SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2025
Project Title:	EURO-CORDEX2 simulations with Harmonie-Climate downscaling the IPSL GCM
Computer Project Account:	spdkchri
Principal Investigator(s):	Ole B. Christensen, special consultant, PhD
Affiliation:	Danish Meteorological Insitute
Name of ECMWF scientist(s) collaborating to the project (if applicable)	
Start date of the project:	1/1/2024
Expected end date:	31/12/2026

Computer resources allocated/used for the current year and the previous one
(if applicable)
Please answer for all project resources

		Previous year		**Current year**	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	10 000 000	18 832 600	27 000 000	26 139 443
Data storage capacity	(Gbytes)	40TB	40TB	80TB	86TB

Summary of project objectives (10 lines max)

Enabling a contribution from the DMI to EURO-CORDEX6, the newest generation of downscaling simulations over Europe, this time based on CMIP6 global climate models following the most recent set of greenhouse gas emission scenarios.The DMI is part of the consortium centred around HARMONIE-CLIMATE, a climate version of the operational weather forecast model HARMONIE. The DMI would contribute a downscaling simulation driven by the IPSL-CM6A-LR global simulation, one of ten CMIP6 simulations selected by the EURO-CORDEX community, which aimed for a GCM simulation selection balanced in signal.

Summary of problems encountered (10 lines max)

Due to an oversight from our side, the originally allocated limit of 10 MSBU for 2025 was seriously exceeded. We apologise for this unintentional extra stress on the ECMWF computer resources! Also, we appreciate the extension of our allowance to match this resource consumption. We will not be using this account for the remainder of 2025 but still hope that the originally planned 10 MSBU for 2026 can be allocated to us.

Summary of plans for the continuation of the project (10 lines max)

In collaboration with the HCLIM community, we will aim at supplementing the HCLIM EURO-CORDEX6 ensemble with a further experiment driven by one of the other selected driving models, which can be seen in Table 1.

List of publications/reports from the project with complete references

No publications based on the HCLIM EURO-CORDEX6 simulations by DMI, SMHI, and met.no have yet been published.

Summary of results

Simulations have been completed, and the output data from simulations have been collected at the same site as other HCLIM simulations with different boundaries performed by our collaborators SMHI and met.no.

At the EURO-CORDEX (e.g., Jacob et al., 2020; Vautard et al., 2020; Coppola et al., 2021; Demory et al., 2020)community level, there is an agreement to wait with the publication of EURO-CORDEX6 data until the end of 2025 in order to avoid the situation where too few, initially released, simulations will be used for studies forming an accidental “canonical” set.

As a consequence of this we are unable to present any intercomparison between our results and corresponding simulations with other models in the collaboration. For now, we will only present validation plots comparing to the latest E-OBS gridded observational dataset (Cornes et al., 2018) as well as climate change plots for our simulation.

We show biases for 2m temperature (Fig. 1) and relative biases for precipitation (Fig. 2) for the overlap period of the scenario-independent historical simulation period 1951-2014; note that the strange results in central Türkiye and other places on the outskirts of the plot are artifacts from the E-OBS dataset. The model results are acceptable but not perfect: There is a general cold bias in the winter period, which exceeds 2 degrees in Northern Europe for DJF. There is a significant wet bias in summer. It remains to be investigated how much of these shortcomings originate in the driving model, vs. how much is due to model and setup issues for HCLIM.

In Figs 3-6 we show comparisons between present and future 30-year periods, 1981-2010 vs. 2071-2100. We show temperature change for ssp370 (Fig. 3) and ssp126 (Fig. 4), and relative precipitation change for ssp370 (Fig. 5) and ssp126 (Fig. 6).

The patterns in these figures generally show the “canonical” features of most European downscaling experiments: The largest warming signals are seen in the north in winter, in the south in summer. Precipitation increases the most in the north, with more positive signals in winter than in summer, and negative signals in the south in summer.

There are, however, some deviations from the general EURO-CORDEX signals: Particularly the summer warming pattern, which shows the largest amplitude in Southeast Europe, where most simulations show a large warming in all of southern Europe. This is probably related to the positive precipitation bias and the limited future drying in the area. The drying-heating feedback seems to be quite small in this simulation.

In the coming period we will compare the new EURO-CORDEX6 simulations in the community and analyse the specific features of each individual simulation in relation to the ensemble of simulations.

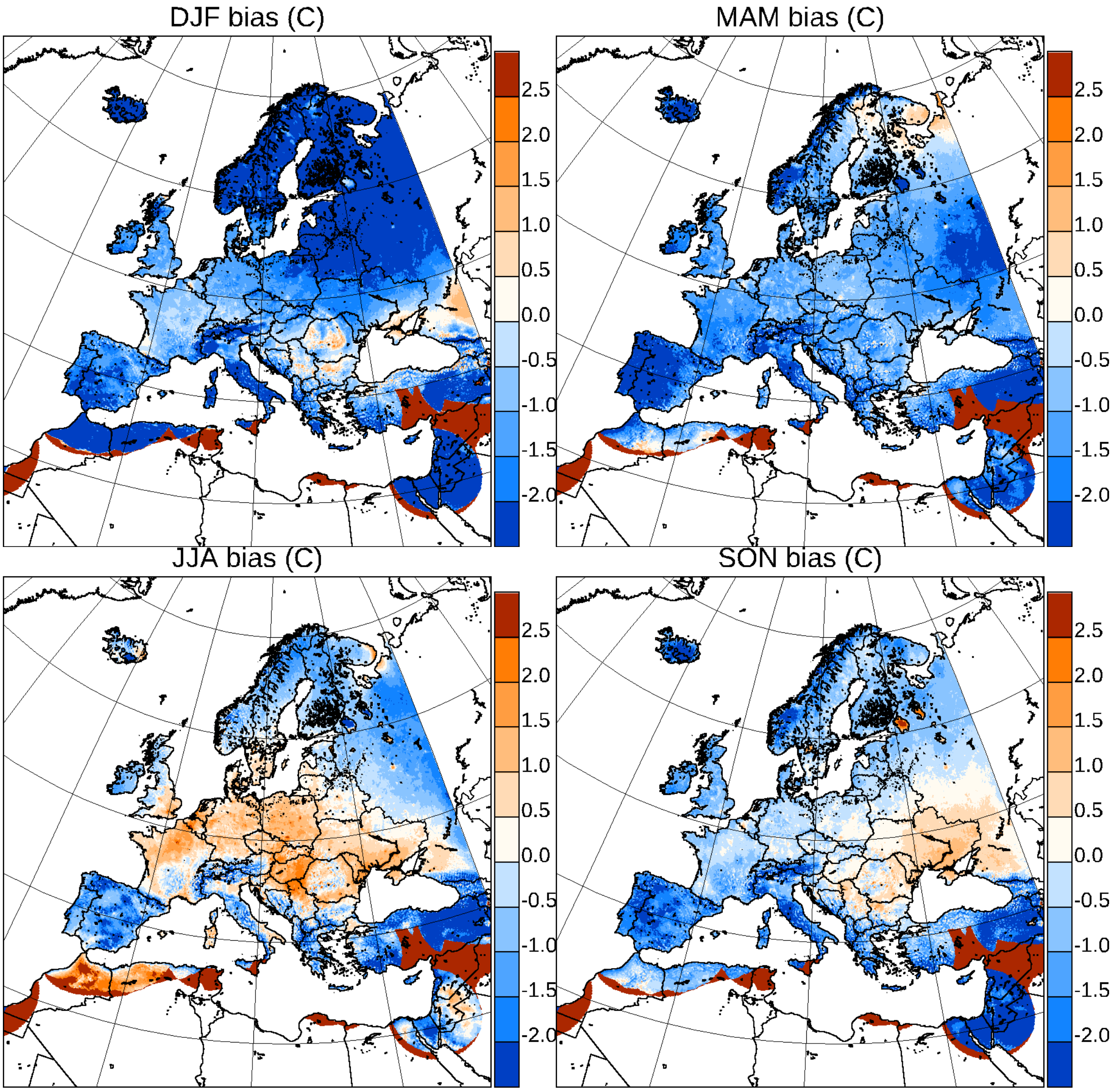

Figure 1 Bias of 2m temperature wrt. E-OBS 1951-2014 for each season.

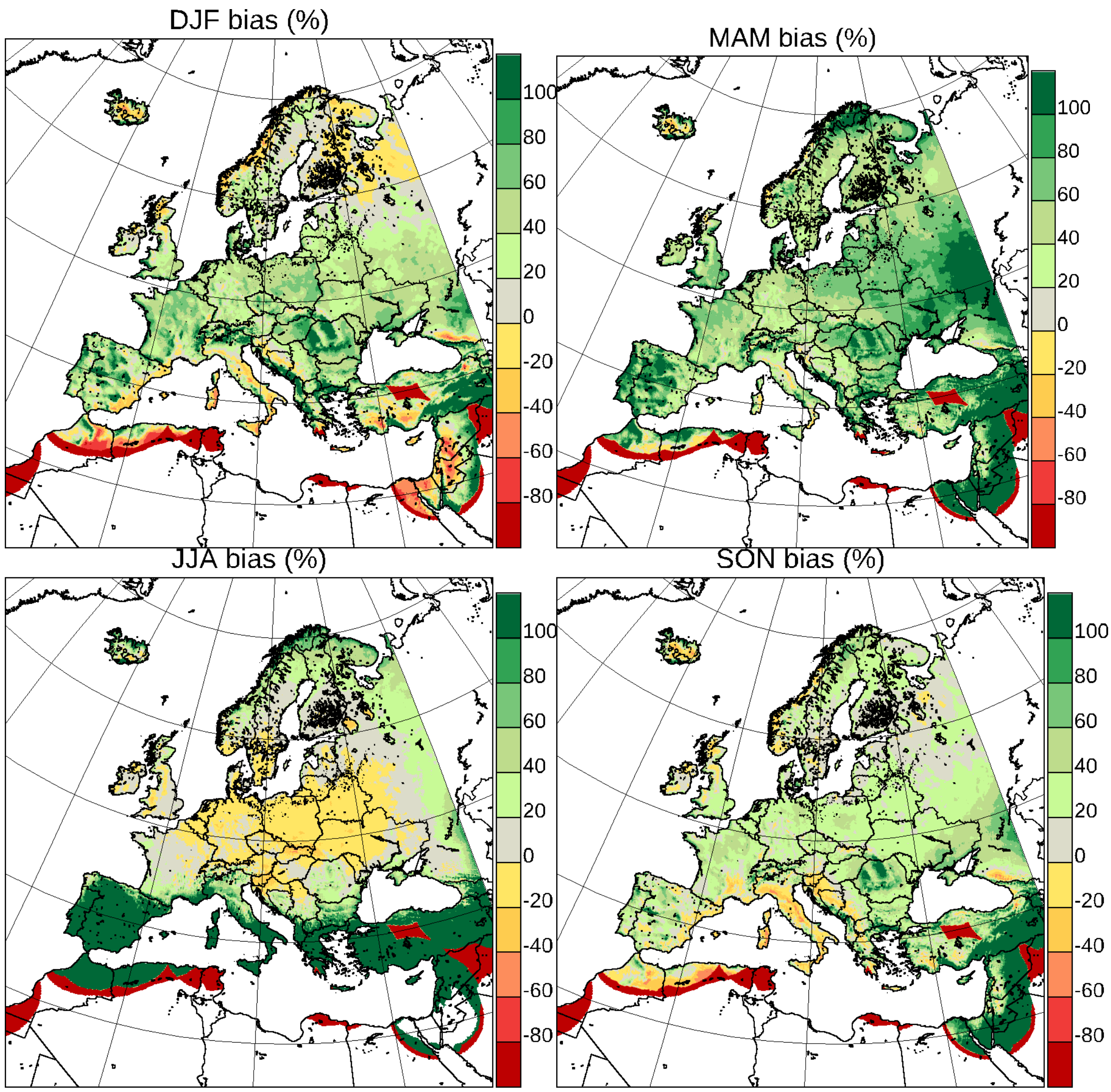

Figure 2 Relative bias of precipitaion wrt. E-OBS 1951-2014 for each season.

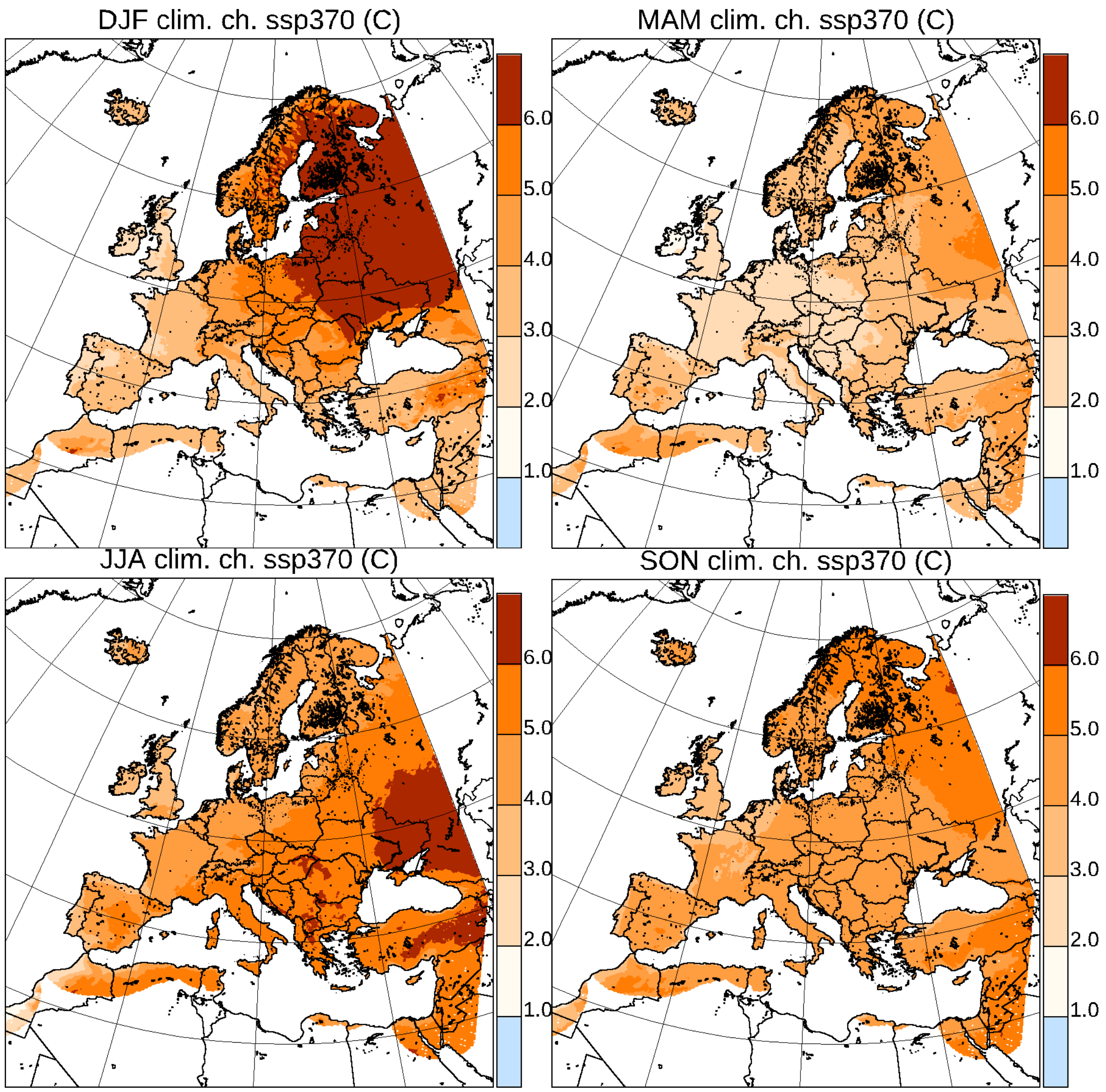

Figure 3 Temperature change for SSP 370 1981-2010 vs. 2071-2100 for each season.

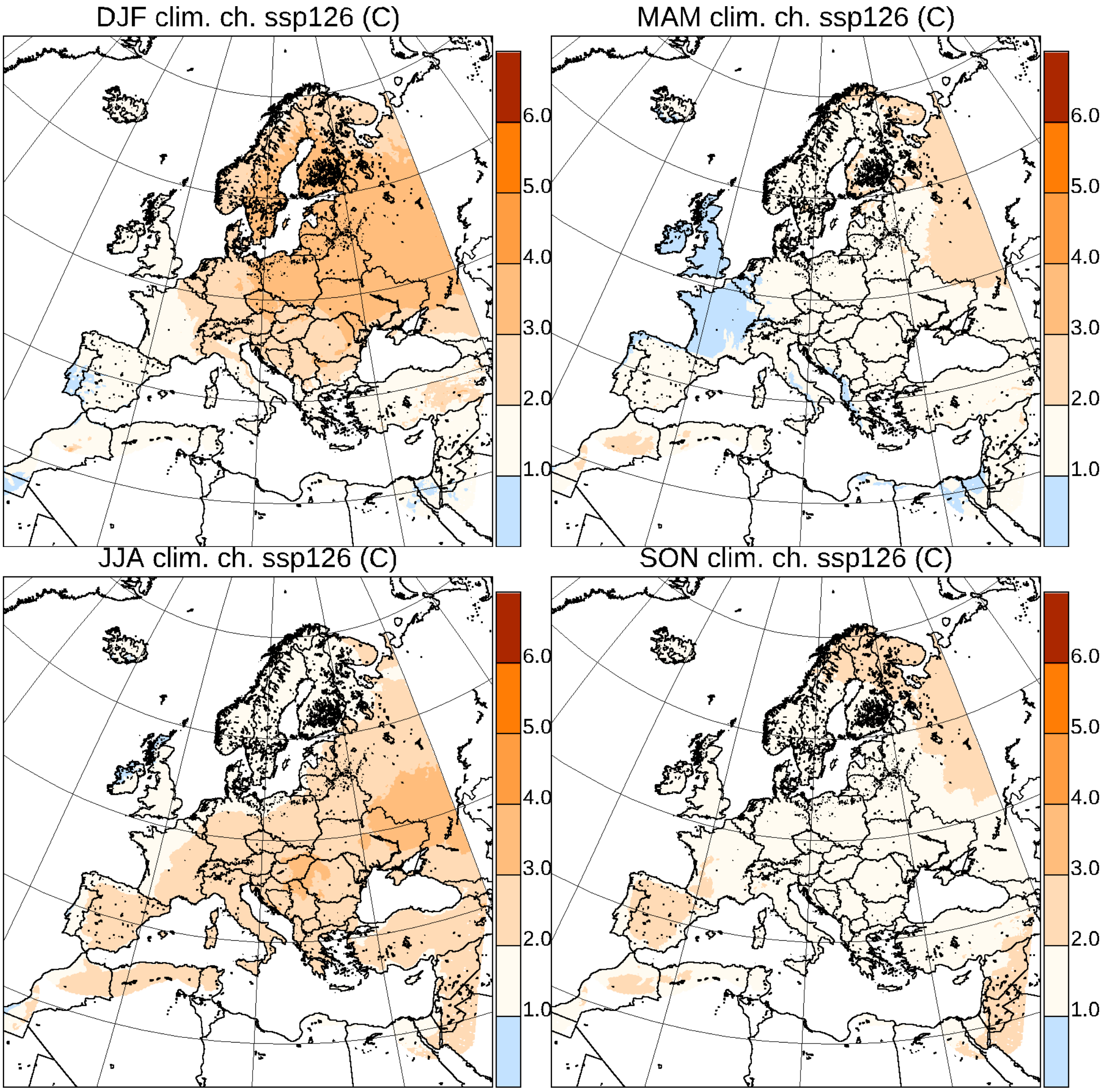

Figure 4 Temperature change for SSP 126 1981-2010 vs. 2071-2100 for each season.

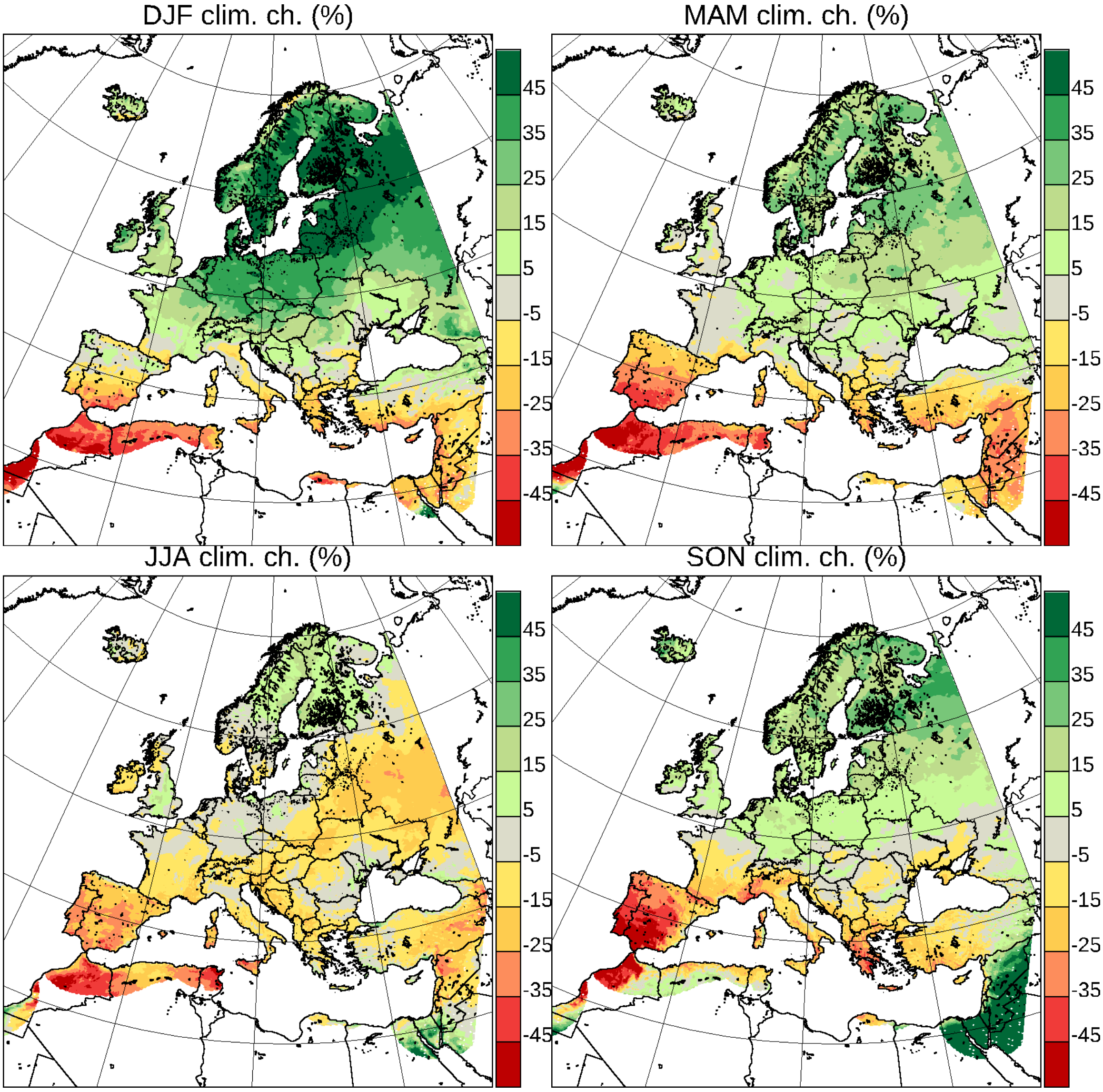

Figure 5 Precipitation relative change for SSP 370 1981-2010 vs. 2071-2100 for each season.

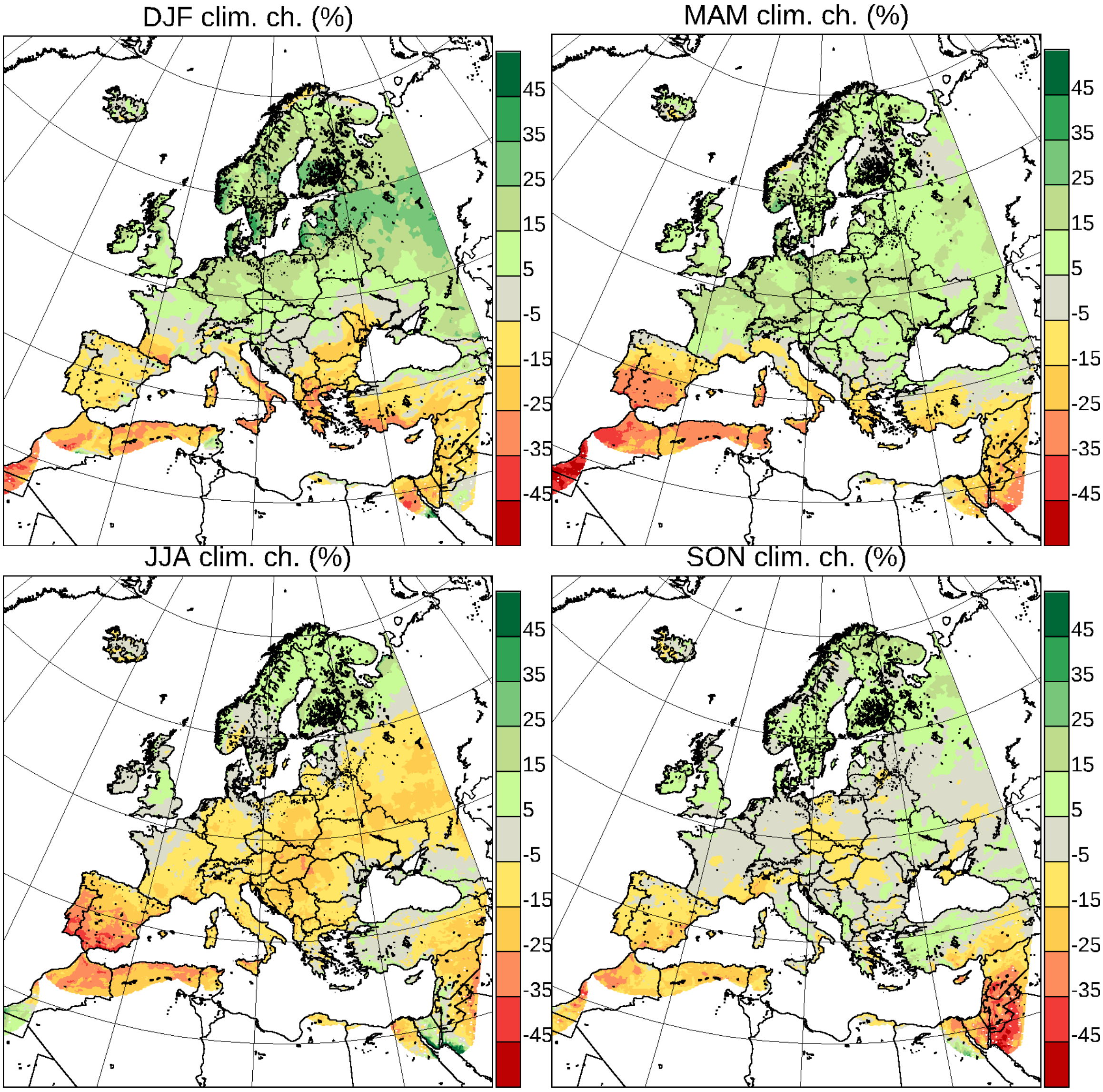

Figure 6 Precipitation relative change for SSP 126 1981-2010 vs. 2071-2100 for each season.
We acknowledge the E-OBS dataset from the EU-FP6 project UERRA (https://www.uerra.eu) and the Copernicus Climate Change Service, and the data providers in the ECA&D project (https://www.ecad.eu).

GCM name	Run
MPI-ESM1-2-LR	r1i1p1f1
NorESM2-MM	r1i1p1f1
MIROC6	r1i1p1f1
MPI-ESM1-2-HR	r1i1p1f1
CNRM-ESM2-1	r1i1p1f2
CESM2	r11i1p1f1
CMCC-CM2-SR5	r1i1p1f1
IPSL-CM6A-LR	r1i1p1f1

EC-Earth3-Veg	r1i1p1f1
UKESM1-0-LL	r1i1p1f2

Table 1. CMIP6 simulations to be downscaled in EURO-CORDEX6.

References

Coppola, E., Nogherotto, R., Ciarlò, J. M., Giorgi, F., van Meijgaard, E., Kadygrov, N., Iles, C., Corre, L., Sandstad, M., Somot, S., Nabat, P., Vautard, R., Levavasseur, G., Schwingshackl, C., Sillmann, J., Kjellström, E., Nikulin, G., Aalbers, E., Lenderink, G., Christensen, O. B., Boberg, F., Sørland, S. L., Demory, M.-E., Bülow, K., Teichmann, C., Warrach-Sagi, K., Wulfmeyer, V., (2021). Assessment of the European climate projections as simulated by the large EURO-CORDEX regional and global climate model ensemble. Journal of Geophysical Research: Atmospheres, 126, e2019JD032356.(2021). https://doi.org/10.1029/2019JD032356

Cornes, R., G. van der Schrier, E.J.M. van den Besselaar, and P.D. Jones. 2018: An Ensemble Version of the E-OBS Temperature and Precipitation Datasets, J. Geophys. Res. Atmos., 123. doi:10.1029/2017JD028200

Demory, M.-E., Berthou, S., Fernández, J., Sørland, S. L., Brogli, R., Roberts, M. J., Beyerle, U., Seddon, J., Haarsma, R., Schär, C., Buonomo, E., Christensen, O. B., Ciarlo, J. M., Fealy, R., Nikulin, G., Peano, D., Putrasahan, D., Roberts, C. D., Senan, R., Steger, C., Teichmann, C., and Vautard, R.: European daily precipitation according to EURO-CORDEX regional climate models (RCMs) and high-resolution global climate models (GCMs) from the High-Resolution Model Intercomparison Project (HighResMIP), Geosci. Model Dev., 13, 5485–5506, https://doi.org/10.5194/gmd-13-5485-2020, 2020.

Eyring, V., Bony, S., Meehl, G. A., Senior, C. A., Stevens, B., Stouffer, R. J., and Taylor, K. E.: Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization, Geosci. Model Dev., 9, 1937-1958, doi:10.5194/gmd-9-1937-2016, 2016.
Jacob, D., C. Teichman, S. Sobolowski, E. Katragkou, I. Anders, M. Belda, R. Benestad, F. Boberg, E. Buonomo, R. M. Cardoso, A. Casanueva, O. B. Christensen, J. H. Christensen, E. Coppola, L. de Cruz, E. L. Davin, A. Dobler, M. Domínguez, R. Fealy, J. Fernandez, M. A. Gaertner, M. García-Díez, F. Giorgi, A. Gobiet, K. Goergen, J. J. Gómez-Navarro, J. J. González Alemán, C. Gutiérrez, J. M. Gutiérrez, I. Güttler, A. Haensler, T. Halenka, S. Jerez, P. Jiménez-Guerrero, R. G. Jones, K. Keuler, E. Kjellström, S. Knist, S. Kotlarski, D. Maraun, E. van Meijgaard, P. Mercogliano, J. P. Montávez, A. Navarra, G. Nikulin, N. de Noblet-Ducoudré, H.-J. Panitz, S. Pfeifer, M. Piazza, E. Pichelli, J.-P. Pietikäinen, A. F. Prein, S. Preuschmann, D. Rechid, B. Rockel, R. Romera, E. Sánchez, K. Sieck, P. M. M. Soares, S. Somot, L. Srnec, S. L. Sørland, P. Termonia, H. Truhetz, R. Vautard, K. Warrach-Sagi and V. Wulfmeyer: Regional climate downscaling over Europe: perspectives from the EURO-CORDEX community. Reg. Environ. Change 20, 51 (2020). https://doi.org/10.1007/s10113-020-01606-9

Vautard, R., Kadygrov, N., Iles, C., Boberg, F., Buonomo, E., Bülow, K., Coppola, E., Corre, L., van Meijgaard, E., Nogherotto, R., Sandstad, M., Schwingshackl, C., Somot, S., Aalbers, E., Christensen, O. B., Ciarlò, J. M., Demory, M.-E., Giorgi, F., Jacob, D., Jones, R. G., Keuler, K., Kjellström, E., Lenderink, K., Levavasseur, G., Nikulin, G., Sillmann, J., Solidoro, C., Sørland, S. L., Steger, C., Teichmann, C., Warrach-Sagi, K., Wulfmeyer, V., (2020). Evaluation of the large EURO-CORDEX regional climate model ensemble. Journal of Geophysical Research: Atmospheres, 126, e2019JD032344. https://doi.org/10.1029/2019JD032344