



STREET NETWORK MODELS AND INDICATORS

FOR EVERY URBAN AREA IN THE WORLD

Geoff Boeing

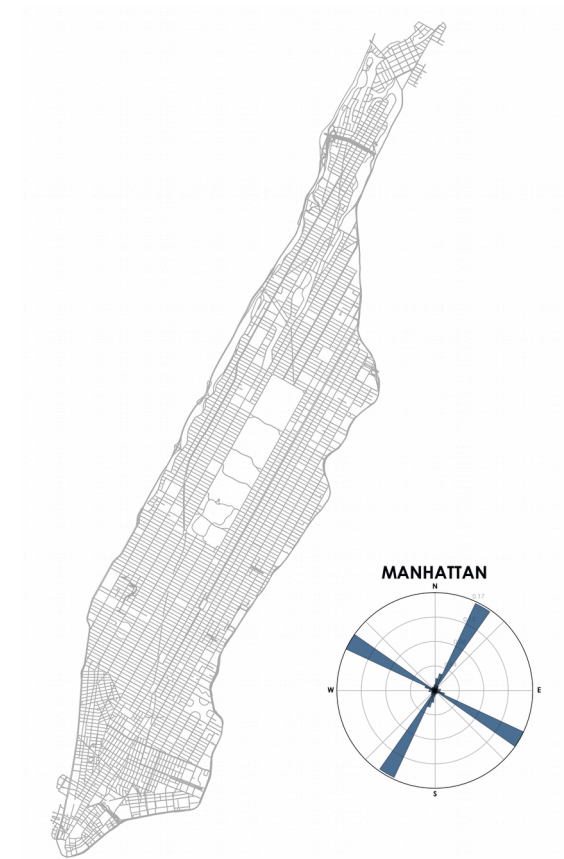
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University of Southern California

<https://geoffboeing.com/>

Talk Overview

- Why analyze street networks
- New tools
- Street network models and indicators
- Analytical findings



MOTIVATION

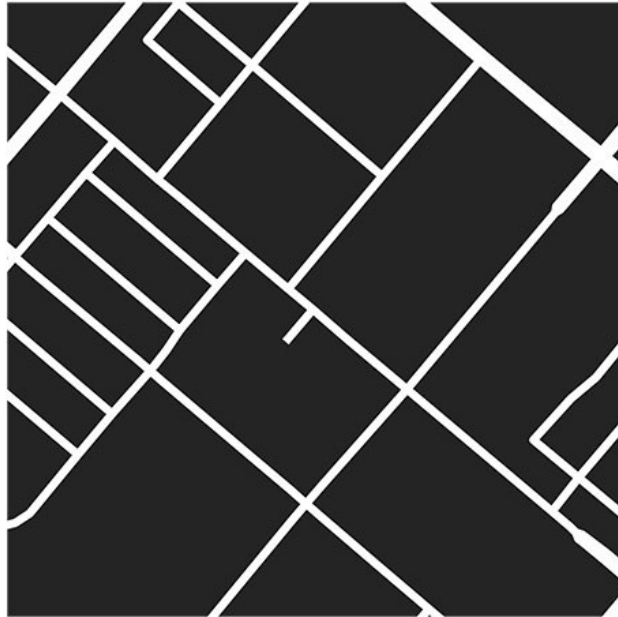
PORTLAND



SAN FRANCISCO



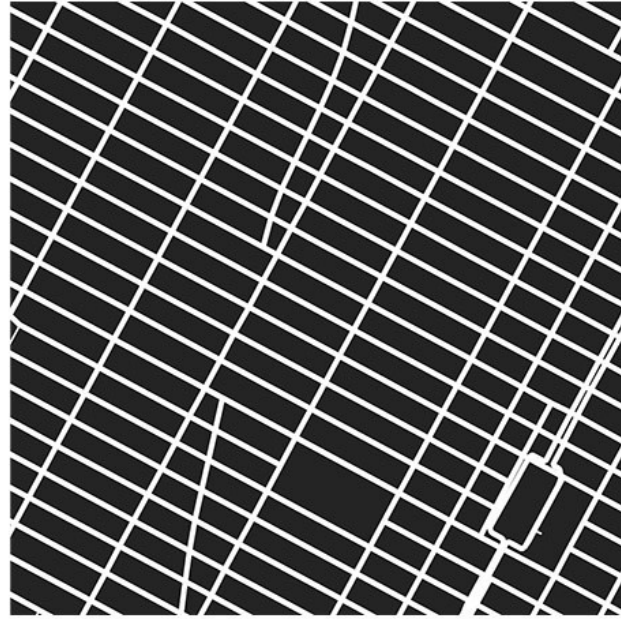
IRVINE



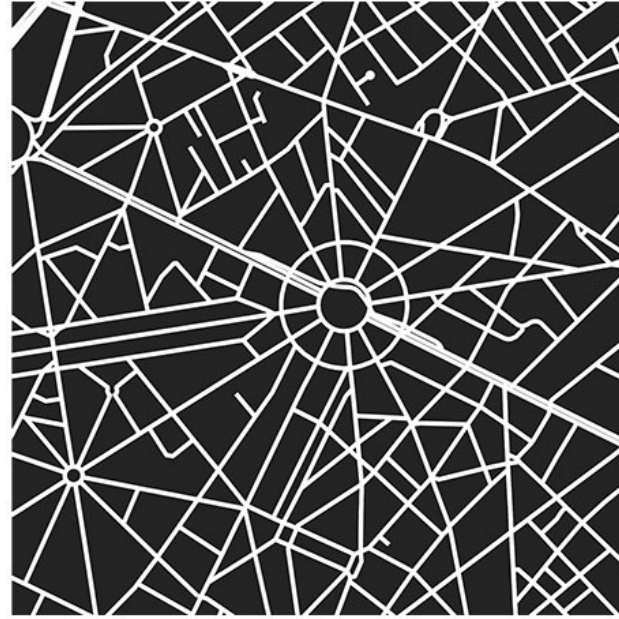
ROME



NEW YORK



PARIS



TUNIS



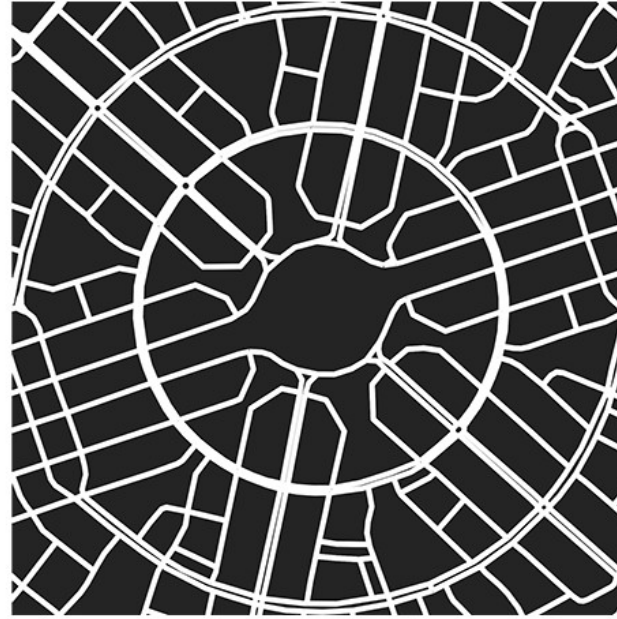
ATLANTA



BOSTON



DUBAI



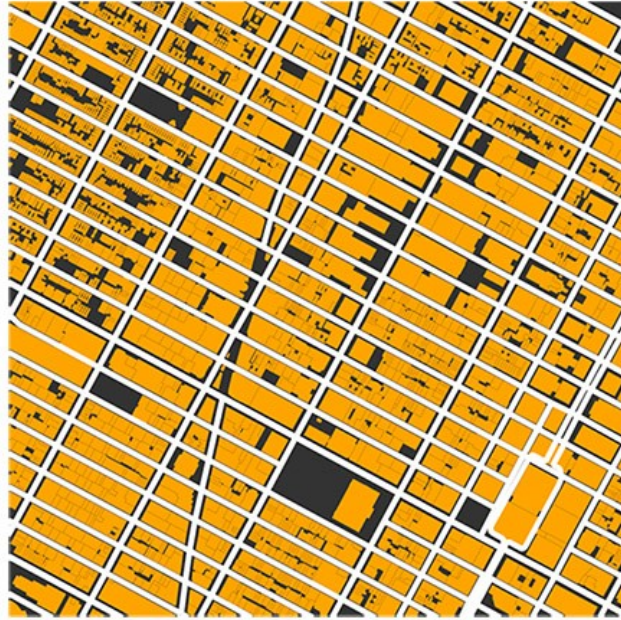
SACRAMENTO



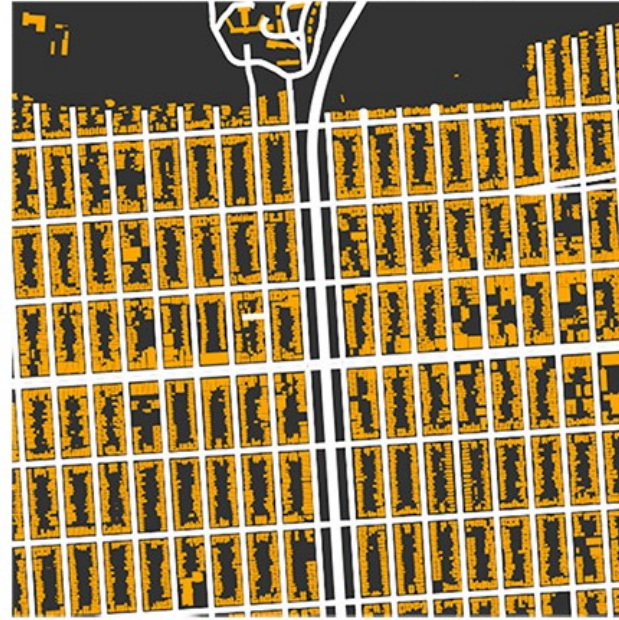
OSAKA



NEW YORK



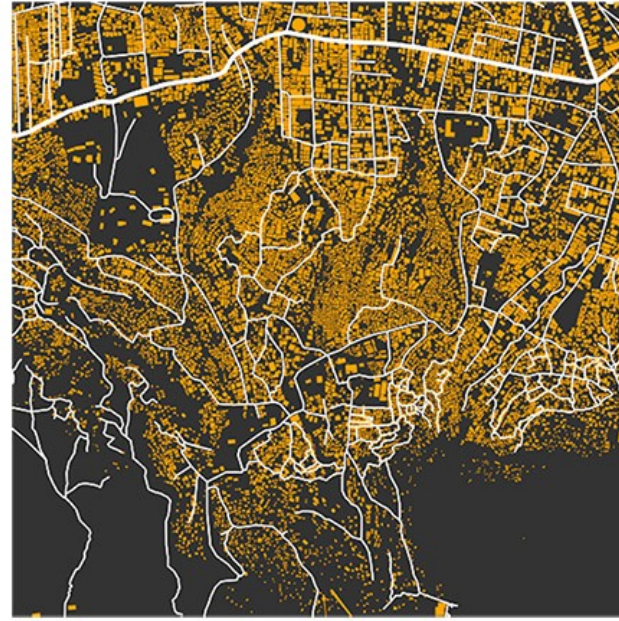
SAN FRANCISCO



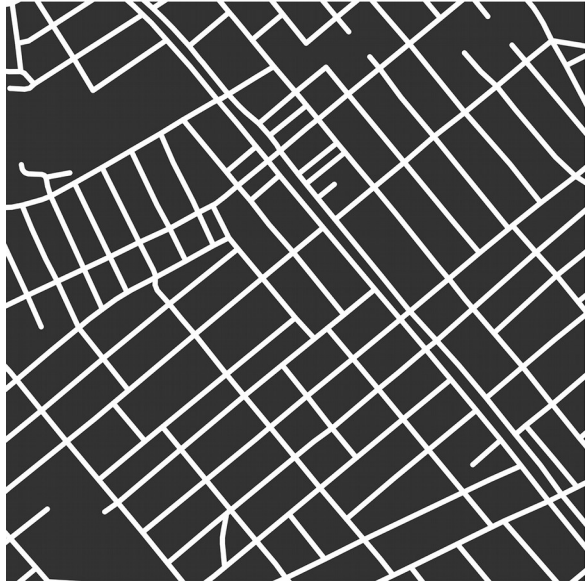
MONROVIA



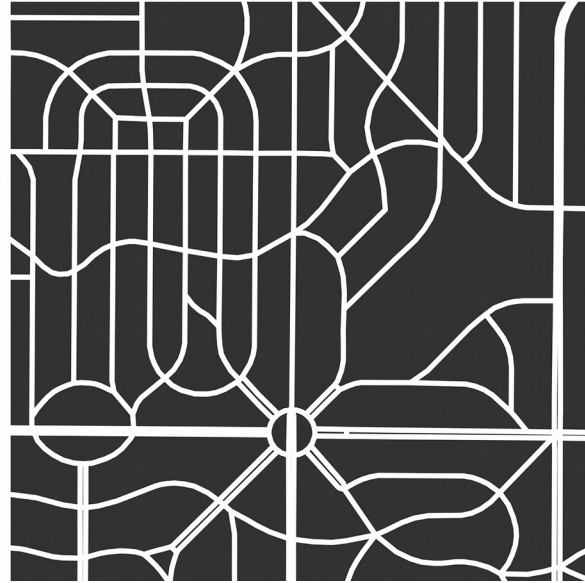
PORT AU PRINCE



1900s



1940s



1990s



OSMnx

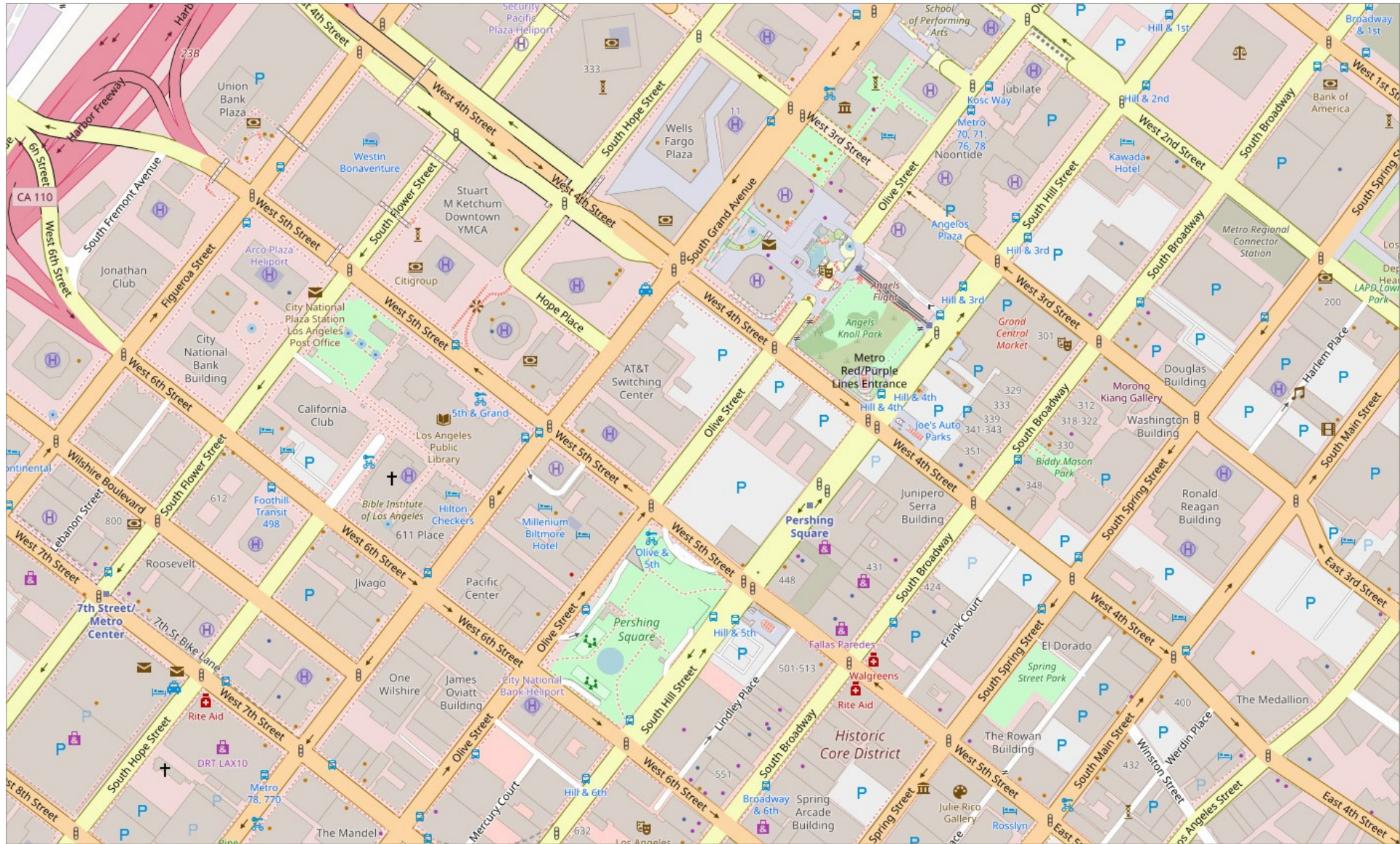
OSMnx

- **OpenStreetMap + NetworkX**

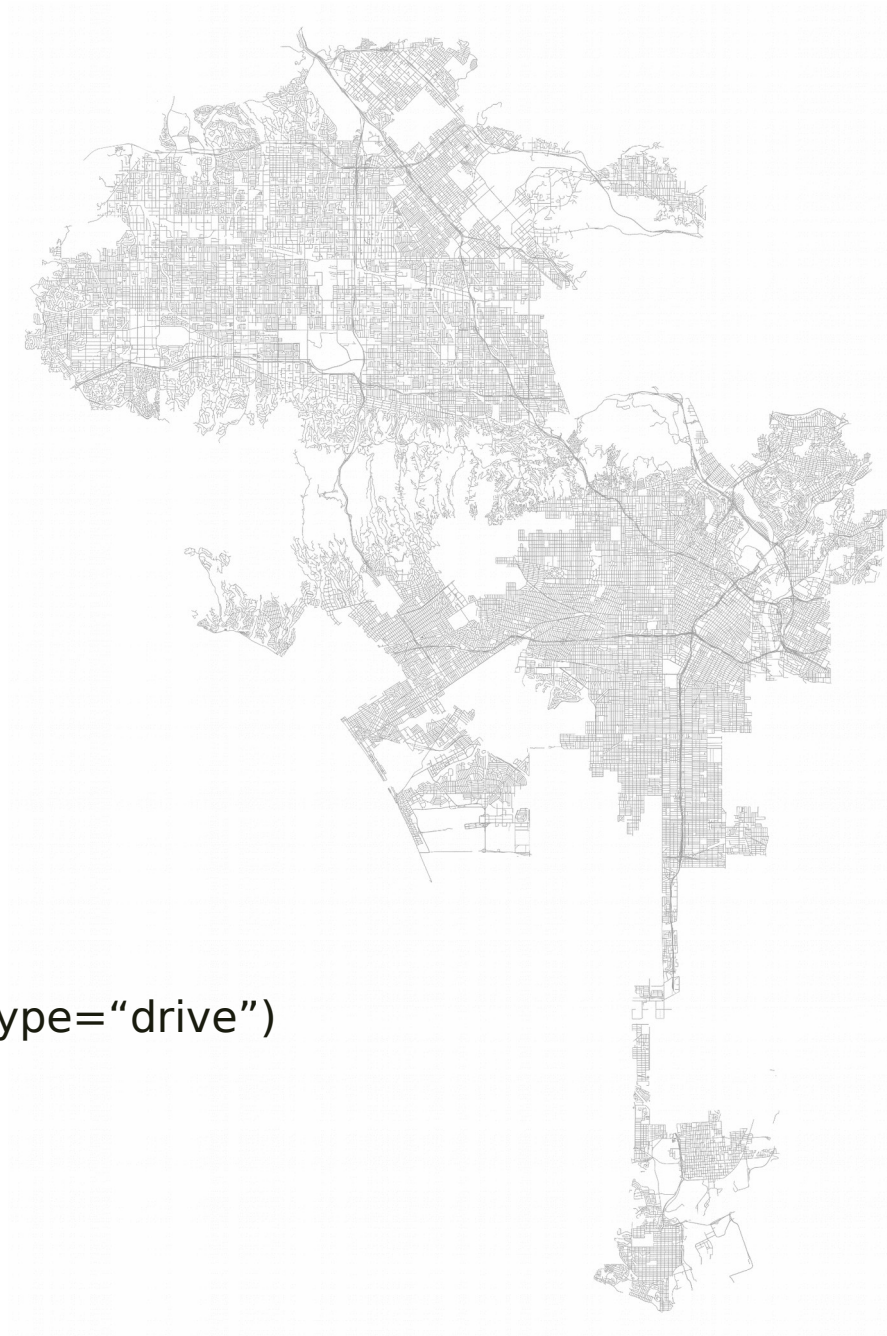
- Software package to easily download, model, analyze street networks

- Key features:

1. Download and model OSM street networks
2. Algorithmic correction and processing of network topology
3. Also download building footprints, points of interest, elevation data
4. Analysis: calculate routes, project and visualize, calculate geometric and topological network indicators



```
ox.graph_from_place("Los Angeles, CA", type="drive")
```

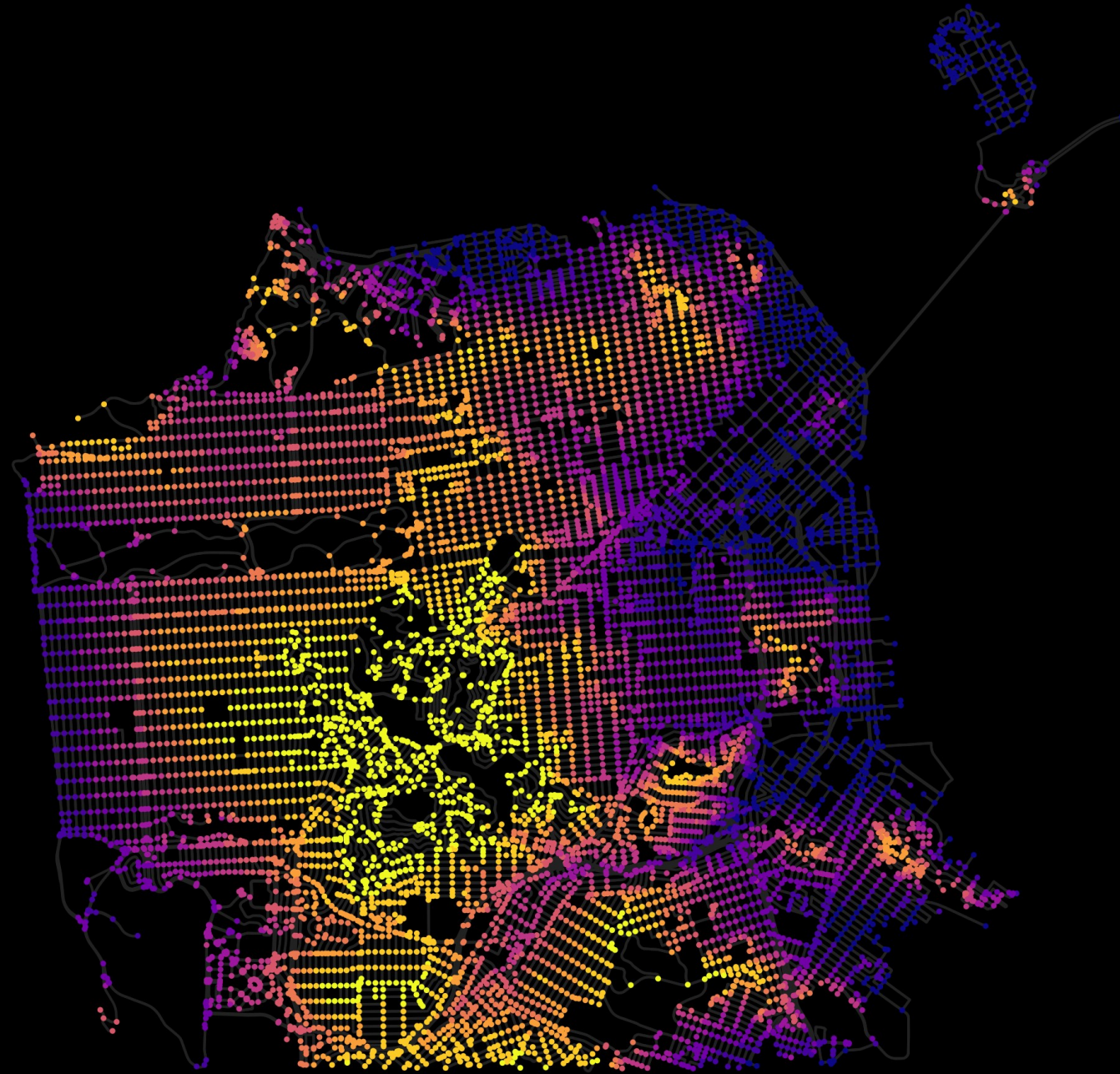


```
ox.graph_from_place("Modena, Italy")
```



ox.graph_from_place("Medina, Tunis, Tunisia")

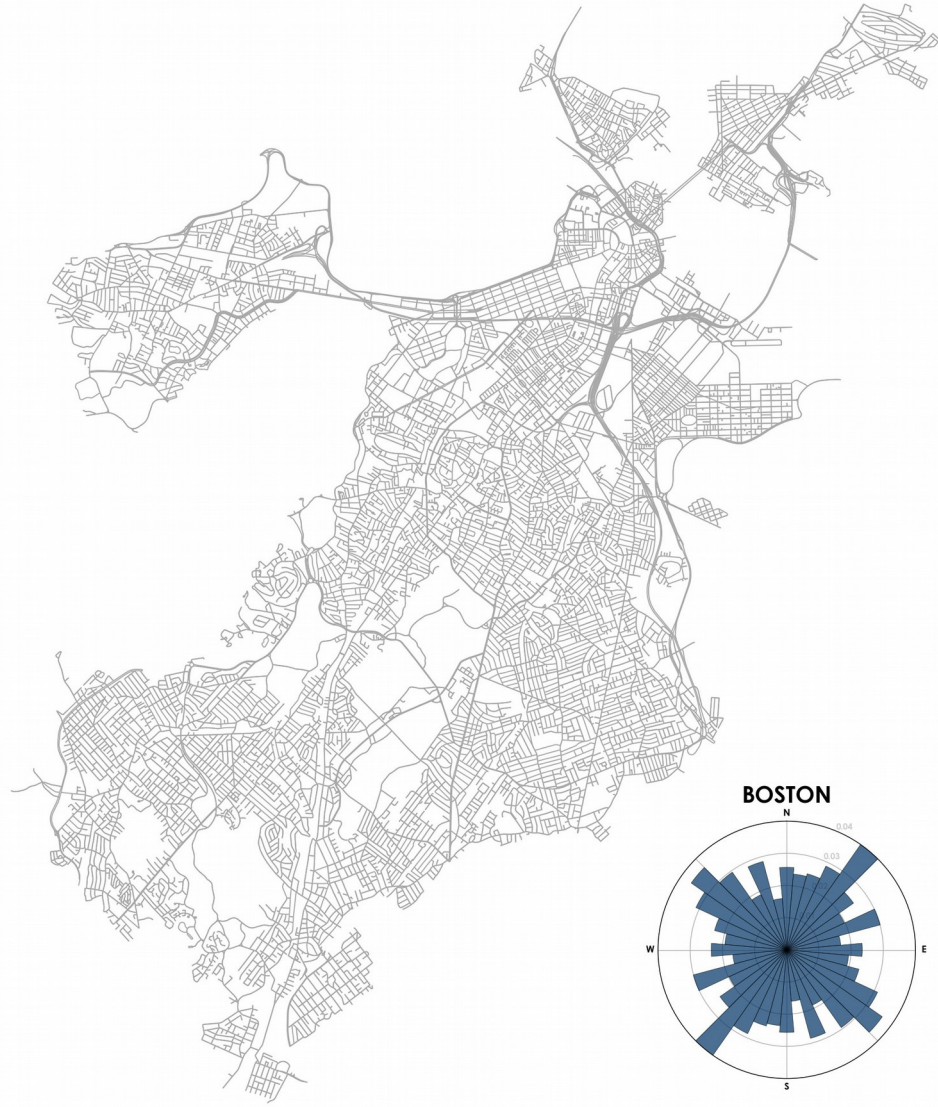
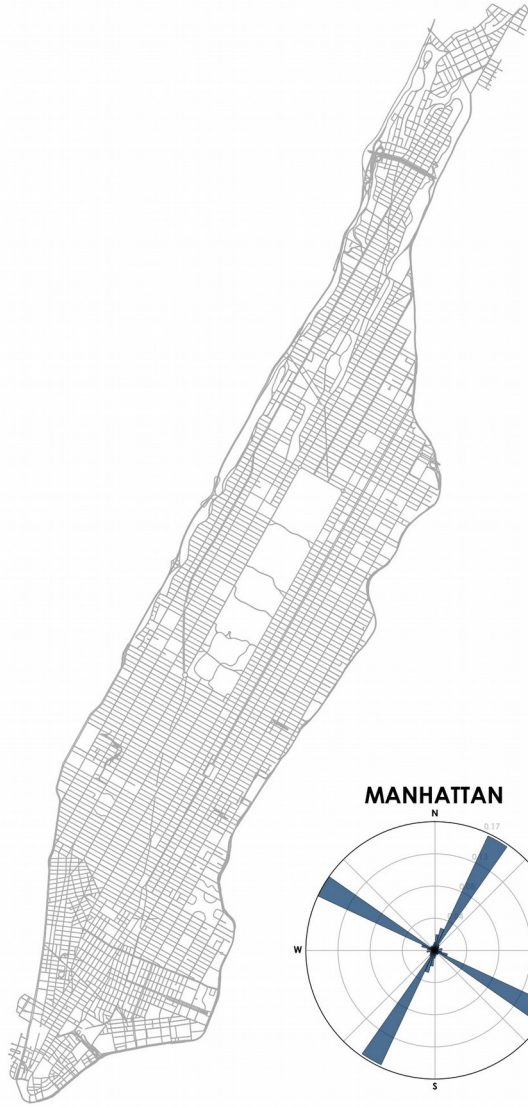


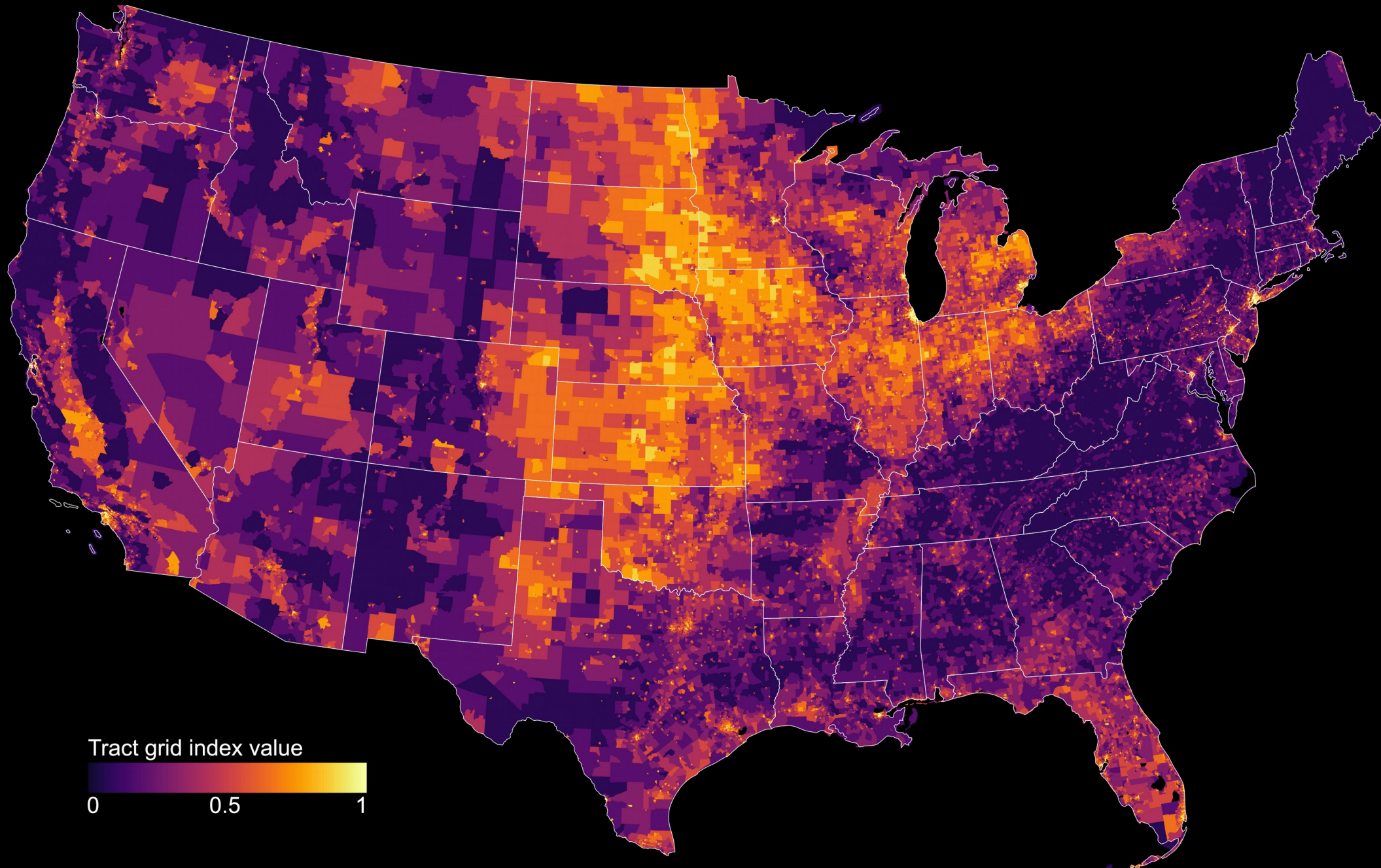


MODELS AND INDICATORS

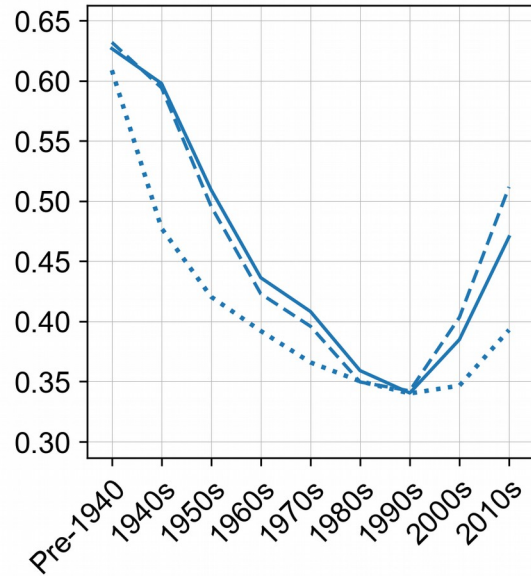
Recent Work

- Model street network of entire US at multiple scales
- Each city, urban area, county, census tract, Zillow neighborhood
- Calculate dozens of indicators for each
- Deposit models + indicators in open data repository

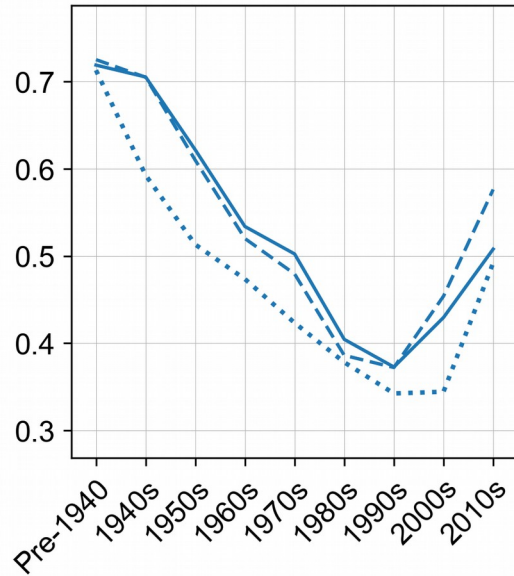




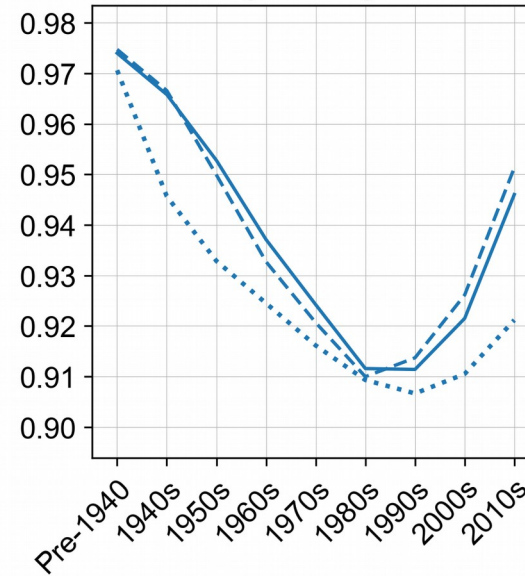
Grid Index



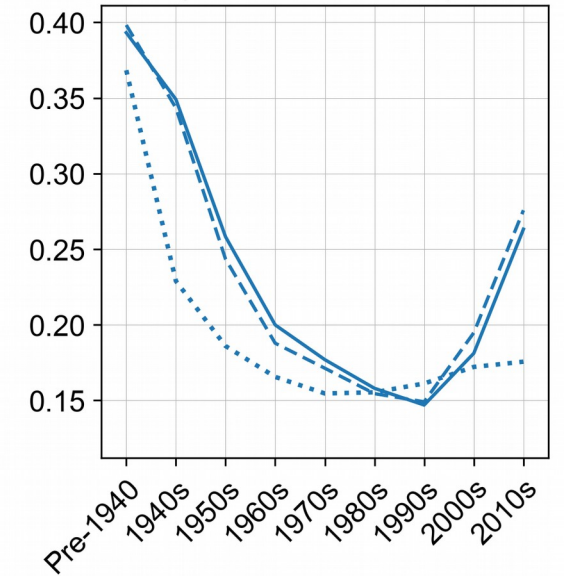
Orientation Order



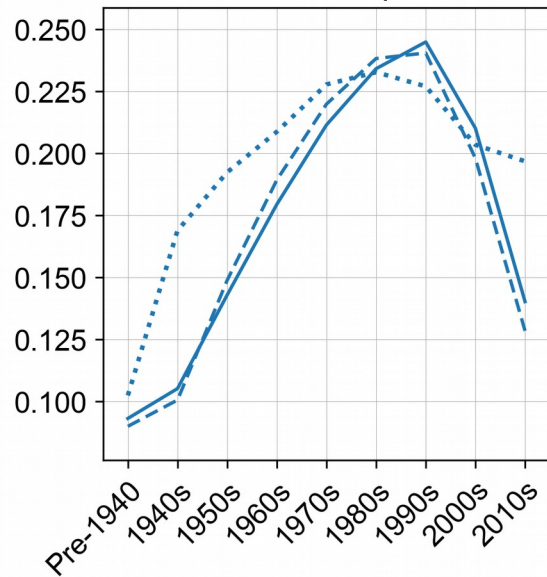
Average Straightness



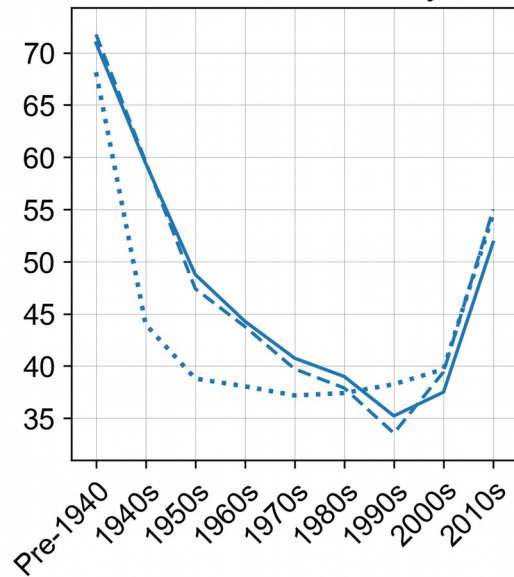
4-Way Intersection Proportion



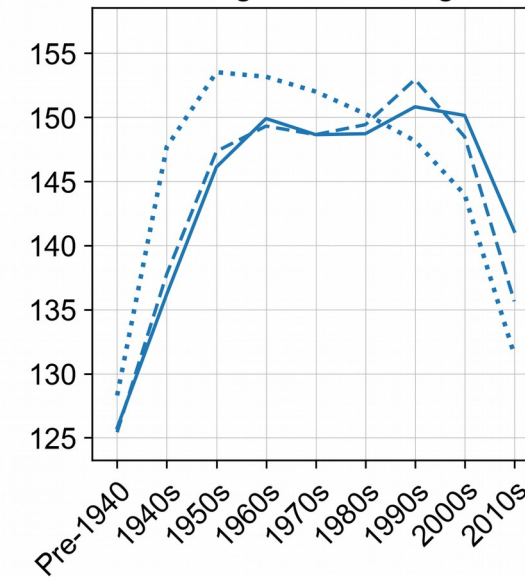
Dead-End Proportion



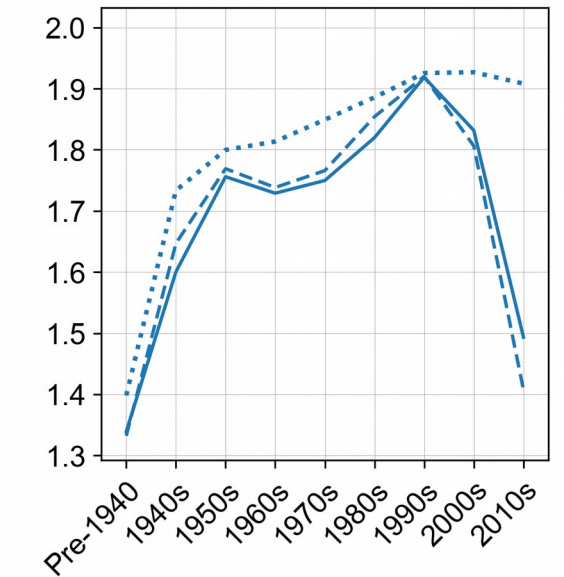
Intersection Density



Average Street Length



Vehicles Per Household



<https://bit.ly/3jnkKyf>



Current Work

- Model street networks of every urban area in the world
- Each urban area in GHSL database
- Calculate dozens of indicators for each
- Deposit models + indicators in open data repository

Worldwide Street Networks

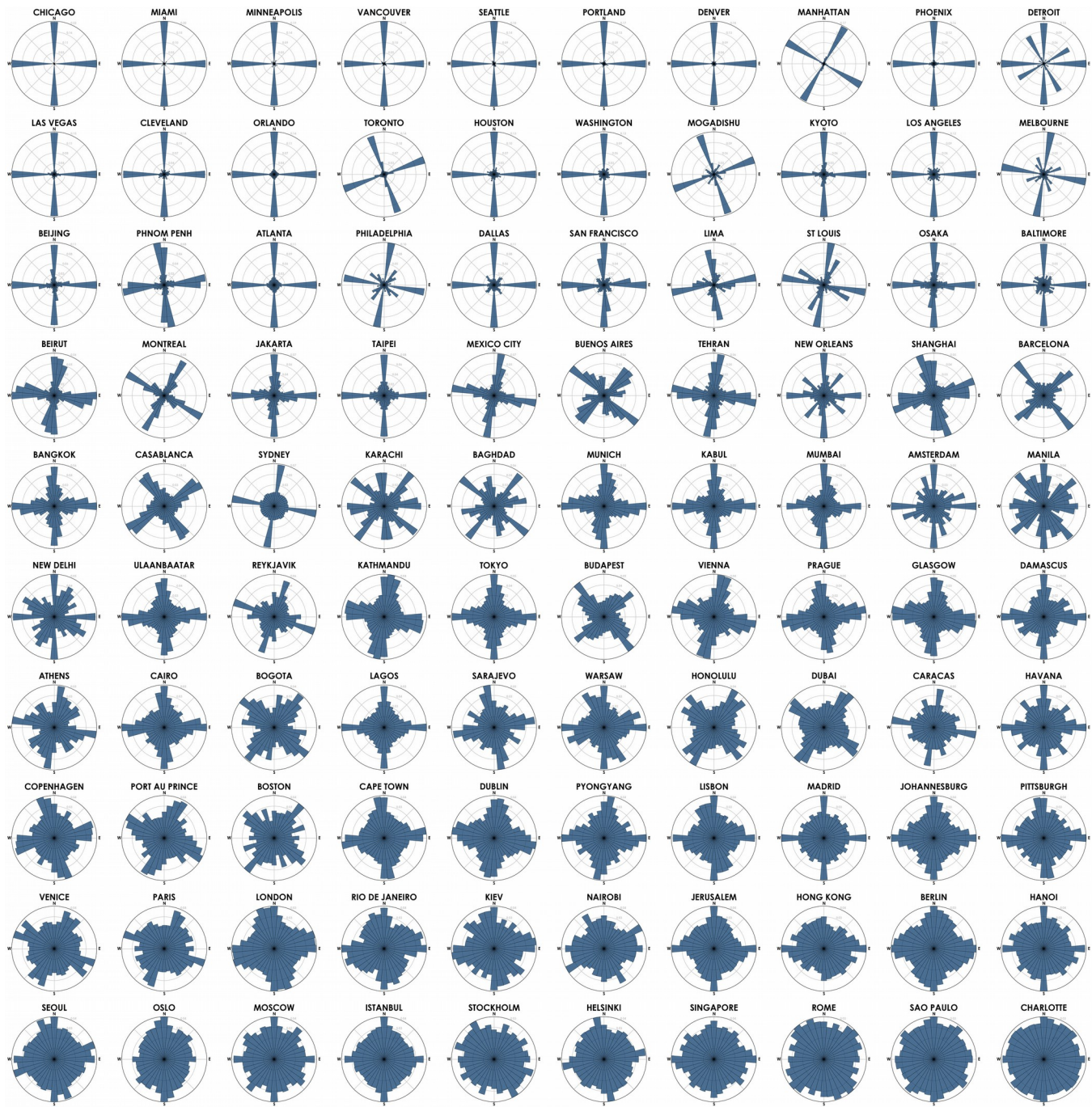
- Each urban area in GHSL database
- Use OSMnx to download and model street network
- Deposit code/models in public repository

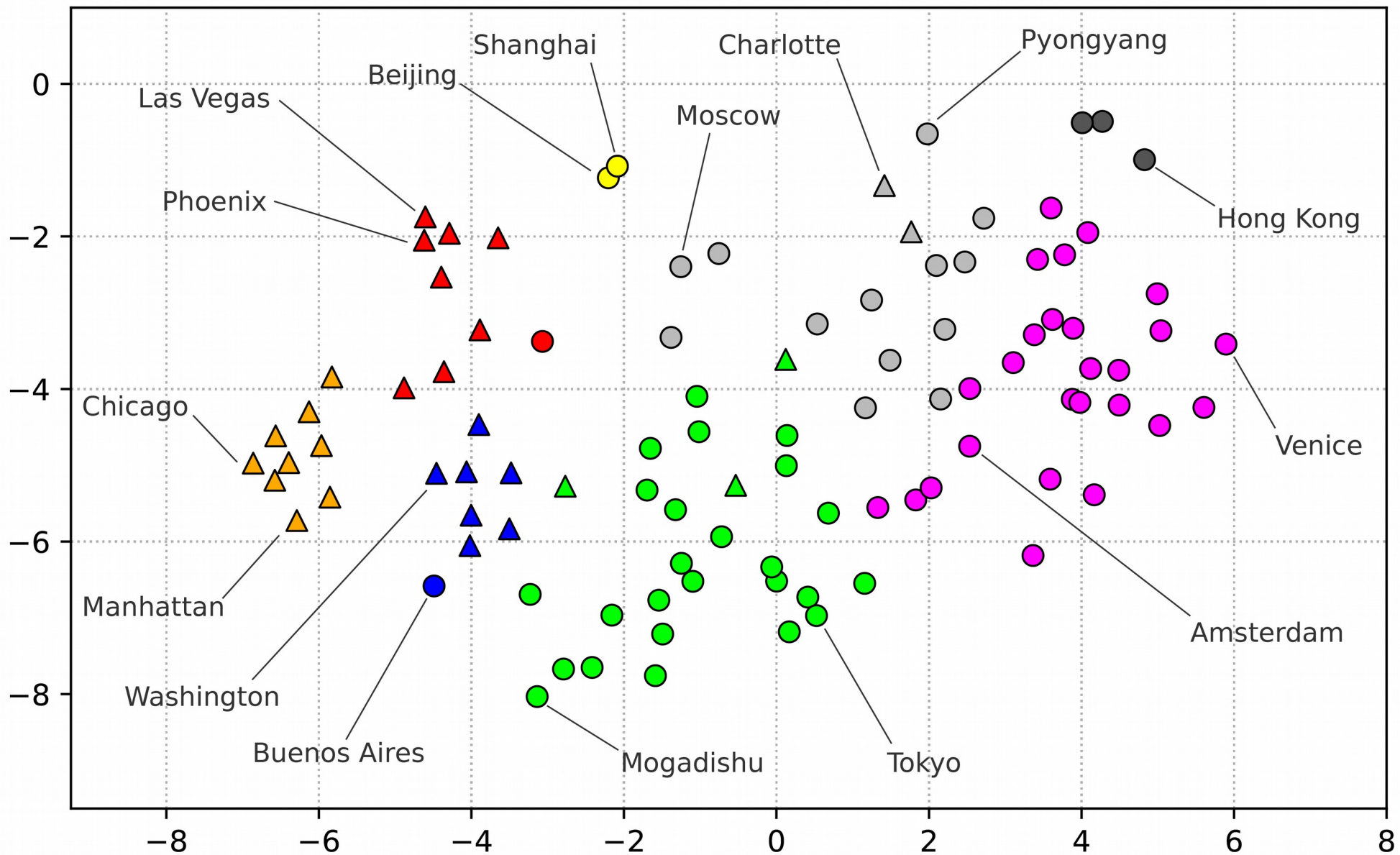
Worldwide Street Networks

- Attach elevation to every node and calculate edge grades
- Sources: ASTER, SRTM3, Google Elevation API
- Imperfect data = trade-offs
- Elevation value selection rules

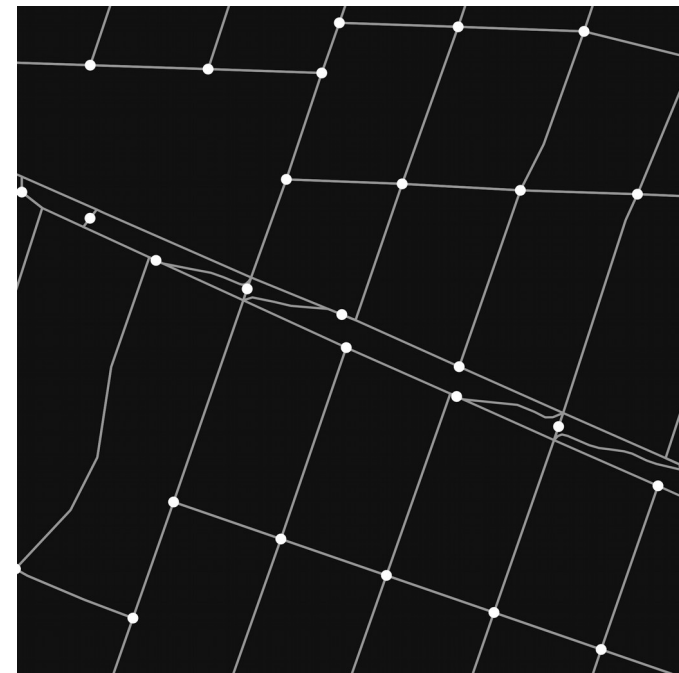
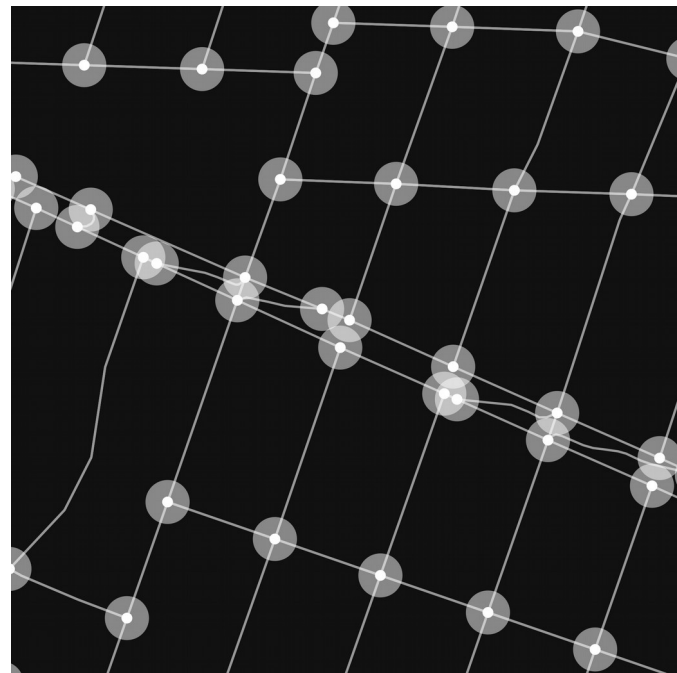
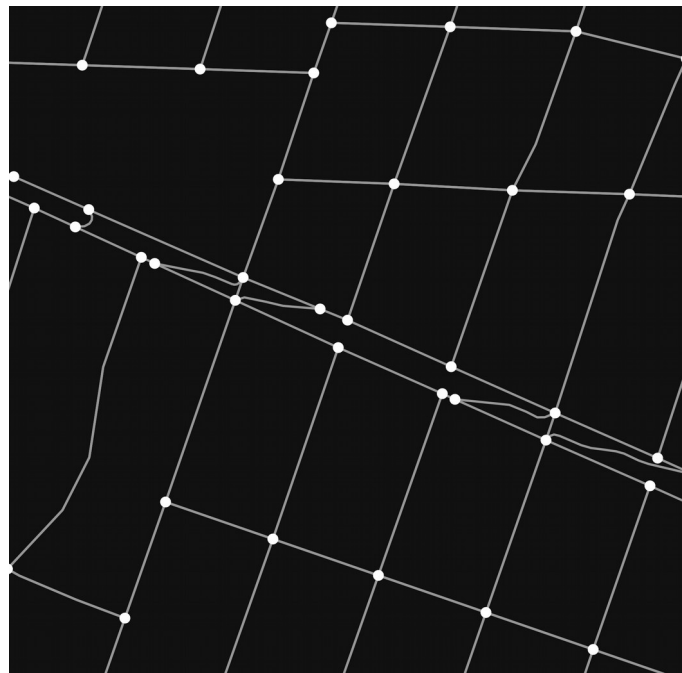
Worldwide Street Networks

- Calculate network indicators for every urban area
- Transport, urban design, network science
 - intersection density
 - block lengths
 - circuitry/straightness
 - orientation entropy
 - many more





Intersection Density



Intersection Density

- Points overcount 16% on average compared to topological method
- Worst regions: Australia/New Zealand and Southern Europe (>29%)
- Worst countries: Australia, Spain, Israel (>33%)
- Bias: 1% ↑ in urban GDP (PPP) per capita, 0.25% ↑ in overcount

Transport CO₂ Emissions

Response = total transport co2 emissions (ln)

R² = 0.54

	coef	std err	t	P> t	[0.025	0.975]
-----	-----	-----	-----	-----	-----	-----
const	-6.9001	0.523	-13.181	0.000	-7.926	-5.874
k_avg ln	-3.1321	0.219	-14.325	0.000	-3.561	-2.703
straightness ln	-5.1467	0.678	-7.596	0.000	-6.475	-3.819
intersect_density_topo_built ln	-0.1540	0.015	-10.067	0.000	-0.184	-0.124
length_total_percap ln	0.4519	0.035	12.800	0.000	0.383	0.521
gdp_ppp_percap ln	0.2656	0.022	12.053	0.000	0.222	0.309
night_light_em_percap ln	0.3096	0.016	19.825	0.000	0.279	0.340
grade_median ln	-0.6217	0.043	-14.327	0.000	-0.707	-0.537
built_up_area ln	0.4367	0.014	30.836	0.000	0.409	0.464
pct_open_space ln	0.8062	0.075	10.711	0.000	0.659	0.954
intersect_count_clean_topo ln	0.2827	0.013	21.930	0.000	0.257	0.308
has_airport	-0.0310	0.050	-0.614	0.539	-0.130	0.068
has_waterport	-0.1728	0.135	-1.282	0.200	-0.437	0.091
LDCL	-0.8496	0.066	-12.969	0.000	-0.978	-0.721
MDR	0.0922	0.050	1.826	0.068	-0.007	0.191

Transport CO₂ Emissions

- 1% ↑ in avg node degree, 3.1% ↓ CO₂
- 1% ↑ in straightness, 5.1% ↓ CO₂
- 1% ↑ in intersect density, 0.15% ↓ CO₂
- 1% ↑ in per capita street length, 0.45% ↑ CO₂

<https://bit.ly/2HzS8F6>



CONCLUSION

Questions?

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