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Integrated pan-European rainfall and floods impact forecasts for cooperation in emergency management

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INLINE Flash Flood Impact Forecast Products

Calum Baugh (ECMWF)

Oisìn Morrison, Karen O'Regan, Dimitar Tasev (ECMWF)
Marc Berenguer, Shinju Park, Victor Gonzalez, Xinyu Li (UPC)

CRAHI UPC Centre de Recerca Aplicada en Hidrometeorologia UNIVERSITAT POLITÈCNICA DE CATALUNYA
ECMWF
ILMATIETEEN LAITOS METEOROLOGISKA INSTITUTET FINNISH METEOROLOGICAL INSTITUTE
AEMet Agencia Estatal de Meteorología
IPMA Instituto Português do Mar e da Atmosfera
EMA Agencia de Emergencias de Andalucía Junta de Andalucía
GOBIERNO DE ESPAÑA MINISTERIO DEL INTERIOR DIRECCIÓN GENERAL DE PROTECCIÓN CIVIL Y EMERGENCIAS
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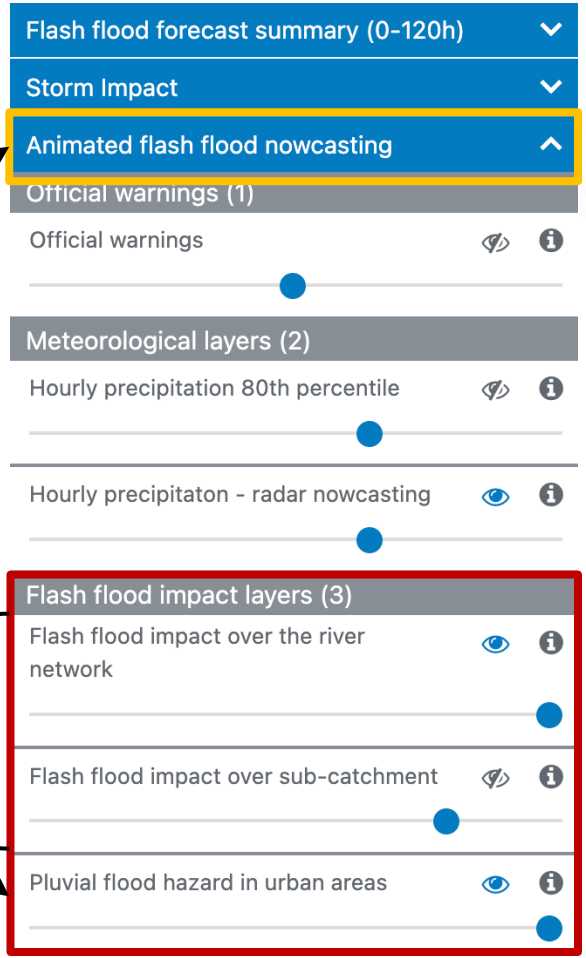
Overview

Found in this product grouping



- River flash flood impact layers
- Pluvial hazard in urban areas layer

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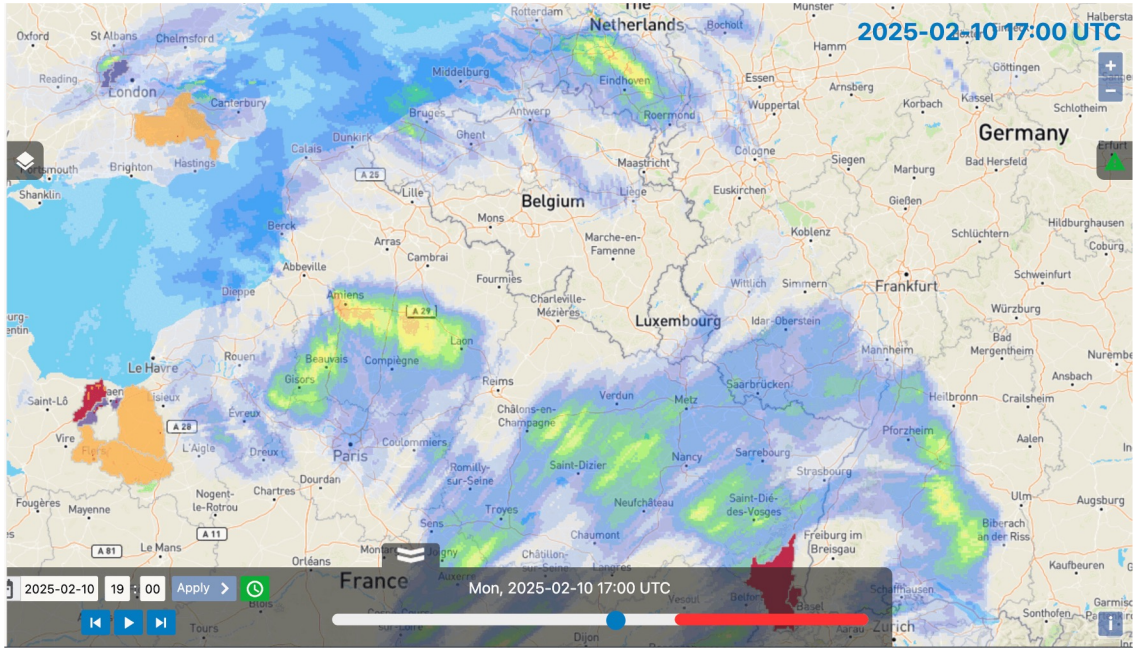
River Flash Flood Impact Forecasts:

- Flash flooding in small rivers:
  - Response time to rainfall <24 hours
  - Drainage area < 2000 km^2
- Forecasts produced every 1 hour

- 0 - 5 h lead time = 1 hr timestep
  - Blending of radar nowcast & ECMWF IFS
- 6 - 120 h lead time:
  - Produced by ECMWF IFS only
  - Summarised between 7-24, 25-48, 49-120h



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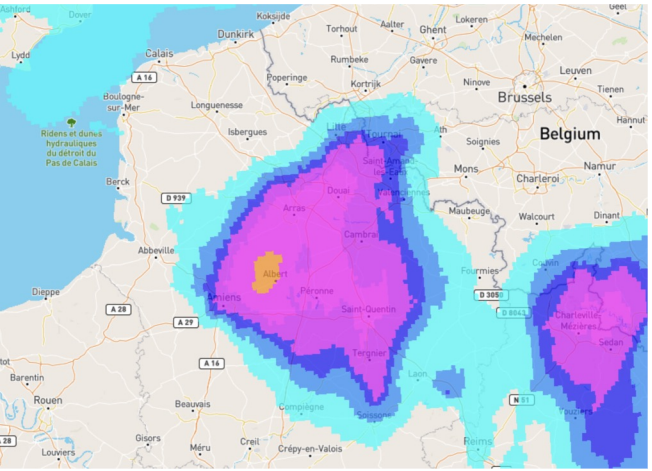
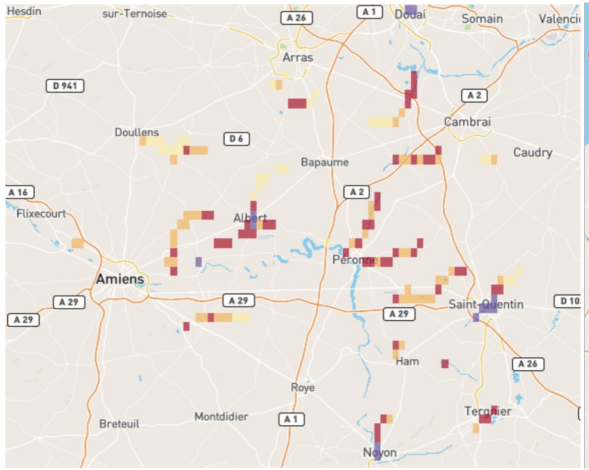
River Flash Flood Impact Forecasts: 3 components

Within the *Animated Flash Flood Nowcasting* tab on the platform

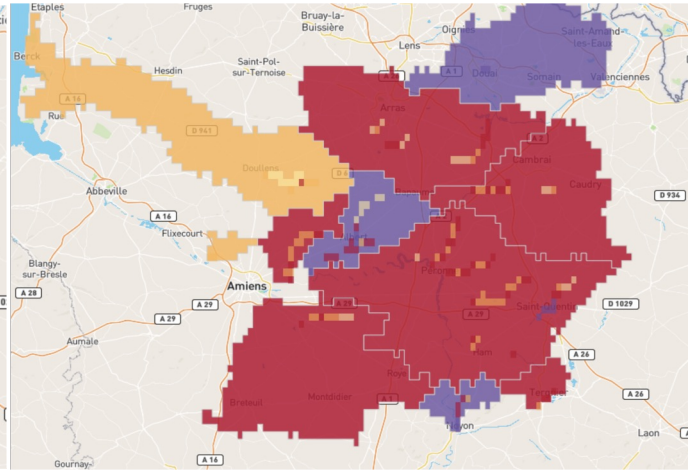
1) Rainfall forecast



2) Impact on the river network



3) Summary at sub-catchment scale



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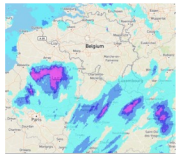
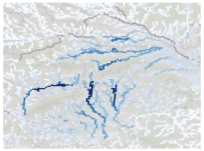
River Flash Flood Impact Forecasts: **Workflow**



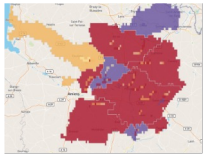
Blended Rainfall Forecast

- Blended ensemble rainfall forecast
- Radar nowcast - 20 member
- NWP forecast - 51 member
- Remove frozen precipitation
- Apply bias correction



Flash Flood Hazard

- Accumulate rainfall on the river channel network
- Compare accumulations vs climatology



Flash Flood Impacts

- Overlay hazard with exposure dataset
  - Population & critical infrastructure
- Summarise impacts at sub-catchment scale

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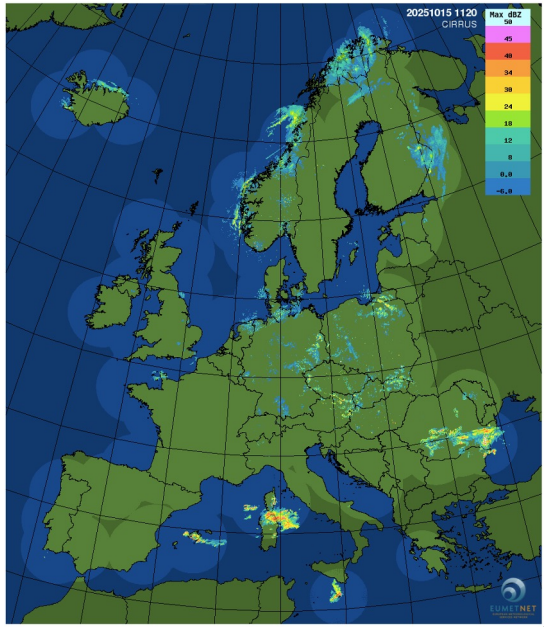
Blended Rainfall Inputs: *1) Radar Nowcasts*

EUMETNET

- Rainfall rate data from pan-European OPERA radar composite
- Data available every 15 mins at 2 km resolution

- Nowcasts are generated using SBMCast (Berenguer *et al.*, 2011)
  - 20 member ensemble generated by randomly perturbing the initial motion fields



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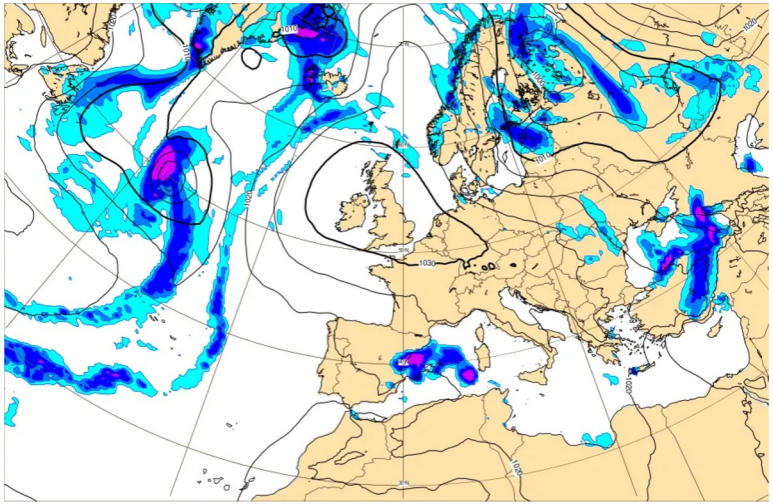
Blended Rainfall Inputs: *2) NWP Forecasts: ECMWF IFS*

- 51-member ensemble with 1-hour timestep
- Forecasts available at 00, 06, 12, 18 UTC
- Spatial extent clipped to match EFAS domain
- Regridded to same 2-km resolution as OPERA radar data
  - Using nearest neighbour method
- Snow removed using same method applied to radar data



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Workflow to Produce Blended Forecast:

$$Tp_{Blend\ t,m} = Tp_{NWP\ t,m} * w_s * w_t + Tp_{Nowcast\ t,m} * (1 - w_s * w_t)$$

Phase shift & bias correct the NWP

Optical flow method to shift the NWP rainfall closer to location of rainfall in radar observation

Bias correct NWP data using Gaussian filter

Compute Temporal & Spatial Weighting

Less weight given to radar further from radar stations

Less weight given to radar at longer lead times

Ensemble Member Matching

Match each NWP ensemble member to closest matching radar nowcast member

'Assignment problem' solved using Hungarian method

Compute Blended Forecast

Radar & NWP data blended according to lead time and spatial weights

2km resolution, 1hr timestep, 5 hour lead time

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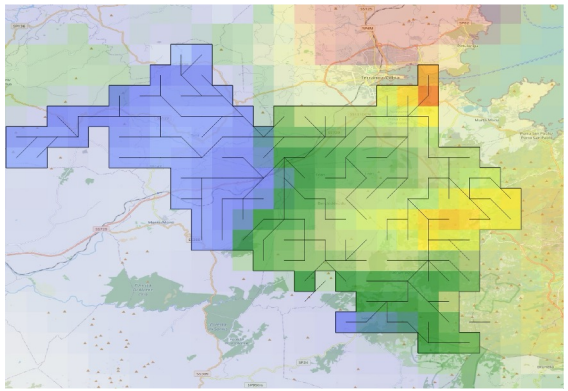
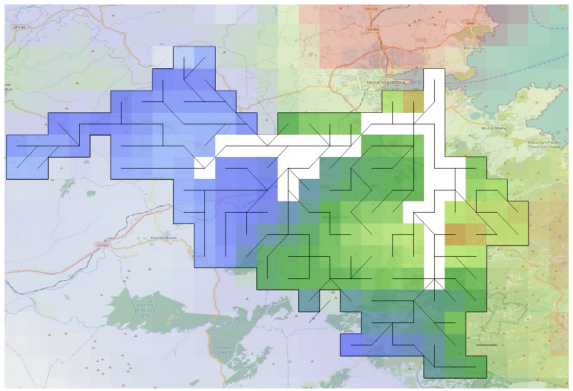
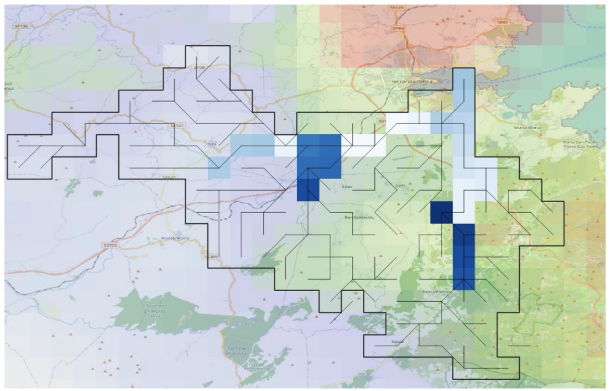
Computing the Flood Hazard

Accumulate Rainfall on Channel Network → Compare Accumulations vs Climatology (2yr return period) → Calculate Exceedance Probability of 2 year return period







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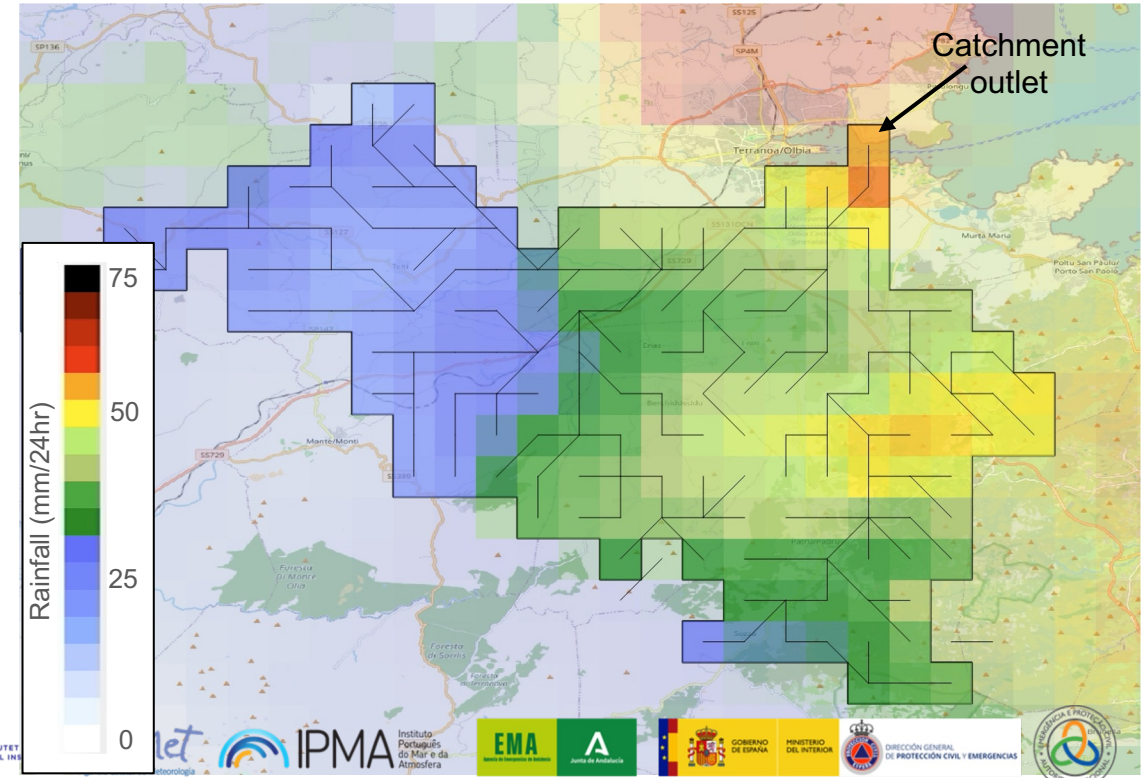
Computing the Flood Hazard: Accumulate Rainfall on Channel Network

- Regrid rainfall to 1 arcmin (~1.4 km) spatial resolution
- Use the gridded river channel network from EFAS
- At each grid cell on channel network:
  - Calculate the rainfall which has accumulated in the upstream area



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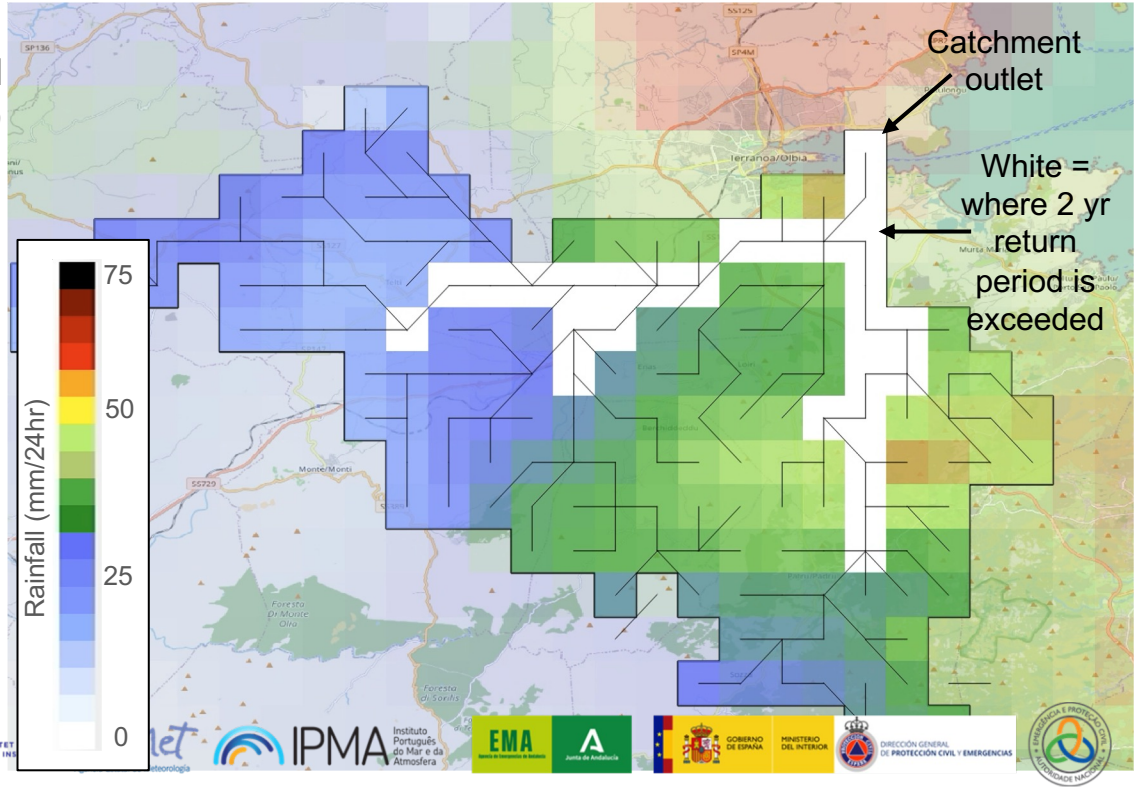
Step 2: Identify Grid Cells which Exceed 2 year Return Period

- Compare the accumulation in each grid cell with the accumulation equivalent to the 2 year return period
- Climatology computed from 8 years of historical radar observations & 20 years of NWP reforecast
- Create a binary map showing grid cells which exceed the 2 year return period



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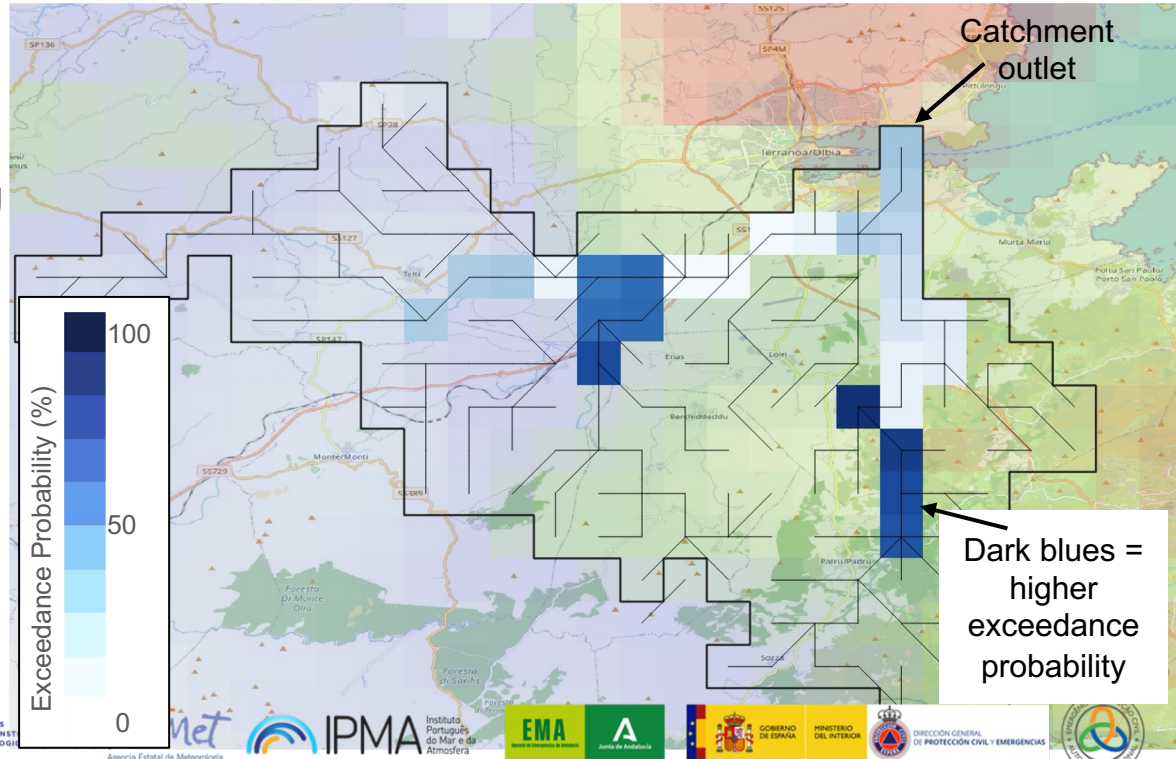
Step 3: Compute Probability of Exceeding 2 year Return Period

- Repeat the previous step for all ensemble members
- Compute the probability of exceeding the 2 year return period



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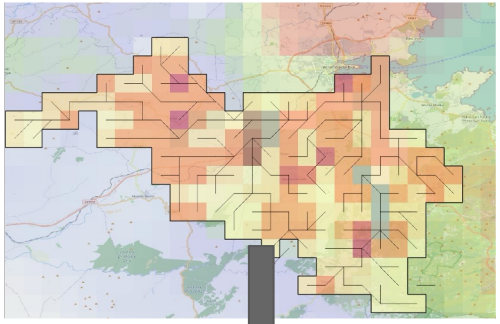
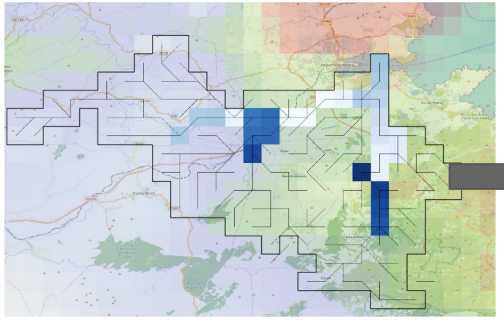
Calculating Flash Flood Impacts

- Overlay the flash flood hazard forecast & static exposure layer on an impact matrix

Population & Critical Infrastructure Exposure

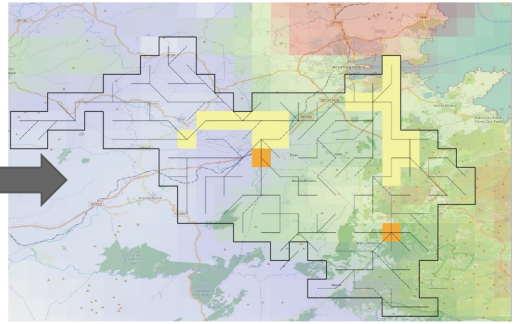


Flash Flood Hazard



Impact Matrix	Low Exposure	Medium Exposure	High Exposure
High Likelihood			
Medium Likelihood			
Low Likelihood			

Flash Flood Impact



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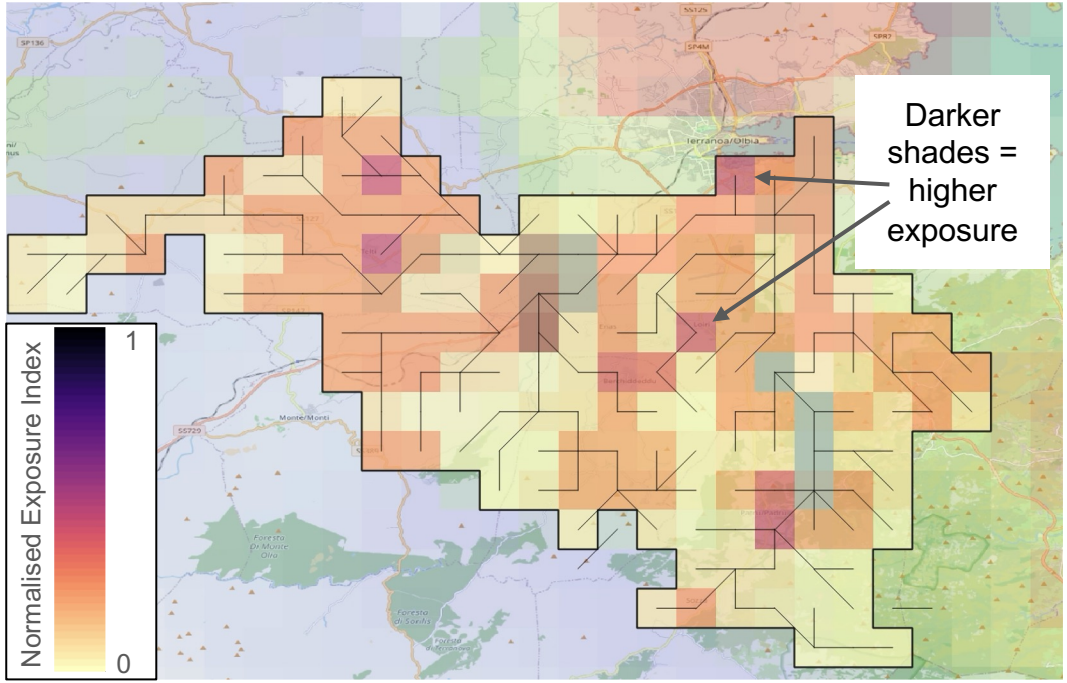
Exposure - Population & Critical Infrastructure

- Darker shades represent higher exposure
- Exposure typically higher in populated areas



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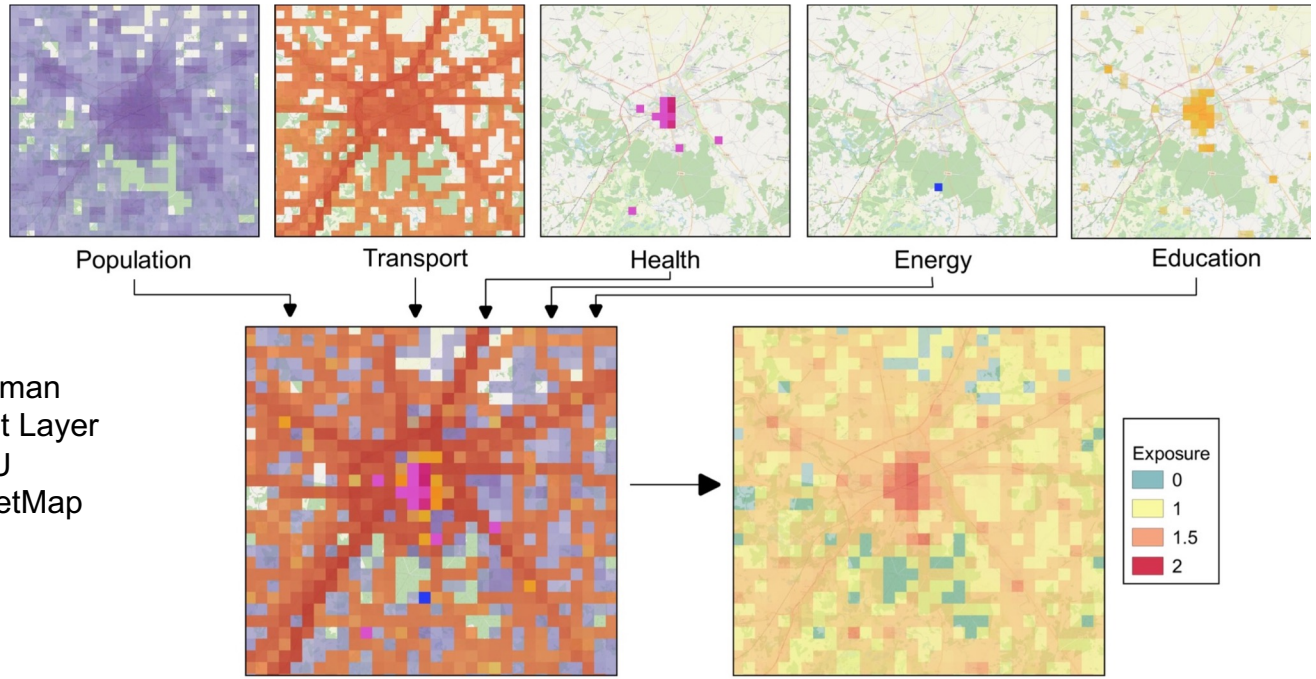
Exposure - Population & Critical Infrastructure

- Static layer which summarises the number of people and critical infrastructure assets in each grid cell



Data sources:

- Global Human Settlement Layer
- HARCI-EU
- OpenStreetMap

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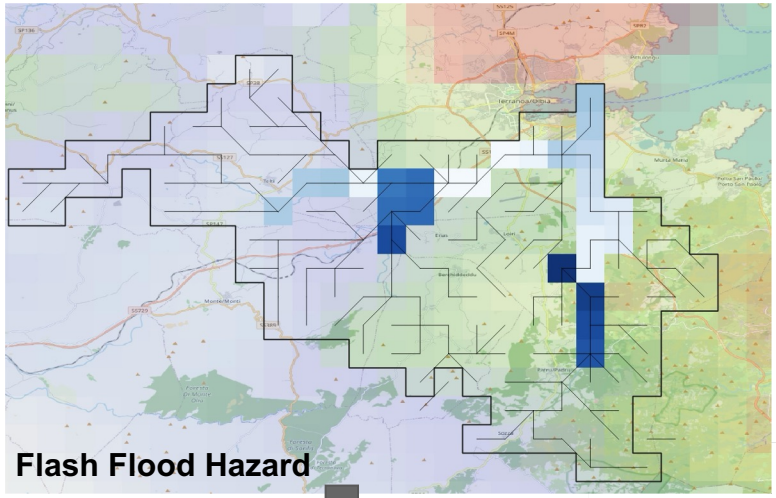
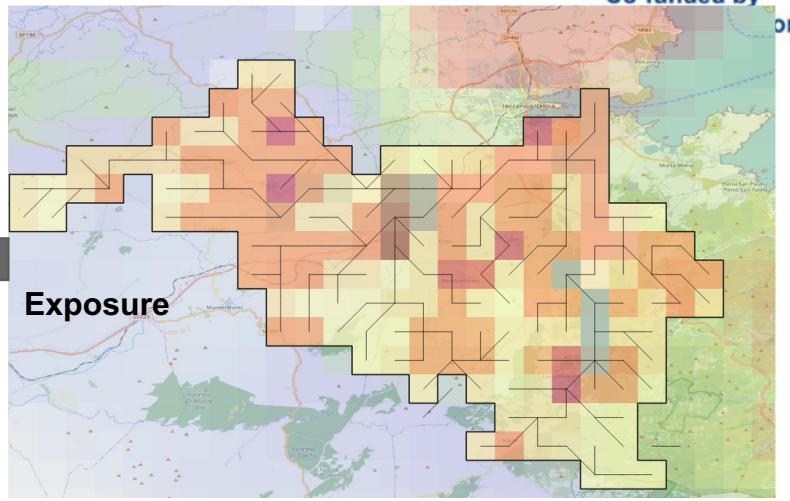
Calculating the Impact





	0.05 - 0.3 Low Exposure	0.3 - 0.6 Medium Exposure	>0.6 High Exposure
>75% High Likelihood			
50 - 75% Medium Likelihood			
5-50% Low Likelihood			

- Data in each grid cell are overlaid onto impact matrix

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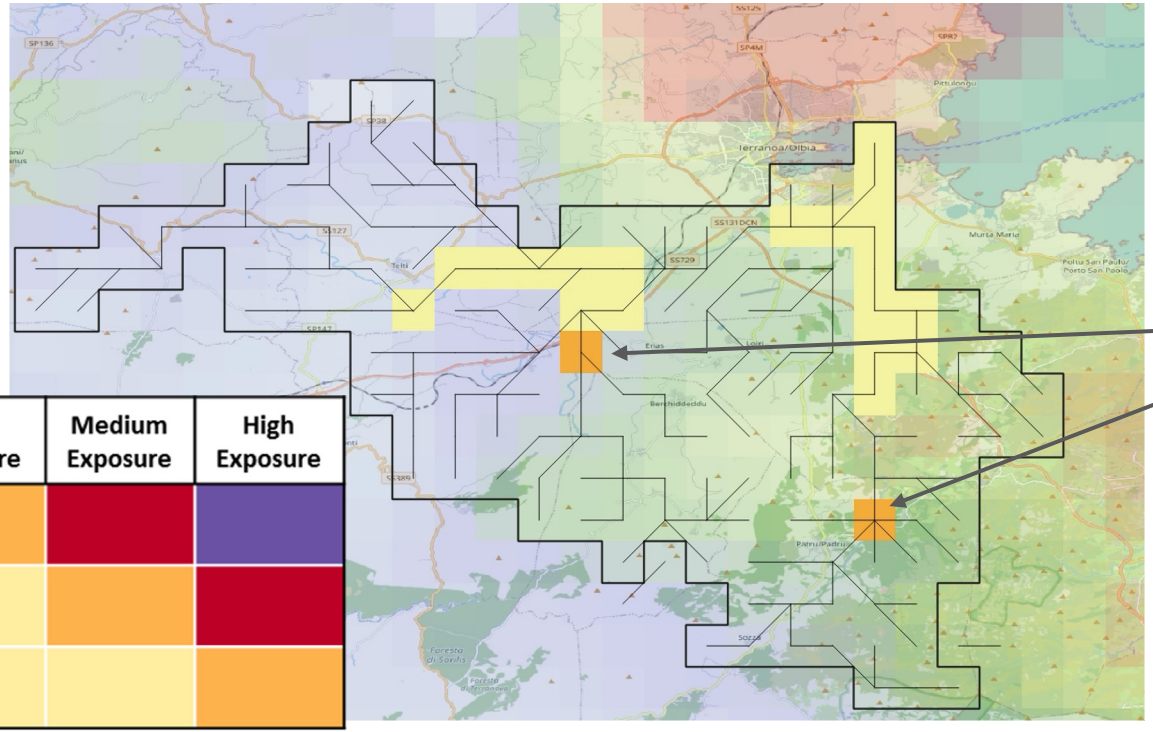
Calculating the Impact



	Low Exposure	Medium Exposure	High Exposure
High Likelihood			
Medium Likelihood			
Low Likelihood			

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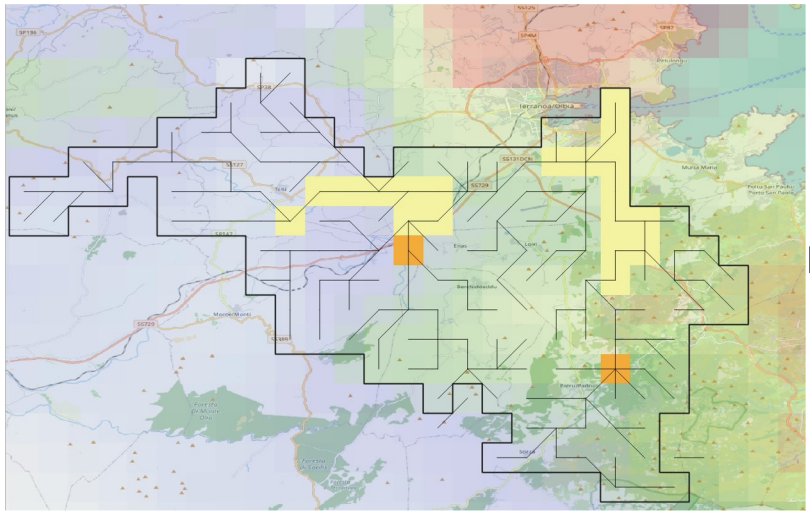
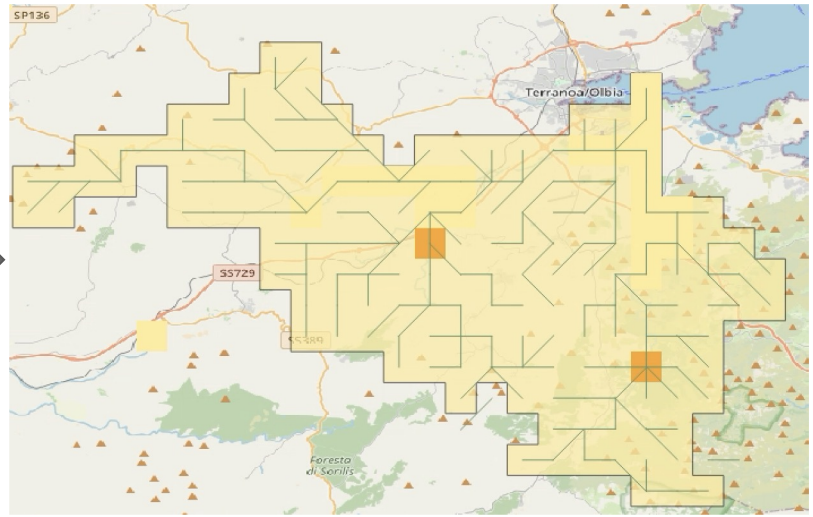
Calculating the Impact - Summary at Sub-Catchment Scale

- In each grid cell, compute maximum impact over 0-6, 7-24, 25-48 & 48-120h



- Compute the 90th percentile within each sub-catchment for each lead time range



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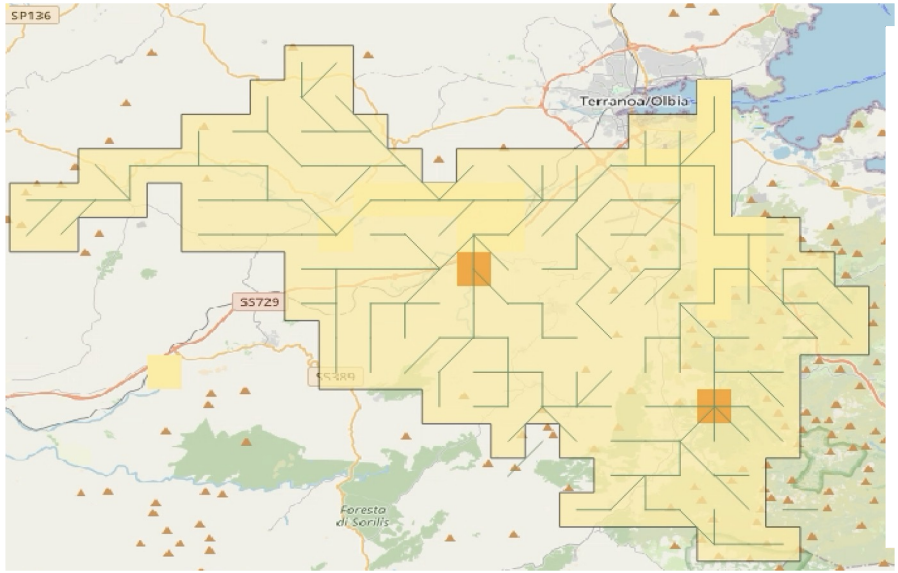
Calculating the Impact - Summary at Sub-Catchment Scale

- Additional information available in pop-out window when sub-catchment is clicked



Impact matrix

	Low Exposure	Medium Exposure	High Exposure
High Likelihood			
Medium Likelihood			
Low Likelihood	✓		

Exposure information

	#
Total population affected	**380**
Education facilities affected	
Health facilities affected	**1**
Energy generation facilities affected	
Time of the event peak	**2025/10/15 16:00:00**

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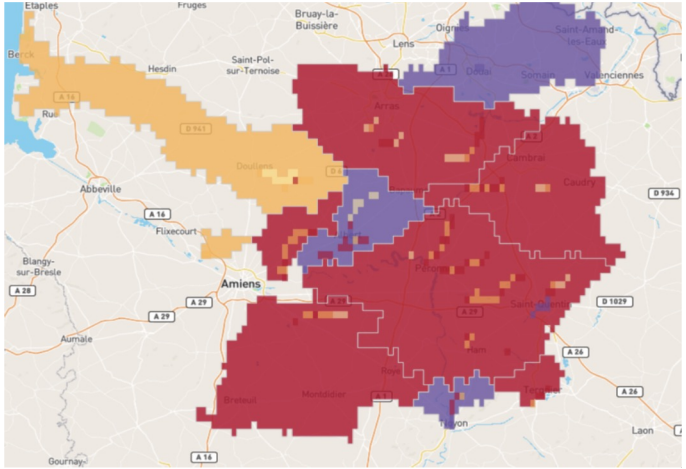
Flash Flood Impact Forecasts - Summary

- Forecasts produced every 1 hour using blend of radar nowcast & NWP forecast data
  - 1 hr timesteps up to 6 hr lead time
  - Summaries for longer lead time: 7-24, 25-48, 48-120 h



Limitations / things to be aware of:

- Skill beyond 48 hours lead time is very limited
- For smaller convective events, skill can be restricted to a few hours ahead
- Larger synoptic systems associated with skill at longer lead times
- Exposure layer is static:
  - More detailed data may be available locally

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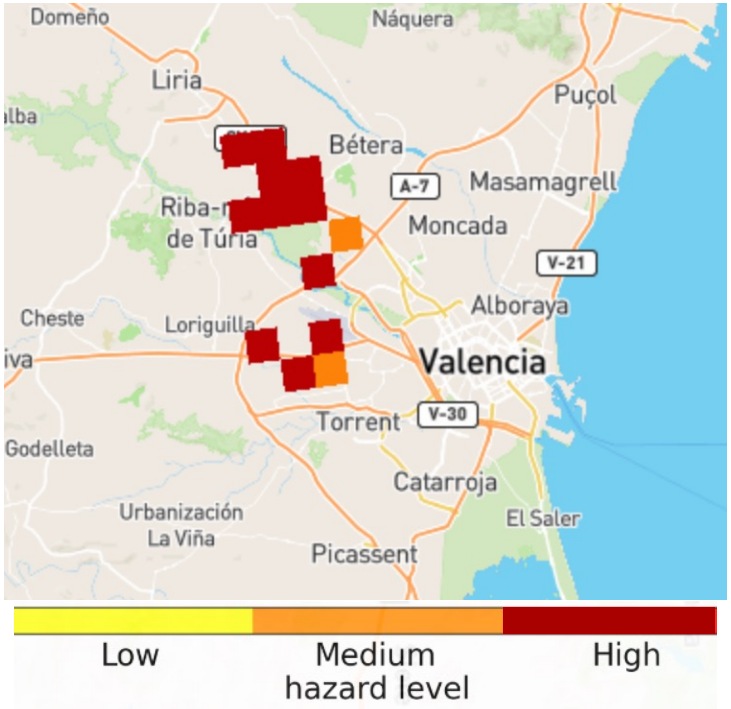
Pluvial Flood Hazard in Urban Areas:

- Developed by UPC
- Highlights where flooding possible in urban areas:
  - When 1-hour rainfall exceeds 2, 5 or 20-year return periods
  - In grid cells where >20% area is urban or highly impermeable

- 2km spatial resolution
- Forecasts produced every 15 minutes
- 0 - 5 h lead time = 15-min timestep
  - Based on deterministic radar nowcasts



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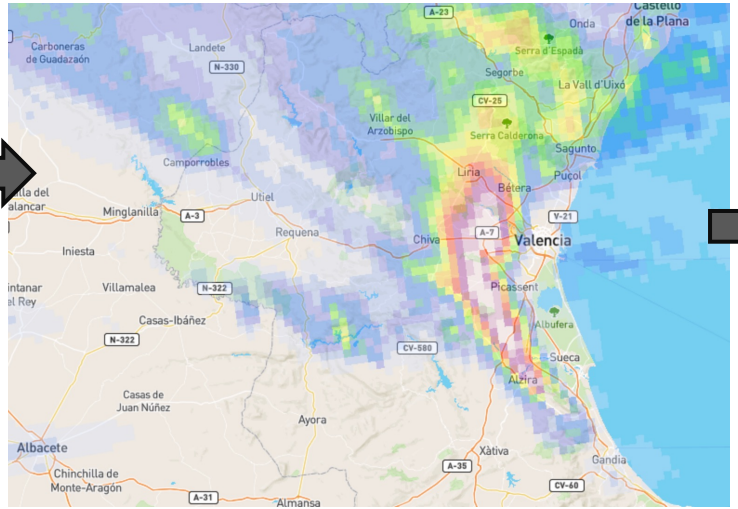
Pluvial Flood Hazard Methodology:

1. Rainfall Nowcast

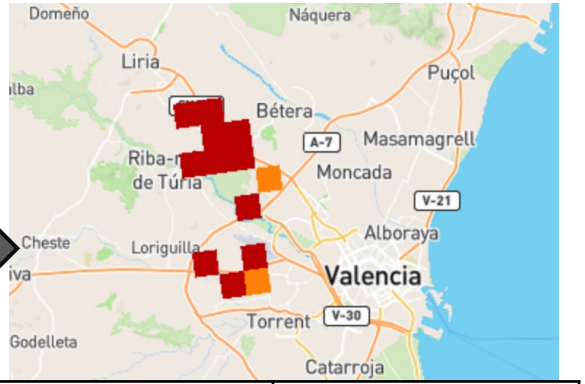
15-min radar rainfall nowcast using OPERA EUMETNET composite – bias adjusted

2. Compute 1-hour accumulations



Rainfall accumulations compared against return period thresholds

3. Compute hazard level



Return Period	Hazard Level
2-year	Low
5-year	Medium
20-year	High