GLOBE: Exciting new directions for the worldwide science education program

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1. Overview

Since its beginnings in the early 1990's, the GLOBE Program (www.globe.gov) has helped students and teachers in over 100 countries collect environmental data as part of the process of learning how to do science and to provide these valuable data to scientists for use in scientific research. It has been this important partnership between students, teachers, scientists, and others that has made this one of the most recognized science and education programs in the world. Recently, the University Corporation for Atmospheric Research (UCAR) and Colorado State University (CSU) were officially awarded a Cooperative Agreement from NASA to assume primary responsibility for administrating the U.S. and international GLOBE Program. As GLOBE enters a new era of growth and opportunity, UCAR and CSU are calling upon the education and scientific community around the world to help chart the future of GLOBE.

The GLOBE Program is a network of over 14,000 K-14 schools, science centers, after-school programs and other organizations where students collect scientific data according to precise protocols and then enter the data into a central database allowing both scientists and students to utilize the data. Through this network, GLOBE trains teachers to help students improve their achievement in science and math and in the use of computer and network technology. In addition, GLOBE increases student awareness of the environment from a scientific viewpoint, without advocacy relative to issues. GLOBE improves student understanding of science because it involves them in performing real science - taking measurements, analyzing data, and participating in research in collaboration with scientists. Through this direct exposure to what science is about, GLOBE helps expand the pipeline of potential future scientists and engineers for academia, government, and the private sector.

The Goals of the GLOBE Program are to:

- Increase scientific understanding of the Earth
- Improve student achievement of science and mathematics
- Enhance the environmental awareness of individuals world-wide.

2. The GLOBE Program and the Meteorological Community

GLOBE can provide useful data to the meteorological community as well as an excellent opportunity to enhance public

awareness of weather and the environment. Of the over 10 million data points that have been collected to date, the vast majority are related to the atmosphere. The new GLOBE administrators plan to continue and expand current GLOBE efforts to include the latest technologies including remote sensing and GIS (Geographic Information Systems). Partnerships have already been developed with numerous NASA satellite missions including atmosphere-focused Aqua, CloudSat, Aura and CALIPSO (all part of the 'A-train' or Afternoon Constellation). Partnerships are also in the works with meteorological field efforts, both nationally and internationally.

GLOBE is not a curriculum, but is instead a series of protocols detailing precise data collection techniques and instrument specifications, along with accompanying learning activities, teacher training, materials and extensive field support. Each GLOBE measurement is part of an ongoing scientific investigation selected through the National Science Foundation's peer review process. Scientists develop measurement protocols and instrument specifications to ensure that the data collected by the students are accurate and consistent. The scientists also continually review GLOBE data reports in the archive for quality control purposes.

All the data collected to date are available at the GLOBE website (www.globe.gov) to anyone interested in using them for research. This includes scientists and students alike. Along with the data, the GLOBE website provides a number of tools for analyzing the data and many links to other databases for comparison to GLOBE data, all freely available to the public.

3. GLOBE Protocols

Table 1. A comprehensive list of GLOBE protocols of potential value to the meteorological community.

Investigation Area	Equipment
Atmosphere	
Cloud Protocols (incl. Contrails)	Cloud Chart
Aerosol Protocol	Sun Photometer
Water Vapor Protocol	Water Vapor Instrument
Barometric Pressure Protocol	Barometer or Altimeter
Relative Humidity Protocol	Sling Psychrometer or Hygrometer
Precip. Protocols (incl. Snow)	Rain Gauge
Temp. (Max, Min) Protocol	Thermometer
Surface Ozone Protocol	Zikua Reader
Auto. Weather Station Protocols	Station
Soil	
Max/Min Soil+Air Temp Protocol	Thermometers
Soil Moisture Protocol (5,10cm)	Drying oven or Microwave
Bulk Density Protocol	Graduated Cylinder and Balance
Water Infiltration Protocol	Concentric Cylinders
Davis Soil Moist/Temp Station Protocol	Station
Land Cover	
Land Cover Protocols	GPS, Satellite images, Compass, Computer software
Earth as a System	
Budburst Protocol	No major equipment
Green-Up Protocol	No major equipment
Green-Down Protocol	No major equipment
Lilac Phenology	Special cloned plants
Phenological Gardens	Special cloned plants

Table 1 lists the GLOBE protocols considered to be of the greatest potential use

to meteorologists (for complete list and details go to www.globe.gov - Teachers' Guide). These include not only 'traditional' measurements of precipitation, cloud cover and type, relative humidity and temperature, as well as fairly advanced measurements of ozone and aerosols, but also include soil moisture and bulk density, seasonal change and land cover types. GLOBE also has protocols for automatic weather stations.

4. GLOBE 2003 and Beyond

As GLOBE has grown, attention has shifted from quantity to quality. The GLOBE dataset is extensive but has not yet reached its full potential. Teachers are excited by GLOBE, but it can be difficult to implement GLOBE protocols in the classroom. Help is needed to fit GLOBE into individual curricula and at the same time meet local, state and national education standards. The cost of instrumentation can be a significant barrier, particularly in developing countries. Because data are primarily collected by K-12 school students, there are often gaps during weekends and vacations. Also, as in all cases, quality control is an issue, and GLOBE data are just now beginning to find use in papers published in the refereed scientific literature.

The solutions of these problems have evolved over the last several years, through the hard work of the previous GLOBE administration. Also, the GLOBE Partners, the people who implement GLOBE in their region, have tried new ideas that can be replicated elsewhere. Finally, the UCAR/CSU group has developed some ideas based on their collective experience in the science and educational outreach areas. The three thrusts of the UCAR/CSU group, below, have their roots in all three places.

1. Enhance GLOBE's presence and impact in K-12 schools.
2. Promote widespread use of GLOBE data in both science and education.
3. Increase community support for and sustainability of the GLOBE program.

The efforts that are planned to meet these three goals are overlapping. Below, some of these plans are summarized with a description of how they address these goals.

Training Workshops. GLOBE will continue to develop trainer workshops and support partner-based teacher workshops. Using the U.S. as a testing ground, these trainer workshops will be organized around themes (i.e. Climate, Agriculture, Watersheds, Urban). These tie the measurements together in ways that the trainers and ultimately teachers can use in their classrooms. Distance-learning courses in advance of the workshops will cover some material and enable more face-to-face time for concepts not easily conveyed online Other distance-learning courses at the end of the workshop will allow the trainers to review the material before they train the teachers. These steps should improve data quantity and quality, while use of themes should lead to more types of measurements taken and a richer and more meaningful experience for teachers and students**.**

Pre-Service Education. Pre-service education refers to the education received by those seeking to become a certified or licensed teacher. There are many opportunities to implement GLOBE as part of a semester course in elementary of secondary school science education methods courses, as part of a science course (biology, atmospheric science, earth as a system), or an "enrichment" (e.g., weekend or summer training course). Several of these courses

could at least in part be taught through distance-learning as well as face-to-face.

Foster Development of GLOBE Learning Communities (GLCs). The most successful GLOBE partnerships involve not only schools, but also other groups such as scouts, senior centers, nature centers, etc. More people involved locally means that GLOBE teachers are not isolated – they have colleagues to go to when they have questions, and the departure of a single teacher has far less impact. Furthermore, other groups can take measurements when schools are not in session. Where scientists are involved in such communities, the GLC can work together on a particular scientific problem or set of problems. Involvement of several schools means that different measurements can be taken by students of different ages, and a student can be exposed to several GLOBE protocols before graduating from high school. Involvement of several groups enables sharing of instrumentation or facilitates fundraising efforts for instrumentation, field trips, etc. Also, GLCs provide an excellent opportunity for pre-service teachers to link with in-service teachers while learning GLOBE protocols and learning activities.

Development of Distance-Learning Courses. Distance-learning courses allow participants in GLOBE workshops to prepare and review material, raising the knowledge and comfort level of teachers trying out GLOBE learning activities and measurements in their classrooms for the first time and thereby improving both quality and quantity of measurements. Also, GLOBE Partners and teachers can be kept up-to-date regarding science content and new protocols. As noted above, this frees valuable face-to-face time in training workshops and can enrich Pre-service education.

GLOBE Schools Participate in Field Programs. GLOBE is seeking opportunities for GLOBE Partners and schools to participate in environmental field programs where such collaboration promises to be mutually beneficial. For example, the African Monsoon Multidisciplinary Analysis (AMMA) field program, slated for 2006, has several objectives whose fulfillment would benefit from student observations of rainfall, land cover, aerosols, and soil moisture. In return, GLOBE is looking for opportunities for country coordinators (international Partners), teachers and students, to experience parts of the field program, participate in science investigations, and would like to leave the instruments at schools, weather stations, etc. after the field program. In a related effort, the GLOBE PIs referred to earlier are co-developing a prototype field program with the local GLOBE Partner and UCAR/CSU GLOBE headquarters that will focus on school investigations of land-use issues in Black Hawk County, Iowa. Finally, GLOBE PIs are developing global networks of schools that will collect reference data for evaluation of satellite data.

5. Potential Interactions with AMS

There are several opportunities for collaboration between AMS and GLOBE. First, there is strong overlap between the subject matter covered by both Project ATMOSPHERE and Project Maury. Indeed, some of the AERAs (Atmospheric Education Resource Agents) are also GLOBE-certified teachers. Second, local chapters of the AMS desiring to work with schools could contact the GLOBE Partnership or schools in their area (listed on the GLOBE web site). GLOBE would also encourage television and radio weathercasters, local Weather Service

employees and other meteorologists to contact GLOBE schools or partners and offer to collaborate.