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External Parameters for Numerical Weather Prediction and Climate Application EXTPAR Introductory User Guide

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Contents

This is a short overview of the general organization “extpar“ software and working environment to generate external parameters for numerical weather prediction and climate applications. More precise information on specific model parts can be found in the technical and scientific documentation.

1 Overall Description

Numerical Weather Prediction (NWP) models and Climate models require geographical localized datasets like the topographic height of the earth surface, the plant cover, the distribution of land and sea and dependent on the schemes used a variety of other so called external parameters.

The EXTPAR software system (EXTPAR - External Parameter for Numerical Weather Prediction and Climate Application) is able to generate external parameters for the different models GME, COSMO, HRM and ICON. The software can run on a UNIX or Linux systems where the raw data is stored. It allows operators (experienced users) running the scripts to create new external parameters controlled by user specifications like the model domain.

The following steps are performed for the generation of external parameters:

1. The target grid has to be specified in a namelist, supported target grids are
   - Rotated and non-rotated longitude-latitude grid (COSMO and HRM)
   - Icosahedral Hexagonal grids (GME)
   - Icosahedral Triangular grids (ICON) with optionally higher resolution in selected regions (’local zooming’)
2. The different raw data sets are aggregated to the target grid considering all raw data elements which are within the target grid element. If the target grid has a higher resolution than the input grid on which the raw data is available either an interpolation is performed or the target grid is filled with the nearest neighbor, but sub-grid scale statistical calculations (e.g. subgrid scale varianceof orograhic height) are dismissed.
3. All the different external parameter sets have to be checked for consistency against each other. In case of conflicts default values are set automatically.
4. In the output Netcdf file information on the input data and the processing software is given.

A number of input dataset or raw datasets are used for the generation of the external parameters.

1.1 Input raw datasets

A number of input dataset or raw datasets are used for the generation of the external parameters, see table 1.

1.2 Output external parameters

The output fields with the external parameters are shown in table 2.

Table 3 shows the association of the GLC2000 Dataset to the external parameters of GME.

Dataset	Source	Resolution
GLOBE orography	NOAA/NGDC	30″
GLC2000 land use	JRC Ispra	30″
DSMW Digital Soil Map of the World	FAO	5′
NDVI Climatotology, SEAWiFS	NASA/GSFC	2.5′
CRU near surface climatology	CRU University of East Anglia	0.5 degree
Aerosol Optical thickness	NASA/GISS (Global Aerosol Climatology Project)	4x5 degree
Global lake database	DWD/ RSHU	30″

Table 1: Input raw datasets

external parameter	short name	unit
geometrical height	HSURF	m
geopotential of earth surface	FIS	$m^2 s^{-1}$
fraction land cover	FR_LAND	1
standard deviation of subgrid scale orographic height	SSO_STDH	m
anisotropy of topography	SSO_GAMMA	1
angle between principal axis of orography and global E	SSO_THETA	1
mean slope of subgrid scale orography	SSO_SIGMA	1
surface roughness	Z0	m
soil texture	SOILTYP	-
ground fraction covered by plants (vegetation period)	PLCOV_MX	1
ground fraction covered by artificial (urban) areas	URBAN	1
ground fraction covered by evergreen forest	FOR_E	1
ground fraction covered by deciduous forest	FOR_D	1
root depth	ROOTDP	m
leaf area index (vegetation period)	LAI_MX	1
plant resistance	PRS_MIN	sm^{-1}
long wave surface emissivity	EMISS_RAD	1
(monthly) normalized differential vegetation index	NDVI	1
Annual maximum of normalized differential vegetation index	NDVI_MAX	1
(monthly) proportion of actual value/maximum normalized differential vegetation index	NDVI_RATIO	1
(monthly) optical thickness from black carbon aerosol	AER_BC	1
(monthly) optical thickness from dust aerosol	AER_DUST	1
(monthly) optical thickness from organic aerosol	AER_ORG	1
(monthly) optical thickness from SO4 aerosol	AER_SO4	1
(monthly) optical thickness from sea salt aerosol	AER_SS	1
Near surface temperature (climatological mean)	T_2M_CL	K
Lake Depth	DEPTH_LK	m
Lake Fraction	FR_LAKE	1
Slope aspect (not yet available)	SLOPE_ASP	deg
Slope angle (not yet available)	SLOPE_ANG	deg
Horizon angles (resolution from 15deg) (not yet available)	HORIZON	deg
Skyview factor (not yet available)	SKYVIEW	-

Table 2: Output external parameters

No.	Description	z0 (m)	max. FP (%)	max LAI (-)	root depth (m)	min RS (m/s)	surface emissivity (-)
1	Tree Cover, broadleaved, evergreen	1.0	80	5	1	175	0.996
2	Tree Cover, broadleaved, deciduous, closed	1.0	90	6	1	240	0.990
3	Tree Cover, broadleaved, deciduous, open	0.15	80	4	2	240	0.993
4	Tree Cover, needle-leaved, evergreen	1.0	80	5	0.6	500	0.996
5	Tree Cover, needle-leaved, deciduous	1.0	90	5	0.6	500	0.990
6	Tree Cover, mixed leaf type	1.0	90	5	0.8	350	0.993
7	Tree Cover, regularly flooded, fresh water	1.0	80	5	1	350	0.996
8	Tree Cover, regularly flooded, saline water	1.0	80	5	1	350	0.996
9	Mosaic: Tree cover / Other natural vegetation	0.20	80	2.5	1	300	0.985
10	Tree Cover, burnt	0.05	50	0.6	0.3	300	0.950
11	Shrub Cover, closed-open, evergreen	0.20	80	3	1	225	0.985
12	Shrub Cover, closed-open, deciduous	0.15	80	1.5	2	225	0.993
14	Sparse Herbaceous or sparse Shrub Cover	0.05	50	0.6	0.3	110	0.950
15	Regularly flooded Shrub and/or Herbaceous Cover	0.05	80	2	0.4	110	0.992
16	Cultivated and managed areas	0.07	90	3.3	1	180	0.990
17	Mosaic: Cropland / Tree Cover / Other natural vegetation	0.25	80	3	1	200	0.990
18	Mosaic: Cropland / Shrub or Grass Cover	0.07	90	3.5	1	150	0.990
19	Bare Areas	0.05	5	0.6	0.3	150	0.950
20	Water Bodies	0.0002	0	0	0	150	0.991
21	Snow and Ice	0.01	0	0	0	150	0.9999
22	Artificial surfaces and associated areas	1.0	20	1	0.6	150	0.960

Table 3: Association of GLC2000 landuse classes and external Parameters for GME (from the documentation of GME external parameters)

2 Software modules

to be extended

In a first step, several programs aggregate various raw datasets to the given target grid of the models into intermediate netcdf files (”buffer“). In the second step the program ”extpar_consistency_check” insures consistency inbetween all the different fields and writes the result to a netcdf and a GRIB file.

1. Aggregate the raw data sets to the target grid with following executables
   - extpar_aot_to_buffer
   - extpar_cru_to_buffer
   - extpar_landuse_to_buffer
   - extpar_globe_to_buffer
   - extpar_ndvi_to_buffer
   - extpar_soil_to_buffer
   - extpar_flake_to_buffer
2. After the above programs have aggregated the data and stored the result into the buffer-files, run the consistency check executable, which finally generates the netcdf and GRIB result files.
   - extpar_consistency_check

2.1 extpar_landuse_to_buffer

- Input: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_LU, glc2000_byte.nc, glcc_usgs_class_byte.nc
- Output: extpar_landuse_cosmo.nc, glcc_landuse_buffer.nc

2.2 extpar_globe_to_buffer

- Input: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_ORO, GLOBE_A10.nc, GLOBE_B10.nc, GLOBE_C10.nc, GLOBE_C10.nc, GLOBE_E10.nc, GLOBE_F10.nc, GLOBE_G10.nc, GLOBE_H10.nc, GLOBE_I10.nc, GLOBE_J10.nc, GLOBE_K10.nc, GLOBE_L10.nc, GLOBE_M10.nc, GLOBE_N10.nc, GLOBE_O10.nc, GLOBE_P10.nc
- Output: GLOBE_buffer.nc

2.3 extpar_aot_to_buffer

- Input: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_AOT, aerosol_optical_thickness.nc
- Output: extpar_buffer_aot.nc

2.4 extpar_cru_to_buffer

- Input: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_TCLIM, absolute_hadcrut3.nc
- Output: crutemp_clim_extpar_buffer.nc

2.5 extpar_ndvi_to_buffer

- Input: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_NDVI, NDVI_1998_2003.nc
- Output: NDVI_buffer.nc

2.6 extpar_soil_to_buffer

- Input: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_SOIL, FAO_DSMW.nc
- Output: FAO_DSMW_buffer.nc

2.7 extpar_flake_to_buffer

- Input: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_FLAKE, lakedepth.nc
- Output: flake_buffer.nc

2.8 extpar_consistency_check

- Input: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_CHECK, extpar_landuse_cosmo.nc, glcc_landuse_buffer.nc, GLOBE_buffer.nc, extpar_buffer_aot.nc, crutemp_clim_extpar_buffer.nc, NDVI_buffer.nc, FAO_DSMW_buffer.nc, flake_buffer.nc
- Output: external_parameter_cosmo_eu.g1, external_parameter_cosmo_eu.nc

2.9 runscript

Here is an example of an runscript which creates the namelists and runs the executable to generate the external parameters for COSMO-EU in this case.

```
#!/usr/bin/ksh

# path to working directory
workdir=${TMPDIR}  # adjust the path setting!
# path to raw data for external parameter
data_dir=/data/hasensio/EP/extpar_rawdata  # adjust the path setting!
# path to binaries
progdir=${HOME}/bin  # adjust the path setting!


binary_lu=extpar_landuse_to_buffer
binary_globe=extpar_globe_to_buffer
binary_aot=extpar_aot_to_buffer
binary_tclim=extpar_cru_to_buffer
binary_ndvi=extpar_ndvi_to_buffer
binary_soil=extpar_soil_to_buffer
binary_flake=extpar_flake_to_buffer

binary_extpar_consistency_check=extpar_consistency_check

if [[ ! -d ${workdir} ]] ; then
  mkdir -p ${workdir}
fi
cd ${workdir}
pwd

# set target grid definition
cat > INPUT_grid_org << EOF_go
&GRID_DEF
 igrid_type = 2,
 domain_def_namelist='INPUT_COSMO_GRID'
```

```
/
EOF_go

#---
cat > INPUT_COSMO_GRID << EOF_grid
&lmgrid
 pollon=-170.0,
 pollat=40.0,
 startlon_tot=-30.125,
 startlat_tot=-24.125,
 dlon=0.0625,
 dlat=0.0625,
 ie_tot=965,
 je_tot=773,
/
EOF_grid
#---

grib_output_filename='external_parameter_cosmo_eu.g1'
netcdf_output_filename='external_parameter_cosmo_eu.nc'

raw_data_aot='aerosol_optical_thickness.nc'
buffer_aot='extpar_buffer_aot.nc'
output_aot='aot_extpar_cosmo.nc'

raw_data_tclim='absolute_hadcrut3.nc'
buffer_tclim='crutemp_clim_extpar_buffer.nc'
output_tclim='crutemp_clim_extpar_cosmo.nc'

raw_data_glc2000='glc2000_byte.nc'
buffer_glc2000='extpar_landuse_buffer.nc'
output_glc2000='extpar_landuse_cosmo.nc'
raw_data_glcc='glcc_usgs_class_byte.nc'
buffer_glcc='glcc_landuse_buffer.nc'
output_glcc='glcc_landuse_cosmo.nc'

raw_data_globe_A10='GLOBE_A10.nc'
raw_data_globe_B10='GLOBE_B10.nc'
raw_data_globe_C10='GLOBE_C10.nc'
raw_data_globe_D10='GLOBE_D10.nc'
raw_data_globe_E10='GLOBE_E10.nc'
raw_data_globe_F10='GLOBE_F10.nc'
raw_data_globe_G10='GLOBE_G10.nc'
raw_data_globe_H10='GLOBE_H10.nc'
raw_data_globe_I10='GLOBE_I10.nc'
raw_data_globe_J10='GLOBE_J10.nc'
raw_data_globe_K10='GLOBE_K10.nc'
raw_data_globe_L10='GLOBE_L10.nc'
raw_data_globe_M10='GLOBE_M10.nc'
raw_data_globe_N10='GLOBE_N10.nc'
raw_data_globe_O10='GLOBE_O10.nc'
raw_data_globe_P10='GLOBE_P10.nc'
buffer_globe='GLOBE_buffer.nc'
output_globe='GLOBE_COSMO.nc'

raw_data_ndvi='NDVI_1998_2003.nc'
```

```
buffer_ndvi='NDVI_buffer.nc'
output_ndvi='ndvi_extpar_cosmo.nc'

raw_data_soil='FAO_DSMW.nc'
buffer_soil='FAO_DSMW_buffer.nc'
output_soil='FAO_DSMW_COSMO.nc'

raw_data_flake='lakedepth.nc'
buffer_flake='flake_buffer.nc'
output_flake='ext_par_flake_cosmo.nc'

# create input namelists
cat > INPUT_AOT << EOF_aot
&aerosol_raw_data
  raw_data_aot_path='',
  raw_data_aot_filename='${raw_data_aot}'
/
&aerosol_io_extpar
  aot_buffer_file='${buffer_aot}',
  aot_output_file='${output_aot}'
/
EOF_aot
#---
cat > INPUT_TCLIM << EOF_tclim
&t_clim_raw_data
  raw_data_t_clim_path='',
  raw_data_t_clim_filename='${raw_data_tclim}'
/

&t_clim_io_extpar
  t_clim_buffer_file='${buffer_tclim}',
  t_clim_output_file='${output_tclim}'
/
EOF_tclim
#---
cat > INPUT_LU << EOF_lu
&glc2000_raw_data
   raw_data_glc2000_path='',
   raw_data_glc2000_filename='${raw_data_glc2000}',
   ilookup_table_glc2000=3
/
&glc2000_io_extpar
   glc2000_buffer_file='${buffer_glc2000}',
   glc2000_output_file='${output_glc2000}'
/
&glcc_raw_data
   raw_data_glcc_path='',
   raw_data_glcc_filename='${raw_data_glcc}'
/
&glcc_io_extpar
   glcc_buffer_file='${buffer_glcc}',
   glcc_output_file='${output_glcc}'
/
EOF_lu
#---
cat > INPUT_ORO << EOF_oro
```

```
&orography_io_extpar
   orography_buffer_file='${buffer_globe}',
   orography_output_file='${output_globe}'
/
&orography_raw_data
  raw_data_orography_path='',
  GLOBE_FILES = '${raw_data_globe_A10}' '${raw_data_globe_B10}'  '${raw_data_globe_C10}'
'${raw_data_globe_D10}'  '${raw_data_globe_E10}'  '${raw_data_globe_F10}'
'${raw_data_globe_G10}'  '${raw_data_globe_H10}'  '${raw_data_globe_I10}'
'${raw_data_globe_J10}'  '${raw_data_globe_K10}'  '${raw_data_globe_L10}'
'${raw_data_globe_M10}'  '${raw_data_globe_N10}'  '${raw_data_globe_O10}'
'${raw_data_globe_P10}'
/
EOF_oro
#---
cat > INPUT_NDVI << EOF_ndvi
&ndvi_raw_data
   raw_data_ndvi_path='',
   raw_data_ndvi_filename='${raw_data_ndvi}'
/
&ndvi_io_extpar
  ndvi_buffer_file='${buffer_ndvi}',
  ndvi_output_file='${output_ndvi}'
/
EOF_ndvi
#---
cat > INPUT_SOIL << EOF_soil
&soil_raw_data
  raw_data_soil_path='',
  raw_data_soil_filename='${raw_data_soil}'
/
&soil_io_extpar
   soil_buffer_file='${buffer_soil}',
   soil_output_file='${output_soil}'
/
EOF_soil
#---
cat > INPUT_FLAKE << EOF_flake
&flake_raw_data
    raw_data_flake_path='',
    raw_data_flake_filename='${raw_data_flake}'
/
&flake_io_extpar
    flake_buffer_file='${buffer_flake}'
    flake_output_file='${output_flake}'
/
EOF_flake
#---
# consistency check
cat > INPUT_CHECK << EOF_check
&extpar_consistency_check_io
   grib_output_filename='${grib_output_filename}',
   netcdf_output_filename='${netcdf_output_filename}',
   orography_buffer_file='${buffer_globe}',
   soil_buffer_file='${buffer_soil}',
   glc2000_buffer_file='${buffer_glc2000}',
```

```
  glcc_buffer_file='${buffer_glcc}',
  flake_buffer_file='${buffer_flake}',
  ndvi_buffer_file='${buffer_ndvi}',
  t_clim_buffer_file='${buffer_tclim}',
  aot_buffer_file='${buffer_aot}'
/
EOF_check

# link raw data files to local workdir
ln -s ${data_dir}/${raw_data_aot}

ln -s ${data_dir}/${raw_data_tclim}

ln -s ${data_dir}/${raw_data_glc2000}
ln -s ${data_dir}/${raw_data_glcc}

ln -s ${data_dir}/${raw_data_globe_A10}
ln -s ${data_dir}/${raw_data_globe_B10}
ln -s ${data_dir}/${raw_data_globe_C10}
ln -s ${data_dir}/${raw_data_globe_D10}
ln -s ${data_dir}/${raw_data_globe_E10}
ln -s ${data_dir}/${raw_data_globe_F10}
ln -s ${data_dir}/${raw_data_globe_G10}
ln -s ${data_dir}/${raw_data_globe_H10}
ln -s ${data_dir}/${raw_data_globe_I10}
ln -s ${data_dir}/${raw_data_globe_J10}
ln -s ${data_dir}/${raw_data_globe_K10}
ln -s ${data_dir}/${raw_data_globe_L10}
ln -s ${data_dir}/${raw_data_globe_M10}
ln -s ${data_dir}/${raw_data_globe_N10}
ln -s ${data_dir}/${raw_data_globe_O10}
ln -s ${data_dir}/${raw_data_globe_P10}

ln -s ${data_dir}/${raw_data_ndvi}

ln -s ${data_dir}/${raw_data_soil}

ln -s ${data_dir}/${raw_data_flake}

# run the programs
# the next seven programs can run independent of each other
time ${progdir}/${binary_aot}
time ${progdir}/${binary_tclim}
time ${progdir}/${binary_lu}
time ${progdir}/${binary_globe}
time ${progdir}/${binary_ndvi}
time ${progdir}/${binary_soil}
time ${progdir}/${binary_flake}

# the consistency check requires the output of
# ${binary_aot}, ${binary_tclim}, ${binary_lu}, ${binary_globe},
# ${binary_ndvi}, ${binary_soil} and ${binary_flake}
time ${progdir}/${binary_extpar_consistency_check}

ls
echo 'External parameters for COSMO model generated'
```