Status Report on UrbanSim and the Open Platform for Urban Simulation

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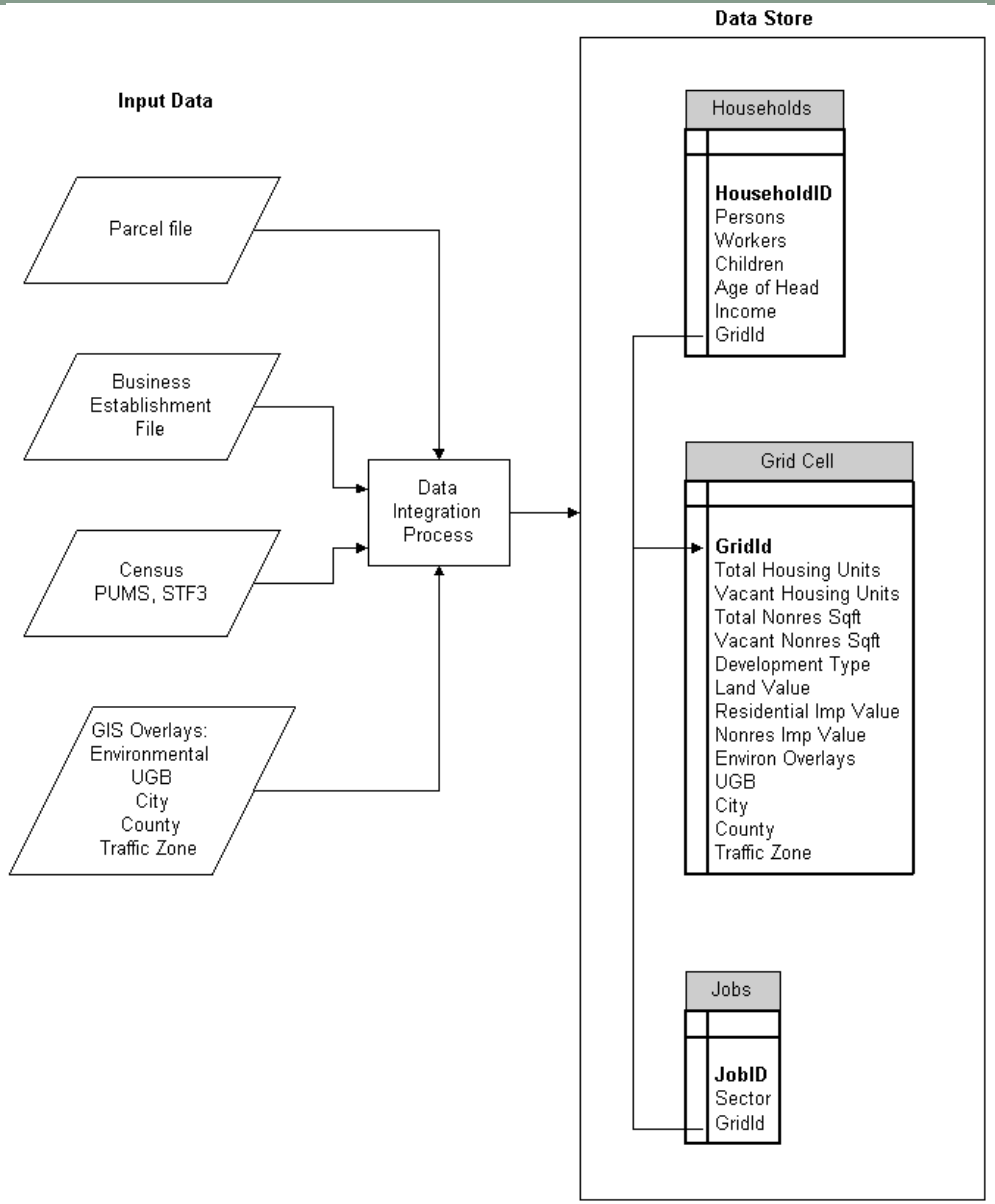
Agenda

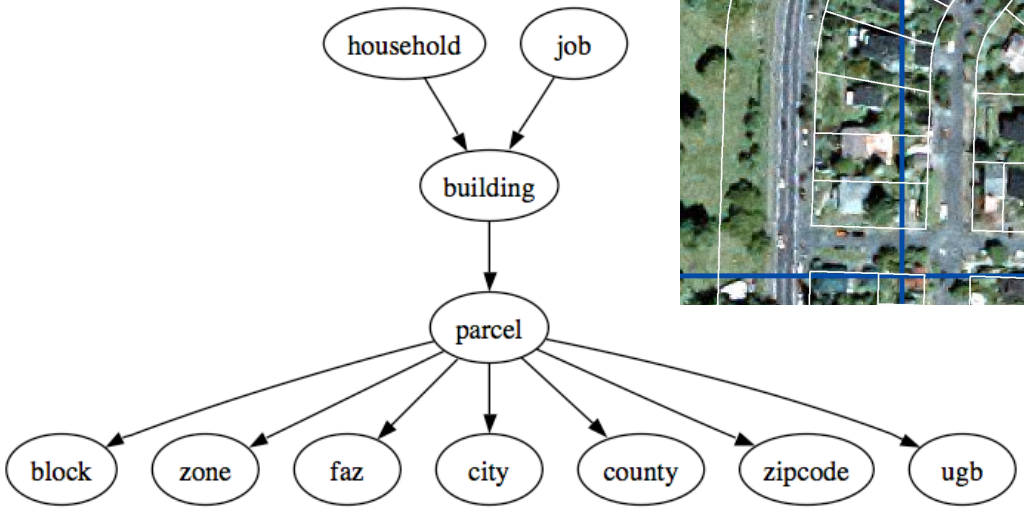
- Brief Updates on UrbanSim Development
  - Data Integration
  - Model Uncertainty
  - Zone version of UrbanSim
  - Interactive Database and Scenario Creation
- Integrated Model Application Case Study: Puget Sound

Data Integration in UrbanSim

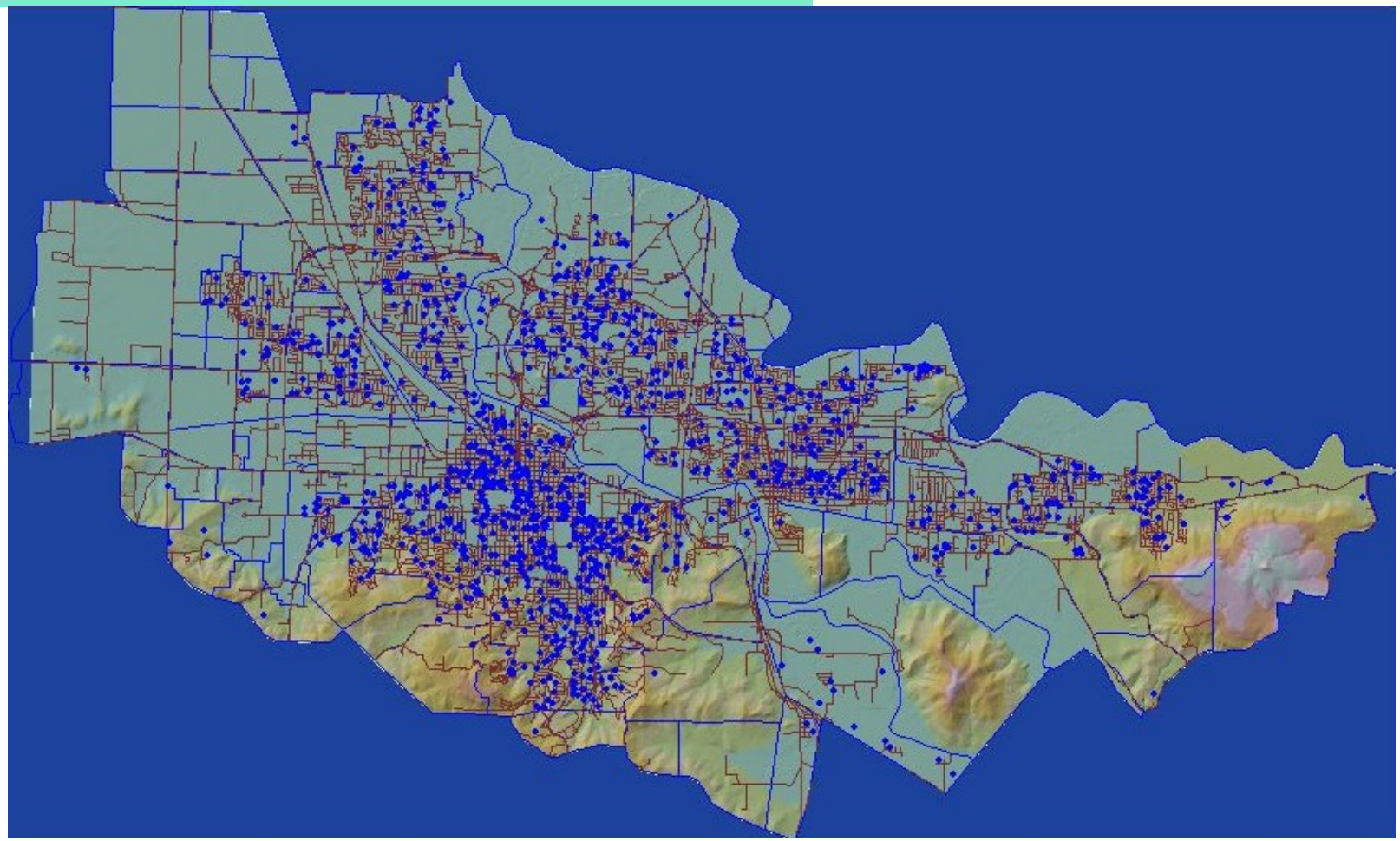
UrbanSim Data Integration Process



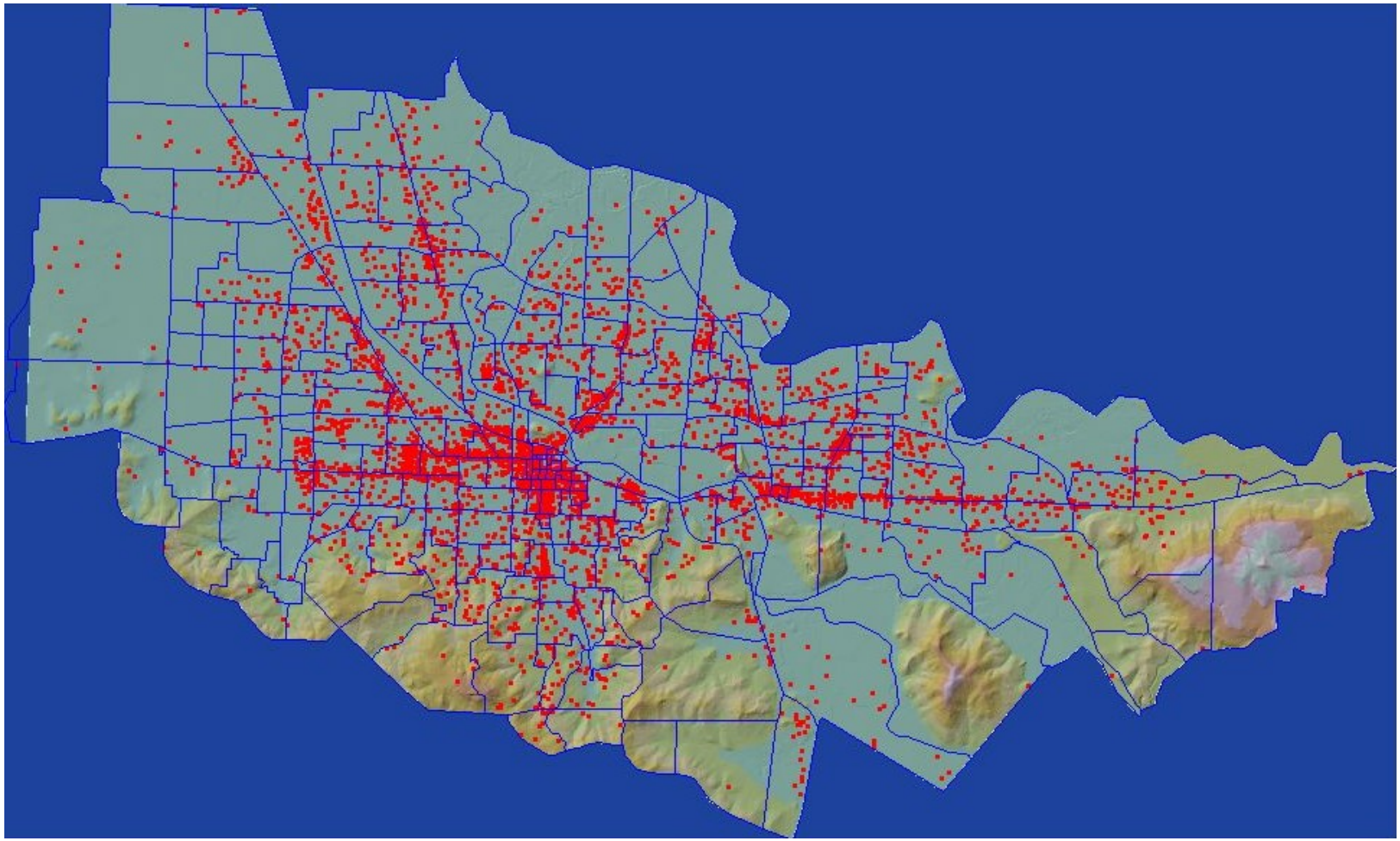
New Model System Based on Parcels and Buildings



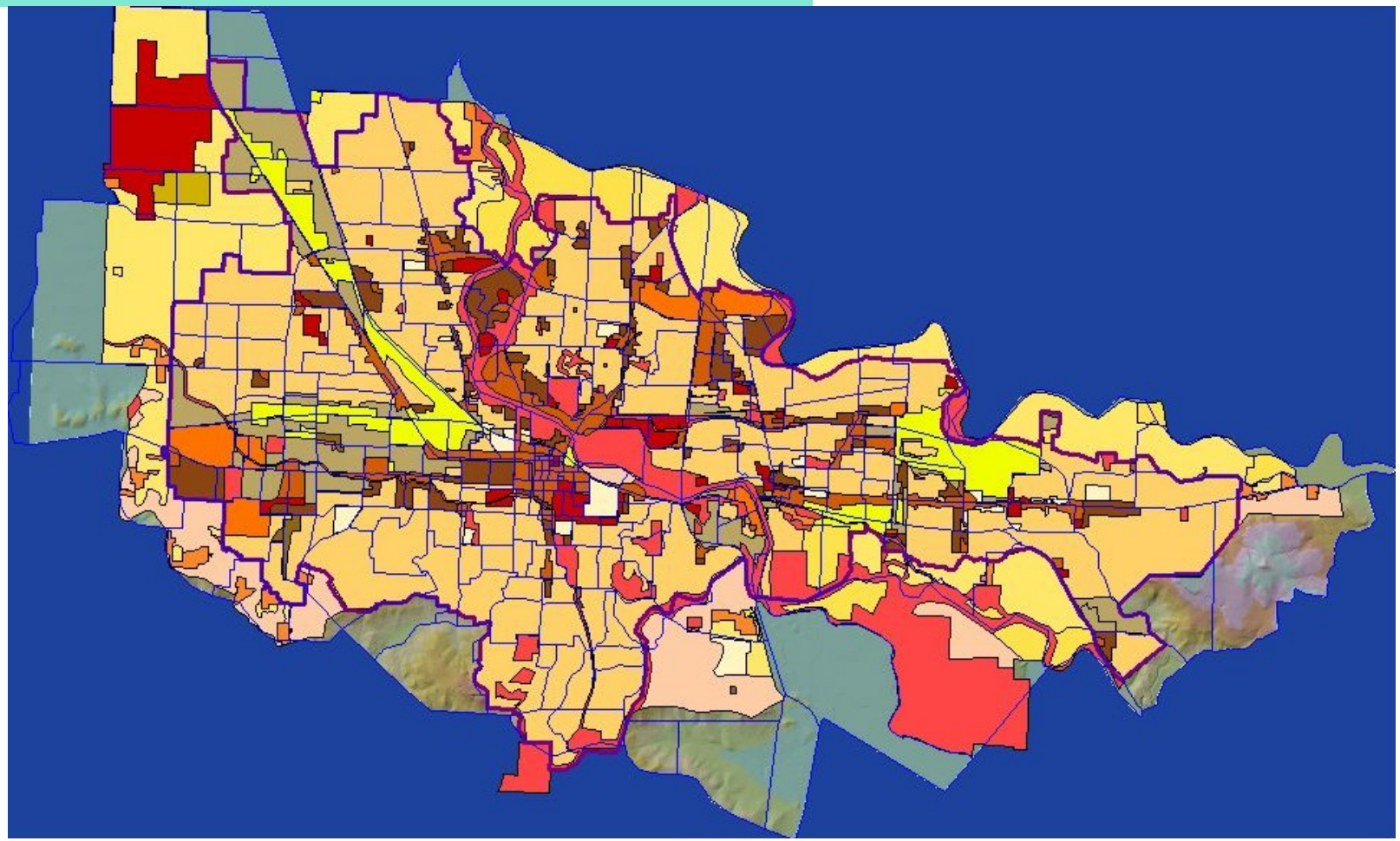
Input Data: Household Survey



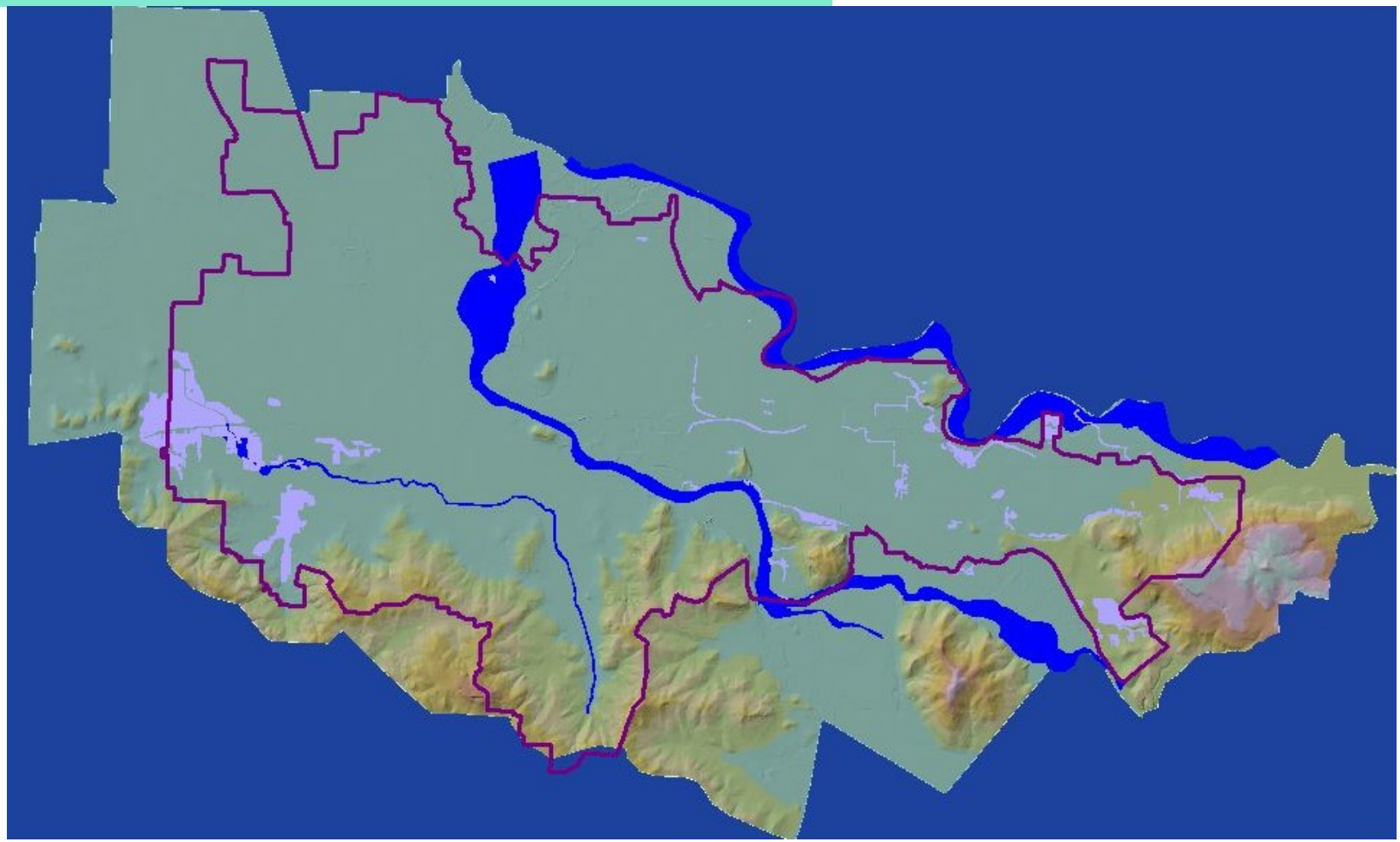
Input Data: Employment



Input Data: Land Use Plan

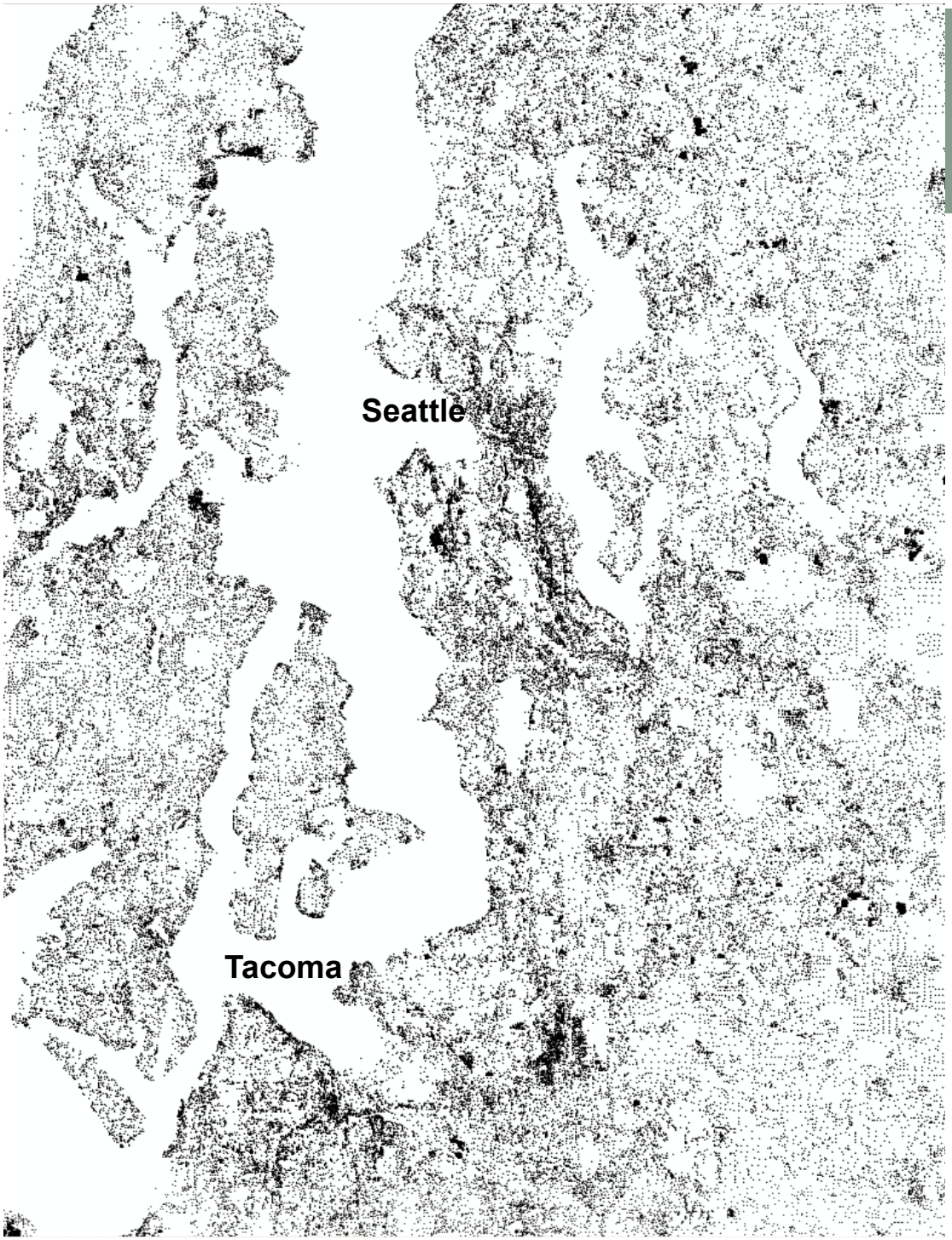


Input Data: UGB and Environmental



Data Integration Challenges

- **Messy Data**
  - Many outliers, errors, and missing data
  - Inconsistent coding schemes among data sources
- **Difficult to integrate with other data sources**
  - Building-level data
  - Business establishment data
  - Market information (vacancies, prices, rents)
- **Volume of data too massive to manually correct**
  - 2+ milliion parcels in Bay Area
- **Problems hard to diagnose**
  - Which data is wrong? (which attributes/sources are incorrect? May have systematic patterns of omissions – e.g. tax-exempt properties)
  - Misgeocoding: some businesses are geocoded to the wrong place. Complicates the diagnosis.



The Magnitude of the Problem

This map shows only buildings with missing values for “Building Type ID”, a description variable.

195,501 out of ~1,200,000
Building Type ID = Null
King, Kitsap, Pierce & Snohomish Co.

Data Imputation Tool

Data Imputation Tool

Ways Forward on Data Integration

Option 1:

- Machine Learning/Data Mining
- Model patterns in the observed data
- Use the models to detect outliers, impute data
- Preliminary work on this now implemented using WEKA library

Option 2:

- In some cases, the missingness level is very high
- Developing countries (e.g. Ghana and South Africa)
- Potential to Synthesize much of the data, subject to constraints, using procedural modeling

Option 3:

- Potential to hybridize statistical/machine learning and procedural modeling, to synthesize from disparate sources?

Data Imputation

K-Nearest Neighbors for Continuous Attributes

Attributes: Stories, Bldg SF, Improvement Value, etc.

KNN Basics:

Finds k closest neighbors in n dimensional space.

Uses k neighbors target values to make prediction.

$$L^n(\mathbf{x}_1, \mathbf{x}_2) = \sqrt[n]{\sum_{i=1}^{\#\dim} |\mathbf{x}_{1,i} - \mathbf{x}_{2,i}|^n}$$

$$\hat{f}(x_q) \leftarrow \frac{1}{k} \sum_{i=1}^{k} f(x_i)$$

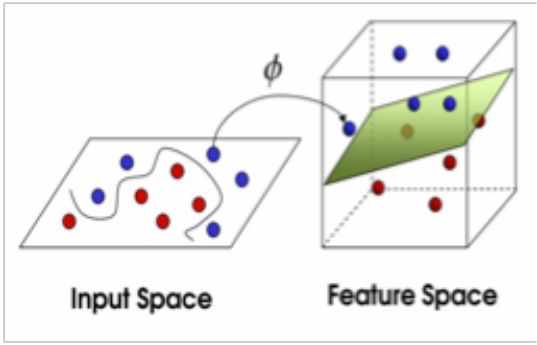
Data Imputation

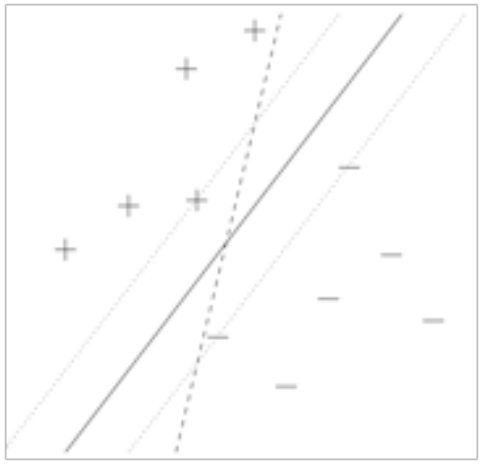
Support Vector Machines for Categorical Atributes

Attributes: Building Use Code, Land Use Code, etc.

SVM maps training instances into higher dimensional space.

Creates hyper planes that have maximum distances from instances as category boundaries.





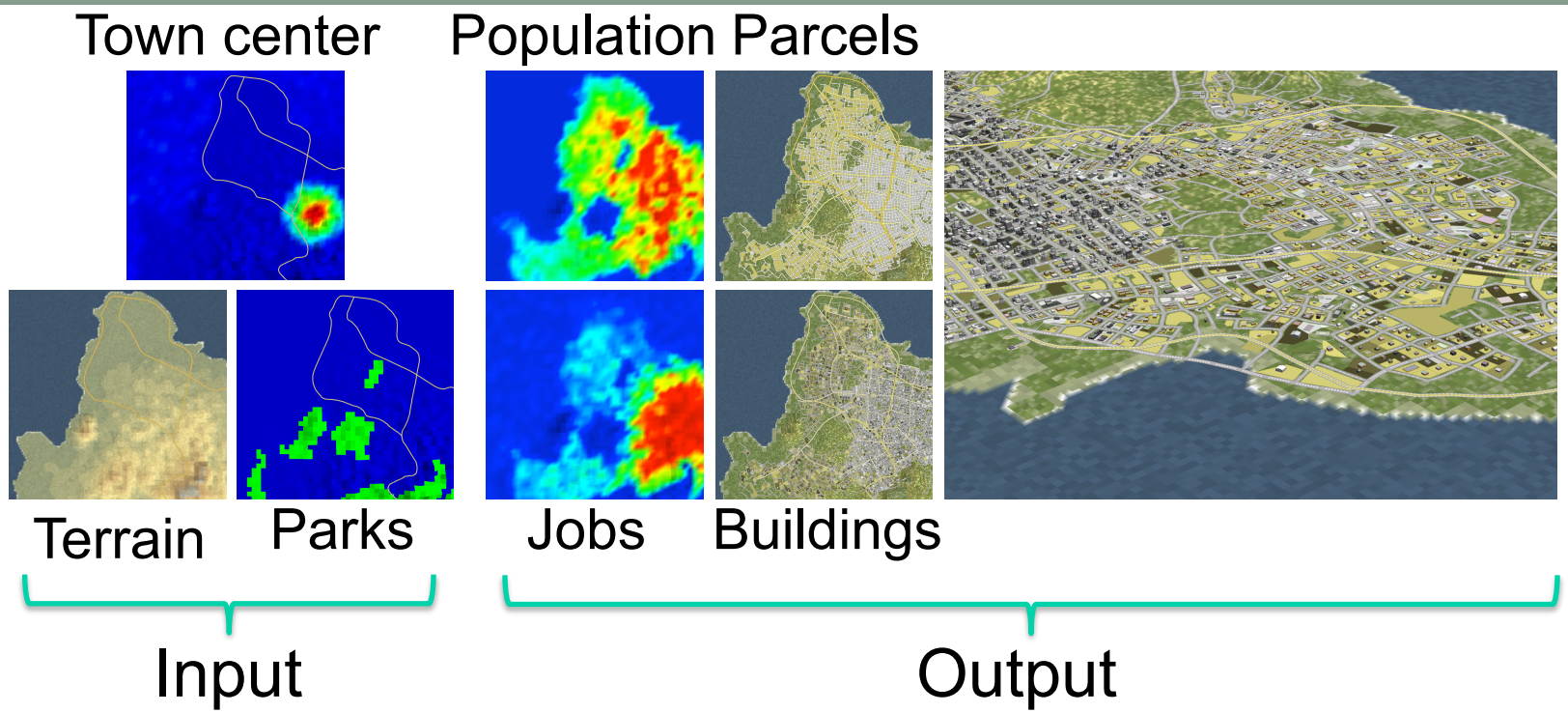
Machine Learning/Data Mining

So far, only applied to single tables, single output

Need to develop analysis for:

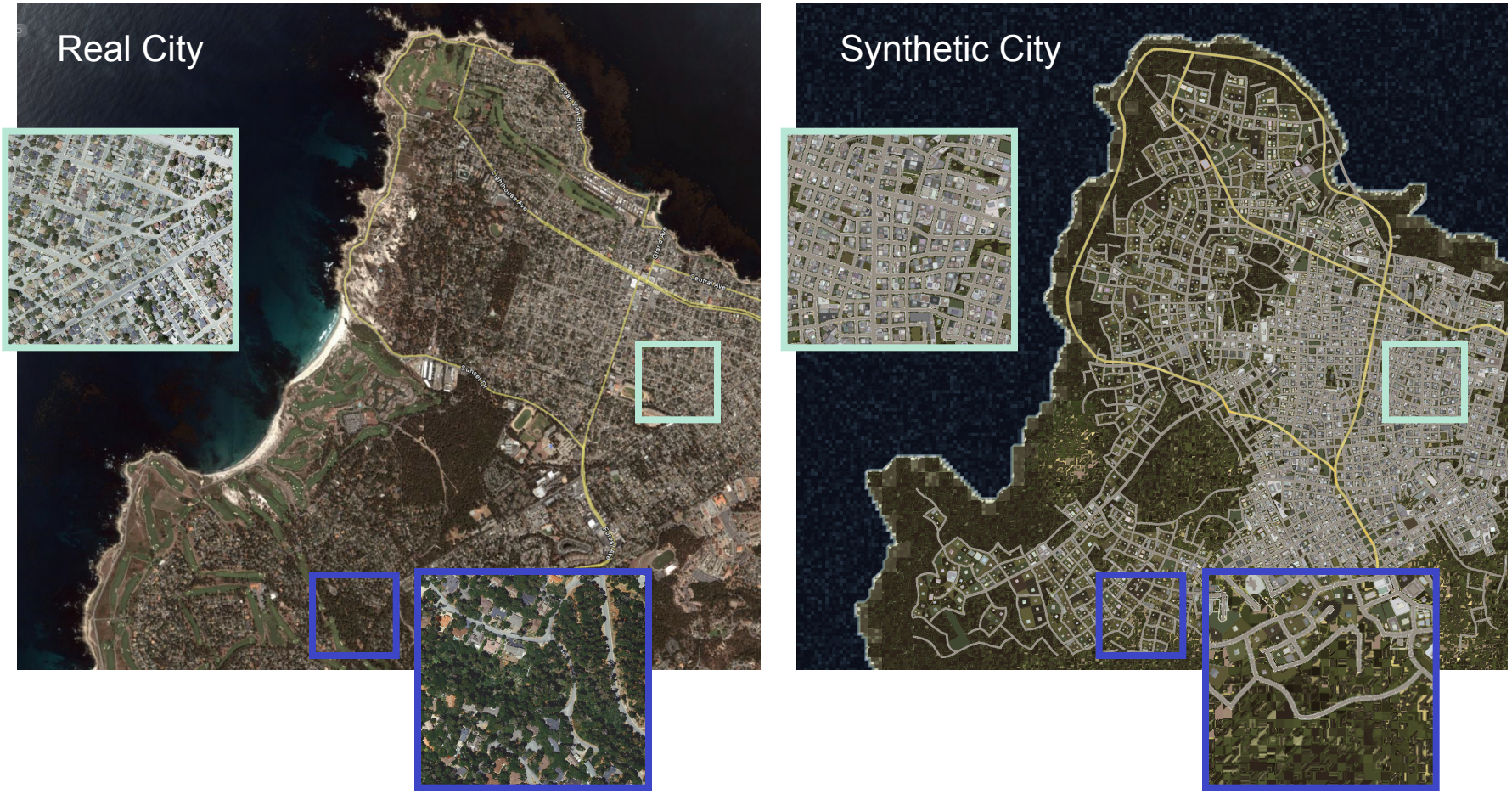
- multivariate outcomes,
- across tables,
- some of which have poorly-defined (spatial) cross-references
- and mixtures of continuous, categorical and ordered outcomes

Option 2: Procedural Modeling



Vanegas, et al, 2009

Results: Completion and Validation



Vanegas, et al, 2009

Model Uncertainty

Assessing Uncertainty: Bayesian Melding

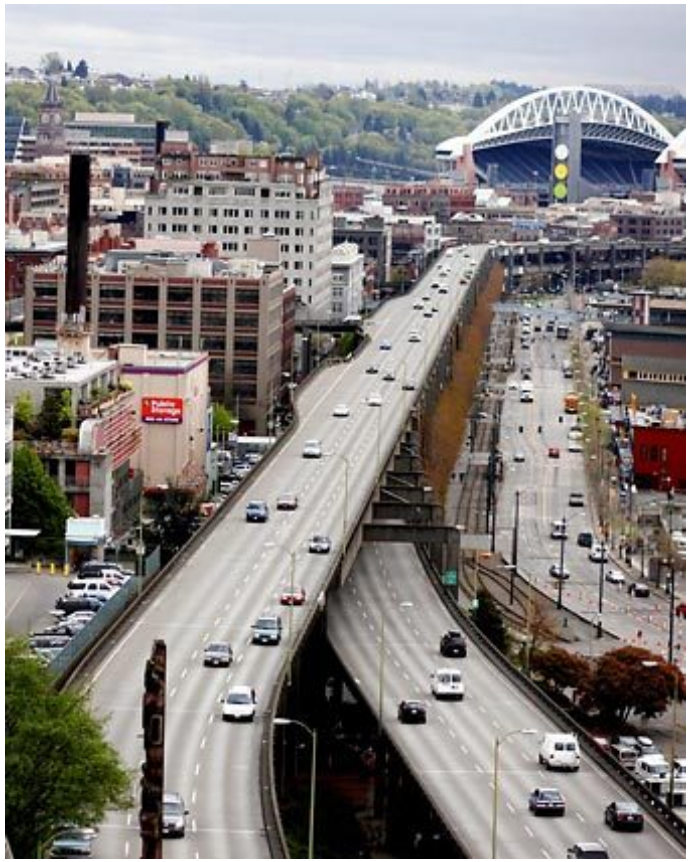
- Developed rigorous methodology for assessment of uncertainty in integrated land use and transport models based on Bayesian Melding (published in Transportation Research A, 2007)

- Currently testing an application to the question: what would happen if the Alaskan Way Viaduct adjacent to the waterfront in the Seattle CBD were demolished? It is at risk of collapse in the next earthquake.

Alaskan Way Viaduct Scheduled for Demolition in…

The next earthquake?

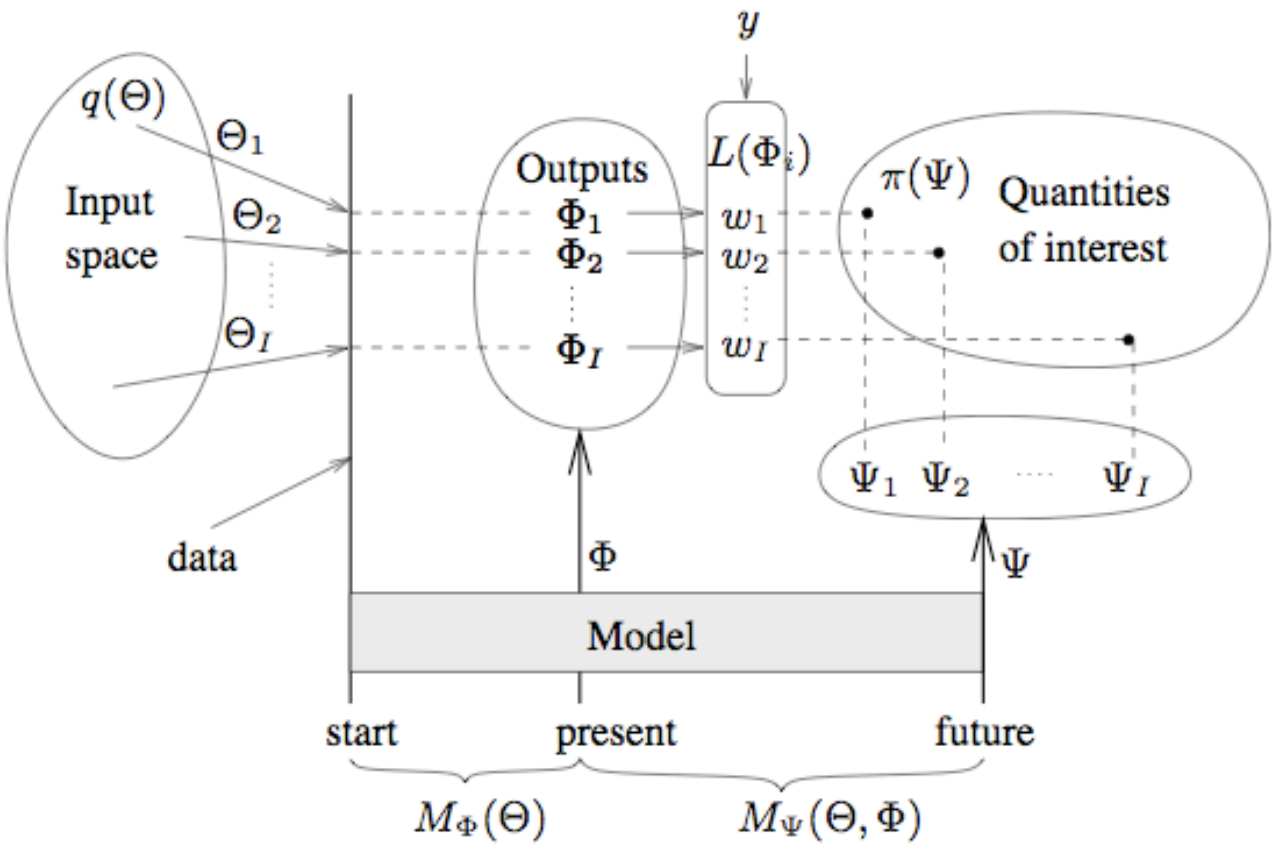
Some claim that alternatives which do not have comparable Traffic capacity will Cause massive failure of traffic in CBD and on I5.



Others claim that we should replace it with surface street and transit, and reclaim the waterfront. It won't cause much traffic impact because people adapt.

How much would a low-capacity alternative affect travel times over 10 years?

Assessing Uncertainty with Bayesian Melding



Assessing Uncertainty with Bayesian Melding

Likelihood and posterior distribution

y_k is sqrt of observed quantity in zone k

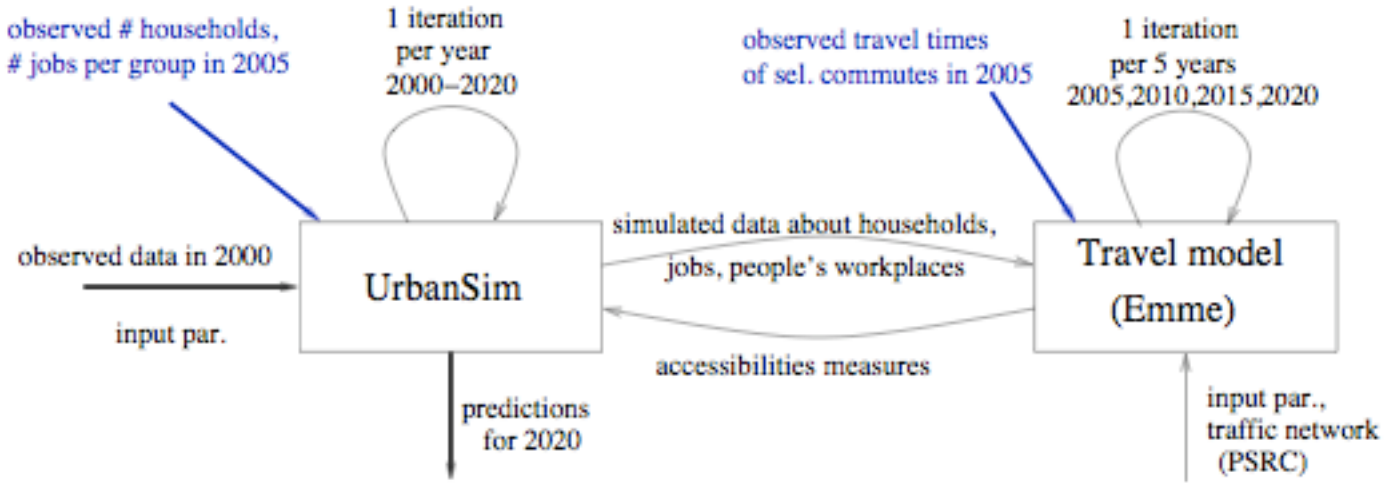
$$y_k|\Theta_i \sim N(\hat{a} + \hat{\mu}_{ik}, \hat{\sigma_i}^2)$$

$$w_i \propto p(y|\Theta_i) = \prod_{k=1}^{K} \frac{1}{\sqrt{2\pi\hat{\sigma_i}^2}} \exp\left[-\frac{1/2(y_k - \hat{a} - \hat{\mu}_{ik})^2}{\hat{\sigma_i}^2}\right]$$

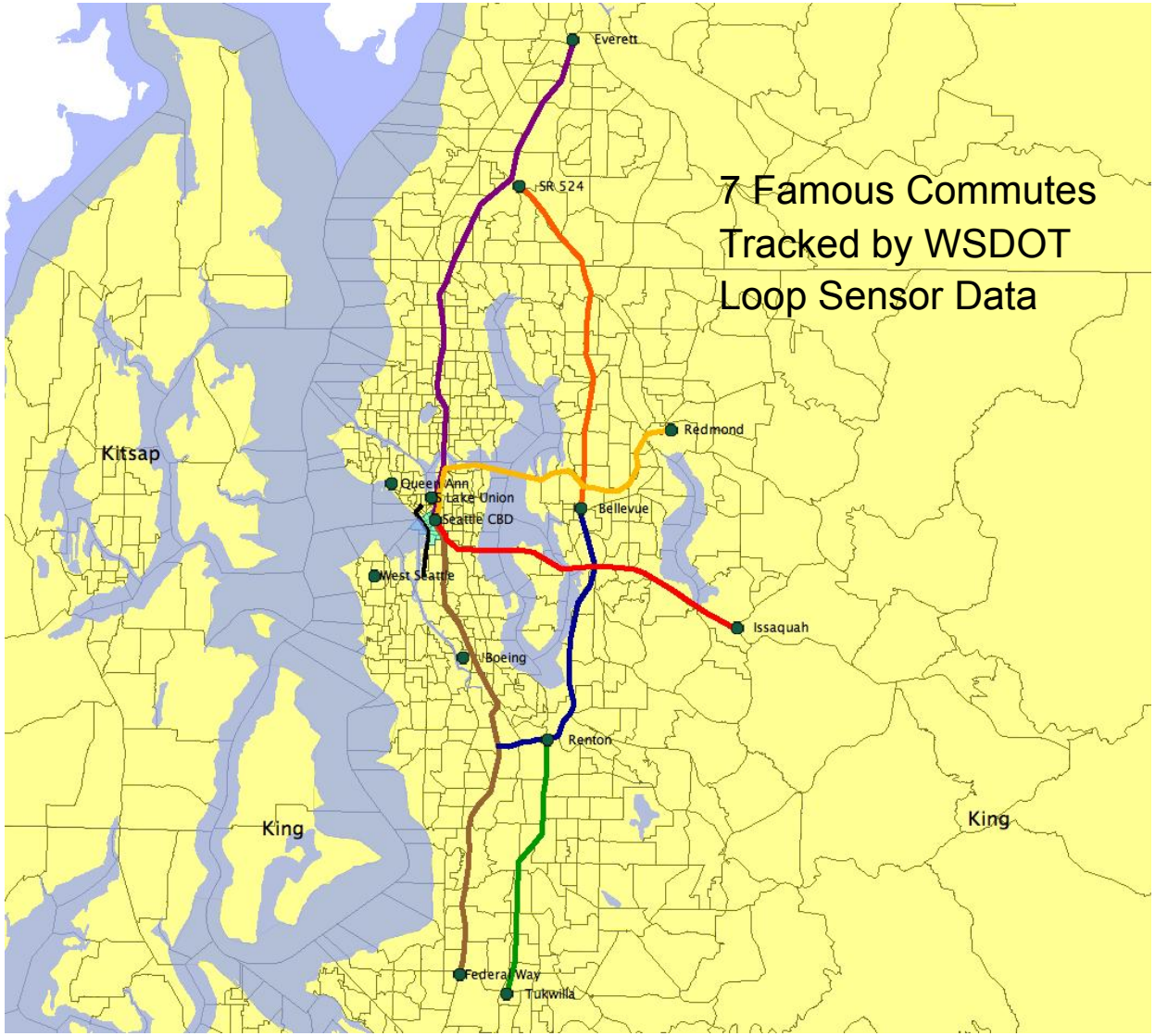
$$p(\Psi_k) = \sum_{i=1}^{I} w_i N(\hat{a}b_a + \Psi_{ik}, \hat{\sigma_i}^2), \quad k = 1, \ldots, K$$

Assessing Uncertainty with Bayesian Melding

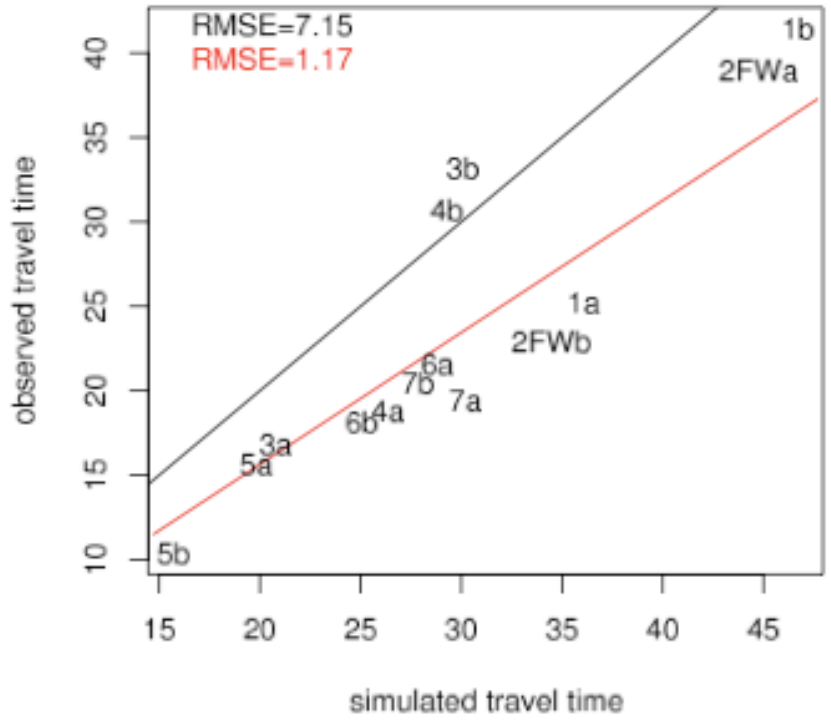
Quantity of interest: Travel times on selected routes



Assessing Uncertainty with Bayesian Melding



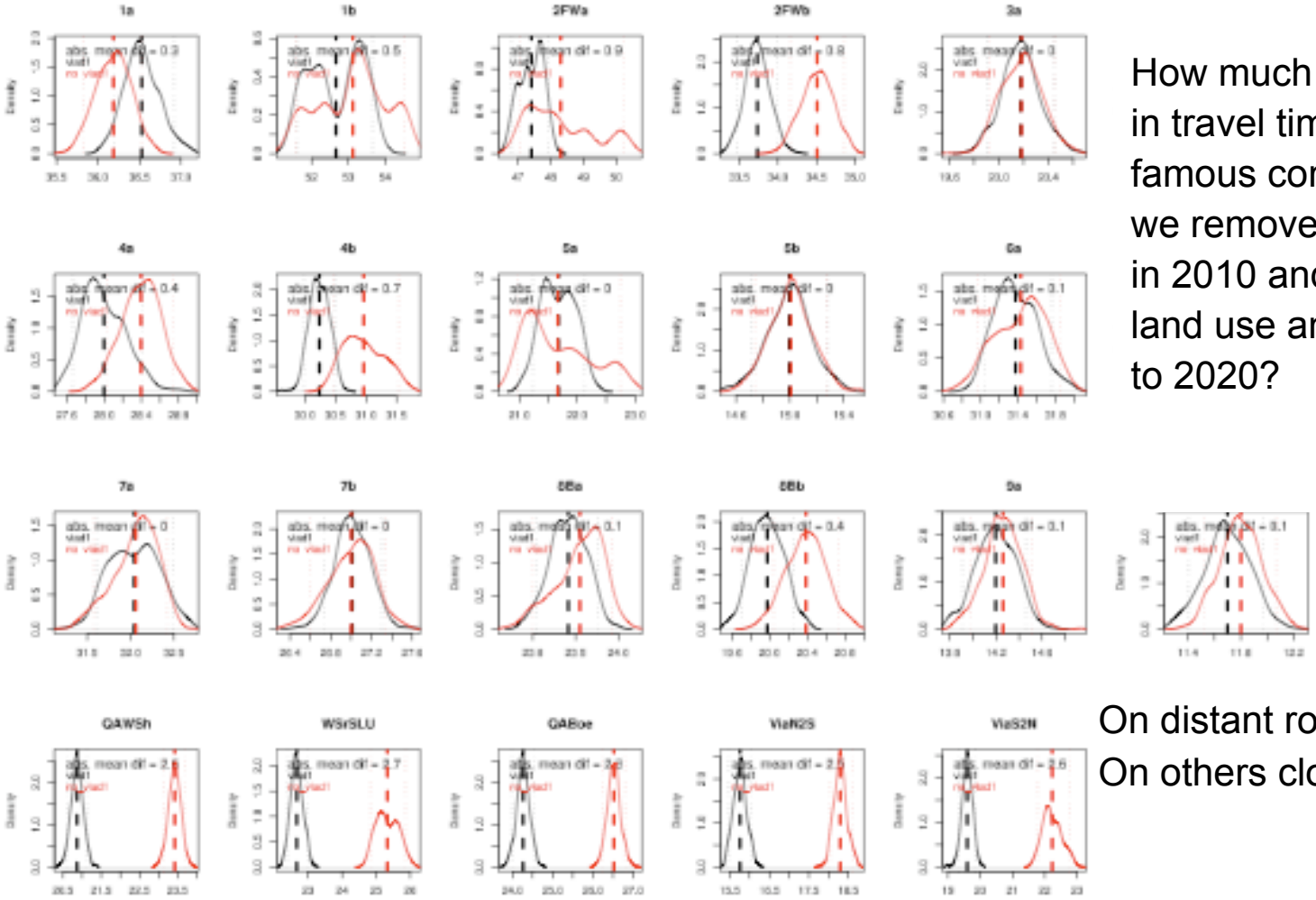
Assessing Uncertainty with Bayesian Melding



Systematic bias in travel times predicted by travel model was corrected

$$\log(T) \sim N(\log(T_{sim}) - 0.25, 0.16^2)$$

Assessing Uncertainty with Bayesian Melding



How much difference in travel time on those famous commutes if we remove the Viaduct in 2010 and simulate land use and transport to 2020?

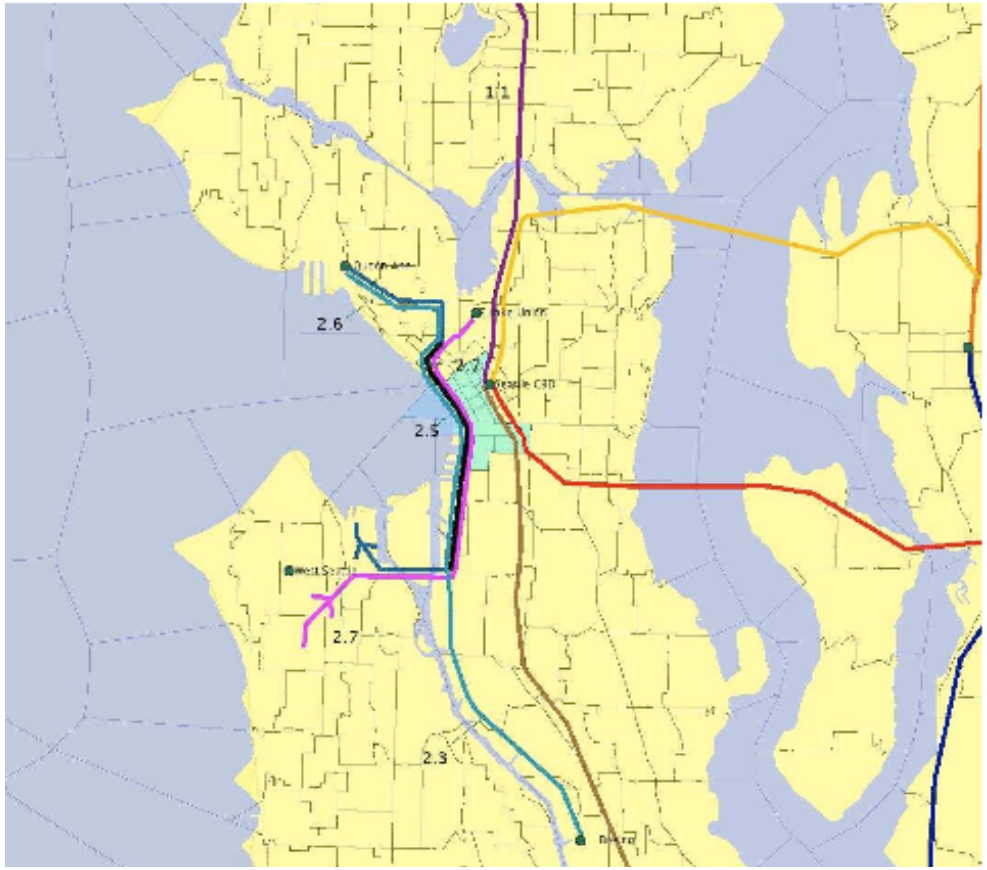
On distant routes < 1 minute,
On others closer to 2-3 minutes

Assessing Uncertainty with Bayesian Melding

route	scen.	2000	2010	inc.	2020	inc.
QAWSh	viad	21.1	21.3		21.1	
(7.4mi)	no v.		23.4	10%	23.7	12%
WSrSLU	viad	20.9	22.1		22.8	
(7.4mi)	no v.		24.7	12%	25.5	12%
QABoe	viad	24.5	24.6		24.5	
(9.9mi)	no v.		26.7	9%	26.8	9%
ViaN2S	viad	16.0	16.1		16.0	
(5.2mi)	no v.		18.4	14%	18.5	16%
ViaS2N	viad	18.1	19.1		19.8	
(5.2mi)	no v.		21.5	13%	22.4	13%

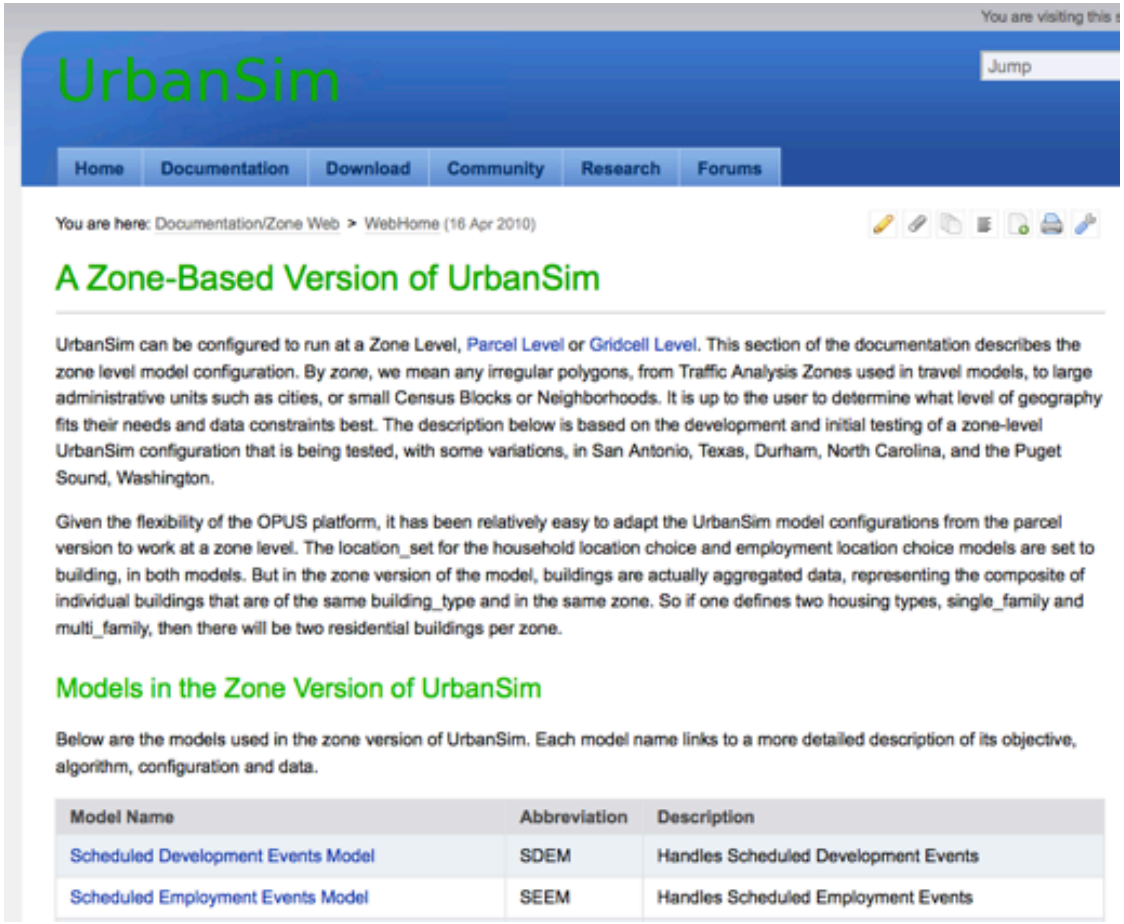
On shorter routes close to Viaduct, these translate to 9 – 16% increases in travel time

Assessing Uncertainty with Bayesian Melding



Zone Version of UrbanSim

Zone Model System Documentation On-line



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UrbanSim

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You are here: Documentation/Zone Web > WebHome (16 Apr 2010)

A Zone-Based Version of UrbanSim

UrbanSim can be configured to run at a Zone Level, Parcel Level or Gridcell Level. This section of the documentation describes the zone level model configuration. By *zone*, we mean any irregular polygons, from Traffic Analysis Zones used in travel models, to large administrative units such as cities, or small Census Blocks or Neighborhoods. It is up to the user to determine what level of geography fits their needs and data constraints best. The description below is based on the development and initial testing of a zone-level UrbanSim configuration that is being tested, with some variations, in San Antonio, Texas, Durham, North Carolina, and the Puget Sound, Washington.

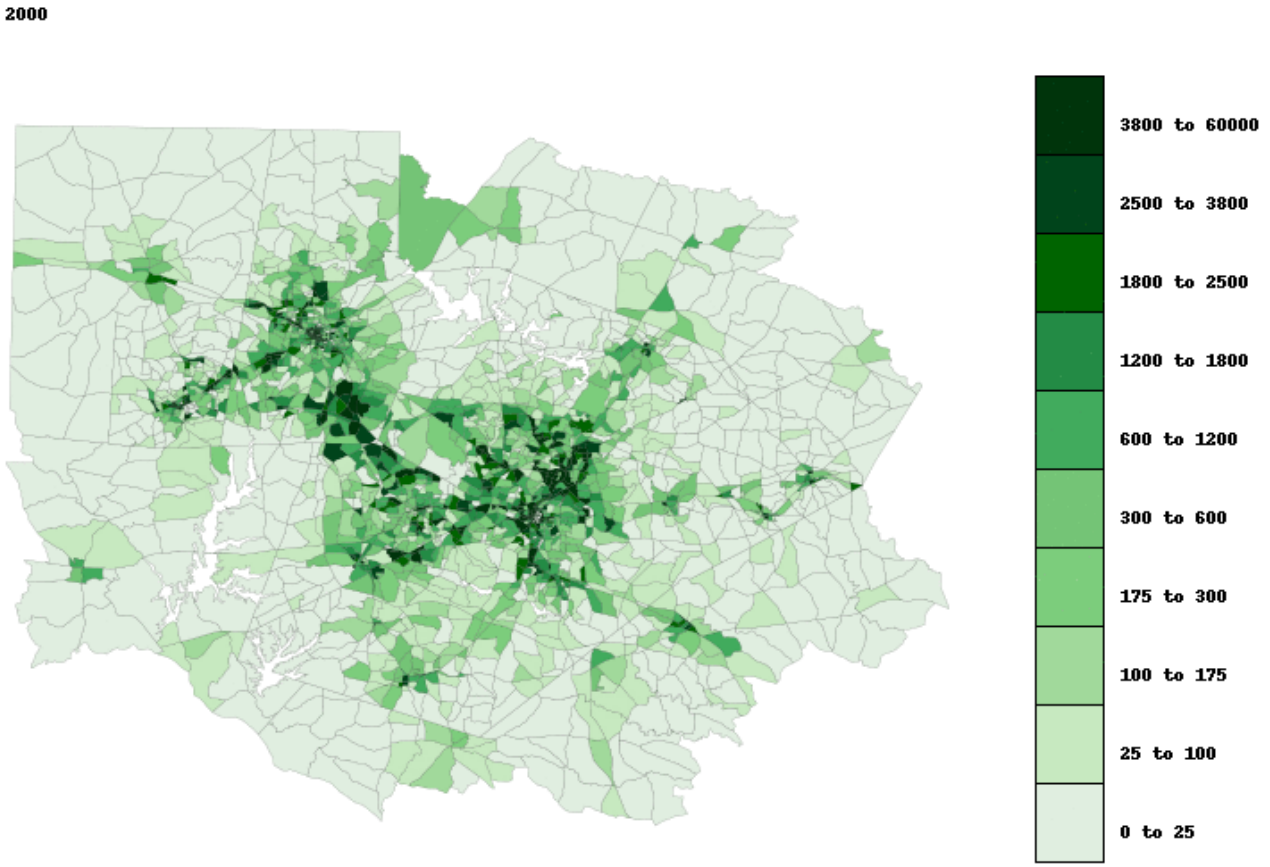
Given the flexibility of the OPUS platform, it has been relatively easy to adapt the UrbanSim model configurations from the parcel version to work at a zone level. The location_set for the household location choice and employment location choice models are set to building, in both models. But in the zone version of the model, buildings are actually aggregated data, representing the composite of individual buildings that are of the same building_type and in the same zone. So if one defines two housing types, single_family and multi_family, then there will be two residential buildings per zone.

Models in the Zone Version of UrbanSim

Below are the models used in the zone version of UrbanSim. Each model name links to a more detailed description of its objective, algorithm, configuration and data.

Model Name	Abbreviation	Description
Scheduled Development Events Model	SDEM	Handles Scheduled Development Events
Scheduled Employment Events Model	SEEM	Handles Scheduled Employment Events

Animated Map Indicators



Automated Animated GIF images produced from Mapnik maps, using ImageMagick

Database and Scenario Creation Tools and Graphical Interface – A Work in Progress

Database Schema Management

- SQLAlchemy is an Object-Relational Mapper and database abstraction library, allowing use of standard Python syntax to create and query databases in multiple back-end database servers:
  - Postres, MySQL, SQLite, MS SQL Server, Access
- Elixir is a Declarative Layer on SQLAlchemy
  - Makes it easy to define database schema
  - Has a GUI builder, called Camelot, for browsing/editing tables

Database Schema Definition using Elixir

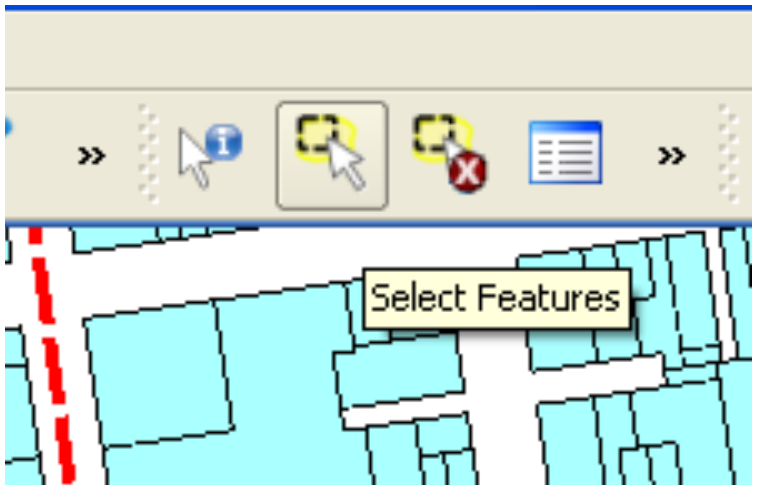
```
class Building(Entity):
    using_options(tablename='buildings')
    building_id = Field(Integer, primary_key=True)
    building_quality_id = Field(Integer)
    building_type = ManyToOne('BuildingType', colname='building_type_id')
    improvement_value = Field(Integer)
    land_area = Field(Integer)
    non_residential_sqft = Field(Integer)
    residential_units = Field(Integer)
    sqft_per_unit = Field(Integer)
    year_built = Field(Integer)
    stories = Field(Integer)
    tax_exempt = Field(Integer)
    parcel = ManyToOne('Parcel', colname='parcel_id')
```

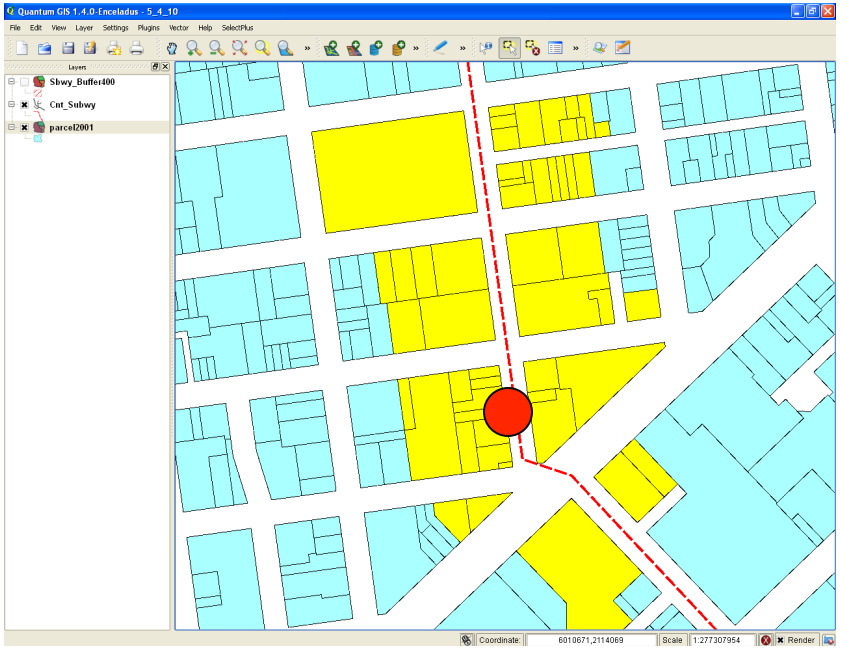
Scenario Creation Graphical Interface

- Requirements
  - Easy means to select parcels or other geographies
  - Ability to edit attributes
  - Ability to edit geometry (where appropriate)
  - Open source, multi-platform, easy to integrate with OPUS
- Strategy:
  - Quantum GIS for spatial data interaction, with customization
  - SQLALchemy/Elixir/Camelot for tabular data management

Geographic Selection

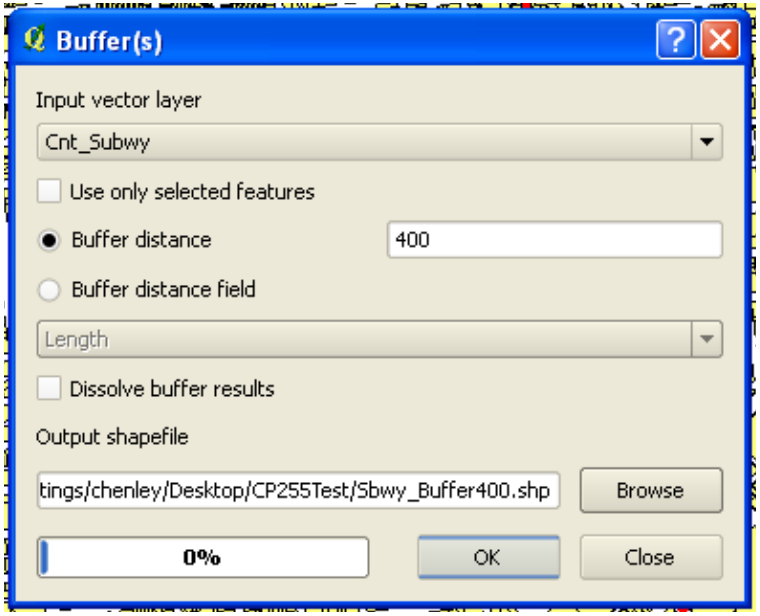
- Basic spatial selection → Point and Click
- e.g. parcels near a planned subway stop

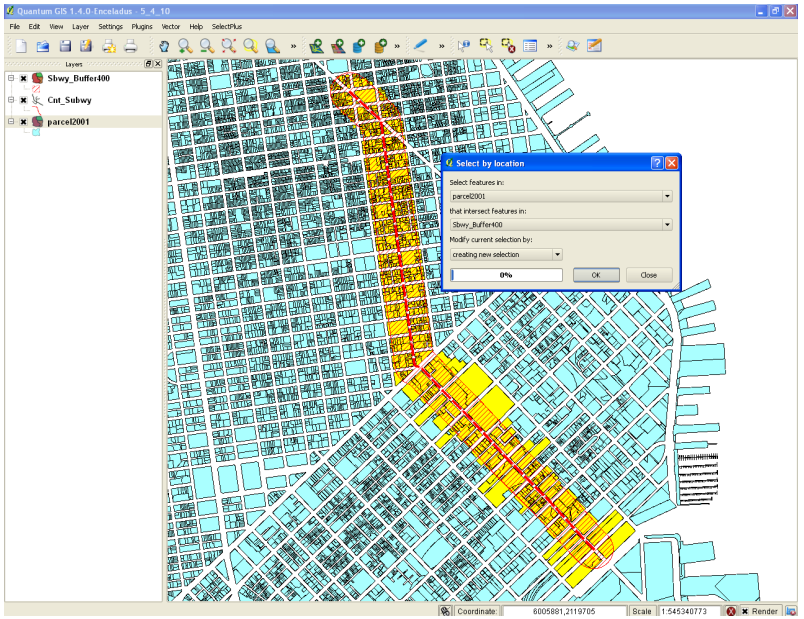




Geographic Selection

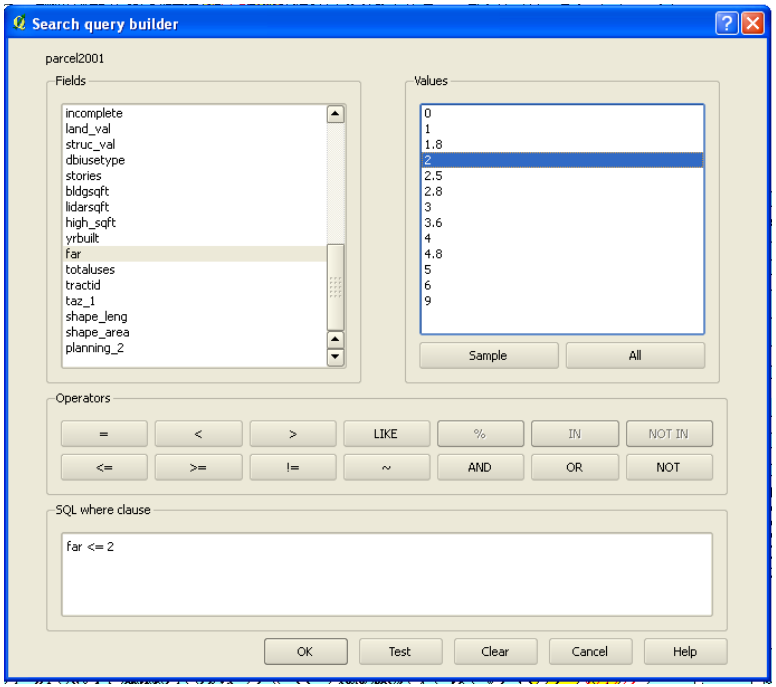
- Location or proximity selection
- e.g. parcels within buffer distance of subway alignment

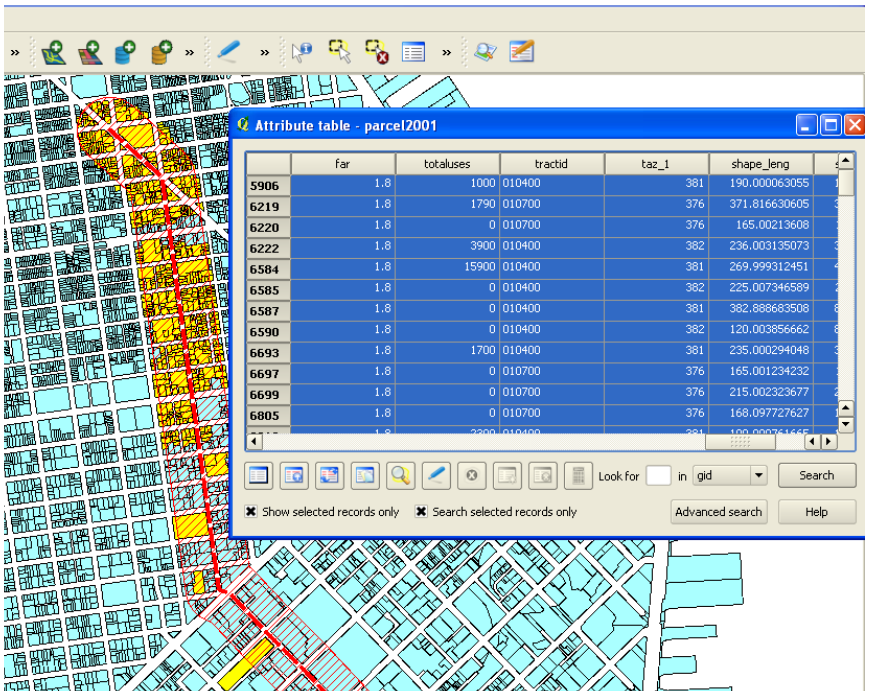




Geographic Selection

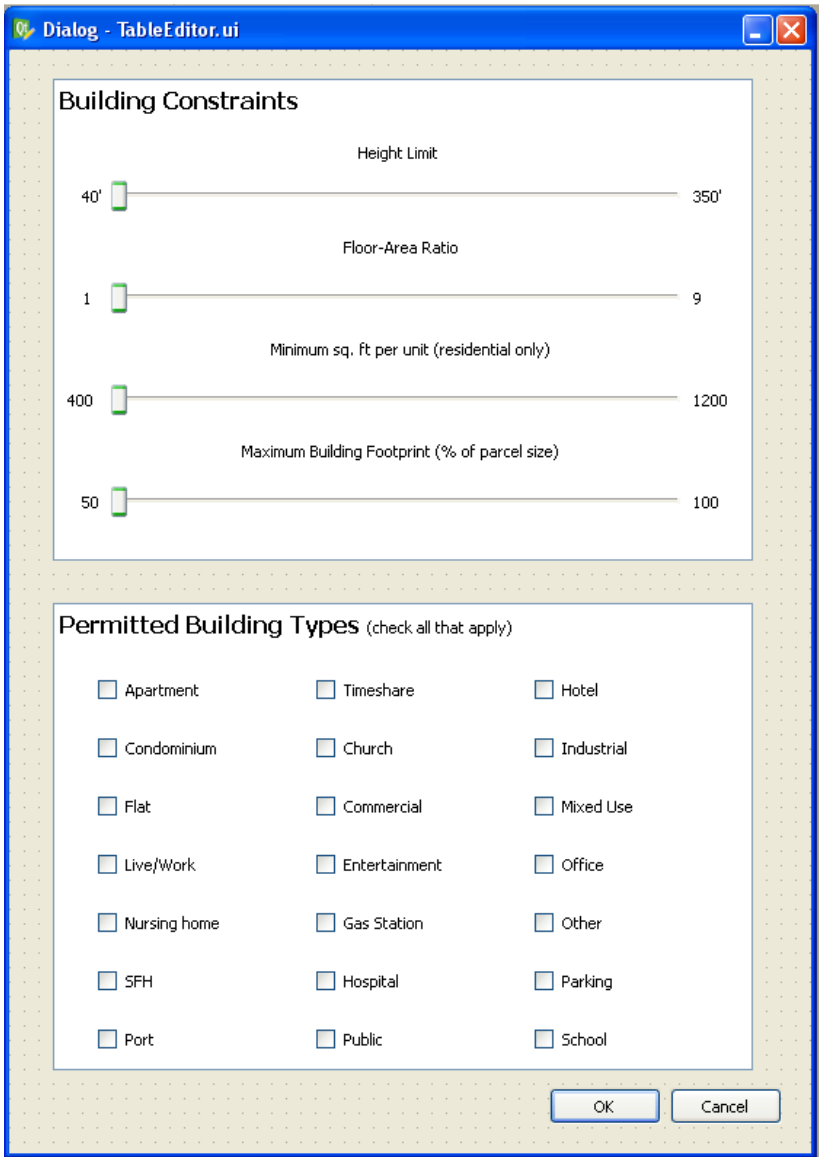
- Selection by attributes
- e.g. parcels within buffer with FAR =< 2





Simple Table Editing

- Edit Development Constraints for Selected Parcels
- Constraint changes are made to a copy of the parcel table
- Changed values override original values in model runs



Simple Interactive Table Filtering/Editing

For example, to edit control totals tables