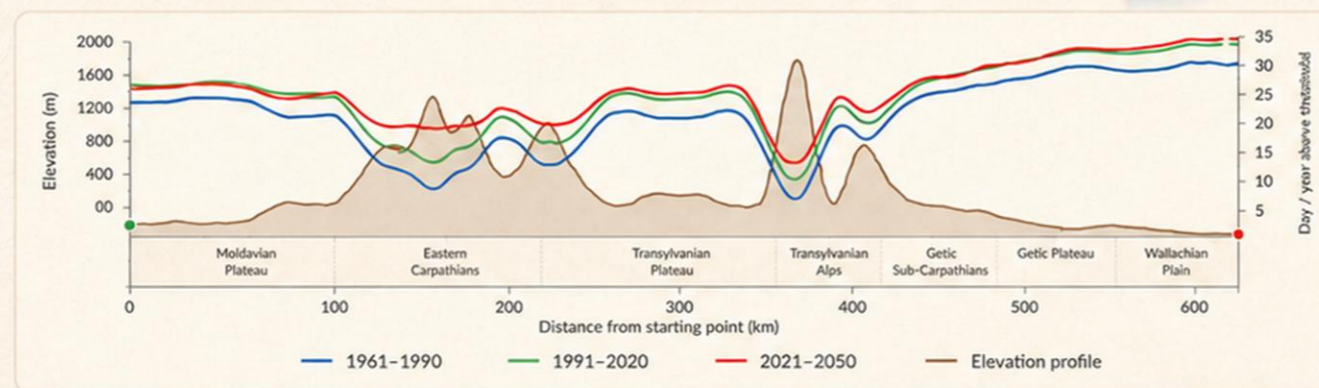
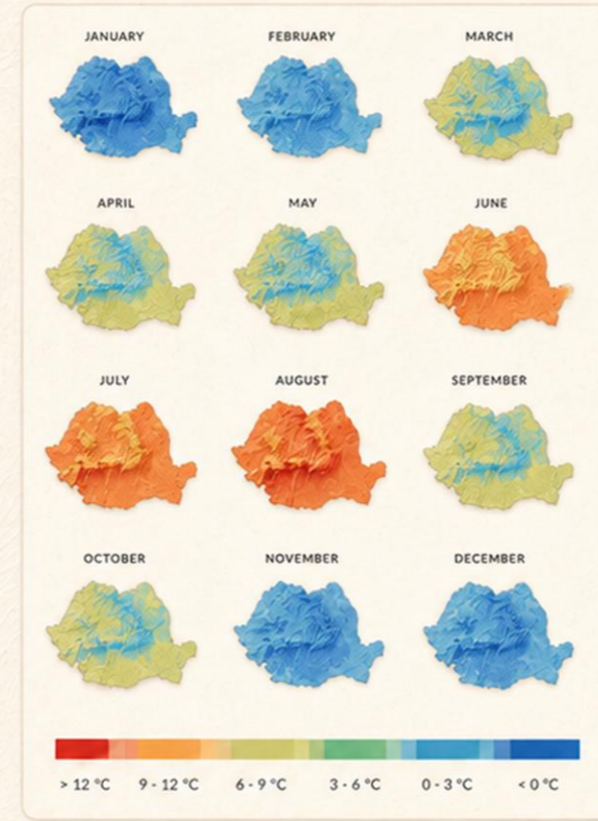
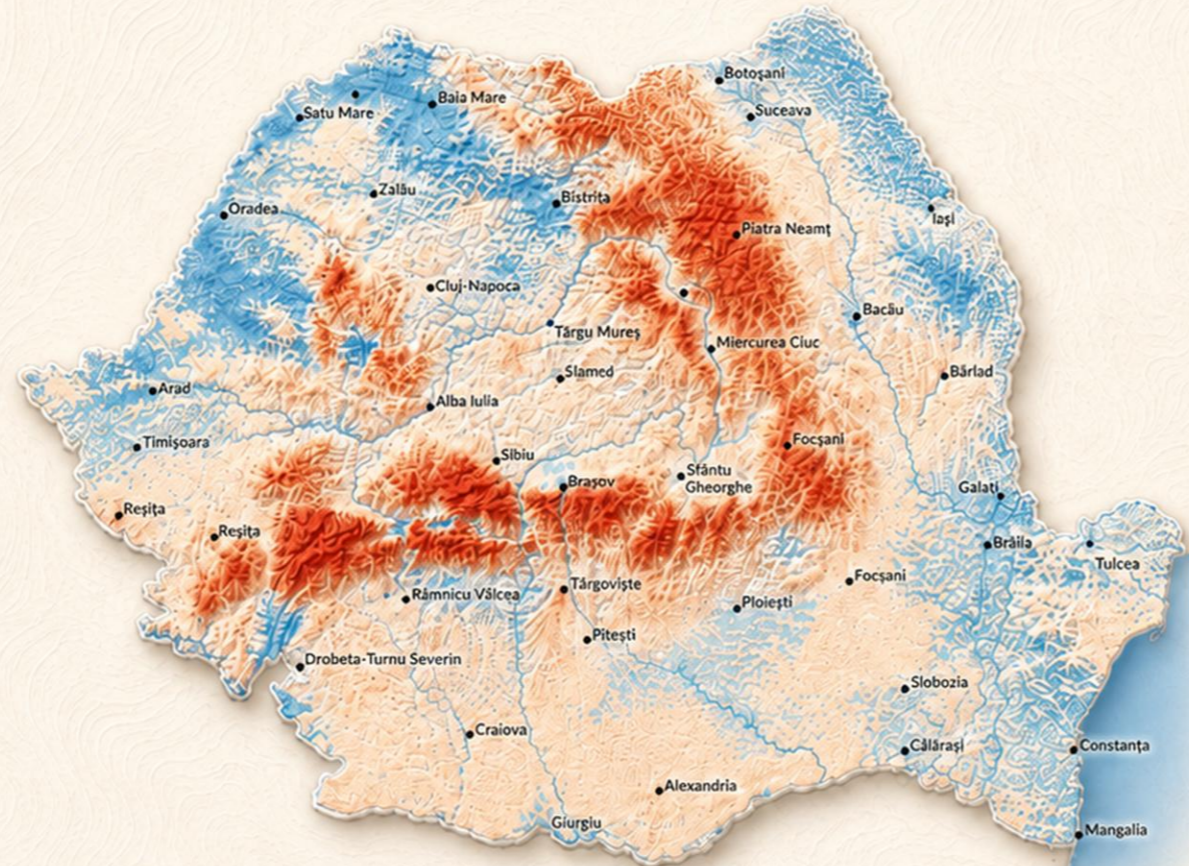


Ionel Haidu · Zsolt Magyari-Sáska · Nicoleta Ionac · Adrian Iraşoc

ATLAS OF ROMANIA'S MAIN CLIMATIC PARAMETERS

Recent Changes, 1961–2020, and Projections for 2021–2050



Area (sqkm)			
	1961 - 1990	1991 - 2020	2021 - 2050
> 12 °C	6	9304	16508
9 - 12 °C	119406	148066	150459
6 - 9 °C	77954	50905	53927
3 - 6 °C	29100	22508	13470
0 - 3 °C	7818	3896	559
< 0 °C	654	259	15

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ATLAS OF ROMANIA'S MAIN CLIMATIC PARAMETERS

Recent Changes, 1961–2020, and Projections for 2021–2050

Ionel Haidu, Zsolt Magyari-Sáska, Nicoleta Ionac & Adrian Iraşoc

This atlas is a special issue of the *journal Geographia Technica*, Volume 21, No. 4.

Presa Universitară Clujeană - 2026

INTRODUCTION

The atlas is based on monthly mean data for the main climatic parameters: mean air temperature, maximum temperature, minimum temperature, cloudiness, sunshine duration, air pressure, wind, relative humidity, precipitation, and snow-cover depth, recorded at 155 meteorological stations.

The WMO defines standard climatological normals as 30-year periods updated every decade, while 1961-1990 remains an important reference period for assessing long-term climate change. 1991-2020 is the most recent observed climatological normal, and 2021-2050 is presented as a projection period constructed on the basis of RCP4.5 / CORDEX - ALADIN.

RCP4.5 is a stabilization pathway used in CMIP5/CORDEX climate experiments. In this atlas it provides the forcing scenario under which the regional projections are interpreted. The CORDEX-ALADIN family consists of high-resolution regional climate models (RCMs) developed by adapting the ALADIN numerical weather prediction model for long-term climate simulations within the international CORDEX initiative. The outputs for 2021–2050 are derived from simulations specifically configured to capture high-resolution atmospheric processes. These data provide a detailed representation of local climate interactions and extreme events, offering a robust foundation for regional impact assessments.

Chapters 2–5 of the atlas comprise 780 maps at various scales, 35 tables, and 95 profiles/graphs distributed by specific parameters and across the three climatological normal periods. Chapter 6 includes summary data tables for the three normal periods for each analyzed climate parameter across 62 meteorological stations, accompanied by indices to capture the changes between normal periods and their statistical significance. Tables for the remaining 93 meteorological stations are also available and can be accessed via the specified link.

We would like to believe that the scientific content is relevant and of interest to researchers, specialists, students, and institutions interested in the fields of climatology, geography, environmental science, and climate change.

The development of this atlas was made possible through the support of the “Geographia Technica” Association.

INTRODUCERE

Atlasul se bazează pe date medii lunare pentru principalii parametri climatici: temperatura medie a aerului, temperatura maximă, temperatura minimă, nebulozitatea, durata de strălucire a Soarelui, presiunea atmosferică, vântul, umiditatea relativă, precipitațiile și grosimea stratului de zăpadă, înregistrate la 155 de stații meteorologice.

OMM definește normalele climatologice standard ca perioade de 30 de ani actualizate o dată la fiecare deceniu, în timp ce 1961-1990 rămâne o perioadă importantă de referință pentru evaluarea schimbărilor climatice pe termen lung. 1991-2020 este cea mai recentă normală climatologică observată, iar 2021-2050 este prezentată ca perioadă de proiecție construită pe baza RCP4.5 / CORDEX - ALADIN.

RCP4.5 este un scenariu de stabilizare utilizat în experimentele climatice CMIP5/CORDEX. În acest atlas, acesta oferă scenariul de forțaj în funcție de care sunt interpretate proiecțiile regionale. Familia CORDEX-ALADIN grupează modele climatice regionale (RCM) de înaltă rezoluție, dezvoltate prin adaptarea modelului numeric de prognoză meteo ALADIN pentru simulări climatice pe termen lung în cadrul inițiativei internaționale CORDEX. Rezultatele pentru perioada 2021–2050 sunt derivate din simulări configurate specific pentru a surprinde procese atmosferice la rezoluție înaltă. Aceste date oferă o reprezentare detaliată a interacțiunilor climatice locale și a fenomenelor extreme, constituind o bază robustă pentru studiile de impact regional.

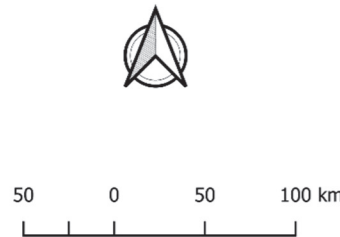
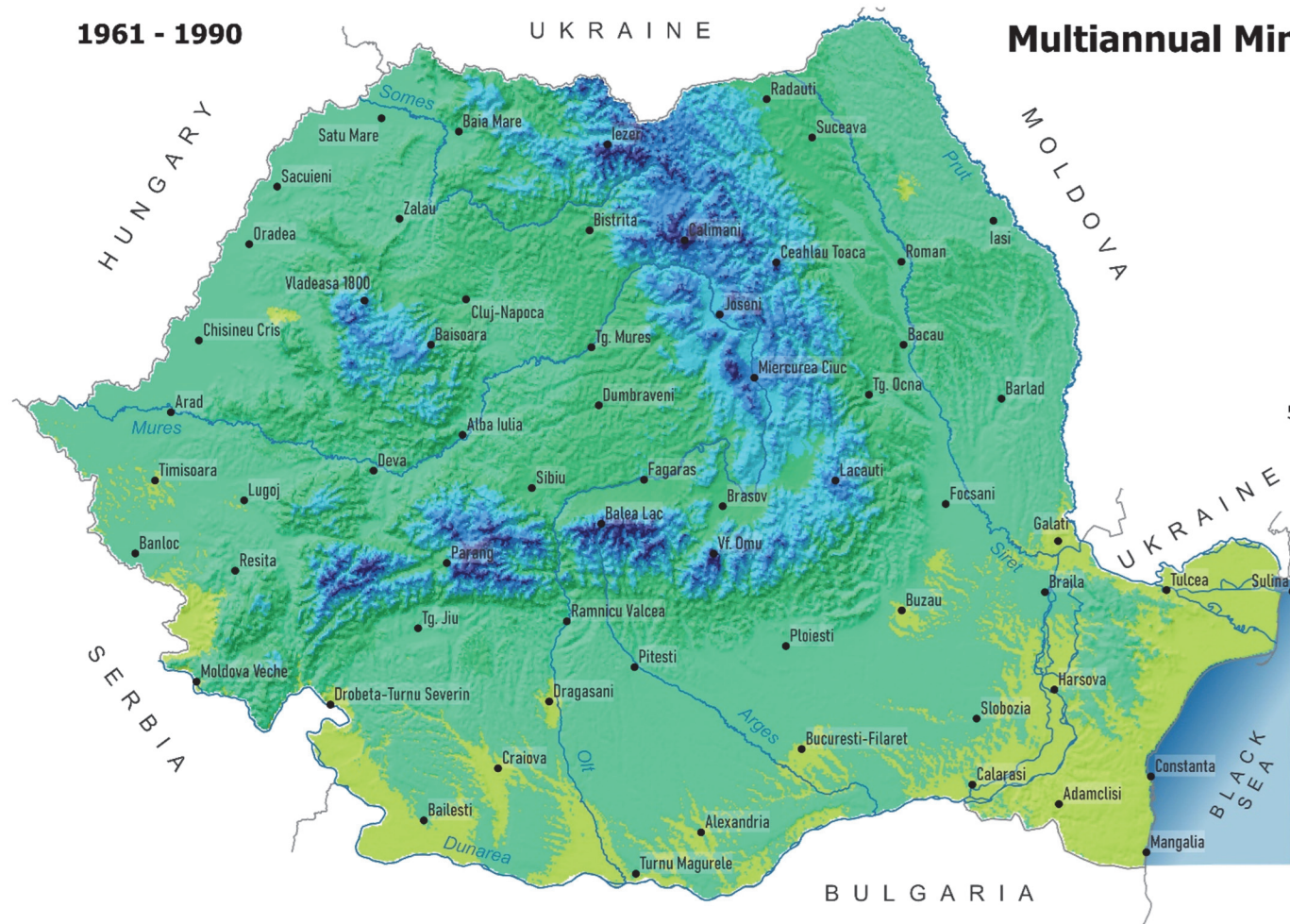
Capitolele 2 -5 ale atlasului însumează 780 de hărți la diferite scări, 35 de tabele și 95 de profile/grafice distribuite pe parametrii specifici și pe cele 3 perioade normale. Capitolul 6 cuprinde tabele de date sintetice pe cele 3 perioade normale pentru fiecare parametru climatic analizat de la 62 de stații meteorologice, însoțite de indicii pentru a surprinde schimbarea dintre perioadele normale și semnificația ei statistică. Există tabele și pentru celelalte 93 de stații meteorologice și pot fi accesate prin linkul specificat.

Avem încredere că acest conținut științific va fi de o reală relevanță și un real interes pentru cercetători, specialiști, studenți și instituții active în domeniile climatologiei, geografiei, științei mediului și schimbărilor climatice.

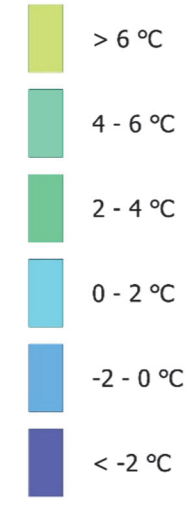
Realizarea acestui atlas a fost posibilă cu sprijinul acordat de Asociația „Geographia Technica”

1961 - 1990

Multiannual Minimum Temperature



Temperature



	Area (sqkm)		
	1961 - 1990	1991 - 2020	2021-2050
> 6 °C	28440	86867	99866
4 - 6 °C	109305	84042	87875
2 - 4 °C	57284	36103	34553
0 - 2 °C	24195	20493	12006
-2 - 0 °C	13091	6586	623
< -2 °C	2623	847	15

- Main rivers
- Meteorological stations

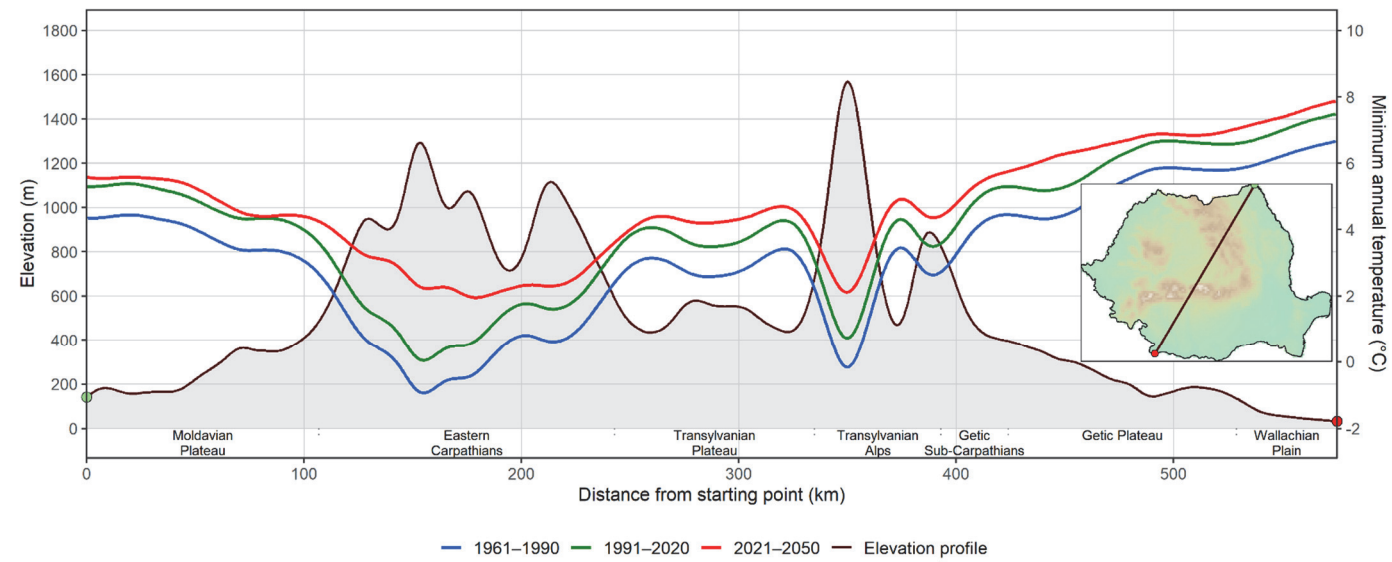
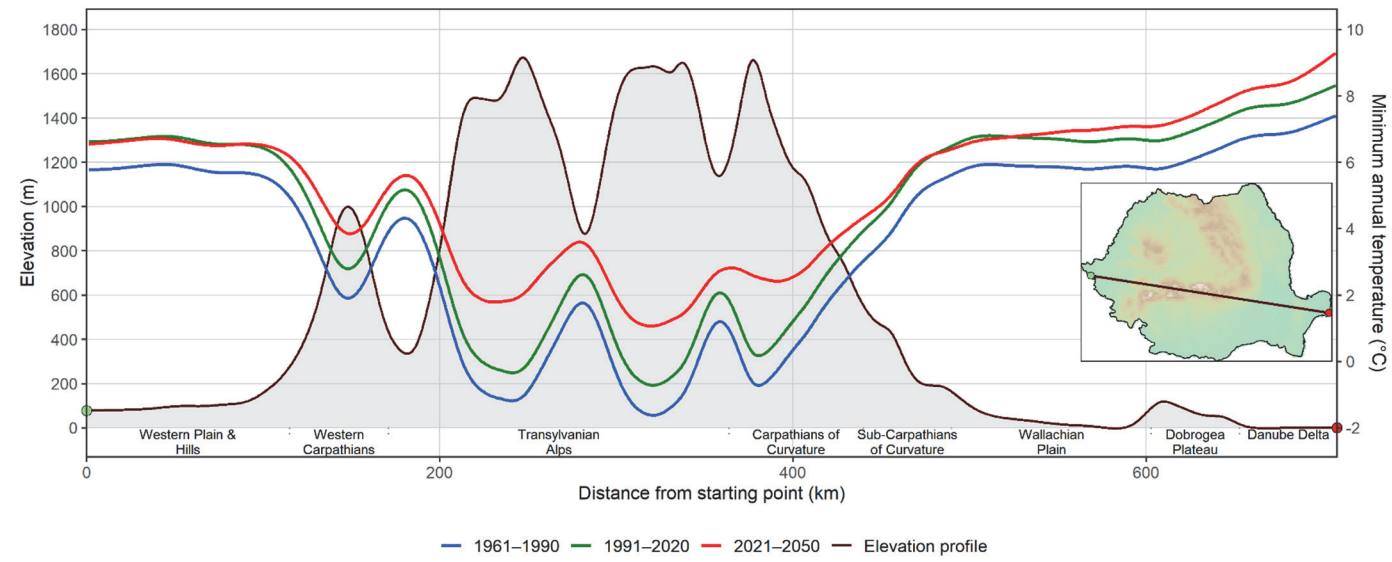
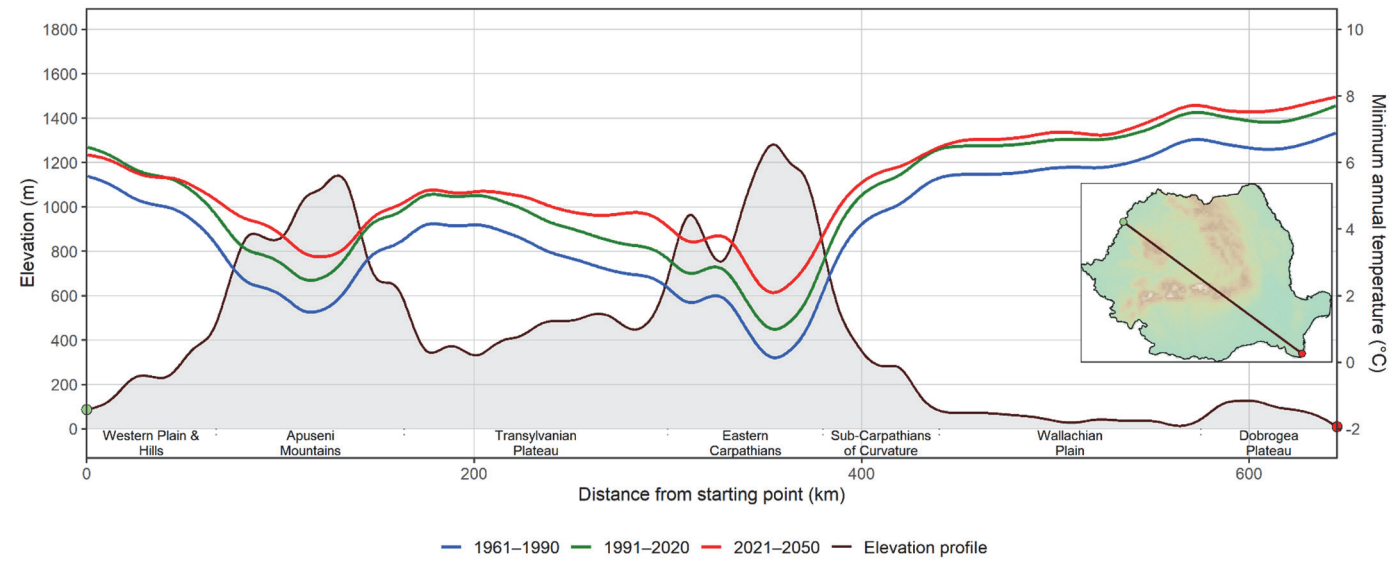
1991 - 2020



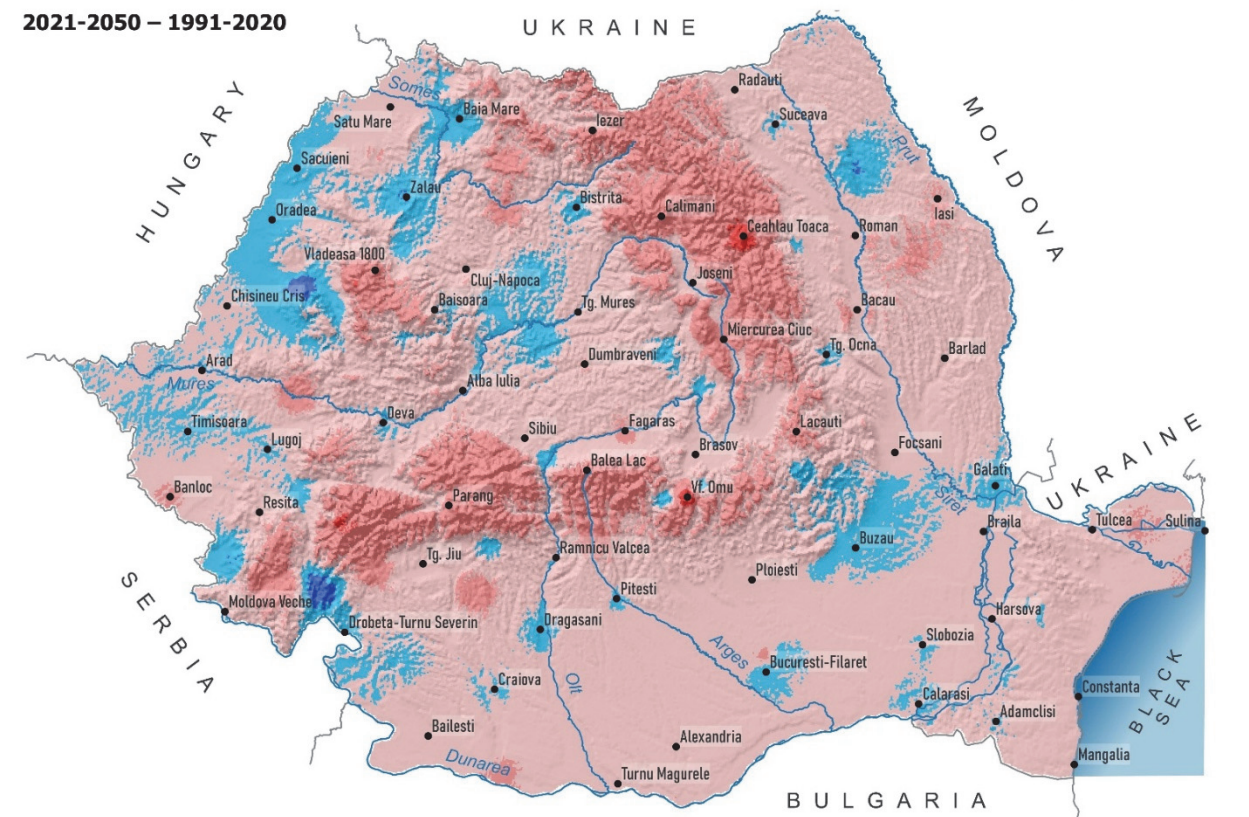
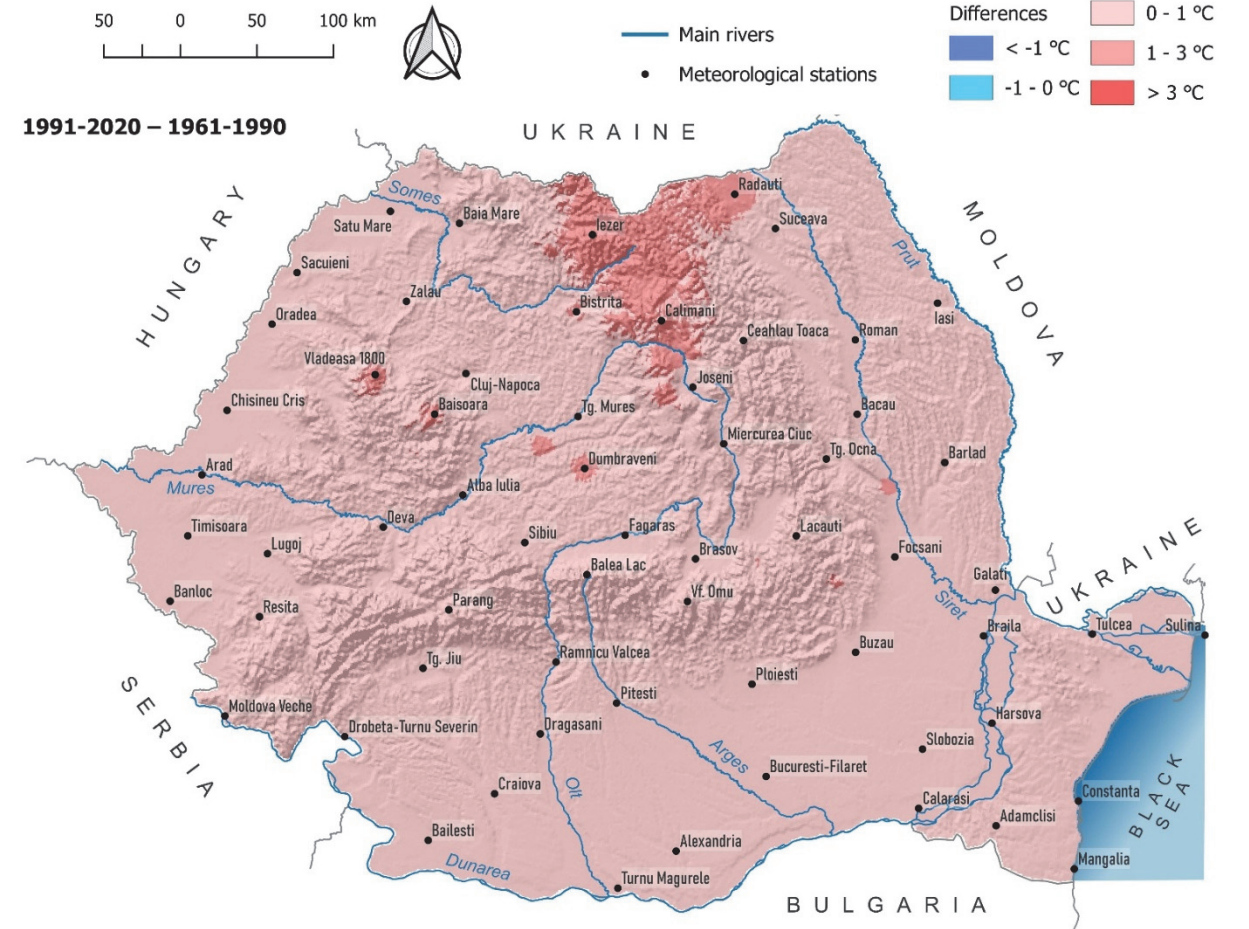
2021 - 2050



Combined elevation and minimum annual temperature profile



Difference maps



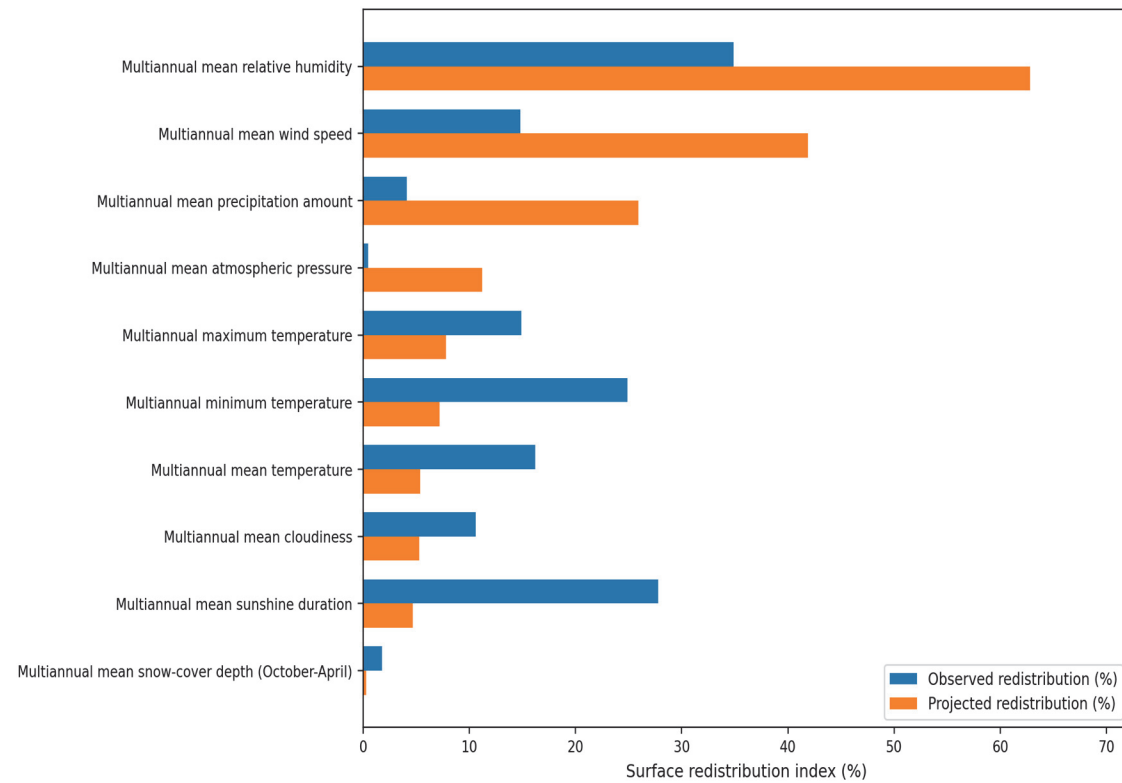


Figure 1. Observed and projected redistribution of areas by legend class.

Spatially, the largest changes with potentially high impact are concentrated in low and intermediate units: the Romanian Plain, the Western Plain, the Moldavian Plateau, the Dobrogea Plateau, the Danube Delta, and the Getic Plateau. These units have low or medium elevations, high temperatures, long sunshine duration, declining relative humidity, and a projected reduction in precipitation. In these areas, the risk of climatic aridization may intensify, especially when temperature increase is combined with the decrease in relative humidity and the expansion of the <400 mm precipitation class.

In mountainous units, the changes are expressed differently. The Southern Carpathians, Eastern Carpathians, and Apuseni Mountains remain the coldest, cloudiest, most humid areas, richest in precipitation and snow cover, but the thresholds shift altitudinally. Cold thermal classes contract, very high precipitation classes decrease sharply in the projection, and thick snow-cover classes decline slightly after 1991-2020. Thus, the mountains do not become similar to the plains, but they lose part of the climatic contrast that differentiates them.

The Subcarpathians, the Western Hills, the Transylvanian Plateau, and the Getic Plateau are transition zones and, for this reason, are sensitive to threshold migration. A temperature increase or a precipitation decrease can shift these units from a relatively favorable climatic regime toward a more pronounced water-stress regime. In terms of snow, the critical zone is not necessarily the highest summit, but the medium altitudinal belt, where slight warming changes the snow/rain ratio and the duration of snow-cover persistence.

In conclusion, the largest projected changes cannot be reduced to air temperature alone. The dominant signal is a combination of warming, greater sunshine, much lower relative humidity, and reduced mean annual precipitation. The smallest areal changes occur for snow cover and, in the observed period, for atmospheric pressure; however, these parameters are strongly linked to altitude and may have important local effects. The atlas therefore shows a Romania that is climatically warmer, sunnier, and potentially drier in the lowlands, while the mountain domain remains distinct but with climatic belts shifted toward higher altitudes.

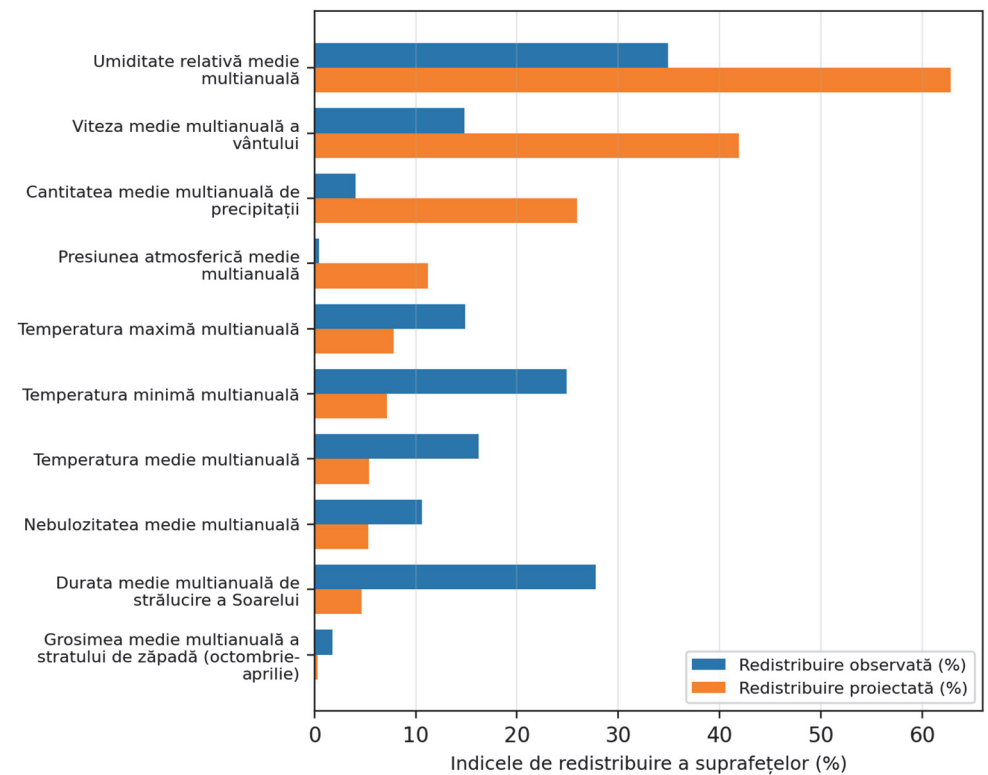


Figura 1. Redistribuirea observată și proiectată a suprafețelor pe clase de legendă

Spațial, cele mai mari schimbări cu impact potențial ridicat se concentrează în unitățile joase și intermediare: Câmpia Română, Câmpia de Vest, Podișul Moldovei, Podișul Dobrogei, Delta Dunării și Podișul Getic. Aceste unități au altitudini joase sau medii, temperaturi ridicate, durată mare de strălucire a Soarelui, umiditate relativă în scădere și o reducere proiectată a precipitațiilor. În aceste regiuni, riscul de aridizare climatică se poate intensifica, mai ales atunci când creșterea temperaturii se combină cu scăderea umidității relative și cu extinderea clasei de precipitații <400 mm.

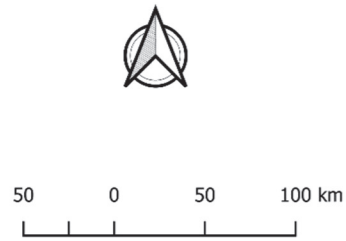
În unitățile montane, schimbările se exprimă diferit. Carpații Meridionali, Carpații Orientali și Munții Apuseni rămân cele mai reci, mai noroase, mai umede arii, cele mai bogate în precipitații și strat de zăpadă, dar pragurile se deplasează altitudinal. Clasele termice reci se contractă, clasele cu precipitații foarte ridicate scad accentuat în proiecție, iar clasele cu strat gros de zăpadă se reduc ușor după 1991-2020. Astfel, munții nu devin asemănători câmpiilor, dar pierd o parte din contrastul climatic care îi diferențiază.

Subcarpații, Dealurile de Vest, Podișul Transilvaniei și Podișul Getic sunt zone de tranziție și, din acest motiv, sunt sensibile la migrarea pragurilor. O creștere a temperaturii sau o scădere a precipitațiilor poate deplasa aceste unități de la un regim climatic relativ favorabil către un regim de stres hidric mai pronunțat. În ceea ce privește zăpada, zona critică nu este neapărat vârful cel mai înalt, ci etajul altitudinal mediu, unde o ușoară încălzire modifică raportul ninsoare/ploaie și durata persistenței stratului de zăpadă.

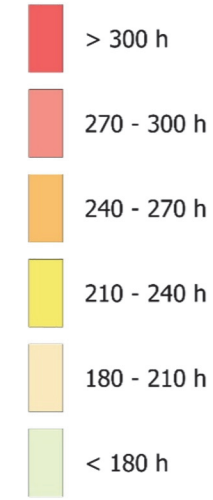
În concluzie, cele mai mari schimbări proiectate nu pot fi reduse doar la temperatura aerului. Semnalul dominant este o combinație între încălzire, insolație mai mare, umiditate relativă mult mai scăzută și reducerea precipitațiilor medii anuale. Cele mai mici schimbări areale apar la stratul de zăpadă și, în perioada observată, la presiunea atmosferică; totuși, acești parametri sunt puternic legați de altitudine și pot avea efecte locale importante. Atlasul arată, așadar, o Românie climatic mai caldă, mai însorită și potențial mai uscată în zonele joase, în timp ce domeniul montan rămâne distinct, dar cu etaje climatice deplasate către altitudini mai mari.

1961 - 1990

Multiannual Sunshine Duration JULY



Sunshine



- Main rivers
- Meteorological stations

Area (sqkm)			
	1961 - 1990	1991 - 2020	2021-2050
> 300 h	35671	73639	85232
270 - 300 h	78364	84051	76227
240 - 270 h	73289	49422	45893
210 - 240 h	31179	20935	20752
180 - 210 h	13451	4920	5013
< 180 h	2984	1971	1821

1991 - 2020



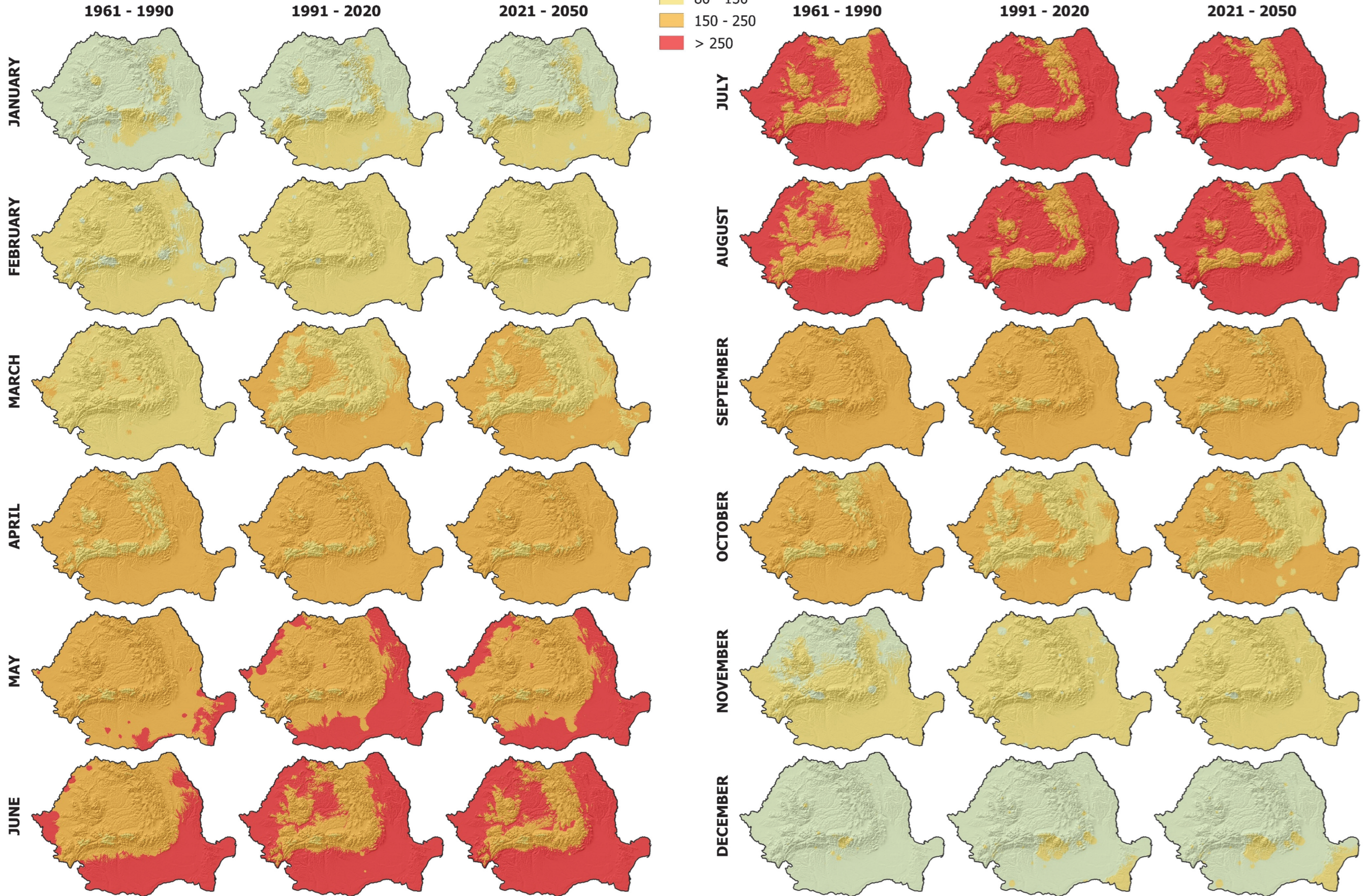
2021 - 2050

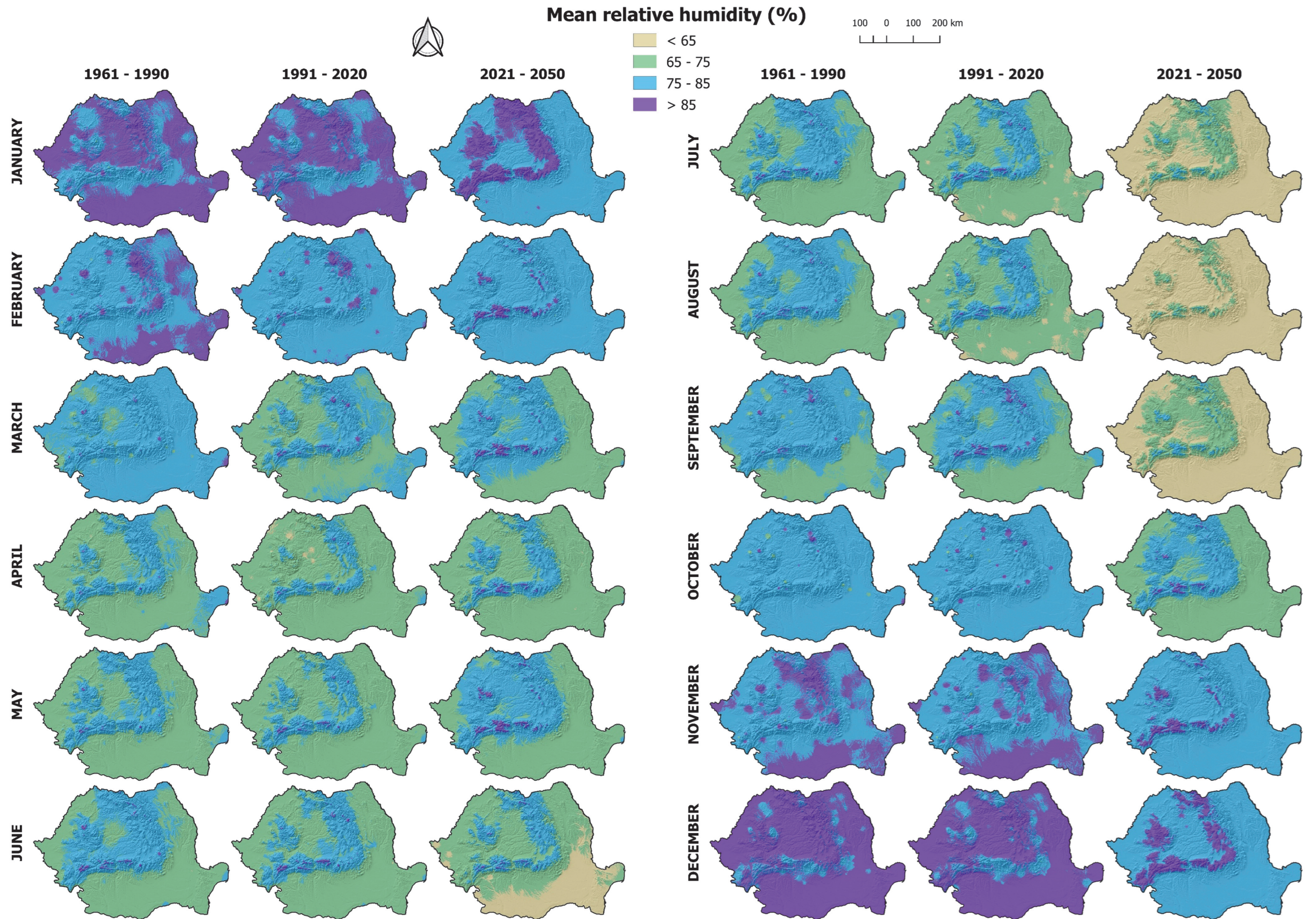


Mean sunshine duration (hours)

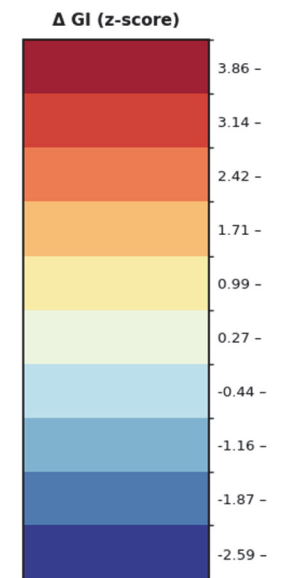
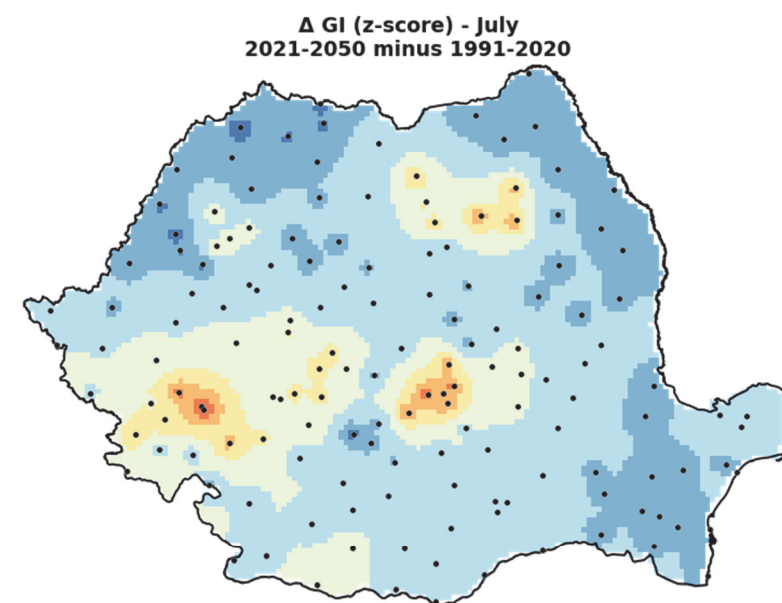
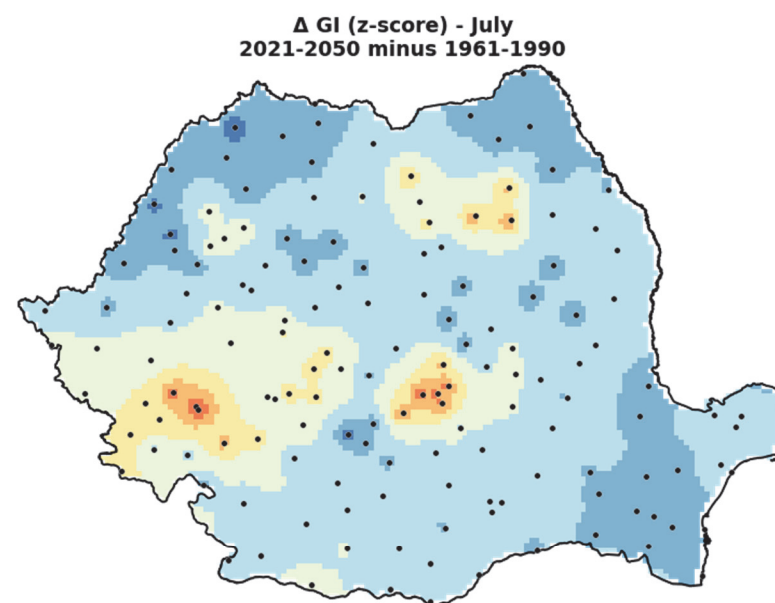
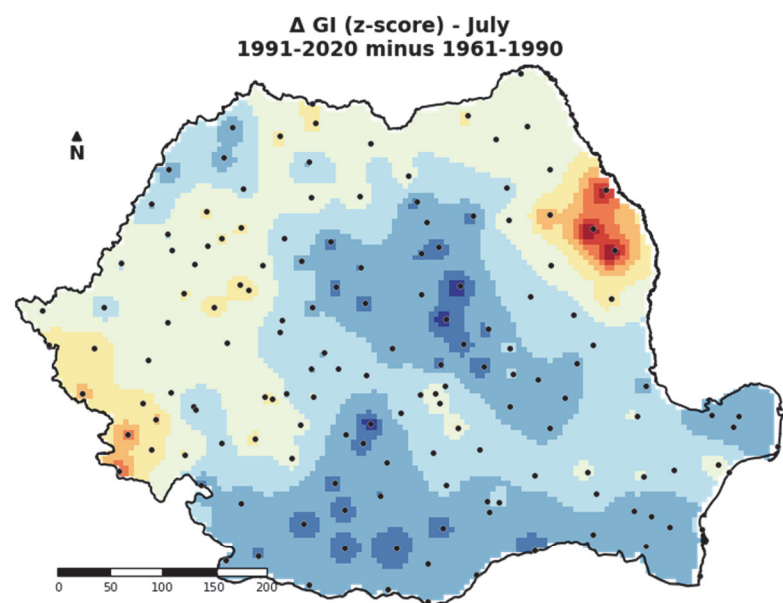
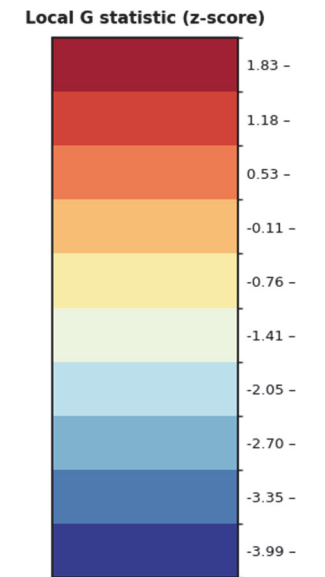
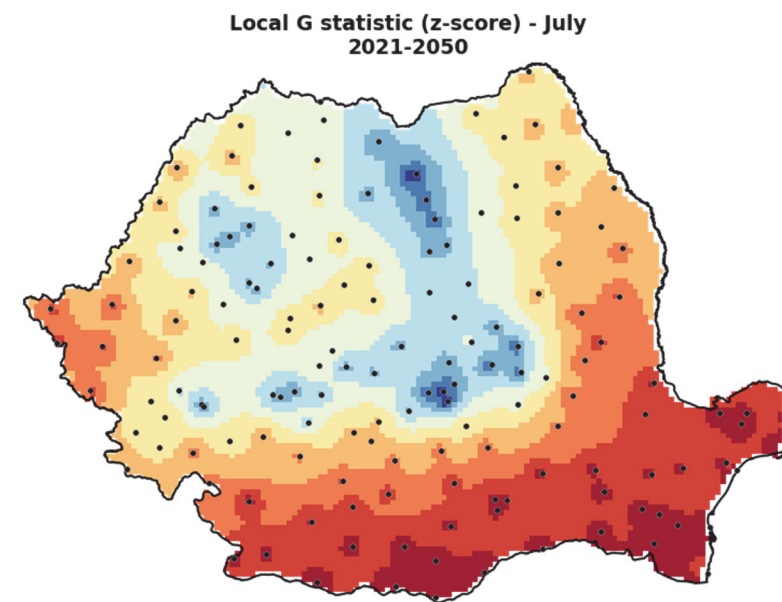
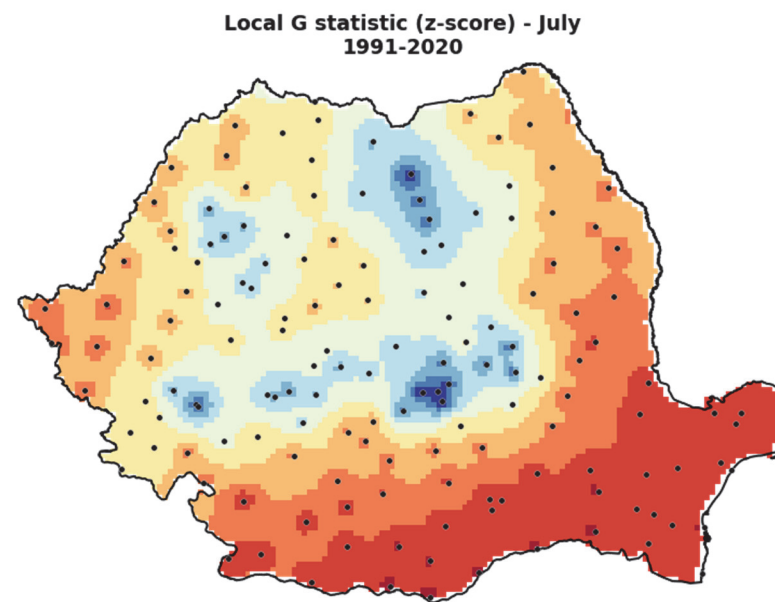
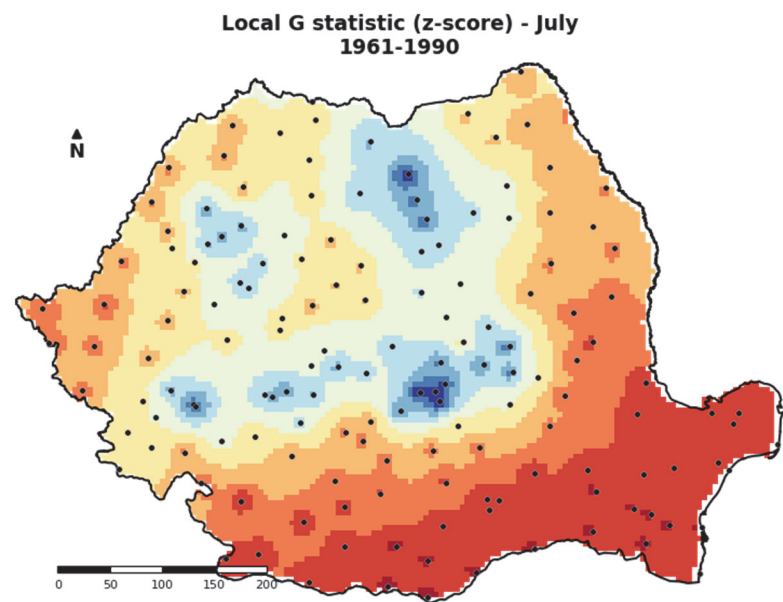
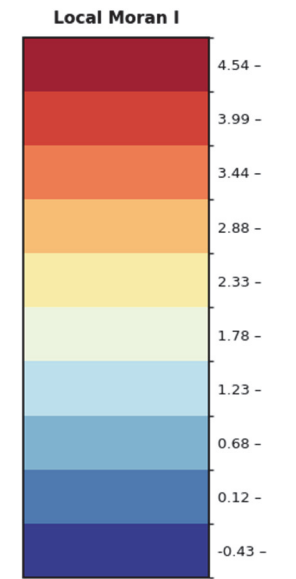
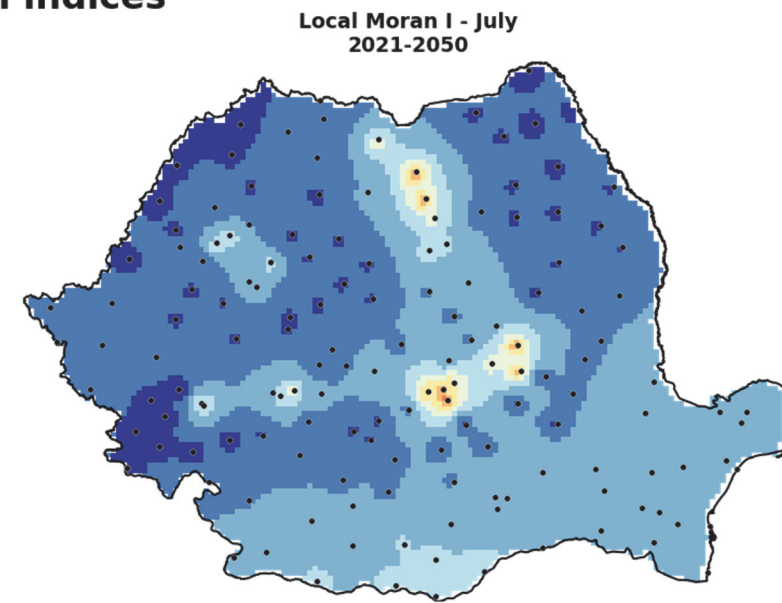
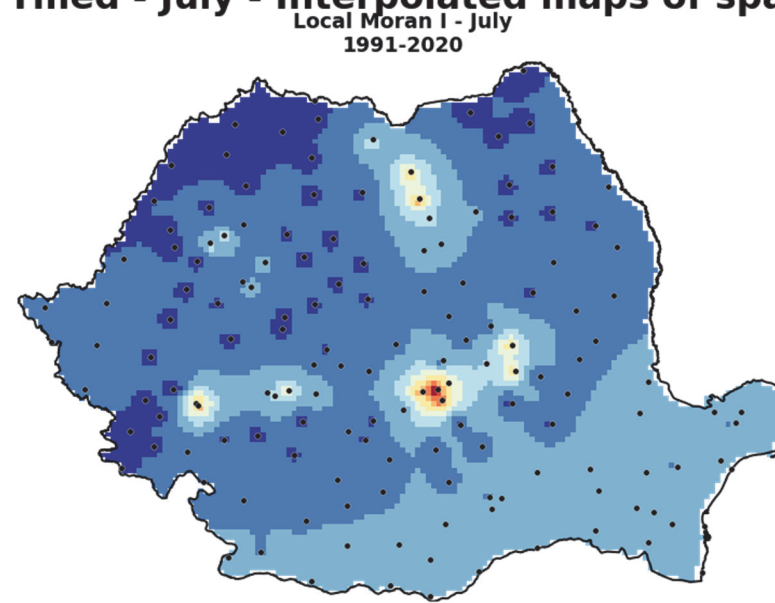
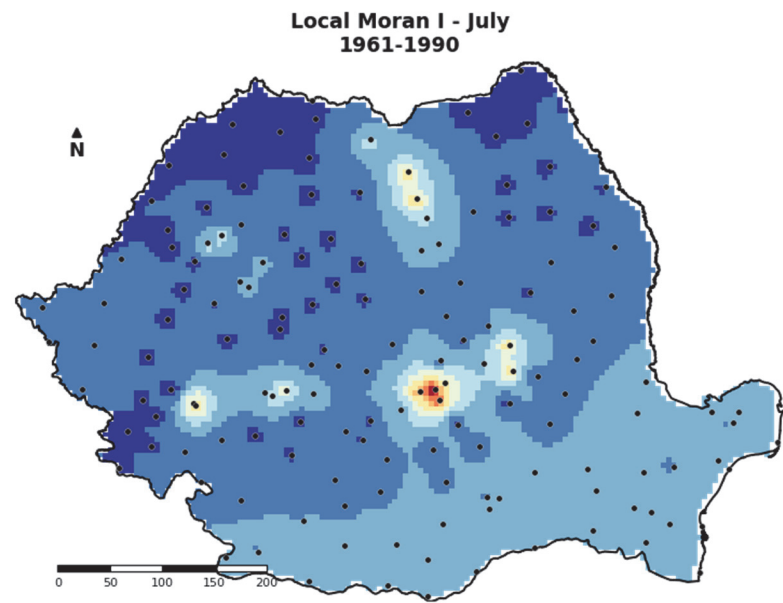


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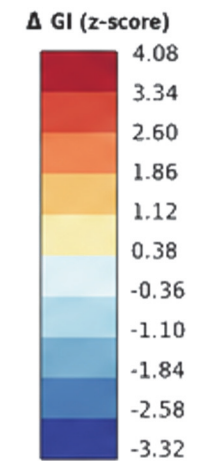
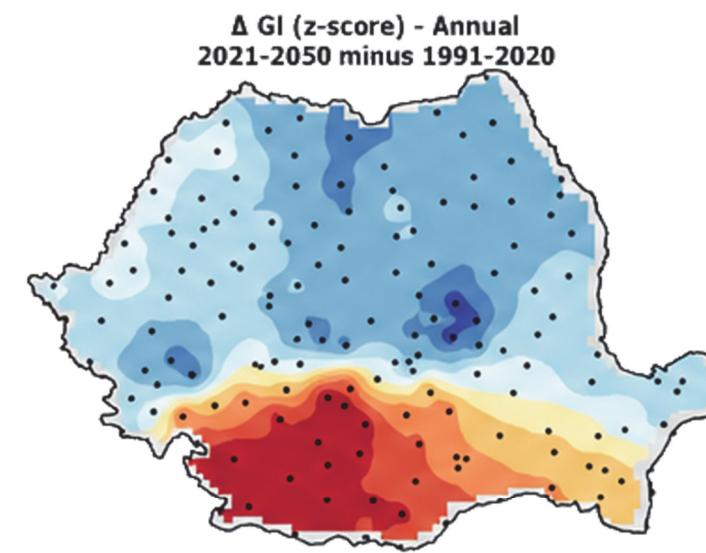
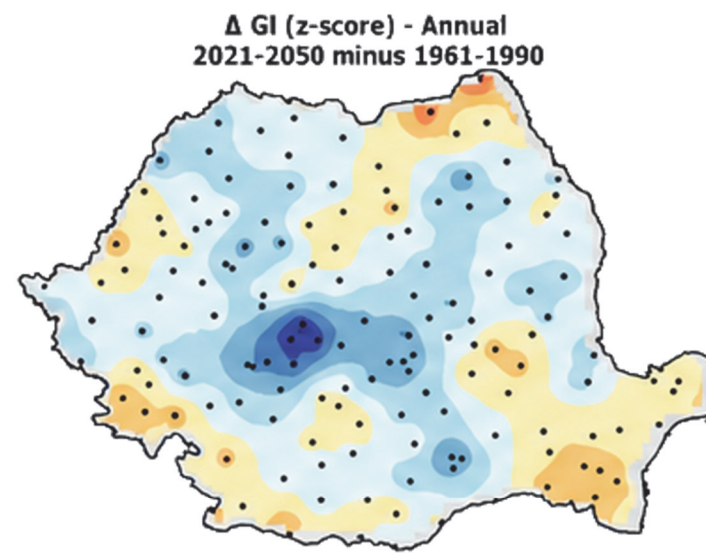
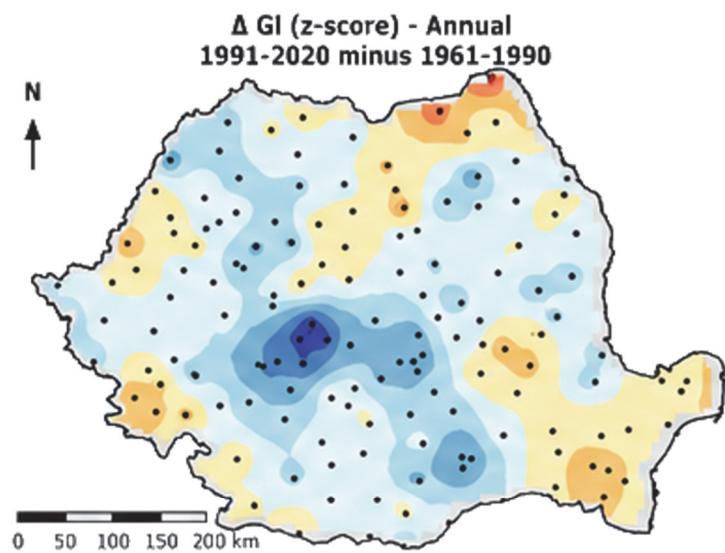
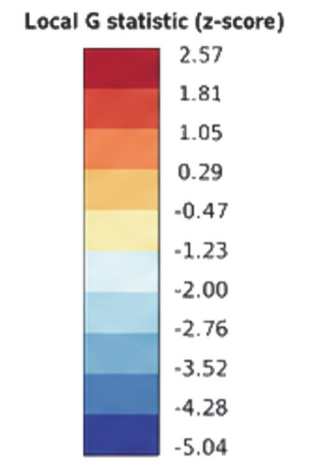
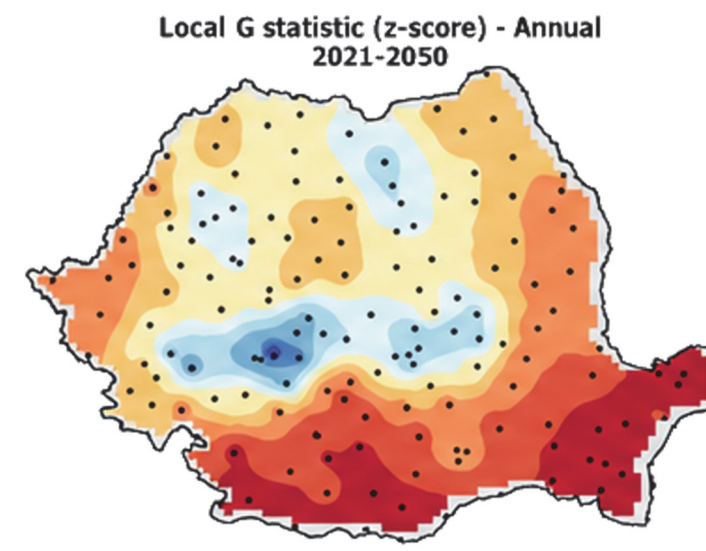
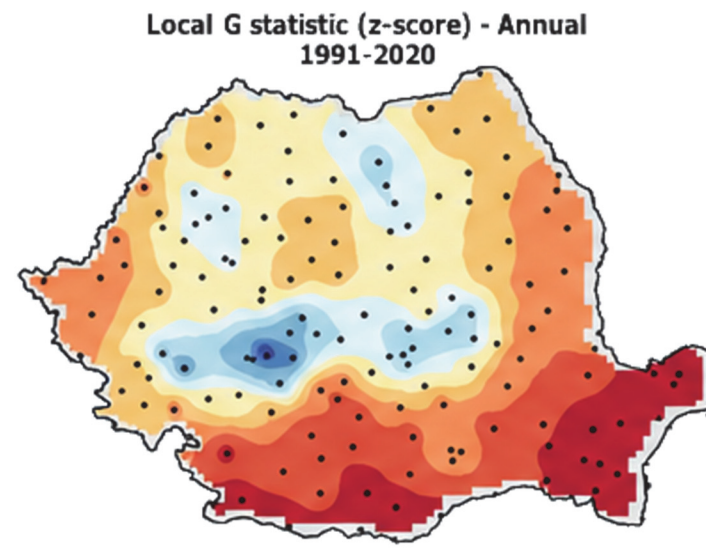
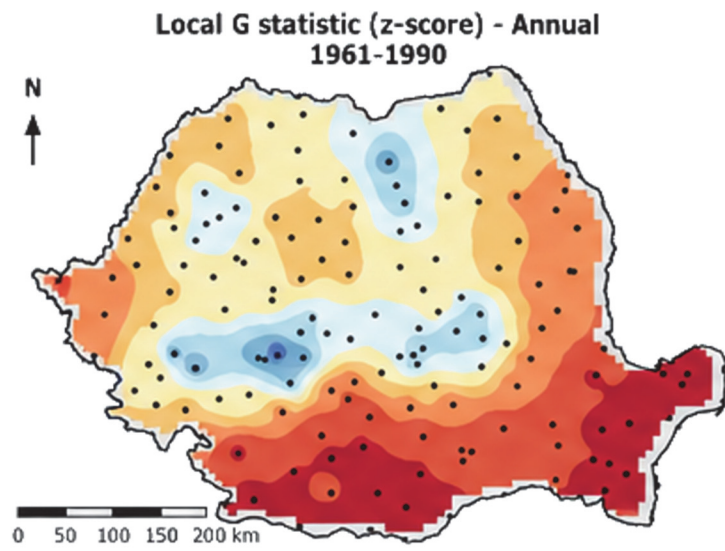
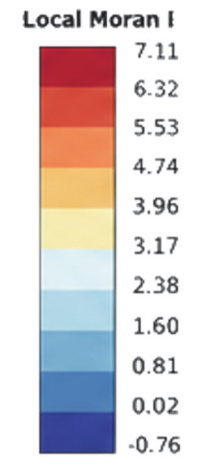
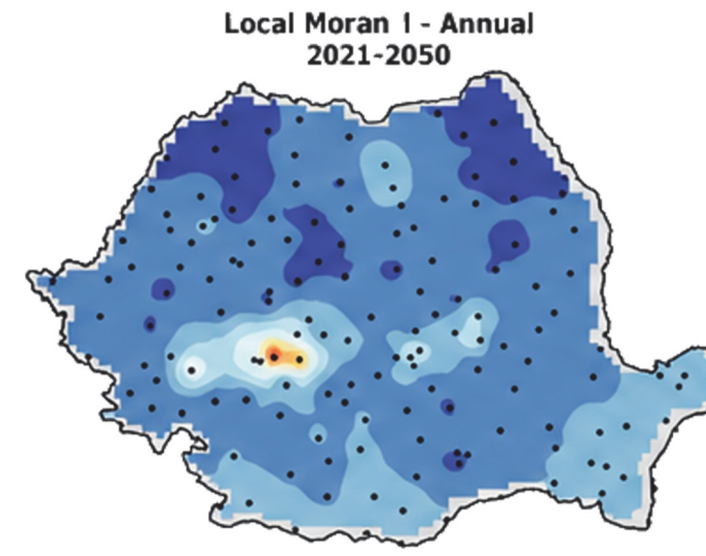
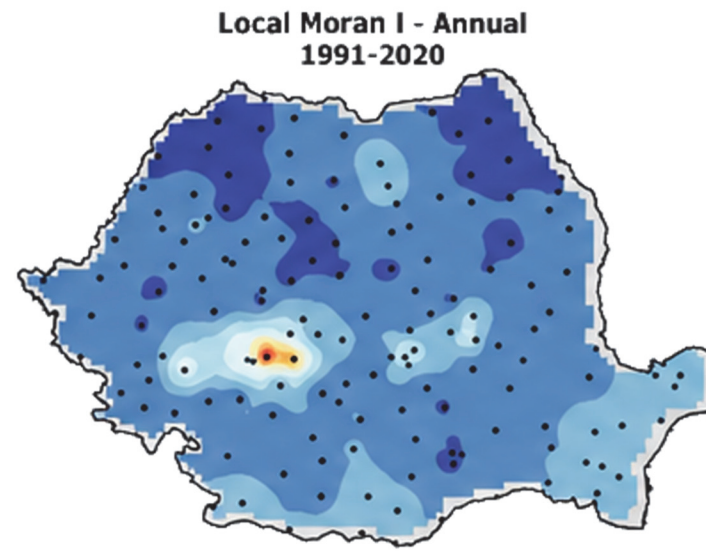
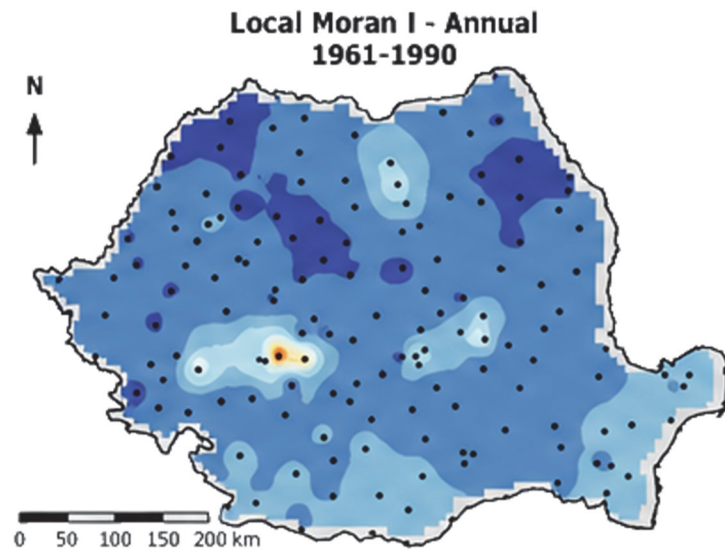




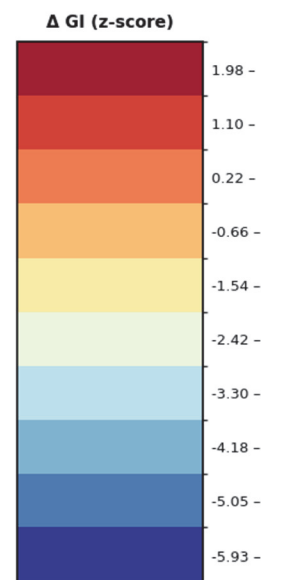
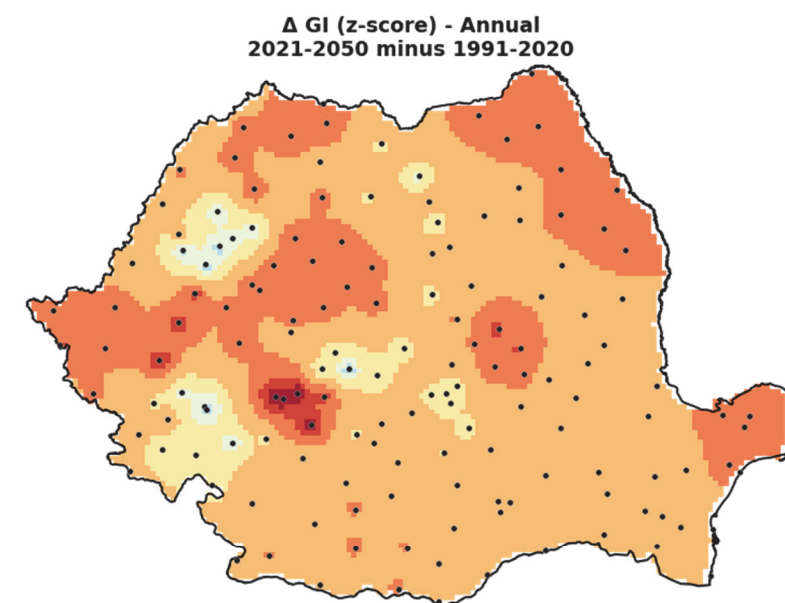
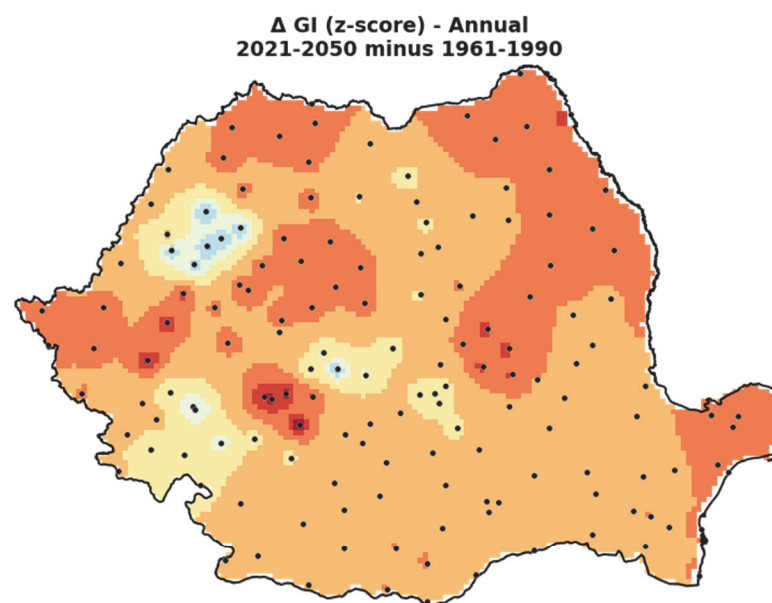
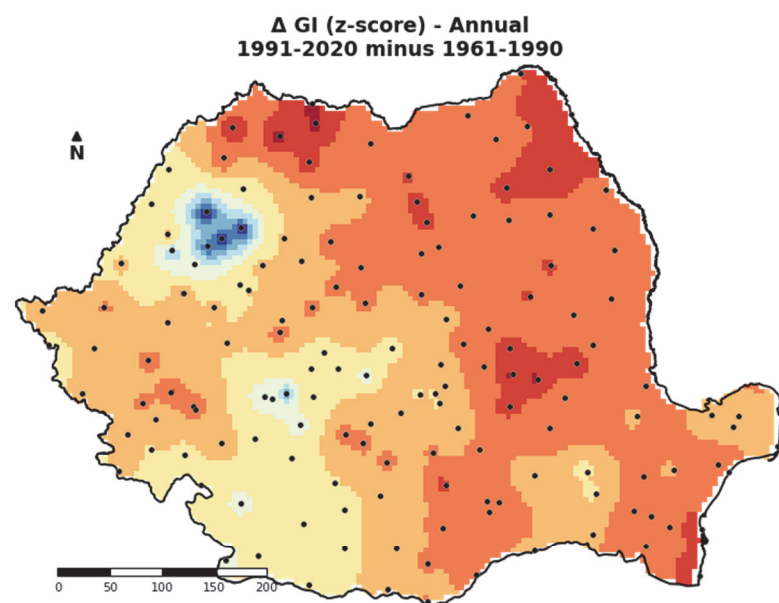
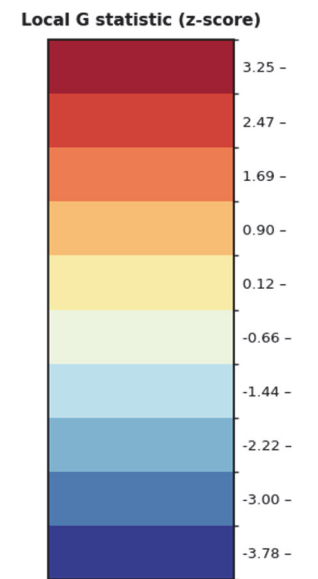
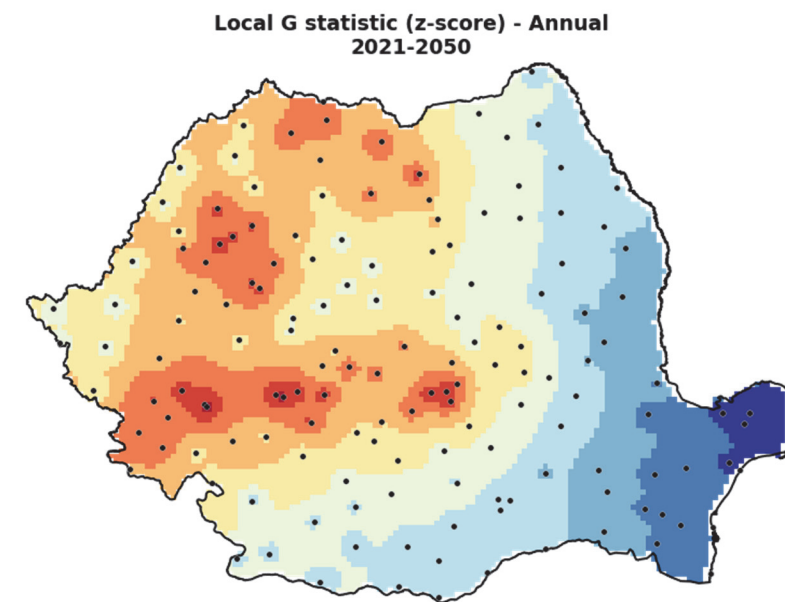
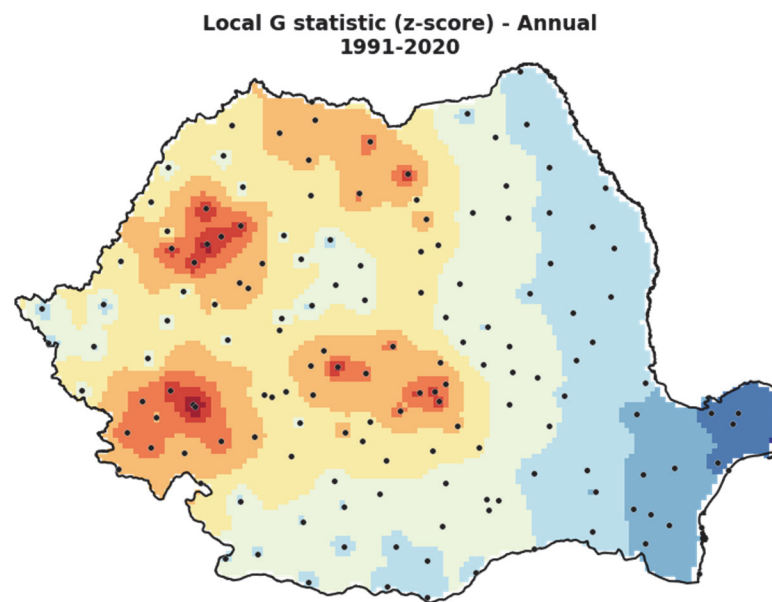
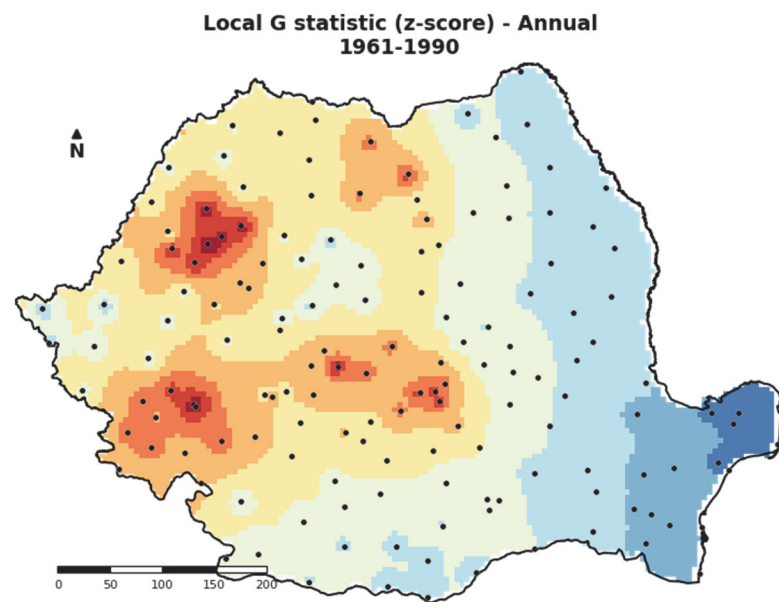
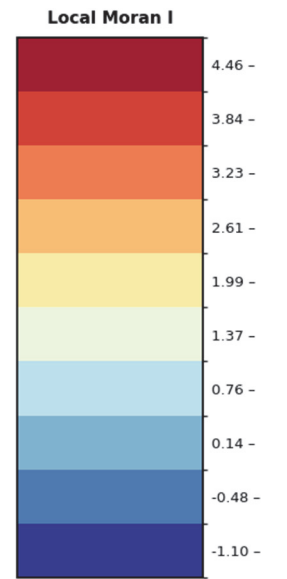
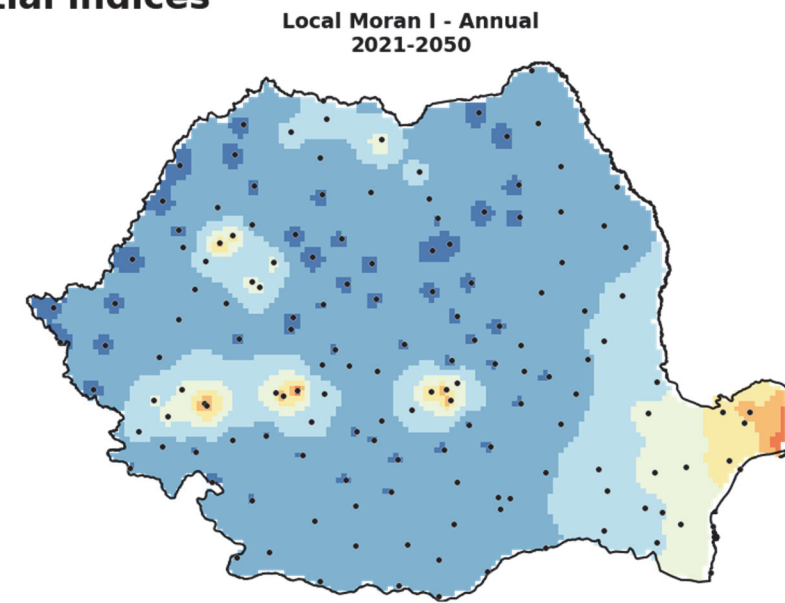
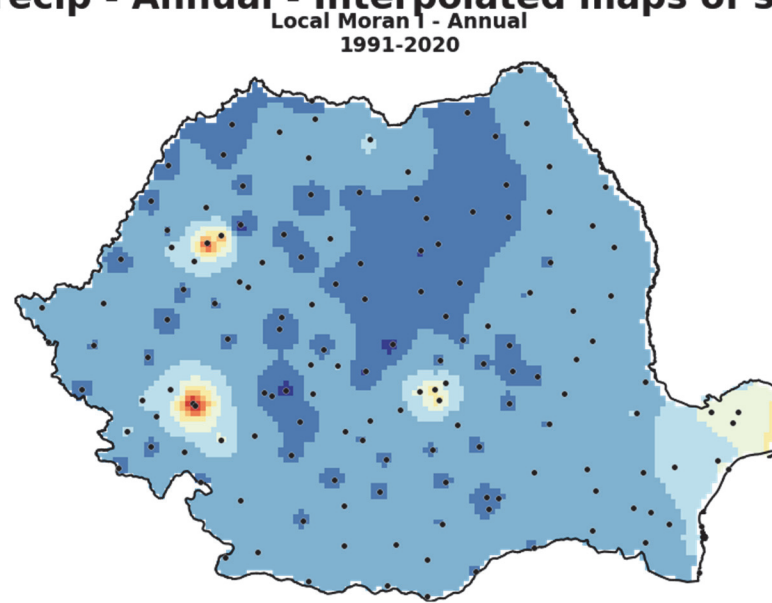
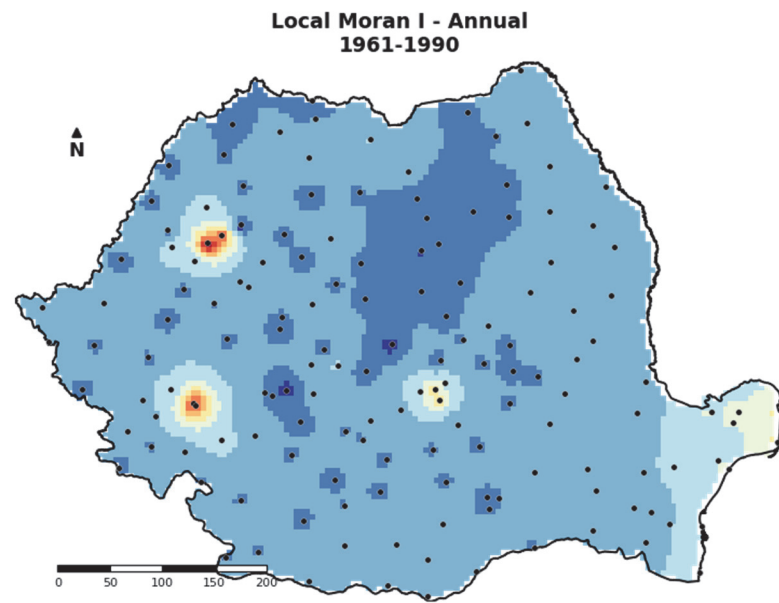
Tmed - July - Interpolated maps of spatial indices



Sunshine Duration - Annual - Interpolated maps of spatial indices



Precip - Annual - Interpolated maps of spatial indices



The differences 2021-2050 minus 1991-2020 should be treated as a projected signal. They are more heterogeneous for temperatures and stronger for humidity, wind, and precipitation. For temperature, part of the country is already within warm classes in 1991-2020, so the projection is often expressed by the displacement of thresholds with altitude and by the expansion of intermediate classes, not only by the increase of the warmest class. For humidity, by contrast, the projection massively changes the spatial classification of the territory: dry classes become dominant over very large areas.

Table 3. Comparative synthesis of climatic parameters, combining annual values, maximum/minimum months, and spatial indices.

Parameter	Dominant annual/monthly signal	Main hot spot / cold spot	Magnitude of change
Mean temperature	>12 °C: 6 -> 9,304 -> 16,508 km ² ; July >22 °C and January >0 °C increase strongly	hot: plains, Dobrogea, Danube Delta; cold: Carpathians and depressions	large in value, medium in spatial reorganization
Maximum temperature	July >30 °C: 7 -> 47,422 -> 48,822 km ² ; January >3 °C becomes very extensive	hot: Romanian Plain, western areas, Dobrogea, low Moldavia; cold: mountains	large, relevant for daytime heat stress
Minimum temperature	annual >6 °C: 28,440 -> 86,867 -> 99,866 km ² ; frost contracts drastically	hot: south, west, coastline; cold: depressions and mountains	highly relevant for warm nights and frost
Cloudiness	reduction of very cloudy classes; August <3.5 tenths increases to 66,677 km ²	hot: mountains/north; cold: southeast and plains	medium, but consistent with insolation
Sunshine duration	annual >2,200 h: 7,049 -> 63,479 -> 74,414 km ² ; July >300 h increases	hot: Romanian Plain, Dobrogea, Danube Delta; cold: Carpathians	large and spatially very coherent
Atmospheric pressure	moderate redistributions between >1,000 and 950-1,000 hPa	hot: low areas; cold: Carpathians	small, dominated by altitude
Wind speed	the projection expands the medium classes: 3-4 m/s annually reaches 132,575 km ²	hot: Dobrogea, Danube Delta, coast, ridges; cold: depressions/sheltered areas	very large, but with modeling uncertainty
Relative humidity	annual <75%: 2,830 -> 23,565 -> 171,069 km ² ; August <60% reaches 176,378 km ²	hot: mountains/north; cold: south, east, Dobrogea, Danube Delta	largest and clearest change
Precipitation	700-1,000 mm decreases to 23,005 km ² ; June and February become drier	hot: Carpathians/Apuseni Mountains; cold: Dobrogea, Danube Delta, southeast	large, with high hydrological risk
Snow cover	small annual change at national scale, but mobile snow-cover thresholds	hot: Carpathians; cold: plains, Dobrogea, Danube Delta	medium annually, large seasonally and altitudinally

Note for Table 3. 'High values' and 'low values' refer to the specific parameter analyzed. Therefore, for humidity, precipitation, cloud cover, or snow, a core of high values does not indicate a warm area, but rather an area with high values of that particular parameter.

The difference 2021-2050 minus 1961-1990 expresses the total signal. It is the most useful for atlas conclusions because it shows climatic transformation over almost a century. In this reading, Romania shifts toward higher thermal classes, higher insolation classes, lower relative-humidity classes, and, in the projection, lower precipitation classes over extensive areas. In the mountains, the total signal is an altitudinal compression of cold, humid, and snow-related classes.

Overall, Romania projected for 2021-2050 under RCP4.5 / CORDEX - ALADIN is warmer, sunnier, and has less humid air in many regions. Not all changes have the same direction or the same robustness: temperature has a robust and easy-to-interpret signal; relative humidity and precipitation are essential for assessing aridization; wind must be read with caution; pressure is dominated by relief; and snow is more relevant through altitudinal thresholds than through total national area. The most appropriate interpretation is not parameter by parameter in isolation, but an integrated one: warming + sunshine increase + decrease in relative humidity + reduction of some pluviometric classes + displacement of snow-cover belts.

Diferențele 2021-2050 minus 1991-2020 trebuie tratate ca semnal proiectat. Ele sunt mai eterogene pentru temperaturi și mai puternice pentru umiditate, vânt și precipitații. Pentru temperatură, o parte a țării se află deja în clase calde în 1991-2020, astfel încât proiecția este adesea exprimată prin deplasarea pragurilor în altitudine și prin extinderea claselor intermediare, nu doar prin creșterea celei mai calde clase. Pentru umiditate, în schimb, proiecția modifică masiv clasificarea spațială a teritoriului: clasele uscate devin dominante pe suprafețe foarte mari.

Tabelul 3. Sinteză comparativă a parametrilor climatici, combinând valorile anuale, lunile de maxim/minim și indicii spațiali.

Parametru	Semnal anual/lunar dominant	Principalele nuclee cu valori ridicate / scăzute	Amploarea schimbării
Temperatura medie	>12 °C: 6 -> 9 304 -> 16 508 km ² ; valorile din iulie >22 °C și din ianuarie >0 °C cresc puternic	valori ridicate: câmpii, Dobrogea, Delta Dunării; valori scăzute: Carpații și depresiunile	mare ca valoare, medie ca reorganizare spațială
Temperatura maximă	iulie >30 °C: 7 -> 47 422 -> 48 822 km ² ; ianuarie >3 °C devine foarte extinsă	valori ridicate: Câmpia Română, zonele vestice, Dobrogea, Moldova joasă; valori scăzute: munți	mare, relevantă pentru stresul termic diurn
Temperatura minimă	anual >6 °C: 28 440 -> 86 867 -> 99 866 km ² ; înghețul se contractă drastic	valori ridicate: sud, vest, litoral; valori scăzute: depresiuni și munți	foarte relevantă pentru nopțile calde și îngheț
Nebulozitate	reducerea claselor foarte noroase; în august <3,5 zecimi crește la 66 677 km ²	valori ridicate: munți/nord; valori scăzute: sud-est și câmpii	medie, dar coerentă cu insolația
Durata de strălucire a Soarelui	anual >2 200 h: 7 049 -> 63 479 -> 74 414 km ² ; iulie >300 h crește	valori ridicate: Câmpia Română, Dobrogea, Delta Dunării; valori scăzute: Carpații	mare și foarte coerentă spațial
Presiunea atmosferică	redistribuire moderată între >1 000 și 950-1 000 hPa	valori ridicate: zone joase; valori scăzute: Carpații	mică, dominată de altitudine
Viteza vântului	în proiecție se extind clasele medii: clasa 3-4 m/s ajunge anual la 132 575 km ²	valori ridicate: Dobrogea, Delta Dunării, litoral, culmi; valori scăzute: depresiuni/arii adăpostite	foarte mare, dar cu incertitudine de modelare
Umiditate relativă	anual <75%: 2 830 -> 23 565 -> 171 069 km ² ; în august <60% ajunge la 176 378 km ²	valori ridicate: munți/nord; valori scăzute: sud, est, Dobrogea, Delta Dunării	cea mai mare și cea mai clară schimbare
Precipitații	clasa 700-1 000 mm scade la 23 005 km ² ; iunie și februarie devin mai uscate	valori ridicate: Carpații/Munții Apuseni; valori scăzute: Dobrogea, Delta Dunării, sud-est	mare, cu risc hidrologic ridicat
Strat de zăpadă	schimbare anuală mică la scară națională, dar praguri mobile ale stratului de zăpadă	valori ridicate: Carpații; valori scăzute: câmpii, Dobrogea, Delta Dunării	medie anual, mare sezonier și altitudinal

Notă pentru Tabelul 3. „Valori ridicate” și „valori scăzute” se referă la parametrul analizat. De aceea, pentru umiditate, precipitații, nebulozitate sau zăpadă, un nucleu cu valori ridicate nu înseamnă o zonă caldă, ci o zonă cu valori ridicate ale parametrului respectiv.

Diferența 2021-2050 minus 1961-1990 exprimă semnalul total. Este cea mai utilă pentru concluziile atlasului, deoarece arată transformarea climatică pe aproape un secol. În această interpretare, România se deplasează către clase termice mai ridicate, clase de insolație mai ridicate, clase de umiditate relativă mai scăzută și, în proiecție, clase de precipitații mai reduse pe suprafețe extinse. În munți, semnalul total este o comprimare altitudinală a claselor reci, umede și legate de zăpadă.

În ansamblu, România proiectată pentru 2021-2050 în scenariul RCP4.5 / CORDEX - ALADIN este mai caldă, mai însorită și are aer mai puțin umed în multe regiuni. Nu toate schimbările au aceeași direcție sau aceeași robustețe: temperatura are un semnal robust și ușor de interpretat; umiditatea relativă și precipitațiile sunt esențiale pentru evaluarea aridizării; vântul trebuie citit cu prudență; presiunea este dominată de relief; iar zăpada este mai relevantă prin pragurile altitudinale decât prin suprafața totală națională. Interpretarea cea mai potrivită nu este parametru cu parametru în mod izolat, ci una integrată: încălzire + creșterea duratei de strălucire a Soarelui + scăderea umidității relative + reducerea unor clase pluviometrice + deplasarea etajelor stratului de zăpadă.

SELECTED TABLES

Adamclisi		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
T mean (°C)	1961-1990	-1.17	0.47	4.41	10.29	15.80	19.64	21.63	21.00	17.16	11.48	6.44	1.47	10.72
	1991-2020	-0.17	1.61	5.61	10.81	16.46	20.92	23.12	22.82	17.82	12.24	6.75	1.58	11.63
	2021-2050	0.78	2.09	5.92	10.88	15.92	20.09	23.38	23.18	18.13	12.04	6.39	1.58	11.70
T max (°C)	1961-1990	2.40	4.35	9.50	16.50	21.88	25.74	27.89	27.50	23.76	17.47	10.87	4.84	16.06
	1991-2020	3.57	6.20	11.12	17.07	22.79	27.17	29.65	29.73	24.47	17.98	11.24	5.29	17.19
	2021-2050	4.20	6.26	10.84	16.65	21.89	25.73	29.46	29.48	24.46	17.46	10.59	4.96	16.83
T min (°C)	1961-1990	-4.00	-2.34	0.88	5.84	10.78	14.40	16.20	15.67	12.27	7.38	3.20	-1.20	6.59
	1991-2020	-2.96	-1.55	1.82	6.17	11.32	15.52	17.50	17.28	13.03	8.32	3.55	-1.23	7.40
	2021-2050	-1.90	-1.30	2.45	6.43	10.96	15.13	17.92	17.61	13.33	8.03	3.23	-1.00	7.57
Precip (mm)	1961-1990	29.21	29.31	30.51	37.08	53.73	67.79	46.13	49.88	35.36	36.93	42.35	39.39	497.68
	1991-2020	38.18	29.84	43.69	40.12	53.47	56.93	51.91	31.57	52.87	46.20	41.86	43.77	530.41
	2021-2050	22.72	21.79	29.85	30.20	38.24	56.34	29.33	16.31	25.43	33.60	43.16	26.30	373.27
UR (%)	1961-1990	86.97	86.02	80.72	74.69	72.93	71.32	69.34	70.45	74.17	79.26	85.01	88.53	78.28
	1991-2020	86.90	83.22	77.91	72.85	72.26	70.25	67.00	66.35	71.94	79.72	85.37	87.39	76.76
	2021-2050	81.21	76.96	72.34	67.75	69.24	62.95	52.71	50.97	58.45	68.79	78.53	80.94	68.40
v (m/s)	1961-1990	3.90	4.40	4.11	4.15	3.56	3.11	2.97	2.84	2.76	2.98	3.41	3.76	3.50
	1991-2020	3.29	3.39	3.45	3.23	2.72	2.44	2.24	2.08	2.48	2.50	2.90	3.17	2.82
	2021-2050	4.32	4.43	4.48	4.15	3.78	3.63	3.63	3.65	3.64	3.78	4.04	4.24	3.98
P (hPa)	1961-1990	1000.04	998.59	997.79	994.39	995.35	994.72	995.07	996.00	998.69	1001.31	999.81	999.02	997.57
	1991-2020	1000.91	999.44	997.49	995.57	995.52	995.09	994.61	995.97	997.84	1000.50	1000.75	1001.26	997.91
	2021-2050	1008.22	1007.17	1005.19	1003.11	1002.18	1001.88	1002.91	1004.16	1005.71	1008.49	1007.80	1008.14	1005.41
Sunshine (hours)	1961-1990	78.82	83.67	127.01	180.26	245.77	271.95	296.40	284.03	222.66	181.48	95.94	70.98	2138.95
	1991-2020	88.12	112.90	137.49	199.09	268.09	293.03	327.71	308.25	224.99	161.08	102.62	87.13	2310.50
	2021-2050	90.49	119.99	133.47	206.00	268.05	302.85	332.55	315.85	224.19	158.09	106.41	89.12	2347.06
Cloud cover (tenths)	1961-1990	6.55	6.77	6.17	5.46	4.78	4.13	3.24	2.84	3.33	4.06	5.92	6.69	5.00
	1991-2020	6.66	6.27	5.95	5.51	5.00	4.19	3.29	2.90	4.00	5.09	6.44	6.66	5.16
	2021-2050	6.71	5.73	5.87	5.37	5.03	3.77	2.94	2.68	3.81	5.35	6.33	6.36	5.00
Snow depth (cm)	1961-1990	2.78	2.10	0.47	0.01						0.00	0.27	0.97	6.60
	1991-2020	4.24	3.01	0.85	0.07						0.00	0.10	1.10	9.33
	2021-2050	4.27	5.30	0.42	0.05						0.00	0.16	1.47	11.67

Alba Iulia		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
T mean (°C)	1961-1990	-2.84	-0.11	4.70	10.13	15.05	18.02	19.62	19.21	15.55	9.90	4.62	-0.17	9.47
	1991-2020	-1.58	0.81	5.68	11.38	16.27	19.86	21.41	21.27	16.10	10.36	4.62	-0.28	10.49
	2021-2050	-0.57	0.73	6.03	11.30	16.01	18.94	21.73	21.29	16.12	10.28	4.35	0.50	10.56
T max (°C)	1961-1990	0.42	4.32	11.32	17.25	22.16	24.93	26.86	26.67	22.97	16.46	8.52	2.58	15.37
	1991-2020	2.20	5.97	12.26	18.42	23.24	26.77	28.61	29.00	23.59	17.34	9.50	3.04	16.66
	2021-2050	3.13	5.57	12.40	18.20	22.68	25.55	28.76	28.68	23.32	16.77	9.02	3.99	16.50
T min (°C)	1961-1990	-4.96	-2.67	0.78	5.18	9.49	12.20	13.37	13.07	10.03	5.28	1.71	-2.12	5.11
	1991-2020	-3.67	-2.20	1.19	5.79	10.28	13.63	14.94	14.74	10.67	5.97	1.70	-2.09	5.91
	2021-2050	-3.25	-2.74	1.30	5.57	10.25	13.74	16.14	15.46	10.96	5.63	0.97	-1.88	6.01
Precip (mm)	1961-1990	25.96	23.60	25.88	48.98	66.26	80.45	65.77	54.69	35.03	33.21	29.05	30.98	519.87
	1991-2020	22.72	20.67	28.99	44.43	63.64	84.31	81.24	55.59	45.50	40.12	27.55	33.66	548.42
	2021-2050	21.16	20.42	34.02	41.84	60.18	75.77	55.93	43.28	38.92	32.59	31.45	23.72	479.27
UR (%)	1961-1990	86.35	83.40	76.42	73.75	75.70	76.96	76.12	77.01	78.55	80.55	84.78	88.15	79.81
	1991-2020	86.61	79.98	70.76	67.92	71.19	72.08	71.98	72.27	75.79	80.93	85.79	87.83	76.93
	2021-2050	82.46	78.18	74.56	70.84	73.30	67.47	59.18	55.85	62.59	73.79	81.53	82.52	71.85
v (m/s)	1961-1990	1.31	1.34	1.61	1.64	1.49	1.38	1.33	1.09	1.12	1.00	1.27	1.31	1.33
	1991-2020	1.53	1.65	1.76	1.65	1.64	1.46	1.36	1.14	1.29	1.26	1.35	1.36	1.46
	2021-2050	2.75	2.87	2.88	2.84	2.62	2.50	2.37	2.36	2.36	2.40	2.52	2.76	2.60
P (hPa)	1961-1990	990.26	988.24	987.23	984.39	985.88	985.82	986.56	987.17	989.52	991.54	989.75	989.40	987.98
	1991-2020	991.23	989.36	987.53	985.52	986.10	986.27	986.21	987.28	988.63	990.64	990.22	991.43	988.37
	2021-2050	971.85	971.02	969.32	967.99	968.36	968.83	970.55	971.82	972.11	973.71	972.14	971.94	970.80
Sunshine (hours)	1961-1990	66.21	88.12	146.51	164.12	211.53	216.46	241.56	239.65	190.45	161.43	79.99	51.08	1857.10
	1991-2020	74.93	105.06	159.01	193.73	232.35	254.90	270.14	266.30	193.43	156.11	88.61	58.78	2053.34
	2021-2050	73.87	107.58	161.95	193.38	232.40	258.54	274.97	269.47	189.32	158.97	91.03	58.44	2069.92
Cloud cover (tenths)	1961-1990	7.02	6.70	6.04	6.21	5.81	5.58	4.78	4.50	4.79	4.79	6.84	7.69	5.90
	1991-2020	7.09	6.63	6.33	6.15	6.15	5.62	4.98	4.59	5.52	5.68	6.75	7.69	6.10
	2021-2050	7.29	6.54	5.97	6.41	6.14	5.44	4.81	4.50	5.95	5.52	6.75	7.63	6.08
Snow depth (cm)	1961-1990	4.54	2.62	0.27	0.00							0.00	0.08	1.52
	1991-2020	2.77	2.39	0.38	0.03							0.00	0.17	1.66
	2021-2050	2.15	1.60	0.29	0.02							0.00	0.05	2.71

Alexandria		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
T mean (°C)	1961-1990	-2.72	-0.25	4.96	11.55	16.95	20.54	22.48	21.87	17.90	11.50	5.25	0.11	10.84
	1991-2020	-1.44	1.02	6.27	11.99	17.63	21.89	23.98	23.86	18.39	12.05	5.87	0.23	11.81
	2021-2050	-0.23	1.58	6.85	12.42	17.43	21.30	24.57	24.39	18.84	11.94	5.51	0.84	12.12
T max (°C)	1961-1990	1.09	4.12	10.80	18.30	23.46	26.88	28.99	28.75	25.14	18.39	10.16	3.68	16.65
	1991-2020	2.47	6.06	12.57	18.76	24.38	28.59	30.93	31.11	25.53	18.46	10.54	4.07	17.79
	2021-2050	3.65	6.60	12.82	19.20	24.08	28.03	31.56	31.59	26.22	18.55	10.25	4.38	18.08
T min (°C)	1961-1990	-5.79	-3.45	0.62	5.87	10.86	14.30	15.99	15.60	11.92	6.40	1.72	-2.58	5.95
	1991-2020	-4.58	-2.70	1.55	6.18	11.36	15.38	17.21	17.16	12.62	7.45	2.52	-2.67	6.79
	2021-2050	-3.17	-2.42	2.16	6.68	11.38	15.21	17.97	17.64	12.96	7.27	2.11	-1.85	7.16
Precip (mm)	1961-1990	37.02	31.90	34.64	44.61	54.57	68.34	68.58	54.40	36.18	27.80	43.01	40.23	541.28
	1991-2020	33.81	27.04	35.02	43.34	65.51	78.54	64.40	39.14	49.82	47.36	35.39	36.87	556.26
	2021-2050	28.07	27.36	36.23	37.82	50.68	63.28	37.06	24.44	31.04	34.54	47.15	29.88	447.55
UR (%)	1961-1990	88.35												

EXPLANATION

To quantify climatic changes between the analyzed periods, a Standardized Index of Interperiod Statistical Change, SI(ISC), was used. It expresses the difference between the monthly mean of a newer period and the monthly mean of the reference period, divided by the standard deviation of the same month in the reference period. Therefore, the index does not express the difference in the original units of the analyzed parameter, but in standard-deviation units, allowing the intensity of changes to be compared across months, regions, and different climatic parameters.

SI(ISC) does not express change in the original units of the parameter, but standardizes it. This means that the result is no longer in °C, mm, hPa, %, hours, or m/s, but is a unitless value.

For example, an increase of 1 °C does not have the same meaning everywhere. If the variability of a given month is low in a region, 1 °C may represent an important change. If natural variability is high, the same increase may be relatively modest. By dividing by the standard deviation, SI(ISC) answers the question:

How large is the change compared with the normal climatic variability of the reference period?

Thus, the index allows changes to be compared across regions, months, and different parameters.

Positive values indicate an increase relative to the reference period, while negative values indicate a decrease. The index should be interpreted as a standardized measure of interperiod statistical deviation, not as a test of statistical significance and not as isolated evidence of climate change in the causal sense. Through this standardization, absolute differences are related to the normal climatic variability of the reference period, which makes it possible to highlight the areas where change exceeds the usual level of interannual variability.

6.1. Five-class classification and cell coloring

1. Strong increase, $SI(ISC) \geq +1.0$, color: dark red
2. Moderate increase, $+0.5 \leq SI(ISC) < +1.0$, color: light red / orange
3. No relevant change, $-0.5 < SI(ISC) < +0.5$, color: no fill or white
4. Moderate decrease, $-1.0 < SI(ISC) \leq -0.5$, color: light blue
5. Strong decrease, $SI(ISC) \leq -1.0$, color: dark blue

6.2. How the sign is interpreted according to parameter

For temperature, a positive SI(ISC) indicates warming, while a negative ISC indicates cooling.

For precipitation, a positive SI(ISC) indicates a relative pluviometric surplus, while a negative ISC indicates a reduction in monthly amounts.

For relative humidity, negative values may indicate a tendency toward air drying, especially in warm months.

For sunshine duration, positive values indicate an increase in sunshine.

For cloudiness, positive values indicate an increase in cloud cover, while negative values indicate a reduction.

EXPLICAȚII

Pentru cuantificarea schimbărilor climatice dintre perioadele analizate, a fost utilizat Indicele standardizat al schimbării statistice interperiodice, SI(ISC). Acesta exprimă diferența dintre media lunară a unei perioade mai noi și media lunară a perioadei de referință, împărțită la abaterea standard a aceleiași luni din perioada de referință. Prin urmare, indicele nu exprimă diferența în unitățile originale ale parametrului analizat, ci în unități de abatere standard, permițând compararea intensității schimbărilor între luni, regiuni și parametri climatici diferiți.

SI(ISC) nu exprimă schimbarea în unitățile originale ale parametrului, ci o standardizează. Aceasta înseamnă că rezultatul nu mai este exprimat în °C, mm, hPa, %, ore sau m/s, ci este o valoare fără unitate de măsură.

De exemplu, o creștere de 1 °C nu are aceeași semnificație peste tot. Dacă variabilitatea unei anumite luni este redusă într-o regiune, 1 °C poate reprezenta o schimbare importantă. Dacă variabilitatea naturală este ridicată, aceeași creștere poate fi relativ modestă. Prin împărțirea la abaterea standard, SI(ISC) răspunde la întrebarea:

Cât de mare este schimbarea în raport cu variabilitatea climatică normală a perioadei de referință?

Astfel, indicele permite compararea schimbărilor între regiuni, luni și parametri diferiți.

Valorile pozitive indică o creștere față de perioada de referință, în timp ce valorile negative indică o scădere. Indicele trebuie interpretat ca o măsură standardizată a deviației statistice interperiodice, nu ca un test de semnificație statistică și nici ca dovadă izolată a schimbării climatice în sens causal. Prin această standardizare, diferențele absolute sunt raportate la variabilitatea climatică normală a perioadei de referință, ceea ce permite evidențierea ariilor unde schimbarea depășește nivelul obișnuit al variabilității interanuale.

6.1. Clasificarea în cinci clase și colorarea celulelor

1. Creștere puternică, $SI(ISC) \geq +1,0$, culoare: roșu închis
2. Creștere moderată, $+0,5 \leq SI(ISC) < +1,0$, culoare: roșu deschis / portocaliu
3. Fără schimbare relevantă, $-0,5 < SI(ISC) < +0,5$, culoare: fără umplere sau alb
4. Scădere moderată, $-1,0 < SI(ISC) \leq -0,5$, culoare: albastru deschis
5. Scădere puternică, $SI(ISC) \leq -1,0$, culoare: albastru închis

6.2. Cum se interpretează semnul în funcție de parametru

Pentru temperatură, un SI(ISC) pozitiv indică încălzire, iar un SI(ISC) negativ indică răcire.

Pentru precipitații, un SI(ISC) pozitiv indică un surplus pluviometric relativ, iar un SI(ISC) negativ indică o reducere a cantităților lunare.

Pentru umiditatea relativă, valorile negative pot indica o tendință de uscare a aerului, mai ales în lunile calde.

Pentru durata de strălucire a Soarelui, valorile pozitive indică o creștere a insolației.

Pentru nebulozitate, valorile pozitive indică o creștere a acoperirii noroase, iar valorile negative indică o reducere.

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ATLAS OF ROMANIA'S MAIN CLIMATIC PARAMETERS

Recent Changes, 1961–2020, and Projections for 2021–2050

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