NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Mobility Energy Productivity (MEP) Metric

New York State Association of Metropolitan Planning Organizations

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Presenter: Stanley E. Young

Supporting Team:
Venu Garikapati, PI
Yi Hou, Ambarish Nag, Tom Grushka

National Renewable Energy Laboratory

Motivation – Mobility Energy Productivity (MEP) Metric

- How do you quantify mobility?
- No 'open' and practical method to quantify mobility
- Existing performance metrics measure utilization or efficiency of road network
  - Vehicle miles travelled / VC ratios
- A metric needed quantifies accessibility by all modes, relative to travel time, affordability, and energy
- Productivity = Mobility Benefits/Costs

DOE's Energy Efficient Mobility System will identify and support technologies and innovations that encourage Maximum-Mobility, Minimum-Energy Future.

"From MPG to Mobility per Gallon"

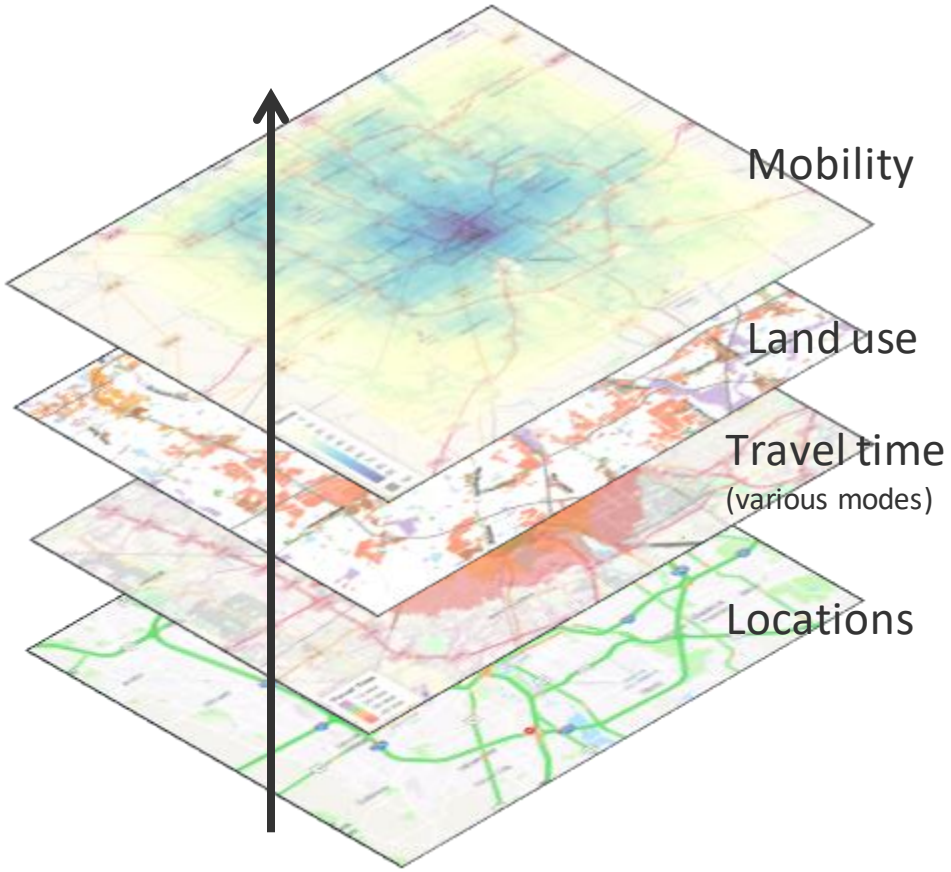
Mobility : The quality of a network or system to connect people to goods, services and employment that define a high quality of life.

Properties of a Good Mobility Energy Productivity (MEP) Metric

- Reflects **efficiency** of accessing a variety of goods, services, and employment
- Can be applied to **any mode** (car, walk, bike, TNC, etc.), and across modes
- Determined by
  - **Travel time, energy and monetary cost** of travel
- Based on **established research**, yet supportable by **available data**
- Can **compare**
  - Two locations within a city (downtown vs. suburb)
  - Two planning strategies (roadway extension vs. transit expansion)
  - Two technologies (EV penetration, AV penetration)
- **Spatially scalable** (applied to a home, district, city, employer)

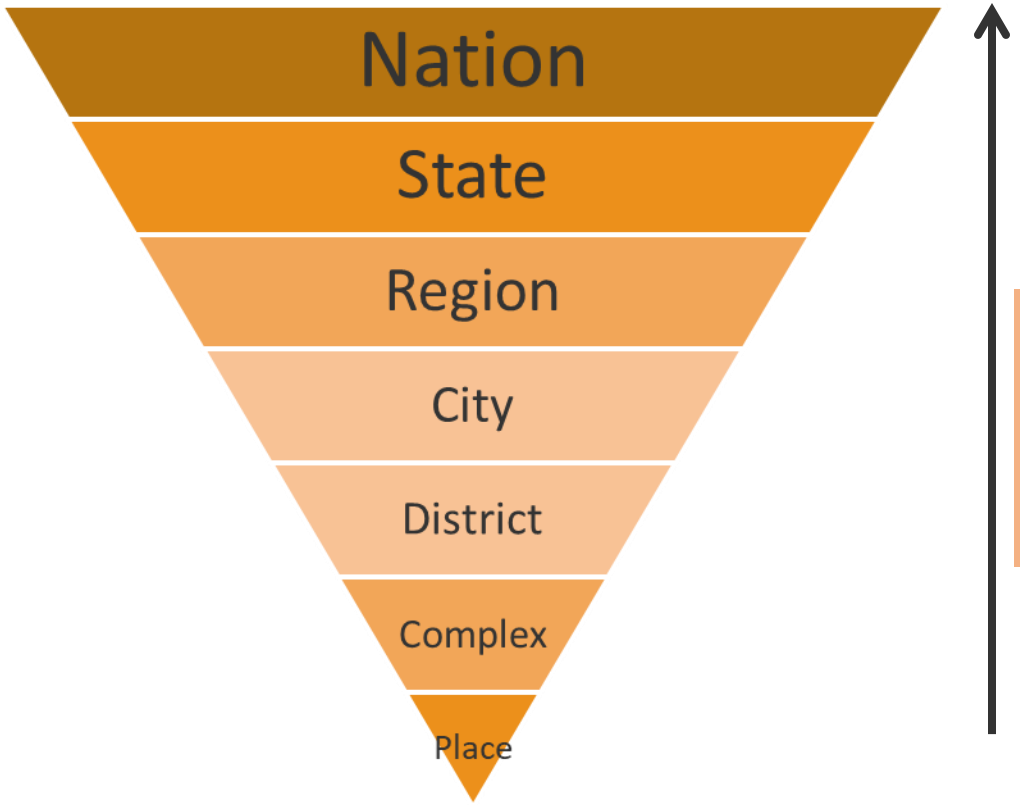
Conceptual Development of the MEP Metric

- Many '**siloed**' metrics such as walk score, bike score, transit score, and average travel time index (by auto) are available to understand the mobility of a neighborhood
- Effectively **combine different modes** into a holistic metric
- **Incorporate the energy & cost** component as well as land use information into the metric



Mobility-Energy Productivity Metric = *F* (mobility weighted by [energy, cost, trip purpose])

Conceptual Development of the MEP Metric



A metric that is easy to scale spatially, as different contexts might need the metric computed at different scales.

- The MEP metric can be customized by different weighting parameters at the local level (activity distributions in Columbus might be different from than in Chicago), and then aggregated by population
- Can be disaggregated by geography, mode, trip type, and population sub-group

Data Spectrum Driving the Metric

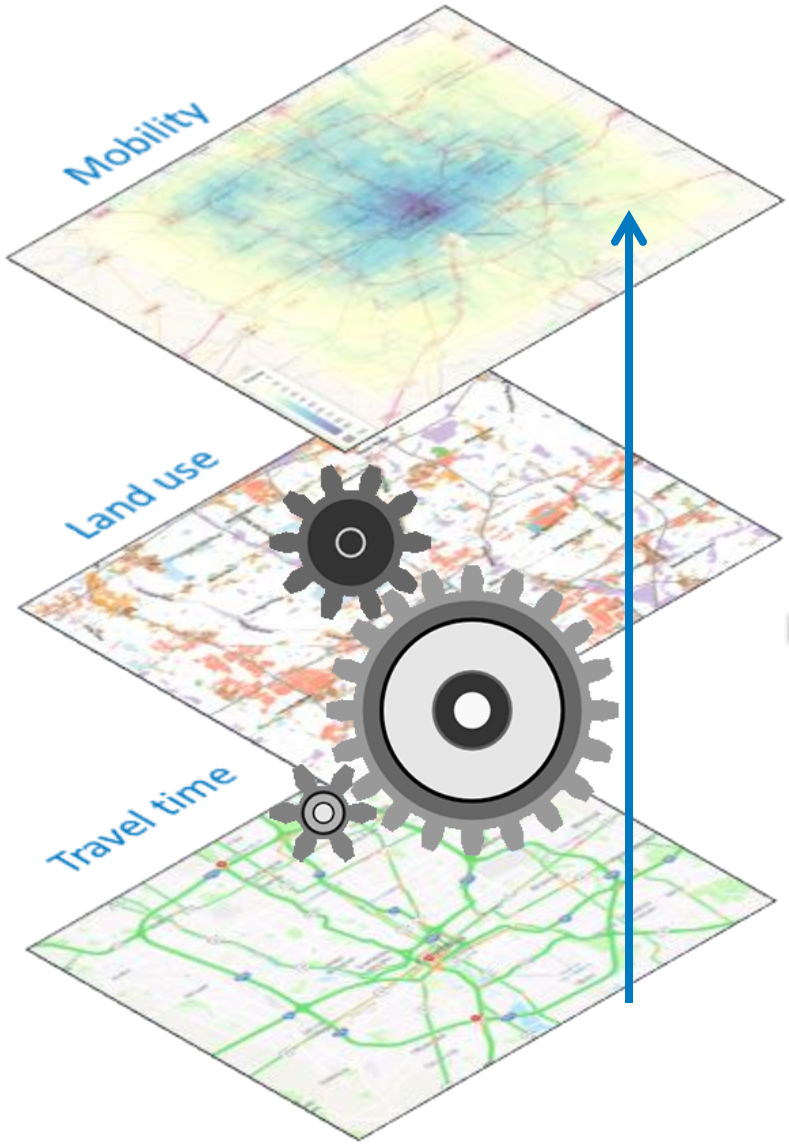
Travel Time and Isochrone
- Third party isochrone APIs (e.g. HERE)
- GPS trajectory data (TomTom, INRIX)
- Travel Demand Models

Land Use Data
- Metropolitan Planning Organizations

Energy Efficiency Measures
- Transportation Energy Data Book
- Other energy intensity studies

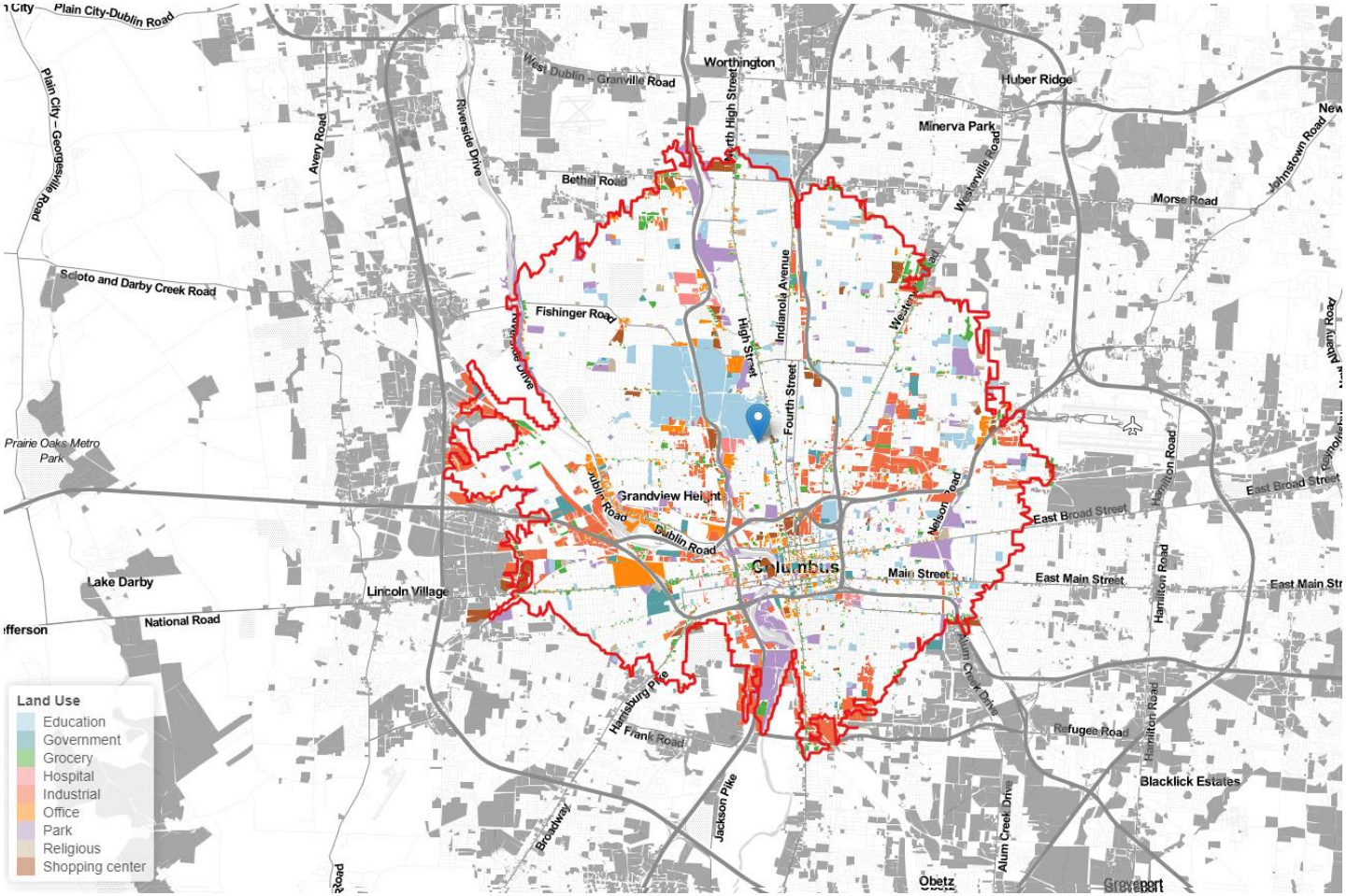
Travel Demand Data
- National Household Travel Survey (NHTS)

Cost Measures
- Capital costs, operational costs
- Value of time



Cumulative Opportunities

Count the opportunities that can be accessed within travel time of 10, 20, 30, 40 minutes for every cell



A example of opportunities accessible by biking

Basic Data Elements of the MEP Metric

- **Quantify the number of opportunities** that people can reach within a certain travel time threshold by different transportation modes

- The opportunity count values are further proportioned across all activities by **frequency of trip purpose**

- The opportunities measure is **weighted by the time, energy and cost efficiency** metrics of different transportation modes

MEP Computation

$$o_{ikt} = \sum_j o_{ijkt} \cdot \frac{N^*}{N_j} \cdot \frac{f_j}{\sum_j f_j}$$

$$\mathrm{MEP}_i = \sum_k \sum_t \left(o_{ikt} - o_{ik(t-10)}\right) \cdot e^{U_{ikt}}$$

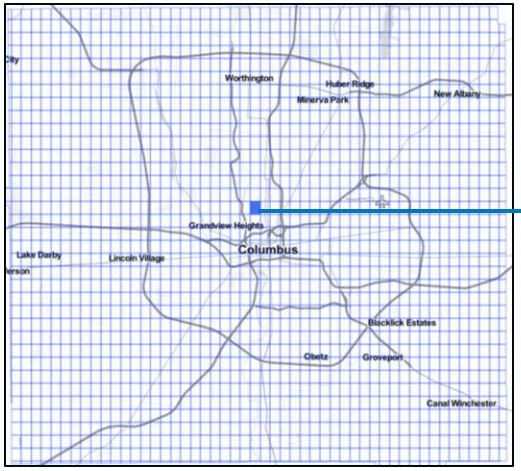
where $U_{ikt} = \alpha e_k + \beta t + \sigma c_k$

e_k – energy intensity of mode k

c_k – cost of mode k

α, β, σ – weighting parameters

Weighting Mechanism for MEP (Illustrative)



Proportioned by activity engagement frequency

	WORK	SHOP	GROCERY
DRIVING	804681	433	1952
TRANSIT	24628	8	109
BIKING	120292	40	676

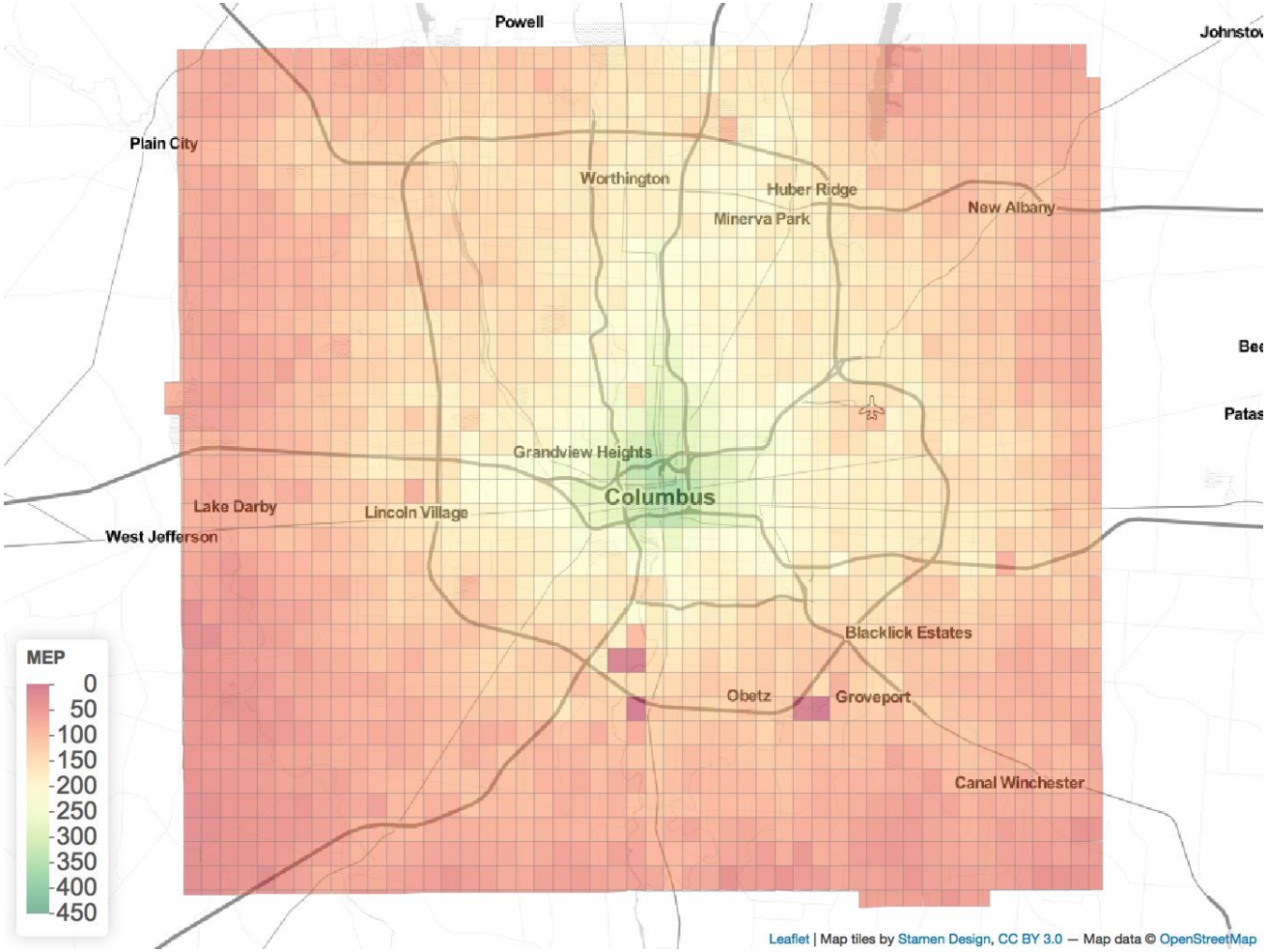
Weighted by time

	CUMULATIVE OPPURTUNITIES
DRIVING	10000
TRANSIT	680
BIKING	450

Weighted by modal energy intensity and cost

MEP
68

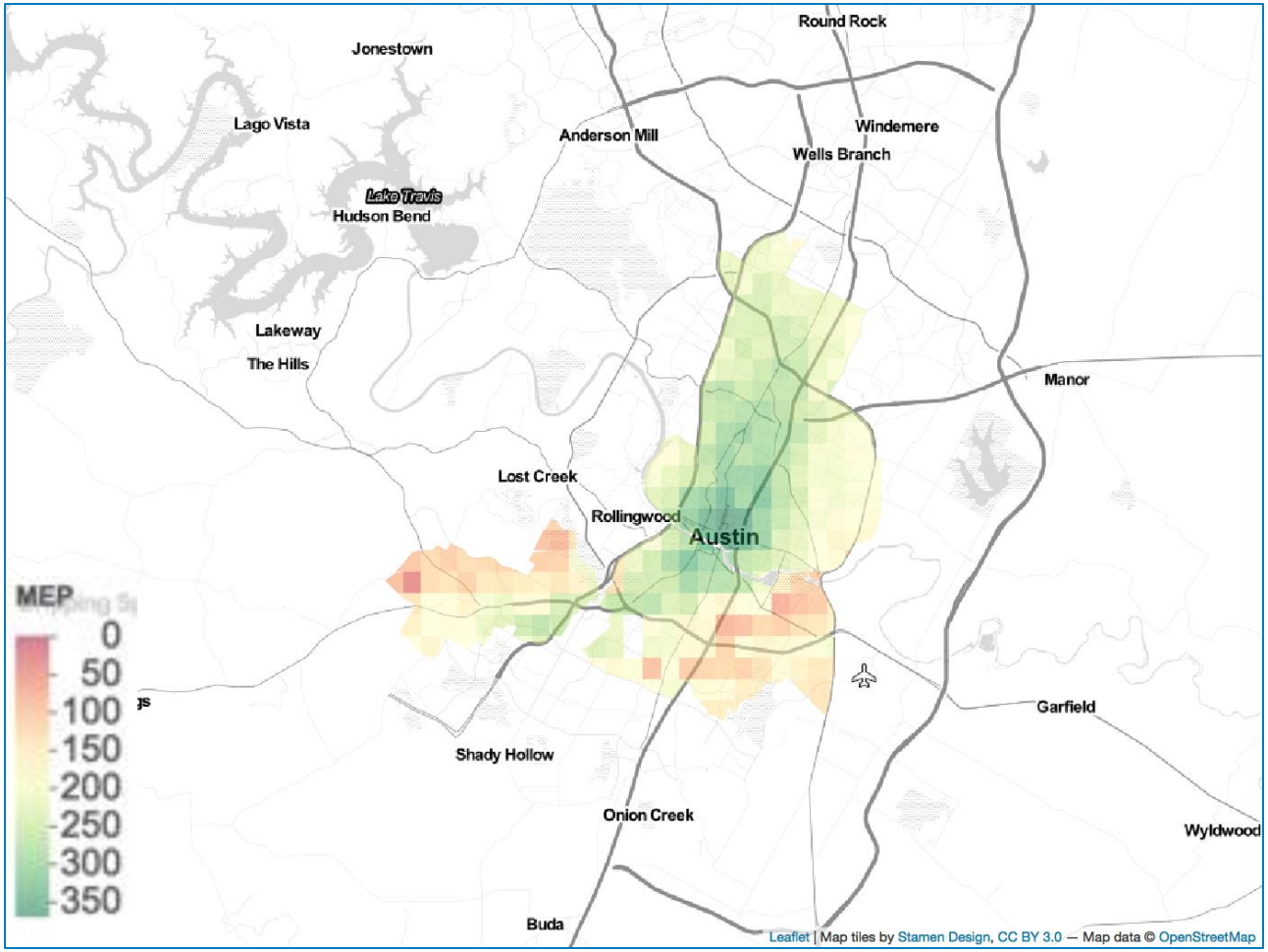
MEP – Columbus, OH



MEP: Population Density Weighted Summation for City Level Aggregation

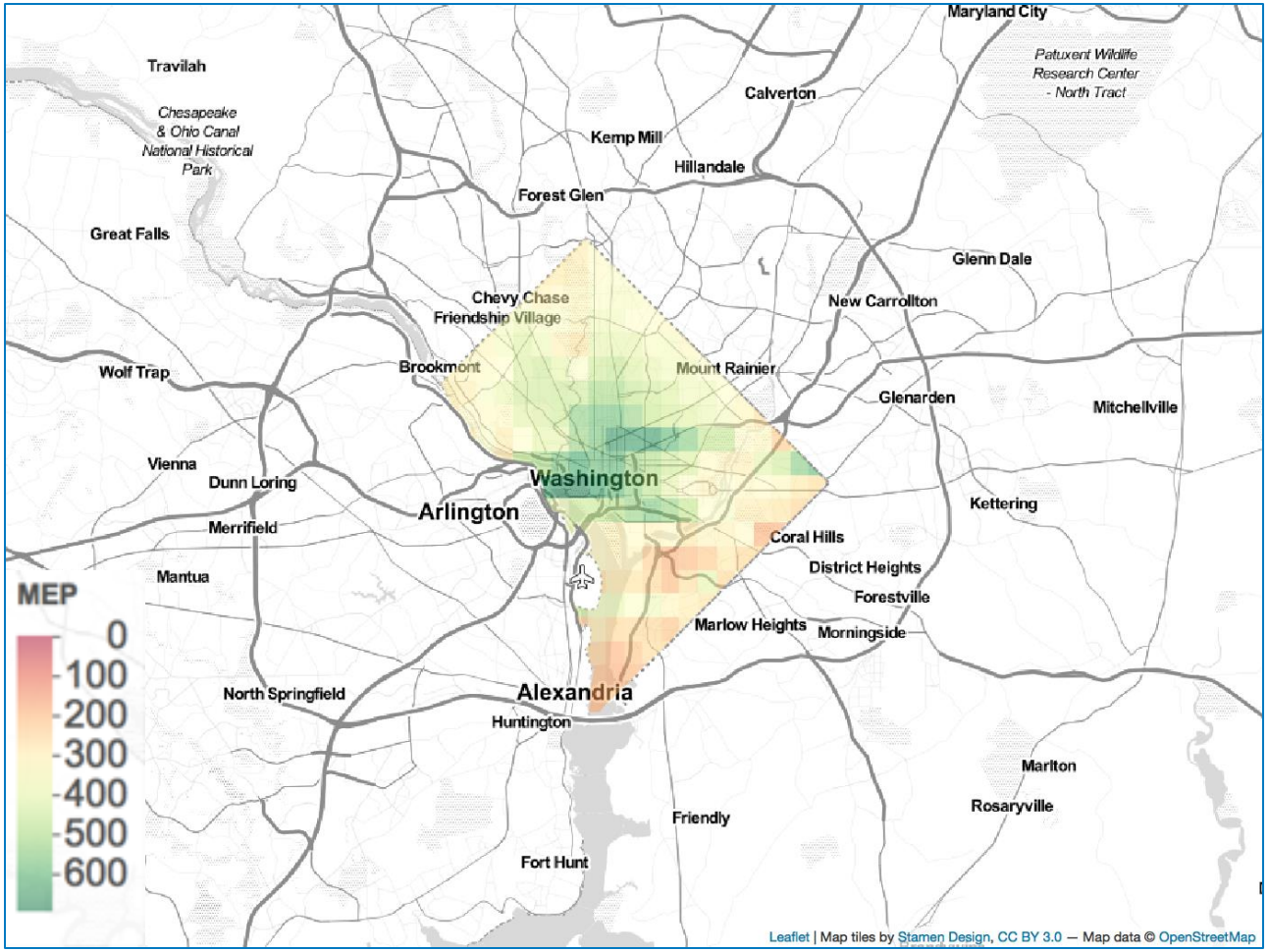
Population Weighted MEP: Austin

Population density weighted metric : 193



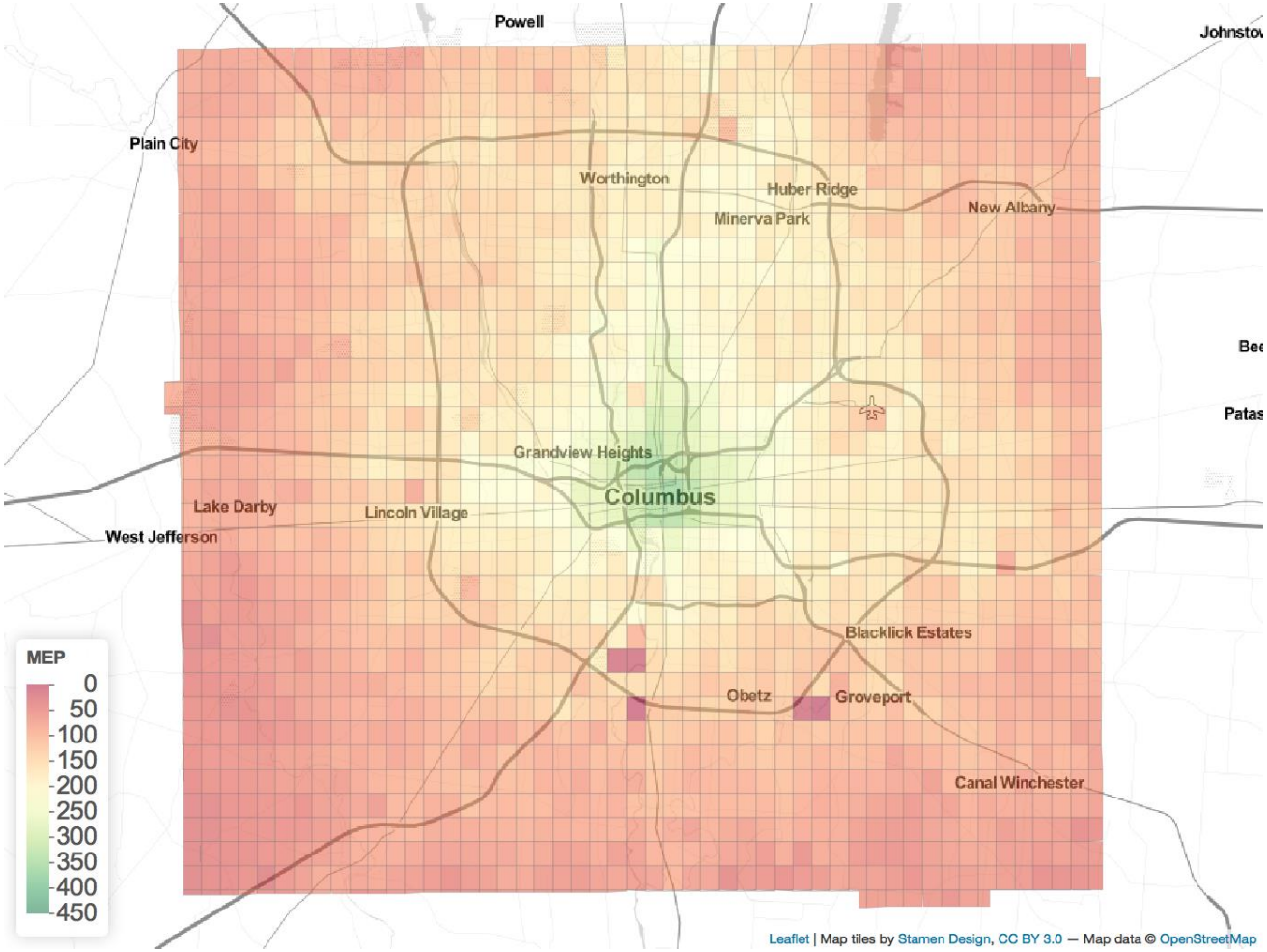
Population Weighted MEP: Washington, DC

Population density weighted metric: 365

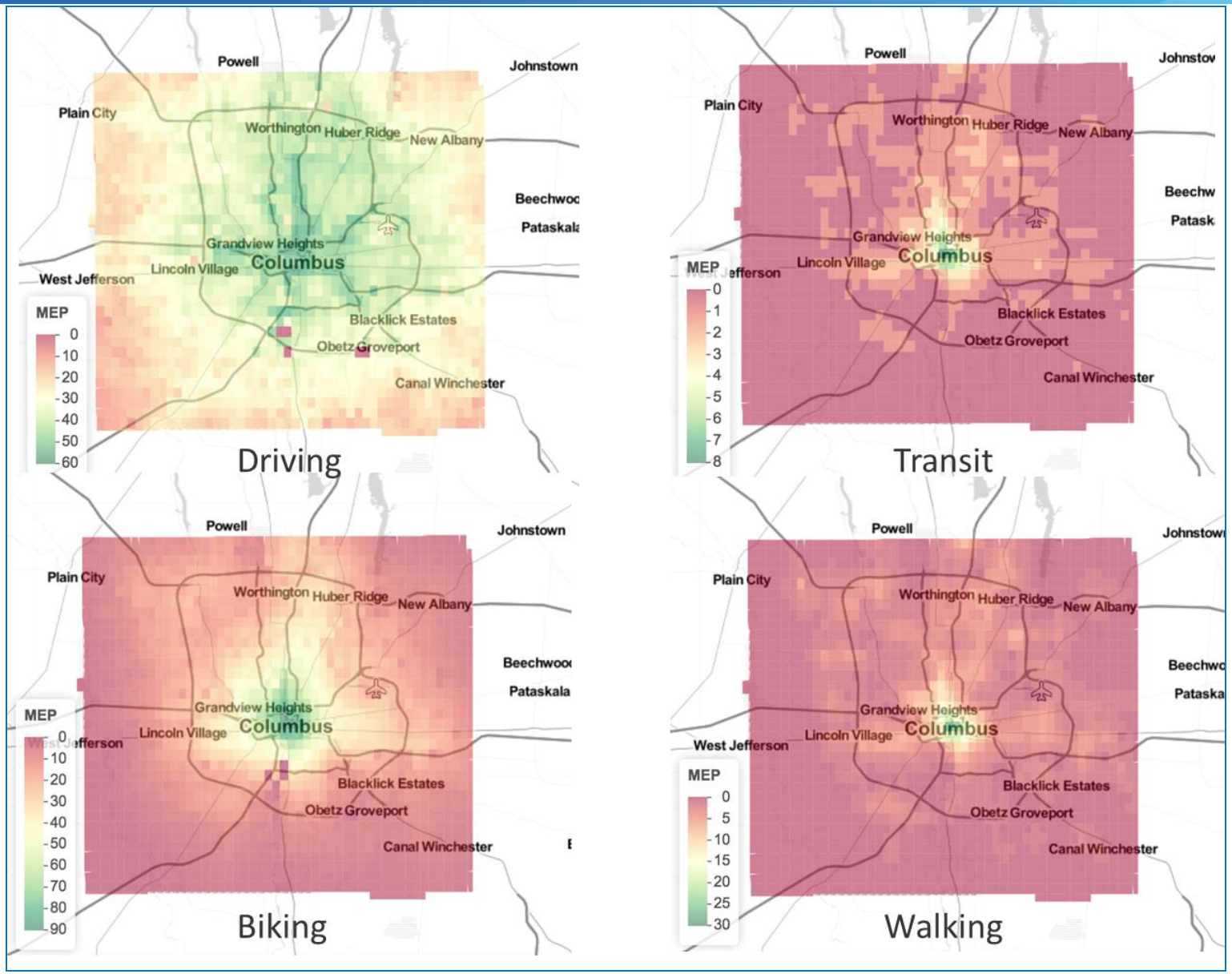


Population Weighted MEP: Columbus, OH

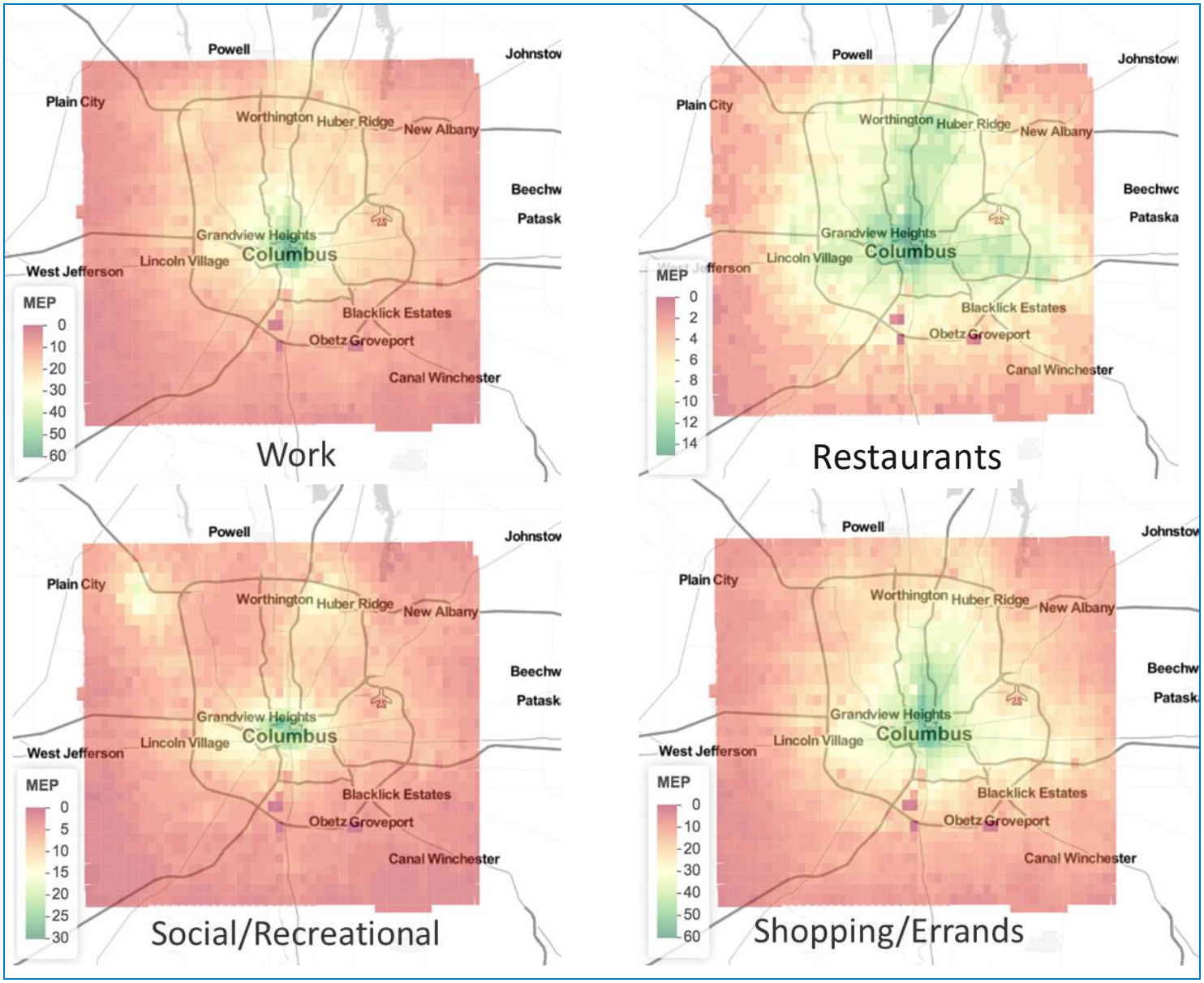
Population Density Weighted Metric: 162



MEP Maps by Mode - Columbus



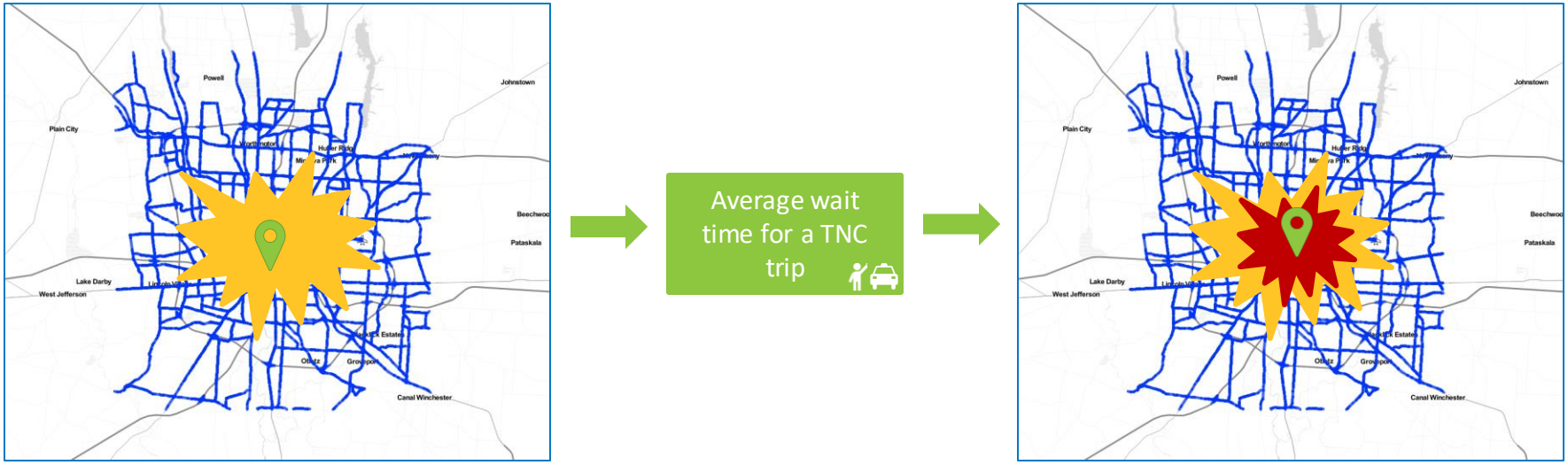
MEP Maps by Activity - Columbus



Introduction of New Modes

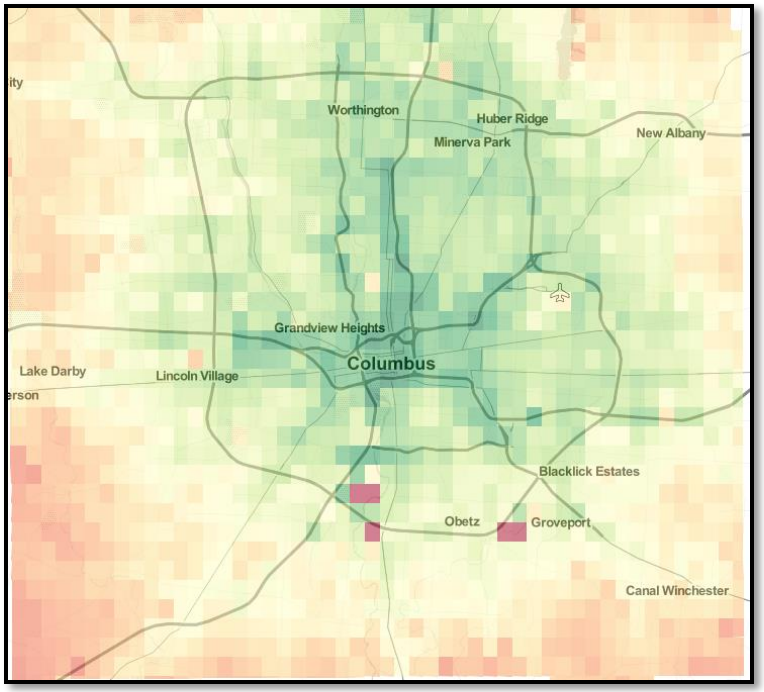
TNC Isochrones

- Isochrones of t minutes by TNC are assumed to be the isochrones of $t - t_w$ minutes by driving, where t_w is waiting time
  - Waiting times obtained from Uber API
- Generating TNC isochrones



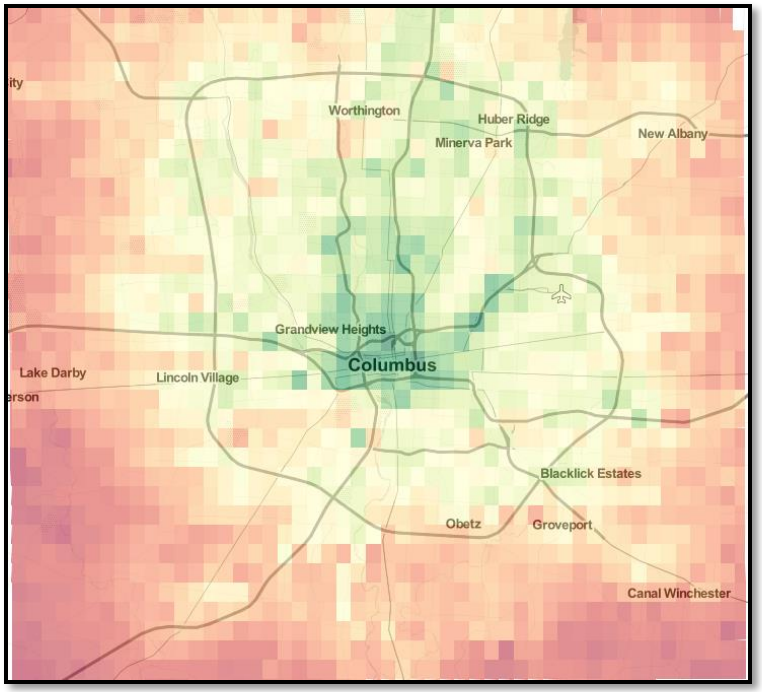
TNC Isochrones

Driving



Driving MEP: 126

TNC

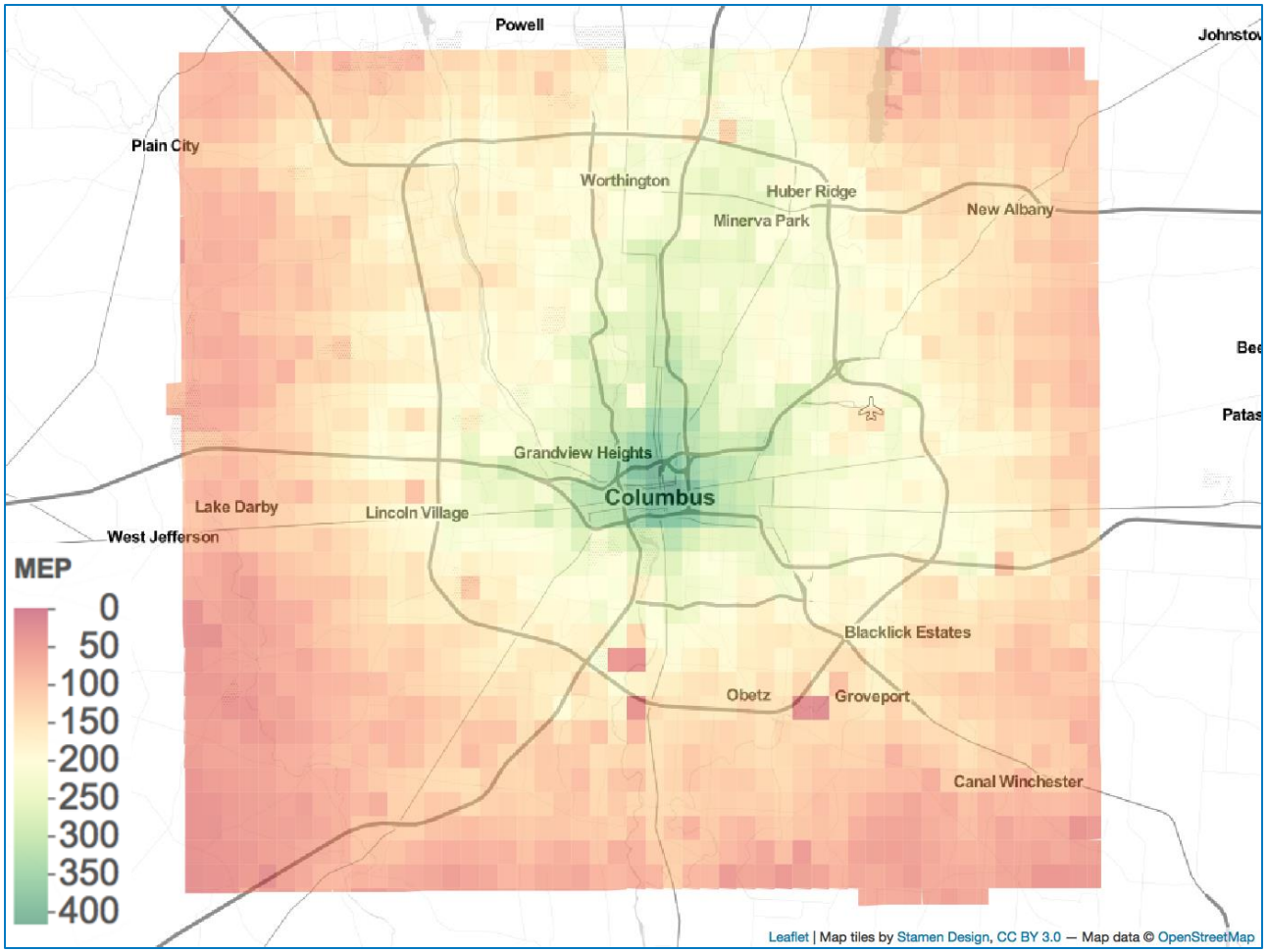


TNC MEP: 92 (27% Less than Driving MEP)

Caveat: The TNC MEP computation does not account for any secondary effects of TNCs such as increased energy (due to deadheading), cost, or congestion effects.

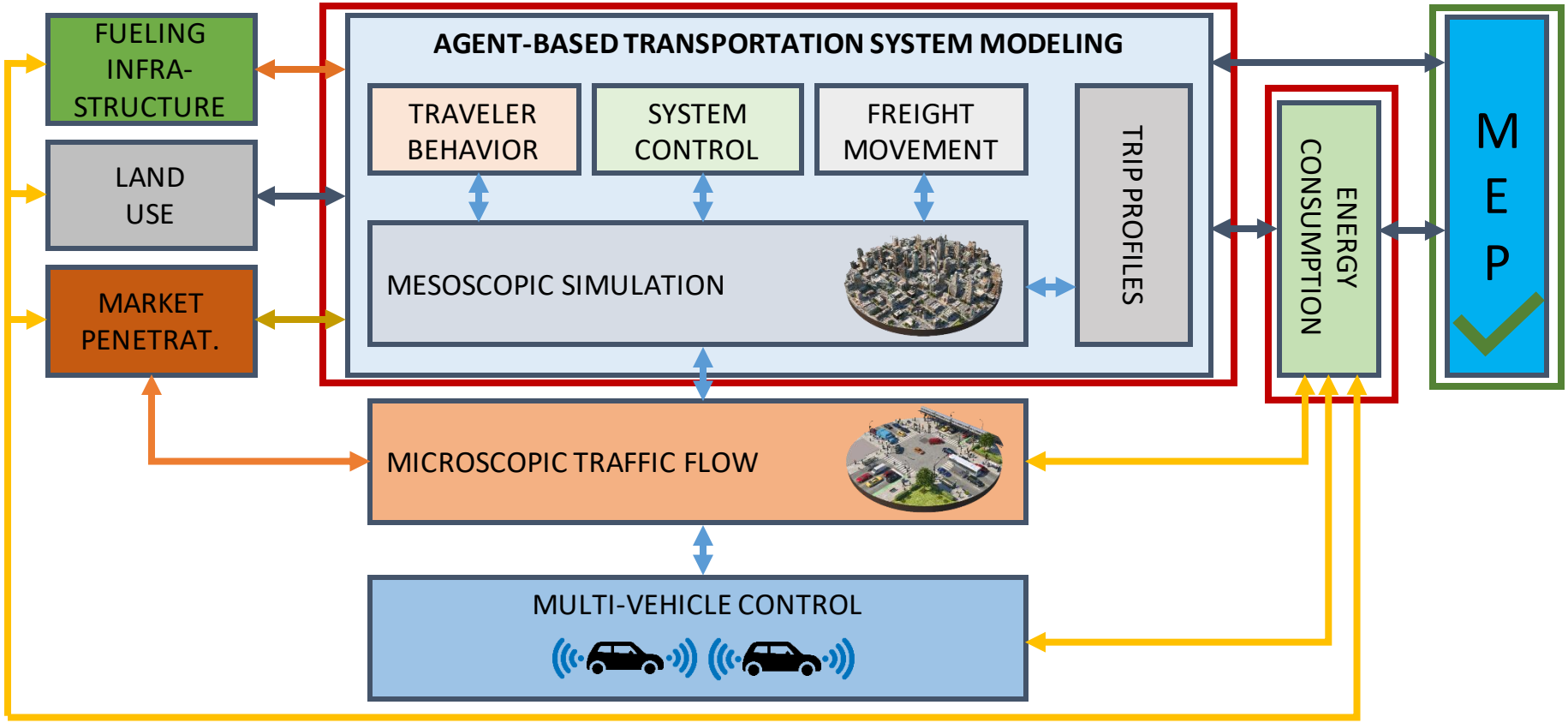
Population Weighted MEP: Columbus

- Population density weighted metric without considering TNC: 162
- Population density weighted metric with TNC : 198



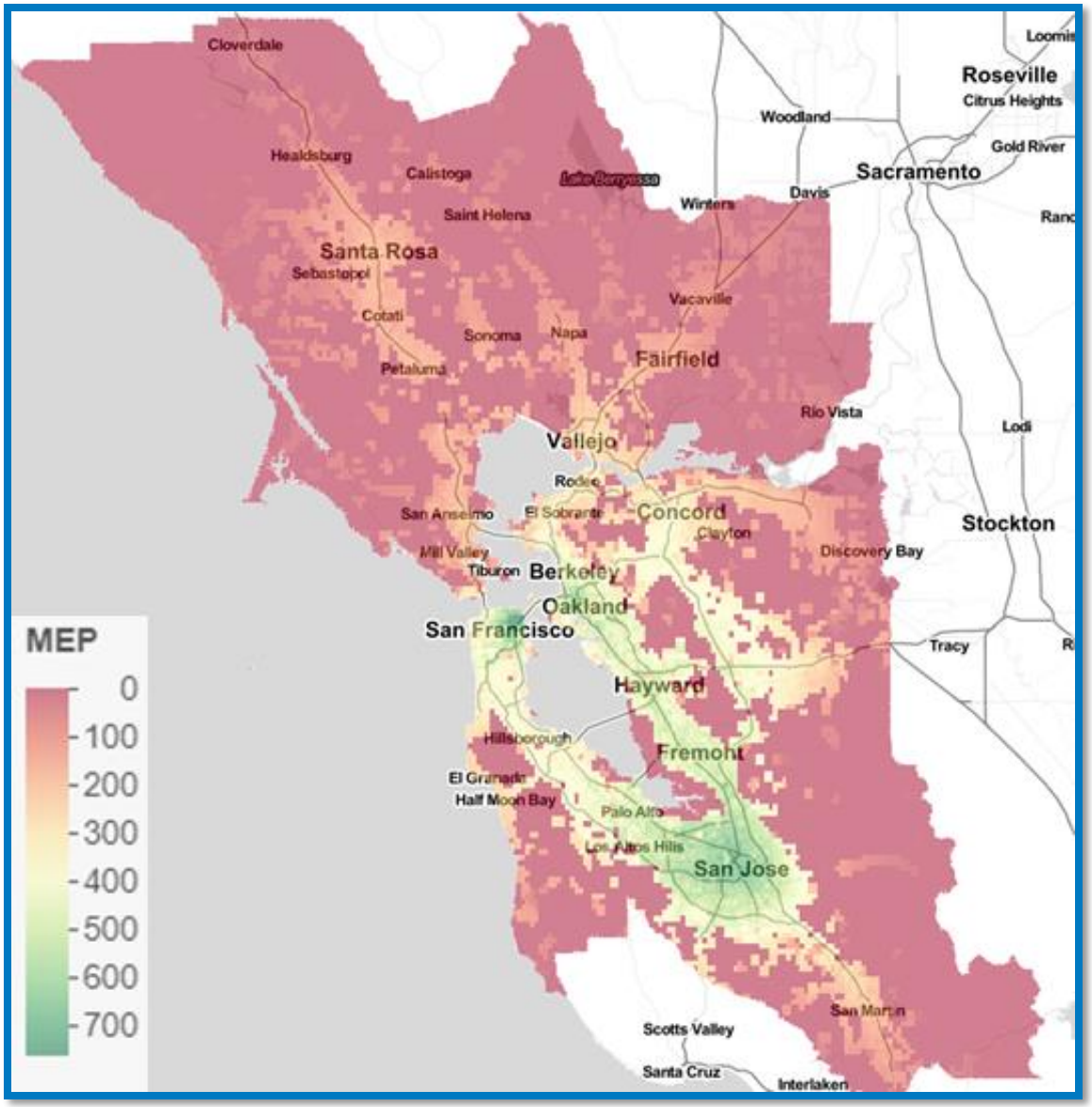
MEP Calculation Based on Outputs from Travel Demand Models

SMART Workflow Modeling

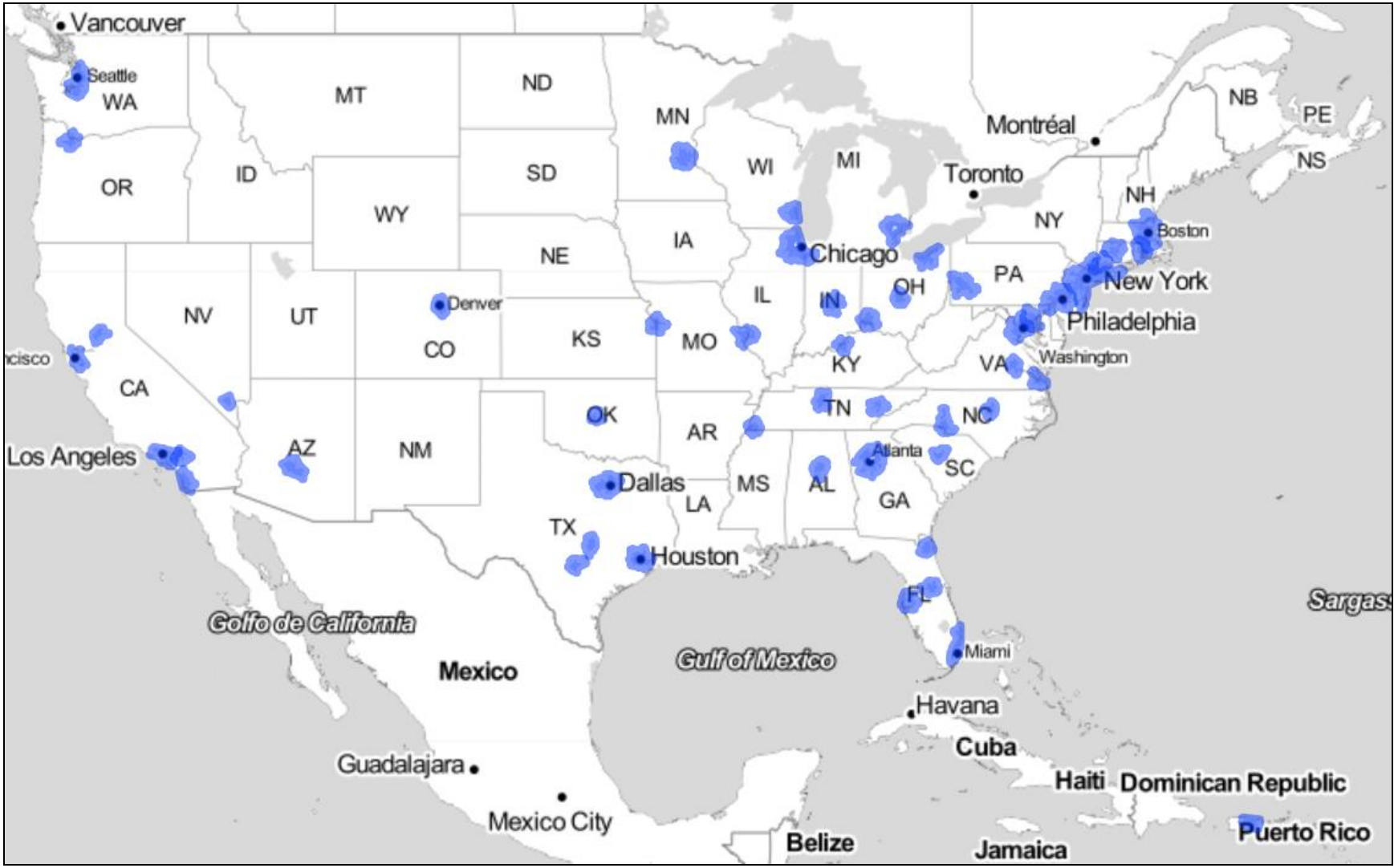


The MEP metric will capture the impact of emerging technologies and land use patterns on accessibility - including impacts on travel time, energy usage, and the cost of different modes of transportation.

MEP – Based on BEAM Outputs (SF Bay Area)



MEP Calculation for Top 50 US Metropolitan Cities



MEP Applications

- MEP will be the **central lens** through which advancements in the DOE - EEMS research portfolio will be assessed.

- NREL has a MOU executed with ASCE to move the MEP methodology forward as a **provisional foundational standard** as part of its Smart Cities standards initiative

- The Connecting Opportunities through Mobility Metrics and Unlocking Transportation Efficiencies (COMMUTE) Act:
  - The **COMMUTE Act** requires USDOT to create a competitive pilot program to provide five states, 10 metropolitan planning organizations, (MPOs), and five rural planning organizations with data sets to calculate how many jobs and services (such as schools, medical facilities, banks, and groceries) are accessible by all modes of travel.

Thank You

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