Impact of climate change on the hydrological cycle of Italy by means of regional climate convection permitting high resolution simulations and CHyM simulations.

Luiza Vargas de Oliveira Heinz

The Abdus Salam International Centre for Theoretical Physics (ICTP)

Università degli Studi di Trieste

Motivation

Use the CETEMPS hydrological model (CHyM) to see climate change impact on Italy's river network by way of convection permitting (CP) models

Asses if there is any improvement in the description of the hydrological cycle when using a convection permitting resolution

Use CP ensemble to

- validate the method against station data of river discharge
- analyse the climate change signal for mid and end of century periods under the SSP585 scenario

Introduction

CETEMPS hydrological model (CHyM)

- ➔ Grid based hydrological model developed at University of L'Aquila
- ➔ Simulates hydrological cycle with an eight-flow direction river network employing a Cellular Automata theory-based algorithm
- ➔ Hourly streamflow simulated for 7 different Italian regions (Calabria and Sicily excluded)

FPSCONV CORDEX

- ➔ Ensemble of convection permitting (CP) models (3km resolution, Great Alpine Domain)
- ➔ Explicit treatment of deep convection without the use of convection parameterization schemes
- ➔ Use of temperature and precipitation **or** runoff from the models to calculate river discharge

EraInterim Driven Evaluation Period (2000 - 2009)

- BCCR
- CICERO
- CLMCom-BTU
- CLMCom-ETH
- CLMCom-JLU
- CLMCom-KIT
- HCLIMcom
- ICTP
- IDL
- KNMI
- MOHC
- UHOH
- WEGC

GCM Driven SSP585 Scenario - Historical (96-05), Mid-Century (40-49) and End-of-Century (90-99)

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Coppola, E., Tomassetti, B., Mariotti, L., Verdecchia, M., & Visconti, G. (2007). Cellular automata algorithms for drainage network extraction and rainfall data assimilation. *Hydrological Sciences Journal*, *52*(3), 579–592.

Ban, N., Caillaud, C., Coppola, E. *et al.* The first multi-model ensemble of regional climate simulations at kilometer-scale resolution, part I: evaluation of precipitation. *Clim Dyn* **57**, 275–302 (2021).

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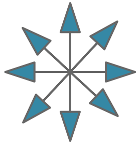
CETEMPS hydrological model (CHyM)



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CHyM - TP

Uses temperature and precipitation to calculate the discharge

CHyM - roff

Directly routes the runoff from climate outputs

Coppola, E., Tomassetti, B., Mariotti, L., Verdecchia, M., & Visconti, G. (2007). Cellular automata algorithms for drainage network extraction and rainfall data assimilation. *Hydrological Sciences Journal*, *52*(3), 579–592.

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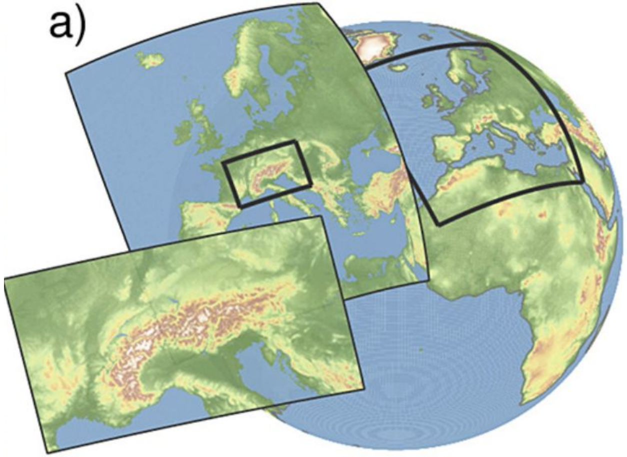

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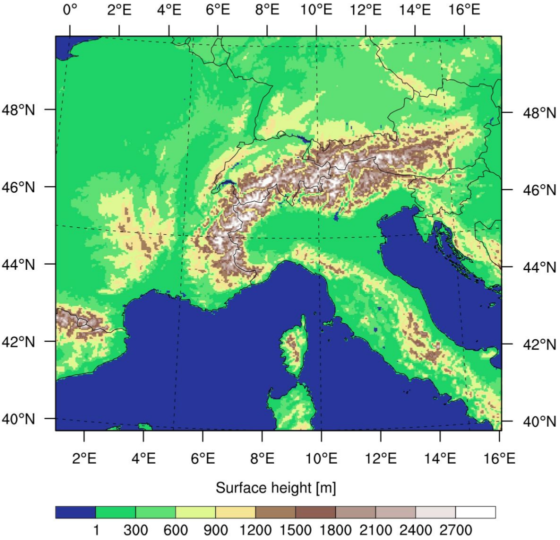

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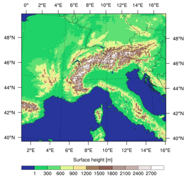
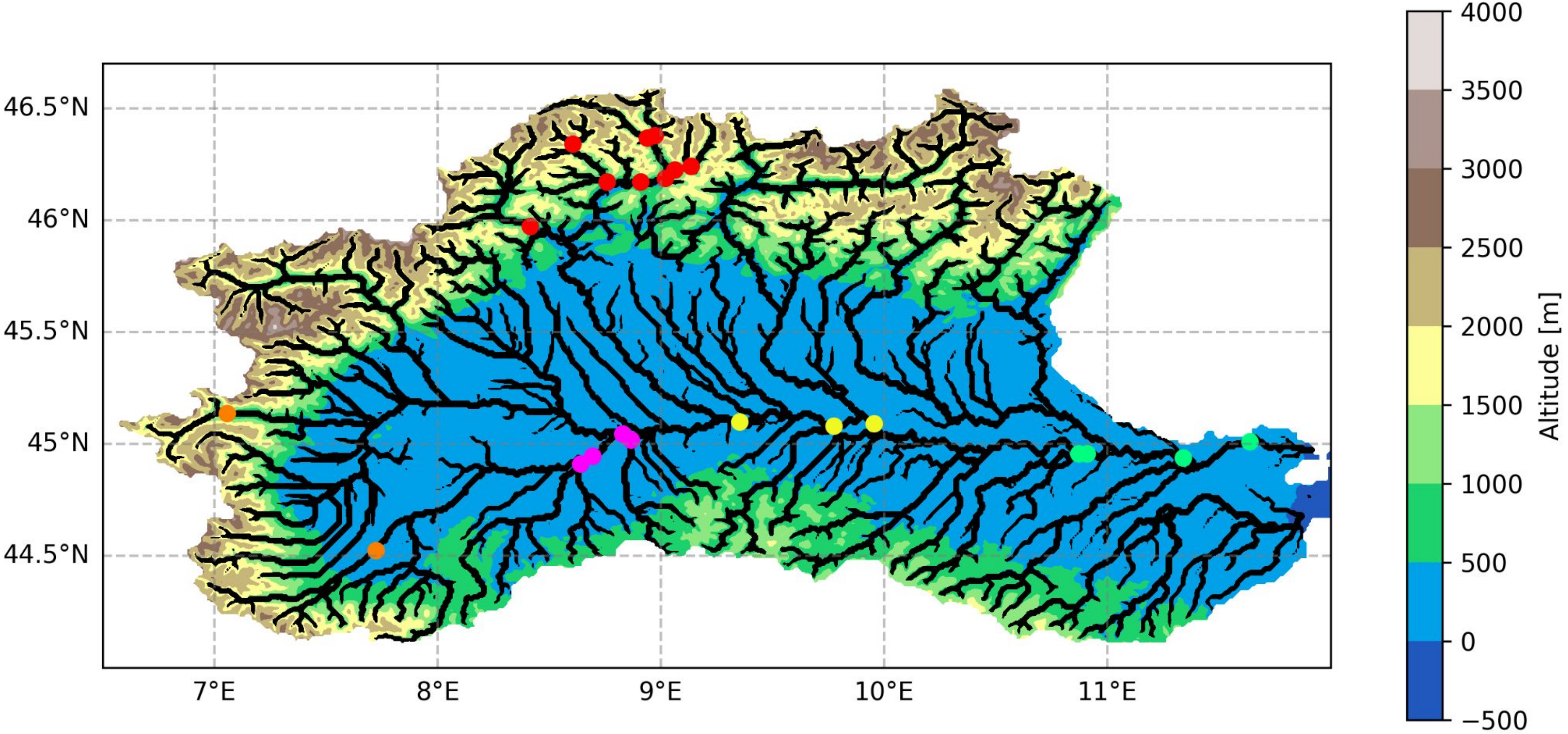
Po Valley Station Selection





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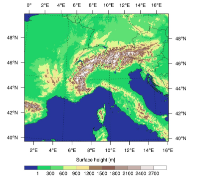

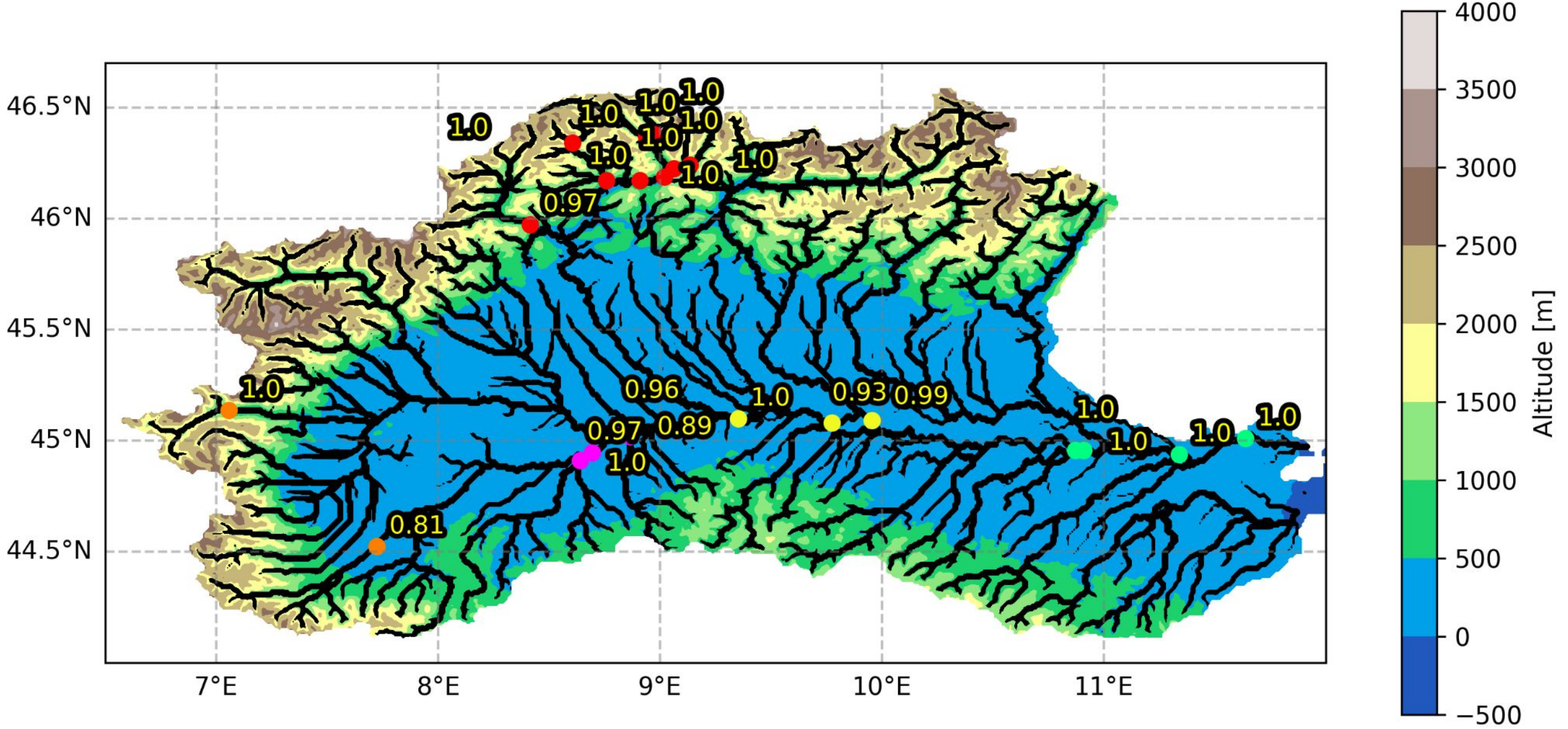

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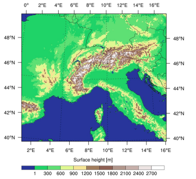
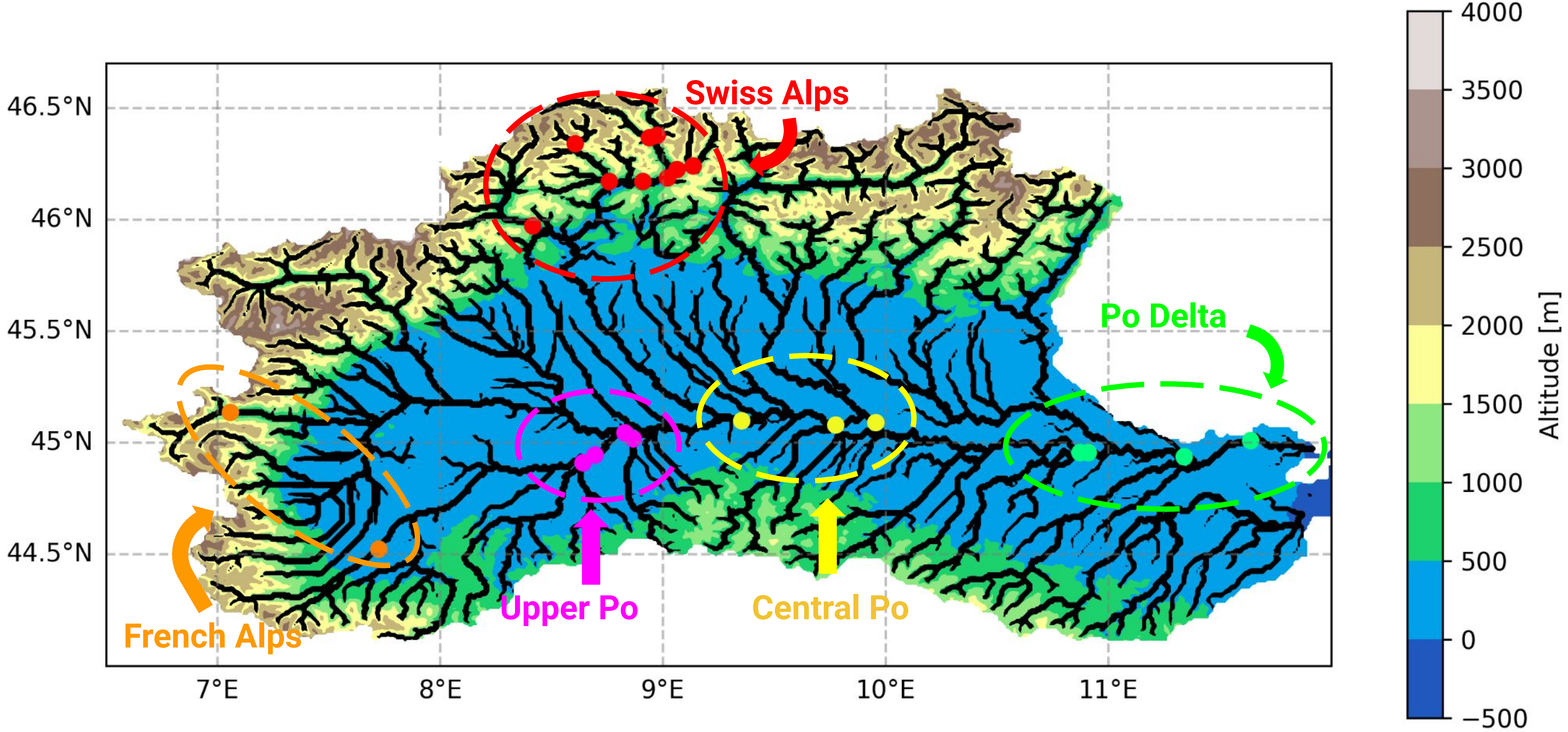
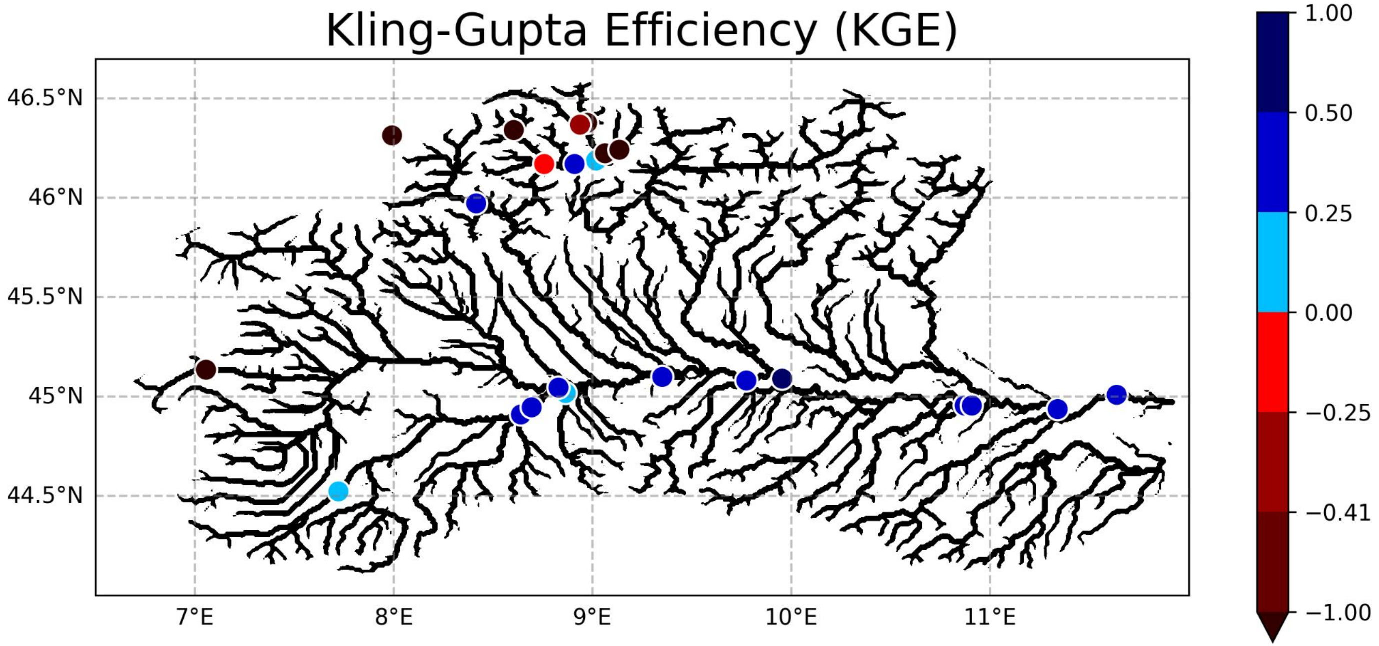
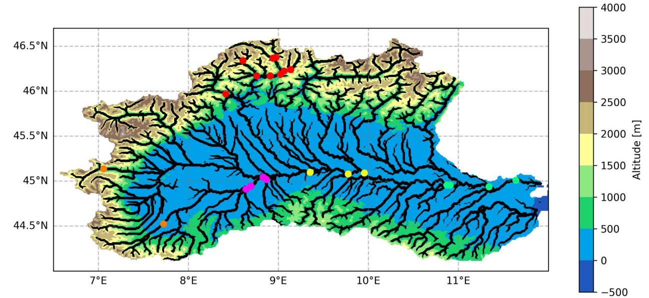




Validation



Skill Score	Equation	Range
Kling-Gupta Efficiency (KGE)	$1 - \sqrt{(r-1)^2 + (\beta-1)^2 + (\alpha-1)^2}$	(-∞, 1]
Correlation term of the KGE (r)	$\frac{\sum_{i=1}^{n}(Q_{sim}(i) - \bar{Q}_{sim})(Q_{obs}(i) - \bar{Q}_{obs})}{\sqrt{\sum_{i=1}^{n}(Q_{sim}(i) - \bar{Q}_{sim})^2 \sum_{i=1}^{n}(Q_{obs}(i) - \bar{Q}_{obs})^2}}$	[-1, 1]
Bias term of the KGE (β)	$\frac{\bar{Q}_{sim}}{\bar{Q}_{obs}}$	[0, ∞)
Variability term of the KGE (α)	$\frac{\sigma_{sim}}{\sigma_{obs}}$	[0, ∞)



García-Valdecasas Ojeda, M., Di Sante, F., Coppola, E., Fantini, A., Nogherotto, R., Raffaele, F., & Giorgi, F. (2022). Climate change impact on flood hazard over Italy. *Journal of Hydrology*, *615*, 128628.

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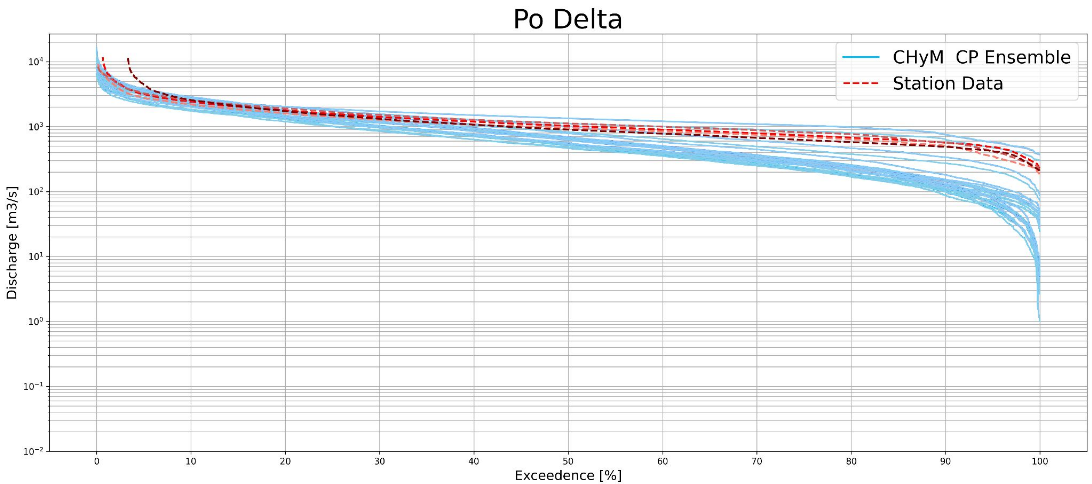
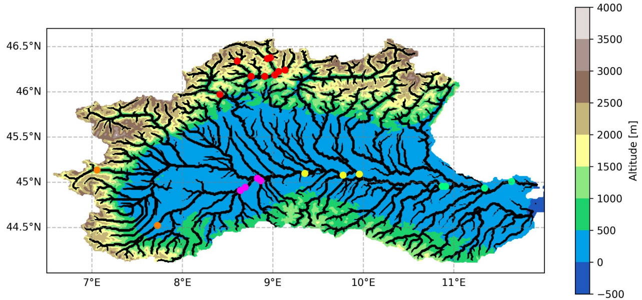
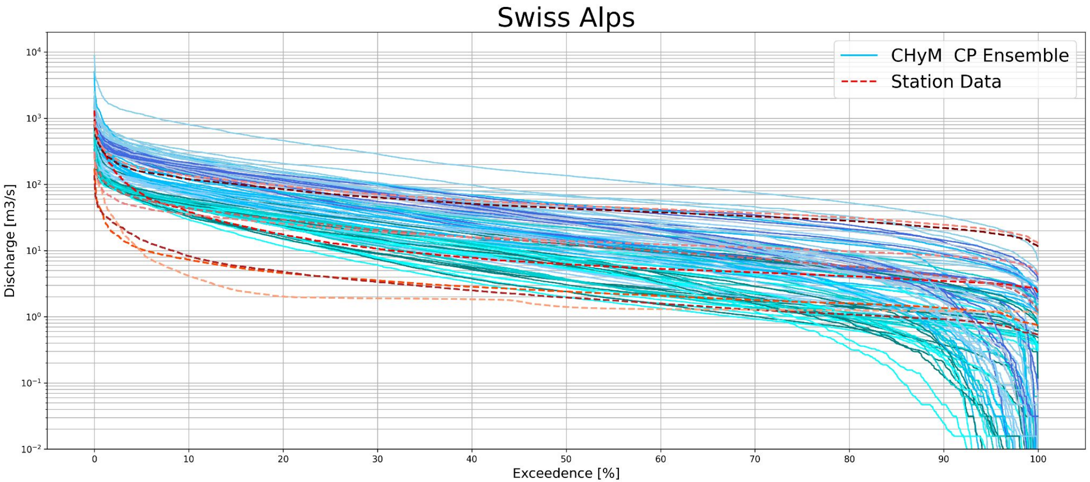
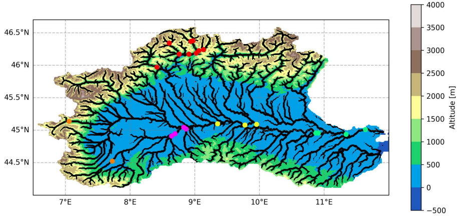

Po Delta
CHyM CP Ensemble
Station Data
Discharge [m3/s]
Exceedence [%]


Altitude [m]

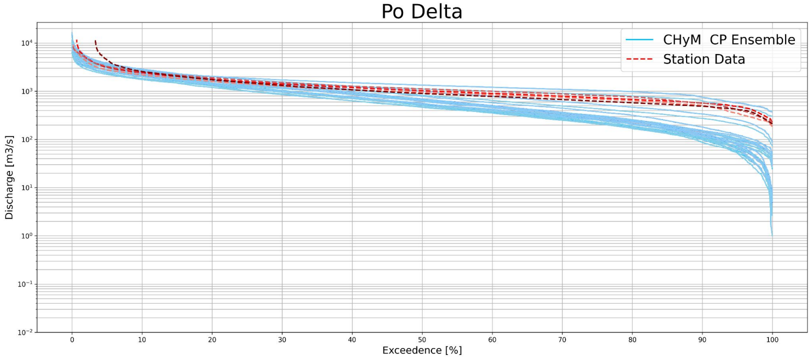

Swiss Alps
CHyM CP Ensemble
Station Data
Discharge [m3/s]
Exceedence [%]

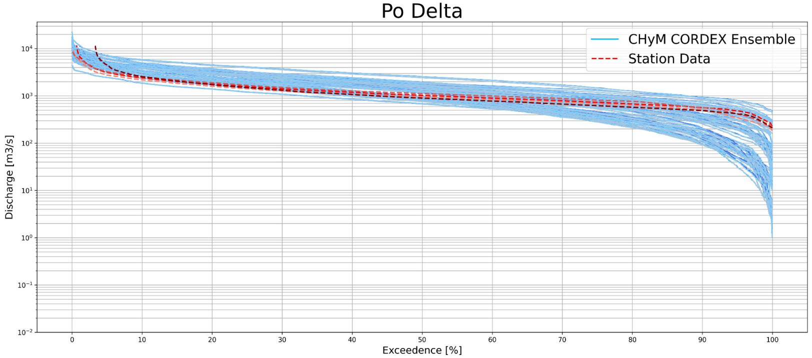
Validation

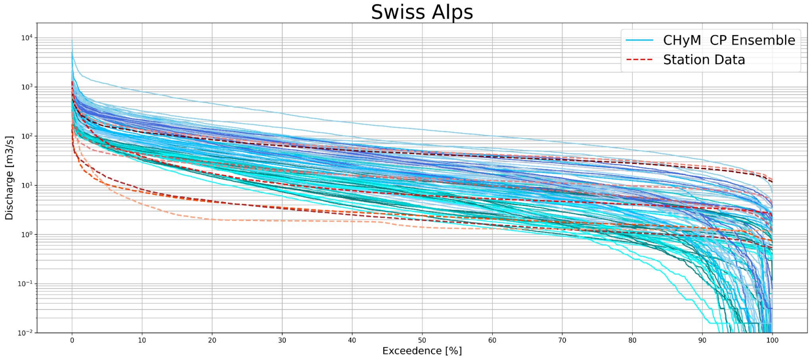
CHyM CP Ensemble

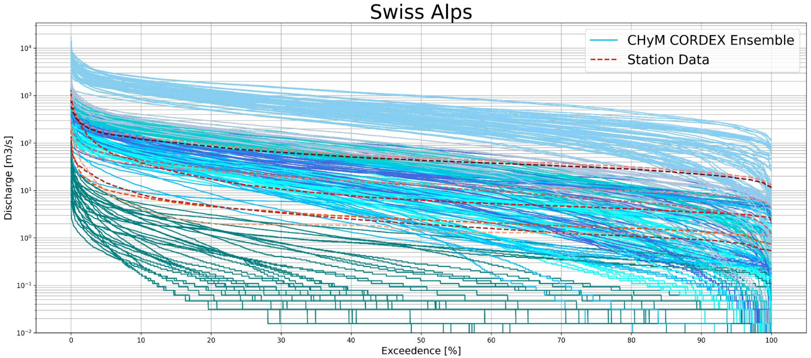


CHyM CORDEX Ensemble









Di Sante, F., Coppola, E., & Giorgi, F. (2021). Projections of river floods in Europe using euro-cordex, cmip5 and cmip6 simulations. *International Journal of Climatology*, *41*(5), 3203–3221. doi:10.1002/joc.7014

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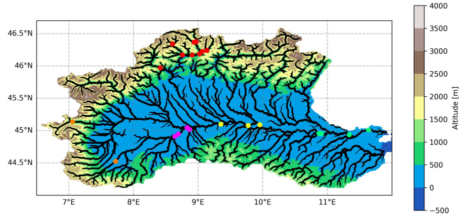

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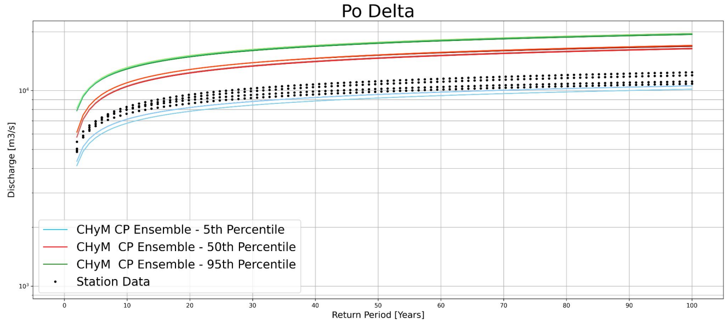

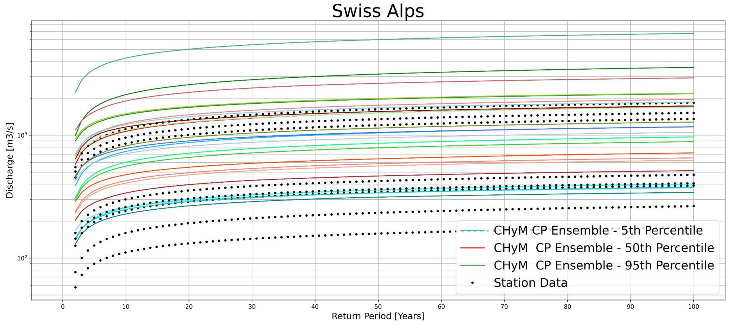

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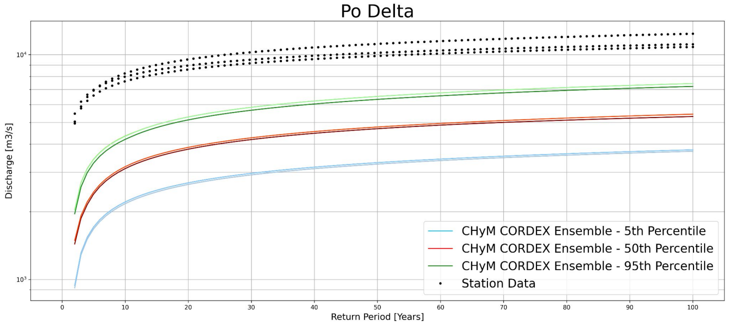

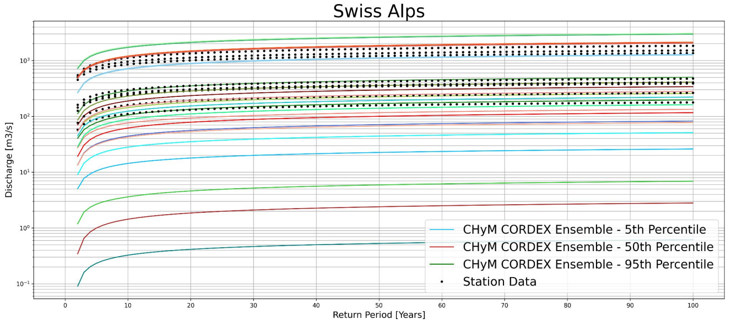

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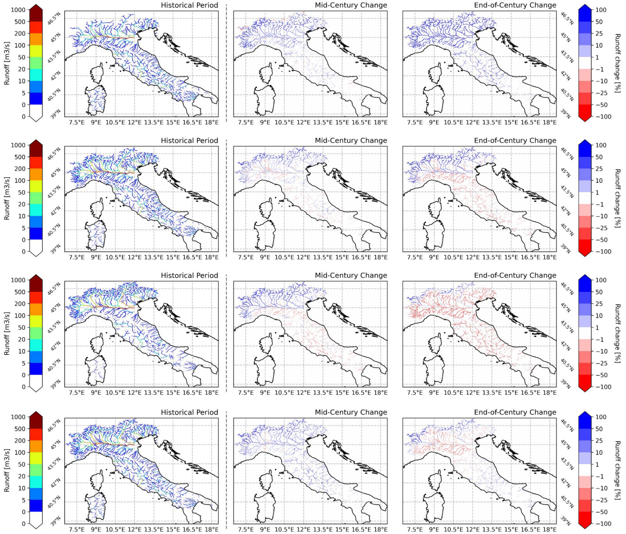


River discharge change [%]

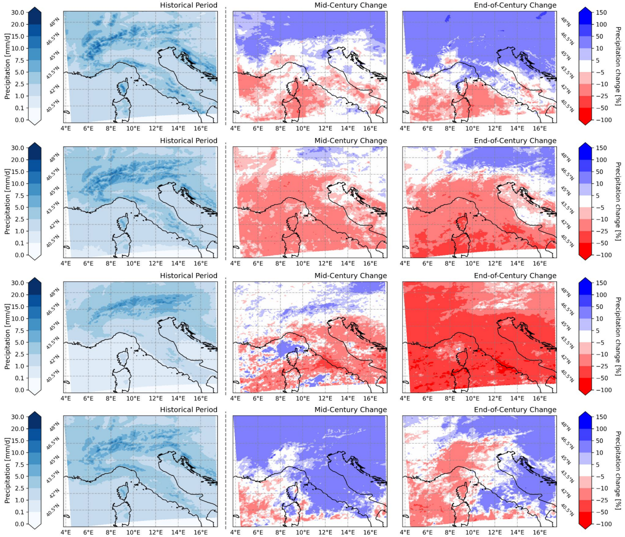
DJF

MAM

JJA

SON

Precipitation change [%]



Seasonal mean flow

GCM Driven SSP585 Scenario - Historical (96-05), Mid-Century (40-49) and End-of-Century (90-99)

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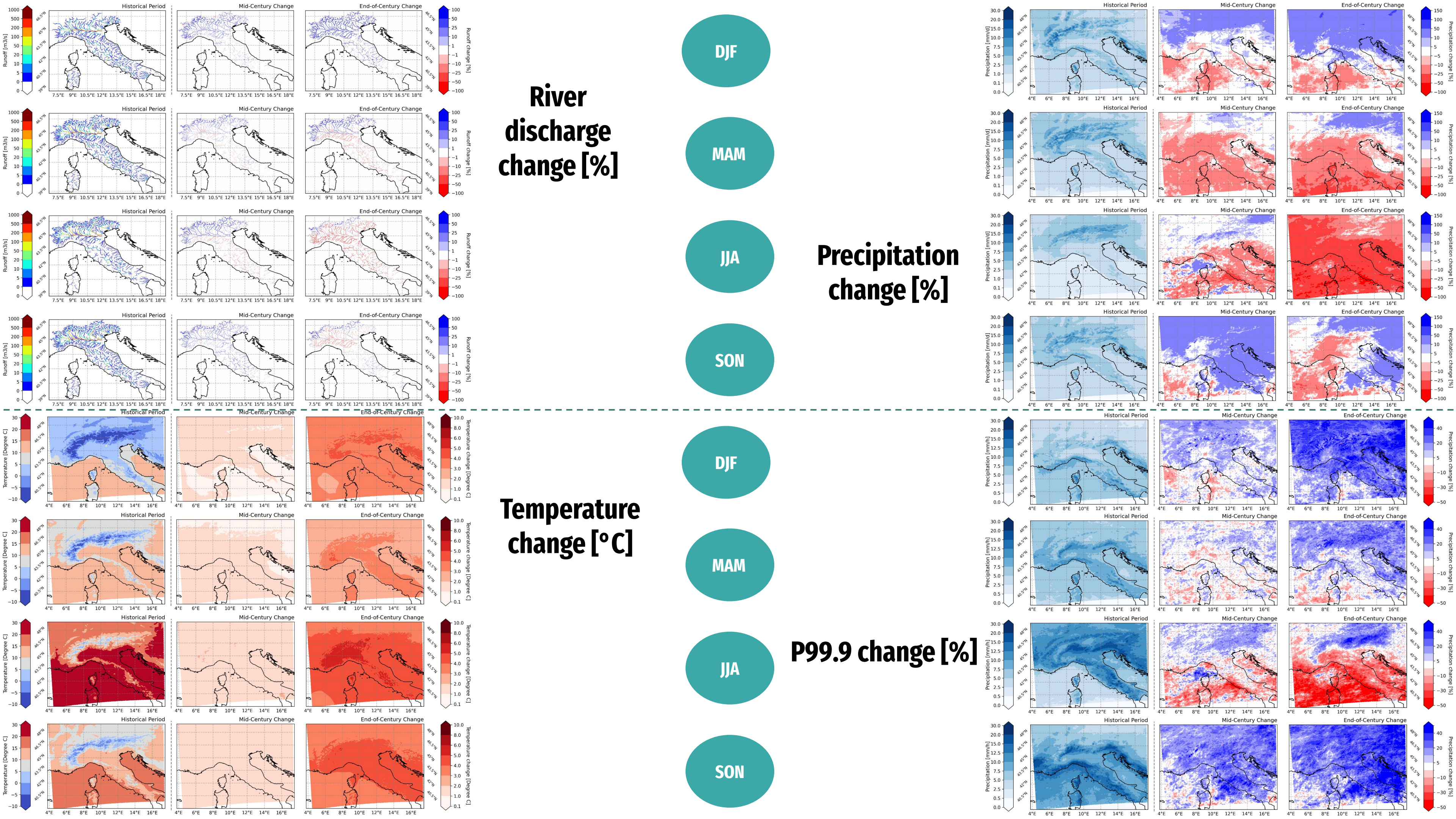
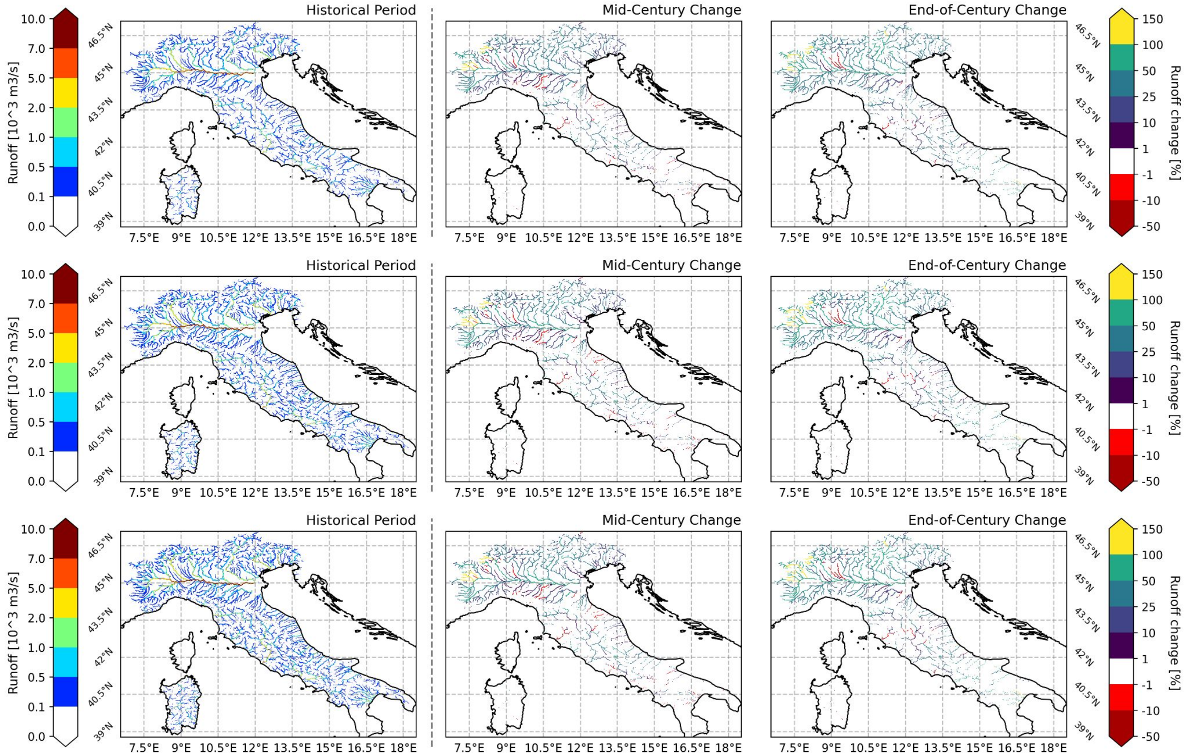

River discharge change [%]
Precipitation change [%]
Temperature change [°C]
P99.9 change [%]
DJF
MAM
JJA
SON
DJF
MAM
JJA
SON
Historical Period
Mid-Century Change
End-of-Century Change
Runoff [m3/s]
Runoff change [%]
Precipitation [mm/d]
Precipitation change [%]
Temperature [Degree C]
Temperature change [Degree C]
Precipitation [mm/h]

Climate change signal SSP585



Q$_{10}$

Q$_{50}$

Q$_{100}$

Peak discharge for different return periods

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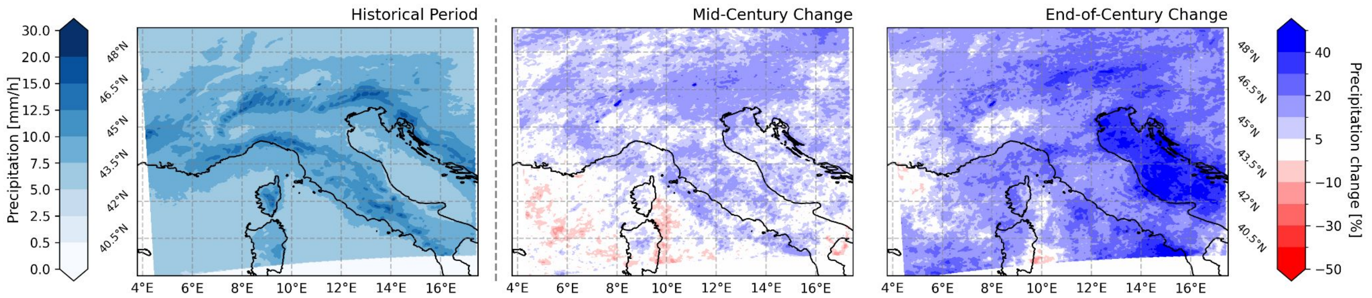
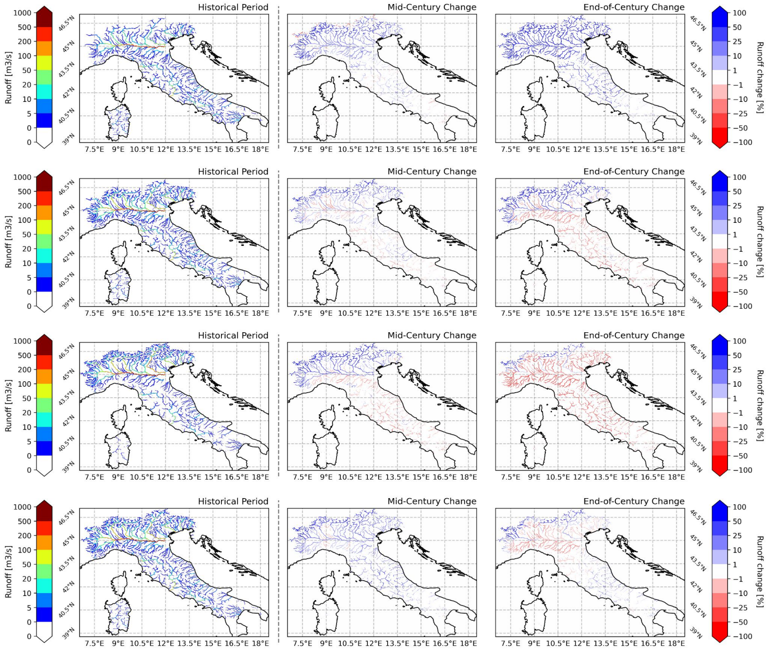
P99.9



Climate change signal SSP585

Seasonal mean flow



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MAM

JJA

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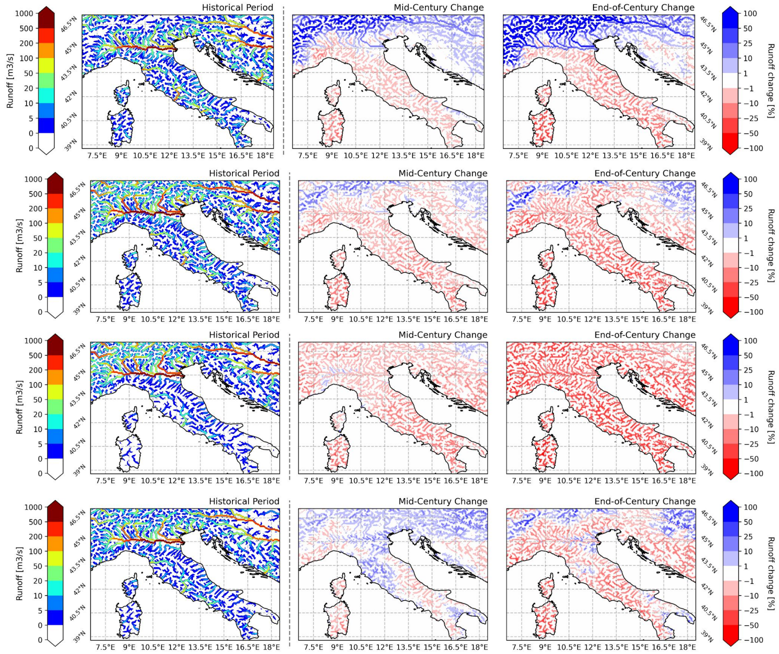

CHyM CP Ensemble

CHyM CORDEX Ensemble

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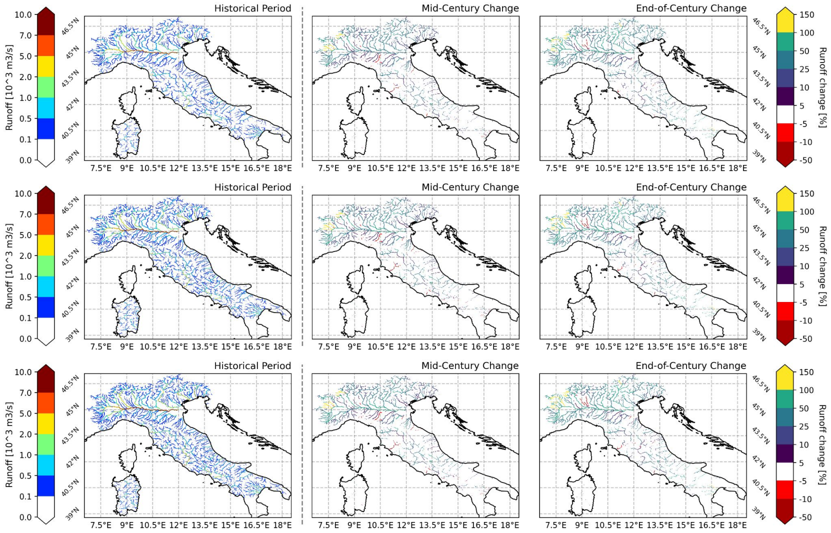
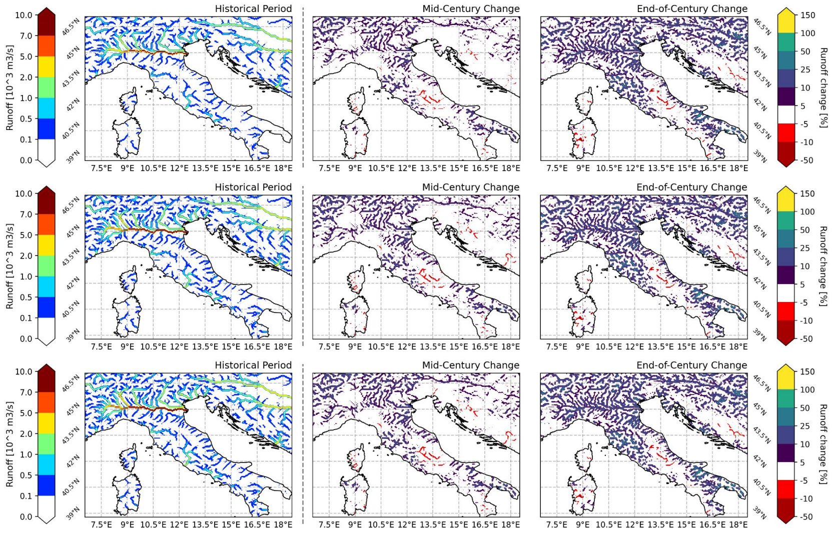


Q10

Q50

Q100



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Conclusions and perspectives

CHyM shows overestimation of high discharge values when comparing to station data, but with good description of mean flow and timing

Decrease of average flow by end of century and increase of high flow rates

Impact of extreme precipitation events on discharge change, specially over the Alps and in the summer months

More detailed signal with CP resolution

Expand the GCM driven ensemble

Further investigate impact of CHyM setting on discharge outputs

Any questions?

Impact of climate change on the hydrological cycle of Italy by means of regional climate convection permitting high resolution simulations and hydrological model simulations.

European Geosciences Union

The Abdus Salam International Centre for Theoretical Physics

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