Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

Dynamical Downscaling of CMIP6 Models over the Med-CORDEX Region: An Application of ENEA-REG 2.0 to the Assessment of Expected Climate Change Impacts

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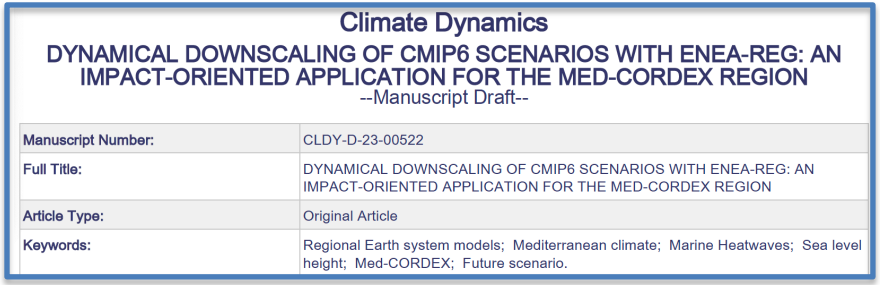
Summary

Focus : effects of the high-resolution air-sea coupling for the representation of high impact events, such as marine heat waves and sea-level height

- Model Setup and experimental design
- Present climate representation (in a glance)
- Projected changes in relevant ECVs and and EOVs
- Impact studies, a couple of examples: Sea Level Rise and Marine Heat Waves



Climate Dynamics

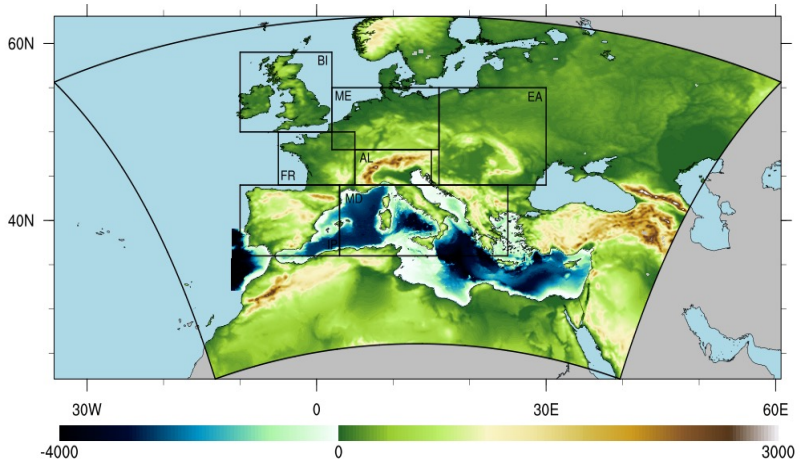
DYNAMICAL DOWNSCALING OF CMIP6 SCENARIOS WITH ENEA-REG: AN IMPACT-ORIENTED APPLICATION FOR THE MED-CORDEX REGION

--Manuscript Draft--

Manuscript Number:	CLDY-D-23-00522
Full Title:	DYNAMICAL DOWNSCALING OF CMIP6 SCENARIOS WITH ENEA-REG: AN IMPACT-ORIENTED APPLICATION FOR THE MED-CORDEX REGION
Article Type:	Original Article
Keywords:	Regional Earth system models; Mediterranean climate; Marine Heatwaves; Sea level height; Med-CORDEX; Future scenario.

Model setup and experimental design

ENEA-Reg2.0 : WRF 4.2.2 - MITgcm z67 - HD 1.0.2 / ESMF-NUOPC

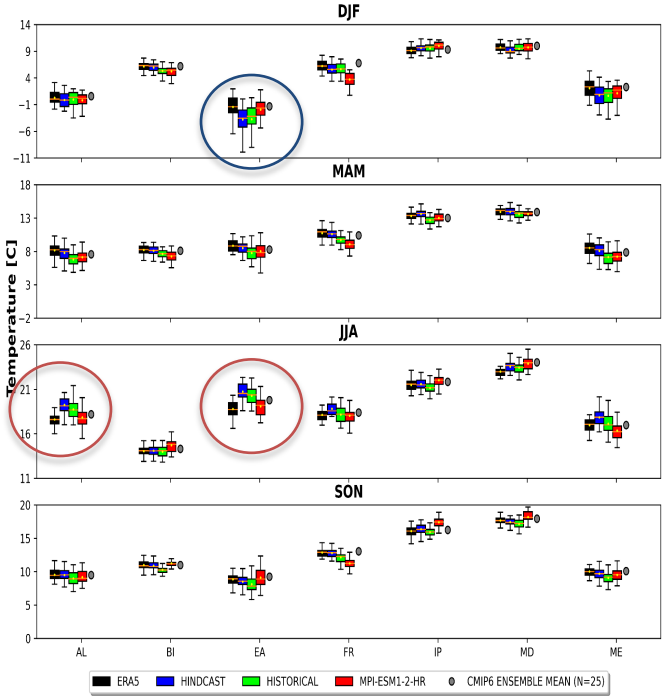


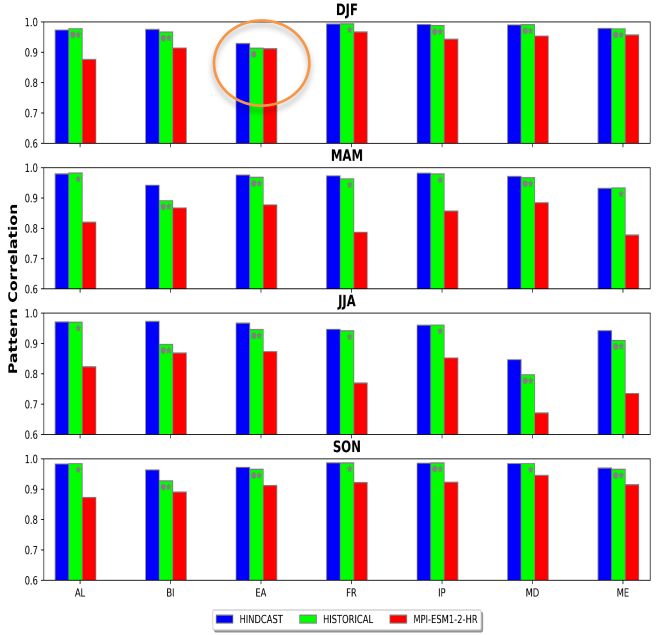
Exp	Driver	LBC	Period	Bias Corr
Hindcast	ERA5	ERA5 & ORAS5	1980-2014	
Historical	MPI-ESM1-2-HR	MPI-ESM1-2-HR	1980-2014	
SSP1-2.6	MPI-ESM1-2-HR	MPI-ESM1-2-HR	2015-2100	Ocean T,S
SSP2-4.5	MPI-ESM1-2-HR	MPI-ESM1-2-HR	2015-2100	Ocean T,S
SSP5-8.5	MPI-ESM1-2-HR	MPI-ESM1-2-HR	2015-2100	Ocean T,S

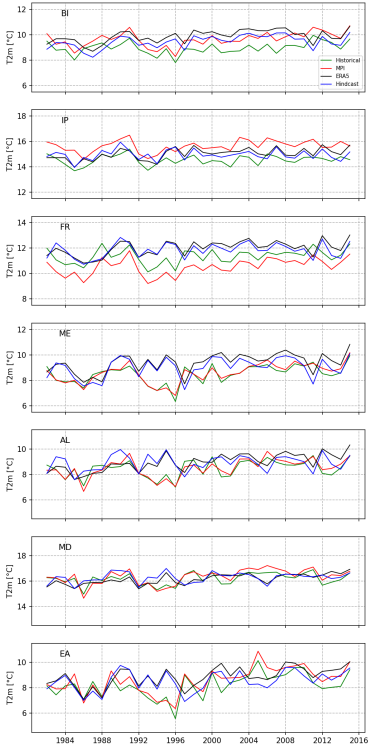
T127 (0.93° or ~ 103 km) atmosphere ; TP04 (0.4° or ~ 44 km) ocean
1/10° or ~ 12 km atmosphere; 1/12° or ~ 10 km ocean

Present climate representation: atmosphere

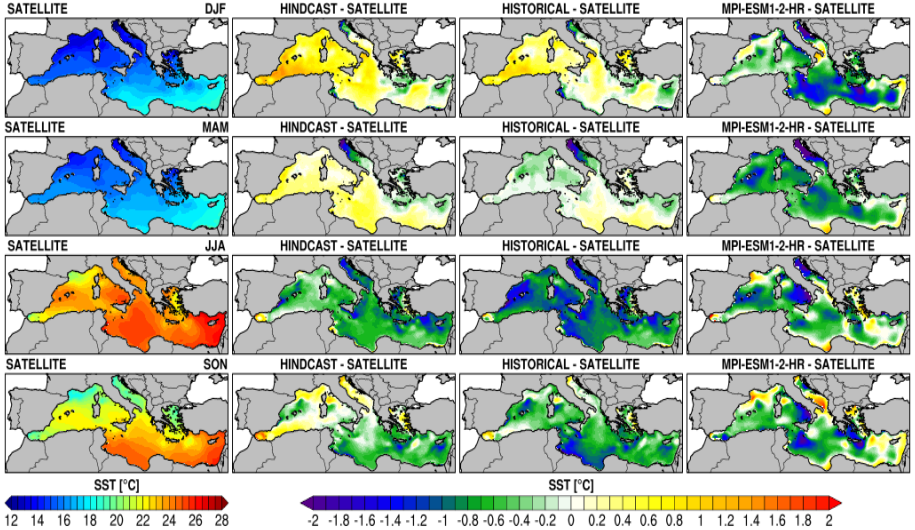
T: Box plots, pattern correlations, inter-annual variability over PRUDENCE regions

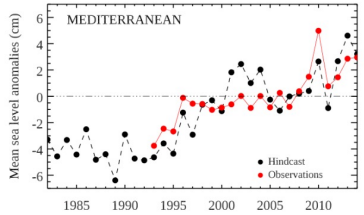


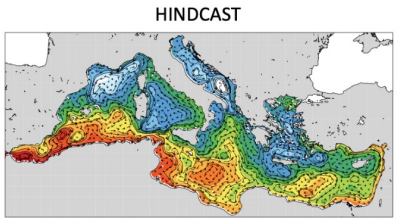


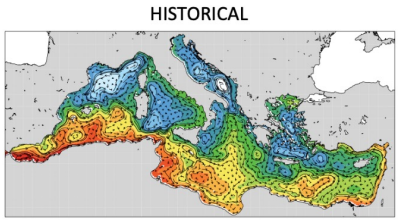


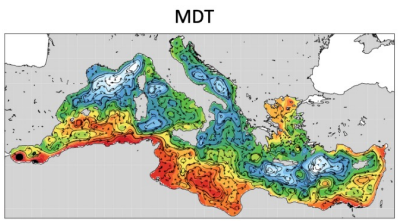
Present climate representation: Ocean

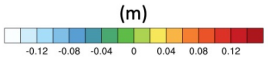




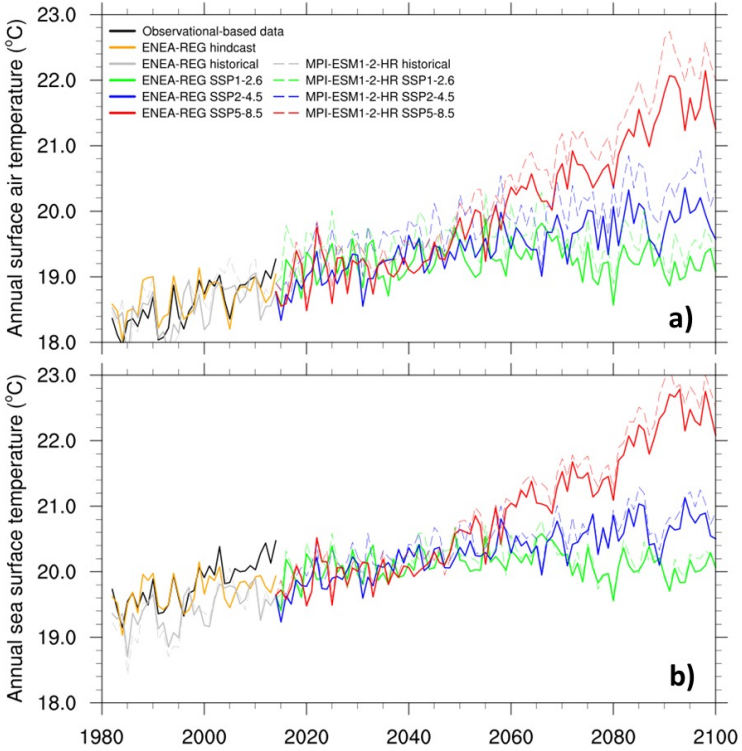




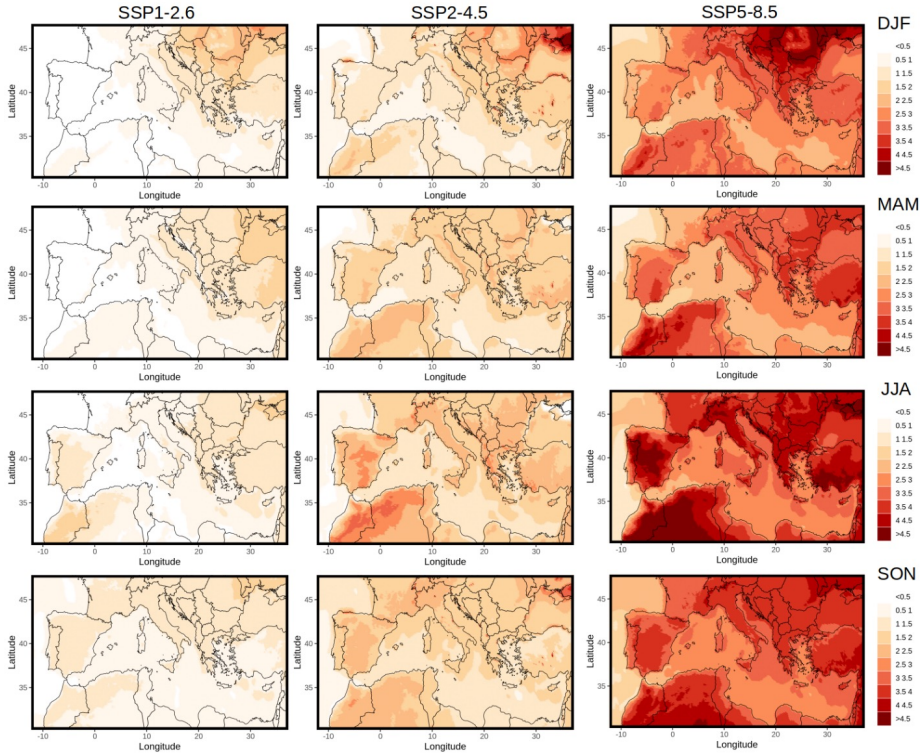




Projected changes in relevant ECVs: surface air and sea temperature

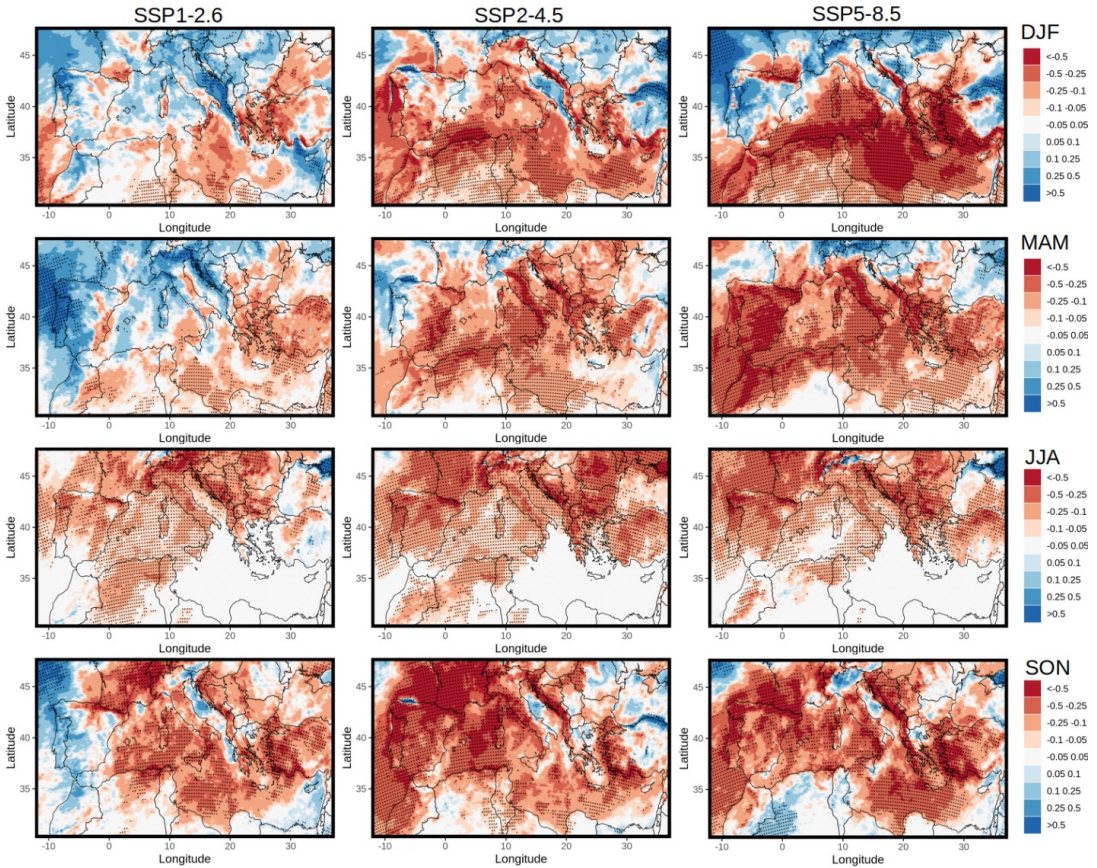


Projected climate change (2071-2100 minus 1985-2014)



Projected changes in relevant ECVs: precipitation

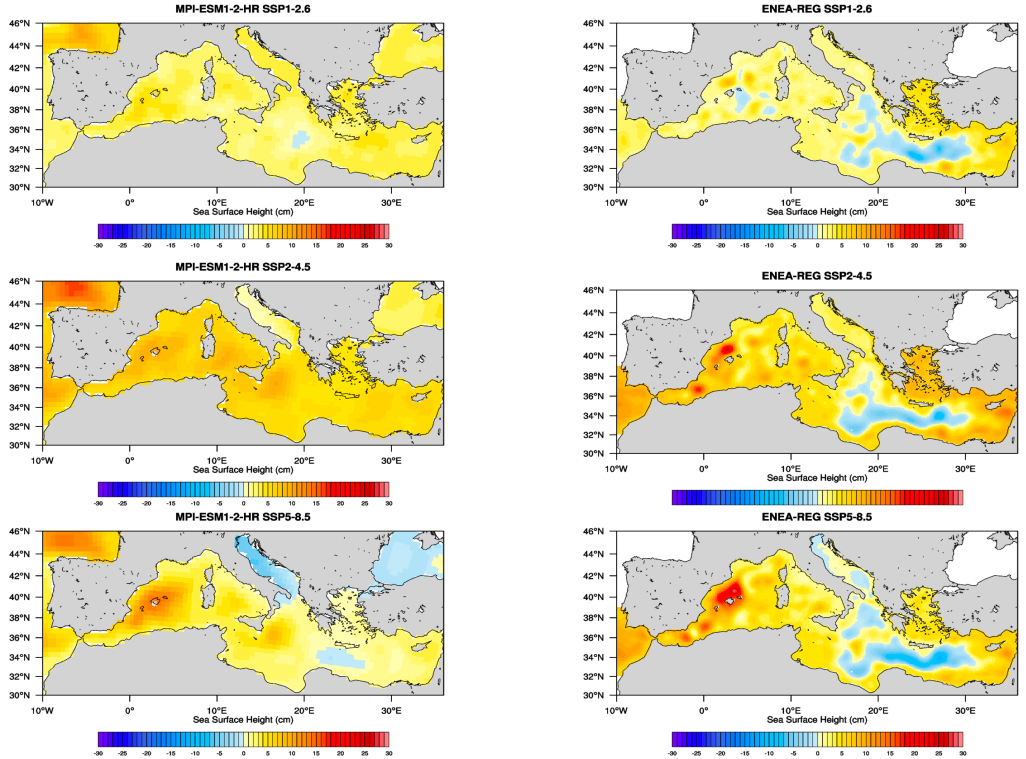
Precipitation (mm/d)
projected climate change
(2071-2100 minus 1985-2014)
scenario simulations:
SSP1-2.6 (left column),
SSP2-4.5 (central column)
SSP5-8.5 (right column).
Black dots indicate 10% level
significance, assessed by
bootstrap procedure with
1000 repetitions.



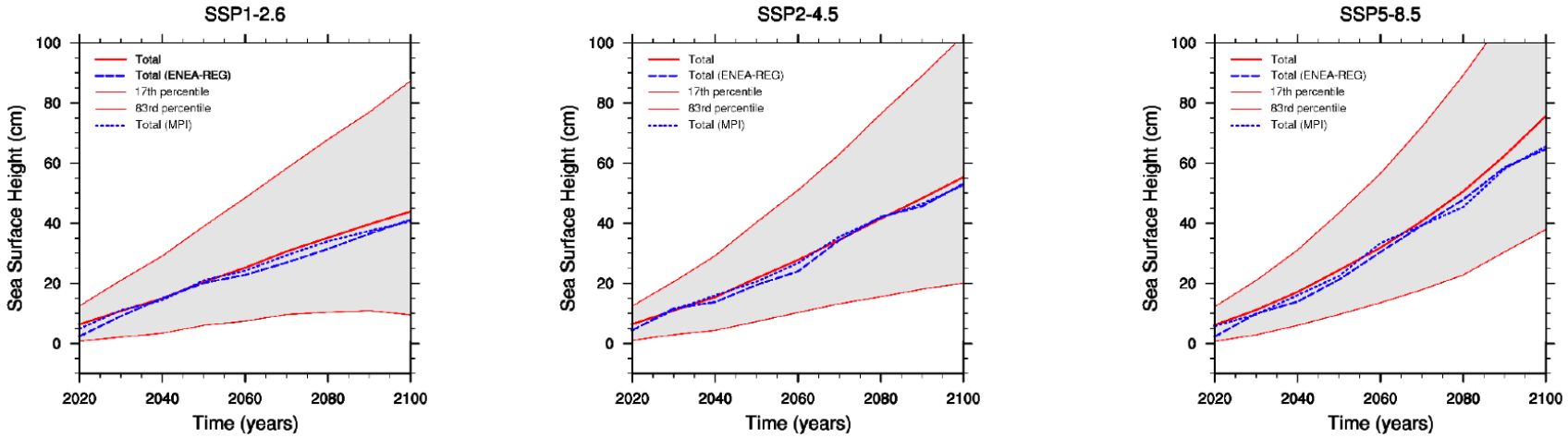
Projected changes in relevant EOVs: T, S, Sea Surface Height

			Depth (m)	
		0-150	150-600	600-3500
			T	
MED	SSP126	0,61	0,91	0,66
	SSP245	1,05	1,11	0,61
	SSP585	2,45	2,08	0,68
WMED	SSP126	0,46	1,12	0,84
	SSP245	0,92	1,47	0,84
	SSP585	2,16	2,40	0,88
EMED	SSP126	0,70	0,78	0,55
	SSP245	1,12	0,89	0,46
	SSP585	2,62	1,89	0,56
			S	
MED	SSP126	-0,15	0,08	0,18
	SSP245	-0,27	0,06	0,15
	SSP585	-0,06	0,22	0,16
WMED	SSP126	-0,21	0,16	0,19
	SSP245	-0,38	0,19	0,18
	SSP585	-0,27	0,33	0,18
EMED	SSP126	-0,12	0,03	0,17
	SSP245	-0,21	-0,01	0,13
	SSP585	0,06	0,16	0,15

SSH 2096/2100 – 1995/2014. circulation component



Climate Change Impact : Sea Level Rise



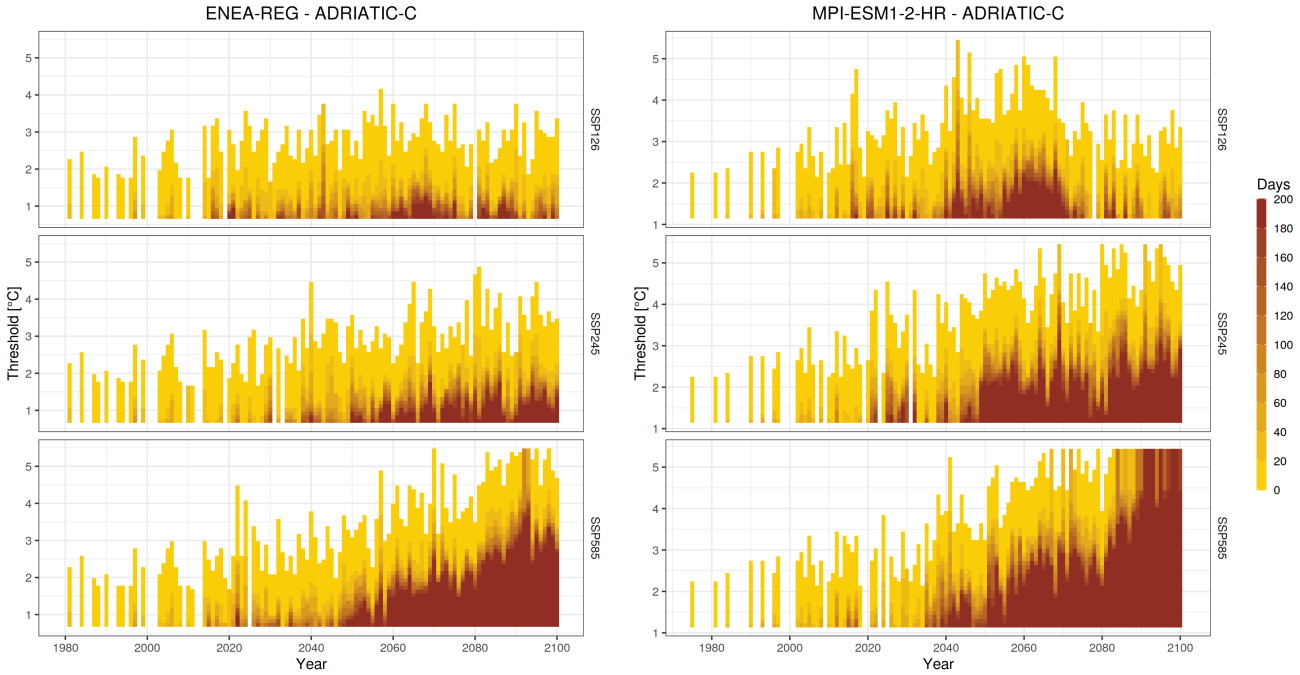
Change of the average total sea level over the Mediterranean basin for the three SSP scenarios (blue curves; dotted=MPI-ESM1-2-HR; dashed=ENEA-REG).

The projections are relative to a 1995-2014 baseline. The thick red line is the median over the AR6 models; the shaded area corresponds to the 17th-83rd percentile range.

Climate Change Impact : Marine Heat Waves

Definition: periods of at least 5 consecutive days during which the mean temperature over a specific area of interest is above the long-term expected daily value (Hobday et al., 2016).

- Intensity and total annual length for Central Adriatic
- Threshold: between the 95-th percentile and the maximum value of the corresponding daily temperature anomalies w/r to the local seasonal cycle during the historical period (1980-2014)



Conclusions

- ✓ Improvements in both A-O components with respect to the former version (bias reduction)
- ✓ A positive trend in temperature until mid-century is observed for all scenarios but SSP1-2.6 then reverse the tendency →the inertia of the climate system is expected to anyway shadow the benefits of climate action for a few decades ahead
- ✓ Spatial and temporal variability of Mediterranean dynamic sea level (circulation component) are enhanced in the regional simulations with respect to the global projections, which might have a non-negligible impact on coastal risk assessments.
- ✓ Marine Heat Waves: we highlighted the potential advantageof using a higher resolution ocean component in describing the impact of local dynamics on shorter-time scale fluctuations, especially over enclosed sub-basins such as the Adriatic Sea
- ✓ intensity, frequency, and duration of MHW will increase under SSP2-4.5 and SSP5-8.5, stabilize for SSP1-2.6
- ✓ MHW in SSP5-8.5 imply potential severe impacts on ecosystems, on ecosystem services and on local communities and on the broader Mediterranean economy.

Acknowledgements

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- CAREHeat (deteCtion and threAts of maRinE Heat waves) project *(ESA, grant agreement no. 4000137121/21/I-DT)*

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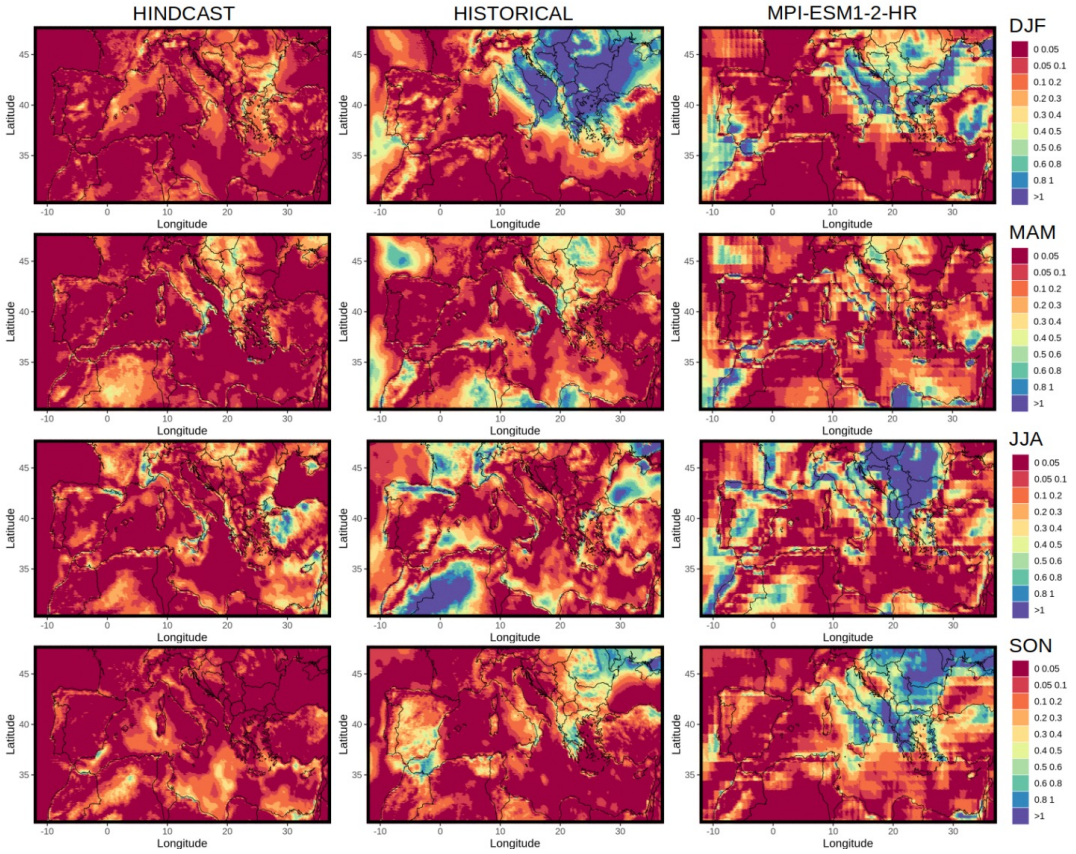
Present climate representation: variability

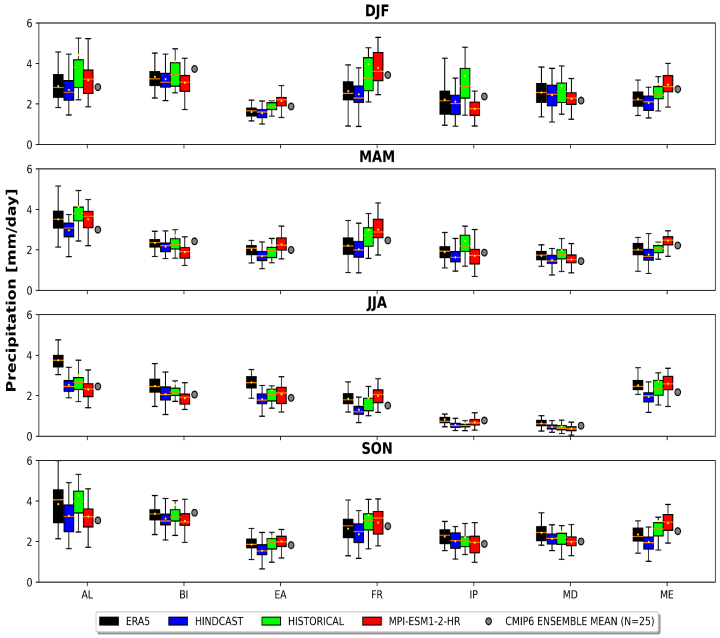
Model Variability Index (MVI) of near-surface air temperature

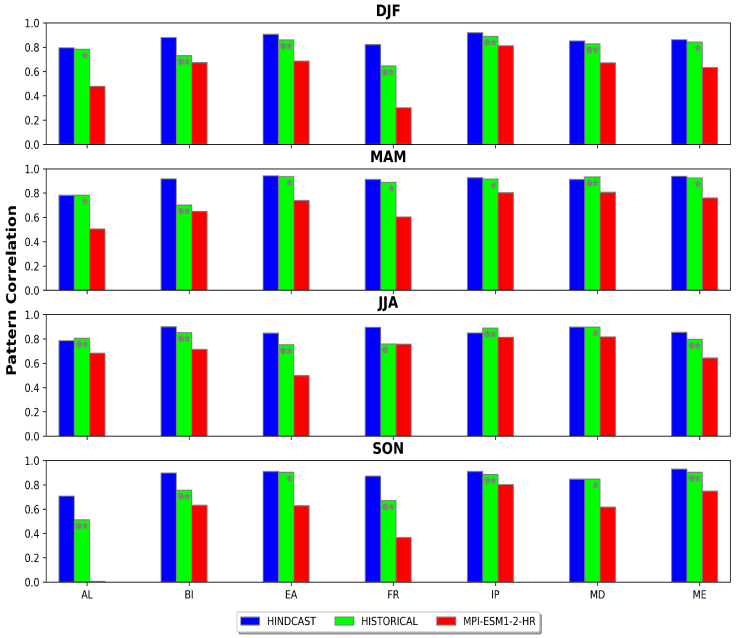
$$MVI=\left(\frac{\sigma_o}{\sigma_m}-\frac{\sigma_m}{\sigma_o}\right)^2$$

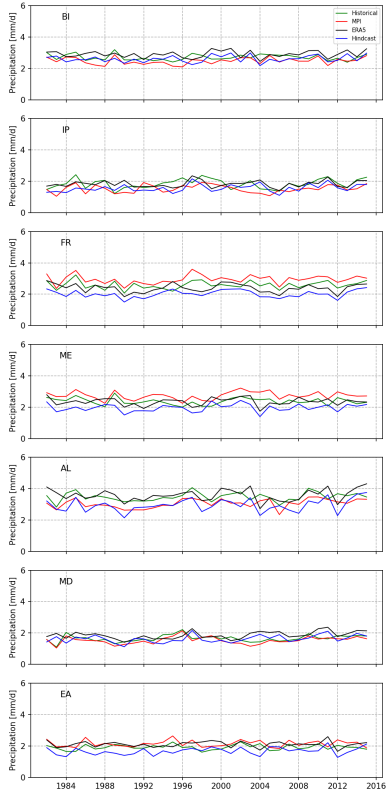
when model variability equals that of the observations the MVI has a value of 0



Present climate representation: land precipitation







Present climate representation: Ocean hydrography

			Depth (m)	
		0-150	150-600	600-3500
			TEMPERATURE	
MED	Reanalysis	16,65	14,05	13,35
	Hindcast	0,09	0,25	0,27
	Historical	-0,04	0,33	0,25
WMED	Reanalysis	15,41	13,46	12,96
	Hindcast	0,43	0,30	0,15
	Historical	0,15	0,25	0,13
EMED	Reanalysis	17,33	14,41	13,57
	Hindcast	-0,08	0,21	0,36
	Historical	-0,12	0,38	0,34
			SALINITY	
MED	Reanalysis	38,41	38,82	38,66
	Hindcast	0,18	0,02	0,12
	Historical	0,15	0,04	0,11
WMED	Reanalysis	37,85	38,50	38,48
	Hindcast	0,04	0,04	0,03
	Historical	-0,01	0,02	0,02
EMED	Reanalysis	38,73	38,85	38,81
	Hindcast	0,22	0,17	0,12
	Historical	0,22	0,21	0,12