Geovisualization

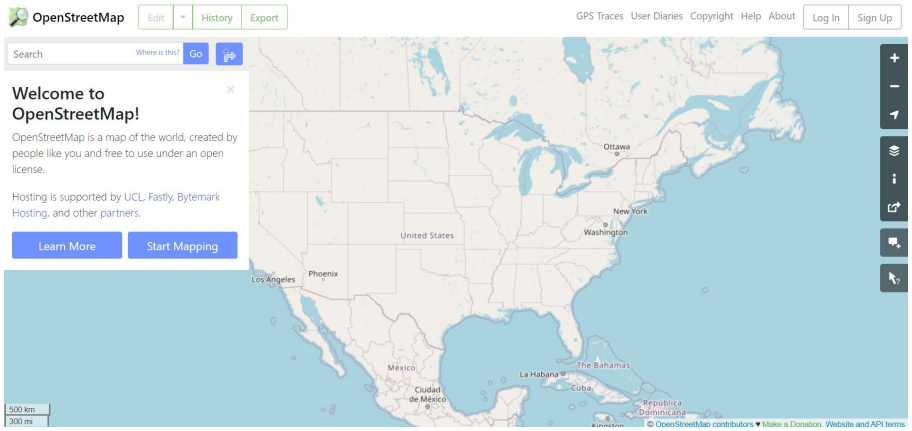
GEOG 5201 – Spring 2022

Outline

- Technological change in cartography
- Geovisualization
  - Background
  - Definitions
  - Goals
  - Techniques
  - Effectiveness

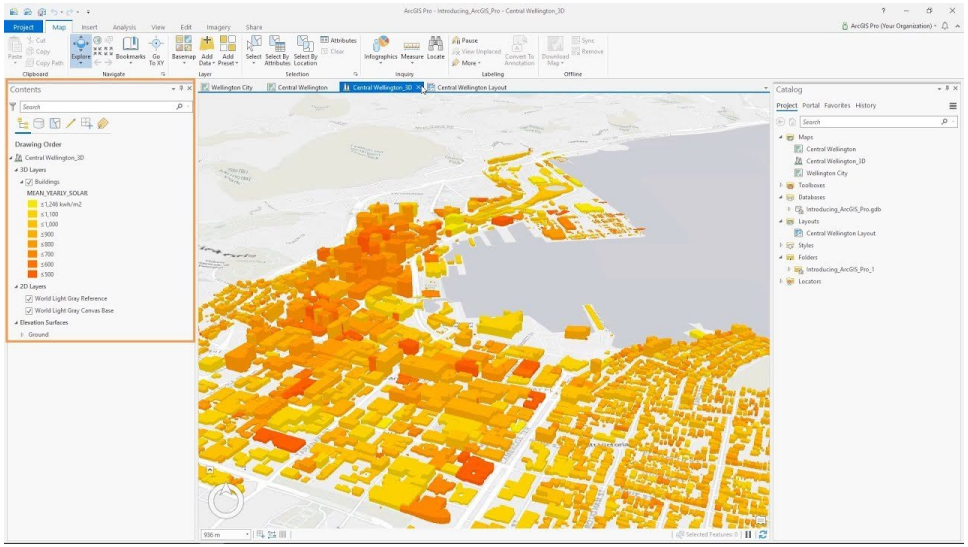
Technological Change in Cartography

- **Dramatically increasing amount of geospatial data**
  - Geospatial big data
    - Contributed by everyone, all the time, everywhere (pretty much)
  - Potential data sources
    - GPS tracking
    - Smart card, transactions
    - Geotagged social media
    - Volunteered geographic information, citizen science (e.g., Mapping slums with user-contributed data)



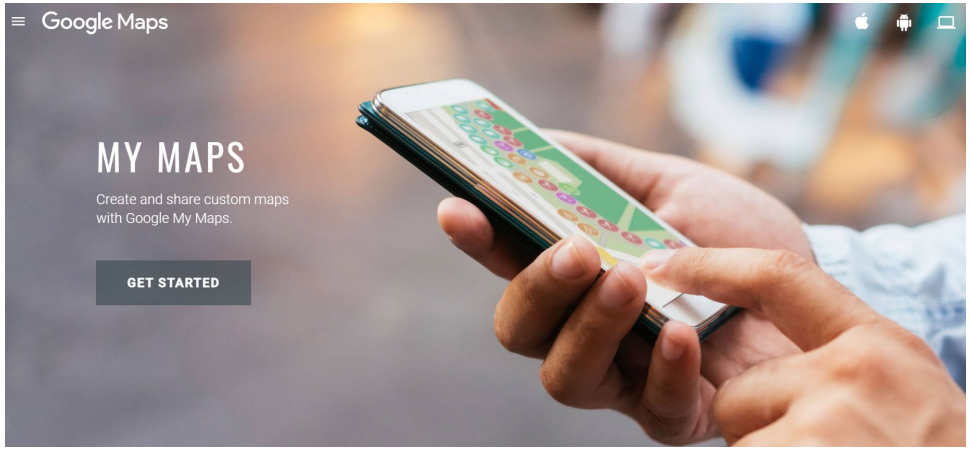
Technological Change in Cartography

- **Accessibilities to modern computers, interactive graphics technology, and the Internet**
  - Interactive graphics: “A computer graphics system that allows the operator or user to interact with the graphical information presented on the display…”
    - Permit users to examine spatial data dynamically and thus develop several different representations of the data – a process termed data exploration



Technological Change in Cartography

- **Accessibilities to modern computers, interactive graphics technology, and the Internet**
  - Democratization of cartography: everyone maps (not just cartographers)
  - Map for “users” (supply-driven) -> Map for ourselves (demand-driven)
  - Popular online interactive mapping tools (non-cartographers friendly):
    - Google My Maps
    - Google Fusion Tables
    - Carto
    - GPS Visualizer
    - MangoMap
    - Mapbox



Technological Change in Cartography

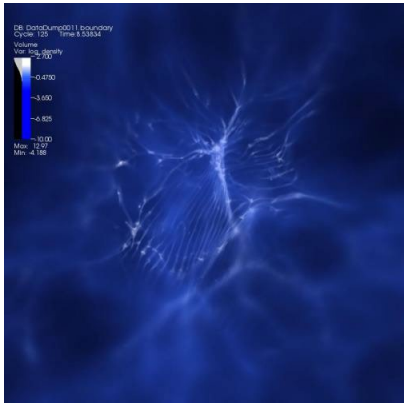
- **Advancement in display technology**
  - Historically: successful abstraction makes the world easier to understand
    - Examples: 2D, static
  - Recently: emphasis on realism
    - Examples: 3D, animation, augmented reality

Geovisualization: Background (Scientific Visualization)

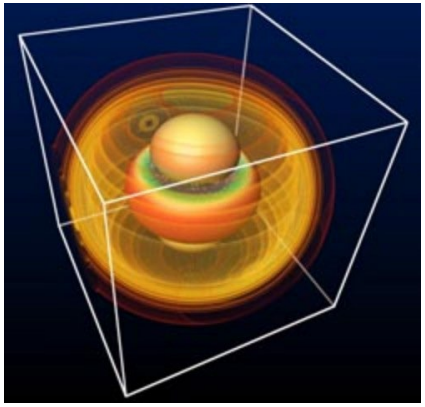
- "The study concerned with the interactive display and analysis of data; sometimes referred to as visual data analysis"
- McCormick, B.H., DeFanti, T.A., and Brown, M.D. (1987) "Visualization in scientific computing." Computer Graphics 21, no.6.
  - "to leverage existing scientific methods by providing… insight through visual methods" (p.3)

Geovisualization: Background (Scientific Visualization)

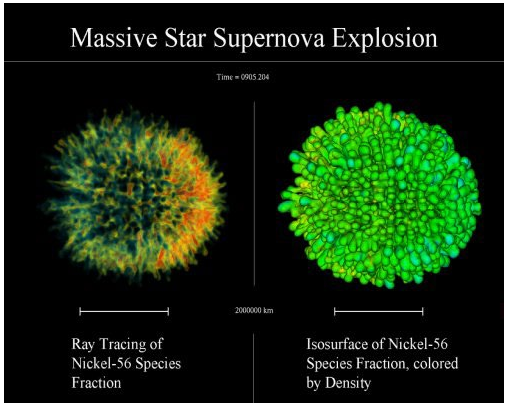
- Scientific Visualization Applications
  - In the natural sciences



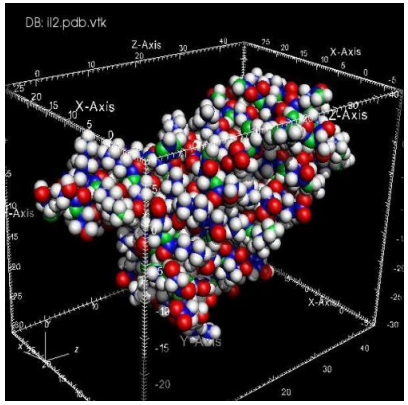
Star formation



Gravitational waves



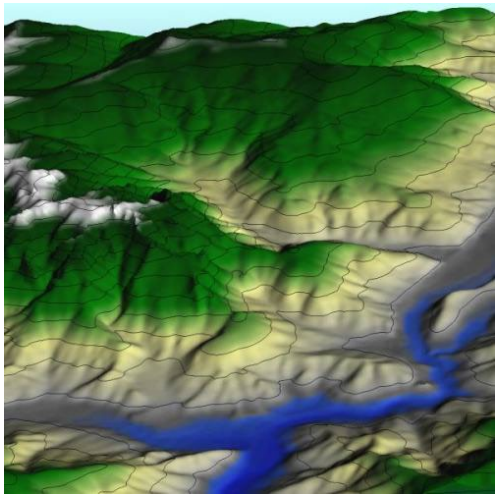
Massive Star Supernova Explosions



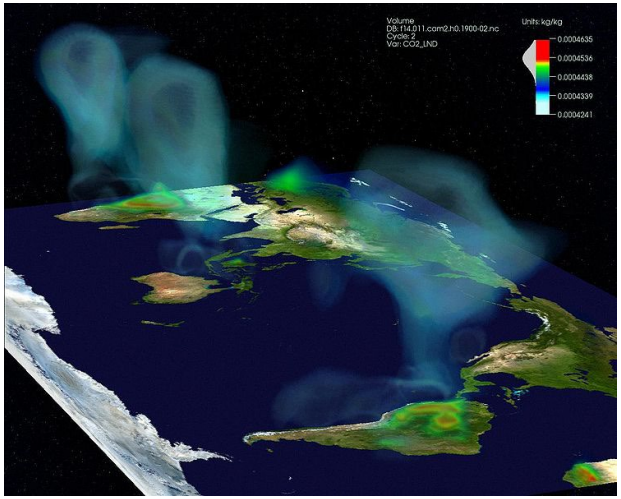
Molecular rendering

Geovisualization: Background (Scientific Visualization)

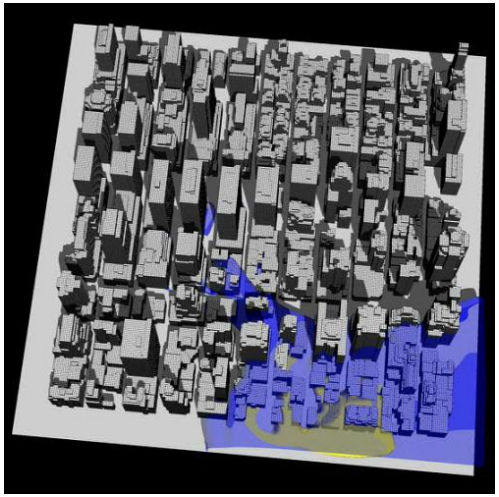
- Scientific Visualization Applications
  - In geography and ecology



Terrain rendering



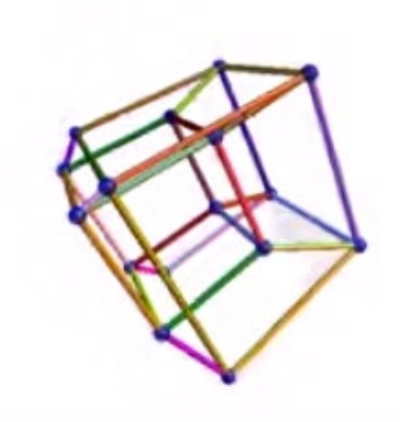
Climate visualization



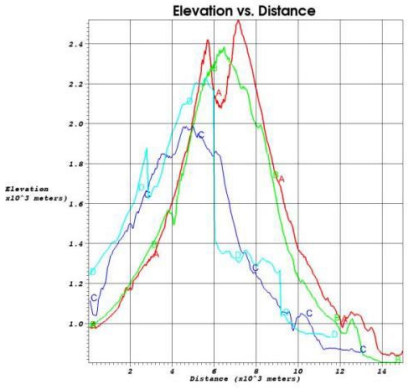
Atmospheric Anomaly in Times Square

Geovisualization: Background (Scientific Visualization)

- Scientific Visualization Applications
  - In mathematics and the formal sciences



Three dimensional shapes



Curve plots

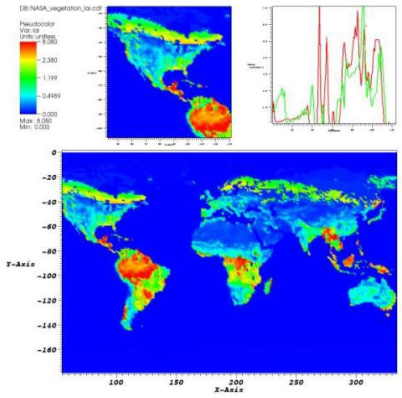
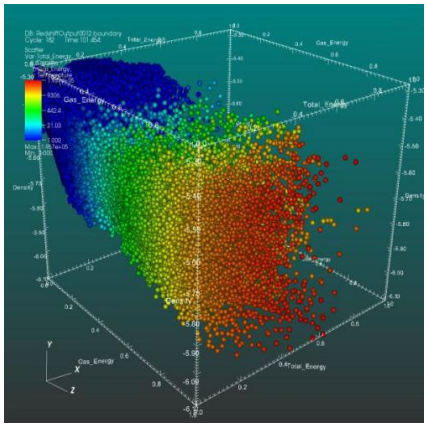


Image annotations

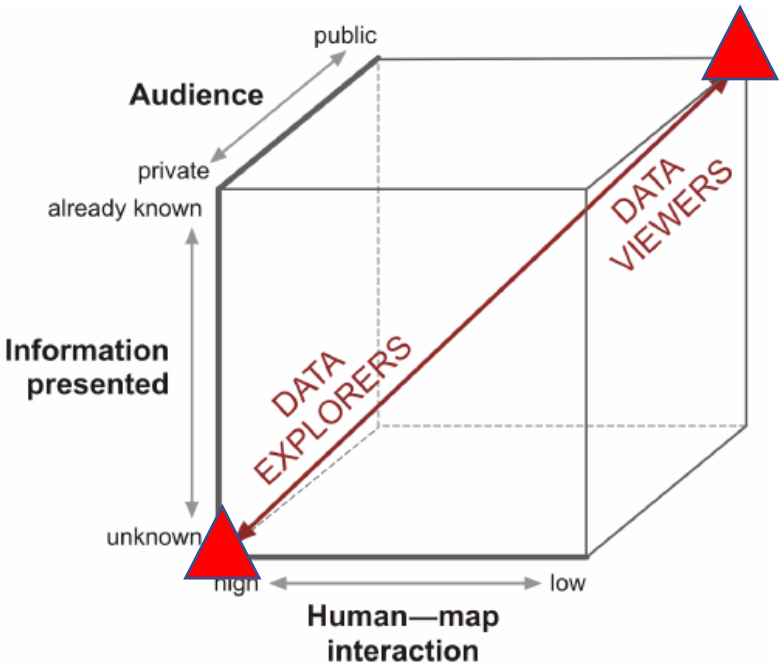


Scatter plot

Geovisualization: Definitions

- "**Geographic visualization** is a private activity in which unknowns are revealed in a highly interactive environment, whereas **communication** is the opposite: a public activity in which knowns are presented in a noninteractive environment."
  - ***High-interactivity***
  - ***Emphasizing exploration***

Map Use Cube



MacEachren, A. M. (1994). Visualization in modern cartography: setting the agenda. *Visualization in modern cartography*, *28*(1), 1-12.

Geovisualization: Definitions

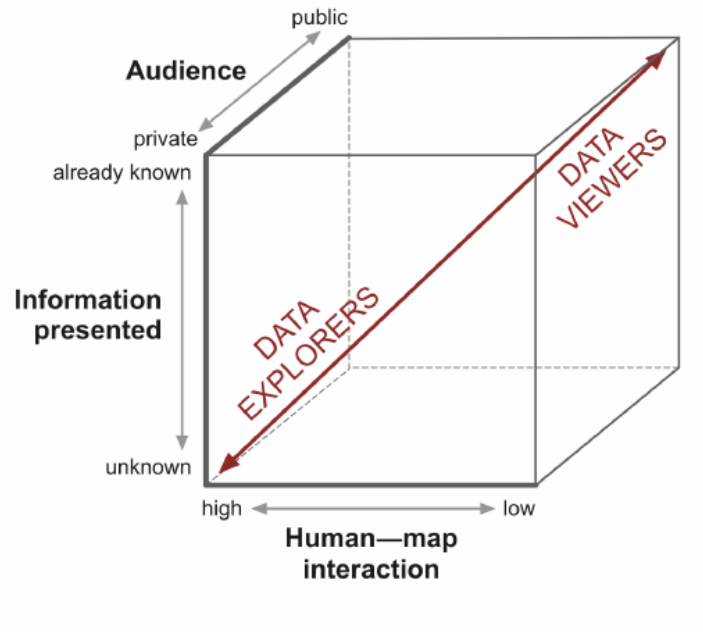
- International Cartographic Association (ICA) Commission on Visualization and Virtual Environments:
  - "Geovisualization integrates approaches from visualization in scientific computing (ViSC), cartography, image analysis, information visualization, exploratory data analysis (EDA), and geographic information systems (GISystems) to provide theory, methods and tools for visual exploration, analysis, synthesis, and presentation of geospatial data."
  - ***High-interactivity***
  - ***Emphasizing both communication and exploration***

Nollenburg, M. (2007). Geographic Visualization. *Human-Centered Visualization Environments, GI-Dagstuhl Research Seminar, Dagstuhl Castle, Germany, March 5-8, 2006, Revised Lectures.*

Question 1-2-1

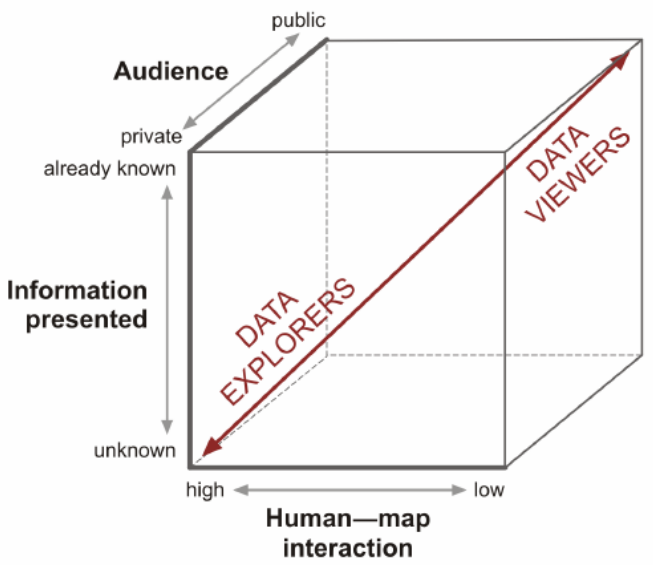
Where should we put the ICA's definition of geovisualization in the map cube?

> "Geovisualization integrates approaches from visualization in scientific computing (ViSC), cartography, image analysis, information visualization, exploratory data analysis (EDA), and geographic information systems (GISystems) to provide theory, methods and tools for visual exploration, analysis, synthesis, and presentation of geospatial data."



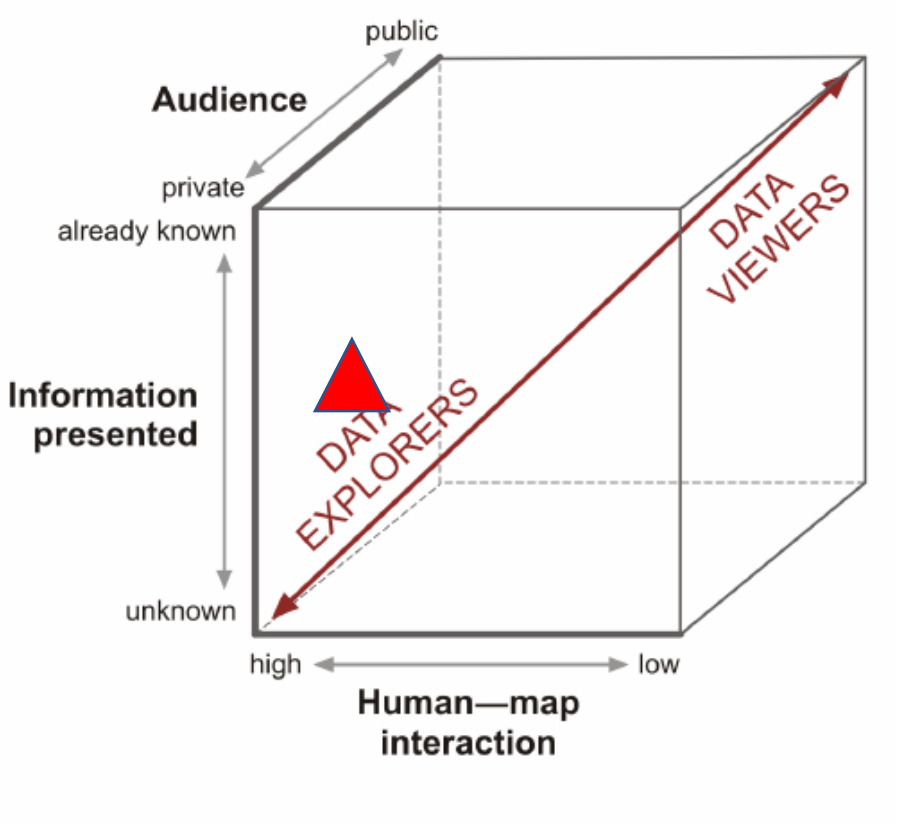
Geovisualization: Goals

- There can be *flexible* goals, especially for different forms of geovisualizations
- The space of visualization goals can be modeled with respect to three dimensions:
  - **Information presented**: range from revealing unknowns and constructing new knowledge to sharing existing knowledge
  - **Human-map interaction**: range from a rather passive low level to a high level where users actively influence what they see
  - **Audience**: range from a single, private user to a large, public audience

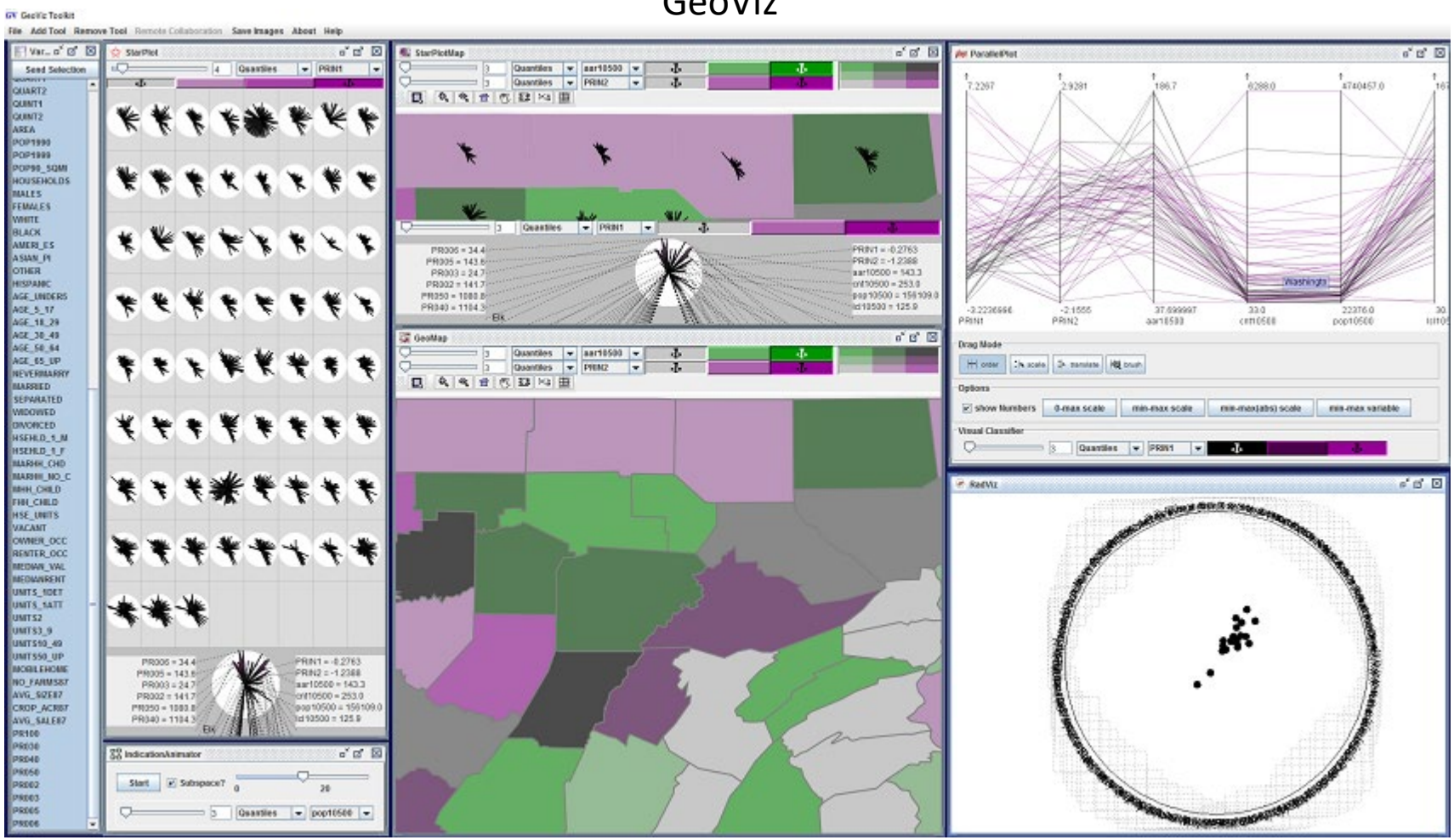


Geovisualization: Goals

- Maps are now frequently seen as an interactive interface to access and explore geospatial data while it still remains its traditional role as a presentational device



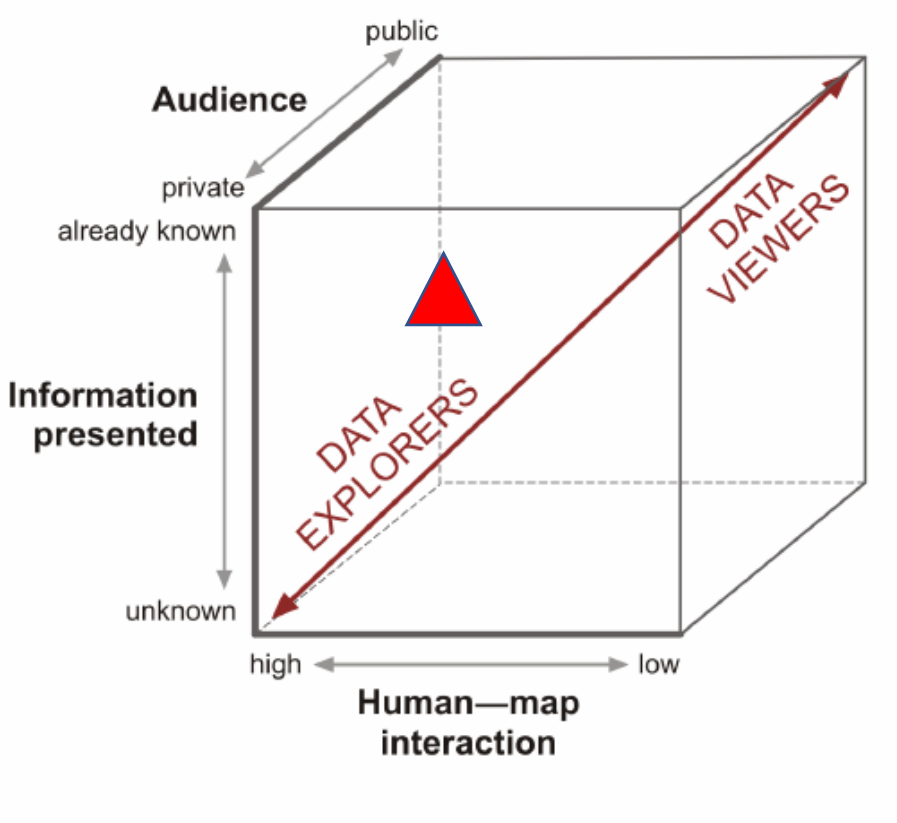
GeoViz



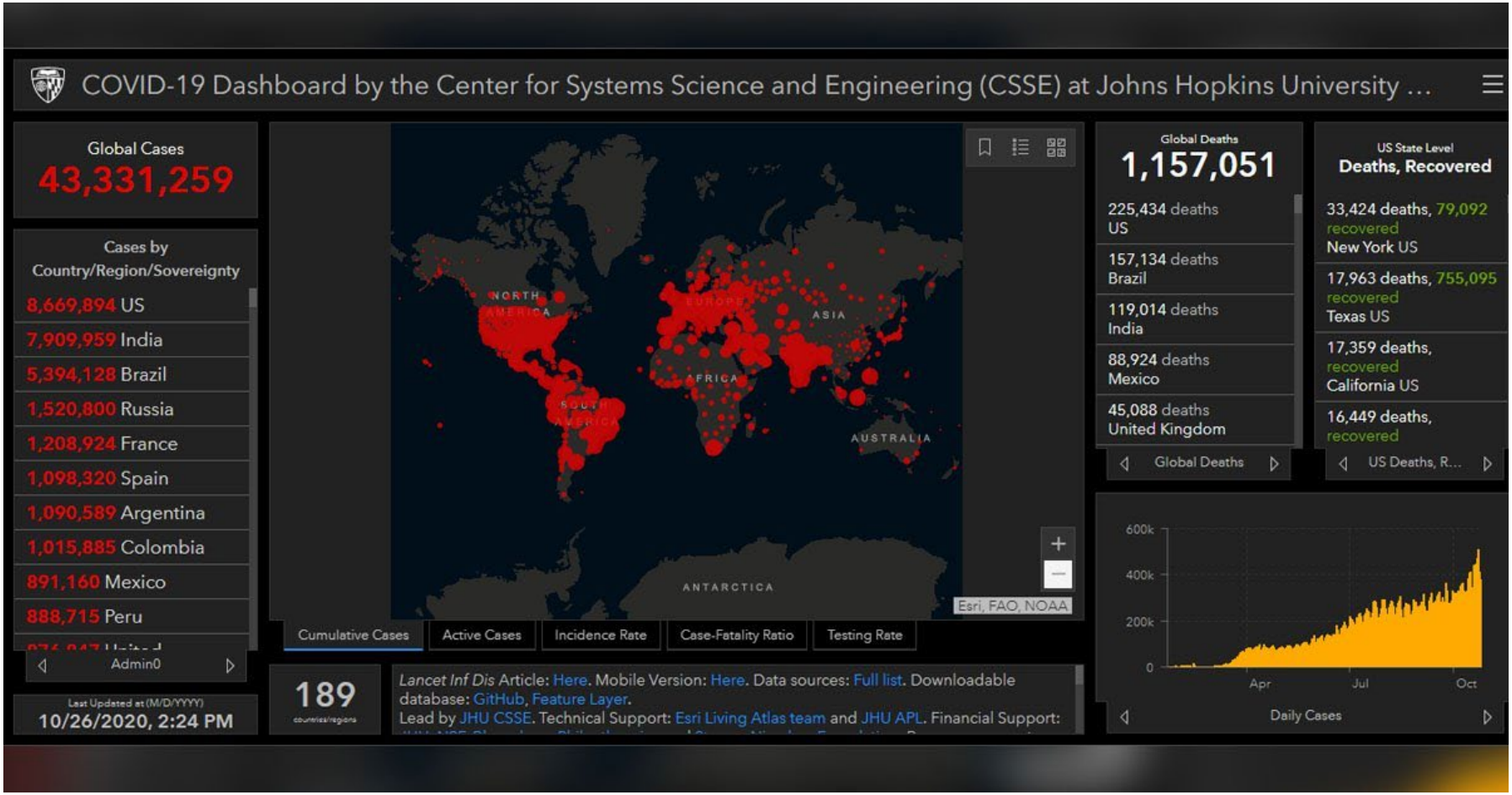
Hardisty, F., & Robinson, A. C. (2011). The geoviz toolkit: using component-oriented coordination methods for geographic visualization and analysis. *International Journal of Geographical Information Science*, *25*(2), 191-210.

Geovisualization: Goals

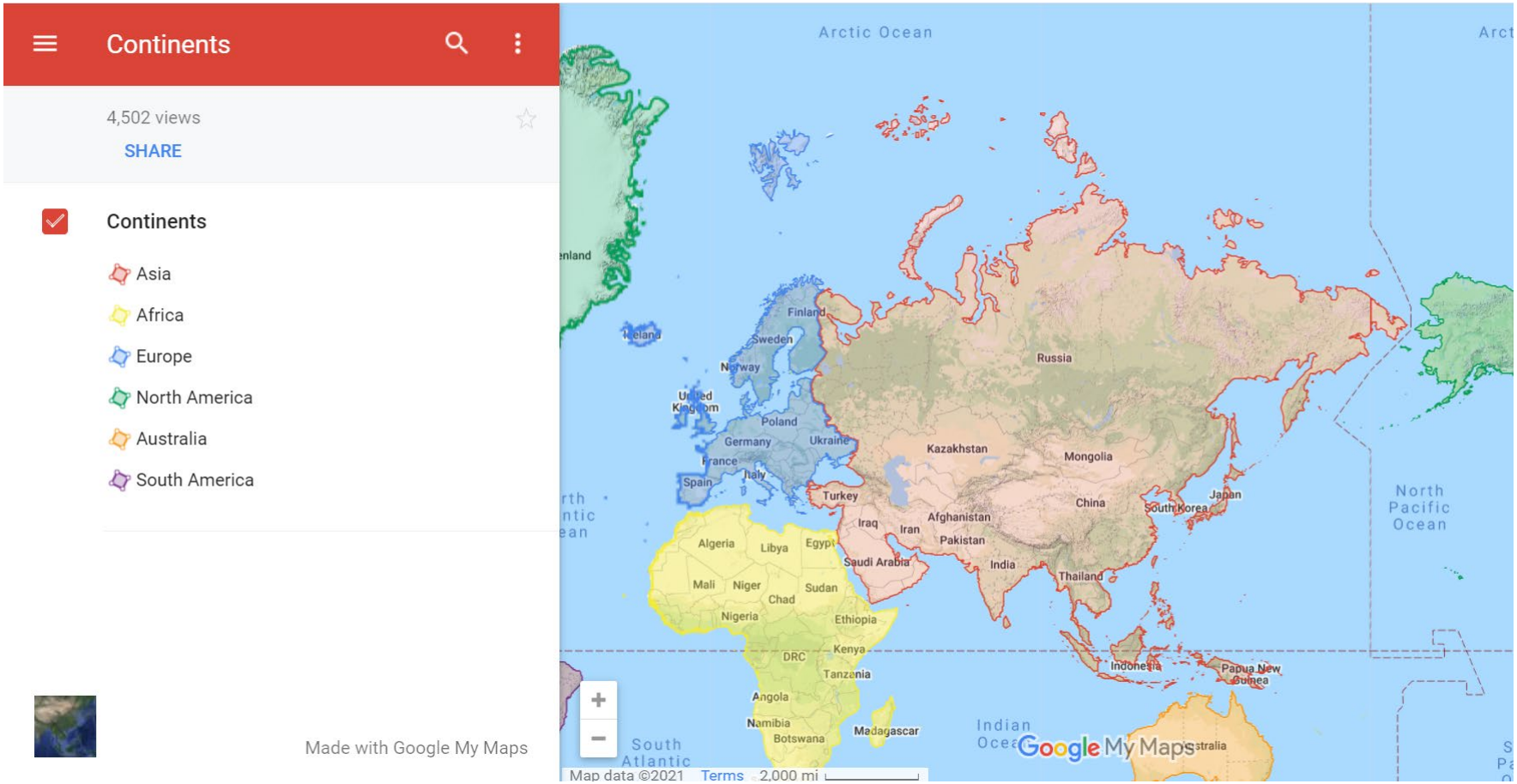
- Recent efforts have emphasized the high-interaction and group use (or public) parts of geovisualization



ArcGIS Dashboard

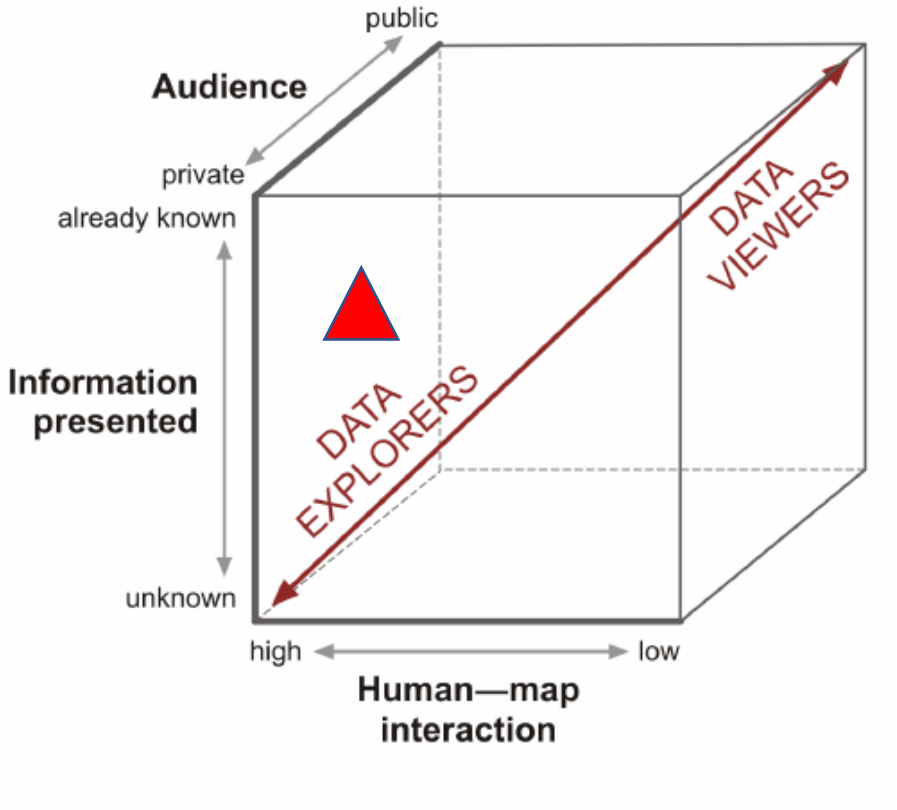


Google My Maps

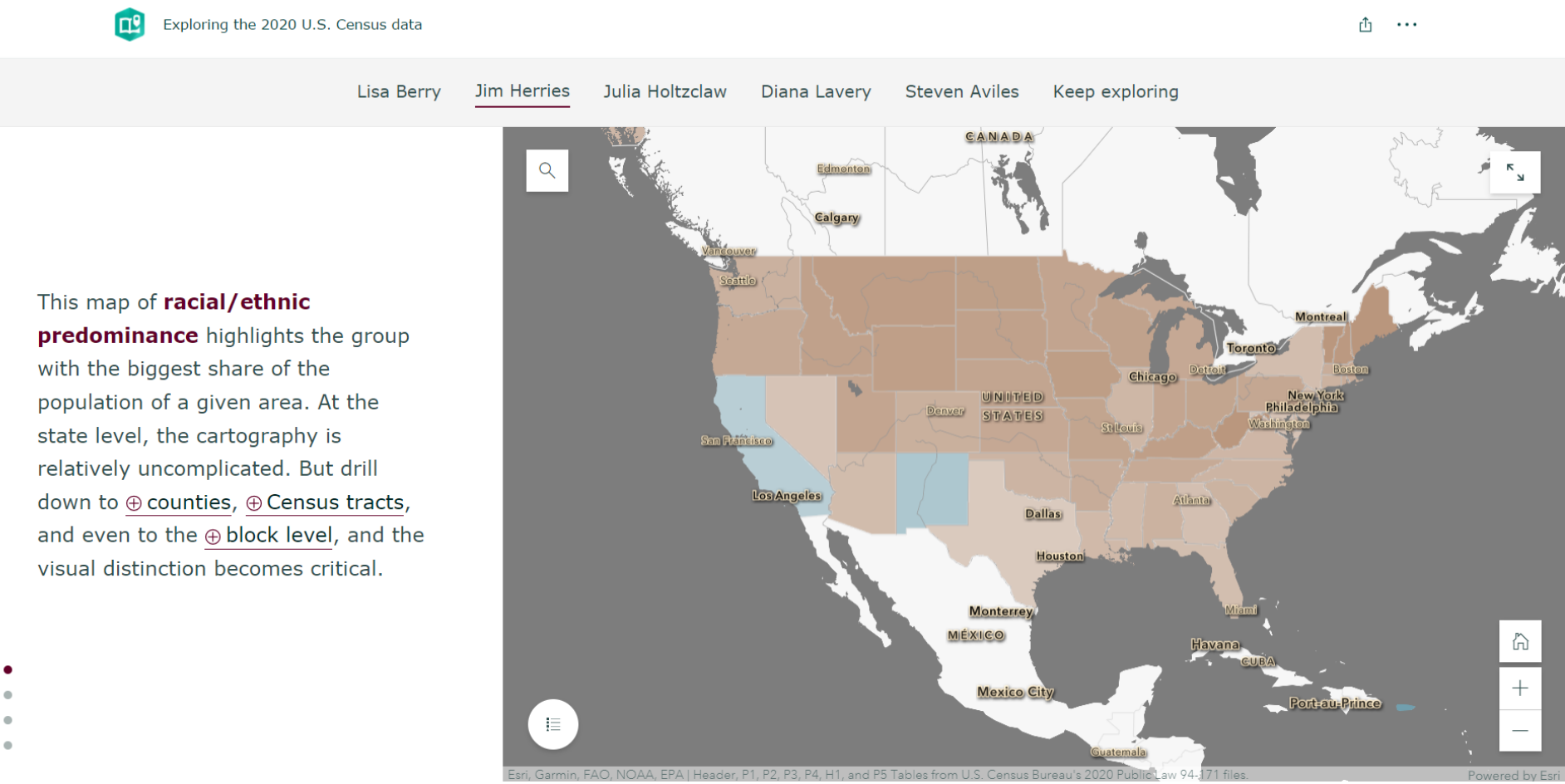


Geovisualization: Goals

- Sophisticated interactive geovisualization methods are now recognized as useful not only for exploration but also for presentation of knowledge through guided discovery



ArcGIS StoryMaps: Exploring the 2020 U.S. Census data

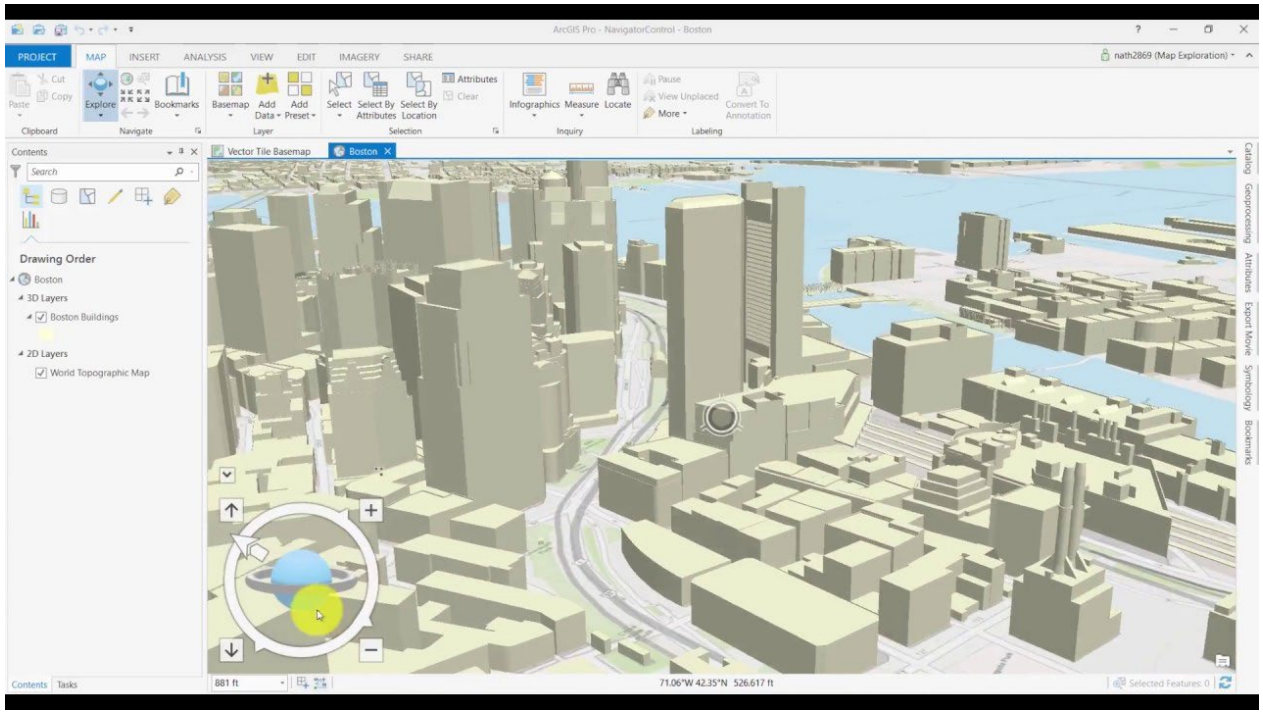


Question 1-2-2

What distinguishes geovisualization from traditional mapmaking in terms of definitions/goals?

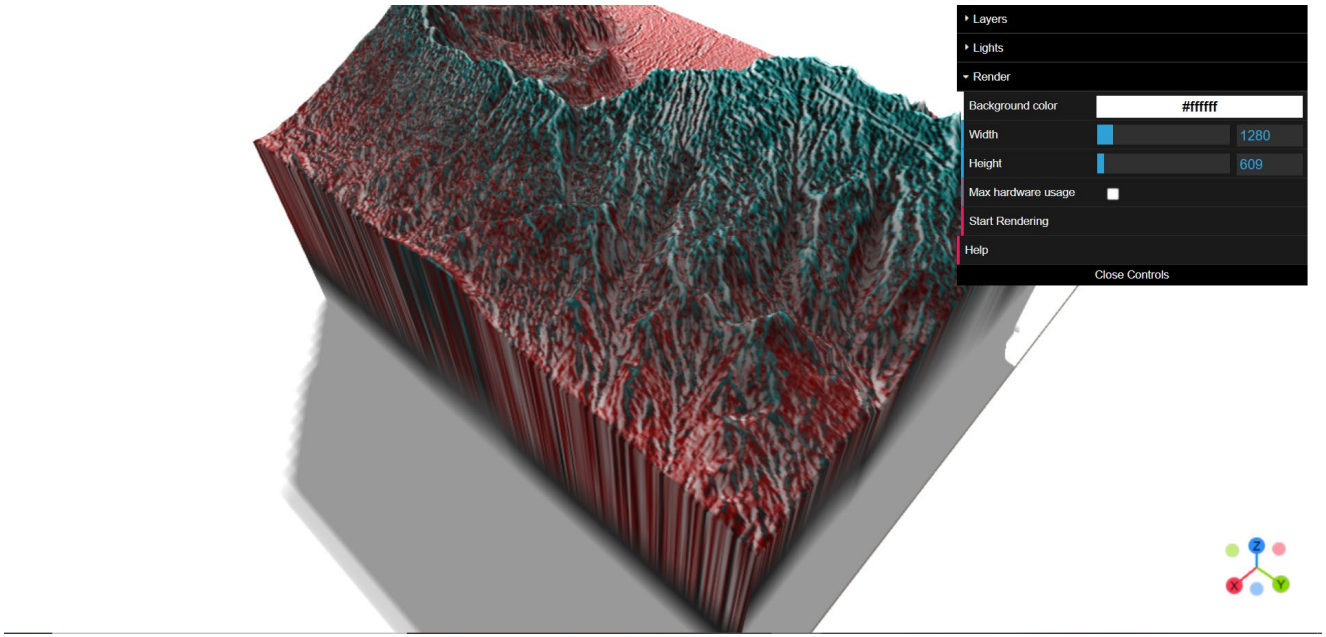
Geovisualization: Related Techniques

- **Geographic information systems (GISs)**
  - Computer based systems used to analyze spatial problems
    - Visualization toolboxes: bivariate choropleth, 3D, animation
    - Spatial analysis capabilities: visualizing nearest bus stop (proximity analysis)



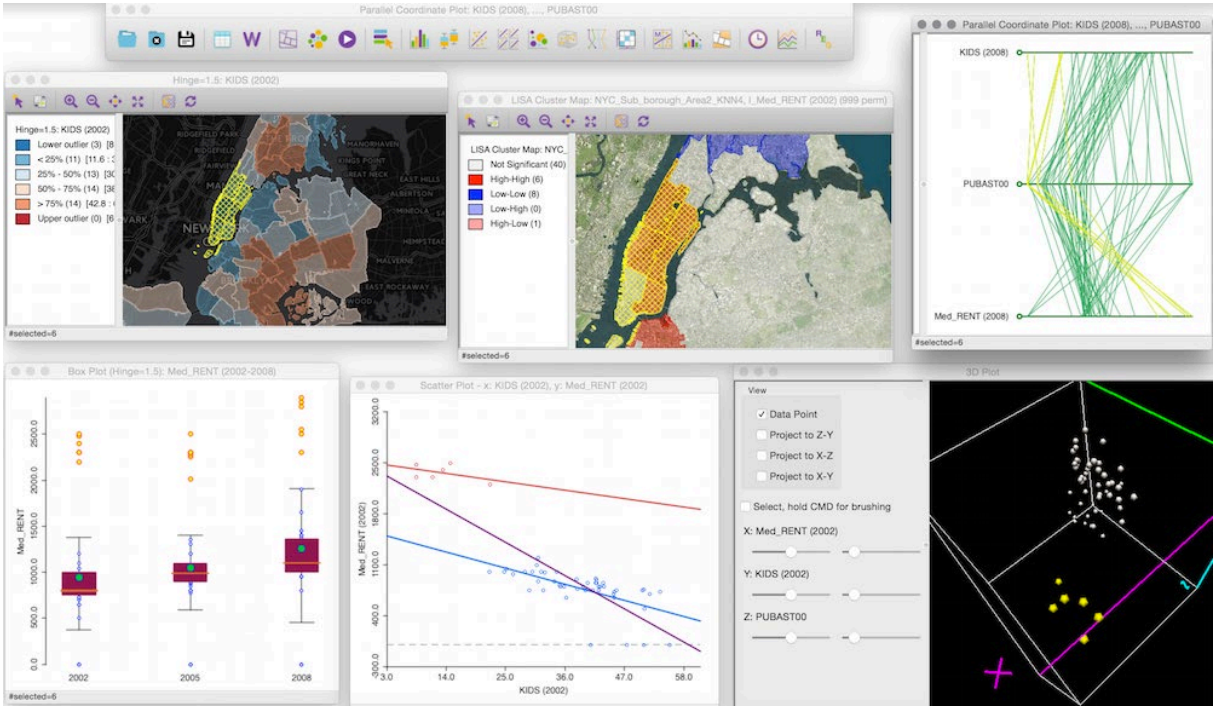
Geovisualization: Related Techniques

- **Remote sensing**
  - Record information about the Earth's surface from a distance (e.g., via satellite and aircraft)
    - Light detection and ranging (LiDAR), digital elevation model (DEM) -> elevation: 3D visualization, terrain visualization



Geovisualization:
Related Techniques

- **Quantitative methods**
  - Statistical analysis of spatial data
    - Relate different patterns identified in geovisualization: death rate and drunk driving



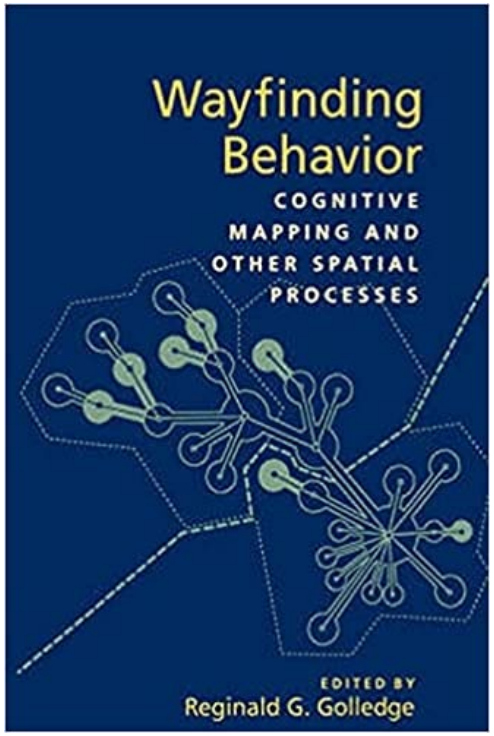
GeoDa

Technologies for This Course

- GIS:
  - ArcGIS Pro (lab 1 for review; throughout this semester)
  - ArcGIS Online (publish web map; throughout this semester)
  - ArcGIS StoryMaps (guided exploration; lab 9)
- Remote sensing:
  - Digital elevation models (DEM) (lab 6 3D)
  - Satellite images (lab 8 animation)
- Quantitative methods:
  - Correlation (lecture 2-1 bivariate mapping)

Geovisualization: Effectiveness

- Theory-driven cognitive research
  - Studies that seek to understand how humans create and utilize mental representations of the Earth's environment, whether via maps or by navigating through the environment
  - Example: research on cognitive aspects of way-finding



Golledge, R. G. (Ed.). (1999). Wayfinding behavior: Cognitive mapping and other spatial processes. JHU press.

Geovisualization: Effectiveness

- Evaluation of methods via usability engineering principles
  - Examine whether visualization responds satisfactorily to the tasks that users expect of it
  - Common methods:
    - Usability testing
    - Interviews
    - Focus groups
    - Questionnaires/surveys

Question 1-2-3

Imagine we develop an immersive geospatial virtual environment to assist school children in visualizing how temperature changes in a lake over the course of the year. Choose one of the following questions, discuss ways to address it from both cognitive and usability aspects.

- Which immersive hardware (e.g., head-mounted display) would be appropriate for children and for this particular application?
- What sort of interface would be most appropriate for children?
- What representation (symbology) would be appropriate for depicting lake temperatures?
- How might such decisions vary as a function of a child's age, sex, culture, and other individual characteristics?

Slocum, T. A., Blok, C., Jiang, B., Koussoulakou, A., Montello, D. R., Fuhrmann, S., & Hedley, N. R. (2001). Cognitive and usability issues in geovisualization. *Cartography and geographic information science*, 28(1), 61-75.