



Nuovi modelli climatici per la previsione di fenomeni convettivi intensi

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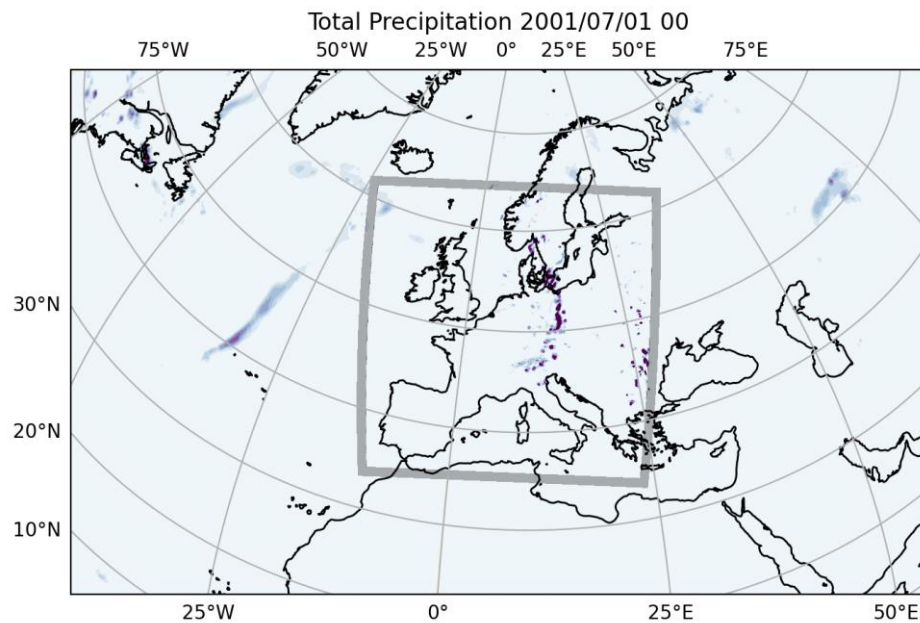
Venerdì
1 dicembre 2023

Hotel Savoia Excelsior Palace,
Riva del Mandracchio, 4 - Trieste

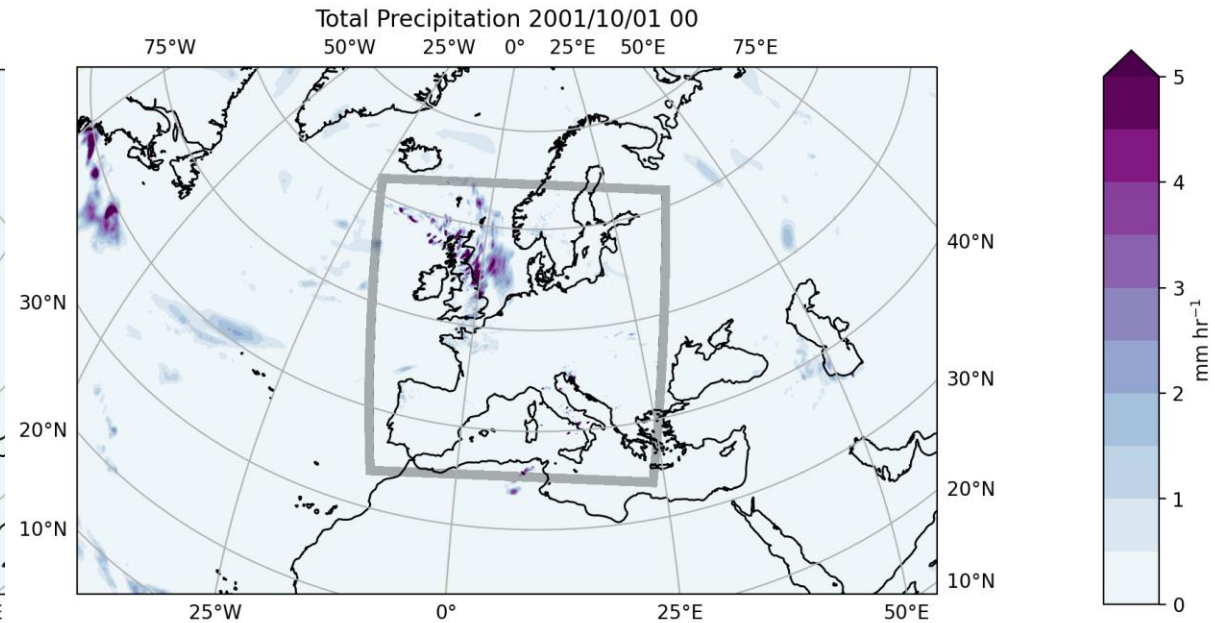
The present

A che punto siamo...

Summer convection is generated inside the domain over the Alpine chain and over the Balcan region



Fall frontal precipitation triggered by large scale dynamical forcing entering from the boundary and propagating correctly inside the domain



The CORDEX CP effort...

Perchè arrivare a scale così risolte nella modellistica climatica?

C'è bisogno di rappresentare *sub scale processes/interaction* che sono cruciali per la rappresentazione del clima locale.

Bisogna ridurre l'incertezza

Cercare di scoprire se ci sono nuove informazioni utili che sono visibili a queste scale.

Perchè abbiamo bisogno di un approccio multi-model?

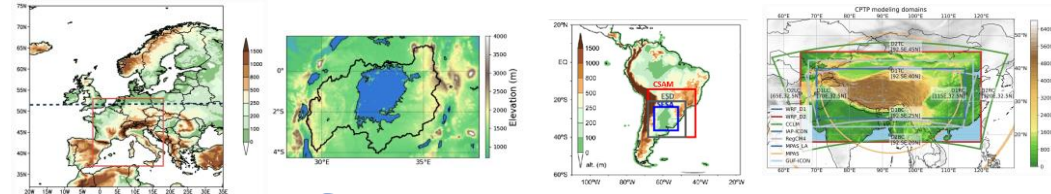
Per avere dei risultati robusti che verifichino i risultati preliminary degli studi fatti con un singolo modello.

Per poter generalizzare le conclusioni ottenute studiando una sola regione.

Validare i nostri modelli alla risoluzione del kilometro e derivare delle conclusioni più robuste a queste scale per proiezioni climatiche.

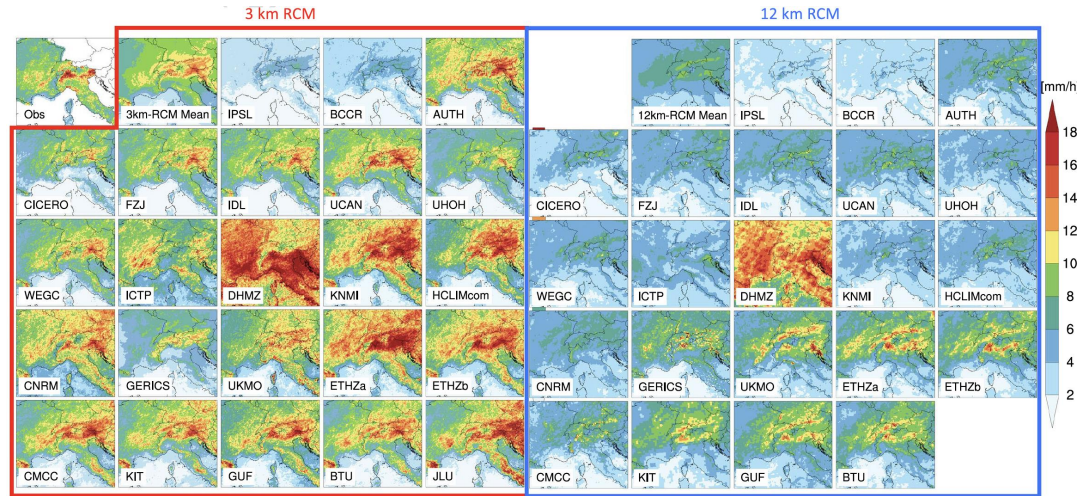
CORDEX Flagship Pilot Study CP

Quali regioni abbiamo studiato finora



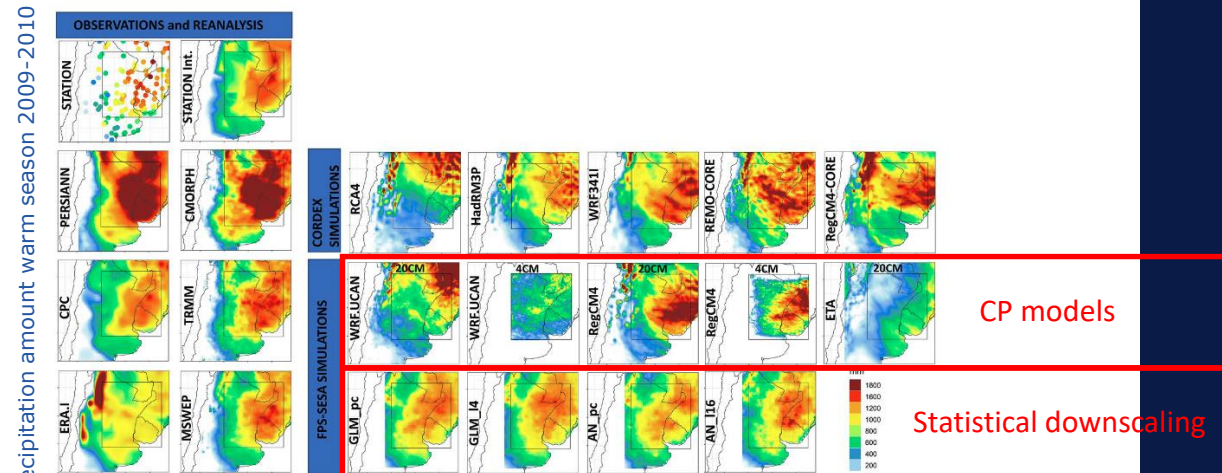
Heavy hourly precipitation in the summer season (p99.9)

CORDEX Flagship Pilot Study Europe



Coppola, E., Sobolowski S. and Coauthors, 2020: A first-of-its-kind multi-model convection permitting ensemble for investigating convective phenomena over Europe and the Mediterranean. *Climate Dyn.*, 55, 3–34, <https://doi.org/10.1007/s00382-018-4521-8>.
 Ban, N., and Coauthors, 2021: The first multi-model ensemble of regional climate simulations at kilometer scale resolution, Part I: Evaluation of precipitation. *Climate Dyn.*, 57, 275–302, <https://doi.org/10.1007/s00382-021-05708-w>.

CORDEX Flagship Pilot Study in southeastern South America

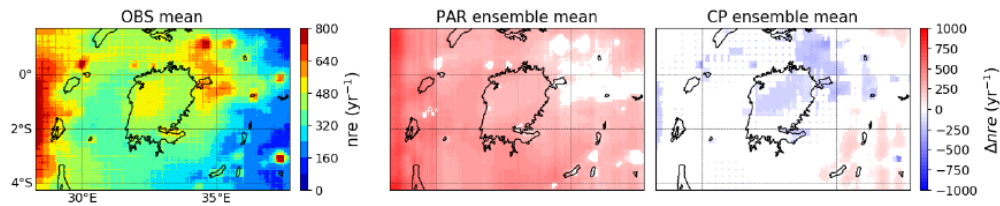


Total precipitation amount warm season 2009-2010

Bettoli, M. L., Solman, S. A., Da Rocha, R. P., Llopart, M., Gutierrez, J. M., Fernández, J., M. E. Olmo, A. Lavin-Gullon, S. C. Chou, D. Carneiro Rodrigues, E. Coppola, R. Balmaceda Huarte, M. Barreiro, J. Blázquez, M. Doyle, M. Feijóo, R. Huth, L. Machado, Cuadra, S. V. (2021). The CORDEX Flagship Pilot Study in southeastern South America: a comparative study of statistical and dynamical downscaling models in simulating daily extreme precipitation events. *Climate Dynamics*, 56(5), <https://doi.org/10.1007/s00382-020-05549-z>, 1589-1608.

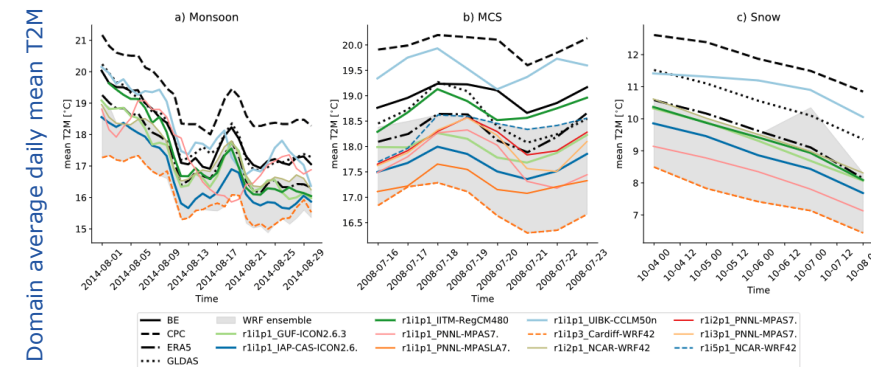
Number of rainy events per year (3h>0.125mm/3h)

CORDEX Flagship Pilot Study ELVIC (Lake Victoria Basin)



Lipzig, N.P.M.v., Walle, J.V.d., Belušić, D. et al. Representation of precipitation and top-of-atmosphere radiation in a multi-model convection-permitting ensemble for the Lake Victoria Basin (East-Africa). *Clim Dyn* 60, 4033-4054 (2023). <https://doi.org/10.1007/s00382-022-06541-5>

CORDEX Flagship Pilot Study Third Pole



Prein AF et al. (2022) Convection-Permitting Third Pole Experiment – Towards Ensemble-Based Kilometer-Scale Climate Simulations over the Third Pole Region. *Climate Dynamics*, <https://doi.org/10.1007/s00382-022-06543-3>

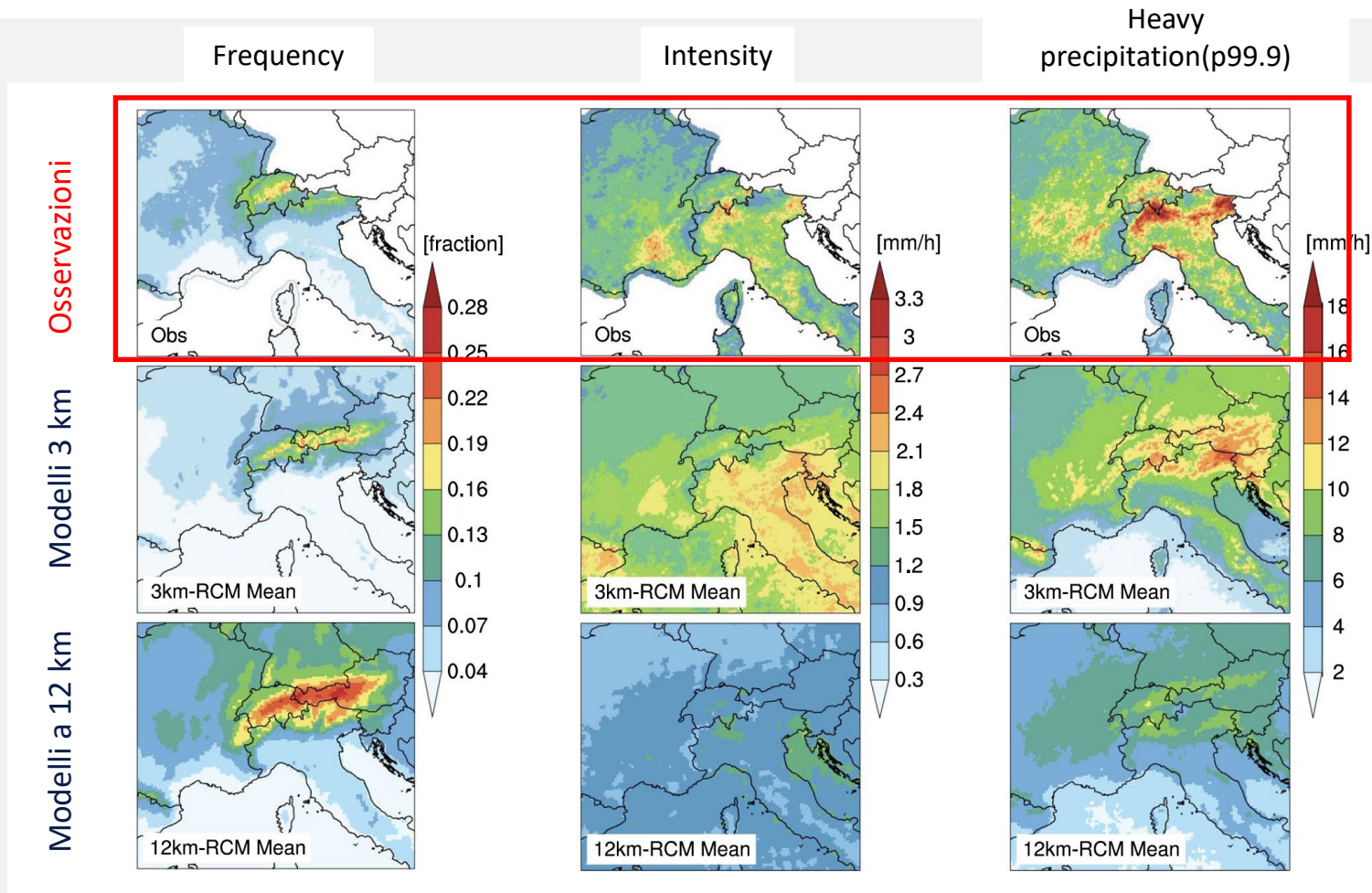
The present

Quali risultati nuovi sono stati ottenuti da questi studi

.....

CORDEX Flagship Pilot Study Europe

Media Multi-model della precipitazione oraria nella stagione estiva

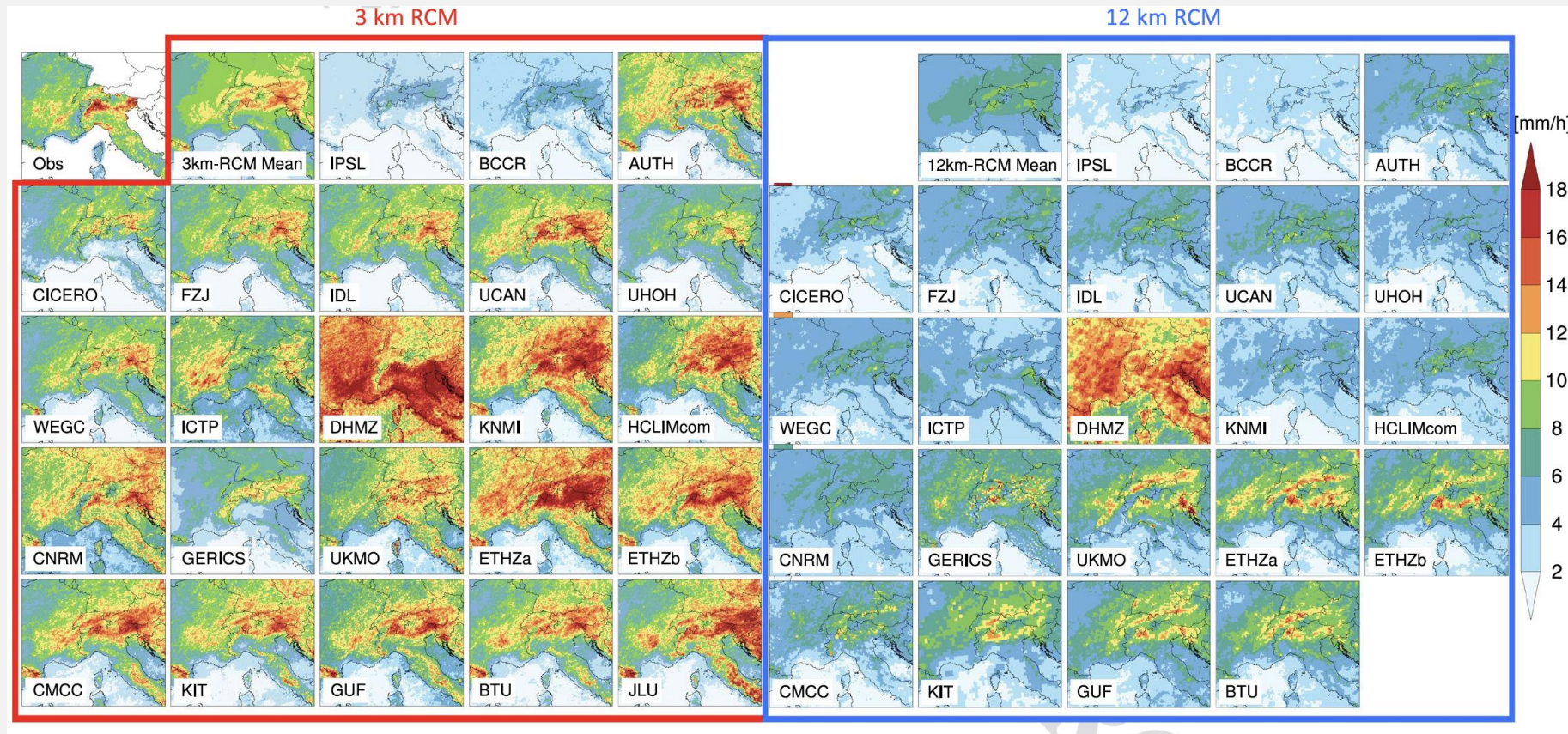


→ 12 km RCM mean shows a large **underestimation** of precipitation **intensity**, and **overestimation** of precipitation **frequency**

→ 3 km CPM mean show better performance in reproducing the spatial patterns of precipitation, driving toward an improvement of the long-standing “*drizzle problem*” with coarse resolution models

CORDEX Flagship Pilot Study Europe

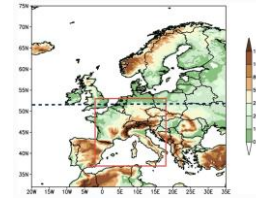
Precipitazione oraria estrema nella stagione estiva (p99.9)



C'e' una grande variabilita' tra i modelli, ma si vede una chiara differenza tra 3km e 12 km RCMs

(Ban, N., et al. 2021)

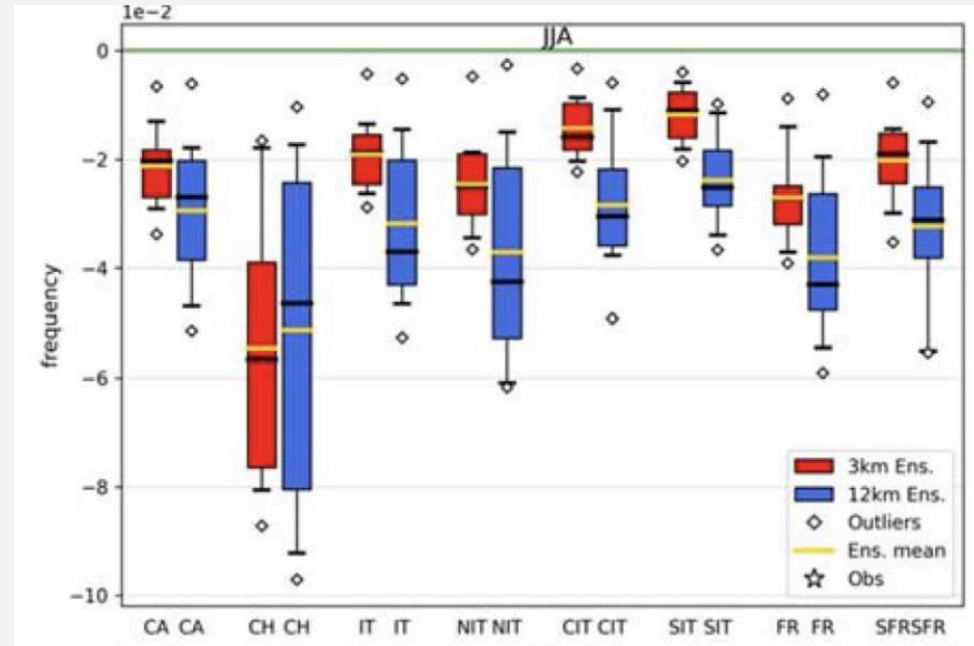
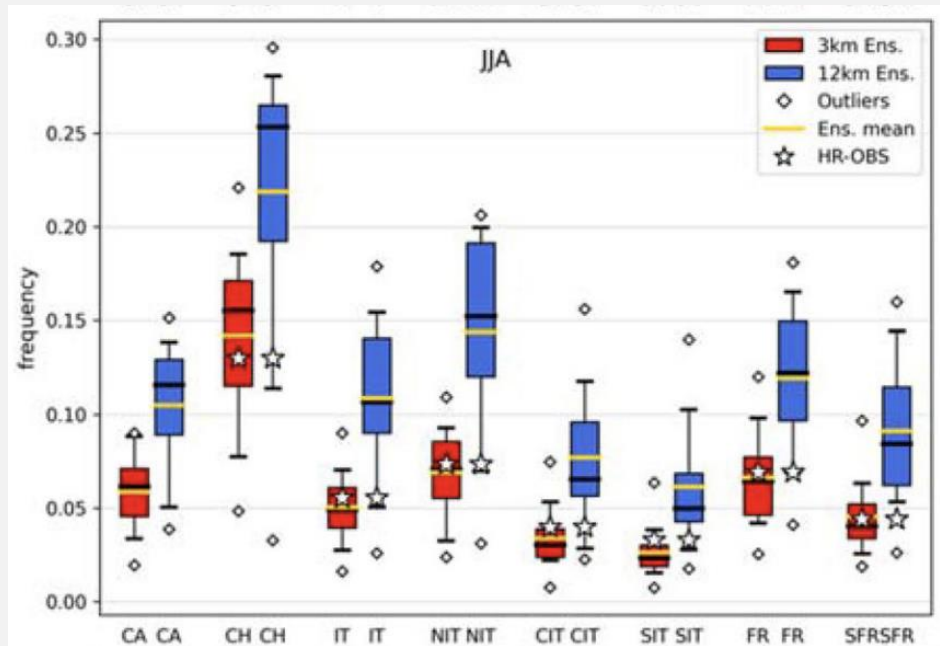
CORDEX Flagship Pilot Study Europe



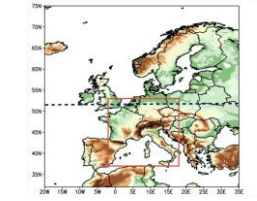
Ensemble CP a piu' alta risoluzione ha meno incertezza

Presente : frequenza precipitazione oraria

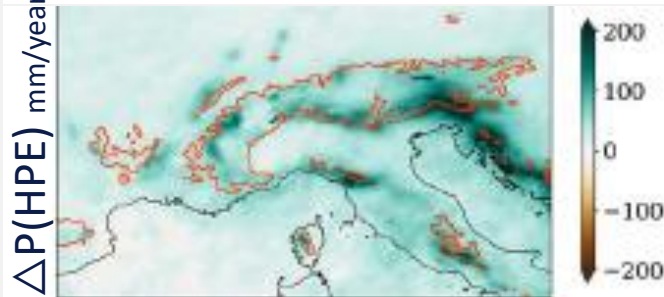
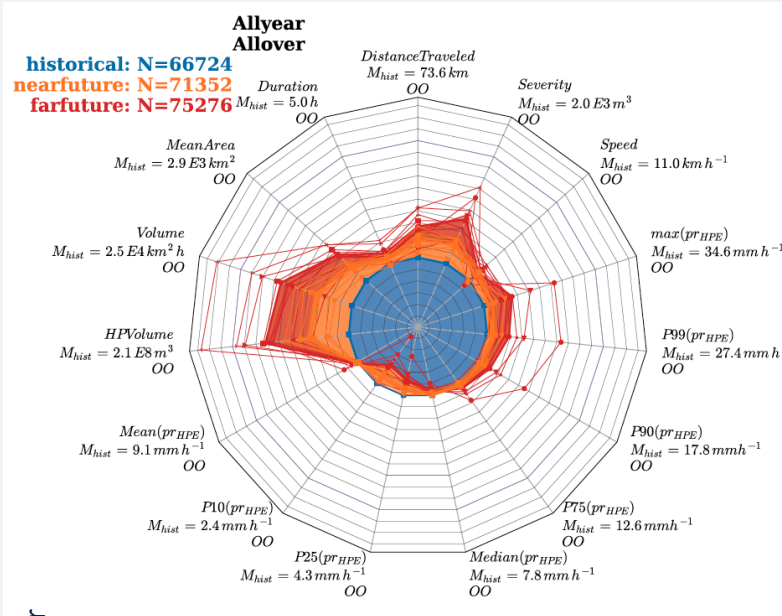
Futuro-presente: frequenza della precipitazione oraria



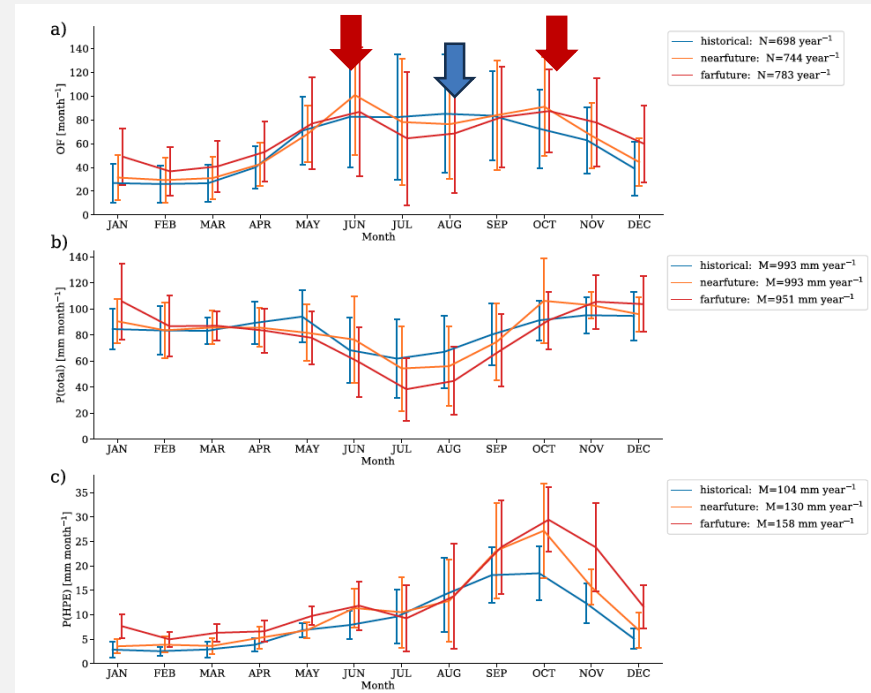
Smaller uncertainties for CPMs at the hourly scale in all regions for most indices and seasons



Impatto del cambiamento climatico sui sistemi che generano precipitazione estrema



HPE property	Percent of change %
Durata	5
Distanza di propagazione e	15
Velocità di propagazione e	13
Volume	30
Media P	3
Volume della P estrema	35
Severity	21

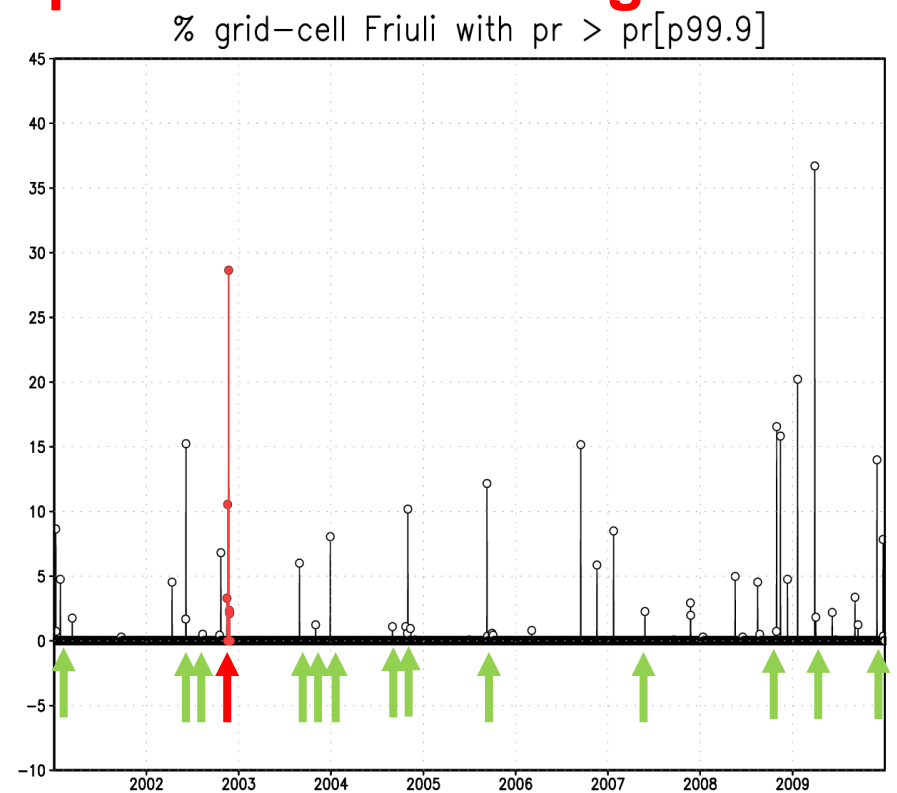
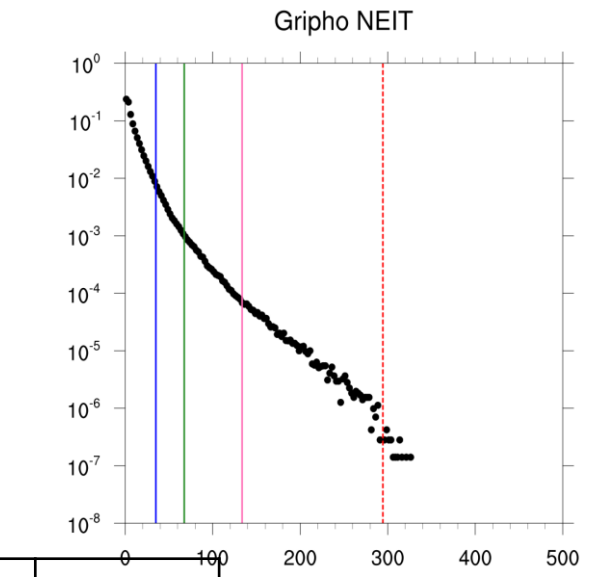
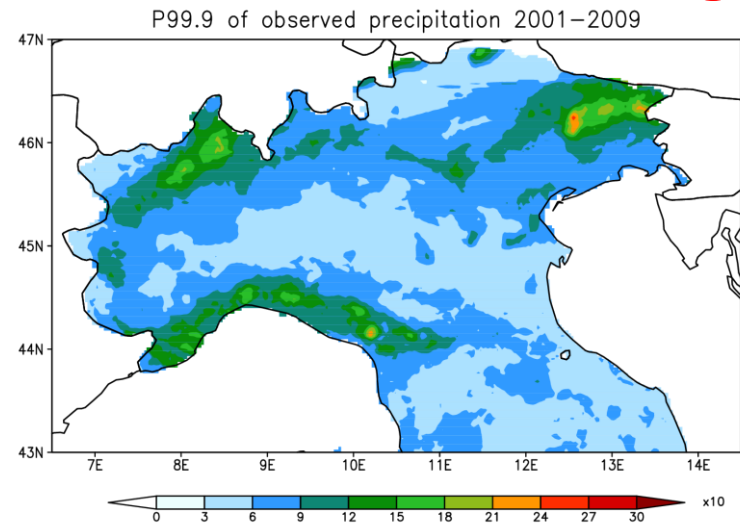


Frequency of the HPE change distribution shape from unimodal to bimodal

The present

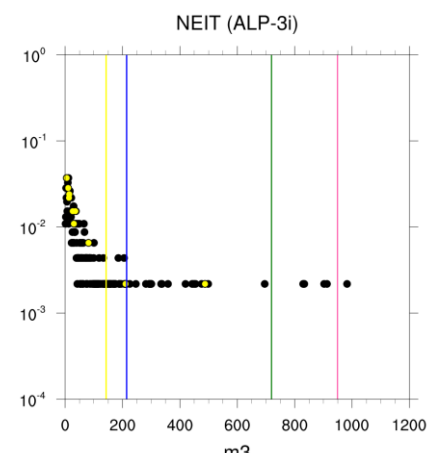
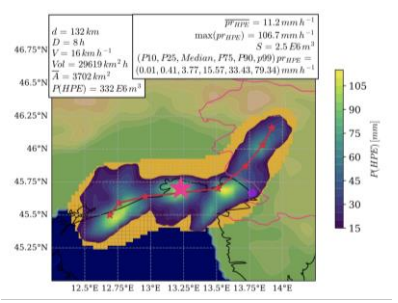
Caratteristiche dinamiche degli eventi di precipitazione estrema. Come cambiano sotto l'effetto del riscaldamento globale.

Metodo di selezioni degli eventi basato sulla precipitazione estrema giornaliera



ex	SON	DJF	MAM	JJA
Obs	30	11	7	11

Metodo basato sull'algoritmo di tracciamento delle tempeste



ex	SON	DJF	MAM	JJA
Obs	15	8	9	17

Mueller et al. (2023, their Table 1)
<https://doi.org/10.1007/s00382-023-06901-9>

The precipitation event in the CP-models world: projections

CORDEX-FPSCONV km-scale simulations

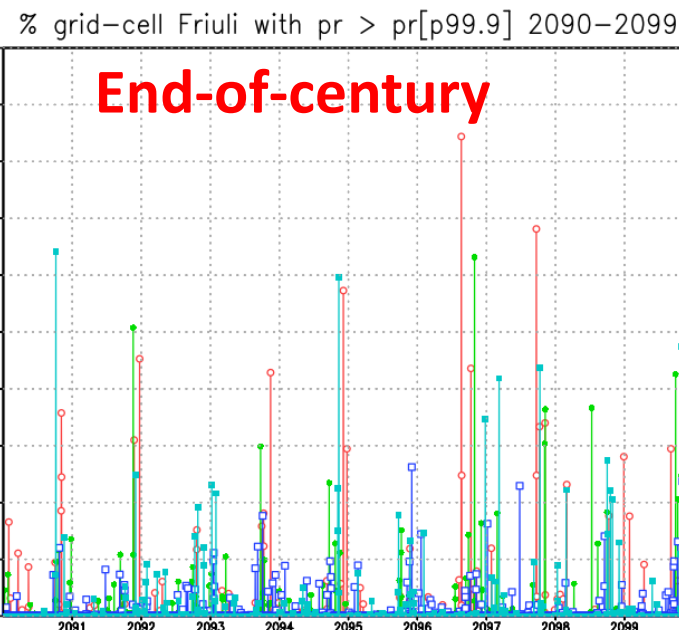
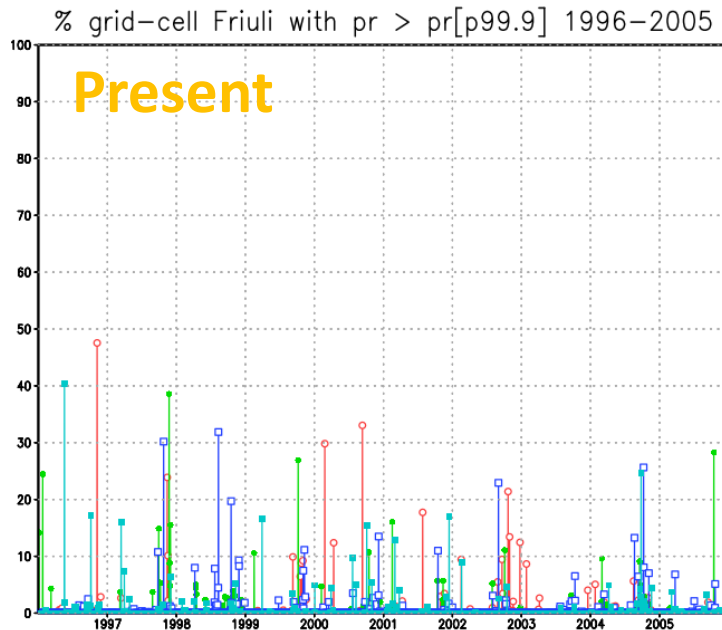
protocol Coppola et al. (2020) DOI: 10.1007/s00382-018-4521-8



Institute	cpRCM	dx(cpRCM) [km]	RCM	dx(RCM) [km]	GCM
CMCC	CLMcom-CMCC-CCLM5-0-9 (E)	3	CCLM (E1)	12	ICHEC-EC-EARTH
CNRM	AROME41t1 (B)	2.5	ALADIN63 (B1)	12	CNRM-CERFACS-CNRM-CM5
DWD	CLMcom-DWD-CCLM5-0-15 (E)	3	CCLM4 (E1)	12	MOHC-HadGEM2-ES
ETHZ	COSMO-crCLIM (F)	2.2	COSMO-crCLIM (F)	12	MPI-M-MPI-ESM-LR
HCLIMcom	HCLIM38-AROME (D)	3	HCLIM38-ALADIN (D)	12	ICHEC-EC-EARTH
ICTP	RegCM4-7-0 (A)	3	RegCM4-7-0 (A)	12	MOHC-HadGEM2-ES
JLU	CLMcom-JLU-CCLM5-0-15 (E)	3	-	-	MPI-M-MPI-ESM-LR
KIT	CLMcom-KIT-CCLM5-0-14 (E)	3	CCLM4 (E1)	25	MPI-M-MPI-ESM-LR
KNMI	HCLIM38h1-AROME (D)	2.5	RACMO (D1)	12	EC-Earth23 (D2)
MOHC	HadREM3-RA-UM10.1 (C)	2.2	-	-	MOHC-HadGEM2-ES

SON	CNRM	ETHZ	HCLIMcom	ICTP
HIST	45	47	40	32
RCP85	83	68	52	43

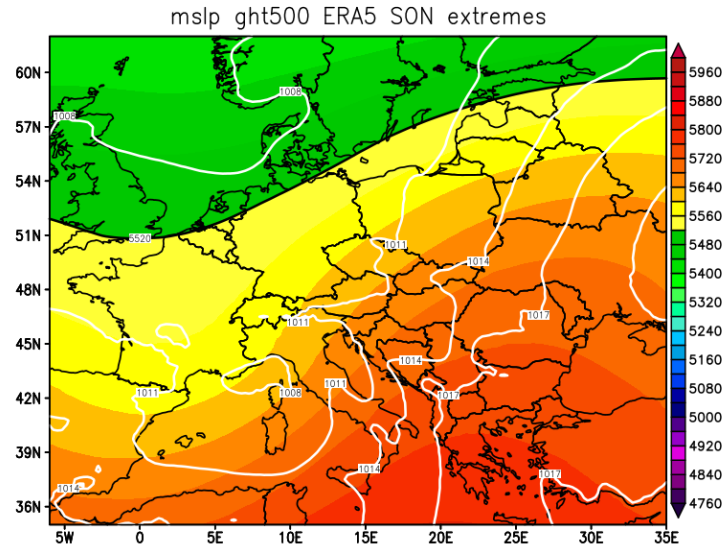
Mueller et al. (2023, their Table 1) <https://doi.org/10.1007/s00382-023-06901-9>



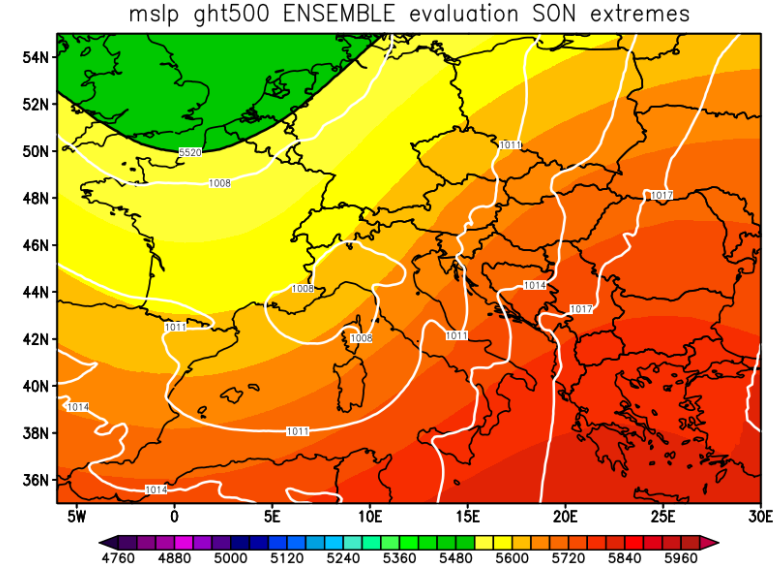
**More HPEs
hitting
larger
areas**

Condizioni medie a larga scala che caratterizzano l'evento

ERA5

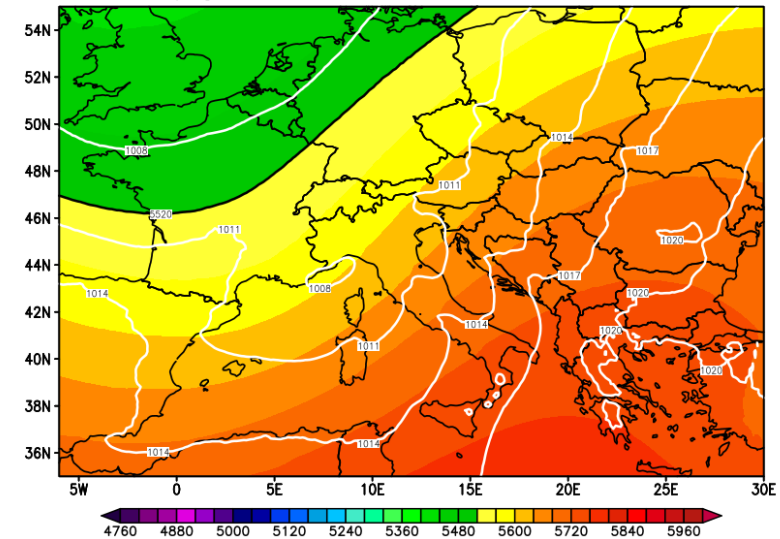


ENSEMBLE evaluation run



Mean sea level pressure
(hPa, contours)
500 hPa geopotential height
(m, colors)

mslp ght500 ENSEMBLE historical SON extremes

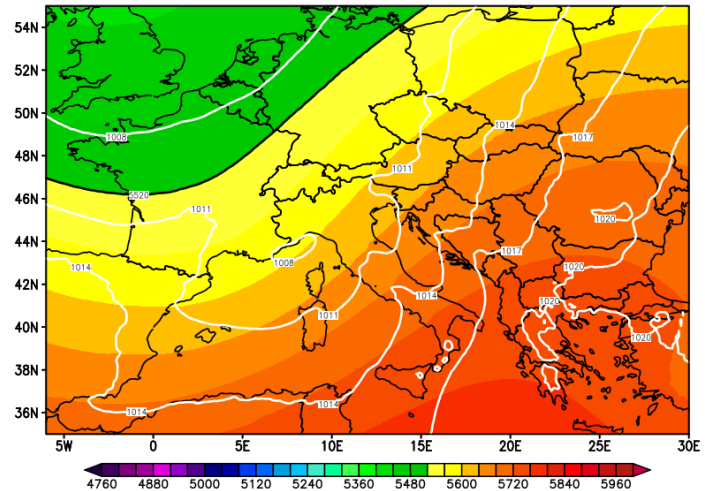


ENSEMBLE historical run

Condizioni medie a larga scala che caratterizzano l'evento

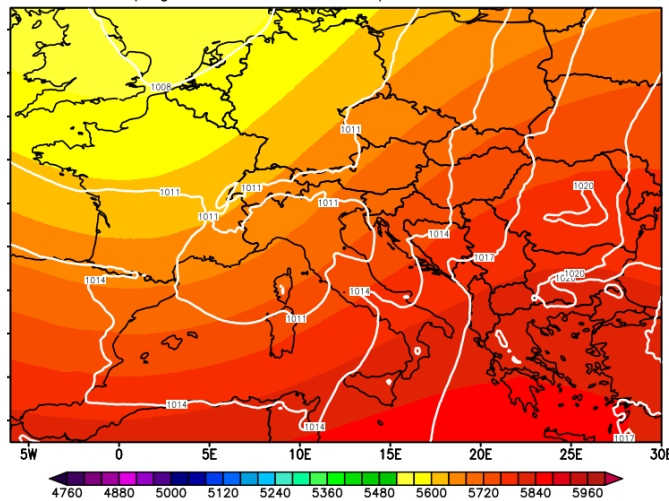
Historical period

mslp_gh500 ENSEMBLE historical SON extremes



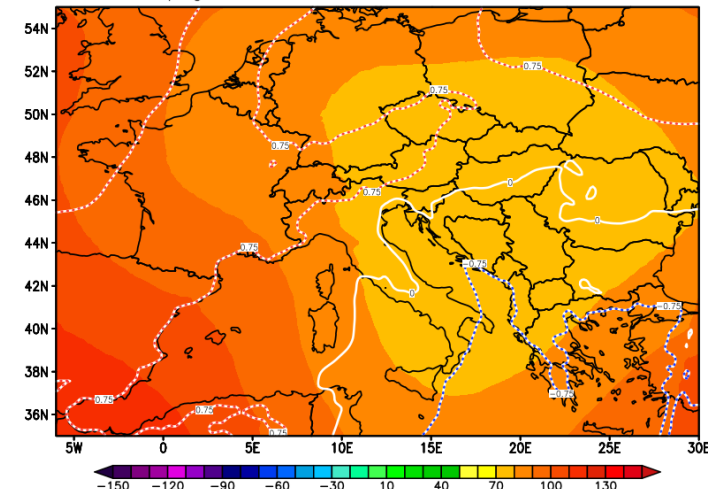
End of Century

mslp_gh500 ENSEMBLE rcp85 SON extremes

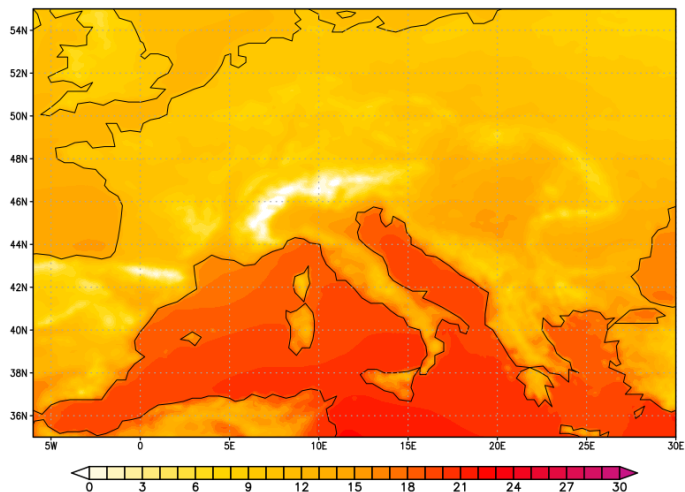


Change

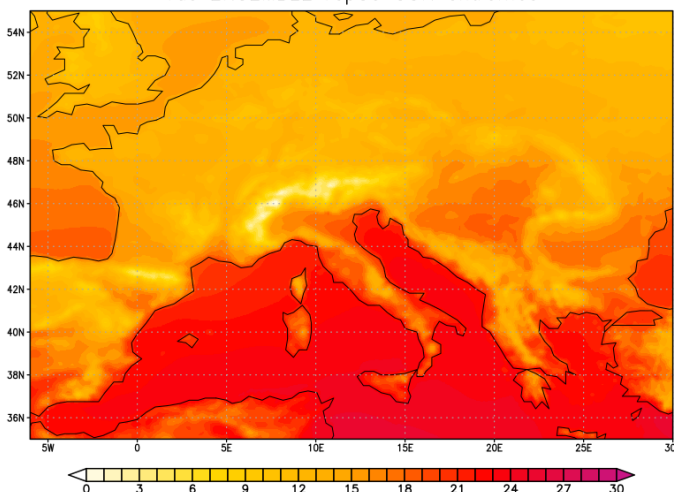
mslp_gh500 ENSEMBLE CHANGE SON extremes



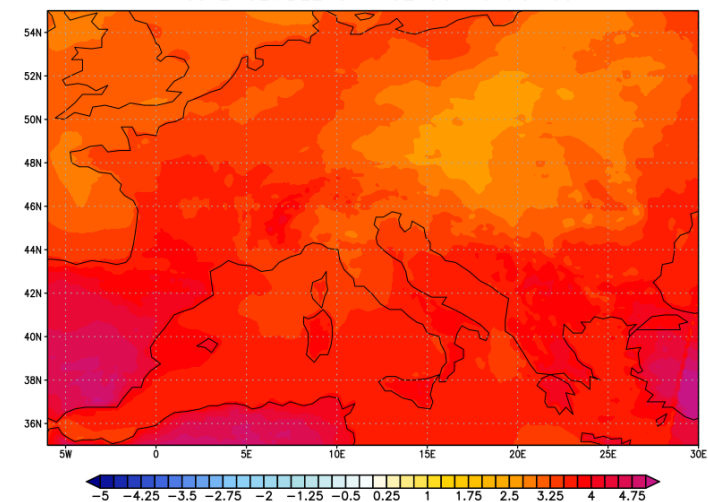
Tas ENSEMBLE historical SON extremes



Tas ENSEMBLE rcp85 SON extremes



Tas ENSEMBLE CHANGE SON extremes



Mslp (hPa)
Ght (m)

Tas (C)

Condizioni medie a larga scala che caratterizzano l'evento

Historical period

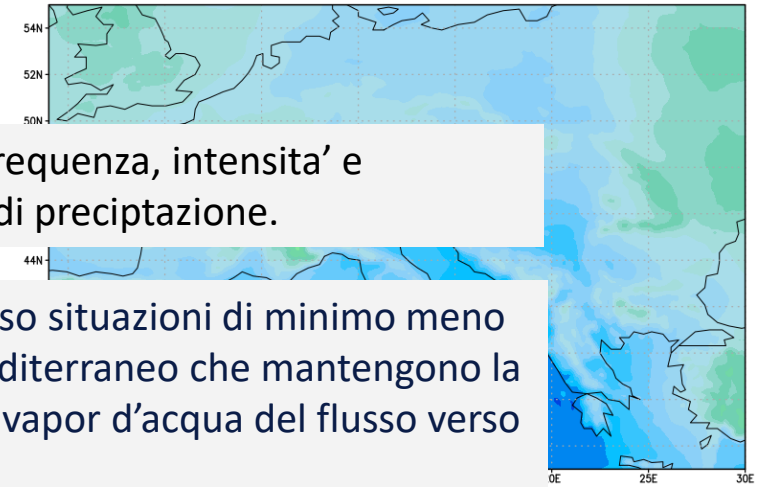
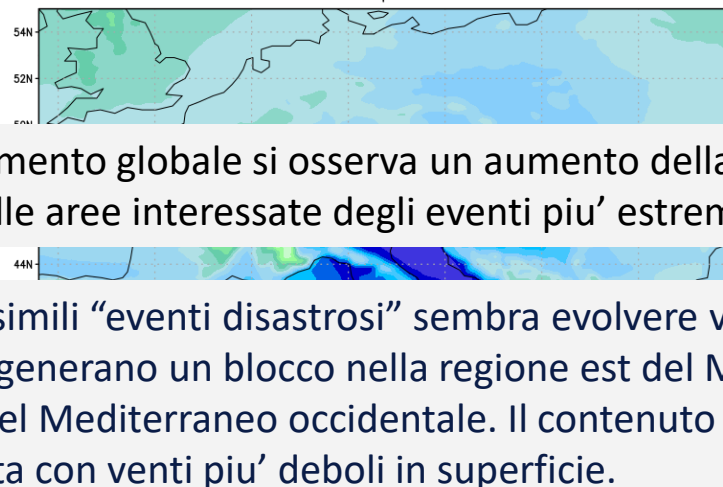
End of Century

Change

Prw ENSEMBLE historical SON extremes

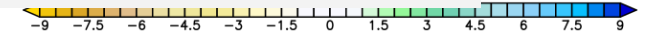
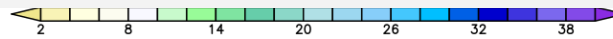
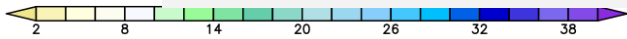
Prw ENSEMBLE rcp85 SON extremes

Prw ENSEMBLE CHANGE SON extremes



- In uno scenario di riscaldamento globale si osserva un aumento della frequenza, intensita' e estensione superficiale delle aree interessate degli eventi piu' estremi di precipitazione.

- La situazione dinamica di simili "eventi disastrosi" sembra evolvere verso situazioni di minimo meno profonde, che comunque generano un blocco nella regione est del Mediterraneo che mantengono la perturbazione confinata nel Mediterraneo occidentale. Il contenuto di vapor d'acqua del flusso verso nord est delle Alpi aumenta con venti piu' deboli in superficie.

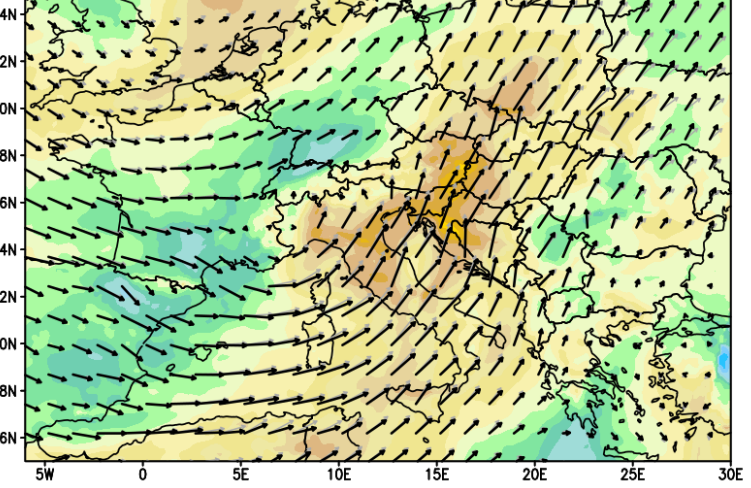
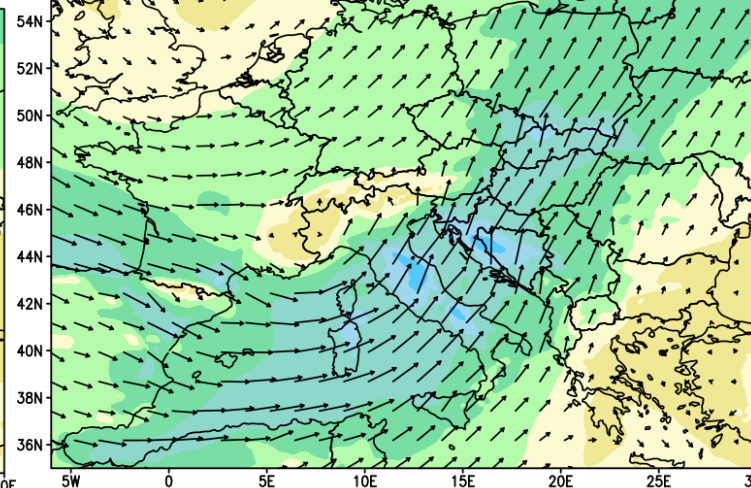
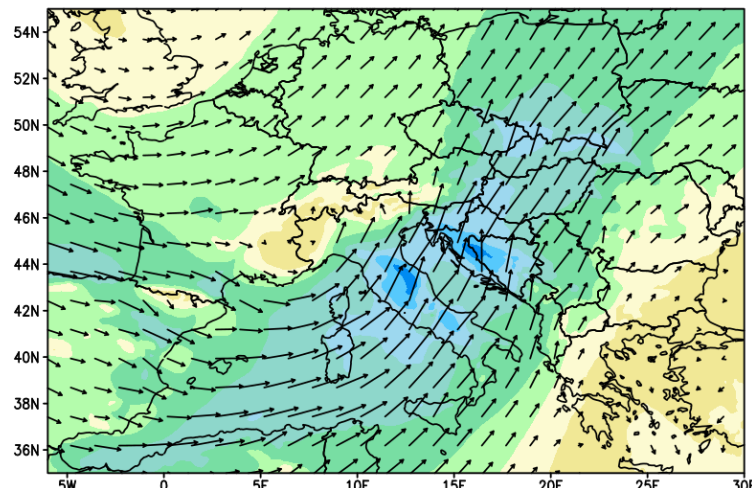


PWV
(mm)

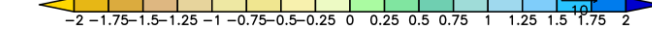
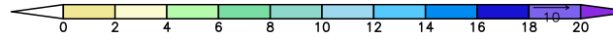
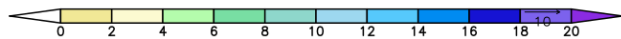
Winds 850 hPa ENSEMBLE historical SON extremes

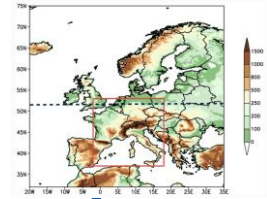
Winds 850 hPa ENSEMBLE rcp85 SON extremes

Winds 850 hPa ENSEMBLE CHANGE SON extremes



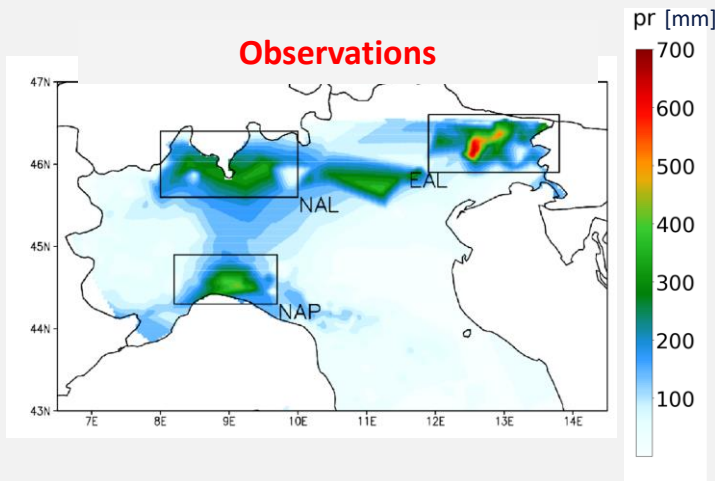
Winds
850mb
(m/s)



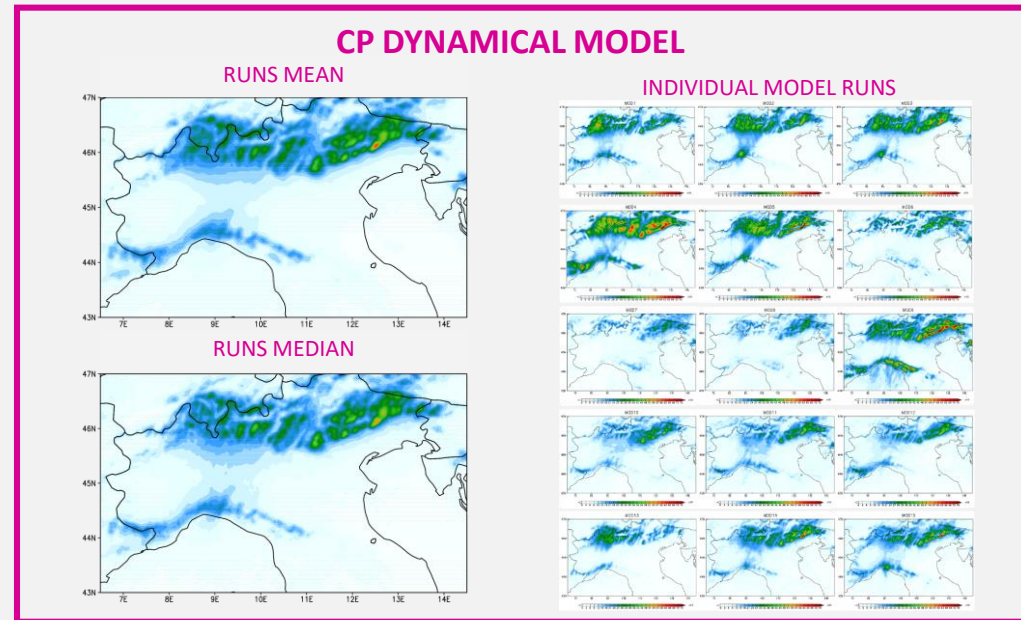
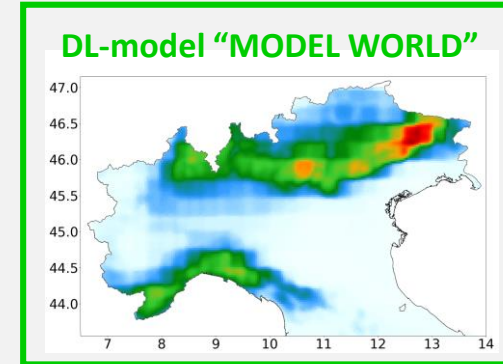
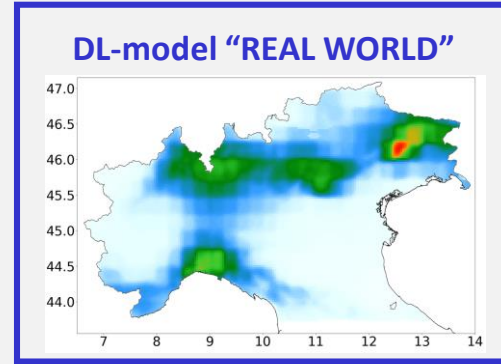


Machine learning emulator ad alte risoluzioni

Extreme event
Nov 22-30, 2002



GROUND TRUTH: GRIPHO observations
"REAL WORLD": ERA5 predictors
"MODEL WORLD": RegCM predictors
CP: Convection Permitting



Riassumendo

La nuova generazione di modelli ad alta risoluzione e a convezione esplicita

- migliora la rappresentazione spaziale e la variabilità temporale delle precipitazioni sia giornaliere e orarie
- migliora la rappresentazione della frequenza oraria e dell'intensità degli eventi di precipitazione
- migliora la rappresentazione del ciclo diurno estivo delle precipitazioni sia in termini di fase che ampiezza
- riduce l'incertezza per il clima attuale e le proiezioni future
- permette di studiare l'evoluzione spaziale e temporale dei sistemi convettivi
- permette lo studio dinamico delle condizioni a larga scala e di come queste cambiano all'aumentare del riscaldamento globale

A wide-angle landscape photograph of a river valley, heavily tinted with a blue color. In the foreground, a river winds through a valley, its banks showing signs of erosion and sediment. The middle ground is filled with a dense forest of trees, and a road or path is visible on the right side. In the background, a range of mountains with snow-capped peaks stretches across the horizon under a cloudy sky. The overall mood is serene and majestic.

Thank you!