Readme WASCAL WRF climate simulations

The overall concept of the high-resolution, long-term climate simulations generated within the WASCAL programme[1] and details on the subset of simulations conducted with WRFV3.5.1 are presented in Heinzeller et al. (2017c). Additional information on the WRF runs, included in the appendix of the publication, is also provided in the following.

The full set of the data described in Sects. 1.–5. is available at the CERA database of the German Climate Computing Center DKRZ (Heinzeller et al., 2017a)[2]. A subset of the data is also available through the PANGAEA Data Publisher for Earth & Environmental Science portal (Heinzeller et al., 2017b)[3].

1. Description of variables

The following table summarises the list of output variables of the WASCAL climate simulations. The table includes all variables that are produced by the WRF model runs. Static variables are provided only once in the static output stream. For further information on the meaning and calculation of these fields, the user is referred to the WRF Users' Guide, in particular to chapter 5[4]. The variable types are "acc" (accumulated values), "coord" (coordinate variables), "const" (constant values), "min" (minimum over last output interval), "max" (maximum over last output interval) and "inst" (instantaneous values).

Note 1. The climate output diagnostic variables contained in stream wrfclm are only available for the high-resolution (12 km) experiments, not for the low-resolution (60 km) experiments.

Note 2. The following time-slice experiments are missing the accumulated radiation budgets (rlds, rldt, rlus, rlut, rsds, rsdt, rsus, rsut; see Sect. 4. and 5. for details): WRF12_MPIESM_HIST/{1979-1990, 1999-2006}, WRF12_MPIESM_RCP45/{2006-2010, 2039-2050, 2089-2100}.

WRF name	Output name	Units	Stream	Type	Description (long name)
ACLWDNB	rlds	J m-2	wrfsfc	acc	Accumulated surface downwelling longwave radiation
ACLWDNT	rldt	J m-2	wrfsfc	acc	Accumulated TOA incident longwave radiation
ACLWUPB	rlus	J m-2	wrfsfc	acc	Accumulated surface upwelling longwave radiation
ACLWUPT	rlut	J m-2	wrfsfc	acc	Accumulated TOA outgoing longwave radiation
ACSWDNB	rsds	J m-2	wrfsfc	acc	Accumulated surface downwelling shortwave radiation
ACSWDNT	rsdt	J m-2	wrfsfc	acc	Accumulated TOA incident shortwave radiation
ACSWUPB	rsus	J m-2	wrfsfc	acc	Accumulated surface upwelling shortwave radiation
ACSWUPT	rsut	J m-2	wrfsfc	acc	Accumulated TOA outgoing shortwave radiation
ALBEDO	alb	1	wrfsfc	inst	Albedo
CANWAT	canwat	kg m-2	wrfsfc	inst	Canopy water
CLDFRA	cl	1	wrfprs	inst	Cloud area fraction
DEPTH	depth	m	wrfsfc	coord	Depth
EMISS	ems	1	wrfsfc	inst	Surface emissivity
GHT	zg	m	wrfprs	inst	Geopotential height
GRDFLX	hfg	W m-2	wrfsfc	inst	Ground heat flux
HFX	hfss	W m-2	wrfsfc	inst	Surface upward sensible heat flux
HGT	orog	m	wrfsta	inst	Terrain height

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[1] http://www.wascal.org, last accessed 2017-09-08
[2] https://cera-www.dkrz.de/WDCC/ui/cerasearch, last accessed 2017-09-08
[3] https://www.pangaea.de, last accessed 2017-09-08
[4] http://www2.mmm.ucar.edu/wrf/users/docs/user_guide_V3/users_guide_chap5.htm, last accessed 2017-09-08

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WRF name	Output name	Units	Stream	Type	Description (long name)
ISLTYP	sltype	1	wrfsta	const	Dominant soil category
IVGTYP	vegtype	1	wrfsta	const	Dominant vegetation category
LANDMASK	sftlf	1	wrfsta	const	Land binary mask (1 for land, 0 for water)
LAT	lat	degrees_north	wrfclm, wrfprs, wrfsfc, wrfsta	coord	Latitude, south is negative
LH	hfls	W m-2	wrfsfc	inst	Surface upward latent heat flux
LON	lon	degrees_east	wrfclm, wrfprs, wrfsfc, wrfsta	coord	Longitude, west is negative
MU	amdry	Pa	wrfsfc	inst	Dry air mass in column
PBLH	zmla	m	wrfsfc	inst	Atmosphere boundary layer thickness
PLEV	plev	hPa	wrfprs	coord	Pressure
PMSL	psl	Pa	wrfsfc	inst	Sea level pressure
PSFC	ps	Pa	wrfsfc	inst	Surface air pressure
Q2	vaps	kg kg-1	wrfsfc	inst	Near-surface water vapor mixing ratio
QCLOUD	clw	kg kg-1	wrfprs	inst	Cloud water mixing ratio
QFX	mfs	kg m-2 s-1	wrfsfc	inst	Surface upward moisture flux
QICE	cli	kg kg-1	wrfprs	inst	Ice mixing ratio
QRAIN	clr	kg kg-1	wrfprs	inst	Rain water mixing ratio
QSNOW	cls	kg kg-1	wrfprs	inst	Snow mixing ratio
QVAPOR	vap	kg kg-1	wrfprs	inst	Water vapor mixing ratio
RAIN	pr	mm	wrfsfc	acc	Accumulated precipitation
RH	hur	%	wrfprs	inst	Relative humidity
RH2	hurs	%	wrfsfc	inst	Near-surface relative humidity
SEAICE	sic	1	wrfsfc	inst	Sea ice binary mask (1 for sea ice, 0 for water)
SHDMAX	vegmax	1	wrfsta	const	Annual max vegetation fraction
SHDMIN	vegmin	1	wrfsta	const	Annual min vegetation fraction
SKINTEMPMAX	tsmax	K	wrfclm	max	Daily maximum surface skin temperature
SKINTEMPMIN	tsmin	K	wrfclm	min	Daily minimum surface skin temperature
SMCREL	mrrlsl	1	wrfsfc	inst	Relative soil moisture
SMOIS	mrlsl	m3 m-3	wrfsfc	inst	Water content of soil layer
SMOIST	mrso	m3 m-3	wrfsfc	inst	Total soil moisture content
SNOALB	albmax	1	wrfsta	const	Annual max snow albedo in fraction
SNOW	snw	kg m-2	wrfsfc	inst	Snow water equivalent
SNOWH	snd	m	wrfsfc	inst	Physical snow depth
SPDUV	wind	m s-1	wrfprs	inst	Wind speed
SPDUV10	sfcWind	m s-1	wrfsfc	inst	Near-surface wind speed
SPDUV10MAX	sfcWindmax	m s-1	wrfclm	max	Daily maxmimum near-surface wind speed

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WRF name	Output name	Units	Stream	Type	Description (long name)
SR	prfz	1	wrfsfc	inst	Fraction of frozen precipitation
SST	tso	K	wrfsfc	inst	Sea surface temperature
SWDDIF	swddif	W m-2	wrfsfc	inst	Shortwave surface downward diffuse irradiance
SWDDIR	swddir	W m-2	wrfsfc	inst	Shortwave surface downward direct irradiance
SWDDNI	swddni	W m-2	wrfsfc	inst	Shortwave surface downward direct normal irradiance
T	ta	K	wrfprs	inst	Air temperature
T2	tas	K	wrfsfc	inst	Near-surface air temperature
T2MAX	tasmax	K	wrfclm	max	Daily maximum near-surface air temperature
T2MIN	tasmin	K	wrfclm	min	Daily minimum near-surface air temperature
TCLDFRA	clt	1	wrfsfc	inst	Total cloud fraction
TD	td	K	wrfprs	inst	Dew point temperature
TD2	tds	K	wrfsfc	inst	Near-surface dew point temperature
TH2	thetas	K	wrfsfc	inst	Near-surface potential temperature
TIME	time	hours since 1970-01-01	wrfclm, wrfprs, wrfsfc, wrfsta	inst	Time
TMN	tsll	K	wrfsfc	inst	Temperature of soil at lower boundary
TSK	ts	K	wrfsfc	inst	Surface skin temperature
TSLB	tsl	K	wrfsfc	inst	Temperature of soil
U	ua	m s-1	wrfprs	inst	Eastward wind
U10	uas	m s-1	wrfsfc	inst	Eastward near-surface wind
U10MAX	uasmax	m s-1	wrfclm	max	Daily maximum eastward near-surface wind
V	va	m s-1	wrfprs	inst	Northward wind
V10	vas	m s-1	wrfsfc	inst	Northward near-surface wind
V10MAX	vasmax	m s-1	wrfclm	max	Daily maximum northward near-surface wind
VEGFRA	veg	1	wrfsfc	inst	Vegetation fraction
W	wa	m s-1	wrfprs	inst	Upward wind

2. Description of streams

The output variables are classified into different output streams, depending on their properties. The streams have different output frequencies. Note that the stream classification does not appear in the directory structure or file names (see Sect. 4. below).

Stream name	Description	Output interval
wrfclm	climate variables (extremes), 2D	day
wrfprs	pressure level variables, 3D	6hr
wrfsfc	surface, subsurface and other 2D variables	3hr
wrfsta	static variables, 2D	fx

3. Pressure levels for stream wrfprs

Pressure-level variables are set to missing values below ground.

Pressure levels [hPa]
1000, 975, 950, 925, 900, 850, 800, 750, 700, 650, 600, 550, 500, 450, 400, 350, 300, 250, 200, 150, 100, 70, 50, 30

4. Description of files

The data is provided in compressed netCDF4 format, CF-1.6 compliant. All data is combined into monthly output files, independent of the output frequency and size of the variables. The coarser 60km runs provide the same data as the 12km runs except for the climate output diagnostics (stream wrfclm is not present). In the following table {sr} denotes the spatial resolution in km, {forcing} the forcing model, {secnario} the scenario, {var} the variable, {yyyy}–{mm} the year and month, and {tr} the output interval (temporal resolution).

Filename pattern:	`wrf{sr}_{forcing}_{scenario}_{var}_{yyyy}-{mm}_{tr}.nc`
Example 1:	`wrf12_eraint_ctrl_tasmax_1982-12_fx.nc`
Example 2:	`wrf12_mpiesm_rcp45_sftlf_2029-01_day.nc`
Example 3:	`wrf60_gfdlesm_hist_ta_2003-04_6hr.nc`
Example 4:	`wrf60_hadgem2_rcp45_tas_2099-12_3hr.nc`

5. Description of nesting strategy and time-slices

The domain configuration is displayed and described in detail in Heinzeller et al. (2017). The high-resolution runs (12 km) are carried out as a nested simulation, using the output of the coarser resolution (60 km) model runs as forcing data set. The coarser model runs are forced by the different re-analysis and GCM data sets described above. An offline-nesting approach is adopted, which implies no feedback from the 12 km experiments to the 60 km experiments. Thus, the 60 km experiments can be considered as standalone experiments at a relatively coarse resolution.

The experiments are conducted as time-sliced runs of 11 year duration each, where the first year is considered as spinup period and should not be used in the analysis. The historical run is carried over into the projection run to provide model data for the WMO reference period 1980–2010. The following time slices are available (including spinup period).

Scenario	**Time-slices**
Control (ctrl)	1979–1990, 1989–2000, 1999–2010, 2009–2014
Historical (hist)	1979–1990, 1989–2000, 1999–2005 (continued as 2006-2010)
Projection (rcp4.5)	2006–2010 (continued from 1999–2005), 2019–2030, 2029–2040, 2039–2050, 2069–2080, 2079–2090, 2089–2100

6. Subset of data available at PANGAEA

To facilitate the use of the WASCAL data for applications that do not require the full set of variables or the full temporal resolution of the data, a subset of the dataset available at CERA is provided through the PANGAEA portal. This subset is derived from the data provided at CERA as follows:

1. Only data from the high-resolution 12 km runs are considered, not from the intermediate-resolution 60 km runs.
2. A subset of variables of potentially high interest are selected.
3. Accumulated data (rainfall, radiation budgets are de-accumulated into precipitation sums and radiation averages between two output time steps).
4. Data at high temporal resolution (3-hourly, 6-hourly) are aggregated to daily or monthly timescales.

5. Atmospheric variables on pressure levels are extracted for 11 out of the 25 available pressure levels.
6. Data are concatenated into 30-year periods 1980–2010 (control, historical), 2020–2050 (RCP4.5), 2070–2100 (RCP4.5), thereby neglecting the 1-year spinup period for each of the time-slice experiments.
7. A slightly different file naming convention is adopted to reflect the above modifications of the data.

Note 1. The accumulated radiation budgets are missing for the runs using MPIESM as forcing data set (see also Sect. 1.).

Note 2. For the periods 1980–2010, the historical runs 1999–2005 are completed by the (continuation) runs 2006–2010 from the RCP4.5 scenario, but the 30-year data sets are labelled as "historical".

The subset of data available at PANGAEA is summarised in the following table. The variables and de-accumulation steps are described in Sects. 1. and 6., the parameters enclosed in curly brackets in Sect. 4.

Variables	
de-accumulated, daily sums/averages	pr, rlds, rldt, rlus, rlut, rsds, rsdt, rsus, rsut
daily averages	hfls, hfss, hurs, mrso, psl, tas, tasmax, tasmin, tds
monthly averages	swddif, swddir, swddni, ua, va, wa, zg
Pressure levels [hPa]	
for variables ua, va, wa, zg	1000, 850, 750, 700, 650, 600, 550, 450, 350, 250, 150
Naming convention	
de-accumulated variables, daily sums	DAC_wa12clmN_{forcing}_{scenario}_{var}_{yyyy}_{yyyy}_DAYSUM.nc
de-accumulated variables, daily averages	DAC_wa12clmN_{forcing}_{scenario}_{var}_{yyyy}_{yyyy}_DAYMEAN.nc
other variables, daily averages	wa12clmN_{forcing}_{scenario}_{var}_{yyyy}_{yyyy}_DAYMEAN.nc
other variables, monthly averages	wa12clmN_{forcing}_{scenario}_{var}_{yyyy}_{yyyy}_MONMEAN.nc

7. Rights of use

The data is provided under the Creative Commons license 4.0. For details about the licensing model, see the following web page: `https://creativecommons.org/licenses/by/4.0/`, last accessed 2017-09-08.

8. Liability/Warranty

1. The data are made available to the user without any warranty. The user is aware that the data have been obtained according to current state-of-the-art science and computational engineering.
2. The data producer must not be taken into any obligation to third parties on the basis of this agreement. Any liability of the data producer for damage of all kinds resulting from the provision and further processing of the data is ruled out. The user indemnifies the data producer from any liability to damaged third parties.
3. The liability disclaimer stated under (1) and (2) does not apply insofar as the data producer has acted in gross negligence or with wilful intent.

References

Heinzeller, D., Dieng, D., Smiatek, G., Olusegun, C., Klein, C., Hamann, I., and Kunstmann, H. (2017a): West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL) High-Resolution Climate Simulation Data. `https://cera-www.dkrz.de/WDCC/ui/Project.jsp?acronym=WASCAL`, last accessed 2017-09-08.

Heinzeller, D., Dieng, D., Smiatek, G., Olusegun, C., Klein, C., Hamann, I., and Kunstmann, H. (2017b): West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL) high-resolution climate simulation data, subset of variables at daily and monthly temporal resolution. `https://www.pangaea.de/MISSING`, last accessed 2017-09-08.

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