Obtain original web presentation here:

https://slides.com/odineidolon/chym2019-2/fullscreen

This PDF version is of lower quality

Climate change impact on hydrology: the Italian case study

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Allianz

The Abdus Salam International Centre for Theoretical Physics

Present climate

PR Change

Future climate

Present hydrology

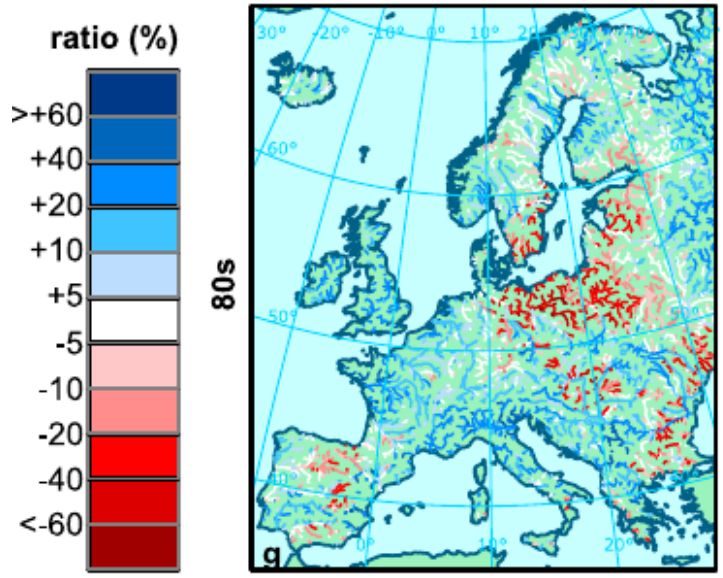
Q Change

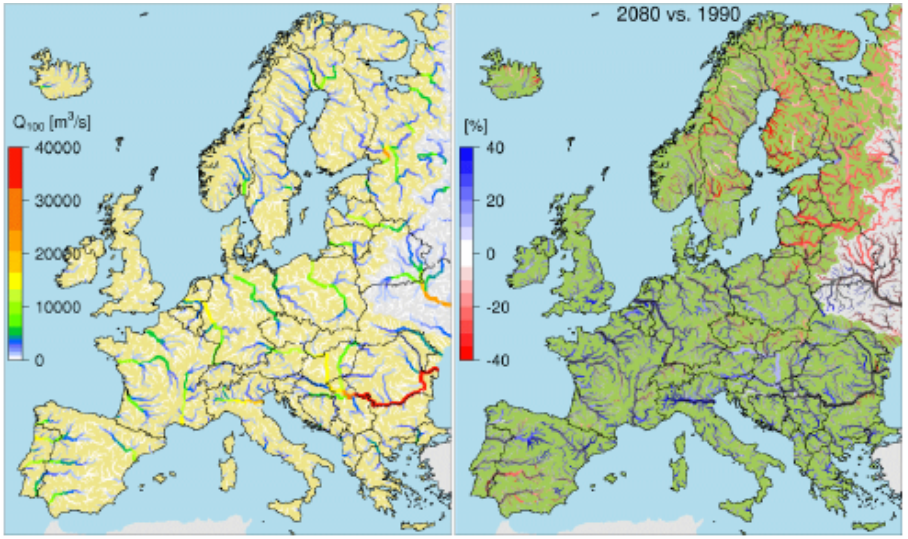
Future hydrology

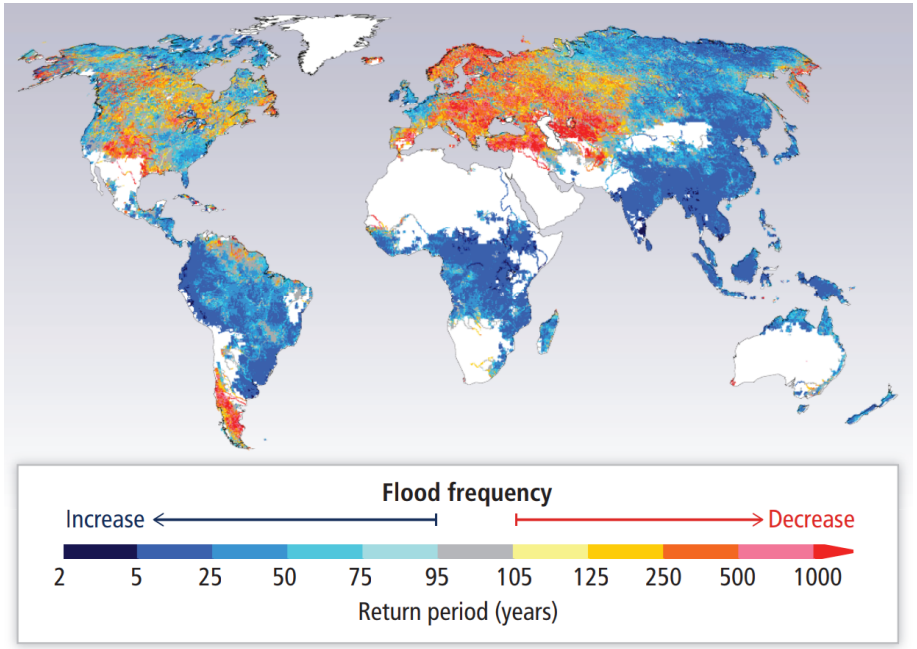
Motivation

Mixed results over Italy in the literature:

- General increase in **flood proxies** by the end of the century
- Especially for Northern Italy
- **Low resolution** does not resolve smaller basins



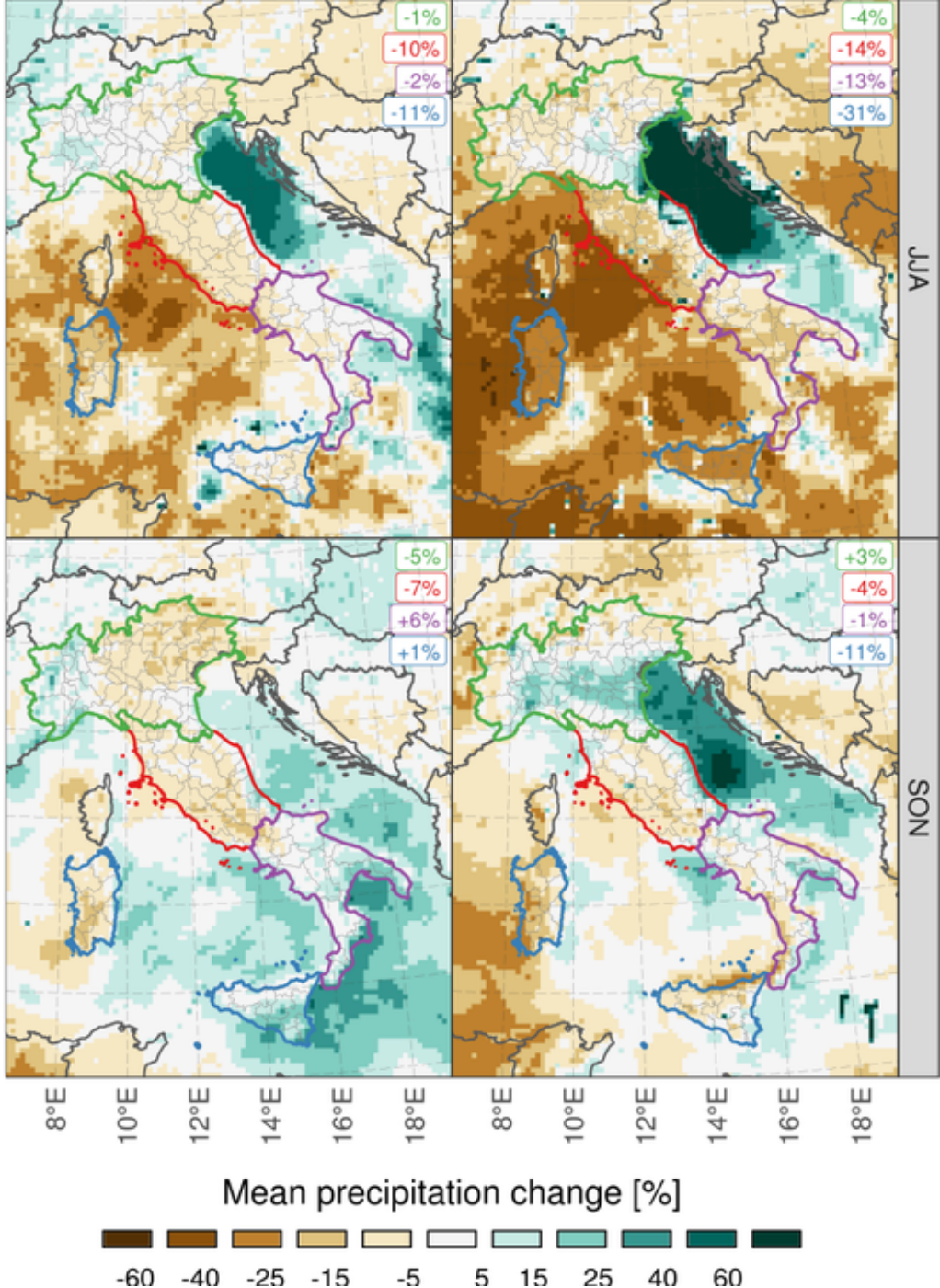




Hirabayashi et al. (2013); Rojas et al. (2012); Alfieri et al. (2015); Thober et al. (2018); Donnelly et al. (2017)

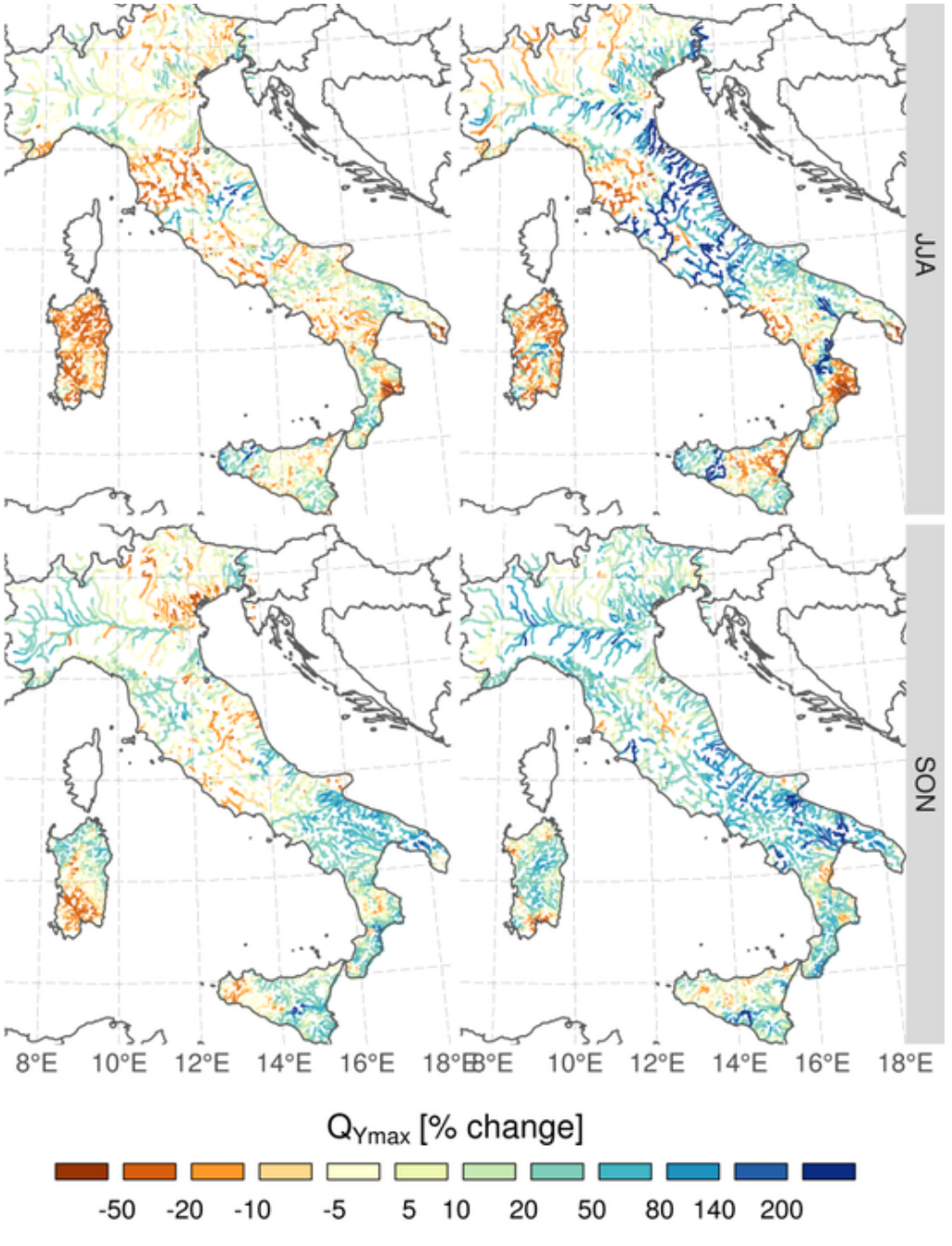
Starting point: RCP8.5 climate simulations

- RegCM 4.6.1 climate simulation
- 1971-2100
- Precipitation and temperature
- HadGEM-driven
- RCP8.5 scenario (business as usual)



Objective: identify future changes in discharge over Italy

- Mean discharges
- **Extremes**
- Do discharge changes follow precipitation changes?



A step back: the GRIPHO dataset

Two main goals:

- Driving the hydrological model with high resolution data
- Validating the regional climate simulations

Raw station data provided by Marco Verdecchia (CETEMPS):

- 2001 - 2016
- Hourly
- 3712 stations (~2200 on average)
- No quality check

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GRIPHO

(GRidded Italian Precipitation Hourly Observations)

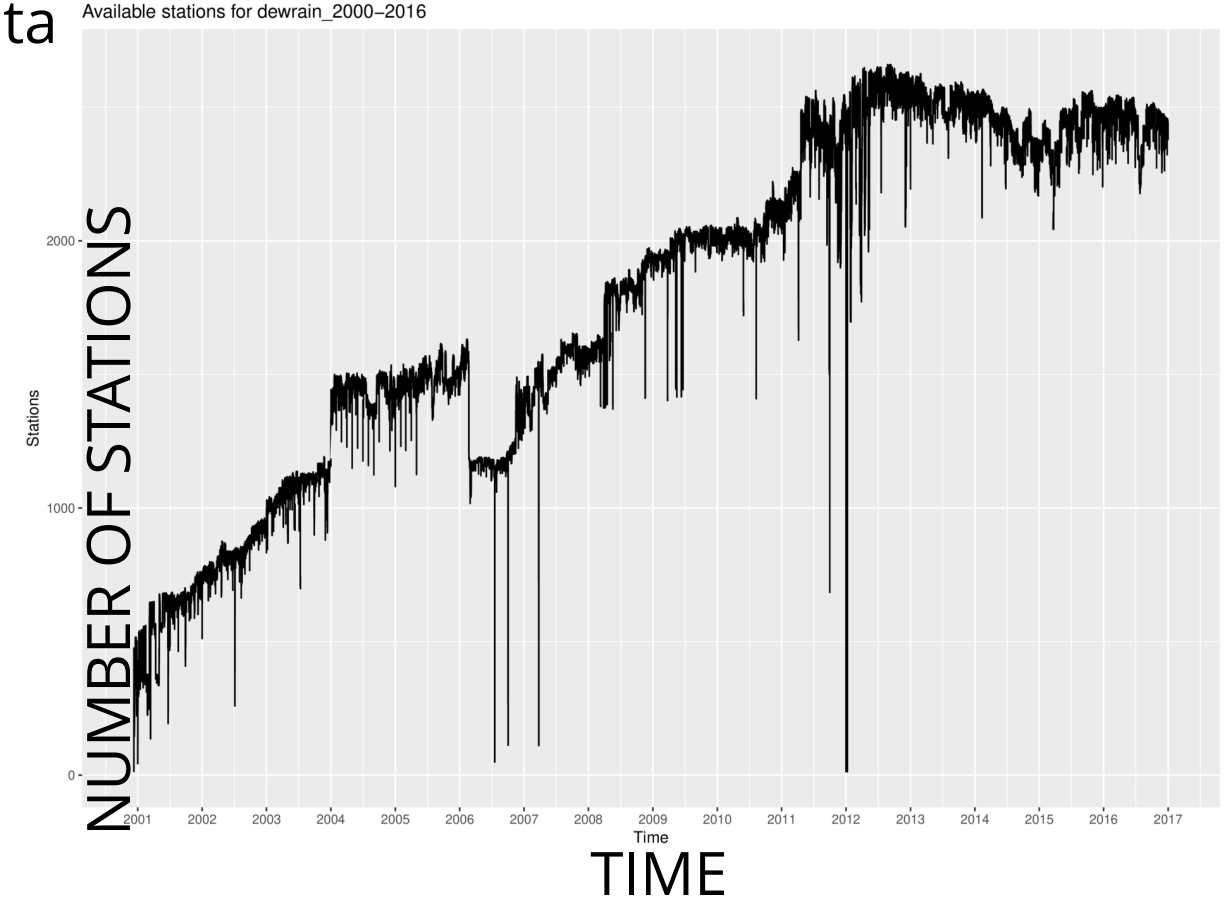
GRIPHO gridding procedure

- 12km Lambert Conformal Conic grid
- Gridding method based on Delaunay polygons using SciPy's interpolate.griddata
- Simple, fast method which minimizes smoothing
- Similar to Norway's KLIMAGRID dataset (Mohr, 2008, 2009)
- NetCDF CF-compliant output format

Mohr M., 2008: New Routines for Gridding of Temperature and Precipitation Observations for seNorge.no
Mohr M., 2009: Comparison of versions 1.1 and 1.0 of gridded temperature and precipitation data for Norway
Velasquez N. et al., 2011: Rainfall distribution based on a Delaunay triangulation method

GRIPHO data issues

- Varying station availability and density across the domain
- Inconsistencies, outliers and data errors
- Only ~15 years or data



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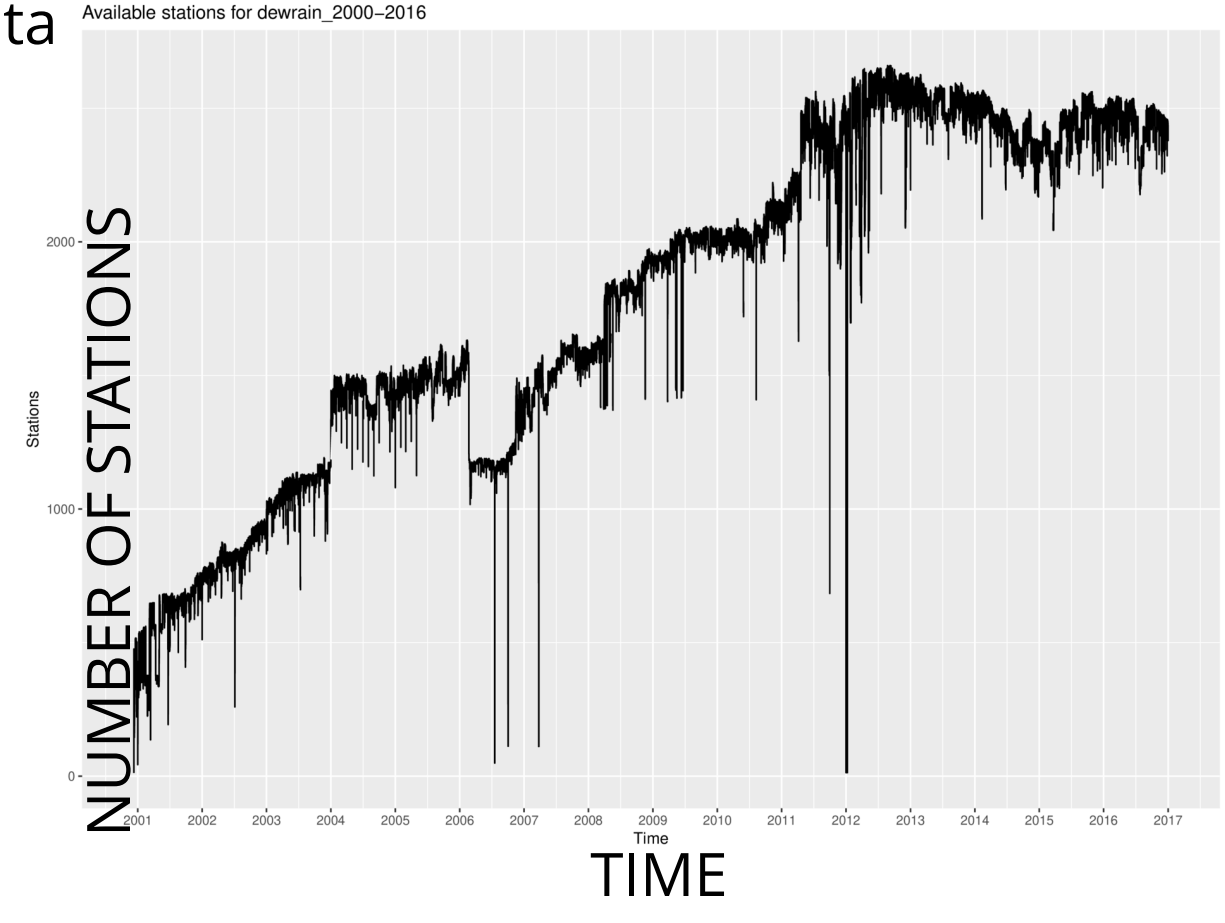


Strong points:

- High station density (~1 station/100km²)
- High temporal resolution (1 hour)
- Only high resolution station-based dataset covering all Italy

GRIPHO cleaning procedure

FIRST-STAGE FILTERING

↓

FLAGGING

↓

FLAG CHECKING

↓

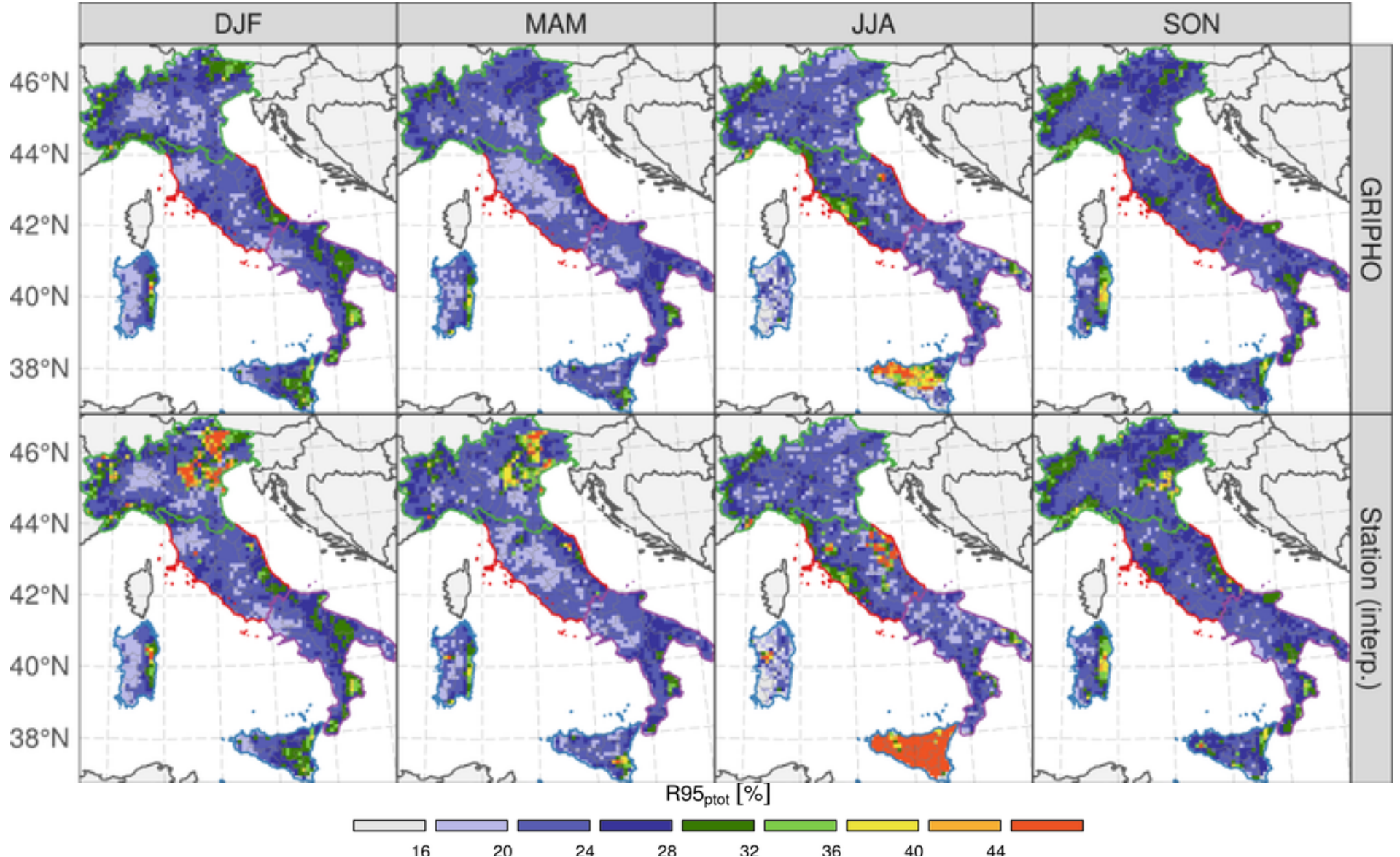
MANUAL DATA CLEANING

↓

CLEANED DATASET!

The effect of data cleaning

R95ptot = % of PR above 95th percentile



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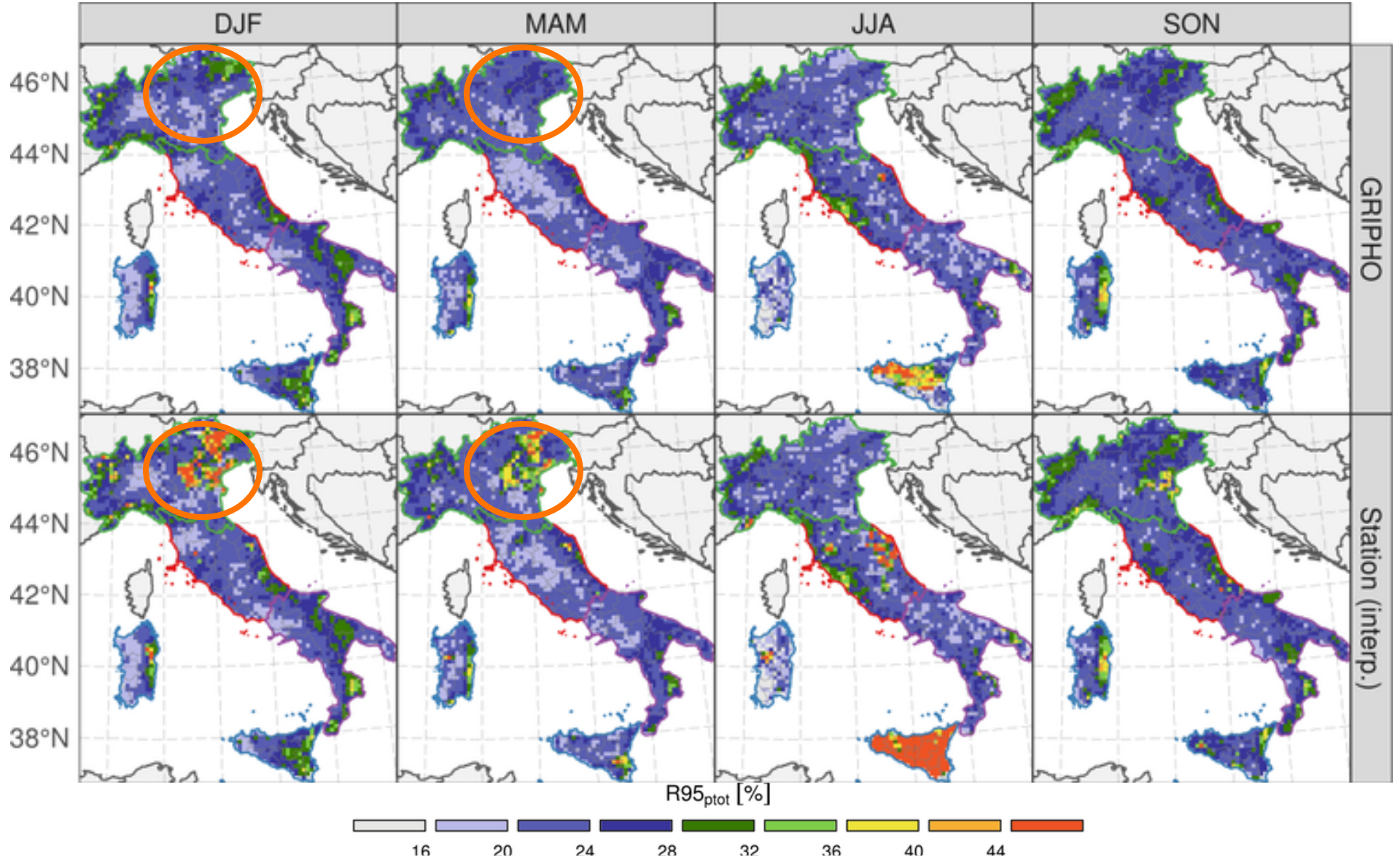

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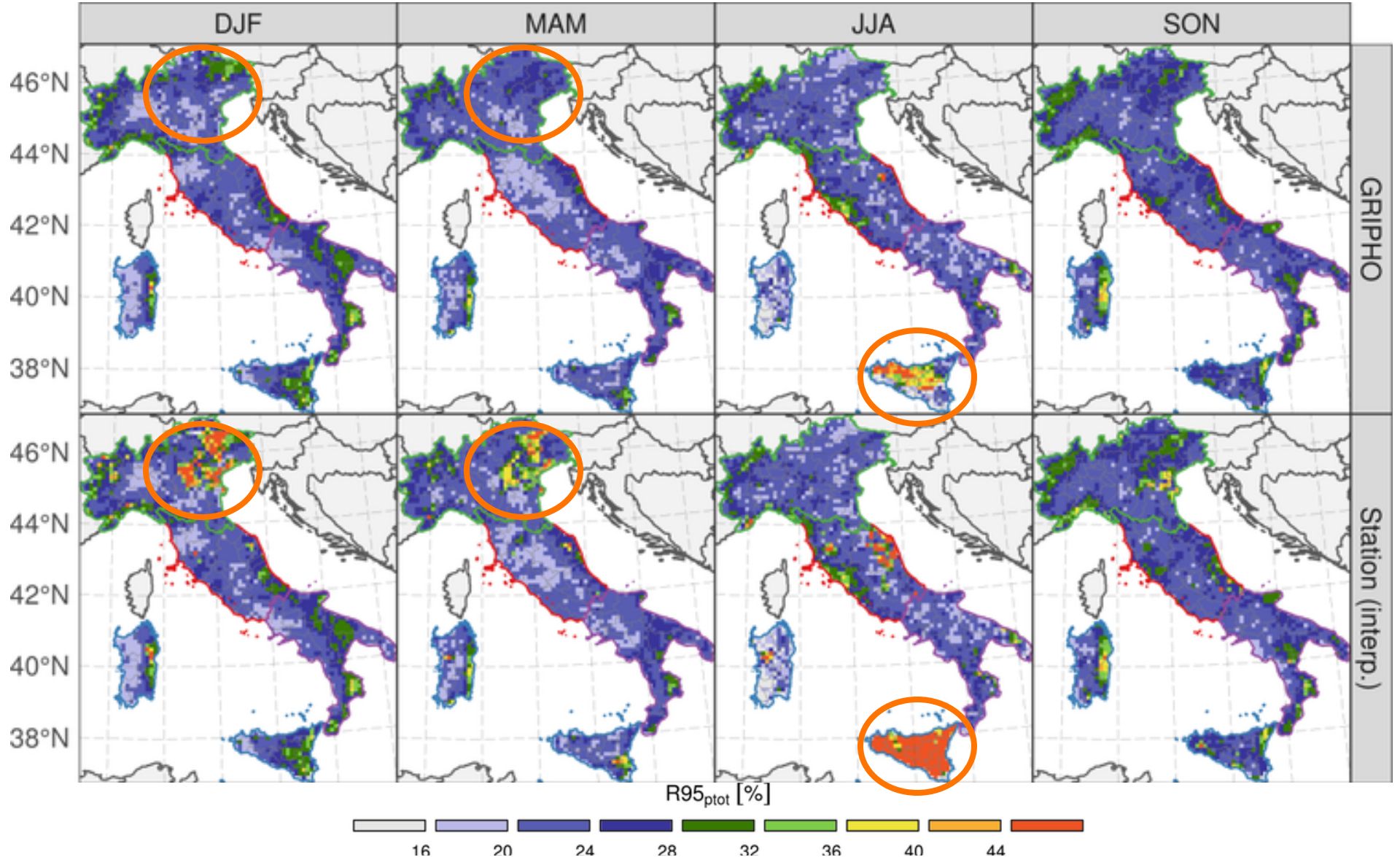

GRIPHO validaiton

Comparison with:

- **E-OBS** (stations, **25km** - new version is 10km)
- **HMR** (stations + reanalysis, **~5km**)
- **ARCIS** (stations, **~5km**, *only Northern Italy*)
- **EURO4M-APGD** (stations, **5km**, *only Northern Italy*)

Metrics:

- Mean seasonal
- Extremes (R95ptot, R99ptot)
- Annual cycles
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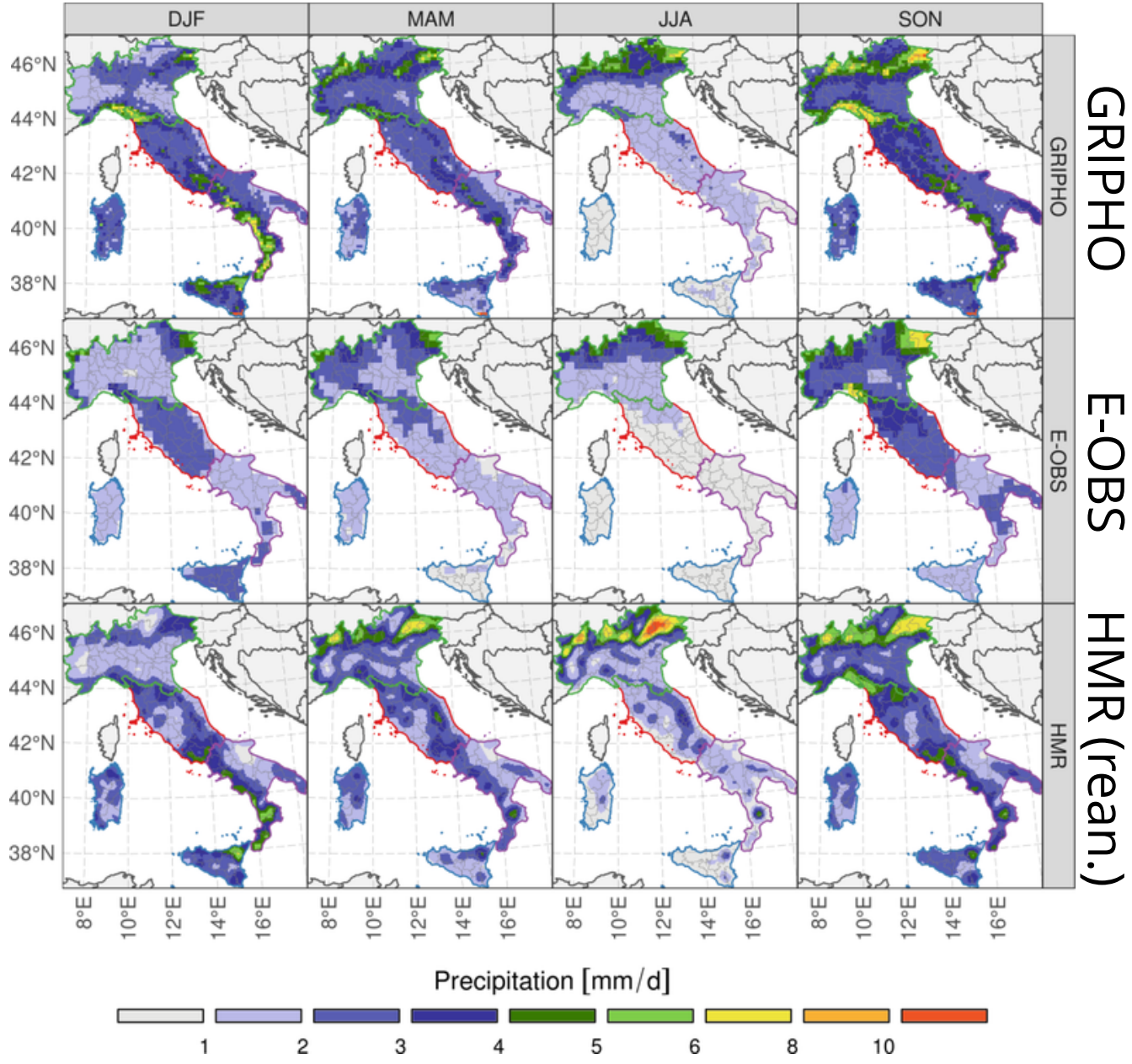

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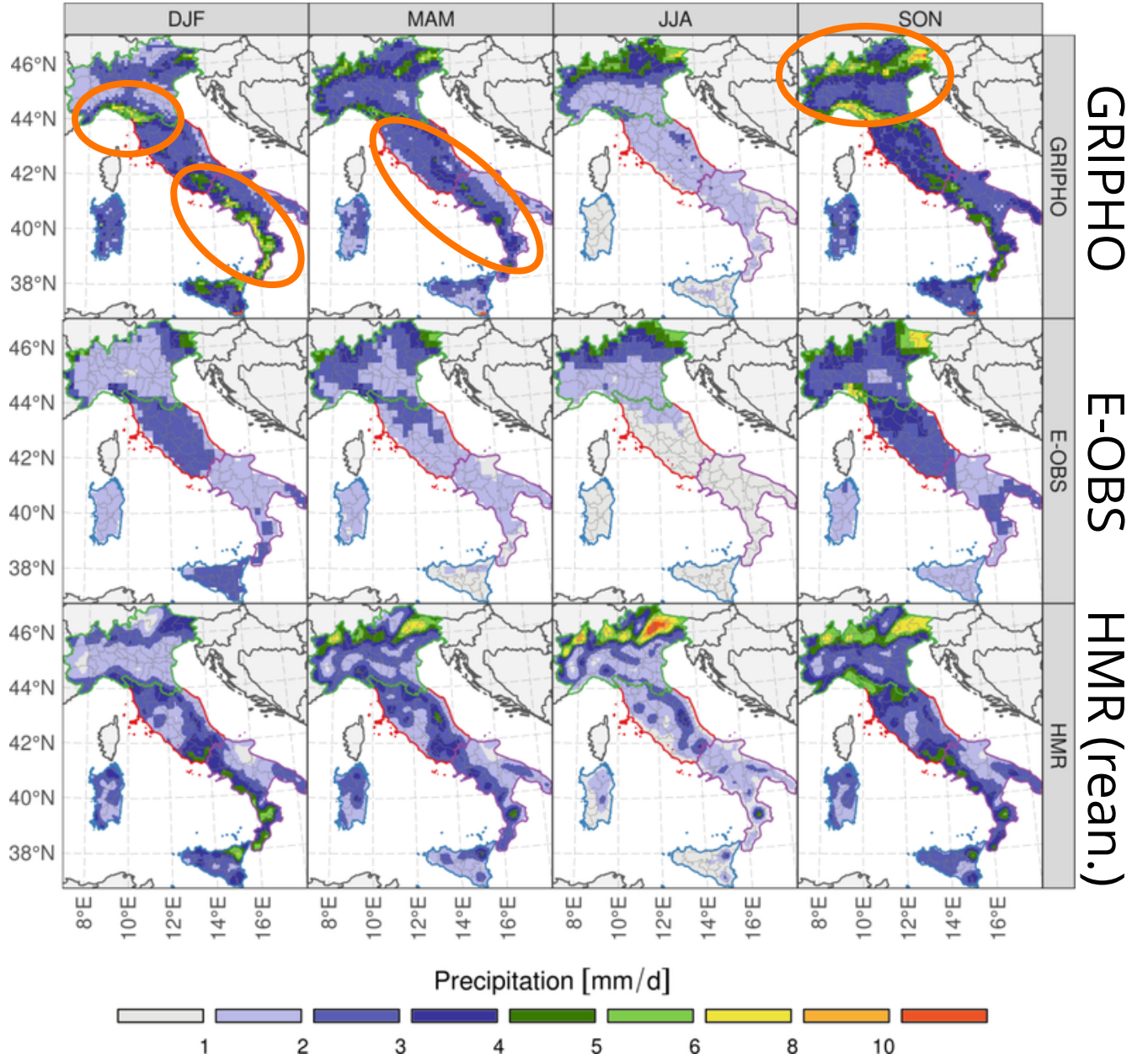
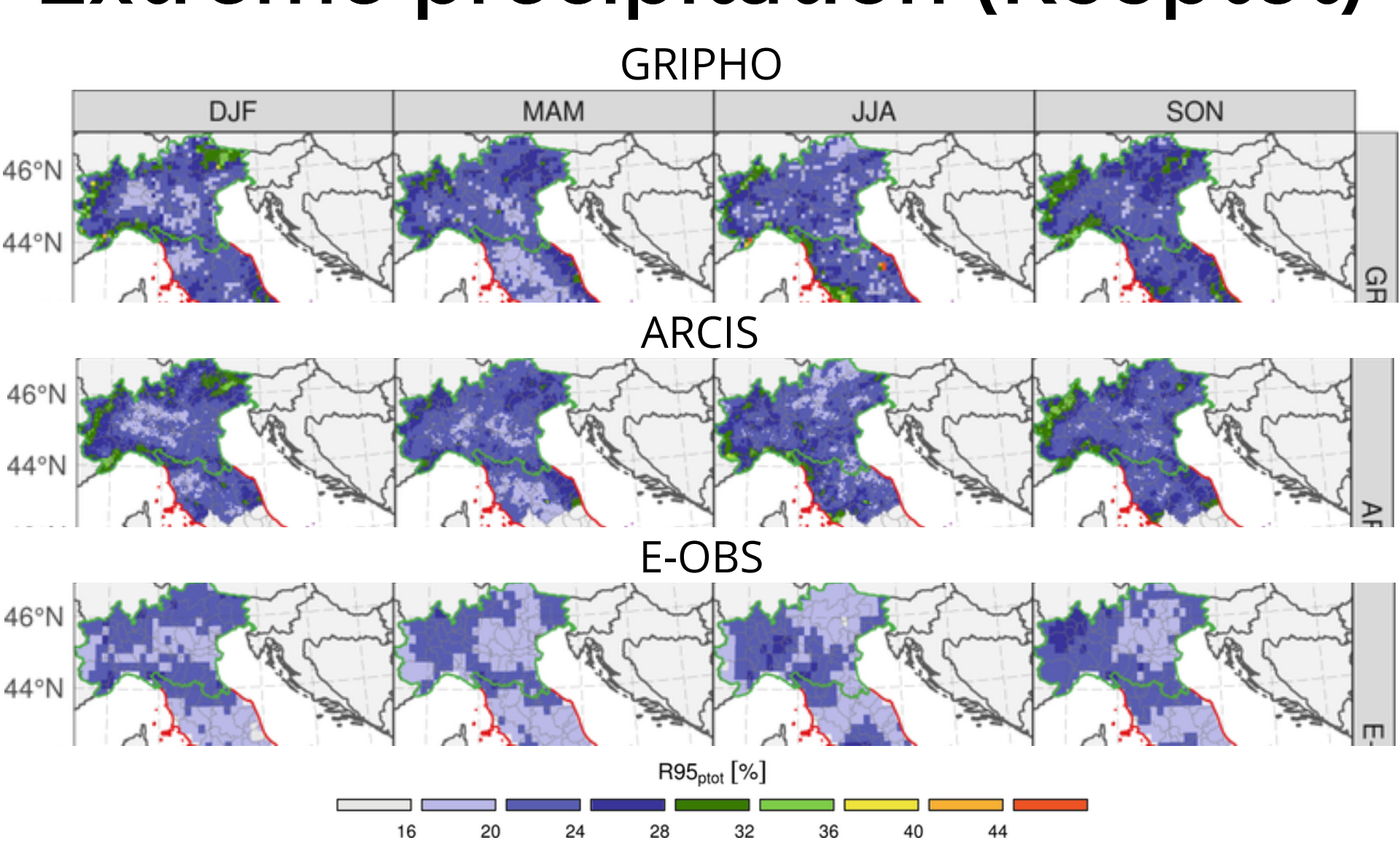
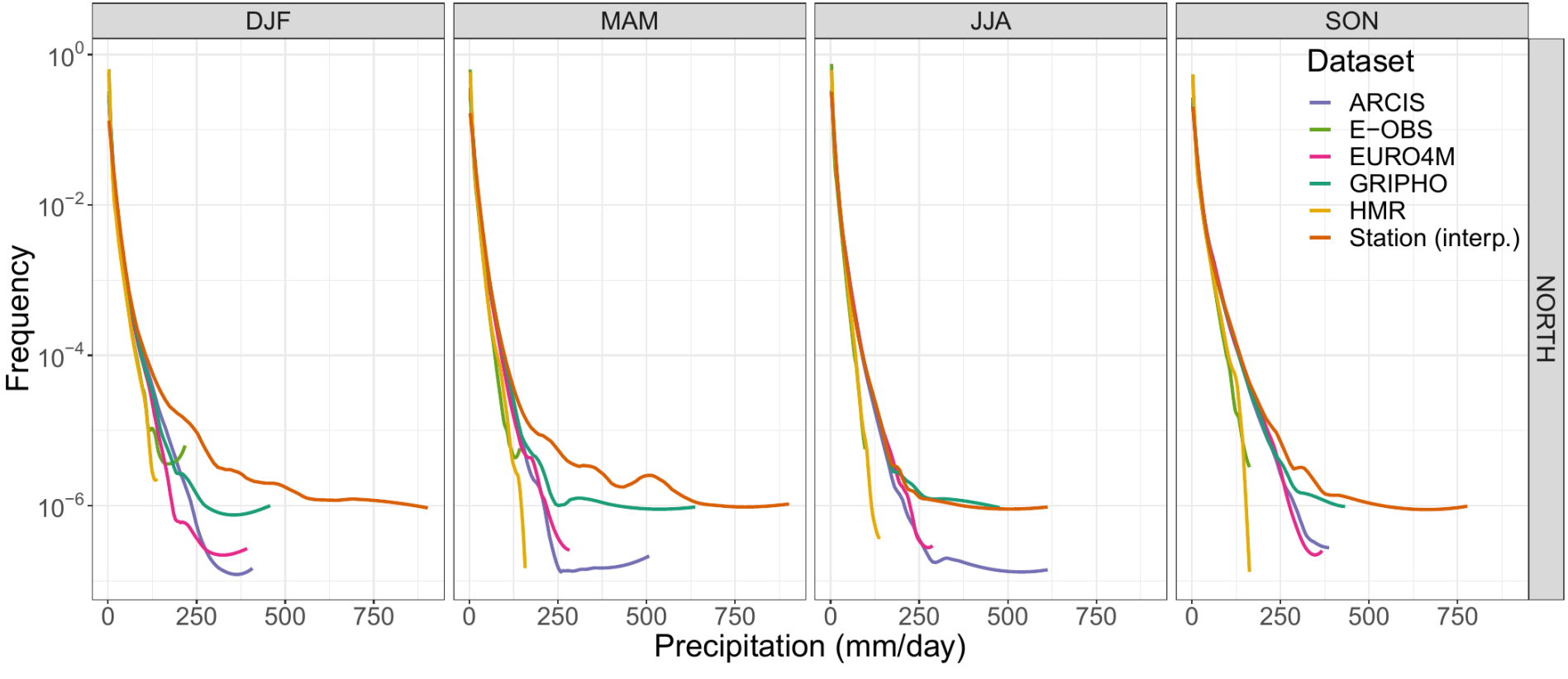


Extreme precipitation (R95ptot)



Precipitation distribution (PDFs)



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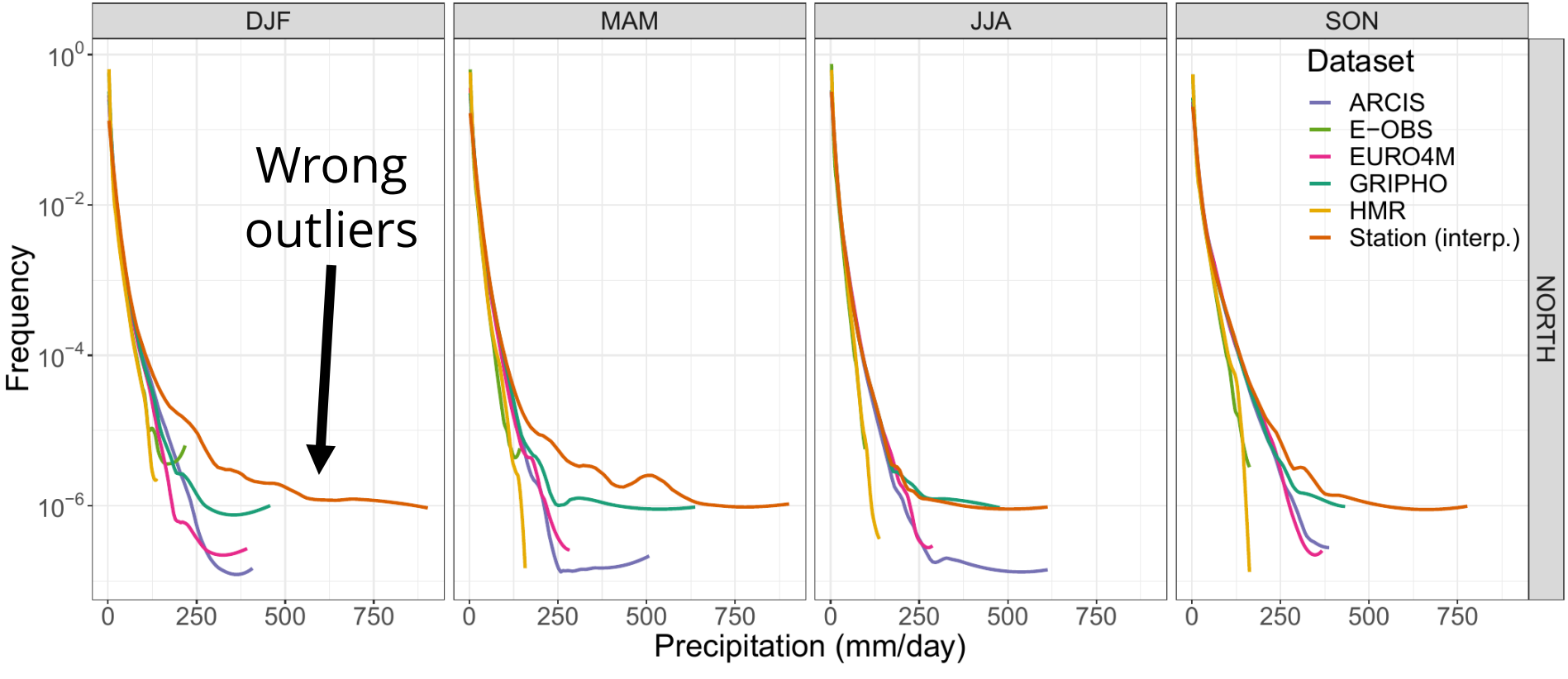

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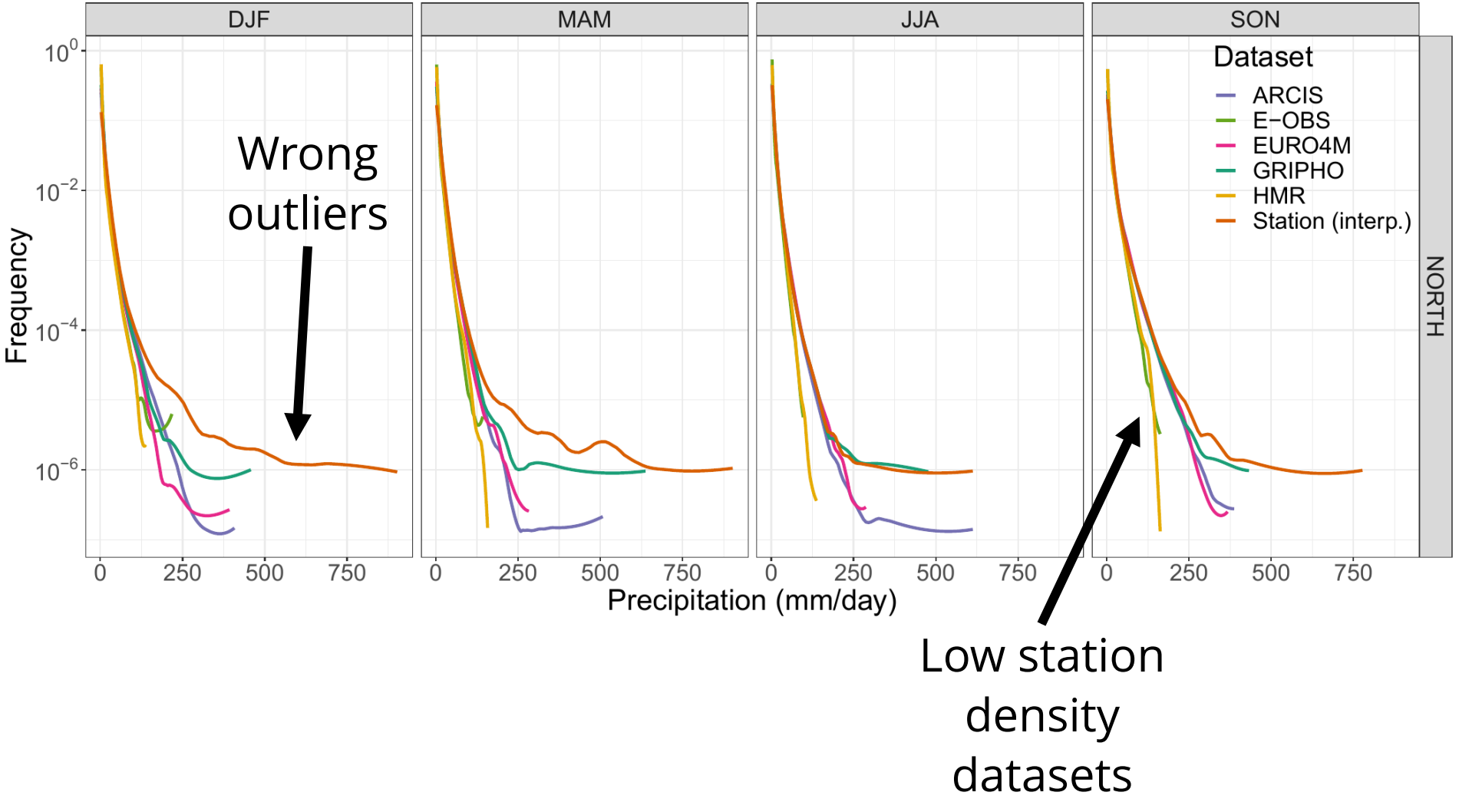

GRIPHO: conclusions

- Performance in the North similar to other high resolution datasets (EURO4M-APGD, ARCIS)
- Much finer details compared to HMR and E-OBS, especially for extremes
- Only station-based dataset over Italy providing hourly precipitation
- Suitable for comparing with the climate model and for driving the hydrological model!

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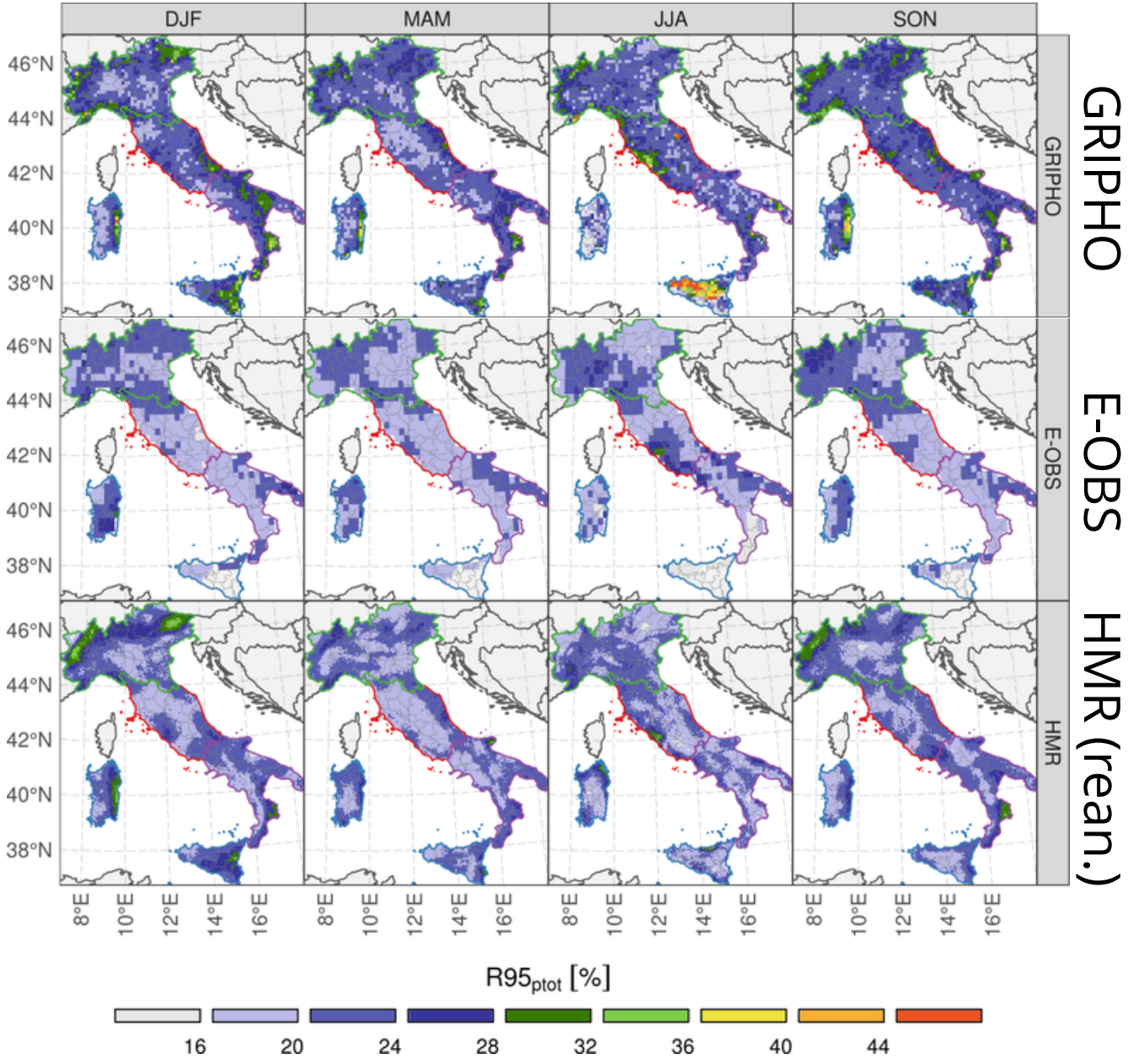
Fantini A., Coppola E., Verdecchia M. and Giuliani G.:

'**GRIPHO: a gridded high-resolution hourly precipitation dataset over Italy**', *in preparation*

Extreme precipitation (R95ptot)



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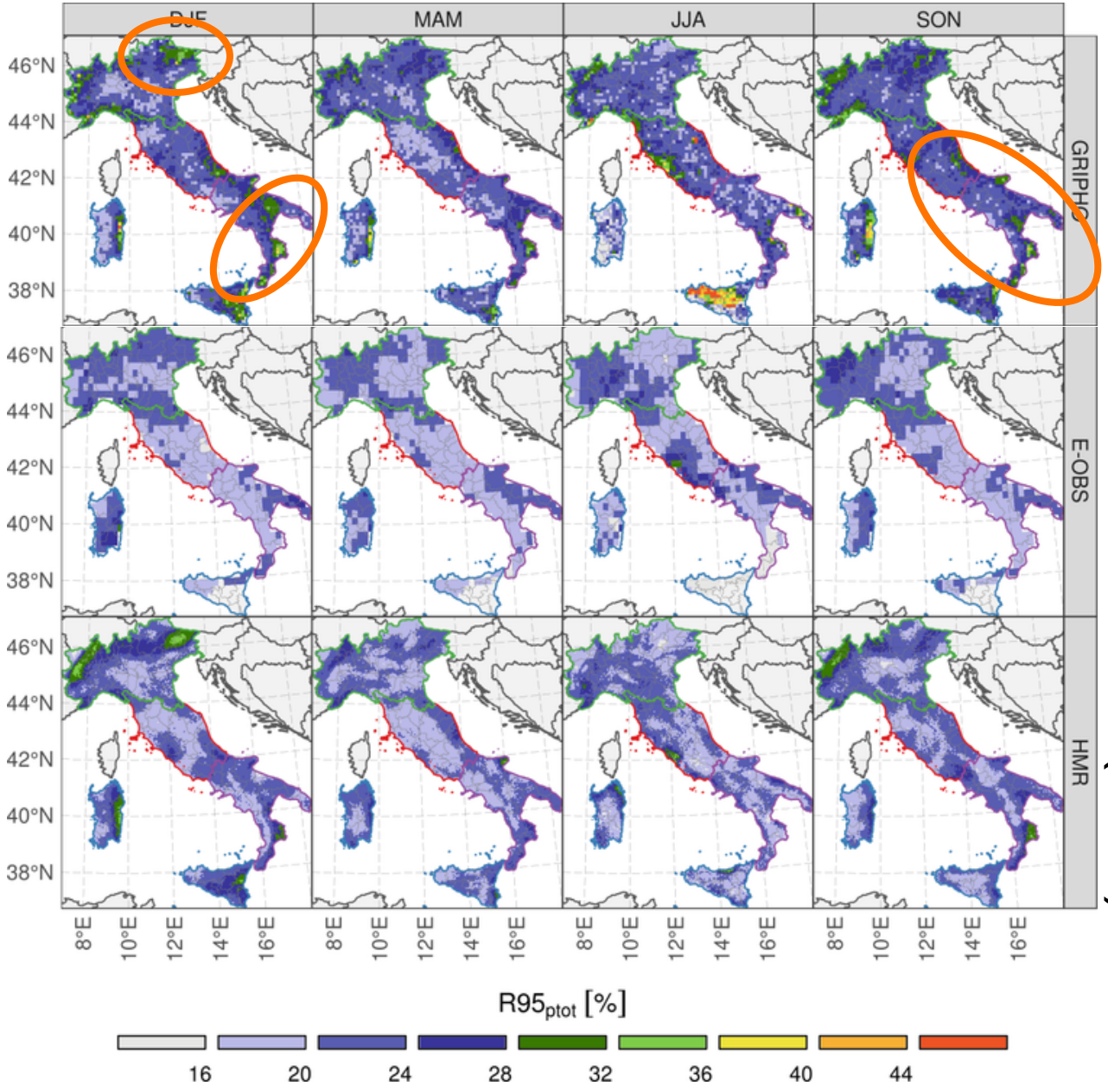
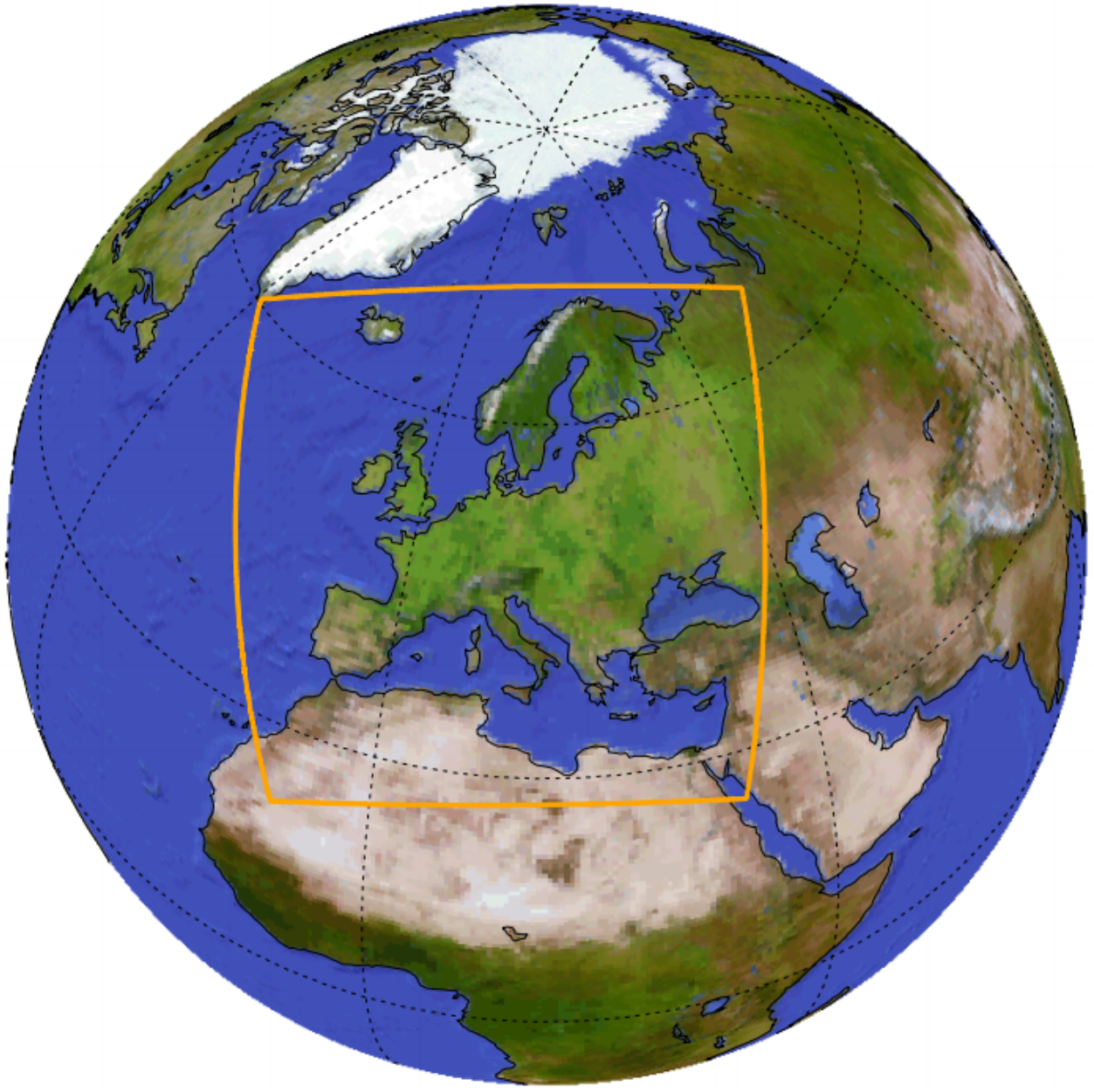


Two regional climate simulations



Two regional climate simulations

Two RegCM 4.6.1 12km EURO-CORDEX simulations run on ICTP's Argo and CINECA's Marconi clusters:

1. ERA-Interim driven 1979-2016 historical simulation
2. HadGEM driven 1971-2100 scenario simulation (RCP8.5)

Thanks to James Ciarlo` for running part of the HadGEM driven simulation!

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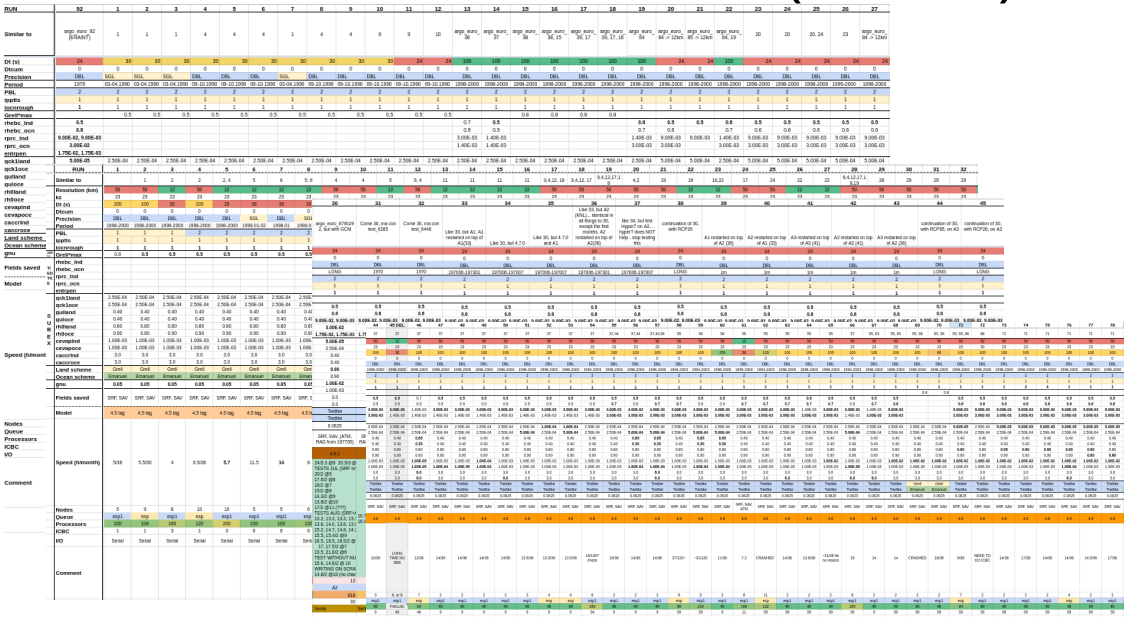
1. ERA-Interim driven 1979-2016 historical simulation
2. HadGEM driven 1971-2100 scenario simulation (RCP8.5)

- 135 3-year tuning experiments
- 6000 runtime hours
- 3 million core-hours
- >100TB disk usage



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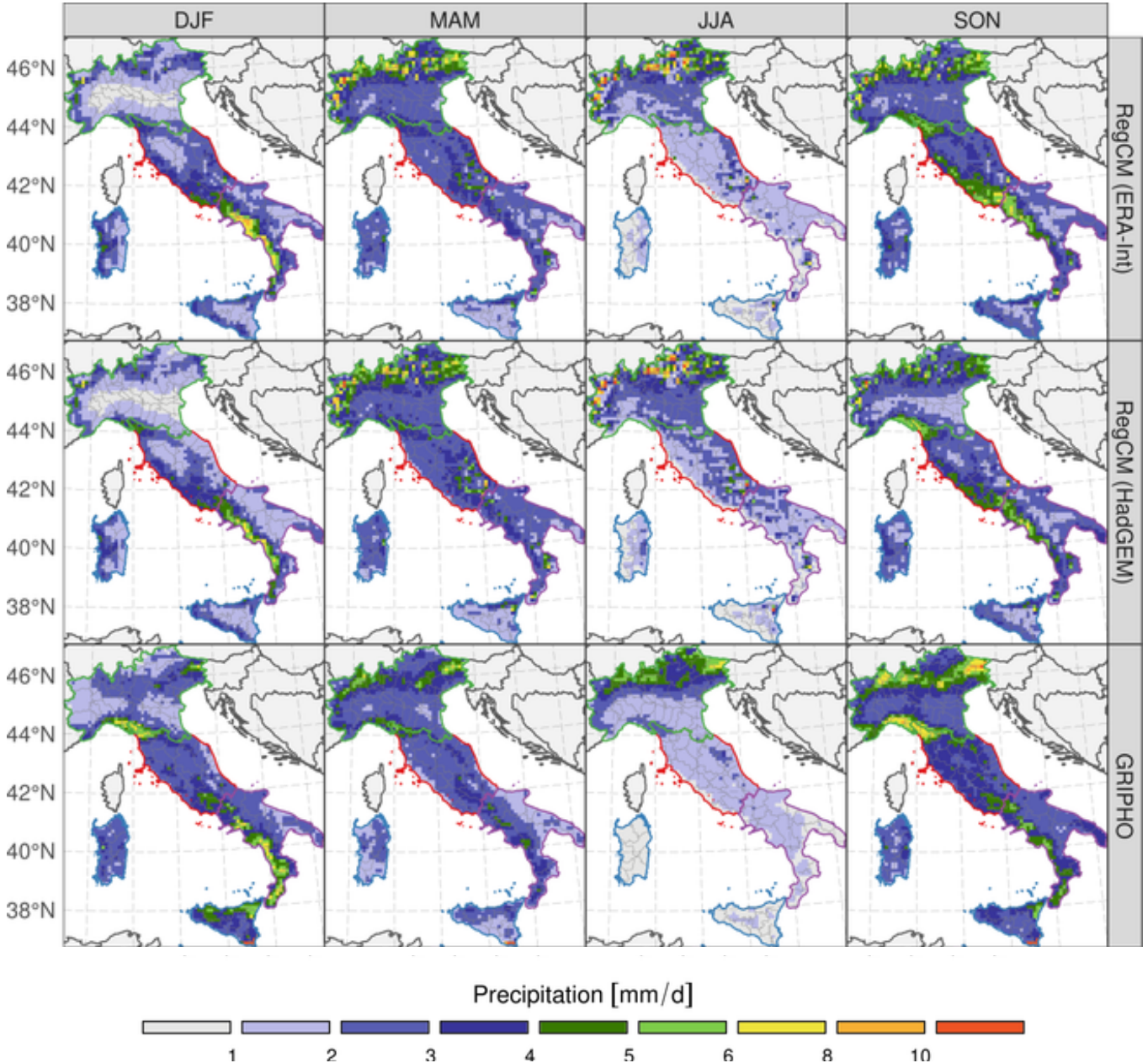
Does the model perform well?

Validation for precipitation + temperature:

- Mean seasonal
- Extremes (R95ptot, R99ptot)
- Annual cycles
- Probability Density Functions

Validation: mean precipitation



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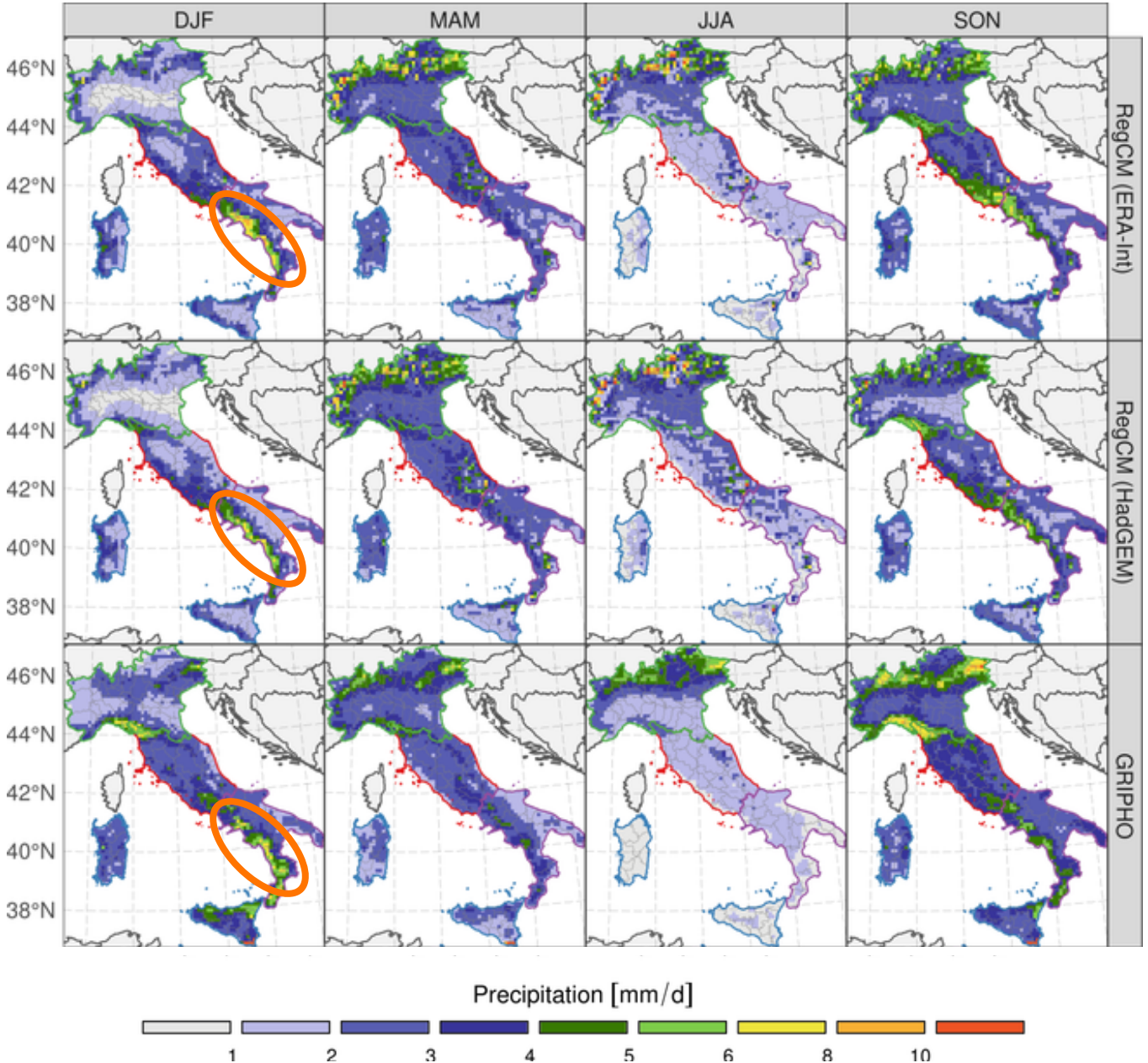

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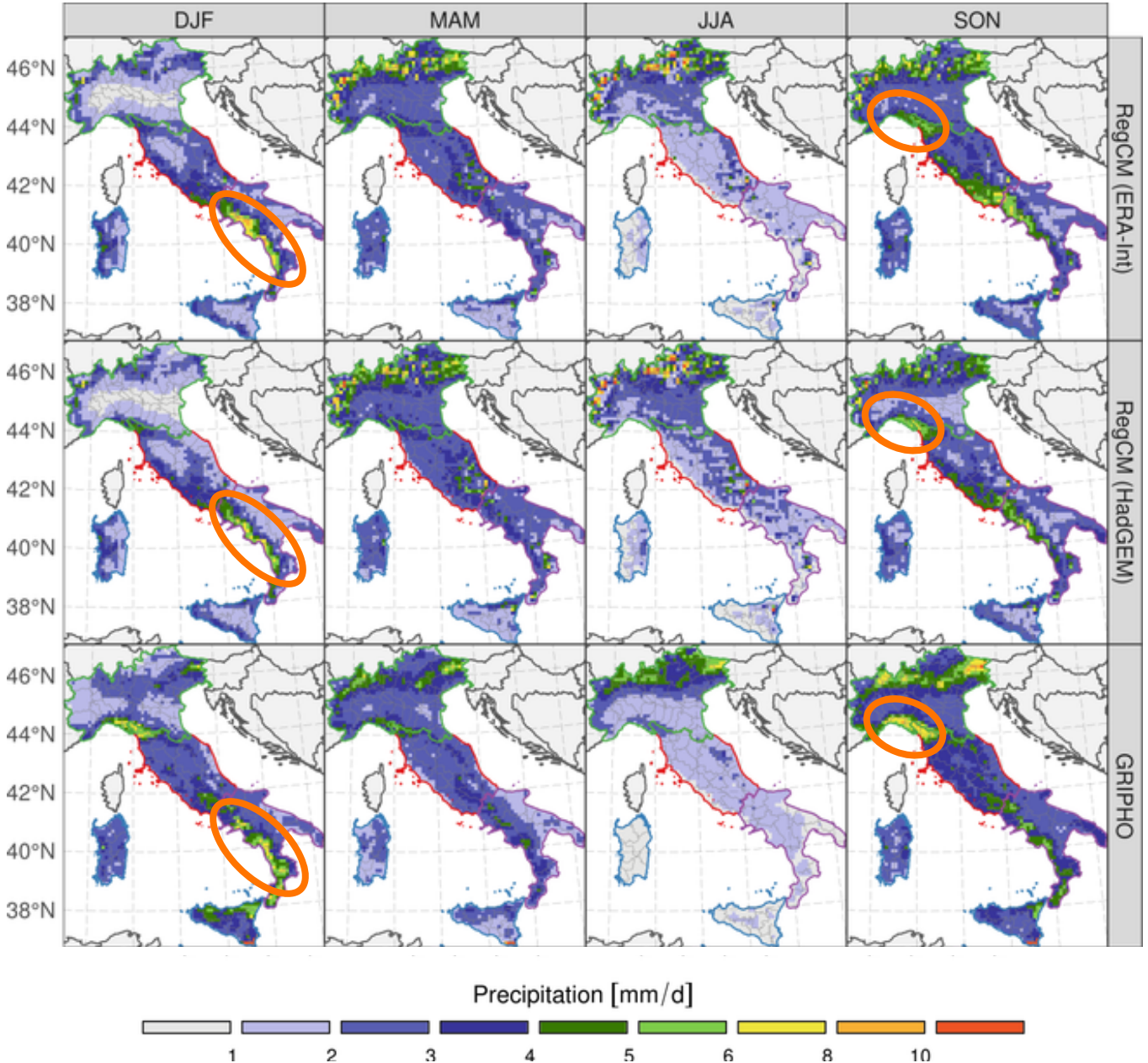

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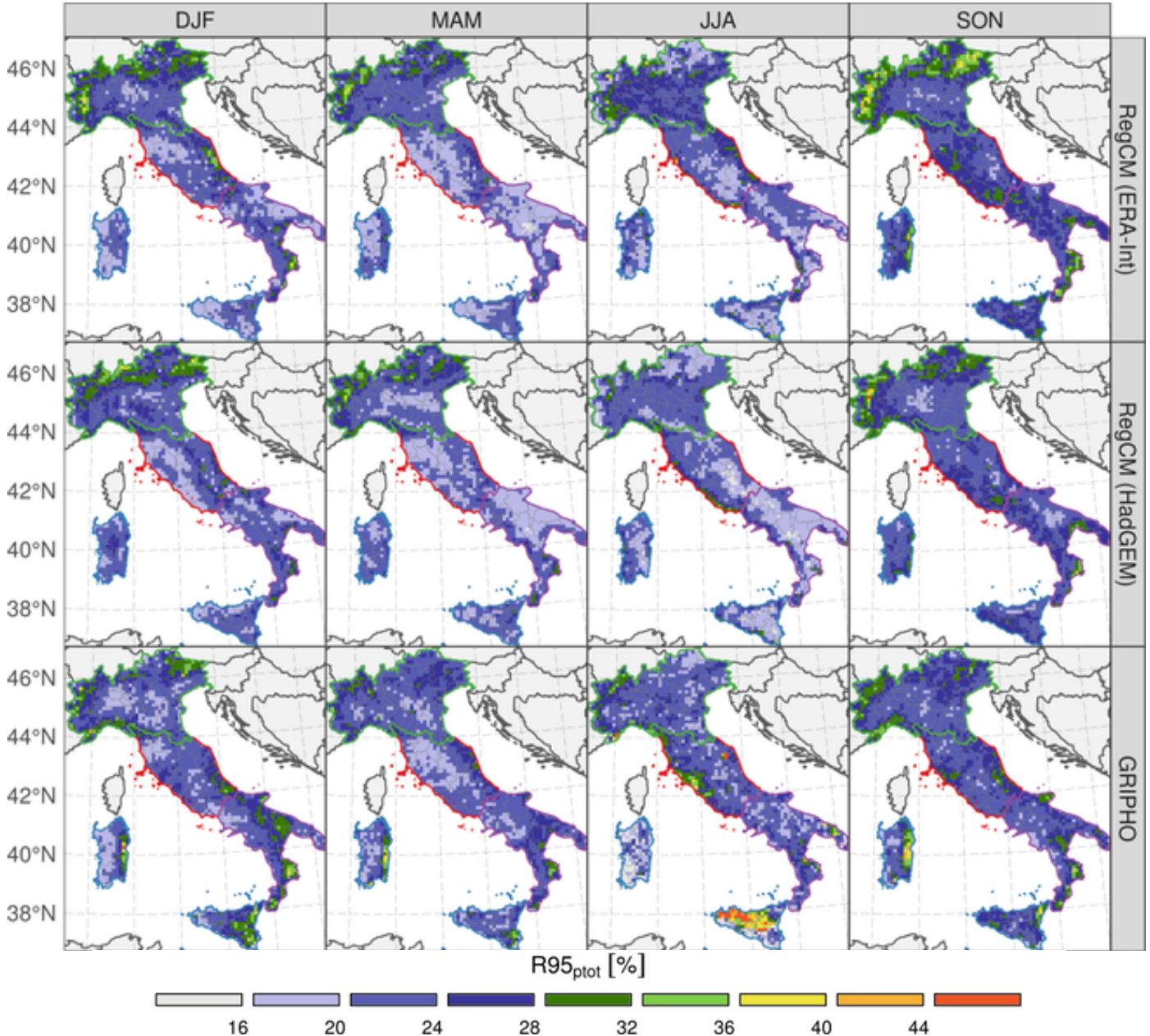

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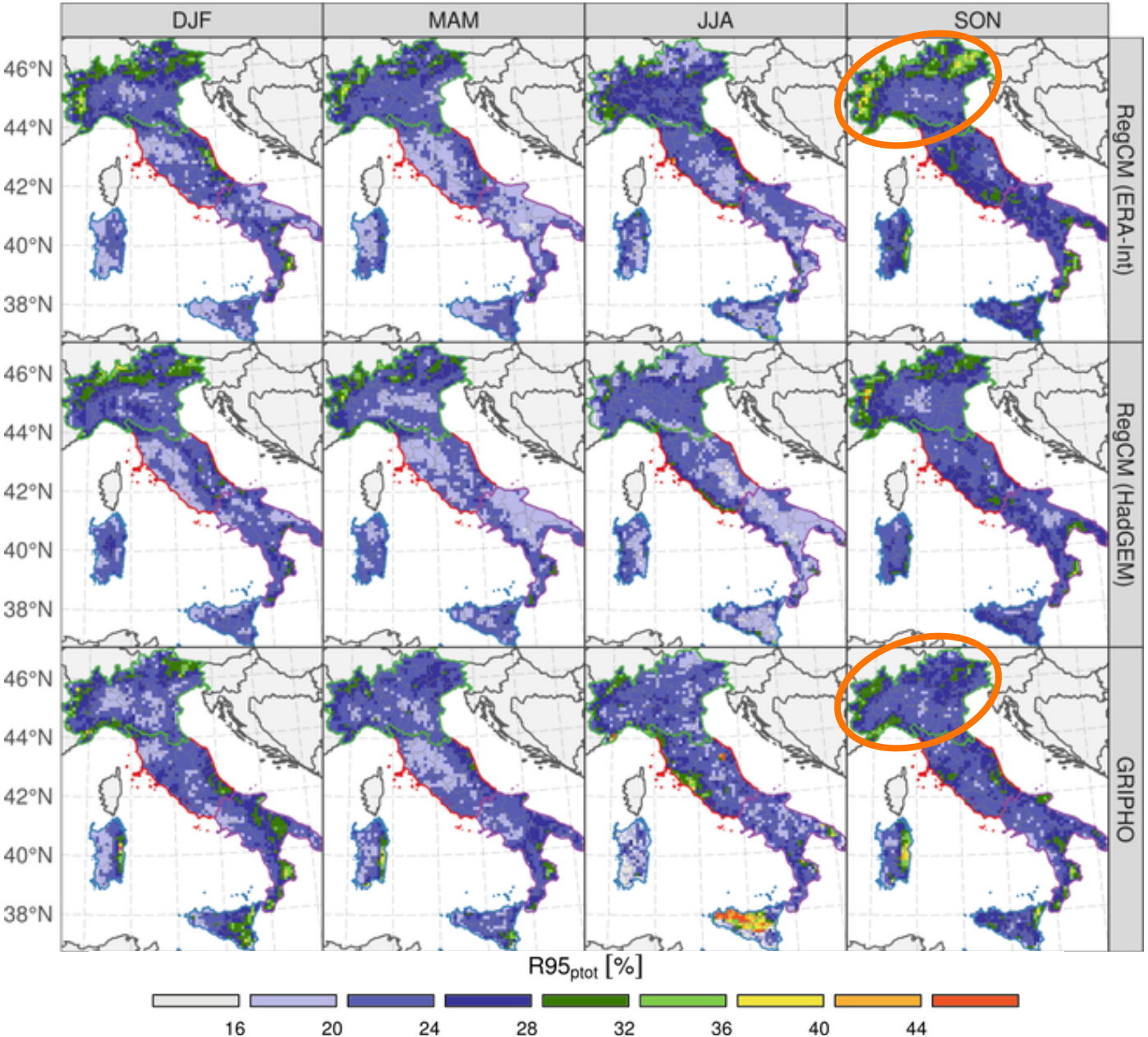
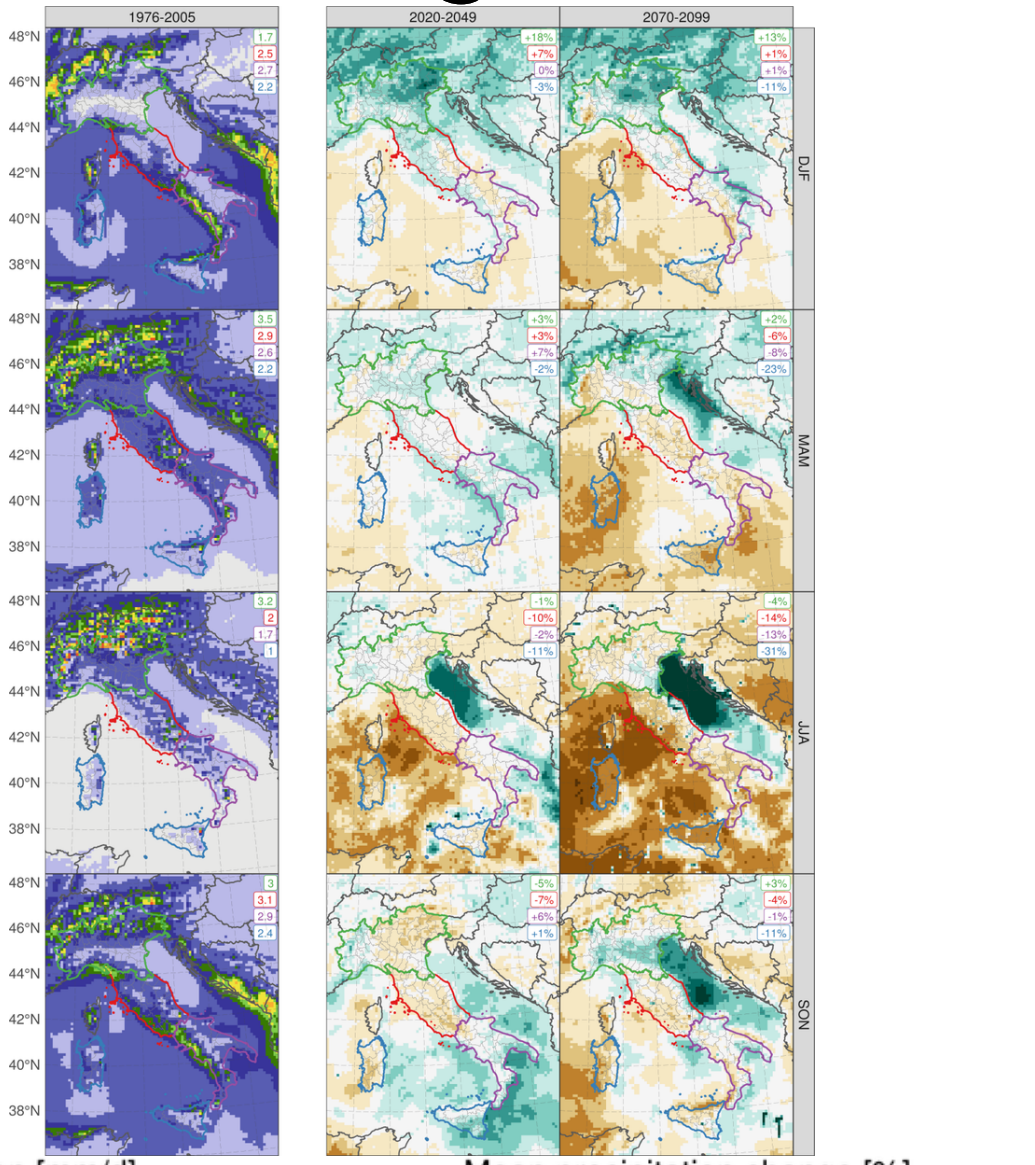


Climate change: mean PR



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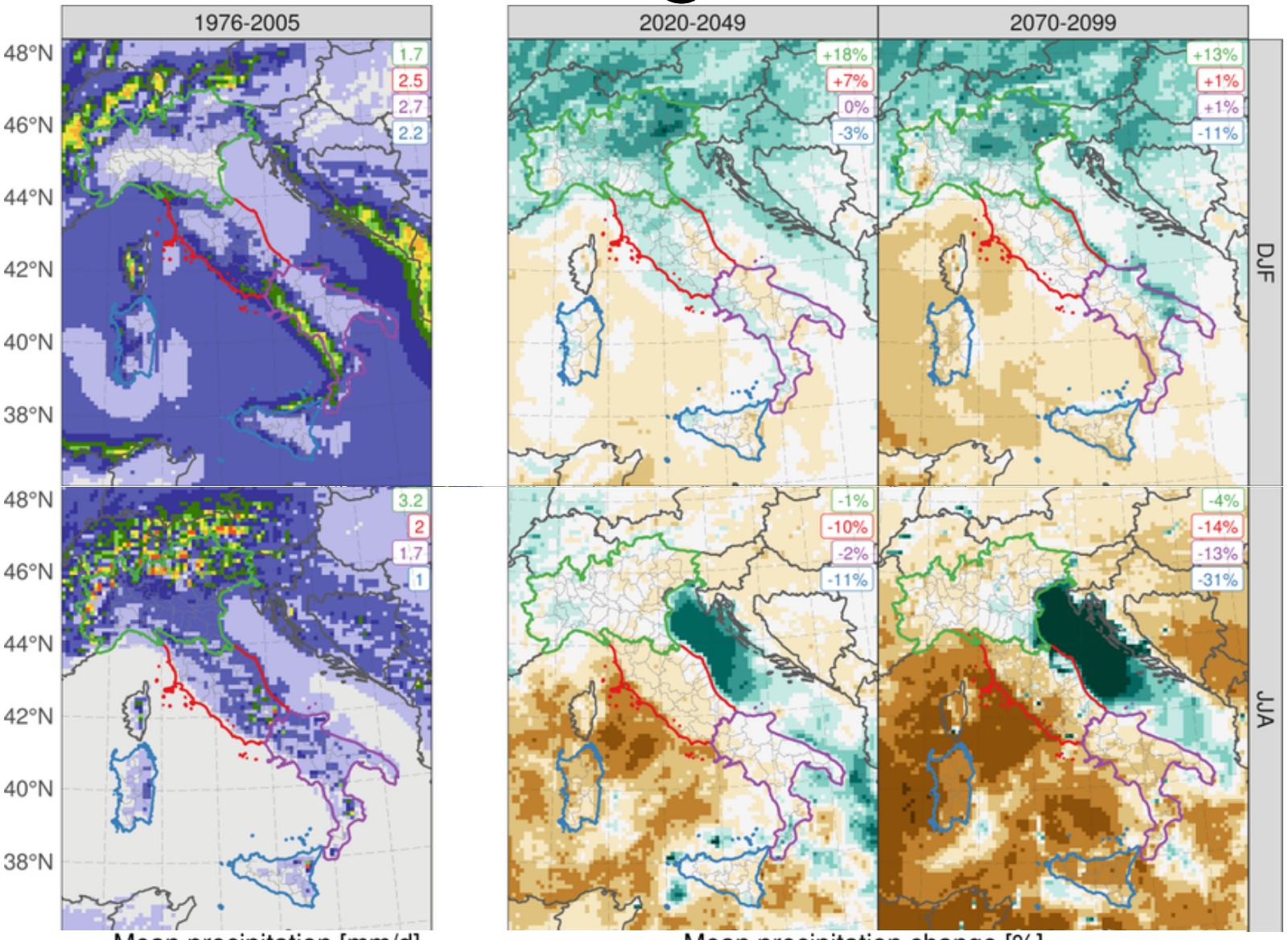

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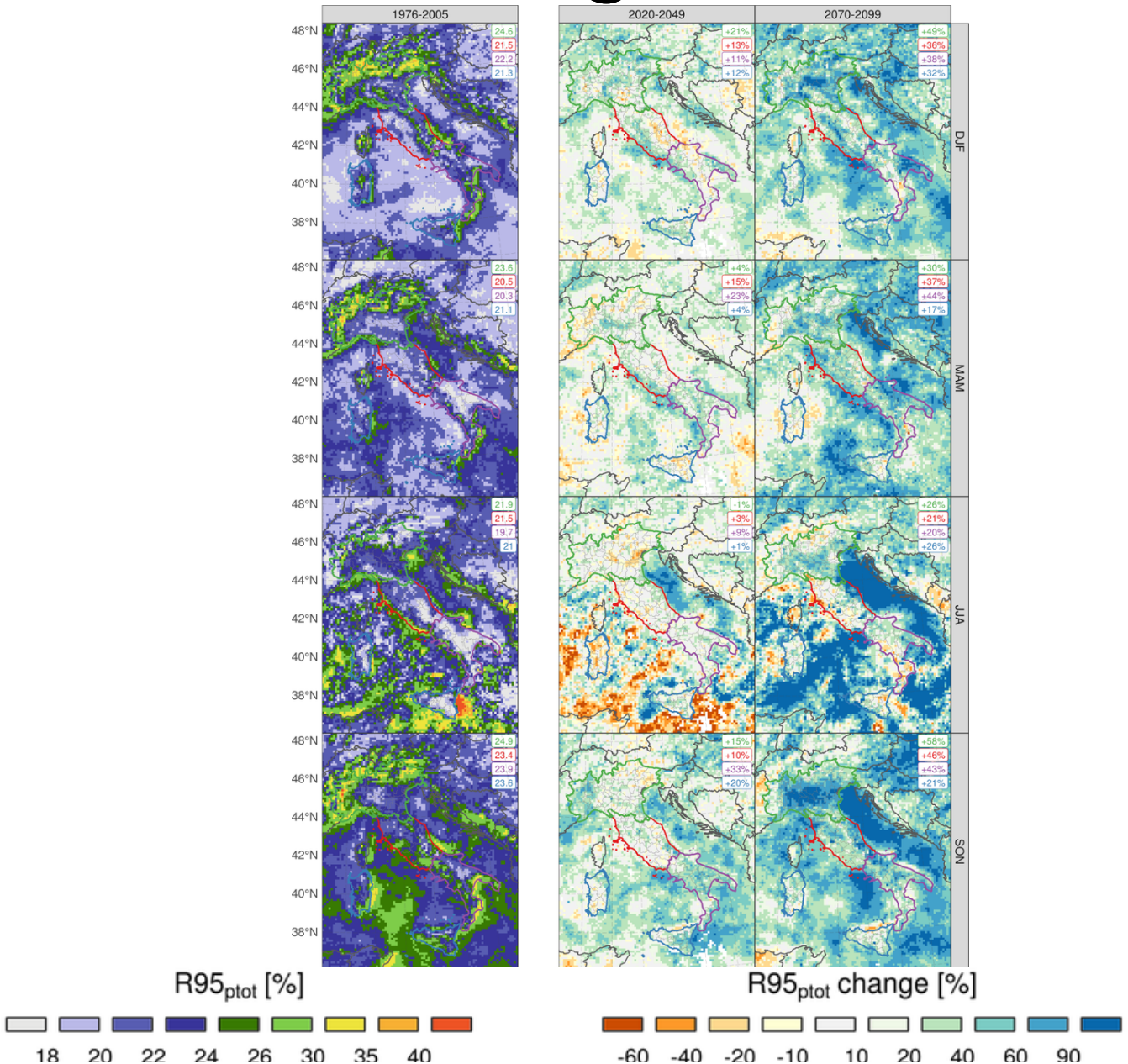

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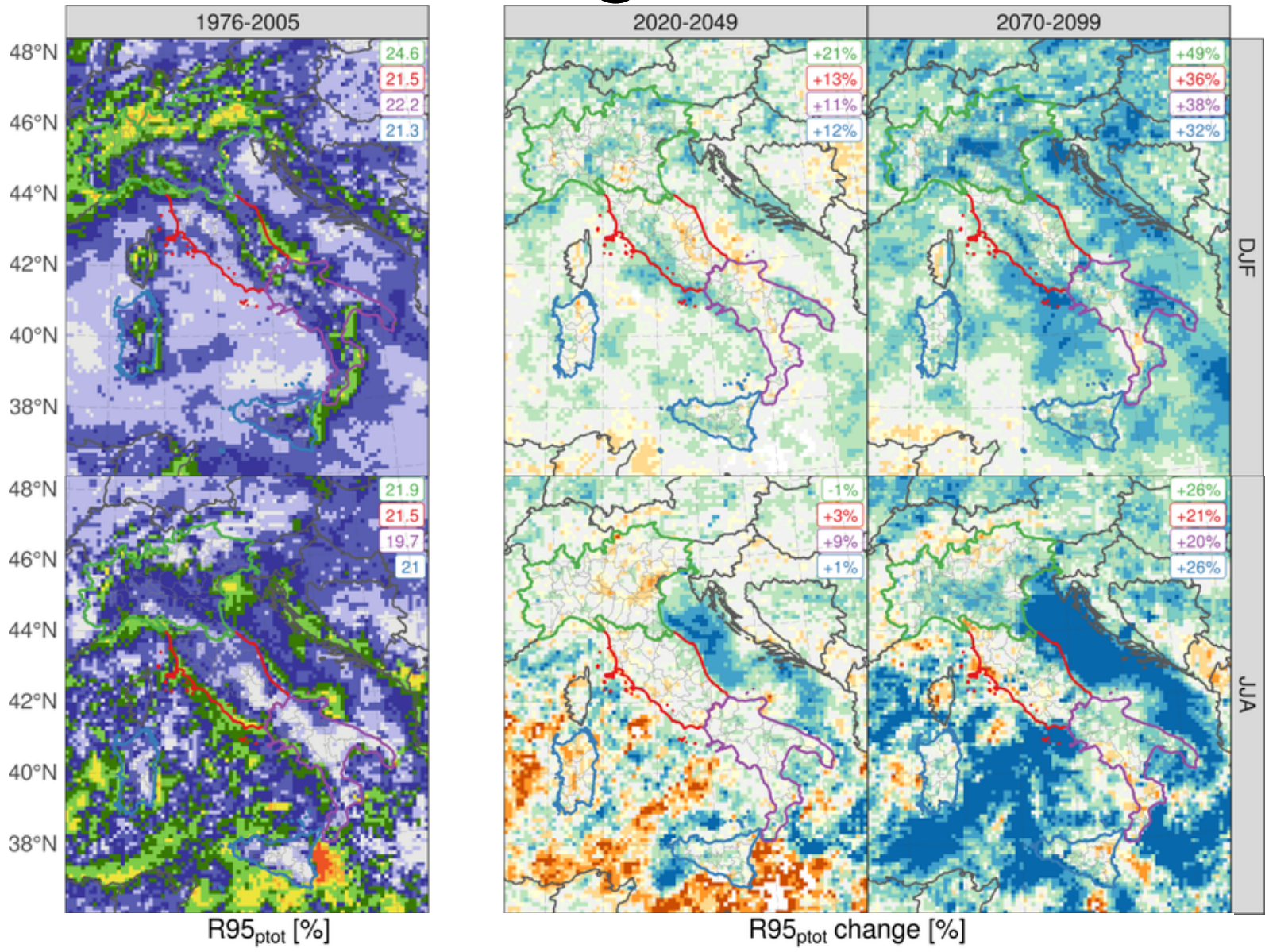
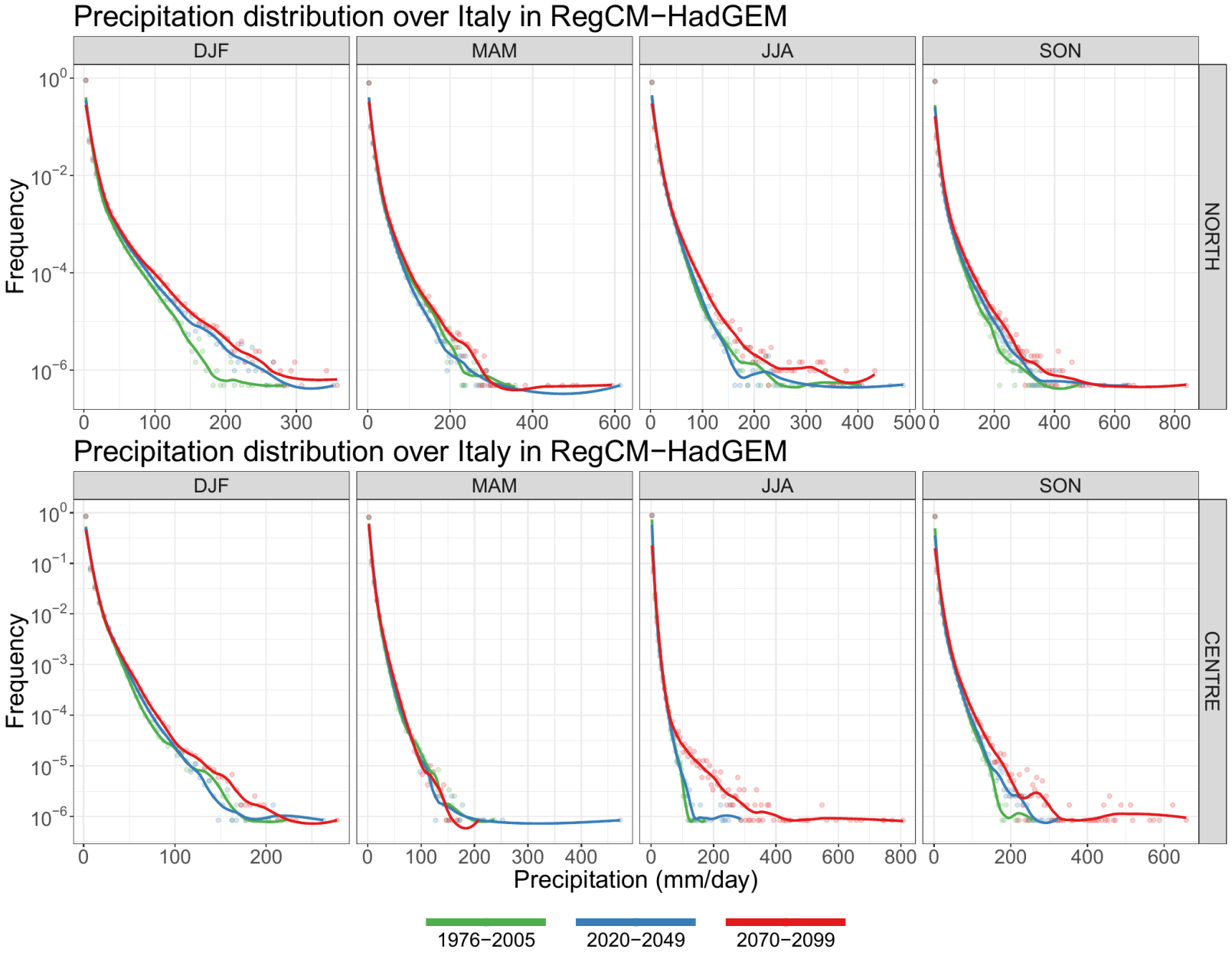
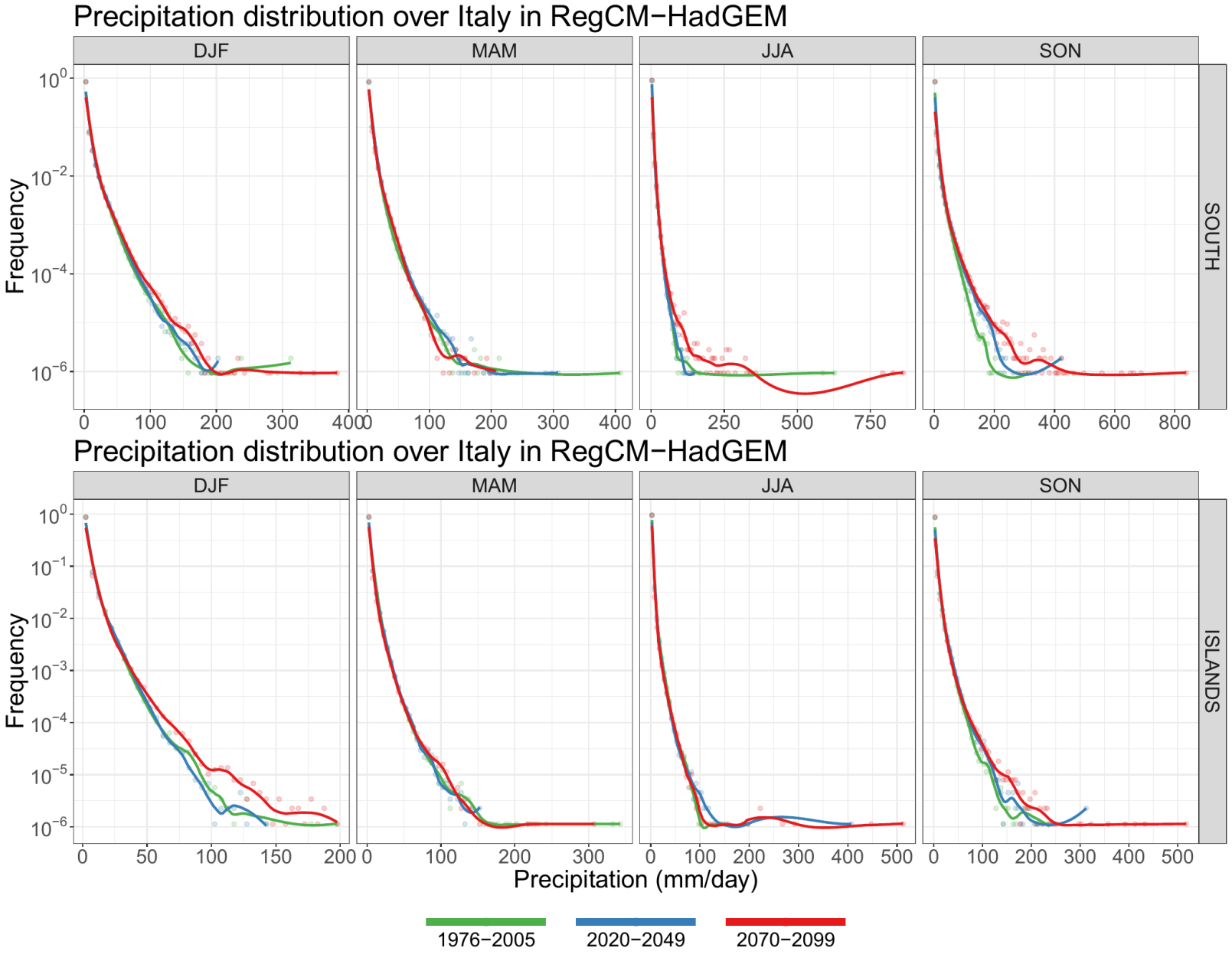


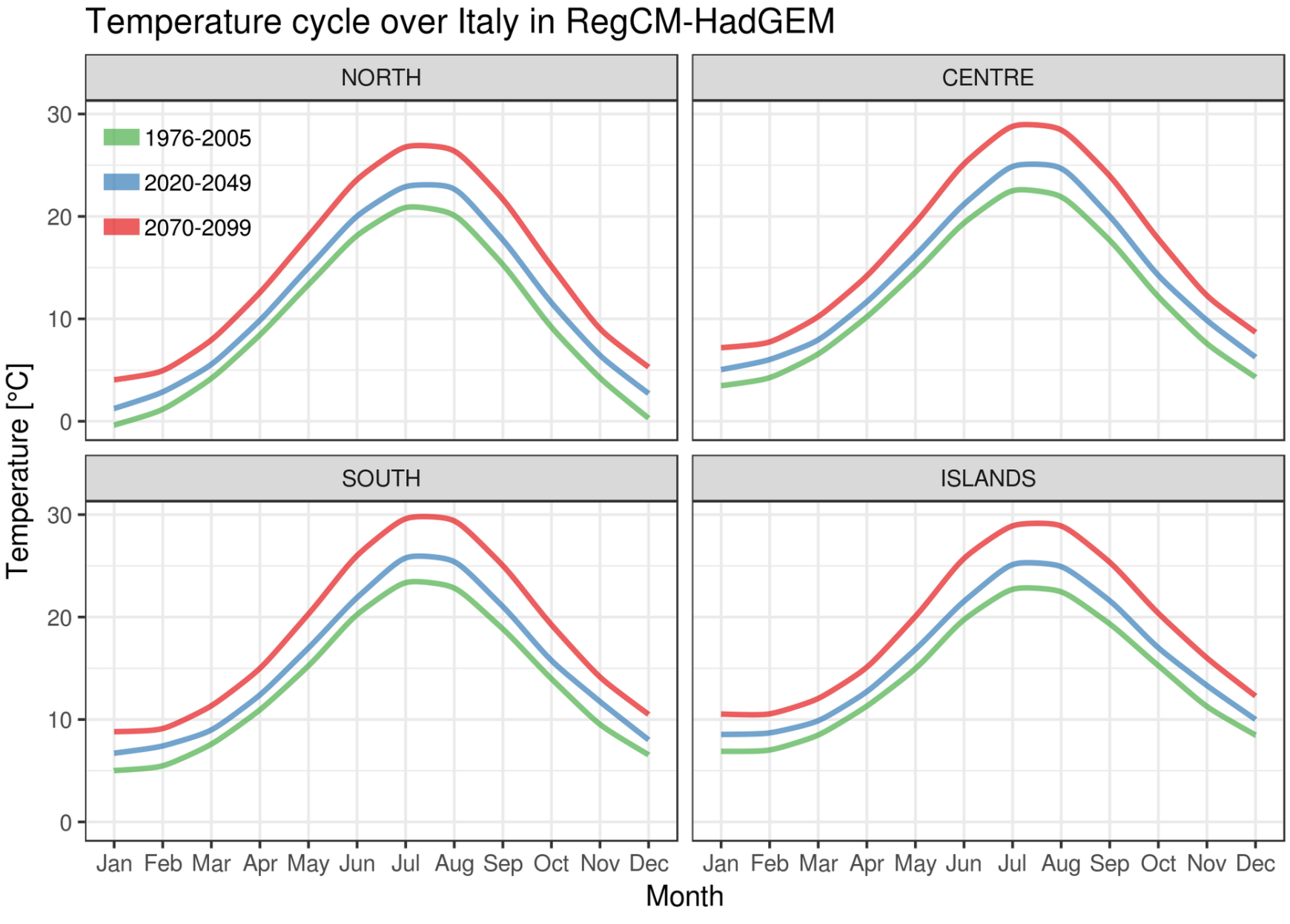
Climate change: PDFs (1)



Climate change: PDFs (2)



Climate change: temperature



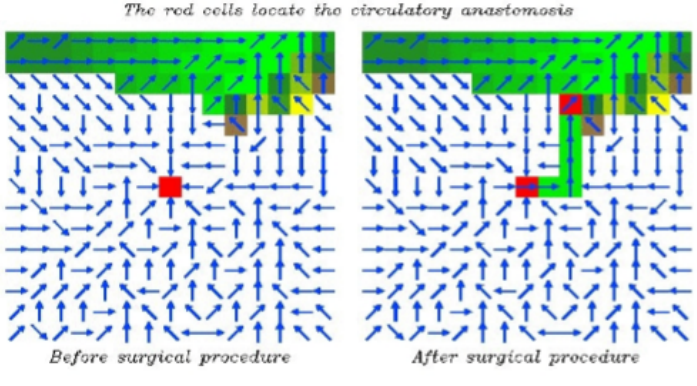
Climate simulation: remarks

- Model precipitation and temperature generally in line with observations
- Increased projected average precipitation by the end of the century in winter in the north; decrease in the south and isles in summer ➡ dipole
- Precipitation extremes projected to strongly increase
- The most extreme events increase more
- In line with the results from other models

Cetemps Hydrological Model

CHyM is a distributed (gridded) hydrological model.
Peculiarities:

- Can build DEM from various sources, smoothing by cellula automata algorithms
- Can use several kind of inputs, such as station observations, gridded model data, etc.
- Designed to work on any domain
- Used daily at CETEMPS for operational forecasts
- Hourly NetCDF output

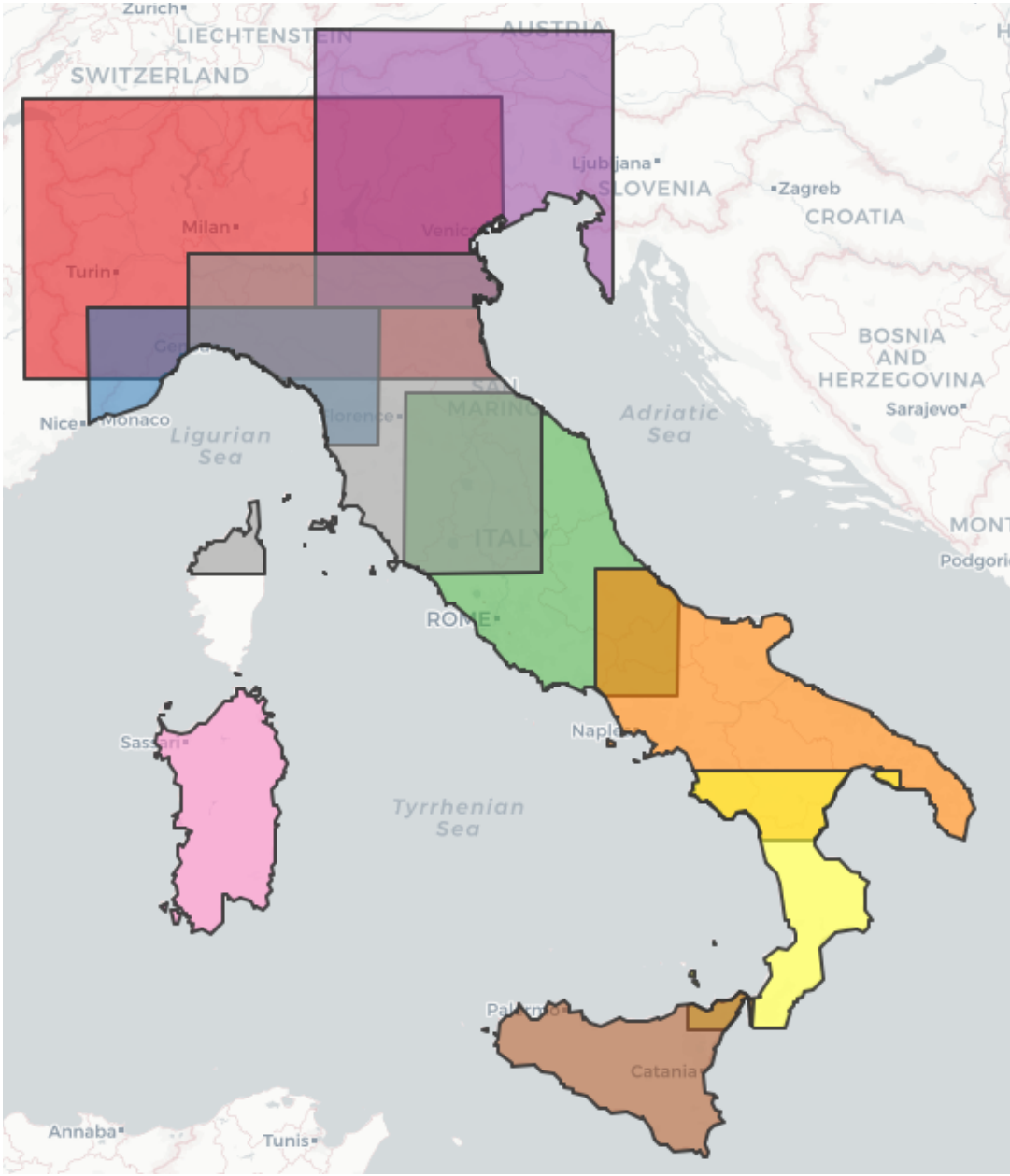


CHyM simulations

- 9 simulated domains
- Tested several Digital Elevation Models, chose HydroSHEDS 90m
- Specific tuning for each region
- 300-900m resolution
- Argo and Marconi clusters
- 3000 runtime hours
- 100k core-hours
- ~35TB

Three PR drivers:

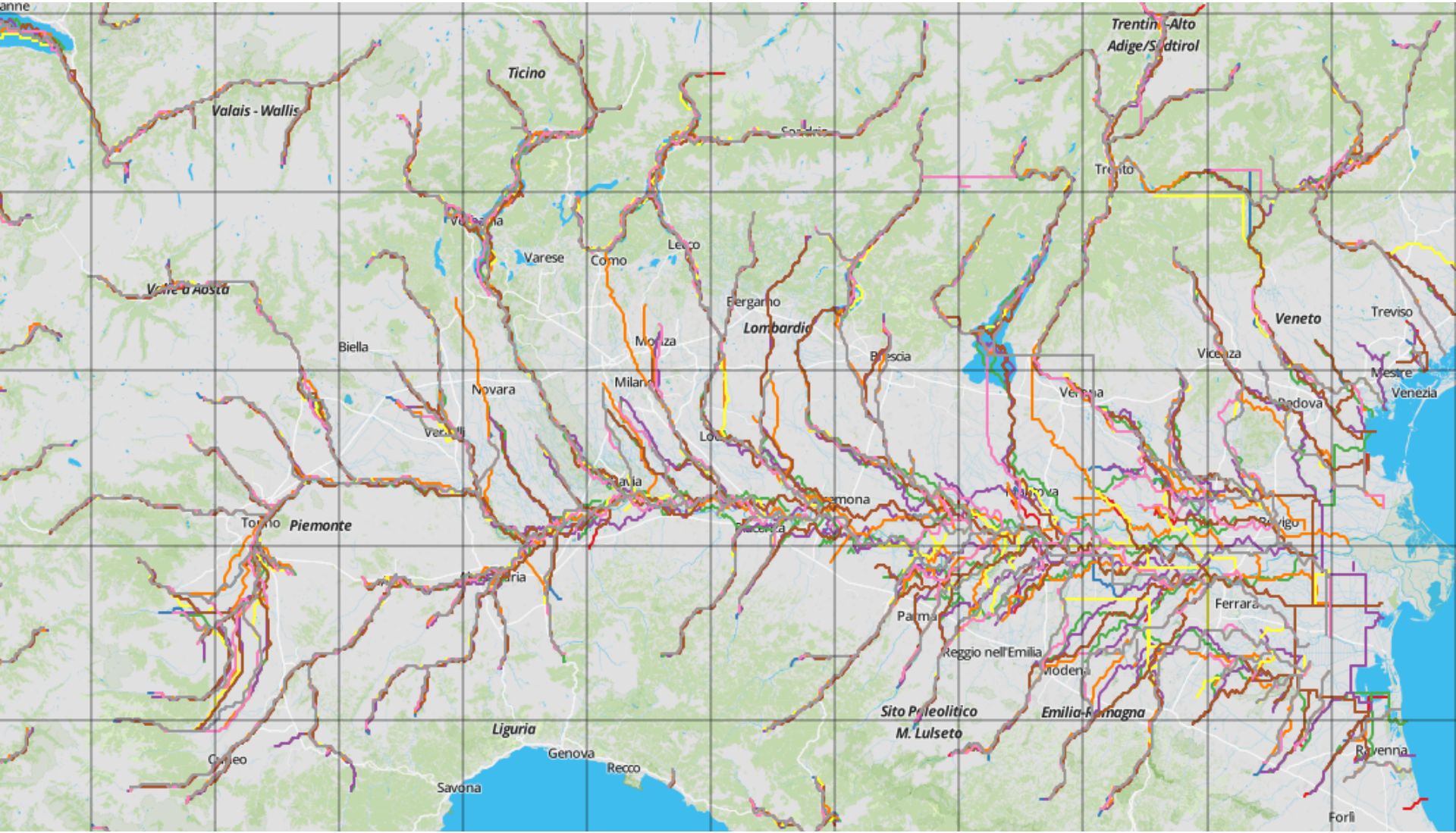
- GRIPHO (MM5) 2001-2016
- RegCM-ERA 1980-2016
- RegCM-HAD 1972-2100



CHyM river network

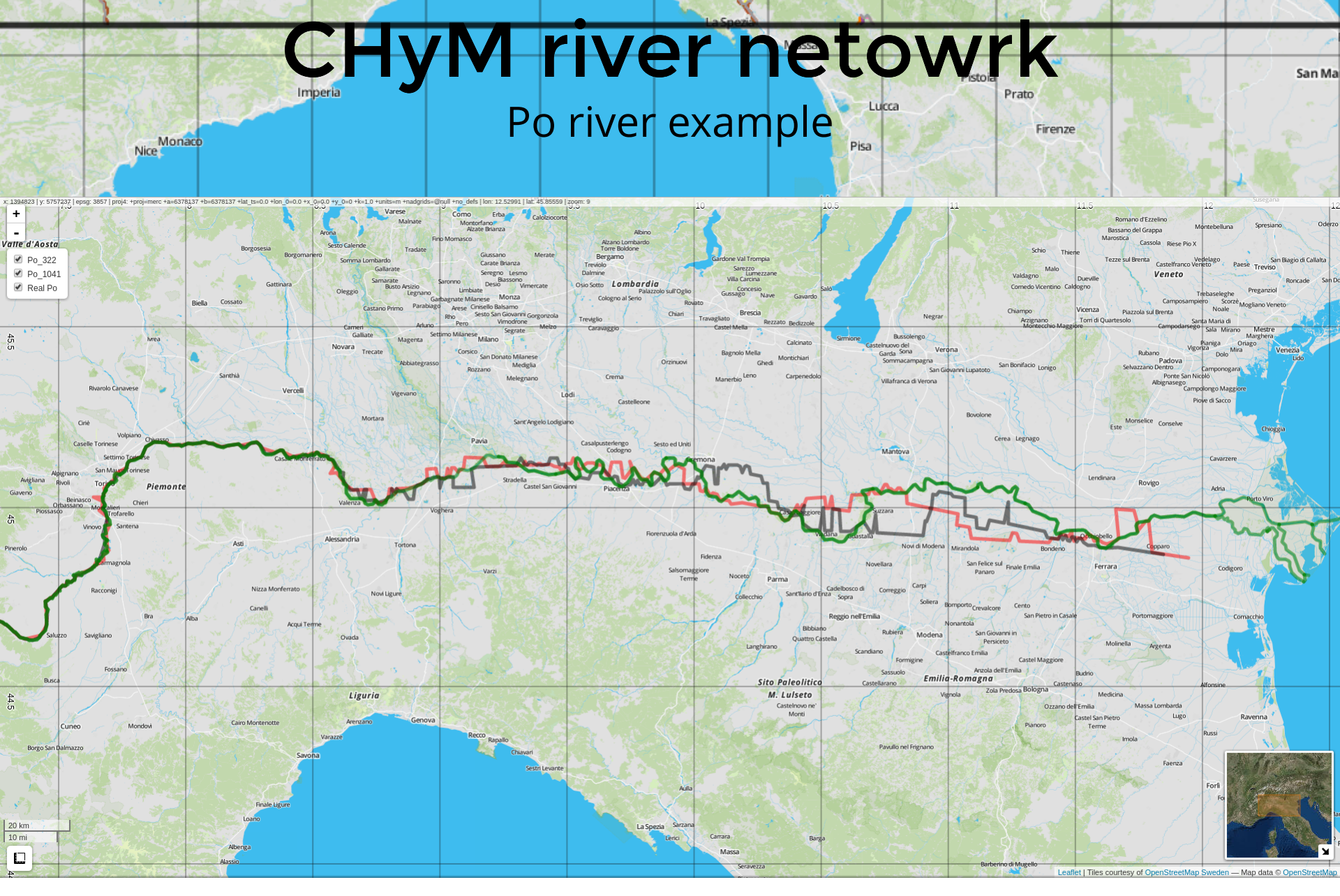
96 river network reconstruction tests for each region

(manual and automatic, with distance measures)



CHyM river netowrk

Po river example



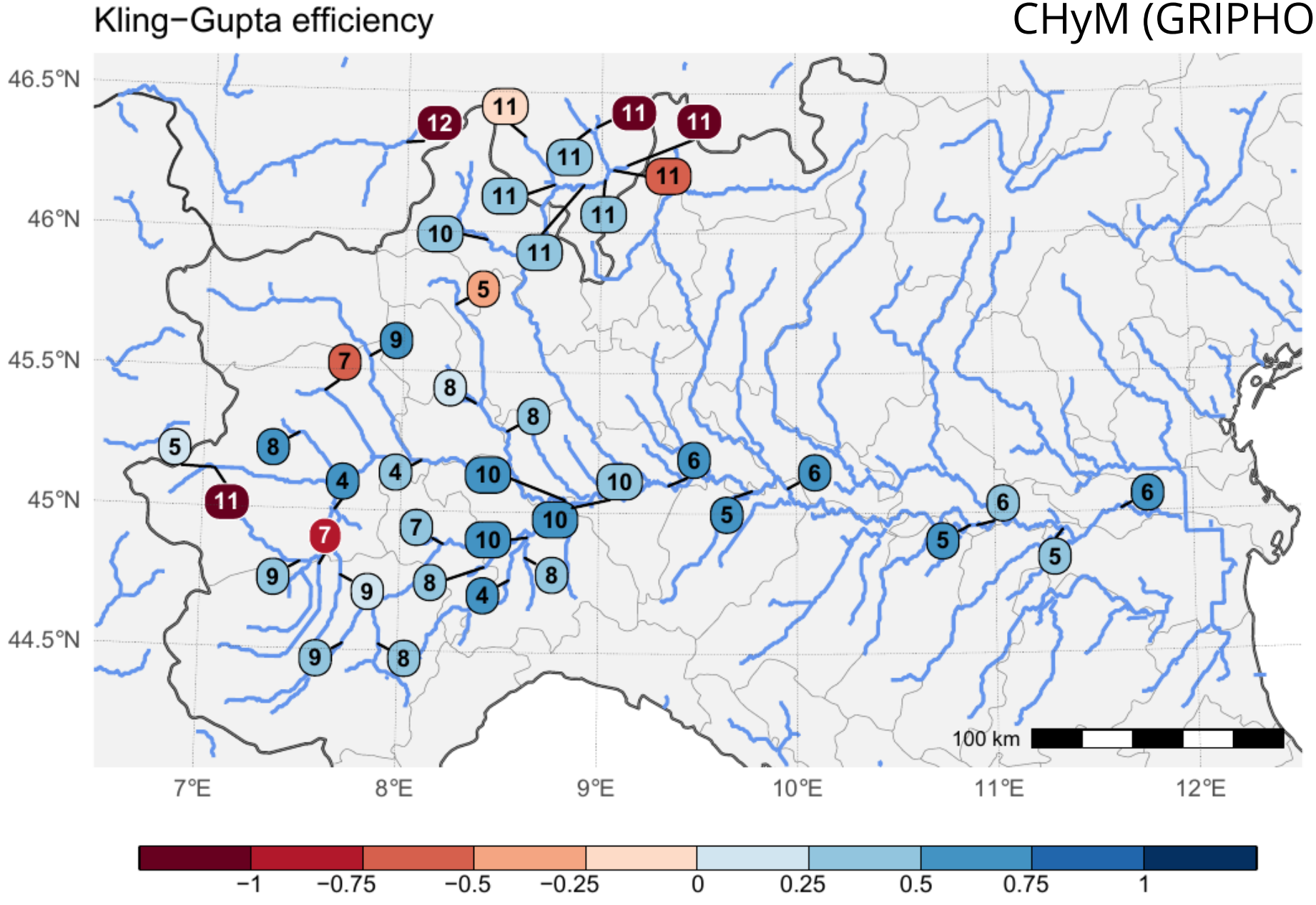
CHyM simulations

Does the model perform well?

Validation only possible against a few discharge stations:

- Average discharge
- Yearly maximum discharge
- Projected Q100 discharge
- Standard hydrological model metrics (NSE, KGE, correlation, index of agreement, ...)... against only a few stations, unfortunately

CHyM validation example



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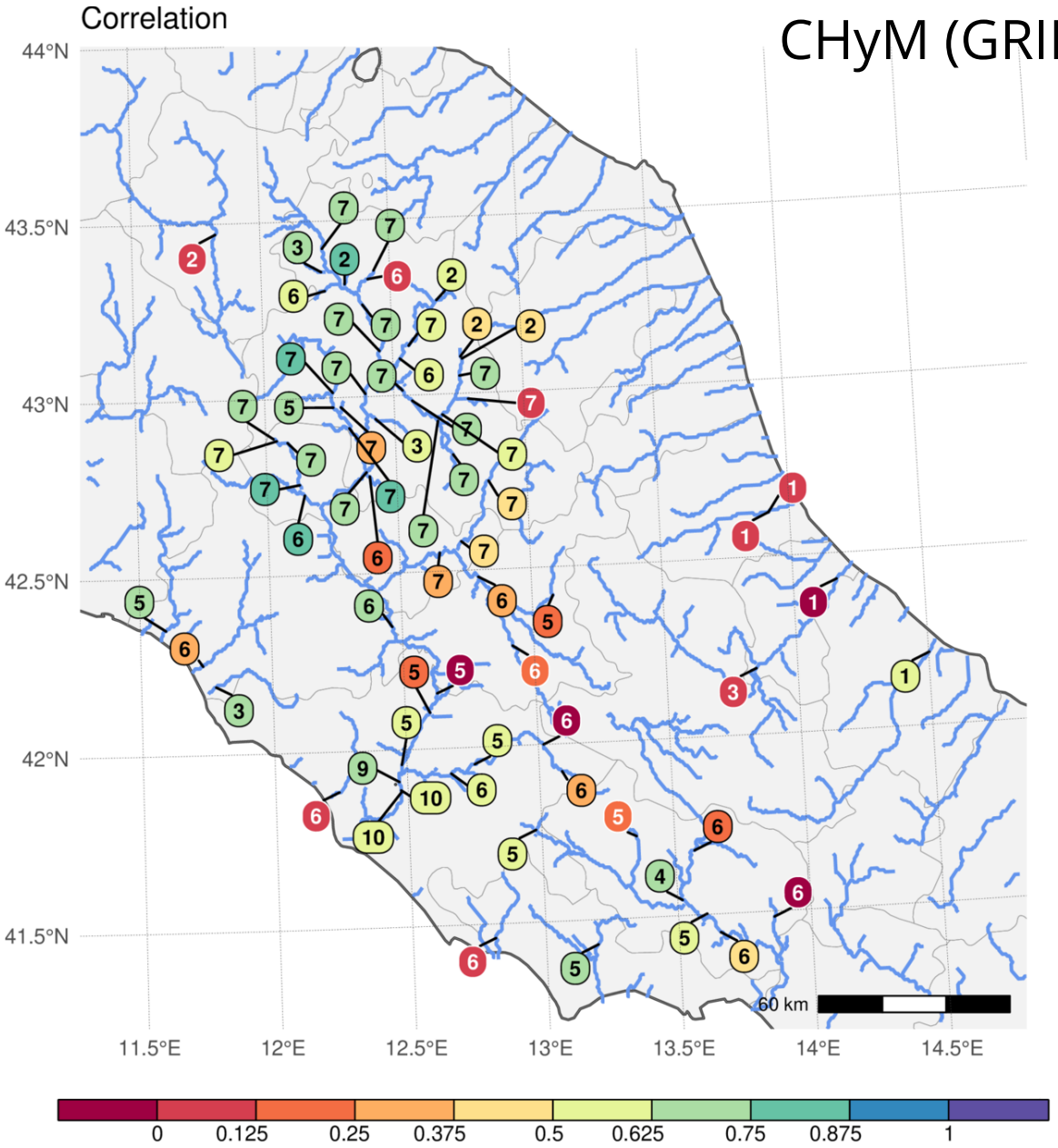
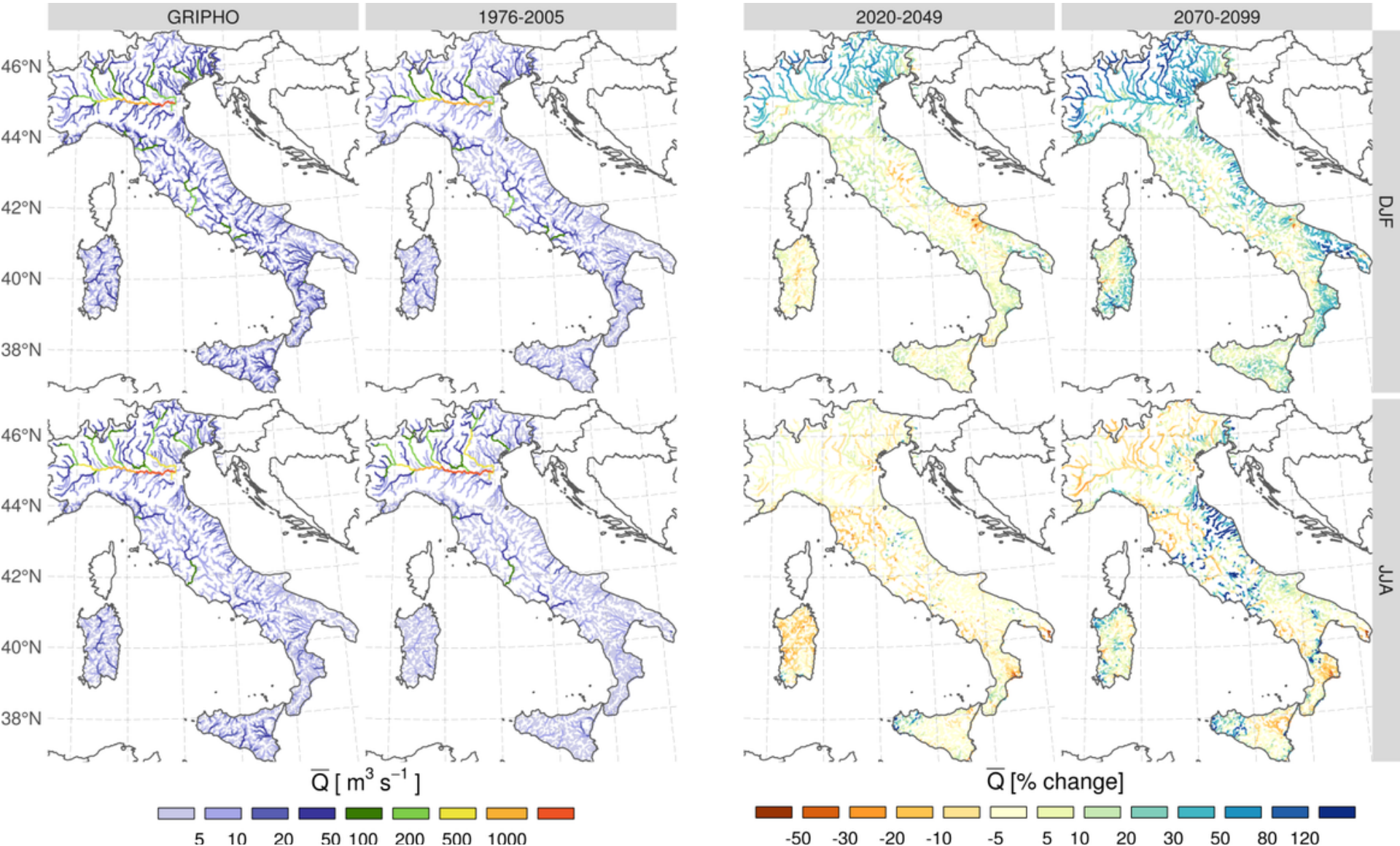


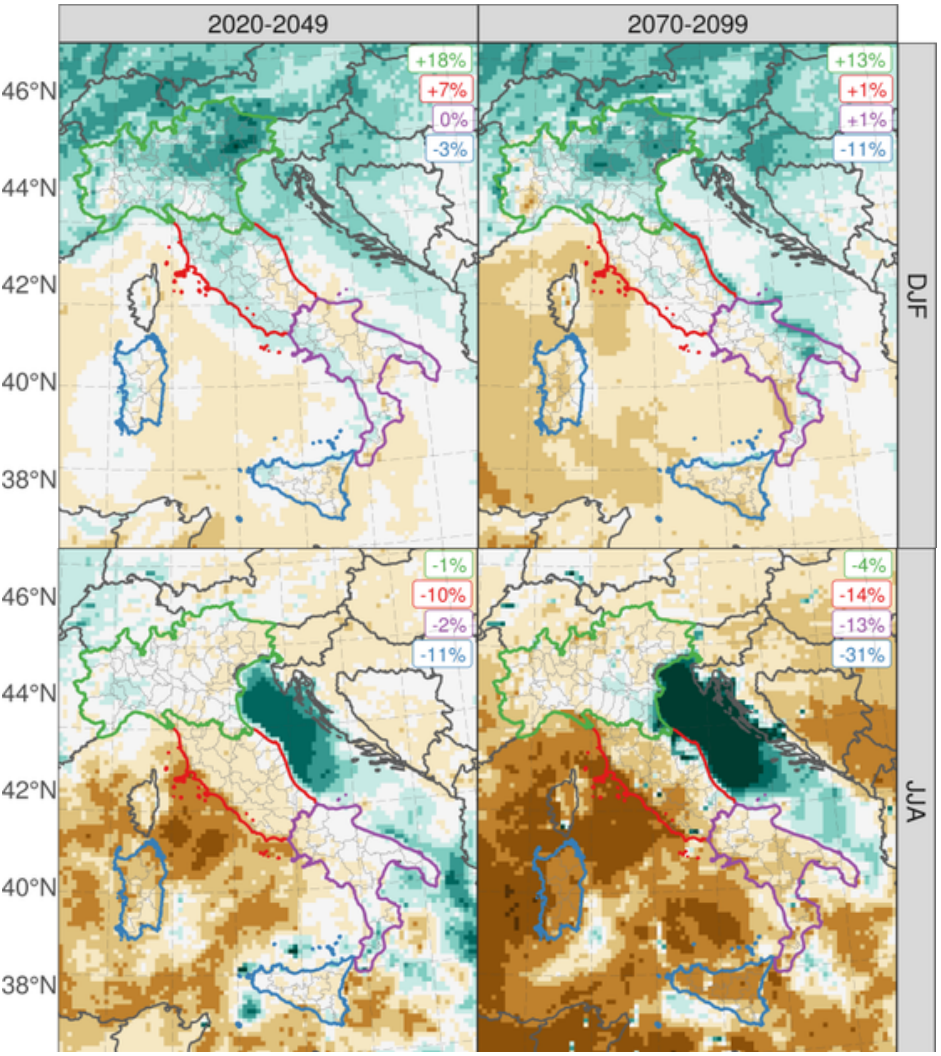
Mean change

MEAN DISCHARGE

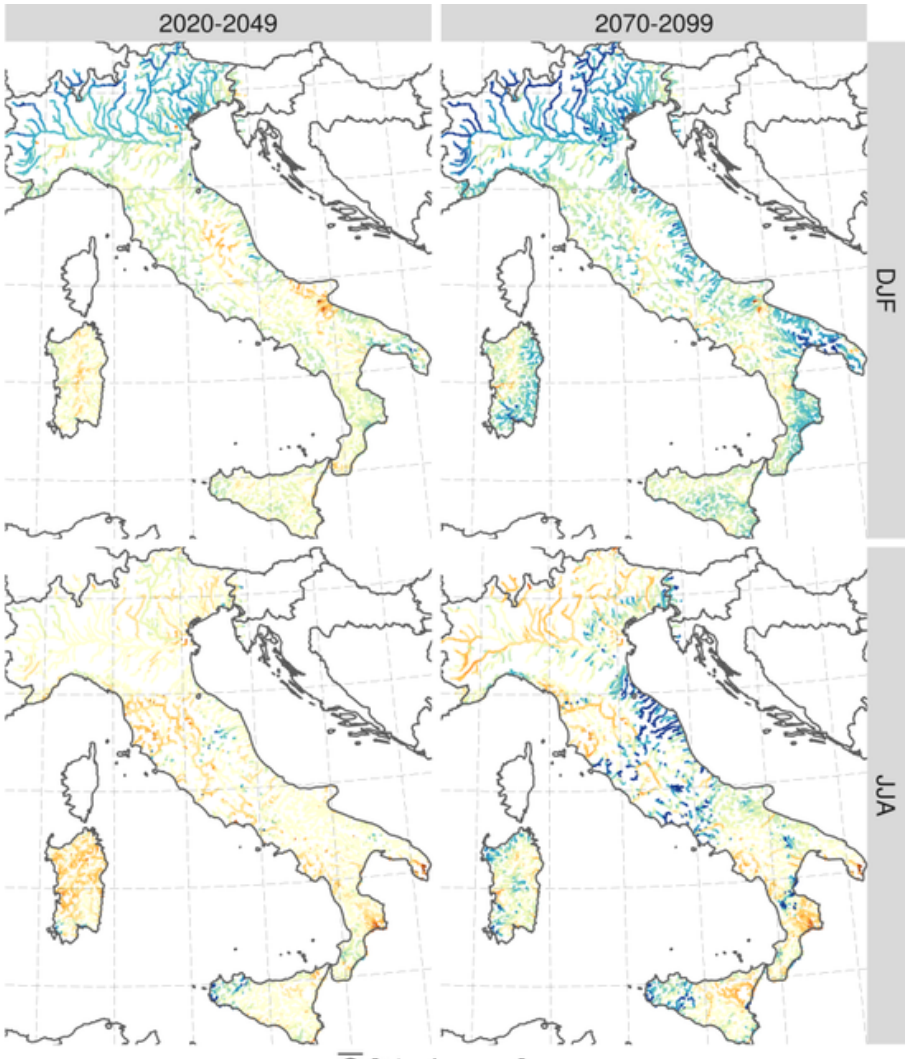


Mean change

MEAN PRECIP CHANGE

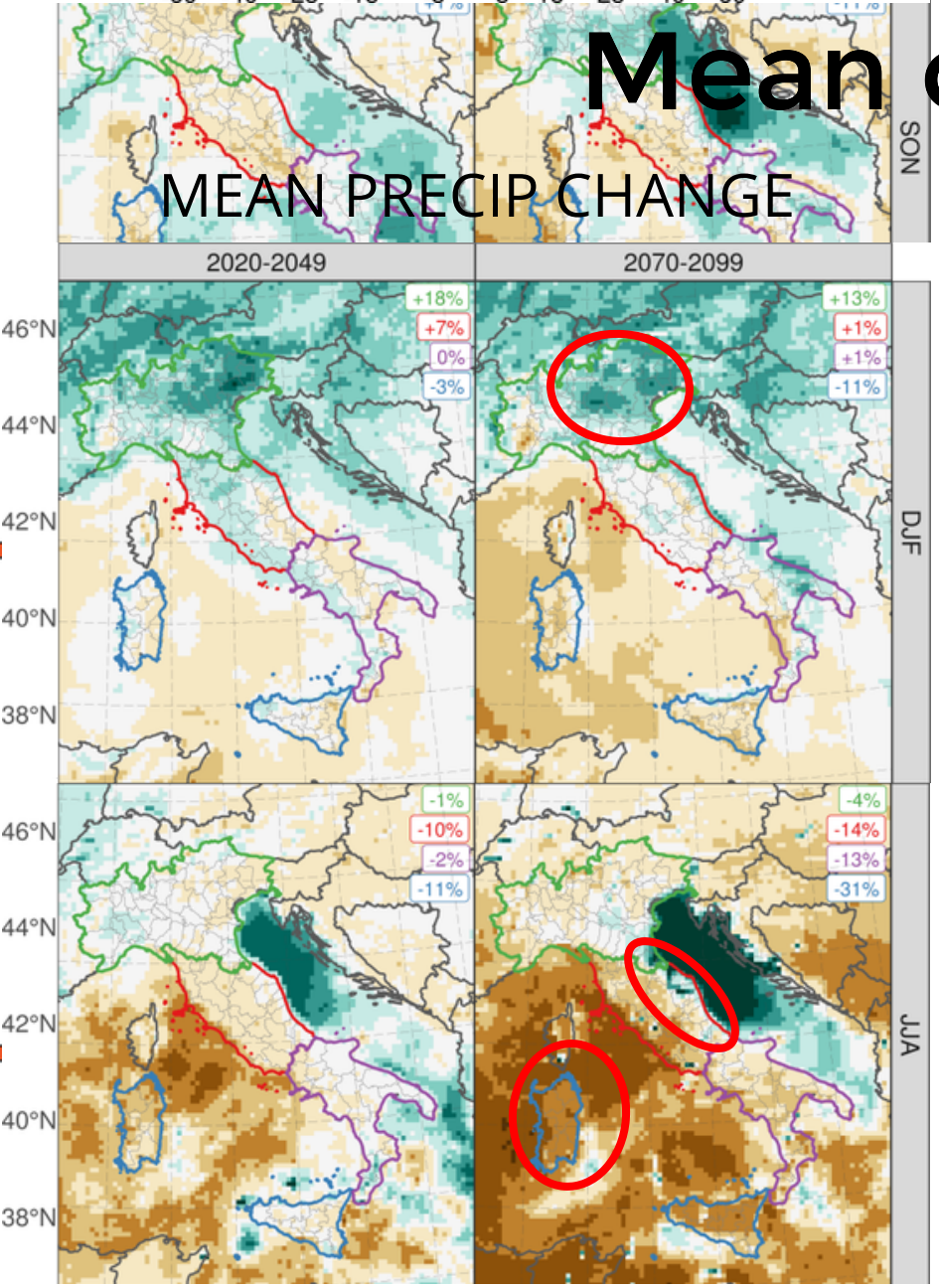


MEAN DISCHARGE CHANGE

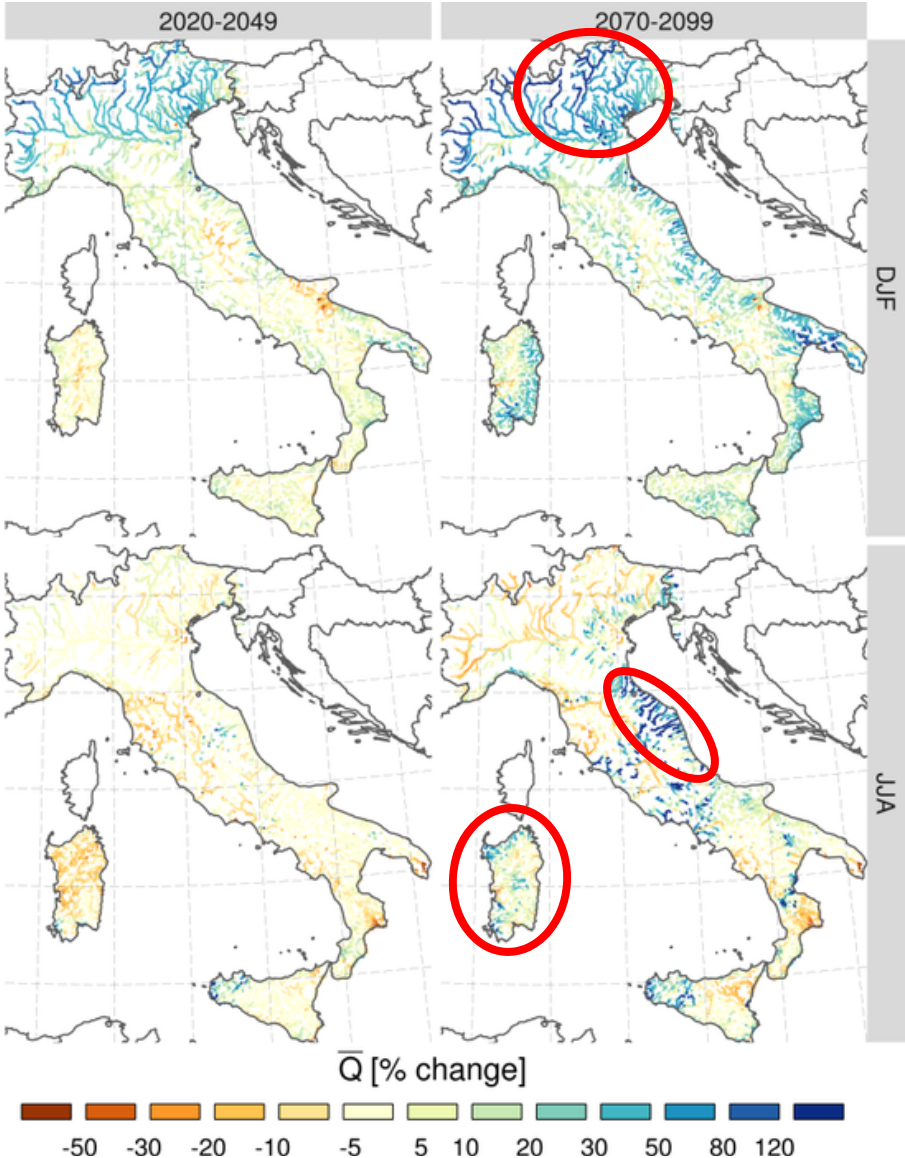


Mean change

MEAN PRECIP CHANGE

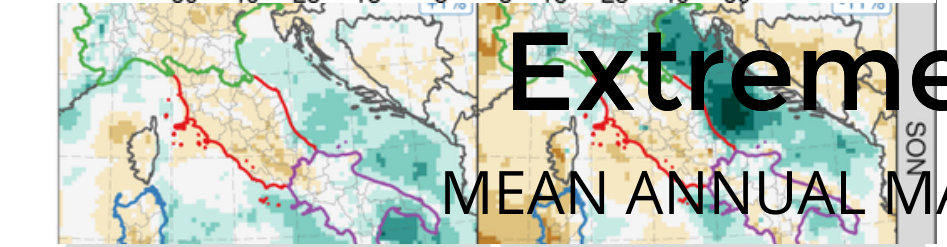


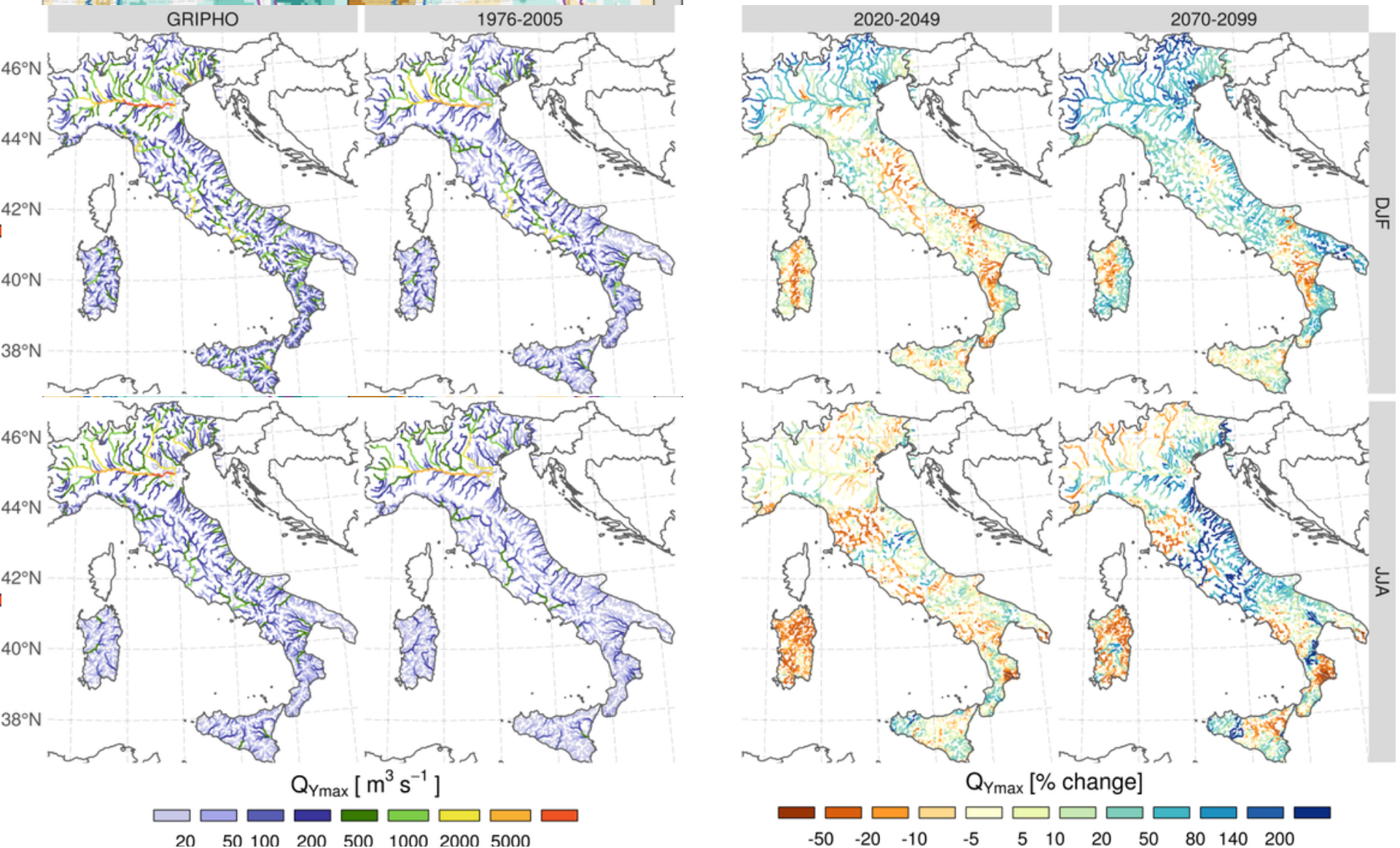
MEAN DISCHARGE CHANGE



Extreme change

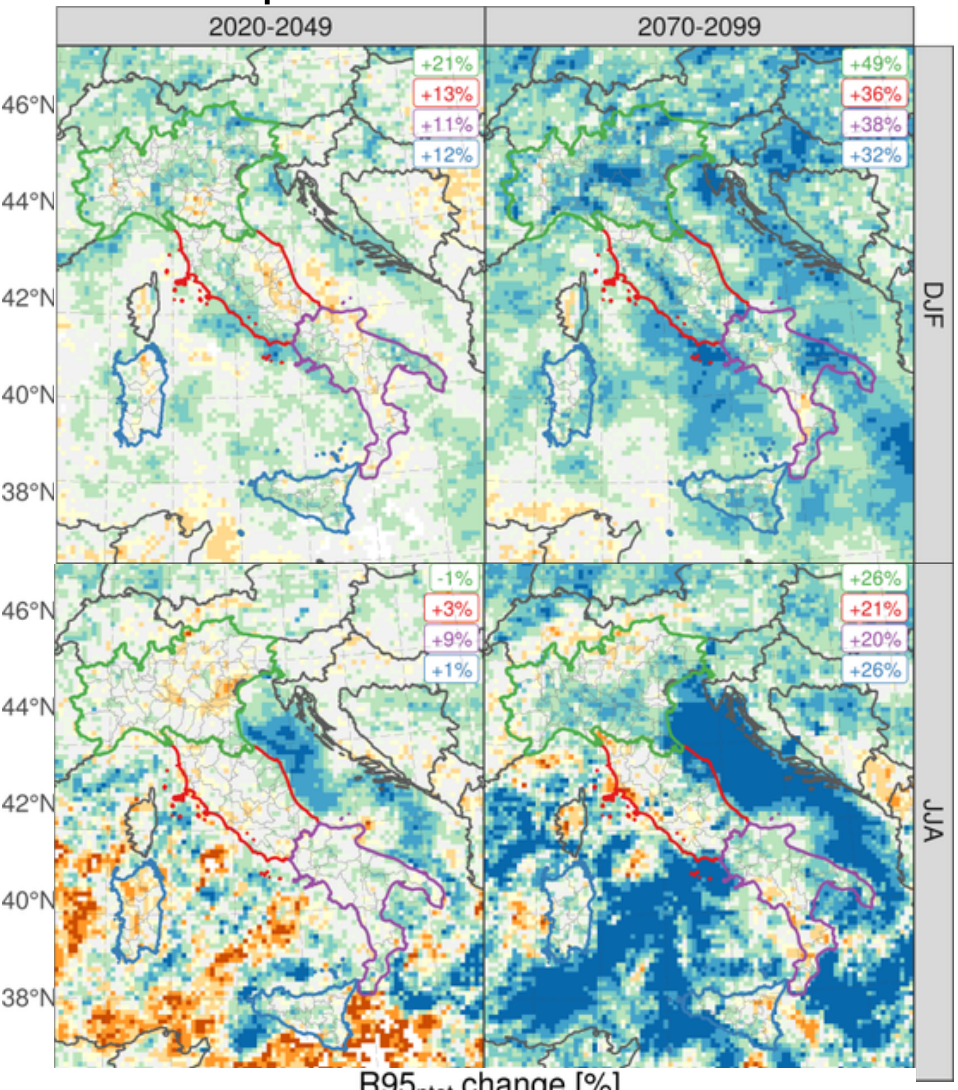
MEAN ANNUAL MAXIMUM DISCHARGE



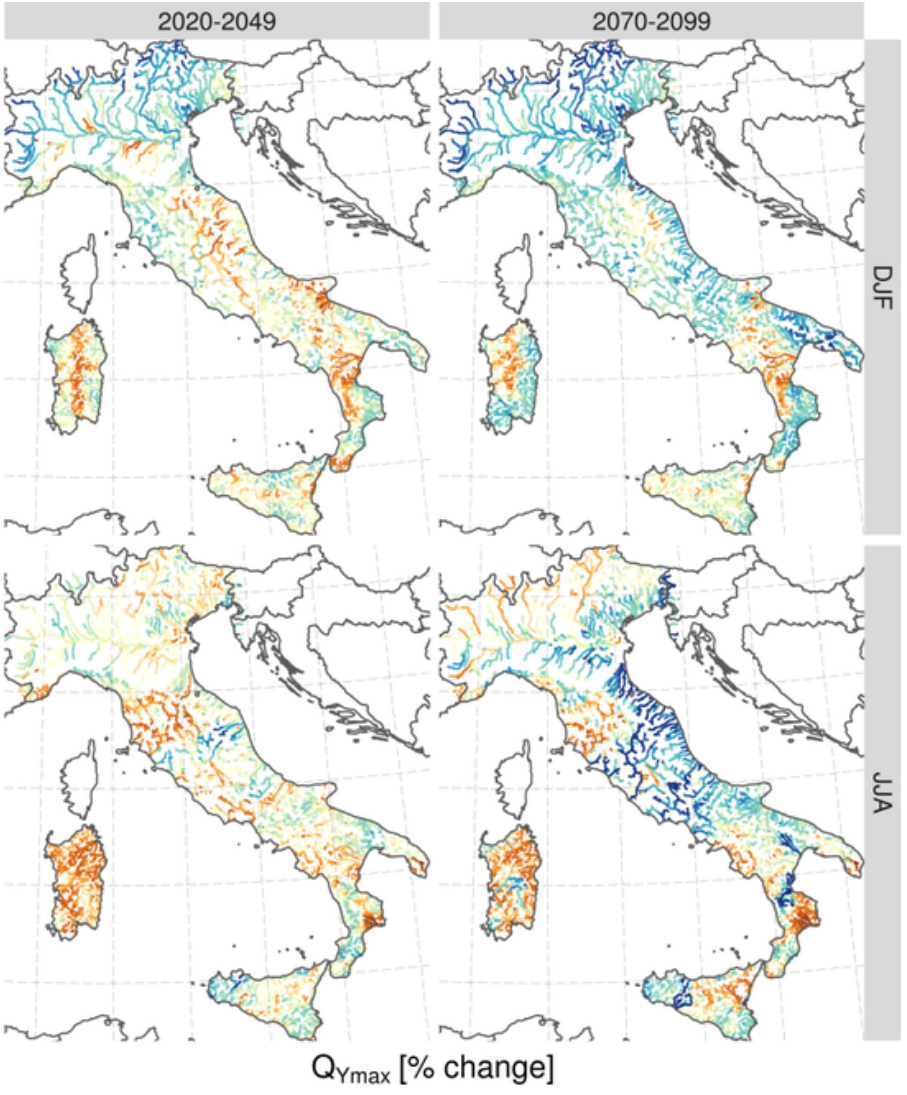


Extreme change

R95ptot PRECIP CHANGE

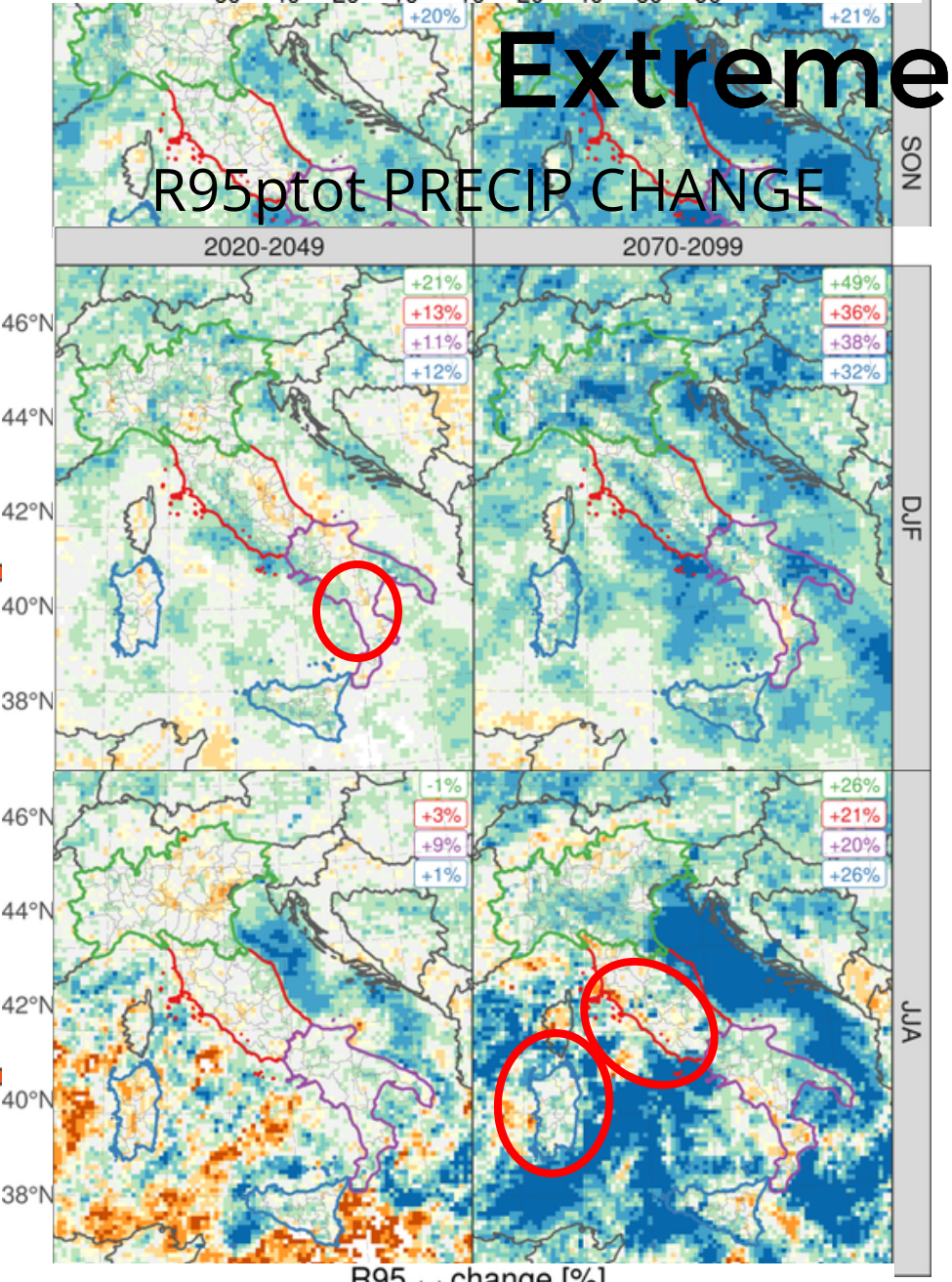


Qymax DISCHARGE CHANGE

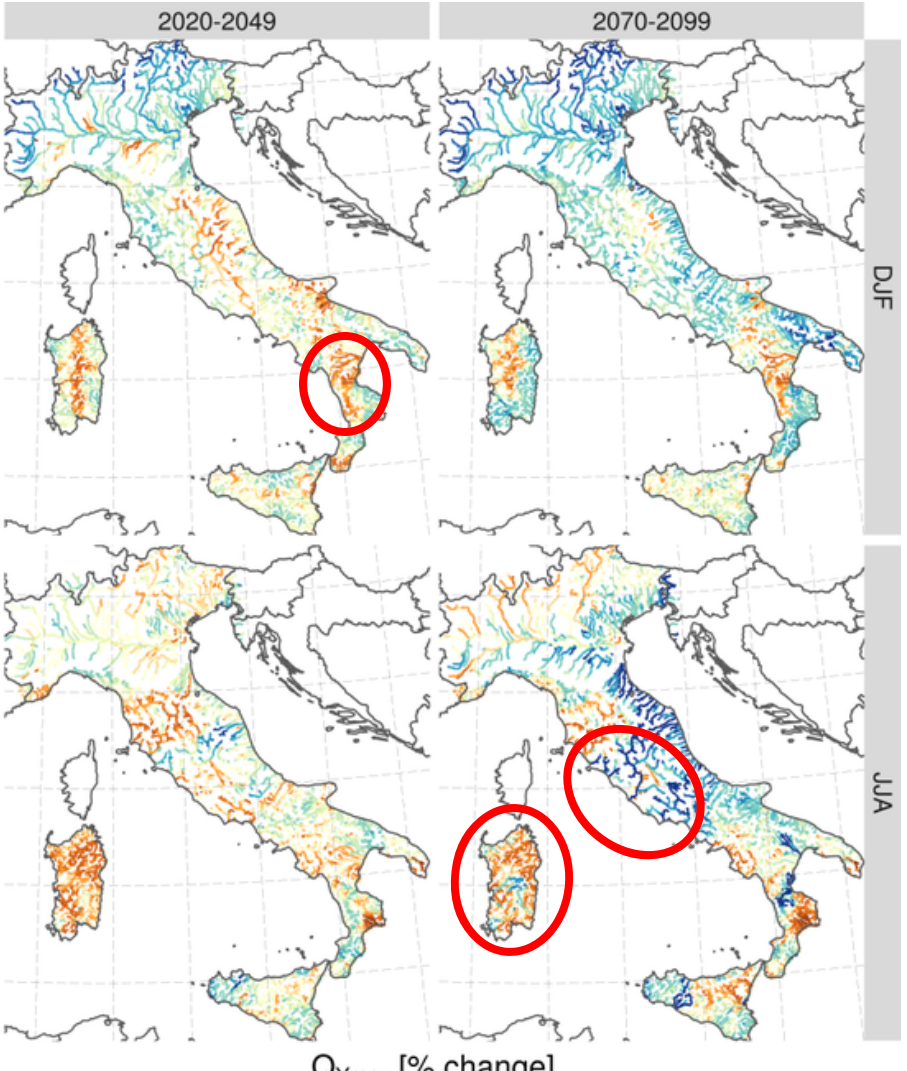


Extreme change

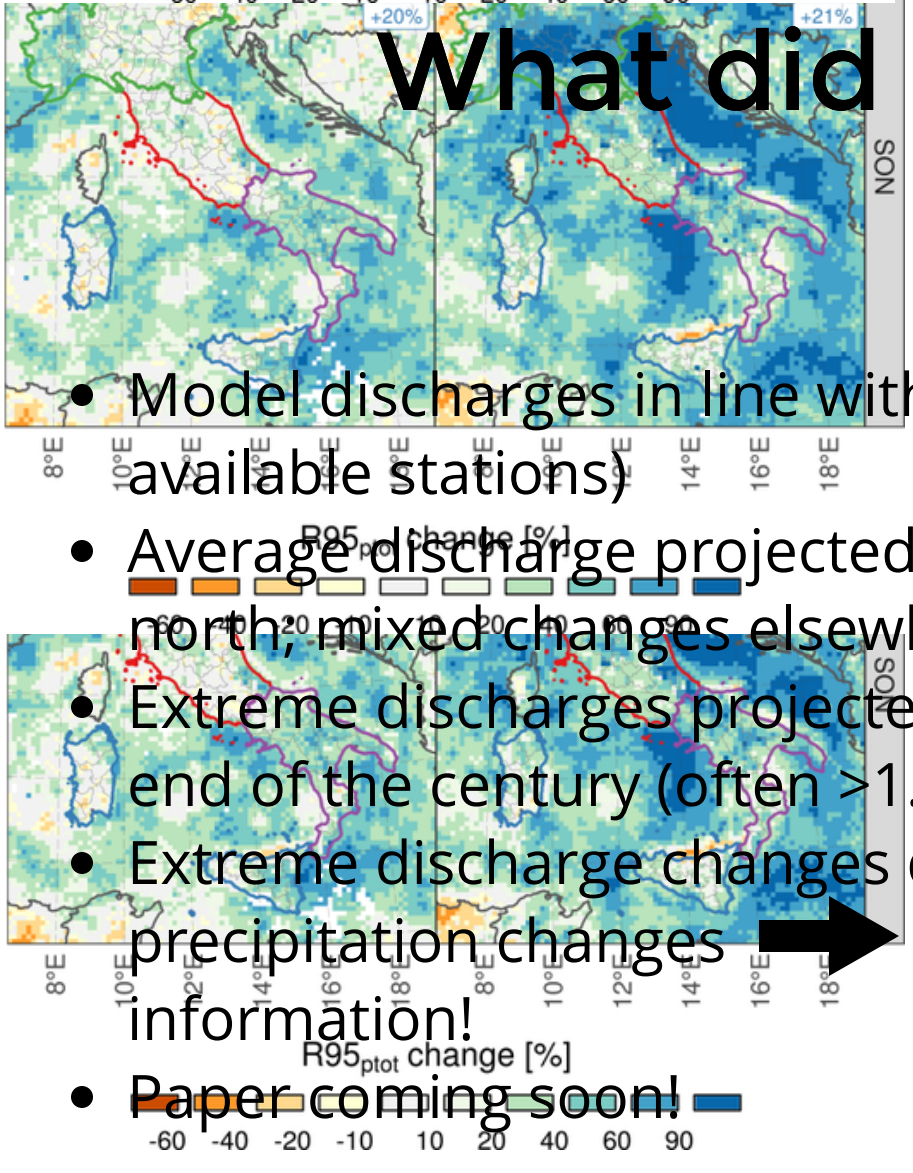
R95ptot PRECIP CHANGE



Qymax DISCHARGE CHANGE



What did we learn?



- Model discharges in line with observations (for the few available stations)
- Average discharge projected to slightly increase in the north, mixed changes elsewhere
- Extreme discharges projected to **strongly** increase by the end of the century (often >1.5x)
- Extreme discharge changes do not match extreme precipitation changes → hydrological model adds useful information!
- Paper coming soon!