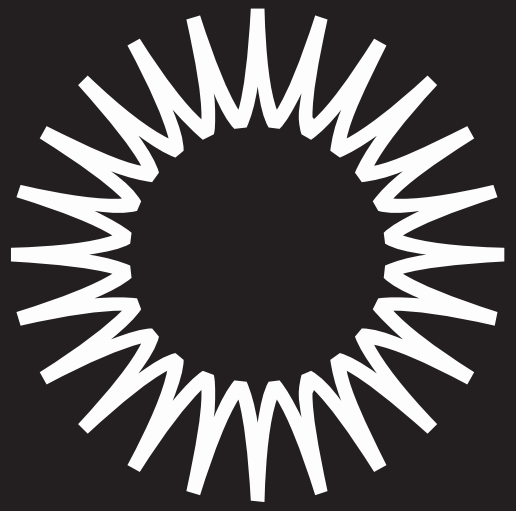


SPUR

Ideas + Action for a Better City

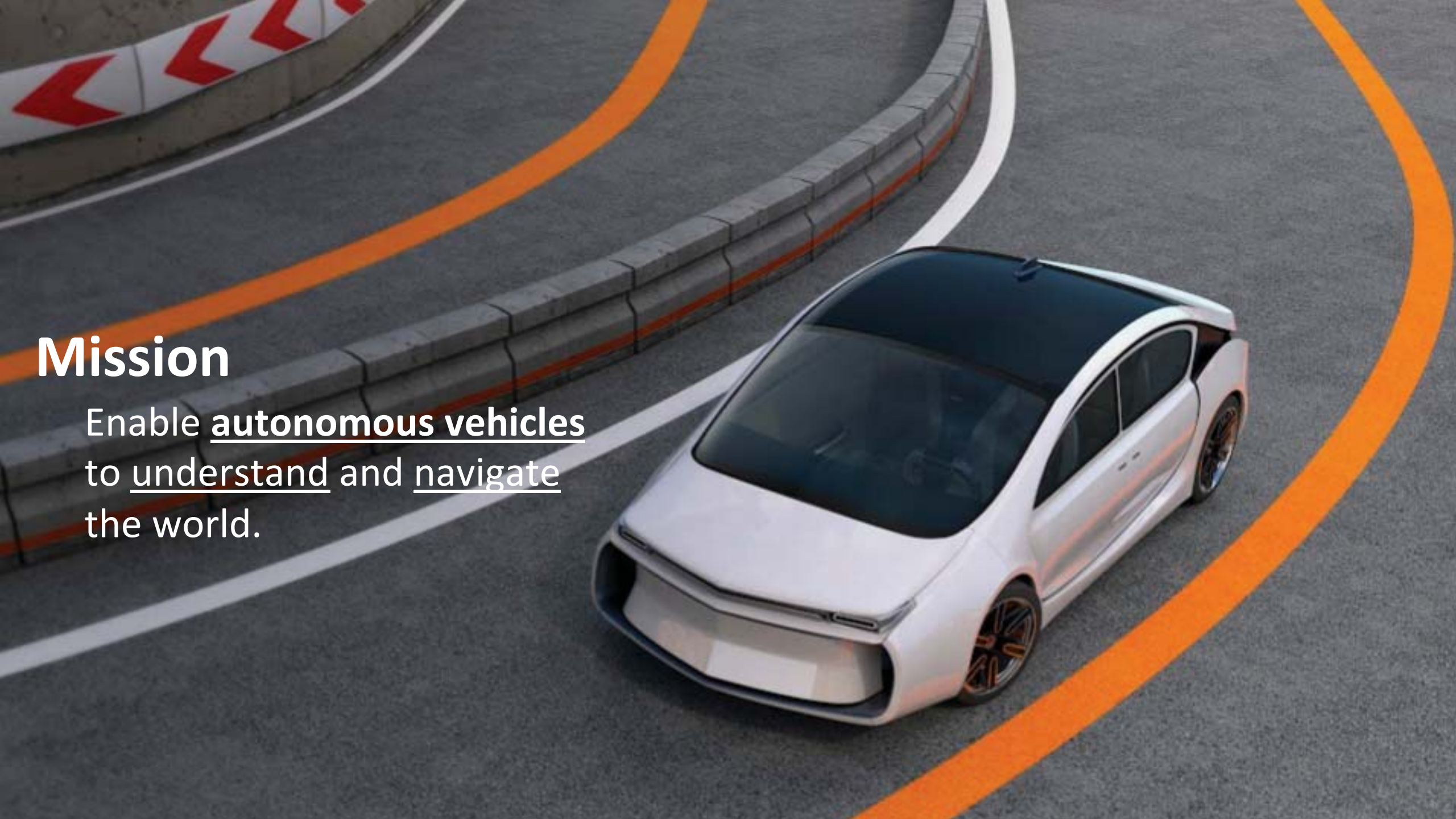
learn more at SPUR.org

tweet about this event:
@SPUR_Urbanist
#FutureOfLocationing

Future of Location

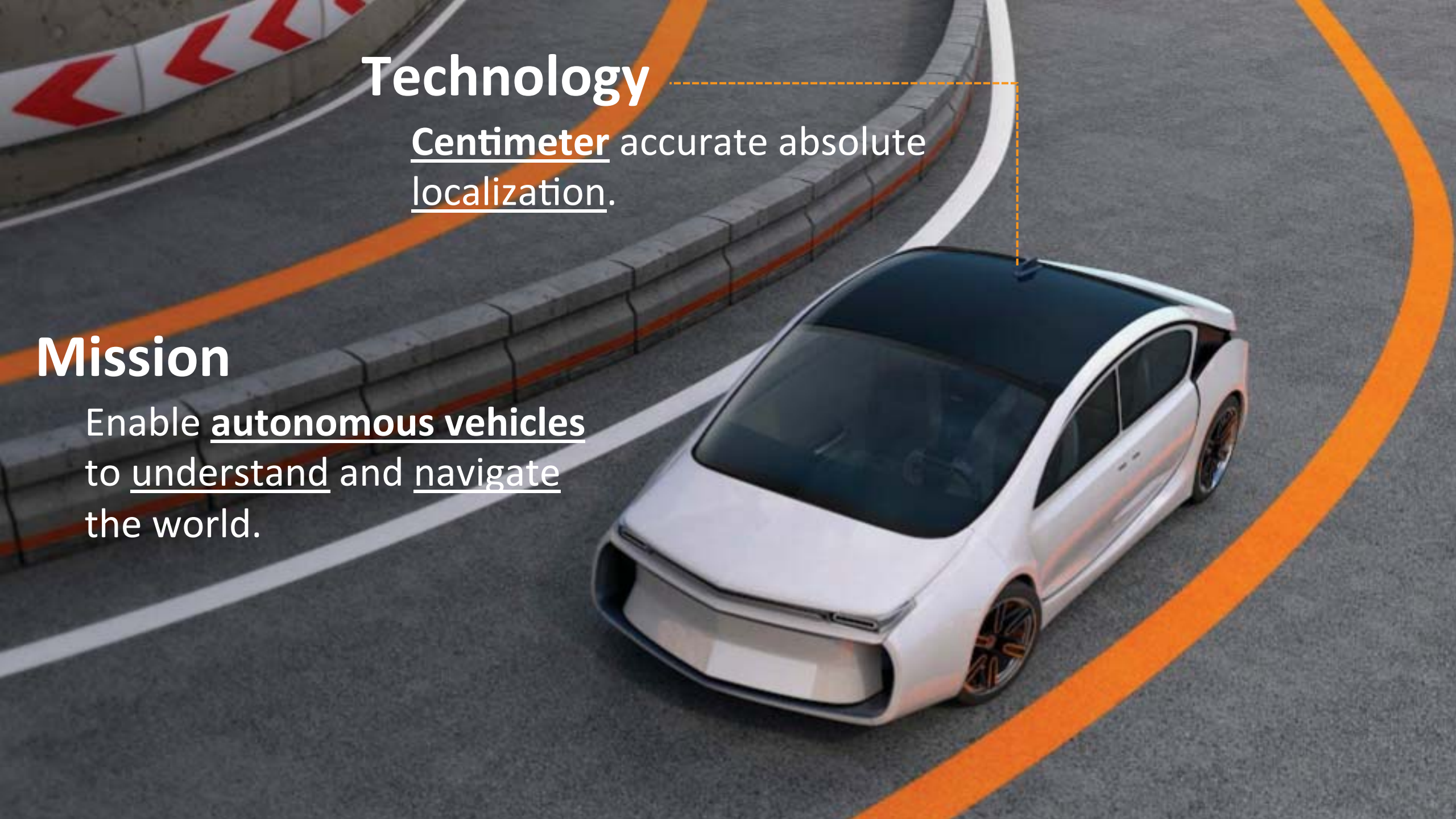
How precise will location be for navigation?

swift NAVIGATION



Mission

Enable **autonomous vehicles** to understand and navigate the world.



Technology

Centimeter accurate absolute localization.

Mission

Enable **autonomous vehicles** to understand and navigate the world.

Swift Overview

- First Round Capital
- Felicis Ventures
- Fall Line Capital
- Qualcomm Ventures
- Lemnos Labs

- Eclipse
- NEA
- Promus Ventures
- Plus all Seed Participants

2009

Development begins at Joby Energy

May 2012

Funded with $100K Angel Investment

Aug 2013

Kickstarter Raises $166K with >300 Backers

April 2014

Piksi™ Beta Product Ships

July 2014

$2.6M Seed Round

Dec 2015

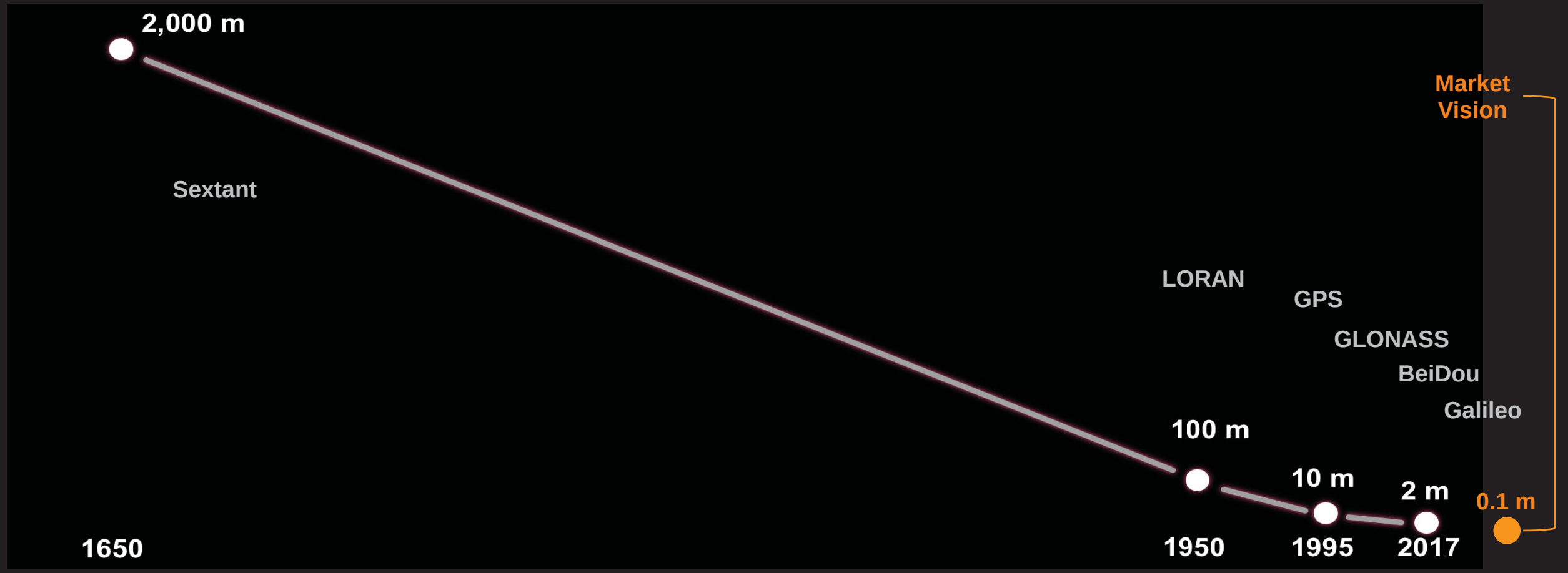
$11M Series A Round

Oct 2016

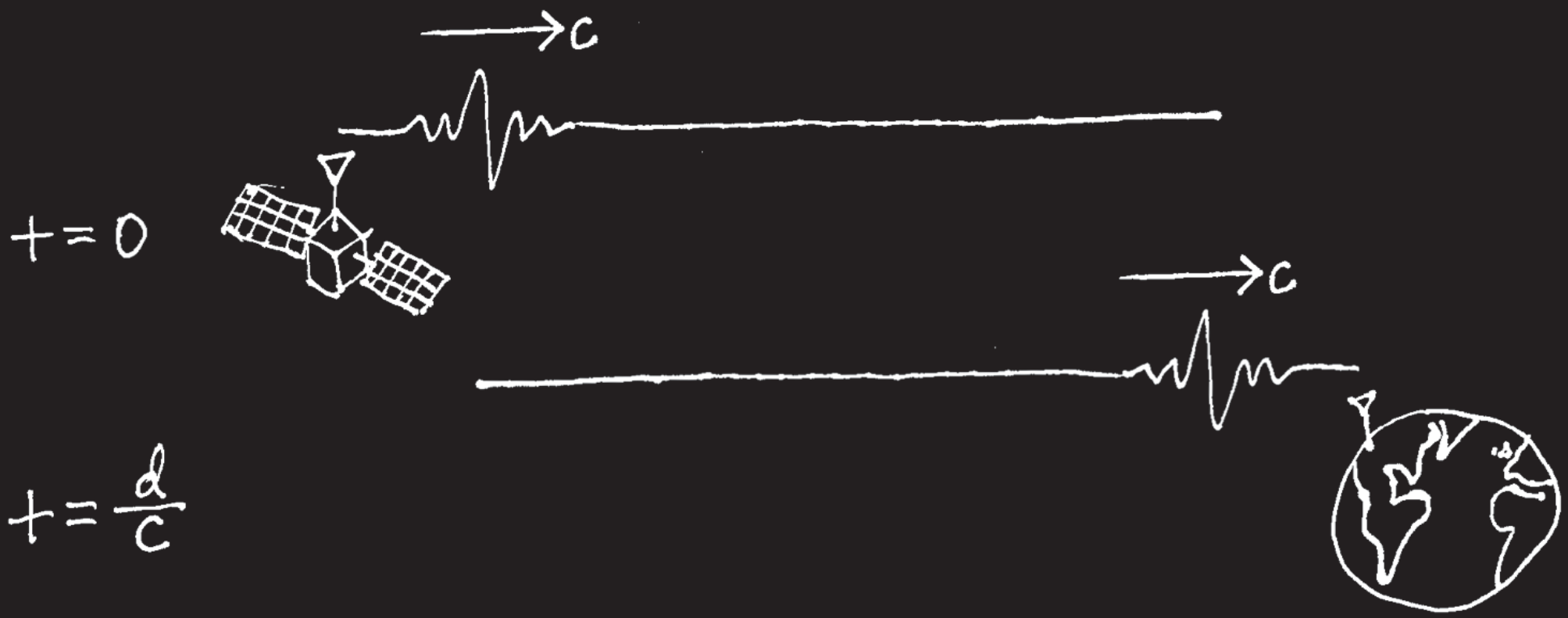
Piksi™ Multi Launch

2009 2012 2013 2014 2015 2016

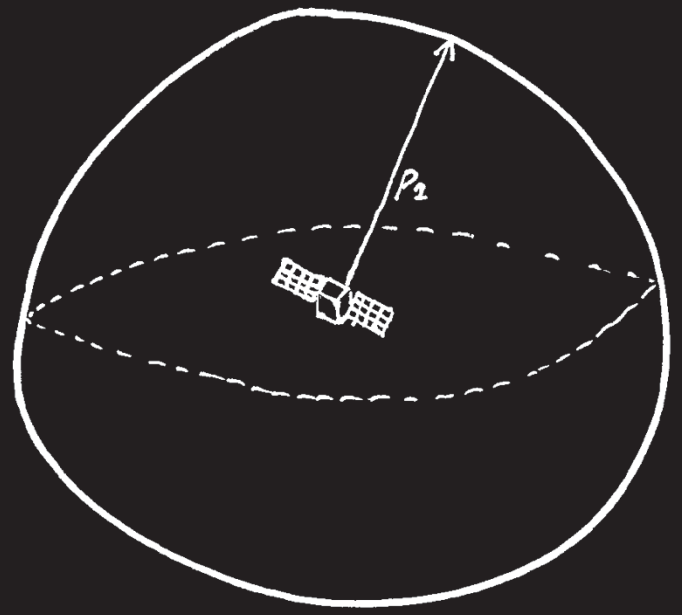
History of Navigation Precision



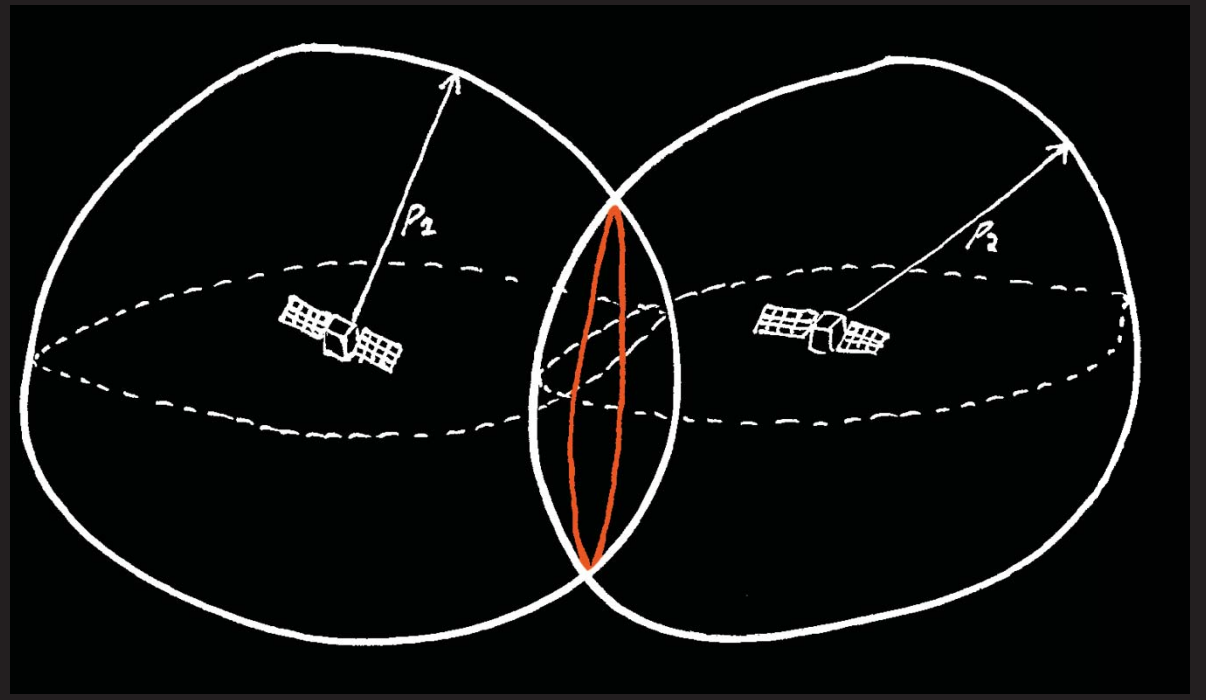
How does GPS work: Measuring distance



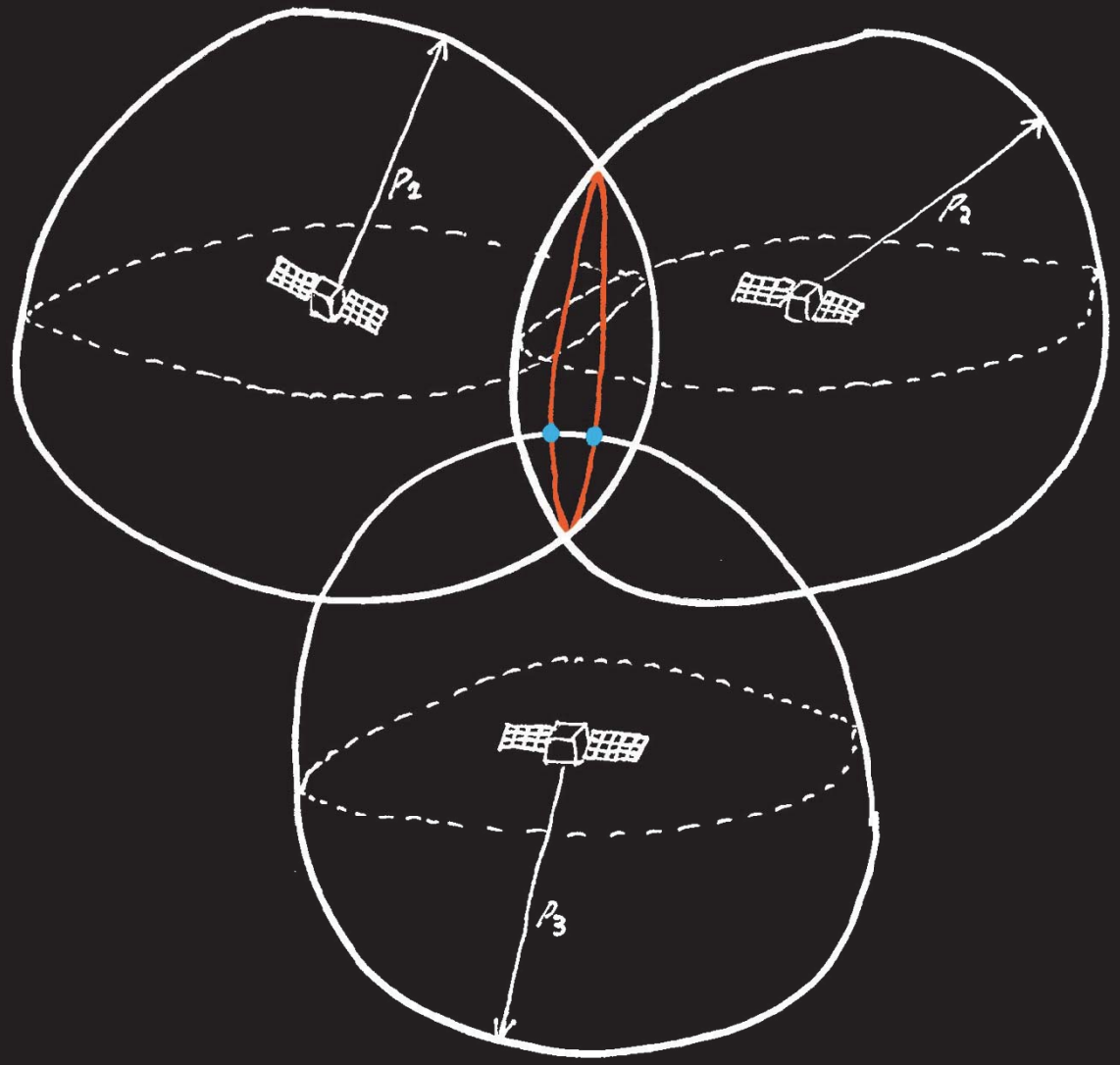
How does GPS work: Solving for Position



How does GPS work: Solving for Position



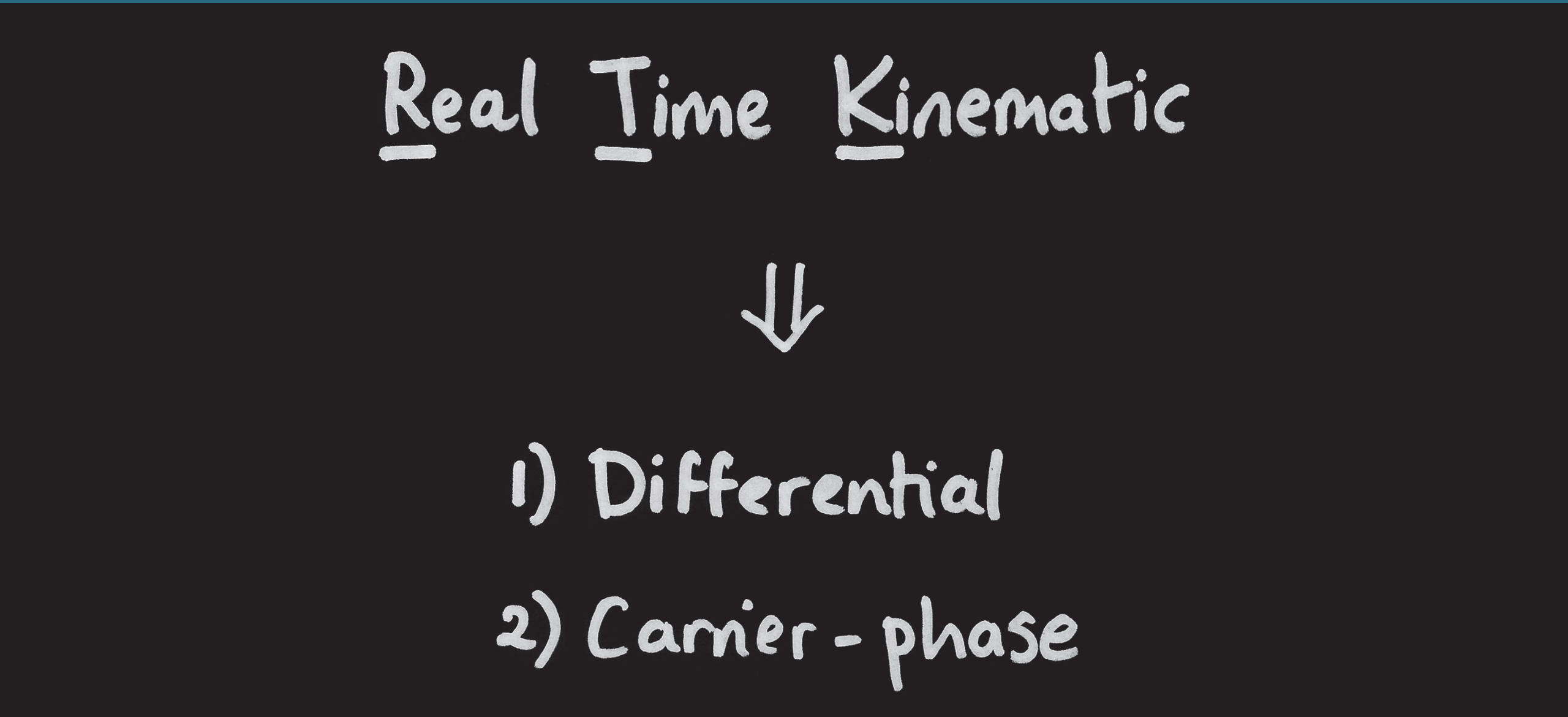
How does GPS work: Solving for Position



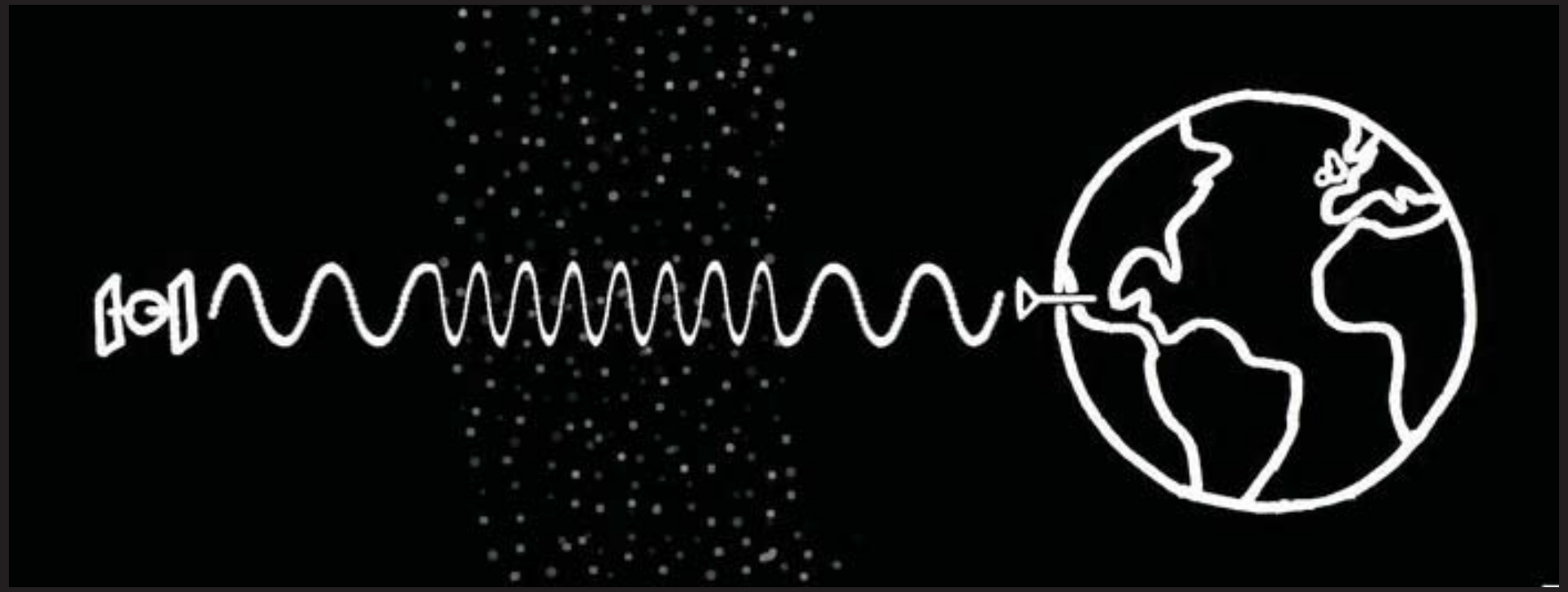
t?

How does Real Time Kinematic GPS work?

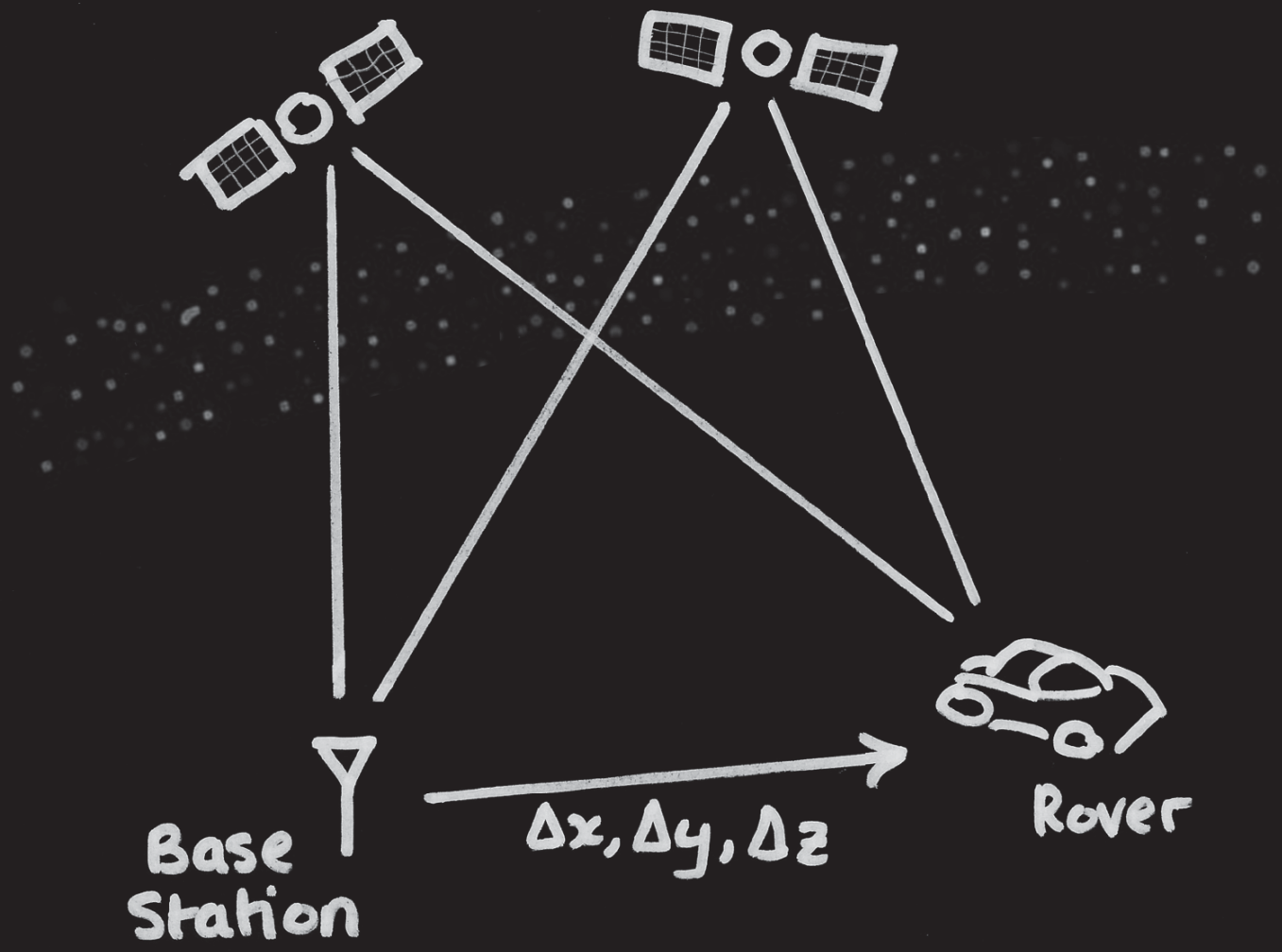
swift NAVIGATION



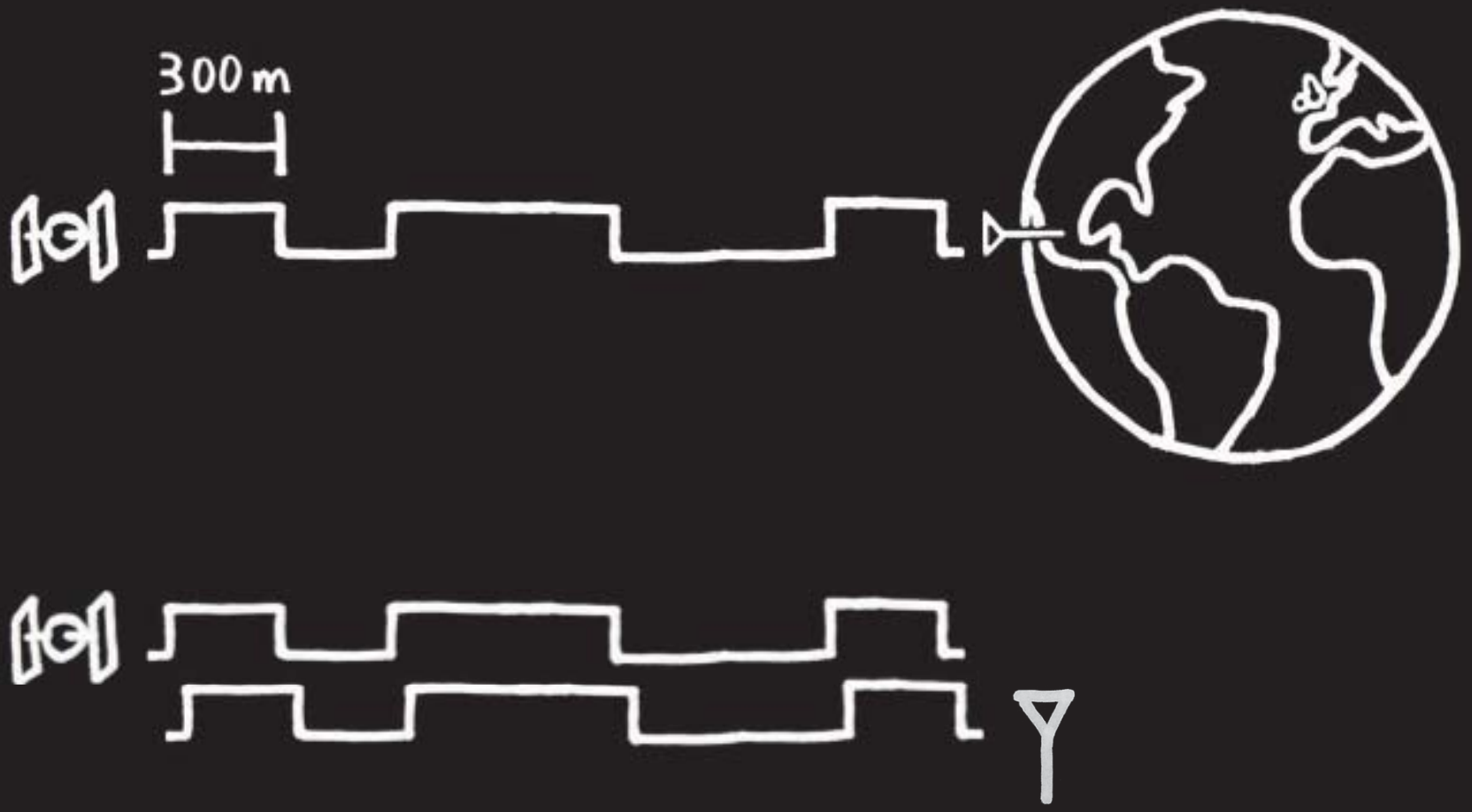
Sources of Error: Ionosphere



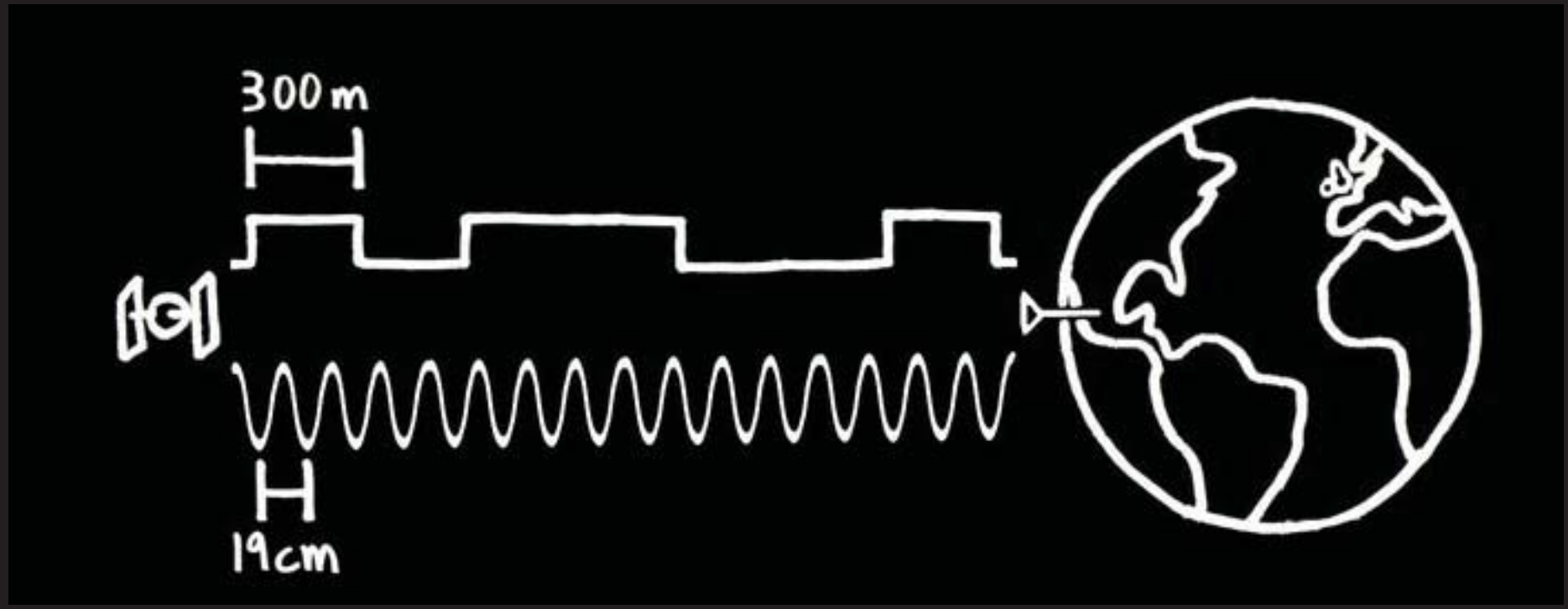
Base Stations for Ionosphere



Sources of Error: Measurement Precision

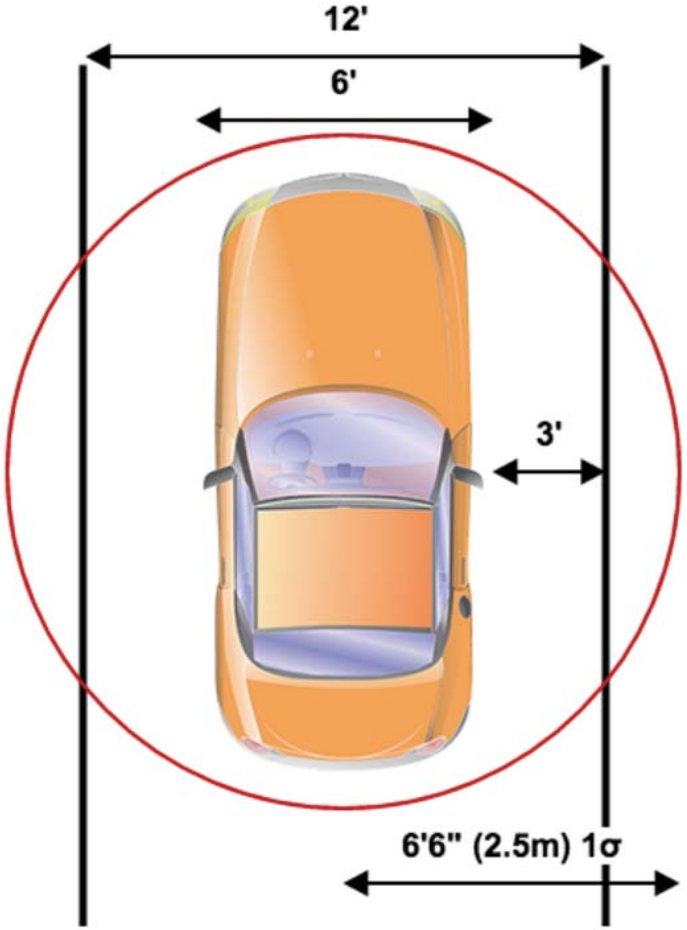


Carrier Phase for Measurement Precision

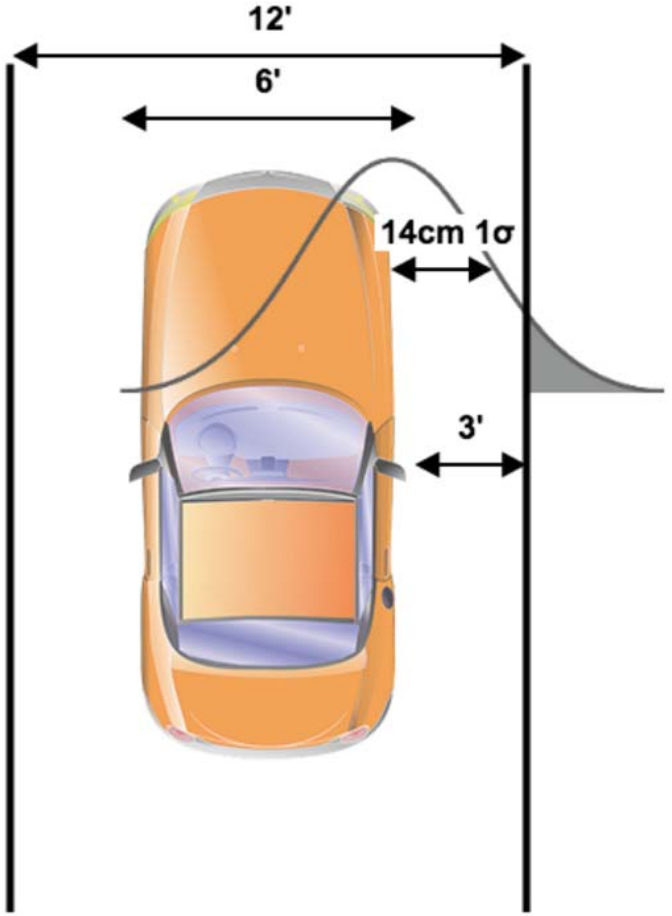


High Precision GNSS Required for L3+ Autonomy

The need for higher accuracy

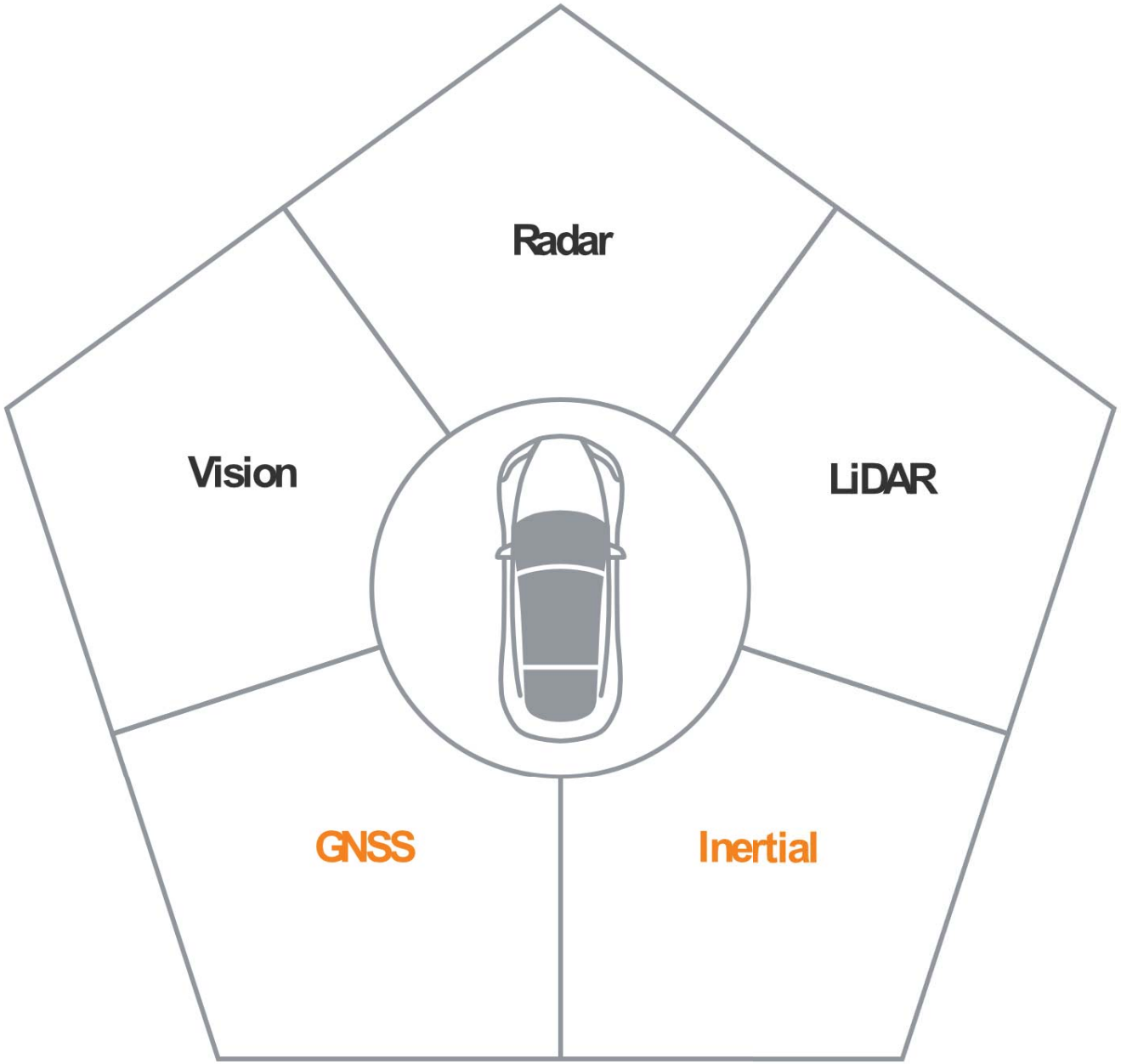


Normal GPS Accuracy - 2.5m 1σ[7]
Error exceeds 3' lane clearance
70% of the time[8]



Autonomous driving will require
dangerous error rate of $<10^{-6}$ per hour
This necessitates 14cm 1σ accuracy[9]

Core Sensor Suite
Level 3+ Autonomy



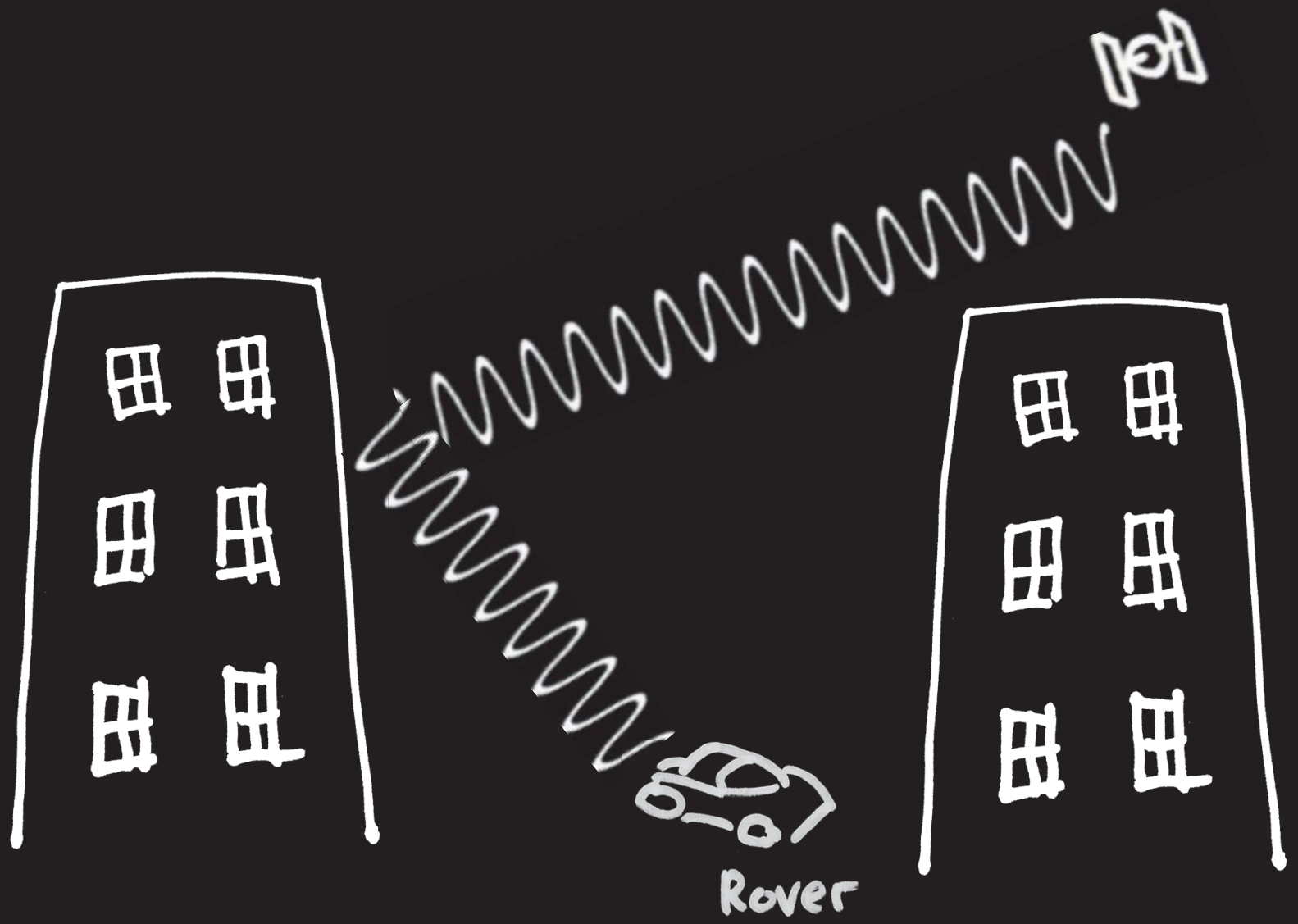
<u>Only</u> sensor that outputs <u>absolute</u>:

- Position
- Velocity
- Time

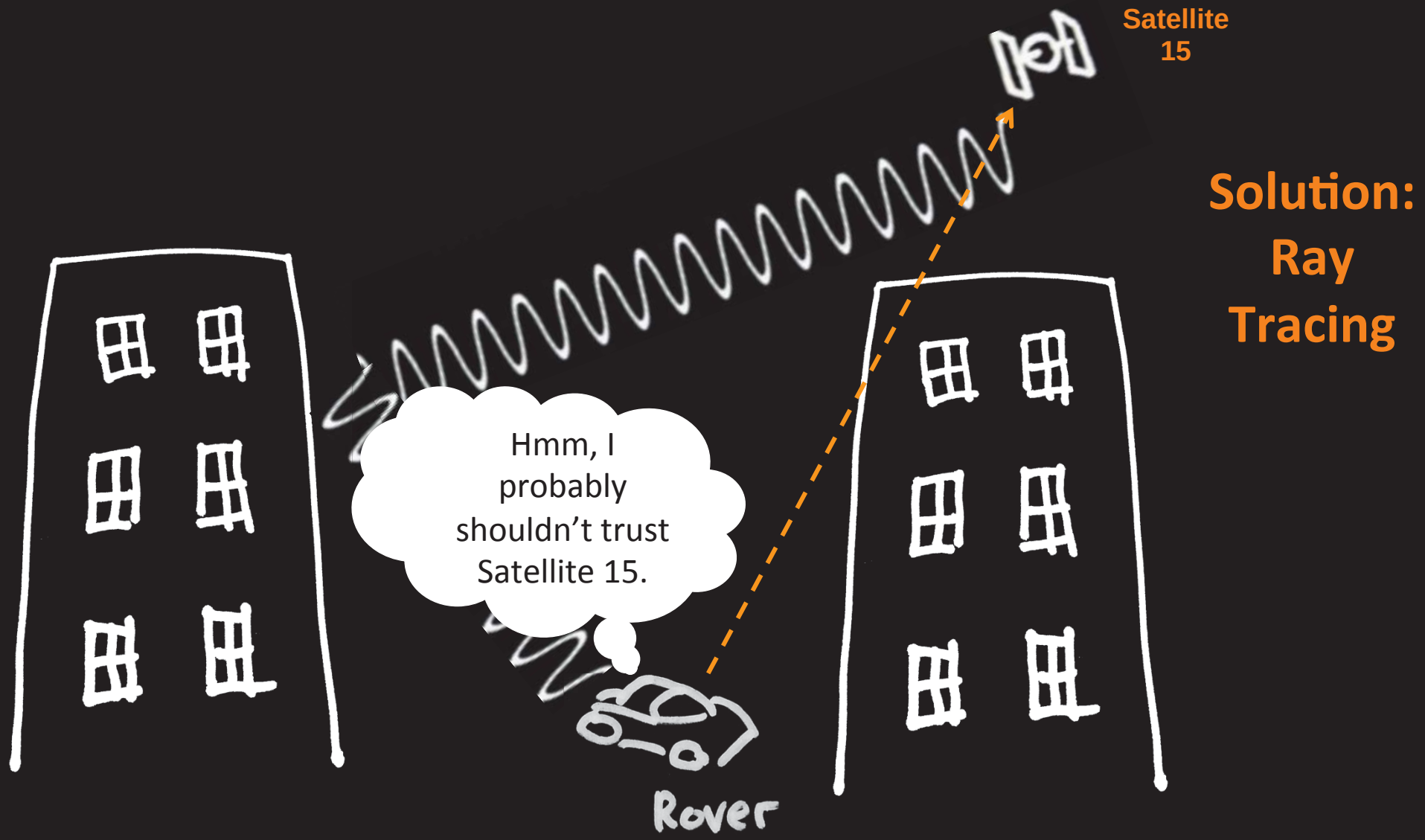
Inclement Weather

Example Data

Challenges: Multipath

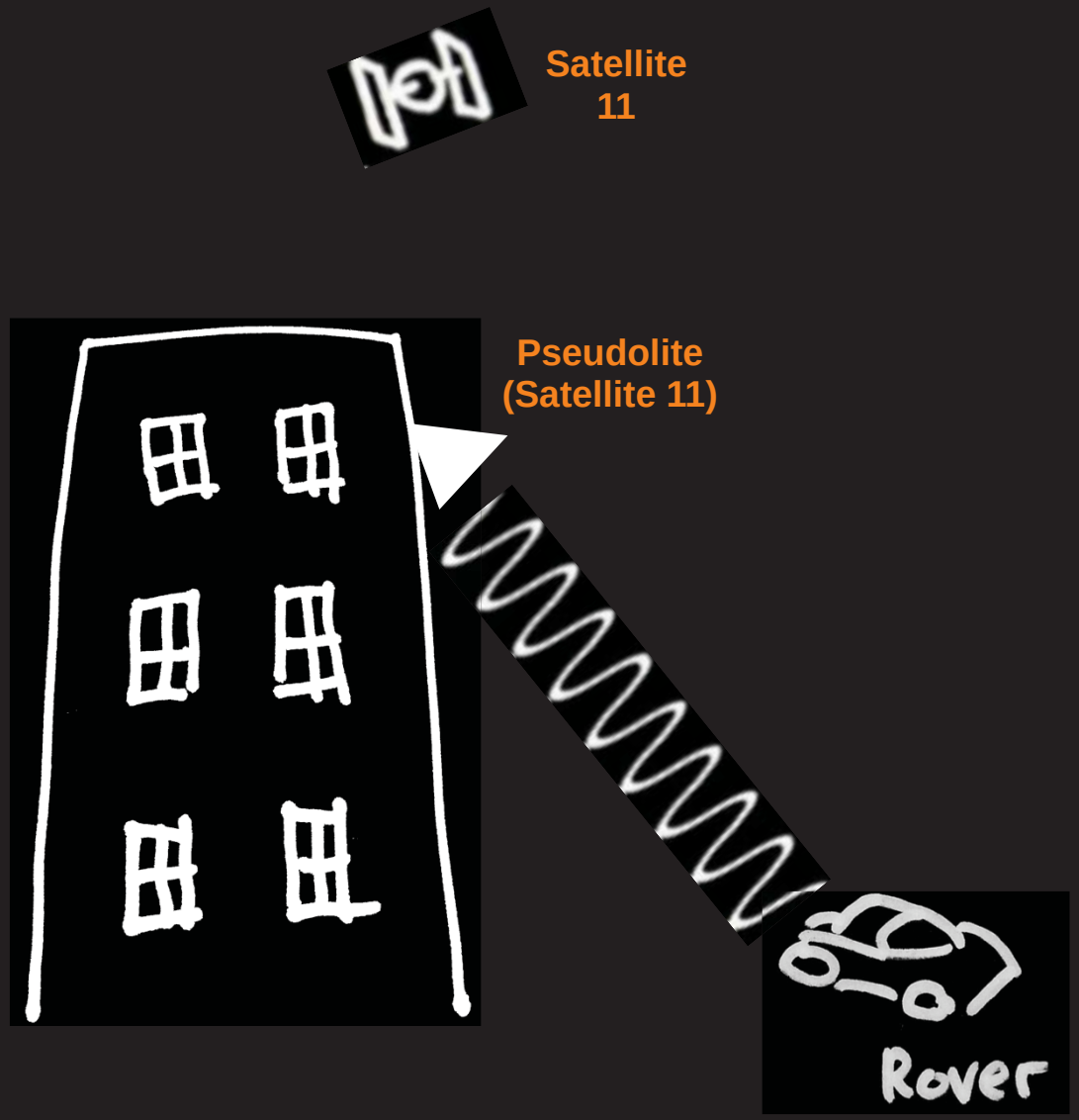


Challenges: Multipath

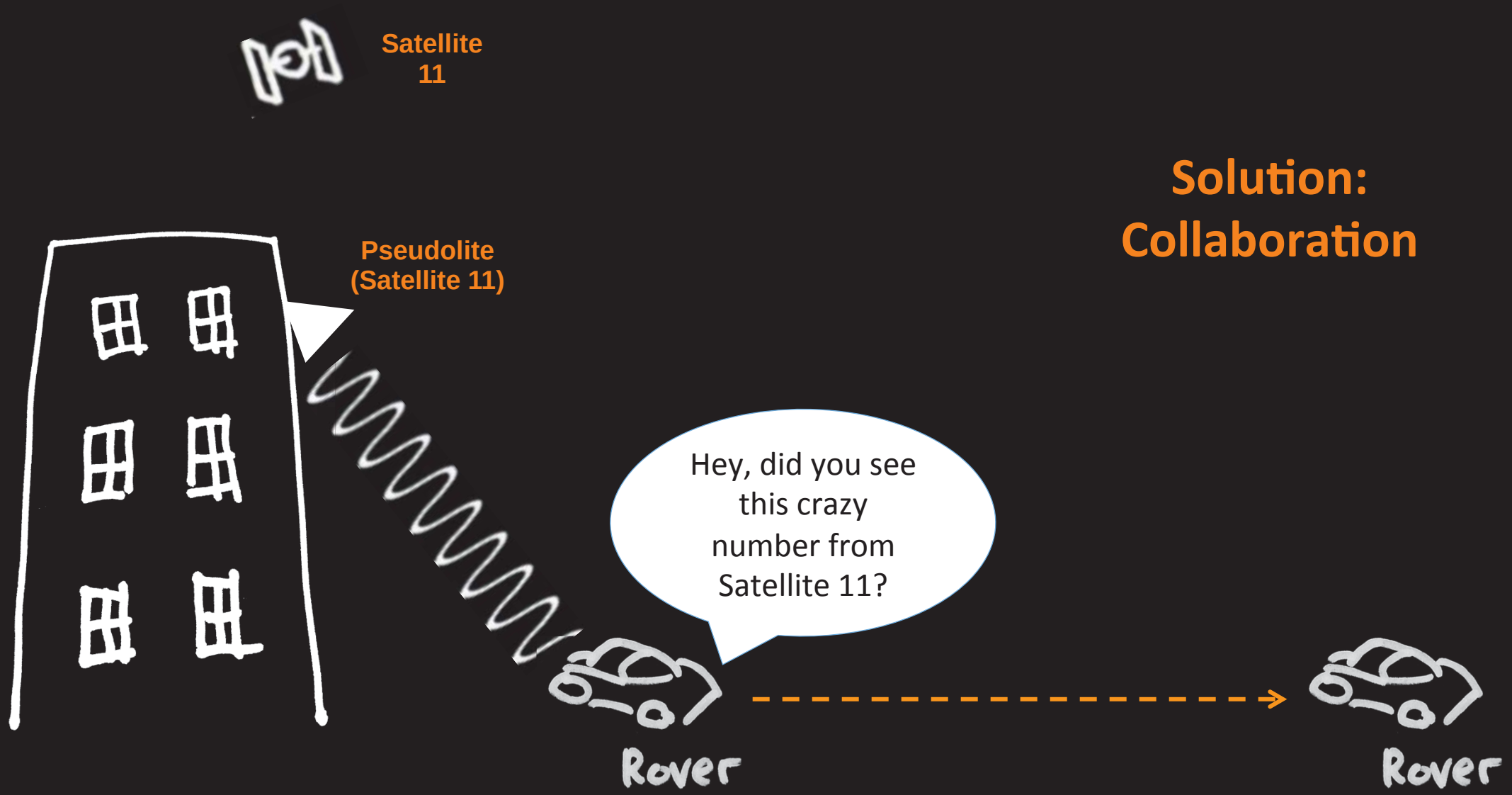


Solution: Ray Tracing

Challenges: Spoofing



Challenges: Spoofing



Solution: Collaboration

Conclusion

Location
centimeter

Time ⟷ **Map**
nanoseconds ⟷ centimeter

Conclusion

Location
centimeter

Time
nanoseconds

Map
centimeter

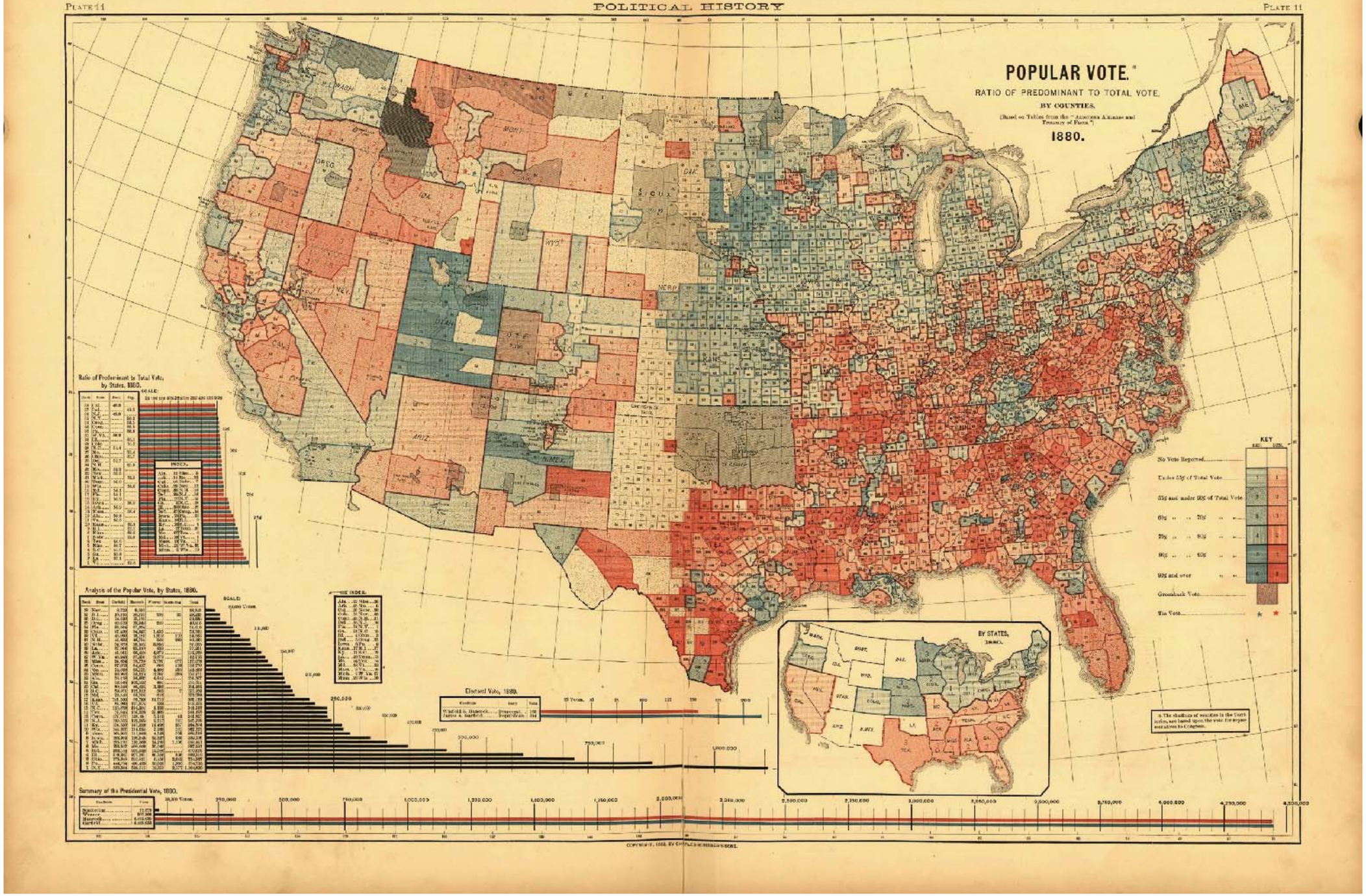
Thank you

Rob Hranac
Business Development
rob@swiftnav.com

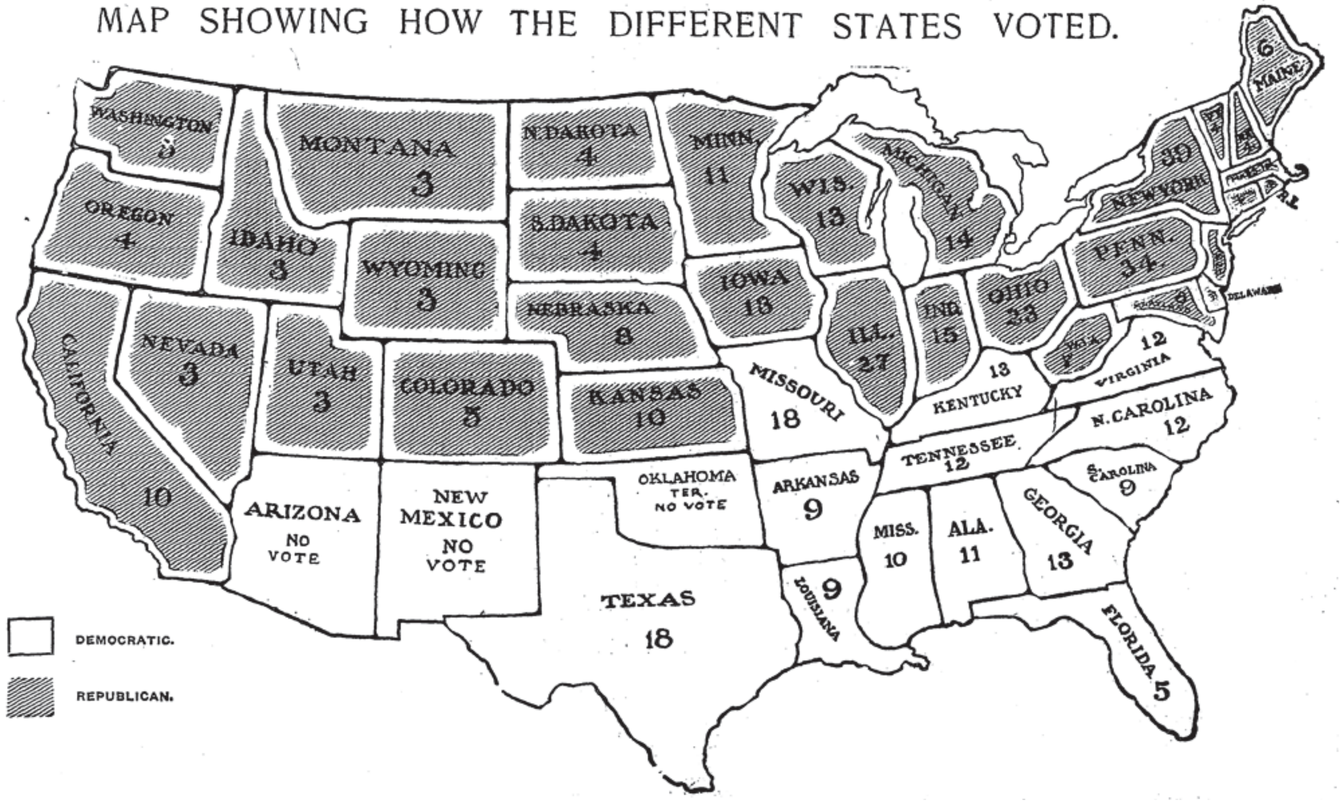
WHERE WE STAND

The power of cartography in an age of big data

Andreas Viglakis
Cartography @ Mapbox

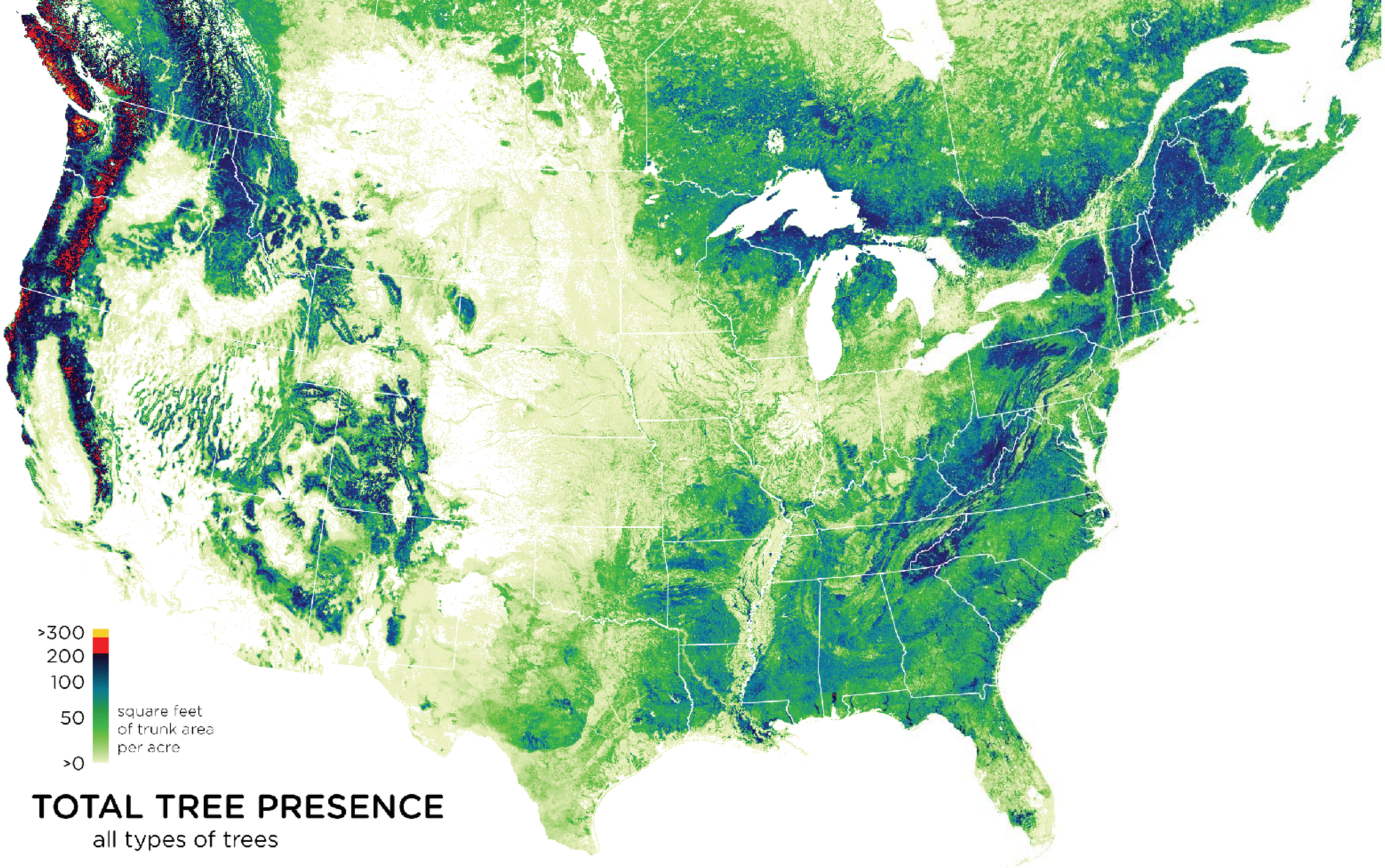


Electoral Map from Scribner's 1883 Statistical Atlas



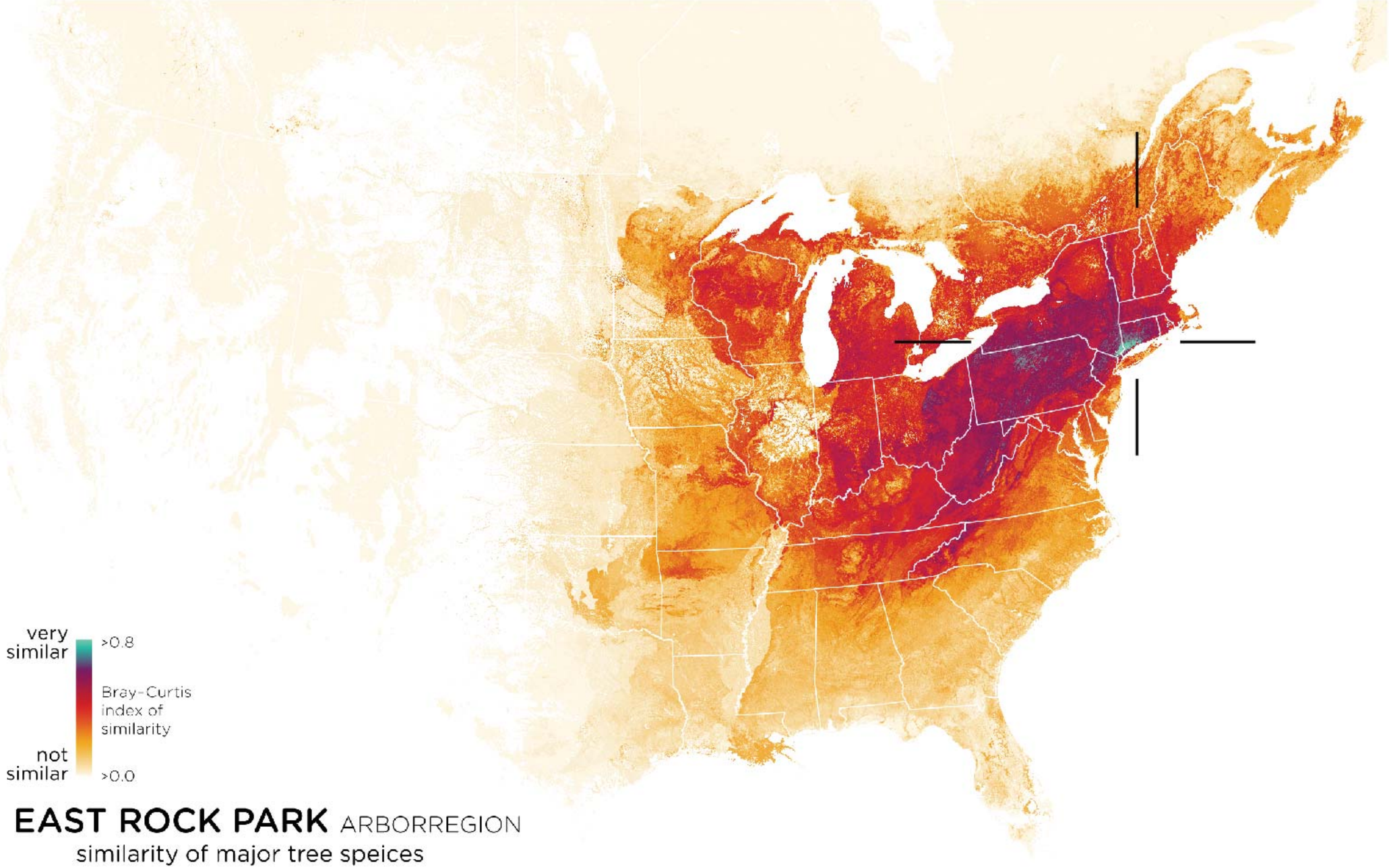
1916 New York Times Election Results Map

THE
UNITED STATES
NATIONAL
GEOGRAPHIC
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
QUEBEC
ONTARIO
MANITOBA
SASKATCHEWAN
ALBERTA
ALASKA
MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO



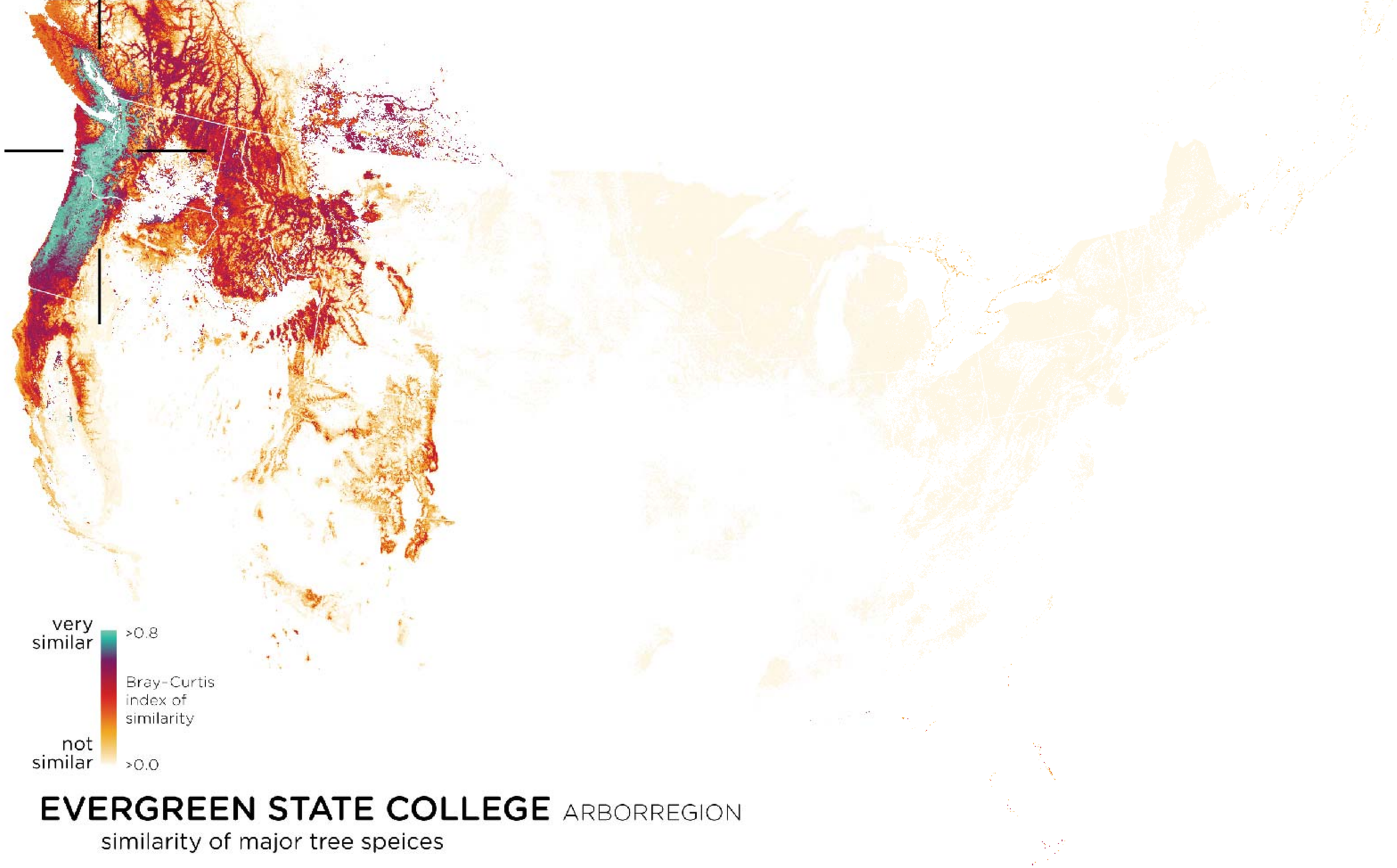
TOTAL TREE PRESENCE

all types of trees



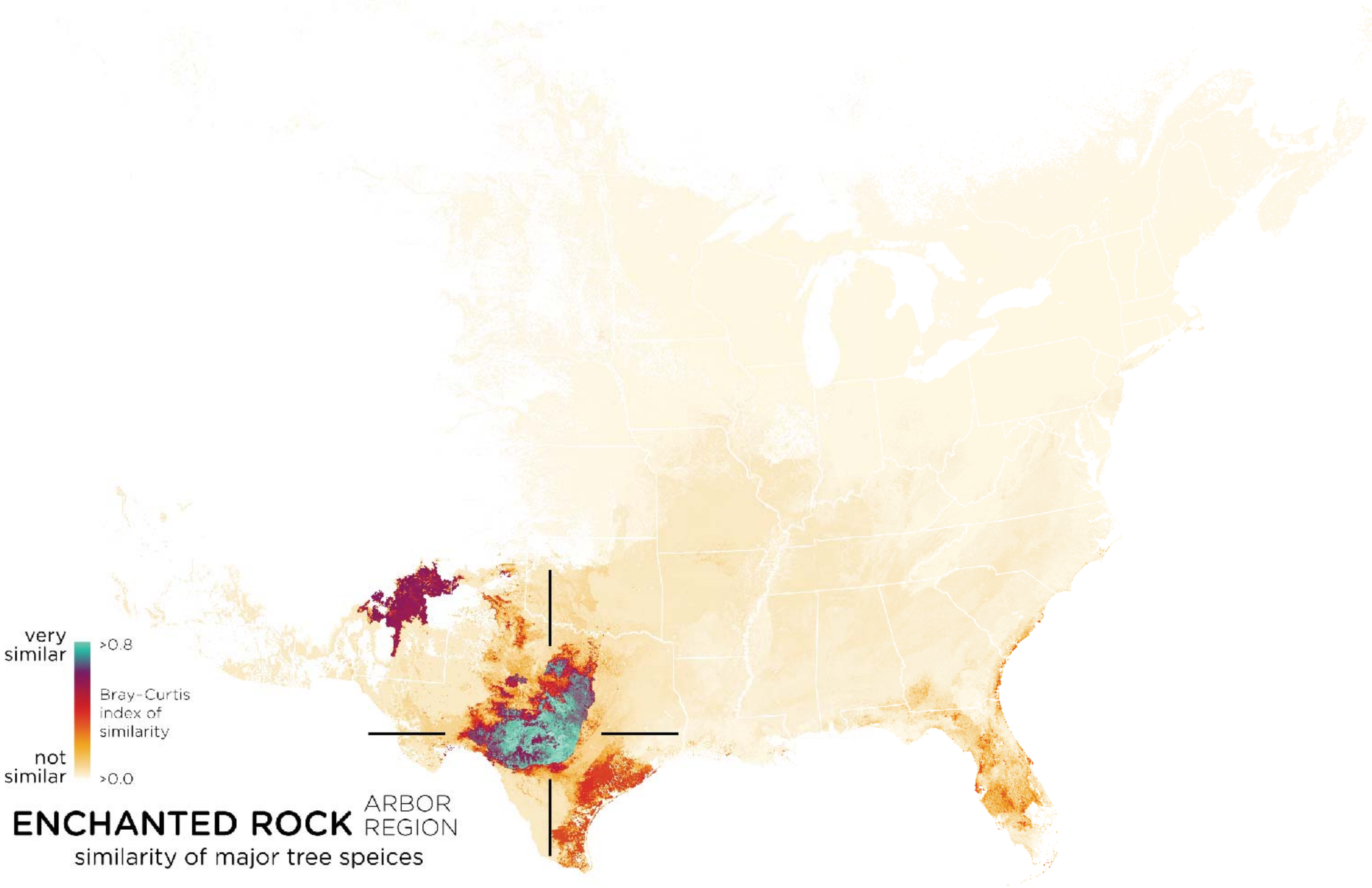
EAST ROCK PARK ARBORREGION

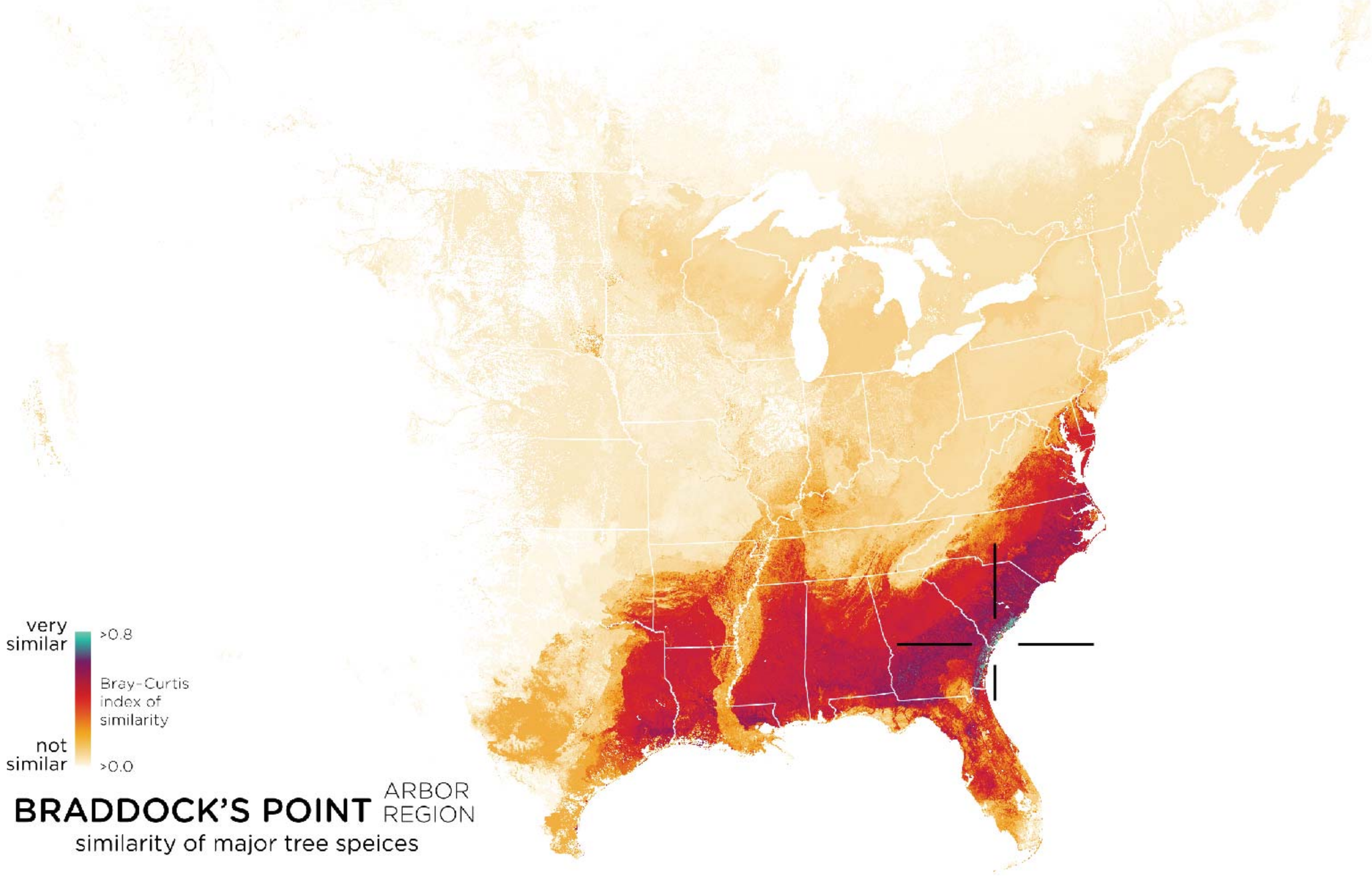
similarity of major tree speices



EVERGREEN STATE COLLEGE ARBORREGION

similarity of major tree speices

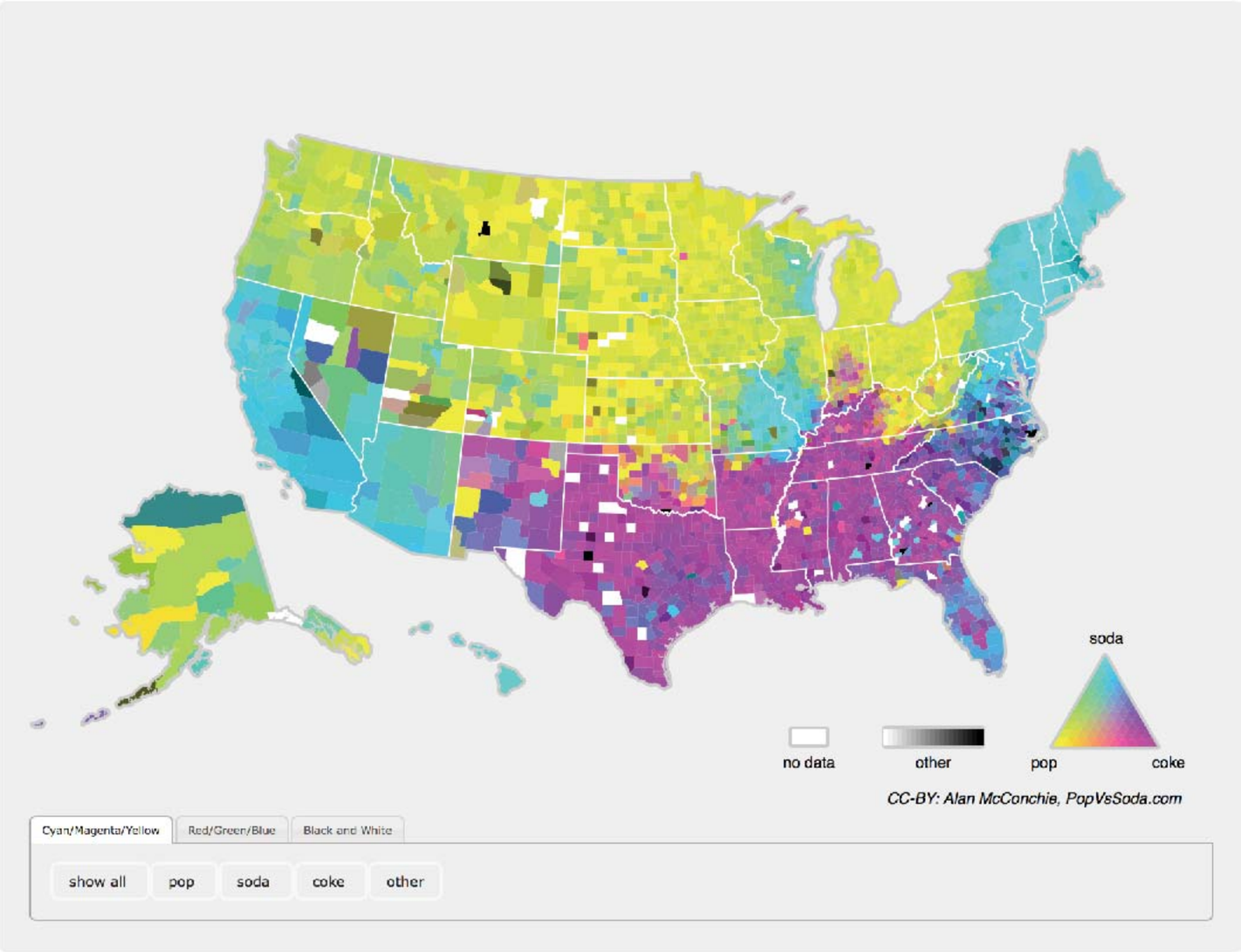

very similar
>0.8
Bray-Curtis index of similarity
not similar
>0.0
ENCHANTED ROCK ARBOR REGION
similarity of major tree speices



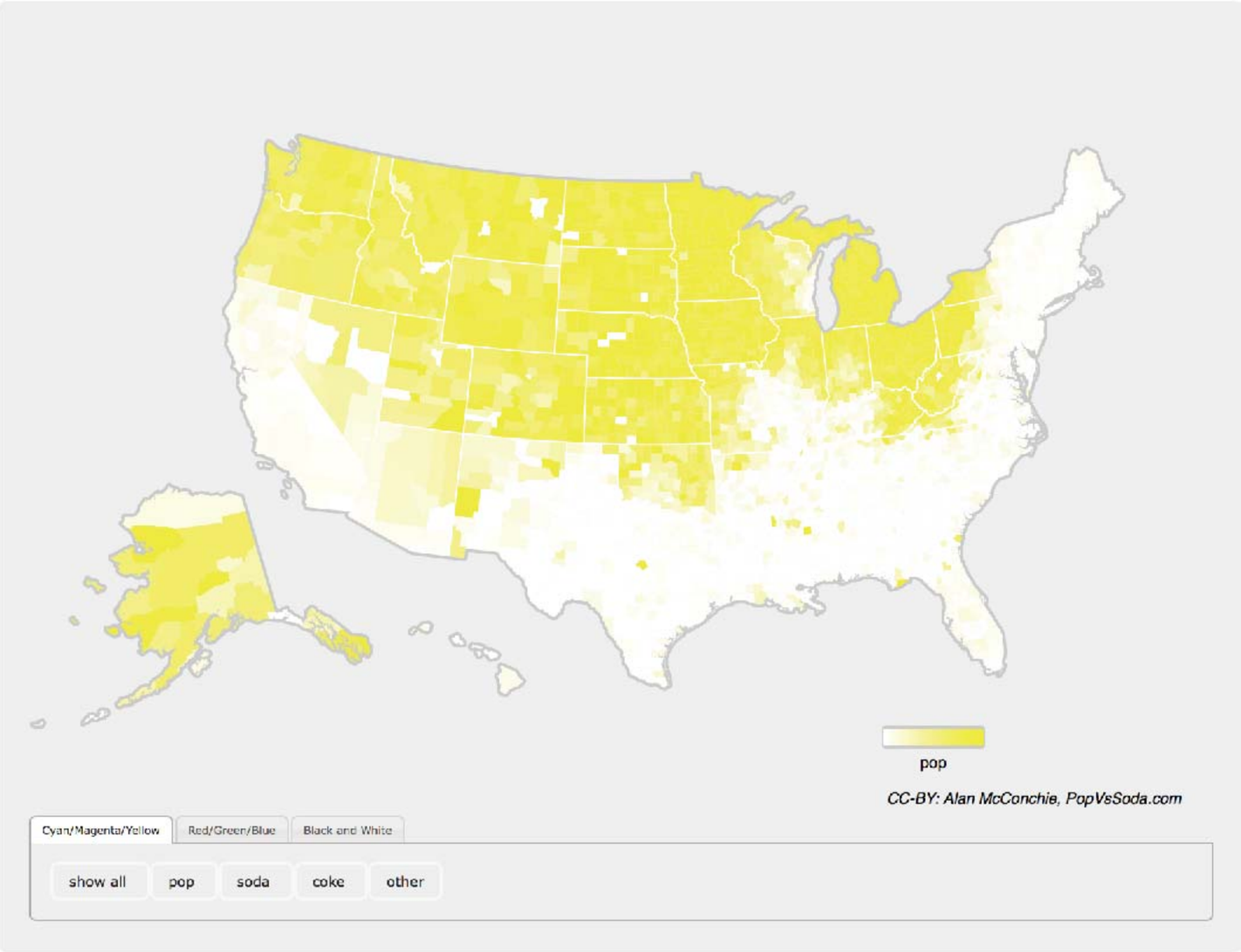
BRADDOCK'S POINT ARBOR REGION

similarity of major tree speices

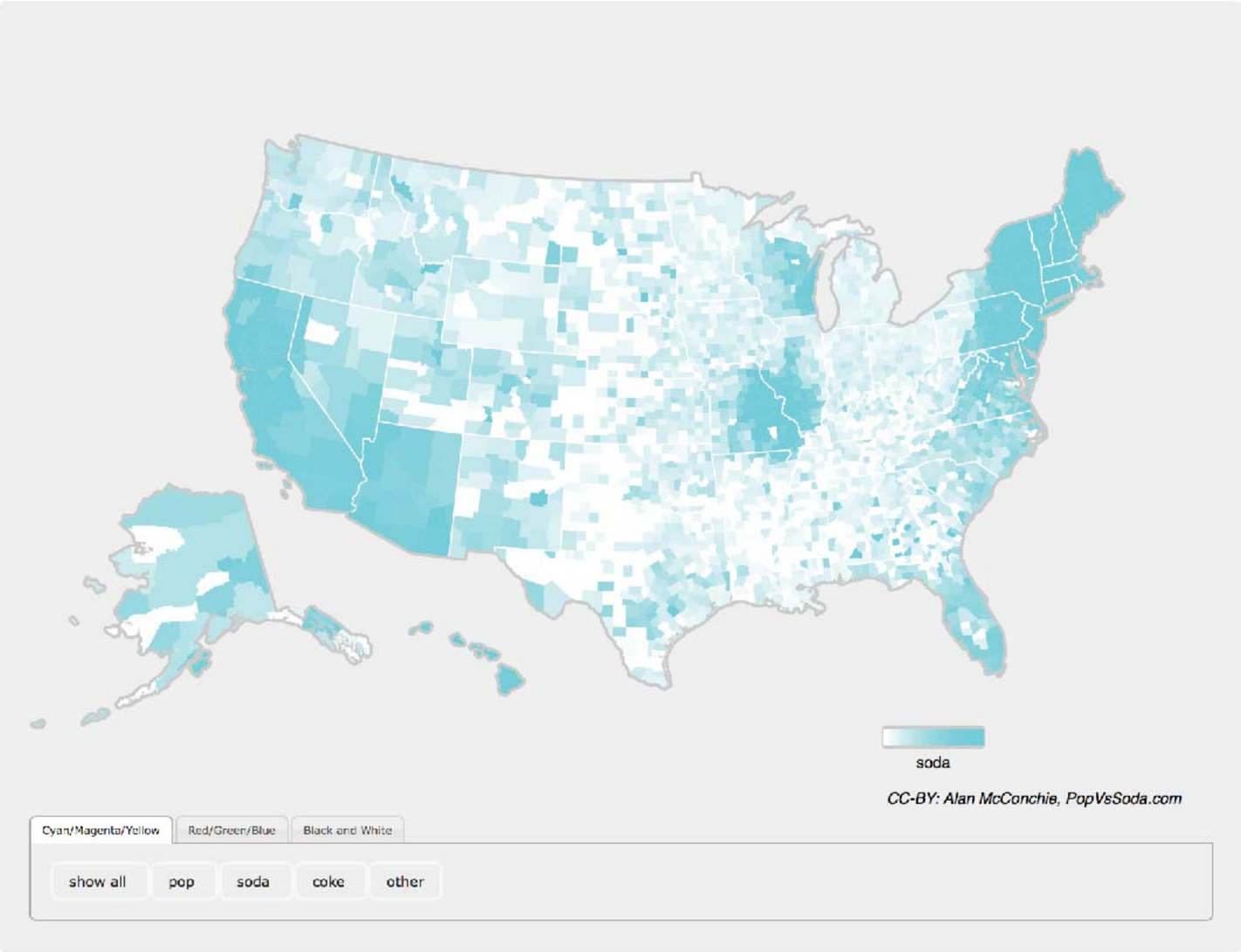
POP vs SODA


soda
no data
other
pop
coke
CC-BY: Alan McConchie, PopVsSoda.com
Cyan/Magenta/Yellow
Red/Green/Blue
Black and White
show all
pop
soda
coke
other

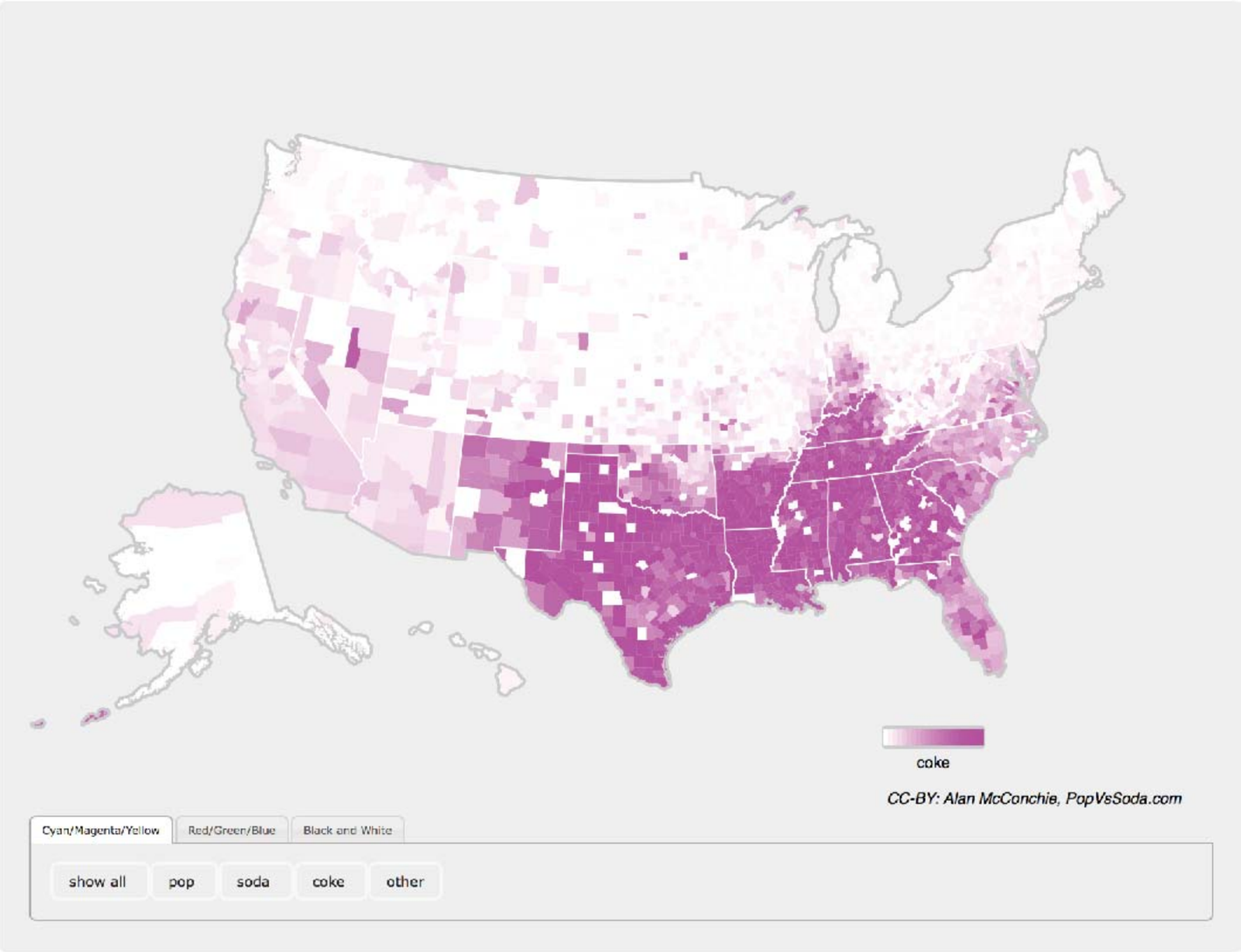
POP vs SODA


pop
CC-BY: Alan McConchie, PopVsSoda.com
Cyan/Magenta/Yellow
Red/Green/Blue
Black and White
show all
pop
soda
coke
other

POP vs SODA

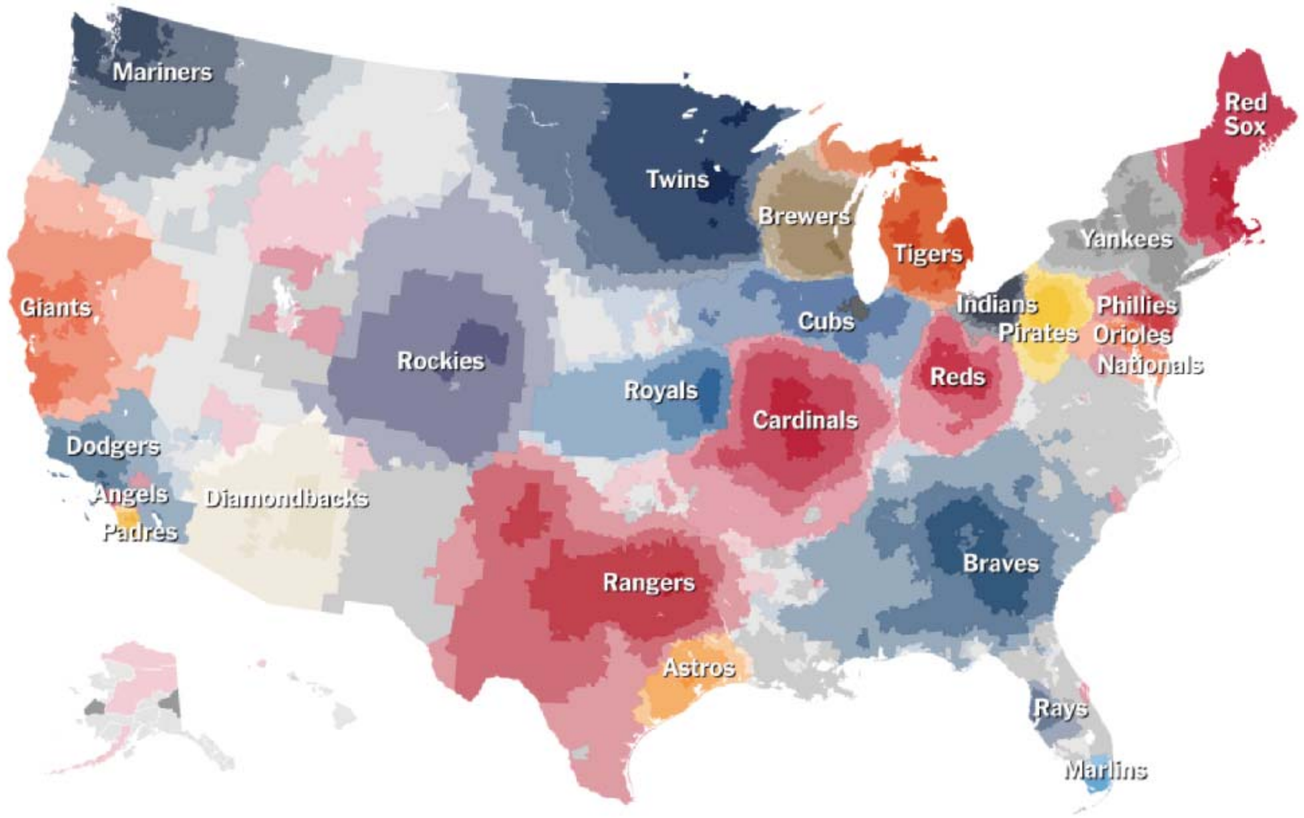

soda
CC-BY: Alan McConchie, PopVsSoda.com
Cyan/Magenta/Yellow
Red/Green/Blue
Black and White
show all
pop
soda
coke
other

POP vs SODA


coke
CC-BY: Alan McConchie, PopVsSoda.com
Cyan/Magenta/Yellow
Red/Green/Blue
Black and White
show all
pop
soda
coke
other

Up Close on Baseball's Borders

By TOM GIRATIKANON, JOSH KATZ, DAVID LEONHARDT and KEVIN QUEALY APRIL 24, 2014

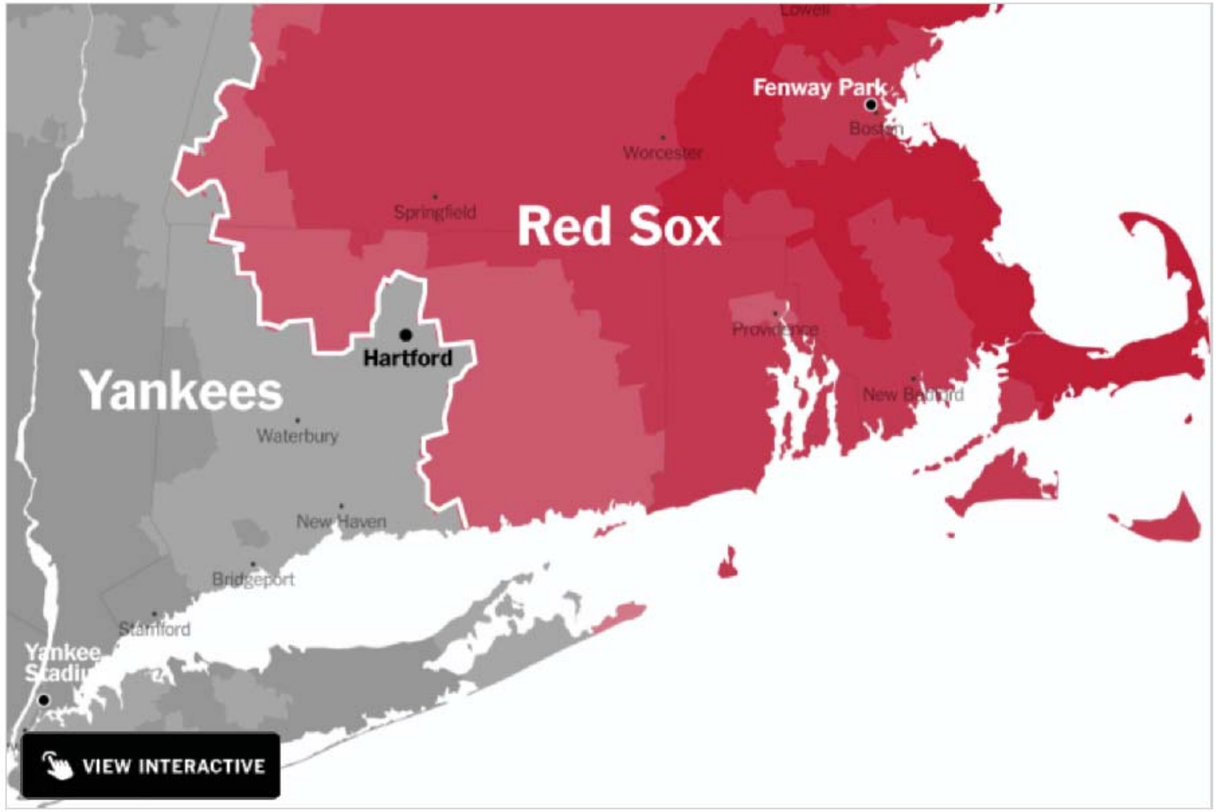


Steve Rushin of Sports Illustrated has called the line running through Connecticut that separates Yankee fans and Red Sox fans the Munson-Nixon line. Mr. Rushin came up with the name — in honor of the late Yankee catcher Thurman Munson and the retired Red Sox right fielder Trot Nixon — in 2003, and he had to guess where the line ran: "north of New Haven but south of Hartford, running the breadth of central Connecticut."

http://www.nytimes.com/interactive/2014/04/23/upshot/24-upshot-baseball.html

New York Yankees vs. Boston Red Sox

Munson-Nixon Redux



We begin with a new take on the Munson-Nixon line, which differs from some previous interpretations in that it shows that Hartford has declared for the Yankees. It's still a border town, but it's a border town the way El Paso is — clearly on the Yankee side. One tidbit: Red Sox Nation seems to have conquered some new territory since 2012, when Ben Blatt tried to draw such a line. (Winning a World Series will do that.) We also encourage you to read our colleague John Branch's attempt at drawing the line in 2006, which is quite impressive and accurate given his shoe-leather means.

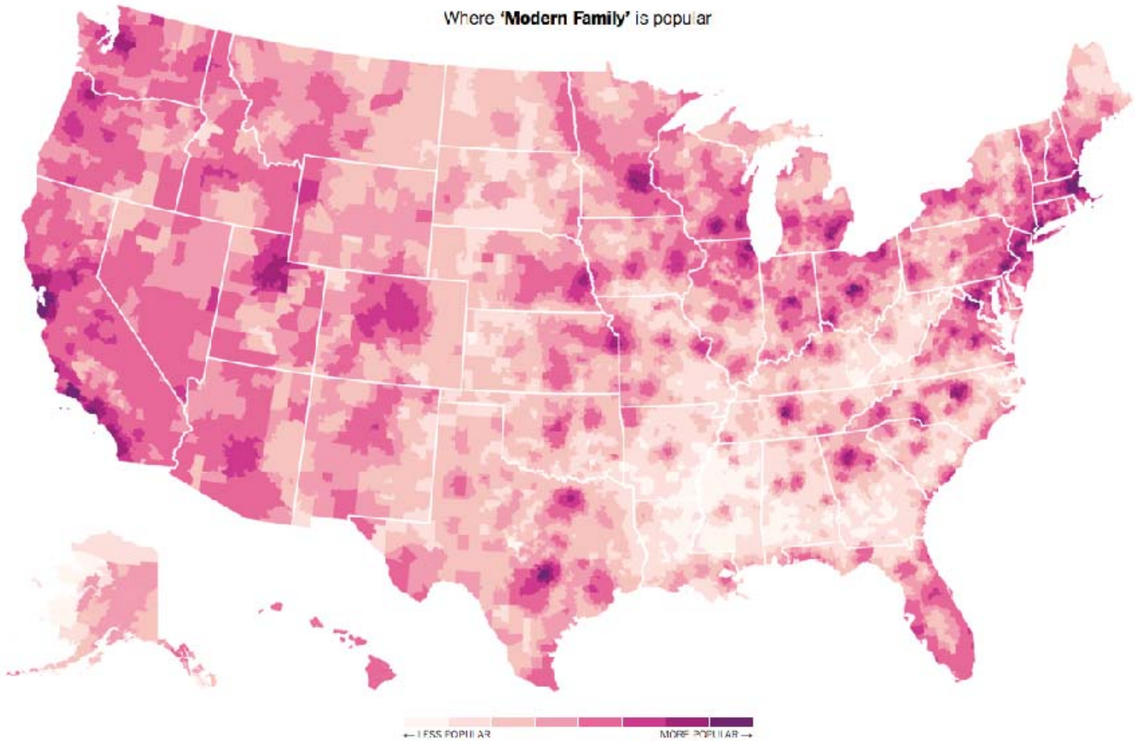
http://www.nytimes.com/interactive/2014/04/23/upshot/24-upshot-baseball.html

Oh, Ohio

On to Columbus

Few states give their fans as many options as Ohio does. A fair-weather fan in the central part of the state could claim allegiance to several teams within a day's drive: not just the Reds and the Indians but the Cubs, the White Sox, the Pirates, the Tigers or even the Cardinals. But most Ohioans stay loyal to the home-state teams, and the border is right where you'd guess. It runs straight though Columbus, Ohio's capital and largest city, in the middle of the state. One small exception to the Reds' and Indians' dominance: The longtime presence of the Tigers' top minor league team in Toledo — the Mud Hens, the favorite team of Corporal Klinger from the television show "M*A*S*H" — has helped the Tigers claim some territory in northern Ohio.

http://www.nytimes.com/interactive/2014/04/23/upshot/24-upshot-baseball.html



'Duck Dynasty' vs. 'Modern Family': 50 Maps of the U.S. Cultural Divide

By JOSH KATZ DEC. 27, 2016

Americans have been clustering themselves into cultural bubbles just as they have clustered in political bubbles. Their TV preferences confirm that.

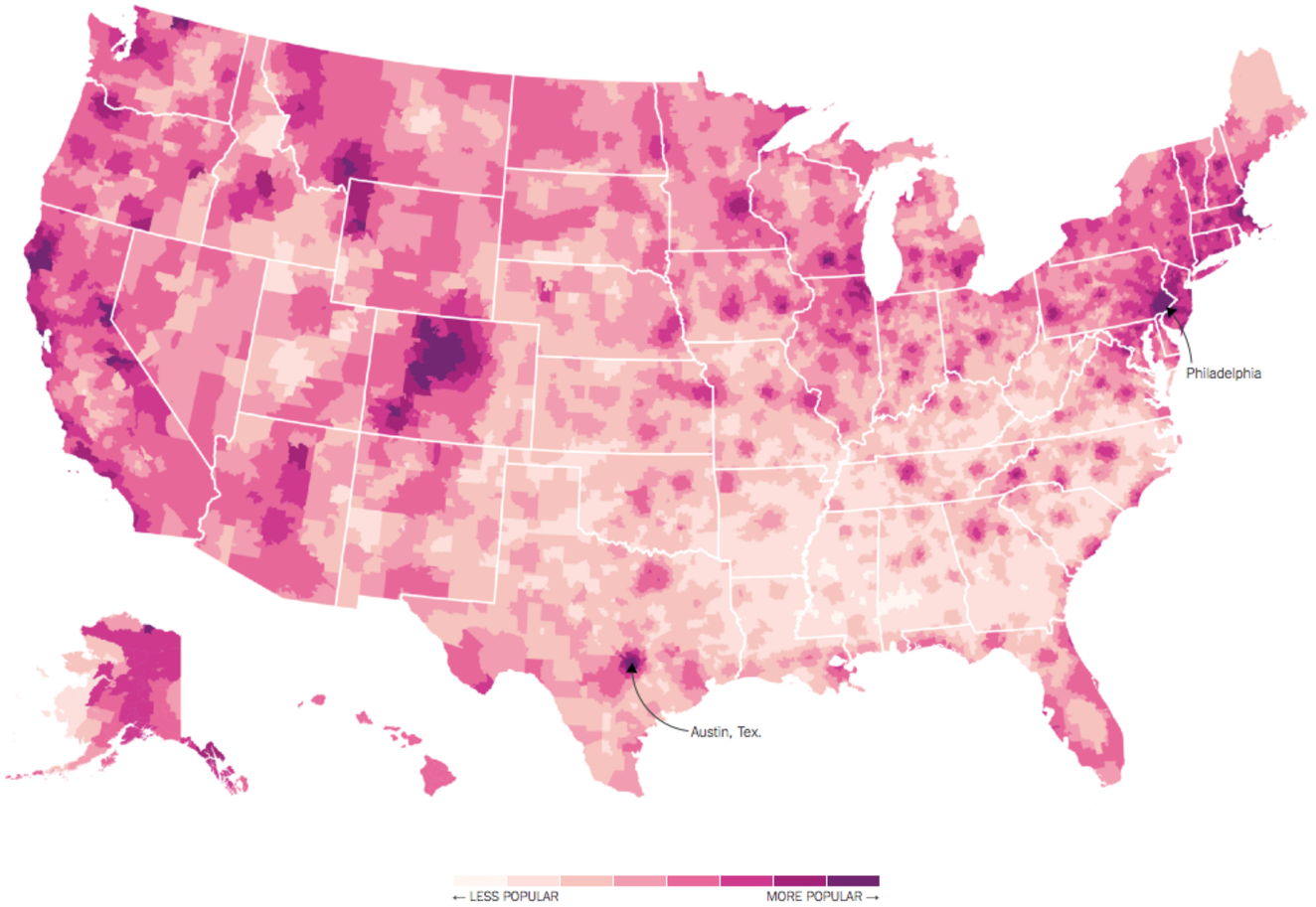
If you had to guess how strongly a place supported Donald J. Trump in the election, would you rather know how popular 'Duck Dynasty' is there, or how George W. Bush did there in 2000? It turns out the relationship with the TV show is stronger.

That's how closely connected politics and culture can be.

The cultural divide largely falls along urban/rural lines. We saw a similar divide in November, with Hillary Clinton winning in cities,

http://www.nytimes.com/interactive/2016/12/26/upshot/duck-dynasty-vs-modern-family-television-maps.html

20. It's Always Sunny in Philadelphia

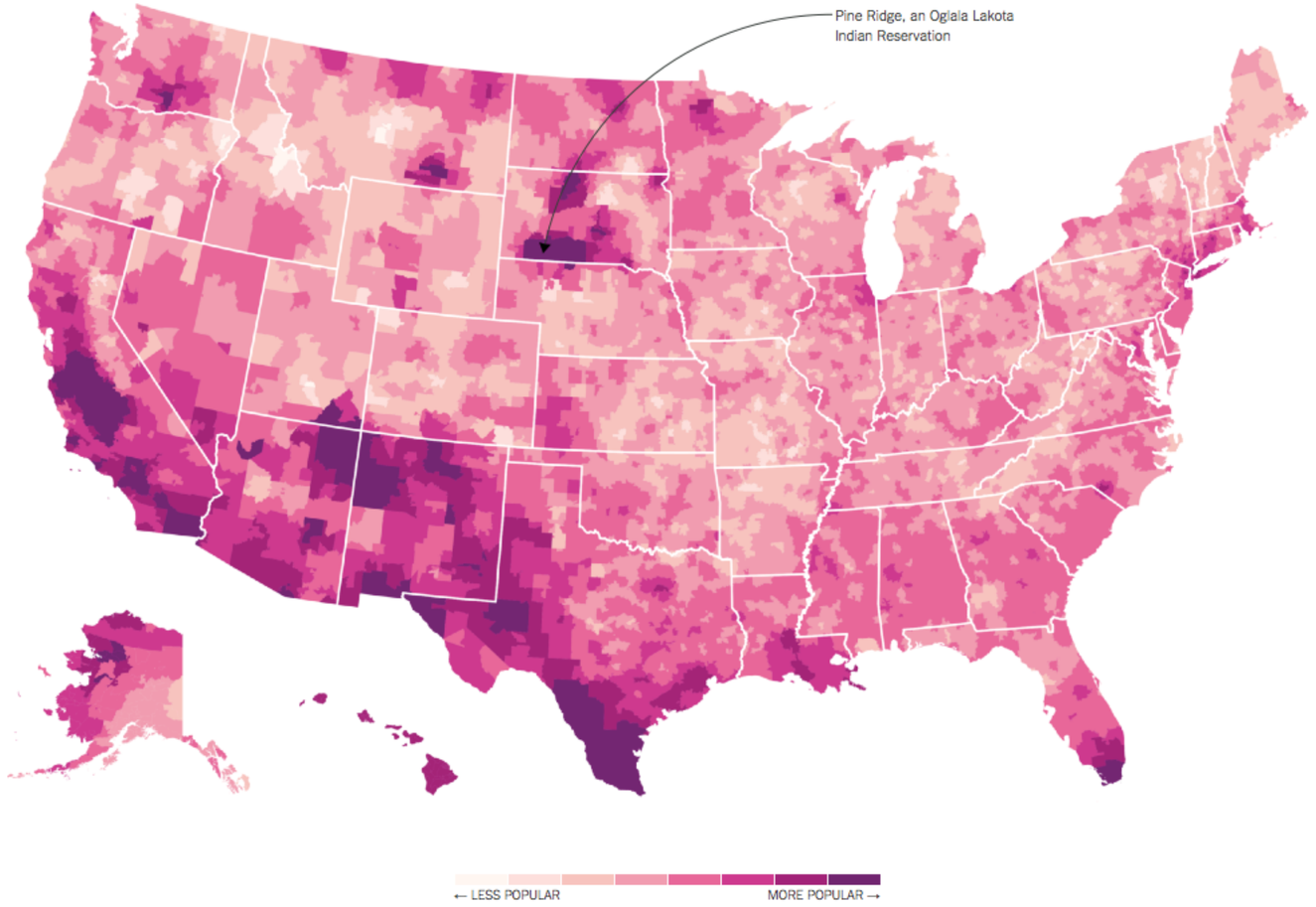


Danny DeVito is one of the gang in "It's Always Sunny in Philadelphia," an oddball and satirical sitcom set in South Philadelphia. It's generally more popular in college towns (and most popular in Philadelphia).

MOST SIMILAR	LEAST SIMILAR
The Daily Show	Teen Mom
Modern Family	16 and Pregnant
Saturday Night Live	Duck Dynasty

http://www.nytimes.com/interactive/2016/12/26/upshot/duck-dynasty-vs-modern-family-television-maps.html

29. Keeping Up With the Kardashians

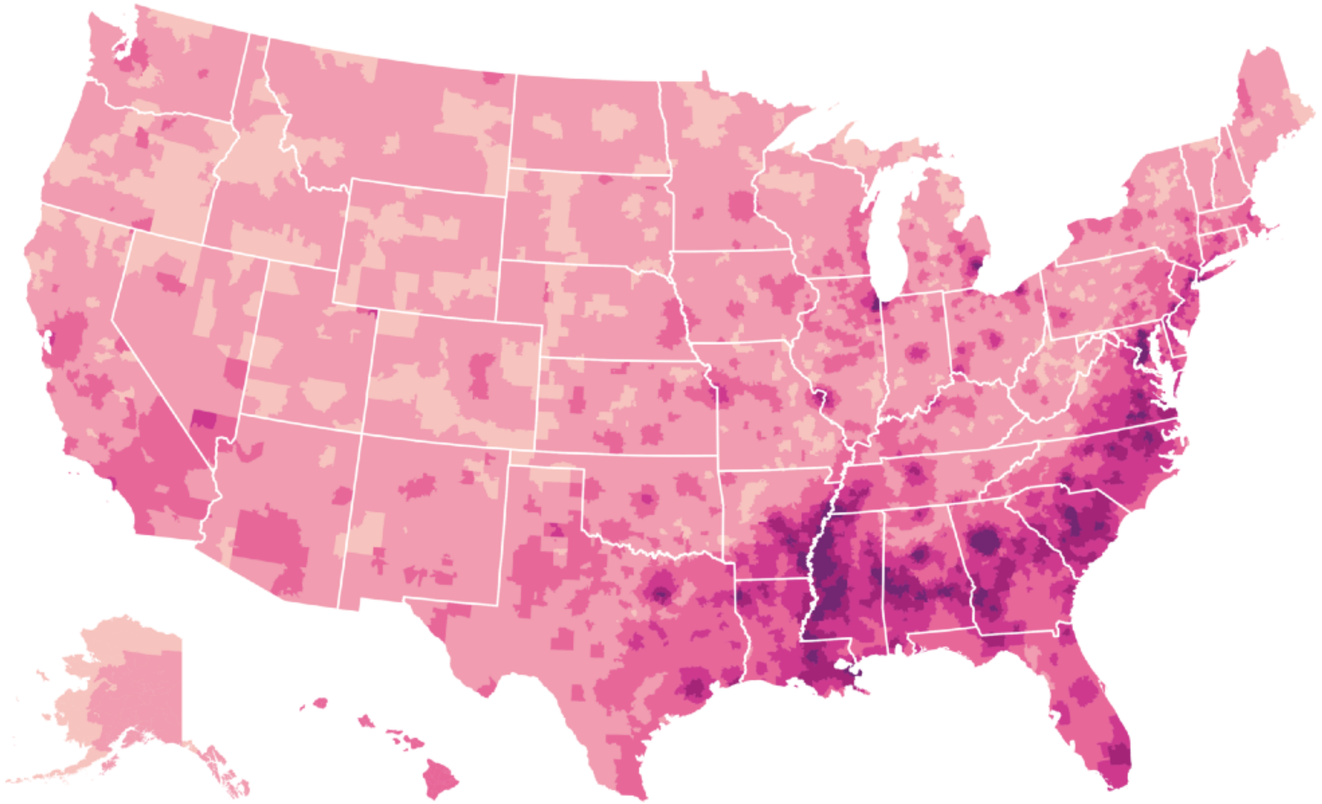


"Keeping Up with the Kardashians" on the E! cable network follows the Kardashian-Jenner family. It has been keeping up with Kim, Khloe, Kourtney and the others since 2007. The show tends to be most popular in areas with large Hispanic populations, particularly in the Southwest.

MOST SIMILAR	LEAST SIMILAR
Empire	Bones
Love & Hip Hop	Pawn Stars
106 & Park	NCIS

http://www.nytimes.com/interactive/2016/12/26/upshot/duck-dynasty-vs-modern-family-television-maps.html

30. Scandal



← LESS POPULAR MORE POPULAR →

"Scandal," produced by Shonda Rhimes, who also produced "Grey's Anatomy," displays the classic pattern of a show popular with a black audience. The show follows the story of Olivia Pope, a crisis manager and independent consultant in Washington, D.C.

MOST SIMILAR

Real Housewives of Atlanta

Empire

106 & Park

LEAST SIMILAR

Supernatural

Rob Dyrdek's Fantasy Factory

Ridiculousness

http://www.nytimes.com/interactive/2016/12/26/upshot/duck-dynasty-vs-modern-family-television-maps.html

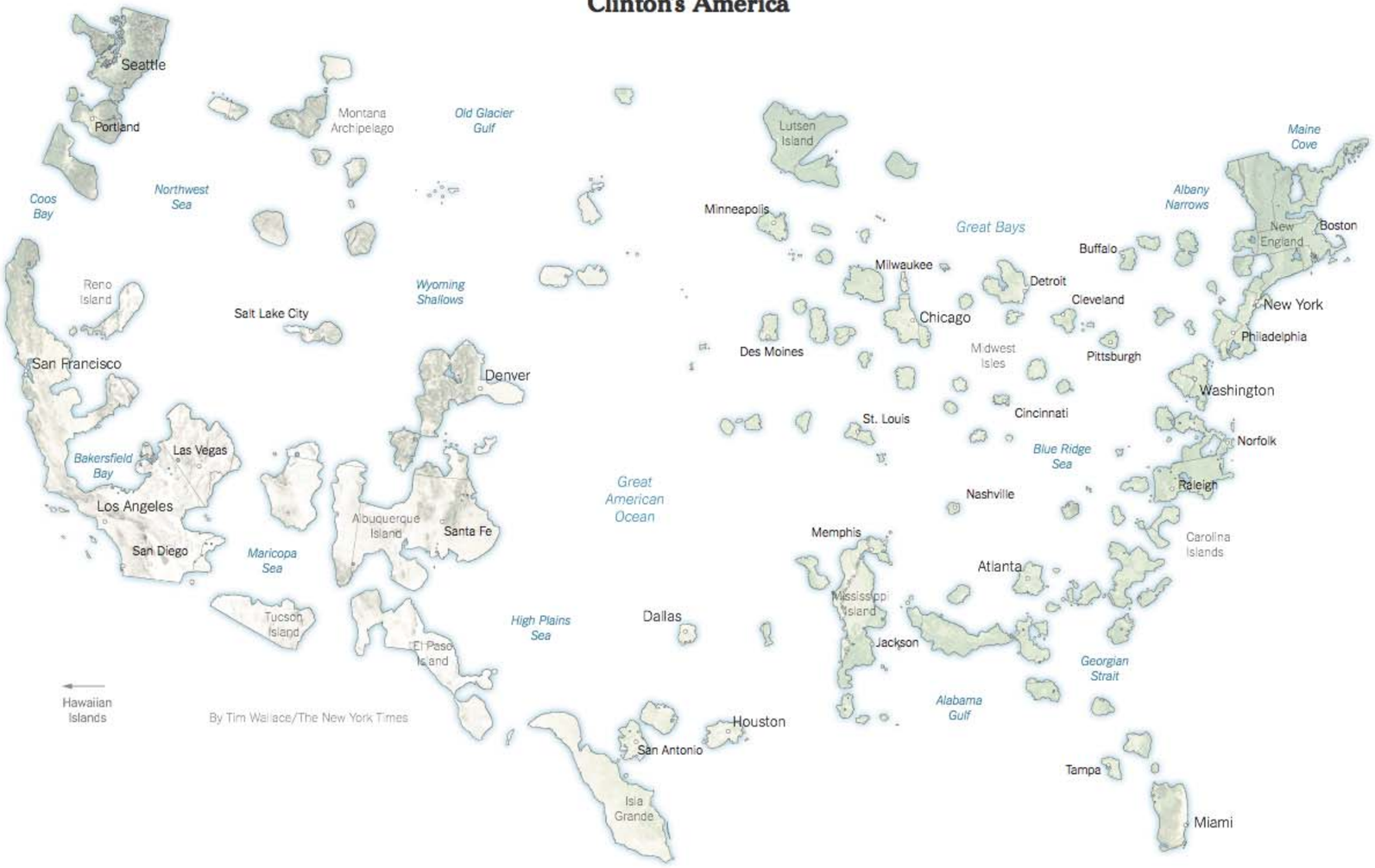
The Two Americas of 2016

By TIM WALLACE NOV. 16, 2016

For many Americans, it feels as if the 2016 election split the country in two.

To visualize this, we took the election results and created two new imaginary nations by slicing the country along the sharp divide between Republican and Democratic Americas.

Clinton's America



http://www.nytimes.com/interactive/2016/11/16/us/politics/the-two-americas-of-2016.html

The Two Americas of 2016

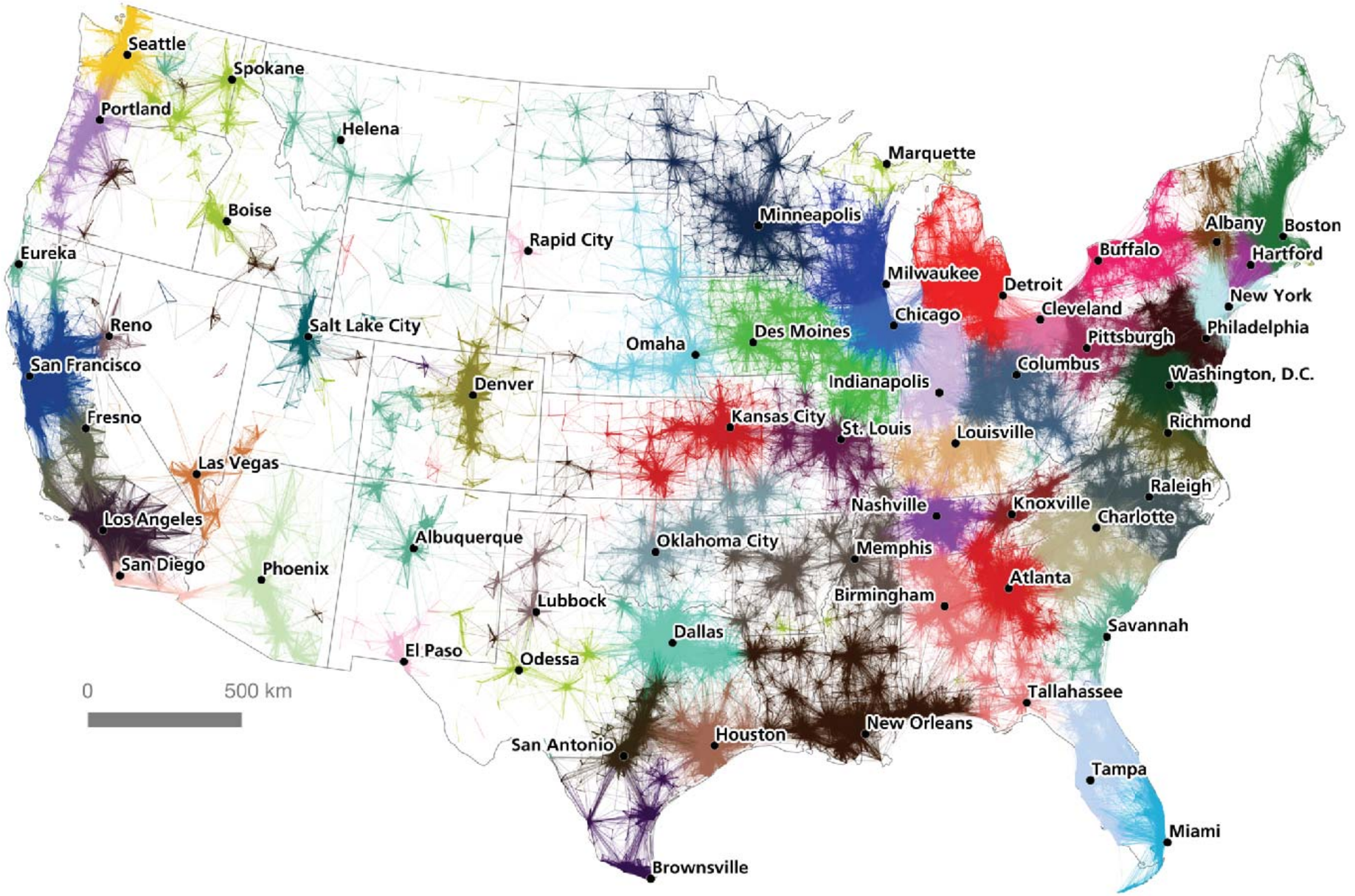
By TIM WALLACE NOV. 16, 2016

For many Americans, it feels as if the 2016 election split the country in two.

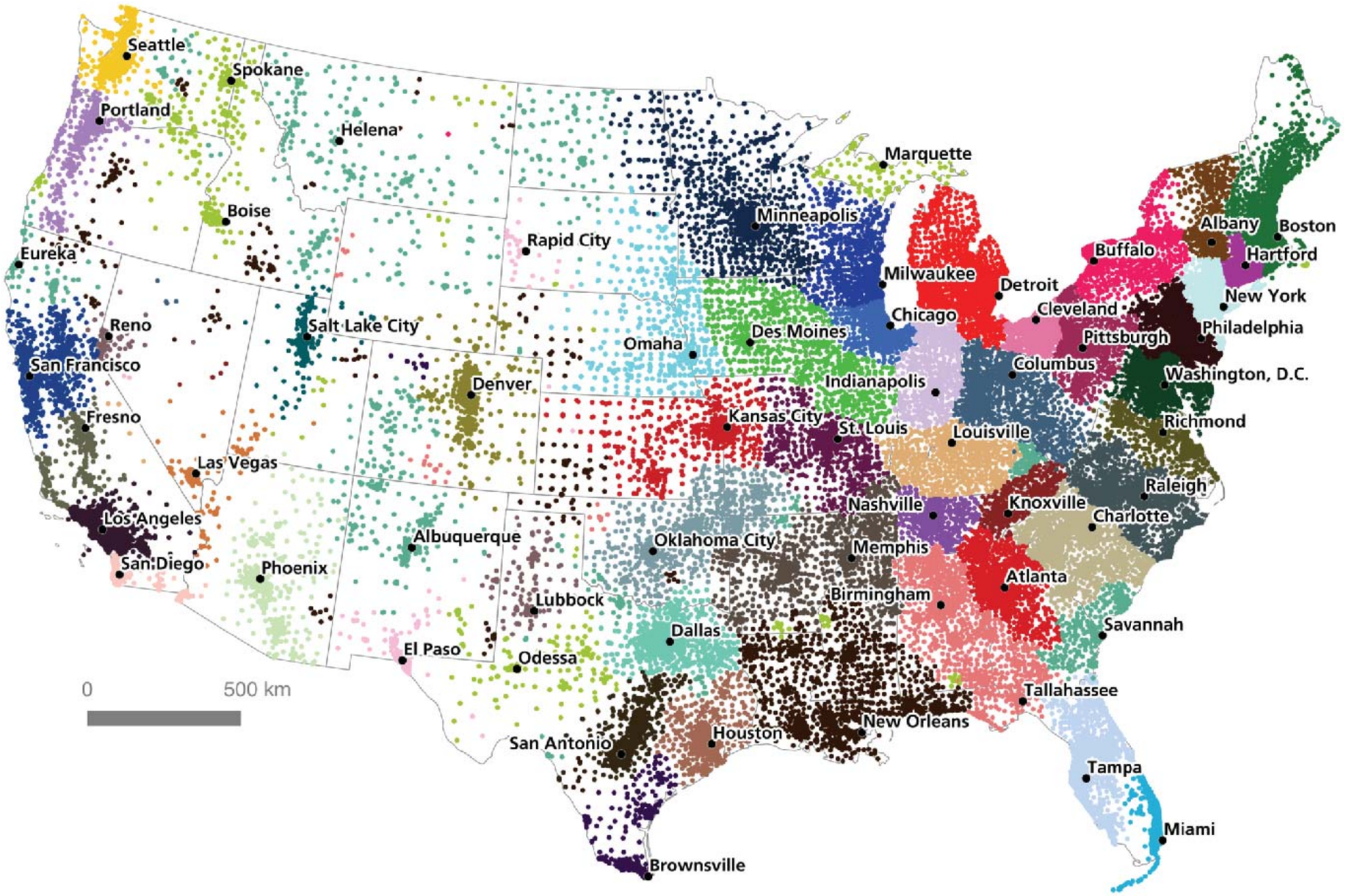
To visualize this, we took the election results and created two new imaginary nations by slicing the country along the sharp divide between Republican and Democratic Americas.

Trump's America

http://www.nytimes.com/interactive/2016/11/16/us/politics/the-two-americas-of-2016.html



Nelson, G. D., & Rae, A. (2016). An Economic Geography of the United States: From Commutes to Megaregions. Plos One



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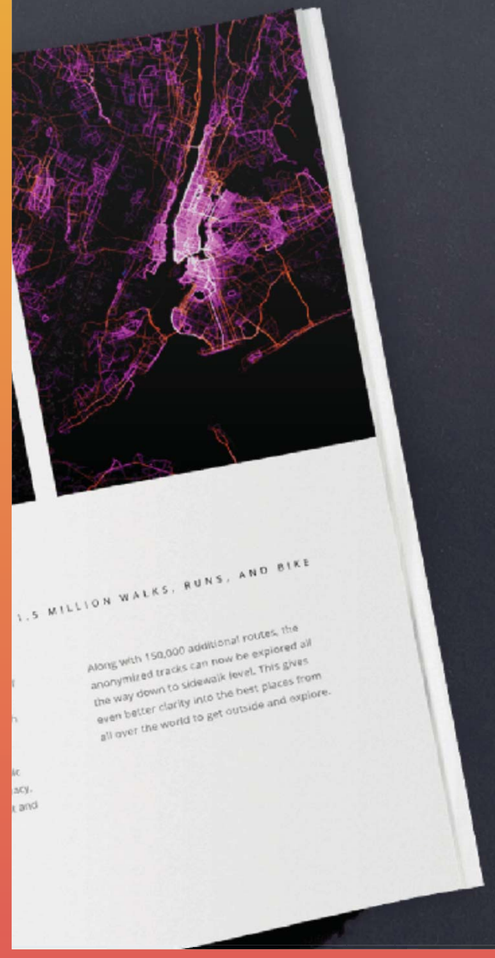
MAPBOX

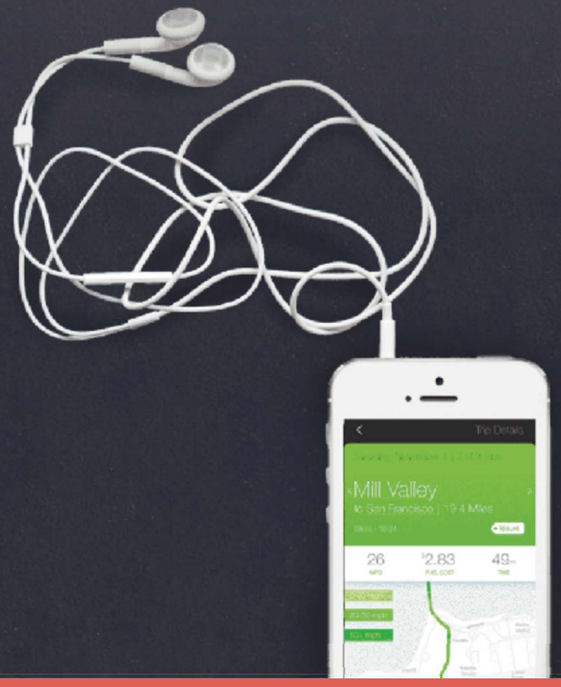
ABOUT US

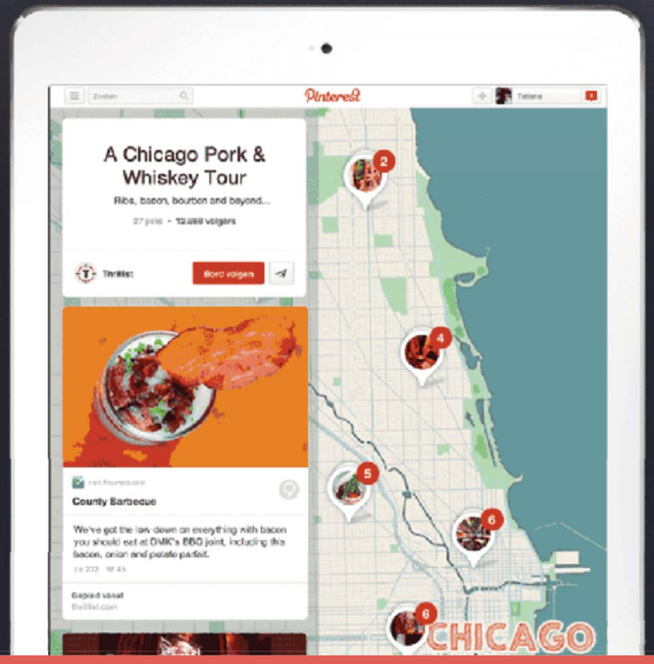
Mapbox is a mapping platform for developers. Our building blocks make it easy to integrate location into any mobile or online application. We want to change the way people move around cities and understand our planet.

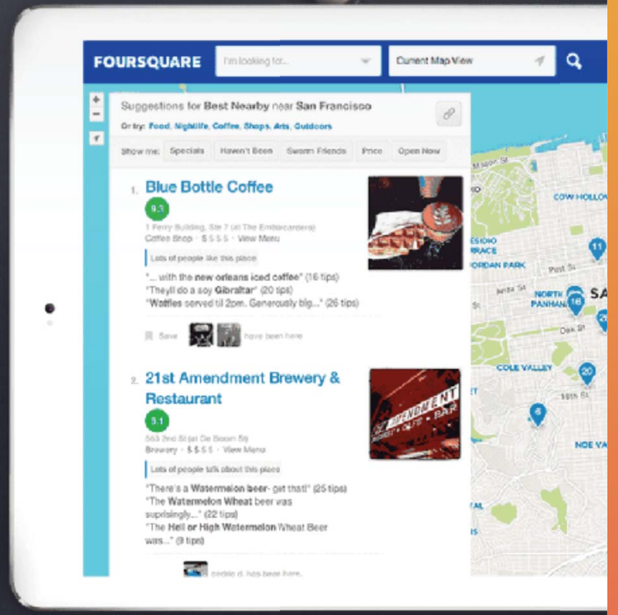
From finding a coffee spot on Foursquare, to pinning a vacation spot on Pinterest, to geo-tagging notes in Evernote – we do the geo stuff so developers can focus on building their app. Mapbox is the foundation for other platforms, letting enterprises analyze their data, drone companies publish flyovers, real estate sites visualize properties, satellite companies process cloud-free imagery, and insurance companies track assets.

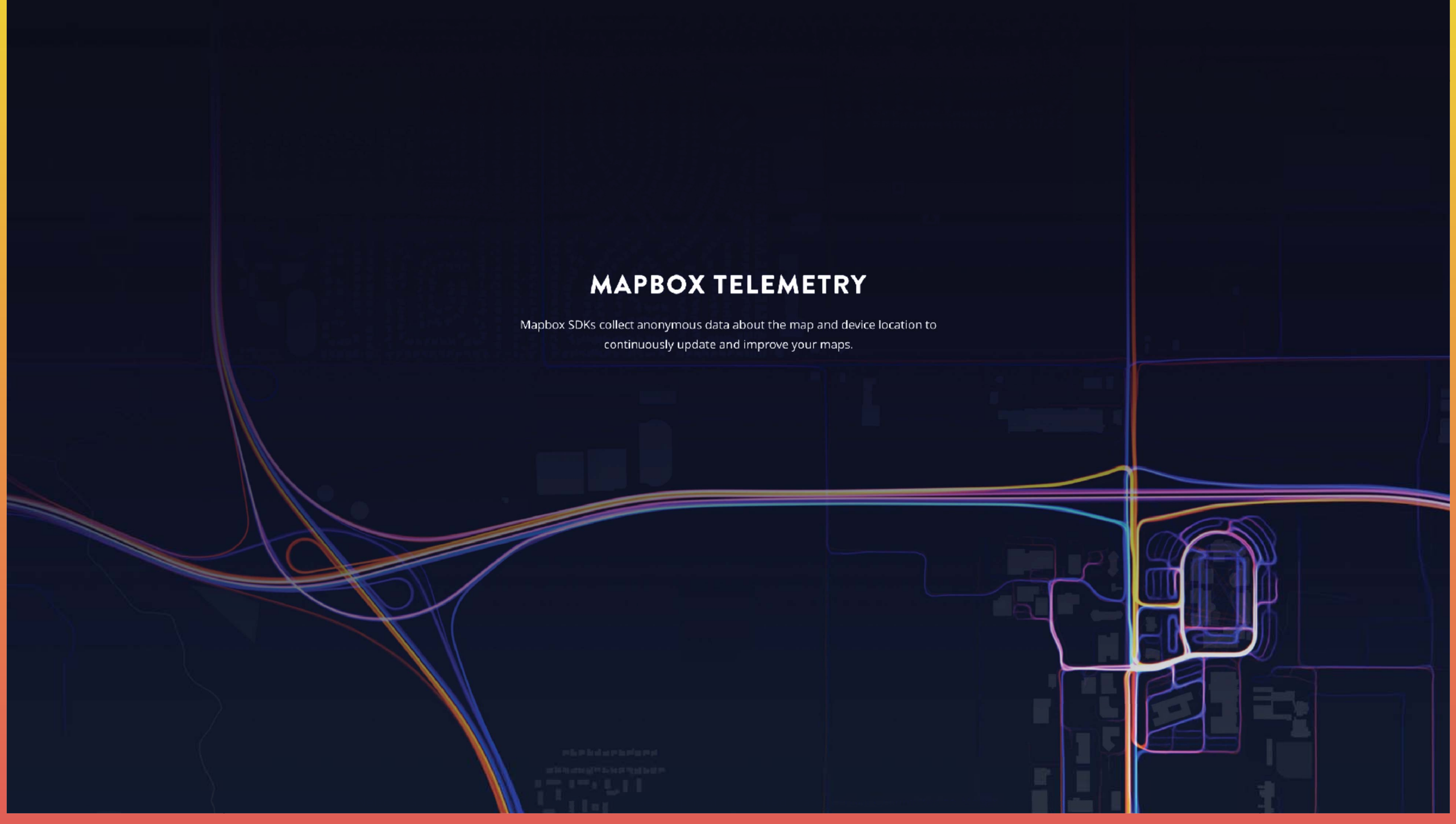
Mapbox is an open source company. We build our product with open source parts, work in the open, and release as much code as possible – it's the right thing for people, technology, and business.

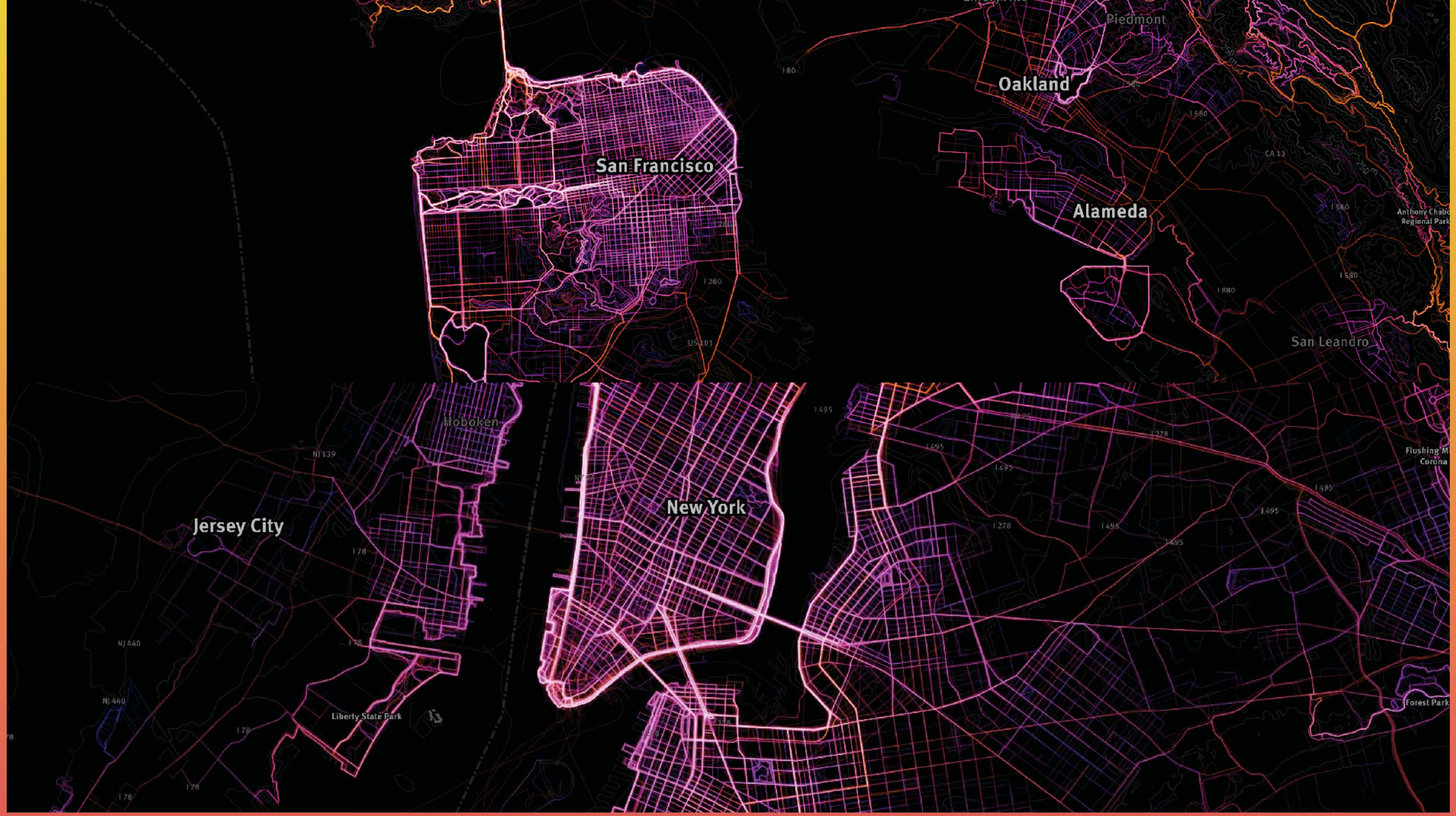









MAPBOX TELEMETRY
Mapbox SDKs collect anonymous data about the map and device location to continuously update and improve your maps.


Piedmont
Oakland
San Francisco
Alameda
San Leandro
Hoboken
Jersey City
New York
Liberty State Park
Forest Park
Flushing M
Corona
Anthony Chabo
Regional Park
I 80
I 580
CA 13
I 280
US 101
I 880
I 495
I 278
I 78
NJ 139
NJ 440

Mapbox Streets data

The best underlying street and place data is updated every minute across our entire platform.

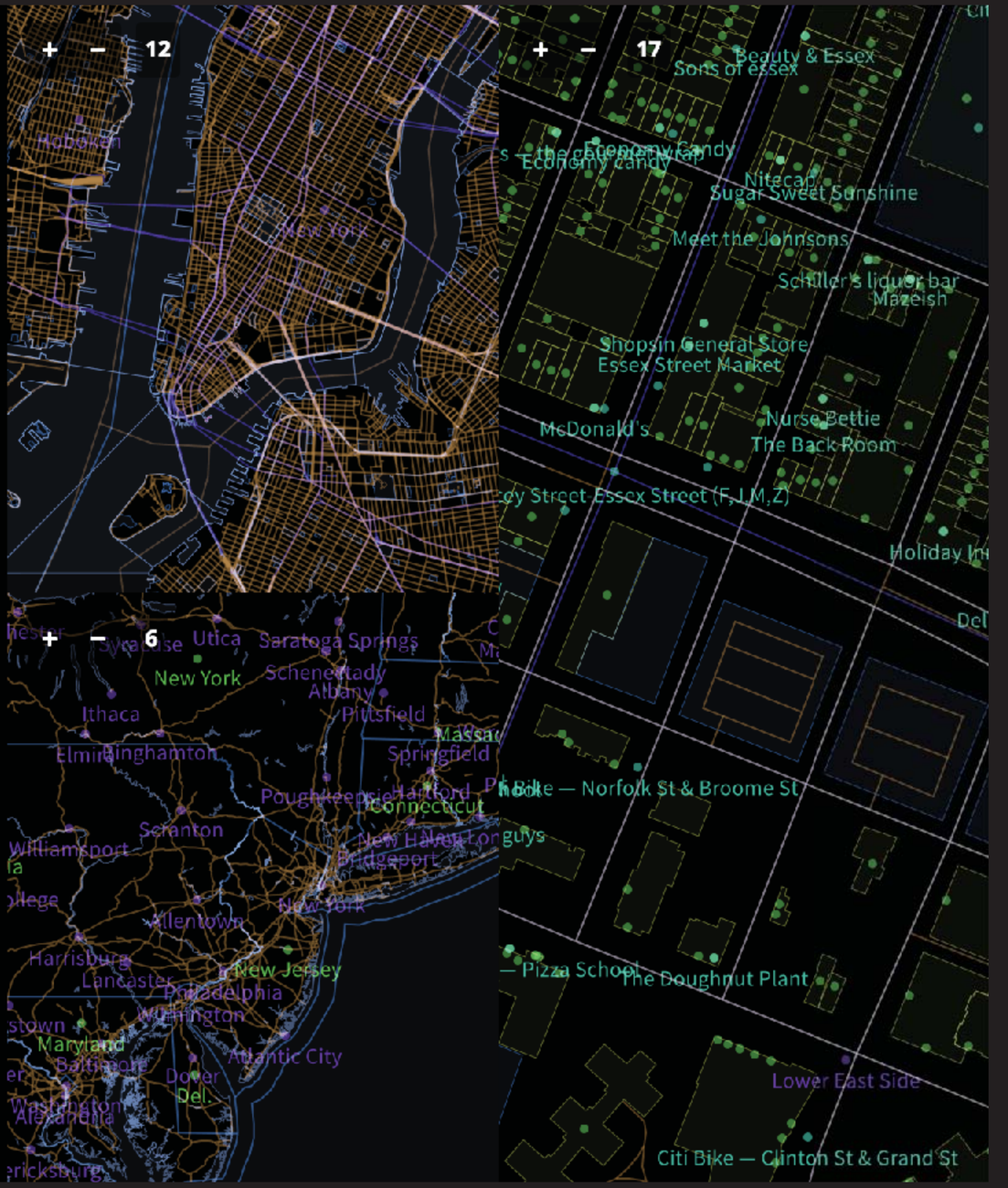
Toggle style

Layers

- landuse
- water
- barrier_line
- landuse_overlay
- road
- admin
- country_label
- state_label
- water_label
- road_label
- housenum_la...
- waterway
- aeroway
- building
- tunnel
- bridge
- country_label_...
- marine_label
- place_label
- poi_label
- waterway_label

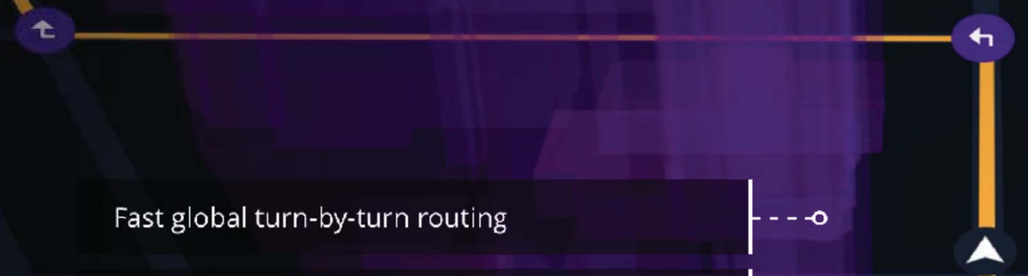
Mapbox Streets documentation ➜

Map data © OpenStreetMap

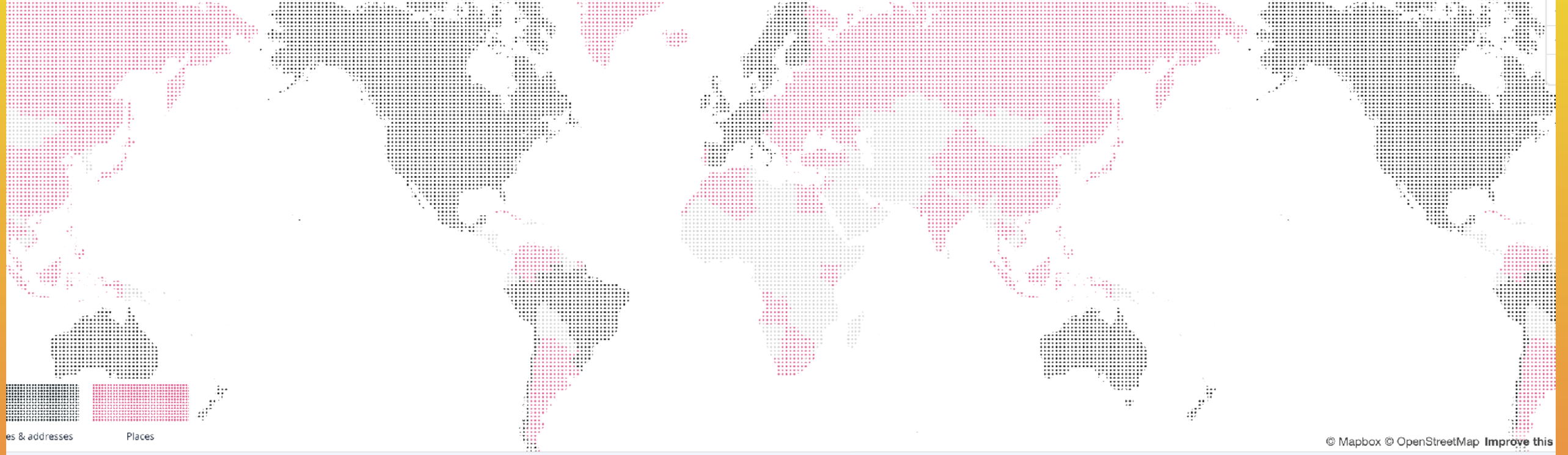


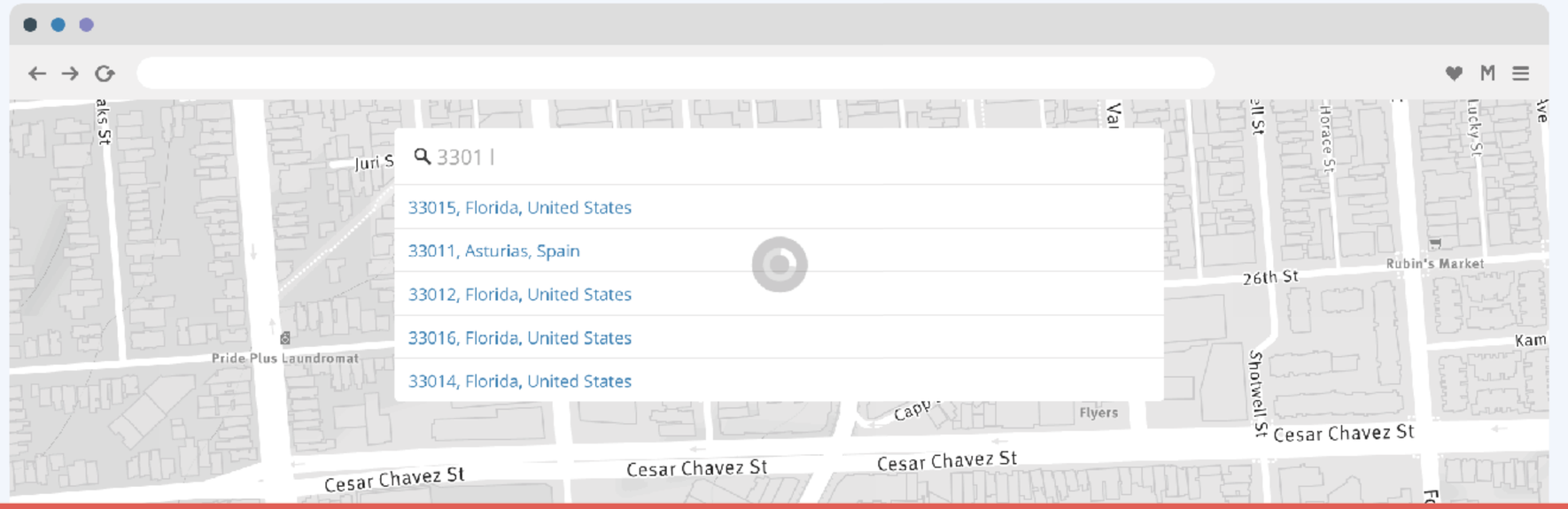
Directions

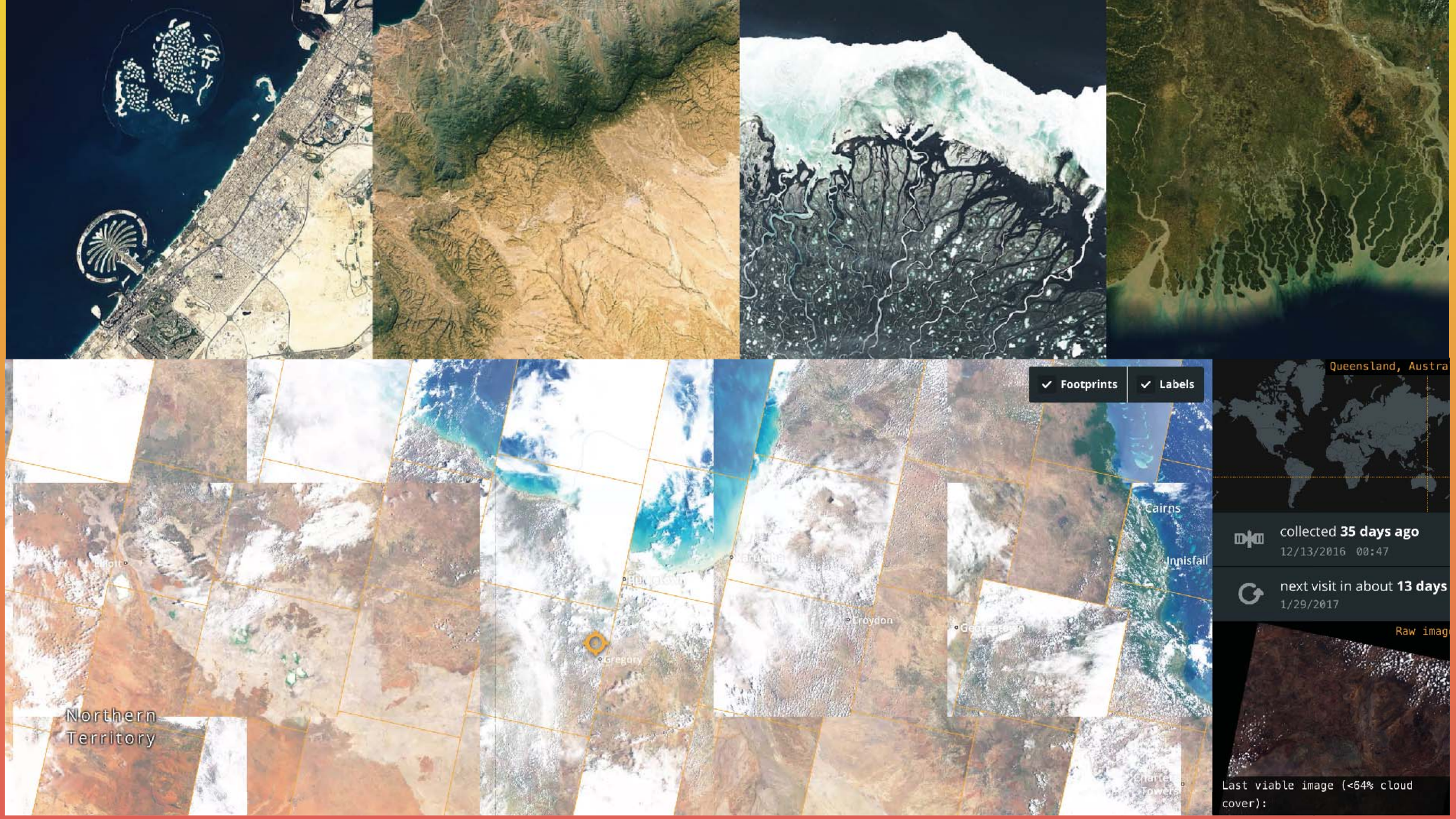
Instantly find the best route to your destination, avoid traffic and navigate turn-by-turn with natural voice and text instructions.

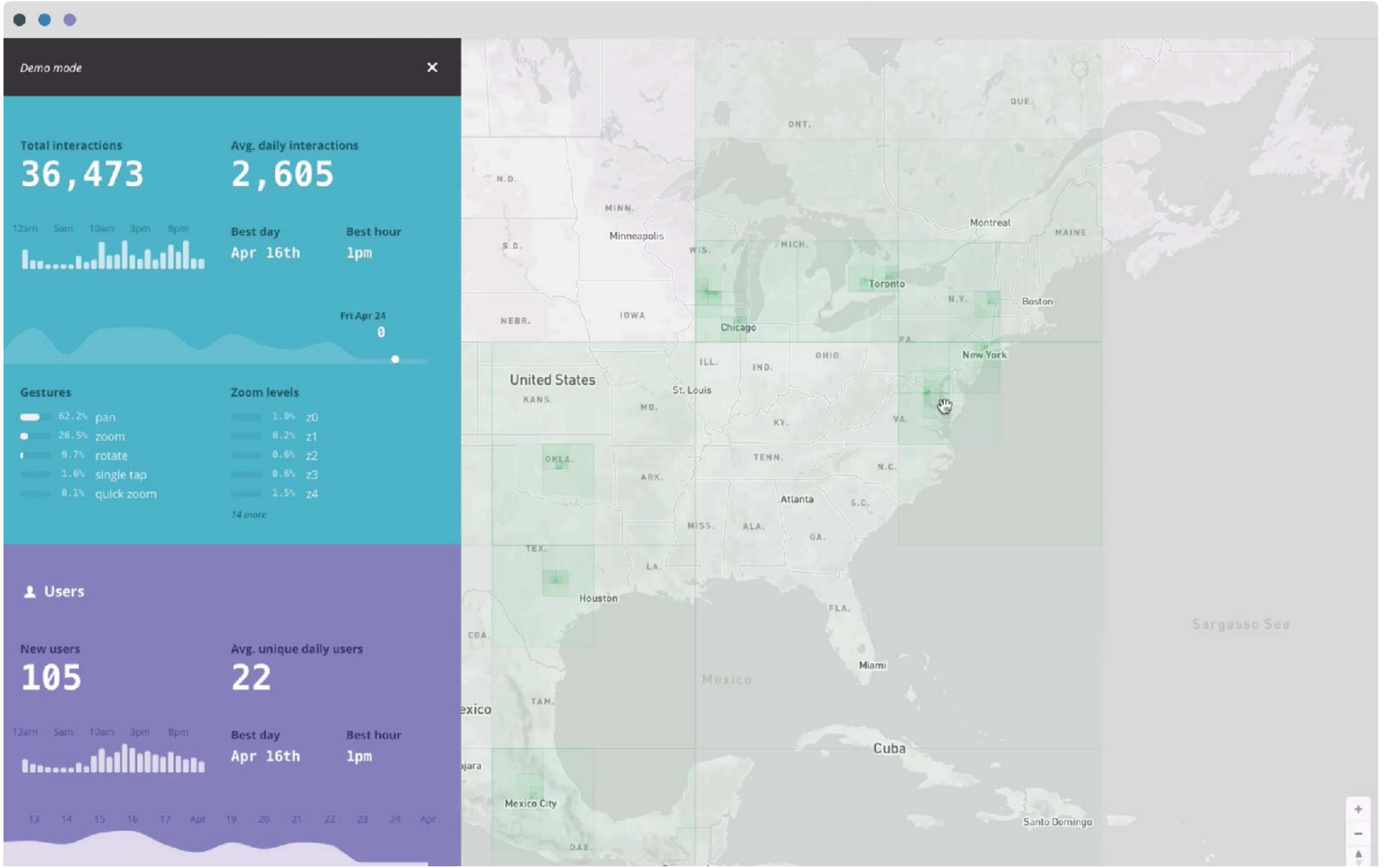


- Fast global turn-by-turn routing
- Designed to avoid traffic on everyday routes
- Advanced lane guidance for complex interchanges
- Online and offline capable
- Fully customizable to fleet characteristics


es & addresses
Places
© Mapbox © OpenStreetMap Improve this


3301 I
33015, Florida, United States
33011, Asturias, Spain
33012, Florida, United States
33016, Florida, United States
33014, Florida, United States
Pride Plus Laundromat
Rubin's Market
26th St
Shotwell St
Cesar Chavez St
Cesar Chavez St
Cesar Chavez St
Cesar Chavez St
Flyers
Horace St
Lucky St

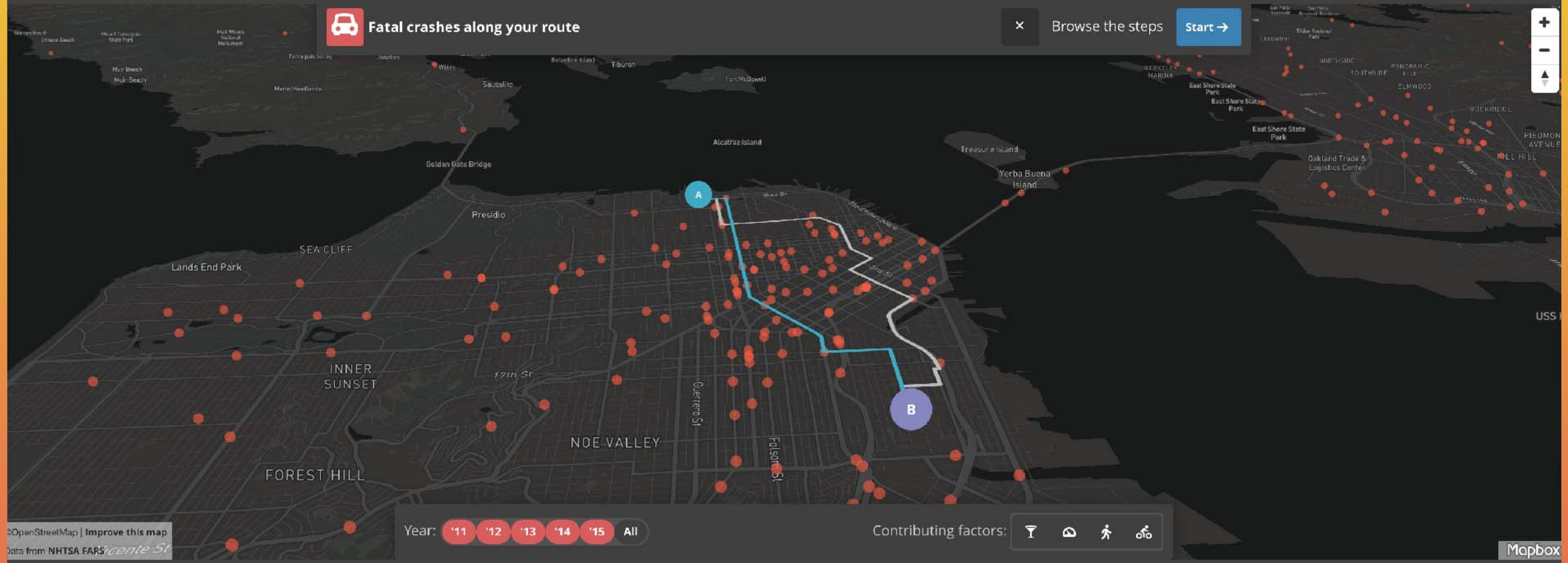

Footprints
Labels
Queensland, Austra
Cairns
Innisfail
Gregory
Croydon
Northern Territory
collected 35 days ago
12/13/2016 00:47
next visit in about 13 days
1/29/2017
Raw imag
Last viable image (<64% cloud cover):


Demo mode
Total interactions
36,473
Avg. daily interactions
2,605
12am 5am 10am 3pm 8pm
Best day
Apr 16th
Best hour
1pm
Fri Apr 24
0
Gestures
62.2% pan
26.5% zoom
9.7% rotate
1.6% single tap
0.1% quick zoom
Zoom levels
1.0% z0
0.2% z1
0.6% z2
0.6% z3
1.5% z4
14 more
Users
New users
105
Avg. unique daily users
22
12am 5am 10am 3pm 8pm
Best day
Apr 16th
Best hour
1pm
13 14 15 16 17 Apr 19 20 21 22 23 24 Apr
QUE.
ONT.
N.D.
MINN.
Minneapolis
S.D.
WIS.
MICH.
Montreal
MAINE
Toronto
N.Y.
Boston
NEBR.
IOWA
Chicago
PA.
New York
ILL.
IND.
OHIO
United States
KANS.
St. Louis
MO.
KY.
VA.
OKLA.
TENN.
N.C.
ARK.
Atlanta
S.C.
MISS.
ALA.
GA.
TEX.
LA.
Houston
FLA.
COA.
Sargasso Sea
Miami
Mexico
TAM.
Cuba
Mexico City
Santo Domingo
DAX.

MAPBOX CITIES

We're working with three cities that are ready to take on their most pressing issues through data.

Learn more


Fatal crashes along your route
Browse the steps
Start →
A
B
Golden Gate Bridge
Alcatraz Island
Treasure Island
Yerba Buena Island
Presidio
SEACLIFF
Lands End Park
INNER SUNSET
NOE VALLEY
FOREST HILL
Sausalito
Tiburon
Belvedere Island
Oakland Trade & Logistics Center
East Shore State Park
Year: '11 '12 '13 '14 '15 All
Contributing factors:
OpenStreetMap | Improve this map
Data from NHTSA FARS
Mapbox

A smarter city: partnering with Melbourne to solve complex urban challenges

By Christina Franken on January 13 2017 | NEWS

cities | open data | transportation | telemetry

Melbourne is changing the way cities are run. Australia's fastest growing city's Smart City Office has a clear vision: *to enhance the aspects of our city that make us uniquely Melbourne, and intelligently prepare for the changing needs of the community, the environment, and the economy*. That's exactly the kind of innovative thinking we launched Mapbox Cities to help support, and we're very excited to announce Melbourne as our first featured partner.

https://www.mapbox.com/blog/mapbox-cities-melbourne/

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Facts about Melbourne

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CityLab

IBM Smarter Cities Challenge 2016

Free wi-fi

Multicultural communities

Suburbs

Melbourne as a smart city

Our vision for Melbourne as a smart city is simple: to enhance the aspects of our city that make us uniquely Melbourne, and intelligently prepare for the changing needs of the community, the environment and the economy.

We're not in the business of rolling out technology's latest bells and whistles for the sake of it. Instead, we're working with the community (residents, workers, businesses, students and visitors) to design, develop and test the best ways for you to live, work and play in Melbourne. In many cases, innovations in technology will have a role to play in creating and enhancing these experiences.

As a smart city, we're already off and running. We're prototyping tailor-made initiatives such as our work with people who are blind, deaf or deaf-blind to better understand how they navigate through the city. As a result of this research, we've partnered with Vision Australia to trial beacon technology in Campbell Arcade, which transmits location-specific information to phones. And our Open Data platform has almost 100 unique data sets that are available for anyone to access and use, such as our 24-hour pedestrian counting system, which helps us understand

Report an issue

I want to...

See City of Melbourne's maps

Explore Melbourne's suburbs

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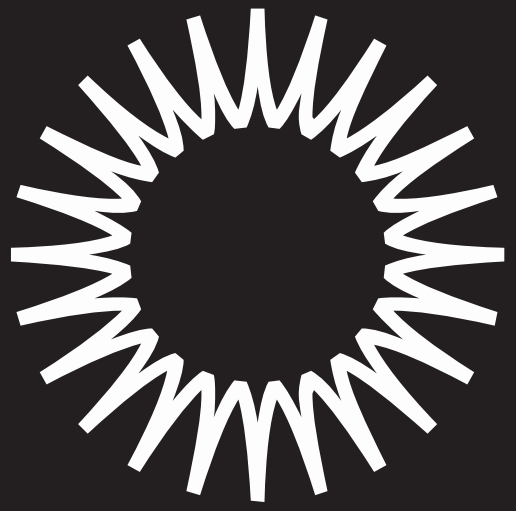
MAPBOX



SPUR

Ideas + Action for a Better City

learn more at SPUR.org

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#FutureOfLocationing