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Review Article

Geospatial Technologies in Crisis Response: Analyzing the 2024 Floods in Valencia, Spain

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Abstract: On October 29, 2024, a cut-off low (DANA) caused the most catastrophic flooding in recent history in Spain and the Mediterranean region, in Valencia, resulting in 228 deaths, more than €13 billion in damages, and the disabling of more than 140,000 vehicles. In the days following the disaster, a lack of information and a limited institutional response created a climate of uncertainty. In this context, satellite imagery became the only reliable source of information. This study adopts a systematic review methodology to reconstruct and critically analyze how geospatial technologies were used for forecasting, documenting, and managing the disaster. It draws on a compilation of meteorological datasets, satellite imagery (e.g., Sentinel, Landsat), GIS outputs, institutional maps, and academic research. The research identifies four chronological phases: First, meteorological data were employed to sound the alarm; second, satellite imagery products were used when the disaster already occurred; third, development of web platforms with geographic information and other institutional servers for data download; and four, new lines of research with the inputs generated in the previous points. The intervention of international coordination platforms—the Copernicus EMS rapid mapping service and the International Charter: Space and Major Disasters—allowed, in record time, the processing of the first satellite images and the expedited mapping of flooded areas. The findings demonstrate that spatial analysis tools are one of the most important inputs when dealing with a natural disaster, especially in the first hours and days following the event. However, prior territorial planning and the prompt intervention of decision-makers when such an event occurs are the most decisive factors in minimizing damage. The study also contrasts climate change-based explanations with historical-geographic interpretations of the disaster, underscoring the need for a comprehensive, geographically grounded approach to future risk management.

Keywords: DANA, cut-off low, GIS, remote sensing, International Charter: Space and Major Disasters, Copernicus Emergency Management Service, natural hazards, disaster management, territorial planning

Highlights:

- Geospatial analysis and geography play a crucial role at the onset of global emergencies.
- At the onset of the event, international remote sensing platforms were the only valid source.
- Climate change and historical geography are the two approaches that explain these floods.
- After DANA, new flood models, hydrometeorological explanations, planning proposals and social vulnerability approaches were developed.

1. Introduction

Floods are the most recurrent natural disasters and those that most affect the world's population (Klein et al., 2003; Gill & Malamud, 2014; Ávila-Aceves et al., 2023). In the last 40 years, it is estimated that more than 2 billion people have been affected by flooding, with more than 225,000 deaths reported (Merz et al., 2021).

According to various authors (Tabari, 2020; Tarpanelli et al., 2022), there is no global, systematized database on floods, but we can use the activity developed by the International Charter: Space and Major Disasters (ICSMD) as a reference parameter to identify the occurrence of natural disasters on a large spatial scale. The ICSMD is the international cooperation system of satellite platforms for the free and rapid provision of imagery in locations where emergency situations are occurring and where support is required for disaster mitigation, management, and relief (Bessis et al., 2004; Martinis et al., 2017). Since its establishment in 2000, there have been 974 ICSMD activations, the most recent on July 17 due to the flooding in the South Chungcheong region of South Korea, where more than a thousand people were evacuated. Among the types of disasters, both natural and anthropogenic, 44% of Charter activations worldwide are due to flooding.

In Europe, the ICSMD has been activated 146 times (15% of the total worldwide), half of which were due to events associated with flooding from rivers bursting their banks, inundation from heavy rains, and, to a lesser extent, ocean waves. Of these, 55% have occurred in floodplains associated with coastal areas with a high degree of urbanization and population density, as is the case in this paper.

After heat waves (sensu Ballester et al., 2023), floods are the leading cause of deaths in Europe due to natural disasters. It is also the most recurrent event and the one that generates the greatest economic damage, in addition to other intangible effects such as impacts on health, the environment, and heritage (Meyer et al., 2013; Merz et al., 2021; Tarpanelli et al., 2022). All this occurs in a climate change scenario, where the spatial dynamics of flooding are varying unevenly across Europe: while the frequency of events is increasing in the north, events are decreasing but with greater intensity in southern and eastern Europe (Tabari, 2020; Ballester et al., 2023).

In the field of natural disasters, and floods in particular, geospatial analysis is used in all facets and phases of a disaster, i.e., before, during, and after the impact. In the pre-impact, diagnostic, and planning phases, these tools are used for mapping areas susceptible to flooding, reconstructing historical events, spatiotemporal analysis, hazard identification, and vulnerability assessment (Fekete, 2009; Rosselló & Grimalt, 2020; Seymenov, 2020). It also enables the development and application of forward-looking simulations using advanced techniques such as machine learning (ML), GIS-based multi-criteria decision making (GIS-MCDA), and neural networks (Ouma & Tateishi, 2014; Tehrany et al., 2014; Durlević, 2021). Models are developed to assess risk, due to flooding or the impacts of climate change, and to generate proposals for territorial and urban planning (Waylen et al., 2018; Reinstaller et al., 2025; Vujović et al., 2025).

When a flood is imminent, geospatial technology is integrated into early warning information systems, typically managed by public entities; and when a flood has already occurred, the tools are used for contingency planning (Yekeen et al., 2020). Specific tools and web applications for real-time monitoring are developed to support management and decision-making (Abdalla & Esmail, 2019; Tomaszewski, 2020).

When the event escalates to a disaster, international satellite information networks, such as the ICSMD described above, come into play. In the European Union, the Copernicus Emergency Management Service (CEMS) Rapid Mapping is also available as part of the Copernicus program. Rapid Mapping provides mapping and GIS as quickly as possible to support the management of natural disasters, humanitarian crises, or other critical events (Aimar et al., 2017).

Satellite information extracted from international cooperation networks is essential in the final phase of a disaster, that is, the post-event phase: impact assessment, damage quantification, generation of new data, identification of responsibilities, systematization of the event, lessons learned, and proposals for improvement (He et al., 2023; Braik & Koliou, 2024). This cycle is repeated until another event occurs. This paper focuses on the management and usage phases of geospatial analysis tools following the tragic floods that occurred in October 2024 south of the metropolitan area of the city of Valencia, east of the Iberian Peninsula, in the Spanish Mediterranean. We consider it relevant to perform a detailed reconstruction of the process, understand how the GIS professional community behaves in disaster situations, critically evaluate the effectiveness and usefulness of these tools, propose lines of improvement for future events, and have greater participation in future territorial planning, especially in urban areas susceptible to flooding such as the one that occurred in Valencia. This contribution will facilitate comparisons with future events, revealing the evolution of a flood through the lenses of spatial analysis. The aim is to convey a narrative through the application of this technology and to highlight the usefulness of the resulting cartographic products.

This entire process of geospatial analysis and satellite-based documentation must be understood in the context of the meteorological phenomenon that triggered the disaster. Specifically, the catastrophic flooding event that struck Valencia in October 2024 was caused by a cut-off low system, known in the Iberian context as DANA (Isolated Depression at High Levels), formerly referred to as Gota fría. These are closed low-pressure atmospheric structures in the upper levels of the troposphere, detached from the general circulation. Their formation involves the detachment of a trough from the jet stream, resulting in a cold air cell at altitude with its own cyclonic circulation, capable of remaining quasi-stationary for several days. These configurations favor the development of deep convection and intense precipitation, especially when interacting with warm and humid air.

Globally, cut-off lows occur predominantly in three major regions of the Northern Hemisphere: southwestern Europe (as in this case), the northeastern Pacific, and eastern Asia (Nieto et al., 2005). In the Southern Hemisphere, they mainly occur in southern Africa and Australia (Qi et al., 1999; Singleton & Reason, 2007). In the Mediterranean context, these systems occur mainly in autumn and are associated with torrential or localized convective rainfall (Porcu et al., 2007). According to Nieto Ferreira (2021), between 1998 and 2018, more than 80% of extreme precipitation events in eastern Spain were linked to cut-off lows.

Since October 20, 2024, the Spanish State Meteorological Agency (AEMET, 2024b) reported the formation of a DANA with the potential for extreme rainfall in the southern and eastern parts of the Iberian Peninsula. On the 25th, forecasts warned of a high probability of extreme rainfall. Starting on October 27, weather warnings escalated to red in several areas of Valencia, with the 29th predicting to be the most critical day. The event culminated in historic rainfall figures: 621 mm in 6 hours recorded in Turís, with a peak of 185 mm in a single hour (AEMET, 2024a).

Although the absolute 24-hour rainfall record remains the 817 mm registered in 1987, the 2024 event was the most tragic flood in the recent history of eastern Spain (AEMET, 2024b). In this case, the highest hourly accumulations ever recorded in Spain occurred—such as the one in Turís—along with new national records for six- and twelve-hour intervals. Comparing the spatial distribution of precipitation with previous episodes, such as those of 1957 and 1982, we find that, spatially, the rainfall in those years affected both coastal and inland areas. In contrast, the 2024 episode showed a marked disparity: inland and mountainous areas received more than 700 mm, while the coast experienced little or no precipitation. This uneven distribution caused flooding in the areas where it did not rain (specifically, the coastal plain where the densely populated metropolitan area of Valencia is located) where the population continued with their daily activities unaware of the danger or receiving any official warning signals. This situation significantly worsened both human losses and material damage. Thus, despite not breaking the 24-hour rainfall record, the 2024 event is considered the most devastating in terms of human casualties (228 deaths) and economic losses, surpassing 13 billion euros and rendering over 140,000 vehicles unusable—figures unprecedented in the flood history of the region (AEMET, 2024a).

In the hours and days following the event, official information was scarce, and the scale of the disaster remained uncertain. In this context, geospatial technologies have become essential tools for producing the first reliable assessments and for coordinating institutional response efforts at multiple scales. This study examines the role of spatial analysis tools in the characterization and management of the floods caused by the DANA in Valencia in October 2024. Particular attention is given to the use of satellite imagery, weather radars, and Geographic Information Systems (GIS) as key instruments for understanding the event's evolution, delineating affected areas, and guiding institutional actions during and after the disaster.

2. Materials and Methods

Adopting a narrative and systematic review approach, this work systematizes and compares technical and scientific sources — such as reports from AEMET, products from the CEMS program, the ICSMD and maps produced by universities and governmental institutions. The analysis follows a sequence in which three stages are distinguished: early prediction and monitoring, immediate response, and impact assessment, also incorporating a critical reflection on the explanatory narratives of the disaster from the perspectives of climate change and the historical geography of risk.

A systematic review was conducted in academic databases such as Mendeley, Scopus, Web of Science, and Google Scholar between November 2024 and June 2025. The keywords used were combinations of terms such as 'Valencia floods 2024', 'DANA 2024', 'Spain floods 2024' with 'geospatial technologies', 'GIS', 'satellite imagery', 'mapping', 'Copernicus EMS'. Peer-reviewed articles, institutional reports, and technical publications relevant to the event analyzed were prioritized. The review also included press reports whose findings were very important during the first days after the disaster, when reliable information was scarcely available. A total of 38 documents were reviewed on the Valencia DANA 2024 in relation to its geographical dimension and the spatial analysis of the disaster.

2.1. Geography of Valencia. The study area

On the eastern side of the Iberian Peninsula, the city of Valencia and its metropolitan area sit on an extensive coastal alluvial plain, bordered by mountainous reliefs to the west and close to wetlands such as the Albufera coastal plain, which shapes the natural drainage of the territory (figure 1). This topographic configuration facilitates the rapid accumulation of surface runoff when rivers and ravines — such as the Turia, Barranc del Poyo, or Carraixet — overflow due to intense rainfall. Furthermore, urban development in vulnerable areas has reduced the soil's infiltration capacity and altered natural watercourses, increasing exposure to flash floods. This interaction between topography, hydrographic networks, and land use exacerbates the effects of extreme weather events, as is the case here.

Figure 1. Map and location of Valencia

3. Results

3.1. Geospatial technologies

3.1.1. Weather satellites

To analyze and document the DANA episode of October 29, 2024, AEMET used satellite data, weather radars, and ground station networks, which enabled the characterization of atmospheric evolution and the quantification of precipitation. The data and images from the Meteosat-11 satellite (MSG-11) were essential to understanding the synoptic dynamics in that region of the world, reporting updates every 15 minutes (Schulz et al., 2009). Using the infrared channel (IR108), it measures cloud top temperatures, and with WV073, water vapor; this allowed the identification of convective structures inside the DANA and the formation of a surface low over the Alboran Sea — both key to understanding the intensification of the humid flow from the Mediterranean (AEMET, 2024a).

Regarding ground-based equipment, AEMET operates C-band Doppler weather radars, which emit microwave pulses and capture signals reflected by raindrops or hail within clouds, generating images of precipitation intensity and movement. These radars cover a spatial range of 250 km and reach altitudes of up to 15 km above sea level. Of the 15 radars deployed across Spain, those in Valencia and Almería were especially relevant on October 29 (AEMETa, 2024). These instruments made it possible to detect rainfall intensity, internal structure of the aforementioned convective systems, and even to locate severe phenomena such as the supercells that struck the Ribera Alta region. Data from the river basin authorities, the Automatic Hydrological Information System (SAIH), and the Agrometeorological Information System for Irrigation (SIAR) were also integrated, playing a crucial role in validating satellite and radar estimates.

In the days following the event, AEMET's meteorological data gradually ceded prominence to the use of Earth observation satellites and spatial analysis tools, which were more focused on assessing the impacts.

3.1.2. Earth observation satellites

On the same day as the DANA event, October 29, the two aforementioned international satellites response mechanisms were activated in a complementary manner: the ICSMD and the CEMS (event code EMSR773 for the Valencia floods). Both were activated on October 30 at the request of the Spanish Directorate General for Civil Protection and Emergencies. This allowed rapid and coordinated access to satellite imagery from various space agencies. For EMSR773, the initial need was to produce maps showing the extent of the flooding, followed by monitoring and damage classification (CEMS, 2024a; CEMS, 2024b; Santini et al., 2025).

Table 1 chronologically compiles the different satellite and aerial sensors employed. Each entry details the image acquisition date, the type of sensor used, its spatial resolution, and the geographic area covered.

Table 1. List of published satellite images, sensor used, spatial resolution and geographical area covered.

Acquisition date	Sensor	Resolution	Study area
30/10/2024	Landsat-8	30 m	Horta Sud
31/10/2024	GeoEye	2 m	Horta Sud
31/10/2024	WorldView-2	0.5 m	Various areas of Horta Sud
31/10/2024	Pléiades-1 A/B	0.5 m	Chera
31/10/2024	Sentinel-2	10 m	Valencia province
31/10/2024	Sentinel-1	20 m	Valencia province
31/10/2024	MODIS	250 m	Valencia province
02/11/2024	Pléiades-1	0.5 m	Torrente, Catarroja
02/11/2024	WorldView-2	0.5 m	Caudete de Las Fuentes
03/11/2024	ICEYE OY	2.5 m	Valencia province
05/11/2024	Sentinel-2	10 m	Valencia province
06/11/2024	Sentinel-1	20 m	Valencia province
06/11/2024	Pléiades	0.5 m	Letur
08/11/2024	COSMO-SkyMed	15 m	Valencia province
08/11/2024	SPOT-6	1.5 m	Provincia de Castellón
10/11/2024	Sentinel-2	10 m	Valencia province
10/11/2024	Pléiades-1A/B	0.5 m	Monserrat, Alcudia
11/11/2024	Pléiades-1A/B	0.5 m	Cheste, Godelleta
11/11/2024	Aerial photos	0.2 m	Various areas (Yátova, Monserrat, Alcudia, etc.)
17-18/11/2024	Aerial photos	0.2 m	Various areas (Pedralba, El Mas del Moro, etc.)

The image captured by NASA's Landsat-8 satellite on October 30, 2024, represents the first publicly available high-resolution optical record of the Valencia floods. The scene allowed for an assessment of the severity of the disaster in the southern sector of the Valencia metropolitan area, particularly in the urban area downstream of the Turia River channel (called Horta Sud), an infrastructure built after the 1957 event that flooded the entire city. The spatial expansion of the coastal lagoon within La Albufera National Park is also visible. The image was acquired using the Operational Land Imager (OLI) sensor, which offers a spatial resolution of 30 meters and nine spectral bands, and was officially published on October 31, 2024, along with comparative images from earlier dates that visually highlighted the impact of the event (NASA, 2024a).

The first input used in the CEMS (2024c) maps was a GeoEye-1 image (Maxar Technologies), acquired on October 31 for a specific sector of the flooding — the municipality of Algemesí — at a 2-meter resolution. On the same day, a Sentinel-2 image was also acquired featuring its 13 spectral bands and spatial resolutions of 10, 20, and 60 meters (ESA, 2024). The scene, published on November 2, provided an overview of the flood area as it passed through Valencia and Horta Sud, and enabled the first accurate mapping of the affected urban and agricultural areas in Horta Sud, where crops, roads, and homes were completely submerged. Sentinel-2's capture proved to be one of the most important inputs at the time, improving spatial accuracy and facilitating more precise decision-making. At the time of its publication, media outlets were using it in their newscasts, and subsequent research used it to generate new, targeted analyses and mapping. Sentinel-1 also played an important role, as its Synthetic Aperture Radar (SAR) sensor was able to detect topographic features—in this case, changes in water cover (Palumbo, 2024).

Also on October 31, MODIS (Aqua), during one of its daily passes over Europe, captured imagery and atmospheric data of the Valencia floods, taking advantage of a brief window of partly clear skies. This image was used to assess hydrological impacts at a regional scale and maintain a synoptic reading of the event (NASA, 2024b).

This entire set of images and combination of sensors—with varying resolutions and technical characteristics (Table 1)—provided a fundamental input both for subsequent mapping efforts (Table 2) and for delivering reliable information to the media. A multiscale and time-sensitive cartographic framework was produced, essential for enabling authorities and emergency management institutions to access updated and accurate information for more rigorous decision-making. These inputs laid the foundation for the next stage — the generation of maps — which we explain below.

3.1.3. GIS and mapping

The maps generated by CEMS (2024a) and ICSMD (2024) were grouped mainly into three categories (table 2): 1, identification and delimitation of flood-affected areas at a crucial time for emergency management; 2, monitoring and temporal evolution of the affected areas (at least four update phases between 3 and 8 November in Valencia and Castellón); 3, damage assessment (grading) and impact mapping using photointerpretation of the degree of damage in different locations (Torrent, Catarroja, Paiporta, Valencia city).

Table 2. List of maps published on the Valencia floods in CEMS and ICSMD.

Publication Date	Subject	Study Area	Scale	Source
31-oct	Delineation	Algemesí	4000, 5000, 28000	CEMS
02-nov	Delineation	Valencia prov	92000, 244000	CEMS
02-nov	Delineation	Horta sud	29000	CEMS
03-nov	Delineation Monitoring 1	Valencia prov	92000, 244000	CEMS, ICSMD
04-nov	Flooding of the Albufera National Park	Albufera National Park		ICSMD
04-nov	Grading Product with the damage grade assessment over Horta Sud	Horta sud	38000	ICSMD
05-nov	Flood impact maps over Torrent and Catarroja areas, Spain	Torrente	10000	ICSMD
06-nov	Delineation Monitoring 2	Valencia prov	92000, 244000	CEMS, ICSMD
06-nov	Delineation Monitoring 3	Valencia prov	92000, 244000	CEMS
06-nov	Grading	Horta sud	3000, 4000, 6000, 38000	CEMS
06-nov	Delineation	Plana de Utiel	3000, 36000	CEMS
06-nov	Sentinel-1 derived map of flood affected urban area - Valencia, Spain	Valencia city		ICSMD

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07-nov	Grading	Letur	1000, 10000	CEMS
08-nov	Delineation Monitoring 4	Valencia prov	92000, 244000	CEMS
08-nov	Delineation Monitoring 1	Castellón prov	75000	CEMS
08-nov	Impact map - Paiporta, Spain	Paiporta	17000	ICSMD
11-nov	Flood Impact Assessment in Valencia, Spain	Valencia prov		ICSMD
11-nov	Grading consolidation	Monserrat	3000 - 10000	CEMS
10-nov	Grading Product with the damage grade assessment over Montserrat	Monserrat	10000	ICSMD
12-nov	Grading Product with the damage grade assessment over Caudete De Las Fuentes	Caudete de las Fuentes		ICSMD
12-nov	Grading Product with the damage grade assessment over Chera	Chera	5544	ICSMD
12-nov	Grading Product with the damage grade assessment over Montserrat	Monserrat		ICSMD
12-nov	Grading Product with the damage grade assessment over Alcudia	Alcudia		ICSMD
13-nov	Grading Product with the damage grade assessment over Godelleta	Godelleta		ICSMD
14-nov	Delineation Product with the identification of the affected areas over Valencia province	Valencia prov		ICSMD
16-nov	Grading consolidation	Turís, Buñol, Valencia sud, Requena, Siete Aguas, Montroi, Llombai, Alginet, Alzira, Benicull de Xuquer, Alhaurín de la Torre, Alcudia, Favara, Cullera, Sueca	1000 - 25000	CEMS
21-nov	Grading	Cases del Riu, Sot de Chera, Campo Arcis, Camporrobles, Pedralba, El Mas del Moro, Alcasser, Paterna	1000 - 15000	CEMS

The timeline of these products reflects a staggered response strategy. The process began early, on October 31, with the first delineation maps in Algemesí, followed progressively by those in Horta Sud and Valencia province up to November 3, when the first monitoring phase also began. Between November 4 and 6, cartographic coverage was consolidated, adding both grading products and impact maps for specific areas, including protected zones such as Albufera Natural Park and urban sectors like Torrent, Catarroja, and the city of Valencia. From November 7 onward, the focus shifted to continuous monitoring and the refinement of damage assessments, which continued until mid-November, with special emphasis on rural or less densely populated localities. This temporal approach illustrates how the scope and detail of the information expanded as new satellite and field data became available, enabling a comprehensive tracking of the disaster's progression.

After CEMS and ICSMD, national and local institutions carried out their own information production and mapping efforts. MapDANA (Zornoza et al., 2024), developed by the University of Valencia on November 8 (Universitat de València, 2024), was created after identifying inaccuracies in some of the available maps. To address this, the Department of Geography took the Rapid Mapping outputs as a reference, improving and refining them to represent the affected areas more precisely. They also used super-resolved Sentinel images (2.5 m) enhanced through SENX4 technology developed by Tracasa Global (Cabello et al., 2020); mathematical algorithms were applied to various spectral ranges, and citizen participation was integrated through the collection of information from local entities and affected individuals. During that period, the resulting cartography became the most reliable input available on the floods (Soriano Cabellos y Pérez Blázquez, 2024).

Among the most recent maps developed and of great public utility was the street-level flood map of l'Horta Sud, produced by the Polytechnic University of Valencia (CGAT-UPV, 2025). It was created in three phases: 1, 6,109 field points were surveyed using topographic rods and GPS, recording visible watermarks on walls and surfaces; 2, these depths were converted into elevation data above sea level using 2023 LiDAR data, interpolating the flooded surface and calculating maximum water depths while masking built-up areas and 3, an interactive web viewer was developed to facilitate public access.

3.1.4. Government GIS web platforms

On November 4, the regional government of the Generalitat Valenciana uploaded the first cartographic inputs related to the DANA to the web map viewer managed by its Cartographic Institute (ICV, 2024). This information has been progressively updated over the following weeks. Among the available data are drone orthophotos from the Emergency Military Unit (UME), 5 cm SPASA photogrammetric flights, vector cartography of affected streets, a damage inventory, recorded water levels reached during the DANA, and the current status of the road network.

The Spanish Ministry of Transport and Sustainable Mobility used the HERMES GIS web platform to integrate and disseminate georeferenced information related to the operation of public transport and the status of communications networks in the Valencia region. HERMES is a web map viewer that integrates data from different state transport sectors into a single platform: road, rail, cable car, sea, and air, including their intermodal connections, network topology, and national coverage (González Jiménez and Calvo Guinea, 2020). For the Valencia floods, specific data layers were added concerning the affected area, such as road closures, unofficial flood boundaries, mobility flows, and displaced population distribution. Thanks to anonymized mobile phone big data and GIS-based visualizations, daily mobility patterns were detected, enabling adjustments to replacement road transport services and the planning of temporary alternatives while critical infrastructure was being rebuilt (Ministerio de Transportes y Movilidad Sostenible de España, 2024).

3.1.5. Follow-up Studies

As can be seen from the previous sections, the considerable volume and quality of published geospatial data has been significant. This is enabling new research in different thematic fields. We have recent publications on environmental monitoring of the Albufera's water quality, where Soria et al. (2025), using satellite images, tracked the change in the lake's characteristics following the low cut-off, based on variables such as chlorophyll-a, suspended solids, and water transparency. Furthermore, the floods in Valencia serve as a study object for the development of new models, such as the one carried out by Alcarás (2025) for automated flood mapping. He uses Landsat 8 from October 30 (NASA, 2024a) to run his Flood Mud Index (FMI), which allows the detection of mud-covered areas after a flood. In this case, the FMI achieved an overall accuracy of 97.64%, being especially effective in flood-prone areas with sediment deposits. Castro-Melgar et al (2025) again resort to the Sentinel and Modis images of October 29 to define new models that successfully identify the impact of the floods, obtaining a cartographic validation of 94.2%.Regarding cultural heritage, Grau-Bové et al. (2024) assessed flood damage to architectural properties; using a collaborative methodological approach, they combined CEMS maps with heritage inventories to identify affected areas, highlighting the usefulness of open data and GIS technologies for rapid disaster response.

Other works focus on developing greater physical-geographical knowledge to explain in greater detail the causes of the phenomenon that occurred in Valencia. On the one hand, Amiri et al. (2025) focus on explaining the increase in sea temperatures in the North Atlantic together with El Niño conditions to explain the DANA in a global atmospheric context. On the other hand, Pérez-Cueva et al. (2025), at the local scale, details the hydrometeorological characteristics of the event in the study area, both in the spatialization of precipitation density and in relation to the hydrological behavior of the overflowing ravines.

New papers are debating the link between this event and climate change. Some researchers (Faranda et al., 2024; Calvo-Sancho et al., 2025; Green et al., 2025; Mishra et al., 2025; Shamsudduha, 2025) argue that the intense rainfall seen in Valencia was a consequence of climate change during one of the wettest years on record, 2024. The premise is that anthropogenic global warming will lead to more frequent and intense DANA.

Another stream of post-DANA Valencia studies refers to historical, paleoenvironmental, and geological records to contextualize the phenomenon that occurred in 2024 (Harrison et al., 2025; Polo-Martín, 2025). These papers point out that more severe events than the current ones have occurred in pre-industrial periods. They adopt a more cautious stance when attributing human activity to these types of events connected with contemporary global warming. An overestimation of human influence could misrepresent the perspective on the natural variability of extreme phenomena. Valencia city has recurrently faced similar disasters, such as the major floods of the Turia River in 1517, 1776, and 1957—severe events that occurred in pre-industrial times. The 2024 floods are not unprecedented phenomena, but rather part of a long history of hydrometeorological exposure, now amplified by both climate change and uncontrolled urbanization (Harrison et al., 2025; Polo-Martín, 2025).

Other recent studies with a geographical focus explore the relationship between urban planning, disaster management, and public health. These works are critical of the urban development taking place in eastern Spain, characterized by an undervaluation of risk maps, often driven by clientelist networks and political decisions oriented toward private profit. Furthermore, the population in these areas, in many cases, has lower socioeconomic levels than the average in the Valencian region, making it more vulnerable to these types of disasters (Delgado, 2024; Fekete et al., 2025; Galvez-Hernández et al., 2025). The effective response capacity of public health services linked to territorial planning is another topic that has been opened to debate following this event. Emphasis is placed on the need to provide a service that guarantees immediate medical care and to address the psychosocial impacts following a tragedy such as the one that occurred in Valencia (Zurriaga et al., 2024). The disaster was not only meteorological but also the result of deficient governance, underscoring the urgent need to rethink urban and public health policies based on principles of prevention, equity, and resilience (Zurriaga et al., 2024; Charalampous et al., 2025; Galvez-Hernández et al., 2025; Romero Hernández et al., 2025). In this sense, proposals for ecological restoration and urban planning and a new strategic framework on resilience and risk management in Valencia are presented (Cortiços & Duarte, 2025; Fekete et al., 2025).

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5. Discussion

The 2024 DANA in Valencia was an extraordinary hydrometeorological event, comparable only to the major floods of the 20th century: the 1957 flood, due to its devastating impact on the urban fabric and high death toll; the 1982 flood and the 1987 event, which holds the national record for the highest 24-hour rainfall ever recorded in Spain (817 mm). This event occurred in the 21st century, in a context of high technological dependency and public expectations for immediate response. The magnitude of the storms caught the population by surprise — and even more so the regional government authorities, who underestimated its severity. Of all the actors and institutions involved, AEMET emerged with the most credibility, as it had already forecasted the severity of the event as early as October 25 through its meteorological data (AEMET, 2024b) (Figure 2).

Figure 2. Chronological summary of the use of geospatial technology in the 2024 Valencia floods

From a social and geographic perspective, the days following the passage of the DANA were marked by uncertainty: the surface extent of the disaster, its impact on the population, and the damage to infrastructure were unknown. In this sudden vacuum of knowledge, satellite imagery and rapid mapping services were the first reliable sources to reconstruct the events, quantify magnitudes, and guide the initial institutional response.

Adopting a geographic perspective in a catastrophe like this means approaching it in a comprehensive and synoptic way, using data, maps, and photographs. Geography is intuitive — it interprets the landscape, what is happening and what has happened. All of this is extremely useful and encouraging during severe events that strike without warning, as was also the case with COVID-19 (Franch-Pardo et al., 2021). Maps and geography play a crucial role at the onset of global emergencies. To adopt a geographic perspective also means to do so from an anthropocenic approach. An event like this becomes a canonical episode — that is, a new layer of sedimentation marked by urban debris across the coastal plain.

The 2024 DANA as a case study led to the development of new spatial analysis tools and original methodologies that were adapted to the specific circumstances of this event. We refer to the maps generated by Valencian universities (MapDANA and the street-by-street flood map), which were widely accepted and used by the general public, the media, and the academic community. New tools such as the Flood Sludge Index were also developed, surpassing the accuracy of previous models.

The spatiotemporal and prospective analysis of this catastrophe opens the debate on climate change, without forgetting the historical context of the floods in eastern Spain, whose geography cannot be understood without them. On the one hand, multiple recent studies attribute the episode's intensity and violence to a global context of atmospheric warming, arguing that the increased frequency and severity of DANA is a manifestation of climate change driven by human activity. On the other hand, a more cautious and contextual perspective, rooted in historical geography, reminds us that the region has long been exposed to catastrophic events, even in pre-industrial times — such as the Turia River floods of 1517, 1776, and 1957. This perspective emphasizes the territory's long-term exposure to extreme hydrometeorological phenomena and how factors like accelerated urbanization and land transformation worsen current impacts (Fernandes et al., 2020). Thus, while climate change offers a global and structural explanation, historical geography provides local and cumulative insights into present vulnerability.

The DANA primarily affected socioeconomically vulnerable populations. According to an analysis by the Valencian Institute of Economic Research (IVIE, 2024), the municipalities most severely impacted by the flooding had household income levels between 5 and 10 percentage points below the provincial average. Furthermore, 3 out of every 10 affected homes were built in flood-prone areas during the Spanish real estate boom prior to the 2008 crisis, despite the fact that the region has had a Territorial Action Plan for Flood Risk Prevention (PATRICOVA) since 2003, which identifies high-risk areas (Delgado, 2024). This case is a prime example that reflects the accumulated disobedience of urban expansion in hazardous areas. Cyclical climate events with medium and long-time spans pose a challenge for disaster planning and the dimension of vulnerability. Given the current climate of global warming, stricter regulations must be developed (Gálvez-Hernández et al., 2025; Romero Hernández et al., 2025). Geotechnological studies, including hazard and risk mapping as is the case of PATRICOVA, must accompany urban expansion and be made as binding as possible in planning regulations. It is imperative that the flood variable be prioritized, especially during urbanization processes and even more so when land use is categorized as residential. As a natural phenomenon, all floods have precedents, which is an advantage for conducting prospective modeling with greater plausibility. However, sometimes the event is more stochastic, with a greater degree of randomness. In one way or another, infrastructure, tools, communication channels, and social awareness must be available to match the severity of the circumstances.

The maps and tools developed after the event were widely disseminated and used by various entities. Beyond the academic research currently underway and documented in this paper, the Rapid Mapping products of the CEMS and ICSMD were incorporated into official reports of the Spanish Government and used by the Directorate General of Civil Protection and Emergencies to coordinate the institutional response. The web viewer of the Valencian Cartographic Institute and the Ministry of Transport integrated these inputs along with drone orthophotos and cartography of affected streets, facilitating access to the general public and municipal entities. The MapDANA, developed by the University of Valencia, was published in the first days following the event, gaining significant relevance, disseminated by regional media, and cited as a reference in technical and academic bulletins. The UPV street-by-street map also became one of the most widely used tools by the public, being especially useful for technical damage assessment. Together, the geospatial products had significant analytical and documentary value, directly influenced the operational management of the emergency at its various stages, and ultimately served to raise public awareness of the magnitude of the disaster.

On the other hand, some gaps have been identified in the research that we assume will be developed over the coming months, particularly regarding the environmental conditions in the Albufera lagoon following the DANA: analysis of the post-event characteristics of the Albufera National Park, the presence of pollutants, sediment analysis, and impacts on biodiversity. There is also room for research using data mining techniques for sentiment analysis and thematic modeling of social media content to better understand public perception of the disaster (sensu Li et al., 2023); geolocated messages on platforms like Twitter can be systematically filtered and interpreted to detect, map, and monitor flood events in real time, offering valuable insights into the spatial distribution and social dimensions of the impact (Arthur et al., 2018).

6. Conclusions

The October 2024 DANA event in Valencia underscored both the structural vulnerabilities of the territory and the strategic role of geospatial technologies in managing hydrometeorological disasters. From early forecasting to post-event damage assessment, the integrated use of satellite imagery, weather radars, GIS, and web-based platforms enabled a dynamic, multi-scalar understanding of the event. It also fostered the development of innovative spatial analysis methods, such as the Flood Mud Index and high-resolution, street-level flood mapping in Horta Sud. The case further revealed significant institutional shortcomings, particularly in territorial planning and in the protection of socially and economically vulnerable populations. The findings of this study suggest that effective disaster response depends not only on advanced technological capacities, but also on strong political will, robust territorial governance, and a proactive culture of risk prevention grounded in geographical knowledge. Addressing such events through geographical and Anthropocenic lenses is essential to fully comprehend their spatial complexity, social implications, and long-term territorial impacts. This approach involves examining them in a holistic and synoptic manner, drawing on data, maps, and photographs. Geography is inherently intuitive: it interprets the landscape, reveals what is happening, and reconstructs what has happened. Such insights are particularly valuable and reassuring during sudden, serious events that occur without warning.

This episode proves once again that the maps, satellite imagery, and the geographic dimension play a crucial role at the onset of global emergencies when available information is very limited and unreliable.

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