

Population distribution response to changing climate

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Prague, September 10, 2015

(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.

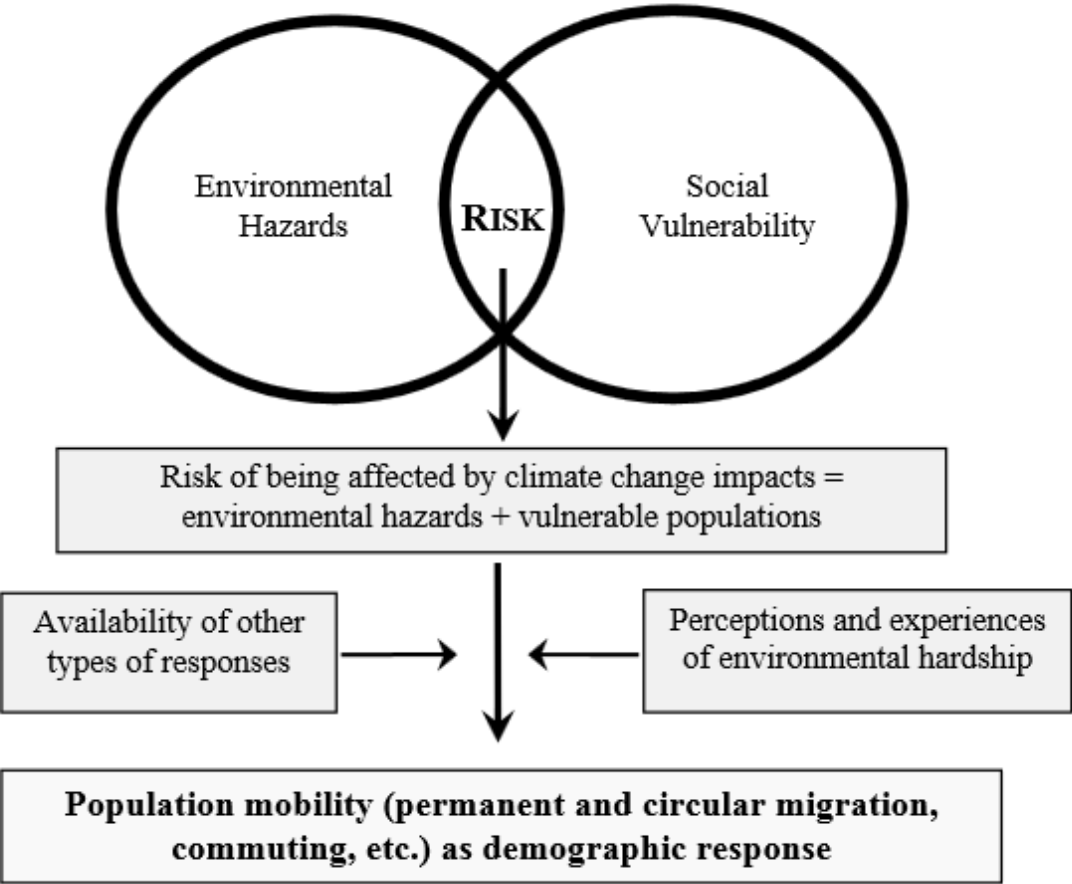
Future surface temperatures will be largely determined by cumulative CO₂, which means climate change will continue even if CO₂ emissions are stopped.

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

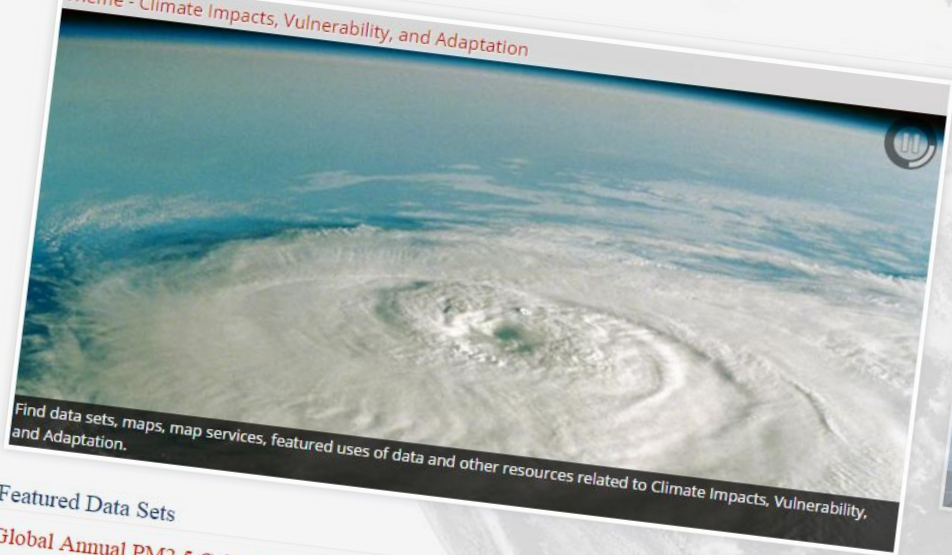


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To provide a continuous surface of concentrations (micrograms per cubic meter) of fine particulate matter of 2.5 micrometers

Environmental Performance Index, 2014 Release (2002–2014)

Environmental Performance Index (EPI)

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To provide quantitative metrics for evaluating a country's environmental performance in different policy categories relative to clearly defined

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GISS Surface Temperature Analysis (GISTEMP)

Graphs and tables are updated around the middle of every month using current data files from NOAA GHCN v3 (meteorological stations), ERSST (ocean areas), and SCAR (Antarctic stations), combined as described in our December 2010 publication (Hansen et al. 2010). These updated files incorporate reports for the previous month and also late reports and corrections for earlier months.

News

2015-01-16: The December 2014 data have been posted. NASA has issued a news release regarding the 2014 annual temperature anomaly.

See the [Updates to Analysis](#) page.

Contacts

Please address all inquiries about the GISTEMP analysis to Dr. Reto Ruedy. Also participating in the GISTEMP analysis are Dr. Makiko Sato and Dr. Ken Lo. This research was previously led by Dr. James E. Hansen, now retired.

Citation

When referencing the GISTEMP data provided here, please cite both this webpage and also our most recent scholarly publication about the data. In citing the webpage, be sure to include the date of access.

- + GISTEMP Team, 2015: GISS Surface Temperature Analysis (GISTEMP). NASA Goddard Institute for Space Studies. Dataset accessed 20YY-MM-DD at <http://data.giss.nasa.gov/gistemp/>.
- + Hansen, J., R. Ruedy, M. Sato, and K. Lo. 2010: Global surface temperature change. *Rev. Geophys.*, **48**, RG4004, doi:10.1029/2010RG000345.

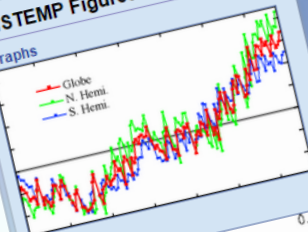
History

The basic GISS temperature analysis scheme was defined in the late 1970s by James Hansen when a method of estimating global temperature change was needed for comparison with one-dimensional global climate models. Most prior temperature analyses, notably those of Murray Mitchell, covered only 20-90°N latitudes. Our first published results (Hansen et al. 1981) showed that, contrary to impressions from northern latitudes, global cooling after 1940 was small, and there was net global warming of about 0.4°C between the 1880s and 1970s.

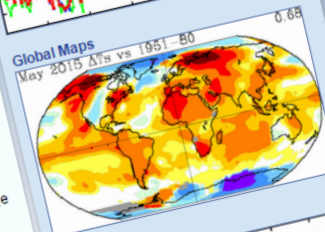
The analysis method was documented in Hansen and Lebedeff (1987), showing that the correlation of temperature change was reasonably strong for stations that extended up to 1200 km, especially at middle and high latitudes. They obtained estimates of the error in annual and 5-year mean temperature change from a spatially complete data set of a long run of observations that have realistic spatial and temporal coverage.

GISTEMP Figures

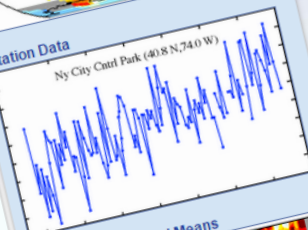
Graphs



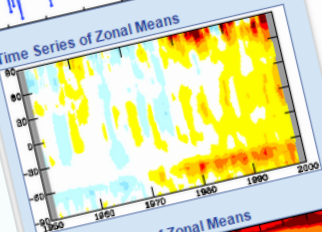
Global Maps



Station Data



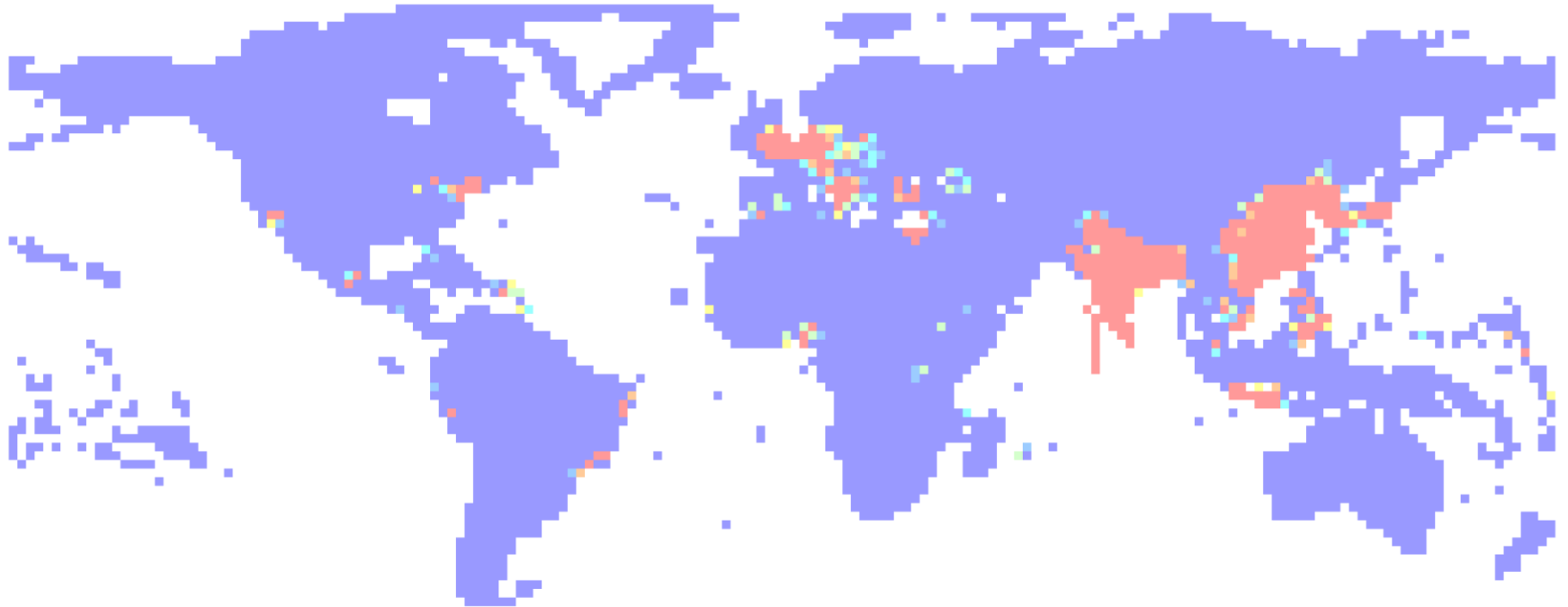
Time Series of Zonal Means



Seasonal Cycle of Zonal Means

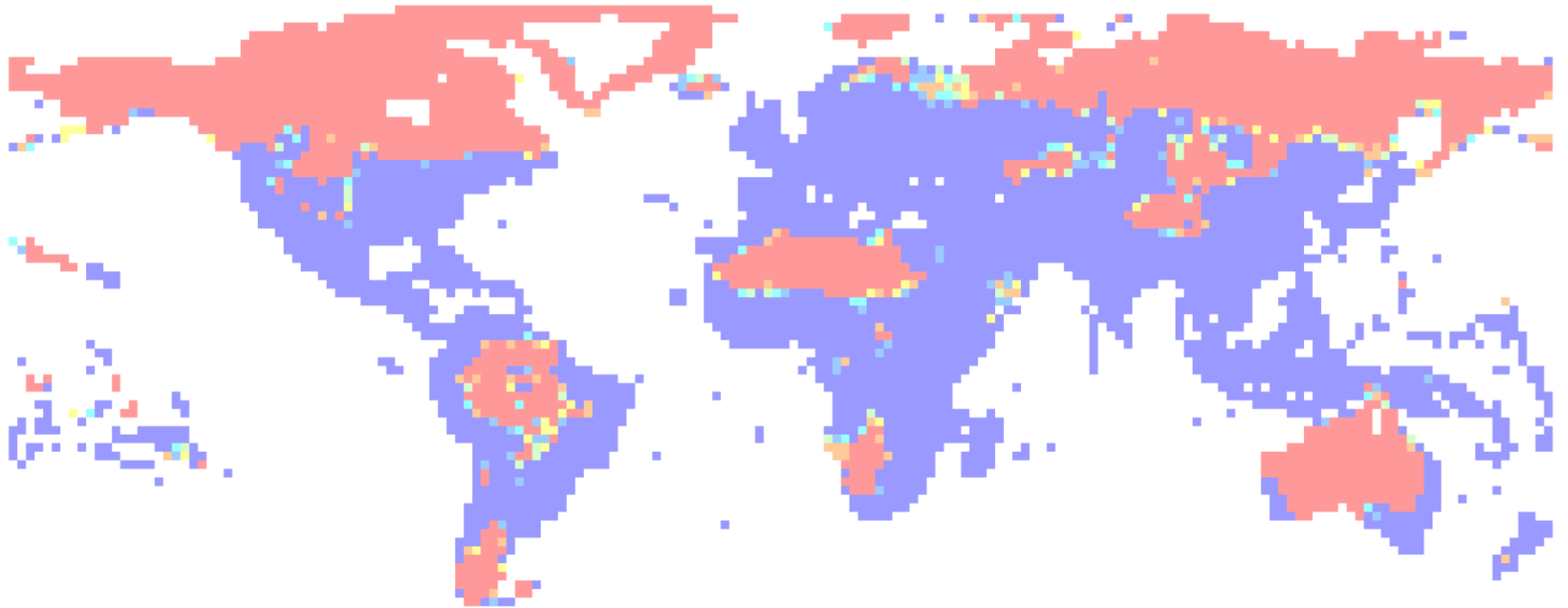


Population density, level (+)



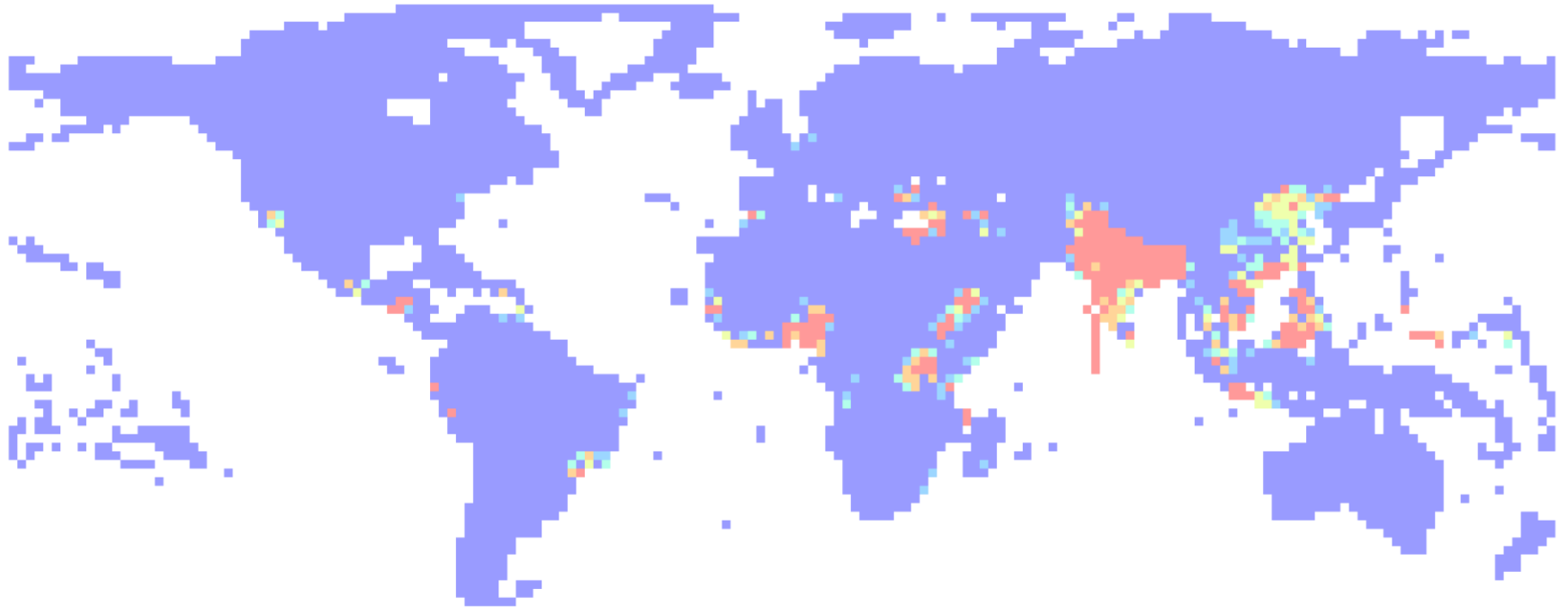
Hot spots, frequency of High/High LISA cluster membership, 1990-2015

Population density, level (-)



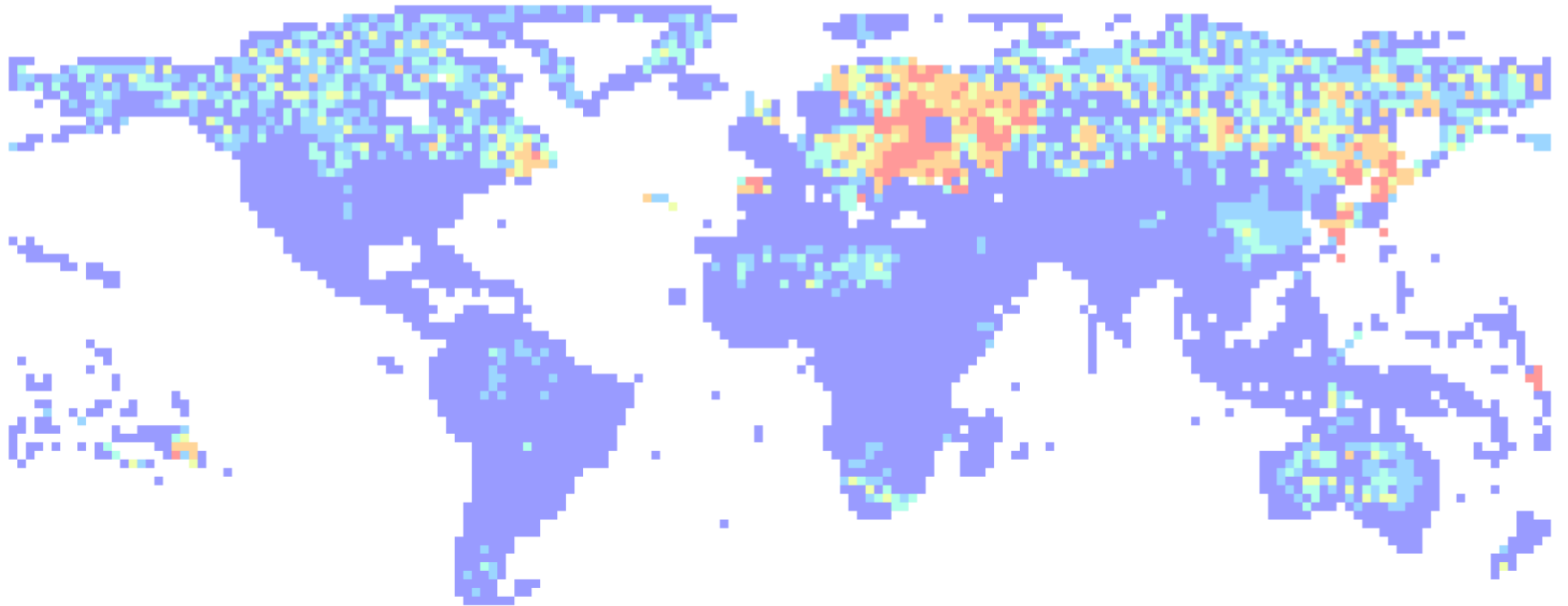
Cold spots, frequency of Low/Low LISA cluster membership, 1990-2015

Population density, change (+)



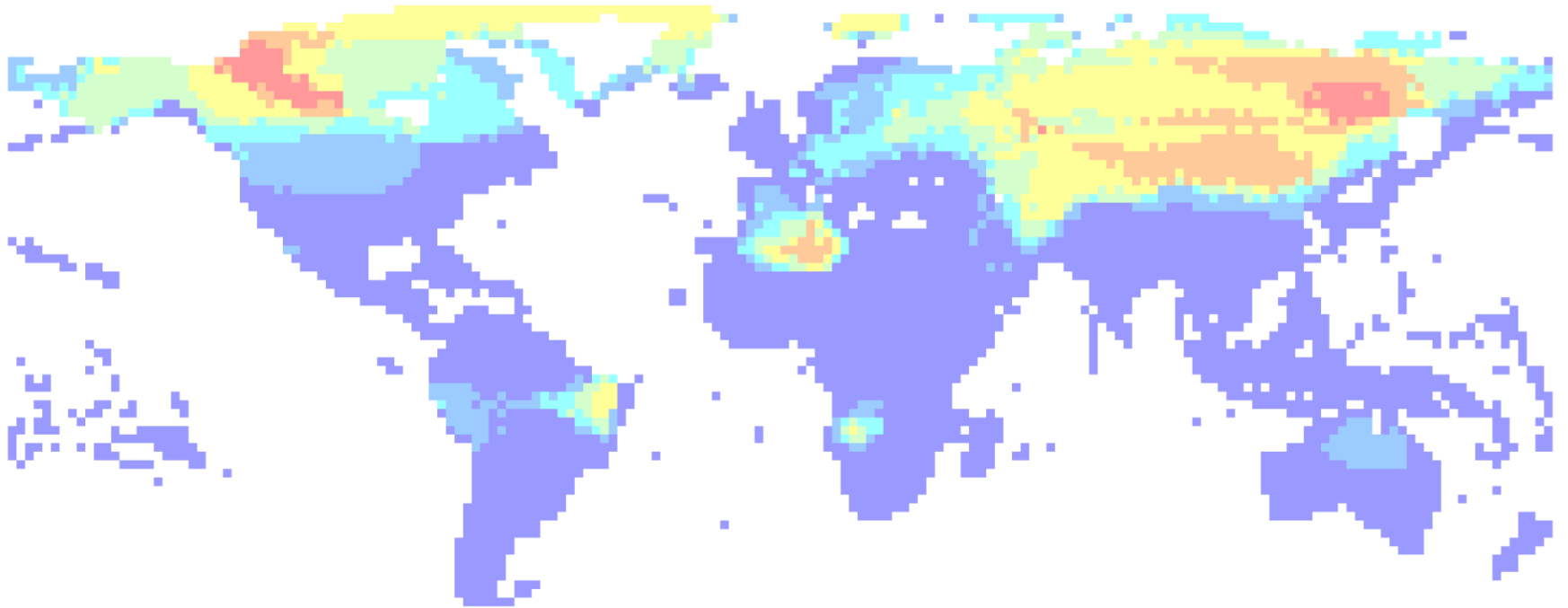
Hot spots, frequency of High/High LISA cluster membership, 1990-2015

Population density, change (-)



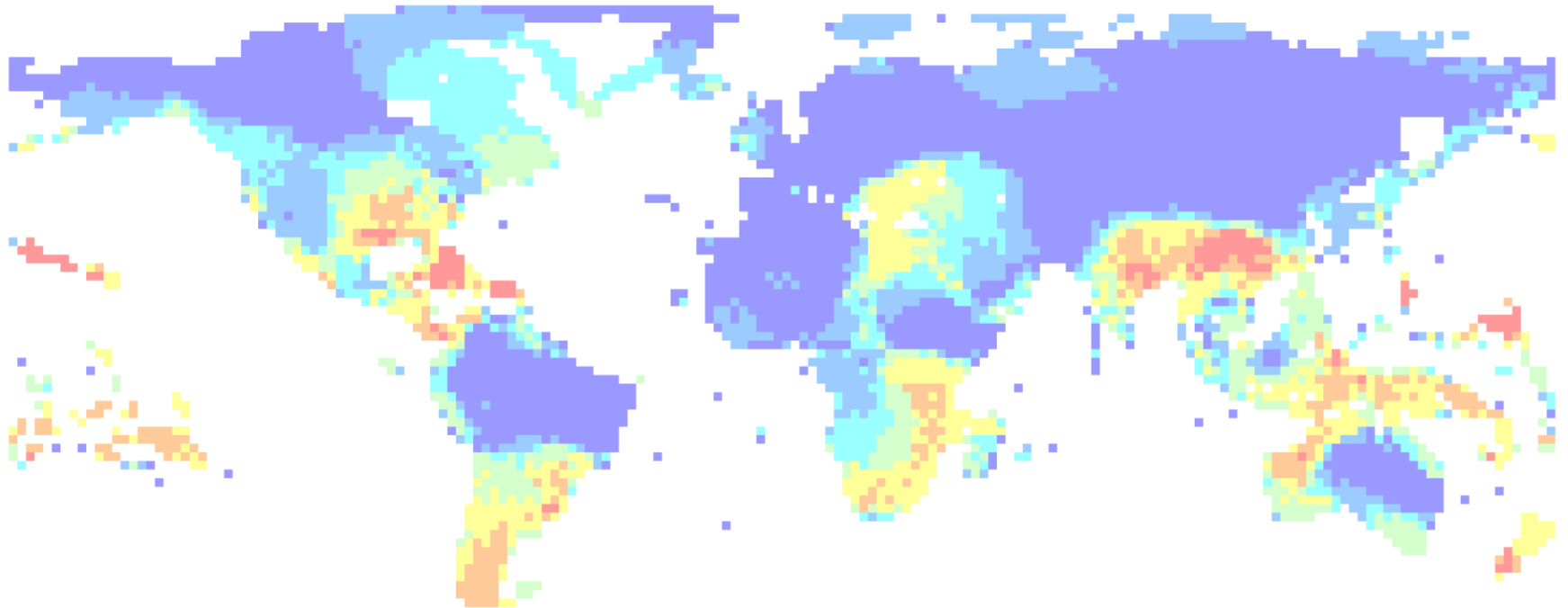
Cold spots, frequency of Low/Low LISA cluster membership, 1990-2015

Surface temperature, anomaly (+)



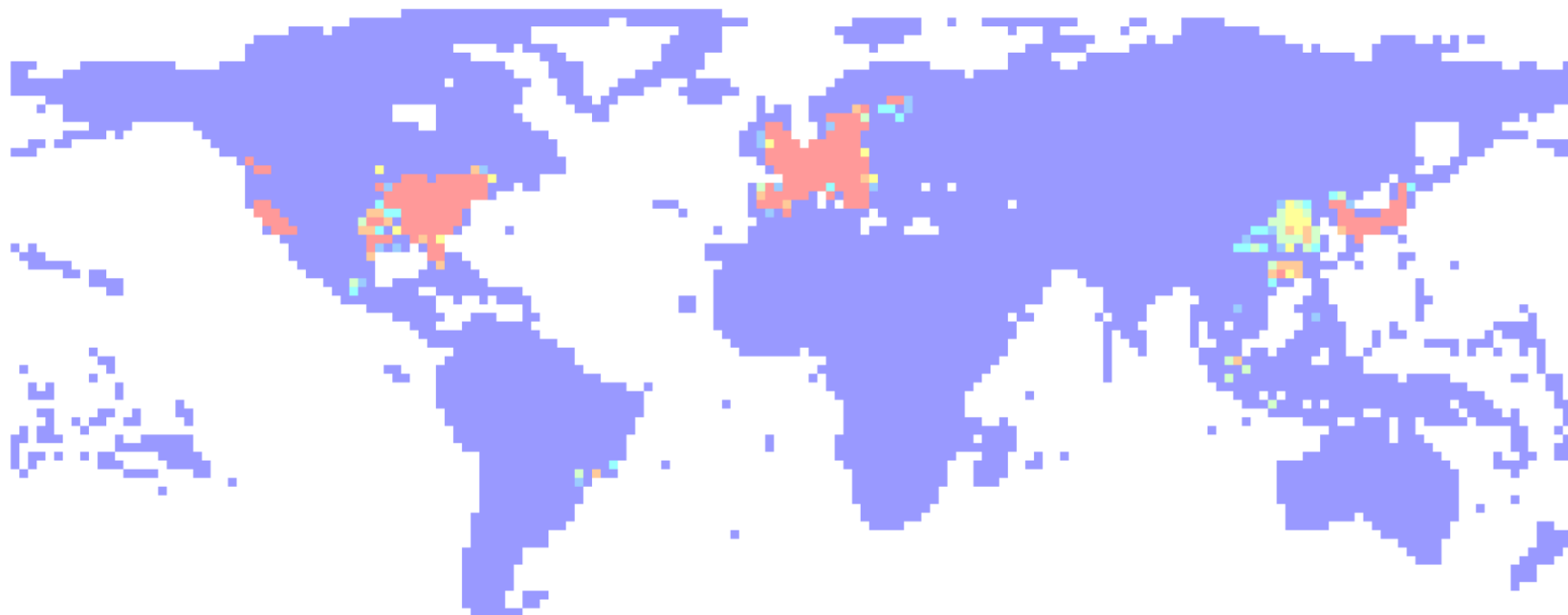
Hot spots, frequency of High/High LISA cluster membership, 1990-2015

Surface temperature, anomaly (-)



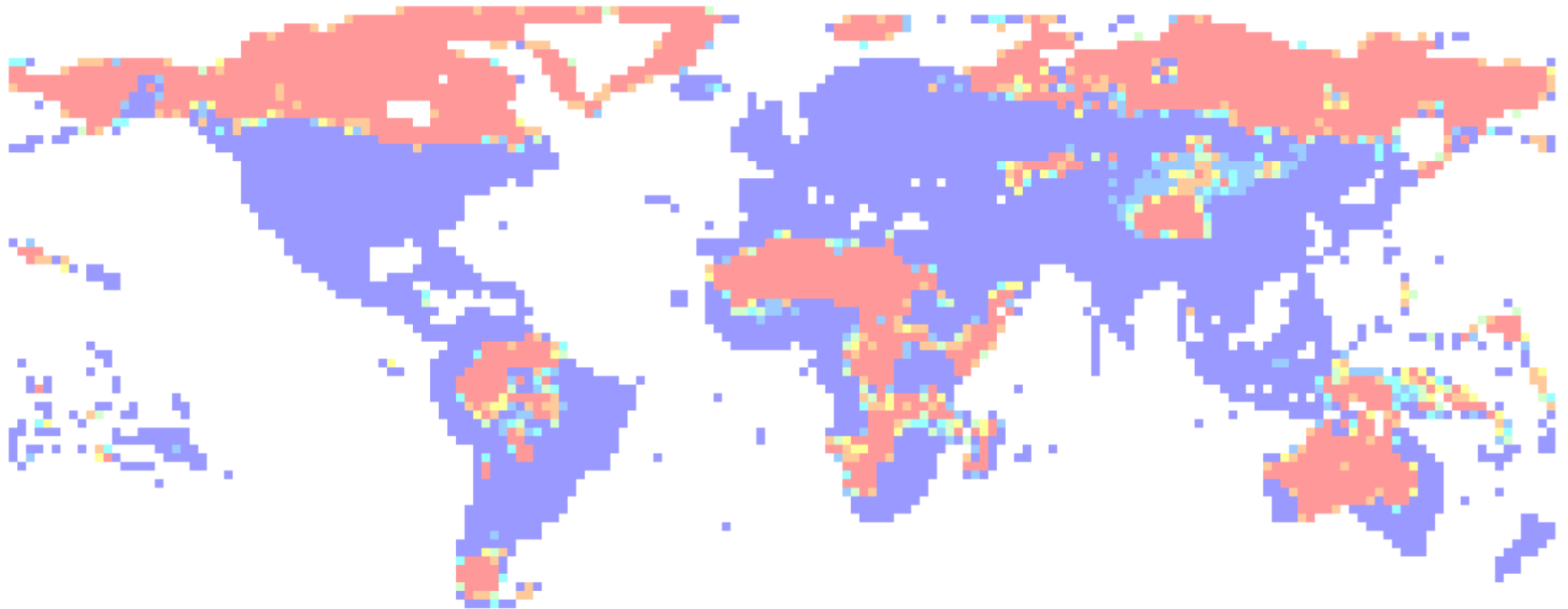
Cold spots, frequency of Low/Low LISA cluster membership, 1990-2015

Gross domestic product, level (+)



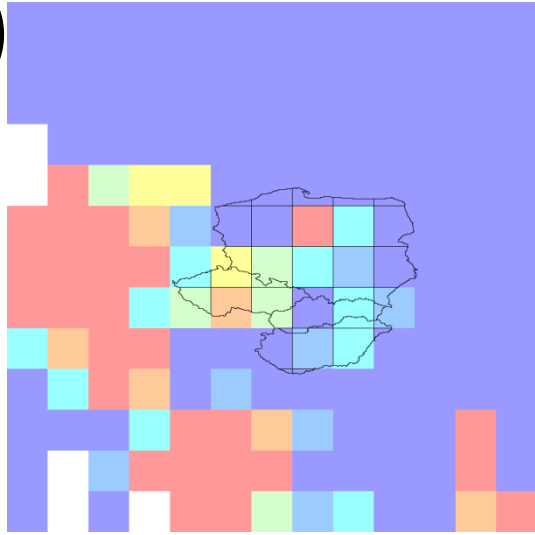
Hot spots, frequency of High/High LISA cluster membership, 1990-2015

Gross domestic product, level (-)

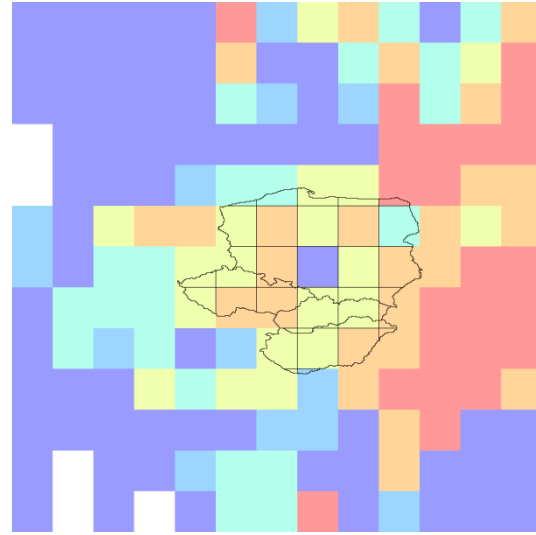


Cold spots, frequency of Low/Low LISA cluster membership, 1990-2015

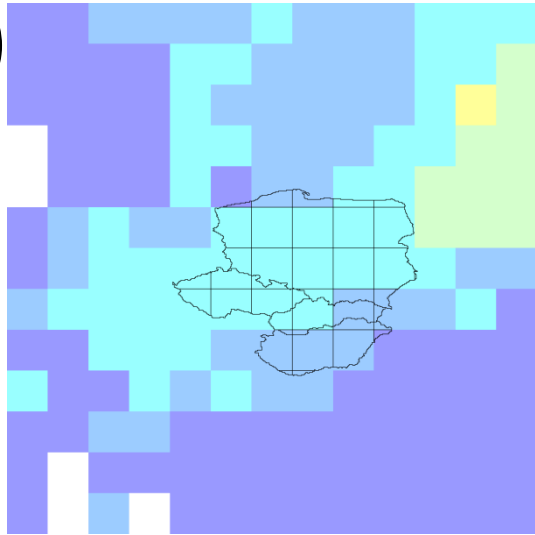
D(+)



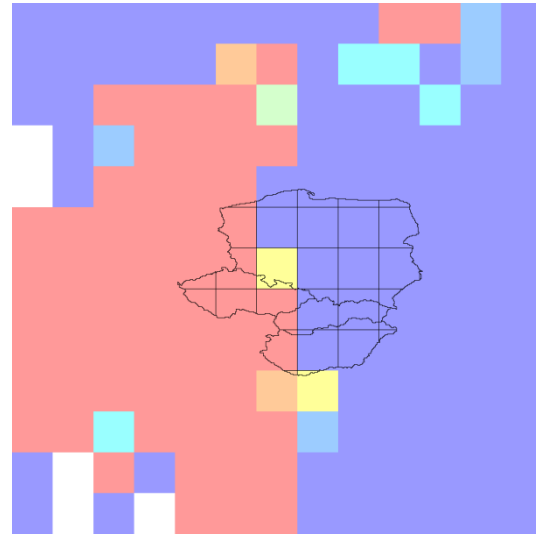
$\Delta D(-)$



A(+)



GDP(+)



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

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

Empirical evidence

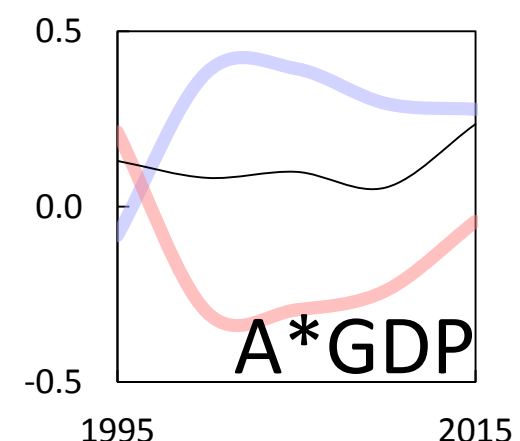
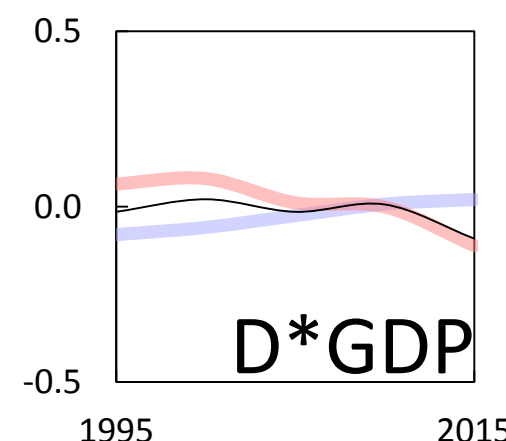
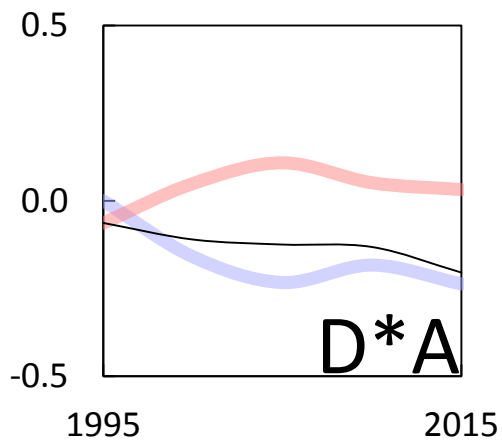
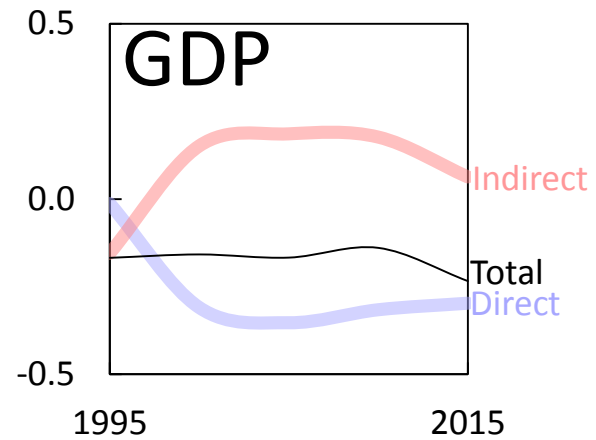
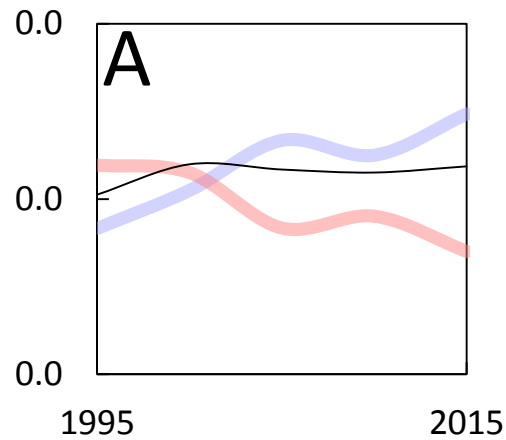
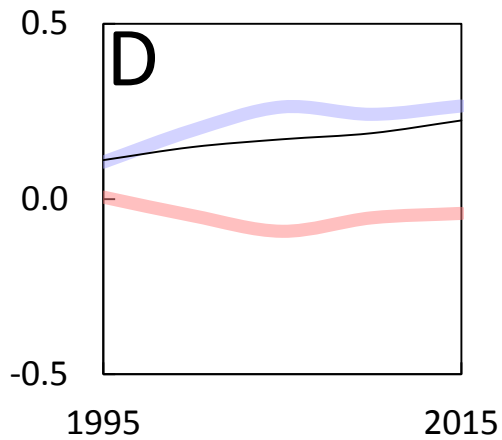
For the case where a global spillover specification is implied by theoretical or substantive aspects of the problem, one need only estimate an SDM specification, the spatial Durbin model

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

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



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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