Methods for Mapping Temporal Data

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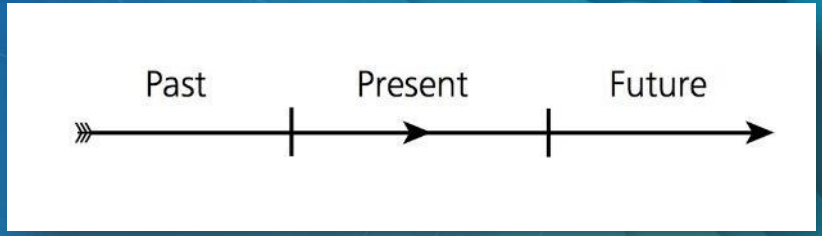
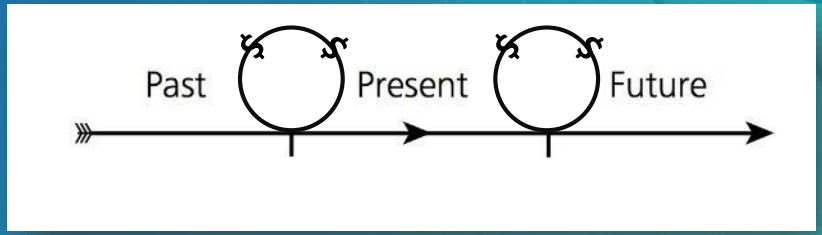
The purpose of mapping temporal data

- To allow for estimation of the degree of change or spatial pattern of cross-correlation between time periods
- The effectiveness of any particular mapping method is related to:
  - Clear and accurate representation of the data and
  - Comprehension by the reader
- Mapping temporal data usually results in increased complexity of the display
- This complexity can lead to:
  - Misunderstanding or misinterpretation, or even
  - Missing the change altogether (change blindness)
- Maps of temporal data benefit fro, clear, explanatory indicators of the current time step within the full range
  - Time slider control
  - Timeline, time text, etc…

The nature of temporal data

- Conceptualizations of time vary
  - Linear (unique, directional time periods)
  - Cyclic (repeating after a specific range in time)
  - Others
- Time is relative to something
  - Clock-driven time – synchronized to a specific clock
  - Event-driven time – synchronized to an event (e.g., BC, AD)
  - State-driven time – synchronized to a change in state
- Time data can be:
  - Point data – specific to point in time
  - Range data – accumulated over a range of time





$T_1\ S_x,\ \ T_2\ S_x,\ \ T_3\ S_x,\ \ldots$
$T_1 - T_0,\ \ T_2 - T_0,\ \ T_3 - T_0,\ \ldots$
$S_1,\ \ S_2,\ \ S_3,\ \ldots$

where T = Time and S = State

http://www.businessinsider.com/how-different-cultures-understand-time-2014-5

Methods to map temporal data

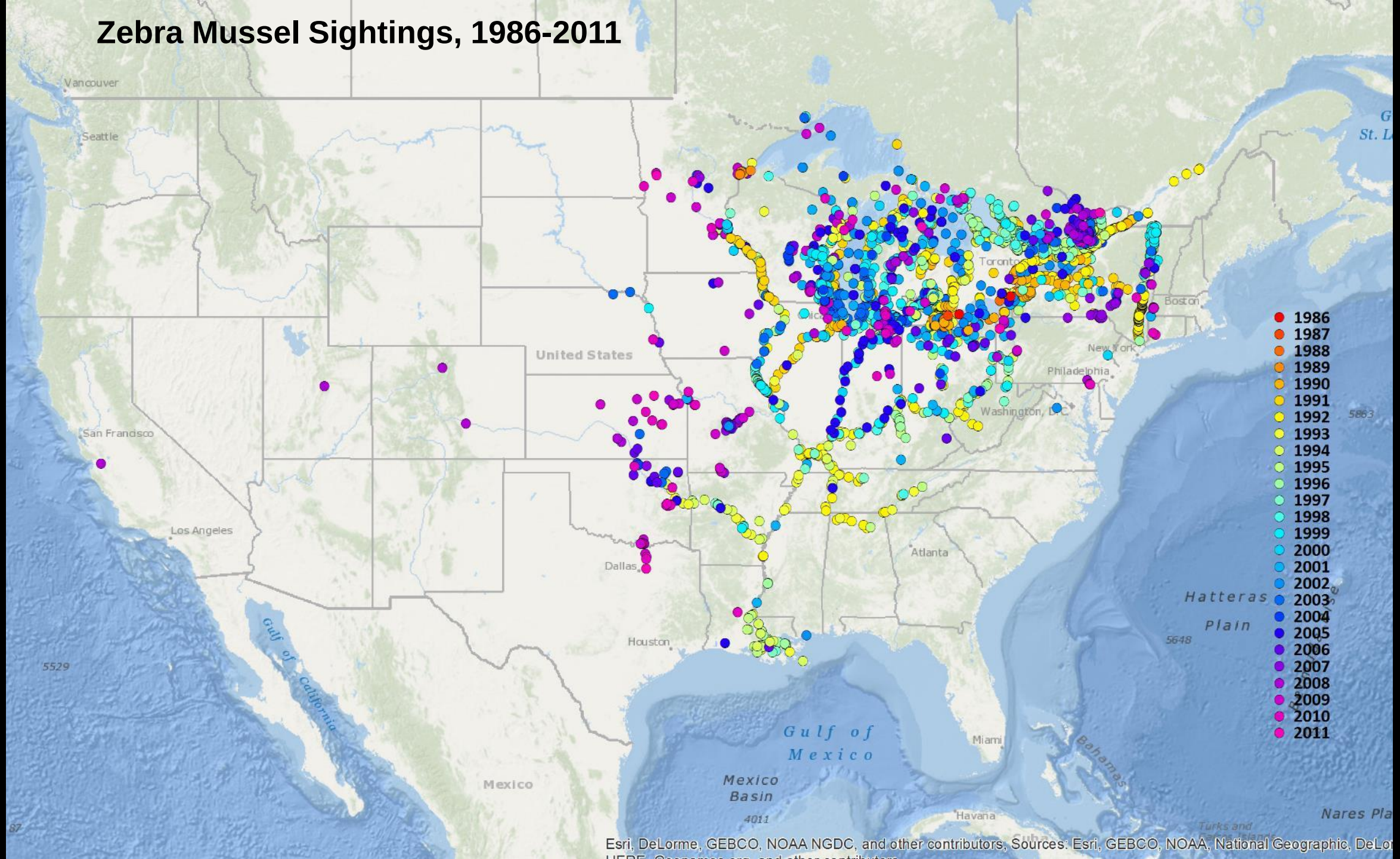
- Static displays
  - Superimposed features
  - Isochron maps
  - Small multiples
  - Complementary graphics
  - Change maps
  - Change analysis maps
  - Space-time cubes

- Dynamic displays
  - Use movement or variation to show or draw attention to change

Superimposed features

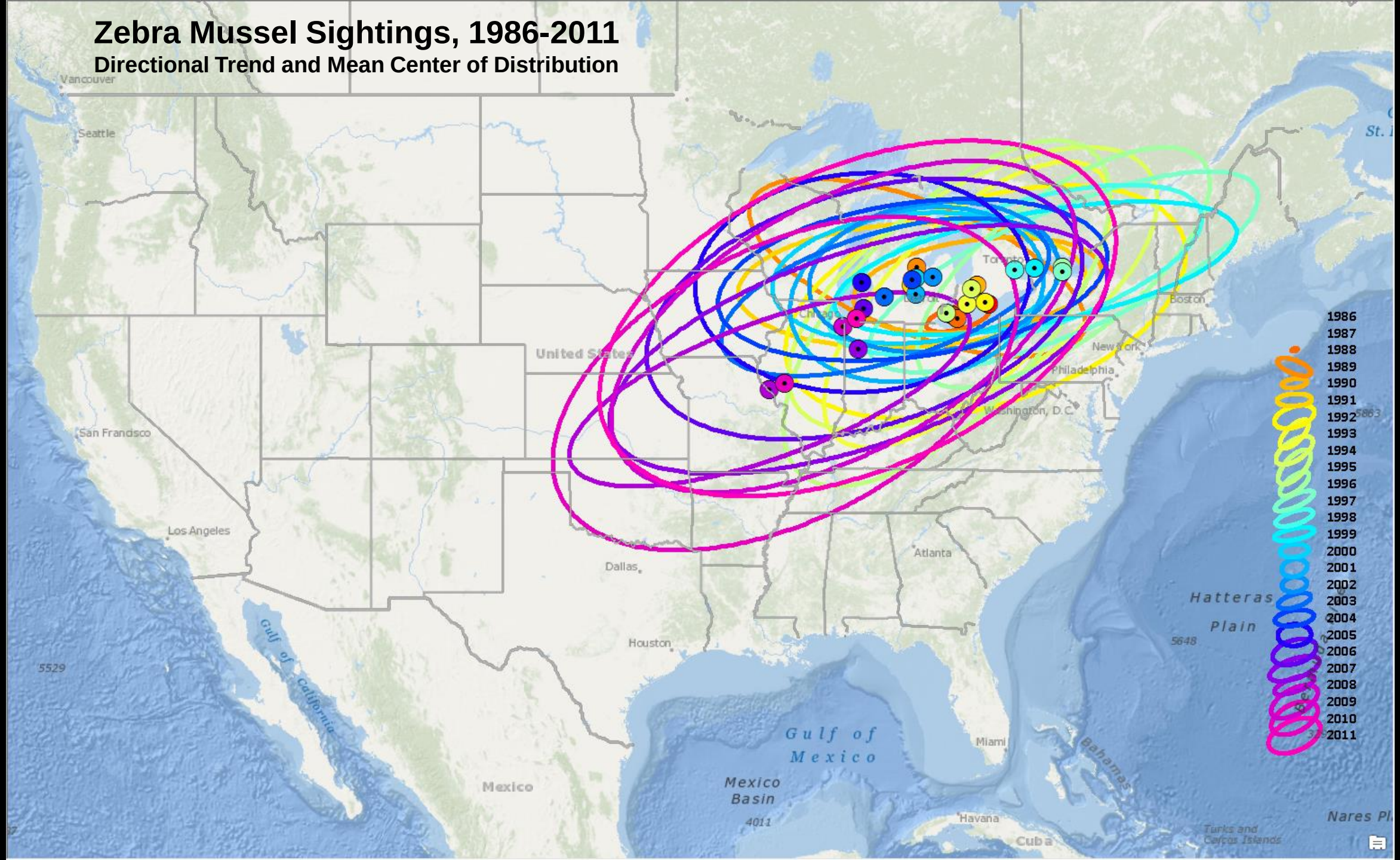
- Superimpose features using distinguishable graphic marks or symbols
- Example
  - Zebra Mussel Sightings

Zebra Mussel Sightings, 1986-2011



Zebra Mussel Sightings, 1986-2011

Directional Trend and Mean Center of Distribution

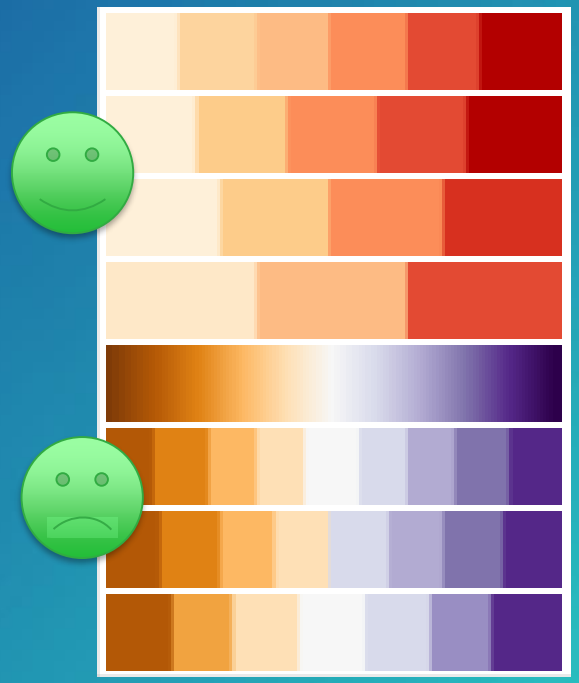


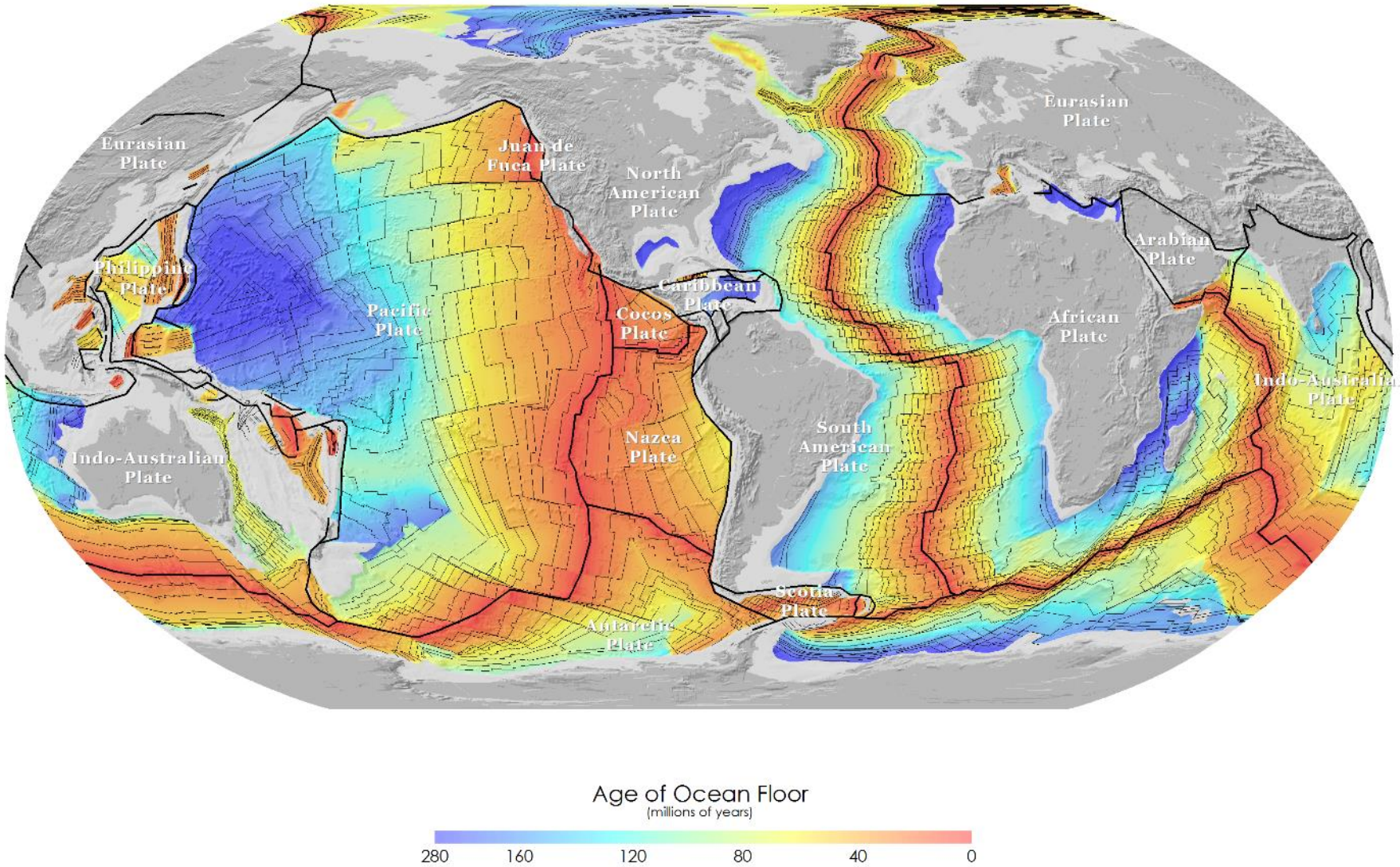
Superimposed features

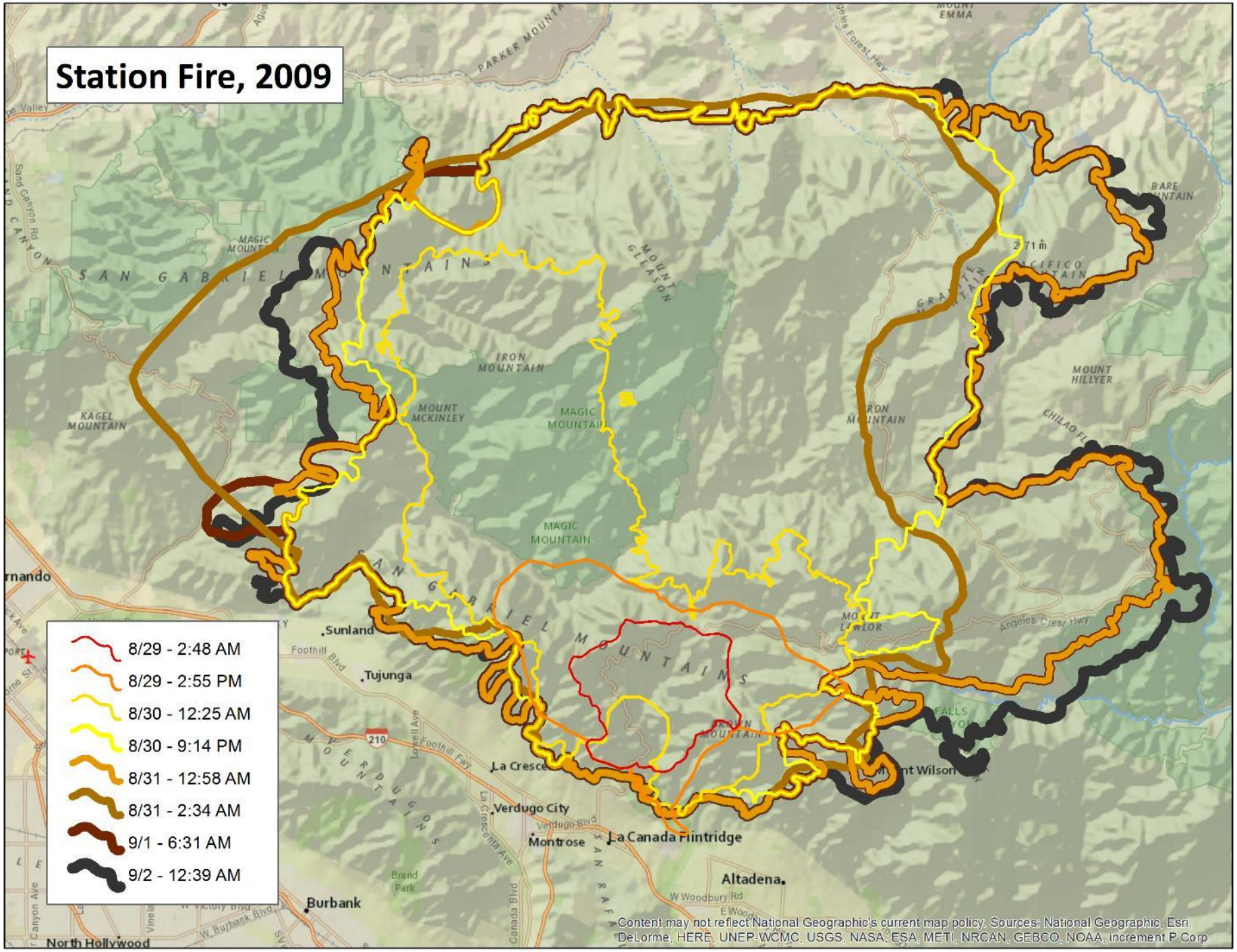
- Limitations
  - Readability decreases as the number of overlapping features increases
  - Difficult to convey the relative importance of features or time periods
- Advantages
  - Conceptually simple to understand
  - Useful for displaying a limited number of features or time periods
  - Useful for inspecting distributions over all time periods

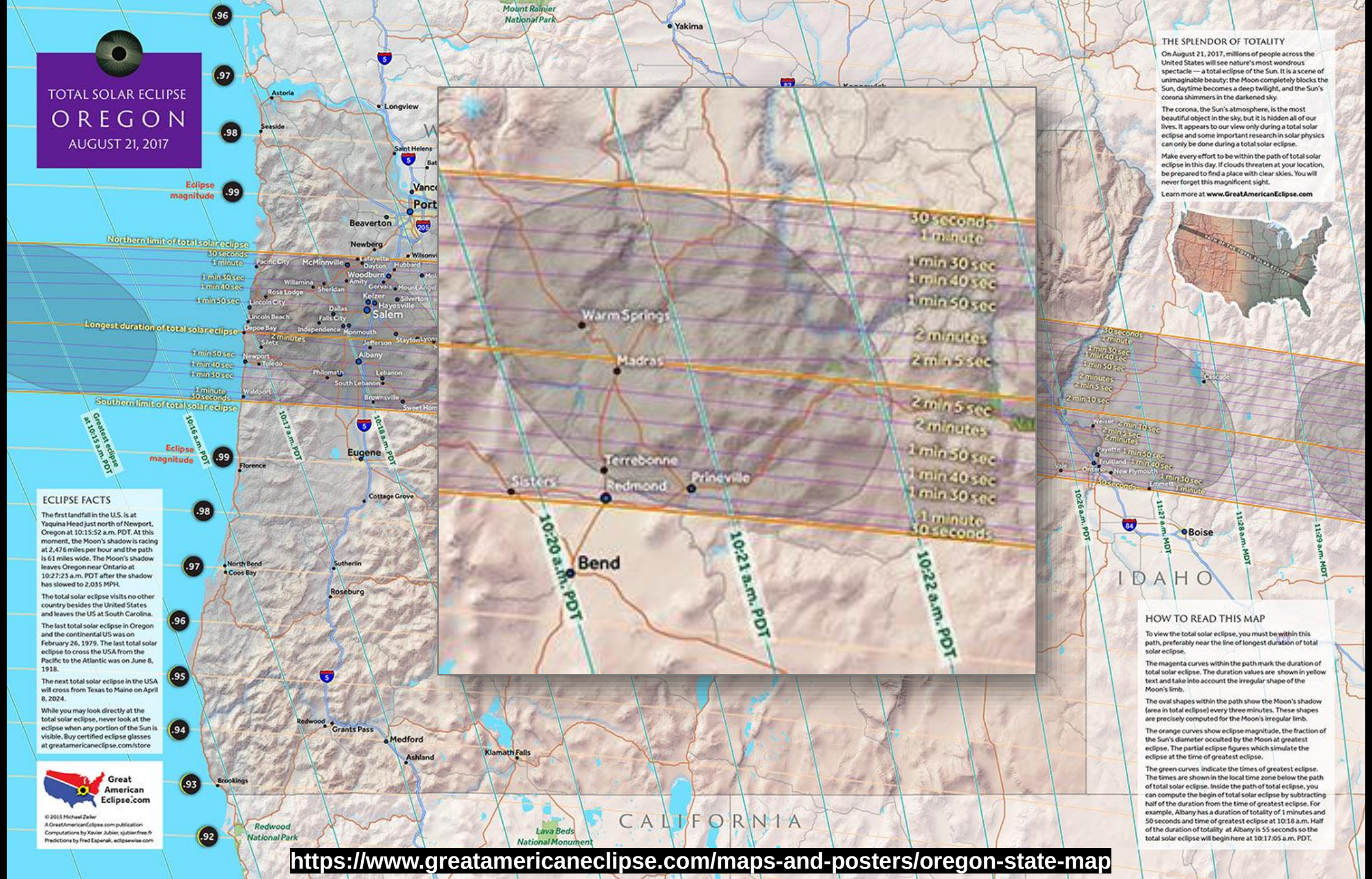
Icochron maps

- Map change over time as a line connecting points relating to the same time or equal time differences
- Areas between isochrones can be colored
- Color selection should reflect the nature of the data (usually sequential)
- Example
  - Age of the Ocean Floor
  - Station Fire, 2009




Eurasian Plate
Eurasian Plate
Juan de Fuca Plate
North American Plate
Philippine Plate
Pacific Plate
Caribbean Plate
Cocos Plate
Arabian Plate
African Plate
Indo-Australian Plate
Indo-Australian Plate
Nazca Plate
South American Plate
Scotia Plate
Antarctic Plate
Age of Ocean Floor
(millions of years)
280
160
120
80
40
0


Station Fire, 2009
8/29 - 2:48 AM
8/29 - 2:55 PM
8/30 - 12:25 AM
8/30 - 9:14 PM
8/31 - 12:58 AM
8/31 - 2:34 AM
9/1 - 6:31 AM
9/2 - 12:39 AM
SAN GABRIEL MOUNTAINS
IRON MOUNTAIN
MOUNT MCKINLEY
MAGIC MOUNTAIN
KAGEL MOUNTAIN
MOUNT GLEASON
MOUNT HILLYER
BARE MOUNTAIN
PACIFICO MOUNTAIN
MOUNT LAWLOR
Sunland
Tujunga
La Crescenta
Verdugo City
Montrose
La Canada Flintridge
Altadena
Burbank
North Hollywood
Mount Wilson
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.



https://www.greatamericaneclipse.com/maps-and-posters/oregon-state-map

Isochron maps

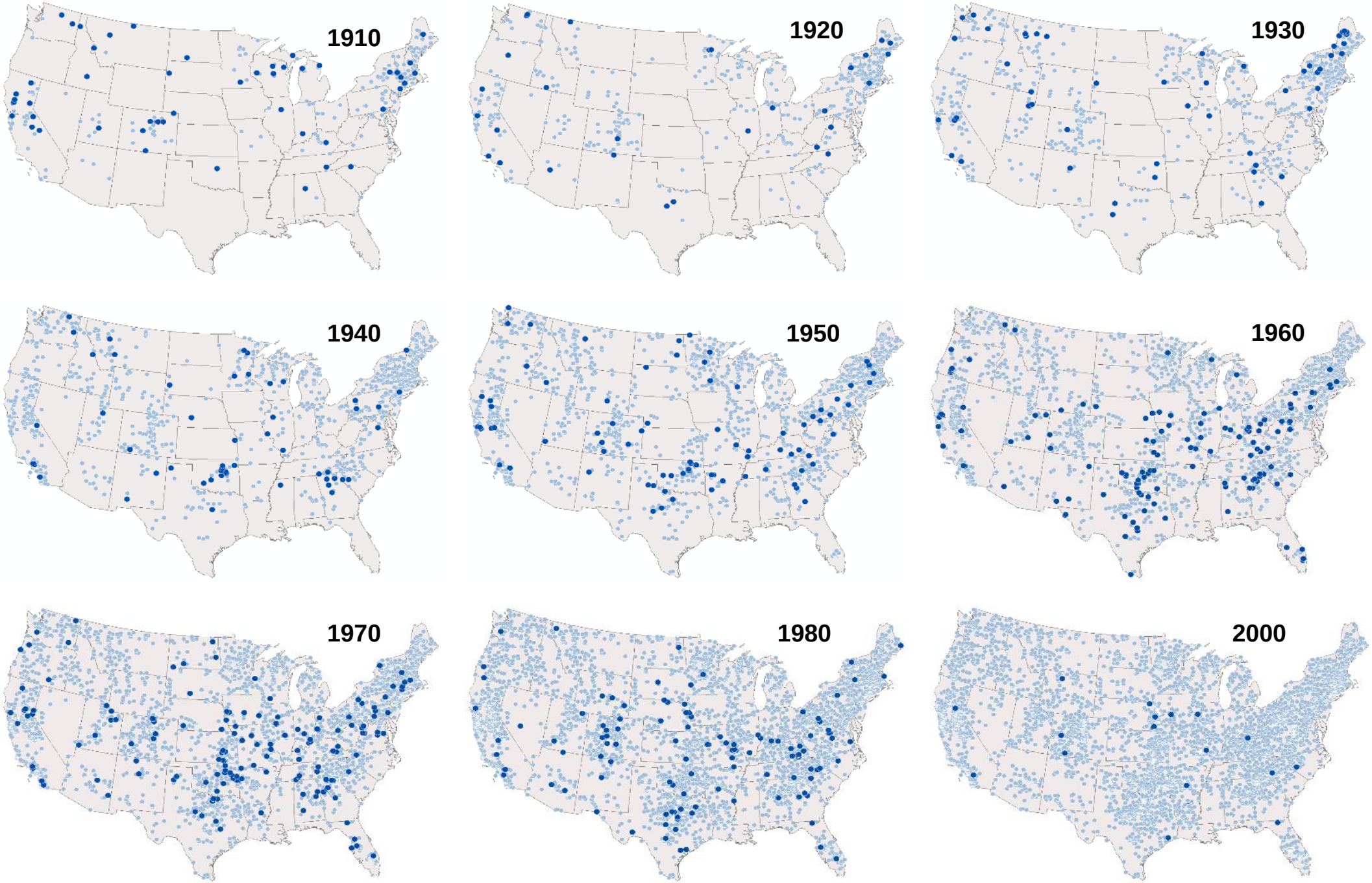
- Limitations
  - Readability often decreases as the number of isochrons increases
  - Overlapping isochrones reduces readability
- Advantages
  - Conceptually simple
  - Useful for displaying a limited number of time periods
  - Useful for visualizing distributions that increase or decrease incrementally

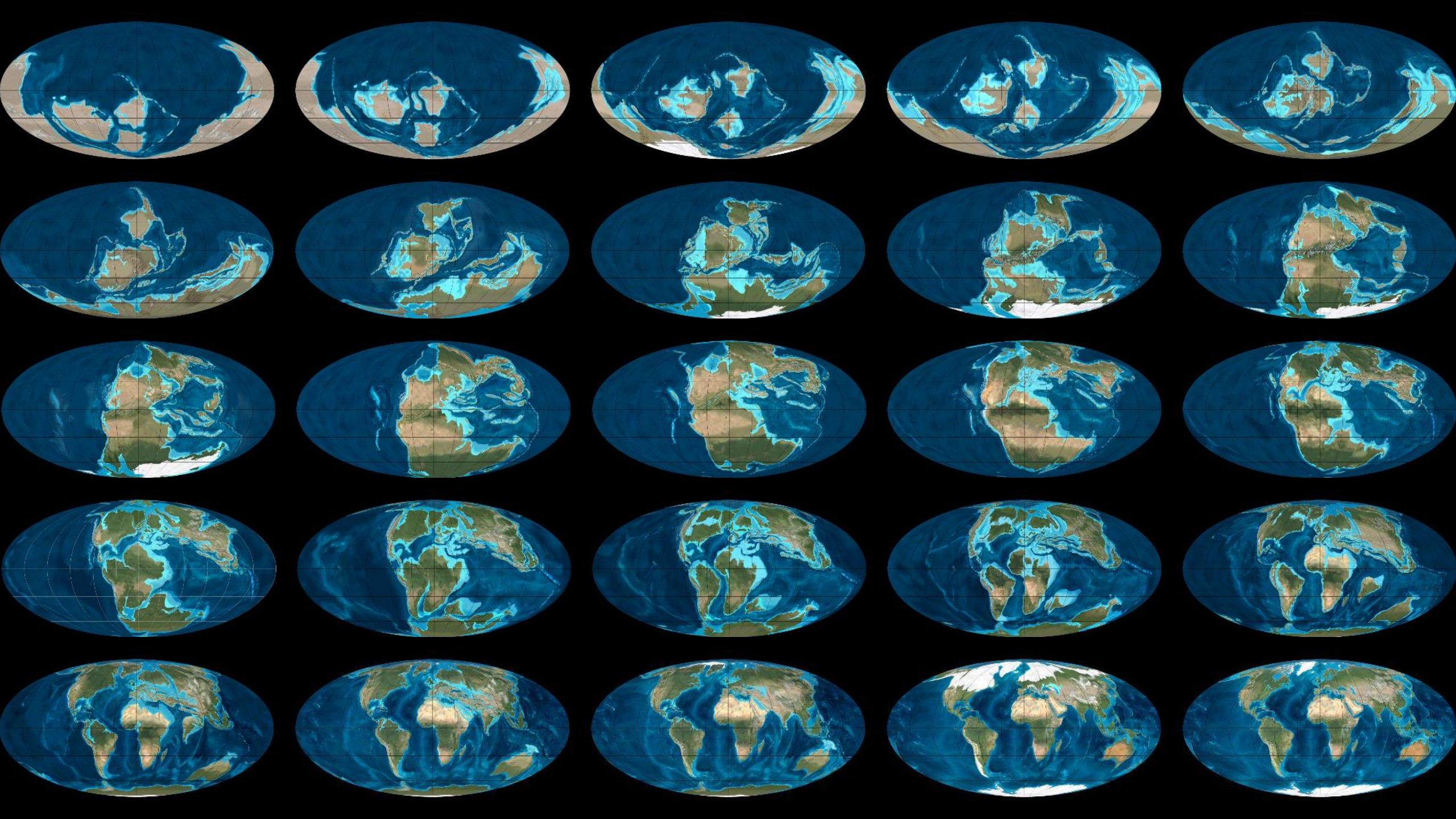
Small multiples

- A series of displays with the same graphic design structure depicting changes from multiple to multiple (i.e., map to map)
- Should be comparable, multivariate, “shrunken, high-density graphics” that are based on a large data matrix and used to show shifts in relationships among variables
- The consistency of design assures that attention is directed toward changes in the data
- Example
  - Dam Construction in the US
  - Plate Tectonics

Dam Construction

- Current Year
- Previous Years



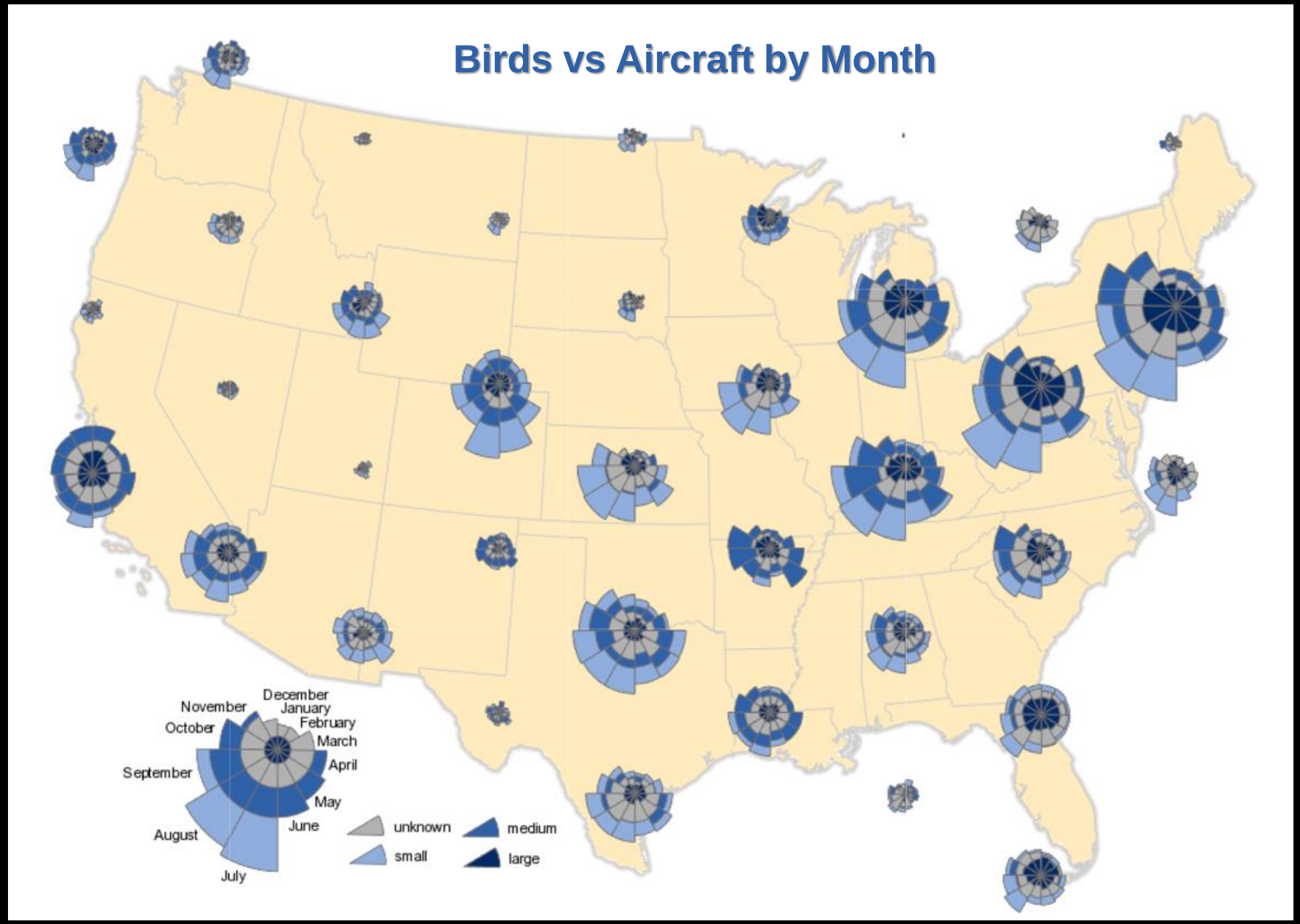


Small multiples

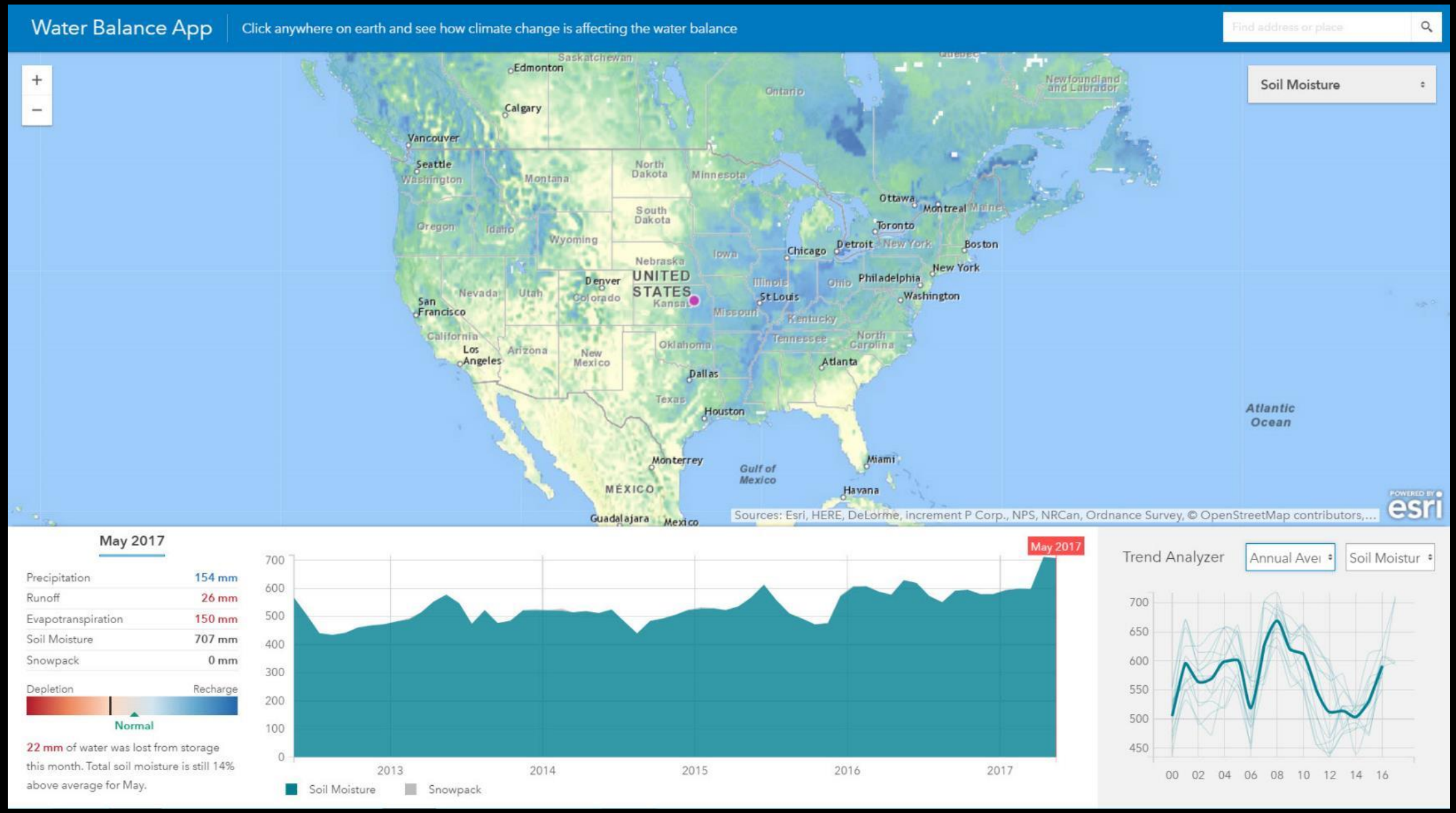
- Limitations
  - Maps cannot contain much base information
  - Legends cannot be on the maps
  - Usually requires an accompanying reference map of the study area
- Advantages
  - Conceptually simple to understand
  - Can be used to show large numbers of maps (i.e., time periods)
  - Better for comparing data sets than distinguishing among data sets, especially if complexity of the display is increased

Complementary graphics

- Combining a map of a single time period with other graphics to display the temporal data
- Graphics used to display the temporal data include:
  - Timelines
  - Time series graphs
  - Spiral displays
  - Circular graphs
- Examples
  - Birds vs Aircraft by Month
  - Water Balance App



http://www.esri.com/products/maps-we-love/birds-vs-aircraft

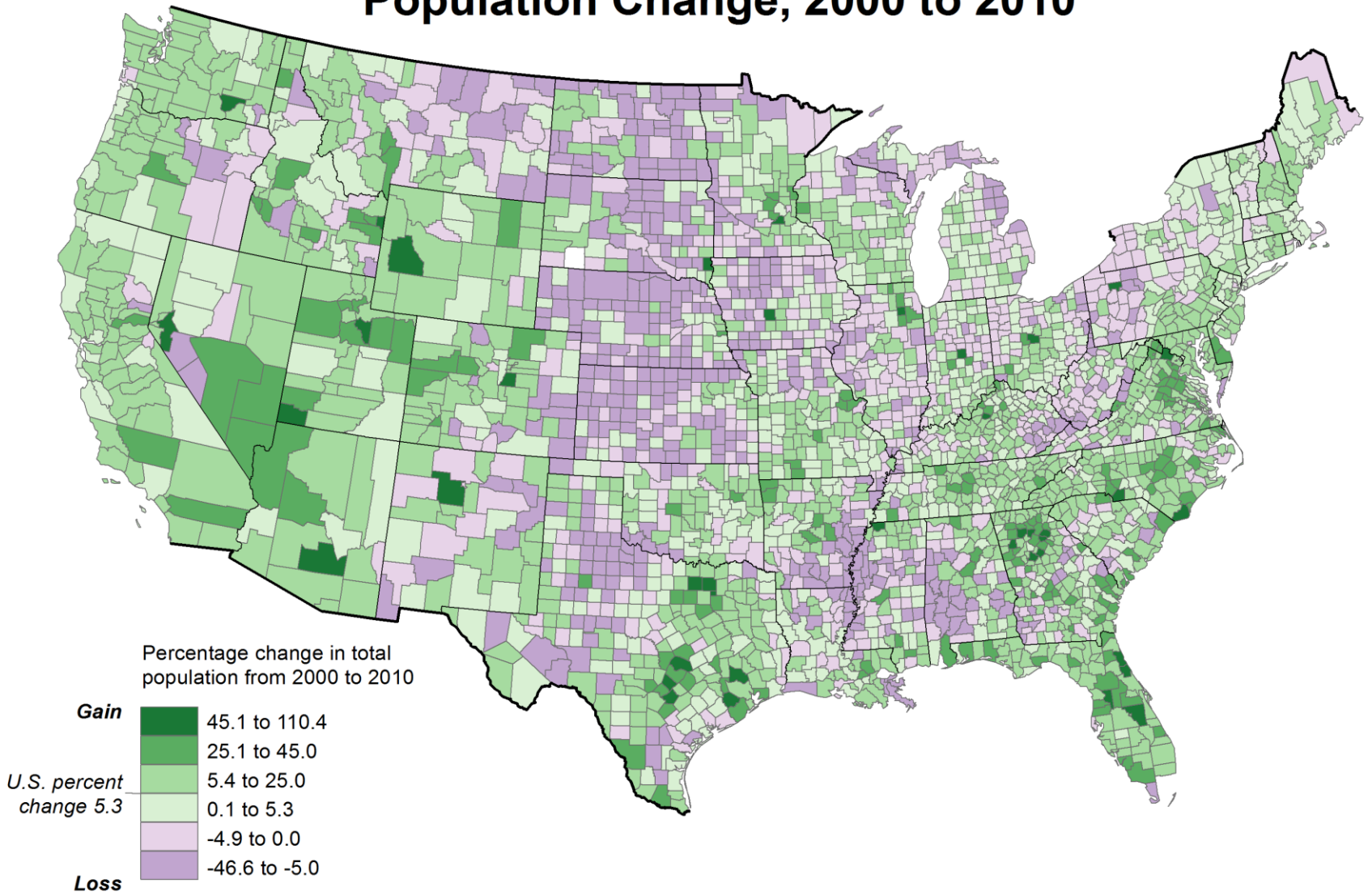


https://vannizhang.github.io/water-balance-app/

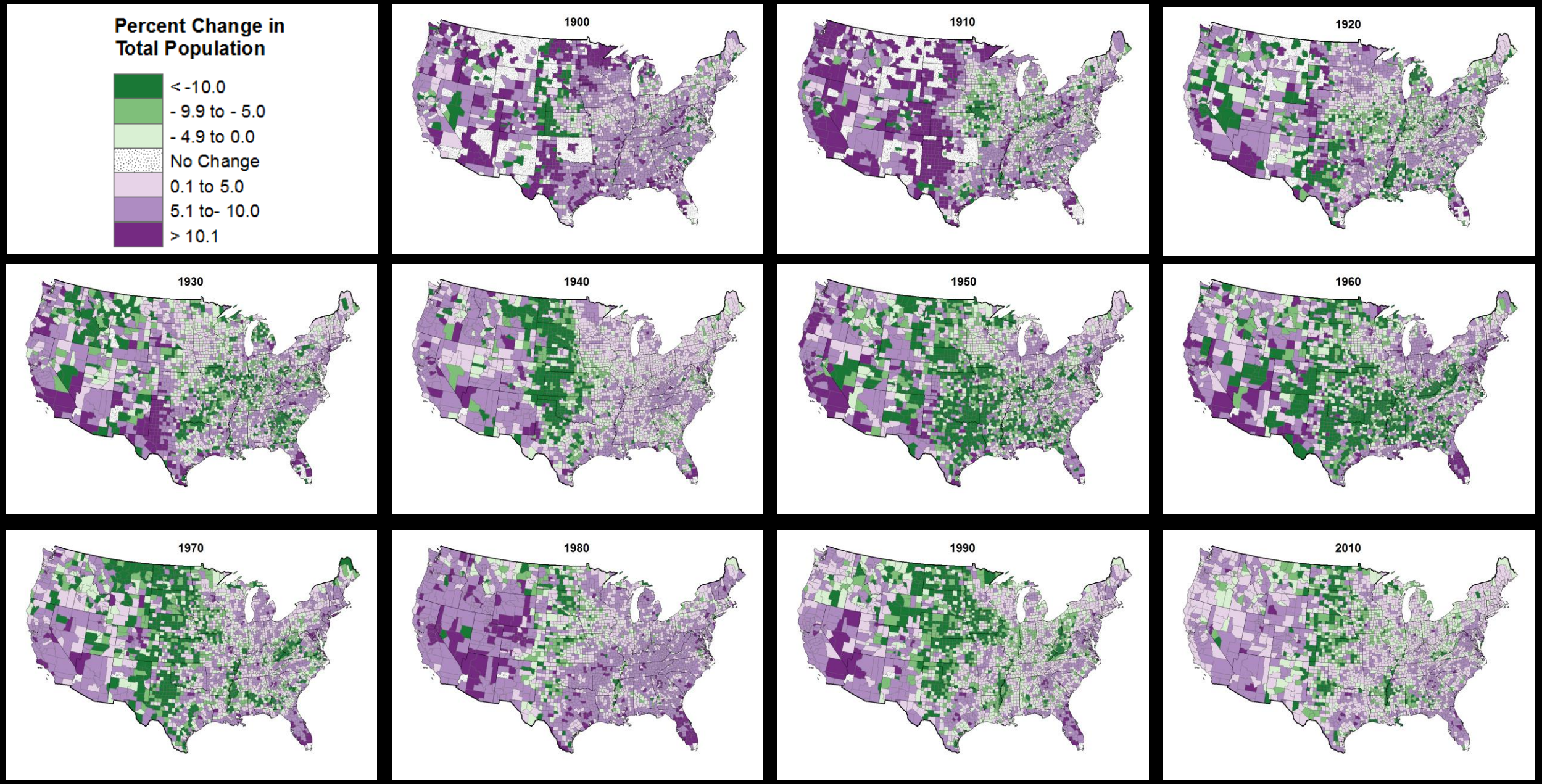
Change maps

- Depict the change over time at point locations, within homogeneous areas, or along linear features
- Calculate the change and map it accordingly
- Often used to show change between only two time periods as the rate of change
- Examples
  - Percent Change in Total Population

Population Change, 2000 to 2010



Population Change, 1900 - 2010



Change maps

- Limitations
  - Because the number of classes the human eye can distinguish is limited, change maps are generally restricted to comparisons of two or few time periods
  - In other words, the maximum number of discernable classes or categories is limited
  - Appropriate symbol (color) selection and classification is important for map comprehension

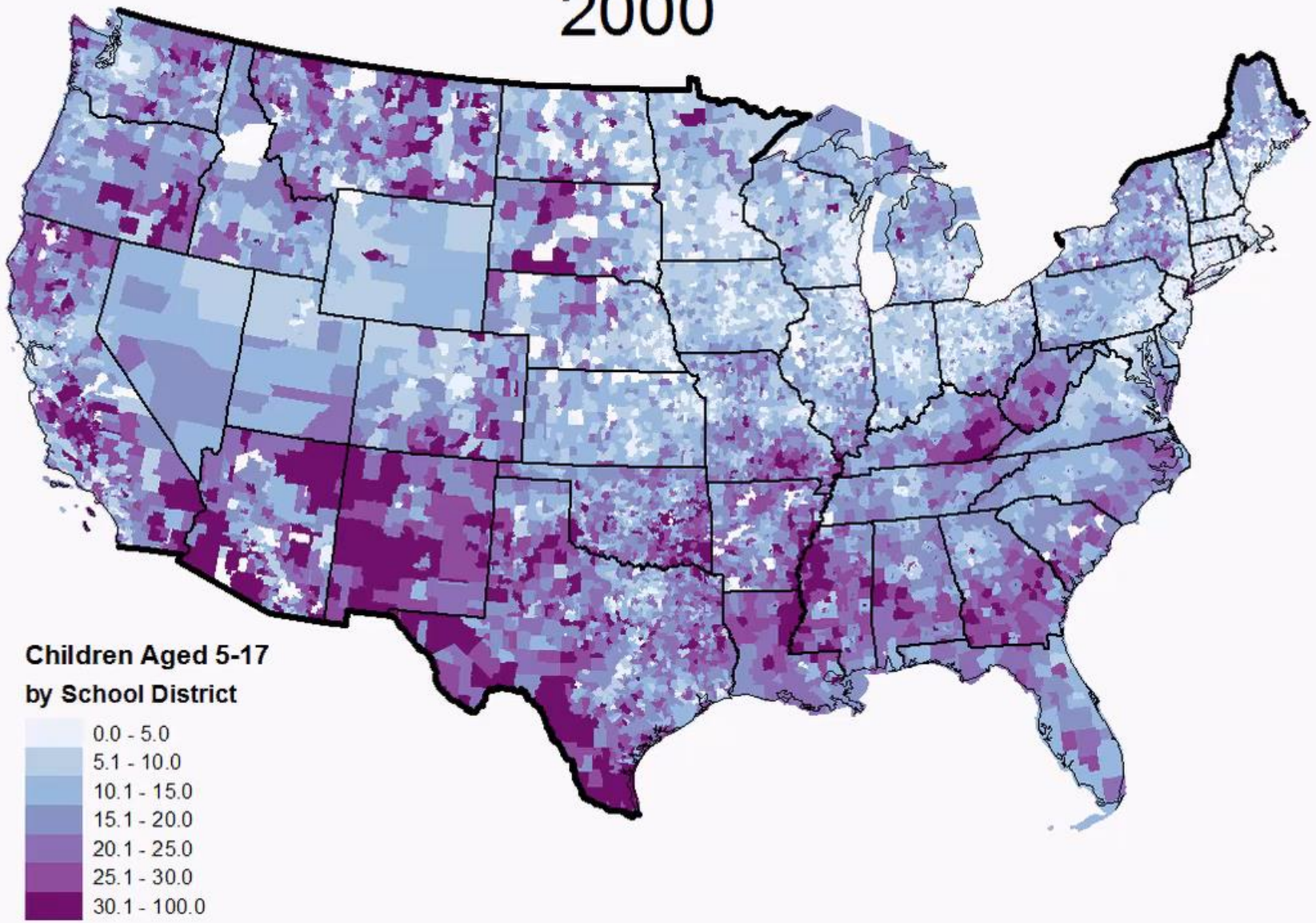
- Advantages
  - Useful for displaying change between two time periods
  - Allow for careful scrutiny of specific types of change

Change analysis maps

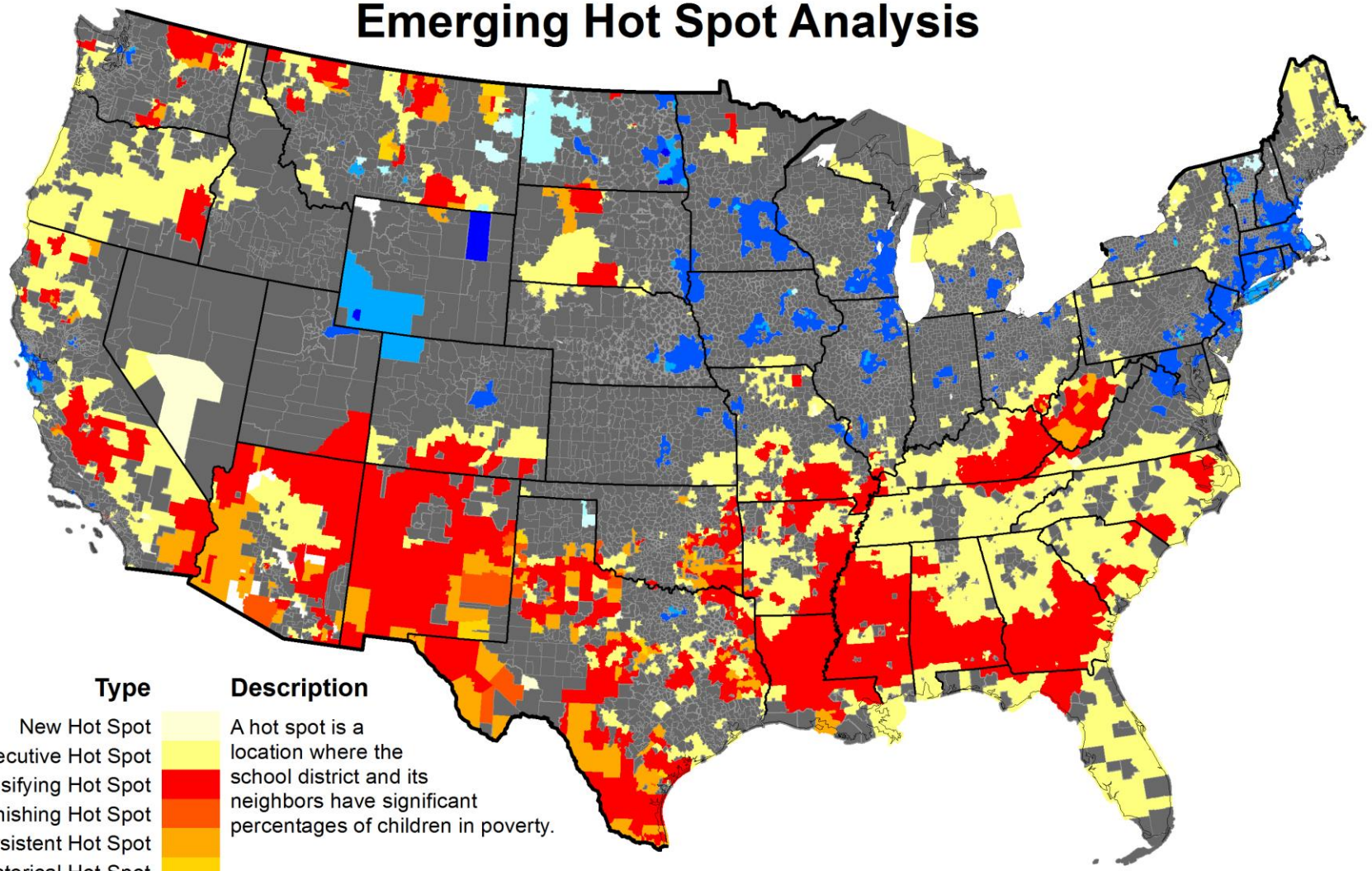
- The change in a variable between time periods or over a range of time periods is analyzed statistically and summarized in a single numerical index displayed on a single map
  - Hot spot analysis
  - Cluster and outlier analysis
- The amount of change is sometimes simplified to a binary index (e.g., increase/decrease)
- Example
  - Percent Change in Poverty Rates of School-Aged Children

Poverty Rates

2000

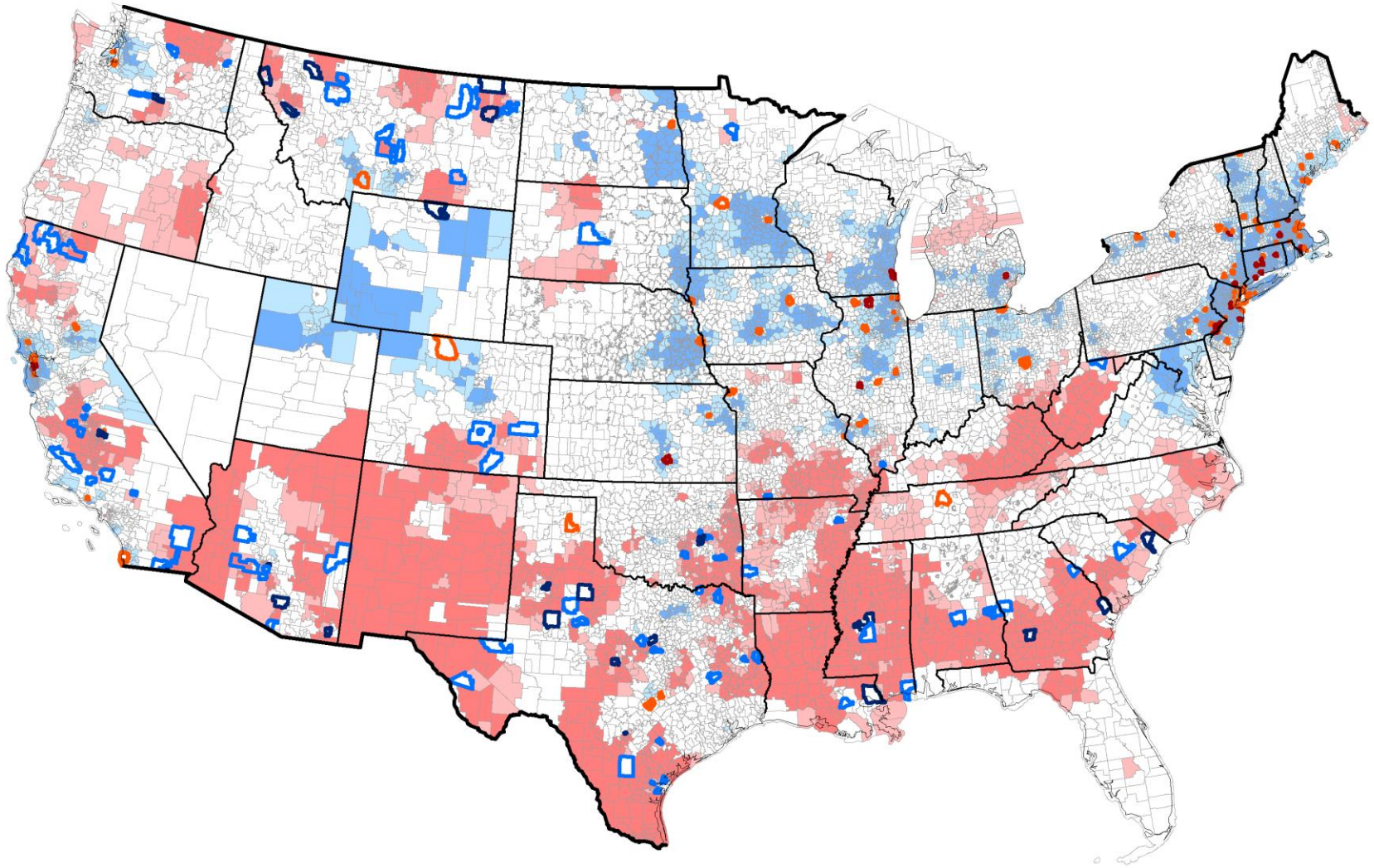


Emerging Hot Spot Analysis



Type	Description
New Hot Spot	A hot spot is a location where the school district and its neighbors have significant percentages of children in poverty.
Consecutive Hot Spot	
Intensifying Hot Spot	
Diminishing Hot Spot	
Persistent Hot Spot	
Historical Hot Spot	
	Not significant
Historical Cold Spot	Significant cold spot for at least 15 of the 16 years, but not 2015
Persistent Cold Spot	Significant cold spot for at least 15 of the 16 years
Diminishing Cold Spot	Significant cold spot for at least 15 of the 16 years, including 2015, and the trend is decreasing
Intensifying Cold Spot	Significant cold spot for at least 15 of the 16 years, including 2015, and the trend is decreasing
Consecutive Cold Spot	Significant cold spot in the last time steps only
New Cold Spot	Significant cold spot in 2015 only

Local Outlier Analysis



- 50 - 75% Outliers with Low Poverty Clild Rates
- 75 - 100% Outliers with Low Child Poverty Rates
- 50 - 75% Outliers with High Poverty Clild Rates
- 75 - 100% Outliers with High Child Poverty Rates
- 50 - 75% Clusters with Low Child Poverty Rates
- 75 - 100% Clusters with Low Child Poverty Rates
- 50 - 75% Clusters with High Child Poverty Rates
- 75 - 100% Clusters with High Child Poverty Rates

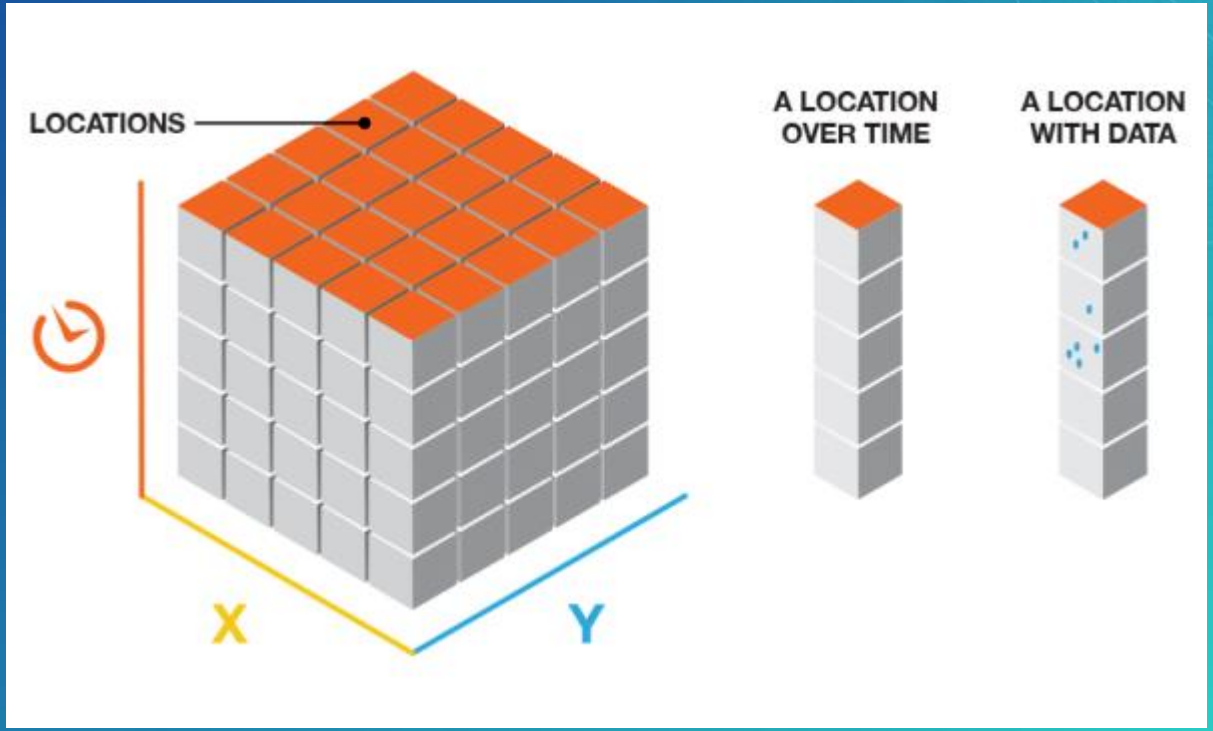
Change analysis maps

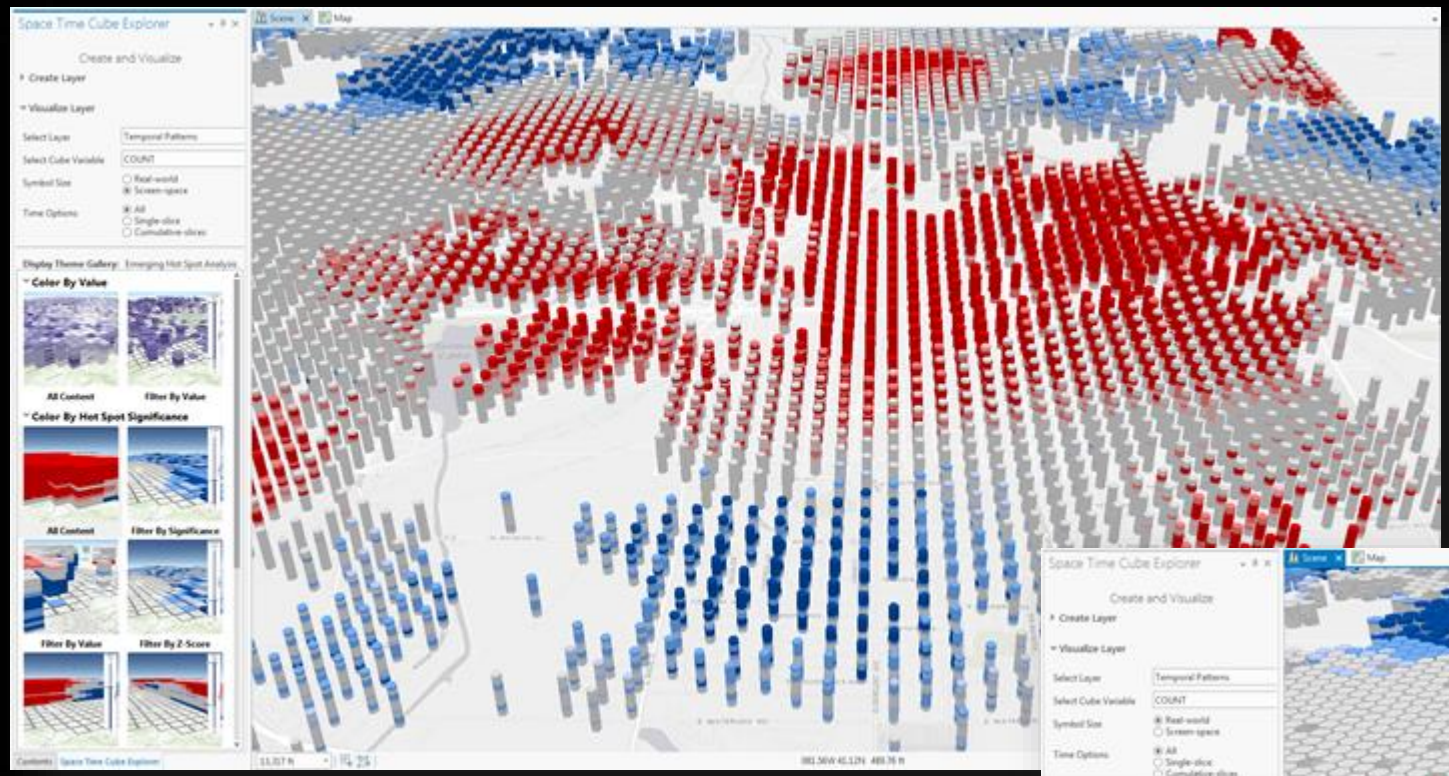
- Limitations
  - Requires spatial data for the variable for the each time period
    - Use the Fill Missing Values tool to impute missing data
  - Often use data that's available rather than data that's appropriate
  - Generally requires GIS technology

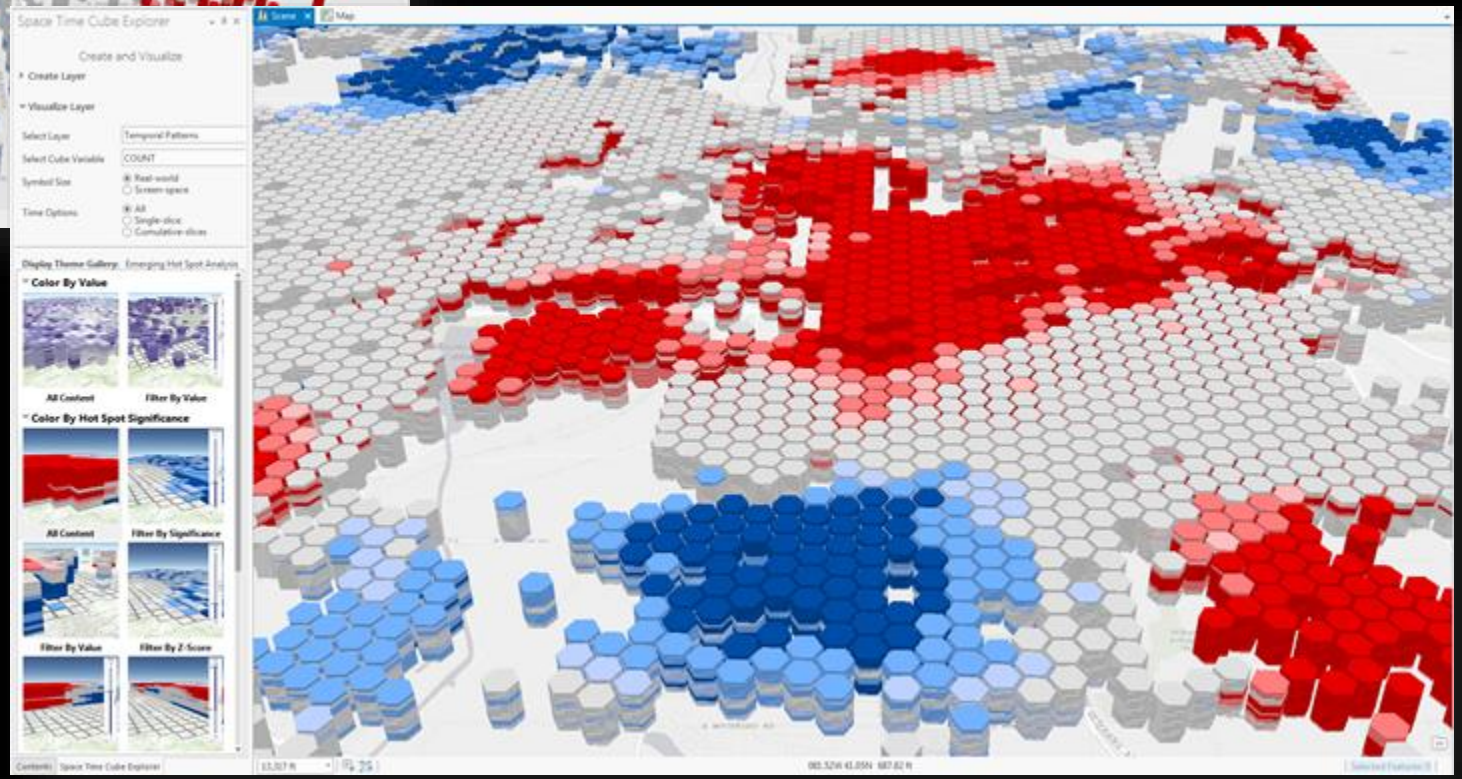
- Advantages
  - The spatial and temporal neighborhood can be specified
  - Good for distinguishing variation/trends across time periods
  - GIS can facilitate analysis of the change, although complex problems may require more sophisticated computing capabilities as more variables are added

Space-time cubes

- Superimpose features using distinguishable graphic marks or symbols
- Examples
  - Space-Time Cube Explorer
  - Napolean’s March on Moscow

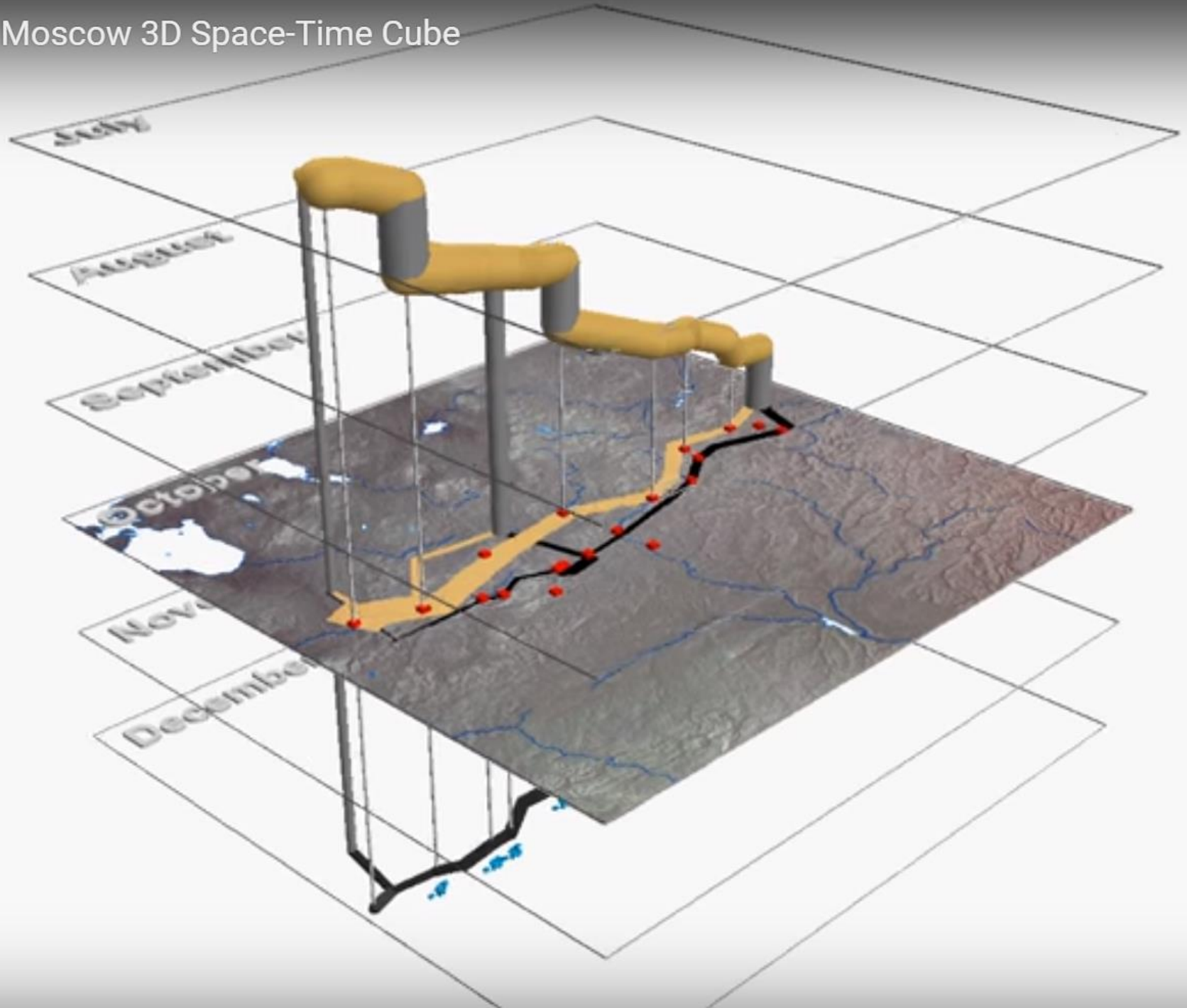






www.esriurl.com\SpaceTimeCubeExplorer

Napoleon's March on Moscow 3D Space-Time Cube



Space-time cubes

- Limitations
  - Easier to understand for linear features
  - Difficult to see adjacent point or polygonal features
  - Difficult to see earlier time periods
  - Some point or polygonal features/time periods are always obscured

- Advantages
  - Somewhat simple to understand
  - Useful for displaying a last few time periods for point or polygonal features
  - Useful to convey the relative importance of features (locations) or time periods

Review: Methods to map temporal data

- Static displays
  - Superimposed features
  - Isochron maps
  - Small multiples
  - Complementary graphics
  - Change maps
  - Change analysis maps
  - Space-time cubes

- Dynamic displays
  - Use movement or variation to show or draw attention to change

Other temporal data sessions

Wednesday, July 12

8:30 am - 9:45 am

Spatial Data Mining II: A Deep Dive Into Space-Time Analysis

SDCC - Ballroom 06 E

If possible, please first attend Spatial Data Mining I

Thursday, July 13

1:30 pm - 2:45 pm

Desktop Mapping: Working with Temporal Data

SDCC - Room 05 A

Thursday, July 13

3:15 pm - 4:30 pm

Spatial Data Mining II: A Deep Dive Into Space-Time Analysis

SDCC - Ballroom 06 E

If possible, please first attend Spatial Data Mining I

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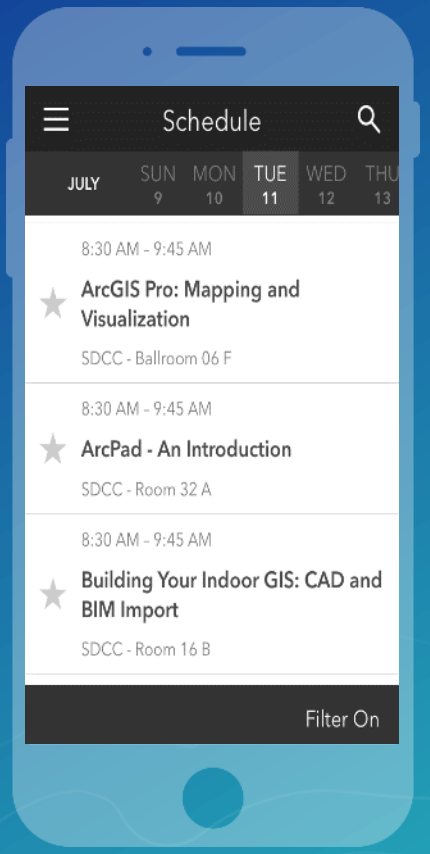
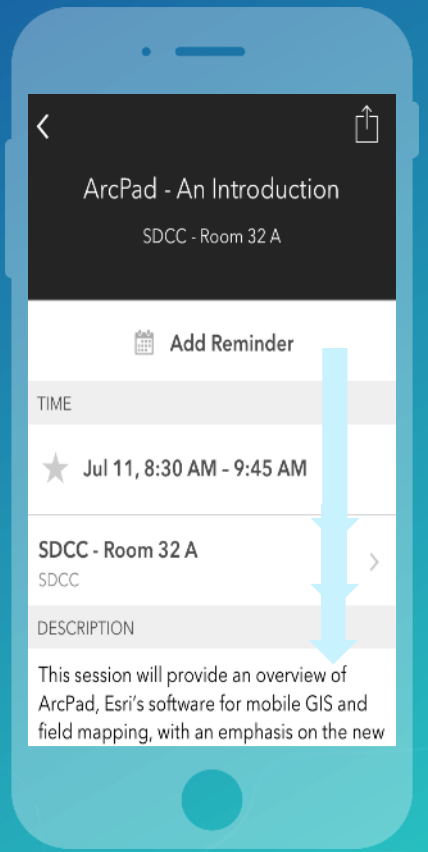
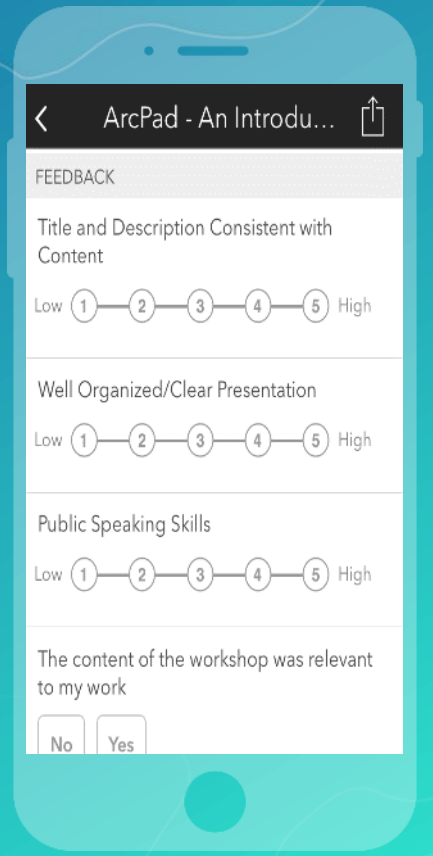


Scroll down to find the survey



Complete Answers and Select "Submit"



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