EGU26 GENERAL ASSEMBLY

Vienna, Austria & Online | 3–8 May 2026

Flash Flood Events in the North-western Black Sea Region under Climate Change

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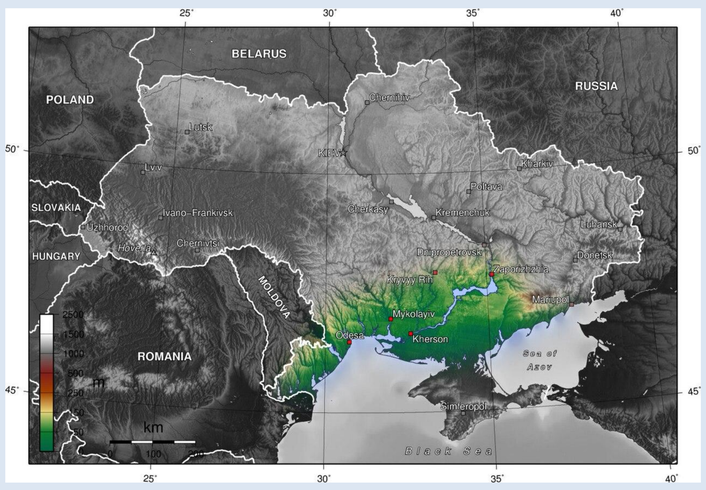
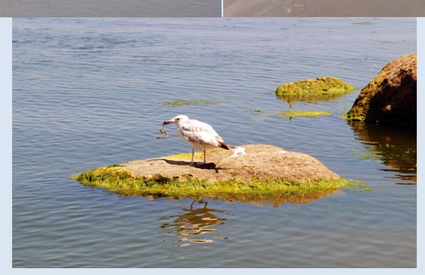
EGU26-14233

Extreme hydrological events have become increasingly frequent in Ukraine over recent decades, reflecting both climate change impacts and existing shortcomings in water resources management. According to the Water Strategy of Ukraine up to 2050, inadequate governance practices remain a major source of anthropogenic pressure on water bodies, while climate change creates additional risks through prolonged droughts interrupted by intense rainfall events, leading to flooding. These challenges are particularly critical in southern Ukraine, where limited local water resources necessitate extensive hydrotechnical regulation and adaptive management.



Flash floods represent one of the most dangerous manifestations of hydrological extremes. They are characterized by a rapid and short-term rise in water levels, usually triggered by intense precipitation. Due to their sudden onset and high flow velocities, flash floods often cause extensive inundation and significant damage to settlements, infrastructure, and agricultural land.

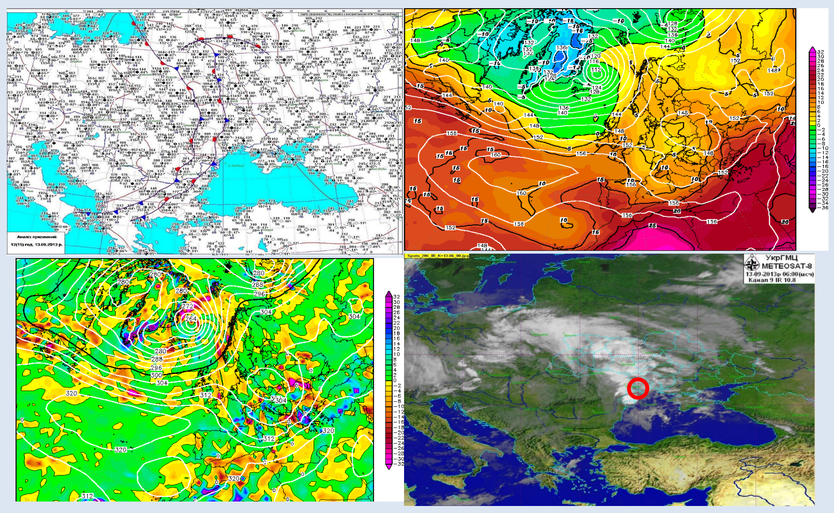


The north-western part of the Black Sea region has experienced several severe flash flood events over the past decade. One of the most significant cases occurred in September 2013 in the Kogilnyk River basin. From 10 to 14 September, anomalously high precipitation totals ranging from 41 mm to 270 mm were recorded. These extreme rainfall conditions were associated with a stationary cold atmospheric front linked to the Asia Minor depression, which caused prolonged convective rainfall accompanied by thunderstorms and squalls. Wind gusts reached up to 22 m/s in the southern districts of the Odesa region.

ACKNOWLEDGEMENTS

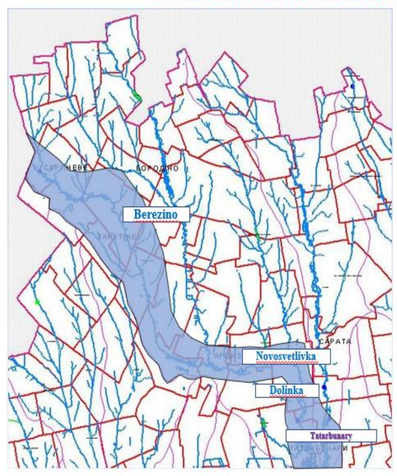
This contribution builds on the conceptual framework of the applied research project "Sustainable Development of Water Resources Management and Modelling in the North-Western Black Sea Region under Conditions of Increasing Climate Extremes and Anthropogenic Pressure", which was approved for funding in the field of Earth and Environmental Sciences by Order No. 23 of the Ministry of Education and Science of Ukraine, dated 9 January 2026 (see https://surl.li/omqxph).

The synoptic processes that led to flash flood



The synoptic conditions (Fig. 1-4) developed as follows. On September 10, an atmospheric front moving eastward from Western Europe across Ukraine caused intense rainfall in Sarata (92 mm in 4.5 hours). Between September 10 and 15, an active wavy cold front from the central Mediterranean influenced the region. On September 13, a cyclone (minimum surface pressure 1009.1 hPa) formed over the Odesa region and moved northeast across Ukraine toward the Central Black Sea region of Russia at 20-30 km/h. The strongest pressure fall (2.0 hPa/3h) occurred in the central Odesa region, while the highest rise (2.3 hPa/3h) was recorded in Sarata. Baric analysis showed the cyclone extending up to 12 km, with its upper-level center shifting northwest (near Prague at 500 and 700 hPa). Continuous cold air advection from the northwest sustained its activity. Strong temperature contrasts (12-15°C behind the front vs. 22-25°C in the warm sector) and moist air inflow from southern seas enhanced its energy and moisture supply.These conditions triggered intense convection, forming powerful cumulonimbus clouds (up to 10-11 km high), resulting in heavy rains, thunderstorms, and squally winds (up to 22 m/s in Izmail on September 13).

Distribution of the flood along the basin of the Kogylnyk River



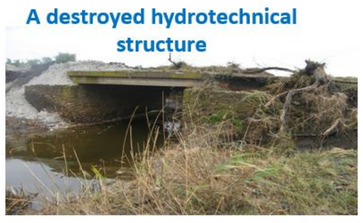
From 10 to 15 September there were rains in the southern part of Odessa region which reached criteria of a heavy rain and a long-lasting rain in some places. According to meteorological stations, agrometeorological and hydrological posts data, the number of precipitations was 92 mm in town Sarata for only 4.5 hours on September 10. The agrometeorological post in the town of Tatarbunary recorded the amount of 60 mm of rainfall during 12 hours at night on September 12. The agrometeorological post in Tarutyne village recorded 196.9 mm rainfall during the daytime on September 12 and 60.0 mm during the daytime on September 13 (i.e. 257 mm for 2 days). The hydrological post #2 in the town of Kiliia fixated 52.0 mm and the hydrological post #1 in the village of Kosa fixated 55.3 mm during only 2 hours in the morning on September 13.

In total during this period such a number of precipitations has fallen: town Sarata counted 181 mm (from September 10 to September 15), the agrometeorological post in Tarutyne village counted 283 mm, the agrometeorological post in the town of Tatarbunary counted 94 mm, and one in the town of Bolgrad recorded 87 mm (from September 11 to September 15).

Flooding of the village Berezino

The village of Berezino – 11 houses were destroyed, 30 were under threat of destruction, and 110 were flooded. The height of the water flow reached up to 2 m

A destroyed hydrotechnical structure



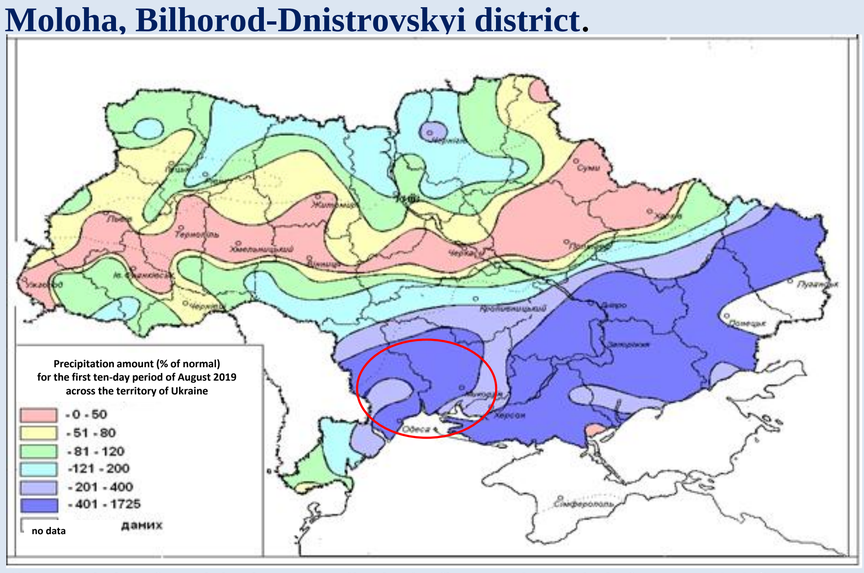
A breach in the dam of the Tarutynsky pond

The lower part of the Tarutynsky Pond

The village of Novoselivka, Saratsky district

A large amount of flood water accumulated in front of the village of Novoselyvka, which prevented the flooding of the villages of Novoselyvka and Dolynka in the Saratsky District

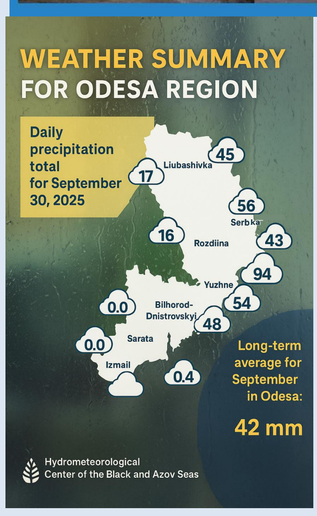
Another notable episode occurred in early August 2019, when unstable atmospheric conditions and the passage of active cyclones led to intense rainfall across southern and eastern Ukraine. On 3–4 August, precipitation amounts reached 130–220% of the monthly norm in several locations. In the Odesa region, rainfall totals of up to 126 mm were recorded, corresponding to nearly three-monthly norms and meeting the criteria for hazardous meteorological phenomena. This event triggered debris flows and localized flash flooding, particularly in the village of Moloha, Bilhorod-Dnistrovskyi district.



Characteristics of precipitation anomalies in the first ten-day period of August 2019 *(based on data from the Ukrainian Hydrometeorological Center www.meteo.gov.ua)*

More recently, in September 2025, an urban flash flood occurred in Odesa, highlighting the increasing vulnerability of urban areas to extreme rainfall. Prolonged heavy rains resulted in widespread flooding, significant damage, and tragic human losses. Emergency services conducted large-scale rescue operations, evacuating hundreds of residents and vehicles.

Odessa, Ukraine, 30/09/2025



In Odesa and the Odesa district, rescuers had been working for nearly a day to deal with flooding caused by heavy rains. Nine people, including a child, have died. A total of 362 people were rescued and 227 vehicles evacuated with the involvement of 255 rescuers and 68 units of equipment, according to the State Emergency Service of Ukraine.

These case studies demonstrate a clear trend toward increasing intensity and impact of flash floods in the north-western Black Sea region. In the context of ongoing climate change, such events are expected to become more frequent, underscoring the urgent need for enhanced hydrological monitoring, early warning systems, climate-adaptive urban planning, and integrated water resources management strategies in southern Ukraine.