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Catalogue on CORDEX data provision, applicability and volume

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Executive summary

To obtain information about the regional climate change aspects, high-resolution regional climate models (RCMs) are used for dynamical downscaling of global climate model (GCM) fields. Regional models are focusing on a selected area with fine horizontal resolution, and the large-scale processes are taken into account in the forcings provided by the global results. The first climate simulation with a regional climate model was carried out in the late 1980s. The RCM was nested into a global climate simulation, which provided the initial and lateral boundary conditions (LBCs). The regional model reproduced realistically the synoptic scale climate features specified by the LBCs and reflected accurately the regional climate statistics due to its finer resolution, better representation of the surface characteristics and mesoscale processes. Positive results gave green light for the wide-range employment of limited area models in climate simulations. In spite of the advantages of RCMs, their simulation results still suffer from multiple deficiencies varying usually from one model to other one. Therefore, it is crucial to consider not only a single run, but also an ensemble of various model simulations.

The first international collaboration, which aims at providing climate projections for Europe with relatively high (50 km) resolution, was the PRUDENCE project (Predicting of Regional Scenarios and Uncertainties for Defining European Climate Change Risks and Effects). Numerous simulations were carried out with a range of global and regional climate models using two basically different IPCC SRES emission scenarios. The RCM outputs of the PRUDENCE project have been freely available since 2004. PRUDENCE was followed by the ENSEMBLES EU FP6 (Sixth Framework Programme of the European Union) initiative in 2004. In the ENSEMBLES project, the participating regional climate modelling institutions successfully coordinated the definitions of the simulation domains and created a database of directly intercomparable model simulations following the SRES medium emission scenario on 25 km horizontal resolution. In the CORDEX (COordinated Regional Downscaling Experiment) initiative, this procedure is extended to the entire world, simultaneously increasing the number of global and regional models, and using the modern RCP scenarios (Representative Concentration Pathways).

Not only the regional climate model simulations have developed, but the user needs have also evolved and extended in the last decades. RCM outputs are applied in several areas: e.g., they serve as input to the next assessment report of the Intergovernmental Panel on Climate Change (IPCC), which support the high-level decision making with up-to-date information; RCM data provides information about the regional climate change features for local impact assessments. Copernicus C3S will

gather all the available and scientifically sound information into the Climate Data Store (CDS) to serve as a primary database for various users. Regarding regional climate projections its primary basis will be the existing dataset of CORDEX covering Europe. The main objective of this data inventory is to provide a compact technical and scientific guideline for the potential users of CDS on applying the CORDEX outputs and later the CDS data. Five CORDEX-domains are investigated in detail which cover Europe partly or entirely: EURO-CORDEX, MED-CORDEX, MENA-CORDEX, Central Asia CORDEX and Arctic-CORDEX. Our main focus is on the EURO-CORDEX database, as it is the most comprehensive and well documented dataset utilizing the recent scenario family and its domain covers the entire continent. A large amount of information is collected to the report and filtered from the users' perspective with provision of references to further interests. The database is evaluated based on the following aspects: data accessibility, involved RCM-GCM combinations, available ensemble members, spatial resolution of the outputs, time horizon of the model experiments, applied emission scenarios, available meteorological variables, the frequency of the outputs stored in the archive, the uncertainty range covered by the ensemble and existence of bias-adjusted data. Assessment of the quality of the different models and their results (i.e., model validation) is beyond the scope of the data inventory, nevertheless, we provide some hints on this issue in the literature review.

There are six European data nodes available hosting CORDEX data for various regions: CEDA, DKRZ, DMI, IPSL, CNRM, NSC/LIU. Four of these also act as index nodes, i.e., the web portal where search can be carried out. All nodes contain exactly the same amount of data and offer a uniformed interface for download. Thus no recommendation is given on the site of the 4 nodes as best one. Should one be interested in bias adjusted data, the IPSL node offers them straightforwardly along with the raw CORDEX RCM simulation outputs (this might be the most convenient way of accessing both raw and post-processed outputs).

Twelve European institutions contributed to the EURO-CORDEX dataset with results of 11 RCMs. Lateral boundary conditions for them were provided by the ERA-Interim re-analysis in the evaluation experiments and by 10 different GCMs in the projections. 3 RCMs have only ERA-Interim driven experiment without further projection runs. On the 0.44-degree resolution (EUR-44) grid, altogether 8 RCMs were driven by 10 GCMs resulting in 18 simulations. A somewhat smaller amount (15) of experiments was conducted on the 0.11-degree resolution (EUR-11) grid with combination of 7 RCMs and 5 GCMs. RCA4 is the only regional model coupled to at least 5 GCMs; while among the GCMs, CNRM-CM5, EC-EARTH, MPI-ESM-LR provide forcings broadly. The most frequently used ensemble member for projections is r1i1p1.

Evaluation experiments commonly cover the period of 1989–2008. Control parts of the projections (historical simulations) start between the years 1951 and 1971 and continue uniformly until 2005. Most scenario runs cover the 21st century, apart from the HadGEM2-ES driven experiment (running only until 2099). Three scenarios are applied: RCP2.6, RCP4.5 and RCP8.5. RCP8.5 and RCP4.5 scenarios are uniformly used in the projections, while RCP2.6 is the least used scenario, employed in 7 EUR-44 and 5 EUR-11 simulations.

The dataset chiefly consists of surface data, but most simulations provide horizontal wind components, temperature and geopotential heights on 850 hPa, 500 hPa, 200 hPa pressure levels, as well. Model level variables are not stored, while constant fields of model orography and land-sea fraction (ratio of land to ocean areas over a grid cell) can be downloaded for all EURO-CORDEX projections. Data are archived mainly with monthly and daily output frequency. Daily precipitation sum, daily mean near-surface air temperature, daily minimum and maximum temperature data are available for all simulations. Taking also the surface wind components, specific humidity, sea level pressure, global radiation, cloudiness, and snowfall, the number of models with daily outputs is reduced to 15 and 9 over EUR-44 and EUR-11, respectively.

Bias adjustment brings new component of uncertainty into the projections originating from the choices regarding the method, the reference dataset and the calibration period. In EURO-CORDEX six methods (mostly based on quantile mapping) are applied with three different observational datasets and the corresponding calibration periods. On the EUR-44 grid, bias adjusted data are available from 26 RCM-GCM combinations, while from 24 ones on EUR-11, mainly for the r1p1i1 ensemble members. Post-processing was employed for the whole time period on which the raw data can be downloaded. The datasets are available for three different RCPs whereas the most data are accessible for RCP4.5 scenario. The bias adjustment was applied primarily for daily precipitation and daily minimum, maximum and mean temperature values. In the case of some EUR-11 simulations, some methods were applied for the 3-hourly radiation and surface wind.

Evaluating the occurrence of daily surface, pressure-level and radiation atmospheric variables from climate projections conducted with all the 3 representative RCP scenarios on 0.44-degree resolution, a 7-member ensemble can be designed. This ensemble consists of 4 members over the EUR-11 grid. If bias adjusted data are also requested, the ensemble size further decreases to 2 members consisting of RACMO22E and RCA4, both driven by HadGEM2-ES on EUR-44, and to 1 member of REMO2009 driven by MPI-ESM-LR on EUR-11. Not requiring the RCP2.6 scenario (nor the bias adjusted data), 5 and 7 extra RCM simulations are added to the selections, resulting in 14- and 9-member ensembles per RCPs over EUR-44 and EUR-11, respectively.

This selection does not represent any qualitative assessment of the model outputs and does not give any information on model skills. Nevertheless, to judge the independency of the RCM simulations in the resulted ensembles, evaluation of the applied RCMs and GCMs as well as of their outputs are needed.

During the assessment of the CORDEX datasets, several technical difficulties and gaps were concluded. Many of them are related to the browsing method and the documentation, both having key importance for the users:

- Some GCMs are overrepresented and some of them are underrepresented in the EUR-44 and EUR-11 ensembles. Overrepresentation can be concluded also for some RCMs. Therefore, a deep assessment is needed regarding the independency of the available RCM simulations and every choice has to be done considering the user objective.
- RCP2.6 scenario is underrepresented (due to the limited availability of GCM runs), forcing the users to analyse basically two future paths.
- Selection possibility for time horizon is missing from the search options on ESGF. One must dig into each metadata information to find out which collection has "followed" the suggested time horizons by the syntax. Scenario runs driven by HadGEM2-ES go until 2099.
- Sub-daily outputs are basically not stored in ESGF. Access to these data has to be organized bilaterally between data user and data provider.
- The Ensemble Member facet is used in CMIP5 to distinguish between several GCM simulations done with the same model, i.e., members of a single-model GCM ensemble. For CORDEX this only serves to distinguish between driving simulations in cases where there are more than one for a model in CMIP5. There is no meaning in using ensemble member names across GCM models.
- The vertical resolution of atmospheric data is quite coarse, containing only 3 pressure levels: 850 hPa, 500 hPa and 200 hPa. To fulfil further requests, future extension of ESGF storage capacity should be considered.
- Bias adjusted data are available only for EURO-CORDEX data on ESGF.
- MED-CORDEX data are not stored on ESGF, but in a different database with a very simple browsing possibility. Metadata are sometimes incomplete in this portal.
- Territory of Turkey is located in the vicinity of the border in all the available CORDEX domains. This issue can be handled with definition of a new domain.

1 Introduction and motivation

1.1 Motivation

In the last half century more and more sophisticated models were developed to describe the individual components of the Earth system and also to take into account the highly non-linear links and feedbacks between these subsystems (Taylor et al., 2012). Due to the rapid scientific, technical and algorithmic evolution of the models and the available enhanced computer power, the horizontal resolution of the global general circulation models (GCMs) developed and exploited by the largest world climate centres reaches nowadays the 100 km range. These models are continuously improving, providing solid basis and realistic projections for the synoptic scale characteristics of the climate, however, they are not sufficient for detailed regional scale estimations. To obtain more information about the regional climate change aspects, high-resolution regional climate models (RCMs) can be used for dynamical downscaling of global fields.

Regional models are focusing on a limited area (e.g., on Europe) with finer horizontal resolution, and the large-scale processes are taken into account by the forcings provided by the global results. Limited area models have already been widely and successfully used in the short-range weather forecast for many decades. Their employment for climate purpose was arisen in the late 1980s. The first climate simulation with a regional climate model, which was developed on the basis of a weather forecasting model, was carried out by Giorgi and Bates (1989). The RCM was nested into a global climate simulation, which provided the initial and lateral boundary conditions (LBCs) for the experiment. The regional model reproduced realistically the synoptic scale climate features specified by the LBCs and reflected accurately the regional climate statistics due to its finer resolution, better representation of the surface characteristics and mesoscale processes. Positive results gave green light for the wide-range employment of limited area models in climate simulations.

In spite of the advantages of RCMs, their simulation results still suffer from multiple deficiencies varying usually from one model to other one. Therefore, at the design of projections, it is crucial to consider not only a single, but also several simulations of various models, because only the ensemble approach provides appropriate tool to specify the uncertain (and certain) aspects in the projections.

The first international collaboration, which aims at providing climate projections over Europe with relatively high (mostly 50 km) resolution, was the PRUDENCE project (Predicting of Regional Scenarios and Uncertainties for Defining European Climate Change Risks and Effects, Christensen et al., 2007). Its main scientific objective was to characterize the reliability of the regional climate change projections for

2071–2100, with distinction of the variabilities coming from the differences between the regional models (model uncertainty) and the internal variability of the climate system. Numerous simulations were carried out with a range of global and regional climate models using two basically different IPCC SRES (Nakicenovic et al., 2000) A2 and B2 emission scenarios. The RCM outputs of the PRUDENCE project have been directly accessible from the project's web page (http://prudence.dmi.dk) since 2004. Most simulations in PRUDENCE used one specific GCM simulation (HadAM3H).

PRUDENCE was followed by the ENSEMBLES EU FP6 (Sixth Framework Programme of the European Union) initiative in 2004. A multi-model RCM system has been developed and applied for Europe (van der Linden and Mitchell, 2009) at 25 km horizontal resolution using the medium SRES A1B emission scenario. This set of simulations makes possible to investigate the impact of the model uncertainty to the climate change signal with assuming the same evolution of the future anthropogenic activity. The data are available and downloadable since 2009 from the ENSEMBLES data server (http://ensemblesrt3.dmi.dk).

CORDEX, the COordinated Regional Downscaling Experiment, was conceived during the ENSEMBLES project by many researchers. It was launched as an initiative through an article in the WMO Bulletin 2009 (Giorgi et al., 2009) and presented as follows: "CORDEX essentially has the twofold purpose to provide a framework to evaluate and benchmark model performance (model evaluation framework); and design a set of experiments to produce climate projections for use in impact and adaptation studies (climate projection framework)." In the ENSEMBLES project, the participating regional climate modelling institutions successfully coordinated the definitions of integration domains and created a database of directly intercomparable model simulations following the SRES A1B emission scenario. In the CORDEX project, this is extended to the entire world, simultaneously increasing the number of global and regional models, and using the modern RCP scenarios (Representative Concentration Pathways; Moss et al., 2010).

Not only the regional climate model simulations have developed, but the user needs have also evolved and extended in the last decades. RCM outputs are applied in several areas: e.g., they serve as input to the next assessment report of the Intergovernmental Panel on Climate Change (IPCC), which support the high-level decision making with up-to-date information; RCM data provides information about the regional climate change features for local impact assessments. Copernicus C3S will gather all the available and scientifically sound information into the Climate Data Store (CDS) to serve as a primary database for various users. Regarding regional climate projections its primary basis will be the existing dataset of CORDEX covering Europe. The main objective of this data inventory is to provide a compact technical and scientific guideline for the potential users of CDS on applying the CORDEX outputs and later the CDS data. A large amount of information about CORDEX is collected to the report and filtered from the users' perspective with provision of references to further interests. Five CORDEX-domains are investigated in detail which cover Europe partly or entirely. Our main focus is on the EURO-CORDEX database, as it is the most comprehensive and well documented dataset utilizing the recent scenario family and its domain covers the entire continent. The database is evaluated based on the following aspects: data accessibility, spatial resolution of the outputs, time horizon of the model experiments, applied emission scenarios, available meteorological variables, the frequency of the outputs stored in the archive, the uncertainty range covered by the ensemble and existence of bias-adjusted data. Assessment of the quality of the different models and their results (i.e., model validation) is beyond the scope of the data inventory, nevertheless, we provide some hints on this issue in the literature review.

The deliverable is structured as follows: this motivation part is followed by an overview of the CORDEX programme, and the introduction section is closed with a literature review about the investigations carried out based on the CORDEX data focusing on EURO-CORDEX studies. Section 2 is dedicated to the approach used in the data inventory: first, the investigated CORDEX domains and the available experiments are described, thereafter, we give an overview about the "tool" of the evaluation, i.e., the evaluation matrix is introduced. Section 3 presents the results and outcomes of the assessment of the chosen CORDEX datasets with special focus on EURO-CORDEX database, while different parts of the evaluation matrix are provided in the Appendix. In Section 4, possible selections of ensembles composed of EURO-CORDEX simulations are shown for Copernicus C3S Climate Data Store; identified gaps are also discussed here, and we give a proposal for the content of a guideline supporting the potential users of CDS. The report is closed by summary of the main conclusions.

1.2 The CORDEX initiative

Climate impact assessments and the development of regional to local-scale adaptation strategies require high-resolution climate change scenarios, including an assessment of their robustness and their inherent uncertainties. The CORDEX initiative (http://cordex.org) of the World Climate Research Programme (WCRP) provides a framework to improve regional climate scenarios with harmonisation of model evaluation activities in the individual modelling centres (Jacob et al., 2014). Important objectives were to better understand relevant regional and local climate phenomena and to generate ensembles of regional climate projections worldwide, but especially for the regions not covered with high-resolution climate change scenarios. Special effort was dedicated to the communication and knowledge exchange with users of regional climate information.

Currently, 14 domains are designed in CORDEX, a sketch is shown in Figure 1. In general the resolutions of CORDEX areas are of the order of 50 km. For Europe, where particularly the EURO-CORDEX collaboration is very active, an integration area of 12.5 km resolution has also been used. A common set of output fields and sampling frequencies were defined along with a detailed data file format protocol based on NetCDF and the CF convention. The simulations, which have been voluntarily provided by many groups across the world, are in general freely accessible through the cloud-based interface of ESGF (Earth System Grid Federation; originally developed for the use of CMIP5 global model data), which allows users to access specific fields and sub-regions easily even if the requested data are actually stored on several data servers. Currently data from 23 different RCM model versions and 13 different GCM model versions plus the ECMWF ERA-Interim reanalysis are accessible in the ESGF archive. A total of 96 different simulations (estimated by the availability of RCP8.5 daily surface temperature data) are in the archive.

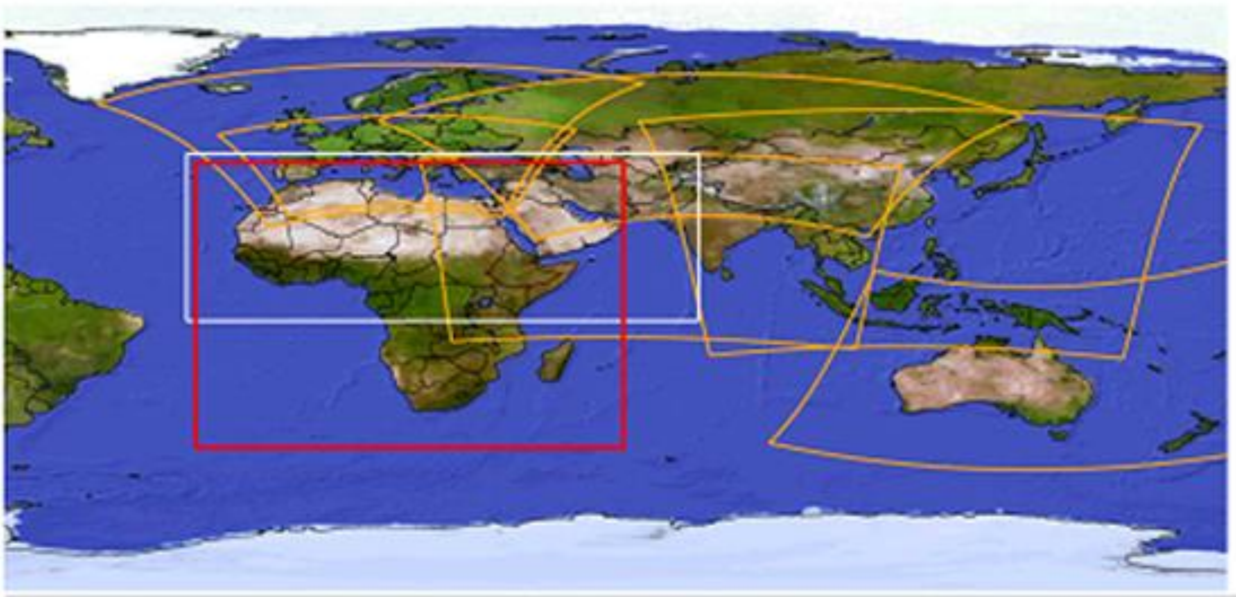

Figure 1: Selection of 8 CORDEX domains.

The standard CORDEX datasets consist of fields at temporal resolution of seasons, months, days, and sub-daily intervals of 3 or 6 hours. Seasonal and monthly data are referred to as “core” data, daily as “Tier 1” and sub-daily as “Tier 2”. The sub-daily data are not planned to be available in the ESGF network due to the large demands on server disk space and bandwidth. Access to Tier-2 data should be organized bilaterally between data user and data provider (i.e., the institution performing the simulation). In the standard variable list, there are 44 core fields and 60 Tier-1 fields.

Today CORDEX has the status as a major WCRP project similarly to CliC, CLIVAR, GEWEX, and SPARC (https://www.wcrp-climate.org/learn-core-projects). There is no funding directly associated with CORDEX, but currently 17 different institutions or institutional collaboration units have performed CORDEX simulations and provided data to the network. A CORDEX project office at SMHI in Sweden takes care of organizational matters and an international 12-member Scientific Advisory Team (SAT) takes decisions. CORDEX-SAT promotes greater interactions between climate modellers, downscalers and end-users to better support adaptation activities and to better communicate the scientific uncertainty inherent in climate projections and downscaled products.

In the recent CORDEX 2 framework, focus has shifted towards more science-based questions. At the same time, it was recognised that addressing these scientific challenges might be problematic within the general CORDEX framework that employs standard sets of simulations for large domains. Thus more targeted experimental set-ups, called “Flagship Pilot Studies (FPS)” have been developed. The FPS are focusing on sub-continental-scale target regions, so as to allow a number of capabilities towards addressing key scientific questions motivated by several issues. For instance, many European modelling centers are involved in FPS on convection-permitting climate modelling and in FPS on investigation of land use change impacts (LUCAS; Land Use and Climate Across Scales).

1.3 Literature review on assessments of CORDEX datasets

The framework of the international CORDEX initiative, including a specification of the simulation domains, has been presented in Giorgi et al. (2009). The MED-CORDEX initiative was discussed in Ruti et al. (2011), while the EURO-CORDEX dataset was introduced by Jacob et al. (2014).

The performance of the RCMs participating in CORDEX has been widely assessed. An ensemble of seven EURO-CORDEX RCMs driven by ERA-Interim re-analyses was evaluated by Kotlarski et al. (2014). That work confirmed the ability of these RCMs to capture the basic features of the European climate, but deficiencies were still found. Seasonally averaged temperature biases were generally smaller than 1.5°C, but for precipitation, biases up to ±40 % occurred. For seasonal mean quantities averaged over large European sub-domains, the biases proved to be of a similar magnitude regardless of the spatial resolution used in the RCM runs. Analogously, Vautard et al. (2013) concluded that a high resolution in the EURO-CORDEX RCMs is not unequivocally beneficial for a realistic simulation of heat waves. By contrast, Prein et al. (2015) reported an improvement in the mean and extreme daily and sub-daily precipitation simulated with high-resolution RCMs, explained with the better representation of orography and the better simulation of convective processes.

Considering the future projections, Jacob et al. (2014) showed that changes in annual mean temperature were substantially larger in EURO-CORDEX RCM simulations under the RCP8.5 scenario than under RCP4.5. This inter-scenario difference was evident also in temperature-based climate indices, but indices describing drought and heavy precipitation were less sensitive to the RCP scenario. As expected, daily precipitation intensities were far larger in the CORDEX RCM simulations compared to the corresponding global model simulations. Ruosteenoja et al. (2016) also compared the signals provided by the RCMs and driving GCMs for Finland. They found stronger winter and weaker summer warming signal in the RCM results, in average, less precipitation increase and solar radiation.

EURO-CORDEX data have been intensively used in impact studies. In Alfieri et al. (2015), an ensemble of seven EURO-CORDEX RCM runs under the RCP8.5 scenario was used to drive a hydrological model in order to assess changes in flood risks in Europe during the 21st century. Meresa et al. (2016) estimated the drought occurrence for ten selected Polish catchment areas representing different hydro-climatic conditions. Tobin et al. (2016) provided an estimation for changes in the conditions of the European wind energy production.

Not only EURO-CORDEX outputs, but also data from other CORDEX co-operations are intensively used and assessed. Arctic area was in the focus of Koenigk et al. (2015), who found a pronounced warming, exceeding 15°C in autumn and winter, substantially increased precipitation, weaker wintertime inversions leading to a less stable stratification in the lower atmosphere under RCP8.5. Wawrzyniak (2016) reported a considerable increase for winter temperature and precipitation in Spitsbergen by 2071–2000 under RCP8.5. Ayar et al. (2016) compared the performance of statistical and dynamical downscaling over the MED-CORDEX region. The results indicated that some properties of rain occurrence and intensity are better modelled by statistical downscaling, while spatial and temporal variability is better described by the RCMs. Bucchignani et al. (2015) evaluated the performance of COSMO-CLM RCM over the CORDEX-MENA domain using various combinations of physical parameters. The model proved to be very sensitive to changes in the parameters, and the simulated climatic features were improved by an optimized configuration. The performance of RegCM RCM has been also assessed by Almazroui et al. (2016) over MENA region and by Ozturk et al. (2016) over the Central Asian area.

2 Methodology

2.1 Investigated CORDEX domains

Currently 14 domains are defined within the CORDEX initiative, however, due to the objectives of the DECM project, the assessment is limited to areas covering partly or entirely the European continent resulting in the following 5 domains:

1. Europe in EURO-CORDEX;
2. The Mediterranean region in MED-ORDEX;
3. Middle East and North Africa in MENA-CORDEX;
4. Central Asia in Central Asia CORDEX;
5. The Arctic region in Arctic-CORDEX.

CORDEX domains are defined on grids applying rotated-pole coordinate systems with various horizontal resolutions and in some cases the model outputs are available also on regular (non-rotated) latitude-longitude grids. These non-rotated grids have boundaries at whole-number degrees of longitude and latitude, and have roughly the same resolution as the rotated grid (Christensen et al., 2014). The assessed CORDEX domains can be seen in Figure 2 and their main parameters (grid spacing, coordinates of their corners) are listed in Table 1. The actual model integration domains are larger than these areas because of the relaxation and extension zones.

Table 1: Characteristics of the investigated CORDEX domains: resolution in degree (column 3), regular coordinates of corners (last 4 columns; TLC, TRC, BLC, BRC: top left, top right, bottom left and bottom right corners, respectively).

CORDEX domain	Name	Resolution	TLC	TRC	BLC	BRC
EURO-CORDEX	EUR-44	0.44	315.86; 60.21	64.4; 66.65	350.01; 22.20	36.30; 25.36
	EUR-11	0.11				
MED-CORDEX	MED-44	0.44	339.79; 50.65	50.85; 52.34	353.96; 25.63	38.33; 26.73
	MED-11	0.11				
MENA-CORDEX	MNA-44	0.44	333.0.; 45.0	76.0; 45	333.0; -7	76.0; -7
	MNA-22	0.22				
Central Asia CORDEX	CAS-44	0.44	11.05; 54.76	139.13; 56.48	42.41; 18.34	108.44; 19.39
Arctic-CORDEX	ARC-44	0.44	214.68; 55.43	140.59; 52.53	324.82; 52.0	40.35; 46.06

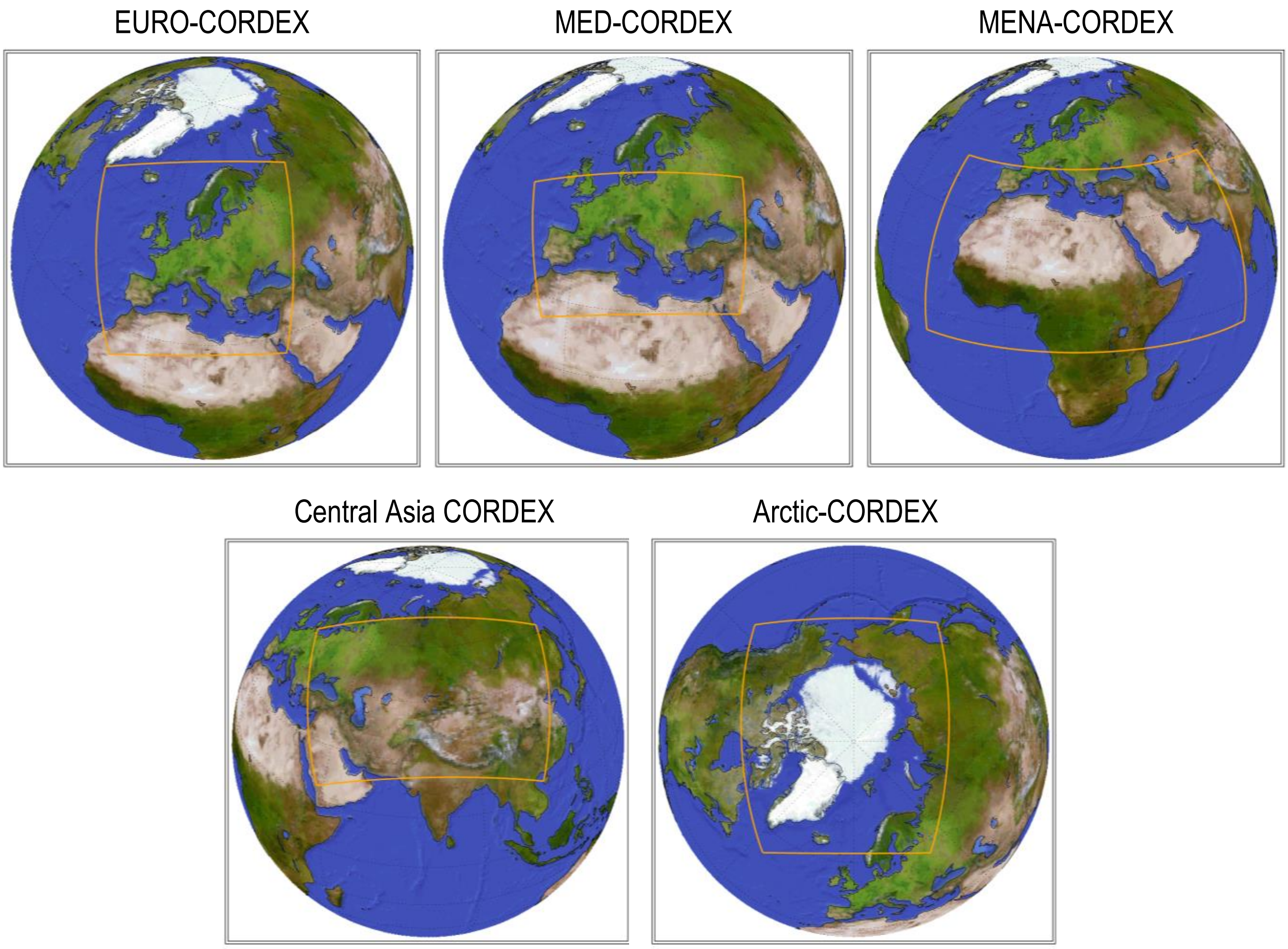

Figure 2: Domains of the investigated CORDEX branches.

2.2 Experiment types in CORDEX

CORDEX experiments provide a large set of regional climate model information resulted by dynamical downscaling of global climate estimations. The RCM outputs are derived from two kinds of simulations:

- Evaluation experiments: Initially, simulations for the past climate were carried out in order to validate the performance of RCMs for a multi-decadal period covered by observations. Lateral boundary conditions were provided by ERA-Interim re-analysis data [created by optimal combination of observational information and short-range numerical predictions using data assimilation techniques (Berrisford et al., 2011)], so the integrations started in 1979. Due to the measurement-based drivings, validation of these experiments shows the deficiencies mainly originating from the regional climate models and serves valuable information to their further improvements.

- Projection experiments: In the ensuing model simulations, the large-scale constraints were ensured by global climate models instead of re-analyses. These experiments consist of two parts: (i) control runs are carried out for the past lasting until 2005 and their validation produces combined information about both the global and regional model deficiencies; (ii) scenario experiments cover the 21st century starting in 2006. The atmospheric concentrations of greenhouse gases follow the observed values until the end of 2005 and from 2006 the concentrations are prescribed as in the RCP scenarios. By evaluating the projection results, the regional climate change can be estimated across a wide range of future greenhouse gas emission scenarios.

2.3 Investigated aspects

CORDEX data are analysed and sorted according to their relevance, usability, accessibility and limitations with respect to their current and future level of usage. This evaluation is focusing on the aspects below:

- Accessibility: Data acquisition is not generally a straightforward part of the assessments. Within the ESGF, basically 4 nodes are available for data search and data download. Data are stored in the NetCDF format, while metadata is available in a text format. Some difficulties make the work with data complicated, e.g., in certain cases it is challenging to narrow the data search, especially in case of MED-CORDEX, data of which are archived on different system (not on ESGF) with a very simple browsing method. In the present data inventory, we are collecting the drawbacks of the search engine of ESGF.
- RCM-GCM combinations: The performance of RCMs are strongly influenced by the lateral conditions, coming from the driving GCMs in practice. Consequently, uncertainty range covered by the RCM projections partly depend on the applied global models. In the inventory, we assess how wide the range of the driving GCMs is and how many RCMs are used in the ensemble.
- Spatial grid and resolution: The horizontal resolution – defined as the horizontal distance between two adjacent grid points – is a key parameter that determines the level of spatial details in model results. The parameter consists of the resolutions along the longitudes and latitudes, however, in CORDEX these two values are equal in every applied grid type. Horizontal resolution can also be a limiting factor in the applicability of model results, since some impact assessment methods require a certain minimal resolution for climate data to be used as input. Climate models provide information not only at the surface, but also in the whole three-dimensional atmosphere, and thus the availability of pres-

sure level and model level data is evaluated, as well. Within CORDEX atmospheric information is given on pre-defined pressure levels (850, 500 and 200 hPa). Some applications require the model orography and the land area fraction (ratio of land to ocean areas within a grid cell) paired with the climate data, and therefore, the availability of these two time-independent fields is also inspected for each CORDEX model. Additionally, it is also examined if there is any European country which is not covered well by any of the CORDEX domains.

- Available ensemble members: Both in case of evaluation runs and projection runs, sometimes several GCM ensemble members are available with the same model instead of a single model run (4 out of 13 GCM model versions). However, these ensemble members are related to the downscaled global climate model simulations, not to the RCM experiments. The individual members carried out with the given global model are distinguished from each other with a code formed from the letters “r”,”i” and “p” paired with three integer numbers, e.g., r1i1p1. The first letter “r” stands for realization number. Different realization numbers show simulations initialized with different but equally realistic initial conditions, for example from different dates. The second letter, “i” represents the initialization method. This refers to simulations initialized with different methodology, for instance by using different observational data. The third letter “p” stands for perturbed physics ensembles, meaning experiments with different physical parameterization settings.
- Time horizon: In the data inventory, the focus is put on projections, therefore, we are categorizing the CORDEX ensemble mostly under control runs until 2005 and RCP-scenario runs from 2006 (as it was also concluded based on personal communication with the Copernicus C3S representatives in the project kick-off meeting). The ERA-Interim driven evaluation experiments uniformly cover the period of 1989–2008, and they can go beyond this period.
- Scenario uncertainty: Scenario runs produce information to investigate the effects of anthropogenic climate change. The chosen emission scenario is a key source of projection uncertainty, so the availability of model runs with different scenarios is crucial to fully cover the uncertainty cascade of the future model results. It is essential to use as many data as possible and scientifically solid. There are three RCP scenarios used within the investigated CORDEX model runs: RCP4.5 (“optimistic”) and RCP8.5 (“pessimistic”) scenarios, additionally, there is a highly idealistic scenario (RCP2.6). To quantify scenario uncertainty at different levels, we are selecting several sets of the available runs.

- Temporal resolution: The highest accessible temporal resolution of the CORDEX model outputs is daily data, sub-daily data are archived in ESGF only for a limited number of simulations. For most user needs and for investigating future tendencies of extremes, daily resolution might be sufficient. Furthermore, the monthly outputs and seasonal climatological means are based on daily sums and averages. User requirements concerning the model output frequency are related to the meteorological variables, consequently, we handle this issue together with the aspects of available variables. In the evaluation we are dealing also with time-independent variables (like orography).
- Available variables: In the current work, atmospheric and land surface variables are analysed. The subject of the investigation was simply the availability or absence of the most frequently used and most important variables, providing also their (monthly, daily, etc.) archive frequencies. Numerous applications require more than one meteorological variables from the same model simulation (e.g., near-surface temperature and precipitation), thus the joint existence of certain variables might provide useful information, as well. For this reason, several "variable packages" were defined (detailed information in Section 3.1.8) and their availability was also evaluated for each model simulation.
- Bias adjusted data: Impact researchers prefer climate model data without systematic errors, and several bias adjustment methods are available for the regional climate model data. On the ESGF under the project name CORDEX-Adjust, there are adjusted simulations for EURO-CORDEX available. The bias adjustment will be extended to other CORDEX regions and probably published at ESGF.

2.4 Construction of the evaluation matrix

Based on the investigated aspects, the available models and the focus of the data inventory, a categorization method was designed on the CORDEX simulations which supports to get a quick and objective overview about the main conclusions. An "evaluation matrix" (EM) is defined in which every single model run is scrutinized if it fulfils the specified criteria; e.g., which anthropogenic scenarios were applied for the simulations with the given model (Table 2). The most valuable part of this evaluation matrix is its summarizing part, providing information about the number of ensemble members in a given category. These values represent the numbers of the simulations in the ensembles and do not include the available parallel realizations of the same global model (although it is also assessed separately). To assess the different aspects of EM together in a summarized way, some multi-criteria filtering methods were also presented with the aim of giving some guidance on choosing a climate model ensemble for a general purpose. For instance, such kind of multi-criteria is that all the important atmospheric variables and two representative anthropogenic scenarios should be available (Table 3). All parts of evaluation matrix can be found in Appendix of the deliverable.

Table 2: Part of the evaluation matrix: available scenario runs with given spatial resolution in CORDEX model simulations as categorized in the evaluation matrix.

EUR-11	**RCM**-GCM chains															
	CNRM-CM5	CNRM-CM5	EC-EARTH	HadGEM2-ES	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CNRM-CM5	EC-EARTH	IPSL-CM5A-MR	HadGEM2-ES	MPI-ESM-LR	MPI-ESM-LR	IPSL-CM5A-MR	
Experiments	**ALADIN53**	**CCLM4-8-17**				**HIRHAM5**	**RACMO22E**		**RCA4**					**REMO2009**	**WRF331F**	**Total number**
Historical	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
RCP2.6	x					x		x		x				x		**5**
RCP4.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
RCP8.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**

Table 3: An example for multiple criteria regarding available variables (the pre-defined *extended basic*, *radiation* and *pressure level packages* with daily outputs) and scenario runs (with both RCP8.5 and RCP4.5) applied on the investigated 0.11-degree resolution EURO-CORDEX model simulations in the evaluation matrix.

Extended basic + Radiation + Pressure level
0.11° horizontal resolution (EUR-11)
historical + RCP8.5 + RCP4.5
HIRHAM5 - EC-EARTH
RACMO22E - EC-EARTH
RACMO22E - HadGEM2-ES
RCA4 - CNRM-CM5
RCA4 - EC-EARTH
RCA4 - IPSL-CM5A-MR
RCA4 - HadGEM2-ES
RCA4 - MPI-ESM-LR
REMO2009 - MPI-ESM-LR
Number of simulations: 9

3 Thorough assessment of CORDEX datasets

3.1 EURO-CORDEX

3.1.1 Accessibility

There are six European data nodes available hosting CORDEX data for various regions: CEDA, DKRZ, DMI, IPSL, CNRM, NSC/LIU. Four of them also act as index nodes, i.e., the web portal where search can be carried out. The direct links to them are the following:

1. CEDA: https://esgf-index1.ceda.ac.uk/search/cordex-ceda, in the United Kingdom;
2. DKRZ: https://esgf-data.dkrz.de/search/cordex-dkrz, in Germany;
3. IPSL: https://esgf-node.ipsl.upmc.fr/search/cordex-ipsl, in France;
4. LIU: https://esg-dn1.nsc.liu.se/search/cordex, in Sweden.

All nodes contain identical lists of all available data and offer a uniform interface for facetted search and download. Thus, no recommendation is given on the site of the 4 nodes as best one.

Tailoring the search is very straightforward for most cases, but here is an example on the DKRZ node how to find data on heatwaves change. To browse in the 0.11-degree resolution EURO-CORDEX experiments, after entering DKRZ search page, choose “CORDEX” and “EUR-11” options under “Project” and “Domain” menu points, respectively (Figure 3). Selecting “Show All Replicas” option is not needed to find all available data for the investigated regions. When picking “Show All Versions”, only for WRF331F has more than one uploaded version added online for historical and scenario runs. Supposed that the impact of different anthropogenic scenarios is of interest, one must click “historical”, “rcp45” and “rcp85” options under the “Experiment” point. Heatwaves are presented on a daily basis that can be set at the point of “Time frequency” and it is based on a near-surface air temperature, so “near-surface air temperature (165)” is set under the “Variable long name”. If a user prefers to concentrate on a single model, the applied RCM with given forcing has to be chosen. After this, the desired variables (“tas” in our case) must be selected under the results of the historical and RCP experiment group of files by using the “Show Files” option, and then to click on the “HTTPServer” link for direct download. Some institutions split their runs into time slices, therefore, all of them must be gathered to fully cover the requested time horizon.

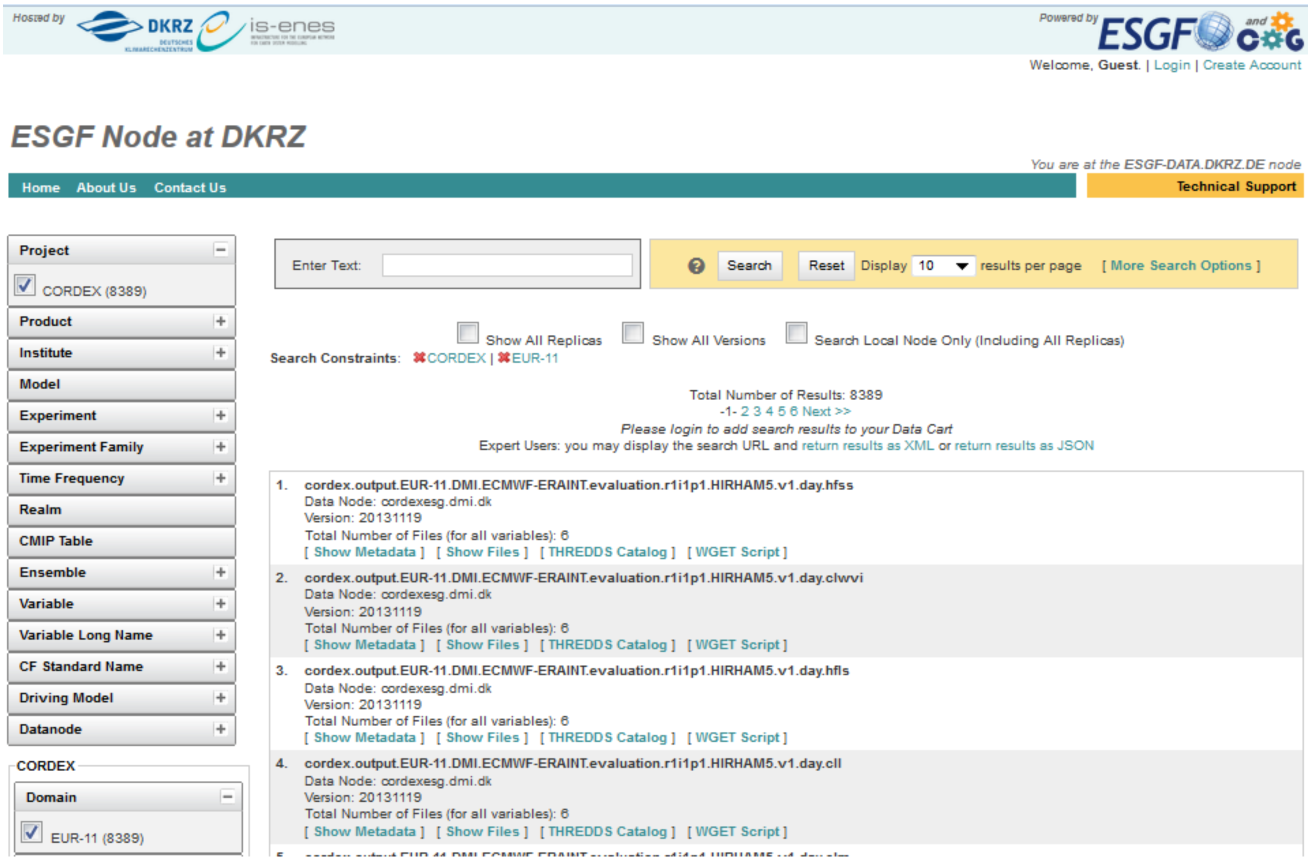

Figure 3: Search options in the DKRZ node of ESGF.

Should one be interested in bias adjusted data, the IPSL node offers them straightforwardly along with the raw CORDEX RCM simulation outputs (this might be the most convenient way of accessing both raw and post-processed outputs). On the other three nodes, bias adjusted files can be reached via a different website and through a slightly modified search interface along with various data related to other projects:

1. CEDA: https://esgf-index1.ceda.ac.uk/search/esgf-ceda;
2. DKRZ: https://esgf-data.dkrz.de/search/esgf-dkrz;
3. LIU: https://esg-dn1.nsc.liu.se/search/esgf-liu.

To retrieve the bias adjusted EURO-CORDEX data files, one should choose “CORDEX-Adjust” option under the “Project” (Figure 4). Selecting “All replicas” or “All versions” does not provide extra data, and all nodes contain identical number of files.

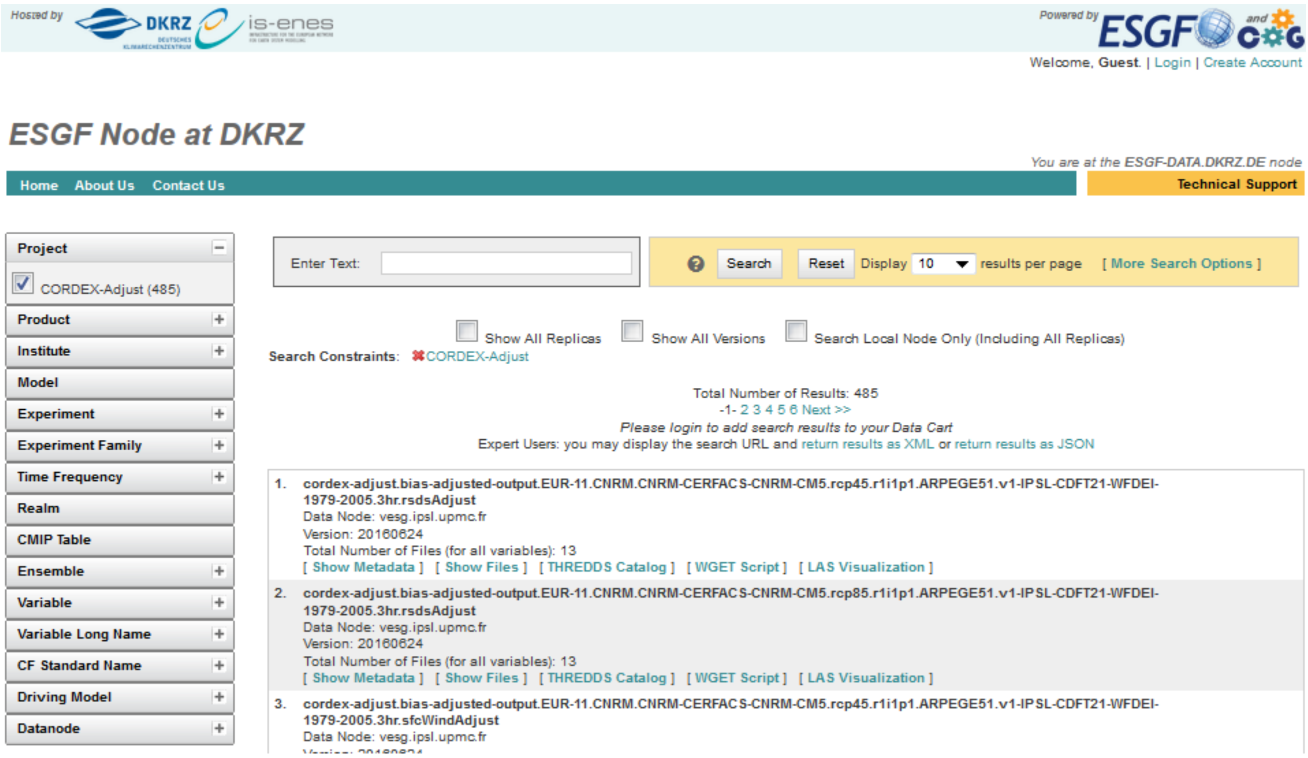

Figure 4: Search options for bias adjusted data in the DKRZ node of ESGF.

3.1.2 RCM-GCM combinations

To the EURO-CORDEX (http://www.euro-cordex.net) dataset 12 European institutions contributed with results of 11 RCMs (Table 4). Lateral boundary conditions for them were provided by the ERA-Interim re-analyses in the evaluation experiments and by 10 different GCMs in the projections. 3 RCMs have only ERA-Interim driven experiment without further projection runs. On the 50 km resolution (EUR-44) grid, altogether 8 RCMs were driven by 10 GCMs resulting in 18 simulations. Smaller amount of simulations was conducted on the finer resolution (EUR-11) grid with combination of 7 RCMs and 5 GCMs. The full RCM-GCM chain can be seen in Table 7 in the Appendix. Most simulations are performed on both resolutions, solely ALADIN52 RCM was not used on EUR-11. On the contrary, RCA4 is the only regional model coupled to all GCMs over the EUR-44 grid, and in EUR-11 it is still driven by 5 global models (CCLM4-8-17 is the second widely used RCM with 4 different LBCs).

Uncertainties of RCM results principally depend on how widely the global models are applied. EC-EARTH is the most represented GCM in EUR-11 with 4 RCMs, while CNRM-CM5, EC-EARTH, MPI-ESM-LR are providing forcings equally broadly in EUR-44. Regrettably, the outputs of CanESM2, CSIRO-Mk3-6-0, GFDL-ESM2M, MIROC5, NorESM1-M global models are only applied in EUR-44.

Table 4: List of EURO-CORDEX models with responsible institutes and references.

	Model	Institute	Reference
1.	ALADIN52	Hungarian Meteorological Service (Hungary)	Herrmann et al. (2011)
2.	ALADIN53	Météo France (France)	Colin et al. (2010)
3.	CCLM4-8-17	CLM Community with contributions by Brandenburg University of Technology (Germany), German Climate Computing Centre (Germany), Swiss Federal Institute of Technology in Zürich (Switzerland)	Rockel et al. (2008)
4.	HIRHAM5	Danish Meteorological Institute (Denmark)	Christensen et al. (2006)
5.	HadGEM3-RA	Met Office Hadley Centre (UK)	Jones et al. (2004)
6.	HadRM3P	Met Office Hadley Centre (UK)	Murphy et al. (2009)
7.	RACMO22E	Royal Netherlands Meteorological Institute (The Netherlands)	Meijgaard van et al. (2012)
8.	RCA4	Swedish Meteorological and Hydrological Institute (Sweden)	Kupiainen et al. (2011)
9.	REMO2009	Climate Service Center Germany (Germany)	Jacob et al. (2012)
10.	RegCM4-2	Croatian Meteorological and Hydrological Service (Croatia)	Giorgi et al. (2012)
11.	WRF331F	Institut Pierre Simon Laplace (France)	Skamarock et al. (2008)

3.1.3 Spatial resolution

The EURO-CORDEX domain covers the entire European continent and the Northern coast of Africa (first panel of Figure 2). Turkey is located in the vicinity of the eastern domain border, which is not an ideal position because RCM results can be hampered by the numerical noises originating from LBC treatment. If we look at the other four domains covering a part of Europe, we can conclude that Turkey is situated similarly in each case.

Data are available on 4 grid types with different spatial resolution:

- **EUR-44** is a rotated latitude-longitude grid with 0.44° (approx. 50 km) horizontal resolution;
- **EUR-11** is a rotated latitude-longitude grid with 0.11° (approx. 12 km) horizontal resolution;
- EUR-44i is a regular (non-rotated) latitude-longitude grid with 0.5° (approx. 57 km) horizontal resolution;
- EUR-11i is a regular (non-rotated) latitude-longitude grid with 0.125° (approx. 14 km) horizontal resolution.

Data of 10 and 5 evaluation runs are available on the coarser EUR-44 grid and higher-resolution EUR-11 grid, respectively (Table 8 in the Appendix). In case of projections, 18 RCM simulations were carried out on EUR-44 grid and 13 of them have outputs also on the non-rotated EUR-44i version. Data of 15 RCMs can be downloaded on the high-resolution EUR-11 grid and only 5 simulations provide results on the EUR-11i grid type.

Availability of the upper-level atmospheric variables is important especially for downscaling the RCM data with dynamical impact models. EURO-CORDEX mostly consists of surface data, but all simulations (apart from ALADIN53) provide horizontal **wind components, temperature and geopotential heights on 850 hPa, 500 hPa, 200 hPa pressure levels**, as well. **Model level variables however are not stored**. Constant fields can be essential in certain studies and applications (e.g., in interpolation, vertical correction of 2-meter temperature), and thus their existence was also inspected. Both **model orography and land-sea fraction** (ratio of land to ocean areas over a grid cell) **can be downloaded for all the EURO-CORDEX projections** (Table 8 in the Appendix).

3.1.4 Available ensemble members

In the database five ensemble member labels related to GCMs are represented: r0i0p0, r1i1p1, r2i1p1, r3i1p1, r12i1p1 (Table 9 in the Appendix). The first, r0i0p0, is reserved for fixed fields common for an ensemble, but has not been used systematically for all simulations. For evaluation runs, r1i1p1 is used for all simulations. Recommendations on selection of ensemble members cannot be provided, as GCM ensemble members by definition are equivalent and as the meaning of the label depends on the driving GCMs.

3.1.5 Time horizon

Different experiment types were explained in Section 2.2. Evaluation experiments commonly run for the period of 1989–2008, but outputs of some simulations are available also for the years before 1989 and after 2008. Control runs uniformly go until 2005, but their starting dates are various: 80% of the simulations are conducted from 1951, while from 1971 all are available.

The starting date for projections is 2006, **16 and 12 RCM runs reach 2100 on EUR-44 and EUR-11 grids, respectively** (Table 10 in the Appendix). Nevertheless, the experiments driven by HadGEM2-ES global model forcings go until 2099, so they can also provide input data for long-term adaptation. Simulations going beyond 2100 would serve information about the relevant far-future paths to orientate the mitigation, however, **EURO-CORDEX data are not available beyond 2100**.

3.1.6 Available scenarios

The uncertainty range arising from the description of future anthropogenic activity in the model simulations is important both from a scientific point of view and from users' perspective. **18 and 15 control runs are conducted on EUR-44 and EUR-11 grids**, respectively and scenario runs are naturally available with them. In EURO-CORDEX projection experiments, three scenarios are applied: RCP2.6, RCP4.5, RCP8.5, and no simulations are achieved with RCP6.0. But taking into account that projected temperature change shows a nearly linear relationship with the greenhouse gas emissions (Stocker et al., 2013), the largest spread in temperature projections can be captured by examining RCP2.6, RCP4.5 and RCP8.5.

RCP8.5 and RCP4.5 scenarios are uniformly used in the projections, with the exception of ALADIN5.2 which has only RCP8.5 run (Table 11 in the Appendix). **RCP2.6 is the least used scenario** resulting in 7 EUR-44 simulations with RACMO22E, REMO2009 and RC4 RCMs and in 5 EUR-11 simulations with HIRHAM5, RACMO22E, REMO2009 and RC4 RCMs. This latter sample is not a subset of the 7-member ensemble: only **three simulations, RACMO22E driven by HadGEM2-ES, RCA4 driven by EC-EARTH and REMO2009 driven by MPI-ESM-LR have projections with RCP2.6 scenario on both grids**. Consequently, these RCMs have all experiments with all RCPs applied in CORDEX.

3.1.7 Temporal resolution

Temporal frequency of the data storage in CORDEX has also been explored in the data inventory, focusing on the 3-hourly, 6-hourly, daily, monthly, and seasonal scales. Additionally, the existence of the constant, time-independent variables is assessed.

Daily and monthly outputs are archived for all simulations (both evaluation and projection runs; Table 12 in the Appendix), whereas seasonal data is not accessible for ALADIN53 and WRF331F. **Sub-daily outputs are not usual**: on the EUR-44 grid they are available only for evaluation runs of HadGEM3-RA and HadRM3P RCMs, while on the EUR-11 grid only the evaluation run and five scenario experiments of RCA4 have 6- and 3-hourly outputs. Orography and land-sea mask are stored for all simulations.

3.1.8 Available variables

Considering all available RCM simulations within EURO-CORDEX, there is a total of 67 different variables. The full and detailed list of CORDEX variables can be found in the original CORDEX Variables Requirement Table (http://is-enes-data.github.io). Their majority are atmospheric variables, so no separate groups were created for the few land surface or ocean variables in the assessment, in which the availability of all the variables was evaluated for monthly, daily, 6-hourly and 3-hourly output frequencies.

Most variables are available on daily output frequency, a little less on monthly and only a few variables are downloadable on sub-daily temporal resolution (Table 12 in the Appendix). Sub-daily output is available only for the RCA4 regional model on 0.11° resolution (for 5 GCM driven and 1 ERA-Interim driven simulations). The **6-hourly variables are: eastward wind at 200 hPa, eastward near-surface wind, northward near-surface wind, geopotential height at 500 hPa**. The 3-hourly variables are: precipitation, sea level pressure, surface downwelling shortwave radiation, near-surface wind speed, near-surface air temperature (Table 13 and Table 14 in the Appendix).

The methods and models of impact researchers generally require several climate variables from the same model simulation as input data; therefore, the joint existence of certain groups of variables could yield useful information. To address this issue, **"variable packages"** were defined and evaluated for each climate model. The variable packages are listed in Table 5. There are normal packages as well as their extended version containing extra parameters often available for a smaller number of model runs. The *basic*, *extended basic*, *extended basic 2* and *radiation packages* are composed of surface variables. The *extended radiation package* includes also some additional radiation component at the top of the atmosphere, *pressure level packages* obviously contain pressure level variables.

Variables belonging to the **basic package** are the near-surface air temperature, the daily minimum near-surface temperature, the daily maximum near-surface temperature, and the precipitation. The package **is stored with monthly and daily output frequency for all of the GCM-RCM model chains** both on EUR-44 and EUR-11 grids (Table 15 in the Appendix). Basic package is extended with wind components, sea level pressure, specific humidity, cloudiness, global radiation, and snowfall. This group is available with daily output frequency for 15 EUR-44 and 9 EUR-11 simulations. Adding the water vapour path to the list, the daily data for extended basic 2 package exists for 14 EUR-44 and 8 EUR-11 simulations. The radiation package consisting of 2 shortwave and 2 longwave surface radiation components and its extended version are found with monthly and daily archive frequency for almost every simulation. Its extended version has no sub-daily occurrence. The pressure level packages are widely available among the models, excluding ALADIN53. **All packages can be downloaded with daily output frequency** for **13 EUR-44 simulations and** it is reduced to **8 simulations with HIRHAM5, RACMO22E and RCA4 RCMs on EUR-11 grid**.

Table 5: The defined variable packages.

Package name	Variable long name	Variable name	Unit
Basic	Near-Surface Air Temperature	tas	K
	Daily Maximum Near-Surface Air Temperature	tasmax	K
	Daily Minimum Near-Surface Air Temperature	tasmin	K
	Precipitation	pr	kg m^{-2} s^{-1}
Extended basic	Basic +		
	Sea Level Pressure	slp	Pa
	Eastward Near-Surface Wind	uas	m s^{-1}
	Northward Near-Surface Wind	vas	m s^{-1}
	Near-Surface Specific Humidity	huss	1
	Surface Downwelling Shortwave Radiation	rsds	Wm^{-2}
	Total Cloud Fraction	clt	%
	Snowfall Flux	prsn	kg m^{-2} s^{-1}
Extended basic 2	Extended basic +		
	Water Vapour Path	prw	kg m^{-2}
Radiation	Surface Downwelling Longwave Radiation	rlds	Wm^{-2}
	Surface Upwelling Longwave Radiation	rlus	Wm^{-2}
	Surface Downwelling Shortwave Radiation	rsds	Wm^{-2}
	Surface Upwelling Shortwave Radiation	rsus	Wm^{-2}
Extended radiation	Radiation +		
	TOA Incident Shortwave Radiation	rsdt	Wm^{-2}
	TOA Outgoing Shortwave Radiation	rsut	Wm^{-2}
	TOA Outgoing Longwave Radiation	rlut	Wm^{-2}
Pressure level	Temperature at 200, 500, 850 hPa	ta[200,500,850]	K
	Eastward Wind at 200, 500, 850 hPa	ua[200,500,850]	m s^{-1}
	Northward Wind at 200, 500, 850 hPa	va[200,500,850]	m s^{-1}
	Geopotential height at 200, 500, 850 hPa	zg[200,500,850]	m

3.1.9 Bias-adjusted data

Impact models typically require high-resolution unbiased climate input data. Global and regional climate models, however, are in general biased. Thus, many users demand some form of bias-adjusted data. However, there is still a scientific debate going on whether bias-adjustment methods can plausibly correct climate change trends (Maraun, 2016).

The **uncertainty related to bias correction is three-fold**. One source of uncertainty comes from the **choice of method** to be applied. There are numerous methods available, which all have different focus and qualities. However, there does not exist the one perfect method. Therefore, the result of the adjustment and thus the uncertainty depends strongly on the chosen method. Assessing this uncertainty is part of the bias correction inter-comparison project (BCIP, Nikulin 2015). Applying different bias-correction methods and different modifications of the same method to the same input datasets allows assessing impact of bias-adjusted technique on climate simulations. These efforts have led to an application of six applied methods (mostly based on quantile mapping) that are currently available at the ESGF (Table 6).

Table 6: Bias-adjustment methods applied in EURO-CORDEX with corresponding references.

Bias-adjustment method	Reference
SMHI-DBS45	Yang et al. (2010)
UCAN-EQM	Déqué (2007), Wilcke et al. (2013)
TUC-MSBC	Grillakis et al. (2013)
METNO-QMAP	Gudmundsson et al. (2012)
UCAN-ISI-MIP	Hempel et al. (2013)
IPSL-CDFT21	Vrac et al. (2016)

A second source of uncertainty is the **choice of reference data** used to calibrate the bias-adjustment methods. High quality of the reference is crucial for these methods. Using different observational datasets is common, to test how large their impact is on the bias-adjusted output. Up to date, the bias-adjusted data available at ESFG are based on three different observational datasets: MESAN, EOBS12, WFDEI. However, bias-adjustment community plans to extend the set of data with additional observational datasets (personal communication).

A third source of uncertainty is the **choice of calibration period**, time frame and length. The length but also the choice of years for the calibration is linked to the relationship built between observation and simulation data. This issue is related to the non-stationarity of the bias, i.e., that the bias for each quantile can be varying over time (Maraun, 2013). All statistical methods assume the stationarity of biases over time. Consequently, there is a need to maximise the calibration period in order to reduce this part of the uncertainty (Reiter et al., 2015). The calibration period depends on the observational dataset and varies for the available data in 1981–2010 (EOBS12), 1979–2005 (WFDEI) and 1989–2010 (MESAN).

Bias-adjustment data were recently added to the ESGF and as mentioned they are visible on all ESGF index nodes under the project name “CORDEX-Adjust”. In total 485 bias-adjusted datasets are available covering mainly daily temperature and precipitation as output. In order to avoid any confusion and to clearly distinguish original and bias-adjusted CORDEX simulation data, the CORDEX variable names received the appending “Adjust” to the variable names, for example in case of precipitation and near-surface air temperature, *pr* and *tas* are modified to *prAdjust* and *tasAdjust*, respectively.

So far, bias adjustment was applied for simulations achieved with combination of ten different driving GCMs (Table 16 in the Appendix):

1. CCCma-CanESM2;
2. CNRM-CERFACS-CNRM-CM5;
3. CSIRO-QCCCE-CSIRO-Mk3-6-0;
4. ICHEC-EC-EARTH;
5. IPSL-IPSL-CM5A-MR;
6. MIROC-MIROC5;
7. MOHC-HadGEM2-ES;
8. MPI-M-MPI-ESM-LR;
9. NCC-NorESM1-M;
10. NOAA-GFDL-GFDL-ESM2M

and seven RCMs:

1. ARPEGE51;
2. CCLM4-8-17;
3. HIRHAM5;
4. RACMO22E;
5. RCA4;
6. REMO2009;
7. WRF331F.

On the EUR-44 grid, **bias-adjusted data are available from 26 RCM-GCM combinations, while from 24 ones on EUR-11** (Table 17 in the Appendix). However, the two subsets are rather complementary of each other: only CCLM4-8-17 driven by MPI-ESM-LR and RACMO22E driven by EC-EARTH have bias-adjusted data on both grids with application of METNO-QMAP method with EOBS12 and MESAN reference datasets, respectively. The bias adjustment was applied mainly on downscaling the r1p1i1 ensemble runs of the given GCM (Table 18 in the Appendix).

Post-processing was employed for the whole time period on which the raw data are available: i.e., **until 2100**, apart from the simulations driven by HadGEM2-ES (Table 19 in the Appendix). The datasets are available for three different RCPs, whereas the **most data can be accessible for RCP4.5 scenario** (21 EUR-44 and 25 EUR-11 simulations; Table 22 in the Appendix). Outputs of 21 and 16 RCP8.5 experiments were bias-adjusted over the EUR-44 and EUR-11 grids, respectively. Data of all the 3 RCP runs were post-processed only for RACMO22E driven by HadGEM2-ES and RCA4 driven by EC-EARTH over the EUR-44 grid applying TUC-MSBC method and EOBS12 reference, and for REMO2009 driven by MPI-ESM-LR over the EUR-11 grid applying SMHI-DBS45 method and MESAN reference.

All simulations have daily outputs, sub-daily (3-hourly) outputs are available only for the bias-adjustment method 2IPSL-CDFT21-WFDEI over the EUR-11 grid (Table 21 in the Appendix). For the EUR-11 simulations that were bias-adjusted with the SMHI-DBS45 method and MESAN reference, monthly means are provided in addition to the daily output.

The **bias adjustment was employed primarily for daily precipitation and daily minimum, maximum and mean temperature values** (Table 24 in the Appendix). In case of some EUR-11 simulations, some methods were applied for the 3-hourly radiation (resulting in rsdsAdjust) and wind (resulting in sfcWindAdjust; Table 25 in the Appendix).

Presumably, the bias-adjusted datasets at ESGF will grow (personal communication). On the one hand, it is planned to apply more available observational datasets for the calibration. On the other hand, the development and refinement of bias-adjustment methods is ongoing.

3.2 Med-CORDEX

Med-CORDEX initiative has been proposed by the Mediterranean climate research community as a follow-up of previous and existing co-operations. The Mediterranean basin is characterized by a complex topography with many small islands, coastlines and numerous rivers. The description of strong land-sea contrast, land-atmosphere feedback, intense air-sea coupling, aerosol-radiation interaction, an enclosed sea with a regional thermohaline circulation, and urbanized littorals provides great challenges for the Mediterranean climate modelling. The region is consequently a good case study for climate regionalization and was naturally chosen as a CORDEX sub-domain leading to the Med-CORDEX initiative endorsed by Med-CLIVAR and HyMeX. Med-CORDEX domain covers Southern and Central Europe even up North till Denmark (second panel of Figure 2).

The MED-CORDEX data are not stored in the ESGF archive system, its search engine is found at https://www.medcordex.eu/search/index.php. It differs from the ESGF search page and has some functionality issues, e.g., neither the search function for RCMs works, nor filtering based on multiple-criteria is possible. Each form corresponds to one simulation and gives some details about the model, the reference article, the modelling group, etc. The simulations are also accessible on the HyMeX database web site (http://mistrals.sedoo.fr/Data-Download-IPSL) after registration.

Projections are available mostly on the 0.44-degree resolution rotated MED-44 grid, furthermore, on the 0.11-degree resolution rotated MED-11 grid and on the 0.5-degree resolution regular MED-44i grid (Table 26 in Appendix). Evaluation runs were carried out on various resolutions, but their majority are accessible on MED-44. Seven GCMs provided LBCs for scenario runs with 10 RCMs, but some simulations cannot be considered as independent ones as they are based on the same RCMs (e.g., CCLM, RegCM) differing only in the version numbers. This has to be taken into account at choice of an RCM ensemble as the uncertainty estimation can be biased by the different model versions. It is especially valid for the ERA-Interim runs (although some RCMs have only evaluation experiment). In MED-CORDEX double nesting is also applied, i.e., driving a high-resolution RCM by its coarser resolution version. Some atmospheric RCM (CCLM4-21, LMDZ4, WRF311) was coupled to regional ocean models like NEMO-MED8, POM, NEMO-MFS.

Most scenario experiments were run until the end of 2100 and none of them go beyond 2100. The RCP8.5 scenario is used the most widely: 9 and 2 simulations were carried out over the MED-44 and MED-11 grids, respectively. RCP4.5 was applied in 7 and 1 experiments on the two grids, resulting in 5 simulations conducted with both anthropogenic forcings. Solely one RCM (ALADIN52v1) have an RCP2.6 simulation over MED-44.

Sub-daily data can be downloaded only for some evaluation runs and one scenario run, most simulation outputs are stored with daily and monthly temporal frequency. Availability of other variables are very heterogeneous for the simulations, for instance CCLM4-8-19v2 RCM provided exclusively water vapour path. Mostly variables of the basic package are archived on both resolutions. There is only a single RCM, CCLM4-8-19v1 which has all variable groups archived on MED-44, and none of them on MED-11.

3.3 MENA-CORDEX

MENA-CORDEX domain was designed to include the Arabian Peninsula and North Africa, but it covers also Southern Europe reaching North until the Alps (third panel of Figure 2). Results are available on the 0.44-degree resolution MNA-44 grid and on the 0.22-degree resolution MNA-22 grid (Table 27 in Appendix). Only one RCM, RCA4 has been used for both domains, but with 3 different GCMs to involve model uncertainty in the results. Simulations over the MNA-22 region were made using LBCs from GFDL-ESM2M and ICHEC-EC-EARTH GCMs, while on MNA-44 one additional GCM, CNRM-CM5 was included. Evaluation simulations exist on both resolutions. Almost every model output is also archived on two additional (0.5° and 0.25° resolution) regular non-rotated grids, on MNA-44i and MNA-22i.

Scenario runs until 2100 are available over the MNA-44 domain for both RCP4.5 and RCP8.5 (EC-EARTH has an additional RCP2.6 experiment), but over MNA-22 only RCP8.5 was applied. The accessible output fields of the simulations are stored on daily, monthly and seasonal temporal frequencies, meaning that impact studies cannot target sub-daily processes.

Orography and land-sea fraction variables are stored for every RCM. Simulation over the MNA-44 and MNA-22 grids contain completely the same variables with one exception: daily maximum hourly precipitation rate is not archived on the MNA-22 grid. Variables of the basic package can be collected in both daily and monthly frequencies, as well as radiation data fields, while extended basic packages are accessible only on daily scale. Furthermore, there is a convenient collection of daily pressure level variables available for all simulations.

3.4 Central Asia CORDEX

The CAS-CORDEX domain covers large parts of Russia, Turkey and the Arabic Peninsula and stretches almost to the Asian Pacific coast (fourth panel of Figure 2). Evaluation matrix is not constructed for CAS-CORDEX, since in the ESGF there is simulation only with one regional model: MOHC-HadRM3P model developed by the Met Office Hadley Centre. MOHC was used to downscaling of the ERA-interim re-analysis data for the period of 1989−2008. According to the latest status (end of 2016, personal communication) no further simulations, neither with RCP scenarios, nor with different models will be uploaded in the near-future.

3.5 Arctic-CORDEX

Arctic CORDEX domain covers the Northern Arctic region including Greenland and the northern parts of the American and Eurasian continents (last panel of Figure 2). Simulations are available for 7 different RCMs driven with 4 GCMs, however, scenario runs were conducted only with 4 of the 7 RCMs: HIRHAM5, RCA4, RCA4-SN and RRCM (Table 28 in Appendix). The most frequently applied emission scenario within Arctic-CORDEX is RCP8.5 (resulting in 9 simulations), the RCP4.5 scenario was applied in 5 projections, while RCP2.6 was considered only in one experiment. Evaluation experiments and control runs are available for all the RCMs with one exception: there is no control experiment with the HIRHAM5-MPI-ESM-LR model chain making the calculation of climate change signals from this run problematic.

All Arctic CORDEX experiments are available on the 0.44-degree horizontal resolution rotated ARC-44 grid. Almost every model output is also archived on an additional 0.5° resolution regular non-rotated ARC-44i grid. Orography and land-sea fraction are stored for every RCM apart from RRCM. Pressure level variables exist in every model output on 850 hPa, 500 hPa and 200 hPa pressure levels.

The output frequency of the model data is uniformly daily, monthly and seasonal, sub-daily data is available only in the evaluation experiment of HadRM3P regional model. All projections cover the whole 21st century ending at 31th of December 2100. Variables from the basic, radiation and pressure level packages are stored on daily and monthly temporal resolution for every projection, while the ones from the extended basic packages are available solely on daily output frequency.

4 Proposals for CDS

Copernicus C3S Climate Data Store is merging all the climate change information relevant for the users. Since the users and their requirements regarding the regional climate projections are diverse, we provide some aspects how a selection of the existing CORDEX projections might serve them. We are focussing on the EURO-CORDEX dataset, as it is the best documented dataset covering the entire continent. First, a multi-criteria method is shown to estimate the size of the available ensembles for different purposes. Thereafter, some gaps and shortcomings of CORDEX are listed which could be handled in CDS. Finally, a proposal is given for the content of a user manual providing guideline for applying and interpreting regional climate model data.

4.1 Multi-criteria method

To assess the different aspects of the evaluation matrix together, in a summarized way, a multi-criteria filtering method is presented with the aim of giving some guidance on choosing a climate model ensemble from all of the available options. The first criterion is applied on the available variables, the second is concerning the spatial resolution and the third one is related to the available scenarios. The different criteria are marked with different colours in Table 24 and Table 25 in the Appendix.

Considering the first criterion, those models are selected, for which the extended basic, the radiation and the pressure level packages are all available with daily output frequency. This condition remains the same throughout all the columns. The second criterion split the data to two sets of 0.44-degree and 0.11-degree resolution experiments. The third criterion specifies the availability of scenario runs:

1. Historical and RCP8.5 runs;
2. Historical, RCP8.5 and RCP4.5 runs;
3. Historical, RCP8.5, RCP4.5 and RCP2.6 runs.

It is clearly visible that using the third scenario criteria (including RCP2.6), the number of involved simulations reduced significantly, resulting in 7- and 4-member ensembles depending on the applied resolution (right columns of Table 24 in the Appendix). If bias-adjusted data are also requested for daily precipitation and for daily minimum, maximum and mean temperature, the size of ensembles further decrease to 2 members consisting of RACMO22E and RCA4 both driven by HadGEM2-ES, and 1 member of REMO2009 driven by MPI-ESM-LR.

Looking at the strictest criterion group (i.e., **high-resolution runs with all scenarios and their daily outputs covering all the defined variable packages**; bottom right block in Table 25 in the Appendix), only **3 EURO-CORDEX simulations remain** with

HIRHAM5 and RCA4 both driven by EC-EARTH, and RACMO22E driven by HadGEM2-ES. Loosening up the criterion regarding the available scenarios, the same subsets of simulations are resulted for RCP8.5 and RCP4.5: 8 simulations are available (first two bottom columns in Table 25). If we do not need high-resolution outputs, these ensembles can be extended with 5 additional simulations of RCA4 RCMs.

It must be emphasised that these tables do not present any qualitative assessment of the model outputs and give no information on model skills and validation results. Therefore, **these models are not considered the "best ones", only the ones with the most abundant available (and downloadable) data**. However, it was already concluded that there are both RCMs (e.g., RCA4) and driving GCMs (HadGEM2-ES) in the RCM-GCM chains which are used more frequently in the simulations than other ones. Nevertheless, in case of RCM results it is difficult to identify their "similarities" based on the applied models, because the climate change signal is affected by the non-linear interaction of the regional model and the forcing field. Consequently, **to judge the independency of the RCM simulations in the resulted ensembles, thorough assessments of the dynamics and physics of the applied RCMs and GCMs as well as their outputs are needed.**

Selecting the time series of a single model run which covers the period 1970–2100, the volume of the downloaded data is 1–8 GB (depending on the horizontal grid distance) for a given variable at daily resolution and less than 1 GB at monthly resolution over the whole continent. Considering the proposed ensemble for the RCP4.5 and RCP8.5 scenarios, consisting of 2x14-2x9 members with daily output frequency, the amount of the requested data can be 16–128 GB for a selected variable. Taking also the sub-set of simulations available for RCP2.6, extra storage of 3–24 GB is needed for a given variable at daily level.

4.2 Gap identification

During the evaluation of the CORDEX datasets, several technical difficulties and gaps were concluded. Many of them are related to the browsing method and the documentation, both having key importance for the users:

- Option of "All replicas" provides completely the same amount of data as without it. When "All versions" option is selected, only one model has a few extra data.
- Some GCMs are not represented through a single RCM in the EUR-11 simulations, while some could deviate the uncertainty if all results are used in an ensemble and a selection method is not applied before data assessment. EC-EARTH GCM is overrepresented in EUR-11. This could be also a problem for the RCA4 RCM under EUR-44, which is forced by all available global models. Deep

assessment is needed regarding independency of the available RCM simulations and every choice has to be done considering the user objective.
- RCP2.6 scenario is underrepresented (due to the limited availability of GCM runs), and this fact forces the users to analyse basically two future paths.
- Selection possibility for time horizon is missing from the search options on ESGF. One must dig into each metadata information to find out which collection has “followed” the time horizons suggested by the syntax. Starting date of the historical runs is various and runs with HadGEM2-ES LBC go until 2099.
- Sub-daily outputs are not stored in ESGF, apart from RCA4 RCM. Access to these data has to be organized bilaterally between data user and the institution performing the simulation.
- Based on a decision made with considerations of storage space, CORDEX atmospheric data are stored on ESGF on 3 pressure levels: 850 hPa, 500 hPa and 200 hPa. For some study this vertical resolution may be coarse. If additional storage capacity could be dedicated to regional climate model outputs in the future, for further downscaling the current roughly 50 daily fields for each model simulations could increase by around 4 (times per day) x 30 (number of model levels) x 4 (at least four variables) times the present amount.
- ALADIN53 RCM output does not contain pressure level variables, while all the other RCMs within EURO-CORDEX have some of them.
- MED-CORDEX data are not stored on ESGF, but in a different database with a very simple browsing possibility. Metadata are sometimes incomplete in this portal.
- Territory of Turkey is located in the vicinity of the border in all the available CORDEX domains. This issue can be handled with definition of a new domain.
- Bias-adjusted data are available only for EURO-CORDEX data on ESGF.

4.3 Suggestions for a user guide on regional climate projections

Climate Data Store supplies not only data for the users, but also a support for them to apply the data. This is particularly needed in the case of climate projections due to their special interpretation. To write a user guide is not the task of the DECM project. Nonetheless, here we provide some content elements which should be included in a guidance on regional climate projections:

- <u>Scientific background of the regional climate projections</u>: introduction of the main components and physical processes of the climate system; summary of the available climate modelling tools with focus on regional climate models; explaining the scientific issues to be investigated with RCMs;

- Basics of numerical modelling (particularly climate modelling): explanation of the grid approximation, horizontal resolution and vertical levels; role of lateral boundary conditions; nature of physical parameterizations (and their role in large deviation of model results); scenario approach to quantify the anthropogenic effects in the models;
- Interpretation of the climate model data: distinguishing the re-analysis-driven simulations and the GCM-driven projections; explaining the area represented by a grid cell and the time horizon represented by a climate projection; explaining what kind of phenomena can be reflected by a regional climate model as well as limitations of climate modelling; showing some example for the typical outputs (climatological means, distributions etc.);
- Validation: explaining the importance and process of the validation; available reference data (re-analyses, gridded observations, station measurements); distinguishing the validation of re-analysis and GCM-driven simulations; clarifying the meaning of the reference period and its selection; showing some possibilities to handle the systematic model errors; providing description about advantages and disadvantages of different bias-adjustment methods;
- Uncertainties: introducing the main sources of projection uncertainties with special focus on uncertainties coming from regional modelling (choice of integration domain, spatial resolution, lateral boundary conditions etc.); presenting the ensemble approach; showing concrete methods for quantification of uncertainty (intervals, probabilities etc.); emphasizing the importance of using a well-balanced ensemble instead of a single model run.

5 Conclusions

In the data inventory, climate simulations of the CORDEX database were assessed regarding their spatial and temporal characteristics (horizontal and vertical resolutions, archived outputs, covered time horizons etc.), their available variables and anthropogenic scenarios, and their feasibility and limitations in different user applications (downscaling, impact research). These aspects were investigated for EURO-CORDEX simulation in detail, and summarized concisely for MED-CORDEX, MENA-CORDEX, Central Asia CORDEX and Arctic-CORDEX (all covering partly Europe).

Considering all the available EURO-CORDEX model results, our investigation was started with 18 and 15 RCM projections on 0.44- and 0.11-degree resolutions, respectively. Among them only the simulations driven by HadGEM2-ES GCM do not reach 2100 (running only until 2099), and none of the experiments goes beyond 2100. Data are archived mainly with monthly and daily output frequencies. Daily precipitation sum, daily mean near-surface air temperature, daily minimum and maximum temperature data are available for all simulations. Taking also the surface wind components, specific humidity, sea level pressure, global radiation, cloudiness, and snowfall, the number of models with daily outputs is reduced to 15 and 9 over EUR-44 and EUR-11 grids, respectively. Pressure-level data are important for dynamical downscaling, nevertheless, they are stored only on three levels of 850, 500 and 200 hPa. Model level data are not archived on ESGF. So for further request, one has to contact the institution responsible for the chosen model experiment (contact details are usually provided in the meta information of model output files).

Evaluating the joint occurrence of the different criteria in the database, a 7-member ensemble can be designed from climate projections with all the 3 representative RCP scenarios which have daily outputs for the selected (surface, pressure-level and radiation) atmospheric variables with 0.44-degree resolution. This ensemble consists of 4 members over the EUR-11 grid. If bias-adjusted data are also requested for daily precipitation and for daily minimum, maximum and mean temperature, the size of ensemble further decreases to 2 members consisting of RACMO22E and RCA4 both driven by HadGEM2-ES on EUR-44, and to 1 member of REMO2009 driven by MPI-ESM-LR on EUR-11. Not requiring the RCP2.6 scenario (nor the bias-adjusted data), 5 and 7 extra RCM simulations are added to the selections, resulting in 14- and 9-member ensembles per RCPs over EUR-44 and EUR-11, respectively.

This selection does not represent any qualitative assessment of the model outputs and does not give any information on model skills and validation results. Nevertheless, to judge the independency of the RCM simulations in the resulted ensembles, evaluation of the applied RCMs and GCMs as well as of their outputs are needed.

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Appendix

Different parts of the evaluation matrix

Table 7: Applied regional climate models (RCMs) and drivings from global climate models (GCMs) in EURO-CORDEX simulations on 0.44- (EUR-44) and 0.11-degree (EUR-11) resolutions.

EUR-44		RCMs											
		ALADIN52	ALADIN53	CCLM4-8-17	HIRHAM5	HadGEM3-RA	HadRM3P	RACMO22E	RCA4	REMO2009	RegCM4-2	WRF331F	Total number
Insitution-GCMs	CCCma-CanESM2								x				1
	CNRM-CERFACS-CNRM-CM5	x	x						x				3
	CSIRO-QCCCE-CSIRO-Mk3-6-0								x				1
	ICHEC-EC-EARTH				x			x	x				3
	IPSL-IPSL-CM5A-MR								x			x	2
	MIROC-MIROC5								x				1
	MOHC-HadGEM2-ES							x	x				2
	MPI-M-MPI-ESM-LR			x					x	x			3
	NCC-NorESM1-M								x				1
	NOAA-GFDL-GFDL-ESM2M								x				1
	Total number	1	1	1	1			2	10	1		1	18

EUR-11		RCMs											
		ALADIN52	ALADIN53	CCLM4-8-17	HIRHAM5	HadGEM3-RA	HadRM3P	RACMO22E	RCA4	REMO2009	RegCM4-2	WRF331F	Total number
Institution-GCMs	CCCma-CanESM2												
	CNRM-CERFACS-CNRM-CM5		x	x					x				3
	CSIRO-QCCCE-CSIRO-Mk3-6-0												
	ICHEC-EC-EARTH			x	x			x	x				4
	IPSL-IPSL-CM5A-MR								x			x	2
	MIROC-MIROC5												
	MOHC-HadGEM2-ES			x				x	x				3
	MPI-M-MPI-ESM-LR			x					x	x			3
	NCC-NorESM1-M												
	NOAA-GFDL-GFDL-ESM2M												
	Total number		1	4	1			2	5	1		1	15

Table 8: Spatial resolution, grid and availability of parameters on surface and vertical levels in ERA-Interim driven (top) and GCM-driven (bottom) RCM experiments of EURO-CORDEX.

Evaluation runs (ERA-Interim driven simulations) / Experiments	**ALADIN52**	**ALADIN53**	**CCLM4-8-17**	**HIRHAM5**	**HadGEM3-RA**	**HadRM3P**	**RACMO22E**	**RCA4**	**REMO2009**	**RegCM4-2**	**WRF331F**	Total number
EUR-44	x	x	x	x	x	x	x	x	x		x	**10**
EUR-11		x	x	x			x	x	x	x	x	**8**
EUR-44i	x			x		x	x	x				**5**
EUR-11i								x		x		**2**

	RCM-GCM chains																					
	CNRM-CM5	CNRM-CM5	CNRM-CM5	EC-EARTH	HadGEM2-ES	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CanESM2	CNRM-CM5	CSIRO-Mk3-6-0	EC-EARTH	IPSL-CM5A-MR	MIROC5	HadGEM2-ES	MPI-ESM-LR	NorESM1-M	GFDL-ESM2M	MPI-ESM-LR	IPSL-CM5A-MR	
Grid type, spatial resolution	**ALADIN52**	**ALADIN53**	**CCLM4-8-17**				**HIRHAM5**	**RACMO22E**		**RCA4**										**REMO2009**	**WRF331F**	Total number
EUR-44 (0.44° resolution)	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**18**
EUR-11 (0.11° resolution)		x	x	x	x	x	x	x	x		x		x	x		x	x			x	x	**15**
EUR-44i (0.5° resolution)	x						x	x		x	x	x	x	x	x	x	x	x	x			**13**
EUR-11i (0.125° resolution)											x		x	x		x	x					**5**
Land area fraction available	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**21**
Orography available	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**21**
Pressure level data available	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**20**

Table 9: Ensemble members of ERA-Interim (top) and GCM-driven (bottom) RCM experiments on different EURO-CORDEX resolutions.

Evaluation runs EUR-44

Ensemble member	ALADIN52	ALADIN53	CCLM4-8-17	HIRHAM5	HadGEM3-RA	HadRM3P	RACMO22E	RCA4	REMO2009	WRF331F	Total number
r0i0p0			x		x	x		x	x	x	**6**
r1i1p1	x	x	x	x	x	x	x	x	x	x	**10**
r2i1p1											**0**
r3i1p1											**0**
r12i1p1											**0**
Total number	**1**	**1**	**2**	**1**	**2**	**2**	**1**	**2**	**2**	**2**	

Evaluation runs EUR-11

Ensemble member	ALADIN53	CCLM4-8-17	HIRHAM5	RACMO22E	RCA4	REMO2009	RegCM4-2	WRF331F	Total number
r0i0p0		x			x	x		x	**4**
r1i1p1	x	x	x	x	x	x	x	x	**8**
r2i1p1									**0**
r3i1p1									**0**
r12i1p1									**0**
Total number	**1**	**2**	**1**	**1**	**2**	**2**	**1**	**2**	

EUR-44 — **RCM**-GCM chains

Ensemble member	**ALADIN52**	**ALADIN53**	**CCLM4-8-17**	**HIRHAM5**	**RACMO22E**		**RCA4**										**REMO2009**	**WRF331F**	**Total number**
	CNRM-CM5	CNRM-CM5	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CanESM2	CNRM-CM5	CSIRO-Mk3-6-0	EC-EARTH	IPSL-CM5A-MR	MIROC5	HadGEM2-ES	MPI-ESM-LR	NorESM1-M	GFDL-ESM2M	MPI-ESM-LR	IPSL-CM5A-MR	
r0i0p0			x				x	x	x	x	x	x	x	x	x	x	x	x	**13**
r1i1p1	x	x	x		x	x	x	x	x		x	x	x	x	x	x	x	x	**16**
r2i1p1																	x		**1**
r3i1p1				x															**1**
r12i1p1										x									**1**
Total number	**1**	**1**	**2**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	

EUR-11 — **RCM**-GCM chains

Ensemble member	**ALADIN53**	**CCLM4-8-17**				**HIRHAM5**	**RACMO22E**		**RCA4**					**REMO2009**	**WRF331F**	**Total number**
	CNRM-CM5	CNRM-CM5	EC-EARTH	HadGEM2-ES	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CNRM-CM5	EC-EARTH	IPSL-CM5A-MR	HadGEM2-ES	MPI-ESM-LR	MPI-ESM-LR	IPSL-CM5A-MR	
r0i0p0		x	x	x	x				x	x	x	x	x	x	x	**11**
r1i1p1	x	x		x	x		x	x	x		x	x	x	x	x	**12**
r2i1p1														x		**1**
r3i1p1						x										**1**
r12i1p1			x							x						**2**
Total number	**1**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	

Table 10: Time horizon of GCM-driven RCM experiments on different EURO-CORDEX resolutions.

EUR-44	RCM-GCM chains																		Total number
	ALADIN52	**ALADIN53**	**CCLM4-8-17**	**HIRHAM5**	**RACMO22E**		**RCA4**										**REMO2009**	**WRF331F**	
Time horizon	CNRM-CM5	CNRM-CM5	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CanESM2	CNRM-CM5	CSIRO-Mk3-6-0	EC-EARTH	IPSL-CM5A-MR	MIROC5	HadGEM2-ES	MPI-ESM-LR	NorESM1-M	GFDL-ESM2M	MPI-ESM-LR	IPSL-CM5A-MR	
RCP experiment not reaching 2100 (2099)						x							x						**2**
RCP experiment until 2100	x	x	x	x	x		x	x	x	x	x	x		x	x	x	x	x	**16**
RCP experiment beyond 2100																			**0**

EUR-11	RCM-GCM chains															Total number
	ALADIN53	**CCLM4-8-17**				**HIRHAM5**	**RACMO22E**		**RCA4**					**REMO2009**	**WRF331F**	
Time horizon	CNRM-CM5	CNRM-CM5	EC-EARTH	HadGEM2-ES	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CNRM-CM5	EC-EARTH	IPSL-CM5A-MR	HadGEM2-ES	MPI-ESM-LR	MPI-ESM-LR	IPSL-CM5A-MR	
RCP experiment not reaching 2100 (2099)				x				x				x				**3**
RCP experiment until 2100	x	x	x		x	x	x		x	x	x		x	x	x	**12**
RCP experiment beyond 2100																**0**

Table 11: GCM-driven historical and scenario experiments on different EURO-CORDEX resolutions.

EUR-44	RCM-GCM chains																		
	CNRM-CM5	CNRM-CM5	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CanESM2	CNRM-CM5	CSIRO-Mk3-6-0	EC-EARTH	IPSL-CM5A-MR	MIROC5	HadGEM2-ES	MPI-ESM-LR	NorESM1-M	GFDL-ESM2M	MPI-ESM-LR	IPSL-CM5A-MR	
Experiments	**ALADIN52**	**ALADIN53**	**CCLM4-8-17**	**HIRHAM5**	**RACMO22E**		**RCA4**										**REMO2009**	**WRF331F**	**Total number**
Historical	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**18**
RCP2.6						x				x		x	x	x	x		x		**7**
RCP4.5		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**17**
RCP8.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**18**

EUR-11	RCM-GCM chains															
	CNRM-CM5	CNRM-CM5	EC-EARTH	HadGEM2-ES	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CNRM-CM5	EC-EARTH	IPSL-CM5A-MR	HadGEM2-ES	MPI-ESM-LR	MPI-ESM-LR	IPSL-CM5A-MR	
Experiments	**ALADIN53**	**CCLM4-8-17**				**HIRHAM5**	**RACMO22E**		**RCA4**					**REMO2009**	**WRF331F**	**Total number**
Historical	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
RCP2.6	x					x		x		x				x		**5**
RCP4.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
RCP8.5	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**

Table 12: Temporal output frequency of ERA-Interim (top) and GCM-driven (bottom) RCM experiments on different EURO-CORDEX resolutions.

Evaluation runs EUR-44 / **Output frequency**	**ALADIN52**	**ALADIN53**	**CCLM4-8-17**	**HIRHAM5**	**HadGEM3-**	**HadRM3P**	**RACMO22E**	**RCA4**	**REMO2009**	**WRF331F**	Total
3-hourly					x	x					**2**
6-hourly					x	x					**2**
daily	x	x	x	x	x	x	x	x	x	x	**10**
monthly	x	x	x	x	x	x	x	x	x	x	**10**
seasonal	x		x	x	x	x	x	x	x		**8**
invariant (fx)	x	x	x	x	x	x	x	x	x	x	**10**

Evaluation runs EUR-11 / **Output frequency**	**ALADIN53**	**CCLM4-8-17**	**HIRHAM5**	**RACMO22E**	**RCA4**	**REMO2009**	**RegCM4-2**	**WRF331F**	Total number
3-hourly					x				**1**
6-hourly					x				**1**
daily	x	x	x	x	x	x	x	x	**8**
monthly	x	x	x	x	x	x	x	x	**8**
seasonal		x	x	x	x	x	x		**6**
invariant (fx)	x	x	x	x	x	x	x	x	**8**

EUR-44	**RCM**-GCM chains																		**Total number**
	CNRM-CM5	CNRM-CM5	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CanESM2	CNRM-CM5	CSIRO-Mk3-6-0	EC-EARTH	IPSL-CM5A-MR	MIROC5	HadGEM2-ES	MPI-ESM-LR	NorESM1-M	GFDL-ESM2M	MPI-ESM-LR	IPSL-CM5A-MR	
Output frequency	**ALADIN52**	**ALADIN53**	**CCLM4-8-17**	**HIRHAM5**	**RACMO22E**		**RCA4**										**REMO2009**	**WRF331F**	
3-hourly																			**0**
6-hourly																			**0**
daily	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**18**
monthly	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**18**
seasonal	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		**16**
invariant (fx)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**18**

EUR-11	**RCM**-GCM chains															**Total number**
	CNRM-CM5	CNRM-CM5	EC-EARTH	HadGEM2-ES	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CNRM-CM5	EC-EARTH	IPSL-CM5A-MR	HadGEM2-ES	MPI-ESM-LR	MPI-ESM-LR	IPSL-CM5A-MR	
Output frequency	**ALADIN53**	**CCLM4-8-17**				**HIRHAM5**	**RACMO22E**		**RCA4**					**REMO2009**	**WRF331F**	
3-hourly									x	x	x	x	x			**5**
6-hourly									x	x	x	x	x			**5**
daily	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
monthly	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
seasonal		x	x	x	x	x	x	x	x	x	x	x	x	x		**13**
invariant (fx)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**

Table 13: Availability of different atmospheric and surface variables in the GCM-driven RCM experiments on 0.44-degree EURO-CORDEX resolution.

EUR-44				RCM-GCM chains																		
				ALADIN52	ALADIN53	CCLM4-8-17	HIRHAM5	RACMO22E		RCA4										REMO2009	WRF331F	
Variable long name	Name	Unit	Frequency	CNRM-CM5	CNRM-CM5	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CanESM2	CNRM-CM5	CSIRO-Mk3-6-0	EC-EARTH	IPSL-CM5A-MR	MIROC5	HadGEM2-ES	MPI-ESM-LR	NorESM1-M	GFDL-ESM2M	MPI-ESM-LR	IPSL-CM5A-MR	Total number
Near-Surface Air Temperature	tas	K	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Daily-Maximum Near-Surface Air Temperature	tasmax	K	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Daily-Minimum Near-Surface Air Temperature	tasmin	K	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Precipitation	pr	kg m-2 s-1	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Surface Pressure	ps	Pa	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month		x																x	2
Sea Level Pressure	psl	Pa	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		17
Near-Surface Relative Humidity	hurs	%	3 h																			0
			6 h																			0
			day	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x			15
			month	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x			15
Near-Surface Specific Humidity	huss	1	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Near-Surface Wind Speed	sfcWind	m s-1	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
Daily-Maximum Near-Surface Wind Speed	sfcWindmax	m s-1	3 h																			0
			6 h																			0
			day			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16
			month			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16
Total Cloud Fraction	clt	%	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		16
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		16
Duration of Sunshine (duration when surface solar radiation flux exceeds 120 W/m2)	sund	s	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			16
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			16

EUR-44				RCM-GCM chains																		
Variable long name	Name	Unit	Frequency	ALADIN52 CNRM-CM5	ALADIN53 CNRM-CM5	CCLM4-8-17 MPI-ESM-LR	HIRHAM5 EC-EARTH	RACMO22E EC-EARTH	RACMO22E HadGEM2-ES	RCA4 CanESM2	RCA4 CNRM-CM5	RCA4 CSIRO-Mk3-6-0	RCA4 EC-EARTH	RCA4 IPSL-CM5A-MR	RCA4 MIROC5	RCA4 HadGEM2-ES	RCA4 MPI-ESM-LR	RCA4 NorESM1-M	RCA4 GFDL-ESM2M	REMO2009 MPI-ESM-LR	WRF331F IPSL-CM5A-MR	Total number
Surface Downwelling Shortwave Radiation	rsds	W m-2	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Surface Downwelling Longwave Radiation	rlds	W m-2	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Surface Upward Latent Heat Flux	hfls	W m-2	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Surface Upward Sensible Heat Flux	hfss	W m-2	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Surface Upwelling Shortwave Radiation	rsus	W m-2	3 h																			0
			6 h																			0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
Surface Upwelling Longwave Radiation	rlus	W m-2	3 h																			0
			6 h																			0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
Evaporation	evspsbl	kg m-2 s-1	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Potential Evapotranspiration	evspsblpot	kg m-2 s-1	3 h																			0
			6 h																			0
			day							x	x	x	x	x	x	x	x	x	x			10
			month																			0
Soil Frozen Water Content	mrfso	kg m-2	3 h																			0
			6 h																			0
			day	x		x		x	x	x	x	x	x	x	x	x	x	x	x			14
			month	x		x		x	x	x	x	x	x	x	x	x	x	x	x			14
Surface Runoff	mrros	kg m-2 s-1	3 h																			0
			6 h																			0
			day			x	x	x	x											x	x	6
			month			x			x											x	x	4
Total Runoff	mrro	kg m-2 s-1	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	16
Total Soil Moisture Content	mrso	kg m-2	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		17
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		17

EUR-44				RCM-GCM chains																		
				CNRM-CM5	CNRM-CM5	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CanESM2	CNRM-CM5	CSIRO-Mk3-6-0	EC-EARTH	IPSL-CM5A-MR	MIROC5	HadGEM2-ES	MPI-ESM-LR	NorESM1-M	GFDL-ESM2M	MPI-ESM-LR	IPSL-CM5A-MR	
Variable long name	**Name**	**Unit**	**Frequency**	ALADIN52	ALADIN53	CCLM4-8-17	HIRHAM5	RACMO22E		RCA4										REMO2009	WRF331F	Total number
Surface Snow Amount	snw	kg m-2	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x											x		7
			month	x	x	x	x	x	x											x		7
Surface Snow Melt	snm	kg m-2 s-1	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		16
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		16
Daily Maximum Hourly Precipitation Rate	prhmax	kg m-2 s-1	3 h																			0
			6 h																			0
			day			x	x	x	x	x	x	x	x	x	x	x	x	x	x			14
			month																			0
Convective Precipitation	prc	kg m-2 s-1	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month																		x	1
TOA Outgoing Longwave Radiation	rlut	W m-2	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
TOA Incident Shortwave Radiation	rsdt	W m-2	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
TOA Outgoing Shortwave Radiation	rsut	W m-2	3 h																			0
			6 h																			0
			day			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16
			month			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16
Eastward Near-Surface Wind	uas	m s-1	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Northward Near-Surface Wind	vas	m s-1	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Daily Maximum Near-Surface Wind Speed of Gust	wsgsmax	m s-1	3 h																			0
			6 h																			0
			day	x		x		x	x	x	x	x	x	x	x	x	x	x	x	x		15
			month																			0
Surface Downward Eastward Wind Stress	tauu	Pa	3 h																			0
			6 h																			0
			day	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x		16
			month		x		x	x														3
Surface Downward Northward Wind Stress	tauv	Pa	3 h																			0
			6 h																			0
			day	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x		16
			month		x		x	x														3

EUR-44				RCM-GCM chains																		
Variable long name	Name	Unit	Frequency	ALADIN52 CNRM-CM5	ALADIN53 CNRM-CM5	CCLM4-8-17 MPI-ESM-LR	HIRHAM5 EC-EARTH	RACMO22E EC-EARTH	RACMO22E HadGEM2-ES	RCA4 CanESM2	RCA4 CNRM-CM5	RCA4 CSIRO-Mk3-6-0	RCA4 EC-EARTH	RCA4 IPSL-CM5A-MR	RCA4 MIROC5	RCA4 HadGEM2-ES	RCA4 MPI-ESM-LR	RCA4 NorESM1-M	RCA4 GFDL-ESM2M	REMO2009 MPI-ESM-LR	WRF331F IPSL-CM5A-MR	Total number
Surface Temperature	ts	K	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month		x																x	2
Height Of Boundary Layer	zmla	m	3 h																			0
			6 h																			0
			day	x		x		x	x	x	x	x	x	x	x	x	x	x	x		x	15
			month																		x	1
Water Vapour Path	prw	kg m-2	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x			15
			month																			0
Condensed Water Path (liquid+ice)	clwvi	kg m-2	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x			15
			month																			0
Ice Water Path	clivi	kg m-2	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x			15
			month																			0
Eastward Wind at 850 hPa	ua850	m s-1	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
Northward Wind at 850 hPa	va850	m s-1	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
Temperature at 850 hPa	ta850	K	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
Specific Humidity at 850 hPa	hus850	1	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
Eastward Wind at 500 hPa	ua500	m s-1	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
Northward Wind at 500 hPa	va500	m s-1	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
Geopotential Height at 500 hPa	zg500	m	3 h																			0
			6 h																			0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18

EUR-44

RCM-GCM chains

Variable long name	Name	Unit	Frequency	ALADIN52 CNRM-CM5	ALADIN53 CNRM-CM5	CCLM4-8-17 MPI-ESM-LR	HIRHAM5 EC-EARTH	RACMO22E EC-EARTH	RACMO22E HadGEM2-ES	RCA4 CanESM2	RCA4 CNRM-CM5	RCA4 CSIRO-Mk3-6-0	RCA4 EC-EARTH	RCA4 IPSL-CM5A-MR	RCA4 MIROC5	RCA4 HadGEM2-ES	RCA4 MPI-ESM-LR	RCA4 NorESM1-M	RCA4 GFDL-ESM2M	REMO2009 MPI-ESM-LR	WRF331F IPSL-CM5A-MR	Total number
Temperature at 500 hPa	ta500	K	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
Eastward Wind at 200 hPa	ua200	m s-1	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
Northward Wind at 200 hPa	va200	m s-1	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
Temperature at 200 hPa	ta200	K	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
Geopotential Height at 200 hPa	zg200	m	3 h																			0
			6 h																			0
			day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
			month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	17
High Cloud Cover (p<440hPa)	clh	%	3 h																			0
			6 h																			0
			day	x			x	x	x	x	x	x	x	x	x	x	x	x	x			14
			month																			0
Medium Cloud Cover (680 hPa > p > 440 hPa)	clm	%	3 h																			0
			6 h																			0
			day	x			x	x	x	x	x	x	x	x	x	x	x	x	x			14
			month																			0
Low Cloud Cover (p>680hPa)	cll	%	3 h																			0
			6 h																			0
			day	x			x	x	x	x	x	x	x	x	x	x	x	x	x			14
			month																			0
Snow Area Fraction	snc	%	3 h																			0
			6 h																			0
			day			x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	15
			month			x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	15
Snow Depth	snd	m	3 h																			0
			6 h																			0
			day			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16
			month			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16
Sea Ice Fraction	sic	%	3 h																			0
			6 h																			0
			day				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
			month				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Snowfall Flux	prsn	kg m-2 s-1	3 h																			0
			6 h																			0
			day	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16
			month																		x	1

Table 14: Availability of different atmospheric and surface variables in the GCM-driven RCM experiments on 0.11-degree EURO-CORDEX resolution.

EUR-11				RCM-GCM chains															
				ALADIN53	CCLM4-8-17				HIRHAM5	RACMO22E		RCA4					REMO2009	WRF331F	
				CNRM-CM5	CNRM-CM5	EC-EARTH	HadGEM2-ES	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CNRM-CM5	EC-EARTH	IPSL-CM5A-MR	HadGEM2-ES	MPI-ESM-LR	MPI-ESM-LR	IPSL-CM5A-MR	
Variable long name	**Name**	**Unit**	**Frequency**																**Total number**
Near-Surface Air Temperature	tas	K	3 h									x	x	x	x	x			**5**
			6 h																**0**
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
Daily-Maximum Near-Surface Air Temperature	tasmax	K	3 h																**0**
			6 h																**0**
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
Daily-Minimum Near-Surface Air Temperature	tasmin	K	3 h																**0**
			6 h																**0**
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
Precipitation	pr	kg m-2 s-1	3 h									x	x	x	x	x			**5**
			6 h																**0**
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
Surface Pressure	ps	Pa	3 h																**0**
			6 h																**0**
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
			month	x														x	**2**
Sea Level Pressure	psl	Pa	3 h									x	x	x	x	x			**5**
			6 h																**0**
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
Near-Surface Relative Humidity	hurs	%	3 h																**0**
			6 h																**0**
			day	x					x	x	x	x	x	x	x	x		x	**10**
			month	x					x	x	x	x	x	x	x	x			**9**
Near-Surface Specific Humidity	huss	1	3 h																**0**
			6 h																**0**
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
Near-Surface Wind Speed	sfcWind	m s-1	3 h									x	x	x	x	x			**5**
			6 h																**0**
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	**14**
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	**14**
Daily-Maximum Near-Surface Wind Speed	sfcWindmax	m s-1	3 h																**0**
			6 h																**0**
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	**14**
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	**14**
Total Cloud Fraction	clt	%	3 h																**0**
			6 h																**0**
			day		x	x	x	x	x	x	x	x	x	x	x	x	x		**13**
			month		x	x	x	x	x	x	x	x	x	x	x	x	x		**13**
Duration of Sunshine (duration when surface solar radiation flux	sund	s	3 h																**0**
			6 h																**0**
			day	x	x	x	x	x	x	x	x	x	x	x	x	x			**13**
			month	x	x	x	x	x	x	x	x	x	x	x	x	x			**13**

EUR-11				RCM-GCM chains															
				ALADIN53	CCLM4-8-17				HIRHAM5	RACMO22E		RCA4					REMO2009	WRF331F	
Variable long name	Name	Unit	Frequency	CNRM-CM5	CNRM-CM5	EC-EARTH	HadGEM2-ES	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CNRM-CM5	EC-EARTH	IPSL-CM5A-MR	HadGEM2-ES	MPI-ESM-LR	MPI-ESM-LR	IPSL-CM5A-MR	Total number
Surface Downwelling Shortwave Radiation	rsds	W m-2	3 h									x	x	x	x	x			5
			6 h																0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Surface Downwelling Longwave Radiation	rlds	W m-2	3 h																0
			6 h																0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Surface Upward Latent Heat Flux	hfls	W m-2	3 h																0
			6 h																0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Surface Upward Sensible Heat Flux	hfss	W m-2	3 h																0
			6 h																0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Surface Upwelling Shortwave Radiation	rsus	W m-2	3 h																0
			6 h																0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Surface Upwelling Longwave Radiation	rlus	W m-2	3 h																0
			6 h																0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Evaporation	evspsbl	kg m-2 s-1	3 h																0
			6 h																0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Potential Evapotranspiration	evspsblpot	kg m-2 s-1	3 h																0
			6 h																0
			day									x	x	x	x	x			5
			month																0
Soil Frozen Water Content	mrfso	kg m-2	3 h																0
			6 h																0
			day		x	x	x	x		x	x	x	x	x	x	x			11
			month		x	x	x	x		x	x	x	x	x	x	x			11
Surface Runoff	mrros	kg m-2 s-1	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x						x	x	9
			month		x	x	x	x	x	x	x						x	x	9
Total Runoff	mrro	kg m-2 s-1	3 h																0
			6 h																0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Total Soil Moisture Content	mrso	kg m-2	3 h																0
			6 h																0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x		14
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x		14

EUR-11				RCM-GCM chains															
Variable long name	Name	Unit	Frequency	ALADIN53 CNRM-CM5	CCLM4-8-17 CNRM-CM5	CCLM4-8-17 EC-EARTH	CCLM4-8-17 HadGEM2-ES	CCLM4-8-17 MPI-ESM-LR	HIRHAM5 EC-EARTH	RACMO22E EC-EARTH	RACMO22E HadGEM2-ES	RCA4 CNRM-CM5	RCA4 EC-EARTH	RCA4 IPSL-CM5A-MR	RCA4 HadGEM2-ES	RCA4 MPI-ESM-LR	REMO2009 MPI-ESM-LR	WRF331F IPSL-CM5A-MR	Total number
Surface Snow Amount	snw	kg m-2	3 h																0
			6 h																0
			day	x	x	x	x	x	x	x	x						x		9
			month	x	x	x	x	x	x	x	x						x		9
Surface Snow Melt	snm	kg m-2 s-1	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x		13
			month		x	x	x	x	x	x	x	x	x	x	x	x	x		13
Daily Maximum Hourly Precipitation Rate	prhmax	kg m-2 s-1	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x			12
			month																0
Convective Precipitation	prc	kg m-2 s-1	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month															x	1
TOA Outgoing Longwave Radiation	rlut	W m-2	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
TOA Incident Shortwave Radiation	rsdt	W m-2	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
TOA Outgoing Shortwave Radiation	rsut	W m-2	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
Eastward Near-Surface Wind	uas	m s-1	3 h																0
			6 h									x	x	x	x	x			5
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Northward Near-Surface Wind	vas	m s-1	3 h																0
			6 h									x	x	x	x	x			5
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Daily Maximum Near-Surface Wind Speed of Gust	wsgsmax	m s-1	3 h																0
			6 h																0
			day		x	x	x	x		x	x	x	x	x	x	x	x		12
			month																0
Surface Downward Eastward Wind Stress	tauu	Pa	3 h																0
			6 h																0
			day	x					x	x	x	x	x	x	x	x	x		10
			month	x					x										2
Surface Downward Northward Wind Stress	tauv	Pa	3 h																0
			6 h																0
			day	x					x	x	x	x	x	x	x	x	x		10
			month	x					x										2

EUR-11				RCM-GCM chains															
				ALADIN53	CCLM4-8-17				HIRHAM5	RACMO22E		RCA4					REMO2009	WRF331F	Total number
Variable long name	Name	Unit	Frequency	CNRM-CM5	CNRM-CM5	EC-EARTH	HadGEM2-ES	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CNRM-CM5	EC-EARTH	IPSL-CM5A-MR	HadGEM2-ES	MPI-ESM-LR	MPI-ESM-LR	IPSL-CM5A-MR	
Surface Temperature	ts	K	3 h																0
			6 h																0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
			month	x														x	2
Height Of Boundary Layer	zmla	m	3 h																0
			6 h																0
			day		x	x	x	x		x	x	x	x	x	x	x		x	12
			month															x	1
Water Vapour Path	prw	kg m-2	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x			12
			month																0
Condensed Water Path (liquid+ice)	clwvi	kg m-2	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x			12
			month																0
Ice Water Path	clivi	kg m-2	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x			12
			month																0
Eastward Wind at 850 hPa	ua850	m s-1	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
Northward Wind at 850 hPa	va850	m s-1	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
Temperature at 850 hPa	ta850	K	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
Specific Humidity at 850 hPa	hus850	1	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
Eastward Wind at 500 hPa	ua500	m s-1	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
Northward Wind at 500 hPa	va500	m s-1	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
Geopotential Height at 500 hPa	zg500	m	3 h																0
			6 h									x	x	x	x	x			5
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
			month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15

EUR-11

Variable long name	Name	Unit	Frequency	ALADIN53 CNRM-CM5	CCLM4-8-17 CNRM-CM5	CCLM4-8-17 EC-EARTH	CCLM4-8-17 HadGEM2-ES	CCLM4-8-17 MPI-ESM-LR	HIRHAM5 EC-EARTH	RACMO22E EC-EARTH	RACMO22E HadGEM2-ES	RCA4 CNRM-CM5	RCA4 EC-EARTH	RCA4 IPSL-CM5A-MR	RCA4 HadGEM2-ES	RCA4 MPI-ESM-LR	REMO2009 MPI-ESM-LR	WRF331F IPSL-CM5A-MR	Total number
Temperature at 500 hPa	ta500	K	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
Eastward Wind at 200 hPa	ua200	m s-1	3 h																0
			6 h									x	x	x	x	x			5
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
Northward Wind at 200 hPa	va200	m s-1	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
Temperature at 200 hPa	ta200	K	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
Geopotential Height at 200 hPa	zg200	m	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
High Cloud Cover (p<440hPa)	clh	%	3 h																0
			6 h																0
			day						x	x	x	x	x	x	x	x			8
			month																0
Medium Cloud Cover (680 hPa > p > 440 hPa)	clm	%	3 h																0
			6 h																0
			day						x	x	x	x	x	x	x	x			8
			month																0
Low Cloud Cover (p>680hPa)	cll	%	3 h																0
			6 h																0
			day						x	x	x	x	x	x	x	x			8
			month																0
Snow Area Fraction	snc	%	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x		x	13
			month		x	x	x	x	x	x	x	x	x	x	x	x		x	13
Snow Depth	snd	m	3 h																0
			6 h																0
			day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
			month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
Sea Ice Fraction	sic	%	3 h																0
			6 h																0
			day						x	x	x	x	x	x	x	x	x	x	10
			month						x	x	x	x	x	x	x	x	x	x	10
Snowfall Flux	prsn	kg m-2 s-1	3 h																0
			6 h																0
			day						x	x	x	x	x	x	x	x	x	x	10
			month															x	1

Table 15: Availability of different variable packages in the GCM-driven RCM experiments on different EURO-CORDEX resolutions.

EUR-44			**RCM-GCM chains**																		**Total number**
			ALADIN52	**ALADIN53**	**CCLM4-8-17**	**HIRHAM5**	**RACMO22E**		**RCA4**										**REMO2009**	**WRF331F**	
			CNRM-CM5	CNRM-CM5	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CanESM2	CNRM-CM5	CSIRO-Mk3-6-0	EC-EARTH	IPSL-CM5A-MR	MIROC5	HadGEM2-ES	MPI-ESM-LR	NorESM1-M	GFDL-ESM2M	MPI-ESM-LR	IPSL-CM5A-MR	
Variable package name	**Variables**	**Frequency**																			
Basic	tas, tasmax, tasmin, pr	3 h																			**0**
		6 h																			**0**
		day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**18**
		month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**18**
Extended basic	tas, tasmax, tasmin, pr, slp, uas, vas, huss, rsds, clt, prsn,	3 h																			**0**
		6 h																			**0**
		day	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x		**15**
		month																			**0**
Extended basic 2	tas, tasmax, tasmin, pr, slp, uas, vas, huss, rsds, clt, prsn, prw	3 h																			**0**
		6 h																			**0**
		day	x			x	x	x	x	x	x	x	x	x	x	x	x	x			**14**
		month																			**0**
Radiation	rlds, rlus, rsds, rsus,	3 h																			**0**
		6 h																			**0**
		day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**17**
		month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**17**
Extended radiation	rlds, rlus, rsds, rsus, rsdt, rsut, rlut	3 h																			**0**
		6 h																			**0**
		day			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**16**
		month			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**16**
Pressure level	ua850, va850, ta850, ua500, va500, ta500, zg500, ua200, va200, ta200, zg200	3 h																			**0**
		6 h																			**0**
		day	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**17**
		month	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**17**
All packages		3 h																			**0**
		6 h																			**0**
		day				x	x	x	x	x	x	x	x	x	x	x	x	x			**13**
		month																			**0**

EUR-11			RCM-GCM chains															
			ALADIN53	CCLM4-8-17				HIRHAM5	RACMO22E		RCA4					REMO2009	WRF331F	Total number
			CNRM-CM5	CNRM-CM5	EC-EARTH	HadGEM2-ES	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CNRM-CM5	EC-EARTH	IPSL-CM5A-MR	HadGEM2-ES	MPI-ESM-LR	MPI-ESM-LR	IPSL-CM5A-MR	
Variable package name	**Variables**	**Frequency**																
Basic	tas, tasmax, tasmin, pr	3 h																**0**
		6 h																**0**
		day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
		month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
Extended basic	tas, tasmax, tasmin, pr, slp, uas, vas, huss, rsds, clt, prsn,	3 h																**0**
		6 h																**0**
		day						x	x	x	x	x	x	x	x	x		**9**
		month																**0**
Extended basic 2	tas, tasmax, tasmin, pr, slp, uas, vas, huss, rsds, clt, prsn, prw	3 h																**0**
		6 h																**0**
		day						x	x	x	x	x	x	x	x			**8**
		month																**0**
Radiation	rlds, rlus, rsds, rsus,	3 h																**0**
		6 h																**0**
		day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
		month	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**15**
Extended radiation	rlds, rlus, rsds, rsus, rsdt, rsut, rlut	3 h																**0**
		6 h																**0**
		day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	**14**
		month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	**14**
Pressure level	ua850, va850, ta850, ua500, va500, ta500, zg500, ua200, va200, ta200, zg200	3 h																**0**
		6 h																**0**
		day		x	x	x	x	x	x	x	x	x	x	x	x	x	x	**14**
		month		x	x	x	x	x	x	x	x	x	x	x	x	x	x	**14**
All packages		3 h																**0**
		6 h																**0**
		day						x	x	x	x	x	x	x	x			**8**
		month																**0**

Table 16: Applied regional climate models, drivings from global climate models and bias-adjustment methods in EURO-CORDEX simulations on 0.44- (EUR-44) and 0.11-degree (EUR-11) resolutions.

EUR-44	RCM-GCM chains															
RCM	CCLM4-8-17	HIRHAM5	RACMO22E *		RCA4										REMO2009	WRF331F
GCM	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CanESM2	CNRM-CM5	CSIRO-Mk3-6-0	EC-EARTH	MIROC5	HadGEM2-ES	IPSL-CM5A-MR	MPI-ESM-LR	NorESM1-M	GFDL-ESM2M	MPI-ESM-LR	IPSL-CM5A-MR
Bias adjustment method: IPSL-CDFT21-WFDEI																
METNO-QMAP-MESAN																
METNO-QMAP-EOBS12	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
SMHI-DBS45-MESAN																
TUC-MSBC-EOBS12	x	x	x	x		x		x		x	x	x				x

EUR-11	RCM-GCM chains													
RCM	ARPEGE51	CCLM4-8-17				HIRHAM5	RACMO22E *		RCA4				REMO2009	WRF331F
GCM	CNRM-CM5	CNRM-CM5	EC-EARTH	MPI-ESM-LR	HadGEM2-ES	EC-EARTH	EC-EARTH	HadGEM2-ES	CNRM-CM5	EC-EARTH	IPSL-CM5A-MR	HadGEM2-ES	MPI-ESM-LR	IPSL-CM5A-MR
Bias adjustment method: IPSL-CDFT21-WFDEI	x					x	x		x	x	x	x	x	x
METNO-QMAP-MESAN		x	x	x		x	x		x	x	x	x		
METNO-QMAP-EOBS12														
SMHI-DBS45-MESAN		x	x	x	x	x	x	x					x	
TUC-MSBC-EOBS12														

* RACMOE22E v1 and v2 are available depending on the driving GCM (not distinguished in the following tables)

Table 17: Spatial resolution, grid and availability of parameters on surface and vertical levels in bias-adjusted GCM-driven RCM experiments of EURO-CORDEX.

	Bias adjustment method	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	SMHI-DBS45-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	SMHI-DBS45-MESAN
	GCM	CNRM-CM5	CNRM-CM5		EC-EARTH		MPI-ESM-LR				HadGEM2-ES	EC-EARTH					EC-EARTH		
	RCM	ARPEGE51	CCLM4-8-17									HIRHAM5					RACMO22E		
Grid type, spatial resolution	EUR-44 (0.44° resolution)								x	x					x	x		x	
	EUR-11 (0.11° resolution)	x			x			x	x		x	x	x	x			x	x	x
	EUR-44i (0.5° resolution)																		
	EUR-11i (0.125° resolution)																		
	Land area fraction available																		
	Orography available																		
	Pressure level data available																		

	Bias adjustment method	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	SMHI-DBS45-MESAN	TUC-MSBC-EOBS12	METNO-QMAP-EOBS12	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	METNO-QMAP-EOBS12	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	METNO-QMAP-EOBS12	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	METNO-QMAP-EOBS12
	GCM			HadGEM2-ES		CanESM2	CNRM-CM5				CSIRO-Mk3-6-0	EC-EARTH				MIROC5	HadGEM2-ES		
	RCM					RCA4													
Grid type, spatial resolution	EUR-44 (0.44° resolution)	x	x		x	x			x	x	x			x	x	x			x
	EUR-11 (0.11° resolution)			x			x	x				x	x				x		
	EUR-44i (0.5° resolution)																		
	EUR-11i (0.125° resolution)																		
	Land area fraction available																		
	Orography available																		
	Pressure level data available																		

	Bias adjustment method	TUC-MSBC-EOBS12	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	IPSL-CDFT21-WFDEI	SMHI-DBS45-MESAN	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	METNO-QMAP-EOBS12	METNO-QMAP-EOBS12	IPSL-CDFT21-WFDEI	SMHI-DBS45-MESAN	METNO-QMAP-EOBS12	IPSL-CDFT21-WFDEI	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	Total number
	GCM		IPSL-CM5A-MR				MPI-ESM-LR				NorESM1-M	GFDL-ESM2M	MPI-ESM-LR			IPSL-CM5A-MR			
	RCM												REMO2009			WRF331F			
Grid type, spatial resolution	EUR-44 (0.44° resolution)	x			x	x			x	x	x	x			x		x	x	26
	EUR-11 (0.11° resolution)		x	x			x	x					x	x		x			24
	EUR-44i (0.5° resolution)																		0
	EUR-11i (0.125° resolution)																		0
	Land area fraction available																		0
	Orography available																		0
	Pressure level data available																		0

Table 18: Ensemble members of bias-adjusted GCM-driven RCM experiments on different EURO-CORDEX resolutions.

EUR-44

Bias adjustment method	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	TUC-MSBC-EOBS12	METNO-QMAP-EOBS12	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	METNO-QMAP-EOBS12	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	METNO-QMAP-EOBS12	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	METNO-QMAP-EOBS12	METNO-QMAP-EOBS12	METNO-QMAP-EOBS12	METNO-QMAP-EOBS12	TUC-MSBC-EOBS12	
GCM	MPI-ESM-LR		EC-EARTH		EC-EARTH		HadGEM2-ES	CanESM2	CNRM-CM5		CSIRO-Mk3-6-0	EC-EARTH		MIROC5	HadGEM2-ES		IPSL-CM5A-MR		MPI-ESM-LR		NorESM1-M	GFDL-ESM2M	MPI-ESM-LR	IPSL-CM5A-MR		
RCM	**CCLM4-8-17**		**HIRHAM5**		**RACMO22E**			**RCA4**															**REMO2009**	**WRF311F**		**Total number**
Ensemble memners: r0i0p0																										**0**
r1i1p1	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**23**
r2i1p1																							x			**1**
r3i1p1		x	x	x																						**3**
r12i1p1												x	x													**2**
Total number	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	

EUR-11

Bias adjustment method	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	SMHI-DBS45-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	SMHI-DBS45-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	IPSL-CDFT21-WFDEI	SMHI-DBS45-MESAN	IPSL-CDFT21-WFDEI	
GCM	CNRM-CM5	CNRM-CM5		EC-EARTH		MPI-ESM-LR		HadGEM2-ES	EC-EARTH			EC-EARTH			HadGEM2-ES	CNRM-CM5		EC-EARTH		IPSL-CM5A-MR		HadGEM2-ES		MPI-ESM-LR		IPSL-CM5A-MR	
RCM	**ARPEGE51**	**CCLM4-8-17**							**HIRHAM5**			**RACMO22E**				**RCA4**								**REMO2009**		**WRF311F**	**Total number**
Ensemble memners: r0i0p0																											**0**
r1i1p1	x	x	x			x	x	x				x	x	x	x	x	x			x	x	x	x	x	x	x	**18**
r2i1p1																									x		**1**
r3i1p1									x	x	x																**3**
r12i1p1				x	x													x	x								**4**
Total number	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	

Table 19: Time horizon of bias-adjusted GCM-driven RCM experiments on different EURO-CORDEX resolutions.

EUR-44

RCM	GCM	Bias adjustment method	RCP experiment not reaching 2100	RCP experiment until 2100	RCP experiment beyond 2100
CCLM4-8-17	MPI-ESM-LR	METNO-QMAP-EOBS12		x	
CCLM4-8-17	MPI-ESM-LR	TUC-MSBC-EOBS12		x	
HIRHAM5	EC-EARTH	METNO-QMAP-EOBS12		x	
HIRHAM5	EC-EARTH	TUC-MSBC-EOBS12		x	
RACMO22E	EC-EARTH	METNO-QMAP-EOBS12		x	
RACMO22E	EC-EARTH	TUC-MSBC-EOBS12		x	
RACMO22E	HadGEM2-ES	TUC-MSBC-EOBS12	x		
RCA4	CanESM2	METNO-QMAP-EOBS12		x	
RCA4	CNRM-CM5	METNO-QMAP-EOBS12		x	
RCA4	CNRM-CM5	TUC-MSBC-EOBS12		x	
RCA4	CSIRO-Mk3-6-0	METNO-QMAP-EOBS12		x	
RCA4	EC-EARTH	METNO-QMAP-EOBS12		x	
RCA4	EC-EARTH	TUC-MSBC-EOBS12		x	
RCA4	MIROC5	METNO-QMAP-EOBS12		x	
RCA4	HadGEM2-ES	METNO-QMAP-EOBS12	x		
RCA4	HadGEM2-ES	TUC-MSBC-EOBS12	x		
RCA4	IPSL-CM5A-MR	METNO-QMAP-EOBS12		x	
RCA4	IPSL-CM5A-MR	TUC-MSBC-EOBS12		x	
RCA4	MPI-ESM-LR	METNO-QMAP-EOBS12		x	
RCA4	MPI-ESM-LR	TUC-MSBC-EOBS12		x	
RCA4	NorESM1-M	METNO-QMAP-EOBS12		x	
RCA4	GFDL-ESM2M	METNO-QMAP-EOBS12		x	
REMO2009	MPI-ESM-LR	METNO-QMAP-EOBS12		x	
WRF331F	IPSL-CM5A-MR	METNO-QMAP-EOBS12		x	
WRF331F	IPSL-CM5A-MR	TUC-MSBC-EOBS12		x	
Total number			**3**	**22**	**0**

EUR-11

RCM	GCM	Bias adjustment method	RCP experiment not reaching 2100	RCP experiment until 2100	RCP experiment beyond 2100
ARPEGE51	CNRM-CM5	IPSL-CDFT21-WFDEI		x	
CCLM4-8-17	CNRM-CM5	METNO-QMAP-MESAN		x	
CCLM4-8-17	CNRM-CM5	SMHI-DBS45-MESAN		x	
CCLM4-8-17	EC-EARTH	METNO-QMAP-MESAN		x	
CCLM4-8-17	EC-EARTH	SMHI-DBS45-MESAN		x	
CCLM4-8-17	MPI-ESM-LR	METNO-QMAP-MESAN		x	
CCLM4-8-17	MPI-ESM-LR	SMHI-DBS45-MESAN		x	
CCLM4-8-17	HadGEM2-ES	SMHI-DBS45-MESAN	x		
HIRHAM5	EC-EARTH	IPSL-CDFT21-WFDEI		x	
HIRHAM5	EC-EARTH	METNO-QMAP-MESAN		x	
HIRHAM5	EC-EARTH	SMHI-DBS45-MESAN		x	
RACMO22E	EC-EARTH	IPSL-CDFT21-WFDEI		x	
RACMO22E	EC-EARTH	METNO-QMAP-MESAN		x	
RACMO22E	EC-EARTH	SMHI-DBS45-MESAN		x	
RACMO22E	HadGEM2-ES	SMHI-DBS45-MESAN	x		
RCA4	CNRM-CM5	IPSL-CDFT21-WFDEI		x	
RCA4	CNRM-CM5	METNO-QMAP-MESAN		x	
RCA4	EC-EARTH	IPSL-CDFT21-WFDEI		x	
RCA4	EC-EARTH	METNO-QMAP-MESAN		x	
RCA4	IPSL-CM5A-MR	IPSL-CDFT21-WFDEI		x	
RCA4	IPSL-CM5A-MR	METNO-QMAP-MESAN		x	
RCA4	HadGEM2-ES	IPSL-CDFT21-WFDEI	x		
RCA4	HadGEM2-ES	METNO-QMAP-MESAN	x		
REMO2009	MPI-ESM-LR	IPSL-CDFT21-WFDEI		x	
REMO2009	MPI-ESM-LR	SMHI-DBS45-MESAN		x	
WRF331F	IPSL-CM5A-MR	IPSL-CDFT21-WFDEI		x	
Total number			**4**	**21**	**0**

Table 20: Bias-adjusted GCM-driven historical and scenario experiments on different EURO-CORDEX resolutions.

EUR-44

RCM	GCM	Bias adjustment method	Historical	RCP2.6	RCP4.5	RCP8.5
CCLM4-8-17	MPI-ESM-LR	METNO-QMAP-EOBS12				x
		TUC-MSBC-EOBS12			x	x
HIRHAM5	EC-EARTH	METNO-QMAP-EOBS12				x
		TUC-MSBC-EOBS12			x	x
RACMO22E	EC-EARTH	METNO-QMAP-EOBS12				x
		TUC-MSBC-EOBS12			x	x
	HadGEM2-ES	TUC-MSBC-EOBS12		x	x	x
RCA4	CanESM2	METNO-QMAP-EOBS12			x	x
	CNRM-CM5	METNO-QMAP-EOBS12			x	x
		TUC-MSBC-EOBS12			x	x
	CSIRO-Mk3-6-0	METNO-QMAP-EOBS12			x	
	EC-EARTH	METNO-QMAP-EOBS12			x	
		TUC-MSBC-EOBS12		x	x	
	MIROC5	METNO-QMAP-EOBS12			x	
	HadGEM2-ES	METNO-QMAP-EOBS12			x	x
		TUC-MSBC-EOBS12		x	x	x
	IPSL-CM5A-MR	METNO-QMAP-EOBS12			x	x
		TUC-MSBC-EOBS12			x	x
	MPI-ESM-LR	METNO-QMAP-EOBS12			x	x
		TUC-MSBC-EOBS12			x	x
	NorESM1-M	METNO-QMAP-EOBS12			x	x
	GFDL-ESM2M	METNO-QMAP-EOBS12			x	x
REMO2009	MPI-ESM-LR	METNO-QMAP-EOBS12				x
WRF311F	IPSL-CM5A-MR	METNO-QMAP-EOBS12			x	x
		TUC-MSBC-EOBS12			x	x
Total number			**0**	**3**	**21**	**21**

EUR-11

RCM	GCM	Bias adjustment method	Historical	RCP2.6	RCP4.5	RCP8.5
ARPEGE51	CNRM-CM5	IPSL-CDFT21-WFDEI			x	x
CCLM4-8-17	CNRM-CM5	METNO-QMAP-MESAN			x	
		SMHI-DBS45-MESAN			x	x
	EC-EARTH	METNO-QMAP-MESAN			x	
		SMHI-DBS45-MESAN			x	x
	MPI-ESM-LR	METNO-QMAP-MESAN			x	
		SMHI-DBS45-MESAN			x	x
	HadGEM2-ES	SMHI-DBS45-MESAN			x	x
HIRHAM5	EC-EARTH	IPSL-CDFT21-WFDEI			x	x
		METNO-QMAP-MESAN			x	
		SMHI-DBS45-MESAN			x	x
RACMO22E	EC-EARTH	IPSL-CDFT21-WFDEI			x	x
		METNO-QMAP-MESAN			x	
		SMHI-DBS45-MESAN			x	x
	HadGEM2-ES	SMHI-DBS45-MESAN			x	x
RCA4	CNRM-CM5	IPSL-CDFT21-WFDEI			x	x
		METNO-QMAP-MESAN			x	
	EC-EARTH	IPSL-CDFT21-WFDEI			x	x
		METNO-QMAP-MESAN			x	
	IPSL-CM5A-MR	IPSL-CDFT21-WFDEI			x	x
		METNO-QMAP-MESAN			x	
	HadGEM2-ES	IPSL-CDFT21-WFDEI			x	x
		METNO-QMAP-MESAN			x	
REMO2009	MPI-ESM-LR	IPSL-CDFT21-WFDEI			x	x
		SMHI-DBS45-MESAN		x	x	x
WRF311F	IPSL-CM5A-MR	IPSL-CDFT21-WFDEI			x	x
Total number			**0**	**1**	**25**	**16**

Table 21: Temporal output frequency of bias-adjusted GCM-driven RCM experiments on different EURO-CORDEX resolutions.

EUR-44

RCM	GCM	Bias adjustment method	3-hourly	6-hourly	daily	monthly	seasonal	invariant (fx)
CCLM4-8-17	MPI-ESM-LR	METNO-QMAP-EOBS12			x			
		TUC-MSBC-EOBS12			x			
HIRHAM5	EC-EARTH	METNO-QMAP-EOBS12			x			
		TUC-MSBC-EOBS12			x			
RACMO22E	EC-EARTH	METNO-QMAP-EOBS12			x			
		TUC-MSBC-EOBS12			x			
	HadGEM2-ES	TUC-MSBC-EOBS12			x			
RCA4	CanESM2	METNO-QMAP-EOBS12			x			
	CNRM-CM5	METNO-QMAP-EOBS12			x			
		TUC-MSBC-EOBS12			x			
	CSIRO-Mk3-6-0	METNO-QMAP-EOBS12			x			
	EC-EARTH	METNO-QMAP-EOBS12			x			
		TUC-MSBC-EOBS12			x			
	MIROC5	METNO-QMAP-EOBS12			x			
	HadGEM2-ES	METNO-QMAP-EOBS12			x			
		TUC-MSBC-EOBS12			x			
	IPSL-CM5A-MR	METNO-QMAP-EOBS12			x			
		TUC-MSBC-EOBS12			x			
	MPI-ESM-LR	METNO-QMAP-EOBS12			x			
		TUC-MSBC-EOBS12			x			
	NorESM1-M	METNO-QMAP-EOBS12			x			
	GFDL-ESM2M	METNO-QMAP-EOBS12			x			
REMO2009	MPI-ESM-LR	METNO-QMAP-EOBS12			x			
WRF311F	IPSL-CM5A-MR	METNO-QMAP-EOBS12			x			
		TUC-MSBC-EOBS12			x			
Total number			**0**	**0**	**25**	**0**	**0**	**0**

EUR-11

RCM	GCM	Bias adjustment method	3-hourly	6-hourly	daily	monthly	seasonal	invariant (fx)
ARPEGE51	CNRM-CM5	IPSL-CDFT21-WFDEI	x		x			
CCLM4-8-17	CNRM-CM5	METNO-QMAP-MESAN			x			
		SMHI-DBS45-MESAN			x	x		
	EC-EARTH	METNO-QMAP-MESAN			x			
		SMHI-DBS45-MESAN			x	x		
	MPI-ESM-LR	METNO-QMAP-MESAN			x			
		SMHI-DBS45-MESAN			x	x		
	HadGEM2-ES	SMHI-DBS45-MESAN			x	x		
HIRHAM5	EC-EARTH	IPSL-CDFT21-WFDEI	x		x			
		METNO-QMAP-MESAN			x			
		SMHI-DBS45-MESAN			x	x		
RACMO22E	EC-EARTH	IPSL-CDFT21-WFDEI	x		x			
		METNO-QMAP-MESAN			x			
		SMHI-DBS45-MESAN			x	x		
	HadGEM2-ES	SMHI-DBS45-MESAN			x	x		
RCA4	CNRM-CM5	IPSL-CDFT21-WFDEI	x		x			
		METNO-QMAP-MESAN			x			
	EC-EARTH	IPSL-CDFT21-WFDEI	x		x			
		METNO-QMAP-MESAN			x			
	IPSL-CM5A-MR	IPSL-CDFT21-WFDEI	x		x			
		METNO-QMAP-MESAN			x			
	HadGEM2-ES	IPSL-CDFT21-WFDEI	x		x			
		METNO-QMAP-MESAN			x			
REMO2009	MPI-ESM-LR	IPSL-CDFT21-WFDEI	x		x			
		SMHI-DBS45-MESAN			x			
WRF311F	IPSL-CM5A-MR	IPSL-CDFT21-WFDEI	x		x			
Total number			**9**	**0**	**26**	**7**	**0**	**0**

Table 22: Availability of different atmospheric and surface variables in the bias-adjusted GCM-driven RCM experiments on 0.44-degree EURO-CORDEX resolution.

EUR-11			Bias adjustment method	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	SMHI-DBS45-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	SMHI-DBS45-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	IPSL-CDFT21-WFDEI	SMHI-DBS45-MESAN	IPSL-CDFT21-WFDEI	
			GCM	CNRM-CM5	CNRM-CM5		EC-EARTH		MPI-ESM-LR		HadGEM2-ES	EC-EARTH			EC-EARTH			HadGEM2-ES	CNRM-CM5		EC-EARTH		IPSL-CM5A-MR		HadGEM2-ES		MPI-ESM-LR		IPSL-CM5A-MR	
			RCM	ARPEGE51	CCLM4-8-17							HIRHAM5			RACMO22E				RCA4								REMO2009		WRF311F	Total number
Variable long name	**Name**	**Unit**	**Frequency**																											
Adjusted Near-Surface Air Temperature	tasAdjust	K	3 h	x								x			x				x		x		x		x		x		x	8
			6 h																											0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	25
			month			x		x		x	x			x			x	x										x		8
Adjusted Daily-Maximum Near-Surface Air Temperature	tasmaxAdjust	K	3 h																											0
			6 h																											0
			day		x	x	x	x	x	x	x		x	x		x	x	x		x		x		x		x		x		17
			month			x		x		x	x			x			x	x										x		8
Adjusted Daily-Minimum Near-Surface Air Temperature	tasminAdjust	K	3 h																											0
			6 h																											0
			day		x	x	x	x	x	x	x		x	x		x	x	x		x		x		x		x		x		17
			month			x		x		x	x			x			x	x										x		8
Adjusted Precipitation	prAdjust	kg m-2 s-1	3 h																											0
			6 h																											0
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	25
			month			x		x		x	x			x			x	x										x		8
Adjusted Near-Surface Wind Speed	sfcWindAdjust	m s-1	3 h	x								x			x	x			x		x		x		x		x		x	9
			6 h																											0
			day																											0
			month																											0
Adjusted Surface Downwelling Shortwave Radiation	rsdsAdjust	W m-2	3 h	x								x			x	x			x		x		x		x		x		x	9
			6 h																											0
			day																											0
			month																											0

Table 23: Availability of different atmospheric and surface variables in the bias-adjusted GCM-driven RCM experiments on 0.11-degree EURO-CORDEX resolution.

EUR-11			Bias adjustment method	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	SMHI-DBS45-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	SMHI-DBS45-MESAN	SMHI-DBS45-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	IPSL-CDFT21-WFDEI	METNO-QMAP-MESAN	IPSL-CDFT21-WFDEI	SMHI-DBS45-MESAN	IPSL-CDFT21-WFDEI	
			GCM	CNRM-CM5	CNRM-CM5		EC-EARTH		MPI-ESM-LR		HadGEM2-ES	EC-EARTH			EC-EARTH			HadGEM2-ES	CNRM-CM5		EC-EARTH		IPSL-CM5A-MR		HadGEM2-ES		MPI-ESM-LR		IPSL-CM5A-MR	
			RCM	ARPEGE51	CCLM4-8-17							HIRHAM5			RACMO22E				RCA4								REMO2009		WRF311F	
Variable long name	**Name**	**Unit**	**Frequency**																											**Total number**
Adjusted Near-Surface Air Temperature	tasAdjust	K	3 h	x								x			x				x		x		x		x		x		x	**8**
			6 h																											**0**
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**25**
			month			x		x		x	x			x			x	x										x		**8**
Adjusted Daily-Maximum Near-Surface Air Temperature	tasmaxAdjust	K	3 h																											**0**
			6 h																											**0**
			day		x	x	x	x	x	x	x		x	x		x	x	x		x		x		x		x		x		**17**
			month			x		x		x	x			x			x	x										x		**8**
Adjusted Daily-Minimum Near-Surface Air Temperature	tasminAdjust	K	3 h																											**0**
			6 h																											**0**
			day		x	x	x	x	x	x	x		x	x		x	x	x		x		x		x		x		x		**17**
			month			x		x		x	x			x			x	x										x		**8**
Adjusted Precipitation	prAdjust	kg m-2 s-1	3 h																											**0**
			6 h																											**0**
			day	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	**25**
			month			x		x		x	x			x			x	x										x		**8**
Adjusted Near-Surface Wind Speed	sfcWindAdjust	m s-1	3 h	x								x			x	x			x		x		x		x		x		x	**9**
			6 h																											**0**
			day																											**0**
			month																											**0**
Adjusted Surface Downwelling Shortwave Radiation	rsdsAdjust	W m-2	3 h	x								x			x	x			x		x		x		x		x		x	**9**
			6 h																											**0**
			day																											**0**
			month																											**0**

Table 24: Joint availability of given scenarios and atmospheric variables in GCM-driven RCM experiments on different EURO-CORDEX resolutions. Existence of bias-adjusted data for daily precipitation and daily minimum, maximum and mean temperature is highlighted in red.

Extended basic + Radiation + Pressure level	Extended basic + Radiation + Pressure level	Extended basic + Radiation + Pressure level
0.44° horizontal resolution (EUR-44)	0.44° horizontal resolution (EUR-44)	0.44° horizontal resolution (EUR-44)
historical + RCP8.5	historical + RCP8.5 + RCP4.5	historical + RCP8.5 + RCP4.5 + RCP2.6
HIRHAM5 - EC-EARTH	**HIRHAM5** - EC-EARTH	
RACMO22E - EC-EARTH	**RACMO22E** - EC-EARTH	
RACMO22E - HadGEM2-ES	**RACMO22E** - HadGEM2-ES	**RACMO22E** - HadGEM2-ES
RCA4 - CanESM2	**RCA4** - CanESM2	
RCA4 - CNRM-CM5	**RCA4** - CNRM-CM5	
RCA4 - CSIRO-Mk3-6-0	**RCA4** - CSIRO-Mk3-6-0	
RCA4 - EC-EARTH	**RCA4** - EC-EARTH	**RCA4** - EC-EARTH
RCA4 - IPSL-CM5A-MR	**RCA4** - IPSL-CM5A-MR	
RCA4 - MIROC5	**RCA4** - MIROC5	**RCA4** - MIROC5
RCA4 - HadGEM2-ES	**RCA4** - HadGEM2-ES	**RCA4** - HadGEM2-ES
RCA4 - MPI-ESM-LR	**RCA4** - MPI-ESM-LR	**RCA4** - MPI-ESM-LR
RCA4 - NorESM1-M	**RCA4** - NorESM1-M	**RCA4** - NorESM1-M
RCA4 - GFDL-ESM2M	**RCA4** - GFDL-ESM2M	
REMO2009 - MPI-ESM-LR	**REMO2009** - MPI-ESM-LR	**REMO2009** - MPI-ESM-LR
Number of simulations: 14	**Number of simulations: 14**	**Number of simulations: 7**

Extended basic + Radiation + Pressure level	Extended basic + Radiation + Pressure level	Extended basic + Radiation + Pressure level
0.11° horizontal resolution (EUR-11)	0.11° horizontal resolution (EUR-11)	0.11° horizontal resolution (EUR-11)
historical + RCP8.5	historical + RCP8.5 + RCP4.5	historical + RCP8.5 + RCP4.5 + RCP2.6
HIRHAM5 - EC-EARTH	**HIRHAM5** - EC-EARTH	**HIRHAM5** - EC-EARTH
RACMO22E - EC-EARTH	**RACMO22E** - EC-EARTH	
RACMO22E - HadGEM2-ES	**RACMO22E** - HadGEM2-ES	**RACMO22E** - HadGEM2-ES
RCA4 - CNRM-CM5	**RCA4** - CNRM-CM5	
RCA4 - EC-EARTH	**RCA4** - EC-EARTH	**RCA4** - EC-EARTH
RCA4 - IPSL-CM5A-MR	**RCA4** - IPSL-CM5A-MR	
RCA4 - HadGEM2-ES	**RCA4** - HadGEM2-ES	
RCA4 - MPI-ESM-LR	**RCA4** - MPI-ESM-LR	
REMO2009 - MPI-ESM-LR	**REMO2009** - MPI-ESM-LR	**REMO2009** - MPI-ESM-LR
Number of simulations: 9	**Number of simulations: 9**	**Number of simulations: 4**

Table 25: Joint availability of given scenarios and relevant atmospheric variables in GCM-driven RCM experiments on different EURO-CORDEX resolutions.

All packages	All packages	All packages
0.44° horizontal resolution (EUR-44)	0.44° horizontal resolution (EUR-44)	0.44° horizontal resolution (EUR-44)
historical + RCP8.5	historical + RCP8.5 + RCP4.5	historical + RCP8.5 + RCP4.5 + RCP2.6
HIRHAM5 - EC-EARTH	**HIRHAM5** - EC-EARTH	
RACMO22E - EC-EARTH	**RACMO22E** - EC-EARTH	
RACMO22E - HadGEM2-ES	**RACMO22E** - HadGEM2-ES	**RACMO22E** - HadGEM2-ES
RCA4 - CanESM2	**RCA4** - CanESM2	
RCA4 - CNRM-CM5	**RCA4** - CNRM-CM5	
RCA4 - CSIRO-Mk3-6-0	**RCA4** - CSIRO-Mk3-6-0	
RCA4 - EC-EARTH	**RCA4** - EC-EARTH	**RCA4** - EC-EARTH
RCA4 - IPSL-CM5A-MR	**RCA4** - IPSL-CM5A-MR	
RCA4 - MIROC5	**RCA4** - MIROC5	**RCA4** - MIROC5
RCA4 - HadGEM2-ES	**RCA4** - HadGEM2-ES	**RCA4** - HadGEM2-ES
RCA4 - MPI-ESM-LR	**RCA4** - MPI-ESM-LR	**RCA4** - MPI-ESM-LR
RCA4 - NorESM1-M	**RCA4** - NorESM1-M	**RCA4** - NorESM1-M
RCA4 - GFDL-ESM2M	**RCA4** - GFDL-ESM2M	
Number of simulations: 13	**Number of simulations: 13**	**Number of simulations: 6**

All packages	All packages	All packages
0.11° horizontal resolution (EUR-11)	0.11° horizontal resolution (EUR-11)	0.11° horizontal resolution (EUR-11)
historical + RCP8.5	historical + RCP8.5 + RCP4.5	historical + RCP8.5 + RCP4.5 + RCP2.6
HIRHAM5 - EC-EARTH	**HIRHAM5** - EC-EARTH	**HIRHAM5** - EC-EARTH
RACMO22E - EC-EARTH	**RACMO22E** - EC-EARTH	
RACMO22E - HadGEM2-ES	**RACMO22E** - HadGEM2-ES	**RACMO22E** - HadGEM2-ES
RCA4 - CNRM-CM5	**RCA4** - CNRM-CM5	
RCA4 - EC-EARTH	**RCA4** - EC-EARTH	**RCA4** - EC-EARTH
RCA4 - IPSL-CM5A-MR	**RCA4** - IPSL-CM5A-MR	
RCA4 - HadGEM2-ES	**RCA4** - HadGEM2-ES	
RCA4 - MPI-ESM-LR	**RCA4** - MPI-ESM-LR	
Number of simulations: 8	**Number of simulations: 8**	**Number of simulations: 3**

Table 26: Evaluation matrix of MED-CORDEX dataset.

MED-CORDEX_EM_filled_toD2.2.xlsx

Table 27: Evaluation matrix of MENA-CORDEX dataset.

MNA-CORDEX_EM_filled_toD2.2.xlsx

Table 28: Evaluation matrix of Arctic-CORDEX dataset.

ARC-CORDEX_EM_filled_toD2.2.xlsx

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