SOLSTICE:
An Electronic Journal of Geography and Mathematics.

(Major articles are refereed; full electronic archives available)

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SPECIAL ISSUE ON INTERNET GEOMETRY AND GEOGRAPHY

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Solstice Archive

- ***Solstice* was a Pirelli INTERNETional Award Semi-Finalist, 2001 (top 80 out of over 1000 entries worldwide)**
- **One article in Solstice was a Pirelli INTERNETional Award Semi-Finalist, 2003 (Spatial Synthesis Sampler).**
- ***Solstice* is listed in the Directory of Open Access Journals maintained by the University of Lund**

where it is maintained as a "searchable" journal.

- *Solstice* is listed on the journals section of the website of the American Mathematical Society, http://www.ams.org/
- *Solstice* is listed in the EBSCO database.
- IMaGe is listed on the website of the Numerical Cartography Lab of The Ohio State University: http://ncl.sbs.ohio-state.edu/4_homes.html

Congratulations to all *Solstice* contributors.

Solstice: An Electronic Journal of Geography and Mathematics,
Volume XVII, Number 2
Institute of Mathematical Geography (IMaGe).

Please contact an appropriate party concerning citation of this article: sarhaus@umich.edu
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MISSION STATEMENT

The purpose of Solstice is to promote interaction between geography and mathematics. Articles in which elements of one discipline are used to shed light on the other are particularly sought. Also welcome are original contributions that are purely geographical or

purely
mathematical. These may be prefaced (by editor or author) with commentary suggesting directions that might lead toward the desired interactions.
Individuals wishing to submit articles or other material should contact an editor, or send e-mail directly to sarhaus@umich.edu.

SOLSTICE ARCHIVES

Back issues of Solstice are available on the WebSite of the Institute of Mathematical Geography, http://www.imagenet.org and at various sites
that can be found by searching under "Solstice" on the World Wide Web. Thanks to Bruce Long (Arizona State University, Department of Mathematics)
for taking an early initiative in archiving Solstice using GOPHER.

PUBLICATION INFORMATION

To cite the electronic copy, note the exact time of transmission from Ann Arbor, and cite all the transmission matter as facts of publication. Any copy that
does not superimpose precisely upon the original as transmitted from Ann Arbor should be presumed to be an altered, bogus copy of *Solstice*. The
oriental rug, with errors, serves as the model for creating this weaving of words and graphics.

Awards and Recognition

(See Press Clippings page for other.)

- Google 3D Warehouse, "Google Picks" then go to "Cities in Development" http://sketchup.google.com/3dwarehouse/ to see textured models of downtown Ann Arbor buildings.
- *3D Atlas of Ann Arbor, Version 2*. Google Earth Community, ranked a "Top 20 Rated Post" on Entrance page, December 8, 2006.
- *3D Atlas of Ann Arbor, Version 2*. Rated a 5 globe production (top score) in Google Earth Community, November 2006.
- Sandra L. Arlinghaus and William C. Arlinghaus, Spatial Synthesis Sampler, *Solstice*, Summer 2004. Semi-Finalist, Pirelli 2003 INTERNETional Award Competition.
- Sandra Lach Arlinghaus, recipient, The President's Volunteer Service Award, March 11, 2004.
- Jeffrey A. Nystuen, won the 2003 Medwin Prize in Acoustical Oceanography given by the Acoustical Society of America. The citation was "for the innovative use of sound to measure rainfall rate and type at sea". It is awarded to a young/mid-career scientist whose work demonstrates the effective use of sound in the discovery and understanding of physical and biological parameters and processes in the sea.
- Sandra L. Arlinghaus, William C. Arlinghaus, and Frank Harary. *Graph Theory and Geography: an Interactive View (eBook)*, published by John Wiley and Sons, New York, April 2002. Finished as a Finalist in the 2002 Pirelli INTERNETional Award Competition (in the top 20 of over 1200 entries worldwide).
- *Solstice*, Semi-Finalist, Pirelli 2001 INTERNETional Award Competition in the Environmental Publishing category.
- *Solstice*, article about it by Ivars Peterson in *Science News*, 25 January, 1992..
- *Solstice*, article about it by Joe Palca, *Science* (AAAS), 29 November, 1991.

Introduction to the Special Issue on Internet Geometry and Geography

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Benoit Mandelbrot brought to life for most of us the work of Karl Weierstrass and numerous other mathematicians from the past who had studied the relationship between differentiability and continuity. Most of us learned about the absolute value function, its continuity and lack of differentiability at the origin, as an interesting function that was often used as an examination question that caught many calculus students off guard. Continuing studies in differentiability led, perhaps, to textbook line drawings in black and white showing simple continuous curves with more than one point where differentiability failed. High excitement came into the picture for those who could visualize Peano's space filling curve and imagine what might happen---but full visualization of it was never satisfactory.

Then, along came Mandelbrot! He offered a stunning array of computer graphics: detailed curves that clearly brought out the "wow" factor for more than a generation of scientists. Curves that had been only partially visible to those who chose to consider them were now portrayed in full-color glory, revealing patterns of self-similarity, self-replication, and so forth. The fractional dimension and the considerations of Hausdorff first came to life only many years after their discovery. Because everyone could now enjoy a fractal through the use of computer graphics, many became motivated to understand at least in part what these remarkable graphics might represent. Current technology provided a breakthrough in scientific communications: fractals piqued the interest of random citizens in what might have appeared to be a 'new' geometry--and, even more important, fractal geometry helped to guide the research of scholars in a wide range of disciplines.

The case of the fractal underscores the importance of the medium of communication in scientific research. The internet, coupled with the recent 2006 versions of Google Earth®, offers exciting new ways to visualize scholarly research. Again, as with fractals, there is the "wow" factor. Again, the images pique the interest of academics as well as others. The challenge is to discover how this new style of communication about the geometry of the Earth might guide research. It is to this challenge that the articles in this Special Issue offer a small set of early responses.

The major authors in this Special Issue are among the early leaders in the use of fractal geometry to guide geographic research. They are also among the early leaders in the use of contemporary technology to guide the communication and diffusion of scholarly information across scientific boundaries. The box below enumerates seven key contributions, from 1985-2006, for each. Some are conventional publications while others are internet publications (with links to external sites).

Sandra Lach Arlinghaus

2006*:* *3D Atlas of Ann Arbor: 2nd Edition,*. *Ann Arbor:* *Institute of Mathematical Geography*.

2006*:* (with input from numerous others noted throughout) *3D Atlas of Ann Arbor: 1st Edition*, Ann Arbor: Institute of Mathematical Geography.

2006*: (with W. C. Arlinghaus)* *Spatial Synthesis: Centrality and Hierarchy, Volume I, Book 1*. Ann Arbor: Institute of Mathematical Geography.
"Spatial Synthesis Sampler" is an included 2003 article that was a 2003 Pirelli INTERNETional Semi-Finalist.

2002: (with W. C. Arlinghaus and F. Harary) Graph Theory and Geography: An Interactive View E-Book, John Wiley & Sons, NY (Wiley's first E-Book publication).

Pirelli INTERNETional Award Finalist, 2002

1990-present: ***Solstice: An Electronic Journal o f Geography and Mathematics*****, Ann Arbor: Institute of Mathematical Geography. Pirelli INTERNETional Award Semi-Finalist, 2001. Written about in *Science* (AAAS) and *Science News* as one of the world's first on-line, peer-reviewed, journals.**

1989: **(with W. C. Arlinghaus) "The fractal theory of central place hierarchies: a Diophantine analysis of fractal generators for arbitrary Loschian numbers," *Geographical Analysis: an International Journal of Theoretical Geography*. Ohio State University Press. Vol. 21, No. 2; pp. 103-121.**

1985: **"Fractals take a central place," *Geografiska Annaler*, 67B, pp. 83-88. Journal of the Stockholm School of Economics.**

Michael Batty

2006: Rank clocks, *Nature*, Vol. 444, 30 November, 2006, doi:10.1038. Link to reprint.

2006: Virtual London, in Heywood, I., Cornelius, S., and Carver, S. *An Introduction to Geographical Information Systems*, Pearson Educational, Harlow, UK, pp. 269-271.

2005: *Cities and Complexity: Understanding Cities Through Cellular Automata, Agent-Based Models, and Fractals*, The MIT Press, Cambridge, MA, xxiii + 565 pp.

2005: (with Hudson-Smith, A., and Evans, S.) Building the virtual city: public participation through e-democracy, *Knowledge Technology and Policy*, 18, 62-85.

1997: Virtual geography, *Futures* 29, 337-352

1991: Cities as fractals: simulating growth and form, in T. Crilly, R. A. Earnshaw, and H. Jones (Editors). *Fractals and Chaos*. Springer Verlag, New York, 41-69.

1985: Fractals: geometry between dimensions, *New Scientist*, 105, 1450, 31-35.

External links are provided, on author names above, to documents containing complete publication listings.

Solstice: An Electronic Journal of Geography and Mathematics, Volume XVII, Number 2
Institute of Mathematical Geography (IMaGe).

Visualizing Rank and Size of Cities and Towns
Part I: England, Scotland, and Wales,1901-2001

Sandra Arlinghaus and Michael Batty

Dr. Sandra Arlinghaus is Adjunct Professor at The University of Michigan, Director of IMaGe, and Executive Member, Community Systems Foundation.
Dr. Michael Batty is Bartlett Professor of Planning at University College London where he directs the Centre of Advanced Spatial Analysis.

Please set screen to highest resolution and use a high speed internet connection.
***Please download the most recent free version of Google Earth®.* Make sure the "Terrain" box in Google Earth® is checked.**

Download the following file to use in Google Earth®:
1901 United Kingdom file

England, Scotland, and Wales: Rank-size Plots, 1901-2001

Rank-size plots have been used for years in a number of contexts: large sizes have small numeric ranks--the largest city in a region has rank 1 (the smallest numeral). Discussions of these plots, merits and drawbacks, example suited and not suited for application, and a host of related matters persist in the social scientific (and other) literature. Our focus in this internet paper is on the geometric visualization of rank-size relations: not only as plots but also in other ways that have come about as a result of contemporary electronic and internet capability. Figure 1 shows a rank-size plot, done in the classical manner, of data for 459 towns and cities in the United Kingdom. Each separate plot shows the rank-size curve for a particular year. The data set is ordered for each of 11 decades as noted in the legend of Figure 1. The goal is to look at change over time.

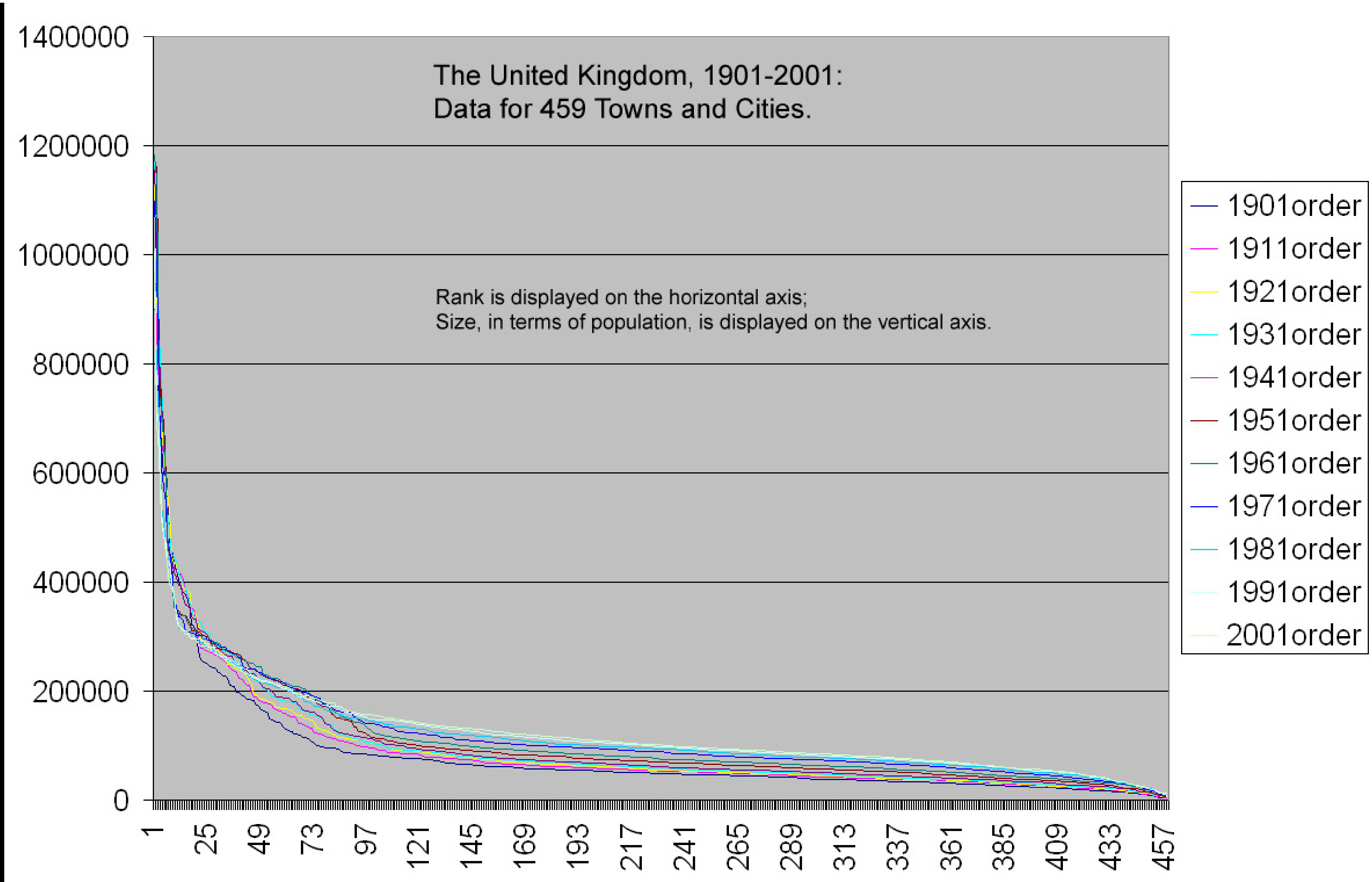
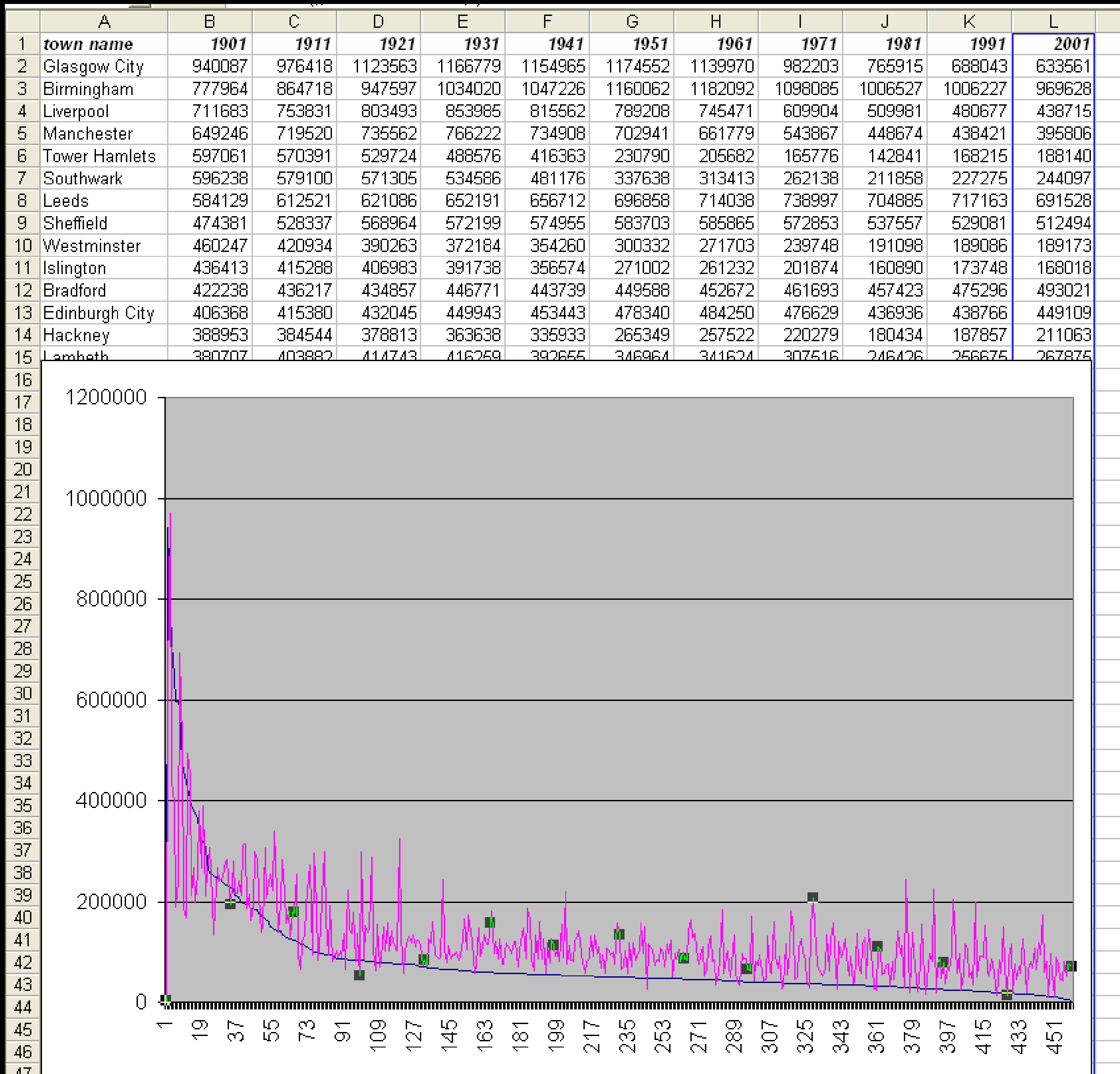


Figure 1. Rank-size plots of the UK data by decade.

The curves in Figure 1 each display the general pattern one expects in rank-size plots. They are similar to one another yet some variation is apparent. What is often deceptive about these plots, when portrayed as in Figure 1, is that it is not always the same city that has the number one (or any other) rank as one moves through time. When considering rank-size plots over time, this factor is a critical one. Thus, when the data set is plotted showing the rank-size plot of 1901 as a benchmark against which to plot remaining decades, the pattern becomes quite different. The animation in Figure 2 shows the data set arranged and graphed according to 1901 rankings.



	town name	1901	1911	1921	1931	1941	1951	1961	1971	1981	1991	2001
2	Glasgow City	940087	976418	1123563	1166779	1154965	1174552	1139970	982203	765915	688043	633561
3	Birmingham	777964	864718	947597	1034020	1047226	1160062	1182092	1098085	1006527	1006227	969628
4	Liverpool	711683	753831	803493	853985	815562	789208	745471	609904	509981	480677	438715
5	Manchester	649246	719520	735562	766222	734908	702941	661779	543867	448674	438421	395806
6	Tower Hamlets	597061	570391	529724	488576	416363	230790	205682	165776	142841	168215	188140
7	Southwark	596238	579100	571305	534586	481176	337638	313413	262138	211858	227275	244097
8	Leeds	584129	612521	621086	652191	656712	696858	714038	738997	704885	717163	691528
9	Sheffield	474381	528337	568964	572199	574955	583703	585865	572853	537557	529081	512494
10	Westminster	460247	420934	390263	372184	354260	300332	271703	239748	191098	189086	189173
11	Islington	436413	415288	406983	391738	356574	271002	261232	201874	160890	173748	168018
12	Bradford	422238	436217	434857	446771	443739	449588	452672	461693	457423	475296	493021
13	Edinburgh City	406368	415380	432045	449943	453443	478340	484250	476629	436936	438766	449109
14	Hackney	388953	384544	378813	363638	335933	265349	257522	220279	180434	187857	211063
15	Lambeth	380707	403882	414743	416259	392655	346964	341624	307516	246426	256675	267875

Figure 2. Envisioning fluctuations in the UK data set based on changes of individual city or town ranks over time. This animation shows the 1901 rank-size plot as the benchmark against which to visualize other decades.

In 1901, Glasgow City has the highest rank (City of London and its boroughs are each separate in this data set; there is no figure for Greater London) . Clearly, by 1961 (at least), Glasgow no longer has the highest rank; Birmingham, for one, has surpassed the population size of Glasgow. Naturally, there are numerous other fluctuations of this sort within this 11 by 459 matrix over the period of a

century. Indeed, it is difficult, looking only at the data, to envision the pattern of such fluctuation. Animation, not possible in conventional publication, does permit one to look at change over time in imaginative ways.

Rank changes over time; if one wishes, however, to understand why such changes occur it may be important to know where the cities and towns are in relation to each other and in relation to other variables such as the natural and built environments. Geographical Information System (GIS) technology permits the association of databases with maps: a change in the underlying database produces an associated change in the map (and vice versa). Flat maps made using GIS technology can be "inflated" to have a 3D appearance, and saved as Virtual Reality (vrml) files and viewed on the internet using a plug-in for the browser. Terrain can be introduced and databases can be viewed against terrain models (such as Triangulated Irregular Networks). What this approach cannot do is place the spatial model on a globe: it is conceived with flat maps.

Base Maps on the Globe: England, Scotland, and Wales

To overcome this noted limitation of GIS software, we use Google Earth®. As a first step, we create an inventory of base maps of the United Kingdom from materials already available on the Internet. The materials listed below are presented in an animation in Figure 3 to give the reader a sense of how boundaries fit together and of how towns and cities are arranged within those boundaries. In order, the frames of the animation of Figure 3 are:

- a global view of the UK
- a view of the UK showing national boundaries [see linked material in reference section to Valery35 and Barmigan]
- a view of the UK showing county boundaries with no labels [see linked material in reference section to Valery35 and Barmigan]
- a view of the UK showing county boundaries with labels [see linked material in reference section to Valery35 and Barmigan]
- a view of the UK showing cities and towns with labels; towns and cities are elevated, as stars perched atop a line, reflecting relative sizes [see linked material in reference section to Bowman]

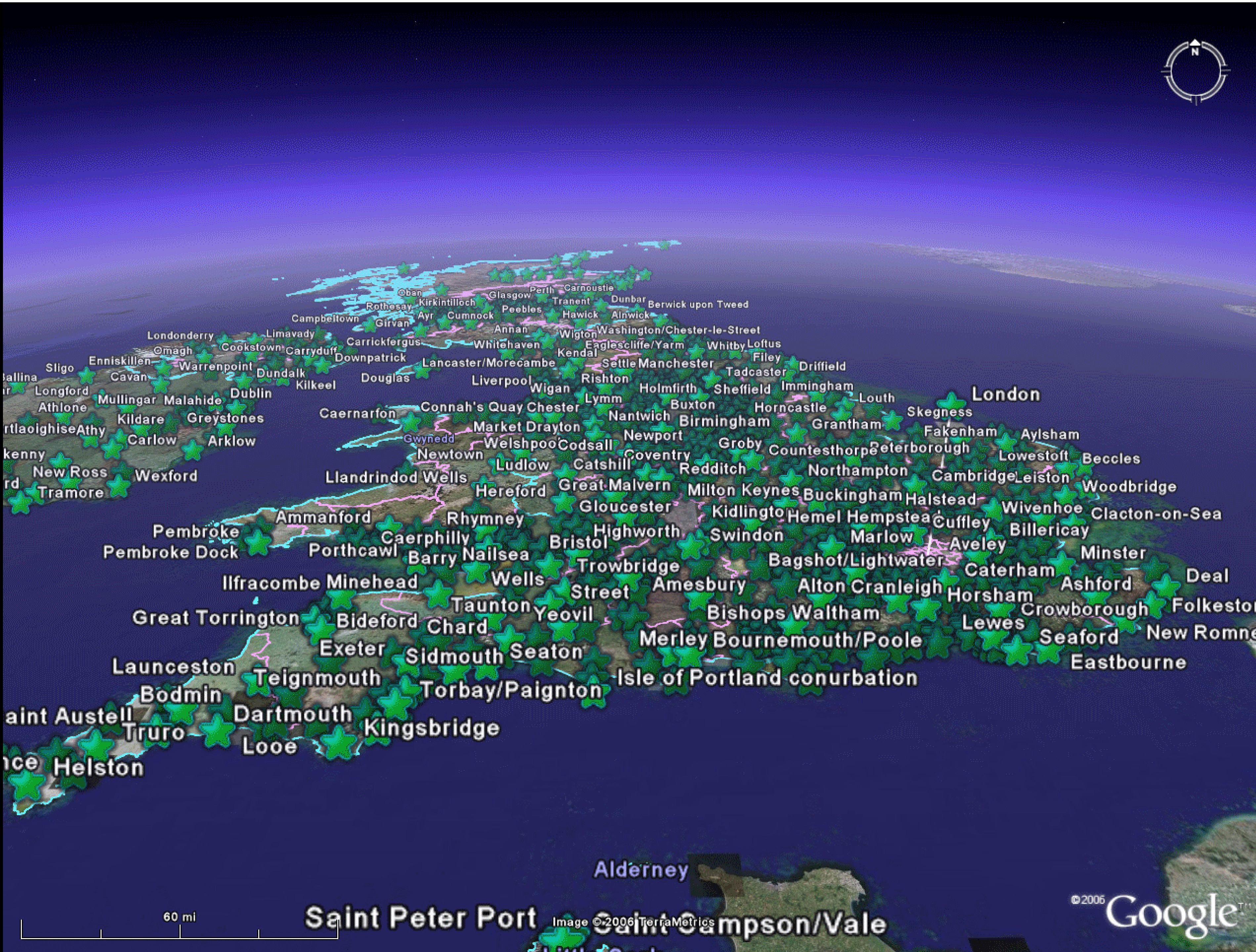


Figure 3. Base maps of the UK from Google Earth. Click here to view a .mov file in which the reader can control the animation rate.

Rank-size Data on the Globe: England, Scotland, and Wales, 1901.

The image in Figure 4 shows size data, from Batty's extensive database, for a selection of towns in England, Scotland and Wales for 1901. At a glance one can see the location on the globe of large cities in relation to small towns. The parallelepipeds anchored on town or city location are scaled according to town or city population. A town with a population of 125,367 is, for example, represented by a parallelepiped of height 125,367 feet, located at appropriate position on the Google Earth® ball. The result is shown in Figure 4a. Notice that Glasgow indeed has the tallest structure while the City of London and its boroughs show the densest concentration of population. If one wishes to add a single figure for all of Greater London, the result is shown in Figure 4b. All the 1901 population bars are shown on the animated base maps of Figure 3.

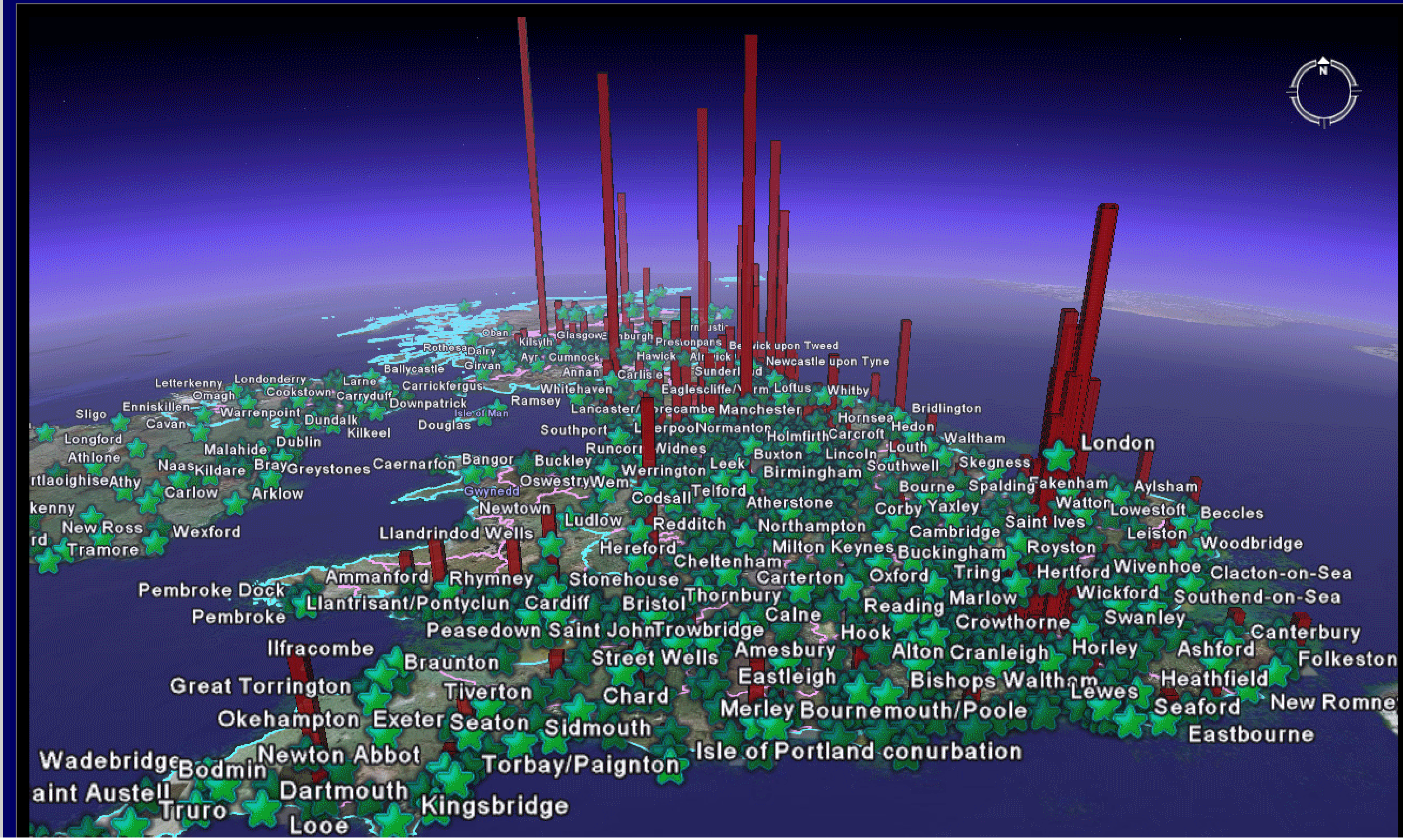


Figure 4a. 1901 population size mapped in Google Earth . Height of parallelepiped reflects directly population size of associated town or city. Click [here] to view a .mov file in which the reader can control the animation rate.

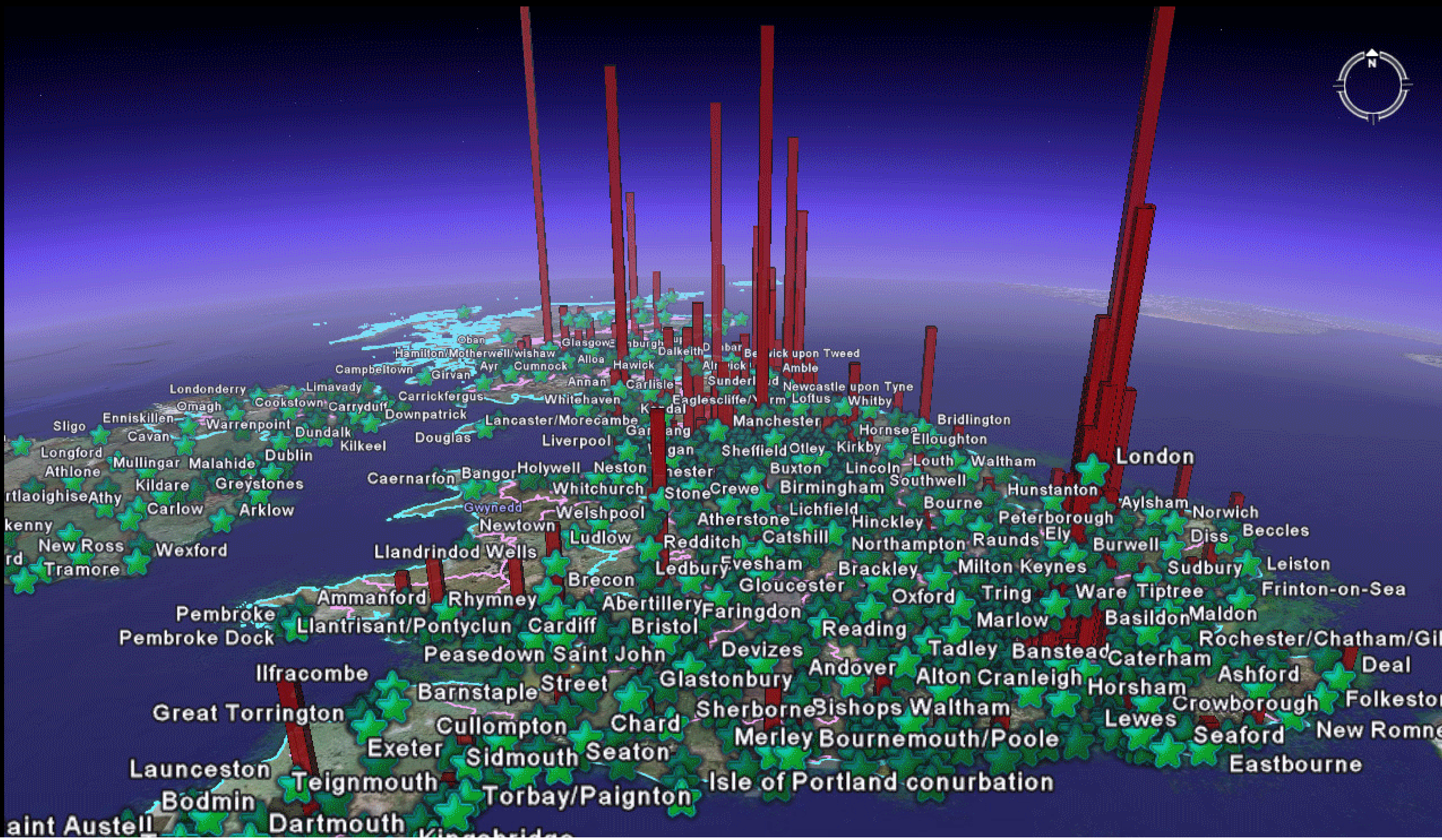


Figure 4b. 1901 population size mapped in Google Earth . Height of parallelepiped reflects directly population size of associated town or city. A single figure for Greater London has been added to this image from Figure 4a above and this parallelepiped rises far above the edge of the image. Click here to view a .mov file in which the reader can control the animation rate.

The Greater London parallelepiped actually rises far above the edge of the animation. One gets, from this animation, simultaneous views of:

- the location of population clusters in 1901 in England, Scotland, Wales.
- an understanding of adjacency patterns of these locations
- an understanding of where places and clusters of places are in relation to national and sub-national boundaries
- an understanding of where places and clusters of places are in relation to the natural and built environments.

Those factors, alone, make it worthwhile to view databases on animated screenshots of the globe. A far richer experience can be gained, however, by downloading the files used to create these animations and drive around in them in Google Earth®.

- Download the linked file (if you have not already done so from the box at the top of this article) and save it on your computer.
- Then, open Google Earth® and go to File | Open.
- Navigate to where you saved the downloaded file.
- Open it.
- Drive around in Google Earth®; look at data in different subdirectories within the downloaded file. Once this file and the subordinate files come up in Google Earth®, manipulate the Google Earth navigational devices in the upper right corner to change viewpoints. Zoom out; drive around throughout the UK countryside. Double-click a single layer. Try to determine your position. Look at the linked Swansea animation (.mov file) and note that the parallelepiped is made of tinted glass so that one can see through the object to keep track of the landscape. Zoom out to a more global scale to see how much the Greater London parallelepiped soars above the others.

As has Batty's recent article in *Nature* on "Rank clocks," the images in Figure 4 give new meaning to the base plot of the 1901 rank-size curve of Figure 2. They are rich in information and capture, as well, adjacency and positional information not present in Figure 2. When one considers them in Google Earth, itself, the opportunity to extend these advantages to all geographic scales, from the local to the global, is an automatic addition as is the opportunity to view them as virtual reality over which the user has total control.

APPENDIX I: MAKE YOUR OWN PARALLELEPIPED TO ADD TO THE DATABASE.

DOWNLOAD, IN ADDITION, A FREE VERSION OF GOOGLE SKETCHUP

DIRECTIONS GIVEN IN TERMS OF EDINBURGH, SCOTLAND, UK. SUBSTITUTE ANY OTHER CITY/COUNTRY COMBINATION.

- Open Google Earth®, the most recent beta version.
- Fly to Edinburgh in Google Earth®. Make sure that the terrain checkbox has a checkmark in it. Make sure the "sidebar" is visible.
- Zoom in to about 15,000 feet in Google Earth®, staying directly overhead. One must get at least this close in order to be able to bring the Google Earth® image into Google SketchUp®.
- Then, open Google SketchUp®, the most recent beta version.
- Go to Google SketchUp® pull-down and select "Current View"--the aerial associated with Edinburgh that was visible in Google Earth® now appears in SketchUp® as a flat image.
- Choose the rectangle tool and draw a rectangle to cover the aerial as close to exact coverage as possible.
- Use the Push-Pull tool to extrude the rectangle AND HOLD DOWN THE LEFT MOUSE BUTTON AS YOU EXTRUDE IT.
- Look up the population of Edinburgh in 1901 and extrude the rectangle that number of inches...type in 406368' in the lower right slot, "Distance," WHILE CONTINUING STILL TO HOLD DOWN THE LEFT MOUSE BUTTON. Hit Enter.
- Now, a large rectangular parallelepiped appears.
- Double-click the paint bucket to open the Materials picker. Choose the red glass+transparent material. Dump the paint bucket into each of the two visible sides of the Parallelepiped.
- Go to the Google SketchUp® pulldown and choose "Toggle Terrain"--that action pumps up the terrain. Adjust the location of the parallelepiped in relation to the terrain, if needed (not generally an issue on relatively flat terrain).
- Use the "zoom extents" tool to view the entire parallelepiped. Color the remaining two sides and top of the Parallelepiped.
- Go to File|Save As and save the file in a folder marked Edinburgh, under Scotland, under UK and save it as 1901Edinburgh.skp
- Go to File|Export and save the file in the folder marked Edinburgh, under Scotland, under UK and save it as 1901Edinburgh.kmz -- or, alternatively, if you want to see in the context of Google Earth® what you are doing, folllow the longer sequence of steps below:
  - Now, go the the Google SketchUp® Pulldown and choose "Place Model"--this action will place the parallelepiped, adjusted if need be for terrain, back on the terrain of Google Earth®.
  - Go back to Google Earth®.
  - The file will come up in "Temporary Places" as SUPreview2.
  - Right-click on SUPreview2 and choose Rename...rename the file 1901Edinburgh.
  - Then, with 1901Edinburgh still highlighted, go to File, choose, Save, Save Place As, and then save 1901Edinburgh in the already-created Edinburgh folder as 1901Edinburgh.kmz.
- This .kmz file can then be sent to others, as an e-mail attachment, and loaded by them into Google Earth®, by going (in Google Earth®) to File|Open...

Repeat the process for successive years in the database simply by calculating the difference between successive years and adjusting the push/pull by clicking once on the top face of the parallelepiped and then typing in that difference, plus or minus.

Multiple aerial pieces can be brought into the same SketchUp file.

RELATED REFERENCES

See links on author names in title material for links to publication lists.

- Arlinghaus, Sandra; Batty, Michael; and, Nystuen, John. 2003. Animated Time Lines: Coordination of Spatial and Temporal Information *Solstice: An Electronic Journal of Geography and Mathematics*, Volume XIV, Number 1, 2003
- Batty, Michael. 2006: Rank clocks, *Nature*, Vol. 444, 30 November, 2006, doi:10.1038. Link to reprint.
- Bowman, Harry. Cities files from http://bbs.keyhole.com/ubb/showthreaded.php/Cat/0/Number/104614/an/0/page/0 *Google Earth® Community*. Last accessed Nov. 27, 2006.
- Tobler, Waldo. The Development of Analytical Cartography. http://www.geog.ucsb.edu/~tobler/publications/pdf_docs/cartography/Analytic_2.pdf

- Tufte, Edward. 1990. *Envisioning Infomation.* Cheshire, CT: Graphics Press, L.L.C.
- Valery35 and Barmigen, 23.02.2006 4:20:46 generated boundary files used here; they were checked and updated by PriceCollins: http://bbs.keyhole.com/ubb/showflat.php/Cat/0/Number/324595 *Google Earth® Community*. Last accessed Nov. 27, 2006.

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Institute of Mathematical Geography (IMaGe).

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Visualizing Rank and Size of Cities and Towns
Part II: Greater London, 1901-2001

Sandra Arlinghaus and Michael Batty

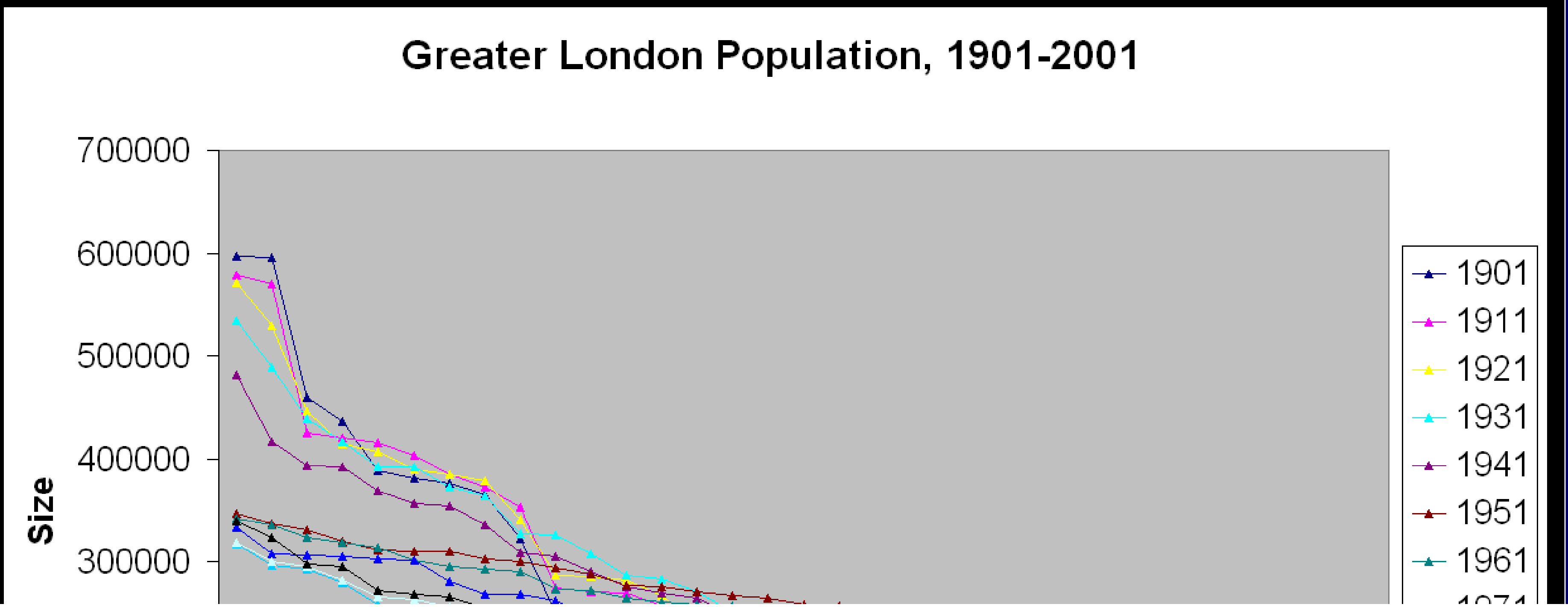
Dr. Sandra Arlinghaus is Adjunct Professor at The University of Michigan, Director of IMaGe, and Executive Member, Community Systems Foundation.
Dr. Michael Batty is Bartlett Professor of Planning at University College London where he directs the Centre of Advanced Spatial Analysis.

Please set screen to highest resolution and use a high speed internet connection.
***Please download the most recent free version of Google Earth®.* Make sure the "Terrain" box in Google Earth® is checked.**

Download the following file to use in Google Earth®:
Greater London

Greater London: A Century of Change

Greater London is composed of the City of London (of quite small population) and 32 boroughs that surround the central city.* As in Part I, we begin looking at changes in the data sets of interest, by decade, over the course of the 20th century. Rank-size plots are shown in Figure 1; the general pattern is as one might expect. There appears to be a change in pattern around the time of World War II.



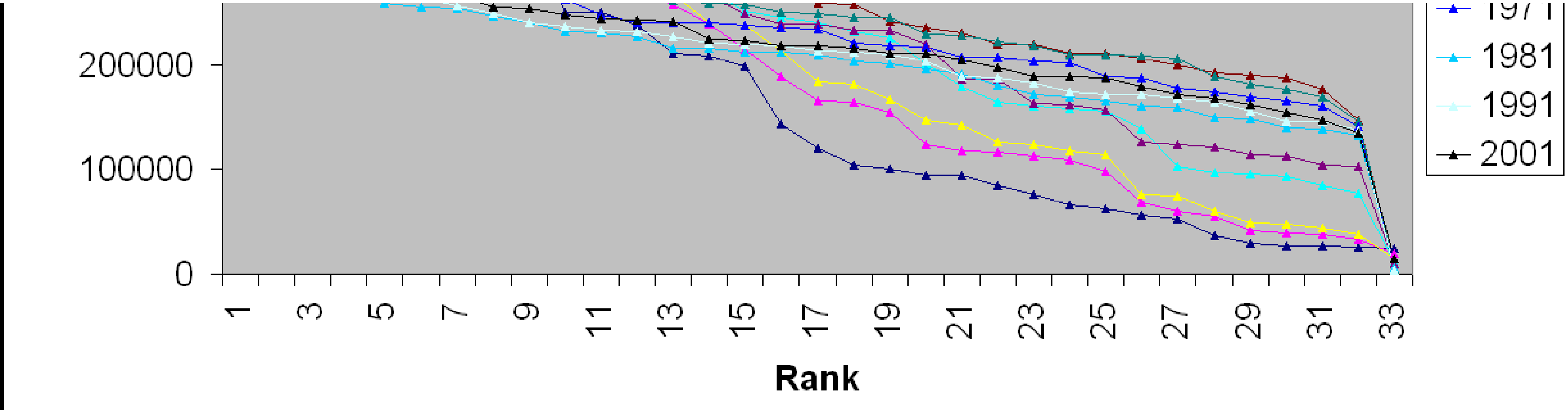


Figure 1. Rank-size plots of the City of London and 32 surrounding boroughs composing Greater London. Click here to view a .mov file in which the reader can control the animation rate.

To take a closer look we separate the rank-plots into two sets, in Figure 2. Figure 2a shows the plots from 1901 to 1941 and Figure 2b shows them from 1951 to 2001.

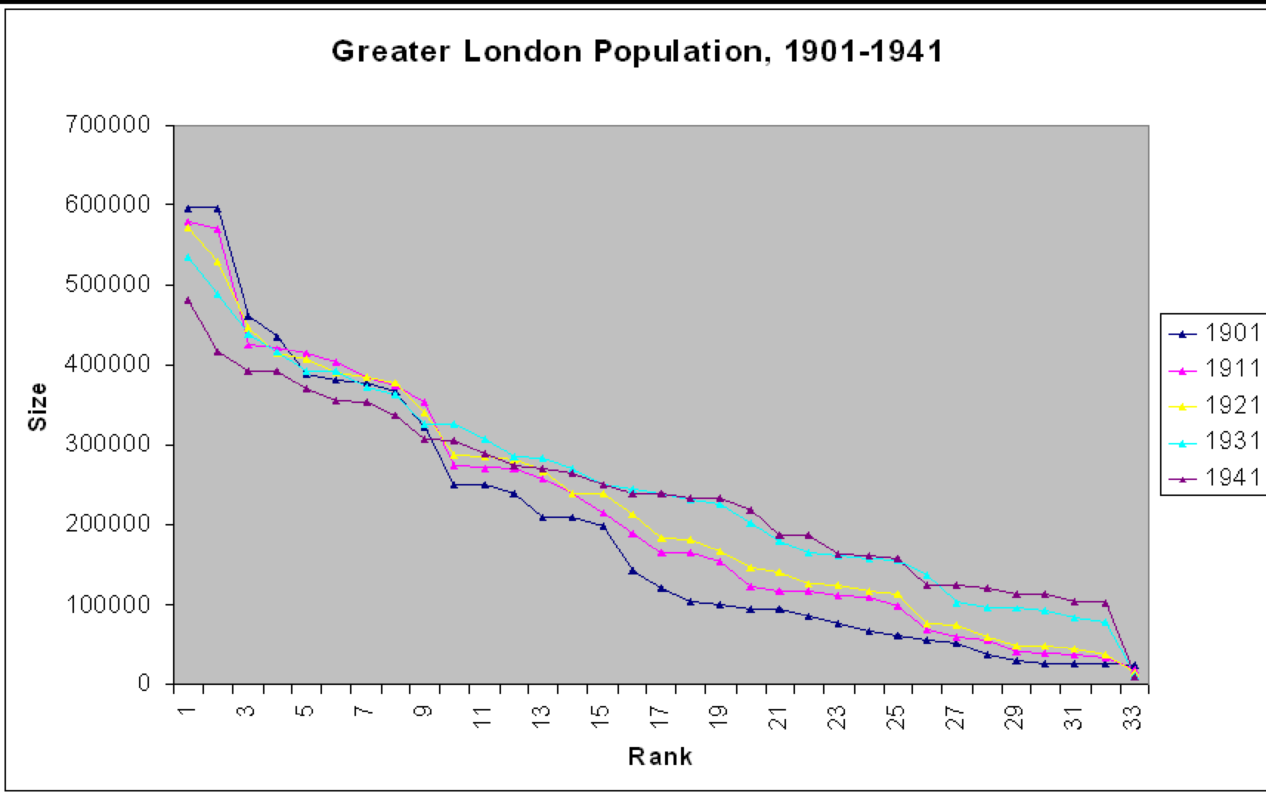


Figure 2a.

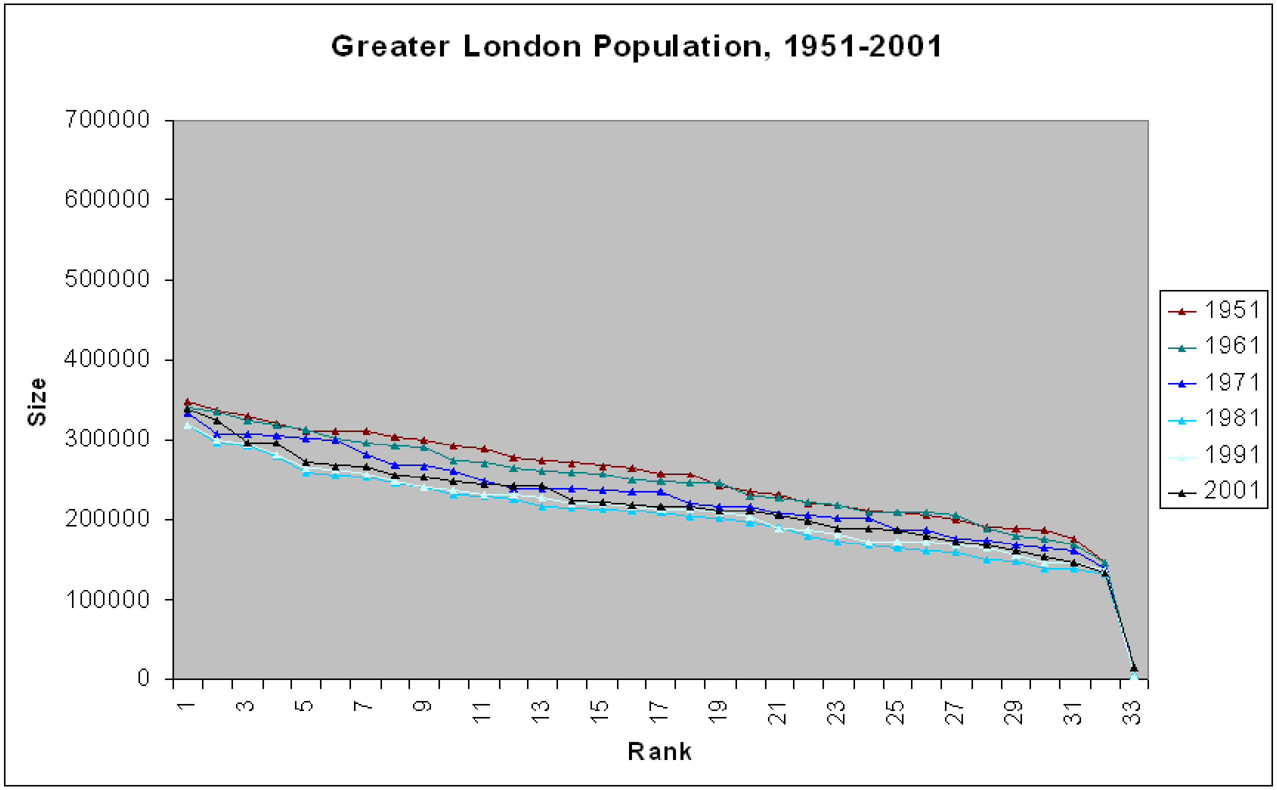


Figure 2b.

Parallel to the Part I case, we note that any given locale is likely to change rank over time. Thus, we look at the data set in relation to 1901 ranks, for the entire century (Figure 3a) and for the pre-and post-World War II data (Figures 3b and 3c). The general pattern appears quite wild while the shorter time span ones centered on either side of World War II offer a more organized picture. Is that picture more organized for Greater London than it is for the entire UK? These observations are perhaps not surprising. They do benchmark strategy and might offer interesting visualizations to those doing policy, planning, or historical studies of the study region.

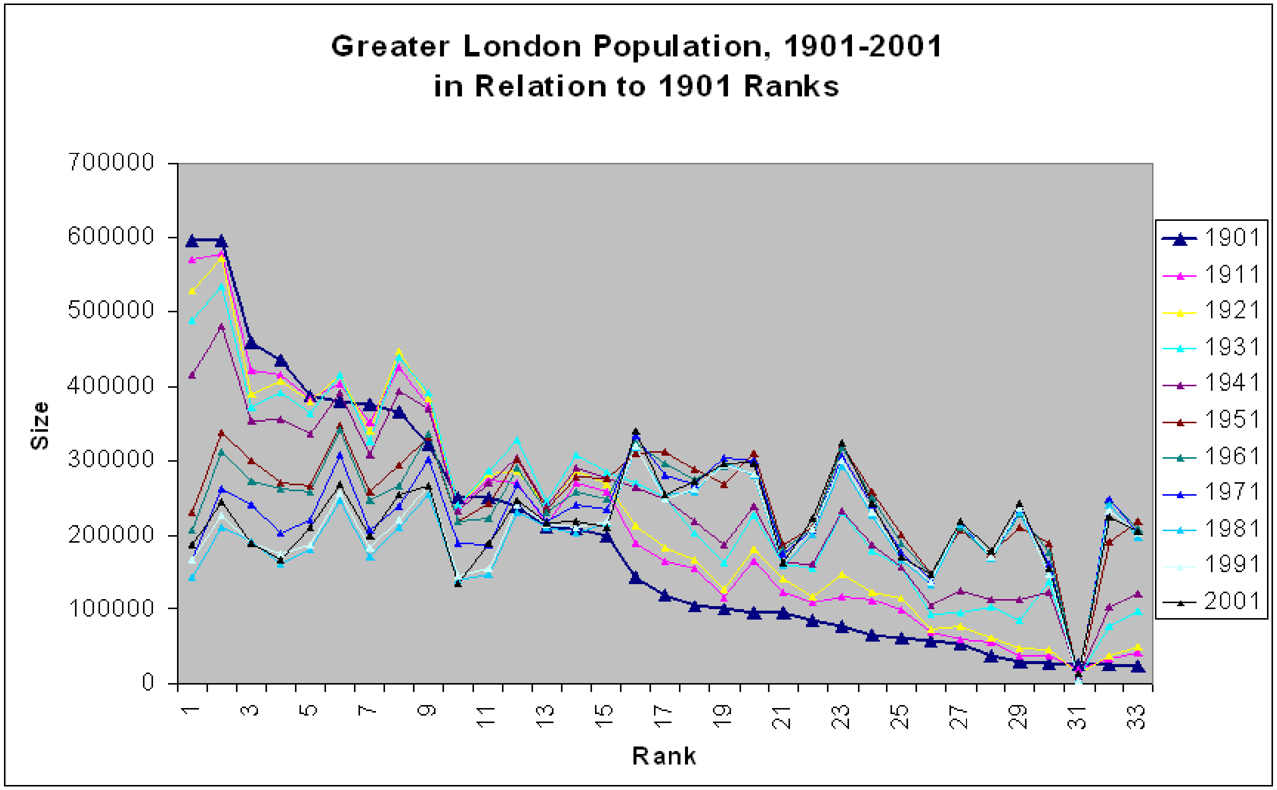
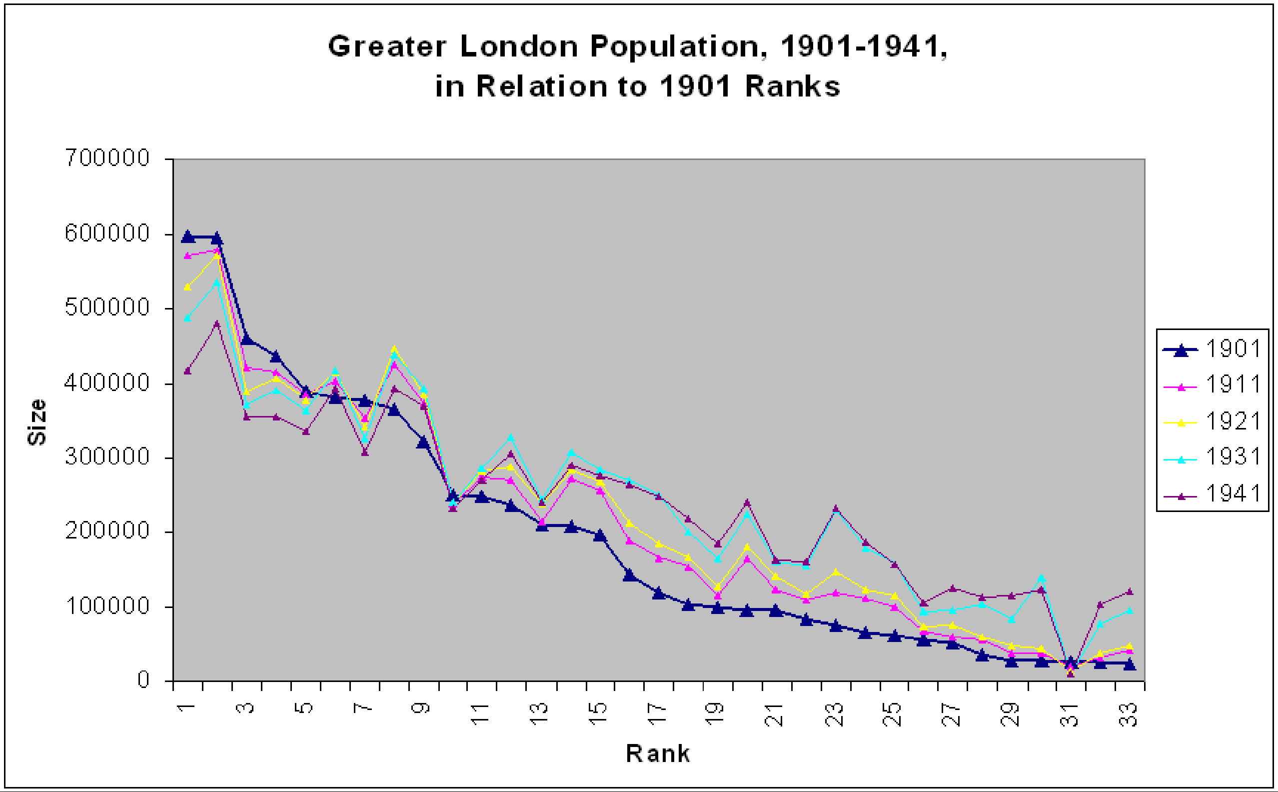

Greater London Population, 1901-2001
in Relation to 1901 Ranks
Size
Rank
700000
600000
500000
400000
300000
200000
100000
0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
1901
1911
1921
1931
1941
1951
1961
1971
1981
1991
2001

Figure 3a.



Greater London Population, 1901-1941, in Relation to 1901 Ranks
Size
700000
600000
500000
400000
300000
200000
100000
0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
Rank
1901
1911
1921
1931
1941

Figure 3b.

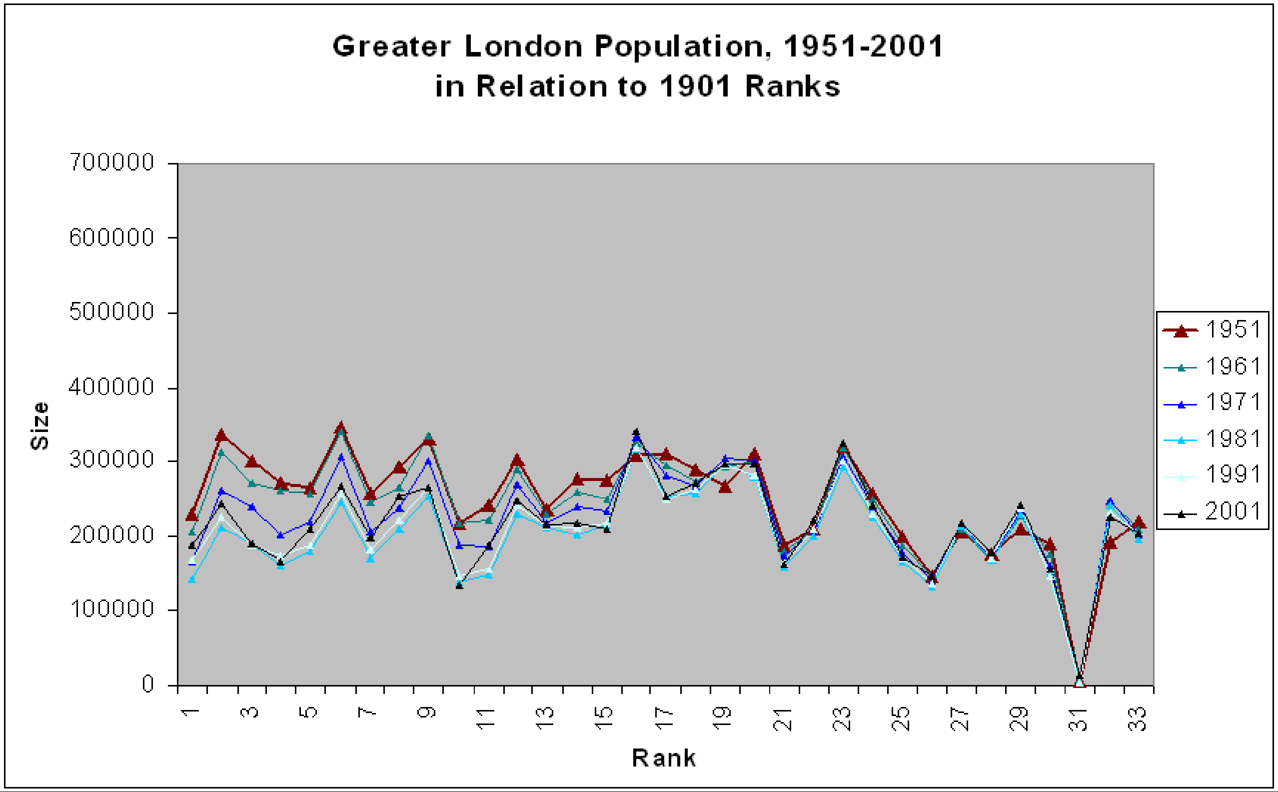


Figure 3c.

Next, we map the data. The Google Earth® screenshots of Figure 4 show not only all the population bars for each borough and for the City of London for 1901 but also for each of the other decades up through 2001. Again, we have animated them so the reader can quickly see such change. Click on any single image in Figure 4 (a-k) to see a larger image. Or, keep track of up to nine changing scenes on the screen at a single time. To drive around, download the associated file used to make the images (Figure 4l).

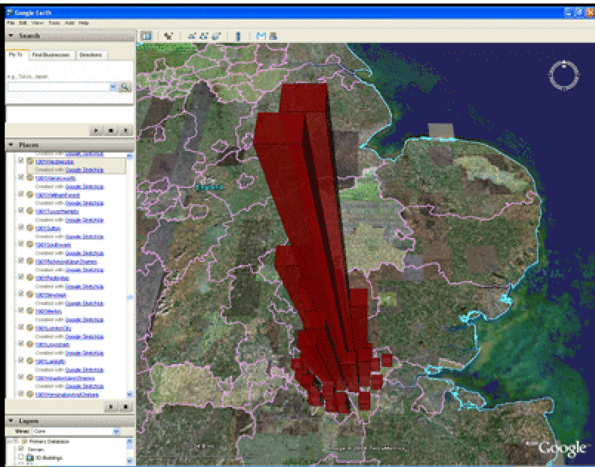


Figure 4a.

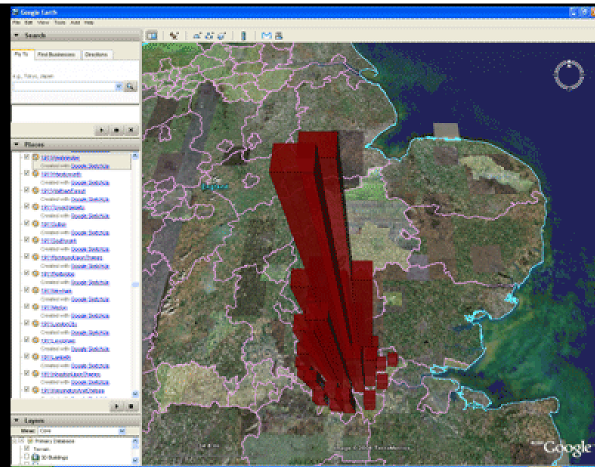


Figure 4b.

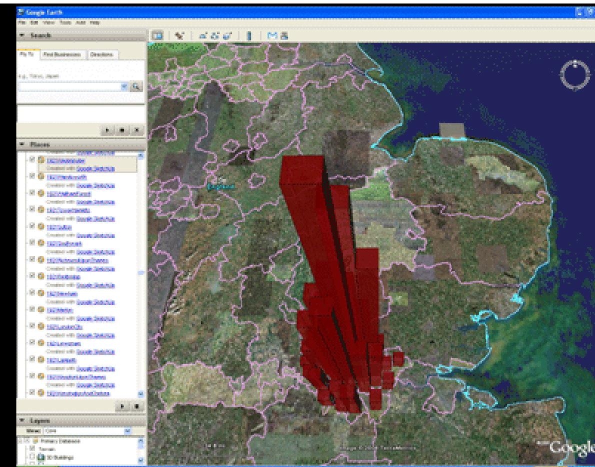


Figure 4c.

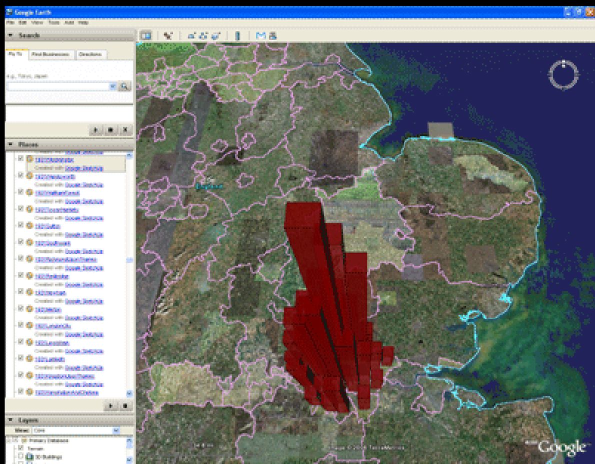


Figure 4d.

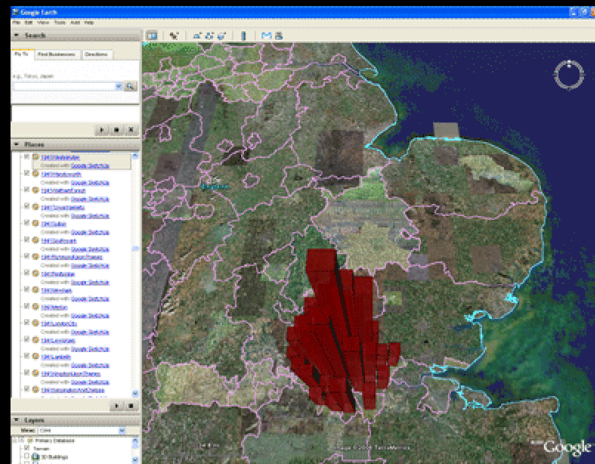


Figure 4e.

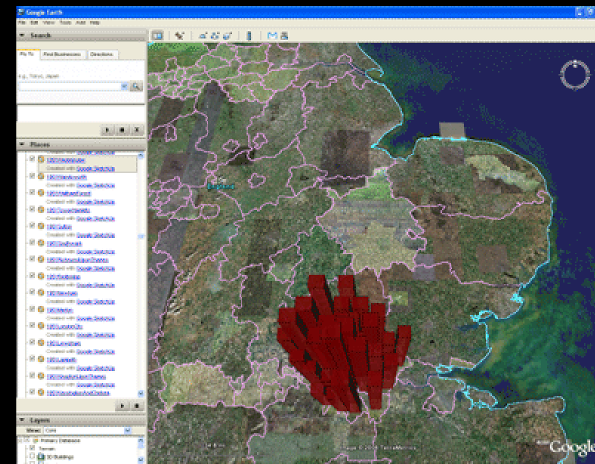


Figure 4f.

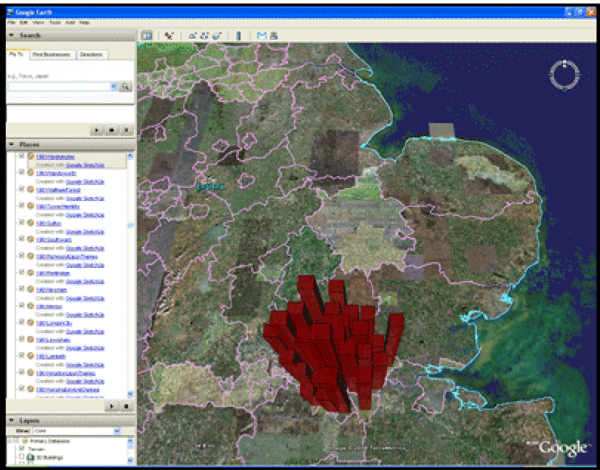


Figure 4g.

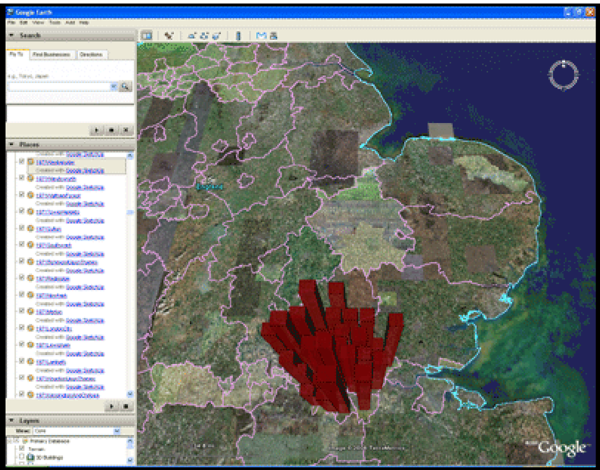


Figure 4h.

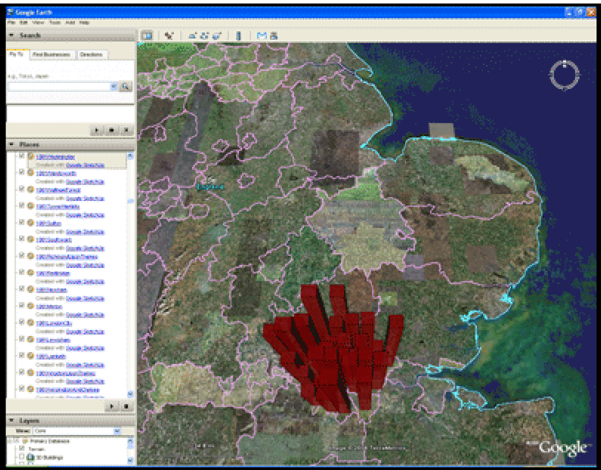


Figure 4i.

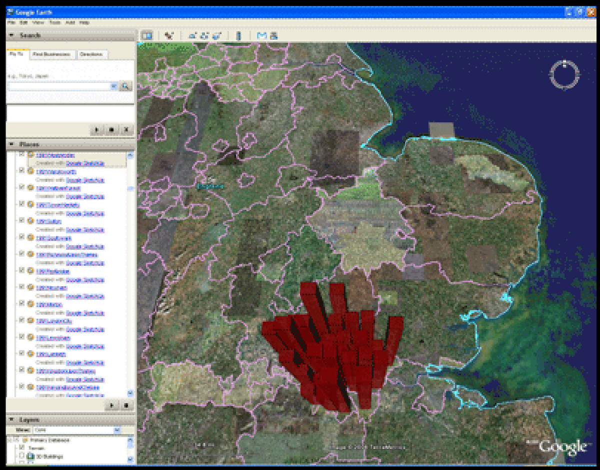


Figure 4j.

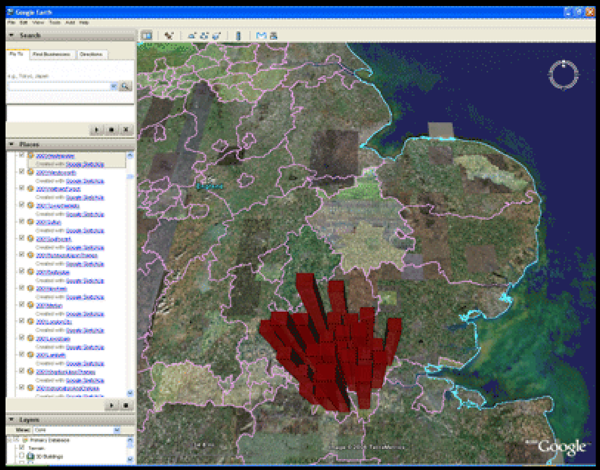


Figure 4k.

Open these files in Google Earth: File|Open and then navigate to where you have stored the files below.

Downloads:

.mov files, user controls animation rate: 1901 1911 1921 1931 1941 1951 1961 1971 1981 1991 2001

Greater London: all kmz files for each decade. If you have not already done so from the box at the top, download GreaterLondon.kmz and open it in Google Earth®, File|Open and then navigate to where you saved GreaterLondon.kmz on your hard drive.

Figure 4l.

There are a number of interesting patterns one can observe; we invite the reader to add to these or to challenge them.

- **Boroughs close to the central city are larger earlier and larger as a group in pre-World War II Greater London. The general pattern is pyramidal with the apex close to the City of London.**
- **Post -World War II sees a flattening of the heights of parallelepipeds across the entire region.**
- **The last two decades begin to see some growth back toward the center.**
- **Early on, the southeast boroughs seemed under-sized in relation to other bars; later, that changes.**

It might be interesting to compare and contrast this situation for London with other major cities, both in the UK and elsewhere, especially in regard to movement patterns in relation to war. Indeed, one might consider applications for this method for other urban areas in order to study land use planning, circulation, and infrastructure in relation to disasters.

Tower Hamlets: A Local View.

The borough of Tower Hamlets is adjacent to the City of London: it is a "close-in" borough.

Simple animation of the rank-size graph easily shows its changing population/size and rank pattern over time (Figure 5). In addition, animation from Google Earth® makes it easy to compare and contrast the relative rise and fall in population of Tower Hamlets in relation to Barnet, a "far out" borough (Figures 6a and 6b; again, to take a closer look at either model, click on the image to link to a bigger file). Thus, scholars investigating patterns associated with sprawl might find this tool to be helpful in a variety of ways.

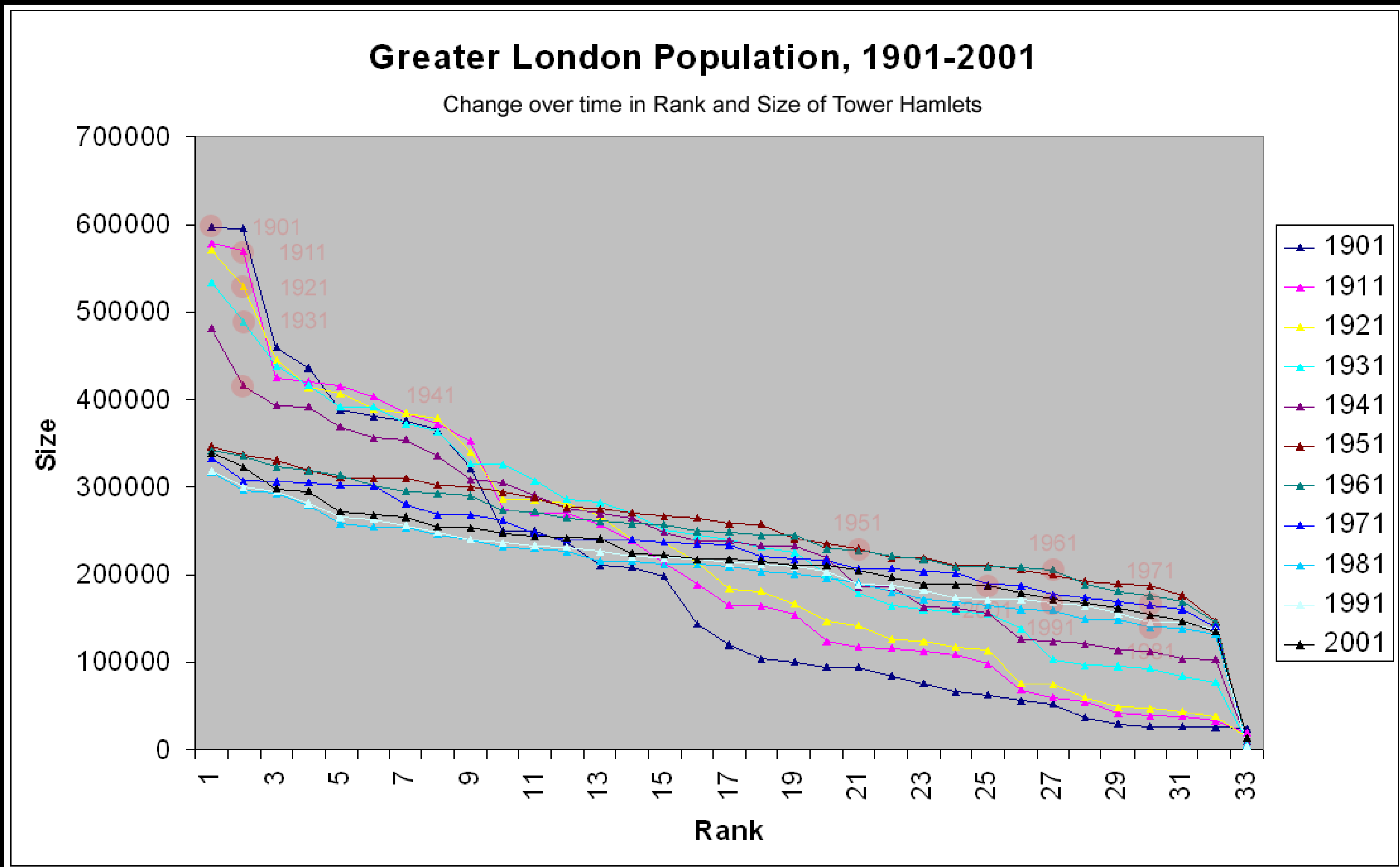


Figure 5.

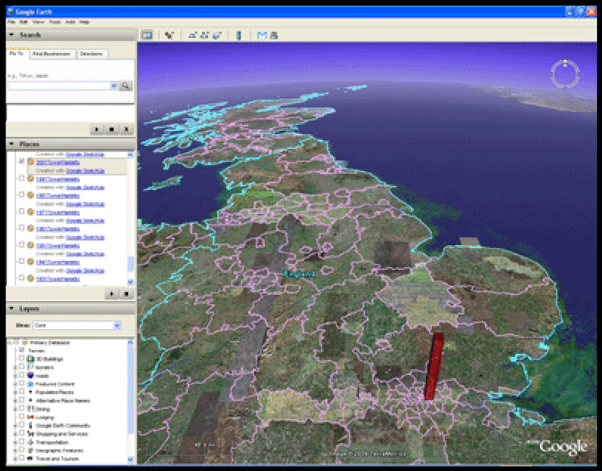


Figure 6a.

2001

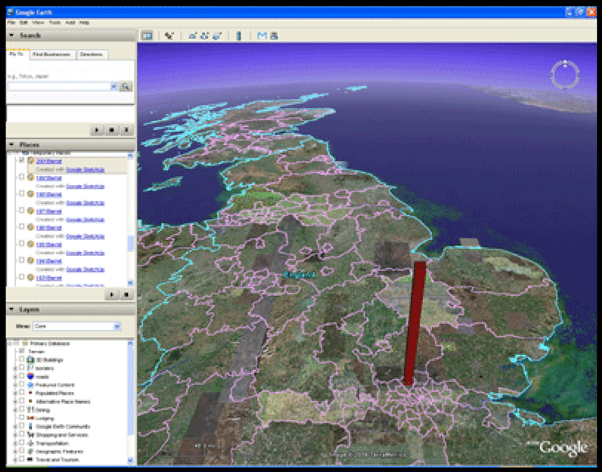


Figure 6b.

A visual limitation in perspective is involved with this procedure. One cannot see changes over time while driving around within the virtual distribution of a single time slice. The animation scheme is useful because it is hard to retain 3D models in the mind and mentally superimpose one time frame on top of another. The strategy developed above, while apparently useful in many ways, does not allow one to see simultaneously the full picture and also see change over time. There may be other strategies that fulfill that need.

Future Directions

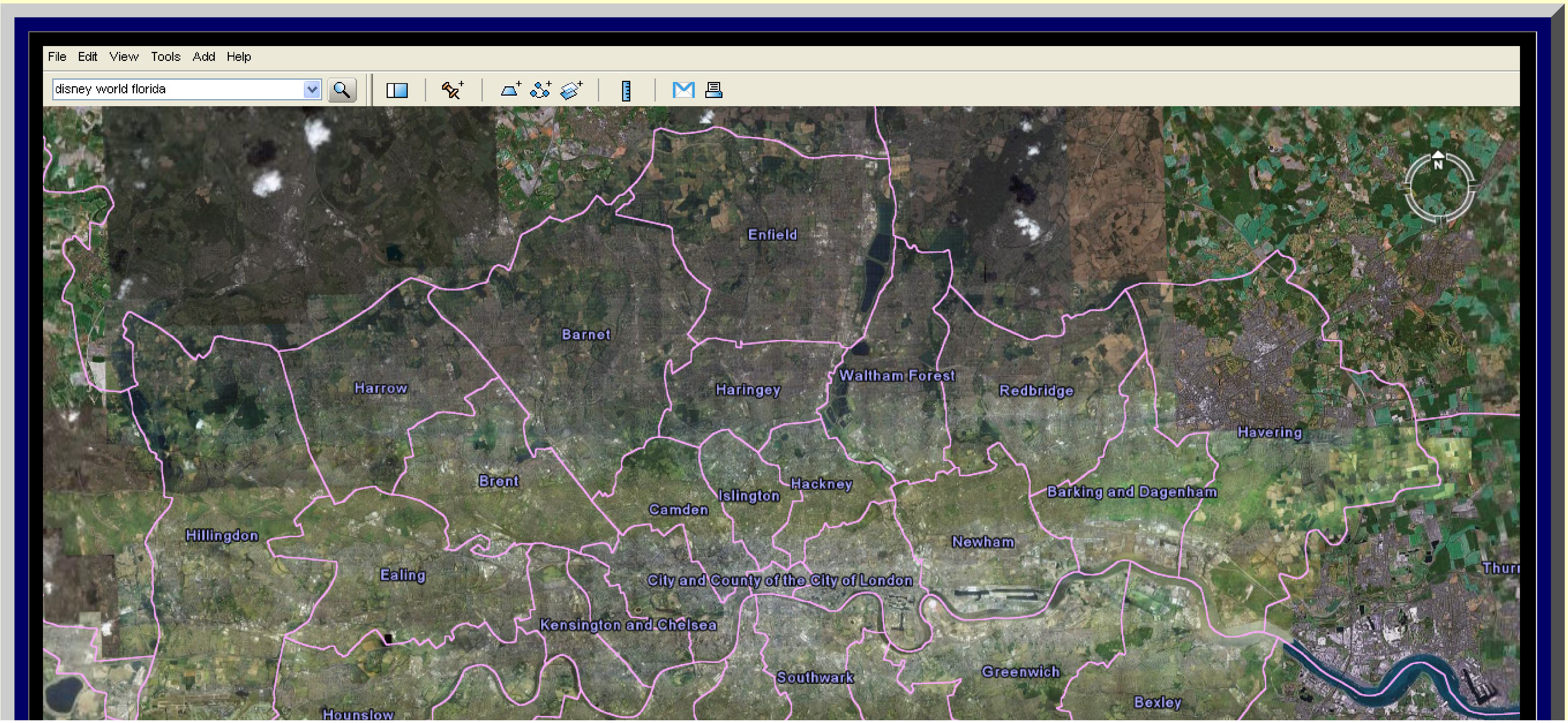
Both authors have recently offered a number of different strategies for visualizing data sets over time and also from different periods of time. In addition, one might imagine that a host of other possibilities will arise given the relative ease of current remarkable visualization techniques.

Add Sound

In order to merge the spatial and temporal concerns, we consider first introducing audio files to supplement the visual. Click on any of the boroughs in the map below. A sequence of notes from a musical scale will play. They represent the rise or fall in rank of that borough during the twentieth century. Different boroughs will play different notes from the musical vectors serving as a basis for a musical vector space in which both rank and size change through time. As the reader listens to change over time he/she is free to study simultaneously spatial aspects of the map Generally, the pattern of the notes works as follows:

- **a musical vector that is relatively high in pitch throughout is one whose associated region has had relatively high rank throughout the time period (and vice versa).**
- **within a musical vector, be it generally high, low, or middle, the higher notes represent higher numerals (hence lower ranks) and vice versa.**

The method of construction of the musical vectors, including much detail, appears in Appendix II. Click on the musical map of Figure 7 and listen to the rise and fall of rank...a guide that those who have vision disabilities may be able to employ.



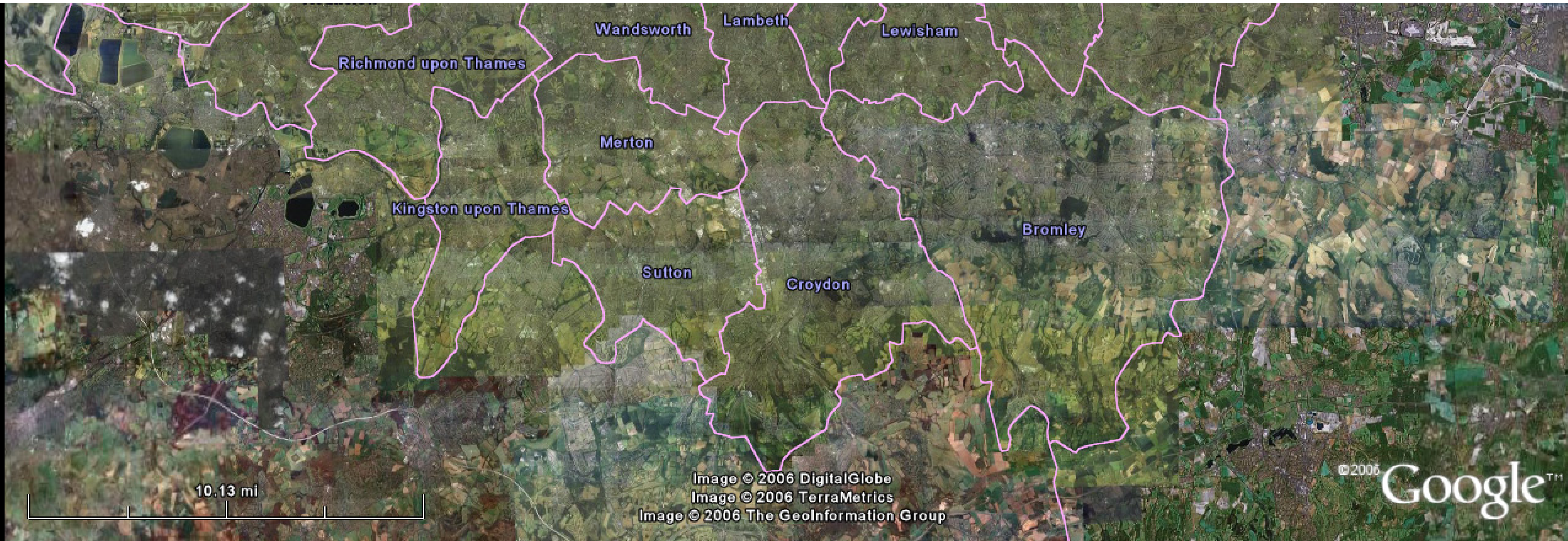


Figure 7. Musical map of Greater London. Click on a borough or the City of London and listen to the general rank pattern and to rise and fall of rank within that general pattern.

Change the Geometry

The methods for looking at spatial change over time outlined above in the context of UK data sets offer exciting prospects for imaginative geometric use of the internet. What they all have in common is that they are couched in Euclidean geometry. The most radical, and perhaps the most interesting, approach might well be to change the geometry--to employ the non-Euclidean. In the last issue of *Solstice*, we announced our interest in this topic and outlined a research agenda for using non-Euclidean geometry to look simultaneously at spatially disparate rank-size plots from different locales, time frames, or both. To that agenda it now seems important to add that we should investigate the role of internet mapping and geometry, especially as they draw from Google Earth®. Might one imagine the Google Earth® "sphere" as a rotating Poincaré Disk on which to embed non-Euclidean views of rank-size plots? Stay tuned...the answers will be coming soon!

APPENDIX

PROCEDURE USED WITH "A MUSICAL GENERATOR®"--DOWNLOAD A FREE DEMONSTRATION COPY AND OPEN IT TO FOLLOW ALONG WITH THE DISCUSSION BELOW.

- Create a matrix showing change in rank, over time, of a city or a set of cities. We choose "Greenwich" for the sake of example of procedure. The row associated with Greenwich will be referred to as its "vector."

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	RANK	1901	1911	1921	1931	1941	1951	1961	1971	1981	1991	2001	
2	Barking and Dagenham	30	30	31	26	27	29	30	31	28	30	30	
3	Barnet	23	21	20	18	18	4	4	3	3	2	2	
4	Bexley	27	27	26	29	26	26	24	20	14	15	16	
5	Brent	17	17	17	15	15	5	7	7	7	8	9	
6	Bromley	19	22	22	22	22	15	8	4	2	3	4	
7	Camden	7	9	9	10	9	17	18	22	23	23	22	
8	City of London	31	33	33	33	33	33	33	33	33	33	33	
9	Croydon	16	16	16	14	14	7	3	1	1	1	1	
10	Ealing	20	18	18	19	17	6	6	6	4	4	3	
11	Enfield	18	19	19	20	20	11	10	9	5	6	5	
12	Greenwich	13	15	15	16	16	20	20	19	16	17	18	
13	Hackney	5	7	8	8	8	16	15	18	22	22	19	
14	Hammersmith and Fulham	11	10	12	12	13	19	22	26	29	29	24	
15	Haringey	14	11	11	11	11	12	14	12	18	18	17	
16	Harrow	33	29	29	28	28	22	25	23	20	20	21	
17	Havering	32	32	32	32	32	28	19	11	9	11	14	
18	Hillingdon	29	31	30	31	29	25	21	16	11	10	12	
19	Hounslow	22	24	24	25	24	24	26	21	19	19	15	
20	Islington	4	5	5	6	6	14	13	24	26	24	28	
21	Kensington and Chelsea	10	14	14	17	19	23	23	25	31	31	32	
22	Kingston upon Thames	26	26	27	30	31	32	32	32	32	32	31	
23	Lambeth	6	6	4	4	4	1	1	2	8	7	6	
24	Lewisham	12	12	10	9	10	8	9	8	10	9	10	
25	Merton	25	25	25	24	25	27	28	27	25	25	27	
26	Newham	8	3	3	3	3	10	12	15	17	14	8	
27	Redbridge	24	23	23	21	21	18	16	13	12	12	13	
28	Richmond upon Thames	21	20	21	23	23	30	29	28	27	28	29	
29	Southwark	2	1	1	1	1	2	5	10	15	13	11	
30	Sutton	28	28	28	27	30	31	31	29	24	26	26	
31	Tower Hamlets	1	2	2	2	2	21	27	30	30	27	25	
32	Waltham Forest	15	13	13	13	12	13	17	17	13	16	20	
33	Wandsworth	9	8	7	5	5	3	2	5	6	5	7	
34	Westminster	3	4	6	7	7	9	11	14	21	21	23	
35													

- Enter data from the row associated with Greenwich into the generator.
  - Direct approach:
    - Choose the tab named "Data"
    - Click on the letter "N" in order to directly enter numerals associated with Greenwich.
    - Type the numerals, leaving a space between successive entries, creating a space-delimited file.
    - Click "OK" when done. You will then see a small chart appear in the previously blank left area of the window. The chart will have the label "data." Change the title to "Greenwich" by right-clicking and choosing "rename."
  - Indirect approach: bring in data directly from Microsoft Excel® (or other software) using directions from the help files of A Musical Generator®.
- Next, generate music from the data.
  - Click to highlight channel 8; it has longer-sounding notes associated with it than does channel 1.
  - Drag the chart entitled "Greenwich" and drop it on top of the graphic on the "Notes" button.
  - Then, hit the "play" button to hear the raw sound of audio associated with the data for Greenwich.
  - Adjust the music. We give the setttings used in the files for the clickable map of Greater London.
    - Set the Tempo to 182: slide the bar.
    - Set the number of measures to 10; there are 11 entries in the vector.
    - Click on the "Duration" button and set the "Maximum" to 33 (the number of possible ranks) and the "Default" also to 33.
    - Click on the "Notes" button. Set the "Minimum" and "Maximum" to correspond with the minimum and

maximum values of the numerals in the rank vector for Greenwich. A Musical Generator® allows values from "c" as the Minimum to "g10" as the Maximum. We use the following assignment pattern to associate musical note value with rank value, from 1 to 33, assuming after considerable experimentation that a musical octave, based on Western style with a "Major" tone scale, is presumed to begin with "c".

- c3=33; d3=32; e3=31; f3=30; g3=29; a3=28; b3=27; c4=26; d4=25; e4=24; f4=23; g4=22; a4=21; b4=20; c5=19; d5=18; e5=17; f5=16; g5=15; a5=14; b5=13; c6=12; d6=11; e6=10; f6=9; g6=8; a6=7; b6=6; c7=5; d7=4; e7=3; f7=2; g7=1. Thus, to cover the entire range of ranks, one would set the Minimum in the "Edit notes aspect" window to c3 and the Maximum to g7--as an absolute maximum and absolute minimum for the rank situation.
- To focus on the general nature of the Greenwich vector, however, we restrict the focus to the local maximum and local minimum of the vector itself. The minimum is 13 and the maximum is 20. Thus, set the Minimum in the "Edit notes aspect" window to b5 (assigned to 13) and the Maximum to b4 (assigned to 20). Now, try playing the associated music once again.
- Save your work both as "Greenwich.tmg" and as "Greenwich.mid"--the latter is a midi file which plays on the internet and elsewhere.

RELATED REFERENCES
See links on author names in title material for links to publication lists.

- A Musical Generator 3.0, from MuSoft Builders, http://www.musoft-builders.com/ Last accessed Nov. 27, 2006.
- Arlinghaus, Sandra and Batty, Michael. 2006. .Zipf's Hyperboloid? Research Announcement, *Solstice: An Electronic Journal of Geography and Mathematics*, Volume XVII, No. 1.
- Arlinghaus, Sandra and Arlinghaus, William. 2005 *Spatial Synthesis* (Chapter 2, scroll to end for music characterizing central place hierarchies). Ann Arbor, MI: Institute of Mathematical Geography.
- Batty, Michael. 2006: Rank clocks, *Nature*, Vol. 444, 30 November, 2006, doi:10.1038. Link to reprint.

*****The City of London population data from 1901 to 1991 is

City of London	26882	19619	14158	11054	5324	4767	4245	5864	5900	4000

Before 1901 the population was likely much higher; indeed, in 1801 the City of London probably had the largest population in the United Kingdom. London lost more than half its population in the interwar years. By 1951 the population was very low, never to recover, as it was all employment by then.

Solstice: An Electronic Journal of Geography and Mathematics, Volume XVII, Number 2
Institute of Mathematical Geography (IMaGe).

Visualizing a Map of Walter Christaller, Poland 1941
Part I: Benchmarking the Map

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School of Natural Resources and Environment, The University of Michigan, Ann Arbor

Please set screen to highest resolution and use a high speed internet connection.
Please download the most recent free version of Google Earth®. **Make sure the "Terrain" box in Google Earth® is checked.**

Links to files to download for use in Google Earth®
Benchmarks
Christaller map

Bringing an Historical Map Across the Digital Divide

One complex system from the early 20th century in the history of geography is the development, by Walter Christaller, of a theory of settlement locations: central place theory. The communication of his ideas is in the printed format of the times. There are black and white maps of complex systems of pattern; they tell one story. What might they look like, however, when recast using contemporary capability? How might this capability expand the research frontier?   The sequence of images and text below will examine a single map of Christaller, from a 1941 document, and bring it into the virtual reality of Google Earth®. When the reader downloads the files above, the power of the Internet is harnessed to permit him/her to replicate the results of the article while reading it and to experiment with related ideas at the same time. Such capability is an important aspect of scientific communication.

Settlements in Eastern Europe: Walter Christaller

Figure 1 shows Christaller's 1941 map of a proposed settlement pattern in Eastern Europe (in the western and central parts of what is today, Poland). Cities, towns, or villages are marked with circles of varying size where the size of the circle represents the number of inhabitants proposed to make up the population. The largest circles represent cities of 450,000 inhabitants, the next largest 100,000, the third largest 30,000 and so on according to the legend. The regional boundaries of varying line weight are drawn also to include a fixed number of inhabitants: the largest region is to include 2.7 million inhabitants, the next largest 210,000 inhabitants, and so on according to the legend. The map from 1941 is a remarkable cartographic effort: layer upon layer is meticulously drawn and labelled by hand. One might speculate in various ways about adjacency patterns, spacing patterns, or others on the existing map. Understanding such patterns from maps is often aided by having the full picture on the map: terrain, physical features, three dimensional effects, and so forth. The map that Christaller drew is already complicated; introducing physical or other features would clutter this two dimensional map and destroy its legibility.

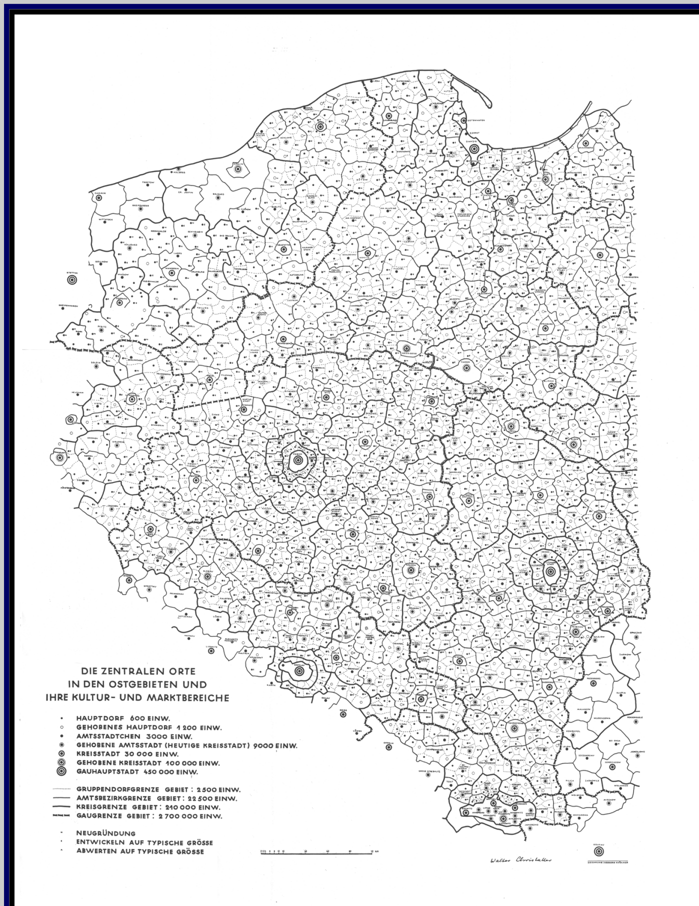


Figure 1. Christaller's map of proposed settlement patterns in Eastern Europe, 1941. Both city/town and regional values are determined by prescribed number of inhabitants to occupy the city or region. [See reference at end]

Figure 2 shows the map from Figure 1 brought directly into Google Earth® where one sees immediately the possibility of visualizing the map in relation to the terrain. When the opaque map is placed on the surface, it is difficult to align the map with the globe. Activating the "populated places" checkbox in Google Earth® brings up a set of points to use as established positions to see if the alignment of the paper map with the software is reasonable.   For additional context in the virtual environment of Google Earth® current subnational boundary files are introduced [see reference to Valery35 and Barmigan for link]. The paper map is made semi-transparent to see simultaneously both the original map and the globe under it. The paper map is manipulated in various ways, suggested in the animation sequence, to improve the alignment. Despite considerable maneuvering, the paper map does not line up very well with the Google Earth® image. Bydgoszcz on the globe should line up with Bromberg on the map; Torun on the globe should line up with Thorn on the map; Lodz on the globe should line up with Litzmannstadt on the map; Poznan on the globe should line up with Posen on the map; Wroclaw on the globe should line up with Breslau on the map; and so forth.   The needed alignment is not present and cannot be made to work simply by importing the map and adjusting its position in relation to known positions. The reader wishing to try may do so using basemaps contained in the second downloaded file from the top of this article.

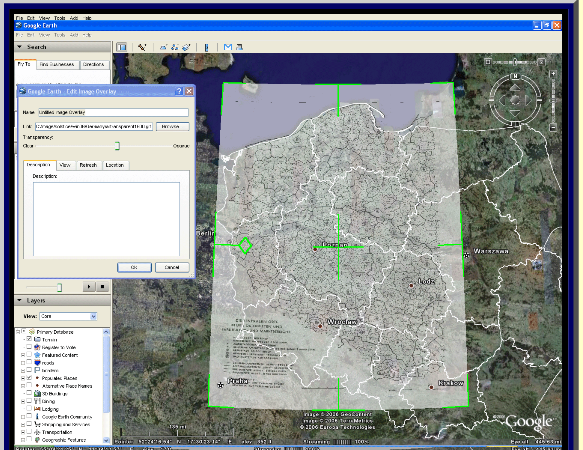


Figure 2

Aligning the Paper Map on the Virtual Earth

Benchmarks

The set of cities already present in Google Earth® was used in Figure 2 as a set of known positions against which to test imported map position. There are two sets of locations:

- one in the virtual world--cities and towns in Google Earth®
- one in a map from the physical world--cities and towns depicted on Christaller's map.

Choose from the intersection of these two sets, all Christaller cities and towns in the three largest categories. Find their corresponding positions on the Google Earth® globe. All of those Christaller cities and towns do appear in the Google Earth® set although one may need to do a bit of research on place names to translate the 1941 place names to the corresponding 2006 place names. *Benchmarks* are carefully positioned reference points from which to infer, or interpolate, other positions. The set of locations just identified in Google Earth®, as the virtual locations corresponding to the top three point categories in the Christaller hierarchy, will serve as a set of benchmarks in the virtual world against which to test position in that world. The image in Figure 3 shows these benchmarks portrayed as rods planted on the globe with rod height corresponding to Christaller hierarchical rank:

- The largest Christaller point locations are represented by the blue rods
- The next largest Christaller point locations are represented by the red rods.
- The third largest Christaller point locations are represented by the gold rods.

The rods emphasize benchmark position. They are translucent so one can see the terrain through them. Structures such as this are easy to create in either Google SketchUp® (free software) that can then be imported to Google Earth® (free software) [see Appendix to Part I of article by Arlinghaus and Batty in this journal]. Or, they can be created directly in Google Earth Pro® (not free)

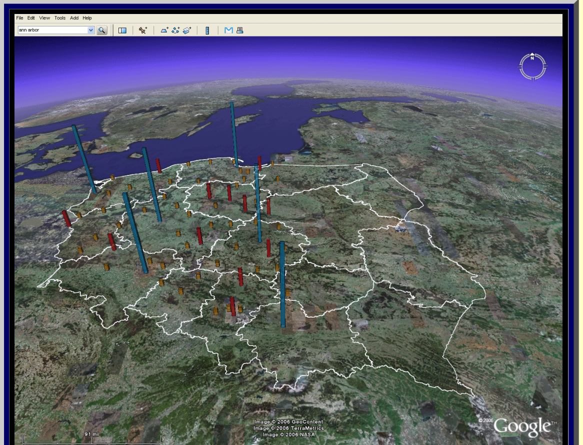
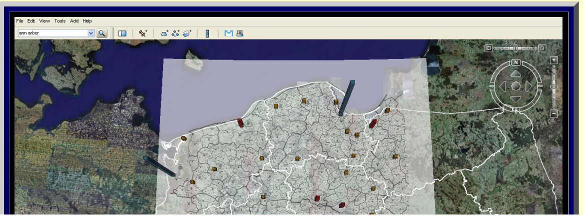


Figure 3. Benchmarks. The blue rods represent locations for cities in the top Christaller category; the red one in the second; and, the gold ones in the third.

Use of the benchmarks for map alignment

The maps in Figure 3 show the position of a subset of Christaller points as benchmarks for extracting the rest of the information from the map. The remaining images in this section suggest ways to use these benchmarks to improve the fit of the map with the surface of the virtual Earth. Figure 4 illustrates the location of the flat map with respect to the benchmarks: clearly, the benchmarks in the virtual world cannot be made to line up with the existing map. One way to improve the fit may be to disassemble the Christaller map into smaller regions, fit thesmaller regions to the benchmarks, and then reassemble the information.

Smaller regions assigned to benchmarks produce a better fit of benchmarks to the map. Such an assignment strategy also spreads the error across the map, away from the benchmarks. Thus, while there are no particular standards for accuracy associated with this sort of mapping in the virtual world, the same ideas apply as when mapping the physical world. Figure out where the error is and tell the reader about it. If possible, develop a quantitative measure to ensure replicable communication (often, when using control points to digitize a map in Geographic Information Systems software, one finds a Root Mean Square error of 0.004 as a default setting).



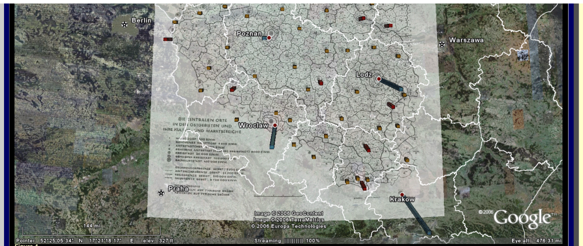


Figure 4

Map Disassembly: Use of the Christaller 2.7 million regions

The Christaller hierarchy associated with place size was used to create a set of mapping benchmarks. It is natural, then, to use the regions in the Christaller hierarchy as the regions in which to disassemble the map. The largest regions in the Christaller map are those designed for 2.7 million inhabitants. Will these regions be small enough? Figure 5 shows the results of using the three largest 2.7 million regions: only the full regions within the map (with Danzig, Litzmannstadt, and Posen as largest cities). The fit of benchmarks in the virtual world to this set of smaller maps is better than it is using the entire map. Nonetheless, there is still much room for improvement. The blue rods necessarily fit, as the foci of the 2.7 million regions, but many of the red rods and gold rods clearly miss the mark. The reader wishing to experiment with alignment may do so, as well. These files are contained in the files at the top of this article.

Figure 5. Alignment of Christaller map with underlying Earth image. The blue rods necessarily fit, as the foci of the 2.7 million regions, but many of the red and gold rods clearly miss the mark.

Map Disassembly: Use of the Christaller 210,000 regions

Assigning transparency in Google Earth® is helpful in seeing, simultaneously, both the map and what is under the map. Another approach that is also useful, especially when looking at detail, is first to remove the polygon interiors from the map. This procedure is simple to execute: save the map pieces in .gif format and assign transparency to white colors. Figure 6 shows an animated sequence of Christaller 2.7 million full regions (Danzig, Litzmannstadt, and Posen) disassembled into the smaller Christaller 210,000 regions and saved as transparent .gifs. (One advance-reader noted the peculiarity that Danzig, as a highest order central place, is not in the center of its apparently "complete" region.)

Figure 6.a. Danzig--2.7 million region disassembled into smaller 210,000 regions.

Figure 6.b. Litzmannstadt--2.7 million region disassembled into smaller 210,000 regions.

Figure 6.c. Posen--2.7 million region disassembled into smaller 210,000 regions.

The focal point of each of the 210,000 regions is assigned to the corrresponding benchmark. One of these regions has a blue rod as focal point, others have red rods as focal points, and yet others have gold rods as focal points. There is no instance, in the case of the full regions, of assigning more than one rod to a 210,000 region; in addition, the entire set is used. Thus, all blue rods, all red rods, and all gold rods (with none omitted) necessarily fit these three reassembled 2.7 million regions. They are shown in Figure 7: the fit is true on the rods with distortion and error increasing away from them.

Figure 7.a. Christaller's 2.7 million Danzig region formed from 210,000 regions assigned to benchmarks.

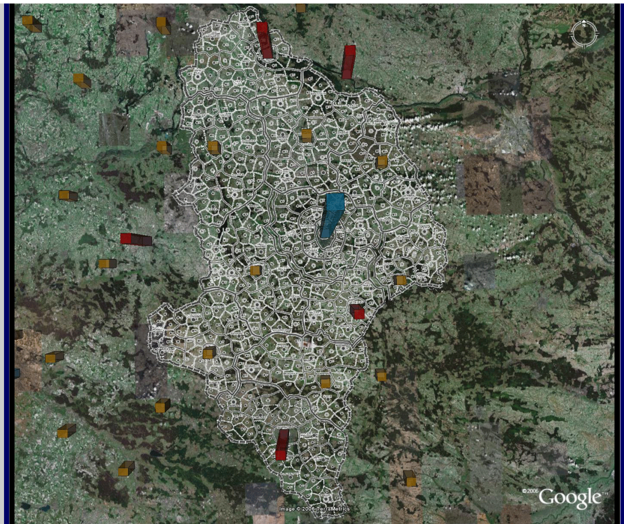


Figure 7.b. Christaller's 2.7 million region Litzmannstadt formed from 210,000 regions assigned to benchmarks.

Figure 7.c. Christaller's 2.7 milion region Posen formed from 210,000 regions assigned to benchmarks.

The Reassembled Full Map

In addition to the three full regions of Danzig, Posen, and Litzmannstadt, there are two incomplete perimeter regions, one to the east and one to the west, as well as regions centered on Breslau, the Katowice region, Krakow, and Stettin. They too were processed, as above, to force the blue, red, and most gold rods to fit the Christaller map. Only in the Katowice region, near the bottom of the map, was there any lack of fit: in that region a red rod is the focal point and in addition there are a number of gold rods also within the same boundary as the red rod. Because that region is small in extent, the error in gold rod placement is also small but increases with distance from the red rod.

Finally, all of these regions were reassembled on the Google Earth globe. The result is shown in Figure 8. All blue and red fit exactly. Most gold rods also fit exactly (except those in the Katowice region). Error is distributed across the map, away from benchmarks. It is also evident at the edges of the map. The fit of the map using smaller regions is superior to any other considered. Again, the reader has all files available to replicate results: to see the terrain in relation to the Christaller map, to drive around through it, to study point location patterns from various perspectives, to visualize the landscape, to turn layers off and on, and to make history and associated policy issues come alive.

Figure 8. The reassembled map. The Christaller map now fits the blue, red, and most gold rods of the virtual world. Error increases away from these rods and at the map perimeter.

The Future

- **A logical next step is to use the map of Figure 8, with the benchmarks, to interpolate intervening Christaller locations (those lower in the hierarchy). That task is completed in Part II of this article.**
- **These 3D maps might offer insight into studies of, or from, the past. Cosgrove notes that "Few geographers outside Germany who took up spatial science were aware at that time that this tradition of settlement landscape study was deeply compromised, not only by its connections with German geopolitics but through Christaller's work for Himmler. The geographer's theories were used in planning the resettlement of the eastern Slavic lands captured after 1939, directly connecting geographical landscape studies and the Nazi project of spatial domination and population engineering. The former Polish and Soviet territories were divided by German geographers into authentically German zones, where farmers from the Rhineland and other 'crowded' rural regions could be relocated, and spaces under German conrol but occupied by lesser (Slavic) races, were to be managed in the interests of the *Reich*. According to the plan, the former zones were to be reshaped and redesigned through the management of field patterns, farmstead architecture, and woodland planting to resemble an ideal of 'German' landscape, while the latter regions, cleansed of 'undesirables,' could be treated precisely as an isotropic plain, a non-place whose landscape design was merely a matter of managerial efficiency and productivity" [Cosgrove, 2004]. How might one use these maps with enhanced capability to consider statements such as these? That task is left to others.**
- **Work with the underlying geometry--outline of various projects underway:**
  - **Incompatibility of geodesic uniqueness from globe (non-unique) to plane (unique).**
  - **The problem of moving from sphere to plane and back to sphere again is an interesting one that is reminiscent of creating a globe from flat sections bent to suggest a sphere (globe gores). What sort of symmetry is there, or is there not, in taking a map (already formed from the imperfect transferral of a sphere to a plane) and trying to stretch it in various ways to fit a globe?**
  - **The importance of the four color theorem (given that regional adjacency is across non-trivial line segments) and the proof (based on stereographic projection) that four colors are all that is ever needed for map coloring on a globe**
  - **Implications of the one-point compactification theorem (demonstrating that stereographic projection misses by one point of creating a one-to-one mapping of the sphere to the plane) and a consideration of mapping in the non-Euclidean world. For that work, a Non-Euclidean Atlas is underway.**

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- Valery35 and Barmigen 23.02.2006 4:20:46 Boundary Files .kmz Checked and updated by PriceCollins http://bbs.keyhole.com/ubb/showflat.php/Cat/0/Number/324595

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Solstice, Volume XVII, Number 2, 2006

Visualizing a Map of Walter Christaller, Poland 1941
Part II: Interpolation of the Benchmarked Map

Sandra Lach Arlinghaus

Adjunct Professor of Mathematical Geography and Population-Environment Dynamics
School of Natural Resources and Environment, The University of Michigan, Ann Arbor

Please set screen to highest resolution and use a high speed internet connection.
Please download the most recent free version of Google Earth®. **Make sure the "Terrain" box in Google Earth® is checked.**

Download the following file to use in Google Earth® in addtion to the files from Part I:
Interpolated placemarks

Christaller's 1941 map of a plan for the settlement of western and central Poland was brought into Google Earth® in Part I of this article. The map was aligned with the globe using a set of benchmarks on the three highest levels of Christaller's hierarchy. It remained to fill in the lower levels of the hierarchy on the Google Earth® globe. The sequence of images below does so.

The strategy for completing the task employs the use of "placemarks" directly in Google Earth® . Placemarks are symbols that can be assigned location (x-y coordinates) and height. They are displayed in a "billboard" format so they always face the driver in the virtual reality scene. The location assigned to placemarks in Figure 1 are those from the Christaller map. The height given to placemarks is assigned by number of inhabitants from the legend in the Christaller map displayed in Part I: a location to be assigned 30,000 inhabitants is given a placemark anchored to the globe from a height of 30,000 meters. All heights correspond directly to those in the legend of the Christaller map except the height for the largest cities: they are to have 450,000 inhabitants but were given a placemark height of 200,000 meters here to keep the symbol within visual range. In the sequence of images below, the large blue crosses represent cities to have 450,000 inhabitants; the large red crosses those of 100,000; and, the red crosses with yellow outline those of 30,000. These three top categories, corresponding to benchmarked places, also are labelled with target inhabitant population. Below that in the hierarchy, places targeted for 9000 inhabitants are marked with a red cross placemark outlined in white; those targeted for 3000 are marked with a yellow square; those targeted fro 1200 with a magenta square, and those targeted for 600 with an evergreen tree. It is not necessary for the reader to keep all that in mind; the legend at the left in Google Earth® will remind the reader. Click on a category and a yellow box will find a representative of that category in the map. Also, when taking a side-looking approach, the relative heights of the placemarks coupled with the Google Earth® legend will help. Drive around in this landscape using the files downloaded at the top.

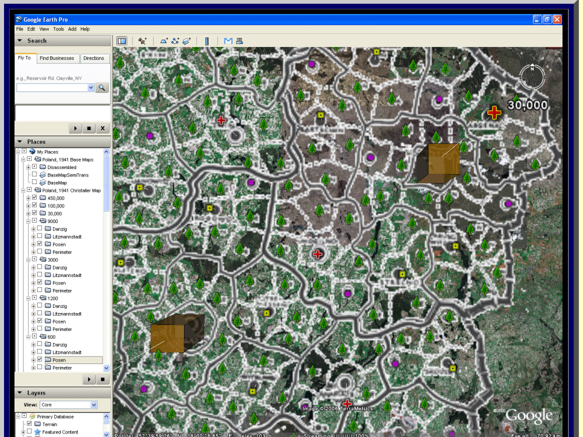


Figure 1. Placemarks interpolate benchmarks on the Google Earth® globe.

Figure 2 shows a side-looking view of Figure 1. Notice the different heights of the placemarks. Figure 3 shows a ground-level view of the same image. Notice that some of the tree symbols are partially obscured by variation in terrain.

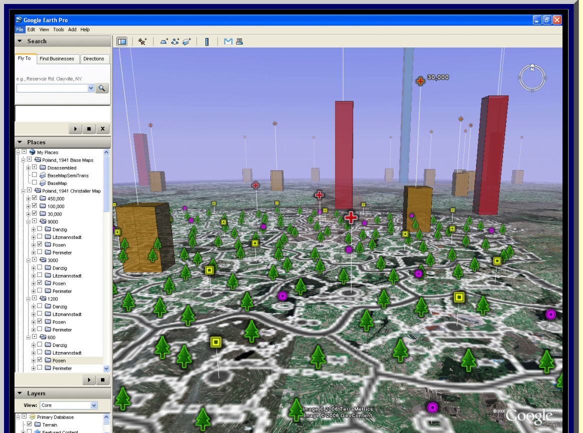
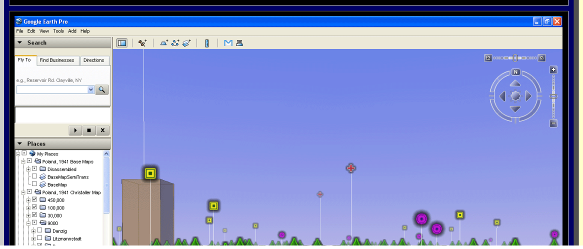


Figure 2. Side-looking view of the map in Figure 1.



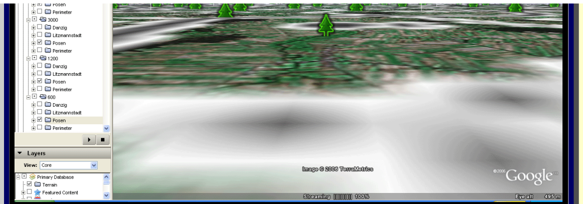


Figure 3. Ground-level view of the image in Figure 1.

It was important to have the Christaller map superimposed on the globe in order to interpolate lower level central places among the benchmarks. However, once the interpolation is complete, the map boundaries may interfere with visualising the landscape in relation to the placemarks. Figure 4 shows the entire set of placemarks with the map removed. Try recreating this picture using the downloaded files. Then, zoom in and drive around the virtual reality landscape.

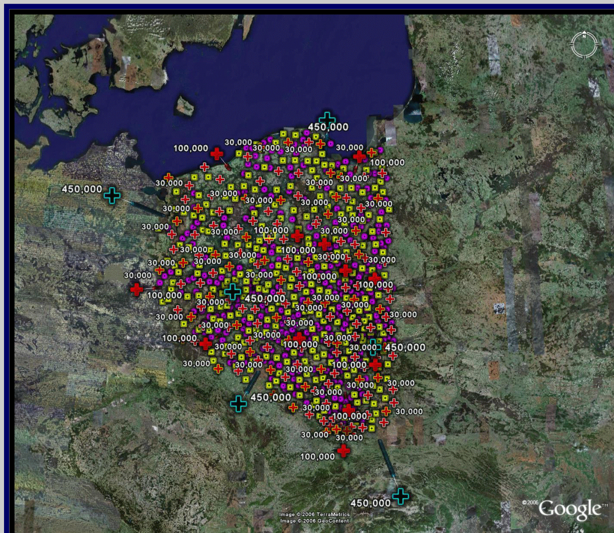


Figure 4. Animation of placemarks. The Christaller map has been removed. Benchmark rods remain.

The benchmarks in Figure 4 may also interfere with a good view of the local landscape. Figure 5 shows a side-looking view of a river valley and placemarks, only. Load the files and recreate this scene. Drive around and look at the fields, towns, and cities of Poland in relation to the placemarks representing Christaller's choices for settlements.

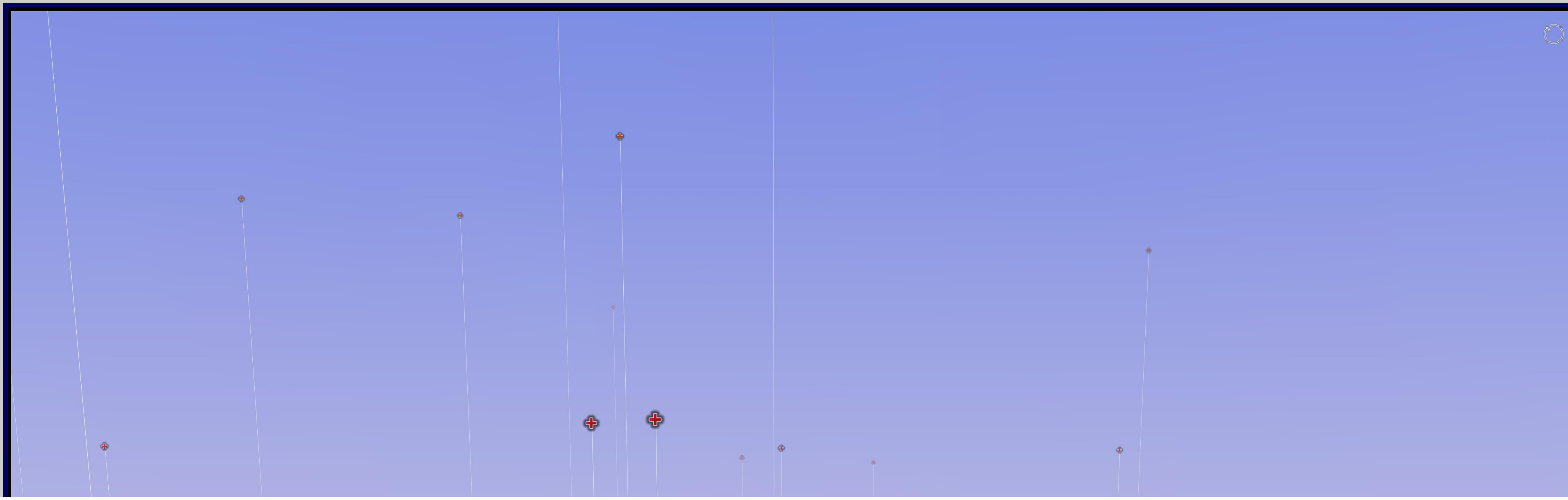


Figure 5.

FOR RELATED REFERENCES, PLEASE SEE THE SET AT THE END OF PART I.

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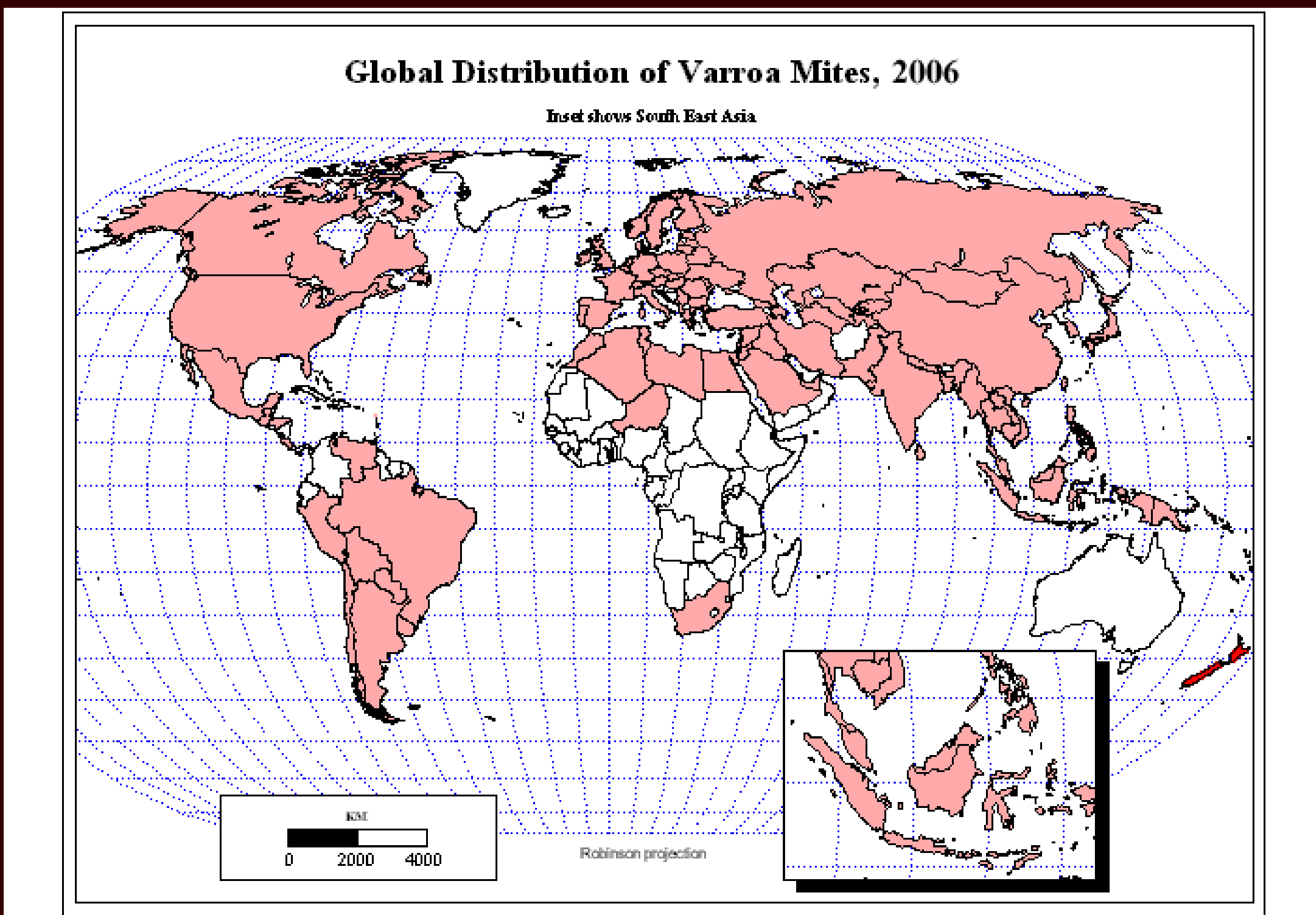
Updated Varroa Mite Map of Data of Diana Sammataro

One advantage to on-line publication is the capability to update files. *Solstice* author Diana Sammataro sends IMaGe current data for her Varroa Mite Map on a regular basis. The map first appeared in Volume IX, Number 1, 1998; a subsequent update appeared in Volume XII, Number 1, 2001.

The current form of the map

- **separates the North Island from the South Island of New Zealand**
- **fine tunes the timing between successive animation frames to emphasize the acceleration of the spread of the mite from the mid-1970s through to the mid-1990s and the subsequent deceleration of spread in later times.**



Map by Sandra L. Arlinghaus and John D. Nystuen.

Announcement: 3D Atlas of Ann Arbor, 2nd Edition*

Sandra Lach Arlinghaus Ph.D.
Adjunct Professor of Mathematical Geography and Population-Environment Dynamics
School of Natural Resources and Environment, The University of Michigan, Ann Arbor

Please set screen to highest resolution and use a high speed internet connection.
Please download the most recent free version of Google Earth®. Make sure the "Terrain" box in Google Earth® is checked.

The animated scene in Figure 1 offered city officials and others an opoptunity to see where contours of the landscape are in relation to existing buildings in downtown Ann Arbor, Michigan. Those who were ambitious could download either Cosmo® or Cortona® virtual reality players and then drive around inside the scene to consider how water might fill the contours the Allen Creek drainage basin in an emergency situation. This scene was first published in Solstice, 2005. It is composed of a sequence of three linked virtual reality files. The first one, of a peaceful downtown set to a backdrop of music from Beethoven's (Sixth) Pastorale symphony, shows quite a bit of detail; subsequent linked files of the emergency do not. What none of these shows, however, is

- the full extent of the drainage basin and the relation of these waters to the entire floodplain
- the relation of these buildings to others in Ann Arbor
- the relation of buildings, streets, waters, or anything else in the scene to the surface of the Earth.

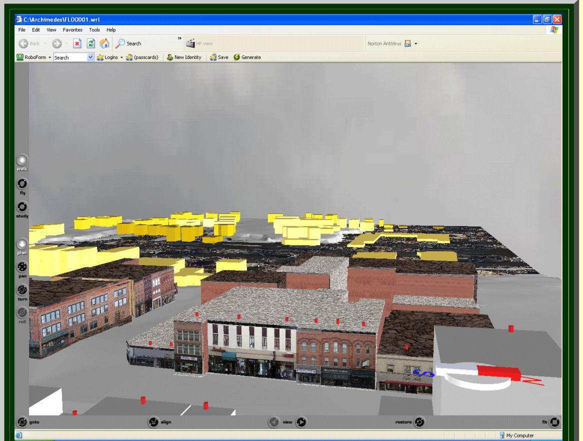


Figure 1. Animated sequence of screen shots taken from three linked virtual reality models, above. To get the full experience, enter the scene and drive around!

Google Earth® software offers a straighforward manner for incorporating the full floodplain, for viewing all digitized buildings in relation to aerials of the entire city, and for placing everything on the surface of the Earth. As one moves around, the pointer offers a read-out not only of position, in terms of latitude and longitude but also of elevation (in units chosen by the reader). The concepts learned* in the creation of the files of Figure 1 (using a combination of ArcView® GIS software from ESRI® together with 3D Studio Max® from AutoDesk® coupled with simple editing of .vrml files in a text editor) aided greatly in the leap to their direct placement in Google Earth® .

Go directly to the recently published *3D Atlas of Ann Arbor, 2nd Edition* via this link
or
Go to the eBooks section of the Institute of Mathematical Geography webpage

OR DOWNLOAD THE FILES BELOW--DRIVE AROUND IN THEM...

- ***GLOBAL FILES***--if the buildings do not show when first downloaded into Google Earth®, put check mark(s) in appropriate box(es) on the left. Once files are opened in Google Earth, parts of one may be viewed with parts of others.

- File showing all buildings--all the same color (maize)
- http://www-personal.umich.edu/~copyrght/3DAtlas2/KMLfiles/3D Atlas of Ann Arbor, no textures, one color.kml

- File showing all buildings--two colors. In this file, buildings of The University of Michigan (UM)are blue (cyan) and those within the boundary of the Downtown Development Authority (DDA) are maize.
- http://www-personal.umich.edu/~copyrght/3DAtlas2/KMLfiles/3D Atlas of Ann Arbor, no textures, two colors.kml

- File showing all buildings along with textured blocks fit into the maize DDA buildings--download all the non-textured buildings and then select from among textured blocks as your equipment permits.
- http://www-personal.umich.edu/~copyrght/3DAtlas2/KMLfiles/Ann Arbor 12 Textured Blocks.kml

OR DOWNLOAD THE SAME FILES FROM THE GOOGLE® 3D WAREHOUSE.

COVER ART SCREENSHOT APPEARS IN FIGURE 2, BELOW

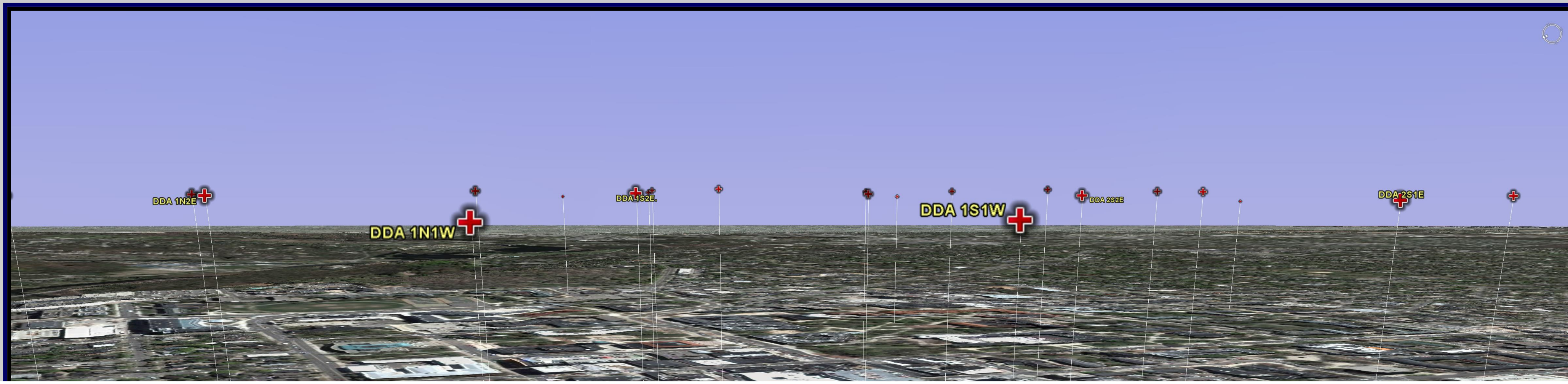


Figure 2. Overview of buildings positioned against aerials on the surface of the Earth. The "balloon" markers offer reference points to a coordinate system so the driver through the virtual scene does not get lost.

*The author wishes to thank Professor Klaus-Peter Beier, the staff of the 3D Laboratory at Duderstadt Center of The University of Michigan, and selected students in Engineering 477, for their continuing support of the 3D Atlas of Ann Arbor project. For full details, please follow this link.

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Banda Aceh: A View on the Globe*

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School of Natural Resources and Environment
The University of Michigan, Ann Arbor

Please set screen to highest resolution and use a high speed internet connection.
Please download the most recent free version of Google EarthÂ®. **Make sure the "Terrain" box in Google EarthÂ® is checked.**

Download the following file to use in Google EarthÂ®:
30 meter placemarks for Banda Aceh

December 26, 2004. A devastating earthquake (9+ on the Richter scale) hit the Indian Ocean from an epicenter just to the west of Sumatra. Killer tsunamis followed this earthquake. These affected severely much of the populated area on the Indian Ocean perimeter. Much has been written about the events and scholars from a wide range of disciplines have analyzed it from numerous perspectives [see a few Internet references below]. One way to look at the current status of the affected region around Banda Aceh, a city in northern Sumatra to the northeast of the earthquake epicenter, is to view the region in Google EarthÂ®

Figure 1 shows a direct screenshot from Google EarthÂ® Scroll across the image; notice destroyed bridges. Much land remains inundated, especially of course along the coast. If one supposes that a tsunami wave might have been 30 meters in depth, then one imagines a sheet of water coming in from the northern tip of Sumatra and extending inland as far as the 30 meter terrain contour. Click here to see a movie, made in Google EarthÂ® , of the devastation surrounding a sequence of markers placed along the coastal region just to the north of Banda Aceh (the movie file is over 47 MB in size).

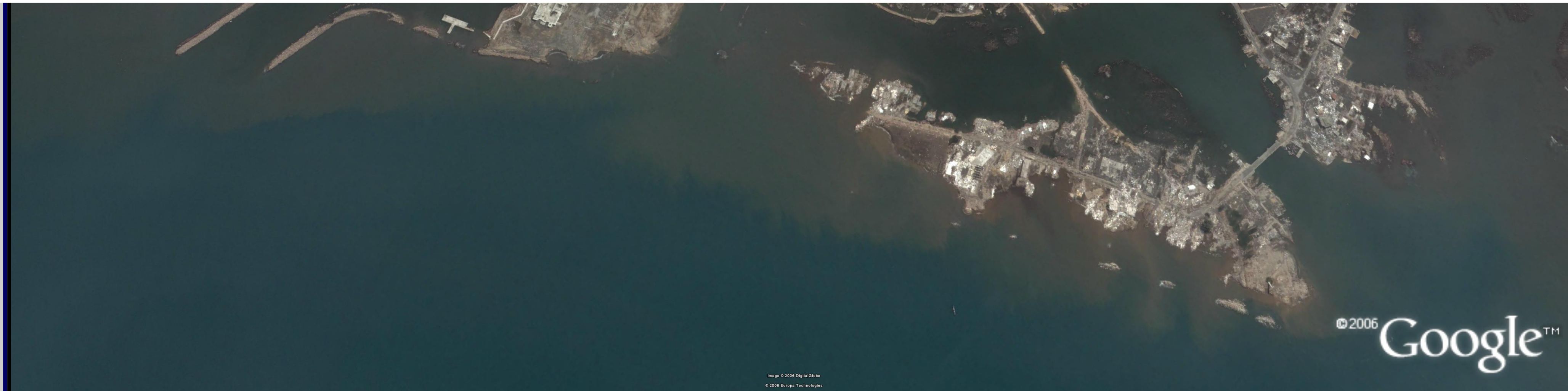

Figure 1. The Banda Aceh region, two years after a hit by a deadly tsunami.

To track the 30 foot contour in Google EarthÂ®, placemarks were located in that software on top of pointer positions at the 30 meter level. Try it yourself in Google EarthÂ®. Download the placemarks file, created by hand, from the box above. Figure 2 shows one screen shot of that file. As expected, there is an inset area away from the coast adjacent to Banda Aceh. Also, though, there is a channel that cuts through to the western coast of Sumatra in the direction on the earthquake epicenter. This channel might have served as a back door for a double-effect hit. Look at the evidence of screen shots in Figures 2 and 3; look at the intersection of coastal zone and the extension from the channel. It appears to have been particularly hard-hit. Drive around in Google EarthÂ® and see for yourself. What do you think? Does the fact that the western Sumatra "backdoor" entry is wide at the coast, and then narrows to a channel through the highlands suggest even further piling up of waters (much as with tides in the Bay of Fundy)? If so, one might expect to see damage above the 30 meter levels--Google EarthÂ®offers that opportunity. Might simple, clear advice in the face of disaster simply be the common sense approach to seek out the high ground (here, perhaps, above 30 meters)? Observations such as these, coupled with the use of state-of-the-art support systems, might help guide future research or relief projects.

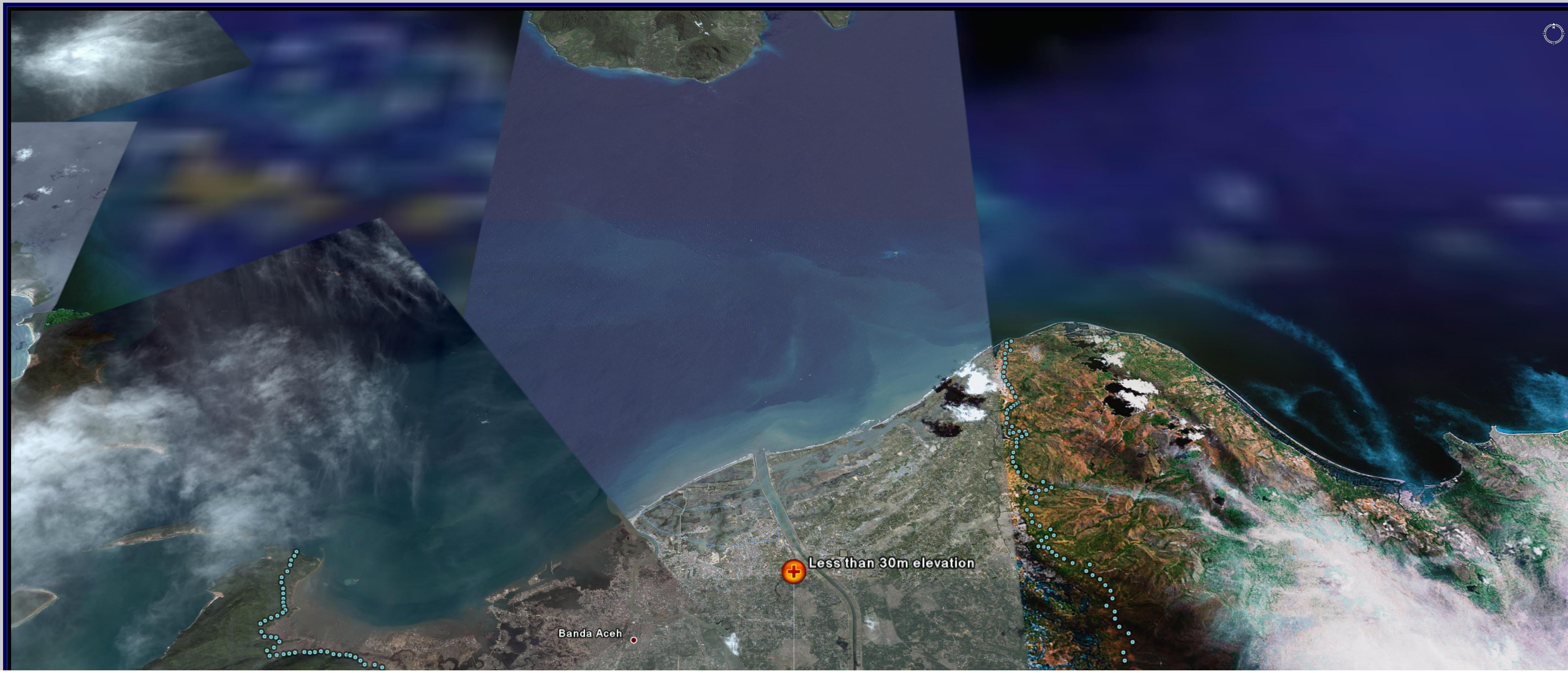

Figure 2. Banda Aceh. Light cyan dots trace out 30 meter contour. Red and white circles mark previous nearby earthquake activity (the Indian Ocean earthquake of 2004 occurred farther to the west and does not appear here).

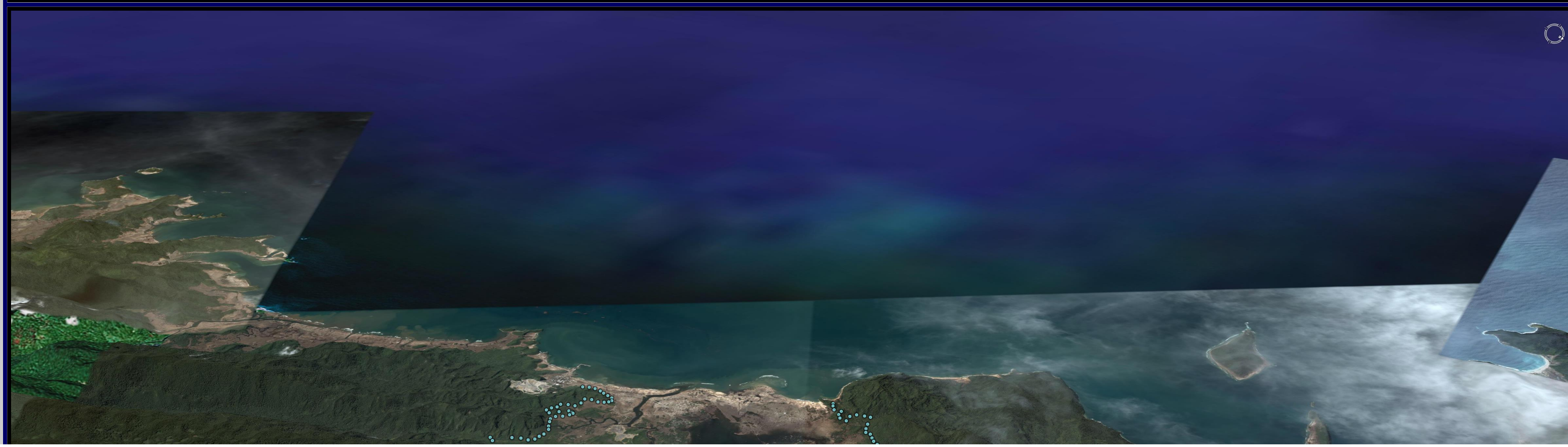

Figure 3 A view toward the west. Scroll across as well as down.

Related References:

- **Asian Tsunami Maps from Global Security.**
- **The December 26, 2004 Sumatran Tsunami.**

* The author wishes to thank Kris S. Oswalt M.B.A., President Community Systems Foundation, 219 S. Main Street, Suite 206, Ann Arbor, MI 48104, for his suggestion of Banda Aceh as a region of interest to consider using this technology.

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Mail

Mail (other than about submitted manuscripts): In addition to sharing scholarly research, Solstice also gets in touch with colleagues and friends, near and far--and, because it is easy to interact, they sometimes send something right back!

Dear Sandra,

Thanks for the fine review and the intriguing suggestions for applications to cartography.

I have recently written a paper called `Spherical and projective trigonometry' that shows how to tackle 3d spherical geometry from the view point of rational trig. This paper is posted at http://wildegg.com at the Author's Corner. Perhaps it will be of interest.

Cheers,
Norman

Dear Sandy,

Hope you're all well and enjoying the summer days. Thanks for your email. I've passed along the link of your Jrl. to our science editors, Christie xxx and Jen xxx--thought they might like to see it.

Best,
Sylvia

Sandy.....you are too modest. I read the awards page. congratulations.

Nate

Hi Sandy,

This was very interesting. Thanks for sending it along. The list of clubs by district and units was especially cool. In the redistricting article, I was wondering why the largest district was not included in any look at balancing the population into equal districts? Do you know?

Thanks,
Sharon

Hello Sandy,
thank you for your solstice-message. I (Carlo) tried to understand one of your exposÃ¨es - but I finished because it is too hot for studiing or something is not present in my background...I hope you are both well. In a week we will go to our summer-domicile in Ticino. Our son will visit us with his partner, because they intend start to learn golf. Later our youngest daughter comes with Nico - he has already nearly 10 kilos and tries to sit and to stand (but it is too early with 7 months, it seams he is very strong and active). When do you come to Switzerland? Kindly regards Rosmary + Carlo

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Sandy:

We celebrated the Solstice down east in Southport, Maine -- about as far east and as long a day as is possible in this part of the world. It was a lovely summer day (one of the few without rain for the past two months!), and we really appreciated the exra daylight with which to enjoy it!

Hope all is well with you! Cheers, Estelle

Thank you for acknowledging my comment! I apologize for being so late in making this acknowledgement.

Sincerely,

Bill J

BTW: What is "Mathematical Geography"?

Thank you for acknowledging my comment.

It is unfortumate that so many people think that the United States can be colored with only two colors; ie Red and Blue!

Regards, Bill J

Hi Sandy,
Thanks for the lastest edition!

Hope all is well.

cheers,

Chuck

Sandy

Thanks for the note

Hope all is well - Happy Summer to you too

Rick

Happy solstice to you too and thank you so much for this.

How is you summer going? I have not given up on the idea of another GIS event of some sort, just bogged down in too many other projects to move.

Best,

Diane
