



**Centre de Recerca Aplicada en Hidrometeorologia**  
UNIVERSITAT POLITÈCNICA DE CATALUNYA

# Rapid flash flood impact assessments at different spatial scales

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# Motivation

- **WHAT:**

Improve the decision support for emergency services during flash floods

- **HOW:**

Automatically translate existing flash flood hazard forecasts (e.g. streamflow) into the expected socio-economic impacts (e.g. population affected)

- **WHY:**

Impact forecasting enables more objective and rapid decisions  
—> more effective emergency response

- **CHALLENGE:**

End-users operating at different spatial scales require different kinds of real-time information

- **SOLUTION:**

Provide context-specific impact forecasts for the different spatial scales (regional vs. continental)



# Requirements of end-users operating at different spatial scales

Spatial scale

| End-user group            | Primary Tasks                                                                          | Required real-time information                                  | Available Methods                                                                                                                                                                                                      |
|---------------------------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Regional authorities      | Location-specific measures (e.g. evacuations, road closures)                           | Quantitative impact estimates in high spatiotemporal resolution | <b>ReAFFIRM</b><br>Real-time Assessment of Flash Flood Impacts - a Regional high-resolution Method<br><br><i>Ritter et al. (2020)</i><br><i>Environment International</i>                                              |
| National authorities      | Coordinating regional authorities; Providing national resources (e.g. military troops) |                                                                 |                                                                                                                                                                                                                        |
| International authorities | Providing information (e.g. satellite images) and international resources              | Order-of-magnitude impact statements over large spatial domains | <b>ReAFFINE</b><br>Real-time Assessment of Flash Flood Impacts at pan-European scale<br><br><i>Ritter et al. (in review)</i><br>For a preprint, contact <a href="mailto:ritter@crahi.upc.edu">ritter@crahi.upc.edu</a> |

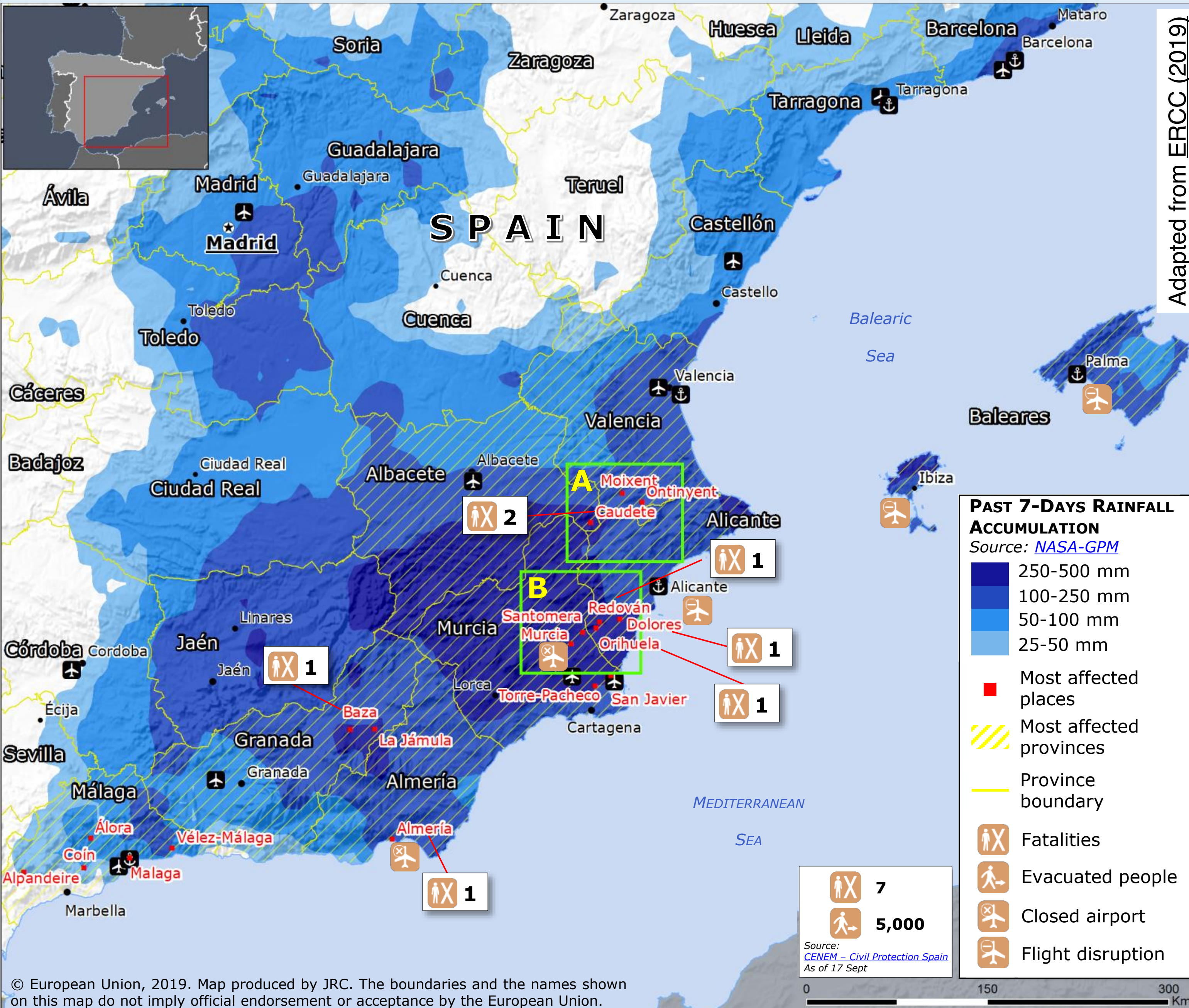
# Flash flood impact forecasts: ReAFFIRM and ReAFFINE

– Spatial scale +

| Characteristic                |                    | ReAFFIRM                                                                                | ReAFFINE                                                                                      |
|-------------------------------|--------------------|-----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Scope                         | Domain             | Regional (SE Spain; 62 000 km²)                                                         | pan-European                                                                                  |
|                               | Stream coverage    | 5 km² ≤ drainage area ≤ 2000 km²                                                        | 5 km² ≤ drainage area ≤ 2000 km²                                                              |
|                               | Rainfall input     | Radar nowcasting                                                                        | Radar nowcasting                                                                              |
| Flash flood hazard estimation | Base               | ERICHA system (regional; Corral et al., 2019)                                           | ERICHA system (Europe; Park et al., 2019)                                                     |
|                               | Spatial resolution | 200 m                                                                                   | 1000 m                                                                                        |
|                               | Hazard variable    | Return period                                                                           | Qualitative hazard level (low-mid-high)                                                       |
| Impact estimation             | Flood maps used    | Official maps (EU Floods Directive)                                                     | Official maps (EU Floods Directive)                                                           |
|                               | Impact categories  | Population in the flooded areas, economic losses [€], affected critical infrastructures | Population and critical infrastructures exposed to the hazard levels; Population impact level |
|                               | Resolution         | 25 m                                                                                    | 1000 m                                                                                        |
|                               | Aggregation level  | Municipalities                                                                          | Regions (NUTS 2 or 3)                                                                         |

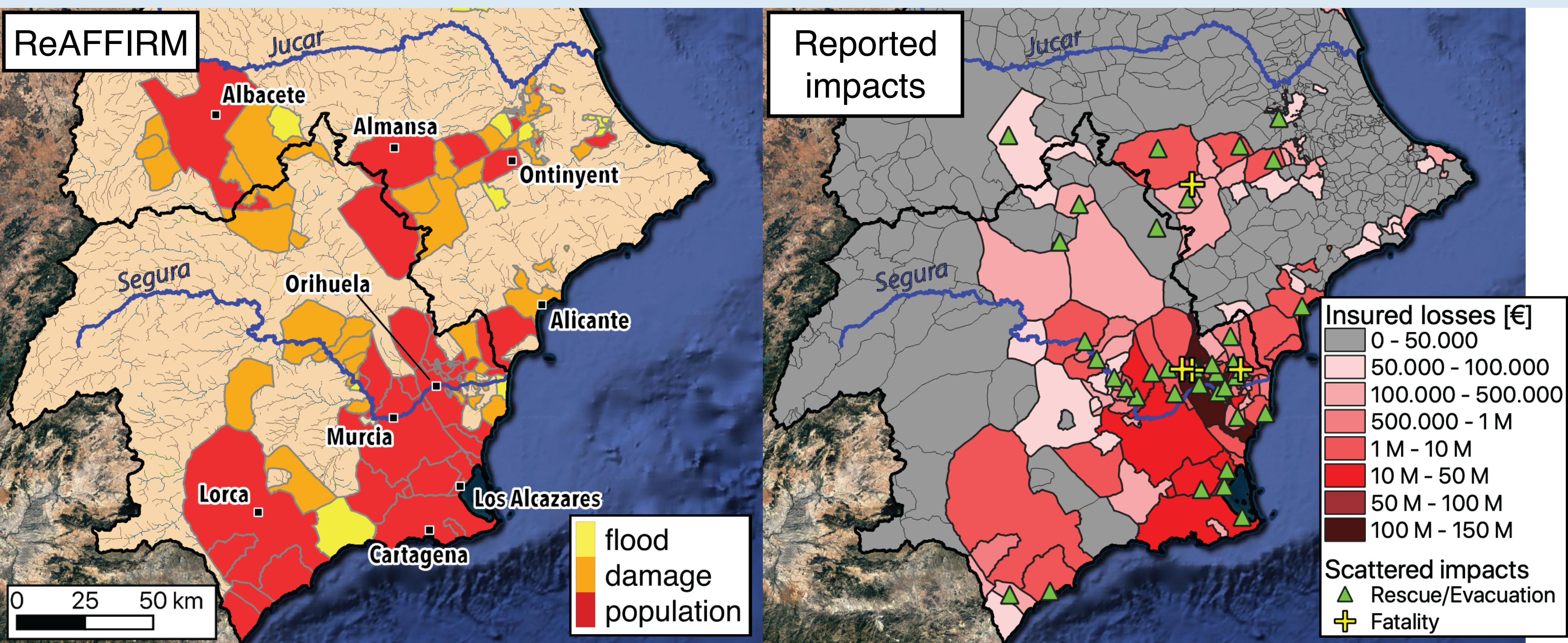
+ Detail –

# The DANA event of September 2019 in SE Spain



- Rainfall accumulations up to 461 mm in 24 h
- Numerous flash floods and a fluvial flood in the Segura River
- Reported impacts:
  - 7 fatalities
  - ~ 5000 evacuated
  - ~ 2.2 billion € economic losses

# ReAFFIRM: Simulated impacts (overall event)



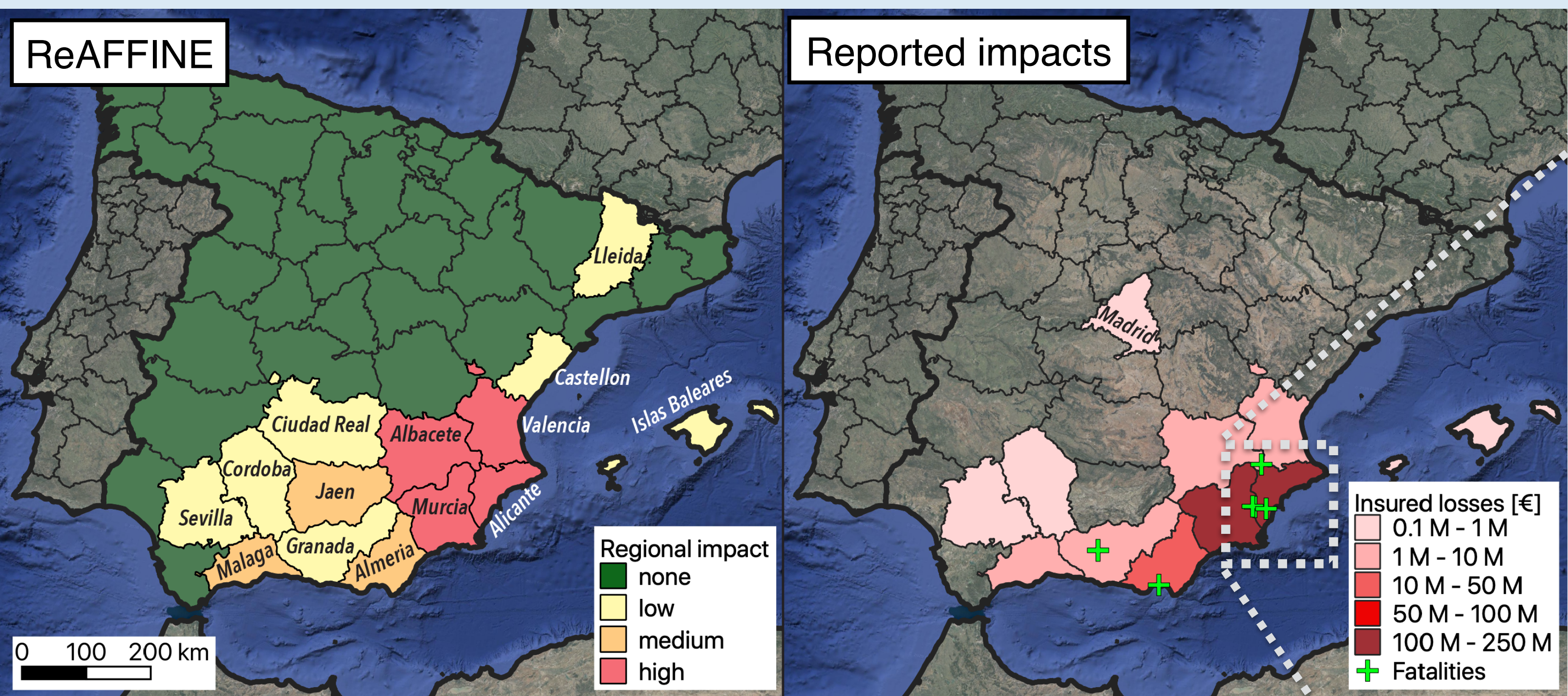
- Simulation results correspond well to reported impacts
- Impacts along the Segura River are underestimated due to coinciding fluvial flooding (which ReAFFIRM is not designed to detect)

|               | Simulated Hazard |                   | Simulated Impacts           |             |                      | Reported Impacts    |                                         |
|---------------|------------------|-------------------|-----------------------------|-------------|----------------------|---------------------|-----------------------------------------|
| Spatial unit  | Max. T [years]   | Flooded area [ha] | Population in flooded areas | Losses [M€] | CIs*                 | Insured losses [M€] | Other                                   |
| SE Spain      | 500              | 26 161            | 43 091                      | 290.2       | 2 EF, 3.5 HF, 10 MG  | 425.2               | 5 fatalities; min. 6 260 evacuated      |
| Cartagena     | 500              | 5 920             | 8 740                       | 67.0        | 1.5 EF, 1 HF, 0.5 MG | 17.9                | evacuations                             |
| Los Alcazares | 200              | 835               | 6 951                       | 19.2        | 1.5 MG               | 60.4                | evacuations                             |
| San Javier    | 200              | 940               | 4 934                       | 21.1        | 1 HF, 1 MG           | 26.0                | evacuations                             |
| Torre-Pacheco | 100              | 3 094             | 4 248                       | 24.1        | 1.5 HF               | 21.0                | evacuations                             |
| Orihuela      | 500              | 3 549             | 2 236                       | 71.5        | 4 MG                 | 105.4               | 2 fatalities; 130 rescued; 70 evacuated |
| Almansa       | 100              | 571               | 2 166                       | 11.5        |                      | 1.5                 | evacuations                             |

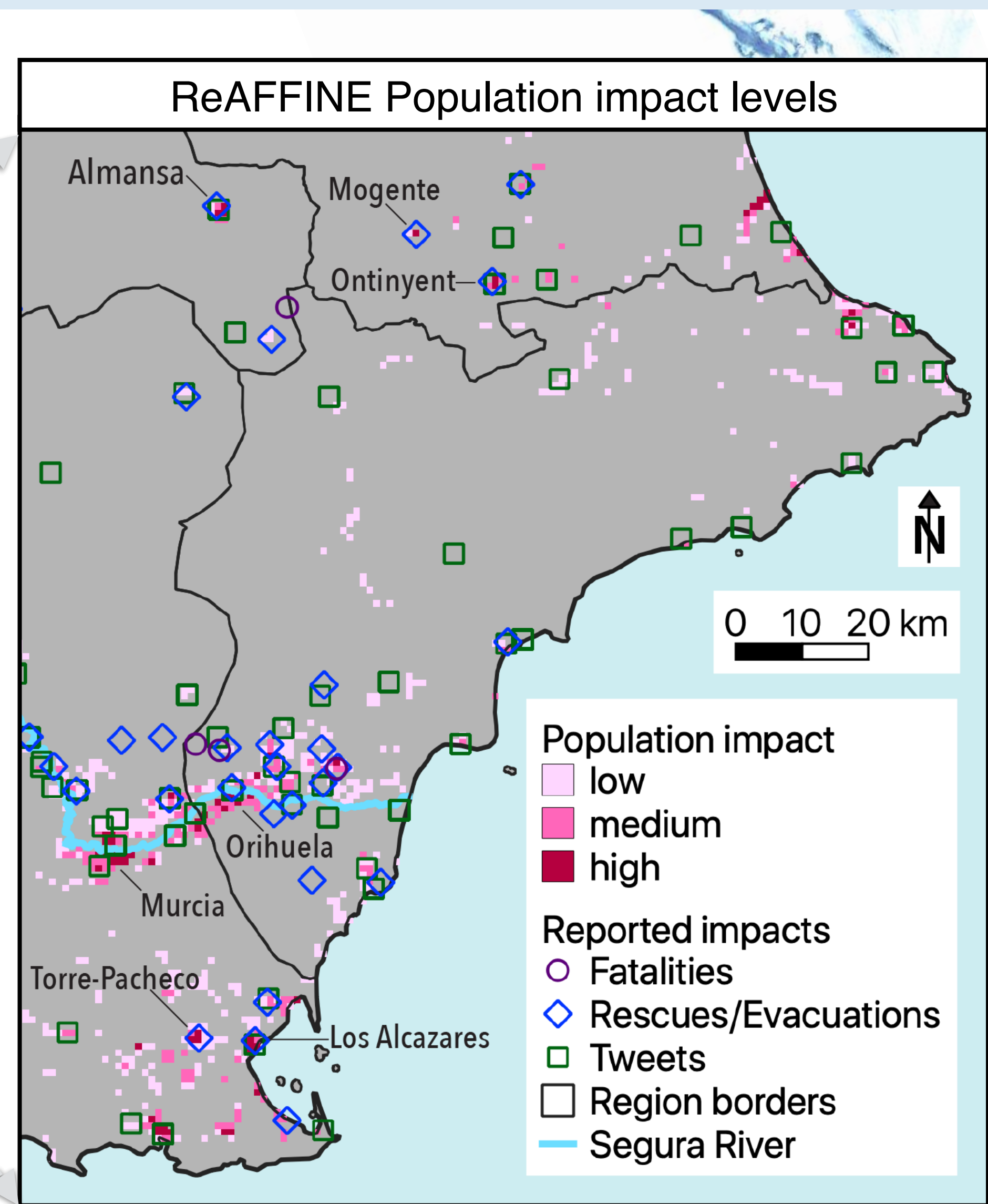
\*Critical infrastructures (CIs): education facilities (EF), health facilities (HF), mass-gathering sites (MF)

↓ 100 municipalities in total

# ReAFFINE: Simulated impacts (overall event)



| REGION     | SIMULATED IMPACTS               |                       |                |               |                |                       |                      |                    | REPORTED IMPACTS  |          |                        |
|------------|---------------------------------|-----------------------|----------------|---------------|----------------|-----------------------|----------------------|--------------------|-------------------|----------|------------------------|
|            | Popu-<br>lation<br>expo-<br>sed | Population exposed to |                |               | CIs exposed to |                       |                      | Regional<br>impact | # Fata-<br>lities | # Tweets | Insured<br>losses [M€] |
|            |                                 | High<br>hazard        | Med.<br>hazard | Low<br>hazard | High<br>hazard | Med.<br>hazard        | Low<br>hazard        |                    |                   |          |                        |
| Murcia     | 182 900                         | 1 860                 | 129 258        | 51 782        | 1 HF           | 6 EF, 21 HF,<br>17 MG | 4 EF, 8<br>HF, 4 MG  | high               |                   | 753      | 203.76                 |
| Alicante   | 79 327                          | 2 188                 | 27 167         | 49 972        |                | 10 EF, 12<br>HF, 7 MG | 2 EF, 15<br>HF, 6 MG | high               | 3                 | 736      | 201.98                 |
| Malaga     | 28 721                          | 0                     | 5 795          | 22 926        |                | 2 MG                  | 1 EF, 1<br>HF, 5 MG  | med.               |                   | 15       | 5.09                   |
| Valencia   | 25 429                          | 1 443                 | 19 357         | 4 629         |                | 2 EF, 4 HF,<br>2 MG   | 1 EF, 1<br>HF, 1 MG  | high               |                   | 199      | 9.69                   |
| Almeria    | 18 861                          | 0                     | 3 817          | 15 044        |                |                       | 1 EF                 | med.               | 1                 | 165      | 11.32                  |
| Islas Bal. | 4 391                           | 0                     | 0              | 4 391         |                |                       |                      | low                |                   | 14       | 0.28                   |
| Albacete   | 4 071                           | 2 555                 | 490            | 1 026         |                |                       |                      | high               | 2                 | 89       | 2.44                   |



↓ 14 regions in total

# Conclusions

- Both methods detected the most important impacts of the DANA event
- Rainfall inputs have been optimised (a posteriori)
  - Lower accuracies should be expected in real-time operation
- The two methods are complementary:
  - ReAFFIRM: Quantitative high-resolution impact estimates to support regional and national authorities in the coordination of location-specific measures (e.g. evacuations or road closures)
  - ReAFFINE: Order-of-magnitude impact statements to support authorities operating over large spatial domains (e.g. transboundary basin authorities or the ERCC)
- Compound flood events are the next challenge
  - ReAFFIRM & ReAFFINE detect impacts from flash floods only
  - Impacts induced by fluvial flooding in the Segura River were missed
  - Long-term vision: Forecast the impacts jointly for the different flood types (fluvial, pluvial, coastal & flash floods)  
—> “Towards compound flood impact forecasting” (Ritter et al., manuscript in preparation)

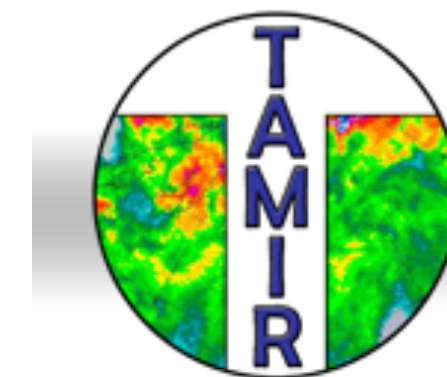


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Looking forward to discuss with you!

vPICO session NH9.5

Wed, 28 Apr, 15:30-17:00 CET



[www.tamir-project.eu](http://www.tamir-project.eu)

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