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CONTEMPORARY RESEARCH IN CARTOGRAPHY AND GISCIENCE

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THE SOURCE

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SPECIAL CONTENT SECTION

Contemporary American cartographic research: a review and prospective

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ABSTRACT
We review recent developments in cartographic research in North America, in the context of informing the 29th International Cartographic Conference, and 18th General Assembly in 2019. The titles of papers published since 2015 in four leading cartographic journals yielded a corpus of 245 documents containing 1109 unique terms. These terms were analyzed using Latent Dirichlet Allocation and by visual analytics to produce 14 topic groups that mapped onto five classes. These classes were named as information visualization, cartographic data, spatial analysis and applications, methods and models, and GIScience. The classes were then used as themes to discuss the recent cartographic literature more broadly, first, to review recent trends in the research and to identify research gaps, and second, to examine prospects for new research over the next 20 years. A conclusion draws some broad findings from the review, suggesting that cartographic research in the future will be aimed less at dealing with data, and more at generating insight and knowledge to better inform society about global challenges.

ARTICLE HISTORY
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KEYWORDS
Cartography; research; literature; visual analytics; content analysis; Latent Dirichlet Allocation

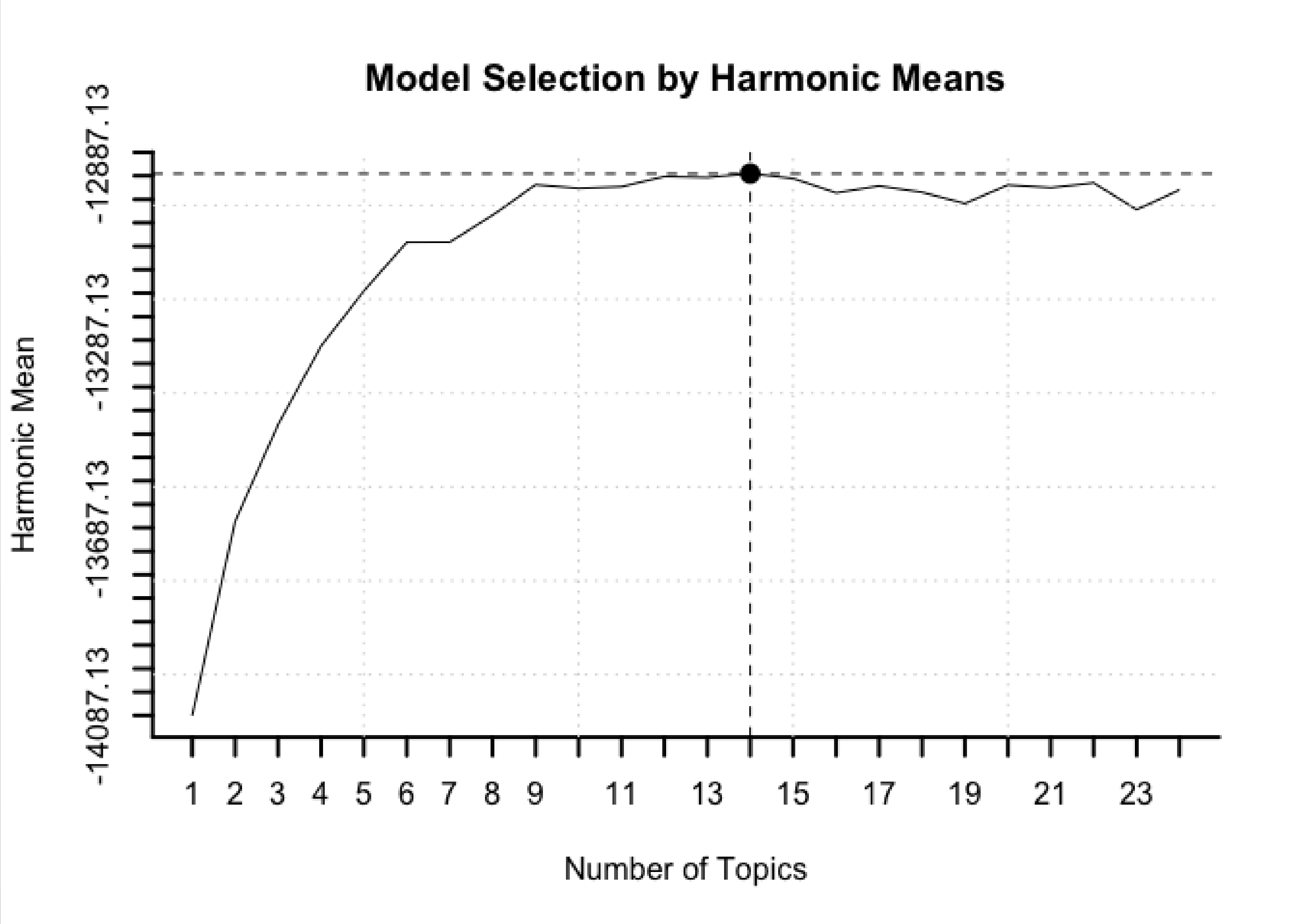
Introduction

During the last decades of the twentieth century, the discipline of cartography experienced a fundamental and

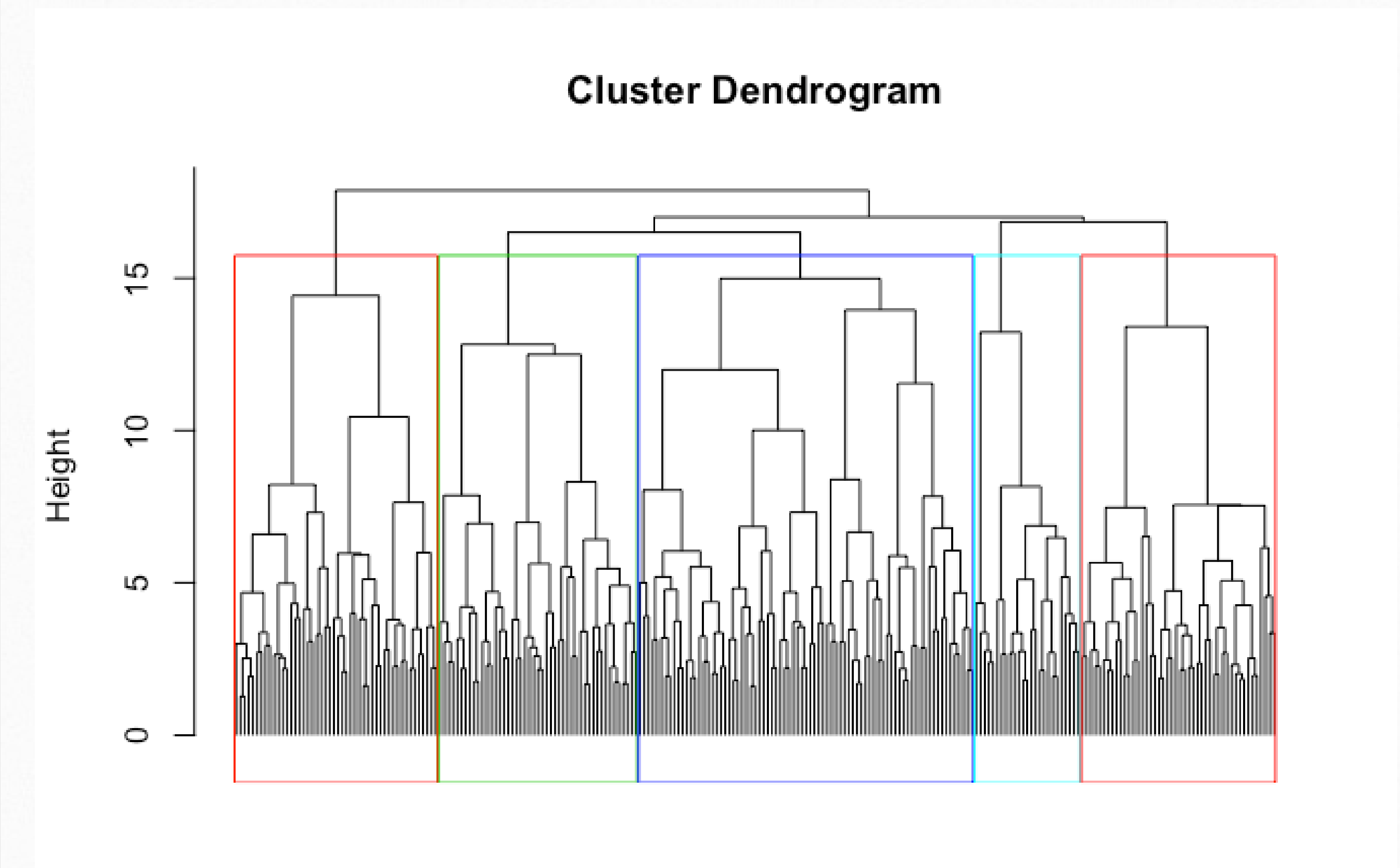
the Tokyo 29th International Cartographic Conference, and 18th General Assembly meeting, nears, the question arises again of what new paradigms in cartographic

WORD CLOUD OF TERMS INCLUDED IN 245 CARTOGRAPHIC RESEARCH PAPER TITLES 2015-2018

HOW MANY TOPICS?



TOPICS FORM 5 CLUSTERS



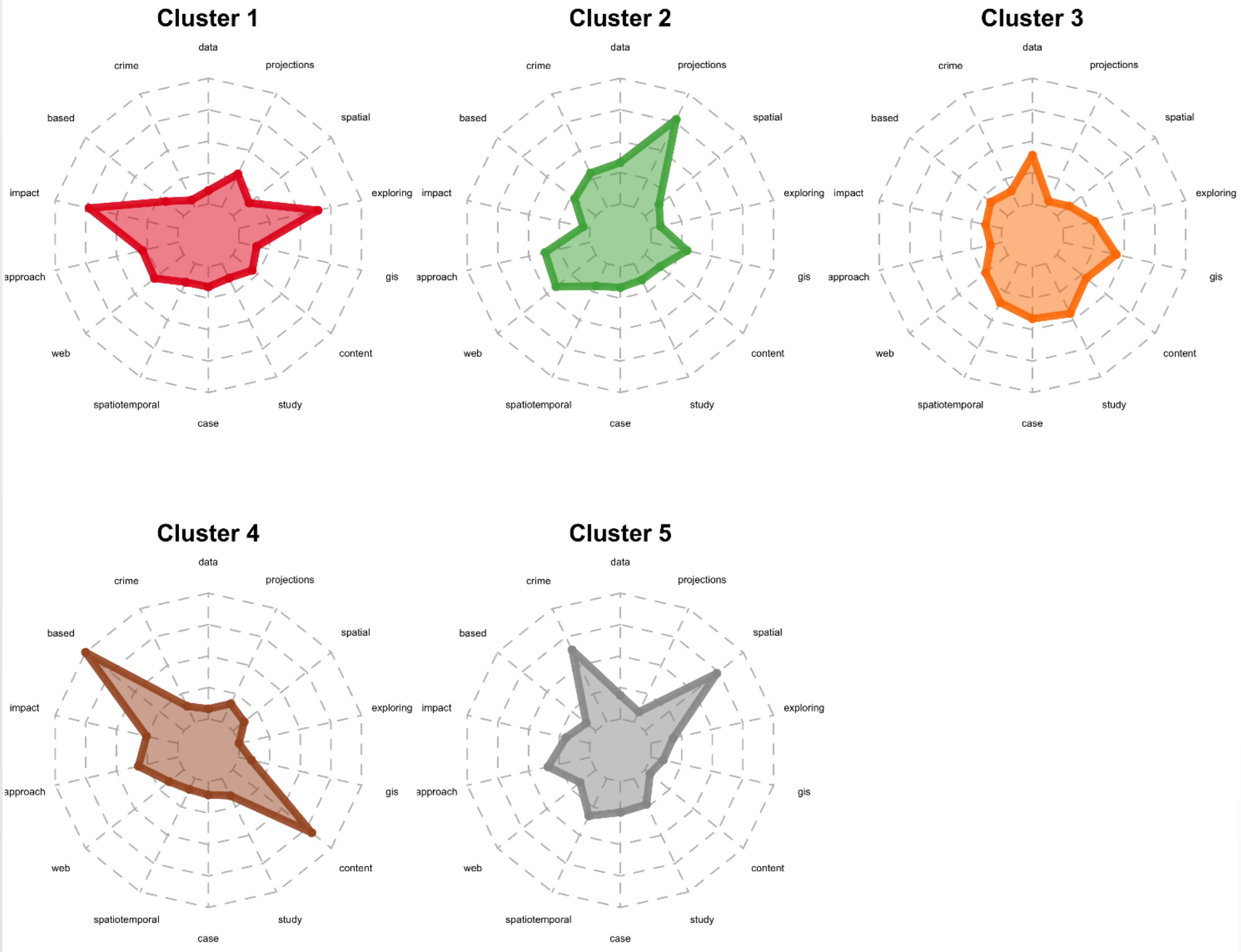
TOPICS BY CLUSTER

	1.	2.	3.	4.	5.
topic1	data	urban	spatial	based	algorithm
topic2	crime	research	networks	media	analysis
topic3	based	spatial	analysis	visualization	evaluation
topic4	impact	scale	system	development	geospatial
topic5	approach	cartographic	visual	user	patterns
topic6	web	cartography	century	risk	assessment
topic7	spatiotemporal	analysis	design	geographic	road
topic8	case	environmental	cartography	area	systems
topic9	study	multi	geovisual	information	analytics
topic10	content	generated	repeat	deconstructing	large
topic11	gis	method	online	source	gps
topic12	exploring	new	data	open	generalization
topic13	spatial	grid	population	knowledge	multi
topic14	projections	social	time	transformation	county

WORDS BELONGING TO MOST TOPIC GROUPS

- data (5)
- urban (5)
- spatial (4)
- based (3)
- networks (3)
- interactive (3)
- accuracy (2)
- acquisition (2)
- automated (2)
- analytical (2)

RADAR PLOTS OF THE LDA PROBABILITIES FOR TERMS WITHIN TOPIC CLUSTERS



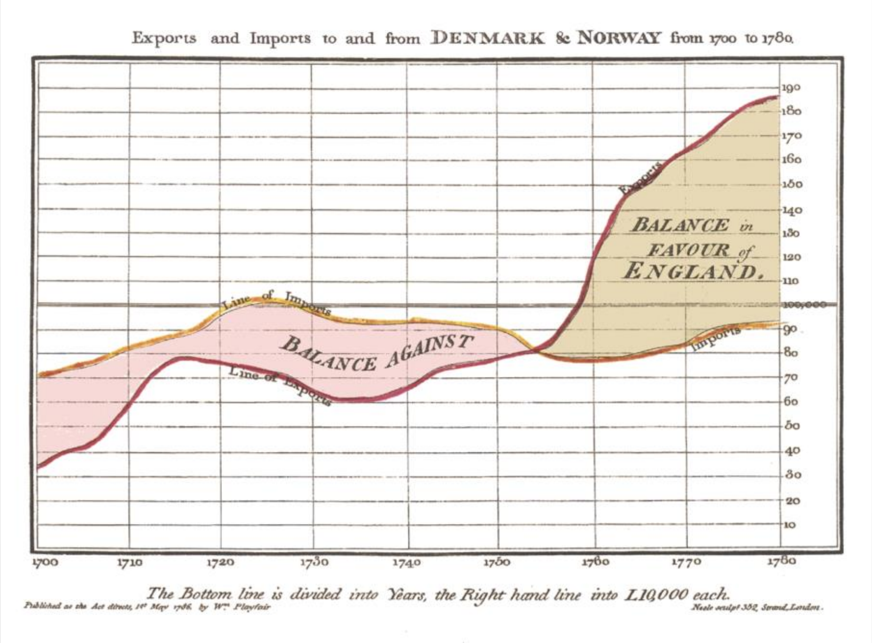
WORD CLOUDS FOR THE FIVE TOPIC CLUSTERS (SHOWING MOST FREQUENT 50 WORDS)

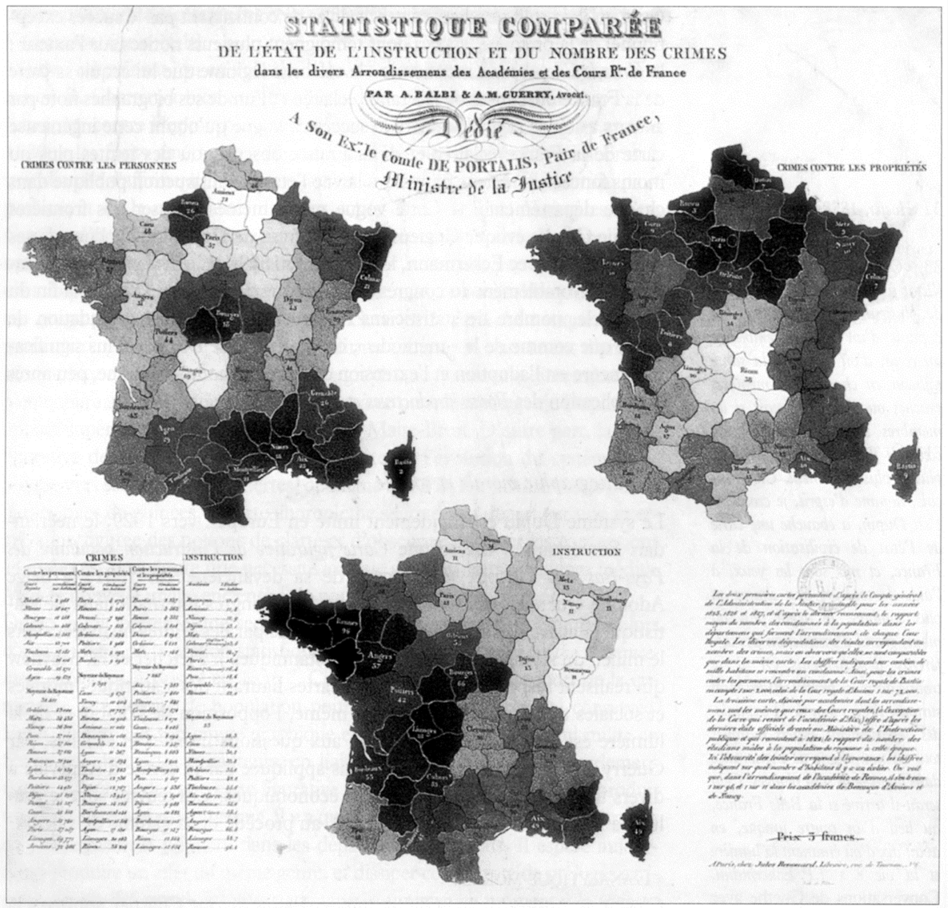
CLASSES

- Classes were :
  - information visualization
  - cartographic data
  - spatial analysis and applications
  - methods and models
  - GIScience
- Classes were used as themes of recent cartographic literature

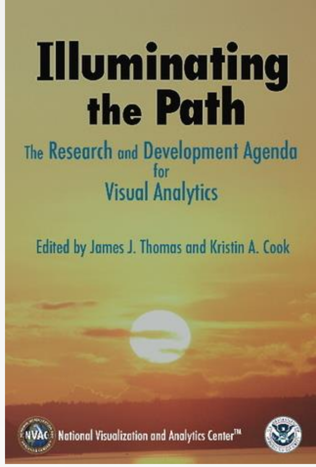
1. INFORMATION VISUALIZATION

Information visualization has a long tradition in cartography: William Playfair, André-Michel Guerry





CARTOGRAPHY VS. GEOVIZ VS. INFOVIZ VS. VISUAL ANALYTICS



(1) analytical reasoning techniques that enable users to obtain deep insights that directly support assessment, planning, and decision-making

(2) data representations and transformations that convert all types of conflicting and dynamic data in ways that support visualization and analysis

(3) techniques to support production, presentation, and dissemination of the results of an analysis to communicate information in the appropriate context to a variety of audiences

(4) visual representations and interaction techniques that take advantage of the human eye's broad bandwidth pathway into the mind to allow users to see, explore, and understand large amounts of information at once (Kielman & Thomas, 2009).

THREE TOBLER EXAMPLES

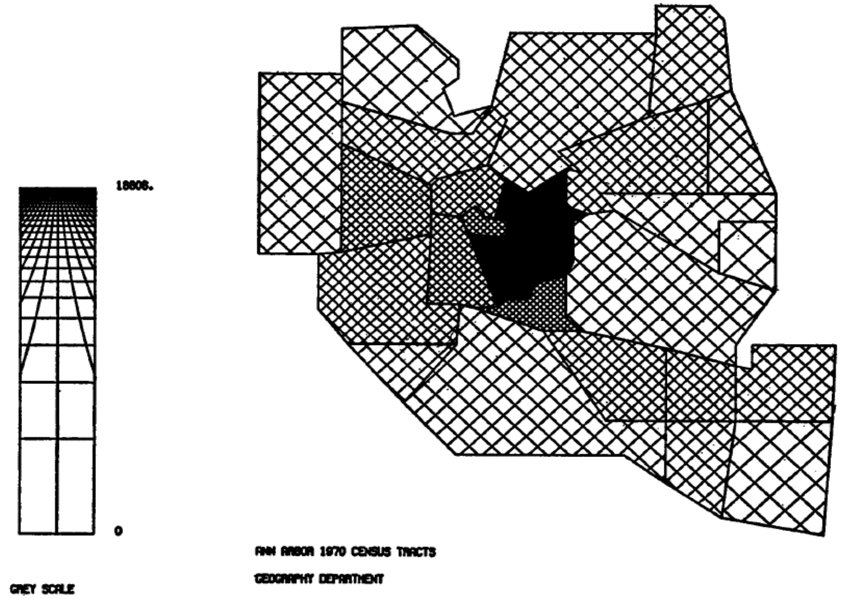
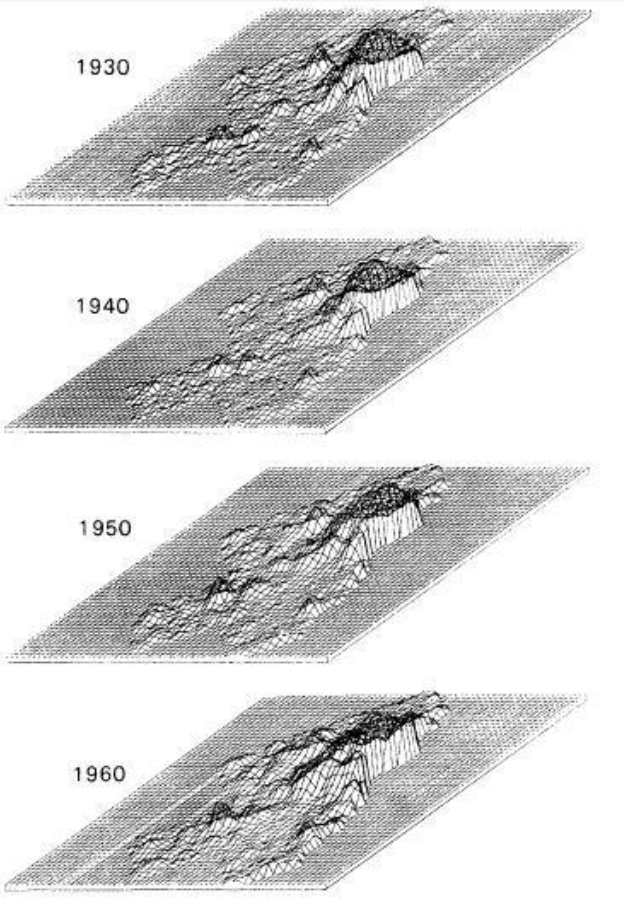
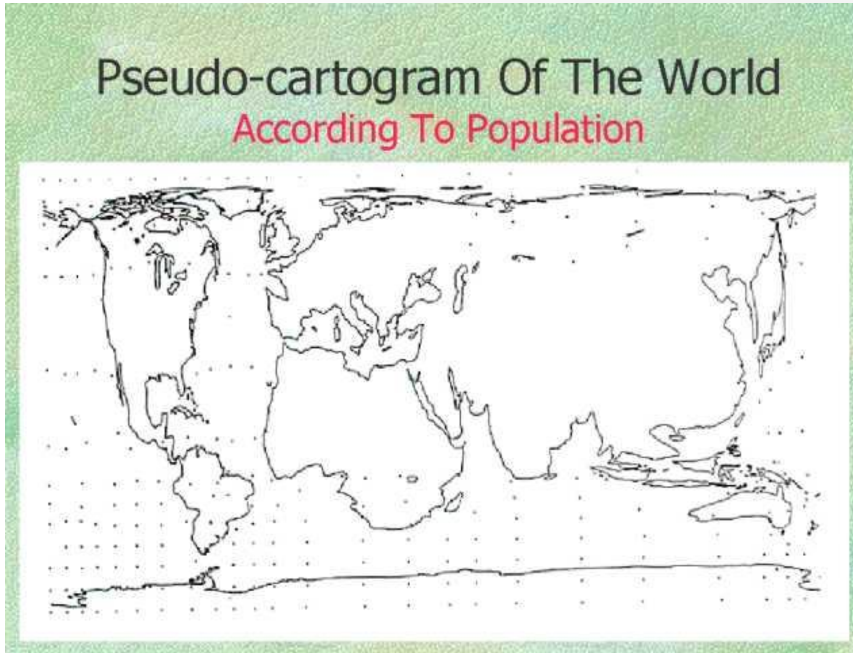


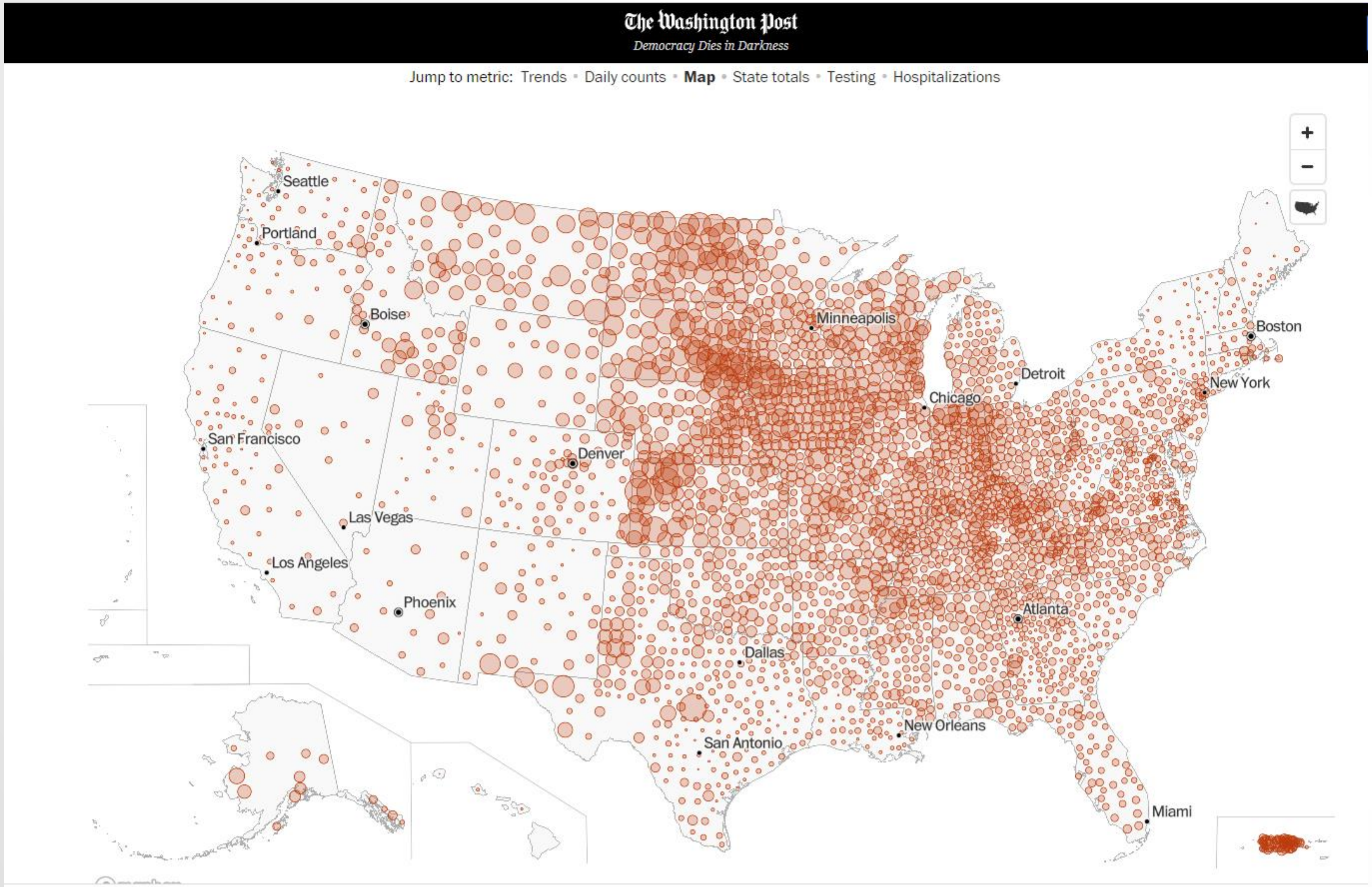
FIG. 1. Choropleth Map Without Class Intervals.



Actual population growth, Detroit Region (non-linear vertical scale).



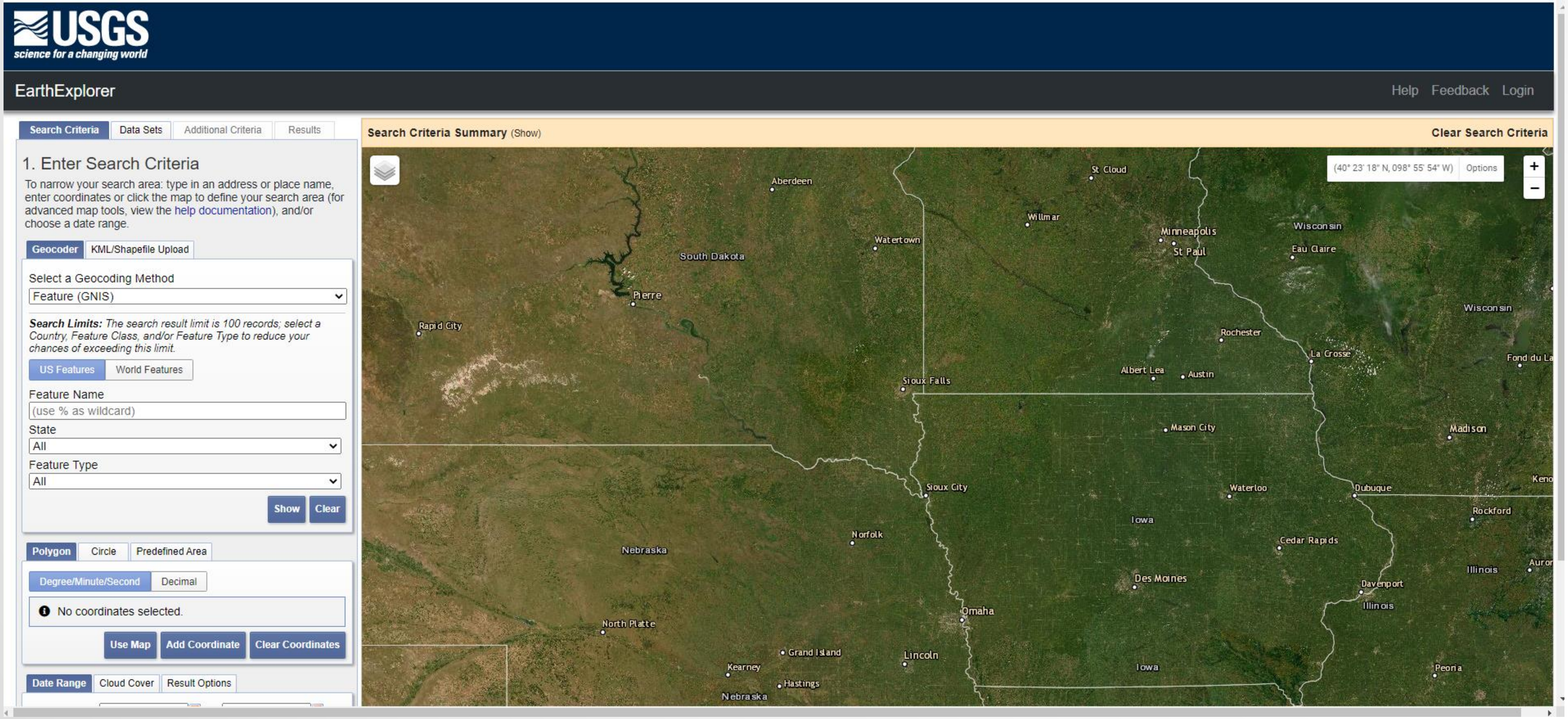
IMMEDIACY OF INTERACTIVE MAPS



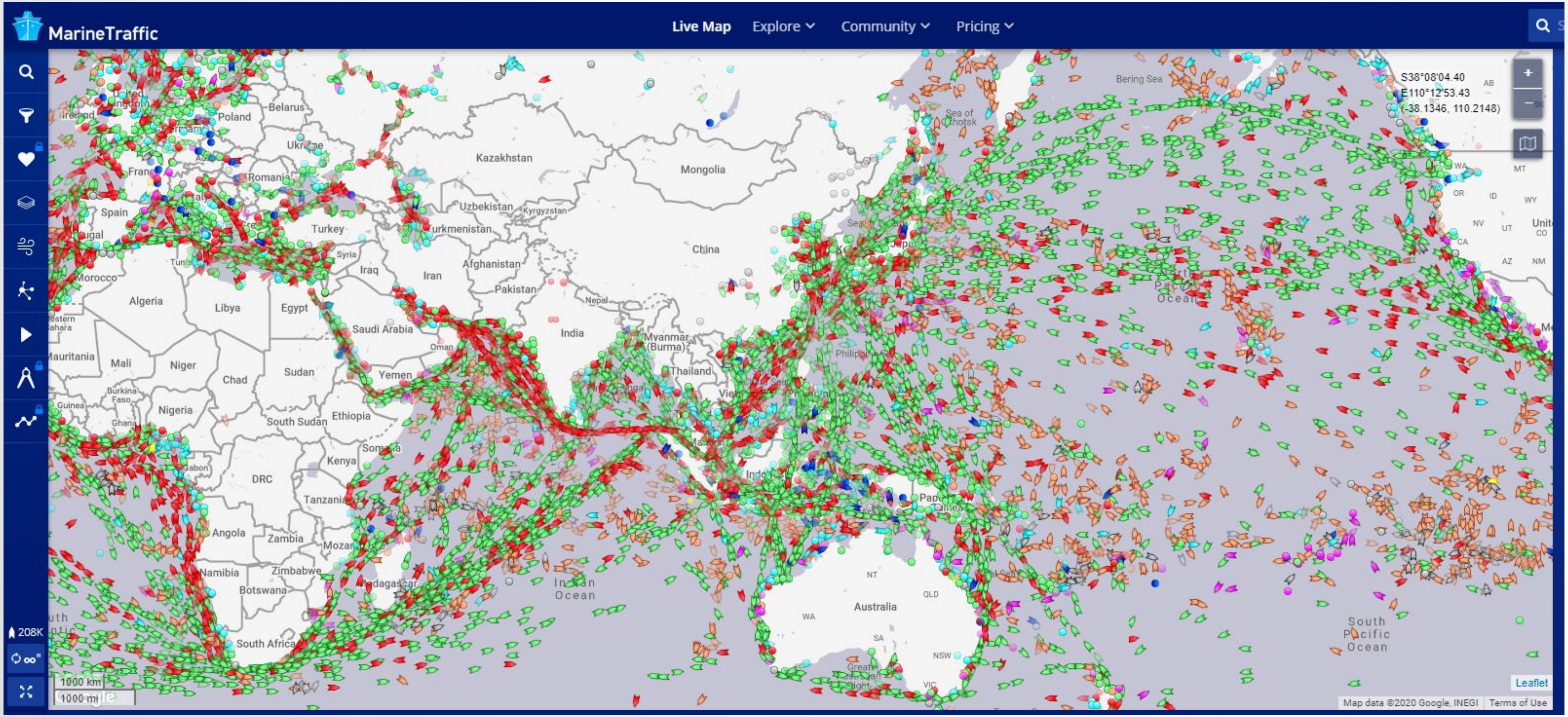
2. CARTOGRAPHIC DATA

- Progression from conversion and storage to access, discovery and real-time streaming, BIG data
- Data sets -> Data collections -> Portals -> Clearinghouses -> Geoplatform -> Services
- Massive improvements in resolution and accuracy e.g. LIDAR
- Many good examples in government: NOAA Digital Coastline, USGS National Map, NASA data via Earth Explorer
- Real time examples now common: Marine and Airline traffic, Google Maps traffic
- Massively facilitated by open source tools, libraries and standards

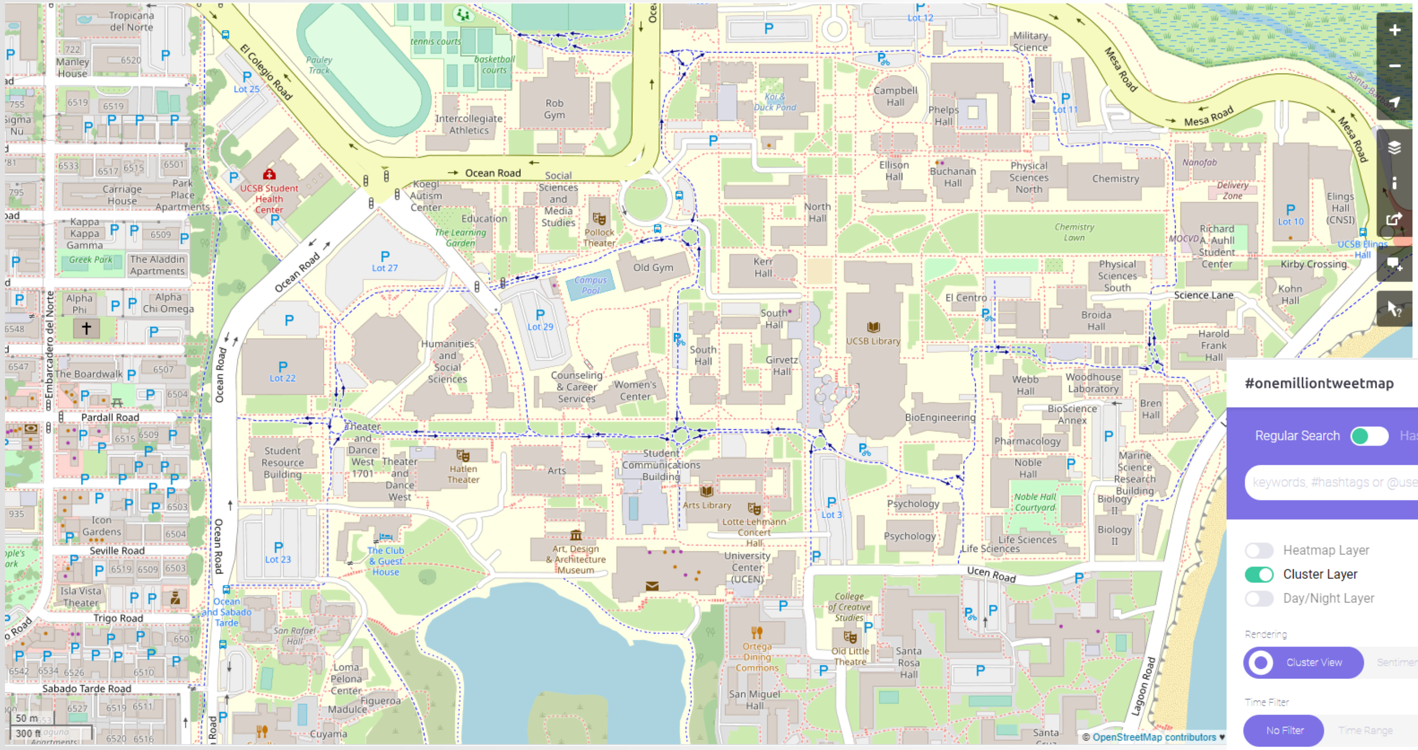
EARTH EXPLORER

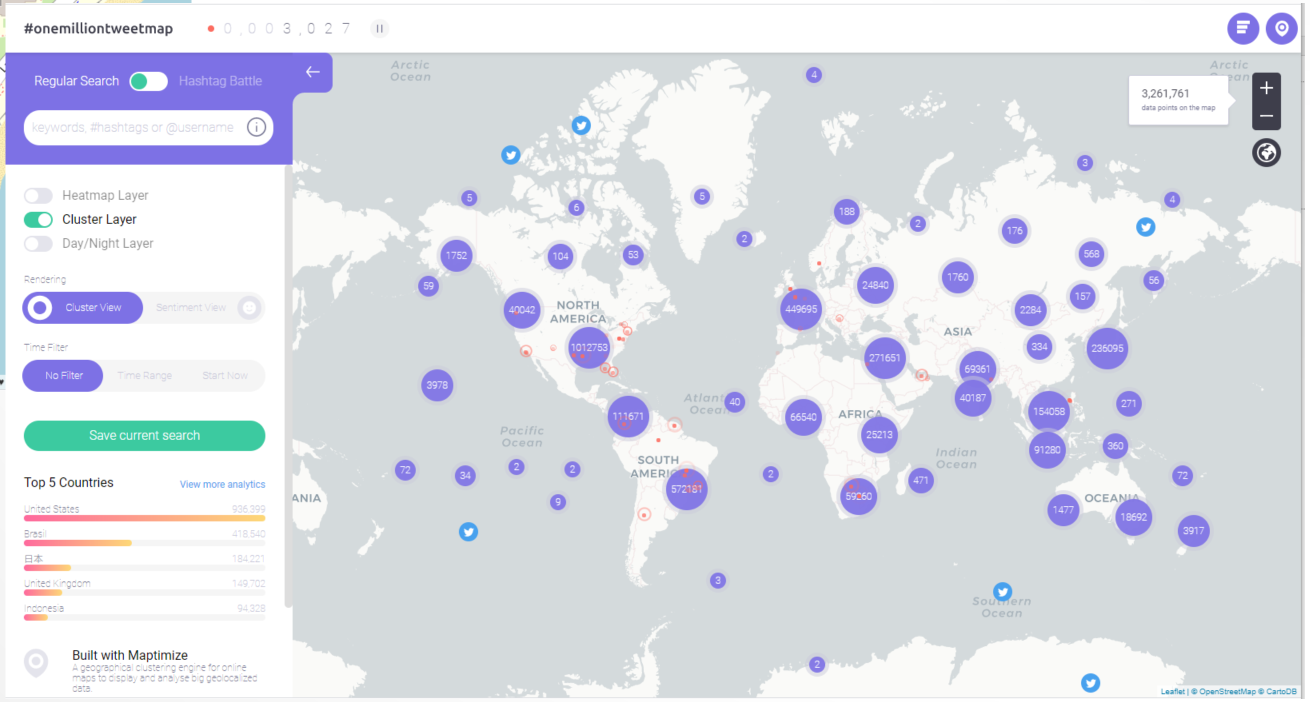


MARINE TRAFFIC



(IN)VOLUNTARY GEOGRAPHIC DATA





3. SPATIAL ANALYSIS AND APPLICATIONS

- Methods of spatial analysis increasingly sophisticated and accessible, e.g. R-studio
- More 3D information (e.g. digital terrain analysis and LiDAR mapping)
- 4D time–space analysis now includes moving object analysis and trajectories
- Web tools enable dynamic, interactive, and animation tools in mapping
- Time line tools have enabled the move from 2D to 4D mapping
- Analysis tools to identify group behavior in trajectories are now beginning to be developed, and event-, pattern- and movement-based syntaxes and semantics are now undergoing research
- New analysis of human mobility data, often revealed through social media and high resolution imagery

R-SCRIPT FOR THE REVIEW PAPER ANALYSIS

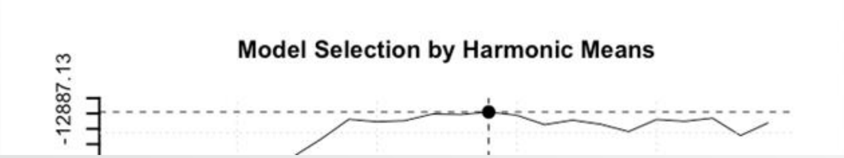
Next, we are interested in how these terms naturally group within the corpus. We can look at this using a LDA model with the parameters laid out in the `water security paper`. In such a model the number of topics must be defined a priori so we run the model for topic sizes ranging from 2 to 25.

With 245 documents, this process takes a while so it was run once and saved.

```
# fitted_many <- lapply(seq(2, 25, 1),
#                       function(k) topicmodels::LDA(attempt2$dtm,
#                                                    k = k,
#                                                    method = "Gibbs",
#                                                    control = list(burnin = 2000,
#                                                                   iter   = 1000,
#                                                                   keep   = 50,
#                                                                   alpha  = 50/k,
#                                                                   best   = T,
#                                                                   delta  = .1,
#                                                                   seed   = 1:5,
#                                                                   nstart = 5
#                         )))
#
# save(fitted_many, file = "/Users/mikejohnson/Documents/GitHub/KeithDocs/fitted_many.rda")

load("/Users/mikejohnson/Documents/GitHub/KeithDocs/fitted_many.rda")
```

With a series of LDA models fit to a number of topics ranging from 2 - 25 we can look at the harmonic mean of the logliklihoods to determine which offers the maximum value (optimal fit):



NOAA TRAJECTORY ANALYSIS PLANNER

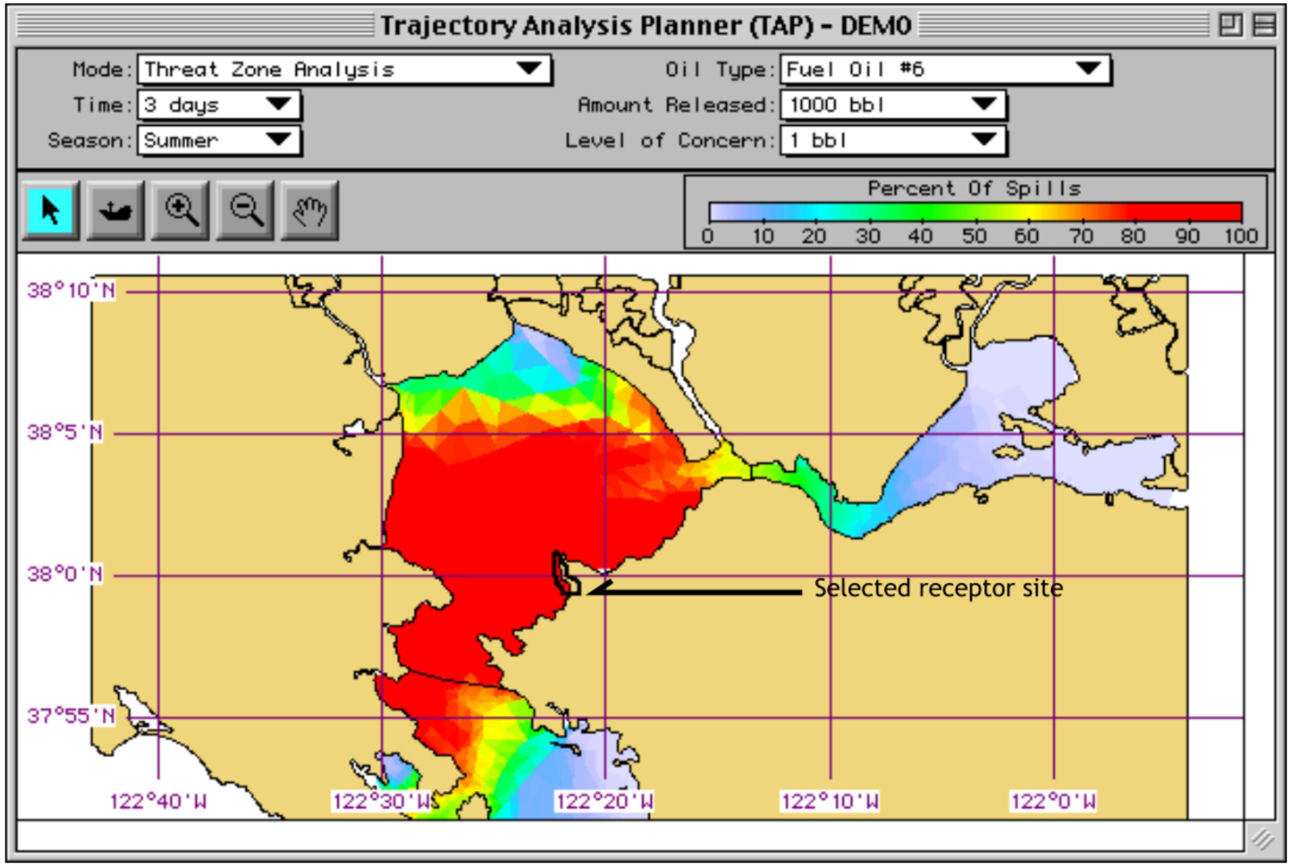


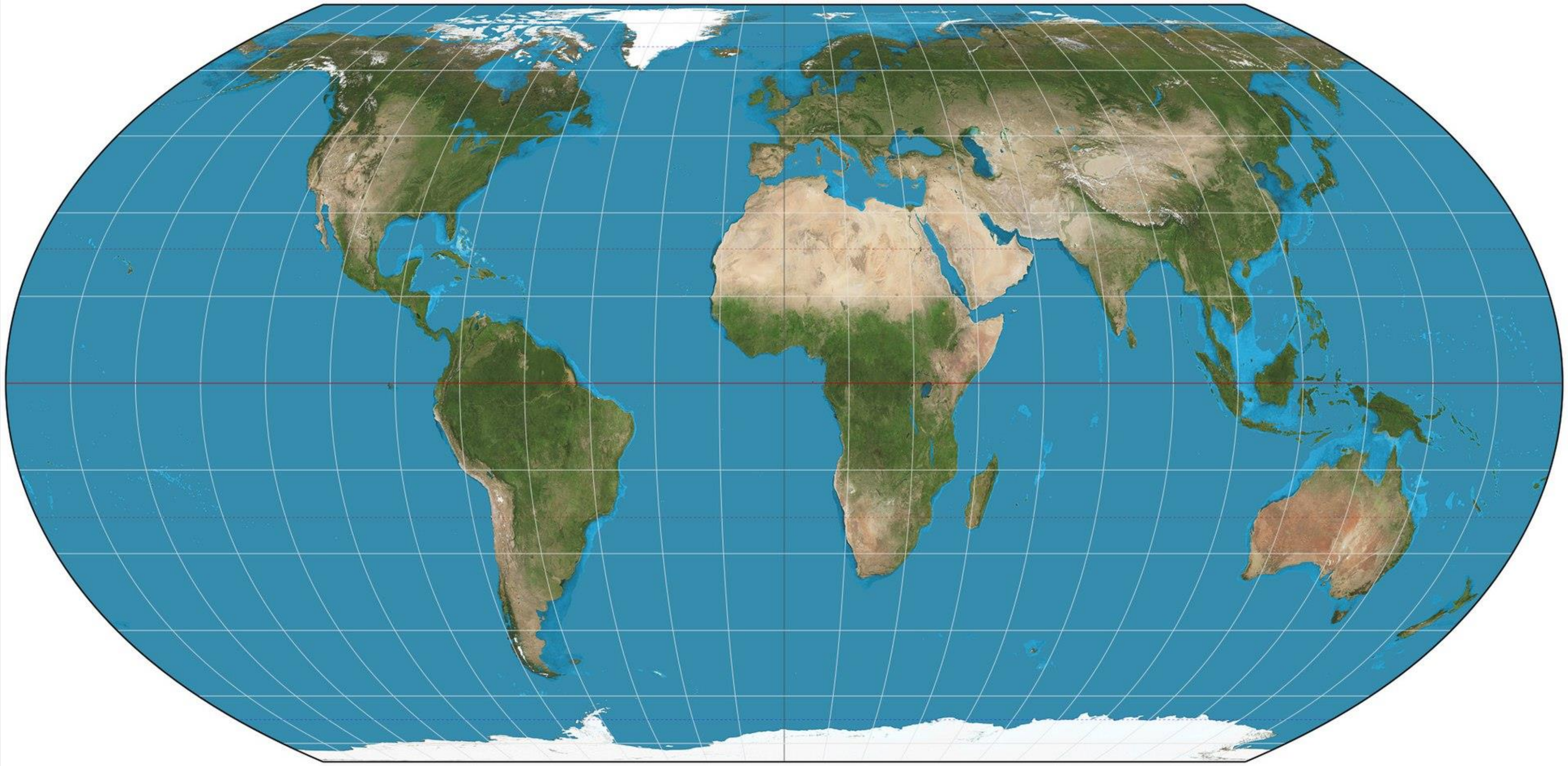
Fig. 2. Example of Threat Zone Analysis for part of San Francisco Bay. Colors indicate the percentage of modeled spills that reached the selected receptor site within 3 days

4. METHODS AND MODELS

- Persistent research on coordinate systems and global grids, map projections, and cartograms, e.g. families and merged projections
- Georegistration – from map to ground, image to ground, map to map, and image to image – of prime concern
- Links increasingly between geographical places and locations on the Internet, and the Internet of Things
- Location uncertainty now includes the vagueness associated with place names and place semantics, e.g. linked data
- Increasing integration of spatial data with process models as the chief means to relate data by colocation in time and space
- Maps are central components of more complex human decision-making systems.
- Map-base modeling methods include agent-based models, cellular automata, and multi-criterion decision making
- Cybersecurity and geospatial privacy now an issue

EQUAL EARTH MAP PROJECTION

EQUAL-AREA PSEUDOCYLINDRICAL PROJECTION FOR WORLD MAPS, ŠAVRIČ, JENNY, AND PATTERSON (2018)



GEOGRAPHIC UNCERTAINTY

Source: NCGIA

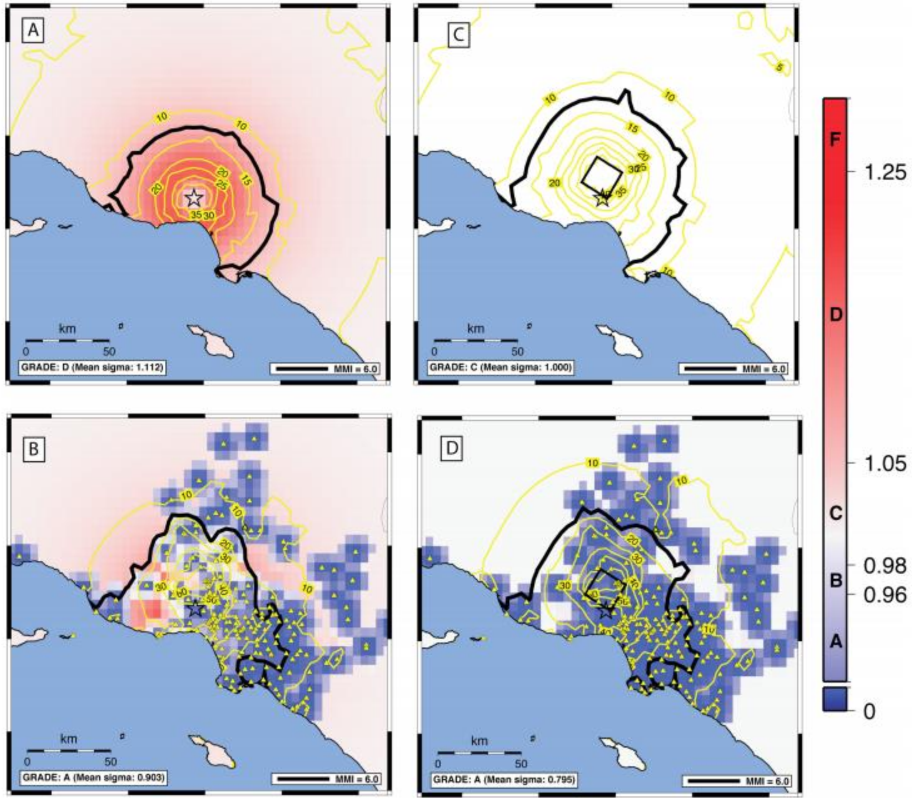
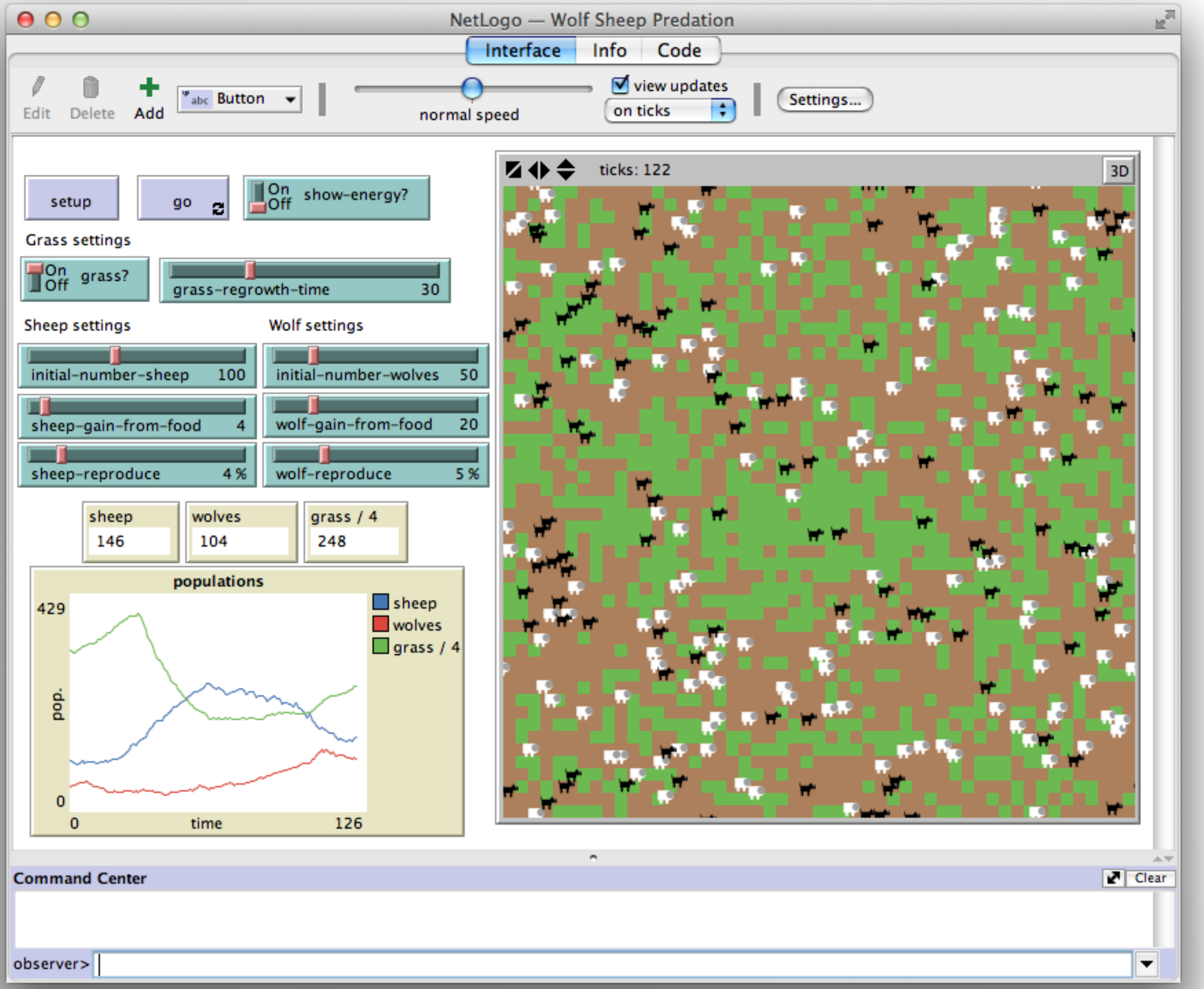


Figure 4. ShakeMap uncertainty maps for the 1994 Northridge, CA, earthquake corresponding to intensity maps in Figure 3. A) Constrained only by magnitude (M6.7) and epicenter, using median distance estimates (see text for details); B) Constrained by magnitude, epicenter, strong motion stations (triangles), and inter-event bias term (see text); C) Constrained by magnitude, and fault dimensions (black rectangle represents the surface projection of the fault from Wald and others (1996); D) Constrained by magnitude, fault dimensions,

Source: USGS Open-File Report 2008-1238

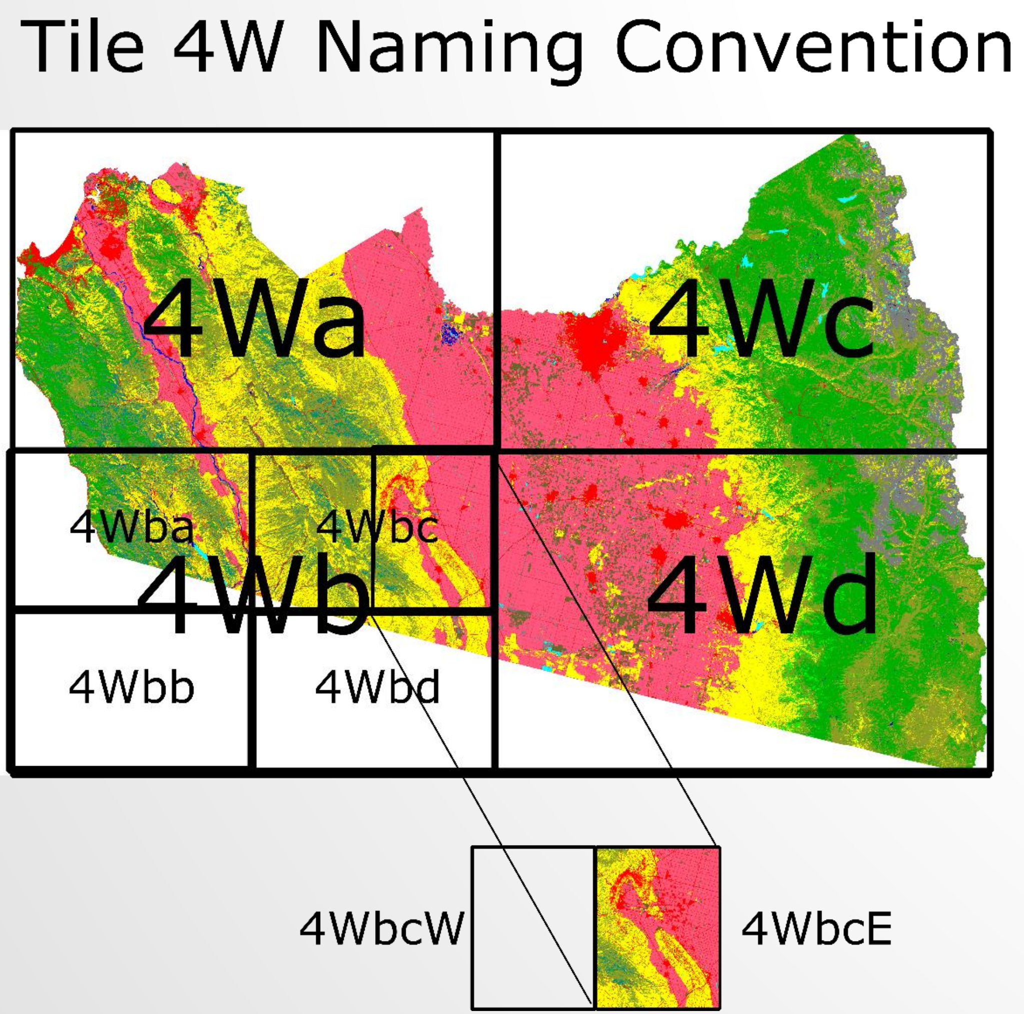
AGENT-BASED MODELS E.G. NETLOGO



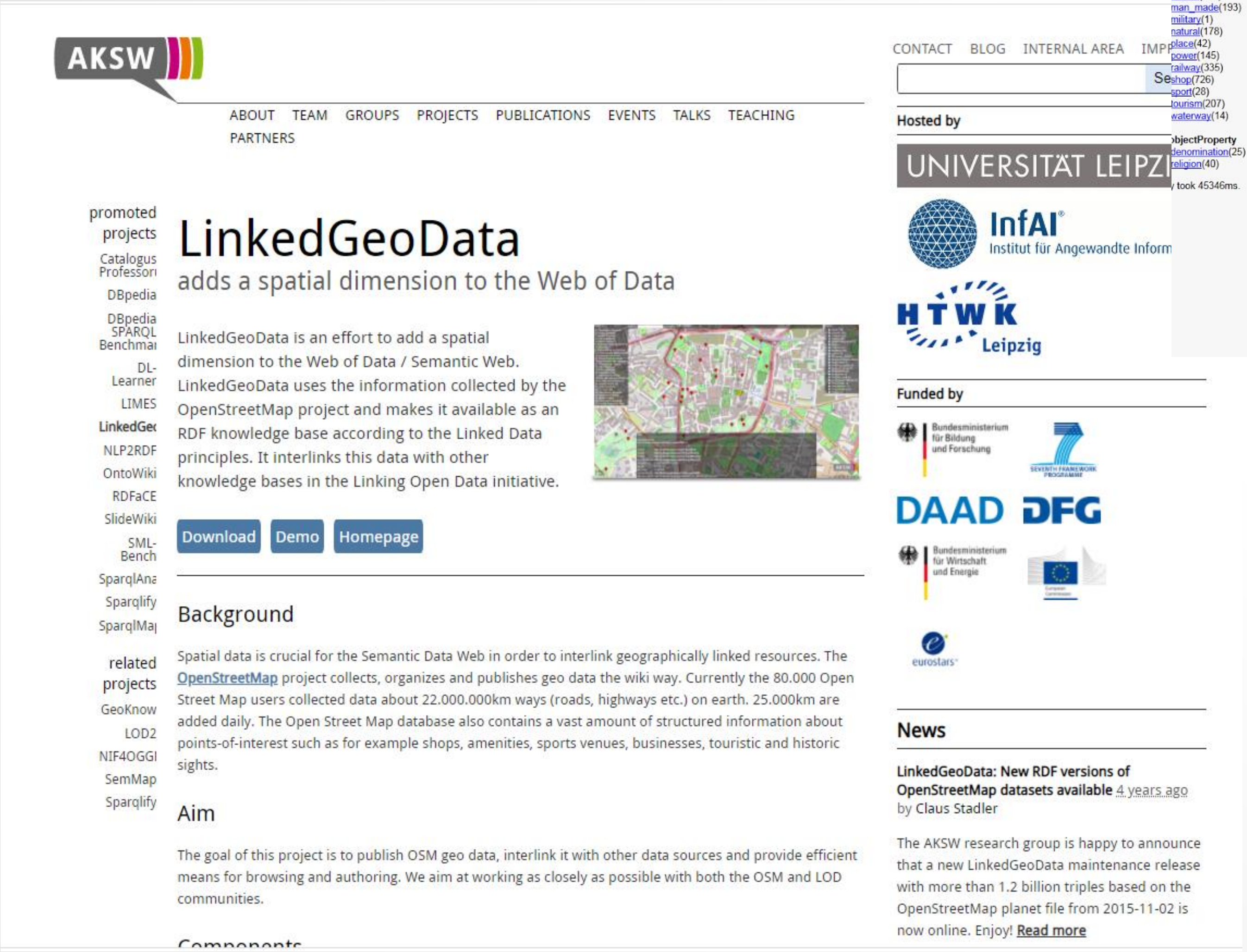
5. GISCIENCE

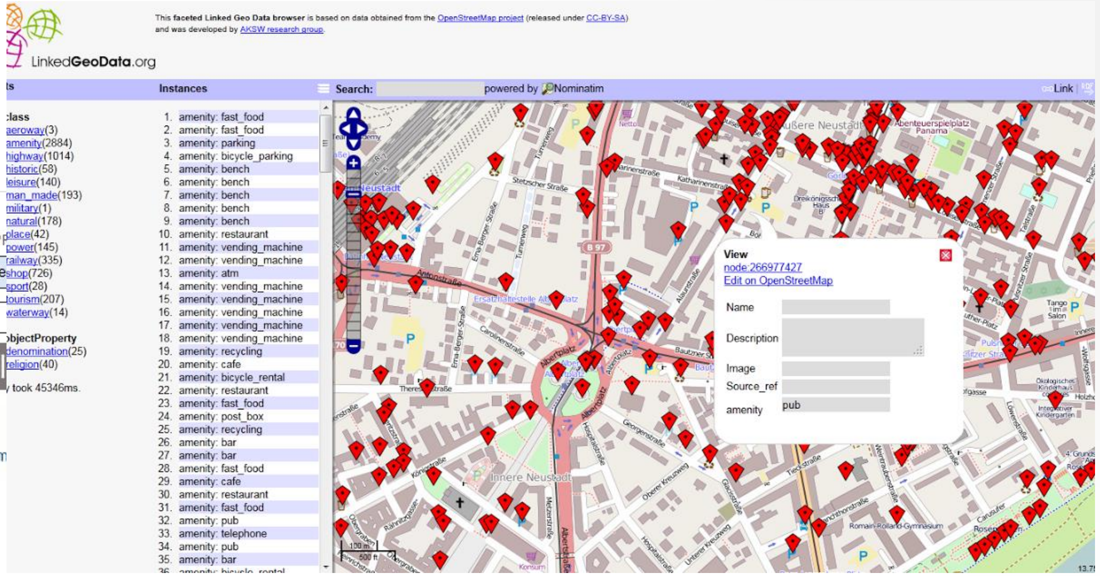
- Emergence of user contributed, crowdsourced, citizen science social media, and tracking data.
- New methods from geostatistics, machine learning, visual analytics, ecology, content analysis, and many other fields.
- Search for fundamental underlying primitives for geographical information
- Computational needs: data partitioning for parallel and high performance computing, cyberGIS
- Emergence of new ontologies for geographical features and objects to logically encode relations among objects. Linked data holds promise for the geospatial web search, data mining and location-based services

DATA PARTITIONING

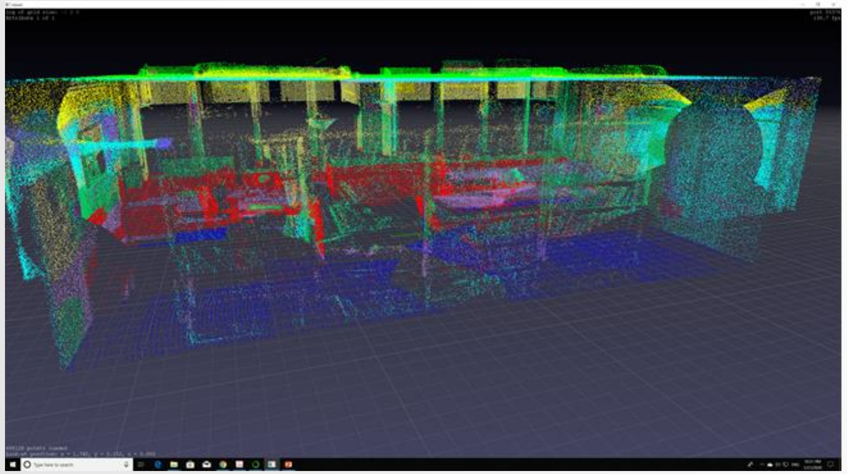


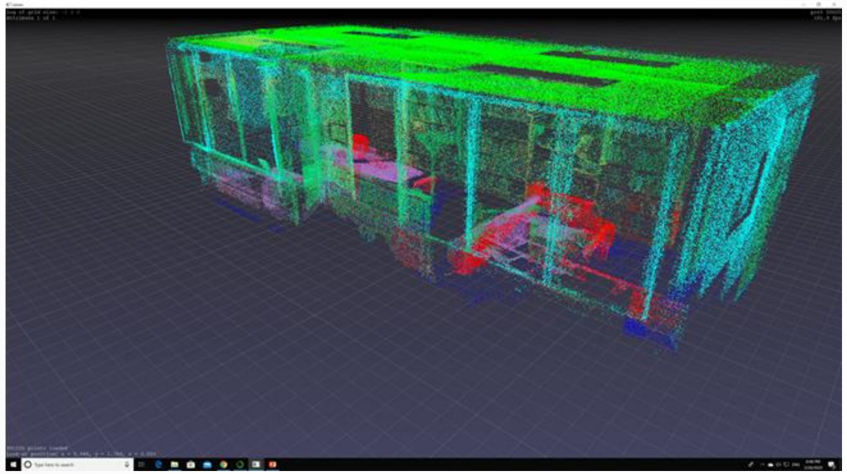
LINKED GEODATA

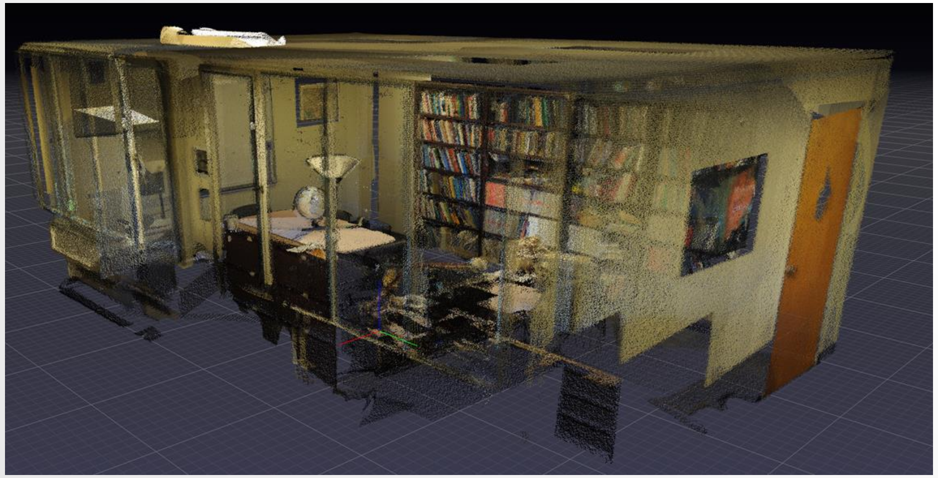




DEEP LEARNING FOR INDOOR CARTOGRAPHY







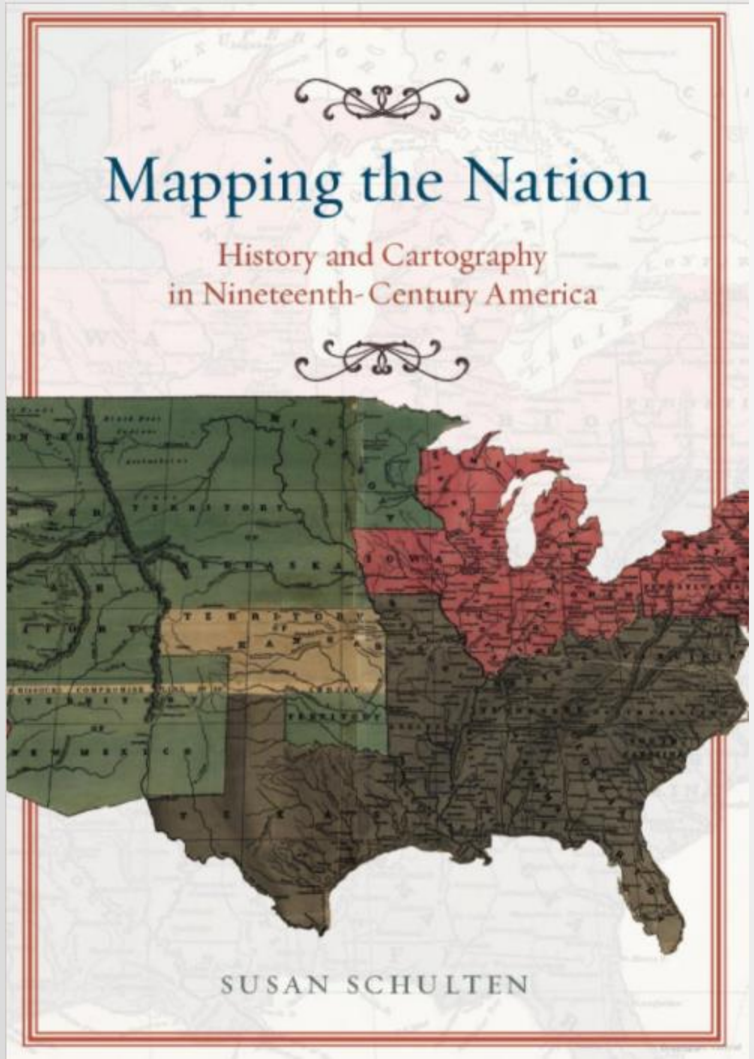
THE NEXT 20 YEARS

- Information visualization—Ubiquitous maps, meta analysis and intelligent indicators
- Data—Sensors everywhere, issues of geoprivacy with digital earth and interior cartography
- Spatial analysis and applications—individuals as data points, with open methods and toolsets
- Methods and models—need to leverage new tools to create new and striking ways of visualizing spatial data
- GIScience—general theory, linked geodata, cyberGIS

CONCLUSION

- Research is the guide to the future of cartography
- Maps will be far more ubiquitous, embedded and functional
- Maps will be part of augmented reality, and can be used to show new narratives
- Every citizen will have the power to search and analyze the world
- Will require new skill sets that current system may be slow to adapt to
- Hopefully maps can help with the coming societal challenges, climate change, and ensuring equity and justice for all

MAPS HAVE POWER



Map showing the distribution of the slave population of the southern states of the United States. Compiled from the census of 1860 (LOC)

Francis Bicknell Carpenter's 1864 painting, "First Reading of the Emancipation Proclamation by President Lincoln"