Seventh Framework Programme

Theme 6

Environment

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High-**E**nd c**L**imate **I**mpacts and e**X**tremes

HELIX WP3 – data availability from global high-res AGCM simulations

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Data availability from global high-res AGCM simulations

This document regards the global modelling and bias correction activities within WP3 of the HELIX project.

The selection of the CMIP5 forcing models for driving the high-res AGCM in the HELIX project was based on the range of fast/slow global warming rates and wet/dry conditions in the HELIX target regions. Details on the selection process can be found in **Appendix A**. Table 1 lists the selected CMIP5 models that were used to force the high-res AGCMs. The table also lists the timing when the global averaged temperature of the forcing model passes a given warming level relative to pre-industrial conditions according to the definition presented in HELIX D2.1.

Table 1. CMIP5 forcing model for global high-resolution atmosphere-only simulations and time when the forcing model passes a given SWL with the RCP85 forcing. The models with ISIMIP=1 are also used as forcing data in ISIMIP.

Member	Model	Ensemble member	SWL1.5	SWL2	SWL4	SWL6	ISIMIP
r0	ERA interim						
r1	IPSL-CM5A-LR	r1i1p1	2015	2030	2068	2102	1
r2	GFDL-ESM2M	r1i1p1	2040	2055	2113	2186	1
r3	HadGEM2-ES	r1i1p1	2027	2039	2074	2110	1
r4	EC-EARTH	r12i1p1	2019	2035	2083		0
r5	GISS-E2-H	r1i1p1	2022	2038	2102	2244	0
r6	IPSL-CM5A-MR	r1i1p1	2020	2034	2069		0

Table 2 illustrates the progress of the AGCM simulations and the availability of cmorized model output.

Table 2. Availability of cmorized model output (April 2016)

	EC-EARTH	HadGEM
r0	1979-2010	
r1	1971-2120	in progress
r2	1971-2100	in progress
r3	1971-2125	in progress
r4	in progress	
r5	1971-2130	
r6	1971-2100	

Table 3 gives an overview of the variables that have been bias-corrected. Completed runs (except r0) are bias corrected against the 0.5 degree Princeton v2 hybrid dataset (Sheffield et al., 2006). We used the ISI-MIP trend preserving bias correction method (Hempel et al., 2013).

Table 3. Availability of bias-corrected variables (April 2016). Variables HURS & HUSS are not bias corrected according the ISI-MIP methodology. These variables are just interpolated for calendar matching (Hempel et al., 2013).

		Variable												
AGCM	Member	HURS	HUSS	PS	PR	PRSN	TAS	TASMAX	TASMIN	WIND	RSDS	RLDS	UAS	VAS
EC-Earth	r1	X	X	X	X	X	X	X	X	X	X	X	X	X
	r2	X	X	X	X	X	X	X	X	X	X	X	X	X
	r3	X	X	X	X	X	X	X	X	X	X	X	X	X
	r4													
	r5	X	X	X	X	X	X	X	X	X	X	X	X	X
	r6	X	X	X	X	X	X	X	X	X	X	X	X	X
HadGEM3	r1													
	r2													
	r3													
	r4													
	r5													
	r6													

The cmorized model output and bias-corrected data can be downloaded from the HELIX sftp server operated by SMHI. The path to the data is

- /helix/SMHI/EC-EARTH3-HR/rcp85/day for the cmorized model outputs
- /helix/TUC/EC-EARTH3-HR/rcp85/day for the bias corrected data

Appendix B provides details about DRS (filename convention) and relevant netCDF attributes.

References

Hempel, S., Frieler, K., Warszawski, L., Schewe, J., and Piontek, F.: A trend-preserving bias correction – the ISI-MIP approach, Earth Syst. Dynam., 4, 219-236, doi:10.5194/esd-4-219-2013, 2013.

Sheffield, J., G. Goteti, and E. F. Wood, 2006: Development of a 50-yr high-resolution global dataset of meteorological forcings for land surface modeling, J. Climate, 19 (13), 3088-3111

Appendix A

Selection of CMIP5 forcing models for HELIX high-res AGCMs

1.1 Dry/wet models in the HELIX target regions at SWL4

The first set of global simulations (r1-r2) was done with models with high and low climate sensitivity and the second set of simulations (r3-r4) with our in-house models (EC-EARTH and HadGEM). The next set of simulations will be done with models that project extreme wet or dry climate conditions in the HELIX target regions (Europe, Africa, SE Asia) to get an estimate about the range of possible outcomes.

For the forcing of the global models with SST and sea-ice from existing CMIP5 simulations, we need information about the climate of the CMIP5 models both globally and in the HELIX target regions. The goal is to find forcing data that lead to a wet or dry climate at a given warming level. Here we focus on SWL4 because it's the high-end scenario for which we still have a sufficiently large number of CMIP5 models. SWL6 on the other hand is only reached by few models – even in the RCP8.5 scenario – and the separation between dry and wet models becomes rather ambiguous.

Figure A.1 shows the average daily precipitation for all CMIP5 models, globally and in the HELIX target regions.

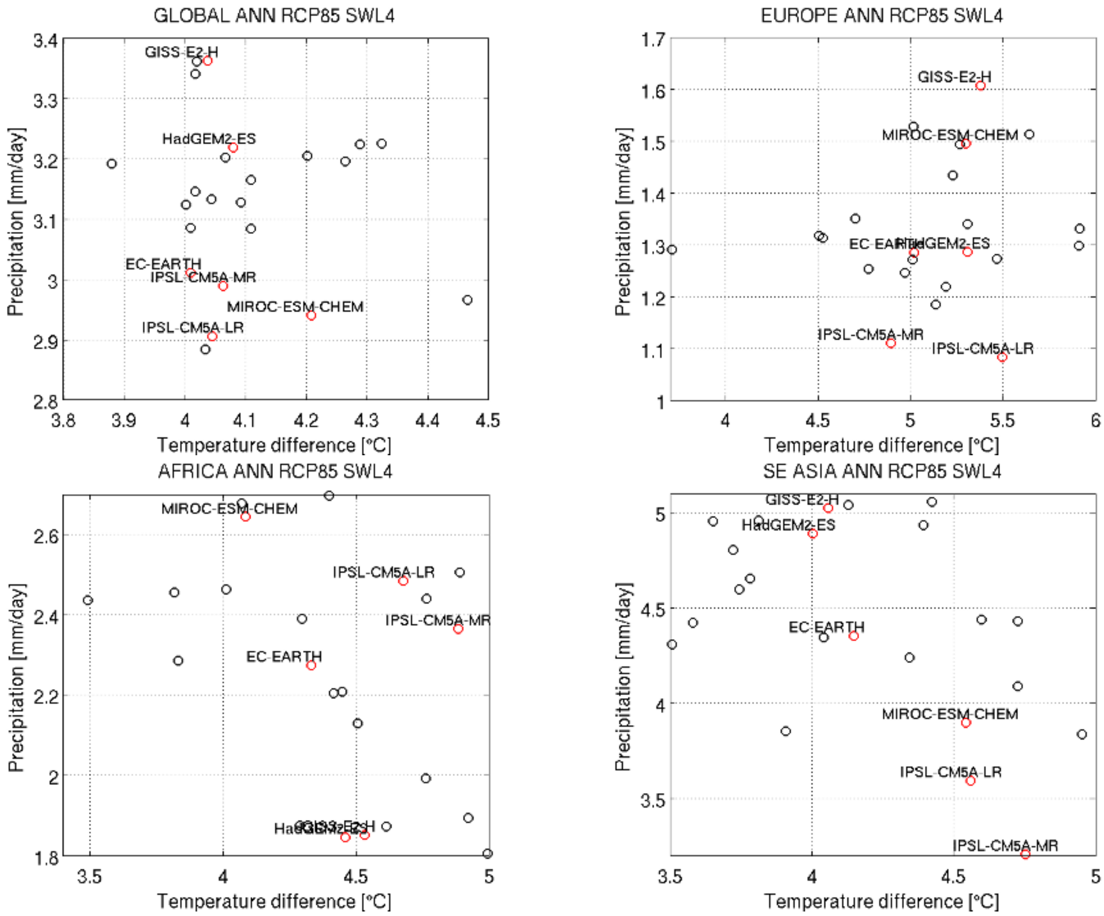

Figure A.1 Precipitation amount (mm/day) and temperature change (°C) at SWL 4 according to different GCMs at scenario RCP 8.5. The GCMs used in HELIX are marked with red colours. Global (top left), Europe (top right), Africa (bottom left) and South East Asia (bottom right).

The precipitation is obtained from a time slice centred for each CMIP5 model on the time when it reached a 4 degree warming compared to pre-industrial conditions (definition of SWL4, see HELIX D2.1). Based on these plots we can identify the dry and wet models for each region. It is not possible to find one model that is the driest/wettest in all seasons and regions. Tables A.1 and A.2 summarise the analysis.

Table A.1 Average amount of precipitation (mm/day) simulated in the top three driest models in each region and season at SWL4.

Africa					
ANN		**DJF**		**JJA**	
GISS-E2-R	1.805	CSIRO-Mk3-6-0	1.449	FIO-ESM	1.615
HadGEM2-ES	1.845	GISS-E2-R	1.822	GISS-E2-R	1.631
GISS-E2-H	1.851	GISS-E2-H	1.826	ACCESS1-0	1.772
Europe					
ANN		**DJF**		**JJA**	
IPSL-CM5A-LR	1.083	IPSL-CM5A-LR	1.435	HadGEM2-AO	0.629
IPSL-CM5A-MR	1.11	CNRM-CM5	1.468	CSIRO-Mk3-6-0	0.688
CanESM2	1.185	EC-EARTH	1.475	HadGEM2-ES	0.702
SE Asia					
ANN		**DJF**		**JJA**	
IPSL-CM5A-MR	3.205	IPSL-CM5A-MR	0.631	IPSL-CM5A-MR	6.491
IPSL-CM5A-LR	3.594	CSIRO-Mk3-6-0	0.696	IPSL-CM5A-LR	6.878
MIROC-ESM	3.837	MPI-ESM-MR	0.851	MIROC-ESM	7.447
Global					
ANN		**DJF**		**JJA**	
CanESM2	2.884	CanESM2	2.891	CanESM2	2.941
IPSL-CM5A-LR	2.906	IPSL-CM5A-LR	2.906	IPSL-CM5A-LR	2.972
MIROC-ESM-CHEM	2.941	MIROC-ESM-CHEM	2.94	MIROC-ESM-CHEM	2.982

Table A.2 The average amount of precipitation (mm/day) simulated in the top three wettest models in each region and season at SWL4.

Africa					
ANN		**DJF**		**JJA**	
MIROC-ESM	2.698	MIROC-ESM	2.938	CNRM-CM5	2.547
CNRM-CM5	2.678	IPSL-CM5A-LR	2.842	MIROC-ESM	2.319
MIROC-ESM-CHEM	2.644	MIROC-ESM-CHEM	2.835	ACCESS1-3	2.289
Europe					
ANN		DJF		JJA	
GISS-E2-H	1.608	BNU-ESM	1.958	GISS-E2-H	1.341
ACCESS1-3	1.529	ACCESS1-3	1.852	MIROC-ESM	1.222
MIROC-ESM	1.514	GISS-E2-H	1.837	GISS-E2-R	1.218
SE Asia					
ANN		DJF		JJA	
ACCESS1-0	5.056	ACCESS1-3	1.816	HadGEM2-CC	10.214
HadGEM2-AO	5.041	GISS-E2-H	1.657	ACCESS1-0	10.022
GISS-E2-H	5.023	GISS-E2-R	1.645	HadGEM2-AO	9.902
Global					
ANN		**DJF**		**JJA**	
GISS-E2-H	3.363	GISS-E2-H	3.379	ACCESS1-3	3.424
ACCESS1-3	3.362	ACCESS1-3	3.352	GISS-E2-H	3.381
GISS-E2-R	3.342	GISS-E2-R	3.344	GISS-E2-R	3.347

Based on the results IPSL-CM5A-MR was chosen as the dry model for the next set of global simulations, since it is among the driest over Europe, South East Asia and globally. GISS-E2-H was chosen as the wet model, since it is the wettest model over Europe, South East Asia and globally.

1.2 Forcing data and associated timing of passing a specific SWL

Based on the above discussion we have selected a set of CMIP5 models that span a good range of fast/slow warming rates and wet/dry conditions in the HELIX target regions. Table A.3 lists the CMIP5 models that have been selected for forcing the global high-resolution atmosphere-only simulations in WP3. The table also lists the timing when the global averaged temperature of the forcing model passes a given warming level relative to pre-industrial conditions according to HELIX D2.1.

Table A.3 CMIP5 forcing model for global high-resolution atmosphere-only simulations and time when the forcing model passes a given SWL with the RCP85 forcing. The models with ISIMIP=1 are also used as forcing data in ISIMIP.

Member	Model	Ensemble	RCP85				ISIMIP
			SWL1.5	SWL2	SWL4	SWL6	
r0	ERA interim						
r1	IPSL-CM5A-LR	r1i1p1	2015	2030	2068	2102	1
r2	GFDL-ESM2M	r1i1p1	2040	2055	2113	2186	1
r3	HadGEM2-ES	r1i1p1	2027	2039	2074	2110	1
r4	EC-EARTH	r12i1p1	2019	2035	2083		0
r5	GISS-E2-H	r1i1p1	2022	2038	2102	2244	0
r6	IPSL-CM5A-MR	r1i1p1	2020	2034	2069		0

1.3 Importance of the choice of RCP on SWL2 climate

Does the climate of SWL2 depend on the forcing of the global model? How different is the climate in a 2-deg warmer world where the forcing follows RCP85 from a 2-deg warmer world that is forced with RCP45? If the differences are found to be large then studies of climate impacts may need to look at SWL2 according to both RCP 4.5 and RCP 8.5. Here, this is investigated in a simple way by plotting temperature and precipitation change at SWL2 according to both scenarios, globally and for the HELIX target areas for winter (DJF) and summer (JJA). Results are shown in Figures A.2 and A.3. SWL2 was chosen because it gives largest model ensembles than SWL4 and SWL6.

Just by looking at the figures there is no apparent difference between the RCP 4.5 ensemble and the RCP 8.5 ensemble. If one were to make a statistical analysis of this some significant differences might be discovered, but at a first glance there is no difference. When comparing the scenarios in the individual models, differences do occur. Climate change according to two scenarios in the same model, for the GCMs used in HELIX (marked with red circles in Figure A.1), is connected by a black line in Figures A.2 and A.3. For the same model the difference in SWL2 climate between RCP 4.5 and RCP 8.5 can be as much as 0.5 °C in temperature and 5 % in precipitation. These differences are not systematic in any way, however and should be considered to be random. Random differences occur naturally in different realisations of the same climate.

There is of course a difference in the timing of SWL2 in the different scenarios. If an application is sensitive to that it might be a point to look also at RCP 4.5, otherwise it doesn't seem to be any point to do it.

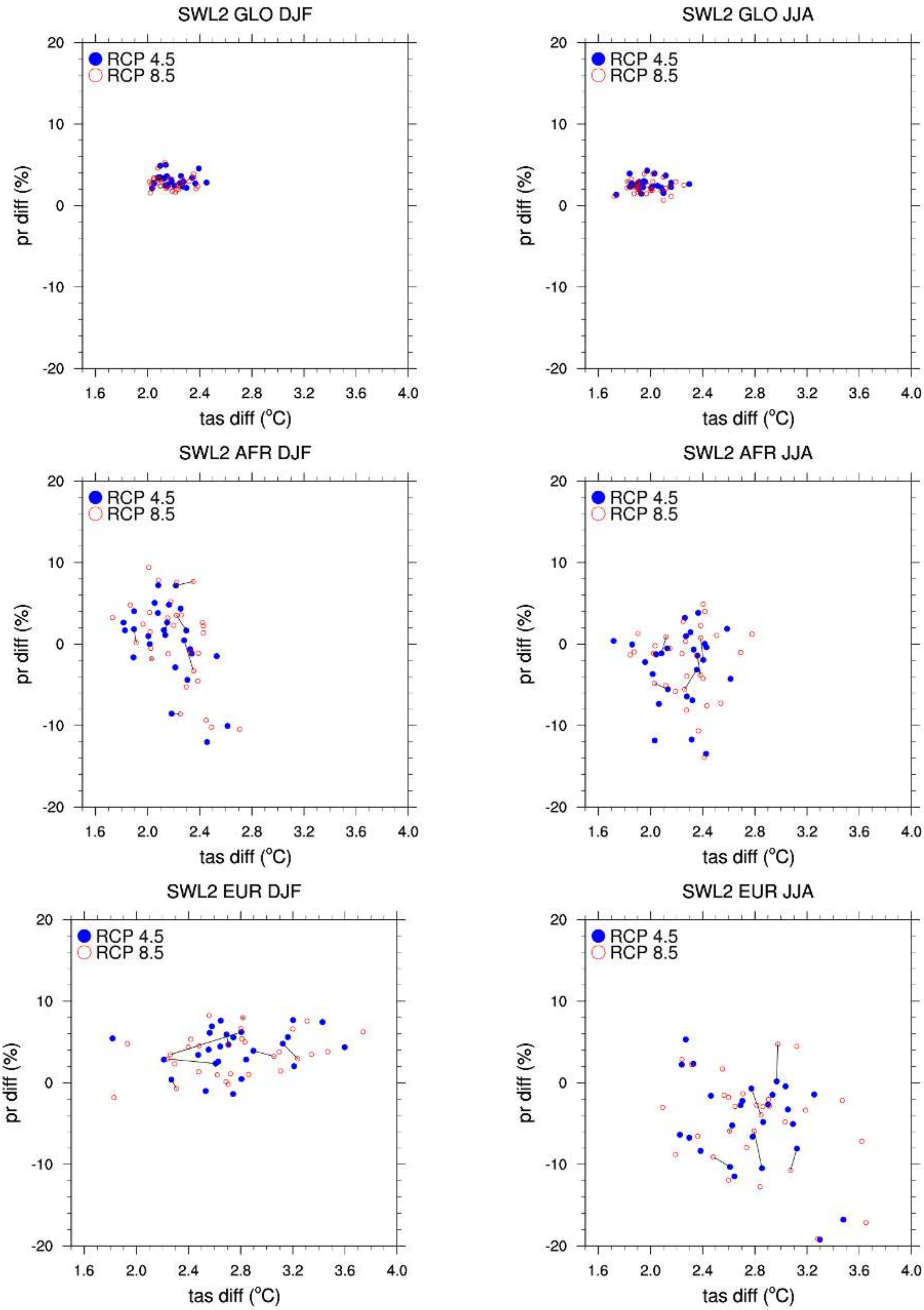

Figure A.2. Precipitation (pr [%]) and temperature (tas [°C]) difference according to scenarios RCP 4.5 (blue dots) and RCP 8.5 (red circles) at SWL2, for winter (DJF, left column) and summer (JJA, right column); globally (GLO, first row), Africa (AFR, second row) and Europe (EUR, third row). For the GCMs used in HELIX, results from the same GCM but different scenarios are connected with a black line.

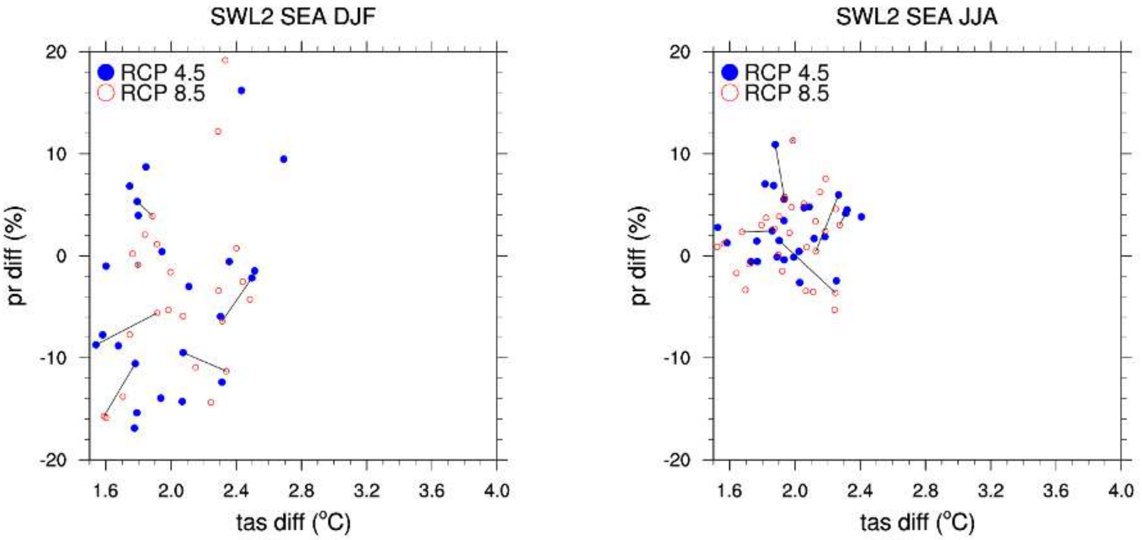

Figure A.3. Same as Figure A.2, but for South East Asia (SEA).

Appendix B

Bias corrected data reference syntax:

The names of the bias corrected files are changed according to the following example:

Cmoized model output:

pr_day_EC-EARTH3-HR_rcp85_r1i1p1_19710101-19711231.nc

Bias corrected:

pr_bced_1981_2010_ec-earth3-hr_historical_r1i1p1_19710101-19801231.nc

Global attributes of the bc files:

:source = "EC-EARTH3-HR v3.1";

:institution = "Swedish Meteorological and Hydrological Institute";

:Conventions = "CF-1.4";

:title_bc = "Model output climate of EC-EARTH3-HR , interpolated to 0.5 degree and bias corrected using observational data Princeton from 1981-2010";

:comment1 = "pr_v2";

:institute_id = "SMHI";

:experiment_id = "rcp85";

:model_id = "EC-EARTH3-HR";

:forcing = "Nat,Ant";

:contact = "<klaus.wyser@smhi.se>";

:comment = "AMIP-style simulation with SST and sea-ice forcing from IPSL-CM5A-LR RCP8.5";

:initialization_method = 1; // int

:physics_version = 1; // int

:product = "output";

:experiment = "RCP8.5";

:frequency = "day";

:creation_date = "2016-01-11T03:10:26Z";

:project_id = "HELIX";

:table_id = "Table day (4 February 2015) 88763b0099ba43b0220925bc073dd226";

:title = "EC-EARTH3-HR model output prepared for HELIX RCP8.5";

:modeling_realm = "atmos";

:realization = 1; // int

:bc_method = "Hempel, S., Frieler, K., Warszawski, L., Schewe, J., and Piontek, F.: A trend-preserving bias correction – the ISI-MIP approach, Earth Syst. Dynam., 4, 219-236, doi:10.5194/esd-4-219-2013, 2013.";

:bc_method_id = "ISI-MIP";

:bc_observation = "Sheffield, J., G. Goteti, and E. F. Wood, Development of a 50-yr high-resolution global dataset of meteorological forcings for land surface modeling, J. Climate, 19 (13), 3088-3111.";

:bc_observation_id = "PGFv2";

:bc_period = "1981-2010";

:bc_info = "Applied by Technical University of Crete in the context of HELIX FP7";

:bc_contact = "Aris Koutroulis <aris@hydromech.gr> & Kostas Seiradakis <kostas@hydromech.gr>";

Variable attribute 'long_name' is modified by appending 'Bias-Corrected' at the beginning, for example, tasmin:long_name = "Bias-Corrected Air Temperature"