

BILANCIO IDROLOGICO E DISPONIBILITÀ DI RISORSA IDRICA

AGGIORNAMENTO 2025, PREVISIONI STAGIONALI
E PROIEZIONI CLIMATICHE

24 marzo 2026
ore 9:00 - 13:30

SALA CONFERENZE ISPRA
Via Vitaliano Brancati, 48



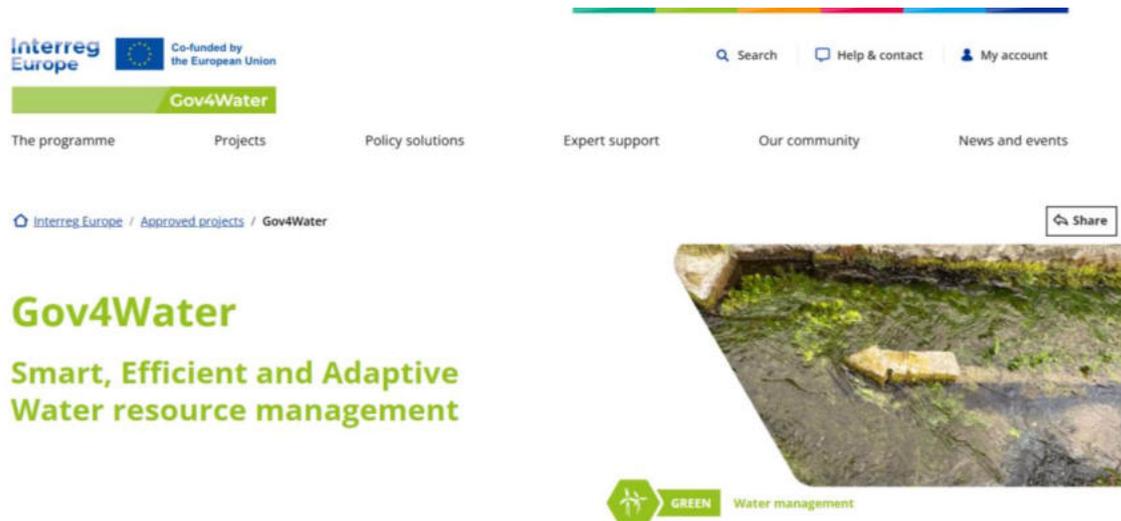
DIPARTIMENTO
DI INGEGNERIA
CIVILE E AMBIENTALE

Valutazione della disponibilità di acqua dolce ai fini di una gestione sostenibile nel contesto del cambiamento climatico nella regione Umbria

Alessia Flammini, Renato Morbidelli, Carla Saltalippi, Jacopo Dari

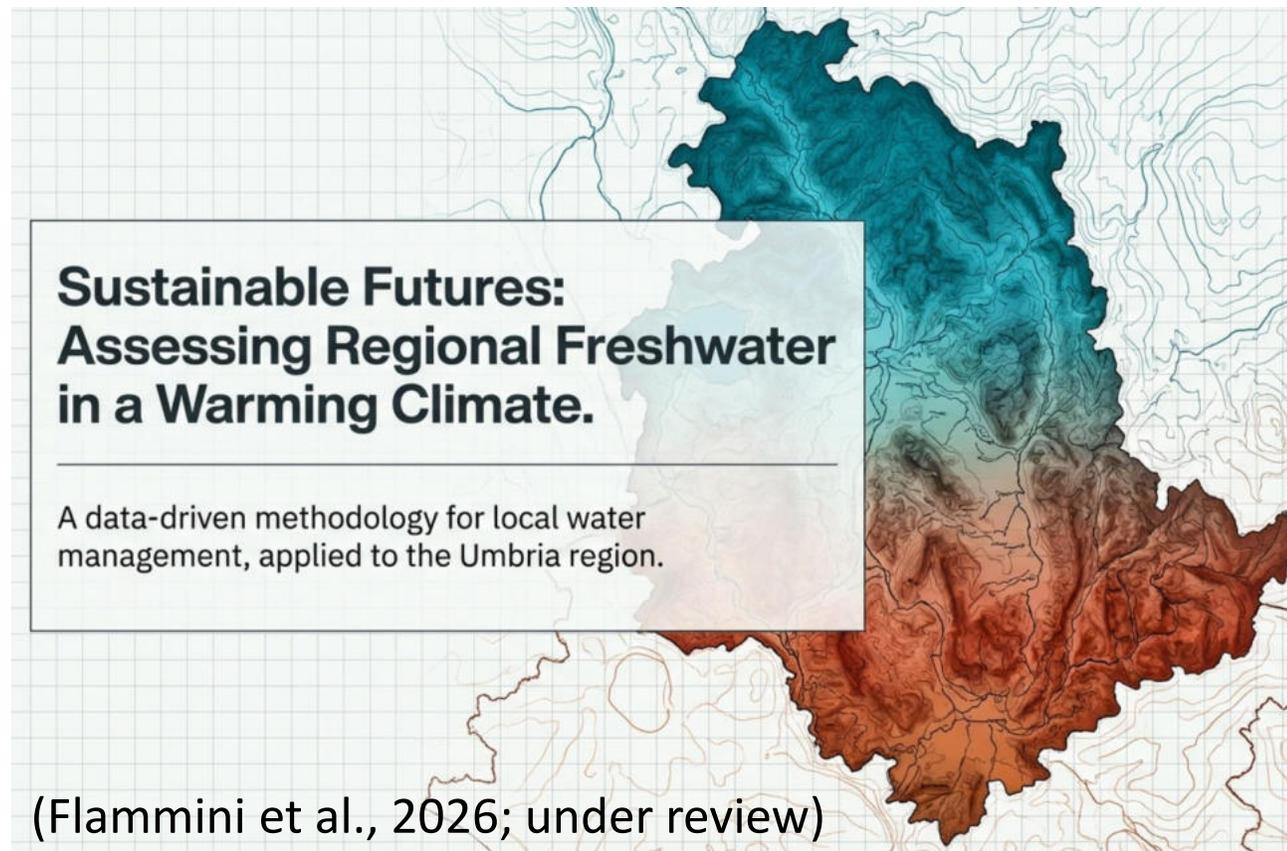
Università degli Studi di Perugia

It arises from a collaboration with the region and AURI



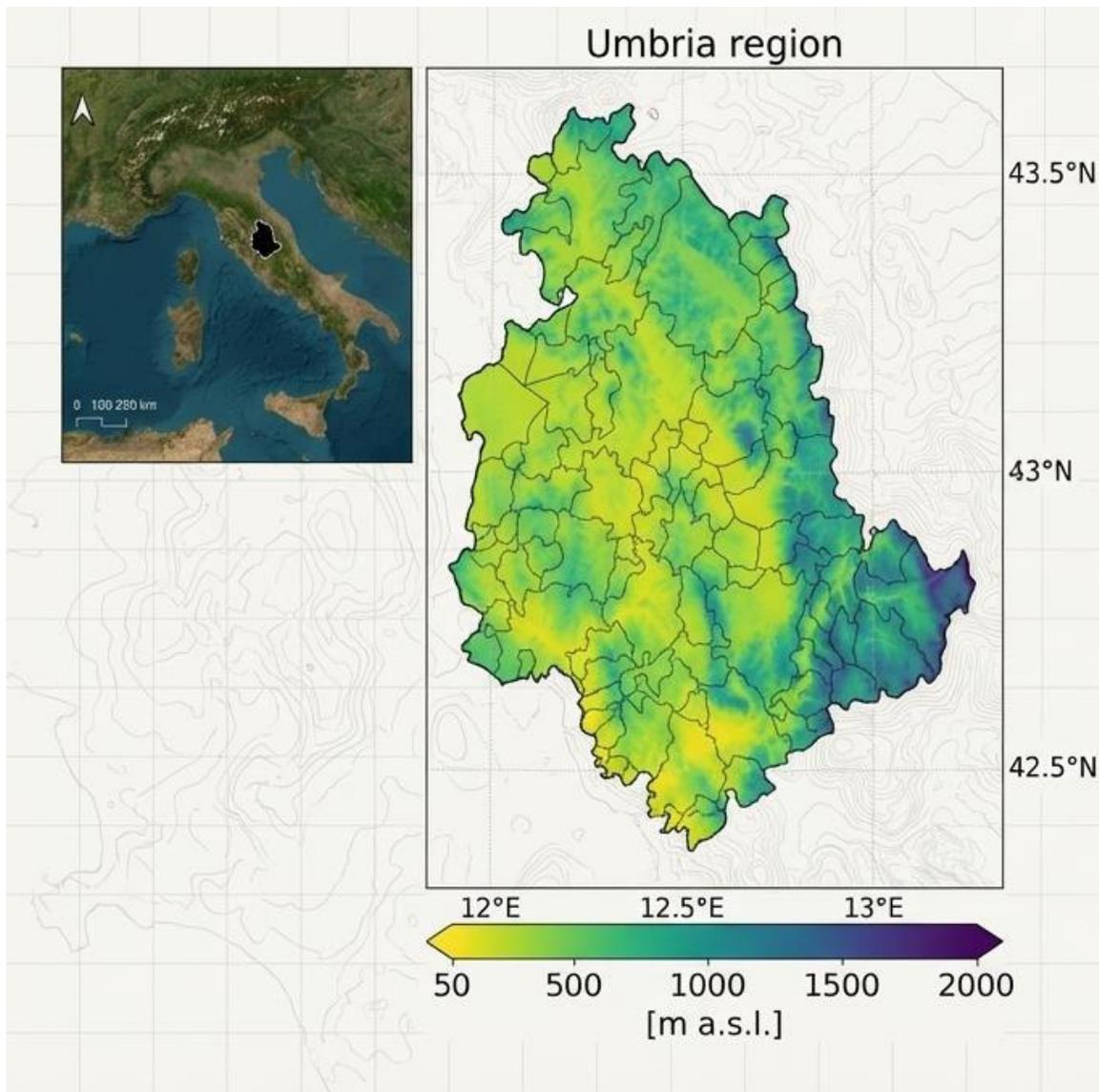
The screenshot shows the Gov4Water website. At the top left, it features the Interreg Europe logo and the text 'Co-funded by the European Union'. Below this is a green bar with 'Gov4Water' in white. A navigation menu includes 'The programme', 'Projects', 'Policy solutions', 'Expert support', 'Our community', and 'News and events'. A search bar, 'Help & contact', and 'My account' are also visible. A breadcrumb trail reads 'Interreg Europe / Approved projects / Gov4Water'. The main content area has a large green heading 'Gov4Water' followed by the subtitle 'Smart, Efficient and Adaptive Water resource management'. Below this is a photograph of a natural water feature with a 'Share' button. At the bottom left, there is a green icon with a leaf and the text 'GREEN Water management'.

Preliminary results submitted to Sustainable Futures (Elsevier)



The image shows the cover of a paper titled 'Sustainable Futures: Assessing Regional Freshwater in a Warming Climate.' The background is a topographic map of the Umbria region, with the northern part shaded in teal and the southern part in brown. A white text box in the center contains the title and subtitle: 'A data-driven methodology for local water management, applied to the Umbria region.' At the bottom, it says '(Flammini et al., 2026; under review)'.

Background of studies on climatic trends in Umbria region



Profile:

8,500 km² territory characterized by the Upper-Middle Tiber River basin.
Land use: 54% agricultural, 39% forested.

Temperatures



Rising at
+0.025 °C/year.

Rainfall



Declining at **-1 to -2 mm/year.**

Runoff



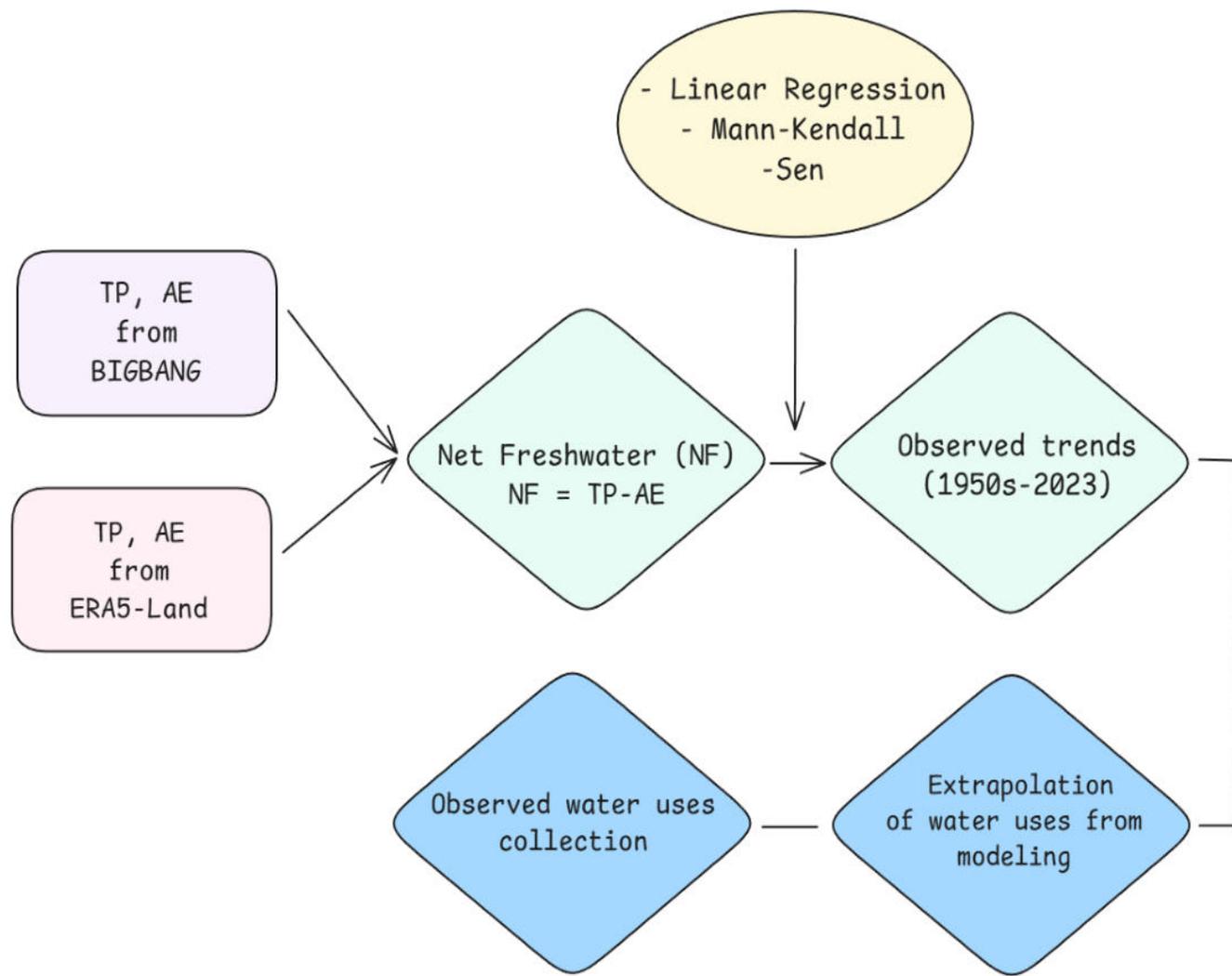
Median loss of
-1.62 mm/year.

Historical Context:

Five severe, natural-disaster-level droughts documented since 2000 (2001–02, 2006–07, 2011–12, 2016–17, 2021–23).

NotebookLM

Selected approach



Two Independent Lenses on Climate Data

Diagnostic Lens Matrix

BIGBANG v8

Scope: Italy-specific (developed by ISPRA).

Resolution: Ultra-high 1km regular grid.

AE Method: Thornthwaite & Mather soil water balance.

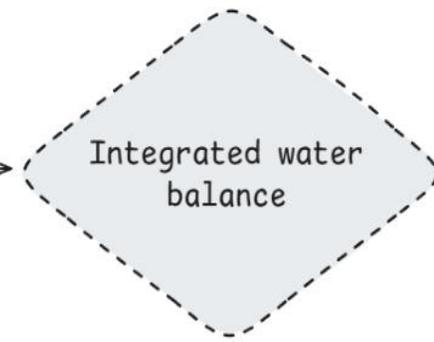
ERA5-Land

Scope: Global Copernicus reanalysis.

Resolution: 9km grid.

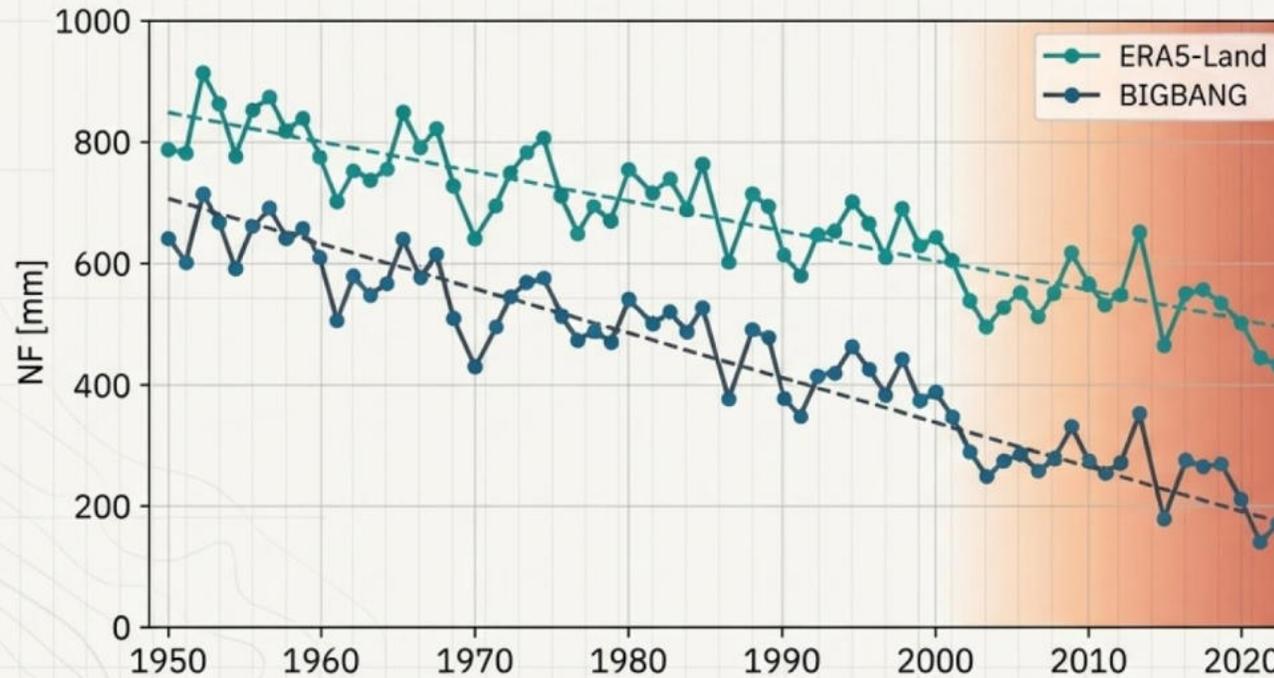
AE Method: H-TESEL (Hydrology-Tiled ECMWF Scheme).

Takeaway: Utilizing two distinct methodologies ensures observed trends are structural climate realities, not model artifacts.



Results: regional-scale aggregated NF trend obtained from the two datasets

73 Years of Monotonic Decline



Key Statistics

BIGBANG Decline Rate:
-2.03 mm/year.

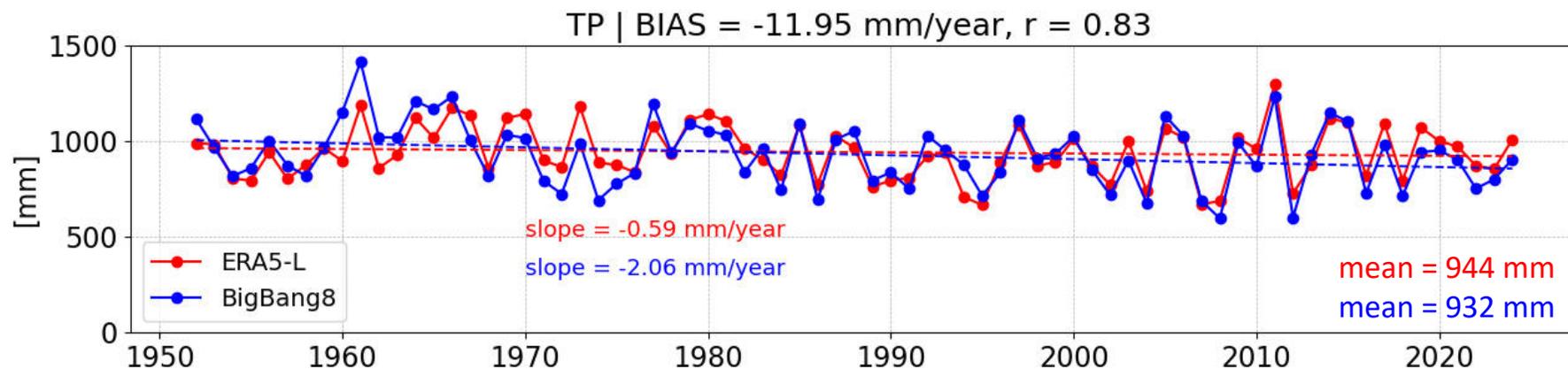
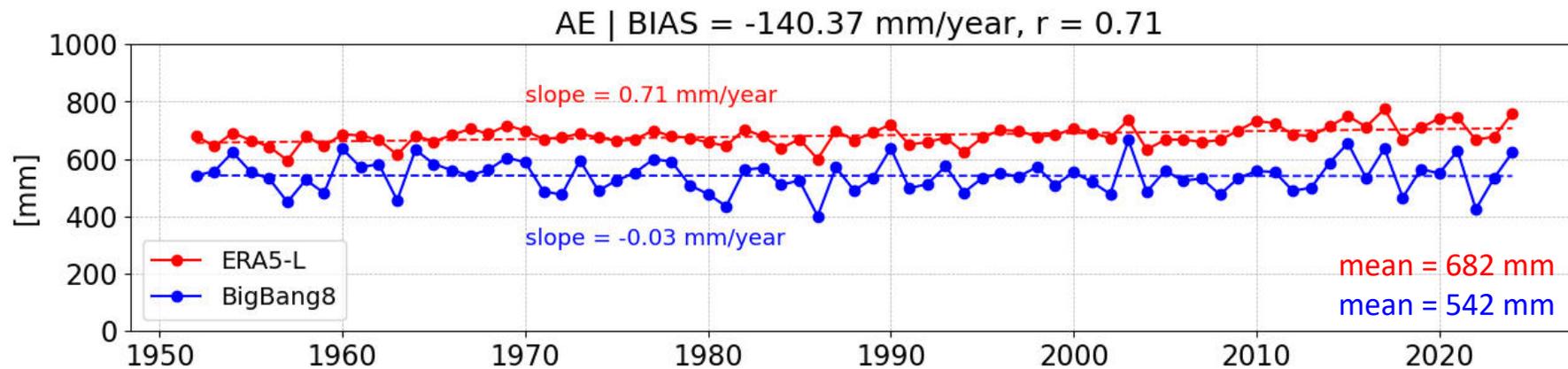
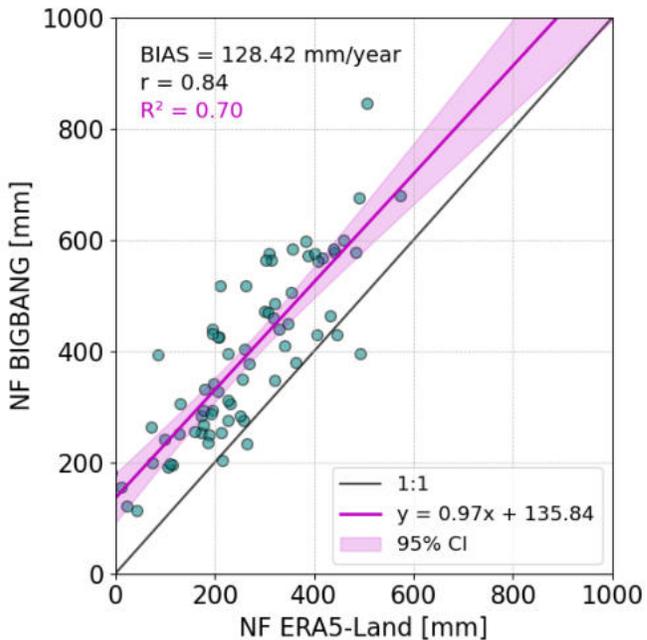
ERA5-Land Decline Rate:
-1.30 mm/year.

Total Loss: Equivalent to losing 10–16% of the region's average annual precipitation over the observed period.

Despite different absolute values, both datasets reveal a statistically significant, monotonically decreasing trend in freshwater availability.

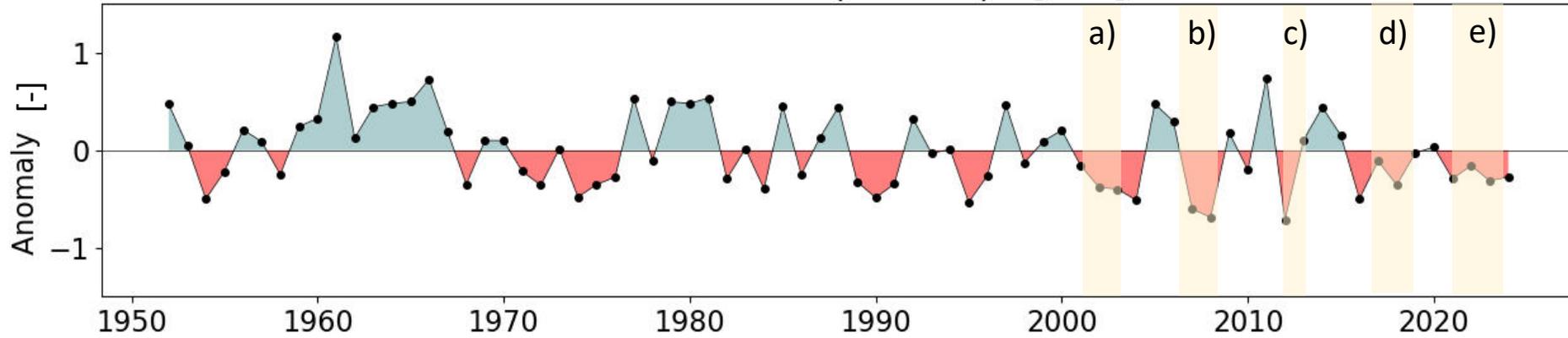
- Statistically significant trend (MK) for BigBang but not for ERA5-Land
- Monotonically decreasing trend (Sen test) for both datasets

Results: explaining the divergence in NF estimates between the BigBang and ERA5-Land datasets

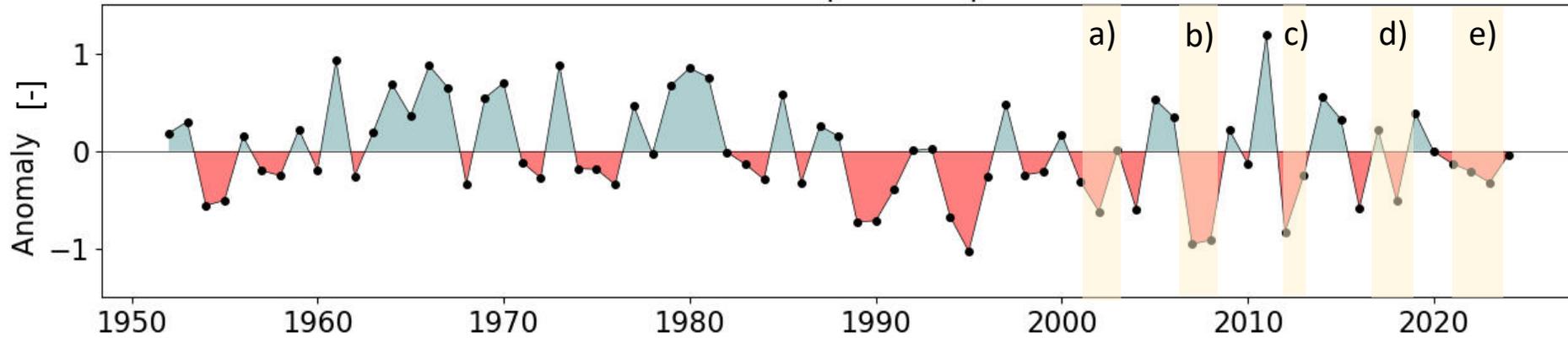


Results: capturing observed droughts

NET FRESHWATER | TP - AE | BigBang8



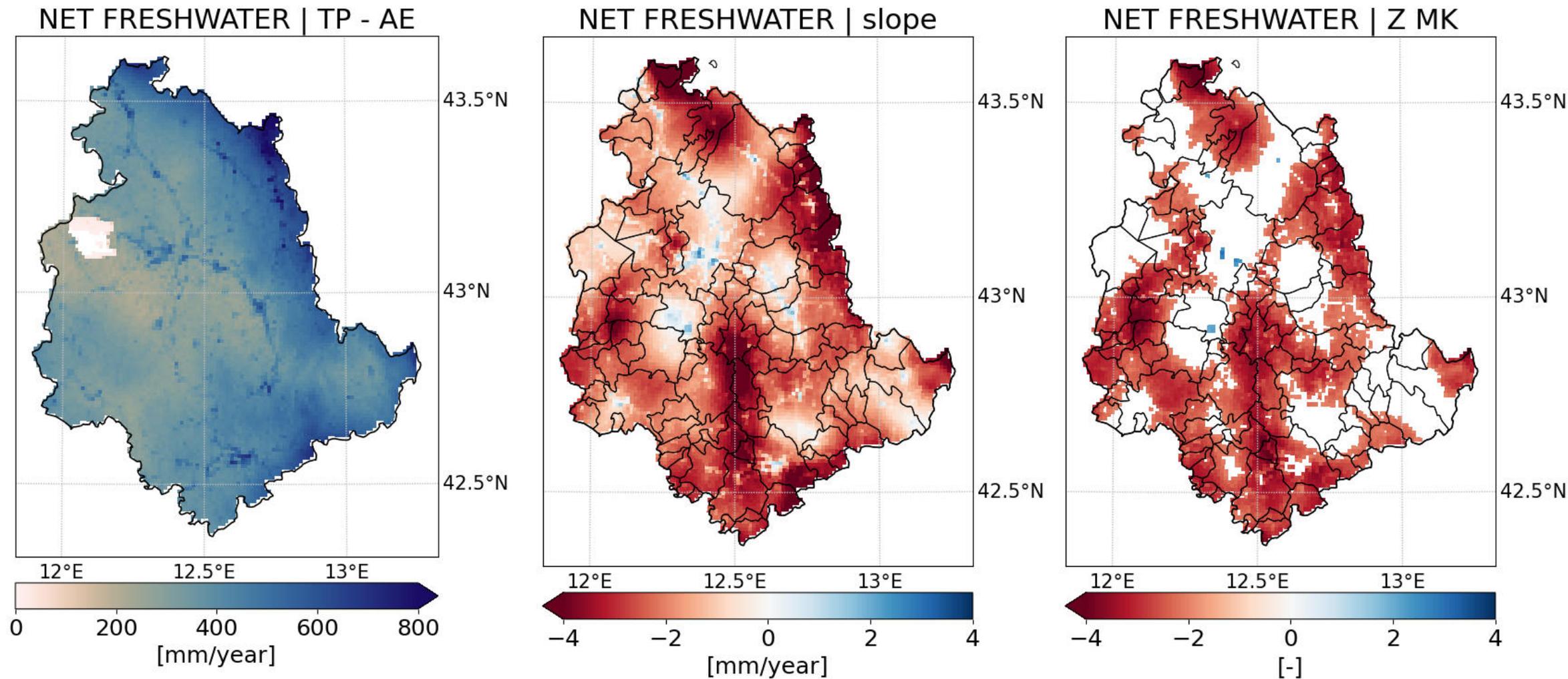
NET FRESHWATER | TP - AE | ERA5-Land



Observed droughts:

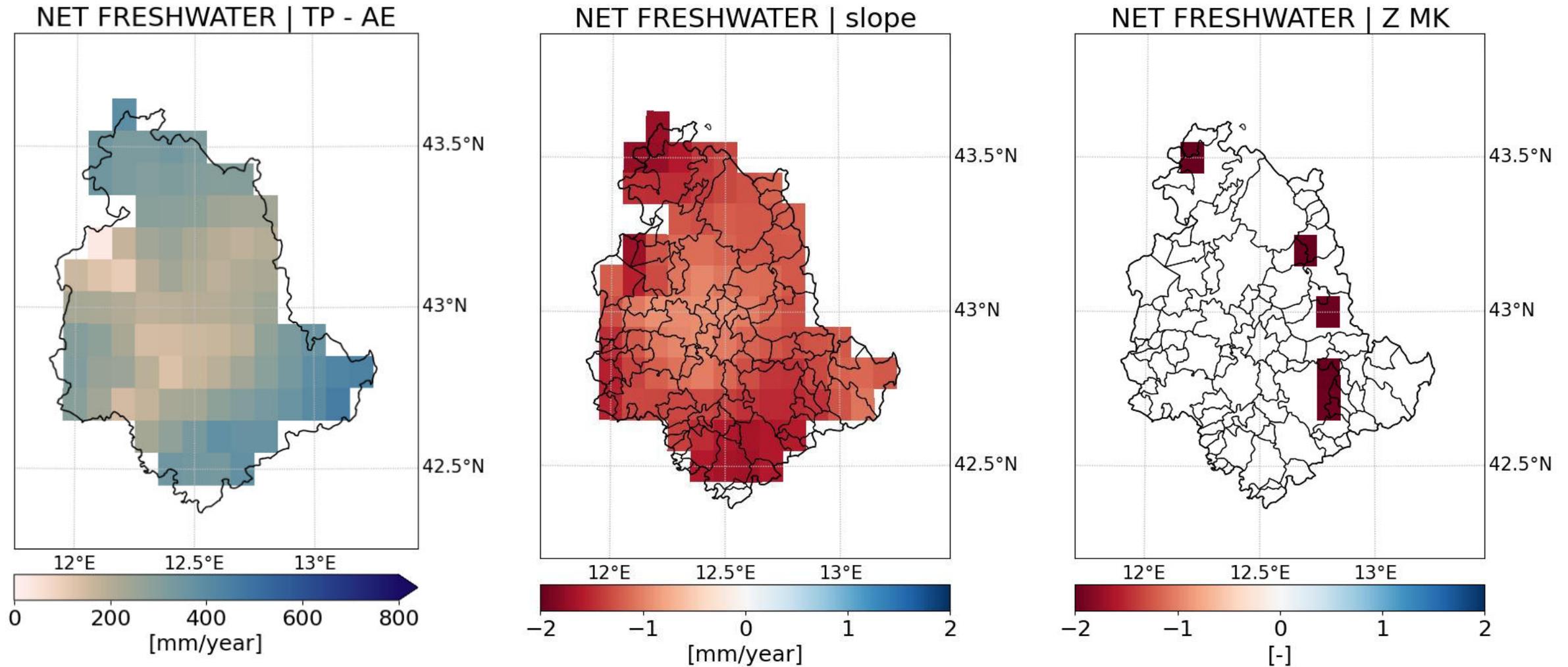
- a) 2001-2002
- b) 2006-2007
- c) 2011-2012
- d) 2016-2017
- e) 2021-2023

Results: temporally averaged NF estimates by BigBang across the region



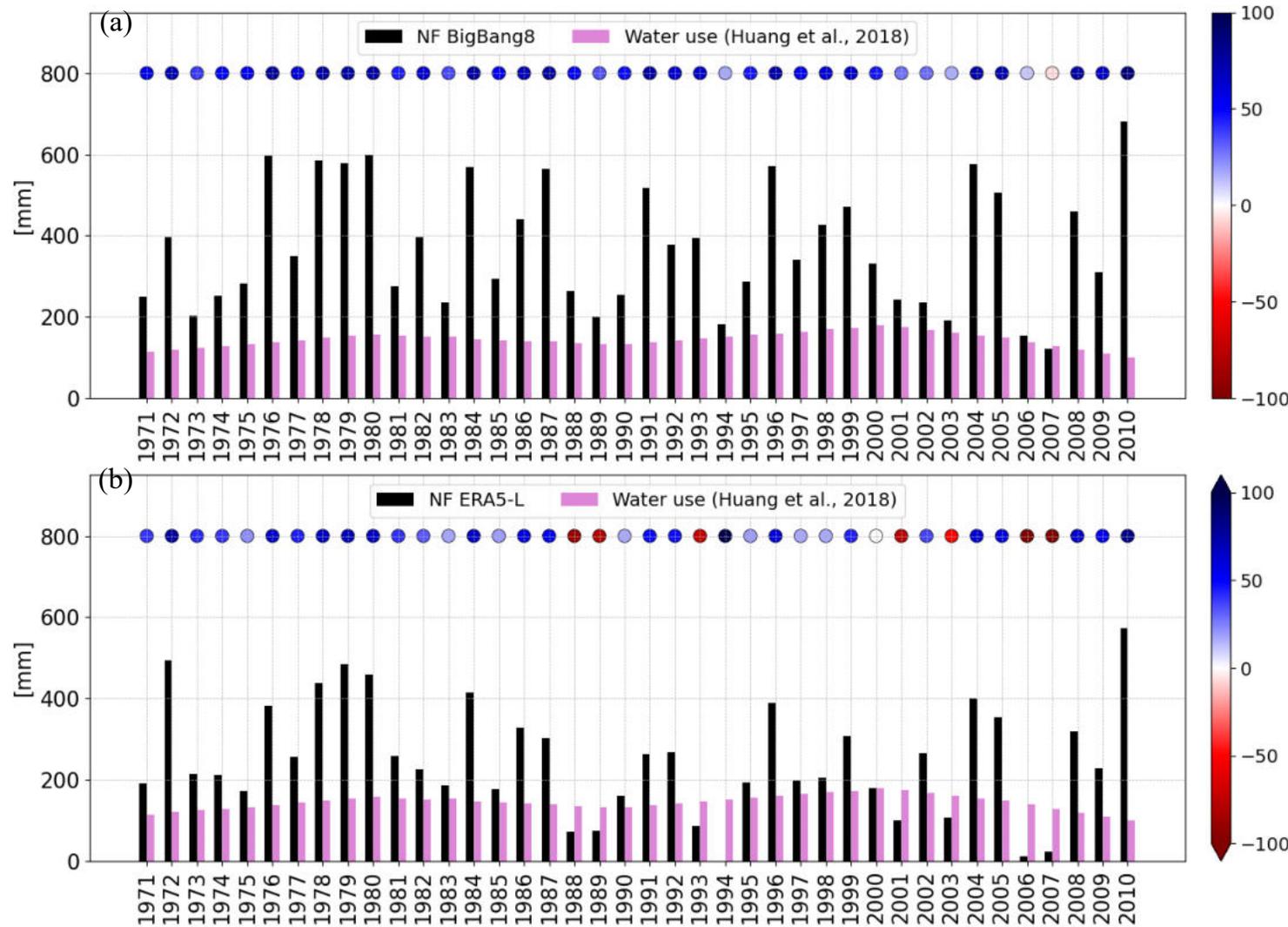
- The areas with the highest average remaining resource are those showing the most pronounced and statistically significant downward trends.

Results: temporally averaged NF estimates by ERA5-Land across the region



- The resolution of ERA5-Land is too coarse to yield useful spatially distributed information. However, downward trends are observed, though they are rarely statistically significant.

Results: estimating water uses by global modeling (Huang et al., 2018)



Annual total water uses by modeling platforms (Huang et al., 2018; <https://doi.org/10.5194/hess-22-2117-2018>) compared with NF derived using

- the BIGBANG data set (a)
- ERA5-Land data set (b)

for the period 1971–2010.

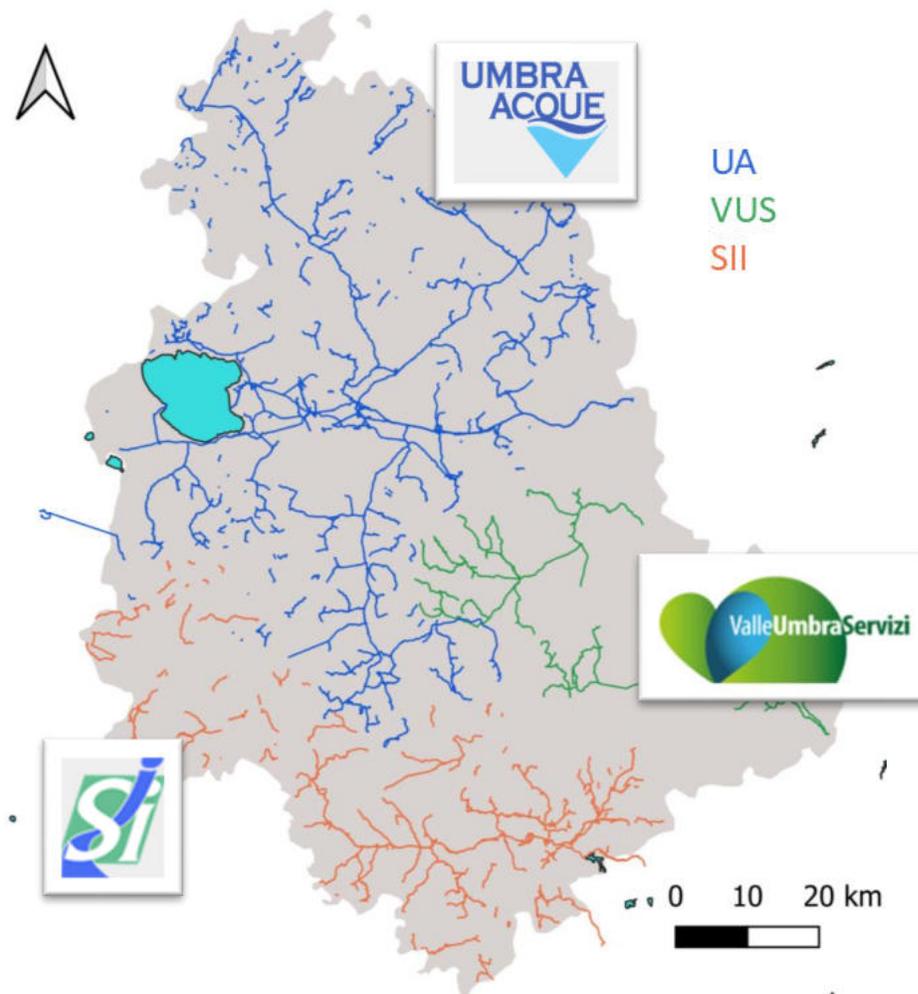
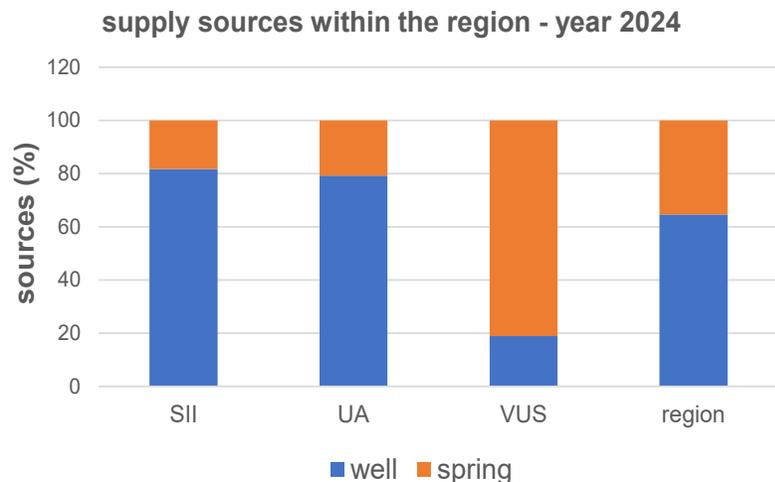
Colour of the circles quantifies the percentage difference between NF and water consumption (Δ).

Ongoing activity: integration of anthropogenic water uses into the hydrological balance



demands related to **civil uses**

- AURI: Umbra Acque, Valle Umbra Servizi, and Servizio Idrico
- more than 90% of the volume withdrawn for civil uses is measured
- water supply: 64.6% from well fields and 34.6% from springs
- the regional water supply system is affected by a high percentage of losses (about 42%)



Ongoing activity: integration of anthropogenic water uses into the hydrological balance

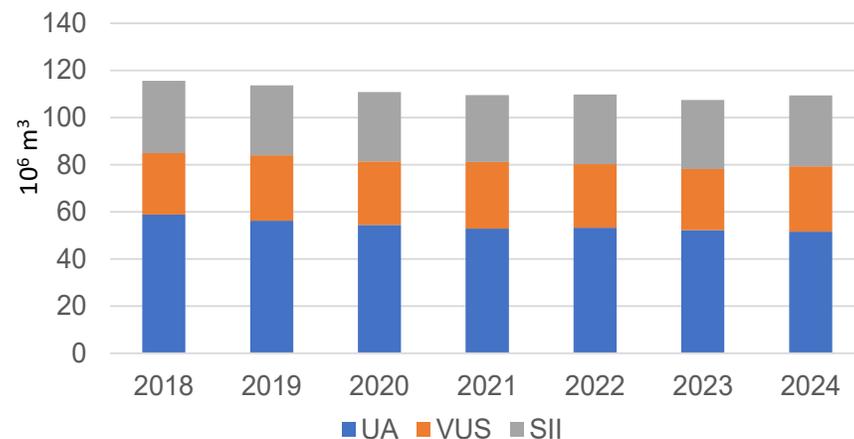


demands related to **civil uses**

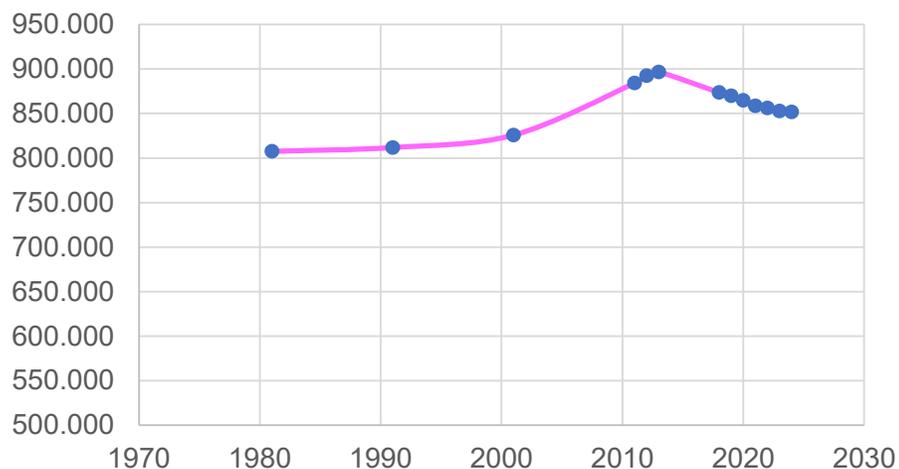
- volumes withdrawn** from water bodies within the regional territory, covering a 6-year period from 2018 to 2024, show a **decreasing trend** with a decline rate of about 110 Mln m³ per year

	Volumes withdrawn from regional territory (m ³)						
	2018	2019	2020	2021	2022	2023	2024
UA	58.819.719	56.287.753	54.410.960	52.915.012	53.238.185	52.233.844	51.606.210
VUS	26.041.460	27.709.144	27.002.206	28.233.031	27.040.897	25.981.908	27.729.482
SII	30.737.236	29.628.465	29.445.391	28.359.939	29.452.044	29.202.084	30.108.272
region	115.598.415	113.625.362	110.858.557	109.507.982	109.731.126	107.417.836	109.443.964

volume withdrawn from environment



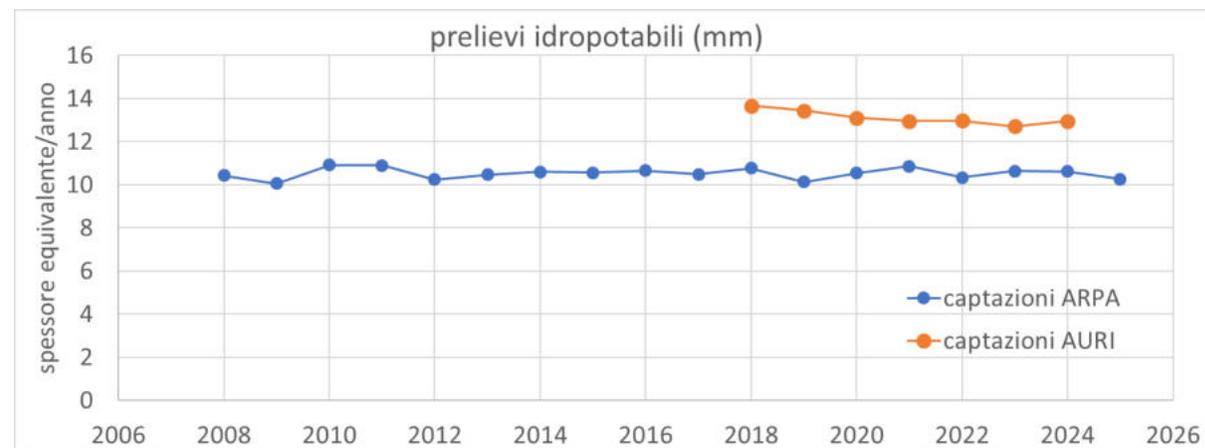
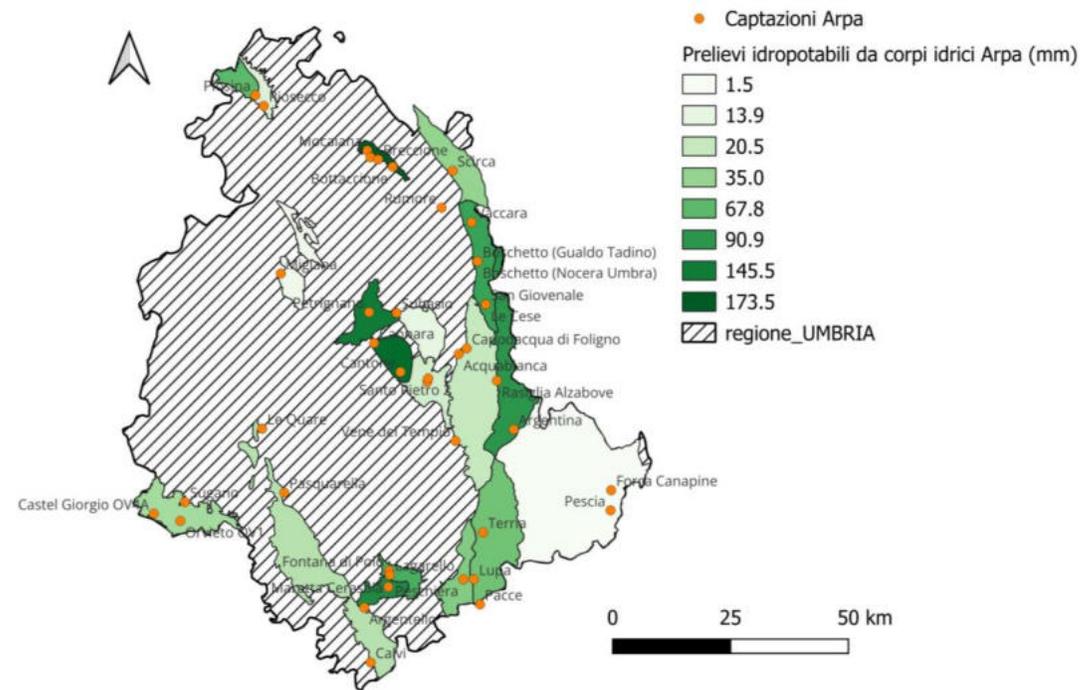
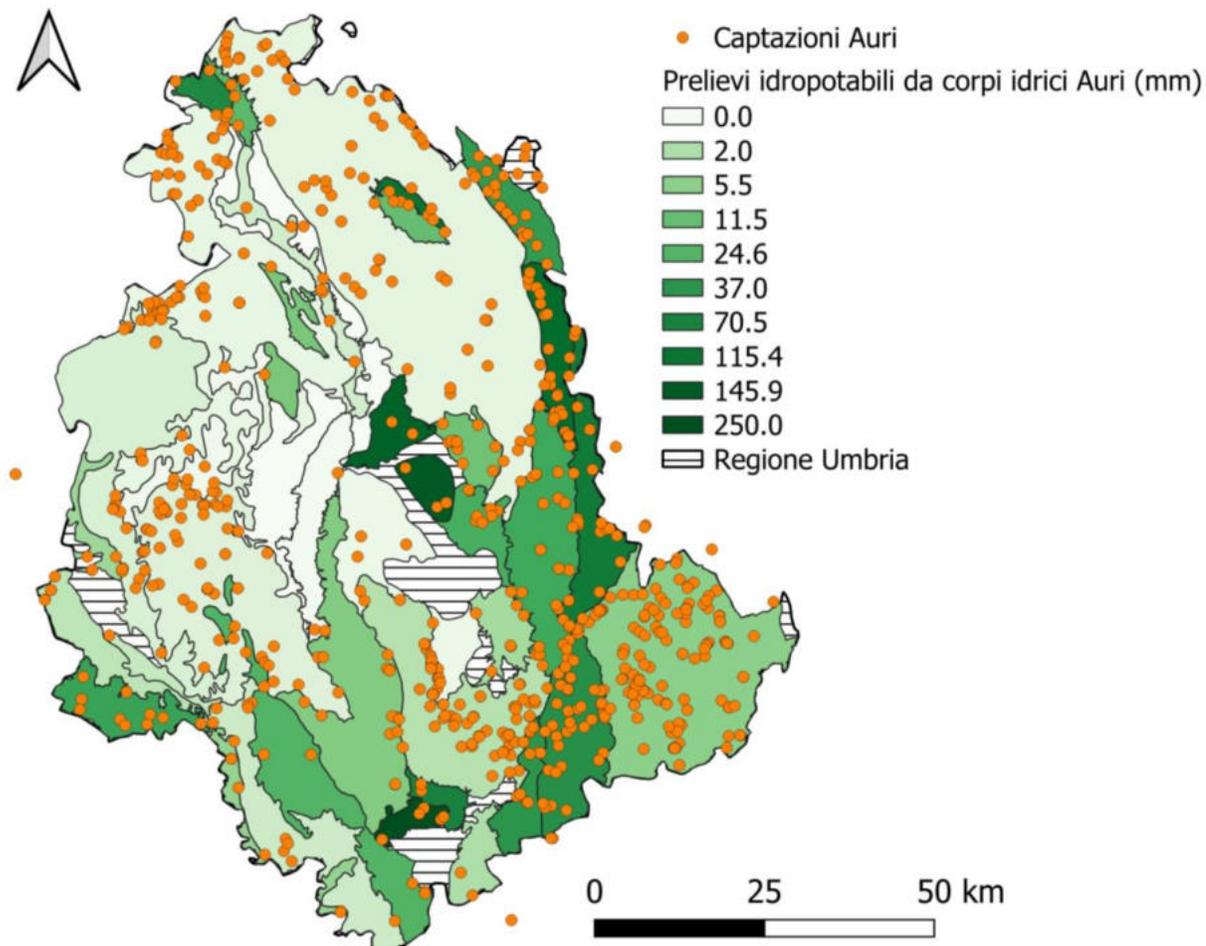
residential population - Umbria region



- resident population** after reaching a peak of about 890,000 inhabitants around 2013, has undergone a **slow decline** down to 851,950 at the end of 2024

Ongoing activity: integration of anthropogenic water uses into the hydrological balance

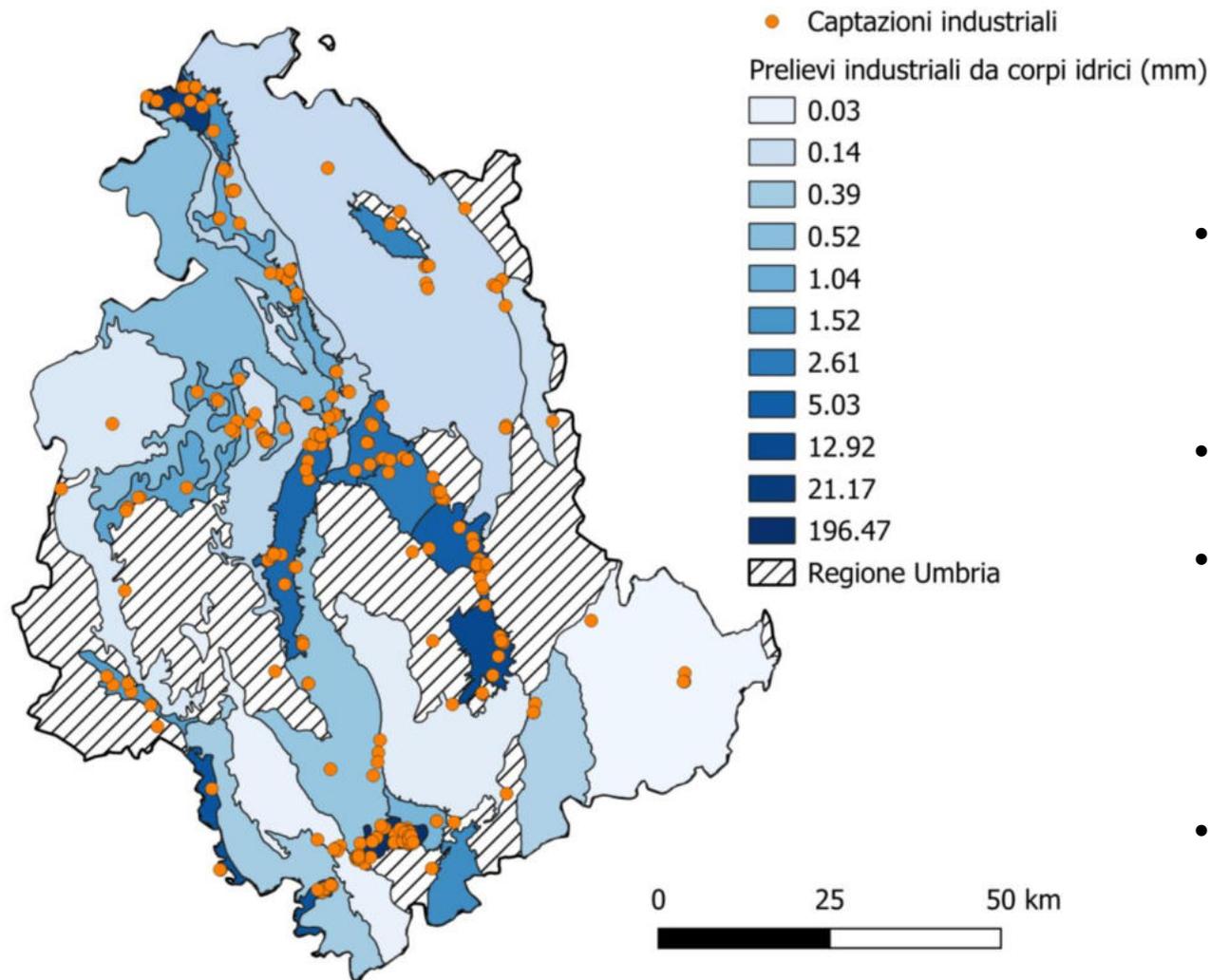
 demands related to **civil uses**



Ongoing activity: integration of anthropogenic water uses into the hydrological balance



demands related to industrial uses



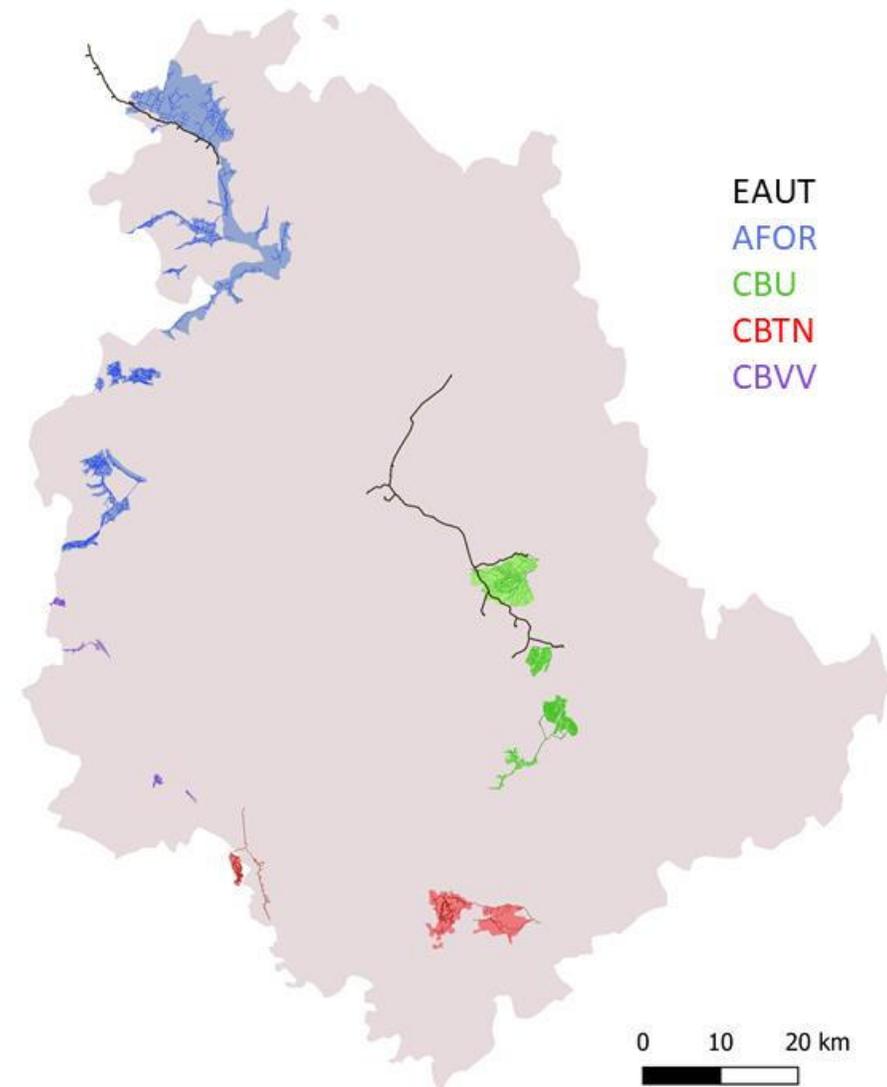
- industrial water withdrawals under concession:
368 Mln m³ (44 mm in equivalent depth)
- 96% from surface waters
- actual consumption data are often lower than the concession volumes, but they are incomplete and cover the period 2019–2024
- some surface water concessions are for hydroelectric purposes, with full return of the resource

Ongoing activity: integration of anthropogenic water uses into the hydrological balance



demands related to **agricultural uses (mainly irrigation)**

- there are **three Land Reclamation Consortia** (Bonificazione Umbra, Tevere-Nera, Val di Chiana Romana and Val di Paglia), the **Regional Forestry Agency (AFOR)**, and the **Umbro-Tuscan Water Authority (EAUT)**
- data on **measured and/or estimated irrigation volumes** are currently being collected for the districts managed by Bonificazione Umbra and AFOR
- **difficulty** in **acquiring explicit, reliable and complete information** on the actual volumes used for irrigation

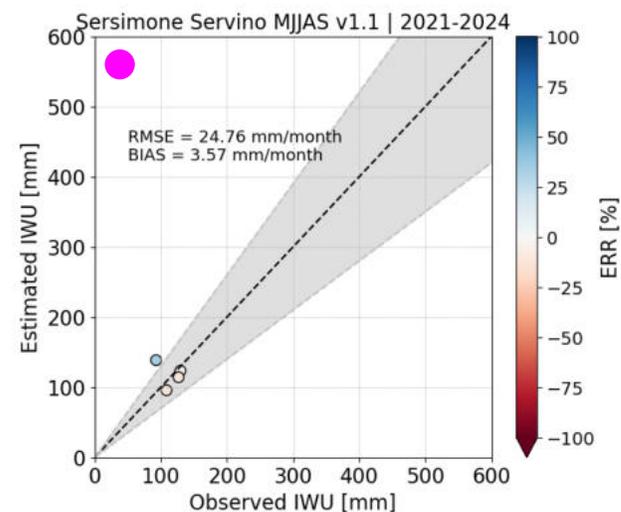
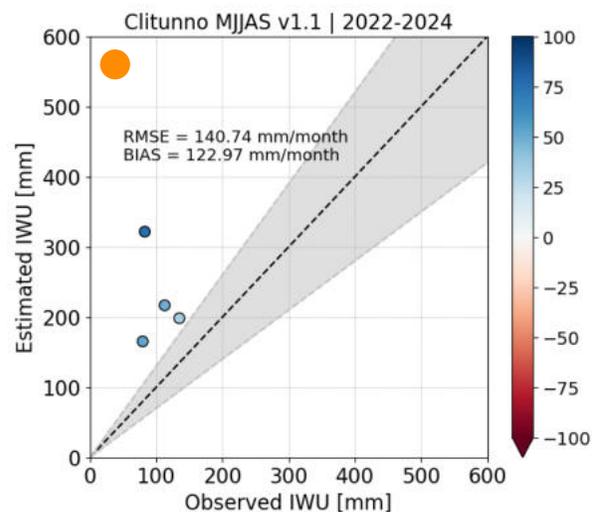
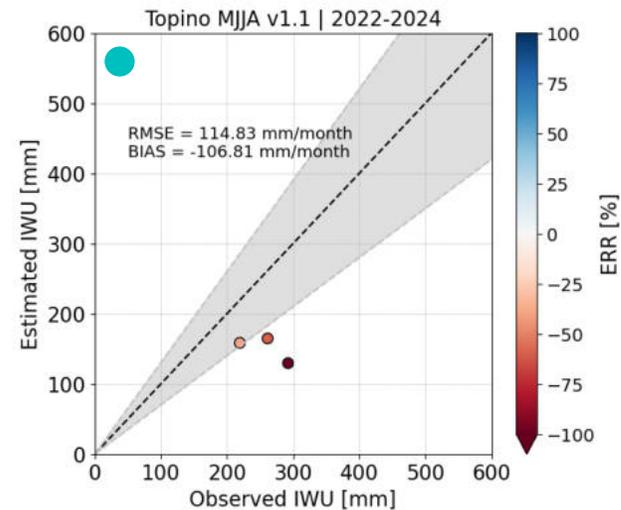
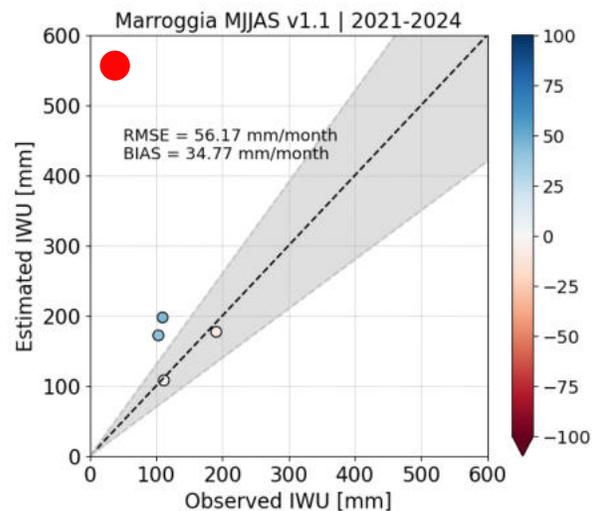
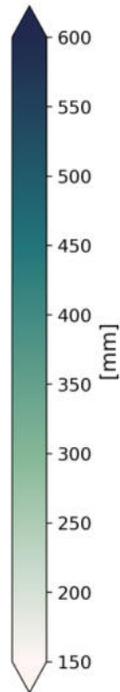
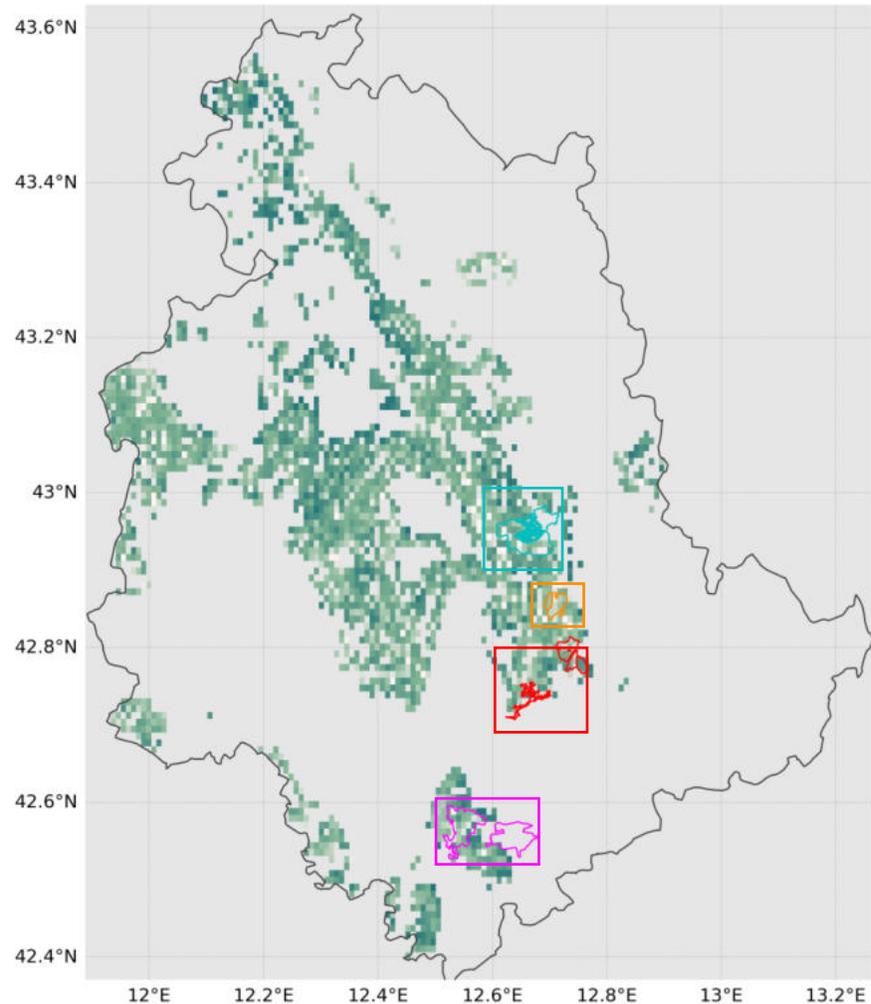


Ongoing activity: integration of anthropogenic water uses into the hydrological balance



demands related to **agricultural uses (mainly irrigation)** → satellite estimates

Average Seasonal IWU 2016–2024



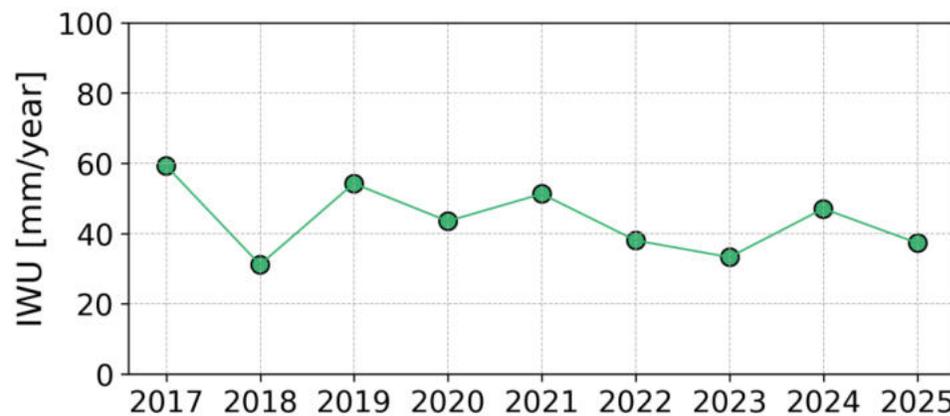
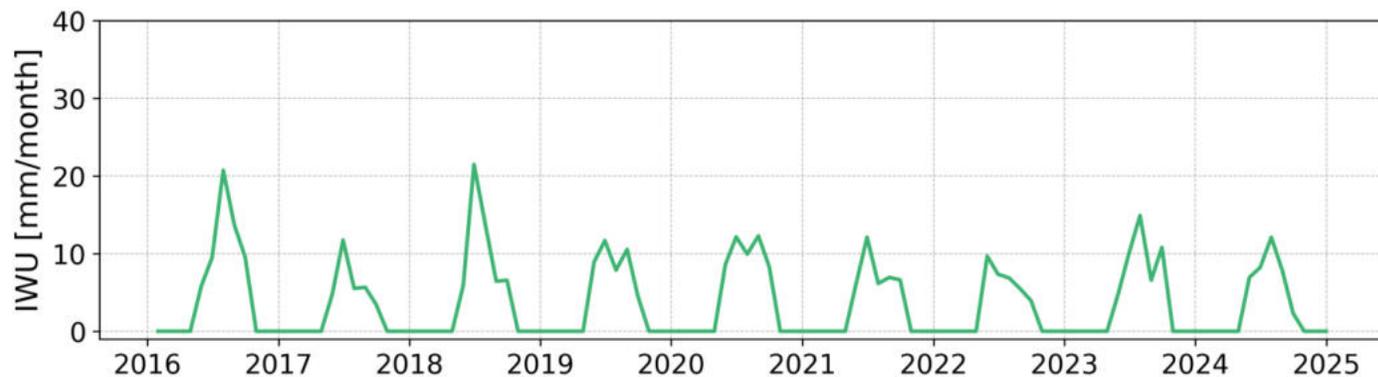
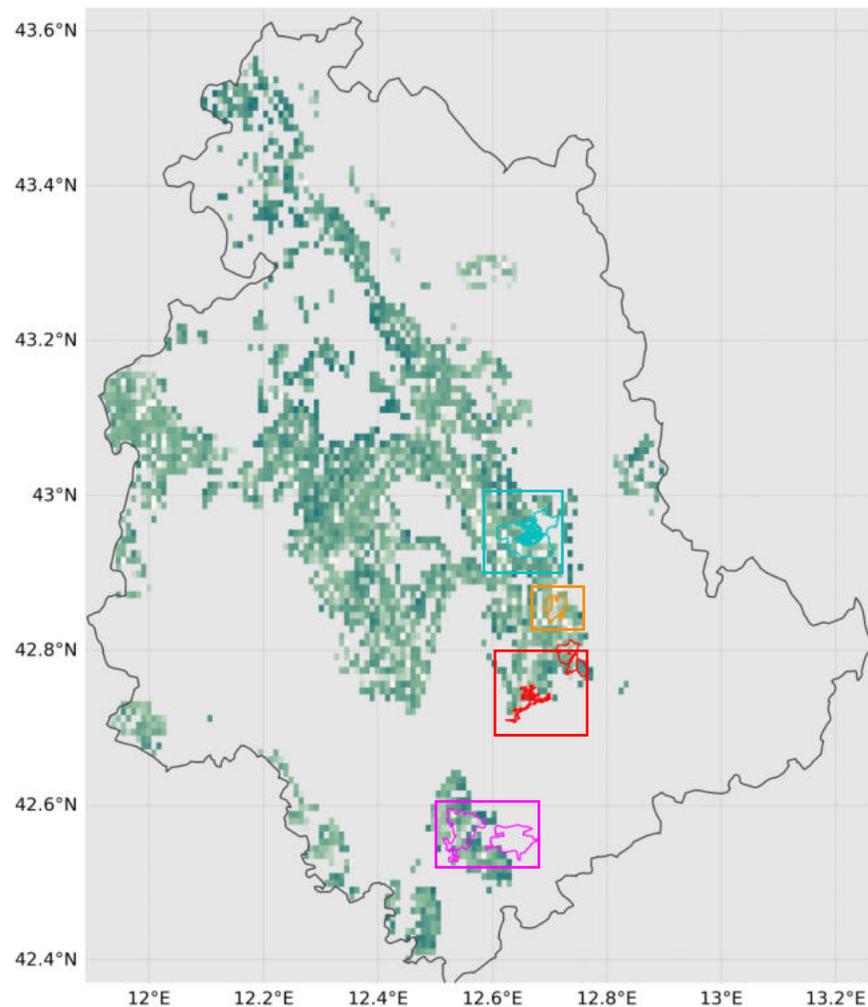
Ongoing activity: integration of anthropogenic water uses into the hydrological balance



demands related to **agricultural uses (mainly irrigation)** → satellite estimates

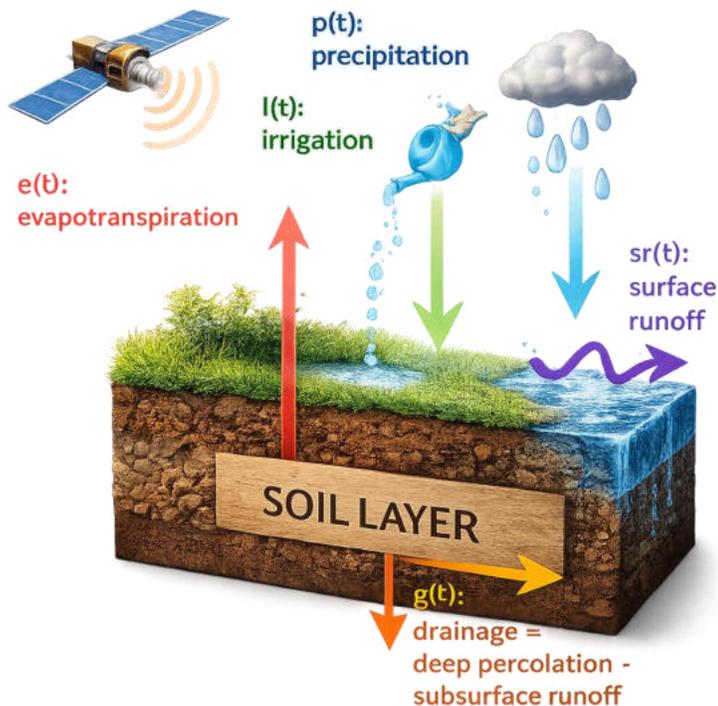


Average Seasonal IWU 2016-2024



Ongoing activity: integration of anthropogenic water uses into the hydrological balance

Background on satellite estimates: **The SM-Inversion approach**



$$nZ \frac{dS(t)}{dt} = i(t) + p(t) - g(t) - sr(t) - e(t)$$

$$g(t) = aS(t)^b \quad sr(t) = 0$$

$$W_{in}(t) = nZ \frac{dS(t)}{dt} + g(t) + e(t)$$

$$W_{in}(t) = Z^* \frac{dS(t)}{dt} + aS(t)^b + F \cdot S(t) \cdot PET(t)$$

$$W_{in}(t) - p(t) = i(t)$$

Parameters a, b, Z^*, F calibrated against rainfall masking out potential irrigation days

(Dari et al., 2023; <https://doi.org/10.5194/essd-15-1555-2023>)



Further developments

Acquire projections for water balance components to develop sustainable resource strategies.

Develop future demand projections across civil, industrial, and agricultural sectors.

Implement these integrated models directly into regional policy through the Interreg Gov4Water framework.

Simulation of hydrological components based on all available meteorological data, using spatial interpolation techniques and different methodologies for evaporation modeling.