CLIMAAX Community of practice

River Flood Risk Assessment: Learning from regions

February 19, 2026
10:30-12 CET

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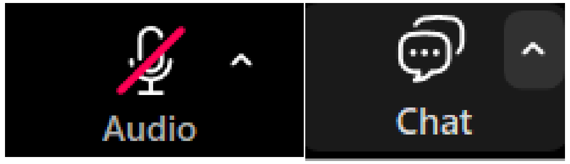
CLIMAAX
climate ready regions

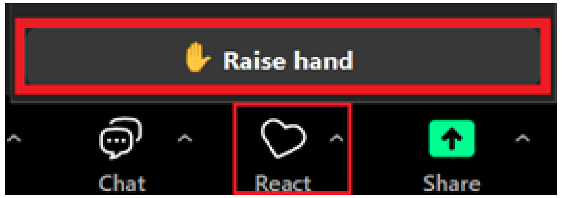
HOUSEKEEPING

- Please note that the meeting is being **recorded**.

- Please, keep your **mic off**.



- Feel free to post your **questions in the chat** (bottom of the screen) or raise your hand to talk



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MEETING AGENDA

- ✓ 10:30-10:35 **Welcome & introduction to the webinar**
- ✓ 10:35-10:50 **Introduction to the *River flood map* and *River discharge* workflows**
  - Speaker: Natalia Aleksandrova (Deltares)
- ✓ 10:50-11:00 **Introduction to the *Building damage and exposed population* Workflow**
  - Speaker: Gloria Mozzi (CMCC)
- ✓ 11:00-11:25 **Regional experiences: Applying and adapting the workflow**
  - Regione Marche, Italy - Speakers: *Gaia Galassi* and *Francesca Sini* (Regione Marche) *"Risk assessment based on floods maps and future discharge scenarios for planning adaptation: the Pesaro case study"*
- ✓ 11:25-11:50 **Panel discussion and Q&A**
  - Moderators: Fulvio Biddau, Maria Katherina Dal Barco and Majid Njazkar (CMCC)
- ✓ 11:50-12:00 **Closing remarks**

NEW HAZARD AND WORKFLOW-FOCUSED SERIES

Moving forward in CLIMAAX CoP from:

- **Thematic webinars** and workshops connecting science, policy and practice to support CRAs using the CLIMAAX Framework and Toolbox
- **Demo & co-design sessions** for refining and fostering usability of CLIMAAX outcomes

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COP NEW PHASE: CONSOLIDATING LEGACY AND IMPACT

- **Regional showcase webinars and dialogues**

Connecting toolbox developers and regional practitioners to exchange lessons learned from regional CRAs

- **Dedicated online community forum**

A new space for P2P exchange and knowledge sharing

- **Promote exchange across climate service communities**

To foster awareness, collaboration, and uptake of solutions for climate resilience in Europe.

Move beyond traditional developer-end user model

Empowering local practitioners to take ownership and an active role in the use, extension and adaptation of CLIMAAX resources

Facilitate the uptake and continuous improvement of CLIMAAX tools and framework

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INTRODUCTION TO RIVER FLOOD MAP AND RIVER DISCHARGE WORKFLOWS

Natalia Aleksandrova
(Deltares)

River flood workflows

Introduction

Presented by Natalia Aleksandrova (Deltares)

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climate ready regions

River floods workflows in CLIMAAX

CLIMAAX Handbook:
https://handbook.climaax.eu/

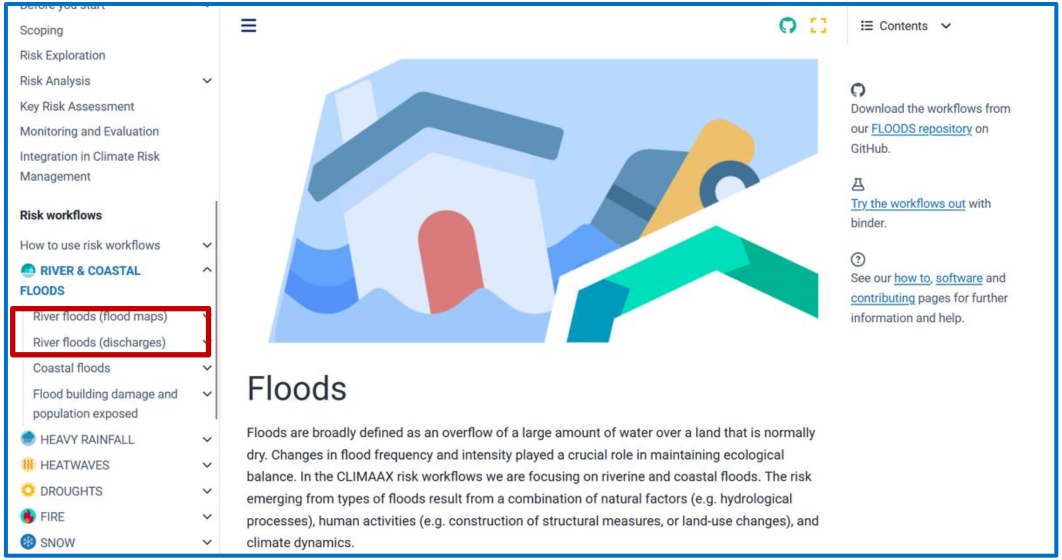
Workflows repository on GitHub:
https://github.com/CLIMAAX/FLOODS

Two river hazard & risk workflows:

- River flood risk based on **flood maps**
- River flood risk based on **river discharges**

Other flood workflows:

- Flood building damage and population exposed
- Coastal floods



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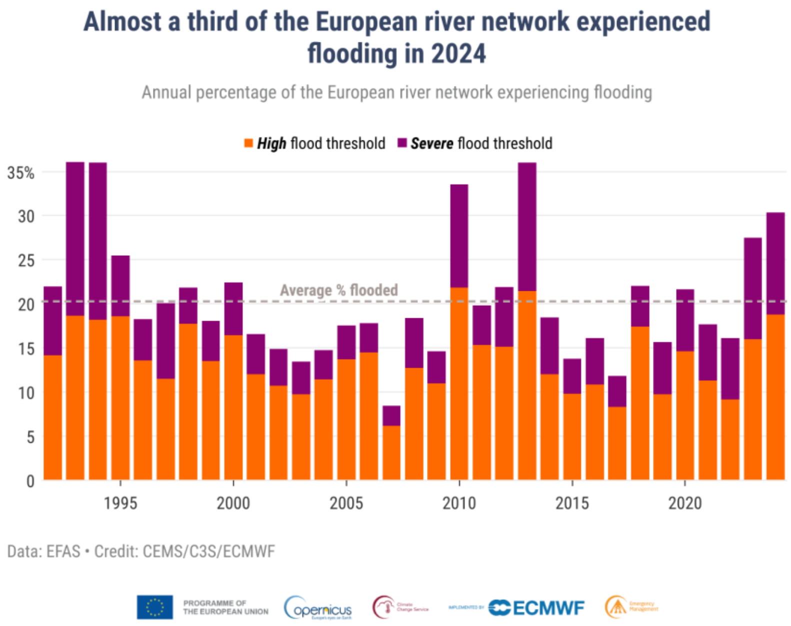
River flooding under climate change

- Climate change causes changes in the water cycle (precipitation, snow melt)
- Damages and exposed population projected to increase sharply
- Damages can be avoided by timely protection of people and infrastructure



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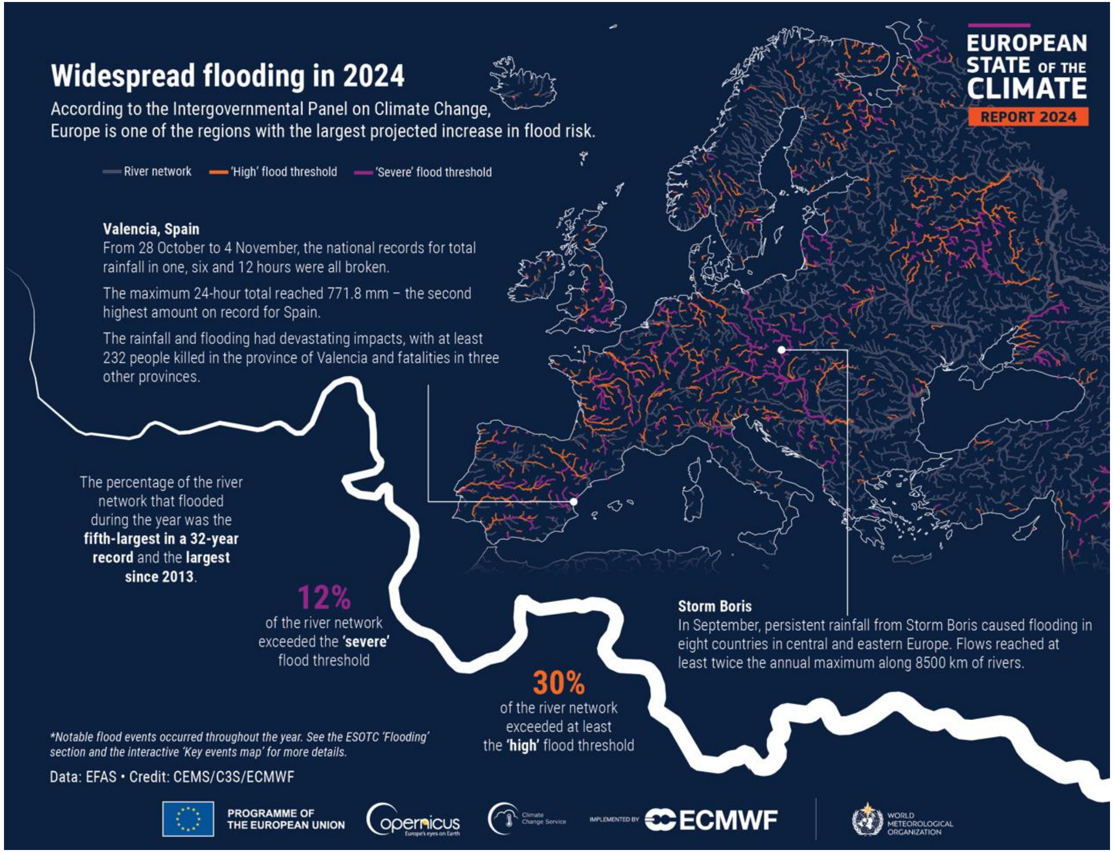

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Available river flood workflows

River flood risk based on flood maps

Mapping hazard and risk in space

Risk calculation based on flood-damage curves (monetary value)

Requires flood maps as input

Challenging to address climate scenarios

River flood risk based on river discharges

Estimating flood hazard based on river flows

Qualitative risk assessment
Provides input to local hydrological / hydraulic / flood assessments

Validation with historical data possible

Climate scenarios explicitly integrated in the river discharge dataset

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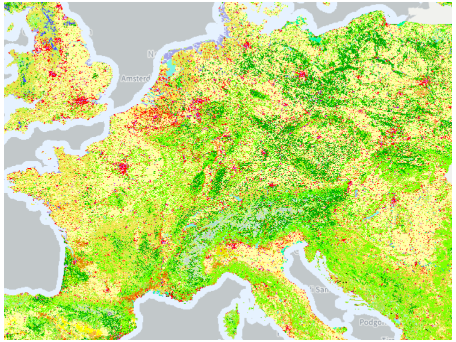
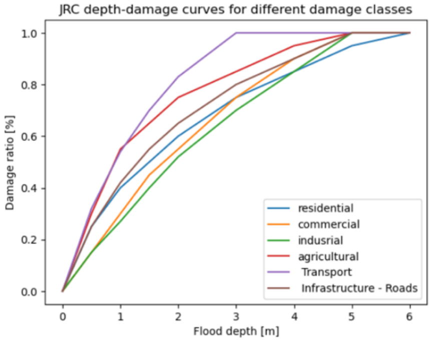
Assessing flood risk based on existing flood maps

Hazard data - flood maps
Extreme events, e.g. once in 100 years



Exposure – land use
Land cover maps



Vulnerability curves
Economic damage per type of land use

Maps of potential economic damage
under rare extreme conditions (return periods)
for identifying hotspots and most vulnerable areas

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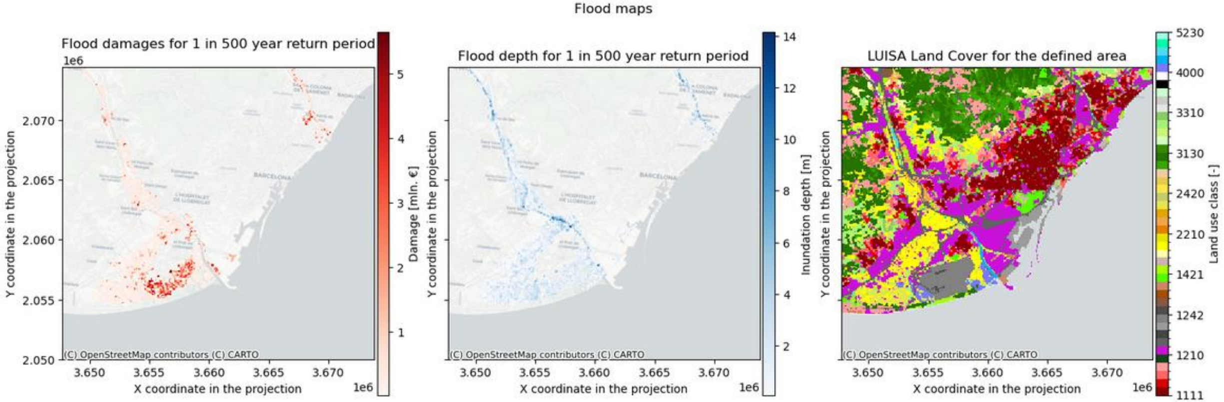
Assessing flood risk based on existing flood maps

Flood maps are key to an accurate assessment.

- EU-wide flood maps available (JRC), but often not representative for smaller rivers.
- Can be available locally (e.g. EU Flood Directive or other dedicated studies).
- Estimating effect of climate change requires flood maps under different climate scenarios or qualitative assessments based on hydrological indicators.



Example workflow output with European flood maps from JRC & LUISA land cover data

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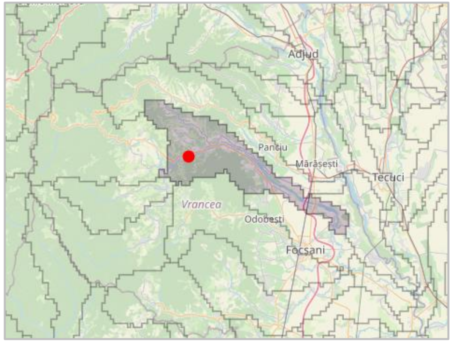
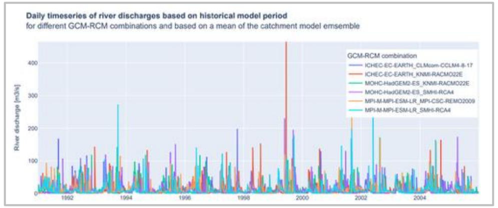
Assessing flood risk based on river discharges

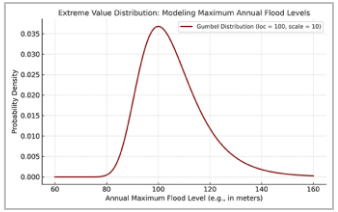
Catchment selection





Discharge timeseries for a selected catchment

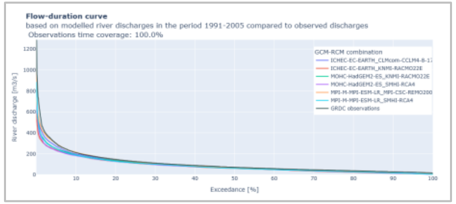
Modelled with a Europe-wide hydrological model for past and future climates



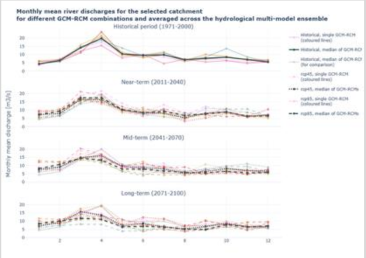
Flood recurrence – extreme values

Return values calculated based on timeseries, for 2, 5, 10, 50 years

Validation - comparing to local discharge measurements



Estimate changes in seasonal discharge statistics caused by climate change



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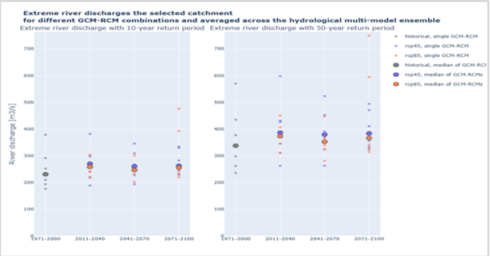

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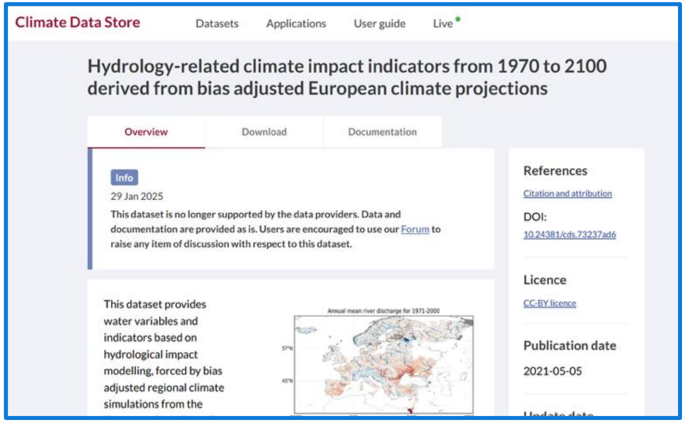
Assessing flood risk based on river discharges

Input data

Hydrological climate impact indicators 1970-2100 available on CDS and produced by SMHI based on the E-HYPE3 model



- ➢ Catchment-level river discharge data
  - ➢ Daily & monthly values
  - ➢ Extreme values (e.g. once in 50 years discharge)
- ➢ Effect of climate change
  - ➢ 7 climate models (GCM-RCM combinations)
  - ➢ 3 climate scenarios (RCP2.6, RCP4.5, RCP8.5)
  - ➢ 4 time periods (spanning 1971-2100)

Small catchments (~12km)

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Assessing flood risk based on river discharges

Statistical analysis

Based on timeseries of modelled river discharges we assess:

1. Seasonal statistics → indication of changes in the water cycle
2. Extreme statistics → proxy for flood hazard

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Assessing flood risk based on river discharges

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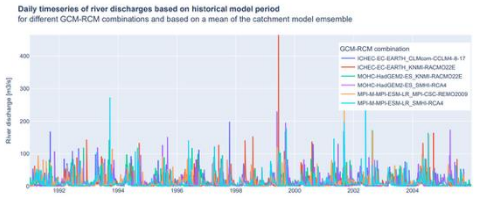
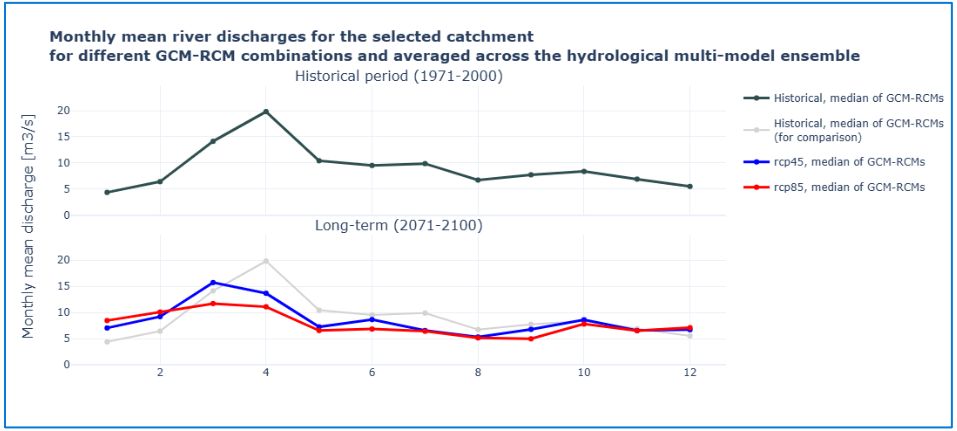


Compute monthly means over 30-year periods



- Is there a general trend towards a wetter or drier climate?
- Is there a significant change in discharge magnitudes?
- How does the discharge peak shift in time?

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Assessing flood risk based on river discharges

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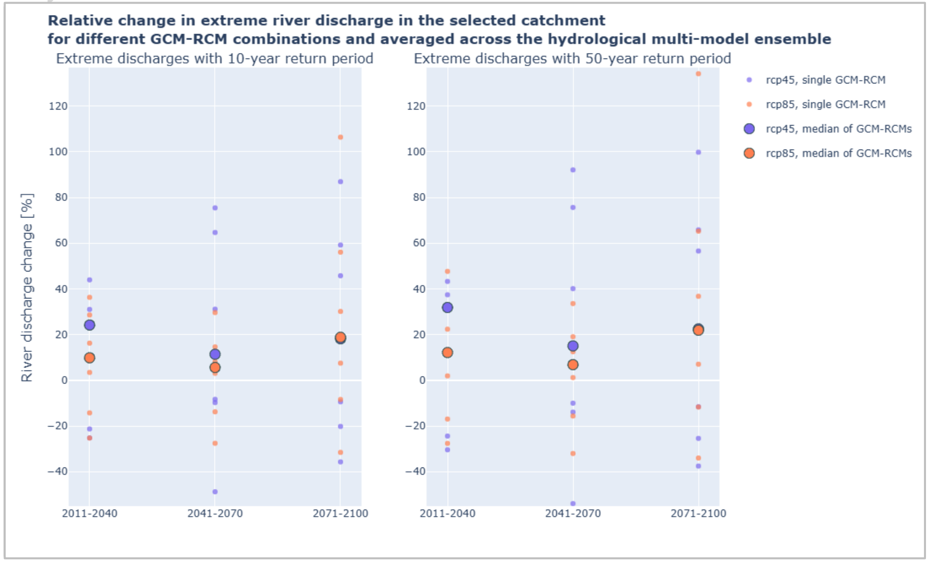
Flood recurrence – extreme values
Return values calculated based on timeseries, for 2, 5, 10, 50 years



- Are extreme discharges generally projected to increase?
- How do different climate scenarios compare?
- How large is the uncertainty range across climate models?

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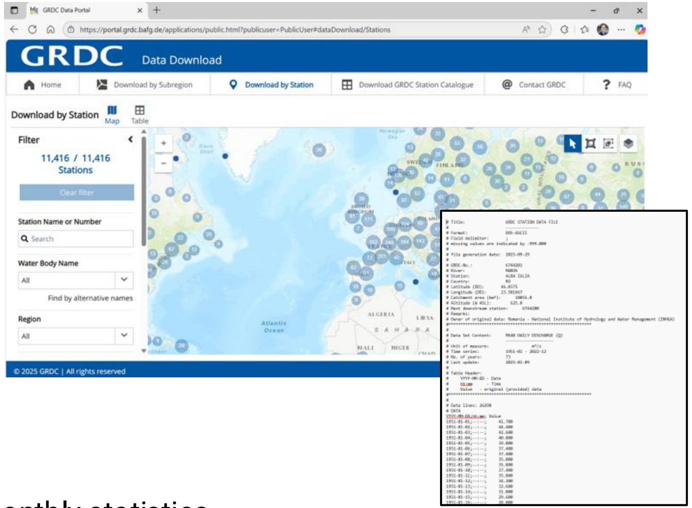
Assessing flood risk based on river discharges

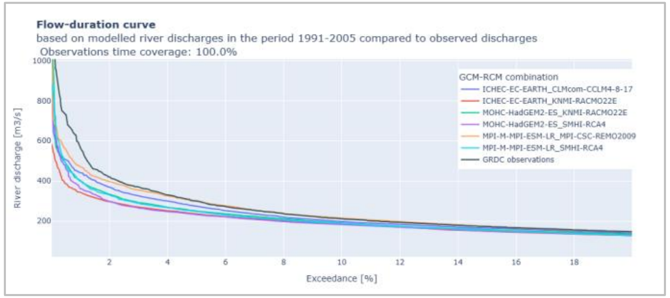
Validation

The performance of a hydrological model will vary across catchments, depending on, for example:
- Size and complexity of the catchment.
- Presence of water management infrastructure.

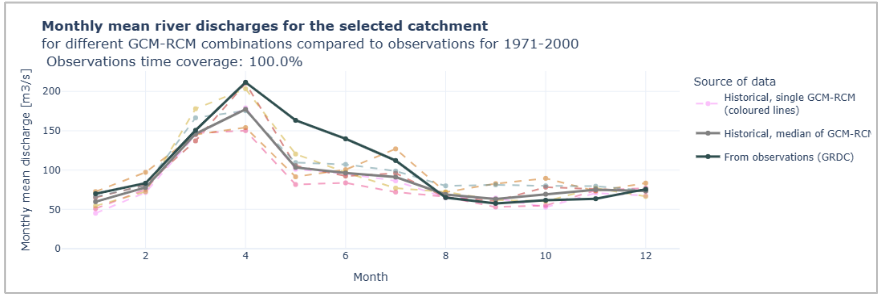
We can check the performance of the model against **local measurements,** focusing on **long-term statistics**.



Flow-duration curve



Seasonal and monthly statistics



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Flood risk assessment – synergy between workflows

A more complete picture of flood risk can be obtained by:

- Applying the workflows based on global or Europe-wide data → **first estimate**
- Gathering available local information and data and consulting local experts → **system understanding**
  - E.g. flood maps, river discharge measurements, past flood events, their causes and impacts)
- Refining the climate risk assessment through, for example: → **in-depth exploration**
  - Integrating local data into the flood workflows (flood maps, discharge measurements)
  - Applying local hydrological and flood models (using projected extreme discharge change)
  - Risk assessment based on impact-based thresholds of river discharges
  - Qualitative assessment of how the frequency of extremes will shift under climate change – based on discharge workflow

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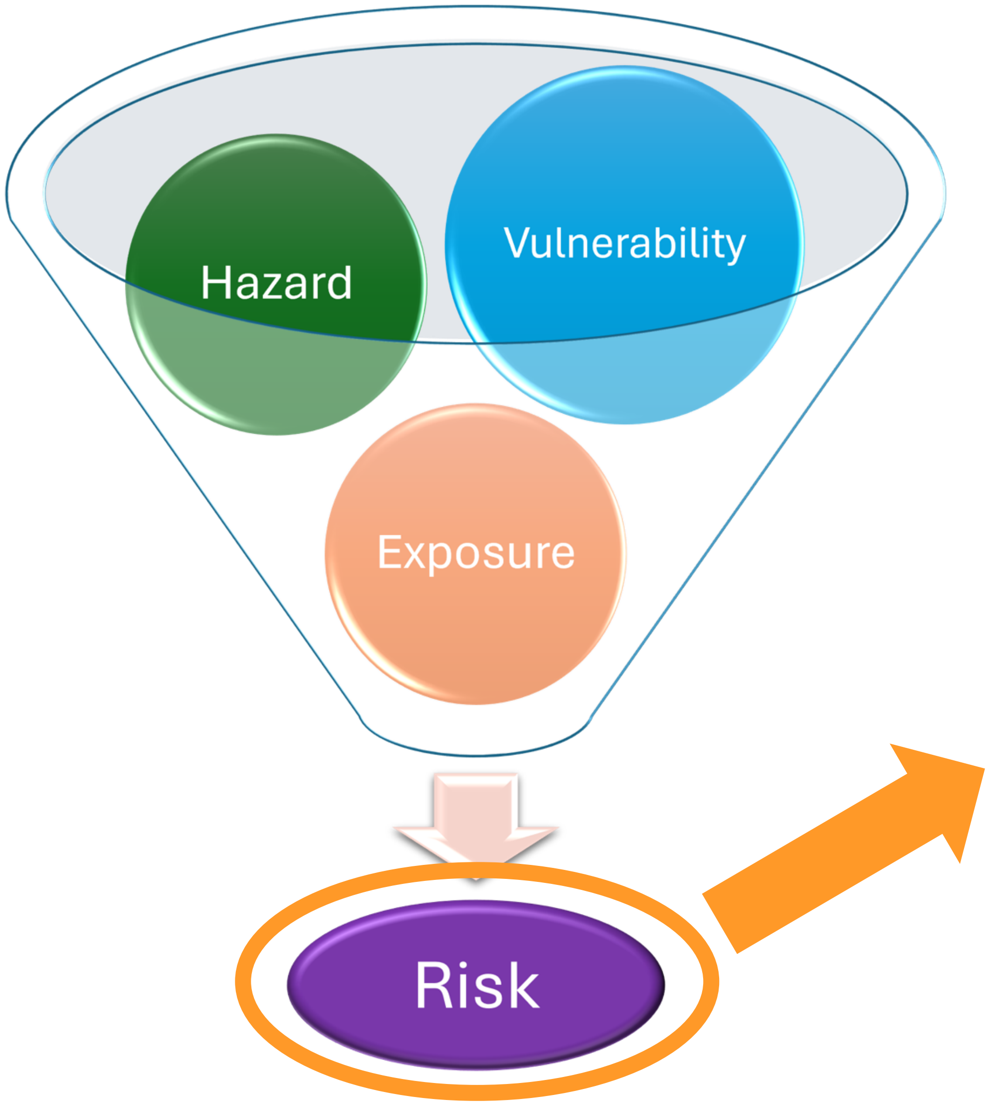
INTRODUCTION TO THE BUILDING DAMAGE AND EXPOSED POPULATION WORKFLOW

Gloria Mozzi
(CMCC)

RIVER FLOOD RISK & IMPACT ASSESSMENT



1. ECONOMIC DAMAGE TO ASSETS

2. POPULATION EXPOSED

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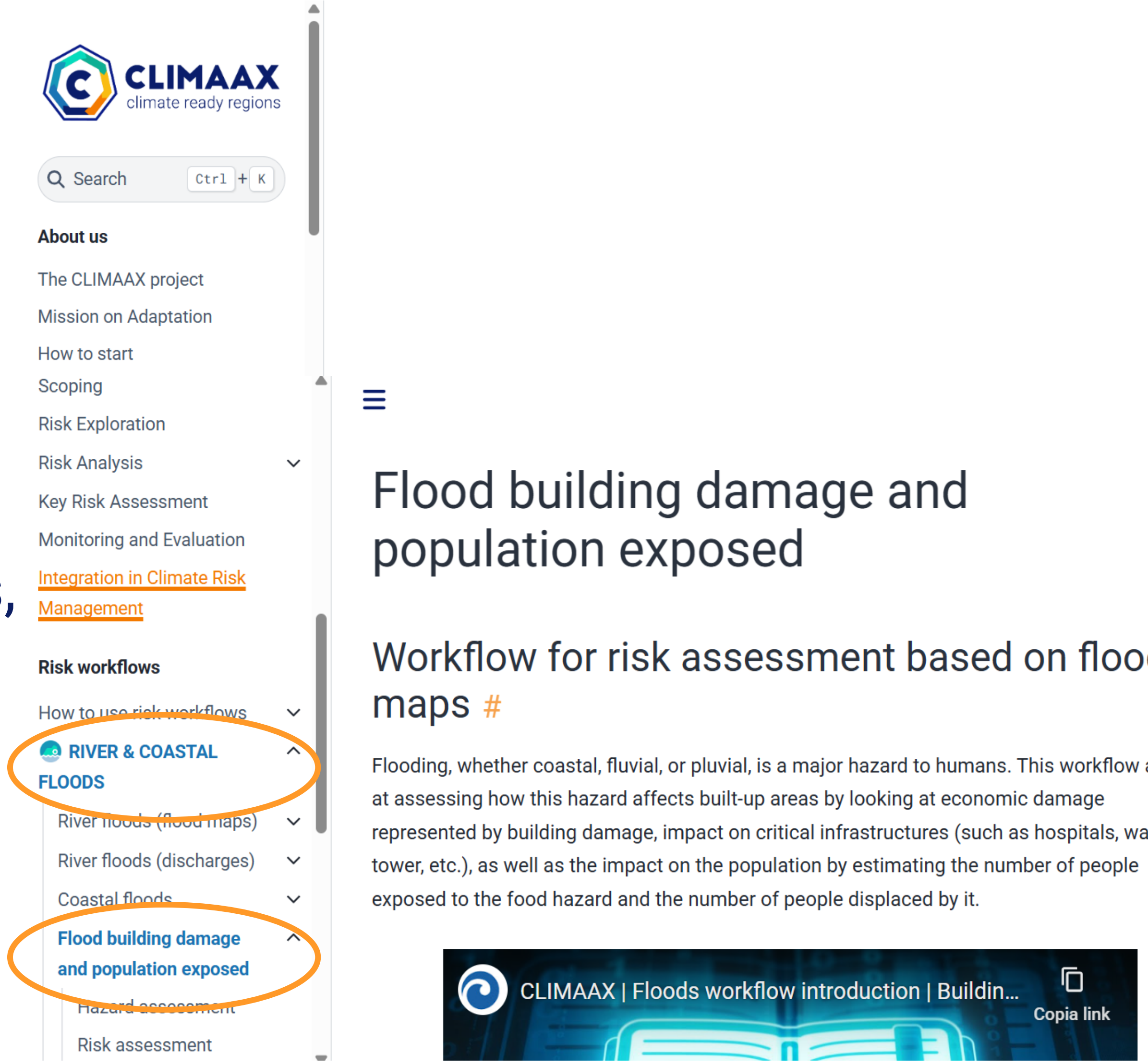
BUILDING DAMAGE AND POPULATION EXPOSED

INPUT DATASETS:

- **Flood maps**: flood water depths over return periods 10, 20, 50, 100, 200, and 500, at a resolution of 3 arc sec created by the Copernicus Emergency Management Service
- **Building datasets**: from OpenStreetMaps, collecting geometry and classification
- **Population density**: GHS-POP R2023A population estimates (1975-2030, 5-year intervals), published by JRC, with a resolution of 3 arc seconds and a global coverage



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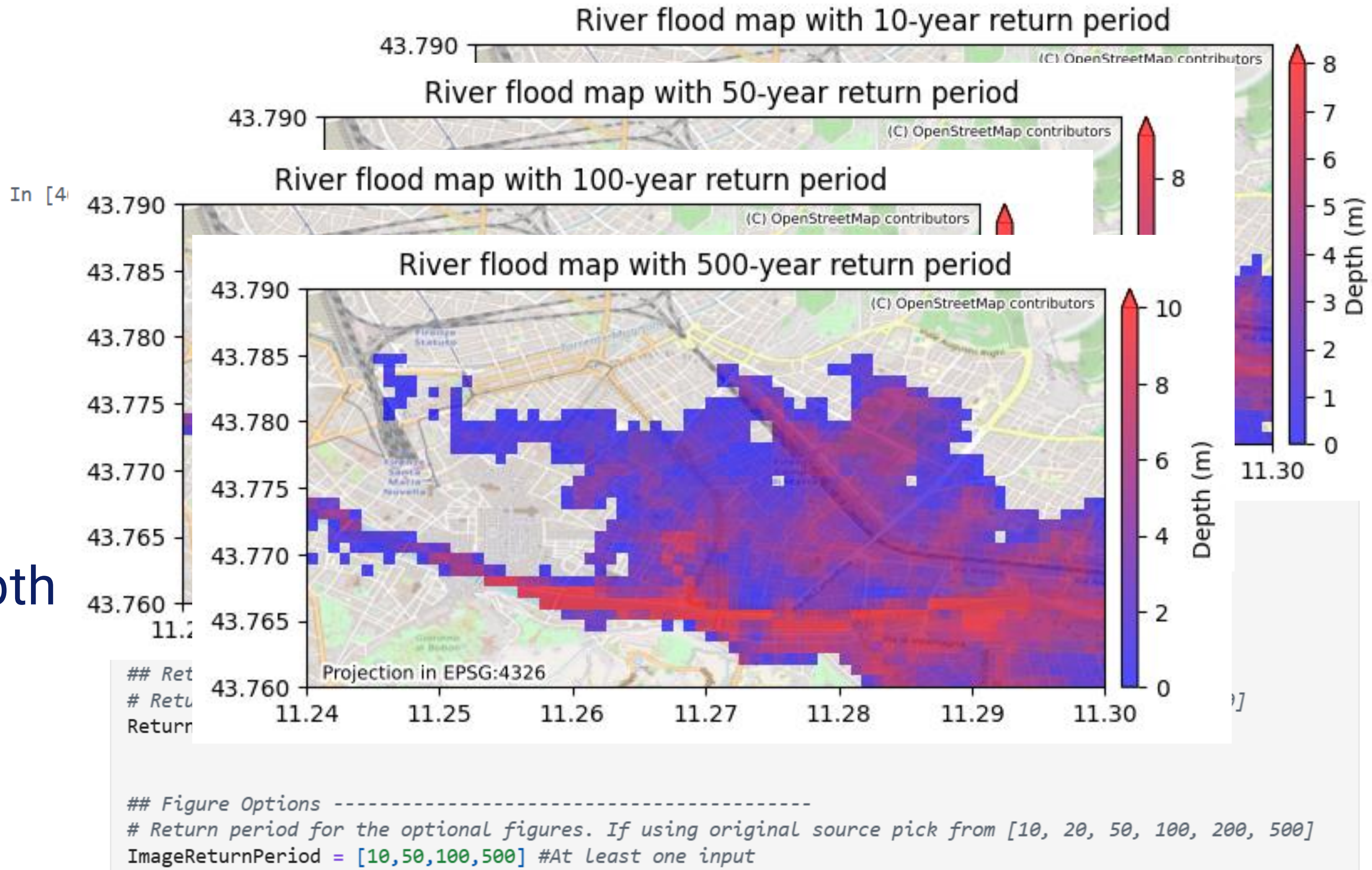
HAZARD ASSESSMENT

1. Define the geographical boundaries of the area under study
2. Select the output of interest
3. Download river flood depth maps



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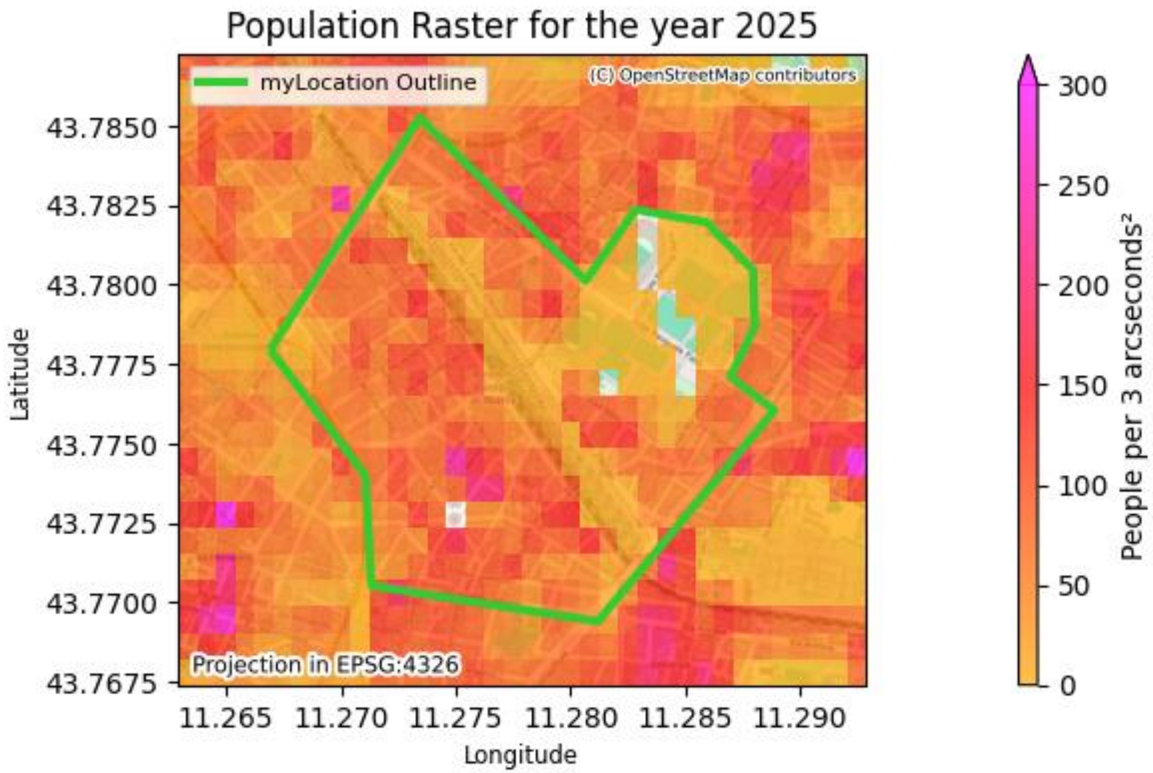
RISK ASSESSMENT – POPULATION EXPOSED

1. Select the return period of interest
2. Download population density datasets
3. Select the year of interest (1975-2030)
4. Compute the **number of people affected**:
   - Exposed: 0 to 1m
   - Displaced: >1m



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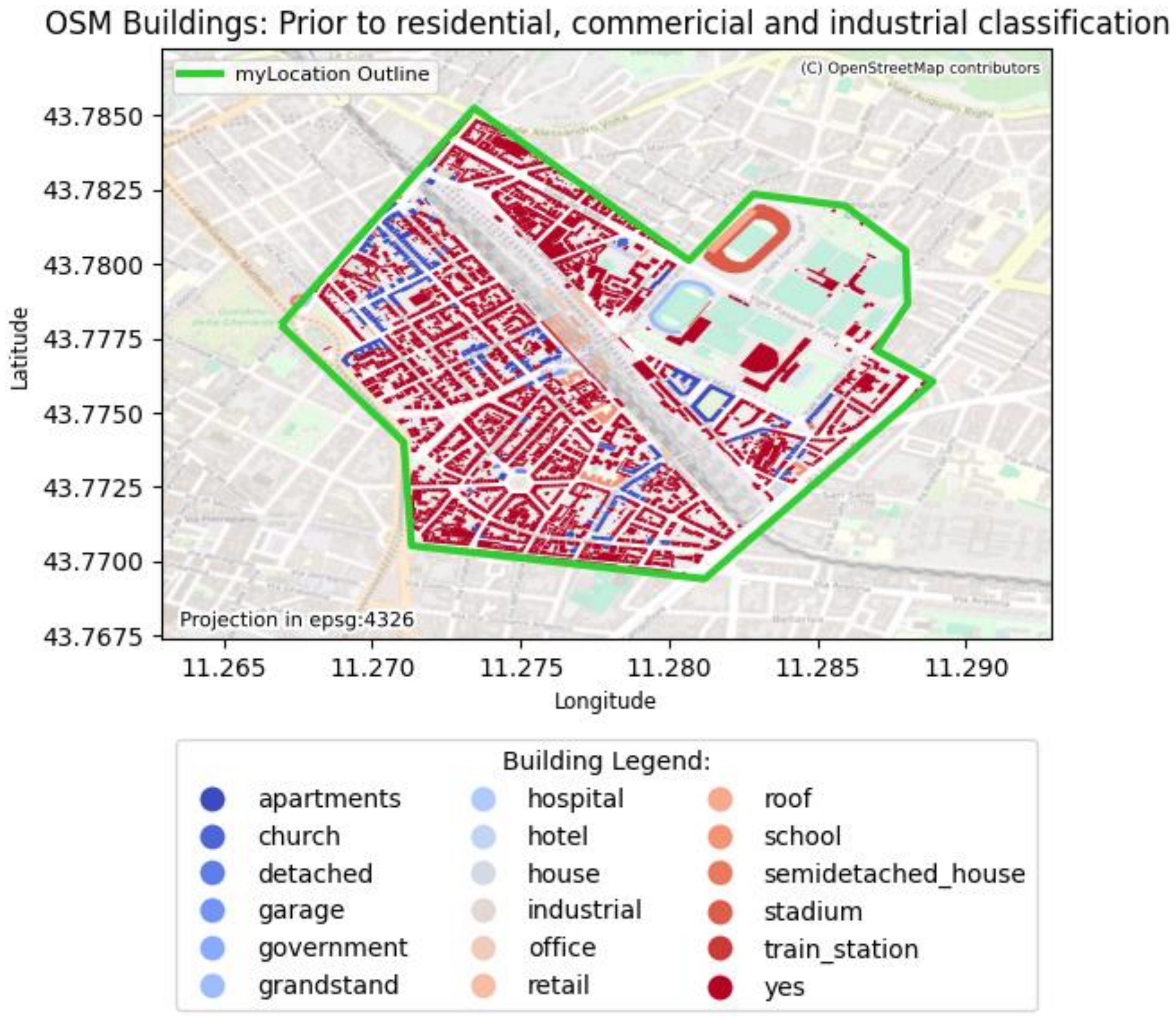
RISK ASSESSMENT – ECONOMIC DAMAGE

1. Download building layers with geometry and classification



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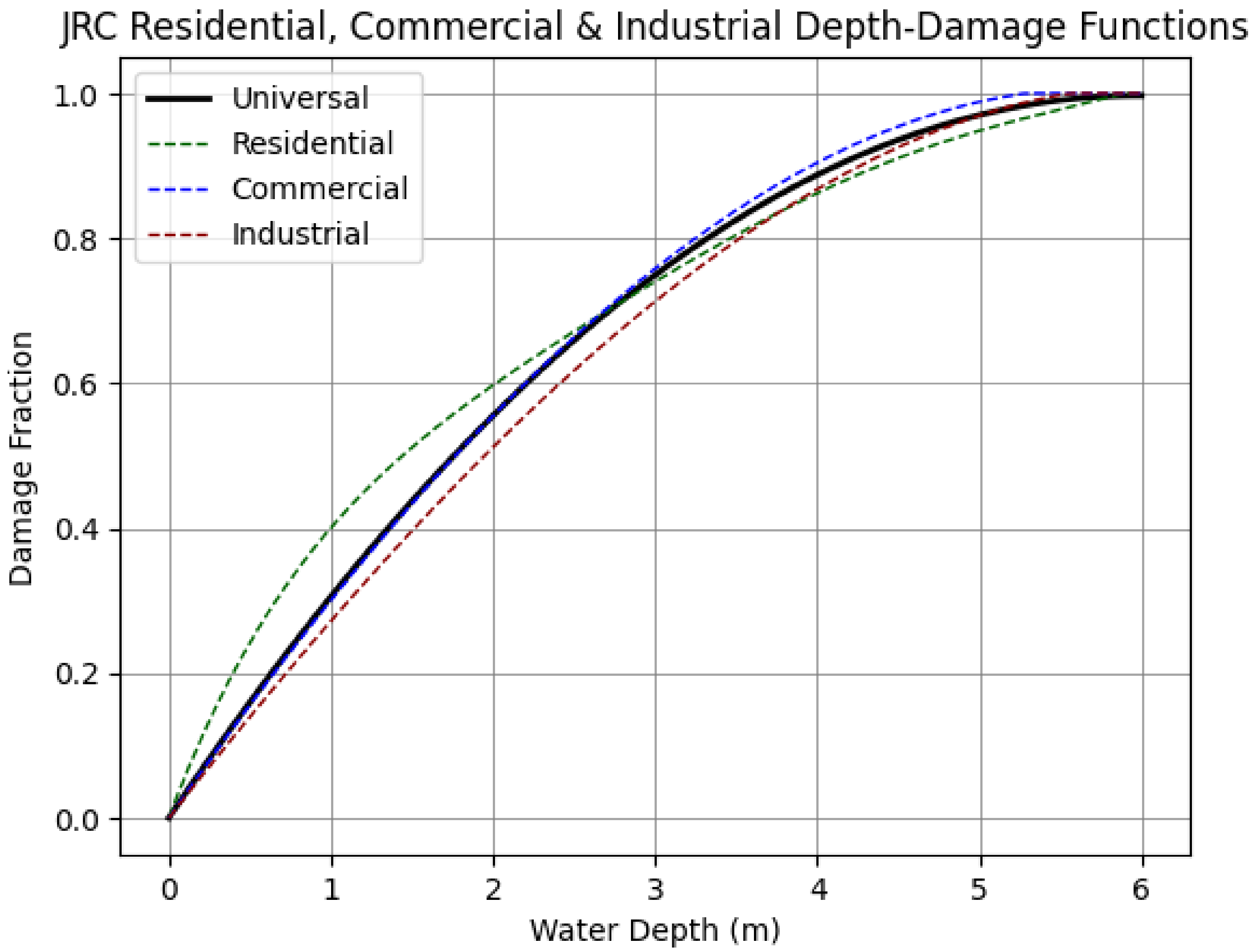
RISK ASSESSMENT – ECONOMIC DAMAGE

1. Download building layers with geometry and classification
2. Set total costs of buildings
3. Define depth-damage functions
4. Compute **total costs**

```
# Define arrays for damage values based on 2010 est
CPI2010 = 100                                      # 20
CPI2022 = 121.8                                    # 20
CPI_Frac = CPI2022 / CPI2010
MaxDmgRES = np.array([480, 240]) * CPI_Frac      # EU
MaxDmgCOM = np.array([502, 502]) * CPI_Frac      # EU
MaxDmgIND = np.array([328, 492]) * CPI_Frac      # EU
MaxDmgAGR = np.array([0.23, 0.46]) * CPI_Frac    # It
MaxDmgCUL = MaxDmgCOM                              # EU
MaxDmgTRS = MaxDmgIND                              # It
MaxDmgUNI = (MaxDmgRES+MaxDmgCOM+MaxDmgIND)/3    # Un
```



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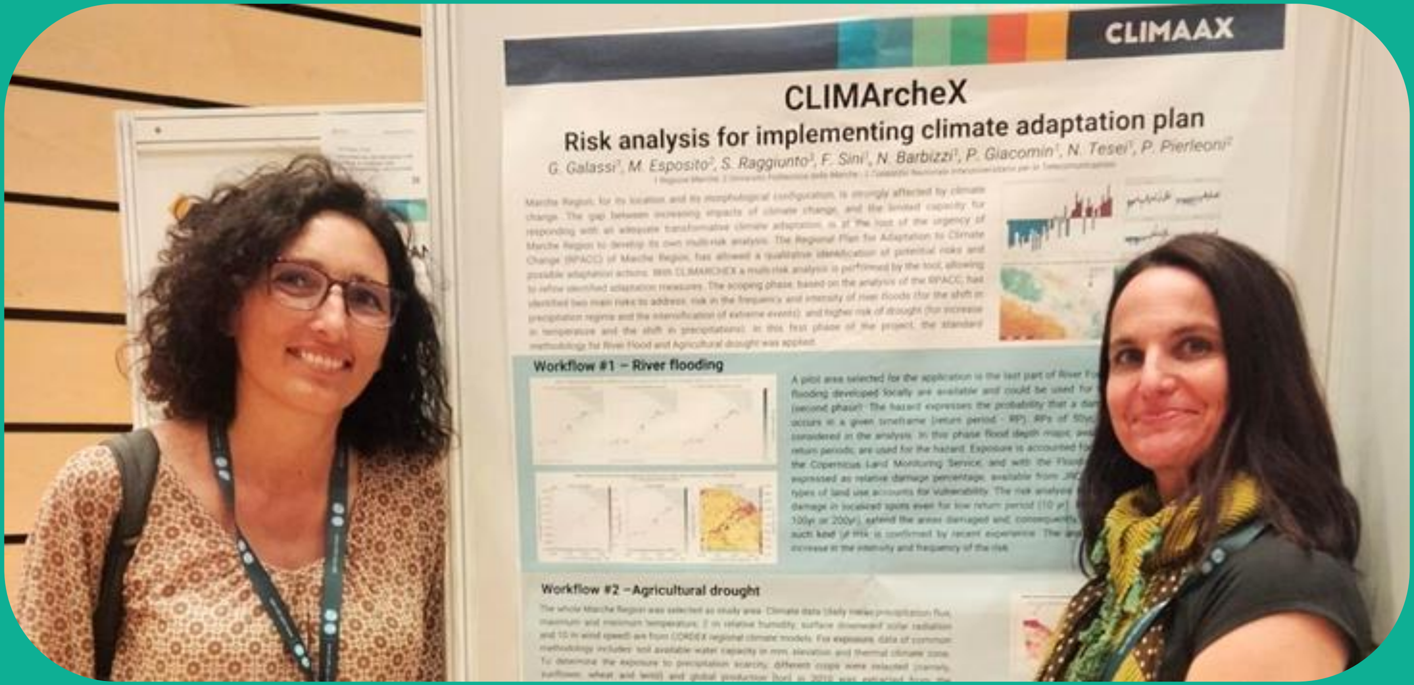
REGIONAL EXPERIENCES

SPEAKERS



Gaia Galassi and
Francesca Sini
(Regione Marche)

Risk assessment based on floods maps and future discharge scenarios for planning adaptation

The Pesaro (IT) case study

Gaia Galassi, Environmental Department, Regione Marche
Francesca Sini, Civil protection Department, Regione Marche

Regione Marche
19 February 2026

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climate ready regions

Project team

Marche regional administration

- ➢ Economic Development Department
- ➢ Environmental Department
  - ✓ Environmental Assessment Office
  - ✓ Energy and waste Office
- ➢ Civil Protection Department

University Polytechnical of Marche Region

Background

Management of sectoral policy relate to climate change

Risk management and climate monitoring

From 2022, activation of policy on climate change adaptation

REGIONE MARCHE

ALLEGATO A

Piano di adattamento al cambiamento climatico

Regione Marche

2023 - 2029

1

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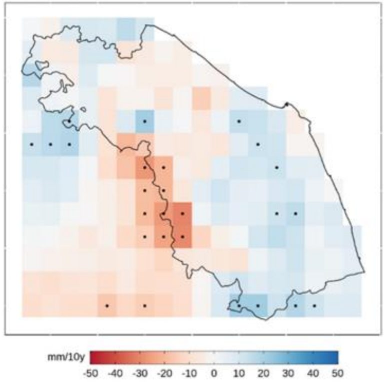
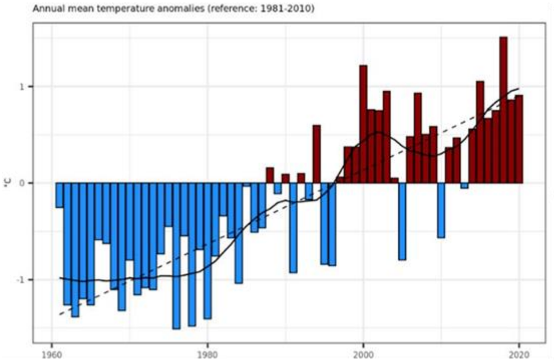
Regional Profile and Context

- **Central Italy**, facing the Adriatic Sea.
- **Area:** 9,694 km² *(with a coastline of 173 km)*.
- **Population:** *1.484.298 inhabitants.*



Regional distribution of heavy rain



Temperature anomalies (1961 - 2020)

Climate projections, compared with historical trend, show:

- ✓ an **increment** of temperature both in terms of average temperature, **summer days and heat waves**,
- ✓ an **increase in dry periods**
- ✓ an intensification of **extreme events**, including flooding and storm surge.

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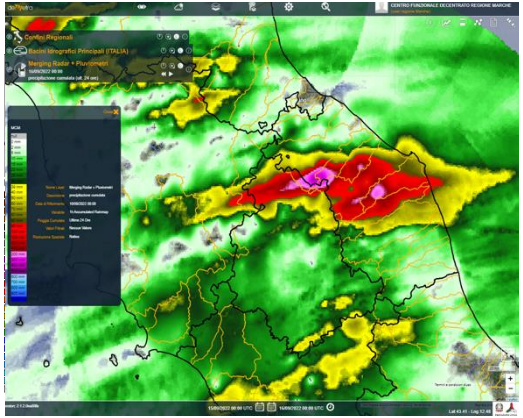
Example of extreme event
(15-16 Sept. 2022)



From the Regional Plan for Adaptation to Climate Change (RPACC)

Climate hazards of Marche RPACC		
Floods	Droughts	Extreme heat
Temperature increase	Storm	Sea level rise
Precipitation (regime shift)	Height wave & storm surge	All-hazard

Key systems (KS) of Marche RPACC			
water management (options A, B)	soil management (option C)	Ecosystems & NbS (options D, E)	Coastal management (option F)
Risk management (option G)	Land use (option H)	Agriculture management (option I)	Tourism management (option J)
Fishing management (option K)	Energy management (option L)	Health & well-being (option M)	Cross -KS

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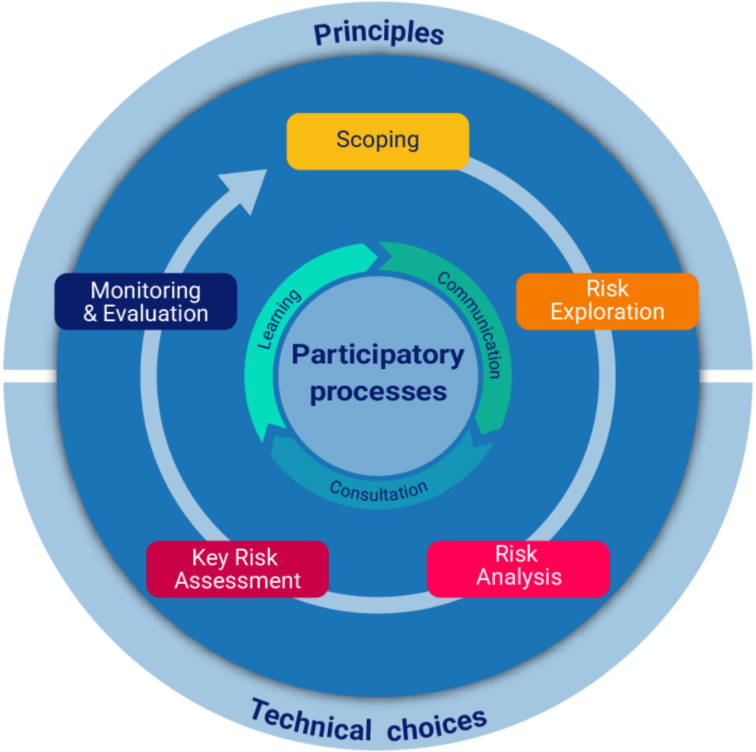
Climate Risk Assessment Framework experience



Risk exploration

Revision of risk analysis performed in the RPACC

Involvement of stakeholder for the selection of main risks to focus on with CLIMAAX toolbox

Connection with P2R project: **river floods** emerged as key risk in the consultation with municipalities and local communities

Governance for risk management
Defined in the RPACC, linked to competences of selected adaptation measures

Regional administration → Local administration

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Overview of adaptation measure for flooding from the RPACC

Prevent/Reduce hydraulic and hydrogeological risk

G.01 Updating the **mapping of river flood** areas required by Directive 2007/60, taking into account the effects of climate change on the triggering event dynamics (precipitation, runoff, river flow rates)

G.05 Promoting **Cost-Benefit Analysis** for structures and infrastructures located in high or very high-risk areas in order to assess the convenience of relocation

G.06 Activation of pilot cases to simplify **relocation** processes in PAI areas

Increase awareness regarding risks

G.09 Strengthening public **training** on how to respond to alerts

Increase climate change resilience of urban and territorial settlements and infrastructures

H.04 Strengthening tools for **hydraulic compatibility assessment**, also considering climate change in areas not regulated by PAI and PGRA

H.03 Initiating processes to assess the climate **resilience of urban planning** measures, aimed at reducing and not increasing climate-related risks

H.06 Defining regional-scale methodologies to increase the resilience of infrastructure projects within environmental assessment processes (climate proofing)

Think in terms of prevention, starting from urban planning

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Risk Analysis

Need of accurate data

Pilot selection

Foglia river mouth, city of Pesaro

Reasons for the selection:

- River mouth in the centre of the city
- Accurate floods map available
- Not critical problems in recent years

Workflow building and population exposed
……and future discharge scenarios applied

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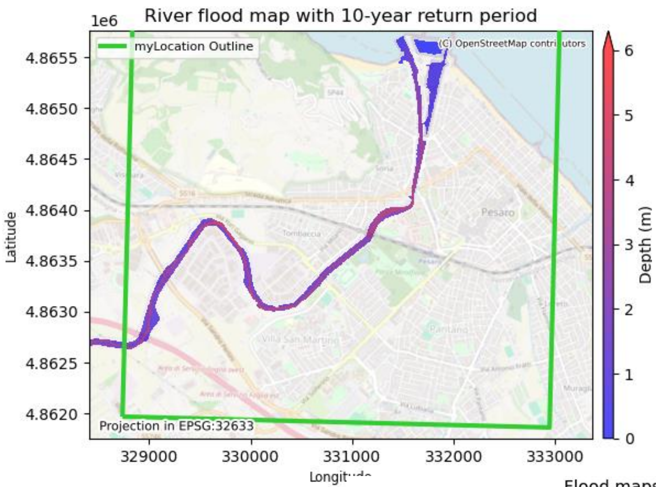
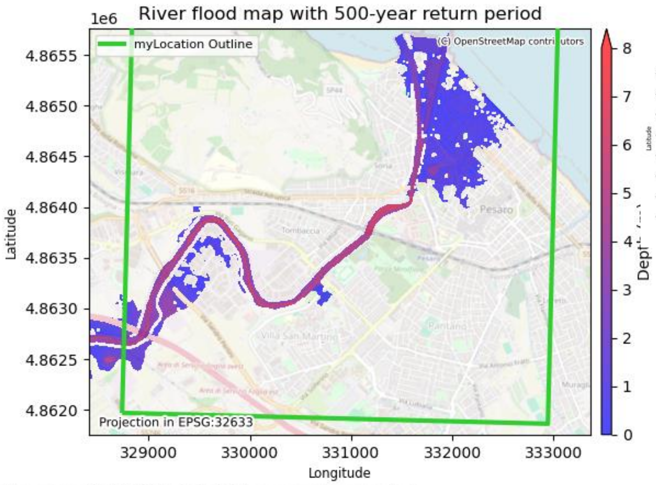
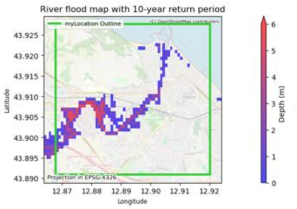
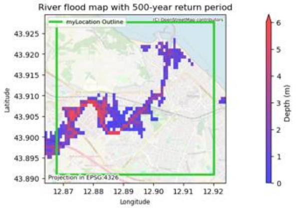
Risk analysis using the CLIMAAX Toolbox



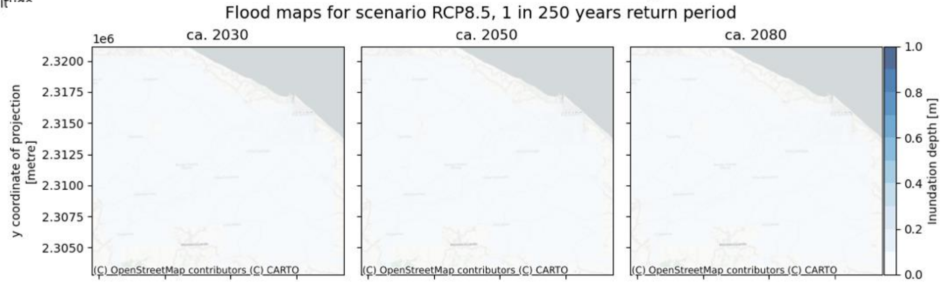






From Interreg Italy-Croatia project "Stream" (Cima foundation). Hazard maps for different return periods from a bidimensional hydraulic model. Buildings, bridge, embankments and perimeter walls have been checked to test permeability and their influence on the dynamic of simulations.

Aqueduct dataset of poor resolution



No pre-processing on exposure and vulnerability data (a comparison with regional data to test coherence)

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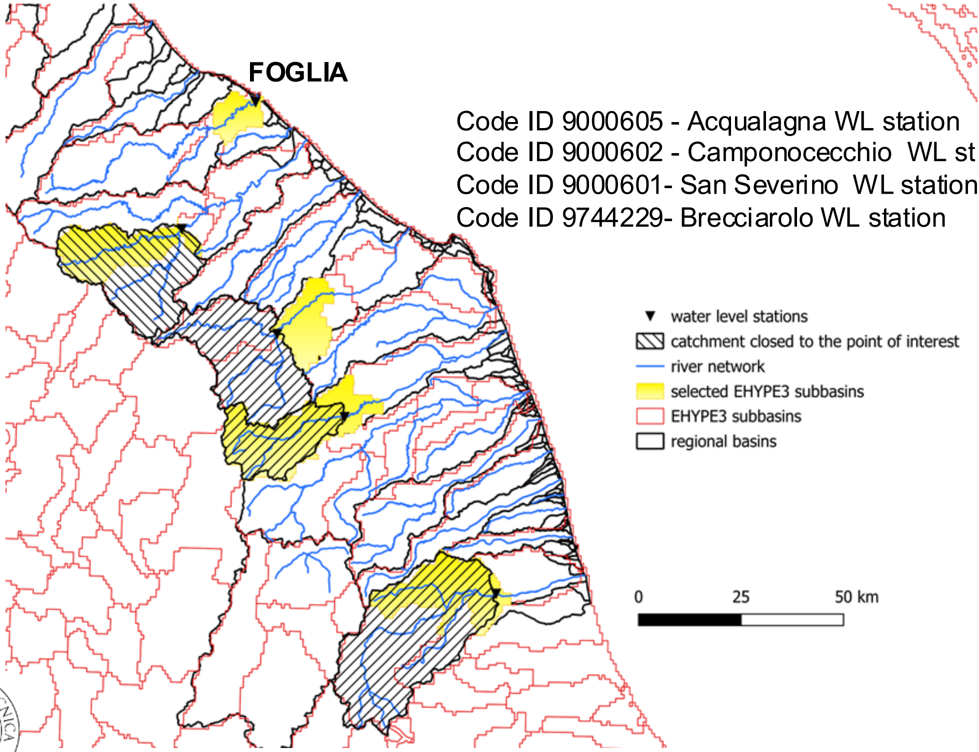
DISCHARGE work flow for Foglia outlet

LIMITS:

- Differences between "real" and EHYPE3 subbasins
- Longer flow data series available only on different river outlet and on different periods

Work flow daily time series for 1991-2005 and monthly means of river discharges for 1971-2000

For Acqualagna site, daily flow data are available from year 1923 to 1979 and from 2007 to 2025, for Camponocecchio, and Brecciarolo from 2005 to 2025, for San Severino from 2010 to 2025.



Tested the robustness of the methodology on 4 sections in order to evaluate future scenarios

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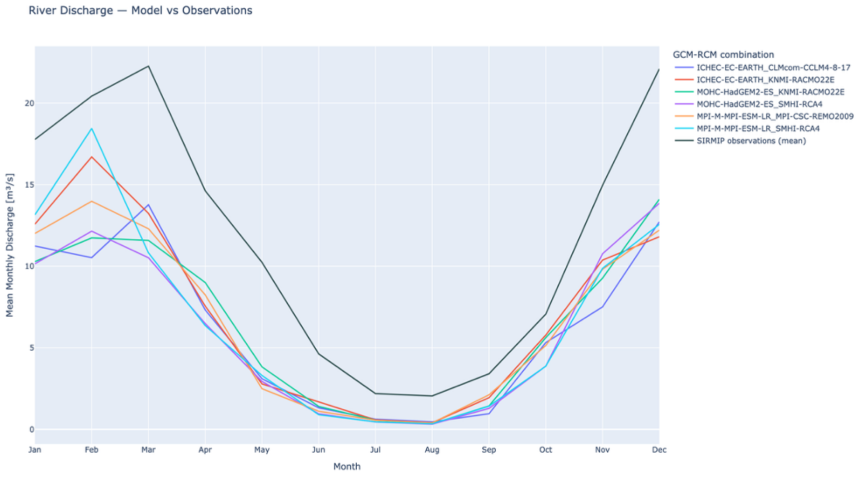
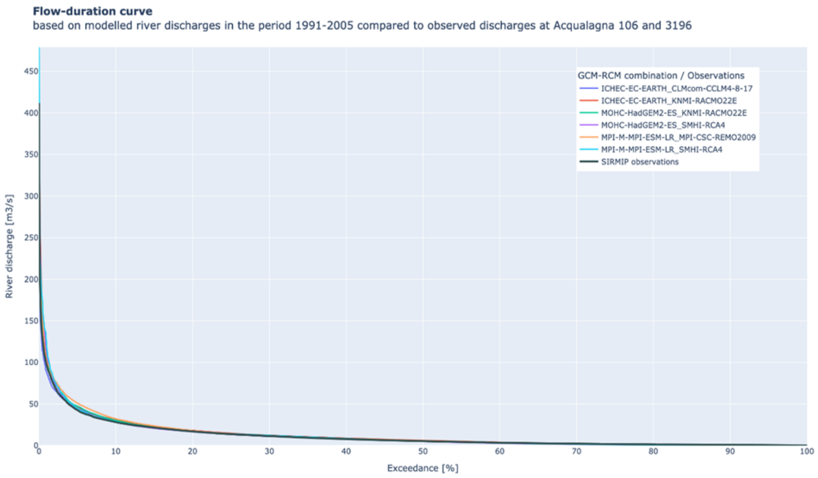
DISCHARGE work flow

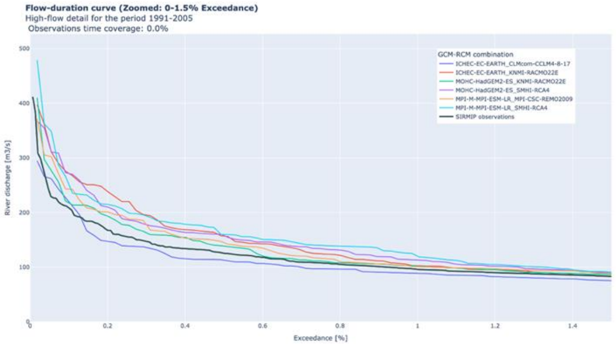
Code ID 9000605 - Acqualagna WL station n. 1185

DATA VALIDATION

merged data from year 1923 to 1979 and from 2007 to 2025







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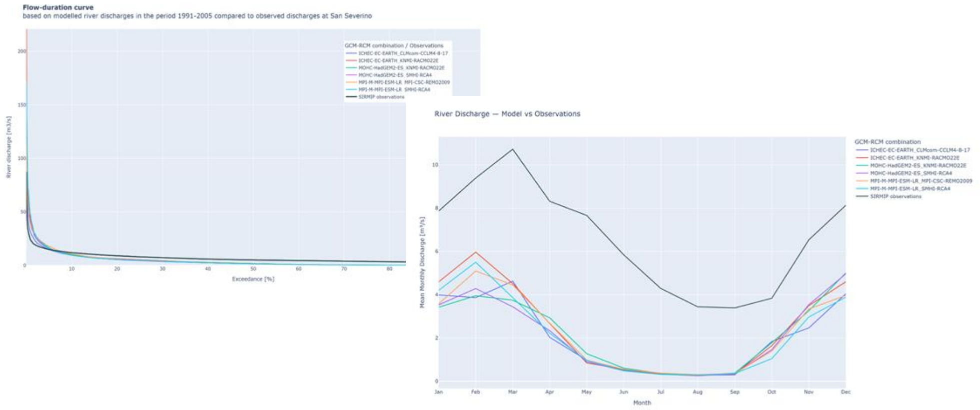
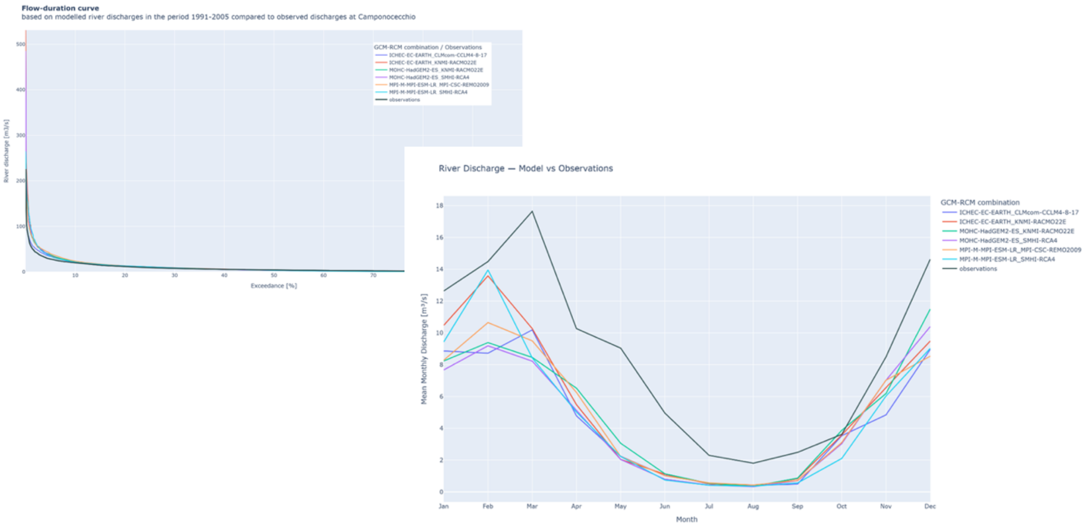
DISCHARGE work flow

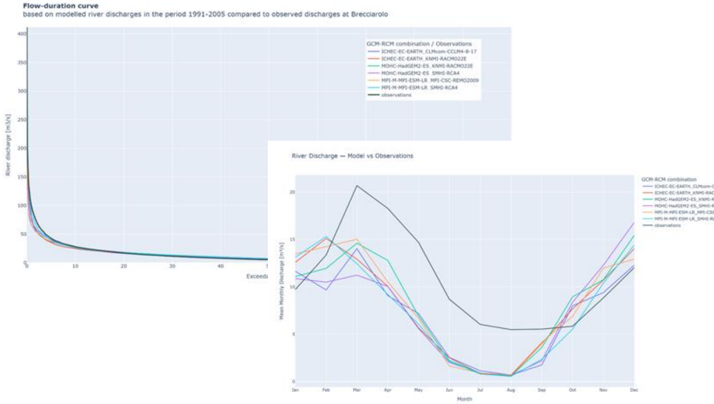
Code ID 9000602 - Camponocecchio WL station n. 1016

Code ID 9000601- San Severino WL station n. 1032

Code ID 9744229- Brecciarolo WL station n. 1108







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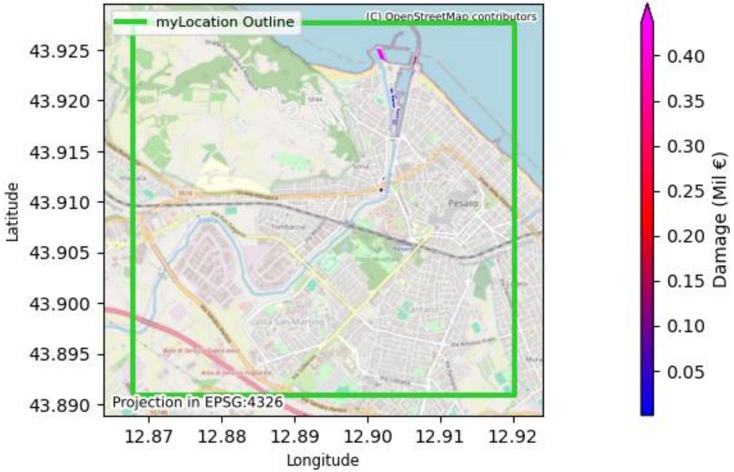
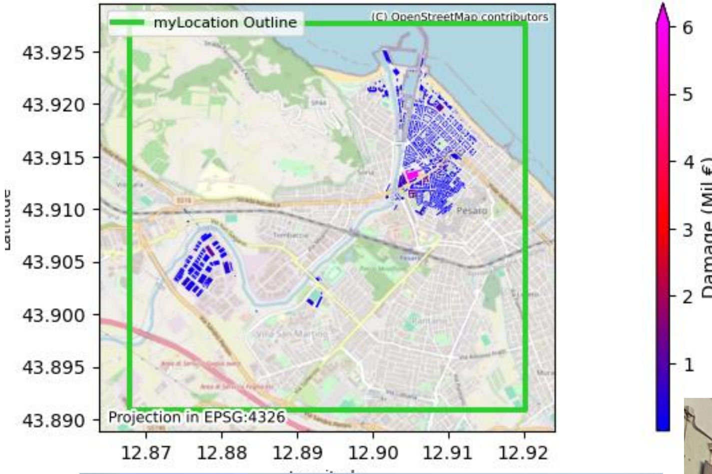
Our CRA results

Damage to buildings by mean flood depth based on flood map with 10 yr and 500 yr RP





Return period	Local floods maps	JRC floods maps
RP=10	1.130.206 €	72.127.617 €
RP=50	13.538.419 €	94.066.685 €
RP=100	36.452.708 €	100.100.947 €
RP=500	74.027.491 €	117.137.149 €

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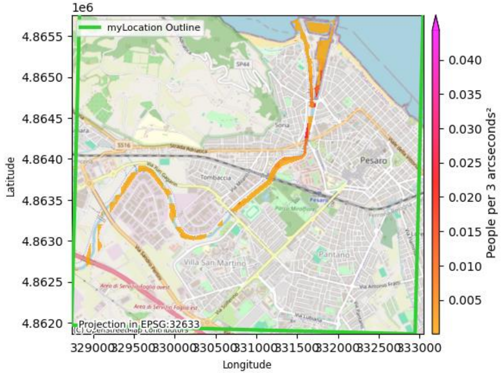
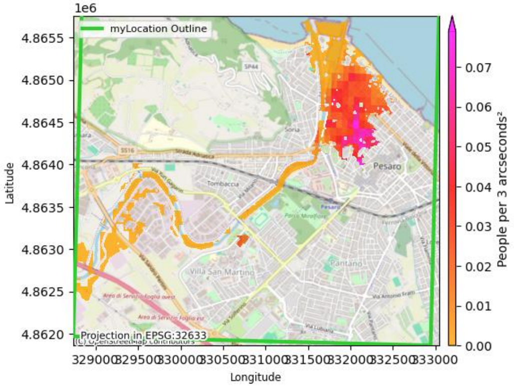
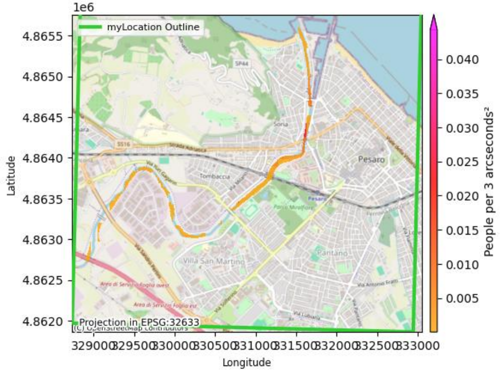
Exposed population for the river flood event with 10 yr and 500 yr return period

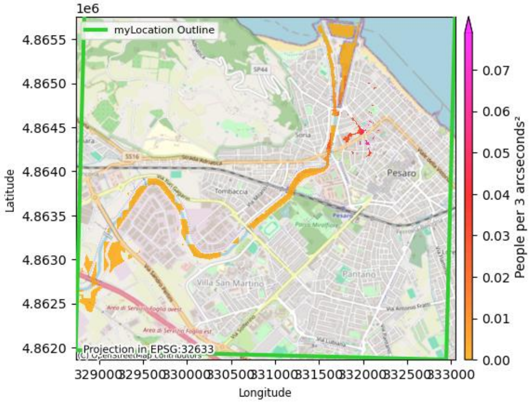




Exposed if Water Depth >0.0m



Displaced if flood depth >1.0m



Displaced if flood depth >1.0m

Return period	Population exposed	Population displaced
RP=10	3365	150
RP=50	3858	299
RP=100	3863	475
RP=500	4196	1383

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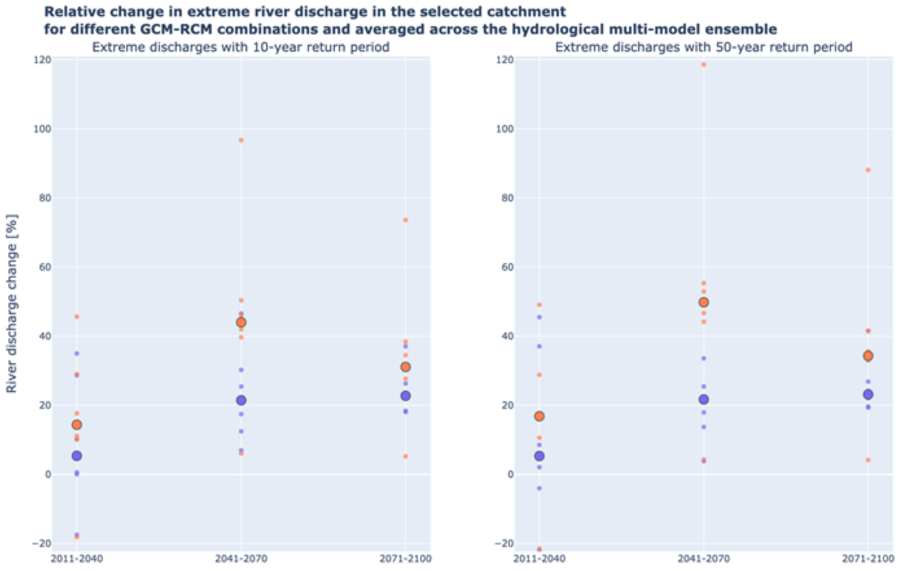
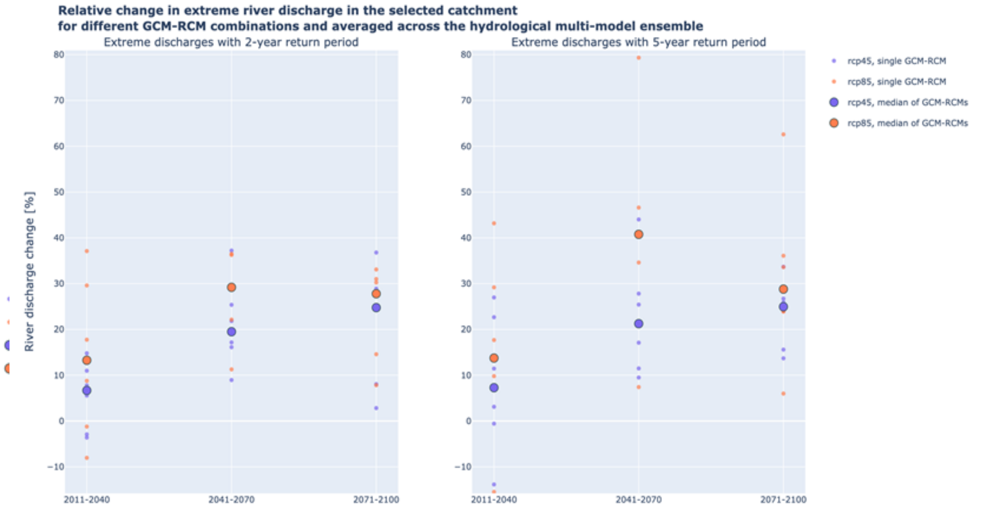
DISCHARGE work flow

Acqualagna

Extreme river discharge





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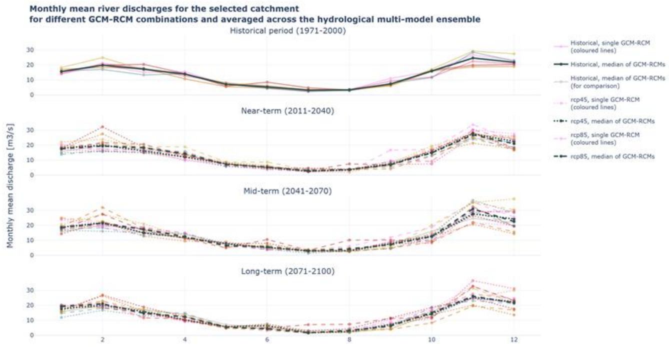
DISCHARGE work flow

Acqualagna



Monthly mean river discharges

NEW PLOT!!!

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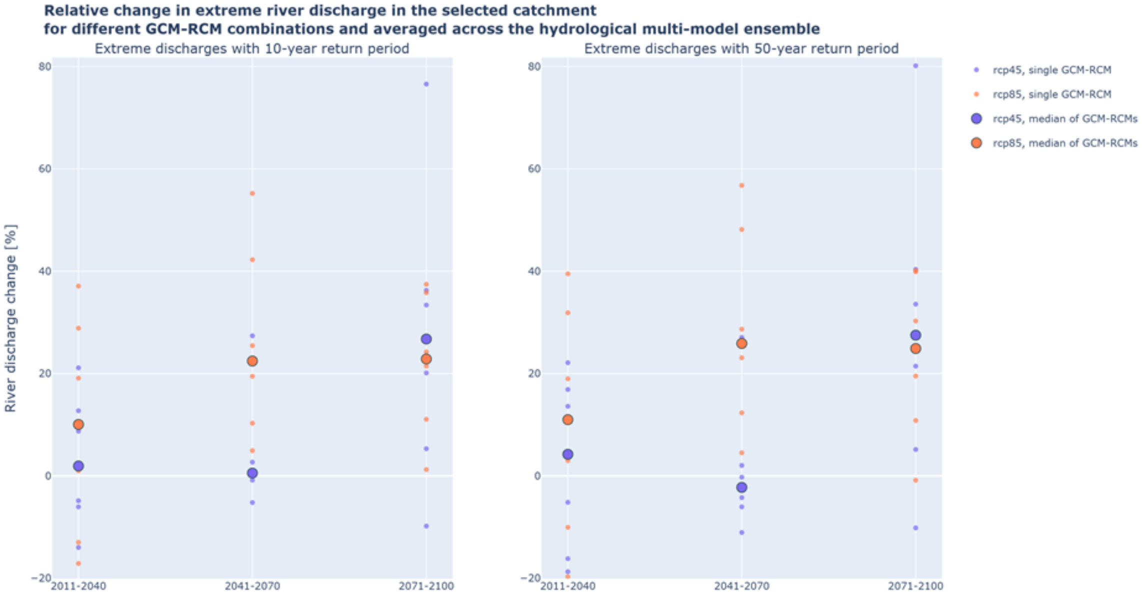
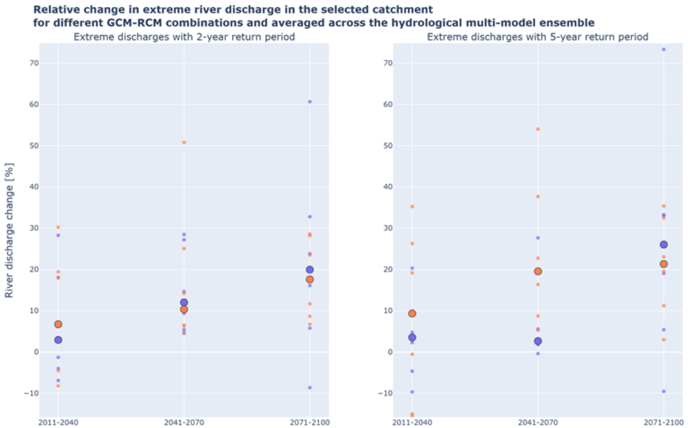
DISCHARGE work flow

Foglia

Extreme river discharge





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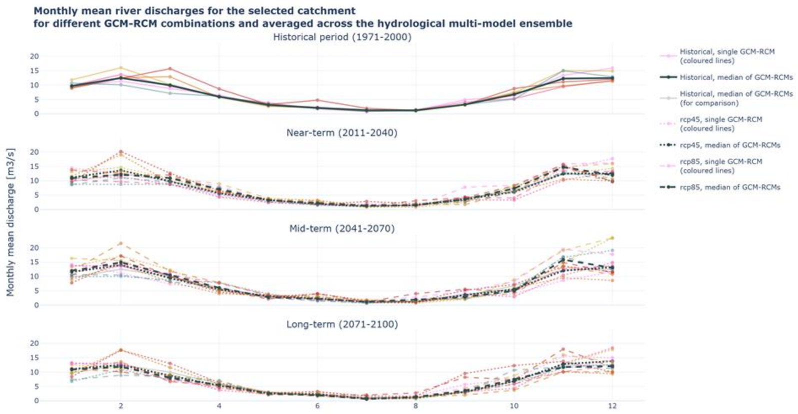
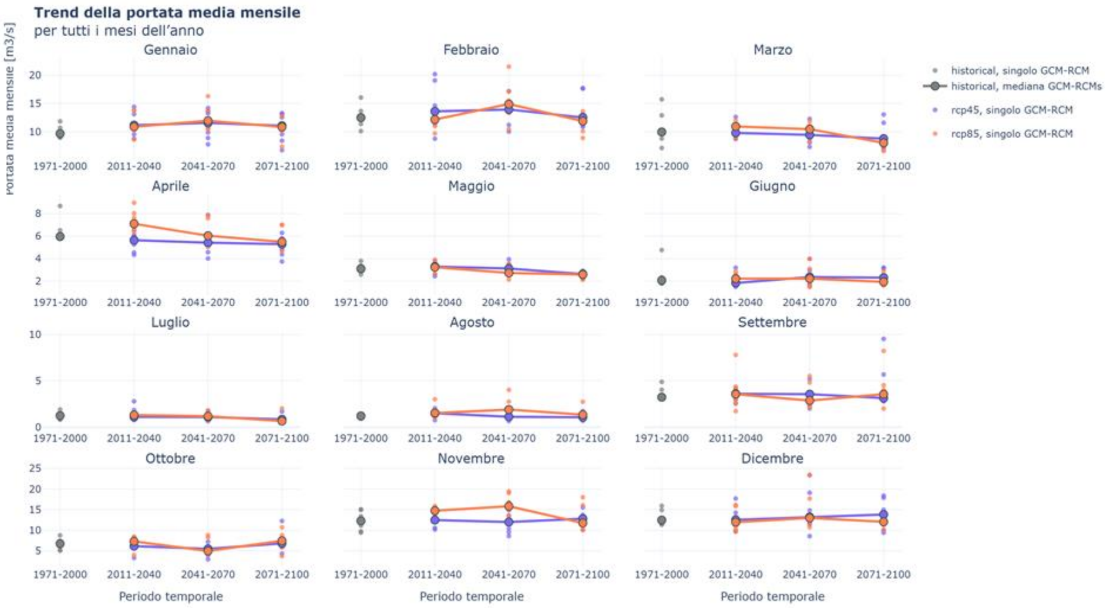
DISCHARGE work flow

Foglia





NEW PLOT!!!

Monthly mean river discharges

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Risk evaluation and management

The **discharge workflow** confirms a future increase in extreme events and so a potential increase of flooded areas on Foglia territories, but at the same time a different distribution of the monthly discharge during the year, that must be thinking to a different organization in terms of water resource exploitation.

Severity: Substantial for the current situation and critical in the future

Urgency: immediate actions required

Risk Workflow	Severity		Urgency	Capacity	Risk Priority
	C	F		Resilience/ CRM	
River flooding					Very hight

Severity
- Critical
- Substantial
- Moderate
- Limited

Urgency
- Immediate action needed
- More action needed
- Watching brief
- No action needed

Resilience Capacity
- High
- Substantial
- Medium
- Low

Risk Ranking
- Very high
- High
- Moderate
- Low

Adaptation capacity: some actions are already in place (as the emergency system of civil protection), but a homogeneous application of adaptation measures for the increase of resilience (as delocalization, deurbanization, etc) is still lacking. This is also due to the lack of precise information to motivate the decisions (as local floods maps, not available for all the basins).

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Reflections on using CLIMAAX toolbox

Strenghts

- Spatialization of risks and identification of priorities
- "Vision" of the need to act (important tool for communicating with policy makers)

Limitations

- Need of accurate information to obtain accurate results… but results are not accurate enough (i.e. if we talk about displacement)
- Lack of information for future scenarios

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Next steps

- Based on results obtained for the pilot of Foglia river, consultation with Pesaro Municipality and stakeholders to understand how the knowledge of risks could be included in urban planning

- Activation of an internal task force (with responsible of urban policies) to identify regulatory tools to apply in similar situation

To transform risk information into actual prevention tools for the entire regional territory

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CLIMAAX
climate ready regions

www.climaax.eu

Thanks

REGIONE MARCHE

MARCHE PROTEZIONE CIVILE REGIONALE

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Q&A AND DISCUSSION

Gaia Galassi
(Regione Marche)

Natalia Aleksandrova
(Deltares)

Francesca Sini
(Regione Marche)

Gloria Mozzi
(Euro-Mediterranean Centre on Climate Change, CMCC)

UPCOMING EVENTS

- 16 April 2026 10.30 CET
  Agricultural droughts

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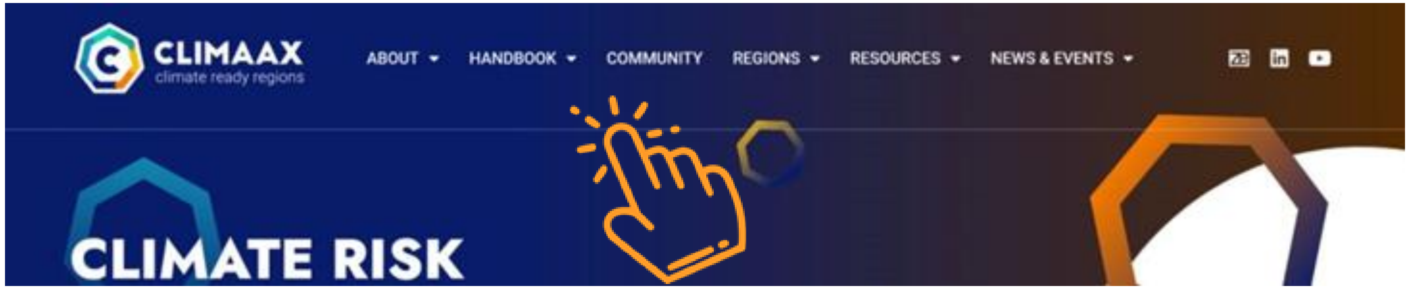
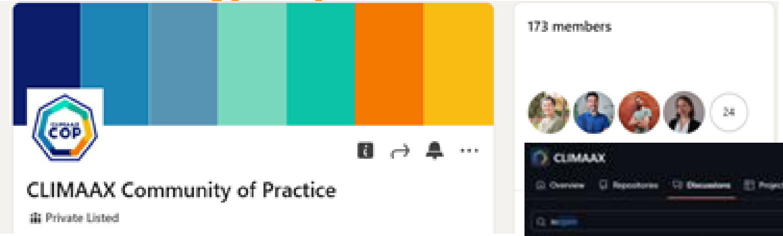
HOW TO ENGAGE IN THE COMMUNITY OF PRACTICE

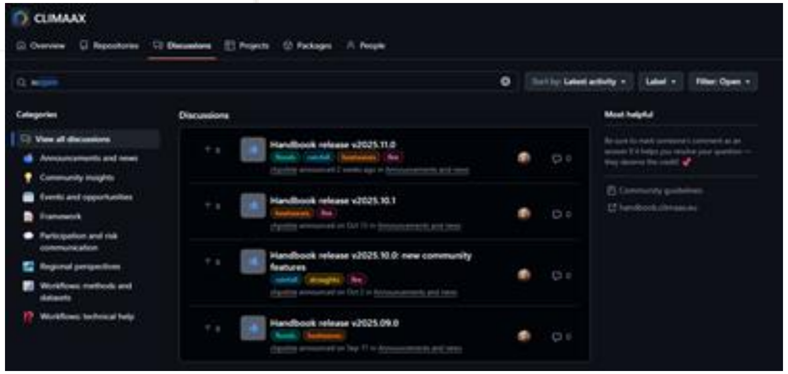


- Join our LinkedIn group and community forum
- Take our surveys
- Subscribe to the CoP to receive communication of further updates

  https://www.climaax.eu/community-of-

!! Scan this !!





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Thank you and see you next time!

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