

# Preferred citation style for this presentation

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Landuse simulation on the Canton of Zurich using UrbanSim

– Current State and First Run,

presented at *12th Swiss Transport Research Conference, Ascona, May 2012.*



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# Landuse simulation on the Canton of Zurich using UrbanSim

## Current State and First Run

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May 2012

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Swiss Transport Research Conference, Monte Verità 02.-04.09. 2012

# Overview

Introduction

Data preparation

Integrated models

Simulations

Next steps / problems

# Introduction

## SustainCity

EU-funded research-project (2010-2012)

12 research institutions participating

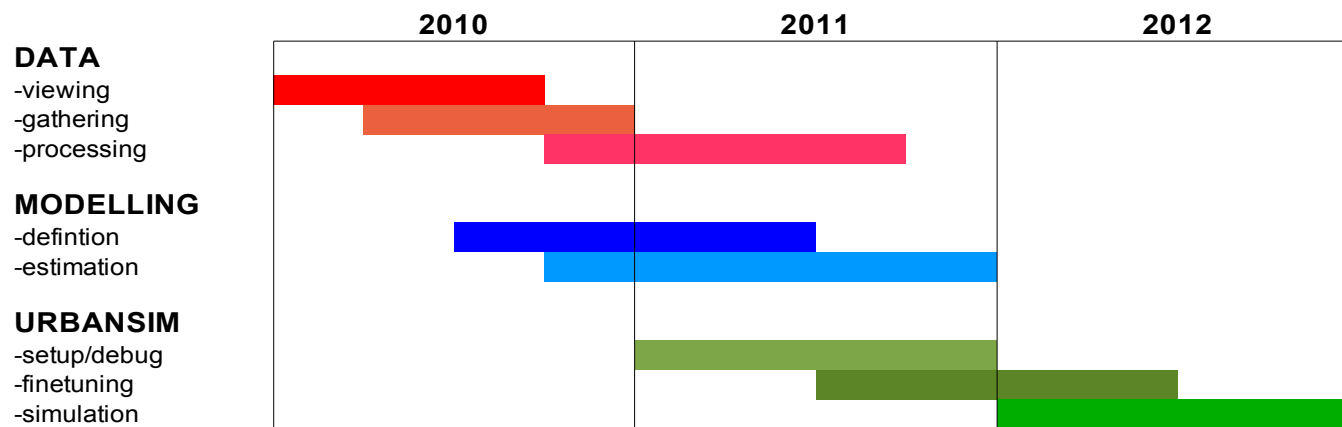
3 case-studies of UrbanSim: Brussels, Paris, Zurich

Previous UrbanSim-experience in all cities (Zurich: Zukunft Urbaner Kulturlandschaften, 2007)

Homepage: [www.SustainCity.org](http://www.SustainCity.org)

Aim of Project:

- adapt 'UrbanSim' to European conditions => version 'UrbanSimE'
- include additional models (demographics, developers, MatSim-exchange,...)
- evaluate and compare results of case-studies





# Introduction

## UrbanSim

Opensource software developed by P. Waddell and colleagues ([www.UrbanSim.org](http://www.UrbanSim.org))

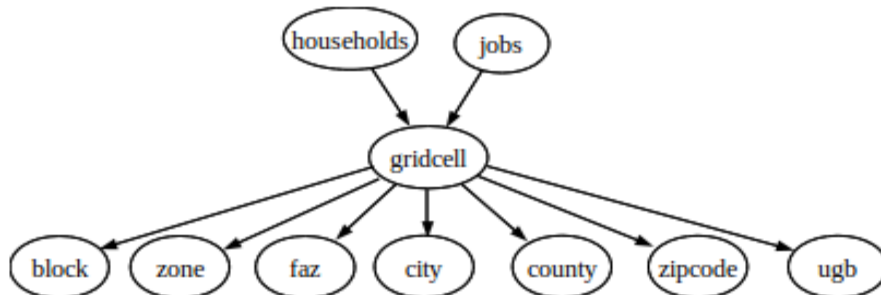
Simulation of land use development with interaction to traffic and accessibility

Microsimulation representing the choice of households, businesses and landowners

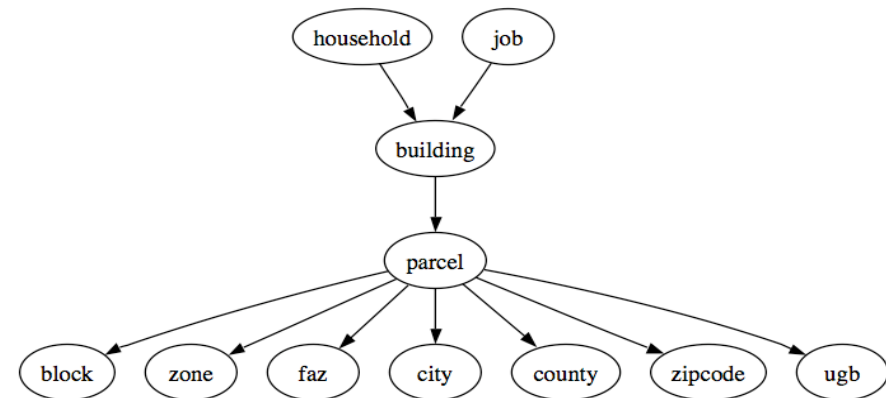
Previously gridcell-based approach, now geometries (zoning and parcel) as reference objects

Various case studies world wide (in Zurich: Zukunft Urbaner Kulturlandschaften, 2007)

(a) Basic model structure of grid cell version



(b) Basic model structure of parcel version



Source: Waddell, P. A. (2010) Overview of UrbanSim and the Open Platform for Urban Simulation, presentation, UrbanSim Tutorial, Zurich

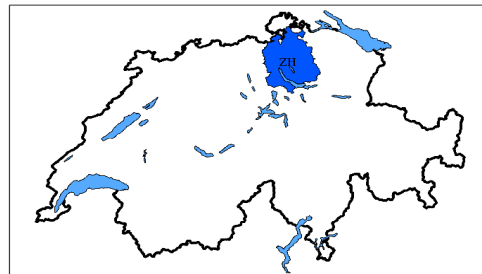
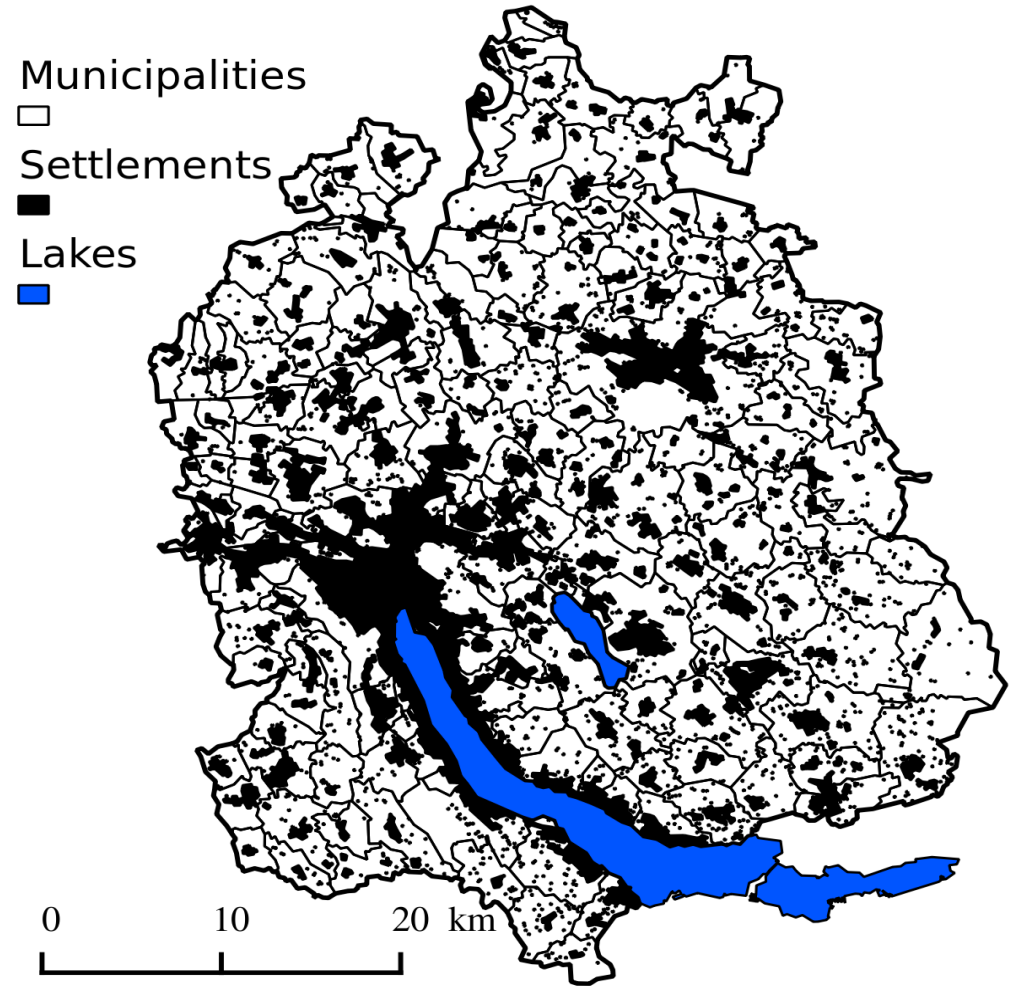
# Basis data

## Simulation area and time period

Simulation start: 2000

Evaluation period: 2000-2010

Simulation period: 2010-2030



# Basis data

## Needs of UrbanSim

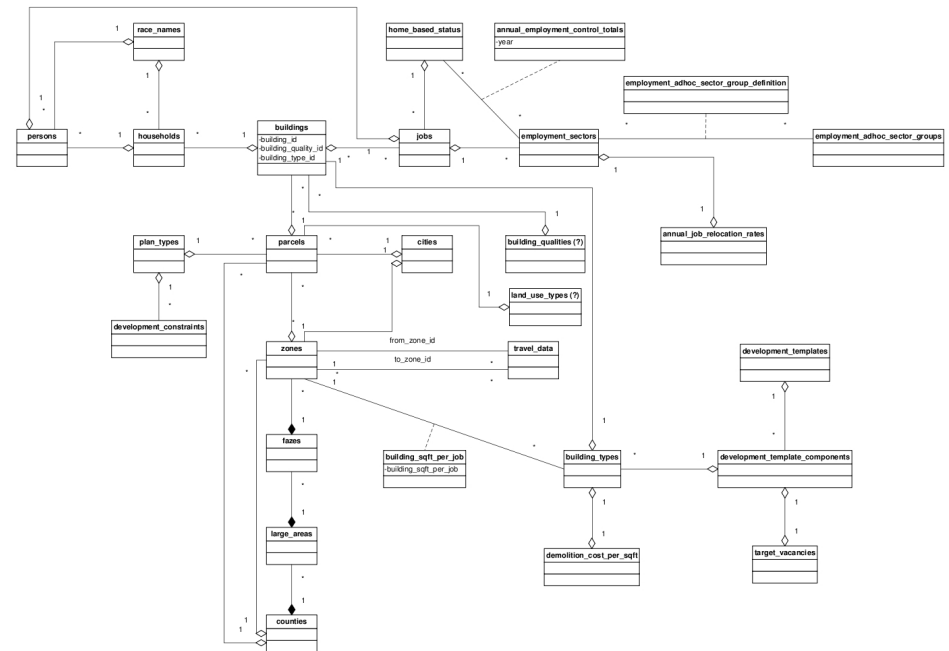
### Simulation tables

- Simulated entities (e.g. parcels, buildings, households, persons, jobs)
- Travel data (zone to zone skims)
- Geographies for aggregation, analysis, visualisation

### Model estimation tables

### Definition tables

- Assumptions/boundary conditions
- Classifications



# Overview

Introduction

**Data preparation**

Integrated models

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# Basis data

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## Data used in the Zurich case study

### *Geometries*

Spatial entities including form

Basis for spatial joins

Cadastral information

- 171 municipalities
- Inconsistency
- Demands backward editing starting in 2010 (buildings)
- Changes in networks & parcels not accounted for

### **Table name**

---

buildings

parcels

zones

cities





# Basis data

---

## Data used in the Zurich case study

### *Cross sectional*

Microscopic information on agents and objects

Objects (buildings) based on

- Federal register of buildings (GWR)
  - mainly residential
- Cantonal building assurance (GVZ)
  - Snapshot of year 2000
  - New buildings, but no construction

Agents (households, persons, jobs) based on census data

- Representing different years
- Use of population synthesiser envisioned

### **Table name**

persons  
households  
jobs  
buildings

### **Basis**

populations census, microcensus (transportation)  
populations census, microcensus (transportation)  
enterprise census  
GWR, GVZ, Documedia

# Basis data

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## Data used in the Zurich case study

*Longitudinal*

Control totals in UrbanSim

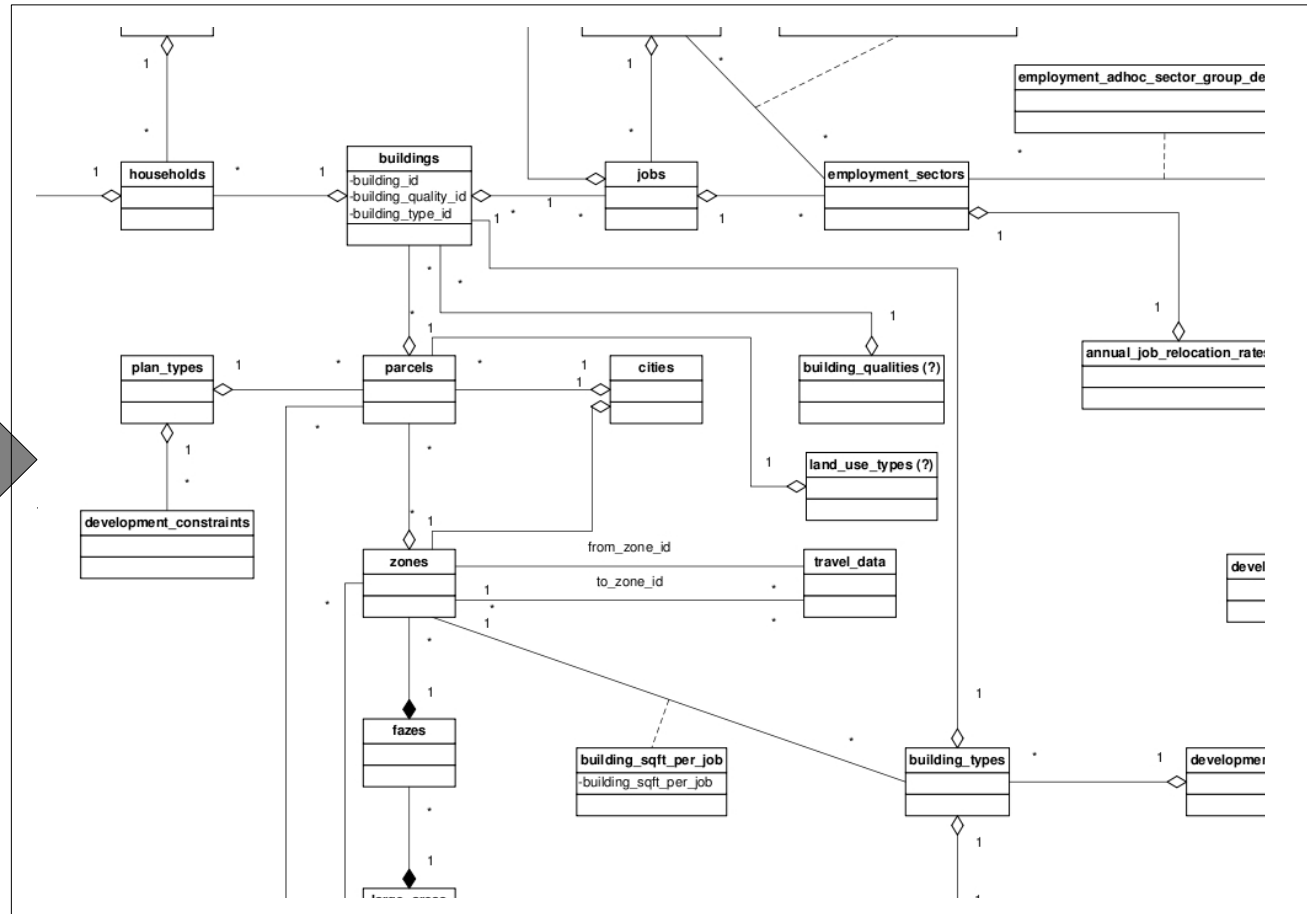
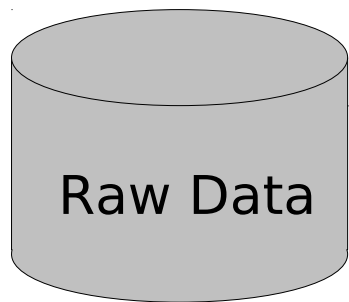
Based on aggregated information from statistic departments

Additional specific statistics collected in previous ZUK-project

- Probability to move (Beige and Axhausen, 2005)

<b>Table name</b>	<b>Basis</b>
annual_employment_control_totals	statistic information, prognosis
annual_household_control_totals	statistic information, prognosis
annual_relocation_rates_for_households	Survey data (Beige, 2008)
annual_job_relocation_rates	ZUK definitions (Loechl et al. 2007)

# Data preparation – Raw data to integrated US structure



Datamodell UrbanSim

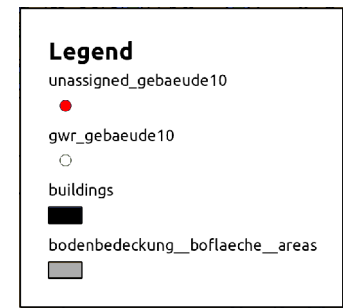
# Data preparation – data quality



*Example: No geometry data available*



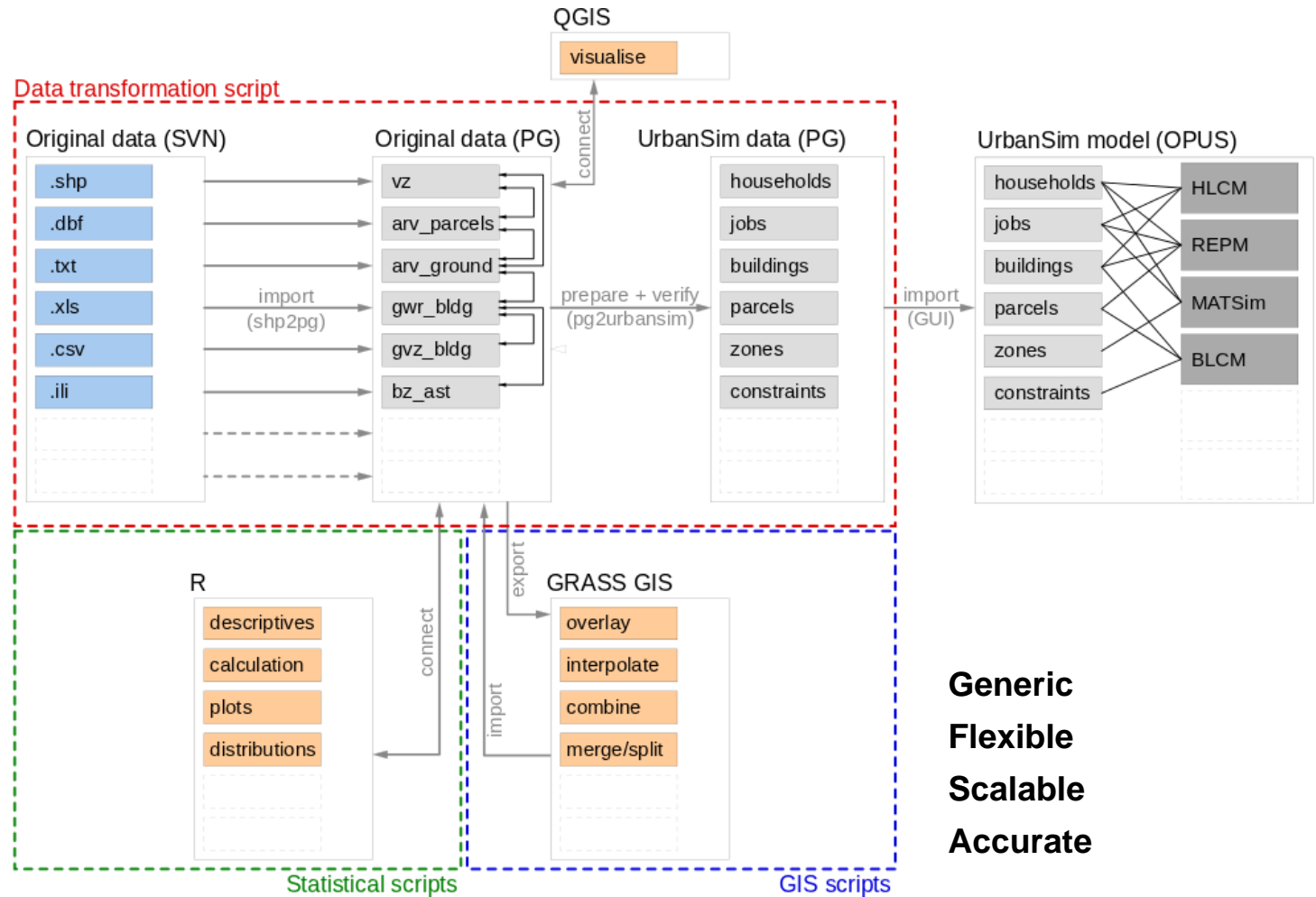
*Example: Missing building separation*



# Data preparation – processing framework

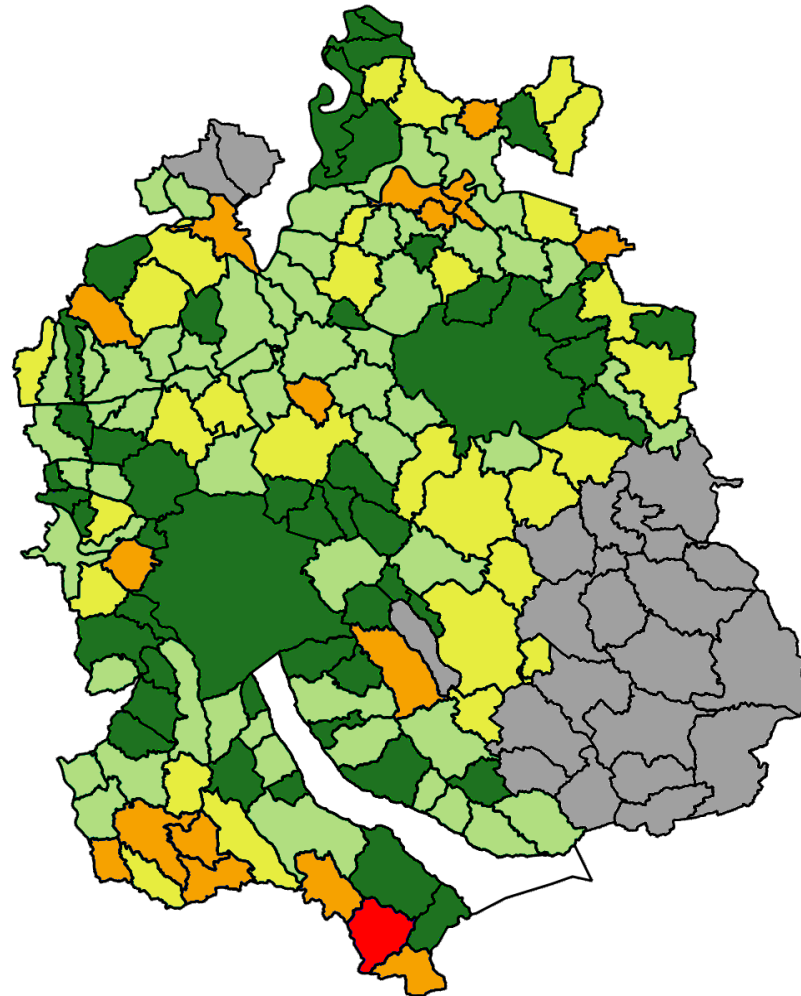
## Data processing

- Spatial Joins
- Attribute Joins
- Imputations
- Populations Synthesis
- Approximations
- Classification





# Data preparation- Relative import quality by assert error rate



# Overview

Introduction

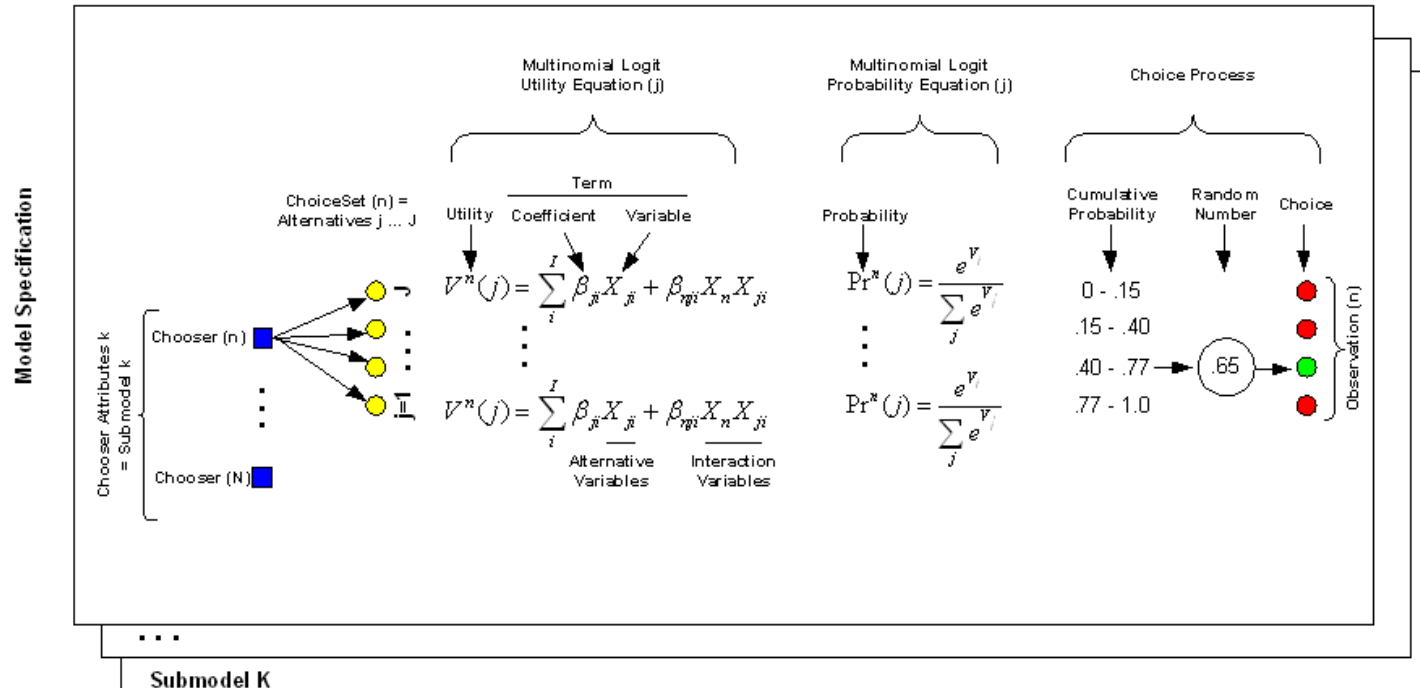
Data preparation

**Integrated models**

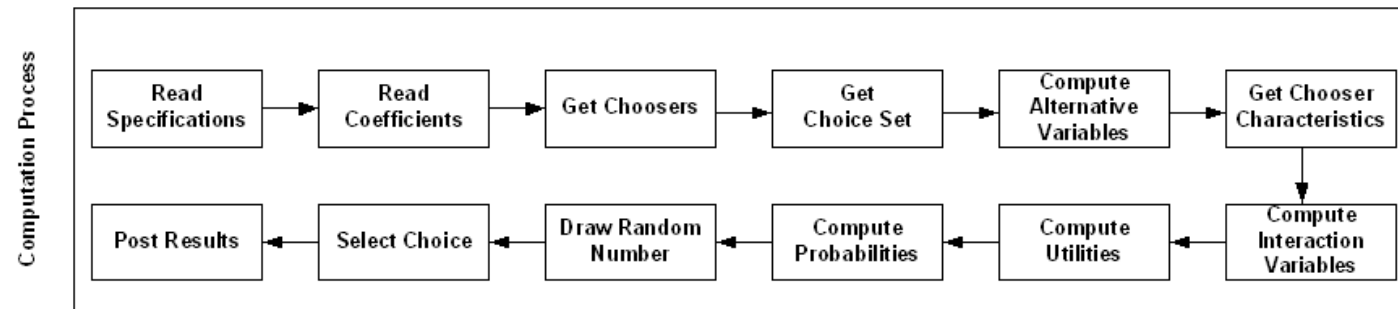
Simulations

Next steps / problems

# Models – UrbanSim Choice Models

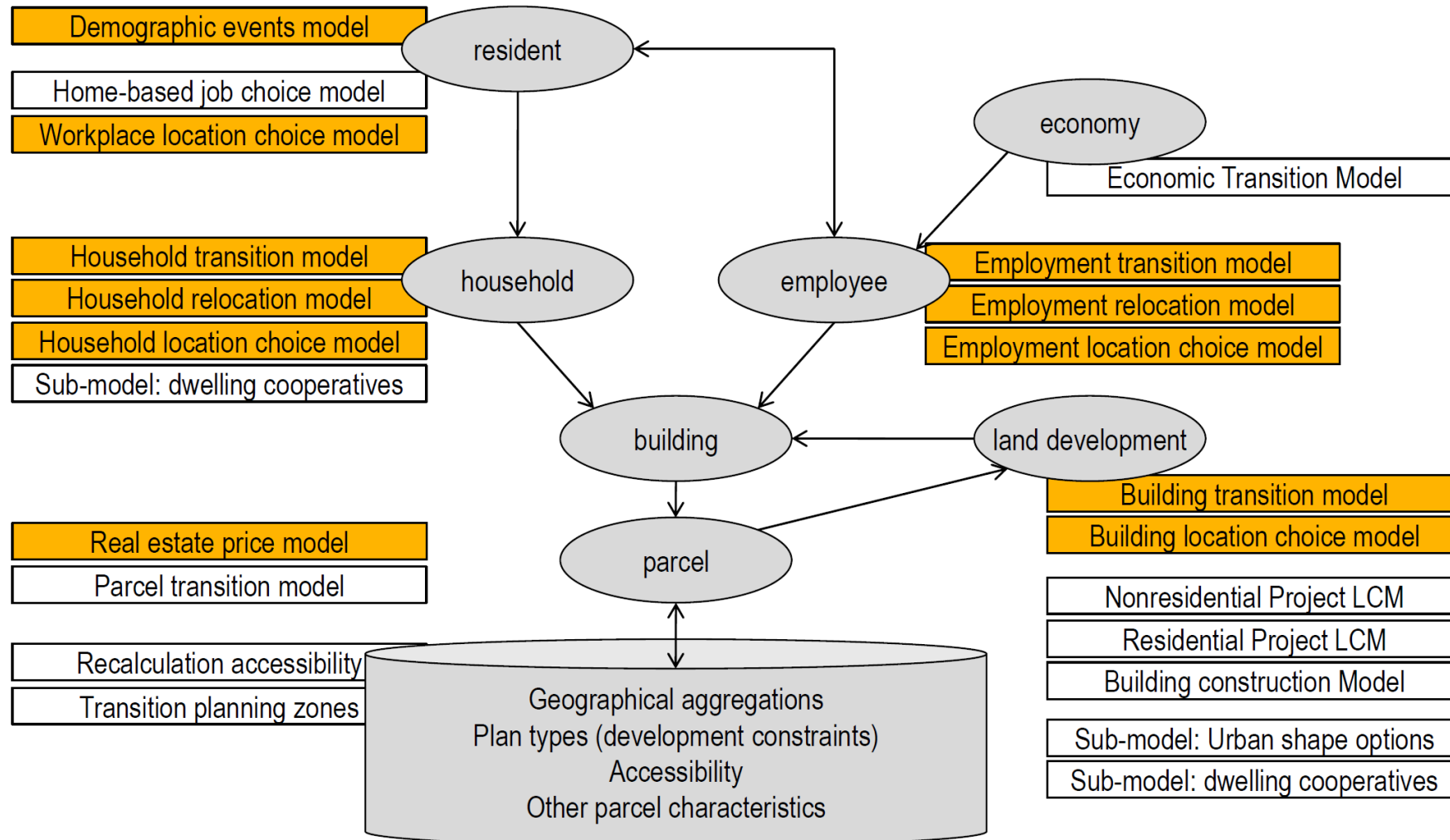


Dimensions for Submodel k: N Choosers x J Alternatives x I Variables

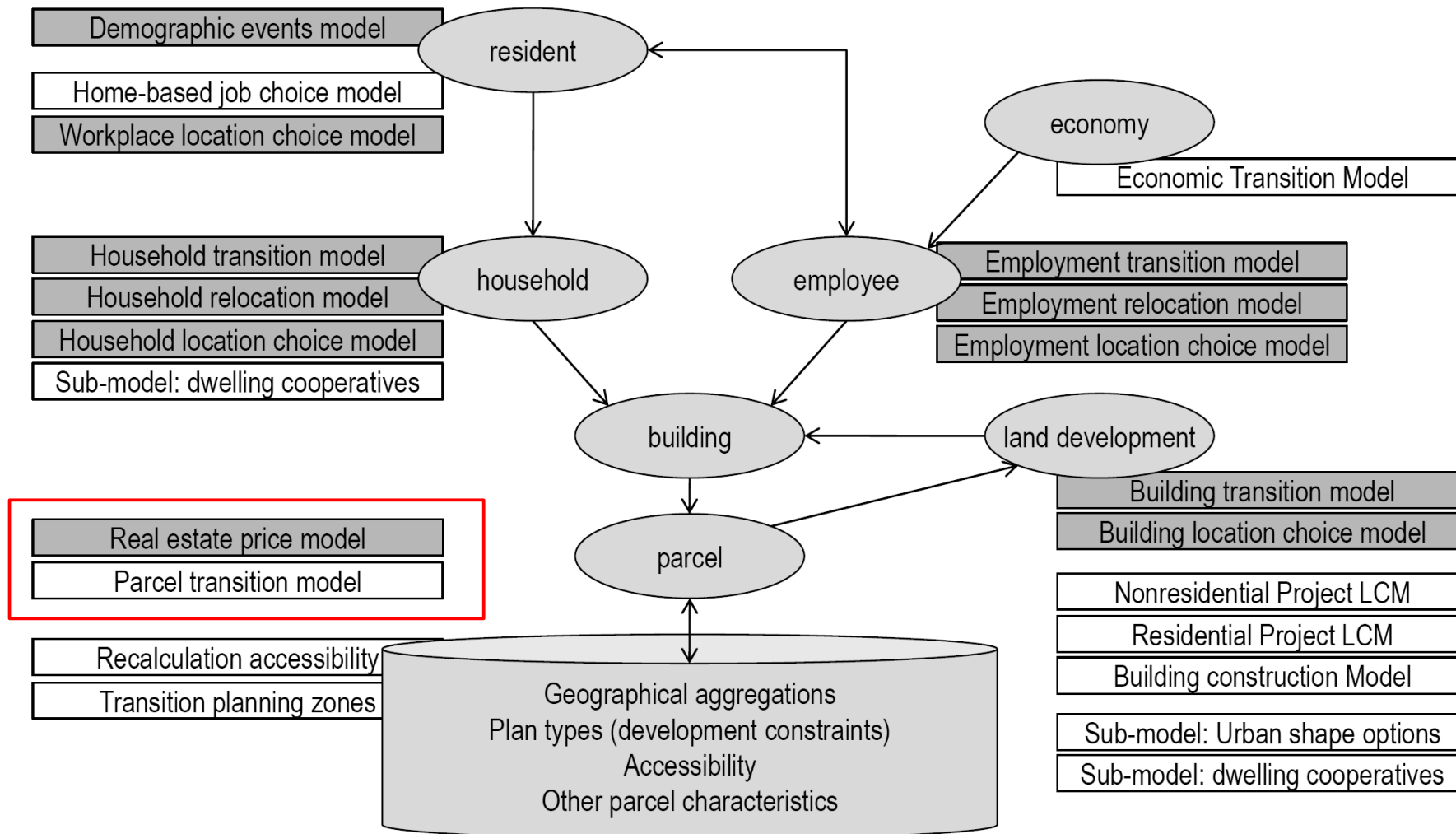


Source:  
Opus\_Userguide (p.18)  
www.Urbansim.org (25.04.2012)

# Models for first run



# Models for first run





# Models – Real Estate Price Model REPM

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## Structure

- Model: OLS regression (estimation of rent prices)
- Dataset: building
- Filter\_attribute: building is residential (numpy.logical)
- Estimation: *external estimation & import of specifications*
  - *Based on the PhD-Thesis of M.Löchli(2010)*
- Configuration:
  - Dependent Variable:  $\ln(\text{zurich\_parcel.building.building\_cost})$

# Models – Real Estate Price Model REPM

---

<b>Coeff_names</b>	<b>estimate</b>
Constant	3.638
Ln (sqm per unit)	0.776
Is House	0.125
Built before 1921	0.109
Built between 1921 and 1930	0.094
Built between 1981 and 1990	0.018
Built between 1991 and 2005	0.067
Accessibility by car	0.119
Accessibility by public transport	0.011
Ln (distance to station)	-0.012
Boolean (highway within in 100m)	-0.067
Ln(jobs in Hotels and Restaurant)	0.032
Ln (population density per ha)	-0.026
Foreigner density per ha (logit)	-0.023
Ln (taxlevel)	-0.223
slope (logit)	0.026

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# Models – Real Estate Price Model REPM

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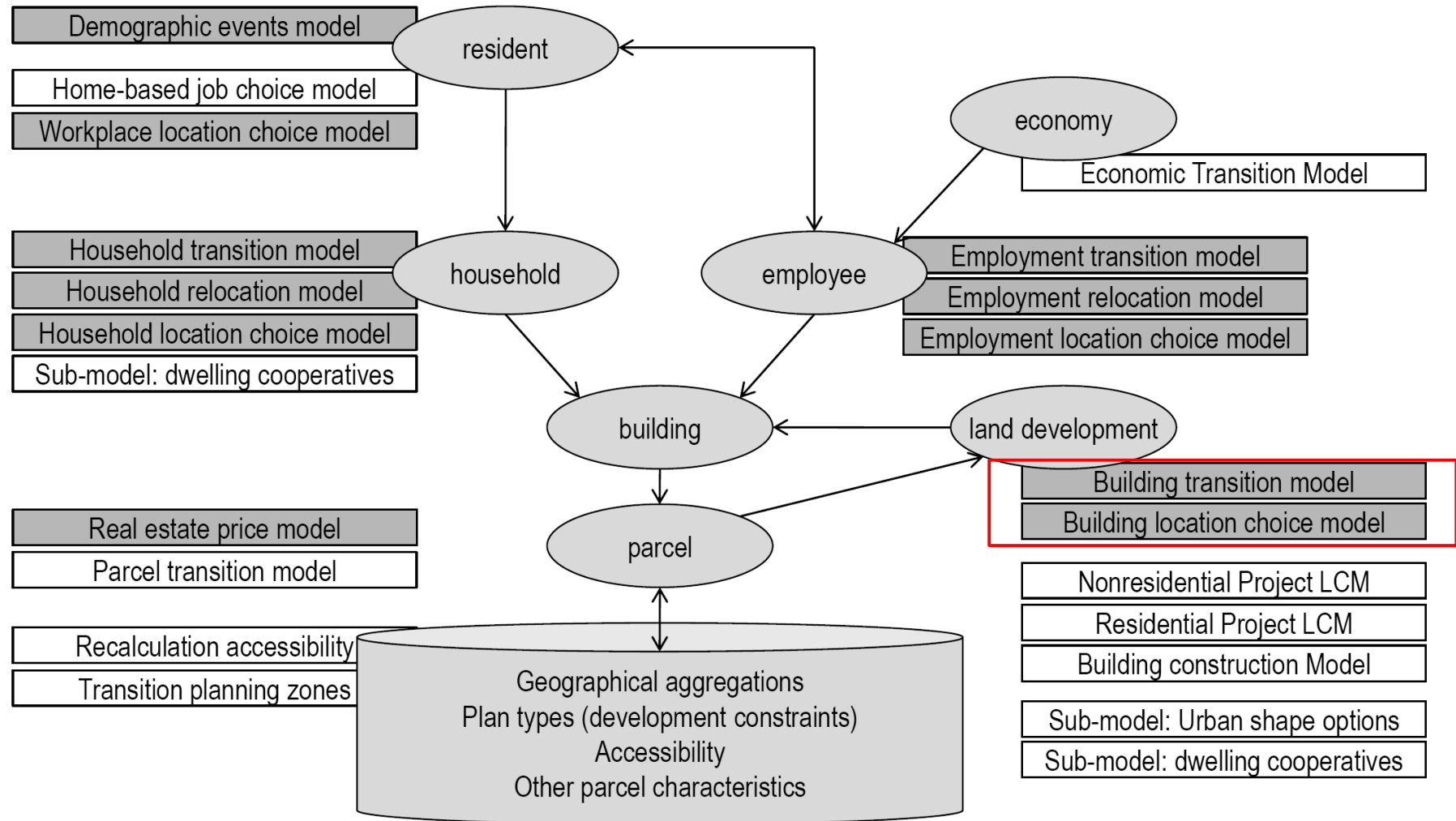
<b>Coeff_names</b>	<b>estimate</b>
Lift	3.638
Fireplace	0.776
Balcony	0.125
GTerrace	0.109
Airnoise	0.094
Ln(View Lake)	0.018
Ln(View All)	0.067
Ln(Solar_eve)	0.119
1Q_04	0.011
2Q_04	-0.012
3Q_04	-0.067
4Q_05	0.032
1Q_05	-0.026
2Q_05	-0.023
3Q_05	-0.223

Not integrated in UrbanSim

---

**Likelihood ratio index** **0.5990**  
*(including additional variables of original model!)*

# Models for first run



# Models – building location choice model BLCM

---

## Structure

- Locations: parcels
- Agents: buildings
- Estimation: *estimation inside UrbanSim based on baseyear data*
  - *Agents for estimation: buildings built in 2000*
- Choices: opus\_core.random\_choices\_from\_index
- Configuration:
  - Sampler: opus\_core.samplers.weighted\_sampler
  - Choices: opus\_core.random\_choices\_from\_index
  - Procedure: AgentLocationChoiceModel from template
  - Capacity: undeveloped land of parcel
  - Filter: undeveloped parcels in construction zone

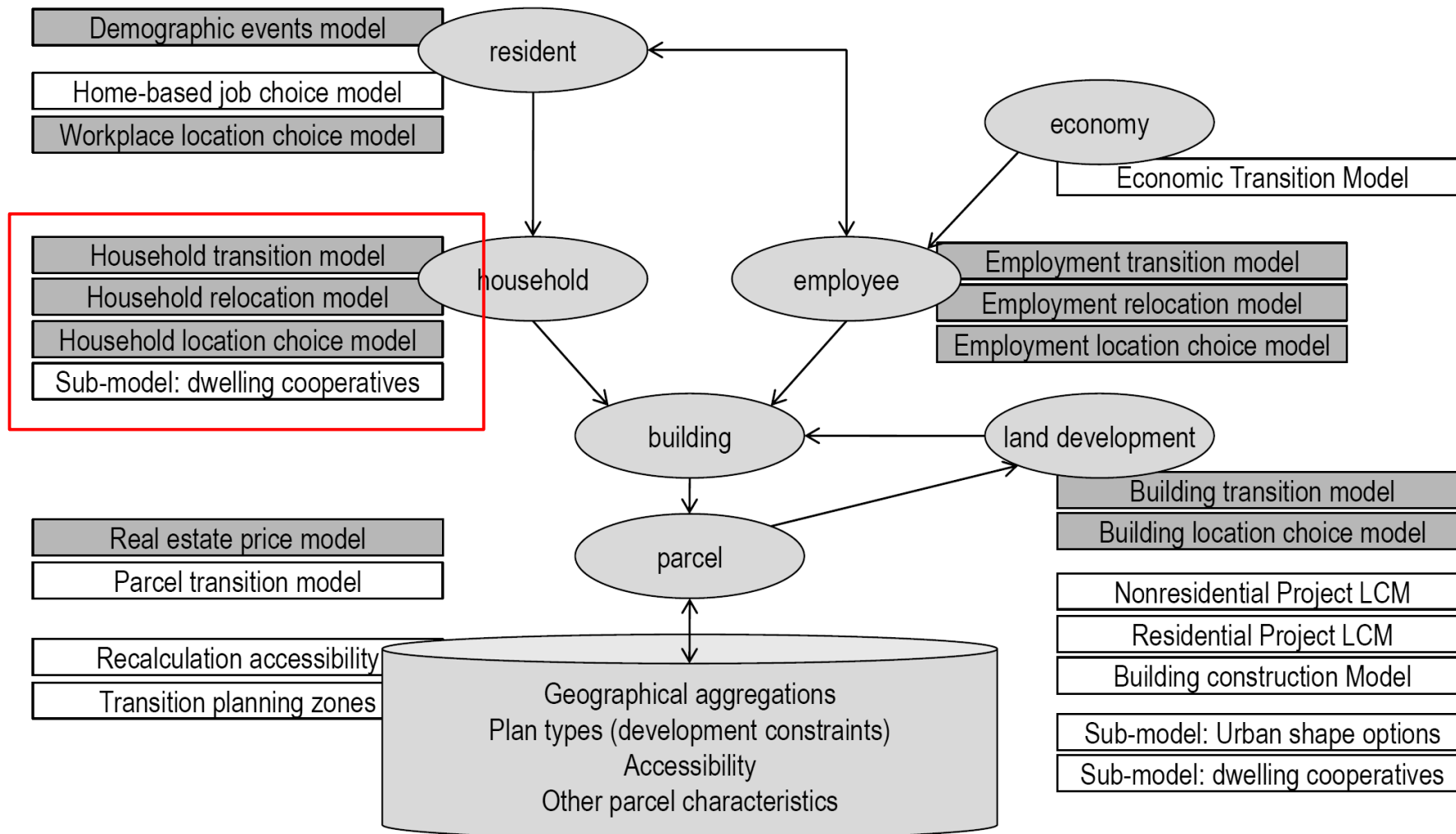


# Models – building location choice model BLCM

---

Coeff_names	estimate	std err	t-values	
Slope	-0.02	0.01	-2.90	
Logit_foreigners_within_ha_of_parcel	-0.40	0.03	-13.08	?cost
ln_population_density_in_ha	0.45	0.02	20.49	
jobs_within_ha_of_parcel	-0.01	6.00E-04	-11.24	?quality
building_fit_parcel	-7.30E-05	1.50E-06	-48.32	

# Models for first run



# Models – Household Transition (HTM) and Relocation (HRM)

---

Household control totals:

- Scenario: assumption 10%growth
- *(observed data)*

Annual relocation rates of households:

- *Survey and census data; S.Beige(2005) used in ZUK (2008)*
- Grouped into 12 categories based on age of head and income

# Models – Household Location Choice Model HLCCM

---

## Structure

- Dependancies: HRM, HTM
- Locations: building
- Agents: household
- Estimation: *external estimation & import of specifications*
- Configuration:
  - Sampler: `opus_core.samplers.weighted_sampler`
  - Choices: `urbansim.lottery_choices`
  - Procedure: `opus_core.bhhh_mnl_estimation`
  - Capacity: `Vacant_residential_units`
  - Filter: `building_is_residential & residential_sqm!=0`
  - Choice set size: 30

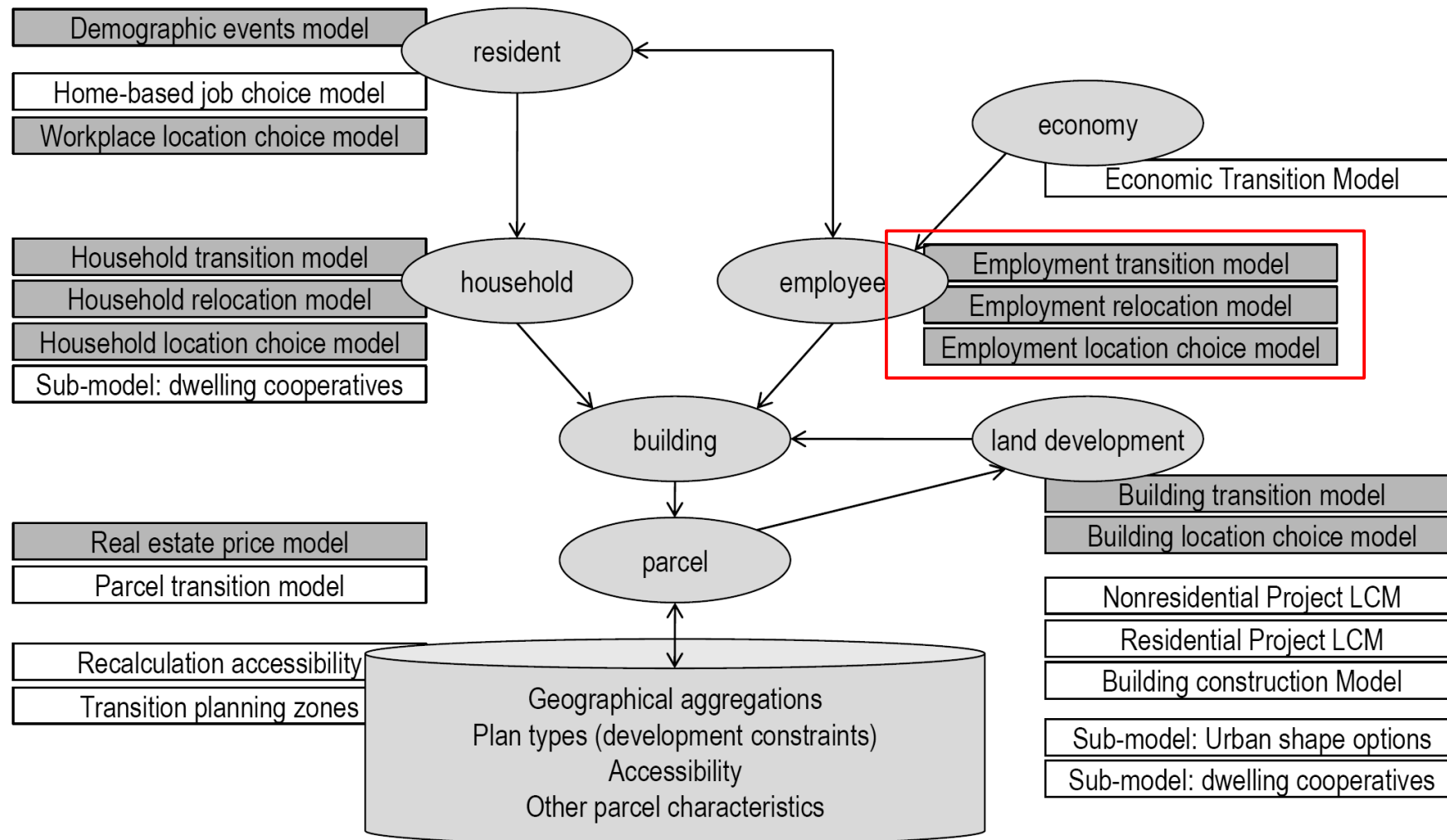
# Models – Household Location Choice Model HLCCM

<b>Coeff_names</b>	<b>estimate</b>	<b>std err</b>	<b>t-values</b>
Age_of_House	0.01	0.00	10.38
Job Density in 1km <sup>2</sup>	-0.69	0.04	-16.63
Pop_density	0.03	0.00	14.31
Distance_to_station	-0.23	0.07	-3.45
historical building	1.32	0.14	9.75
Accessibility of PT* no_car_ownership	0.15	0.05	3.21
Rent Vacancy in municipality	-0.11	0.05	-2.24
Traveltime to Zürich CBD by car	0.00	0.00	5.21
Distance to last residence	3.76	0.19	19.82
Distance to workplace	1.57	0.29	5.41
ETA_last residence	-0.15	0.01	-14.60
ETA_distance to workplace	-0.09	0.02	-5.65

Not integrated in UrbanSim

<i>Log-likelihood is</i>	<i>-1749.81</i>
<i>Null Log-likelihood is</i>	<i>-2679.74</i>
<i>Likelihood ratio index</i>	<i>0.35</i>
<i>Adj. likelihood ratio index</i>	<i>0.34</i>
<i>Number of observations</i>	<i>685.00</i>
<i>Number of alternatives</i>	<i>50.00</i>

# Models for first run



# Models – Employment Transition (ETM) and Relocation (ERM)

---

Employment control totals:

- Scenario: assumption 5%growth
- *(observed data)*

Employment relocation rates:

- *Based on Definitions used in ZUK (Loechl et al.2007)*
- Grouped into 8 categories of NOGA-codes



# Models – Employment Location Choice Model (ELCM)

---

## Structure (Model created by EPFL)

- Dependancies: ERM, ETM
- Locations: building
- Agents: job
- Estimation: *estimation inside UrbanSim based on baseyear data*
- Submodels: *categories used in relocation rates*
- Configuration:
  - Sampler: `opus_core.samplers.weighted_sampler`
  - Choices: `urbansim.lottery_choices`
  - Procedure: `opus_core.bhhh_mnl_estimation`
  - Capacity: `vacant_SSS_job_space`
  - Filter: `building_.non_residential_sqft`
  - Choice set size: 10

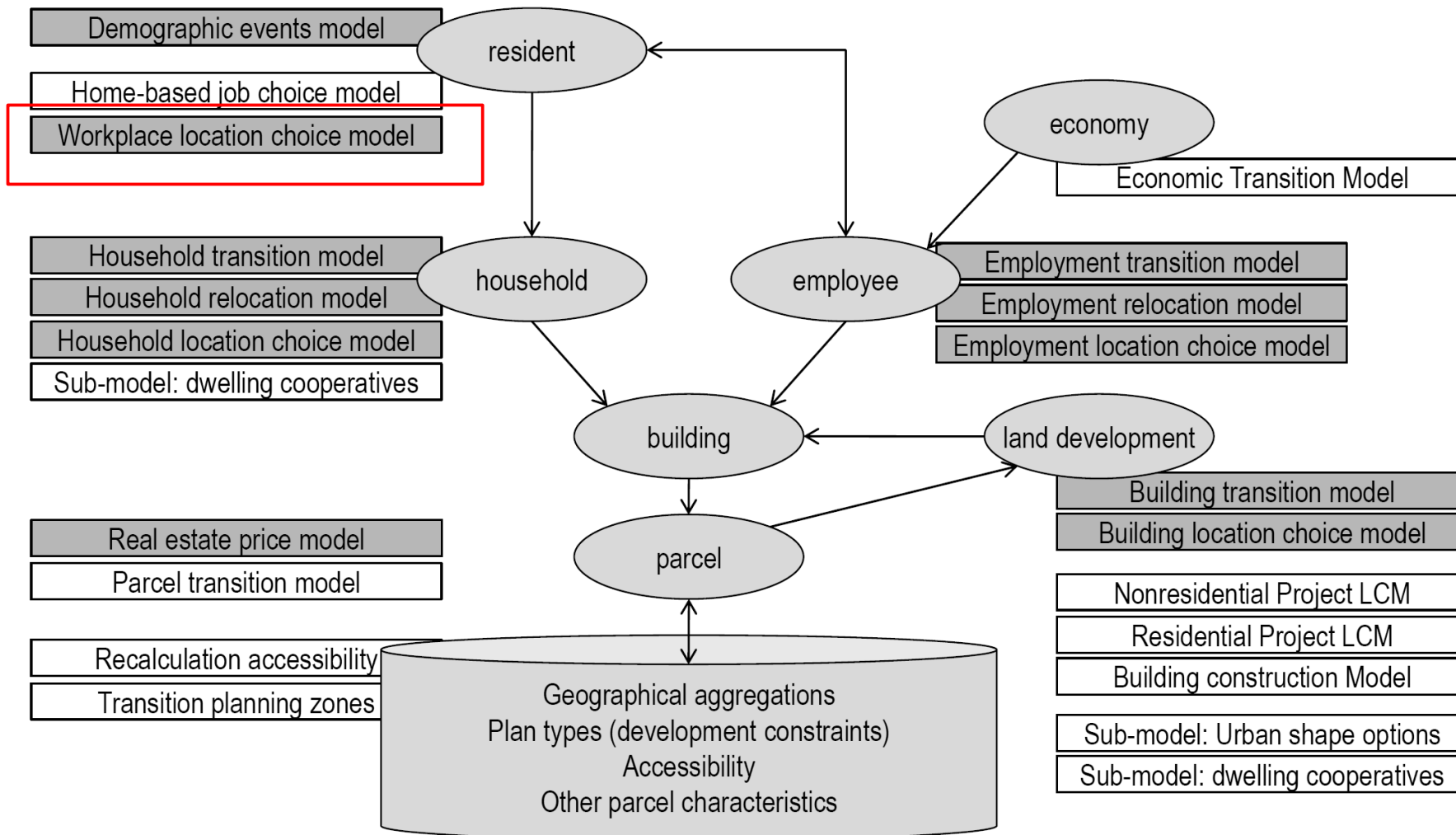
# Models – Employment Location Choice Model (ELCM)

## Assumptions on occupied space:

- Manufacturing, Trade, Retail, Hotel & Restaurant: 50
- Construction, Transport: 100
- Services: 15
- Health: 25
- *Other: 100*

Coeff_names	manufacturing		construction		trade		retail		hotel&gastro		transport		services		health	
	est	t_stat	est	t_stat	est	t_stat	est	t_stat	est	t_stat	est	t_stat	est	t_stat	est	t_stat
ln_(non_residential_sqm in building)	-	-45.13	-	-33.66	-	-38.12	-	-33.21	-	-21.38	-	-38.01	-	-52.29	-	-16.39
avrg_income_in_zone	+	8.12	-	-0.593	+	4.18	+	0.52	-	-0.53	-	-12.33	-	-13.92	-	-8.97
number_of_jobs_in_same_sector	+	44.92	+	25.06	+	38.04	+	20.4	+	28.3	+	39.17	+	67.51	+	47.56
number_of_jobs_sector1	***	***	+	5.45	-	-0.62	-	-2.3	-	5.34	-	-8.42	-	-0.99	+	1.64
number_of_jobs_sector2	+	1.52	***	***	-	-2.7	+	0.72	-	-1.09	-	-9.13	-	-1.79	-	-0.54
number_of_jobs_sector3	+	6.47	+	5.25	***	***	+	3.8	+	1.02	+	14.35	+	3.18	-	-3.38
number_of_jobs_sector4	-	-2.91	-	0.43	-	-1.17	***	***	-	-1.19	+	12.21	+	8.19	+	5.12
number_of_jobs_sector5	-	-4.10	+	4.23	+	1.57	+	8.77	***	***	-	-3.74	+	2.52	-	-1.8
number_of_jobs_sector6	-	-4.35	-	-8.5	+	1.91	-	-3.33	-	-5.53	***	***	+	3.71	-	-1.53
number_of_jobs_sector7	+	-4.38	-	-3.03	+	0.28	+	2.85	+	4.42	-	-1.76	***	***	-	-0.76
number_of_jobs_sector8	-	-2.72	-	-5.48	-	-4.67	-	-5.07	-	-1.07	-	-4.48	-	-9.42	***	***
distance_to_highwayaccess	-	-3.74	-	-5.59	-	-2.95	-	-1.83	-	-2.56	-	-2.12	-	-7.7	+	7.63
distance_to_station	-	-0.99	-	-4.84	-	-7.9	-	-11.5	-	-4.41	-	-14.82	-	-20.94	-	-9.96

# Models for first run



# Models – Workplace Location Choice Model WLCM

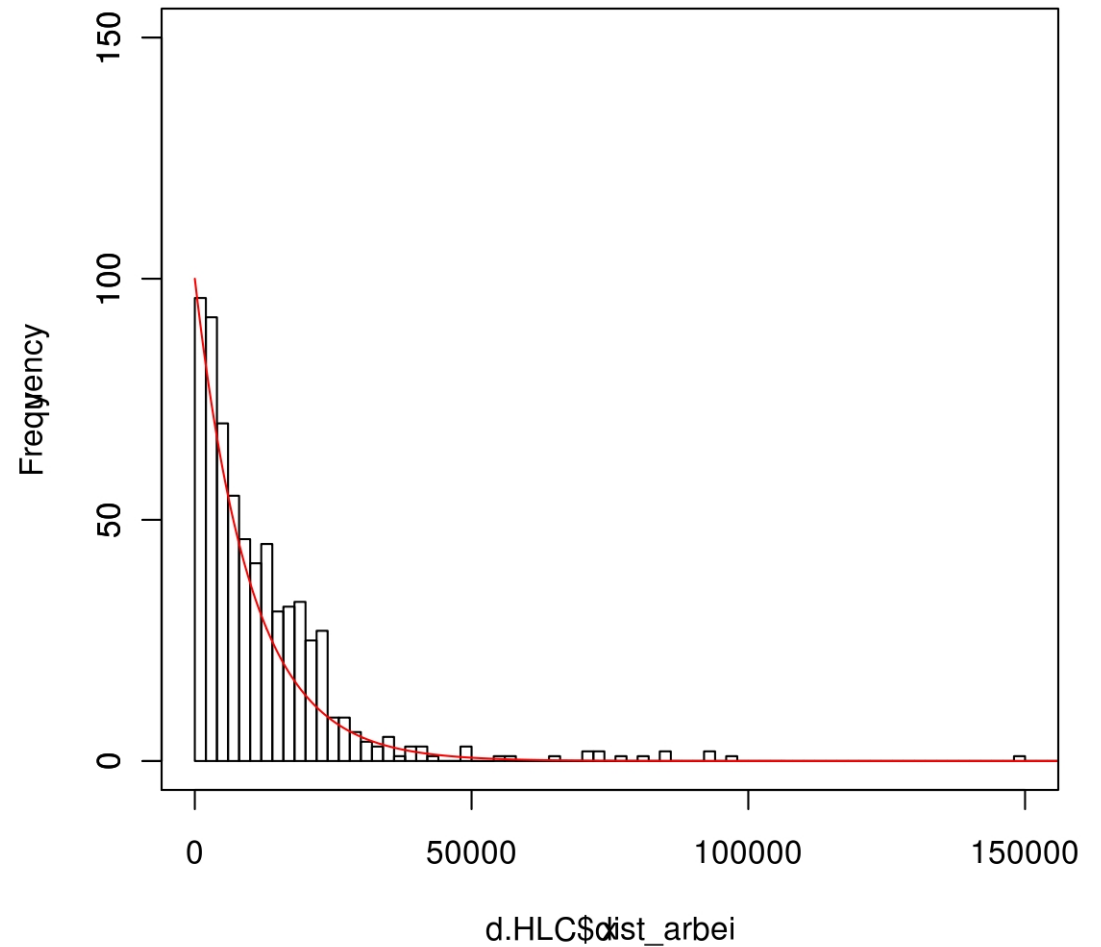
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## Structure

- Dependancies: *ELCM, HLCM (implicit through missing link)*
- Locations: job
- Agents: person
- Filter: `number_of_agents(person)==0`
- Estimation: *definition based on observed distribution*
- Configuration:
  - Module: `urbansim.models.agent_location_choice_model`
  - Sampler: `opus_core.samplers.weighted_sampler`
  - Choices: `urbansim.lottery_choices`
  - Utilities: `opus_core.linear_utilities`
  - Probabilities: `opus_core.mnl_probabilities`
  - Choice set size: 30

# Models – Workplace Location Choice Model WLCM

Distance to residence (distanceR):  $U=0.1629*\exp(-0.00008*distanceR)$



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# Models – Real Estate Price Model REPM

---

## Running the simulation (2001)

- Number of agents: 173318 (total residential: 173692)
- Number of calculations loops: 1
- Total time for run: 6min

=> Works as expected

=> Resulting values for rent price still to be checked

=> Only rent prices created.... other uses?

# Models – building location choice model BLCM

---

## Running the simulation (2001)

- “nothing to be done”
- Vacancy rates have error?

```
numpy.logical_and(building.year_built > 1990, building.building_type_id<>7)...0.0 sec
```

building_type	actual	target	difference	action
0	0	0	0	0
1	78079088	22245899	-55833189	0
2	4469434	-120448	-4589882	0
3	1260933	-98134	-1359067	0
4	2775240	-419277	-3194517	0
5	11573916	-1576450	-13150366	0
6	1235066	-210975	-1446041	0
7	2404615	-96645	-2501260	0

# Models – Household Location Choice Model HLCM

---

## Running the simulation (2001)

- Number of agents: 30.570 (total: 521.148)
- Available capacity: 109.585 units (total: 549.820)
- Number of chunks: 2 in first loop
- Number of distribution loops: 2
- Successful distribution: yes
- Total time for run: 1h 11min

=> Works as expected

=> Capacities seem to be very high

# Models – Employment Location Choice Model (ELCM)

---

## Running the simulation (2001)

- Number of agents: 624.622 (total: 720.819)
  - *Ignored because of missing relocation rates: 103.405*
- Available capacity: 724.931 units (total: 67.465.215 sqm)  
<=>min: 674.652 jobs, max: 4.497.681 jobs
- Number of chunks: 13 in first loop
- Number of distribution loops: 3
- Successful distribution: yes
- Total time for run: 10min 18sec

=> works as expected, but...

=> all jobs redistributed every year

# Models – Workplace Location Choice Model WLCM

---

## Running the simulation (2001)

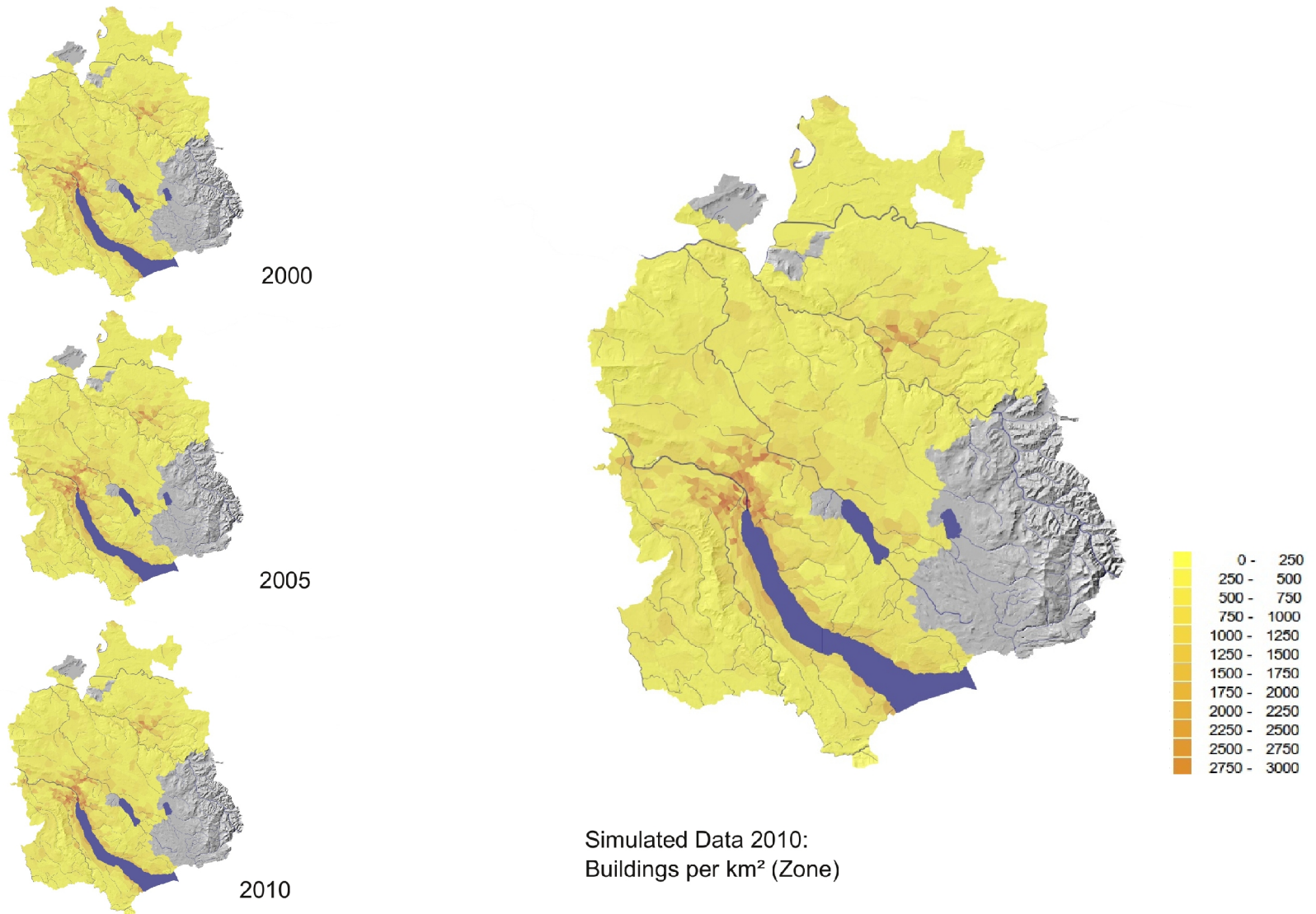
- Number of agents: 1.016.601 (total: 1.089.858)
- Available capacity: 408.657 units (total: 720.819 sqm)
- Number of chunks: 21 in first loop
- Number of distribution loops: 2
- Successful distribution: no (abortion when no capacities remaining)
- Total time for run: 2h 4min

=> All Agents redistributed every year

=> No filtering of “workers”

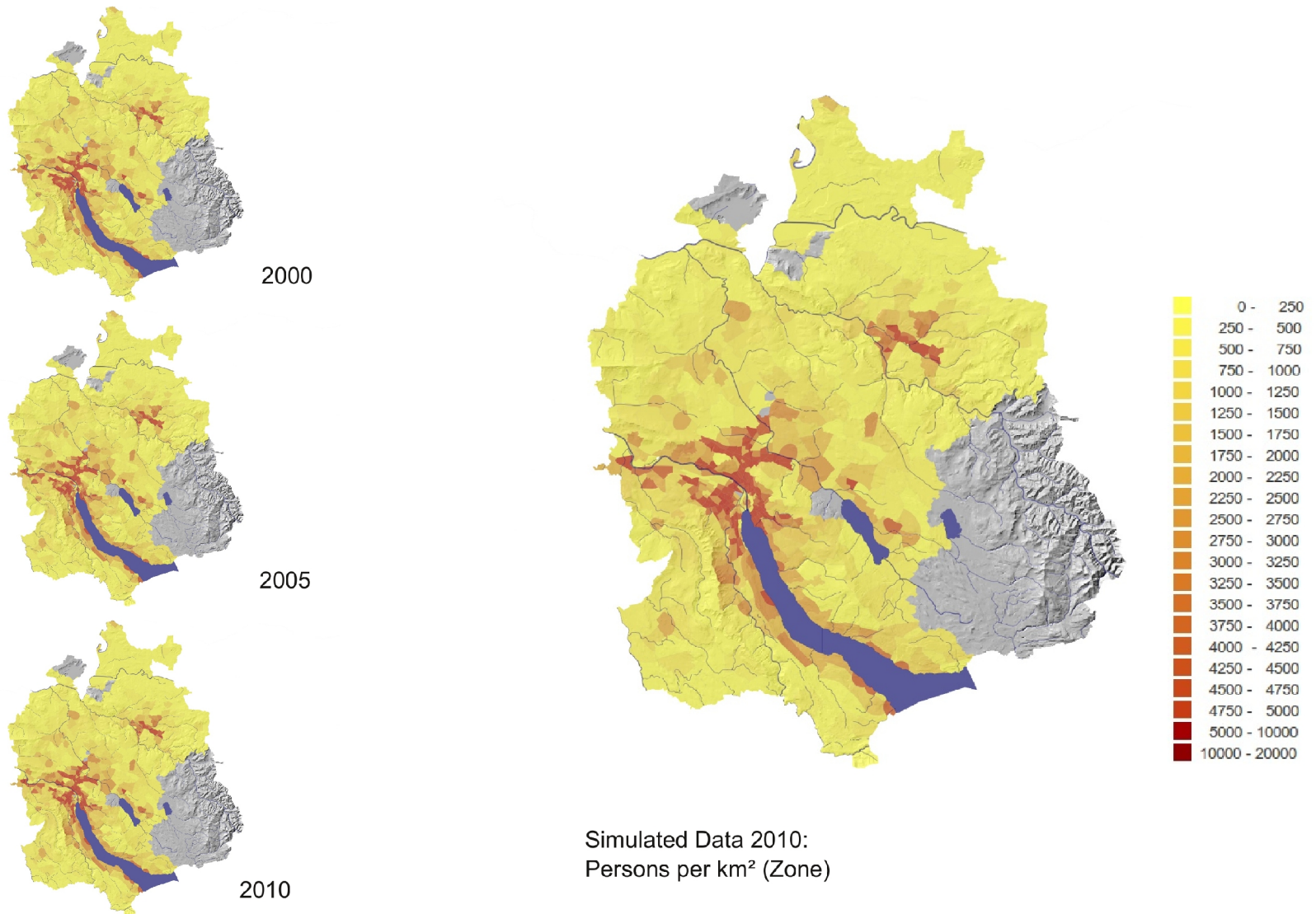
=> Number of jobs does not fit expectation

# Simulation - Buildings

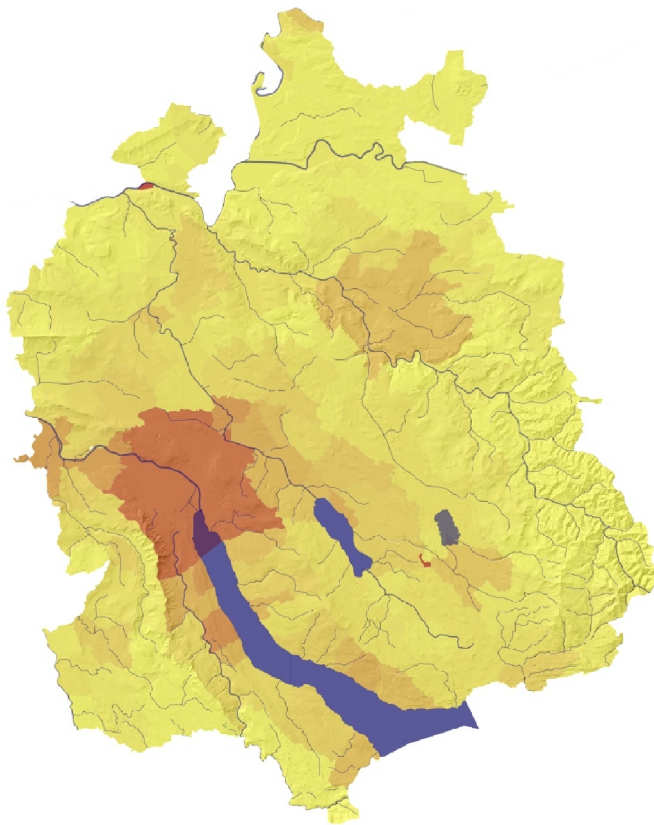




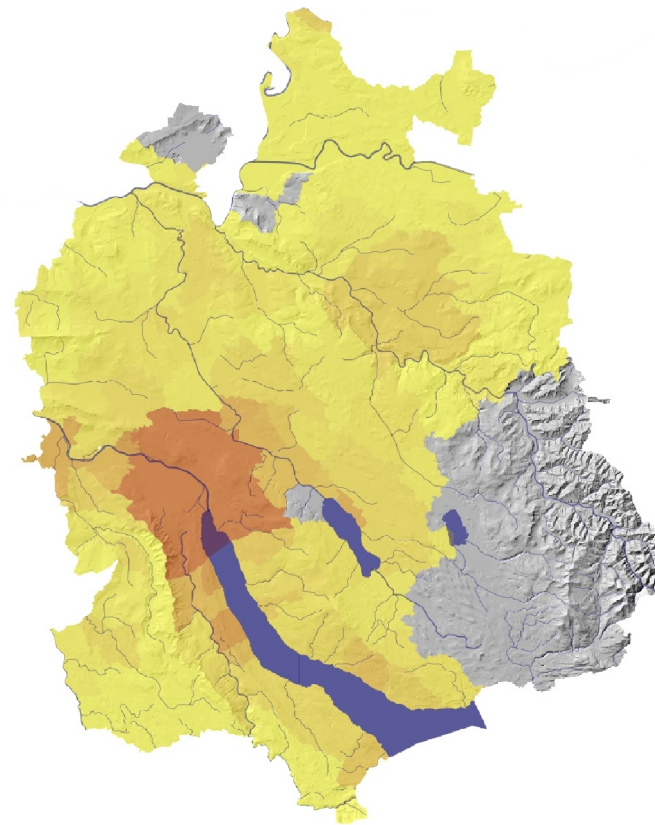
# Simulation – Persons



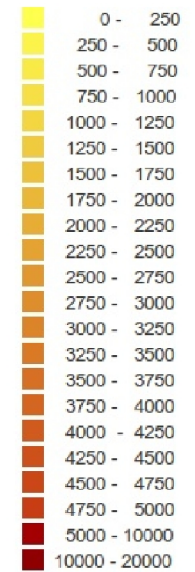
# Simulation - Persons



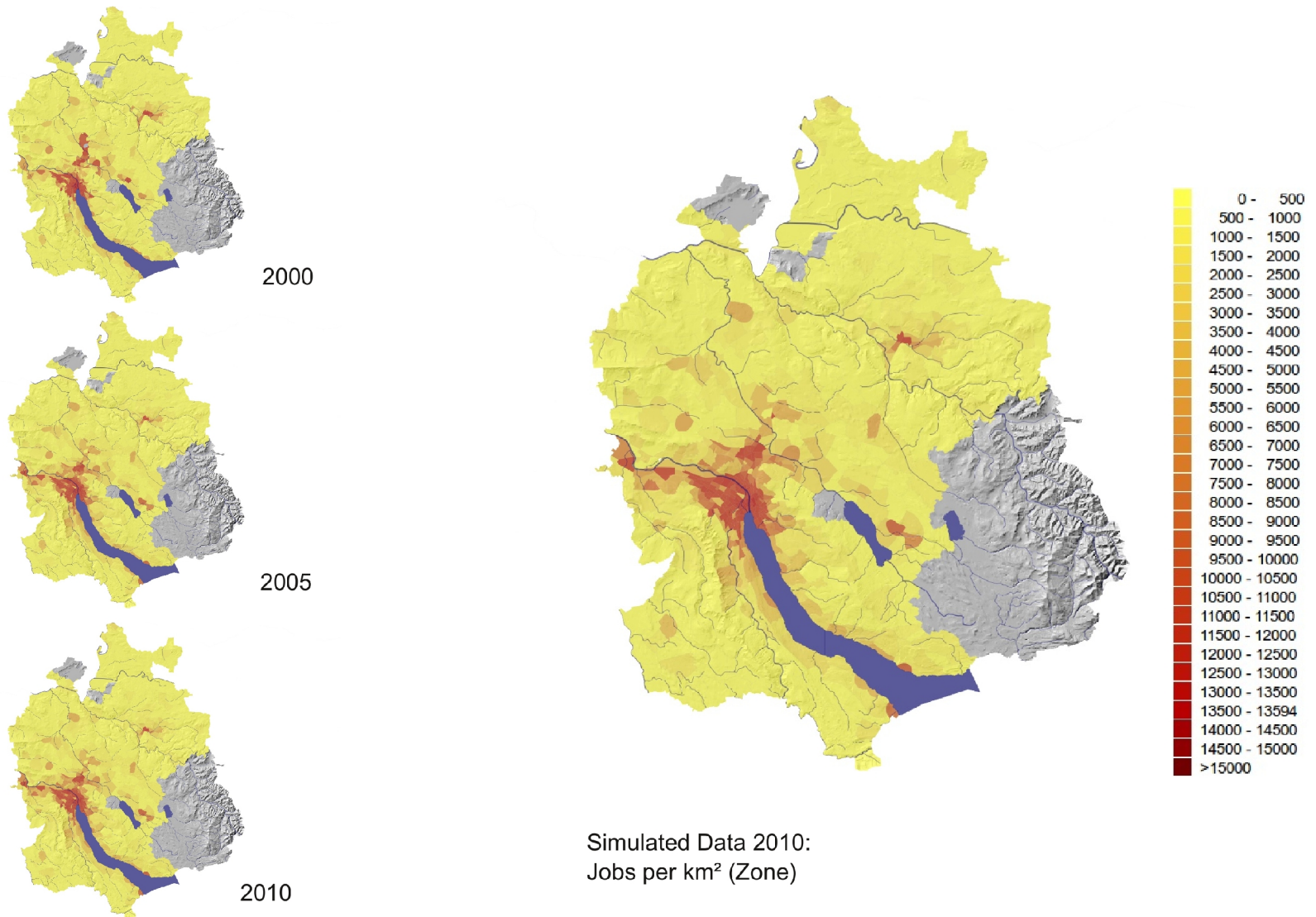
Observed Data 2010:  
Persons per km<sup>2</sup> (Municipality)



Simulated Data 2010:  
Persons per km<sup>2</sup> (Municipality)

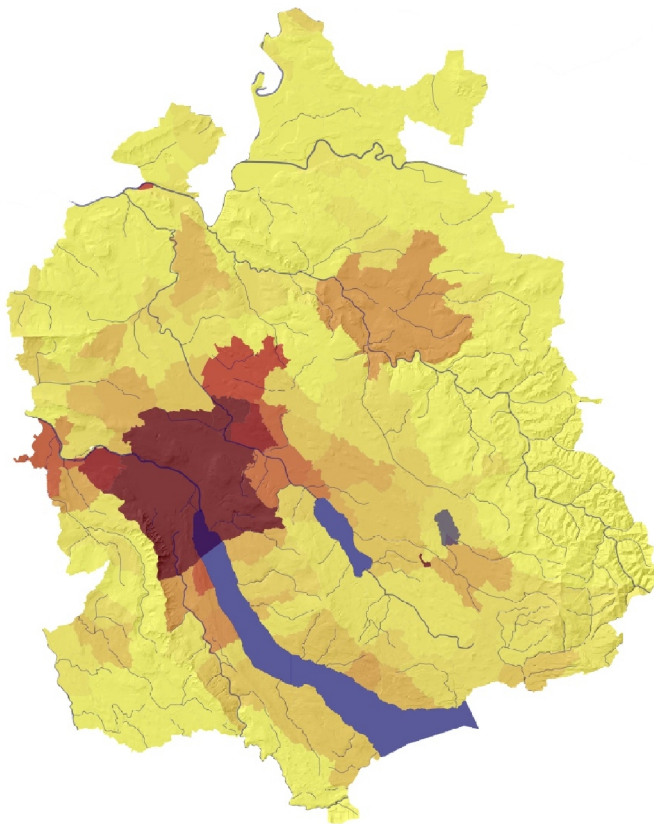


# Simulation - Jobs

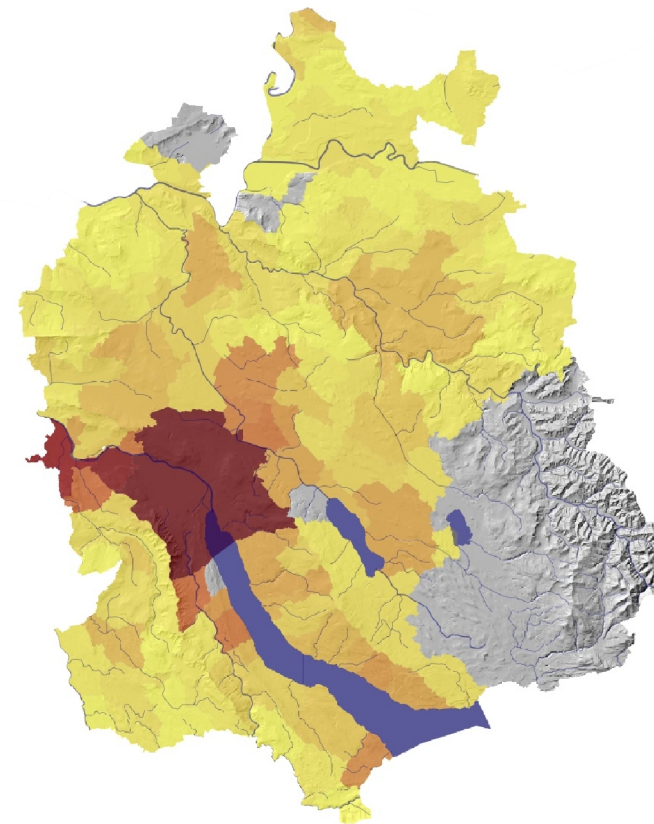




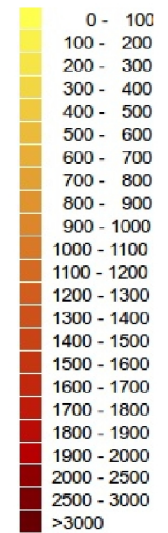
# Simulation - Jobs



Observed Data 2010:  
Jobs per km<sup>2</sup> (Municipality)



Simulated Data 2010:  
Jobs per km<sup>2</sup> (Municipality)



# Overview

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**Next steps / problems**



# Simulation - summary

---

Many errors remain to be solved in this “first run”....

## Agents

- BLCM does not run due to vacancy rates (or error of units)
- ELCM & WLCM distribute all agents
- ELCM seems to have very high available capacities

## Modeling

- Control totals are an approximation
- REPM & HLCM include only parts of original variables
- REPM price only for residential
- BLCM is a dummy model
- Weighted sampler vs. random sampling of external estimations



# Simulation - summary

---

And still results are somewhat promising....

## Simulation

- Finally: NO ERRORS any more!
- ELCM runs (and filters)
- REPM seems to run as expected (to be checked on values)
- HLCCM seems to run as expected
- Employment location seems to filter as expected
  
- Distribution of jobs and households mainly fit to real world observation
  - Airport not included
  - “holes” in simulation?

# Further steps

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## Baseyear

- Include whole canton
- Account for border problem
- Improve data (income, car-ownership, buildings, parcel merge,...)

## Sensitivity

- Definition of categories/Change of control totals
- Order of Models/Interaction of models
- Impact of single variables (and quality in baseyear)

## Models

- Demography
- MatSim-exchange
- Developers

## Evaluation

- Comparability to observed data: lags, subsets, ...

# Further steps

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## Policy scenarios

- New transport infrastructure (Motorway A50/A51)
- Land use (Limitation of settlement area)
- Designation of a new building zone area (Airport Dübendorf)
- Real estate market (real estate prices bubble: economic decline)

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