Integration of the MATSim transport model into the DAFNI platform

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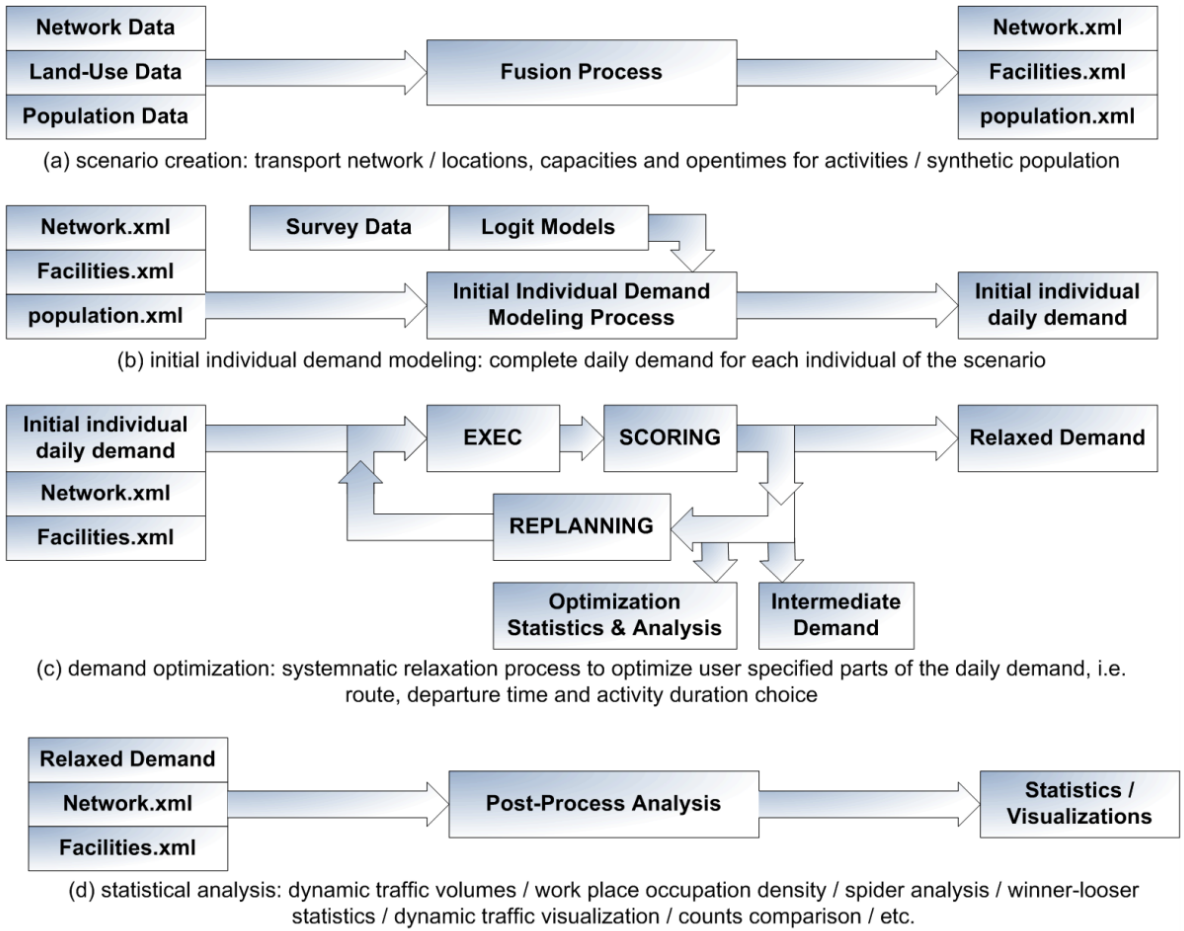
Urban transportation models

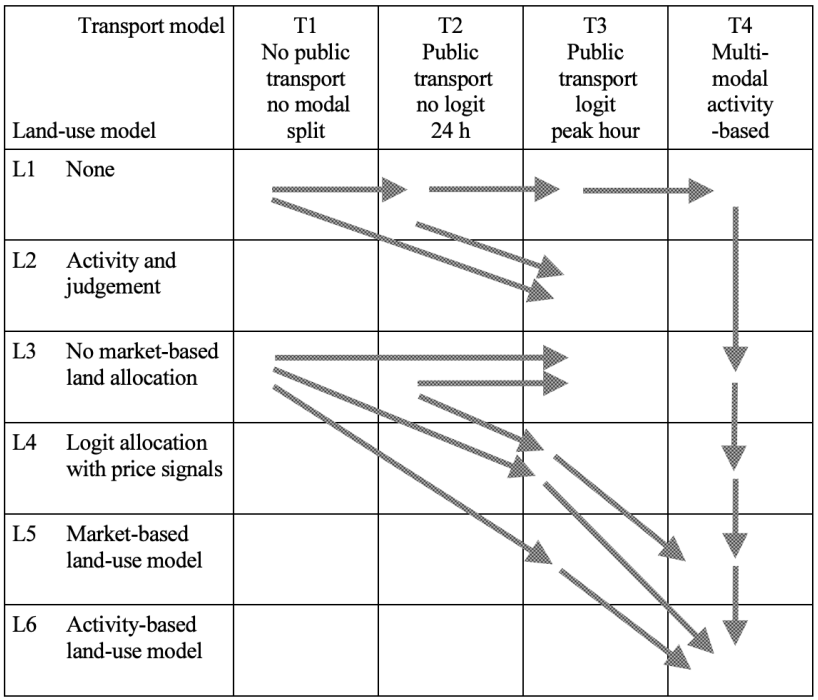
MATSim model: heterogenous data and integration of many sub-models



Source: [Balmer et al., 2009]

Land-use transport models

Land-use transport models as a progressive complexification through coupling of detailed sub-models



Models	Speed of change							
	Very slow		Slow		Fast		Immediate	
	Networks	Land use	Work-places	Housing	Employ-ment	Popula-tion	Goods transport	Travel
BOYCE	+				+	+		+
CUFM		+	+	+	+	+		
DELTA/START	+	+	+	+	+	+	+	+
HUDS				+	+	+		
IMREL	+	+	+	+	+	+		+
IRPUD	+	+	+	+	+	+		+
ITLUP	+	+			+	+		+
KIM	+				+	+	+	+
LILT	+	+	+	+	+	+		+
MEPLAN	+	+	+	+	+	+	+	+
METROSIM	+	+	+	+	+	+		+
MUSSA	+	+			+	+		+
POLIS		+			+	+		+
RURBAN		+			+	+		+
STASA	+	+	+	+	+	+	+	+
TRANUS	+	+	+	+	+	+	+	+
URBANSIM		+	+	+	+	+		+

Source: [Wegener and Fürst, 2004]

Towards modular models using workflow systems

Build modular urban transportation models from the bottom-up using scientific workflow systems, open source sub-models and open data

→ Sub-models coupled into the workflow, can be easily replaced
→ Reproducibility and transparency
→ Easier transferability of model application
→ Application of model validation methods

Implementation: *integration of the MATSim transport model into the DAFNI platform*

Case study: integrated models

Case study: *Construct a modular four-step multimodal transportation model using open source projects and data*

Integrated models:

- MATSim model (MATSim Community) for the transportation system `https://www.matsim.org/` [Horni et al., 2016]
- SPENSER model (University of Leeds) for the synthetic population `https://github.com/nismod/microsimulation`
- QUANT model (CASA, University College London) for spatial interactions to generate home-work plans `http://quant.casa.ucl.ac.uk/` [Milton and Roumpani, 2019] (*specific scala implementation*)
- spatialdata library (OpenMOLE community) for data processing `https://github.com/openmole/spatialdata` [Raimbault et al., 2020]

Case study: data and implementation

Data:
Generic for any Functional Urban Area (GHSL [Florczyk et al., 2019]) in the UK: NOMIS census, OrdnanceSurvey roads, Transport National Dataset

Implementation
Currently integrated into the DAFNI platform:

- synthetic SPENSER population with uniform job locations
- QUANT model to generate home-work commuting flows
- network and plans prepared into MATSim xml files and fed into a one-mode MATSim (multimodal version still tested locally)
- models integrated as Docker containers

DAFNI workflow for coupled model

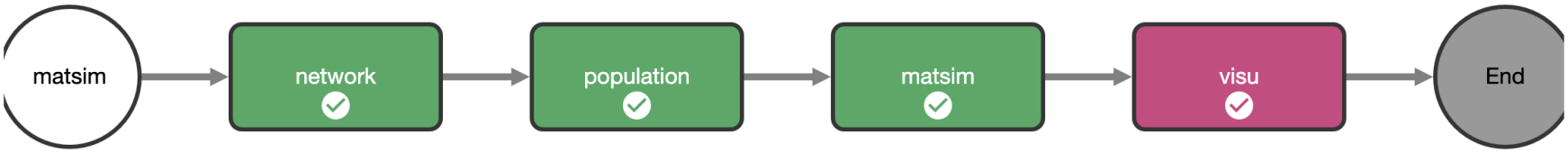
Home / Workflows / Workflow Status

Workflow Status

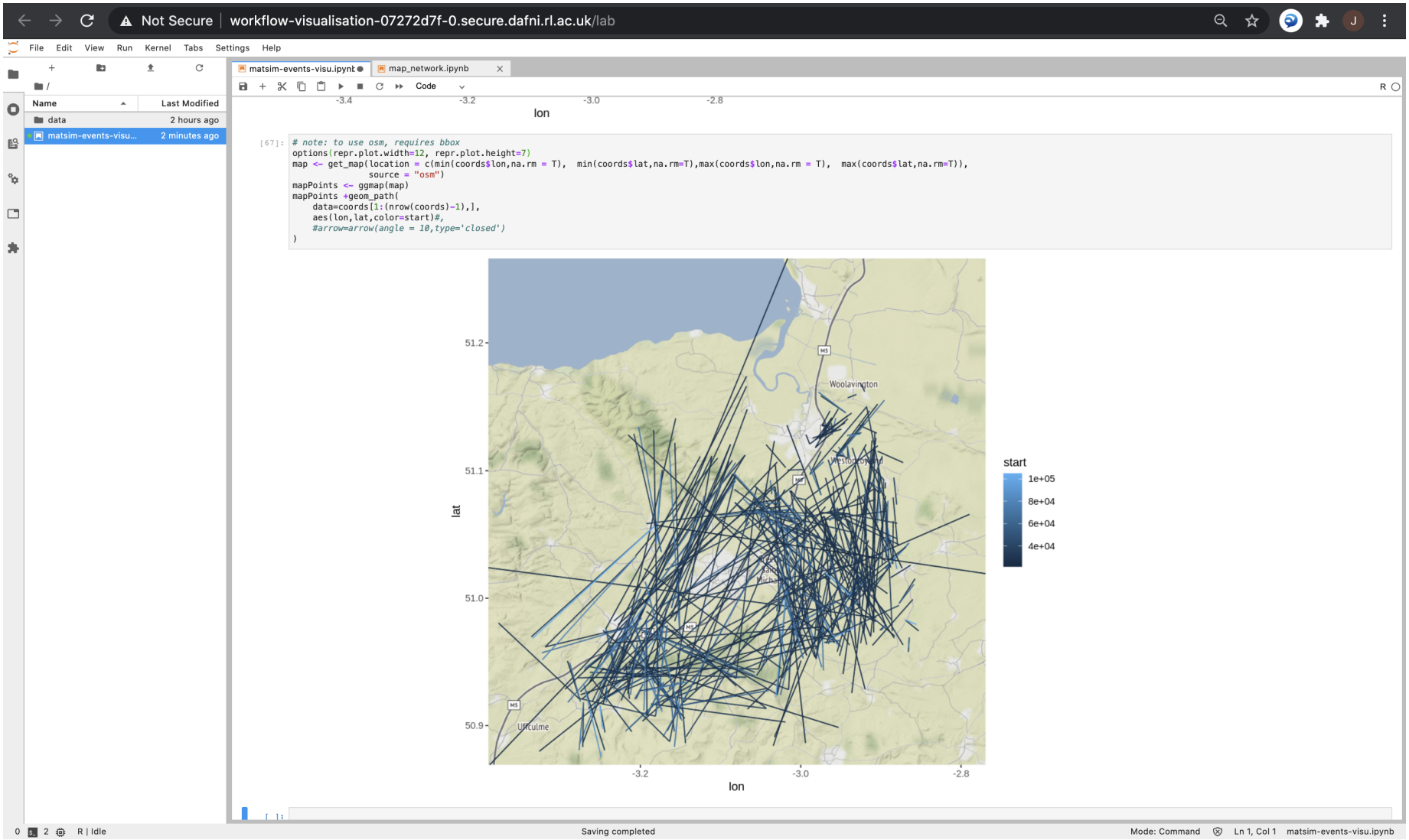
Key: Iterator | Template | Model | Publisher | Visualisation

Reset position

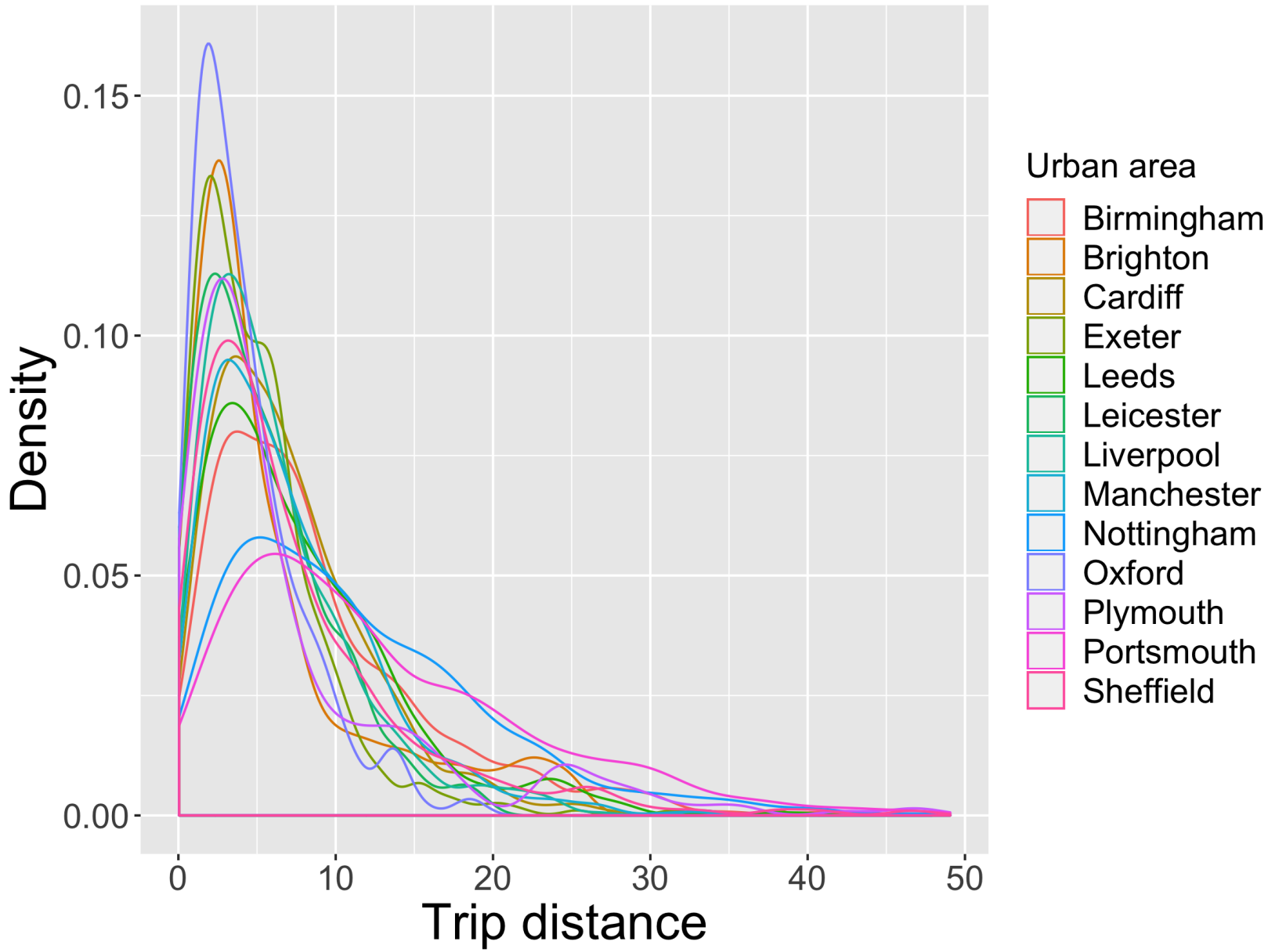
Click and drag on the white area around the Workflow to pan the canvas.



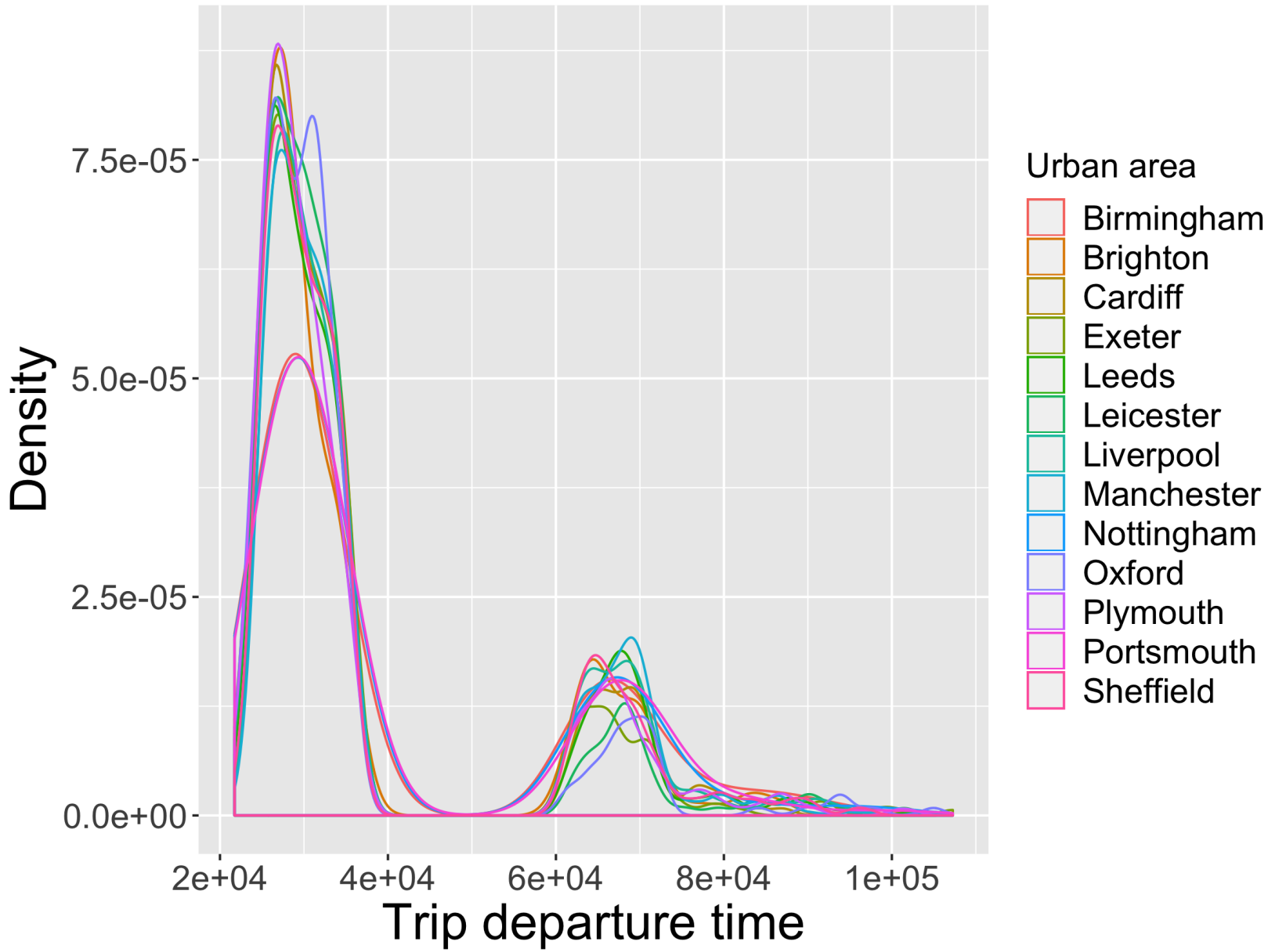
Visualization within DAFNI



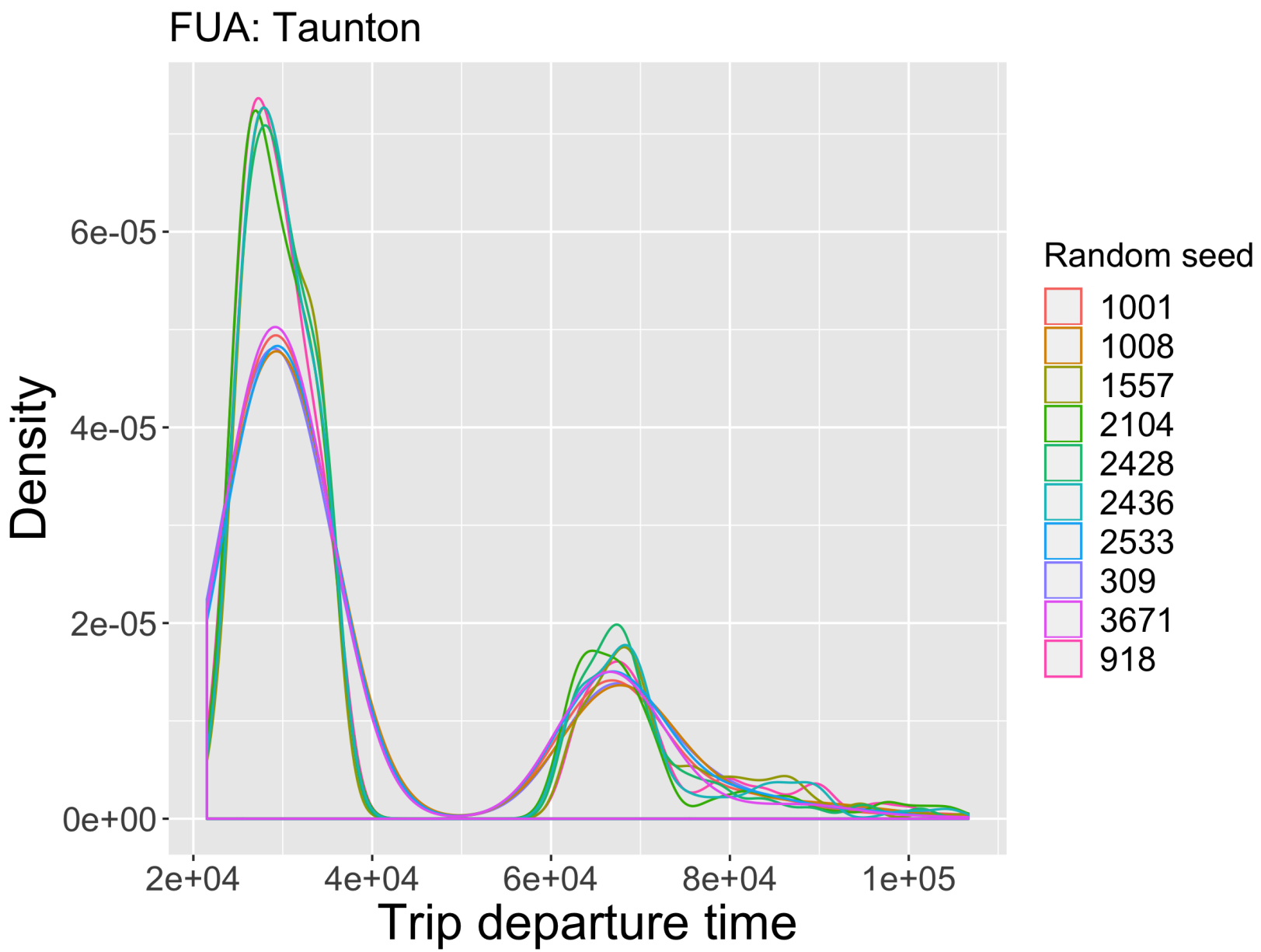
Simulation results: travel distances



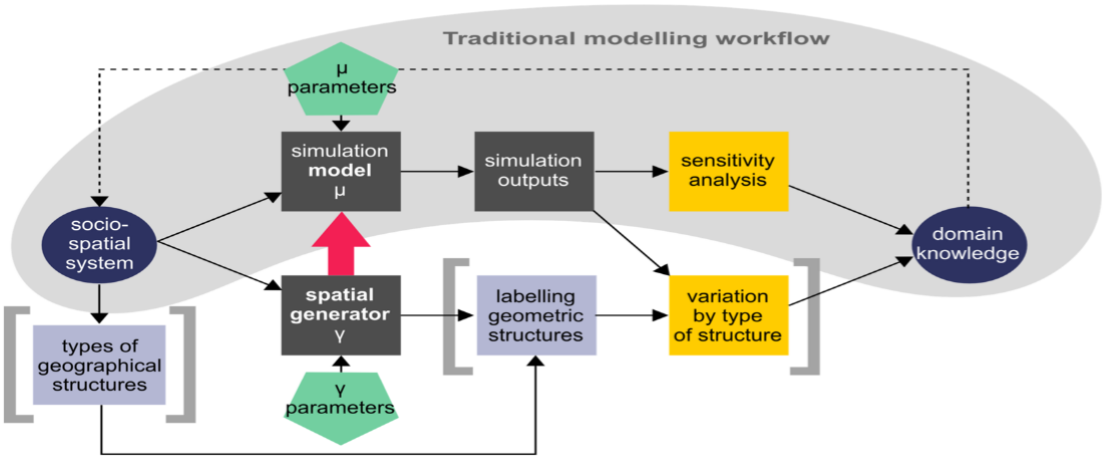
Daily travel patterns



Role of stochasticity

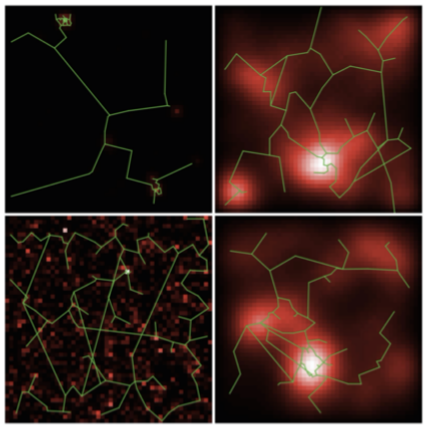


Validation: towards spatial sensitivity analysis



Raimbault, J., Cottineau, C., Le Texier, M., Le Nechet, F., Reuillon, R. (2019). Space Matters: Extending Sensitivity Analysis to Initial Spatial Conditions in Geosimulation Models. *Journal of Artificial Societies and Social Simulation*, *22*(4).

Raimbault, J., Perret, J., & Reuillon, R. (2020). A scala library for spatial sensitivity analysis. *GISRUK 2020 Proceedings, 32.*



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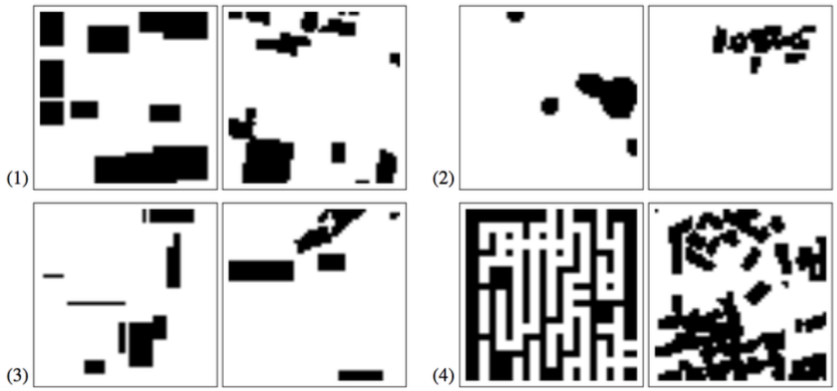

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OpenMOLE workflow engine

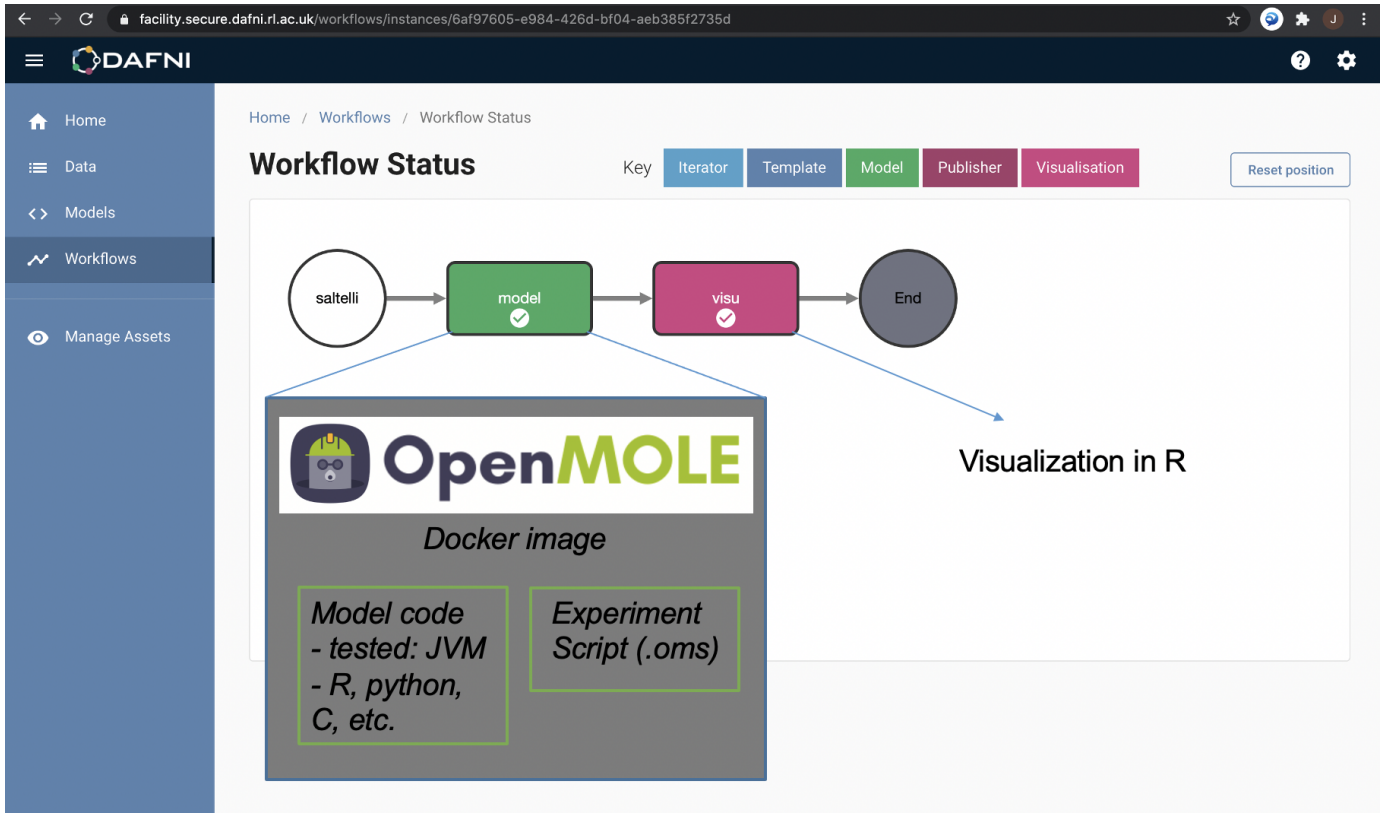
OpenMOLE model exploration open source software
[Reuillon et al., 2013]

Enables seamlessly (i) model embedding; (ii) access to HPC resources; (iii) exploration and optimization algorithms

`https://openmole.org/`

Towards advanced validation experiments

OpenMOLE integrates methods for: sensitivity analysis, spatial sensitivity analysis, design of experiments, calibration, diversity search, inverse problems, model reduction.



Integration of OpenMOLE into DAFNI

Discussion

Developments

→ Integration of multi-modal MATSim, calibration of mode choice parameters

→ Visualisation of MATSim agents dynamics (MATSim visu features not open)

→ Dynamical strong coupling of QUANT and SPENSER to combine population projections with the transport model

Applications

→ Validation of sub-models and integrated models using advanced model validation methods

→ Use MATSim outputs to quantify effective densities in public transport: potential exposure indicators in the COVID-19 context

→ Impact of policies and interventions on transport system dynamics and potential contaminations

Conclusion

→ Open, reproducible and validated urban models as elementary bricks towards larger integrated models
→ Central role of the DAFNI platform: workflow system to couple models, data platform, integrated access to computational resources

Open repositories

`https://github.com/JusteRaimbault/UrbanDynamics` for workflows

`https://github.com/openmole/spatialdata` for data processing

Workflow engines

DAFNI: `https://dafni.ac.uk/`

OpenMOLE: `https://openmole.org`

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