Multi-scale spatial models: linking macro and micro

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Integrated land-use transport models

Today's integrated land-use transport models suffer from several ***weaknesses***:

- Their classification of households and individuals is too crude; ***individual lifestyles*** cannot be represented.
- Their transport models are not ***activity-based*** and cannot address "soft" transport policies.
- Their spatial resolution is too ***coarse*** to take account of small-scale local policies.
- Forecasting ***environmental impacts*** such as air pollution, land take and traffic noise is difficult, modelling ***environmental feedback*** is impossible.
- Issues of spatial ***equity*** cannot adequately be addressed.

Microsimulation

New activity-based ***microsimulation models*** improve urban simulation models:

- ***Individual lifestyles*** can be represented, households and individuals are disaggregated to the agent level.
- ***Environmental impacts*** can be modelled with the required spatial resolution.
- ***Environmental feedback*** between environment and land use and transport can be modelled.
- ***Microlocations*** can be represented. Households affected by environmental impacts can be localised.

However ...

To date, no full-scale microsimulation model of urban land use, transport and environment has become operational.

There are still unresolved problems regarding the ***interfaces*** between the submodels.

The ***feedback*** between transport and location and environmental quality and location has not yet been implemented.

Serious problems of ***calibration***, ***stability*** and ***stochastic variation*** have not been solved.

The ***computing time*** for existing models is calculated in terms of ***weeks*** or ***days,*** not ***hours***.

How much micro is enough?

Despite these problems, microsimulation modellers engage in ever more ambitious plans to further raise the complexity and spatial resolution of their models.

The common belief among most microsimulation modellers seems to be: the more micro the better.

This is the dream of the ***one-to-one Spitfire***.

The Spitfire

The one-to-one model of the Spitfire

The one-to-one Spitfire

"Simplifying assumptions are not an excrescence on model-building; they are its essence. Lewis Carroll once remarked that a map on the scale of one-to-one would serve no purpose. And the philosopher of science Russell Hanson noted that if you progressed from a five-inch balsa wood model of a Spitfire air plane to a 15-inch model without moving parts, to a half-scale model, to a full-size entirely accurate one, you would end up not with a model of a Spitfire but with a Spitfire".

Robert M. Solow (1973)

How much micro is enough?

There seems to be little consideration of the benefits and costs of microsimulation:

- Where is microsimulation really needed?

- What is the price for microsimulation?

- Would a more aggregate model do?

For spatial planning models, the answer to these questions depends on the planning task at hand.

For instance, for modelling the impacts of transport on land use, much simpler travel models are sufficient.

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Macro or micro?

These considerations lead to a reassessment of the hypothesis that eventually all spatial modelling will be microscopic and agent-based.

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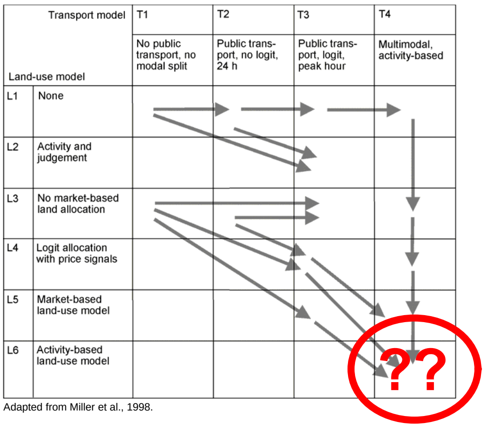
Macro or micro?



Adapted from Miller et al., 1998.

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Conclusions (1)

Only integrated ***microsimulation*** land-use transport models models permit the modelling of

- **"soft"** and **local** planning policies
- individual ***lifestyles***
- environmental ***impacts*** and ***feedback***
- ***microlocations*** and spatial ***equity.***

However, there is a price for the microscopic view in terms of ***data requirements*** and long ***computing times***.

There are ***privacy*** concerns and ***ethical*** issues involved.

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Conclusions (2)

Under constraints of ***data collection*** and of ***computing time***, there is for each planning problem an optimum level of ***conceptual***, ***spatial*** and ***temporal*** resolution.

This suggests to work towards a ***theory*** of balanced ***multi-scale models*** which are as ***complex*** as necessary for the planning task at hand and as ***simple*** as possible but no simpler.

Future urban models will be ***modular*** and ***multi-scale*** in ***scope***, ***space*** and ***time***.

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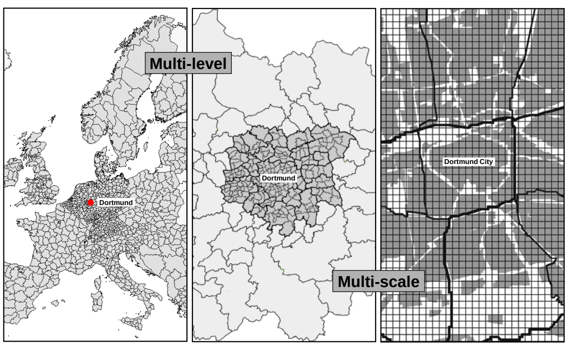
Multi-Scale Modelling
The Dortmund Example

Model levels



Regions *Zones* *Raster cells*

15

Level 1: Regions

Model levels

Regions · *Zones* · *Raster cells*

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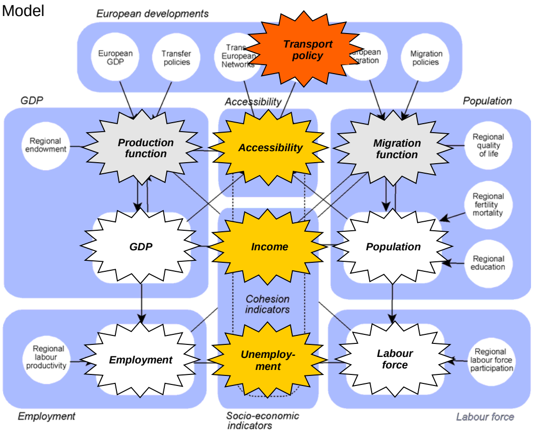
SASI Model



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The STEPs Project (2004-2006)

The EU 6th RTD Framework project ***STEP****s* (*Scenarios for the Transport System and Energy Supply and their Potential Effects*) ***developed*** and ***assessed*** possible ***scenarios*** for the ***transport system*** and ***energy supply*** of the future.

In the project ***five urban/regional models*** were applied to forecast the long-term economic, social and environmental impacts of different ***scenarios*** of ***fuel price increases*** and different combinations of ***infrastructure***, ***technology*** and ***demand regulation*** policies.

Here the model results for the urban region of ***Dortmund, Germany***, will be presented.

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The STEPs Project: Scenarios

The project developed a set of scenarios assuming different rates of energy price increases with three sets of policies:

	Fuel price increase		
	+1% p.a.	**+4% p.a.**	**+7% p.a.**
Do-nothing	**A-1**	**B-1**	**C-1**
Business as usual	**A0**	**B0**	**C0**
Infrastructure & technology	**A1**	**B1**	**C1**
Demand regulation	**A2**	**B2**	**C2**
All policies	**A3**	**B3**	**C3**

A-1 *Reference Scenario*

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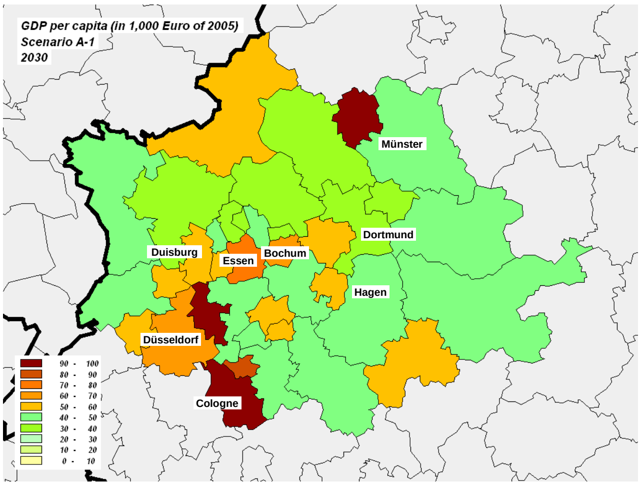
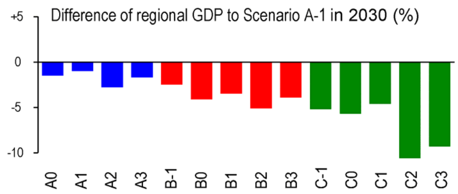


Economic impacts for the Dortmund region

According to the SASI model, the fuel price increases and related policies of the scenarios have significant ***negative*** impacts on the ***economy*** of the Dortmund urban region:



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Level 2: Zones

Model levels

Regions · *Zones* · *Raster cells*

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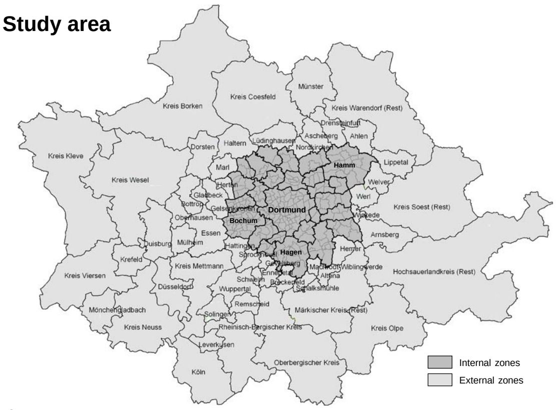
Study area



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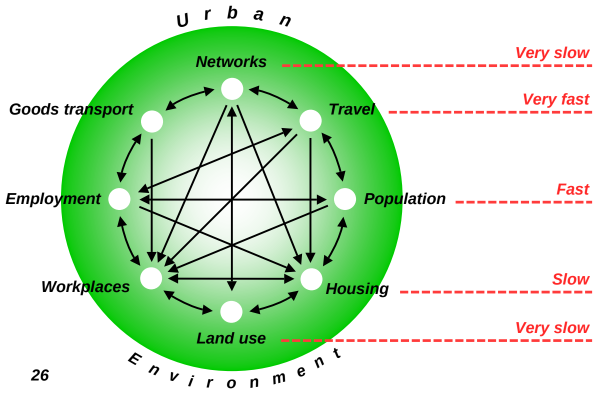
Urban systems



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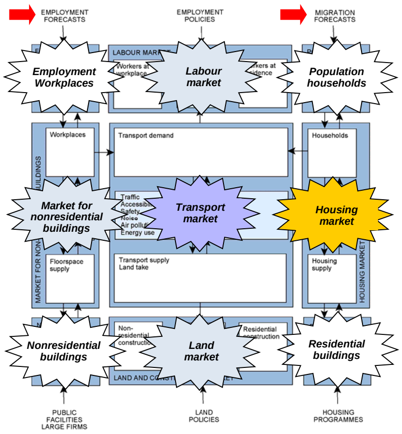
Dortmund model



from SASI model

Microsimulation

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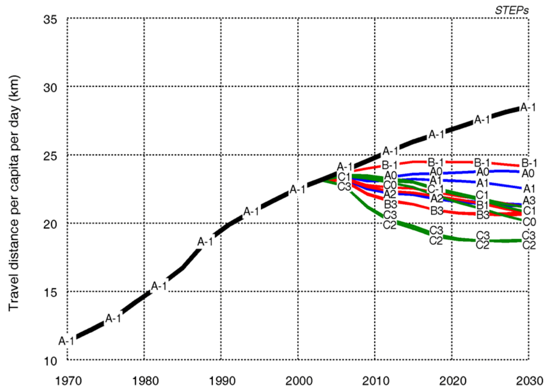
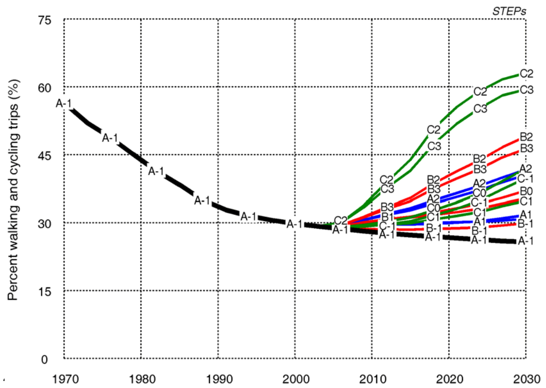
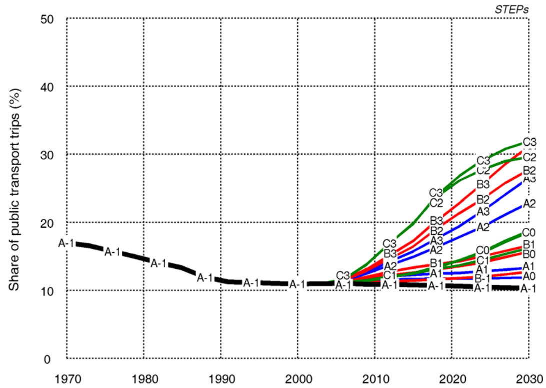
Travel distance per capita per day (km)



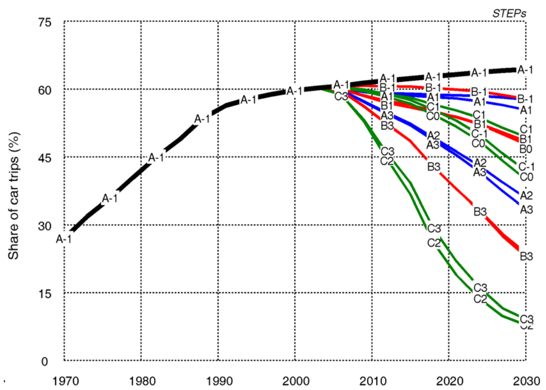
Share of walking and cycling trips (%)



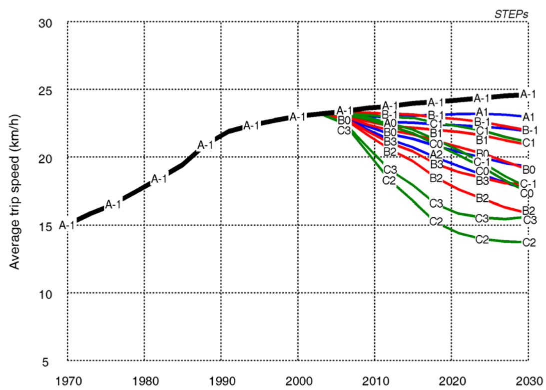
Share of public transport trips (%)



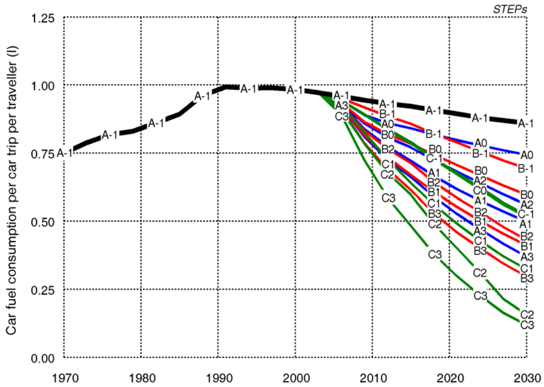
Share of car trips (%)



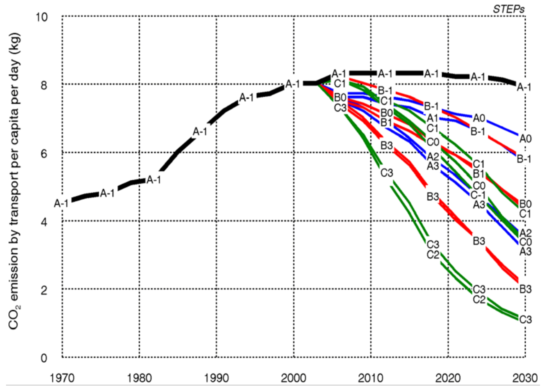
Average trip speed (km/h)



Car fuel consumption per car trip per traveller (l)

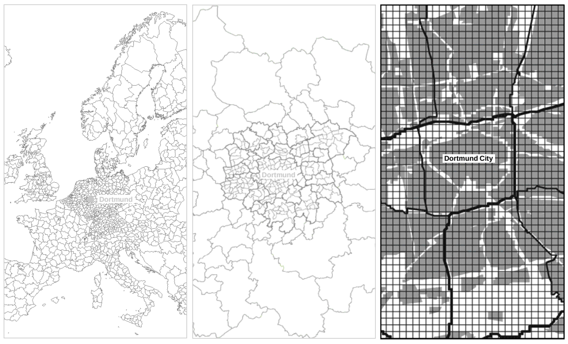


CO_2 emission by transport per capita per day (kg)



Level 3: Raster Cells

Model levels



Regions Zones ***Raster cells***

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The ILUMASS Project (2001-2006)

The project ILUMASS (Integrated Land-Use Modelling and Transport Systems Simulation) embedded a microscopic dynamic simulation model of urban traffic flows into a comprehensive model system incorporating both changes of land use and the resulting changes in transport demand as well as their environmental impacts.

For ***testing*** the ***land use submodels***, the transport and environmental submodels were replaced by the ***aggregate transport model*** of the IRPUD model and simpler envir-onmental impact models ***(= reduced ILUMASS model)***.

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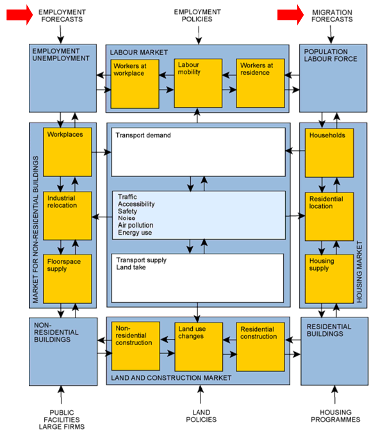
Reduced ILUMASS model



from SASI model

Microsimulation

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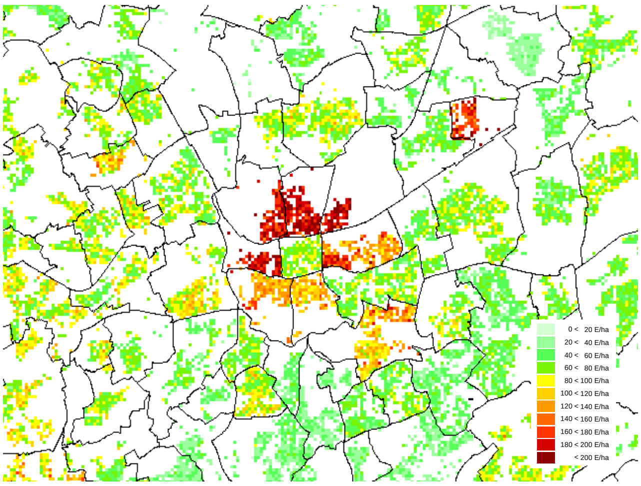
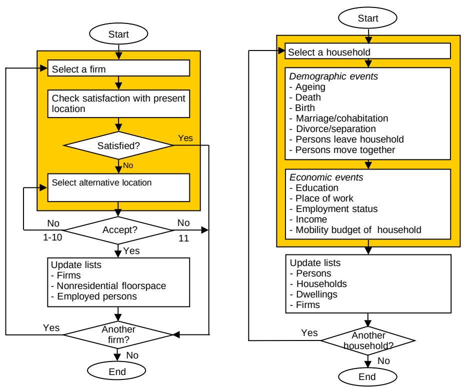


Firms and households



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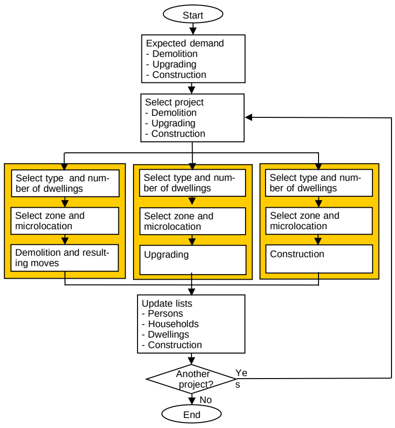
Dwellings



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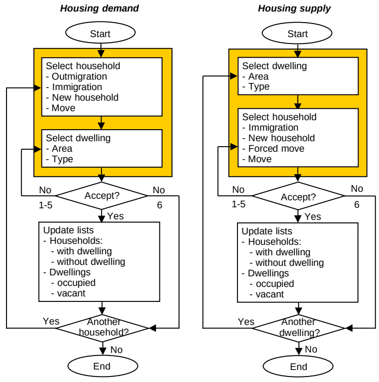
Moves



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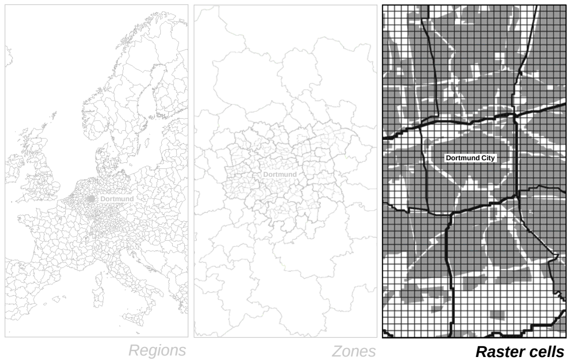
Environmental Impacts and Feedback

Model levels



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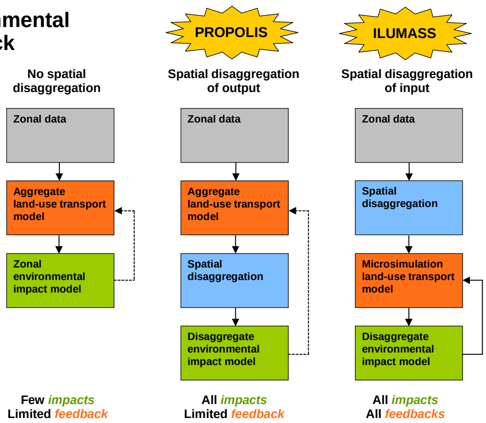
Environmental feedback



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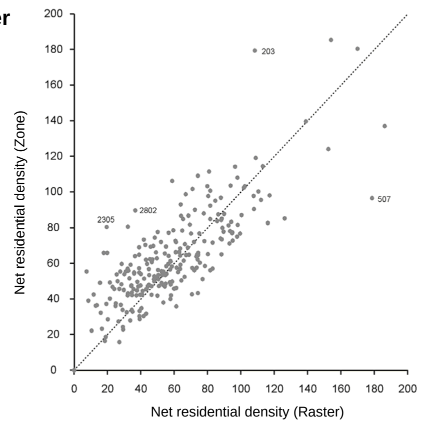
Zone v. Raster
Density



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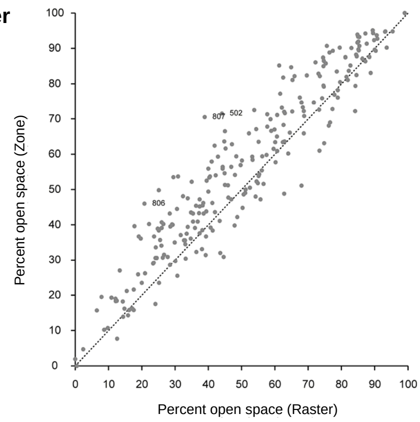
Zone v. Raster
Open space



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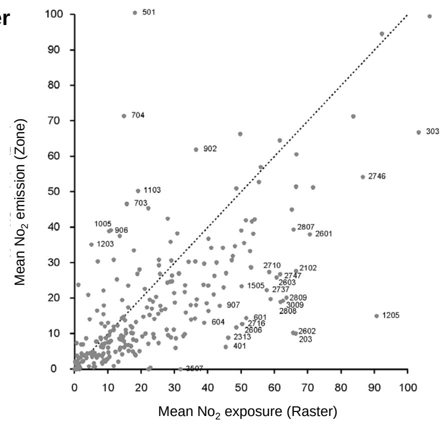
Zone v. Raster
Air pollution



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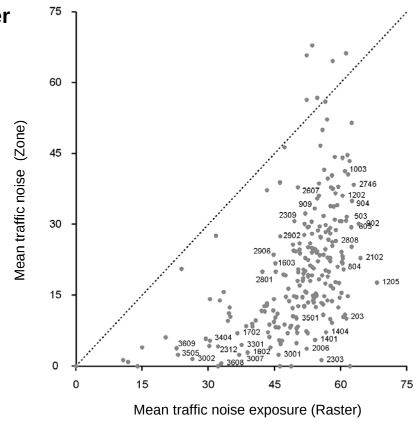
Zone v. Raster
Traffic noise



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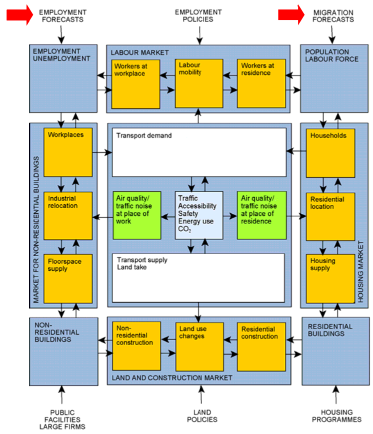
Reduced ILUMASS model



from SASI model
Microsimulation
Environmental impacts

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Typical Model Run

Model dimensions

1.2 million	households
2.6 million	persons
1.2 million	dwellings
80,000	firms
92,000	industrial sites
8,400	public transport links
848	public transport lines
13,000	road links
246/54	internal/external zones
209,000	raster cells
30	simulation periods (years)
90	minutes computing time

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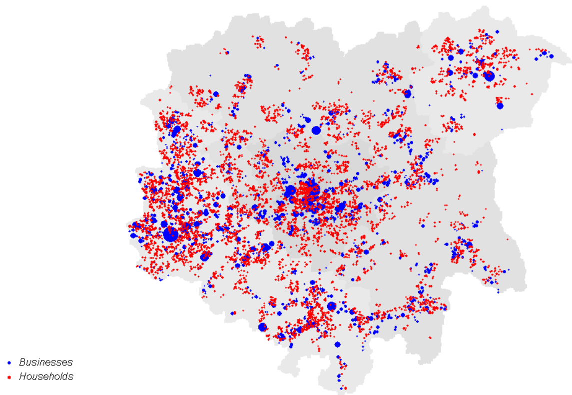
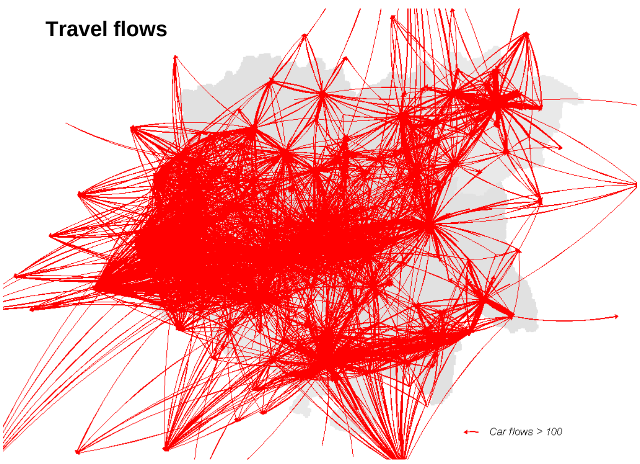
Model parameters

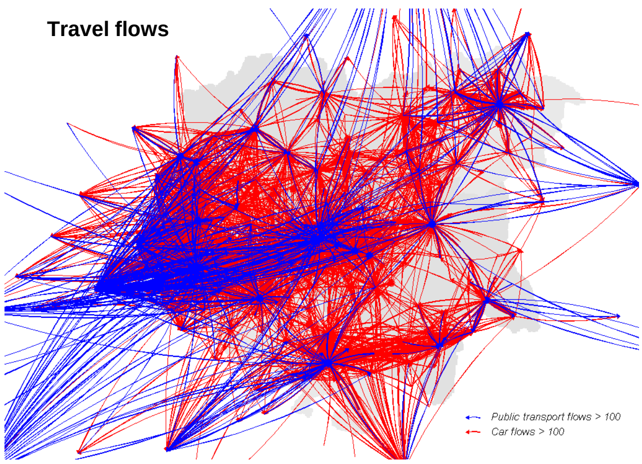
Micro data



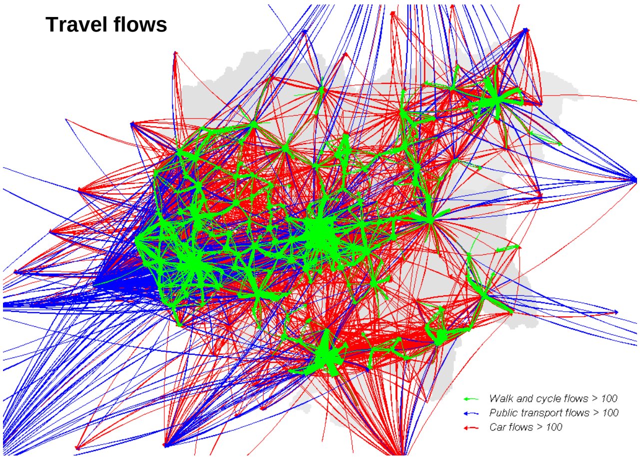
Travel flows



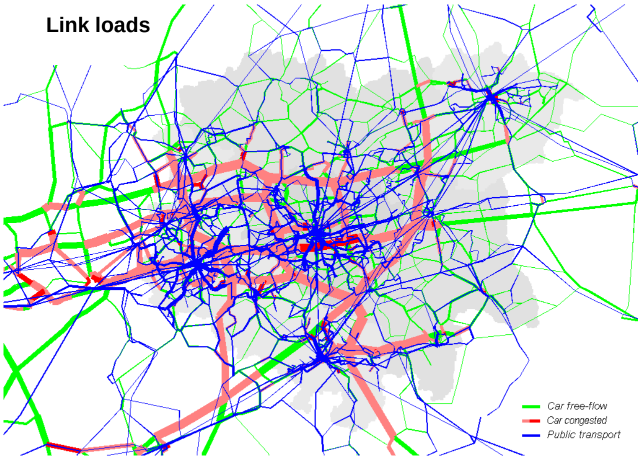
Travel flows



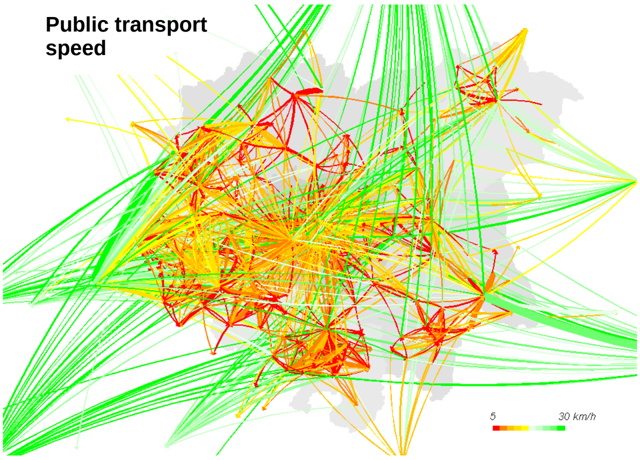
Travel flows



Link loads



Public transport speed

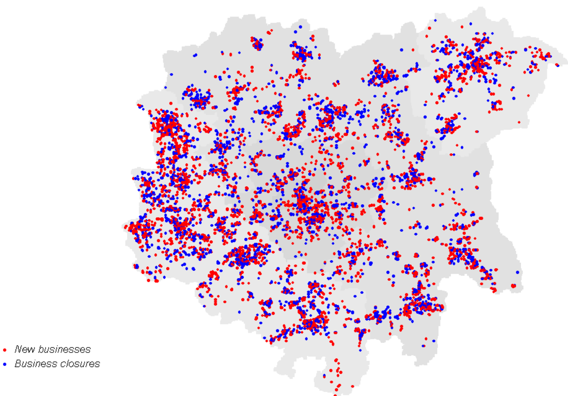


Public transport speed

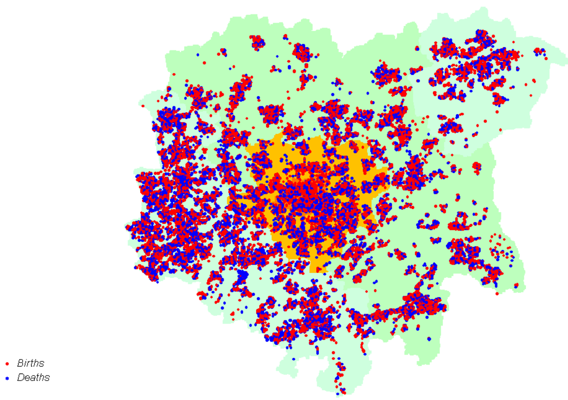
Air quality
NO_2

Traffic noise
dB(A)

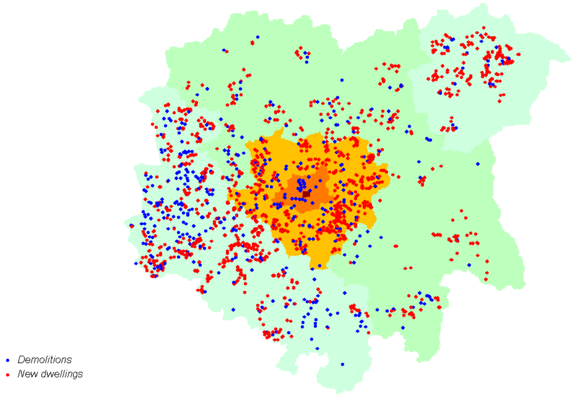
Firms



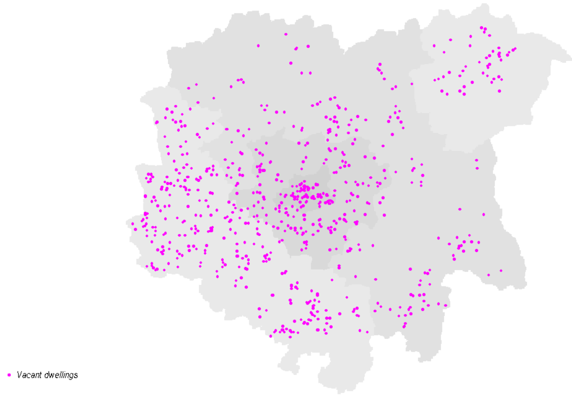
Households



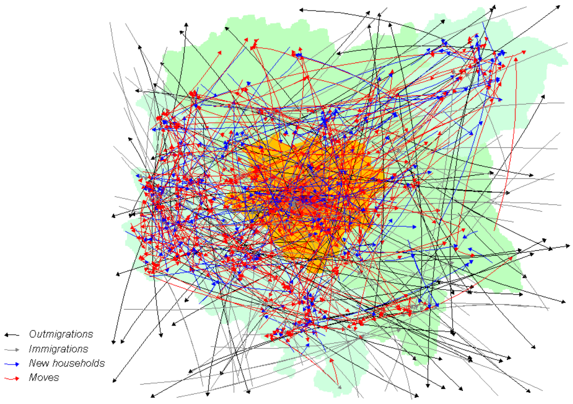
Dwellings



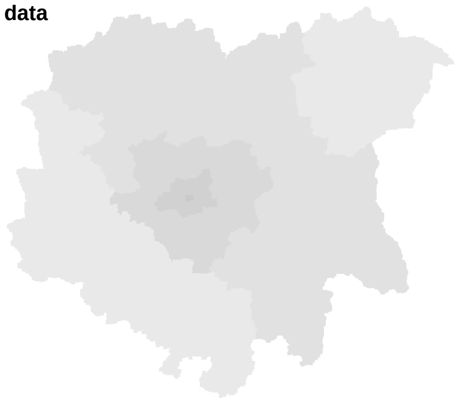
Vacant dwellings



Moves

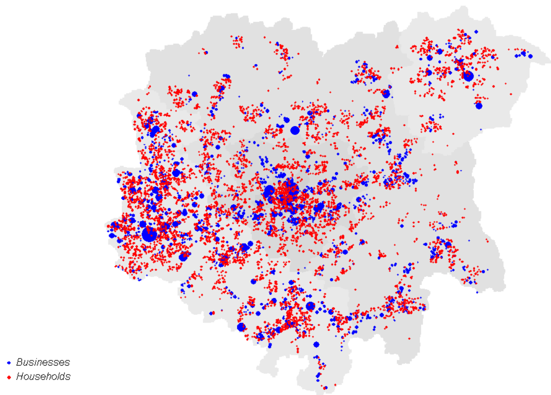


Compression of micro data

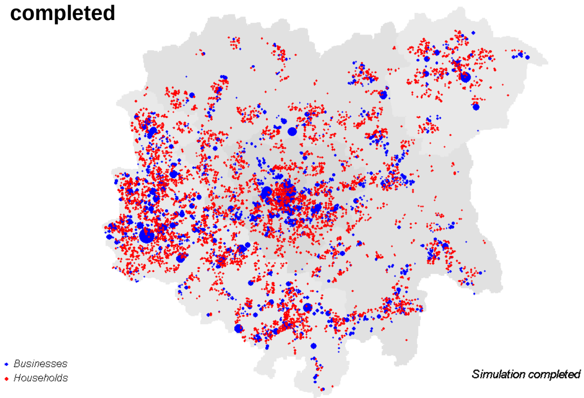


Aggregation to zones

Micro data



Simulation completed



More information

Moeckel, R., Schwarze, B., Spiekermann, K., Wegener, M. (2007): Simulating interactions between land use, transport and environment. *Proceedings of the 11th World Conference on Transport Research*. Berkeley, CA: University of California at Berkeley.

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Wegener, M. (1998): The IRPUD Model: Overview. http://www.raumplanung.uni-dortmund.de/irpud/pro/mod/mod_e.htm.

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