Multi-scale assessment of regional high-resolution reanalyses precipitation fields over Italy

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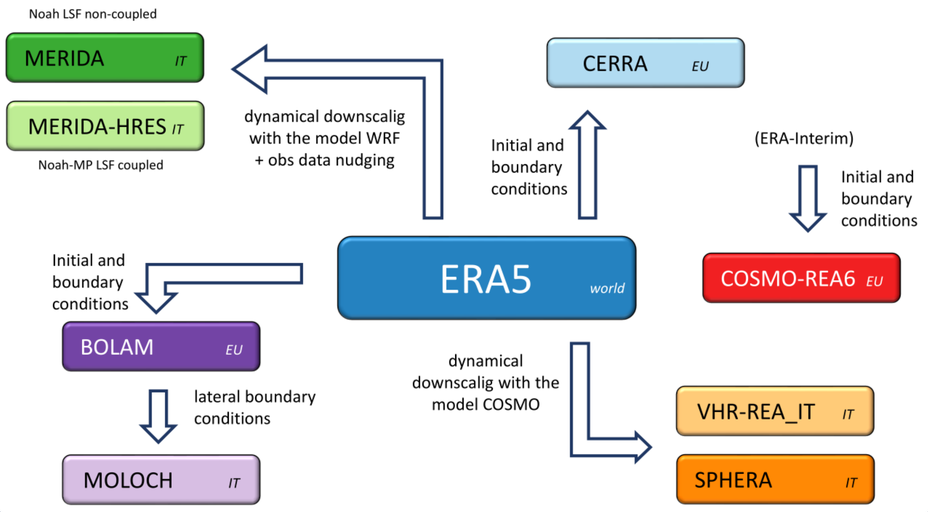
nine reanalysis products considered

	Name	Producer	Model	Resolution	Period	Area	Init. & bound. conditions	Explicit convection
GLBR (global reanalyses)	ERA5 [1]	ECMWF	IFS	31 km	1940-2023	global	/	No
RRA (regional reanalyses)	MERIDA [2]	RSE	WRF	7 km	1991-2020	Italy	ERA5	No
	CERRA [3]	ECMWF	ALADIN	5.5 km	1984-2022	Europe	ERA5	No
	COSMO-REA6 [4]	DWD	COSMO	6 km	1995-2019	Europe	ERA-Interim	No
	BOLAM [5]	LAMMA	BOLAM	7 km	1979-2019	Europe	ERA5	No
VHRR (very high resolution reanalyes)	MERIDA-HRES	RSE	WRF	4 km	1991-2020	Italy	ERA5	Yes
	MOLOCH [6]	LAMMA	MOLOCH	2 km	1979-2019	Italy	BOLAM	Yes
	VHR-REA_IT [7]	CMCC	COSMO	2 km	1991-2020	Italy	ERA5	Yes
	SPHERA [8]	ARPAE	COSMO	2 km	1995-2019	Italy	ERA5	Yes

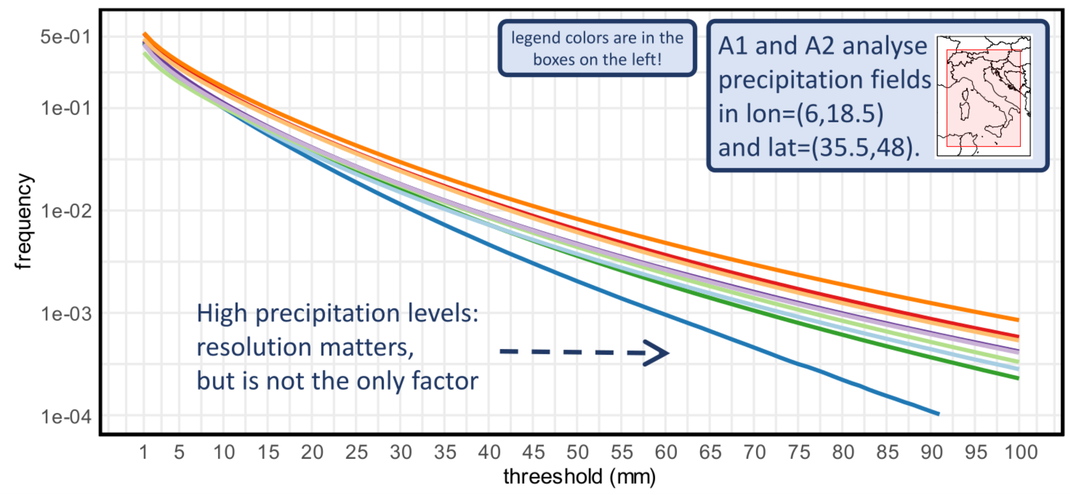


A. What is the effective resolution of reanalyses?

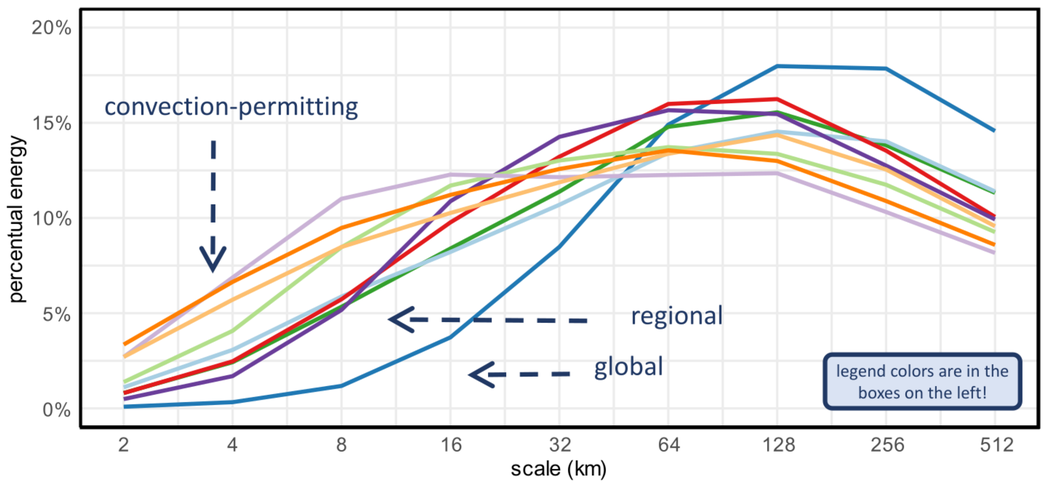
key findings:

- ERA5 reproduces events exceeding 20 mm with lower frequencies (A1).
- COSMO-REA6, SPHERA, and VHR_REA-IT exhibit the highest frequencies for extreme events at higher thresholds (A1).
- According to wavelets decomposition, the distribution of percentual energy among spatial scales displays distinct profiles for ERA5, regional, and convection-permitting reanalyses (A2).
- In scales below 10-km, only convection-permitting reanalyses show more than 5% of the energy (A2).
- The scale with the highest percentual energy shifts to smaller values as model resolution increases (A2).

A1. Frequency distributions of daily rainfall in wet days [9]



A2. Wavelet decomposition in energy components at different scales [10]

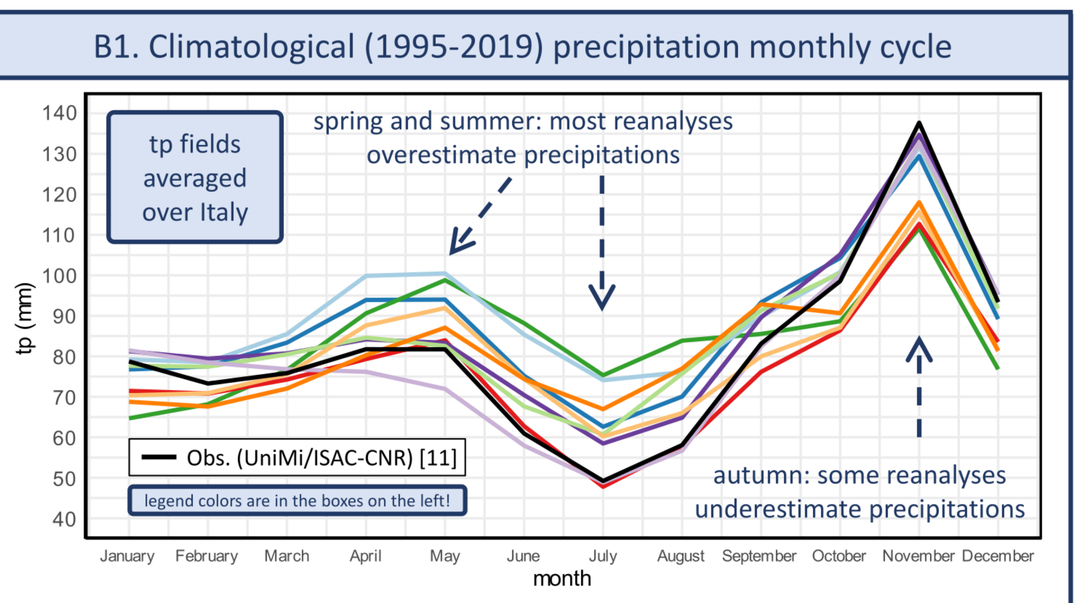


B. How well do reanalyses mirror observational data?

key findings:

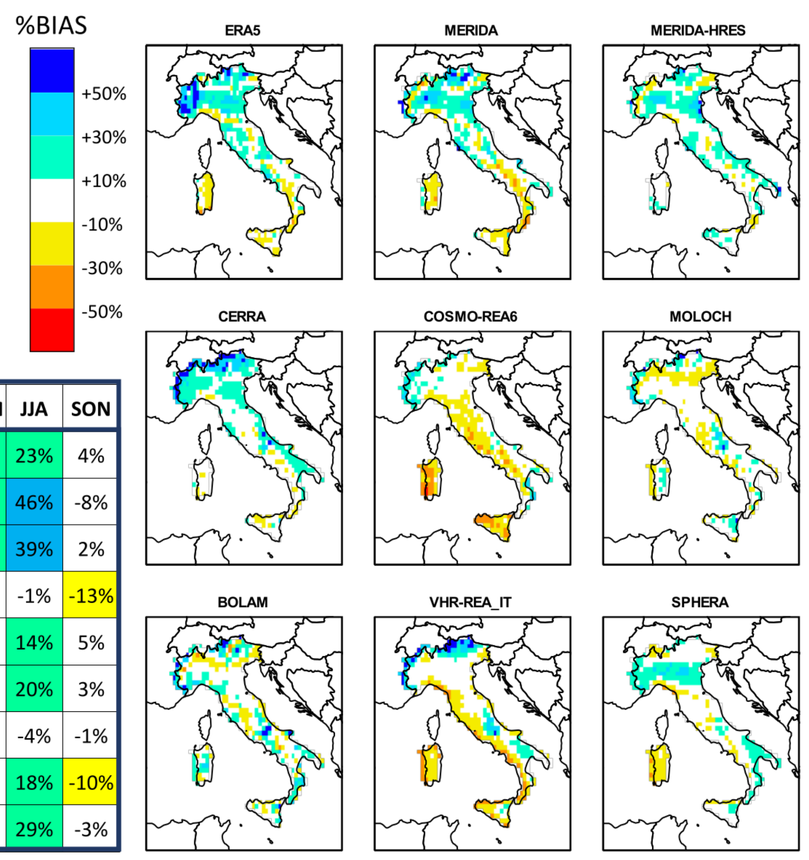
- ERA5, CERRA, and VHR exhibit the wettest bias over the Alps (B2).
- MERIDA, COSMO-REA6, and VHR-REA-IT demonstrate the driest bias in southern Italy and the main islands (B2).
- According to SEEPS, ERA5, CERRA, and MERIDA-HRES stand out as the best-performing reanalyses (B3).
- Summer consistently yields lower SEEPS skill scores (B3).
- Misplacement issues, particularly on the Apennines (MERIDA), the west coast (VHR_REA-IT), and southern Italy (COSMO-REA6, SPHERA), contribute to low SEEPS scores in that areas (B3).
- All reanalyses (with the exception of VHR_REA-IT) exhibit an increasing trend in the annual total precipitation bias (B4).

B1. Climatological (1995-2019) precipitation monthly cycle



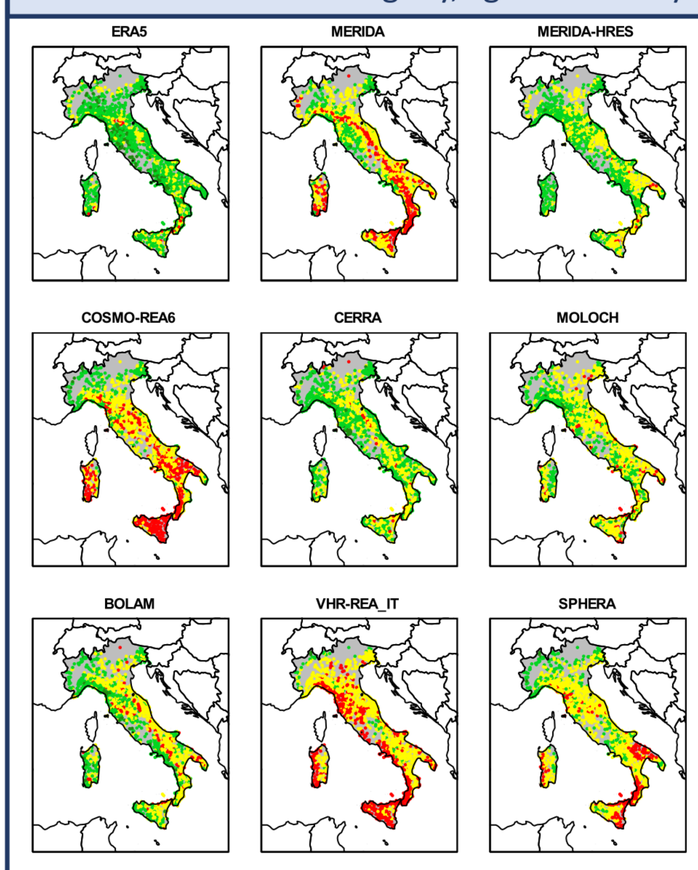
B2. Normal (1995-2019) annual cumulate percentual bias maps

precipitation fields upscaled to ERA5 res. and compared to observational gridded dataset [11]



	DJF	MAM	JJA	SON
ERA5	0%	14%	23%	4%
MERIDA	-13%	11%	46%	-8%
CERRA	3%	20%	39%	2%
COSMO-REA6	-7%	0%	-1%	-13%
BOLAM	5%	4%	14%	5%
MERIDA-HRES	2%	4%	20%	3%
MOLOCH	5%	-5%	-4%	-1%
VHR_REA_IT	-8%	7%	18%	-10%
SPHERA	-10%	0%	29%	-3%

B3. Discrimination among dry, light and heavy daily precipitation



weather stations [12] compared to the nearest reanalysis cell

Skill Score used: **Stable Equitable Error in Probability Space (SEEPS)** [13]

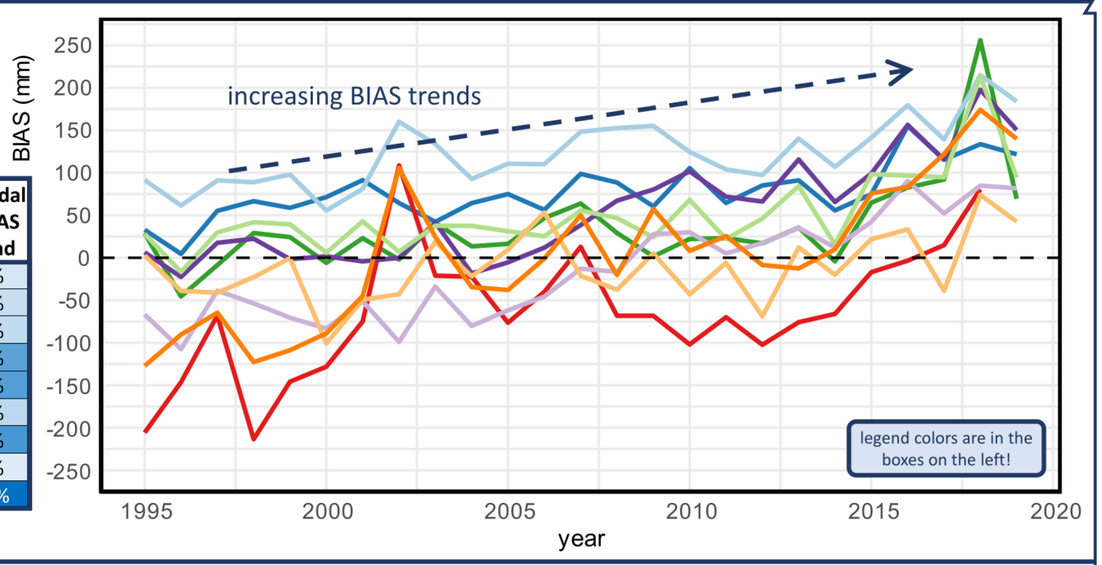
Categorical score divided in 3 levels:
- dry (rr < 1 mm)
- light rain
- hard rain

with light occuring twice than hard.

	DJF	MAM	JJA	SON
ERA5	0.67	0.65	0.49	0.65
MERIDA	0.59	0.58	0.41	0.55
CERRA	0.67	0.64	0.46	0.62
COSMO-REA6	0.58	0.58	0.42	0.55
BOLAM	0.63	0.60	0.45	0.60
MERIDA-HRES	0.69	0.62	0.43	0.63
MOLOCH	0.64	0.58	0.41	0.61
VHR_REA_IT	0.57	0.54	0.42	0.54
SPHERA	0.57	0.59	0.47	0.58

SEEPS: 1, 0.8, 0.7, 0.6, 0.5, 0.3, 0

B4. Total annual precipitation differences with a time coherent obs. dataset [11]



	decadal %BIAS trend
ERA5	3%
MERIDA	3%
CERRA	3%
COSMO-REA6	7%
BOLAM	7%
MERIDA-HRES	4%
MOLOCH	7%
VHR_REA_IT	2%
SPHERA	10%

Essential bibliography

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