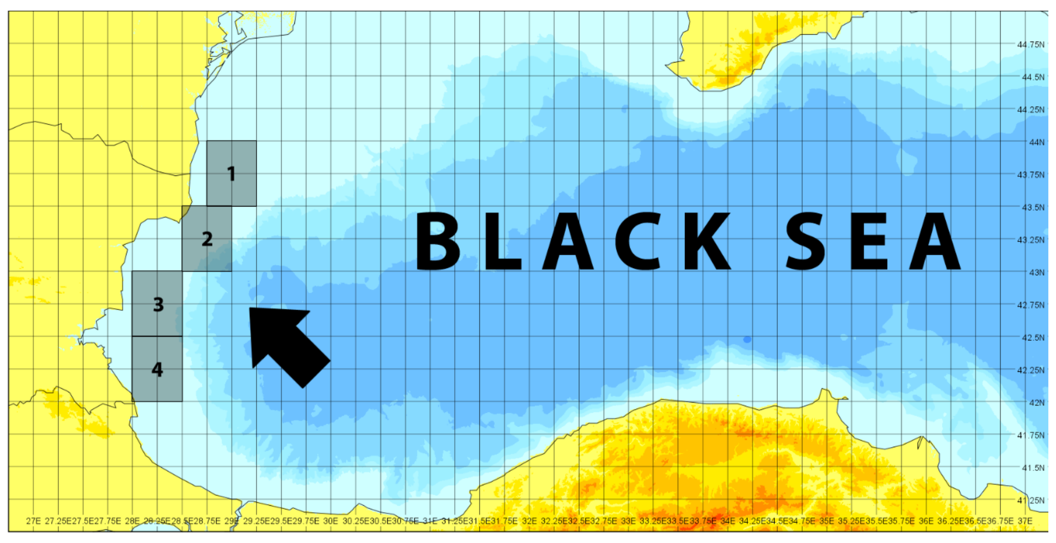
Atmospheric circulation changes and their impact on some climatic elements in the area of the Balkan Peninsula

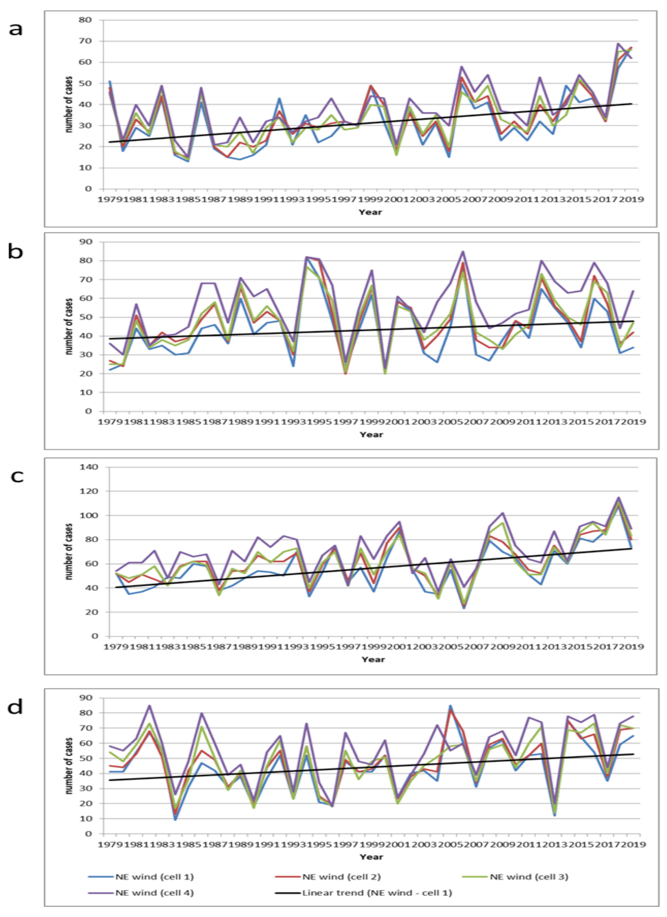
Prof. Peter Nojarov, Climate, Atmosphere and Water Research Institute, Bulgarian Academy of Sciences

Impact of climate change on atmospheric circulation, wind characteristics and wave in the western part of the Black Sea

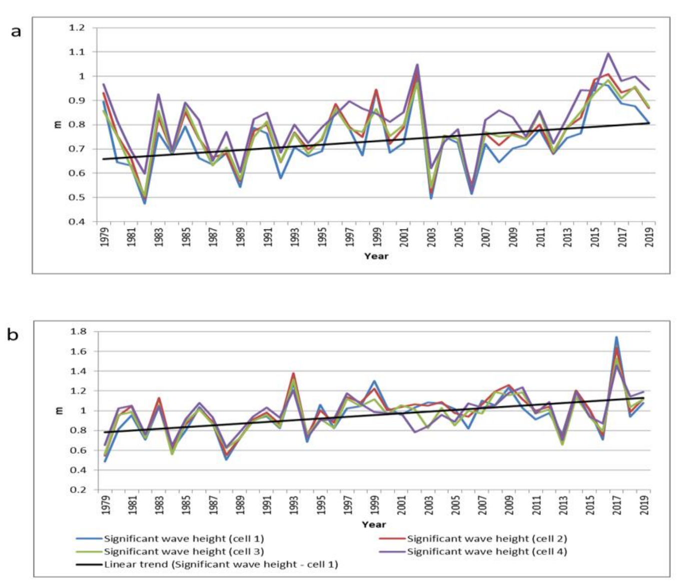
This study reveals changes in atmospheric circulation over the western part of the Black Sea during the period 1979–2019 and related changes in wind conditions and sea wave in the active tourist season, which at the Bulgarian coast spans from June to September. There has been a significant increase in the number of cases and the speed of the northeasterly wind. This has led to an increase in the wave. The most significant changes in the studied elements are observed in August and September. The causes for these changes are the change in atmospheric circulation, expressed in the north-northeastward shift of the Azores High. Thus it exerts a greater impact on the western part of the Black Sea. The rise of sea level pressure north of the Black Sea along with the low pressure south of it increases the horizontal baric gradient, which leads to stronger and more frequent northeasterly winds. The main economic activity affected by these trends is tourism. Revealed tendencies in the studied climatic elements and wave in the last decades represent an immediate threat and an obstacle to the development of tourism along the Bulgarian Black Sea coast.



Location of the study area in the western part of the Black Sea. The 4 rectangles show the 4 grid cells (first cell 43.5–44°N, 28.75–29.25°E; second cell 43–43.5°N, 28.5–29°E; third cell 42.5–43°N; 28–28.5°E; fourth cell 42–42.5°N, 28–28.5°E).



Variations of the number of cases with northeasterly (NE) wind in June **a**, July **b**, August **c** and September **d** in the four cells during the period 1979–2019. Linear trend of the northernmost cell (cell 1) is also shown in the figure.



Variations of significant wave height (in m) for the cases with wind from northeastern quarter of the horizon in August **a** and September **b** in the four cells during the period 1979–2019. Linear trend of the northernmost cell (cell 1) is also shown in the figure.

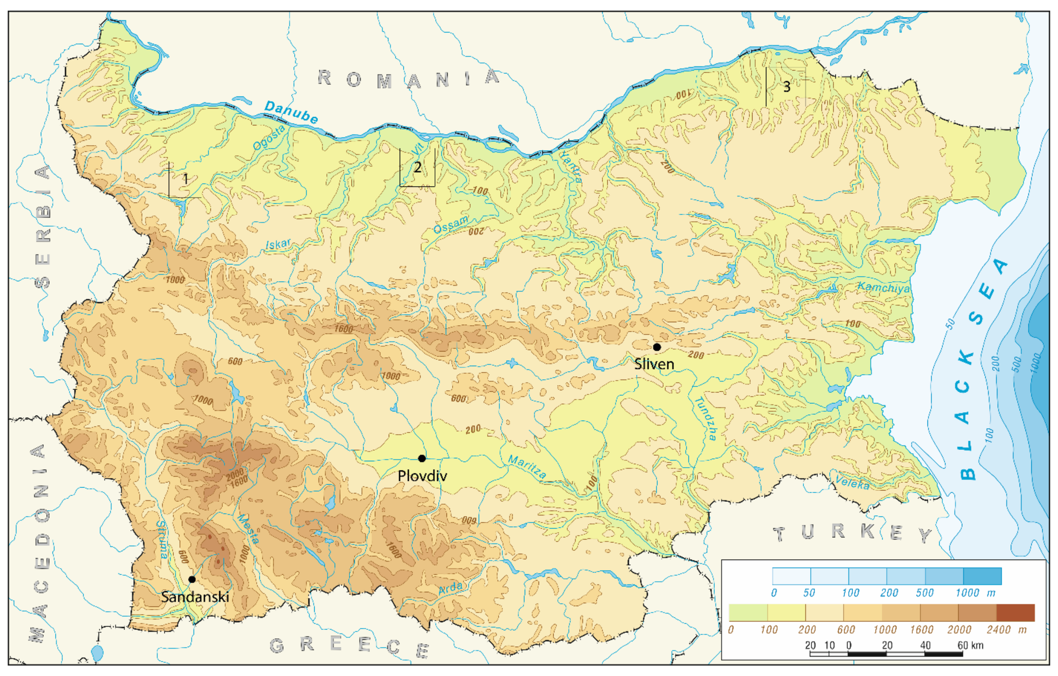
Spearman correlation between drownings (per 100 000 people), and significant wave height - all wind directions, number of cases with NE wind, wind velocity - NE wind and significant wave height - NE wind for the period 2005 – 2022 by gridcells and by districts. Statistically significant numbers are bolded.

Gridcell	Parameter	drownings per 100 000 people		
		Dobrich district	Varna district	Burgas district
1	Significant wave height - all wind directions (m)	-0.39		
	Number of cases with NE wind	-0.26		
	Wind velocity - NE wind ($m*s^{-1}$)	-0.25		
	Significant Wave Height - NE wind (m)	-0.22		
2	Significant wave height - all wind directions (m)	-0.40	-0.02	
	Number of cases with NE wind	-0.30	-0.10	
	Wind velocity - NE wind ($m*s^{-1}$)	-0.14	0.10	
	Significant Wave Height - NE wind (m)	-0.22	-0.02	
3	Significant wave height - all wind directions (m)		-0.12	**0.59**
	Number of cases with NE wind		-0.27	**0.58**
	Wind velocity - NE wind ($m*s^{-1}$)		0.01	0.30
	Significant Wave Height - NE wind (m)		-0.08	0.27
4	Significant wave height - all wind directions (m)			**0.61**
	Number of cases with NE wind			**0.47**
	Wind velocity - NE wind ($m*s^{-1}$)			0.45
	Significant Wave Height - NE wind (m)			**0.47**

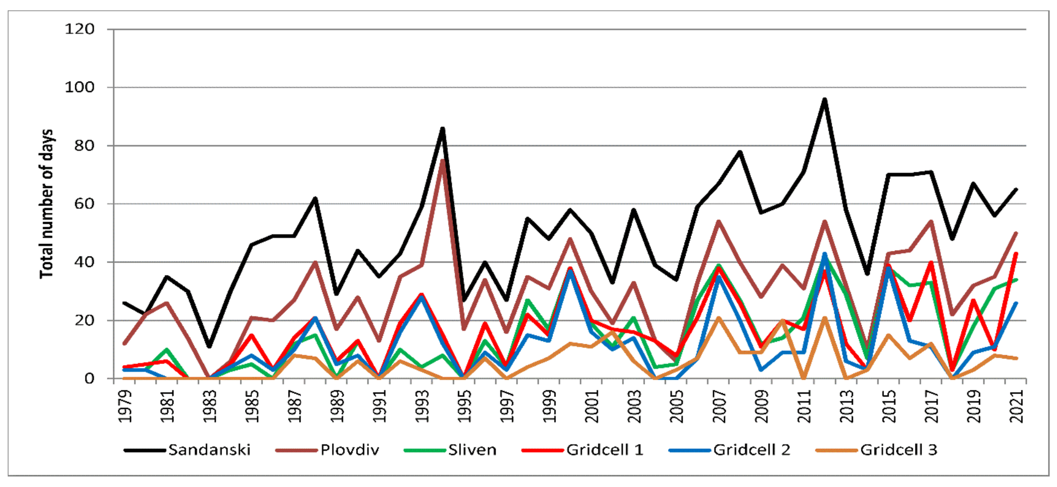
Reference: Nojarov P. 2021. Impact of climate change on atmospheric circulation, wind characteristics and wave in the western part of the Black Sea. Natural Hazards, 109: 1073-1095. https://doi.org/10.1007/s11069-021-04869-5

Heat waves in Bulgaria

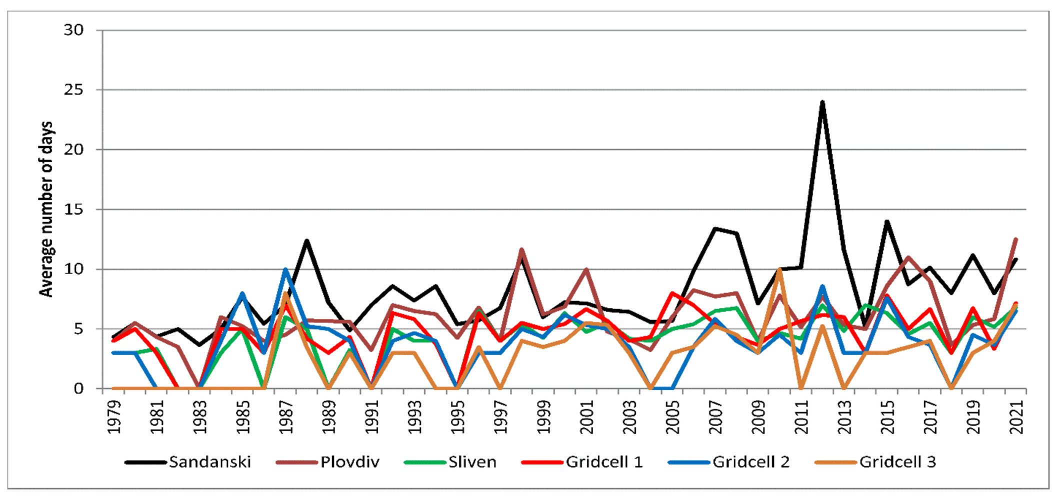
This study reveals the dynamics in the number and intensity of heat waves in Bulgaria in the late 20th and early twenty-first century. Over the last four decades, there has been a statistically significant trend of increasing number of days belonging to heat waves. There is no significant trend (except in southwestern Bulgaria) in the average maximum temperatures of heat waves in the period 1979–2021. This is due to a change in the atmospheric circulation over Bulgaria in the twenty-first century toward increased transport of air masses from northeast in summer.



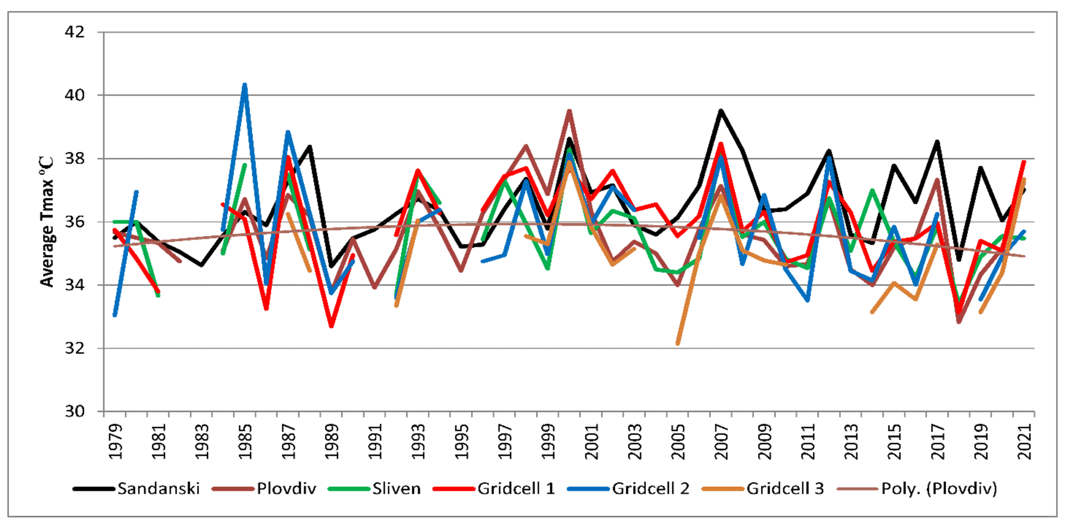
Location of the three meteorological stations in southern Bulgaria and of the three gridcells (1 having coordinates of the center 43.5°N, 23.2°E, 2 having coordinates of the center 43.6°N, 24.7°E, and 3 having coordinates of the center 44°N, 27.1°E) in northern Bulgaria.



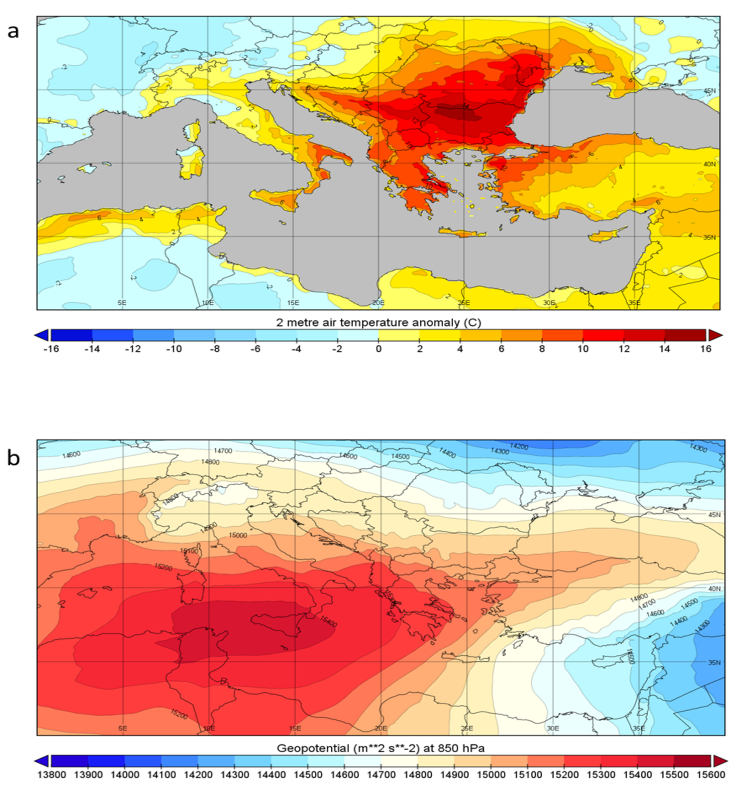
Variations of the total number of days of heat waves in a given year in the six regions for the period 1979–2021.



Variations of the average number of days of heat waves in a given year in the six regions in Bulgaria for the period 1979–2021.



Variations of the average maximum temperature of the heat waves in a given year in the six regions for the period 1979–2021. The polynomial of station Plovdiv is included in the figure.

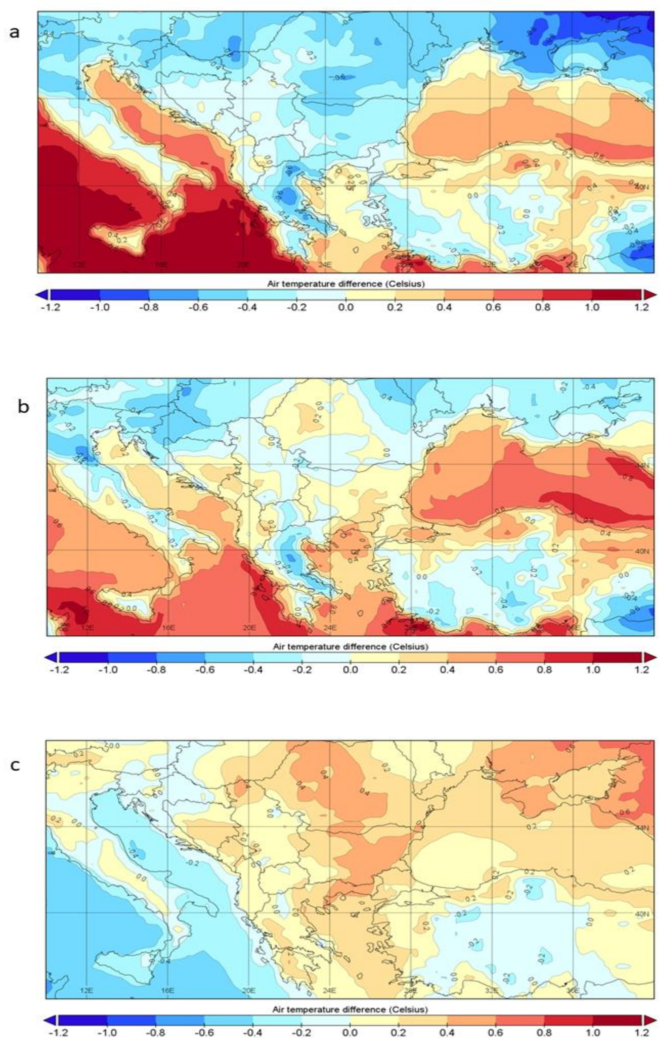


2 m air temperature anomaly (°C) (**a**) and geopotential (m^2*s^{-2}) at 850 hPa level (**b**) at 1200UTC on 05.07.2000 (the day with the highest air temperature in Bulgaria).

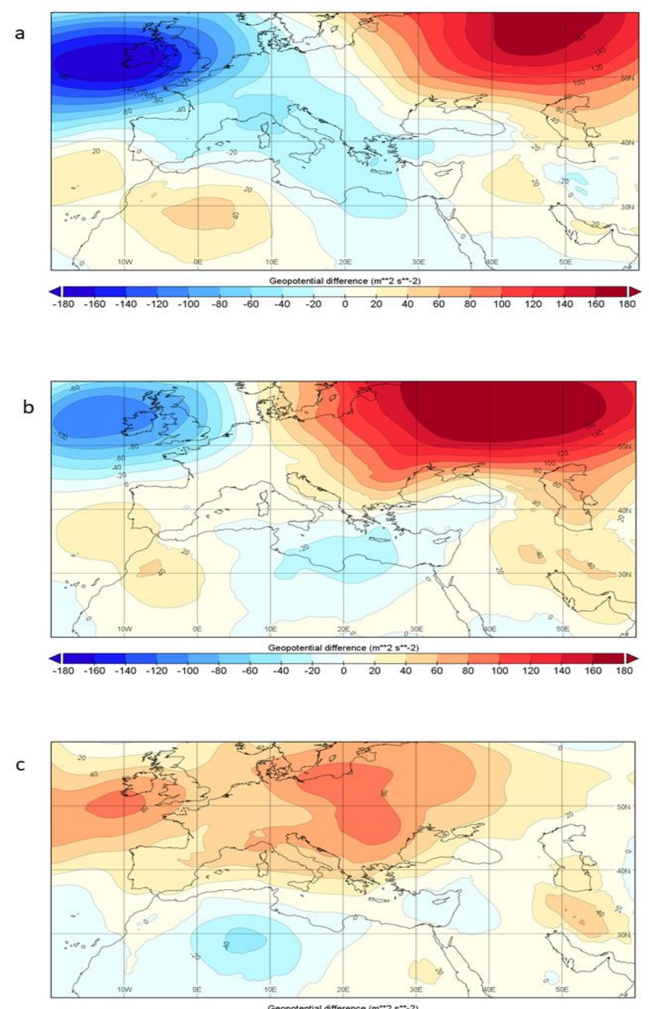
Reference: Nojarov P, Nikolova M. 2022. Heat waves and forest fires in Bulgaria. Natural Hazards, 114: 1879-1899. https://doi.org/10.1007/s11069-022-05451-3

Strengthening of the maritime influence on the Balkans in summer as a result of changes in atmospheric circulation

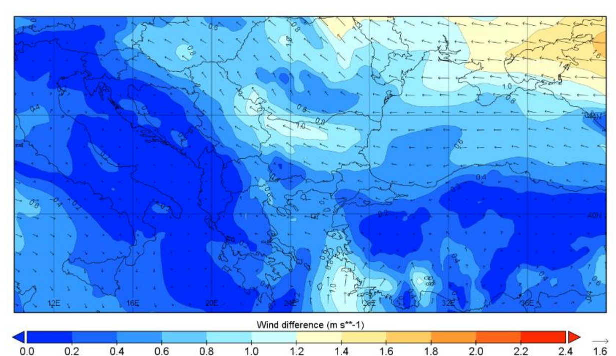
This study focuses on the strengthening of the maritime influence on the Balkan Peninsula in summer in the period 1979–2020. The results show that in the beginning of the twenty-first century in southeastern Europe there is a tendency of faster increase in the average August air temperatures compared to the increase in average July air temperatures. Thus, the temperature in August is already higher than that in July. The causes for these changes are changes in atmospheric circulation in summer. Over the last two decades, the transport of air masses from east and southeast has been strengthening, which for the Balkan Peninsula means a transport from water basins toward land. The intra-annual course of air temperature above a water basin, which has a maximum in August, is now becoming typical over land. This feature is not yet present in the entire studied region.



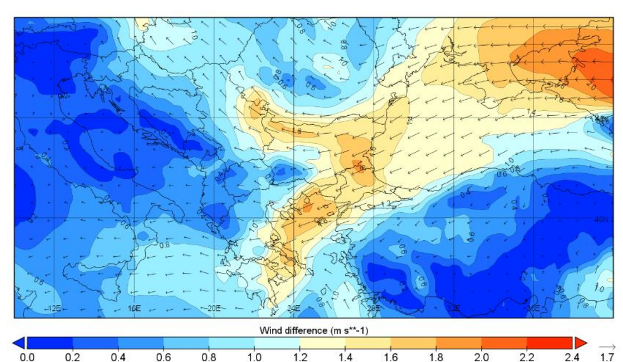
Difference (in °C) between the average August and average July temperatures for the period 1979–1999 (**a**), for the period 2000–2020 (**b**), and difference in air temperatures between the August difference (period 2000–2020 minus period 1979–1999) and July difference (period 2000–2020 minus period 1979–1999) (**c**) for the study area according to ERA5 reanalysis data.



Difference in geopotential (m^2*s^{-2}) at 850 hPa between the period 2000–2020 and the period 1979–1999 in July (**a**), in August (**b**), and difference in geopotential at 850 hPa between the August difference (period 2000–2020 minus period 1979–1999) and July difference (period 2000–2020 minus period 1979–1999) (**c**) according to ERA5 reanalysis data.



Difference in wind speed ($m*s^{-1}$) and direction at 850 hPa between the period 2000–2020 and the period 1979–1999 in July according to ERA5 reanalysis data.



Difference in wind speed ($m*s^{-1}$) and direction at 850 hPa between the period 2000–2020 and the period 1979–1999 in August according to ERA5 reanalysis data.

Reference: Nojarov P. 2023. Strengthening of the maritime influence on the Balkans in summer as a result of changes in atmospheric circulation. Climate Dynamics, 60: 3225-3239. https://doi.org/10.1007/s00382-022-06501-z