What Does Google Earth Mean for the Social Sciences?

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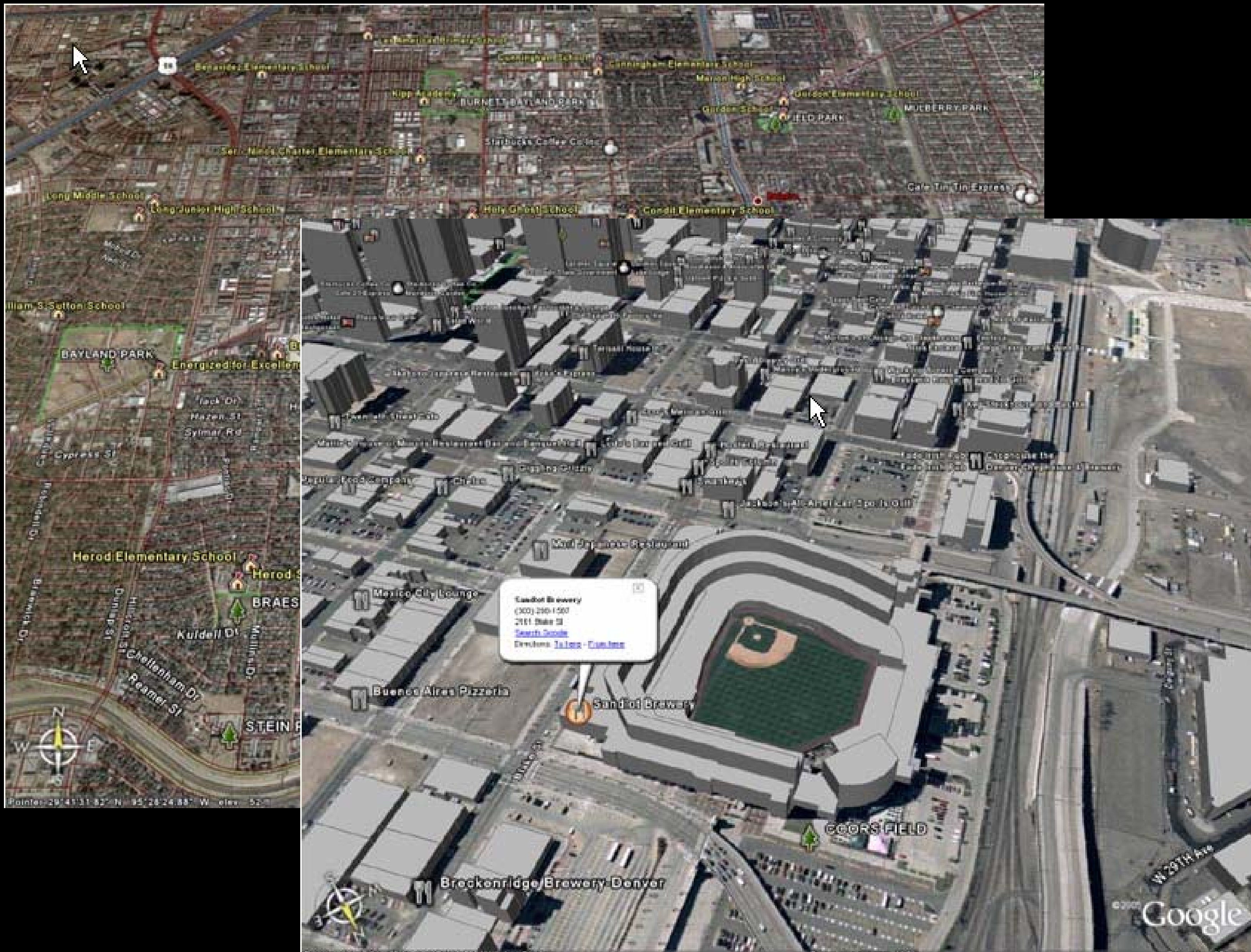
Milestones

- 1992 Gore vision of Digital Earth
- 1998 Gore Digital Earth speech
- 2001 Earthviewer
- 2003 ArcGlobe, NASA Worldwinds
- 2005 Google acquisition, rebranding, redesign of user interface, release of KML
- 2005 Microsoft Virtual Earth

“Imagine, for example, a young child going to a Digital Earth exhibit at a local museum. After donning a head-mounted display, she sees Earth as it appears from space. Using a data glove, she zooms in, using higher and higher levels of resolution, to see continents, then regions, countries, cities, and finally individual houses, trees, and other natural and man-made objects. Having found an area of the planet she is interested in exploring, she takes the equivalent of a ‘magic carpet ride’ through a 3-D visualization of the terrain.”


Benavidez Elementary School
Cunningham Elementary School
Marion High School
Gordon Elementary School
MULBERRY PARK
Kipp Academy
BURNETT BAYLAND PARK
Long Middle School
Long Junior High School
Holy Ghost School
Condit Elementary School
BAYLAND PARK
Herod Elementary School
Cypress St
Kuldell Dr
Chellenham Dr
Reamer St
Mexico City Lounge
Buenos Aires Pizzeria
Sandlot Brewery
Search Google
Directions: To here - From here
COORS FIELD
Breckenridge Brewery Denver
Google

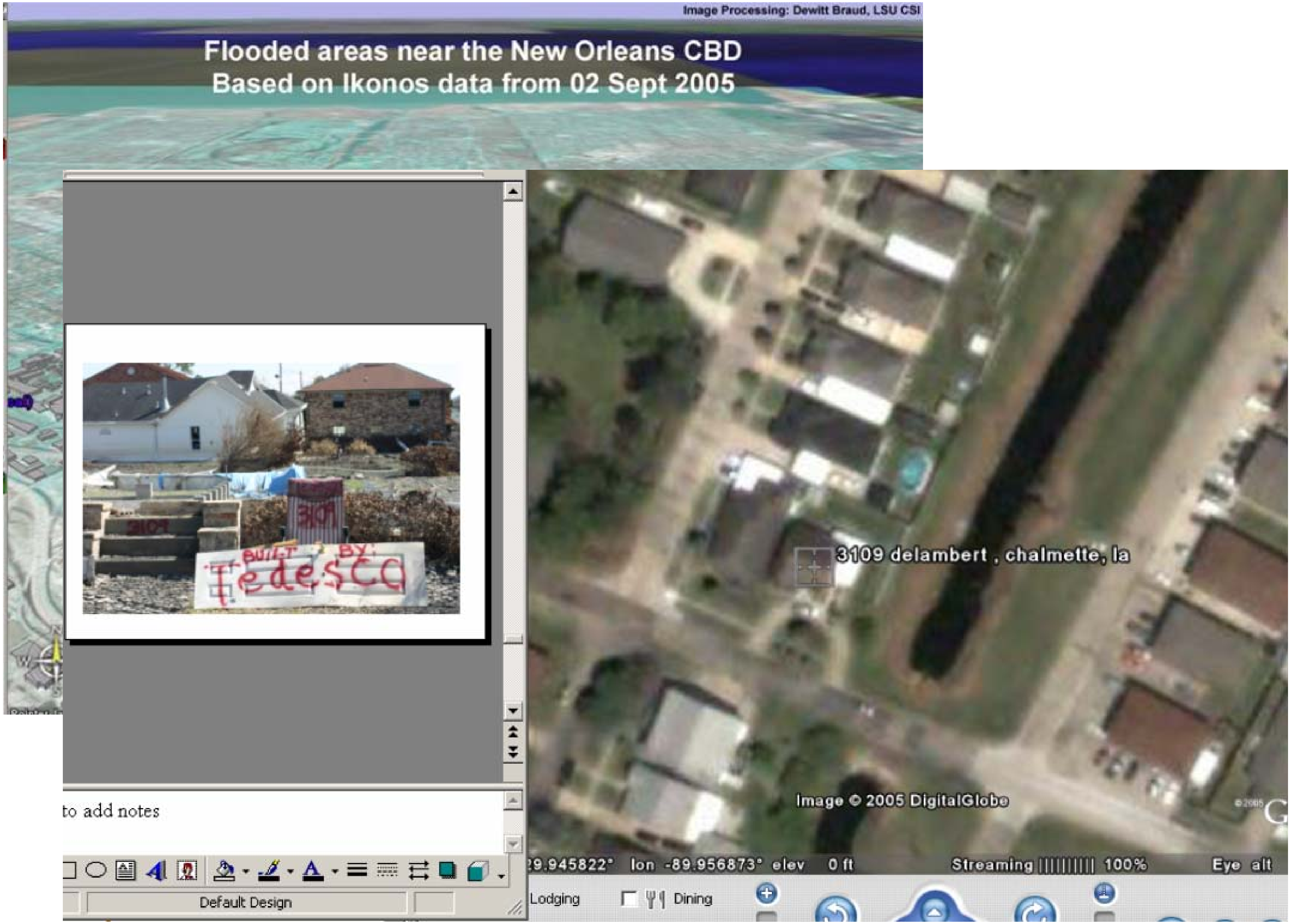


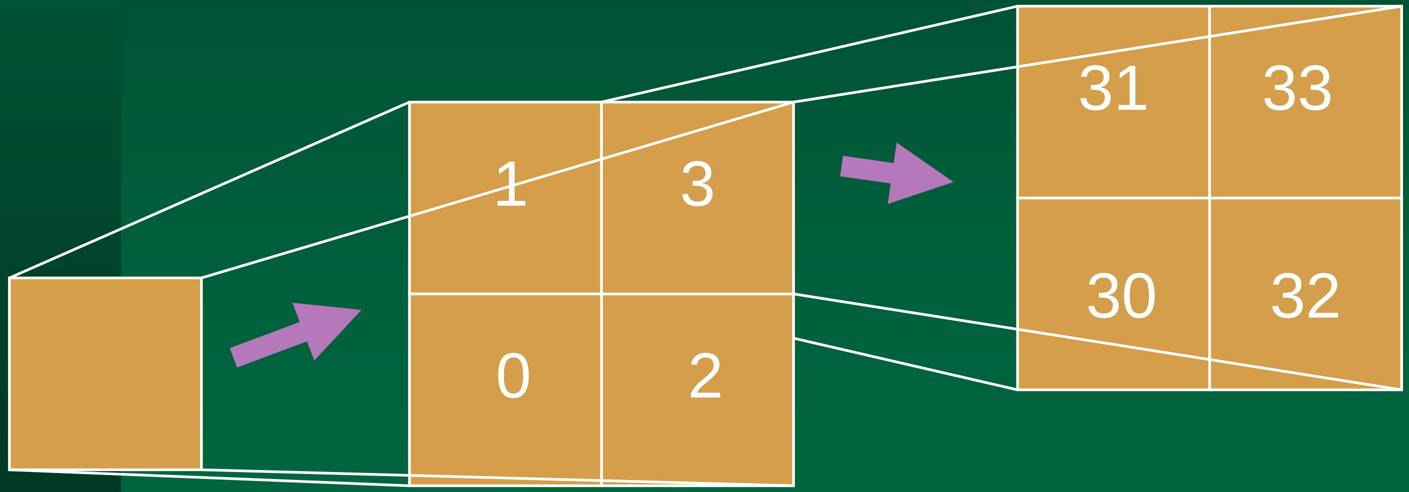
Image Processing: Dewitt Braud, LSU CSI
Flooded areas near the New Orleans CBD
Based on Ikonos data from 02 Sept 2005
BUILT BY:
Tedesco
3109
3109 delambert , chalmette, la
Image © 2005 DigitalGlobe
to add notes
Default Design
lon -89.956873° elev 0 ft
Streaming 100%
Eye alt
Lodging
Dining

Major features

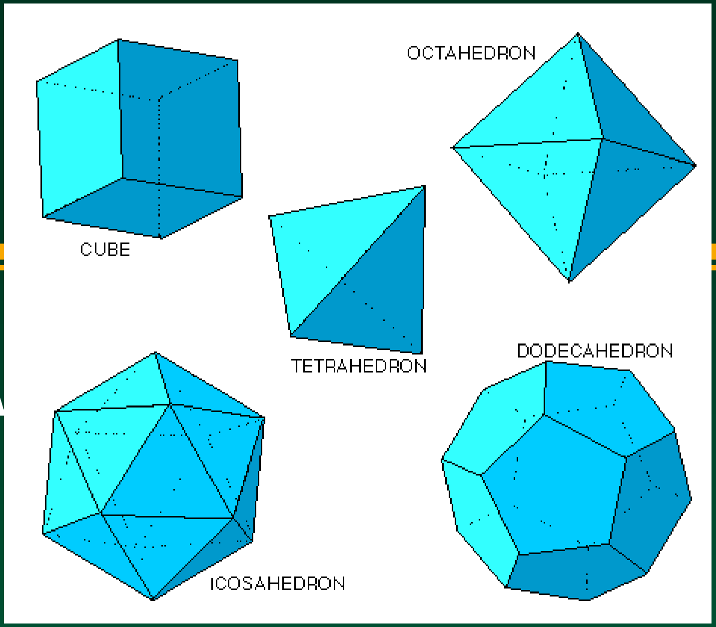
- Internal data structure
  - hierarchical tesselation
- Web transactions
  - the numbers
  - level-of-detail management
  - thick client
  - 32MB graphics card
- Layered
- Oblique perspective, flyby
- KML
  - programming interface

The quadtree

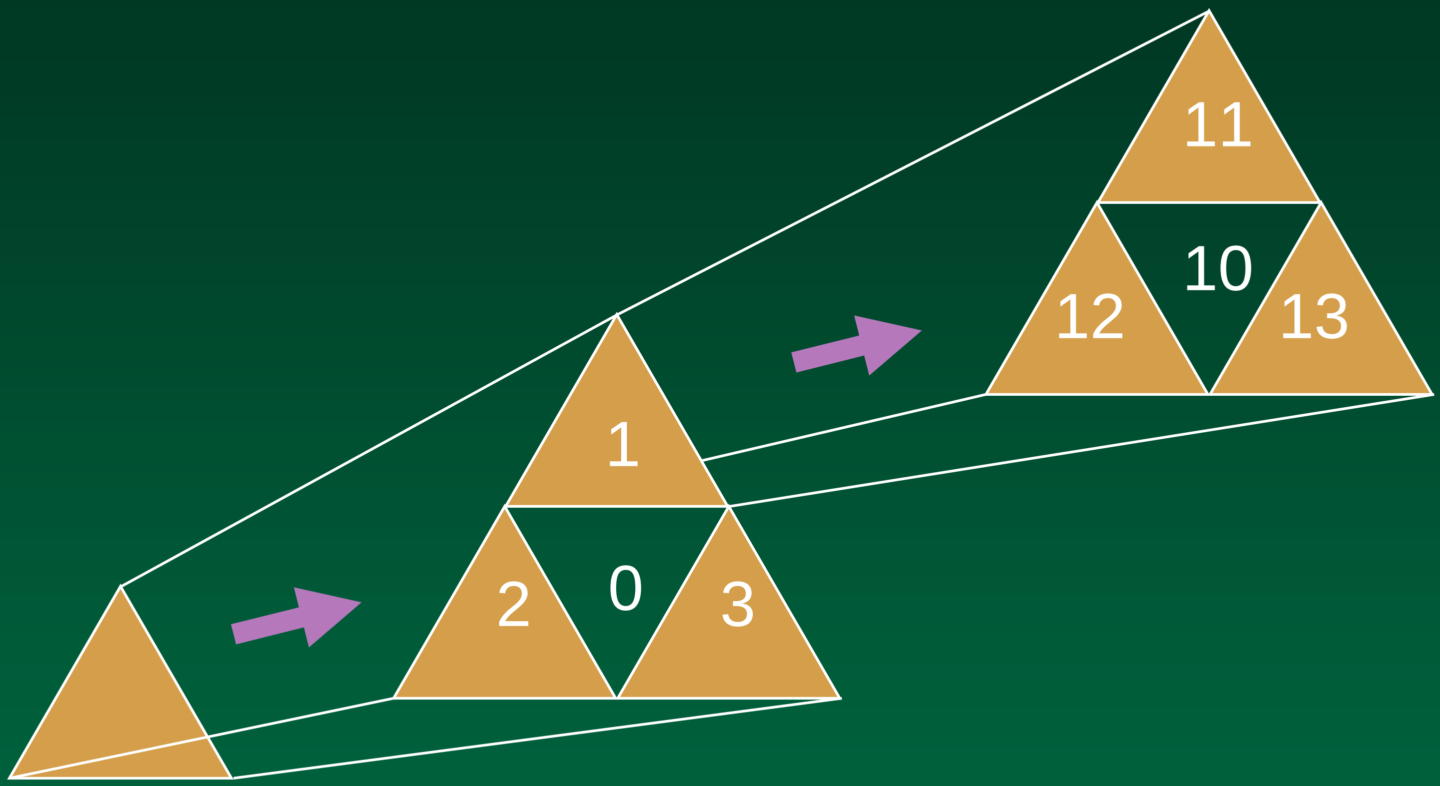
- Recursive subdivision
  - variable depth depending on local detail



Grids on the globe



- Impossible to tile a curv
  squares
- Five Platonic solids
  - tetrahedron: 4 triangles
  - cube: 6 squares
  - octahedron: 8 triangles
  - dodecahedron: 12 pentagons
  - icosahedron: 20 triangles



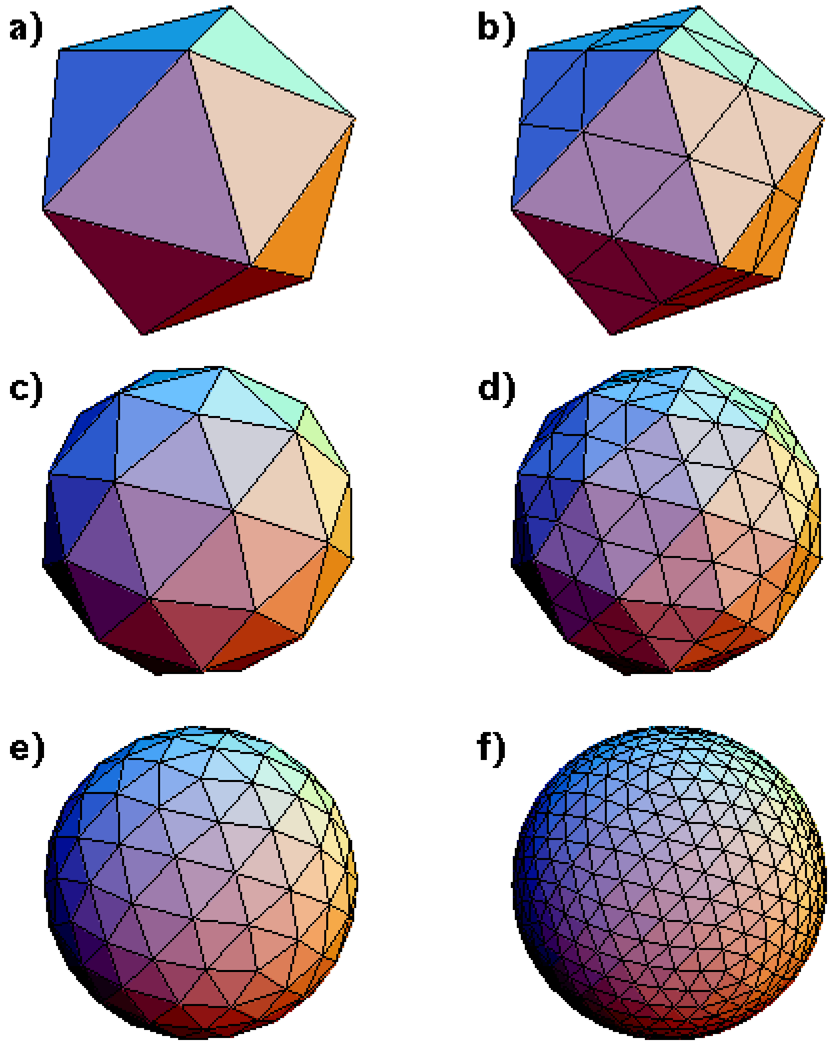
Octahedron: 1 base 8 digit plus unlimited base 4 digits

Discrete global grid based on the Icosahedron (20 triangles, 1:4 recursive subdivision)

Ross Heikes and David Randall, Colorado State University

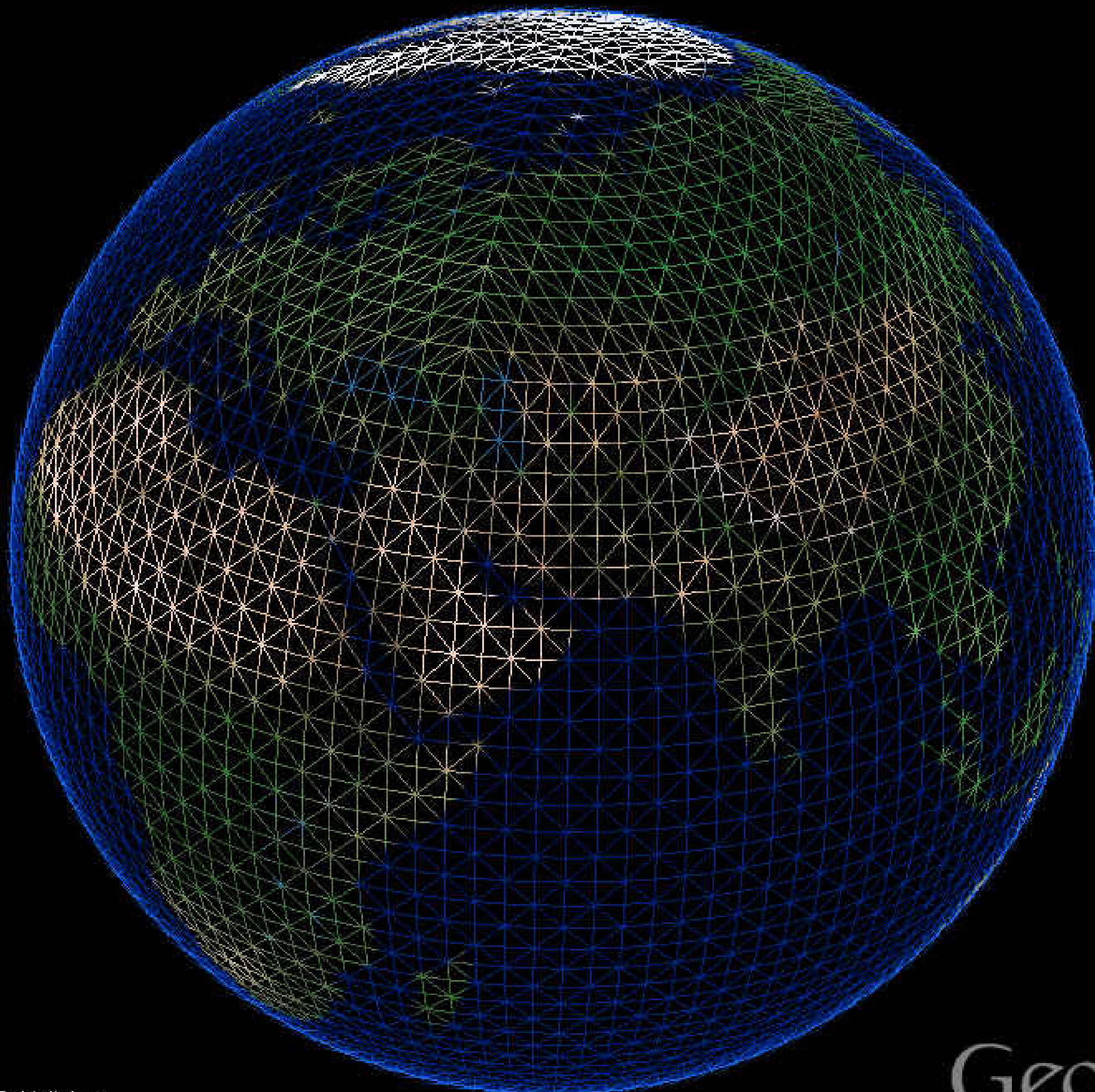
Construction of a simple Icosahedral grid

a) Suppose we have an icosahedron inscribed inside of a unit sphere.
b) Bisecting each edge forms 30 new vertices, and partitions each equilateral face into four pieces.
c) Project the new vertices onto the unit sphere.
d) Bisect and partition again.
e) Project again.
f) And so on.... The result is a sequence of polyhedrons that increasingly approximate the sphere.



Comparison of Criteria for the Assessment of Global Grids

Criteria in Goodchild (1994)	*Criteria in Kimerling et al. (1999) (Goodchild's Numbers given in parentheses)*
1. Each area contains one point	Areal cells constitute a complete tiling of the globe, exhaustively covering the globe without overlapping. (3,7)
2. Areas are equal in size	Areal cells have equal areas. This minimizes the confounding effects of area variation in analysis, and provides equal probabilities for sampling designs. (2)
3. Areas exhaustively cover the domain	Areal cells have the same topology (same number of edges and vertices). (9, 14)
4. Areas are equal in shape	Areal cells have the same shape. ideally a regular spherical polygon with edges that are great circles. (4)
5. Points form a hierarchy preserving some property for m < n points	Areal cells are compact. (10)
6. Areas form a hierarchy preserving some property for m < n areas	Edges of cells are straight in a projection. (8)
7. The domain is the globe (sphere, spheroid)	The midpoint of an arc connecting two adjacent cells coincides with the midpoint of the edge between the two cells.
8. Edges of areas are straight on some projection	The points and areal cells of the various resolution grids which constitute the grid system form a hierarchy which displays a high degree of regularity. (5,6)
9. Areas have the same number of edges	A single areal cell contains only one grid reference point.(1)
10. Areas are compact	Grid reference points are maximally central within areal cells. (11)
11. Points are maximally central within areas	Grid reference points are equidistant from their neighbors. (12)
12. Points are equidistant	Grid reference points and areal cells display regularities and other properties which allow them to be addressed in an efficient manner.
13. Edges are areas of equal length	The grid system has a simple relationship to latitude and longitude.
14. Addresses of points and areas are regular and reflect other properties	The grid system contains grids of any arbitrary defined spatial resolution. (5,6)



Imagery courtesy of WorldSat Intl. Inc.

GeoFusion

Imagery courtesy of WorldSat Intl. Inc.

GeoFusion

Is Digital Earth feasible?

- 500,000,000 sq km
  - 5 million at 10km resolution
  - 500,000,000,000,000 at 1m resolution

[illegible]

Transmitting Digital Earth

- 1m resolution at T1 (order 10 megabits/sec)
  - 69.4 working years
- 1m resolution at 56k
  - done in 12,400 years
- The Internet-killer

The LS ratio

- Computer screen - 1000
- Digital camera - 1500
- Remotely sensed scene - 3000
- Paper map - 5000
- Dimensionless
- $Log_{10}L/S$ in range 3-4
- Human eye - 10,000

What's possible at 500 kbps?

- 50 kbytes/sec
- 10,000 new triangles/sec
  - 1% of screen/sec at full resolution
- 25 refreshes/sec
  - 400 new triangles/refresh
- Sufficient if:
  - resolution degraded in periphery
  - resolution degraded during flyby

Broader implications

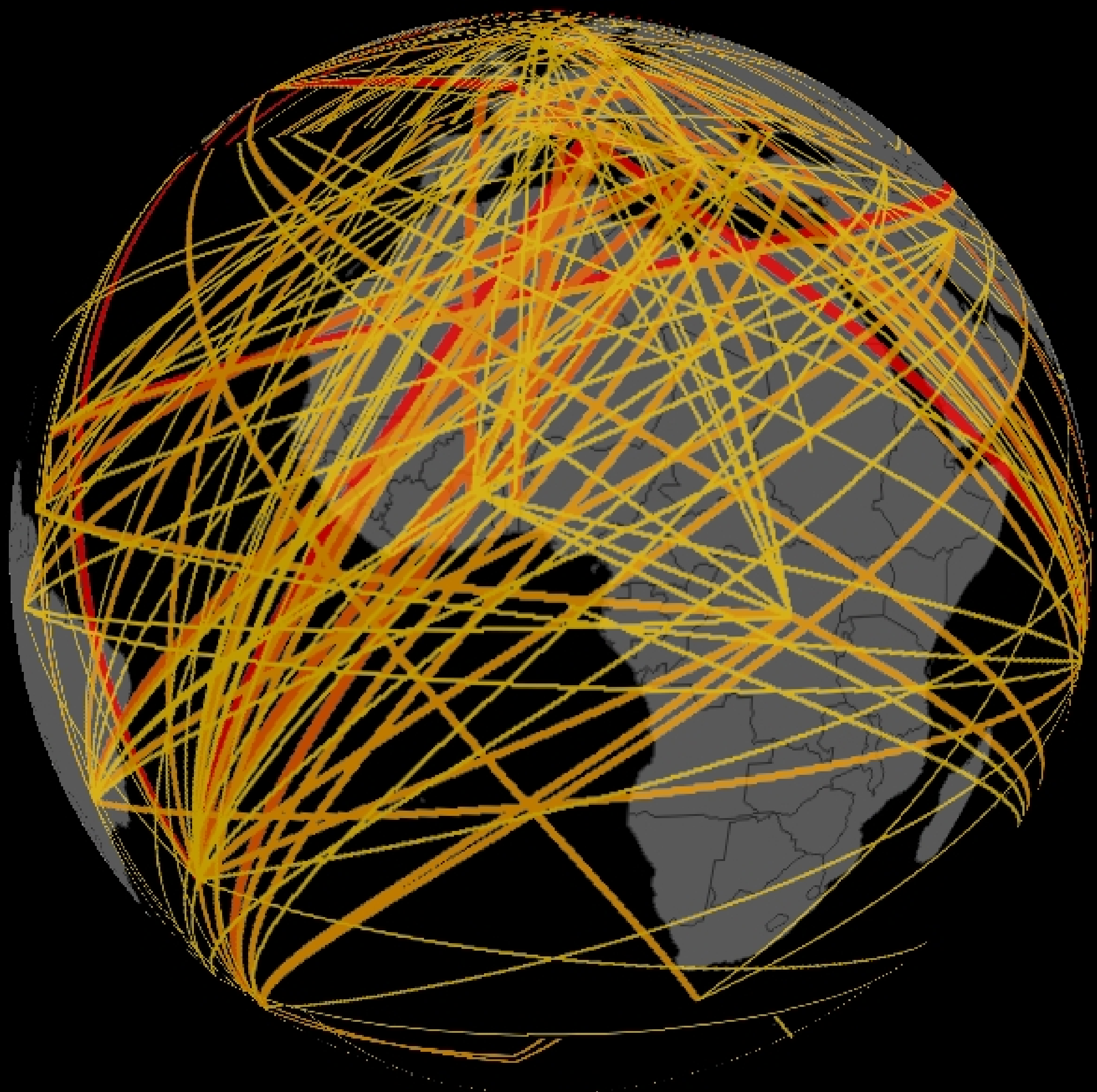
- GIS and the Flat Earth Society
- Enabling extensions through KML
- User interfaces and the Child of Ten
- A standard structure

North Korea's missile threat

Type	Maximum range	Payload	Status
Nodong	1,300 km (810 miles)	700 kg (1,550 pounds)	Currently deployed
Taepodong-1	Up to 10,000 km	Several hundred kg	Test failed 1998, not yet operational
Taepodong-2	10,000–15,000 km	Several hundred kg	Not yet tested

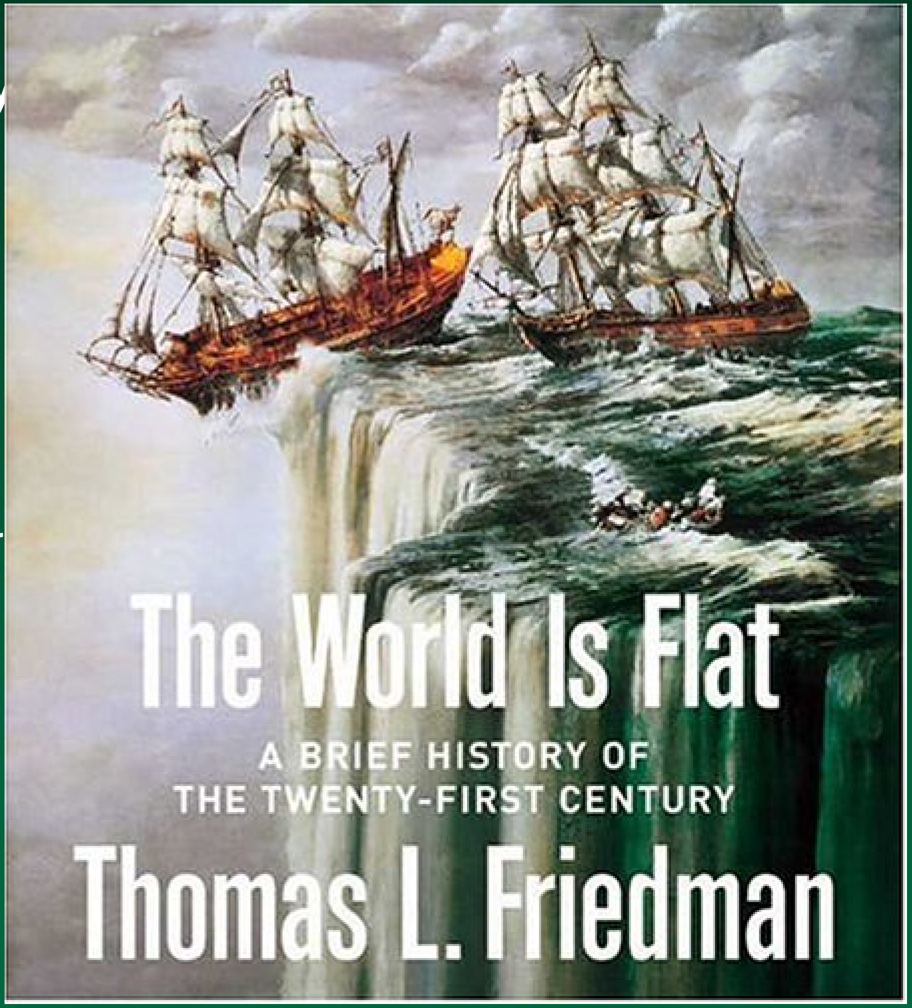
Source: Task Force for US Korea Policy, Centre for International Policy

The Economist, May 17, 2003



GIS and the Flat-Earth Society

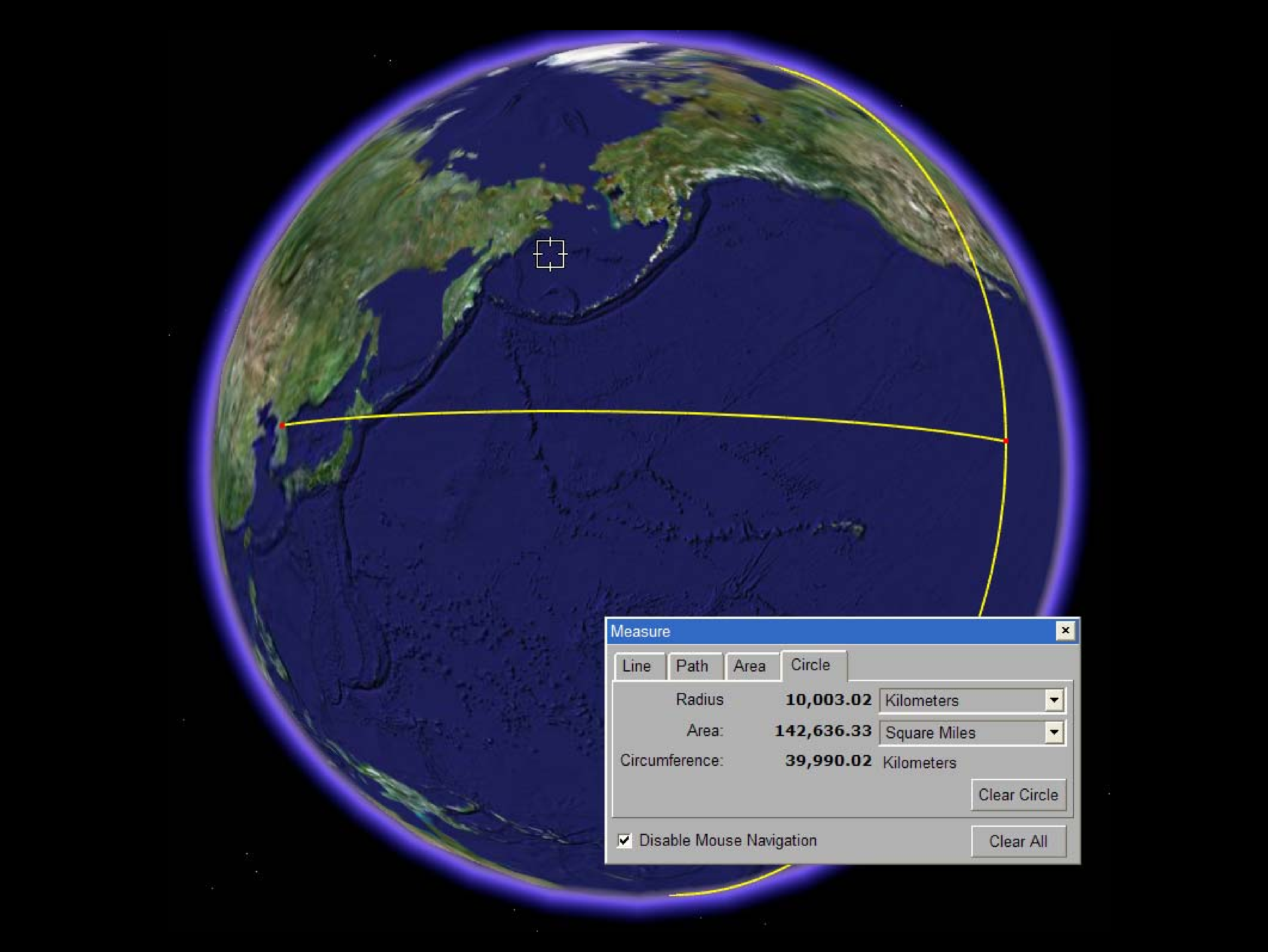
- The historic legacy
  - paper maps
  - rasters
  - local studies
  - algorithms use pla



Two approaches to global GIS

1. Projected GIS back-projected to the sphere
   - inverting the projection equations
   - the Perspective Orthographic Projection
2. Doing the spherical (or ellipsoidal) geometry
   - no straight lines (only arcs of ellipses)
   - no lengths (only subtended arcs)
   - a new kind of computational geometry


Measure
Line
Path
Area
Circle
Length:
5,403.03
Miles
Clear Line
Disable Mouse Navigation
Clear All


Measure
Line
Path
Area
Circle
Radius
10,003.02
Kilometers
Area:
142,636.33
Square Miles
Circumference:
39,990.02
Kilometers
Clear Circle
Disable Mouse Navigation
Clear All

http://www.thesalmons.org/lynn/wh-greenwich.html

KML

- Enables users to add value to Google Earth
  - objects to display based on lat/long
  - internal conversion to hierarchical structure
  - tapping the creative energy of humanity
- A large community adding value
  - compare to the development staff of your favorite GIS
- KML comparable to other open standards
  - underlying constant hierarchical structure
  - compare the Meridian Convention

The Child of Ten standard

- Can a child do something useful with this in ten minutes?
  - compare video games
  - compare GIS
- The Concert Pianist standard
  - confines tool to the expert
- Google Earth is already known to more people than GIS

Challenges to the research community

- Horizontal edgematching
  - the partial update problem
- Vertical edgematching
  - on-the-fly rubber sheeting
- User interface design
  - the video-game standard
- Rendering the non-visual
  - beyond the camera metaphor

Challenges (2)

- Interfacing global and local standards
  - the Second Law of Geography
  - geographic heterogeneity
- Global data collection
  - the International Map of the World
  - remote sensing
  - a global spatial data infrastructure
  - ground-based sensor networks
- Analysis and modeling
  - an ideal geo-visualization tool

Challenges (3)

- A one-stop shop for the planet
  - thematic priorities
  - harvesting methods
  - ontological issues
  - alphabets, diacriticals
- A global gazetteer
  - vernacular entries
  - from 10^7 to 10^8 to 10^9
- Geobrowsers
  - organizing Web searches geographically

Conclusions

- Close to Gore’s vision
- Better at spherical functions than GIS
- Potential to extend spatial science to a much larger community
  - of social scientists
  - of developers and adders of value
  - of users
  - of students
- Extensive challenges for the spatial sciences