



Centro Nazionale di Ricerca in HPC,
Big Data and Quantum Computing

ANNUAL MEETING

Del Centro Nazionale di Ricerca in HPC,
BIG DATA AND QUANTUM COMPUTING

ISOLA D'ELBA – LA BIODOLA, 5 - 8 OTTOBRE 2025

Spoke 4 – Earth and Climate

S. Gualdi, A. Alessandri + Spoke 4 team

Obiettivi-Achievements



Aumentare e migliorare l'utilizzo delle risorse HPC di nuova generazione e Big-Data processing per la modellistica climatica, incluso l'up-take di nuove metodologie (AI);



Consolidare il ruolo di primo piano della ricerca italiana nel dibattito scientifico internazionale sul cambiamento climatico;

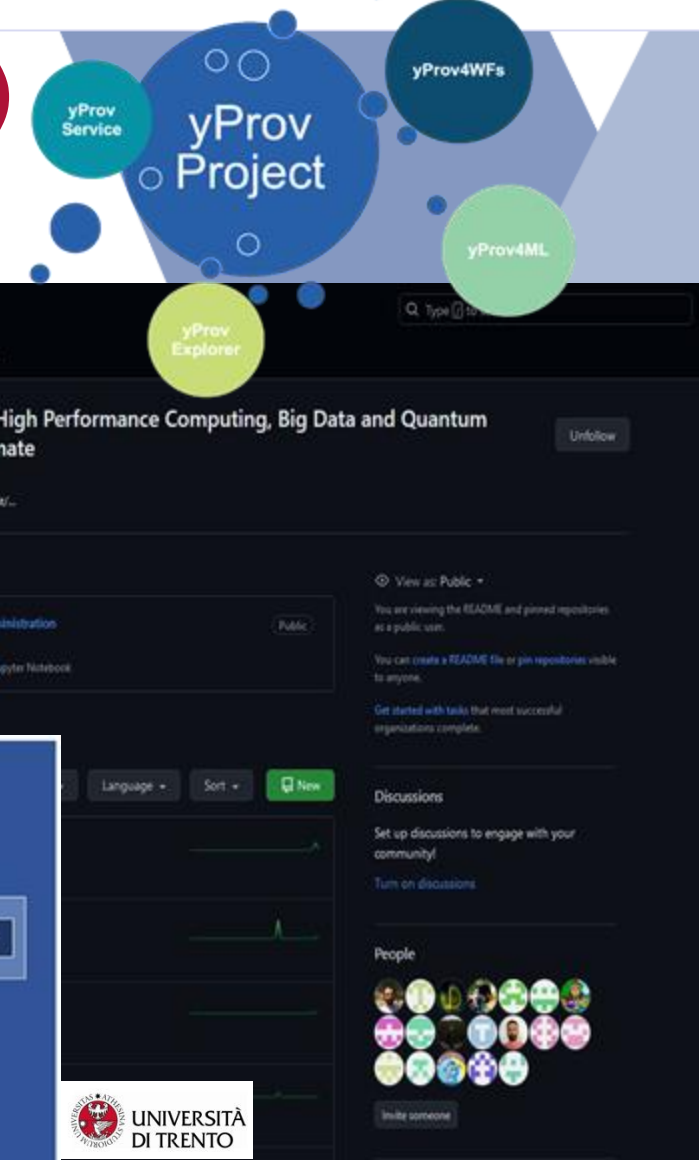


Nuovi dati e informazioni utili, pertinenti e tempestive per rafforzare la capacità del sistema-Paese di fronteggiarne la crisi climatica

HPC – Big Data engineering – Data science (AI)

A “Software Hub” for Earth System modelling, best practices, training and support

- A central hub to gather software developments produced within Spoke 4
- Facilitate **software sharing, collaborative efforts.**
- Include **provenance software** ecosystem for climate experiments.
- Foster a **sustainable, community approach** (32 teams involved).
- **Training initiatives** (3 schools).



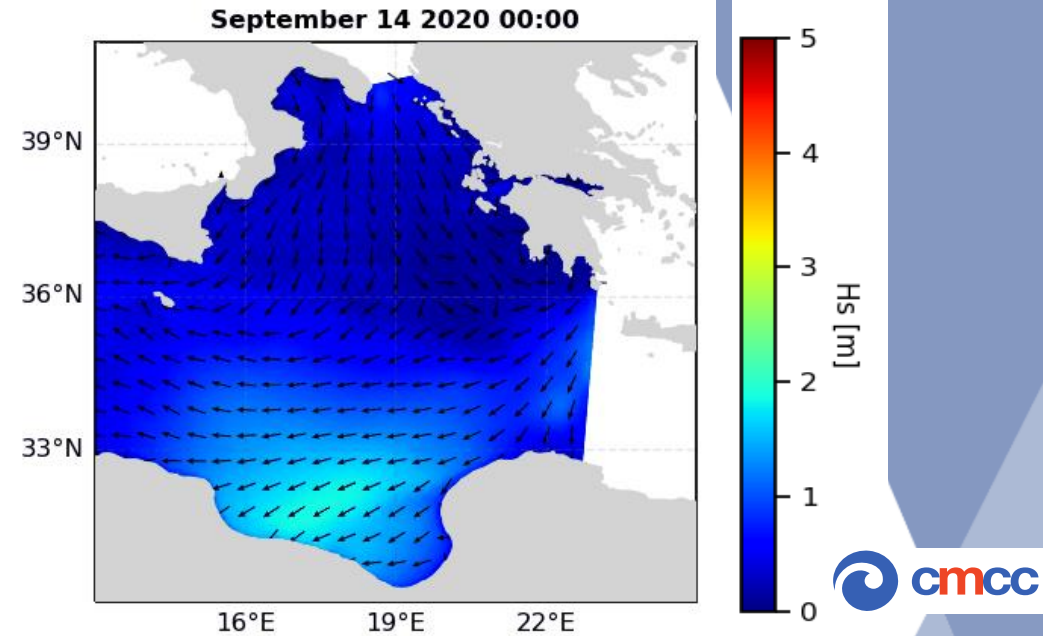
Ianos Medicane (2020)

Simulazione altezza (shading)
e direzione (frecce) dell'onda

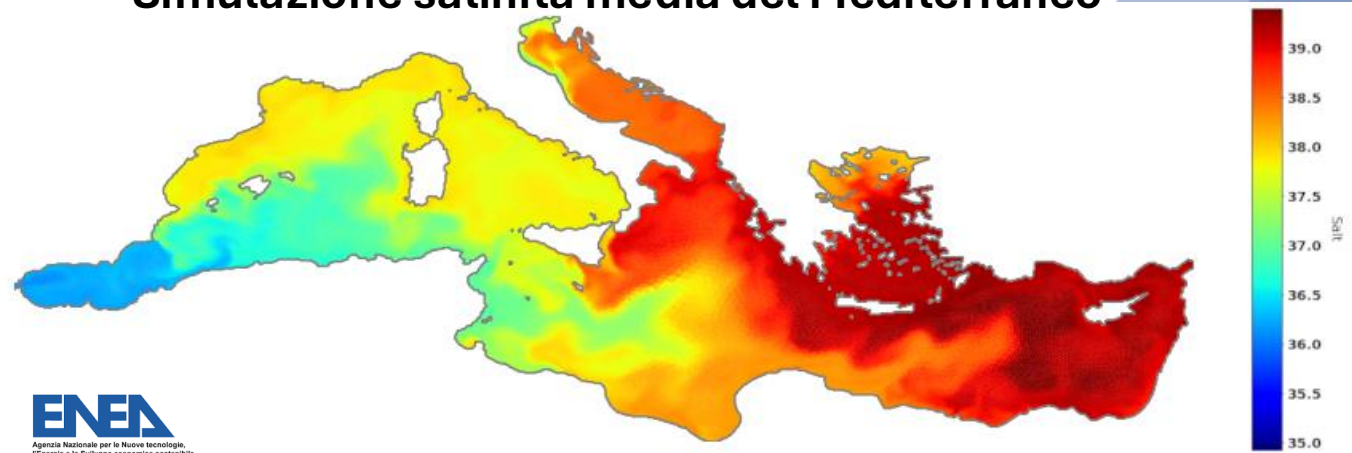
Improved modelling & climate data

Global and Regional Earth System Models (>10)

- improvements performed for all modelling systems (e.g. wave-ocean coupling).
- Testing simulations performed with all new global and regional ESMs.
- Code sharing, documentation and user manual.



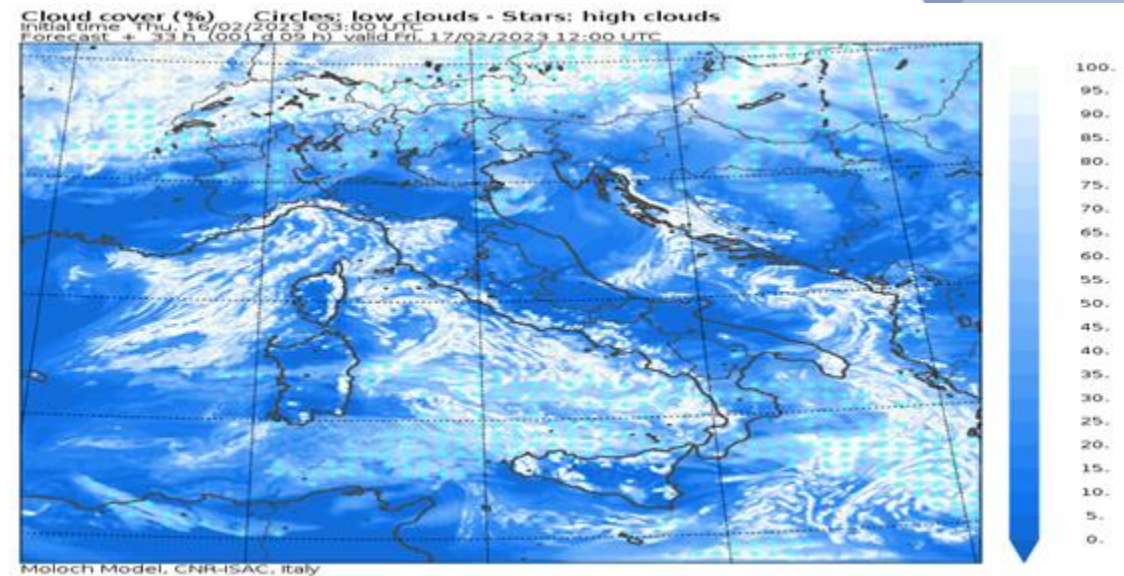
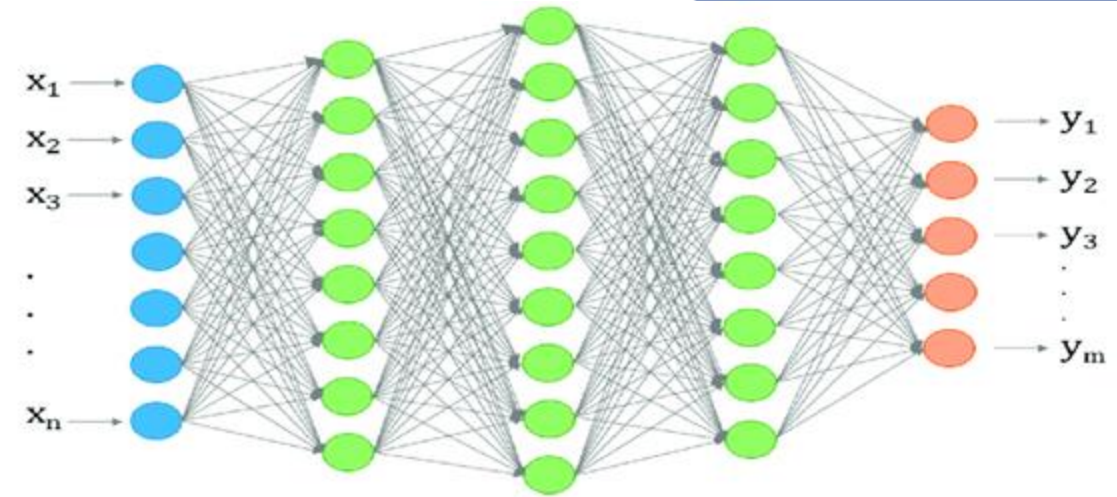
Simulazione salinità media del Mediterraneo



Improved modelling & climate data

Parametrization of physical processes & ML (>20)

..., e.g., a prototype
ML emulator of cloud
cover and cloud
water/ice content.



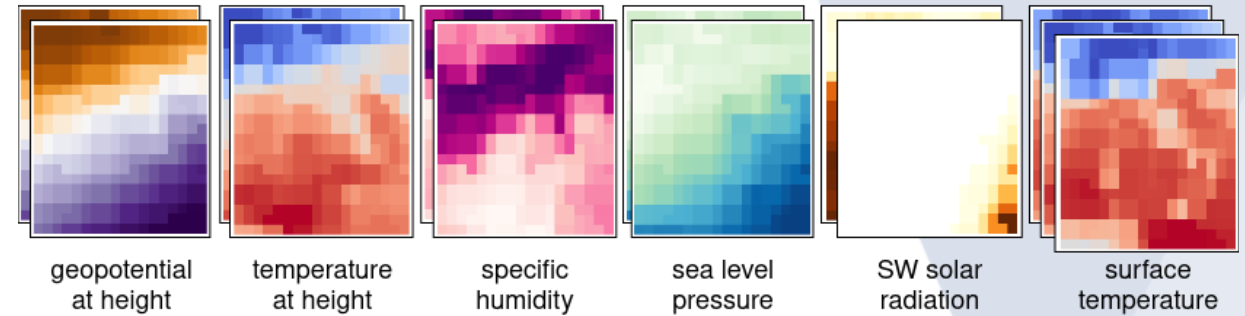
Improved modelling & climate data

New data-driven algorithms for
downscaling, bias correction
and calibration (>4)

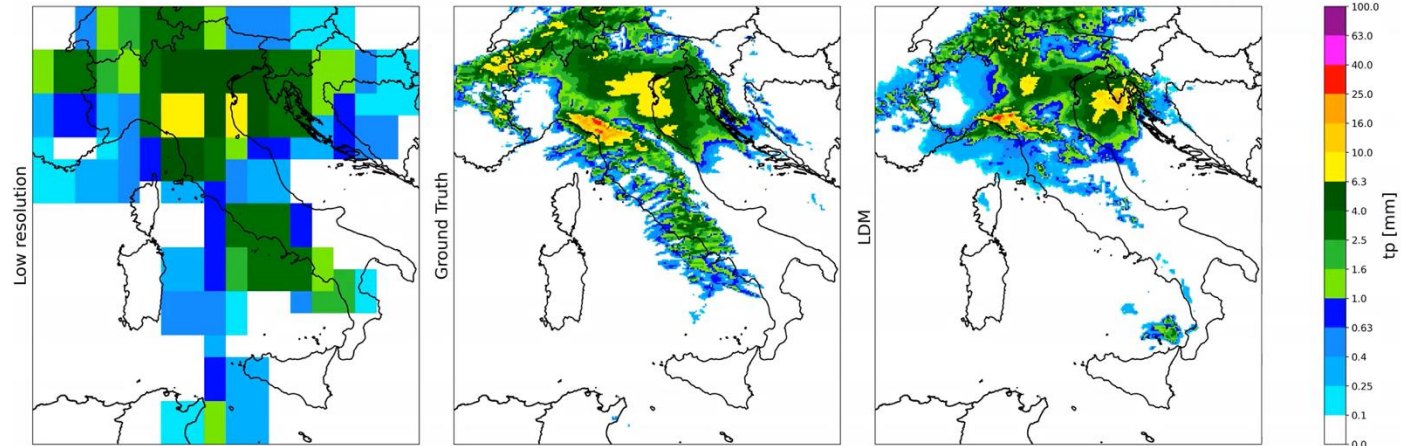
Deep learning-based downscaling of
low-resolution analysis or model
predictions from ~100km to kilometric
resolution over the Italian Peninsula.

1,500 years of data in 150 GPU-hours;
with traditional methods (dynamical
models) it would require **100 million
CPU-hours.**

Predictors



2009-01-01 02:30:00



Low-res precipitation
from global models or
analysis (~100km)

**High-resolution
Ground truth
(4km)**

**ML model
downscaling
(4km)**

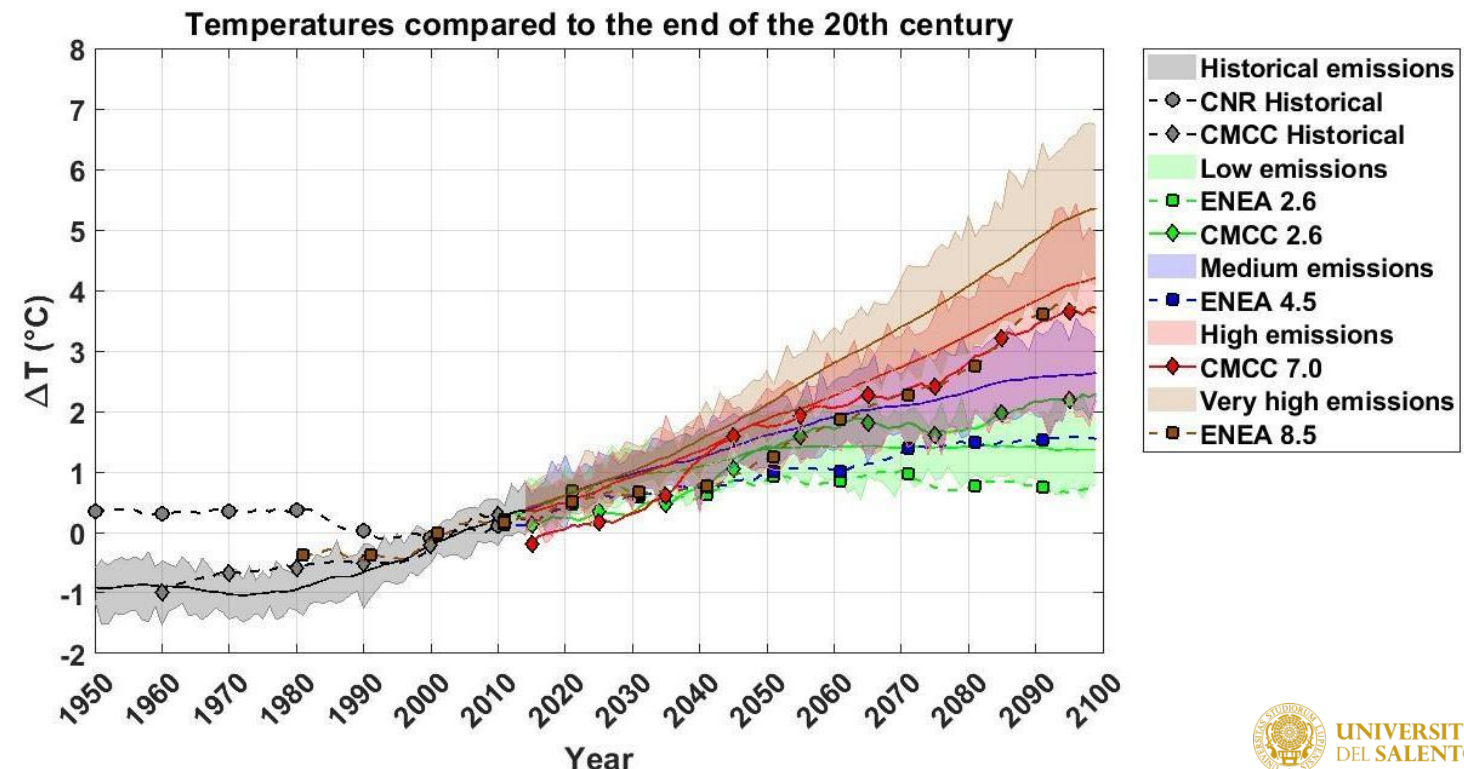
Improved modelling & climate data (>10 new climate scenarios)

Simulations and predictions of the Italian and Mediterranean climate

New knowledge and data on climate impact drivers with a focus on the Mediterranean region

- New set of high-quality climate projections for the whole Mediterranean region or specific areas at sub-regional scale (e.g. Alps, Adriatic Sea).

2 m air temperature mean annual evolution for the Mediterranean region from 1950 to 2100

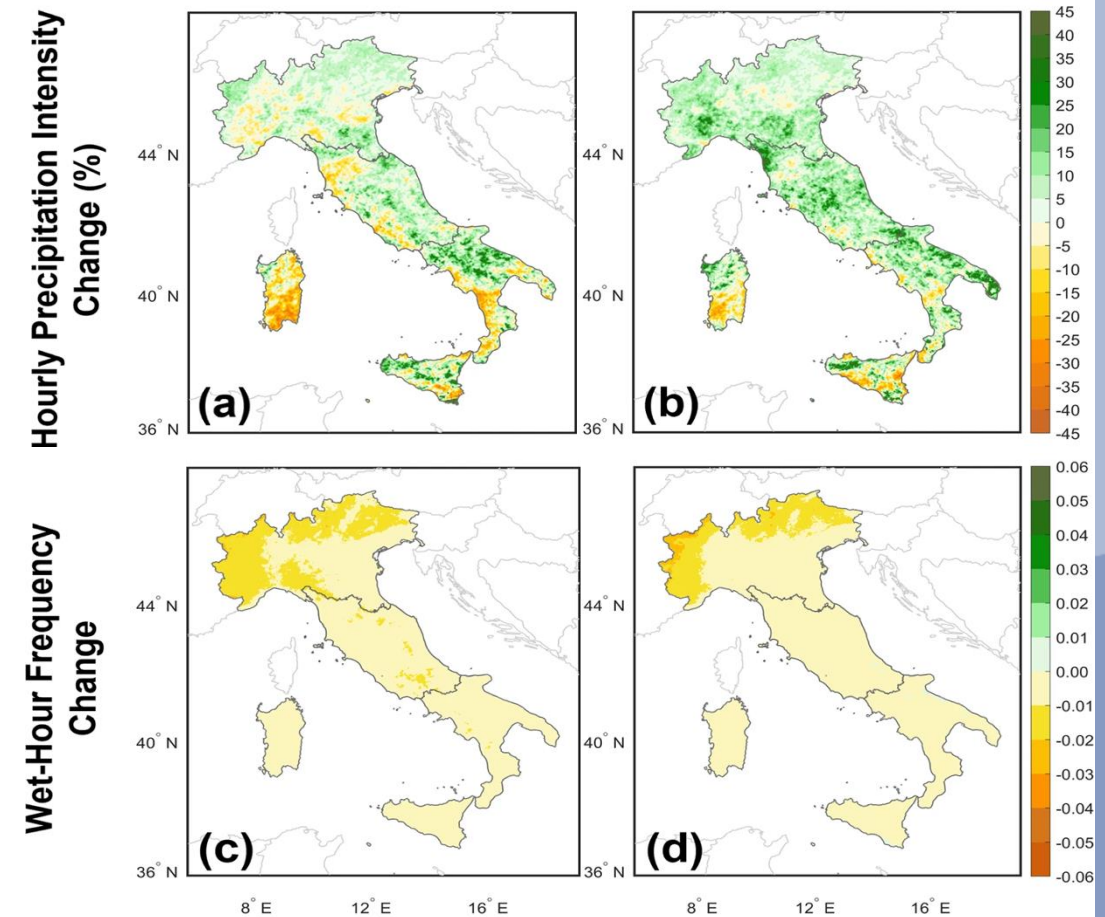


Improved modelling & climate data (>10 new climate scenarios)

Evolution and shifts of extreme events

Provide information on the predictability of droughts, heat waves, extreme precipitation, storms and on their future frequency

- Evolution and significant changes in the statistics of extreme events in the Italian Peninsula and in the Mediterranean basin.
- Machine Learning approaches for the detection of extreme events (e.g cold spells and heat waves).



Change of the **summer hourly rainfall** over 2021–2050 (wrt 1989–2018): (a,b) **intensity change (%)**, (c,d) **wet-hour frequency change**, in RCP4.5 and RCP8.5 scenarios.

ClimateData-IT



Cos'è

- **Hub climatico nazionale** (scala Petabyte);
- Earth System Grid Federation (**ESGF**) **Tier0** (IPSL, DKRZ, CEDA) dati climatici in support ai report IPCC (Science-to-Policy);



Attori

- task force nazionale modellistica climatica (CMIP, CORDEX, ItaliaMeteo, ecc) + CINECA (calcolo, rete, storage);
- Spoke4: coordinamento + software stack, modelli, dati
 - DASSTER (Bando a Cascata): servizi data platform
 - RETE & HAMMON (Innovation Projects): data management
- ICSC: interfaccia stakeholder e altre comunità;



Impatto

- Asset strategico (analisi di impatto, sviluppi AI, etc...);
- Benefici → comunità scientifica + agenzie pubbliche + imprese;



Governance

- Definizione avviata da Spoke4
- Strategia di lungo termine post-CN1





Finanziato
dall'Unione europea
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Ministero
dell'Università
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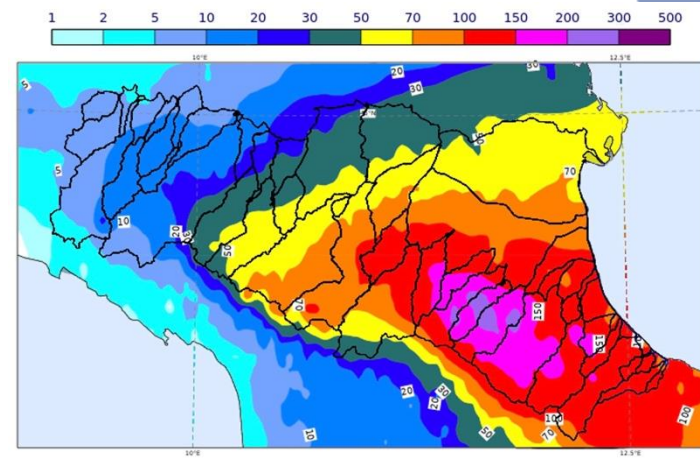
Grazie

«Negli ultimi tre anni, grazie alle attività dello Spoke 4 e al supporto di ICSC, abbiamo consolidato e potenziato competenze, prototipi, piattaforme dati e workflow HPC, contribuendo al miglioramento della modellistica climatica italiana e rendendola più efficace e competitiva a livello internazionale.

Guardando al futuro, quali sono le sfide e le opportunità per rafforzare la capacità del sistema italiano di affrontare gli impatti (già in atto e futuri) della crisi climatica?»

In Emilia Romagna nel 2023 e 2024 quattro eventi alluvionali con precipitazioni senza precedenti e impatti devastanti

- Diciotto **vittime**;
- **>10 miliardi di danni** a privati, infrastrutture, imprese, settore agricolo.
- Decine di migliaia gli **sfollati**.



Pioggia accumulata giornaliera



Bandi a cascata

Project name	Area	Funding	Co-funding	Total Budget €	% in Southern Regions	Start date End date
ADELE4RAIN	3	236.911,50	151.500,00	388.411,50	100%	02/08/2024 01/08/2025
CTA	3	330.000,00	70.000,00	400.000,00	100%	06/08/2024 05/08/2025
DASSTER	2	234.448,34	66.155,89	300.604,23	0%	06/08/2024 05/08/2025
ENGAGEMENT	3	399.938,61	0	399.938,61	0%	02/09/2024 01/09/2025
GLOWPP	1	260.029,05	57.945,11	317.974,16	100%	09/08/2024 08/08/2025
IT-WATER	4	335.280,00	0	335.280,00	0%	09/08/2024 08/08/2025

2.142.274,50 €

71% (3.200.000 €)

52% (1.106.385 €) al sud