



The Growth of Natural Cities in Switzerland

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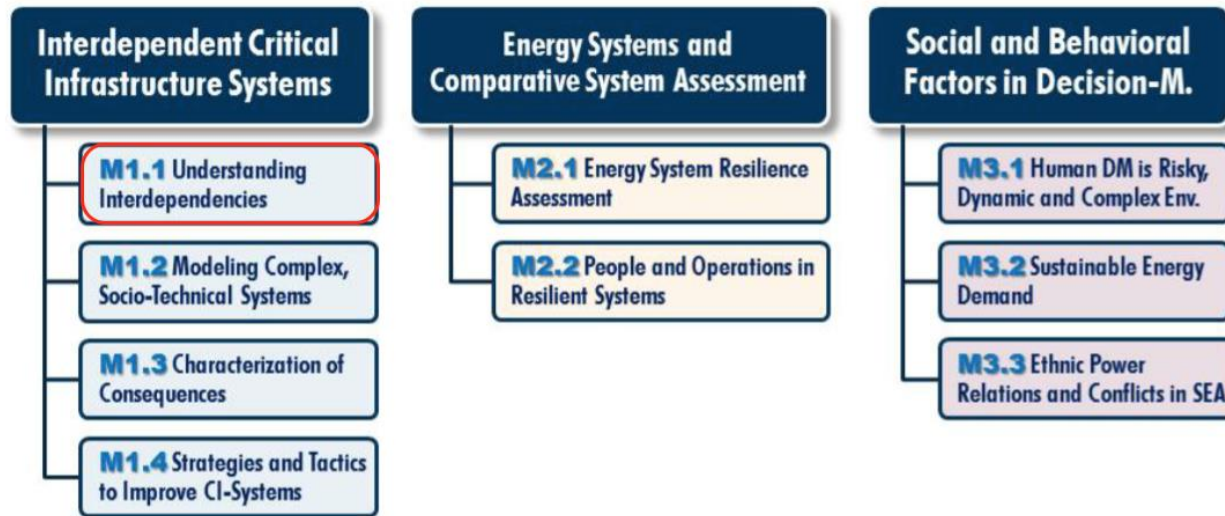
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Outlines

- Background
- Natural Cities
- Data
- Methodology
- Extraction of Natural Cities
 - Nighttime light data
 - Street network
- Conclusion

Background



- Key topics:
 - Organisational Interdependencies
 - Hidden Interdependencies
 - *Growth and Evolution of City Infrastructure*
- Objective:
 - Improve our understanding of how cities growth and evolution adapt to urbanisation

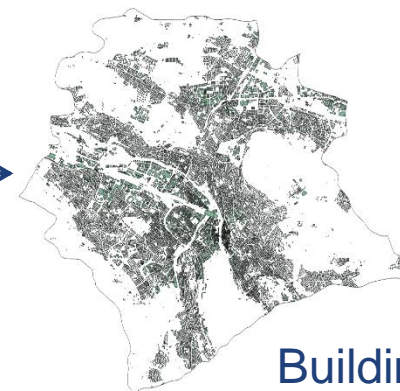
Natural Cities

■ Traditional method



Administrative
boundary

Extract



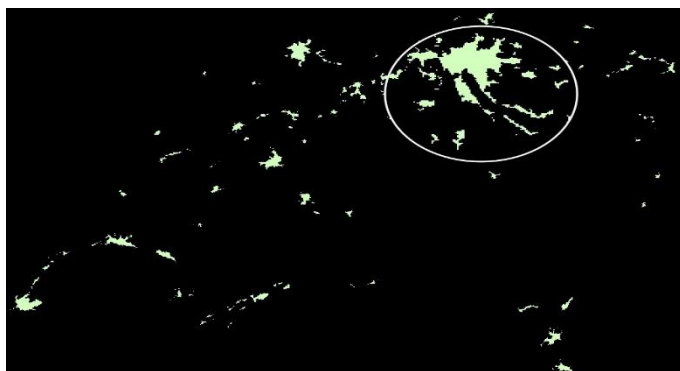
Buildings

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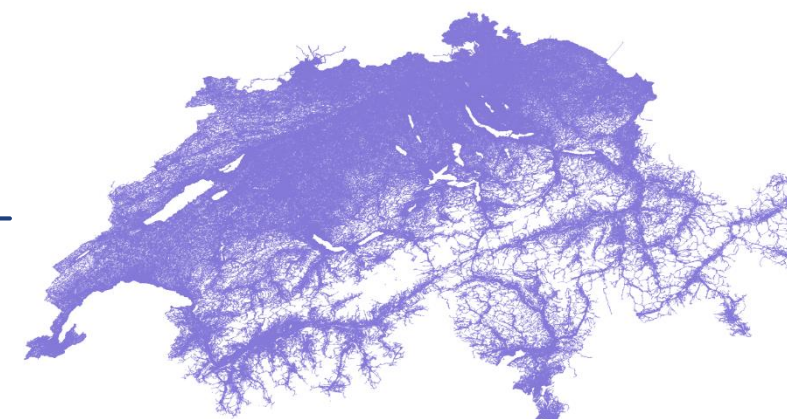


Roads

■ Natural cities [1]



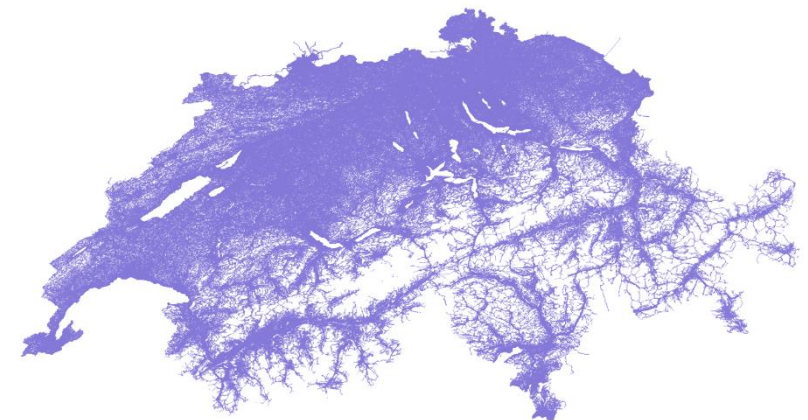
Collect



1. Jiang, B. and T. Jia (2011). Zipf's law for all the natural cities in the united states: a geospatial perspective. International Journal of Geographical Information Science 25(8), 1269–1281.

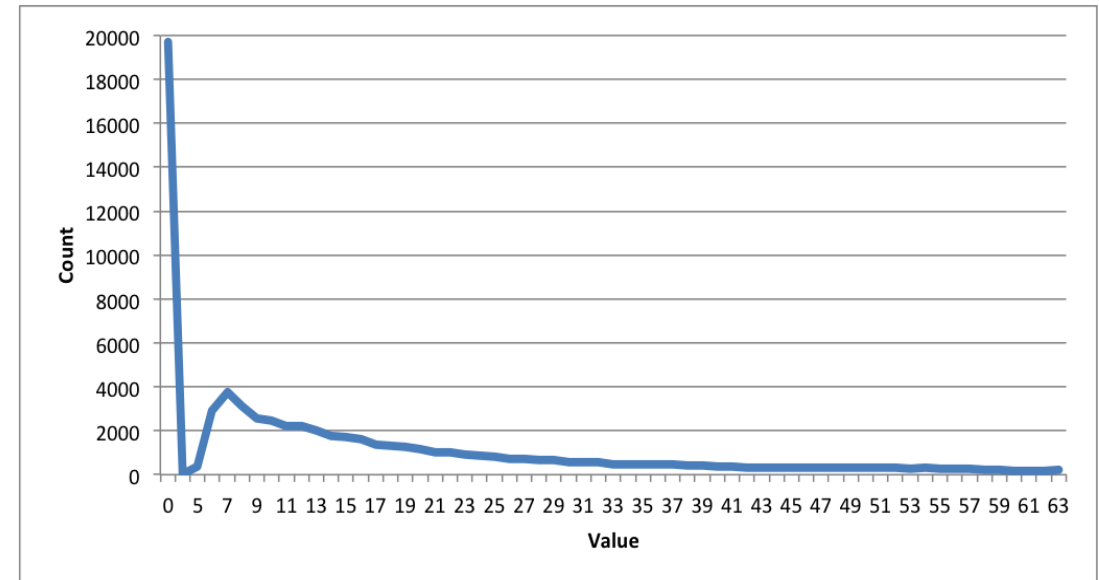
Data

- Nighttime light data
 - DMSP/OLS
 - Stable lights: city lights, fires, gas flares, etc.
 - A 3000 km swath
 - Digital number (DN) value: 0 ~ 63
 - 1992~2013
- Street network
 - swissTLM3D 1.x GDB
 - 2014



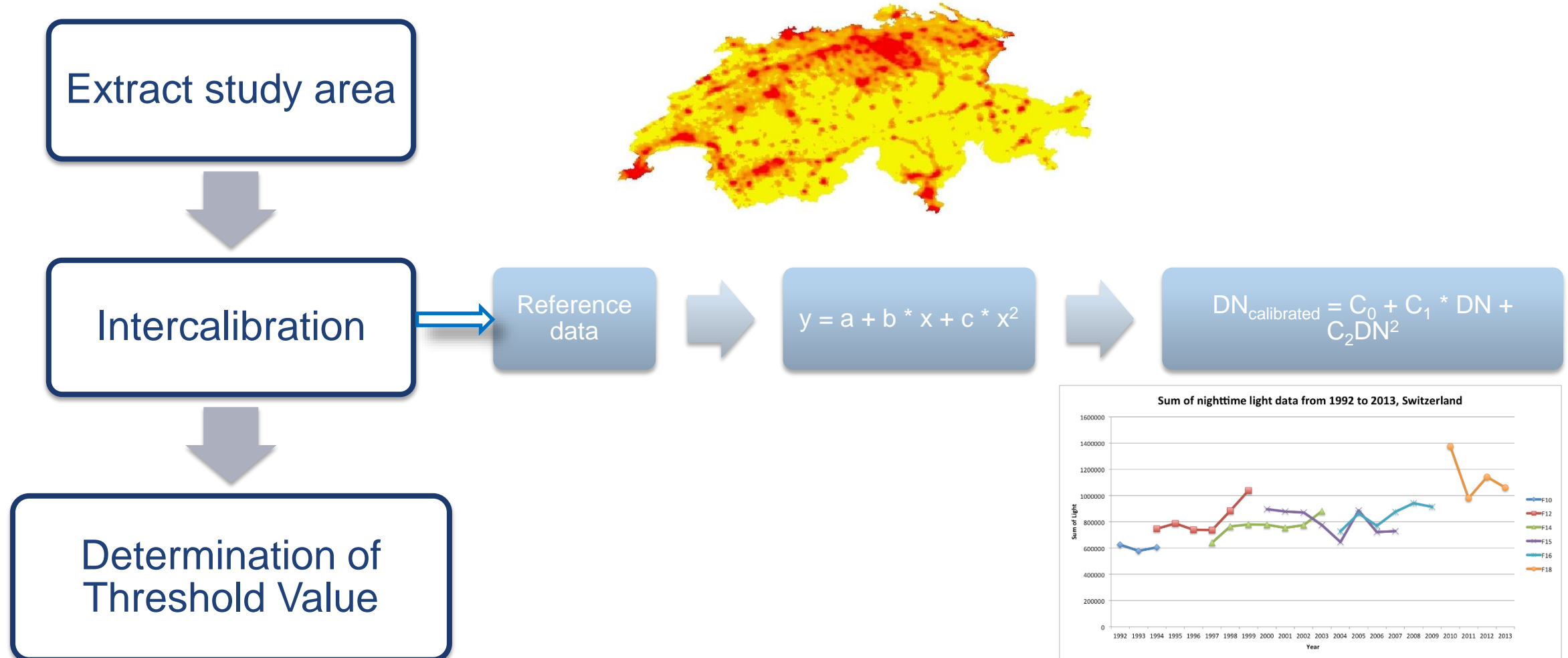
Methodology

- Head/tail Breaks Classification [1]
 - heavy-tailed distribution
 - low frequency events
 - “given a variable x , if its value x follows a heavy-tailed distribution, then the mean (m) of the values can divide all the values into two parts: a high percentage in the tail, and a low percentage in the head”



1. Jiang, B. (2013). Head/tail breaks: A new classification scheme for data with a heavy-tailed distribution. The Professional Geographer 65 (3), 482–494.

Extraction of Natural Cities from Nighttime Light Data



Natural Cities from Nighttime Light Data

- Statistics for the head/tail breaks for the Switzerland NTL imagery data in 2009

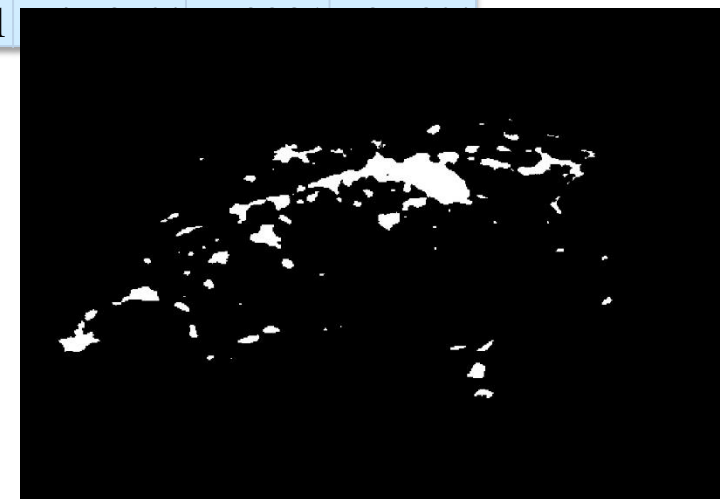
Light	Count		Mean	In head#	In		In tail%
	Light	Light*Count			head%	In tail#	
1-63	70891	1346251	18.9	30048	42.39%	40843	57.61%
19-63	30048	1064576	35.4	13030	43.36%	17018	56.64%
36-63	13030	618680	47.4	6222	47.75%	6808	52.25%
48-				2941			



Mean: 19

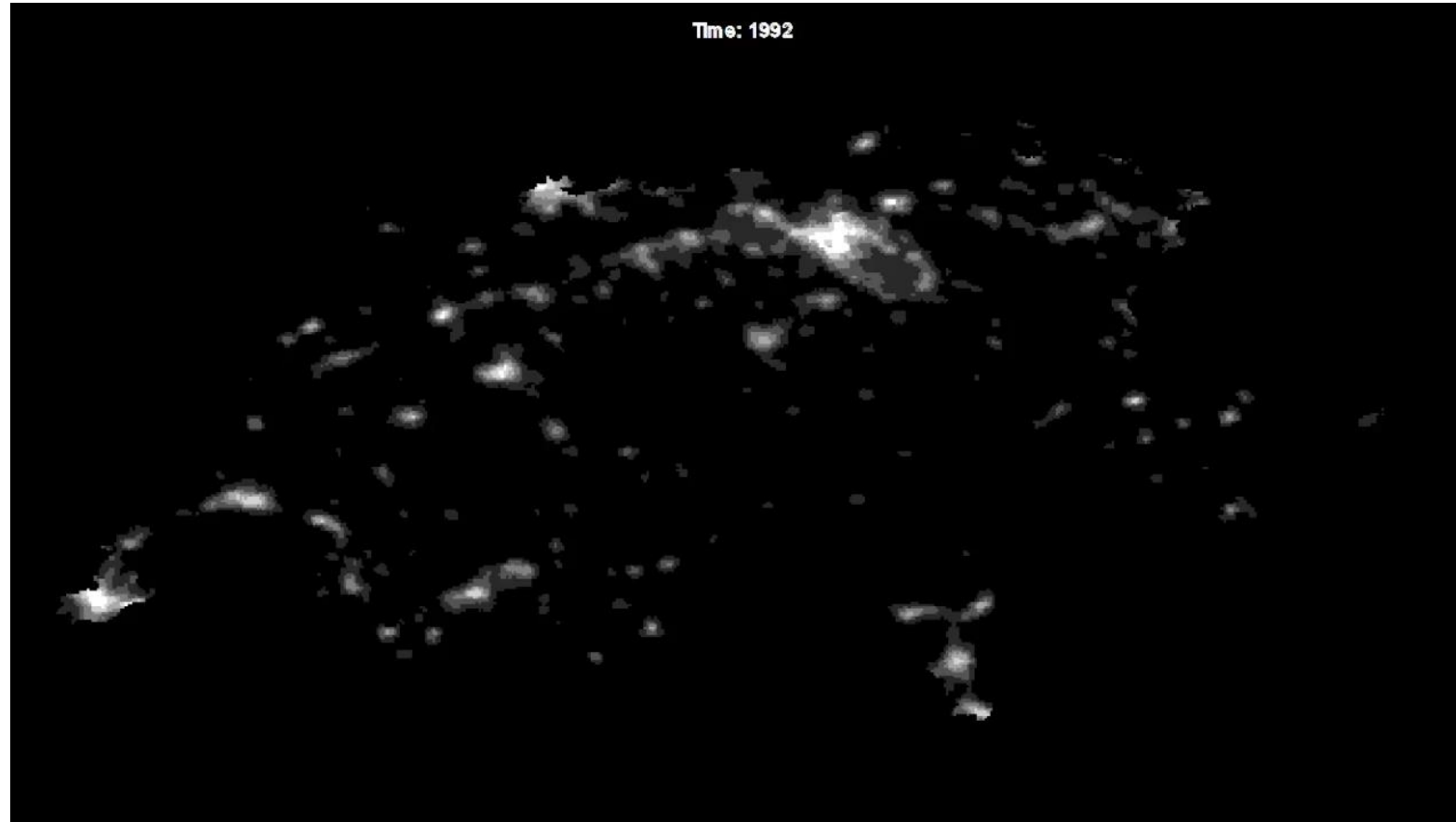


Mean: 34

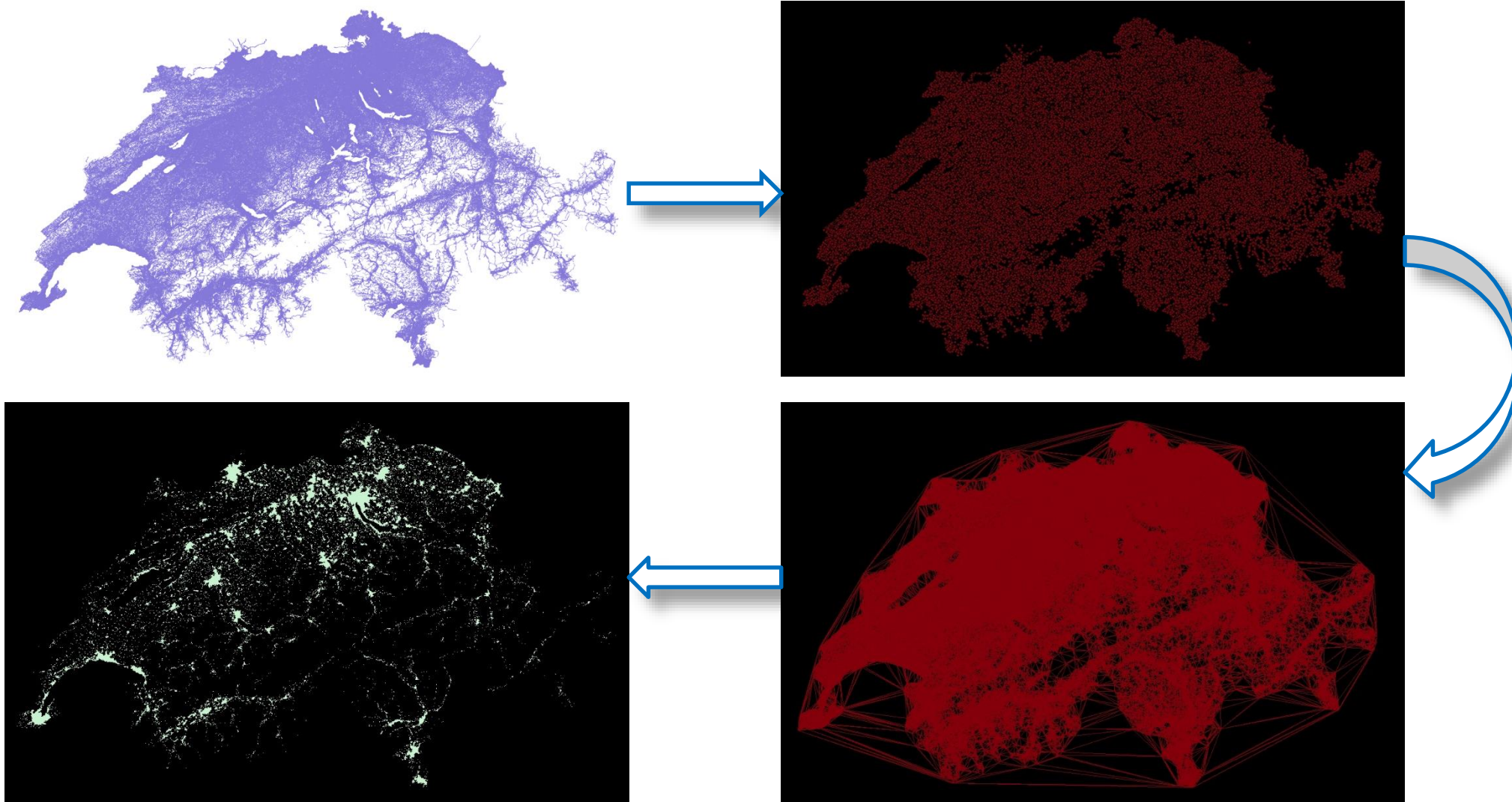


Mean: 47

Natural Cities from Nighttime Light Data

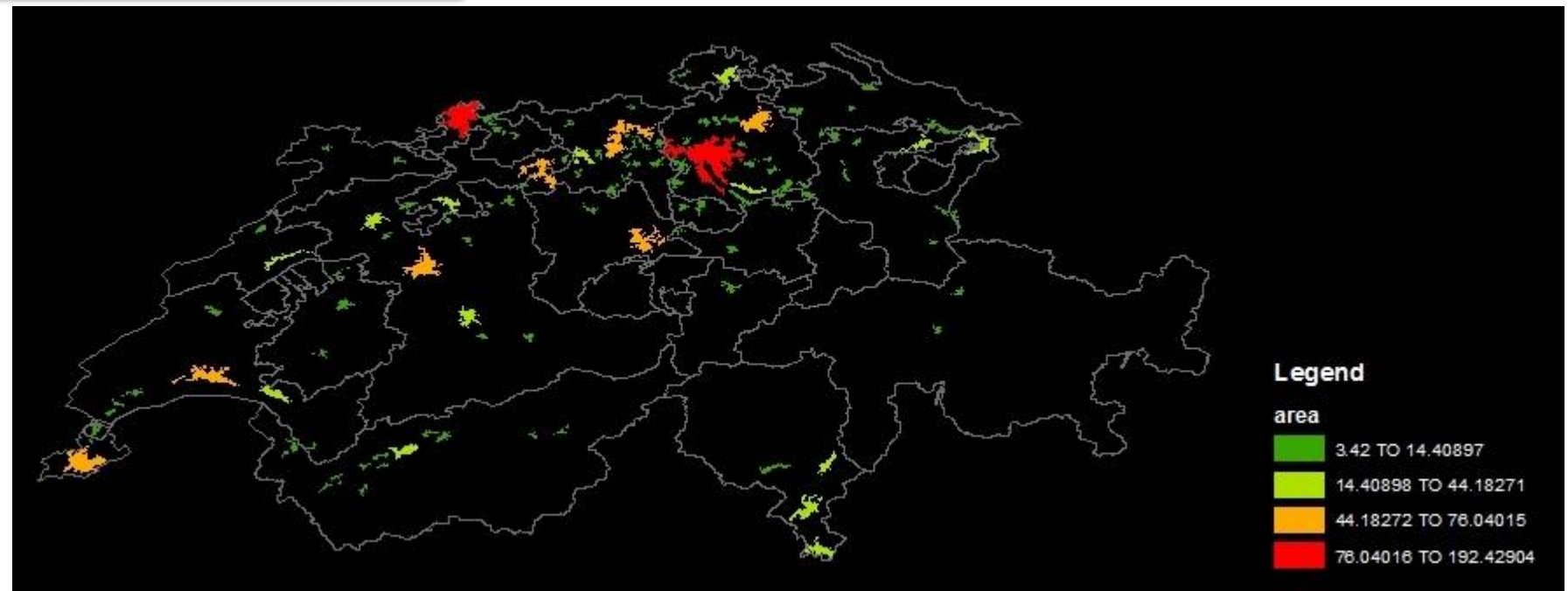


Extraction of Natural Cities from Street Network



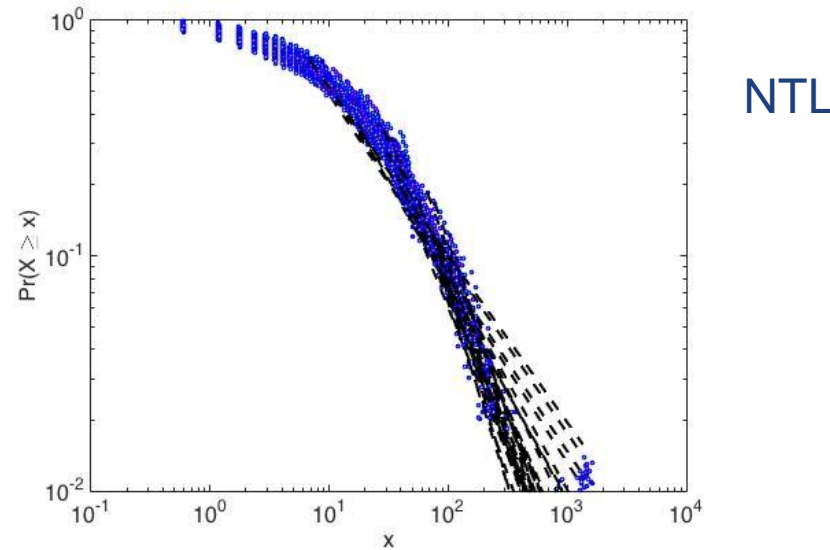
Natural Cities from Street Network

Area (km2)	Count	Mean	In head#	In head%	In tail#	In tail%
0-76.01	68595	0.05	4891	7%	63704	93%
0.05-76.01	4891	0.608	680	14%	4211	86%
0.608-76.01	680	3.41	109	16%	571	84%
3.41-76.01	109	14.41	23	21%	86	79%
14.41-76.01	23	44.18	9	39%	14	61%
44.18-76.01	9	76.01	2	22%	7	78%

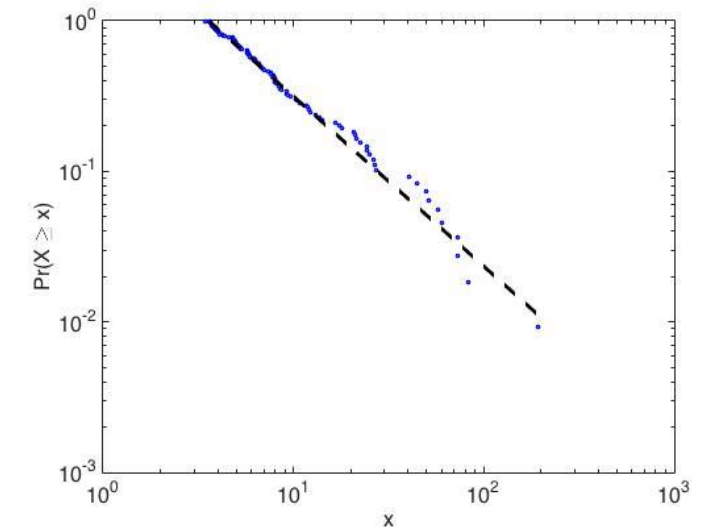


Power Law Detection

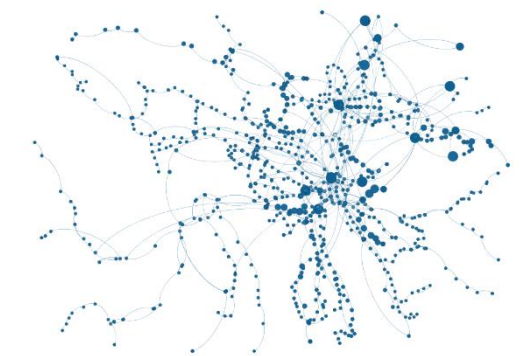
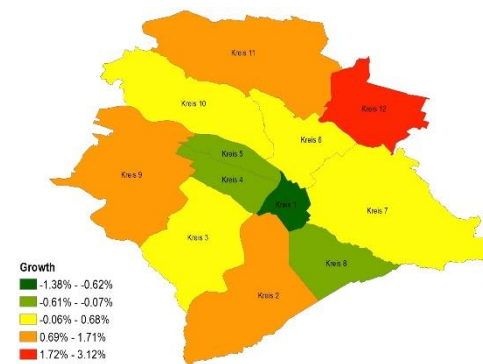
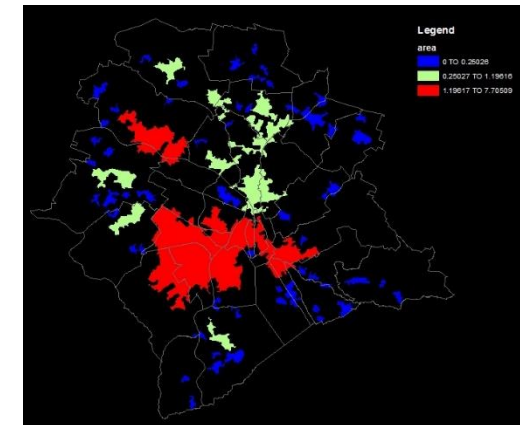
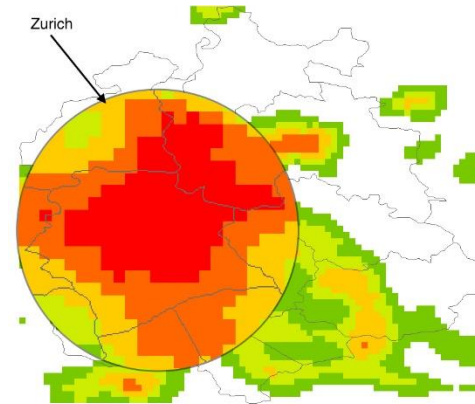
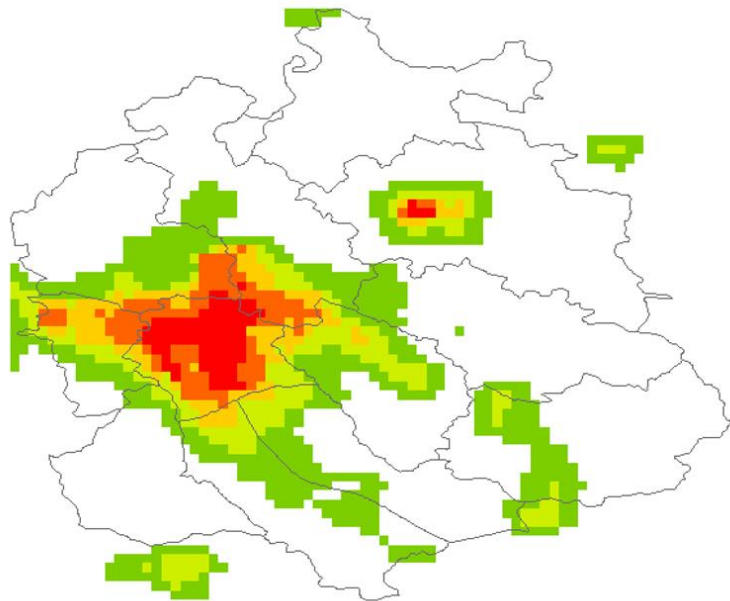
Year	Image	p-value	δ	Year	Image	p-value	δ
1992	F10	0.269	1.8954	2002	F15	0.944	2.3324
1993	F10	0.799	2.863	2003	F14	0.587	1.9108
1994	F10	0.224	2.6245	2003	F15	0.822	2.1121
1994	F12	0.816	2.2171	2004	F15	0.891	2.4191
1995	F12	0.418	2.3286	2004	F16	0.909	2.7892
1996	F12	0.034	1.796	2005	F15	0.942	2.4036
1997	F12	0.427	2.4242	2005	F16	0.438	2.1845
1997	F14	0.962	2.3986	2006	F15	0.729	1.8954
1998	F12	0.402	2.2494	2006	F16	0.796	2.165
1998	F14	0.007	1.7582	2007	F15	0.72	2.2661
1999	F12	0.512	2.2591	2007	F16	0.824	2.1978
1999	F14	0.296	2.2229	2008	F16	0.474	2.0582
2000	F14	0.031	1.7413	2009	F16	0.342	2.4828
2000	F15	0.805	2.2225	2010	F18	0.076	1.9218
2001	F14	0.485	2.2836	2011	F18	0.922	2.2818
2001	F15	0.554	2.1199	2012	F18	0.901	2.5597
2002	F14	0.944	2.4558	2013	F18	0.02	1.7117
2014	Street	0.6	2.1294				



Street



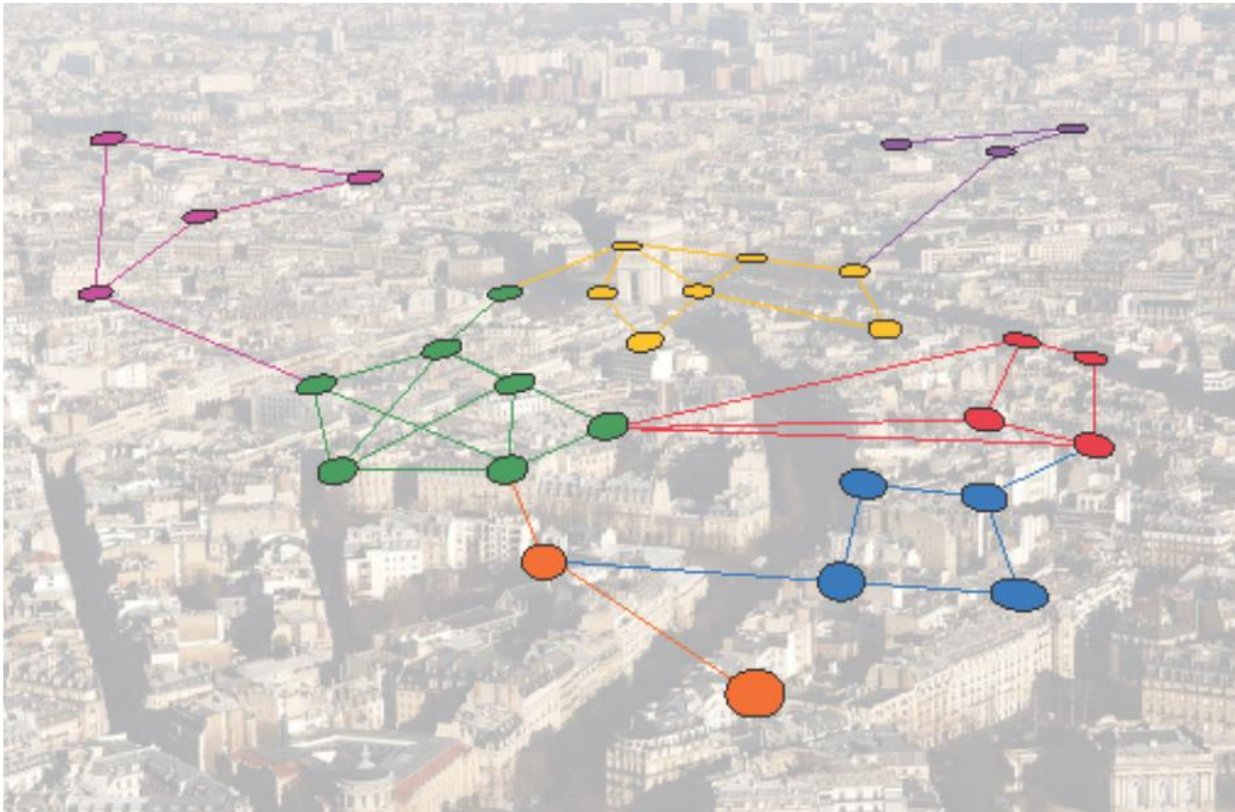
Zoom in City Level



Conclusion

- The results of this work have no subjective views of human influence.
- The growth of the urban area is nonlinear in Switzerland
- All the natural cities follow the power law distribution at the country level.
- The evolution of small regions can be influenced by their neighbors.

Social networks and travel behaviour



**Thank you
Q & A**