ClimDexCalc

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1 Purpose

This Plugin uses the ClimDex software provided by UNSW Australia and Pacific Climate Impacts Consortium (PCIC) to calculate extreme indices. Based on the `R`-package `climdex.pcic` [Bronaugh, 2020] and `climdex.pcic.ncdf` [Bronaugh, 2017] several indices for temperature and precipitation are estimated for a specified dataset (reanalysis, historical, decadals) and optionally linked to the Central Evaluation System for further calculation. Note, the Plugin was originally developed by Igor Kröner for the application in the context of decadal prediction experiments. Adjustments that go beyond the scope of the decadal predictions are in progress and still under development.

2 Introduction

In the context of changes in climate extremes it might be useful to have some standardised parameters to compare temperature and precipitation extremes between different datasets. For this, the joint CCl/CLIVAR/JCOMM Expert Team (ET) on Climate Change Detection and Indices (ETCCDI) provide a software to calculate 27 several climate extreme indices on the basis of daily temperature and precipitation data (`http://etccdi.pacificclimate.org/list_27_indices.shtml`) [Karl et al., 1999, Peterson et al., 2001]. The ClimDex software given by the R-packages `climdex.pcic` and `climdex.pcic.ncdf` is implemented as a Plugin for the Central Evaluation System (CES) and can be used for observations, reanalyses, historical and future simulations as well as for decadal experiments. Depending on the extreme index, monthly and/or annual values with respect to frequency, duration or amplitude aspects are calculated.

3 User Manual

At first, the input data from data-browser via the options **project**, **product**, **institute**, **model**, **experiment**, and **ensemble** must be selected. In case the data is a decadal experiment, **is_decadal** is set to *True*.

Next, the **timeperiod** of interest which should be analysed have to be given in the comma-separated format *firstyear,lastyear*. In case of decadal experiments, this options defines the first and last year of initialisation. The parameter **baseperiod** defines the base period for percentile-based climate indices. In case of decadal experiments, the base period is referred to lead year 1. In **time_frequency_output** the temporal aggregation level of the resulting output can be chosen. Some indices are only available for "annual" aggregation level. Please check before or use the selection "all".

In **indices**, the climate indices (`http://etccdi.pacificclimate.org/list_27_indices.shtml`) in a comma-separated format can be selected. The data-browser should be checked to ensure the index-related variables "tas", "tasmax", "tasmin" and/or "pr" are available for the chosen input data. Note, tx10p/tx90p or tn10p/tn90p or r90p/r95p can not be calculated individually and need to be kept in pairs. In case of decadal experiments, the calculation of duration based indices (wsdi,csdi,cdd,cwd) are not supposed be

combined with percentile indices. For percentile-based indices the method of threshold-calculation can be selected in the option **percentile_method**. More information about the methods can be found in section 4. In case already calculated thresholds are to be used, an existing threshold file calculated via the Plugin can be specified in **percentilefile**. In case of multiple files for tasmin/tasmax/pr-percentiles the name of the variable must be substituted with xxxxx. If lead time dependent percentiles are given, lead time is substituted with yyyyy. (e.g. /link/to/your/file/threshold_xxxxx_day_mpi-esm-lr_historical_r1i1p1_1961-1990_ltyyyyy.nc)

Finally, the number of parallel-processing tasks (**ntask**), the output (**outputdir**) and cache (**cachedir**) directories have to be specified. Further the options to just show founded files for processing (**dryrun**), to remove the cache directories (**cacheclear**) and to link the resulting data into the system (**link2database**) can be used.

3.1 Input Parameter

Table 1: Input options for the ClimDexCalc Plugin.

project	Choose project e.g. CMIP5, Reanalysis, your data, etc. (check data-browser)
mandatory	*default*: none
product	Choose product (check data-browser)
mandatory	*default*: none
institute	Choose institute (check data-browser)
mandatory	*default*: none
model	Choose model (check data-browser)
mandatory	*default*: none
experiment	Choose experiment (check data-browser)
mandatory	*default*: none
ensemble	Choose ensemble member - multi selection possible (comma separated), use * for all members
mandatory	*default*: none
is_decadal	Set "True" in case forecast experiment is a decadal experiment
mandatory	*default*: True
timeperiod	Decadal Experiment: First and last year of Initialization (comma separated) of the time period of interest. Others: First and last year (comma separated) of the time period of interest.
mandatory	*default*: 1971,2010
baseperiod	First and last year (comma separated) of base period. If percentile-based-indices are selected, this period is used for their calculation. It is suggested to use 1961,1990 to guarantee comparability to other studies. If "is_decadal" is "True" base period is referred to lead time 1. If nothing is selected but percentile-indices are calculated the whole time period is used as basis for percentile calculation.
mandatory	*default*: True
time_frequency _output	Temporal resolution of the output time series you want to analyze.Valid options are "annual", "monthly" and "all" (both monthly and annual). Note: Some indices are only available for "annual". Please check before!
mandatory	*default*: all

Table 1 continued

indices	Comma separated list of indices that will be calculated. Default are all - except duration indices. If you only need some, delete the others. See `www.climdex.org` for description of the indices. Check data-browser to ensure the index-related variables "tas", "tasmax", "tasmin" and/or "pr" are available for the chosen input data! Be aware of tx10p/tx90p or tn10p/tn90p or r90p/r95p. Can not be calculated individually and need to be kept in pairs! FOR DECADALS: Calculation of duration based indices (wsdi,csdi,cdd,cwd) are not supposed be combined with percentile indices!
mandatory	*default*: tx10p,tx90p,tn10p,tn90p,txx,txn,tnx,tnn, id,fd,su,tr,dtr,prcptot,rx5day,rx1day,r10mm,r20mm,r95p,r99p,sdii
percentile _method	Method of calculating percentile-based threshold. climdex-pcic: Original method from the R-Package climdex.pcic. decadal-eval: Method adapted for decadal evaluation.
mandatory	*default*: climdex-pcic
percentilefile	Optional link to an existing percentile file. If several files for tasmin/tasmax/pr-percentiles then substitute the name of the variable xxxxx. If lead time dependent percentiles are given, substitute the lead time with yyyyy. e.g. /link/to/your/file/threshold_xxxxx_day_mpi-esm-lr_historical_r1i1p1_1961-1990_ltyyyyy.nc.
mandatory	*default*: None
ntask	Choose number of tasks on machine, default set by Freva for batch-mode.
mandatory	*default*: depends on system
dryrun	Whether or not only data-search should be done.
mandatory	*default*: False
outputdir	Choose your output directory. Default is set by Freva.
mandatory	*default*: /miklip-work/b/*user*/evaluation_system/output/climdexcalc/*date*
cachedir	Choose your cache directory. Default is set by Freva.
mandatory	*default*: /miklip-work/b/*user*/evaluation_system/cache/climdexcalc/*date*
cacheclear	Option switch to NOT clear the cache.
mandatory	*default*: True
link2database	Option whether the output data should be linked or not. *default*: False

3.2 Output Parameter

The resulting files contain the selected climate indices – one individual file for each index. The files follow the CMOR structure of the system, where the variable of a specific index is named as INDEXetccdi (e.g. `tx10petccdi_yr_reanalysis_eraint_r1i1p1_1980-2000.nc` for climate index tx10p). In case percentile-based indices are calculated and no threshold

file is given by the user, the calculated threshold file is located in the cache directory if the option **cacheclear** is set to "False".

3.3 Previous Applications and Test

The Plugin was used to compare climate extreme indices of decadal experiments with respect to reanalysis data.

4 Scientific Background

The detailed description of the climate indices can be found on the website `http://etccdi.pacificclimate.org/list_27_indices.shtml`. For the indices using thresholds based on percentiles (tx10p, tx90p, tn10p, tn90p, wsdi, csdi, r95p, r99p) two method for calculating the percentiles (**percentile_method**) can be applied in case no percentile file is given by the user. The first method *climdex-pcic* uses the originally implemented `R`-routine from the software, while the second method (*decadal-eval*) is based on a routine especially adapted for decadal experiments. Nevertheless, both methods can be applied to non-decadal experiments, depending on the needs of the user. The substantive and technical differences between the two methods are listed below.

- *climdex-pcic*:
  - percentile calculation based on the routines implemented in the `R`-package `climdex.pcic.ncdf`
  - percentile of a calendar day is centred on a 5-day window with respect to the given base period using the `R-quantile` function type 8
  - calculation of percentiles separately for years inside and outside the base period [Zhang et al., 2005], but the calculated percentile file just contains the out-base values
  - in case of an ensemble: percentiles are calculated individually for each member
- *decadal-eval*:
  - percentile of a calendar day is centred on a 5-day window with respect to the given base period using the `R-quantile` function type 7
  - calculation of percentiles is NOT separated for years within and outside the base period
  - in case of an ensemble: percentiles are calculated on the basis of all members

5 Additional Information, Remarks and Installation

5.1 Installation

Software:

- `Python`
- `NetCDF4`
- `udunits`
- `CDO` (>= 1.7)
- `R` (>= 3.2)
- relevant `R`-packages plus dependencies: `climdex.pcic, climdex.pcic.ncdf, ncdf4, snow, Rcpp, caTools, PCICt, SPEI, functional, udunits2`

Installation Steps:

1. Get the Plugin from the git repository via:
   `git clone git@gitlab.met.fu-berlin.de:tools4freva/climdexcalc.git climdexcalc`
2. Adapt the files `climdexcalc/software/getsoftware4climdex` and `climdexcalc/software/export_paths.sh` to load modules and set/export necessary system variables
   (a) make a copy from the templates:
   `cp climdexcalc/software/getsoftware4climdex-TEMPLATE climdexcalc/software/getsoftware4climdex`
   `cp climdexcalc/software/export_path-TEMPLATE climdexcalc/software/export_path.sh`
   (b) adapt the files `climdexcalc/software/getsoftware4climdex` and `climdexcalc/software/export_path.sh` to the relevant system settings (e.g. module names, paths etc.)
   - load correct module name of CDO (>= 1.7), NetCDF4, R (>= 3.2)
   - set correct paths of udunits
3. Make sure you have installed all needed `R`-Packages with the correct chosen `R` version you have set in `climdexcalc/software/getsoftware4climdex`
4. optionally you can install the `R`-Packages via the script `climdexcalc/software/RLibraryInstaller.R`
5. if not exist: create a blank py-initialization file in the directory with `touch __init__.py`

Updating the Plugin with git:

1. `cd <PATH2PLUGIN>`
2. `git pull`

References

David Bronaugh. *Functions to compute CLIMDEX indices over a NetCDF grid*, 2017. R package version 0.5-4.

David Bronaugh. *PCIC Implementation of Climdex Routines*, 2020. URL `https://cran.r-project.org/web/packages/climdex.pcic/index.html`. R package version 1.1-11.

Thomas R. Karl, Neville Nicholls, and Anver Ghazi. Clivar/gcos/wmo workshop on indices and indicators for climate extremes - workshop summary. *Climatic Change*, 42(1):3–7, 1999. ISSN 0165-0009. doi: 10.1023/A:1005491526870.

Thomas C. Peterson, Christopher Folland, George Gruza, William Hogg, Abdallah Mokssit, and Neil Plummer. Report on the activities of the working group on climate change detection and related rapporteurs 1998–2001. *World Meteorological Organization Rep. WCDMP-47*, WMO-TD 1071:143pp, 2001. URL `http://etccdi.pacificclimate.org/docs/wgccd.2001.pdf`.

Xuebin Zhang, Gabriele Hegerl, Francis W. Zwiers, and Jesse Kenyon. Avoiding inhomogeneity in percentile-based indices of temperature extremes. *Journal of Climate*, 18(11):1641–1651, 2005. doi: 10.1175/JCLI3366.1. URL `https://doi.org/10.1175/JCLI3366.1`.