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GOOGLE EARTH AND ARCHAEOLOGY

Jason Ur

Jason Ur is Assistant Professor of Anthropology at Harvard University.

Once upon a time, three-dimensional (3-D) visualization of landscapes was the exclusive realm of highly trained computer experts. The production of an oblique view of a landscape took several detailed stages, each involving obscure datasets, arcane knowledge, and expensive software (and occasionally large amounts of money). This situation changed in 2005 with the release of Google Earth, a new visualization and mapping program by the ever-expanding Google suite of applications. The Google Earth program (free download from <http://earth.google.com>) presents the user with an interactive globe. As the user rotates it or zooms in closer on any spot, the initial low-resolution imagery is replaced with increasingly higher-resolution views, giving an extremely realistic feeling of descent. As one moves from place to place, the ground rotates below in a manner vivid enough to inspire nausea in the weak-stomached.

In Google Earth, the entire planet is covered by medium-resolution, simulated, true-color images derived from Landsat data. Some select areas of the world, mostly American and western European cities, are covered by high-resolution Digital Globe satellite imagery, and some urban areas are covered by aerial photography. In some cases, the latter is so good that it allows the user to identify car models. These imagery sets are draped atop a digital terrain model, so surface topography is also represented. This is where Google Earth can elicit gasps: the user is not limited to a vertical perspective, and with oblique and near-horizontal viewing angles, this combination of imagery and terrain produces amazing 3-D perspectives on the landscape with no need for Geographic Information Systems (GIS) training.

The program contains a vector component as well. The user can overlay roads, political boundaries, lines of longitude and latitude, and a wide variety of point locations (most of the latter are various sorts of commercial establishments not immediately relevant to the study of the past, but archaeologists have to eat too). More significant is the ability to mark places—a sort of “bookmark” for a spatial location on the earth. These “Place-

marks” can be saved, annotated, emailed, and even published online via the Google Earth Community bulletin board site at <http://bbs.keyhole.com> (a sample set of Placemarks for the sites and landscapes mentioned in the text can be downloaded from http://www.people.fas.harvard.edu/~jasonur/SAA_ArchRec.kmz). All these features are available from the free version. A Google Earth Plus license (\$20/year) enables the user to upload waypoints from a Global Positioning System (GPS) receiver, and the Professional version (\$400/year) includes the capacity to import various raster and vector data from standard GIS programs (ESRI Shapefiles, IMAGINE images, GeoTIFs, etc.) into Google Earth’s KML format.

In the year that I have been using Google Earth, it has become indispensable. It is normally my first step in locating a business, and I would not dream of driving in Boston without first plotting my journey. Google Earth quickly became established in my archaeological life as well. However, although I think this resource is of great importance to archaeology, I also think it necessary to warn of how it could ultimately harm sites, if the archaeological community is not careful about how we use it.

Google Earth and Archaeological Research

Google Earth is an interface to a giant database of imagery of the earth’s surface. Some archaeologists will be delighted to see their sites or regions of interest appear in brilliant detail. Since ancient Mesopotamia is my primary geographic focus, I am one of the lucky ones: Iraq probably hosts the most high-resolution areas outside of the U.S. and the U.K. Even northeastern Syria sports inexplicably good coverage. At Tell Brak, where I am involved with an ongoing survey project, one can make out the square patches of bare earth where we’ve cleared off the sherds for our tent footings! However, the limited extent of imagery with such a high resolution will likely disappoint many, for this coverage seems to be limited to important urban places and their suburbs. If you are lucky enough to be working in Massachusetts, New Jersey, or Indiana, you will find that the entire state is covered; elsewhere, the coverage is a patchwork of high-

and medium-resolution imagery, the latter being too coarse to observe most cultural features.

Google Earth is not a file server, and imagery cannot be downloaded in a georeferenced format. It is possible, however, to perform a screen capture to save a screen image, which can then be pasted into PowerPoint or into Photoshop for further manipulation. One clever colleague noted that since the program displays the geographic coordinates of the cursor as it moves across the scene, it provides the control points to georeference captured scenes in a remote sensing program such as ERDAS Imagine or ENVI. He had made systematic screen captures across his survey region, georeferenced them individually, stitched them together, and used the output as the base field map for a survey.

Hardcore remote sensing users will not be impressed with this quick-and-dirty approach since the image compression on these scenes means that they are of poor spectral resolution (although the spatial resolution seems not to suffer). Through their partnership with Digital Globe, Google makes it easy to browse the original high-resolution QuickBird satellite imagery. Turning on a vector layer shows the footprints of available scenes, and clicking on the footprint calls up a low-resolution version, complete with acquisition dates, coordinates, atmospheric conditions, and ordering information. Google Earth thus makes it quite easy to legally acquire these images, but keep in mind the archived scenes are rather expensive. Most of the aerial photographs of the U.S. are available through state GIS agencies for free (as they've already been paid for by taxpayers), but be prepared to navigate some user-unfriendly websites.

Google Earth's ability to create and share Placemarks makes collaboration with distant colleagues very efficient. For example, I was recently browsing the former areas of marshland along the border between Iran and Iraq, not far from Basra, and came across a variety of interesting landscape features. Were these ancient sites now rendered visible by Saddam's marsh drainage program? Or were they the desiccated and abandoned former villages of the Marsh Arabs? Or were they the remnants of military positions constructed during the Iran-Iraq war that was fought in this area in the 1980s? I made Placemarks with some comments and sent them off to colleagues who had studied the region or visited it in earlier, less-troubled times. This ability to tap colleagues' geographic expertise has greatly enhanced my own abilities to interpret landscape signatures in places where I have never set foot and has offered me new insights into how I interpret the landscapes in which I do work.

Google Earth in the Classroom

While Google Earth is a convenient adjunct for research, it has

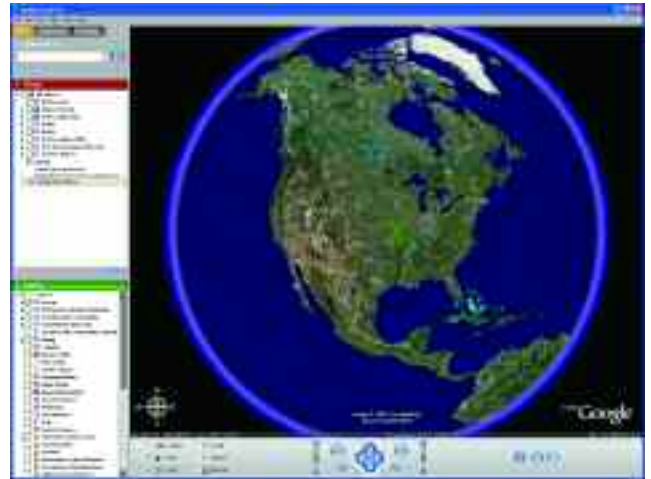


Figure 1: The Google Earth interface.

enormous potential as a teaching tool, and it is this aspect which is the most promising for archaeology. The dynamic visualization possibilities of Google Earth allow the geographic aspects of sites and their locations to come alive. Most lectures show a series of static maps. My lectures now start from an oblique view of our classroom in the Peabody Museum; from there, we fly to ancient sites and regions around the world. The movement of landforms imparts to the students a better appreciation of scale and is more intuitively grasped by individuals whose experience of landscape in the real world involves movement through it. The scale independence and flexible viewing angle also allow me to interact with landscapes in ways that lead to better understanding. For example, a discussion of Pompeii starts with a low-altitude vertical perspective to illustrate its internal organization. A shift to a smaller scale (zooming out) puts the site in the context of its now-silted harbor. Finally, a shift in the viewing angle to near-horizontal brings the mass of Mount Vesuvius looming over the doomed city, a vivid illustration of how human society can be at the mercy of its environment, a perspective that elicits gasps from the students.

The students enjoy watching me fly up the Nile or zoom across the Andes, but greater understanding comes from self-guided interaction. After the lectures, I upload the Placemarks from the lectures onto our class website so the students can explore on their own time. As Google Earth becomes more common on students' personal computers and in campus computer labs, GIS can finally become a part of laboratory sections at introductory levels. Most GIS software is far too expensive for individual students, and has a steep learning curve, and is thus impractical to incorporate into introductory archaeology courses. Google Earth is the solution to this problem. Instructors can upload Placemarks of places and landscape features and ask the stu-

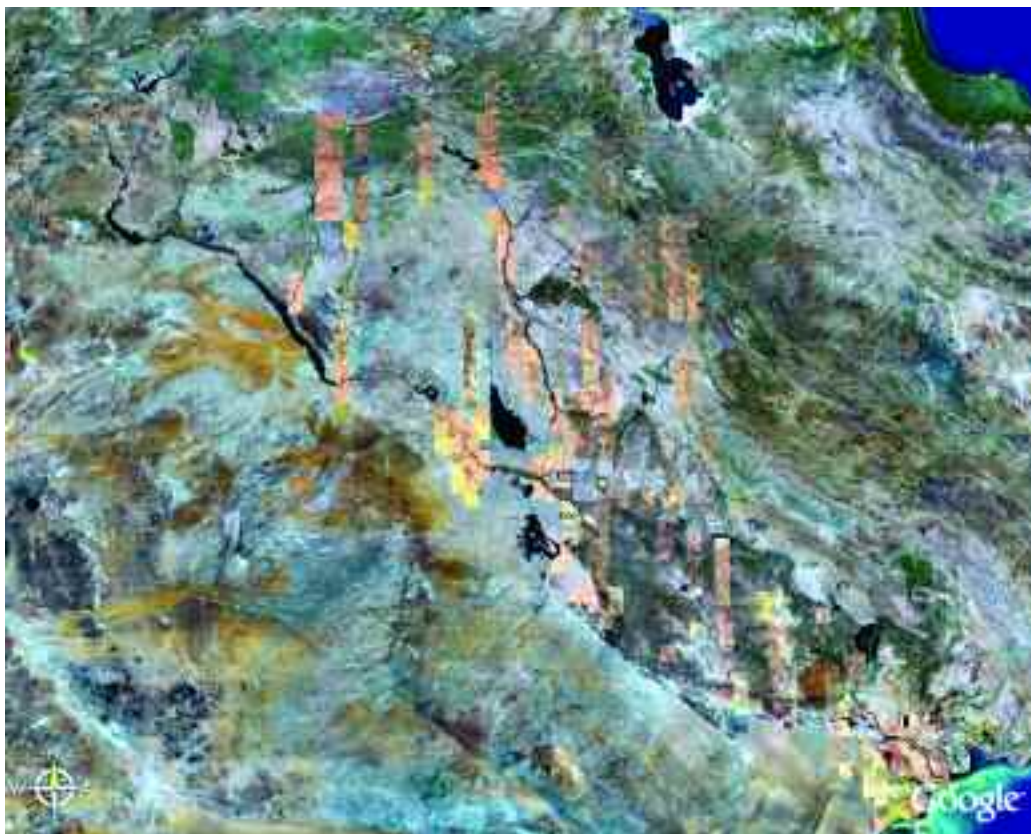


Figure 2: Medium- and high-resolution imagery coverage for the Middle East. The buff squares and north-south strips are areas of sub-meter Digital Globe QuickBird scenes.

dents to answer basic geographic questions. How long is the Avenue of the Dead at Teotihuacán? How are the water features at Angkor organized? What is the terrain around Macchu Picchu like? The importance of geography is better appreciated when students answer these questions on their own.

Google Earth as a Potential Threat to Archaeology

Two of the great strengths of Google Earth can potentially result in harm to the archaeological record if users do not exercise some caution. Archaeologists owe it to the public to share our findings, and indeed public education is the best hope for protecting our cultural heritage. However, we cannot assume that all users who seek out archaeological sites are doing so out of a positive interest in antiquity. Google Earth is also a potential tool for those who see archaeological sites as a source of saleable artifacts: pothunters and looters.

In a paper publication, one can accurately plot sites on a map at a scale of 1:250,000 without necessarily providing precise loca-

tional information. The scale independence of the Google Earth interface means that a Placemark (assuming it is correctly placed) is accurate at a regional level or at the street level. Thus, an unscrupulous user has access to precise geographic coordinates that can be easily uploaded into a GPS for navigation to a site. For some parts of the world, the unsuspecting Google Earth interface is more than happy to provide turn-by-turn driving directions, complete with estimated travel times!

The convenience of Placemark files makes them easily posted online at publicly accessible websites, such as Google Earth's community bulletin board site. A search of some of these forums indicates that most posted Placemarks are for well-known historical and archaeological sites already developed for tourism (and thus presumably monitored). Other archaeologist-maintained websites also offer downloadable Placemarks (for example, important Near Eastern sites at the ArchAtlas site: <http://web.arch.ox.ac.uk/archatlas/IndexAAP2.htm>).

This combination of accuracy and ease of dissemination could



Figure 3: An oblique perspective on the landscape of Pompeii and its hinterland. In the foreground is the doomed city; in the background is Mt. Vesuvius.

put sites at risk. Clearly, there is a need for balance. Our research is enabled to a large extent by public funding, and we should present what we learn to the public. But we can ask ourselves if this obligation requires the level of precision made possible by Google Earth. Is the benefit of public education greater than the risk of enabling damage to the very cultural resource in question? I am not discouraging the posting of Placemarks to Chaco Canyon or Stonehenge; we should encourage people to visit archaeological sites that have the educational and security infrastructure to handle them. On the other hand, unexcavated sites are of little interest to most laypersons. In such a case, the archaeologist's mission might be to give the public a general idea of the extent of ancient settlement without handing out a roadmap (literally) that could be abused by pothunters. Looters have done quite well for themselves without any additional electronic aids.

I can foresee one critical response: these images are online for everyone to see already, so what's the big deal? I would not advocate taking down the high-resolution images to "protect" sites.

But these images do not speak directly to the viewer; they require interpretation, as do all remote sensing datasets. Through field survey, archaeologists have hard-won, ground-control skills that allow us to decode these images. With the advent of Google Earth, these skills take on new responsibility.

Conclusions: Archaeological GIS for Everyone

Google Earth has emerged as a fantastic tool for archaeology at multiple levels. Although it can serve as a very basic tool for archaeological research, GIS and remote sensing specialists are not going to abandon ArcGIS and Imagine; the ease of Google Earth comes at the expense of flexibility and the capacity for advanced spatial analyses. Ultimately, Google Earth's significance for archaeology lies at the interface with students and the interested public. The world's past is accessible in a vivid and immediate way that cannot be captured in static maps and photographs. There are risks here, but these can be circumvented with a bit of forethought, and they are greatly outweighed by the benefits of exciting our students and the public with what we do.