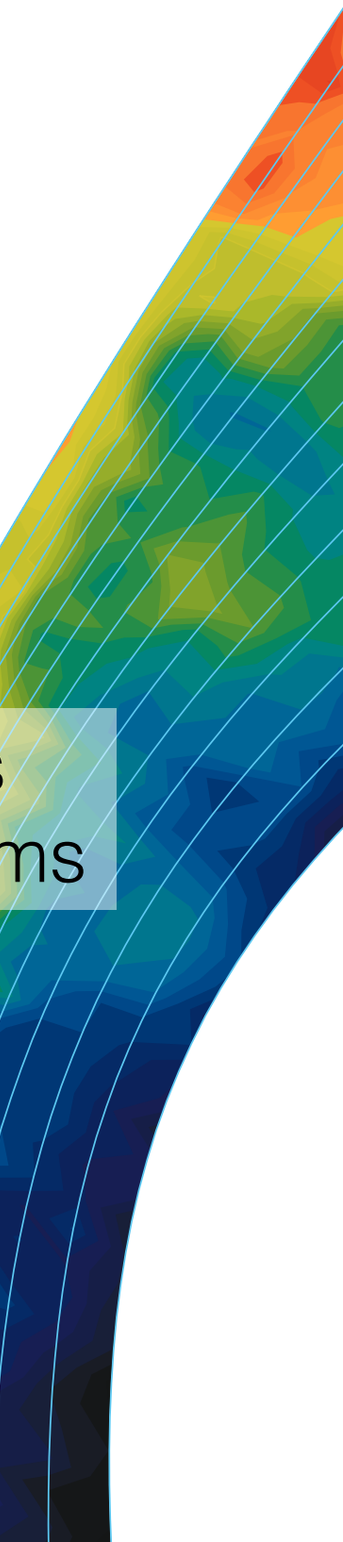
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en Hidrometeorologia
UNIVERSITAT POLITÈCNICA DE CATALUNYA

Flash flood forecasting
some results from EU projects

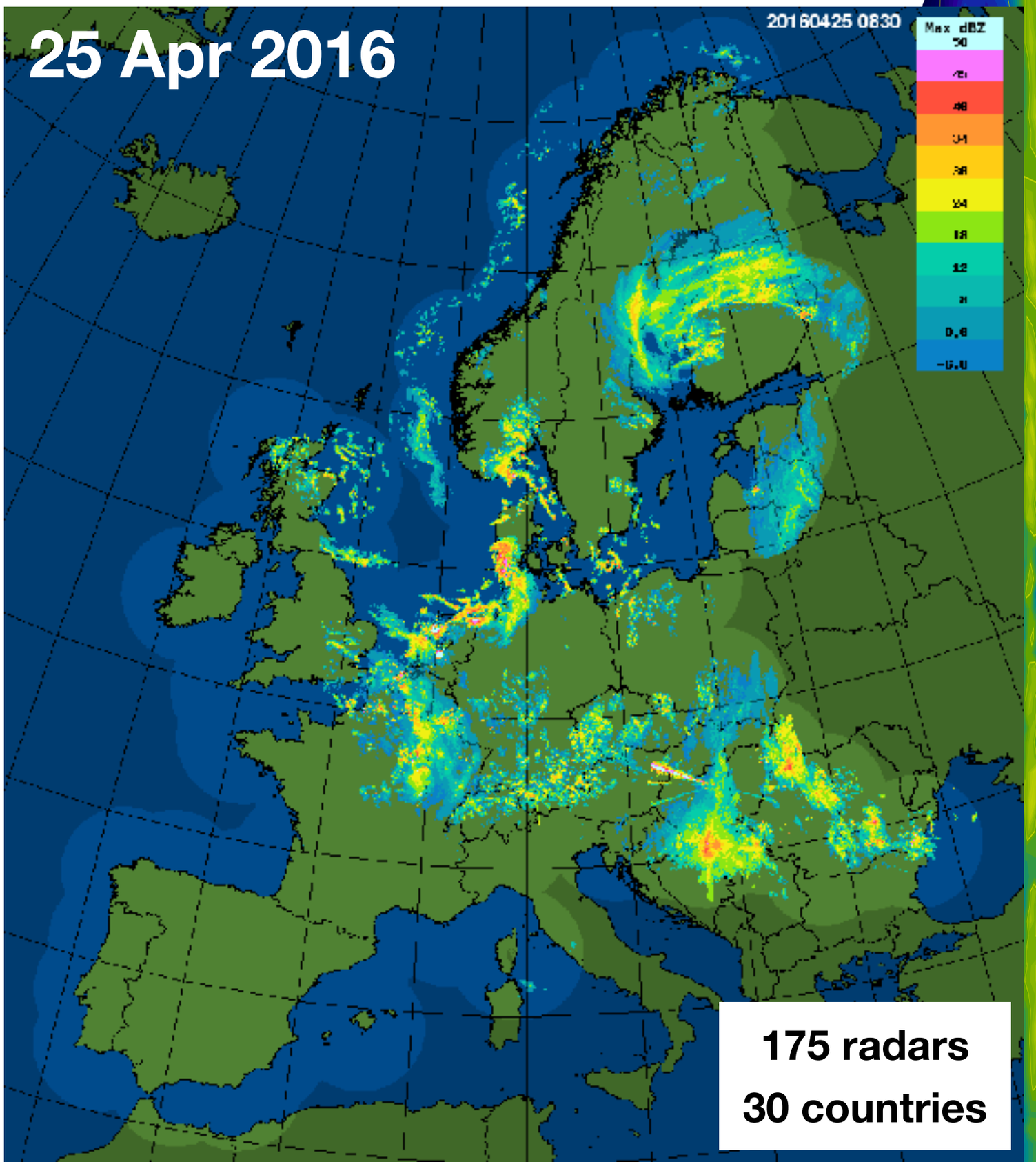
Marc Berenguer

with contributions from Carles Corral, Shinju Park, Josias Ritter, Daniel Sempere-Torres and the TAMIR & EDERA teams

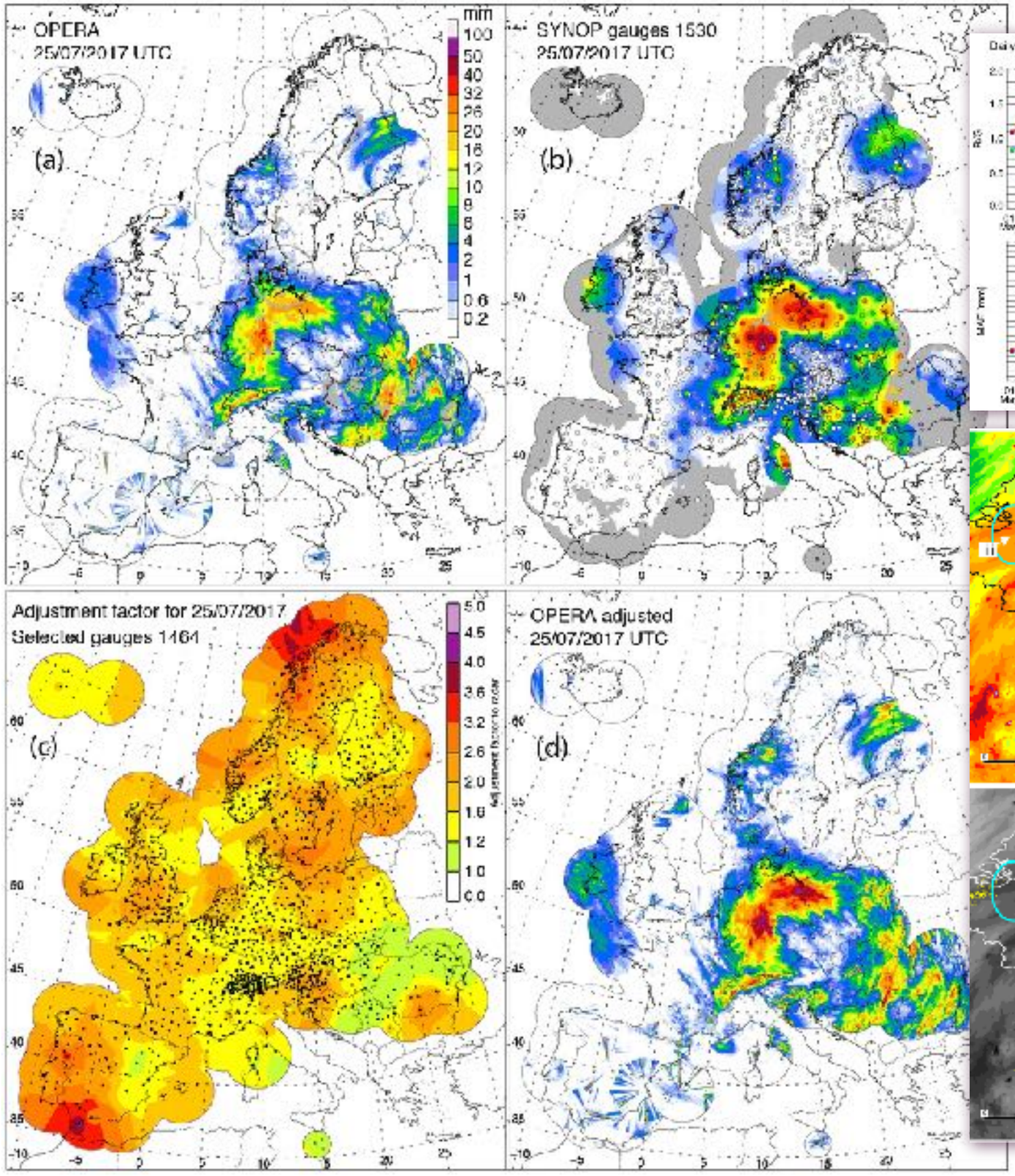


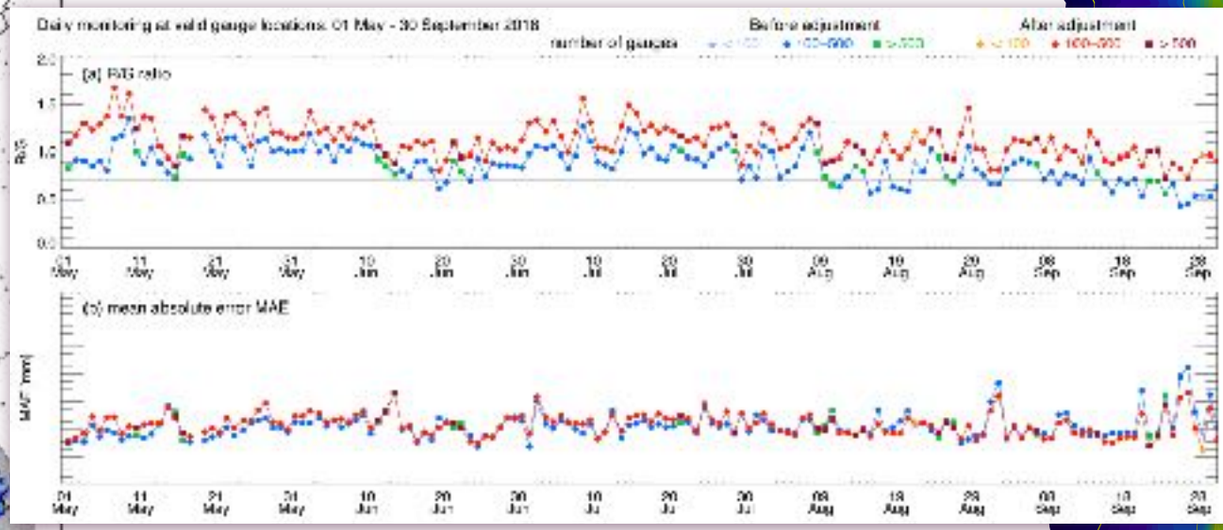
OPERA radar mosaics

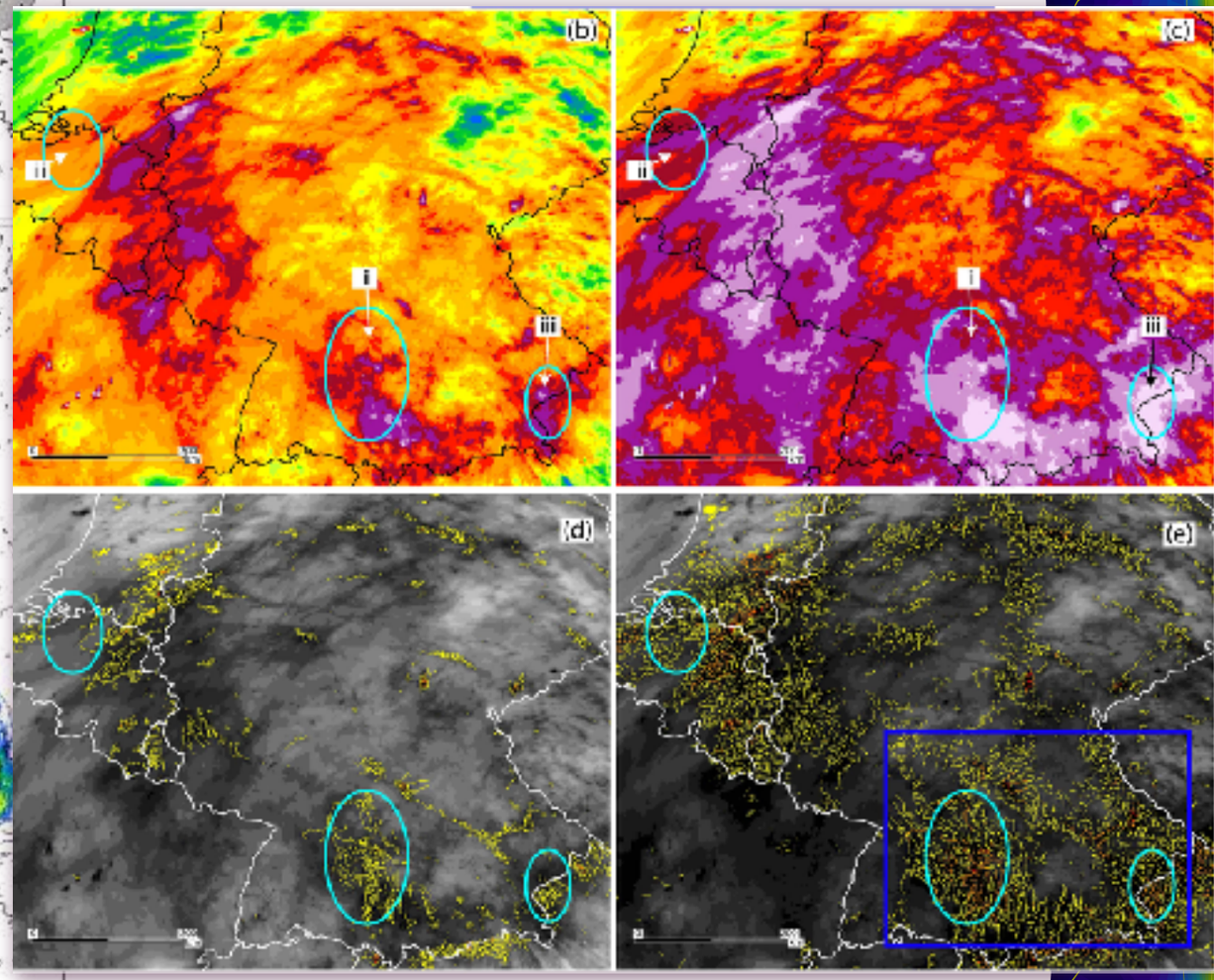
- Precipitation observations over Europe @2 km and every 15 minutes.
- Operationally produced since mid 2011.
- Available < t+15 min.
- Delivered products:
  - +Rainfall intensity
  - +dBZmax
  - +Hourly accumulation



OPERA QPE

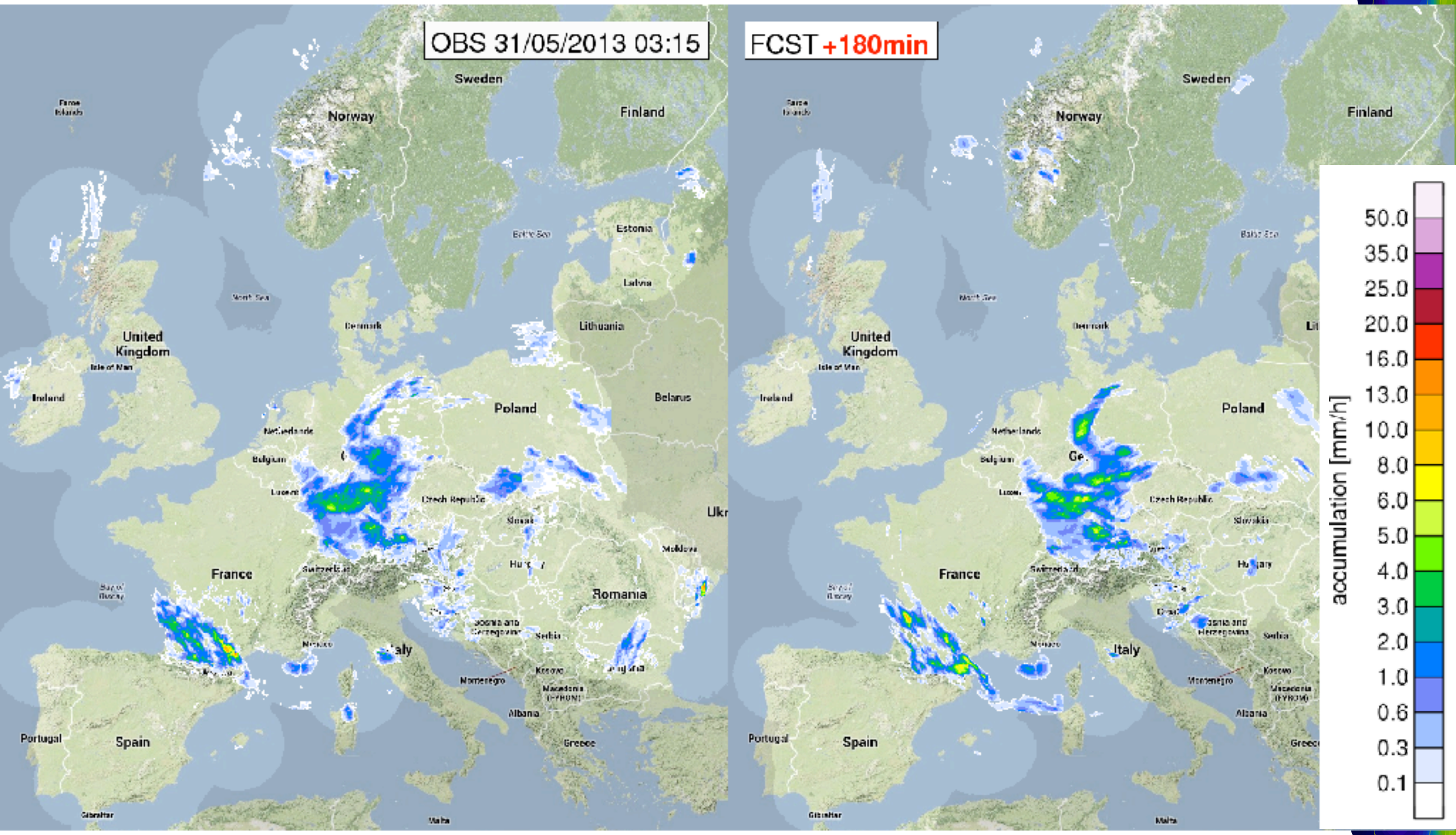






Park, S., Berenguer, M., Sempere-Torres, D., 2019: Long-term analysis of gauge-adjusted radar rainfall accumulations at European scale. Journal of Hydrology,573, 768-777.

Forecasted rainfall accumulations

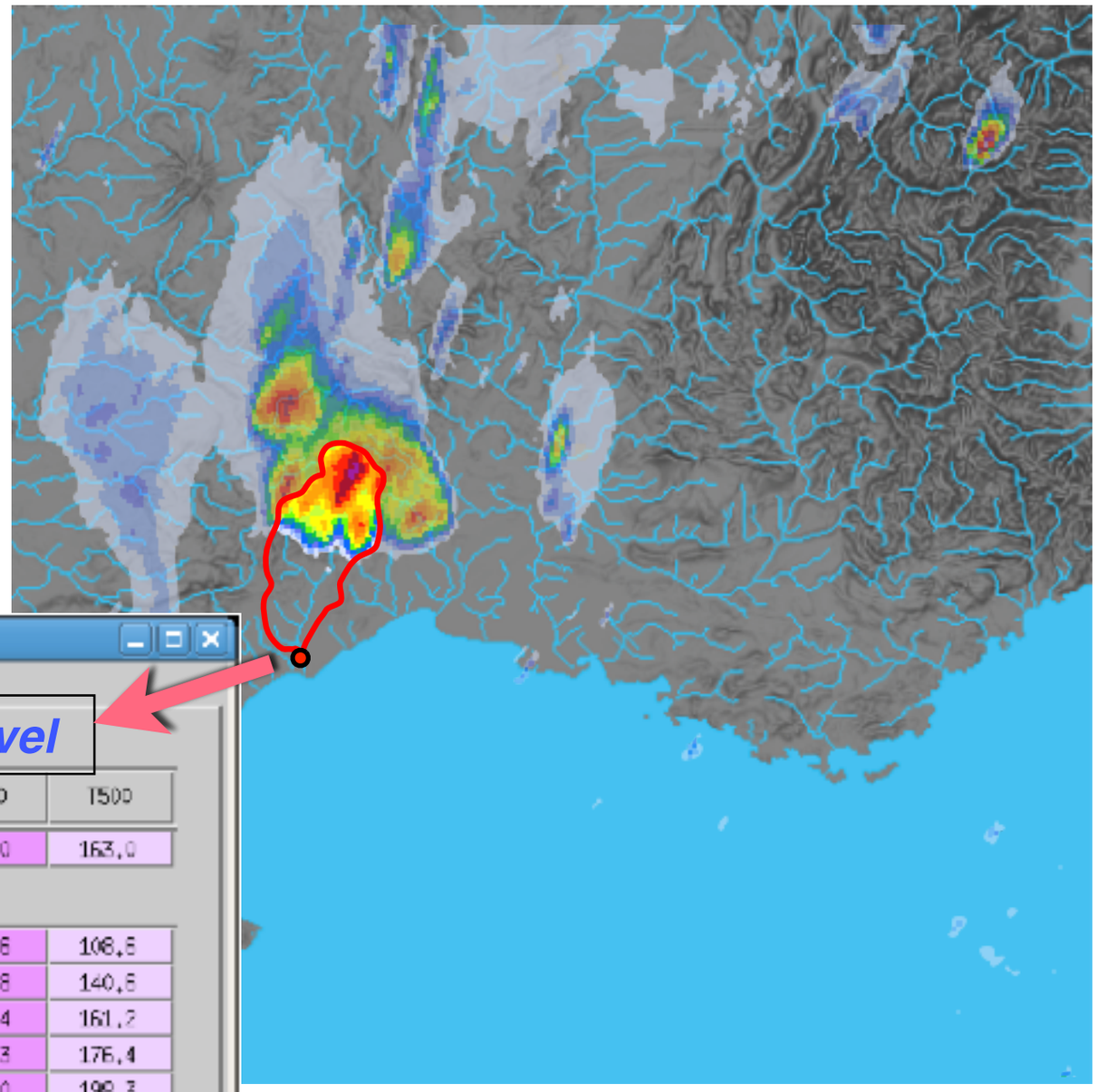


ERICHA flash flood hazard indicator

Based on observations & nowcasts of **basin-aggregated rainfall** at each point of the drainage network.

Drainage network (@ 1km)





Finestra stats 426, 4600

ACC30 | Cabal | Grafica IDF | Taula IDF

Hazard level

	T2	T5	T10	T25	T50	T100	T200	T500
30m	41,3	59,2	72,9	90,8	106,6	122,4	139,0	163,0

Taula IDF (mm)

1h	27,5	39,4	48,6	60,5	71,0	81,6	92,6	108,8
2h	35,6	51,0	62,9	78,3	91,9	105,6	119,8	140,8
3h	40,8	58,5	72,1	89,8	105,4	121,0	137,4	161,2
4h	44,6	64,0	78,9	98,2	[illegible]	132,5	150,3	176,4
6h	50,2	72,0	88,7	110,4	129,7	148,9	169,0	198,3
12h	59,7	85,5	105,4	131,2	[illegible]	177,0	200,8	235,6
24h	68,3	97,9	120,6	150,2	176,4	202,6	229,9	269,7

Coordenades de punt (425.5,4600.5) km

Duration

Accum Rainfall thresholds

accumulated over the the basin (1-24 hours)

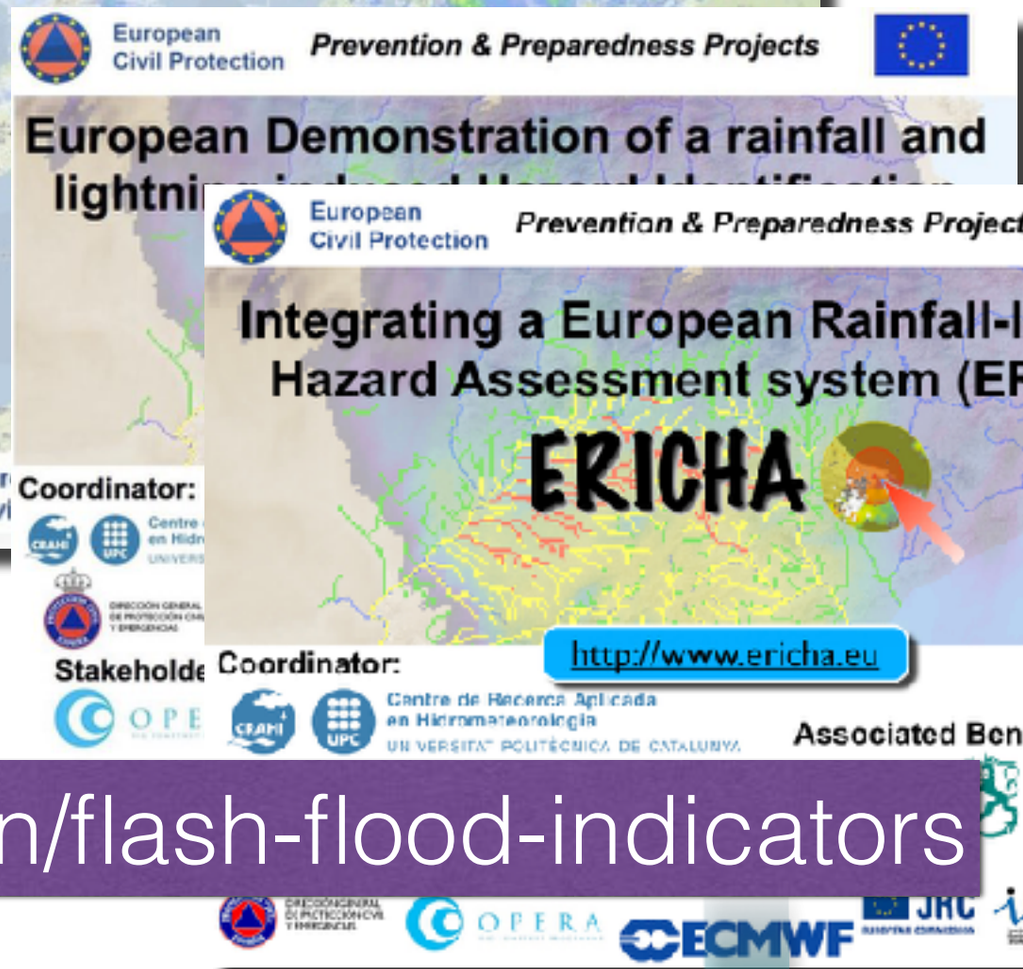
2008: FF-EWS operational at the Catalan Water Agency

2009-2012



2012-2017





https://www.efas.eu/en/flash-flood-indicators

EPIC
(now ERIC)
Index of Flash Flood Hazard into EUROPEAN FLOOD AWARENESS SYSTEM (EFAS)

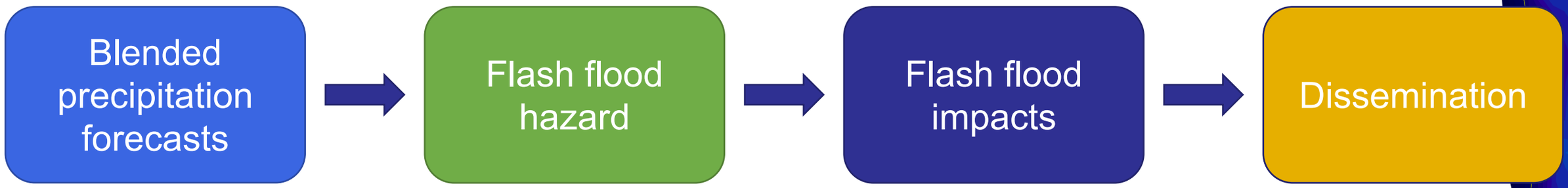
BASED ON EPS

Flash Flood Hazard BASED ON OPERA in EFAS

BASED ON RADAR

Flash flood forecasting system in TAMIR

- Forecasts hourly over the 1 - km river network for the first 6 hours, and every 6 hours afterwards up to next 5 days
- Updated once per hour



- Created by seamless blending of the probabilistic radar-based nowcasting and Numerical Weather Prediction forecasts.
- The blending technique is applied for the first 6 hours.

- Precipitation forecasts are accumulated on a 1km channel network.
- Accumulated values are compared to thresholds derived from radar and model climatology.

- Flash flood hazard forecasts are combined with exposure information to highlight areas at risk of high impacts.

- The products are distributed as showcase tools through EFAS since Oct 2022

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CRAHI UPC Centre de Recerca Aplicada en Hidrometeorologia
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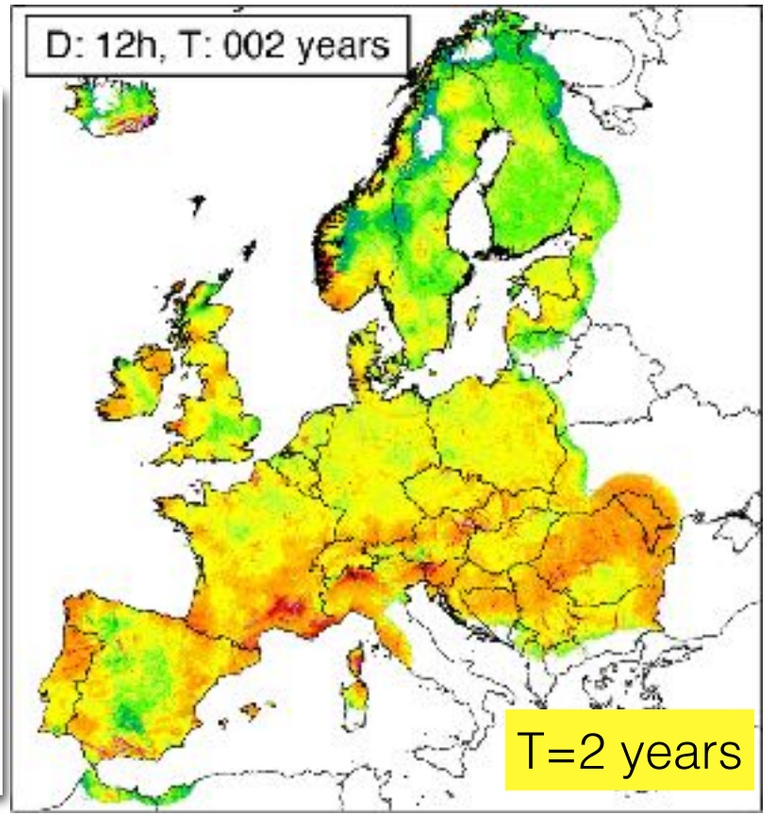
ECMWF

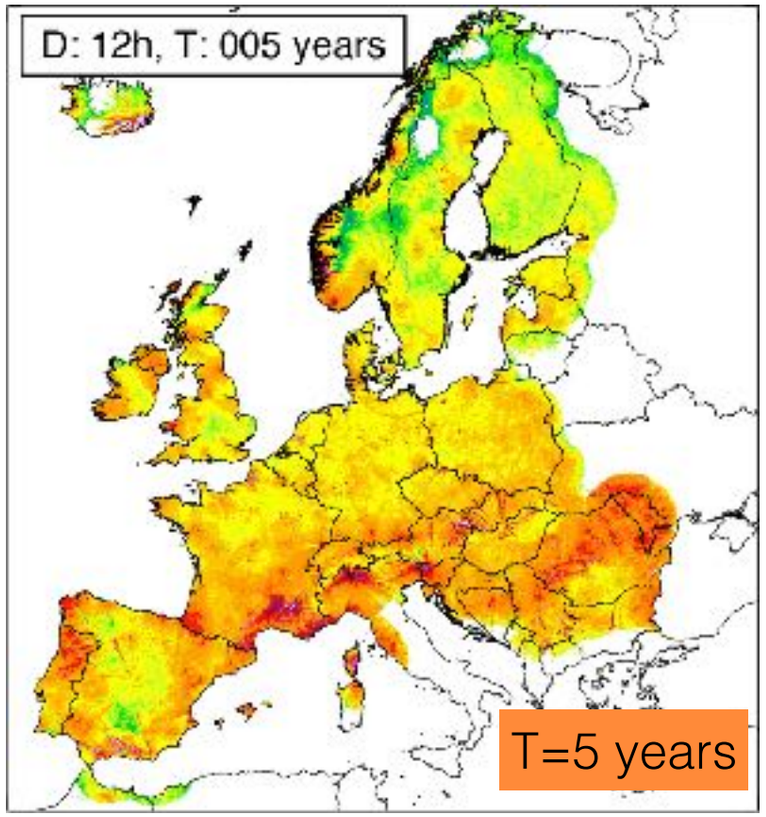
KYMPE

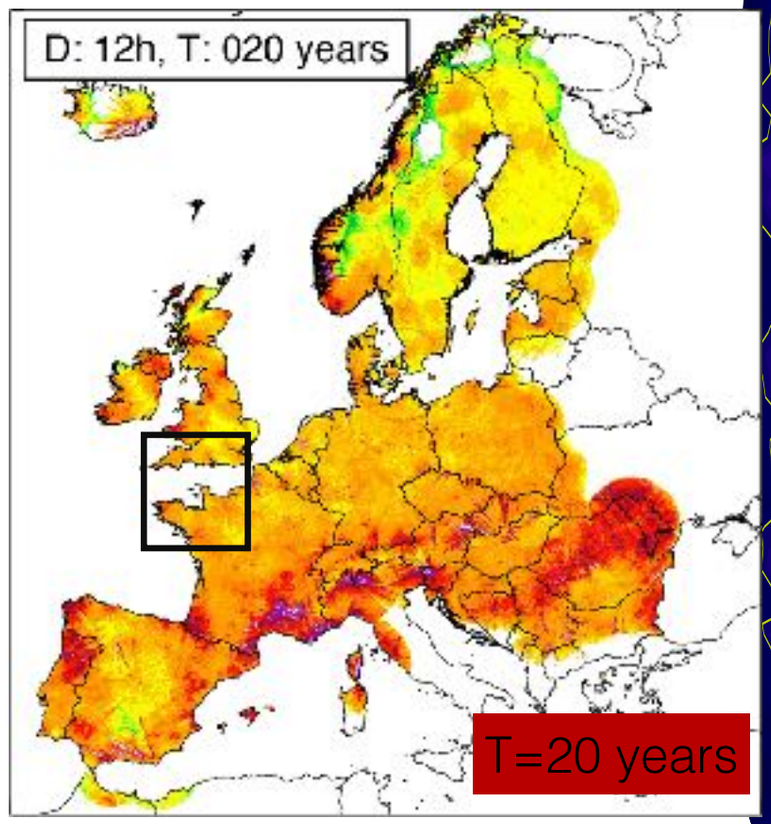
ERICHA flash flood hazard indicator

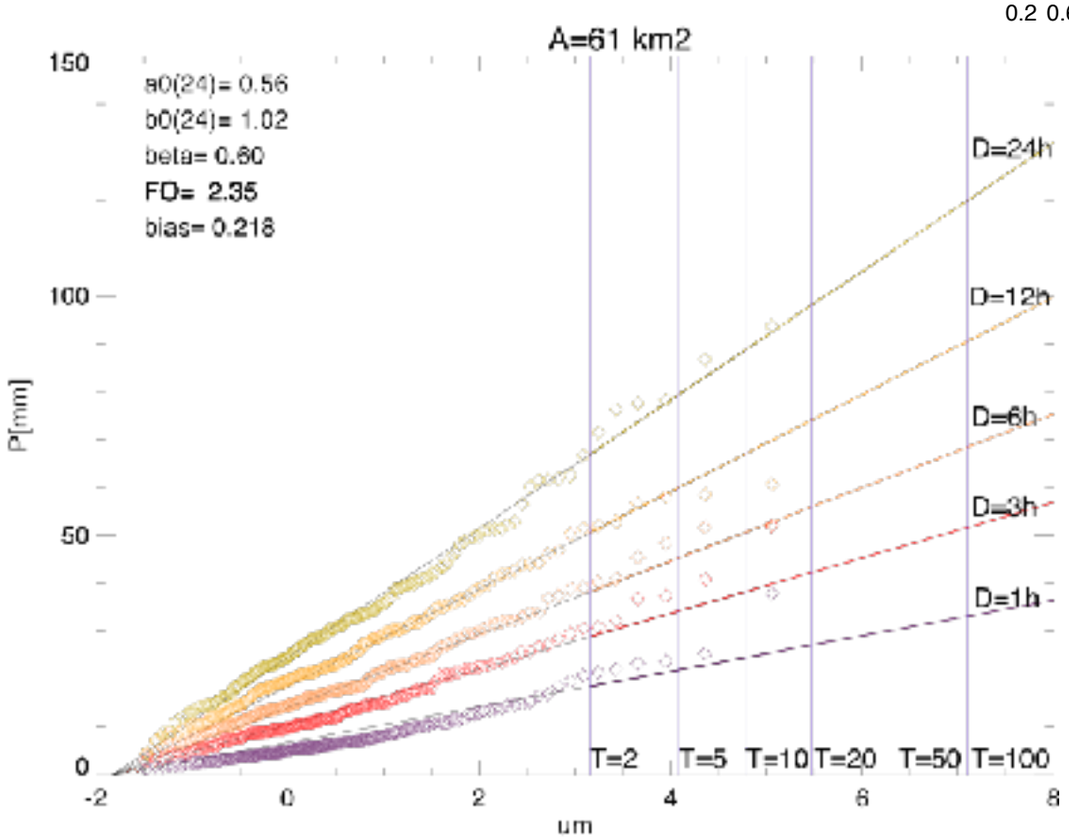
From the available OPERA accumulations

12-h accumulations



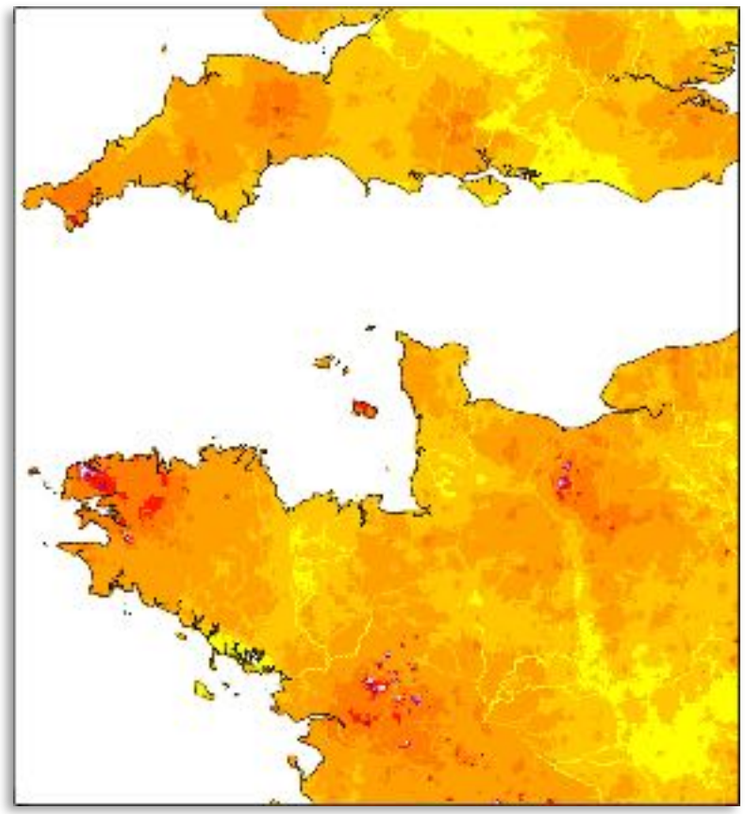






$$I_d \overset{\text{dist}}{=} \left(\frac{d}{D}\right)^{-\beta} I_D$$

(d=1,3,6, 12, 24 h)

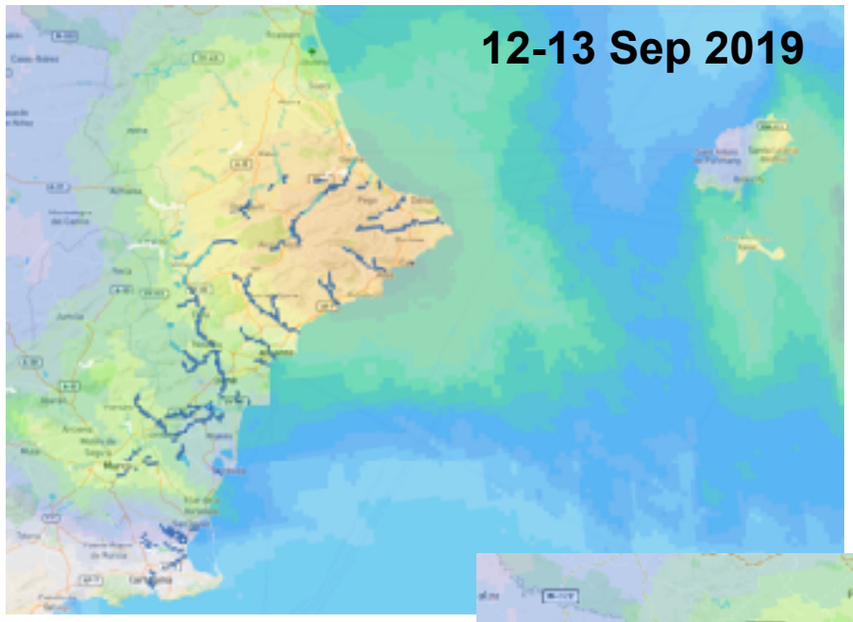


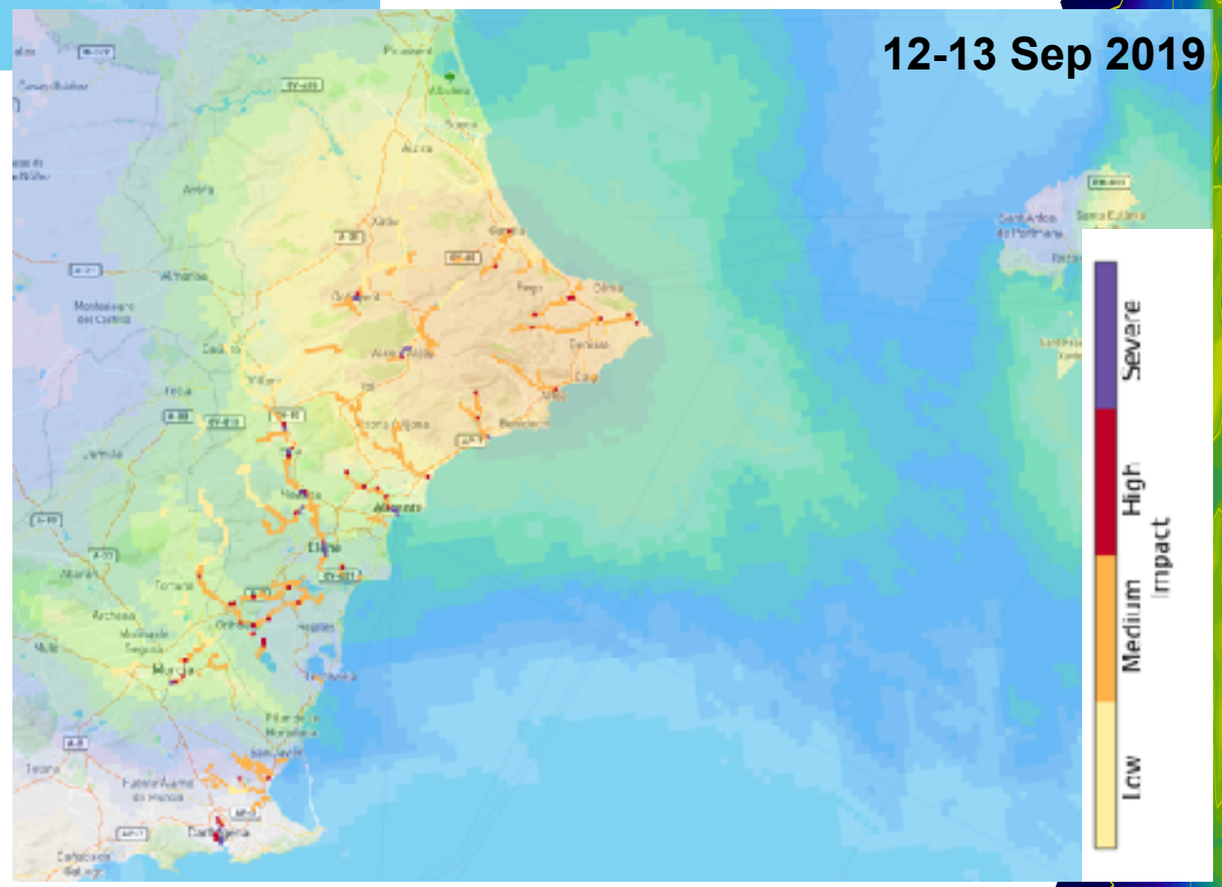
From hazard to impacts

The flash flood impact level forecasted for the upcoming 5 days.

$$Impact = Hazard * Exposure$$



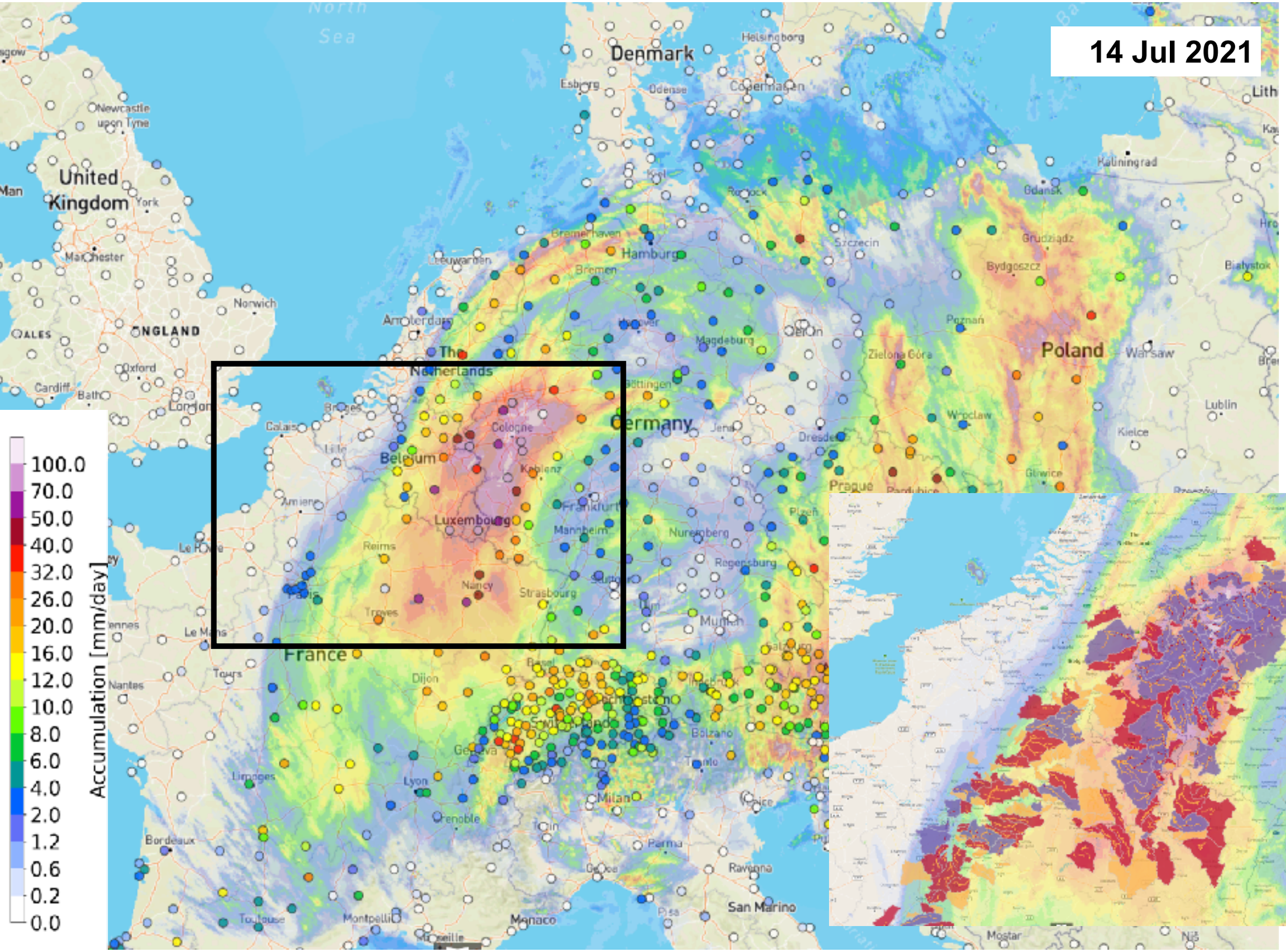




Combined Exposure

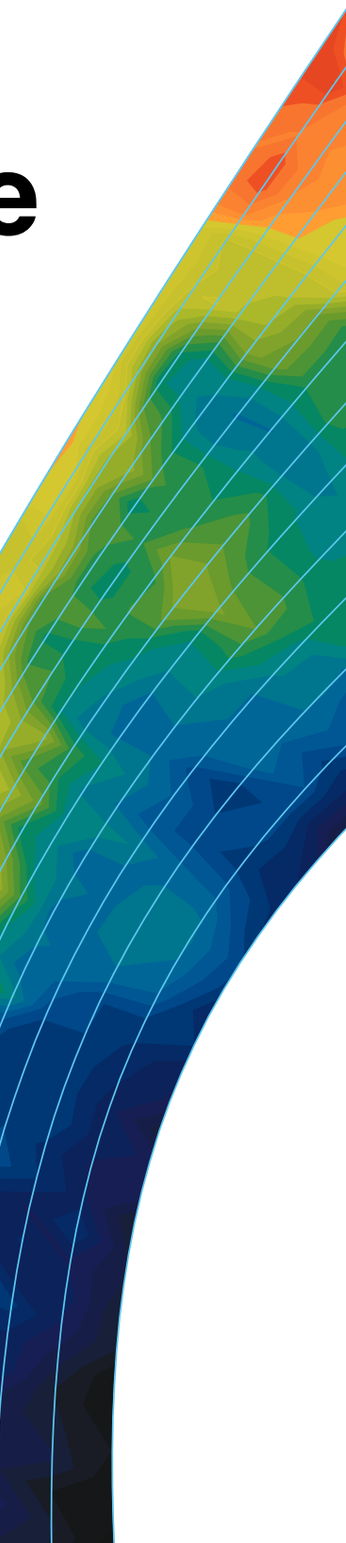
probability	Low Exposure	Medium Exposure	High Exposure	
High Likelihood				Severe
Medium Likelihood				High
Low Likelihood				Medium
				Low

Example cases on TAMIR-platform



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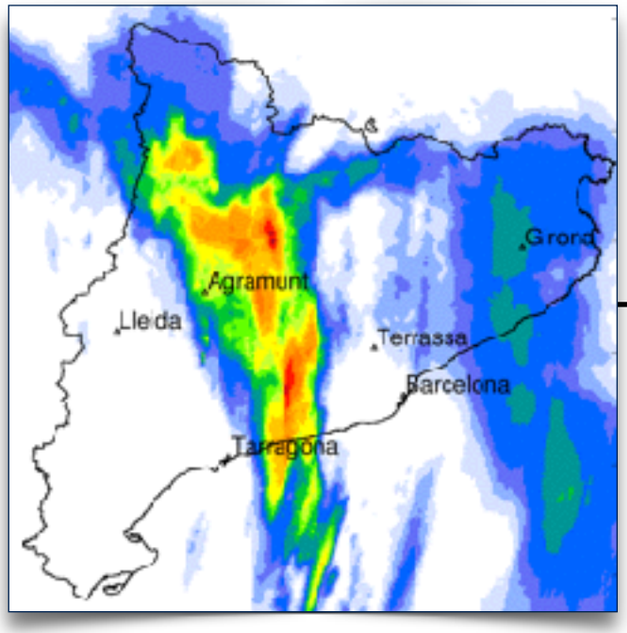
Impact assessment at regional scale



Ritter, J., Berenguer, M., Corral, C., Park, S., Sempere-Torres, D. (2020) Environment International 136, 105375.

From hazard to impact

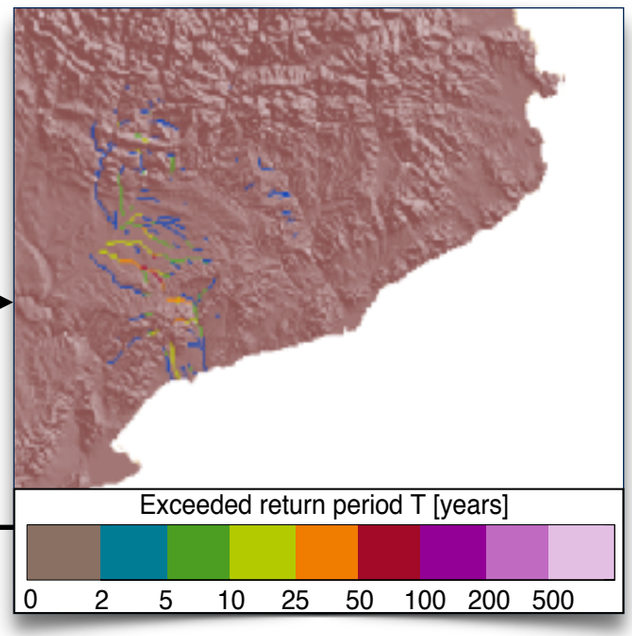
High-resolution rainfall obs & nowcsts



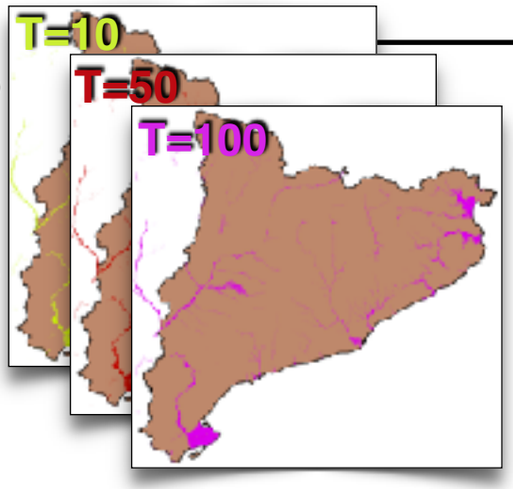
Rainfall thresholds

Hazard module

ERICHA FF index

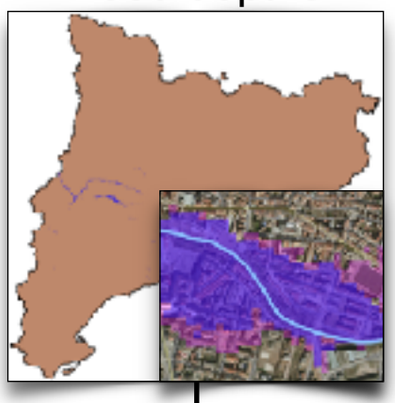


Flood maps catalogue

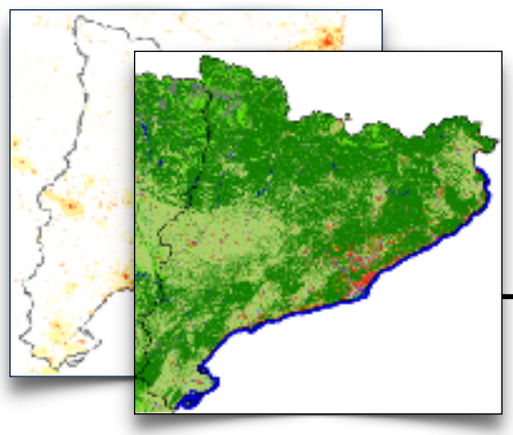


Flood map module

Flood depths

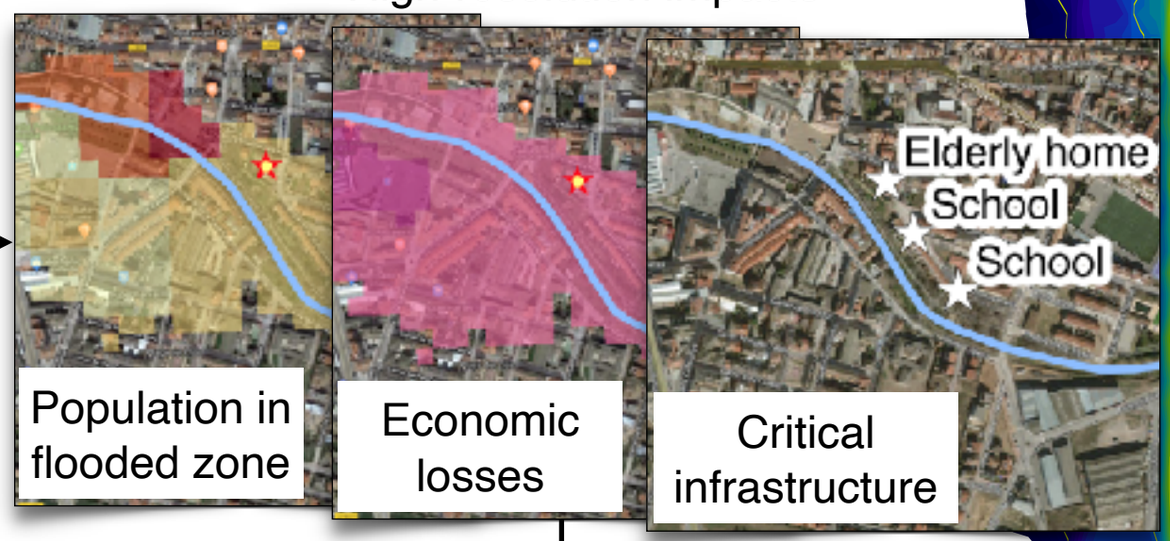


Exp. & Vulnerability

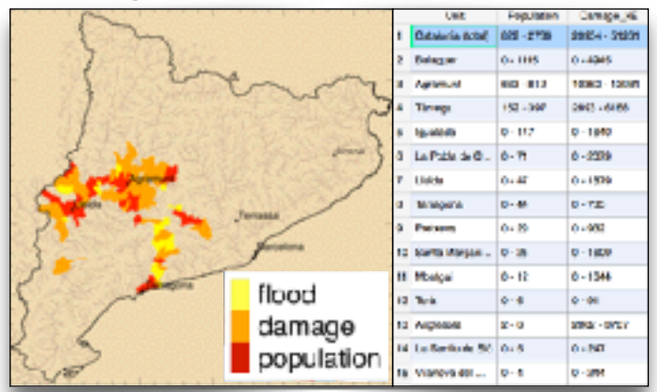


Impact assessment module

High-resolution impacts



Regional Impact summary



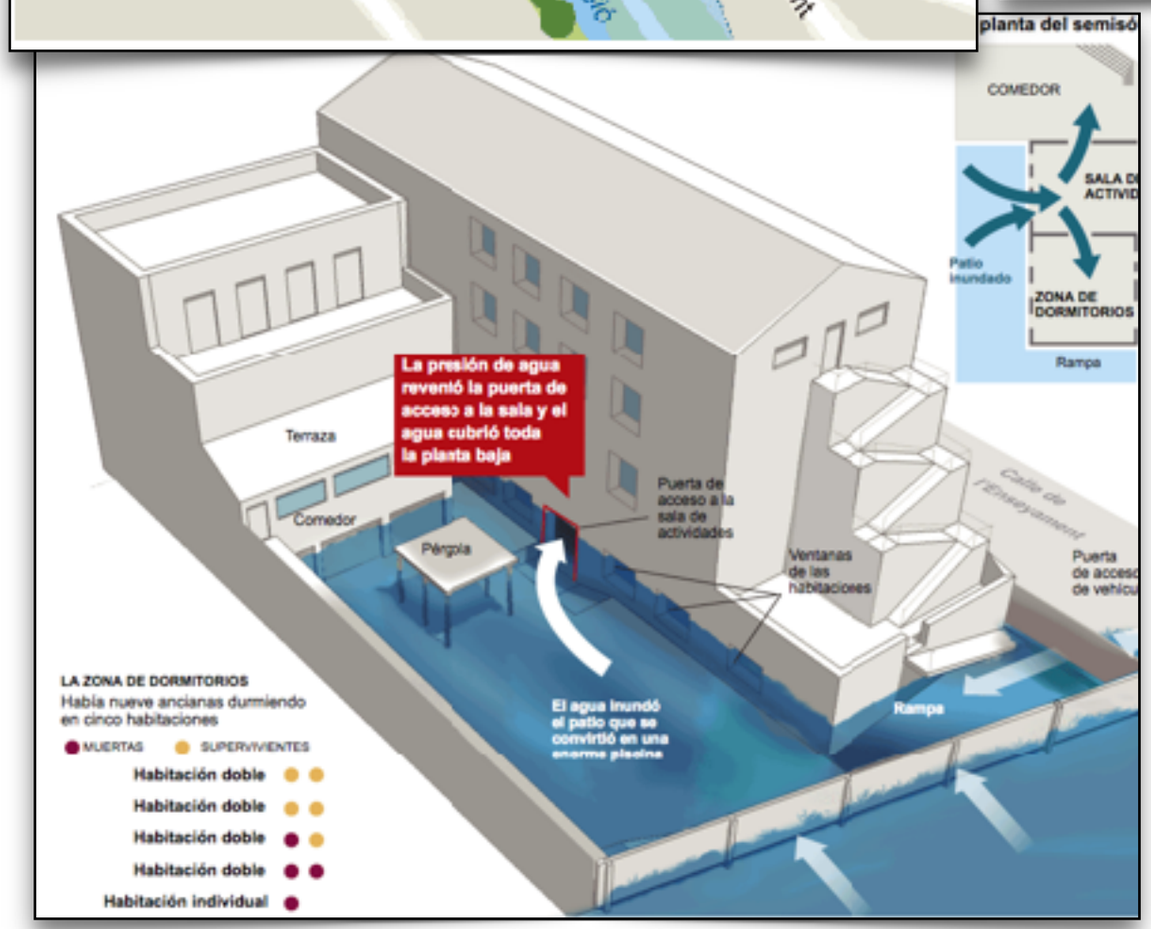
Case Study (Agramunt 02-03 Nov 2015)





Source: El Imparcial (2015)

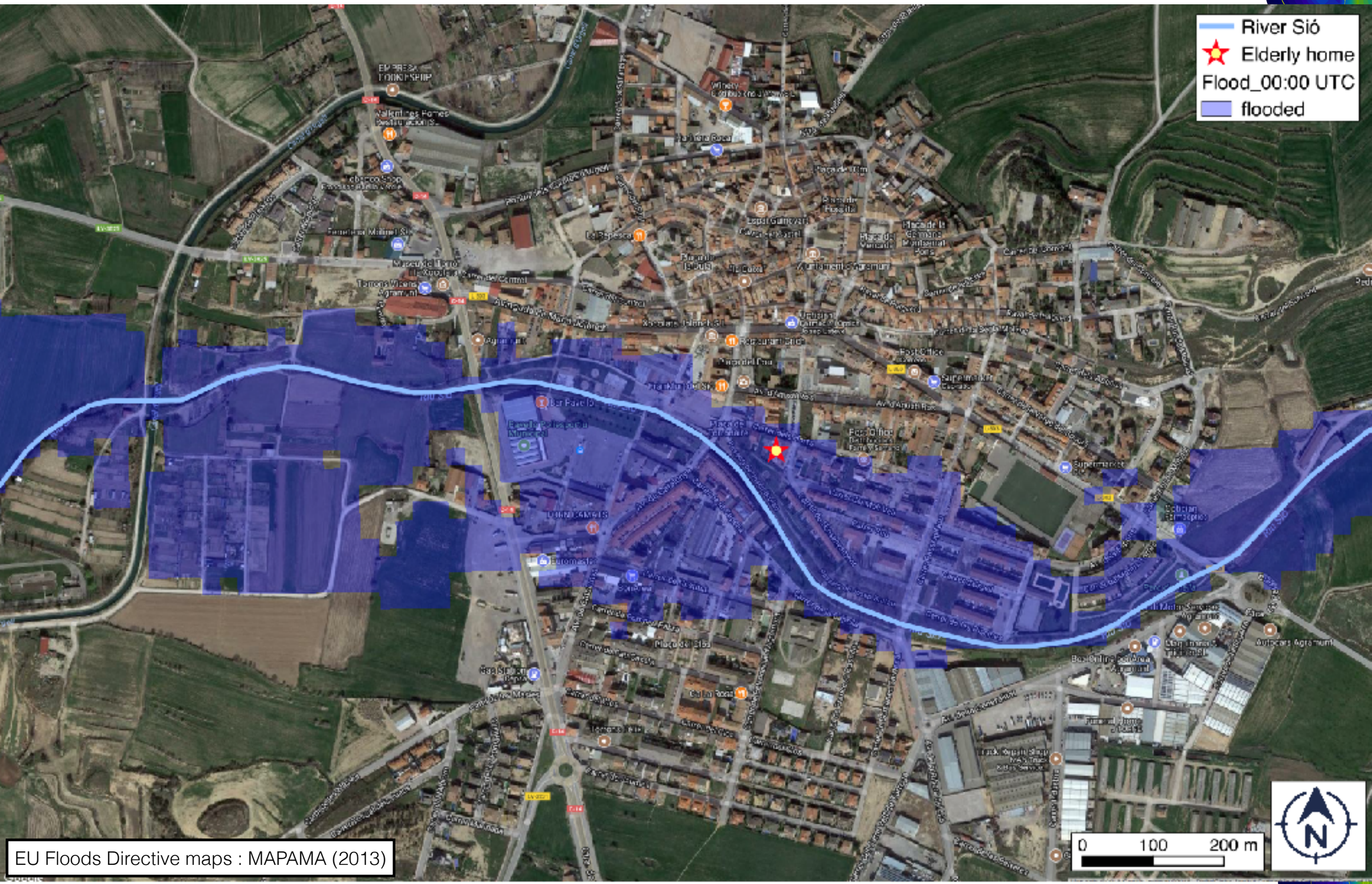




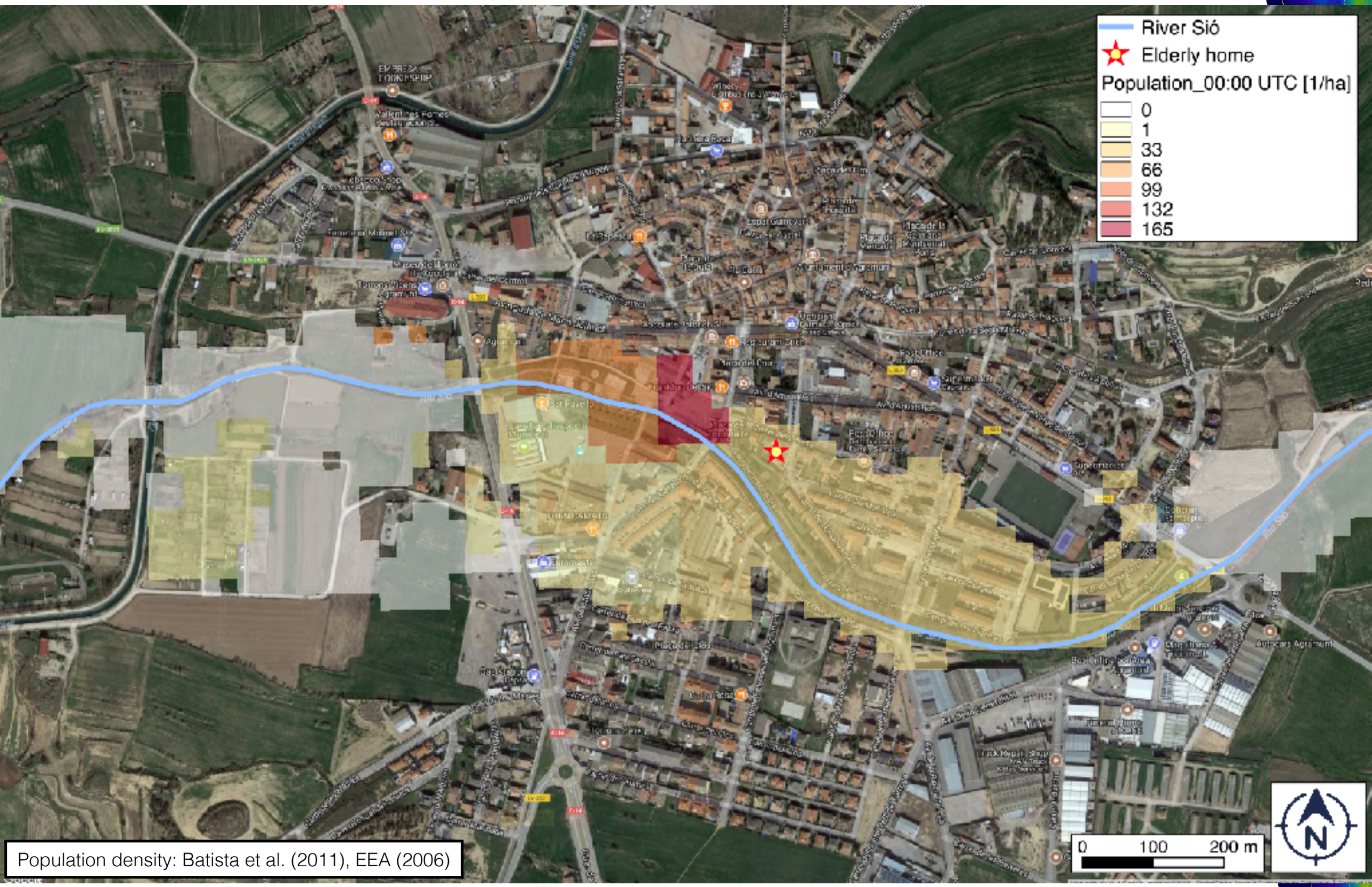
Source: El Periodico (2015)

- Impacts:
  - 5 casualties
  - Significant economic damage
- Emergency management:
  - 02:21 UTC:
    High water levels reported 10 km upstream
  - 03:00 UTC:
    River starts to flood parts of the town
  - 03:03 UTC:
    Elderly home informed by fire brigades
  - 03:05 UTC:
    112 call, too late to evacuate basement

Inundation extent 00:00 UTC

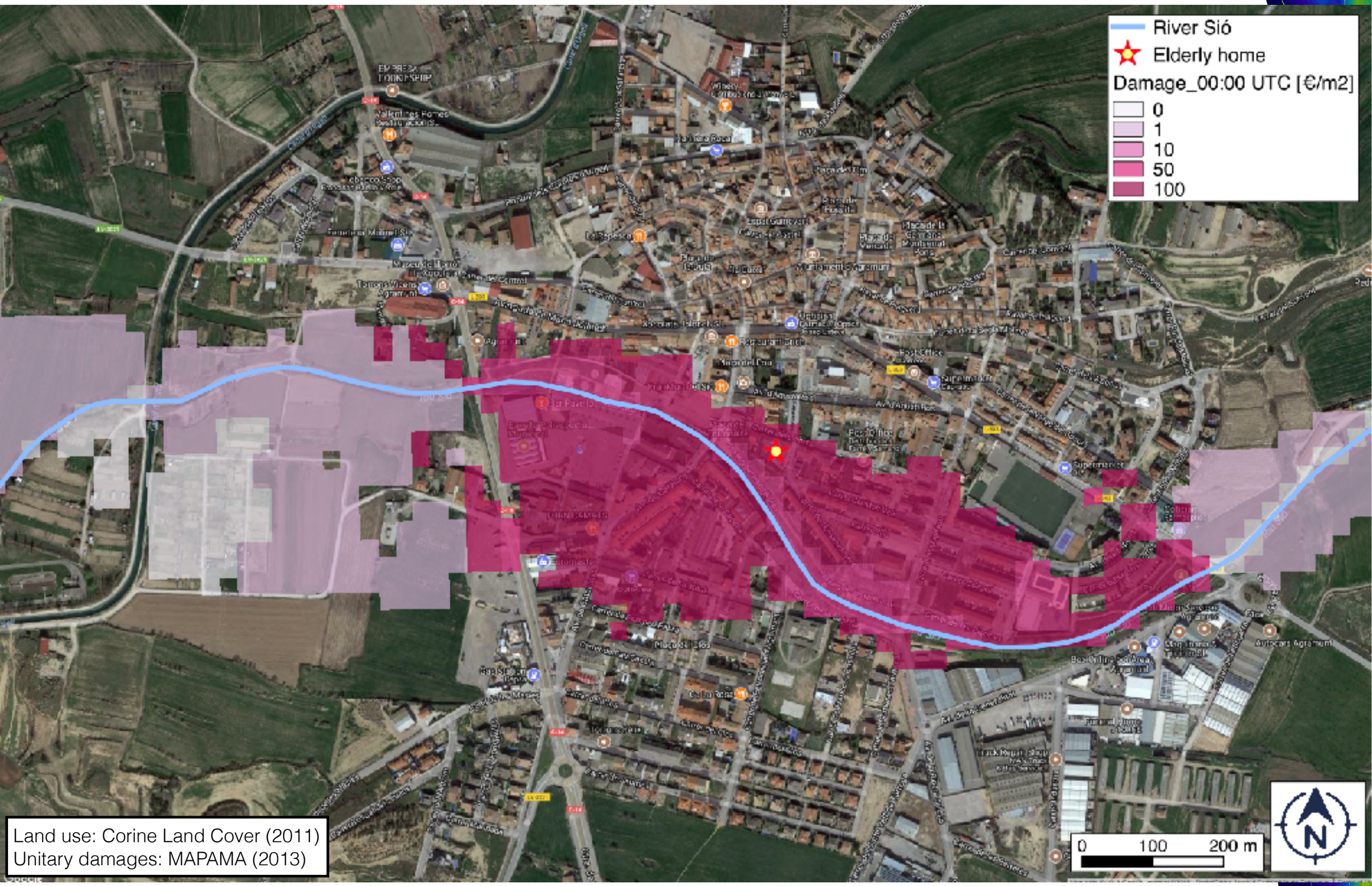


Population in flood zone 0000 UTC

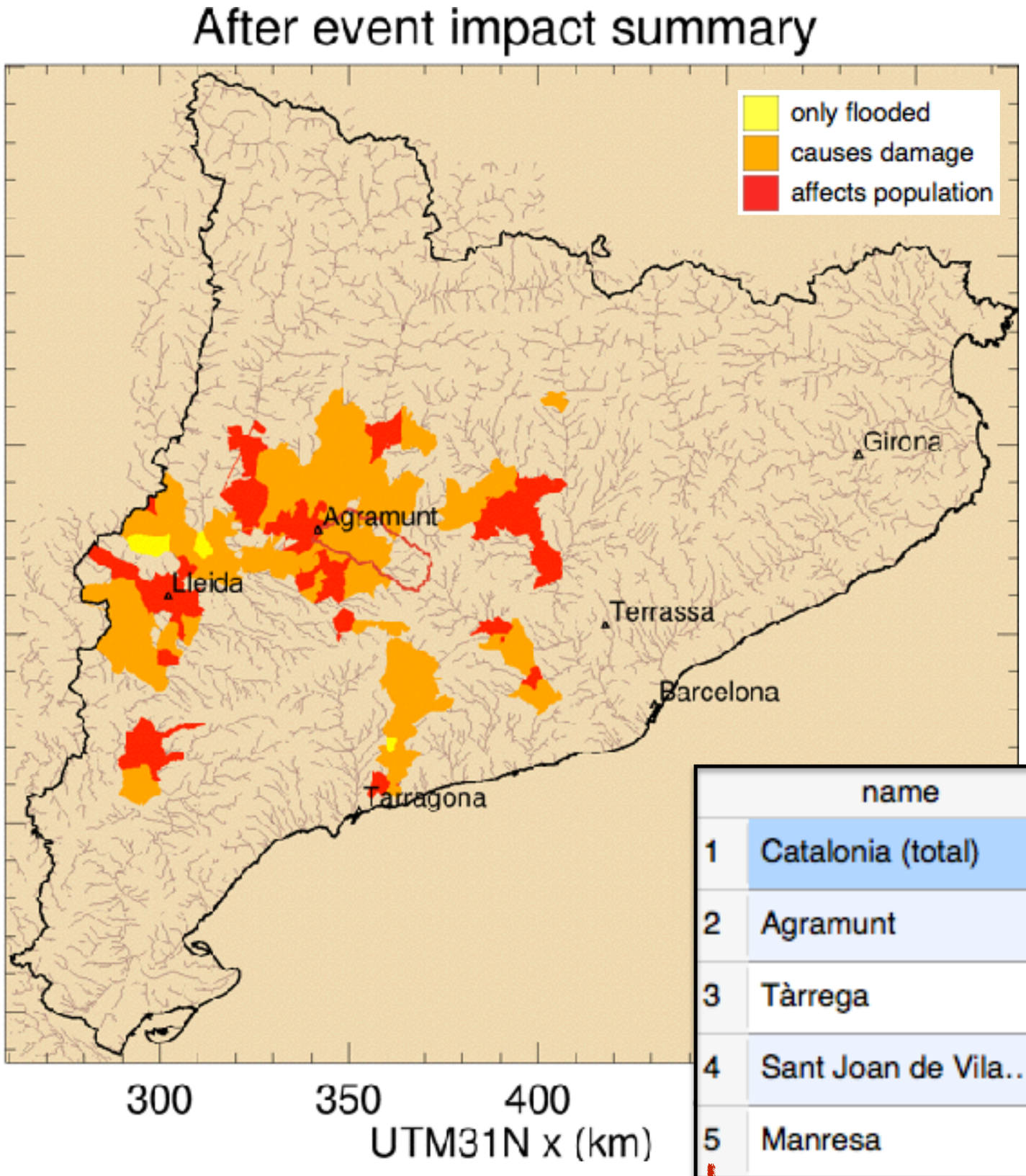


Population density: Batista et al. (2011), EEA (2006)

Economic damage 0000 UTC



Impact summary - After event validation



Reported damages in Agramunt

- 421.000 € in ***public*** infrastructure
- ca. 50 ***private*** houses
- ca. 50 destroyed cars

- 2 schools
- 1 elderly home

Sources: LleidaDiari, Nova Tàrrega (2015)

Work in progress:
- Damage overestimation
- Missing infrastructure layers

Modelled damages in Agramunt

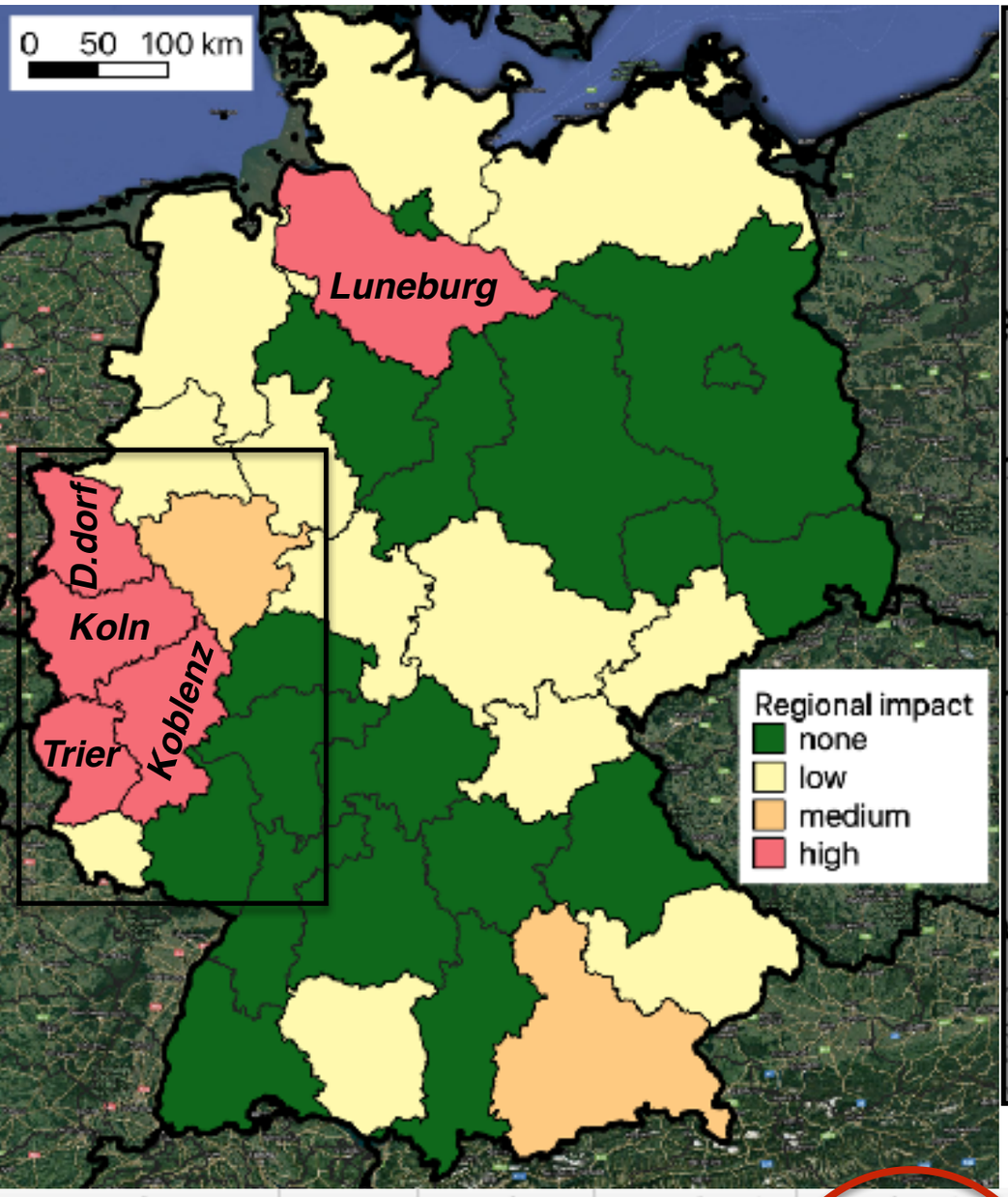
- 20 M € in Agramunt

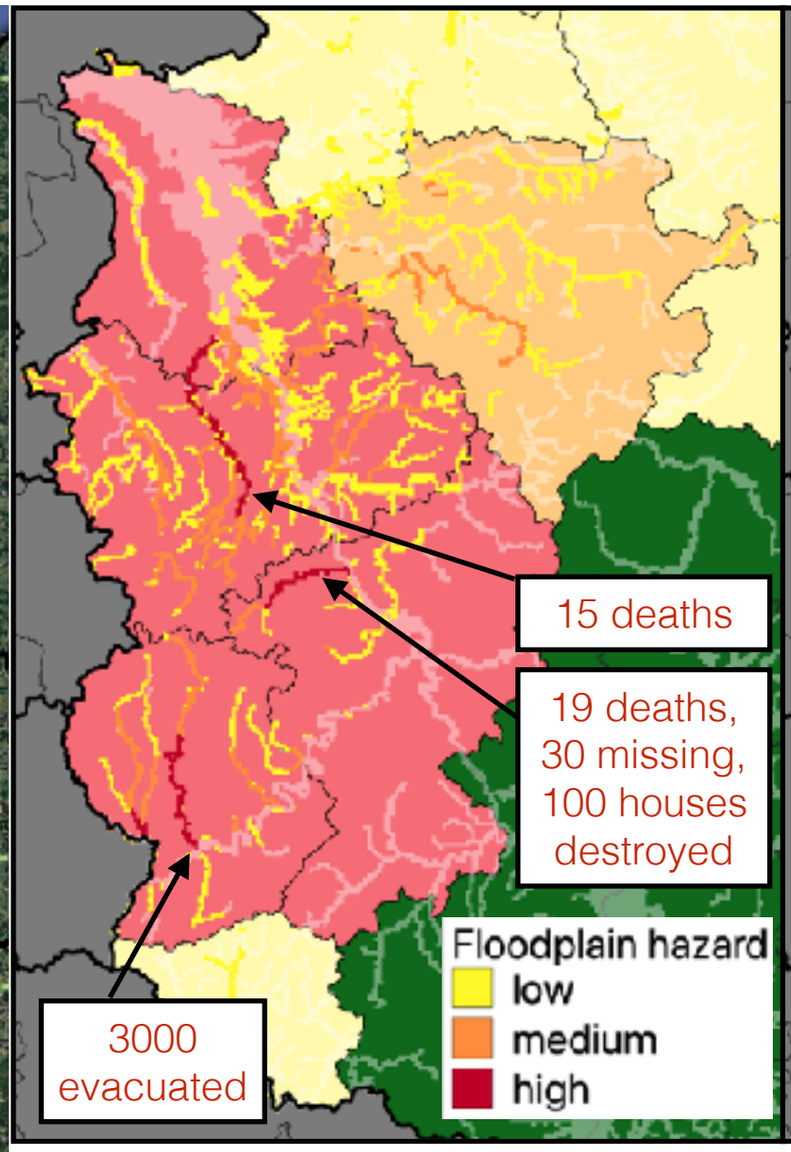
- 2 schools

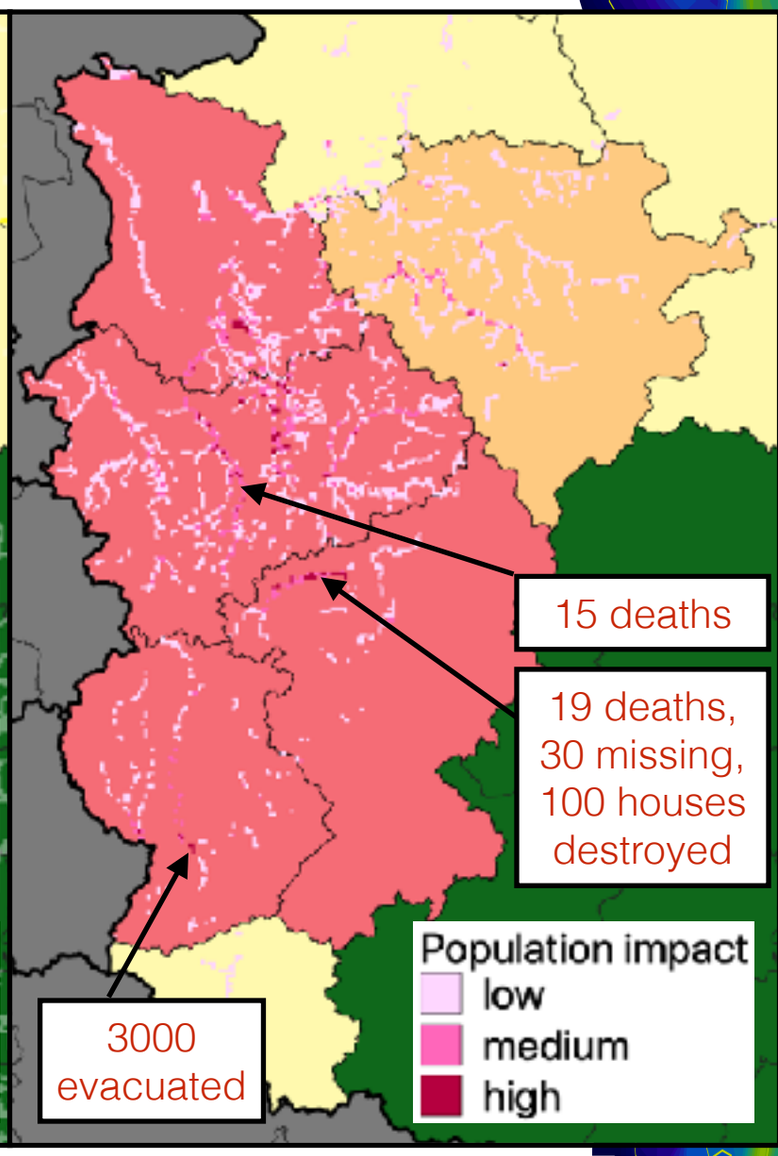
	name	popul_imp	damage_EUR	crit_infr
1	Catalonia (total)	1405	134701266	3 School;
2	Agramunt	663	19816561	2 School;
3	Tàrrega	152	5018438	
4	Sant Joan de Vila…	125	1942630	
5	Manresa	90	5896189	

98 Municipalities in total

Central Europe Jul 2021







Population exposed to high hazard

region	country	pop_haz1	pop_haz2	pop_haz3	ci_haz1	ci_haz2	ci_haz3
Koblenz	DEU	20176	573	5745	22 EF, 16 HF, 8 MG,		3 EF, 4 HF,
Trier	DEU	6309	3842	4002	5 EF, 3 HF, 2 MG,	4 EF, 1 HF,	13 EF, 1 MG,
Koln	DEU	197586	133113	3525	94 EF, 31 HF, 23 MG,	42 EF, 22 HF, 22 MG,	4 EF, 2 MG,
Dusseldorf	DEU	227203	93252	360	130 EF, 34 HF, 50 MG,	72 EF, 28 HF, 48 MG,	

Ritter, J., Berenguer, M., Park, S., Sempere-Torres, D., 2021: ReAFFINE: Real-time Assessment of Flash Flood Impacts at pan-European scale, Journal of Hydrology, 603, 127022.

EDERA
Early warning Demonstration of pan-European rainfall-induced impact forecasts

European Union
Civil Protection and Humanitarian Aid

EDERA: Early warning Demonstration of pan-European rainfall-induced impact forecasts

UCPM-2022-PP

www.edera-project.eu

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Agencia de Medio Ambiente y Agua de Andalucía
Consejería de Agricultura, Pesca, Agua y Desarrollo Rural
Consejería de Sostenibilidad, Medio Ambiente y Economía Azul

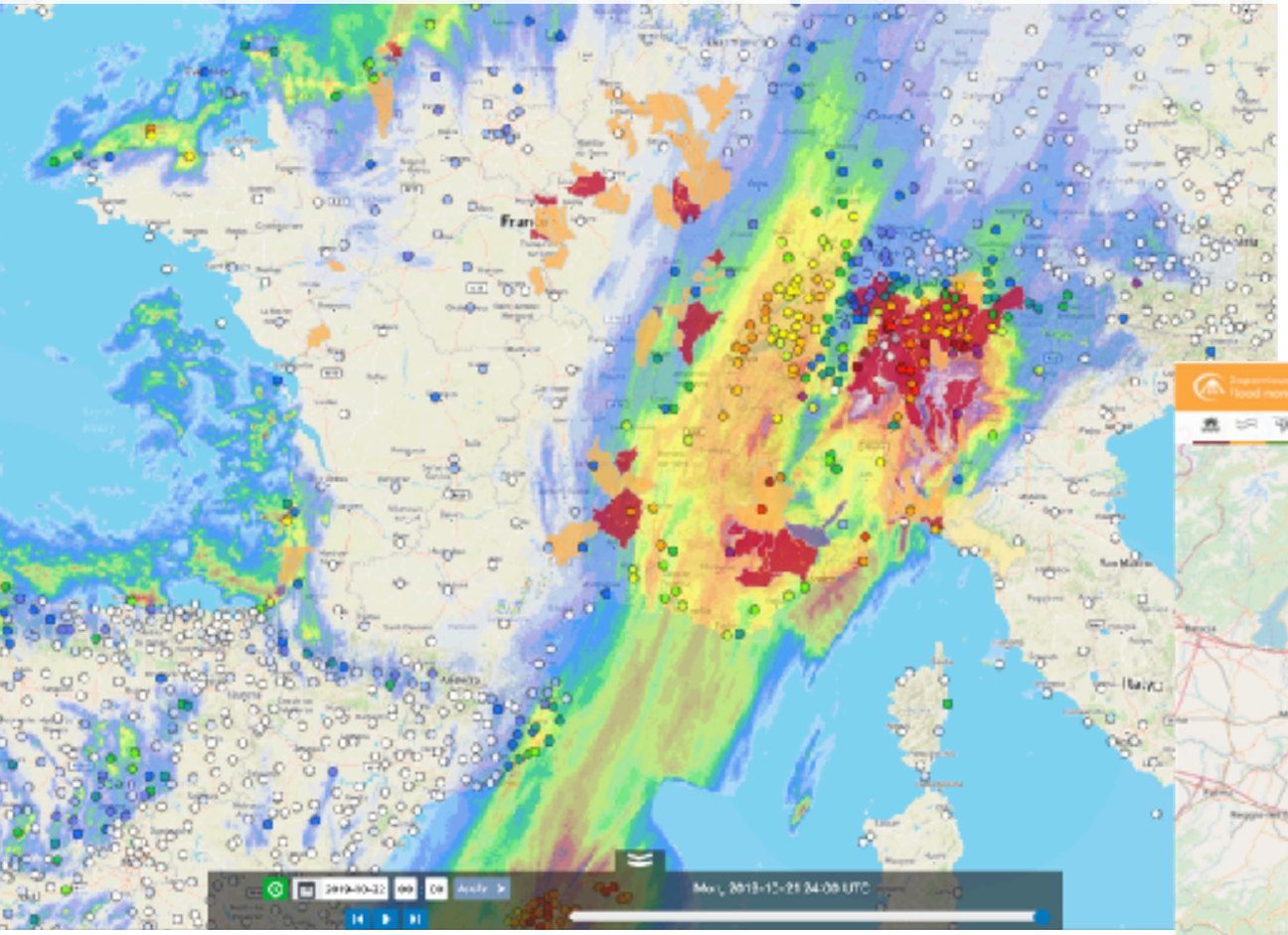
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Main objective

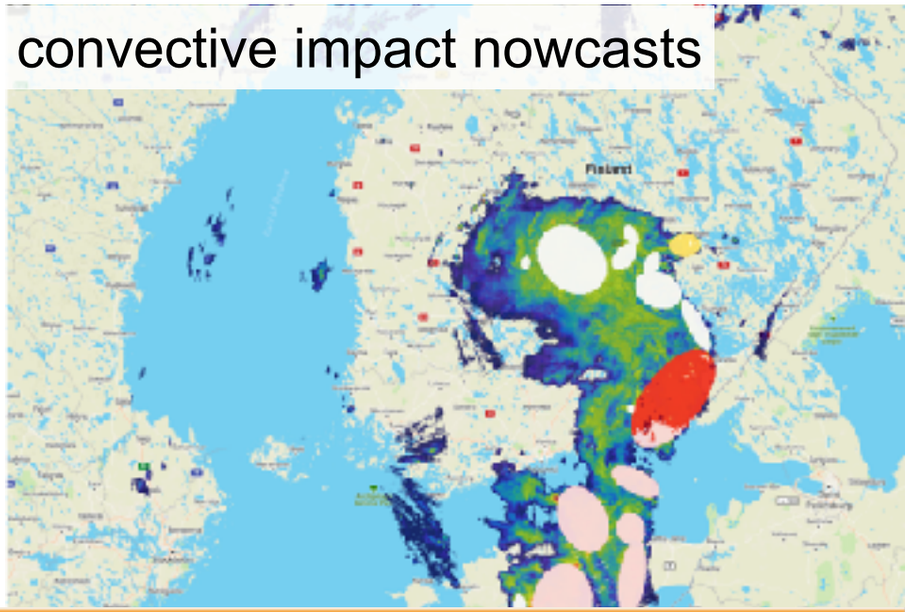
Integrating the TAMIR FF impact products into the operational EWSs of national, regional and local CPAs, fostering sharing information and cooperation of CPAs during cross-border events and coordination between CPAs.

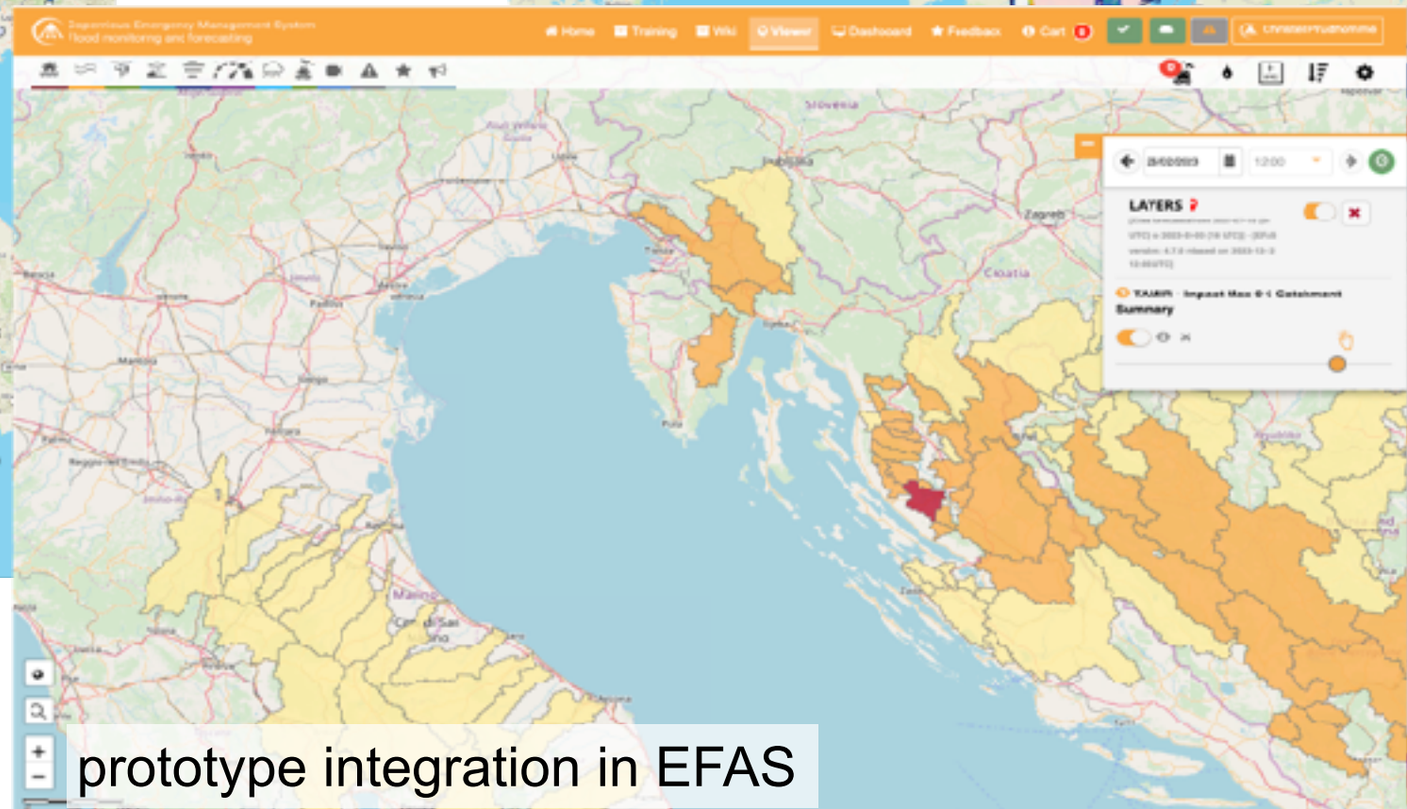
TAMIR products

Real-time pan-European FF impact forecasts (0-120 h).



convective impact nowcasts





prototype integration in EFAS

EDERA

Specific objectives and expected outputs

- **Extend the convective hazard and pluvial flood forecasts over Europe.**
- **Increase the adaptability of the flood impact forecasts to the needs of the end users**, applying an improved strategy for improved impact forecasting, and implement configurable user-defined notifications.

→ *Improved products for flood impact forecasting at European scale*

- **Integrate the flood impact forecasts to the EWS platforms of the end users** for improved preparedness and response management during flood events.
- **Demonstrate the added value of seamless flood impact forecasts through a robust evaluation**, at European scale and in two pilot sites, with end-users analysing the added value for CPAs cooperation in cross-border operations and coordination.

→ *Demonstration for a period of 15 months*

→ *Recommendations for coordination and cross-border cooperation between CPAs*

- **Develop comprehensive guidance material** delivered through dedicated training workshops and e-learning materials.
- **Integrate the developments within the CEMS-Floods EFAS system.**

→ *Sustainability of the products*

EDERA

EDERA demonstration

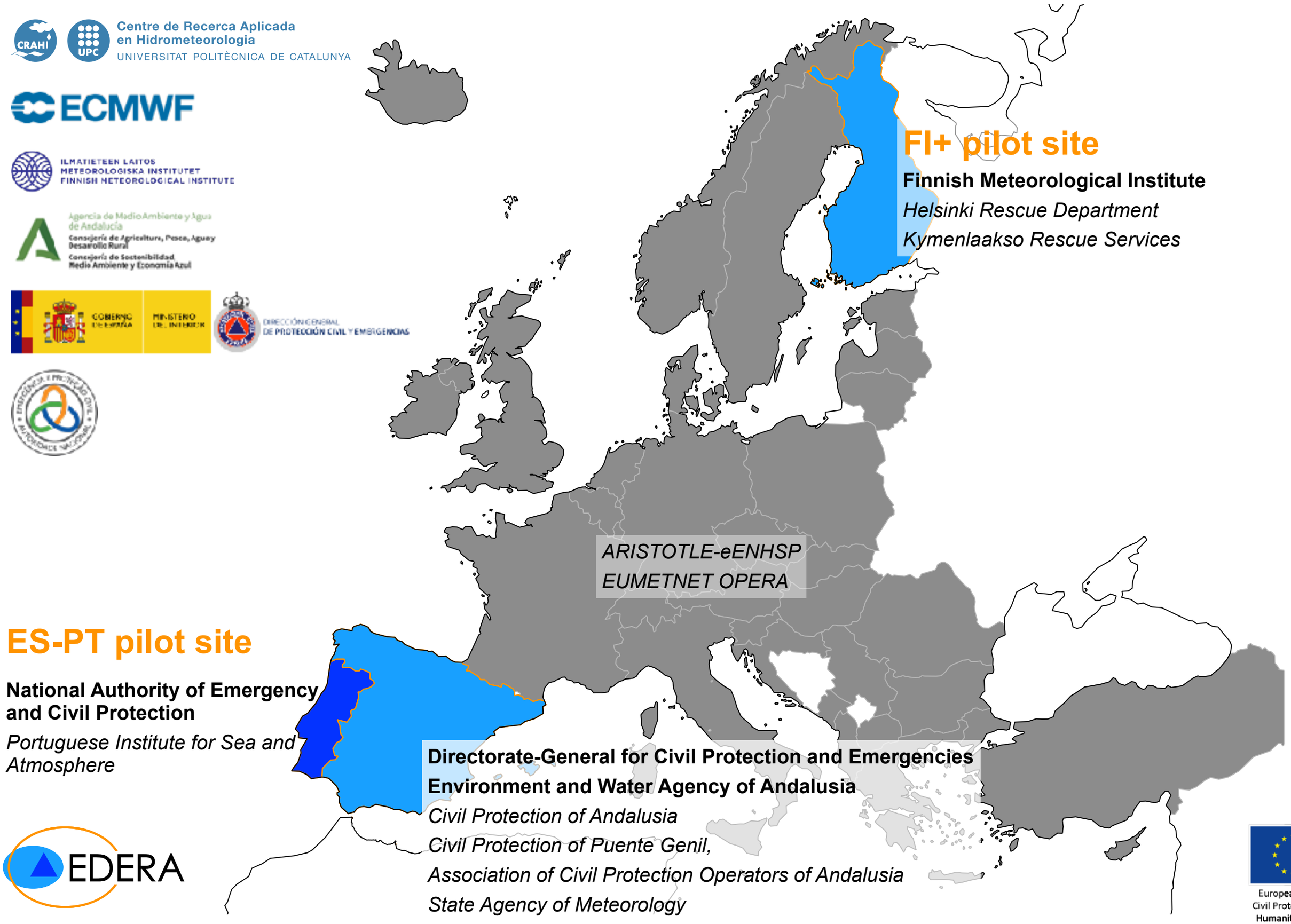
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DIRECCIÓN GENERAL DE PROTECCIÓN CIVIL Y EMERGENCIAS



FI+ pilot site

Finnish Meteorological Institute
Helsinki Rescue Department
Kymenlaakso Rescue Services

ARISTOTLE-eENHSP
EUMETNET OPERA

ES-PT pilot site

National Authority of Emergency and Civil Protection
Portuguese Institute for Sea and Atmosphere

Directorate-General for Civil Protection and Emergencies
Environment and Water Agency of Andalusia
Civil Protection of Andalusia
Civil Protection of Puente Genil,
Association of Civil Protection Operators of Andalusia
State Agency of Meteorology

EDERA

European Union
Civil Protection and Humanitarian Aid

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ANYWHERE

Thank you!

Flash flood forecasting
some results from EU projects

