Exploratory Data Analysis

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Mini-Courses — January @ GSAS
2018

Goal

Learn the Philosophy of Exploratory Data Analysis

Exposure, the effective laying open of the data to display the unanticipated, is to us a major portion of data analysis…

It is not clear how the informality and flexibility appropriate to the exploratory character of exposure can be fitted into any of the structures of formal statistics so far proposed.

[The Future of Data Analysis, Tukey 1962]

Nothing - not the careful logic of mathematics, not statistical models and theories, not the awesome arithmetic power of modern computers - nothing can substitute here for the flexibility of the informed human mind.

Accordingly, both approaches and techniques need to be structured so as to facilitate human involvement and intervention.

[The Future of Data Analysis, Tukey 1962]

Anscombe's Quartet

A		*B*		*C*		*D*	
X	Y	X	Y	X	Y	X	Y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.8

Summary Statistics

$u_X = 9.0$ $\sigma_X = 3.317$

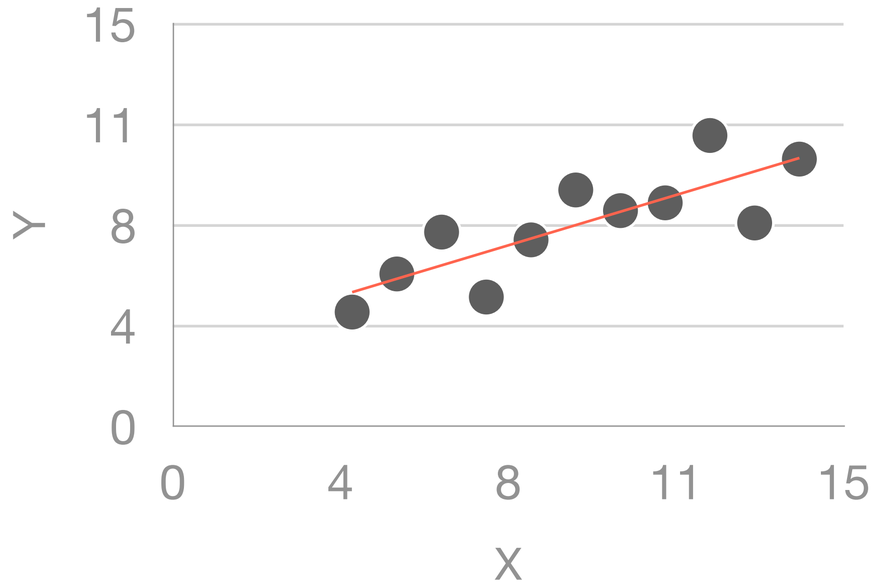
$u_Y = 7.5$ $\sigma_Y = 2.03$

Linear Regression

$Y = 3 + 0.5\,X$

$R^2 = 0.67$

A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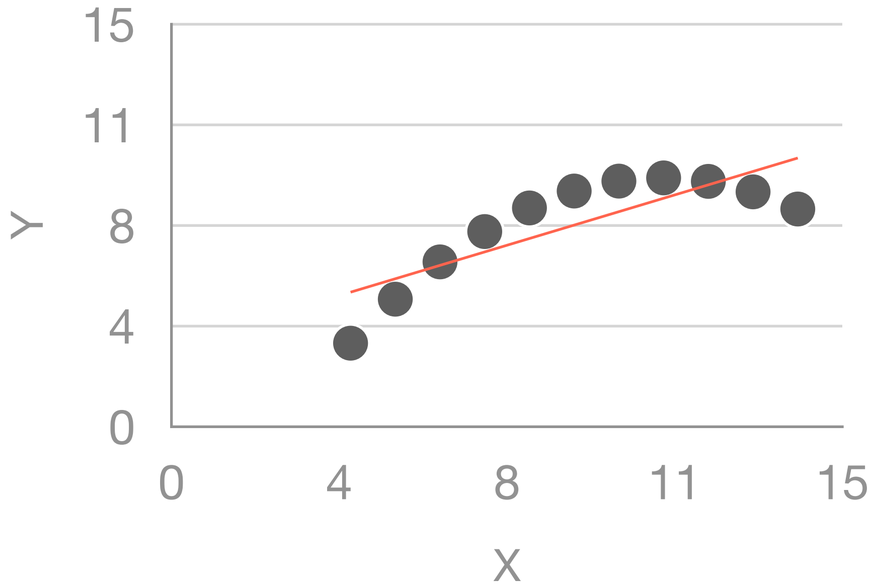
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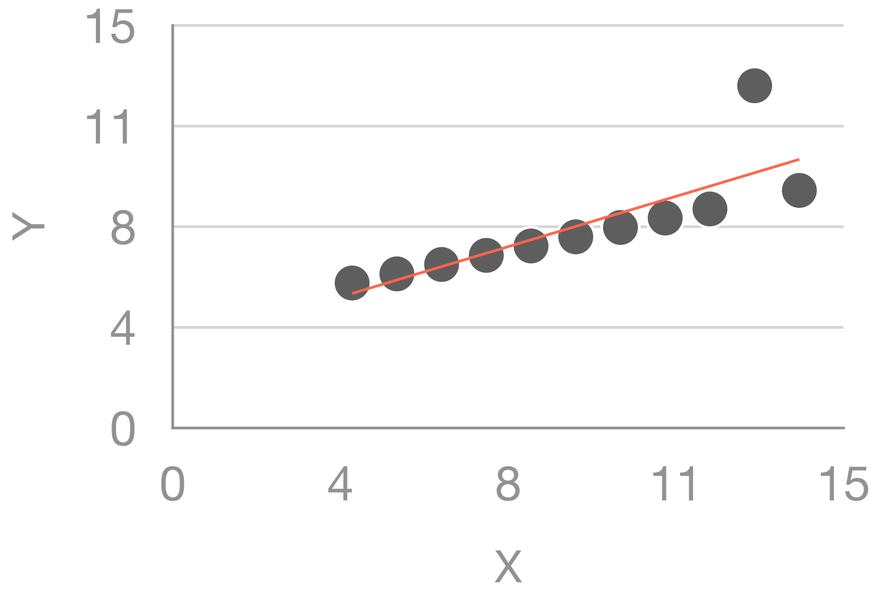
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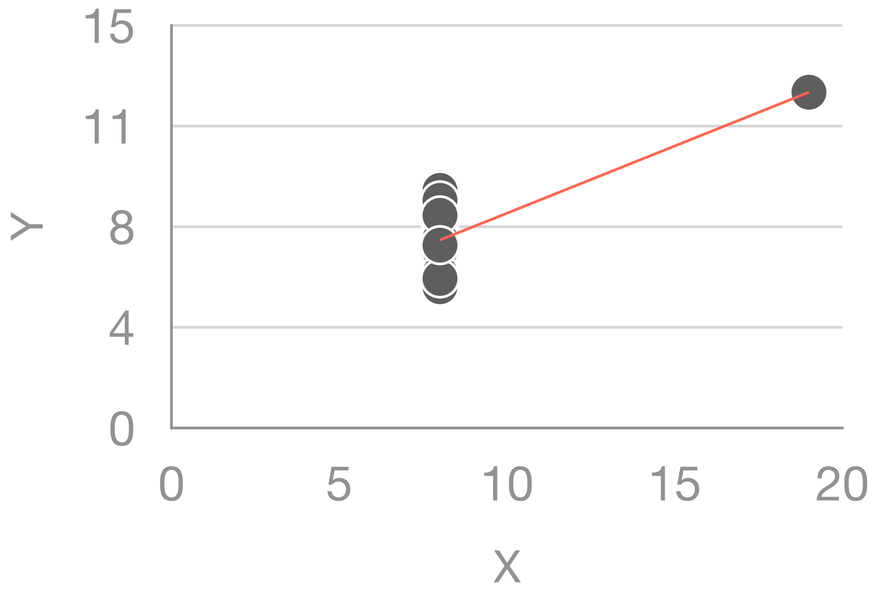
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X

Topics

- What is exploratory analysis
- Stages of data analysis
- Exploratory analysis with Tableau

What is Exploratory Data Analysis?

An philosophy for data analysis that employs a variety of techniques (mostly graphical):

1. maximize insight into a data set
2. uncover underlying structure
3. extract important variables
4. detect outliers and anomalies
5. test underlying assumptions

http://www.itl.nist.gov/div898/handbook/eda/eda.htm

It’s Iterative Process

Ask questions

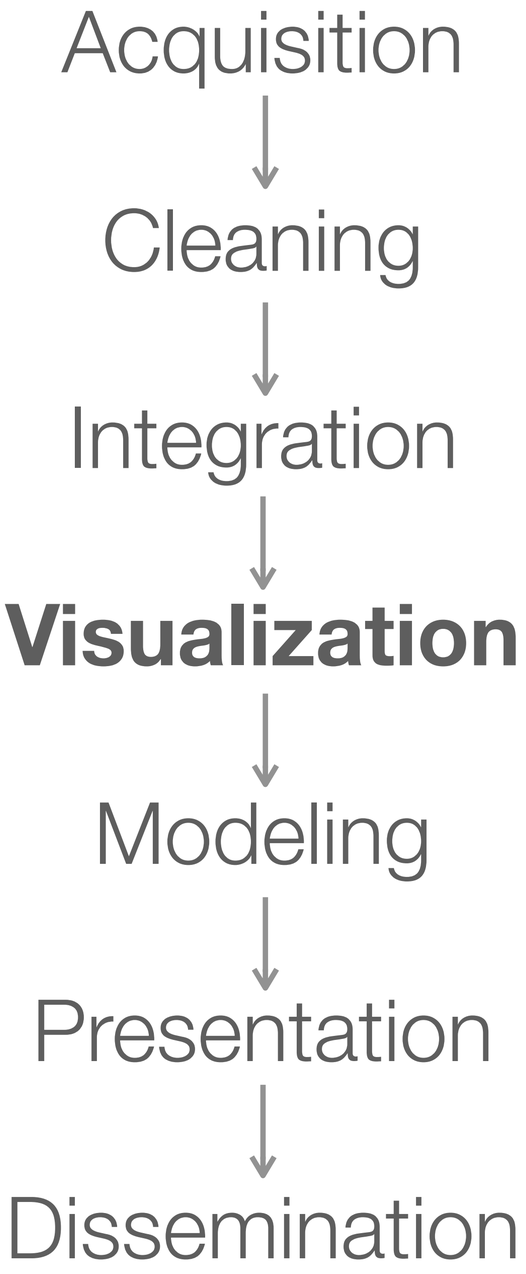
Construct graphics to address questions

Inspect “answer” and assess new questions

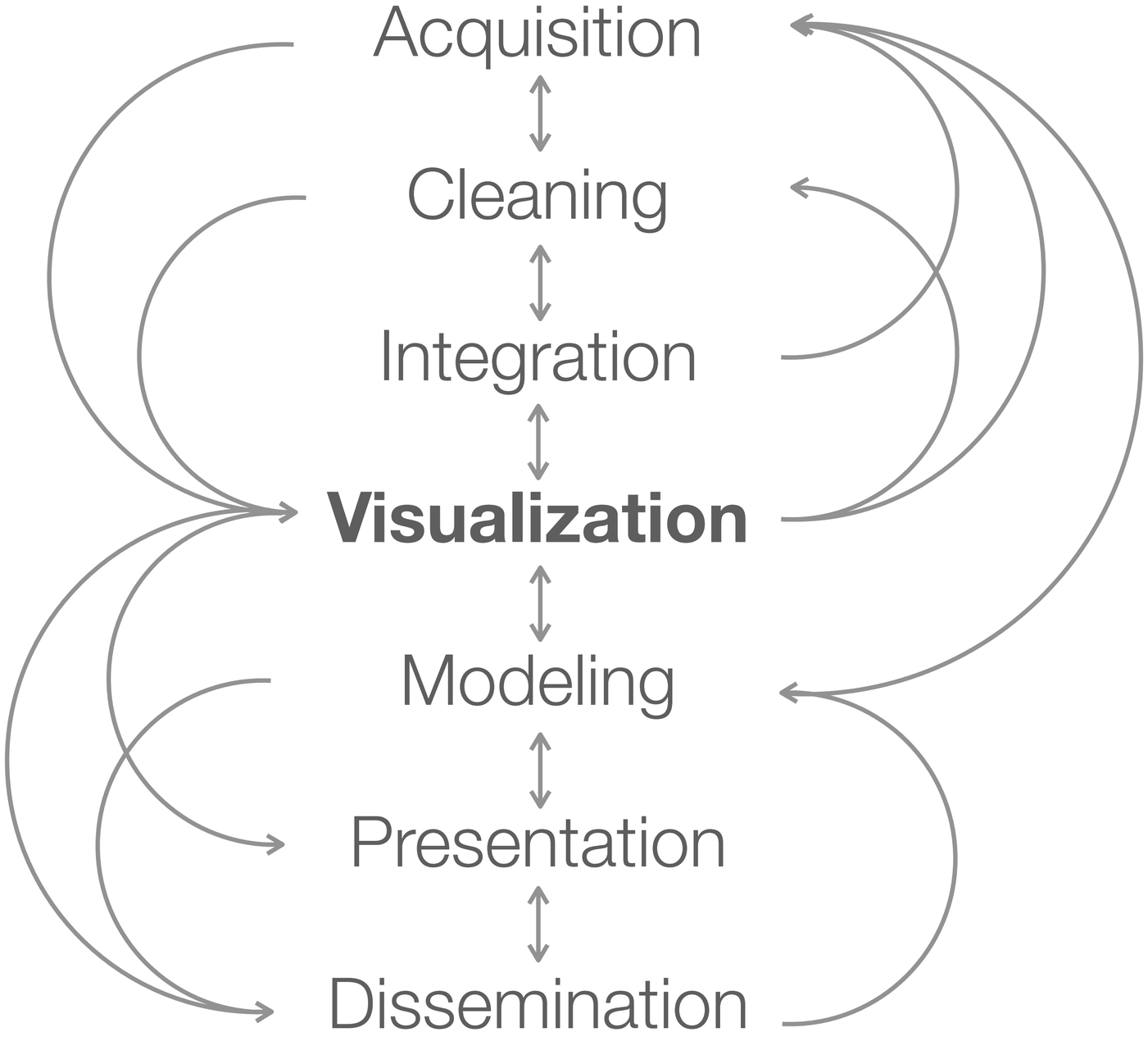
Repeat...

“Show data variation, not design variation” —Tufte

Visualization is just one, although critical, to enable better interaction with data


Acquisition
Cleaning
Integration
Visualization
Modeling
Presentation
Dissemination

[J. Heer]


Acquisition
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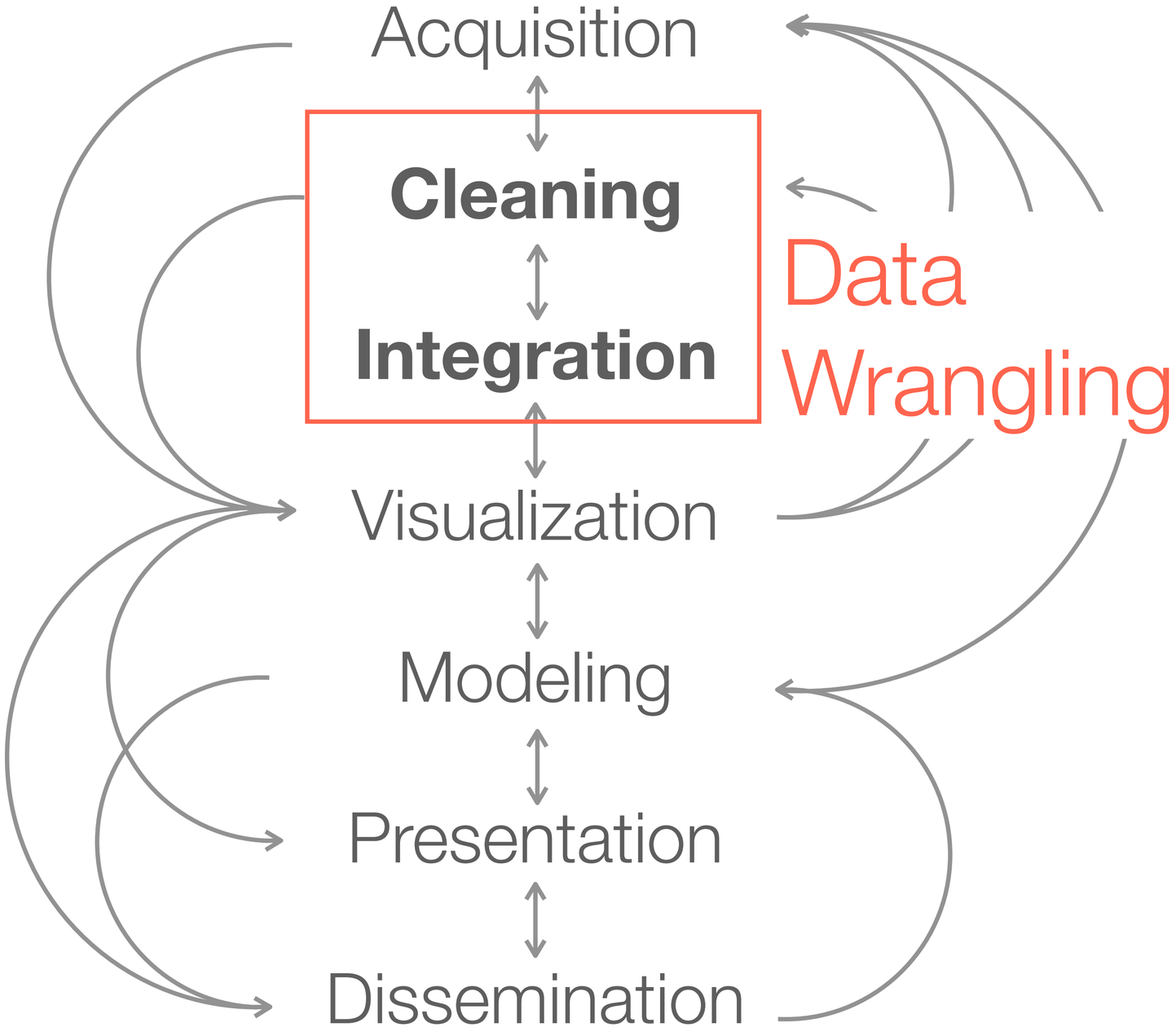
[J. Heer]


Acquisition
Cleaning
Integration
Data Wrangling
Visualization
Modeling
Presentation
Dissemination

[J. Heer]

I spend more than half of my time integrating, cleansing and transforming data without doing any actual analysis. Most of the time I'm lucky if I get to do any "analysis" at all.

—Anonymous Data Scientist [Kandel et al. '12]

Big Data Borat
@BigDataBorat

Follow

In Data Science, 80% of time spent prepare data, 20% of time spent complain about need for prepare data.

6:47 PM - 26 Feb 2013

Bureau of Justice Statistics - Data Online
http://bjs.ojp.usdoj.gov/

Reported crime in Alabama

Year	Population		Property crime rate		Burglary rate	Larceny-theft rate	Motor vehicle theft rate
2004	4525375	4029.3	987	2732.4	309.9		
2005	4548327	3900	955.8	2656	289		
2006	4599030	3937	968.9	2645.1	322.9		
2007	4627851	3974.9	980.2	2687	307.7		
2008	4661900	4081.9	1080.7	2712.6	288.6		

Reported crime in Alaska

Year	Population		Property crime rate		Burglary rate	Larceny-theft rate	Motor vehicle theft rate
2004	657755	3370.9	573.6	2456.7	340.6		
2005	663253	3615	622.8	2601	391		
2006	670053	3582	615.2	2588.5	378.3		
2007	683478	3373.9	538.9	2480	355.1		
2008	686293	2928.3	470.9	2219.9	237.5		

Reported crime in Arizona

Year	Population		Property crime rate		Burglary rate	Larceny-theft rate	Motor vehicle theft rate
2004	5739879	5073.3	991	3118.7	963.5		
2005	5953007	4827	946.2	2958	922		
2006	6166318	4741.6	953	2874.1	914.4		
2007	6338755	4502.6	935.4	2780.5	786.7		
2008	6500180	4087.3	894.2	2605.3	587.8		

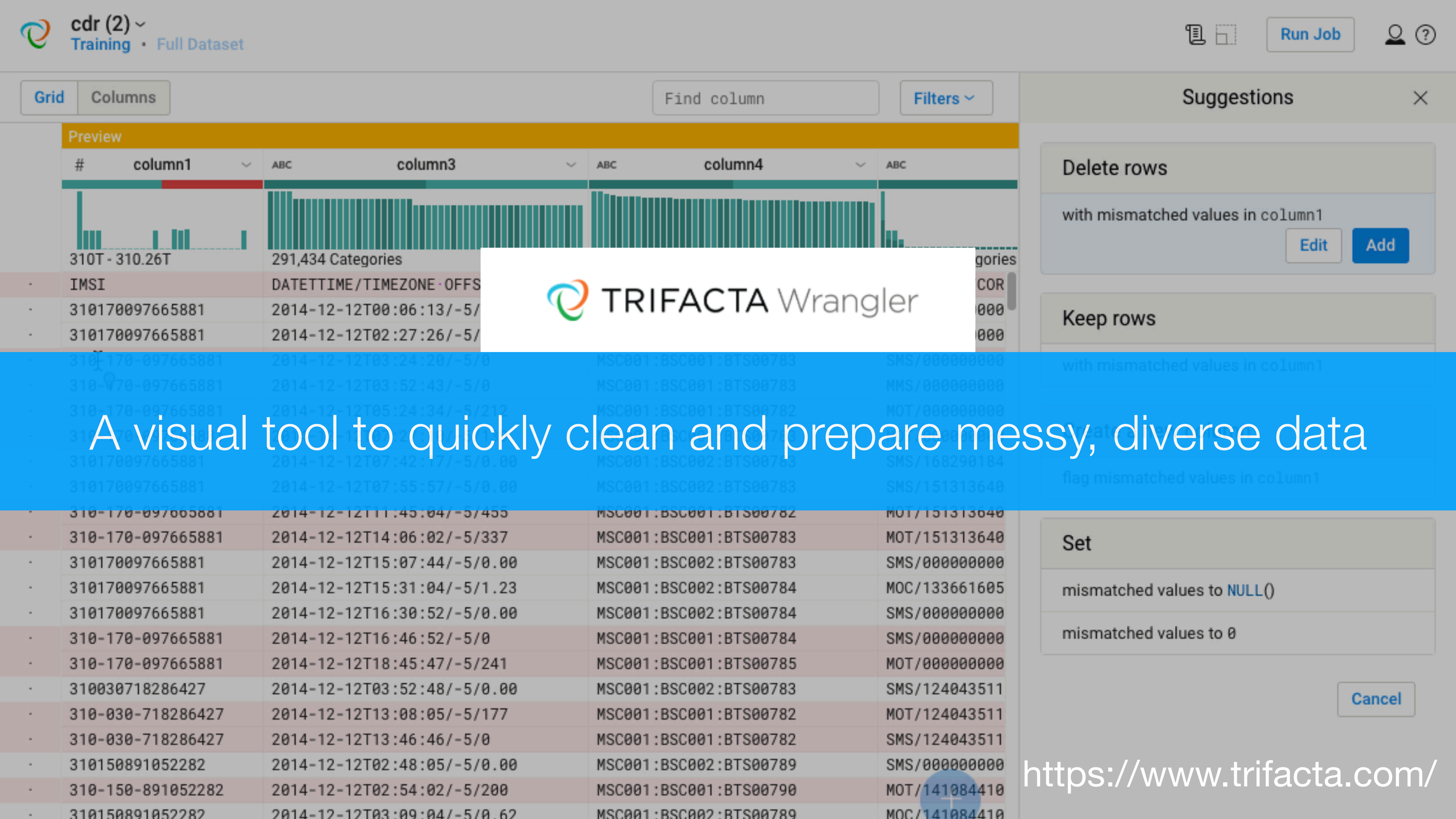
Reported crime in Arkansas

Year	Population		Property crime rate		Burglary rate	Larceny-theft rate	Motor vehicle theft rate
2004	2750000	4033.1	1096.4	2699.7	237		
2005	2775708	4068	1085.1	2720	262		
2006	2810872	4021.6	1154.4	2596.7	270.4		
2007	2834797	3945.5	1124.4	2574.6	246.5		
2008	2855390	3843.7	1182.7	2433.4	227.6		

Reported crime in California

Data Quality Hurdles

Missing Data	no measurements, redacted, ...?
Erroneous Values	misspelling, outliers, ...?
Type Conversion	e.g., zip code to lat-lon
Entity Resolution	diff. values for the same thing?
Data Integration	effort/errors when combining data


cdr (2)
Training • Full Dataset
Run Job
Grid
Columns
Find column
Filters
Suggestions
Preview
column1
ABC column3
ABC column4
ABC
310T - 310.26T
291,434 Categories
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DATETIME/TIMEZONE·OFFS
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310170097665881 2014-12-12T02:27:26/-5/
TRIFACTA Wrangler
A visual tool to quickly clean and prepare messy, diverse data
Delete rows
with mismatched values in column1
Edit
Add
Keep rows
with mismatched values in column1
flag mismatched values in column1
Set
mismatched values to NULL()
mismatched values to 0
Cancel
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310170097665881 2014-12-12T15:07:44/-5/0.00 MSC001:BSC002:BTS00783 SMS/000000000
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310170097665881 2014-12-12T16:30:52/-5/0.00 MSC001:BSC002:BTS00784 SMS/000000000
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https://www.trifacta.com/

Exploratory Analysis with Tableau

IACS ComputeFest Workshop:

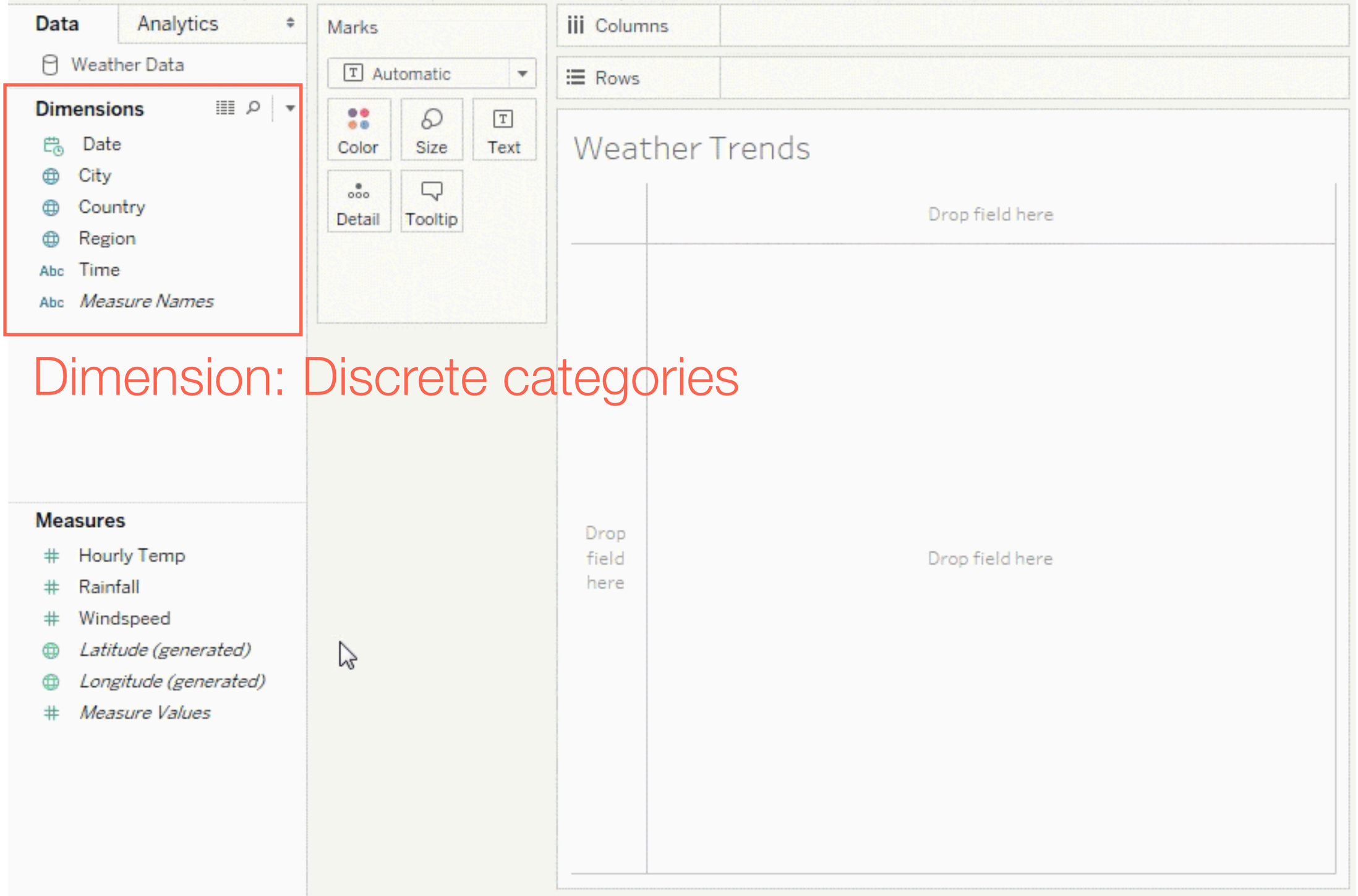
Introduction to Tableau

Wednesday, January 11, 2017
12:00 PM - 2:30 PM

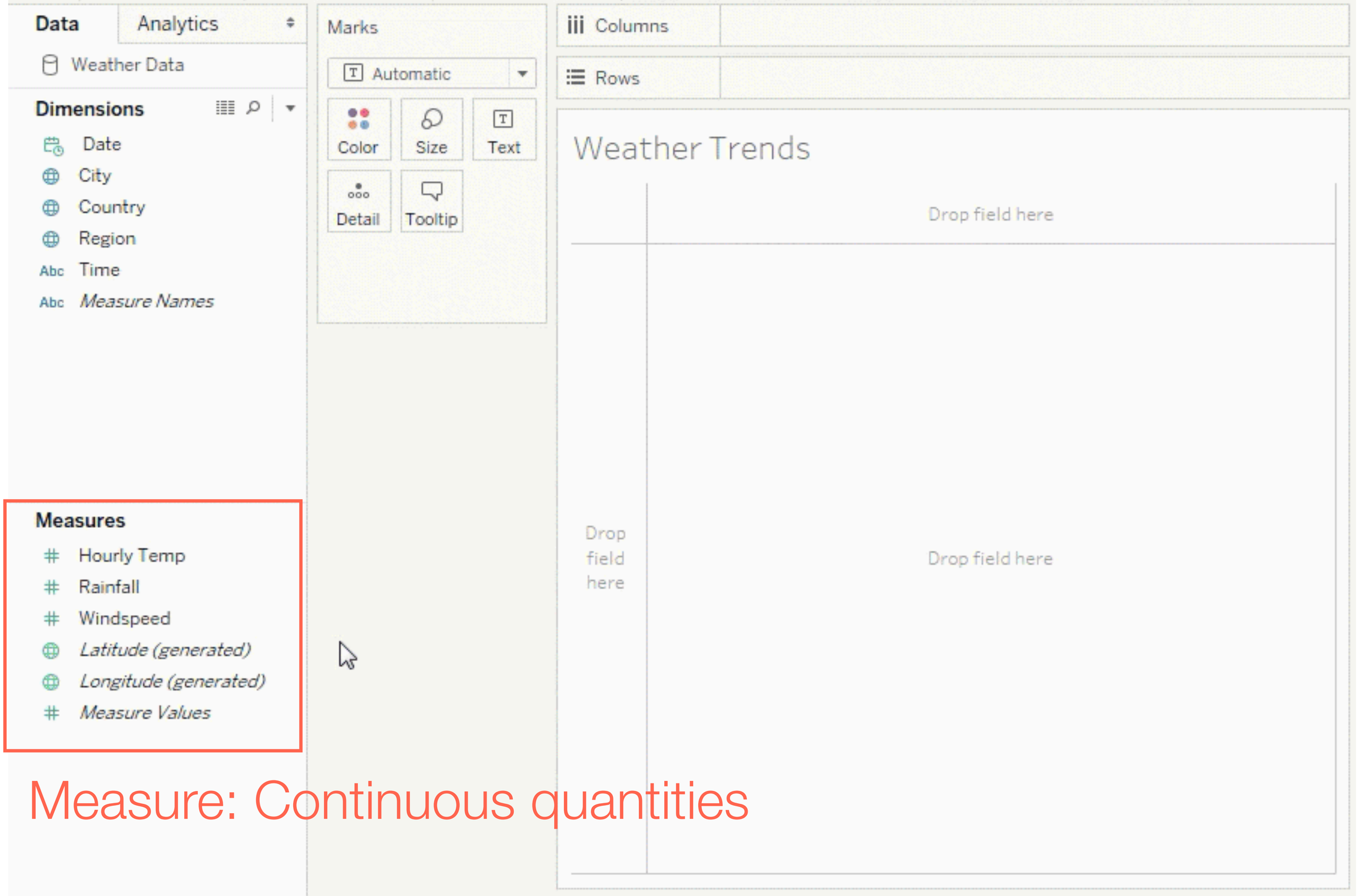
What is Tableau?

Software to rapidly construct visualizations of data and perform exploratory analysis of data

Download: https://public.tableau.com
Dataset: http://www.namwkim.org/datavis/h1b_kaggle_sample.csv



Dimension: Discrete categories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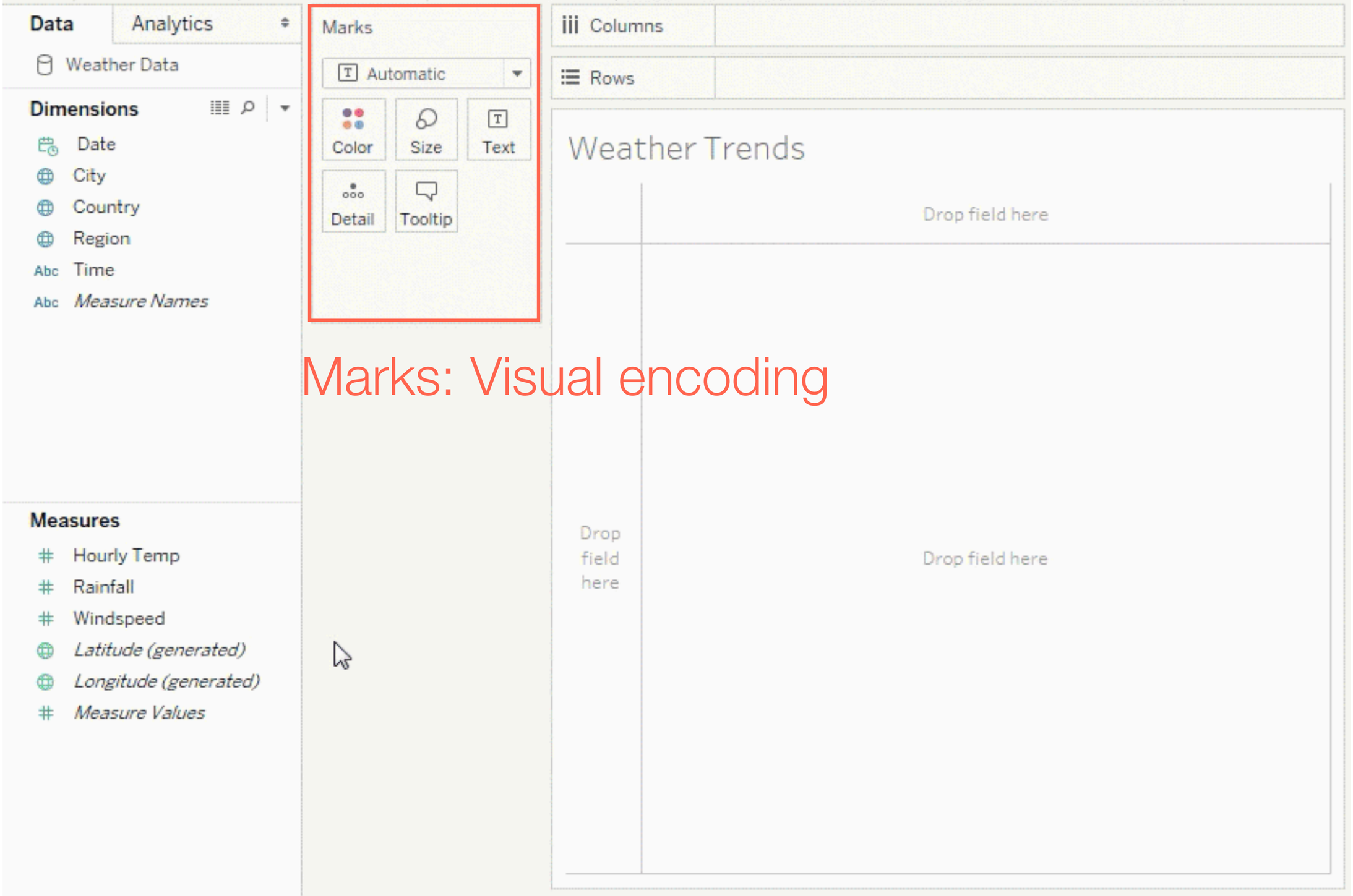
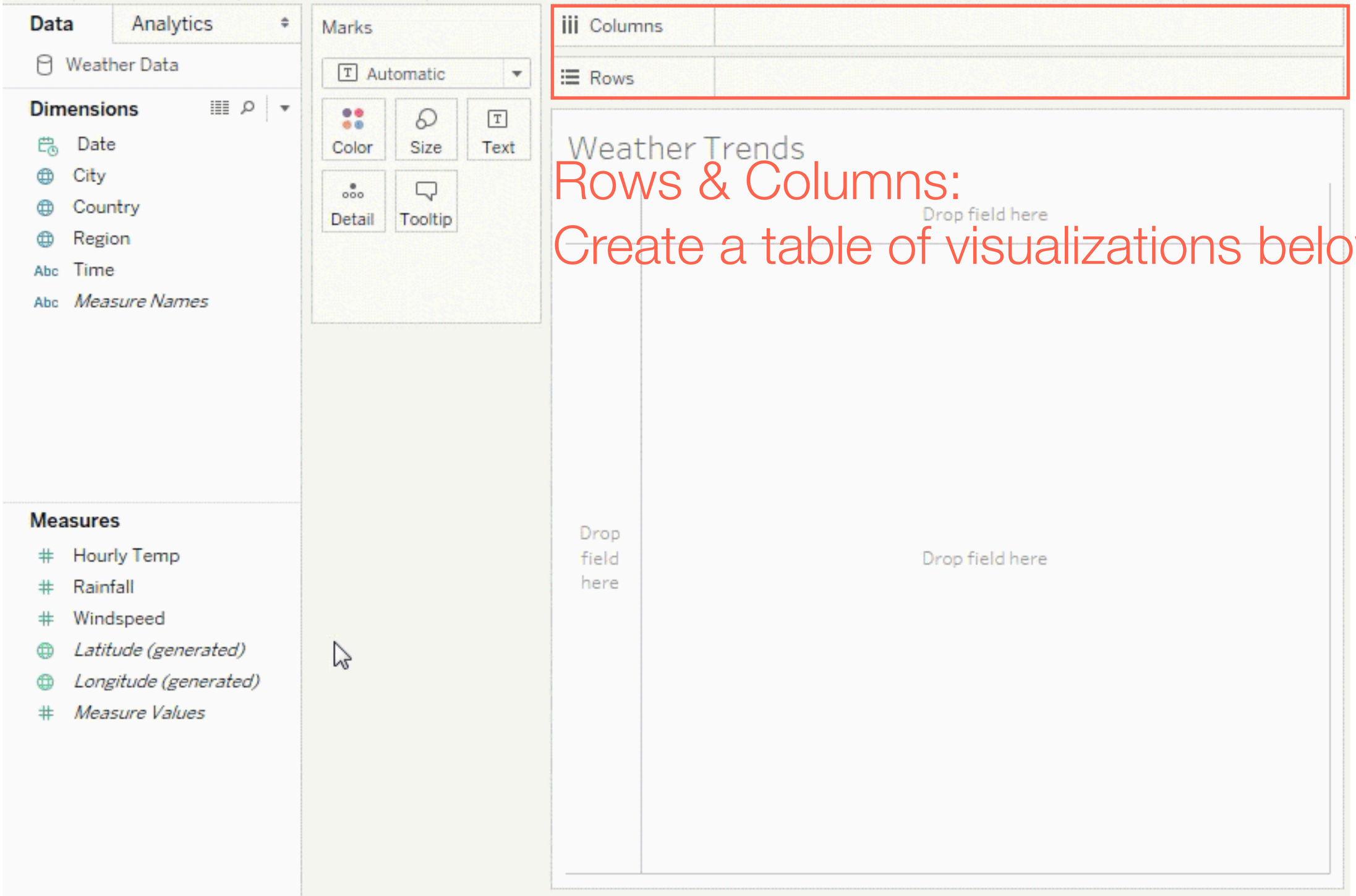
Longitude (generated)
Measure Values
Measure: Continuous quantities



Marks: Visual encoding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Measure Values
Marks
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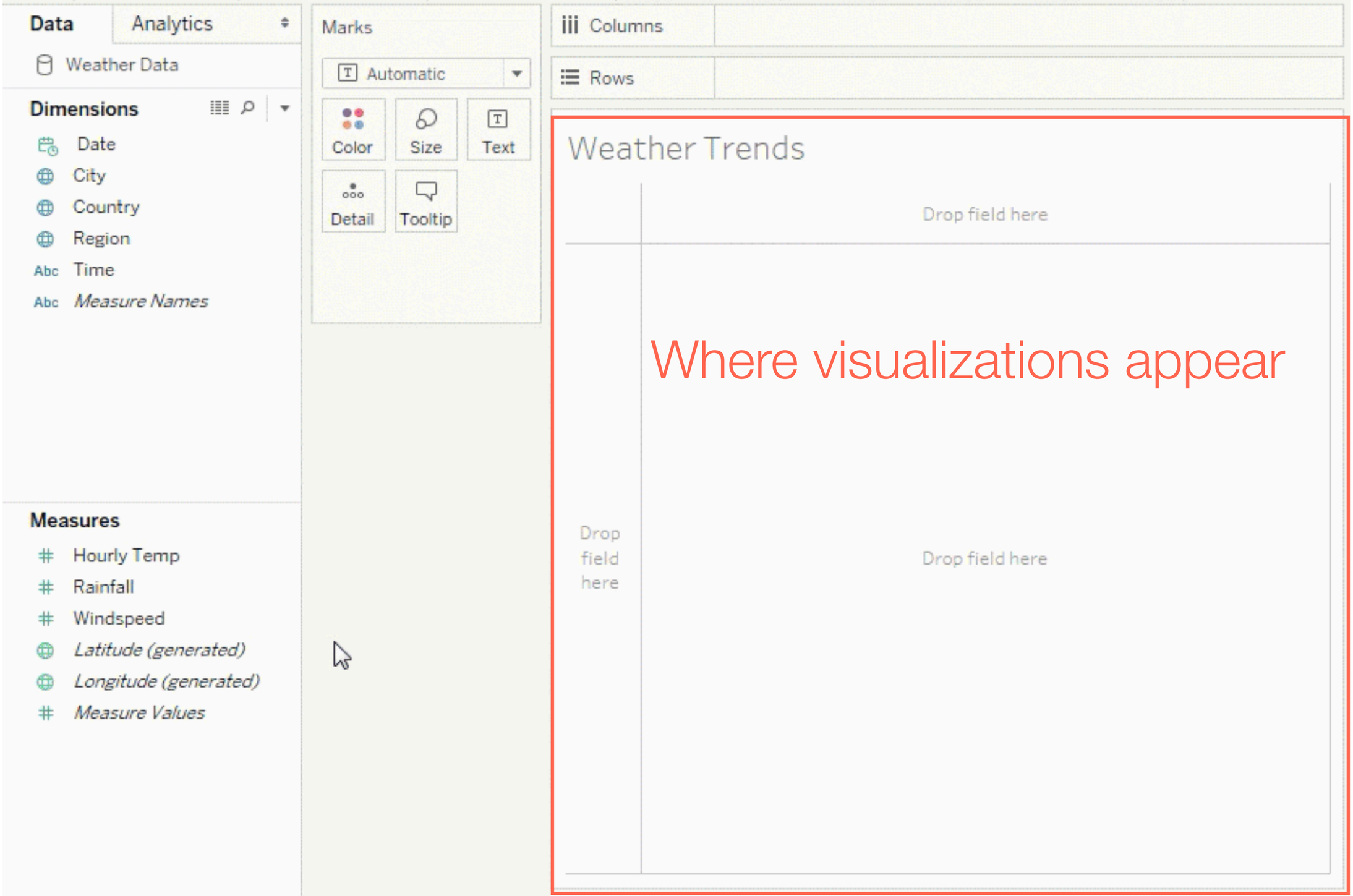
Rows & Columns:
Create a table of visualizations below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Measure Values
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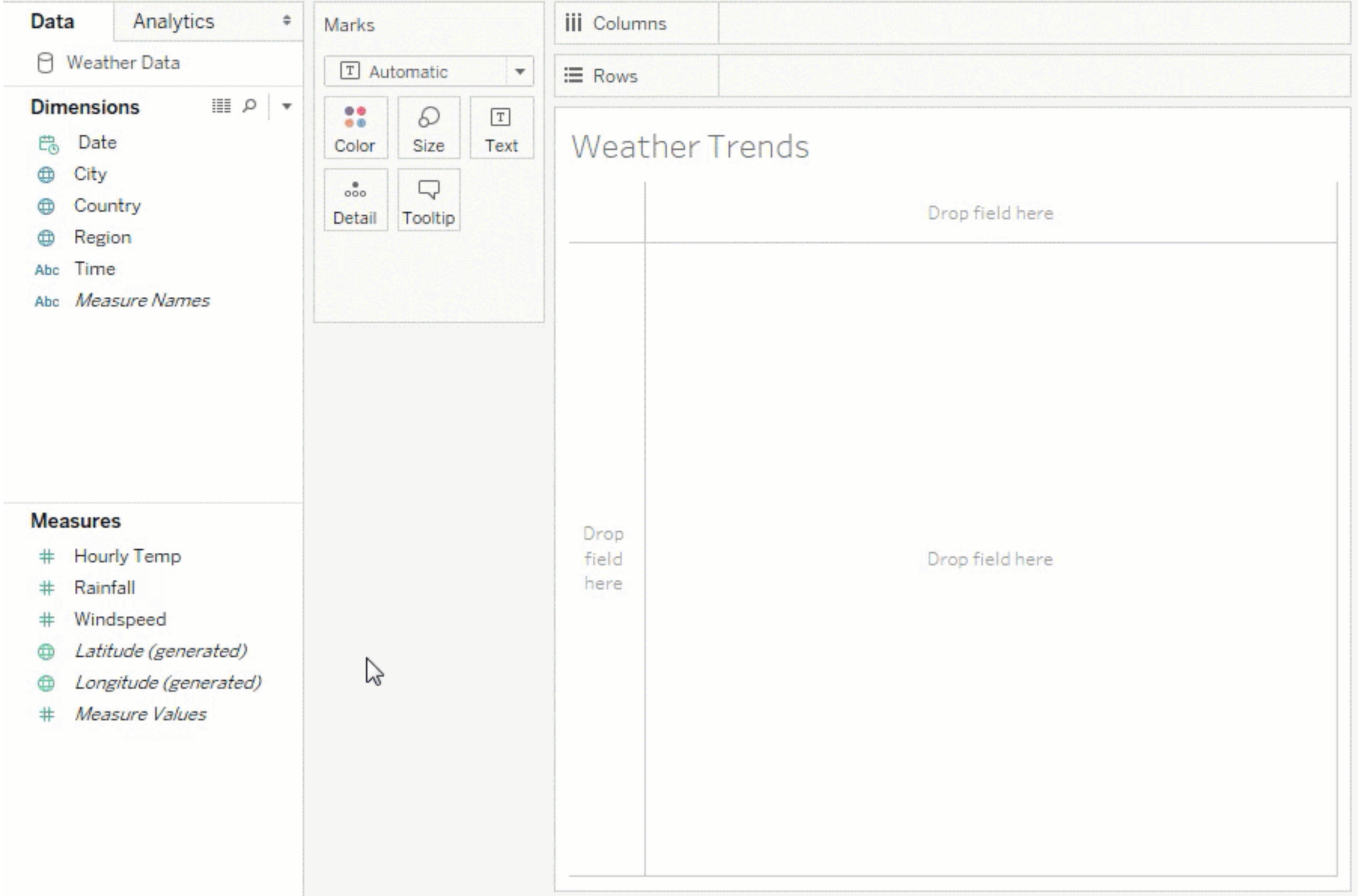
Where visualizations appear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Analysis Example:
H-1B Visa Petitions 2011-2016

Dataset: H1B Visa Petitions (2011-16)

H1B is a Employment-based, non-immigrant visa category for temporary foreign workers

The raw data was published by The Office of Foreign Labor Certification (OFLC)

The data was cleaned by Sharan Naribole, featured on Kaggle: https://www.kaggle.com/nsharan/h-1b-visa

Dataset: H1B Visa Petitions (2011-16)

CASE_STATUS (N): “Certified” (means eligible not approved) “Denied”….

EMPLOYER_NAME (N) — Company submitting this petition

SOC_NAME (N) — Standard occupational name

JOB_TITLE (N) — Title of the job

FULL_TIME_POSITION (N) — Y = Full Time Position; N = Part Time Position

PREVAILING_WAGE (Q) — the average wage paid to similar workers in the company

YEAR (O): Year in which the H-1B visa petition was filed

WORKSITE (N): City and State information of the foreign worker's intended area of employment

lon (Q): longitude of the Worksite

lat (Q): latitude of the Worksite

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3 million records of H-1B Visa Petitions

492MB!!

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~~**WORKSITE (N)**:~~ **City and State** ~~information of the foreign worker's intended area of employment~~

City (N)

State (N)

~~**lon (Q)**: longitude of the Worksite~~ **Tableau can infer this from worksite**

~~**lat (Q)**: latitude of the Worksite~~

Dataset: H1B Visa Petitions (2011-16)

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And removed rows of missing data
and randomly sampled 40% of the whole data

lon (Q): longitude of the Worksite **Tableau can infer this from worksite**

lat (Q): latitude of the Worksite

Dataset: H1B Visa Petitions (2011-16)

EMPLOYER_NAME (N) — Company submitting this petition

SOC_NAME (N) — Standard occupational name

JOB_TITLE (N) — Title of the job

PREVAILING_WAGE (Q) — the average wage paid to similar workers

YEAR (O): Year in which the H-1B visa petition was filed

City (N): City of the worksite

State (N): State of the worksite

~20MB

Hypotheses

What might we learn from this data?

Do petitions increase over time?

Which company files petitions the most?

What kind of job is the most applied?

Which company offers the highest salary

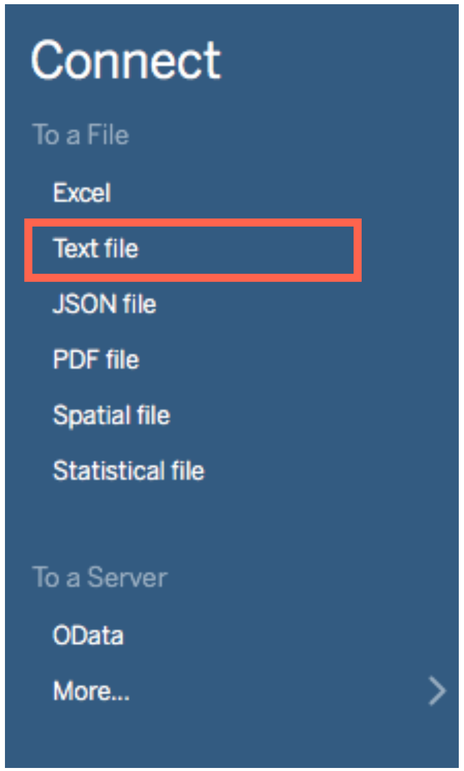
What kind of job is offered the highest salary?

Which states/cities file petitions the most?

What are differences in salaries across states & cities?

Tableau Demo

Load data

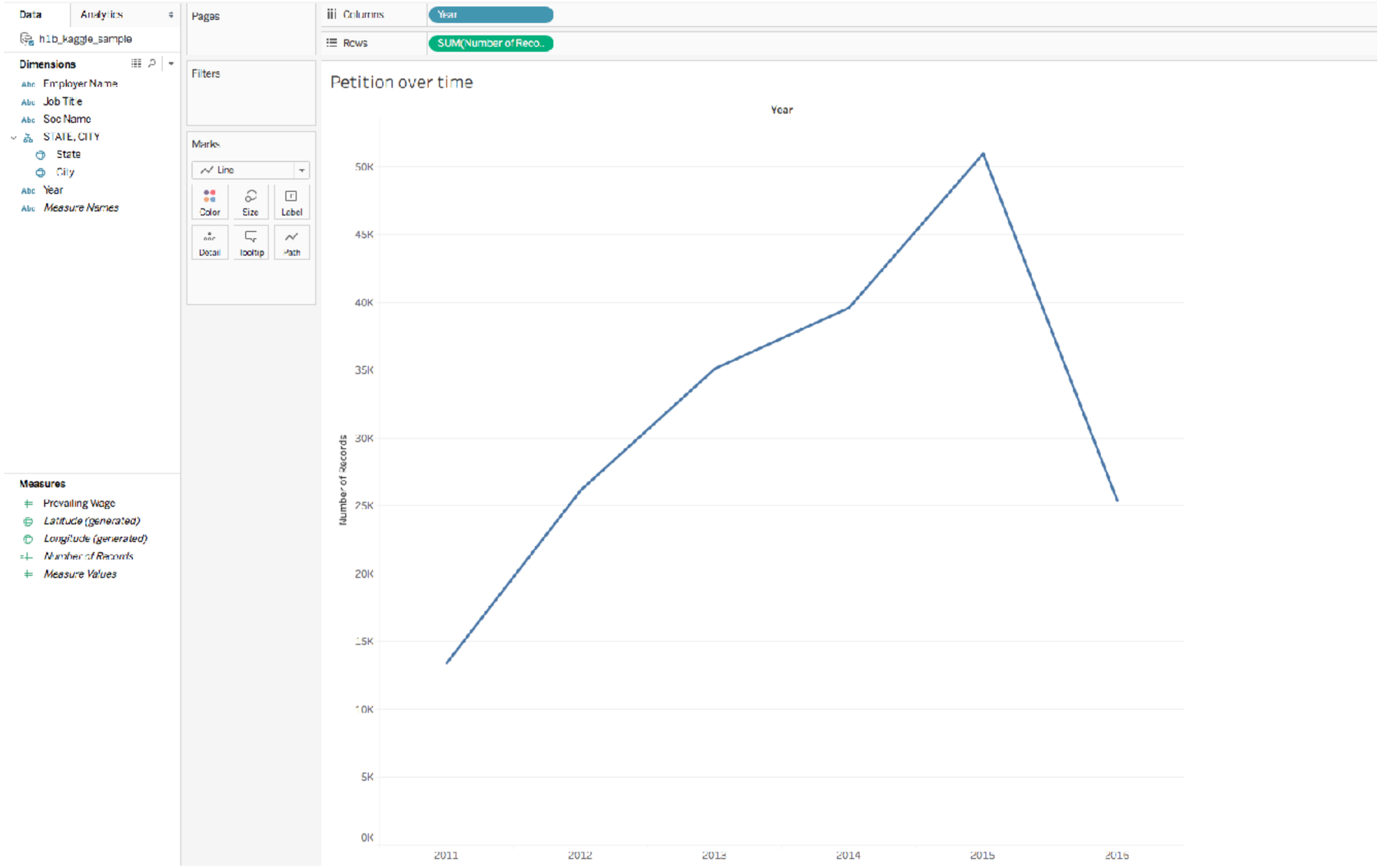


Change Year to String Type

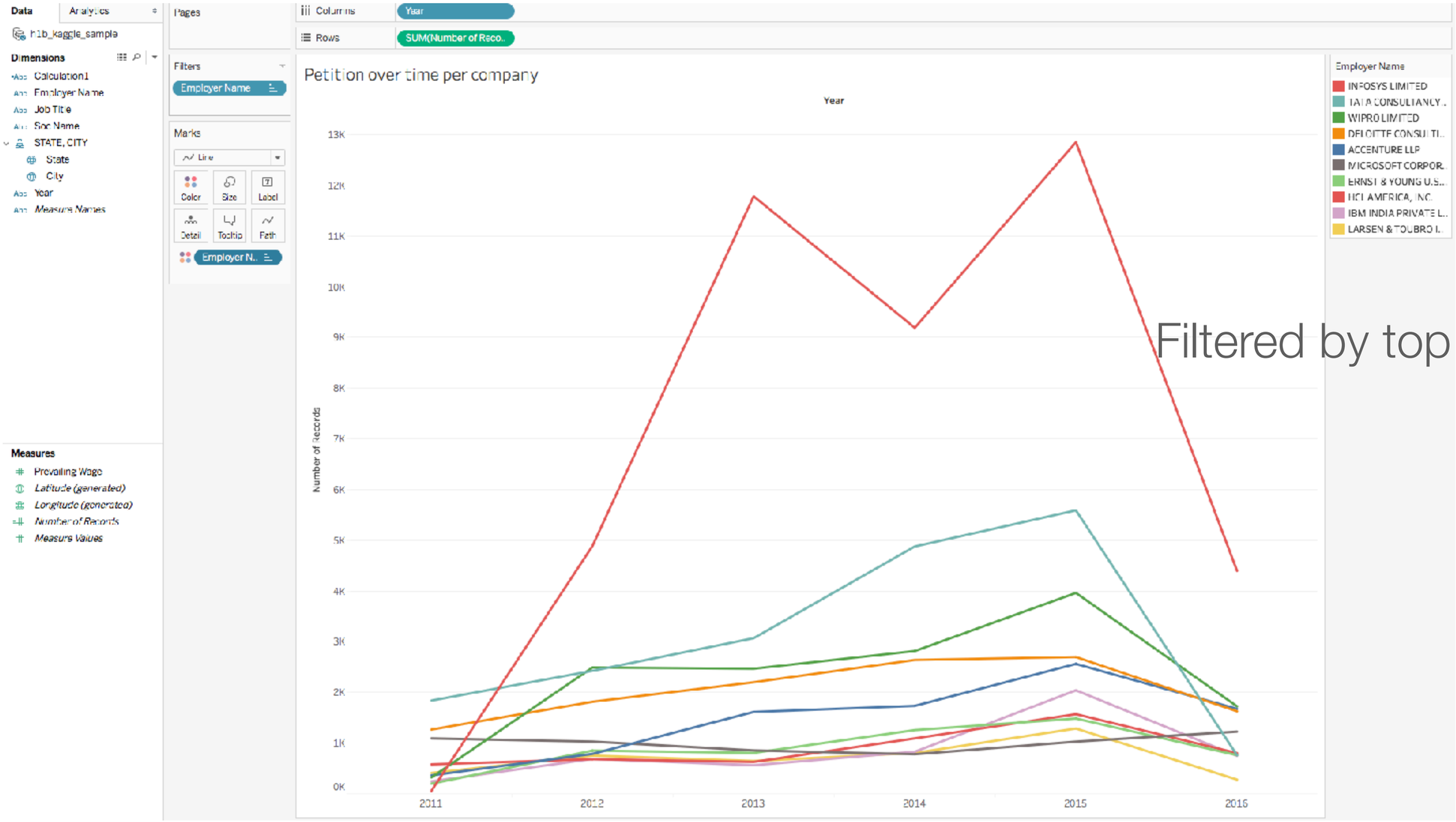
Sort fields: Data source order

Employer Name	Soc Name	Job Title	Prevailing Wage	Year	City	State
WAL-MART ASSOCIA...	Computer Systems Analysts	PROGRAMMER ANALYST	40,061.00	2011	BENTONVILLE	ARKANSAS
KPMG LLP	Accountants and Auditors	MANAGER	81,640.00	2011	SAN FRANCISCO	CALIFORNIA
LARSEN & TOUBRO LI...	Commercial and Industrial De...	INDUSTRIAL DESIGNER	39,437.00	2011	PLAYA VISTA	CALIFORNIA
LARSEN & TOUBRO I...	Computer Programmers	COMPUTER PROGRAMMER	54,870.00	2011	SAN DIEGO	CALIFORNIA
GOOGLE INC.	Computer Software Engineers...	SOFTWARE ENGINEER	90,480.00	2011	SAN BRUNO	CALIFORNIA
MICROSOFT CORPOR...	Computer Software Engineers...	SOFTWARE DEVELOPMENT ENGI...	98,530.00	2011	MOUNTAIN VIEW	CALIFORNIA
CAPGEMINI U.S. LLC	Computer Software Engineers...	CONSULTANT	66,602.00	2011	BURBANK	CALIFORNIA
DELOITTE CONSULTI...	Computer Software Engineers...	SENIOR CONSULTANT	83,512.00	2011	IRWINDALE	CALIFORNIA
DELOITTE CONSULTI...	Computer Software Engineers...	SPECIALIST SENIOR	71,490.00	2011	RANCHO CORDOVA	CALIFORNIA
INTEL CORPORATION	Computer Software Engineers...	SOFTWARE ENGINEER	124,363.00	2011	SANTA CLARA	CALIFORNIA
MICROSOFT CORPOR...	Computer Software Engineers...	SOFTWARE DEVELOPMENT ENGI...	85,904.00	2011	MOUNTAIN VIEW	CALIFORNIA
HCL AMERICA, INC.	Computer Systems Analysts	SYSTEMS ANALYST	58,427.00	2011	SAN JOSE	CALIFORNIA
PERSISTENT SYSTEM...	Computer Systems Analysts	PROGRAMMER ANALYST	63,107.00	2011	REDWOOD CITY	CALIFORNIA
UST GLOBAL INC.	Computer Systems Analysts	SYSTEMS ANALYST	68,682.00	2011	WOODLAND HILLS	CALIFORNIA
INTEL CORPORATION	Electronics Engineers, Except ...	HARDWARE ENGINEER	86,732.00	2011	SANTA CLARA	CALIFORNIA
LARSEN & TOUBRO I...	Management Analysts	BUSINESS SYSTEMS ANALYST	44,387.00	2011	SANTA ANA	CALIFORNIA
LARSEN & TOUBRO LI...	Commercial and Industrial De...	INDUSTRIAL DESIGNER	34,278.00	2011	NORTH HAVEN	CONNECTICUT
ACCENTURE LLP	Computer Programmers	COMPUTER PROGRAMMER/CON...	71,885.00	2011	HARTFORD	CONNECTICUT
V-SOFT CONSULTING	Computer Systems Analysts	SYSTEMS ANALYST	63,648.00	2011	WINDSOR	CONNECTICUT

Do petitions increase over time?

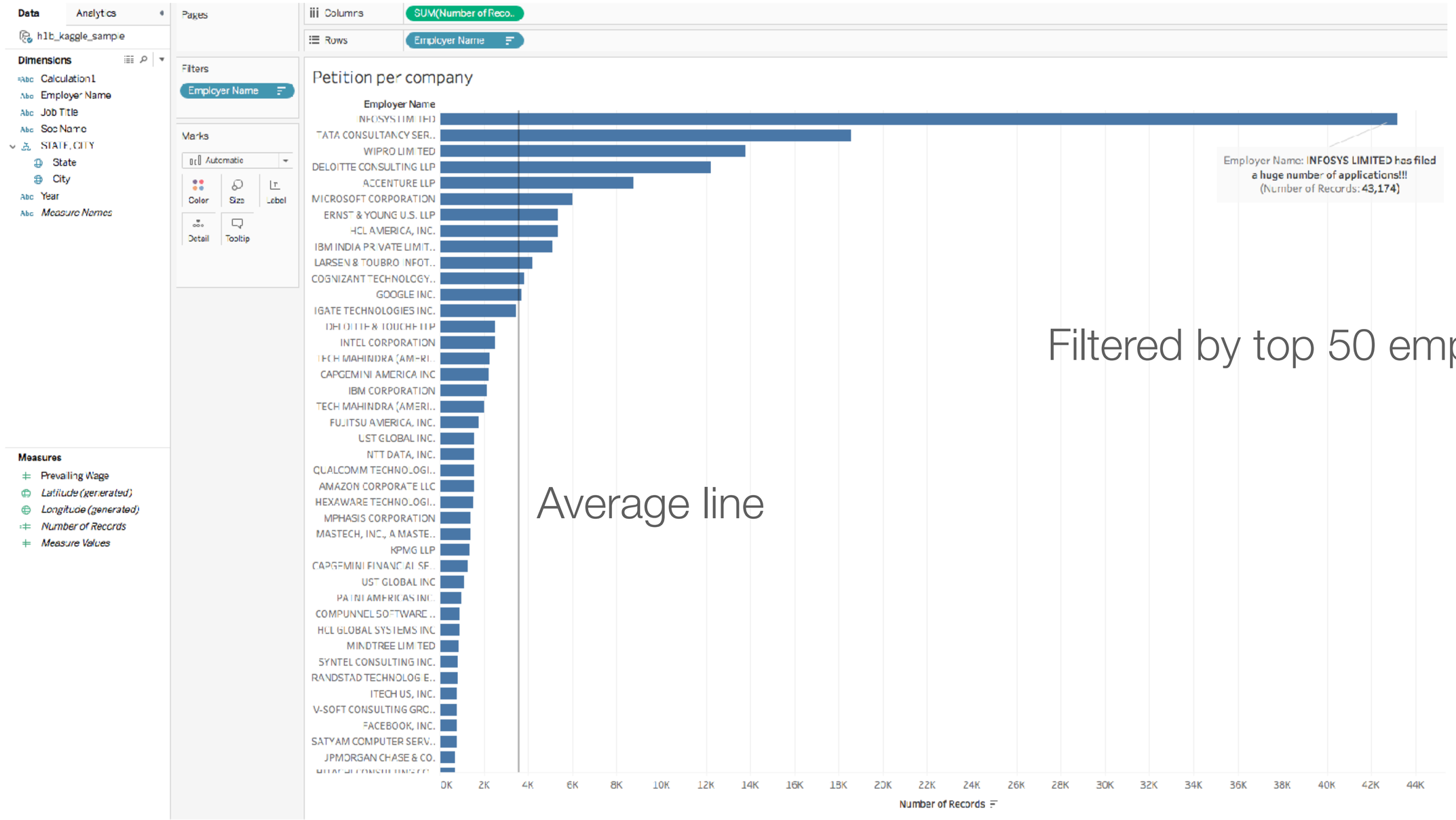


Do petitions increase over time?



Filtered by top 10 employers

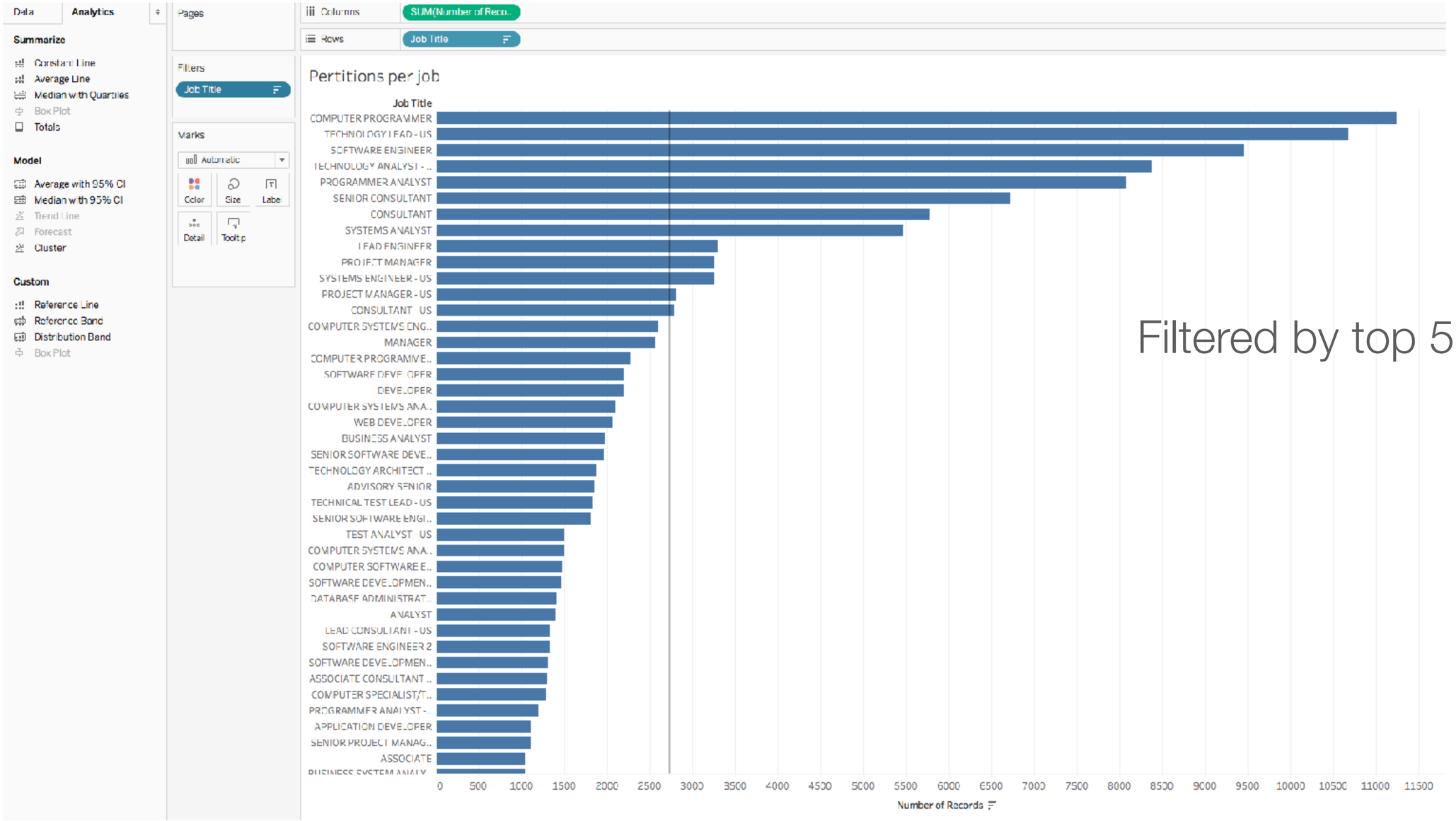
Which company files petitions the most?



Filtered by top 50 employers

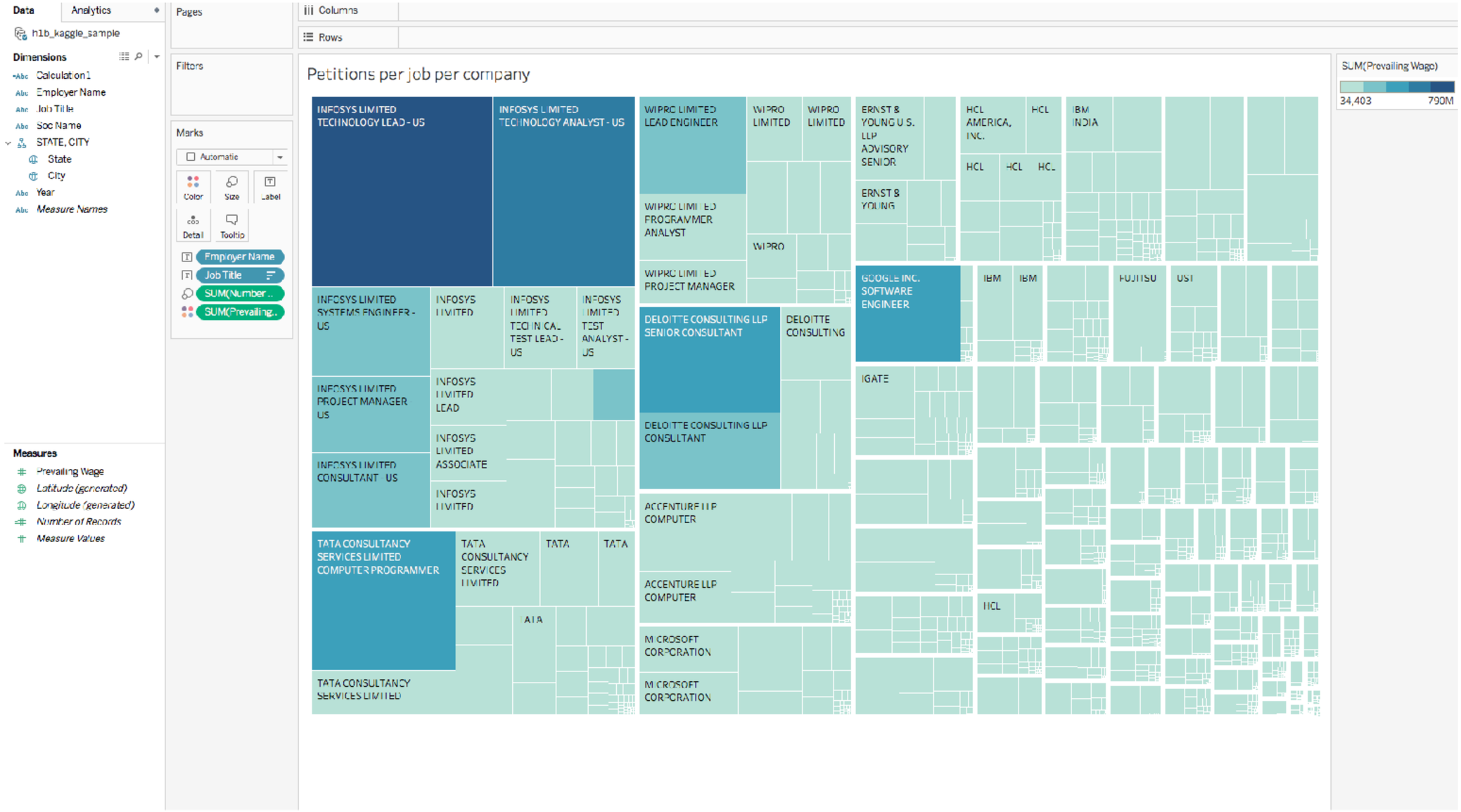
Average line

What kind of job is the most applied?

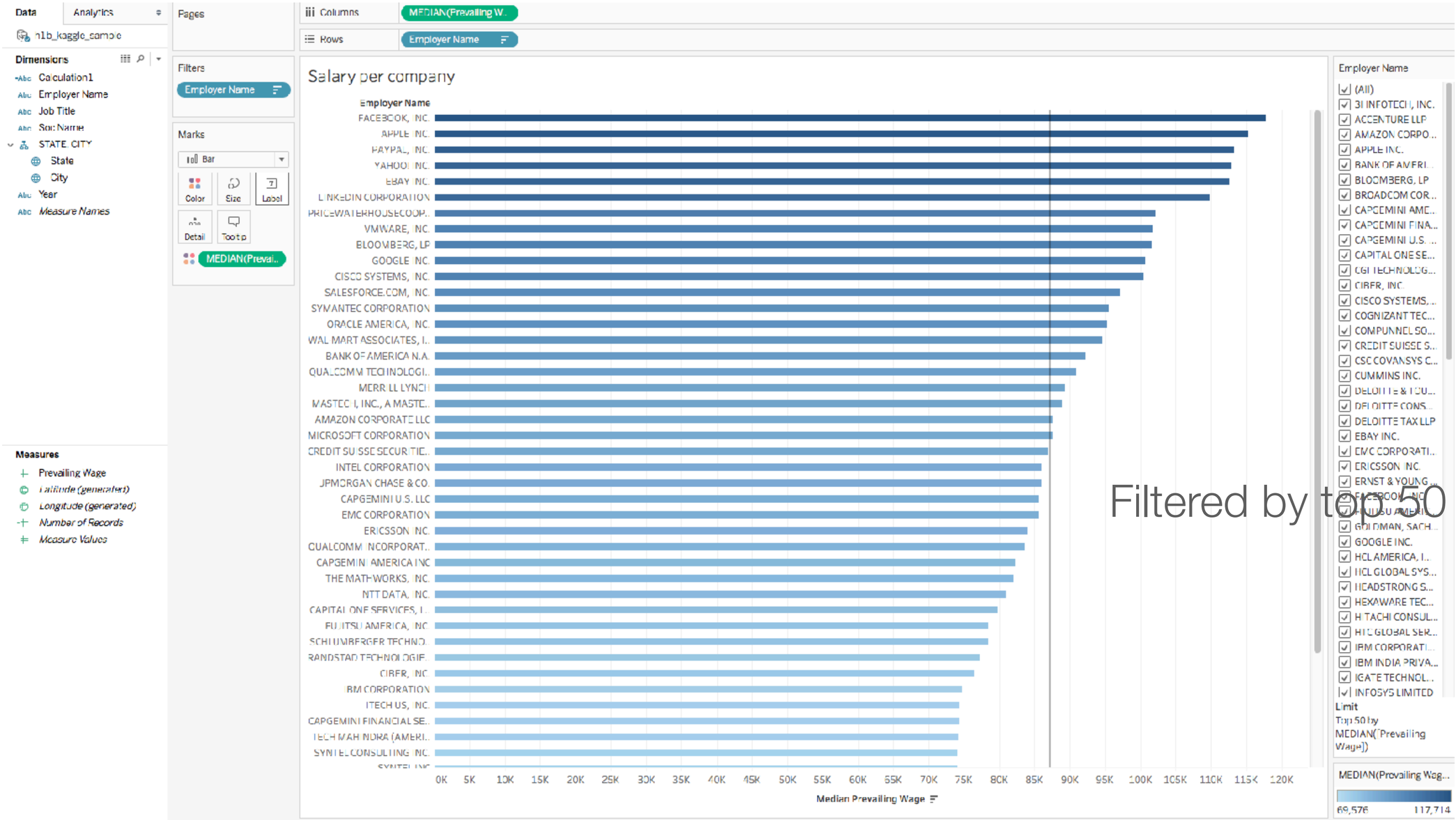


Filtered by top 50 jobs

Petitions per job per company

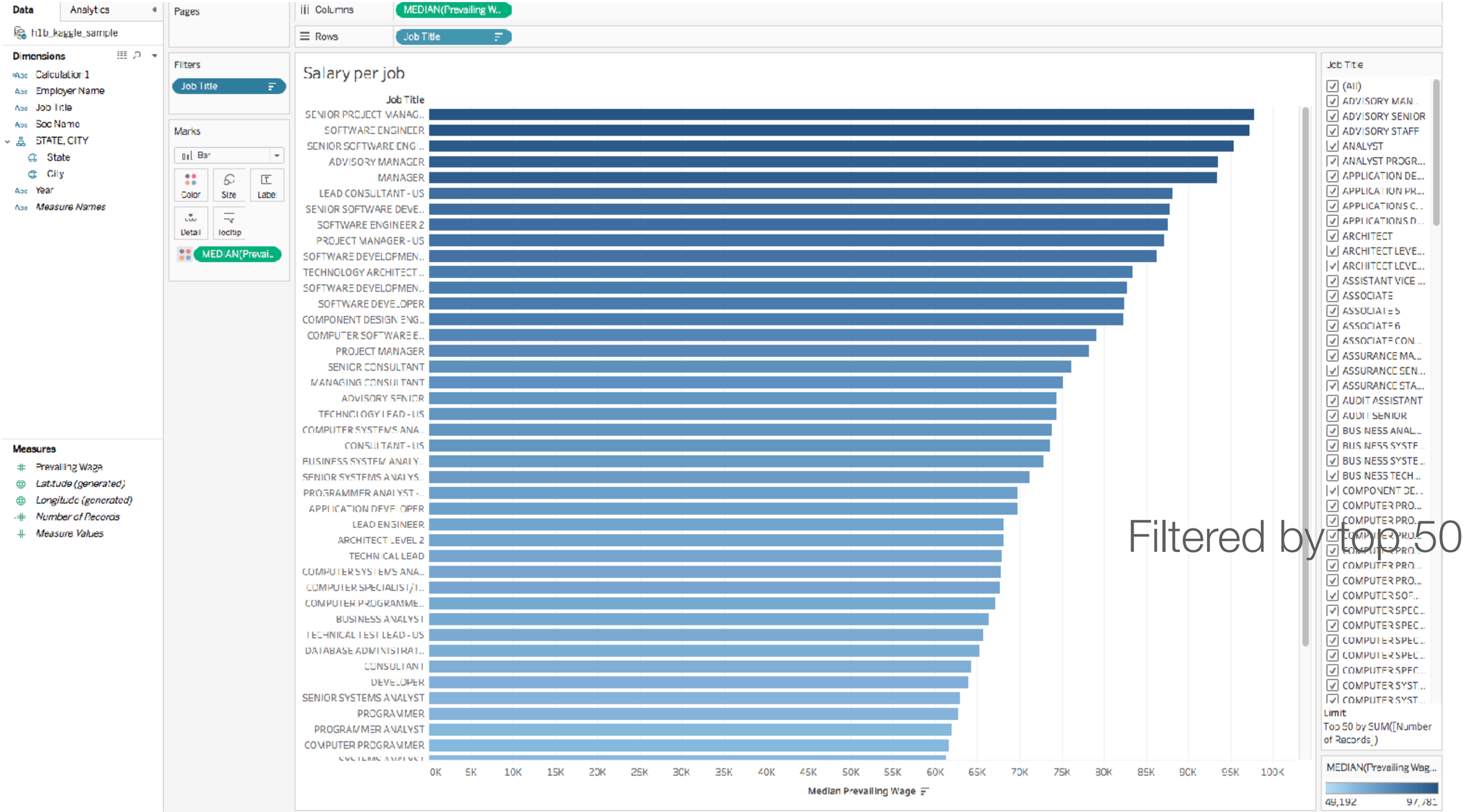


Which company offers the highest salary?



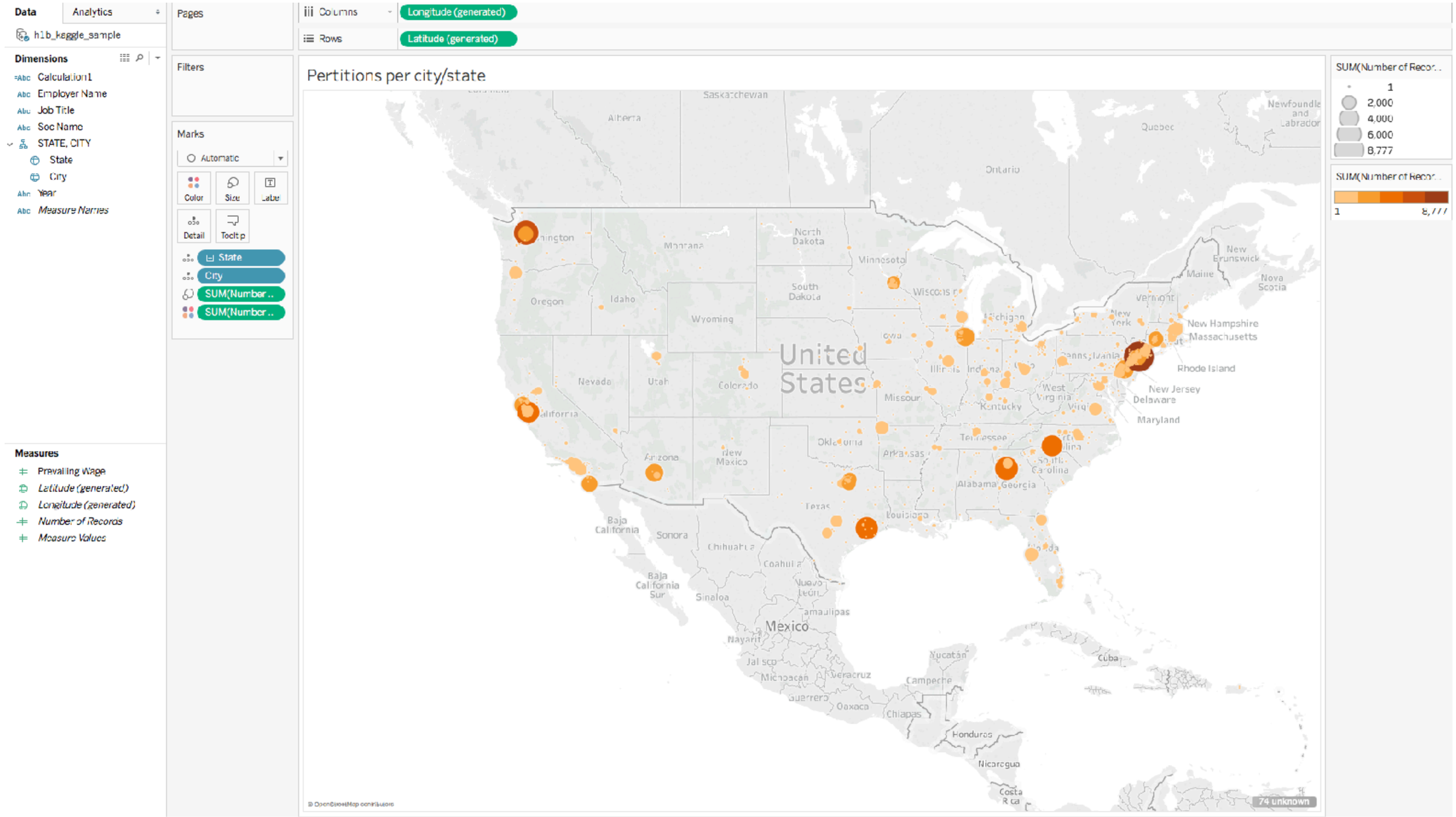
Filtered by top 50 employers

What kind of job is offered the highest salary?

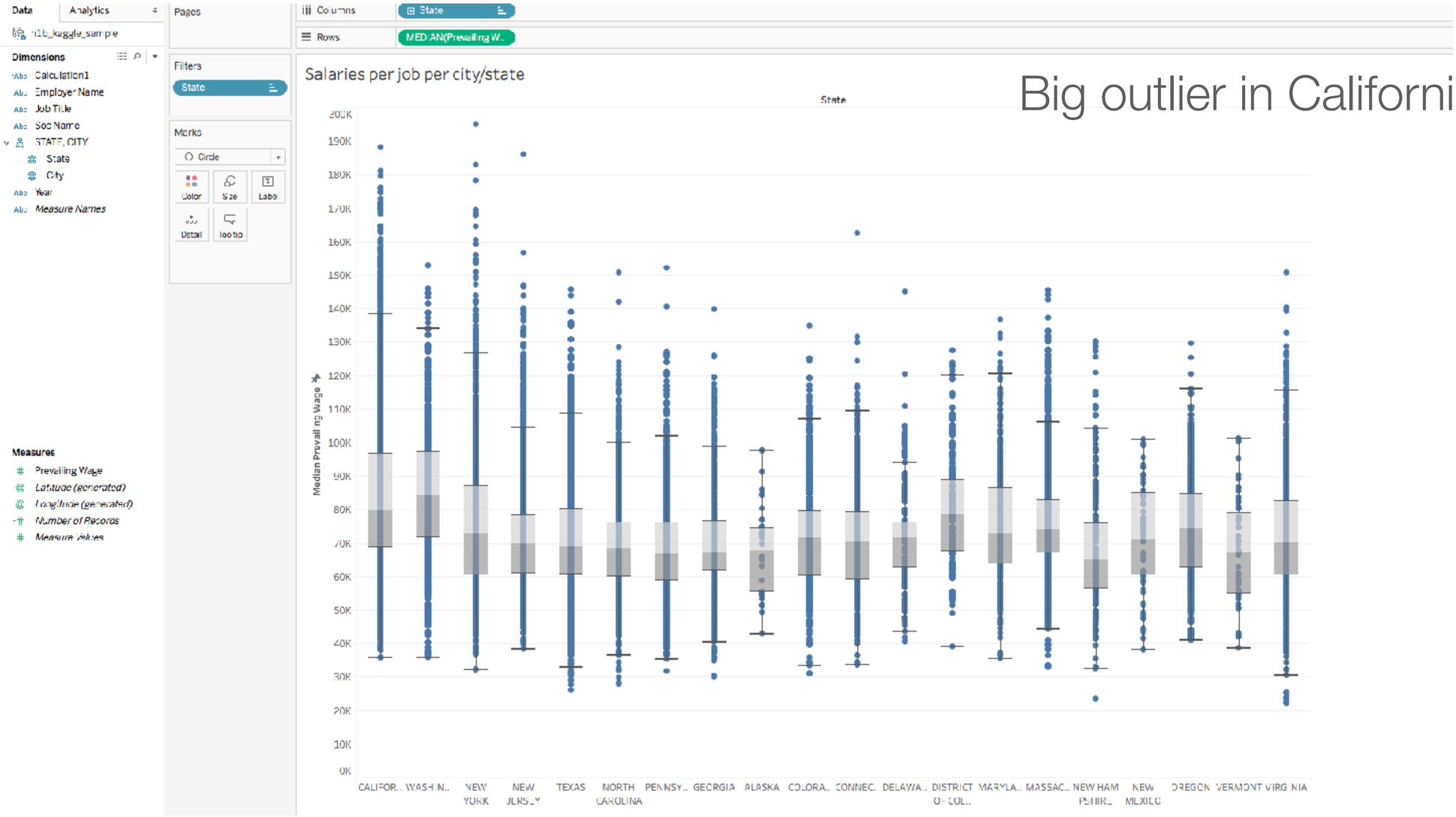


Filtered by top 50 jobs

Which states/cities files petitions the most?



What are differences in salaries across states & cities?



Big outlier in California removed

Scatter Plot

Next

Storytelling with Data

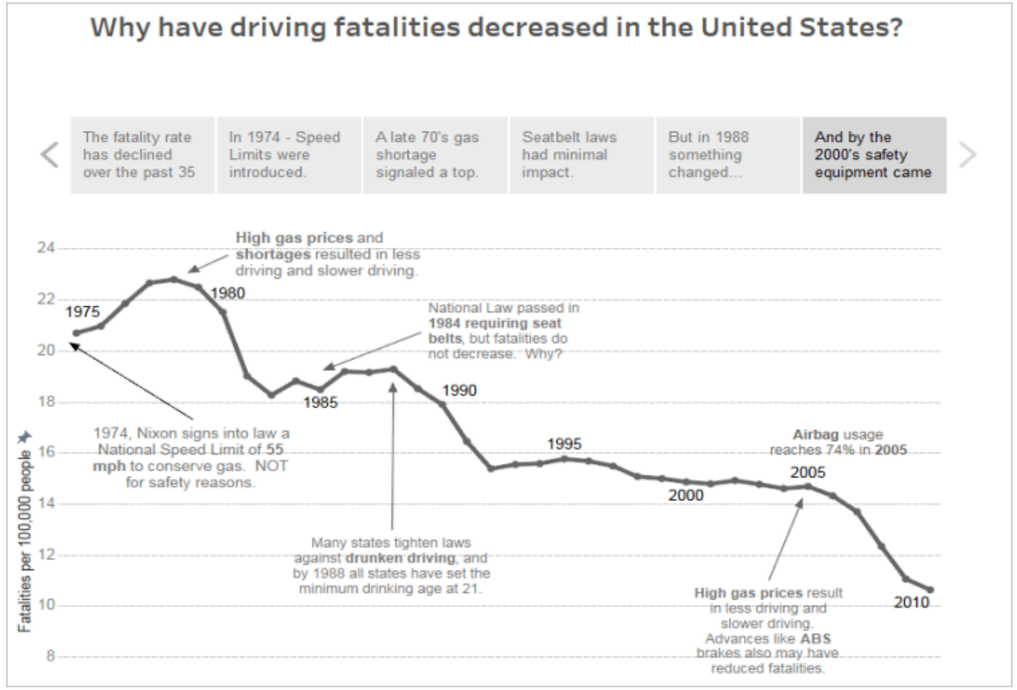


Tableau Story Points

10 min break