

GLOBE ONE: A Community-Based Environmental Field Campaign

Rebecca Boger PhD, Peggy LeMone PhD, John McLaughlin,
Sharon Sikora PhD, Sandra Henderson PhD

Abstract—The Global Learning and Observations to Benefit the Environment (GLOBE) program is an international environmental science and education program involving scientists, teachers and students in the collection, analysis, and display of data used in environmental monitoring and research. Since its formation in 1994, students have collected over 11 million data points in Atmosphere, Hydrology, Soils, Land Cover/Biology and Phenology investigation areas. At present, over 14,000 schools in 106 countries participate in GLOBE (www.globe.gov). In 2003, GLOBE scientists, K-12 teachers and students, and citizen volunteer groups in Black Hawk County, Iowa started collaborating on a multi-disciplinary intensive data collection effort called GLOBE ONE. Research questions for this campaign focus on a community-specific generated issue; the central scientific objective compares quantitatively the environmental effects of various soil tillage techniques in Black Hawk County. Multiple data sets are being collected over a two-year period with the bulk of data collection performed by GLOBE students collaborating with scientists. GLOBE ONE and GLOBE Iowa supply an infrastructure for community and partner aid to the GLOBE schools and supplement measurements when required. This low-cost campaign provides a model for future scientific partnerships involving GLOBE students, teachers, scientists, and community organizations. While providing scientific data, this community-based campaign sets the stage for sustainable environmental stewardship, monitoring and planning.

Introduction

GLOBE ONE is a field campaign involving a first hand partnership between students and scientists to collect a structured, multidisciplinary data set designed to answer a research question. The campaign started in spring 2004 and will run through to fall 2005. GLOBE ONE was developed by GLOBE science Principal Investigators (PI) with the help of GLOBE Program Office to demonstrate the capability of GLOBE student-teacher-scientist partnerships to produce scientific results publishable in refereed journals.

The GLOBE Program (www.globe.gov) is an international science and education programs that involves K-12 students in meaningful science. Formed in 1994, GLOBE has grown to include 14,000 schools in 106 countries. GLOBE dedicates resources to develop and support over 50 protocols including data entry, storage, and access mechanisms that are capable of supporting true scientific research. GLOBE supports PI research teams charged with providing scientific publications based on GLOBE data. Students are collecting measurements in the areas of Atmosphere and Climate, Hydrology, Soils, Land Cover, and Phenology.

GLOBE is managed by the University Corporation for Atmospheric Research (UCAR) and supported by the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and the U.S. Department of State. Implementation in the United States depends upon the efforts of more than 100 U.S. Partners—universities, state departments of education, school districts, and other non-profit organizations. U.S. Partners raise their own funds, leveraged off the Federal investment in the program, to deliver GLOBE in their areas. U.S. Partners recruit schools, train teachers, provide follow-up support, and help in the adaptation of the program to state and local standards and requirements. Because broad international participation is integral to the implementation of the program, GLOBE enters into formal agreements with countries all over the world. In these partnerships, GLOBE provides the program infrastructure. Each international partner manages and provides funding for its own implementation, acquiring the resources from government, private sector, and non-profit sources. GLOBE partners determine implementation strategies consistent with their countries' educational systems and priorities.

Rationale

The GLOBE Program offers science and education materials that are used all around the world. The data, available from the GLOBE Web site, is used to help answer a variety of questions at local, regional and global scales. However, the data can lack temporal or spatial continuity, and thus limits the scientific usefulness. Furthermore, for an integrated Earth system approach, multiple types of data may be required at a given location or region. GLOBE ONE was designed to get a temporally and spatially intense data set. Furthermore, it was designed at the onset to have broad-based community interest and involvement. It is hoped that this will help set the stage for continued environmental monitoring and research by many different people and organizations (e.g., primary and secondary schools, universities, private sector, volunteer organizations) within the community.

Science Objectives

The science objectives of GLOBE ONE involve comparing the environmental impacts of tillage techniques used in agriculture. Specifically, scientists are investigating the impacts associated with varying the frequency and intensity of soil tillage and with varying the amount of crop residue left after crops are planted. The central question being asked is:

For corn and soybeans, what are the environmental impacts associated with different frequencies and intensities of soil tillage farming, and with different amounts of crop residue left after planting as compared to prairie and urban sites?

Tillage is a manipulation of soil by physical means to create soil conditions suitable for plant growth (Gajri and others 2002). Conventional tillage, also known as intensive tillage, involves intense manipulation of the soil, generally via plowing, and leaves less than 15 percent of crop residues on the soil surface after planting (Koller 2003). This tilling practice is used to prepare the soil for seeding and to remove weeds. However, it also removes crop residue that protects the surface of the soil, and can make the soil vulnerable to erosion.

In recent years there has been a rise in the use of alternative tillage practices that serve to reduce erosion, namely reduced tillage, conservation tillage and no-tillage. Reduced tillage is a practice in which the soil is tilled to some degree and 15-30 percent of the soil surface is covered with crop residue after planting (Gajri and others 2002). Conservation tillage refers to

any tillage practice the leaves at least 30 percent of the soil surface covered with crop residue after planting, the intensity and frequency of the tillage can vary but do not involve turning the soil completely upside down (Koller 2003). No-tillage refers to a practice in which the soil is not physically disturbed from harvest to planting (Koller 2003). The amount of crop residue left at the time of planting can be varied with no-tillage.

For each investigation area (Atmosphere, Hydrology, Phenology, and Soils), there are additional questions being asked. The multidisciplinary perspective that GLOBE ONE applies to assess the environmental impacts of an alteration in land management practices is key in assessing the environmental impacts.

Education Objectives

The involvement of GLOBE ONE Principal Investigators and local scientists with the schools may have tremendous impact on the accessibility of science as a career choice in addition to the overall attitude students have toward the nature of science. The National Science Education Standards for Professional Development of teachers include involving teachers in authentic research as a means of improving science education in their classroom. Teachers who have had research experience can positively affect the environment for learning science in their classrooms (Caton and others 2000, Johnson 2002, Odom 2001). Teachers and their students in GLOBE ONE will contribute to real science investigations of the effects of land use change on components of the Earth System.

Direct interaction with scientists occurs through a series of protocol workshops, field trips, and school site visits. As well, students will be encouraged to develop their own research questions and work with scientists on the development of these projects. In March 2005, an education workshop is scheduled for Iowa teachers to discuss the implementation of GLOBE ONE activities in the classroom.

Study Location

Black Hawk County, an agricultural area in northeastern Iowa, is the location of the field campaign. Black Hawk County was chosen for a number of reasons. The scientific questions match both the land-surface types found in the county and community concerns regarding land usage. Black Hawk County has a strong existing partnership with the University of Northern Iowa. The University of Northern Iowa offers the opportunity for

support and collaboration. Also, there are several other local organizations that have been tapped into to join the GLOBE ONE effort.

Data Collection

GLOBE students and volunteers in collaboration with scientists are collecting most of the data in this field campaign. GLOBE ONE and GLOBE Iowa supply an infrastructure for community and partner aid to the GLOBE schools and supplement measurements when required.

GLOBE ONE currently involves students from thirty classrooms in the Waterloo School District, University of Northern Iowa summer enrichment programs, local girl scouts, and IOWATER (a volunteer water monitoring organization). The Waterloo School District is one of four school districts in Black Hawk County. Active recruitment efforts are underway to include teachers and students from the other three districts. High school students enrolled in the University of Northern Iowa's Upward Bound program are collecting data for GLOBE ONE. Upward Bound serves high school students from low-income families, high school students from families in which neither parent hold a bachelors degree, and low-income, first-generation military veterans who are preparing to enter postsecondary education. The rigorous academic nature of GLOBE ONE aligns well with the goals and objectives of Upward Bound. A local Girl Scout troop from Black Hawk County is also participating in the data collection.

The list of the protocols used, required instruments, frequency of measurements and type of site is listed in table 1 – Data Collection Details. Sites are designated as either intensive or extensive. Intensive sites are the actual investigative sites where the data will be rigorously collected, while extensive sites are external to the actual investigation providing additional metadata to assist in the interpretation of the results especially in the area of Earth as a system. Ten intensive sites are being used to characterize areas with tillage of notable frequency and intensity (four sites), no-tillage (four sites), and prairie (two sites). Extensive sites are located at schools and feature student-driven measurements.

Potential Impacts/ contributions of GLOBE ONE

GLOBE ONE is gathering numerous complementary datasets to support GLOBE and non-GLOBE scientists in their study of the interaction of land cover and land

use with weather, water, and biota. These datasets are used for basic research and have many management applications. The participating students and teachers have a remarkable opportunity to work directly with these scientists, and obtain an inside view of a major research campaign. GLOBE ONE features measurements taken by students with the oversight and support of scientists. Both students and scientists will analyze the collected data to help answer the central and numerous related research questions.

In particular, some of the benefits of the GLOBE ONE include:

1. The current GLOBE ONE dataset is quality-controlled and continuous.

In GLOBE ONE, quality-controlled and continuous data will be achieved through intensive PI involvement, active local supervision, incentive systems, and extensive community involvement. Some data will be gathered using automated weather stations. Students and PIs involved in answering the science questions will be looking at the data as it is collected both for data assessment and to obtain early insights into answering the GLOBE ONE research questions.

2. The GLOBE ONE data set is comprehensive.

GLOBE ONE implements a large portion of scientifically-robust interdisciplinary Earth System Science (ESS) toolkit for measuring soil, atmosphere, hydrologic, land cover, and phenological states and processes that is provided by the GLOBE protocols.

3. GLOBE ONE involves the community.

The central science questions of GLOBE ONE were developed in collaboration with scientists in Black Hawk County, ensuring both the collection of the proper data, and community interest. This is important because the ideal GLOBE implementation scheme requires participation from multiple sectors of the local communities. Having many different groups working together to collect data allows creation of a larger and more complete data sets than could possibly be obtained by individual schools. GLOBE ONE serves to set up a strong example of how these partnerships can work. Scientists and local groups are working hands-on with schools to collect data.

Conclusion

In GLOBE ONE, many scientists have a vested interest in the data being collected, and these scientists are coordinating their activities to create a multidisciplinary dataset among themselves while working with students and other members of the Black Hawk community. Likewise the

Table 1. Data Collection Details.

Protocol	Instruments and Supplies	Sites	Frequency
Soil temperature Soil moisture Air temperature Precipitation Relative humidity Wind speed Barometric pressure Wind direction	Automated weather stations	10 intensive	Continuous wireless or downloads every 3 weeks/ month
Soil characterization: texture, structure, color, consistence, horizon, bulk density, particle density, root and rock, pH, slope		10 intensive, and 4 extensive, smaller set of measurements for MUC and Soil-a-thon	One time
Soil organic matter, carbon and nitrogen, ,psd, fertility, .3 and 1.5MPA water, bulk density	Supplementary in lab of Dr. Sparrow and/or Levine	10 intensive	One time
Greenup/greendown	Ruler, color charts	10 intensive and 4 extensive	Twice weekly, seasonal
Hummingbird*	Feeder, optional; Nectar plants, optional	4 extensive	Daily, spring to fall
Water pH	Meter, calibration solution	10 intensive	Weekly (non-frozen)
Water conductivity	Meter and calibration solution	10 intensive	Weekly
Water turbidity	Turbidity tube	10 intensive	Weekly
Water dissolved oxygen	Probe and/or test kit	10 intensive	Weekly
Water nitrates	Probe or test kit	10 intensive	Weekly
Water temperature	Probe and/or thermometer	10 intensive	Weekly
Water alkalinity	Probe and/or test kit	10 intensive	Weekly
Rain	Rain gauge	4 extensive	Daily
Snow	Snow board and meter stick	4 extensive	Daily
Precipitation pH	pH meter and calibration solution	4 extensive	Daily
Clouds and contrails	Cloud charts, web photos	4 extensive	Daily
Aerosols	Sun photometer	2 extensive	Daily
Water vapor	GLOBE/GIFTS Water Vapor Instrument	2 extensive	Daily
Surface Temperature	Infrared thermometer	10 intensive	Daily or weekly
Land Cover Sample Site and Biometry (MUC-A-THON)	cameras, GPS', MUC Field Guide, densiometers, clinometers	many	Once a year
Mapping	satellite imagery, transparencies and markers or computers with MultiSpec	one per school	Once
solar insolation, and UVA**	Specially designed "full sky" instruments	2 extensive	Data logged, requires weekly download

* this protocol included due to educational benefits, and special request of Iowa schools.

** these measurements may be piggybacked to aid in PI research, but are not GLOBE protocols or essential to main research question.

community has a vested interest in the questions being asked and the types of research being conducted by scientists and students. By working together, a model for a learning community is being developed. This learning community enables students to use the environment as a focus of study while providing data that can be used for research, monitoring, and management. This broad-based community participation will hopefully continue after the completion of GLOBE ONE in Black Hawk County. In addition, the model can be adopted in other communities to address other research questions utilizing local institutions and organizations.

References

- Caton, E., Brewer, C., & Brown, F., 2000. Building Teacher-Scientist Partnerships: Teaching about Energy through Inquiry. *School Science and Mathematics* 100: 7-15.
- Gajri, P.R., Akora, V.K., Prihar, S.S. 2002. *Tillage for Sustainable Cropping*. New York: Food Products Press.
- Johnson, M., 2002. Teacher as Researcher. *Science Teacher* 69: 40-42.
- Koller, K., 2003. Techniques of Soil Tillage, in Koller, A. (ed.), *Soil Tillage in Agroecosystems*. 2003, CRC Press, 1-25.
- Odom, A.L., 2001. Inquiry-Based Field Studies Involving Teacher-Scientist Collaboration. *Science Educator* 10: 29-37.