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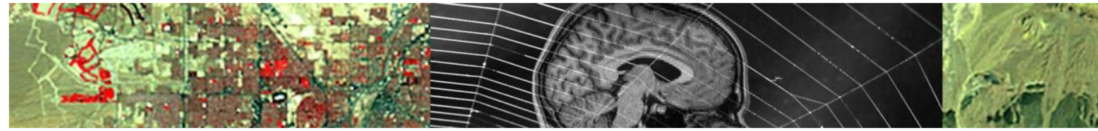
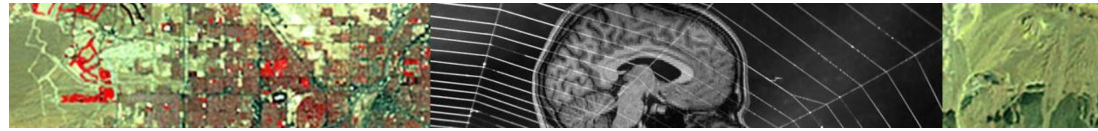
perspectives for teaching and research



Building Geospatial Infrastructure

Jack Dangermond, Esri

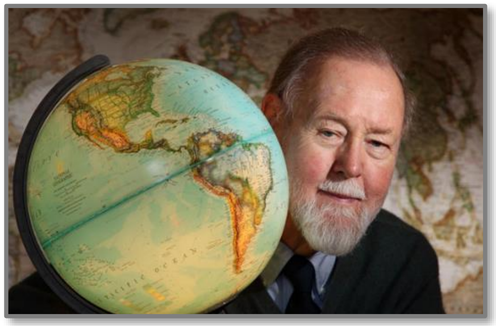
Michael F. Goodchild, UC Santa Barbara

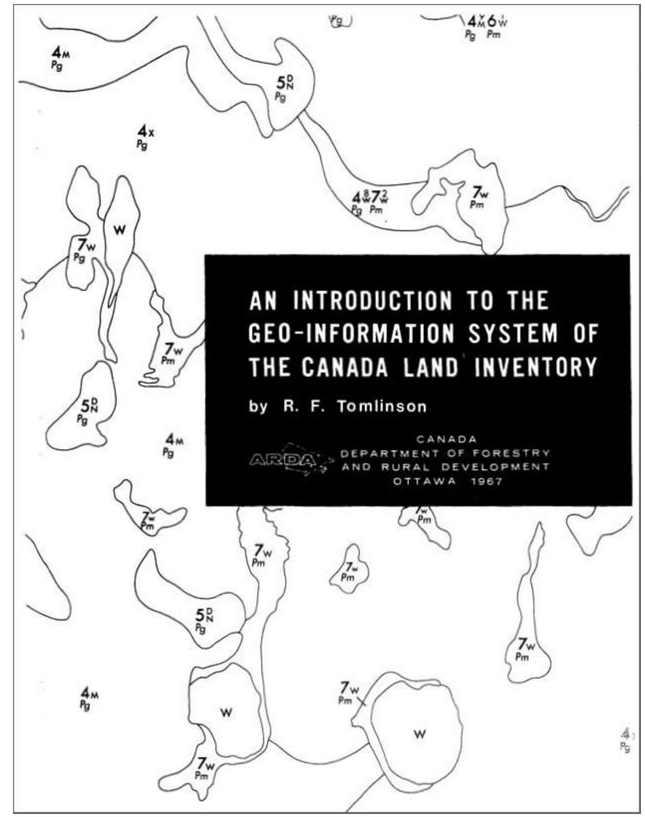


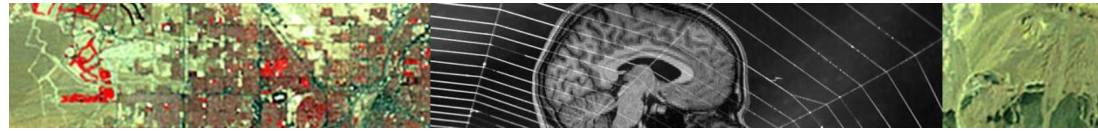
A vision for 2019

- Where is geospatial technology headed?
  - what should our vision be?
- A legacy of past visions
- Integration or fragmentation?

Dr Roger Tomlinson, 1933-2014







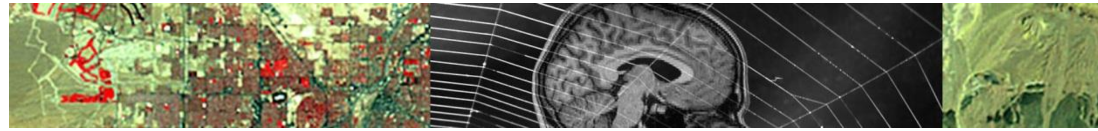
The Canada Land Inventory

- Land in 1955 was underutilized
  - how much land is being used for *x* and might be used for *y*?
- 7 map layers
  - current land use
  - land capability for agriculture, forestry, recreation,…
- 50,000 map sheets
- How to measure area
  - on combinations of map sheets?

Soil Capability for Forestry - 021I

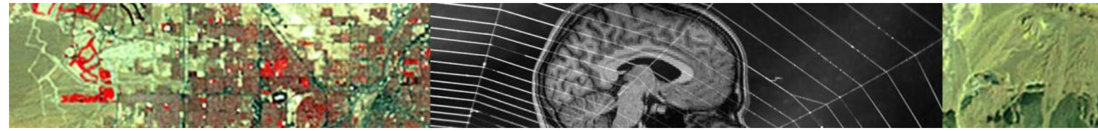
Put the maps in a computer

- Where simple algorithms can overlay layers and measure areas precisely
  - and output the required statistics
- In 1965?
  - with computers that have less power than your smart phone
  - where all data must be stored on magnetic tape
  - when scanners to input map sheets did not exist
  - where algorithms had to be invented from scratch



The CGIS vision

- Multiple flat layers of data
  - represented as boundary networks forming non-overlapping polygons
  - no allowances for uncertainty
  - the map is the truth
- Overlay to combine layers
- All output statistical
- Vision I: “Spatial data handling” (1970)

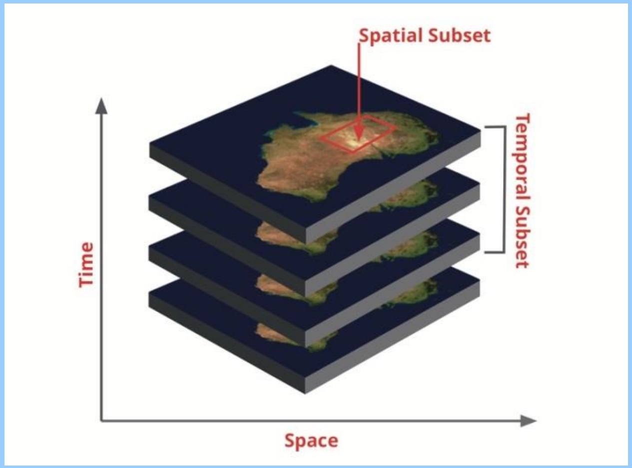


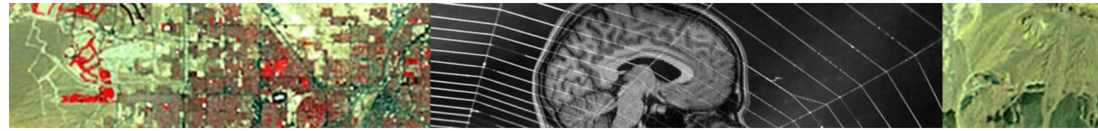
Enlarging the vision

- Meetings of the IGU Commission on Data Sensing and Processing
  - 1970, 1972
- A system capable of capturing, storing, analyzing, visualizing, archiving, sharing
  - any kind of geographic information
  - any information about what is where
  - Vision II: “A geographic information system” (1974)
- By 1980 many commercial companies producing and selling GIS software

The layer

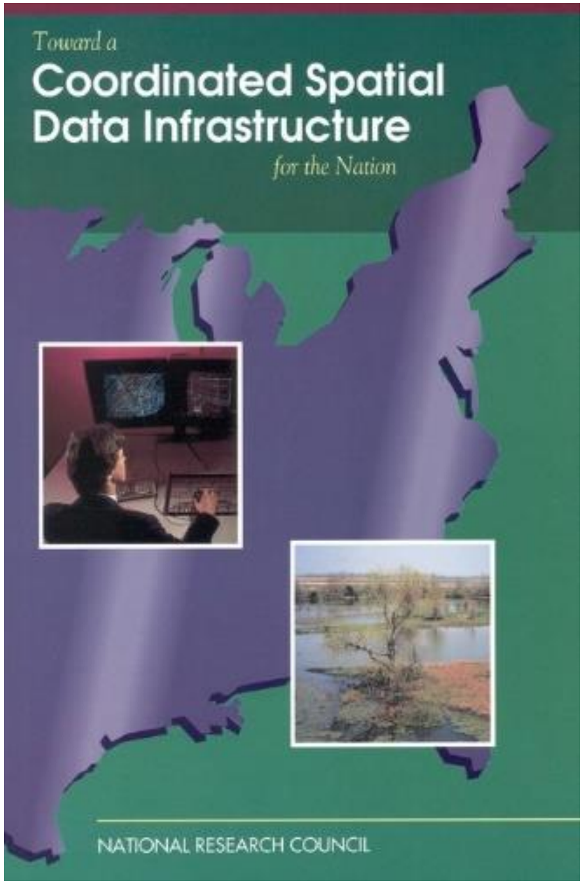
- Data integrated into horizontal layers
  - maintaining the conceptual link to maps
  - we could slice the 3D cube (or 4D hypercube) in many other ways





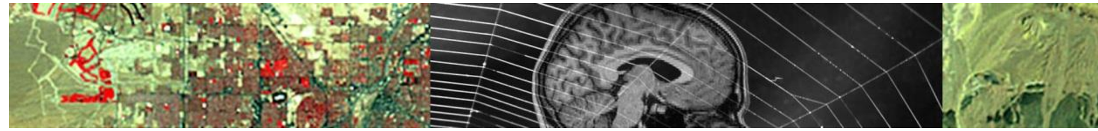
Maps or globes?

- Maps: easy to print, store, ship, any scale
- Globes: fixed scale, hard to print, store, ship
  - but digital globes are easy to store and ship, and readily zoomed
  - and digital globes such as Google Earth were not even imagined in 1965
  - Tomlinson’s choice was the right one at the time
    - but is it still the right one?



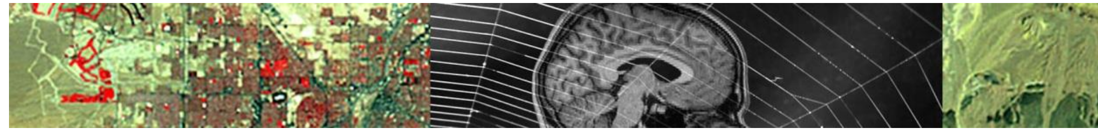
- Fast forward to 1992
- The costs of spatial data production were declining rapidly
- The federal government no longer had a monopoly on spatial data production
- Its future role would be more as a coordinator, developer of standards

http://www.nap.edu/catalog.php?record_id=2105



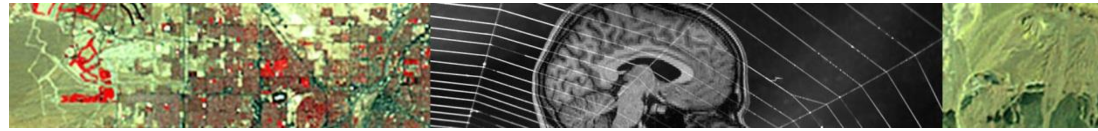
1994 authorization

- April 11, Executive Order 12906
  - “The National Performance Review has recommended that the executive branch develop, in cooperation with State, local, and tribal governments, and the private sector, a coordinated National Spatial Data Infrastructure to support public and private sector applications of geospatial data in such areas as transportation, community development, agriculture, emergency response, environmental management, and information technology.”
  - “Now, Therefore, by the authority vested in me as President…” (Bill Clinton)
- Vision III: “Spatial data infrastructure”



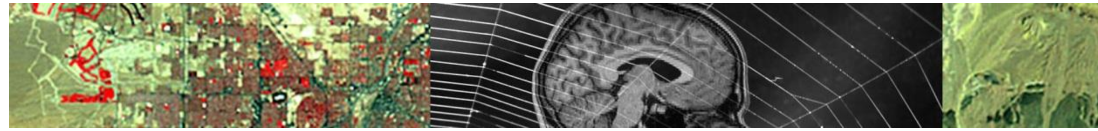
Framework data sets

- Data sets to which other information could be attached
  - geodetic control
  - hydrography
  - administrative boundaries
  - transportation
  - topography
  - the cadaster
  - orthoimagery
- “Data you can trust”



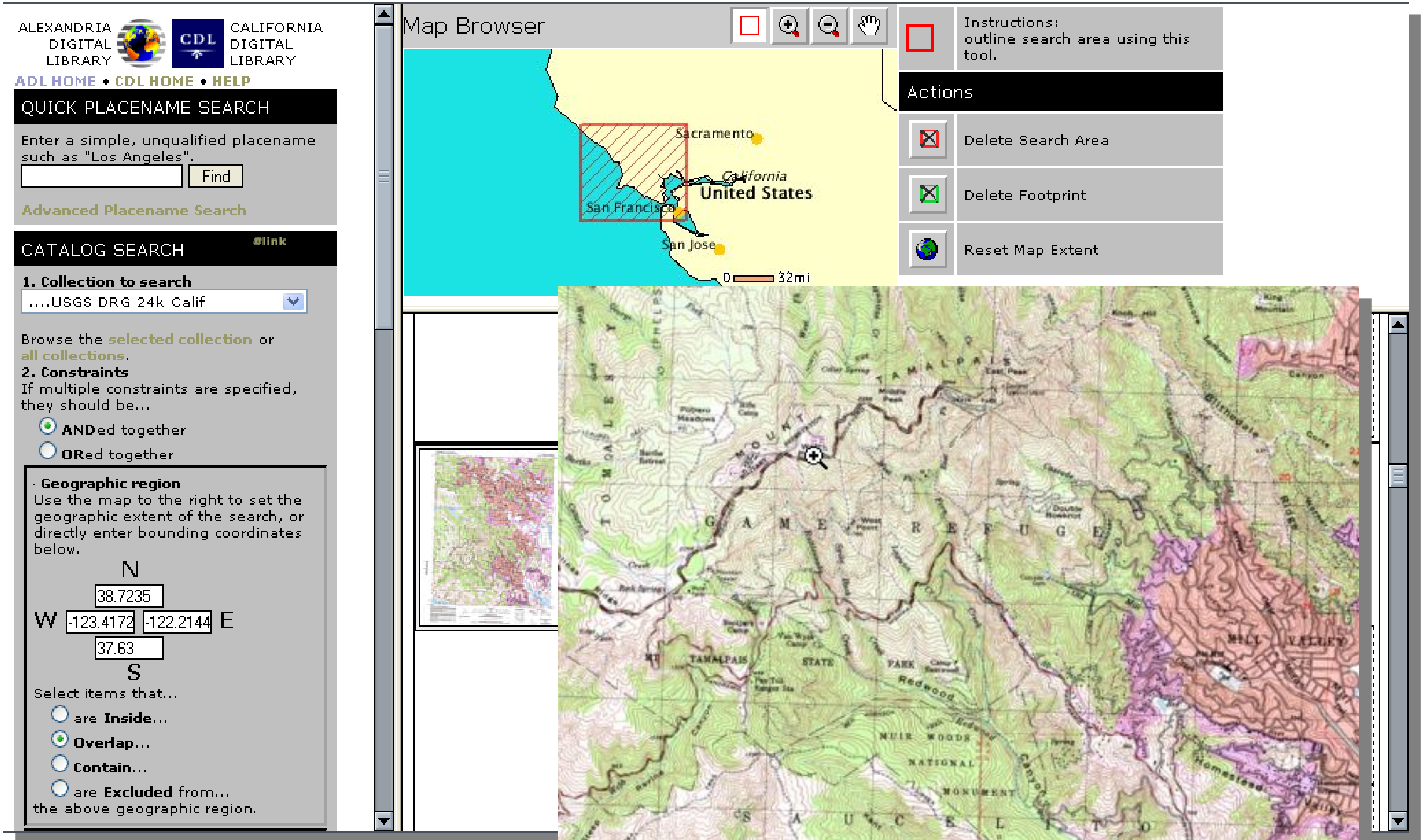
Early activities

- Metadata
  - descriptions of data sets
  - useful for spatial search, deciding fitness for use
- “What’s in it for me?”
  - grants to provide metadata
    - “Don’t duck metadata” campaign
- Metadata standards
  - Content Standard for Digital Geospatial Metadata
  - ISO 19115 etc.



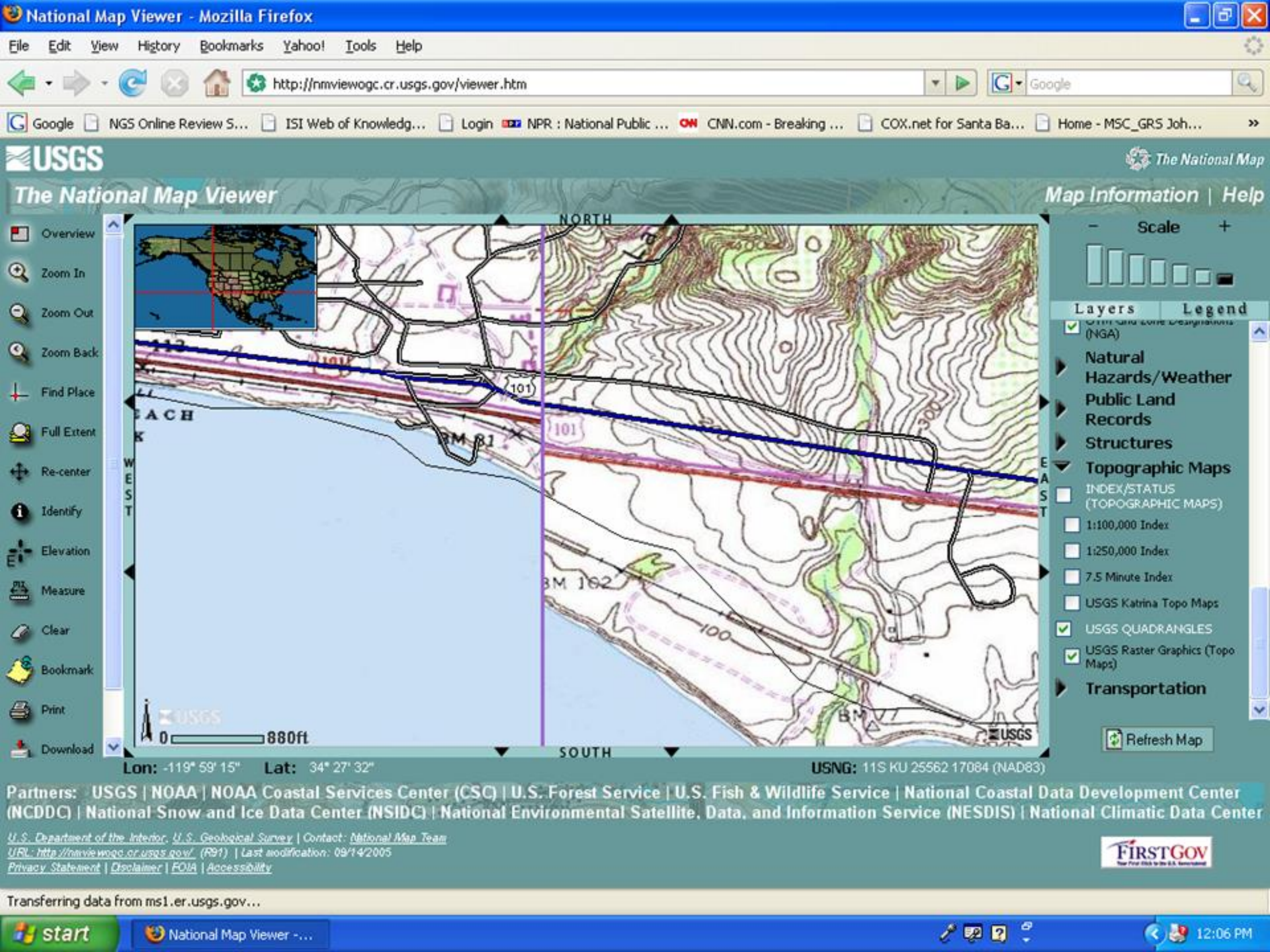
Early activities

- Data sharing
- The data warehouse
  - the “One-Stop Shop” for geospatial data
  - how to choose between warehouses?
    - collection-level metadata
- The geoportal
  - harvesting metadata records from many warehouses
  - allowing users to search through a single library and gain remote access to a source



- The geolibrary: a library searchable by location
    - not just author, title, subject

https://nationalmap.gov/


National Map Viewer - Mozilla Firefox
File Edit View History Bookmarks Yahoo! Tools Help
http://nmviewogc.cr.usgs.gov/viewer.htm
Google NGS Online Review S... ISI Web of Knowledg... Login NPR : National Public ... CNN.com - Breaking ... COX.net for Santa Ba... Home - MSC_GRS Joh...
USGS
The National Map
The National Map Viewer
Map Information | Help
Overview
Zoom In
Zoom Out
Zoom Back
Find Place
Full Extent
Re-center
Identify
Elevation
Measure
Clear
Bookmark
Print
Download
NORTH
SOUTH
WEST
EAST
101
BM 81
BM 102
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300
0 880ft
USGS
Scale
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Legend
(NGA)
Natural Hazards/Weather
Public Land Records
Structures
Topographic Maps
INDEX/STATUS (TOPOGRAPHIC MAPS)
1:100,000 Index
1:250,000 Index
7.5 Minute Index
USGS Katrina Topo Maps
USGS QUADRANGLES
USGS Raster Graphics (Topo Maps)
Transportation
Refresh Map
Lon: -119° 59' 15" Lat: 34° 27' 32"
USNG: 11S KU 25562 17084 (NAD83)
Partners: USGS | NOAA | NOAA Coastal Services Center (CSC) | U.S. Forest Service | U.S. Fish & Wildlife Service | National Coastal Data Development Center (NCDDC) | National Snow and Ice Data Center (NSIDC) | National Environmental Satellite, Data, and Information Service (NESDIS) | National Climatic Data Center
U.S. Department of the Interior, U.S. Geological Survey | Contact: National Map Team
URL: http://nmviewogc.cr.usgs.gov/ (R91) | Last modification: 09/14/2005
Privacy Statement | Disclaimer | FOIA | Accessibility
FIRSTGOV
Transferring data from ms1.er.usgs.gov...
start
National Map Viewer -...
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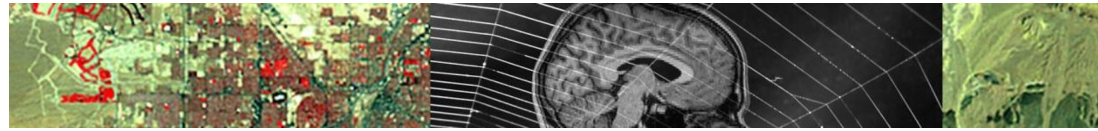
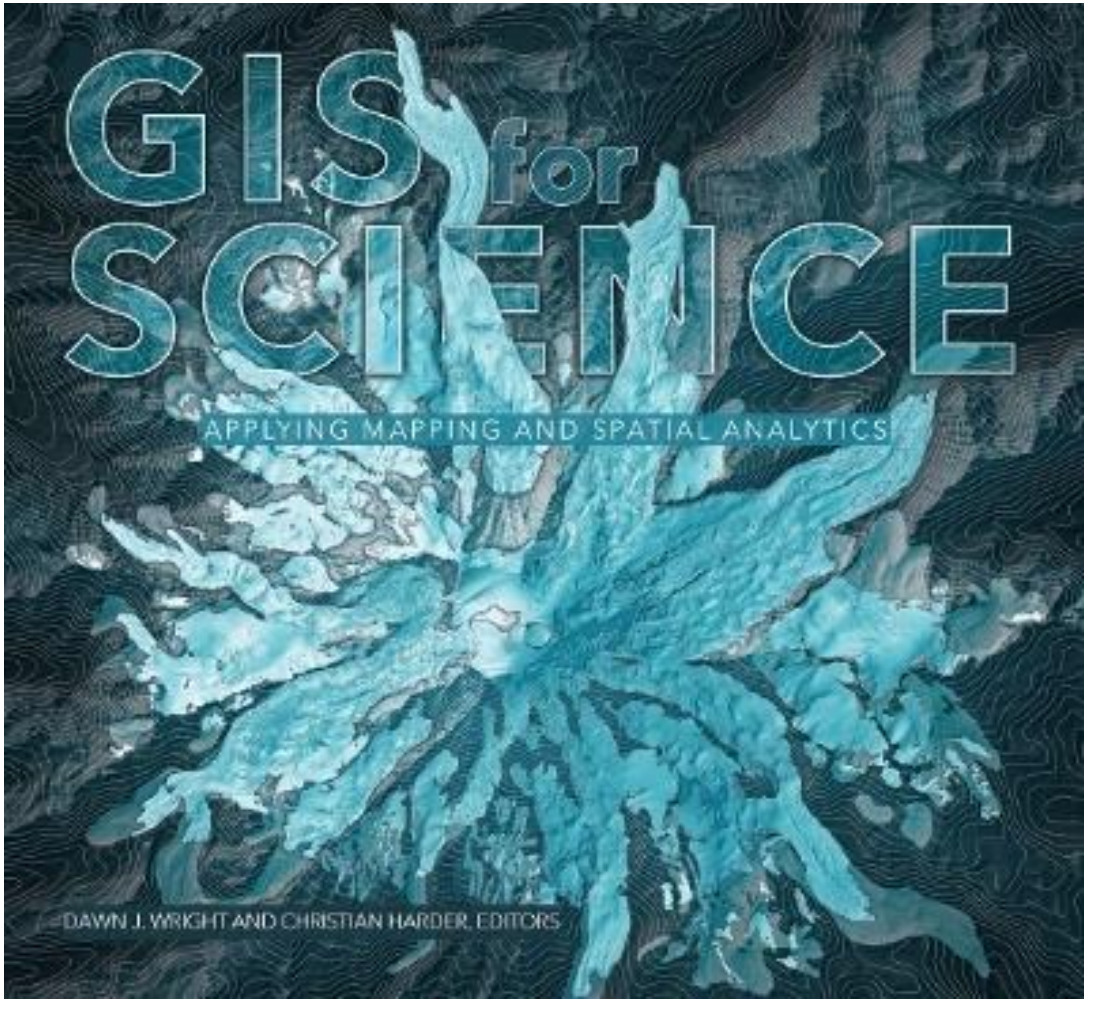


Vision IV: The science of where

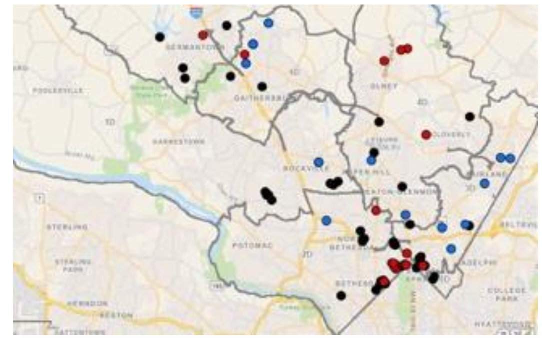
- Geographic information science
  - a set of principles based in theory and empirical observation
  - implemented in GIS
  - what the experienced user of GIS thinks about
    - it's more than a tool
- Geospatial technology and the scientific method
  - replicable and reproducible
  - standard terms
  - concern for accuracy



GIS for Science: Applying Mapping and Spatial Analytics
Dawn Wright and Christian Harder, Esri Press

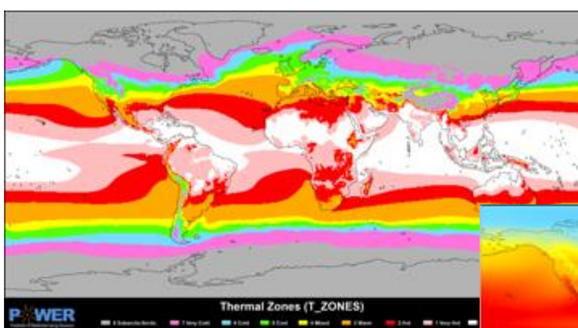
Analyzing automobile crashes

Crime analysis

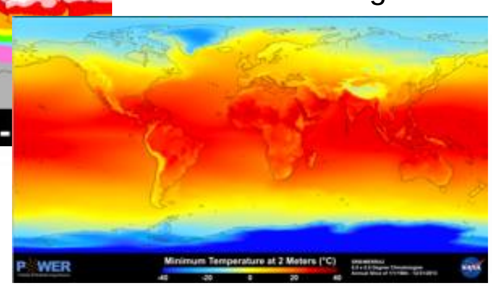


Montgomery County
Police Dept
Maryland

Thermal Zones



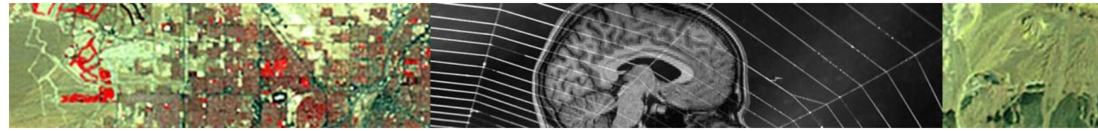
Climate Modeling



NASA
Global

Fire Risk

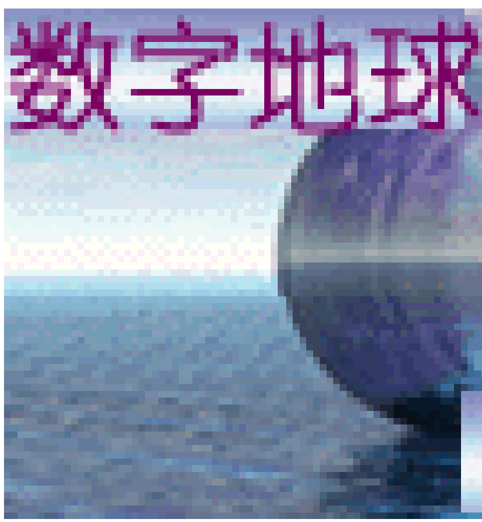
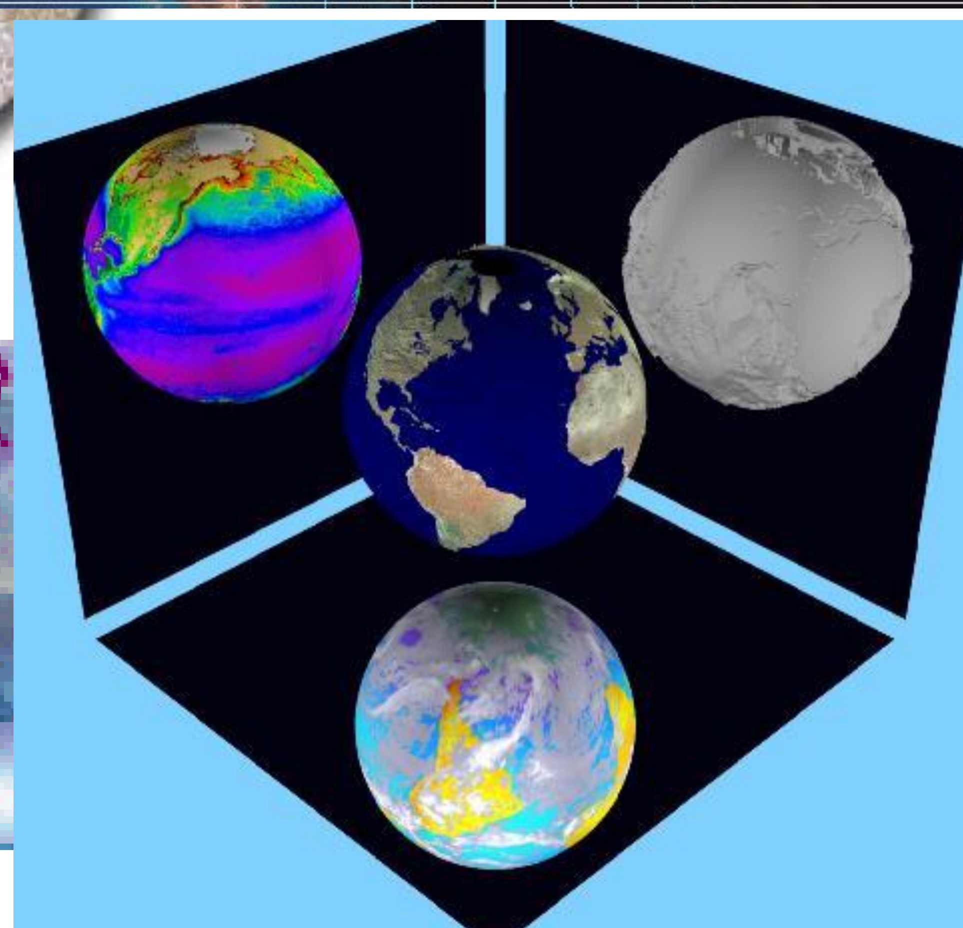
FlameMapper
California



Vision V: “Digital Earth”

- Back to the globe (at last)
  - a digital twin for the planet
  - resolutions from 10km to 1cm
  - integrating all geospatial data in a single structure
- The Gore speech of 1998
  - ISDE in Beijing 1999
  - 20-year anniversary Manual of Digital Earth
- Early prototypes
  - Keyhole Earthviewer becomes Google Earth


BUILDING THE DIGITAL EAR

Digital
Earth
SRI International

数字地球


Perspectives on Digital Earth

- 1. An immersive environment
  - “I believe we need a 'Digital Earth'. A multi-resolution, three-dimensional representation of the planet, into which we can embed vast quantities of geo-referenced data.” U.S. Vice President Gore, 1/98
- Spin, zoom, pan
  - "fly-by" technology

Digital Earth

A very visual Earth explorer that lets Scientists – both young and old – examine information about the Earth to learn how the forces of biology and geology interact to shape our home planet.

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.

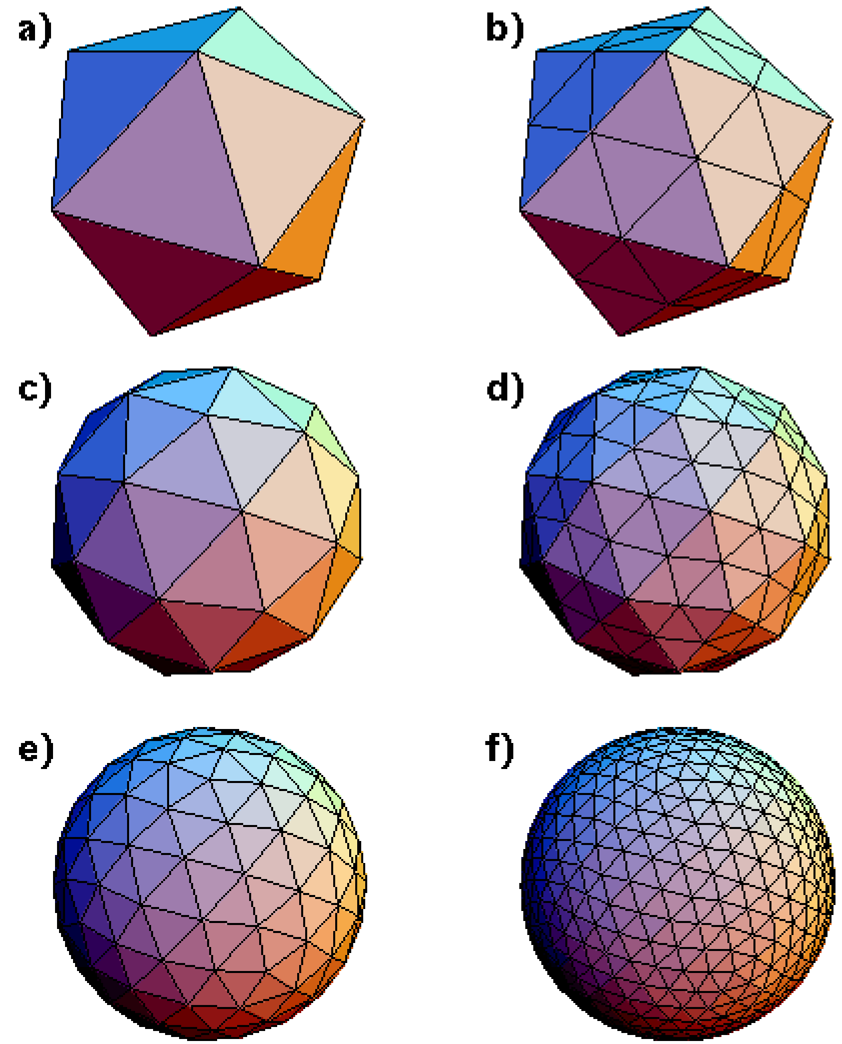
b) Bisecting each edge forms 30 new vertices, and partitions each equilateral face into four pieces.

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.



Summary: four perspectives

- An immersive environment
- A metaphor for information organization
- A distributed database transparent to the user
- A representation of the planet's dynamics

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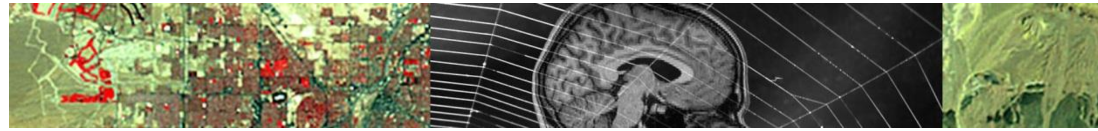
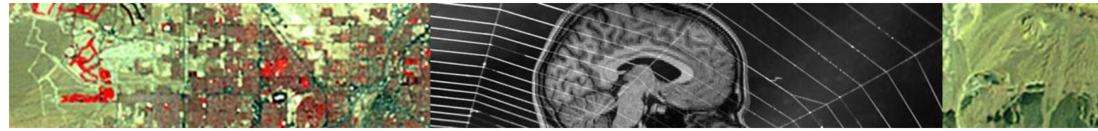


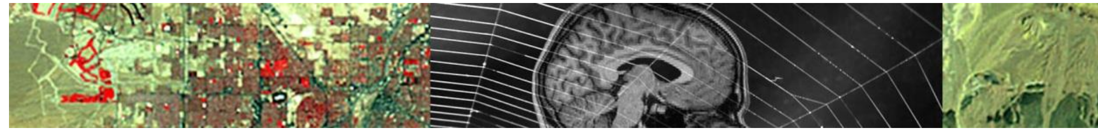
Vision VI: "A nervous system for the planet"

- New data sources
  - crowdsourcing and volunteered geographic information
  - the Internet of things
  - remote sensing
- New communication and processing power
- Global change as motivation
  - near-real-time monitoring



What next?

- Artificial intelligence, data science
- Big data
- Platforms
- Neogeography
  - citizens as engaged consumers and producers
- Sharing
  - of data, software, expertise

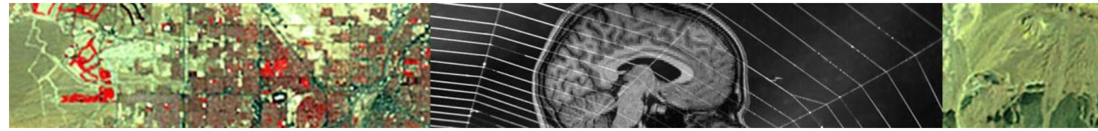


Vision VII: “Geospatial infrastructure”

- Fully 4-dimensional data model
- Interfaces for different user groups
  - from Story Maps and ArcGIS Online to ArcGIS Pro
- Interfaces that respond to questions
  - rather than functions
  - organized around application domains
- Handling of uncertainty
  - in inputs, transformations, and outputs
- Emphasis on sharing and communication

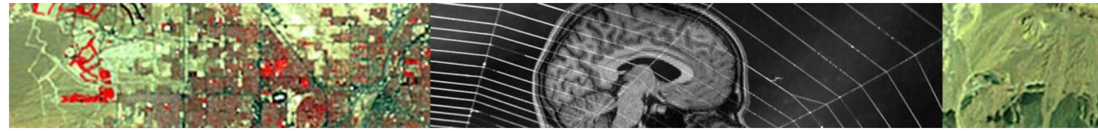
AI and machine learning

- How to handle uncertainty?
- How to incorporate geospatial principles?
  - spatial dependence, Tobler’s First Law
  - spatial heterogeneity



Monolithic GIS

- A vision from the 1970s
  - a single, integrated software package
- Is it still viable?
  - if the user interface is organized by question
  - domain-specific GIS on a common platform
  - the old economies of scale are no longer important
- Local versus global
  - two distinct technologies
  - flatten the Earth only at display time



Concluding points

- Geospatial infrastructure provides a new vision for geospatial technology
- Past visions are still with us as legacies
  - it is time to move beyond them
- Technology has advanced to the point where a new vision is both feasible and desirable