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Zöllig Renner, C., P. Schirmer, K. Müller and B. Bodenmann (2013)

Case Study Zurich
– Current status, problems, scenarios

presented at *Case Study Meeting*, Brussels, Feb. 2013.

Case Study Zurich – Current status, problems, scenarios

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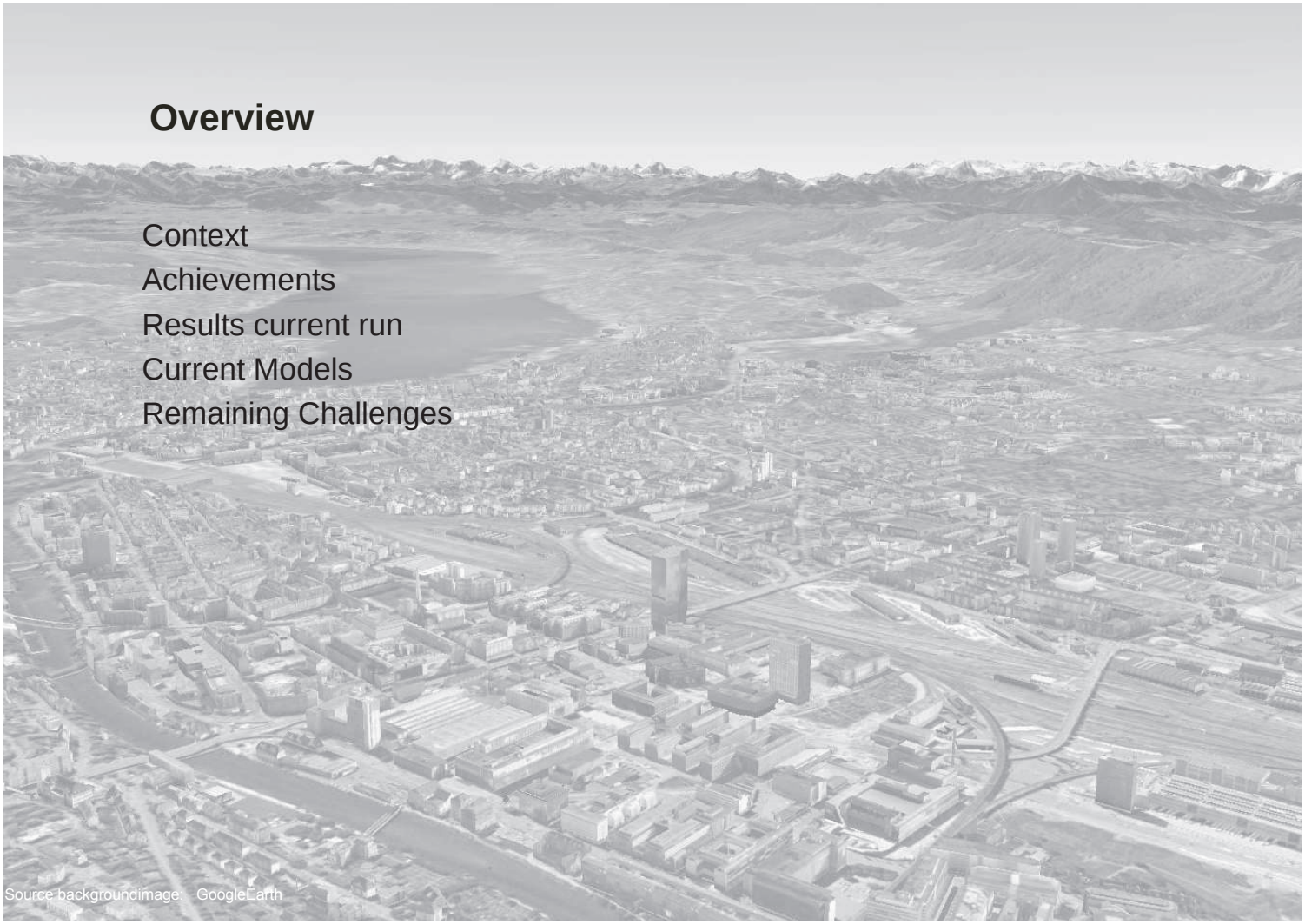
Overview

Context
Achievements
Results current run
Current Models
Remaining Challenges



Source backgroundimage: GoogleEarth

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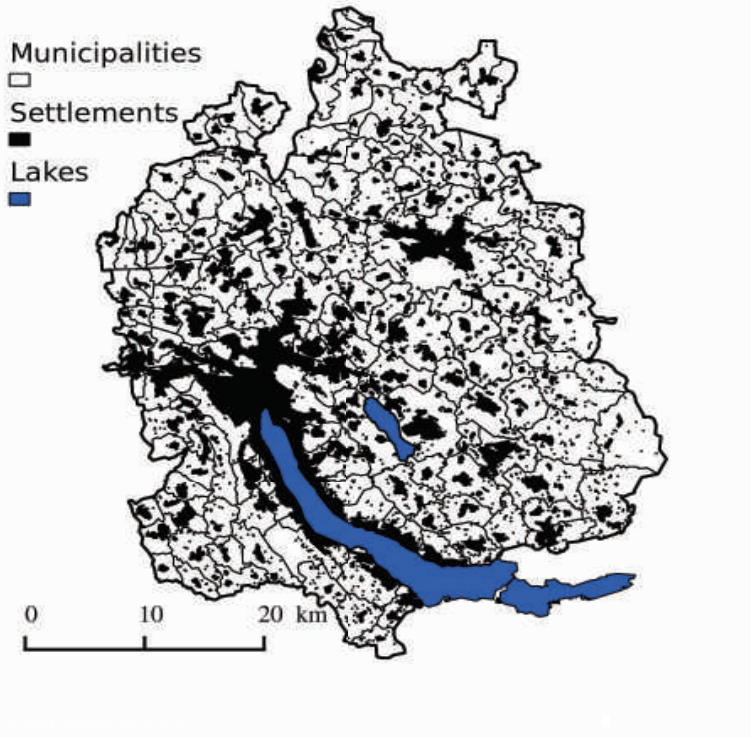
Simulation

Simulation area and time period

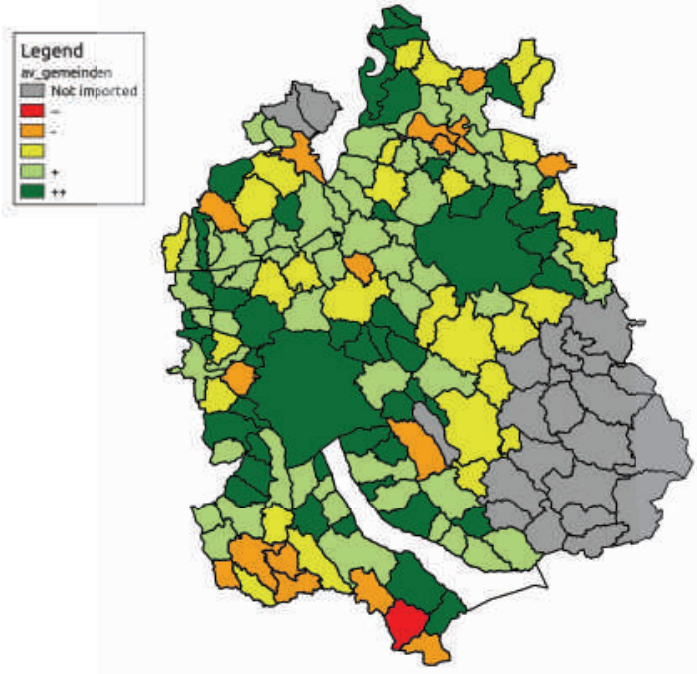
Simulation start: 2000

Evaluation period: 2000-2010

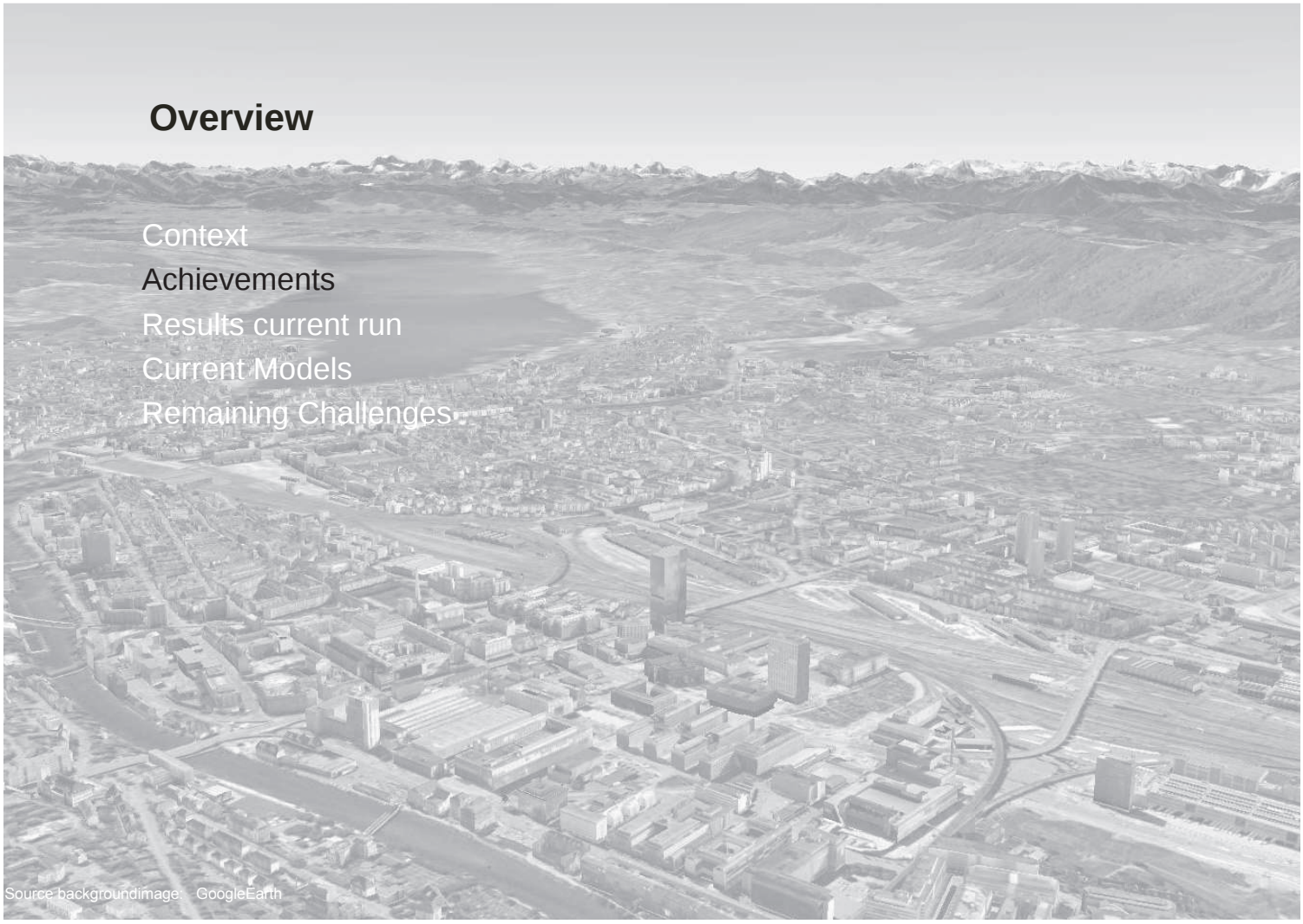
(Simulation period: 2010-2022)



Data preparation- Import quality (assert error rate)



Overview



Achievements

Use of living units

- rent price per unit vs. price/sqm
- unit attributes in HLCM

MATSim integration

Demography integration

- Birth problem solved
- Mapping of attributes
- Car availability model
- Income model

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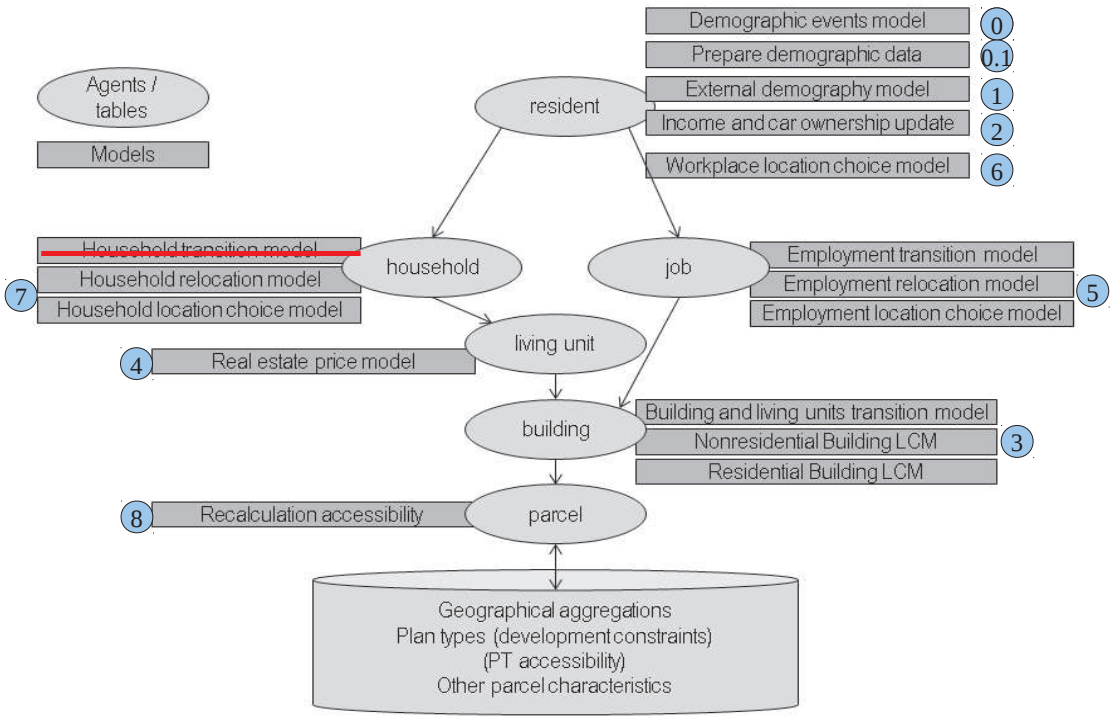
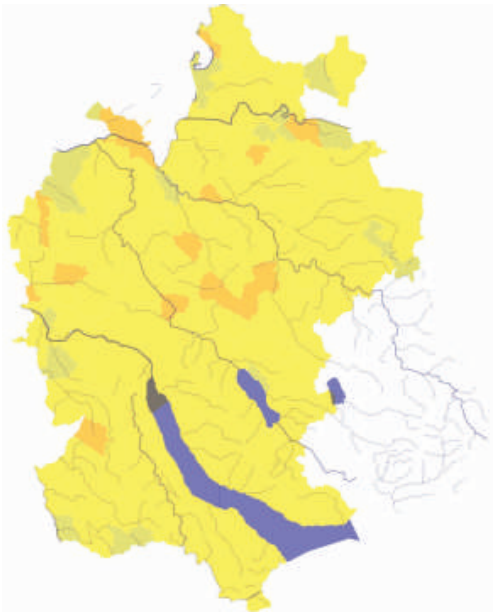
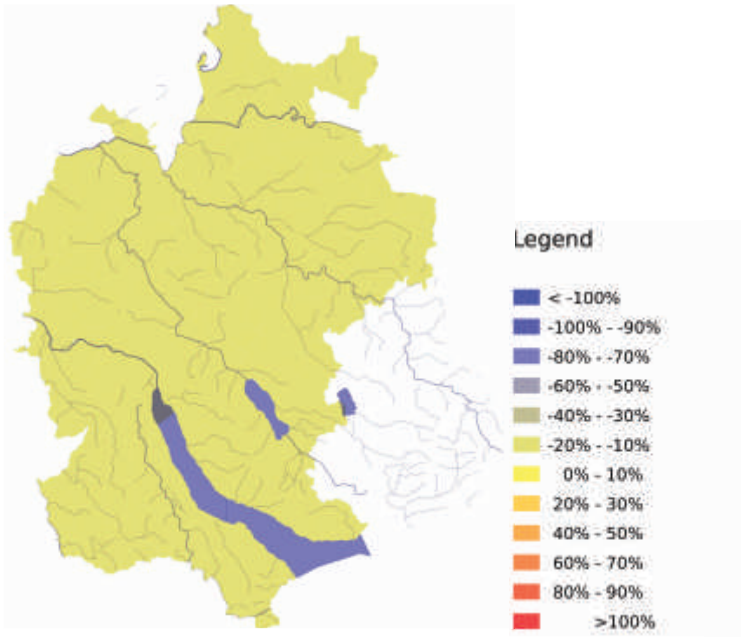
Current run – Simulated models



Simulation - Persons

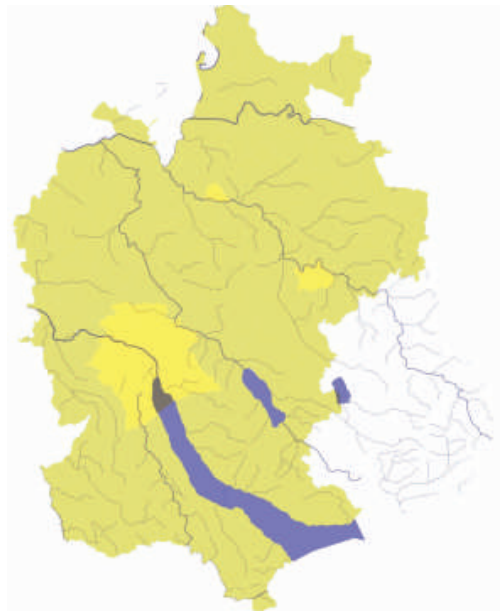


Observed development 2001 - 2008:
Persons per km2 of municipality

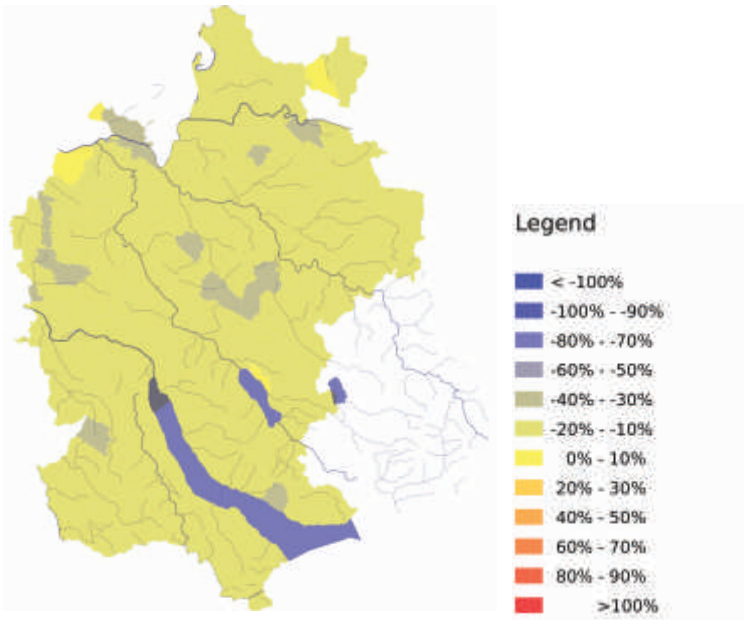


Simulated development 2001 - 2008:
Persons per km2 of municipality

Simulation - Persons

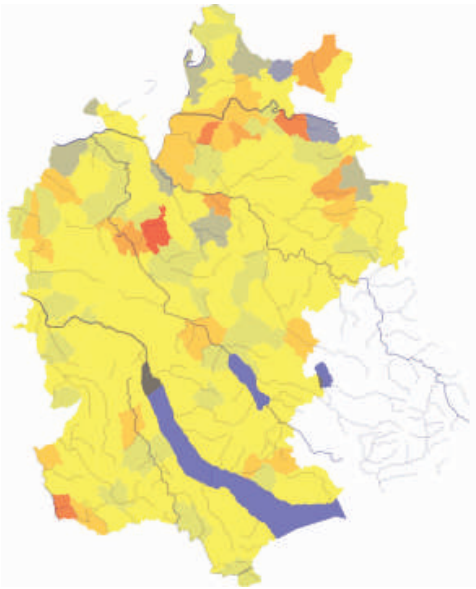


Difference of simulation to validation 2001:
Persons per km^2 of municipality

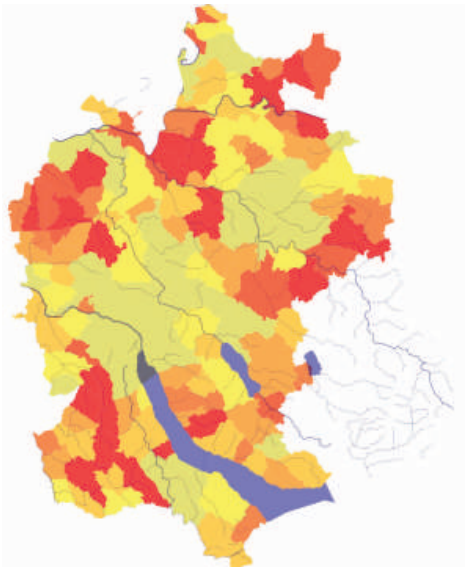


Difference of simulation to validation 2008:
Persons per km^2 of municipality

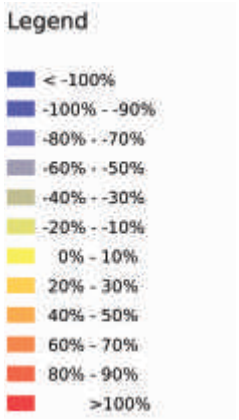
Simulation - Jobs



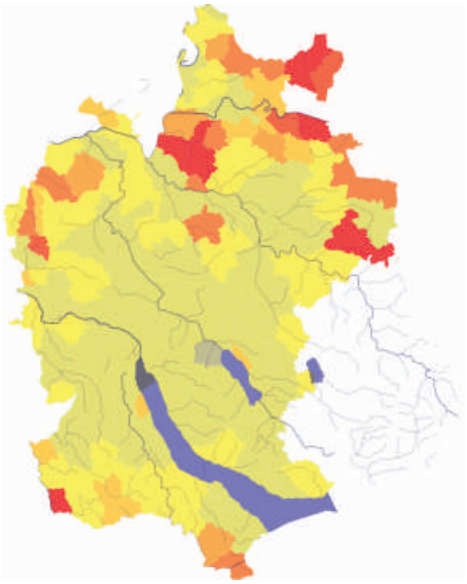
Observed development 2001 - 2008:
Jobs per km2 of municipality



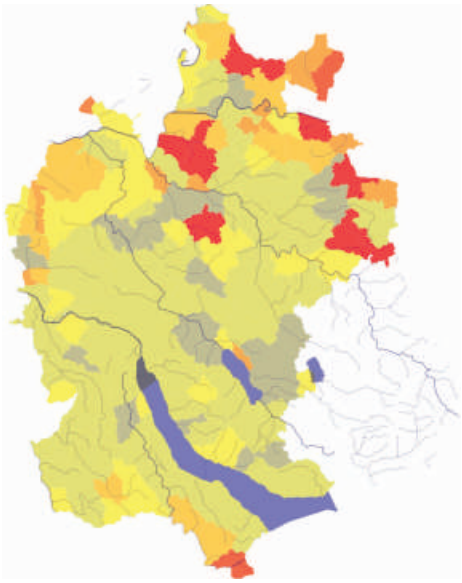
Simulated development 2001 - 2008:
Jobs per km2 of municipality



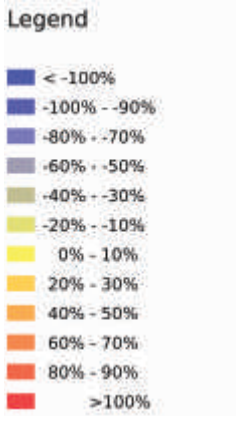
Simulation - Jobs



Difference of simulation to validation 2001:
Jobs per km^2 of municipality



Difference of simulation to validation 2008:
Jobs per km^2 of municipality



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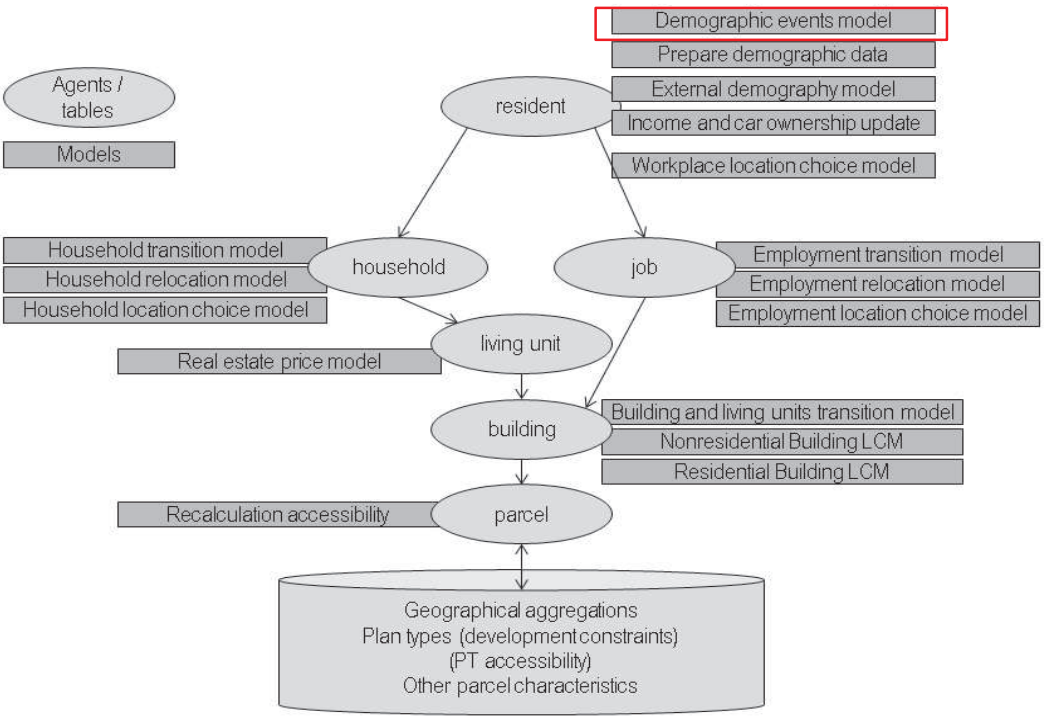
Source backgroundimage: GoogleEarth

Current Models – Demography



Demographic model

Current state

Memory limitation of 32-bit version: Run ends after 24 years

Switzerland specific parameters but for fertilities and emigration

Rough calibration regarding overall size

One replicate

Configuration: Omitting communal model (social housing)→ done by HLCM
Complex households probabilities set to 0 → no complex households
Solved birth problem (wrong data type) → Version 3

Runtime: less than 24 hours

External model vs. static baseyear

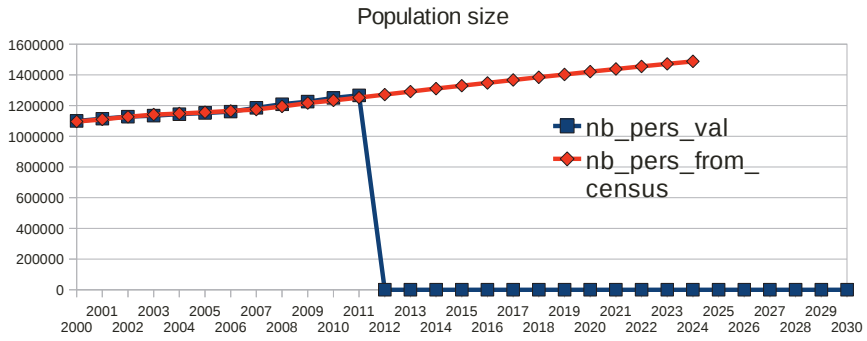
Mapping of attributes needed

Models do not react on changes in household configurations

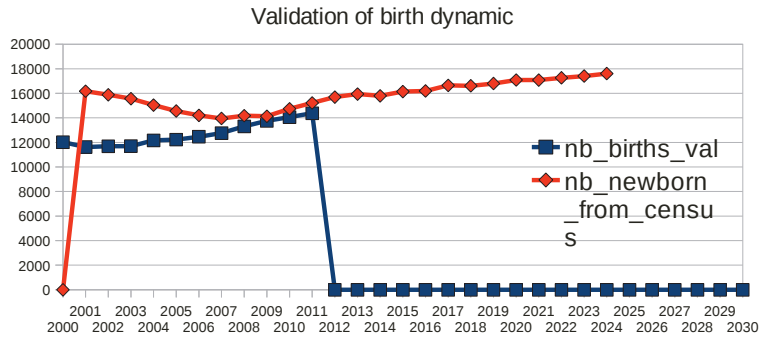
Observations/imputations of baseyear overwritten, e.g. age of head, car availabilty, income

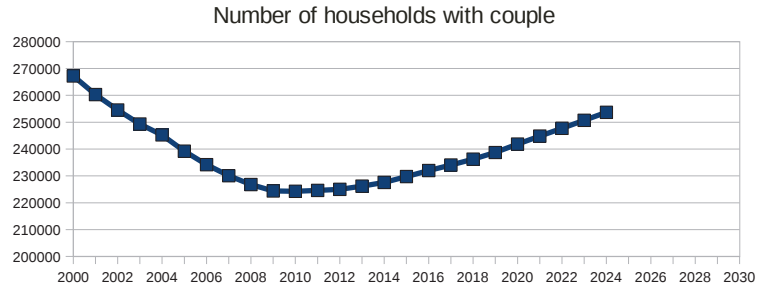
Postprocess of data needed at beginning of every year

Demographic model – Calibration

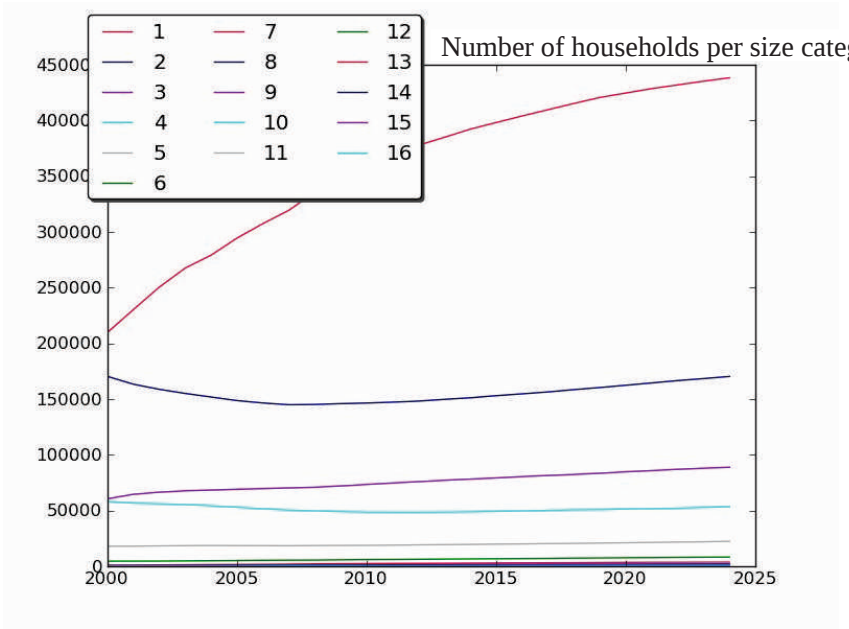


Demographic model – Reduction of couples and births





Demographic model – Household size affected



Demographic model

Integration with UrbanSim

prepare_demographic_data.py → .hdf5, runtime: several hours for the entire data
external_demography_model.py → reading each year hh and persons, runtime: 21 sec/year

Demographic data used:

- Persons and households
- HLCM function of:
  - persons per household
  - age_of_head
  - race_id
  - Income
  - Car ownership
- WCLM function of:
  - worker

Population data untreated by demographic model,

- Estimate models for income and car ownership in UrbanSim
- Income → Income regression model, postprocess_model
- Car ownership → Binary choice model (opus_core.choice_model), postprocess_model

Demographic model

Income Regression Model (IRM) & Car Availabilty Model (CAM)

Postprocess of demography in UrbanSim *(no additional rate based selection within Simulation)*
Estimation in UrbanSim using computed/imputed Baseyear-data
Estimation using Microcensus-observation is future work

Income Regression Model

variable	beta	stdev	t-value	
constant	3780	11.95	316.269	
number of cars in household	1.169	6.412	0.182	used in imputation of baseyear
number of persons	1736.990	4.477	387.963	
level of eduction	1640.090	6.205	264.298	

Adjusted R-Squared: -0.06

Car Availability Model

choice	variable	beta	stdev	t-value
no car	constant	0.810	0.021	37.464
car	income	0.000	0.000	2.874
	level of eduction	0.218	0.053	4.132
	number of persons	0.799	0.020	37.464
	distance to cbd	0.000	0.000	22.675

Demographic model

Possible improvements

Demographic model

Resolve couple shrinkage (Ids?, union formation process?)

Further calibration

Output tables are not created if run ends with error → Validation tools (also if run stops before last scheduled year)

Calibration tools to modify parameters

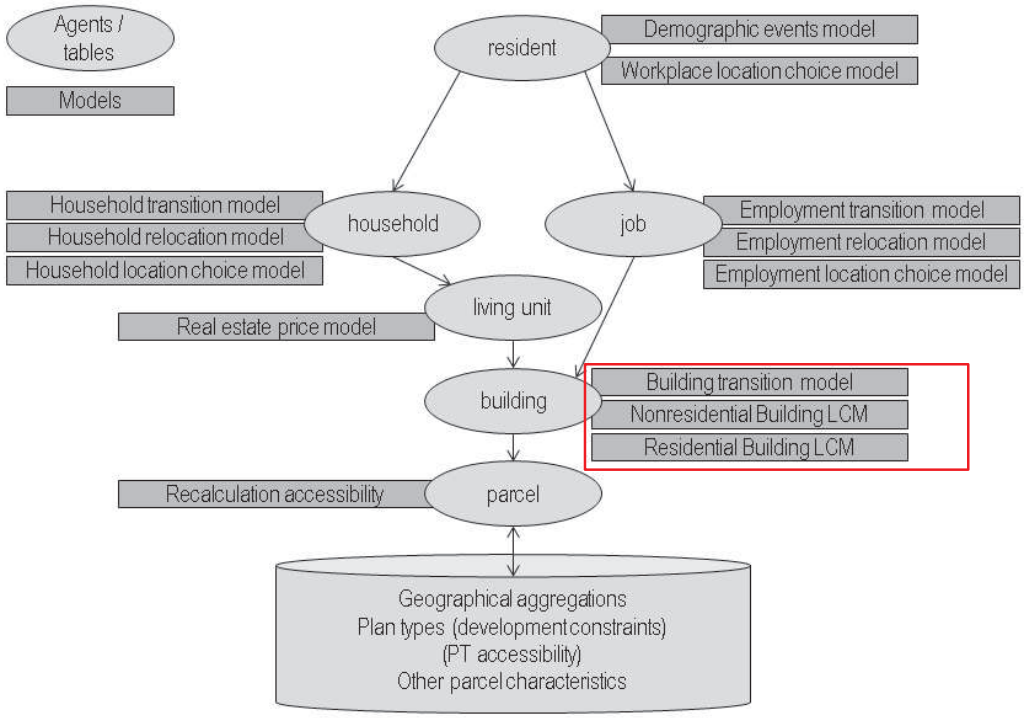
Integration

Consistent of base year preparation and attribute update

Relocation probabilities depending on HH mutation.

- Use lag-variable to find changes in household-configuration
- Household.aggregate(persons)? VS. change of person_id
- Use HLCM to define location of changed households

Current Models – Land Development Models



Models – Land Development Models

Building transition model (BTM)

Modified real_estate_transition_model.py, update of living units table

New built space provided when vacancy below target

Constraints:

- Not in line with mixed use buildings
- uses control totals of upcoming year to avoid failure of to less living_units
- Control totals also used when run with demographics (by now corrected)

Building location choice models

Using agent location choice model template

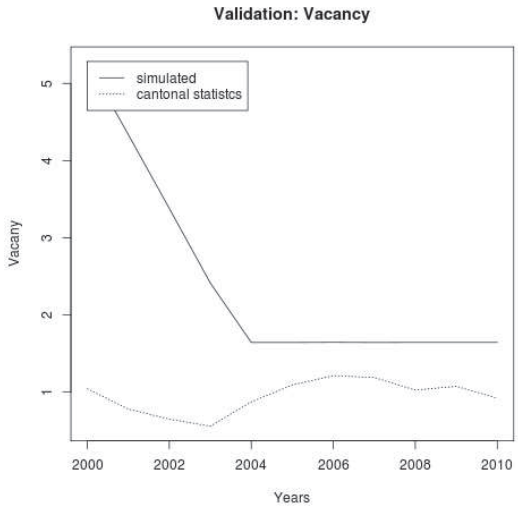
Residential buildings (RBLCM)

Stratification according to building types

- Single family house (SFH)
- Multi family house (MFH)
- Mixed use (WSU)

Non-residential buildings (NRBLCM)

No stratification



Models – Building Location Choice Model (BLCM)

Structure

Locations: parcels

Capacity: unexploited density

Agents: buildings

Estimation: *inside UrbanSim; based on development_event_history (2001 – 2010), single buildings*

Configuration: submodels for residential and nonresidential

Run Order: has to run before HLCM (to create roomspace) and REPM (to overwrite sampled rent_price)

Running the simulation (2005)

Number of agents: 1607 resi/ 7 nonresi

0 unplaced

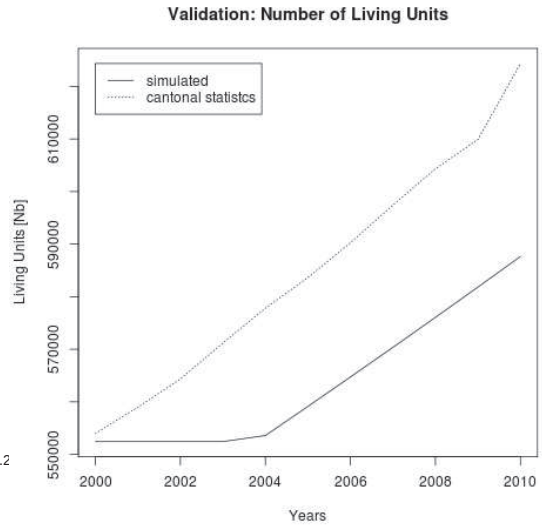
Number of chunks: 1

Total time for run: 4 sec

Insufficiencies land development modelling

Supply and demand linked by vacancy, not by price

Way too much non-residential floor space



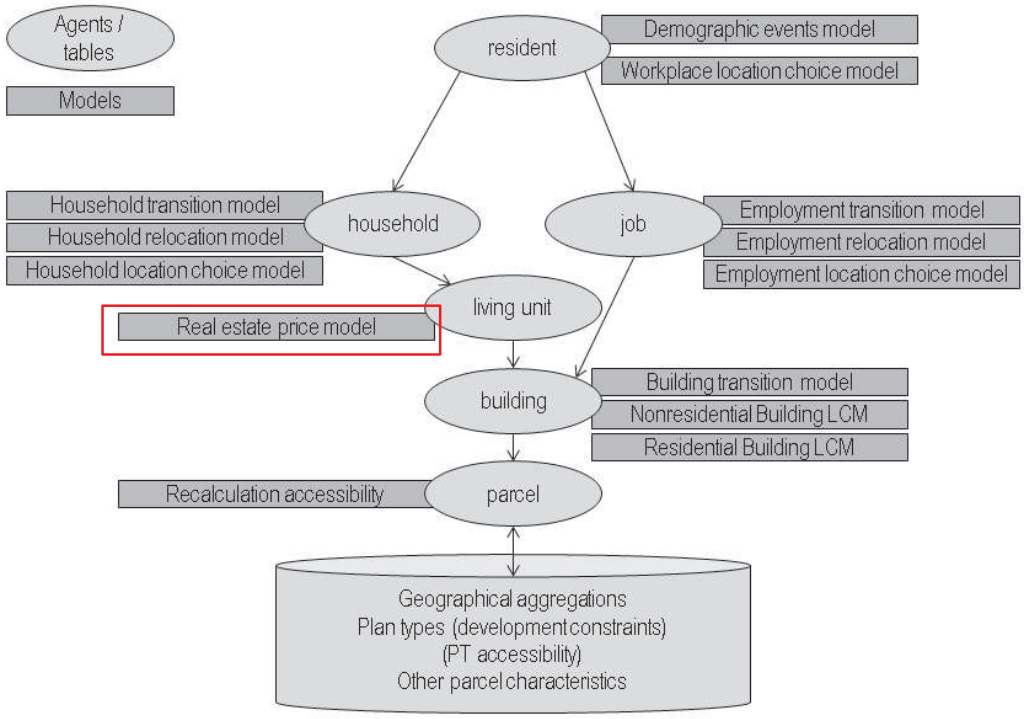
Models – building location choice model (BLCM)

Single family housing

Coeff_names	estimate	std err	t-values
sc_acc_car	-0.9987	0.0508	-19.6538
sc_acc_pt	-0.0384	0.0054	-7.0638
sc_dist_to_school	0.0004	0.0000	12.2912
sc_price_permitted_floor_m2	0.0000	0.0000	-2.6455
sc_slope	0.0278	0.0028	10.0272
sc_dev_fit_permitted_floor_m2_step_ln	0.0000	0.0000	1.7092
sc_new_bldgs_within_150_of_parcel	0.0436	0.0005	82.9377

Log-likelihood is:	-26396.156
Null Log-likelihood is:	-30957.699
Adj. likelihood ratio index:	0.147
Number of observations:	9102.000
Suggested |t-value| >	3.019

Current Models – Real Estate Price Model



Models – Real Estate Price Model (REPM)

Structure

Model: OLS regression (estimation of rent price per unit)

Dataset: living_units

Estimation: *estimation inside UrbanSim based on observed bid-prices (2005)*

Configuration: *Variables on residential unit (!!) and location included*

Running order: *at beginning of Simulation to overwrite sampled rent prices (BLCM)*

Running the simulation (2005)

Total time for run: 15min/sim year

Constraints

No commercial rent prices / implement model from Haase (2011)

No environmental services included / include findings of Fuhrer (2012)

Models – Real Estate Price Model (REPM)

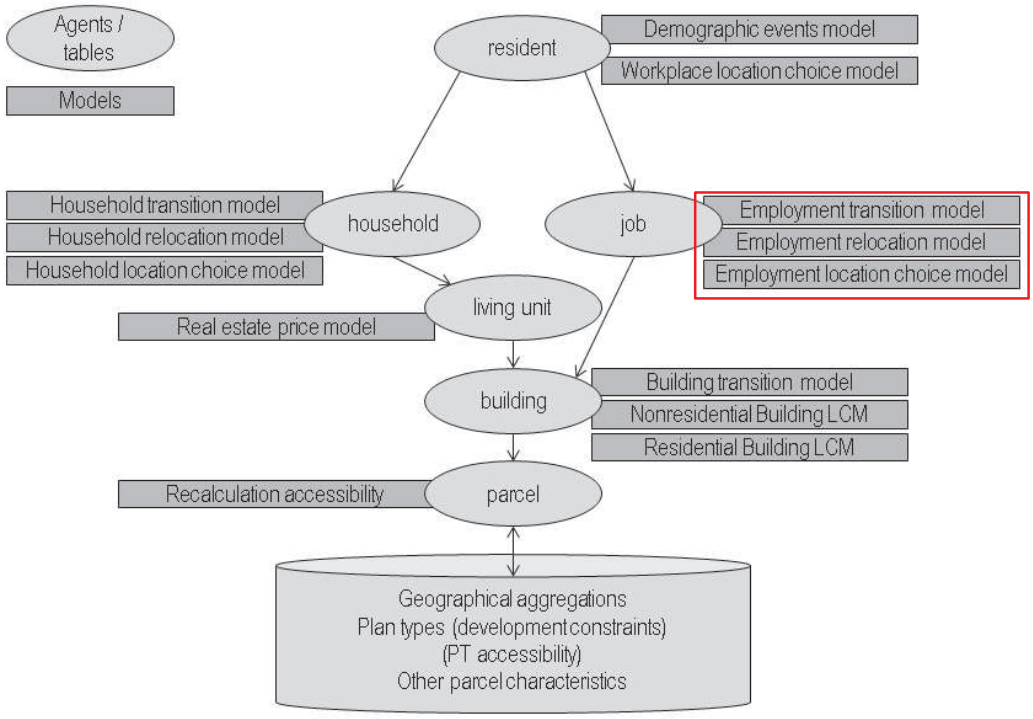
	UrbanSim		Survey (Löchl, 2007)		Diff(%)		Comment
	mean	stdev	mean	stdev	mean	stdev	
sc_acc_car	9.968	0.353					*not used*
sc_acc_pt	11.343	1.540	10.694	1.602	6.064	-3.875	
sc_building_built21to30	0.017	0.129	0.027	0.162	-37.288	-20.399	*Survey has more buildings for all periods*
sc_building_built81to90	0.136	0.343	0.166	0.372	-17.936	-7.804	
sc_building_built91tonow	0.178	0.383	0.202	0.402	-11.949	-4.752	
sc_building_is_pre_1921	0.093	0.291	0.105	0.306	-10.890	-5.002	
sc_dist_to_station	900.739	628.535	0.913	0.656	98568.970	95718.299	*1000m = 1km*
sc_highway_within_100m	0.021	0.145	0.019	0.138	9.159	5.162	
sc_is_house	0.023	0.151	0.021	0.144	11.074	5.268	
sc_jobs_G52_H_within_1km	448.621	1086.865	4.539	1.491	9784.332	72815.771	*Löchl has devided to density/ha?*
sc_lakeview_ha	1557.906	1563.023	1465.570	1567.724	6.300	-0.300	
sc_ln_pop_ha	4.487	0.725	4.256	0.921	5.422	-21.252	
sc_ln_sqm_per_unit	4.383	0.401	4.433	0.427	-1.120	-6.085	
sc_logit_foreigners_within_300m	4.814	0.977	59.797	57.928	-91.950	-98.314	*survey did not use logit!=>corrected*
sc_logit_slope	-3.277	0.721	-3.274	0.722	0.109	-0.053	
sc_sunhine_eve	-0.775	2.654	-0.643	2.741	20.488	-3.189	

Models – Real Estate Price Model (REPM)

Coeff_names	estimate	SE	t-values	
constant	2.909	0.083	35.253	
sc_acc_car_lu	0.108	0.008	13.127	*estimation of loechl uses traveltime to CBD*
sc_acc_pt_lu	0.022	0.002	12.830	
sc_building_built21to30_lu	0.127	0.018	7.268	
sc_building_built81to90_lu	0.007	0.007	1.062	
sc_building_built91tonow_lu	0.071	0.006	10.992	
sc_building_is_pre_1921_lu	0.079	0.009	9.163	
sc_dist_to_station_lu	-1.4791e-05	3.84118e-0	-3.851	
sc_highway_within_100m_lu	-0.055	0.016	-3.535	
sc_is_house_lu	0.073	0.015	4.837	
sc_jobs_G52_H_within_1km_lu	6.28633e-05	2.37052e-0	26.519	
sc_lakeview_ha_lu	4.18646e-05	2.37792e-0	17.606	
sc_ln_pop_ha_lu	-0.059	0.004	-16.082	
sc_ln_sqm_per_unit_lu	0.788	0.006	123.613	
sc_logit_foreigners_within_300m	**0.007**	**0.003**	**2.144**	*changed to use density instead of logit*
sc_logit_slope_lu	0.039	0.003	11.423	
sc_sunhine_eve_lu	0.007	0.001	8.528	

Number of observations: 6496
R-Squared: 0.783
Adjusted R-Squared: 0.782
Suggested |t-value| > 2.96

Current Models - Employment



Models – Employment Location Choice Model (ELCM), EPFL

Structure (Model created by EPFL)

Dependancies: ERM, ETM (5%growth scenario)

Locations: building with non_residential_sqft

Capacity: zurich_parcel.building.vacant_SSS_job_space

Agents: job; assumptions on job space per job-type

Estimation: *estimation inside UrbanSim based on baseyear data*

Submodels: *categories for jobs as used in relocation rates*

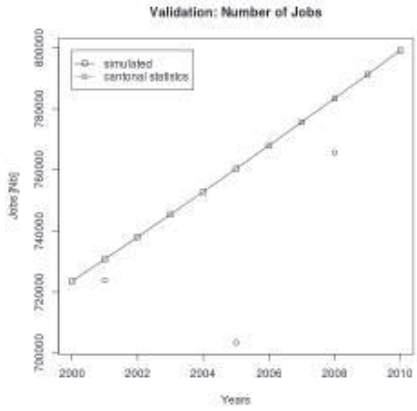
Specificationi: mainly clustering of jobs;

Running the simulation:

Unplaced employment (2005: 5241; 2010: 10749)

2001: Relocating: 26541 Total movers: 33494

2005: Relocating: 26853 Total movers: 38291



Possible imporvements

Locate all employment

Acc. variables (scenario sensitivity)

Establishments / Bodenmann, 2011

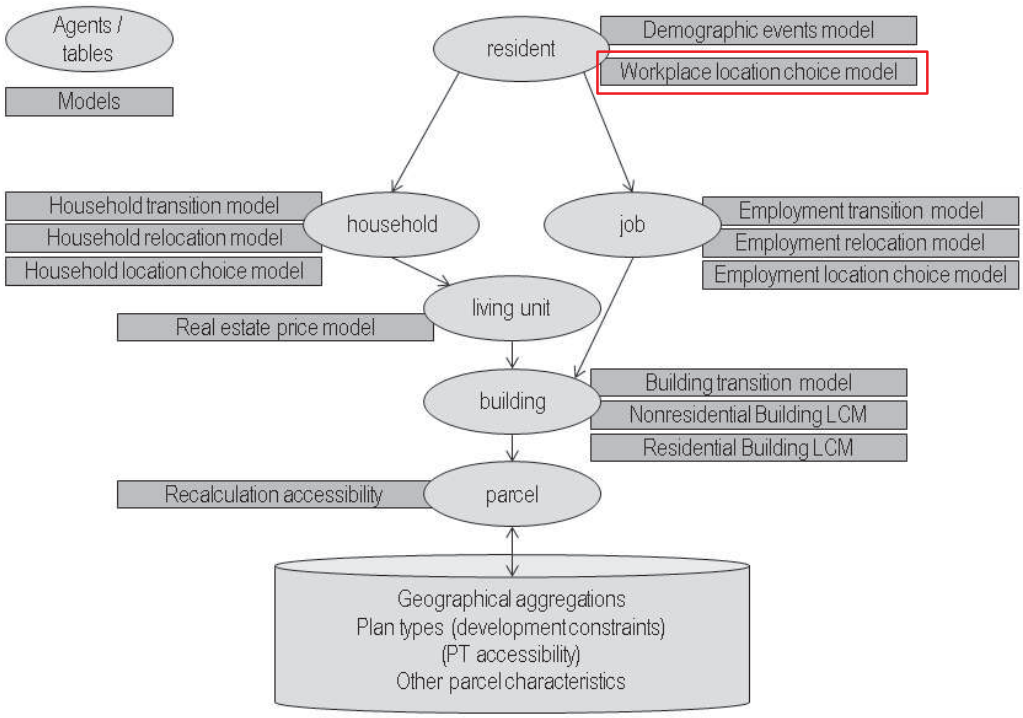
Models – Employment Location Choice Model (ELCM)

Retail trade

Coeff_names	estimate	std err	t-values
rh_zonal_income	0.4085	0.0160	25.5923
rh_zone_jobs_type3	0.0005	0.0000	22.1889
rh_zone_jobs_type7	0.0000	0.0000	-2.2857
rh_ln_surf_sect4	1.1649	0.0065	180.0960
rh_pop_dens_trade	-0.0001	0.0000	-3.9187
rh_zone_jobs_type6	0.0000	0.0000	-2.4269
rh_zone_jobs_type8	-0.0005	0.0000	-15.4587
rh_ln_surf	-1.5381	0.0080	-193.4450
sc_dist_to_station	-0.0003	0.0000	-27.2545
rh_zone_jobs_type5	0.0006	0.0000	14.6232
rh_zone_jobs_same	0.0015	0.0000	72.1614
rh_zone_jobs_type1	0.0000	0.0000	-1.4784
rh_zone_jobs_type2	-0.0001	0.0000	-1.7182
sc_dist_to_highway	0.0000	0.0000	3.1606

Log-likelihood is:	-43828.6833119
Null Log-likelihood is:	-212282.016366
Adj. likelihood ratio index:	0.793469630342
Number of observations:	54264
Suggested |t-value| >	3.30175957674

Current Models – Workplace Location Choice Model



Models – Workplace Location Choice Model (WLCM)

Structure

Dependancies: *ELCM, HLCM (implicit)*

Locations: job

Agents: person

Estimation: *estimation inside UrbanSim using Baseyear (=population census)*

Configuration: *includes only distance to residence; Random Choice Set*

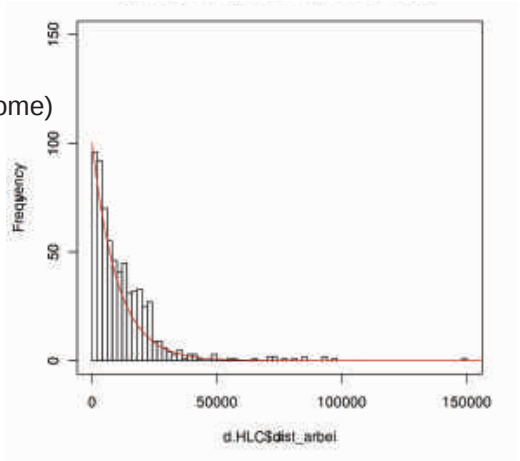
Insufficiencies

Choiceset formation unclear/unobserved

Timeline observation missing (e.g. gain/losses vs previous income)

Khivasara et al. 2012 (in work)

- Education
- Gender
- Working Hours
- Hierarchy

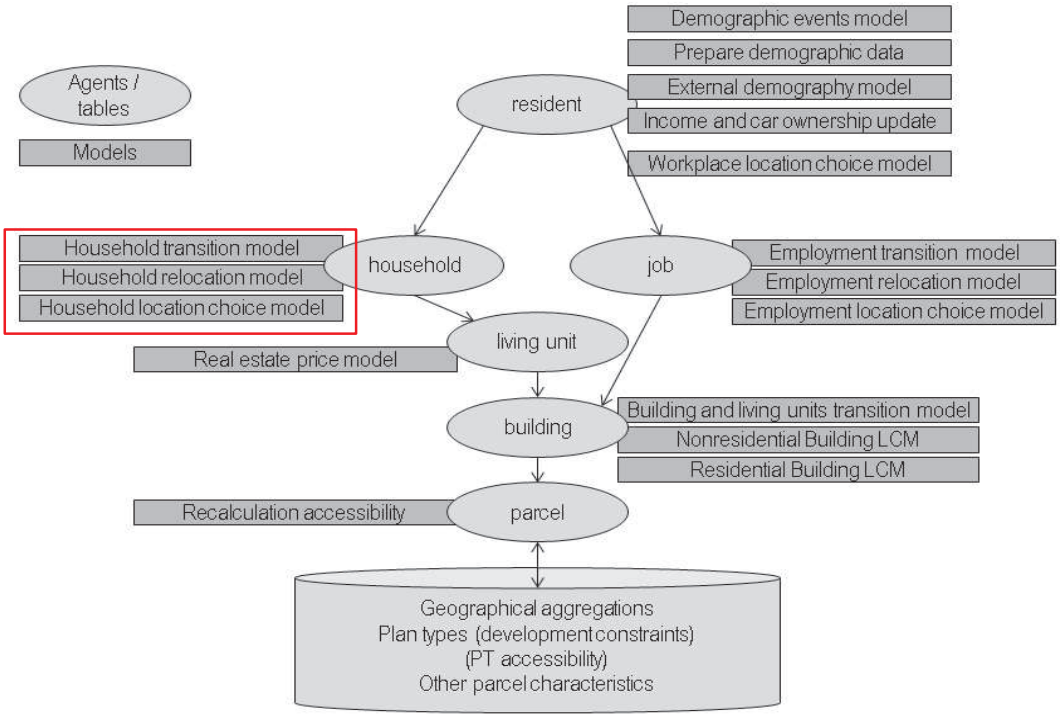


Models – Workplace Location Choice Model (WLCM)

Coeff_names	estimate	SE	t-values
sc_dist_pers_to_job_interaction_exp_0106	4.95736	0.060274	82.2474

Number of observations:	5292
Number of alternatives:	30
Likelihood ratio index:	0.171
Adj. likelihood ratio index:	0.171
Suggested |t-value| >	2.928

Current Models – Households

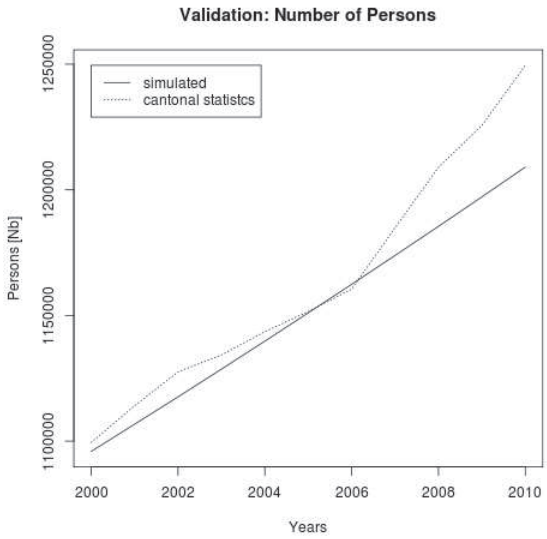


Models – Household Transition (HTM) and Relocation (HRM)

Household control totals:

Alternatives:

- *external demography*
- *(observed data)*



Annual relocation rates of households:

Survey and census data: S.Beige (2005)

Grouped into 12 categories based on age of head and income

=>age of head and income is postprocess of Demography!!

Runtime: 0.8 sec/ sim year

Models – Household Location Choice Model HLCM

Motivation

IATBR 2012; CUPUM 2013 (in work) Schirmer et al.:

=> Impact of residential units and environment (socioeconomic, points of interest, built environment)

Structure

Dependancies: Demography, HRM

Model: Discrete Choice (Multi Nomial Logit)

Locations: living units

Capacitiy: one to one match

Agents: household

Estimation: external estimation on survey; internal estimation on baseyear; comparison of choice set

Configuration: *Variables on price, location, residential unit in interaction with hh-attributes*

Running the simulation

2001: 60894 movers HH in chunks: 60894 Total: 1109794 HH

2005: 60859 movers HH in chunks: 60859 Total: 1156020 HH

Number of calculations loops: 2 chunks + 2 loops for unplaced → 0 unplaced

Total time for run: 40min

Models – Household Location Choice Model (HLCM)

MEASUREMENTS		dat2	avrg. Impact dat2'	Values of observed choices mean*	median*	s.d.*
Household						
HH_DIST_PREVLOC	-	-7.070 **			*(interaction)*	
HH_DIST_WORK	-	-3.220 *			*(interaction)*	
HH_ETA_PREVLOC	+	0.163 **			*(interaction)*	
HH_ETA_WORK	+	0.203 **			*(interaction)*	
(interaction distance to previous location)			*-37.827*	*29418.60*	*3626.60*	*385233.10*
(interaction distance to workplace)			*-28.191*	*43815.86*	*3251.59*	*542495.90*
Accessibility						
LA_MIVACC_CAR	-	-0.302 **	-2.769	9.17	9.13	0.62
LA_PTACC_NOCAR	+	0.541 **	5.706	10.55	10.86	2.21
Built environment						
LB_NETWORK_BUF	-	-0.304 *	-0.304	1	*(dummy)*	*(dummy)*
Points of Interests						
LP_CBD_ZH_DIST	+	0.000 **	0.805	12104.98	11425.50	7834.76
LP_HIGHWAY_ACCESS_DIST_x_CAR	-	0.000 *	-0.205	2231.03	1729.19	1621.07
LP_STATION_DIST_x_NOCAR	-	0.000	-0.213	927.36	744.95	720.88
LP_RETAIL_DENS	-	-0.003 **	-0.053	16.46	1.00	56.91
LP_SCHOOL_DIST	+	0.000 **	0.133	446.98	359.93	357.36
LP_SERVICE_DENS	-	-0.001 **	-0.039	61.10	5.00	206.60
Socioeconomic Environment						
LS_SAME_HH_AGE_SHARE	+	0.684 **	0.262	0.38	0.40	0.13
Residential Unit						
RU_LOG_BUILDING_AGE	+	0.360 **	1.090	3.03	3.47	1.43
RU_NEW_BUILDING	+	0.578 **	0.578	1	*(dummy)*	*(dummy)*
RU_RENT_INCOME_RATIO	-	-3.400 **	-18.153	5.34	4.89	3.15
RU_ROOMS_PERSON	-	-0.677 **	-1.280	1.89	1.66	0.83
RU_SQM_ROOM	+	0.000 **	0.000	28.32	27.00	9.13

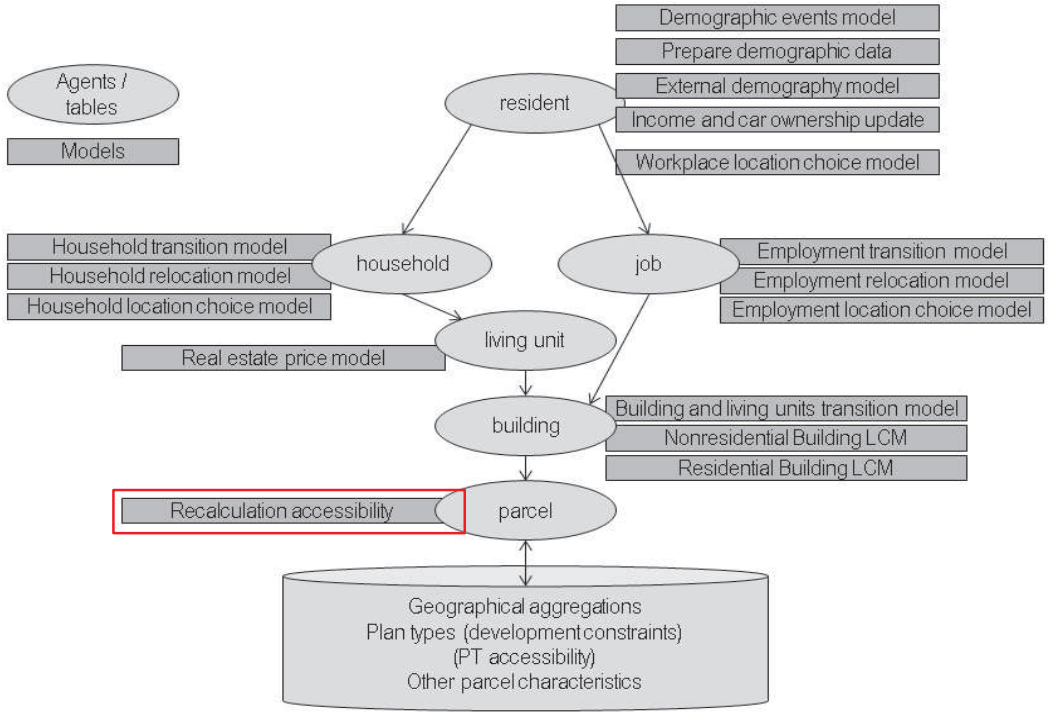
log_init	-2679.736
log_final	-1261.079
R^2	0.529
adj R^2	0.522

Schirmer, van Eggermond and Axhausen (forthcoming)

Choice sets- Household Location Choice Model (HLCM)

	UrbanSim		Survey		Diff (%)		
name UrbanSim	mean	stdev	mean	stdev	mean	stddev	
sc_acc_car_lu_x_car	9.892	0.494	9.073	0.606	9.028	-18.450	
sc_acc_pt_lu_x_no_car	11.973	0.789	11.155	1.086	7.334	-27.341	
sc_building_age_less_10_lu	0.104	0.305	0.235	0.424	-55.957	-28.150	recent movers=new buildings
sc_building_age_log_lu	3.458	0.942	3.027	1.432	14.248	-34.248	
sc_dist_to_highwayaccess_lu_x_car	2147.807	1499.415	2333.565	1696.847	-7.960	-11.635	
sc_dist_to_school_lu	420.500	289.423	446.984	357.359	-5.925	-19.011	
sc_dist_to_station_lu_x_no_car	800.856	463.512	723.718	450.855	10.659	2.807	
sc_dist_to_zh_cbd_lu	10299.550	7368.730	12104.985	7834.758	-14.915	-5.948	
sc_highway_within_100m_lu	0.018	0.138	0.077	0.266	-76.383	-48.154	recent buildings close to highway
sc_jobs_retail_density_300m_lu	83.816	190.463	16.459	56.913	409.242	234.656	recent buildings low densities as peripherical areas?
sc_jobs_service_density_300m_lu	255.842	628.819	61.097	206.596	318.748	204.372	recent buildings low densities as peripherical areas?
sc_rent_price_to_income_lu	0.003	0.027	0.244	0.177	-98.924	-84.622	rent price (comparis) is to low!!!
sc_rooms_per_person_lu	1.930	1.118	1.894	0.833	1.903	34.243	
sc_share_of_hh_age_0_40_within_300m_lu	0.376	0.086	0.371	0.111	1.297	-22.494	
sc_share_of_hh_age_40_65_within_300m_lu	0.366	0.078	0.463	0.097	-20.906	-19.625	
sc_share_of_hh_age_65_99_within_300m_lu	0.214	0.068	0.200	0.086	7.069	-20.845	
sc_sqm_per_room_lu	26.475	8.192	28.323	9.132	-6.524	-10.290	

Current Models – MATSim



Current Models - MATSim

Config:

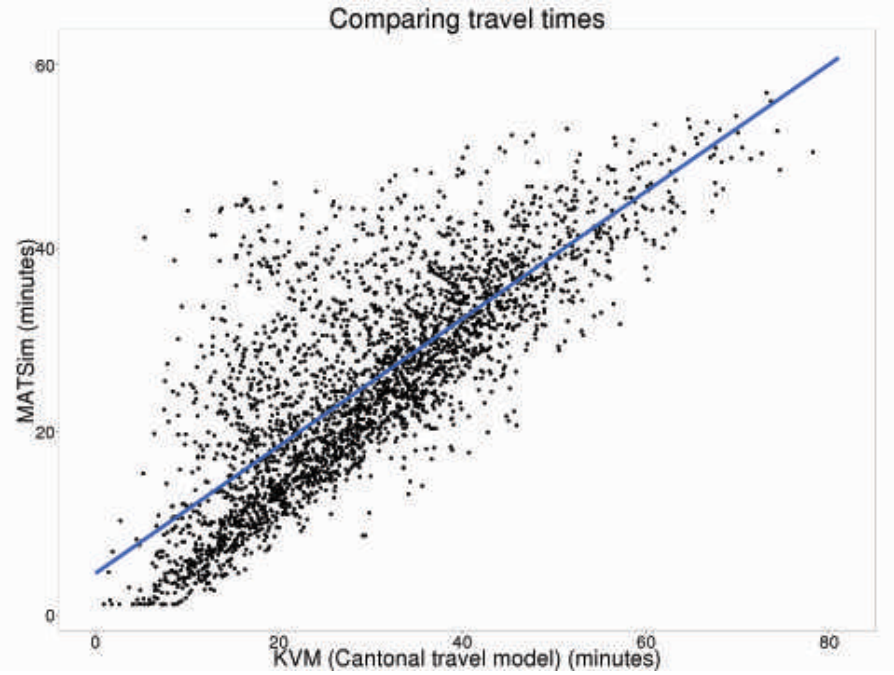
- Population sampling rate = 10 %
- Accessibility parameters:
  - accessibility_destination_sampling_rate = 1
  - Raw sum, logarithmized
  - Accessibility scale parameter: -0.2 [1/min?]
  - Beta travel time car = -12/hr = -0.2/min
  - Beta travel time walk = -12/hr = -0.2/min
  - Cell size: 100 m
- years to run: 2005, 2010, 2015, 2020
- last_iteration: 100

Custom model coordinator: <scenario><advanced><skip_non_travel_models_first_year>

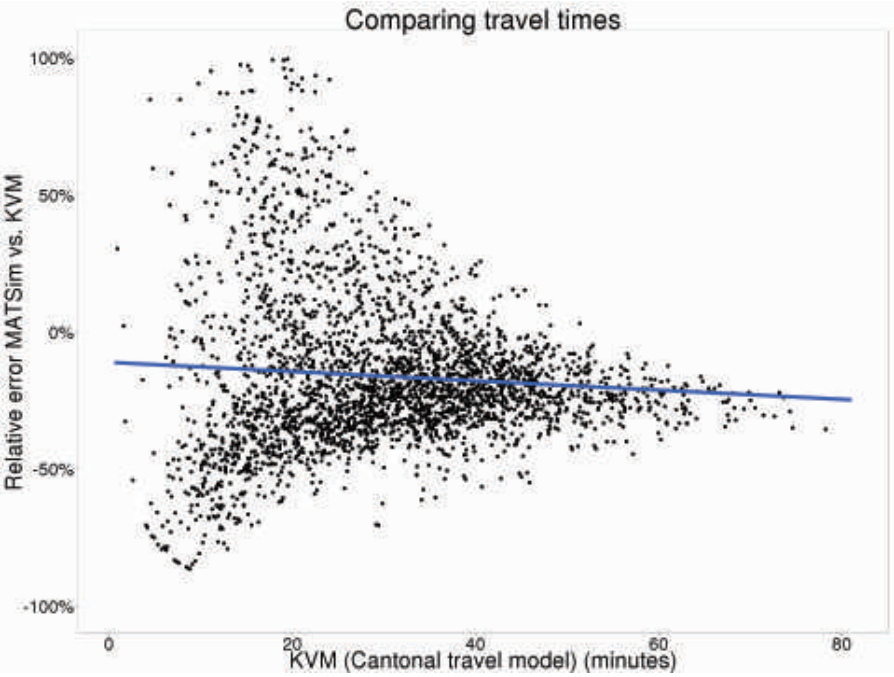
In simulation only in 2005 (warmstart failed?)

Runtime: ~1h

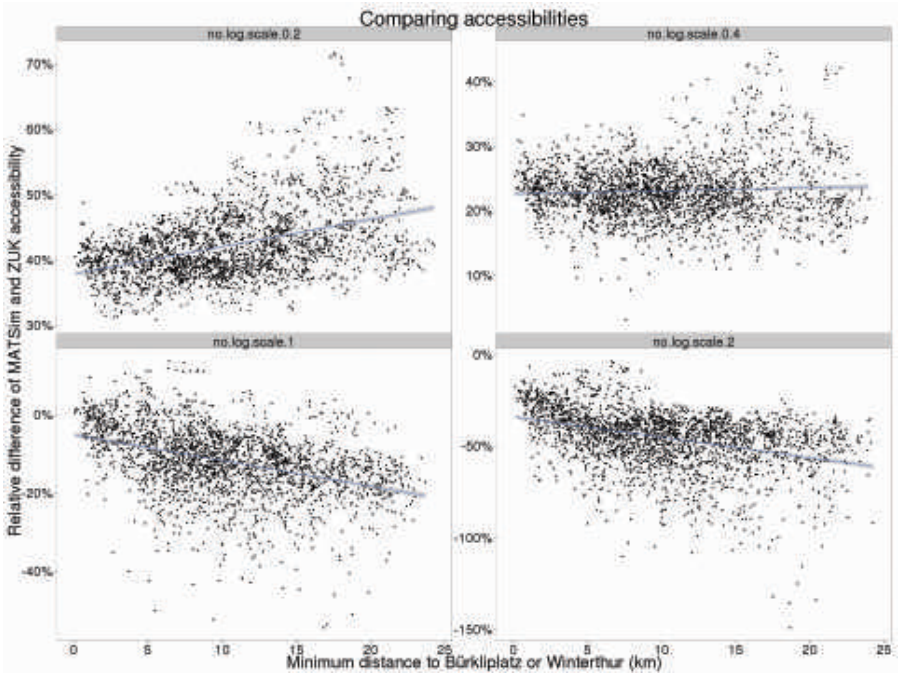
Current Models - MATSim



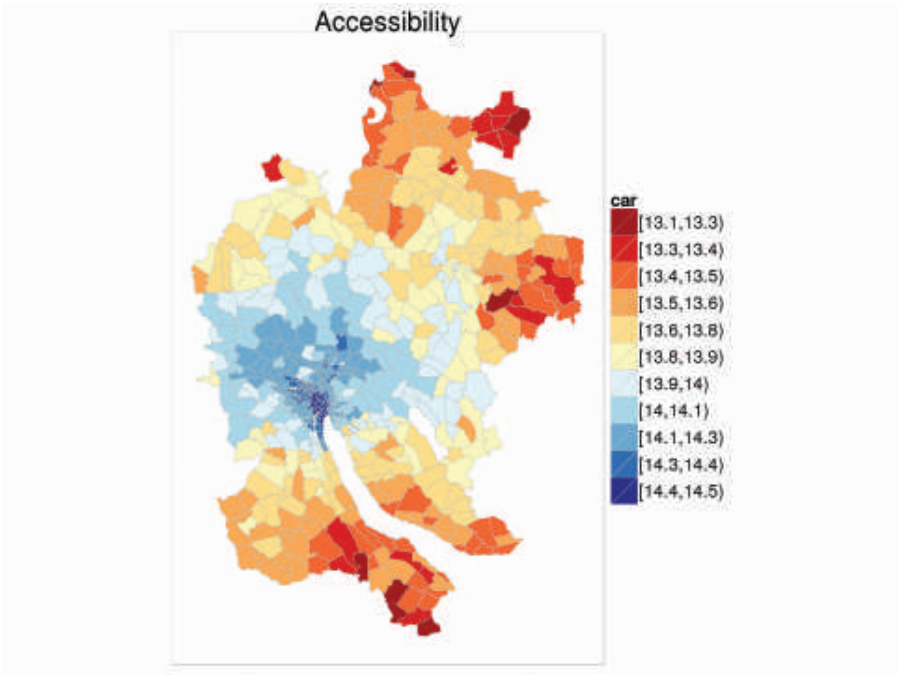
Current Models - MATSim



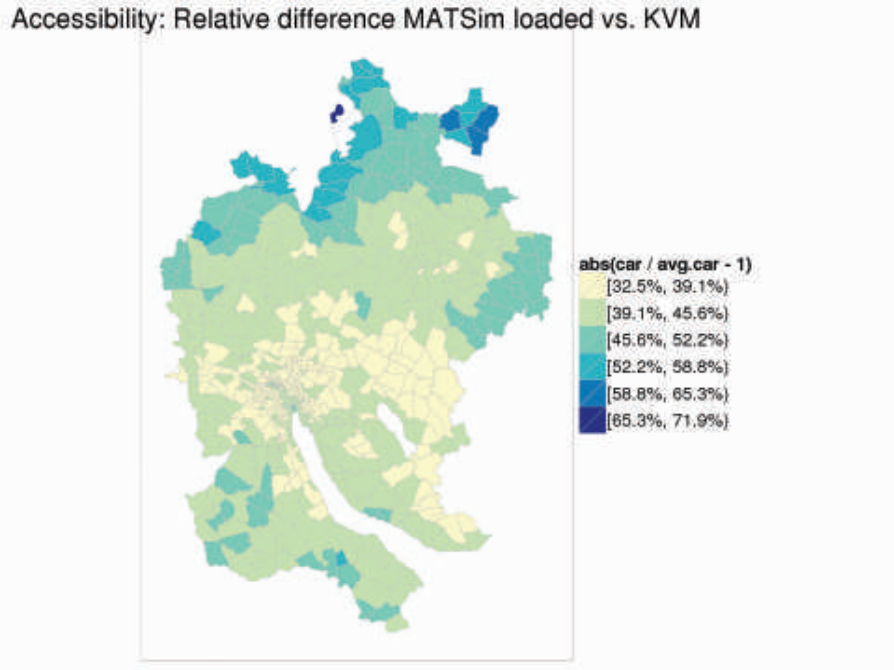
Current Models - MATSim



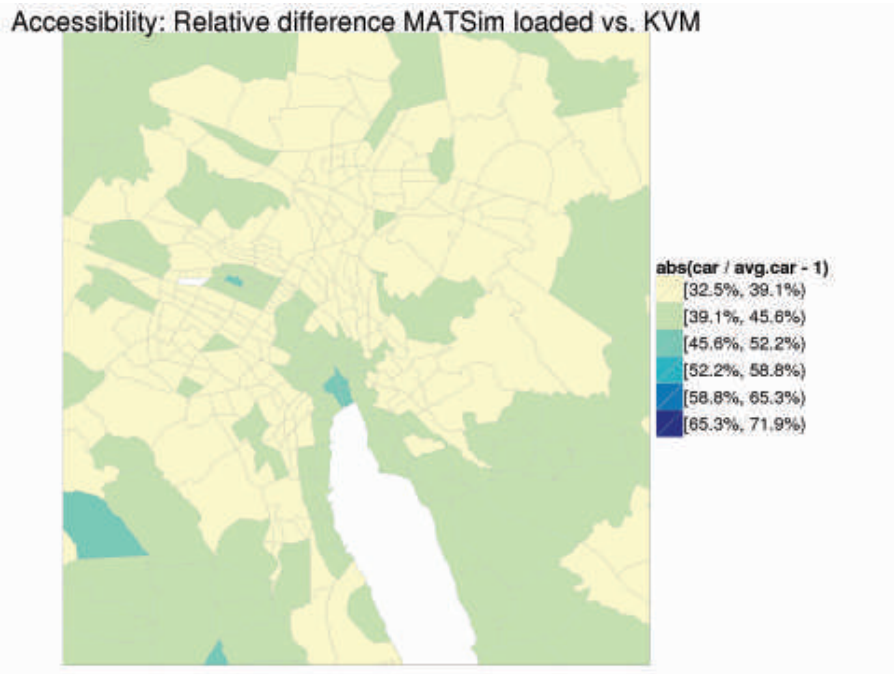
Current Models - MATSim



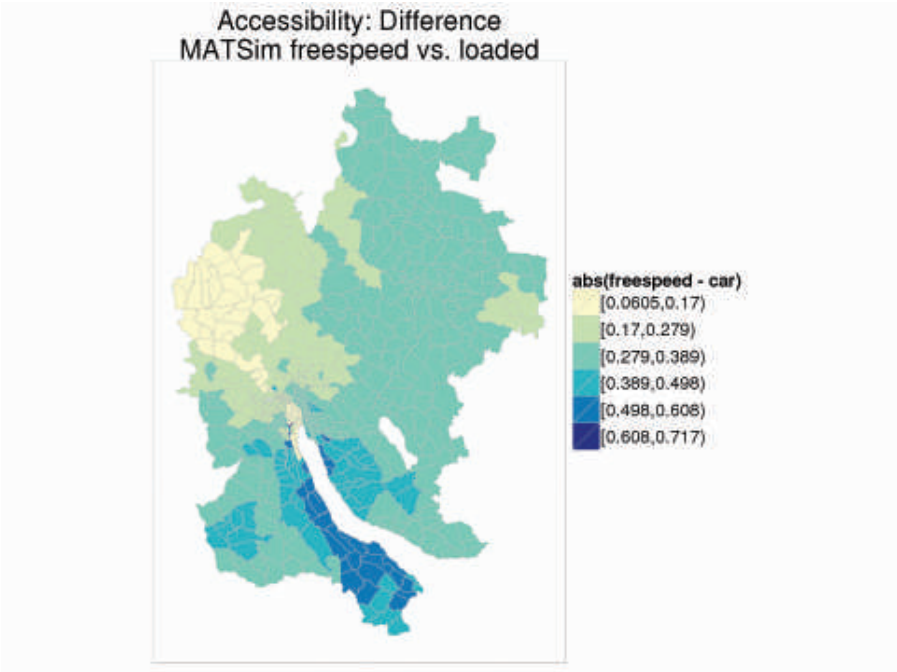
Current Models - MATSim



Current Models - MATSim



Current Models - MATSim



Overview

Context
Achievements
Results current run
Current Models
Remaining Challenges

Source backgroundimage: GoogleEarth

Remaining Challenges

Scenario definition

Define road pricing scenario in MATSim (not affecting public transport travel time)

Densification plan for UrbanSim

Generate planning network with new major road

Demographics

MATSim with demography

Bugfixing / Calibration

To what extent?

Indicators

Indicator module available?

Improve models

Sensitivity towards scenarios

Extension of data model: Points of Interest

Remaining Challenges – Improving models

ELCM

Insert accessibility attribute

Land development models

Use parcel model with calculating return on investment

Introduce developer agents and ownership structure

HRM (Relocation based on change in HH size)

HLCM

Replace dist_to with more specific acc. Variables

REPM

Non-residential rents

Scenario: Road pricing

Theme

Road pricing in cities Zurich and Winterthur

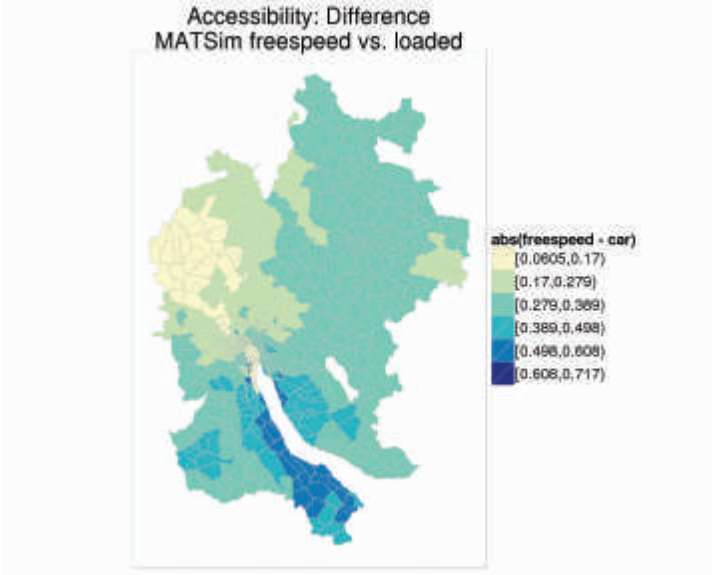
Traffic light regulation

Implementation

MATSim config (configCalibration5.xml)

Model choice

Public transport solution of SUPat?



Scenario: Densification

Theme

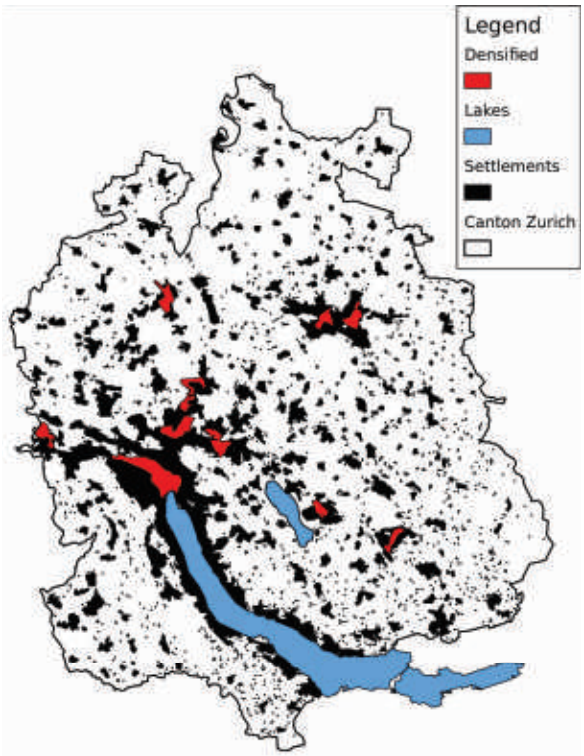
Cantonal directive plan (11 densification areas)

Densification of centers

Implementation

Increase far of parcels in densification zones
using PgSQL script

Import into run/<desired year>/parcels



Scenario: Densification

Theme

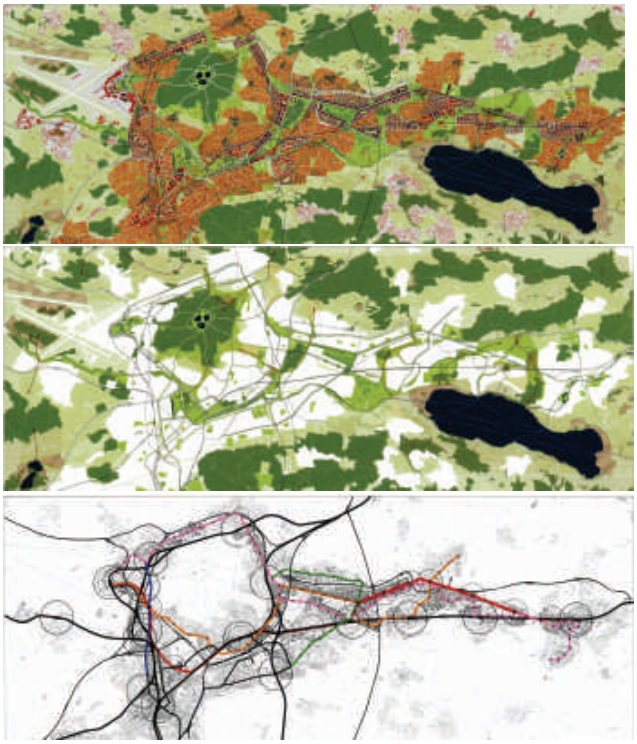
Airport Dübendorf

Planning “Krokodil”

Implementation

Increase far of parcels in densification zones
using PgSQL script

Import into run/<desired year>/parcels



Project “Krokodil”;
Source: archithese 03.2011

Scenario: New Infrastructure

Theme

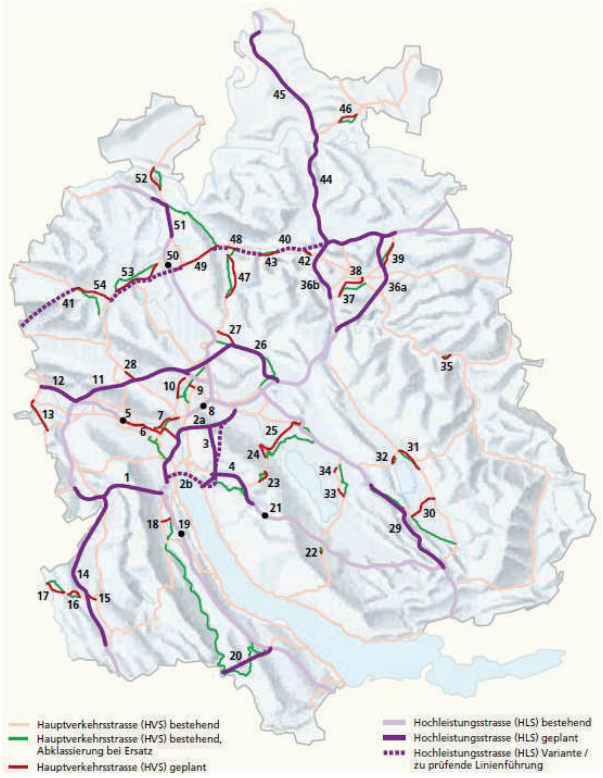
New infrastructures from cantonal directive plan

Implementation

Convert VISUM network to MATSim network

Use scenario network file for MATSim

How time consuming is technical implementation?



Source: Canton Zurich (2007), Cantonal Directive Plan

Validation - Scenario assessment

Define MATSim indicators?
Use indicator module

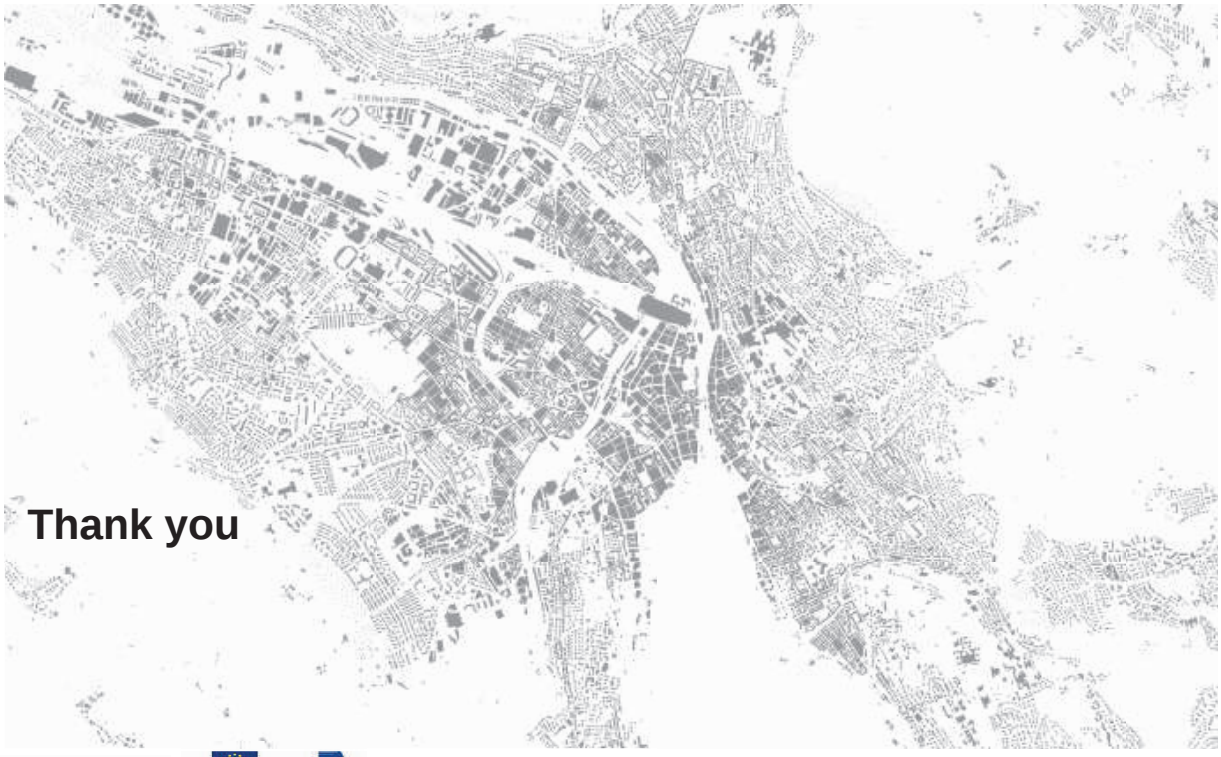
Qualitative interpretation only?

Open Questions

Strategy for scenario comparison? Focus on road pricing?
Best practice for calibration? What is a calibrated run? 5% relative error of what indicators?
How do you assess the UrbanSim results? With indicator batches? Something else?
What indicators are calculated by matsim4urbansim?

Paris team

- Id shift in demography model initialisation → How do you maintain consistency?
- How do you update kept attributes of households?



Thank you

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*

Data preparation – processing framework

Data processing

Spatial Joins

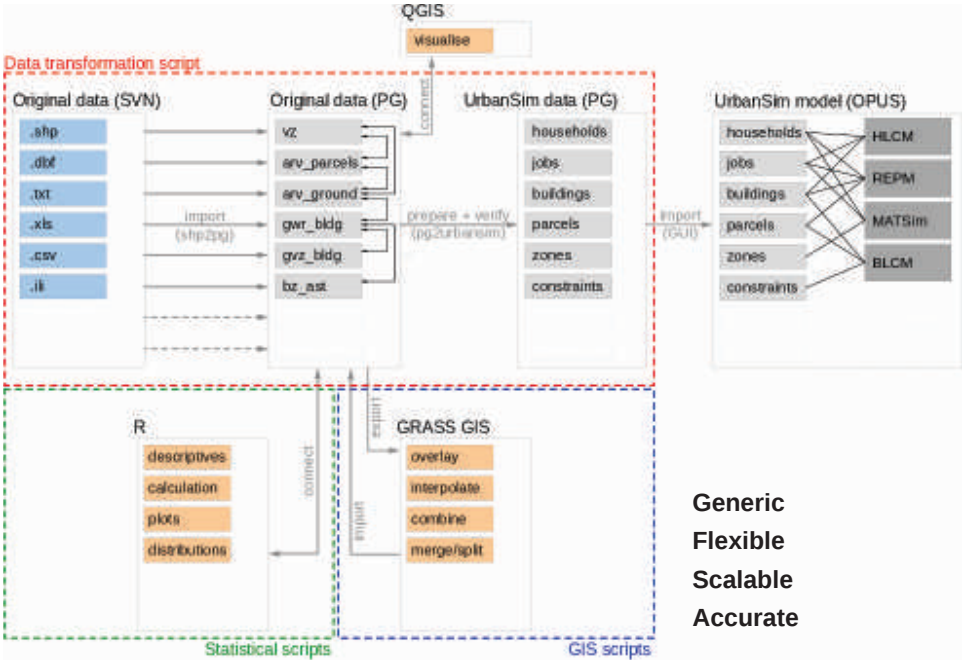
Attribute Joins

Imputations

Populations Synthesis

Approximations

Classification



Generic

Flexible

Scalable

Accurate