

# Why visualize data?

**CS424: Visualization & Visual Analytics**

**Fabio Miranda**

<https://fmiranda.me>

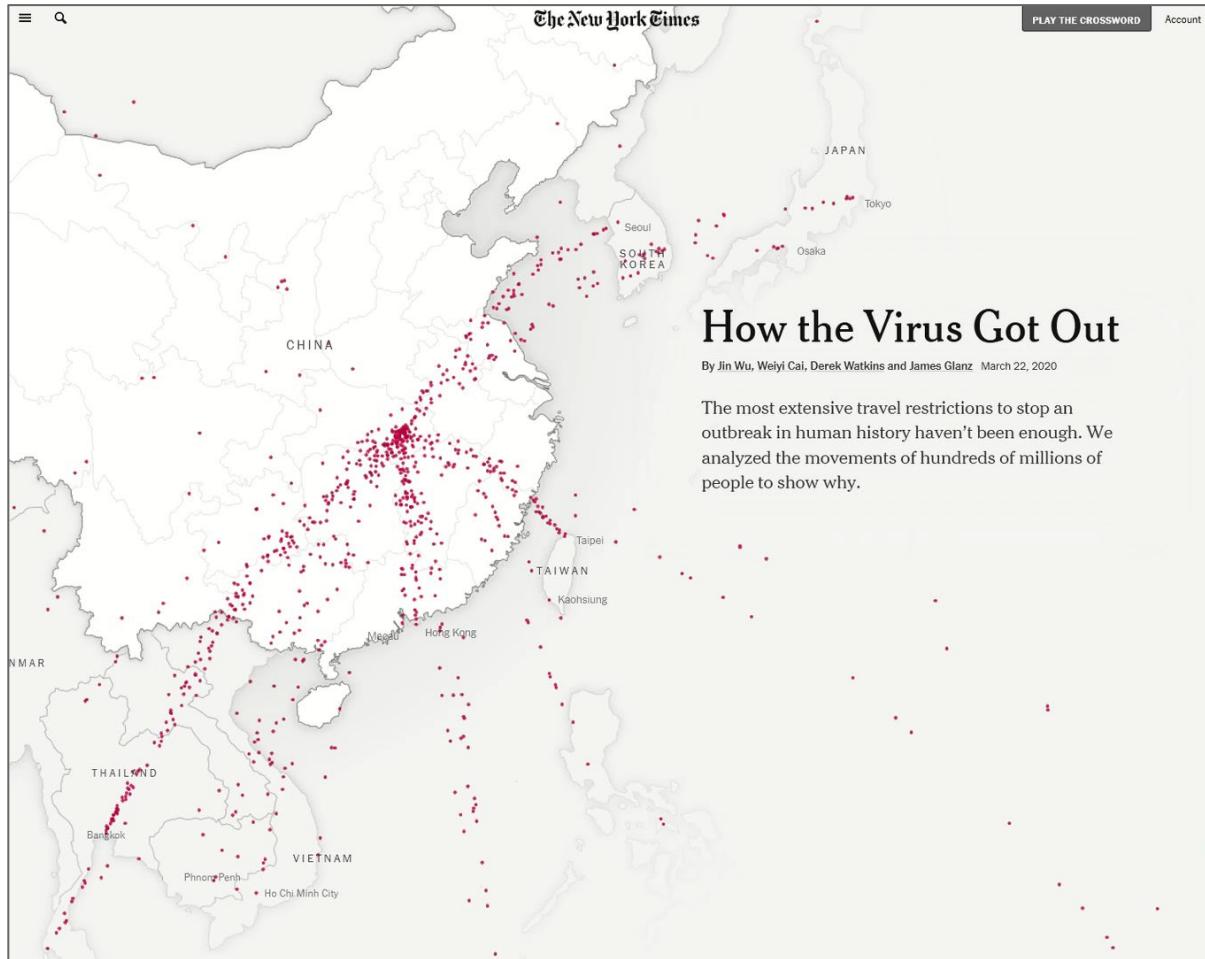
# Visual analytics

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*“Visual analytics is the formation of abstract visual metaphors in combination with a human information interaction that enables detection of the expected and discovery of the unexpected within massive, dynamically changing information spaces.”*

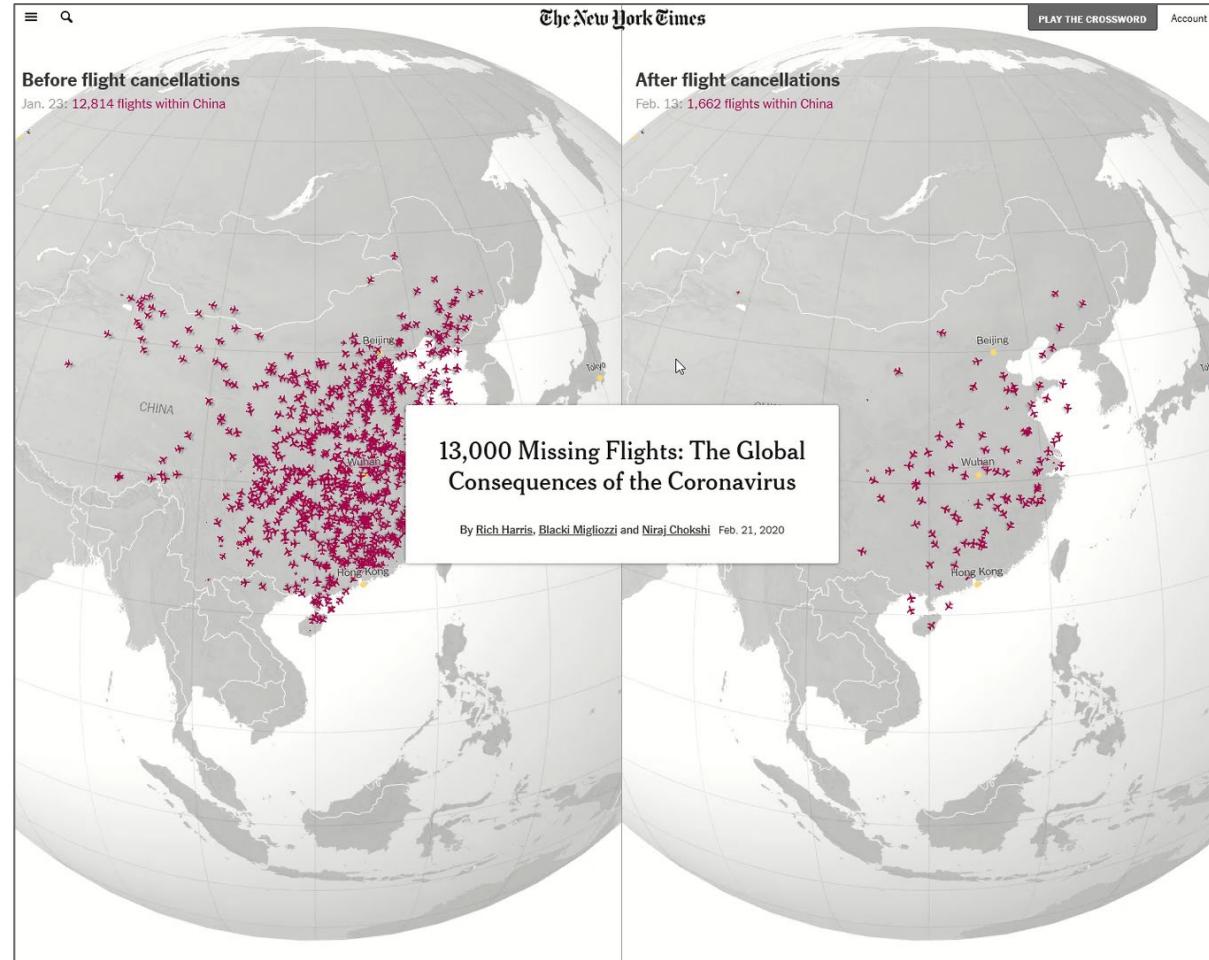
[Wong and Thomas, 2004]

# Example: communicating findings



<https://www.nytimes.com/interactive/2020/03/22/world/coronavirus-spread.html>

# Example: communicating findings



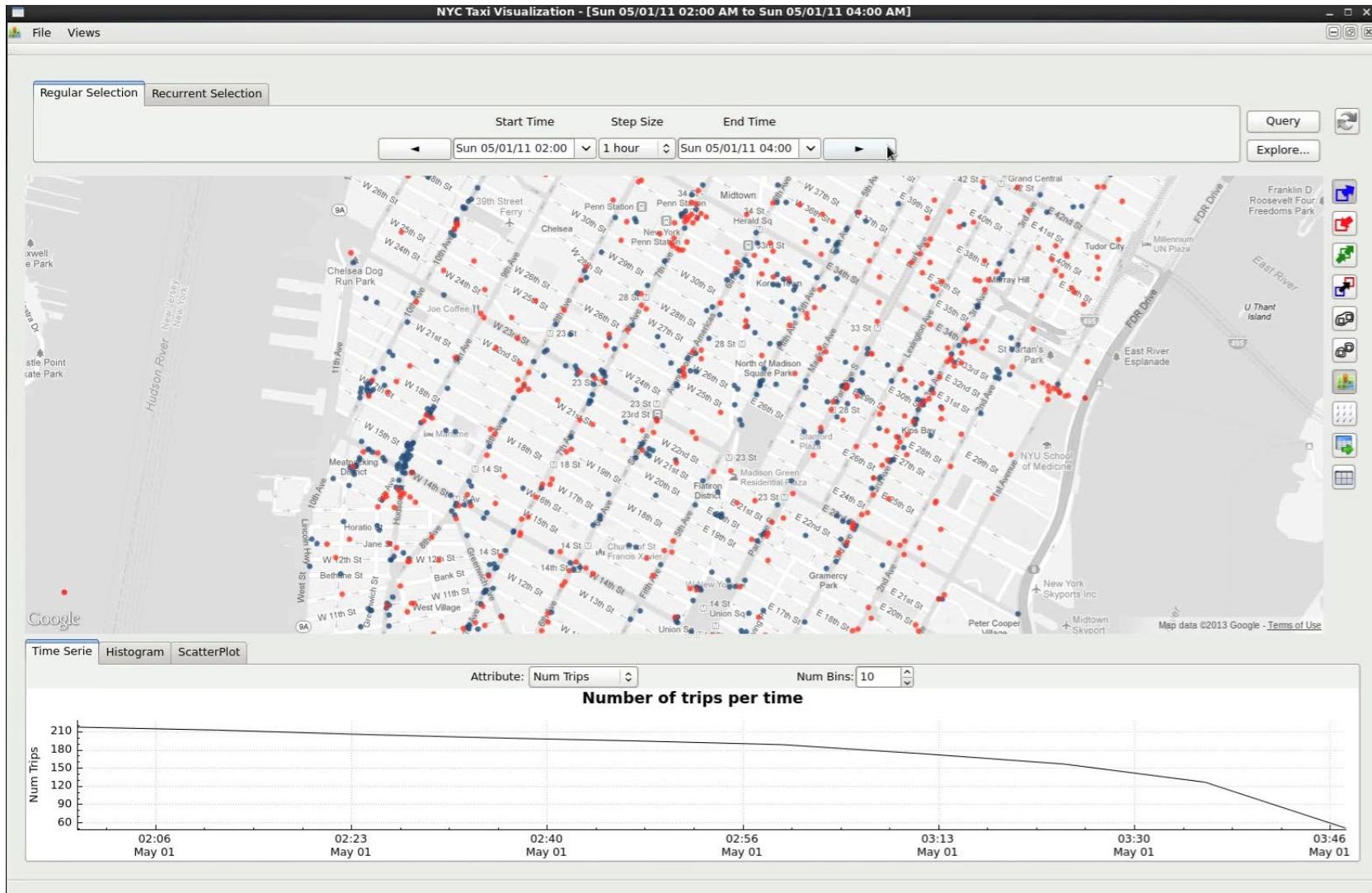
<https://www.nytimes.com/interactive/2020/02/21/business/coronavirus-airline-travel.html>

# Example: exploration + communicating findings



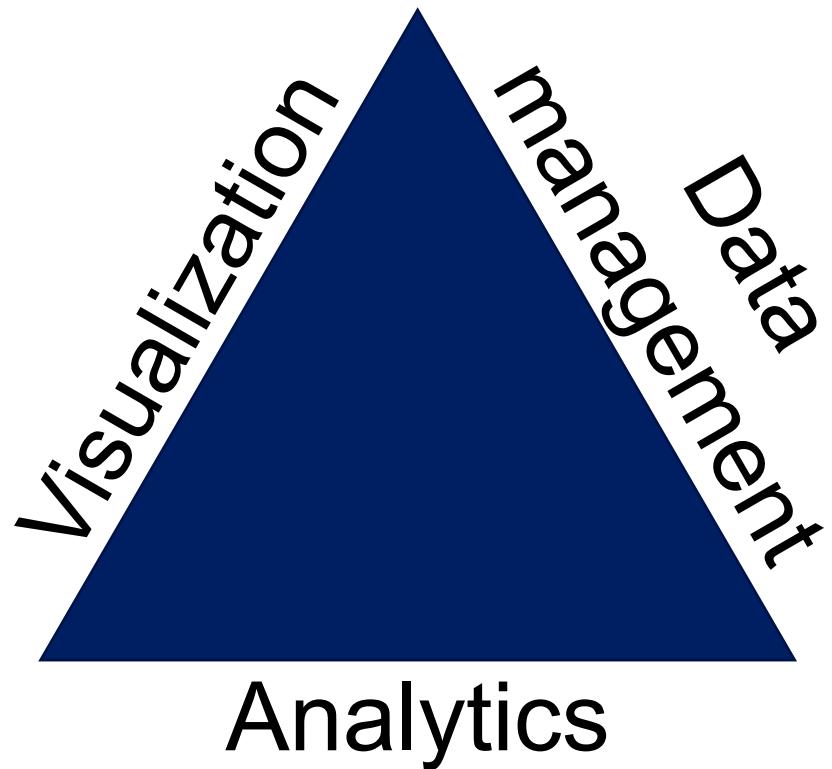
<https://www.nytimes.com/interactive/2016/12/21/upshot/Mapping-the-Shadows-of-New-York-City.html>

# Example: visual analysis of data



# Visual analytics

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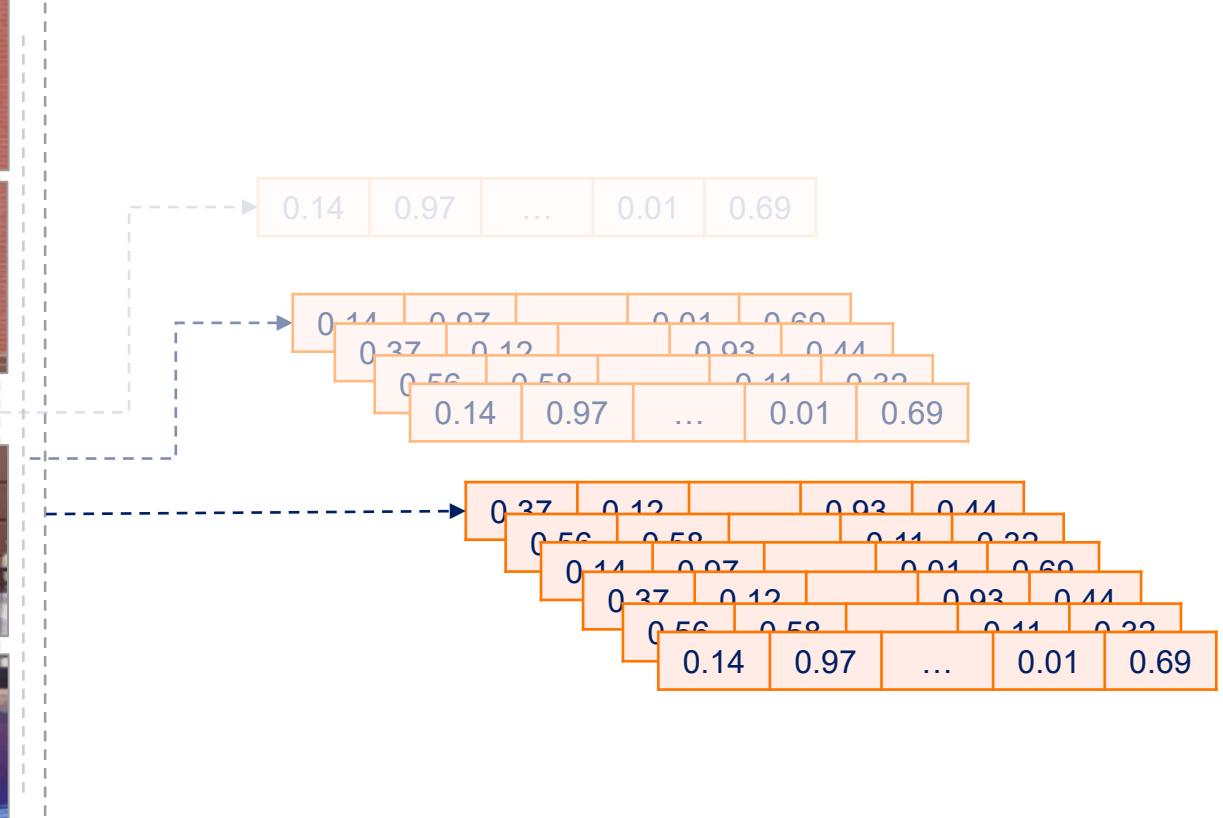
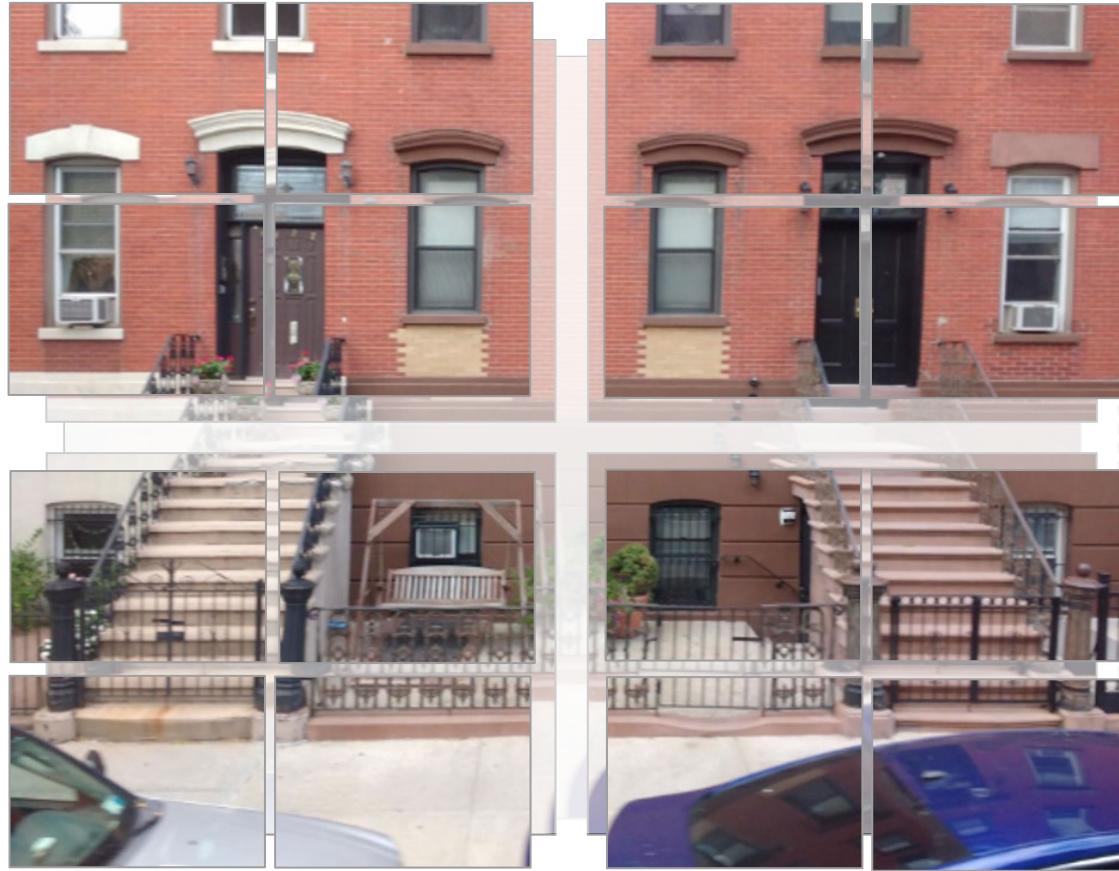


# Images

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# Images

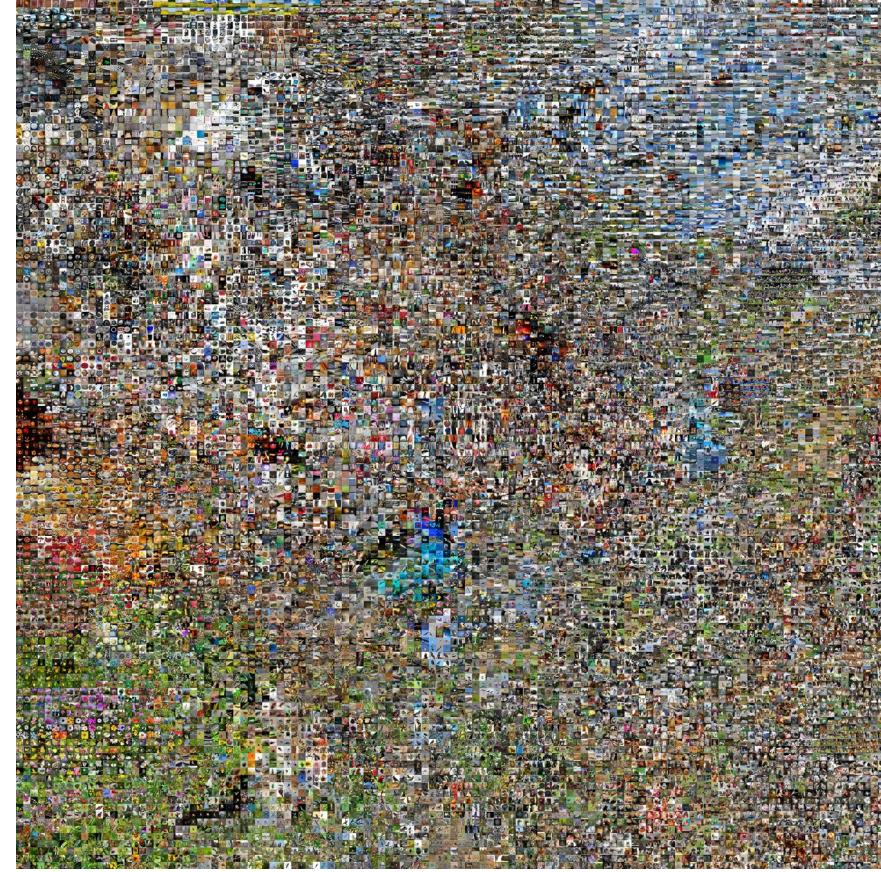
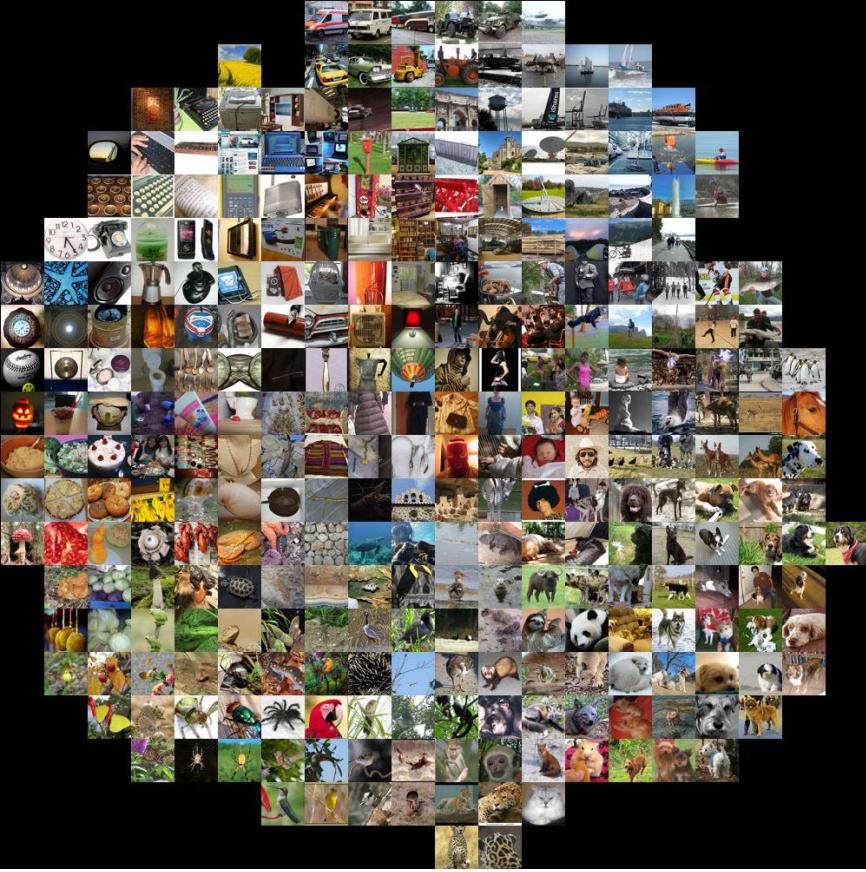


# tSNE

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# tSNE



# Audio

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# Taxi patterns

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- NYC taxi data:
  - ~175 million trips / year
  - Spatiotemporal
  - Other attributes:
    - Fare, tip
    - Distance
    - Duration
    - ...

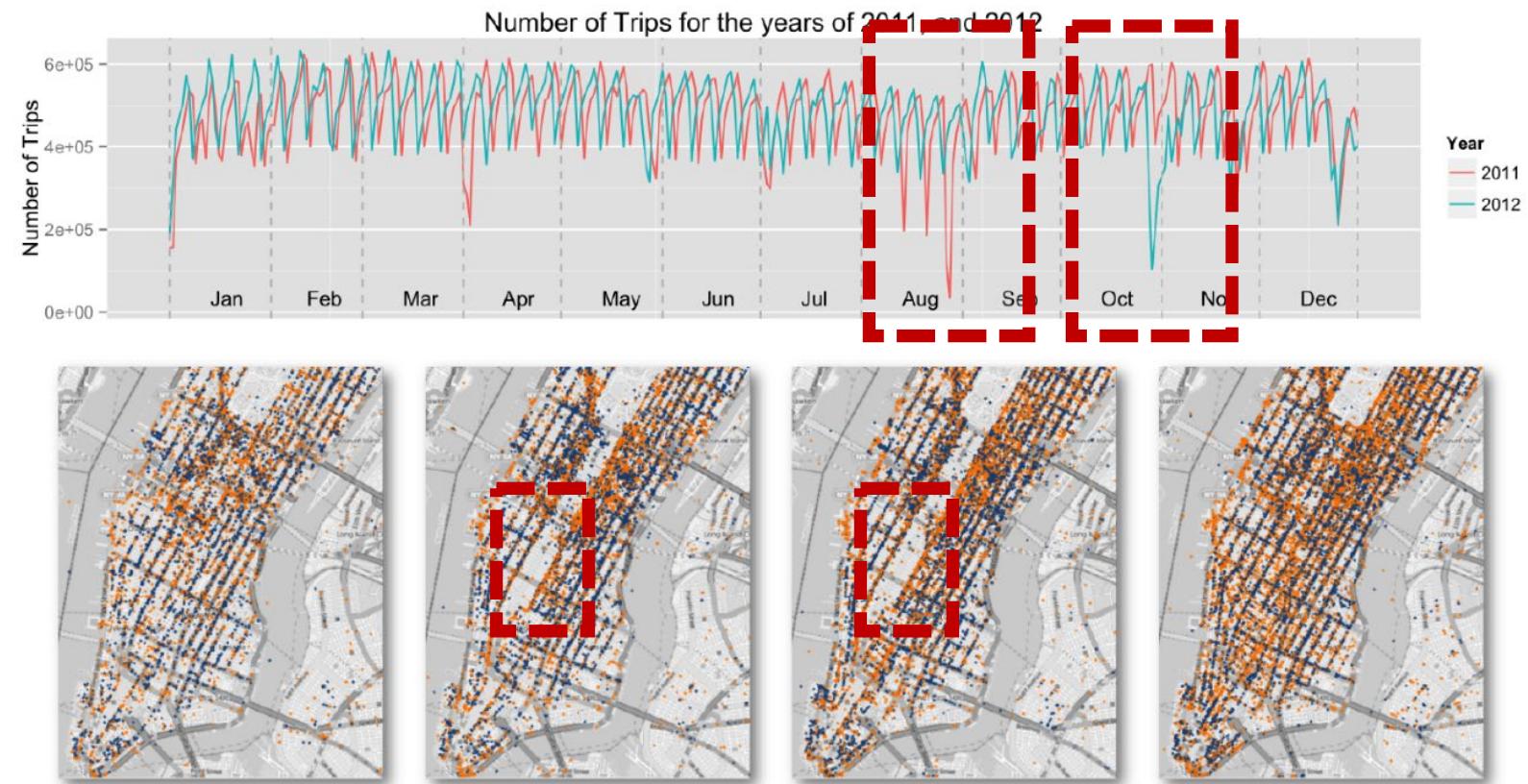


# Taxi as sensors of city life

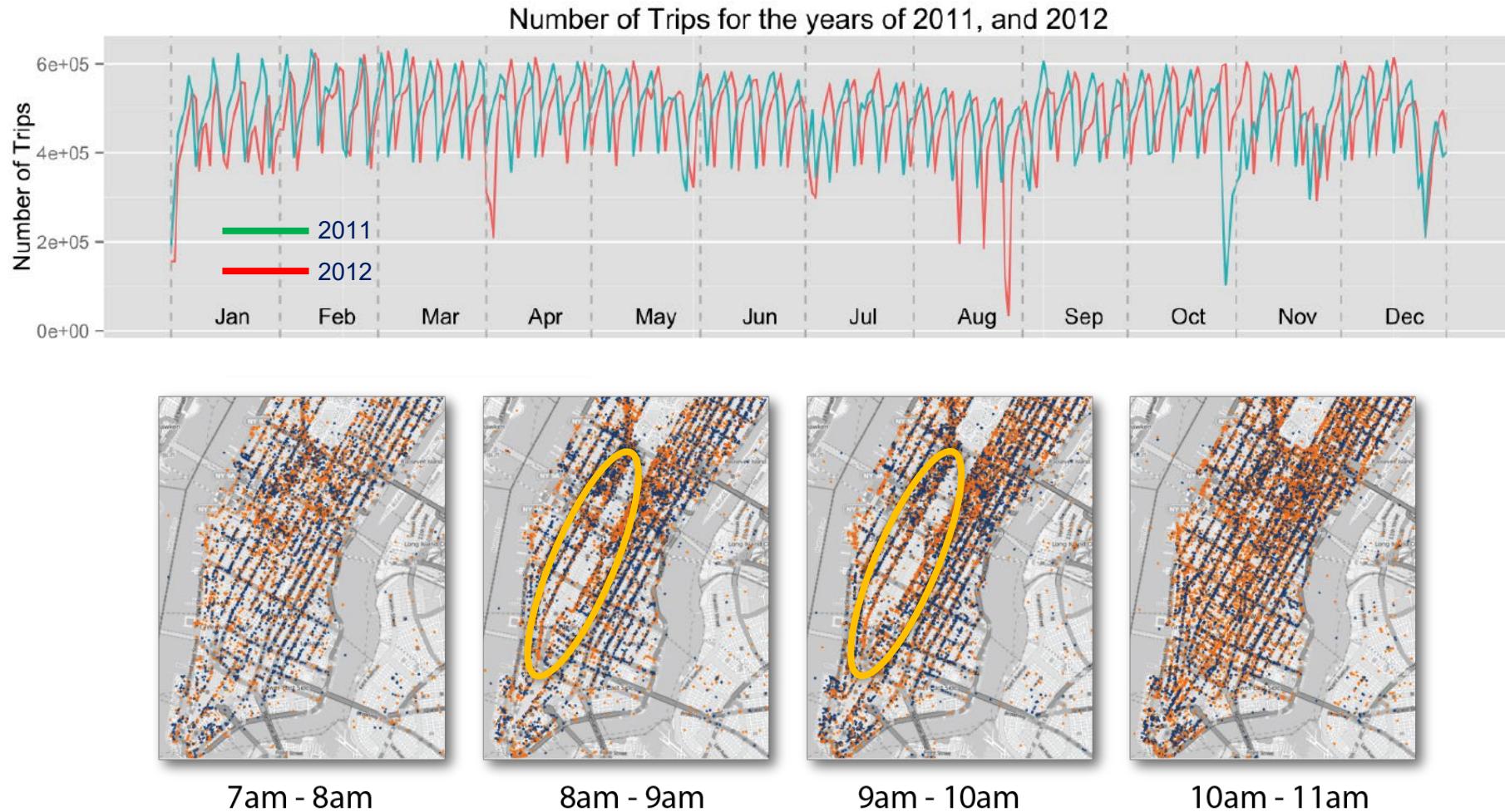
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- Understanding the dynamics of the city, how different aspects of the data vary over space and time:
  - “*What is the average trip time from Midtown to the airports during weekdays?*”
  - “*How does the movement changes between Midtown and JFK throughout the day, over different days of the week?*”
  - “*How does the taxi fleet activity vary during weekdays?*”
- Ability to quickly test hypotheses: starting with one query about a specific place (“*movement patterns between Midtown and JFK*”) and generalize to all neighborhoods.

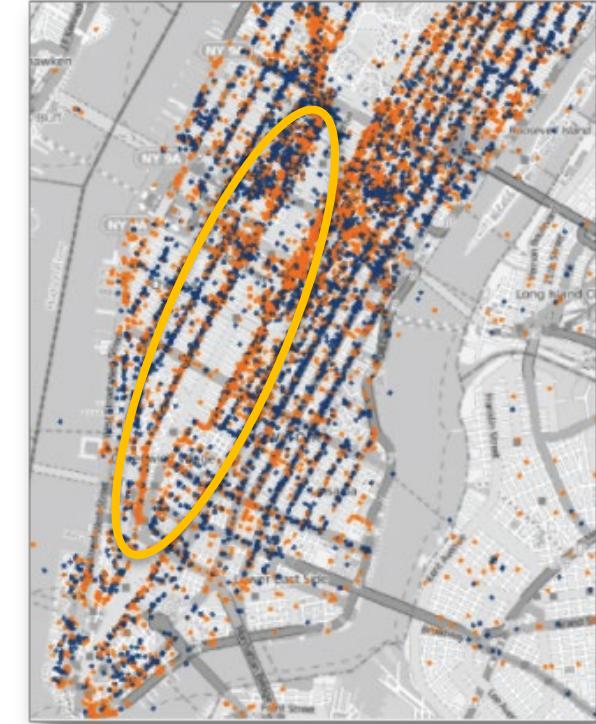
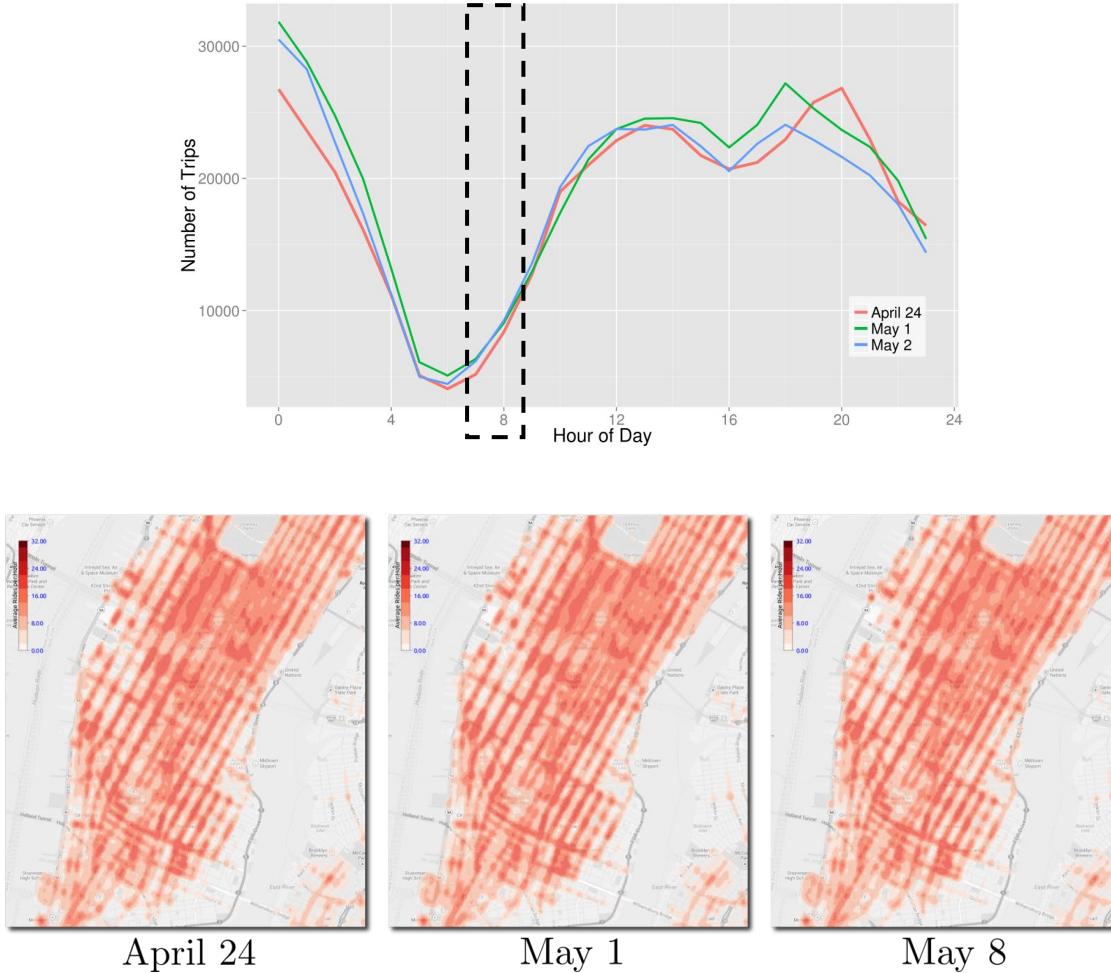
# Taxis as sensors of city life



# Taxi data slices

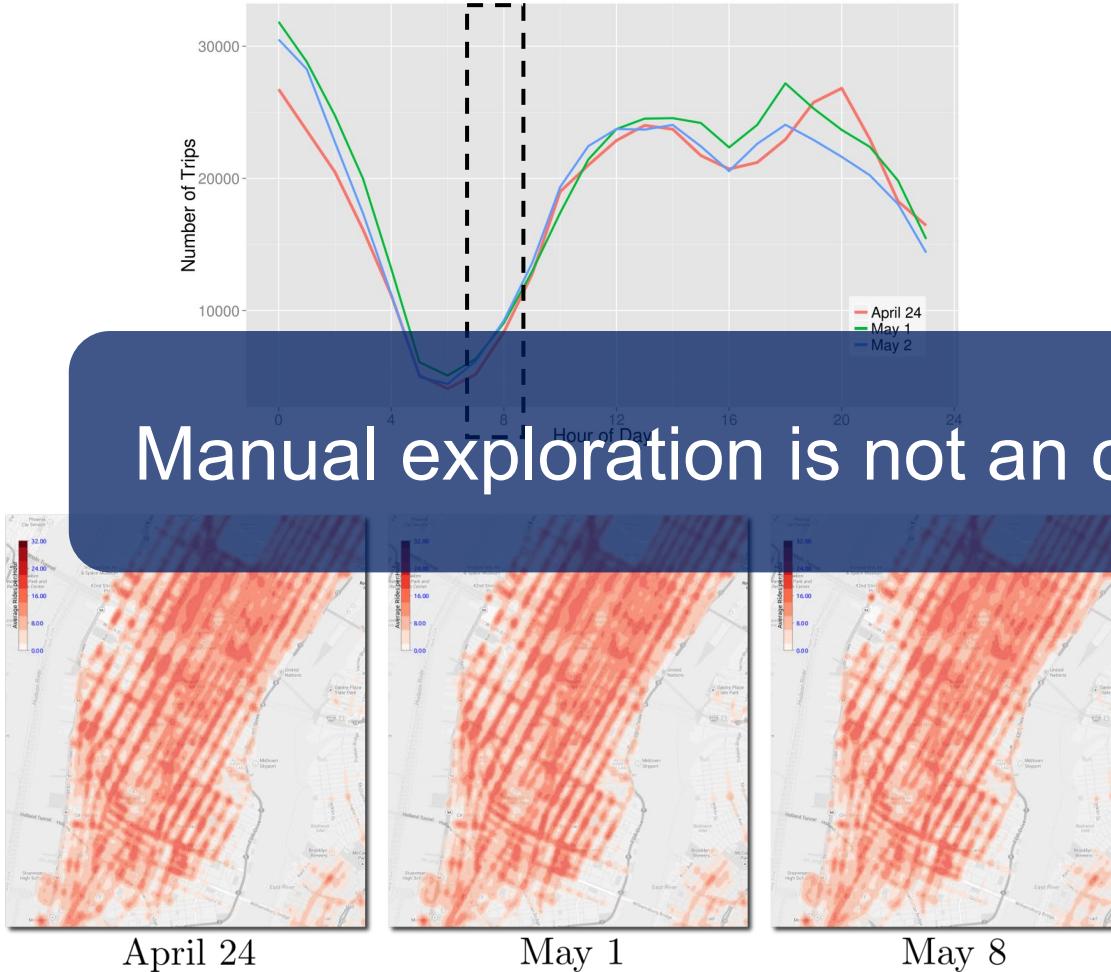


# Taxi data slices



8am - 9am

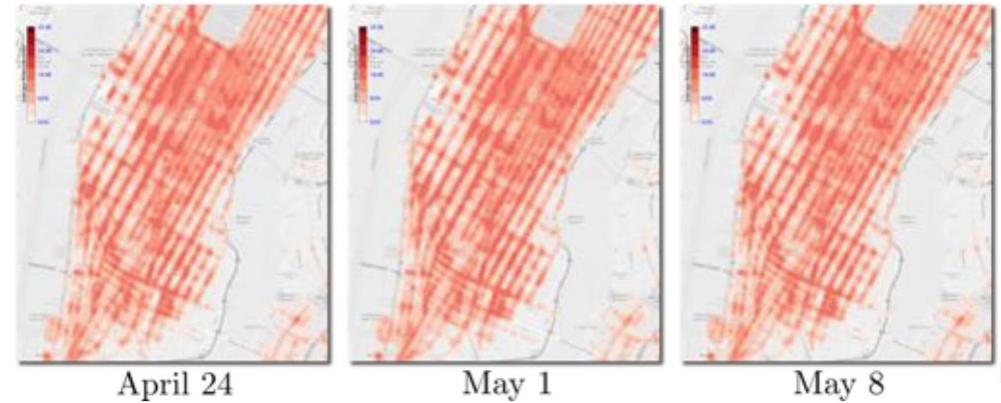
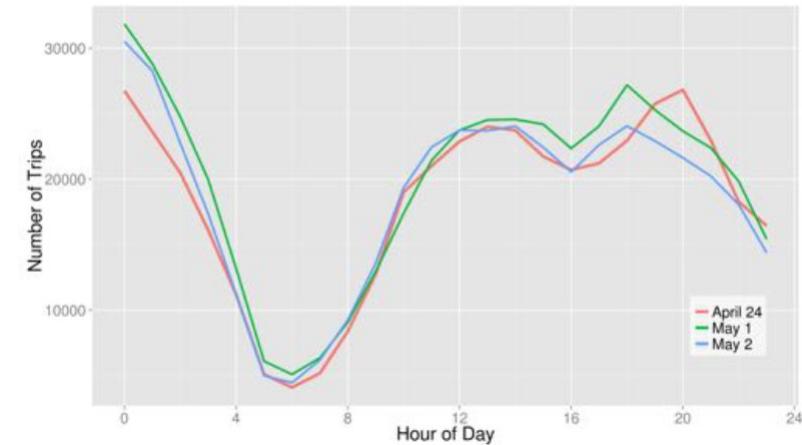
# Taxi data slices



# Visual analysis process: taxi data



- Too many slices
- $365 \times 24$  1-hour slices in just one year
- Which slices are interesting?



# Visual analysis process: taxi data



- Too many slices
- $365 \times 24$  1-hour slices in just one year
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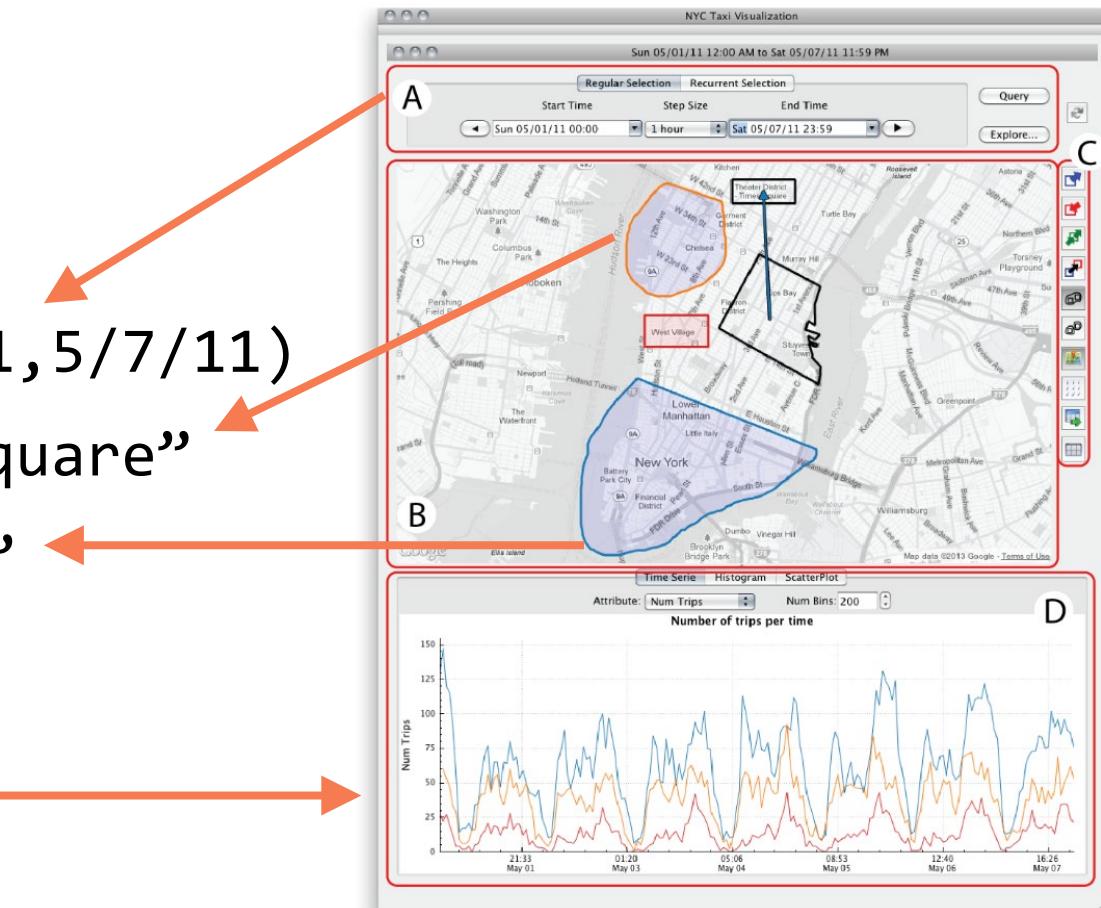


May 1 (8-9am)

# Usability through visual operations

```
SELECT *  
FROM trips  
WHERE pickup_time in (5/1/11,5/7/11)  
AND dropoff_loc in “Times Square”  
AND pickup_loc in “Gramercy”
```

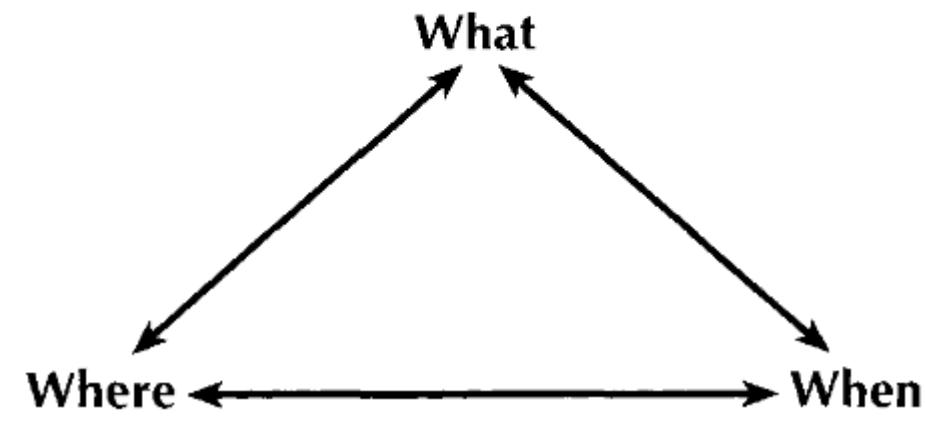
Data selection and result exploration are unified



# Visual query model

- Expressive Triad framework:
  - *Where + when → what*: describe the objects (what) that are present at certain locations and times.
  - *When + what → where*: describe the locations occupied by objects at a given time.
  - *Where + what → when*: describe the times that objects occupied a given location.

## THE BASIC VIEW COMPONENTS OF THE TRIAD FRAMEWORK



[Peuquet, 1994]

# Visual query model

- Expressive Triad framework:
  - *Where + when → what*: “What is the average trip time from Midtown to the airports during weekdays?”
  - *When + what → where*: “Where are the hot spots in Manhattan in the weekends?”
  - *Where + what → when*: “When were activities restored in Lower Manhattan after the Sandy hurricane?”

What? Where? When?



# Comparison of taxi trips: characterizing neighborhoods

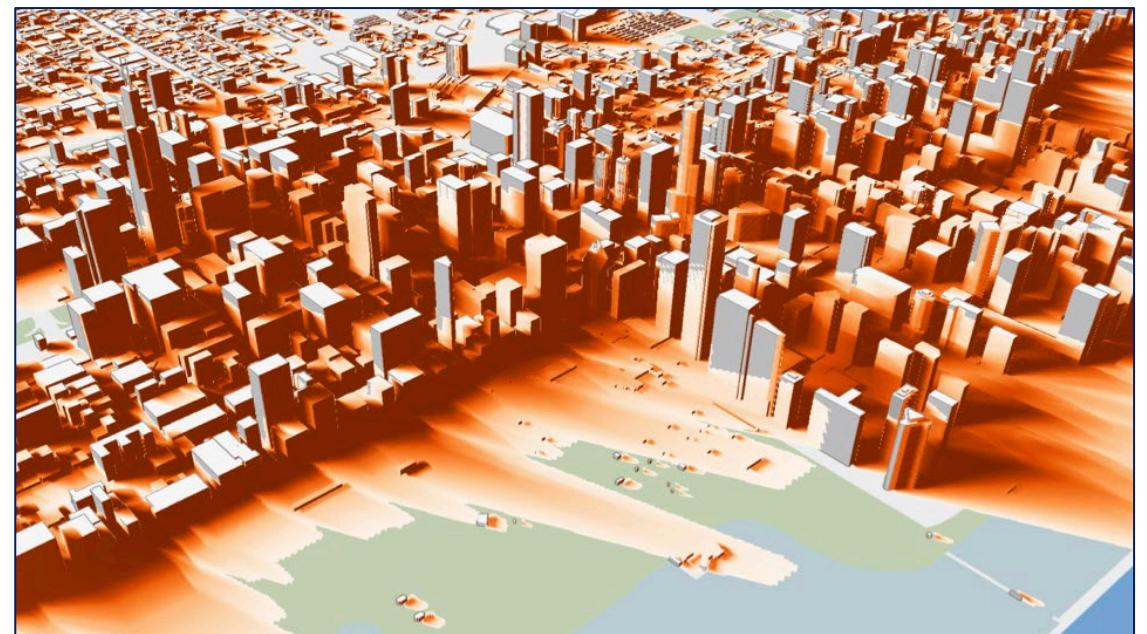


- Midtown and Upper East are the most active areas.
- Midtown is a popular destination in the morning and downtown in the night.
- Over the weekend, increase number of drop-offs in Downtown.
- Harlem is underserved by taxis.

**Ability to quickly test hypotheses: starting with one query about a specific place and generalize to all neighborhoods.**

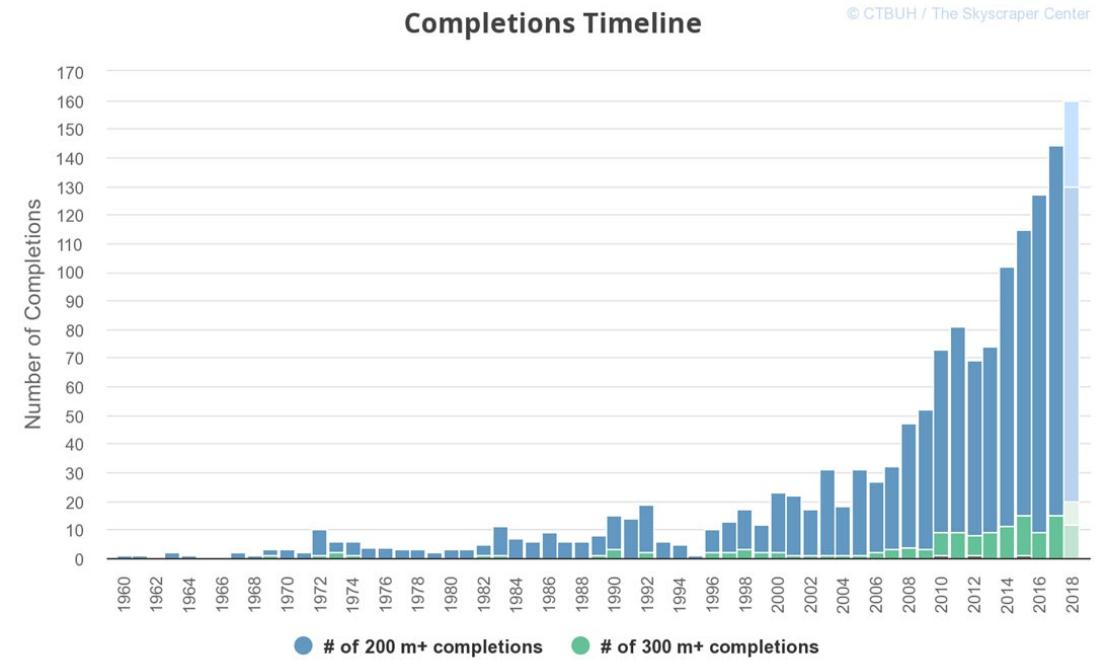
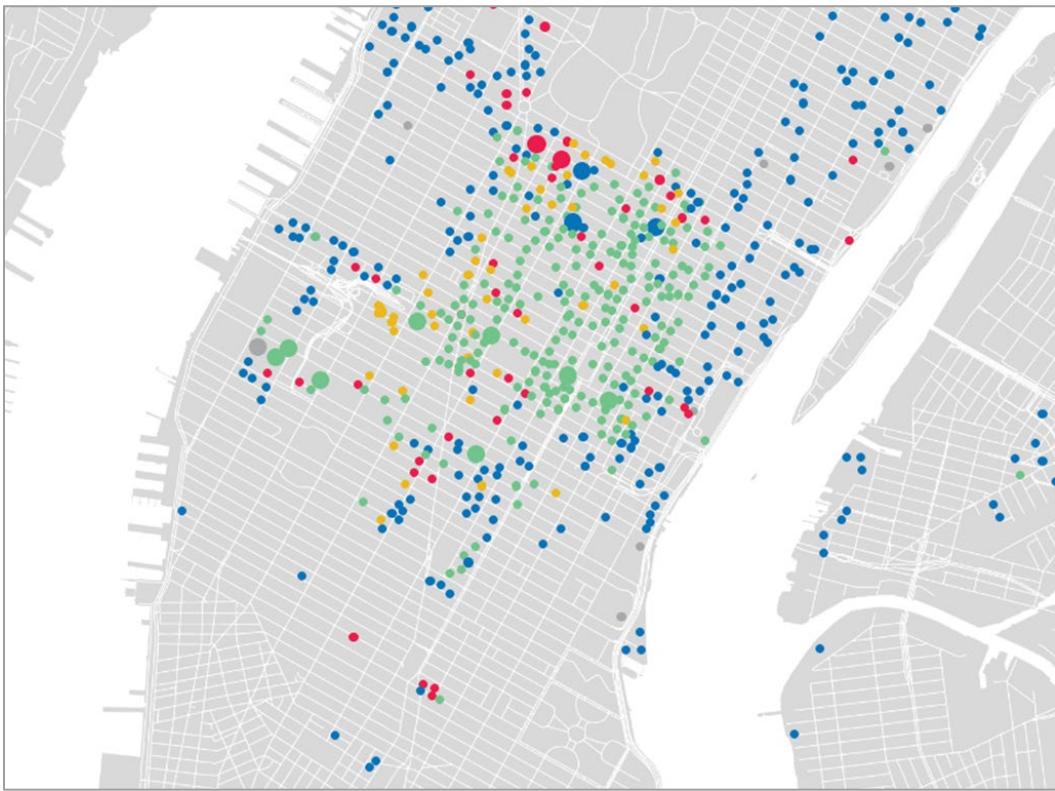
# Shading data at street level

- Why shadow / shading information?
  - Identify the potential places with higher risk of **black ice formation**.
  - Improve the pedestrian level of comfort by identifying places with more **shade in summer**.



*Shadow Accrual Maps: Efficient Accumulation of City-Scale Shadows over Time, TVCG 2019*

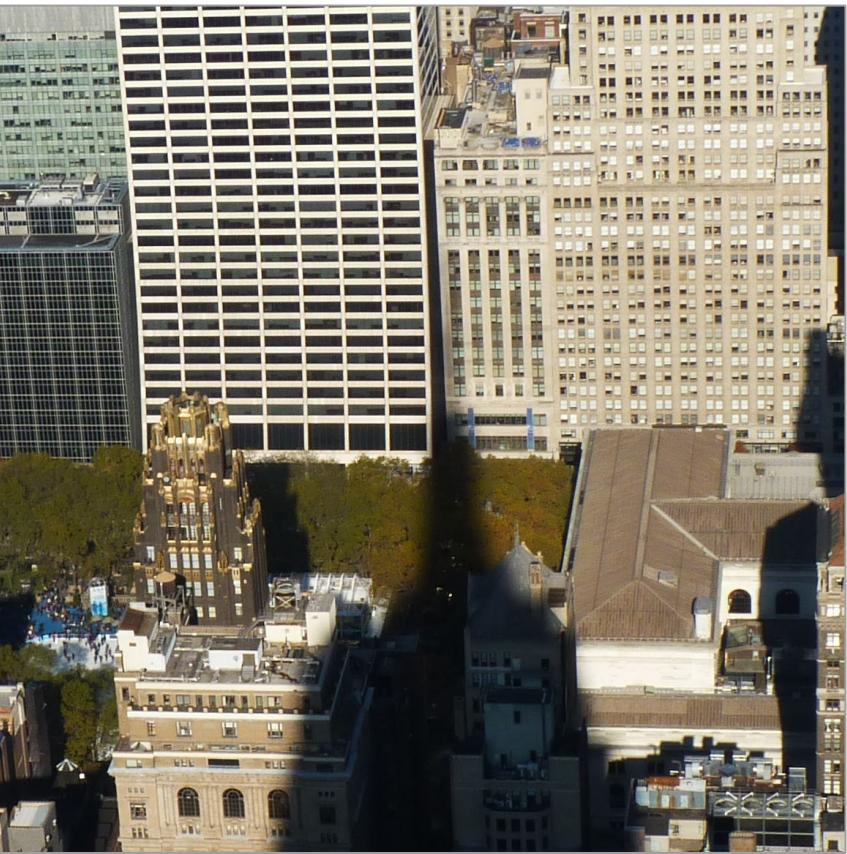
# Skyscrapers



Source: Skyscraper Center

# Shadow impact

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# Shadow dispute



**Meet:** Columbus Circle, Sunday, November 8, 2015, 10:30am.  
March begins at 11:00 am sharp--east on 57th St. to Sutton Place. (Rain or shine!)

Bring a black umbrella to symbolize the shadows the towers will cast.

**Why:**  
Central Park, New York City's front yard, is under siege by developers building super-tall towers that will cast 1,000-foot shadows over the park...castles in the sky for the privileged few at the expense of everyone else's sunshine.

**In a city where small businesses can be choked by red tape, developers can legally build higher than the Freedom Tower without asking anyone's permission.** Because zoning laws were written before architects could build sliver towers this high, developers can simply buy air rights and use empty floors to work around height limits.

**It's time to update our zoning laws!**

**We are not anti-development. We are pro smart-development,** taking into account community needs and the protection of green spaces, public parks and waterways across New York City.

We're calling on our elected officials to issue a temporary moratorium on the construction of towers over 600 feet until city and community leaders can work with developers to enact reasonable changes to zoning laws.

[Facebook.com/StandAgainstTheShadows](#) [@NYC\\_Shadows](#)  
#StandAgainstTheShadows

## Boston developer wants exception to shadow law

Tall order is sought for tower proposal

Donna Goodson Monday, April 10, 2017



## Boston City Council votes in favor of changing 'shadow' law

Council backs shade

Dan Atkinson Thursday, April 27, 2017

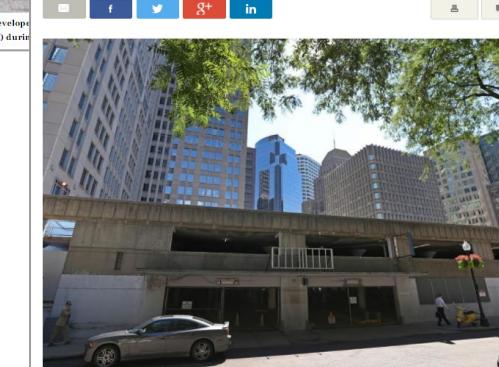


## Shadow debate shows how desperate Boston is for money

PUBLIC GARDEN Aug. 24, 7:05 a.m.



## The absurdity of the Boston Common shadow debate



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- In Vermont's remote Northeast Kingdom, two acres of mystery
- Bill Maher to Elizabeth Warren: 'They don't like you, Pocahontas'
- On final day of NFL Draft, Patriots make two trades, draft a DE Deatrich Wise and OT Conner McDermott
- The disaster of Pyre Festival played out on social media for all to see
- After slashing taxes, Oklahoma struggles to fund schools, other basic services
- 100 days in, what came true?
- Netflix's '13 Reasons Why' has gone viral. So has alarm over its depiction of suicide
- Life has changed dramatically for former Red Sox and Cubs catcher David Ross and he's enjoying it
- Boston College cries foul after footage is used in video by House Speaker Paul Ryan
- Thousands rally on Boston Common to demand action on climate change

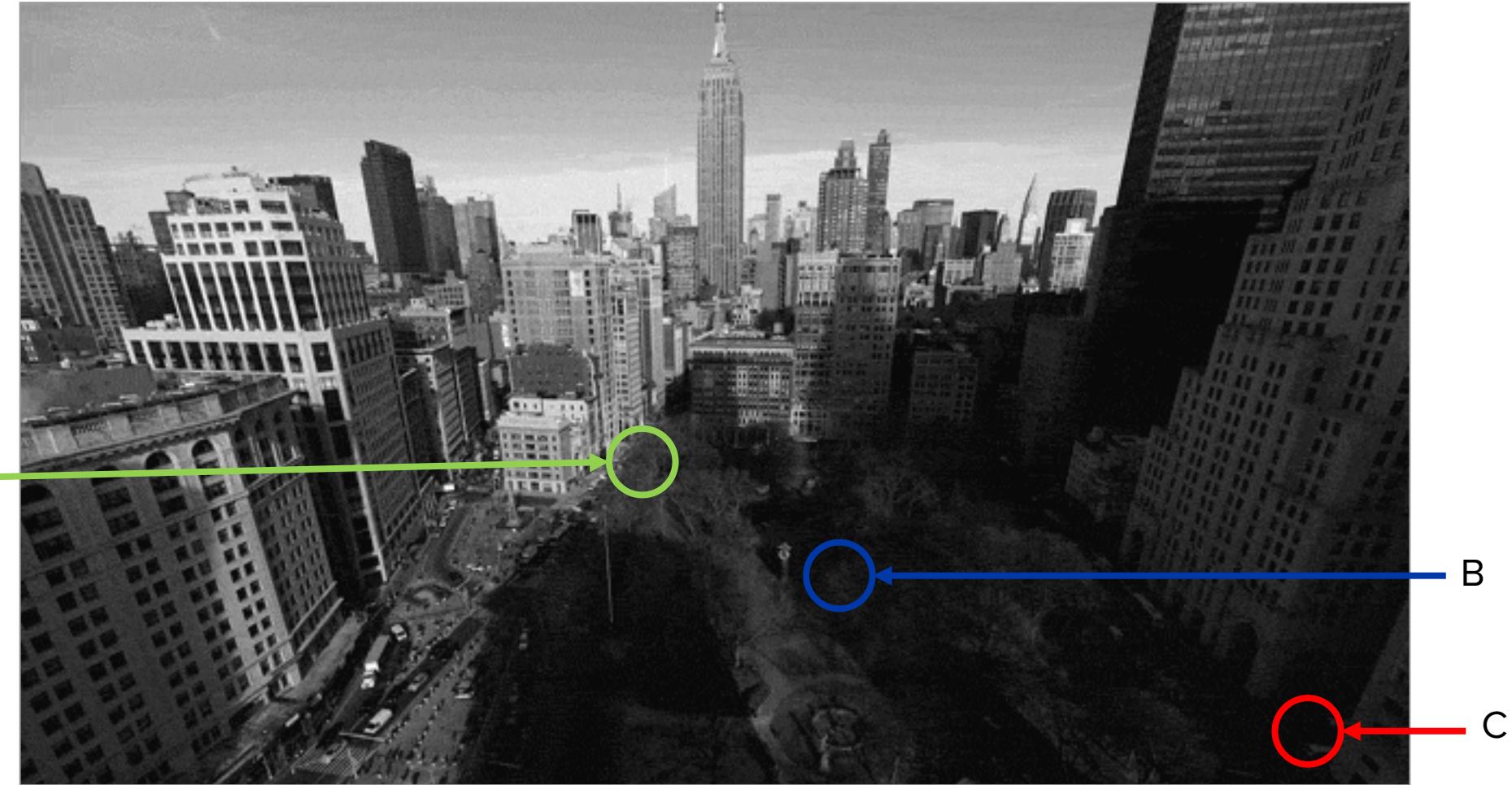
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# Quantifying shadow



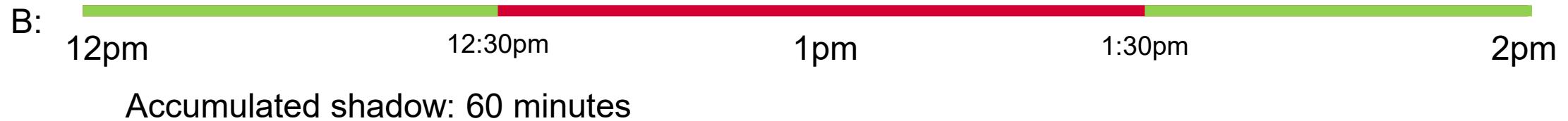
~2 hours time lapse

Mapping the Shadows of New York City - The New York Times



COMPUTER SCIENCE

# Quantifying shadow



# Objectives

Support the comprehensive **interactive analysis of city-scale shadows**;  
Accumulated shadow.

Enable analyses considering **large periods** (e.g. months);  
Amount of shadow in Central Park during summer vs. amount of shadow in  
Central Park during winter.

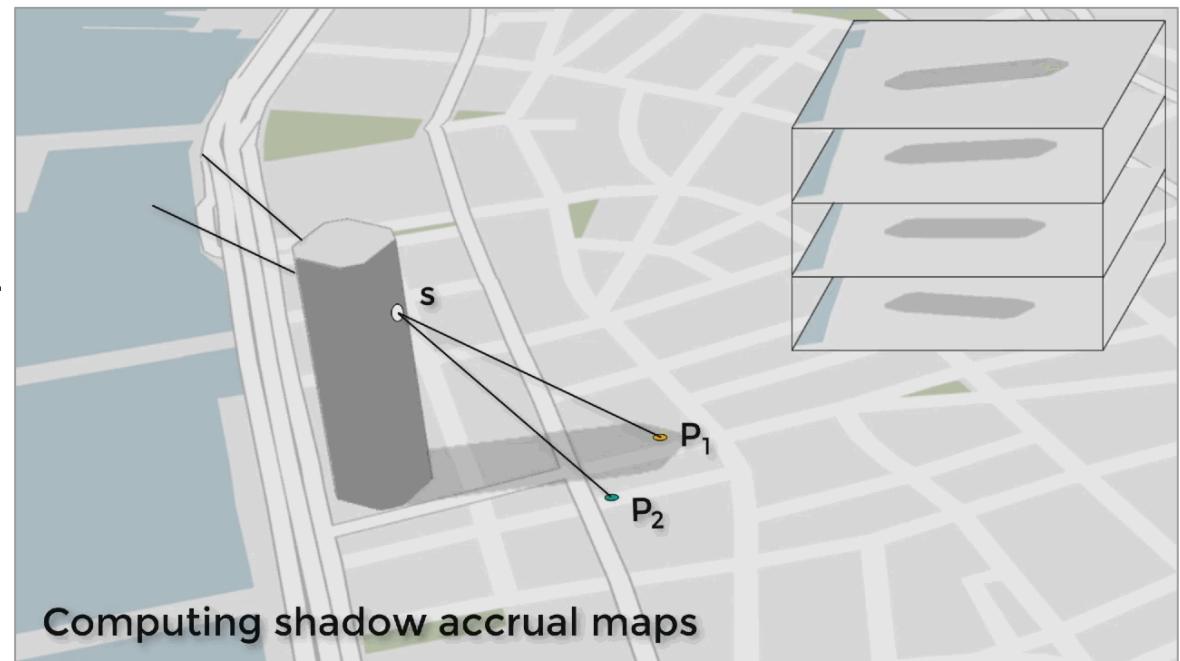
**Different analysis measures**;  
Differentiate between shade and shadow:  
-Shade: positive during hot summers.  
-Shadow: negative during cold winters.  
Shadow contribution of each building.

# Shadow Accrual Map

3D texture where each 2D slice is a timestep.

Consider shadows cast by  $s$  at timestep  $t_1$  (e.g. 12 pm) and  $t_2$  (e.g. 1pm) being  $p_1$  and  $p_2$ .

The values between  $t_1$  and  $t_2$  will be linearly interpolated between  $p_1$  and  $p_2$  and stored in the corresponding 2D slice.



Shadow Accrual Map is the same as computing shadow maps for every step (proof in the paper)

# Inverse Accrual Maps

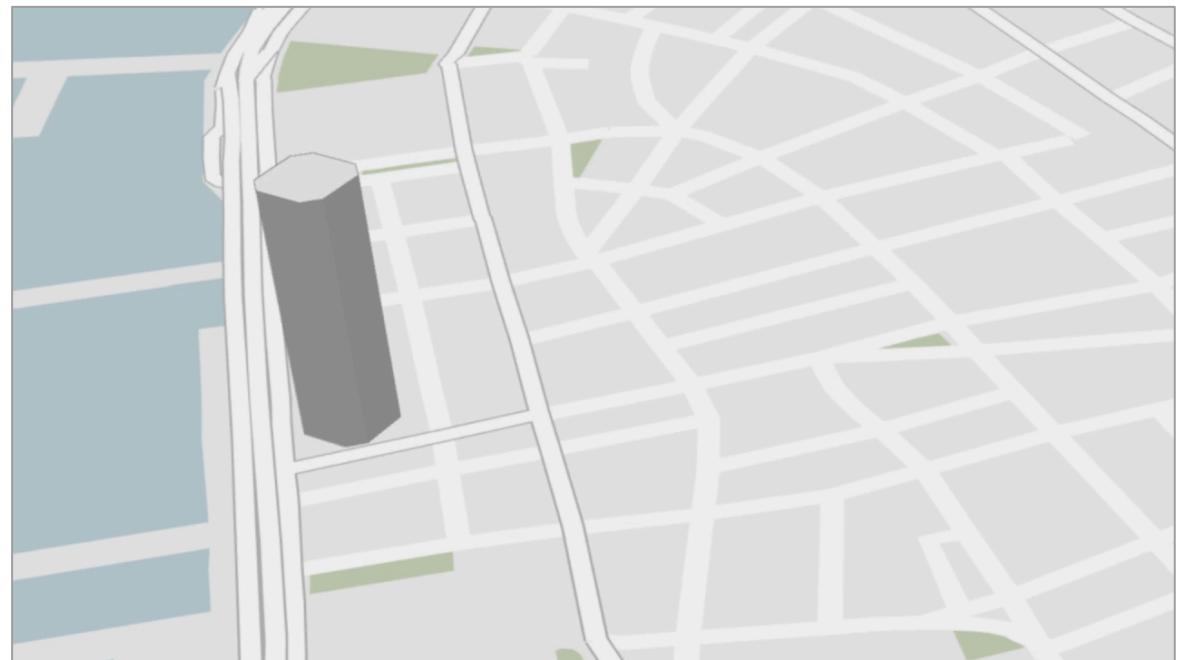
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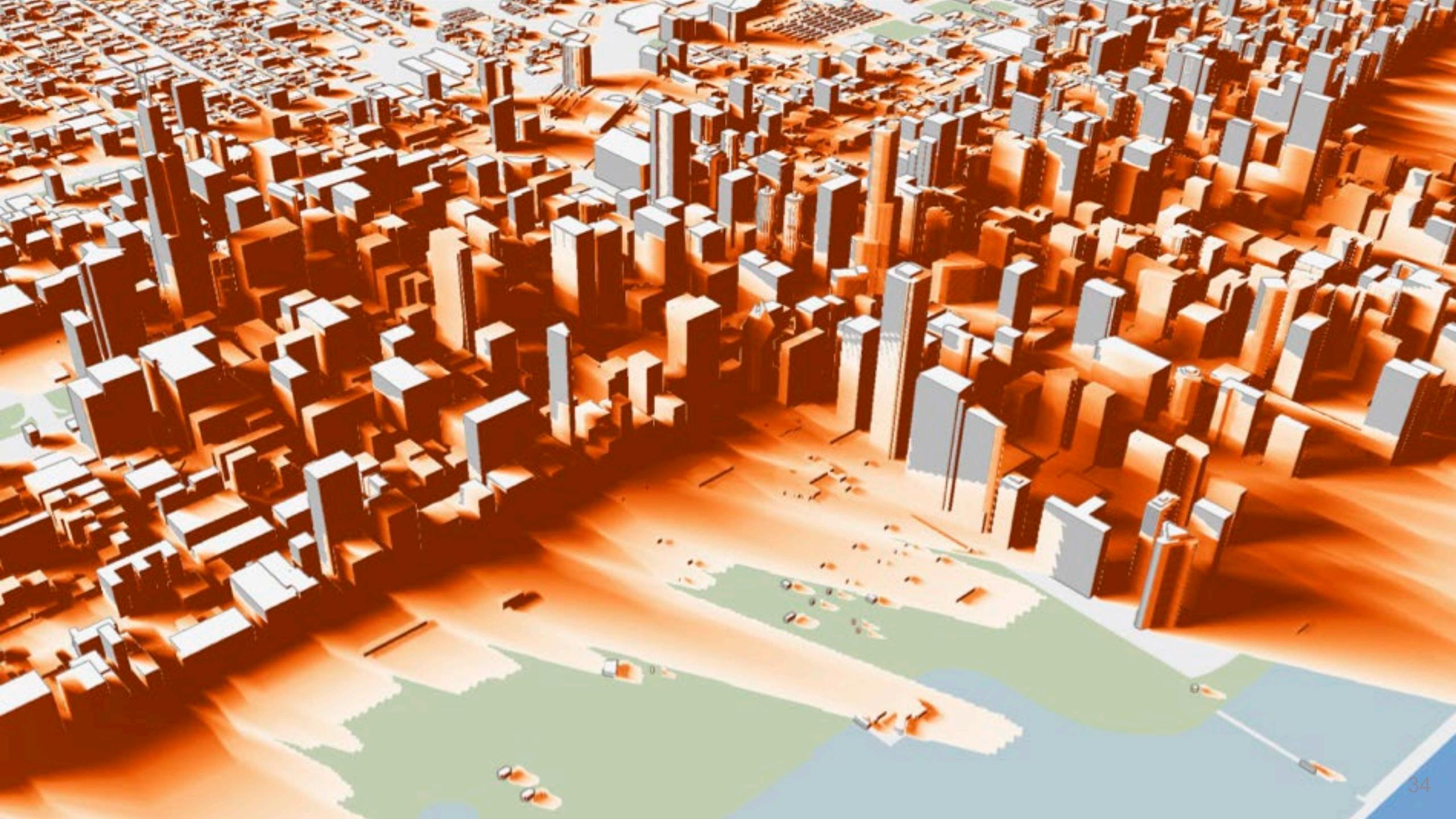
Ray tracing-based.

More accurate than Shadow Accrual Maps.

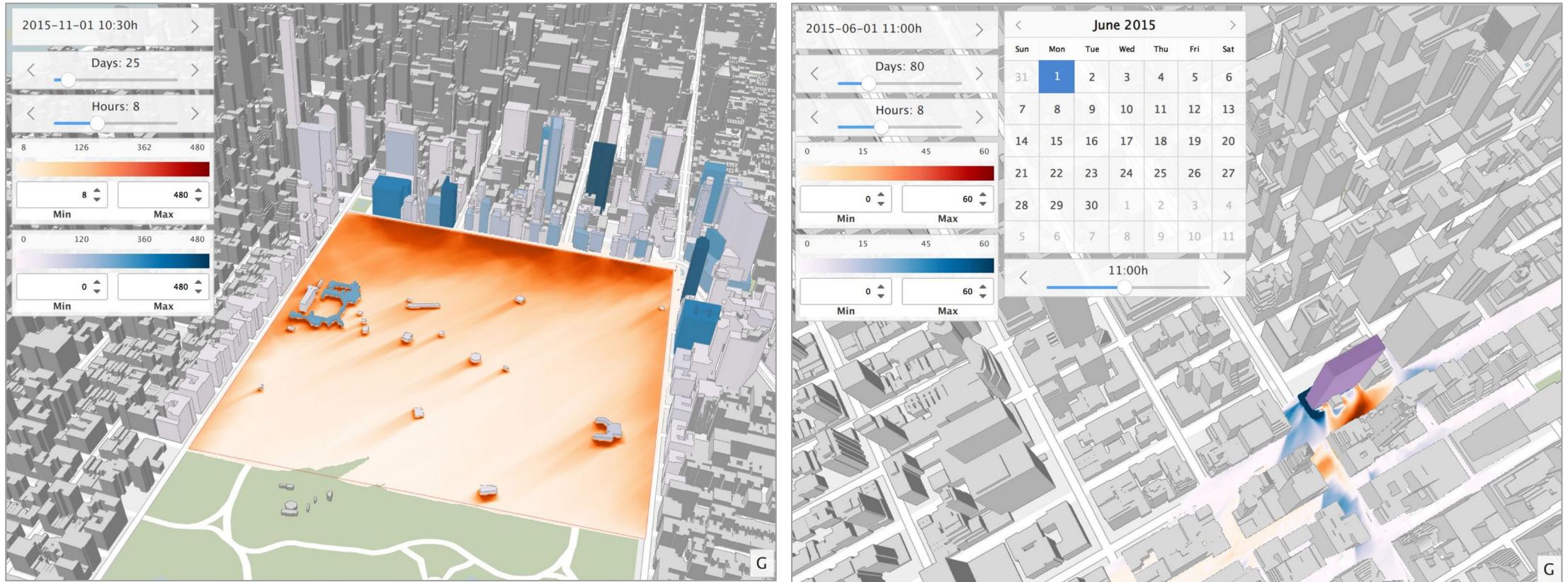
Used for detailed shadow analysis.

Same principle of considering linear sun movement.





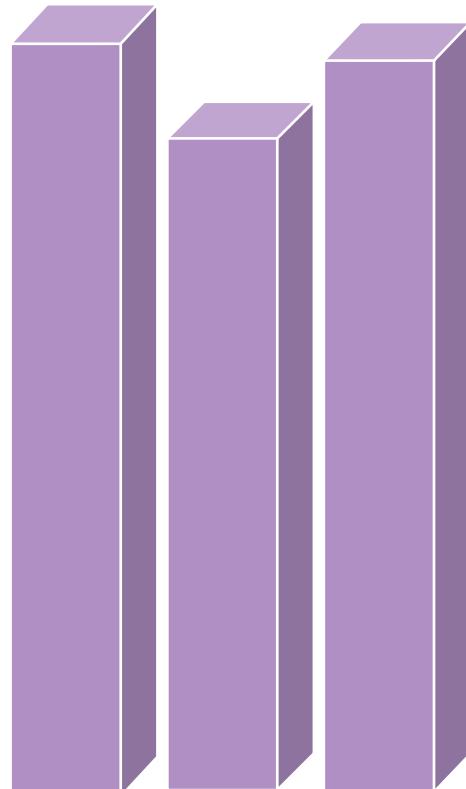
# Shadow Profiler



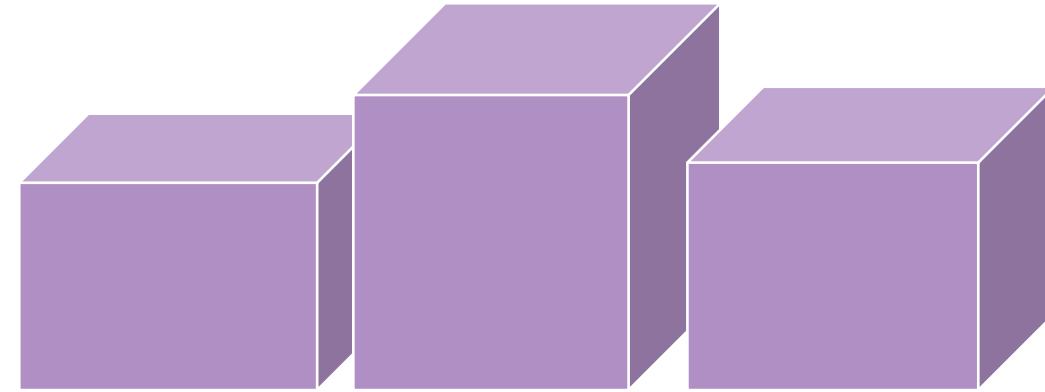
# Shadow impact of two scenarios

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Analysis of the impact of two different scenarios, with buildings with **same total floor area**



Scenario 1: Lean and tall buildings



Scenario 2: Bulky and short buildings

2015-09-21 17:00h >

< Days: 1 >

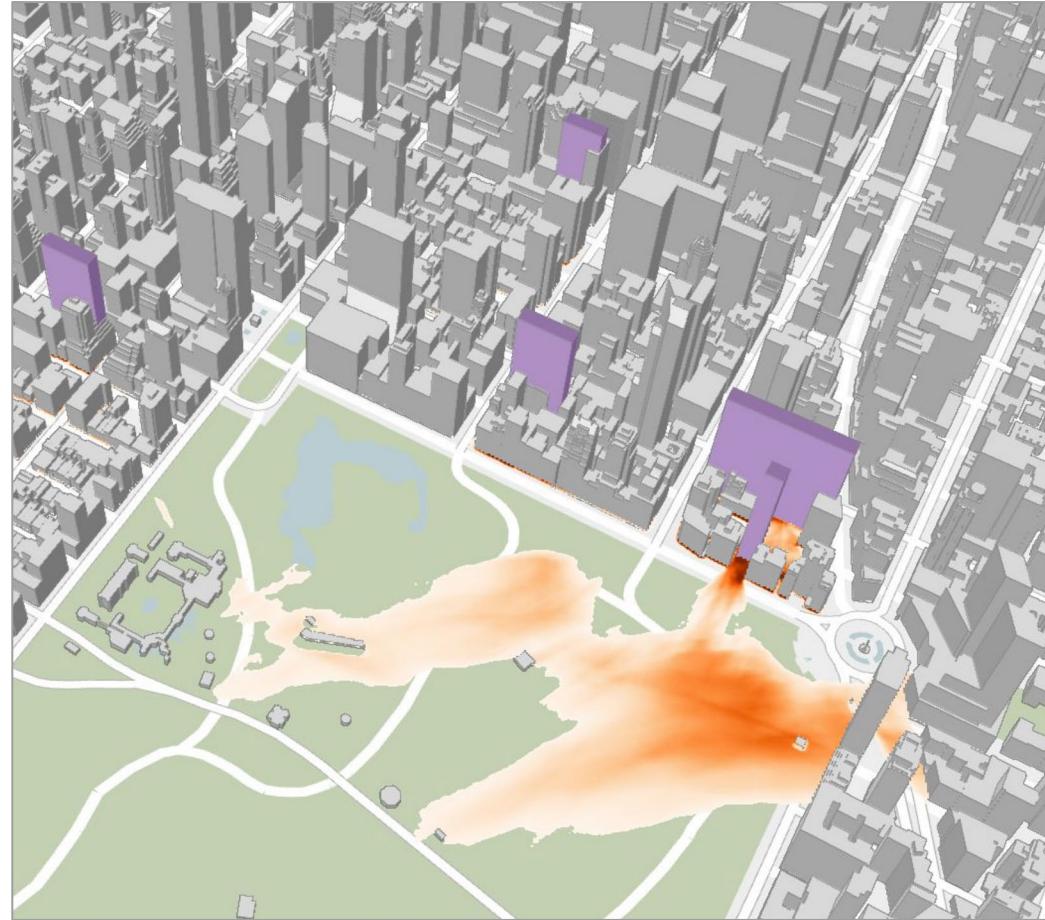
< Hours: 0 >



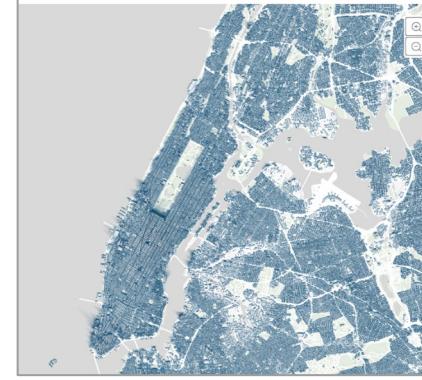
# Shadow impact of two scenarios



Shadow impact of scenario 1



Shadow impact of scenario 2



Winter

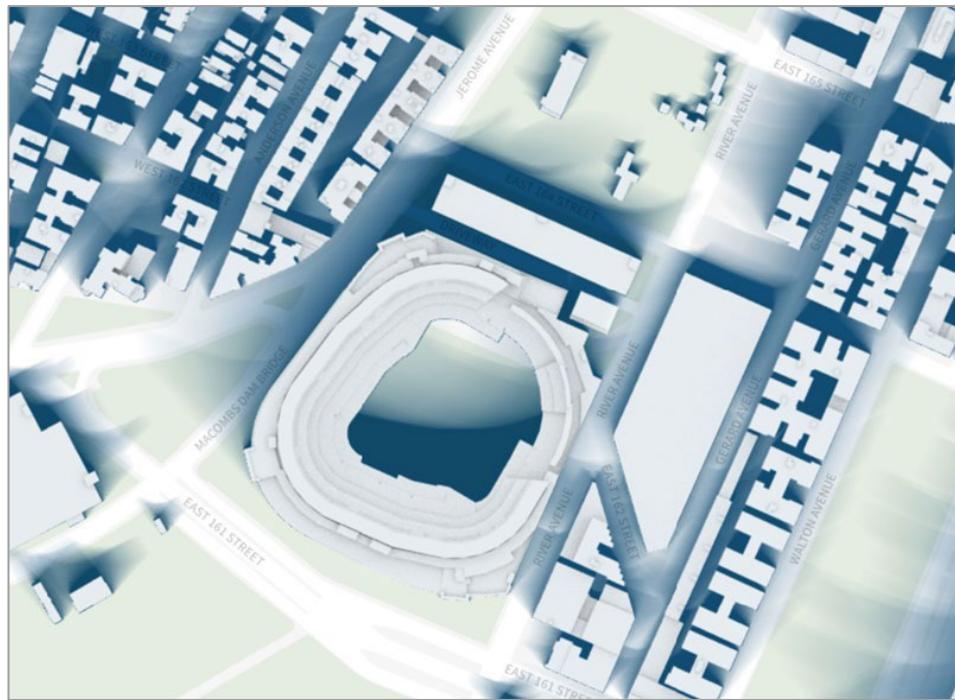


Spring /  
Fall



Summer

# Mapping the shadows of New York City



Yankee Stadium



Financial District



Broadway Avenue

# Mapping the shadows of New York City



New York Times  
<https://nyti.ms/2k0bF0G>

A life in the shadows: Take a look at some of Manhattan's darkest and brightest streets

By JASON SAYER (@ADJASONCIES) • December 21, 2016

East Media

The Manhattan Skyline at sunset.

This amazing map shows shadows of New York City

By Aleks Buczkowski - December 27, 2016

Every GeoGeek knows the Urban Canyon phenomena that affects GPS signal in the cities with narrow streets and high buildings. But the fact that cities are growing up influences also the amount of sun that reaches the street level. New York Times has recently published an amazing map which is a comprehensive shadow study of NYC.

The map has three layers with the city's shadow profiles: Winter, Summer and Spring/fall each of them based on data from Dec. 21 (the winter solstice), June 21

MAPS / NEW YORK TIMES, SHADOWS

Map of New York City shadows

Dec 22, 2016

Shadows cast by buildings affect the feel and flow of a city, and lack of sunlight can change aspects of daily living, such as rent. In a place like New York City, where there are tall buildings aplenty, the effects are obvious. Quoctron Bui and Jeremy White for The New York Times mapped the darkness.

CREATIVE

Dec. 23, 2016 9:45 am

The Times just created a stunning map of every building's shadow in New York

Exploring our city in new, unexpected ways.

By Tyler Woods / CONTRIBUTOR

NYT studies the shadows of the city.

CITY LIVING, MAPS

Interactive map reveals the shadows cast by every New York City building

POSTED ON WED, DECEMBER 21, 2016 BY DIANE PHAM

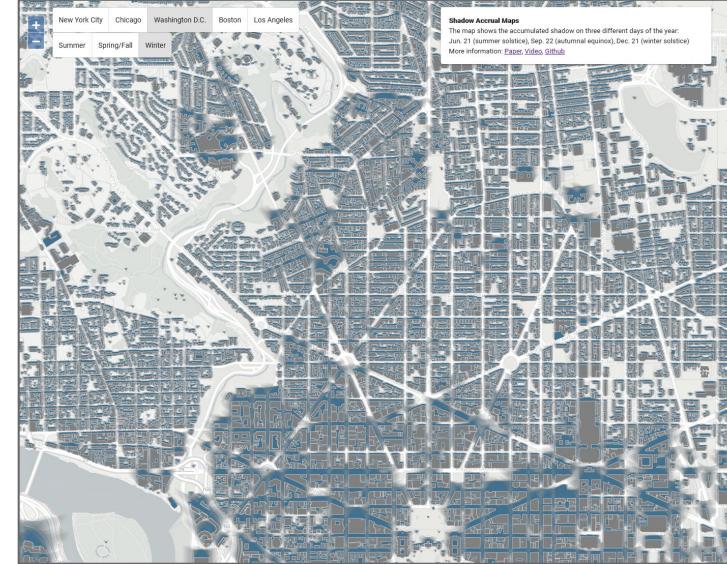
The Times calls the phenomenon a "struggle for light and air." And indeed, while New York City architecture is lauded for both its design and innovation, the decades-long race to build bigger and taller has taken a toll on the cityscape, particularly in the form of shadows. While any recent criticism of the effect has been directed towards the towers rising along Billionaire's Row, as The Uptown's map reveals, New Yorkers on the whole spend a lot of their time cutting through long stretches of shadow. The map documents thousands of buildings across the five boroughs, denoting age, height and the resulting shadows cast at ground level over the course of one day, down to the minute, during all seasons. As seen above, tall-tower haven Central Park South is cloaked in darkness 24/7 during the fall, winter, spring and summer months—but then again, if you peruse the map, you'll see a lot of other blocks are too.

# Mapping the shadows across the US

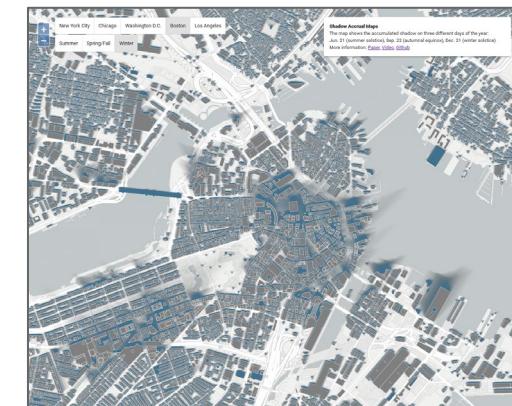
Chicago



Washington DC



Los Angeles  
Boston



<https://github.com/VIDA-NYU/shadow-accrual-maps/>

# SONYC: Sounds of New York City



- 55 sensors
- 3 boroughs
- Over 75 terabytes of audio data



# Deployment numbers

55

Sensors deployed

1

Mobile sensor

5

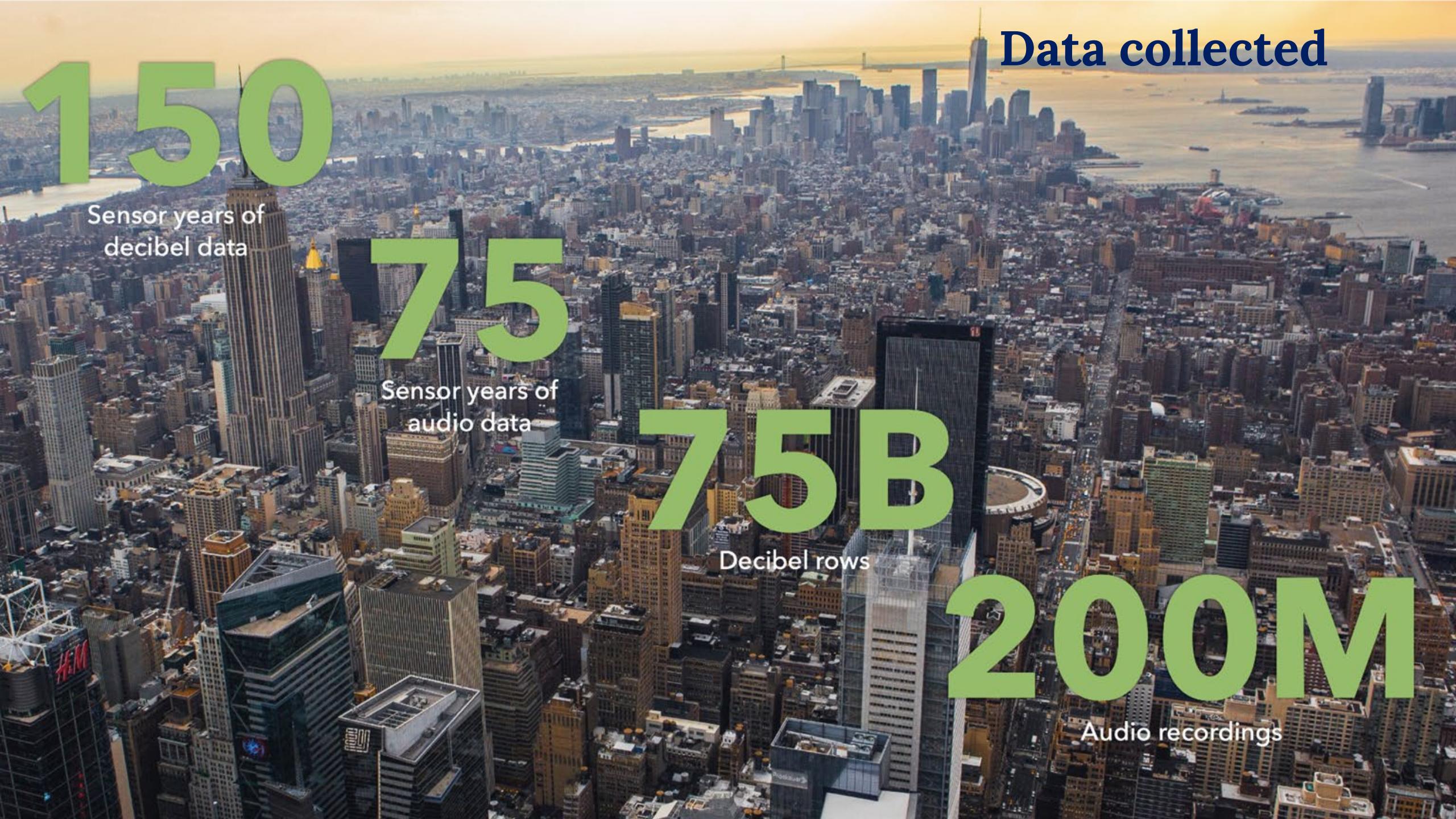
Years of sensing

7

City agencies

3

Business improvement  
districts

The background image shows a wide-angle aerial view of the New York City skyline during sunset. The Hudson River is visible in the foreground, and the Manhattan Bridge is in the distance. The Empire State Building is prominent on the left, and the One World Trade Center is visible on the right. The city lights begin to glow as the sun sets over the horizon.

Data collected

150

Sensor years of  
decibel data

75

Sensor years of  
audio data

75B

Decibel rows

200M

Audio recordings

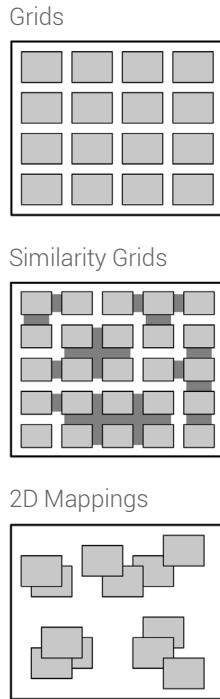
# SONYC

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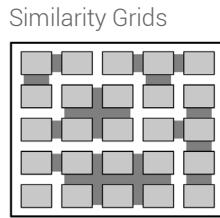
- Goal: improving quality of life through smart noise monitoring.
- Established sensor network and expertise:
  - Increased civic engagement in noise awareness.
  - Collaboration with key city agencies and infrastructure providers.
- Convergence research around data.

# Urban data exploration

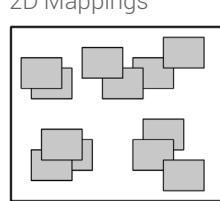
## Image data



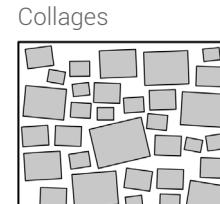
Grids



Similarity Grids



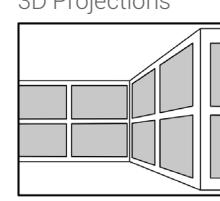
2D Mappings



Collages

1.jpg	...	...
2.jpg	...	...
3.jpg	...	...
4.jpg	...	...
5.jpg	...	...

Spreadsheets

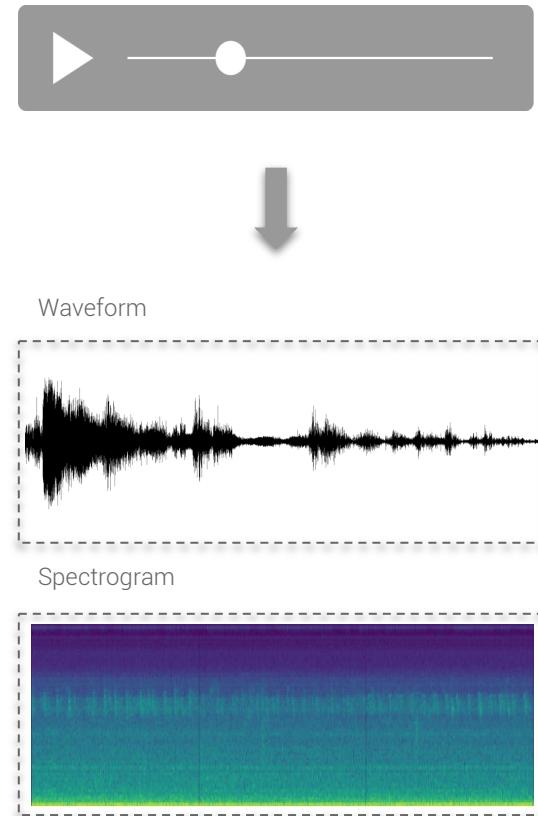


3D Projections

- Natural pictorial representation of image data
- Humans are able to visualize and understand sets of images in a ***parallel approach***
- Organization approaches for images were proposed in the past. These approaches try to optimize the observation of specific ***patterns present in collections of images***

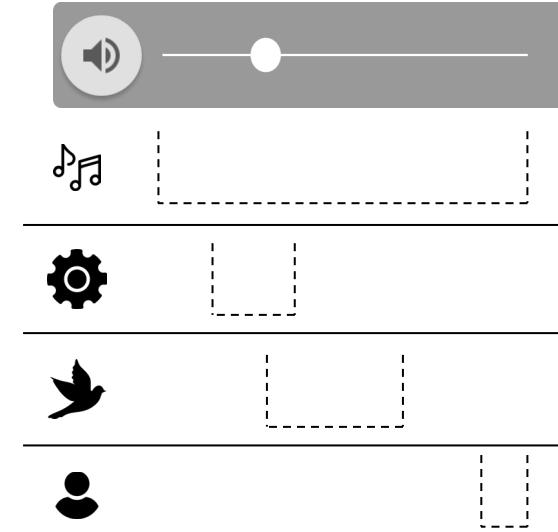
# Urban audio data exploration

- Audio recordings are consumed in a **serial** way by us.
- To understand events happening in a 10-second audio snippet, users **must listen through the entire recording**.
- Although the **visualization of specific frequencies or loudness** can help identify interest periods of the recording, it is still difficult to build a **semantic understanding** of the recording.



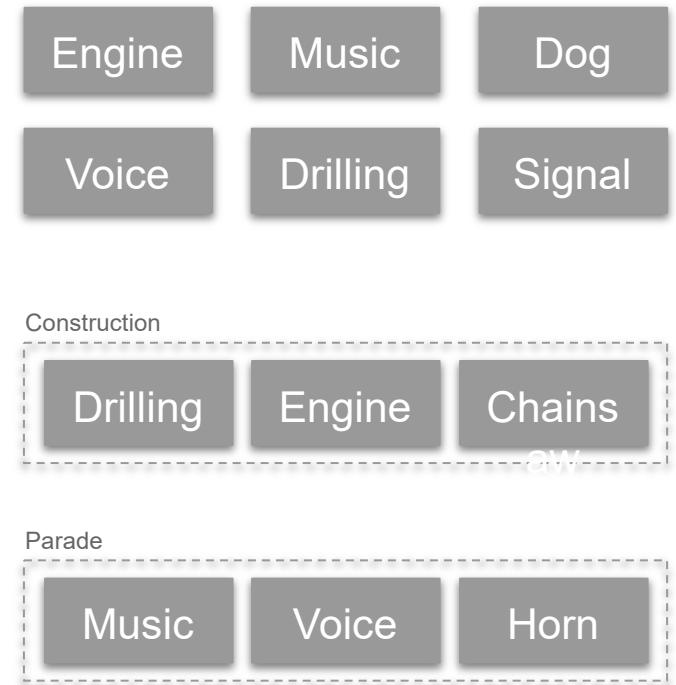
# Urban audio data exploration

- Unlike images, where visual objects are opaque, sound objects are conceptually ***transparent***, meaning that multiple objects (sound sources) can have energy at the same frequency.
- At any given instant in time, a sound recording might have a **mixture of background** (birds, dog barks) and **foreground sounds** (party, sirens).



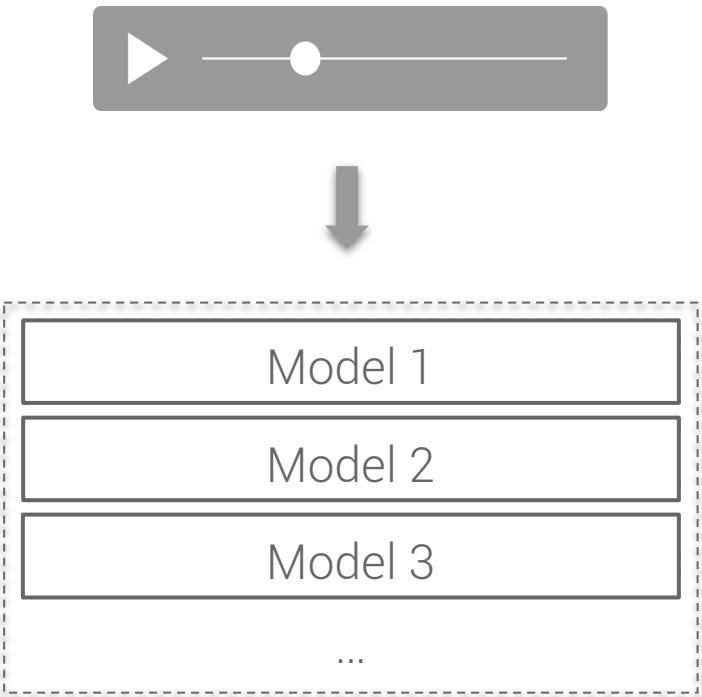
# Urban audio data exploration

- **Class vocabularies are limited**, providing a narrow view of the rich and varied soundscape of the city
- Also, they do not account for classes that are a composition of previously created classes



# Urban audio data exploration

- The **scarcity of labeled urban audio data** makes it hard to generate models capable of transforming audio into representations that can represent different audio classes.
- Also, the **complexity of the urban soundscape** makes it even harder for models to be representative of such a dynamic environment.



# Urban Rhapsody

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**[R1] Interactive Identification and Labeling of Similar Sounds:** Given the highly complex acoustic environment we observe in cities, audio representations cannot clearly encode specific audio events that users might be interested in.

**[R2] Projection Steering Based on User Perception:** When exploring audio embeddings extracted from urban recordings through multidimensional projections, we often recognize clusters that do not represent the user's perception of the soundscape

**[R3] Iterative Creation of Classification Models:** Considering that current machine listening models present certain limitations, the system should provide the capability to iteratively create new classification models based on the data points labeled by the user (and, therefore, the user's perception of the soundscape)

*Urban Rhapsody: Large-scale Visual Exploration of Urban Soundscapes, EuroVis 2022*

# Urban Rhapsody

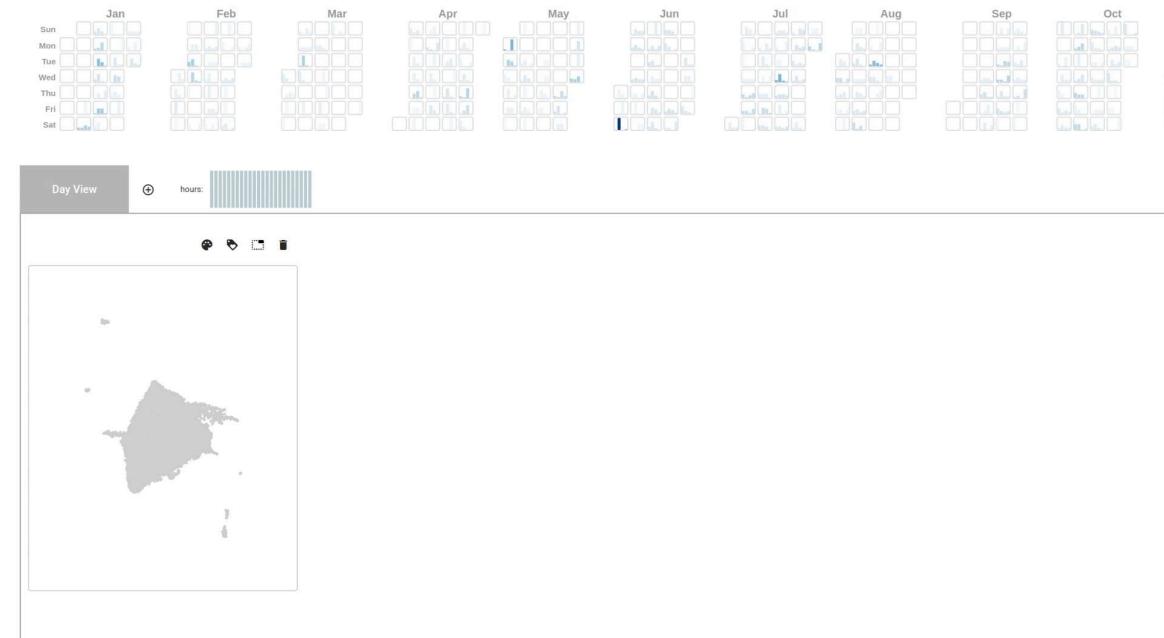


# Urban Rhapsody: Creating prototypes

Binary Classification Model



Representatives



# Bioacoustics monitoring

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- Does exposure to loud urban noise lead to significant changes in bird's song traits and the time and frequency of their chorus?
- Do loud siren noises halt birds' dawn chorus?
- Are the birds nesting in noisy urban areas like Manhattan local parks adapted to the level of urban noise?

# Bioacoustic monitoring

