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Articles

The word clouds (formed in Tagxedo, online) serve as a visual "abstract" of the adjacent article!

Global Singularity
In Memory of David Barr

Sandra L. Arlinghaus

Introduction

Sculptor David Barr was a longtime friend of IMaGe (Institute of Mathematical Geography) and *Solstice*. It is with sadness that we note his recent passing but it is with joy that we remember him and his work (Michigan *Legacy* Art Park, 2016). From Barr's 'Four Corners Project' and 'SunSweep' to the *Solstice* articles (Arlinghaus, Barr, and Nystuen 1991; Arlinghaus, 2009) and IMaGe *Monograph* (Arlinghaus and Nystuen, 1986) and eBook chapter (Arlinghaus, 2008) that Barr's art inspired, his imaginative approach to the fine arts was one that meshed well with our various projects and interests. His approach was singular, yet global.

In Barr's memory, I revisit work done a while ago (2008), and bring forward some of the mathematical and structural concepts behind it.

Barr's 'Four Corners Project'

In the late 20th century, Michigan sculptor David Barr set out to build an Earth-sized sculpture composed of small granite tetrahedra representing the vertices of an abstract tetrahedron inscribed in the Earth-sphere. To realize the concept, Barr actually travelled to four remote locations and planted the granite corners suggesting terrestrial protrusions of his embedded giant tetrahedron. He began in Easter Island, continued to the Kalahari Desert in southern Africa, went to the Greenland icecap, and ended up on a small island just off Irian Jaya/New Guinea in Indonesia. His adventure, which took many years, is chronicled in a variety of places including in film shot by a crew from the Archives of American Art (Smithsonian Institution) that traveled with him (YouTube release, 2014).

It is an obvious, and attractive, idea to want to visualize these locations on a globe. Using Placemarks (icons) positioned at the sites of the four corners on the Google Earth globe is perhaps a natural choice. Figure 1 shows a Placemark located at the Easter Island position on that globe.

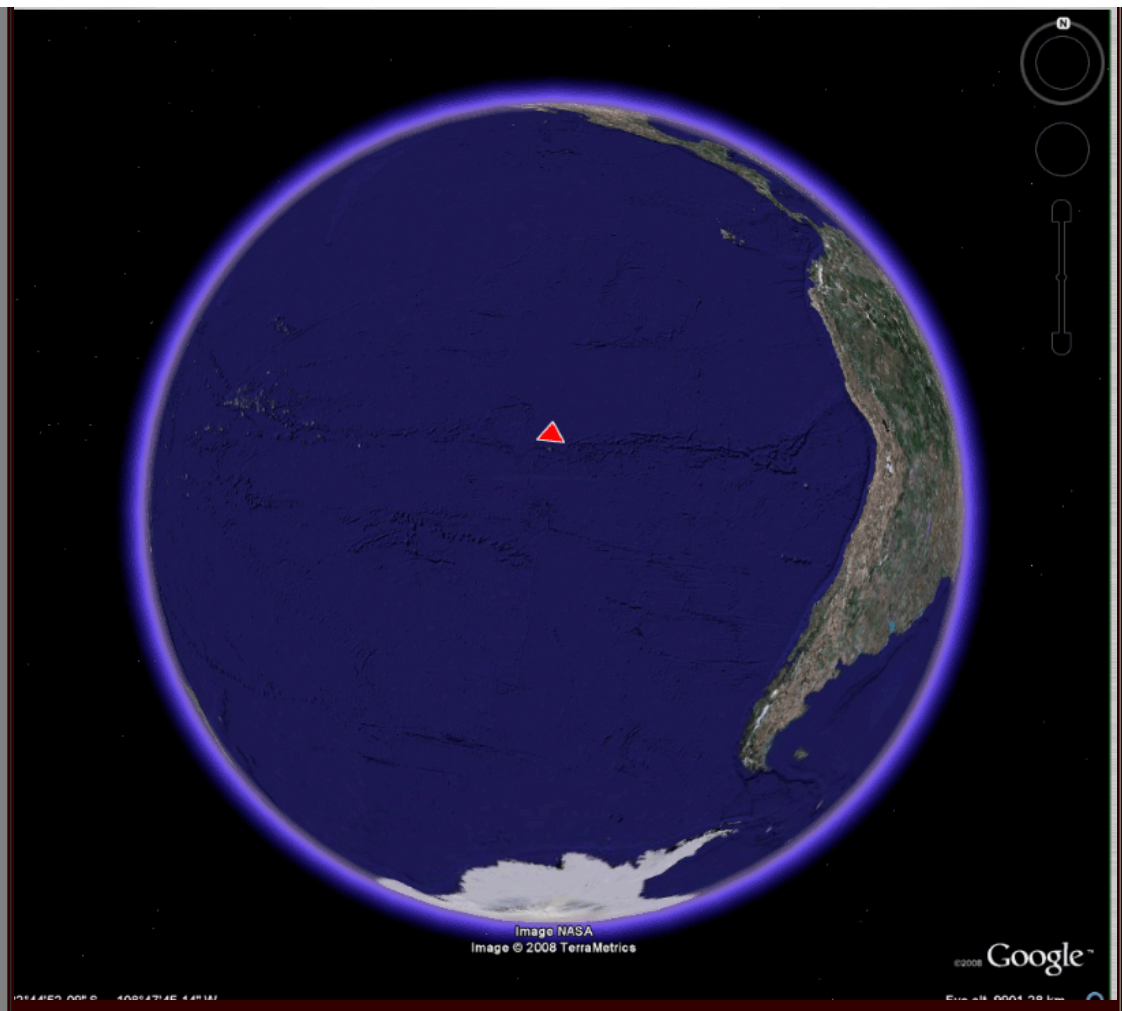

Figure 1. **Placemark on the Google Earth globe positioned at Barr's Easter Island vertex. Original image from 2008 reference.** Original source: Institute of Mathematical Geography.

The image in Figure 1 gives little context to suggest the sculpture. To give some context, locate the remaining vertices and add lines on the surface of the globe, joining the four tetrahedral prominences (Figure 2).

Figure 2. **Placemark on the Google Earth globe positioned at Barr's Easter Island vertex with remaining vertices placed on the globe and lines drawn joining them. Original image from 2008 reference.** Original source: Institute of Mathematical Geography.

While Figure 2 offers a small amount of added context, it is still discouraging not to be able to see the rest of the vertices.

Global Visualization: The Importance of Transparency

In Figure 3, the image of the Earth is removed and the four corners appear on the Google Earth globe: the globe has its skin removed. Transparency replaces the Earth-skin on the Google Earth globe.

Figure 3. **Placemarks for all four of Barr's corners come into view on the Google Earth globe once transparency is introduced. Easter Island is in the center of the image. Original image from 2008 reference.** Original source: Institute of Mathematical Geography.

Figure 4 shows an animation produced by rotating the transparent Google Earth globe of Figure 3.

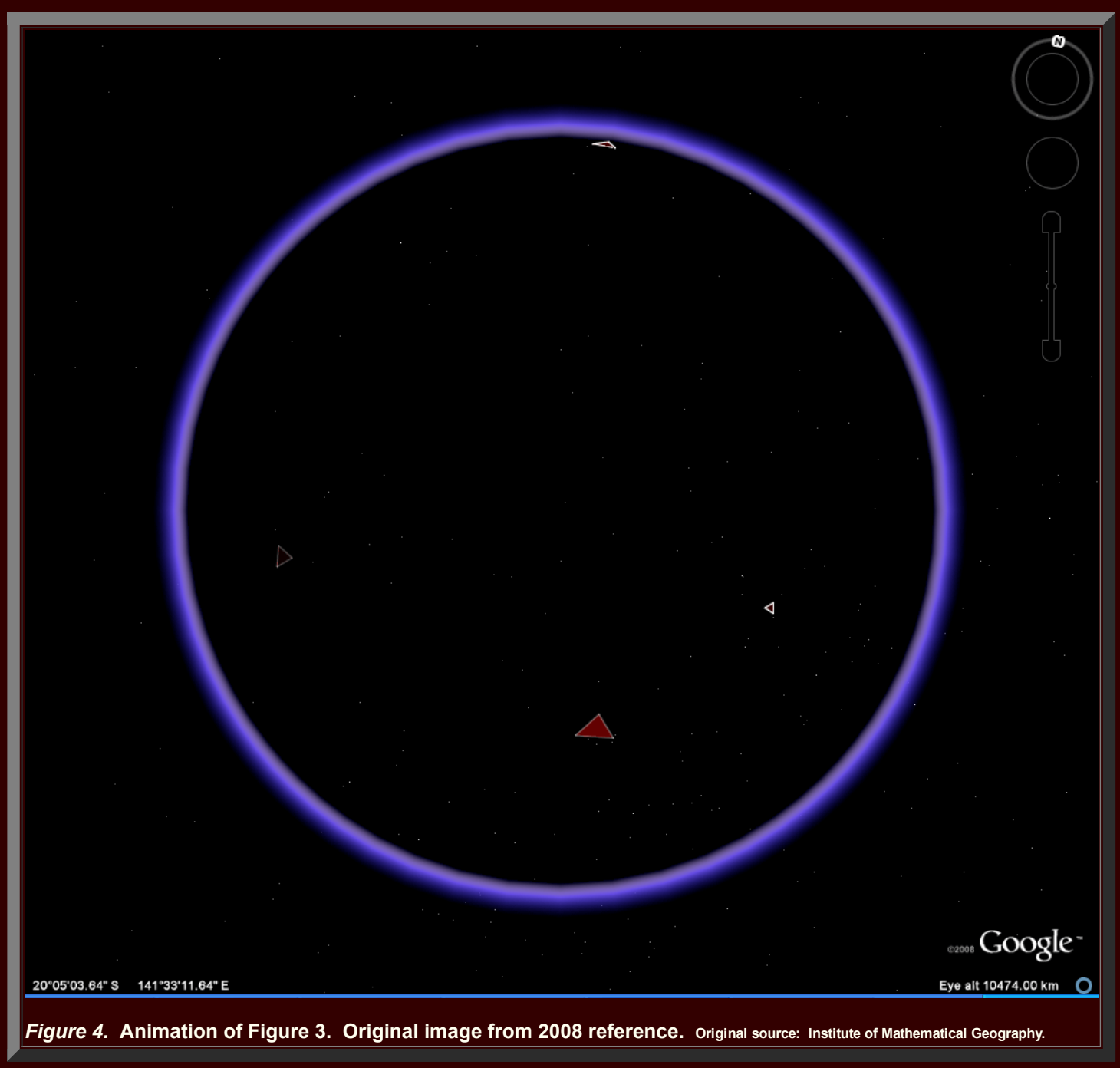

Figure 4. **Animation of Figure 3. Original image from 2008 reference.** Original source: Institute of Mathematical Geography.

A natural next step is to introduce the lines, linking the vertices, back into the image. Thus, Figures 5 and 6 show an image sequence to parallel that of Figures 3 and 4.

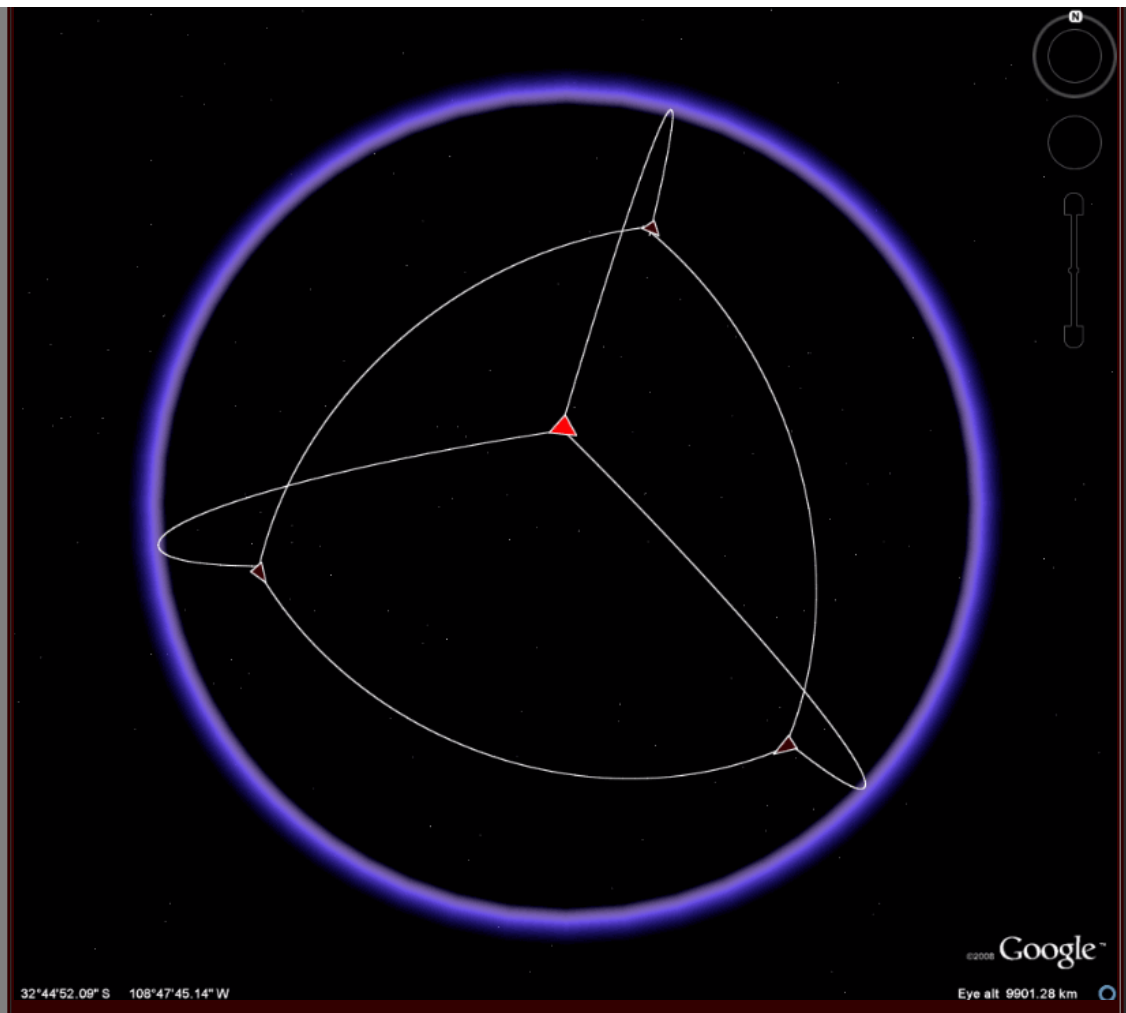

Figure 5. **Placemarks for all four of Barr's corners come into view on the Google Earth globe once transparency is introduced. Lines suggest linkage. Easter Island is in the center of the image. Original image from 2008 reference.** Original source: Institute of Mathematical Geography.

Barr enjoyed using these, and related images, in his teachings and in communications with others.

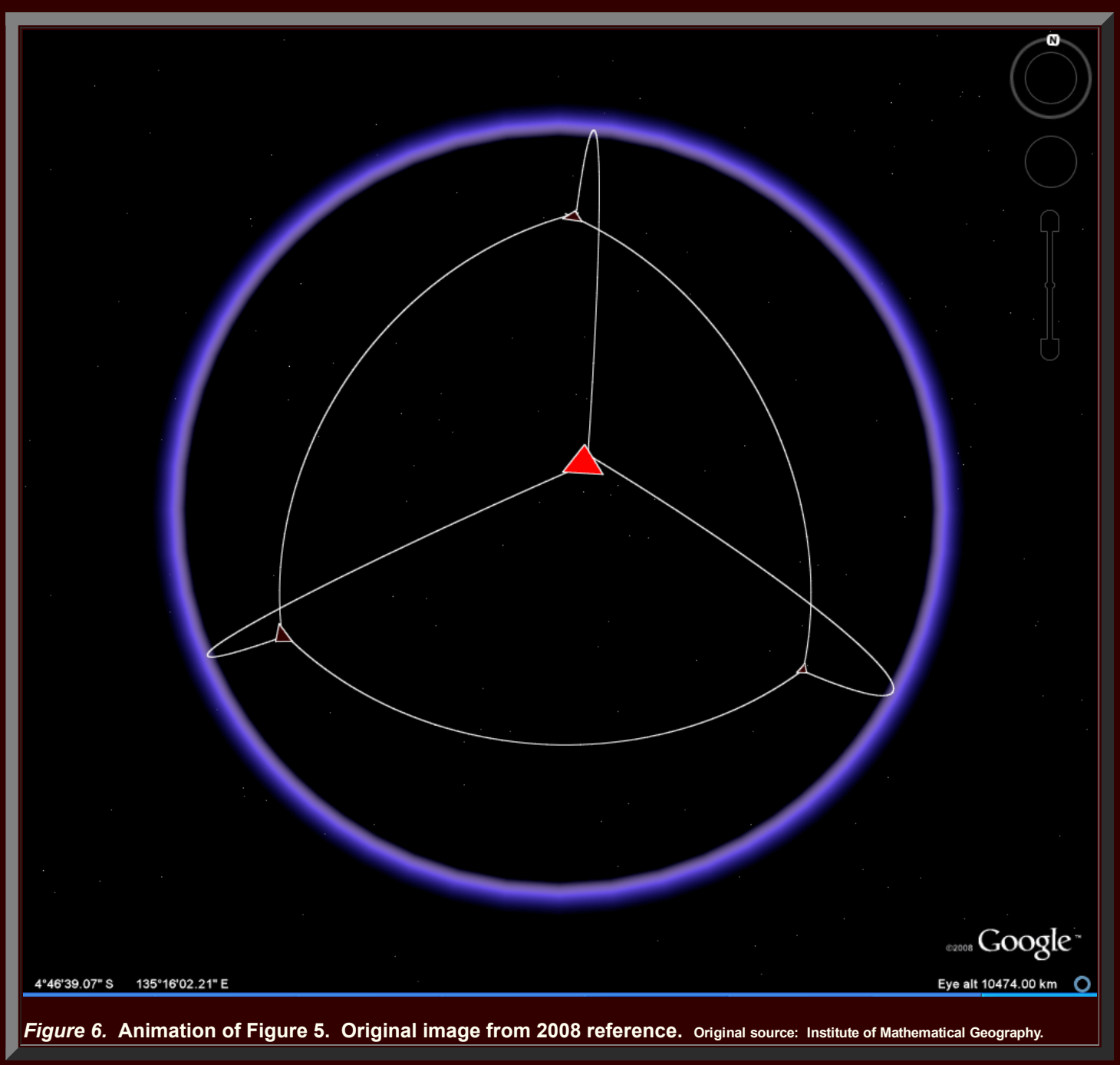

Figure 6. **Animation of Figure 5. Original image from 2008 reference.** Original source: Institute of Mathematical Geography.

John Nystuen suggested that inserting an outline map of the world would add some extra reference. Figure 7 shows that arrangement. Note that because Africa is on the back side of the globe, it appears 'inverted' from east to west, as the reader is looking through the transparent globe at it.

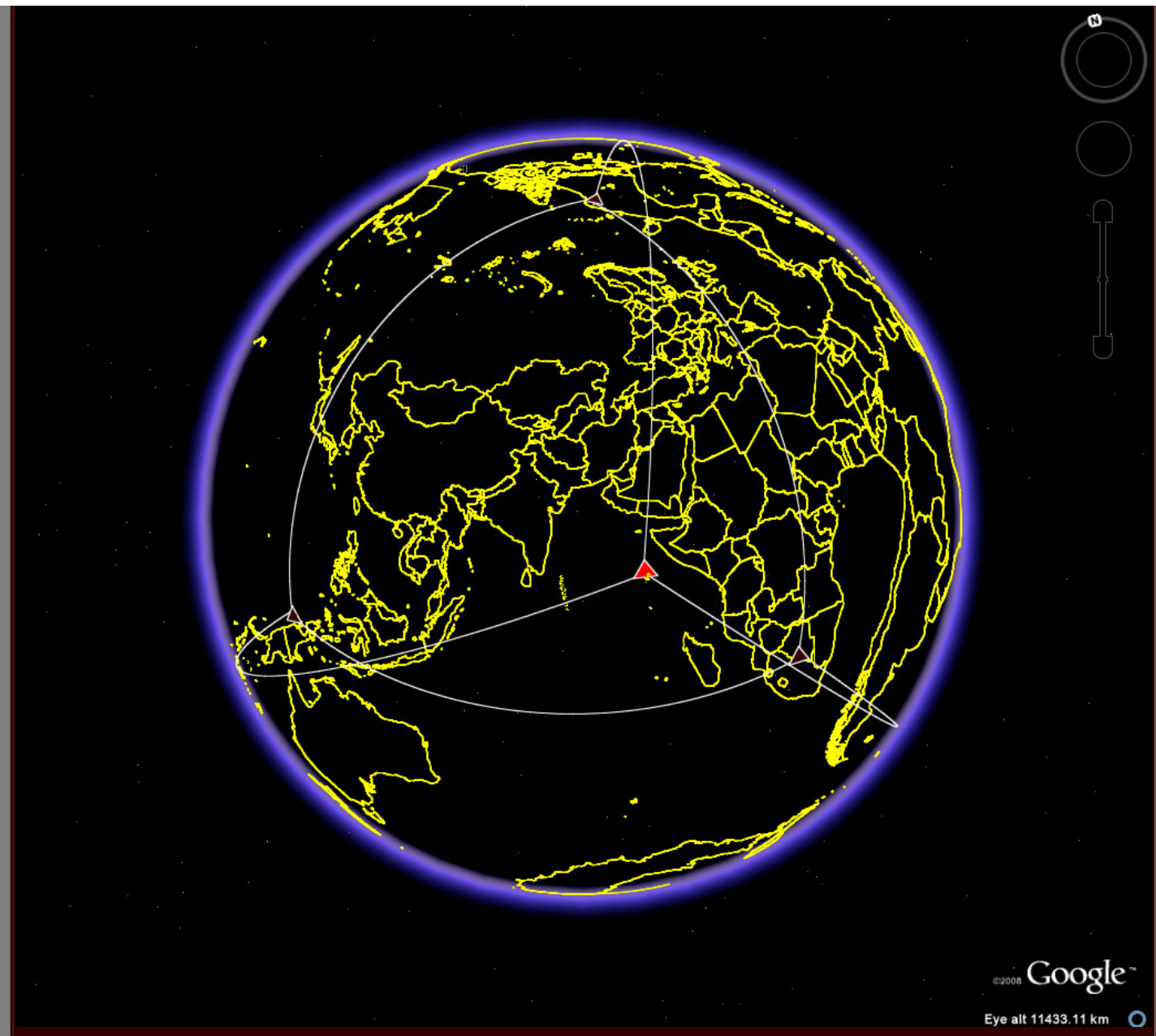

Figure 7. **Continental and country outlines, imported as a shapefile, also show through the transparent Earth-sphere. Easter Island is the bright red vertex closest to the center; the vertex to the left and on the other side of the globe is on Irian Jaya. The vertex in the Kalahari Desert is on the back side of the globe (east/west pattern in Africa is thus inverted). Original image from 2009 reference.** Original source: Institute of Mathematical Geography.

Singularity on the Globe: Visualization Unwrapped

The casual user of Google Earth might wonder how to make the globe become transparent. Indeed, that is an interesting question. To do so, I used a version of Google Earth that was released in 2007. Figure 8 illustrates how I was able to remove the Earth-skin. Notice that there is no check mark in the 'Primary database' checkbox. The initial frame of the animation shows Google Earth with continents, oceans, and so forth. The second frame shows the graticule placed on the globe of continents. The third frame shows highlighting of the layer 'Primary database' in the Layers box on the left. In the fourth frame, the slider in the 'Places' box, at the bottom, is moved all the way to the left. This sliding action causes the continental skin to become obscured and reveals a transparent globe on which the graticule is evident all around the globe.

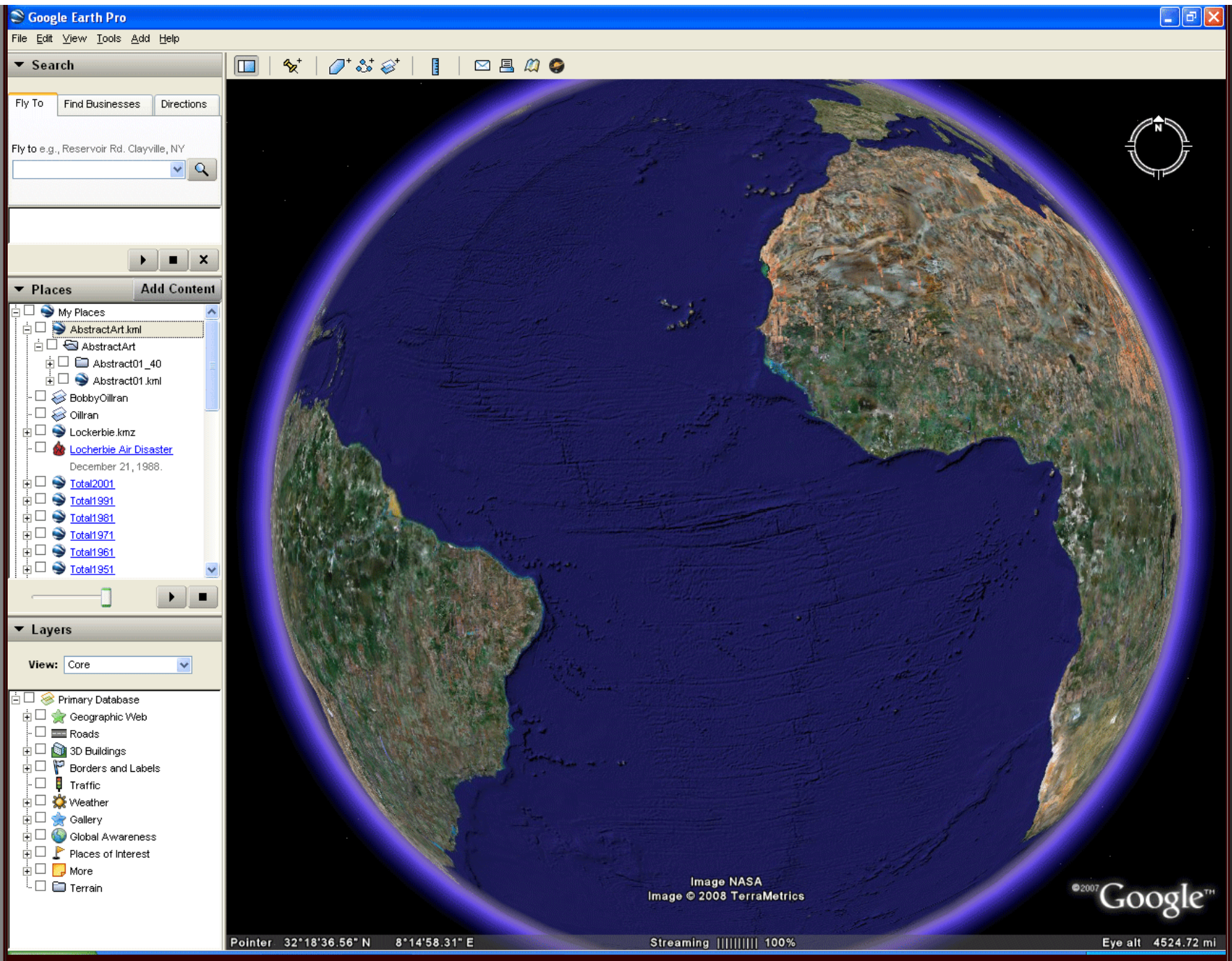

Figure 9. Removing the continental skin from the Google Globe to reveal the underlying transparent globe. Original image from 2008 reference.
Original source: Institute of Mathematical Geography.

Another question I have been asked is 'how did you decide to do things this way and figure out what to do'? One source of questions such as these came up in response to a poster displayed at presented at the first "Scientific Applications with Google Earth Conference," October 22-23, 2008, at The University of Michigan, Ann Arbor (Figure 10). (Link to full-sized poster presented by the author; link to poster with embedded links.) It appeared that several scholars present at that conference also saw value in being able to use the globe without the continents!

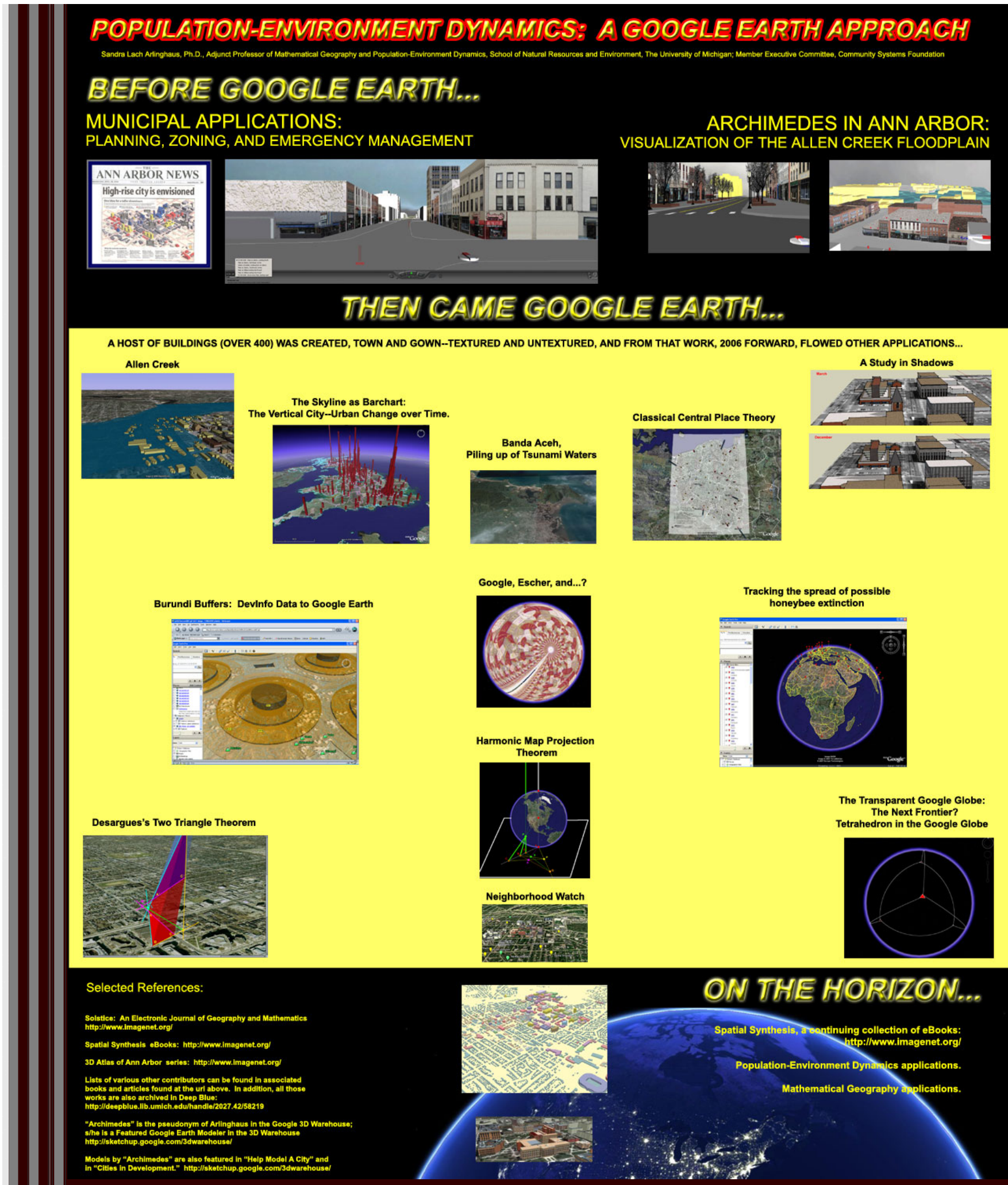

Figure 10. Poster display involving the transparent globe, 2008; link to full-sized clickable poster. Original source: Institute of Mathematical Geography.

That too is an interesting question and it is one that is rooted in mathematics underlying the transformation of the surface of the globe to plane. The surface of the sphere cannot be mapped, in a one-to-one and onto fashion to the plane. There must remain at least one point on the sphere that does not map to the plane. Stereographic projection illustrates this idea--all but the north pole is projected into the plane--the image of the north pole goes to infinity, as Figure 11 suggests.

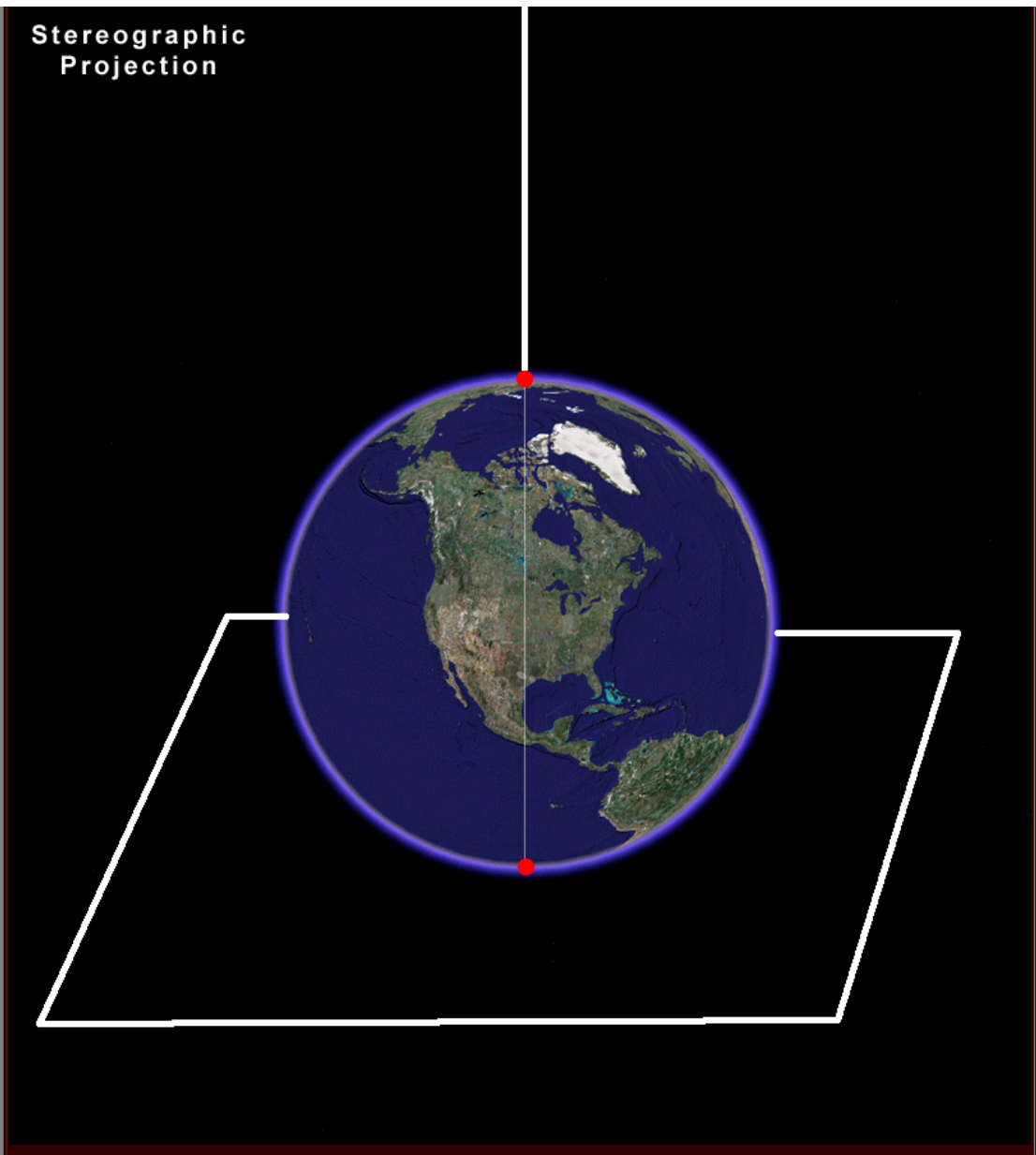

Figure 11. **Stereographic projection. All points on the surface of the sphere may be projected into the plane, except one at the north pole.** Original source: Institute of Mathematical Geography.

I knew from studying topology (Kelley, 1975), that the Alexandroff Extension theorem provided that inverse stereographic projection produced a one-point compactification of the plane to the sphere. The plane is not compact; the sphere is. Use inverse stereographic projection to suck the plane up to the sphere. All of the sphere except one point is covered; add the one point to make a compact surface. So, I looked to see where on the continental skin there might be a missing point and then sought to, so to speak, put my finger in it and stretch it out with transparency. The gap sought seemed to be at the south pole, and the way to stretch seemed to be to use the slider. It's odd, sometimes, how mathematical concepts can come into play in unexpected ways! In any event, it worked.

Does the procedure still work today? Sadly, it appears it does not; thus, .kml files linked to earlier materials do not work either. The animations made from those kml files do continue to work, of course. Perhaps the one point has been sealed up. Perhaps I do not know where to look. Current versions of Google Earth, however, do not seem to permit the removal of the continental skin to reveal a transparent globe. Other software, such as Google/Trimble SketchUp can be used to create a sphere (using the 'Follow Me' tool) and to create a tetrahedron (3DVinci.net)--but not directly in the globe (Figure 12).

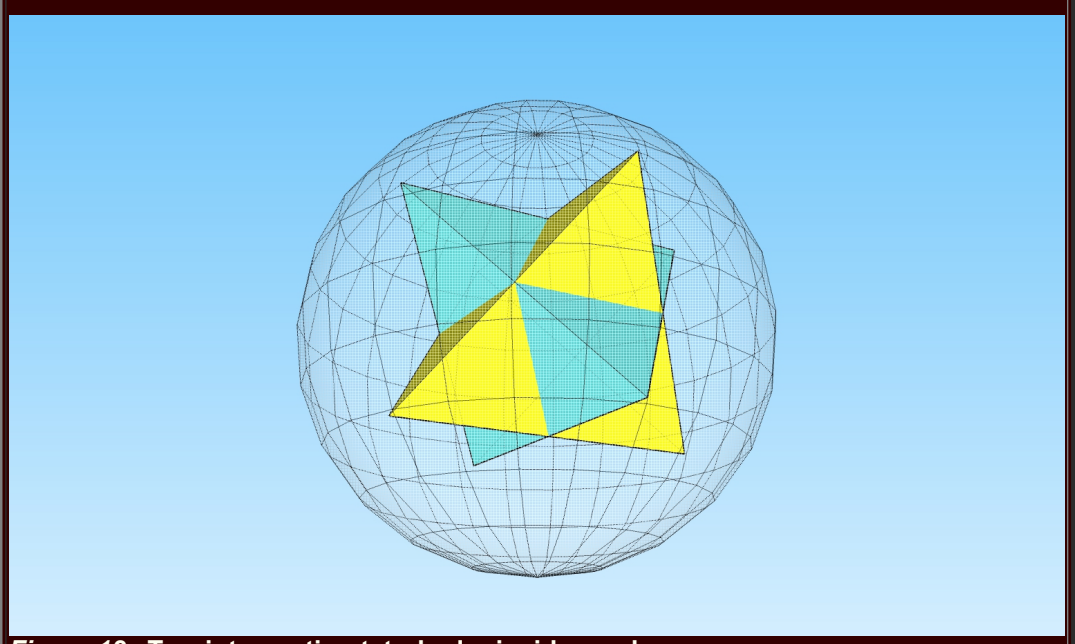

Figure 12. **Two intersecting tetrahedra inside a sphere.**

Figure 12 illustrates two intersecting tetrahedra (or a stellated octahedron) inside a sphere; SketchUp suggests interesting alternatives, although the stellated octahedron cannot be embedded inside the globe subject to the constraint that all vertices lie on landmasses (1986). However, the capability to use Google Earth directly, to create a tetrahedron embedded in the Earth-sphere, is perhaps a bit like Barr himself--an important memory from the past that can help to guide paths in the future!

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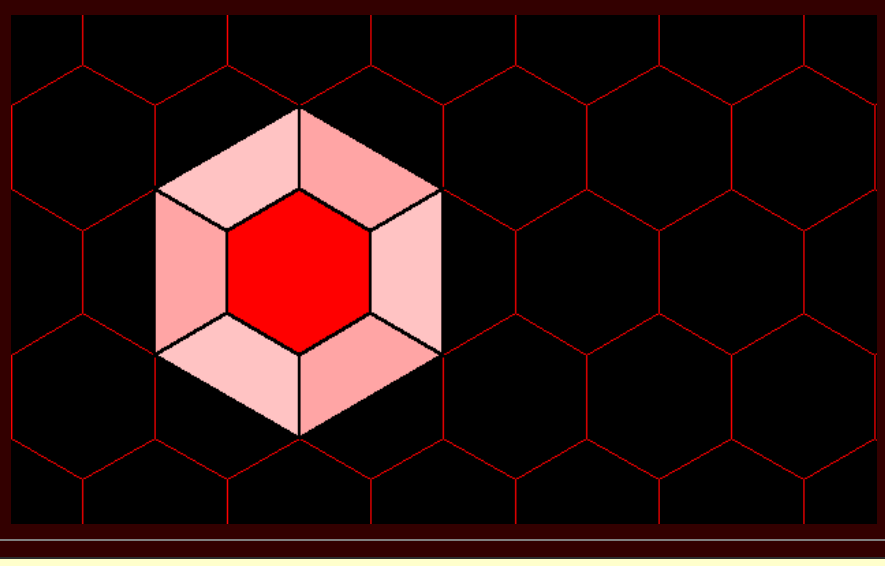
In the In



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RECENT NEWS...

1. *Quaestiones Geographicae*, Special Issue
2. Chene Street History Project.
3. ***Spatial Mathematics: Theory and Practice Through Mapping***. Sandra L. Arlinghaus and Joseph Kerski, (2013), CRC Press Linked video Published July 2013,
4. The work above is the first volume in a series of books to be published by CRC Press in its series "**Cartography, GIS, and Spatial Science: Theory and Practice**." If you have an idea for a book to include, or wish to participate in some other way, please contact the series Editor, Sandra L. Arlinghaus.
5. Virtual Cemetery with William E. Arlinghaus; an ongoing project that continues in development run in the virtual world in parallel with the trust-funded model of a real-world cemetery.

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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

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Congratulations to all *Solstice* contributors.

Remembering those who are gone now but who contributed in various ways to *Solstice* or to IMaGe projects, directly or indirectly, during the first 28 years of IMaGe:

Allen K. Philbrick | Alma S. Lach | Donald F. Lach | Frank Harary | William D. Drake | H. S. M. Coxeter | Saunders Mac Lane | Chauncy D. Harris | Norton S. Ginsburg | Sylvia L. Thrupp | Arthur L. Loeb | George Kish |

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