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An Electronic Journal of Geography and Mathematics.

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- ***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).

Congratulations to all ***Solstice*** contributors.

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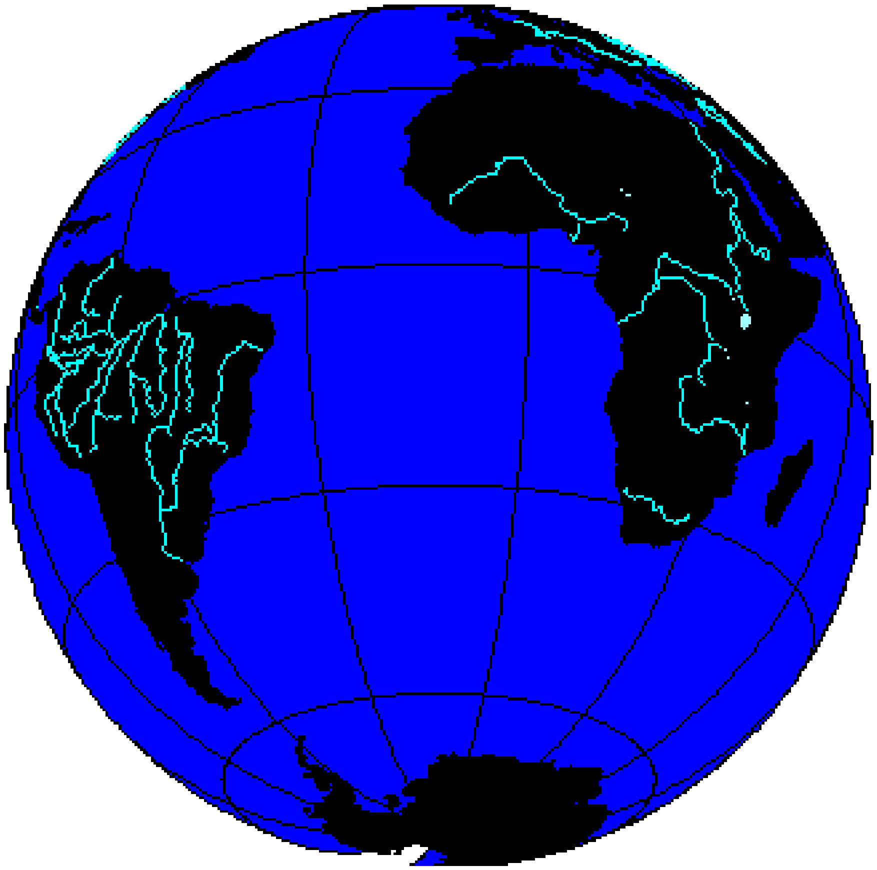


Earth: with 23.5 degrees south latitude as the central parallel.

Volume XV
Number 2
December, 2004

SOLSTICE: AN ELECTRONIC JOURNAL OF GEOGRAPHY AND MATHEMATICS

http://www.imagenet.org

Winter, 2004

VOLUME XV, NUMBER 2

ANN ARBOR, MICHIGAN

WebSite: http://www.imagenet.org

Electronic address: sarhaus@umich.edu

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

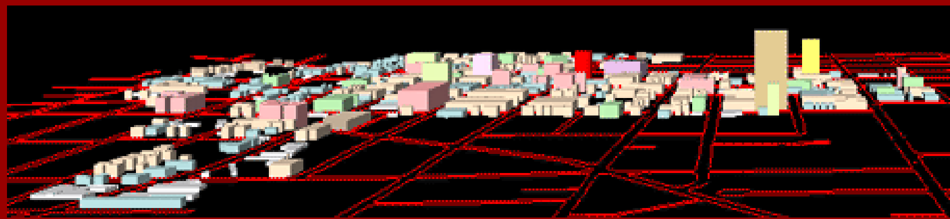
To cite the electronic copy, note the exact time of transmission from Ann Arbor, and cite all the transmission matter as facts of publication. Any copy that does not superimpose precisely upon the original as transmitted from Ann Arbor should be presumed to be an altered, bogus copy of *Solstice*. The 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.)

- 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). Link to Pirelli website and to downloaded pages concerning this particular competition: 1, 2, 3.
- *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.

HOME



Spatial Synthesis: 3D Atlas of Ann Arbor

Sandra Lach Arlinghaus*
University of Michigan; Community Systems Foundation; IMaGe

On June 7, 2004, the Downtown Residential Taskforce, appointed by the Mayor of the City of Ann Arbor Michigan, presented recommendations for increasing residential land use in the downtown to the City Council of the City of Ann Arbor (with follow-up on November 15, 2004). Some of the policy statements in that document derived support from this author's global three-dimensional models showing simple box-like models of buildings in the area of the Downtown Development Authority (DDA). The purpose of the models was to give the taskforce, and others, a sense of how added tall buildings, designed to increase residential and commercial opportunity, might alter the existing skyline and general downtown environment. In all, the Taskforce was presented with about 500 alternative, modeled, scenarios. The techniques involved static maps (2D and 3D) made in Geographical Information Systems software, animations of maps, virtual reality and animations of virtual reality. All were presented using the Internet -- not only to expert panels but also to members of the public so that they might have a useful vision of how change suggested by elected and appointed officials could affect their local urban environment. The Internet was *necessary* to the presentation of information modeled via animation and virtual reality.

Previous articles in *Solstice* display the complete chronological unfolding of these models used by this Taskforce, primarily as tools in urban planning (consult links on the "Archive" page that cites articles and provides external links to them). This article reviews briefly some of the elements of those articles and then offers a fresh view of the synthesis of local and global models useful not only in urban planning but also in emergency management involving security as well as environmental issues. Click on a building in a virtual model and go to a web page to see what activities take place inside the building; "enter" via an "ENTERnet" connection! Thus, the Internet plays a vital role in offering an inventory of building interiors that can be critical knowledge in times when rapid response from emergency forces is required.

Click on the buttons on the left to view sample models, to see models that have been in use by City officials, and to see one possible wave of the future in urban planning, emergency management, and environmental security preparation. First, install Cosmo Player or Cortona (or some other virtual reality viewer) in your Internet browser and set the headlight to the "on"

position (terminology associated with Cosmo Player). These models were tested using Cosmo Player.

***The advice, kindness, wisdom, and support of numerous individuals and groups has been critical in helping the author build this Atlas. Errors or misinterpretations that remain are, of course, hers alone. She does, however, owes a great debt to the following individuals and groups of individuals:

- Professor Klaus-Peter Beier, Ph.D., Director of the 3D Laboratory of the Duderstadt Center of The University of Michigan, and professor in Engineering 477, Principles of Virtual Reality (in which the author served for two years, 2003-2004, as a Faculty Advisor)
- Matthew Naud, Environmental Coordinator and Emergency Manager Advisor, City of Ann Arbor
- Graduate Student Instructors in Engineering 477, The University of Michigan: Thana Chirapiwat, Jamie Cope, Bonnie Bao
- Staff in the 3D Laboratory of the Duderstadt Center of The University of Michigan: Lars Schumann, Brett Lyons, Scott Hamm, Eric Maslowski, Steffen Heise
- Merle Johnson, City of Ann Arbor, ITS Department
- Chandra Hurd Gochanour, City of Ann Arbor, Planning Department
- Donald T. Uchman, Coordinator of Space Graphics, Space Information and Planning, Plant Extension--AEC, The University of Michigan
- Downtown Residential Taskforce members: Susan Pollay (Executive Director, Downtown Development Authority), Karen Hart (Former Planning Director, City of Ann Arbor), Jean Carlberg (City Council), Wendy Woods (City Council), Steve Thorp (Former Chair, Planning Commission), Frances Todoro (Mayor's Office), Douglas Kelbaugh (Dean, Taubman College of Architecture and Urban Planning), Fred Beal (President, JC Beal Construction), Robert F. Gillett (Legal Services of Southeastern Michigan), and William D. Kinley (President, Phoenix Co./Phoenix Contractors, Inc.)
- Graduate Student Team, 2003: Taejung Kwon, Adrien Lazzaro, Paul Oppenheim, and Aaron Rosenblum. Faculty Advisors with the author were Matthew Naud and John D. Nystuen in Prof. Beier's Engineering 477
- Graduate Student Team, 2004: Nikolai Nolan, Rasika Ramesh, Itzhak Shani; Faculty Advisor with the author was Matthew Naud in Prof. Beier's Engineering 477
- Brian Barrick and Peter Pollack, both of Pollack Designs
- Ray Detter, Citizens Advisory Committee of the Downtown Development Authority
- Members of the public attending a public hearing in which the models were shown, April 27, 2004; linked audio, full transcript, from that meeting in Council Chambers, City Hall, with acknowledgement for the models.

Cross-discipline Analogy: Information Impedance Matching

Peter Martin

Martin and Riener Technical Services
and
Oregon State University**

When Claude Elwood Shannon effectively laid the foundations of information theory in his mathematical theory of communication (Shannon, 1948), he showed how something as seemingly intangible as information and its transmission could be studied quantitatively. As is often the case when new insight is gained, the theory was expressed formally in the language of mathematics, but its understanding was motivated by analogy to other fields of study. For example, the concept of "entropy", usually associated with disorder or the direction in which energy tends to flow, in the contexts of statistical mechanics or thermodynamics, was adopted to refer to information, when information is treated in terms of probability.

Geographic Information Science and cartography are concerned with the communication of geographic information, and Tobler (1997) has commented on the relevance of information theory to cartography. Interesting and fruitful analogies have been developed between problems of Geographic Information Science (including cartography) and those of other fields of science and engineering.

For example, Johnson (2004) recently wrote on the analogy between physical diffusion models and the generation of cartograms, referring to the work of University of Michigan physicist Mark Newman on efficient computer algorithms to generate maps in which the areas of entities (such as states) are transformed to represent relative attributes of those entities (such as number of electoral votes). In his review of computer cartograms, Tobler (2004) notes that Rushkin (1971) made the analogy between cartograms and the physical model of a rubber sheet map with inked dots whose number and placement represented, again, some attribute such as number of electoral votes. In this analogy, stretching the rubber map to uniform dot density then results in a cartogram.

Newman, viewing diffusion (such as that of dopant atoms within a silicon chip during semiconductor manufacture) likewise as a process of density equalization, perceived that the same theory could be applied to the computer generation of cartograms. So cross-discipline analogy often leads to improved techniques and better understanding.

Following Shannon's work, the terms "entropy" and "energy" are used commonly in the contexts of information science and signal processing. This leads to the suggestion of another term of analogy, namely that of "information impedance matching".

In electrical (power) and electronics (signal) engineering, "impedance" is defined as the ratio of voltage to current, and the term might be understood intuitively as a relation between how much is offered and how much flows (and to what degree the flow is in sync with the force). Already this hints at communication.

Impedance has meaning in other areas of wave propagation, too: for example, in optics the "index of refraction" is a ratio of impedances; the impedance of glass to the passage of light is higher than that of air, so there is refraction, making lenses possible. In geophysics, different rock impedances result in different speeds of propagation of seismic waves, and there is reflection of these waves at impedance discontinuities, making possible subsurface profiling using seismic waves.

As suggested above, impedance discontinuities result in a sort of "bounce", and prevent an unimpeded flow of energy. “Impedance matching” is a design process to achieve the most effective transfer of energy from one part of a circuit to another part by matching the parts, with certain characteristics, in a complementary way: the impedances should be complex conjugates at the operating frequency resistances should be equal and the capacitive reactance of one should equal the inductive reactance of the other. For example, to produce as much light as possible with a certain battery and an incandescent bulb use a bulb not of extremely high resistance nor of extremely low resistance, but of resistance equal to the battery’s (internal) resistance. Match the filament impedance to the battery impedance, and you will maximize the flow of energy.

Similarly, in the communication of information the best transfer of information occurs when the data are displayed at the resolution indicated by the source: one pixel to one pixel. This is not merely a matter of finding the most powerful way to represent information, but rather of optimizing the compatibility of the information representation used by the source, and the information representation used by the receiver. Thus, in loose analogy to the principle of electrical impedance matching, the principle of information impedance matching suggests itself, to describe the optimal matching of an information source and an information receiver. This analogy seems appropriate because the fields of information theory and signal processing implicitly recognize the equivalence of energy and information when speaking of “energy compaction” in transform coding for purposes of compression and similar ideas (Goyal, 2001). Geographic data, as spatial or temporal distributions of values, can be regarded as cases of “signals”, carriers of information to be detected by those who use maps or other displays of geographic information. Thus, the application of ideas from signal processing and information and communication theory is justified, and may provide practical insight for spatial data communication in geographic information science.

The material that follows offers some reflections on geographic information impedance matching derived from the electrical/electronics analogy noted above. To apply impedance matching ideas to the communication of geographic information, one might first inquire as to the likely location and quantity of information that can be carried by a geographic data set, in a given representation, such as an image or an electronic file. Representations are not absolute. They should not be confused with that which they represent, notwithstanding Wittgenstein's (1922) claim that a symbol must have something in common with that which it represents. Representations might closely resemble reality; they are, however, mere models or symbols—not reality, and can be transformed without loss of information.

The squared norm of a signal, as the sum of the squares of all its component values, is a measure of its deviation from the origin of function space, and is called its energy. "Energy compaction" refers to use of a transform to arrive at a coordinate system in which the location of the signal in function space can be approximated by a few orthogonal components in the new coordinate system. Then the projection of the signal onto those components' axes contains most of the signal's energy. It can be argued that this coordinate system allows a more "natural" representation of the signal, at least for the purposes of information transmission and storage. The sum of mutually-exclusive projection energies should equal the full-dimension energy.

Energy is always defined in relation to a frame of reference, such as a coordinate system, and the same is true of information. This is not the distinction between information and meaning or truth noted by many (e.g. Tobler, 1997), but rather the distinction between that part of a signal that is certain, given the context, and that part which "comes as a surprise", as a variance, and truly informs. If all signals from a source have a bias, we may ignore the bias without losing information. We may tell the source not to send the bias; we will simply adjust the origin of our coordinate system to reproduce it.

Information is the figure perceived against the ground, even if the location of meaning can be argued (Hofstadter, 1979). The ground reference is the context of the signal, and if the source and receiver agree on this common ground, then just the figure can be transmitted, for that is the carrier of information. In this case, source and receiver are well matched. If this is not the case, the ratio of information flow to data flow becomes small. Awareness of these ideas might prevent errors in geographic information science.

Cartographers are concerned with the effective transfer of spatial information, which depends on attention to information impedance matching in data collection, data conversion, and data representation. The risks of neglecting information impedance matching are information loss, pseudo-information generation, and loss of efficiency

In data collection, one rule is not to record more apparent significant digits of a numerical measurement than are justified by the precision of the instrument (or by other practical or theoretical considerations of maximum possible precision). Ignorance of this rule results in an information impedance mismatch insofar as much of the flow of numbers conveyed is overburden, not representing information.

In data conversion, any sort of re-sampling or re-projection of data likely constitutes an information impedance mismatch. Re-projection generally entails interpolation of a regular grid, where original data are discarded and new data are created. It is inevitable that information will be lost and pseudo information created in this process; the severity of the mismatch is of the most interest. Different spatial patterns will be affected in different ways by such mismatches. For example, even if a grid of data is simply “reprojected” to a grid of coarser resolution, it may in some cases be preferable simply to subsample; in other cases it may be preferable to use a convolution filter, to minimize discontinuities or to maintain subband definition for purposes of scale analysis. In the familiar case of image size reduction, subsampling might preserve “sharpness” of certain features, while resampling with a convolution filter may better display continuity of areas and of edges not aligned with the grid axes.

A form of pseudo-information that might arise in resampling is aliasing. Kimerling (2000) reported on the Moire-like patterns apparent in data quality maps of resampled equal-angle grids. Information impedance mismatching can produce similar patterns (or similarly-caused patterns) in the presentation of the data itself, which should be of considerable concern to those who prepare and analyze spatial information.

Figure 1 is a pair of images of the 256 x 256 discrete cosine transform (DCT) matrix. The image on the right was resized twice, which is expected to produce subsampling discontinuities. Displayed properly, the images would reveal hyperbolic bands bending toward the upper left corner, and a fainter hyperbolic cross at 2/3 across and 2/3 down from upper left. Any other variations seen are aliasing artifacts that result from information impedance mismatching. When viewing this document on a computer screen, try changing the magnification; the patterns should change.

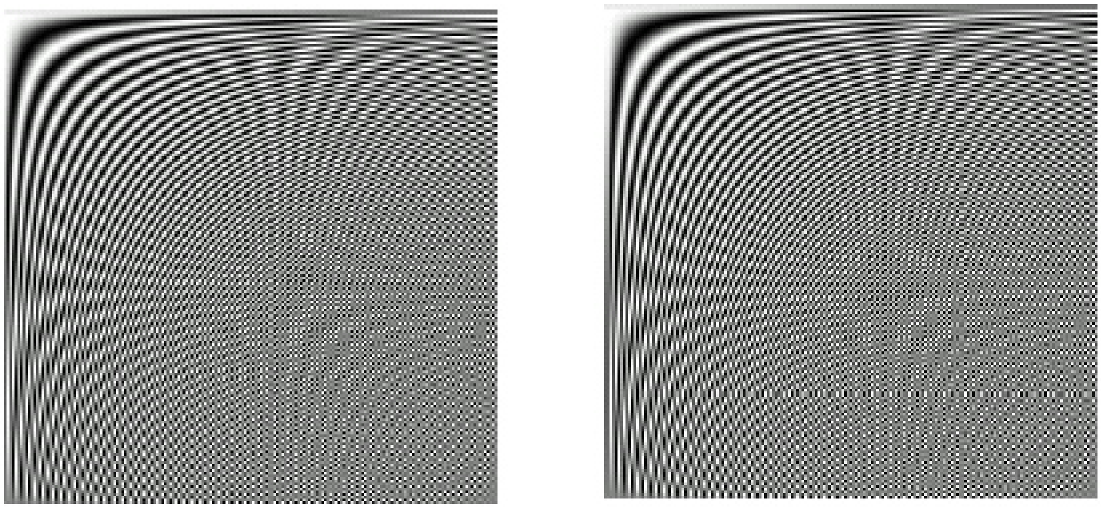


Figure 1. 256^2 DCT matrix. Reduced and enlarged image on right.

These DCT matrix representations have undergone several conversions, including the conversion of 32-bit floating point numbers to 8-bit integers as well as conversions involving resizing, transformation raster to vector data and vector to raster data. There may be the illusion that we have a picture of the original matrix, whereas what we really have may be a picture of a representation of a conversion of... an original representation of the matrix itself.

Because of the profusion of electronically-manipulated spatial data and the demands to reformat data sets for compatibility, it is incumbent upon those who work in geographic information science to be consciously aware of the distinction between the signal and its representation, and to minimize conversion and representation mismatches.

Loss of efficiency in information transmission matters because when efficiency drops, so does communication —consider for example a cluttered map, or a web page that is slow to load. Any representation of information is a sort of symbol. The key to avoiding information impedance mismatch is to have a sense of what the essential information components of a set of data are, and to employ representations that encode information in similar terms (and in this respect we are in accord with Wittgenstein).

All representations are models, or symbols. The customary way to represent certain geographic data may not be the most “natural” choice. For example, graphs comprising lines and plots are not efficiently represented by the JPEG (Joint Photogaphic Experts Group) image format, whose components are smooth waves; such information would be represented more efficiently in vector format, such as EPS (Encapsulated PostScript), or if they must be in raster format for compatibility, then GIF (Graphics Interchange Format), PNG (Portable Network Graphics) or compressed TIFF (Tagged Image File Format) might be a better choice

—the ratio of display quality to file size would be much higher.

Information impedance matching applies to non-spatial data as well. Common examples of information impedance mismatches that result in loss of efficiency are the conversion of documents from one format to another, and the conversion of text to image. In the parlance of signal analysis, the latter is a projection from one signal space to a much higher dimension signal space. Conversely, when numerical data (such as images) are encoded as ASCII (American Standard Code for Information Interchange) characters, as they are for email, a double conversion has taken place, with resulting loss of efficiency. A case in point is the passage of information electronically over the Internet, as in the case of a map server or other geographic data server. The price paid for a poor choice of data format is slow transfer of data. Data are not necessarily information, and it is only information that really needs to be served.

Information impedance matching can be summarized as facilitating information flow by making appropriate joints and transmission lines between information source and information receiver, employing transformation where appropriate, but avoiding it otherwise. Modular thinking cannot be discarded, but geographic information science practitioners must take the responsibility to understand the so-called "transparent" processes, such as data conversion or reformatting, that affect their geographic information and its effective communication.

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**The author is a graduate student at Oregon State University; mailto:martinp@science.oregonstate.edu

Goode's 80th!

Sandra Lach Arlinghaus

In 1925, Professor J. P. Goode of the University of Chicago Geography Department superimposed a sinusoidal and a Mollweide (homolographic) projection and noted similarities in the maps on either side of the equator [**3**]. Eureka! The "homolographic" projection was born (Figure 1). Anderson and Tobler note that the "kinks" in the edge of the Goode homolosine, at about 40 degrees north and south latitude, show where the Mollweide is joined to the sinusoidal: sinusoidal is central and Mollweide is polar [**1**]. This familiar equal area interrupted projection is often used to display global distributions of terrestrial phenomena.

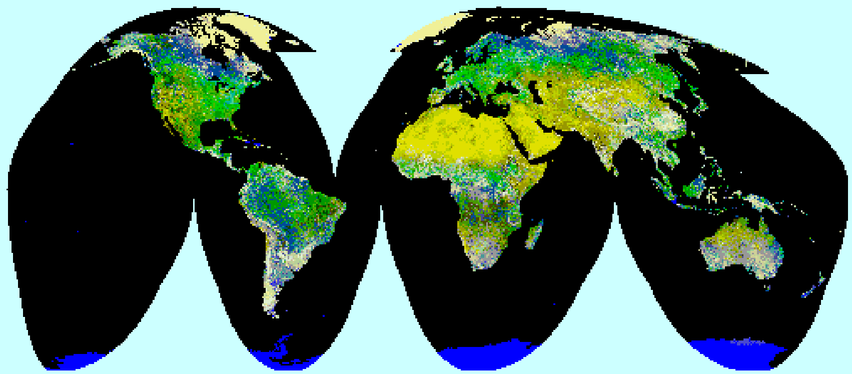

Figure 1. Goode's homolosine projection used to portray global land use patterns (source: [**4**] Lethcoe, Kent J. and Klaver, Robert W. Simulating the Interrupted Goode Homolosine Projection with ArcInfo. Used with permission of the authors and the USGS/EROS Data Center).

Goode documented his observations using the technology of the time; it was not possible to offer a visual display, in a bound journal, of the act of overlaying one map on another. Thus, Goode's actual, direct observation could not be recorded. In an electronic journal, it is possible to offer such displays. The maps in Figure 2 show a Mollweide (Figure 2a) and a sinusoidal projection (Figure 2b) in adjacent rows of a table. These maps were made using ArcView 3.2 GIS (ESRI) and scaled so that the equator and prime meridian have identical length in both projections. In both, small circles are line segments parallel to the equator. In the Mollweide, meridians are halves of ellipses; in the sinusoidal, meridians are formed from arcs of the sine curve. The two projections are similar in geometric construction but differ in the formulae used to make calculations within that general structure. The reader interested in the detail of construction might wish to read the clear and thorough explanantion offered by Snyder [**5**].

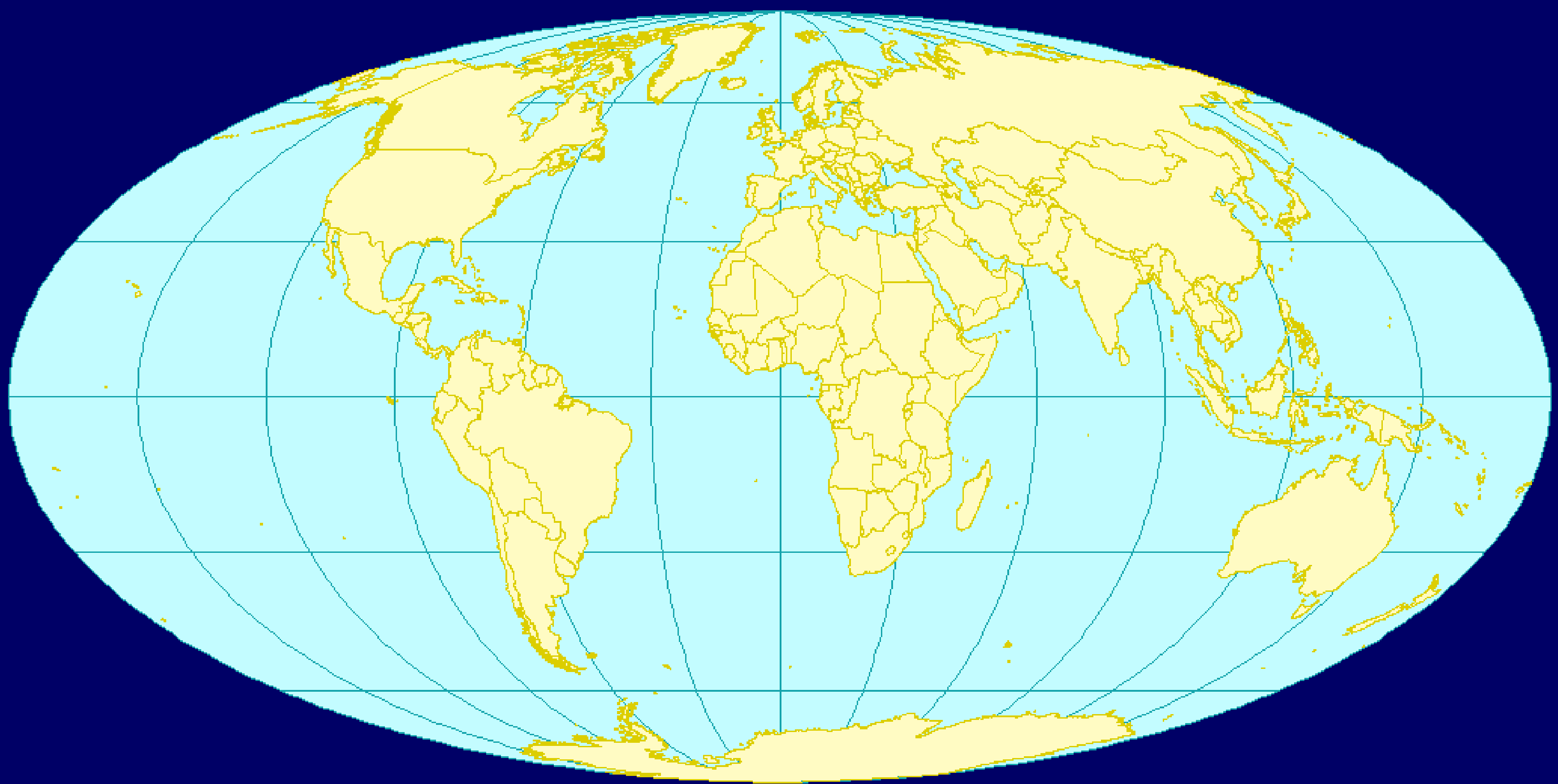

Figure 2a. Mollweide projection. Meridians are halves of ellipses of increasingly sharp curvature as one moves away

from the central meridian.

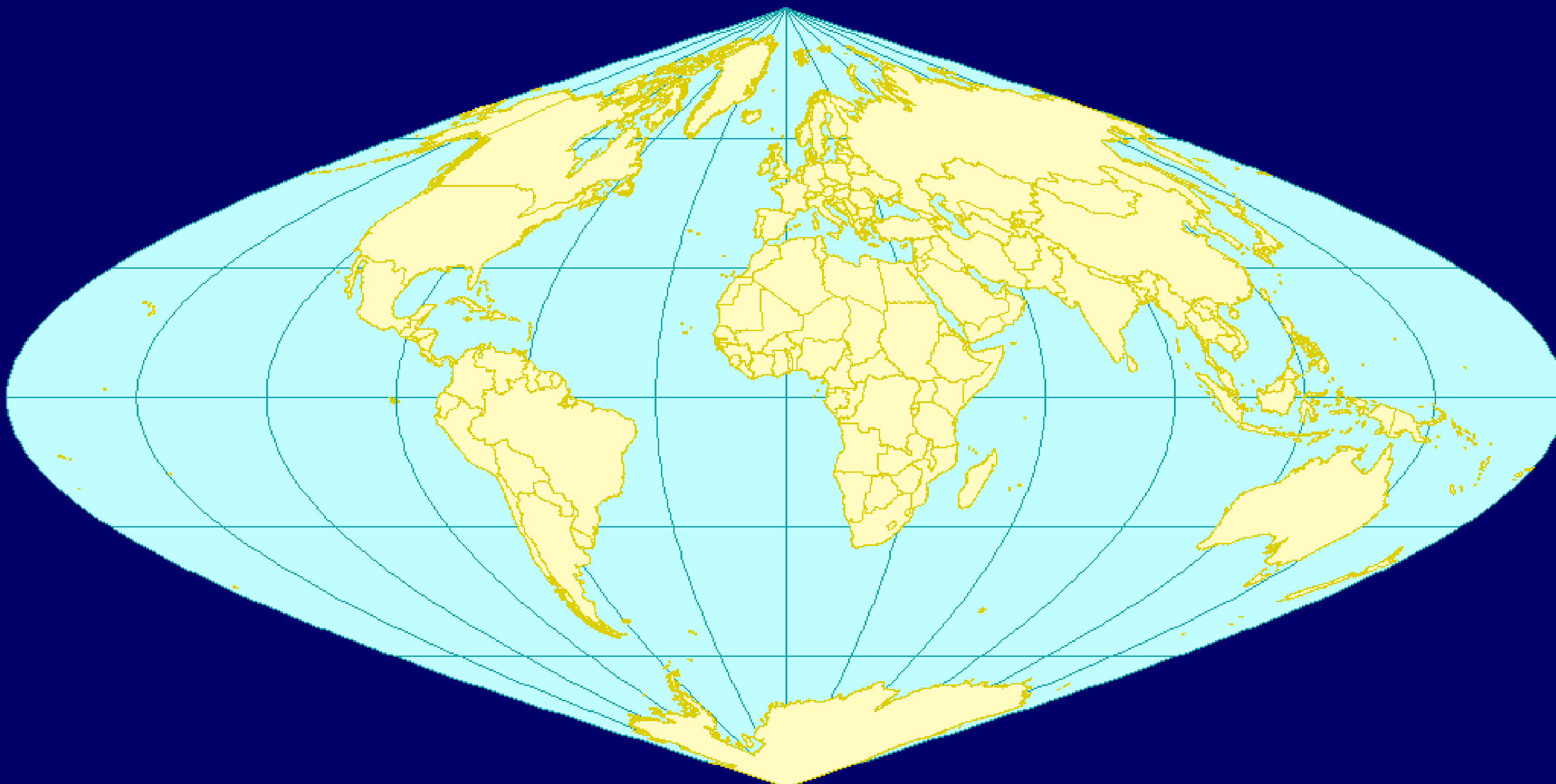

Figure 2b. Sinusoidal projection. Meridians are arcs of a sine wave of increasingly sharp curvature as one moves away from the central meridian.

When one looks at Figure 2a, and then at Figure 2b, it may not be clear how Figure 1 arises from the images in Figure 2. A simple solution is to overlay the images and see if we might imagine today what it was that captured the imagination of Professor Goode in 1925. Figure 3 shows an overlay of the Mollweide and the sinusoidal in a QuickTime (trademark, Apple) movie format. The movie should play once in the browser, automatically. The reader has complete control over the movie and can scroll it back and forth using the "controller" bar below the animation. Animated maps are useful because they combine elements of a presentation that cannot be captured in the static form of the printed page. Often, they merge space with time [**2**]. Here, they offer a means to capture a thought process and give the reader interactive control of it: to enter a process from 80 years ago and imagine what might Goode have seen!

Figure 3. Overlay of Mollweide and sinusoidal projections captured as an animation (in .mov format). Drag the handle on the controller bar to see elements of the overlay. If the animation is not running automatically, and you wish to have it do so, pressing the reload button on the browser is one alternative that should work independent of other issues (presuming that QuickTime (Apple) is loaded on your computer (independent of brand)).

In the animation, watch the tip of South America. As the animation progresses, the southern part of South America seems to fly off the globe in the sinusoidal while the northern part of South America remains relatively clear in both projections but perhaps closer to globe-form in the sinusoidal. Thus, one might imagine that a scholar, such as Professor Goode, would wish to capture the closer-to-globe form of the sinusoidal on either side of the equator and couple it with the closer-to-globe form of the Mollweide closer to the poles. Notice, however, that exaggeration in the sinusoidal increases as one moves away from the central meridian. Focus attention on the meridians in the animation of Figure 3. Clearly the Mollweide and the sinusoidal are closer together near the central meridian than they are toward the edges of the map where the rate of increase in curvature of the sine wave greatly exceeds the rate of increase in curvature of the ellipse. Thus, one might consider introducing multiple central meridians so that no land mass is ever too far from some central meridian: hence, the need to interrupt the map to achieve this goal.

Animation has long been present as an entertainment device. It offers, however, a largely untapped source of power in academic endeavors of all sorts. Here, the simple idea of actually looking at the overlay, as Goode might have 80 years earlier, offers insight into research process and blends past effort with future technology.

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Diana Sammataro. 1998. Animaps. Solstice: An Electronic Journal of Geography and Mathematics. Ann Arbor: Institute of Mathematical Geography. Other articles on animated maps appear in later issues of *Solstice*.

3. Goode, J. P. 1925. "The Homolosine Projection: A New Device for Displaying the Earth's Surface Entire," *Annals*, Association of American Geographers, 15, 3: 119-125

4. Lethcoe, Kent J. and Klaver, Robert W. Simulating the Interrupted Goode Homolosine Projection with ArcInfo. Archived at http://gis.esri.com/library/userconf/proc98/PROCEED/TO850/PAP844/P844.HTM (downloaded Dec. 1, 2004)

5. Snyder, John P. 1993. *Flattening the Earth: Two Thousand Years of Map Projections.* Chicago and London: The University of Chicago Press.

Software used:

- Adobe Photoshop, v. 7.0.
- Adobe ImageReady, v. 7.0
- Apple Quicktime
- ArcView GIS, v. 3.2. ESRI.
- Google
- Microsoft Internet Explorer
- Netscape Composer, v. 4.78

Hardware used:

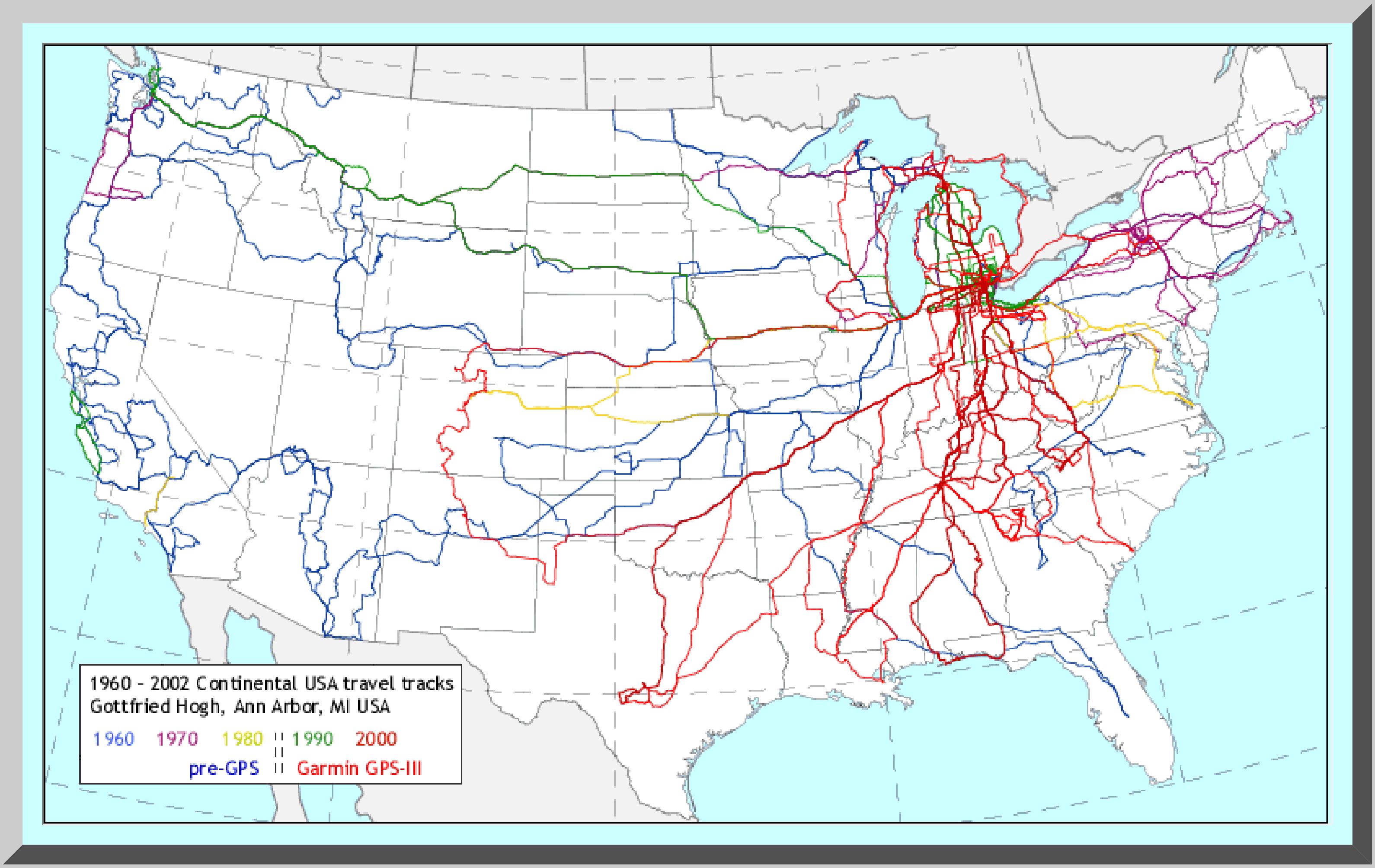
- Hewlett-Packard Pavilion running Microsoft Windows 98 operating system.
- Hewlett-Packard laptop running Microsoft Windows XP Professional operating system.

Continental USA Travel Tracks

Gottfried Hogh*
http://www.tidd-williams.com/Obituaries/gottfried_hogh.htm

One of my computer projects these past few years has been the development of a life-long travel record in the form of a database from which various maps and graphics may be drawn. The advent of GIS and other route mapping software and low cost, consumer GPS units has brought this dream closer to realization.

Some U S A tracks:



This map is an Albers Equal Area projection of the contiguous United States, centered on 100 West longitude. The post-February, 1998 tracks were captured with a Garmin GPS-III. The earlier tracks are reconstructed from my old, pre-GPS records. These are now about 90% complete as far as the various records I've kept since about 1957. While the overall data (even for the older records) are quite good, these obviously are not as precise in space and time as are the GPS generated tracks. The two, unconnected 'blips' on the northwestern border are from side trips down into Glacier National (International Peace) Park from Alberta [in 1967 VW Squareback; 20 June 1968], and along the beautiful Okanogan Valley from British Columbia, Canada. A much more recent trip to the Puget Sound area (19-25 August 1999) is tracked in overall fashion as is a Montana segment where the 1986 Porsche 911 Carrera was able to perform on the road.

Modified: 17 June 2003 by: Gottfried Hogh

***Gottfried Hogh died this past July 30, 2004.**

Two Rivers Ridge: Capturing Art

Research Announcement of a Collaborative Effort of Sandra Arlinghaus and Braxton Blake*

Geographical environments have long served as inspiration for artistic performance: in the worlds of painting, sculpture, musical performance, and musical composition. From pointillist views of A Sunday on La Grande Jatte to musical vistas of the Grand Canyon, artists have found nature evocative. Even in the small world of the cathode ray tube, Windows Media Player (with Windows XP) offers computer users flights of fancy into abstract images that appear to respond, in an electronic dance, to music as it is played on a CD.

The boundary between art and science is often blurred. Insight and leaps forward might be "art"; the ability to repeat a process consistently might be "science." Transformations, often mathematical, can offer means to traverse this vague border. Thus, we propose the following research effort, linking fields of geography and music, using a bridge of mathematics realized in current technological environments.

A musical conductor often uses a score from which to lead an orchestra. Novices in the audience may see the conductor as useless; the musicians have their parts of the score so why is a conductor needed--as a traffic officer to keep violins from interfering with the flow of the horn section? Far more, however, the conductor is an artist who sees the whole, the parts, the whole as a sum of the parts, and the whole as greater than or less than the sum of the parts. Two different conductors using the same score will produce music that is identifiable but that sounds different as it reflects their personalities as artists. In that regard, the musical score is the scientific instrument: it is the score that is transferable and allows for repetition, at some level, of results. How then, might one characterize the performance of the artistic effort of the conductor? When the conductor simultaneously becomes a composer as he/she conducts, as is often the case with improvisational ensembles that respond musically to and with the conductor, that question becomes even more vexing.

A recent performance at The University of Michigan's Duderstadt Center, November 11, 2004, featured The University of Michigan Creative Arts Orchestra (an improvisional ensemble), conducted by Michael Nickens. Nickens donned a tight body suit covered with sensors and entered the immersion CAVE of the 3D Laboratory of The University of Michigan (Prof. Dr. Klaus-Peter Beier, Director). From within the CAVE, Nickens moved around as he wished and the ensemble, in another part of the building, responded with music appropriate to his actions. His actions were transmitted in real-time, as his body and its movements, captured as a discrete "point-cloud" by the sensors on the suit, was transmitted live, from the CAVE, directly to the room with the ensemble. Because the movements of the conductor were transmitted electronically, they are captured as a quantitative dataset that could be repeated. Thus, the immersion CAVE brings to the conductor-composer a method for quantifying the previously unquantifiable.

One step beyond the electrifying performance that Nickens gave, might be to introduce an environment into the CAVE to which the conductor might respond. Thus, we propose introducing geographic, or other environments into the CAVE. Then, have two (or more conductors) conduct the ensemble from the CAVE as they respond to being immersed in specific geographic environments. Because the movements of each conductor will be captured electronically, it will be possible to compare and contrast elements of style of musical conducting and composition, and create a learning tool for new conductors and a research tool for veterans.

Further, because all conductors are responding artistically to the same geographic environment, the professional geographer will also have an electronic atlas of human response to selected geographic scenes. One of the vexing problems of the geographer is that the real-world is his/her laboratory--one with few controls. Immersion CAVEs offer greater control over selected, but mathematically simulated, environments. Nonetheless, an atlas that captures human response in a systematic fashion has great implications for the geographer and spatial scientist.

To begin, we wish to consider an environment that is compact (so that it will work in the CAVE), that is interesting, that is not well-known (to reduce knowledge bias), and that might be chosen for some "reason" rather than chosen at "random." Because Michigan is the "Great Lakes State" we chose the Great Lakes. NOAA has made interesting bathymetric maps of the Great Lakes (lake bottoms) that

are probably not well-known to most (Figure 1).

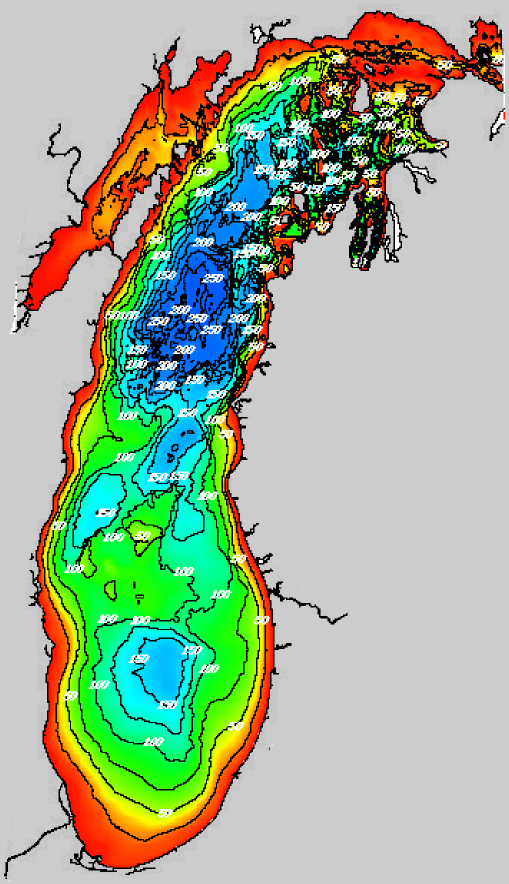


Figure 1. NOAA bathymetric map of Lake Michigan

This year (2004) is the 100th anniversary of a car ferry from Ludington, Michigan to Manitowoc, Wisconsin (Figure 2). The route of the ferry travels over the "Two Rivers Ridge."

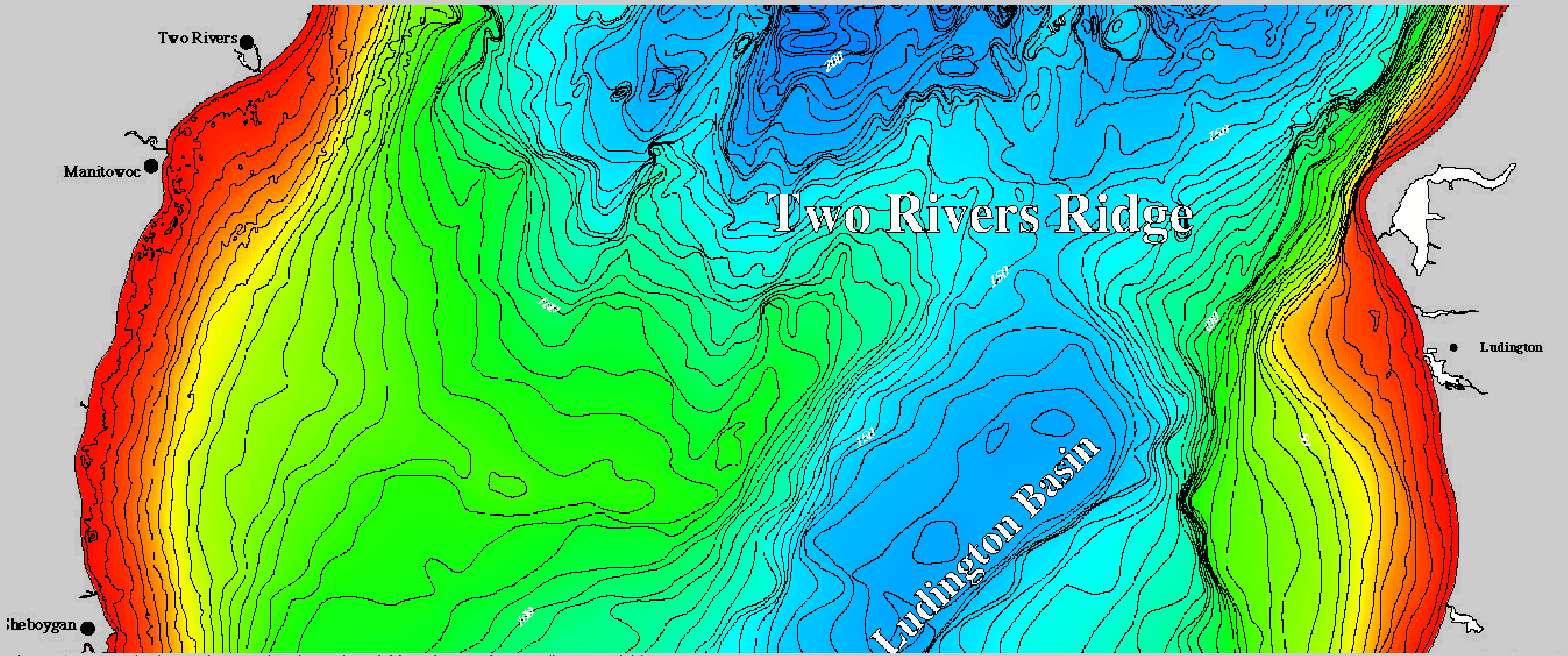


Figure 2. NOAA bathymetric map showing Lake Michigan bottom from Ludington, Michigan to Manitowoc, Wisconsin, across the Two Rivers Ridge.

The swath of lake surface linking these ports, together with the bathymetry under it and a vertical profile of that bathymetry, is a "compact" environment. To capture this environment for the CAVE, we converted a digital map into a Triangulated Irregular Network, as a three-dimensional bas-relief of the region (Figures 3, 4, and 5).

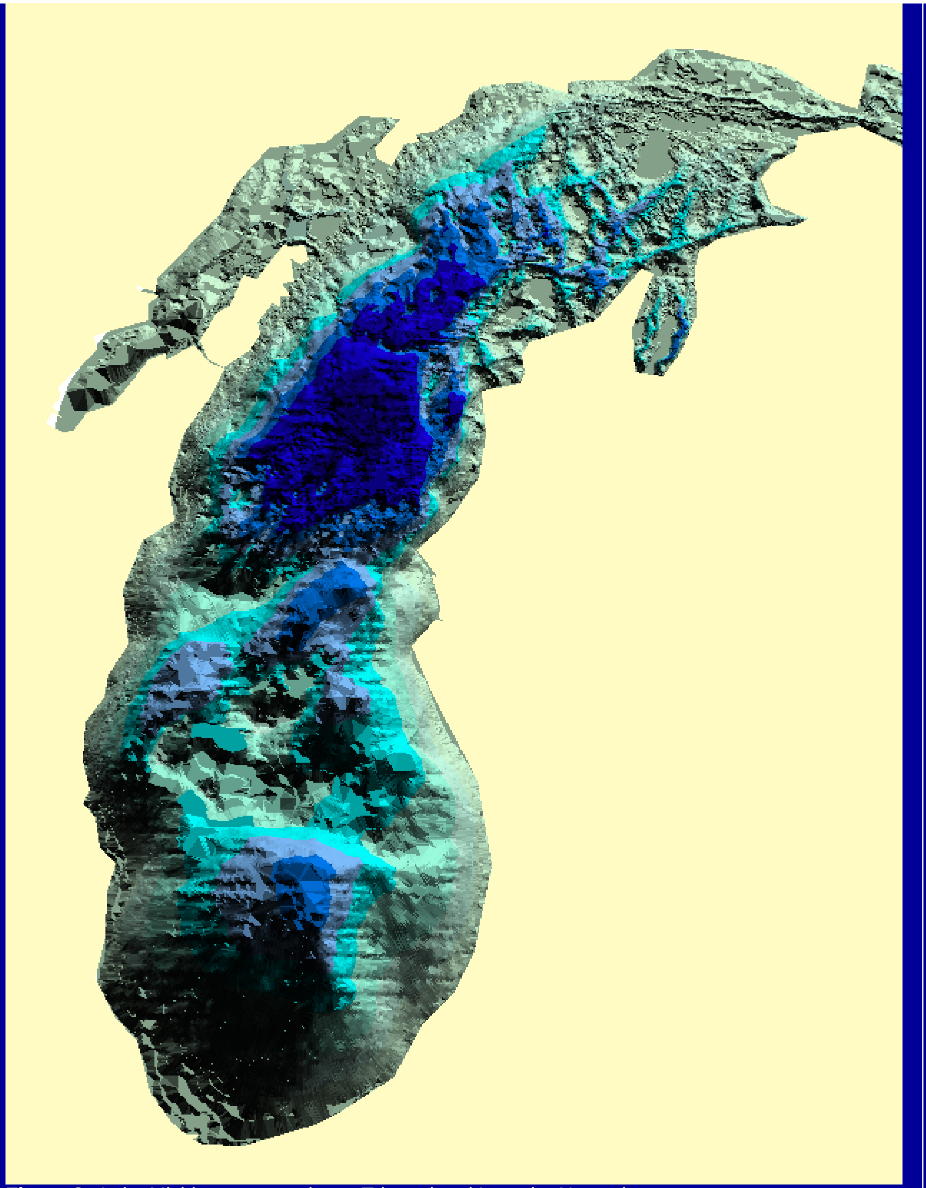


Figure 3. Lake Michigan captured as a Triangulated Irregular Network.

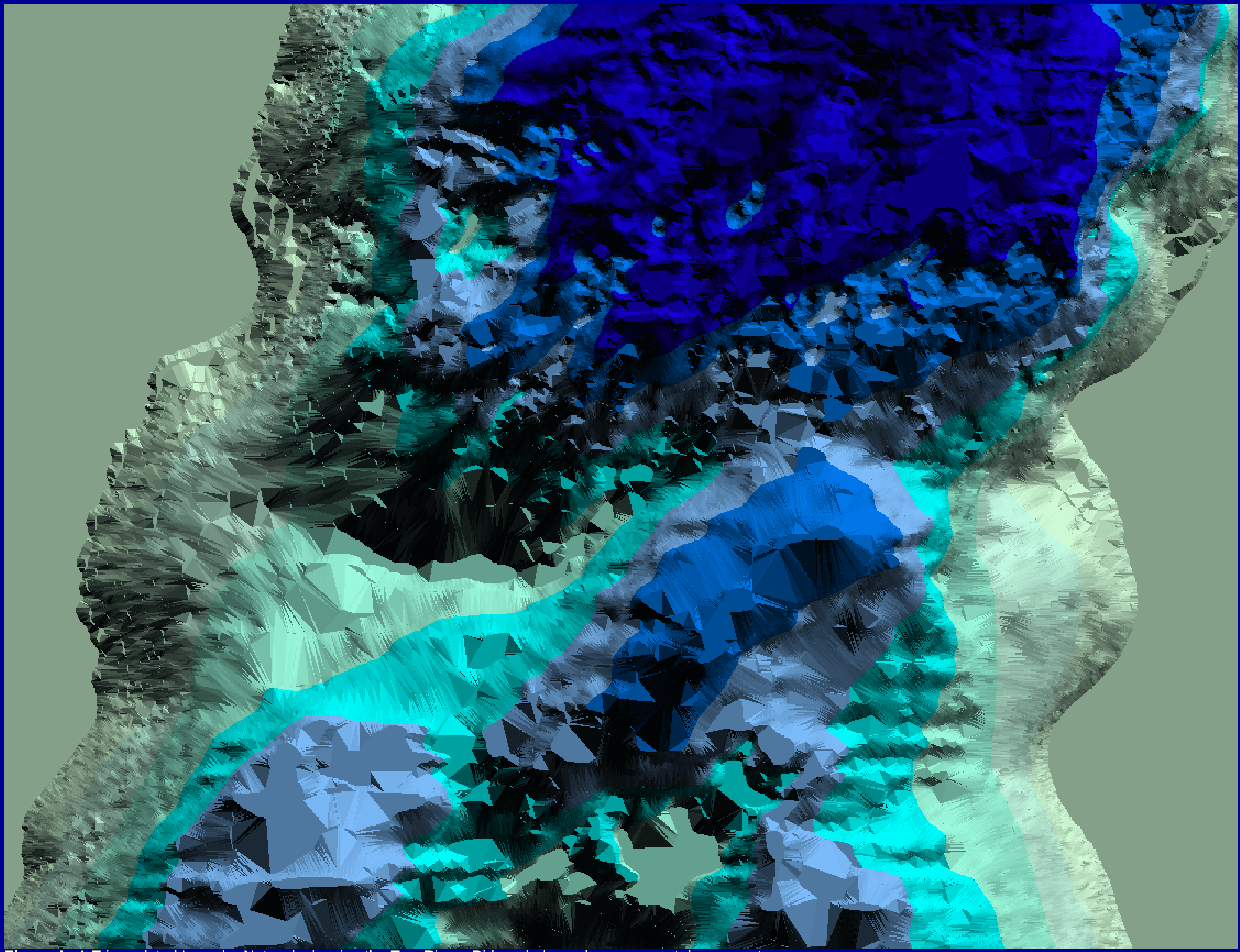


Figure 4. A Triangulated Irregular Network showing the Two Rivers Ridge; darker colors represent deeper parts of Lake Michigan.

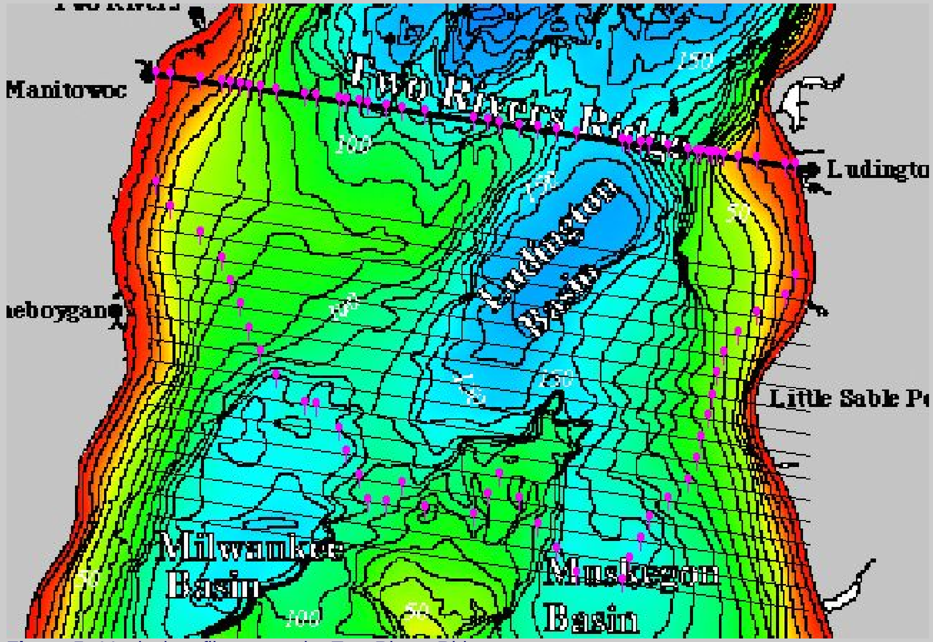


Figure 5. Vertical profile across the Two Rivers Ridge.

When the 3D maps are converted to Virtual Reality Modeling Language, they can be used on the Internet as a virtual display of the region and an animation made from them to show, in a browser, what the region might look like (Figures 6 and 7).

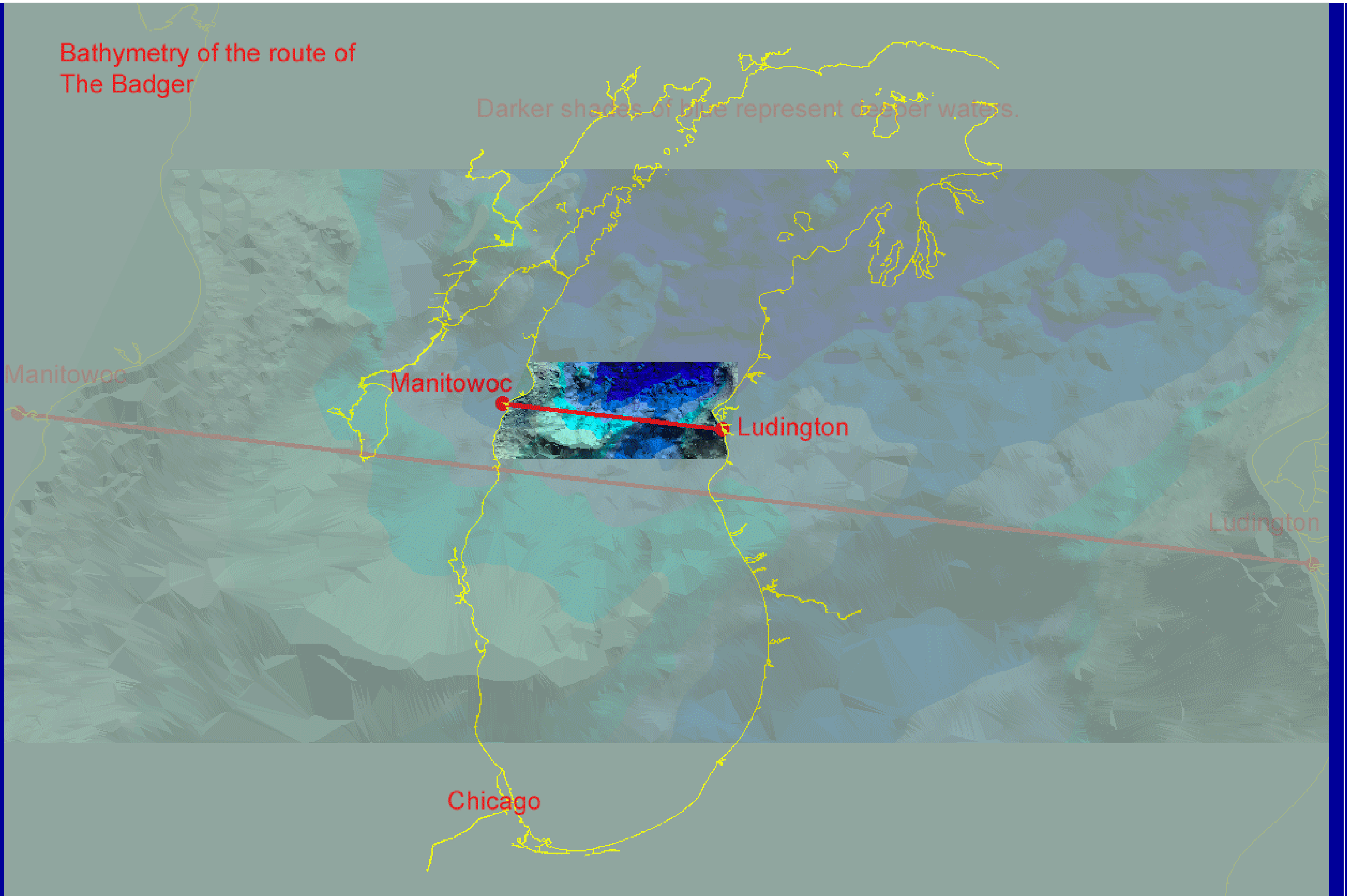


Figure 6. Animation shows transformation.

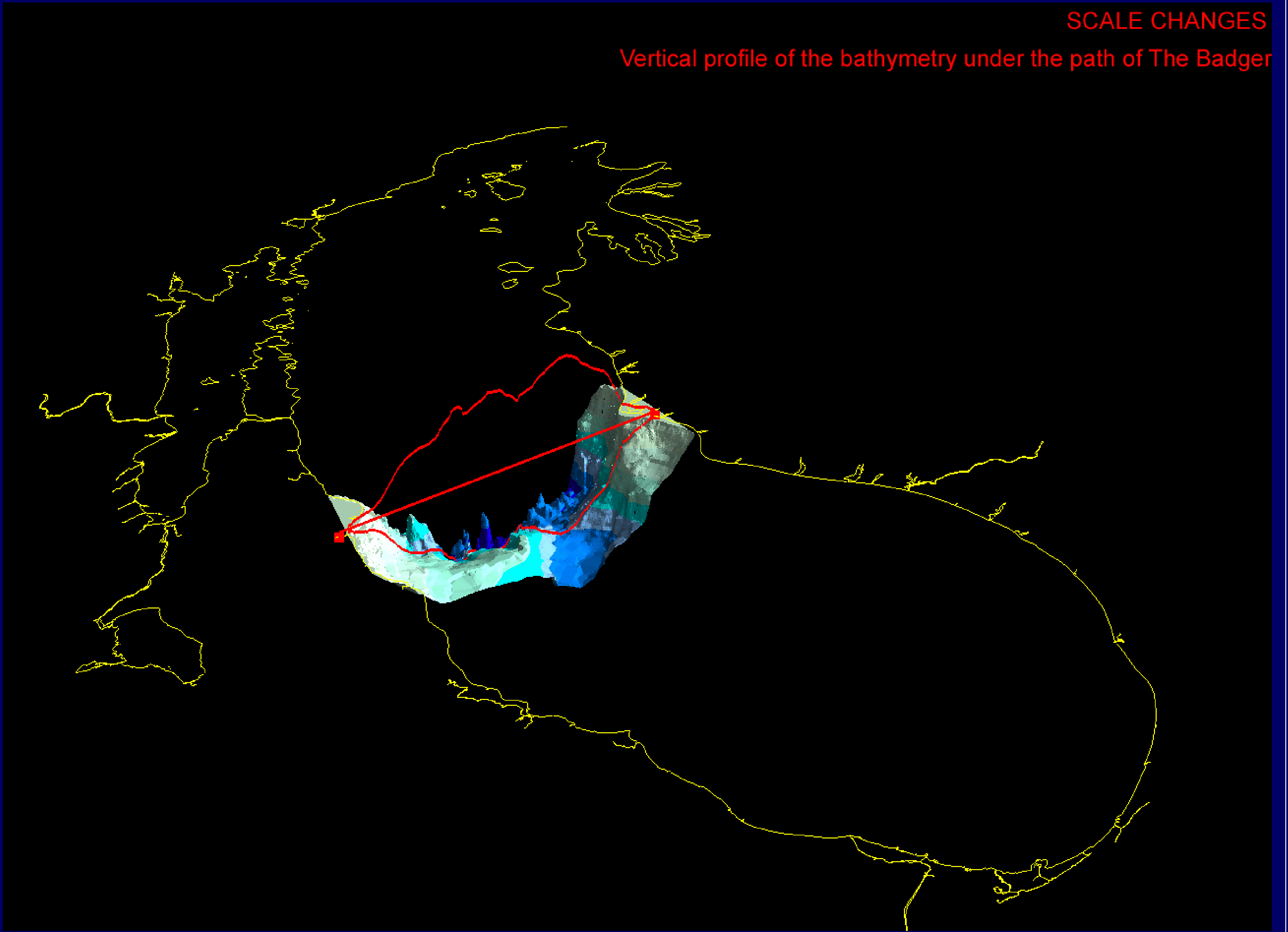


Figure 7. Animation shows scale change.

The Virtual Reality (.vrml) model from which Figure 7 was derived is linked here. It is the sort of model

that can play in the CAVE and might well serve our initial purposes: one can traverse the bottom of Lake Michigan on dry land. Thus, as a first step, we propose to make a model for the CAVE of the Ludington/Manitowoc route and to introduce that to two conductors, have each conductor react to that environment in the CAVE as an improvisational ensemble reacts to the conductor in free form spatial arrangements in a black-box theatrical environment separated from the CAVE. Following the actual theatrical productions, analysis of data will show common elements and differences in technique and viewpoint of conducting style and resultant composition, and it will also show the same for reaction to a specific geographic environment viewed in a CAVE. With feedback from a pilot study in hand, we would then be in a position to assess prospects for the future.

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*Thanks to Peter Vincent, Great Lakes Environmental Research Laboratory and University of Michigan graduate student, for assistance in obtaining NOAA files.

Mail

(in reference to material from *Solstice*, Volume XV, Number 1, Summer 2004)

Sandra,
This is a very impressive issue. I look forward to your and Bill's forthcoming book. ...

Waldo Tobler
Professor Emeritus
Department of Geography
University of California, Santa Barbara
June 20, 2004

Sandy,
Congrats on another fine issue of Solstice! I particulary like the Huron Hills Golf Course piece; even though I am not a golfer, I can appreciate both the GIS work that was required and the great benefit that the information will be to course users.
Zeb Acuff
graduate student
School of Natural Resources and Environment and Taubman College of Architecture and Urban Planning
The University of Michigan
June 21, 2004

Sandra,
... you are the most forward thinking person about electronic delivery that I personally know. ...

Steve Quigley
Executive Editor
John Wiley and Sons
November 5, 2004