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WEATHER ANOMALIES AS A FACTOR OF AGROCLIMATIC RISKS FOR UKRAINE'S AGRICULTURE UNDER CLIMATE CHANGE

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Aim. To identify the characteristics of weather anomalies in Ukraine in the context of current climate change and to assess the associated agroclimatic risks to agriculture, using the weather conditions of 2025 as an example. **Materials and methods.** The analysis was conducted based on daily observational data from Ukraine's national hydrometeorological observation network for 2025 and the climatological norm for key meteorological factors for 1991–2020. The study covers the western, central, and northern regions of Ukraine, as well as the Odesa and Mykolaiv regions. The areas where observations were not conducted or were conducted irregularly due to temporary occupation or war hostilities (which made it impossible to form continuous data series) were excluded from the study. Monthly weather reviews from the Ukrainian Hydrometeorological Center were used to analyze hazardous meteorological events. Spatiotemporal specificities and seasonal variability of indicators in 2025 were identified using climatological, statistical, and spatial analysis methods. The agricultural impacts of weather anomalies were assessed by comparing the obtained results with data from JRC MARS (Ben Aoun et al., 2025a, 2025b) on crop conditions and yields in Ukraine and Europe, as well as with global assessments by the FAO (FAO, 2025) regarding the impact of climate extremes on agrofood systems. **Results.** In Ukraine, 2025 ranked among the five warmest years since 1961; the annual average air temperature across most of the country was 1–2°C above the norm. Particularly pronounced were the rise in minimum temperatures, the decrease in the number of frost days, and the increase in tropical nights. Precipitation patterns were characterized by an overall deficit and sharp spatiotemporal heterogeneity. The most significant factors for agricultural production were insufficient winter moisture accumulation, the early resumption of growing after an abnormally warm March, three cold spells in April, a cold and wet May, summer heat, and a prolonged precipitation deficit in the south and east, as well as excessive July precipitation in the west. This combination of factors reduced the yield potential of winter crops in arid regions, created a risk of damage to rapeseed, fruit, and vegetable crops from late frosts, deteriorated conditions for the development of corn, sunflower, and soybean crops in the south and east, and complicated the harvest and reduced the quality of grain and rapeseed in the western regions. At the same time, sufficient moisture conditions in the northern and western regions supported the potential of summer crops. **Conclusions.** Weather conditions in 2025 demonstrated that, for Ukraine's agriculture, climate risk is determined not only by general atmospheric warming but, above all, by a combination of drought, heat, late cold spells, and localized waterlogging during critical phases of crop development. Spatial contrasts in agrometeorological conditions are increasing, which heightens the need for regionalized climate services, early warning systems, adaptive crop and variety selection, optimization of fieldwork schedules, and soil moisture management.

Keywords: climate change, agroclimatic risks, air temperature, precipitation, drought, frost, heat waves, crop yield, agriculture, Ukraine.

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Agriculture is among economic sectors most dependent on climatic conditions and weather variability. Rising air temperatures, changes in precipitation patterns, and an increase in the frequency and intensity of extreme weather events affect the length of the growing season, the phenological development of plants, water and heat regimes in soil, the timing of fieldwork, and formation of crop yields (IPCC, 2023; FAO, 2025). At the same time, the impact of current climate change on agricultural production is ambiguous. The lengthening of the warm season and the reduction in the severity of winter conditions in regions with cool climates may offer certain advantages for crop production, but these are increasingly offset by intensified heat and water stress, as well as the growing frequency of droughts, heat waves, excessive moisture, and other extreme events (IPCC, 2023; Hultgren et al., 2025).

Current research indicates that one of the most significant impacts of climate change on agriculture is the increased risk of simultaneous high temperatures and moisture deficits. The analysis of global data has shown a significant increase in the likelihood of hot and dry conditions during the growing season in major crop-growing regions, and the combination of these conditions poses a much greater risk to crop yield than the isolated effects of individual meteorological factors (Heino et al., 2023). The reproductive stages of plant development are particularly vulnerable. For wheat, a combination of extreme heat and drought during flowering can significantly disrupt reproductive development and grain formation, and as global warming continues, the contribution of heat stress to crop yield losses may increase substantially (Senapati et al., 2026).

A significant increase in agroclimatic risks is observed in Europe, where current warming rates exceed the global average. The analysis of the impact of droughts and heat waves on crop production showed that over the past five decades, the severity of associated yield losses in Europe has increased significantly (Brás et al., 2021). Research findings at the individual farm level confirm this trend. The analysis of 423,815 crop yield observations in Germany showed that, among the extreme events considered — droughts, heat, frost, and waterlogging — drought was the primary factor contributing to yield losses in grain crops. At the same time, the nature and magnitude of the impact depended significantly on the crop, region, and phenological stage during which the extreme event occurred (Schmitt et al., 2022).

Similar spatial and biological heterogeneity in crop responses to weather anomalies has also been observed in other regions of Europe. In Sweden, the largest negative crop yield anomalies were associated with summer heat waves, droughts, or excess moisture, with spring crops proving to be more sensitive to extreme weather events than winter crops; in the north of the country, a greater threat was posed by excess moisture, while in the south — by the drought (Sjulgård et al., 2023). In the Netherlands, significant crop yield variations in recent decades have also been linked to both drought and excessive moisture, with the response differing substantially for cereals, potatoes, sugar beets, onions, and forage crops (van Oort et al., 2023). The aggregate estimates for Europe also confirm that temperature and hydrological anomalies result in multidirectional changes in crop yield depending on the crop and region (Schmidt, Felsche, 2024).

In addition to moisture deficits, excessive precipitation and soil waterlogging can cause significant losses in agricultural production. A global meta-analysis of 2,419 experimental comparisons showed that waterlogging reduced crop yield by an average of 32.9%, and the magnitude of losses depended significantly on crop type, growth stage, and duration of stress (Tian et al., 2021). The greatest vulnerability was observed during the reproductive phase. Excessive moisture can also delay planting and harvesting, complicate the use of machinery, contribute to lodging and disease development, and reduce the quality of the harvested crop (van Oort et al., 2023; Sjulgård et al., 2023). Thus, an increase in precipitation intensity coupled with a simultaneous increase in the duration of rainless periods can create two opposing but interrelated types of water stress for agricultural production.

Late spring frosts also remain a significant agroclimatic risk. A general rise in air temperature does not necessarily mean a proportional reduction in the danger they pose to plants. Warming causes earlier resumption of growth, bud break, and the onset of flowering in perennial crops, so sensitive developmental stages may occur while the danger of cold air intrusions still persists. A global analysis of the relationship between spring frost indicators and crop yield losses for major crops confirmed that not only the frequency of frost events but also the amplitude of temperature fluctuations, their duration, and the timing of their occurrence are of great importance (Guo et al., 2024). This highlights the need to assess frost risk in the context of changing phenological phases, rather than solely based on trends in minimum temperatures.

Of particular importance is the interaction of several climatic factors and the sequence in which they occur. A previous drought can reduce plant-available soil moisture reserves and exacerbate the negative effects of a subsequent heat wave; an unusually warm early spring can accelerate plant growth and increase their vulnerability to a subsequent cold spell; heavy precipitation following a prolonged dry spell does not always compensate for the accumulated moisture deficit and, at the same time, can cause surface runoff, erosion, and localized waterlogging. Therefore, current research is increasingly shifting from the analysis of individual climate indicators to the assessment of compound and sequential extreme events and their overlapping with critical phases of crop development (Heino et al., 2023; Schmitt et al., 2022; Senapati et al., 2026).

Even when accounting for adaptations in agricultural production, current global warming remains a significant risk to food production. New global assessments that account for producers' actual adaptive responses show that climate change continues to have significant negative impacts on the yields of major crops (Hultgren et al., 2025). At the same time, the effectiveness of adaptation depends largely on the availability of regional climate information. The use of climate services, forecast information, and adaptive variety selection can reduce potential losses and increase the resilience of crop production to climate change (Toreti et al., 2022).

For Ukraine, this issue is of particular importance due to the high dependence of crop production on natural precipitation and significant interregional differences in agroclimatic resources (Dmitrenko, 2000). Over the past decades, Ukraine has seen a steady rise in air temperature, an increase in the frequency of hot days and heat waves, a shortening of the frost period, and a shift in precipitation patterns (Balabukh et al., 2018; Osadchyi et al., 2018; Krakovska, 2024). It has previously been established that changes in temperature and precipitation are already affecting grain crop yields in Ukraine (Balabukh, 2023). At the same time, warming does not eliminate the risk of sudden spring cold spells: in the 21st century, these continue to occur after the start of the active growing season and pose risks to agricultural production (Balabukh et al., 2024).

The weather conditions of 2025 are particularly telling given the combination of conflicting agroclimatic anomalies. A winter precipitation deficit limited the replenishment of soil moisture reserves; an abnormally warm March contributed to an early resumption of the growing season; April saw several cold spells with frosts; a cold and excessively wet May slowed the development of heat-loving crops; in the summer, the southern and eastern regions were affected by high temperatures and a precipitation deficit, while some western and northern regions experienced excessive moisture and heavy precipitation. This sequence created fundamentally different conditions for crop development in individual agroclimatic zones of Ukraine.

On a global scale, 2025 was also characterized by a high frequency of heat waves, droughts, intense precipitation, and floods (WMO, 2026; C3S, 2026). However, when assessing the impacts of these processes on agriculture, what matters most is not the year's ranking in the global temperature index, but rather how temperature and precipitation anomalies manifested during the growing season, to what extent they coincided with critical phases of crop development, and what their spatial heterogeneity was.

The aim of this study is to identify the characteristics of weather anomalies in Ukraine under current climate change conditions and to assess the associated agroclimatic risks to agriculture, using the weather conditions of 2025 as an example.

To achieve this objective, the study aims to: (1) assess the spatial characteristics of temperature and precipitation patterns in 2025; (2) identify seasonal anomalies and the most significant extreme meteorological events; (3) identify periods during which potentially unfavorable agrometeorological conditions may occur and determine how these periods correspond to critical growth stages of major agricultural crops; (4) assess the role of the 2025 weather conditions within the context of current climate change trends in Ukraine and determine their significance for the adaptation of the agricultural sector.

MATERIALS AND METHODS OF THE STUDIES

The study was conducted based on daily observational data from Ukraine's network of meteorological stations, which are part of the state hydrometeorological observation system, as well as on the aggregated data from the Ukrainian Hydrometeorological Center (UkrHMC, 2025). The analysis covers the territory of Ukraine, with the exception of areas where, due to temporary occupation or war hostilities, regular meteorological observations were suspended or conducted irregularly, making it impossible to form continuous observation series. The research results are presented for the western, central, and northern regions of Ukraine, as well as for the Odesa and Mykolaiv regions.

The primary source data consisted of daily, monthly, and annual averages of air temperature, maximum and minimum temperatures, and precipitation, as well as the data on hazardous and extreme meteorological phenomena recorded throughout 2025. To assess the characteristics of temperature and precipitation regimes, the study used such indicators as the number of days with an average daily air temperature below 0°C, as well as the number of days with a minimum temperature below –10°C, the number of frost days, the number of tropical nights, and characteristics of seasonal temperature regime and precipitation.

The 1991–2020 climate norm, recommended by the World Meteorological Organization for contemporary climate research (WMO, 2017), was selected as the reference period for assessing anomalies. Air temperature anomalies were defined as the difference between the actual values in 2025 and the average perennial values for the base period. Precipitation anomalies were calculated as percentages relative to the climatological norm.

To assess the spatial characteristics of climatic conditions, the methods of spatial analysis of meteorological fields were applied, followed by the cartographic representation of temperature regime characteristics, precipitation, and their anomalies. The analysis of temporal variability was performed by comparing the monthly, seasonal, and annual averages for 2025 with the corresponding climatic norms and perennial observation series.

When analyzing the seasonal characteristics of weather conditions, the nature of atmospheric circulation, prevailing synoptic processes, the passage of cyclones and atmospheric fronts, as well as the intrusion of Arctic, temperate, and subtropical air masses which determined the formation of temperature regime and moisture conditions were taken into account.

The assessment of the extremity of weather conditions was based on an analysis of the recurrence of temperature records, heat and cold spells, droughts, heavy and extreme precipitation, squalls, thunderstorms, hail, freezing rain, and other hazardous meteorological events in accordance with the current regulatory documents of the Ukrainian Hydrometeorological Center (UkrHMC, 2025).

Comparative, statistical, and climatological methods of analysis were used to interpret the results, which made it possible to assess the position of 2025 within the perennial observational series, identify the main weather anomalies, and evaluate their consistency with current climate change trends in Ukraine.

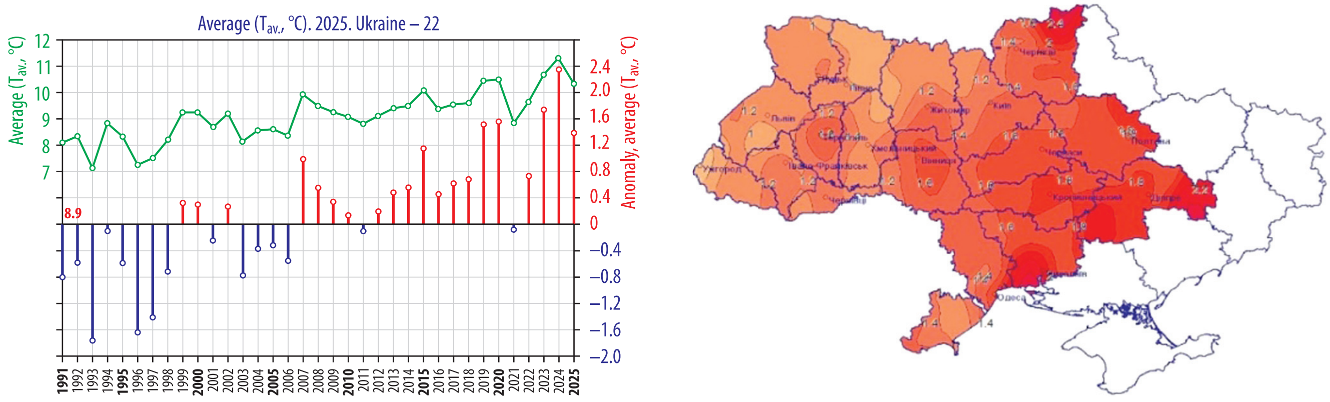
Data processing and the compilation of time series, maps of spatial distribution, and maps of meteorological anomalies were performed using modern methods of statistical analysis and geoinformation mapping. To characterize climatic conditions, the World Meteorological Organization's recommendations regarding the use of the 1991–2020 climatic norm were applied (WMO, 2017), and the results were interpreted in light of current assessments of global climate change.

RESULTS OF STUDIES

The analysis of perennial meteorological observation series shows that recent decades in Ukraine have been characterized by a steady rise in air temperature (Boychenko, Maidanovych, 2024; Boychenko, Maidanovych, 2025; Balabukh et al., 2018; Krakovska et al., 2024). The annual average air temperature during the current climatic period (1991–2020) exceeds the corresponding values of the 1961–1990 climate norm by 1.1–1.5°C across a significant portion of the country, and by more than 1.5°C in certain regions.

In 2025, the warming trend in Ukraine continued. Weather conditions were characterized by elevated background temperatures, sharp temperature fluctuations, significant spatiotemporal variability in precipitation, frequent extreme weather events, and an intensification of climatic risks for the population and economic sectors.

The average annual air temperature across Ukraine in 2025 was predominantly 9–11°C, reaching 12–13°C in the south of the country and along the Black Sea coast. At the same time, it remained lowest in the Carpathians, at around 5–7°C. These air temperatures exceeded the current climatic norm by 1.0–2.0°C or more. The greatest anomalies were observed in the



a) trends in the average annual air temperature and its anomaly in Ukraine

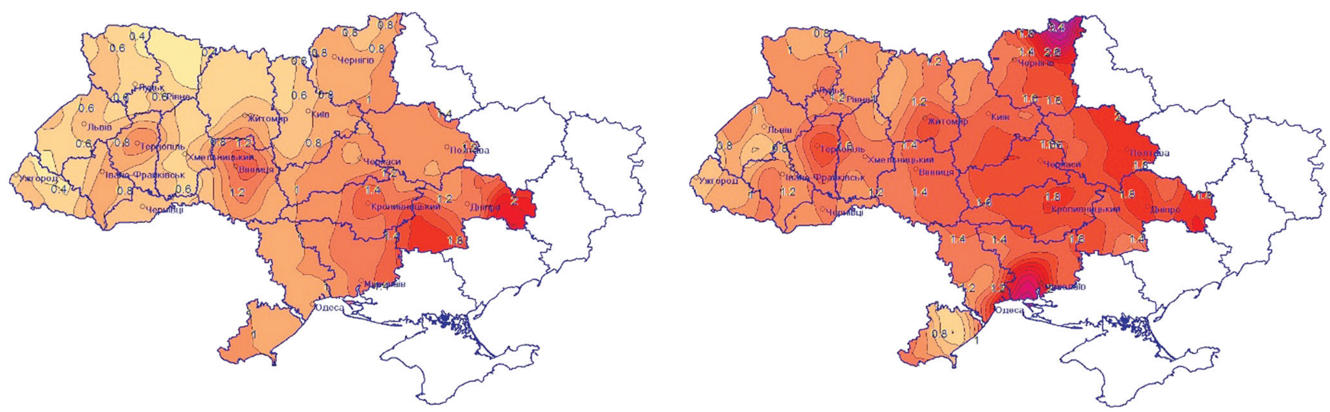
b) spatial distribution of the average annual air temperature anomaly

Fig. 1. The dynamics in the average annual temperature and air temperature anomalies (*a*) and the spatial distribution of average annual temperature anomalies (*b*) in Ukraine in 2025 as compared to 1991–2020

Chernihiv Polissia, the central and eastern Forest-Steppe, and the Steppe zone. As a result, 2025 ranked among the five warmest years in Ukraine since 1961, coming in fifth place behind 2024, 2020, 2023, and 2019 **(Fig. 1)**.

The rise in background temperatures was most pronounced due to increases in both maximum and minimum air temperatures **(Fig. 2)**. The annual average maximum temperature in 2025 exceeded the norm across virtually the entire country. Anomalies increased from the northwest (0.4–0.6°C) toward the southeast and reached their highest values (over 1.5°C) in the Steppe zone, peaking in the Dnipropetrovsk region **(Fig. 2)**. Throughout the year, new maximum temperature records were repeatedly set for specific dates. The most intense heat wave was observed in July, when daytime air temperatures in the south and east of the country rose to nearly 40°C.

The annual average minimum temperature was also above the norm across most of Ukraine. These anomalies significantly exceeded those of maximum temperatures and ranged from 0.8–1.0°C in the west of the country to 1.5°C and higher in the Chernihiv Polissia, the central and eastern Forest-Steppe, and the southern Steppe **(Fig. 2)**. An increase in minimum temperature is one of the most reliable indicators of current climate warming. It was precisely the rise in nighttime temperatures that accounted for a significant portion of the positive anomaly in the annual average air temperature. One of the most characte-



a) spatial distribution of the anomaly in the annual average maximum air temperature

b) spatial distribution of the anomaly in the annual average minimum air temperature

Fig. 2. The anomalies in the annual average maximum and minimum air temperatures as compared to 1991–2020 in Ukraine

ristic features of current changes in the temperature regime in Ukraine is a significant increase in minimum air temperatures (Osadchyi et al., 2018). The consequences of this process include a decrease in the number of frost days, a shortening of the cold period and the winter season, and an increase in the frequency of warm nights.

In 2025, the highest number of days with an average daily air temperature of 0°C or lower was observed in the high-altitude regions of the Ukrainian Carpathians, where it ranged from 50 to 70 days or more per year. In the lowland areas of Ukraine, the number of such days decreased systematically from the north and northeast toward the south and southwest — from 50 days or more to 30 days or fewer. Across the entire territory of Ukraine, the number of days with an average daily temperature of 0°C or lower was significantly lower than the 1991–2020 climatic norm. Negative anomalies ranged from 20–25 days in the western and southern regions and increased to 30–34 days or more in the central, northeastern, and eastern regions, as well as in the Ukrainian Carpathians. The greatest deviations from the norm were observed in the central and northeastern parts of the country.

In 2025, Ukraine recorded the lowest number of frosty days in the last 25 years that is, days when the daily minimum air temperature fell below 0°C. The number of frosty days ranged from 60 days or fewer in the southern regions of the Odesa and Mykolaiv regions, as well as in the Transcarpathian region, to 80 days or more in Polissia and the western Forest-Steppe. In the high-altitude regions of the Ukrainian Carpathians, it exceeded 100 days per year.

Compared to the 1991–2020 climate norm, a significant reduction in the duration of the frost period was observed throughout the country. The anomalies in the number of frosty days in 2025 increased from west to east, ranging from 15–20 days in the western regions to 40–45 days or more in the central, northeastern, and eastern regions. The largest negative anomalies were recorded in the Kirovohrad, Dnipropetrovsk, Poltava, and Chernihiv regions, where the number of frosty days was 40–45 days below the perennial average values.

An important characteristic of the thermal regime during the cold season is the number of days with a minimum air temperature of –10°C or lower, which determines the severity of winter conditions. In 2025, the number of such days in Ukraine was significantly lower than the perennial average values. Compared to the 1991–2020 climatic norm, their number decreased by nearly one month.

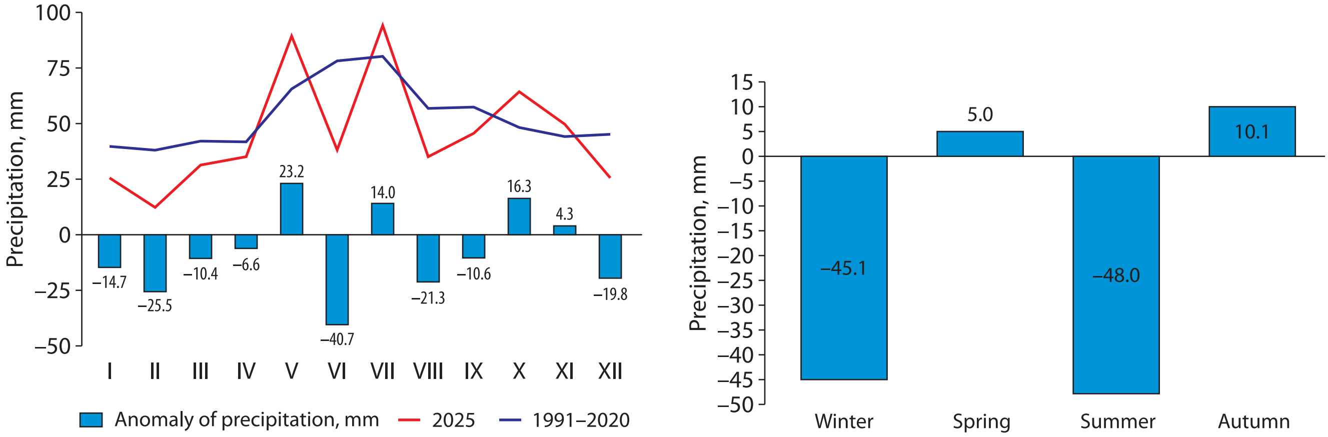
Negative anomalies in the number of days with a minimum air temperature of –10°C or lower were observed throughout the country in 2025. They were smallest in southern Ukraine and in the Right-Bank Polissia, where they ranged from 4 to 8 days. Toward the northeast, the magnitude of the anomalies increased, exceeding 12 days in the northeastern regions, the Precarpathian region, and the Ukrainian Carpathians.

Since the daily minimum air temperature in Ukraine is predominantly observed during nighttime hours, its rise is one of the manifestations of climate warming and is accompanied by an increase in the number of warm nights. Nights during which the minimum air temperature does not drop below 20°C are classified as tropical. The increasing frequency of tropical nights is one of the most characteristic manifestations of contemporary climate change both globally and in Ukraine (Balabukh et al., 2018; Shevchenko, Snizhko, 2019).

In 2025, tropical nights were observed across virtually the entire territory of Ukraine. Their highest frequency was observed in the southern Steppe, where the number of such occurrences reached 15 or more per year. The highest number of tropical nights was recorded in the south of the Odesa and Mykolaiv regions, where 20–25 or more such occurrences were observed throughout the year.

The widespread occurrence of tropical nights in 2025 indicates a significant increase in minimum air temperatures and a greater heat stress on the population, especially in the southern regions of the country. The increasing frequency of warm nights is an important indicator of climate change, as it contributes to heat accumulation in urban areas, impairs the human body's ability to recover at night, and increases health risks to the population during heat waves (Karamushka et al., 2022). These changes are consistent with global warming trends documented by the World Meteorological Organization's Copernicus Climate Change Service and the U.S. National Oceanic and Atmospheric Administration (WMO, 2026; C3S, 2026; NOAA, 2026).

A distinctive feature of 2025 was the combination of prolonged dry periods with episodes of extremely intense precipitation **(Fig. 3)**. The moisture conditions regime in 2025 was characterized by a precipitation



a) anomaly and monthly average precipitation

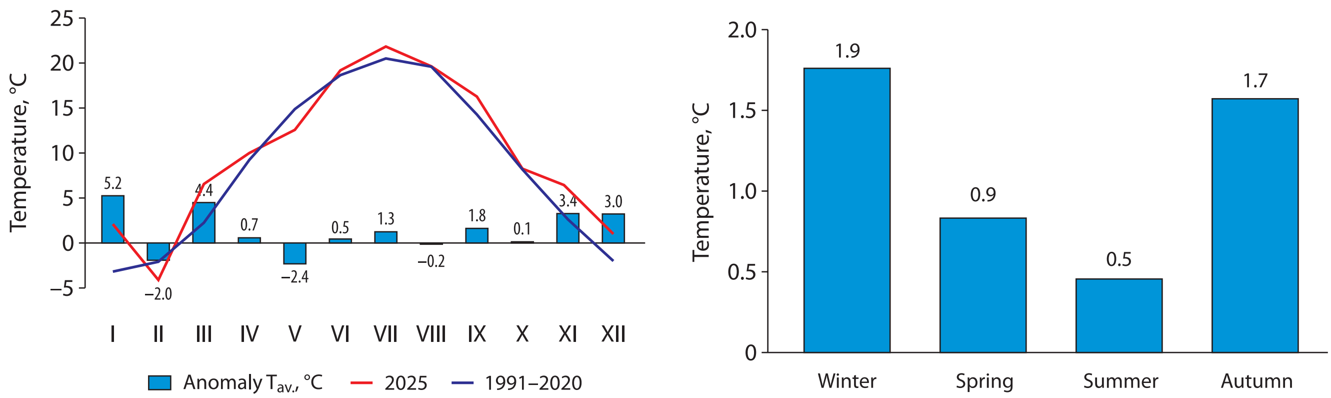
b) anomaly of the average seasonal precipitation

Fig. 3. The anomalies in monthly (*a*) and seasonal (*b*) precipitation in 2025 in Ukraine as compared to 1991–2020

deficit across the entire territory of Ukraine and an uneven distribution of precipitation both throughout the year and across the country. Across most of the country, annual precipitation ranged from 500 to 650 mm. In the Carpathians, precipitation exceeded 800 mm, and in some places it exceeded 1,000 mm. The lowest amount of precipitation was observed in the Black Sea region, where it did not exceed 350–450 mm. A precipitation deficit was observed across almost the entire country, with the exception of some areas in the Khmelnytskyi, Vinnytsia, and Zhytomyr regions. The driest region was the Right-Bank territory of Ukraine, where the annual precipitation deficit reached 20–30% or more. A significant precipitation deficit was also observed in the Lviv and Transcarpathian regions.

The seasonal pattern of weather conditions in 2025 was characterized by significant contrasts and frequent changes in atmospheric circulation patterns. Throughout the year, prolonged anticyclonic periods alternated with the passage of active cyclones and atmospheric fronts, leading to significant fluctuations in air temperature and an uneven distribution of precipitation **(Fig. 3*b*)**.

The 2024–2025 winter season. For most of the winter season, westerly and southwesterly air mass flows prevailed over Europe. Air masses that formed over the abnormally warm Atlantic Ocean and moved into Ukraine contributed to abnormally warm weather throughout December and January **(Fig. 4*a*)**. February was the coldest month of 2025 and marked the end of a relatively mild winter season. Its weather



a) anomaly and monthly average air temperature, °C

b) anomaly and average seasonal air temperature, °C

Fig. 4. The anomaly of the average monthly (*a*) and average seasonal (*b*) air temperature in 2025 in Ukraine as compared to 1991–2020

conditions were influenced by anticyclonic circulation and the influx of cold continental and Arctic air from eastern and northeastern Europe. As a result, the monthly average air temperature across most of Ukraine was 1.1–2.9°C below normal.

Overall, the winter season was nearly 2°C warmer than the climatological norm **(Fig. 4)**.

The average winter temperature across most of Ukraine was 1–3°C above the norm **(Fig. 4)**. The warmest regions were the Transcarpathian, the Black Sea region, and the southern regions of the country. The largest positive anomalies were observed in the northeast and east of the country. The duration of the frost period during the winter remained below the perennial average **(Fig. 5)**.

The winter season was also characterized by a precipitation deficit **(Fig. 3)**. In most regions of Ukraine, precipitation amounted to 50–80% of the norm. The southern regions, the central part of the country, and part of the Left-Bank territory were particularly dry. Due to insufficient precipitation and unstable snow cover, moisture accumulation in the soil was inadequate. In many areas, plant-available soil moisture reserves in the spring were only 60–80% of the perennial averages. This created conditions for the development of atmospheric and soil drought in the spring.

The spring of 2025 was one of the most contrasting seasons in recent years, and March was one of the warmest since 1961 **(Fig. 4)**. The monthly average air temperature in the study area was 4.4°C above the climatic norm and ranged from 2.4°C to 5.9°C. According to data from the Ukrainian Hydrometeorological Center, in most districts of the Transcarpathian, Lviv, Volyn, Ivano-Frankivsk, Zhytomyr, Poltava, and Odesa regions, it was one of the warmest on record for the entire observation period. During the second ten-day period and at the end of the month, maximum air temperatures reached 20–25°C, which is more typical of the second half of April or early May. This abnormally warm weather led to an early start to the spring growing season and the active emergence of perennial crops. Despite the high average temperatures, March was not wet enough **(Fig. 3*a*)**. Across most of the country, precipitation amounted to only 23–79% of the normal amount. The moisture deficit was particularly acute in the southern and central regions, where atmospheric and soil drought conditions that had begun in the fall of 2024 continued to develop.

April 2025 was characterized by exceptionally unstable temperature patterns and significant fluctuations in air temperature. During the month, three cold waves were observed across Ukraine (April 6–9, 10–13, and 27–28), during which frosts were recorded in many regions both on the soil surface and in the air. The minimum air temperature dropped to –5...–8°C, and in the Ukrainian Carpathians—to –13°C. At the same time, a sharp warming occurred in the second ten-day period of the month, causing maximum air temperatures to rise to +25...+30°C. Thus, the range of temperature fluctuations over the month exceeded 35°C in some regions, indicating the extremely contrasting nature of weather conditions. Despite brief periods of very warm weather, the number of days with an average daily air temperature above 0°C and above 5.0°C throughout Ukraine was below the climatic norm. As a result, the average monthly air temperature across most of the country remained close to normal, deviating by no more than 0.7°C **(Fig. 4)**.

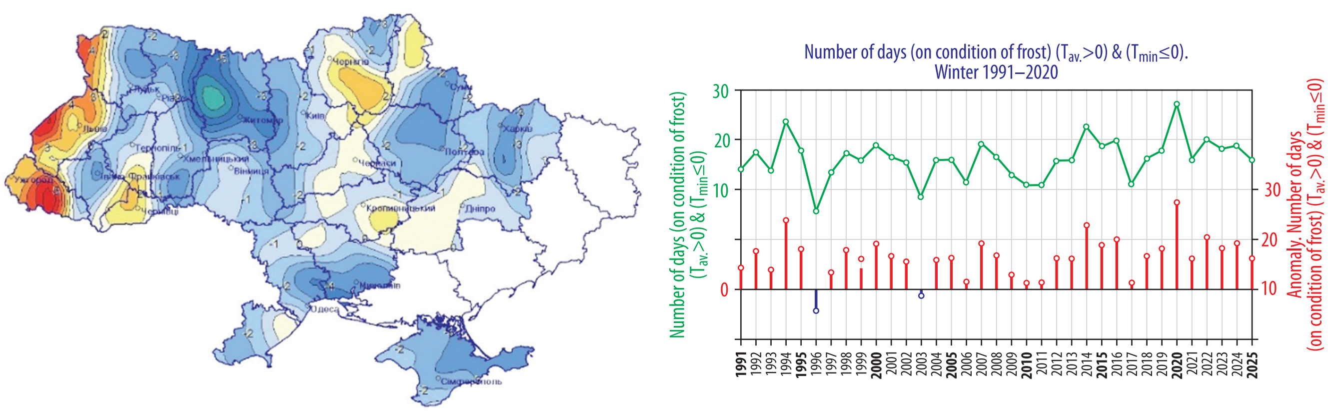


Fig. 5. The anomaly in the number of frosty days ($T_{av.}$>0 and T_{min}≤0) in the winter of 2025 in Ukraine as compared to 1991–2020

A distinctive feature of April 2025 was a significant precipitation deficit **(Fig. 3*a*)**, which was observed across nearly the entire country, with the exception of the Lviv, Rivne, Chernihiv, and Mykolaiv regions, and reached 40% or more in the southwestern and southern regions and in the Transcarpathian region.

May was one of the coldest and wettest months in recent decades. It was the coldest month of the spring season and stood in sharp contrast to the exceptionally warm March. The predominance of cyclonic activity led to frequent precipitation and the inflow of cool air from northern latitudes. The average monthly air temperature was 2.4°C below normal **(Fig. 4)**. Many regions recorded record-low minimum temperatures on specific dates. Temperature conditions were particularly anomalous in the western part of the country. This region recorded the greatest anomalies in both average minimum temperatures (–2.0...–3.0°C) and average maximum temperatures (–4.5...–5.4°C). May was also one of the wettest months of the year **(Fig. 3*a*)**. Most regions received between one and two times the average monthly precipitation, while in Vinnytsia region, precipitation exceeded the average by more than three times (192 mm). Frequent rains and low temperatures slowed the growth of heat-loving crops and delayed field operations. At the same time, the significant precipitation partially offset the soil moisture deficit that had developed as a result of the dry conditions in previous months.

The summer of 2025 was also characterized by unstable weather, with alternating cold and heat waves, dry periods, and heavy rainfall. The average seasonal air temperature across much of the country was within the normal range (0.5°C); in the northeast, it was below normal, while in the southwest and Transcarpathian region, it was above normal **(Fig. 4*b*)**. The first month of summer was marked by a gradual transition to dry conditions. Temperatures were generally close to normal, but the first heat waves began to form in the south and east of the country. Maximum temperatures exceeded 35°C in some places and reached 39°C in certain areas of the Kharkiv region. Most regions experienced a precipitation deficit, particularly in the Steppe zone. Against the backdrop of high temperatures and intense evaporation, the condition of winter crops deteriorated rapidly. The signs of atmospheric and soil drought began to appear in the southern regions. Dry winds and an increased risk of fire danger were observed. July 2025 in Ukraine was characterized by predominantly abnormally warm, unstable, and contrasting weather conditions. Throughout the month, there were significant temperature fluctuations, with periods of intense heat alternating with brief cold spells caused by the passage of active atmospheric fronts. July became the hottest month of the year and the culmination of the summer season. The average monthly air temperature across most of the country exceeded the climatic norm by 1.3°C **(Fig. 4)**. Subtropical air masses lingered over Ukraine for an extended period, causing an intense heat wave. In the southern, central, and eastern regions of the country, maximum temperatures reached 38–40°C, and in some regions, new all-time high air temperatures were recorded both for specific dates and for July as a whole. Precipitation was distributed extremely unevenly across the country. In most western, northern, and some central regions, precipitation levels exceeded the climatic norm by 1.0–2.5 times, and in some areas reached three times the monthly norm, while in the southern regions and in some parts of the central and eastern regions, there was a significant precipitation deficit **(Fig. 3)**. Throughout the month, there was a high frequency of hazardous and extreme weather events, including heavy and extreme rainfall, intense downpours, squalls, and hail, which in some regions led to flooding, damage to infrastructure, and disruptions to people's activities.

Thus, July 2025 was marked by a combination of abnormally high air temperatures, significant spatial heterogeneity in precipitation, and increased activity of hazardous convective processes which is a characteristic feature of current climate change in Ukraine.

August 2025 in Ukraine was characterized by predominantly moderate temperatures, significant spatial heterogeneity in precipitation and weather conditions, insufficient moisture conditions over most of the country's territory, and a high fire danger. The average monthly air temperature across most of the country was close to the climatic norm **(Fig. 4)**, while in some areas of the northern, western, and eastern regions it was below the norm. Significant fluctuations in air temperature were observed throughout the month, with alternating periods of hot weather and brief cold spells associated with the passage of atmospheric fronts and cyclones. At the end of the month, absolute maximum temperatures for specific dates were exceeded in the northeastern regions. Precipitation was distributed extremely unevenly across the country. In most of Ukraine, precipitation amounted to only 20–78% of the monthly norm, and in certain areas of the Odesa, Volyn, and Chernivtsi regions — only 2–19% of the norm. At the same time, in the Kharkiv region and in some parts of the Kirovohrad, Dnipropetrovsk, and Mykolaiv regions, precipitation exceeded the norm by 1.3–1.6 times **(Fig. 3)**. Despite the prevailing precipitation deficit, isolated instances of heavy rain, thunderstorms, squalls, and hail were observed throughout the month; however, the number of hazardous weather events was significantly lower than in July. A key feature of August was the prolonged persistence of an extreme fire danger (Class 5) across a significant portion of the country, which was caused by a precipitation deficit, high air temperatures, and predominantly anticyclonic weather conditions.

The autumn of 2025 in Ukraine was generally warm, mainly due to an abnormally warm September and, in particular, November, during which the average monthly air temperature exceeded the climatic norm by 1.8°C and 3.4°C, respectively **(Fig. 4)**. September was one of the warmest autumn months in recent years. Across almost all of Ukraine, the weather was practically summer-like: the average daily air temperature remained above 15°C almost until the end of the month. The average monthly temperature was 1.8°C above normal, and in some regions, the deviation reached 2.5°C or more. Maximum air temperatures rose to 28–36°C. Throughout the month, new all-time high temperatures were recorded on multiple occasions, both for specific dates and for September as a whole, confirming the continuing trend toward a warming climate. The predominance of anticyclonic circulation led to prolonged periods of dry and mostly clear weather. Most of Ukraine experienced a precipitation deficit, which was particularly significant in the eastern regions. For example, in the Kharkiv, Dnipropetrovsk, Poltava, and Sumy regions, only 5–19% of the monthly precipitation norm fell, and in Izium, September was the driest on record. At the same time, in the western regions, as well as in some parts of the Odesa, Mykolaiv, and Kyiv regions, precipitation exceeded the norm by 1.0–1.8 times, and locally — up to 2.4 times the norm.

Despite the generally dry nature of the month, September saw isolated hazardous and extreme meteorological events, primarily associated with the passage of active atmospheric fronts, including heavy and extreme rainfall, thunderstorms, squalls, and hail. At the end of the month, temperatures dropped sharply due to the influx of Arctic air. Ground frost was recorded in most regions, and in some places even in the air, while the first snow cover formed in the highlands of the Carpathians on September 30. For much of the month, an extreme fire danger (Class 5) persisted across most of Ukraine.

October 2025 in Ukraine was characterized by a predominance of cyclonic circulation, significant variability in weather conditions, and an uneven distribution of precipitation. Despite the frequent passage of atmospheric fronts and cyclones, the average monthly air temperature across most of the country remained close to the climatic norm **(Fig. 4)**. At the same time, it exceeded the norm in the east of the country, while in the Transcarpathian region and the Carpathians it was 1.0–2.5°C below the norm. Throughout the month, weather conditions were shaped by active cyclonic activity, which led to frequent fluctuations in air temperature and prolonged periods of precipitation. Maximum air temperatures rose to 15–25°C, while minimum temperatures dropped to 4°C above freezing to 5°C below freezing, and in the Carpathiansand in some parts of the Precarpathian region — to 6–8°C below freezing. In the second half of the month, many regions of the country experienced ground and air frosts, which in some places reached hazardous levels. Precipitation was distributed extremely unevenly across the country. In most regions, precipitation levels were close to normal; however, in the southern, northern, and central regions, as well as in the Kharkiv region, some areas received 1.0–2.3 times the monthly normal, and in certain districts of the central regions and the Odesa region, up to 2.4–3.1 times the norm **(Fig. 3*a*)**. Due to the increase in precipitation, the situation with soil moisture reserves improved somewhat; however, a moisture deficit persisted in the Lviv and Transcarpathian regions, as well as in some parts of the Ivano-Frankivsk, Volyn, and Rivne regions. According to data from the Ukrainian Hydrometeorological Center, a significant number of hazardous meteorological events were observed throughout October, including heavy rain, heavy snow, thunderstorms, squalls, fog, and frosts. In the highlands of the Carpathians, a stable snow cover formed on multiple occasions, and at the end of the month, there were instances of heavy snow and freezing rain. Despite the prevalence of cyclonic weather, an extreme fire danger (Class 5) persisted in some eastern regions at the beginning of the month.

November 2025 was characterized by abnormally high average temperatures, a predominance of cyclonic activity, significant spatial variability in precipitation, and the late but intense onset of winter weather conditions in the western and northern regions of Ukraine. The average monthly air temperature was 3.4°C above the norm, and in the south, anomalies reached 5.0°C or more. The predominance of westerly air flow ensured the inflow of warm and humid air masses from the Atlantic. Throughout the month, new all-time high temperatures were recorded on several occasions for specific dates, particularly in the central, eastern, and southern regions, confirming the trend toward a significant warming of the cold season in Ukraine. Despite the calendar start of the cold season, weather conditions remained unseasonably warm for most of the month. Maximum air temperatures rose to 12–22°C, reaching 24°C in the south of the Odesa region. At the same time, during periods of cold air incursions, minimum temperatures dropped to 0–10°C below freezing, and the first sustained winter conditions were observed in the western and northern regions. Precipitation was generally distributed quite unevenly, but over most of the territory, the amount was close to the climatic norm **(Fig. 3*a*)**. In the far west, as well as in the northern, central, Odesa, and Mykolaiv regions, some areas received 1.2–2.4 times the average monthly precipitation. At the same time, the western and southern regions experienced a precipitation deficit, which in some places reached 50% or more below the climatological norm. According to data from the Ukrainian Hydrometeorological Center, weather conditions throughout the month were primarily determined by active cyclonic activity, which led to frequent precipitation of varying intensity, strong winds, fog, freezing rain, and wet snow accumulation. In the second half of November, mixed-phase precipitation was observed in the western and northern regions, while a stable snow cover up to 28 cm deep formed in the Carpathians and certain areas of the western regions. In the highlands of the Carpathians, heavy snowfall, strong winds, and severe winter weather conditions were repeatedly recorded. December continued the trend of a warm second half of the year. Air temperatures across most of Ukraine were 3.0°C above the norm **(Fig. 4*a*)**. The month was characterized by prolonged periods of anticyclonic weather, which led to a precipitation deficit. The number of days with precipitation was below the climatological norm **(Fig. 3*a*)**, and the number of frosty days decreased significantly. A stable snow cover did not form over most of the country. Fog, thaws, and frequent temperature fluctuations around 0°C prevailed. In the Carpathians and Transcarpathian region, complex accumulations of freezing rain and rime were observed. Thus, December provided further evidence of the gradual mildening of winter conditions in Ukraine against the backdrop of current climate change.

AGROCLIMATIC IMPACTS OF THE 2025 WEATHER CONDITIONS ON UKRAINE'S AGRICULTURE

The sequence of weather anomalies in 2025 created complex risks for Ukraine's agricultural sector, with the nature and scale of these risks varying significantly across regions and crops. The precipitation deficit during the winter of 2024–2025 and in March limited the replenishment of plant-available soil moisture reserves, especially in the south, east, and parts of the central regions. An abnormally warm March accelerated the resumption of growth in winter crops and the onset of development in perennial crops, increasing their sensitivity to subsequent cold spells. Three cold waves in April and late-spring cold spells posed risks of damage to the reproductive organs of fruit crops and rapeseed, while a cold and wet May slowed the development of heat-loving crops and field operations but also partially replenished soil moisture reserves.

In the summer, the main limiting factor in the southern and eastern regions was a combination of high temperatures, a prolonged lack of precipitation, and increased evaporative demand. This coincided with the critical stages of yield formation for corn, sunflowers, and soybeans. JRC MARS estimates confirm that in southern and eastern Ukraine in the summer of 2025, the yields of summer crops were significantly below average, while in the northern and western regions, adequate moisture supply made it possible to maintain higher yield potential (Ben Aoun et al., 2025a). At the national level, expectations for corn and soybeans were better than the five-year average, while those for sunflowers were lower, reflecting the regional distribution of crops and the more severe impact of drought in the south.

Excessive precipitation in July in the western regions had a different type of negative impact: it delayed the harvest of early grains and rapeseed and degraded product quality. Thus, the agrometeorological conditions of 2025 in Ukraine were characterized not by a single dominant stressor, but by a sequence and combination of divergent hazards. For agricultural production, this means that not only average climate changes but also the timing of extremes relative to crop phenological phases are becoming increasingly important. That is why adaptation strategies must be based on regional agroclimatic indicators, monitoring of plant-available soil moisture reserves, forecasts of heat waves and frosts, as well as flexible management of sowing and harvesting dates and crop rotation structure.

DISCUSSION

The results of the study showed that the agroclimatic characteristics of 2025 in Ukraine were determined not so much by the magnitude of the average annual temperature anomaly as by significant seasonal variability, spatial heterogeneity of moisture, and a succession of weather extremes of varying directions. The combination of a warm, snow-poor winter, an abnormally warm March, cold spells in April, a cold and wet May, summer heat and drought in some regions, and excessive moisture in others created risks for agricultural crops that varied in both mechanism and consequences. This pattern of weather conditions aligns with the current understanding of agroclimatic risk, according to which crop yield losses are increasingly caused not by the isolated effect of a single meteorological factor, but by the interaction of several stressors and their coincidence with critical phases of plant development (Schmitt et al., 2022; Heino et al., 2023).

One of the key features of 2025 was a significant deficit in winter precipitation. Across most of Ukraine, precipitation amounted to only 50–80% of the climatic norm, and soil moisture reserves in the spring were below the average perennial values in many regions. From an agronomic perspective, this anomaly was significant not only as a characteristic of the winter season. Insufficient replenishment of soil moisture created unfavorable initial conditions for spring vegetation and increased the sensitivity of crops to subsequent precipitation deficits. The results of European studies confirm that drought remains one of the most significant factors contributing to year-to-year variability in crop yields. In Germany, drought was found to be the most significant of the extreme weather events studied in terms of yield losses in field crops (Schmitt et al., 2022), and an analysis of long-term changes in Europe indicates an increase in yield losses associated with droughts and heat waves (Brás et al., 2021). For the Forest-Steppe of Ukraine, long-term observations also indicate a transformation in soil moisture conditions under current climate change. In particular, in the central part of the Left-Bank Forest-Steppe, a persistent trend toward signs of a non-leaching water regime in chornozem has been observed, indicating increasing aridization of growing conditions for agricultural crops (Demydenko & Velychko, 2025).

At the same time, the impact of the moisture deficit in 2025 varied significantly throughout the season. Heavy rainfall in May in many regions partially offset the spring soil moisture deficit, which may have improved conditions for winter and spring grains. However, the cold weather in May hindered heat accumulation and the development of heat-loving crops. Thus, the positive effect of increased moisture reserves was accompanied by temperature-induced limitations on plant development. This once again demonstrates that assessing agrometeorological conditions based on a single indicator — temperature or precipitation — can lead to an incomplete interpretation of their impact on crop yield.

Another characteristic manifestation of this compound risk was the combination of an exceptionally warm March with subsequent cold spells in April. The average temperature in March was 4.4°C above the norm, which contributed to the early resumption of vegetative growth in winter crops and accelerated the development of perennial crops. This was followed by three cold spells in April, during which the minimum temperature dropped to –5...–8°C, and in the Carpathians—to –13°C. Under these conditions, agricultural risk was determined not only by the absolute value of the minimum temperature but also by its occurrence following an abnormally warm period when plant growth had been accelerated.

This situation is consistent with the findings of recent studies on spring frosts. Guo et al. (2024) showed that crop yield losses are associated not only with the frequency of frost events but also with the amplitude of temperature fluctuations, their duration, and the timing of their occurrence. Therefore, the overall trend toward a shorter frost period observed in Ukraine should not be interpreted as a proportional reduction in agricultural risk from late cold spells. On the contrary, an earlier resumption of vegetation growth may increase the exposure of sensitive developmental stages to brief cold air intrusions. This pattern has previously been observed in Ukraine as well (Balabukh et al., 2024).

During the summer, the main agroclimatic risk for the southern regions and parts of the central and eastern regions was a combination of high air temperatures and a precipitation deficit. Conditions were particularly unfavorable during the July heat wave, when maximum temperatures in the south and east reached 38–40°C. High temperatures increase atmospheric demand for moisture and the intensity of evapotranspiration; therefore, even the same amount of precipitation under different temperature conditions can result in fundamentally different levels of water stress.

It is precisely these simultaneous hot and dry conditions that are considered one of the most dangerous manifestations of modern climate change for crop production. Heino et al. (2023) demonstrated that the likelihood of such conditions occurring during the growing season is increasing in many major global agricultural regions, and the occurrence of these combined extremes is associated with significant negative crop yield anomalies. The coincidence of heat and water stress with reproductive phases is particularly critical. According to model estimates by Senapati et al. (2026), potential losses in global wheat yields due to extreme heat stress during flowering could increase significantly with further warming. The results obtained for Ukraine confirm the need to analyze not only the number of days with high temperatures but also the timing of their occurrence relative to the phenological development of crops.

At the same time, weather conditions in 2025 demonstrated significant spatial contrast in agroclimatic risks. While the southern and some eastern regions experienced a moisture deficit, the western and northern regions saw excessive precipitation during certain periods. This heterogeneity in the response of agricultural production to weather conditions is also characteristic of other European countries. In Sweden, drought had a greater impact on crop yields in the southern part of the country, while in the north, excess moisture was the more negative factor (Sjulgård et al., 2023). In the Netherlands, extremely wet conditions during field operations and harvest caused significant losses for certain crops, whereas in other years, drought was the dominant factor (van Oort et al., 2023). This confirms that the same climatic anomaly cannot be considered universally negative or positive for all agroclimatic zones.

For Ukraine, this pattern is particularly important due to the country's significant territorial extent and natural and climatic heterogeneity. Rising temperatures in the northern and western regions, coupled with sufficient moisture during certain periods, may create more favorable thermal conditions for heat-loving crops. In contrast, in the Steppe and southern Forest-Steppe, the temperature anomaly itself combined with a precipitation deficit exacerbates water stress and may reduce productivity. Thus, the agricultural consequences of warming are determined not only by the magnitude of the temperature change but also by the region's baseline climatic conditions and moisture availability (Schmidt, Felsche, 2024).

Excessive precipitation observed in certain regions in May and July cannot be viewed solely as compensation for the previous moisture deficit either. At certain intensities and durations, it causes soil waterlogging, impairs soil aeration, and complicates field oeprations and harvesting. A global meta-analysis by Tian et al. (2021) showed an average 32.9% reduction in crop yields under waterlogged conditions, with losses being greatest when waterlogging occurred during the reproductive phase and increasing as the duration of stress increased. Therefore, during the agroclimatic assessment, it is important to consider not only monthly or seasonal precipitation totals but also precipitation intensity, the duration of wet periods, and the timing of precipitation.

The results also indicate that traditional indicators such as annual temperature and annual precipitation are no longer sufficient for assessing climate risks to agricultural production. In 2025, a positive average annual temperature anomaly was accompanied by a cold May and several spring cold spells, while the overall annual precipitation deficit was accompanied by local monthly totals that were several times higher than normal. It was precisely the seasonal structure and sequence of these anomalies that determined their agronomic significance.

This conclusion is consistent with current approaches to assessing the impact of climate on agriculture. Yield response depends significantly on the crop, local soil and climate conditions, and the stage of plant development (Schmitt et al., 2022; Sjulgård et al., 2023). Therefore, it is advisable for Ukraine to further develop a system of agroclimatic indicators that combine characteristics of temperature, precipitation, evaporation, plant-available soil moisture reserves, and crop phenology.

At the same time, the study results should be interpreted with certain limitations in mind. Due to the temporary occupation of territories and war hostilities, regular meteorological observations in parts of the eastern and southern regions were either absent or incomplete. These territories are among the driest agroclimatic zones in Ukraine and play an important role in the production of grain and oilseed crops. Therefore, the actual spatial heterogeneity of drought and heat stress may have been greater than reflected in the available data. Furthermore, this study focuses primarily on the meteorological conditions underlying the formation of agroclimatic risks; quantifying the attribution of specific crop yield losses to individual weather events requires combining meteorological data with regional crop yield statistics, phenological observations, soil characteristics, and cultivation practices.

On a global scale, new assessments show that adapting agricultural production can partially reduce climate-induced losses, but does not eliminate them entirely (Hultgren et al., 2025). For Ukraine, this underscores the need to shift from reacting to individual adverse weather events to systematically managing agroclimatic risks. Promising areas include adaptive selection of crops and varieties, optimization of planting and harvesting dates, soil moisture conservation, improved irrigation efficiency, diversification of crop patterns, and the use of climate forecasts. Another key element of adaptation is the management of plant-available moisture reserves through the optimization of crop rotations and tillage systems, as these factors significantly influence the accumulation and utilization of soil moisture by agrocenoses (Demydenko et al., 2021; Demydenko & Velychko, 2025).

Climate services, which convert meteorological and climate information into indicators directly applicable to agronomic decision-making, are also of great importance for agricultural adaptation. A study by Toreti et al. (2022) shows that the use of climate information for adaptive management, particularly in variety selection, can mitigate the negative impacts of climate change on crop production. For Ukraine, it makes sense to focus such services primarily on monitoring and forecasting plat-available soil moisture deficits, droughts, heat waves, late spring frosts, excessive precipitation, and their potential overlap with critical growth stages of major agricultural crops.

Thus, the weather conditions of 2025 demonstrate that current climate change in Ukraine affects agriculture not only through a general rise in temperature. Equally important are the increasing spatiotemporal variations in precipitation, shifts in seasonal patterns, the occurrence of extreme events, and the formation of combined heat and water stress. It is precisely these characteristics that should form the basis for further assessment of agroclimatic risks and the development of measures to help Ukraine's agriculture adapt to climate change.

CONCLUSIONS

An analysis of Ukraine's weather and climate conditions in 2025 showed that this year provided further confirmation of the current trend toward global warming. In terms of average annual temperature, it ranked among the five warmest years since 1961, and air temperatures across most of the country exceeded the 1991–2020 climate norm by 1–2°C. The largest positive anomalies were observed in the northern, central, and eastern regions of Ukraine.

One of the most significant features of the year was the earlier rise in minimum air temperatures compared to maximum temperatures, which manifested in a significant reduction in the number of frosty days, days with temperatures below 0°C, and days with minimum temperatures below –10°C, as well as an increase in the frequency of tropical nights. These changes indicate a further mildening of winter conditions and an increase in heat stress during the warm season.

In 2025, high spatiotemporal variability in atmospheric precipitation persisted. Despite an overall annual moisture deficit across most of Ukraine, certain periods were characterized by extremely intense precipitation and were accompanied by dangerous convective phenomena. The combination of prolonged dry periods with localized heavy rains indicates an increase in the contrast of the moisture regime, a characteristic feature of contemporary climate change.

Seasonal weather patterns were marked by significant variability. The most anomalous conditions included a record-warm March, a contrasting April with several cold spells, a cold and very wet May, a hot July with heat waves, and an abnormally warm November. This combination of heat and cold anomalies, droughts, heavy downpours, and other hazardous meteorological events is a characteristic feature of the current climate transformation in Ukraine.

The results confirm the intensification of climatic and agroclimatic risks in Ukraine. For agriculture in

2025, the most significant factors were insufficient winter-spring moisture accumulation, early plant development following a warm March, late spring cold spells, summer drought and heat in the south and east, and excessive precipitation in certain western regions. The impact of these factors depended on the phenological stage and region: drought reduced the yield potential of winter and summer crops, frosts posed a risk to rapeseed and perennial plantations, and excessive moisture complicated harvesting and degraded product quality. This justifies the shift from evaluating individual climate indicators to a comprehensive assessment of composite agroclimatic risks and the development of regionalized climate services for the agricultural sector.

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ПОГОДНІ АНОМАЛІЇ ЯК ЧИННИК АГРОКЛІМАТИЧНИХ РИЗИКІВ ДЛЯ СІЛЬСЬКОГО ГОСПОДАРСТВА УКРАЇНИ В УМОВАХ ЗМІНИ КЛІМАТУ

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Мета. Виявити особливості прояву погодних аномалій в Україні в умовах сучасної зміни клімату та оцінити пов’язані з ними агрокліматичні ризики для сільського господарства на прикладі погодних умов 2025 року. **Матеріали і методи.** Для аналізу використано щоденні дані спостережень державної мережі гідрометеорологічних спостережень України за 2025 рік і кліматичну норму основних метеорологічних чинників за 1991–2020 рр. Дослідження охоплює західні, центральні та північні регіони України, а також Одеську й Миколаївську області. Території, де через тимчасову окупацію або бойові дії спостереження не проводили або здійснювали нерегулярно (що унеможливило формування безперервних рядів даних), виключено з дослідження. Для аналізу небезпечних явищ погоди залучено щомісячні огляди погоди Українського гідрометеорологічного центру. Просторово-часові особливості та сезонну мінливість показників у 2025 році виявлено за допомогою методів кліматологічного, статистичного й просторового аналізу. Аграрні наслідки погодних аномалій оцінено шляхом зіставлення отриманих результатів із даними JRC MARS (Ben Aoun et al., 2025a, 2025b) щодо стану та врожайності культур в Україні й Європі та глобальними оцінками FAO (FAO, 2025) щодо впливу кліматичних екстремумів на агропродовольчі системи. **Результати.** 2025 рік в Україні увійшов до п’ятірки найтепліших з 1961 року; середня за рік температура повітря на більшій частині території перевищувала норму на 1–2°C. Особливо виразним було підвищення мінімальної температури, скорочення кількості морозних днів і поширення тропічних ночей. Режим опадів характеризувався загальним дефіцитом і різкою просторово-часовою неоднорідністю. Для аграрного виробництва найбільш значущими були недостатнє зимове накопичення вологи, раннє відновлення вегетації після аномально теплого березня, три хвилі холоду у квітні, холодний і вологий травень, літня спека та тривалий дефіцит опадів на півдні й сході, а також надмірні липневі опади на заході. Таке поєднання чинників знижувало потенціал озимих культур у посушливих районах, створювало ризик пошкодження ріпаку, фруктових та овочевих культур пізніми заморозками, погіршувало умови формування врожаю кукурудзи, соняшнику та сої на півдні й сході та ускладнювало збирання і якість зерна та ріпаку в західних областях. Водночас достатнє зволоження в північних і західних регіонах підтримувало потенціал літніх культур. **Висновки.** Погодні умови 2025 року продемонстрували, що для сільського господарства України кліматичний ризик визначається не лише загальним потеплінням атмосфери, а насамперед поєднанням посухи, спеки, пізніх похолодань та локального перезволоження в критичні фази розвитку культур. Просторова контрастність агрометеорологічних умов зростає, що підсилює потребу в регіоналізованих кліматичних сервісах, ранньому попередженні, адаптивному доборі культур і сортів, оптимізації строків польових робіт та управлінні ґрунтовою вологою.

Ключові слова: зміна клімату, агрокліматичні ризики, температура повітря, атмосферні опади, посуха, заморозки, хвилі тепла, урожайність, сільське господарство, Україна.