The "Next Generation" GLOBE (NGG): Developing Strategic Partnerships to Improve Science Education, Enhance Environmental Awareness, and Increase Understanding of the Earth as a System

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Executive Summary

GLOBE is a large, international program founded in 1994 with 106 International Partners, over 100 U.S. partners, as well as agreements with other federal agencies, and has involved tens of thousands of schools and teachers, and over 1 million students. Since the beginning, GLOBE has had as its core missions to improve science education, to increase environmental awareness, and to contribute to understanding of the Earth as a system.

This paper describes the next step in the evolution of the GLOBE Program, a step we are describing as the "Next Generation GLOBE (NGG)." The features of NGG are based on an intensive self-study conducted by GLOBE Program Office staff, extensive input and recommendations from the worldwide community of GLOBE participants, and guidance from GLOBE's U.S. Government funding agencies.

The vision of the NGG is of a Program working in close partnership with the National Aeronautic and Space Administration (NASA) and the National Science Foundation (NSF) integrated Earth systems science programs to give the worldwide GLOBE Community access to the United States' top scientists, and expose them to programs that are on the cutting edge of Earth systems science research. To achieve this vision, GLOBE will promote and support students, teachers, and scientists to collaborate on inquiry-based investigations of the environment and the Earth System.

As part of the NGG, GLOBE will experiment with, and assess, three new approaches to Program implementation: Regional Consortia, Projects-Based Management, and the development of GLOBE Schools Networks (GSNs).

This transformation will be accomplished while retaining the Program's essential elements of being both education and Earth Systems Science, a bridge between these two international communities, a worldwide collaborative community of practice, and a program that employees inquiry-based educational activities that involve students in "authentic" hands-on science, the manipulation and analysis of data and the use of scientifically-tested protocols.

In NGG, the critical central infrastructure needs, partnerships with integrated Earth systems science programs and other government-funded science projects, development of overarching worldwide themes, and customer service for U.S. and International Partners will continue to be funded by GLOBE's U.S. Government sponsoring agencies. Local, regional, and international projects; grassroots and student-led science investigations; and other activities that are unrelated to the objectives of the U.S. Government agencies will be organized and funded by a GLOBE International Foundation with support from the private and public sectors.

In conclusion, we believe NGG provides GLOBE with the tools and resources necessary to work effectively with Partners, NASA, NSF, and other donor agencies; and Integrated Earth systems science programs to the worldwide GLOBE community's benefit.

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INTRODUCTION

This paper describes the next step in the evolution of the GLOBE Program, a step we are describing as the "Next Generation GLOBE" (NGG). Since the Program's debut in 1994, much has been accomplished of which we are all rightly proud. GLOBE has a long and proud tradition of success.

We also recognize that since 1994 much has changed. Charles Darwin said, "It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change." If GLOBE is to thrive and prosper for another decade, the Program must reflect the changing needs of the worldwide GLOBE community as well as those of the Program's funding agencies. NGG is our effort to be responsive to the changes that have occurred over the past few years. NGG will build upon GLOBE's success, not supplant it.

THE NGG VISION

The vision of the NGG is of a Program working in close partnership with NASA and NSF integrated Earth systems science programs to give the worldwide GLOBE Community access to top scientists in the United States' as well as abroad, and expose them to programs that are on the cutting edge of Earth Systems Science research. NGG will strive to become financially self-sufficient with increased administrative flexibility that emphasizes the educational potential of the program; that focuses its resources more narrowly in order to have a bigger impact; that is flexible and experiments with, and regularly assesses, different approaches with more local and regional relevance to fulfilling its mission; that is more international in scope and outlook; that uses its "brand" to exert more leadership among similar programs, facilitating closer collaborations that allow resources to be leveraged better; and that makes better and more efficient use of technology.

This transformation will be accomplished while retaining the Program's essential elements of being both education and Earth Systems Science, a bridge between these two international communities, a worldwide collaborative community of practice, and a program that employees inquiry-based educational activities that involve youngsters in "authentic" hands-on science, the manipulation and analysis of data and the use of scientifically-tested protocols.

NGG will build upon the Program's long and proud tradition of success. We anticipate a year of transition to the major components of NGG described herein, after which we will continue to be responsive to the needs of the GLOBE Community and funding agencies. Successfully implementing NGG will require the participation of all people of good will interested in GLOBE's continuing success.

NGG will be formally introduced at the 2005 GLOBE Annual Conference in Prague by both the Director as well as by representatives from NASA and NSF. It is anticipated that NGG will be fully functional by the 2006 GLOBE Annual Conference.

BACKGROUND

GLOBE is a large, international 10-year-old program with 106 International partners, over 100 U.S. partners, as well as agreements with other federal agencies, and has involved tens of thousands of schools and teachers, and over 1 million students. During its first decade, GLOBE has had as its core missions to improve science education, to increase environmental awareness, and to improve understanding of the Earth as a system.

GLOBE has a 10-year history of interacting with, and serving as a bridge between, the educational and scientific communities. During the past 10 years, GLOBE has been widely promoted as a science *and* education program. This duality has been a key feature of the GLOBE brand.

Previous NSF-Funded GLOBE Science

In the past, the NSF has provided funding to "GLOBE PIs" to work with the program in a variety of ways, but with the expectation that the funding would result in scientific contributions to understanding the Earth as a system. In total, over the first 10 years of GLOBE, fifteen PIs have received NSF funding for this work. Underlying these efforts has been the premise that, by working with GLOBE on the development of protocols for use in schools and in other ways, scientists would have access to data collected by students that would not be otherwise available, and that would be integrated into the GLOBE PIs' research programs. One of the NSF metrics against which the success of this effort was evaluated was the number of publications in refereed scientific journals that made use of the student-collected data in the context of a scientific investigation. To date, six such publications have appeared in the literature.[1]

Aside from the scientific outcomes of the collaboration, the NSF-funded GLOBE PIs have provided a variety of important other services to the GLOBE Program. These have included:

- Providing scientific expertise to GLOBE's staff and community.
- Providing scientific content for, and checking the accuracy of, educational materials.
- Working with GLOBE to develop protocols and keeping them current and accurate.
- Ensuring the quality of data reported by schools to the GLOBE database.
- Assisting in the development of training materials.
- Serving as Master Trainers in Train-The-Trainer workshops.
- Working directly with schools and teachers on specific projects.
- Organizing networks of schools for special projects.
- Working with the Systems Team on the development of data entry pages and visualizations located on the GLOBE Web site.
- Offering Web sites outlining their work with GLOBE to which GLOBE links.
- Attending GLOBE Annual Conferences and GLOBE Learning Expeditions, working with students at these events in organized field campaigns, as well as presenting their research, and its relationship to GLOBE schools' efforts.

[1] See Appendix A for a list of these publications.

Since GLOBE's connection with NASA satellite missions has traditionally been a part of the Program's scientific activities, many of the current GLOBE PIs foster student data collection in support of NASA satellite data/algorithm evaluation.

Existing Partnership Agreements

The U.S. Government has in place bilateral agreements with 106 countries that specify that the GLOBE Program will provide certain services to its foreign partners. In addition, the GLOBE Program has existing "partnership" agreements with over 100 organizations in the United States.

In both the international and U.S. agreements, the organizations involved commit to recruiting, training, and supporting teachers who then implement the GLOBE program with students. The GLOBE Program is obligated to provide specified services and resources to partner organizations and their teachers in return.

Over the last 10 years, the Program's international and U.S. partners have established and funded GLOBE-related activities based, at least in part, on the agreements. Partners are a vital part of GLOBE. In 2001-2002, Dixon Butler, the previous GLOBE Director, made a "conservative back-of the envelope estimate" that Partners were contributing $10 million dollars a year on their operations for GLOBE. If one adds teacher time for measurements and training, equipment purchases, and support of TTT workshops, the GLOBE community brought in at least $14 million per year during that time.

SELF-STUDY AND IMPROVEMENT EFFORTS

When management of the GLOBE Program was awarded to the University Corporation for Atmospheric Research (UCAR) in October, 2003, under a Cooperative Agreement with NASA, the Program Office began a self-study to better understand the status of the program as it was inherited from NASA. While many impressive successes were identified in GLOBE, the self-study identified important limitations of the Program that could be improved such as teacher retention rates, data reporting participation, research into the educational effectiveness of program materials and activities, Web site usability, communication between schools and scientists, and so forth. The self-study also identified new opportunities that could be pursued.

As part of the self-study, the GLOBE Program Office solicited input starting at a Community Meeting held in Boulder, Colorado, in January 26 – 28, 2004, and ending with a meeting of outside experts[2] hosted in Broomfield, Colorado, in December 8 – 10, 2004. During this period, input was also solicited from members of the GLOBE Program Office staff, members of the GLOBE Advisory Board, the worldwide community of GLOBE participants, UCAR administrators, NASA and NSF Program Officers, and experts from education, science, government agencies, and business and industry. GLOBE solicited input about what participants believed were the essential elements of GLOBE, limitations inhibiting the Program, and what recommendations they had to improve the Program's effectiveness.

[2] Participants at the January and July meetings consisted mainly of GLOBE Partners and PIs. For a list of the outside experts participating in the December meeting, see Appendix D.

Essential Elements

During the self-study period when Program Office staff sought input concerning the improvement of the Program, many opinions were expressed about “fundamental characteristics” or “essential elements” of GLOBE; “fundamental” or “essential,” in the sense that participants felt that there are attributes that fundamentally or essentially define the Program, and differentiate it from other programs, and which should be retained in the future to maintain the unique nature of GLOBE.

The following list of such attributes was created based on input from the GLOBE community and around which there appeared to be general consensus.

GLOBE is:

- Education and Science.
- Earth System Science.
- A bridge between the educational and scientific communities.
- An international network of partners and schools.
- A sense of "community."
- Collaboration among schools, and between scientists, educators, and students.
- Inquiry-based education.
- Students engaged in hands-on, "authentic" science including collecting environmental data and using this and other data in their research.
- Scientifically tested, rigorous protocols appropriate for primary and secondary student use.

Recommendations

The following are the major themes that emerged in the self-study and the series of meetings during which input was gathered. It includes a synopsis of the input, an explanation in more detail, and the recommendations that were made to address the specific theme. Later in the paper we describe how NGG will address these issues.

Put Education First

Synopsis of input: Programmatic priorities and activities have been mostly driven by scientists and scientific values and needs. Educational values and needs have had less emphasis.

Description: During the first ten years, the Program was described as a Science and education program, when the reality of where Program resources flowed and activities occurred indicated that GLOBE was in fact an Education and science program. Although science is seen as at the heart of GLOBE, participants felt that the scientific agenda and rigorous standards have historically driven the development and implementation of the Program’s materials and activities, especially protocol use and data collection and reporting. Initially it was thought that teachers had the expertise and tools to integrate activities into their curriculum requiring little support from GLOBE. As the program matured, it was recognized that teachers needed more

support, so the program began to put more emphasis on the educational needs of students and teachers in the past several years. However, the predominant science emphasis contributed to uncertainty about the Program's educational relevance, limited program adoption, and resulted in lower than expected teacher participation and retention rates.

Recommendations: In the future, participants suggested that GLOBE recognize this and adopt educational goals to guide the development of its services, products and activities with science playing a supporting, albeit a necessary and important, role including maintaining rigor and scientific accuracy. Community members also suggested that, at the core of GLOBE education should be support for inquiry-based, student investigations of the environment and the Earth System. It was also recommended that GLOBE materials needed to become more "education-friendly." This was specifically mentioned about the GLOBE Web site and Teacher's Guide. It was also suggested that GLOBE needed to do a better job of evaluation, developing robust criteria for assessment, or "measures of success," for educational objectives instead of counting the numbers of teachers trained, measurements reported to the database, partner organizations recruited, and so on. Finally, U.S. partners stressed that GLOBE's educational materials and activities need to align with national science education standards, and help students perform well on standardized achievement tests.

Focus Resources

Synopsis: The Program is trying to do too much with too few resources and, because it lacks focus, is having less educational and scientific impact than it would were it to focus its efforts more narrowly.

Description: For the past 10 years, a small group of Program staff have made conscientious and concerted efforts to facilitate the implementation of the Program in over 100 countries, while providing support to almost 100 U.S. partners and working with a variety of GLOBE PIs and other participating organizations. Program staff have created libraries of educational materials, provided hundreds of professional development workshops, and created and maintained a network infrastructure for thousands of teacher-trainers, tens of thousands of teachers, and as many as a million students from primary school through pre-service education programs at the university level. GLOBE has provided materials development, training and ongoing participant assistance in five broad scientific areas – Atmosphere/Climate, Hydrology, Phenology, Soils, Land cover/Biology. The latter has included the development and support of over 50 scientific protocols for use in schools.

Recommendations: If the Program is to become more effective, it needs to focus its resources on more reasonably obtainable objectives, cover less subject matter, address a more limited audience, and develop and support fewer services and products. Among the recommendations was that GLOBE work with schools instead of individual teachers as the unit of engagement because educational research indicates that this is a more effective way to integrate an innovation into the curriculum. Feedback also indicated that the Program should focus its efforts on quality, for instance developing high quality materials, activities and support services, rather than on quantity, for example recruiting large numbers of participating countries, schools, teachers or students.

Integrate Evaluation

Synopsis: The Program currently lacks clearly defined measures of success and an evaluation strategy and plan to assess progress toward meeting its goals and fulfilling its three missions: improving science education, enhancing environmental awareness, and contributing to our understanding of the Earth as a system.

Description: Historically, the metrics used and cited to demonstrate the success of GLOBE were focused on growth in scale, and involved easily gathered, quantifiable data like the number of teacher-trainers attending GLOBE workshops, the number of teachers trained by the trainers, the number of schools from which GLOBE data were reported, the number of individual student-collected environmental measurements reported to the GLOBE database, and so forth. These metrics have provided little information about the Program's effectiveness in improving science education, increasing environmental awareness, or contributing to our understanding of the Earth as a system, and hence are of limited use in understanding the value or impact of NASA and NSF's investment in GLOBE.

In addition, NSF has funded SRI International to conduct an annual "outside" evaluation of the Program, although in practice there has been close collaboration between the NSF-funded SRI PIs and GLOBE management staff in the selection of topics, research design, and framing of the results. The SRI evaluations have been focused on the growth-in-scale issues, and for other topics specifically on U.S. educational and partner support aspects of the Program, not the international aspects. SRI made frequent use of case study methodology[3] intended to provide illustrations of what GLOBE looked like in different educational settings and to illustrate ways that U.S. partners and teachers had to adapt the program to suit local circumstances. The results of the case studies were thought not to be easily generalized to the broader GLOBE community, and to have not provided a critical mass of information about the Program's overall effectiveness in achieving its goals or fulfilling its three central missions.

Recommendations: The Program should, as part of developing the "Next Generation GLOBE," build an evaluation plan into the proposal. GLOBE's evaluation strategy should be aligned with GLOBE's goals and the resources necessary should be allocated to support the costs of evaluation. The GLOBE Program Office should be able to conduct both formative and summative evaluations on different aspects of the program to assess how effectively and efficiently the NGG is being implemented, and what impact it is having in schools.

Finally, it should be noted that although participants in the self-study were not aware of this development, NSF has decided not to fund the SRI annual evaluation of GLOBE in the future, making it even more critically important that the GLOBE Program Office incorporate evaluation into its activities.

[3] In addition to case study research, SRI has conducted three population-wide partner surveys (Years 4, 8, and 9), seven nationally-representative teacher surveys (Years 1, 2, 3, 4, 5, 7, and 10 - planned), and seven studies of student achievement in GLOBE (Year 2, 4, 5, 6, 7, 9, and 10 - planned). For a summary of SRI findings from student learning assessments see Appendix E.

Become More International

Synopsis: GLOBE is seen as being too U.S.-centric by some of its international partners; too driven by U.S. scientific and educational priorities.

Description: Historically, although the Program is dependent upon partners, GLOBE has been based on a centralized model in which materials, services, activities, and perhaps most importantly, decision-making, have been the responsibility of the GLOBE Program Office staff. Although consulting with partners, and while partners were given substantial flexibility to meet their own objectives, nonetheless as the Program matured many partners began to seek a different model where they are more integrated into the decision-making process and collaborate on joint development of products and services and self-sustainment of the program. After ten years of implementation, the Program was seen by some as having become rigid in its methods of implementation, and not quickly adapting to changing education environments.

Recommendation – With the Program's recent move towards regionalizing GLOBE activities and support worldwide, and with the emergence of the first GLOBE Regional Consortium (GLOBE-Europe), participants recommended that a new model be implemented in which decision-making[4] was shared among international partners with the sponsoring agencies and the GLOBE Program Office, as well as responsibility for initiating activities, creating curriculum, providing support and soliciting funding. This change has been characterized as the difference between the Peace Corps Model and the United Nations Model, with the former being a U.S. program that is "exported" to other countries, while the latter is a collaboration of countries working together to develop mutually beneficial programs. In addition, input suggested that the Program needs to become more flexible and able to respond more quickly to changing events and needs.

Emphasize Local and Regional Relevance

Synopsis: GLOBE Central Office activities are centered on long-term, planet-wide environmental research programs which, although indisputably important, have less immediate local impact or relevance which is limiting participation in the Program.

Description: Some participants felt that the connection between what is being studied by GLOBE PIs and the needs and interests of local communities is tenuous, and because of this lack of connection, GLOBE is seen as less relevant to local educational needs. This has resulted in less participation, and poor teacher retention. Although GLOBE has encouraged local initiatives such as a malaria study conducted by students in Benin, GLOBE's primary focus has been on large-scale, long-term investigations. This focus has meant that students have been expected to collect the same data using the same protocols regularly throughout the year. Students find this repetition boring, and teachers feel that the educational value of such activity is limited. Since instructional time is short, and there are competing priorities, they would rather have students

[4] Although the GLOBE Community recommended playing more of a role in the decision-making process, the reality is that the Community, including the International Partners, serves an advisory role. Decision-making is the prevue of the sponsoring agencies that provide the resources for GLOBE activities, in consultation with members of the GLOBE Community and the GLOBE Program Office.

participating in activities perceived as having more educational value. Also, students and teachers received insufficient feedback regarding whether the data they collected was useful, or information about how their local data was contributing to scientific understanding.

Recommendations: The Program should increase its efforts to promote and support community-initiated local or regional GLOBE projects and field campaigns that can build communities of practice among local or regional schools and scientists tied to scientific or environmental questions with clear local or regional impact and relevance.[5]

Such initiatives could take the form of community-based, project-focused, inquiry-driven, limited-duration Earth Systems Science investigations by GLOBE students working with teachers, local scientists, and others, rather than broad, long-term data collection across numerous disciplines for distant scientists.

Local and regional investigations on topics of broad interest and scope (e.g. water quality, air quality, weather-climate change), could also contribute to "State of the Earth" reports created periodically by the GLOBE Program Office with participating GLOBE students, teachers, and scientists, and presented to the UN or other national and international organizations in parallel with those groups' efforts. For example, the subject of a GLOBE "State of the Earth" report could be matched to the annual theme of the UN's World Environment Day (WED) activities.

The GLOBE Learning Community (GLC)[6] concept encourages a broad range of community participation in the development of regionally and locally relevant activities and has been well-received by GLOBE's partners. These efforts should be expanded and continue.

Become a Leader

Synopsis: GLOBE has high visibility, a solid reputation, a worldwide community, and should play more of a leadership role in the ESS and Environmental Education communities.

Description: GLOBE is a unique program with a worldwide community of participants and a good track record. GLOBE should exploit these advantages and take more of a leadership role in the ESS and Environmental Education communities.

Recommendations: GLOBE should organize meetings and conferences to bring the ESS and Environmental Education communities together provide a "one-stop-shop" portal online for access to all of the program-related Web sites and resources, develop an international program of recognition for outstanding participants, broker the exchange of resources and activities between groups, and facilitate collaborations.

[5] A critical component of selection will be how well projects help meet the goals of GLOBE's sponsoring agencies. Projects that do not address these goals will need to be funded by other local or regional means. See Appendix F for an example of how such local or regional projects might be identified, developed and supported.
[6] GLCs are described more fully later in this document under "Partners."

Diversify Funding and Leverage Partnerships

Synopsis: The Program is under-resourced and dependent upon too few funding sources, and should do a better job of leveraging its existing resources by closer collaboration with similar groups.

Description: The scope of work defined when the GLOBE Program Office was within the U.S. Government and had access to additional resources can no longer be supported with the resources currently available. The program needs to increase its resource base and diversify its sources of funding by actively seeking individual, corporate, and foundation investors and sponsors, as well as partnering with other U.S. Government agencies and NGOs.

Recommendations: The Program needs to focus and scale back its activities so that it can operate more efficiently and effectively, and free up resources to be applied to development efforts. High priority should be given to development efforts, even if it results in the current level of GLOBE activities and services being reduced. In addition, the Program Office should seek partnerships with other organizations that would allow it to leverage its limited resources. Input included that the GLOBE Program Office should work collaboratively with its partners to become self-sustaining worldwide, including provide assistance to both U.S. and international partners in their efforts to secure funding for the regional and local implementation of the Program.[7]

Create More Opportunities for Collaboration

Synopsis: For many participating schools, there has been little or no communication or collaboration among schools and with GLOBE PIs.

Description: GLOBE is an international program that serves as a bridge between the educational and scientific communities. Some GLOBE community members feel disconnected from GLOBE science, with little interaction between GLOBE PIs and schools, and little feedback to students and teachers about the value of the data being collected locally and the results of the scientists' investigations. The Program has fostered connections between some scientists and schools, and among some schools in different countries, but should make creating and nurturing such collaborations an integral part of GLOBE activities.

Recommendations: Build collaboration into more GLOBE activities, create "mini-communities" of schools for specific projects, develop activities that engage local scientists with local schools so that there can be more interaction between the scientific and educational participants, make better use of collaborative technologies like computer-mediated-conferencing systems, and expand school interactions to incorporate cultural content.

[7] Because development efforts can consume a great deal of resource, the GLOBE Program Office will need to identify goals and develop a budget for these activities. All new agreements with other organizations will need prior approval from GLOBE's primary funding agencies.

Reduce Level and Increase Effectiveness of Technology Spending

Synopsis: GLOBE should reduce the amount of resources allocated to technology development and support, and should redirect efforts towards supporting educational objectives with educationally friendly and relevant applications. GLOBE should create a more distributed technology infrastructure.

Description: GLOBE's use of technology should be better aligned with educational practices and priorities. The emphasis should be on supporting educational objectives. The Web site is cumbersome and too difficult to navigate, data entry is difficult, the visualizations are of limited use educationally and expensive to maintain, and not enough emphasis is given to newer educational applications. All of GLOBE's technology support efforts are centralized at the GLOBE Program Office. GLOBE should work with its partners to facilitate the development of a distributed technology infrastructure.

Recommendations: Redesign the Web site for use by students and teachers, with participation of end-users in the process, and eliminate all but essential features. Scan the educational environment to identify "best practices" for how technology is being used to support learning and teaching. Experiment with new applications that have educational potential like games, simulations and streaming video. Facilitate the creation of a worldwide GLOBE technological infrastructure bringing together all of the GLOBE Web sites into a system that seamlessly provides information and support. As regional projects develop, support the creation and interoperability of specialized databases distributed throughout the GLOBE network.

"NEXT GENERATION GLOBE" FEATURES

GLOBE staff have been working on the "Next Generation GLOBE" (NGG) proposal since January 2005 using: (1) the recommendations that have been gathered over the past year (previous section), (2) NASA and NSF's new funding strategy to focus on direct connections with major NSF/GEO, NSF/OPP and/or NASA Earth-Sun research programs that are related to Earth systems science, (3) NASA Education's "six principles" for NASA-funded educational programs against which NGG will be evaluated, as well as (4) what are commonly seen as the essential elements of the Program, to guide their work. Although the NGG is and will continue to be a work in progress as we innovate, experiment, implement, and evaluate our combined efforts to enhance, extend, and improve GLOBE, it is possible to describe what some of the major features of the transformed program will be.

Change in NSF/NASA's Funding Strategy for GLOBE Science

The sponsoring agencies wish to ensure that GLOBE can meet the goals laid out in its mission statement, and that the program can achieve sustainability by 2014. A critical ingredient in improving GLOBE's impact and achieving GLOBE's sustainability is the participation of the best possible science teams in GLOBE, working at the cutting edge of Earth systems science in large integrated Earth systems science programs. Connecting the excellence of the GLOBE concept and structure with the United States' premier Earth systems science programs is a logical step for GLOBE that will continue to give GLOBE access to top scientists, and expose them to

programs that have been designated as scientific priorities. Students, teachers, parents, and their communities will be able to see how scientists of many disciplines work together to learn about the Earth system.

The next Announcement of Opportunity (AO) released by the NSF in the summer of 2005 will target partnerships between GLOBE and NSF/NASA-funded integrated Earth systems science programs. The focus for the program will be on the education use of data rather than scientists' use of student data. For protocols, the primary focus will be instructional, and secondarily on data collection for scientists.

Teams proposing to this solicitation must demonstrate:

- A focus on direct connections with major NSF Geosciences and Polar Programs and/or NASA Earth-Sun research programs that are related to Earth systems science.[8]
- A demonstrable benefit to GLOBE and to NSF Geosciences and Polar Programs or NASA Earth-Sun education goals (providing access to program researchers and data, working with GLOBE in setting up campaigns where possible, using tested GLOBE or non-GLOBE protocols to the greatest extent possible, actively participating in the wider GLOBE community including schools, among other goals).
- An international component.
- How the existing educational efforts of the large science program will coordinate with GLOBE.
- An Earth systems science education focus, rather than a protocol-support focus.
- A rigorous evaluation and assessment component that will collaborate with the Geosciences Education assessment contractor and with the GLOBE Office's evaluation and assessment activities.
- Contact and discussions with the GLOBE Office regarding understandings of roles and responsibilities.

This redesign of the science component will allow GLOBE to:

- Broaden the pool of scientists involved;
- Align activities and materials with research programs of national priority;
- Continue to receive guidance from top scientists; and
- Be more competitive for broader impact awards.

Applicants will be expected to provide ways for the GLOBE community to interact with a larger group of scientists from science programs as part of a wider joint Earth systems science educational strategy (the sponsoring agencies', GLOBE's, and the participating programs'). Because such interactions take time away from research, the actual time devoted by individual scientists might be smaller, but the time devoted by educational specialists at integrated Earth systems science programs will probably increase.

[8] Examples of 'major NSF/GEO programs' may be found in the document "Facilities to Empower Geosciences Discovery 2004-2008," available at: http://www.nsf.gov/geo/facilities/NSF_Geo2003.pdf.

International Aspects of NSF RFP and Non-U.S. Scientist Involvement

As in the past, NSF has asked the GLOBE Office to solicit nominees from its international partners for the NSF peer review for its upcoming solicitation.

In the solicitation, NSF will ask science teams associated with NSF and NASA integrated Earth Systems Science Programs to demonstrate a current or planned international component in their proposals. NSF awards will go to U.S. institutions which in turn may make sub awards for their international components.

Once the solicitation is issued, the GLOBE Office will inform the international partners that the solicitation is released and encourage them to make this information known to their scientists. Those scientists who have links to these programs should be encouraged to participate in teams that are applying to the solicitation.

The selection criteria for the solicitation will make it clear that the science teams selected will represent as significant a global perspective as possible. The solicitation will encourage proposals that use existing protocols to the maximum extent possible. If none of the program science teams covers a specific protocol that a partner uses and wants to continue to use, the partner will be encouraged to find a scientist for the protocol. GLOBE Regional Consortia will also be encouraged to invite scientists in their region to become involved in GLOBE either through their own grants, joint scientist/Consortium proposals to other organizations in their region, or funding provided by the Consortium.

NSF will communicate with its counterpart agencies in other countries about the solicitation and find out if their large Earth science programs have an education component to see if there is an opportunity for collaboration or other coordinated efforts. Similarly, NASA will communicate with its counterpart agencies and other participants through the GEOSS process about the solicitation to promote the involvement of their scientists in GLOBE and identify opportunities for collaboration or other coordinated efforts.

The ultimate goal is to have a truly international team of GLOBE scientists who receive funding from different sources, with NSF being only one of them. Any scientist who works with GLOBE locally, nationally, regionally or internationally will be called a GLOBE Scientist and will be a member of the GLOBE Science Team.

Meeting NASA and NSF's Performance Expectations

Historically and currently, NASA and NSF have provided financial support necessary for the GLOBE Program to operate. GLOBE, in turn, has provided one means for its funding agencies to address their strategic goals, objectives, and priorities. GLOBE will be responsive to the funding agencies' performance expectations – and to other funding stakeholders than may, in the future, provide financial support. For instance, in the case of NASA, GLOBE will align its activities with the agency's "Six Operating Principles" for education. [9] In the case of NSF,

[9] Available from NASA at <http://education.nasa.gov/about/strategy>.

GLOBE's activities will support NSF's "Broader Impact Criterion" and "Strategic Framework of People, Ideas, and Tools."[10]

Organizing the NGG

In the next section, we will describe how the NGG will be organized to address the changing needs of the worldwide GLOBE community as well as those of the Program's U.S. Government funding agencies, melding together the essential features of the GLOBE Program, the results of the year-long GLOBE self-study and review, and the changes in funding strategy for the Program proposed by NSF and NASA.

Administration

Oversight of the GLOBE Program by NASA and NSF is accomplished via interaction between agency staff assigned as GLOBE Program Managers and the GLOBE Director, and through various reporting mechanisms and agency evaluation procedures.

Responsibility for the implementation of the Program is shared among a three-level hierarchy – The GLOBE Program Office, GLOBE U.S. and international partners, and GLOBE Teachers. The latter two categories consist of advocates within participating organizations that share GLOBE's objectives but receive no direct funding for their work on behalf of the Program from NASA, NSF or the GLOBE Program Office.

The UCAR GLOBE Program Office has overall responsibility for the Program's operation worldwide. The U.S. and international partners[11] are responsible for recruiting, training and supporting teachers. And finally, teachers who have attended a GLOBE workshop do the actual implementation of the Program in the classroom.

Three New Approaches

As part of the NGG, GLOBE will experiment with, and assess, three new approaches to Program implementation.

Regional Consortia

GLOBE will facilitate and support the formation of consortia of countries to collaborate on regional GLOBE implementation.[12] These new "GLOBE Regional Consortia" [13] will play a

[10] See National Science Foundation, *National Science Foundation In A Changing World: The National Science Foundation Strategic Plan*, Arlington, Virginia, National Science Foundation, 1995, NSF #95-24.

[11] U.S. partners may be any one of a variety of types of organizations including institutions of higher education, science centers, and museums. Internationally, GLOBE works through Country Coordinators selected by each participating country that may be located in a ministry of education, a ministry of science and technology, a ministry of environment, or an NGO or university.

[12] The first such GLOBE Regional Consortium, "GLOBE Europe," has already been formed. More information may be found at the Consortium's Web site <www.globe-europe.org>. Similar Regional Consortia are already under development in Asia, the Middle East, the Caribbean, and Latin America.

[13] See Appendix G for a draft description of how GLOBE Regional Consortia might be organized.

more significant role in the advisement process by membership on a GLOBE International Advisory Board (IAB). Membership on the IAB will include ex-officio representation from donor agencies such as NASA and NSF. Regional Consortia will also assume some of the responsibilities of the GLOBE Program Office in creating and supporting the Program's activities in each region.

Projects-Based Management

The GLOBE Program Office will implement a "project-based" approach to organizing educational and scientific activities as well as for managing staff work. As GLOBE transitions to a "projects-based" approach, instead of five permanent teams[14] based on general areas of activity, we will experiment with a "project team" approach in which interdisciplinary teams are formed as needed to address specific projects, including partnerships with Integrated Earth systems science programs. If there are recurrent, small-scale activities, e.g., Web-based, short duration projects, that do not justify the formation of a single team for each, these may be grouped together. Each project team will have a project manager and may include members from outside the GLOBE Program Office staff, e.g., scientists, local teachers, local partners as appropriate. The team will be responsible for the planning, implementation, and evaluation of a single project working with an integrated Earth systems science program.

The selection of suitable projects will be negotiated with donor agencies and organizations such as NASA and NSF, and will take into account the advice of the GLOBE International Advisory Board (IAB) as well as available resources.

This approach will require a good deal of flexibility and oversight to ensure the efficient and effective use of GLOBE resources, and ongoing evaluation, as project teams will likely need to adjust their skill sets depending upon the project's requirements, and projects will be starting and ending on different schedules.

Moreover, it is suggested that there are some functions of GLOBE that should not be included in the "project-based management" approach including overall program management, and critical services like development, marketing, and communications, customer support, basic IT support, and clerical support. The staff required to provide these services will likely be housed in the Program Directorate.

GLOBE Schools Networks (GSN)

The third level of the hierarchy responsible for the implementation of the Program is GLOBE Teachers. Although it is common to refer to "GLOBE Schools" and to the "GLOBE network of schools," these conventions do not reflect the actual situation. GLOBE does not now, either directly or through its partners, have agreements with schools. Currently, any school in which a

[14] The GLOBE Program Office is currently organized into five separate "teams," each with a "Team Leader," representing the major areas of activity programmatically – management (Directorate), education (Education), customer service (Partners /Outreach), science (Science Team), and technology development and support (Systems Team).

GLOBE trained teacher works is considered a GLOBE School. If the GLOBE-trained teacher leaves a school, it is no longer a GLOBE School.

As a central part of the transformation to the NGG, the GLOBE Program Office will undertake, with our partners, the development of true "GLOBE Schools Networks (GSN)." GLOBE will strive to establish a worthy, showcase program tied to specific projects with these schools that will have measurable educational results and demonstrable impact on Earth Science education.

The Program will establish criteria for a school to be designated a "GLOBE School," within a specific project to provide exclusive benefits for participation, in exchange for which the schools will commit to specific activities.[15] Partners will help define the nature and scope of the GSNs, set qualifications for school participation, identify likely candidates, and participate in providing members with support and services.

It is anticipated that the development of GSNs will parallel the development of large scale projects, and that the ultimate number of schools may be relatively small compared to what is currently perceived as a GLOBE network of 16,000 schools. However, creating a worldwide network of 1,000 schools actively participating in several integrated Earth systems science programs' projects would be a major step forward in program development. GLOBE's partner support/customer service staff will work with all Regional Consortia, their respective Country Coordinators, and U.S. partners to build GSNs.

Although GLOBE and its partners will work primarily with schools engaged in one of the GSNs associated with a GLOBE project, GLOBE will also work with other GLOBE schools that wish to make use of existing GLOBE materials and protocols without committing to participating in a specific project. These schools will have access to existing resources on the GLOBE Web site and the database, but may not have help desk support, development or training for these legacy resources. Such schools will not receive the same level of support or the benefits of being a member of one of the GSNs, but they will receive a basic level of support to help them succeed. These schools will be encouraged to join one of the ongoing or upcoming GLOBE- integrated Earth systems science programs' sponsored projects.

Resource Allocation

The "projects-based" management structure will also require a different approach to resource allocation. This new approach will improve budgetary accountability, increase programmatic flexibility, as well as help focus GLOBE's efforts to attract investors and sponsors.

In the NGG, resources will not be pre-allocated to support distinct areas of activity for five years based on predetermined milestones as is now the case, but rather will be annually allocated in support of specific projects and basic program operations. GLOBE development efforts will be centered, at least in part, on attracting sponsors and investors for major projects.

For instance, one of GLOBE's primary missions is to increase environmental awareness among participants. At times, catastrophic environmental events, such as hurricanes, typhoons,

[15] See Appendix H for an example of how GSNs might be organized.

earthquakes and tsunami, bring the environment to the forefront of news media around the world. These events, tragic though they may be, provide rare opportunities to study the consequences and also provide a "teachable moment" as students' attention becomes focused on the event. An annual budgeting process done in collaboration with the sponsoring agencies that focuses on projects will provide such flexibility to Program management.

Focus

Rather than trying to provide a wide range of products and services in five broad scientific areas with 106 partner countries, almost 100 U.S. partners, and, in theory, 26,000 teachers in 16,000 schools worldwide, Program resources will be aligned in support of 3 – 5 large projects annually.[16] Customer service, educational materials development, systems support, training, and so forth will all be targeted towards making these projects or campaigns as successful as possible.

This focus will include working with the GLOBE Schools Networks (GSNs) as a primary audience for integrated Earth systems science programs' activities, but such activities will not be exclusive to members of the GSNs. Other schools will be able to participate. In addition, a basic set of services will be provided to partners and teachers who are not actively engaged in a integrated Earth systems science program project or campaign or are members of one of the GSNs, but the focus of GLOBE's efforts will be in support of activities with integrated Earth systems science programs.

If it is possible to do so, GLOBE, in consultation with and approval from funding agencies, will select projects that are synergistic and provide opportunities to share development and implementation costs to further focus resources. For instance, it may be possible to identify 2-3 new projects that are similar in nature, one growing out of GLOBE's partnership with an integrated Earth systems science program, one being initiated by a Regional Consortium, and another an international project initiated by an NGO, and to merge efforts between these activities to share and reduce costs and to increase impact.

Science

In NGG, science will reflect the focus of the integrated Earth systems science programs which NSF and NASA select to work with the Program, as well as the outgrowth of local and regional interests and needs. For the former, NSF and NASA will provide resources for GLOBE's partnerships with the NASA and NSF integrated Earth systems science programs. For the latter, additional resources will need to be sought by partners from sponsors and investors.

GLOBE/integrated Earth systems science programs investigations will be carefully crafted to be a close fit to the educational needs and requirements of schools to improve student learning; have a high degree of local or regional relevance; and engage teachers and students in limited duration

[16] It is unlikely that all new GLOBE projects and campaigns will be synchronized, starting and ending at the same time each year, but it is certain that the Program will only be able to support a limited number at any one time. What that "limited number" is cannot be determined without more information concerning the scope and expense of the activities. In this context, "3-5" is only speculation.

field campaigns and project-based investigations about local, regional, and global environmental issues.

In collaboration with premier NSF and NSF funded integrated Earth systems science programs, projects may be initiated by students, teachers, collections of schools, local scientists, Country Coordinators, Regional Consortia, or the GLOBE Program Office. Projects may be relatively simple and require very little input or involvement beyond the participating group, or they may be worldwide activities requiring a significant investment of resources by GLOBE to coordinate, for example an international project focused on the carbon cycle coordinated with NSF, NASA and International PIs.

A salient feature of these projects will be regular interaction and feedback between schools and scientists, as well as a culminating experience or event that provides an opportunity for students to report on their work, as well as to receive feedback from the scientific community. As part of its role as facilitator and broker of worldwide GLOBE activities, the GLOBE Program Office will work to identify common areas of interest and facilitate collaboration among local and regional efforts, and between such efforts and U.S. science and scientists.

Since the traditional role of "GLOBE PI" will not be part of the NGG, the concept will be modified to "GLOBE Scientist," and will be expanded to include integrated Earth systems science programs scientists working with GLOBE on the development and implementation of an international or national campaign or project, as well as scientists from local or regional universities, government agencies, NGOs, or business and industry who are serving as the scientific mentor for a school engaged in a specific campaign or project.

However, these individuals will not, in most cases, be expected to provide the same full range of services to GLOBE as did the original GLOBE PIs. Instead, because such interactions take time away from scientific research, it is anticipated that the actual time devoted by individual scientists might be smaller, but the time devoted by educational specialists at integrated Earth systems science programs will increase.

If appropriate within the context of the learning objectives of a project, students will continue to observe, collect and report data to the GLOBE Web site, but emphasis will be on using data in the classroom (e.g. with data access and visualization tools) and sharing data with other schools to promote students scientific understanding of important scientific, mathematical, and geographic concepts, rather than with the expectation that such data will be useful scientifically. Student collected data will be available for scientists to use in their own studies and to use in their publications, but the primary audience for these data will be students, not scientists.

In some cases, depending upon the desired learning outcomes of the activity, GLOBE activities may not engage students in data collection, but may instead engage them in learning activities that make use of access to large data sets, for example from NSF and NASA programs, in the context of learning activities that include data analysis.

Whenever possible, projects will make use of the existing, rigorous, GLOBE protocols to collect data so that it can be shared with other schools. Based on prior experience, there is significant

cost and effort associated with developing and maintaining protocols. During the transition, on-line training materials will be developed for selected Atmosphere protocols, because of the likelihood that they will be useful to at least a subset of the final group of Integrated Earth systems science programs. In the NGG, if new protocols are needed for a GLOBE-endorsed project, GLOBE will endeavor to identify, validate, and use existing protocols developed by other organizations rather than undertake new protocol development. For example, a host of protocols have been developed and used with schools by scientists in other organizations, e.g., NOAA, for marine science, or EPA for environmental monitoring, that could be adapted for use within GLOBE.

In the rare cases that new protocols are necessary, these protocols will be developed by scientists from other organizations, for example Integrated Earth systems science programs, working with GLOBE staff much in the same way that the GLOBE PIs did. However, because it is anticipated that the emphasis will be on learning, not scientific outcomes, in some cases it may be possible to increase the flexibility involved in GLOBE protocol development and training, and thereby reduce the time and expense necessary for protocols to be implemented by students. In order to differentiate the existing protocols from new measurements developed less rigorously, it may be useful to give them a different name, such as "GLOBE measurement." Savings could also accrue because there may be a diminished need to continually update these measurements to meet the needs of up-to-the-minute science investigations or to retrain participants to use modified versions.

The GLOBE database and education materials in support of all of the existing GLOBE protocols will continue to be accessible to students and scientists as they are now, but only those protocols actively being used as part of GLOBE-endorsed projects will be maintained and supported, keeping them current and accurate and ensuring the quality of data reported by schools to the GLOBE database. Likewise, further enhancements to data entry, access, and display will be limited to those measurements that are being used as part of GLOBE-endorsed projects.

It is also anticipated that data collected using adapted or newly developed protocols may not be incorporated into the GLOBE database. The data may, instead, be collected and managed online by one or more of the participating organizations if that is a necessary outcome of their campaign or project. In such instances, the GLOBE Web site will "point" to those resources, but no GLOBE Program Office resources will be expended in their support.

For instance, if GLOBE Europe initiates a project that only involves European scientists and schools, and that requires the use of one or two new protocols, the protocols will be developed and the data collected and managed by the members and participants in the European GLOBE Regional Consortium, and made available more broadly ,as appropriate, via the Consortium's Web site.

This does not preclude the possibility that new protocol development and student data collection may be an integral part of some GLOBE partnerships with Integrated Earth systems science programs, but rather that the fundamental purpose of data collection will be for educational purposes, and that publications by scientists in refereed journals that incorporate GLOBE student data will no longer be used as a major metric to evaluate the benefits of GLOBE participation.

In support of some Integrated Earth systems science programs, schools may be asked to collect and report data and GLOBE will help facilitate the recruitment and involvement of these GLOBE schools. We will encourage Integrated Earth systems science programs to involve students in data collection because the use of student-collected data by the scientific community can be a powerful motivator for students and teachers. However, it is anticipated that some Integrated Earth systems science programs will simply want students to use their data, rather than collect data for them. GLOBE will partner with these Integrated Earth systems science programs and with other groups like the Digital Library for Earth System Education (DLESE) and the National Science Digital Library (NSDL) to develop and evaluate relevant educational materials and activities that make use of the Integrated Earth systems science programs data sets in effective and engaging ways.

And finally, in the NGG, scientists will be actively recruited through Integrated Earth systems science programs and other programs to act as spokespersons, and to provide advice, ideas, mentoring, and support for high profile, regional and international Earth system science investigations of interest to GLOBE schools and communities. As possible, GLOBE will partner with organizations such as the Space Science Institute in Boulder that offer workshops for scientists on working within school settings and help make such opportunities available to interested integrated Earth systems science programs' scientists.

Partners

GLOBE will move to become a more truly international organization with Regional Consortia that will participate more actively in advising the Program and that may, eventually, take over some of the responsibilities of the GLOBE Program Office for providing online resources, curriculum, customer service, and so on, as well as seeking sponsors and investors to support Consortia activities in each region.

It is anticipated that Regional Consortia will organize and support regional projects made possible with local and regional sponsorship. The GLOBE Program Office will provide information and advice about seeking sponsorships, but each Regional Consortium will be responsible for building their own capacity in this regard and planning and conducting such development activities.

GLOBE Regional Consortia that have been formally recognized as such by the GLOBE Program Office and funding agencies will participate on the GLOBE International Advisory Board (GIAB) providing programmatic advice to GLOBE Program Office staff and representatives from funding agencies.[17]

GLOBE is increasingly expanding worldwide, and interest on the part of GLOBE countries in working collaboratively on a regional basis is growing. GLOBE countries are seeking these regional relationships because they offer an opportunity to work together, in a flexible manner, on a variety of activities that benefit their specific programs and schools such as securing

[17] GLOBE Program Office Staff, working with partners, are currently developing a draft Consortium agreement for approval by the funding agencies.

funding, promoting school-to-school communications, developing regional science campaigns and projects, and holding regional events for their schools. As previously mentioned, the formation of Regional Consortia will allow individual countries within each region to assume some of the responsibilities of the GLOBE Program Office in creating and supporting the Program's activities in their region. This would allow the GLOBE Program Office's limited resources to have more influence as well as move the program in the direction that our international partners have requested.

The move towards regionalization will also help focus GLOBE's efforts in recruiting and supporting countries. Instead of trying to recruit all of the remaining the countries that are not yet members of GLOBE, recruiting will be centered on building the capabilities of the Regional Consortia. So, for example, if one of GLOBE's goals is to create a Southeast Asia Regional Consortium, then recruiting efforts in that part of the world might focus on Malaysia, Singapore, Indonesia, Laos, and Vietnam who, if they joined, would, along with current members Thailand and the Philippines, constitute a Regional Consortium that could be closely tied to the Association of Southeast Asian Nations (ASEAN), a synergistic relationship from which all countries in this specific region would benefit through collaborative efforts between the ASEAN Country Coordinators and their staff.[18]

In terms of support, this shift to Regional Consortia, it is envisaged, will eventually result in much of what is now provided by the GLOBE Program Office being provided collaboratively by the country members. This might include training of teacher trainers, development of training materials, help desk support, and so on.

The U.S. GLOBE Partner Support structure follows a local control model, similar to the U.S. educational system (there are 17,000 education agencies in the U.S., approximately 14,500 are regular school districts working with approximately 94,000 elementary and secondary schools). No one control model is appropriate for the United States, since no one model fits the different needs of each state, and therefore a local control network has been established as a foundation of the current U.S. Partner Support model that was created and implemented in the fall of 2003.

These models requires U.S. partners to provide the GLOBE Program Office with a signed Recommitment Form each year indicating that they will remain active in the Program, and agree to recruit, train, and mentor GLOBE teachers in their service area as well as to provide at least one training and/or follow-up event for their GLOBE teachers in their service area each year. The U.S. partnership network has grown significantly since 2003, currently consisting of over 80 U.S. partners who have agreed to actively work with GLOBE in 2005. It has been suggested that the Annual Recommitment Form to be distributed in the fall of 2005, in preparation for the 2006 implementation year, should contain an additional clause indicating that each U.S. GLOBE partnership must also connect to and mentor a minimum of two schools in their service area participating in GLOBE Schools Networks (GSNs) activities, further strengthening the GSNs.

[18] GLOBE activities in international partner countries are administered by Country Coordinators who have been assigned in each country by the appropriate officials of that country, to establish and maintain a centralized structure of GLOBE efforts in accordance with the Bilateral Agreement. Therefore, each Country Coordinator controls all program activities in their respective country.

GLOBE Program Office staff will continue to assist U.S. partners to build community support following the GLOBE Learning Community (GLC) model. GLCs encourage participation of a broad range of community members who share a common commitment to supporting GLOBE schools in the implementation of GLOBE for the benefit of their community. GLCs typically combine GLOBE Partner efforts with local scientists, higher education, State Departments of Education, local parent associations (PTA), teacher associations, youth clubs, senior citizen groups, community centers and museums, local businesses, government agencies and other community members to build local, and in the best case scenarios, state-wide GLOBE Partnership infrastructures. GLCs can help make learning and science relevant by focusing on the local and regional environment.

Measures of Success

Evaluation is necessary to understand how, and how well, the Program is functioning and adjust direction as necessary. One of the lessons learned as a result of the self-study was that GLOBE needs to do a better, and ongoing, job of evaluation, and needs to develop metrics to measure more relevant variables. NGG – as funding permits – will develop and implement methods to assess progress in meeting programmatic goals.

GLOBE's primary goals since 1994 have remained the same: To improve science education, to increase environmental awareness, and to contribute to our understanding of the Earth as a system. Evaluation efforts to assess whether or not GLOBE is achieving these goals will focus at three levels. First, overall program evaluation to answer questions such as: Is GLOBE accomplishing its goals effectively and efficiently while meeting the expectations of its funding agencies and partners? These issues are within the purview of the Program Office. Second, individual projects with integrated Earth systems science programs will be evaluated, i.e., is the project being implemented effectively, is it meeting GLOBE, the funding agencies, and the Integrated Earth systems science programs educational and scientific (if applicable) objectives? And finally, NGG will work with partners who will assess educational impact: Is engagement with GLOBE materials and activities helping students learn more about science, become more environmentally aware, become more engaged with "authentic" science? Are teachers teaching science more effectively because of attendance at GLOBE professional development workshops and the use of GLOBE methods and materials?

Although there are some clearly identified desirable outcomes the Program aims to achieve such as improved student learning, successful scientist/school collaborations, increased environmental awareness, and more involvement of under-represented groups in science education, the GLOBE Program Office does not interact directly with students or teachers and depends wholly on partners to achieve some programmatic goals.

In addition to evaluating success at meeting specific objectives of our sponsoring agencies that are within the control of the Program Office, such as increasing diversity, GLOBE will engage its partners and other groups with which it works in the evaluation process to measure those outcomes for which partners have primary responsibility such as increasing environmental awareness among teachers and students. As GLOBE partners with an integrated Earth systems science program, part of the relationship will include a collaborative effort to assess the impact

of the outcomes of the partnership. The GLOBE Program Office may also work with outside contractors to perform additional evaluations.

Furthermore, the GLOBE Program Office will create opportunities for graduate students, post-docs, scientists and research organizations to conduct research into the Program's impact aligned with their interests. By working with these individuals and groups, GLOBE will leverage its limited resources and be able to do more evaluation.

Educational Materials Development

During the first decade of GLOBE, the Teacher's Guide (TG) was the single biggest endeavor in the area of educational materials development. Developed primarily by GLOBE PIs and science staff, the TG is a comprehensive volume rich in scientific background and procedures focused on the implementation of the GLOBE protocols so that data could be collected for scientific use.

In the NGG, new educational activities and materials will be developed in support of GLOBE's partnerships with Integrated Earth systems science programs. The assessments of GLOBE clearly show that the largest impact on student learning and understanding of science occurs when actual analysis of data is carried out, but not when only data collection occurs. The focus for the program will be on the educational use of data (collected by large science programs, by student operated stations, or by students by hand), rather than the use of students by scientists to collect data.

In NGG, educational materials will be developed to meet the evolving needs of new NGG projects and existing content from the TG will be repackaged to fit the needs of the new projects. Specifically, materials from the TG will be used with an eye toward developing thematic units at grade appropriate levels. All NGG education materials will be developed with target audiences in mind recognizing the cognitive abilities at different grade levels. Encouraging and supporting student research will be a key element in all GLOBE education materials.

The call for data use in the classroom has been a tenet of recent reform efforts in science education (NSES, 1996; NRC, 2000; Barstow & Geary, 2002, etc.). Furthermore, the evaluations of GLOBE conducted by SRI International have clearly demonstrated that one of GLOBE's main educational strengths is engaging students in data manipulation and analysis. However, there is little evidence that students are able to use large, raw data sets effectively without context. It is not enough to simply make data sets available for classroom use, it is imperative that such data sets be situated within sound pedagogy, scientific content and the context of classroom learning, and be available at age appropriate levels. Therefore, it can be anticipated that NGG educational activities will engage students with data from Integrated Earth systems science programs as well as from the GLOBE data base, other data sources, and their own data collection efforts.

NGG will create, through a combination of existing TG materials and new materials, robust units that meet specified educational standards. In the United States, the National Science Education Standards will be used as the foundation. These new products will be mapped to existing U.S. K – 12 curricula and identified student learning outcomes required for district/state/national

assessments. GLOBE will work with partners in other countries who wish to map these materials to their national and local educational standards as well.

All new NGG educational materials will be field-tested with the target audience to assess their effectiveness. In addition, NGG education materials will be submitted to the NASA educational materials quality review process to help ensure the materials are of the highest possible standard.

Professional Development

GLOBE's professional development activities originally targeted classroom teachers as the audience for training related to the use of protocols. As GLOBE matured and grew, GLOBE's partners took over responsibility for teacher training while GLOBE focused on professional development of trainers of classroom teachers. During the last several years, efforts had begun to shift from protocol training to more emphasis on educational needs such as curriculum integration, effective pedagogy, inquiry-based learning, and classroom management of GLOBE materials and activities.

In the NGG, GLOBE's professional development efforts will continue to be primarily focused on supporting partners' efforts to recruit, train, and support GLOBE teachers who are part of GSN's, but may include some online classes that partners could use with their teachers. Also in the NGG, the shift in emphasis to educational outcomes will continue. There is a strong research base concerning the design and delivery of effective professional development programs for educators. The U.S. National Science Education Standards (NSES) outlines standards for professional development for teachers of science. These standards are seen by many as having applicability worldwide. NGG's professional development activities will be grounded in the research and aligned with the NSES standards.

GLOBE recognizes that a major challenge for professional development activities is to bridge the educational and scientific "cultures," and link classroom science teachers to high quality science research content and programs, while ensuring that educational priorities guide such linkages so that the activities are relevant to the needs of the teachers. NGG teacher professional development will be built on the educational value of integrated Earth systems science programs' research efforts. Significant attention will be given to instruction and practice in student research and inquiry.

Three other significant changes will occur. First, GLOBE has recently begun to move towards the delivery of professional development activities online. These efforts will be expanded to reduce the Program's dependence on resource-intensive, face-to-face workshops. Interactive Web-based learning will become a key feature of NGG professional development activities. Although GLOBE will make more and better use of online instruction to reduce the need for traditional face-to-face workshops, Program staff do not believe that such electronic instruction can completely replace the need for all face-to-face interactions. Face-to-face professional development activities are still useful for specific purposes – for instance, for presentations from integrated Earth systems science program scientists, instruction on use of relevant computer software, and instruction on selected protocols.

In the NGG, for some instructional purposes Web-based instruction will stand alone. In other situations, a "mixed design" approach to professional development will be used. The "mixed design" approach is a combination of face-to-face workshops and online instruction. Besides serving as the primary medium of instruction, distance learning provides an excellent tool for supporting face-to-face workshops and extending follow-up support and professional development opportunities beyond the workshops.

Second, GLOBE's professional development offerings will be expanded beyond using GLOBE materials to include online science courses that provide the critical science knowledge that many teacher trainers and classroom teachers lack who are responsible for GLOBE's implementation. Such courses may take a variety of forms, e.g., short-courses covering specific knowledge related to a NGG campaign or project, introductory courses on more general science topics in Earth Systems Science. These courses will be developed and taught as collaborative efforts between GLOBE staff, GLOBE's partners, and scientists engaged with the program. GLOBE will also link teachers to other, high-quality professional development offerings such as Earth System Science courses for middle and high school teachers offered by ESSEA 21 universities, and content-rich courses offered by Annenberg-CPB.

The third significant change will be that NGG professional development activities will also be made available for scientific audiences interested in learning more about education, and about working within the educational community effectively. These professional development activities may be attractive to integrated Earth systems science program science staff and other scientists who work with schools. Professional development activities will draw on best practices from existing programs that have demonstrated success in promoting successful collaborations and communications between the science community and the education community.

Sustainability

At present, GLOBE activities are organized by a central program office at UCAR with funding from the U.S. Federal Government. The Cooperative Agreement Notice for the GLOBE Program issued in October 2002 stated that one objective for the GLOBE program was to become self-sufficient. It is also UCAR's desire for the Program to diversify its funding sources to include cooperating government agencies, NGOs, foundations, corporations and other sponsors which will allow GLOBE to supplement and build on the core NGG work being supported by NASA and NSF. Since coming to UCAR, GLOBE has formed a Sustainability Working Group, populated the GLOBE Advisory Board with some individuals with experience and connections that could assist with development efforts, and, last year, funded the creation of a detailed development plan that was completed in January 2005.[19]

The GLOBE development plan contains several recommendations ranging from the establishment of a GLOBE independent nonprofit organization, i.e., a GLOBE Foundation (see discussion below), to seeking support from a variety of government and non-governmental sources, and identifies a variety of public and private sector entities as potential partners and sponsors including federal, state and local government; corporations; foundations; individuals,

[19] Copies of the development plan have been shared with NASA, NSF and UCAR.

and so forth. The development plan also provides strategies and specific actions and time lines, and identifies staffing needs, including hiring development and communications staff.

In NGG, the critical central infrastructure needs, partnerships with integrated Earth systems science programs and other government-funded science projects, development of overarching worldwide themes, customer service for U.S. and Country Partners, and U.S. Education goals will continue to be funded by the NASA Cooperative Agreement. The GLOBE Program will collaborate with NASA on the integration of other government agencies, and potentially with corporate sponsors and foundations, in creating a sustainable and diversified funding base for the program. Corporate sponsorships will focus on projects of mutual benefit to GLOBE, the corporation, and to GLOBE's Federal funding agencies. These efforts will strengthen programs that fit with integrated Earth systems science programs on a regional, nationwide, and worldwide basis. The programs funded in this way will be carried out by staff of the GLOBE Program at UCAR, though collaboration with other groups with consonant missions will be sought.

Local, regional, and international projects; grassroots and student-led science investigations; and other activities that are unrelated to the objectives of the U.S. Government agencies that fund NGG will be organized and funded by a GLOBE International Foundation with support from the private and public sectors. The separation of the two units does not fall along political lines – the core GLOBE Program will remain international in scope but will be focused on partnerships with integrated Earth systems science programs. Projects funded by the GLOBE Foundation will be outside of the purview of these partnerships. These projects will apply to specific needs of GLOBE's worldwide community, rather than GLOBE's U.S. funding agencies. A separate paper is being prepared that will address the needs and strategies of the GLOBE International Foundation.

In order to implement the sustainability effort described here, the GLOBE Program will contract with, or hire, a development specialist to assist current program staff in the research and relationship building required to assist with these endeavors. While cause-related and corporate marketing efforts may be integral to sponsorships and grants, in no case will advertising be the sole product of the effort for the corporation. The GLOBE Program Development Office use of NASA funds for development purposes will follow the guidelines of OMB Circular A-122. Development activities that fall outside of the allowable uses will need to be funded from other sources.

Technology

In the Next Generation GLOBE (NGG), the focus of technology efforts will be on supporting student learning, enhancing teacher professional development and facilitating collaboration among schools and scientists. Our approach to technology development will be open and distributed; with multiple partners developing, contributing, and maintaining data, tools, and other elements of the GLOBE Web space. We will use existing solutions, including commercial-off-the-shelf and open source products whenever possible, and seek to reduce or eliminate the expenses related to GLOBE custom-developed and maintained software. When in-house development is required, we will adopt flexible practices and architectures that allow for rapid prototyping, testing and deployment of products and services. Through these approaches,

GLOBE will make more efficient use of its resources and better integrate its use of technology in support of our primary mission.

The majority of our new technology development activities will be directly related to education. Any and all technology development in support of education in GLOBE will be conducted as part of an integrated solution addressing a specific identified educational need or objective in our GLOBE community. These solutions will be based on researched best-practices and pedagogical theory and the many other criteria already used in GLOBE, including usability, disability access, bandwidth issues, graphics design, and other conventional hardware/software and Web development standards. Project teams creating educational technology products will consist of an interdisciplinary staff with the skills required to define, design, develop, evaluate and disseminate high quality product and will involve substantial leadership from the existing system team.

GLOBE will also use technology to better facilitate and support collaboration among schools and between schools and scientists. This may include Web chats, Blogs, Wikis, instant messaging, bulletin boards, shared whiteboard, RSS feeds, video-conferencing, or other collaboration technologies. However, computers and software alone are not enough to build an online community. Investments in these technologies will be supported by personal interaction and active collaboration building by GLOBE staff, partners, and scientists.

In specific regard to the GLOBE Web site, we will be redesigning the site from an education perspective, with a basis in pedagogical theory, the other criteria mentioned above, and with the input and participation of our schools and Partners. We have already received redesign input from the GLOBE community and advisory groups. Our intention is to increase the focus on teacher and student needs, to greatly simplify the site, to reduce the amount of content and the number of options, and to improve the user interface.

In addition to education, GLOBE relies heavily on technology to support the management and operations of the program. We will continue to use technology to allow our partners to manage their own activities and track the activities of their schools. Where appropriate, we will use the GLOBE Web site and database to evaluate our success based on the new metrics and desired outcomes being defined for the Program.

The NGG future envisions a wide variety of activities, investigations, and campaigns; some developed by our NSF-funded science program partners, some by GLOBE partners or regional consortia, and others by schools.

Traditionally, GLOBE has provided a mechanism for schools to send their data via the web (or email) where it is then archived into a central GLOBE database. Additionally, “reference” datasets from NOAA and NASA have been collected, processed and archived for users of the GLOBE Web site to compare student data against.

In the NGG, instead of a centralized database to store all GLOBE data and materials, we will be moving toward a more distributed model of a GLOBE data system similar to models that cutting edge digital libraries have adopted. For example, we anticipate that many of the partnering

organizations or projects may already have in place mechanisms for collecting (and possibly disseminating) the scientific data collected as part of these projects. GLOBE's role in this is to link to these datasets, find other public datasets, and when applicable, to complement them with the existing GLOBE datasets in the GLOBE database.

GLOBE, in collaboration with projects like DLESE and NSDL, will take the lead in developing policies and guidelines for standards-based interoperability that will allow the burden of operating the technical infrastructure to be shared. Again GLOBE will, whenever possible, use existing software, either commercial or public domain, and select the appropriate open or industry standards that best support our users. The data in various GLOBE related databases, as well as from relevant NASA, NSF, and other science projects and missions, will be freely and transparently shared, with the end user seeing only a rich and seamless environment of data and tools to support learning. This could be realized in many ways. If the project is already offering their data in raw text, HTML or XML without needing to pull the data over to GLOBE, we can simply link to the data from GLOBE. Or, if the partnering program has their data stored in a relational database (e.g. mySQL / Oracle), we can create database views to effectively merge this data with other datasets and display the data via a web interface. In terms of visualizations, projects may be offering their rendered data as web services (Web Mapping Service). Here we can pull an image of their data and overlay it with other datasets in a way that adds educational value to data analysis. We will explore this carefully to ensure that important aspects of the GLOBE data approaches are not undermined.

Further, we will be evaluating the use of client-side and third party server-side visualization tools that will allow GLOBE to serve the data already in Data Access where our clients can download it as text files and import into a data analysis tool of their choice. GLOBE could work closely with interested commercial companies serving educational markets on the development of specific educational activities making use of the vendor's products, and in doing so reduce costs and attract investments.

Although many important details will need to be worked out, ultimately we plan to decrease the amount of money that is specifically targeted to technology, and use technology wherever appropriate in the program to more effectively leverage resources and meet the educational goals of NGG.

CONCLUSION

In this paper, we have connected three "puzzle pieces" into a coherent, and we think effective, picture. The three pieces of the puzzle are the essential features of the GLOBE Program, the results of the year-long GLOBE self-study and review, and the changes in funding strategy for the Program proposed by NSF and NASA. The picture we have created illustrates how the Next Generation GLOBE Program can work effectively with partners; NASA, NSF, and other donor agencies; and Large Scale Science Programs (Integrated Earth systems science programs) to the benefit of the worldwide GLOBE community.

NSF/NASA's new funding strategy offers exciting opportunities for the GLOBE Program and its community of participants to work with innovative world-class scientists studying state-of-the-

art science. Furthermore, we believe that these new opportunities are well aligned with the Community's wishes and GLOBE program office staff's effort to enhance and improve the Program.

APPENDICES

Appendix A:

Refereed Publications using Globe Data in Scientific Investigations

Hiemstra, C.A., G.E. Liston, R.A. Pielke, Sr., and D.L. Birkenheuer. 2005. Comparing Local Analysis and Prediction System (LAPS) assimilations with observations. Monthly Weather Review (accepted with revisions).

Morrill, J.C., R.C. Bales, and M.H. Conklin. 2005. Estimating stream temperature from air temperature: Implications for future water quality. Journal of Environmental Engineering 131(1): 139-146.

Robin, J., E. Levine, and S. Riha. 2005. Utilizing satellite imagery and GLOBE student data to model soil dynamics. Ecological Modelling 185: 133-145.

Verbyla, D. 2001. A test of detecting spring leaf flush within the Alaskan boreal forest using ERS-2 and Radar SAR data. International Journal of Remote Sensing 22: 1159-1165.

White, M., M. Schwartz and S. Running. 2000. Young students, satellites aid understanding and climate biosphere link EOS Transactions of the American Geophysical Union (January 4) 81:1,5.

Appendix B: December 8 – 10, 2004, Meeting Participants

The outside experts who attended the December 8 – 10, 2004, meeting in Broomfield, Colorado, to discuss how best GLOBE might be organized and operated included:

- Paula Coble, Program Scientist, Earth Science Education, NASA Headquarters
- Kevin Coyle, National Environmental Education & Training Foundation (NEETF)
- Daniel Edelson, Associate Professor, Learning Sciences and Computer Science, Northwestern University
- Paul E. Filmer, Program Director, National Science Foundation
- Ira Geer, Director, Education Program, American Meteorological Society
- Margaret Kelly, Associate Dean, College of Education, California State University, San Marcos
- Norman Lederman, Chair, Department of Mathematics and Science Education, Illinois Institute of Technology
- Judith Lederman, Illinois Institute of Technology
- George Matsumoto, Senior Education and Research Specialist, Monterey Bay Aquarium Research Institute
- Steven McGee, NASA/Classroom of the Future
- Everett McGlothlin, Coronado, California
- Stephen Pompea, Manager of Science Education, National Optical Astronomy Observatory
- James Rattling Leaf, Sinte Gleske University
- Will Schweller, Chevron Exploration Technology Company
- John T. Snow, Dean, College of Geosciences, University of Oklahoma
- Mark Sparn, Retired Principal, Flatirons Elementary School
- Nancy West, Math and Science Coordinator, Williamsburg-James City County Public Schools

Appendix C: SRI Evaluation Findings

GLOBE Evaluation Findings from Student Learning Assessments

Prepared by Bill Penuel, *SRI International*

What We Have Found

Since 1995, SRI International's evaluation activities have examined some aspect of GLOBE's effects on students' learning in science. In our investigations, we have relied on assessments of our own design, rather than on standardized measures of science achievement. Many of our assessment items look (in appearance) like standardized test items, but they are focused on concepts that are actually taught as part of GLOBE. Our aim in using our own measures has been to provide evidence from evaluation data based on *instructionally sensitive* assessments, that is, tests that would be able to detect changes in student learning brought about by participation in GLOBE. Most of our studies have used comparison group designs, although none of the studies has used random assignment of teachers or students to treatment and control groups.

In studies conducted as part of the Year 2, 6, 7, and 9 evaluations, we found that GLOBE contributed to development of students' *science knowledge*. In the Year 2 study, for example, items that discriminated between GLOBE and non-GLOBE students were ones related closely to GLOBE data collection protocols. GLOBE students were more likely to recognize when variation in data among a group of students recording temperature was too great to trust an average reading and more likely to be able to use GLOBE-like tools to measure tree canopy cover. In Year 6, we found that, compared with non-GLOBE students, GLOBE students scored higher on a test of Atmosphere and Hydrology concepts. GLOBE students were better than non-GLOBE students in answering questions related to pH and to identifying where and how to test the influence of human activities on water quality in a watershed. In Year 7, we administered a test of Atmosphere concepts to GLOBE students and found that those students who had more exposure to direct teaching of these concepts and who had opportunities to analyze GLOBE data outperformed those students with more limited exposure to course content and no opportunities to analyze data. Finally, in the Year 9 evaluation, we found that GLOBE students outgained students in a comparison group on a test of Hydrology concepts after implementing a small number of protocols and learning activities. Results of the Year 2, 6, and 7 studies are to be published in a forthcoming book on scaling up technology-supported innovations in mathematics and science education (Means & Penuel, in press) and were presented at the most recent meeting of the American Association for the Advancement of Science.

In studies conducted in Years 4 and 5, we found that GLOBE contributed positively to the development of a *scientifically informed perception of the environment*. We found that, over the two years we measured students' environmental awareness, GLOBE students consistently outperformed their counterparts in comparison classrooms. We also found in these studies that GLOBE students were more likely to make reference to "big ideas" in science—such as cycles and interdependencies of systems—than were

comparison students when presented with a photograph of an environmental scene. We discovered in Year 5 that they cited these big ideas without prompting, moreover, to a greater extent than did comparison students. When students were provided with a simple prompt to describe how the water cycle shaped the environmental scene, GLOBE students' mentions of specific aspects of the water cycle doubled. Results of these studies were published in a peer-reviewed journal article (Coleman & Penuel, 2000).

SRI has also found that GLOBE has had positive effects on students' *problem-solving and inquiry skills*. In an extended performance task administered to more active and less active GLOBE students in Years 4 and 5, we found that students in more active GLOBE classrooms outperformed students in less active GLOBE classrooms. GLOBE students in both years were able to marshal more and better evidence to support arguments they made on the basis of GLOBE-like data about where to locate the next Winter Olympics. In Year 7, we analyzed how GLOBE students constructed and analyzed data from a hypothetical Atmosphere inquiry task. We found that most students had difficulty planning investigations and using data to solve an extended problem in the Atmosphere investigation area. However, students who had had more exposure to the subject matter content of the task and who participated in more inquiry-oriented science instruction did better. In Year 9, GLOBE students outgained students from a comparison group on a similar test of inquiry skills in the Hydrology investigation area. A manuscript is in preparation for submission to the *Journal of Geoscience Education* that will report on the Year 9 results.

Difficulties Faced in Collecting Student Data

We have faced three main difficulties in collecting data on student achievement in science: (1) finding suitable assessments, (2) recruiting samples, and (3) collecting matching pre-post data from large enough numbers of classrooms.

The first problem is that too few assessments are suitable to measure GLOBE's effects. State assessments cover many more topics than GLOBE covers in any given year; moreover, state assessment data cannot be equated from state to state. We have therefore developed and validated our own assessments and reported results of our validation studies in peer-reviewed articles and in our annual evaluation reports to GLOBE.

A second challenge has been in recruiting classrooms to participate in the study. The problem has multiple aspects: the GLOBE database often contains old information about teachers no longer in the school; teachers are unwilling to commit to the study because of other pressures, such as standardized testing; and only two investigation areas (Atmosphere and Hydrology) are implemented in enough classrooms that a sample can be drawn with enough power to detect moderate effects on student achievement. To overcome these challenges, we have developed our own databases for purposes of recruiting, which we update as we learn about teachers who have moved; we have provided modest incentives for teachers to participate ($100 per classroom); and we have focused our assessments on those areas most often implemented.

A third problem is collecting matching pre-post data from a national sample. Most teachers cannot anticipate whether they will be able to implement GLOBE in any given year. We have therefore relied more on posttest-only designs or, as in the case of the Year 9 study, pre-post designs with a limited number of classrooms. In addition, for Year 10 we have planned to use a *proxy pretest*, a technique used in quasi-experimental designs that can help control for initial differences in student achievement between treatment and control groups (Shadish, Cook, & Campbell, 2002). We will use student reports of grades in science and mathematics as proxy pretest scores, and we will use scores on our own posttest assessments of Atmosphere concepts and inquiry skills to measure student achievement.

The Planned Year 10 Study

We are planning to conduct a study of the *efficacy* of GLOBE in fall 2004. An efficacy study is a study of a program's effects under specified conditions. In our case, the specified conditions are ones we have identified from earlier studies as potentially critical to learning in GLOBE: data collection, use of GLOBE learning activities, and data analysis. We will use a quasi-experimental design with 25 GLOBE-implementing and 25 non-GLOBE-implementing middle-school classrooms in the Midwest participating. Where possible, we are recruiting GLOBE teachers who are not implementing the program for the control group.

Because of the range of ways in which teachers might implement GLOBE in the classroom, the GLOBE teachers will need to meet specific criteria to ensure that results can reasonably be attributed to GLOBE activities. Those criteria are to do the following within a *10-week* period this fall.

- Conduct at least one GLOBE learning activity with students.
- Facilitate data collection using GLOBE protocols at least three times.
- Complete at least one activity in which students have an opportunity to look at and discuss the GLOBE data they have collected.

Teachers will also be asked to keep a weekly log of GLOBE activities, using a checklist that will be provided. At the end of 10 weeks, they will use materials provided by SRI to administer the assessment of student learning and then return those materials to SRI. For each classroom participating in the assessment, the teacher will receive a $100 gift card.

Results will be analyzed with a combination of statistical methods. To measure the efficacy of GLOBE, we will calculate an *effect size* (Cohen, 1988) by subtracting the control group mean from the treatment group mean and dividing the result by the pooled standard deviation of the two groups. We have determined that a sample size of 50 classrooms will detect an effect size of 0.46, with a power of 0.80 and intraclass Correlation of +0.30. This is a moderate-sized effect (Cohen, 1988), and is in line with what was found in the most recent GLOBE study we conducted in North Carolina, where the effect size was +0.49. We will also perform an *analysis of covariance*, using the proxy pretest value as our covariate and the posttest scores on our assessments as the

outcome measure. We will analyze whether the effect of group (GLOBE or non-GLOBE) on the scores is statistically significant at a $p = 0.05$ level. Finally, we will construct a *hierarchical linear model* to test the effects of being in a GLOBE classroom versus not being in a GLOBE classroom and to measure the influence of data collection, analysis on students' posttest scores.

References

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.

Coleman, E. B., & Penuel, W. R. (2000). Web-based student assessment for program evaluation. *Journal of Science Education and Technology*, *9*(4), 327-342.

Means, B., & Penuel, W. R. (in press). Research to support scaling up technology-based educational innovations. In C. Dede, L. Honan & L. Peters (Eds.), *Scaling Up Success*. San Francisco, CA: Jossey-Bass.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston, MA: Houghton-Mifflin.

Appendix D: Identifying, Developing and Supporting GLOBE Projects

1. Fundamentally, there are two kinds of potential GLOBE projects – those that are initiated by GLOBE and its sponsoring agencies (e.g., NASA, NSF) in support of the mission of the sponsoring agencies, and those that grow out of local or regional interests.
2. GLOBE and its sponsoring agencies, after seeking advice from the GLOBE worldwide community through the GIAB and other means, will make decisions concerning which projects will be initiated by the GLOBE Program Office with sponsoring agency support.
3. GLOBE Regional Consortium, a group of partners, individual partner or a teacher may propose a new project for GLOBE, for instance the Tsunami Project in Thailand, or a Southeast Asian project focusing on Mangroves proposed by an (as yet nonexistent) GLOBE/ASEAN Southeast Asian Consortium. In this event, if a GLOBE sponsoring agency believes the project is aligned with that agency's mission, it may decide to support the project. In most cases it can be anticipated that support for such local and regional projects will need to be drawn from local or regional resources, not from one of GLOBE's sponsoring agencies.
4. In either case, each proposal is reviewed by the sponsoring agencies and members of the GLOBE International Advisory Board to seek recommendations before a decision is made to adopt the proposed activity as an "official" GLOBE project.

   Some possible criteria for project selection might include:
   - It is consistent with the funding agency and GLOBE's mission and goals.
   - The subject matter has a high probability of attracting widespread participation.
   - It has international relevance and appeal.
   - It has high intrinsic value educationally and scientifically and in terms of publicity, credibility, etc.
   - It is "doable" within the resources available, or additional resources for GLOBE would be forthcoming if the project were adopted.
   - The project includes the participation of local scientists, and can be tied back to work being done by scientists working within the sponsoring agency.
   - It is of limited duration (i.e., days, months, a year or two - not decades).
   - It includes significant interaction between the educational and scientific participants.
   - It has a culminating event that provides feedback to all participants.

5. A project manager is assigned to develop a work plan, including a budget, timeline, staffing needs, etc. This plan goes back to the management group for approval.
6. Once the plan is approved, a project team is assembled to work on designing, developing, implementing, and evaluating the project under the leadership of the Project Manager.

7. Possible Team Membership (the number of individuals and level of effort in each category to depend on the scope of the work):

GLOBE Program Office:[20]

- Project Manager
- Scientific advisor
- Instructional Designer/Curriculum Developer(s)
- Web master
- Programmer(s)
- Partner support specialist(s)
- Evaluation/research specialist
- Development specialist.

Other:

- Local educator(s)
- Local scientist(s)
- Scientist(s) and/or Educational Specialists, from sponsoring agencies.

8. The Project Team works under the leadership of the Project Manager to identify GLOBE materials (educational materials, protocols, training materials, etc.) that can be used for the project, modifying these material or developing new materials as necessary. A partner support plan, evaluation plan, and online support plan will also be developed by the Project Team.
9. Concurrently, if necessary the Development Specialist seeks sponsors and investors for the upcoming Project.
10. The products are field-tested and revised as necessary.
11. The products are advertised, and then disseminated, to the schools that sign up to participate as part of a GLOBE Schools Network.
12. The project is evaluated during its implementation to fine-tune its implementation, and after it has ended to evaluate its impact.
13. The evaluation information is fed back into the new project development process and to GLOBE's sponsors and participants.
14. The project team stays together to begin a new project or the members are reassigned to other projects.

[20] For local and regional projects, Project Teams may be formed by GLOBE Partners, not the GLOBE Program Office. However, in such cases the sponsoring agencies and the GLOBE Program Office will reserve right of approval for projects carrying the GLOBE Trademark to ensure quality control.

Appendix E: GLOBE Regional Consortia

GLOBE Regional Consortia Concept Paper

GLOBE is increasingly expanding worldwide, and interest on the part of GLOBE countries in working collaboratively on a regional basis is growing. This interest began in Europe when a European Country Coordinator Committee (CCC) was established in May 1996, resulting in many regional activities including the development of the first GLOBE Regional Web site. CCCs were subsequently established in West Africa. GLOBE countries in Asia, the Middle East, and the wider Caribbean region and Latin America are currently focusing their efforts on establishing CCCs.

GLOBE countries are seeking these regional relationships because they offer them an opportunity to work together on a variety of activities that benefit their programs and schools such as securing funding, promoting school-to-school communications, developing regional science projects, and holding regional events for their GLOBE schools.

With the ten-year anniversary of the GLOBE Program, it is appropriate to look at how GLOBE has been operating and to ask if there are new ways of doing business that would benefit our partners and enhance worldwide implementation of GLOBE. The GLOBE Program Office is very pleased with the interest in regional collaboration because of the many benefits it provides to GLOBE countries. We would like to further promote the discussion of regional consortia development, encourage regions to take on more leadership and responsibility for GLOBE, and work with GLOBE partners to find the means to accomplish this. By doing so, these consortia could enhance the synergy of GLOBE activities in a region, minimize duplication and overlap of efforts currently undertaken by individual GLOBE countries, and identify capabilities that are missing within a region and find ways to address them. As a result, these consortia would foster stronger GLOBE activities worldwide.

Involving government and related industry or business leaders and scientists in the region would strongly enhance the effectiveness of GLOBE Regional Consortia. However, critical to the development of these consortia is that the leadership established within each one has a high degree of autonomy to develop the consortium and its activities according to regional needs and interests. With this in mind, the following list of responsibilities is offered in order to initiate discussions regarding ideas and examples of the types of activities that a GLOBE Regional Consortium could do.

- Provide leadership and support for GLOBE in the region or targeted area(s).
- Work with GLOBE to collaboratively train a regional corps of Master Trainers who would train GLOBE Trainers who train teachers in each country.
- Develop and share workshops, materials and Trainers across countries.
- Operate a regional GLOBE Web site that would mirror the GLOBE Web site, translate web pages into regional languages, and provide scientific, educational

and environmental information of interest to the students, teachers and scientists in the region.
- Translate GLOBE materials into regional languages.
- Provide support to partners, trainers and teachers in the region.
- Organize regional GLOBE conferences, workshops, and learning expeditions.
- With local funding, develop regional science projects focused on issues relevant to the region and involve scientists within the region.
- Develop links with researchers/universities in the region.
- Develop publications and implementation materials relevant to the region.
- Develop and implement a strategy for the sustainability of GLOBE in the region (identification of partners, sponsors, fundraising, public and political awareness, etc.).
- Partner with organizations, institutions, universities and networks in the region in order to enhance the overall regional program as well as program content and structure for partners and schools in the region.
- Recruit new countries in the region to join GLOBE.
- Develop a periodic E-newsletter to share with nearby countries.
- Represent the region at meetings of regional consortia organized regionally or by the GLOBE Program Office.

In the spirit of initiating formal discussions within regions, the GLOBE Program Office has made it a priority to work with GLOBE partners in the traditional GLOBE regions to seek partners and sponsors for establishing and supporting regional consortia and to work with these consortia on a continuous basis from initiation to steady-state operations. By focusing its efforts on supporting these regional consortia, the GLOBE Program Office would be better able to support GLOBE Partners while they collectively strengthen their capabilities and expand their activities to meet their goals and objectives as well as maximize the benefits of GLOBE for their schools.

Regional Consortium can encompass an entire geographic region or sub regions. Therefore, Consortia can be defined in numerous ways according to the needs of the constituent organizations. For instance, a consortium may be based on spatially defined regions or even based on a common theme (Oceans, Polar, etc.). In some cases, Regional Consortia may want to include countries outside their regions which have similar languages or other interests. Again, critical to the establishment and success of these consortia is that GLOBE countries in a region have a high degree of autonomy to develop the consortium and its activities according to their own regional needs and interests.

International examples could include:

- Regional Consortia such as Europe, Asia, Latin America, Africa, etc.
- Sub regional Consortia such as Wider Caribbean Region, West Africa, Southeast Asia, Pacific, etc.
- GLOBE Countries forming a consortium centered on worldwide research activities (such as UNESCO World Heritage Sites).
- GLOBE Countries located on one continent.

- GLOBE Countries that speak the same language.

U.S. examples could include:

- State Space Grant, Broker Facilitators, ERC Directors, AESP Representatives, and Explorer Schools working with the State Department of Education, Local Businesses and Community Members.
- NASA Explorer Schools could form a consortium of schools within the United States.
- North America Regional Consortia (Canada, Mexico and the U.S.)
- USA Regional Consortia—Regional distinction based on traditional regions in the country such as the SE, NW, SW, NE, and Central to form Regional Coordinating Committees (e.g., NW Consortia (Alaska, Idaho, Oregon and Washington).
- State Consortia combining existing partnerships within one state.

Note: Since schools in the U.S. are governed at the state level, not the federal level, it makes sense that they have "state" education entities collaborating with partners to form State Coordinating Committees.

Appendix F: GLOBE Schools Networks (GSNs)

Abstract

In this model, GLOBE focuses on creating (strengthening) and supporting highly-successful, highly visible projects-based networks of GLOBE schools around the world. Schools participate in environmental studies of their local environments and participate in regional, national, and international projects of interest to them and to the GLOBE Program Office. The GLOBE Program Office facilitates the involvement of scientists, large-scale science programs, and other organizations interested in working with and supporting a GLOBE Schools Network.

Rationale

Many individuals and organizations already perceive that GLOBE currently has a strong network of schools so this GLOBE model would help make that perception a stronger and more effective reality. Having strong networks would allow GLOBE to be responsive to short-term environmental events (e.g. Tsunamis, hurricanes, floods), and to possible participation of international or regional science programs who need a strong outreach network to conduct their work. Focusing on training and support for schools provides greater likelihood that GLOBE will be successful (educationally) than focusing on individual teachers.

Differences

In this model, GLOBE Schools become the focal point of all GLOBE activity and support. Individual teacher involvement in GLOBE may or may not continue, but support for Schools is where GLOBE Program Office resources and projects are directed. The success of GLOBE is dependent on the success of individual GLOBE schools and the networks as a whole, not on the numbers of teachers trained or measurements submitted to the GLOBE database. This model requires a strong international GLOBE program, strong country partners, the development of selection criteria and incentives for becoming part of a GLOBE Schools Network, and reorienting of education, science, systems, and partner efforts toward the success of schools in GLOBE School Networks.

Qualifications for participation as a member of a GSN

District Concurrence

- Commitment to achieving the highest standards in teaching Earth system science and/or environmental education in the school curriculum as demonstrated by involvement in past GLOBE or other environmental education programs.
- A letter of support and endorsement from the district superintendent and/or science coordinator. Letter acknowledges commitment to participation and assessment activities related to a GLOBE project, and pledges to provide necessary support to the participating schools.

- Commitment by science coordinator or other appropriate district staff to helping assess GLOBE's implementation and impact in participating schools.

Community Engagement

- Document ties to the local scientific and business communities.
- Establishment of a GLOBE Community Committee consisting of administrators, teachers, parents, local scientists and businesspeople to conduct a self-evaluation as well as guide and assess school's progress at meeting GLOBE objectives.

School Administration:

- Endorsement of the school head administrator and/or school board including a commitment to supporting implementation of a GLOBE project in the school.
- Commitment to participating in a GLOBE project throughout the life of the project.
- Commitment to working with local media to publicize school involvement in a GLOBE project.
- Commitment to include and acknowledge GLOBE activities in the participating teacher's evaluation process.
- Encourage sharing of the GLOBE program implementation at the school level through assemblies, faculty meetings, etc.

Teachers

- Three or more teachers on staff certified as GLOBE teachers and are each implementing a GLOBE project in one or more classes/courses each.
- Commitment to share GLOBE activities with other educators through meetings, professional development activities, or presentations.
- Commitment to share GLOBE activities with other teachers in the GLOBE community (including international).
- Required to submit annual progress reports to the GLOBE program office.

Students

- Students have demonstrated their ability to collect data, conduct research, and use GLOBE student and/or reference data in their analysis, as well as to report data to the GLOBE Web site.

Benefits of membership in a GSN

- The prestige of being a member of a recognized group of successful, innovative schools.
- The opportunity to participate in a larger worldwide network that is contributing not only to education, but to local and global environmental awareness.
- A suitably attractive plaque for their school office and/or flag or banner.

- Publicity to other schools and the media as a model GLOBE school site.
- The opportunity to market the school as being differentiated from the mainstream.
- Support for an existing school-wide focus (e.g., magnet and specialty schools)
- Designation on GLOBE Web site as member of a GLOBE Schools Network.
- Special interaction with world-class scientists.
- Special online events, resources and communications channels for network schools including Specific online professional development courses for members.
- Expert review/critique of student research designs and reports.
- Preferential opportunity to participate in new GLOBE activities.
- A small annual stipend to support GLOBE activities as a matching grant, and discounts on GLOBE equipment and/or materials.
- Guaranteed slots at a Partner sponsored GLOBE workshop for a minimum of two district teachers, curriculum specialists, or administrators annually.
- Early announcements of GLOBE TTT Summer Institutes for district teachers, curriculum specialists, or administrators.
- Telephone “hotline” support for participating teachers (special number)
- "First Look" at new GLOBE curriculum materials
- Opportunity to partner with GLOBE in the design, development, testing and evaluation of innovative educational activities, materials, tools, and technologies.
- Framework for student and teacher research projects
- Connections to other resources like DLESE, NSDL, data and image banks, and so forth.
- Research findings that demonstrate being involved in a GLOBE School Network improves student interest and achievement in science.
- Assistance with alignment of GLOBE learning activities and investigations with the school’s curriculum goals and standards.

Responsibilities of GSN Schools

- Implement GLOBE project activities with at least three classes.
- Participate in at least one GLOBE project-based investigation, field campaign or other GLOBE activity annually.
- Send at least one representative from the district to a local, regional, national, or international GLOBE event, e.g., Partner Event, Regional Consortium event, GLOBE Annual Meeting, GLE, or related student events such as local science fairs.
- Complete annual GLOBE Schools Network survey, including summary of GLOBE activities and assessment of impacts of participation in the project.
- Communicate GLOBE involvement and activities to local media.
- Participate in GLOBE materials testing, program evaluations, and survey research.
- Invite parents, local scientists and businesspeople to at least one GLOBE school event annually.