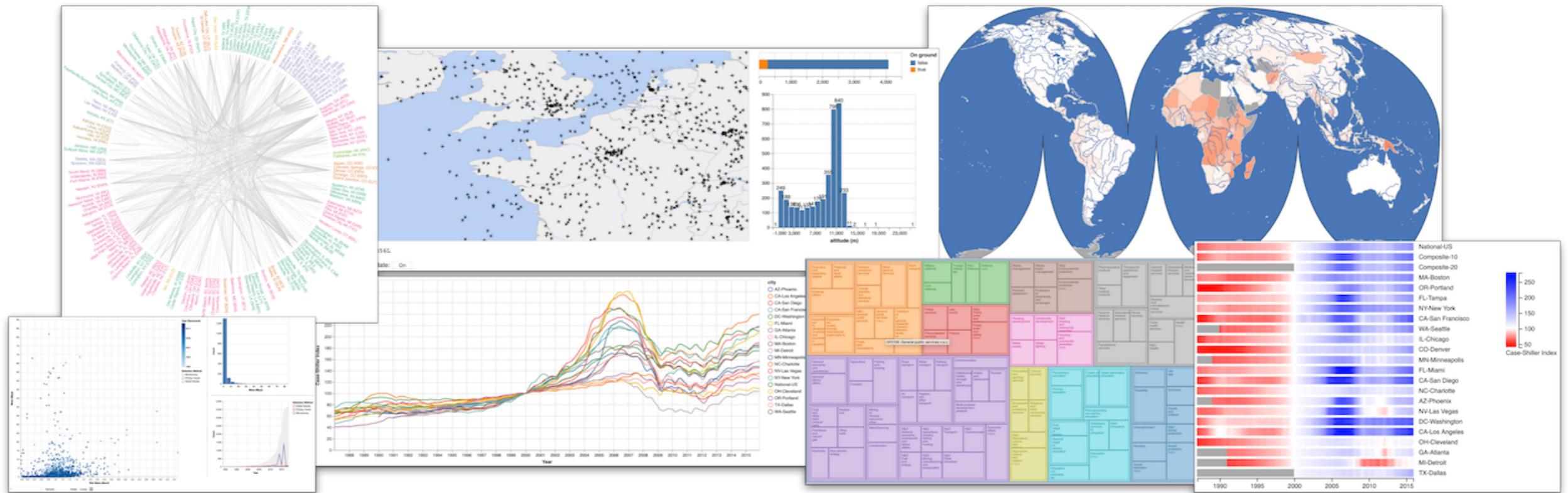


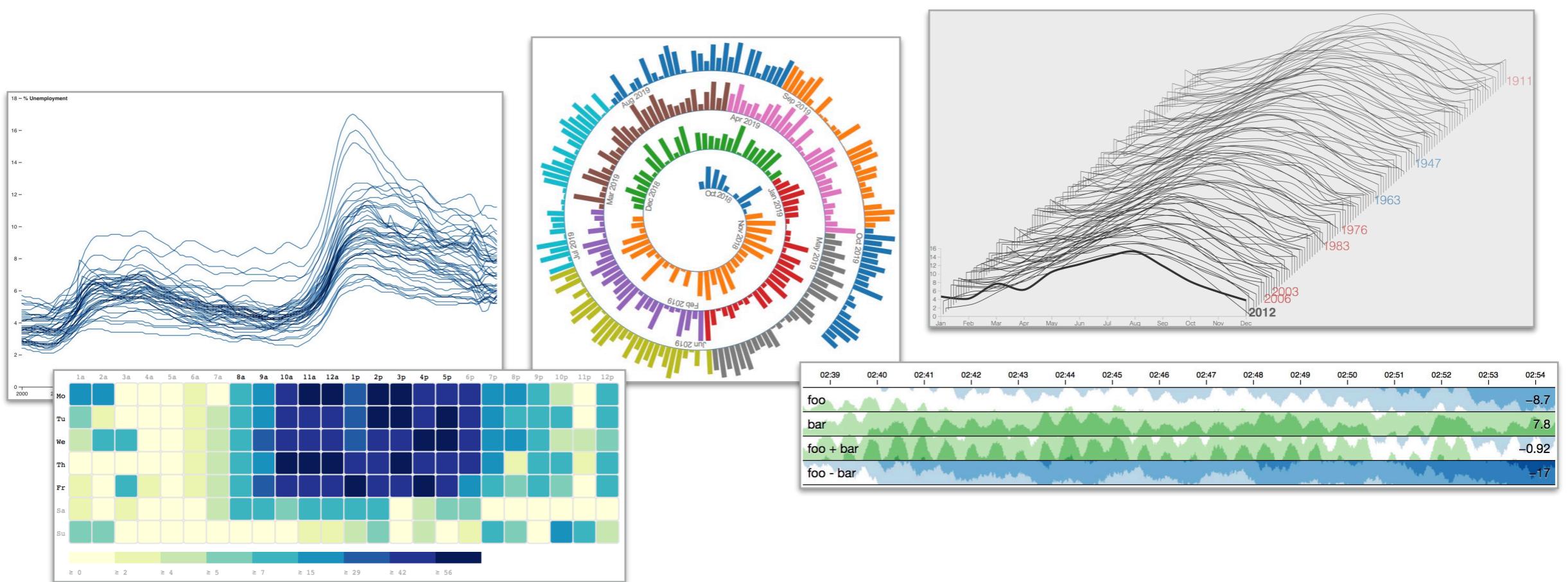
Data Visualization

INF552 (2023-2024)

Session 05 Visualization of Temporal Data (time-series) Animation



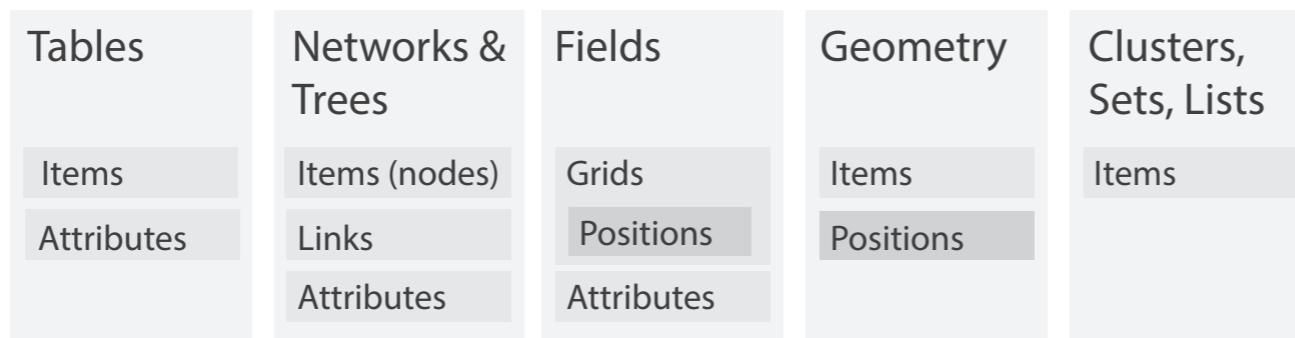
Time-series



→ Data Types

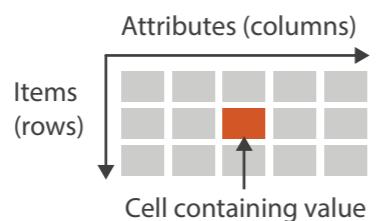
→ Items → Attributes → Links → Positions → Grids

→ Data and Dataset Types

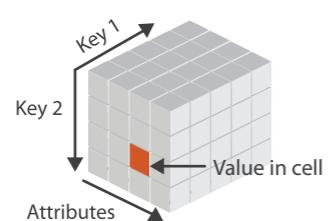


→ Dataset Types

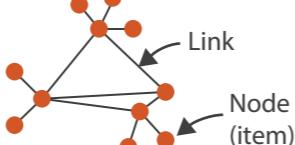
→ Tables



→ Multidimensional Table



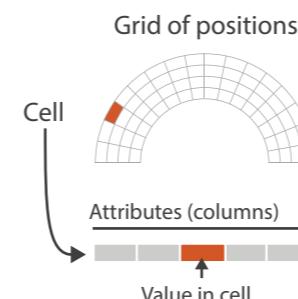
→ Networks



→ Trees



→ Fields (Continuous)



→ Geometry (Spatial)



→ Attribute Types

→ Categorical



→ Ordered

→ Ordinal



→ Quantitative



→ Ordering Direction

→ Sequential



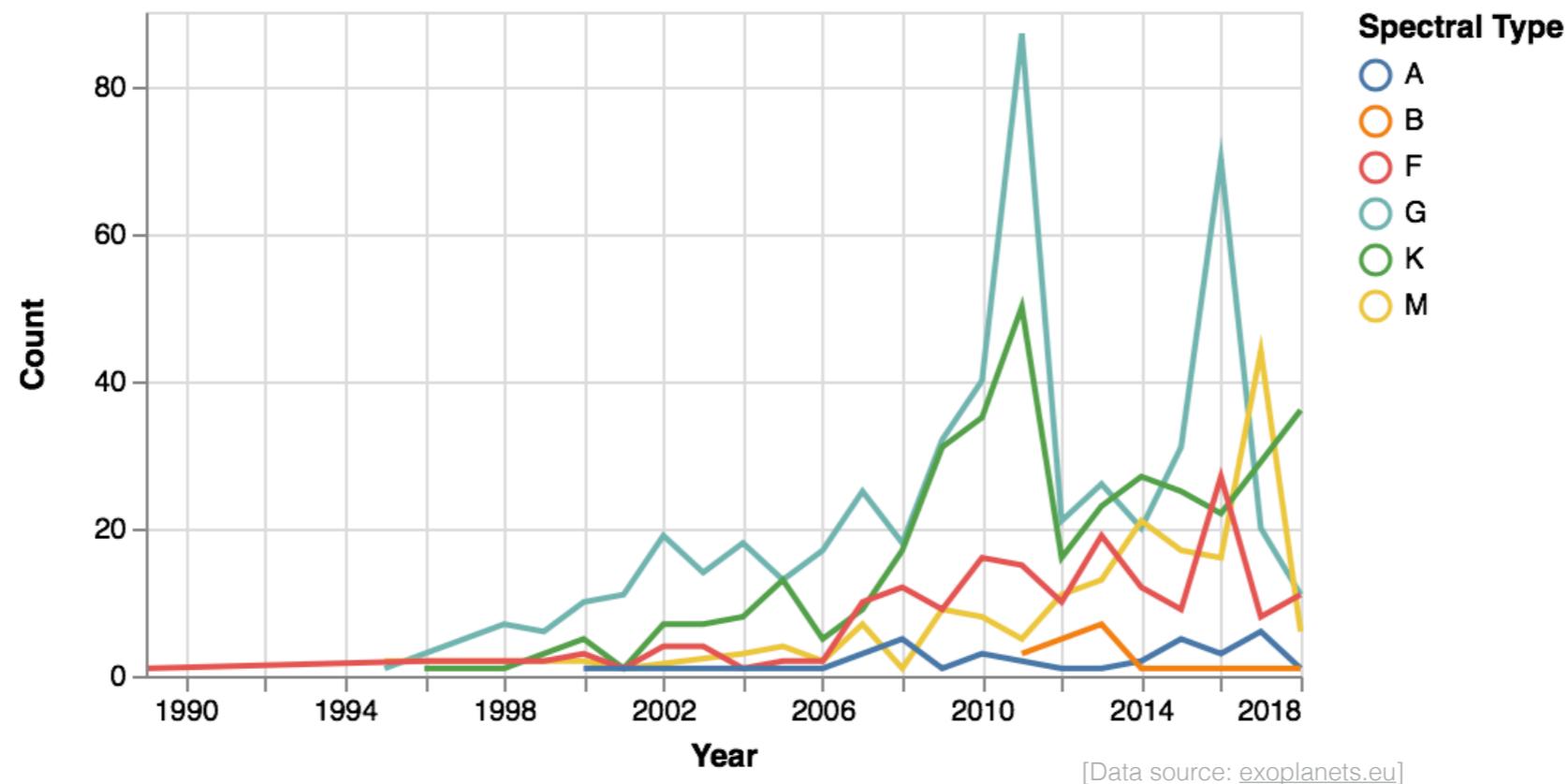
→ Diverging



→ Cyclic



How does an attribute vary continuously?

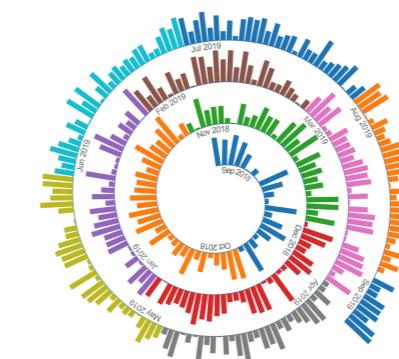


The independent variable is often time...

... for which we have the notion of seasonal patterns,

... and which aggregates meaningfully at multiple levels

... though these levels do not all work well together (non-strict hierarchy).



[By: [Arpit Narechania](#)]

But much of it actually applies to any case where the variable imposes an ordering of the data.

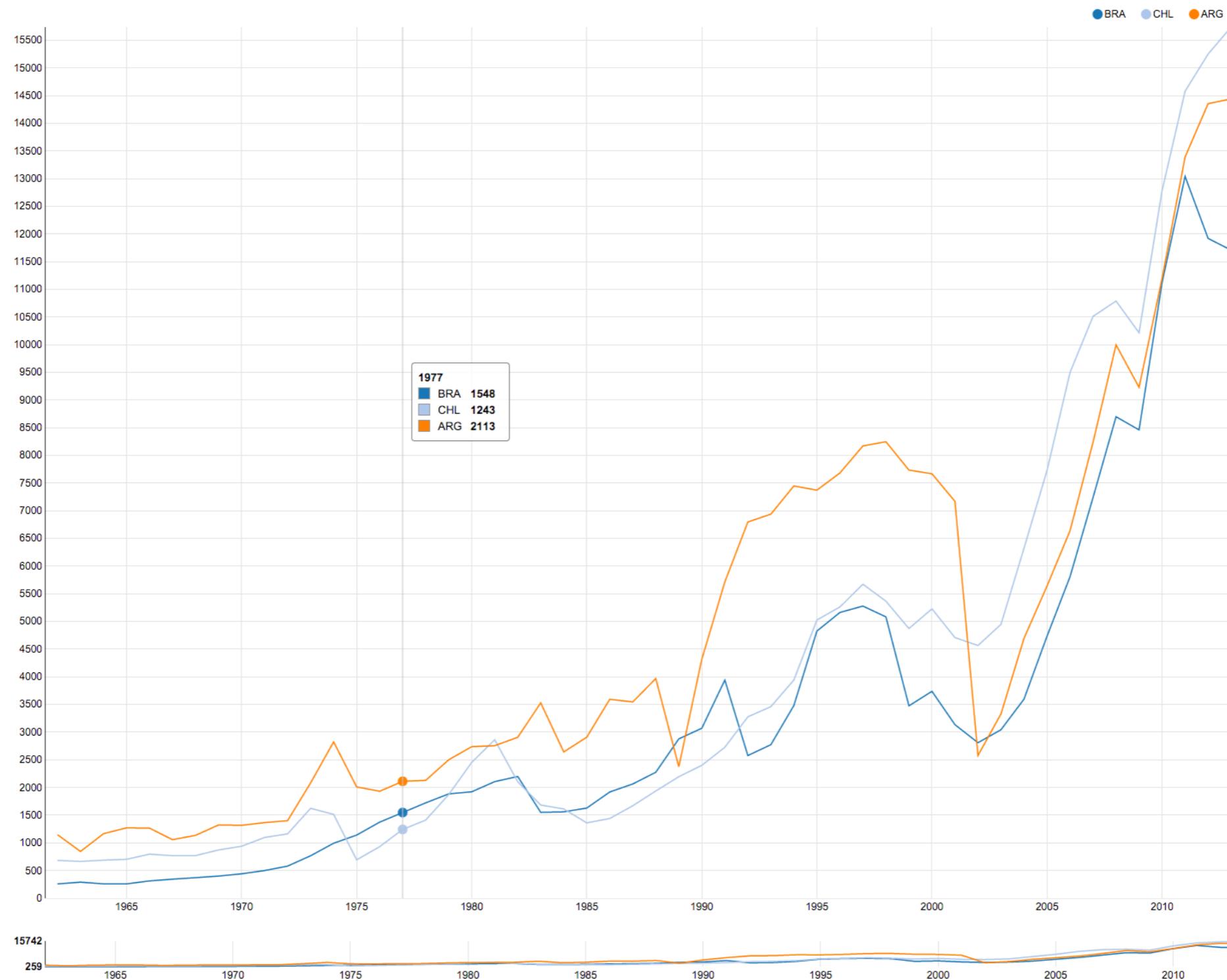
Definitions

- Time-varying semantics: temporal attributes can have either key or value semantics.
 - Example (key): sensors tracking location of moving entities every minute.
 - Example (value): year of discovery of exoplanets (TD s#02+03).
- Time-series: ordered sequence of time-value pairs (time is the key).
 - Often spaced at uniform temporal intervals.
- Discrete points, intervals, spans
- Ordered vs. branching time
- Chronons and granules:
 - e.g., days/weeks/fortnights, milliseconds/seconds/minutes/hours

Time-to-space vs. time-to-time mapping

Time axis and temporal data require screen real-estate.

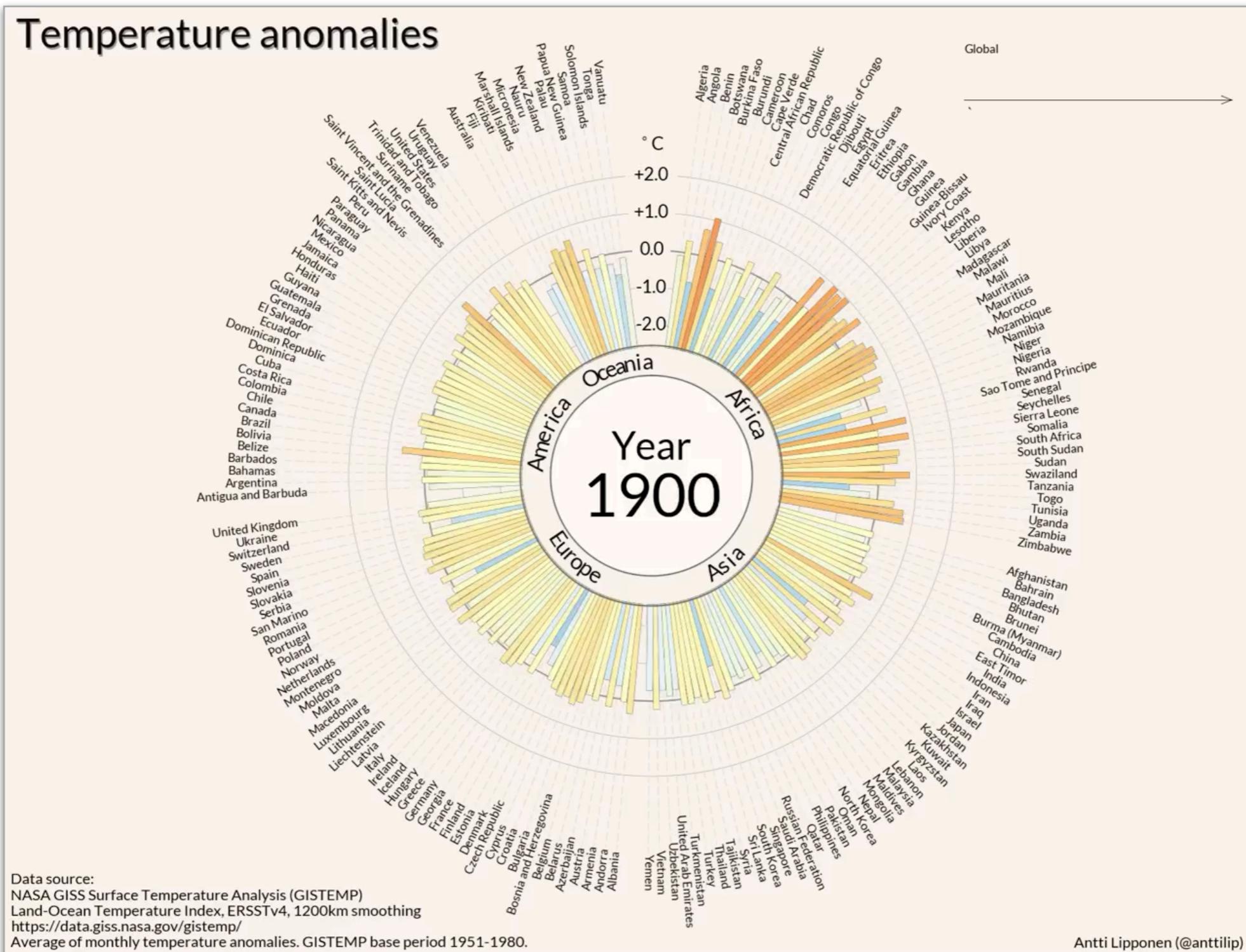
Explicitly represented. Facilitates visual comparison of different time points/intervals.



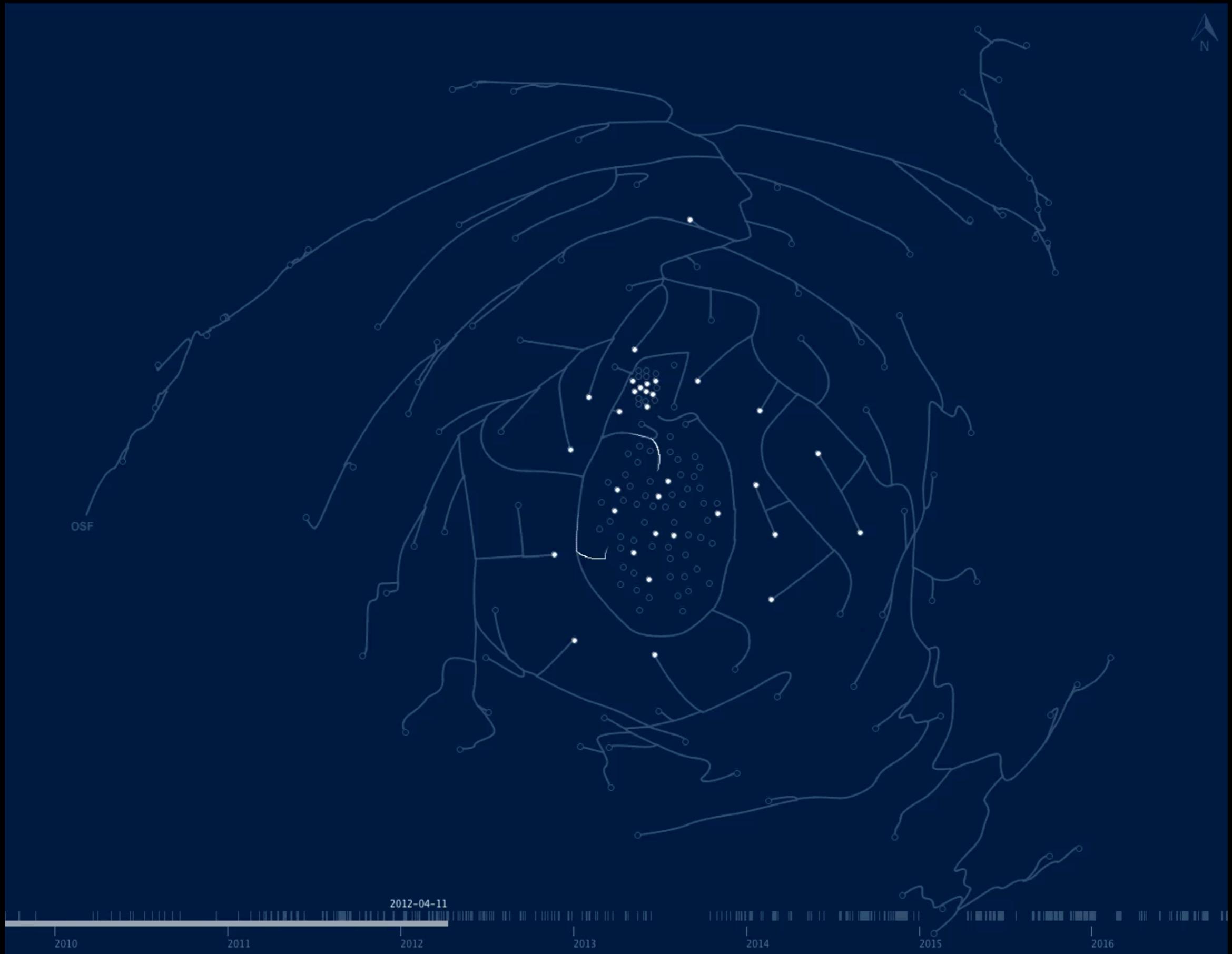
Time-to-space vs. time-to-time mapping

Time axis and temporal data do not require screen real-estate.

Spatial dimensions are used to visualize the time-dependent data attributes. Not time itself.



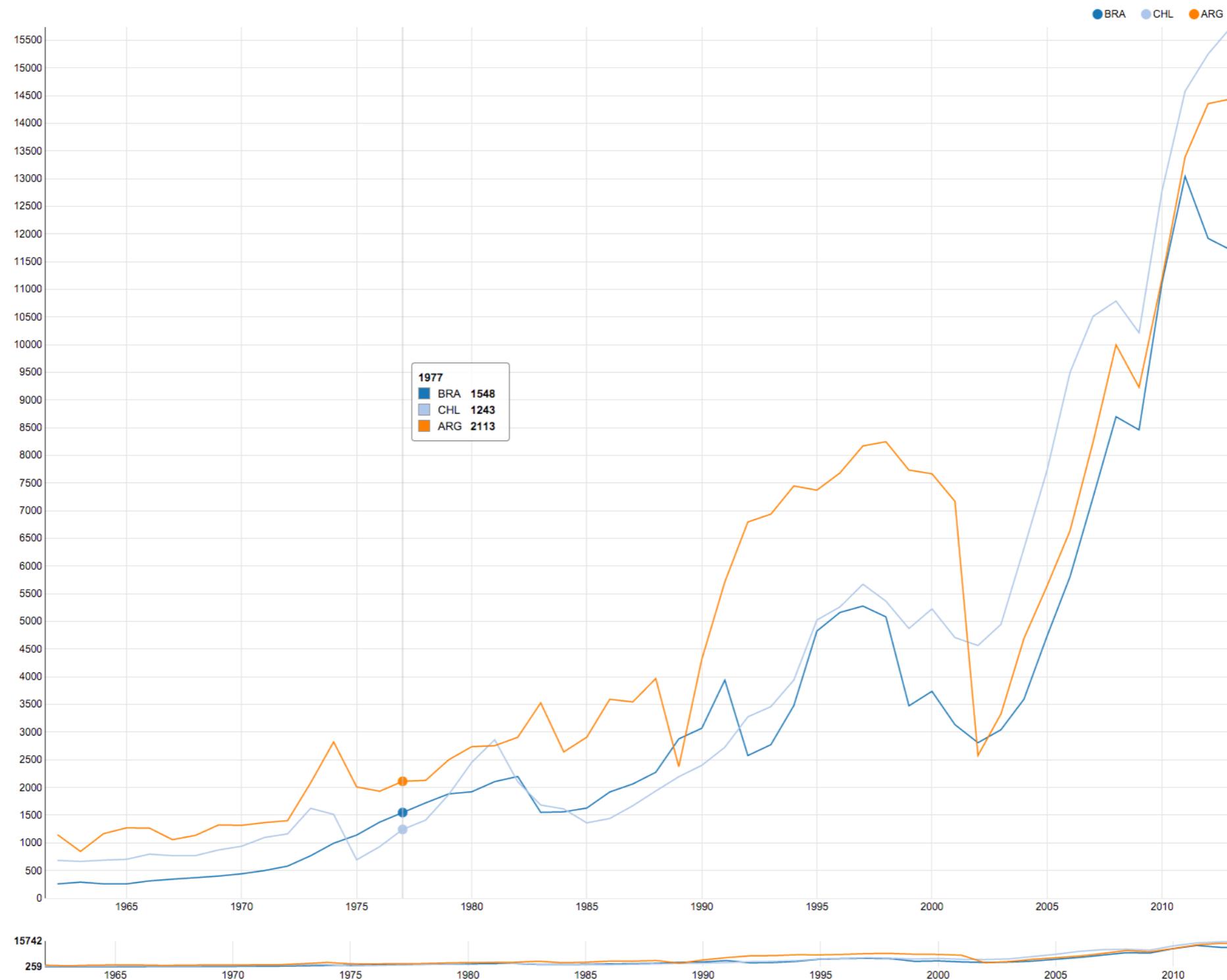
Time-to-space + time-to-time mapping



Time-to-space vs. time-to-time mapping

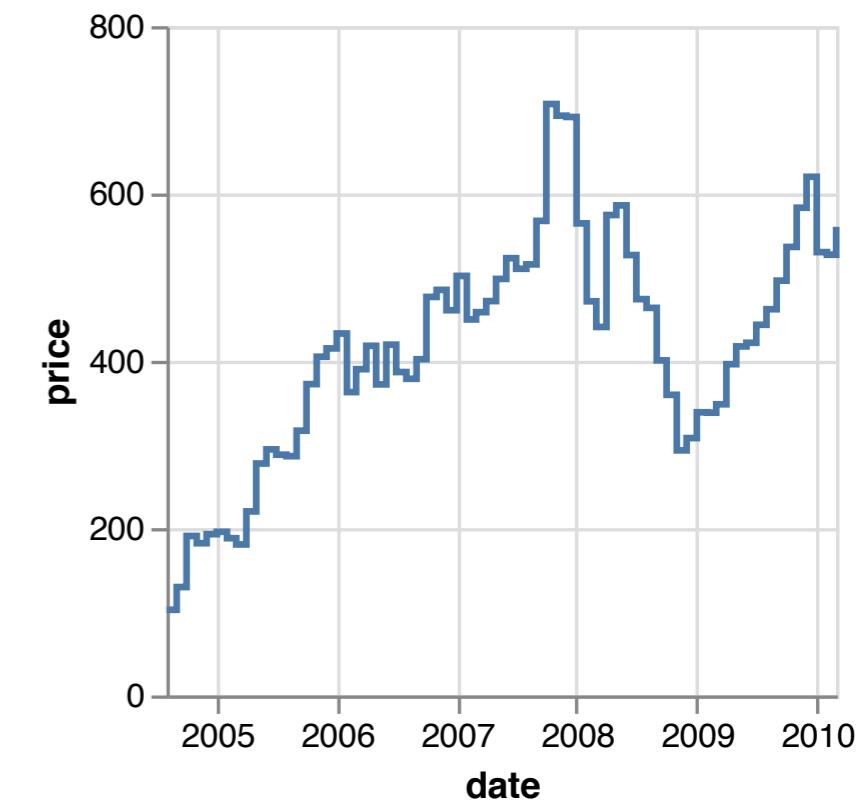
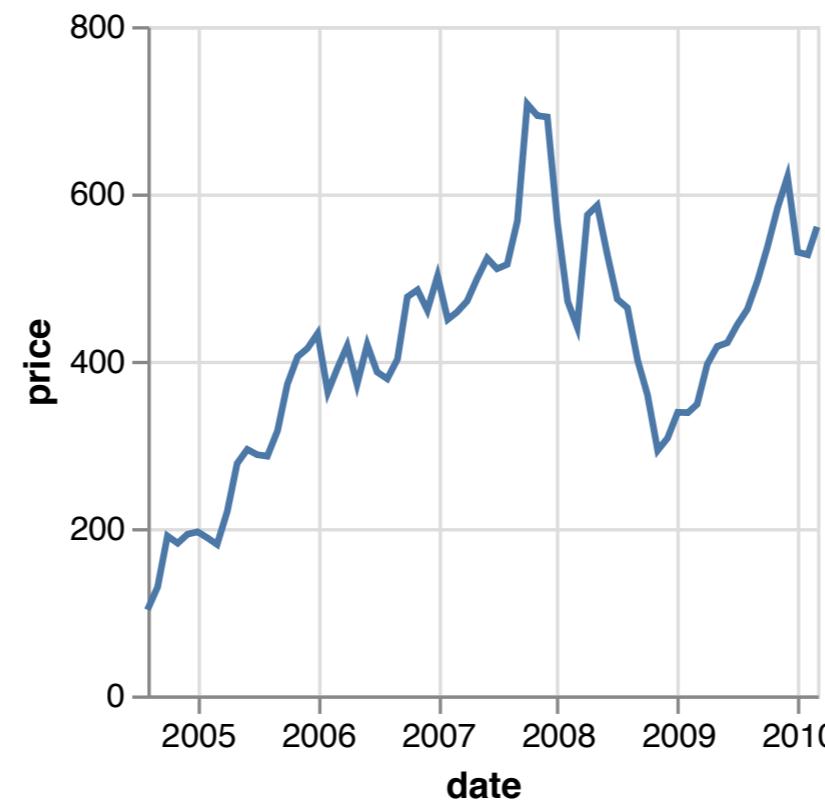
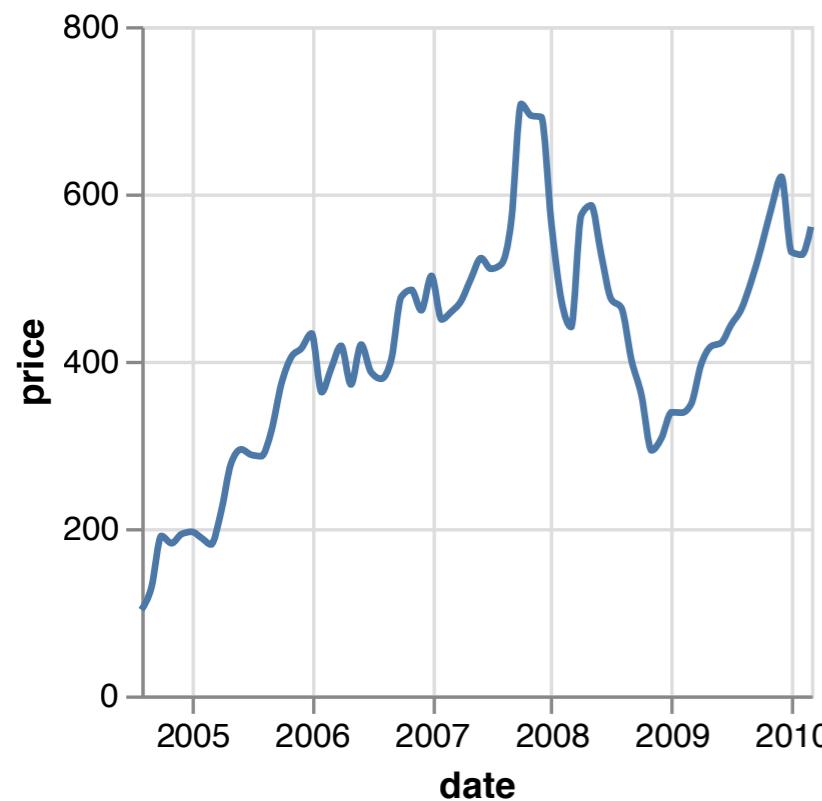
Time axis and temporal data require screen real-estate.

Explicitly represented. Facilitates visual comparison of different time points/intervals.



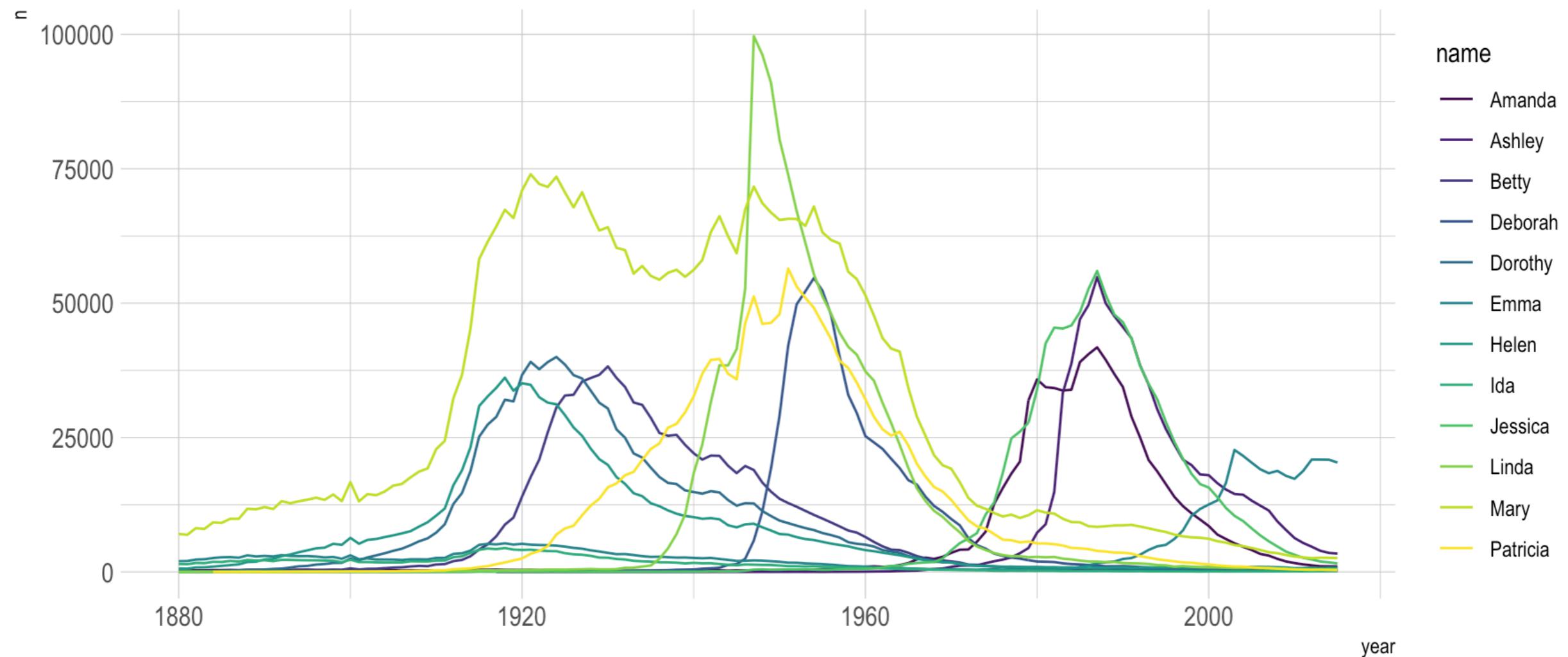
Time-to-space vs. time-to-time mapping

Interpolation: smoothing, stepped line for abrupt changes.



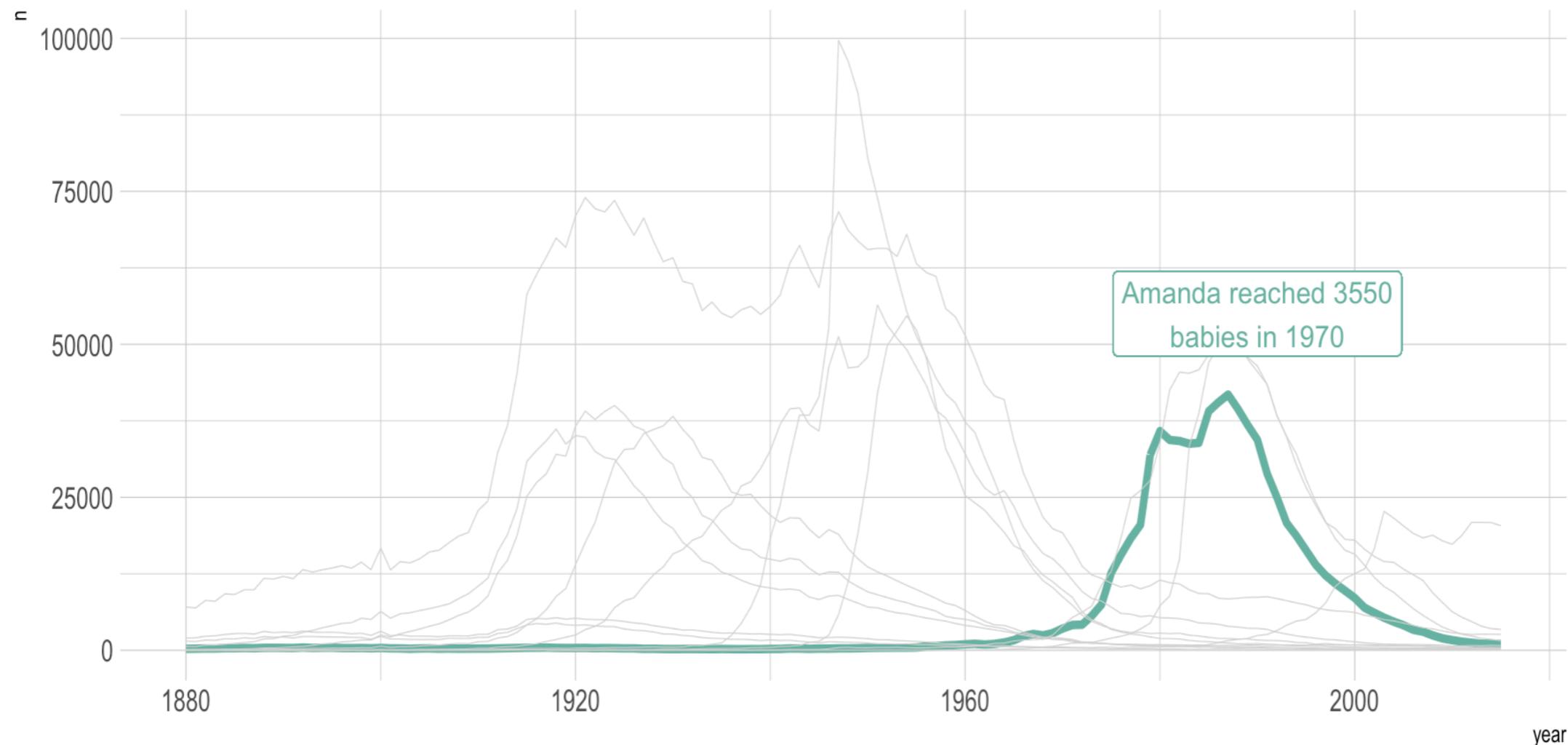
Mark data points when there are few, if they are unevenly spaced.

Time-to-space: scaling to multiple series



Popularity of American names in the last 30 years

Time-to-space: scaling to multiple series

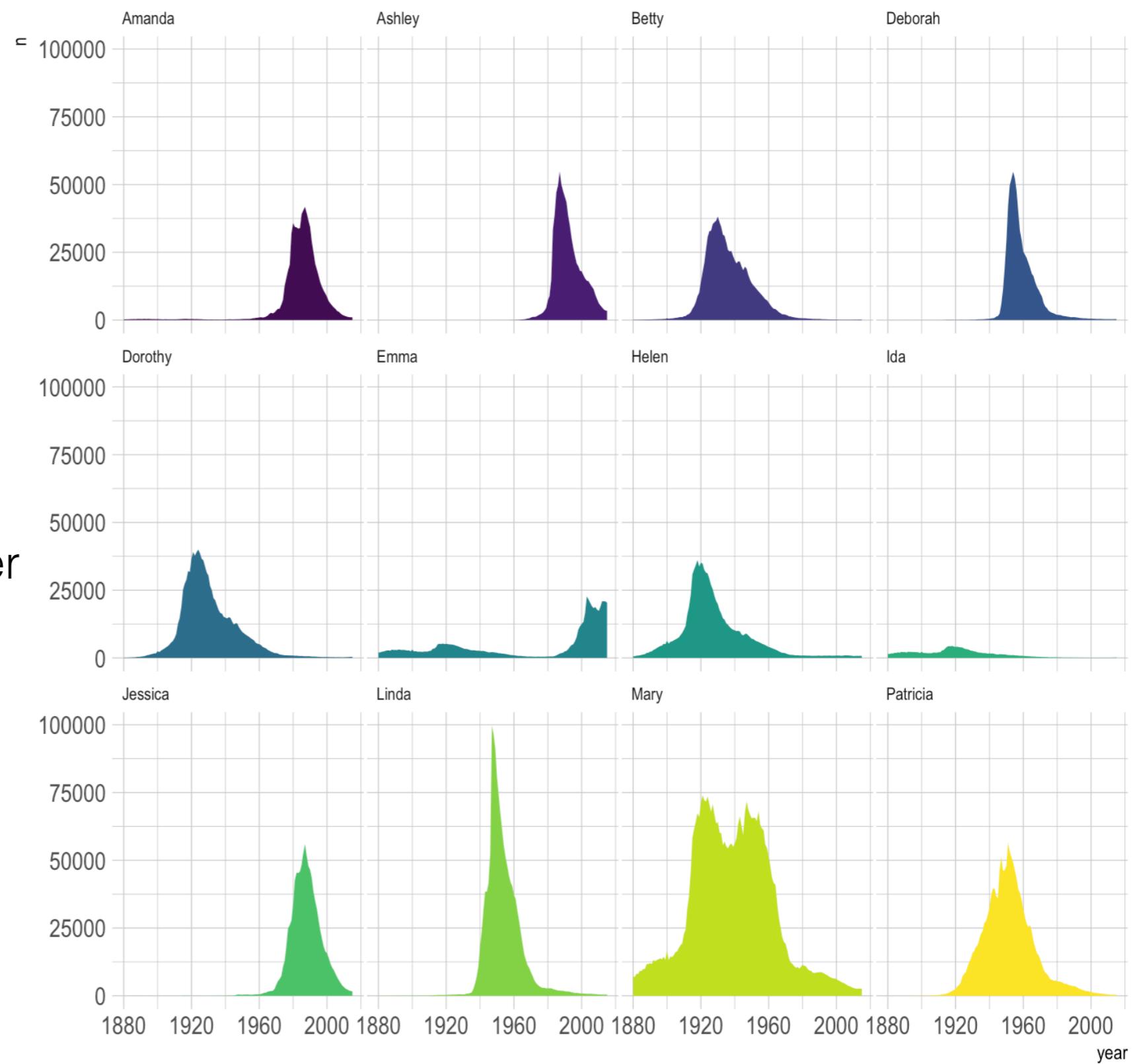


Popularity of American names in the last 30 years

Time-to-space: scaling to multiple series

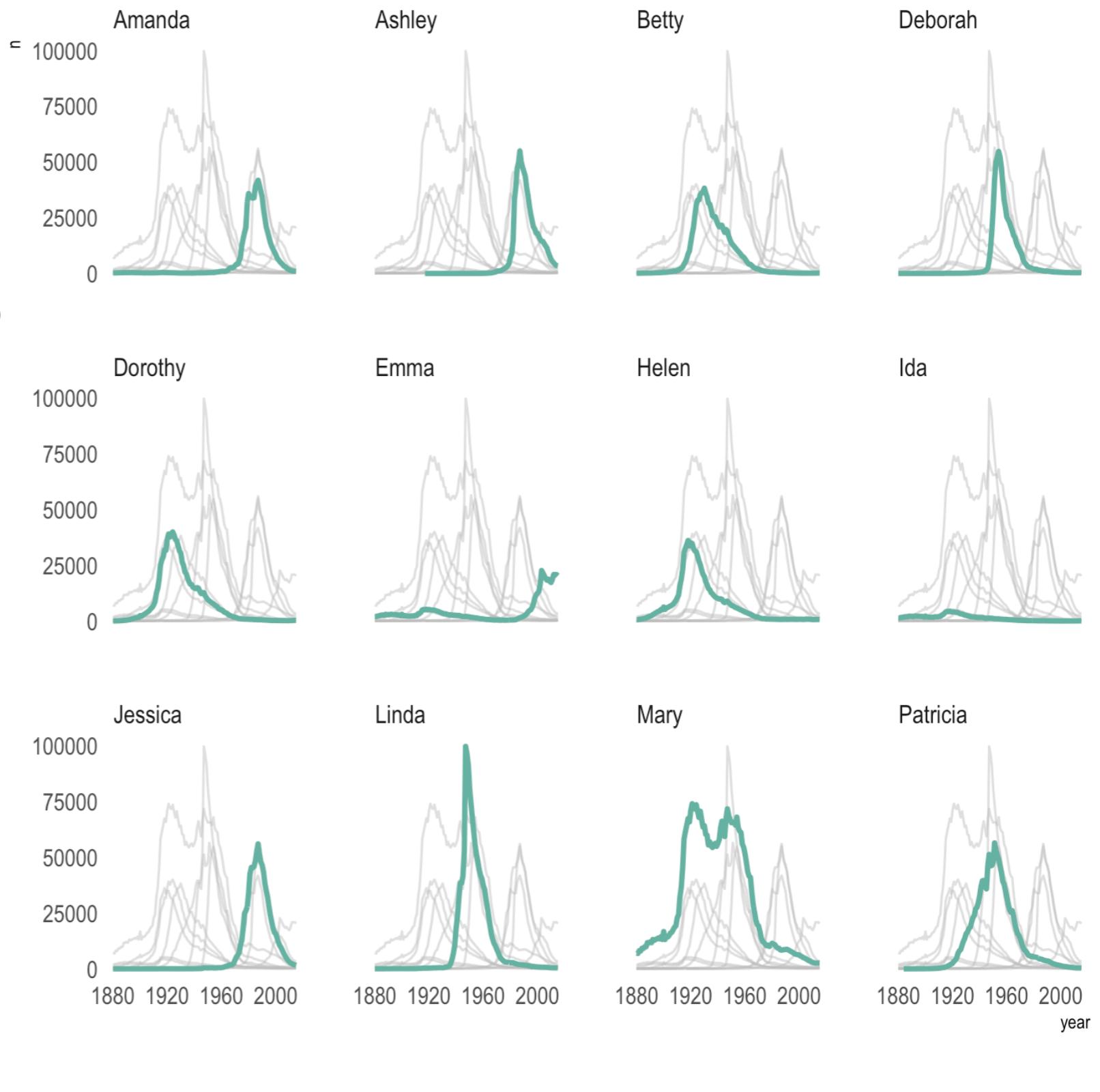
Using
small multiples.

Color encoding is no longer
necessary, actually.



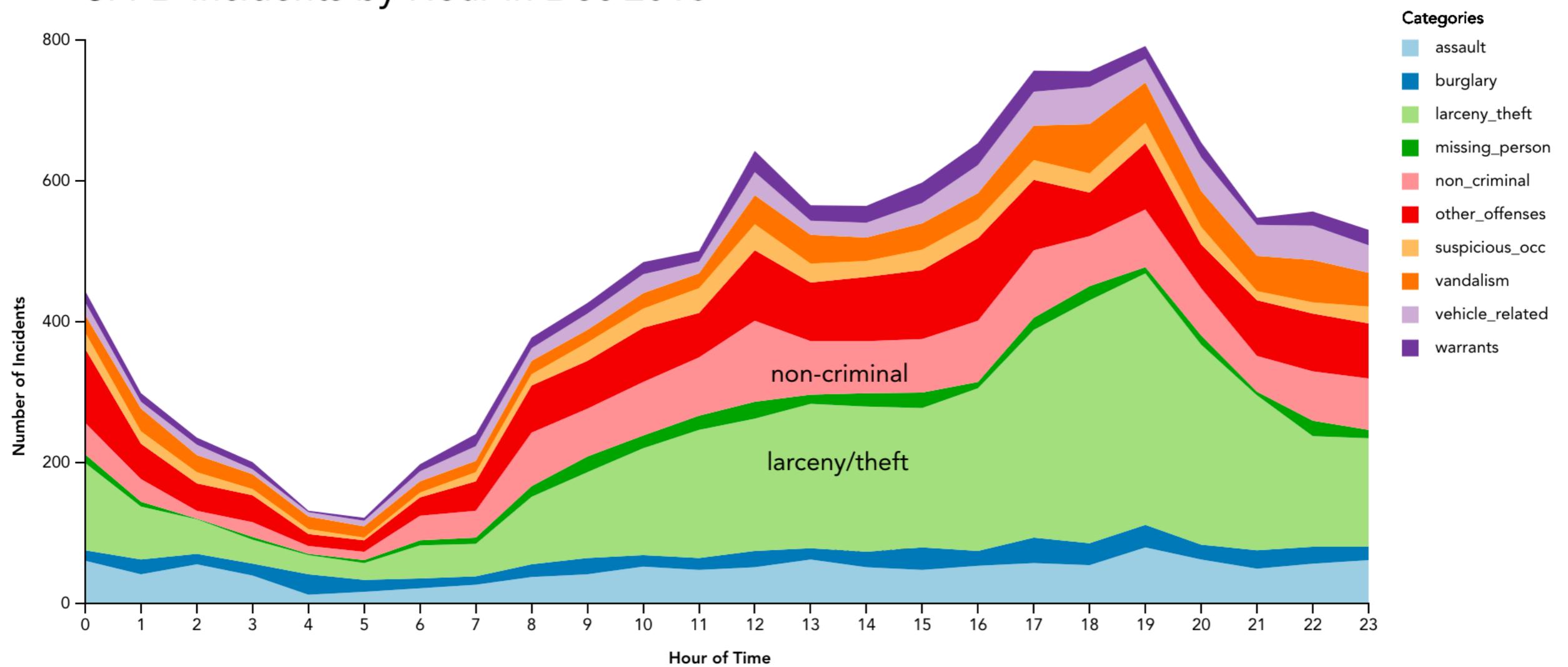
Time-to-space: scaling to multiple series

Drawing line plots makes it possible to show other series in the background, making some comparisons easier.



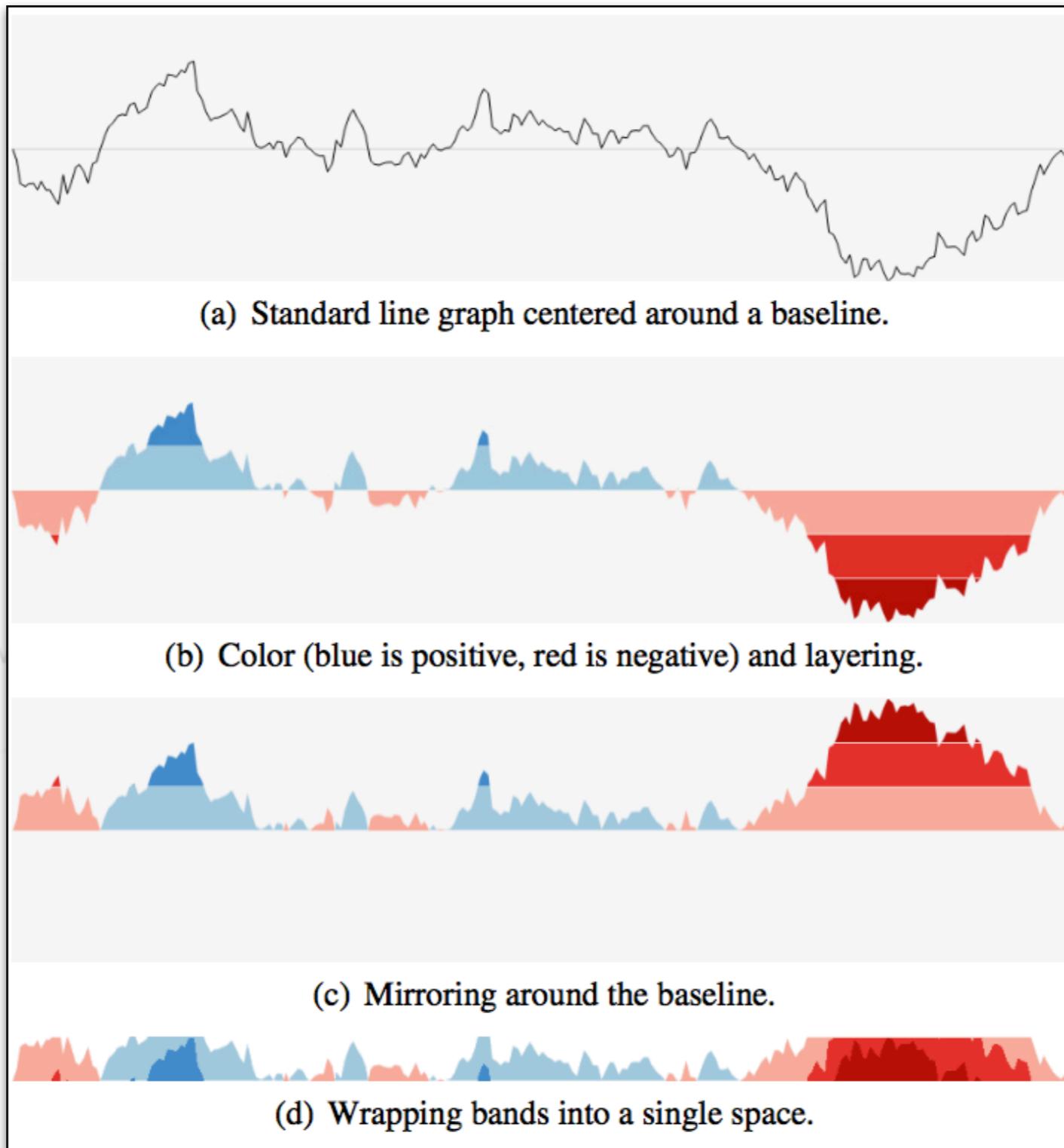
Stacked Area Chart

SFPD Incidents by Hour in Dec 2016

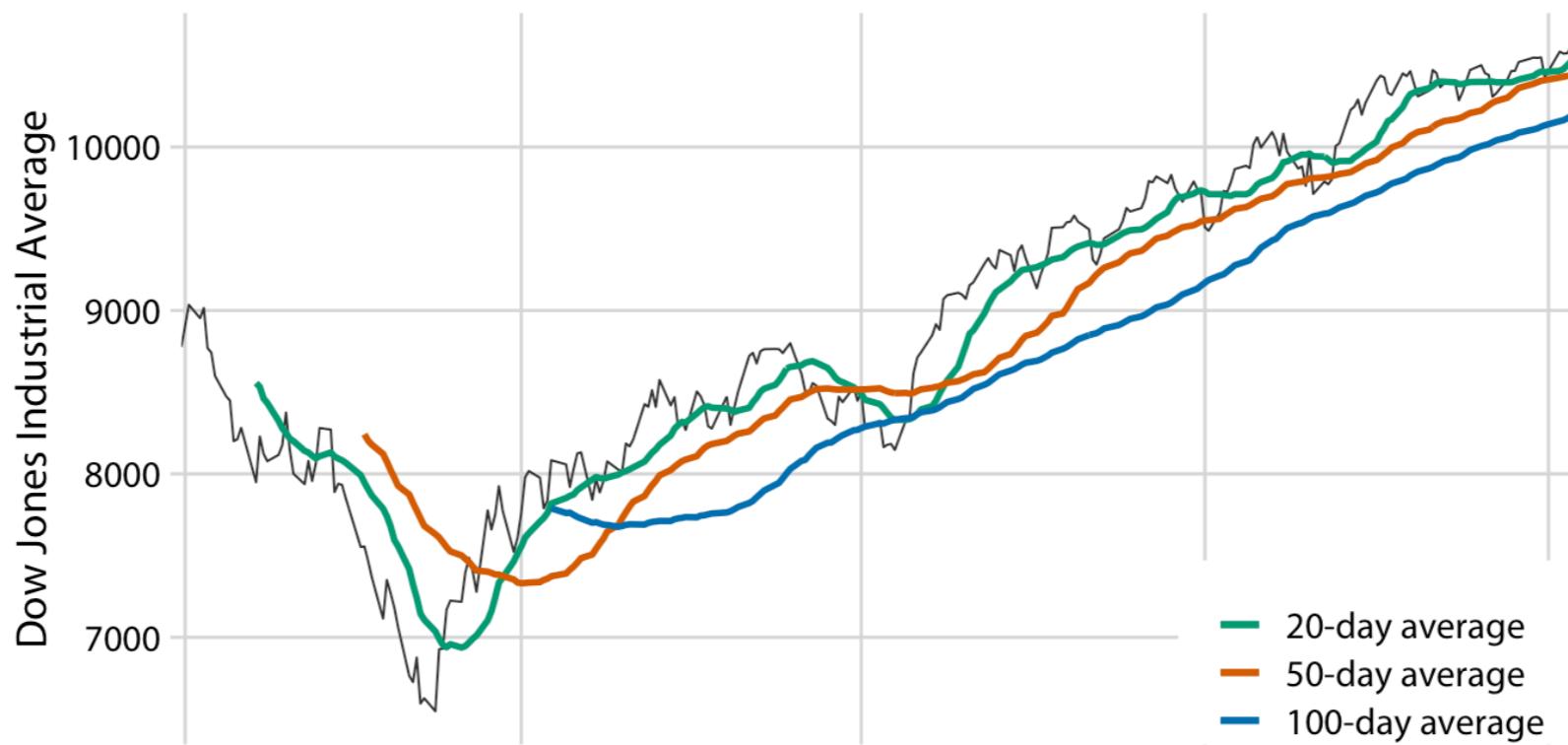


Advantage: emphasizes the total sum while giving information about constituent parts.
Drawback: variable baseline \Rightarrow difficult to evaluate individual variations.

Horizon Graphs



Smoothing and showing trends



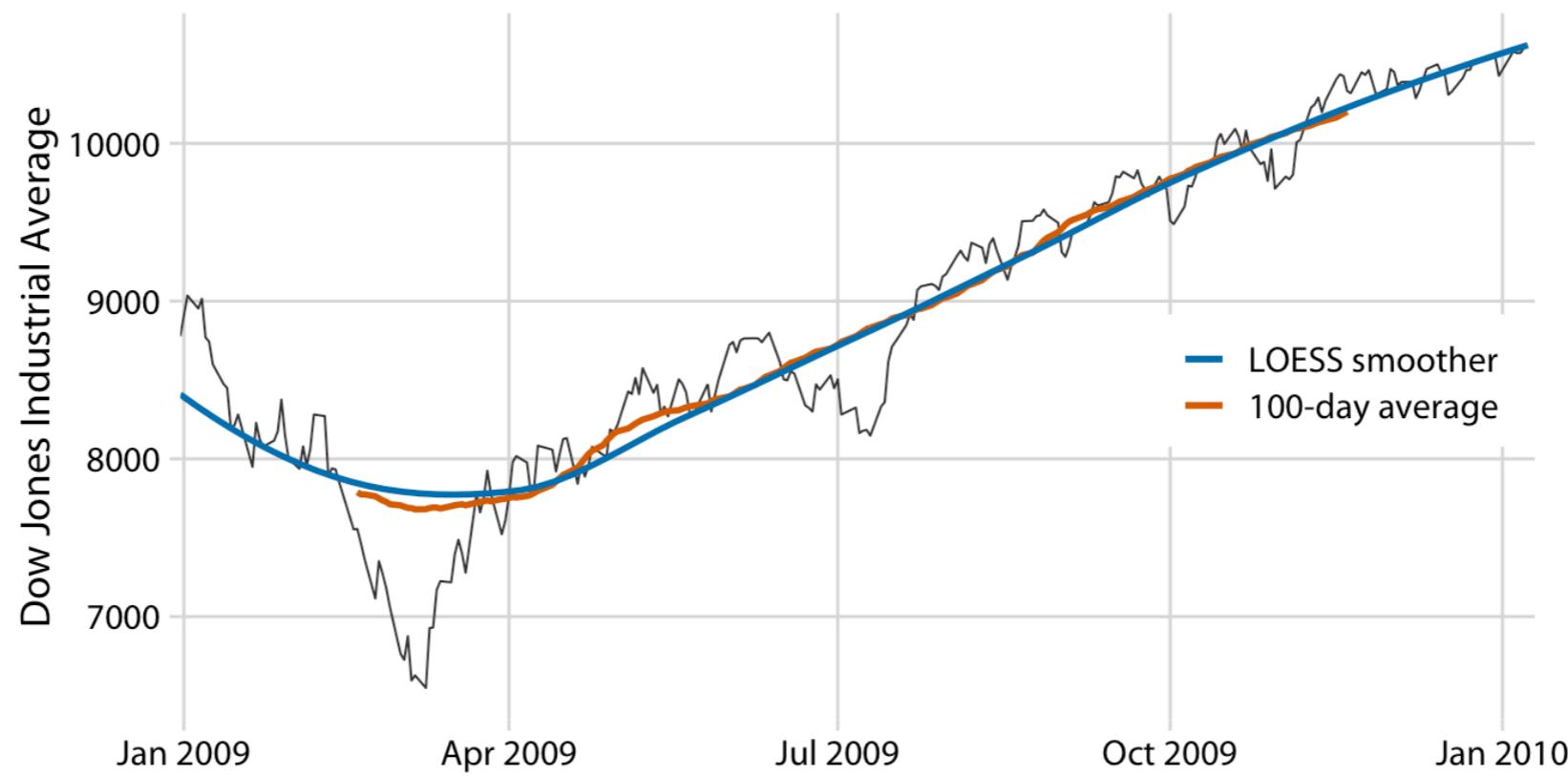
Emphasize key patterns by removing irrelevant detail or noise.

Simple approach: **moving average** with all data points weighted equally

- time-window width impacts smoothing (loss of detail);
- time-window position (w.r.t time point) impacts lag.



Smoothing and showing trends



Locally-estimated scatterplot smoothing (LOESS):

- non-uniform weights to points in the time-window (weighted least squares);
- fits low-degree polynomials to subsets of the data \Rightarrow slow for large datasets.

Such general-purpose smoothers can be unpredictable.

Different methods/parameters can yield widely different curves.

Parameters are not meaningful.

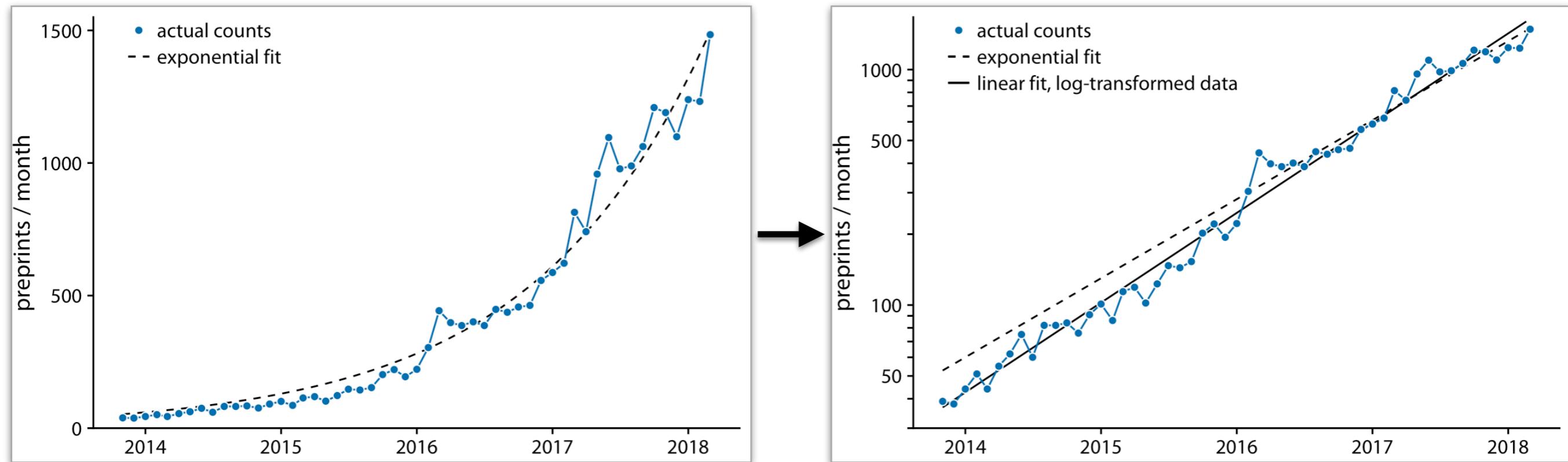
Smoothing and showing trends

When possible, best to use specific functional forms for fitting, that have parameters with clear meaning.

$$y = a \cdot x + b$$

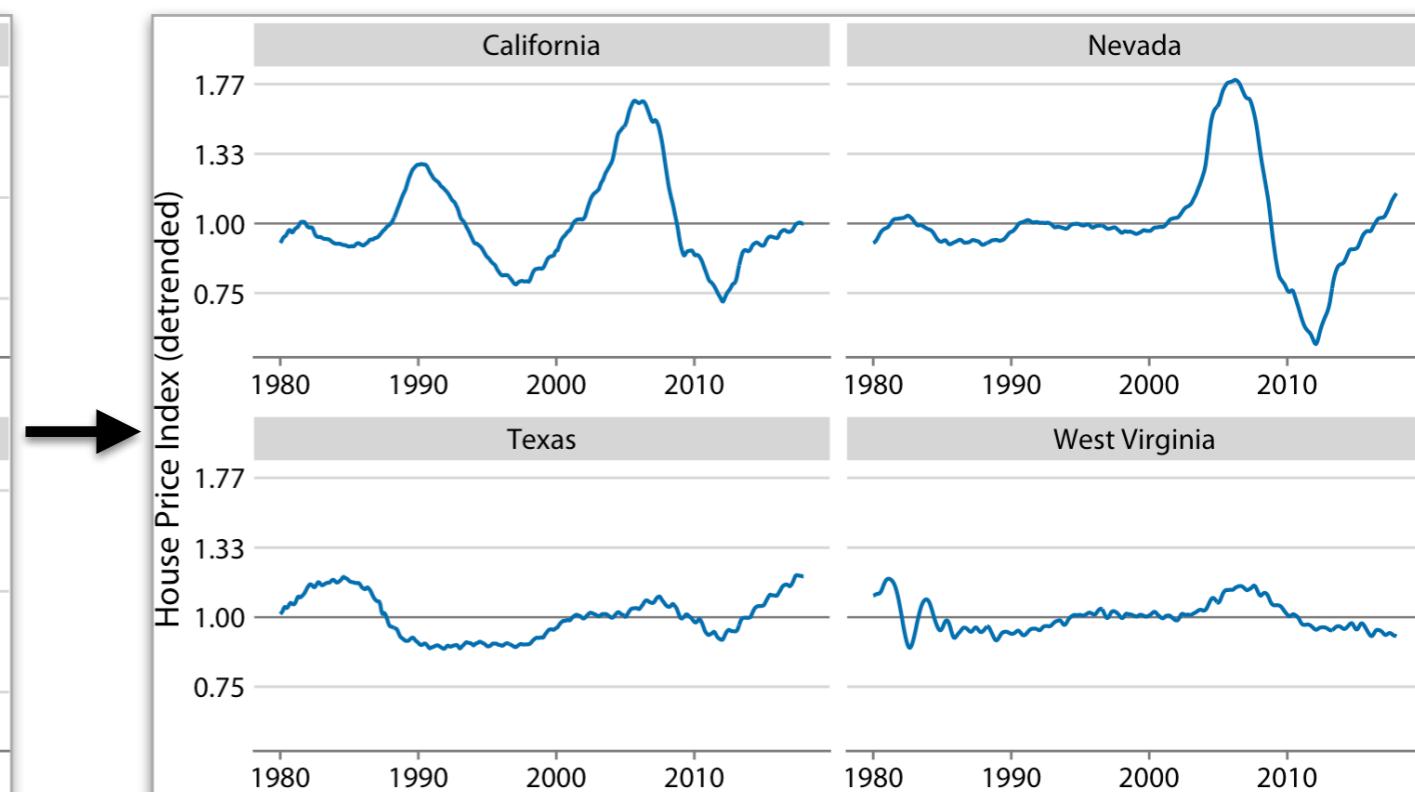
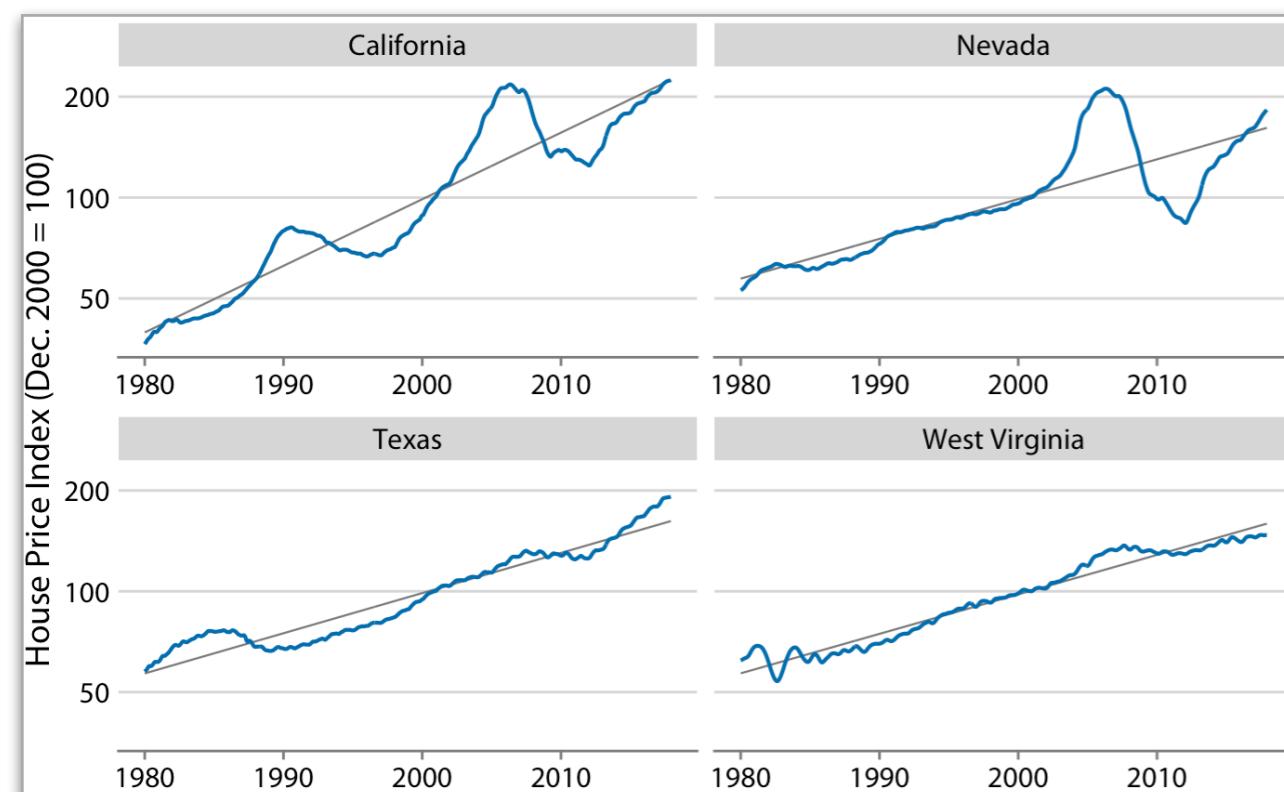
$$y = b \cdot e^{ax}$$

$$\log(y) = a \cdot x + \log(b) \quad \dots$$



Smoothing and showing trends

Detrending: divide by the long-term trend value at each time point to remove it:



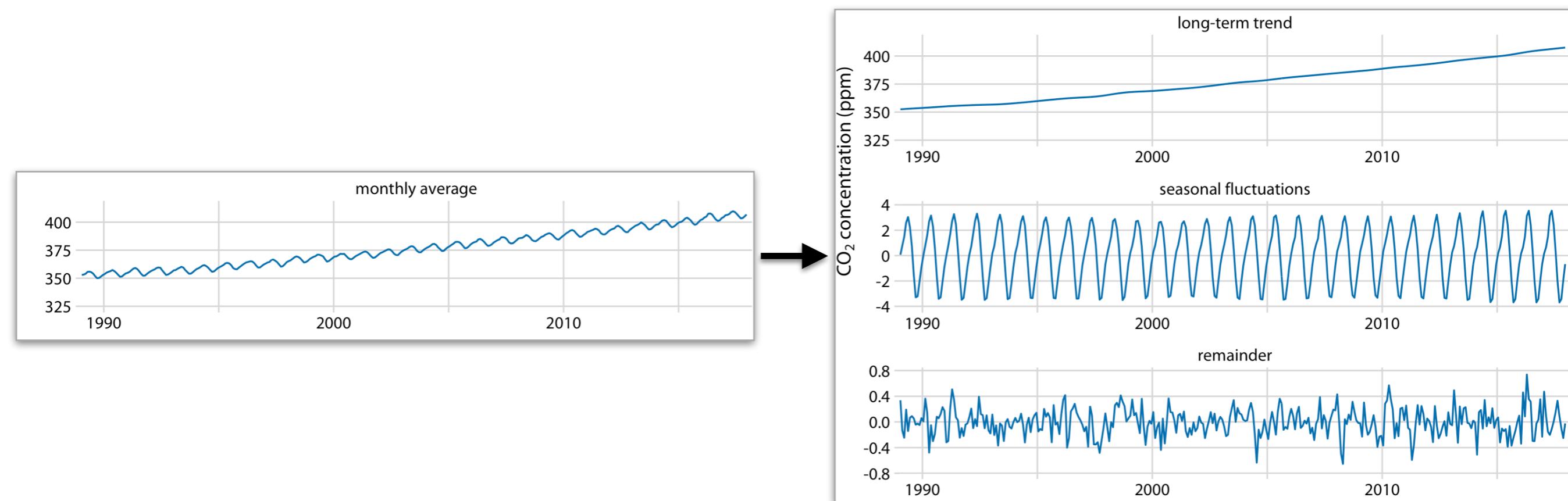
Time-series Decomposition

$$v(t) = T(t) + S(t) + I(t)$$

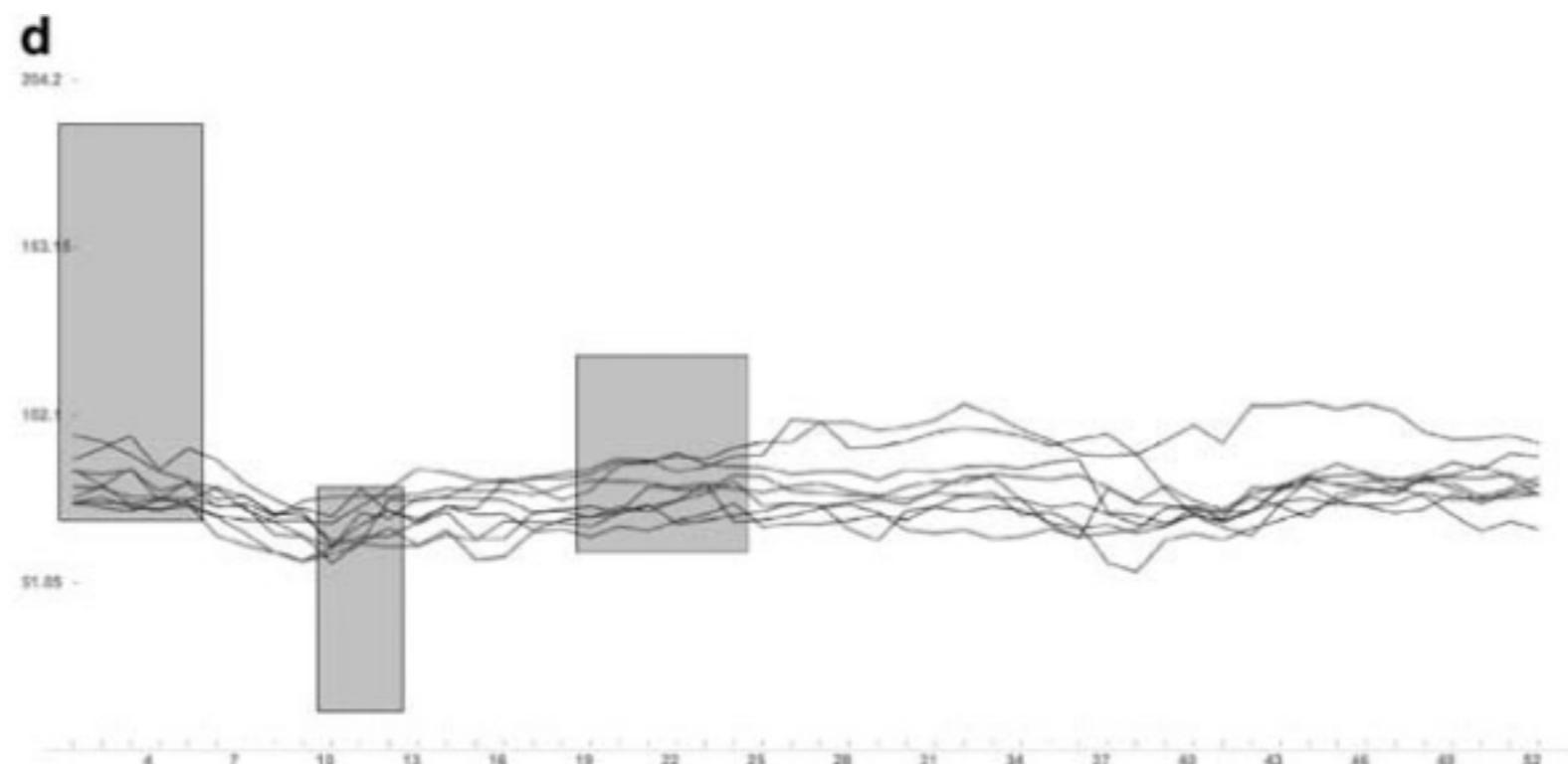
Decomposition into a long-term trend (T) + seasonal fluctuations (S) + remainder (I):

- I , the remainder, represents random noise or irregular influences (events)

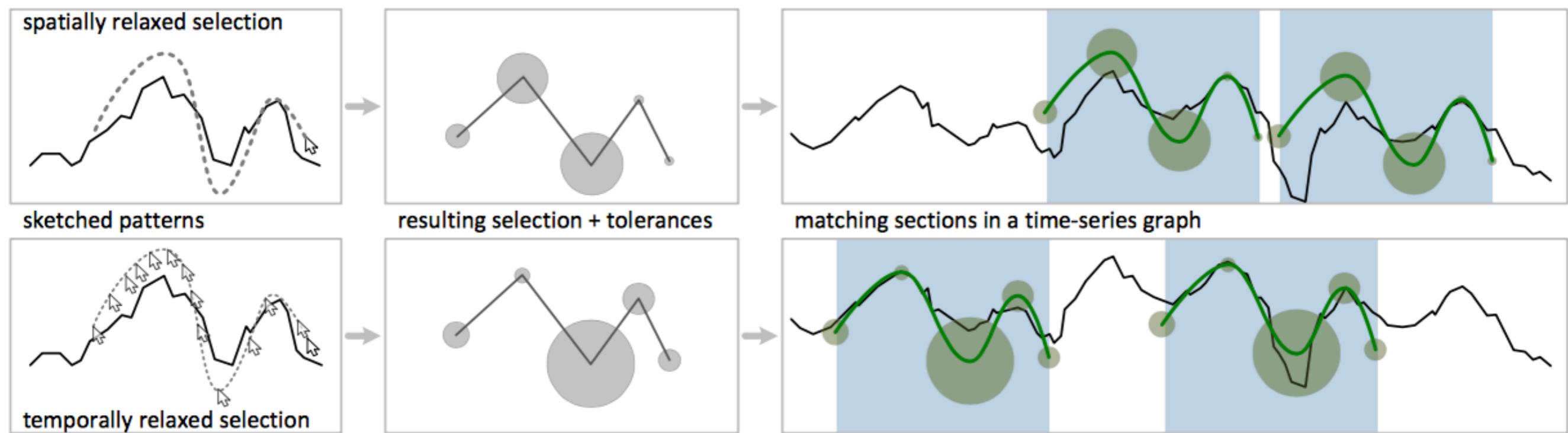
Example using Seasonal decomposition of Time series by LOESS (STL):



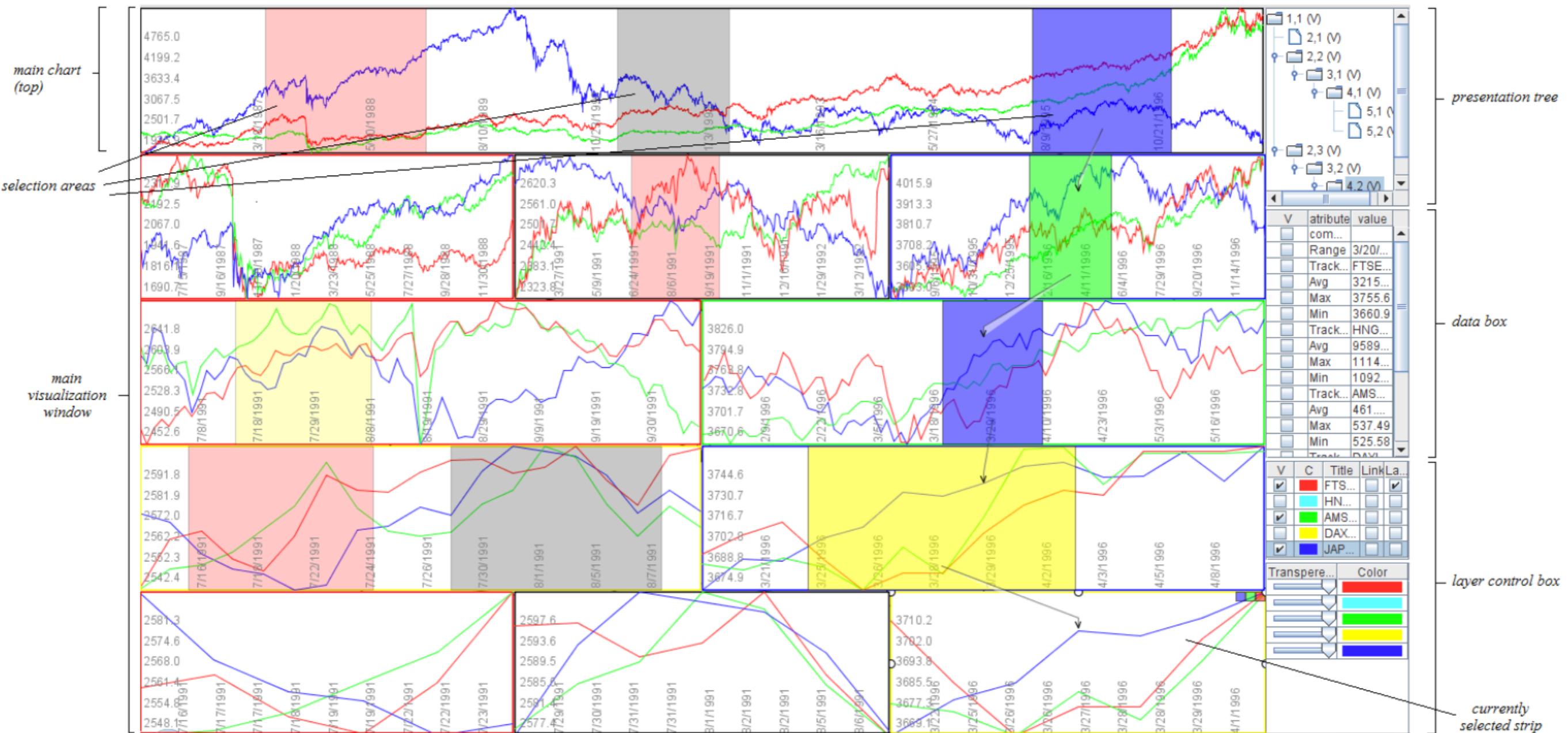
Interaction: filtering, dynamic queries



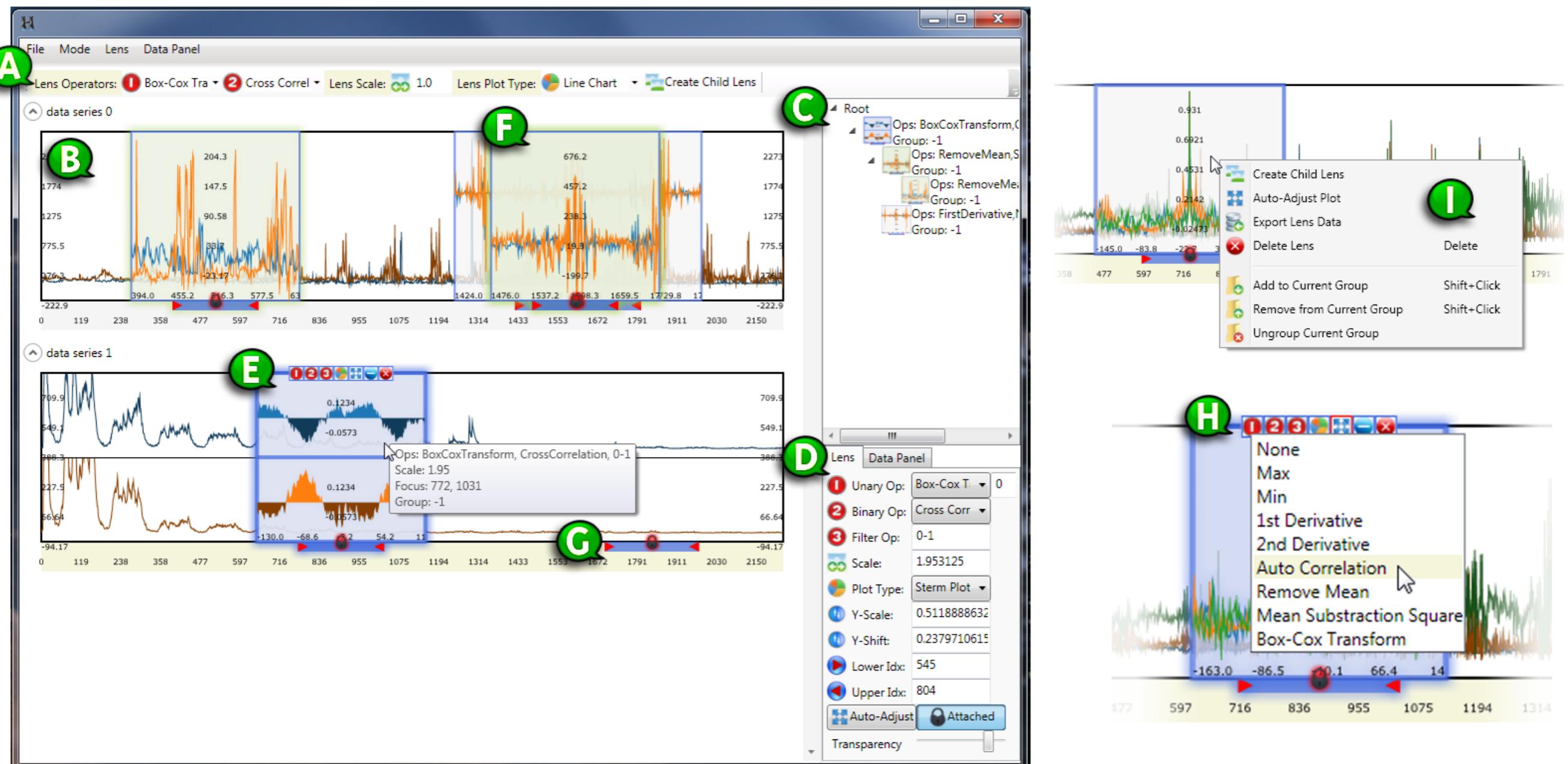
Interaction: filtering, dynamic queries



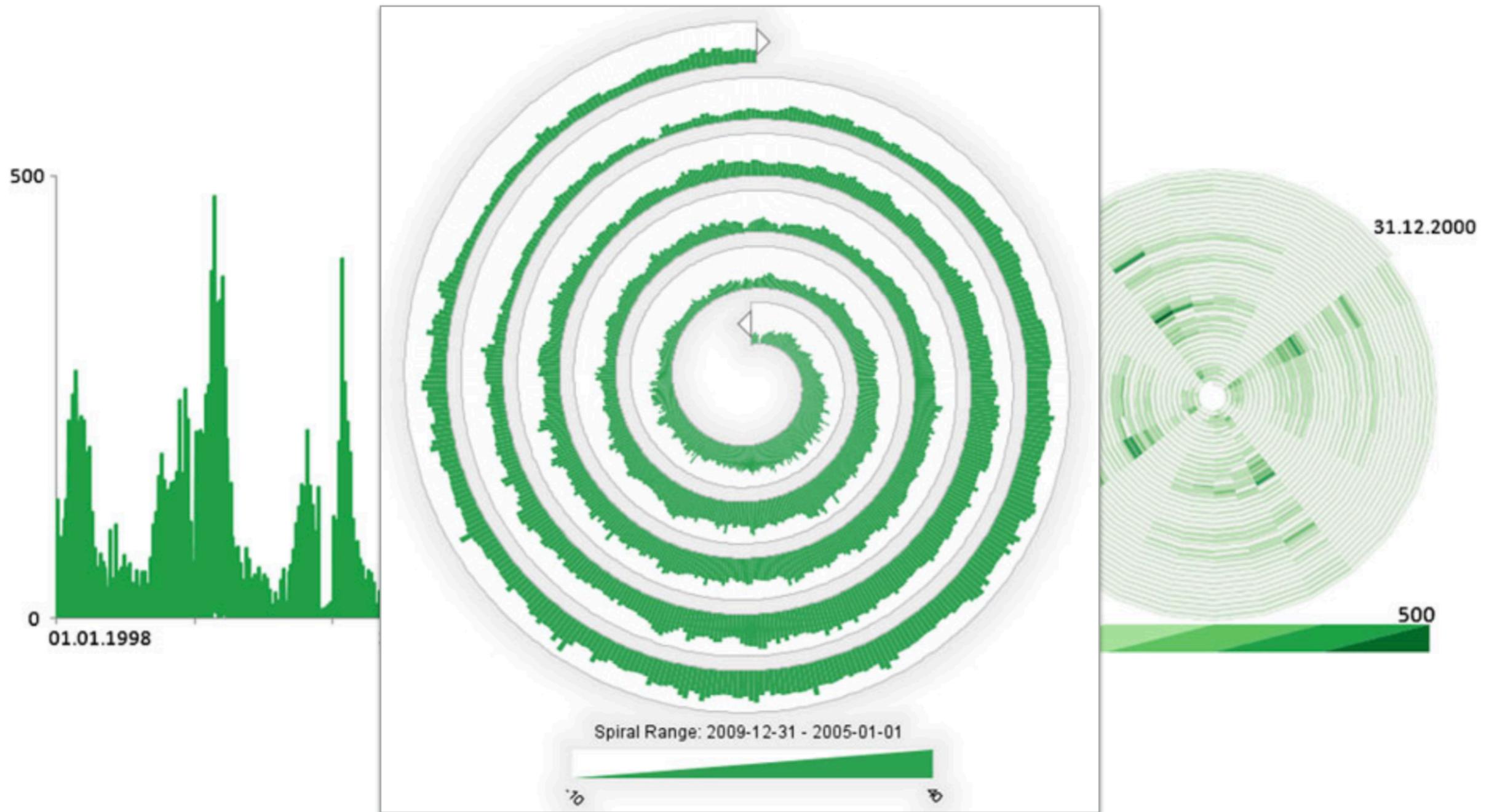
Interaction: overview+detail



Explicit encoding



Spiral to emphasize temporal cycles

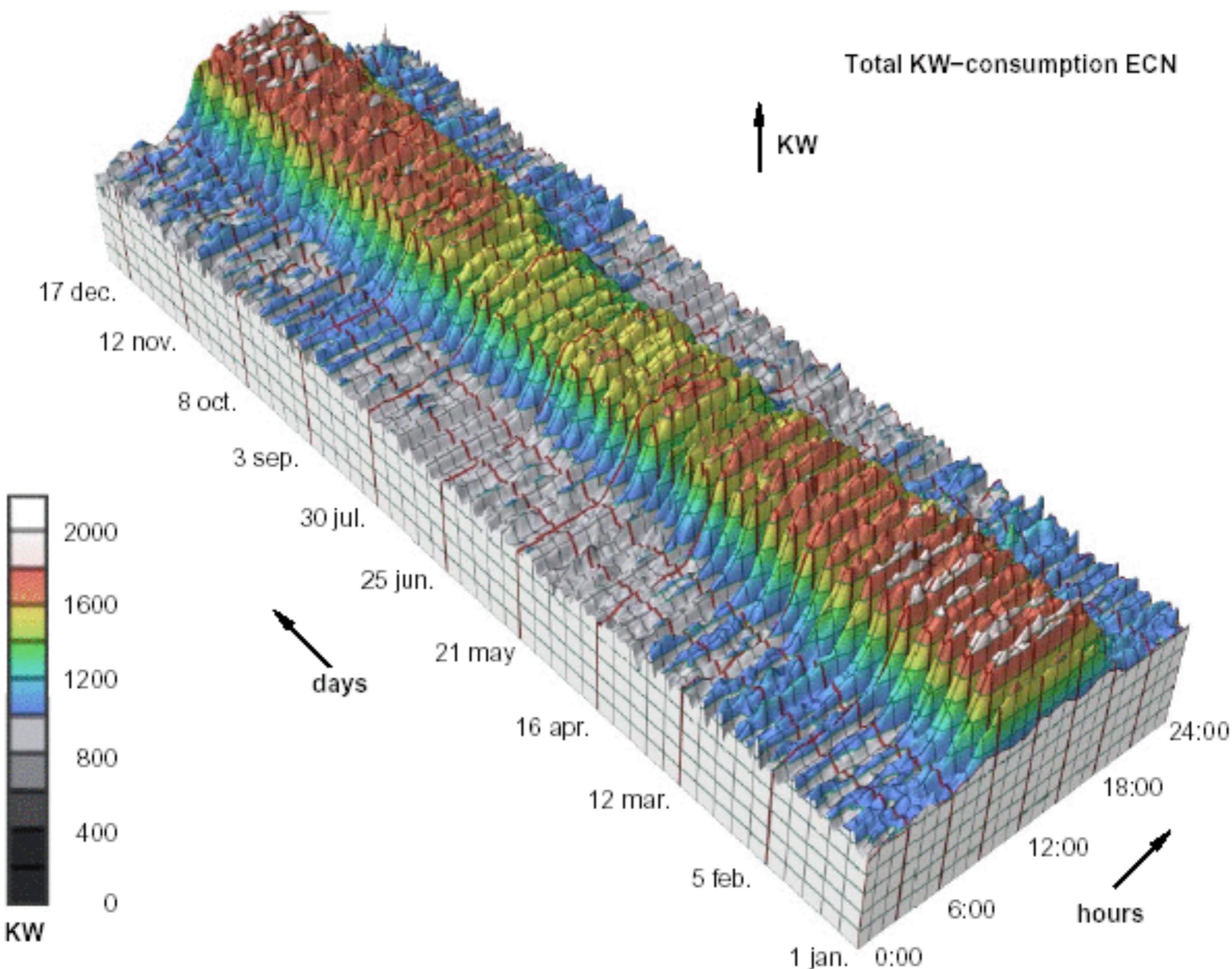


[Source: Wolfgang Aigner, Silvia Miksch, Heidrun Schumann, and Christian Tominski. 2011. Visualization of Time-Oriented Data (1st ed.). Springer]

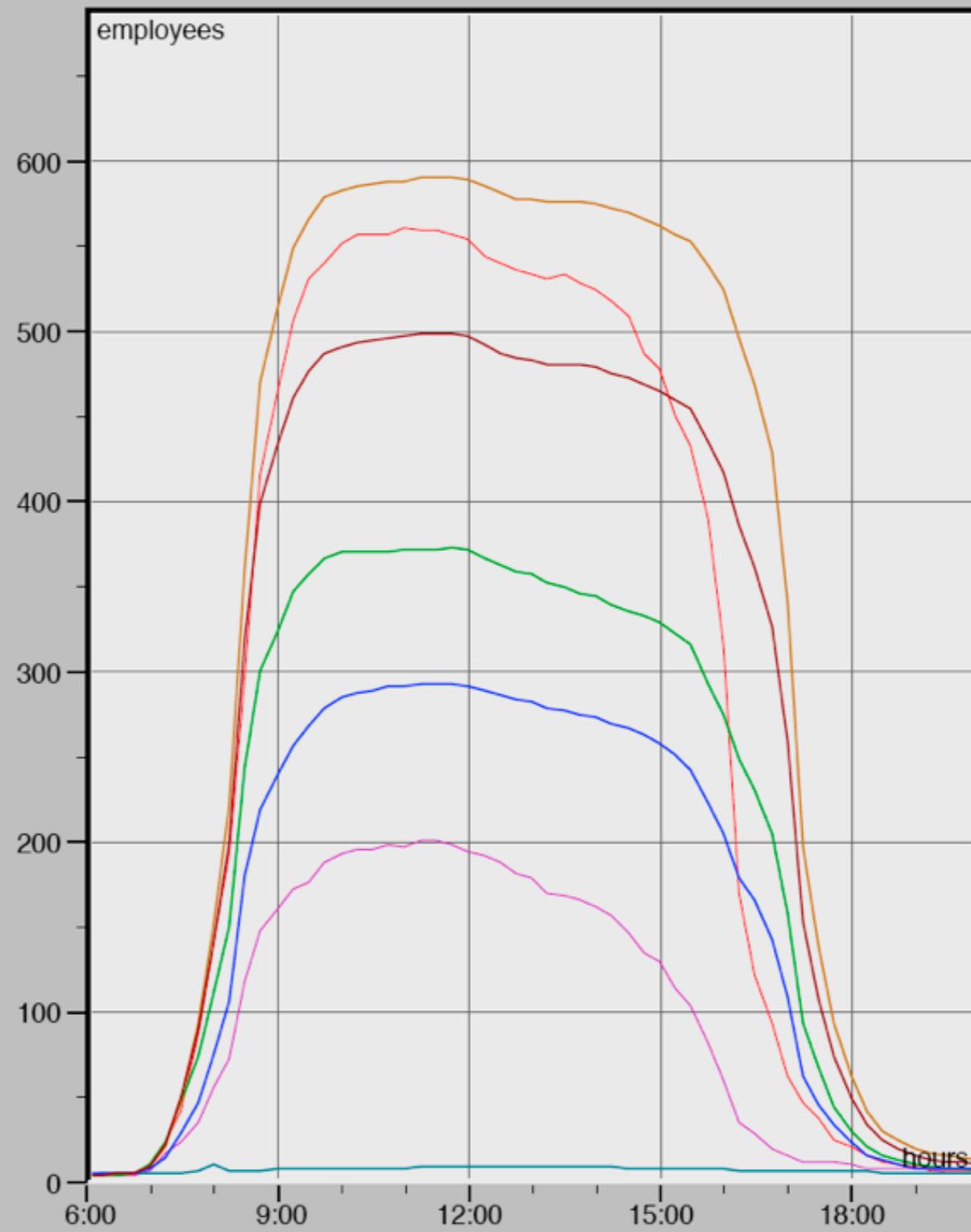
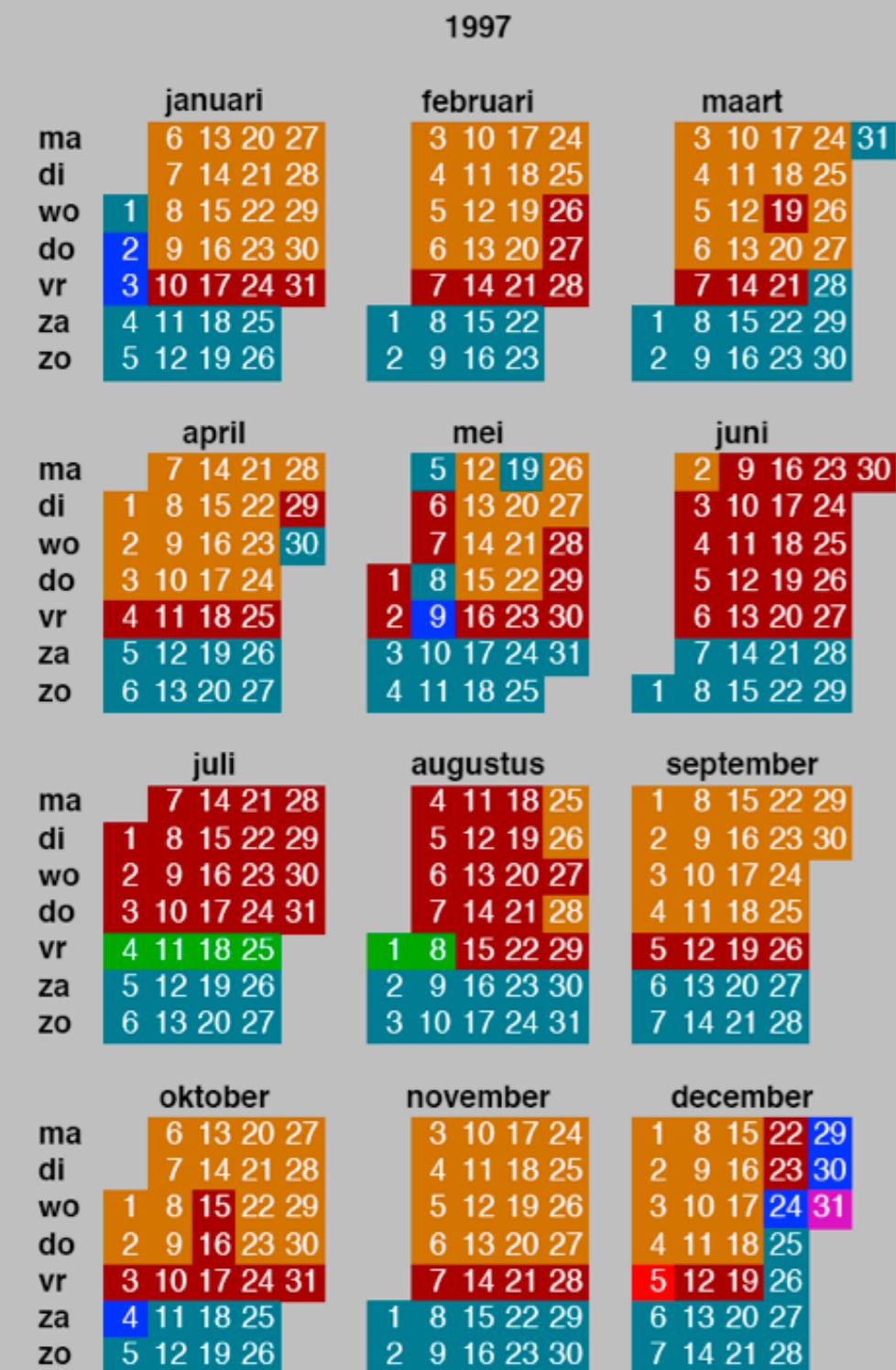
Calendar-based visualization / tile maps



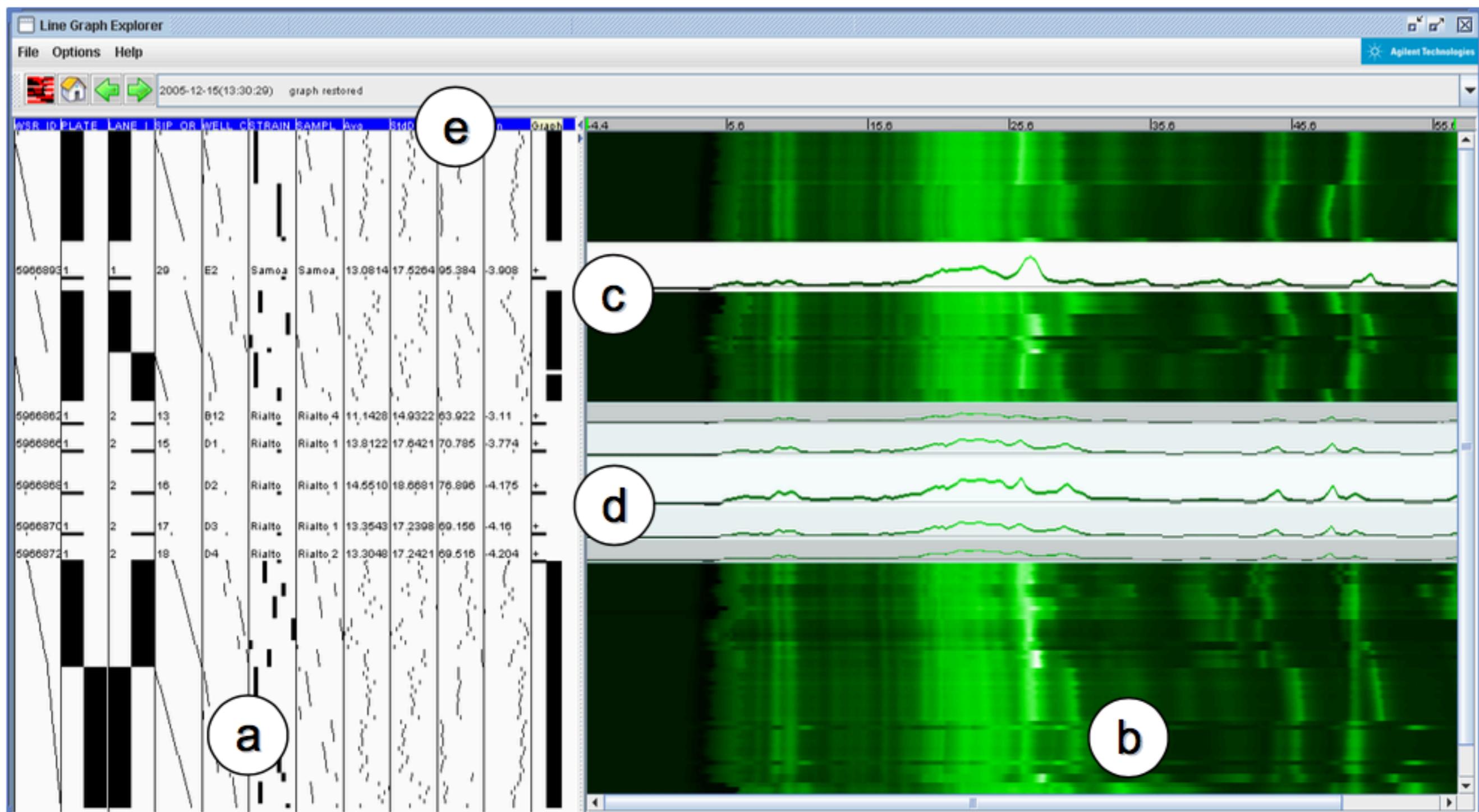
Clustering + calendar + lineplot



Clustering + calendar + lineplot



LineGraphExplorer



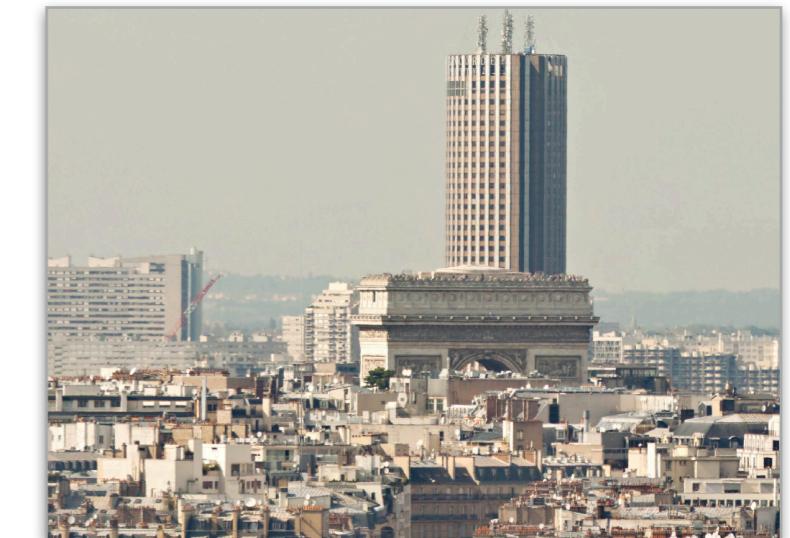
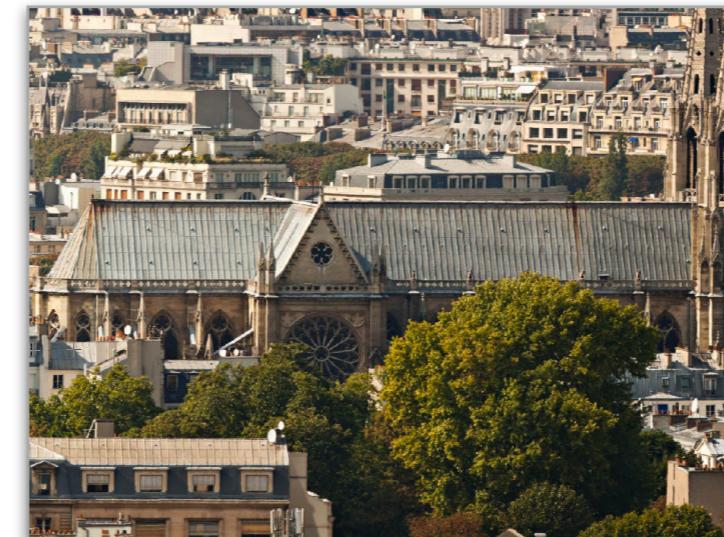
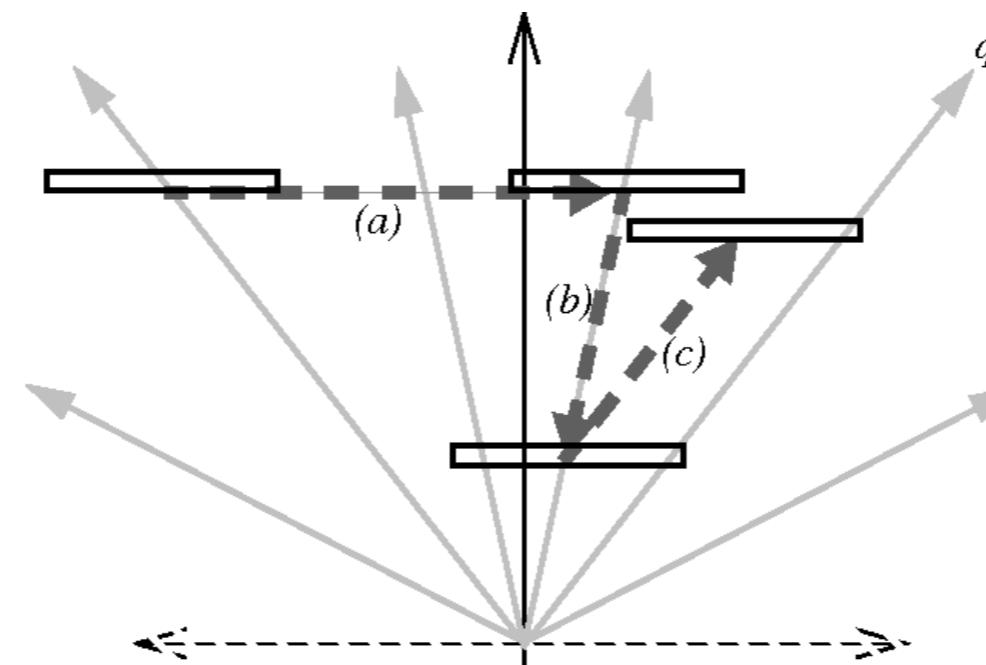
Animated Transitions

Roles of Animation

Categories	Roles
KEEPING IN CONTEXT	1. Staying oriented during navigation 2. Supporting tracking during layout changes 3. Maintaining up to date 4. Replaying history, summarizing
TEACHING AID	5. Affordance and preview 6. Training, demonstration by example 7. Explaining how a system works 8. Illustrating an algorithm 9. Teaching a new representation of information
USER EXPERIENCE	10. Hooking the user 11. Keeping the user engaged 12. Providing visual comfort and aesthetics 13. Making activity and progress visible 14. Revealing/Hiding Content 15. Providing a virtual tour 16. Providing feedback of input mechanism
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VISUAL DISCOURSE	21. Supporting a narrative 22. Highlight content 23. Persuading and convincing



Pan & Zoom

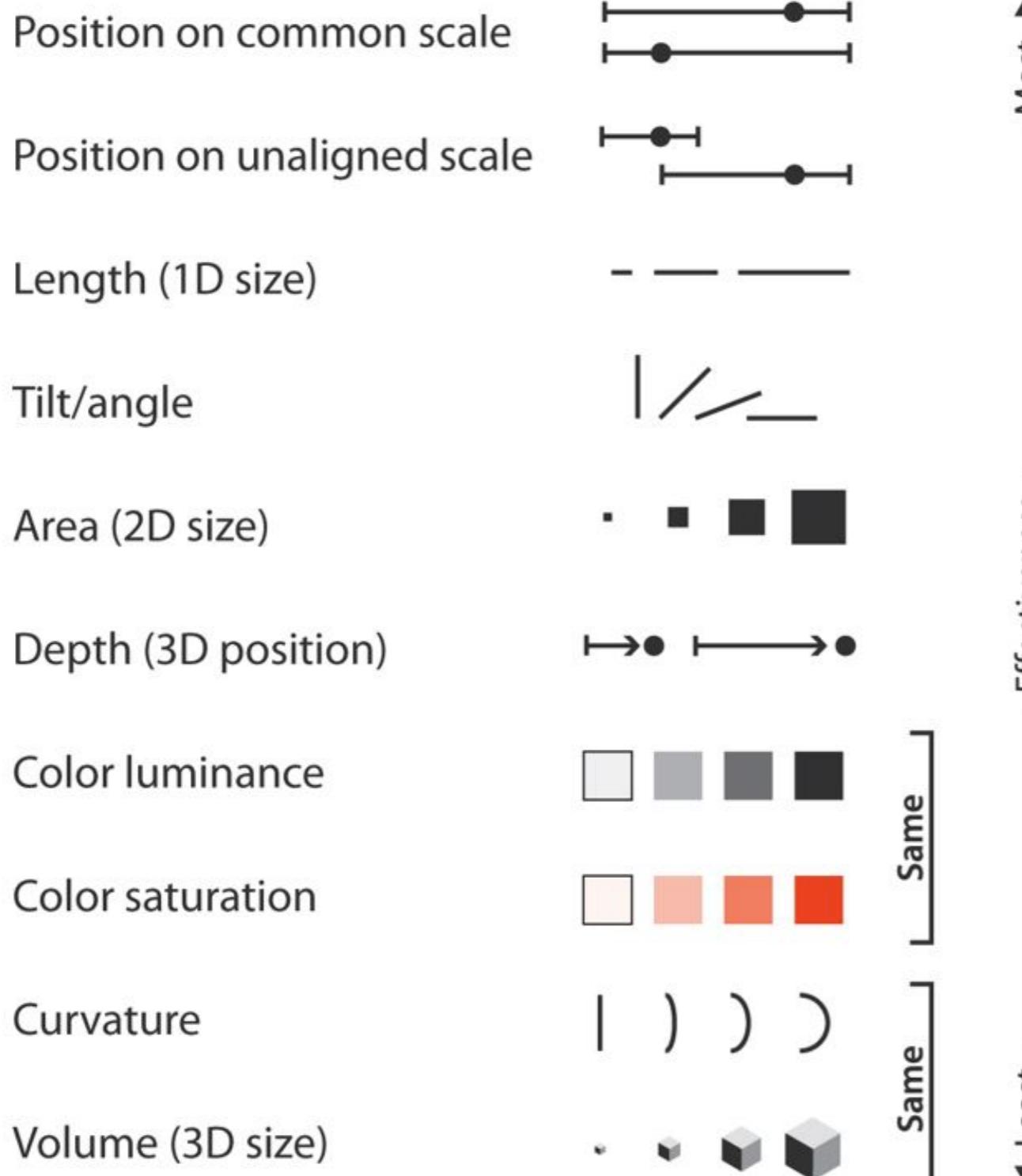


[Image source: Kolor, Paris 26 Gigapixels, 2010
354,200 × 75,570]

Animating changes to any visual encoding channel

Channels: Expressiveness Types and Effectiveness Ranks

→ **Magnitude Channels: Ordered Attributes**



→ **Identity Channels: Categorical Attributes**

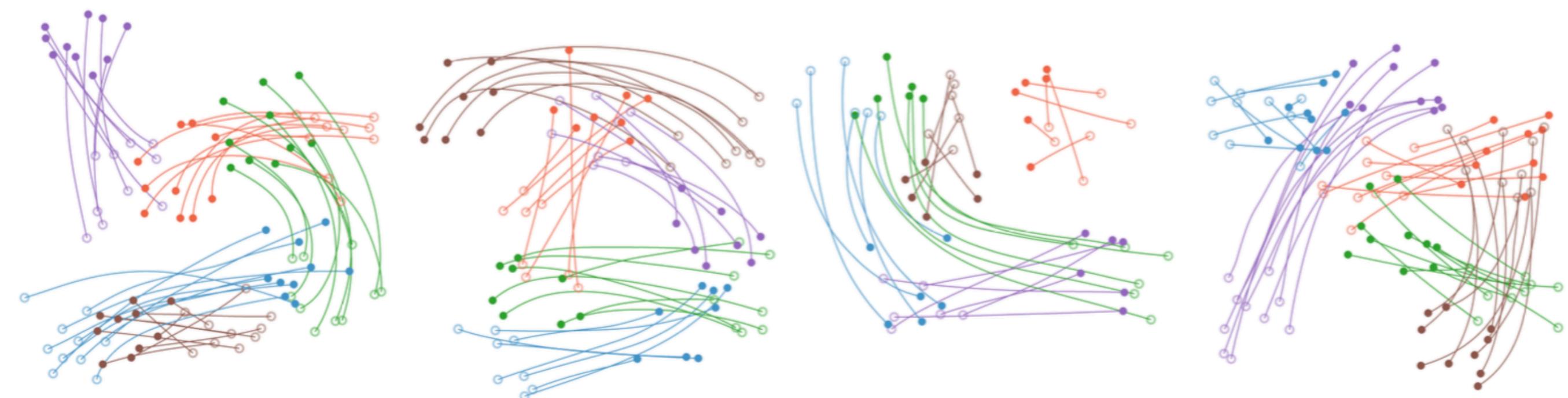


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Tracking changes



Tracking changes

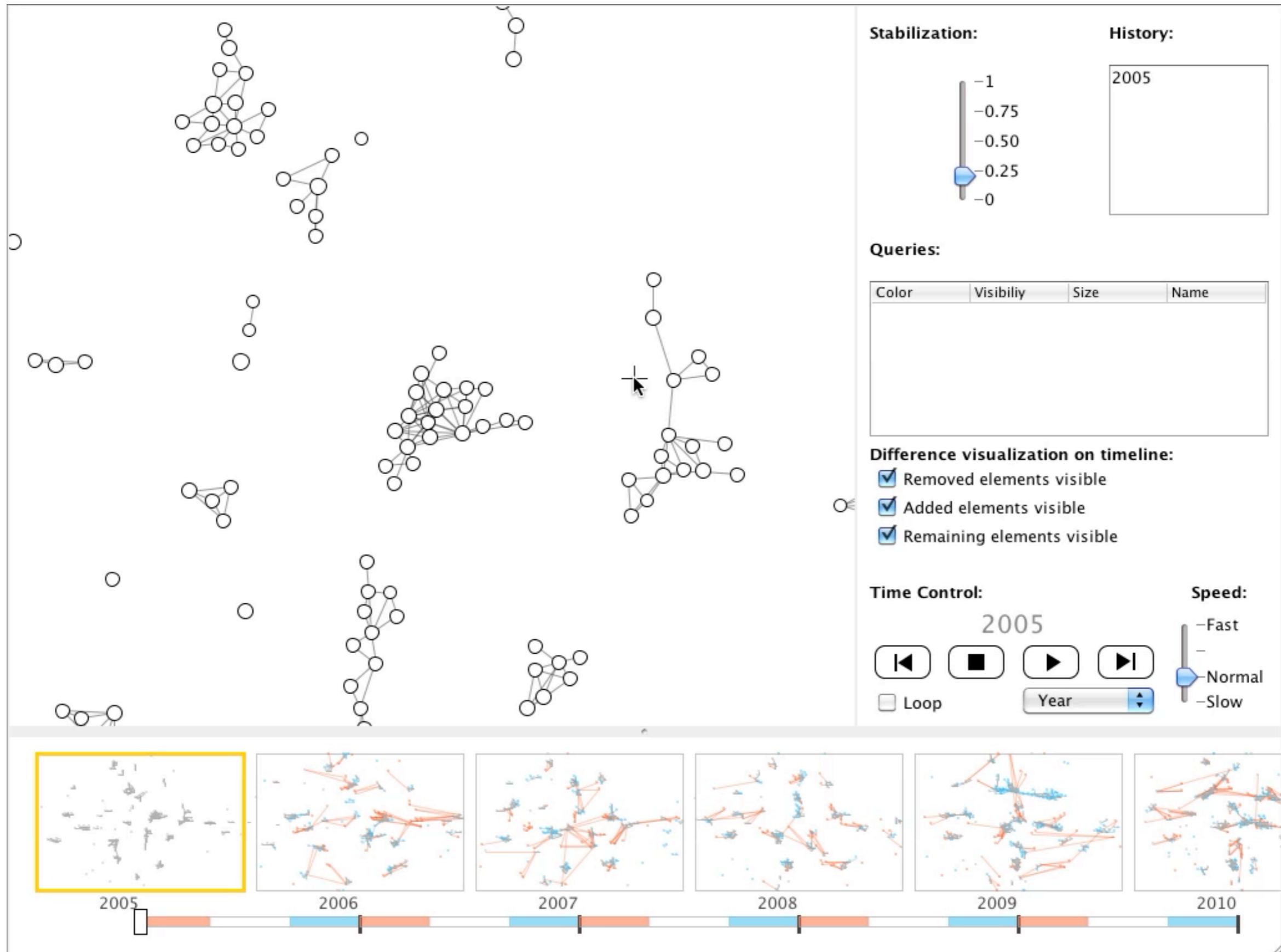
Prior studies have shown that two factors can affect visual object tracking in animated transitions:



Crowding should be avoided
(Crowding Avoidance)

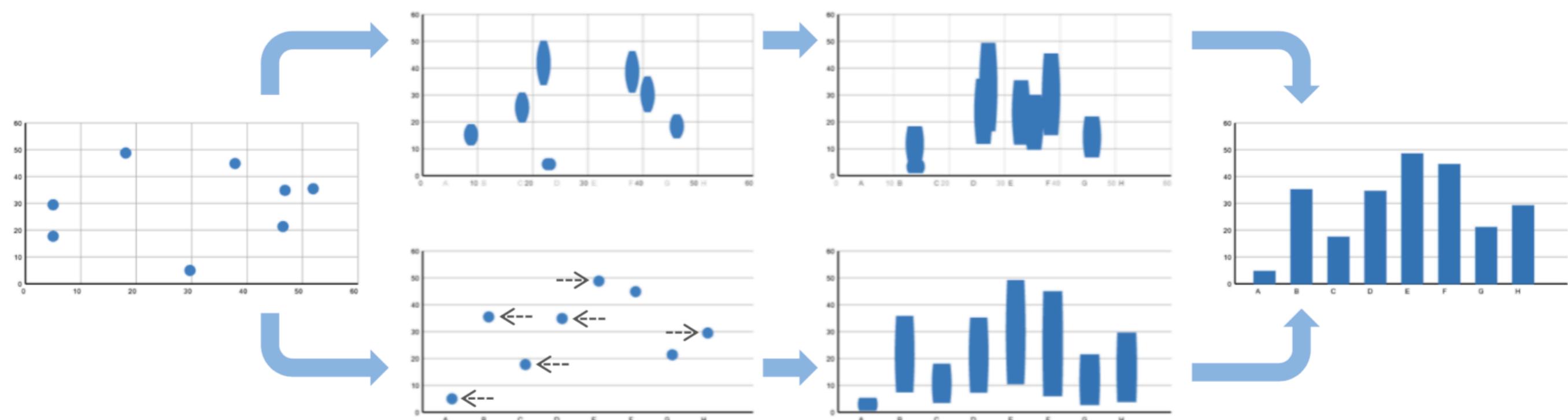
Points of the same group should move with similar trajectories
(Coordinated Motion)

Tracking changes



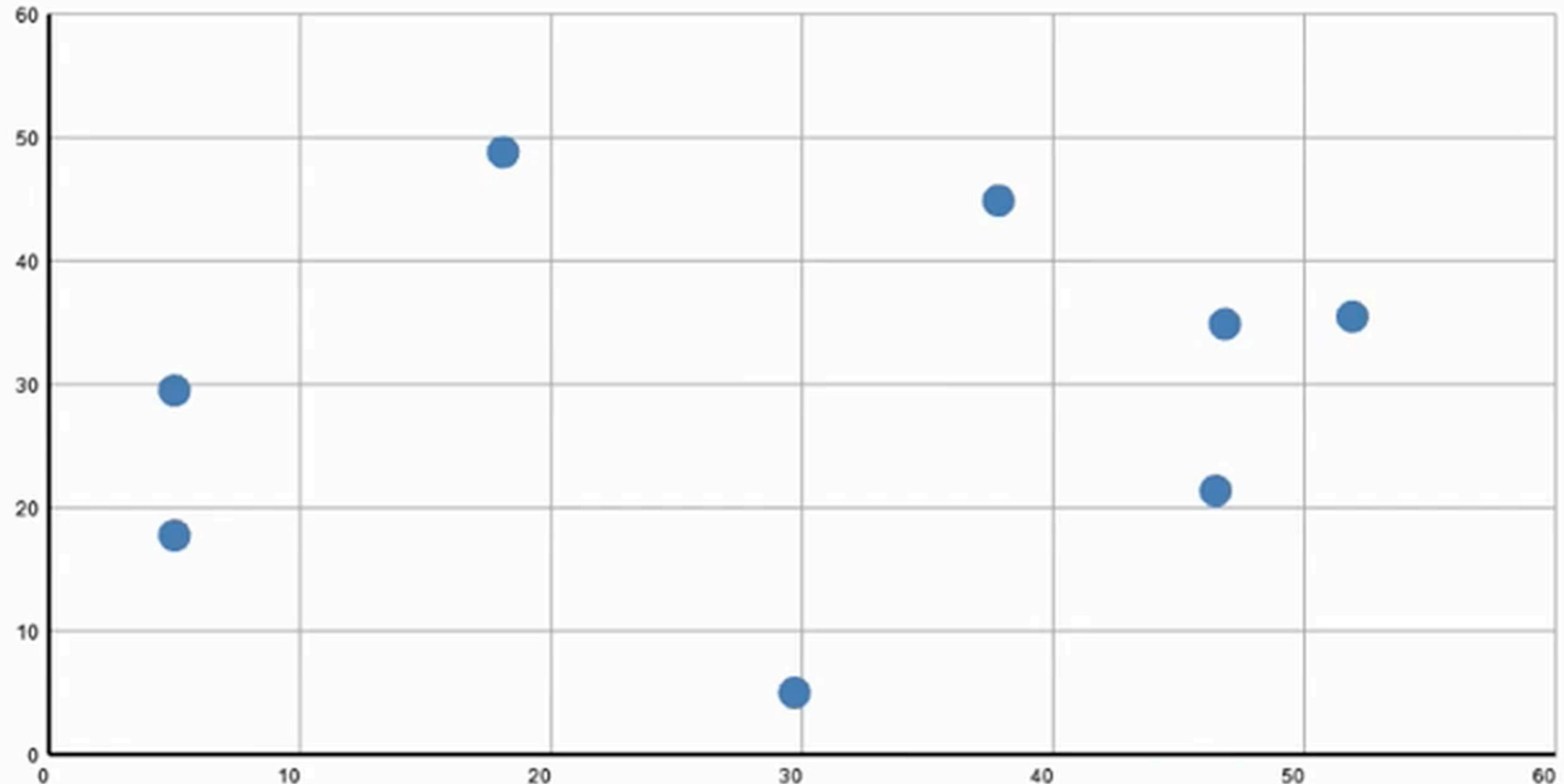
Tracking changes

direct interpolation



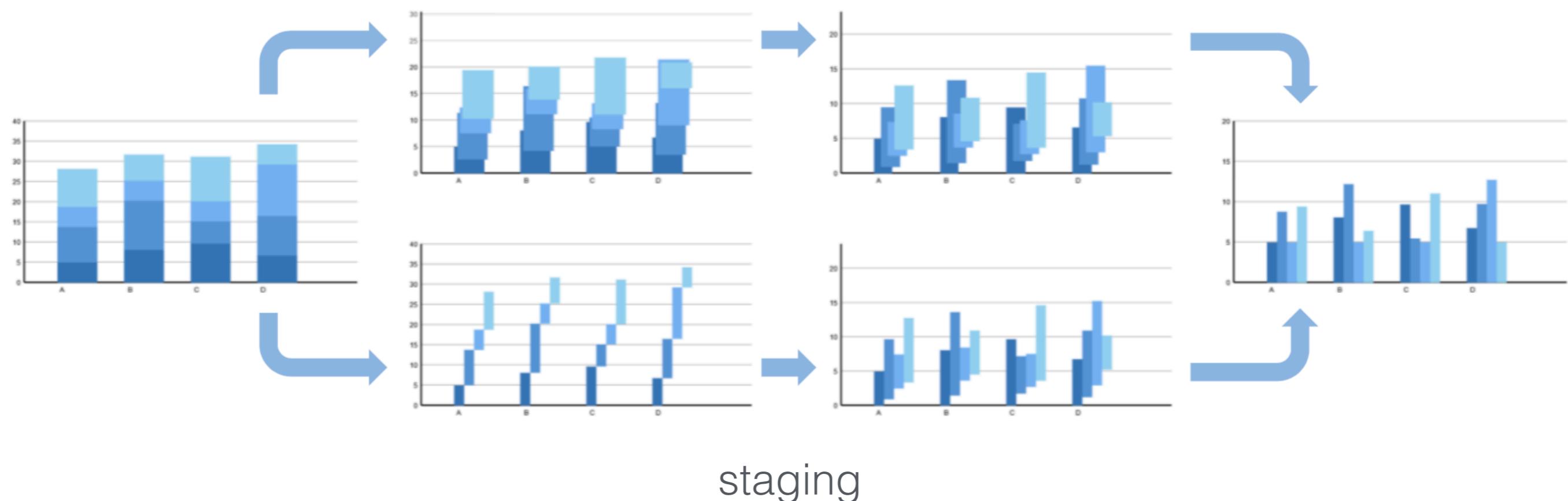
staging

Tracking changes



Tracking changes

direct interpolation



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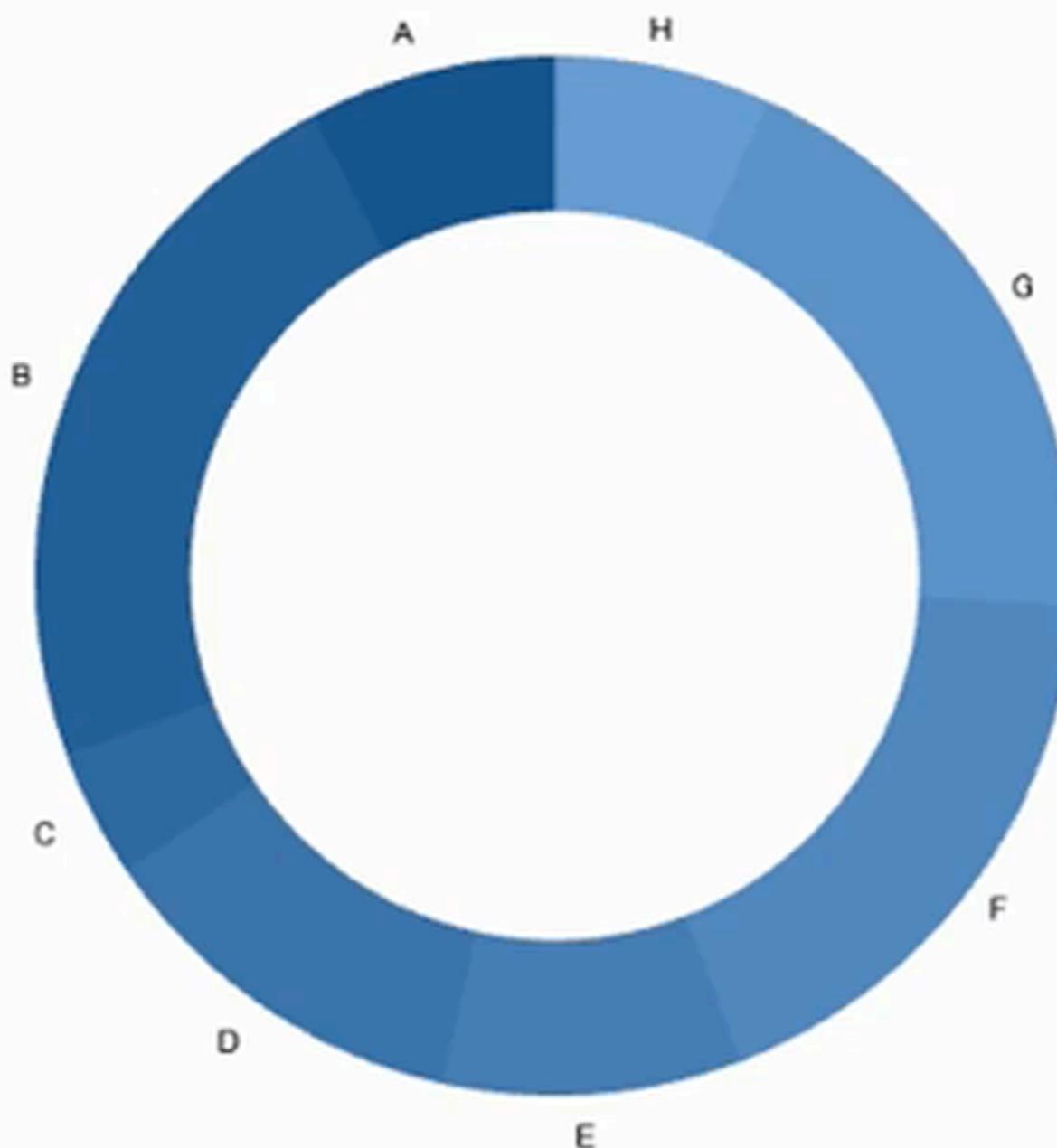


Tracking changes & staging



multiple stages

Tracking changes & staging

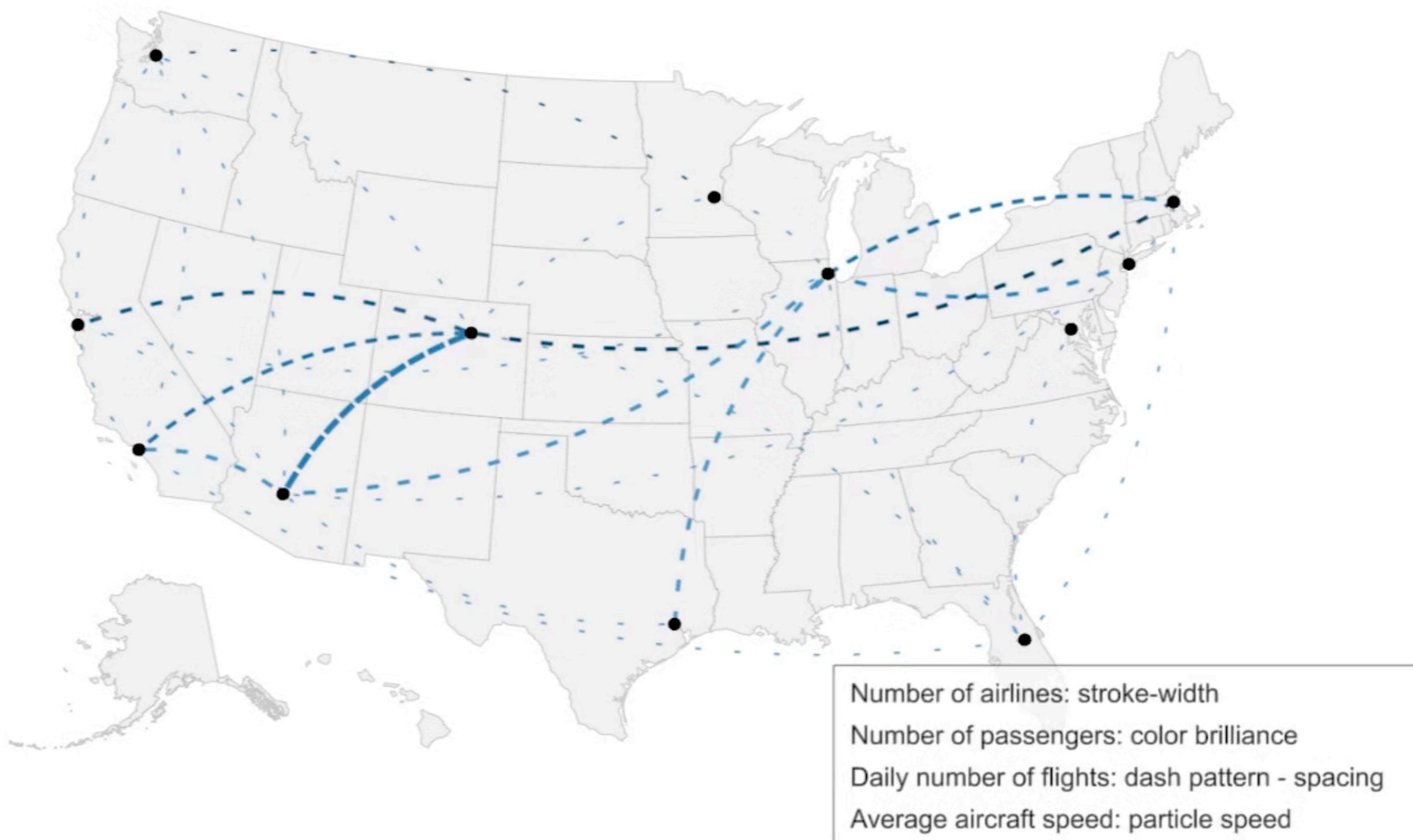


Roles of Animation

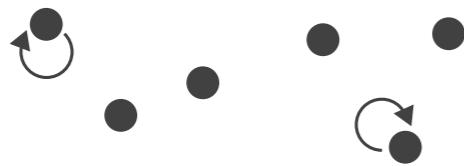
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Data Encoding



Motion



... and other types of animation



Pattern Frequency



Particle Speed

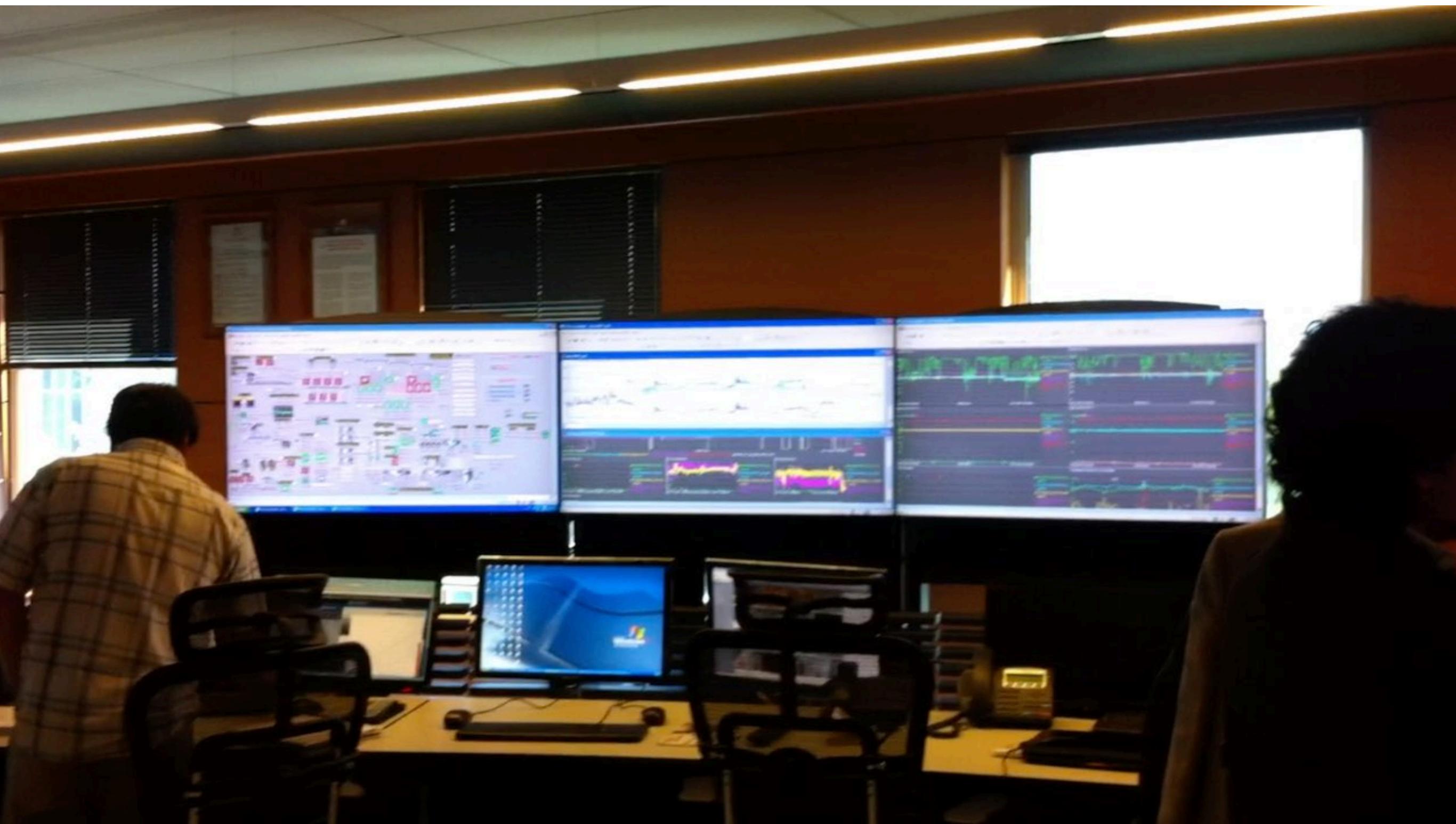


Particle Pattern



Frequency-Adjusted Speed
(Follow Up)

Motion and other animated representations

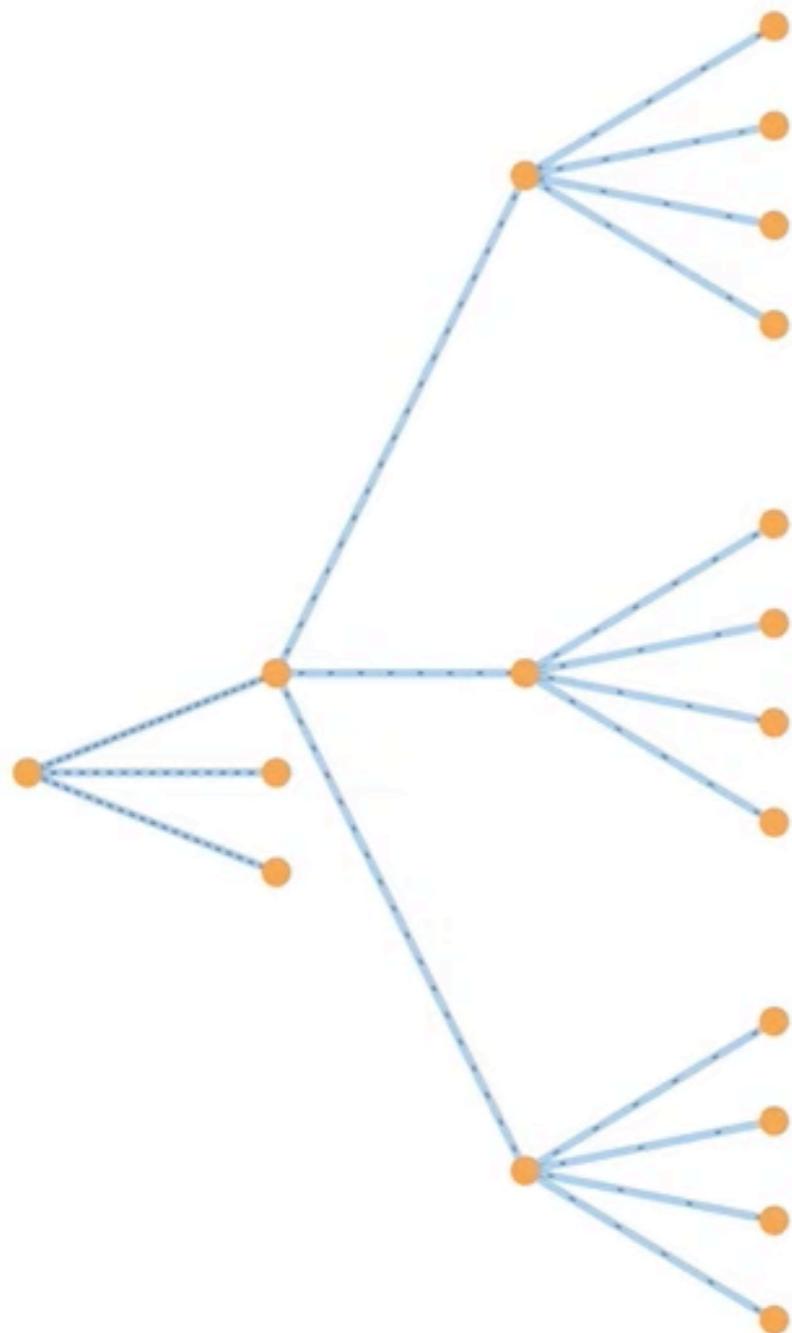


Roles of Animation

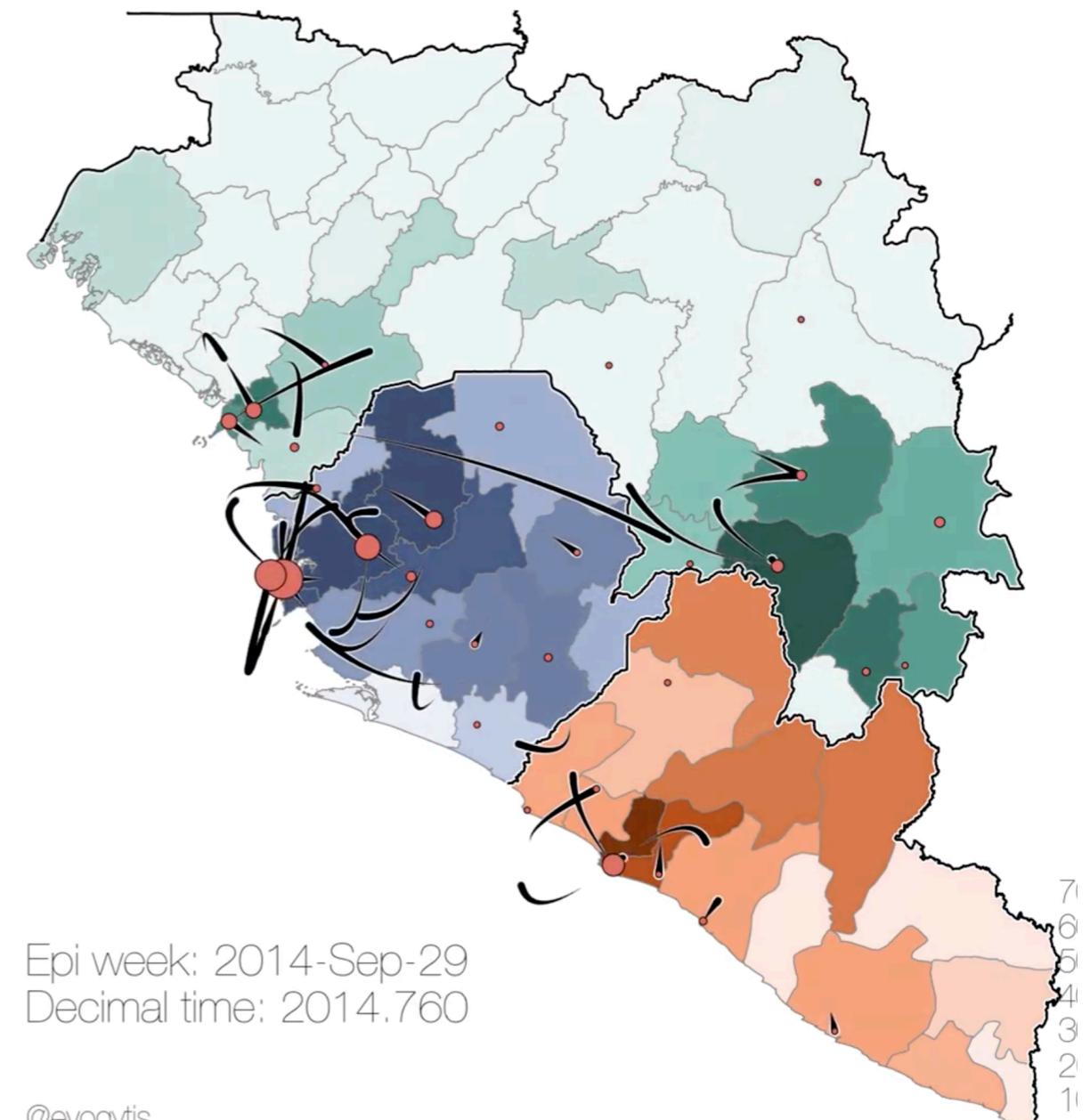
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Data Encoding



[H. Romat et al., Animated Edge Textures in Node-Link Diagrams: a Design Space and Initial Evaluation, CHI '18: Proceedings of the 36th SIGCHI conference on Human Factors in computing systems, pages 187:1–187:13, April 2018.]



[Gytis Dudas, Luiz Max Carvalho, ..., and Andrew Rambaut. 2017. Virus genomes reveal factors that spread and sustained the Ebola epidemic. *Nature* 544, 7650 (2017), 309. DOI: <http://dx.doi.org/10.1038/nature22040>]

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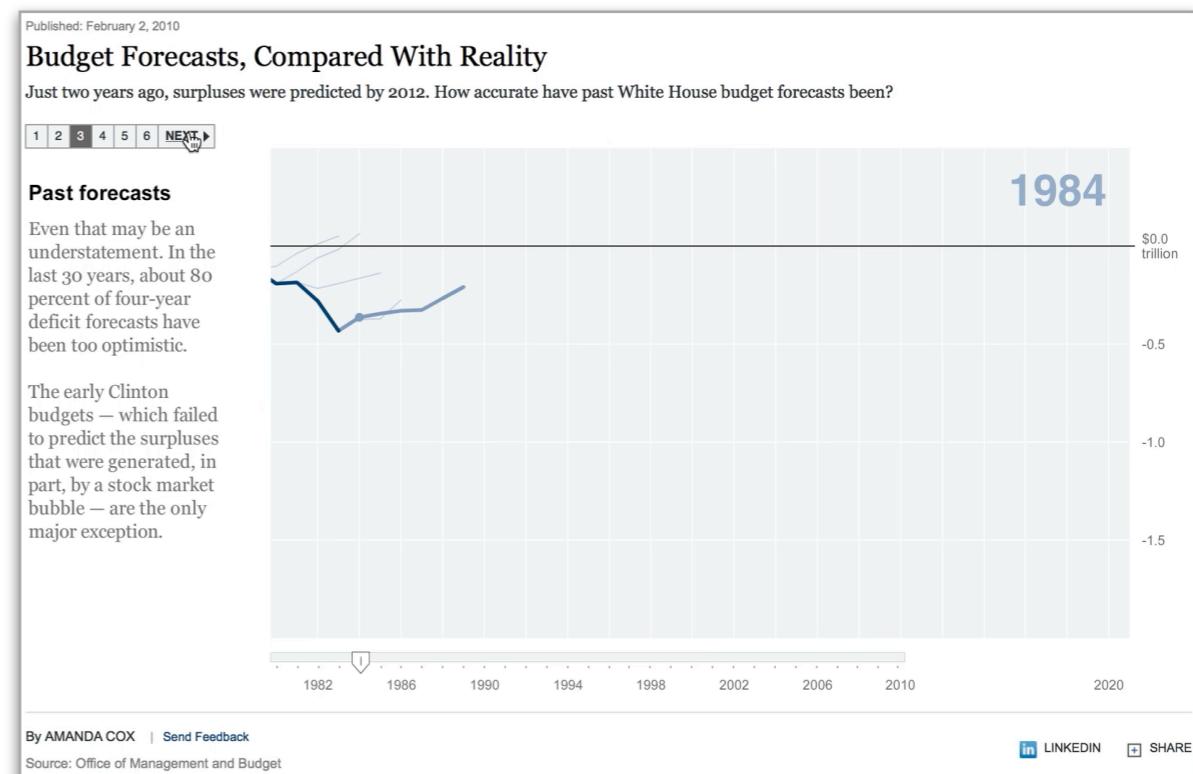


Animated visualization for the purpose of communication

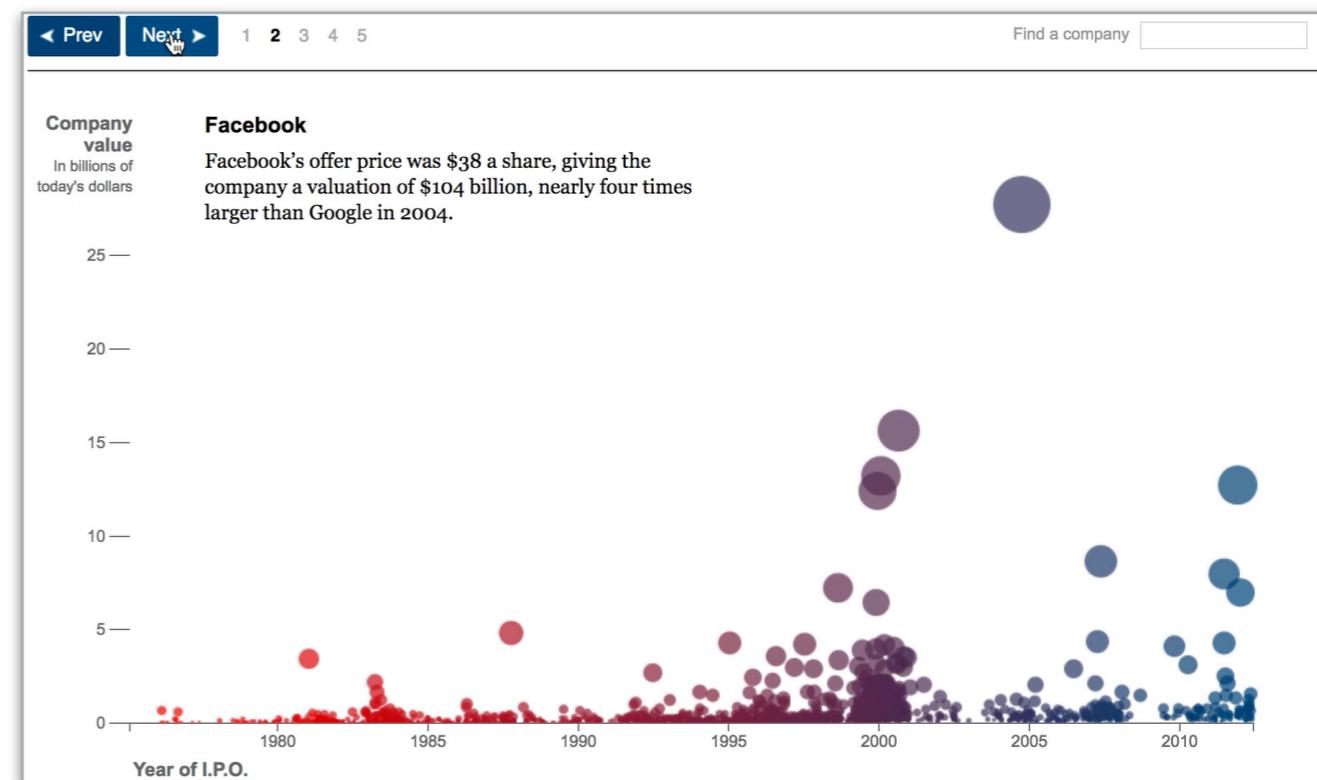
Data Storytelling



[Hans Rosling, TED Talk, 2006]



[A. Cox, New York Times, 2010]



[J. Ashkenas, M. Bloch, S. Carter and A. Cox, New York Times, 2012]



[Pietriga & Barkats, ALMA Antenna Dance, 2014]