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What is This?
Map stories can provide dynamic visualizations of the Anthropocene to broaden factually based public understanding

Andrew Zolnai

Abstract
Provision of broadly accessible and spatially referenced visualizations of the nature and rate of change in the Anthropocene is an essential tool in communicating to policy makers and to the wider public, who generally have little or no contact with academic publications and often rely on media-based information, to form and guide opinion. Three examples are used to demonstrate the use of geo-referenced data and GIS-based map compilations to provide accurate and widely accessible visual portrayals of historical processes. The first example shows the spread of Neolithic agriculture from Mesopotamia west and north across Europe over several millennia. The second plots the history of the drainage of the Fens (wetlands) in eastern England from the early seventeenth century onward. A third example illustrates one way in which releasing data in the public domain can lead to the enhancement of public data holdings. A concluding discussion outlines ways in which the methodology illustrated may be applied to processes key to understanding the Anthropocene.

Keywords
Anthropocene processes, data-based visualization, geographic information systems (GIS), map stories, public understanding

Introduction
Many non-specialists, who have an interest in current environmental change and its likely future consequences, gain their insights and form their opinions on the basis of what appears in the media or is available via the internet. Both sources of information can be readily manipulated by those with a vested interest in promoting a particular point of view. It follows that the quality of information that is beyond specialist, peer-reviewed literature and is openly available, should be
The Anthropocene Review

One of the aims of a transdisciplinary journal concerned with the Anthropocene must be to widen the access to factually based reconstructions of key processes in ways that demonstrate their nature, rate and spatially differentiated impacts. The present contribution to the journal’s ‘Perspectives’ theme is presented with this aim in mind. Two linked and complementary goals are involved – the portrayal of the results derived from specialist research in ways that make them understandable for a non-specialized audience, and the development of modes of information diffusion that essentially democratize the understanding gained. This article illustrates a methodology, familiar to a growing number of environmental scientists, which has the potential to achieve both these goals. The examples used are contrasted in terms of the processes, timescales and impacts involved. They serve to illustrate the scope of the approach used and its applicability to a wide range of changes, processes and impacts key to understanding the role of human activities in the Earth system in the past, at present and in the future. A third example illustrates the positive role that the technology now available can play in augmenting and enhancing existing government agency data holdings.

The nature of the technology

Twenty-five years ago, Ray Price (1989) noted that ‘human activities now involve an annual flux of earth materials equal to that of plate tectonics’. While he did not comment on when that influence started, he also stated that ‘new technologies for digital data bases and for digital geoscience maps and sections offer exciting new prospects for better integration and analysis of geoscience data, even on a global scale’. The technology now available makes this readily achievable.

First there is the huge volume of ongoing research and publication in fields ranging across the humanities, social and environmental sciences. Some of the results appear in peer-reviewed journals, others in current affairs media. Many are illustrated by figures and maps that use geographic boundaries, basic cultural features such as rivers, roads and cities, and relevant administrative boundaries such as countries, states or counties, depending on location. A recent trend has emerged to put many such studies in broader and more fully articulated spatial and social contexts. This stems partly from the increasingly interdisciplinary nature of many studies. As location is often the common underpinning, it makes sense to use maps as the common platform upon which to post all the information. The next section will show how the use of spatially referenced data spanning a wide range of social or environmental information can tease out relationships that were obscured when it was tabulated without its geographic context. Martin Lewis (Geocurrents 2014) a geo-historian at Stanford University took pains to illustrate his research in maps, and to popularize it via his blog. His work includes examples where his ability to embed spatially referenced results in a fuller context allows him to correct reports and resultant misconceptions popularized in the press – for example Lewis (2012) rectifies recent research throwing new light on the sensitive topic of Indo-European racial and linguistic origins.

A great deal of research data is in the public domain, and is available online barring publication, copyright and media barriers. Recently, governments have also been releasing their geographic data into the public domain (Ordnance Survey, 2010), so that the geographic reference information is widely available to the public; and where that is neither complete nor available, ‘crowd sourcing’ by soliciting contributions especially from an online community has started to fill in the gaps (British Library, 2014). Hardware and software to personally publish this information has also become more affordable if not free. Personal computers can now handle data of virtually any size; the web allows data users to access and distribute the same.
The current scope of digital mapping allows the precise location of data and offers the means to illustrate spatial, temporal and attribute relationships. Last but not least, there is an increasing library of free data available on the web that allows the posting of geo-referenced data against relevant backdrops that set the context for the data.

One of the main ways to process and display these maps today is through the use of ‘geographic information systems’ (GIS) that are designed to capture, store, manipulate, analyse, manage and present all types of geographical data. Their use in scientific literature has increased rapidly in recent years, often in combination with ‘DEMs’ (digital elevation models or 3D representation of a terrain’s surface) and other Remote Sensing products such as satellite imagery, air photos and ‘LiDAR’ (a detection system which works on the principle of radar, but uses light from a laser). Some sense of the scope and breadth of applications can be gained from examples such as Yang (2009), Wilson et al. (2004), Nettley et al. (2013) and the many products of ESRI (www.esri.com). Most examples deal with contemporary trends and their future implications for vulnerability and management, though there are rarer examples documenting past changes (Salzer and Bunn, 2012/2013).

A second vital tool is ‘web mapping service’ (WMS), a standard protocol to serve over the Internet geo-referenced map images that are generated by a map server using data from a GIS. The first thrust of this paper is that (a) GIS offers new ways to combine, analyse and display the maps and data, and (b) WMS offer new ways to publish the same data, not only for widespread public access but also in a way that engages experts, stakeholders and the public alike. The second thrust of this paper is that both GIS and WMS greatly enhance the scope for an informed public debate on the key issues that Anthropocene studies will raise.

Two contrasted examples are used below to illustrate the power of this approach. In terms of time frames, they are drawn from the Neolithic and the pre-/post-Industrial Revolution period. They are used to show how GIS and WMS in combination can help make processes, changes and problems in the Anthropocene visually accessible, whilst maintaining the integrity of the historical data, thus underpinning broader understanding and rational discourse. A third example shows how making public the data used in such studies helps government custodianship and transparency of the critical underpinning of the studies.

**The spread of Neolithic agriculture**

Although many researchers accept the original Crutzen and Stoermer (2000) definition of the Anthropocene, linking it to industrial development from around AD 1800 onwards, several authors, focusing on the gradual transformation of the Earth’s surface through the development of agriculture, with the consequent impacts on atmospheric greenhouse gas concentrations, see the Anthropocene as beginning much earlier (Ruddiman, 2013). Key to their view of the Anthropocene is the spread of Neolithic agriculture from Mesopotamia west and north across Europe, a process spanning over 5 millennia.

Through detailed and intricate spatial interpolation, Pinhasi et al. (2005) discussed how early agriculture spread in the Neolithic (11,000–4500 BC) from Mesopotamia though the Middle East and Southern Europe to Northwest Europe. Whether ‘indigenous and animated by imitation (cultural diffusion) or else […] driven by an influx of dispersing populations (demic diffusion)’ (the authors suggest the latter), it pinpoints an early onset of ‘the relationship between humans and their environment’ through farming (Oldfield et al., 2013) – in other words a deep and lasting effect on the environment as opposed to, say, hunter-gatherers with less impact (Lee, 2005).
But how are such intricate details effectively conveyed to others who do not have the background to grasp their significance, whilst maintaining geo-historical accuracy and promoting rational debate? The data themselves are in the public domain (Pinhasi et al., 2005), but accompanying maps are only accessible as images that do not lend themselves to further investigation. New tools are, however, at hand in the form of software that allows posting spreadsheet data on the internet. As long as there is a location attribute to pinpoint data on a map, these can then be transformed into ‘map stories’ that can communicate the meaning and significance in a form more readily engaging the attention of a non-specialist audience daunted by the original academic sources. Among the many options available, ESRI ArcGIS Online helps post maps directly on the internet (Figure 1).

**The drainage of the English Fens**

One of the most distinctive landscapes of lowland Britain is that of the Fens, lying along the eastern edge of southern England. Geologically, they comprise areas of low-lying marine silt fringed landwards by extensive areas of peat. In their present form they are a man-made landscape resulting from extensive draining from the early seventeenth century onwards. The history of the drainage of the Fens as they evolved from medieval swamplands to drained fenlands before and after the English Civil War was documented by H C Darby (1969). Together with a companion book on the medieval fenlands, Darby’s two books contain 25 and 35 map figures in 200 and 310 pages, respectively.

The recent release of Ordnance Survey (2010) OpenData has made it possible to post Darby’s data from the figures in his two books. Parishes are the geographic units that have remained constant since the Middle Ages. OpenData now provides free infrastructure data such as counties and parishes, roads and rivers, etc. in digital map format. It is therefore easy to derive a local subset for the counties of East Anglia. As parishes were the constant geographic unit since Domesday, attributes were simply added to those map files and augmented with Darby’s classifications. Data and details (Zolnai, 2011) are available on an Academic data share website and on ArcGIS Online.

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**Figure 1.** Data posted directly on the internet (Zolnai, 2012) from sources discussed in the text: this map story has the abstract at left, the map at centre and the legend at right. It is a synoptic view putting all information in the line of sight along with its geographical context. Panning left and right or zooming in and out helps orient the reader and facilitate a better grasp of the details.
The British Geological Survey (2014) also released its bedrock and superficial geology data as files and as web services. These were readily combined with the above on a web map combining Mapcentia GeoCloud2 and Amazon Web Services (Figure 2), together with the all-important metadata posted right in the table of contents: ‘Boundary Lines’ from the Ordnance Survey must be attributed as part of the government’s fair-use policy, and the metadata allow the viewer to explore and evaluate the origin and validity of the attribute data.

The 1794–1813 agricultural land cover was derived by assigning a land cover class per Parish from Darby’s *The Draining of the Fens*. This land cover and the 1641 Lay Subsidy classes correlate quite well: this supports Darby’s conclusion that the economic regime did not vary much after the Middle Ages. The 1877 and current superficial geology also correlate well (Figure 3), but subtle differences can be seen: silt and peat have similar extents, as do clay in the north, central and south-eastern Cambridgeshire, however the clay belt running SW–NE at centre appears to have shrunk significantly from the 1800 to the present, presumably as a result of the effects of cultivation where it forms only a thin layer overlying peat.

While it has been argued that the Industrial Revolution marks the onset of the Anthropocene, this study illustrates one way in which, at a regional level, significant human effects on the environment as the drainage of the Fens, started in pre-Industrial Revolution seventeenth-century East Anglia. It parallels some of the indications of early industry noted by Fischer-Kowalski et al. (2014).

Illustrating one benefit of placing data in the public domain

The East Anglia Fenlands data set has had a varied history. It started as an aid to the Fens Historic Environment Project (Akeroyd et al., 2010) to do geo-historic research to help plan environmental
conservation and tourism in East Anglia. It survives as the Great Fen Action Plan (Great Fen Team, 2010), jointly supported by the UK government and Wildlife Trust. The maps were created in 2011 (Zolnai, 2011), when funding was cut and the project stalled. Whilst it amounted to a not-insignificant amount of volunteer work from the author, the free software (www.qgis.org) initially used allowed the GIS part to proceed without funding. All data were then posted on an academic share site (www.sharegeo.ac.uk) as industry-standard shape files under a Creative Commons license. Finally they were posted online as described in the previous paragraph using tools on Amazon Web Services on a ‘freemium’ model (initial use is free, then usage fees increment as pay-as-you-go, and generally remain nominal – most anti-virus software is free, for example, but a modest annual fee adds automatic upgrades and technical support).

The 1SpatialCloud has an online validation service (Zolnai, 2013) the author helped test by running validation checks on: (a) attribute data that had been hand-entered by the author in the GIS, and (b) UK Ordnance Survey Parrish polygons to which attribute data were added. The manual data entry showed no errors, but the Ordnance Survey data did – communications with them showed that the errors found (submetric) fell below their quality control threshold (metres), but they invited the author to upload the corrected data for inclusion in the next government data repository upload in 2012 – the corrected Boundary Line vector data were downloaded and re-tested in 2013, and the number of errors dropped from 25 to 1 in 1900 polygons (Zolnai, 2013).

This is a success story of ‘volunteered geographic information’ (Goodchild, 2007) helping improve government data repositories. It illustrates how, in making data freely accessible, governments can foster cooperation through public input. Volunteer geography thus fosters public engagement in the process of government data custodianship in this simple example.

Summary and potential application to the Anthropocene

These examples shown above illustrate a variety of ways in which the Anthropocene can be explained to and explored by the widest possible audience. In the first example, multiple data sets
from a variety of sources have been combined; in the second case, material from a single major source has been compiled and combined with related, open access, geo-referenced data. The final section illustrates one way in which data quality can be enhanced by placing data in the public domain and making it widely accessible. They show that:

- Research published with geographic coordinates can be posted directly on web services and made into engaging web stories.
- Published figures can be added to administrative boundary data freely available from certain governments and combined into ‘geo-history’ maps.
- Freely available government data services can be used directly to display phenomena at the present day or from the recent past.

The methodology used here is in effect very simple:

- Harvest relevant material from specialist publications already available.
- Ensure that the metadata includes:
  - the detailed attribute information produced by research specialists in their own fields,
  - the exact geographic locations either from the data itself, or added to authoritative geographic data.
- Post the data on maps and/or on the internet for the broadest possible reach.

Some of the opportunities ripe for exploitation include the presentation of spatially disaggregated time series of the dramatic trends highlighted by Steffen et al. (2004) and taken as markers for the Great Acceleration. This could also reinforce the key point made by Malm and Hornberg (2013) in their counter to the view that Anthropocene is not, in terms of its human drivers, a global phenomenon. Similar treatment could be used to present integrated time series data on many of the contemporary issues such as resource depletion, energy use and environmental, including marine ecosystem damage.

This will ensure that the most authoritative data are published in a manner that is both fully transparent and as widely accessible as possible. Like all other presentation formats, map stories are open to distortion and manipulation. Complete transparency and full documentation of all metadata are therefore essential in order to allow critical evaluation of sources, questions of biased selectivity and misrepresentation.

The thrust of this ‘perspectives’ contribution is that publishing authoritative data in a readily accessible and engaging manner benefits both general public and researcher. Researchers see the chances of data corruption and misinterpretation reduced, and the public sees their understanding and trust increased; both sides can thus foster real debate based on accessible, authenticated data, thereby promoting ‘data democracy’: that may well become the single best way, alongside the initiatives illustrated by Barnosky et al. (2014a, 2014b) both to influence policy makers, and to inform the public at large.

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**Note**

1. ‘Online spatial validation’ is a process whereby GIS vector data are uploaded to a web service, where some rules are drawn up, and the data passed through algorithms that measure how well they meet the
prescribed rule criteria. A simple rule for polygons and polylines is that all segments join up to form a closed polygon or continuous line – tolerances can be set for how far apart segments can be and still be joined – vectors are usually scanned or digitized to varying specs, say for electrical wires inside buildings (centimetres), drainage pipes along roadsides (tens of centimetres) or cross-country transmission lines (metres).

References


