LocAll4Flood | Interreg Euro-MED | Co-funded by the European Union

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REPORT ON THE TESTING OUTCOMES OF THE EARLY WARNING SYSTEM [EWS]

https://locall4flood.interreg-euro-med.eu

Deliverable D2.2.1

Project acronym	LocAll4Flood
Project title	Flash flood risk prevention & resilience in Mediterranean area through an Integrated Multi-stakeholder Governance Model, gathering prevention, adaptation and mitigation solutions
Project mission	Protecting, restoring and valorising the natural environment and heritage
Project priority	Greener MED
Specific objective	RSO2.4: Promoting climate change adaptation and disaster risk prevention, resilience, taking into account ecosystem based approaches
Type of project	Test
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Work package title	TESTING LOCALL4FLOOD integrated multi-stakeholder governance model - IMGM
Activity name	Prevention: Test forecasting tools and early warning systems
Activity number	A2.2
Partner in charge (author)	HYDS
Partners involved	All

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Executive summary

LocAll4Flood deployed the Early Warning Systems (EWS) -previously detailed in the deliverable "D1.2.1 Report on the Early Warning System [EWS] to be implemented in the pilot sites"- through an iterative process involving pilot leaders and relevant stakeholders. Following implementation, each pilot carried out a testing phase in which the systems were used regularly, particularly during periods of heavy rainfall. This process generated valuable insights into system performance and its potential incorporation into routine operational workflows.

This document presents a summary of the results from the testing phase for each EWS, including:

- Technical overview
- Performance in real events
- Feedback on the system
- Identification of potential users
- Recommendations for improvement and integration
- Next priority steps from the EWS developer perspective

Overall, the findings highlight differences across the EWS related to data availability and other conditions. Users expressed general satisfaction with the tools and recognized their potential usefulness in real-world scenarios.

Introduction

Deliverable overview and structure

This deliverable follows deliverable "D1.2.1 Report on the Early Warning System [EWS] to be implemented in the pilot sites" and covers the actual implementation process and the testing period of the EWS for each pilot.

The introduction section has two more subsections besides this one: In the first one, we describe the general methodology followed during the implementation and testing period; in the next one, we explain transversal advancements carried out in the Argos platform that affect implementations in all pilot regions.

Later, there is a section for each EWS implemented (as in the previous deliverable), which contains several subsections:

- Technical overview: Relevant technical issues and difficulties found during the implementation are highlighted here.
- Performance in real events: Examples of real events (even minor cases) occurred during the testing period and were followed using the EWS.
- Feedback on the system: Comments gathered from stakeholders after the testing period
- Identification of potential users: The management of (potentially) flooding events differs a lot among countries and administrations. For each pilot region, we identified the appropriate actual user of the EWS.
- Recommendations for improvement and integration: The following steps (both technical and administrative), needed in each pilot region for the EWS, become a useful integrated operational tool.
- Next priority steps from the EWS developer perspective: Wrap-up of the status and which should be the priority next steps from the point of view of the EWS developer.

Methodology

Complete versions of the EWS were implemented for each pilot region (Catalonia, Balearic Islands, Varna, Malta, Puglia, and Central Macedonia) in early 2025, and presented at local workshops. Informal and formal interaction with pilot leaders led to improvements in implementation through the end of August. In September, the testing period officially began and training sessions with stakeholders took place. It was closed at the beginning of December to produce the present document, but all EWS will be online and actively maintained until the end of the project (summer 2026) either for dissemination purposes or testing contributions.

Two formal feedback documents were filled by stakeholders and pilot leaders to homogenise and organize testing outcomes, and they are the main source for the following sections. The first one was sent and answered in May, it was oriented to finalize the implementation and prepare the testing phase, and the second one, gathered at the start of December, was devoted to assessing the EWS after the testing phase.

So, for each EWS section, subsections of "Performance of real events", "Feedback on the System", "Identification of potential users" and "Recommendations for improvement and integration" are based on stakeholders answers to feedback documents gathered and summarized by pilot leaders. The stakeholders involved in testing phase are listed below.

EWS	Pilot leader	Stakeholders involved in testing phase
Catalonia	BETA	Gurb City Council Vic City Council (Civil Protection department)
Balearic Islands	UIB	Palma Firefigthers Balearic Islands Government (Water resources department)
Kamchia	BDCA	Regional / District Administration of Varna Municipality of Dalgopol (Civil Protection Department) Regional Fire Safety & Civil Protection Directorate

Malta	EWA	Energy and Water Agency (Water department)
Puglia	CNR	Technical Office of the Metropolitan City of Bari (Infrastructure Department)
Central Macedonia	AUTH	Municipality of Thermi Municipality of the Delta Hellenic Hydrotechical Association kartECO Consultion Researcher AUTH

Transversal advancements in Argos

Argos platform is in continuous evolution and during this period three features were developed to engage final users with the different implementations:

- Newsletter: Daily e-mails with official warnings report if there is intense rainfall expected for the next three days.

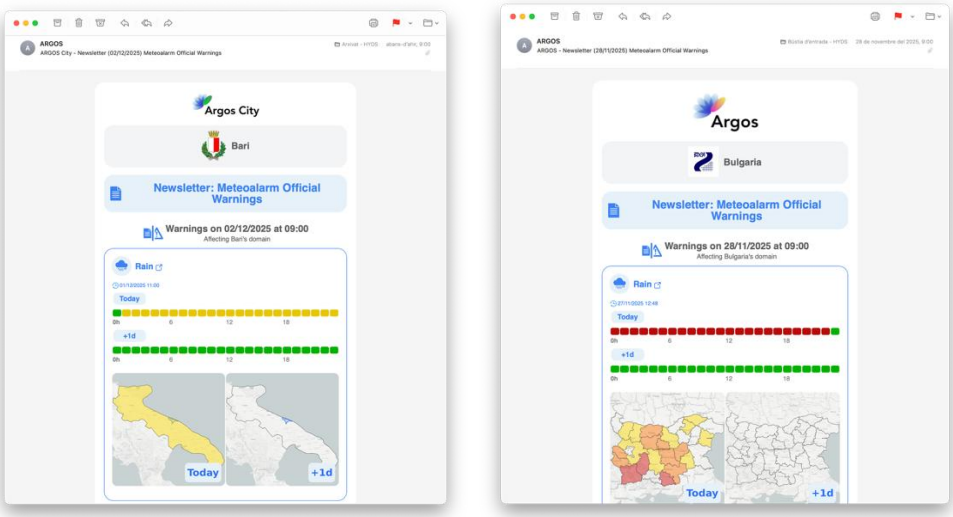

Figure 1. Example of newsletter for Bari (Italy) and Bulgaria implementations of Argos.

- Dashboard: Relevant information can be summarized in simple and customizable cards, so the user does not need to interact with the map screen every time.

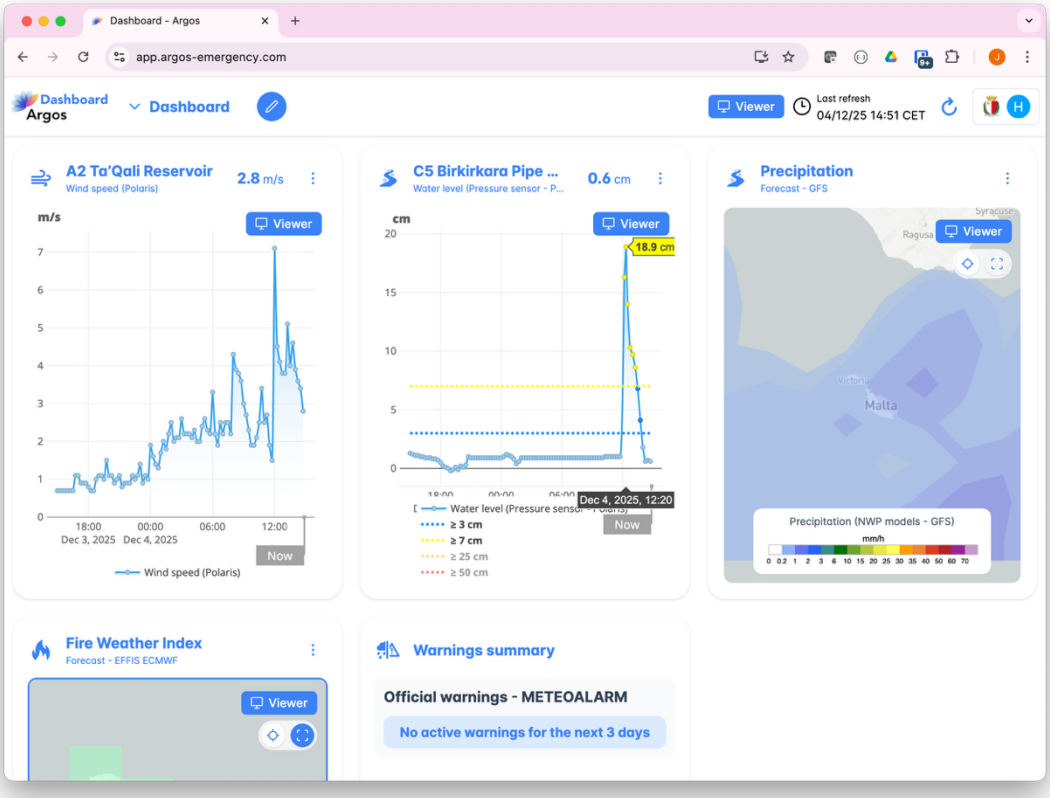

Figure 2. Example of dashboard in Argos Malta.

- Historical viewer: Past episodes can be accessed and reproduced with a calendar interface, via a calendar interface, allowing users to see exactly which data was available in the system at any given time.

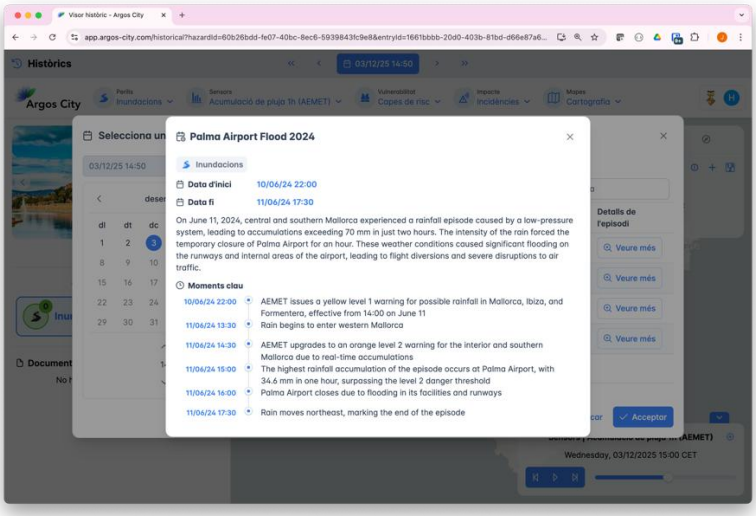

Figure 3. Example of dashboard in Argos City for Palma (Balearic Islands).

Catalonia EWS (Spain)

Technical overview

The Vic-Gurb pilot site has a very complete EWS with a great variety of data sources including radar data and existing local water level sensors. LocAll4Flood promoted the incorporation to the system of an extra sensor covering the intermittent stream "Torrent de l'Esperança". Local sensors require maintenance and we experienced so:

- Just before the start of the testing period, this extra sensor blacked out and no data were registered, fortunately the company in charge of the maintenance checked out and resolved the problem in a few days.
- During the implementation process, another local sensor started to give irregular false alarms due to the growing vegetation around the sensor. Actions were taken by the Vic City Hall, and false alarms stopped after a few weeks.

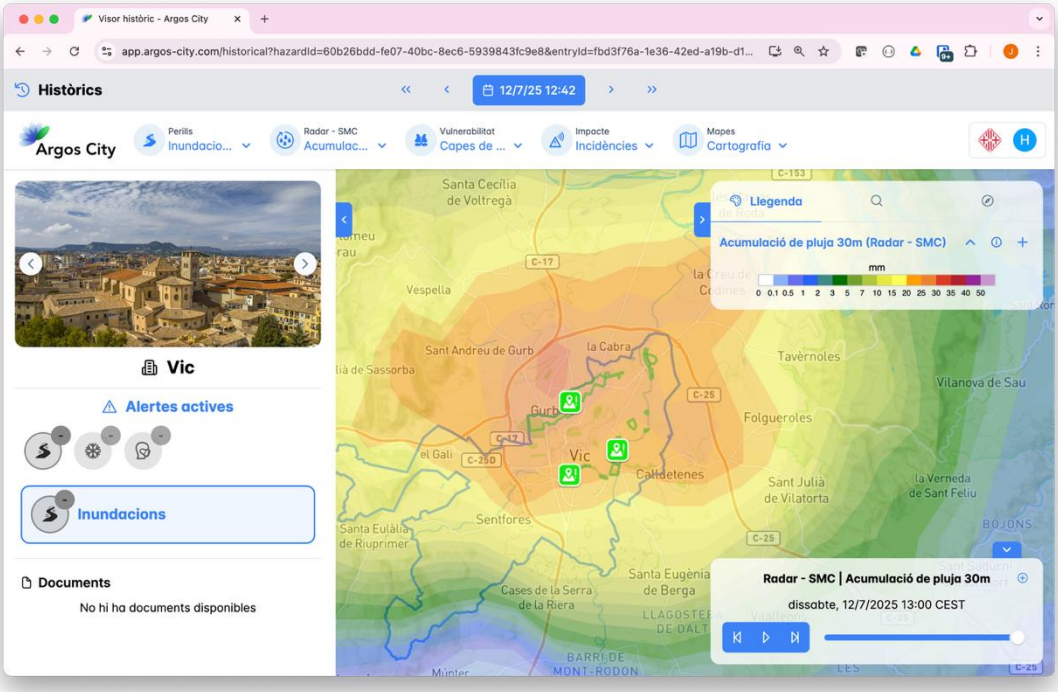

Figure 4. Screenshot of Argos City for Vic (Catalonia).

Performance in real events

Dates: *"15-16/10/2025"*	**12/07/2025**
Significant values occurred: *"25 mm in the city center"*	24,3 mm in Vic
Description: *What happened?*	On July 12, 2025, the northeast of the Iberian Peninsula suffered a strong episode of rainfall throughout the day. No damages reported in Vic or Gurb.
EWS use: *What could we see in the tool?* *Any notification received?*	On July 10: - The SMC activates the orange warning for rains in the area on the 12th - AEMET activates the orange warning for rains in the Barcelona area on the 12th On July 12: -The radar records 20 mm in 30 minutes over Vic -SMC activates Red warning for rain from 2pm - Argos City activates level 2 due to SMC red warning sending mails and sms - The river Mèder water level increases 60 cm in a few minutes due to rainfall

Dates: *"15-16/10/2025"*	**21/09/2025**
Significant values occurred: *"25 mm in the city center"*	SMC (Catalan Weather Service) issued an official warning of level 4 (of 6) in the area
Description: *What happened?*	Strong rainfall over the day
EWS use: *What could we see in the tool?* *Any notification received?*	Prevention. Following different storm cells with weather radar products during the day around Vic and Gurb.

Dates: *"15-16/10/2025"*	**13/10/2025**
Significant values occurred: *"25 mm in the city center"*	Up to 10mm in Vic
Description: *What happened?*	Short showers along the day, but storms don't really hit Vic
EWS use: *What could we see in the tool?* *Any notification received?*	Warning because of Forecasted radar rainfall with 25 years of return period near Vic. (e-mail and sms) Monitoring through the tool (radar, raingauges, official warnings).

Dates: *"15-16/10/2025"*	**06/11/2025**
Significant values occurred: *"25 mm in the city center"*	More than 20 mm in every place within Vic and Gurb
Description: *What happened?*	Strong rainfall specially during the morning
EWS use: *What could we see in the tool?* *Any notification received?*	Several warnings due to radar values.

Feedback on the system

- **Is the general concept of the tool appropriate for a Flood EWS?**

  The tool is very useful and fully appropriate for an Early Flood Warning System, as it integrates relevant information – sensors, official alerts and mapping – in real time. This integration enables the early detection of risk situations and facilitates both the communication of alerts and the monitoring of operational tasks, aspects fundamental to the proper compliance with the established protocol.

- **Is the tool user friendly enough? Is the information easy to understand?**

  The information presented is clear, intuitive and easy to interpret.

- **Which products (official warnings, sensors, forecasts) are more useful? Which are missing?**

  As for the available products, they all add value, since their joint display allows for an overall assessment of the episode's evolution. As a possible improvement, one could consider incorporating the CECAT bulletins (CECAT is the Emergency Center of Catalonia, in charge of operational management of emergencies at regional level), understanding that these are a different type of alert but could complement the available operational information.

- **Beyond the visualization on the map and the trigger of warnings, specific features (newsletter, historical viewer, dashboard) were developed for a better user experience, what is your opinion?**

  The ability to customise the **dashboard** allows the information deemed most relevant to be consolidated on a single page, which is particularly useful for

simultaneously displaying charts, alerts, sensors or radar data, thereby enhancing the capacity for rapid analysis during an event.

The **historical viewer** is a particularly relevant feature, as it allows the analysis of past events and the linking of precipitation impact to hydrological response and river flooding.

The **newsletter** seems a nice feature, but we don't need it at operational level so we don't use it.

Identification of potential users

Civil Protection Department in Vic City Hall is already a user of the tool, so could be the Gurb City Council. However, Gurb doesn't have any personnel devoted to Civil Protection because of its small size. In this case, may be appropriate that a supra-municipal entity as the Osona County Council (Consell Comarcal d'Osona) take the lead similarly as they do when providing other services to small municipalities.

Regarding the monitoring of local fluvial courses, the Catalan Water Agency (Agència Catalana de l'Aigua) is interested in taking benefit of the data.

Recommendations for improvement and integration

- **Which is your general impression of the tool?**

  My overall impression of the tool is very positive. The system is stable, well-designed and runs smoothly, presenting information clearly and consistently, which makes navigation intuitive. For small municipalities like Gurb, a product that is both reliable and easy to operate is essential. The system is recognised as a robust, practical and effective tool for flood risk prevention.

- **In your opinion, is the tool useful for operational uses in your region as it is? If no, what needs to be added or improved?**

  Yes, the tool is already useful for operational uses in our region in its current form. The implementation for the Vic-Gurb pilot site is considered very comprehensive, as it incorporates vital data sources such as radar and local water level sensors. The information structure, dashboard, automatic alerts

and early warning functionalities provide significant support for monitoring and response activities.

Furthermore, following the round table with various stakeholders, new layers of local vulnerable elements that we considered relevant to our area were incorporated.

However, based on our experiences during the testing phase, the reliability and validation of sensors could perhaps be improved. We experienced technical issues, including a local sensor that "went off" just before testing began, and another that gave intermittent false alarms due to vegetation growth. To improve operational confidence, it would be beneficial to add features such as a station battery level display. Furthermore, providing periodic images of the site via installed cameras could help to validate measurements and discrepancies, thereby improving overall value and reducing false alarms.

- **Once this is achieved, what would be the next steps for actual integration in the operational chain of response?**

  In Vic, the system is already integrated in the operational chain of response. However, for Gurb, the following crucial steps should focus on the formal adoption of the platform, especially by the supramunicipal entity, the Osona County Council, which is identified as the appropriate body to take the initiative for Gurb.

  Integration requires several key actions:

  - **Defining Protocols and SOPs**: We must define official usage protocols that specify how and when the tool should be consulted and integrate these updates into the Standard Operating Procedures (SOPs). We are currently working with the County Council on the update of the local DUPROCIM (Municipal Document of Civil Protection) which contains such procedures.
  - **Training and Adoption**: Full integration requires comprehensive training for staff from all relevant organisations, ensuring consistent

and informed use. All involved stakeholders must have specific access and training.

- **Testing and Simulations**: The system must be tested through drills or exercises to evaluate performance, response times, and information flows before operational deployment.
- **System Interoperability**: We must ensure full interoperability and integration of the system with other existing systems used within the operations centres and coordination units (such as the County Council's).

Next priority steps from the EWS developer perspective

Some interesting technical proposals emerged during the testing phase, such as visualizing the sensor battery levels and incorporating live cameras in certain areas. However, the main focus should be on integrating the EWS into Gurb's operational procedures, as already implemented by the Vic City Council. As a small town, Gurb has limited economic and human resources compared to Vic, which is why the role of the Osona County Council should be strengthened. In this regard, following their participation in the LocAll4Flood workshops, HYDS began discussions with the County Council to provide Early Warning services to multiple towns in the county.

Balearic Islands EWS (Spain)

Technical overview

Argos City for Palma also has a very complete set of real-time data implemented. Official warnings, forecasts from numerical models, weather radar data and precipitation stations. Unfortunately, we missed the network of raingauges from Balearic Government (Department of Water Resources). Several interactions took place to integrate such network, but the technical infrastructure wasn't ready.

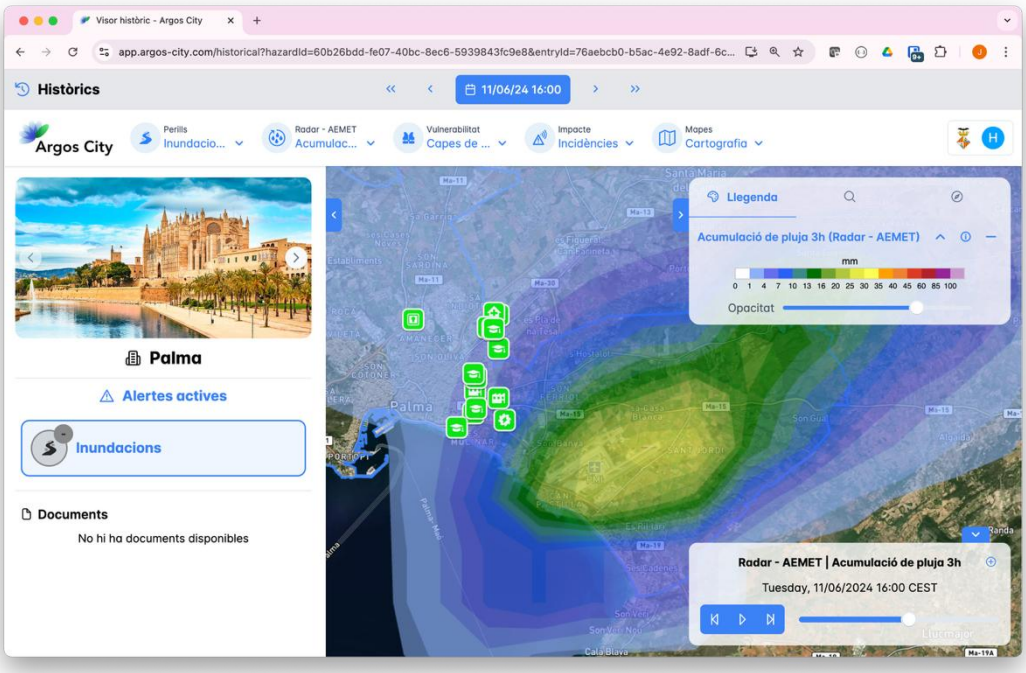

Figure 5. Screenshot of Argos City for Palma (Balearic Islands).

Performance in real events

The following are the events that have taken place in the Palma area. No big storms or large accumulations have been produced during the testing phase (September-December 2025), although we think that this tool has been very useful from the point of view of prevention, since every so often (in our case 6 hours) the system sends you a notice via mail in case of prediction of rainfall that can cause flooding.

Dates: *"15-16/10/2025"*	**12/10/2025**
Significant values occurred: *"25 mm in the city center"*	26.3 mm in 1 hour in parts of Palma. Son Rapinya station collected 33 mm in 1 hour.

Description: *What happened?*	A storm that left many problems on the island of Ibiza arrived with less force and affected mainly the western and northern part of Palma. There were flooded streets (not too dangerous) and torrents began to run and experienced a flash flood start although they never overflowed.
EWS use: *What could we see in the tool?* *Any notification received?*	The system has given me a warning of the 1-hour precipitation of the Portopí station. However, it did not rain much in the floodable area, so no warnings were issued to vulnerable elements. However, in the torrent it did start to run the water (video that we can attach). The days before we received low and medium level warnings for accumulations of precipitation and warnings from AEMET.

Dates: *"15-16/10/2025"*	**06/11/2025**
Significant values occurred: *"25 mm in the city center"*	Very strong storm, with wind gusts of more than 100 km/h in areas of Palma. The storm has been short-lived but has been recorded in 20 minutes, accumulations around 20-30 mm depending on the Palma area.
Description: *What happened?*	A mesoscalar system of storms that has formed in the Balearic Sea, has ended up affecting Mallorca, especially in the area of Palma and Calvià. Several damage has been seen with fallen trees, small local floods...
EWS use: *What could we see in the tool?* *Any notification received?*	I received several warnings on 11/04 for AEMET alerts, which were updated the day after, and which I was also warned by ARGOS. He also sent me an ECMWF warning for accumulations in the basin greater than 20mm.

Dates: *"15-16/10/2025"*	**08/11/2025**
Significant values occurred: *"25 mm in the city center"*	...
Description: *What happened?*	On 06/11 I received alert notifications of level 1 of ARGOS due to the activation by the AEMET in the south of Mallorca of a yellow alert for accumulations of rain in 1 hour and 12 hours and storms. In addition, the ECMWF alert was also received for accumulations of more than 10 mm. All these yellow alerts (Picture attached).

	Finally, a day before I received a level 3 warning for worsening predictions. Finally, predictions failed and fell less than 2mm (between 0.8 to 1.8 mm).
EWS use: *What could we see in the tool?* *Any notification received?*	Prevention. It has been informing us day by day of how the weather prediction has evolved, and to be alert, although it failed and then it did not rain as expected.

Dates: *"15-16/10/2025"*	**16/11/2025**
Significant values occurred: *"25 mm in the city center"*	…
Description: *What happened?*	On the 17/11 we have received yellow alert for the same day and warnings for accumulations of more than 10 mm in the basin of the torrent gros by ARGOS. However, the rain has not reached 5mm, although in some areas of northern Mallorca, there have been more problems.
EWS use: *What could we see in the tool?* *Any notification received?*	Prevention. It has been informing us day by day of how the weather prediction has evolved, and to be alert, although it failed and then it did not rain as expected.

Dates: *"15-16/10/2025"*	**27/10/2025**
Significant values occurred: *"25 mm in the city center"*	The alert is for next Wednesday the 3rd.
Description: *What happened?*	A dia 27/10, hem rebut avisos de nivell baix-intermig (canvia segons l'hora), bàsicament per acumulacions que segons el ECMWF pot superar els 20 mm en la zona de la conca del torrent gros.
EWS use: *What could we see in the tool?* *Any notification received?*	Prevention. It informs us day by day. Sunday has no longer warned us, so we think that forecasts have decreased the amount of precipitation expected.

Feedback on the system

- **Is the general concept of the tool appropriate for a Flood EWS?**

  Yes, the general concept of the tool is appropriate for an EWS, because it helps us a lot in prevention on days with possible risk of flooding (as we have already said before). Although during these two months we have not had especially important episodes in the area of Palma and Marratxí, except for a storm that has been more of wind than rain, the tool has been very useful to have controlled the warnings, the possible accumulations of precipitation and to be more pending of the radar in the most sensitive days. However, we will continue to use it for more sensitive episodes in the coming months.

- **Is the tool user friendly enough? Is the information easy to understand?**

  Yes, the tool is user-oriented enough and the information is easy to understand for almost anyone. In addition, each user can receive the notices in different ways (by SMS, by email every 6 hours, as we have done in our case), which makes it easier to be informed according to the preferences of each one. In general, we think that information and the warning system can be understood by anyone.

- **Which products (official warnings, sensors, forecasts) are more useful? Which are missing?**

  As we have seen in recent months, the most useful products are mainly forecasts and information associated with official warnings in case of probability of flood episodes. These warnings have allowed us to know in advance when there could be risk and to be more aware of the situation.

  Regarding what we miss, we think it would be interesting that, in case of flooding, the tool could send specific warnings indicating that for certain vulnerable elements the risk increases, or some similar functionality (maybe it already exists, but in our case no episodes of this type have been activated and we have not been able to verify it).

We also consider very useful how the page is organized, with the map, the visualization of the vulnerable elements and the possibility of consulting, historically, past days to see if there have been alerts or flood events. As for what could be added, we would be positive to incorporate new layers of vulnerable elements (for example, homeless people, which we have not yet been able to provide) and more meteorological stations, such as those in BALEARSMETEO, or flowmeters in the torrents, to have even more complete information.

- **Beyond the visualization on the map and the trigger of warnings, specific features (newsletter, historical viewer, dashboard) were developed for a better user experience, what is your opinion?**

  As mentioned above, we consider that these functionalities add a lot of value to the tool and clearly improve the user experience. The dashboard helps to have a quick view of the situation, daily emails with official notices make it easier to be informed without having to continuously enter the platform and the historical viewer is especially useful to review past days and analyze if there have been alerts or flood episodes (in case you have not entered for any reasons).

Identification of potential users

The potential users of the tool are the 112 department in Balearic Islands Government (Departament General d'Emergències), local governments (Ajuntament de Palma and Ajuntament de Marratxí), firefighters of Mallorca (Bombers del Consell de Mallorca), local civil protection an local firefighters (Palma).

Recommendations for improvement and integration

- **Which is your general impression of the tool?**

  The overall impression of the tool is positive. It is a solid, practical and effective tool for flood risk prevention.

- **In your opinion, is the tool useful for operational uses in your region as it is? If no, what needs to be added or improved?**

  Yes, it can always be improved. As we have said, more layers of flowmeters or meteorological stations could be added (request to BALEARSMETEO). In addition, vulnerable elements such as homeless people are missing (although we should not load much the map since if it is not stop understanding). However, from a start-up perspective we believe that the tool is very useful and has a lot of potential to be used in the near future.

- **Once this is achieved, what would be the next steps for actual integration in the operational chain of response?**

  That is what we think is more difficult. In the Balearic Islands there is already a similar system known as RISCBAL, and this complicates a little the involvement of the emergency parties or the government in the importance of this tool.

  However, in the meetings they have let us know that they are interested in the tool and that it can function as an extrapolable element, which can be combined with the existing systems to improve the prevention of the population, which is the true objective of this project.

Next priority steps from the EWS developer perspective

The main priority for completing the Palma EWS should be the integration of river gauges into the system. This was not possible during the project, primarily due to the lack of data distribution infrastructure. However, this infrastructure is expected to be in place in the near future, enabling the availability of real-time data from fluvial streams.

With regard to system integration, Palma firefighters already use their own operational platforms. It should therefore be assessed whether the EWS could function as a complementary tool or whether its outputs should instead be integrated into existing legacy software. Both approaches are viable, but further detailed coordination would be required to determine the most appropriate solution.

Kamchia EWS (Bulgaria)

Technical overview

The Bulgarian EWS implementation was limited by the difficulty to access national data sources. Fortunately, the pilot leader provided access to three local sensors of their own, giving water level at the Kamchia river for the two pilot areas. This was complemented with precipitation forecast from the GFS global model, and official warnings from MeteoAlarm. Rain gauges belonging to the international network SYNOP were also included but only for descriptive purposes. They are not suitable for warnings because of its low density and low frequency (12h).

At the beginning of the testing period, the system missed an event on the 3rd-4th October due to a misconfiguration of the sensor units, and so the defined thresholds were not appropriate.

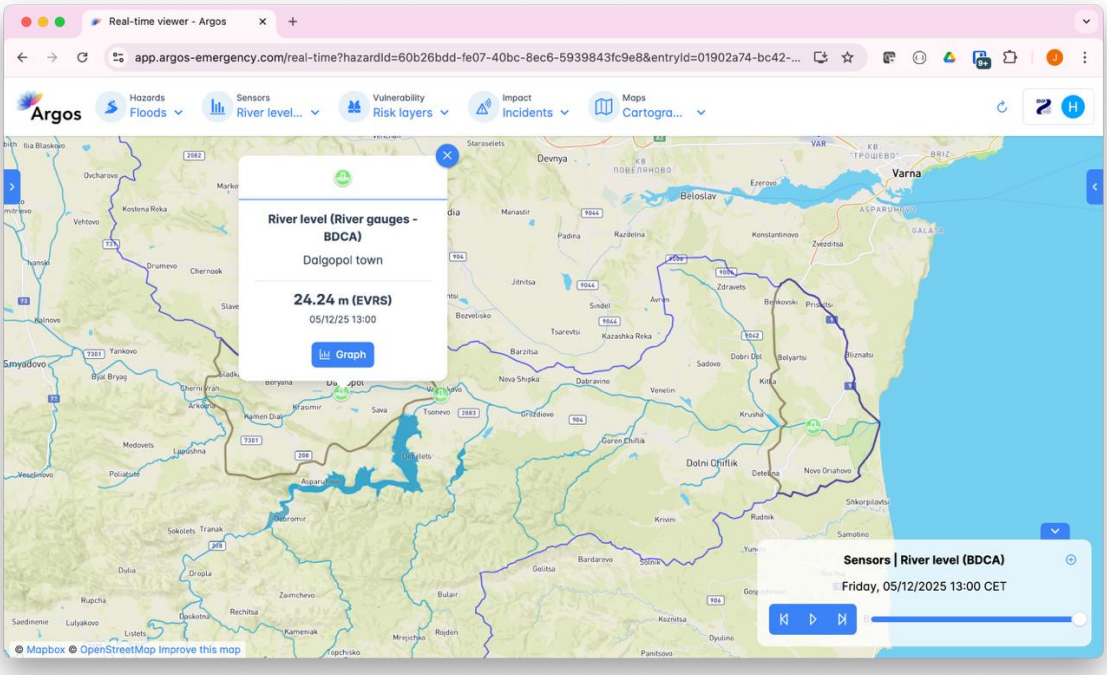

Figure 6. Screenshot of Argos for Kamchia (Bulgaria).

Performance in real events

For the pilot site Dalgopol (urban):

Dates:	**03-04.10.2025**
Significant values occurred: *"example 25 mm in the city center"*	92.0 mm for 24 hours measured by Weather station Dalgopol;
Description: *What happened?*	100-120 mm flow observed in some street in the city center in certain moments; Water level increase of 0.40 m observed at WL Sensor Dalgopol at 13:15 on 04.10.2025
EWS use: *What could we see in the tool? Any notification received?*	No warning received by EWS/ARGOS on 2nd, 3rd or 4th of October.

Dates:	**07-08.10.2025**
Significant values occurred: *"example 25 mm in the city center"*	51.0 mm for 24 hours measured by Weather station Dalgopol; 75.3 mm measured in neighbouring station Nova Shipka, 82.0 measured in station Sindel.
Description: *What happened?*	100-120 mm flow observed in some street in the city center; Water level increase of 0.87 m observed at WL Sensor Dalgopol at 18:00 on 09.10.2025
EWS use: *What could we see in the tool? Any notification received?*	Warning received by EWS/ARGOS on 8th of October, Level 2 for Varna, Level 3 (high) for Shumen.

Dates:	**08-09.11.2025**
Significant values occurred: *"example 25 mm in the city center"*	20.0 mm for 24 hours measured by Weather station Dalgopol
Description: *What happened?*	Nothing observed in Dalgopol town
EWS use: *What could we see in the tool? Any notification received?*	Warning level 1 received on 08.11.2025 for the water level (which was wrong, as the increase was some 20 cm or so, when the

	level 1 warning shall be activated at 2.0 m increase; Warning level 1 for rain received by EWS/ARGOS on 9.11.2025, however it regards areas (Vratsa, Kyustendil) at 400 km distance from the pilot site area.

For the pilot site Kamchia river mouth and beach area (coastal):

Dates:	**03-04.10.2025**
Significant values occurred: *"example 25 mm in the city center"*	35.4 mm for 24 hours measured by Weather station Gorni Chiflik on 03.10.2025; 71.3 mm for 24 hours measured by Weather station Gorni Chiflik on 04.10.2025;
Description: *What happened?*	Water level increase of 0.43 m observed at WL Sensor Poda (close to the river mouth) at 00:15 on 04.10.2025. Visual increase of water level of approx 40 cm observed at the river mouth.. No any significant impacts observed in the tourist complex, roads, or neighbourhoods.
EWS use: *What could we see in the tool?* *Any notification received?*	No warning received by EWS/ARGOS on 2nd, 3rd or 4th of October.

Dates:	**07-08.10.2025**
Significant values occurred: *"example 25 mm in the city center"*	28.2 mm for 24 hours measured by Weather station Gorni Chiflik on 07.10.2025; 28.3 mm for 24 hours measured by Weather station Gorni Chiflik on 08.10.2025;
Description: *What happened?*	Water level increase of 0.48 m observed at WL Sensor Poda (close to the river mouth) at 02:45 on 08.10.2025. Visual increase of water level of approx 40-50 cm observed at the river mouth. No any significant impacts observed in the tourist complex, roads, or neighborhoods.

EWS use: *What could we see in the tool?* *Any notification received?*	Warning received by EWS/ARGOS on 8th of October, Level 2 for Varna, Level 3 (high) for Shumen.

Dates:	**08-09.11.2025**
Significant values occurred: *"example 25 mm in the city center"*	26.4 mm for 24 hours measured by Weather station Gorni Chiflik
Description: *What happened?*	Nothing observed in river water level, or in urbanized and coastal areas at the pilot site.
EWS use: *What could we see in the tool?* *Any notification received?*	Warning level 1 received on 08.11.2025 for the water level (which was wrong, as the increase was lee than 20 cm, when the level 1 warning shall be activated at 1.2 m increase; Warning level 1 for rain received by EWS/ARGOS on 9.11.2025, however it regards areas (Vratsa, Kyustendil) at 400 km distance from the pilot site area.

Feedback on the system

- **Is the general concept of the tool appropriate for a Flood EWS?**

  Yes, in general

- **Is the tool user friendly enough? Is the information easy to understand?**

  In general, the information is easy to understand.

  However, the graphs showing water level are only showing the last few hours (i.e. a flat line, which does not give any idea of the trend - is the level rapidly increasing (flood condition), or is going down …

  Sending warnings for areas far (400-500 km) from the pilot sites (e.g. areas of Vratsa, Kyustendil, Sofia, etc) shall be avoided.

  Also, the warning threshold values should be finally discussed/adjusted, in order to get more realistic warnings.

- **Which products (official warnings, sensors, forecasts) are more useful? Which are missing?**

  All testing persons were mostly interested to follow:

- Rain forecast & official warnings – as an indirect indicator for potential flash flood
- Water level (sensors) – as a clear indicator for forthcoming riverine flood

However, as long as the warnings sent concerns larger areas (e.g. Bulgaria, or Northern District), and the warnings often come at lower probability (e.g. level 1), their role was somewhen neglected.

- **Beyond the visualization on the map and the trigger of warnings, specific features (newsletter, historical viewer, dashboard) were developed for a better user experience, what is your opinion?**

  The testing persons say they are tired of daily newsletters, they would prefer to receive only warnings, when they are available.

Identification of potential users

The potential users for the Dalgopol pilot are:

- Municipality of Dalgopol – Defence & Mobilisation Dept.
- Regional Fire Safety and Civil Protection Service

While for the Kamchia river mouth pilot the users should be:

- Municipality of Dolni Chiflik – Defence & Mobilisation Dept.
- Municipality of Asparuhovo/Varna - Defence & Mobilisation Dept.

Recommendations for improvement and integration

- **Which is your general impression of the tool?**

  Positive

- **In your opinion, is the tool useful for operational uses in your region as it is? If no, what needs to be added or improved?**

  It is of course useful; however some minor improvements could contribute more, for instance:

  - Please do not circulate daily newsletter every day, but only warnings, in the days when warnings occur.

- Count only warnings in the concerned regions: Varna, Burgas, Shumen, Targovishte, Dobrich. Receiving warnings for regions that are e.g. 500 km away is not suitable. Please see below the map of the regions.
- Please rescale the graphs for the water level in such a way that the Y-axis minimum value corresponds to the bottom of the river (and not equal to 0 - which may be e.g. 15-20 m underground). Please use the following values:
  - Sensor Dalgopol: axis Y starts 23.20 m
  - Sensor Velichkovo: axis Y starts 19.30 m
  - Sensor Poda: axis Y starts 0.25 m
- Please change the color of the layer "Kamchia Railways" from black to red, which is the recognized color for railways on maps in Bulgaria.
- Please check again why sensor Poda is not shown (or not shown regularly) in ARGOS
- We will review/revise and fix the warning thresholds for water level sensors, as they look not precise now.

- **Once this is achieved, what would be the next steps for actual integration in the operational chain of response?**

  It will be accepted in two municipalities (Dalgopol and Dolni Chiflik) as well as in the Fire and Civil Protection Department, as an "informative" tool, which they can use in their daily work, and also to start preparing in case of warnings (of course, it is not going to override or compete the official early warning system).
- **Any other feedback will be more than welcome**

  Testing will continue coming weeks/months, and we will provide feedback when/if appropriate.

Next priority steps from the EWS developer perspective

The Kamchia EWS still requires additional data sources to be fully developed. At present, it relies on national warnings, European-wide forecasts, and data from three sensors at pilot sites. Incorporating more localized data, such as rain gauge networks and higher-resolution national forecasts, could enhance the accuracy of the warnings.

During the testing phase, several suggestions were made to improve the visualization of the information, and issues with user configuration also emerged. These matters should be relatively easy to address.

Malta EWS

Technical overview

The Malta EWS is well defined, besides weather forecasts and official warnings, it includes a good network of local sensors for both precipitation (raingauges) and river level (rivergauges). Also, a previously worked set of thresholds were integrated making the defined warnings more meaningful. Malta has a weather radar, that would be of interest for the EWS, but its data was not accessible during the project.

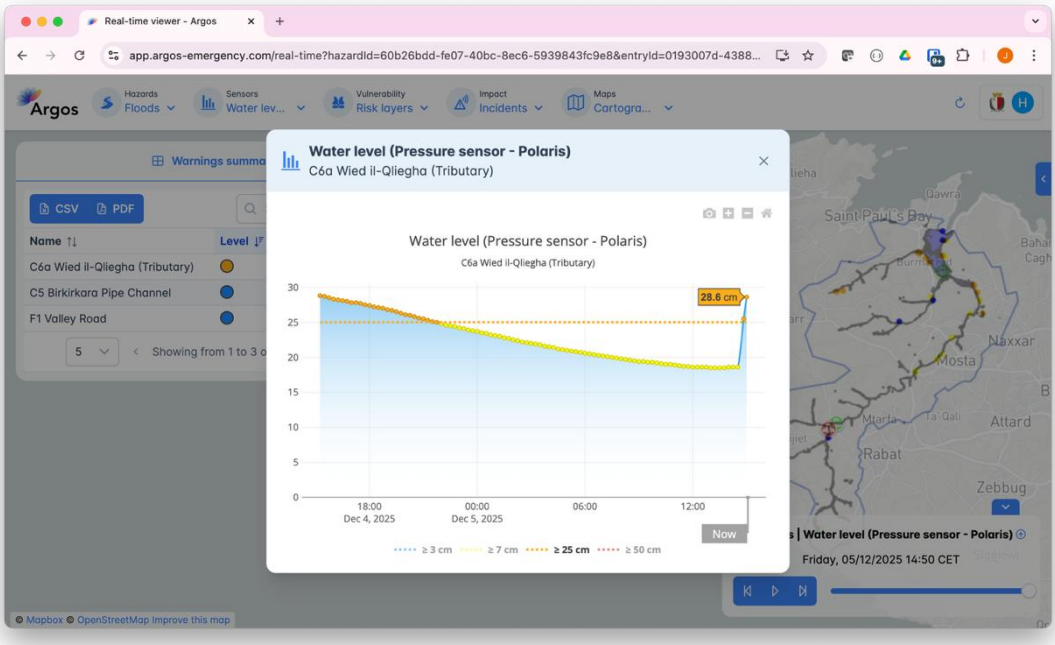

Figure 7. Screenshot of Argos for Malta.

Performance in real events

The comments included in "EWS use", besides warnings issued by the system, includes differences with the current monitoring system Polaris.

Dates: *"15-16/10/2025"*	**24/09/2025**
Significant values occurred: *"25 mm in the city center"*	Accumulation – A1: 4.7mm, A2: 1.7mm, A4: 5.7mm, A6: 3.6mm Intensity – A1: 2.1mm/h – 8.3mm/h, A2: 3.1mm/h, A4: 2.8mm/h, 7.3mm/h, A6: 2.8mm/h, 4.3mm/h
Description: *What happened?*	Varying rainfall and rainfall intensity recorded across all stations
EWS use: *What could we see in the tool?* *Any notification received?*	Blue warning (rain accumulation) – A1 (20:15)

Dates: *"15-16/10/2025"*	**27/09/2025**
Significant values occurred: *"25 mm in the city center"*	Accumulation – A1: 1.6mm, A2: 3.9mm, A4: 2.3mm, A6: 4.1mm Intensity – A1: 29.8mm/h, A2: 12.4mm/h & 10.3mm/h, A4: 23mm/h, A6: 12.5mm/h
Description: *What happened?*	Varying rainfall accumulation and intensity recorded across all stations
EWS use: *What could we see in the tool?* *Any notification received?*	Rain accumulation different from Polaris A2 and A6 over 1st accumulation threshold A1 & A4 over 2nd intensity threshold A2 & A6 over 1st intensity threshold C5 peak 1 (5.4cm) over 1st threshold, peak 2 (31.5cm) over 3rd threshold F1 peak 1 (8.8cm) over 1st threshold, peak 2 (21.3cm) over 2nd threshold Blue warning (rain accumulation) – A2 (14:30) & A6 (15:00) Blue warning (rain intensity) – A2 (14:45) & A6 (15:15) Yellow warning (rain intensity) – A1 (14:45) & A4 (14:45) Yellow warning (water level pressure sensor) – F1 (14:40) Orange warning (water level pressure sensor) – C5 (14:50)

Dates: *"15-16/10/2025"*	**01/10/2025**

Significant values occurred: *"25 mm in the city center"*	Accumulation – A1: 5.1mm, A2: 1.4mm, A4: 4.8mm, A6: 5.7mm Intensity – A1: 20.7mm/h & 5.9mm/h, A2: 35mm/h, A4: 14.9mm/h & 10.5mm/h, A6: 39.8mm/h & 7.8mm/h
Description: *What happened?*	Varying rainfall accumulation and intensity recorded across all stations
EWS use: *What could we see in the tool?* *Any notification received?*	Rain accumulation different from Polaris A1 & A2 over 2nd intensity threshold A4 over 1st intensity threshold A6 over 3rd intensity threshold C5 peak 1 (9.3cm) over 2nd threshold C6a peak 1 (27.4cm) over 3rd threshold, peak 2 (9.3cm) over 2nd threshold F1 peak (15.6cm) over 2nd threshold Blue warning (rain intensity) – A4 (12:15) Yellow warning (rain intensity) – A1 (12:15) & A2 (12:15) Orange warning (rain intensity) – A6 (12:15) Yellow warning (water level pressure sensor) – C5 (12:20) & F1 (12:20) Orange warning (water level pressure sensor) – C6a (12:30)

Dates: *"15-16/10/2025"*	**13/10/2025**
Significant values occurred: *"25 mm in the city center"*	Accumulation – A2: 1.5mm, A4: 1.3mm, A6: 0.6mm Intensity – A2: 3.9mm/h & 1.5m/h, A4: 1.8mm/h & 3.3mm/h, A6: 11.3mm/h & 24.3mm/h
Description: *What happened?*	Minimal rainfall accumulation and intensity recorded at A2, A4 & A6
EWS use: *What could we see in the tool?* *Any notification received?*	Rain accumulation different from Polaris A6 over 2nd intensity threshold C5 peak (45.3cm) over 3rd threshold C6a peak (24.7cm) over 2nd threshold near to 3rd threshold F1 peak 1 (5.5cm) over 1st threshold, peak 2 (21.4cm) over 2nd threshold F2 peak (11.8cm) over 1st threshold Yellow warning (intensity) – A6 Blue warning (water level pressure sensor) – F2 (11:20) Orange warning (water level pressure sensor) – C5 (11:10) Yellow warning (water level pressure sensor) – C6a (09:30) & F1 (11:20)

Dates: *"15-16/10/2025"*	**15/10/2025**
Significant values occurred: *"25 mm in the city center"*	Accumulation – A1:3.9mm, A2:5mm, A4: 10.6mm, A6: 6.6mm Intensity – A1: 57.2mm/h, A2: 22.9mm/h & 4.3mm/h, A4: 50mm/h & 3.8mm/h, A6: 44.4mm/h & 3.8mm/h
Description: *What happened?*	Varying rainfall accumulation and intensity recorded across all stations
EWS use: *What could we see in the tool?* *Any notification received?*	Rain accumulation different from Polaris A4 over 2nd accumulation threshold A6 over 1st accumulation threshold C5 peak 1 (19.9cm) over 2nd threshold, peak 2 (8.3cm) over 2nd threshold C6a peak 1 (31.4cm) over 3rd threshold, peak 2 (17.4cm) over 2nd threshold F1 peak 1 (17.4cm) over the 2nd threshold, peak 2 (10.7cm) over the 1st threshold Blue warning (rain accumulation) – A6 (12:30) Yellow warning (rain accumulation) – A4 (12:30) Yellow warning (rain intensity) – A2 (13:00) Orange warning (rain intensity) – A1 (12:45, A4 (12:45) & A6 (12:45) Yellow warning (water level pressure sensor) – C5 (12:50) & F1 (13:00) Orange warning (water level pressure sensor) – C6a (12:50)

Dates: *"15-16/10/2025"*	**18/10/2025**
Significant values occurred: *"25 mm in the city center"*	Accumulation – A1: 12.5mm, A2: 11.6mm, A4: 13.1mm, A6: 12.3mm Intensity – A1: 5mm/h & 4.6mm/h, A2: 4.9mm/h & 3.3mm/h, A4: 5.2mm/h & 4.4mm/h, A6: 5.3mm/h & 3.5mm/h
Description: *What happened?*	Varying rainfall accumulation and intensity recorded across all stations
EWS use: *What could we see in the tool?* *Any notification received?*	C5 peak 1 (7.4cm) over 2nd threshold, peak 2 (7cm) over 2nd threshold, peak 3 (3.6cm) over 1st threshold C6a equal to 1st threshold for majority of day, peak (17.2cm) over the 2nd threshold F1 peak 1 (8cm) over 1st threshold, peak 2 (7.7cm) over 1st threshold Blue warning (water level pressure sensor) – F1 (15:40) Yellow warning (water level pressure sensor) – C5 (16:00) & C6a (16:10)

Dates: *"15-16/10/2025"*	**07/11/2025**
Significant values occurred: *"25 mm in the city center"*	Accumulation – A1: 3.3mm, A2: 5.1mm, A4: 2.6mm, A6: 5.6mm Intensity – A1: 4.4mm/h & 7mm/h, A2: 3.9mm/h & 9.5mm/h, A4: 18.2mm/h & 6.1mm/h, A6: 8.5mm/h & 14.2mm/h
Description: *What happened?*	Varying rainfall and rainfall intensities were recorded across all four stations
EWS use: *What could we see in the tool?* *Any notification received?*	Rain accumulation different from Polaris A2 & A6 over 1st accumulation threshold A4 & A6 over 1st intensity threshold C5 peak (5.7cm) over 1st threshold C6a peak 1 (15.9cm) over 2nd threshold, peak 2 (15.8cm) over 2nd threshold F1peak 1 (10.1cm) over 1st threshold, peak 2 (12.2cm) over 1st threshold Blue warning (accumulation) – A2 (13:45) & A6 (05:00) Blue warning (intensity) – A4 (05:00) & A6 (05:45) Blue warning (water level pressure sensor) – C5 (07:00) & F1 (06:00) Yellow warning (water level pressure sensor) – C6a (06:10)

Dates: *"15-16/10/2025"*	**22/11/2025**
Significant values occurred: *"25 mm in the city center"*	Accumulation – A1: 3.5mm, A2: 3mm, A4: 5.4mm, A6: 7mm Intensity – A1: 15.9mm/h & 3.9mm/h, A2: 1.4mm/h, 4.3mm/h & 2mm/h, A4: 7.7mm/h & 3.4mm/h, A6: 6.7mm/h & 7.4mm/h
Description: *What happened?*	Varying rainfall and rainfall intensities were recorded across all four stations
EWS use: *What could we see in the tool?* *Any notification received?*	Rain accumulation for A1 different from Polaris C5 peak (3.8cm) over 1st threshold C6a slightly under 1st threshold for entire day Blue warning (rain intensity) – A1(03:00) Blue warning (water level pressure sensor) – C5 (03:50)

Dates: *"15-16/10/2025"*	**23/11/2025**
Significant values occurred: *"25 mm in the city center"*	Accumulation – A1: 5.4mm, A2: 3.8mm, A4: 2.7mm, A6: 3.2 mm

	Intensity – A1: 4.8mm/h & 8.6mm/h, A2: 1.9mm/h, 4.3mm/h & 3mm/h, A4: 1.5mm/h, 1.7mm/h & 2.7mm/h, A6: 1.5mm/h, 2.4mm/h & 3.7mm/h
Description: *What happened?*	Varying rainfall and rainfall intensities were recorded across all four stations
EWS use: *What could we see in the tool?* *Any notification received?*	Rain accumulation for A1 over 1st threshold C5 peak (5.2cm) over 1st peak C6a slightly under 1st threshold for entire day F1 peak (7.3cm) over 1st threshold Blue warning (rain accumulation) – A1 (23:00) Blue warning (water level pressure sensor) – C5 (10:20) & F1 (10:20)

Dates: *"15-16/10/2025"*	**28/11/2025**
Significant values occurred: *"25 mm in the city center"*	Accumulation – A1: 7mm, A2: 6.8mm, A4: 9.7mm, A6: 8.2mm Intensity – A1: 6.9mm/h, 4.6mm/h & 4.7mm/h, A2: 8.1mm/h & 15.8mm/h, A4: 10.7mm/h & 10.0mm/h, A6: 21.3mm/h
Description: *What happened?*	Varying rainfall and rainfall intensities were recorded across all four stations
EWS use: *What could we see in the tool?* *Any notification received?*	Rain accumulation for A4 & A6 over 1st threshold Rain intensity for A2 & A4 over 1st threshold, A6 over 2nd threshold C5 peak 1 (8.4cm) over 1st threshold, peak 2 (8.2cm) over 1st threshold C6a peak 1 (25.1cm) over 3rd threshold, peak 2 (29.3cm) over 3rd threshold F1 peak 1 (8.7cm) over 1st threshold, peak 2 (10.1cm) over 1st threshold Blue warning (rain accumulation) – A4 (05:30) & A6 (05:30) Blue warning (rain intensity) – A2 (05:45) & A4 (05:45) Yellow warning (rain intensity) – A6 (05:45) Blue warning (water level pressure sensor) – F1 (00:10) Yellow warning (water level pressure sensor) – C5 (00:20) Orange warning (water level pressure sensor) – C6a (00:45)

Feedback on the system

- **Is the general concept of the tool appropriate for a Flood EWS?**

  Yes, since the provided information aids in the determination of potential flood events.
- **Is the tool user friendly enough? Is the information easy to understand?**

  Yes, the tool is very user-friendly, and the information provided is straightforward.
- **Which products (official warnings, sensors, forecasts) are more useful? Which are missing?**

  The most useful products are the issued warnings and sensor values given forecast could not be used since radar values were not provided from our end.
- **Beyond the visualization on the map and the trigger of warnings, specific features (newsletter, historical viewer, dashboard) were developed for a better user experience, what is your opinion?**
  - Dashboard: Very helpful for easily determining key information.
  - Newsletter: Straightforward.
  - Historical viewer: Very useful for providing a detailed account on events that have taken place.

Identification of potential users

The most indicated potential user would be the Civil Protection Department in Malta Government.

Recommendations for improvement and integration

- **Which is your general impression of the tool?**

  The tool is very useful and easy to operate. However, it would be more user-friendly if it allows users to view all alerts for issued warnings for the entire day regardless of the selected time slot is displayed. Additionally, indicating the start and end time of each alert might be helpful.
- **In your opinion, is the tool useful for operational uses in your region as it is? If no, what needs to be added or improved?**

Yes, the tool would be particularly beneficial for individuals without access to other platforms. Additionally, incorporating features such as displaying the station's battery level, enabling comparison of sensor readings across dates, and providing regular site images through installed cameras to validate any discrepancies in measurements would significantly enhance its value.

- **Once this is achieved, what would be the next steps for actual integration in the operational chain of response?**

  The next steps will focus on driving adoption of the platform across the operational response chain identified in the Integrated Multi-Stakeholder Governance Model (IMGM). Formal integration will be achieved through comprehensive training, updates to Stand Operating Procedures (SOPs), and ensuring full system interoperability. In addition, all stakeholders involved in the process should be granted access and provided with targeted training to ensure a fully integrated and responsive operational chain.

Next priority steps from the EWS developer perspective

The Malta EWS could achieve a significant improvement in quality by incorporating weather radar data, which would be particularly beneficial for its small catchments. While this is neither easy nor quick to implement, requesting data sharing between administrations should be feasible. In addition, the use of more localized numerical weather prediction models would further enhance the system, as it currently relies on forecasts from the European Centre (ECMWF). The existing sensor network is already comprehensive and readily available.

Puglia EWS (Italy)

Technical overview

In the case of Puglia EWS, we could include a quite dense local network of raingauges in the area but we lack of water level data. Several steps were carried out during the implementation process to access other relevant data in real-time but we found some administrative barriers that we couldn't overcome. However, raingauges were complemented with weather forecasts and official warnings for Puglia region.

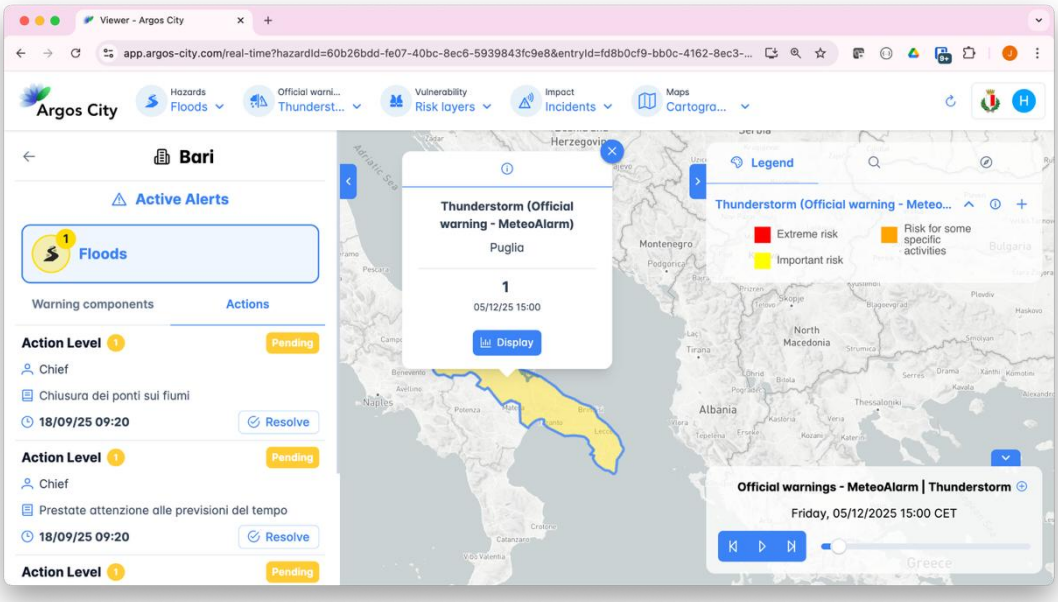

Figure 8. Screenshot of Argos City for Bari (Puglia).

Performance in real events

Dates: *"15-16/10/2025"*	16/10
Significant values occurred: *"25 mm in the city center"*	20 mm
Description: *What happened?*	Flooding of streets in some areas of the city. Specifically, in neighborhoods adjacent to the city center.
EWS use: *What could we see in the tool?* *Any notification received?*	Yes, the notification arrived with the following alerts: • Rain from 2:00 AM to 10:00 AM • Thunderstorm from 6:00 PM to 12:00 PM • Wind throughout the entire day

	In addition, a Level 1 flood hazard warning was issued, along with the table of stations that triggered the alert.

Dates: *"15-16/10/2025"*	17/10
Significant values occurred: *"25 mm in the city center"*	20 mm
Description: *What happened?*	Some underpasses in the central areas of the city were closed due to flooding, causing major traffic disruptions.
EWS use: *What could we see in the tool?* *Any notification received?*	Yes, the notification arrived with the following alerts: • Rain from 12:00 AM to 6:00 PM • Thunderstorm from 12:00 AM to 6:00 PM • Wind from 12:00 AM to 1:00 AM In addition, a Level 1 flood hazard warning was issued, along with the table of the stations that triggered the alert.

Dates: *"15-16/10/2025"*	03/11
Significant values occurred: *"25 mm in the city center"*	10 mm
Description: *What happened?*	Moderate rainfall and an evening weather alert for thunderstorms lasting until midnight.
EWS use: *What could we see in the tool?* *Any notification received?*	Yes, the notification arrived with the following alerts: • Thunderstorm from 6:00 PM to 12:00 PM • Wind all day, with increased intensity from 6:00 PM to 12:00 PM In addition, a Level 1 flood hazard warning was issued, along with the table of the stations that triggered the alert.

Dates: *"15-16/10/2025"*	09/11
Significant values occurred: *"25 mm in the city center"*	10 mm
Description: *What happened?*	Flooding of streets, basements, and underpasses, local collapses, and blackouts.
EWS use: *What could we see in the tool?*	Yes, the notification arrived with the following alerts:

Any notification received?	• Thunderstorm from 6:00 AM to 12:00 PM • Wind all day, with increased intensity from 12:00 AM to 11:00 AM In addition, a Level 2 flood hazard warning was issued, along with the table of the stations that triggered the alert.

Dates: *"15-16/10/2025"*	10/11
Significant values occurred: *"25 mm in the city center"*	10 mm
Description: *What happened?*	The damage from the cloudburst is being assessed: in the city of Bari, flooded underpasses, fallen trees (including in front of the Castle), pavement washouts, and numerous flooded streets have been reported.
EWS use: *What could we see in the tool?* *Any notification received?*	Yes, the notification arrived with the following alerts: • Rain from 12:00 AM to 12:00 PM • Thunderstorm from 6:00 AM to 12:00 AM • Wind from 6:00 AM to 6:00 PM In addition, a Level 1 flood hazard warning was issued, along with the table of the stations that triggered the alert.

Feedback on the system

- **Is the general concept of the tool appropriate for a Flood EWS?**

  Yes, it is appropriate. It is a tool that provides information well in advance, offering forecasts and early signals of potentially critical phenomena. Thanks to this type of early warning system, authorities can activate the necessary measures in a timely manner, plan interventions, deploy operational teams, and take all the precautions needed to mitigate the effects of the event.

- **Is the tool user friendly enough? Is the information easy to understand?**

  Yes, absolutely. The tool is intuitive and well-structured: the various sections are easily accessible thanks to clear and recognizable icons, allowing users to orient themselves quickly. Navigation within the page is simple and smooth, with a coherent layout that makes the content immediately understandable.

Overall, the interface is user-friendly and supports effective use even by non-expert operators, reducing the time needed to access information and improving the efficiency of monitoring activities.

- **Which products (official warnings, sensors, forecasts) are more useful? Which are missing?**

  Official e-mail alerts and newsletters are extremely useful tools, as they ensure timely and direct communication to users. Through these channels, it is possible to receive immediate updates, operational information, and notifications of any critical issues without having to access the platform manually. This allows authorities, technicians, and operators to remain constantly informed, improving their response capacity and preparedness in the event of potentially hazardous situations. Moreover, the structured format of the newsletters provides a clear overview of the sources of information.

- **Beyond the visualization on the map and the trigger of warnings, specific features (newsletter, historical viewer, dashboard) were developed for a better user experience, what is your opinion?**

  The **dashboard** is a highly valuable feature. The summary cards displayed immediately upon login provide a quick overview of system status, current weather conditions, and any active alerts. This setup allows users to orient themselves quickly, reducing the time needed to retrieve information and improving operational efficiency. Its visual clarity and well-organized structure contribute to a smooth and intuitive user experience.

  The daily **newsletters** are extremely useful for keeping users constantly informed. Receiving active alerts and relevant updates directly via e-mail ensures that users remain aware of evolving situations even when they are not actively using the platform. This strengthens response capability and enables technicians, operators, and authorities to anticipate potential critical issues. The concise, clear, and well-structured format also facilitates quick reading and immediate understanding of the information provided.

The **historical viewer** is particularly valuable, as it allows users to browse a well-organized archive of past events. This feature is essential for retrospective analysis, assessing the effectiveness of past measures, and understanding local dynamics of the phenomena. Access to detailed event files provides a useful level of depth for technical studies, reporting, and planning activities. Overall, this tool significantly enhances the platform and broadens its operational capabilities.

Identification of potential users

For the Bari pilot site, the ideal institutional users of the Argos-City platform would be:

- Civil Protection Department (Regional and Local level): Responsible for local emergency planning, risk monitoring, and public safety measures. This department has the authority to issue alerts, manage evacuations, and coordinate with responders.
- Risk and Environmental Agency (ARPA PUGLIA): To supports environmental risk assessments. Could integrate Argos-City into its existing operational workflow.
- Local Police / Municipal Technical Office: Relevant for operational field response, road closures, and infrastructure safety assessments.

Recommendations for improvement and integration

- **Which is your general impression of the tool?**

  The overall impression of the tool is very positive. The system is stable, well-designed, and operates smoothly. Information is presented clearly and coherently, navigation is intuitive, and the main features are immediately accessible. Overall, it appears to be a mature and reliable product, designed to effectively support operational activities.

- **In your opinion, is the tool useful for operational uses in your region as it is? If no, what needs to be added or improved?**

Yes, the tool could be useful even in its current form. The structure of the information, the automatic alerts, the dashboard, and the early warning functionalities provide significant support for monitoring and response activities.

However, to further enhance operational effectiveness, a few improvements could be considered, such as:

- a dedicated section for the rapid sharing of information with other operational units;
- a section for collecting citizen feedback, allowing for more precise and tailored alert customization.

- **Once this is achieved, what would be the next steps for actual integration in the operational chain of response?**

  The next steps for full integration into the operational response chain could include:

  - defining official usage protocols, specifying how and when the tool should be consulted;
  - training personnel to ensure consistent and informed use of the tool's functionalities;
  - launching campaigns to promote and disseminate the tool;
  - integrating the tool with other systems already in use within operations centers and coordination units;
  - testing the system through drills or simulations to assess performance, response times, and information flows

- **Any other feedback will be more than welcome.**

  With a coordinated integration process and some operational refinements, the tool could become a key asset in risk management and civil protection activities.

Next priority steps from the EWS developer perspective

Users of the Puglia EWS provided valuable proposals regarding features for information dissemination and feedback collection. The next steps should therefore focus on examining in detail how the tool could be beneficial in an operational context. From the outset, the tool should support practical actions in a clear and visible way, which requires a careful analysis of current procedures and roles. These efforts may also provide insights into additional data to be integrated and how existing features could be better exploited.

Central Macedonia EWS (Greece)

Technical overview

Central Macedonia EWS has a very complete set of data sources: besides GFS forecasts and official regional warnings, the pilot leader provided model forecasts at very high resolution in real time. They included outputs from meteorological models, such as rainfall or mean sea-level pressure, as well as coastal models' results, including sea-surface height or coastal flood height. No national network could be included, but two weather stations near the pilot site were integrated. Although they had no machine-to-machine easy access we could automate reading directly on each website.

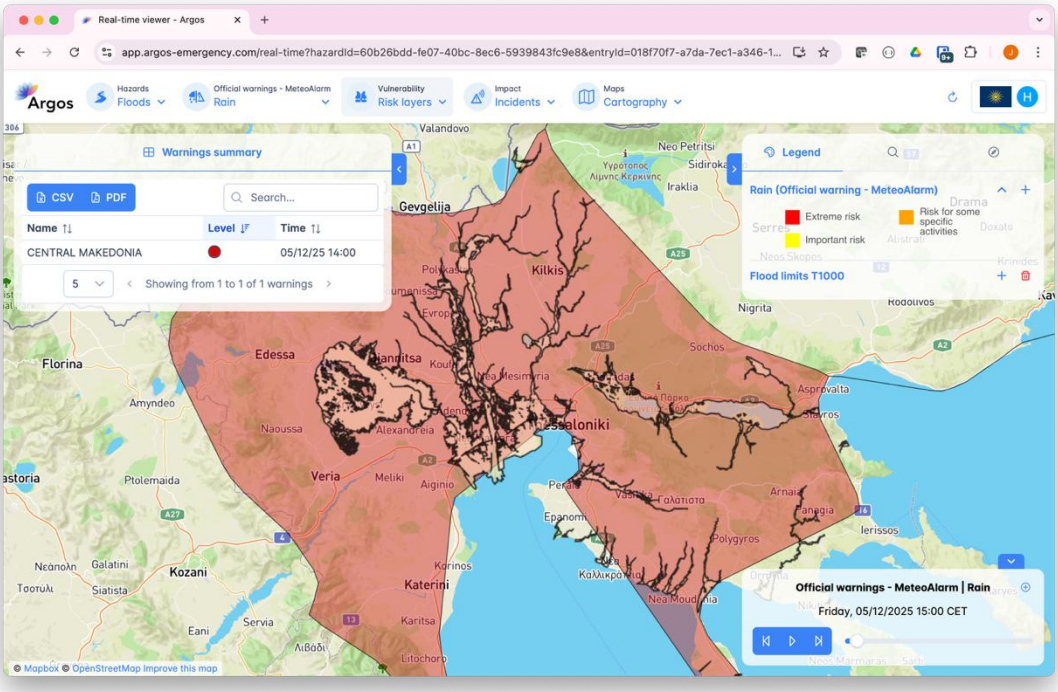

Figure 9. Screenshot of Argos for Central Makedonia.

Performance in real events

During September–December 2025, the ARGOS Early Warning System (EWS) was tested operationally for the Anthemountas River basin (Central Macedonia, Greece). The tester (PP8 – AUTh) monitored ARGOS during forecast rainfall and thunderstorm events and received automated email/SMS warnings based on MeteoAlarm thresholds for rain and thunderstorms across the wider Thessaloniki/Central Macedonia region. In total, 28 alerts of Levels 1–3 (Low–High) were recorded between 12 September and 28 November 2025. These tests aimed to assess (a) if the tool correctly anticipates hazardous weather situations relevant for flash-flood risk in the basin, and (b) how useful and user-friendly the warnings and visual products are for an operational user.

Dates:	**25–27/11/2025**
Significant values occurred:	Storm Adel makes landfall on Greek mainland and coastal areas; estimated cumulative rainfall height: 100-120mm.

Description: *What happened?*	The broader metropolitan area was affected by heavy precipitation and a severe windstorm, with estimated cumulative rainfall heights reaching 100-120 mm. Flooding was reported on the streets in the centre of Thessaloniki. Urban and rural floods reporting on news: https://www.youtube.com/watch?v=Y1-JtigvX4A Observed situation: rain intensity and local flooding/ponding reports from residents and media, etc.).
EWS use: *What could we see in the tool?* *Any notification received?*	ARGOS tool showed: - Official Warnings by MeteoAlarm - AUTh Forecast of rain accumulation (high level) Alerts #2, 4, 6, and 9, shown below, were sent by ARGOS via SMS and email. 25/11: "Newsbeast" and "Ta Nea" mass media talked about updates about severe weather with increasing rainfall and storm impacts all over Greece, and "gradually enhanced rainfall" in Thessaloniki as the ADEL storm low-pressure system approaches. 26/11: "Ta Nea" and "eMakedonia" mass media describe the main impact of "Adel", with "locally intense rainfall and storms" in central and Eastern Macedonia, and especially in the broader Thessaloniki area 27/11: Similar reports from "Newsbeast", "Oraiokastro24", "iNews", "Newsit", and "in.gr" about related coverage of "Adel" storm report The sequence of Level-2/3 ARGOS warnings closely coincides with the major ADEL severe-weather episode, as documented for Central Macedonia.

Dates:	**10/11/2025**
Significant values occurred:	Medium rainfall
Description: *What happened?*	Weather: Increased cloudiness with local rains. Sporadic storms occurred mainly in eastern Macedonia. Precipitation: Medium cumulative rainfall height Winds: From southerly directions >5 Bf. Temperature: Lowest values <8°C in western Macedonia.
EWS use: *What could we see in the tool?* *Any notification received?*	ARGOS tool showed: - Official Warnings by MeteoAlarm

	- AUTh Forecast of rain accumulation (medium level) Alerts #10 and 12, shown below, were sent by ARGOS via SMS and email. 9/11 "News247" relays a new HNMS/EMY emergency weather prediction broadcast, noting for Thessaloniki "intense cloudiness with local severe rainfall and isolated storms". https://www.news247.gr/kairos/neo-ekakto-emi-isxires-kataigides-mexri-tin-triti-oi-perioxes-pou-epireazontai/?utm_source=chatgpt.com 10/11 "Ta Nea" publish "Weather: intense stroms and severe weather phenomena", with the bulletin stating "Thessaloniki: Cloudiness, rainfalls and stormy winds, at times strong." Strong agreement between ARGOS medium-level alerts and documented heavy weather with locally intense storms.

Dates:	**3–4/11/2025**
Significant values occurred:	Medium rainfall
Description: *What happened?*	Weather: Increased cloudiness with local rains. Sporadic storms occurred mainly in eastern Macedonia. Precipitation: Low-medium cumulative rainfall height Winds: 5-6 Bf. Temperature: Lowest values <5°C in Central Macedonia.
EWS use: *What could we see in the tool?* *Any notification received?*	ARGOS tool showed: - Official Warnings by MeteoAlarm - AUTh Forecast of rain accumulation (medium level) Alerts #14 and 17, shown below, were sent by ARGOS via SMS and email. 4-5/11 No significant impacts reported. Just regular rainy weather.

	3/11 HNMS issues an emergency bulletin about stormy rains based on "News247". 4/11 multiple outlets ("Newsbeast", "CrisisMonitor", local "SalonicaNews") describe local rains and stormy weather, specifically for Thessaloniki 3–4/11 alerts capture an HNMS-flagged disturbance with showers and some thunderstorms reaching Central Macedonia. Agreement between ARGOS medium-level alerts and documented rainy weather with local storms.

Dates:	**01–02/10/2025**
Significant values occurred:	Medium rainfall
Description: *What happened?*	Weather: Increased cloudiness with local rains. Sporadic storms occurred mainly in eastern Macedonia. Precipitation: Low-medium cumulative rainfall height Winds: 5-6 Bf. Temperature: Lowest values <5°C in Central Macedonia.
EWS use: *What could we see in the tool?* *Any notification received?*	ARGOS tool showed: - Official Warnings by MeteoAlarm - AUTh Forecast of rain accumulation (medium level) Alerts #20 and 22, shown below, were sent by ARGOS via SMS and email. 1-2/10 "Avgi" report: 112 alert sound in Central Macedonia and other regions https://www.avgi.gr/koinonia/512549_ihise-112-se-thessaloniki-halkidiki-kai-serres-anamenontai-ishyres-brohoptoseis 30/09 "Popaganda" and "Athens Voice" mention unsettled conditions with clouds and showers. Some convective activity regionally reported; probably weak–moderate in the pilot area. 1–3/10/2025 (L1–L3 rain & thunderstorms)

	Forecasts for 1–2/10 highlight strong deterioration: "BusinessDaily" warns for "cloudiness and rainfall" in Thessaloniki. 2/10 a civil protection 112 SMS is sent for "intense storm in Thessaloniki, Chalkidiki, and Serres", widely reported by "Libre", "eMakedonia" and other outlets. 3/10 "RThess" and other local media describe "strong rainstorms during nighttime until early morning hours in Thessaloniki. The cluster of Level 2/3 ARGOS alerts clearly match a well-documented severe weather episode over Central Macedonia. Agreement between ARGOS high/medium-level alerts and documented heavy rain and hail weather with local storm winds.

Dates:	**04–06/12/2025**
Significant values occurred:	Medium rainfall
Description: *What happened?*	Weather: Medicane-type storm "Byron" making landfall on the Greek mainland with increased winds, cloudiness and precipitation.
EWS use: *What could we see in the tool?* *Any notification received?*	ARGOS tool showed: - Official Warnings by MeteoAlarm - AUTh Forecast of rain accumulation (medium level) Alerts #1–4, shown below, were sent by ARGOS via SMS and email. 4/12 "Naftemporiki" report: 112 alert sound in Central Macedonia and other regions https://www.naftemporiki.gr/society/2042508/kakokairia-byron-sfodri-epelasi-se-oli-tin-ellada-apanota-112/ 4/12 "ProtoThema" red alerts for storm "Byron" conditions in 8 regions in Greece. https://en.prototothema.gr/2025/12/04/severe-weather-byron-heavy-rain-and-thunderstorms-for-the-next-48-hours-the-8-regions-on-red-alert/

	5/12 "LiFo" mentions severe storm conditions with heavy thunderstorms, clouds, and showers. https://www.lifo.gr/now/greece/kakokairia-byron-poy-ehei-kataigides-tora-ti-ora-stamata-brohi-stin-attiki Storm Byron impacts in Greece: https://www.youtube.com/shorts/JV5vFqljvtY https://www.youtube.com/shorts/M-2TwN3RwrA 6/12 "ERT News" report on the aftermath of Storm Byron passing from the Central MACEDONIA REGION, Thessaloniki, and Thermaikos Gulf (impacts on coastal waters from river discharges, etc.) https://www.ertnews.gr/eidiseis/ellada/o-thermaikos-allakse-opsi-apo-tin-kakokairia-byron/ Agreement between ARGOS high/medium-level alerts and documented heavy rain and severe localized storm impacts.

For almost all dates with Level-2 or Level-3 alerts, there is clear support from HNMS/EMY weather bulletins and national/local media that significant rain or thunderstorms affected Central Macedonia and/or Thessaloniki within ±1 day.

- The only clear "miss" is **24/09/2025**, where the weather appears generally fair and no impactful storms are reported near the pilot area.
- A few dates (e.g. 30/09, 25/11) correspond to **approaching or moderate events**, with clouds and scattered showers but limited reported impacts; ARGOS behaved conservatively, which is acceptable for an EWS.
- Email/SMS arrived on time and supported the operationally sound lead time.

Feedback on the system

- **Is the general concept of the tool appropriate for a Flood EWS?**

  ARGOS integrates official MeteoAlarm warnings with a basin-centred map view and automated notifications. For Anthemountas, this is appropriate as a pre-flood meteorological warning layer upstream of any hydrological or impact-based models.

- **Is the tool user friendly enough? Is the information easy to understand?**

  Yes, the disseminated info is clear, and the tool is user-friendly for people accustomed to web-GIS tools, with a clear dashboard and intuitive colour-coded warning levels. The daily email/SMS alerts reduce the need to log in proactively.

- **Which products (official warnings, sensors, forecasts) are more useful? Which are missing?**

  Most useful products:

  - Official MeteoAlarm layers for rain/thunderstorms in Central Macedonia.
  - Daily email "newsletter" summarising warnings for the next 24 h.
  - Time-navigable map for checking past events during post-event analysis.

  Less used/missing:

  - Direct linkage to Anthemountas-specific rainfall/stream gauges when available.
  - A simple impact scale (e.g. "nuisance – severe – potentially damaging") or link to local civil-protection guidelines.
  - Option to overlay LocAll4Flood hazard/risk maps (flood-prone river reaches, hotspots) on forecast rain/flood maps to better interpret the warnings.

- **Beyond the visualization on the map and the trigger of warnings, specific features (newsletter, historical viewer, dashboard) were developed for a better user experience, what is your opinion?**

  - Dashboard: Nice feature for the most significant outputs
  - Newsletter: This is the most important feature! Keeps stakeholders informed and alert.
  - Historical viewer: This is a nice feature, though no forecast maps have been uploaded yet.

Identification of potential users

Several institutions are suitable to take advantage of the implemented EWS:

- Municipality of Kalamaria (Deputy Mayor for Environment - Civil Protection)
  Administration - Civil protection and related territorial services
- Hellenic Agricultural Insurance Organization (ELGA)
  Administration - State Insurance and related administration
- kartECO Environmental Consulting Company
  Private Sector Businesses and industries located within risk zones
- Region of Central Macedonia (Civil Protection Unit)
  Administration - Civil protection and related territorial services
- Municipality of Thermi (Civil Protection office)
  Administration - Civil protection and related territorial services
- Hellenic National Meteorological Service (Macedonia Airport SKG)
  Administration - Civil protection and related territorial services
- Decentralized Administration - Region of Central Macedonia (Civil Protection Unit)
  Administration - Public Sector Water and Agricultural Management

Recommendations for improvement and integration

- **Which is your general impression of the tool?**
  In general, stakeholder users were pleased to have an automated SMS warning service. Really easy to use and interpret. The user interface for ARGOS Notifications adjustment is also easy to use. From Sept–Nov 2025, the system showed **good skill in identifying hazardous episodes**, especially for the major October and late-November storms, with only very few apparent false alarms.

- **In your opinion, is the tool useful for operational uses in your region as it is? If no, what needs to be added or improved?**
  The CoastFLOOD and HEC-RAS2D operational forecasts of coastal and inland (fluvial+pluvial) inundation extents should be added.

Forecast – AUTH should be presented in better resolution, and it should be reported that it is more detailed than GFS for the region. The wind fields should also display wind direction vectors, not just the magnitude of speed.

The range of the color scales is extensive, and therefore, the spatial variability is difficult to identify. For example, wind speeds up to 200 km/h never occur over the area (e.g., hurricanes). The same with sea level pressure (range from 980 to 1035 is sufficient). The min-max limits of color bars should be automatically reformulated daily.

Forecasts AUTh:

- Rainfall accumulation 1h: check color bar discretization to show differentiations in case of rainy weather across the map. Contouring and interpolation schemes (e.g., Kriging) are advised for visualization.
- Mean SLP: same here; A trick is to read every 3-day or 10-day minimum-maximum value of the results and automatically reformulate the color bar's minimum-maximum limits. Contouring and interpolation schemes (e.g., Kriging) are advised for visualization.

- **Once this is achieved, what would be the next steps for actual integration in the operational chain of response?**

  For operational adoption in Anthemountas, the next logical steps would be:

  Coupling the ARGOS meteorological warnings with basin-scale rainfall-runoff and flash-flood modelling.

  Establishing local thresholds (e.g. "when Level-3 thunderstorm + >X mm forecast, notify municipal civil protection/schools").

- **Any other feedback would be more than welcome.**

  Providing **Greek-language guidance** within the platform for local end-users (municipal services, stakeholders) on how to react to each warning level.

Next priority steps from the EWS developer perspective

The main priority should be the integration of the CoastFLOOD and HEC-RAS 2D operational forecasts for coastal and inland (fluvial and pluvial) inundation extents.

This would provide valuable information for anticipating flood events. As highlighted by users, such integration would enable the coupling of ARGOS meteorological warnings with basin-scale rainfall–runoff and flash-flood modeling. Subsequently, localized warnings could be issued for specific vulnerable elements. In addition, other national-level data sources, such as sensor networks and weather radar data, should also be explored.

General conclusions

After the implementation of the six EWS in Activity 1.2 of LocAll4Flood project, which were described in previous deliverable "D1.2.1 Report on the Early Warning System to be implemented on the pilot sites", Activity 2.2 consisted of the iterative improvement of each implemented system, deliver of the EWS to pilot leaders and stakeholders, and a testing period in autumn.

The outcomes of the testing period are presented in this deliverable, with a dedicated section for each implemented EWS. Within each section, the "Technical overview" subsection briefly summarises the progress achieved in the implementation and the challenges that arouse in the process. In "Performance in real events", actual rainfall events occurred during the testing period are listed together with the corresponding responses of the EWS. Based on this experience with the system, users provided insights that were compiled by pilot leaders in "Feedback on the system" subsection. Given the diversity on the administration organization across countries, the following subsection identifies the institutions that could potentially integrate the EWS. Finally, in "Recommendations for improvement and integration" subsection, users reflect on the steps required to bring the EWS to an operational context.

Both in the implementation process and the testing period, differences in the maturity level of the various EWS became evident. The most notable factor is the availability of real-time data sources. Regions with local sources of observational data, nowcasting and forecasting -such as Balearic Islands or Central Macedonia- were able to achieve a more complete implementation than those that had to rely on regional warnings and European-wide forecasts. This disparity was reflected on the users experience during the testing period: in the former regions, users engaged more complex interactions with the EWS, while in the latter, although feedback was positive, they only could appreciate the potential of the tool rather than its full capacities. Despite advances in European open data policies, LocAll4Flood was able to establish that there are still relevant technical and administrative barriers in Euro-mediterranean countries when trying to access public sector information (PSI).

For instance, weather radar information makes a difference when it comes to flash floods. Even in the relatively short testing period, users in the regions of Catalonia and Balearic Islands, whose EWS integrate radar data, were able to receive preventive warnings and following storm cells. This helped them to interpret the real-time situation, understand some false alarms and engage with the system. Most of the Euro-mediterranean countries have weather radars, use them for meteorological purposes, even show them in websites, but the data is not accessible. Besides that, other aspects also influenced the evolution of the EWS as the institutions involved (more or less distant to the operational context), the nature of the pilot site (catchment size…), the available knowledge on relevant thresholds…

Regarding technical aspects of the EWS, users are generally satisfied with the overall system as well as with provided features as the Newsletters, Dashboards and Historical viewer, with different intensities. As an illustrative example, users of the Bulgarian EWS reported to be “tired” of receiving newsletters, that it would be preferable to only receive actual warnings, while in Greece the daily mail was considered the most important feature to be aware of the situation. Many factors contribute the user experience as the specific role, the ultimate use of the tool and institutional context. This only emphasises the importance of the particular

adaptation of the platform not only to each site (flexibility to integrate different sources, geographical constraints…) but also to each user (giving options, speaking their language…).

LocAll4Flood took Early Warning Systems for Flash Floods one big step ahead in Euro-Mediterranean pilot sites. It provided users experience, implementation knowledge and essential context in Flood risk management.