Case Study of the 3 June 2025 Severe Rainfall in the Eastern Black Sea Region of Türkiye Using ECMWF Forecast Products

REPUBLIC OF TÜRKİYE
MINISTRY OF ENVIRONMENT, URBANIZATION AND CLIMATE CHANGE

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INTRODUCTION

The Eastern Black Sea region of Türkiye is highly prone to heavy rainfall events due to its complex topography and the moist air inflow from the Black Sea. During the summer months, the jet stream tends to shift towards northern latitudes over Europe, allowing upper-level troughs to more frequently influence the northern parts of Türkiye. On 3 June 2025, a severe rainfall event impacted the provinces of Ordu, Giresun, Trabzon, and Rize, causing floods and seriously affecting daily life.
In this case study, different ECMWF forecast products—the Integrated Forecasting System (IFS), the Artificial Intelligence Forecasting System (AIFS), the Ensemble Prediction System (EPS), and the Extreme Forecast Index (EFI)—were evaluated at lead times of 24, 48, and 72 hours. These products were used in an integrated manner by the Turkish State Meteorological Service (TSMS) to predict the event and to provide timely early warnings.
By comparing model outputs with observational data from meteorological stations, this study highlights the strengths and limitations of each forecasting system and provides valuable insights into their performance.

MATERIAL AND METHOD

Precipitation observations from TSMS stations in Ordu, Giresun, Trabzon, and Rize were compared with ECMWF forecasts. Deterministic (IFS), ensemble (EPS), AI-based (AIFS), and risk-based (EFI) products were analysed for T+24, T+48, and T+72 lead times. Model outputs were verified against station data to assess forecast accuracy in terms of precipitation amount, timing, and spatial distribution.

SYNOPTIC CHARTS

On the surface chart, a 1024 hPa high pressure centre is located over the Mediterranean Sea, and its ridge extends northward to Russia. Over Kazakhstan, there is a low pressure centre, and its cold front reaches the Caucasus. At one synoptic station in the Eastern Black Sea region of Türkiye, the observations were: temperature 18 °C, wet-bulb temperature 14 °C, pressure 1017.5 hPa, pressure tendency decreased by 0.8 hPa in the last 3 hours, cloud cover 7/8, and cloud type low-level stratocumulus. (Figure 1.a).
At the 850 hPa level, the map shows high geopotential height over Italy and the Balkans, with a value of 156 dam and a temperature of 15 °C, influencing the western part of Türkiye. Over Russia, the map shows low geopotential height with a value of 138 dam and a temperature of 5 °C. In the Eastern Black Sea region of Türkiye, the map shows conditions on the 153 dam geopotential height contour and within the 10–12.5 °C isotherms, with northerly winds moving from the Black Sea**.** (Figure 1.b**)**
At the 500 hPa level, the map shows an upper-level low over Russia, with a geopotential height of 552 dam and cold air of -20 °C. The map also shows a shortwave trough affecting the northeastern parts of Türkiye, characterized by a geopotential height of 576 dam and a temperature of -15 °C. (Figure 1.c)

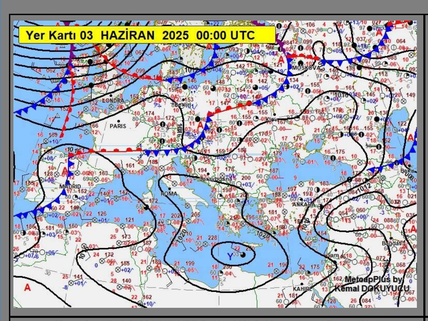


Figure 1.a: 03.06.2025 00.00 UTC Surface MSLP, Meteorological Station, Wind

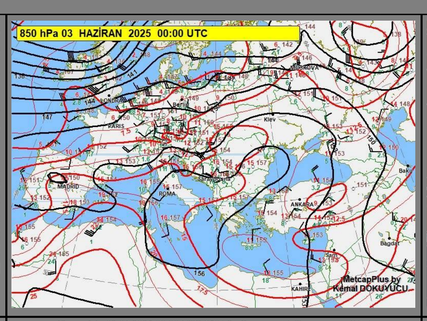


Figure 1.b: 03.06.2025 00.00 UTC 850 hPa Geopotantial, Temperature, Wind

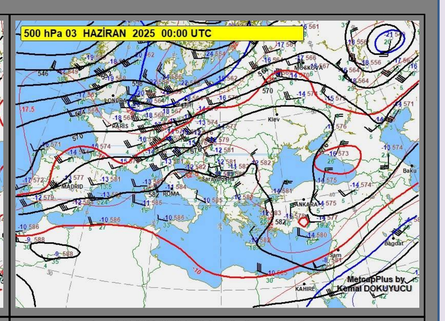


Figure 1.c: 03.06.2025 00.00 UTC 500 hPa Geopotantial, Temperature, Wind

RADAR AND SATELLITE IMAGES

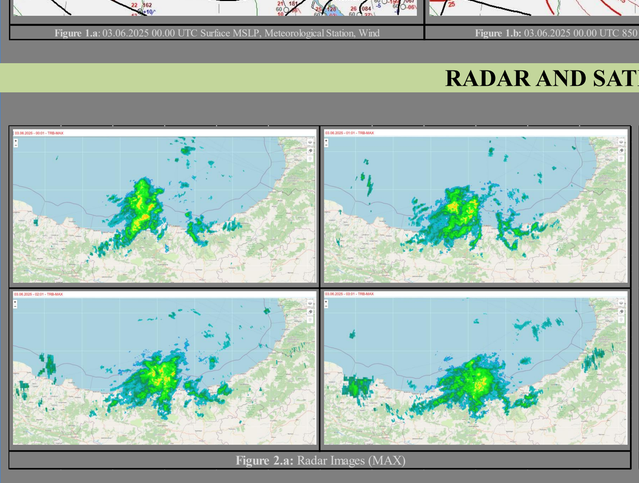


Figure 2.a: Radar Images (MAX)

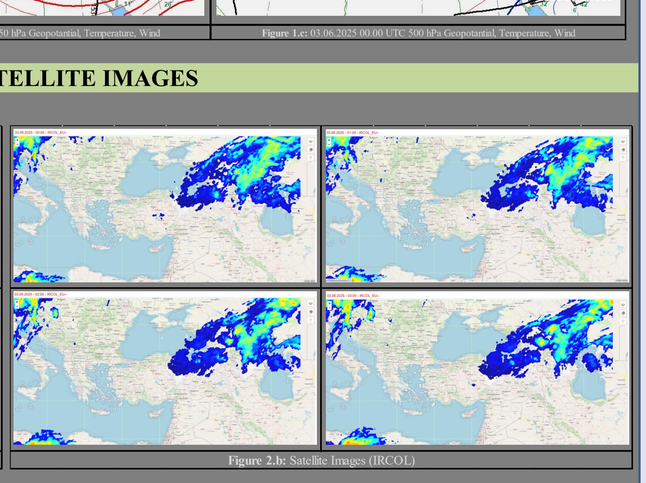


Figure 2.b: Satellite Images (IRCOL)

ECMWF PRODUCTS

IFS

The IFS run initialized 1 June 2025 (T+72) predicted 35.7 mm of precipitation in the Ordu area, 37.2 mm in the Giresun area, and 16.5 mm in both the Trabzon and Rize areas for 3 June 2025 (Figure 3.a)

The IFS run initialized 2 June 2025 (T+48) predicted 30.0 mm of precipitation in the Ordu area, 27.6 mm in the Giresun area, 29.8 mm in the Trabzon area, and 27.1 mm in the Rize area for 3 June 2025. (Figure 3.b)

The IFS run initialized 3 June 2025 (T+24) predicted 33.9 mm of precipitation in the Ordu area, 64.7 mm in the Giresun area, 33.2 mm in the Trabzon area, and 26.7 mm in the Rize area for 3 June 2025. (Figure 3.c)

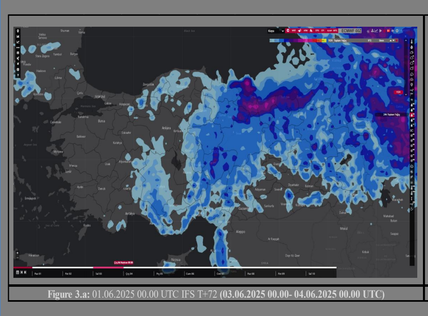


Figure 3.a: 01.06.2025 00.00 UTC IFS T+72 **(03.06.2025 00.00- 04.06.2025 00.00 UTC)**

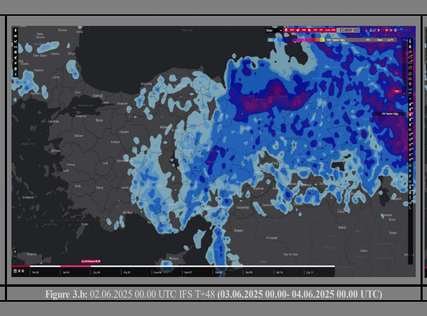


Figure 3.b: 02.06.2025 00.00 UTC IFS T+48 **(03.06.2025 00.00- 04.06.2025 00.00 UTC)**

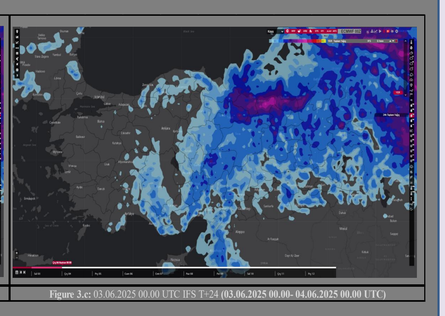


Figure 3.c: 03.06.2025 00.00 UTC IFS T+24 **(03.06.2025 00.00- 04.06.2025 00.00 UTC)**

AIFS

The AIFS run initialized 1 June 2025 (T+72) predicted 12.1 mm of precipitation in the Ordu area, 11.7 mm in the Giresun area, 9.3 mm in the Trabzon area, and 9.9 mm in the Rize area for 3 June 2025. (Figure 4.a).

The AIFS run initialized 2 June 2025 (T+48) predicted 13.2 mm of precipitation in the Ordu area, 12.9 mm in the Giresun area, 10.3 mm in the Trabzon area, and 11.0 mm in the Rize area for 3 June 2025. (Figure 4.b).

The AIFS run initialized 3 June 2025 (T+24) predicted 21.7 mm of precipitation in the Ordu area, 22.3 mm in the Giresun area, 13.2 mm in the Trabzon area, and 11.2 mm in the Rize area for 3 June 2025. (Figure 4.c).

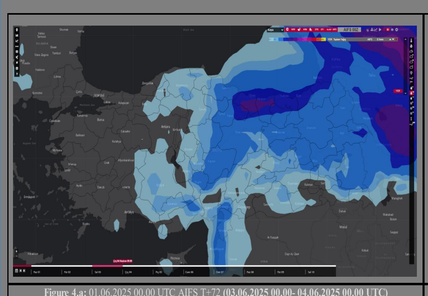


Figure 4.a: 01.06.2025 00.00 UTC AIFS T+72 **(03.06.2025 00.00- 04.06.2025 00.00 UTC)**

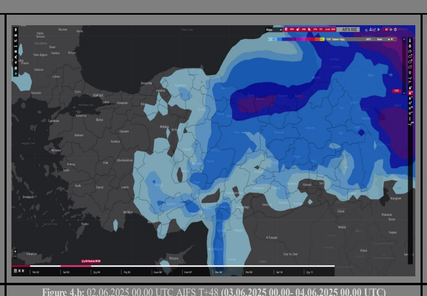


Figure 4.b: 02.06.2025 00.00 UTC AIFS T+48 **(03.06.2025 00.00- 04.06.2025 00.00 UTC)**

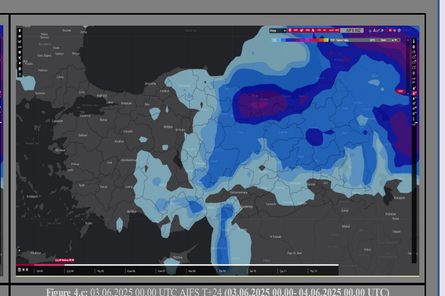


Figure 4.c: 03.06.2025 00.00 UTC AIFS T+24 **(03.06.2025 00.00- 04.06.2025 00.00 UTC)**

EPS

The EPS run initialized 1 June 2025 (T+72) predicted probabilities of precipitation exceeding 20 mm at 77.5% for the Ordu area, 80.5% for the Giresun area, 24.0% for the Trabzon area, and 31.5% for the Rize area for 3 June 2025 (Figure 5.a).

The EPS run initialized 2 June 2025 (T+48) predicted probabilities of precipitation exceeding 20 mm at 78% for the Ordu area, 64% for the Giresun area, 33% for the Trabzon area, and 39% for the Rize area for 3 June 2025 (Figure 5.b).

The EPS run initialized 3 June 2025 (T+24) predicted probabilities of precipitation exceeding 20 mm at 87% for the Ordu area, 96.5% for the Giresun area, 43.5% for the Trabzon area, and 61% for the Rize area for 3 June 2025 (Figure 5.c).

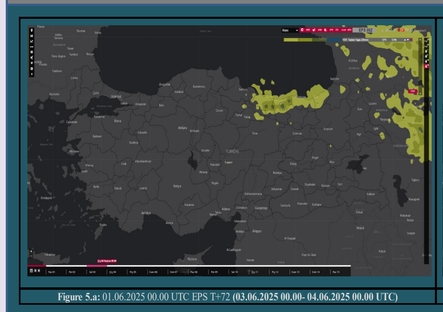


Figure 5.a: 01.06.2025 00.00 UTC EPS T+72 **(03.06.2025 00.00- 04.06.2025 00.00 UTC)**

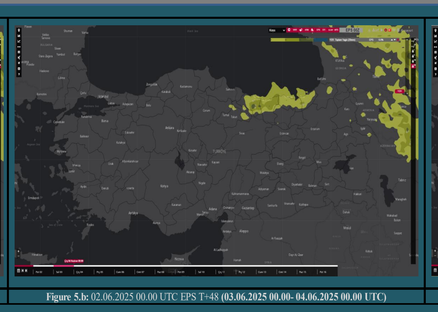


Figure 5.b: 02.06.2025 00.00 UTC EPS T+48 **(03.06.2025 00.00- 04.06.2025 00.00 UTC)**

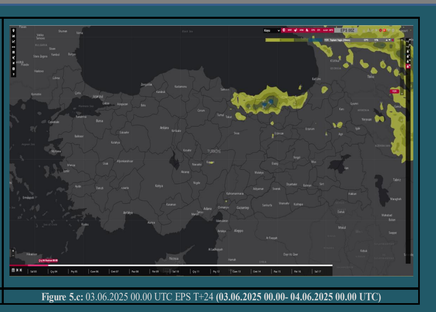


Figure 5.c: 03.06.2025 00.00 UTC EPS T+24 **(03.06.2025 00.00- 04.06.2025 00.00 UTC)**

EFI

The EFI run initialized 1 June 2025 (T+48) predicted values of approximately 0.8 in the Ordu area, 0.8 in the Giresun area, 0.5 in the Trabzon area, and 0.7 in the Rize area for 3 June 2025 (Figure 6.a).

The EFI run initialized 2 June 2025 (T+48) predicted values of approximately 0.8 in the Ordu area, 0.8 in the Giresun area, 0.6 in the Trabzon area, and 0.7 in the Rize area for 3 June 2025 (Figure 6.b).

The EFI run initialized 3 June 2025 (T+48) predicted values of approximately 0.9 in the Ordu area, 0.9 in the Giresun area, 0.8 in the Trabzon area, and 0.8 in the Rize area for 3 June 2025 (Figure 6.c).

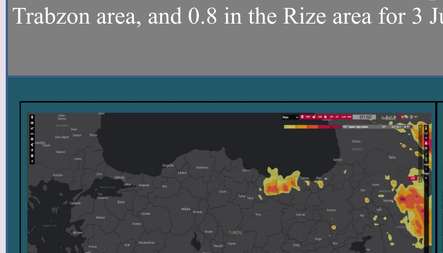


Figure 6.a: 01.06.2025 00.00 UTC EFI T+72 **(03.06.2025 00.00- 04.06.2025 00.00 UTC)**

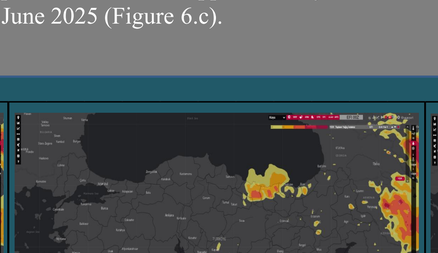


Figure 6.b: 02.06.2025 00.00 UTC EFI T+48 **(03.06.2025 00.00- 04.06.2025 00.00 UTC)**

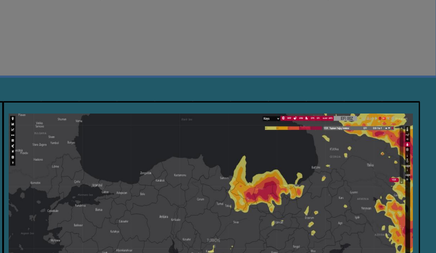
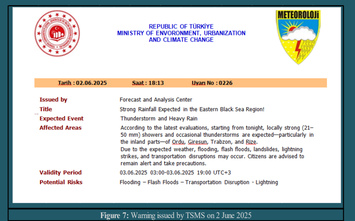


Figure 6.c: 03.06.2025 00.00 UTC EFI T+24 **(03.06.2025 00.00- 04.06.2025 00.00 UTC)**

Meteorological Warning Issued And Impact


REPUBLIC OF TÜRKİYE
MINISTRY OF ENVIRONMENT, URBANIZATION AND CLIMATE CHANGE
METEOROLOJİ

Tarih : 02.06.2025 Saat : 18:13 Uyarı No : 0226

Issued by	Forecast and Analysis Center
Title	Strong Rainfall Expected in the Eastern Black Sea Region!
Expected Event	Thunderstorm and Heavy Rain
Affected Areas	According to the latest evaluations, starting from tonight, locally strong (21–50 mm) showers and occasional thunderstorms are expected—particularly in the inland parts—of Ordu, Giresun, Trabzon, and Rize. Due to the expected weather, flooding, flash floods, landslides, lightning strikes, and transportation disruptions may occur. Citizens are advised to remain alert and take precautions.
Validity Period	03.06.2025 03:00-03.06.2025 19:00 UTC+3
Potential Risks	Flooding – Flash Floods – Transportation Disruption - Lightning

Figure 7: Warning issued by TSMS on 2 June 2025

DATE (GMT)	STATION	TOTAL PRECIPITATION (00.00-24.00)
3.06.2025	18223 | GIRESUN | CANAKCI	73,6
3.06.2025	19366 | TRABZON | ORTAHISAR	62,8
3.06.2025	18730 | GIRESUN | GORELE/SIS DAGI	57,4
3.06.2025	17037 | TRABZON | TRABZON BOLGE	55,6
3.06.2025	18732 | RIZE | IKIZDERE/CAGRANKAYA YAYLASI	55,6
3.06.2025	18921 | GIRESUN | DERELI/KUMBET KAYAK MERKEZI	53,2
3.06.2025	18572 | TRABZON | MACKA/ORNEKALAN KOYU	46,4
3.06.2025	19243 | RIZE | ARDESEN	45,7
3.06.2025	18935 | RIZE | GUNEYSU/HANDUZU YAYLASI	43,8
3.06.2025	18575 | TRABZON | VAKFIKEBIR/HAMZALI KOYU	43,5

Figure 8: Observed precipitation amounts at TSMS stations on 3 June 2025


Figure 9: Impacts of the heavy rainfall event in Trabzon, where flooding resulted in one fatality.

CONCLUSION AND DISCUSSION

On 3 June 2025, severe rainfall in the Eastern Black Sea region of Türkiye caused floods, landslides, and overflows in several provinces. In particular, one person died due to flooding in the city center of Trabzon.
The surface chart indicated that the cold front extending from Kazakhstan to the Caucasus could influence the Eastern Black Sea region. This was supported by synoptic station observations and satellite data. At the 850 hPa level, northerly winds transported moisture from the Black Sea, contributing to rainfall formation. At the 500 hPa level, a shortwave trough and a -15 °C cold-core low, together with cyclonic wind rotation, supported the development of a convective instability over the region.

Analysis of ECMWF products showed that:
IFS: The predicted rainfall amounts for Trabzon and Rize were lower than the observed values; however, as the forecast lead time shortened, the model outputs showed an increasing trend. A decrease was seen for Ordu and Giresun in the run initialized on 2 June 2025, while the forecasts from 3 June 2025 became more consistent with the observed rainfall.
AIFS: Similarly, initial forecasts underestimated rainfall, but values increased noticeably as the event approached in all provinces.
EPS: The probability of receiving 20 mm or more rainfall increased for Ordu, Trabzon, and Rize, while only Giresun showed a decrease on the second day, consistent with IFS results.
EFI: Index values rose as the event approached. On 3 June 2025, all provinces had values between 0.8 and 1.0, indicating that rainfall was unusual and severe compared to the model climate.

All these ECMWF products were used by the Turkish State Meteorological Service to issue timely and accurate warnings, which were shared with the public, local users, and the media.

In conclusion, this case study demonstrates that ECMWF forecast products are powerful tools for predicting severe weather events in regions with complex topography such as the Eastern Black Sea. By monitoring upcoming adverse weather conditions days in advance and comparing model outputs with observations, forecasters can improve the reliability of predictions. Evaluating deterministic and probabilistic products together increases the accuracy of warnings and provides valuable information to decision-makers. In the future, the use of AI-based systems such as AIFS is expected to further enhance this accuracy.

ACKNOWLEDGMENTS

I would like to thank my colleagues at the Turkish State Meteorological Service (TSMS) for their support in data provision and evaluation. I also extend my sincere gratitude to ECMWF for providing data and forecast products that enable researchers and users to conduct scientific studies.

REFERENCES

[1] Çöleri, M., et al. (2007). *Hava Analiz ve Tahmin Teknikleri* [Weather Analysis and Forecasting Techniques]. Publications of the Turkish State Meteorological Service, Ankara.
[2] ECMWF. *Forecast Products and Data Services.* Available at: https://www.ecmwf.int
[3] Turkish State Meteorological Service (TSMS). *Operational Forecast Archives.*
[4] Turgut, Ü. (2007). Doğu Karadeniz Bölgesinde Sel Felaketine Neden Olan Sinoptik Modellerin Tahmin Tekniği Açısından İncelenmesine Dönük Karşılaştırmalı Bir Araştırma, TMMOB Disaster Symposium, Ankara
[5] Yayvan, M. (2023). *Meteorolojik Haritalar* [Meteorological Charts], Ankara.