CORDEX experiment design for dynamical downscaling of CMIP6

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The **COordinated Regional climate Downscaling EXperiment** (CORDEX) was implemented under the auspices of the World Climate Research Program (WCRP) in order to improve downscaling techniques and their use in the provision of robust regional climate information for application in vulnerability, impacts and adaptation (VIA) studies. The first-phase CORDEX activities included a validation stream aimed at assessing and improving regional climate downscaling models and techniques, along with a regional projection stream based on downscaling of global projections from the fifth phase of the Climate Model Intercomparison Project (CMIP5).

This document presents a simulation framework for dynamical downscaling of global projections from the sixth phase of CMIP (CMIP6). The general aim is to downscale a subset of climate scenarios from the CMIP6 ensemble of projections generated within the ScenarioMIP and to make these downscaled regional scenarios publicly available (Gutowski et al. 2016). The framework presented here to achieve these goals consists of the following components.

1. CORDEX domains

14 CORDEX standard domains have been approved and include: *South America, Central America, North America, Europe, Mediterranean, Middle East North Africa, Africa, Central Asia, South Asia, East Asia, Southeast Asia, Australasia, Arctic and Antarctica*. The simulations have to follow the size specifications for the CORDEX domains (link to the CORDEX domain doc, to be provided), giving particular attention to the specified minimum domain sizes. In this sense **the CORDEX domain has to be fully inside your model domain and not include any of the boundary relaxation zones**. It is appreciated that domains will not be identical and for various reasons groups will choose to modify their actual domains somewhat.

In addition to the 14 CORDEX domains, the Flagship Pilot Studies (FPS) programme within CORDEX facilitates downscaling to very high spatial resolutions (including convection permitting resolutions) over selected domains (e.g. over lakes, mountains, etc.). FPS are evaluated by the CORDEX Science Advisory Team (SAT) and external reviewers and would adhere to the protocols described in this document (see for more details CORDEX FPS).

2. Resolution/Grid spacing

In order to provide an advancement compared to the previous CORDEX simulations and to resolve additional features of regional climate, the grid spacing of the new CORDEX simulations ideally should be of the order of a few tens of kilometers. However, a flexible choice of grid spacing between different domains and even within the same domain is allowed, to accommodate needs and capacities of different communities and groups.

The primary target is grid spacing of 25 and 12.5km. The CORDEX domains should decide on what resolution they need and can afford with a preference for high resolutions where possible. The Point-of-Contact (POC) for each domain should provide guidance on resolution commonly used for their domain.

3. Evaluation experiment

All groups must carry out first an evaluation simulation driven by the **ERA-Interim** reanalysis for each domain they simulate. The **ERA-Interim** reanalysis covers 1979-2018 (last full year) and the evaluation experiment has to cover the entire 1979-2018 period. As a second step, the **ERA-Interim** driven evaluation experiment could be complemented by downscaling the latest **ERA5** reanalysis for a longer period, depending on availability of the **ERA5** forcing. Participating in this second evaluation experiment is strongly encouraged but not required.

The CORDEX domains can also carry out additional evaluation experiments (e.g. at different resolutions and/or driven by other reanalyses) to complement the common ERA-Interim and ERA5 driven experiments. It is up to the CORDEX domains to set up their own experiment design for such additional reanalysis-driven simulations depending on resources and scientific questions.

It is recommended that prescribed sea surface temperature and sea-ice fraction also be obtained from the driving reanalyses. Land use/vegetation maps that match the reanalysis or are a regional models default are acceptable. The driving reanalyses should be taken at their native resolution.

GHG forcing

Until 2014, RCM groups should use the same historical atmospheric greenhouse gas (**GHG**) forcing as in CMIP6. For periods starting from 2015 and onwards it is recommended to use the scenario GHG forcing for the SSP2-4.5 as the mid-range scenario. The global and annual-mean time series of GHG concentrations for both the historical and scenario periods are available from the input4MIPs database (see for more details Meinshausen et al. 2017 and Meinshausen et al. 2019).

Aerosol

When possible, it is recommended that RCM groups apply up-to-date regional or global aerosol datasets with realistic variability in time (monthly variation and trend) and space.

Spectral nudging
If an RCM group uses large-scale spectral nudging, two evaluation simulations (with and without nudging) have to be provided.

4. Historical experiment

Boundary conditions from the CMIP6 historical experiment, requested by CORDEX, are available for 1950-2014 (a link to a list with GCMs that have provided boundary conditions for RCM, when available). In addition to the current reference period (1981-2010 for the 2011-2020 decade) the World Meteorological Organisation (WMO) has also recommended to use 1961-1990 as a standard reference period for long-term climate change assessments. The CORDEX historical simulations have to cover at least **1960-2014** or preferably the entire **1950-2014** period. The first year of the historical experiment (1950 or 1960) should be considered as a spin-up.

GHG forcing
RCM groups should use the same historical GHG forcing as in the driving CMIP6 models (see for more details Meinshausen et al. 2017).

Land use/Land cover
When possible, it is recommended that RCM groups apply land cover changes corresponding to the historical period being modelled. These changes should be derived from the Land Use Harmonized Dataset Version 2 v2f (LUH2-v2f, Hurtt et al. 2019).

Aerosol
When possible, it is recommended that RCM groups apply the same aerosol forcing as in the driving CMIP6 models.

5 Scenario experiment

Boundary conditions from the CMIP6 ScenarioMIP, requested by CORDEX, are available for 2015-2100. The main focus in the CORDEX Request to CMIP6 is on the Tier 1 **SSP5-8.5** and **SSP1-2.6** scenarios. These two scenarios for one ensemble member have to be downscaled first for the entire **2015-2100** period. It is recommended to downscale additionally the **SSP2-4.5** scenario after downscaling the **SSP5-8.5** and **SSP1-2.6** scenarios.

If the CORDEX modeling groups have sufficient resources, additional complementary simulations for other ensemble members and scenarios are also welcome. It is up to the CORDEX domains to define a set of additional scenario simulations depending on resources and scientific questions. It is strongly recommended that individual CORDEX RCM groups should coordinate their simulations with the International Project Office for CORDEX (IPOC) and CORDEX POCs for respective domains in order to avoid uncoordinated efforts leading to sparse RCM-GCM matrices.

GHG forcing

RCM groups should use the same scenario GHG forcing as in the driving CMIP6 models (see for more details Meinshausen et al. 2019).

Land use/Land cover

When possible, it is recommended that RCM groups apply land cover changes corresponding to the scenario being modelled - LUH2-v2f (see for more details Hurtt et al. 2019).

Aerosol

When possible, it is recommended that RCM groups apply the same aerosol forcing as in the driving CMIP6 models.

6. RCM Documentation

Climate model documentation, providing all necessary details on model configurations, experiments etc., is an integral part of climate modeling activities. The Earth System Documentation (ES-DOC) is an international effort to develop tools to describe Earth system models from the CMIP5 and CMIP6 activities. Such kind of coordinated effort is still missing in CORDEX and currently there is no common system for collecting and providing RCM details, although work in this direction is ongoing. Nonetheless, when possible, it is strongly recommended to create free style RCM documentation that details all aspects of the experiments and made it available upon request.

7. RCM-GCM matrices

It is up to the CORDEX domains to analyse the ability of the CMIP6 models to simulate important aspects of regional and global climate and to decide on which CMIP6 models should be downscaled over a specific domain. It is also up to the CORDEX domains to decide on a minimum number of simulations and design of RCM-GCM matrices for a specific domain.

8. Output variables

The CORDEX Data Request (DR) details variables and frequencies to be saved and their priorities for delivery (link to CORDEX DR, to be provided).

9. Archiving and publishing specifications

CORDEX output shall be published on the Earth System Grid Federation (ESGF) in order to be consistent with the CMIP6 archive and to make the output available to as many users as possible. All CORDEX simulations have to be formatted (cmorised) according to the CORDEX archive specifications that provide technical aspects of CORDEX data format and guidance for publishing CORDEX data on ESGF (link to CORDEX archive specs, to be provided).

References

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