Data Reference Syntax (DRS) for bias-adjusted C3S-CMIP5 simulations

Levavasseur, G.[1] and Noël, T.[2]

Guillaume Levavasseur
Institut Pierre Simon Laplace, SU/CNRS, Paris, France

Thomas Noël*,
The Climate Data Factory, Paris, France

*corresponding author :
 E-mail: thomas@theclimatedatafactory.com

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[1] Institute Pierre Simon Laplace (IPSL, France) | [2] The Climate Data Factory (TCDF, France)

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This document specifies the Data Reference Syntax (DRS) elements for managing bias-adjusted C3S-CMIP5 simulation data. 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 CMIP5 simulation data should be as close as possible to the [CMIP5 archiving specifications](). If needed, the bias-adjusted CMIP5 DRS could also include Bias-correction information and grid-label information are added to the CMIP5 DRS following some the guidelines of [CORDEX_Adjust]() and [CMIP6]() archives design.

Three bias-correction DRS sub-elements are introduced:

- **`bc_name`** is an identifier for the applied bias-correction method that includes a dash-separated combination of acronyms for the institute and the bias-correction method (e.g. TCDF-CDFt23, SMHI-DBS43, LSCE-IPSL-CDFt, UCAN-EQM etc.).
- **`obs_name`** 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.
- **`ref_period`** is the 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 CMIP5 DRS creating a new element *called* **`bias_adjustment`**. The new **`bias_adjustment`** element is a bit long but provides all necessary information about the bias adjustment methodology.

One grid label DRS element is introduced:

- ***grid_label*** is the information of the regridded data used for bias-adjustment.

Example:

A CMIP5 simulation is bias-adjusted by TCDF-CDFt23 method using ERA5 as a reference observational dataset for the 1981-2010 period, the `bias_adjustment` becomes `TCDF-CDFT23-ERA5-1981-2010` (*i.e., bc_name-obs_name-ref_period*). Note that dashes in sub-elements can be dropped for consistency and easy automatic parsing.

2. File names, variable names, and NetCDF attributes

The names of the files in the C3S-CMIP5-Adjust project are made up of the CMIP5 DRS elements, CMIP6 DRS and CORDEX-Adjust DRS with the changes described above. The elements are separated by underscores ("_") and must appear in the following order:

`VariableName_MIPtable_GCMModelName_CMIP5ExperimentName_CMIP5En sembleMember_GridLabel_BiasAdjustment[_StartTime-EndTime].nc`

In order to avoid any confusion and clearly distinguish original and bias-adjusted CMIP5 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, for instance `pr` variable becomes `prAdjust` (used also in [ISI-MIP](#)).

The long variable names (`long_name` NetCDF attribute) have to be also modified by pre-pending "`Bias-Adjusted`", for instance `Near-Surface Air Temperature` becomes `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.

input files containing original uncorrected model results:

```
tas_day_IPSL-CM5A-MR_rcp45_r1i1p1_20060101-20151231.nc
```

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

```
tasAdjust_day_IPSL-CM5A-MR_rcp45_r1i1p1_gr025_TCDF-CDFT23-ERA5-198
1-2010_20060101-20151231.nc
```

`gr025` is the metadata for the regridding method.

3. Time periods for each data file

Bias-corrected daily CMIP5 data sets have to include the same years (time records) as requested for the input CMIP5 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 CMIP5 files and some of them have to be modified. Also, a number of new global NetCDF attributes have to be added to bias-adjusted CMIP5 data sets. See attached table [CMIP5-Adjust DRS attributes](#).

`product` as change for bias-adjusted
`project_id` as change for C3S-CMIP5-Adjust

`institution` of the CMIP5 dataset as save in `input_institution`
`institute_id` of the CMIP5 dataset as save in `input_instition_id`
`tracking_id` of the CMIP dataset as save in `input_tracking_id`

new global NetCDF attributes to bias-adjusted CMIP5 data set :
- `bc_method`
- `bc_method_id`
- `bc_observation`
- `bc_period`
- `bc_info`

Optional : metadata for the regridding:
- `grid_label`
- `grid_resolution`
- `grid_interpolation_method`

- `grid_info`

5. DRS directory structure

The data have to be managed with the following directory structure:

```
<activity>/
  <product>/
    <institute>/
      <model>/
        <experiment>/
          <frequency>/
            <modeling_realm>/
              <cmor_table>>/
                <ensemble>/
                  <grid_label>/
                    <bias_adjustment>/
                      <variable>/
                        <version>/
```

Note that the upper 2 levels `<activity>/<product>` are fixed to `C3S-CMIP5-Adjust/bias-adjusted-output`.

6. Examples of bias-adjusted CMIP5 netcdf files

New information in blue.

IPSL-CM5A-MR simulation interpolated at 0.25° and bias-adjusted by TCDF using CDFt v2.3 and the ERA5 daily gridded observational dataset, 1981-2010 period as reference.

tasAdjust_day_IPSL-CM5A-MR_rcp45_r1i1p1_gr025_TCDF-CDFT23-ERA5-1981-2010_20060101-20151231 {
dimensions:
        time = UNLIMITED ; // (3650 currently)
        lat = 721 ;
        lon = 1440 ;
        bnds = 2 ;
variables:
        double time(time) ;
        time:bounds = "time_bnds" ;
        time:units = "days since 1850-01-01 00:00:00" ;
        time:calendar = "365_day" ;
        time:axis = "T" ;
        time:long_name = "time" ;
        time:standard_name = "time" ;

```
        double time_bnds(time, bnds) ;
        double lat(lat) ;
        lat:bounds = "lat_bnds" ;
        lat:units = "degrees_north" ;
        lat:axis = "Y" ;
        lat:long_name = "latitude" ;
        lat:standard_name = "latitude" ;
        double lat_bnds(lat, bnds) ;
        double lon(lon) ;
        lon:bounds = "lon_bnds" ;
        lon:units = "degrees_east" ;
        lon:axis = "X" ;
        lon:long_name = "longitude" ;
        lon:standard_name = "longitude" ;
        double lon_bnds(lon, bnds) ;
        double height ;
        height:units = "m" ;
        height:axis = "Z" ;
        height:positive = "up" ;
        height:long_name = "height" ;
        height:standard_name = "height" ;
        float tasAdjust(time, lat, lon) ;
        // global attributes:tasAdjust:standard_name = "air_temperature" ;
        tasAdjust:long_name = "Bias-Adjusted Near-Surface Air Temperature" ;
        tasAdjust:units = "K" ;
        tasAdjust:original_name = "tasAdjust" ;
        tasAdjust:cell_methods = "time: mean" ;
        tasAdjust:cell_measures = "area: areacella" ;
        tasAdjust:history = "2020-03-26T22:00:13Z altered by CMOR: Treated scalar dimension:
\'height\'. 2020-03-26T22:00:13Z altered by CMOR: replaced missing value flag (9.96921e+36) with
standard missing value (1e+20). 2020-03-26T22:00:19Z altered by CMOR: Converted type from \'d\'
to \'f\'." ;
        tasAdjust:coordinates = "height" ;
        tasAdjust:missing_value = 1.e+20f ;
        tasAdjust:_FillValue = 1.e+20f ;
        tasAdjust:associated_files     =     "baseURL:     http://cmip-pcmdi.llnl.gov/CMIP5/dataLocation
gridspecFile:           gridspec_atmos_fx_IPSL-CM5A-MR_rcp45_r0i0p0.nc           areacella:
areacella_fx_IPSL-CM5A-MR_rcp45_r0i0p0.nc" ;


        :grid_label = "gr025" ;
        :grid_resolution = "0.25°" ;
        :grid_interpolation_method = "remapbic" ;
        :grid_info = "ERA5" ;
        :bc_method = "Cumulative Distribution Function Transform (CDFt) method - Vrac, M., T. Noël,
and R. Vautard (2016), Bias correction of precipitation through Singularity Stochastic Removal:
Because    occurrences    matter,    J.    Geophys.    Res.    Atmos.,    121,    5237–5258,
doi:10.1002/2015JD024511." ;
        :bc_method_id = "TCDF-CDFT23" ;
```

```
        :bc_observation = "Copernicus Climate Change Service (C3S) (2017): ERA5: Fifth generation
of ECMWF atmospheric reanalyses of the global climate . Copernicus Climate Change Service
Climate Data Store (CDS), date of access. https://cds.climate.copernicus.eu/cdsapp#!/home" ;
        :bc_observation_id = "ERA5" ;
        :bc_period = "1981-2010" ;
        :bc_info = "TCDF-CDFT23-ERA5-1981-2010" ;
        :input_tracking_id                =                "81c7bc40-7df1-47c9-a5c8-4602f3e63ab6,
b842770b-8026-4070-b85a-da519edf3715" ;
        :input_institution = "IPSL (Institut Pierre Simon Laplace, Paris, France)" ;
        :input_institute_id = "IPSL" ;
        :institution = "TCDF (The Climate Data Factory)" ;
        :institute_id = "TCDF" ;
        :experiment_id = "rcp45" ;
        :source = "IPSL-CM5A-MR" ;
        :model_id = "IPSL-CM5A-MR" ;
        :forcing = "Nat,Ant,GHG,SA,Oz,LU,SS,Ds,BC,MD,OC,AA" ;
        :parent_experiment_id = "historical" ;
        :parent_experiment_rip = "r1i1p1" ;
        :branch_time = 2005. ;
        :contact = "thomas@theclimatedatafactory.com  Data manager : Thomas NOEL (TCDF)" ;
        :comment = " " ;
        :references = "P.-A. Michelangeli, M. Vrac, H. Loukos. \'Probabilistic downscaling
approaches: Application to wind cumulative distribution functions\'. Geophysical Research Letters, 36,
L11708, doi:10.1029/2009GL038401, 2009" ;
        :initialization_method = 1 ;
        :physics_version = 1 ;
        :product = "bias-adjusted-output" ;
        :experiment = "RCP4.5" ;
        :frequency = "day" ;
        :creation_date = "2020-03-26T22:00:19Z" ;
        :Conventions = "CF-1.4" ;
        :table_id = "Table day (August 2016) 9aa49c452e13de8f13e1a0dea4c70a6c" ;
        :title = "IPSL-CM5A-MR model output prepared for CMIP5-Adjust RCP4.5" ;
        :parent_experiment = "historical" ;
        :modeling_realm = "atmos" ;
        :realization = 1 ;
        :cmor_version = "2.9.3" ;
        :tracking_id = "1a7f52a8-b0e9-4022-be0b-6aa98805c8f2" ;
        :NCO = "\"4.6.1\"" ;
        :history = "2020-03-26T22:00:19Z CMOR rewrote data to comply with CF standards and
CMIP5-Adjust requirements" ;
        :project_id = "C3S-CMIP5-Adjust" ;
}
```

7. Listing of global NetCDF Attributes

NetCDF Attribute	Status	Value	Example
experiment_id	*Unchanged*		rcp45
experiment	*Unchanged*		RCP4.5
model_id	*Unchanged*		IPSL-CM5A-MR
forcing	*Unchanged*		Nat,Ant,GHG,
parent_experiment_id	*Unchanged*		historical
parent_experiment_rip	*Unchanged*		r1i1p1
branch_time	*Unchanged*		
initialization_method	*Unchanged*		1
physics_version	*Unchanged*		1
realization	*Unchanged*		1
parent_experiment	*Unchanged*		historical
product	*Modified*	Fixed	**bias-adjusted**
project_id	*Modified*	Fixed	**C3S-CMIP5-Adjust**
contact	*Modified*	Contact information of institution that is responsible for bias-adjusted datasets	
institution	*Modified*	Full name of institution that is responsible for bias-adjusted datasets	TCDF (The Climate Data Factory)
institute_id	*Modified*	Short acronym for the institution responsible for bias-adjusted data sets	TCDF
creation_date	*Modified*	Creation date of the dataset	
tracking_id	*Modified*	New UUID to generate	
bc_method	*New*	Full name of the bias correction methods applied and its references	Cumulative Distribution Function Transform
bc_method_id	*New*	Acronym of the bias correction methods (i.e., bc_name DRS sub-element)	IPSL-CDFT23
bc_observation	*New*	Full name of the observation data used as a reference for bias correction and its references	
bc_observation_id	*New*	Acronym for the observation data used as a reference for bias correction	ERA5
bc_period	*New*	Reference period used for bias correction (i.e., ref_period DRS sub-element)	1981-2010
bc_info	*New*	Combination of bc_method_id, bc_observation_id and bc_period separated by dashes	IPSL-CDFT23-ERA5-1981-2010
input_institution	*New*	Full name of institution that is responsible for input CMIP5 datasets	
input_institute_id	*New*	Short acronym for the institution responsible for input CMIP5 datasets	
input_tracking_id	*New*	UUID from input CMIP5 files	
grid_label	*Optional*	Acronym for the grid name (i.e., grid_label DRS element)	gr025
grid_resolution	*Optional*	Grid resolution	0.25°
grid_interpolation_method	*Optional*	Interpolation method	remapbic
grid_info	*Optional*	Additional information on the grid	ERA5