

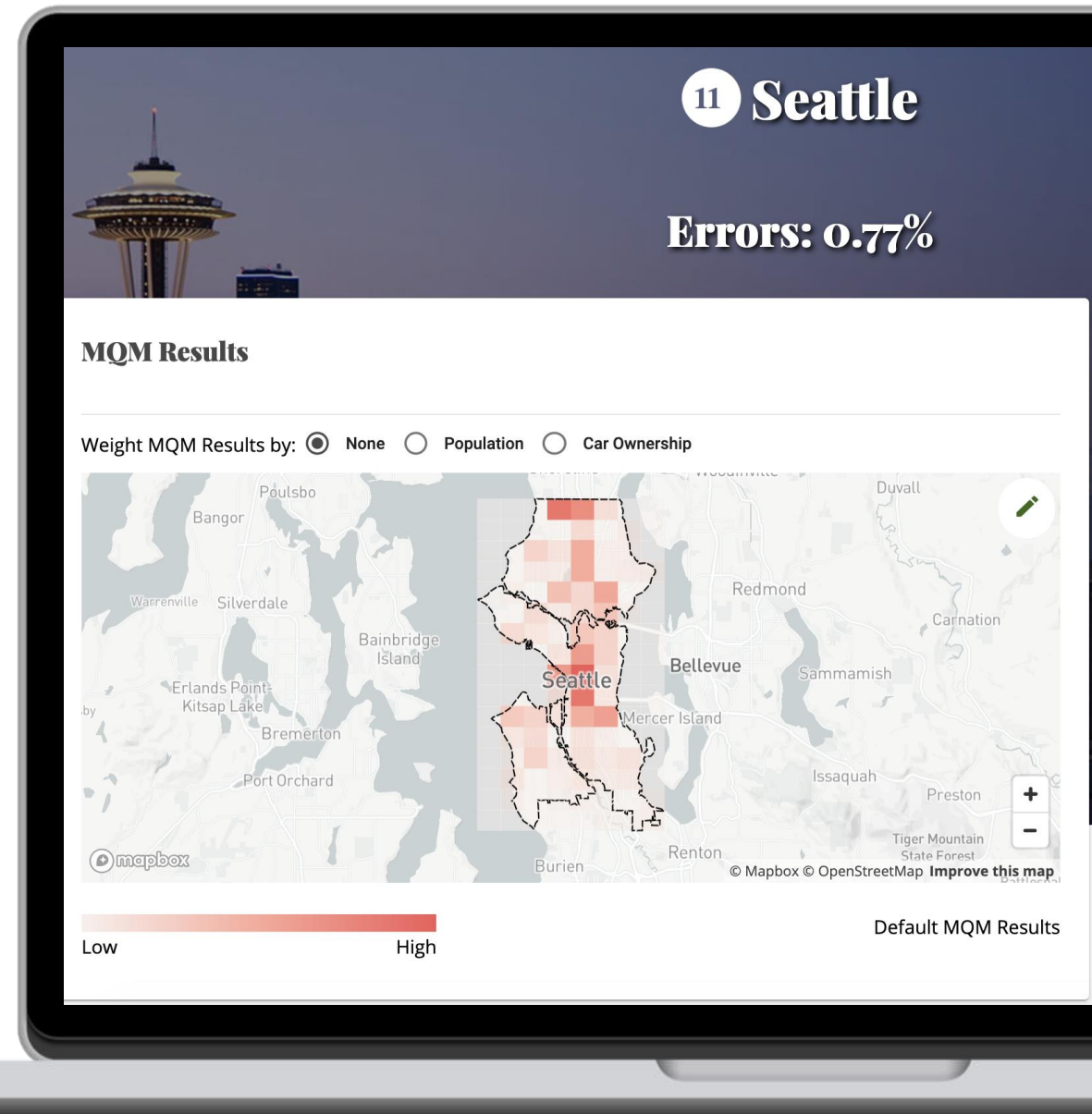
CRITIGEN

MAP QUALITY MEASUREMENTS (MQM)

US Cities Road Data Quality on OpenStreetMap

CUGOS – Fall Fling 2019

Monica Brandeis, Senior GIS/Data Analyst
Critigen



OSM Data Integrity Assurance



Rule-Based Validation

- Finding Data Inconsistency (map errors)
 - Geometry-based
 - Attribute -based

Geometry-Based Map Error

Minneapolis BuildingRoadIntersectionCheck

Minneapolis Checks | [Contact Owner](#) | [Inspect](#)

INSTRUCTIONS

- Building (id-92914739) intersects road (id-653969784), which is a SERVICE road. Please verify whether the intersection is valid or not.
- Building (id-92914739) intersects road (id-653969784), which is a SERVICE road. Please verify whether the intersection is valid or not.

COMPLETION

Add MR Tags

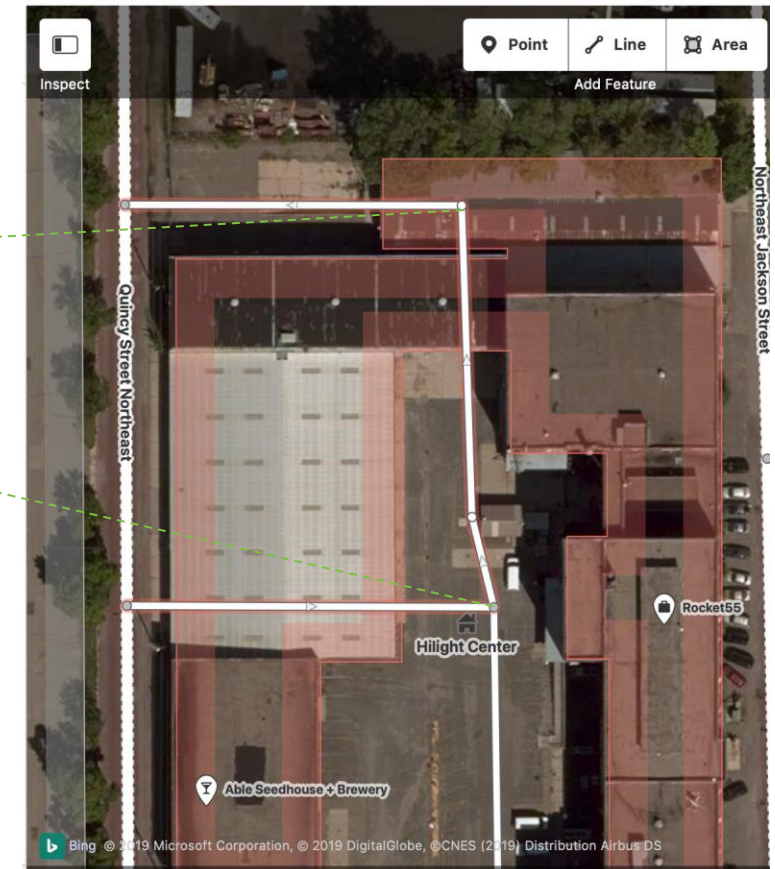
Current Editor: [Edit in ID \(web editor\)](#)

[Edit](#)[Not an Issue](#)[Skip](#)[Other...](#)

LOCATION

Minneapolis, Hennepin County, Minnesota, USA

Lon/Lat: -93.2505746,44.9996792



Attribute-Based Map Error

Minneapolis UnusualLayerTagsCheck

Minneapolis Checks | [Contact Owner](#) | [Inspect](#)

INSTRUCTIONS

1. Bridges must have a layer tag set to a value in [1, 5].

COMPLETION

Add MR Tags

Current Editor: [Edit in ID \(web editor\)](#)

Edit

Not an Issue

Skip

Other...

LOCATION

Minneapolis, Hennepin County, Minnesota, USA

Lon/Lat: -93.3188186,44.905368

Way: Xerxes Avenue (101471788)

TIGER name expansion

Edited over 6 years ago by [bot-mode](#)

Version #3 · Changeset #[15817968](#)

Tags

| | |
|-------------------|----------------|
| bridge | yes |
| highway | tertiary |
| name | Xerxes Avenue |
| name_1 | County Road 31 |
| ref | CR 31 |
| tiger:cfcc | A41 |
| tiger:name_base | Xerxes |
| tiger:name_base_1 | County Road 31 |
| tiger:name_type | Ave |
| tiger:reviewed | no |
| tiger:zip_left | 55431 |
| tiger:zip_right | 55431 |

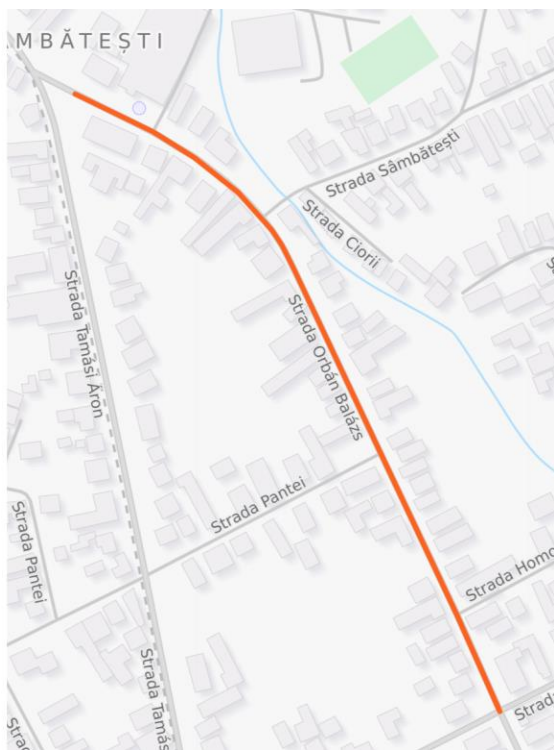
Atlas Checks



A java based program that systematically flags various types of map errors

Atlas Checks

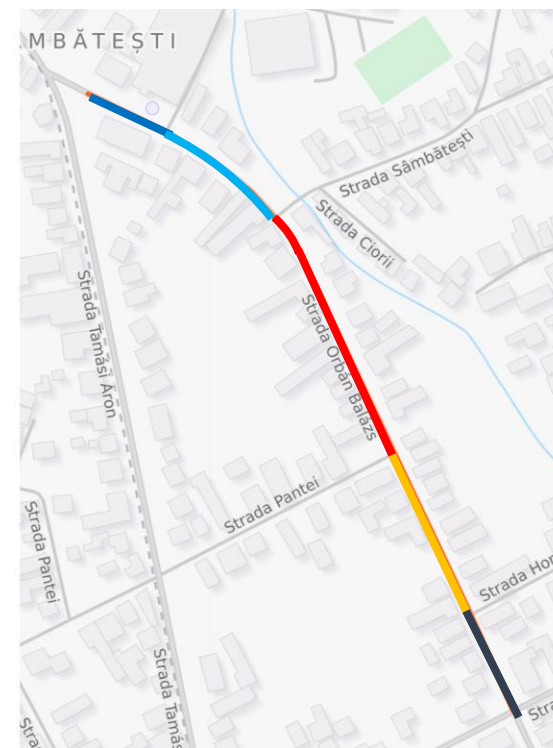
- ✓ In order to run, need turn OSM data into atlas (a connected graph representation of the road network)



1 OSM Road



CRITIGEN



5 Atlas Features

Where to focus first?

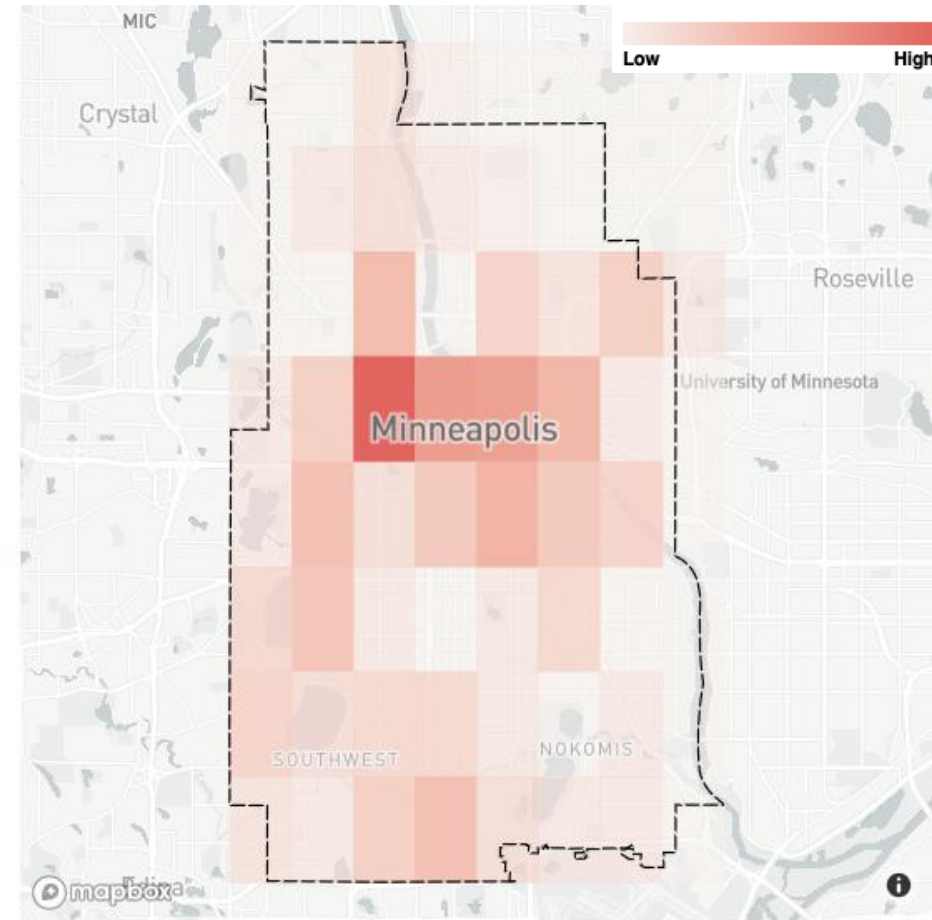
Sign Post Check

+ Unusual Layer Check

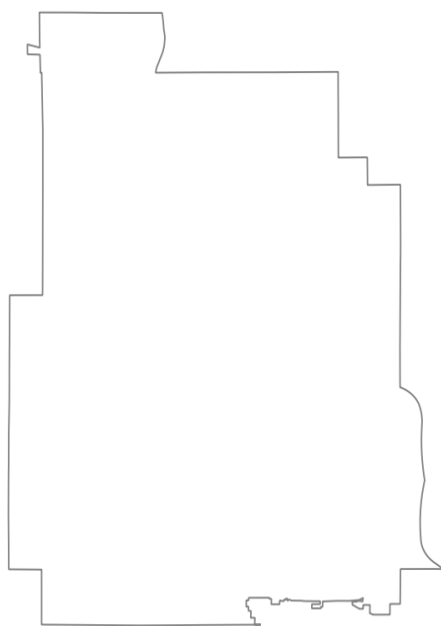
+ Invalid Access Tag Check

Map Quality Measurement (MQM) Tool

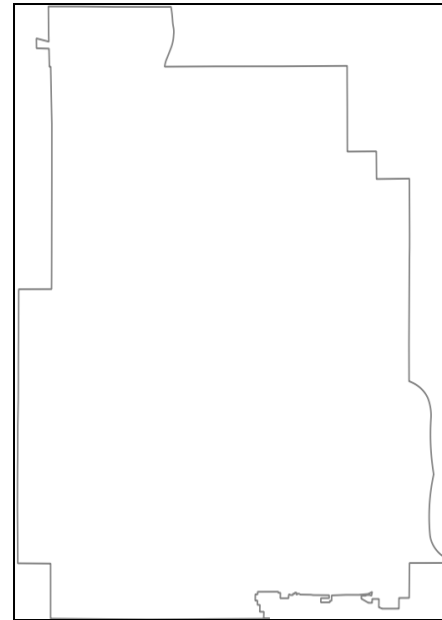
- ✓ A vector grid layer showing map error hotspots
- ✓ Grid size is determined by the distribution of map errors



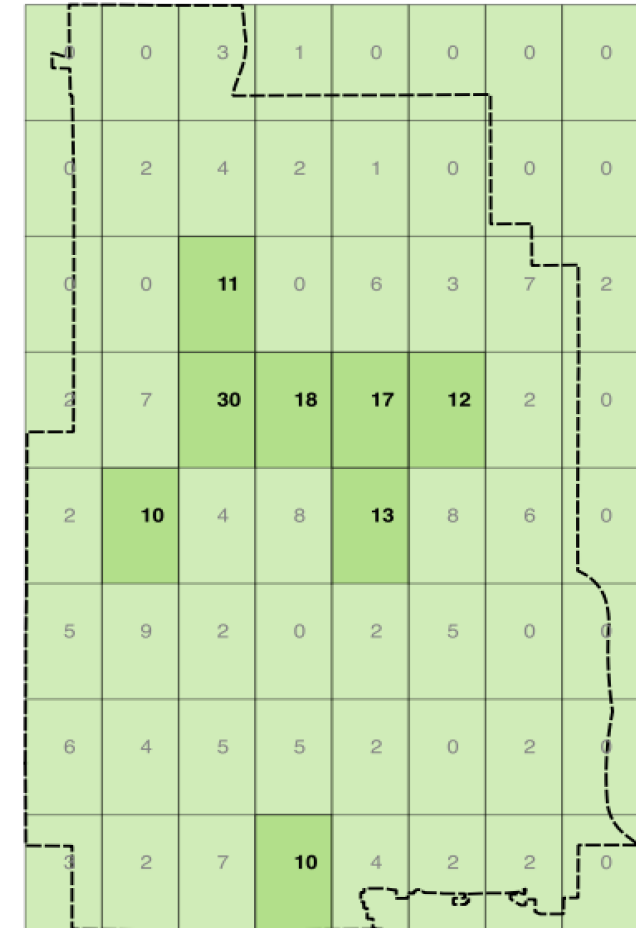
MQM Grids Generation



City Boundary

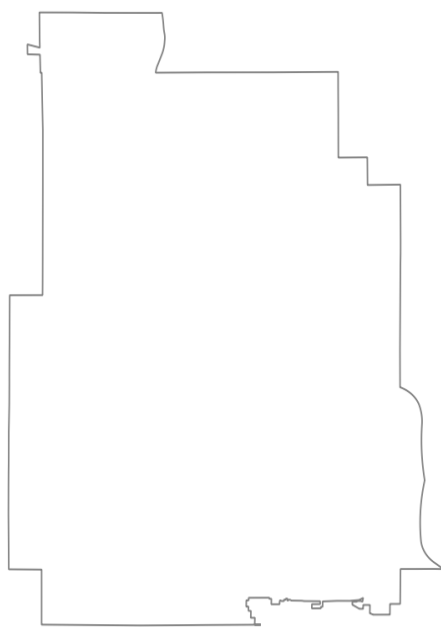


Generate Bounding Box

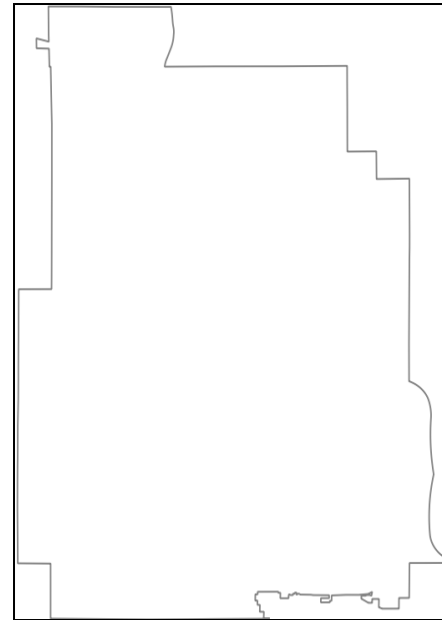


90% of grids have <10 errors on OSM features
10% of grids (HOTSPOT)

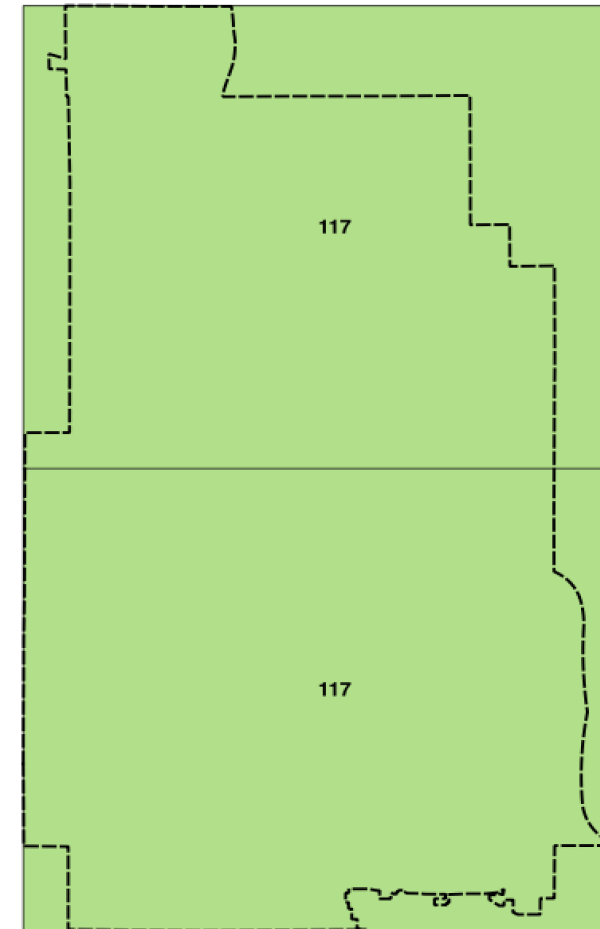
MQM Grids Generation



City Boundary

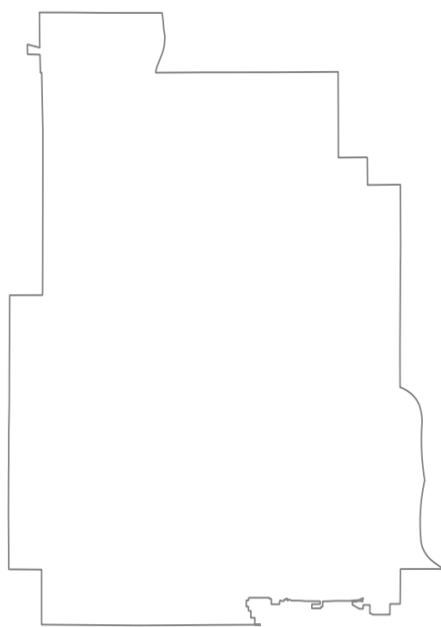


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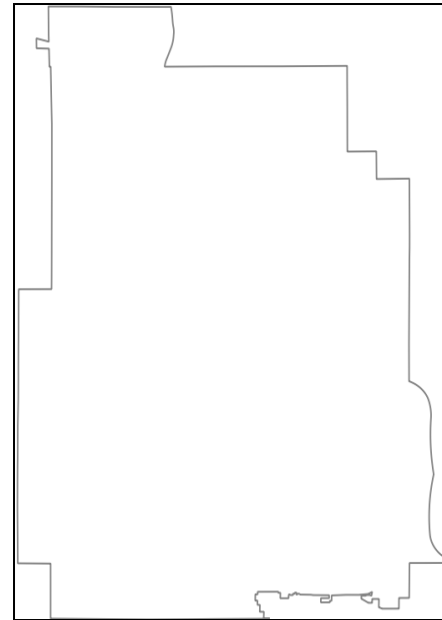


Recursively Divide it into half using K-D Tree

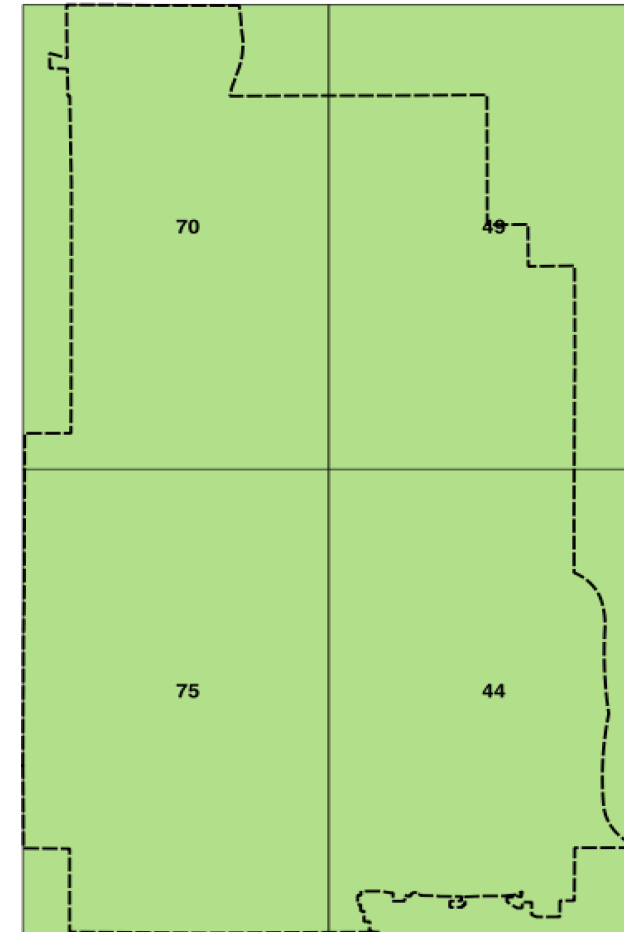
MQM Grids Generation



City Boundary

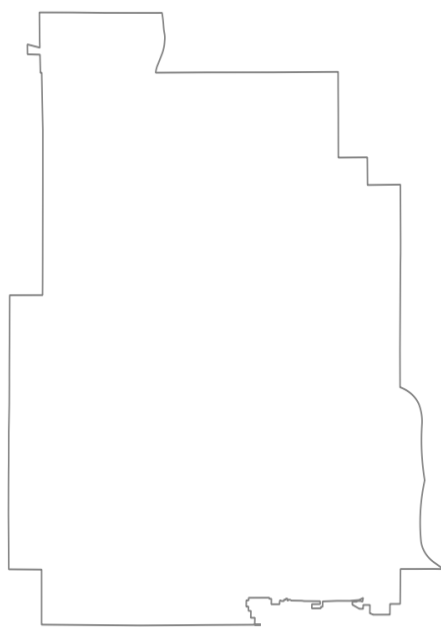


Generate Bounding Box

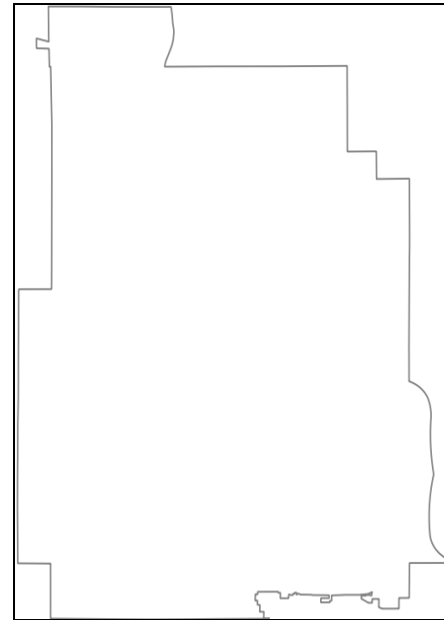


Recursively Divide it into half using K-D Tree

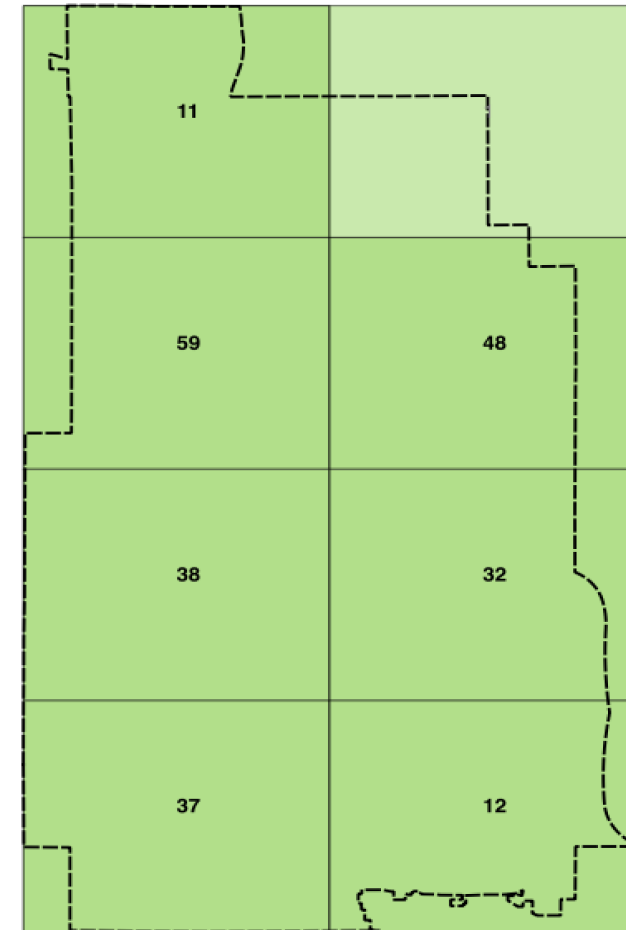
MQM Grids Generation



City Boundary

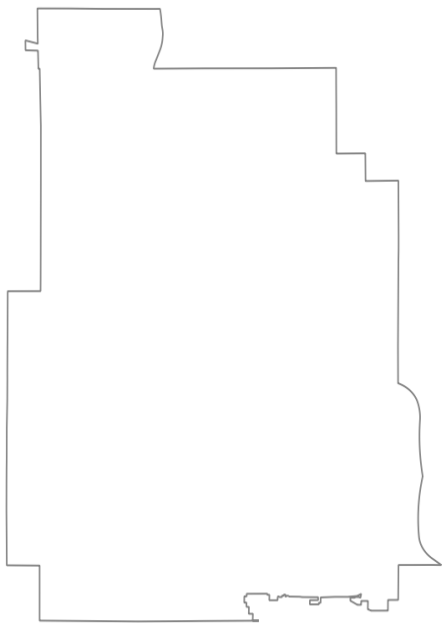


Generate Bounding Box

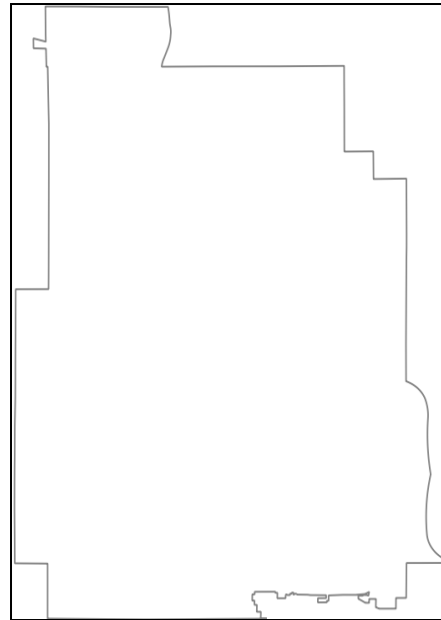


Recursively Divide it into half using K-D Tree

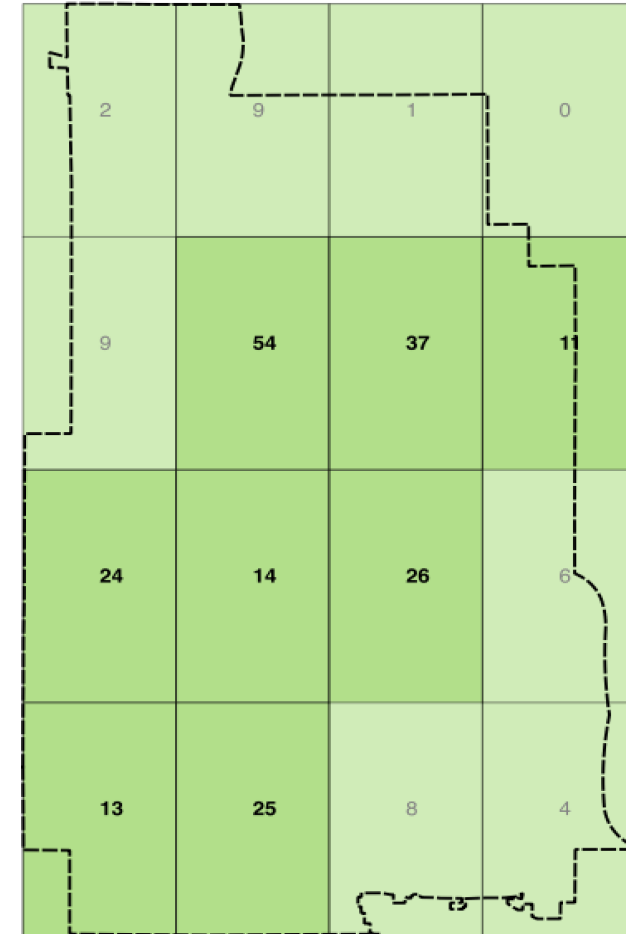
MQM Grids Generation



City Boundary

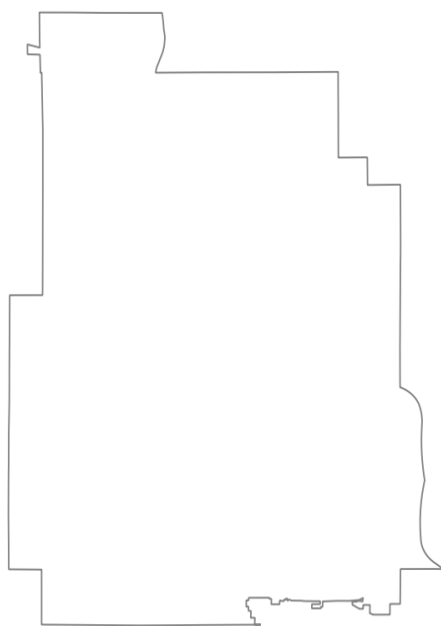


Generate Bounding Box

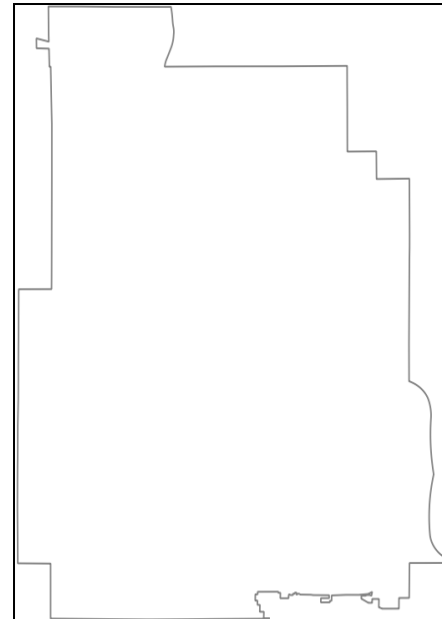


Recursively Divide it into half using K-D Tree

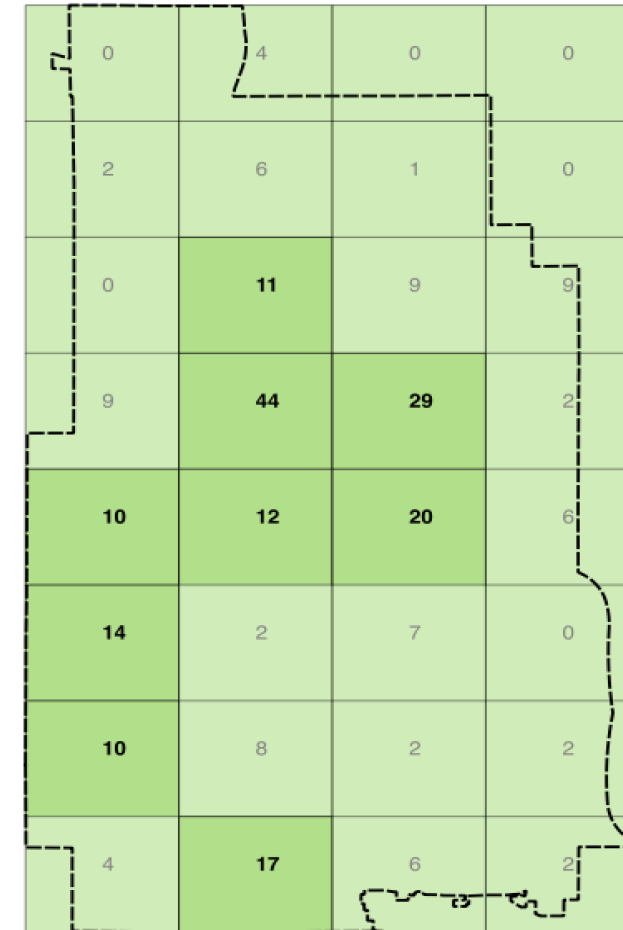
MQM Grids Generation



City Boundary

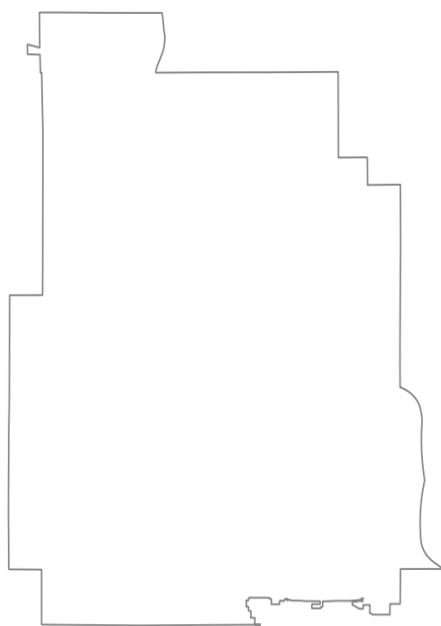


Generate Bounding Box

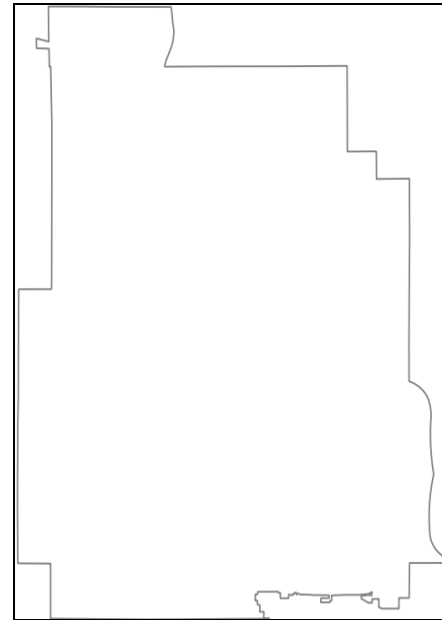


Recursively Divide it into half using K-D Tree

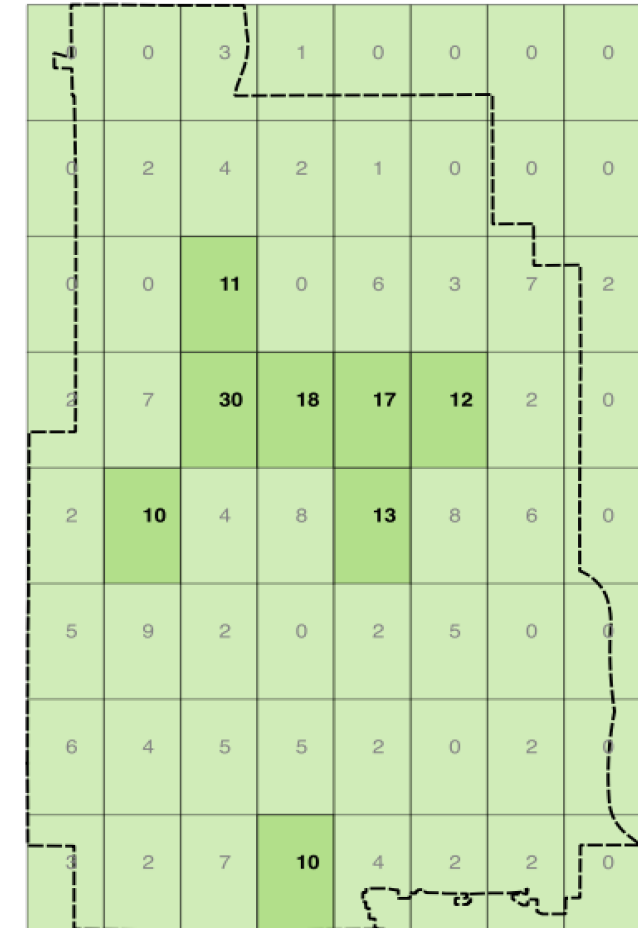
MQM Grids Generation



City Boundary



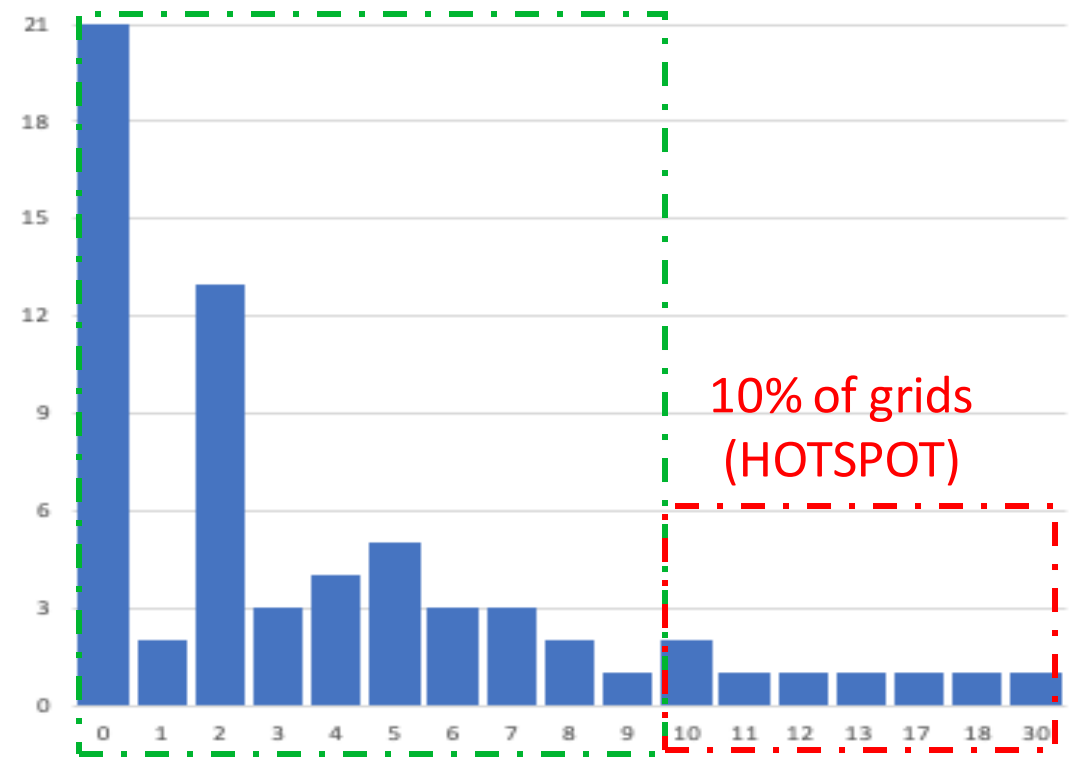
Generate Bounding Box



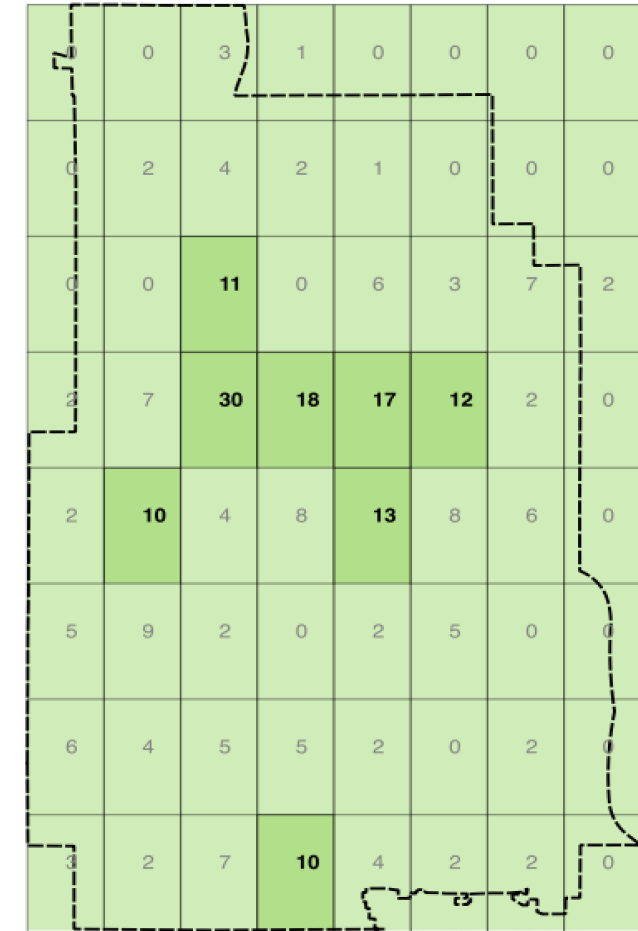
Recursively Divide it into half using K-D Tree

MQM Grids Generation

90% of grids have <10 errors on OSM features

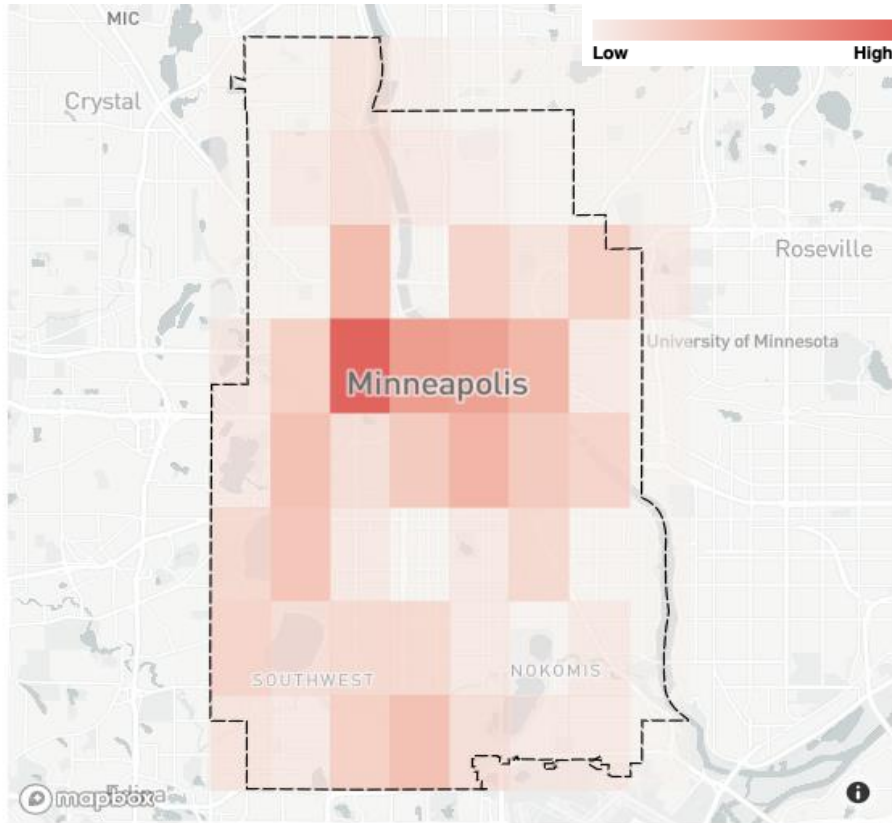


Stop when $\geq 90\%$ of the grids have <10 features

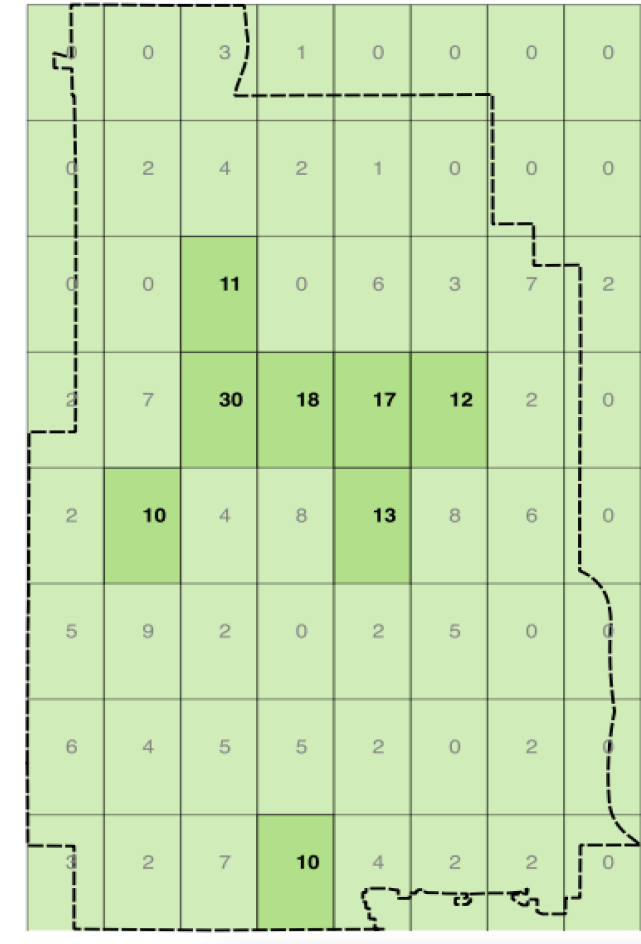


Recursively Divide it into half using K-D Tree

MQM Grids Generation

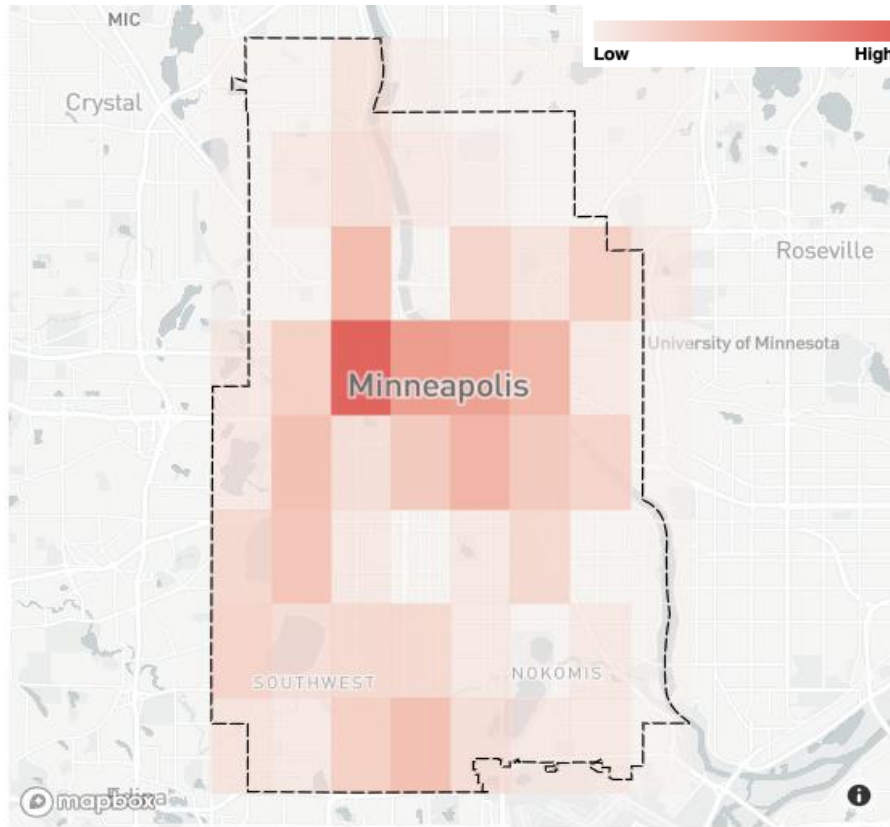


Final MQM Layer



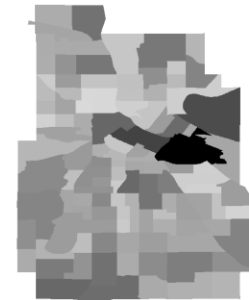
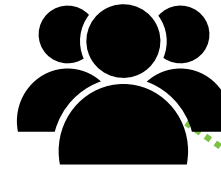
Recursively Divide it into half using K-D Tree

Re-prioritize Map Error Hot-Spots by Usage



Final MQM Layer

Population



Population by
Census Tract

% of Population
without Vehicles

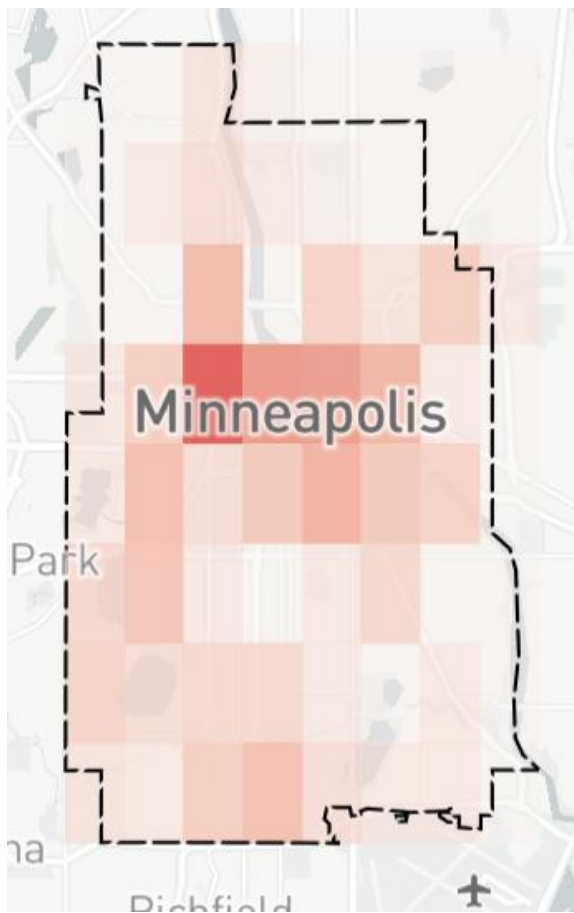


Usage

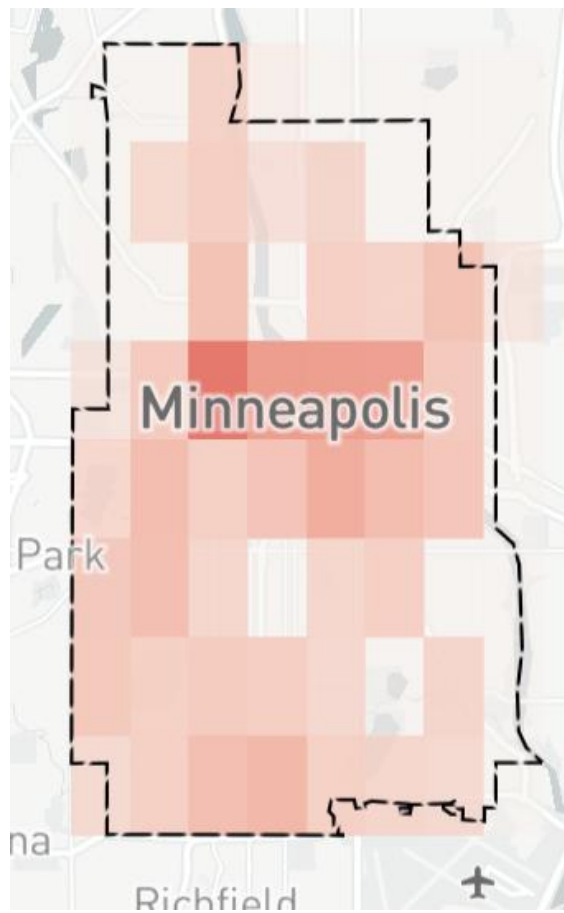


Car Ownership

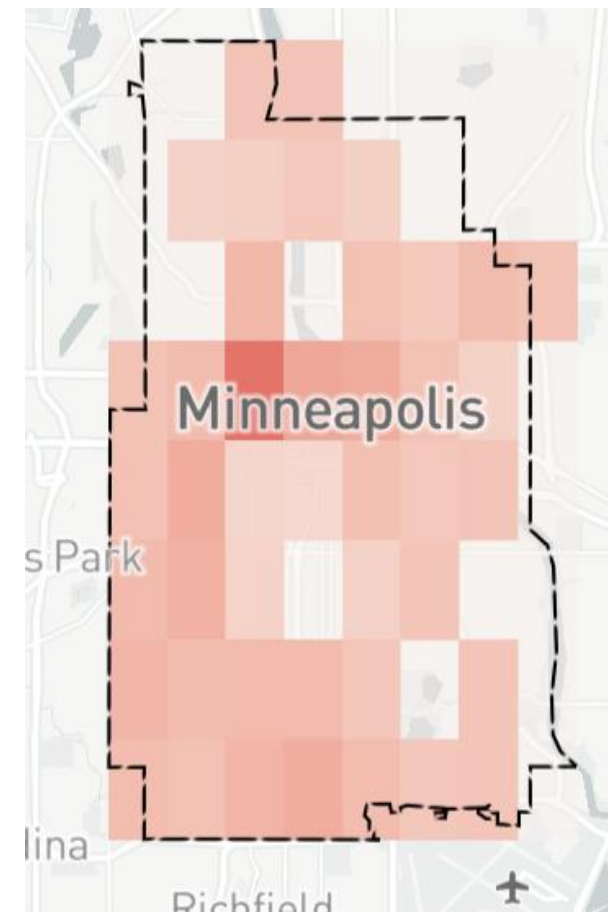
Final 3 Layers



MQM



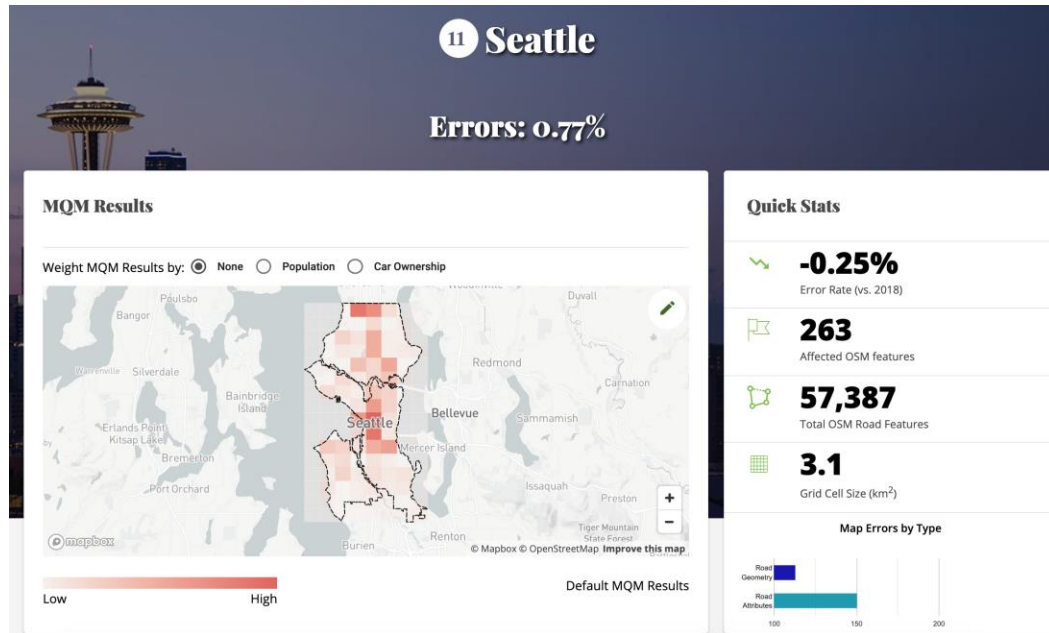
MQM + Population



MQM + Car Ownership

The MQM Web App

<https://osmquality.io>



MQM Visualization and Stats for each city

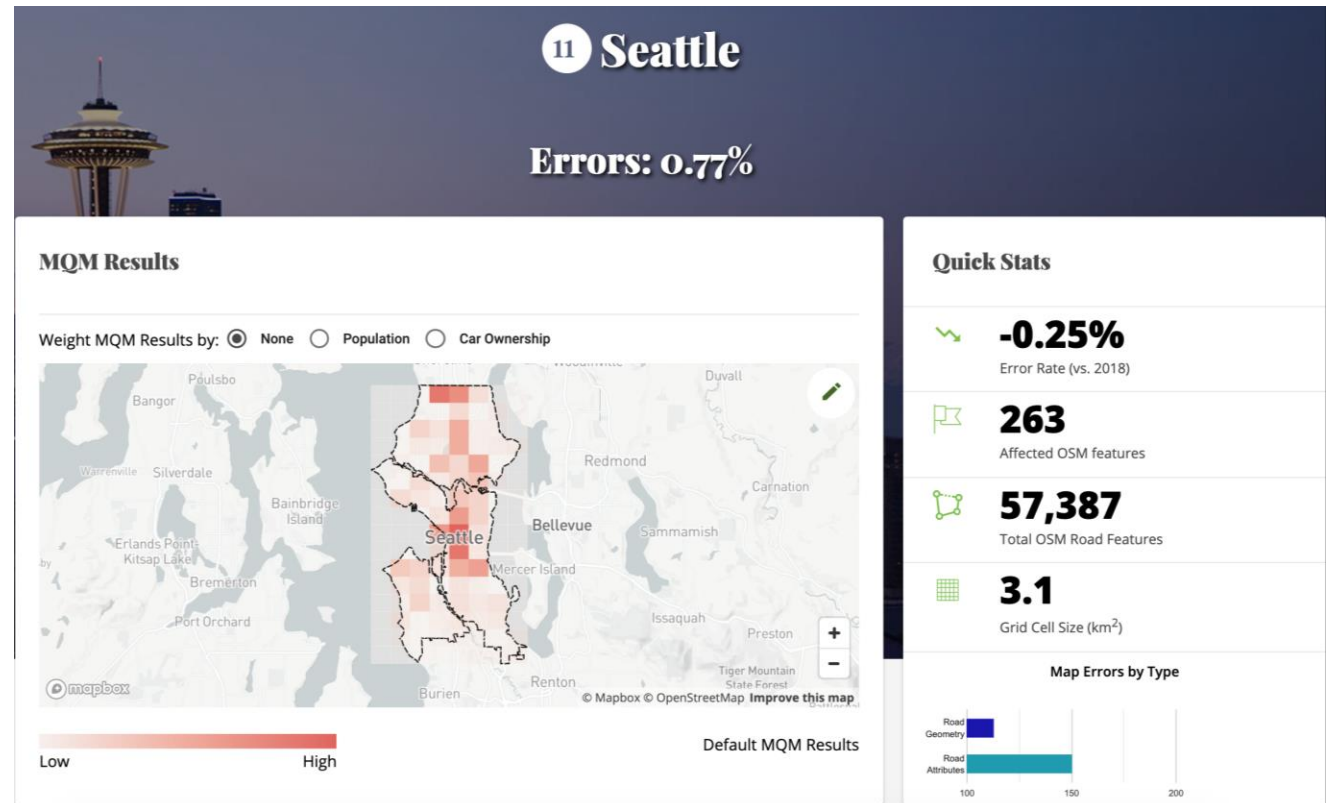
Ranking List for 51 U.S. Cities

| | | | |
|------------------------------------|-----------------------------------|-------------------------------------|-------------------------------------|
| Detroit, MI Errors: 0.39% | Billings, MT Errors: 0.89% | Oklahoma City, OK Errors: 1.26% | Fargo, ND Errors: 1.96% |
| Portland, OR Errors: 0.52% | Burlington, VT Errors: 0.91% | Columbus, OH Errors: 1.29% | Virginia Beach, VA Errors: 2.17% |
| Des Moines, IA Errors: 0.57% | Tucson, AZ Errors: 0.91% | Salt Lake City, UT Errors: 1.34% | Boston, MA Errors: 2.27% |
| Manchester, NH Errors: 0.61% | Madison, WI Errors: 0.95% | Charleston, WV Errors: 1.35% | Washington, DC Errors: 2.27% |
| Kansas City, MO Errors: 0.62% | Boise, ID Errors: 0.99% | Sioux Falls, SD Errors: 1.41% | Louisville, KY Errors: 2.40% |
| San Francisco, CA Errors: 0.65% | Dallas, TX Errors: 0.99% | Portland, ME Errors: 1.45% | Jackson, MS Errors: 2.67% |
| Wilmington, DE Errors: 0.68% | Baltimore, MD Errors: 1.02% | Atlanta, GA Errors: 1.46% | Honolulu, HI Errors: 2.68% |
| Omaha, NE Errors: 0.71% | Orlando, FL Errors: 1.03% | Huntsville, AL Errors: 1.49% | Newark, NJ Errors: 3.56% |
| Denver, CO Errors: 0.76% | Indianapolis, IN Errors: 1.04% | Hartford, CT Errors: 1.50% | New Orleans, LA Errors: 3.98% |
| Columbia, SC Errors: 0.76% | Philadelphia, PA Errors: 1.07% | Anchorage, AK Errors: 1.61% | |
| Seattle, WA Errors: 0.77% | Wichita, KS Errors: 1.12% | Memphis, TN Errors: 1.71% | |
| New York, NY Errors: 0.83% | Cheyenne, WY Errors: 1.17% | Providence, RI Errors: 1.74% | |
| Little Rock, AR Errors: 0.84% | Minneapolis, MN Errors: 1.21% | Charlotte, NC Errors: 1.78% | |
| Las Vegas, NV Errors: 0.87% | Albuquerque, NM Errors: 1.22% | Chicago, IL Errors: 1.92% | |

Future Enhancements

- Flexible data inputs (e.g., Overpass Turbo Results)
- Focus on other map layers (e.g., address, building, water, etc.)
- Other measurements for OSM data quality
- Tool incorporation (e.g. JOSM, HOT Task Manager, or MapRoulette)

MQM 2020



More Detail: <https://youtu.be/8lpvf9aeyNI>

Acknowledgment

Micah Nacht

Sayana Saithu

Ahmend Ahmouda

Lukas Kucinski

Ana Ordonez

Keahi Konishi

Amelia Watts

Mara Rae

Adam Shaw

Stephen Cerqueira

Daniel Baah

Kim Kearns

Todd Slind



Which city has the best OSM quality?

[Explore OSM Quality Ranking](#)

Thank you!

Stay Connected with Critigen:



Contact Info

www.critigen.com

Monica.Brandeis@critigen.com



Telephone

Office Phone: +1 (859) 312-9267



Address

1430 Summit Ave, Suite 100C
Seattle, WA 98122



Selected Atlas Checks for Road Network



Road Geometry

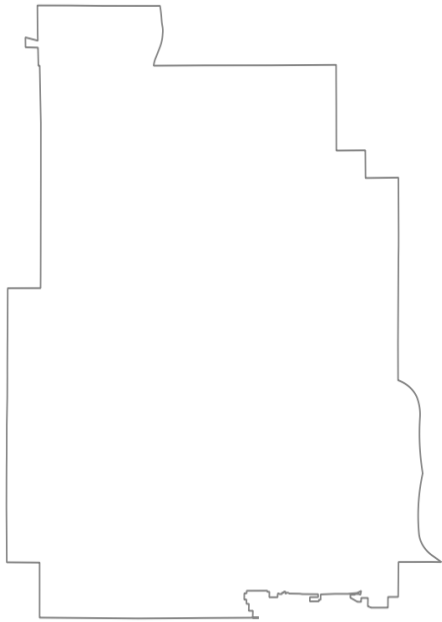
- EdgeCrossingEdgeCheck
- BuildingRoadIntersectionCheck
- SnakeRoadCheck
- RoundaboutValenceCheck
- InvalidMiniRoundaboutCheck



Road Tag and Relation

- SignPostCheck
- InvalidAccessTagCheck
- StreetNameIntegerOnlyCheck
- UnusualLayerTagCheck
- InvalidLanesTagCheck
- InvalidTurnRestrictionCheck

MQM Grids Generation



City Boundary

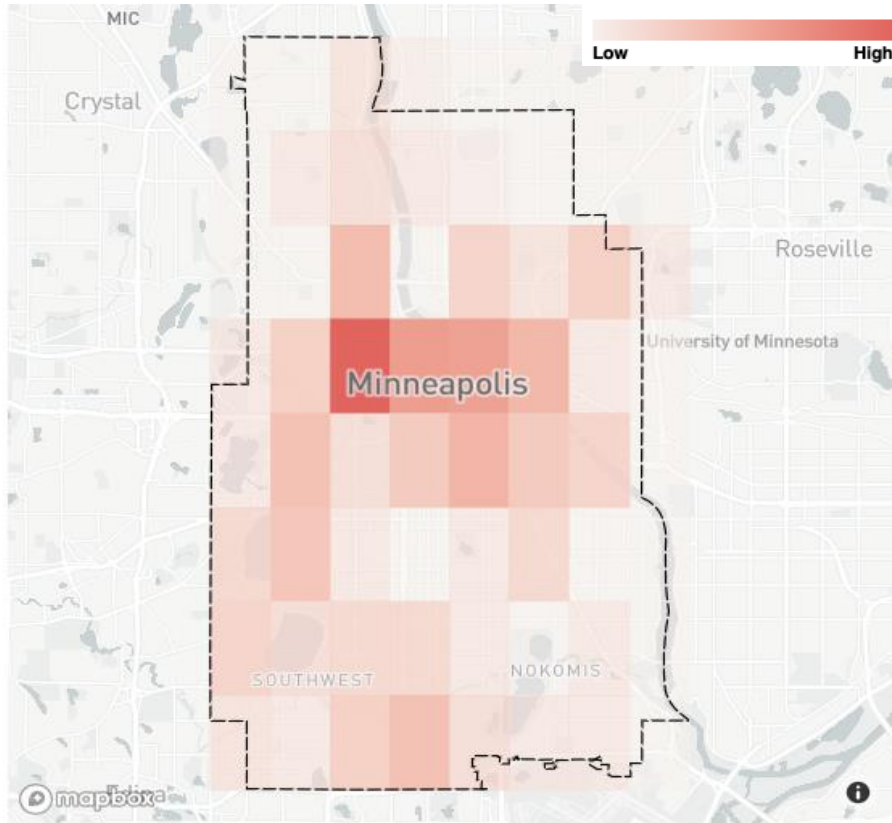
MQM Grids Generation



City Boundary

Generate Bounding Box

Re-prioritize Map Error Hot-Spots by Usage

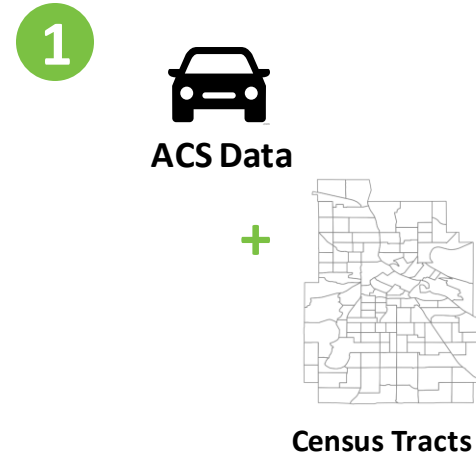


Final MQM Layer

Data Processing

Data Processing

- Join American Community Survey (ACS) data to the census tracts



Data Processing

- Join American Community Survey (ACS) data to the census tracts
- Generate raster layers

1

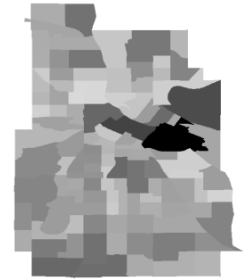


ACS Data

+



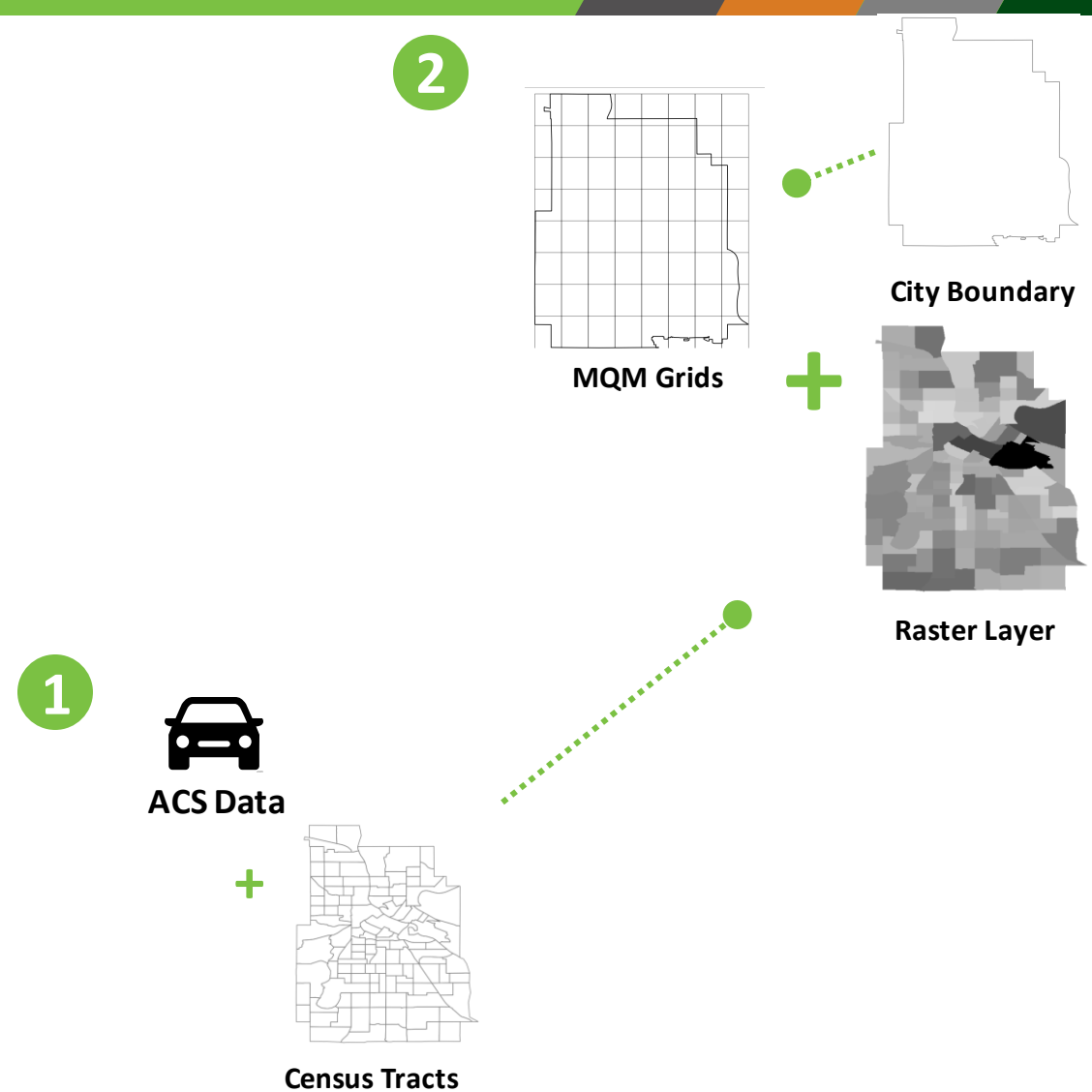
Census Tracts



Raster Layer

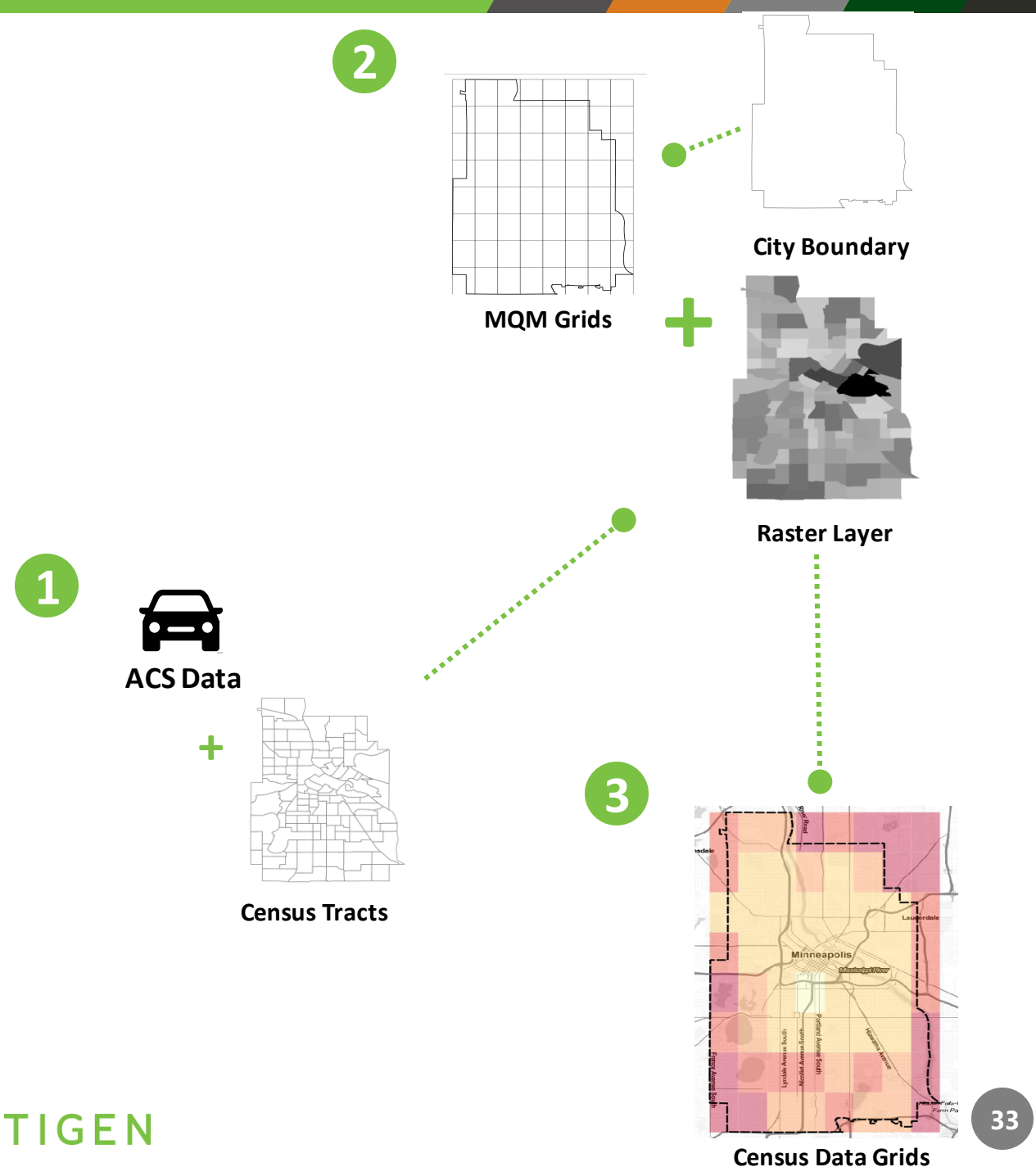
Data Processing

- Join American Community Survey (ACS) data to the census tracts
- Generate raster layers
- Generate grids using the city boundary

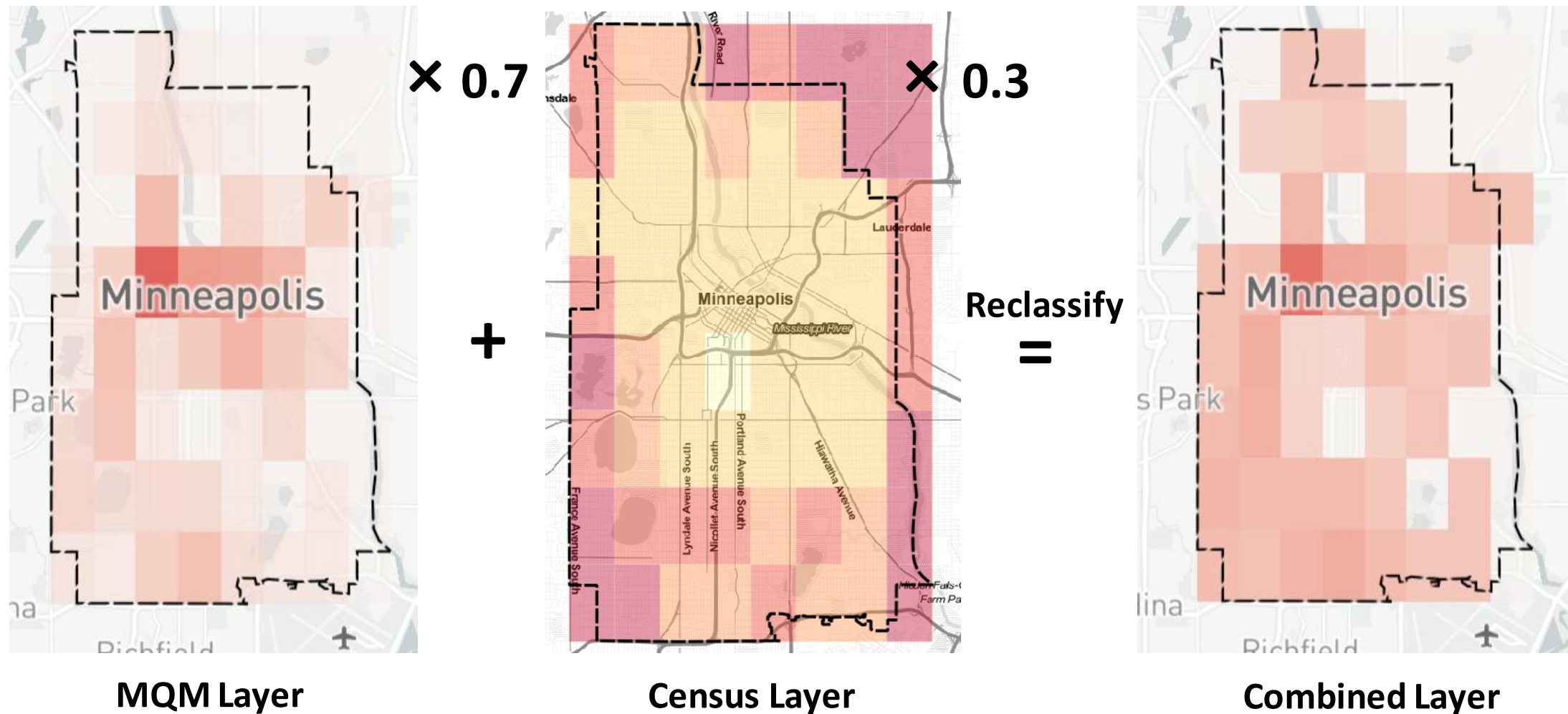


Data Processing




















































- Join American Community Survey (ACS) data to the census tracts
- Generate raster layers
- Generate grids using the city boundary
- Calculate the mean value of raster layer for each grid
- Normalize values and visualize the results



Combining MQM and Census Scores

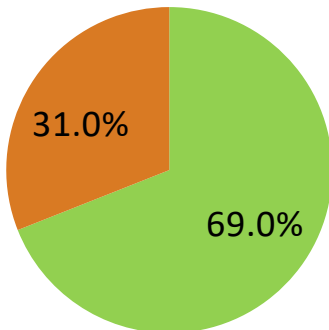


OSM Data Quality Improved Overall

| | | | |
|---|---|--|--|
|  Detroit, MI Errors: 0.39% |  Billings, MT Errors: 0.89% |  Oklahoma City, OK Errors: 1.26% |  Fargo, ND Errors: 1.96% |
|  Portland, OR Errors: 0.52% |  Burlington, VT Errors: 0.91% |  Columbus, OH Errors: 1.29% |  Virginia Beach, VA Errors: 2.17% |
|  Des Moines, IA Errors: 0.57% |  Tucson, AZ Errors: 0.91% |  Salt Lake City, UT Errors: 1.34% |  Boston, MA Errors: 2.27% |
|  Manchester, NH Errors: 0.61% |  Madison, WI Errors: 0.95% |  Charleston, WV Errors: 1.35% |  Washington, DC Errors: 2.27% |
|  Kansas City, MO Errors: 0.62% |  Boise, ID Errors: 0.99% |  Sioux Falls, SD Errors: 1.41% |  Louisville, KY Errors: 2.40% |
|  San Francisco, CA Errors: 0.65% |  Dallas, TX Errors: 0.99% |  Portland, ME Errors: 1.45% |  Jackson, MS Errors: 2.67% |
|  Wilmington, DE Errors: 0.68% |  Baltimore, MD Errors: 1.02% |  Atlanta, GA Errors: 1.46% |  Honolulu, HI Errors: 2.68% |
|  Omaha, NE Errors: 0.71% |  Orlando, FL Errors: 1.03% |  Huntsville, AL Errors: 1.49% |  Newark, NJ Errors: 3.56% |
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|  Little Rock, AR Errors: 0.84% |  Minneapolis, MN Errors: 1.21% |  Charlotte, NC Errors: 1.78% | |
|  Las Vegas, NV Errors: 0.87% |  Albuquerque, NM Errors: 1.22% |  Chicago, IL Errors: 1.92% | |

OSM Data Quality Improved Overall

- 69% of the cities (36 out of 51) have a decreased amount of error features

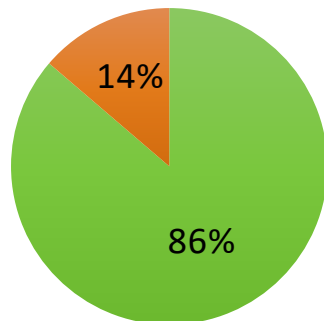


■ increased map errors ■ decreased map errors

| | | | |
|--|---|---|---|
| Detroit, MI Errors: 0.39% 01 | Billings, MT Errors: 0.89% 15 | Oklahoma City, OK Errors: 1.26% 29 | Fargo, ND Errors: 1.96% 43 |
| Portland, OR Errors: 0.52% 02 | Burlington, VT Errors: 0.91% 16 | Columbus, OH Errors: 1.29% 30 | Virginia Beach, VA Errors: 2.17% 44 |
| Des Moines, IA Errors: 0.57% 03 | Tucson, AZ Errors: 0.91% 17 | Salt Lake City, UT Errors: 1.34% 31 | Boston, MA Errors: 2.27% 45 |
| Manchester, NH Errors: 0.61% 04 | Madison, WI Errors: 0.95% 18 | Charleston, WV Errors: 1.35% 32 | Washington, DC Errors: 2.27% 46 |
| Kansas City, MO Errors: 0.62% 05 | Boise, ID Errors: 0.99% 19 | Sioux Falls, SD Errors: 1.41% 33 | Louisville, KY Errors: 2.40% 47 |
| San Francisco, CA Errors: 0.65% 06 | Dallas, TX Errors: 0.99% 20 | Portland, ME Errors: 1.45% 34 | Jackson, MS Errors: 2.67% 48 |
| Wilmington, DE Errors: 0.68% 07 | Baltimore, MD Errors: 1.02% 21 | Atlanta, GA Errors: 1.46% 35 | Honolulu, HI Errors: 2.68% 49 |
| Omaha, NE Errors: 0.71% 08 | Orlando, FL Errors: 1.03% 22 | Huntsville, AL Errors: 1.49% 36 | Newark, NJ Errors: 3.56% 50 |
| Denver, CO Errors: 0.76% 09 | Indianapolis, IN Errors: 1.04% 23 | Hartford, CT Errors: 1.50% 37 | New Orleans, LA Errors: 3.98% 51 |
| Columbia, SC Errors: 0.76% 10 | Philadelphia, PA Errors: 1.07% 24 | Anchorage, AK Errors: 1.61% 38 | |
| Seattle, WA Errors: 0.77% 11 | Wichita, KS Errors: 1.12% 25 | Memphis, TN Errors: 1.71% 39 | |
| New York, NY Errors: 0.83% 12 | Cheyenne, WY Errors: 1.17% 26 | Providence, RI Errors: 1.74% 40 | |
| Little Rock, AR Errors: 0.84% 13 | Minneapolis, MN Errors: 1.21% 27 | Charlotte, NC Errors: 1.78% 41 | |
| Las Vegas, NV Errors: 0.87% 14 | Albuquerque, NM Errors: 1.22% 28 | Chicago, IL Errors: 1.92% 42 | |

OSM Data Quality Improved Overall

- 69% of the cities (35 out of 51) have a decreased amount of error features
- 86% of the cities (44 out of 51) have a lower MQM Errors rate

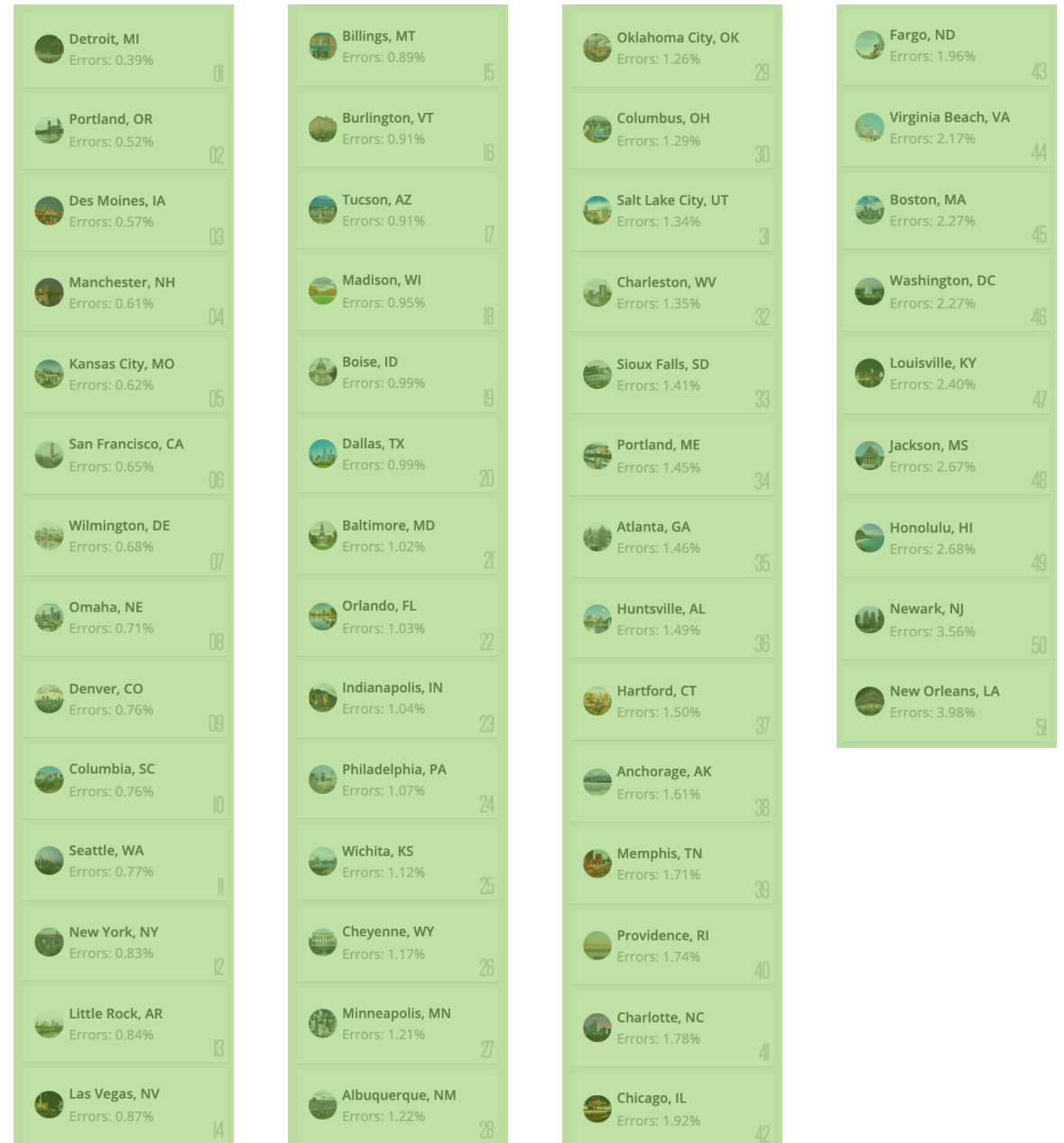


■ Better Quality ■ Worse Quality

| | | | |
|--|---|---|---|
| Detroit, MI Errors: 0.39% 01 | Billings, MT Errors: 0.89% 15 | Oklahoma City, OK Errors: 1.26% 29 | Fargo, ND Errors: 1.96% 43 |
| Portland, OR Errors: 0.52% 02 | Burlington, VT Errors: 0.91% 16 | Columbus, OH Errors: 1.29% 30 | Virginia Beach, VA Errors: 2.17% 44 |
| Des Moines, IA Errors: 0.57% 03 | Tucson, AZ Errors: 0.91% 17 | Salt Lake City, UT Errors: 1.34% 31 | Boston, MA Errors: 2.27% 45 |
| Manchester, NH Errors: 0.61% 04 | Madison, WI Errors: 0.95% 18 | Charleston, WV Errors: 1.35% 32 | Washington, DC Errors: 2.27% 46 |
| Kansas City, MO Errors: 0.62% 05 | Boise, ID Errors: 0.99% 19 | Sioux Falls, SD Errors: 1.41% 33 | Louisville, KY Errors: 2.40% 47 |
| San Francisco, CA Errors: 0.65% 06 | Dallas, TX Errors: 0.99% 20 | Portland, ME Errors: 1.45% 34 | Jackson, MS Errors: 2.67% 48 |
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OSM Data Quality Improved Overall

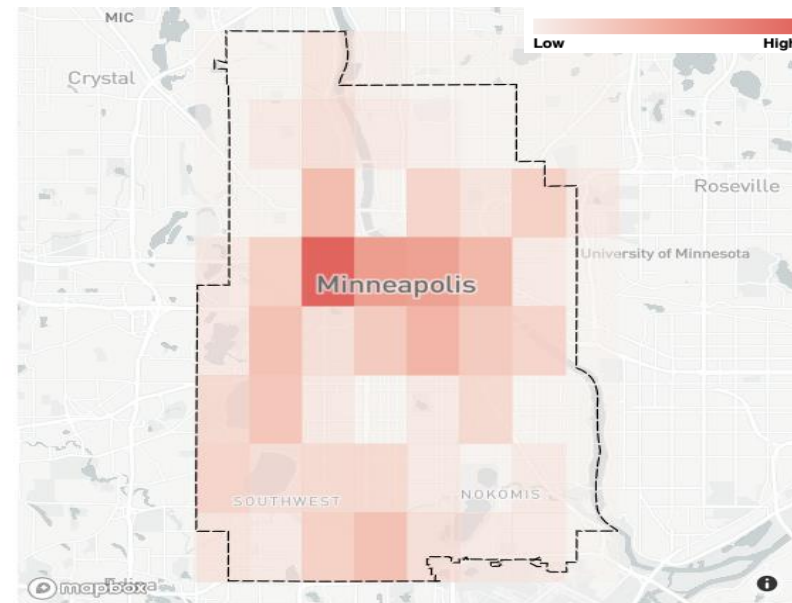
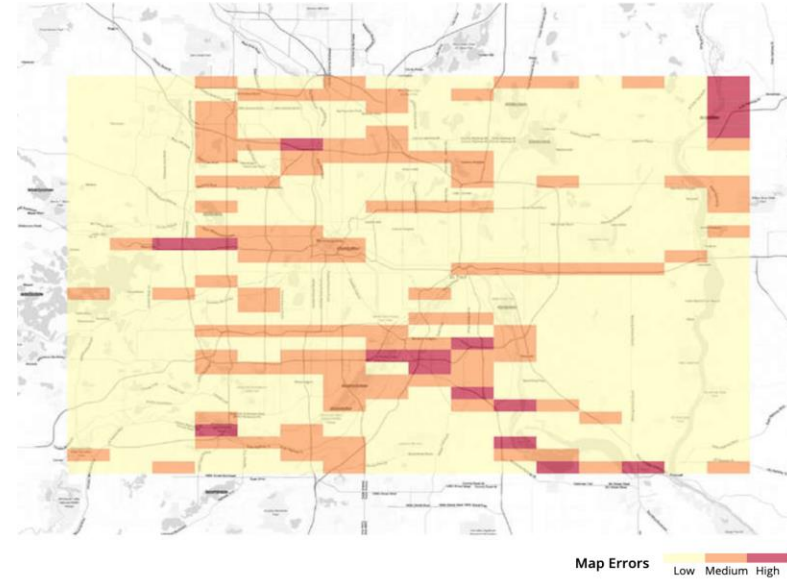
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- 86% of the cities (44 out of 51) have a lower MQM Errors rate
- The total feature counts increased in each city



2019 MQM Enhancements

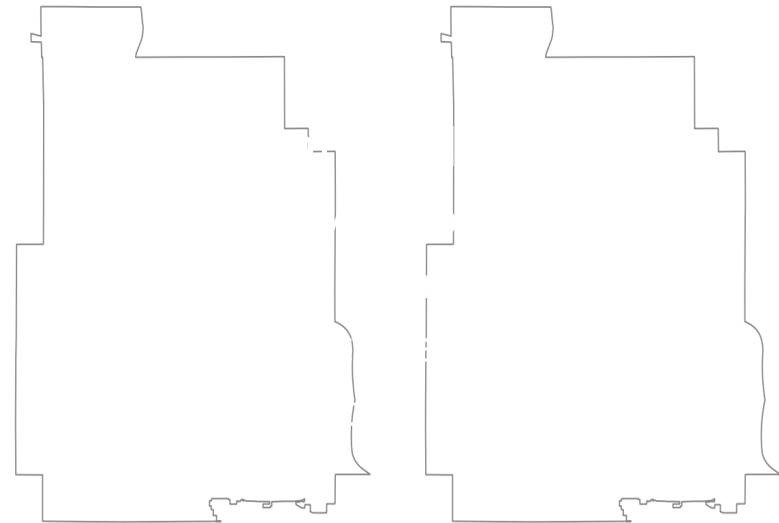
2019 MQM Enhancements

- More accurate representations of cities



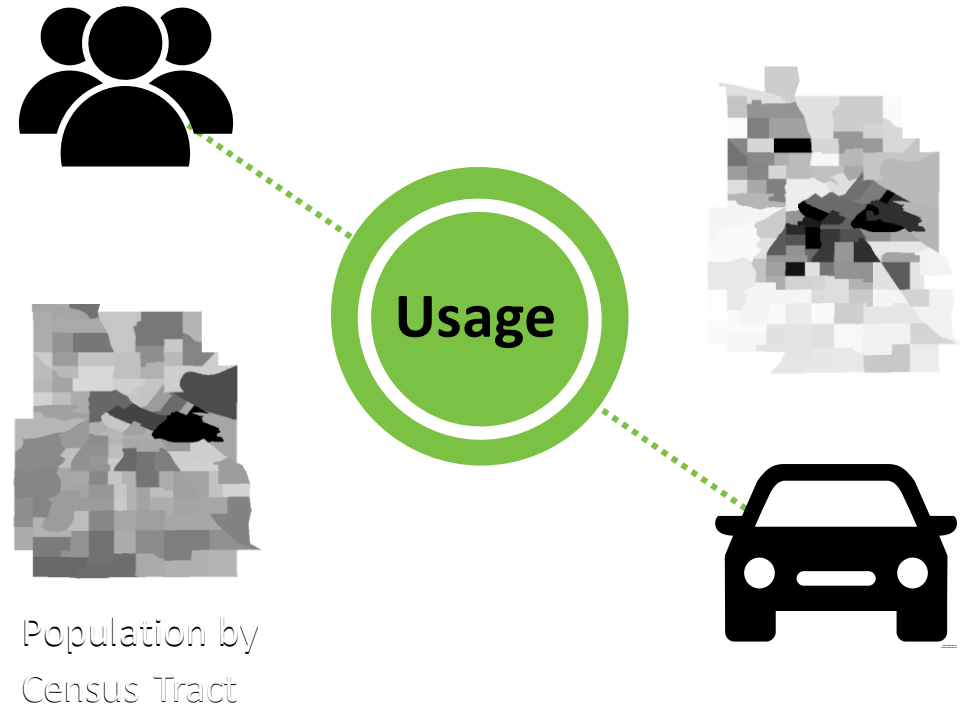
2019 MQM Enhancements

- More accurate representations of cities
- Different OSM data source



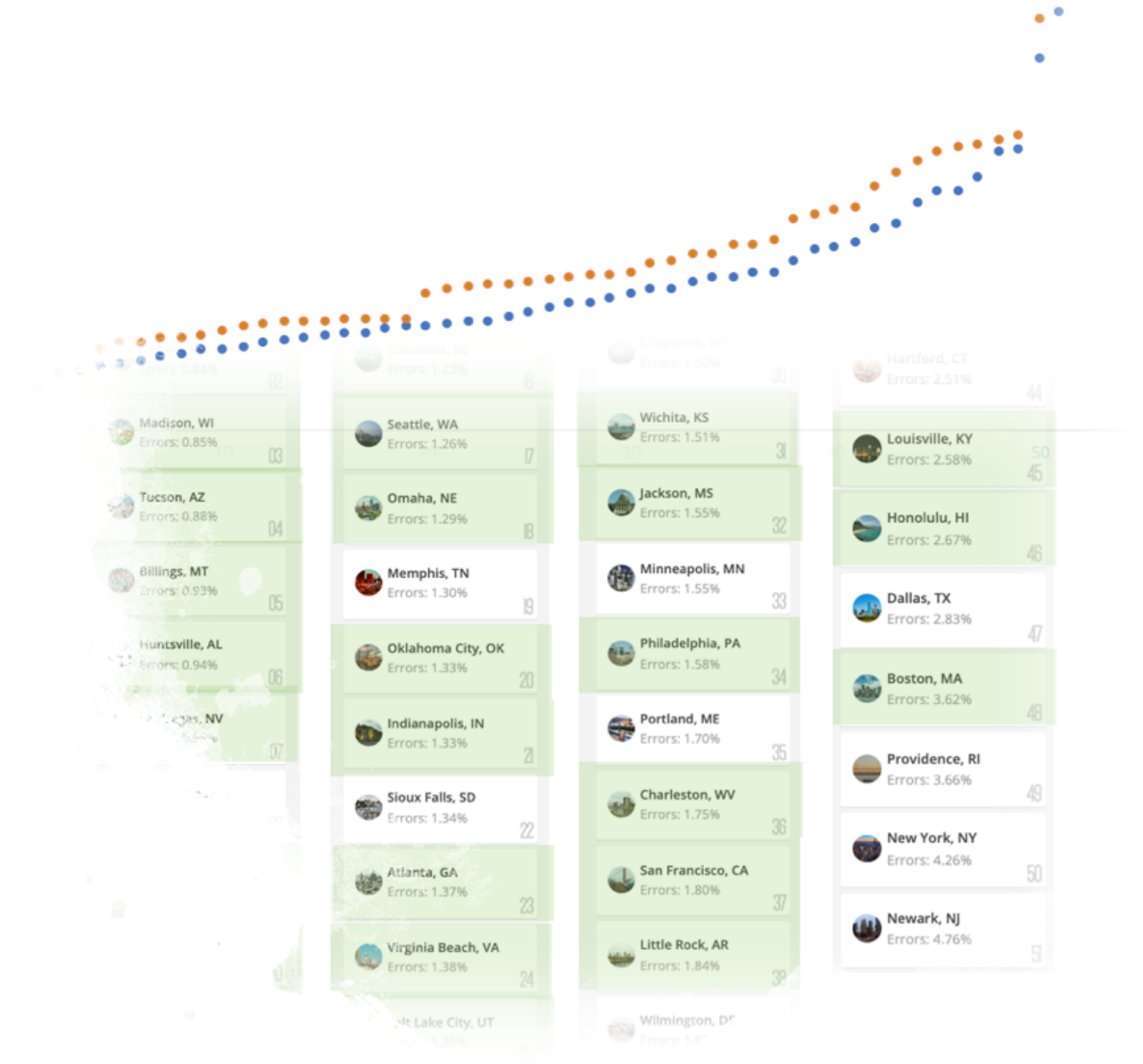
2019 MQM Enhancements

- More accurate representations of cities
- Different OSM data source
- Map error hot-spots re-prioritization by usage






















































2019 MQM Enhancements

- More accurate representations of cities
- Different OSM data source
- Map error hot-spots re-prioritization by usage
- Trend Analysis between 2018 and 2019



City Rankings

- Rankings are based on errors rates
- Error rate = $\frac{\#error\ features}{\#total\ features} \times 100\%$
- The error rate is an estimation of the percentage of road features that have mapping errors
- A city with increasing error features might rank higher than a city with decreasing error features

| | | | |
|--|--|---|---|
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- 86% of the cities (44 out of 51) have a lower MQM Errors rate
- The total feature counts increased in each city
- The MQM Errors rate at each ranking decreased

MQM Errors Rate between 2018 and 2019

