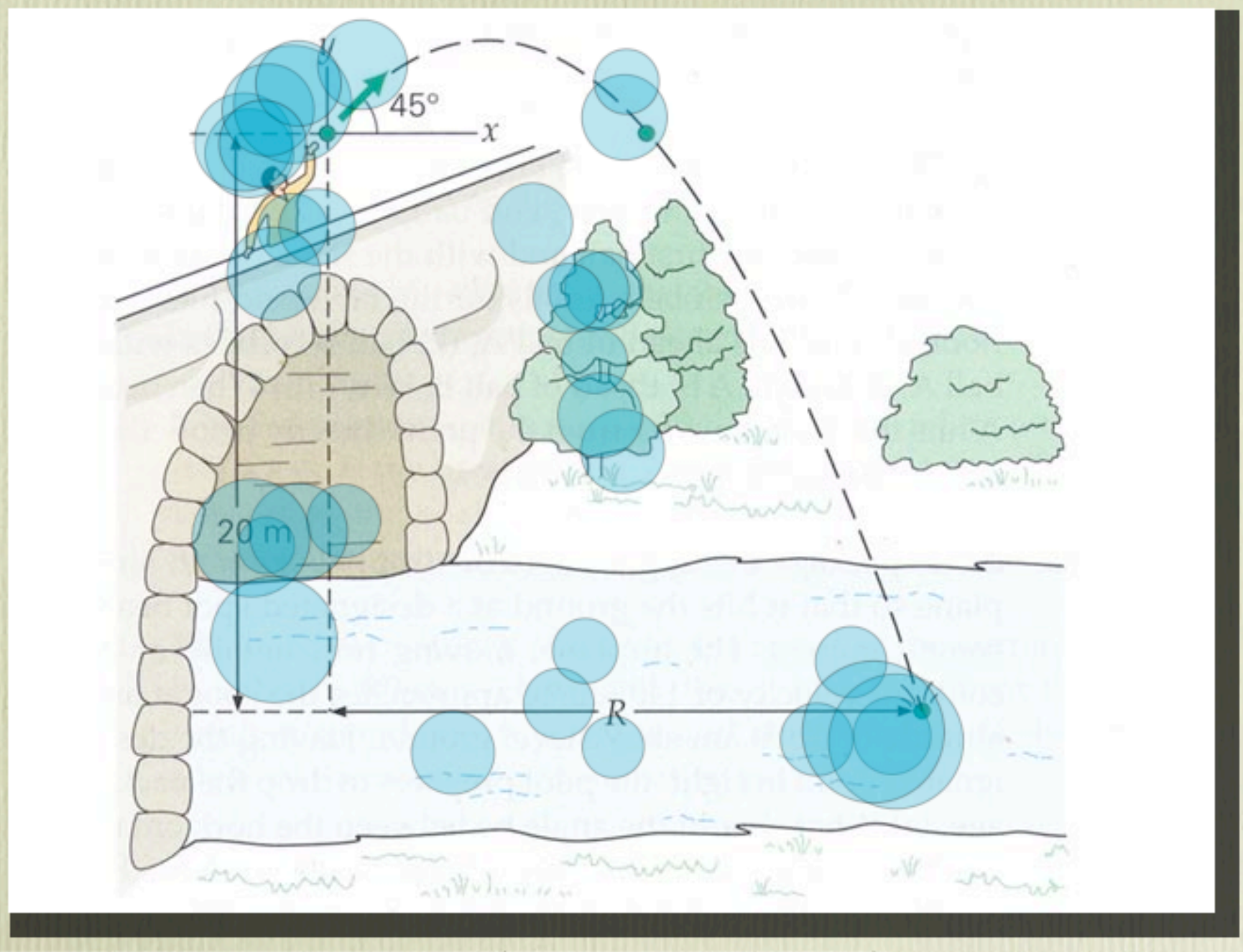
3. Simple is usually* better

The power of visualizations comes from their ability to **clarify** relationships rather than from reproducing exactly the natural world. Thus, a design which emphasizes the desired relationships or information is likely to be more successful than one that makes every effort to be realistic. (Uttal et al., 2006)

*Over-simplification can create misconceptions
*Realism is helpful in some cases



Wilson and Buffa, 5th Ed. (Prentice Hall, 2003)



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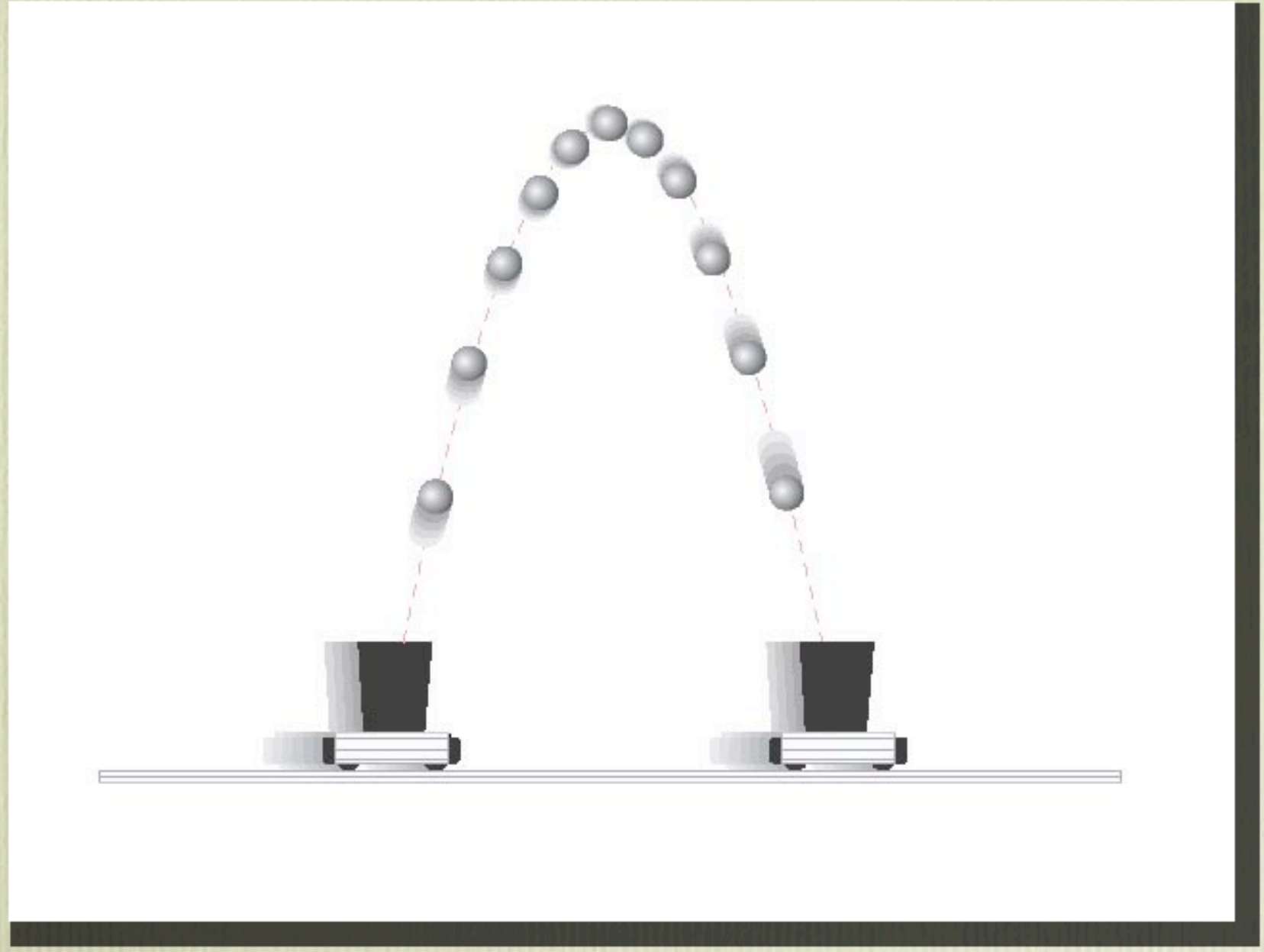
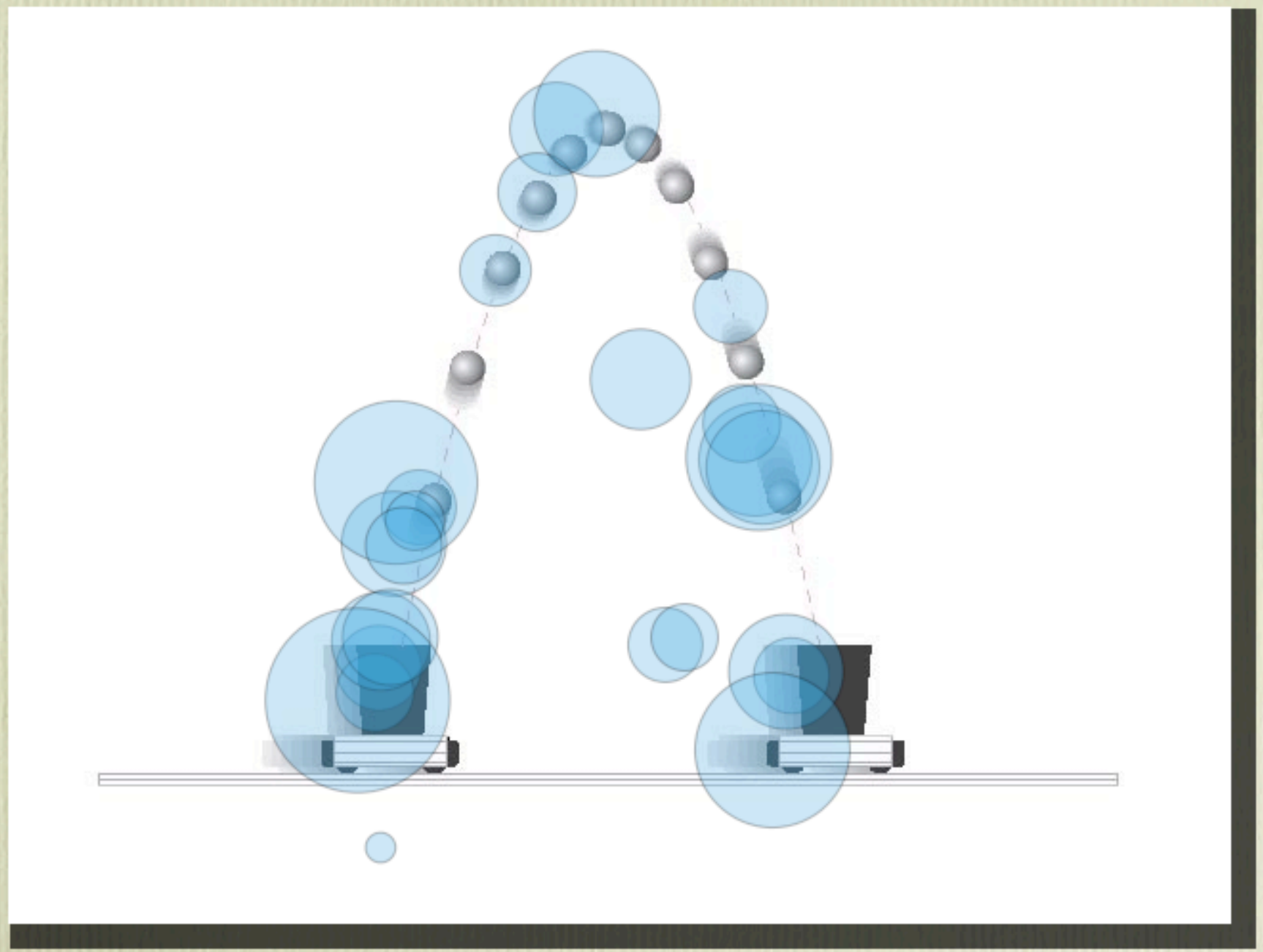


Mazur (Prentice Hall, 200?)



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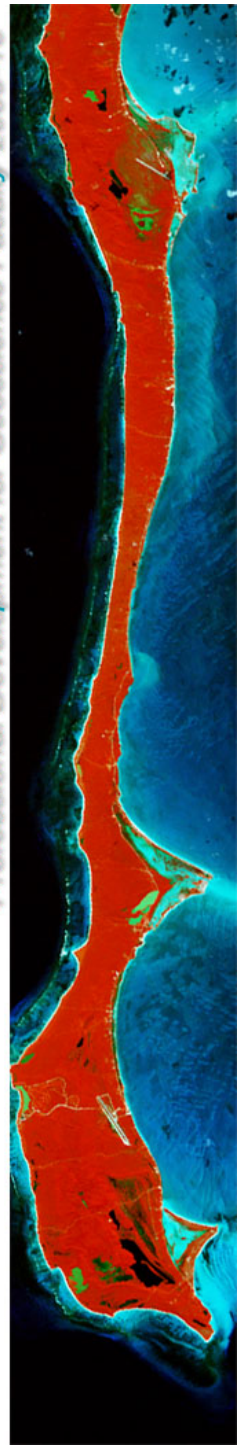
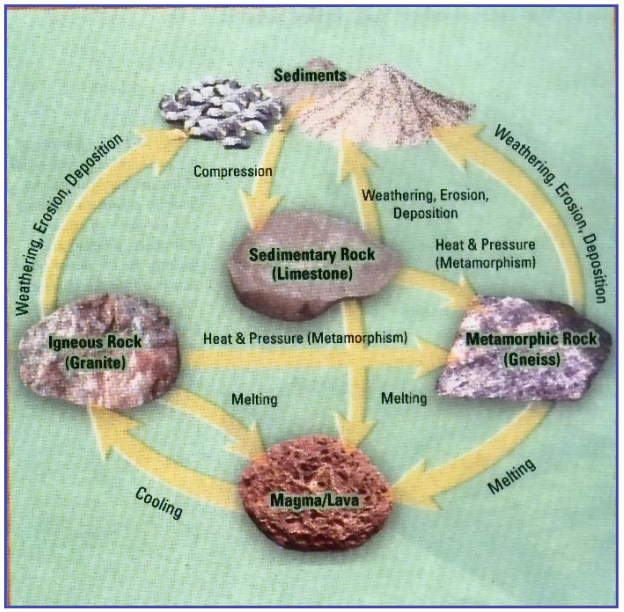


4. Context is important & is easily lost

- Effective visualizations maintain the contextual relationships between the different parts of the visualization and between the visualization and whatever it represents.



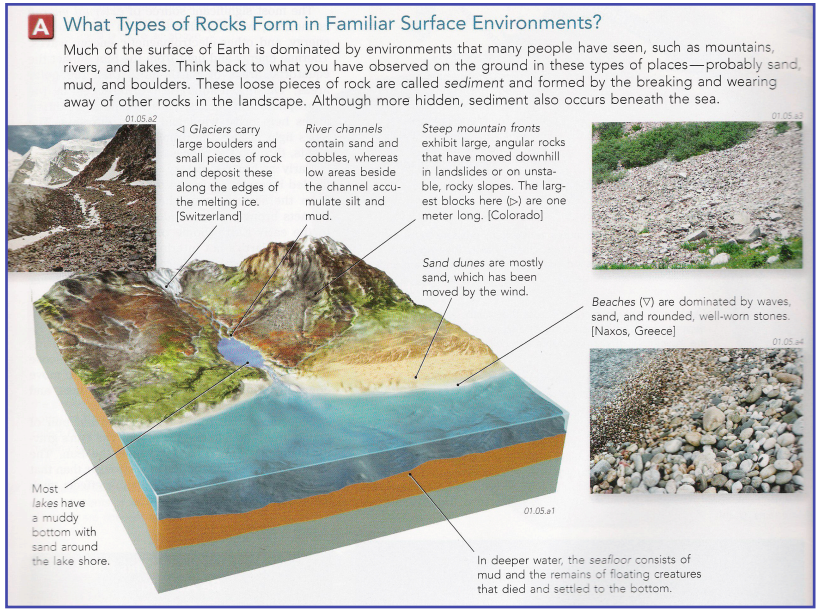
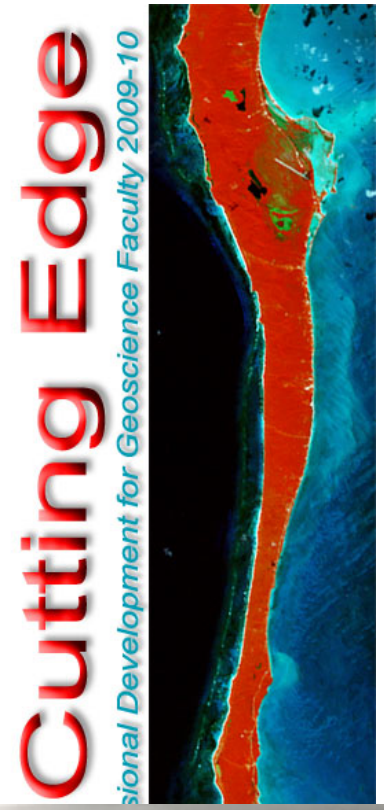


Diagram from *Exploring Geology* (Reynolds et al.)



5. Consider the mental model you want students to construct

- If you want students to create a series of still images in their mind to represent a geologic process, a series of still images will be most effective in conveying information. Similarly, if students create a mental movie, an animation may be more effective (Tversky et al., 2002).

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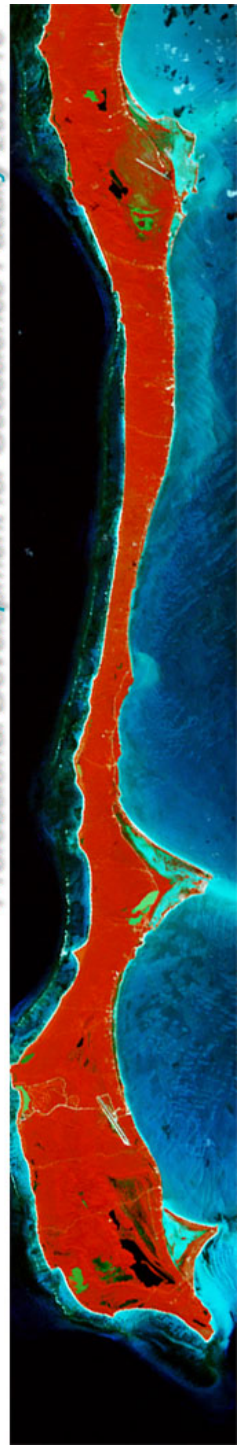

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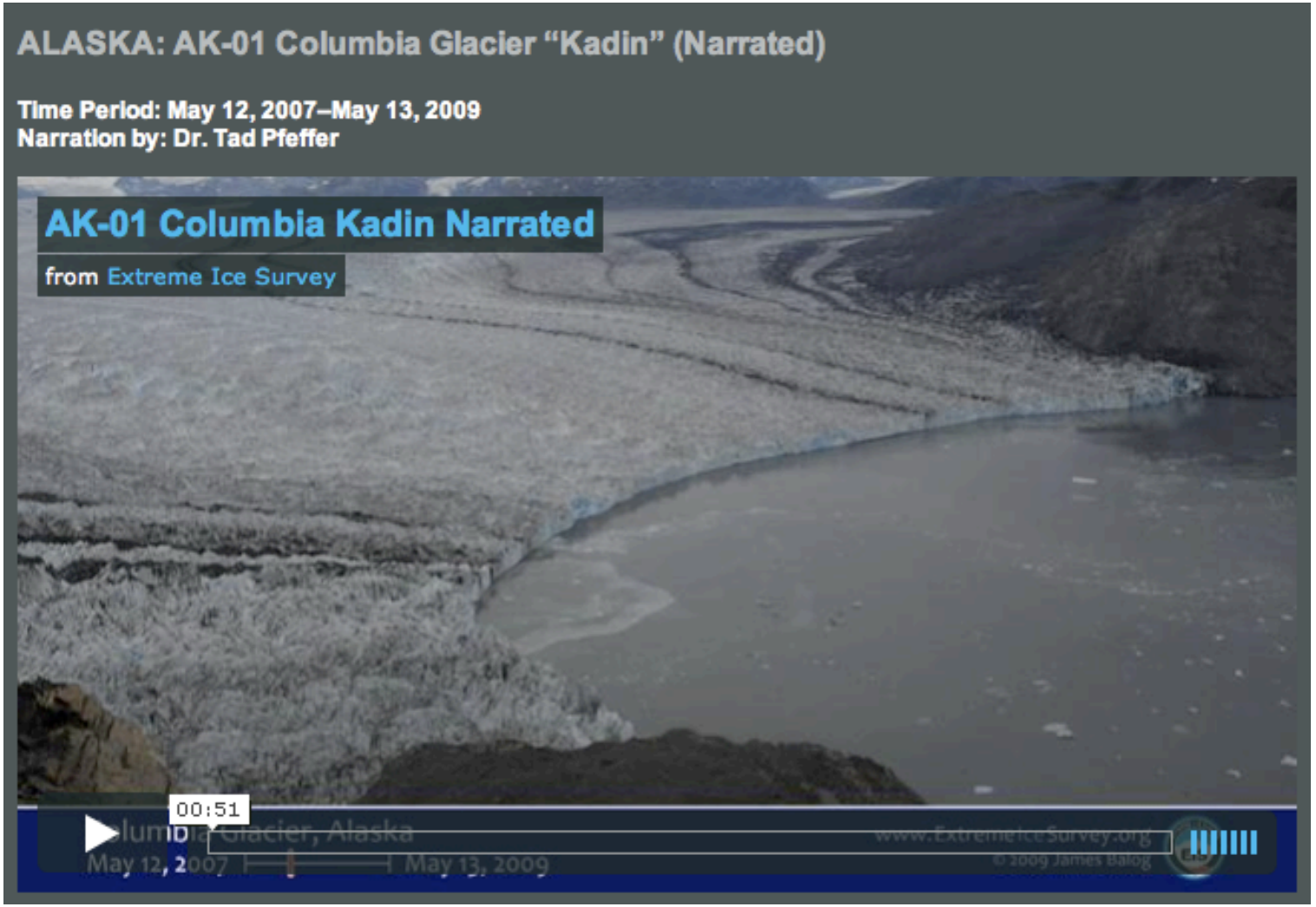

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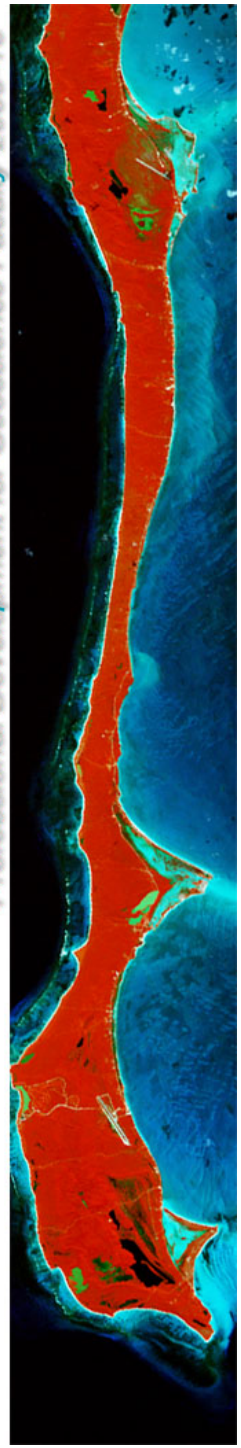


6. Guidance helps

- Visualizations present a large number of relationships at a single time.

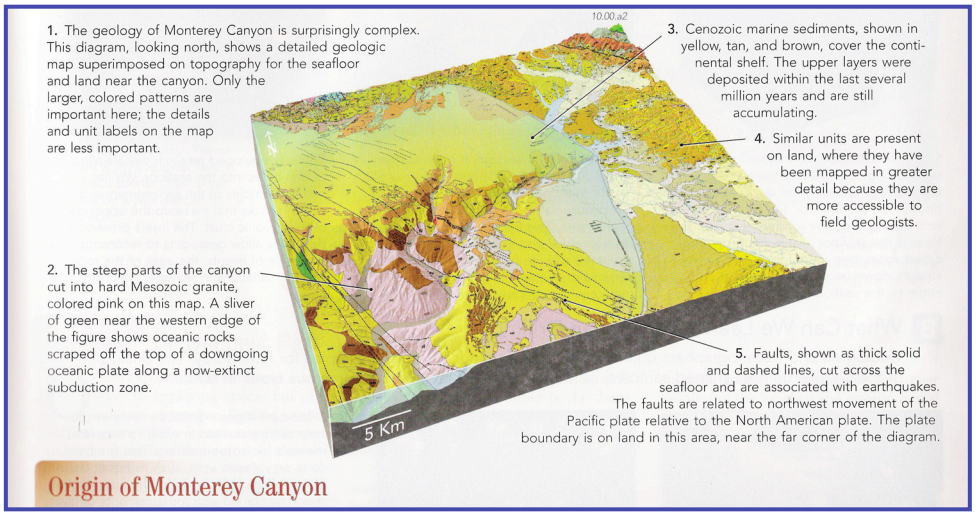
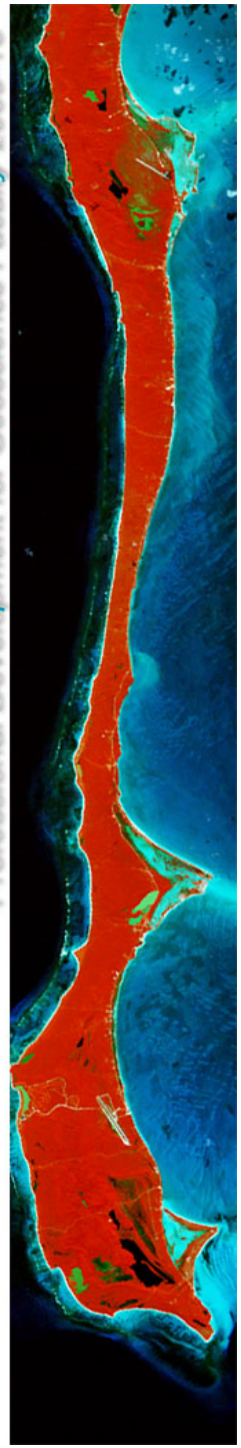


Diagram from *Exploring Geology* (Reynolds et al.)

Visual or textual clues can focus attention on meaningful items or guide the learner through the visualization in a particular order.



Affective impacts of using visualizations

- Illustrations elicit emotional response (i.e. Al Gore's CO_2 graph)
- Using visual tools provides a welcome break from traditional lecture

Image from Wikimedia Commons

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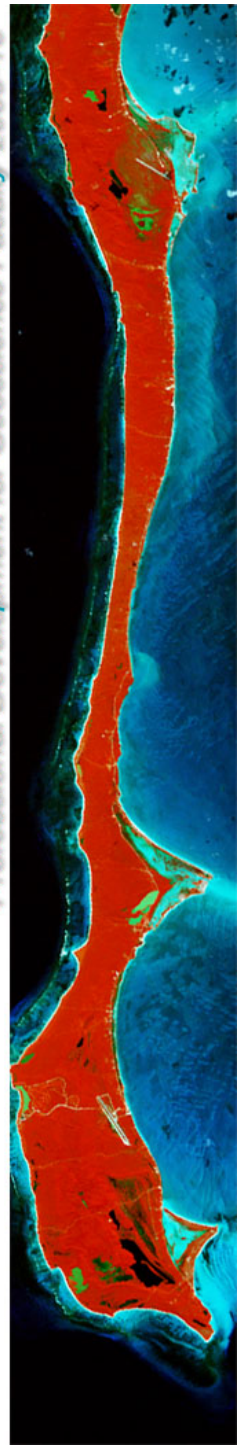

Affective impacts of using visualizations

- Interactive nature lets students be in control (Reeve and Jang, 2006)
- Allows students to explore, hypothesize, play
- Students can see their effect on a larger picture (i.e. their own data set as part of larger data series)
- Today's students are comfortable with technical media; many will appreciate activities that take advantage of technology
- Poorly chosen visualizations can lead to frustration

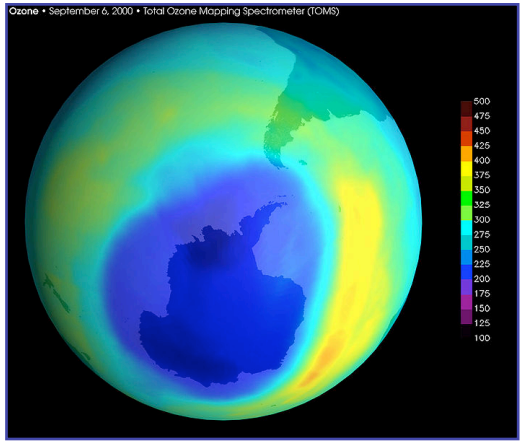

Image from NASA

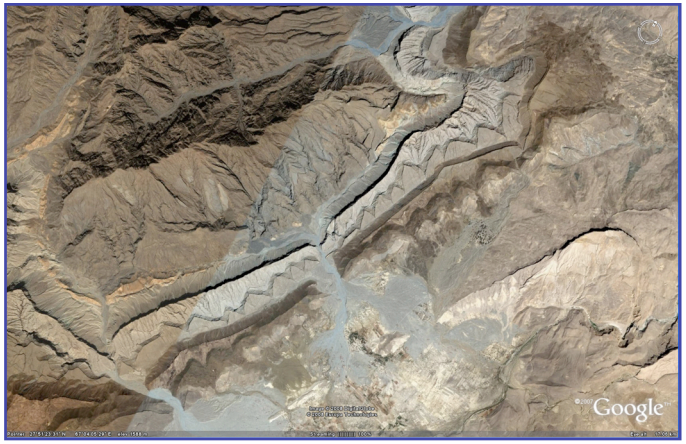

Image from Google Earth

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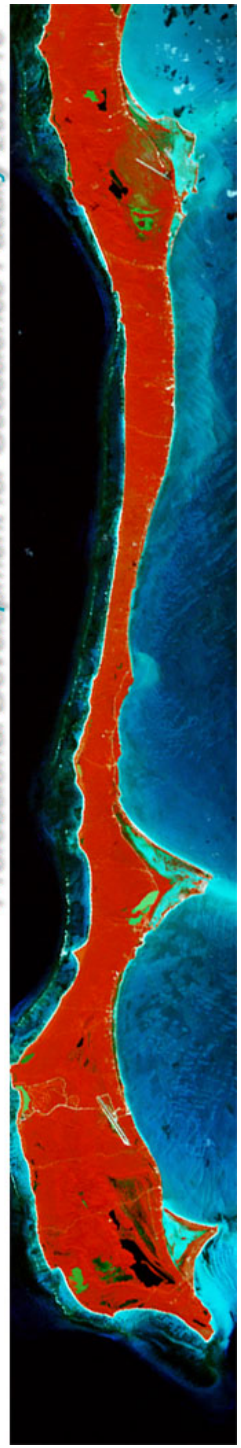

Evaluating visualizations for use in teaching

1. Does the visualization
   - Fit my learning goals?
   - Build on what students already know?
   - Clearly illustrate the concepts at hand, including contextual information?
   - Emphasize or isolate the key concept?
   - Contain sufficient arrows, labels, scale and other information so that students can orient themselves?
   - Match the mental model I want students to create?
   - Help students overcome common areas of difficulty?
   - Allow students to work with data and manipulate the imagery to create a deeper understanding?
   - Allow opportunities for reflection, discussion, and synthesis?
2. In what context(s) can I use this visualization? (illustrated lecture, interactive lecture, lab activity, independent exploration, reflection/synthesis, assessment)
3. What kind of scaffolding, guidance, or instructions will I need to provide along with the visualization?
4. How will I assess whether the students are achieving the learning goals?

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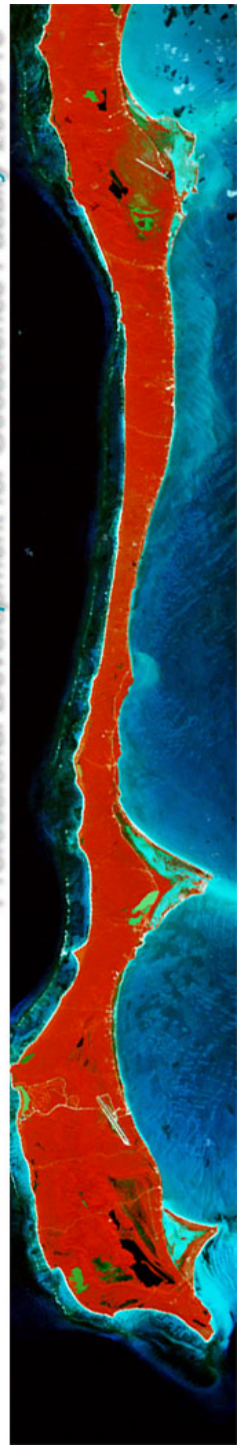
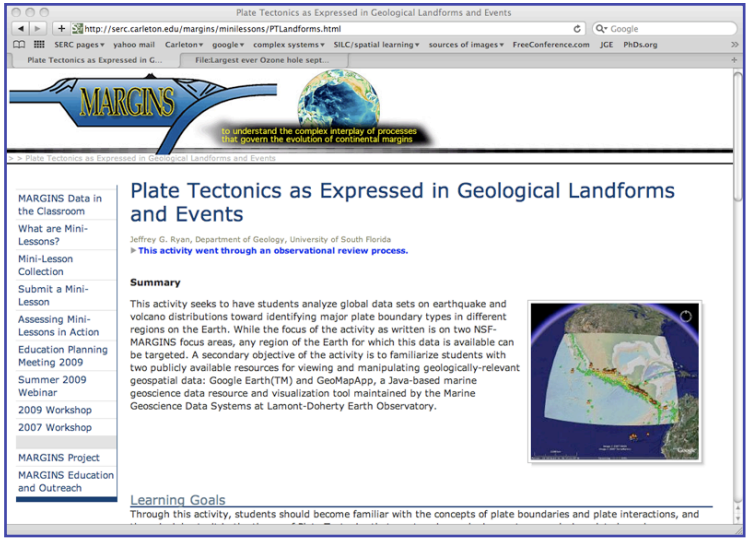


Resources on our website

- Collections of visualizations
- Collections of activities using visualizations
- Recommended readings and an annotated bibliography
- Workshop program
- Links to Teaching with Google Earth, Teaching with Data, Simulations & Models, & other related sites
- Share your favorite visualization or activity



http://serc.carleton.edu/NAGTWorkshops/visualization