Workshop to Define Student Collaborative Climate Research

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http://www.pages.drexel.edu/~brooksdr/DRB_web_page/NSFWorkshop/

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Goal and Objectives

Goal: To provide specific guidance for engaging students, teachers, and scientists in authentic collaborative research about Earth's changing climate, one of the major science topics for the 21st century.

Objectives:

1. Define what it means for students, educators, and scientists to conduct authentic collaborative climate science research and examine the role of student climate-related research in high-quality science education.

2. Define climate-related research areas that are of interest to the climate science community and that can be conducted by students and their teachers, in collaboration with scientists.

3. Within promising research areas, define specific collaborative research projects in sufficient detail to guide future development.

Student and Scientist Partnerships

"Student and Scientist Partnerships (SSPs) are a new kind of collaboration between science and education based on the ability of students to contribute to scientific research. These partnerships offer science new ways of extending its community and hold the promise of revitalizing education by infusing authentic science into the school culture."

(cover page) Proceedings of The National Conference on Student & Scientist Partnerships, 23-25 October 1996. NSF/The Concord Consortium/TERC. http://ssp.terc.edu/ssp.html

“research”: definition

1. careful or diligent search
2. studious inquiry or examination; *especially*: investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws
3. the collecting of information about a particular subject

(http://www.merriam-webster.com/netdict/research)

How does “research” differ from “inquiry”?

“Inquiry” is a process:

“Inquiry is a multifaceted activity that involves

- ***Making observations;***
- ***Posing questions;***
- ***Examining books and other sources of information to see what is already known;***
- ***Planning investigations;***
- ***Reviewing what is already known in light of experimental evidence;***
- ***Using tools to gather, analyze, and interpret data;***
- ***Proposing answers, explanations, and predictions;***
- ***Communicating the results.***

Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.”

(National Committee on Science Education Standards and Assessment, National Science Education Standards, p23, http://www.nap.edu/openbook.php?record_id=4962)

My definition: “Research” is the inquiry process PLUS content. You can have inquiry without authentic science research, but you cannot have authentic science without inquiry.

What is “climate research”?

Climate research is any research activity that:

1. Increases our understanding of the current state of Earth’s climate and its interactions within Earth’s systems – atmosphere, biosphere, hydrosphere, lithosphere.
2. Increases our understanding of the forces that have shaped, are shaping, and will shape climate, both natural and anthropogenic.
3. Proposes future scenarios for Earth’s climate, based on observation, historical evidence, analysis, modeling, and theory.

What is “student research”?

- How can we tell if a student activity is “research” or something else, e.g., “learning about” activities?
- The “Is it research?” question: ***“If students do this activity following the prescribed protocol for an appropriate length of time, when they get done, will scientists care whether they did it or not?”***
- If the answer is “Yes,” then the activity *could* be authentic research. If the answer is “No,” the activity may still be valuable for students, but it is not research.
- Student research is an activity that helps participants learn the language and practices of science (the “inquiry” process) and, **at the same time, provides scientifically interesting results.**

What student climate research is *not,* for example:

- "Learning about" Earth's weather and climate.
- Routine meteorological measurements.

  "At first blush, meteorology seems ideal for student involvement until you realize that existing meteorological monitoring is so extensive that students can add little, except where their observations are unique. Examples of the latter are: quantifying atmospheric haze, doing microclimate studies, and making observations, such as in the West Pacific, where other reports are not available." (Tinker, Robert: Potential of Student and Scientist Partnerships. Proceedings of The National Conference on Student & Scientist Partnerships, 23-25 October **1996**. NSF/The Concord Consortium/TERC. http://ssp.terc.edu/ssp.html)

- The "big questions" of climate science, e.g., "Is the Earth getting warmer?"; "Are sea levels rising?"; "Will the polar ice caps melt?"

  These are questions to which climate scientists not only do not have answers, but are not even sure ***how*** to answer them.

Why the focus on student “research”?

- “Research” is different from inquiry and other kinds of hands-on “learning about” activities.
- Research is how scientists learn more about Earth’s climate and this experience should be part of student learning, too.
- Research involves formulating and investigating questions to which answers are not known ahead of time.
- Involvement from scientists is absolutely necessary to ensure that that what students learn about climate is accurate and fair. **Authentic collaborative research in which all stakeholders benefit is the best way to encourage and sustain engagement by the science community.**

Why is science important?

“Knowledge of science can enable us to think critically and frame productive questions. Without scientific knowledge, we are wholly dependent on others as ‘experts.’ With scientific knowledge, we are empowered to become participants rather than merely observers. Science, in this sense, is more than a means for getting ahead in the world of work. It is a resource for becoming a critical and engaged citizen in a democracy.”

(Sarah Michaels, Andrew W. Shouse,and Heidi A. Schweingruber: Ready, Set, Science!: Putting Research to Work in K-8 Science Classrooms, National Academy of Sciences, 2008.)

“Without scientific knowledge, …”

- “The whole [global warming] thing is created to destroy America's free enterprise system and our economic stability.”
  Jerry Falwell (fundamentalist preacher)
- “Global warming -- at least the modern nightmare vision -- is a myth. I am sure of it and so are a growing number of scientists. But what is really worrying is that the world's politicians and policy makers are not.”
  David Bellamy (environmentalist, author)
- “The best thing we can do with environmentalists is shoot them. These headbangers want to make air travel the preserve of the rich. They are Luddites marching us back to the 18th century.”
  Michael O'Leary (Ryanair CEO)
- “Environmental organizations are fomenting false fears in order to promote agendas and raise money.”
  Michael Crichton (author)
- “Some of the scientists, I believe, haven't they been changing their opinion a little bit on global warming? There's a lot of differing opinions and before we react I think it's best to have the full accounting, full understanding of what's taking place.”
  George W Bush (former U.S. President)
- “Much of the debate over global warming is predicated on fear, rather than science… [the threat of catastrophic global warming is the] greatest hoax ever perpetrated on the American people.”
  James Inhofe (U.S. Senator)
- “Climate is gone… [A new Republican House of Representatives] sure as heck [will not pass climate-change legislation that the outgoing Democratic Congress had been unable to pass.]”
  Karl Rove (Republican strategist and former Bush White House official)

Sources: http://www.allgreatquotes.com/global_warming_quotes.shtml, http://www.realclimate.org/index.php/archives/2005/01/senator-inhofe/, www.philly.com

Why is student research important?

- *"Involving the public in the process of scientific investigation… can provide an incredible opportunity to complement… a more rigorous but limited research program."*
- *"People will not rely on scientific information if they don't understand it, or they question the motivation or integrity of the research methods that were used to generate it."*

("Transitions and Tipping Points in Complex Environmental Systems," NSF, 2009)

See the global climate change debate and quotes on previous slide!

Support for student climate research: How are we doing?

- NSF, NOAA, NASA, and other agencies specifically recognize the need to stimulate and support student interest in Earth science to build a future scientific and technical (STEM) workforce. **But…**
- In the competition for students' attention, at least as reflected in what kinds of science are being done in high-level national student competitions, **Earth/climate science is losing!**
- Why? Because there is virtually no supporting infrastructure to encourage authentic student Earth/climate science research.

How is the competition doing (locally)?

- **Biosciences:** a huge institutional and corporate infrastructure to support student research. (Some question whether this represents a “level playing field” for student science research, or amounts to “corporate research” done by students.)
- **Mathematics/computer science:** a continuous, intensive math curriculum from pre-school through university. (Today’s students are lucky to get *one* Earth science course in 8th-9th grade and maybe an “environmental science” course. There is still debate about whether to accept such courses as “real” science at the college/university level.)

How is the competition doing (globally)?

- The World Economic Forum ranks the United States 52nd (out of 139) in quality of mathematics and science education (45th the previous year).

  (*The Global Competitiveness Report 2009-2010*. http://www.weforum.org/pdf/GCR10/Report/Countries/United%20States.pdf)

- The "Gathering Storm" committee (National Academies of Science) concluded that "the United States appears to be on a course that will lead to a declining, not growing, standard of living for our children and grandchildren." The most pervasive concern [of the original "Gathering Storm" report committee] was considered to be the state of United States K-12 education, which on average is a laggard among industrial economies—while costing more per student than any other OECD country… **Today, for the first time in history, America's younger generation is less well-educated than its parents."**

  Number one recommendation to reverse this course: "Move the United States K-12 education system in science and mathematics to a leading position by global standards."

  (*Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5,* National Academy of Sciences. *http://www.nap.edu/catalog.php?record_id=12999)*

  National Assessment of Adult Literacy (NAAL):A First Look at the Literacy ofAmerica's Adults in the 21st Century. http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2006470)

Why a “scientific interest” requirement?

- Climate science is changing very rapidly, and even “learning about” activities need to be monitored to make sure their content is accurate and reflects our current understanding of climate and changes in climate.
- “Scientific interest” can take many forms, but without that interest, it will not be possible to sustain high-quality climate-related education or to promote Earth/climate science as an attractive career choice.
- Sustainable scientific interest is motivated and sustained by looking at interesting science questions and engaging in authentic collaborative research.
- Even “learning about” science activities are best developed and implemented in the context of actual research practices, through sustainable scientist/educator partnerships.

Scientist involvement… What should it mean?

"Scientists are an integral part of the SCRC. Scientists' expertise in their areas of specialization, and their strong general science background, are valuable resources to teachers and students. For this [SCRC] project, the primary role of the scientists will be to explain the scientific research process and share and discuss their experiences with students."

OSTP, "A Review of Global Learning & Observations to Benefit the Environment (GLOBE), April 2010. (http://www.whitehouse.gov/sites/default/files/microsites/ostp/globe-report-2010.pdf)

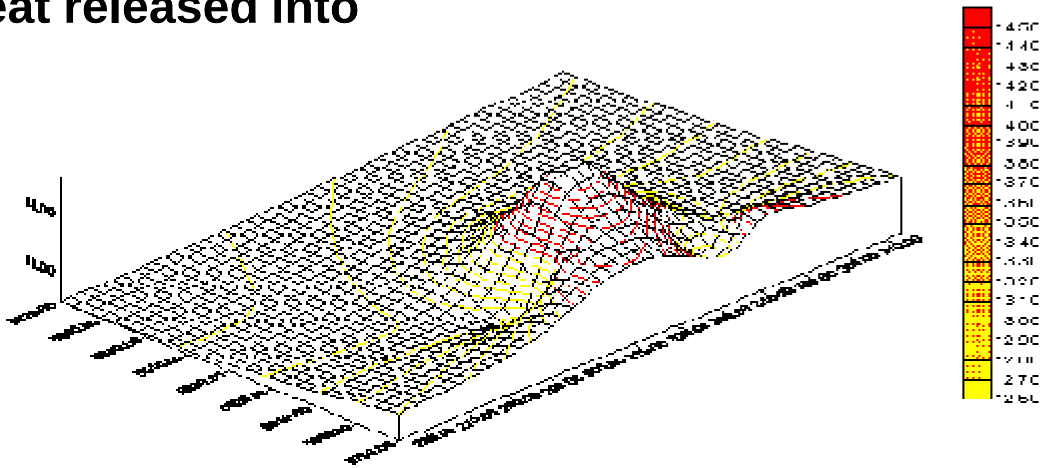
Is this *really* where we want to set the bar for scientist involvement with student research *or* learning? This level of involvement is inconsistent with real student climate-related research.

An alternative vision for student research and scientist involvement

- Student climate science research projects start with interesting questions posed by scientists, who then work with educators and students to design a range of collaborative activities, **including and emphasizing those which meet the "Is it research?" test.**
- Teachers are engaged because **the activities help them meet their responsibilities to address applicable STEM standards**. Students are engaged because there are opportunities for hands-on data collection, experimentation, analysis, and recognition.
- Ongoing feedback and support from scientists includes **an honest and clearly articulated message about why the research is useful** and includes **appropriate instrumentation**, professional development, and **personnel**, as required to implement the project successfully.
- Scientists remain engaged because **student results are unique, interesting, reliable, and genuinely useful for research and/or teaching.**
- Authentic research projects engage a **variety of participants and stakeholders.**

Even basic measurements can be useful if they are done within the framework of a well-defined science objective.

“The warming of the nighttime temperature [even in small towns when they are growing] is due to the Urban Heat Island (UHI) effect, which is the result of two main features of urban areas. First, buildings, roads and paved surfaces store heat during the day, which is then released slowly over the evening due to the thermal properties of the surface materials and the building geometry which traps the heat stored during the day. The second contributing factor to the UHI is due to the artificial heat released into the urban atmosphere by combustive processes from vehicles, industrial activity and the heat that escapes from commercial and domestic air conditioning.”



Mean summer urban heat island effect, 1985-1994, Melbourne, Australia, 1.81ºC

(http://www.earthsci.unimelb.edu.au/~jon/WWW/uhi-melb.html, http://www.earthsci.unimelb.edu.au/~jon/WWW/deniliquin.html)

Projects involving climate observations are very difficult to start and maintain in any fashion that adds useful data to the understanding of long term climate change. The main barrier here is time, followed closely by instrument accuracy.

However, there are a variety of smaller scale studies that can tell an interesting story about climate processes with relatively low cost instruments:

1. Urban heat island - your example below is quite feasible as long as temperature observations take place in a comparable manner at individual locations. For example some schools are part of school-based obs networks, but the instruments are clamped on to the roof or some similarly inappropriate locations. If they are all like that, fine, but the problem comes with inconsistency of siting across a network ... the results would not be spatially comparable. You might be better off driving along the main axes of a town with a car with a good temperature output, rather than use an inconsistent observation network.

2. Land use/land cover and climate - transects of climate measurements can be designed on a very local scale to go across ecotones where there is a transition from one ecosystem to another, or smaller field scale changes where you go from one land cover to another. Fairly low cost instruments can be deployed with the cooperation of the land owner(s); for instance, HOBO temperature instruments, and still allow sufficient accuracy to see the potential impacts of land cover change on temperature, or can be tied in to vegetation gradients. Land cover change can lead to climate change on a local basis. A simple 2-point study would compare the diurnal temperature cycle over an irrigated lawn versus over a non-irrigated lawn ... might be able to get cooperation from a local golf course. Finally, transect near water bodies might also be interesting to characterize.

3. Topographic gradients - like (2), except temperature and precipitation differences across stations located at different elevations and on slope facets facing in a variety of directions.

4. Climate station representativeness - with the cooperation of a climate station observer and the owner of the land where it is situated, set up low cost instruments both at the site and at random locations around the station to see how representative its measurements are of the local environment. In situ measurements are made at a point and some points may be better than others in representing the overall climate conditions of an area.

Studies based on measurements usually come down to spatial gradients in climate, if one does not have many years for a study. The main point is to be consistent in the way one measures, quality of site, exposure of instruments, etc. Other student studies based on using historical climate observations taken by others, or on using simple to complex climate models are also available, if the student has an aptitude for and access to good computers. I do not know if anyone plays around with physical models of climate (like terrariums subject to changing radiation levels, moisture availability, etc.), but I guess that is more of a demonstration of processes rather than an actual science experiment. That would be fun for looking at aspects of geoengineering.

Michael A. Palecki, Science Project Manager, U.S. Climate Reference Network, NCDC, Asheville, NC (email, 11/11/2010

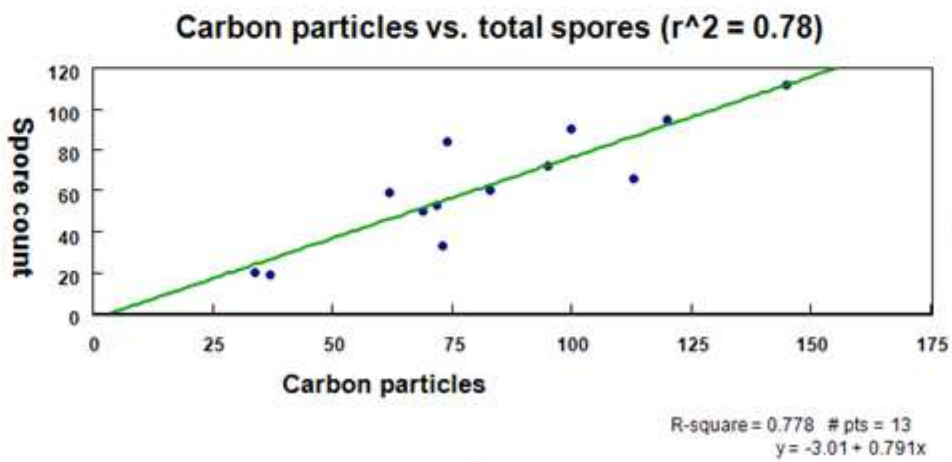
Applications of Temperature and Insolation Data – Not Just For Atmospheric Science

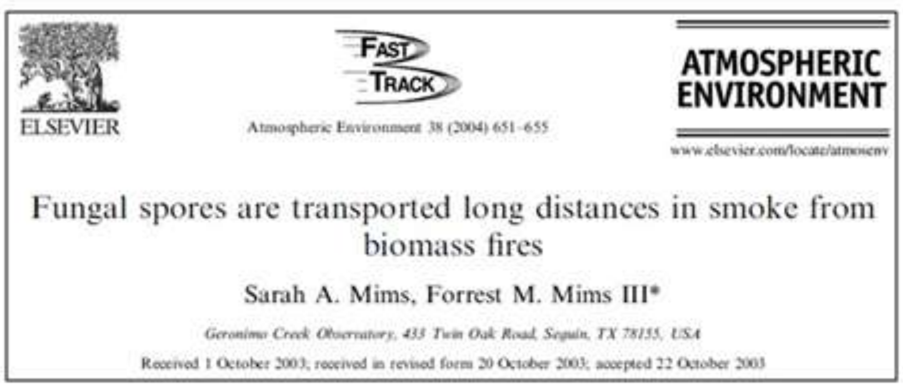
Fire pond at the Schuylkill Center for Environmental Education, Philadelphia, PA
(360 undeveloped acres inside Philadelphia city limits, with woods and open fields).

http://www.pages.drexel.edu/~brooksdr/DRB_web_page/DEP/SEEPeTHome.htm

- Ideal site for urban heat island and other microclimate studies because of its size and proximity to a large urban area.
- Students at Green Woods K-8 Charter School (located on SCEE grounds) track emergence of toads at two ponds on SCEE grounds. The dates of emergence depend on energy input to the system (air, soil, water temperature, plus insolation).
- A classic example of a situation where interesting student climate research could be done. But so far, even though charter schools have more flexibility in designing their curriculum, this school has not yet developed the infrastructure to support such projects.

Unexpected discovery from student research!

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Atmospheric Environment 38 (2004) 651–655
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Fungal spores are transported long distances in smoke from biomass fires

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Students *can* do real climate-related research if:

1. we expect them to do real research;
2. we tell them the truth about what it means to do real research;
3. we provide them with the appropriate type and level of support.

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