

# Storm Gloria 2020

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## Introduction

In the Autumn and Winter of 2017/2018, Météo-France, AEMET (Spanish Meteorological Agency) and IPMA (Portuguese Institute of the Sea and the Atmosphere) began to name significant storms coming from the Atlantic Ocean to mainland Europe. However, during discussions about future storm seasons, it appeared necessary to extend the area of naming to the western Mediterranean Sea as well as mainland Europe. This was used for the first time for Storm Adrian that hit Corsica in October 2018, which affected Italy and Austria and caused severe damage (cf article « Storm Adrian » in WGCEF newsletter N°24, September 2019). In January 2020, Storm Gloria was named by AEMET and affected both Spain and France. Orange and red vigilances/warnings were issued in both countries for several parameters such as winds, snow, coastal damage, avalanches, rain and flooding. Formation and evolution of Storm Gloria.

## Formation and evolution of Storm Gloria

During Friday the 17<sup>th</sup> of January 2020, a vortex in the upper atmosphere over the North Atlantic quickly moved towards Europe, whilst a low-pressure system began to form at the surface. At noon on Saturday the 18<sup>th</sup> of January, the vortex and the depression were over the northwest of the Iberian Peninsula. During the afternoon of the 18<sup>th</sup> and the early hours of the 19<sup>th</sup>, both the low-pressure system at the surface and the upper vortex crossed the peninsula towards the southeast, reaching the Mediterranean Sea. After passing to the leeward side of the peninsula, the surface depression deepened slightly and it was there when it was classified as Storm Gloria, centred between Ibiza and Cape Nao at 12 o'clock on the 19<sup>th</sup> of January. Despite not having a particularly low pressure value at its centre (around 1011 hPa), a very power-

ful anticyclone was centred to the south of Great Britain with a maximum of 1050 hPa. This established a strong pressure gradient from southern France to the Balearic Archipelago. This gradient caused strong winds with very strong gusts and a swell/storm surge that reached record values in the Mediterranean region, along with high humidity and precipitation in coastal regions of Spain, France and Balearic Islands.

Storm Gloria remained almost stationary for at least 24 hours before it moved southwest, later being absorbed by a larger depression on Monday the 20<sup>th</sup> of January that was centred over the Alborán Sea and covered the southern half of the peninsula and most of Morocco. This wide low-pressure system (which, strictly speaking, was not Storm Gloria anymore) persisted until Wednesday the 22<sup>nd</sup> of January, alongside the powerful anticyclone located at the north of the peninsula. This resulted in the easterly storm surge initiated by Gloria to supply great amounts of precipitation to the regions surrounding the Mediterranean Sea, including snow at relatively low altitudes - below 300 metres in some cases. Some provinces in Spain, such as: Tarragona, Castellón and Teruel, and in France, Pyrénées Orientales, experienced up to 1 metre of snowfall.

## Storm Gloria in Spain

Storm Gloria, the seventh named storm by the SW Group for the 2019/20 storm season, was named by the Spanish National Weather Service (AEMET) on Friday the 17<sup>th</sup> of January 2020 at 00:00 UTC. Red and orange level weather warnings were issued for wind gusts, rain, snow, and coastal events valid from early morning of Sunday 19<sup>th</sup> January over parts of the northern and western Iberian Peninsula, as well as Balearic Islands. Storm Gloria itself had a short life, as it was soon absorbed by a larger low-pressure system which was centred over the south of the Iberian

Peninsula during Monday the 20<sup>th</sup> of January and remained active for the rest of the week. The wind, rain, snow and sea storm effects generated by Gloria, which persisted during the next days due to the bigger depression (which for convenience continued to be named Gloria), had an exceptional nature, not only because of the meteorological records but also due to the associated impacts, including 14 casualties in Spain.

## Warnings Issued

Prior to the formation of Gloria and to the issuing of the MeteoAlarm warnings on Thursday the 16<sup>th</sup> of January, AEMET delivered an information note to the press (as is usually done when adverse weather is forecasted) announcing an important change of weather conditions for the Iberian Peninsula and Balearic Islands.

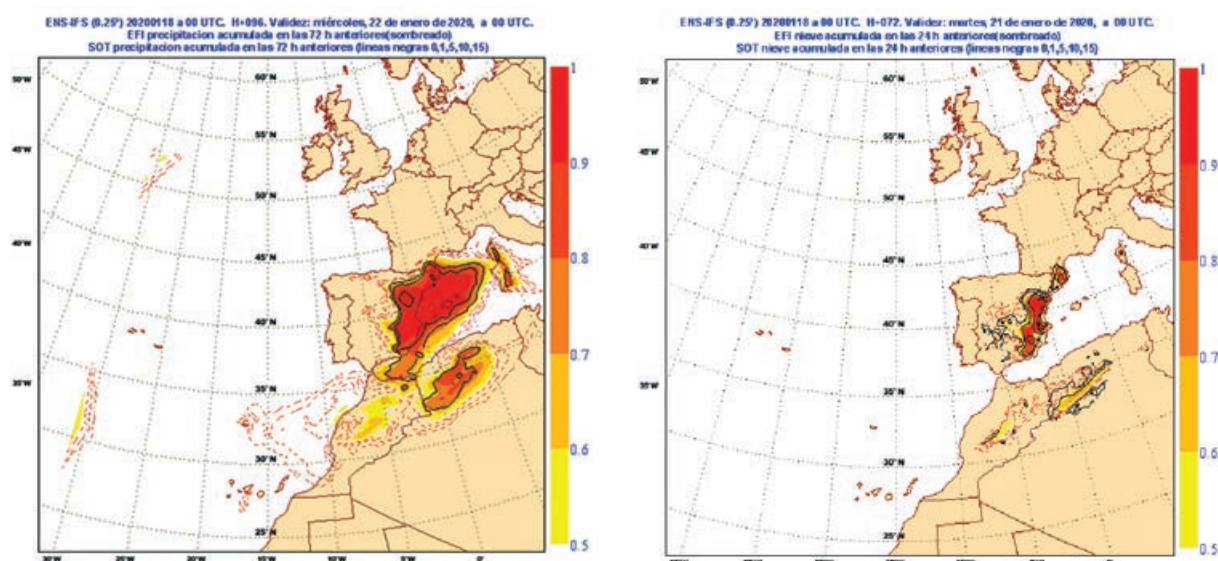
This information note warned about the formation of a storm, on Sunday the 19<sup>th</sup> of January, to the southwest of the Peninsula. It noted that it “will very likely cause northerly winds and a marked decrease of temperatures in the Peninsula and Balearic Islands. The storm will also bring a destabilisation of the atmosphere to the east and Balearic Archipelago, with abundant precipitation in the Mediterranean region. This will gradually move inland towards to Cantabrian region of northern Spain, however as it travels further west the precipitation amount will decrease. The strong winds from the north and the east will affect numerous

areas, especially the Mediterranean, and may result in storm surges across the region. Along with the temperature decrease, the snow level will also drop down to a considerably lower than average altitude, possibly reaching 300-600 metres at eastern and northern zones. There will be abundant snowfall inland and in the eastern third of the Peninsula, with the possibility of affecting other eastern and central regions.”

There were numerous weather warnings released because of Storm Gloria. A red warning was issued for strong gusts (130 km/h threshold) for the coasts of Alicante and southern parts of Valencia province. An orange level warning was issued for the rest of the Valencian Autonomous Community, and parts of Murcia, Cataluña and Castilla y León principally.

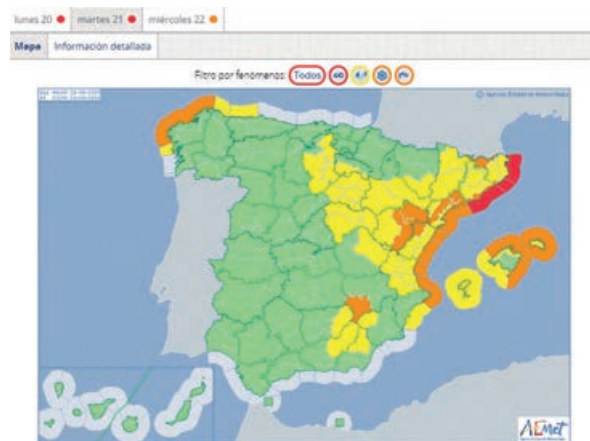
A red warning issued for coastal damage affecting most of the littorals of Balearic Islands, Cataluña and Valencia Autonomous Community from the 19<sup>th</sup> to the 20<sup>th</sup>, was extended to 21<sup>st</sup> in Cataluña. Orange or yellow warnings were issued for the rest of the Mediterranean littorals on these days.

On the 19<sup>th</sup> and 20<sup>th</sup>, a red snowfall warning was issued for accumulation of more than 20 to 50 cm, depending on the zone, for different regions of Castellón, Teruel, Valencia, Alicante, Murcia and Albacete provinces. Orange or yellow warnings were put in place for the wide strip around the red warning zone, which covered all the high lands of the eastern Peninsula.



▲ Figure 1: Model ENS-IFS EFI at 00 UTC on January 18<sup>th</sup> for 72 h precipitation from January 19<sup>th</sup> to 21<sup>st</sup> (left); 24h snowfall for January 20<sup>th</sup> (right).



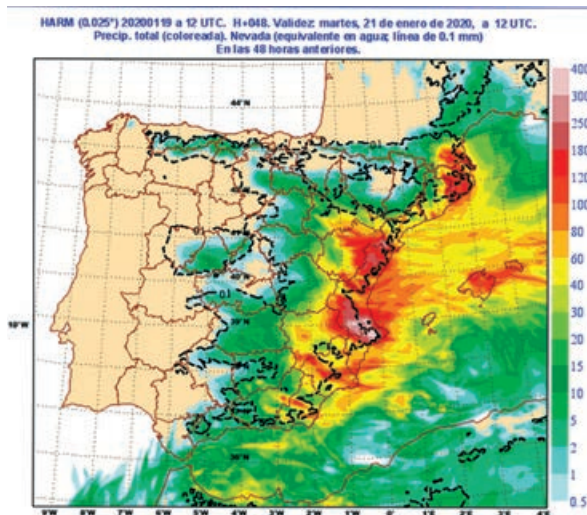


▲ Figure 2. Warnings issued on January 20<sup>th</sup> (left) and 21<sup>st</sup> (right)

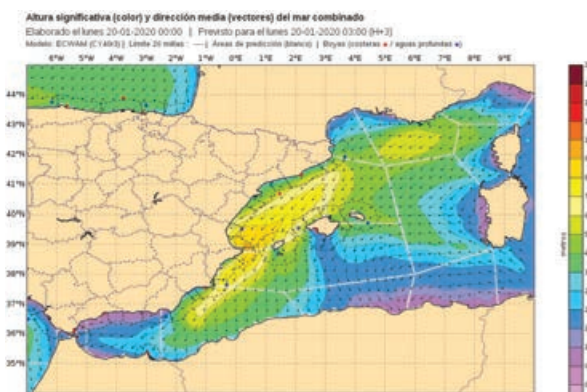
Persistent orange rain warnings (more than 100 or 120 mm in 24 hours) were issued for the Balearic Islands and littoral zones of Cataluña and Valencia Autonomous Community..

## Main Impacts

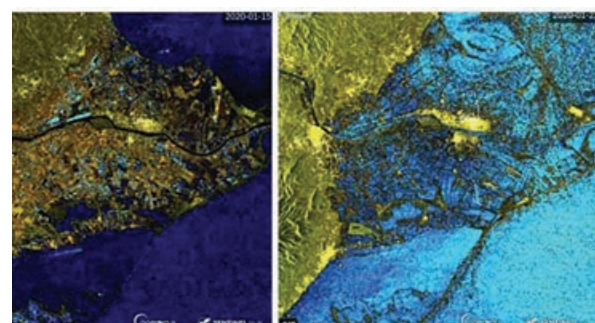
It was reported that there were 14 casualties as a result of Storm Gloria, most of them in the Mediterranean region on 20<sup>th</sup> and 21<sup>st</sup> of January, according to data from Civil Protection and other sources. There was also damage to roads, railways, power and telephonic networks. In addition, some towns were isolated due to snow accumulation and there was swelling of numerous rivers and destruction of sea fronts and wide coastal strips, especially at the Ebro Delta (Tarragona province) which was totally flooded.



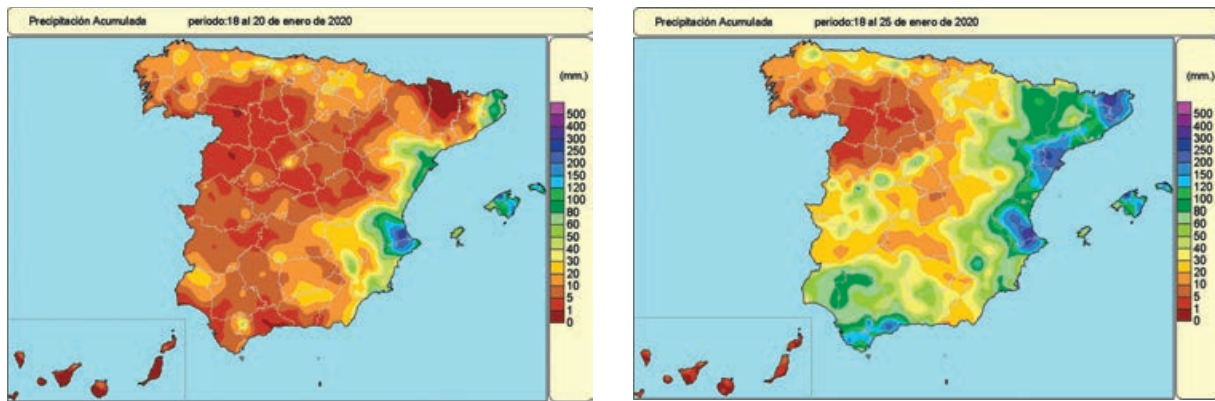
▲ Figure 3: HARMONIE-AROME forecasted precipitation on 19<sup>th</sup> January, 12 UTC run, for the next 48 hours. Around Cape Nao, between Valencia and Alicante, 300 to 400 mm were forecasted.



▲ Figure 4: ECWAM model forecast for significant wave height (colour) and mean direction (vectors) on 20<sup>th</sup> January, 00 UTC run, for the same day at 03:00 UTC. Maximum values, also next to Cape Nao, were between 8 and 9 metres of significant wave height.



▲ Figure 5: Ebro Delta before (January 15<sup>th</sup>) and after (January 21<sup>st</sup>) flooding (Source: Copernicus/Sentinel)



▲ Figure 6: Accumulated precipitation between 18<sup>th</sup> and 20<sup>th</sup> January, corresponding to Storm Gloria itself, (left) and between 18<sup>th</sup> and 25<sup>th</sup> January, corresponding to the wider episode of easterly windstorm, including Storm Gloria during its first stage (right)

mum height of 14.77 m at 12 UTC; the previous record by Mahón buoy (Menorca, Balearic Islands) of 8.15 m was recorded in January 2003.

Precipitation reached historical values, consistent with the model's predictions, even though the non-hydrostatic model HARMONIE-AROME forecasted higher values than hydrostatic ECMWF HRES-IFS, as usual in this type of situation.

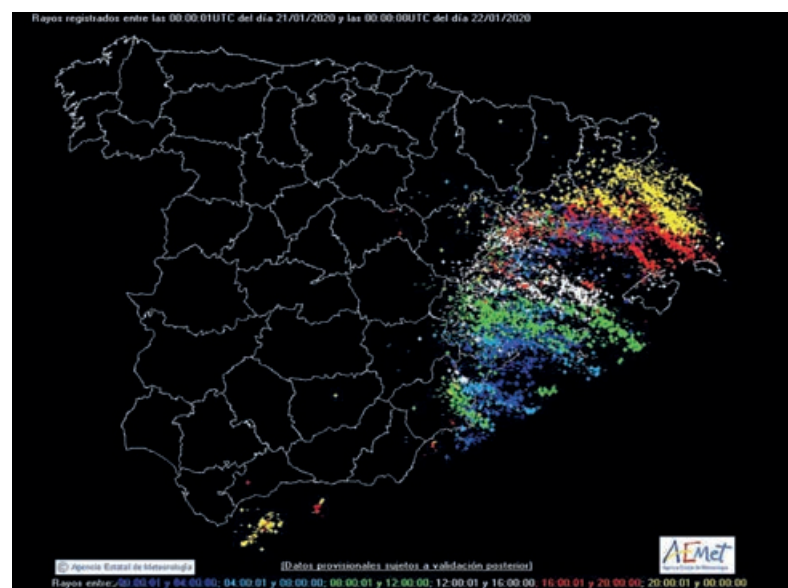
Precipitation data registered by AEMET automatic station network for the whole period, including Storm Gloria, recorded over 300 mm (locally 400 mm) in some regions in Cataluña (Ebro Delta and Pyrenees above all), Valencia Autonomous Community and Balearic Islands. Over approximately 5 days (from 00 UTC on the 19<sup>th</sup> of January to 15 UTC on the 23<sup>rd</sup> of January 2020), 7 stations accumulated more than 300 mm, among them one which surpassed 400 mm - Valencia with 433 mm. This record contributed to four times the mean total accumulated value for the month of January. The rainiest day was Tuesday the 21<sup>st</sup> of January, with numerous records over 100 mm in 24 hours, and a maximum record of 220.4 mm in Horta de Sant Joan (Tarragona).

Another relevant phenomena during the episode was the wind. Gusts exceeded 100 km/h at many locations in the Mediterranean during Sunday the 19<sup>th</sup> and Monday the 20<sup>th</sup> of January. These storms, being especially active during Tuesday the 21<sup>st</sup> of January, contributed to snowfall that covered a large part of the mountainous regions next to the Mediterranean, with a snow level sometimes going below 300 metres above sea level. A snowfall depth of 86 cm was recorded on the

21<sup>st</sup> of January in Vilafranca (Castellón), exceeding the historical maximum of 80 cm, which was recorded on the 7<sup>th</sup> of March 1968.



▲ Figure 7: Vilafranca (Castellón) after the snowfall (Source: Ignasi Llopis)



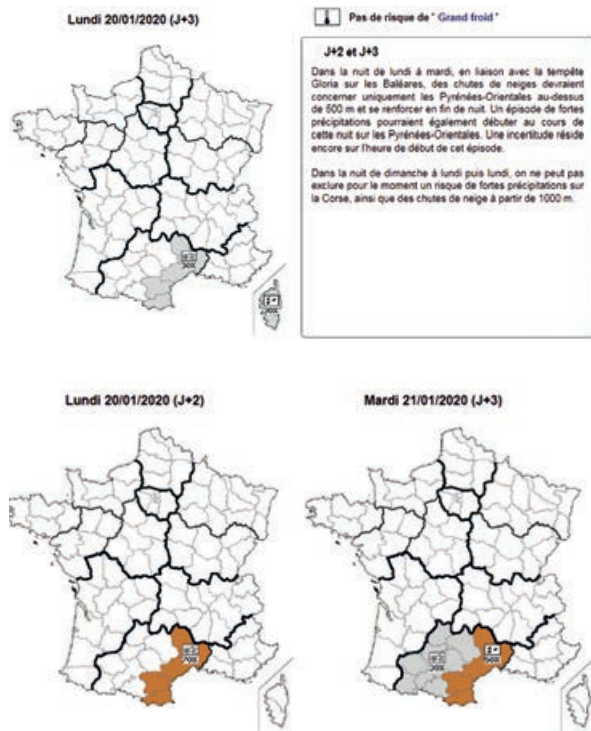
▲ Figure 8: Recorded lightning between 00 UTC on 21<sup>st</sup> January and 00 UTC on 22<sup>nd</sup> January



# Storm Gloria in France

## Before the event

Storm Gloria was named by AEMET on Friday the 17<sup>th</sup> of January 2020, with a first warning issued on the 19<sup>th</sup> of January. The vigilance chart produced by Meteo France is valid for the following 24 hours. For day +2 and day +3, a 'pre-vigilance' chart is produced with a lower resolution and a scale of risk from 0 to 3, illustrated by a colour code from white to brown. On the 17<sup>th</sup> of January, this 'pre-vigilance' chart indicated a risk of heavy snowfall over the Roussillon on Monday the 20<sup>th</sup> of January and then a risk of heavy rain. The following day, the scale of risk of both snow and heavy rainfall was increased.

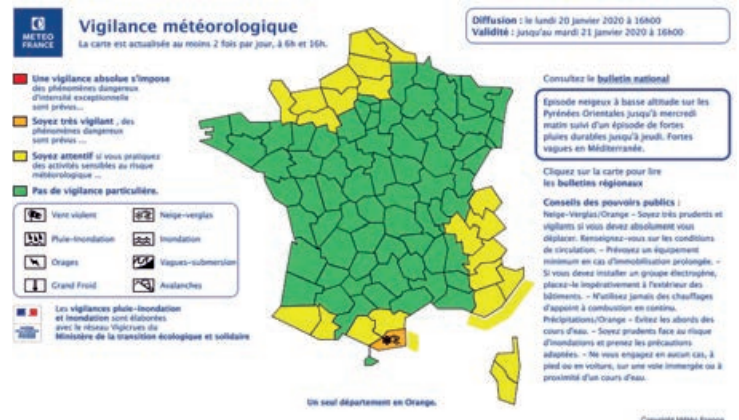


▲ Figures 1: pre-vigilance charts issued on 17/01/2020 (top) and 18/01/2020 (bottom)

Due to early reports of high impacts of Gloria over Spain, and pressure from private meteorological companies and websites, it appeared necessary for Meteo France to communicate to both the media and authorities. The media department of Meteo France issued an infographic for the whole storm episode which was widely distributed. Civil Security officers are fond of this kind of graphical forecast that clearly summarised the issues of a situation.



▲ Figure 2: Media chart produced on 20/01/2020 to summarise the meteorological issues over France for the next few days.



▲ Figure 3: First snow orange vigilance chart on 20/01/2020 at 06h (top) and rain/avalanche orange vigilance chart on 21/01/2020 at 16h (bottom)

► Figure 4: 24 hours rainfall on Tuesday 21/01/2020

## Monday 20<sup>th</sup> and Tuesday 21<sup>st</sup> January 2020

The first orange vigilance began on the morning of Monday 20<sup>th</sup> January, with an orange snow alert over Pyrenees Orientales - heavy snowfall was forecast down to very low altitudes due to the cooling of the airmass by precipitation overnight and into Tuesday morning (cf figure 3). Rainfall accumulation was added as the main issue on Tuesday afternoon as the zero-degree isotherm quickly rose and rainfall was expected to last at least 48 hours. Heavy snowfall however continued at higher altitudes over the eastern part of the Pyrenees and an orange warning was also issued for avalanches.

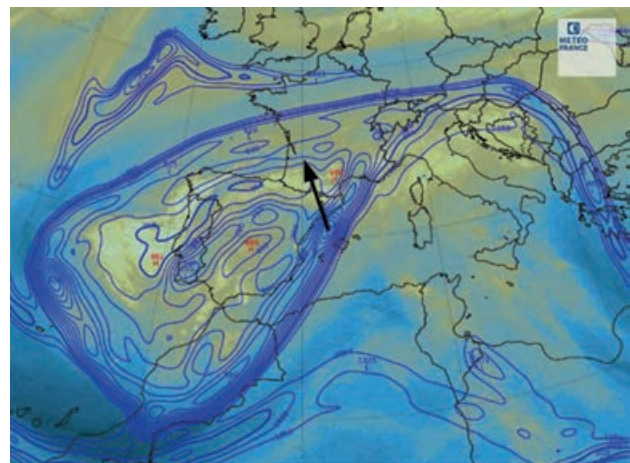
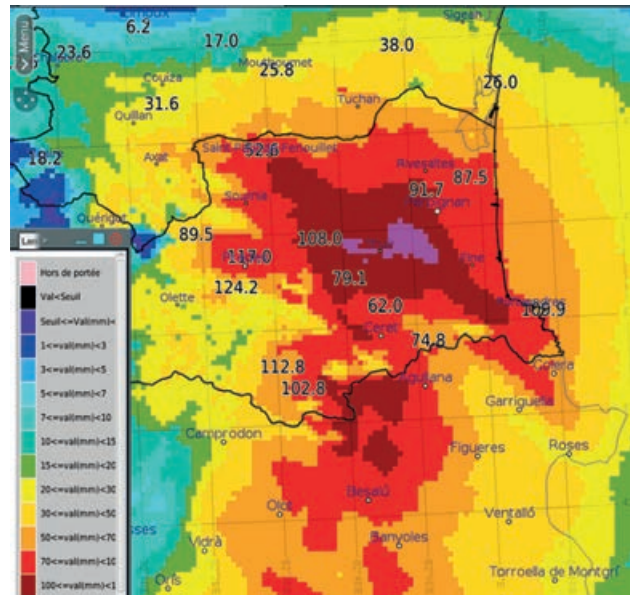
During the first 24 hours, rainfall was continuous and moderate with a maximum intensity between 5 mm/h and 10 mm/h. 24 hours rainfall accumulations over eastern parts of Pyrénées Orientales reached 100 to 150 mm as predicted in the forecasts (figure 4).

## Wednesday 22/01/2020

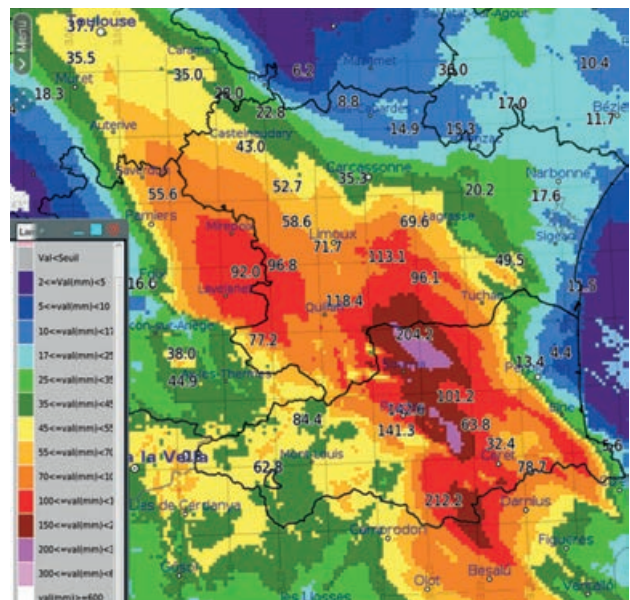
During the early morning of Wednesday the 22<sup>nd</sup> of January, warmer air was advected towards Roussillon and a short-wave trough moved from Catalonia to the eastern Pyrenees. These two factors led to an intensification of precipitation with intensities of 15 to 30 mm/h (cf figure 5).

There were some uncertainties concerning the precise areas of highest rainfall accumulations as some runs of AROME (high resolution model) put it further east in the Gulf of Lion. This option was rejected by forecasters considering synoptic features and after consultation with the Harmony Model from AEMET that had the birth of the convective system in its initial fields. Rainfall accumulations during the second 24 hours of the rainfall system were higher than during the first 24 hours; a maximum of 150 to 200 mm was reached but displaced to the west compared to the first 24 hours maximum (cf figure 6).

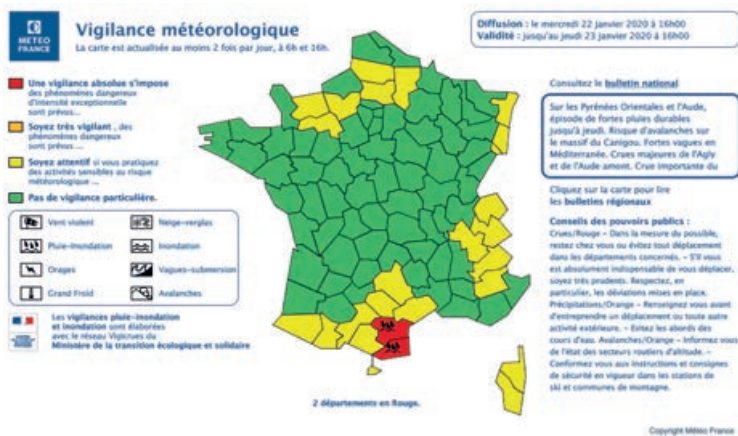
► Figure 6: 24 hours rainfall on 22/01/2020.



▲ Figure 5: WV imagery and Z=1,5 PVU ARPEGE analysis on 22/01/2020 06Z. The black arrow indicates the movement of the minimum of PV i.e. short-wave trough and thus the synoptic forcing.







▲ Fig 7: Vigilance chart at 15 UTC on 22/01/2020 (top) and Aude River before and during flooding event (bottom)



As a result of continuous intense rainfall, combined with melting snow, many rivers originating in the Pyrenees began to flood, especially Aude and Agly rivers. Vigilance for flooding was upgraded to orange and then to red.

## End of the event: Thursday 23/01/2020

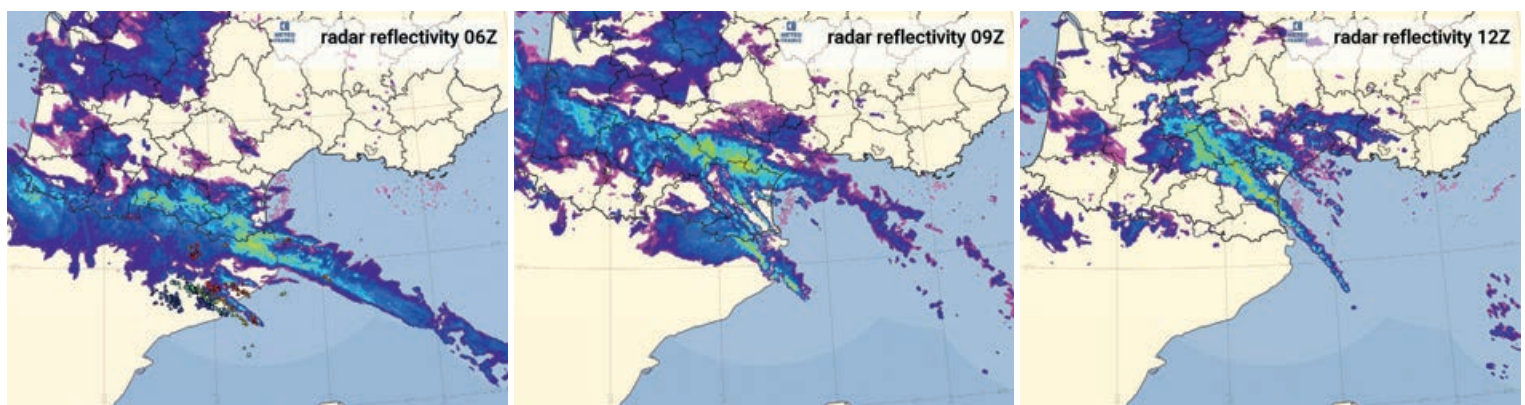
On Thursday 23<sup>rd</sup> January, the main upper level trough moved north-eastward from Eastern Spain towards Gulf of Lion. Two bands of heavy rains and thunderstorms triggered by this trough crossed Roussillon in the morning and rainfall declined dramatically throughout the afternoon (cf figures 8). This was the end of meteorological events but river flooding only decreased 24 hours later.

## Conclusion

Storm Gloria had a greater impact in Spain than in France in terms of covered territory and intensity.

The lag between the extreme events of Spain and France and the media coverage about the storm probably encourage people in Roussillon (France) to be more careful and take appropriate precautions.

This again helps to show that Storm naming can efficiently group all dangerous phenomena under one concept. The general public are more prepared and pay more attention to advice from Civil Security when a storm is named.



▲ Fig 8: radar reflectivity at 06, 09 and 12Z on 23/01/2020