Task Abstraction

Florian Windhager

Reading

- Munzner, “Visualization Analysis and Design”:
  Chapter 3 (Why? – Task Abstraction)
  see also https://www.youtube.com/watch?v=pHIjd-cgICY

- Shneiderman, “The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations,” IEEE Symposium on Visual Languages, 1996

- Brehmer+Munzer, “A Multi-Level Typology of Abstract Visualization Tasks,” InfoVis 2013. (link)

Tableau Dataset: 20w_data_happiness_development:

https://vda.univie.ac.at/Teaching/Vis/21s/data/20w_data_happiness_development.csv

Cushman Photography Collection:

https://vda.univie.ac.at/Teaching/Vis/21s/data/20w_data_happiness_development.csv

Last lectures:

Data/sets Types & Semantics

- Data Types
- Dataset Types
- Attribute + Dataset Semantics

Visual Encoding Principles

Today: Tasks

- The three-part Framework
- Task Taxonomies (Why?)
- VIS Design (How?) – Preview
- Tableau Examples

Follow-up lectures:

- Specific VIS techniques

Schedule

Week	Date	Tuesday	Friday
1	Mar 01/04	Introduction (TM) pdf in-class [Munzner Ch. 1] Rosling at TED 2006; Krulwich at RadioLab	D3 Tutorial (BJ) zip browser in-class
2	Mar 08/11	Design Principles (LK) pdf in-class	Rector's Day
3	Mar 15/18	Data(set) Types and Semantics (BF) pdf online Task Typology	Tableau Tutorial (BJ) in-class
	Mar 20	Due: A1 (23:5[illegible])	
4	Mar 22/25	Visual Encoding Principles (BF) pdf online Learning perceptual kernels for vis design Livingstone: What Art can tell us about the brain (Vis 2008 keynote);	D3 Tutorial (BJ) in-class
5	Mar 29/Apr 01	Tasks (FW) pdf online [Munzner Ch. 2+3] Task Typology	Arrange Tables + Spatial Data (SR) pdf in-class [Munzner Ch. 7+8]
	Apr 03	Due: A2 (23:55)	
6	Apr 05/08	Arrange Tables + Spatial Data (SR) pdf in-class [Munzner Ch. 7+8]	Q&A and D3 Tutorial (BJ) in-class
7	Apr 12/15	Easter	Easter
8	Apr 19/22	Easter Monday	Easter
9	Apr 26/29	Facet into Multiple Views (AC) pdf in-class [Munzner Ch. 12] Improvise	VIS in Digital Humanities I (FW) in-class
	May 01	Due: A3 (23:5[illegible])	
10	May 03/06	Arrange Networks/Trees (CK) pdf in-class [Munzner Ch. 9+10]	VIS in Digital Humanities II (FW) in-class
11	May 10/13	Arrange Networks / Trees (CK) pdf in-class [Munzner Ch. 9+10] Example: GraphDiaries by Bach et al.	No Lecture
	May 15	Due: A4 (23:5[illegible])	
12	May 17/20	Reduce Items & Attributes (BF) pdf online [Munzner Ch. 13] DimStiller	No Lecture
13	May 24/27	Manipulate View, Embed: Focus+Context (BF) pdf online [Munzner Ch. 11+14]	Assumption Day
14	May 31 / Jun 03	Design Studies (FW) pdf online [Munzner Ch. 4] (MizBee) An example of a design study	No Lecture
15	Jun 07/10	No Lecture	No Lecture
16	Jun 14/17	TextVis (TM) pdf in-class	Corpus Christi
	Jun 19	Due: A5 (23:55)	
17	Jun 21/24	Visual Data Science / Explainability Ethics / Evaluation (TM) pdf in-class [Overview paper]	No Lecture
18	Jun 28/Jul 01	Final	No Lecture

no lecture — subject to modifications — due/exam

Recap: A Three-part analysis framework

to analyze any exsiting visualization

unknown vis

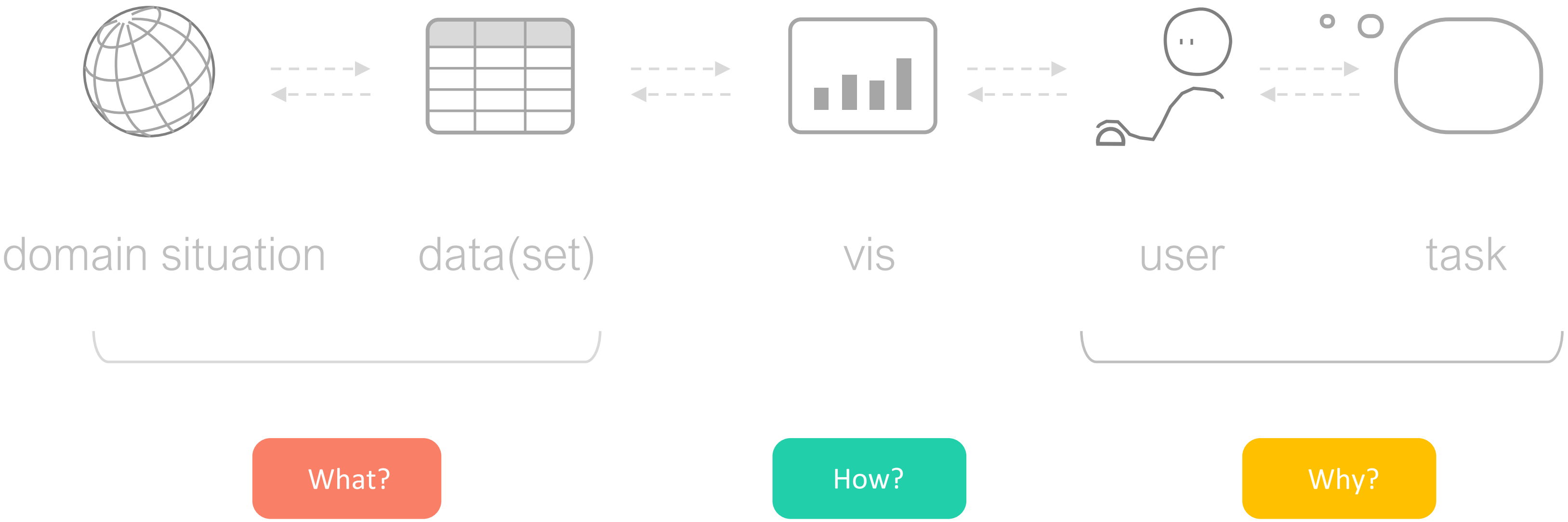
ask yourself

What? — What data is shown?

Why? — Why is the user looking at it? Which tasks are pursued?

How? — How is it shown?

(Munzner, 2014, p. 17 ff.)


domain situation
data(set)
vis
user
task
What?
How?
Why?

Data/set Types + Semantics & Tasks

What?

- What — Data abstraction

Why?

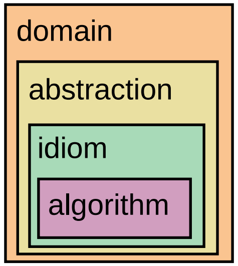
- **Why + How — Task abstraction**
  - Shneiderman's Mantra
  - Empirical Study: Amar+Eagan+Stasko
  - Typology: Brehmer + Munzner
    - Why
      - consume / produce
      - search
      - query
    - How (=Preview)
      - encode
      - manipulate
      - introduce
      - facets
      - reduce

How?

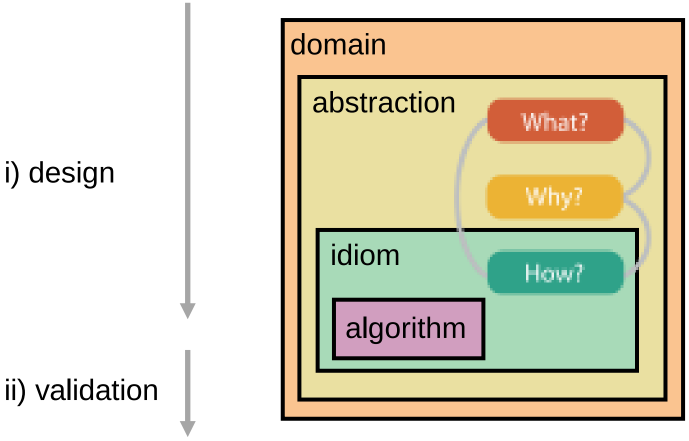
Specific VIS techniques / idioms

Munzner's Analysis Framework : Four levels, three questions

- ***domain* situation**
  - who are the target users?
- ***abstraction***
  - translate from specifics of domain to vocabulary of vis
  - **what** is shown? **data abstraction**
  - **why** is the user looking at it? **task abstraction**
- ***idiom***
  - **how** is it shown?
    - **visual encoding idiom**: how to draw
    - **interaction idiom**: how to manipulate
- ***algorithm***
  - efficient computation



A Nested Model of Visualization Design and Validation.
Munzner. IEEE TVCG 15(6):921-928, 2009]



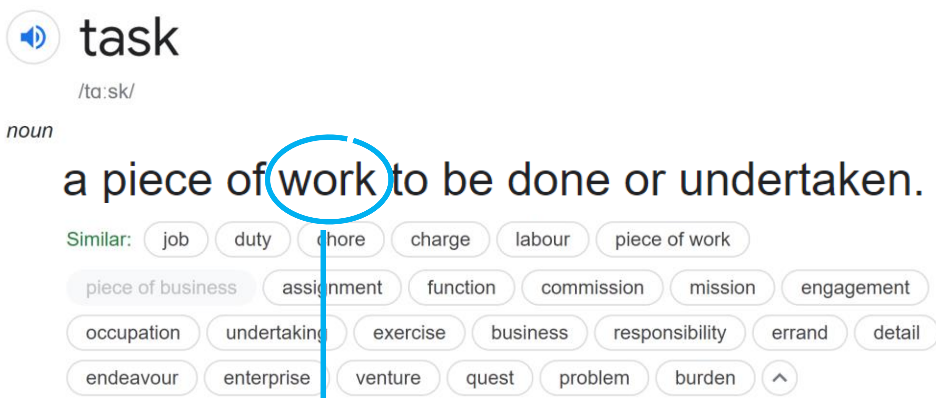
A Multi-Level Typology of Abstract Visualization Tasks
Brehmer & Munzner. IEEE TVCG 19(12):2376-2385, 2013

▸▸ More on the whole framework in Lecture No. 13 ("Design Studies")

Q: Why should we be interested in users‘ „*tasks*“?
If we were – how do we get a grip on them?

Def: “Visualization systems provide visual representations of data-sets intended to help people carry out some **task** more effectively”

(Munzner)


task

/tɑːsk/

noun

a piece of work to be done or undertaken.

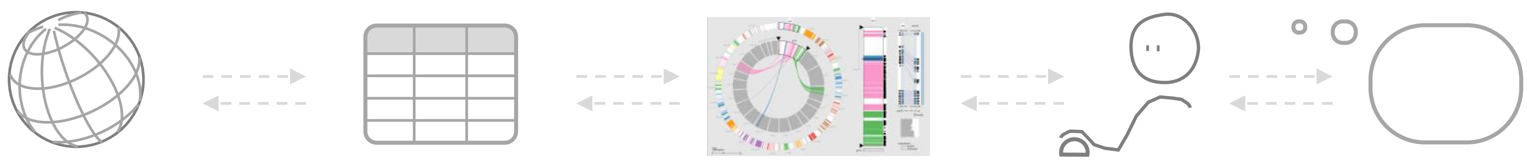
Similar: job duty chore charge labour piece of work piece of business assignment function commission mission engagement occupation undertaking exercise business responsibility errand detail endeavour enterprise venture quest problem burden

The world is full of **work** to be done. → VIS aims to „help people carry out some **work** more effectively“ →

Thus good VIS development starts with analyzing and abstracting „tasks“ as specific work practices and related challenges of people in real world domains.

Example No.1:

Meyer et al. (2009). *MizBee: A Multiscale Synteny Browser.*



domain	data(set)	vis	user	task
Genetics (Study of genetic information)	Syntenic data (How to localize genetic loci on chromosomes)	Mizbee VIS (A visualization proto-type by Meyer et al.)	Biologists	?

What?

How?

Why?

Task Abstraction – Meyer et al.

We have identified a set of 14 fundamental questions that biologists ask to gain scientific insight at different stages of the data analysis pipeline, shown in Table 1. We have organized them according to the scale at which they operate and the type of conservation relationship they address. Some of these questions pertain to the early data generation stage, probing the results of computational algorithms that de-

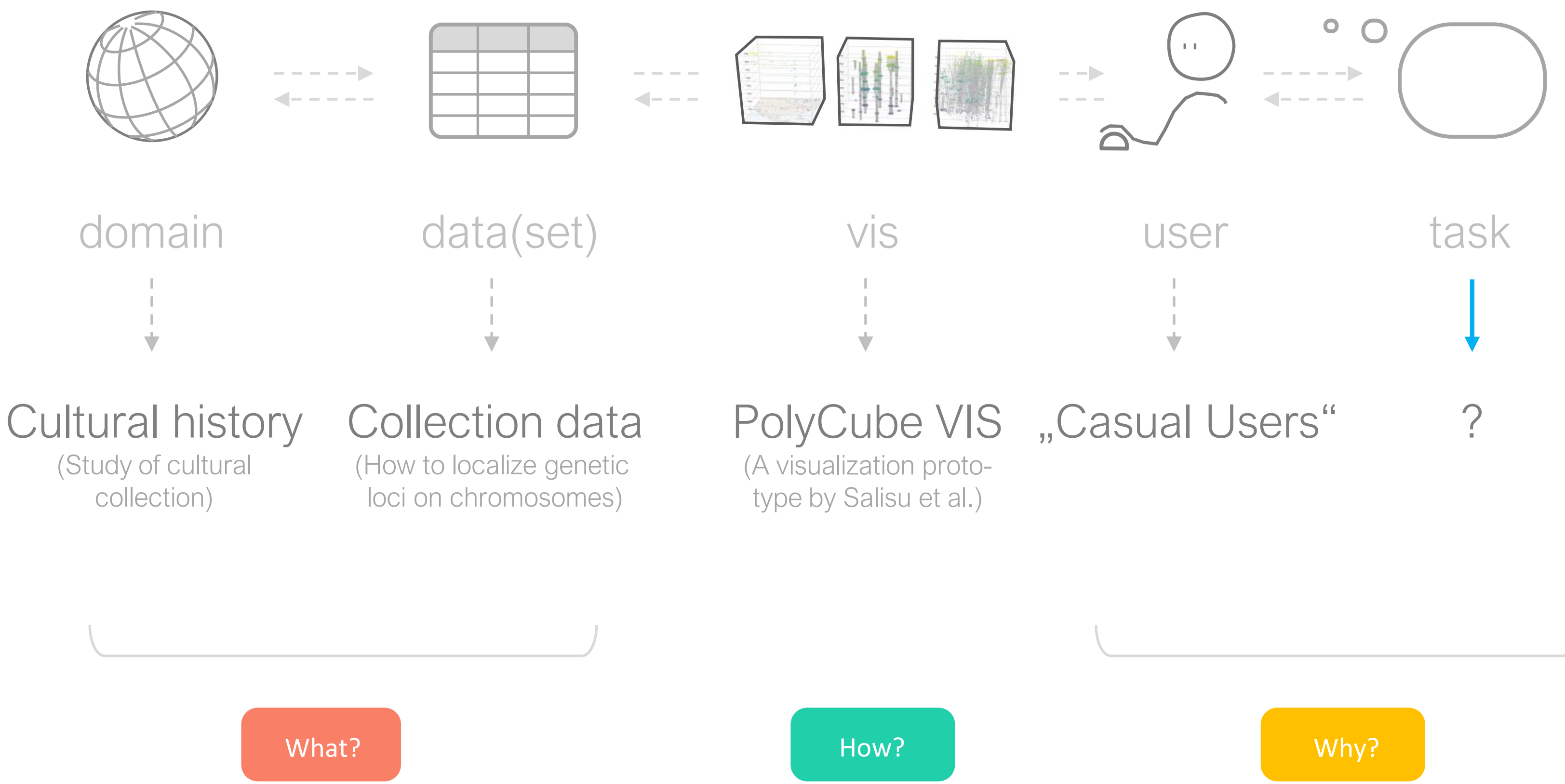
Table 1. Questions for the analysis of conserved syntenic data, with the scale and relationship addressed by each. The scales are: g, genome; c, chromosome; b, block; and f, feature. The relationships are: p, proximity/location; z, size; o, orientation; and s, similarity.

	question	*scale*				*relationship*			
		g	*c*	*b*	*f*	*p*	*z*	*o*	*s*
1	Which chromosomes share conserved blocks?	X				X			
2	For one chromosome, how many other chromosomes does it share blocks with?	X	X			X			
3	What is the density of coverage and where are the gaps on: chromosomes? blocks?	X	X	X		X			
4	Where are the blocks: on chromosomes? around a specific location on a chromosome?	X	X			X			
5	What are the sizes and locations of other genomic features near a block?		X			X	X		
6	How large are the blocks?		X				X		
7	Do neighboring blocks go to the same: chromosomes? relative location on a chromosome?	X	X			X			
8	Are the orientations matched or inverted for: block pairs? feature pairs?		X	X				X	
9	Do the orientations match for pairs of: neighboring blocks? features within a block?		X	X				X	
10	Are similarity scores alike: with respect to neighboring blocks? within a block?		X	X					X
11	Are the paired features within a block contiguous?			X		X			
12	How large is a feature relative to other genes within a block?			X			X		
13	What are the sizes, locations, and names of features within a block?			X		X	X		
14	What are the differences between individual nucleotides of feature pairs?				X				X

[Meyer et al., MizBee: A Multiscale Synteny Browser, 2009]

Example No.2:

Windhager et al. (2019). *PolyCube Collection Visualization*



Task Abstraction

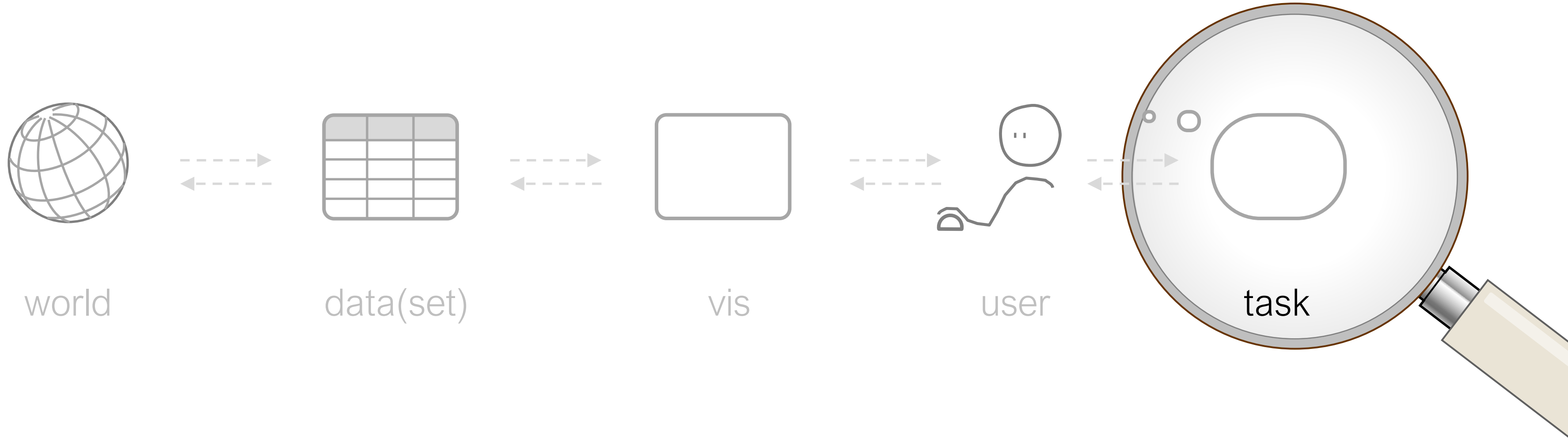
Users: Regarding the users of our system, we intended to support casual users, i.e., a heterogeneous group of users with different levels of visual literacy, expert knowledge, and interest. As they explore cultural collections mainly for leisure purposes, they are not necessarily motivated to invest high amounts of cognitive load to fully process and interconnect all information and perspectives available. Therefore, casual users can benefit from visualization designs, which actively assist them in the construction of a mental model.

In addition, it is important to be aware that casual users will only persist in exploration as long as it is rewarding for them (i.e., engaging, aesthetically pleasing, interesting, or intriguing). Hermetic and complex system designs can easily terminate the interaction at an early stage.

Tasks: Casual users of cultural collections often have no specific information needs, but look around and browse for something interesting, which they can access for details on demand. They do not pursue concrete tasks, but they are keen on gaining an overview and exploring the digital collection. When designing and developing PolyCube, we attempted to clarify these rather vague tasks as follows: 1) gaining a (synoptic) overview and conceptual orientation regarding the distribution of the major data dimensions of a cultural collection (e.g., time, space, categories, relations), 2) finding single objects of personal interest and inspecting their details, and 3) browsing through objects (e.g., according to time, relations, geographic origins, or shared categories). These tasks align with the task typology proposed by Brehmer and Munzner,[13] as the users in this case are consumers of the visualization and want to *explore*, *browse*, and *enjoy*.

Windhager et al. (2020), Many Views Are Not Enough: Designing for Synoptic Insights in Cultural Collections. https://doi.org/10.1109/MCG.2020.2985368

Task Taxonomies



- Q: What are the most important types of tasks or activities users frequently (want to) pursue in complex information spaces and for various data?
- Can we describe, cluster and abstract these information activities, so that we arrive at a more general understanding of tasks (i.e. task taxonomies or typologies), and use it to guide our own VIS developments?

A: Dozens of task taxonomies and typologies has already been developed. Let‘s have a look at important concepts from a couple of them, including

- Shneiderman, B. (1996). "The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations," *IEEE Symposium on Visual Languages.*
- Amar, R., Eagan, J., & Stasko, J. (2005). "Low-level components of analytic activity in information visualization," *InfoVis.*
- Brehmer, M. & Munzner, T. (2013). A Multi-Level Typology of Abstract Visualization Tasks, *InfoVis*.
- Munzner, T. (2014). *Visualization Analysis and Design*. **Chapter 3** (Why? – Task Abstraction)

→ see also the video lecture: https://www.youtube.com/watch?v=pHljd-cgICY

Shneiderman’s
Task by Data Type Taxonomy

[Shneiderman, 1996, link]

Shneiderman‘s Basic Tasks

- **Overview**: Gain an overview of the entire collection
- **Zoom**: Zoom in on items of interest
- **Filter**: filter out uninteresting items
- **Details-on-demand**: Select an item or group and get details when needed
- **Relate**: View relationships among items
- **History**: Keep a history of actions to support undo, replay, and progressive refinement
- **Extract**: Allow extraction of sub-collections and of the query parameters

The Mantra

[Shneiderman, 1996]

Shneiderman's
Visual Information Seeking Mantra

[Shneiderman, 1996]

There are many visual design guidelines but the basic principle might be summarized as the Visual Information Seeking Mantra:

Overview first,

zoom and filter, then

details-on-demand

e.g.: https://galaxy.opensyllabus.org

Empirical Study:
Amar, Eagan & Stasko

[Amar, Eagan & Stasko, 2005, link]

- Q: What are the most important types of analytical tasks or users frequently (want to) pursue when using visualizations and visual analytics tools?
- Amar, Eagan & Stasko conducted an empirical study with students, who were given five different datasets - and documented their analytic activities.
- They recorded about 200 different analytical activities, and clustered them with an affinity diagram into 10 distinct types of tasks.

Task Abstraction (Amar, Eagan & Stasko, 2005)

4 An Analytic Task Taxonomy

The ten tasks from the affinity diagramming analysis are:

- Retrieve Value
- Filter
- Compute Derived Value
- Find Extremum
- Sort
- Determine Range
- Characterize Distribution
- Find Anomalies
- Cluster
- Correlate

Examples:
- Order the cars by weight.
- Rank the cereals by calories.

[Amar, Eagan, & Stasko, 2005]

1. **Filter**: Find data that satisfies conditions
2. **Find Extremum**: Find data with extreme values
3. **Sort**: Rank data according to some metric
4. **Determine Range**: Find span of data values
5. **Find Anomalies**: Find unexpected / extreme values

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Examples:
- What Kellogg's cereals have high fiber?
- What comedies have won awards?
- Which funds underperformed the SP-500?

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Examples:
- Are there exceptions to the relationship between horsepower and acceleration?
- Are there any outliers in protein?

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Typology: Why?

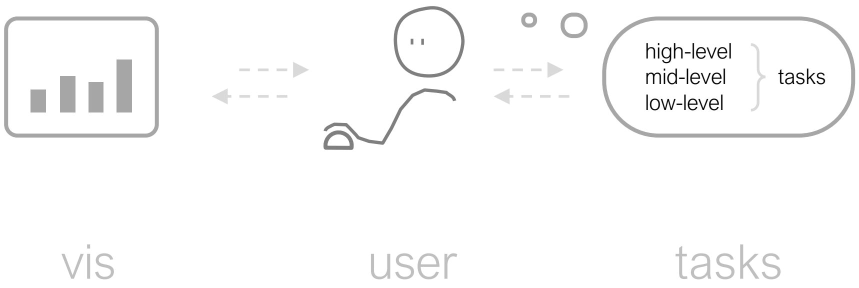
Brehmer & Munzner

[Brehmer+Munzner, 2013, link]

Why? → Task Abstraction!

Munzner provides a hierarchy of

- high-level tasks: consume / produce
- mid-level tasks: search
- low-level tasks: query



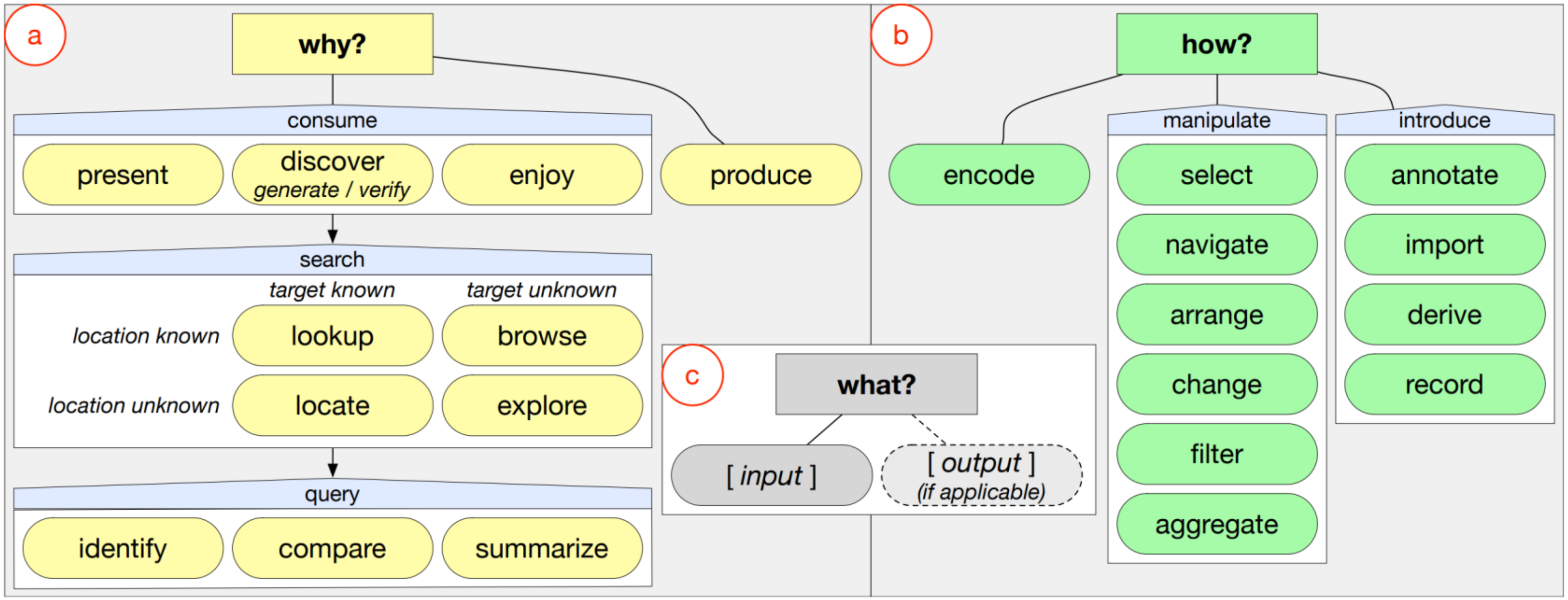
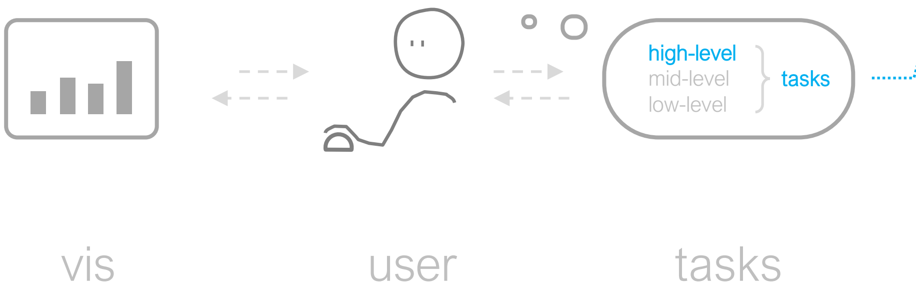


Fig. 1. Our multi-level typology of abstract visualization tasks. The typology spans *why*, *how*, and *what*; task descriptions are formed by nodes from each part: a) *why* a task is performed, from high-level (consume vs. produce) to mid-level (search) to low-level (query). b) *how* a task is executed in terms of *methods*, defined as families of related visual encoding and interaction techniques. c) *what* the task inputs and outputs are.

[Brehmer+Munzner, 2013, link]

Consume vs. Produce (High-level)



High-level tasks

consuming data with a VIS

- *presenting data with a VIS*
- *discovering data with a VIS*
- *enjoying data with a VIS*

producing something with a VIS

- *creating annotations on a VIS*
- *creating recordings of a VIS*
- *deriving new data from a VIS*

Consume vs. Produce (High-level)

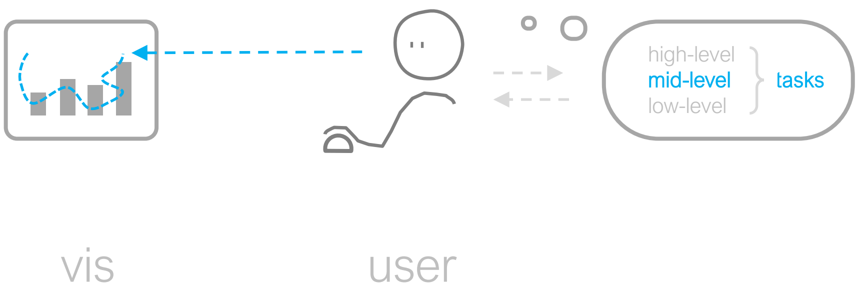
- Consume (most common)
  - **present**
    - not just static (e.g. interactive graphics in newspapers / NY Times)
  - **discover**
    - generation / verification of hypothesis
  - **enjoy**
    - “casual” vis
    - e.g. Name Voyager (http://www.babynamewizard.com/voyager)

- Produce
  - help the user produce something based on a VIS, e.g. annotations, recordings, derivates

Search (Mid-level)

Search: Regardless of whether the intent is to `present`, `discover`, or merely `enjoy`, the user must find elements of interest in the visualization.

(Brehmer+Munzner, 2013)



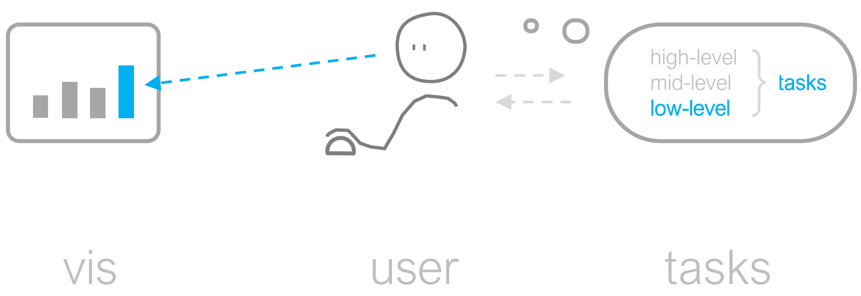
searching & exploring a VIS for elements of interest

	target known	*target unknown*
location known	lookup	browse
location unknown	locate	explore

Query (Low-level)

Query: Once a target or set of targets has been found, a user will `identify`, `compare`, or `summarize` these targets.

(Brehmer+Munzner, 2013)

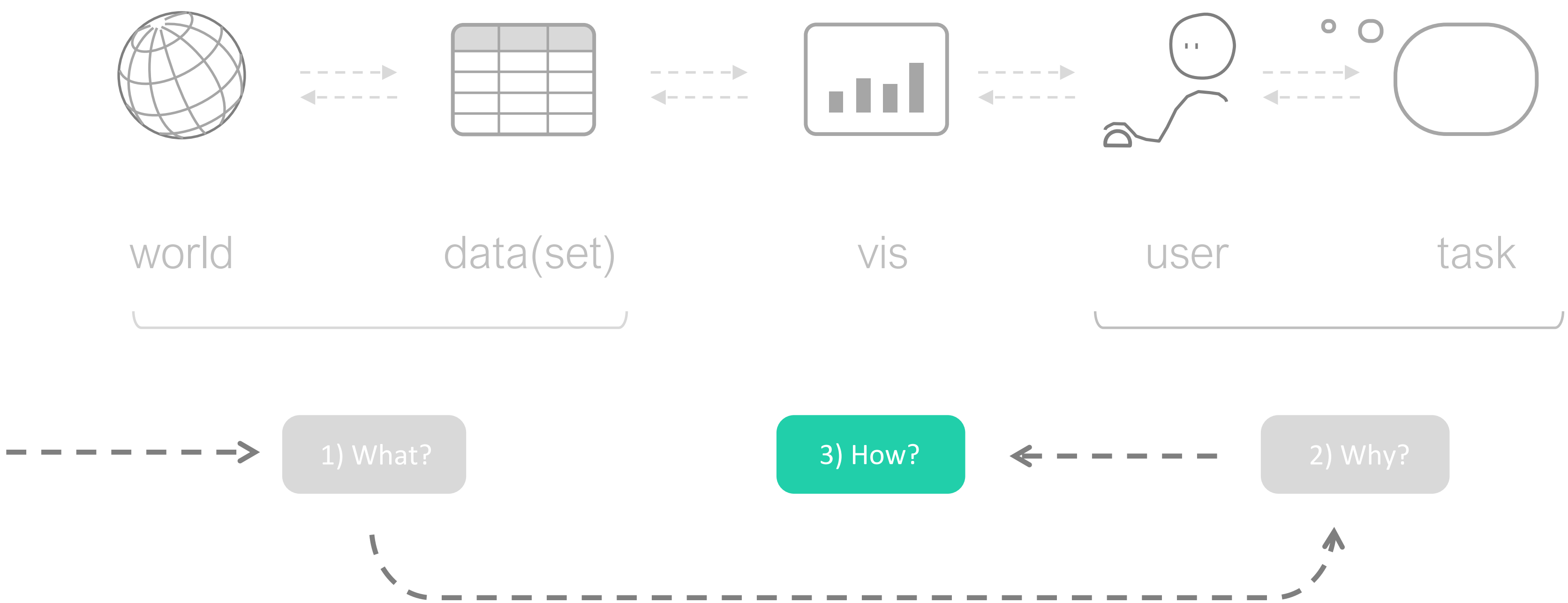


- *identifying* single targets
- *comparing* two or multiple targets
- *summarizing* a whole set of targets

Typology: How? (Preview)

Brehmer & Munzner

[Brehmer+Munzner, 2013]



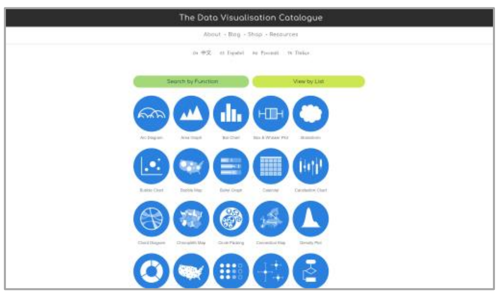
[After learning about what and why, we] "*now turn our consideration to the **how** part of our typology, which contains methods, defined as families of related visual encoding and interaction techniques. […] We distinguish between three classes of methods: those for encoding data, those for manipulating existing elements in a visualization, and those for introducing new elements into a visualization*." (Brehmer & Munzner, 2013)

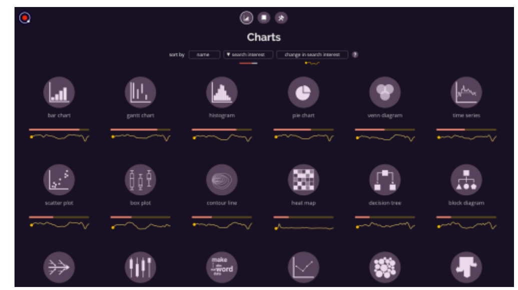
How can interactive visualizations be designed to support people to carry out their tasks? Munzner suggests three classes of methods to so:

- methods to **encode** data into a VIS
- methods to **manipulate** existing elements of a VIS
- methods to **introduce** new elements into a VIS

Encode

visually encoding information through marks and channels (e.g. color, shapes, size, position etc.) – to create any known or new kind of VIS





https://datavizcatalogue.com/index.html https://datavizproject.com/ http://visualizationuniverse.com/charts/

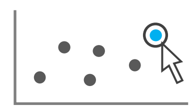
→ see last lecture for „general encoding principles“ and the following lectures for specific encoding techniques (e.g. arrangments of tables, spatial data, networks, or tree visualizations)

Manipulate

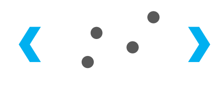
→ see specific lecture on “Reduce – Items and attributes”

The following methods affect existing elements of a visualization, modifying them to some extent. (Brehmer & Munzner, 2013)

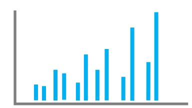
- select



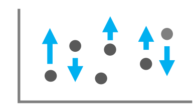
- navigate



- (re-)arrange

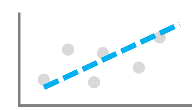


- change



- filter

- aggregate



Introduce

Introduce: While manipulate methods alter existing elements of the visualization, `introduce` methods add new elements.

(Brehmer & Munzner, 2013)

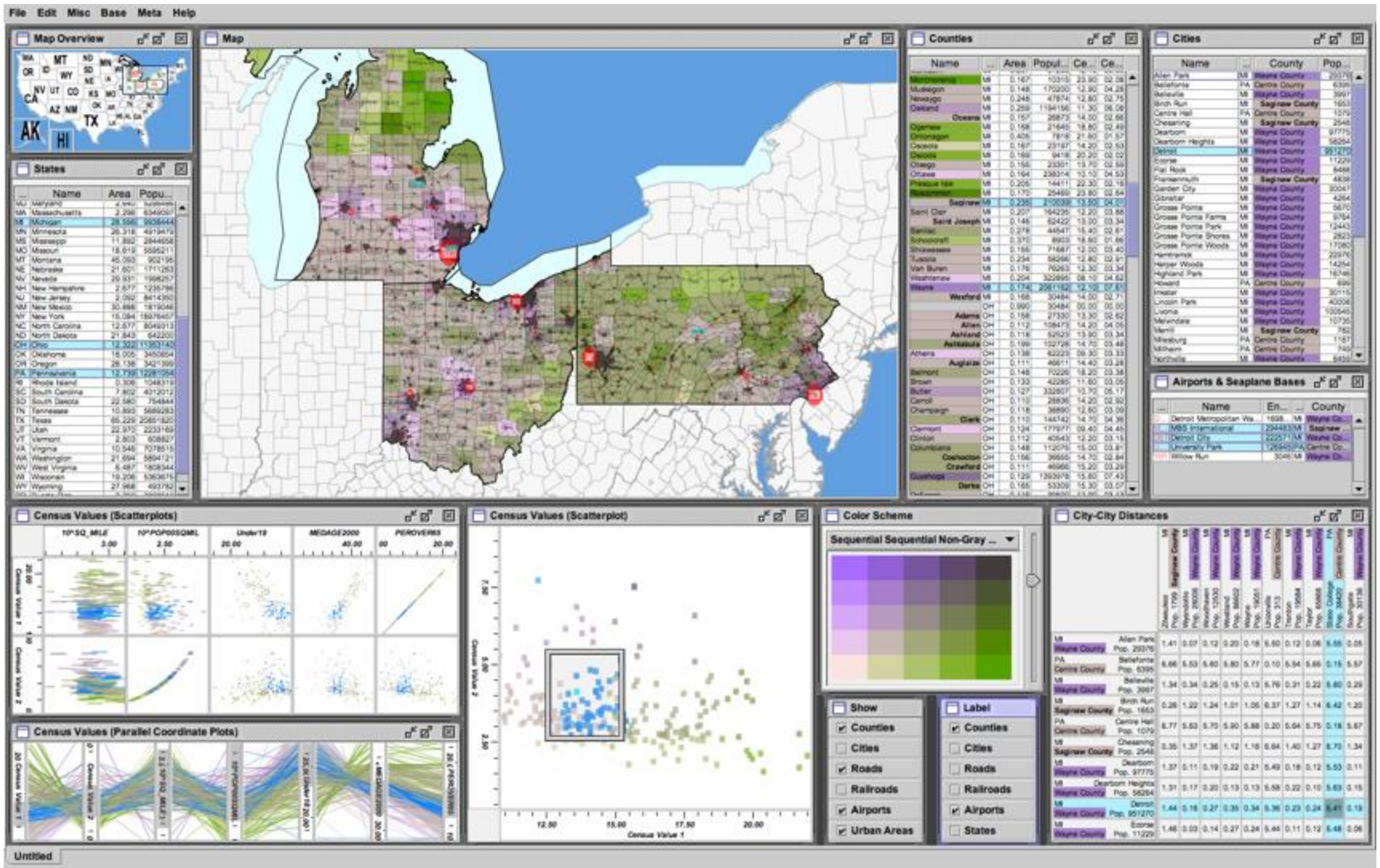
- annotate
  - with text label etc. (classification)
  - acts as a new attribute
- import
  - new data items to be loaded
- derive
  - derive new data attributes
- record
  - screenshots, bookmarks, parameter settings, logs, etc.
  - graphical / use history
  - analytical provenance!

Facets (Preview)

How to use multiple views?

- juxtapose (multiple views, side-by-side)
- superimpose (multiple layers)
- change (layout, encoding → interaction)
- select (demarcation, highlighting)
- coordinate (brushing+linking, linking views)

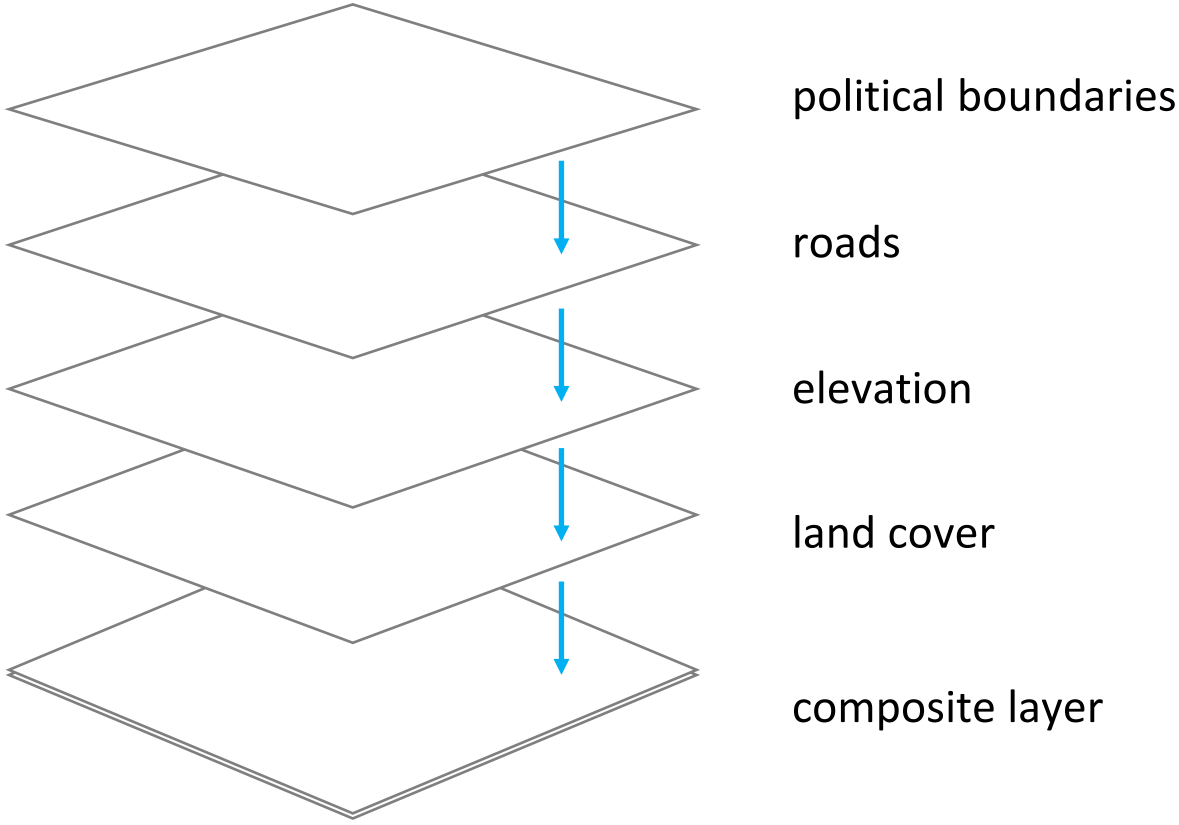
Partition & Juxtaposition



[Weaver, 2004]

Superimposition

e.g. multiple GIS layers, projected upon each other



Linking (coordinate)

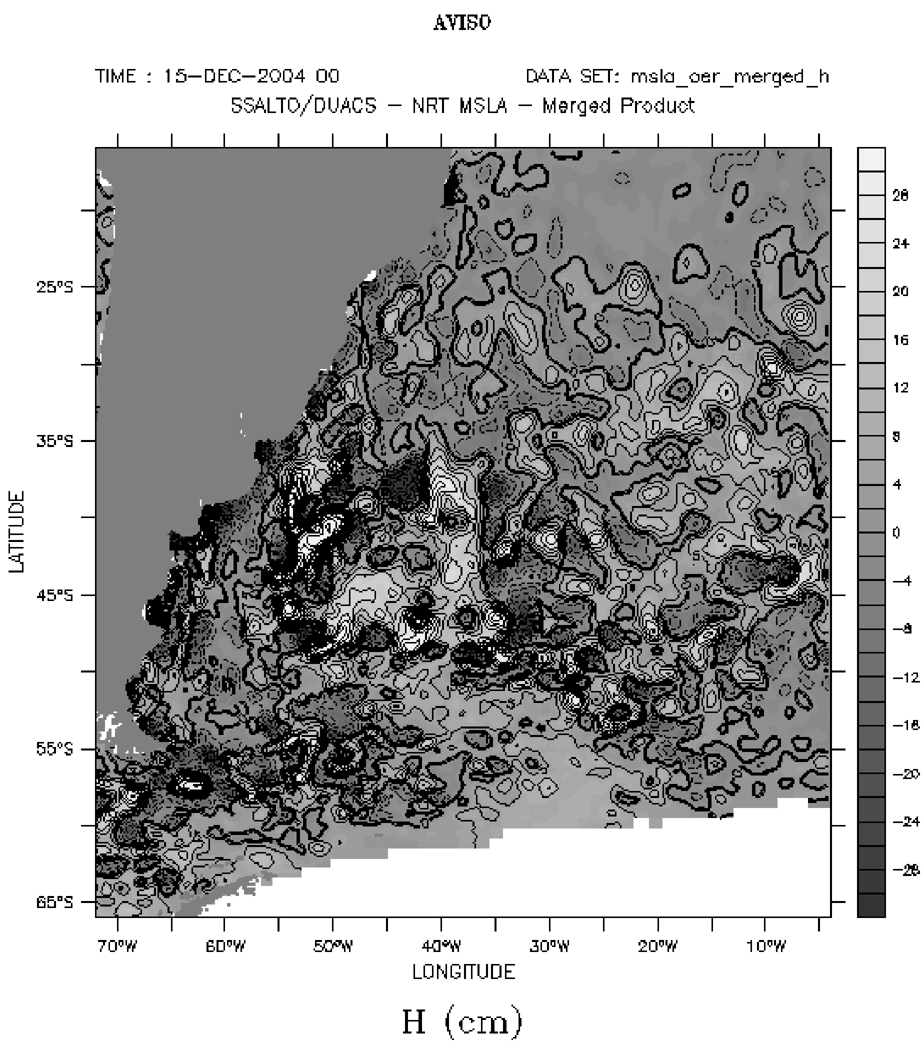
How to reduce?

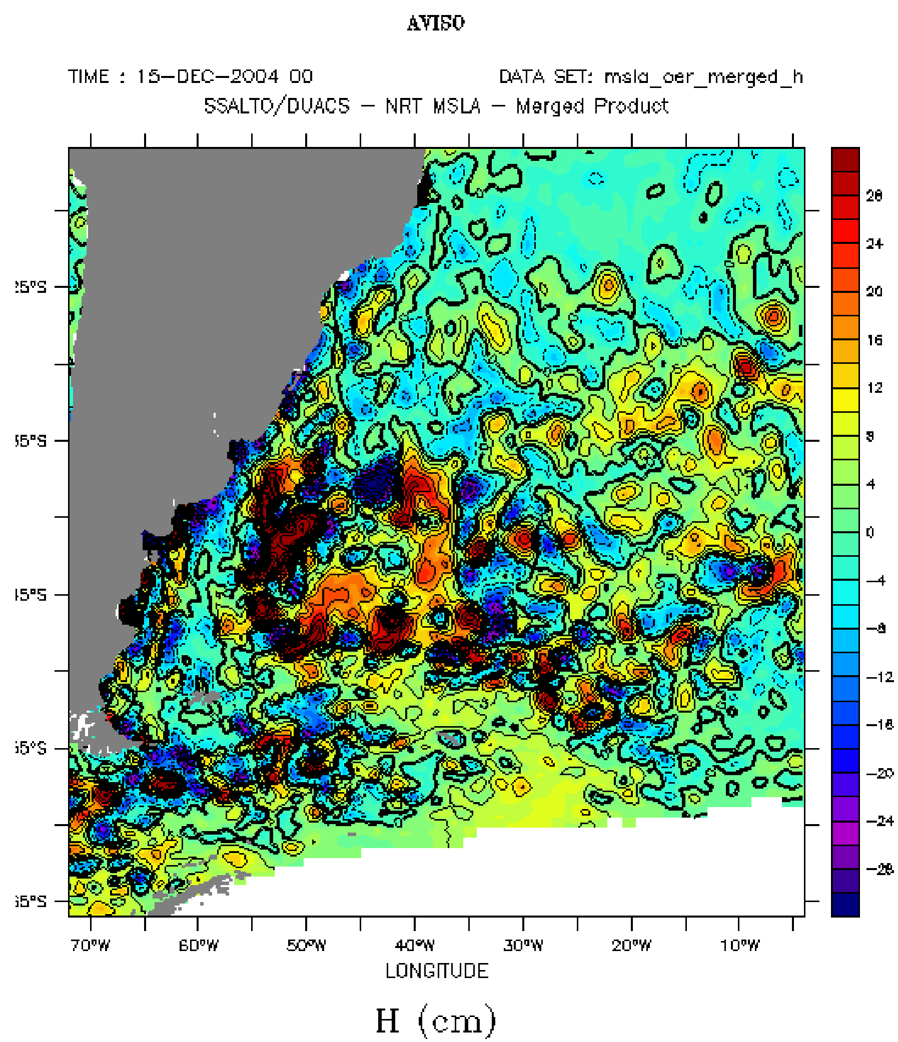
Reduce / increase number of elements shown

- filter
- aggregate
- navigate (e.g. alter viewpoint, zooming, detail-on-demand)
- embed in a single view (focus+context)

Color and Tasks

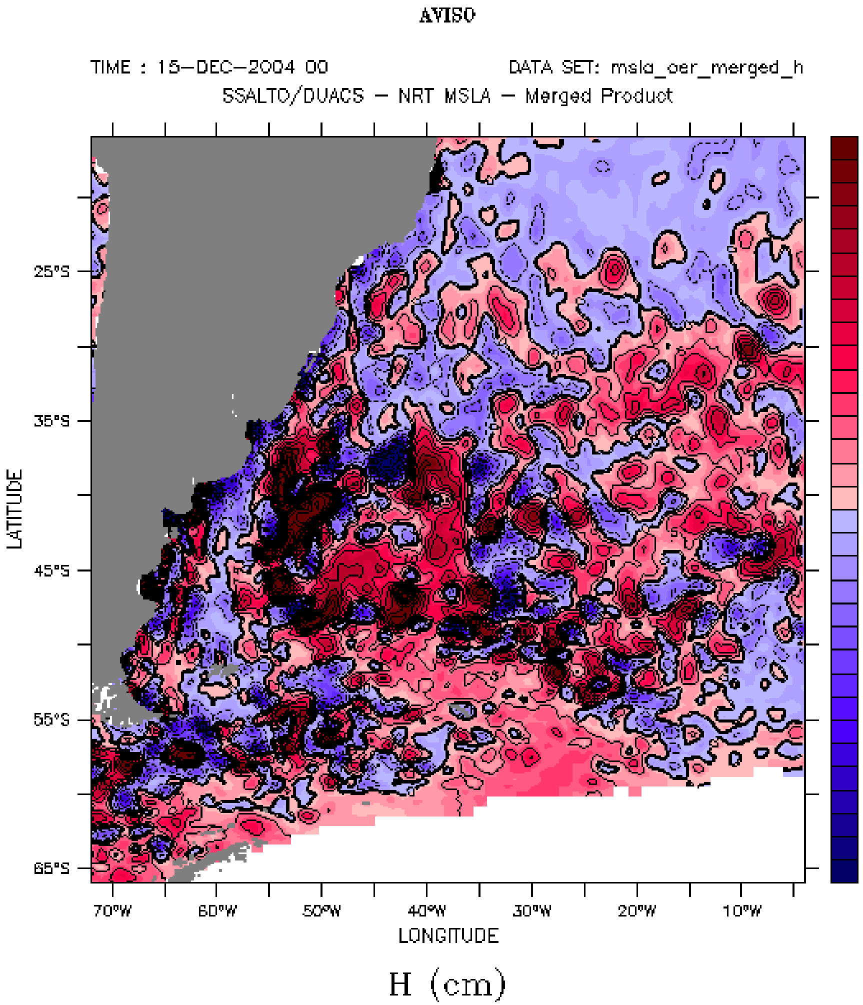
Task: Find high & low anomalies

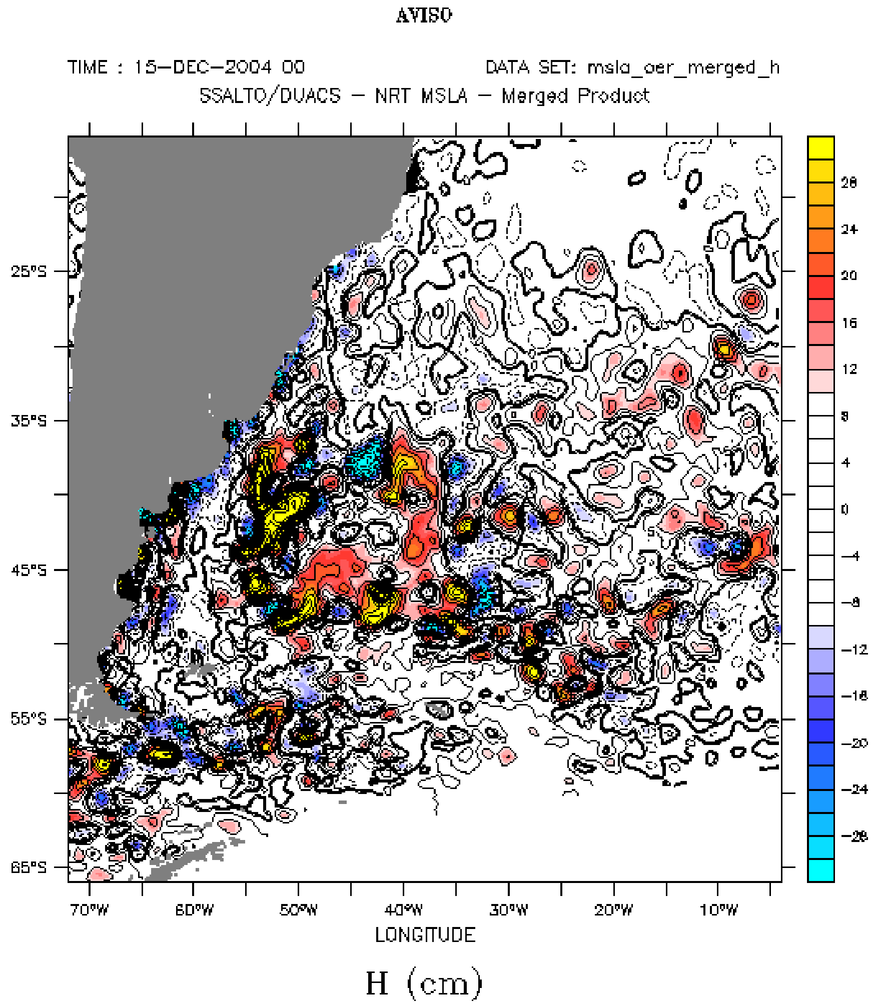




http://www.jason.oceanobs.com/html/donnees/las/2005-03_uk.html

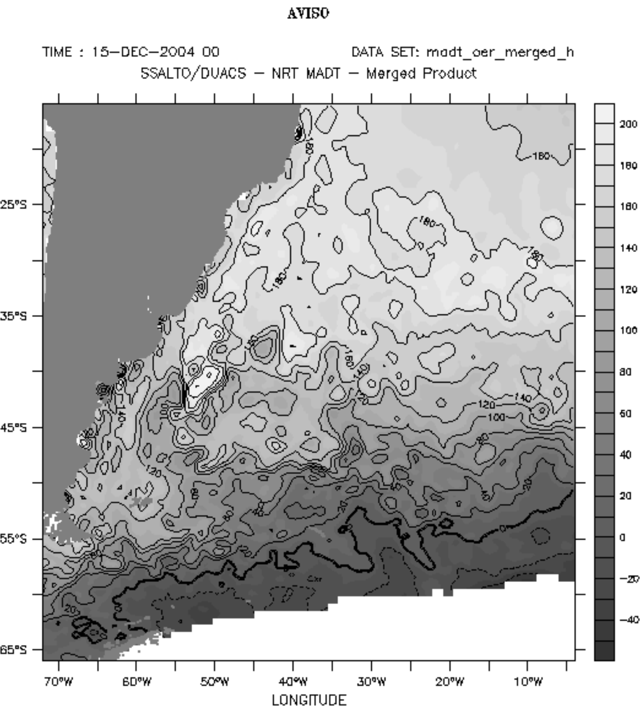
Task: Find high & low anomalies



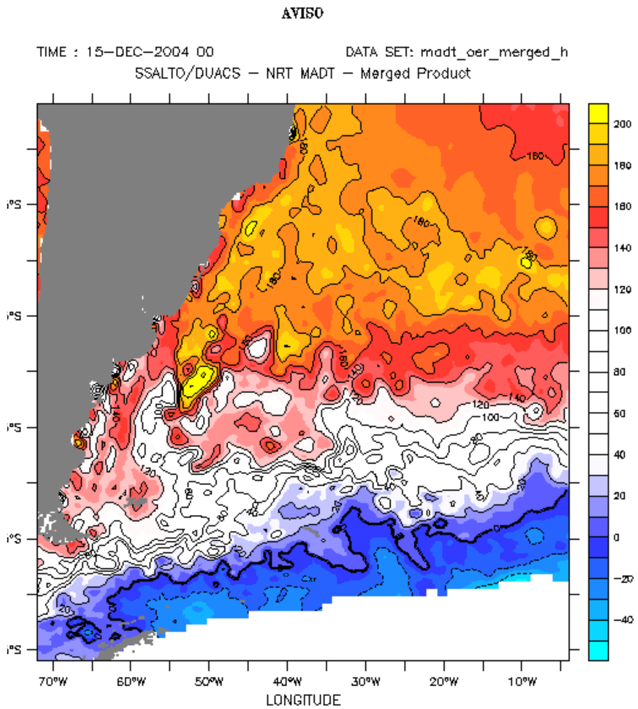


http://www.jason.oceanobs.com/html/donnees/las/2005-03_uk.html

Task: Understand relative height



H (cm)



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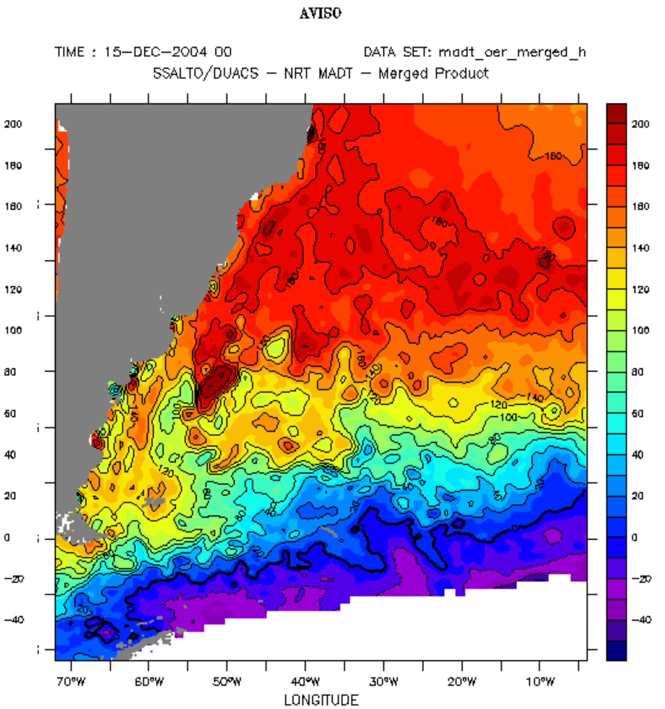
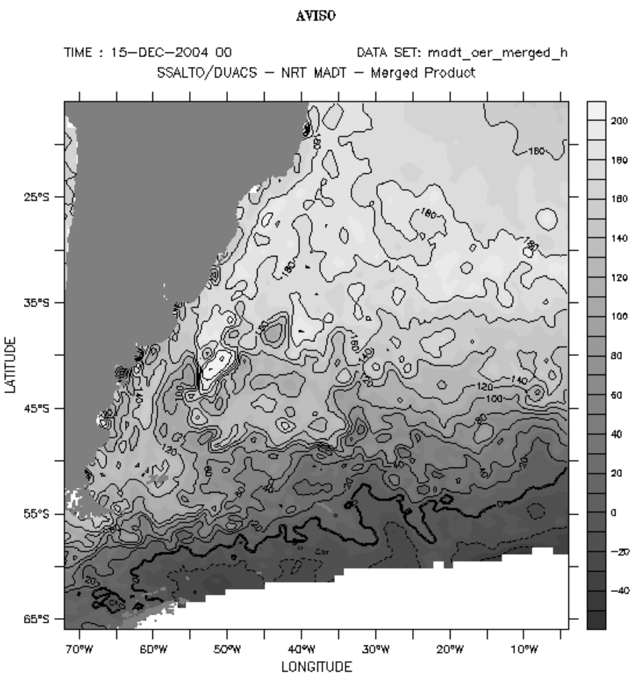


H (cm)

http://www.jason.oceanobs.com/html/donnees/las/2005-03_uk.html

Task: Find height 120



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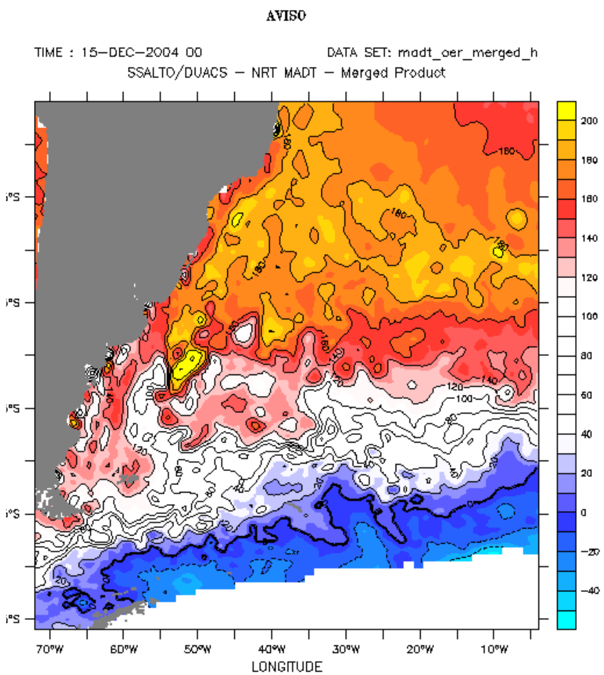

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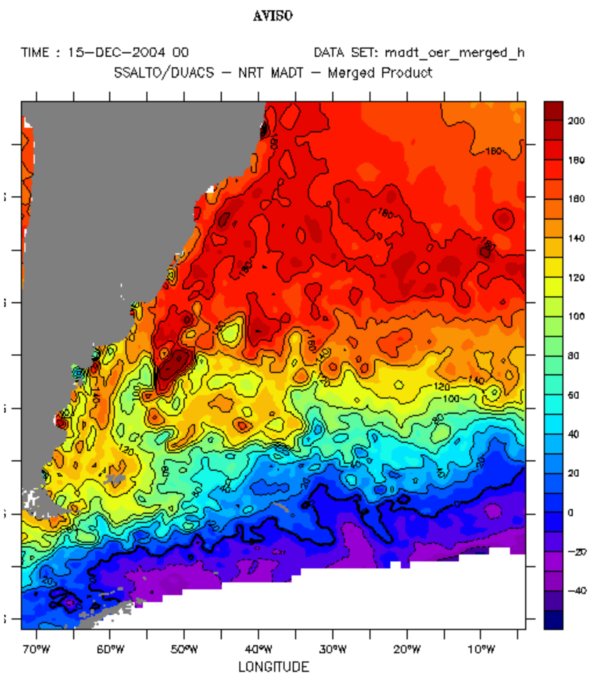


H (cm)

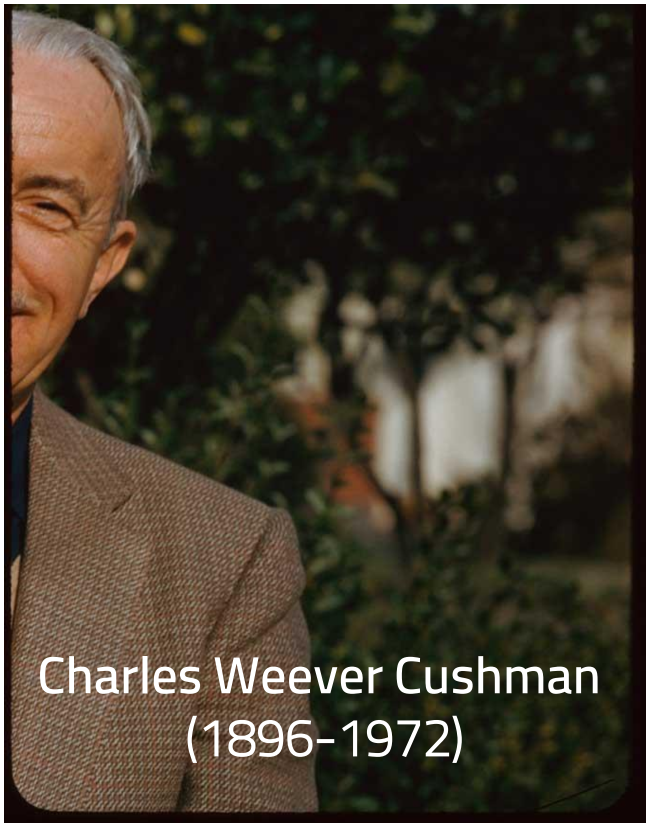
http://www.jason.oceanobs.com/html/donnees/las/2005-03_uk.html

Tableau Examples

Let us explore the impact of tasks & questions on visualizations

Cushman Dataset

https://www.dropbox.com/s/2y157rrnx9551s6/cushman_collection_data_a1.csv?dl=0


Charles Weever Cushman
(1896-1972)

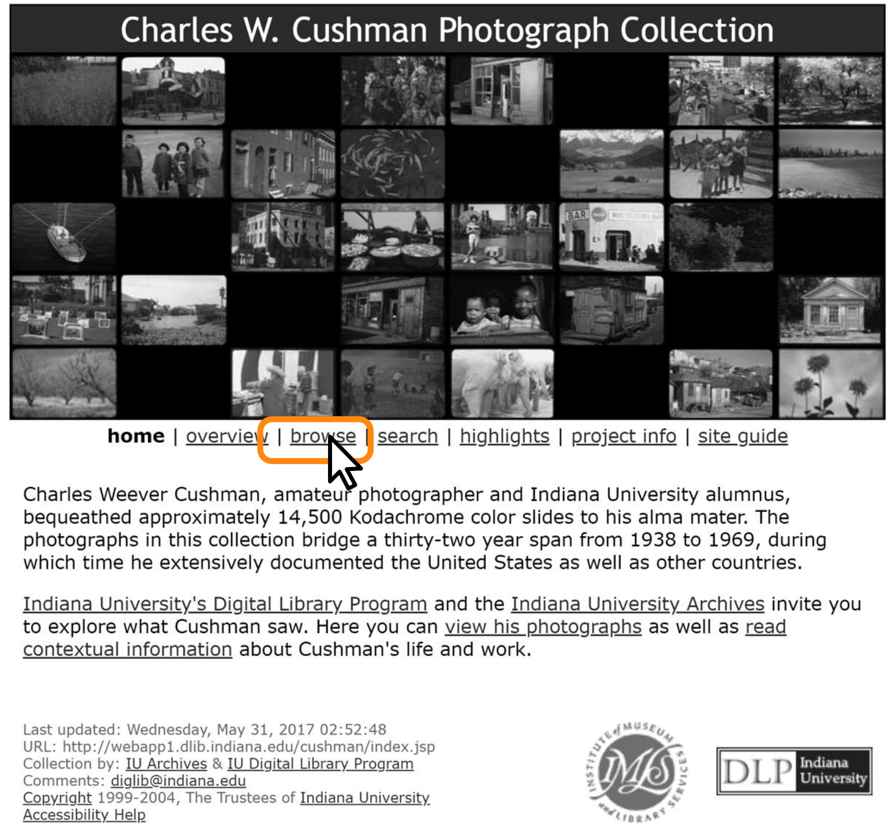
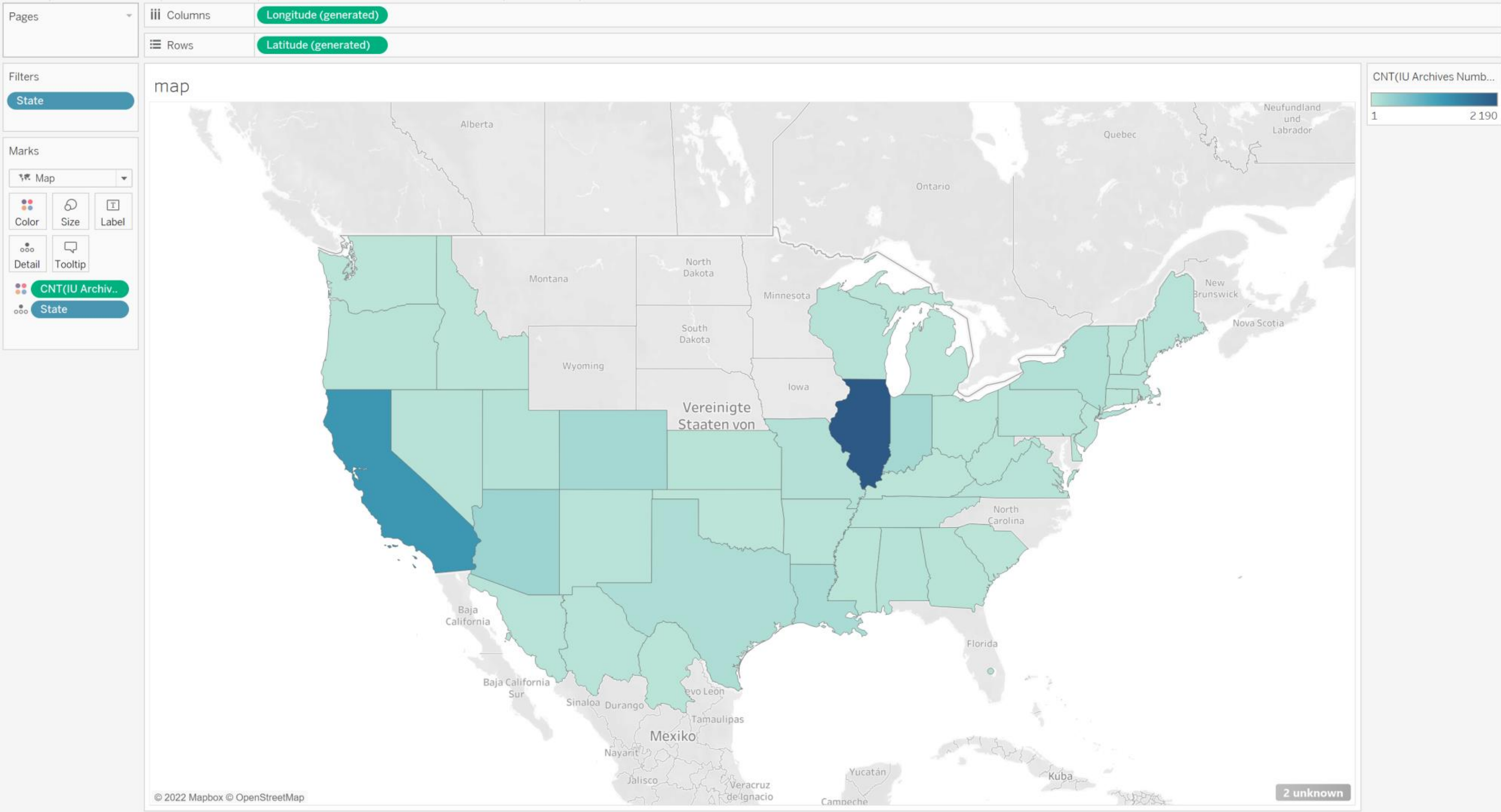

Charles W. Cushman Photograph Collection
BAR
home | overview | browse | search | highlights | project info | site guide
Charles Weever Cushman, amateur photographer and Indiana University alumnus, bequeathed approximately 14,500 Kodachrome color slides to his alma mater. The photographs in this collection bridge a thirty-two year span from 1938 to 1969, during which time he extensively documented the United States as well as other countries.
Indiana University's Digital Library Program and the Indiana University Archives invite you to explore what Cushman saw. Here you can view his photographs as well as read contextual information about Cushman's life and work.
Last updated: Wednesday, May 31, 2017 02:52:48
URL: http://webapp1.dlib.indiana.edu/cushman/index.jsp
Collection by: IU Archives & IU Digital Library Program
Comments: diglib@indiana.edu
Copyright 1999-2004, The Trustees of Indiana University
Accessibility Help
DLP Indiana University

Tableau Examples

I. What is the **geographic distribution** of these historical photographs?

II. What is the **temporal distribution** of the photographs?

III. What is the **distribution of genres** in the collection?



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North Carolina
Baja California
Florida
Baja California Sur
Sinaloa
Durango
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Yucatán
Kuba
Campeche
© 2022 Mapbox © OpenStreetMap
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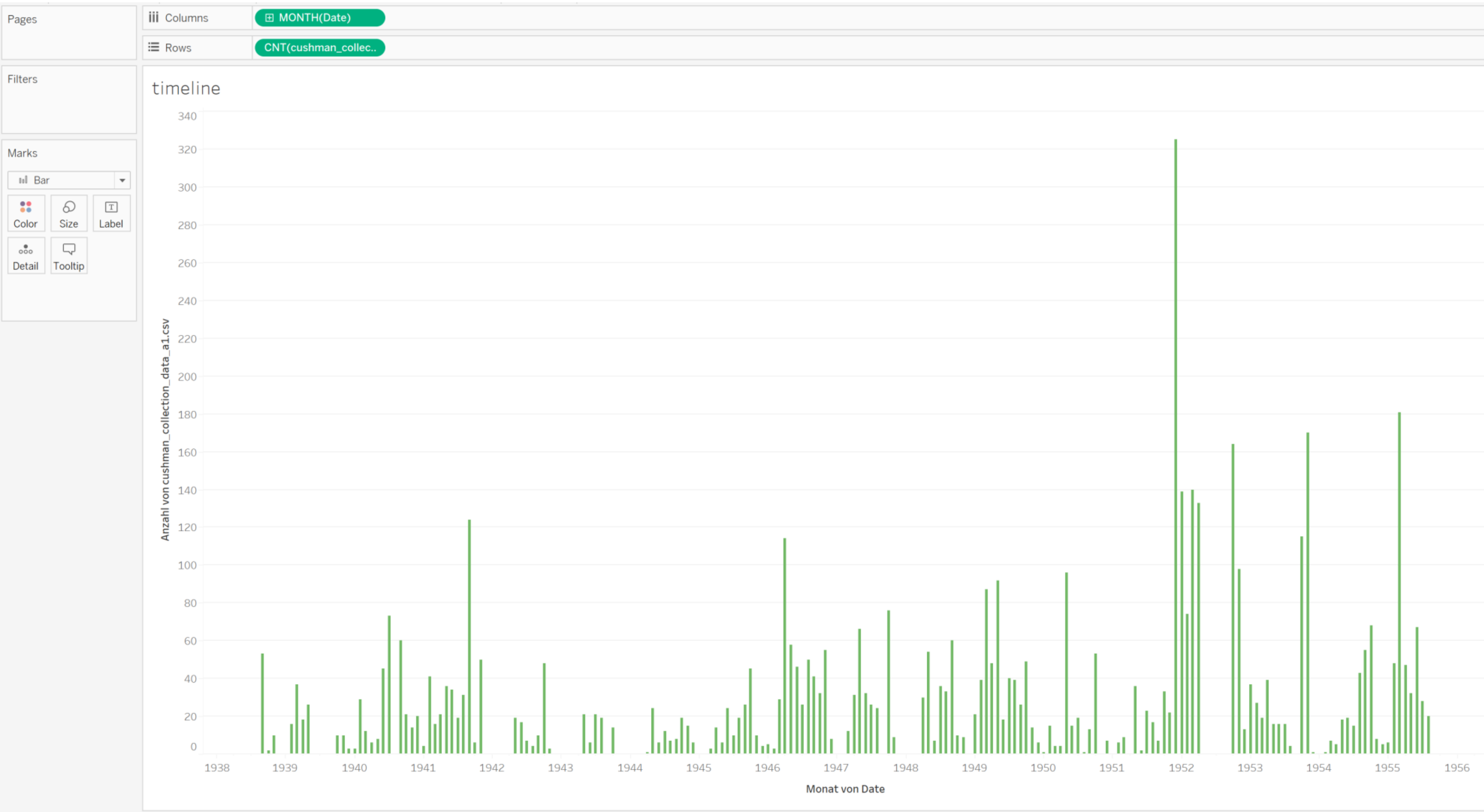
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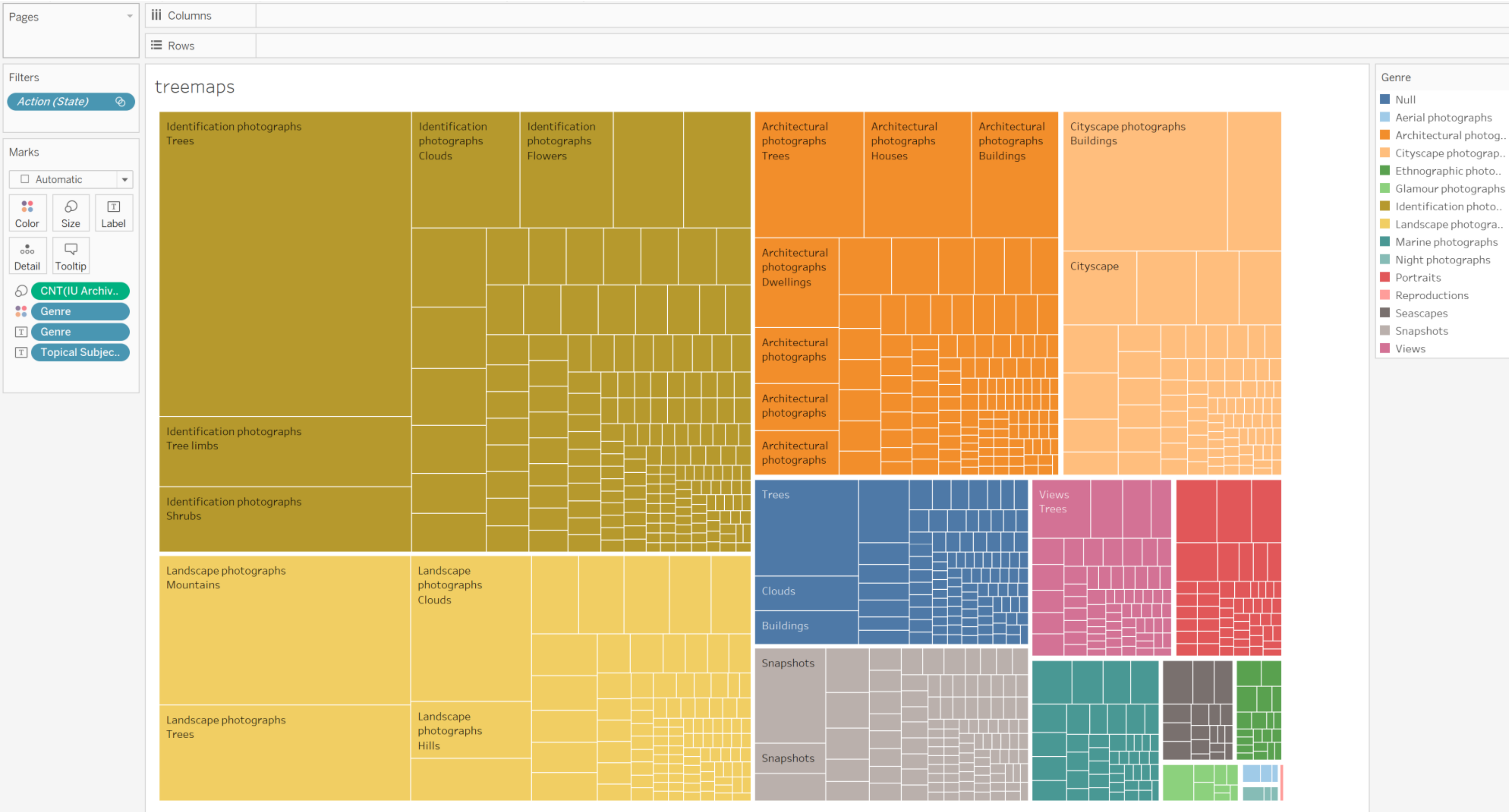
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Clouds
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Night photographs
Portraits
Reproductions
Seascapes
Snapshots
Views

Happiness Dataset

https://vda.univie.ac.at/Teaching/Vis/21s/data/20w_data_happiness_development.csv

Tableau Dataset: 20w_data_happiness_development:

https://vda.univie.ac.at/Teaching/Vis/21s/data/20w_data_happiness_development.csv

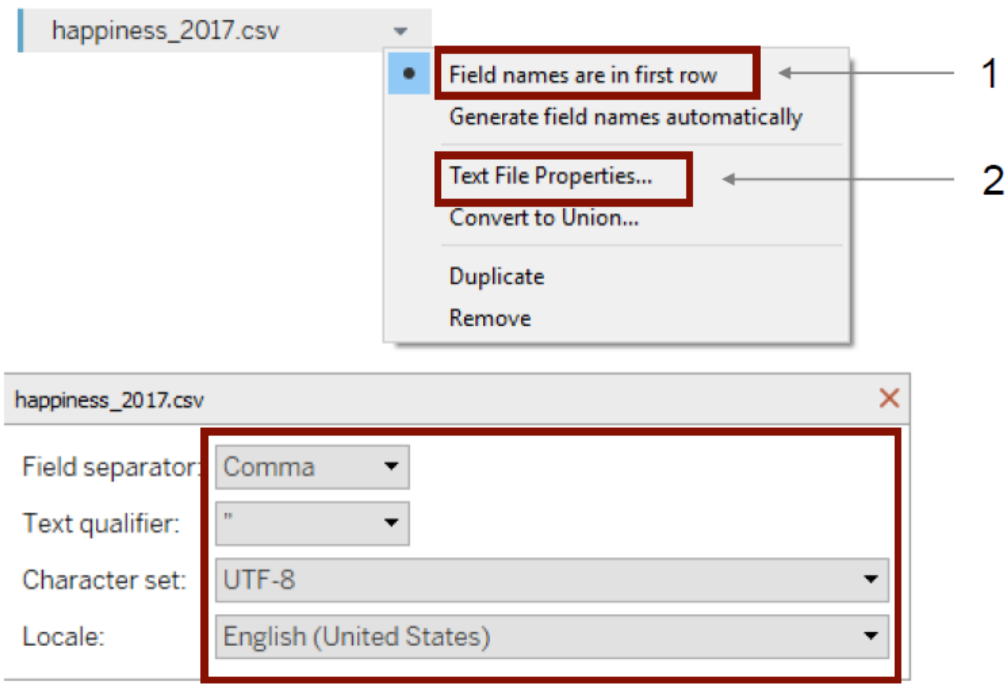

Tableau Example

- Is there a correlation between **Happiness Score** and **Inequality in Education?**

- Using the same visualization add the **Map Reference** to see if there are correlations within continents.

Tableau Example

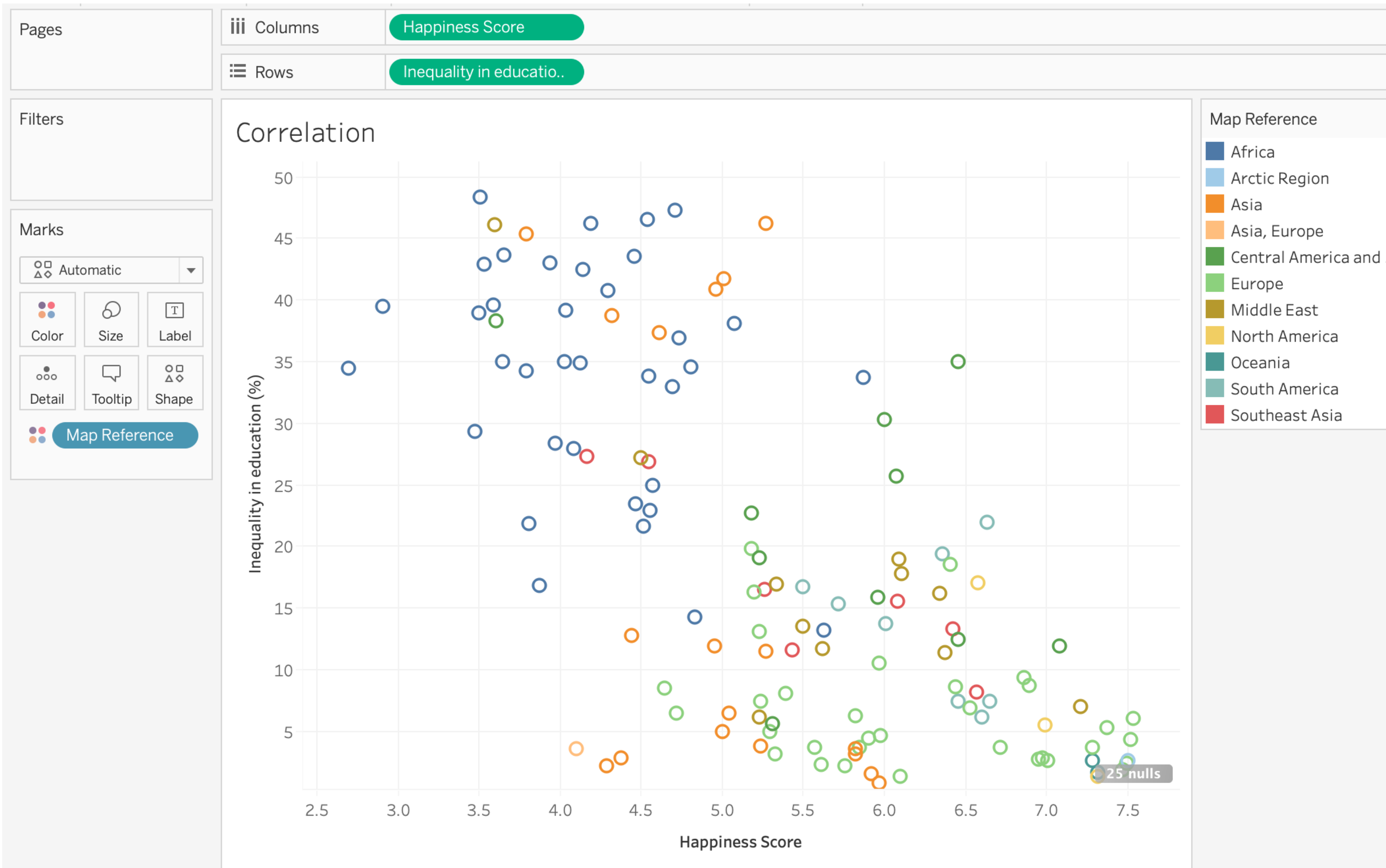

Tableau Example

- How are the two fields (**Happiness Score** and **Inequality in Education**) distributed within each continent?

- Can you see interesting patterns?

Tableau Example

Tableau Example

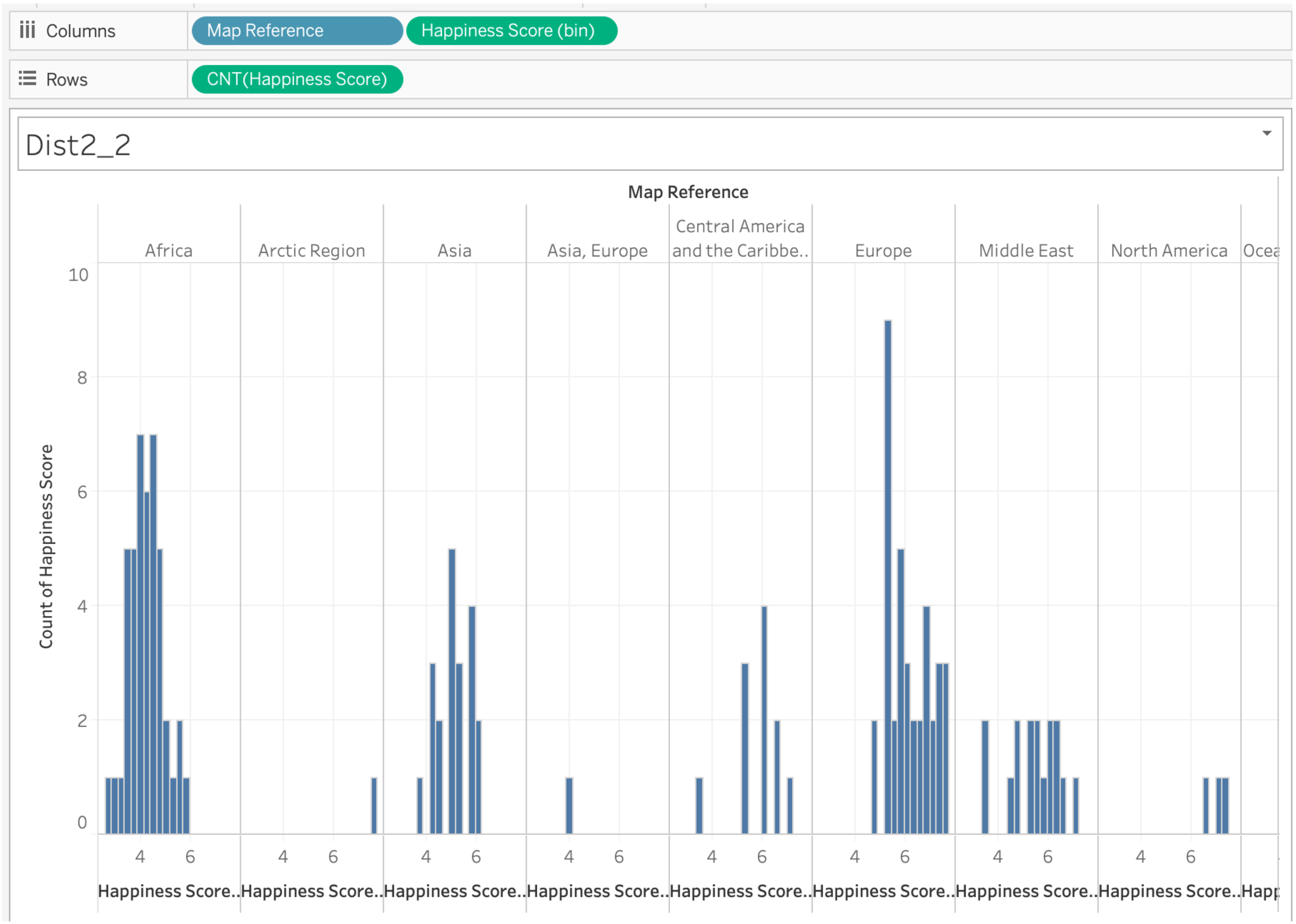

Tableau Example

Tableau Example

We start with a new set of questions focusing on language

Tableau Example

Which language is the most used (in terms of people speaking it) **official language?**

Tableau Example

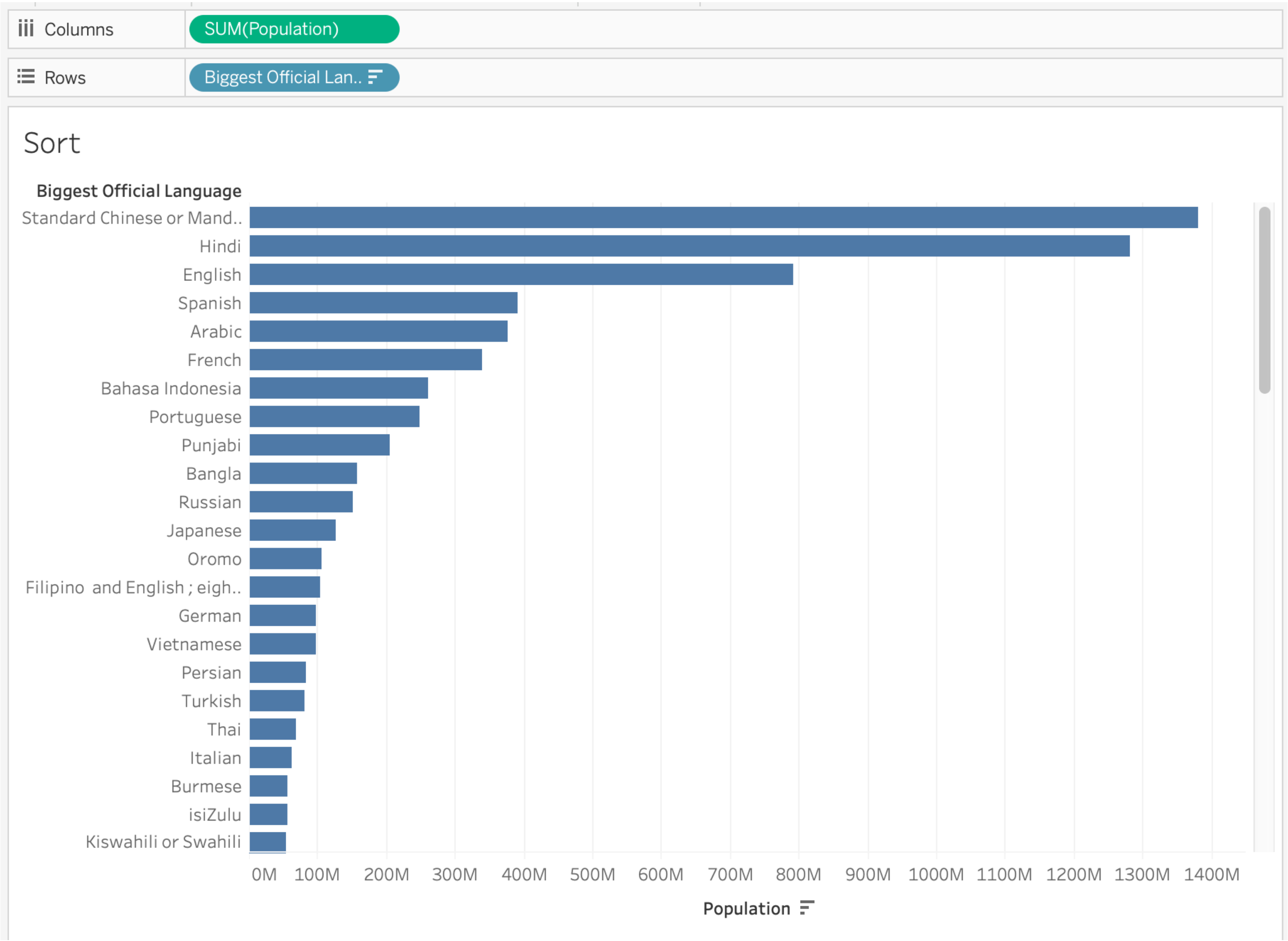

Tableau Example

As we use English in this lecture please tell me what are the top three (by looking at the number of people) countries speaking english?

Tableau Example

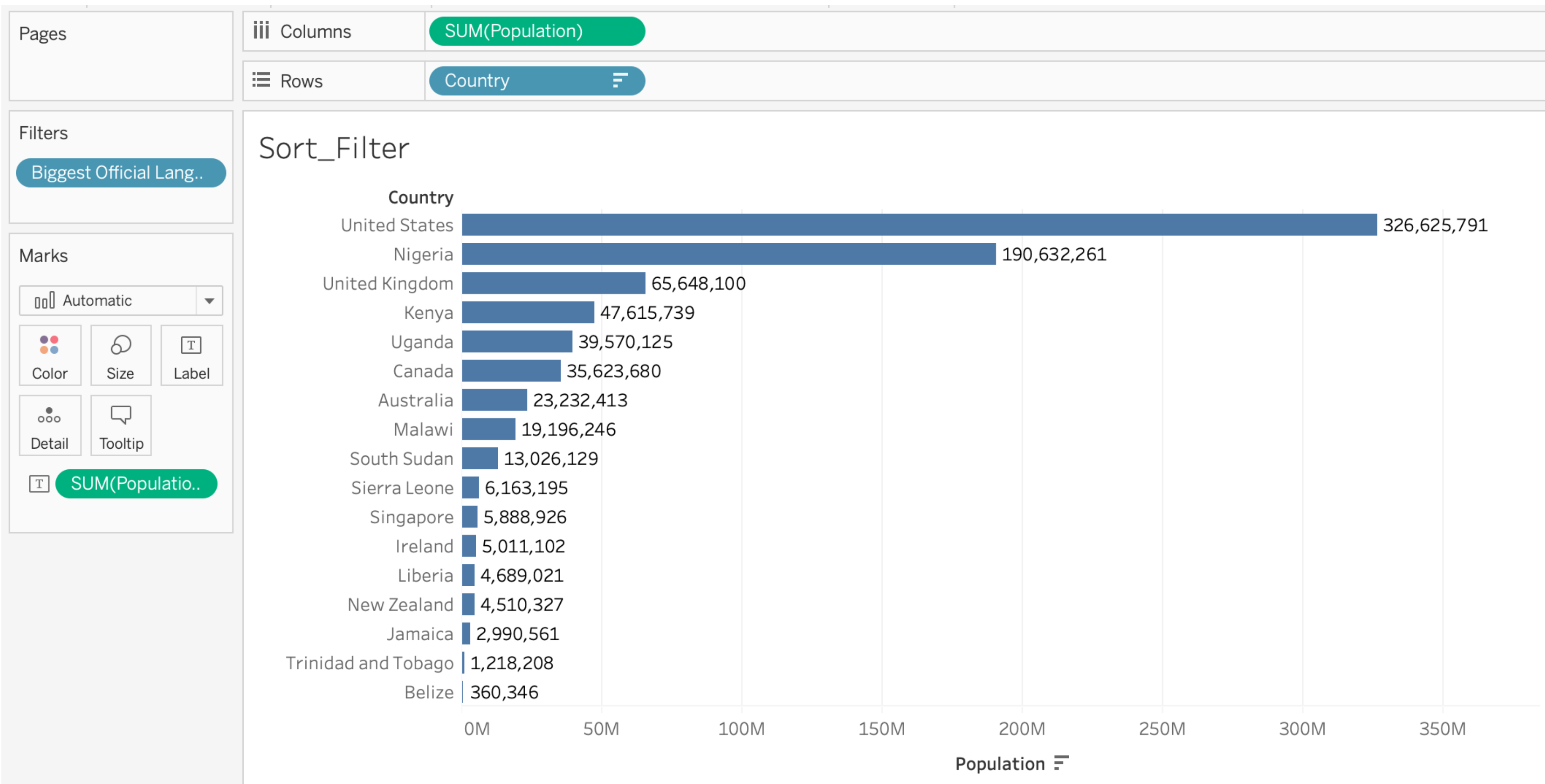

Tableau Example

Given only the top 10 most spoken languages, are there any interesting outliers (**countries**) when looking at the **inequality of education** and **inequality of life expectancy?**

Tableau Example

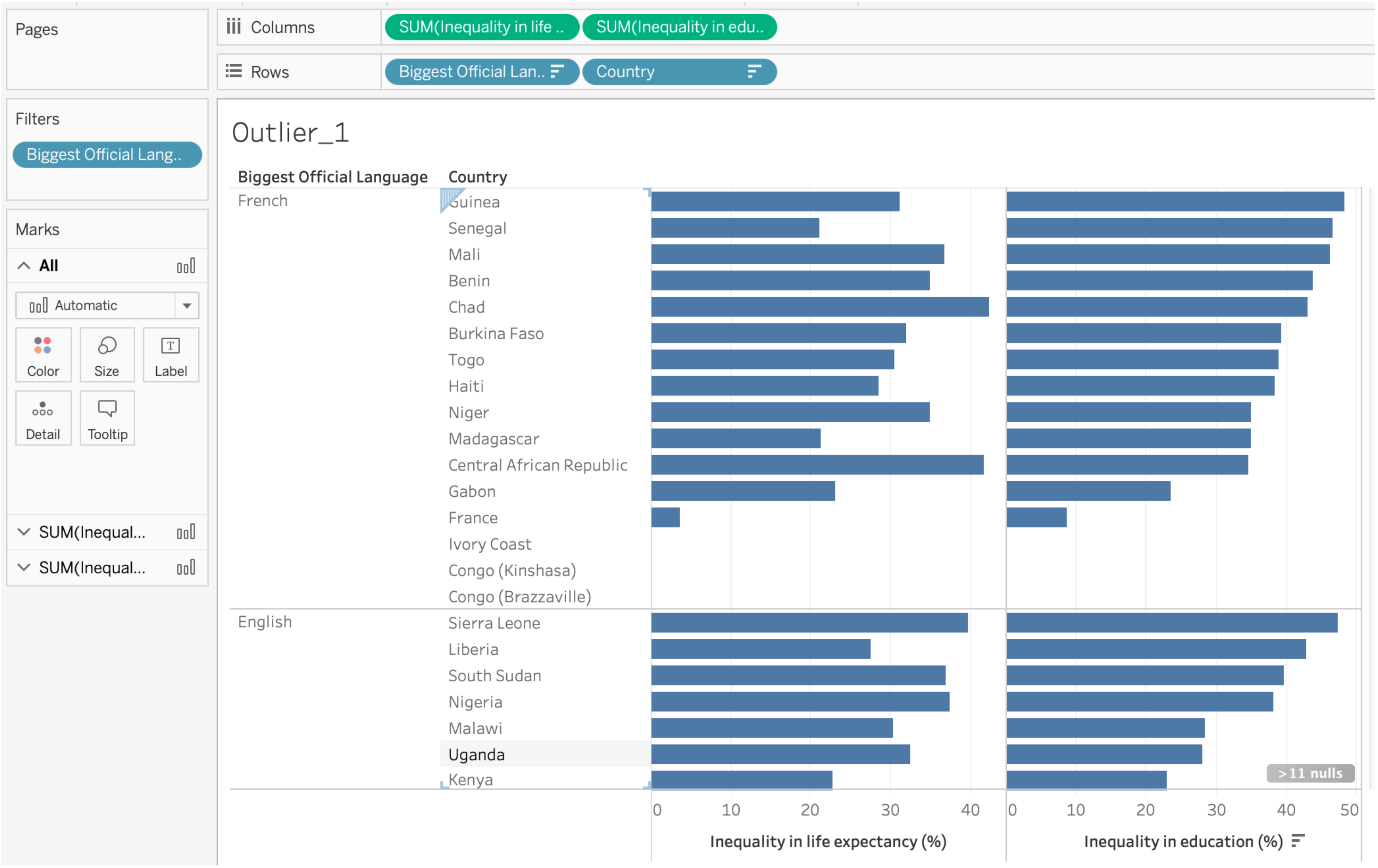

Tableau Example

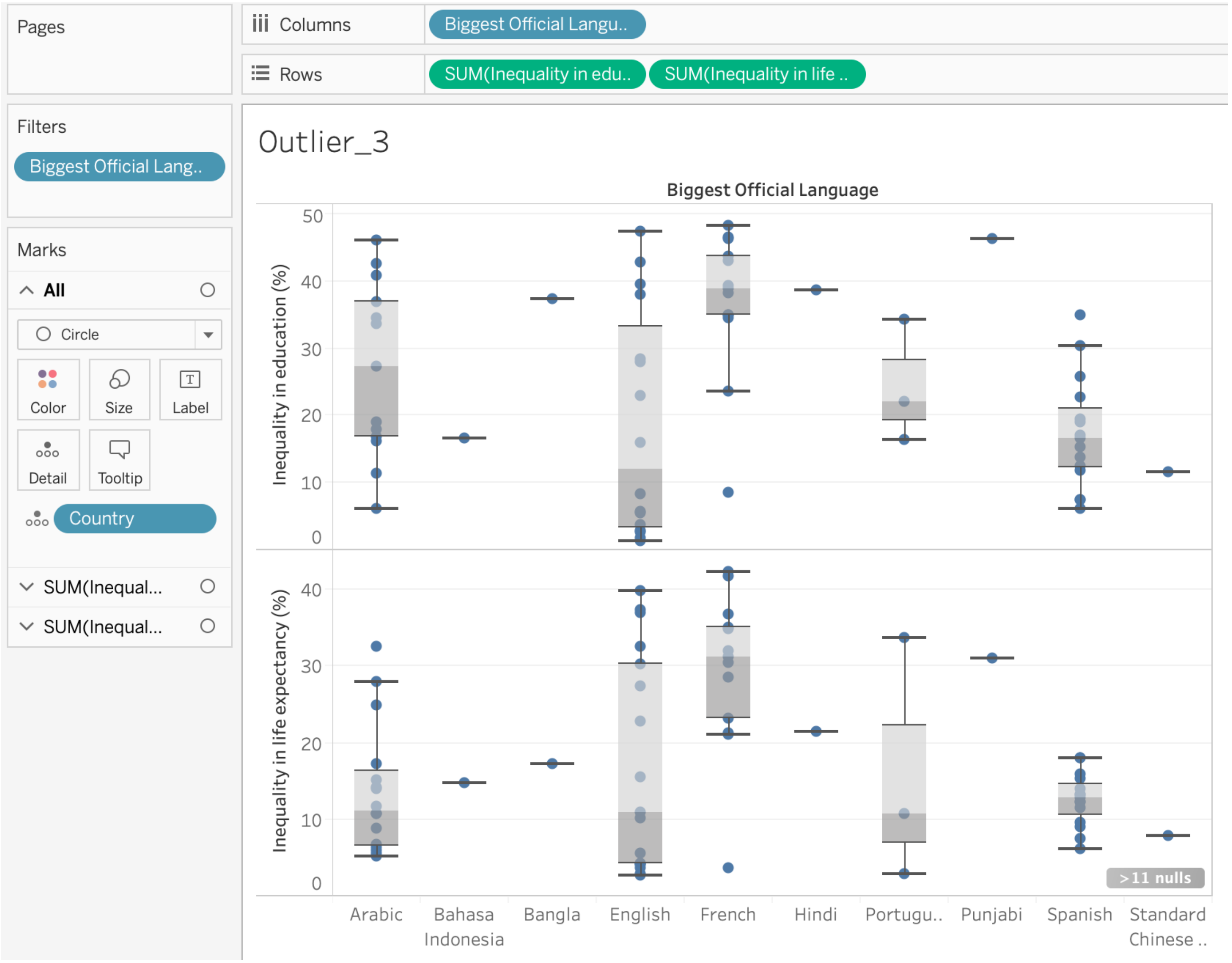

Tableau Example

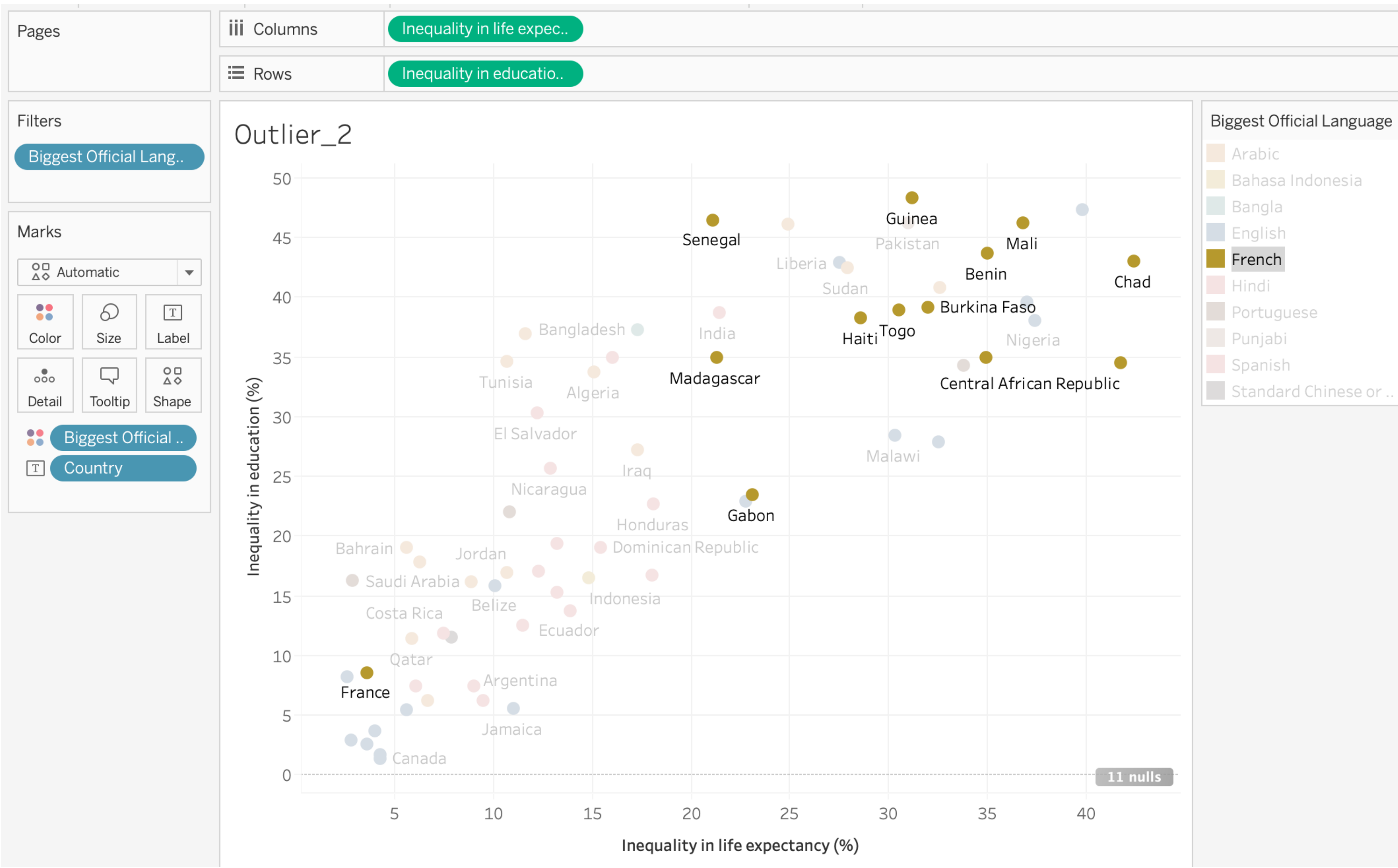

Tableau Example

Using the same fields is there a connection between the top third of the **military expenditures** field and the two inequality (education and life expectancy) fields?

Tableau Example