Data Reference Syntax (DRS) for bias-adjusted CMIP6 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

Data Reference Syntax (DRS) for bias-adjusted CMIP6 simulations

Levavasseur, G.[1] and Noël, T.[2]

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

April 10th, 2021

This document specifies the Data Reference Syntax (DRS) elements for managing bias-adjusted CMIP6 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 CMIP6 simulation data should be as close as possible to the CMIP6 archiving specifications. If needed, the bias-adjusted CMIP6 DRS could also include Bias-correction information to the CMIP6 DRS following some the guidelines of CORDEX_Adjust 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. 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 CMIP6 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 modified:

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

Example:
A CMIP6 simulation is bias-adjusted by TCDF CDFt method using ERA5 Land as a reference observational dataset for the 1981-2010 period, the `bias_adjustment` becomes `TCDF-CDFT23-ERA5Land-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-CMIP6-Adjust project are made up of the CMIP6 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_Frequency_GCMModelName_CMIP6ExperimentName_CMIP6EnsembleMember_GridLabel_BiasAdjustment[_StartTime-EndTime].nc`
In order to avoid any confusion and clearly distinguish original and bias-adjusted CMIP6 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 (ssp126, ssp246 and ssp585) in file names for the entire bias correction period even for the historical experiment (until 2014 in the CMIP6).

Example:
input files containing original uncorrected model results:

tas_day_IPSL-CM6A-LR_ssp585_r1i1p1f1_gr_20150101-21001231.nc

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

`tasAdjust_day_IPSL-CM6A-LR_ssp585_r1i1p1f1_gr010_TCDF-CDFT23-ERA5Land-1981-2010_20160101-20251231.nc`

`gr010` is the metadata for the regridding method.

3. Time periods for each data file

Bias-corrected daily CMIP6 data sets have to include the same years (time records) as requested for the input CMIP6 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 CMIP6 files and some of them have to be modified. Also, a number of new global NetCDF attributes have to be added to bias-adjusted CMIP6 data sets. See attached table CMIP6-Adjust DRS attributes (section 7. “Listing of global NetCDF Attributes”)

`product` as change for bias-adjusted-output
`project_id` as change for CMIP6-Adjust

`institution` of the CMIP6 dataset as save in `input_institution`
`institute_id` of the CMIP6 dataset as save in `input_institition_id`
`tracking_id` of the CMIP6 dataset as save in `input_tracking_id`
`grid_label` of the CMIP6 dataset as save in `input_grid_label`
`grid` of the CMIP6 dataset as save in `input_grid`
`nominal_resolution` of the CMIP6 dataset as save in `input_nominal_resolution`

new global NetCDF attributes to bias-adjusted CMIP5 data set :

- `bc_method`
- `bc_method_id`
- `Bc_observation`
- `bc_observation_id`
- `bc_period`
- `bc_info`

Optional : metadata for the regridding:

- `grid_resolution`
- `grid_interpolation_method`
- `Grid_info`

5. DRS directory structure

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

```
<project_id>/
  <product>/
    <institute_id>/
      <source_id>/
        <experiment_id>/
            <member_id>/
               <table_id>/
                  <bias_adjustment>/
                     <variable_id>/
                        <grid_label>/
                           <version>/
```

Note that the upper 2 levels `<project_id>/<product>` are fixed to `CMIP6-Adjust/bias-adjusted-output`.

6. Examples of bias-adjusted CMIP6 netcdf files

New information in blue

IPSL-CM6A-LR simulation interpolated at 0.10° and bias-adjusted by TCDF using CDFt v2.3 and the ERA5-Land daily gridded observational dataset, 1981-2010 period as reference.

tasAdjust_day_IPSL-CM6A-LR_ssp585_r1i1p1f1_gr010_TCDF-CDFT23-ERA5Land-1981-2010_20260101-20351231 {
dimensions:
	time = UNLIMITED ; // (3652 currently)
	lat = 1801 ;
	lon = 3600 ;
	bnds = 2 ;
variables:
	double time(time) ;
		time:bounds = "time_bnds" ;
		time:units = "days since 2015-01-01 00:00:00" ;
		time:calendar = "standard" ;

```
                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) ;
                tasAdjust:standard_name = "air_temperature" ;
                tasAdjust:long_name = "Bias-Adjusted Near-Surface Air Temperature" ;
                tasAdjust:comment = "Bias-Adjusted near-surface (usually, 2 meter) air
temperature" ;
                tasAdjust:units = "K" ;
                tasAdjust:original_name = "tasAdjust" ;
                tasAdjust:cell_methods = "time: mean" ;
                tasAdjust:cell_measures = "area: areacella" ;
                tasAdjust:coordinates = "height" ;
                tasAdjust:missing_value = 1.e+20f ;
                tasAdjust:_FillValue = 1.e+20f ;

// global attributes:
                :branch_method = "standard" ;
                :branch_time_in_child = "0" ;
                :data_specs_version = "01.00.28" ;
                :external_variables = "areacella" ;
                :further_info_url =
"https://furtherinfo.es-doc.org/CMIP6.IPSL.IPSL-CM6A-LR.ssp585.none.r1i1p1f1" ;
                :license = "CMIP6 model data produced by IPSL is licensed under a Creative
Commons Attributi" ;
```

:mip_era = "CMIP6" ;
:parent_activity_id = "CMIP" ;
:parent_mip_era = "CMIP6" ;
:parent_source_id = "IPSL-CM6A-LR" ;
:source_id = "IPSL-CM6A-LR" ;
:parent_time_units = "days since 1850-01-01 00:00:00" ;
:source_type = "AOGCM BGC" ;
:sub_experiment = "none" ;
:sub_experiment_id = "none" ;
:variable_id = "tas" ;
:variant_label = "r1i1p1f1" ;
:realm = "atmos" ;
:grid = "interpolated grid at 0.10 (1801x3600 latxlon)" ;
:grid_label = "gr010" ;
:grid_resolution = "0.10°" ;
:grid_interpolation_method = "remapbil" ;
:grid_info = "ERA5-Land" ;
: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 = "Muñoz Sabater, J., (2019): ERA5-Land hourly data from 1981 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). 10.24381/cds.e2161bac" ;
:bc_observation_id = "ERA5-land" ;
:bc_period = "1981-2010" ;
:bc_info = "TCDF-CDFT23-ERA5-land-1981-2010" ;
:input_tracking_id = "hdl:21.14100/4fbbc635-6702-4b9d-be25-7bd2e7a9d433" ;
:input_institution = "Institut Pierre Simon Laplace, Paris 75252, France" ;
:input_grid_label = "gr" ;
:activity_id = "ScenarioMIP" ;
:input_grid = "LMDZ grid" ;
:institution = "TCDF (The Climate Data Factory)" ;
:experiment_id = "ssp585" ;
:source = "IPSL-CM6A-LR (2017): atmos: LMDZ (NPv6, N96; 144 x 143 longitude/latitude; 79 levels; top level 40000 m) land: ORCHIDEE (v2.0, Water/Carbon/Energy mode) ocean: NEMO-OPA (eORCA1.3, tripolar primarily 1deg; 362 x 332 longitude/latitude; 75 levels; top grid cell 0-2 m) ocnBgchem: NEMO-PISCES seaIce: NEMO-LIM3" ;
:model_id = "IPSL-CM6A-LR" ;
:parent_experiment_id = "historical" ;
: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" ;

:product = "bias-adjusted-output" ;
:frequency = "day" ;
:creation_date = "2021-02-28T18:32:19Z" ;
:history = "2021-02-28T18:32:19Z CMOR rewrote data to comply with CF standards and CMIP6-Adjust requirements." ;
:project_id = "CMIP6-Adjust" ;
:table_id = "Table day (Jan 2020) cdd7e9b9044b6539bf6483098893d2a3" ;
:title = "IPSL-CM6A-LR model output prepared for CMIP6-Adjust SSP585" ;
:parent_experiment = "historical" ;
:modeling_realm = "atmos" ;
:cmor_version = "2.9.3" ;
:tracking_id = "35c037f6-347a-4ef1-9f01-1e994d47888d" ;
:input_institution_id = "IPSL" ;
:institution_id = "TCDF" ;
:forcing_index = "1" ;
:parent_variant_label = "r1i1p1f1" ;
:branch_time_in_parent = 60265. ;
:initialization_index = 1 ;
:physics_index = 1 ;
:realization_index = 1 ;
:experiment = "update of RCP8.5 based on SSP5" ;
:Conventions = "CF-1.7 CMIP-6.2" ;
:nominal_resolution = "11 km" ;
:variant_info = "Each member starts from the corresponding member of its parent experiment. Information provided by this attribute may in some cases be flawed. Users can find more comprehensive and up-to-date documentation via the further_info_url global attribute." ;
:contact = "support@theclimatedatafactory.com Data manager : Thomas NOEL (TCDF)" ;
:comment = "The data was processed on the IPSL mesocenter ESPRI facility that is supported by CNRS, SU, and Ecole Polytechnique partly funded by IS-ENES3 project." ;
:input_nominal_resolution = "250 km" ;

}

7. Listing of global NetCDF Attributes

NetCDF Attribute	Status	Value	Example
experiment_id	*Unchanged*		ssp585
experiment	*Unchanged*		update of RCP8.5 based on SSP5"
model_id	*Unchanged*		IPSL-CM6A-LR
initialization_index	*Unchanged*		**1**
physics_index	*Unchanged*		**1**
realization_index	*Unchanged*		**1**
forcing_index	*Unchanged*		**1**
variant_label	*Unchanged*		r1i1p1f1
parent_experiment_id	*Unchanged*		historical
parent_variant_label	*Unchanged*		r1i1p1f1
parent_experiment	*Unchanged*		historical
mip_era	*Unchanged*		CMIP6
parent_acrivity_id	*Unchanged*		CMIP
parent_mip_era	*Unchanged*		CMIP6
product	*Modified*	Fixed	bias-adjusted-output
project_id	*Modified*	Fixed	CMIP6-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	
grid	*Modified*	*grid from adjust files*	interpolated grid at 0.10 (1801x3600 latxlon)"
nominal_resolution	*Modified*	nominal resolution from adjust files	11 km
grid_label	*Modified*	Acronym for the grid name (i.e., `grid_label` DRS element)	gr010
bc_method	*New*	Full name of the bias correction methods applied and its references	Cumulative Distribution Function Transform (CDFt) method
bc_method_id	*New*	Acronym of the bias correction methods (i.e., `bc_name` DRS sub-element)	TCDF-CDFT23
bc_observation	*New*	Full name of the observation data used as a reference for bias correction and its references	ERA5-land
bc_observation_id	*New*	Acronym for the observation data used as a reference for bias correction (i.e., `obs_name` DRS sub-element)	ERA5-land
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 (i.e., `bias_adjustement` DRS element)	TCDF-CDFT23-ERA5-Land-1981-2010
input_institution	*New*	Full name of institution that is responsible for input CMIP6 datasets	
input_institute_id	*New*	Short acronym for the institution responsible for input CMIP6 datasets	
input_tracking_id	*New*	UUID from input CMIP6 files	
input_grid_label	*New*	Original Grid_label from input CMIP6 files	
input_grid	*New*	grid from input CMIP6 files	
input_nominal_resolution	*New*	nominal resolution from inout CMIP6 files	250 km
grid_resolution	*Optional*	Grid resolution	0.10°
grid_interpolation_method	*Optional*	Interpolation method	remapbil
grid_info	*Optional*	Additional information on the grid	ERA5-Land