Population distribution response to changing climate

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(Central Europe in global circumstances)

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Introduction

Intergovernmental Panel on Climate Change (IPCC, 2014) states that there is mounting scientific evidence of ongoing climate change.

AR5 report emphasizes that the world is on the brink of potentially severe climatic changes that will have far reaching implications for the human populations and their geographic distributions

Further warming will continue if emissions of greenhouse gases continue.

The global surface temperature increase by the end of the 21st Century is likely to exceed 1.5°C.

The global water cycle will change, with increases in disparity between wet and dry regions, as well as wet and dry seasons.

The oceans will continue to warm, with heat extending to the deep ocean, affecting circulation patterns.

Decreases are very likely in Arctic sea ice cover, Northern Hemisphere spring snow cover, and global glacier volume.

Global mean sea level will continue to rise.

Changes in climate will cause an increase in the rate of CO2 production. Increased uptake by the oceans will increase the acidification of the oceans.

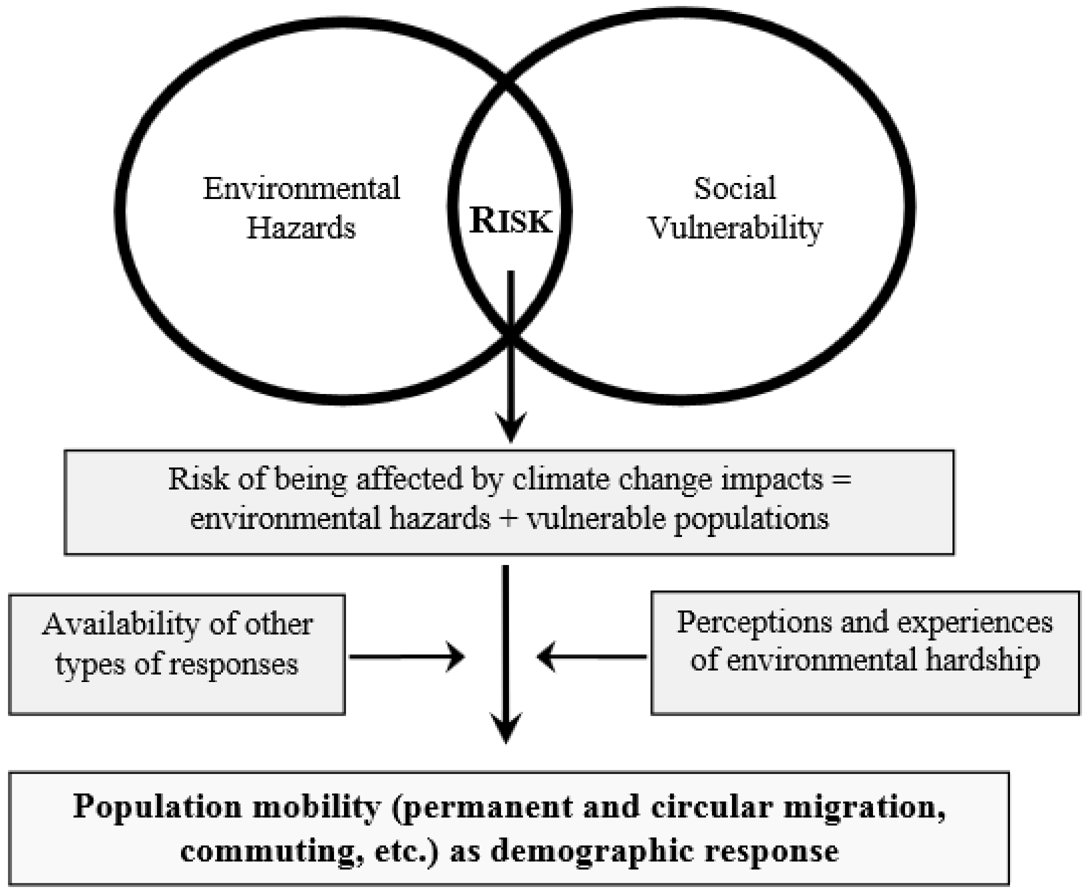
Future surface temperatures will be largely determined by cumulative CO_2, which means climate change will continue even if CO_2 emissions are stopped.

Government of the UK's Stern Review (Stern, 2006) :

Climate change will affect the basic elements of life for people around the world - access to water, food production, health, and the environment.

Hundreds of millions of people could suffer hunger, water shortages and coastal flooding as the world warms.

Population distribution is influenced by political, cultural, socioeconomic, demographic, and geophysical factors. The extent of each influence is variable and is the subject of some controversy.



Source: Adamo and Sherbinin (2011)

Data

Data source: NASA SEDAC, NASA GISS, 2015

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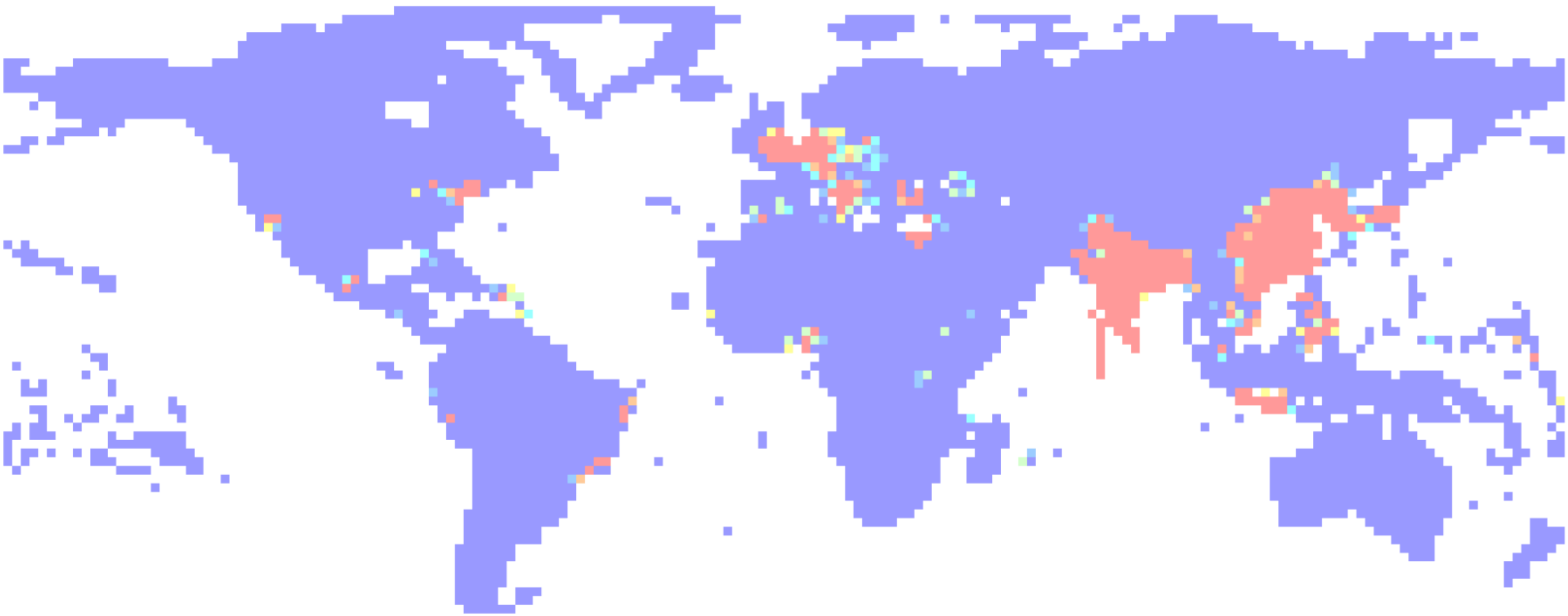
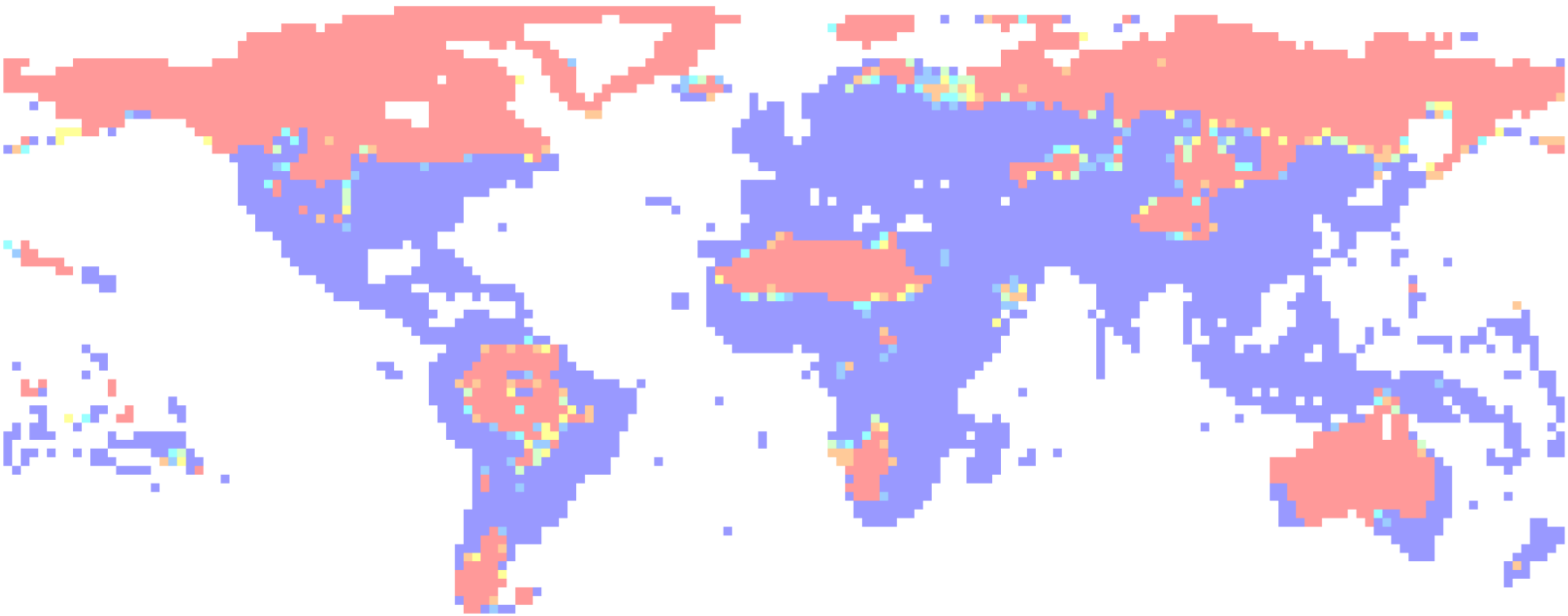
Population density, level (+)



Hot spots, frequency of High/High LISA cluster membership, 1990-2015

Data source: NASA SEDAC, NASA GISS, 2015

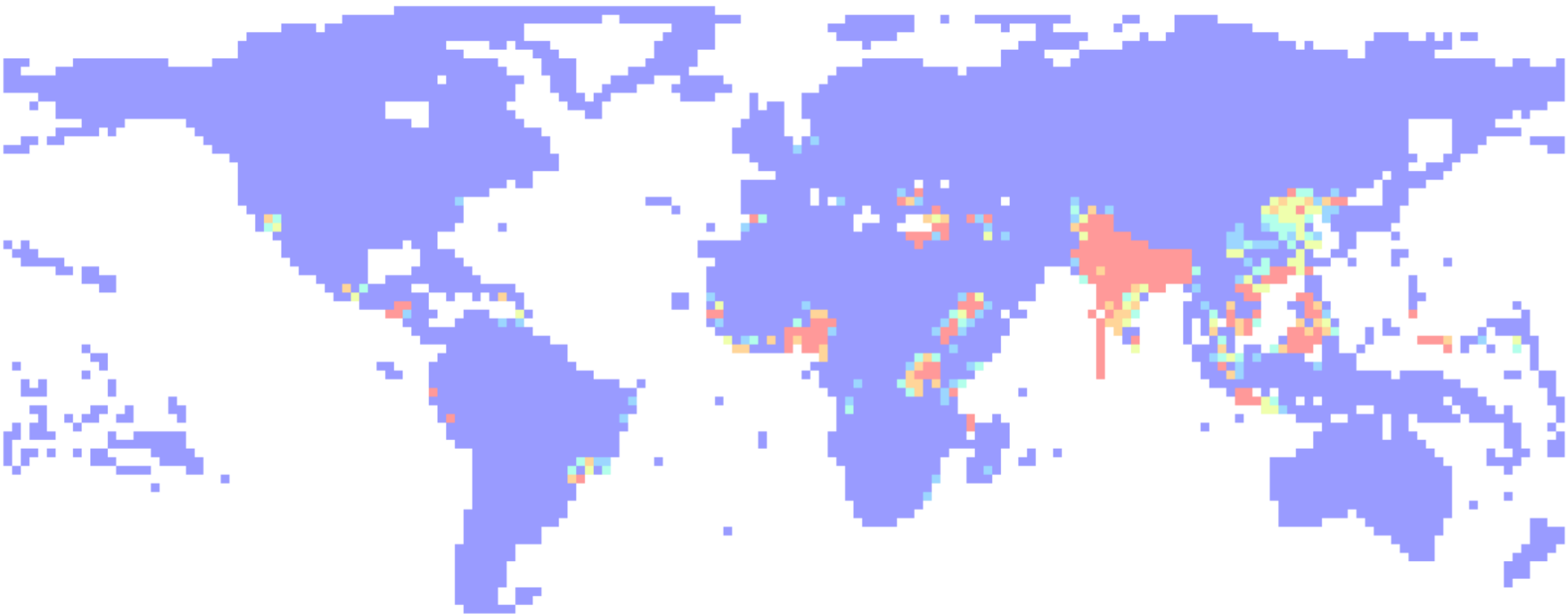
Population density, level (-)



Cold spots, frequency of Low/Low LISA cluster membership, 1990-2015

Data source: NASA SEDAC, NASA GISS, 2015

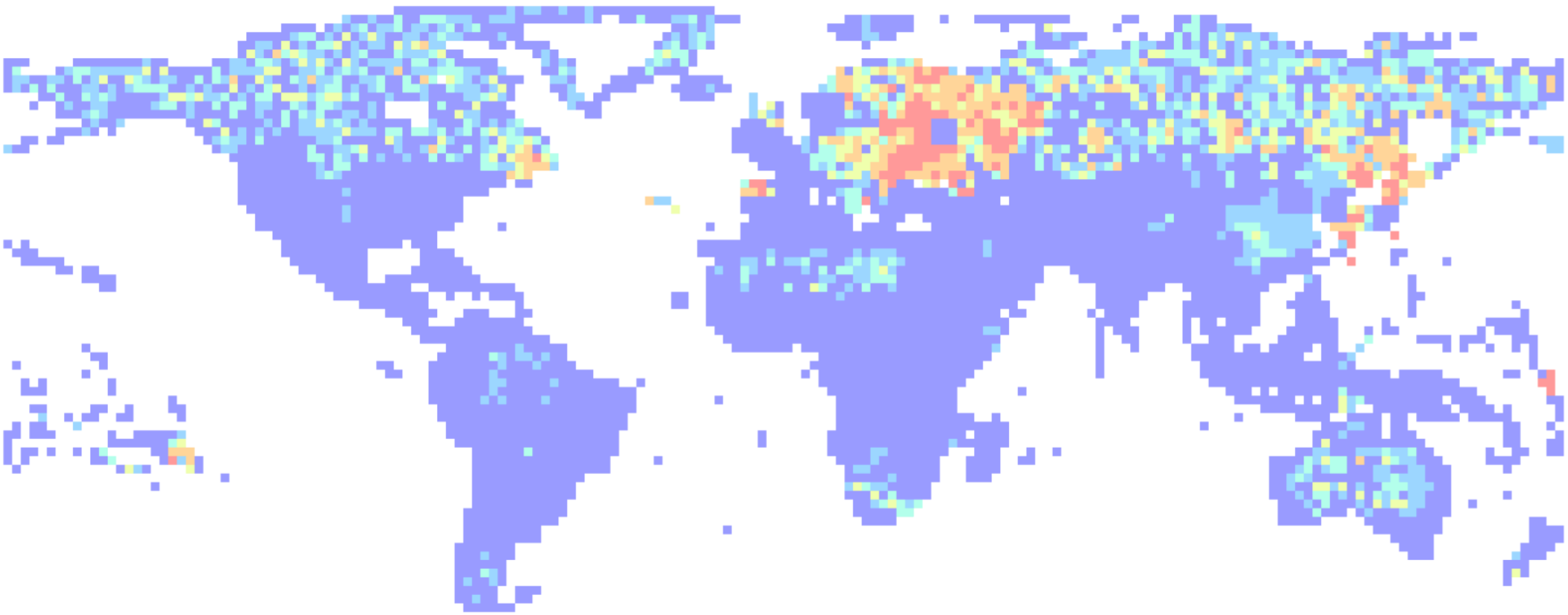
Population density, change (+)



Hot spots, frequency of High/High LISA cluster membership, 1990-2015

Data source: NASA SEDAC, NASA GISS, 2015

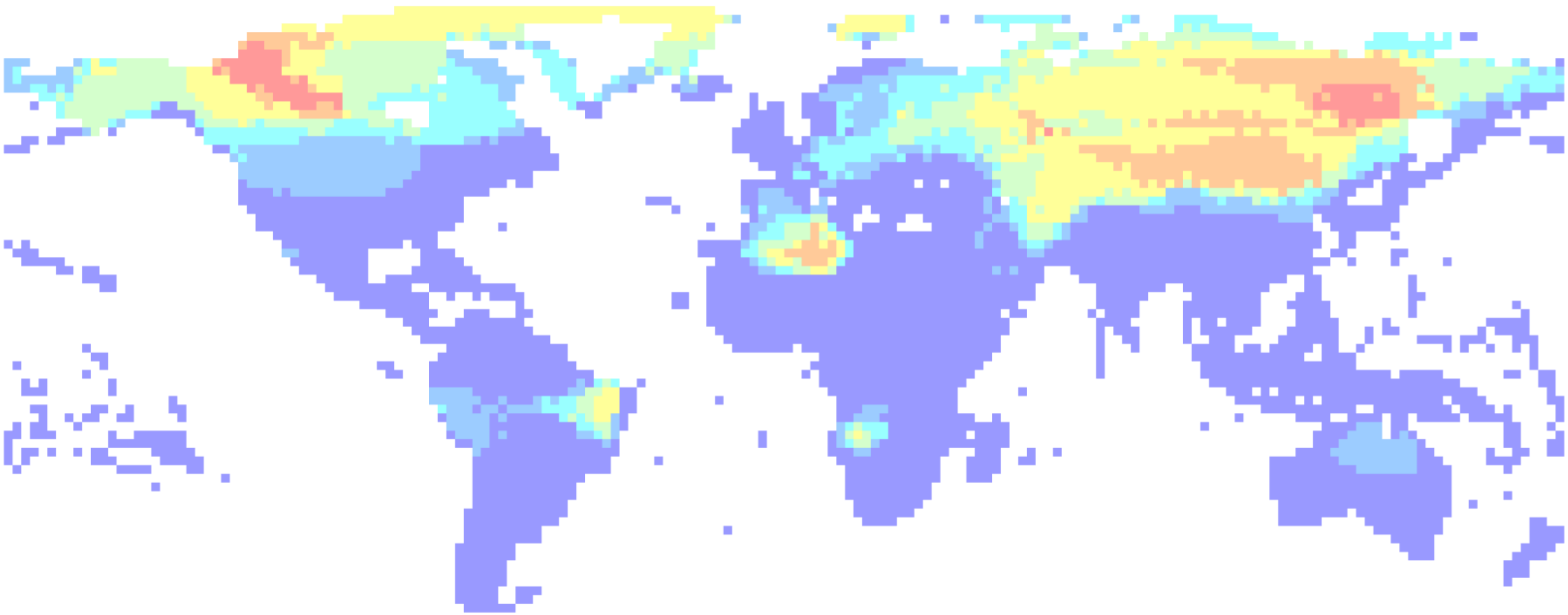
Population density, change (-)



Cold spots, frequency of Low/Low LISA cluster membership, 1990-2015

Data source: NASA SEDAC, NASA GISS, 2015

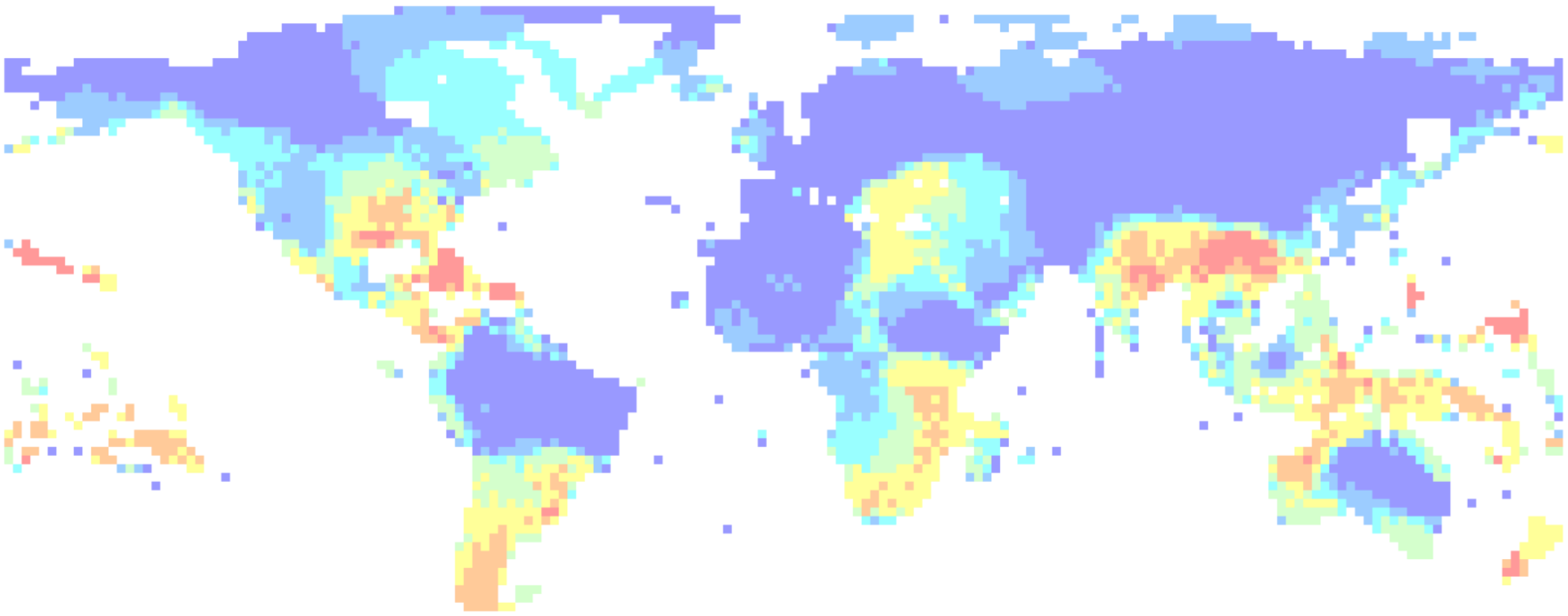
Surface temperature, anomaly (+)



Hot spots, frequency of High/High LISA cluster membership, 1990-2015

Data source: NASA SEDAC, NASA GISS, 2015

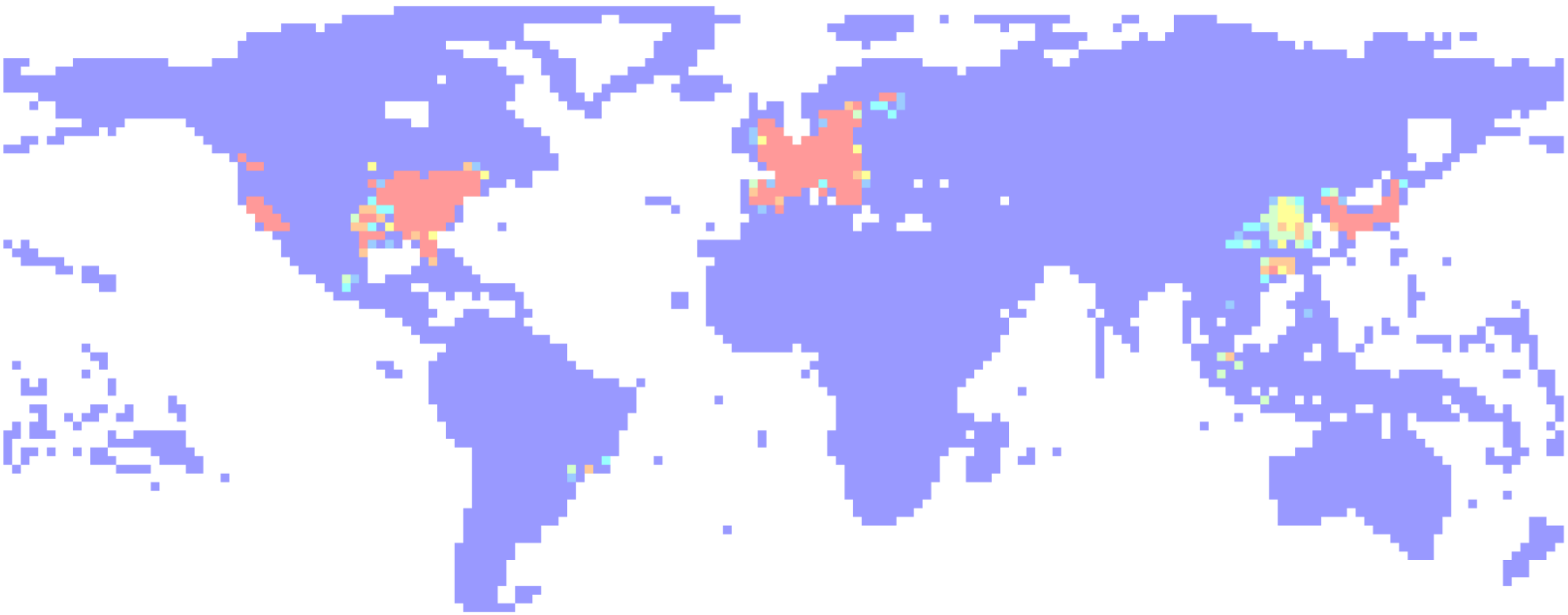
Surface temperature, anomaly (-)



Cold spots, frequency of Low/Low LISA cluster membership, 1990-2015

Data source: NASA SEDAC, NASA GISS, 2015

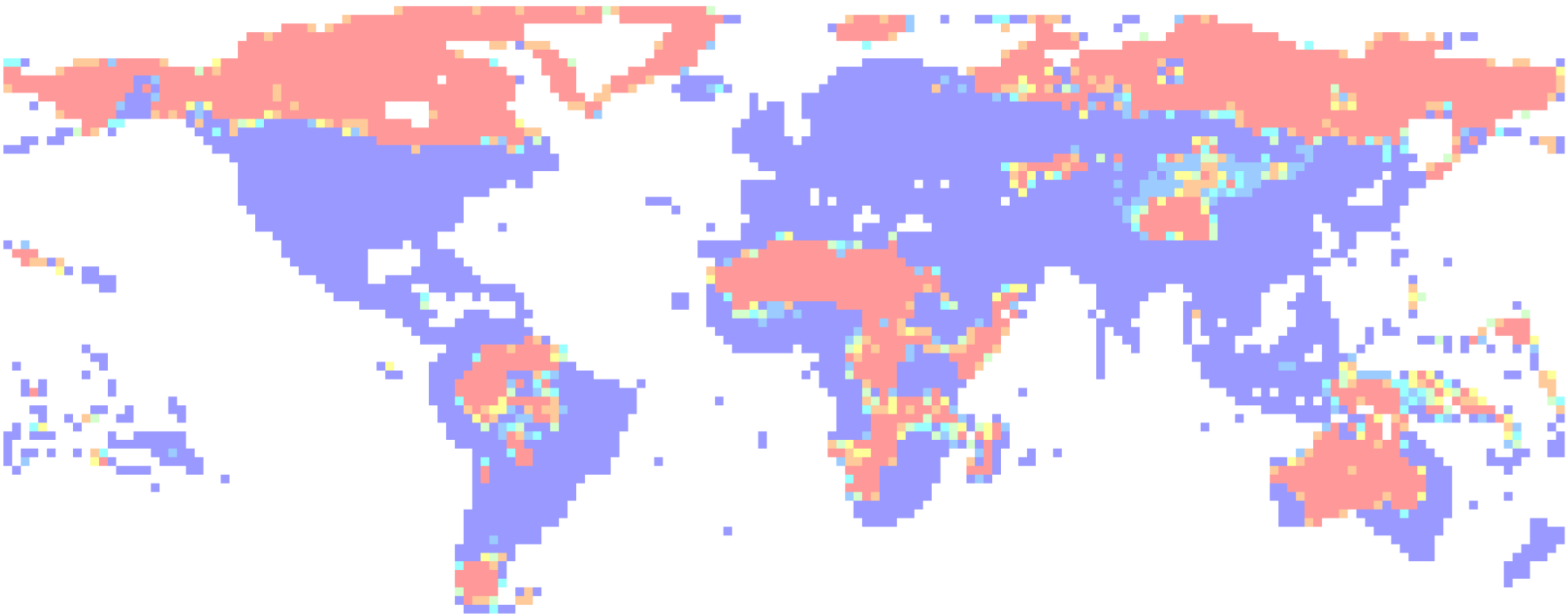
Gross domestic product, level (+)



Hot spots, frequency of High/High LISA cluster membership, 1990-2015

Data source: NASA SEDAC, NASA GISS, 2015

Gross domestic product, level (-)



Cold spots, frequency of Low/Low LISA cluster membership, 1990-2015

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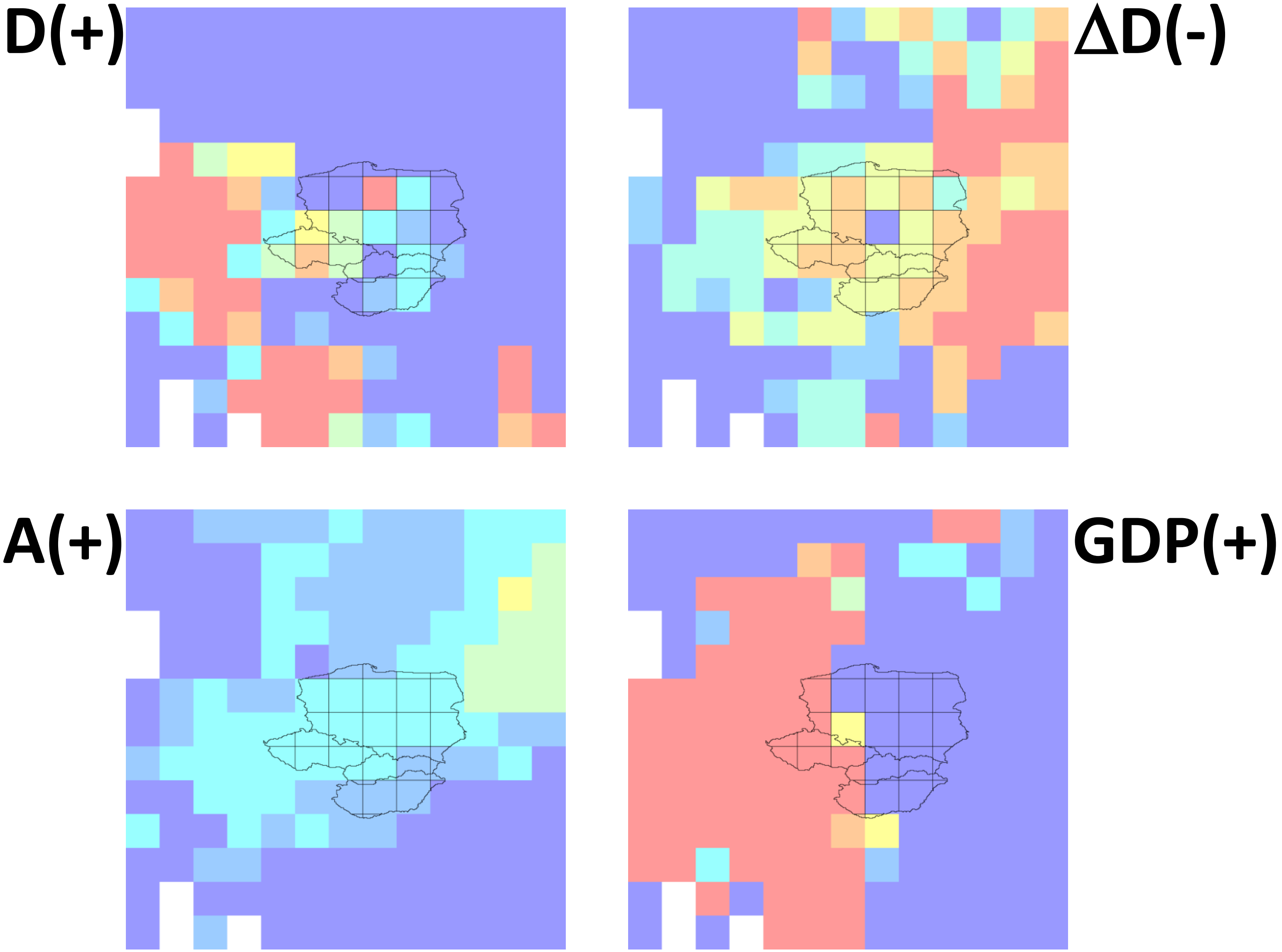


Data source: NASA SEDAC, NASA GISS, 2015

Global sample

	1990	1995	2000	2005	2010	2015
Global observations						
			Population density, level			
Min	0.0	0.0	0.0	0.0	0.0	0.0
Mean	40.2	43.2	46.1	49.0	52.0	54.9
SD	131.0	143.6	157.3	172.7	190.3	211.0
Max	3560.4	4314.8	5219.5	6325.9	7642.6	9151.8
			Population density, change			
Min		-270.5	-195.5	-143.3	-101.7	-70.2
Mean		3.0	2.9	2.9	2.9	2.9
SD		16.0	16.9	19.1	22.2	32.1
Max		754.4	904.8	1106.4	1316.7	1541.4
			Surface temperature, anomaly			
Min	-0.6	-1.0	-0.3	-0.1	-0.3	-0.3
Mean	0.4	0.5	0.7	0.9	1.0	1.0
SD	0.3	0.4	0.3	0.4	0.5	0.5
Max	1.4	1.8	1.8	2.0	2.7	2.7
			Gross domestic product			
Min	0.0	0.0	0.0	0.0	0.0	0.0
Mean	4.4	5.4	6.5	7.5	8.5	9.5
SD	22.7	26.3	30.4	34.8	39.5	44.3
Max	674.8	737.2	799.7	862.1	1066.8	1309.1

Data source: NASA SEDAC, NASA GISS, 2015

Visegrad sub-sample

	1990	1995	2000	2005	2010	2015
Visegrad countries observations						
			Population density, level			
Min	36.4	37.3	37.6	37.8	38.0	38.0
Mean	107.5	107.8	107.5	106.7	105.7	104.5
SD	48.5	48.5	47.1	46.0	45.0	44.1
Max	250.4	249.5	245.5	240.1	234.7	228.9
			Population density, change			
Min		-8.2	-7.0	-6.5	-5.8	-5.8
Mean		0.4	-0.3	-0.9	-1.0	-1.1
SD		2.6	2.3	2.0	1.8	1.8
Max		3.9	5.8	2.5	2.8	2.9
			Surface temperature, anomaly			
Min	0.3	0.5	0.6	0.8	1.1	1.3
Mean	0.5	0.7	0.7	0.9	1.2	1.4
SD	0.1	0.1	0.1	0.1	0.1	0.1
Max	0.6	0.8	0.8	1.1	1.3	1.5
			Gross domestic product			
Min	1.3	1.7	2.0	2.3	2.6	2.9
Mean	19.1	22.1	25.0	28.0	31.0	34.0
SD	27.7	31.1	34.6	38.0	41.4	44.9
Max	139.3	156.7	174.1	191.5	208.9	226.3

Data source: NASA SEDAC, NASA GISS, 2015

Empirical evidence

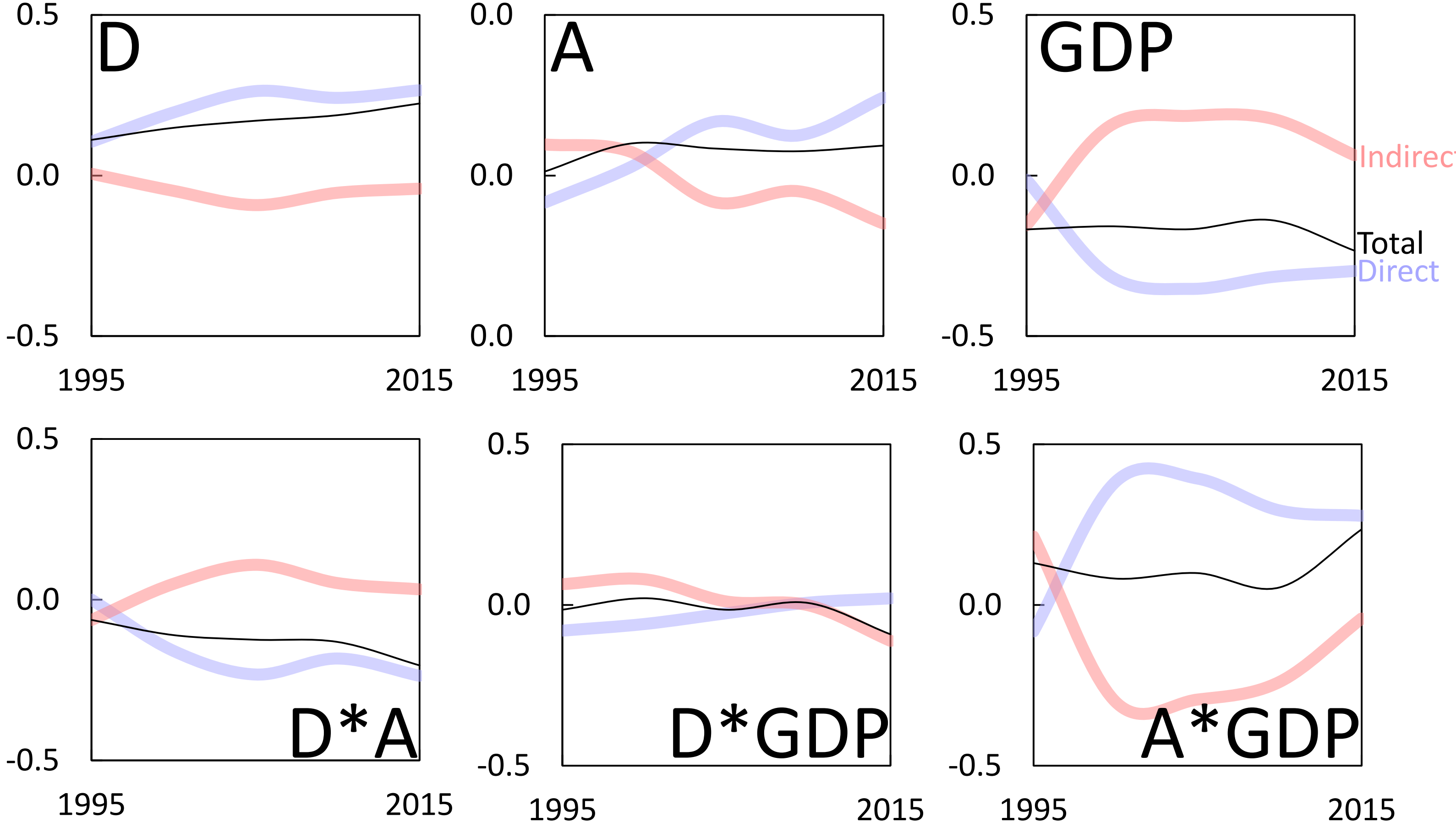
For the case where a global spillover specification is implied by theoretical or substantive aspects of the problem, one need only estimate an SDM specification, the spatial Durbin model

$$y = \rho Wy + \alpha \iota_n + X\beta + WX\beta_2 + \varepsilon$$

A key facet of global spillovers is that endogenous interaction and feedback effects are present.

Endogenous interaction leads to a scenario where changes in one region/agent/entity set in motion a sequence of adjustments in (potentially) all regions in the sample such that a new long-run steady state equilibrium arises (LeSage, 2014).

	1990-1995	1995-2000	2000-2005	2005-2010	2010-2015
Direct effects					
D	0.105	0.196	0.262	0.241	0.265
A			0.003		
GDP		-0.309	-0.353	-0.316	-0.297
D*A		-0.159	-0.233	-0.183	-0.236
D*GDP	-0.080	-0.059			
A*GDP		0.383	0.394	0.294	0.278
Indirect effects					
D		-0.048	-0.092	-0.054	-0.041
A					
GDP	-0.155		0.186	0.177	
D*A	-0.063	0.049	0.109	0.052	
D*GDP					
A*GDP	0.213	-0.301	-0.294	-0.239	
Total effects					
D	0.111	0.148	0.170	0.188	0.224
A		0.002	0.002	0.002	0.002
GDP	-0.168				-0.234
D*A	-0.062	-0.110	-0.124	-0.131	-0.204
D*GDP					
A*GDP					0.236



0.5
D
0.0
-0.5
1995
2015
0.0
A
0.0
0.0
1995
2015
0.5
GDP
0.0
-0.5
Indirect
Total
Direct
1995
2015
0.5
0.0
-0.5
D*A
1995
2015
0.5
0.0
-0.5
D*GDP
1995
2015
0.5
0.0
-0.5
A*GDP
1995
2015

Conclusions

Global population density has increased by 36% during the last 25 years. In the same time, inequality of spatial distribution has grown even faster, by 61%.

Population change itself is becoming more diverse, inequality grows by 101%.

The world is becoming more wealthy on average. Local GDP per capita has increased by 116% during the last 25 years. Inequality is rising slower, by 95%.

Surface temperature anomaly to the reference period 1951-1980 shows a warming global climate. Increase between 0.4°C and 1.0°C represents 146%. Variance of distribution grows by 58%.

Central Europe is a part of four spatial clusters at the global scale: densely inhabited, wealthy, with declining population, and warming climate.

Population density level is 2.3-times higher than global average, with minor decrease during the last 25 years, by 3%.

GDP level is 3.9-times higher than global average, increasing by 78%.

Warming of local climate is stronger than global level, on average by 21%, and further rising, by 204%.

Population grows faster in places already densely populated. Positive effect is 2.0-times higher between the start and the end of sample. The evidence of global scale concentration.

The effect of wealth is negative, significant only at the beginning and again at the end of the sample period, now 40% stronger. Better economy slows down population growth.

Climate warming is positively correlated, and significant since late 1990s. Rising importance, 7.8-times stronger effect at the end of sample. More people will have to deal with direct influence of warmer climate on their lives.

Pairwise interaction variables measure potential synergies, joint effects of concentration, wealth and climate change.

Interaction between density and temperature anomaly is negative and significant, 3.3-times stronger at the end of sample. Concentration process slows with climate change intensity.

Despite intuition, interaction between density and wealth is never significant at global scale.

Joint effect of wealth and climate change is positive, appearing significant recently. Wealth helps to maintain concentration process in warming areas.

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