Activity name: GPS Instruments, Geo-caching, & Mapping

By Dr. Maureen Clayton, University of Northern Iowa, ATEEC Fellows Institute Co-Director

Introduction to Global Positioning System (GPS)

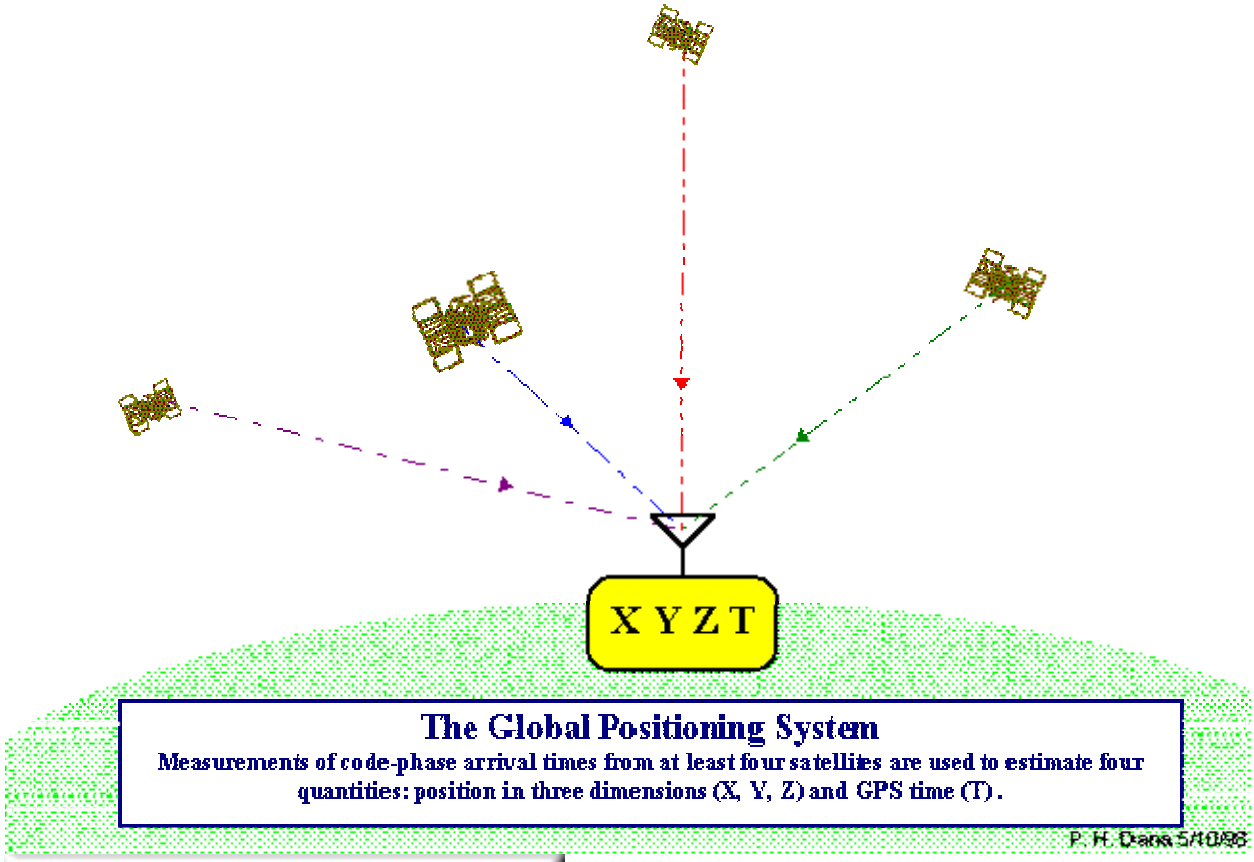
The Global Positioning System (GPS) is a navigational system that uses satellites to determine location with a high degree of precision. The two components of the system are a hand-held receiver purchased by the user and a series of radio signal transmitting satellites known as Navigation Satellite Timing and Ranging (NAVSTSR) maintained by the US Department of Defense. In order to accurately determine position by triangulation, the receiver must lock on to the signal of at least three satellites of known position. The receiver then determines the user's position by comparing the time the signal was sent with the time it was received. Ground stations at known positions improve the accuracy by correcting for some errors in the signal. Positions determined by this method are accurate to within approximately 15 meters.

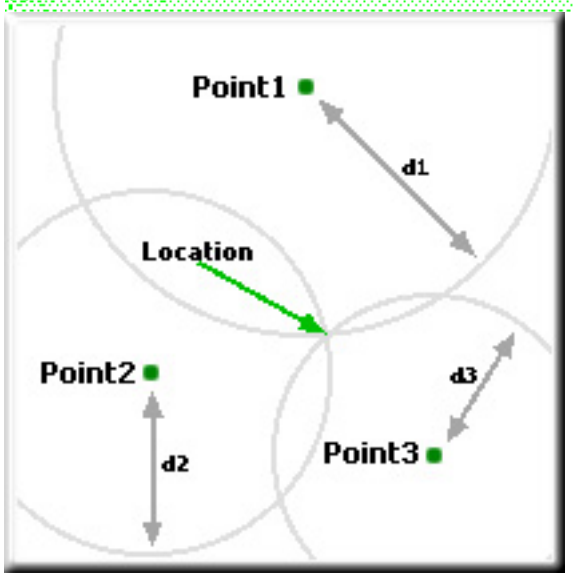
To improve accuracy, the Federal Aviation Administration (FAA) implemented the Wide Area Augmentation System (WAAS). Additional ground reference systems correct the signals from the satellites for errors including orbit and clock drift and delays from signal passage through the atmosphere and ionosphere. WAAS can improve accuracy to approximately ± 3 meters if you use a WAAS enabled GPS receiver. This technology is currently only available in North America.

There are two major applications of GPS technology in Environmental Science research. When conducting fieldwork, GPS can be used for navigation. Destinations can be entered and the *GOTO* or *routes* functions direct the user to follow the pointer arrow or with the built-in compass. Additionally, the *track log* and *TracBack* features act like a bread crumb trail, allowing you to find your way back to your starting point. GPS can also be used to accurately determine the locations where samples were collected. With this spatial information, Geographic Information Systems (GIS) techniques can be applied to display and/or analyze the sample data.

Photo top: Dr. Maureen Clayton (blue jacket) observes a group of Fellows' use of the GPS instrument before they try the activity set up in the woods.
Photo middle: A "Mentor" Fellow hides an "invasive species" card under a foot-bridge.
Photo bottom: Fellows set waypoints on a GPS instrument after finding an "invasive plant".

In a two-dimensional world, 3 satellites are needed to accurately fix a location. In our three-dimensional world, however, a minimum of 4 satellites are required. Additional satellites provide a more accurate location.





Introduction to Geographic Information Systems (GIS)

Geographic Information Systems uses commercially available software to assist in the visualization and analysis of geospatial data. Files are built of layers of data that can be collected by the user or purchased and/or freely downloaded from data repositories. The data have a geospatial component, meaning that they are linked to a specific location on the Earth's surface. User collected data can be used as long as the data is collected at known locations, usually with the aid of GPS. If GPS coordinates are not available, it is sometimes possible to obtain precise positional information on-line (www.lat-long.com or www.usno.navy.mil – look for sunrise/sunset).

There are two major software packages used for GIS. The first is a suite of programs produced by ESRI and collectively known as ArcGIS. This software is the most commonly used by GIS professionals and has the best suite of statistical analysis tools, but it is rather expensive. Google Earth is a relatively new product that is available at a more reasonable price. The base version of Google Earth does not support GPS, but Google Earth Pro does. It appears that Google Earth may become the version of choice for ecosystem management, but it still lacks some of the more advanced features useful in research.

Potential sources of data layers include:
US Data

- Geospatial one stop (www.geo-one-stop.gov/)
- National Atlas (www.nationalatlas.gov/)

Iowa Data

- Iowa Geospatial Data Clearinghouse (maps.gis.iastate.edu/clearinghouse/explorer.jsp)
- DNR GIS (www.igsb.uiowa.edu/nrgislibx/)
- Iowa Geographic Map Server (ortho.gis.iastate.edu/)
- Iowa Department of Transportation GIS (www.gis.dot.state.ia.us/downloads/default.asp)

For more information, check out the following sites and associated links.

- www.esri.com
- earth.google.com
- www.gis.com (sponsored by ESRI)

The following sites from major manufacturers of GPS receivers may be helpful.

- Garmin (www.garmin.com)
- Magellan (www.magellangps.com)
- Trimble (www.trimble.com)

Ormsby, T., E. Napoleon, R. Burke, C. Groessl and L. Feaster. 2004. *Getting to know ArcGIS desktop*. ESRI Press. (includes a trial copy of ArcGIS desktop).

Geo-caching Activity

Materials

- 1 GPS receiver for each group of students
- trinkets and storage containers
- permission from landowner

Methods

This activity is based on a popular outdoor recreational activity known as geo-caching (see http://www.geocaching.com for more details). The instructor hides caches of trinkets (you can use pretty much anything except food) and records the location of each cache as a waypoint on a GPS unit. **The students use GPS receivers to navigate to the positions to try to find the trinkets.** Since GPS units will direct the students only to the vicinity of the cache, you may need to provide a clue to help them find the treasure. Once they find the site, students can take a trinket, leaving the cache in place for the next group.

Mapping Activity

Materials

- 1 GPS receiver for each group of students
- computers with GIS software (Google Earth Pro or ArcGIS (ArcInfo) – note that ArcGIS is not available in Mac format)
- permission from landowner

Methods

Students are divided into groups, each equipped with a GPS receiver and sent out to look for various features* (specific plant species, geologic features, animal tracks, etc.). When these items are located, **students use the GPS to create a waypoint** indicating the location (for patches instead of points, have them record a waypoint at each of the vertices of the polygon delimiting the patch). In a field notebook, the students should record any relevant information for each waypoint.

Upon return to the classroom, connect the GPS receiver to the computer running the GIS software and download the waypoints. The two major GIS software packages available are ArcGIS (www.esri.com) and GoogleEarth (earth.google.com). When using GoogleEarth, a base map based on aerial photos is built in. With ArcGIS, you will have to find the other layers that you intend to use and import them into the software.

Data analysis will vary, depending on the situation. Students could focus on distributional patterns, thinking about invasion mechanisms, or produce maps to be used for inventories or as a guide in control efforts.

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*For the Fellows' activity, Dr. Clayton prepared laminated cards of various invasive species. Staff members distributed the cards through the site to be investigated. As Fellows found the species cards, they set waypoints on their GPS instruments. See the second and third photos on the first page of this file. In one a staff member (mentor Fellow) hides an "invasive species" card under a foot-bridge. In the other, Fellows use GPS to set an "invasive species" waypoint.

Dr. Clayton's PowerPoint™ files of the species are included on the ATEEC web site for teachers' use: http://www.ateec.org/ > Products > Free Resources.