

# Data Reference Syntax (DRS) for bias-adjusted CORDEX simulations

Grigory Nikulin<sup>1</sup> and Stephanie Legutke<sup>2</sup>

<sup>1</sup> Swedish Meteorological and Hydrological Institute (SMHI, Sweden)

<sup>2</sup> German Climate Computing Center (DKRZ, Germany)

15 June 2016

[CORDEX](#), the Coordinated Regional Downscaling Experiment focuses on high-resolution climate information produced by different dynamical and statistical downscaling techniques. One of the CORDEX aims is to provide coordinated sets of high-resolution regional climate projections worldwide. A large number of CORDEX Regional Climate Model (RCM) simulations are already openly available through the Earth System Grid Federation (ESGF) and also through regional data portals ([CORDEX data access](#)). These CORDEX simulations are widely used for vulnerability, impacts, and adaptation (VIA) studies which in turn provide guidance for decision-making at regional and local scales.

It has been widely recognised that climate model results, as an input to impact models, cannot always be used directly and some kind of adjustment towards the observed climatology is necessary.

Nowadays, bias adjustment or bias correction (the two terms are used interchangeably here) has been integrated as a standard optional part of pre-processing of climate simulations for use in impact modeling studies. These bias-corrected data, however, usually are not easily available to a wider community.

In order to close this gap, it was decided at [the 2<sup>nd</sup> CORDEX Science Advisory Team \(SAT\) meeting](#) to make bias-adjusted CORDEX simulations available on the ESGF in a coordinated way under a new “CORDEX-Adjust” project. Introducing the new project name “CORDEX-Adjust” aims to avoid any confusion and to clearly distinguish between the original CORDEX RCM simulation results and bias-adjusted versions of them.

This document specifies the Data Reference Syntax (DRS) elements for publishing bias-adjusted CORDEX simulation data through the ESGF. The document includes file naming conventions and metadata as NetCDF attributes. The DRS elements are allowed to either assume values defined by Controlled Vocabularies (CV), or free text, or free text with build rules.

## 1. Bias-adjustment DRS sub-elements

It is proposed that the DRS for bias-adjusted CORDEX simulation data should follow that for CORDEX data properly described in the [CORDEX archiving specifications](#), keeping the same number of the CORDEX DRS elements in file names. Bias-correction information is simply added to one of the CORDEX DRS elements. Such approach allows publishing of the bias-adjusted CORDEX simulation data under the CORDEX-Adjust project on ESGF using the existing [CORDEX-ESGF configuration](#) with a minimum of changes.

Three bias-correction DRS sub-elements are introduced:

**BCname** (CV) is an identifier for the applied bias-correction method that includes a combination of acronyms for the institute and the bias-correction method, separated by dashes "-" (e.g. SMHI-DBS43, LSCE-IPSL-CDFt, UCAN-EQM etc.).

**OBSname** (CV) is an acronym for the observation/reanalysis datasets used as reference data for bias adjustment. Presently, there is no unique CV for regional observational datasets, and acronyms for observations have to be defined in consultation with institutions responsible for the observational products.

**REFperiod** - reference or calibration period in YYYY-YYYY format (e.g. 1971-2000 or 1981-2010).

These 3 sub-elements are attached using dashes (-) to the CORDEX DRS element *RCMVersionID* (the 'Downscaling Realisation' search facet in the CORDEX-ESGF segment) creating a new element **BiasAdjustment**. The new **BiasAdjustment** element is a bit long but provides all necessary information about the bias adjustment methodology.

**Example:**

If *RCMVersionID*='v1', and a CORDEX simulation is bias-adjusted by SMHI-DBS43 method using E-OBS10 ([E-OBS gridded dataset, version 10.0](#)) as a reference observational dataset for the 1981-2010 period, **BiasAdjustment** becomes **v1-SMHI-DBS43-EOBS10-1981-2010 (RCMVersionID-BCname-OBSname-REFperiod)**. Note that the dash ("-") in E-OBS10 has dropped for consistency and easy automatic parsing.

## 2. File names, variable names, and NetCDF attributes

The names of the files in the CORDEX-Adjust project are made up of the CORDEX DRS elements with the changes described above. The elements are separated by underscores ('\_') and must appear in the following order:

*VariableName\_Domain\_GCMMModelName\_CMIP5ExperimentName\_CMIP5EnsembleMember\_RCMModelName\_BiasAdjustment\_Frequency[\_StartTime-EndTime].nc*

In order to avoid any confusion and clearly distinguish original and bias-adjusted CORDEX simulation data, it has been decided to follow an approach used in CMIP5 ([CMOR Table Amon: 2-D bias-corrected fields on atmospheric grid](#)) for the adjustment of decadal experiment results by appending 'Adjust' to the variable name DRS elements in file names and in NetCDF files: **pr -> prAdjust, tas -> tasAdjust** (used also in [ISI-MIP](#)).

Long names (the long\_name NetCDF attribute) have to be also modified by adding 'Bias-Adjusted' in front of the long names (**Near-Surface Air Temperature -> Bias-Adjusted Near-Surface Air Temperature**).

One issue which has to be taken into account is a situation when the reference/calibration period includes years from both historical and scenario experiments. In this case a different bias-adjusted historical simulation is created for each scenario experiment instead of the same input one for all scenarios. It is proposed to use only the scenario acronyms (rcp26, rcp45 and rcp85) in file names for the entire bias correction period even for the historical experiment (until 2005

in the CMIP5 and CORDEX). No changes are needed for the ERA-Interim driven CORDEX evaluation experiment.

**Example:**

**input files containing original uncorrected model results:**

```
pr_EUR-44_IPSL-IPSL-CM5A-MR_historical_r1i1p1_SMHI-  
RCA4_v1_day_20010101-20051231.nc
```

```
pr_EUR-44_IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_SMHI-RCA4_v1_day_20060101-  
20101231.nc
```

```
pr_EUR-44_IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_SMHI-RCA4_v1_day_20110101-  
20151231.nc
```

**bias-adjusted file (new/modified information is in blue)**

```
prAdjust_EUR-44_IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_SMHI-RCA4_v1-SMHI-  
DBS43-EOBS10-1981-2010_day_20010101-20051231.nc
```

```
prAdjust_EUR-44_IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_SMHI-RCA4_v1-SMHI-  
DBS43-EOBS10-1981-2010_day_20060101-20101231.nc
```

```
prAdjust_EUR-44_IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_SMHI-RCA4_v1-SMHI-  
DBS43-EOBS10-1981-2010_day_20110101-20151231.nc
```

### **3. Time periods for each data file**

Bias-corrected daily CORDEX data sets have to include the same years (time records) as requested for the input CORDEX files (see 5.4 “Time periods for each data file” in [CORDEX archiving specifications](#)).

### **4. Global attributes**

A number of global attributes have to be copied from input CORDEX files and some of them have to be modified. Also, a number of new global NetCDF attributes have to be added to bias-adjusted CORDEX data sets.

CORDEX global attributes have to be copied without changes:

**CORDEX\_domain**

**driving\_model\_id**

**driving\_model\_ensemble\_member**

**driving\_experiment\_name**

**experiment\_id**

**rcm\_version\_id**

**model\_id**

CORDEX global attributes have to be modified:

**product:** “bias-adjusted-output”

**project\_id:** "CORDEX-Adjust"

**contact:** contact information (name, e-mail) of institution that is responsible for bias-adjusted data sets

**institution:** full name of institution that is responsible for bias-adjusted data sets

**institute\_id:** a short acronym for the institution responsible for bias-adjusted data sets

**creation\_date:** has be modified accordingly

**tracking\_id:** a new tracking ID has to be generated

New global attributes have to be added:

**bc\_method:** full name of the bias correction methods applied and, reference to more detailed information (URL, article, report, handbook etc.).

**bc\_method\_id:** acronym of the bias correction methods (the same as the **BCname** DRS sub-element)

**bc\_observation:** full name of the observational dataset used as a reference for bias correction;

**bc\_observation\_id:** an acronym for the observational dataset used as a reference for bias correction (the same as the **OBSname** DRS sub-element)

**bc\_period:** reference period used for bias correction (the same as the **REFperiod** DRS sub-element)

**bc\_info:** combination of **bc\_method\_id**, **bc\_observation\_id** and **bc\_period** separated by dashes (-)

**input\_institution:** the institution global attribute has to be copied from input CORDEX files to corresponding bias-adjusted files by creating a new global attribute **input\_institution**

**input\_institute\_id:** the institute\_id global attribute has to be copied from input CORDEX files to corresponding bias-adjusted files by creating a new global attribute **input\_institute\_id**

**input\_tracking\_id:** the tracking\_id global attribute has to be copied from input CORDEX files to corresponding bias-adjusted files by creating a new global attribute **input\_tracking\_id**.

*Additionally the tracking ids from files with reference observations (if the tracking \_global attribute exists) may be also copied to bias-adjusted files by creating a new global attribute "obs\_tracking\_id" (optional).*

## 5. DRS directory structure

The data have to be transferred to the ESGF data nodes with the following directory structure:

```
<activity>/<product>/<Domain>/<Institution>/<GCMModelName>/<CMIP5ExperimentName>/<CMIP5EnsembleMember>/<RCMModelName>/<BiasAdjustment>/<Frequency>/<VariableName>
```

Note that the upper 2 levels **<activity>/<product>** are always the same (*CORDEX-Adjust/bias-adjusted-output*) and that **<Institution>** refers to the institution that is responsible for the CORDEX RCM simulations.

## 6. ESGF search facet for bias-adjustment information

The bias-adjustment information is presented by the *BiasAdjustment* DRS element and under the CORDEX-Adjust project a corresponding ESGF search facet is 'Bias Adjustment'. Note that the *RCMVersionID* DRS element and the 'Downscaling Realisation' search facet do not exist separately in the CORDEX-Adjust project but this information is included to the *BiasAdjustment* DRS element and to the 'Bias Adjustment' search facet. All other DRS elements and search facets are the same as in the CORDEX project.

## 7. Terms of Use (ToU)

By default if the input CORDEX simulation results have the "non-commercial" ToU (see [CORDEX RCM list](#)), bias-adjusted CORDEX simulation data have to have the same "non-commercial" ToU. This can be relaxed only in cases where modelling groups decide that derived products based on their "non-commercial" CORDEX simulations can be distributed with the "unrestricted" ToU.

Note also that some observational datasets have different kinds of "non-commercial" ToU. If such datasets are used for bias correction by default bias-adjusted CORDEX simulations have to be "non-commercial". This can be relaxed only if the institution responsible for the observations decides that derived products based on their "non-commercial" observational dataset can be distributed with the "unrestricted" ToU.

## 8. Registration

All groups interested in making their bias-adjusted CORDEX simulations available on ESGF should register by contacting [CORDEX-ESD registration](#) with the following information:

- 1) Full institution name
- 2) Short institution name (acronym)
- 3) Contact person and e-mail
- 4) Full bias adjustment name
- 5) Short bias adjustment name (acronym)
- 6) Reference to bias adjustment method
- 7) Software package if available
- 8) Observational datasets used for bias-adjustment
- 9) CORDEX domains with bias-adjusted simulations
- 10) Terms of Use: unrestricted or non-commercial only

**Acknowledgements:** Development of this Data Reference Syntax for bias-adjusted CORDEX simulations has received support from the European Union's Seventh Programme for research, technological development and demonstration under grant agreements: No 312979 (IS-ENES2), No 607418 (CLIP-C), No 603864 (HELIX), No 603629 (GLOBAQUA), No 282746 (IMPACT2C), No 308291 (EUPORIAS) and from the EU Horizon 2020 research and innovation programme under grant agreement No 641816 (CRESCENDO). We also thank to Lars Barring and Michael Kolax (SMHI) and to all groups involved in the Bias Correction Intercomparison Projects (BCIP) for valuable comments and suggestions.

## Examples of bias-adjusted CORDEX netcdf files

(new information is highlighted in blue)

IPSL-INERIS-WRF331F EUR-44 simulation driven by IPSL-IPSL-CM5A-MR and bias-adjusted by SMHI using Distribution Based Scaling method v. 4.3 (DBS43) and the E-OBS daily gridded observational dataset, version 10 for the 1981-2010 period as reference

### DRS directory structure

*CORDEX-Adjust/bias-adjusted-output/EUR-44/IPSL-INERIS/IPSL-IPSL-CM5A-MR/rcp85/r1i1p/IPSL-INERIS-WRF331F/v1-SMHI-DBS43-EOBS10-1981-2010/day/tasminAdjust*

```
tasminAdjust_EUR-44_IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_IPSL-INERIS-WRF331F_v1-  
SMHI-DBS43-EOBS10-1981-2010_day_19760101-19801231 {  
dimensions:  
    rlat = 103 ;  
    rlon = 106 ;  
    vertices = 4 ;  
    time = UNLIMITED ; // (1827 currently)  
    bnds = 2 ;  
variables:  
    double rlat(rlat) ;  
        rlat:units = "degrees" ;  
        rlat:axis = "Y" ;  
        rlat:long_name = "latitude in rotated pole grid" ;  
        rlat:standard_name = "grid_latitude" ;  
    double rlon(rlon) ;  
        rlon:units = "degrees" ;  
        rlon:axis = "X" ;  
        rlon:long_name = "longitude in rotated pole grid" ;  
        rlon:standard_name = "grid_longitude" ;  
    int rotated_pole ;  
        rotated_pole:grid_mapping_name = "rotated_latitude_longitude" ;  
        rotated_pole:grid_north_pole_latitude = 39.25 ;  
        rotated_pole:grid_north_pole_longitude = -162. ;  
    double lat(rlat, rlon) ;  
        lat:bounds = "lat_vertices" ;  
        lat:long_name = "latitude coordinate" ;  
        lat:standard_name = "latitude" ;  
        lat:units = "degrees_north" ;  
    double lat_vertices(rlat, rlon, vertices) ;  
        lat_vertices:units = "degrees_north" ;  
    double lon(rlat, rlon) ;  
        lon:bounds = "lon_vertices" ;  
        lon:long_name = "longitude coordinate" ;  
        lon:standard_name = "longitude" ;  
        lon:units = "degrees_east" ;  
    double lon_vertices(rlat, rlon, vertices) ;  
        lon_vertices:units = "degrees_east" ;  
    double height ;  
        height:units = "m" ;  
        height:axis = "Z" ;  
        height:positive = "up" ;  
        height:long_name = "height" ;  
        height:standard_name = "height" ;  
    double time(time) ;  
        time:bounds = "time_bnds" ;  
        time:units = "days since 1949-12-01 00:00:00" ;  
        time:calendar = "gregorian" ;  
        time:axis = "T" ;  
        time:long_name = "time" ;  
        time:standard_name = "time" ;  
    double time_bnds(time, bnds) ;  
    float tasminAdjust(time, rlat, rlon) ;  
        tasminAdjust:standard_name = "air_temperature" ;
```

```

tasminAdjust:long_name = "Bias-Adjusted Daily Minimum Near-
Surface Air Temperature"
tasminAdjust:units = "K" ;
tasminAdjust:cell_methods = "time: minimum" ;
tasminAdjust:coordinates = "height lat lon" ;
tasminAdjust:_FillValue = 1.e+20f ;
tasminAdjust:missing_value = 1.e+20f ;
tasminAdjust:grid_mapping = "rotated_latitude_longitude" ;
;

// global attributes:
:Conventions = "CF-1.6" ;
:CORDEX_domain = "EUR-44" ;
:driving_model_id = "IPSL-IPSL-CM5A-MR" ;
:driving_model_ensemble_member = "rli1p1" ;
:driving_experiment_name = "historical" ;
:experiment_id = "historical" ;
:rcm_version_id = "v1" ;
:model_id = "IPSL-INNERIS-WRF331F" ;
:frequency = "day" ;

:contact = "dbs@smhi.se" ;
:institution = "Swedish Meteorological and Hydrological
Institute, Rosby Centre" ;
:institute_id = "SMHI" ;
:project_id = "CORDEX-Adjust" ;
:product = "bias-adjusted-output" ;
:creation_date = "2015-02-09-T00:03:02Z" ;
:tracking_id = "d5f0707d-e03b-4fe0-8eb2-834875975e32" ;

:bc_method = "Distribution-Based Scaling (DBS); Dahne et al.
2014: Post-processing of climate projections for hydrological impact studies,
IAHS Publications, in press; Yang et al. 2010: Distribution-based scaling to
improve usability of regional climate model projections for hydrological
climate change impact studies, Hydrol. Res., 41, 211-229,
doi:10.2166/nh.2010.004" ;
:bc_method_id = "SMHI-DBS43" ;
:bc_observation = "European daily high-resolution gridded
observations, version 10; www.ecad.eu/E-OBS; Haylock et al., 2008: European
daily high-resolution gridded dataset of surface temperature and
precipitation. J. Geophys. Res (Atmospheres), 113, D20119,
doi:10.1029/2008JD10201" ;
:bc_observation_id = "EOBS10" ;
:bc_period = "1981-2010" ;
:bc_info = "SMHI-DBS43-EOBS10-1981-2010" ;
:input_tracking_id = "bd9d1ee5-099a-4afc-90a0-5a8aa9f9021d" ;
:input_institution = "IPSL (Institut Pierre Simon Laplace) and
INNERIS (Institut National de l'Environnement industriel et des RISques)" ;
:input_institute_id = "IPSL-INNERIS" ;s

```

SMHI-RCA4 EUR-44 simulation driven by IPSL-IPSL-CM5A-MR and bias-adjusted by the University of Cantabria using Empirical Quantile Mapping (EQM) method and the E-OBS daily gridded observational dataset (v. 10) for the 1981-2010 period as reference

## DRS directory structure

*CORDEX-Adjust/bias-adjusted-output/EUR-44/SMHI/IPSL-IPSL-CM5A-MR/rcp85/r1i1p/SMHI-RCA4/v1-UCAN-EQM-EOBS10-1981-2010/day/prAdjust*

```
prAdjust_EUR-44_IPSL-IPSL-CM5A-MR_rcp85_r1i1p1_SMHI-RCA4_v1-UCAN-EQM-EOBS10-1981-2010_day_20360101-20401231 {
dimensions:
    bnds = 2 ;
    time = UNLIMITED ; // (1825 currently)
    rlon = 106 ;
    rlat = 103 ;
variables:
    double rlat(rlat) ;
        rlat:standard_name = "grid_latitude" ;
        rlat:long_name = "latitude in rotated pole grid" ;
        rlat:units = "degrees" ;
        rlat:axis = "Y" ;
    double rlon(rlon) ;
        rlon:standard_name = "grid_longitude" ;
        rlon:long_name = "longitude in rotated pole grid" ;
        rlon:units = "degrees" ;
        rlon:axis = "X" ;
    char rotated_pole ;
        rotated_pole:grid_mapping_name = "rotated_latitude_longitude" ;
        rotated_pole:grid_north_pole_latitude = 39.25 ;
        rotated_pole:grid_north_pole_longitude = -162. ;
    double lon(rlat, rlon) ;
        lon:standard_name = "longitude" ;
        lon:long_name = "longitude" ;
        lon:units = "degrees east" ;
    double lat(rlat, rlon) ;
        lat:standard_name = "latitude" ;
        lat:long_name = "latitude coordinate" ;
        lat:units = "degrees north" ;
    double time(time) ;
        time:standard_name = "time" ;
        time:long_name = "time" ;
        time:units = "days since 1949-12-1 00:00:00" ;
        time:calendar = "365_day" ;
        time:axis = "T" ;
        time:bounds = "time_bnds" ;
    double time_bnds(time, bnds) ;
    float prAdjust(time, rlat, rlon) ;
        prAdjust:standard_name = "precipitation_flux" ;
        prAdjust:long_name = "Bias-Adjusted Precipitation" ;
        prAdjust:units = "kg m-2 s-1" ;
        prAdjust:coordinates = "lat lon" ;
        prAdjust:_FillValue = 1.e+20f ;
        prAdjust:missing_value = 1.e+20f ;
        prAdjust:cell_methods = "time: mean" ;
        prAdjust:grid_mapping = "rotated_pole" ;

// global attributes:
    :Conventions = "CF-1.6" ;
    :CORDEX_domain = "EUR-44" ;
    :driving_model_id = "IPSL-IPSL-CM5A-MR" ;
    :driving_model_ensemble_member = "r1i1p1" ;
    :driving_experiment_name = "rcp85" ;
    :experiment_id = "rcp85" ;
    :model_id = "SMHI-RCA4" ;
    :rcm_version_id = "v1" ;
    :frequency = "day" ;
```

```
:contact = "eqm@unican.es" ;
:institution = "Meteorology Group, University of Cantabria" ;
:institute_id = "UCAN" ;
:project_id = "CORDEX-Adjust" ;
:product = "bias-adjusted-output" ;
:creation_date = "2016-04-24-T13:19:27Z" ;
:tracking_id = "d5f0707d-e03b-4fe0-8eb2-834875975e32";

:bc_method = "Quantile-quantile mapping" ;
:bc_method_id = "UCAN-EQM" ;
:bc_observation = "European daily high-resolution gridded
observations, version 10; www.ecad.eu/E-OBS; Haylock et al., 2008: European
daily high-resolution gridded dataset of surface temperature and
precipitation. J. Geophys. Res (Atmospheres), 113, D20119,
doi:10.1029/2008JD10201" ;
:bc_observation_id = "EOBS10" ;
:bc_period = "1981-2010" ;
:bc_info = "UCAN-EQM-EOBS10-1981-2010" ;
:input_tracking_id = "973b8e97-34ae-4c99-8bf6-f84c0aa064c6" ;
:input_institution = "Swedish Meteorological and Hydrological
Institute, Rosby Centre" ;
:input_institute_id = "SMHI" ;
```