European Flood Awareness System

EFAS *Bulletin*

August – September 2019

Issue 2019(5)

NEWS

New features

LISFLOOD released as open source

LISFLOOD is at the heart of the flood forecasting systems EFAS and GloFAS and contributing to the drought systems EDO and GDO. It furthermore has been used also frequently as a tool for general water management related issues including climate change projections of future water availability in Europe. Given the high interest in the model from universities, other research centres, as well as water authorities, LISFLOOD has now been released as a fully open-source code. Making the model open-source will increase transparency of model outputs for the users and will engage a large community of developers to further improve LISFLOOD.

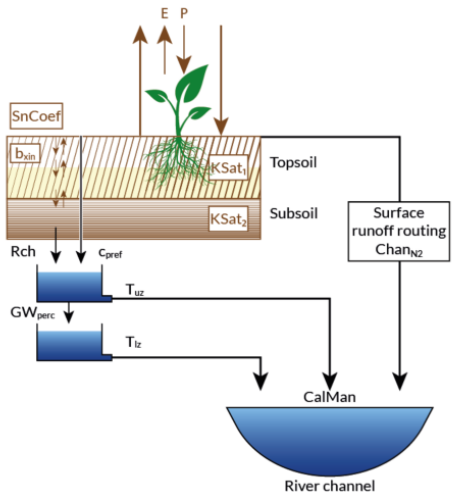

Figure 1. Schematic representation of LISFLOOD

In addition to LISFLOOD, there are also several related tools available such as LISVAP (calculates potential evapotranspiration in pre-processing mode) a model calibration tool, and some other utilities. More info can be found on GitHub: https://ec-jrc.github.io/lisflood/

Two new post-processing stations added in EFAS

Two new stations, Masier de Roda (Ter i Gurri) and Sortida d'Embassament de Sau (Vilanova de Sau), have been included into the EFAS real time hydrographs layer (post-processed discharge forecast). The workflow of adding new post-processed station is to first create a post-processing model for each station. They are then added to the post-processing operational suite and post-processing layer.

New reporting point layer released in EFAS

A new reporting point layer replaced the reporting points high and low layers on the EFAS web interface. The new layer provides an overview of reporting points with a flood signal expected in the next 10 days, as well as stations for which hydrological information is shared from EFAS partners. This will enable the users to see information that was previously spread over multiple layers in one single layer. The layer was put into operation with the release of EFAS v3.3 on 8 October 2019. For more info on this the layer, please see here. For more info on EFAS releases, we refer the EFAS wiki.

New webinar on EFAS rapid impact assessment

A webinar demonstrating EFAS rapid flood mapping and impact assessment has been published on the website. It describes the layers, the technical background and some case studies. This and other webinars can be found under Resources/Webinars.

Meetings

CEMS present at Copernicus Eyes on Earth Roadshow

The Copernicus Eyes on Earth Roadshow made its second appearance in Rotterdam, 24-25 September. The roadshow is an opportunity for students. entrepreneurs, companies and other interested citizens to know more about the Copernicus program and its services and products. The two days were a mixture of inspirational talks, lectures and master classes on how to use earth observation data to solve specific problems. The CEMS activities were presented by Paolo Barbosa, JRC. This was the second stop of the roadshow, the first was in Darmstadt, Germany, and the third was held in Tallinn, Estonia in October.

Figure 2. Stijn Vermoote from ECMWF talks to students about CDS

Webinar on seamless probabilistic forecasting of heavy rainfall and flooding

The SMUFF project team held two webinars on 1-2 October which focussed on recent advancements in predicting heavy rainfall and flooding. The webinars are broadcasted from the Interactive Seminar on Seamless Probabilistic Forecasting of Heavy Rainfall and Flooding organized by the SMUFF project at the European Centre for Medium-Range Weather Forecasts (ECMWF) in Reading, UK.

Upcoming events

ANYWHERE final conference

There are still a few places available for the ANYWHERE Final Conference! Take the chance to see the latest development of the multihazard platform and see how it has been implemented in several pilot studies across Europe, as well as in a pan-European version. This event will be held in Brussels (Belgium), on 29th-30th October 2019, at the Square Brussels Convention Centre. For more information and registration, see: ANYWHERE Final Conference

Figure 3. The ANYWHERE final workshop will be held in Brussels on 29-30 October 2019.

HEPEX/H SAF workshop

In late November, two scientific initiatives, HEPEX and H-SAF, jointly organize a workshop at ECMWF to highlight and strengthen the link between satellite products and hydrological downstream applications, the theme of the workshop is: "Satellite inspired hydrology in an uncertain future". To steer more the interest the H-SAF team will present the H-SAF soil moisture, snow and precipitation products. Find more information here.

RESULTS

Summary of EFAS Flood and Flash flood Notifications

The 9 formal and 19 informal EFAS flood notifications issued in August-September 2019 are summarised in Table 1. The locations of all notifications are shown in Figure 25 and Figure 27 in the appendix.

145 Flash flood notification were issued in August - September 2019. They are summarised in Table 2. The locations of all notifications are shown in Figure 26 and Figure 28 in the appendix.

Meteorological situation

by EFAS Meteorological Data Collection Centre

August 2019

The meteorological situation in August 2019 was characterised by low-pressure systems in the north and stable high-pressure systems in the south of the EFAS domain. Some regions received more while other, even nearby, regions received less than normally expected precipitation amounts. Like the previous month, the monthly mean temperature was below normal in the most western and eastern parts of the EFAS domain while in the centre and southern parts above normal monthly mean temperatures were recorded.

At the beginning of August, a large low-pressure system was situated over Russia and caused persistent rain as a smaller system south of Iceland moved over Great Britain and Ireland towards southern Scandinavia and a high-pressure system influenced the southern parts of the EFAS domain. Later, a low-pressure system moved from the Atlantic Ocean via Great Britain and Ireland to Scandinavia causing many heavy precipitation events between Great Britain and France in the west, Italy and Hungary in the south and Poland and Slovak Republic in the east. Instable air masses occurred also at the Balkans and south-eastern Europe causing heavy precipitation and large hailstones. The low-pressure system over Russia was replaced by a new one moving eastward.

Another large low-pressure system moved from the Atlantic Ocean to the Norwegian Sea, whereas high pressure influenced the other parts of the EFAS domain except Turkey, where an upper level low occurred causing heavy precipitation events. Later, an upper

level trough developed from the Icelandic low southward to the western Iberian Peninsula resulting in a cut-off upper level cold drop and heavy precipitation was reported from the Iberian Peninsula. At the same time, a high-pressure system developed over eastern Europe and persisted until the end of the month. Heavy convective precipitation events were reported from several countries in central Europe and Morocco, causing flash floods.

In August 2019, the highest monthly precipitation totals were observed in Great Britain and Ireland, and southern Norway, the Alps, the Tatra Mountains, Russia and the southeast coast of the Black Sea (Figure 11). Nearly no precipitation fell in some parts of the Iberian Peninsula, France, Italy and Greece as well as in the south and east of the Mediterranean Sea and some regions near the Caspian Sea. Less than normal precipitation fell in a belt across central France, Germany, Poland, the Baltic to the Kola Peninsula but also in Iceland, locally around the Mediterranean Sea, the Balkans but also in Ukraine and Southern Russia (Figure 12). More than normal precipitation fell in parts of Great Britain and Ireland and the Iberian Peninsula, southern Scandinavia as well as in a region from the Czech Republic, Slovakia, southern Poland, Belarus to Russia and south-eastern Ukraine to Russia. In addition, some smaller areas in other regions received more than normal precipitation amounts, e.g. in Italy, Turkey and northwest Africa.

The monthly mean air temperature ranged from -0.7°C to 38.6°C with the highest temperatures in the southern parts and lowest temperatures in the northern and mountainous parts of the EFAS domain (Figure 15). Temperature anomalies ranged from -4.4°C to 7.8°C with abnormally low temperatures in the western part of northwest Africa, the western Iberian Peninsula, Iceland, eastern Scandinavia and from Russia southward to the Caspian Sea and Turkey (Figure 16). In nearly all other regions temperatures rose above normal.

September 2019

The meteorological situation in September 2019 was characterised by an intensified Azores high pressure, which also extended to the east-northeast and abnormal low monthly mean surface pressure over northern Russia and in the southeast of the EFAS domain. Precipitation totals were above normal in the north and below normal in the middle and the south of the EFAS domain, except for some regions with high impact precipitation events. The monthly mean air temperature was above normal in most parts of the EFAS domain.

At the beginning of September, a low-pressure system over the Norwegian Sea brought large-scale precipitation to central and eastern Europe. In the next days, a low-pressure system developed south of Iceland and moved via Great Britain and Ireland and the North Sea to northern Scandinavia. Simultaneously, several heavy precipitation events caused flash floods in Algeria and Morocco. Nearly the whole EFAS domain was influenced by high-pressure systems in the following days. An upper-level low-pressure system developed over Central Europe and brought again large-scale precipitation.

As the high-pressure situation persisted, another upper-level low-pressure system was cut-off west of Great Britain and moved via France to the western Mediterranean region. It caused intense precipitation events mainly in Spain (including floods and landslides) and Algeria, but also in Southern France, Tunisia and Morocco. At the same time, a low-pressure system developed around Newfoundland and moved via the Atlantic Ocean and Iceland to Scandinavia. High precipitation totals caused floods in Western Norway. The low-pressure system stayed over Northern Russia for the next days and led to precipitation there. In addition, intense precipitation events were reported from Greece, Turkey and the eastern coast of the Adria. In the last days of September, several low-pressure systems moved via Great Britain and brought a lot of rain with subsequent floods.

In September 2019, the highest precipitation totals were observed in Norway, Great Britain, Spain and the east coast of the Black Sea (Figure 13). No precipitation fell in the south-eastern parts of the EFAS domain and in some parts of Turkey, Greece, Romania, Morocco and Algeria. Due to the predominant high-pressure systems, most parts of the EFAS domain received less than normal precipitation amounts (Figure 14). More than normal precipitation amounts were observed in parts of Spain, Tunisia, Algeria and Morocco due to some days with heavy precipitation and many regions in the north and east of the EFAS domain.

The monthly mean temperature ranged from -5.4°C to 36.8°C with the highest temperatures in the southern parts and lowest temperatures in the northern and

mountainous parts of the EFAS domain (Figure 17). Temperature anomalies ranged from -4.3°C to 9.9°C with abnormally low temperatures in the eastern parts of the EFAS domain, Scandinavia, Portugal, Morocco and Algeria (Figure 18). Temperatures rose above normal in nearly all other regions.

Hydrological situation

by EFAS Hydrological Data Collection Centre

August 2019

For the month of August, the highest concentration of stations that exceeded their lowest threshold level was in Po river basin, Italy, and in Czech Republic, Rhine river basin. A more dispersed distribution of stations with exceedances occurred in Danube river basin (Serbia, Hungary and Slovakia) and in Norway.

Stations that registered discharge values above the 90% were very few. They are in disperse way in the following countries: Germany, Austria, Norway, United Kingdom and Ireland. In Spain there are some stations with values above 90% due to floods of low duration.

Stations under the 10% quantile were concentrated in central Europe (Germany and Poland), especially in the basins of the Elbe and Oder rivers. Also a few stations are in the Rhine and Vistula river basins (Germany and Poland respectively) and in Belgium and Austria were below the threshold. Further, a few stations with low values were found in Norway, Sweden, Romania, Serbia, United Kingdom, Ireland and northern Spain.

September 2019

For September, the highest concentration of stations that exceeded their lowest threshold level was in Norway, and the Po river basin in Northern Italy. In the rest of Europe, exceedances occurred in isolated stations in the Danube river basin, the Oder river basin in northern Poland, the Hiyon river basin in Israel and Minho-Sil river basin in north-western Spain. Special mention should be made of several stations in the Mediterranean river basins in south-eastern Spain (Almanzora, Andarax and Guadalhorce), where mayor exceedances occurred due to the so-called "cold drop" meteorological phenomenon which caused severe flash floods and floods in the area.

Stations that registered discharge values above the 90% quantile are mostly located in England and south-eastern Norway. In the rest of Europe, just only isolated stations fulfil this condition: Guadalquivir river basin in southern Spain, Rhine river basin in Germany, Danube river basin in Austria, Ythan river in Scotland and Moy river in Ireland.

Stations registering values below the 10% quantile were mainly in Germany (the Elbe and Rhine river basins), Poland (Oder and Vistula river basins) and Eastern Danube river basin A lower concentration of stations is found in Dnieper and Dniester river basins in Ukraine, Ebro river basin in Spain, Scheldt and Meuse river basins in Belgium, Rhine river basin in Switzerland and basins in south-eastern Sweden. Finally, Maritsa river basin in Bulgaria, Thames river basin in England and Glomma river basin in Norway just have one station with this condition.

Verification

Figure 4 and Figure 5 shows the EFAS headline score, the Continuous Ranked Probability Skill Score (CRPSS) for lead times 1 and 5 days for the August to September period across the EFAS domain for catchments larger than 2000km^2. A CRPSS of 1 indicates perfect skill, 0 indicates that the performance is equal to that of the reference, and any value <0 (shown in orange-red on the maps) indicates the skill is worse than the reference. The reference score is using yesterday's forecast as today's forecast.

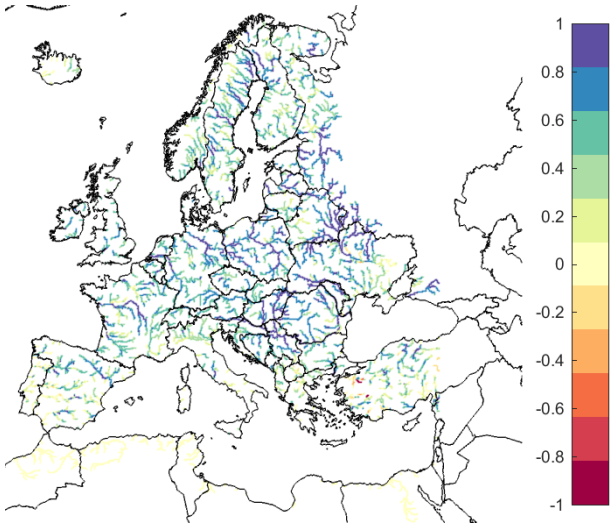

Figure 4. EFAS CRPSS at lead-time 1 day for the August-September 2019 period, for catchments >2000km2. The reference score is persistence of using previous day's forecast.

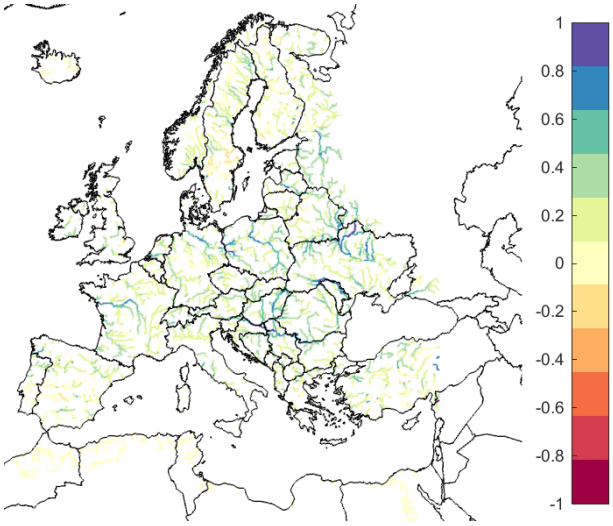

Figure 5. EFAS CRPSS at lead-time 5 days for the August-September 2019 period, for catchments >2000km2. The reference score is persistence of using previous day's forecast.

These maps indicate that across much of Europe for forecasts are more skilful than persistence at both lead times. Regions shown in blue are those where EFAS forecasts are more skilful than persistence, with darker shading indicating better performance.

The skill of the forecast was quite good, although lower than the same period last year (Figure 6). The scores for this year are more as expected, whereas the unusual dry summer last year affected the results and gave very positive scores. An interannual variability of the scores is to be expected.

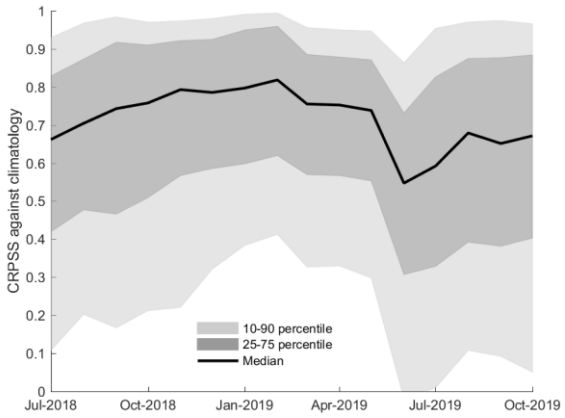

Figure 6. Monthly means of CRPSS the for lead-time 5 days for all the major river points in Europe with ECMWF ENS as forcing. Reference forecast was climatology. The skill is largest during the winter months, when there is less variation in the flow in large parts of Europe.

ARTICLES

Workshop on Flood Early Warning in the Rhine basin

by Eric Sprokkereef, EFAS Dissemination Centre

As a joint contribution to the realization of the Flood Risk Management Plan for the International Rhine basin (measure 4.3 (2)), the Flood Forecasting Centres along the Rhine organized on 25 and 26 June 2019 a workshop on Flood Early Warning at the office of the secretariat of the International Commission for the Protection of the Rhine (ICPR) in Koblenz. The workshop was attended by about 20 participants from 13 different forecasting centres in 6 countries of the Rhine basin. The aim of the workshop was to learn from each other through the exchange of information and experience about the national state of affairs and plans for the future on (hydrological) early warning and early warning systems, flash floods and extreme precipitation events.

The representatives of the forecasting centres presented their daily work, ongoing projects and expected developments, but also limitations in early warnings. In addition, some examples of European projects and projects from other river basins were also presented. The purpose was to find common interests and synergies in the daily work and plans for the future of the different forecasting centers and to avoid overlaps.

Forecast requirements in Switzerland and Austria

The representative from Switzerland presented the efforts in the field of nowcasting for Alpine rivers where a lead time of 6 hours is considered as maximum. A 2 hours lead time would already be off great benefit. At present, the Swiss authorities do not provide a nowcasting product. A prototype of a nowcasting system for 2 or 3 regions is under development.

The situation in the Austrian part of the Rhine basin is similar to the ones in Switzerland; the river basins are small and steep and react extremely fast on precipitation. Therefore, early warning depends highly on precipitation forecasts. However, the forecasting model for the Rhine catchment rivers in Austria is not very good in forecasting flash floods and experiences from other areas are needed.

Figure 7. Participants in the workshop

Pilot studies and new systems in Germany

In Bavaria, a pilot study for early warning in small catchments is currently conducted. The model that is used is the grid based LARSIM model with a 0.7 km resolution. The model is driven by a combination of radar observations, radar tracking and an EPS weather forecast.

In the federal state Rhineland Palatinate, efforts are made to improve early warnings for smaller river by using radar precipitation data. At present new model approaches are tested to simulate infiltration processes during extreme precipitation events on dry soil. In the federal state of Saxony in Germany extreme precipitation events have caused much damage in the past years. Up to 150 mm of precipitation in a period of 12 hours have been observed during these events. A new forecasting system for catchments smaller than 200 km^2 has been developed which provides forecasts with a lead time of 24 hours. It has been concluded that in some extreme cases numerical weather forecasts cannot predict the exact location, time and intensity of an extreme precipitation event. Further, precipitation is in some cases detected by the radar only 15 or 30 minutes before the flood event. Early warning may extend the warning time but also the uncertainty.

Forecasting systems in France

The representative from the French DREAL Grand Est presented the Vigicrues Flash system, a new operational flash flood warning system that was implemented in France in March 2017. The warning system combines radar-gauge rainfall grids with a simplified distributed rainfall-runoff model for flash flood warnings at ungauged locations.

EFAS forecasts

A presentation on early warning on a pan-European scale was given by Eric Sprokkereef from the EFAS Dissemination Centre. An overview of EFAS and GLOFAS focusing on the existing functionality, recent developments and expected innovations was presented. In connection to the subject of the workshop, special attention was given to the flash flood part of EFAS. Participants concluded that flash floods on a European scale are something completely different from flash floods on a regional scale. In the EFAS system we give information for "flash floods" with a lead time up to 3 days ahead, whereas the regional services are very happy when the can provide a forecast for an event with a lead time of 6 to 12 hours. Participants discussed the meaning of the word "Early" in Early Warning and it was concluded that the earliness depends highly on the size and characteristics of the catchment warnings are provided for.

EFAS training for Italy

by Bettina Matti, EFAS Dissemination Centre

This workshop was arranged by the request of the administrative contact for the new EFAS partner the Italian Civil Protection Agency.

The objective of the mission was to:

- Give them an introduction to EFAS and train them in how to use the EFAS-IS
- Show them how to provide feedback for received notifications
- Instruct them how to provide hydrological and meteorological station data

The training took place in Rome, Italy at the Civil Protection Agency on 19 -20 September 2019. It was held by Eva Kopáčiková and Bettina Matti from the EFAS Dissemination Centre, Mercedes García Padilla and Rafael J. García Sánchez from the Hydrological Data Collection Centre, Armin Rauthe-Schöch from the Meteorological Data Collection Centre and Cinzia Mazzetti from the Computational Centre. Participants were officers from national and regional civil protection agencies, people working with hydrological data and hydrological models and researchers from CIMA (Centro Internazionale di Ricerca in Monitoraggio Ambientale). Some of them had previous experience using EFAS, for some people it was their first meeting with the system.

The training started with an overview of activities and workflow at the Italian Civil protection for the EFAS representatives. After that, a joint introduction of the EFAS (EFAS general information, information about LISFLOOD model, probabilistic forecasting, meteorological inputs, EFAS thresholds, EFAS notifications, and flash floods) was held before a discussion section took place taking up the topics of EFAS performance compared to the performance of national systems and the process of becoming an EFAS partner.

Figure 8. Participants from the EFAS centres participating in the EFAS workshop at the Italian Civil protection in Rome.

Then, the EFAS Hydrological Data Collection Centre and the EFAS Meteorological Data Collection Centre presented their operations and workflows talking about data transfer, data harmonization, data quality control and validation, collaborations in EFAS products such as reports and bulletins, incident management and partner communications. Further presentations led by the EFAS DISS were about the feedback process for EFAS notifications, new EFAS products (rapid impact assessment and rapid flood mapping, seasonal outlooks and 6-hourly calibration) and an Italian case study.
Discussion sections took place also on the second day where specific questions and concerns were discussed as well as a hands-on session on how to use the EFAS-IS was conducted. Participants were encouraged to follow along using their own computers. The participants were satisfied with the workshop and expressed their gratitude for the training.

Floods in southeastern Spain, September 2019

by Richard Davies (FloodList) and Fredrik Wetterhall, EFAS Computational Centre

Torrential rainfall from 11 to 14 September 2019 caused major flooding in south-eastern Spain. Among the worst hit areas were Valencia, Alicante, Murcia, Albacete and Almería provinces.

Roads and schools were closed along with Murcia and Almería airports. More than 1,100 military personnel along with personnel from police, fire service, Civil Protection and Red Cross were deployed to assist flood-hit communities. Prime Minister Pedro Sánchez visited affected areas on 14 September. A total of around 3,500 people were evacuated, including 2,000 residents of the town of Santomera in Murcia as a precaution due to a controlled release from a local dam. Seven people died in the floods and two fatalities were reported in Caudete in Albacete Province, two in Orihuela in Alicante Province, one in Almería and another in La Jámula in Granada. The body of a man who went missing in Dolores, Alicante Province, was found on 18 September.

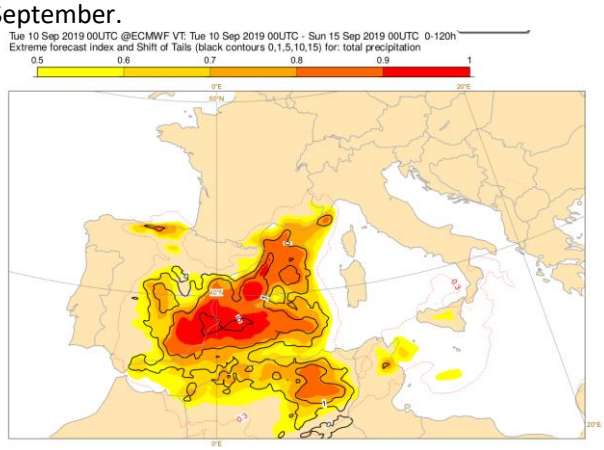

Figure 9. ECMWF Extreme Forecast Index (EFI) for the period 10-15 September 2019, issued on the 10 September.

Extreme precipitation recorded

According to AEMET Valencia, Ontinyent in Valencia Province recorded 296.4 mm of rain in 24 hours to 12 September. This equates to about half the yearly average and is the second highest daily rainfall total on record for Ontinyent, behind the 316.0mm which fell on 04 November 1987. Beniarrés in Alicante Province recorded 359mm of rain during the same period.
AEMET Spain said the intense rainfall was caused by a "Depresión Aislada en Niveles Altos", sometimes referred to as DANA or gota fría. By 12 September several

rivers had broken their banks. Around 40 people had to be rescued and 150 evacuated from their homes after the Clariano river in Ontinyent. Spain's Ministry for the Environment said record rainfall was reported in 6 locations and the rain in Vega Baja del Segura was the worst in over 100 years.

The overflowing Segura river caused major flooding in the town of Orihuela, Alicante Province, where 130 people were rescued, and 70 people evacuated. Flood waters left Orihuela isolated for several days. Flooding from the Cànyoles river in Moixent, Valencia Province, caused major material damages.

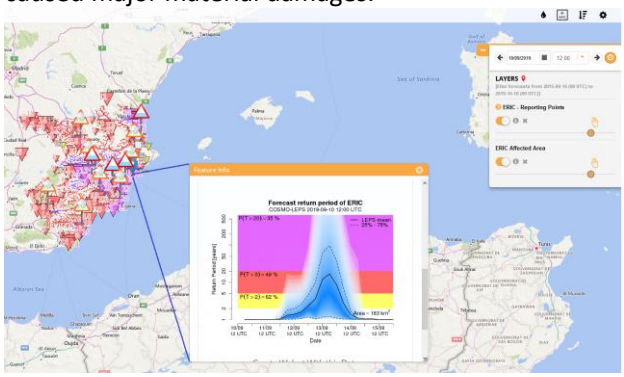

Figure 10. Screenshot from EFAS website 10 September 2019.

CEMS responses

The event was well forecasted by EFAS, and a total of 10 flash flood notifications and 2 formal flood notifications were sent out before the event. The ERIC flash-flood forecasts are based on COSMO-LEPS, and for this event it underestimated the total rainfall. However, the signal was strong enough to send out notifications. The ECMWF ensemble forecasts showed areas with 100% probability of over 150 mm rain over the next 10 days which covered the area, which was a stronger signal of an extreme event than for COSMO-LEPS for this event.

On 12 September the Copernicus EMS Rapid Mapping module was activated by the Centro de Coordinación Operativa (CECOP) de la Dirección General de Protección Civil y Emergencias (Operational Coordination Centre of the Spanish Civil Protection).

Acknowledgements

The following partner institutes and contributors are gratefully acknowledged for their contribution:

- DG GROW - Copernicus and DG ECHO for funding the EFAS Project
- All data providers including meteorological data providers, hydrological services & weather forecasting centres
- The EFAS Operational Centres
- Richard Davies, Floodlist.com

Cover image: Massive floods wiped out bridges and roads in Valencia Province 12 to 13 September 2019. Credit: Diputacio de Valencia (Provincial Council of Valencia).

Appendix - figures

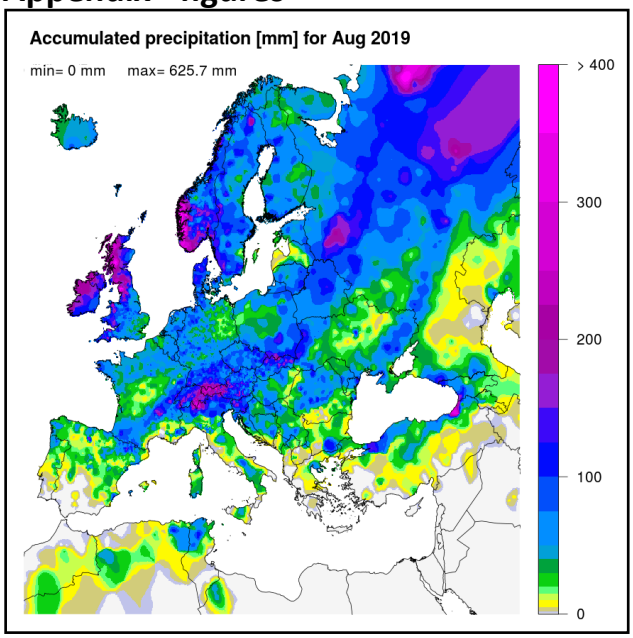

Figure 11. Accumulated precipitation [mm] for August 2019.

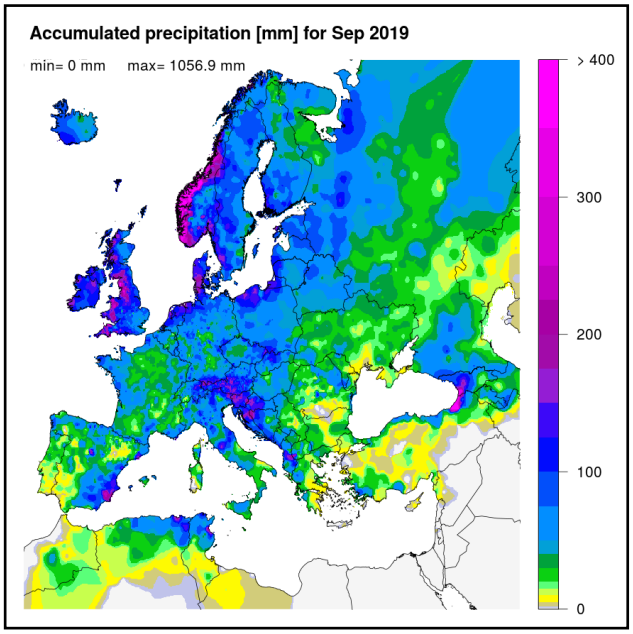

Figure 13. Accumulated precipitation [mm] for September 2019.

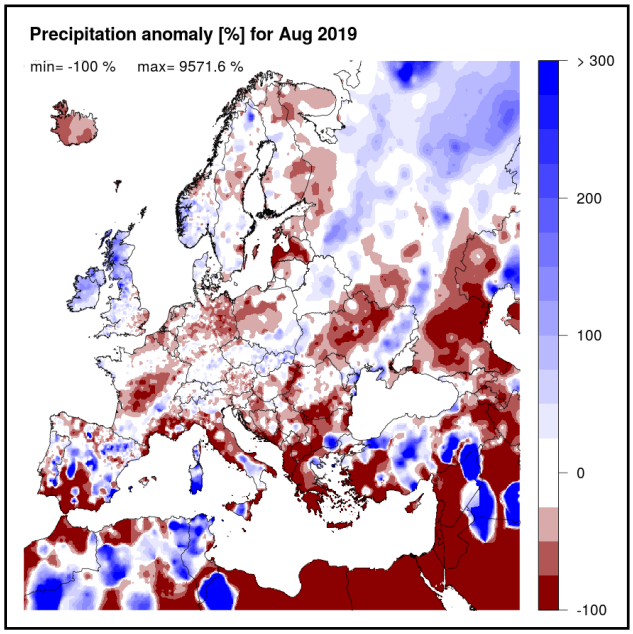

Figure 12. Precipitation anomaly [%] for August 2019, relative to a long-term average (1990-2013). Blue (red) denotes wetter (drier) conditions than normal.

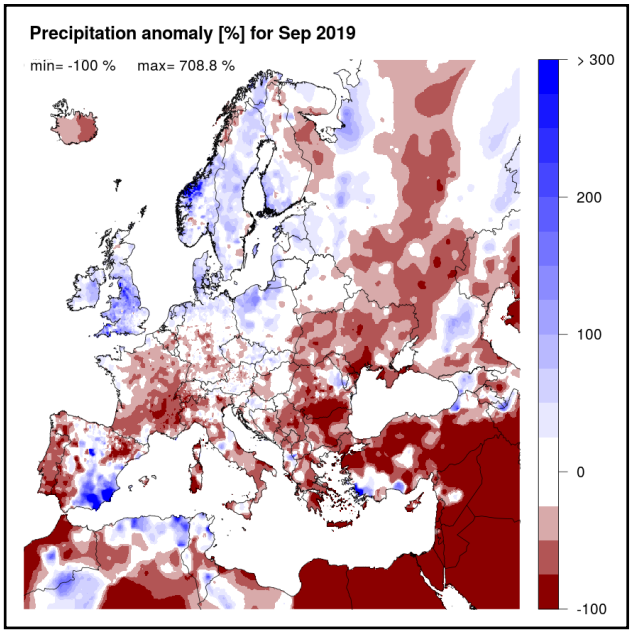

Figure 14. Precipitation anomaly [%] for September 2019, relative to a long-term average (1990-2013). Blue (red) denotes wetter (drier) conditions than normal.

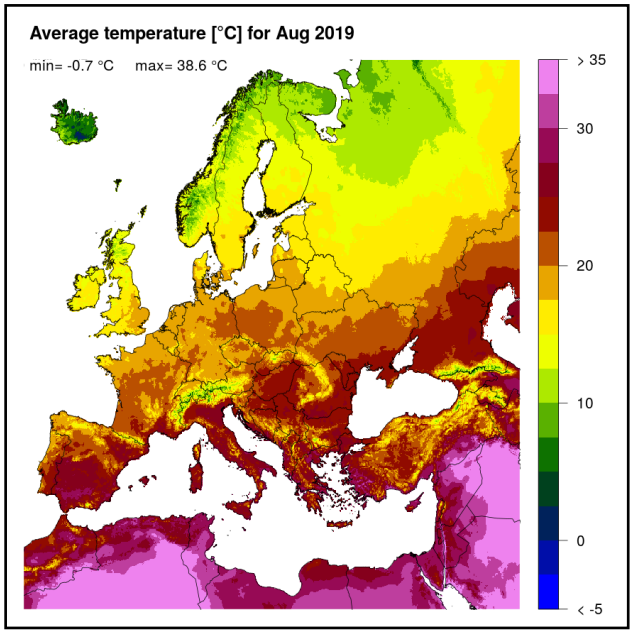

Figure 15. Mean temperature [°C] for August 2019.

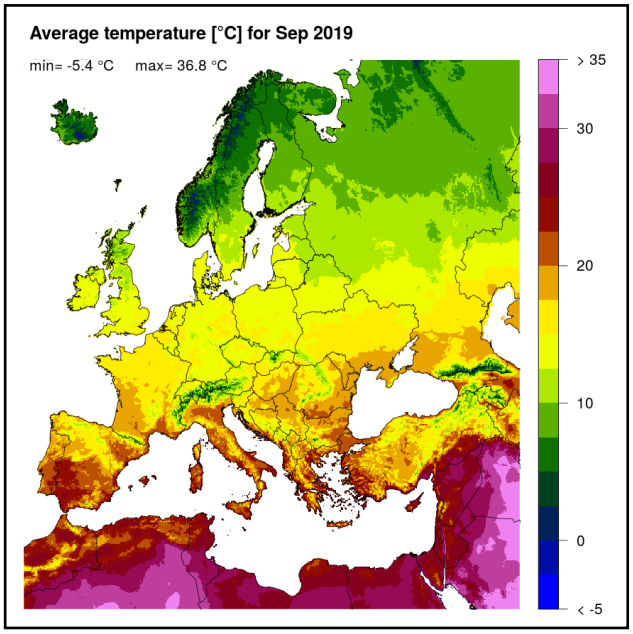

Figure 17. Mean temperature [°C] for September 2019.

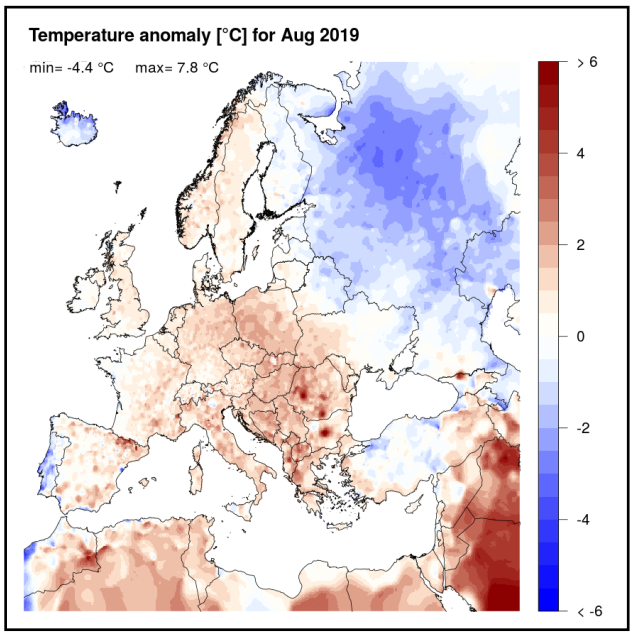

Figure 16. Temperature anomaly [°C] for August 2019, relative to a long-term average (1990-2013). Blue (red) denotes colder (warmer) temperatures than normal.

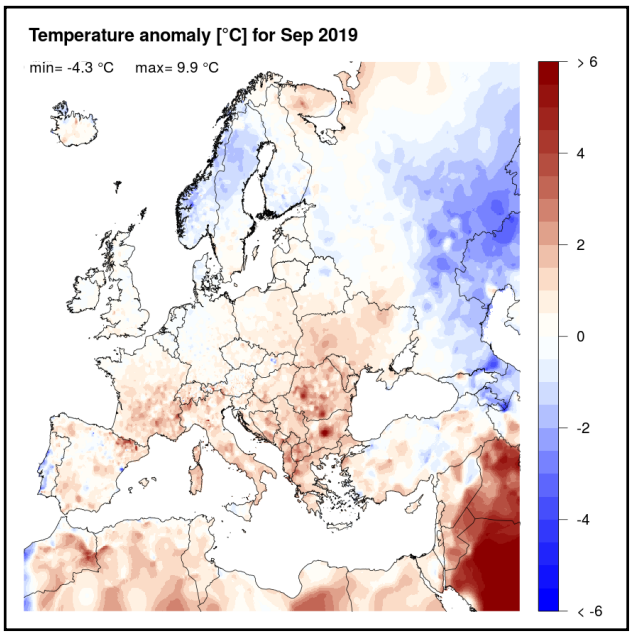

Figure 18. Temperature anomaly [°C] for September 2019, relative to a long-term average (1990-2013). Blue (red) denotes colder (warmer) temperatures than normal.

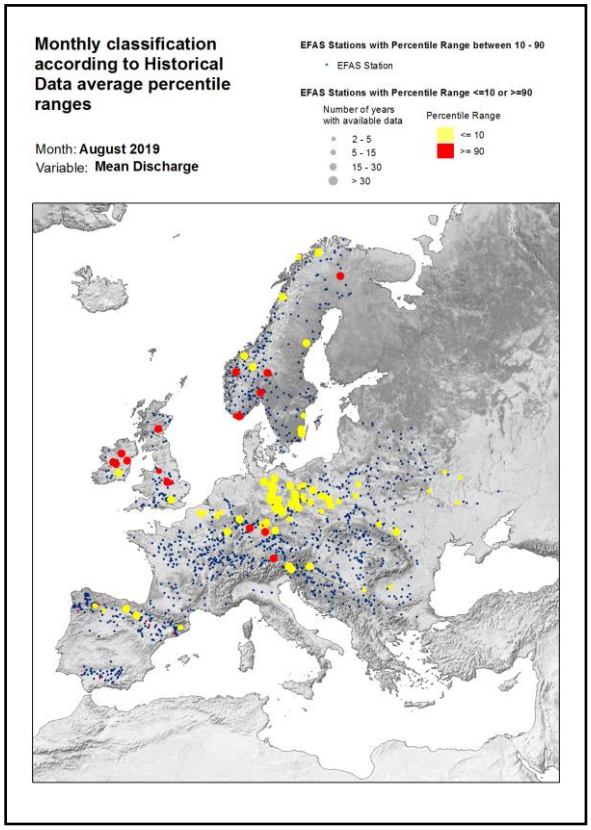

Figure 19. Monthly discharge anomalies August 2019.

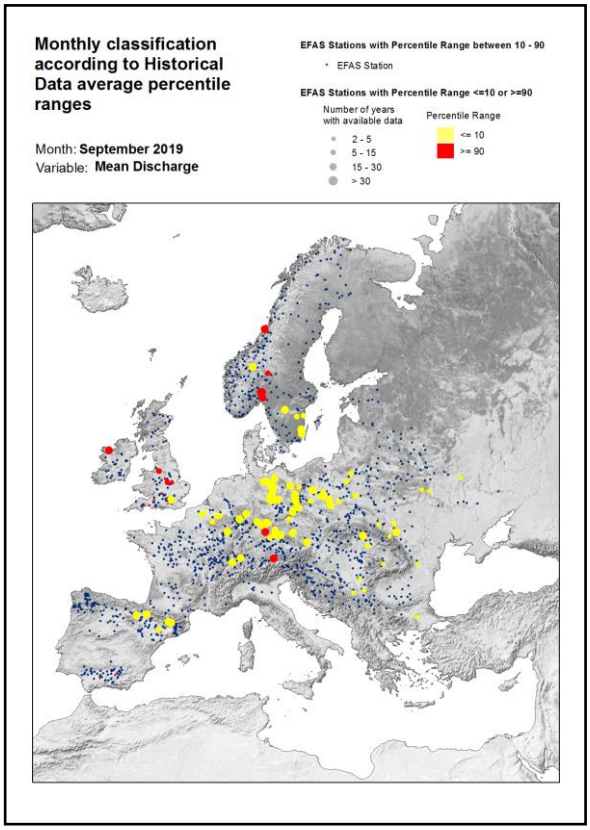

Figure 21. Monthly discharge anomalies September 2019.

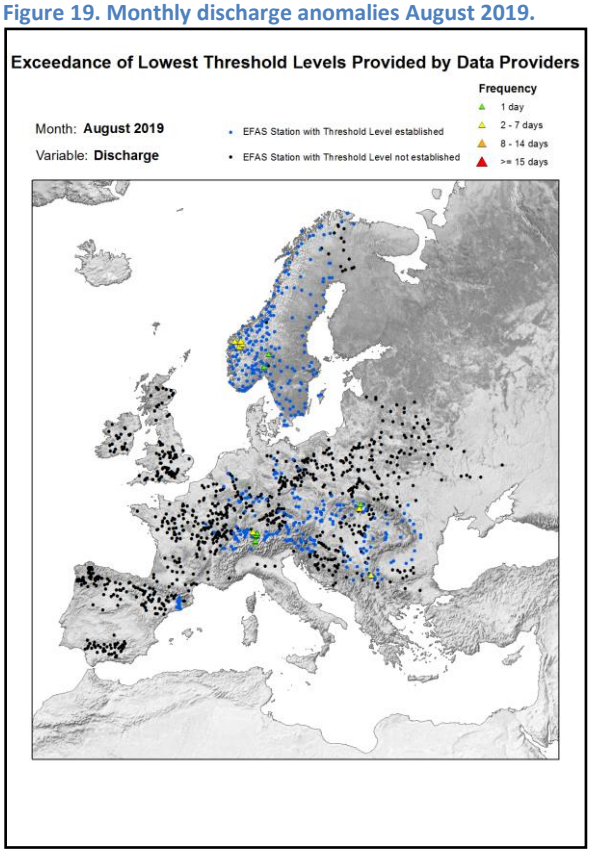

Figure 20. Lowest alert level exceedance for August 2019.

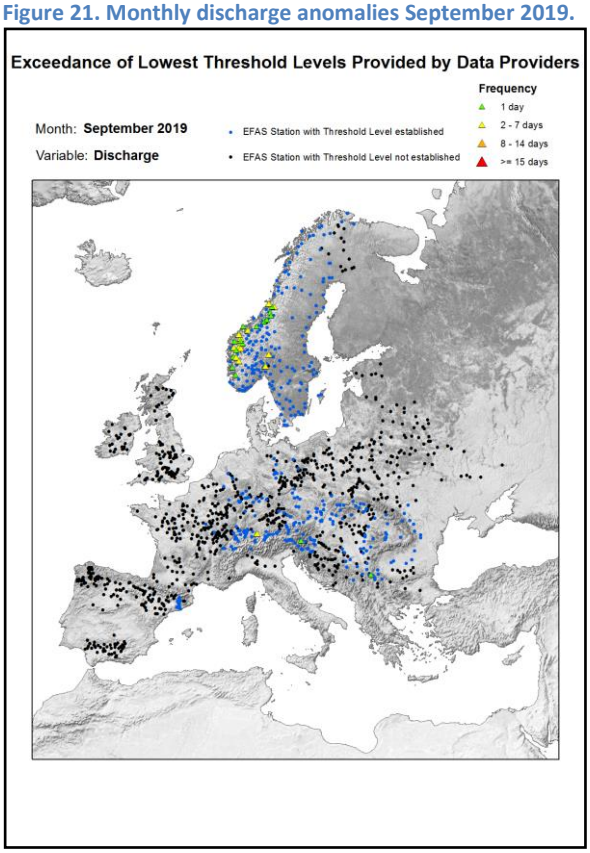

Figure 22. Lowest alert level exceedance for September 2019.

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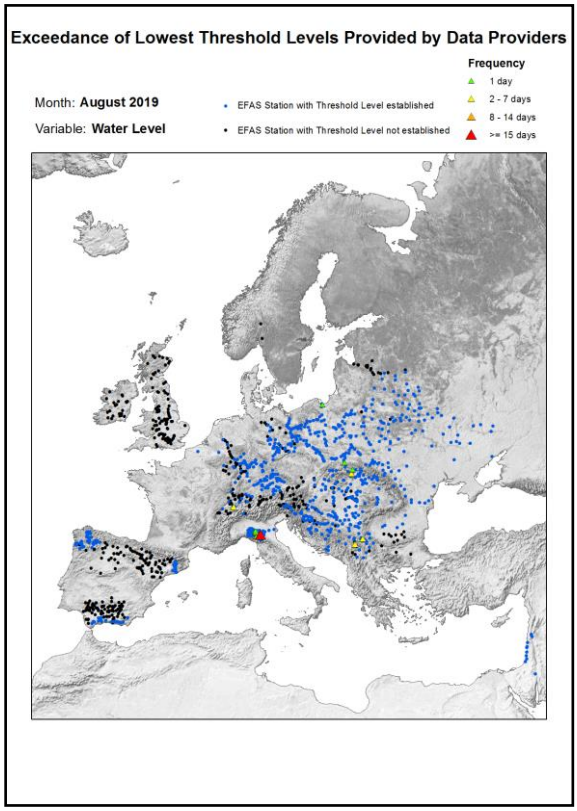

Figure 23. Lowest threshold exceedance for August 2019.

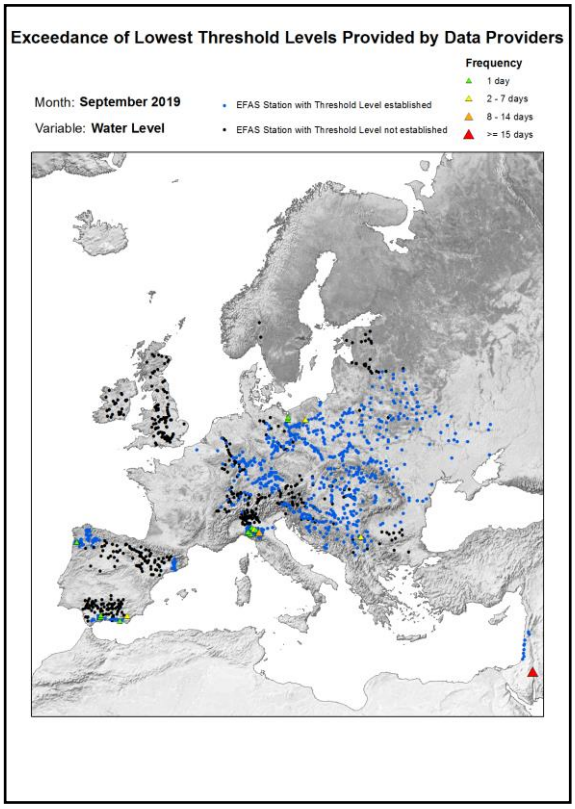

Figure 24. Lowest threshold exceedance for September 2019.

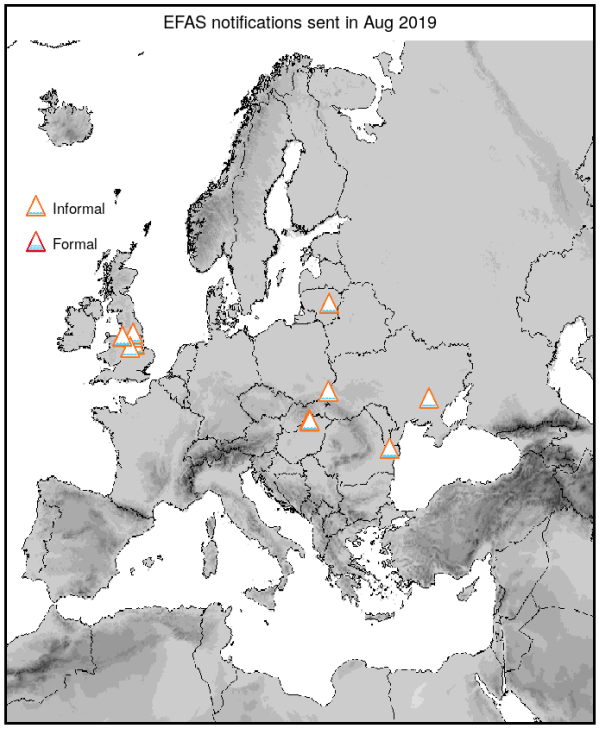

Figure 25. EFAS flood notifications sent for August 2019.

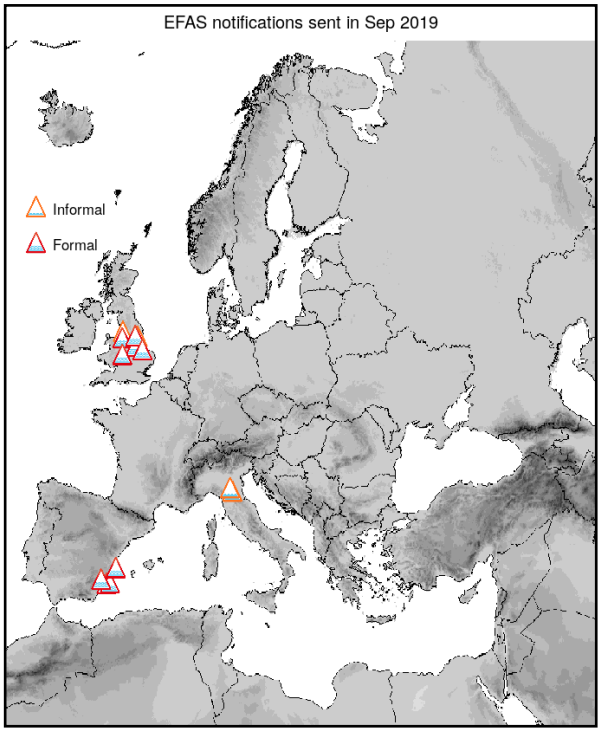

Figure 27. EFAS flood notifications sent for September 2019.

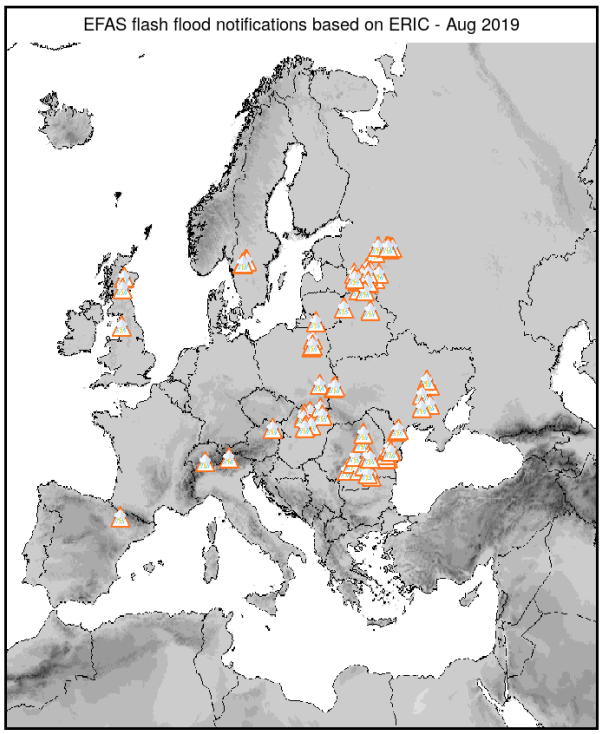

Figure 26. Flash flood notifications sent for August 2019.

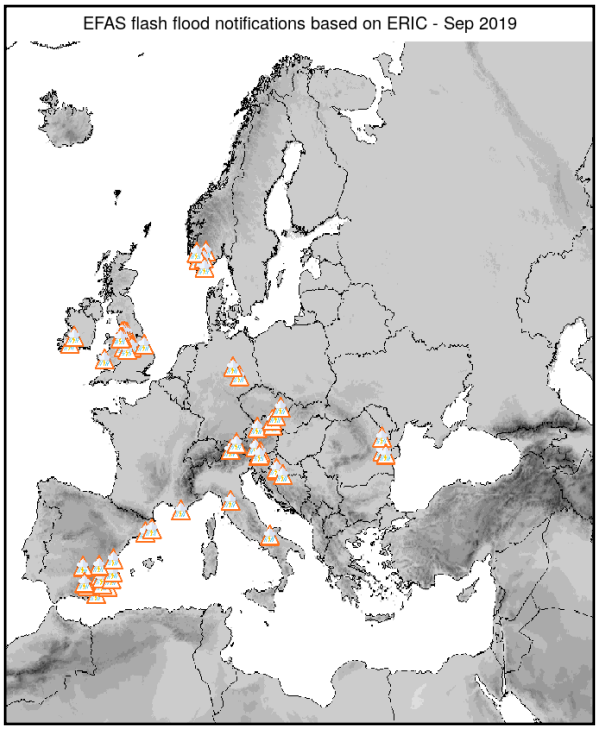

Figure 28. Flash flood notifications sent for September 2019.

Appendix - tables

Table 1. EFAS flood notifications sent in August - September 2019

Type	Forecast date	Issue date	Lead time	River	Country
Informal	02/08/2019 12UTC	03/08/2019	1	Dnepr	Ukraine
Informal	03/08/2019 00UTC	03/08/2019	1	Donau	Ukraine
Informal	07/08/2019 12UTC	08/08/2019	0	Swale, Ouse	United Kingdom
Informal	07/08/2019 12UTC	08/08/2019	0	Don	United Kingdom
Informal	07/08/2019 12UTC	08/08/2019	0	Trent	United Kingdom
Informal	09/08/2019 00UTC	09/08/2019	0	Mersey	United Kingdom
Informal	09/08/2019 00UTC	09/08/2019	0	Trent	United Kingdom
Informal	13/08/2019 00UTC	13/08/2019	1	Slana	Slovakia
Informal	13/08/2019 12UTC	14/08/2019	0	Sajo	Hungary
Informal	14/08/2019 12UTC	15/08/2019	0	San	Poland
Informal	15/08/2019 00UTC	15/08/2019	2	Mersey	United Kingdom
Informal	22/08/2019 00UTC	22/08/2019	0	Sventoji	Lithuania
Formal	10/09/2019 00UTC	10/09/2019	2	Segura	Spain
Formal	10/09/2019 00UTC	10/09/2019	3	Segura	Spain
Formal	10/09/2019 00UTC	10/09/2019	2	Jucar	Spain
Formal	10/09/2019 00UTC	10/09/2019	2	Segura	Spain
Informal	20/09/2019 12UTC	21/09/2019	2	Reno	Italy
Informal	21/09/2019 12UTC	22/09/2019	1	Po	Italy
Informal	24/09/2019 00UTC	24/09/2019	2	Ouse	United Kingdom
Informal	24/09/2019 00UTC	24/09/2019	1	Trent	United Kingdom
Formal	26/09/2019 00UTC	26/09/2019	3	Mersey	United Kingdom
Informal	26/09/2019 12UTC	27/09/2019	3	Trent	United Kingdom
Formal	27/09/2019 12UTC	28/09/2019	2	Trent	United Kingdom
Informal	27/09/2019 12UTC	28/09/2019	1	Ribble	United Kingdom
Informal	28/09/2019 00UTC	28/09/2019	3	Swale, Ouse	United Kingdom
Formal	28/09/2019 12UTC	29/09/2019	2	Severn	United Kingdom
Formal	28/09/2019 12UTC	29/09/2019	2	Welland	United Kingdom
Formal	28/09/2019 12UTC	29/09/2019	2	Swale, Ouse	United Kingdom

* Lead time [days] to the first forecasted exceedance of the 5-year simulated discharge threshold.

Table 2. EFAS Flash flood notifications sent in August - September 2019

Type	Forecast date	Issue date	Lead time	Region	Country
Flash Flood	31/07/2019 12UTC	01/08/2019	54	Bolzano-Bozen	Italy
Flash Flood	01/08/2019 00UTC	01/08/2019	72	Brasov	Romania
Flash Flood	01/08/2019 00UTC	01/08/2019	60	Valcea	Romania
Flash Flood	01/08/2019 00UTC	01/08/2019	60	Arges	Romania
Flash Flood	01/08/2019 00UTC	01/08/2019	60	Gorj	Romania
Flash Flood	01/08/2019 00UTC	01/08/2019	72	Ilfov	Romania
Flash Flood	01/08/2019 00UTC	01/08/2019	60	Prahova	Romania
Flash Flood	01/08/2019 12UTC	02/08/2019	48	Dambovita	Romania
Flash Flood	01/08/2019 12UTC	02/08/2019	54	Harghita	Romania
Flash Flood	02/08/2019 00UTC	02/08/2019	36	Giurgiu	Romania
Flash Flood	02/08/2019 00UTC	02/08/2019	66	Poltava	Ukraine
Flash Flood	02/08/2019 00UTC	02/08/2019	66	Kherson	Ukraine

Flash Flood	02/08/2019 00UTC	02/08/2019	66	Dnipropetrovs'k	Ukraine
Flash Flood	02/08/2019 00UTC	02/08/2019	66	Kirovohrad	Ukraine
Flash Flood	02/08/2019 00UTC	02/08/2019	42	Tulcea	Romania
Flash Flood	02/08/2019 12UTC	03/08/2019	30	Taraclia	R. Mold, Ukraine
Flash Flood	02/08/2019 12UTC	03/08/2019	24	Buzau	Romania
Flash Flood	02/08/2019 12UTC	03/08/2019	30	Gagauzia	Rep. Of Moldova
Flash Flood	02/08/2019 12UTC	03/08/2019	30	Neamt	Romania
Flash Flood	02/08/2019 12UTC	03/08/2019	30	Covasna	Romania
Flash Flood	02/08/2019 12UTC	03/08/2019	30	Braila	Romania
Flash Flood	02/08/2019 12UTC	03/08/2019	30	Galati	Romania
Flash Flood	02/08/2019 12UTC	03/08/2019	30	Odessa	Ukraine
Flash Flood	02/08/2019 12UTC	03/08/2019	42	Mykolayiv	Ukraine
Flash Flood	03/08/2019 00UTC	03/08/2019	24	Stefan Voda	Rep. Of Moldova
Flash Flood	03/08/2019 00UTC	03/08/2019	24	Transnistria	Rep. Of Moldova
Flash Flood	06/08/2019 00UTC	06/08/2019	36	Inverness & Nairn and	United Kingdom
Flash Flood	07/08/2019 00UTC	07/08/2019	66	Tver'	Russian Fed.
Flash Flood	07/08/2019 00UTC	07/08/2019	66	Novgorod	Russian Fed.
Flash Flood	07/08/2019 00UTC	07/08/2019	48	Tver'	Russian Fed.
Flash Flood	07/08/2019 00UTC	07/08/2019	54	Pskov	Russian Fed.
Flash Flood	07/08/2019 00UTC	07/08/2019	54	Pskov	Russian Fed.
Flash Flood	07/08/2019 00UTC	07/08/2019	54	Pskov	Russian Fed.
Flash Flood	07/08/2019 00UTC	08/08/2019	66	Novgorod	Russian Fed.
Flash Flood	07/08/2019 00UTC	08/08/2019	60	Pskov	Russian Fed.
Flash Flood	07/08/2019 00UTC	08/08/2019	54	Pskov	Russian Fed.
Flash Flood	07/08/2019 00UTC	08/08/2019	48	Pskov	Russian Fed.
Flash Flood	07/08/2019 00UTC	08/08/2019	60	Pskov	Russian Fed.
Flash Flood	07/08/2019 00UTC	07/08/2019	24	Wiener Umland/Nordteil	Austria
Flash Flood	07/08/2019 00UTC	07/08/2019	66	Tver'	Russian Fed.
Flash Flood	07/08/2019 00UTC	08/08/2019	60	Pskov	Russian Fed.
Flash Flood	07/08/2019 00UTC	08/08/2019	60	Pskov	Russian Fed.
Flash Flood	07/08/2019 00UTC	08/08/2019	60	Pskov	Russian Fed.
Flash Flood	07/08/2019 12UTC	08/08/2019	48	Vitsyebsk	Belarus
Flash Flood	07/08/2019 12UTC	08/08/2019	42	Vitsyebsk	Belarus
Flash Flood	07/08/2019 12UTC	08/08/2019	54	Tver'	Russian Fed.
Flash Flood	07/08/2019 12UTC	08/08/2019	54	Tver'	Russian Fed.
Flash Flood	07/08/2019 12UTC	08/08/2019	48	Pskov	Russian Fed.
Flash Flood	07/08/2019 12UTC	08/08/2019	36	Pskov	Russian Fed.
Flash Flood	08/08/2019 00UTC	08/08/2019	36	Perth & Kinross and Stirling	United Kingdom
Flash Flood	08/08/2019 00UTC	08/08/2019	24	Pskov	Russian Fed.
Flash Flood	08/08/2019 00UTC	08/08/2019	24	Pskov	Russian Fed.
Flash Flood	08/08/2019 00UTC	08/08/2019	24	Pskov	Russian Fed.
Flash Flood	08/08/2019 00UTC	08/08/2019	24	Pskov	Russian Fed.
Flash Flood	08/08/2019 00UTC	08/08/2019	36	Pskov	Russian Fed.
Flash Flood	08/08/2019 00UTC	08/08/2019	24	Pskov	Russian Fed.
Flash Flood	08/08/2019 00UTC	08/08/2019	36	Pskov	Russian Fed.
Flash Flood	08/08/2019 00UTC	08/08/2019	36	Tver'	Russian Fed.
Flash Flood	08/08/2019 00UTC	08/08/2019	36	Pskov	Russian Fed.
Flash Flood	08/08/2019 00UTC	08/08/2019	42	Tver'	Russian Fed.
Flash Flood	08/08/2019 00UTC	08/08/2019	36	Pskov	Russian Fed.
Flash Flood	09/08/2019 12UTC	10/08/2019	48	Vastra Gotalands lan	Sweden
Flash Flood	09/08/2019 12UTC	10/08/2019	60	Vastra Gotalands lan	Sweden

Flash Flood	09/08/2019 12UTC	10/08/2019	60	Vastra Gotalands lan	Sweden
Flash Flood	09/08/2019 12UTC	10/08/2019	54	Varmlands lan	Sweden
Flash Flood	09/08/2019 12UTC	10/08/2019	48	Vastra Gotalands lan	Sweden
Flash Flood	09/08/2019 12UTC	10/08/2019	54	Varmlands lan	Sweden
Flash Flood	09/08/2019 12UTC	10/08/2019	48	Vastra Gotalands lan	Sweden
Flash Flood	11/08/2019 00UTC	11/08/2019	42	Valais	Switzerland
Flash Flood	11/08/2019 12UTC	12/08/2019	48	Vitsyebsk	Belarus
Flash Flood	11/08/2019 12UTC	12/08/2019	48	Pskov	Russian Fed.
Flash Flood	12/08/2019 00UTC	12/08/2019	36	Hrodna	Belarus
Flash Flood	12/08/2019 12UTC	13/08/2019	48	Tarnobrzeski	Poland
Flash Flood	13/08/2019 00UTC	13/08/2019	42	Przemyski	Poland
Flash Flood	13/08/2019 00UTC	13/08/2019	30	Zilinsky kraj	Slovakia
Flash Flood	13/08/2019 00UTC	13/08/2019	30	Banskobystricky kraj	Slovakia
Flash Flood	13/08/2019 00UTC	13/08/2019	30	Presovsky kraj	Slovakia
Flash Flood	13/08/2019 12UTC	14/08/2019	30	Lublin	Poland, Ukraine
Flash Flood	13/08/2019 12UTC	14/08/2019	24	Nograd	Hungary
Flash Flood	13/08/2019 12UTC	14/08/2019	24	Borsod-Abauj-Zemplen	Hungary
Flash Flood	13/08/2019 12UTC	14/08/2019	24	Presovsky kraj	Slovakia
Flash Flood	13/08/2019 12UTC	14/08/2019	24	Kosicky kraj	Slovakia
Flash Flood	13/08/2019 12UTC	14/08/2019	30	Banskobystricky kraj	Slovakia
Flash Flood	15/08/2019 00UTC	15/08/2019	42	East Cumbria	United Kingdom
Flash Flood	19/08/2019 12UTC	20/08/2019	42	Ostrolecki	Poland
Flash Flood	19/08/2019 12UTC	20/08/2019	24	Huesca	Spain
Flash Flood	19/08/2019 12UTC	20/08/2019	42	Lomzynski	Poland
Flash Flood	19/08/2019 12UTC	20/08/2019	42	Elcki	Poland
Flash Flood	20/08/2019 00UTC	20/08/2019	42	Kaliningrad	Russian Fed.
Flash Flood	20/08/2019 12UTC	21/08/2019	30	Pskov	Russian Fed.
Flash Flood	31/08/2019 12UTC	01/09/2019	48	Innsbruck	Austria
Flash Flood	01/09/2019 00UTC	01/09/2019	72	Foggia	Italy
Flash Flood	01/09/2019 00UTC	01/09/2019	24	Tiroler Unterland	Austria
Flash Flood	01/09/2019 00UTC	01/09/2019	30	Linz-Wels	Austria
Flash Flood	01/09/2019 12UTC	02/09/2019	24	Olomoucky kraj	Czech Rep.
Flash Flood	01/09/2019 12UTC	02/09/2019	24	Wiener Umland/Nordteil	Austria
Flash Flood	01/09/2019 12UTC	02/09/2019	36	Klagenfurt-Villach	Austria
Flash Flood	01/09/2019 12UTC	02/09/2019	24	Jihomoravsky kraj	Czech Rep.
Flash Flood	01/09/2019 12UTC	02/09/2019	24	Weinviertel	Austria
Flash Flood	07/09/2019 00UTC	07/09/2019	48	Westliche Obersteiermark	Austria
Flash Flood	07/09/2019 00UTC	07/09/2019	48	Unterkarnten	Austria
Flash Flood	07/09/2019 12UTC	08/09/2019	60	Nordsachsen	Germany
Flash Flood	07/09/2019 12UTC	08/09/2019	36	Klagenfurt-Villach	Austria
Flash Flood	07/09/2019 12UTC	08/09/2019	60	Magdeburg, Kreisfreie	Germany
Flash Flood	08/09/2019 12UTC	09/09/2019	54	Barcelona	Spain
Flash Flood	09/09/2019 00UTC	09/09/2019	36	Var	France
Flash Flood	09/09/2019 00UTC	09/09/2019	30	Cataluna	Spain
Flash Flood	10/09/2019 12UTC	11/09/2019	72	Region de Murcia	Spain
Flash Flood	10/09/2019 12UTC	11/09/2019	78	Murcia	Spain
Flash Flood	10/09/2019 12UTC	11/09/2019	78	Albacete	Spain
Flash Flood	10/09/2019 12UTC	11/09/2019	72	Granada	Spain
Flash Flood	10/09/2019 12UTC	11/09/2019	78	Comunidad Valenciana	Spain
Flash Flood	10/09/2019 12UTC	11/09/2019	72	Alicante / Alacant	Spain
Flash Flood	10/09/2019 12UTC	11/09/2019	78	Albacete	Spain

Flash Flood	10/09/2019 12UTC	11/09/2019	72	Andalucia	Spain
Flash Flood	10/09/2019 12UTC	11/09/2019	72	Murcia	Spain
Flash Flood	12/09/2019 00UTC	12/09/2019	30	Jaen	Spain
Flash Flood	12/09/2019 00UTC	12/09/2019	36	Ciudad Real	Spain
Flash Flood	12/09/2019 12UTC	13/09/2019	30	Valencia / Valencia	Spain
Flash Flood	12/09/2019 12UTC	13/09/2019	72	Vest-Agder	Norway
Flash Flood	12/09/2019 12UTC	13/09/2019	72	Aust-Agder	Norway
Flash Flood	12/09/2019 12UTC	13/09/2019	72	Rogaland	Norway
Flash Flood	12/09/2019 12UTC	13/09/2019	72	Telemark	Norway
Flash Flood	21/09/2019 00UTC	21/09/2019	54	Firenze	Italy
Flash Flood	22/09/2019 12UTC	23/09/2019	36	Sisacko-Moslavacka Zupan-	Croatia
Flash Flood	23/09/2019 00UTC	23/09/2019	24	Zagrebacka Zupanija	Croatia
Flash Flood	23/09/2019 00UTC	23/09/2019	36	Sisacko-Moslavacka Zupan-	B.&Herz., Croatia
Flash Flood	25/09/2019 00UTC	25/09/2019	54	Vest-Agder	Norway
Flash Flood	25/09/2019 00UTC	25/09/2019	54	Galati	Romania
Flash Flood	25/09/2019 12UTC	26/09/2019	48	Vaslui	Romania
Flash Flood	25/09/2019 12UTC	26/09/2019	48	Tulcea	Romania
Flash Flood	27/09/2019 00UTC	27/09/2019	54	South-West (IE)	Ireland
Flash Flood	28/09/2019 00UTC	28/09/2019	24	South West Wales	United Kingdom
Flash Flood	28/09/2019 00UTC	28/09/2019	30	Staffordshire CC	United Kingdom
Flash Flood	28/09/2019 00UTC	28/09/2019	30	Warrington	United Kingdom
Flash Flood	28/09/2019 00UTC	28/09/2019	30	East Lancashire	United Kingdom
Flash Flood	28/09/2019 00UTC	28/09/2019	24	Mid-West	Ireland
Flash Flood	28/09/2019 00UTC	28/09/2019	30	Mid Lancashire	United Kingdom
Flash Flood	28/09/2019 00UTC	28/09/2019	30	Calderdale and Kirklees	United Kingdom
Flash Flood	28/09/2019 12UTC	29/09/2019	72	South and West Derby-	United Kingdom
Flash Flood	28/09/2019 12UTC	29/09/2019	72	Nottingham	United Kingdom
Flash Flood	29/09/2019 00UTC	29/09/2019	60	East Merseyside	United Kingdom
Flash Flood	29/09/2019 00UTC	29/09/2019	48	Warrington	United Kingdom
Flash Flood	29/09/2019 00UTC	29/09/2019	48	Staffordshire CC	United Kingdom
Flash Flood	29/09/2019 00UTC	29/09/2019	48	Lincolnshire	United Kingdom

* Lead time [hours] to the forecasted peak of the event

The European Flood Awareness System (EFAS) produces European overviews of ongoing and forecasted floods up to 10 days in advance and contributes to better protection of the European citizens, the environment, properties and cultural heritage. It has been developed at the European Commission's in-house science service, the Joint Research Centre (JRC), in close collaboration with national hydrological and meteorological services and policy DG's of the European Commission.

EFAS has been transferred to operations under the European Commission's COPERNICUS Emergency Management Service led by DG GROW in direct support to the EU's Emergency Response Coordination Centre (ERCC) of DG ECHO and the hydrological services in the Member States.

ECMWF has been awarded the contract for the EFAS Computational centre. It is responsible for providing daily operational EFAS forecasts and 24/7 support to the technical system.
A consortium of Swedish Meteorological and Hydrological Institute (SMHI), Rijkswaterstaat (RWS) and Slovak Hydro-Meteorological Institute (SHMU) has been awarded the contract for the EFAS Dissemination centre. They are responsible for analysing EFAS output and disseminating information to the partners and the ERCC.
A Spanish consortium (REDIAM and SOOLOGIC) has been awarded the contract for the EFAS Hydrological data collection centre. They are responsible for collecting discharge and water level data across Europe.
A German consortium (KISTERS and DWD) has been awarded the contract for the EFAS Meteorological data collection centre. They are responsible for collecting the meteorological data needed to run EFAS over Europe.
Finally, the JRC is responsible for the overall project management related to EFAS and further development of the system.

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