Meteorology and climatology education outreach: weathering the education paradigm

AMS 2010 Education Symposium

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Abstract

With the imminent reforms in the nation's education system, the K-12 science education paradigm is beginning to change. We know science professionals have the greatest impact on the minds of young scientists. And yet, despite the eagerness for professional science involvement in K-12 education, well-meaning projects usually fail to show sustainable impact in classrooms. Seeking to find a place for industry involvement in science education reform, the University of Oklahoma's (OU) Educating for Economic Growth project (NSF PFI# 0538924) with OU's K20 Center for Educational Renewal have developed innovative and sustainable approaches for bringing scientists and researchers into K-12 science education. These approaches include creating education, government, and industry partnerships from Oklahoma's weather enterprise, developing a vision for atmospheric science education, preparing teachers and atmospheric scientists for collaborative inquiry-based lessons, and using technology to enhance classroom instruction.

The Weather and Climatology Education and Workforce Development summit, held in 2008 with OU's Social Science Woven into Meteorology (SSWIM) program, provided a unique opportunity to open dialogue on issues of education. Some of the dialogue included frustrations regarding the atmospheric sciences in K-12 education, a need to broaden meteorology as a discipline, and an eagerness to organize and participate in education efforts. This session will report findings from the education summit and the Educating for Economic Growth project, and

introduce how the atmospheric science community can play an active role in 21st century science education and help prepare the next generation of meteorologists and climatologists.

Introduction

In 2006, the University of Oklahoma's (OU) K20 Center for Education and Community Renewal received a three year Partnerships for Innovation grant (NSF# 0538924) from the National Science Foundation to investigate how research and industry networks in biosciences and weather research could enhance STEM teaching and learning in secondary schools (Fig 1). This project, Advancing Biotechnology and Climatology (ABC), created interactions among common schools, community colleges and universities, government agencies, government representatives, economic development agencies, foundations, and private industry. This partnership was tailored to meet the specific needs addressed in Oklahoma's Economic Development Generating Excellence (EDGE) report, a comprehensive statewide study of the state's economic future, and assist Oklahoma, with its many rural areas, to accommodate education, service, research, and development, with the goal of advancing local social and economic opportunities and producing a better trained workforce. As an outcome, the networking would create a more sustainable infrastructure for advancing innovations in technology, climatology and biotechnology.

The K20 Center is a large education research center with a focus on K-12 whole school reform, technology integration, and advancing math and science education. The K20 Center develops it's programs on a three-phase model of teaching and learning, beginning with school principals and administrators, whole faculty professional development with technology integration, and authentic learning with an emphasis in science, technology, engineering, and

mathematics (STEM) education. The K20 Center works with a network of nearly 800 schools across the state of Oklahoma. In it's twelve year history, the center has received over $40 million in grants from the Bill and Melinda Gates Foundation, National Science Foundation, US Department of Education, and others.

The ABC project, modeling OU's Sasaki Applied Meteorology Research Institute (SAMRI), worked with the Oklahoma biosciences industry sector to develop OKBio, the Oklahoma Biosciences Association, an organization to support the growing industry in central Oklahoma. Through a common vision for biosciences education reform, several group members, with added resources from a second foundation grant, would sponsor a K20 expert teacher liaison, several Oklahoma high school biosciences curriculum programs, summer camps, and student and teacher field trips. Using research from the K20 Center on authentic learning strategies and inquiry-based science instruction, these biotech schools demonstrated a science teaching reform model that connected science experts, expert teacher liaisons, and science teachers to create engaging and relevant inquiry based science lessons (Fig. 2) that were successfully incorporated into the regular science curriculum. This triadic model, combined with the education and workforce vision of industry stakeholders, provided a sustainable means for advocating biosciences career pathways while meeting the educational needs of Oklahoma high school students.

The ABC project had envisioned creating a similar model to develop several meteorology and climatology high school programs using the inter-organizational networks of SAMRI along with the K20 Center's triadic science reform model. SAMRI's mission was "to foster and support the development of new applications for weather and climate information for the operational

community, especially in decision-making processes." SAMRI acted as an interface between University programs and the wider community working with its consortium members to identify the needs of the private meteorological community and other operational entities and identify the research and development capabilities of the University's weather and climate programs that can meet those needs. The ABC project intention was to connect the consortium members of SAMRI around a central vision for weather and climatology education.

While OKBio developed into a successful support group for the growing Oklahoma biosciences industry, SAMRI was incorporated into a business development unit of the University of Oklahoma and moved away from a support or association model. Without a clear inter-organizational support structure, developing a common vision for education reform from the Oklahoma meteorology community proved difficult. This prompting the ABC project to support an extensive and ongoing inter-organizational network study of the Oklahoma weather enterprise[1].

As a final project of the ABC grant and in an effort to prompt the meteorology community to begin working towards a common vision for weather and climate education in Oklahoma, in partnership with OU's Social Science Woven into Meteorology (SSWIM) organization, the ABC project organized a Weather and Climatology Education and Workforce Development Summit on the Research Campus of the University of Oklahoma. Using the meteorology networks created by the three-year PFI project, 40 individuals, representing nine weather organizations and five affiliates, opened discussions focused on K-20 education, public literacy, policy and workforce needs. The proceedings from the summit reveal a profound need

[1] As of this writing, the inter-organizational network study was pending completion.

for the weather community to take an active seat on the public education debate, rethink meteorology higher education, and redefine funding policies to insure a citizenry adequately prepared for taking responsible action in light of advance weather warnings. These findings can support the move towards a common vision for meteorology and climatology education and best practices for locally supporting education efforts.

This paper outlines a model for weather and climatology education reform based on the the results of the three-year ABC project, the summit proceedings, and the work of the K20 Center.

K-12 Science Education

The PFI project revealed a significant role for meteorology and climatology on the nation's science education curriculum. The research of the K20 Center and findings from the biotech project schools reveals lasting and significant gains in science knowledge when science is based on authentic (real-world) issues, has direct connections to local research and development efforts, and is rooted in inquiry-based learning. For educators fixed on a textbook paradigm of teaching, bringing authenticity into classrooms has proven challenging. The K20 Center has repeatedly found science teachers prepared through textbook-centered pre-service training struggle with inquiry-based strategies in science curriculum. While current pre-service teacher education programs are beginning to address these inconsistencies, the K20 Center has found whole school reform and in-service teacher support strategies are needed to assist teachers as they develop the skill sets to develop authentic and inquiry based lessons.

The K20 Center has found science education reform is best served through development of three-part networks consisting of science experts, expert teachers liaisons, and in-service science teachers (Fig. 2). Science experts are generally scientists, but may include highly qualified technical content expertise. Expert teachers are teacher-mentors that have previous experience working with science experts and creation of authentic and inquiry based lessons. In-service science teachers are teachers currently teaching in schools that are moving from textbook-based science to authentic and inquiry based approaches. In this triad, expert teachers work directly with science teachers in workshops and research experiences to create standards-based lessons based on authentic content provided by science experts. Expert teachers work directly with science experts to shape an understanding of the educational needs of the teachers. Science experts then provide authentic experiences for the science teachers through research experiences and field trips. The outcomes of the triadic relationship are standards-based inquiry lessons grounded in authentic real-world experiences. The authenticity is enhanced through the use of science content that is both relevant and local to the lives of the students.

Development of this triad revealed through several important findings by the K20 Center and PFI project. First, the disciplinary differences between the science experts and science teachers revealed numerous communicative constraints to effect collaboration. Providing expert teachers as liaisons that could bridge the two domains provided an ideal strategy for science teachers to begin incorporation of authentic science into curriculum. These expert teachers were needed on a long-term basis as science teachers would sometimes take years to develop the necessary skill sets to work independently with science experts. Second, direct involvement of science expertise in both teacher professional development and in-classroom contact provided a

significant difference in science education outcomes. Teachers are able to see the value and significance in inquiry-based science education. Students make lasting connections when science is made relevant through face to face contact with local science expertise, even when the contact is virtual. Importantly, content expertise added to classroom experiences without consideration for local educational needs fails to become sustainable.

The role of the expert teacher is critical to the success of the triadic model. Schools present unique challenges to incorporating science content that both meets state educational standards and is authentic and relevant. Teachers are not adequately prepared to incorporate cutting edge science content, nor engage the technology often used to access and utilize the content. Science teachers are prepared in the use of textbooks to teach science with little, if any, experience in authentic science. Time and student achievement mandates constrains incorporation of innovative and engaging content and teaching strategies. As such, engaging science often becomes relegated to after school programs, summer camps, and day trips unrelated to standard science curriculum. The expert teachers are able to guide both the content expert in how to tailor content to educational needs and in-service teachers in how to develop lessons that meet educational standards without overly taxing time constraints.

Finding authentic science experiences that are relevant to all students can be challenging. In preparation for the PFI grant, the K20 Center and PFI project identified two authentic experiences that would have particular relevance to the lives of Oklahoma secondary students: biology and weather. Like many states, Oklahoma has specific biology education standards. Also like many states, Oklahoma has little weather and climatology standards. Oklahoma weather instruction does have a place in K-12 education through hazardous weather education efforts, as

well as summer programs offered through the Oklahoma Climatological Survey. Other K20 Center STEM education programs have found in-service teachers working in the science education reform triad have been able to develop lessons involving weather and climatology, specifically addressing Oklahoma educational standards in physics, chemistry, and critical thinking skills.

The triadic science education model can be used to successfully incorporate meteorology and climatology science lessons into science curriculum that is engaging, authentic, inquiry-based, and meets state-specific education standards. It remains for the meteorology and climatology enterprise to meet the challenge of engaging expert teachers as liaisons and providing content experts that demonstrate a common vision for science education that aligns with state and national education standards.

Need for Industry Dialogue on Education

The national dialogue on educational change has included voices of concern from many industry groups that require a skilled and educated workforce. A downward trend faced by the United States in international educational rankings, recently spotlighted in Thomas Friedman's *The World is Flat* (2005), has propelled numerous state and national initiatives aimed at improving student achievement and encouraging youth to pursue STEM careers.

Engineering organizations have been one of the most vocal, prompting discourse that has led to publications such as the National Academy of Engineering's *The Engineer of 2020*, and national educational outreach efforts such as FIRST Robotics. Initiatives can be found in many

states and are often tied to regional industry needs. Many efforts are not necessarily to mitigate a shortage of engineers, but to raise the caliber of graduates. As explained in the *Engineer of 2020*, the roles and responsibilities of engineers require new abilities to adapt quickly to evolving technologies and increased soft skills that require greater ability to communicate, collaborate, and understand user needs. The engineering profession recognizes many of these necessary interdisciplinary skill sets, in addition to strong math and science, begin as early as elementary school. The industry has prioritized the need to influence K-12 and college education and has initiated efforts to effect policy changes in the the nation's education system. For example, the aerospace engineering industry in Oklahoma has prompted legislation to ensure future workforce needs are being met.

Communication research suggests soft skills in science and engineering communication should be recursively developed through repeated interactions with the public and through cross-disciplinary collaboration. For science and engineering industries, outreach would provide hands-on development in communication and collaboration. While not researched, but as expected, content experts working with in-service science teachers increasingly showed collaboration competence through repeated interactions. Specifically, the scientists ability to communicate their scientific research to non-science audiences were notably improved over time. This could lead to increased opportunities for cross-disciplinary research and development opportunities, assist in broader impact requirements for grants, and bring broader public understanding to the science.

The national biosciences industry closely parallels engineering with regards to a vision for education. The industry has created the Biotechnology Institute (http://

www.biotechinstitute.org/) to support national and state biosciences education initiatives. The institute has drafted guides for state industry associations to create and support local education efforts. The institute also hosts national bioscience education conferences and provides scholarships to and events for educators and students at the large industry sponsored biotechnology conference, the Bio International Convention.

Engineering and the biosciences comprises large economic sectors, multiple large and small firms in nearly all states, and commands a large percentage of STEM college majors. Such large and extended networks would seemingly find it difficult to find a common voice for national initiatives, and yet both sectors have fostered a common vision for education challenges. Both sectors regularly address education needs in national conferences and support policy and funding initiatives that insure a workforce adequately prepared to meet the future of their industries. With a unified voice for education and workforce needs, the sectors command a significant voice in education research, innovation, and policy.

It may be presumptuous to assume every industry needs a voice in workforce preparation, but as national education paradigms are being questioned and new policies for student achievement are being drafted, it is in the best interest for any industry with unique workforce needs to engage the education debates. Science education, in particular, will increasingly have a role for authentic experiences for students based on real world research and development to both increase student achievement and engage interests in science and math careers. Meteorology and climatology, regardless of workforce needs, has a particular place in providing relevant opportunities for science education. Weather already has a place in much public education through the need to provide hazardous weather information. Changing public behavior in the

light of climate change is on the horizon. Meteorology and climatology has a unique position in public education to tie current informational programs with science education. This opportunity to make environmental science education relevant through local weather and climate information should not be missed, but needs the support of a national vision democratically supported throughout the meteorology and climatology industry.

Industries that have actively engaged the education sector have come prepared with a unified vision for workforce needs, authentic science experiences developed with the assistance of educators, and availability of content experts prepared to engage students and teachers. The K20 Center has found successful industry engagement that leads to higher student achievement and sustained interest in STEM careers occurs when expert educators, supported by the industry, are made available to teachers to develop authentic and relevant inquiry-based lessons and to content experts to assure content knowledge and educational needs are matched.

The Weather and Climatology Education and Workforce Summit

The Weather and Climatology Education and Workforce Summit was held to create a dialogue within the weather and climatology enterprise to consider education issues that will inform and influence community, state, and national educators and policy makers with regards to weather and climatology education and preparedness. Participants were asked how the weather enterprise could (1) support the Atmospheric Science Literacy Framework, (2) better prepare citizens for interpreting forecasts and preparing for weather events, and (3) best prepare a future meteorology and climatology workforce.

The summit acknowledged both the work of UCAR's ASCL Workshop held in November 2007 and the Oklahoma Climatological Survey's (OCS) outreach efforts in public education. Sponsored by the OU's K20 Center, NWC's Social Science Woven Into Meteorology (SSWIM), and with funding from the OU's NSF Partnerships for Innovation grant (NSF# 0538924), the summit opened with presentations from Quyen Arana, the Associate Director for Industry Partnerships at the K20 Center, Renee McPherson, director of the Oklahoma Climatological Survey, and John Snow, Dean of the College of Geographic and Atmospheric Sciences at the University of Oklahoma. Quyen Arana provided a educational backdrop for the summit presenting the work of the K20 Center and the ABC project. Renee McPherson provided an overview of OCS, and in particular EarthStorm, the OCS K-12 outreach program. John Snow provided background on the UCAR ASCL Workshop and the development of the Atmospheric Science Literacy Framework.

The afternoon dialogue was structured to maximize input from all participants by having them evenly disperse into 5 groups then rotate through tables to discuss predetermined topics: K-12, Higher Ed, Public Literacy, Workforce, and Policy Issues. Participants were asked to reflect upon (1) supporting evidence, (2) obstacles and (3) next steps. Each group designated a recorder to take group notes on paper tablets left at each table. In addition, a student scribe sat at each table to take notes of the conversations. A moderator allotted each group 10 minutes per each table before rotating to the next. Newly rotated groups reviewed the previous group's notes and provided further comments. Shared consecutive notes were generated by participants on paper tablets and recorded by student scribes. The last table reported out significant issues and possible next actions. A brief discussion involving all participants followed.

Results

Recorder and scribe notes were reviewed. Notes written by the recorders were considered dominant with scribe notes supplementing and clarifying. Results from each topic are described below.

1. K-12 Education

Obstacles to meteorology education in K-12 focused primarily on formal science education. Participants recognized the lack of national standards for meteorology but acknowledged there appeared little room to add content beyond core science topics. In addition, without standards, teachers have little formal pre-service education in weather topics (earth science curriculum was acknowledged but participants felt meteorologic topics were lacking). A dearth in meteorology k-12 education likely was part in blame for common career misconceptions, such as a focus on broadcast meteorology and storm chasing. The lack of good meteorology teaching resources was noted.

Outside of formal education, current K-12 education outreach is often sporadic and limited to a focus on weather safety.

Participants acknowledged getting meteorology standards into schools should be a priority, yet may be long coming with so many other issues in education (mentioned issues included academic accountability, teacher pay, science education accountability, adequate

science teacher preparation). Short term solutions included increasing outreach from weather professionals and NOAA. Specific suggestions were field trips, investment in new media, getting more schools involved, and teacher workshops. Participants acknowledged the meteorologic community should support education funding and policy initiatives. Education and outreach should utilize NOAA's current Atmospheric Science Literacy document.

2. Higher Education

Participants began by questioning whether K-12 was adequately preparing high school graduates for undergraduate meteorology studies. Also, high school and undergraduates are often misinformed regarding the high math and physics prerequisites needed to be successful. Within the meteorology program, washout may also be from core classes coming late in the program (3rd/4th year) and lack of hands-on classes (field work, real-time forecasting).

Antiquated core requirements or too much specialization may also be an issue. This could be addressed by looking at future workforce/graduate needs to reveal a broadening of the discipline, specifically to incorporate more environmental sciences and provide flexibility for graduates to enter other similar fields.

It was suggested meteorology students could further their own education and experiences by contributing to weather K-12 education and public literacy. Increasing internship and summer experience opportunities was suggested.

3. Workforce

Within the current meteorology workforce two primary issues were discussed: (1) application of meteorology to society and (2) informatics. It was noted the current workforce is struggling to make weather information applicable, specifically regarding societal behavior to forecast and events, communication, perceptions of meteorology, and economics. Participants noted the increasing complexity of forecasting is causing greater demand for meteorologists skilled in programming, communications technologies, and GIS. It was suggested continuing and professional education would assist needs in current workforce.

Workforce saturation was noted. Participants noted this could be assisted through increasing interdisciplinary training to broaden the field, especially towards environmental sciences. With interdisciplinary education, meteorologists could look to careers in energy management, hydrology, computer science, environmental prediction, and climate change. Nonetheless, current students should be made aware of workforce saturation.

Participants suggested the workforce should engage in stronger outreach to assist in preparation of next generation workforce, both in K-12 and higher education.

4. Public Literacy

Discussion regarding public literacy began with a focus on the "message". NWS terminology was acknowledged to sometimes be misunderstood (particularly "watch" vs "warning"), complex (yet, do not "dumb down"), difficult to find and inconsistent. The group turned to education and training initiatives as a means to improve understanding. These included

K-12 education, public messages (advertising), use of recent weather events to inform the public, and creative ways to relay information (social networks, games). Use of Emergency Management networks and partnerships should be considered, with particular attention to issues of diversity (language and ethnicity).

Public literacy efforts were acknowledged to lack organization and vision. Participants noted change will require public literacy become a government priority, take leadership and receive adequate funding.

5. Policy Issues

Participants noted weather and climate education begins at two levels: (1) general climate and weather education, and (2) hazardous weather education (weather safety). Responsibility, the underlying theme within the policy conversations, for the climate and weather education was noted to be with educators. It was noted NOAA has been increasingly playing a advisory role, seen with the release of the most recent Atmospheric Science Literacy standards.

The policy discussions largely were framed within the later, responsibility for hazardous weather education. Three primary stakeholders were suggested: government entities, the media and individuals. NOAA was acknowledged to have a mandate to educate (albeit, with limited or no funding). Hazardous weather education was also noted largely to be a local issue, as weather events tend to be geographically specific. In the local context, hazardous weather education should require coordination of regional NWS, state and local education and community agencies,

and local Emergency Management (EM). It was noted that weather safety is often taught in K-12 and we should not underestimate the ability of children to inform parents of weather safety.

Due to the lack of consistency with regards to local weather education, differences in the level of hazardous weather education in communities is likely. It was suggested community awareness of weather safety should be researched and community profiles created to determine best practices. It was noted that regardless of the education provided, responsibility to act upon a warning is in the hands of the individual. Leadership and funding issues were mentioned repeatedly, as leadership is focused primarily on forecasting and less on education.

Discussion

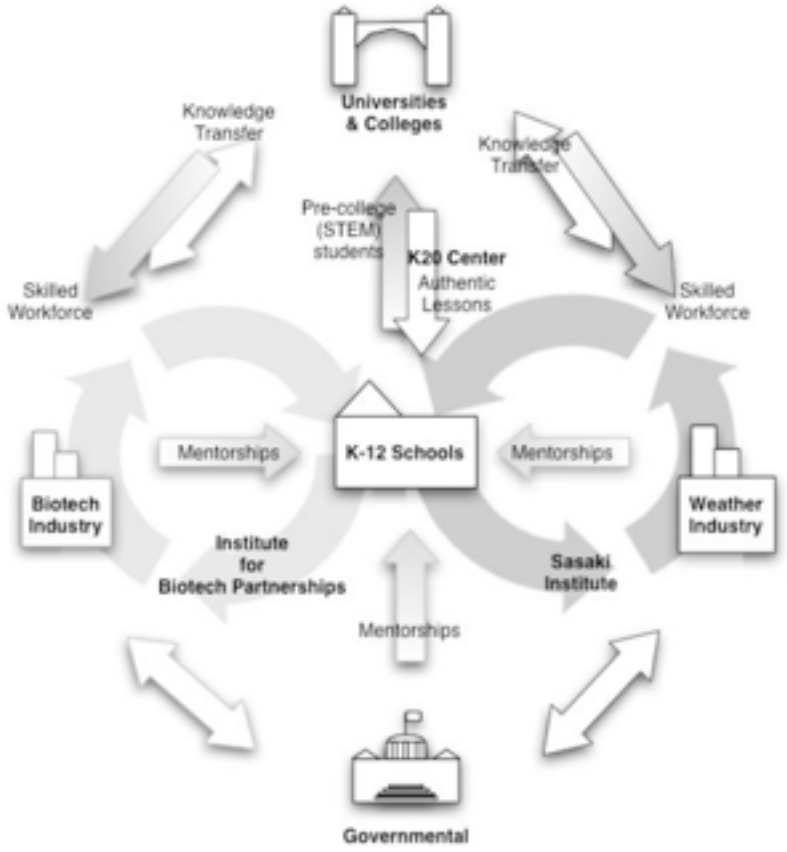
The summit discussions, combined with the ABC project's findings and the K20 Center research on educational reform, suggests the meteorology and climatology industry could make a significant difference in national STEM, weather and climate education through:

1. Creation of partnerships and networks between stakeholders and communities to support development and dissemination of a unified vision for weather and climate education, policy directives and interdisciplinary approaches to meteorology and climatology education;
2. Support weather and climate outreach initiatives by development of a national network of local content experts to deliver authentic and relevant experiences for teachers, students, and the general public; and,

3. Support local expert teacher liaisons to partner weather and climate content experts with schools and in-service teachers.

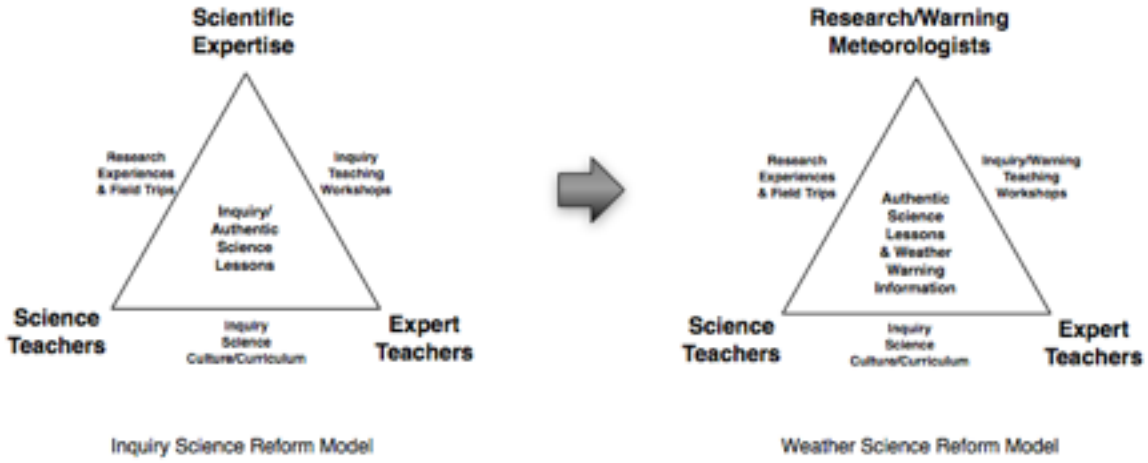
The summit demonstrated the many in the meteorology and climatology disciplines are ready to lend expertise and participate in education initiatives. Those currently in the meteorology workforce, including NOAA employees, industry employees, and faculty and researchers in meteorologic and climate research at institutions of higher education, need incentives and assistance to best support local education agencies and educators. Incentives should include paid time off when engaged in educational outreach, as well as reward structures (advancement, travel expense compensation, etc.). Assistance should be provided by expert teacher liaisons that can bridge local education standards with meteorology and climate content. Industry support for expert teacher liaisons insures sustainable and successful initiatives, and demonstrates commitment to the successful triadic science reform model that can lead to a difference in national science education and a public better versed in weather and climate issues.

Figure 1.



ABC model for industry and education partnerships.

Figure 2.



Triadic science reform models.