External Parameters for Numerical Weather Prediction and Climate Application EXTPAR v2_0 User and Implementation Guide

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This short overview of the 'extpar' software discribes the working environment and the necessary steps to generate external parameters for numerical weather prediction and climate applications. More detailed information on specific modules of extpar 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, 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 variance of 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. In the Netcdf output, information on the input data and the processing software is given.

1.1 Input raw datasets

The information for the external parameters is aggregated from various raw datasets for land use data, orogaphy or soil data, see table 1 for a detailed list of the raw datasets.

These raw datasets can be found on the Linux-workstations and the hpc at DWD in the directory ˜routfor/routfox/extpar/rawdata

Dataset	Source	Resolution
GLOBE orography	NOAA/NGDC	30″
ASTER orography (limited domain: 60°N - 60°S)	METI/NASA	1″
Globcover 2009	ESA	10″
GLC2000 land use	JRC Ispra	30″
GLCC land use	USGS	30″
DSMW Digital Soil Map of the World	FAO	5′
HWSD Harmonized World Soil Database	FAO/IIASA/ISRIC/ISSCAS/JRC	30″
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 (GLDB)	DWD/RSHU/MeteoFrance	30″
MODIS albedo	NASA	5′

Table 1: Input raw datasets

1.2 Output external parameters

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

external parameter	short name	unit	raw dataset
geometrical height	HSURF	m	GLOBE/ASTER
geopotential of earth surface	FIS	m^2s^{-1}	GLOBE/ASTER
standard deviation of subgrid scale orographic height	SSO_STDH	m	GLOBE/ASTER
anisotropy of topography	SSO_GAMMA	1	GLOBE/ASTER
angle between principal axis of orography and global E	SSO_THETA	1	GLOBE/ASTER
mean slope of subgrid scale orography	SSO_SIGMA	1	GLOBE/ASTER
surface roughness	Z0	m	GLC2000, GLOBE/ASTER
Slope aspect	SLOPE_ASP	deg	GLOBE/ASTER
Slope angle	SLOPE_ANG	deg	GLOBE/ASTER
Horizon angles (resolution from 15deg)	HORIZON	deg	GLOBE/ASTER
Skyview factor	SKYVIEW	-	GLOBE/ASTER
soil texture	SOILTYP	-	DSMW/HWSD
fraction of sand	FR_SAND	%	HWSD
fraction of silt	FR_SILT	%	HWSD
fraction of clay	FR_CLAY	%	HWSD
fraction of organic carbon	FR_OC	%	HWSD
bulk density	BULK_DENS	gcm^{-3}	HWSD
deep soil texture	SUBSOILTYP	-	HWSD
deep soil fraction of sand	SUB_FR_SAND	%	HWSD
deep soil fraction of silt	SUB_FR_SILT	%	HWSD
deep soil fraction of clay	SUB_FR_CLAY	%	HWSD
deep soil fraction of organic carbon	SUB_FR_OC	%	HWSD
deep soil bulk density	SUB_BULK_DENS	gcm^{-3}	HWSD
fraction land cover	FR_LAND	1	GLC2000/Globcover
ground fraction covered by plants max (vegetation period)	PLCOV_MX	1	GLC2000/Globcover

external parameter	**short name**	**unit**	**raw dataset**
ground fraction covered by plants min (vegetation period)	PLCOV_MN	1	GLC2000/Globcover
ground fraction covered by artificial (urban) areas	URBAN	1	GLC2000/Globcover
ground fraction covered by evergreen forest	FOR_E	1	GLC2000/Globcover
ground fraction covered by deciduous forest	FOR_D	1	GLC2000/Globcover
root depth	ROOTDP	m	GLC2000/Globcover
leaf area index max(vegetation period)	LAI_MX	1	GLC2000/Globcover
leaf area index min (vegetation period)	LAI_MN	1	GLC2000/Globcover
plant resistance	PRS_MIN	sm^{-1}	GLC2000/Globcover
long wave surface emissivity	EMISS_RAD	1	GLC2000/Globcover
(monthly) normalized differential vegetation index	NDVI	1	SEAWIFS
Annual maximum of normalized differential vegetation index	NDVI_MAX	1	SEAWIFS
(monthly) proportion of actual value/ maximum normalized differential vegetation index	NDVI_RATIO	1	SEAWIFS
(monthly) optical thickness from black carbon aerosol	AER_BC	1	GACP
(monthly) optical thickness from dust aerosol	AER_DUST	1	GACP
(monthly) optical thickness from organic aerosol	AER_ORG	1	GACP
(monthly) optical thickness from SO4 aerosol	AER_SO4	1	GACP
(monthly) optical thickness from sea salt aerosol	AER_SS	1	GACP
Near surface temperature (climatological mean)	T_2M_CL	K	CRU
Lake Depth	DEPTH_LK	m	GLDB
Lake Fraction	FR_LAKE	1	GLDB
Albedo	ALB	%	MODIS
Near Infrared Albedo	ALNID	%	MODIS
Ultra Violett Albedo	ALUVD	%	MODIS

Table 2: Output external parameters

2 Software modules

The software EXTPAR is composed of nine autonomous programs. Eight programs are responsible for aggregating a raw data to the target grid, which is specified by the user. The ninth program, the consistency check, is performed in the end. The executables are called extpar_*_to_buffer, whereas the star stands for aot (aerosol optical thickness), cru (temperature climatology of the Climate Research Unit (CRU)), landuse, topo, ndvi (normalized difference vegetation index), soil, flake (fraction lake) and albedo, respectively. In Fig. 2 a schematic representation of EXTPAR is drawn. For the sake of clarity only the topography and land-use path is shown. The same can be applied for the other six raw data sets. For all these programs there exist namelists. Most of the namelist only contain the name and path of the raw data file and the name of the buffer file, which is later used for the consistency check, and the name of the output of the final external variables. This is true for the following namelists: 'INPUT_AOT', 'INPUT_TCLIM' (it does temporarily contain a switch to choose between the old and new data set), 'INPUT_NDVI', 'INPUT_FLAKE' and 'INPUT_ALB'. The latter does additionally include the variable names used in the raw data files.

The namelist 'INPUT_LU' contains two integer switches which allow to choose between two raw data sets (GLC_2000 and Globcover) and their lookup tables. But it also has an additional raw data file name and path for the single global raw land-use data set GLCC. It is the only one that contains the Antarctica and provides the information for the area below around 60 degrees south as the aforementioned land-use data sets are not able to provide any information there.

The namelist 'INPUT_ORO' gives the possibility to switch between two raw orographical data sets. It must be considered, that ASTER is not yet completely downloaded and is therefore not globally available. The downloaded region extends from 60°N to 60°S and from 180°W to 180°E. It is not recommended to derive the topographical parameters from ASTER if the region is beyond 60 degrees north or south. This is due to quality issues. The ASTER files are arranged as displayed in Fig. 1. As the computational time of the program *extpar_topo_to_buffer* depends mainly on the number of ASTER files that are read in, two new parameters are introduced in the namelist. These two parameters give the number of columns and rows of the used ASTER files. The filenames of the desired ASTER files must be given manually. Figure 1 gives an example on how to use these parameters in the case of COSMO-2. If GLOBE is used the columns and rows are set to 4 and all GLOBE files must be listed in the *topo_files* parameter. A check in the program *extpar_topo_to_buffer* is introduced, which gives a warning if the boarders of the domain are exceeded. This is followed by an abortion of this program. As there is no need to calculate the subgrid scale parameters (SSO) for high resolution setups, there is the logical switch *lsso_parm* to turn of the calculation of the SSOs.

The namelist 'INPUT_SCALE_SEP' provides information needed to calculate the SSO parameters and roughness lenght based on a 3 km filtered topography. The logical switch lscale_separation allows the user to decide whether a scale separation is desired or not. Note that the scale separation can only be applied for GLOBE and not for ASTER. Furthermore the user must decide whether the calculation of the SSO parameters make sense or not (compare for this table 3).

In the namelist 'INPUT_OROSMOOTH' all parameters that are used to smoothen the topography, as also implemented in Int2lm, are given. These values can be changed by the user, compare the namelist orography_smoothing in chapter 4.3. There is also a logical switch that allows to disable the orographical smoothing.

The third topographical based namelist is 'INPUT_RADTOPO'. It contains a logical switch that allows to turn of the topographical corrected radiation parameters. Additionally the number of horizons must be specified. It is not recommended to deviate from 24.

The namelist 'INPUT_SOIL' includes an integer sitch, which allows to choose between the two data sets FAO (1) and HWSD (2). Because the HWSD data also provides deep soil types, there is a logical switch which can turn off these calculations. Be aware that the deep soil can only be calculated if the HWSD data are used for the topsoil. Additionally to the buffer and output file names, the path to the raw data files and the file names are specified. The latter must be manually changed for the topsoil if the raw data is changed from FAO to HWSD and vice versa. Next to these parameters the file names of the lookup tables for the HWSD data must be specified.

The namelists 'INPUT_grid_org' and either 'INPUT_COSMO_GRID' or 'INPUT_ICON_GRID' or 'INPUT-_GME_GRID' are used in all nine programs, as they contain the general information of the target grid to which the raw data should be aggregated.

The task of the consistency check that is performed at the end is to find inconsistencies in the soil data, the lake data and the NDVI data. In the soil data problems may appear between the soil type and the land-use, in particular for water and ice grid elements. For the fraction lake, minimal and maximal lake depth must be introduced and some seas such as the Caspian and the Death Sea as well as Lake Constance must be defined manually. For more information compare chapter 2.9.

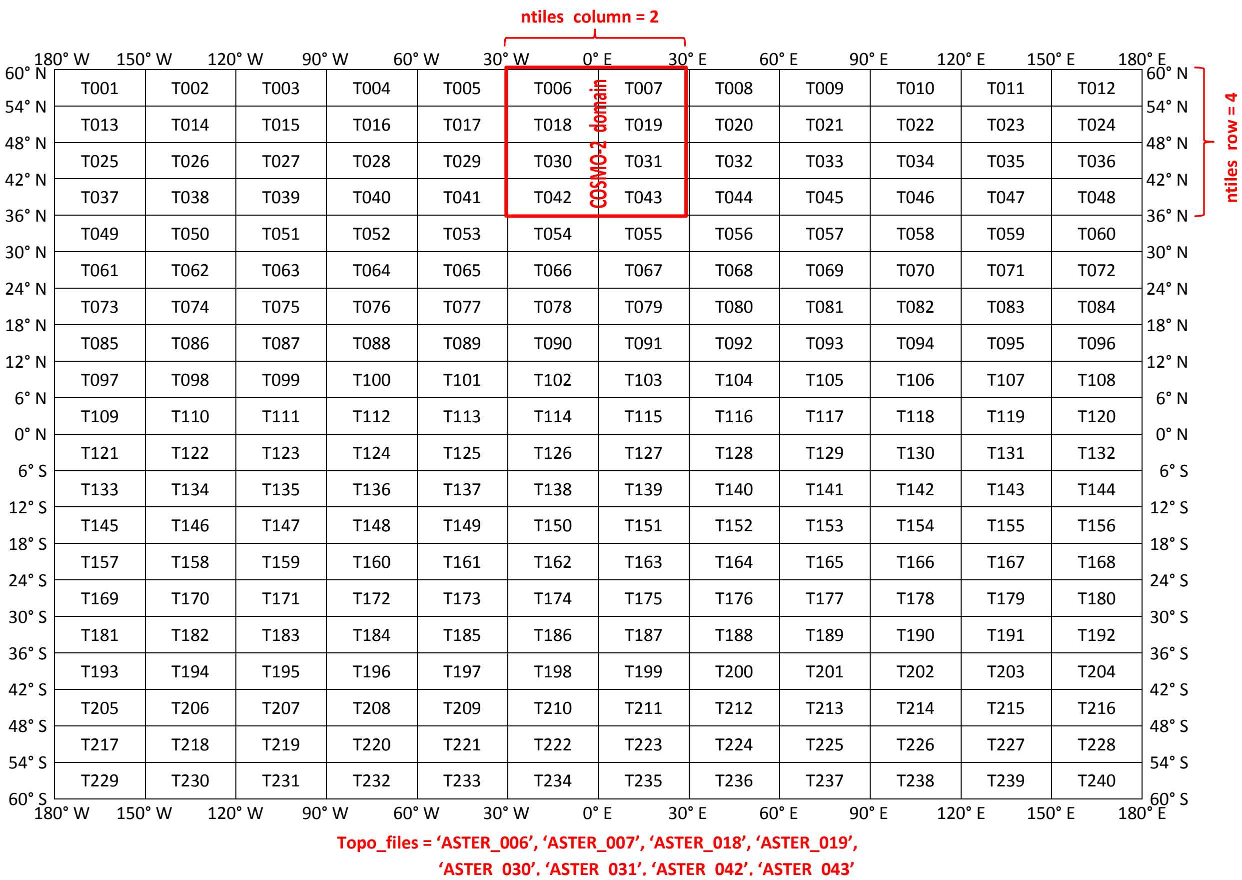

Figure 1: Illustration of the single domains of the 240 ASTER tiles. An example on how the three parameters ntiles_columns, ntiles_row and topo_files in the namelist could look like is given in red.

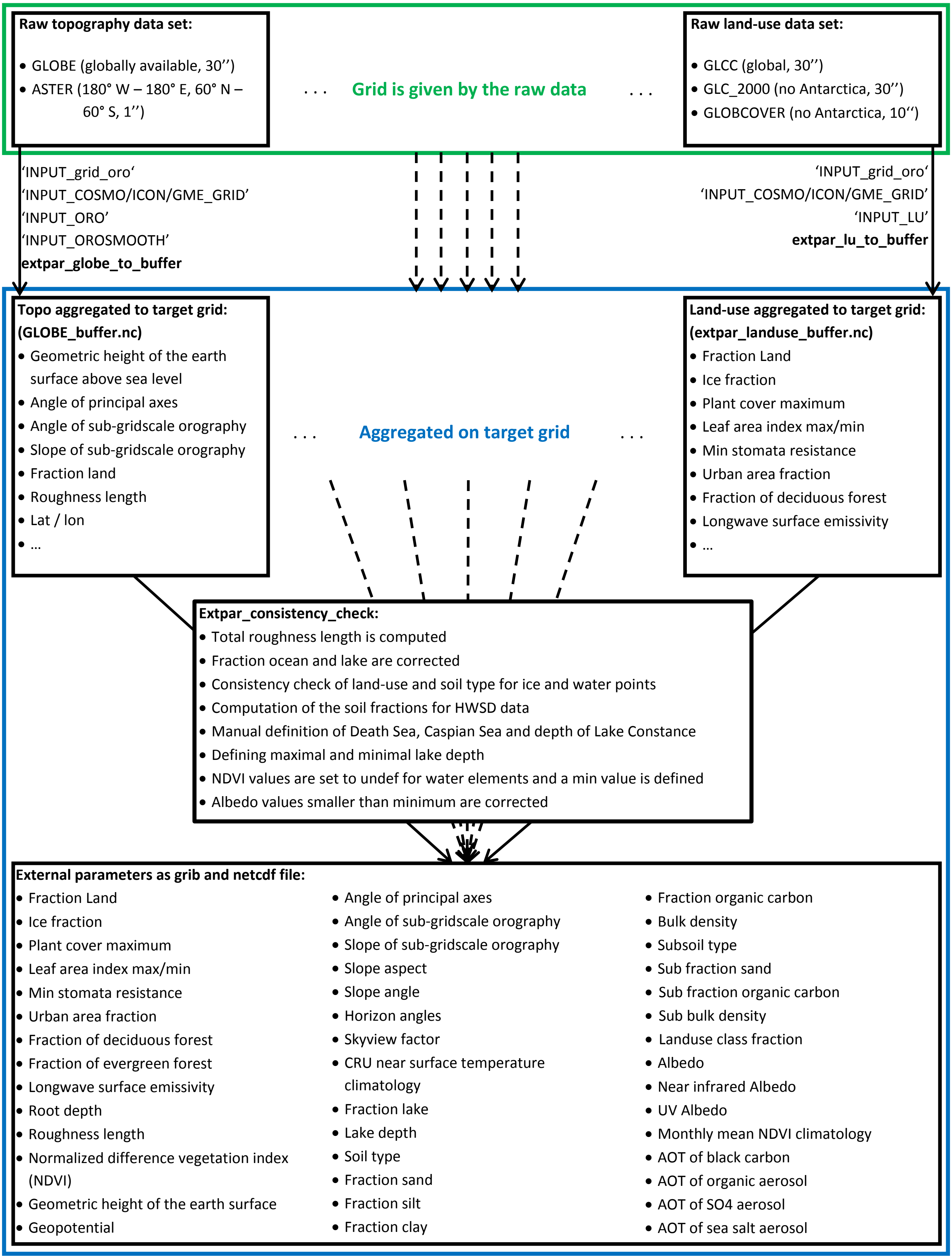

Figure 2: Schematic illustration of the software EXTPAR.

Summary

The external parameters can be generated by using eight programs to aggregate the various raw datasets to the target grid and after this by calling the final program for the important consistency check.

1. In a first step, the target grid and other parameters have to be specified by the user in the run-script, see section 4.2 for the details.
2. Then the aggregation of the raw datasets listed in table 1 to the given target grid can be performed by calling following executables
   - extpar_aot_to_buffer
   - extpar_cru_to_buffer
   - extpar_landuse_to_buffer
   - extpar_topo_to_buffer
   - extpar_ndvi_to_buffer
   - extpar_soil_to_buffer
   - extpar_flake_to_buffer
   - extpar_albedo_to_buffer

   These programs generate intermediate netcdf files ("buffer") with the aggregated data.
3. The executable
   - extpar_consistency_check

   reads in the buffer-files, performes an automated consistency check and finally generates the output fields listed in table 2.

2.1 extpar_topo_to_buffer

2.1.1 Short description of the subprogram *extpar_topo_to_buffer*

The program *extpar_topo_to_buffer* aggregates the orography of the GLOBE or the ASTER dataset to the target grid.

Target grid definition

The first part of this program contains several routines that read the namelists defined in the run script (see chapter 4 for more information on the run scripts). The first routine (init_target_grid) collects all the information needed to define the target grid with an integrated routine that gathers the variables given in the namelist 'INPUT_grid_oro'. The variable igrid_type, which can either attain 1 ('ICON'), 2 ('COSMO') or 3 ('GME') is an integer switch to define the target grid.

Then a routine reads the namelist of the corresponding grid, which is either 'INPUT_ICON_GRID', 'INPUT_COSMO_GRID' or 'INPUT_GME_GRID' depending on the chosen grid type. In the run script there is only one of the three namelists contained and this must be manually changed by the user. These namelists contain among other variables the resolution of the grid, the user specified domain and the location of the center of the grid (for closer information about the namelists compare chapters 4.2.2 - 4.2.4). This allows an exact definition of the target grid.

Raw topography data

In a second step, the namelist 'INPUT_RADTOPO' is read. It contains the information if the user desires the calculation ot the topographical corrected radiation parameters or not. Additionally the number of horizons is specified in the namelist. For the COSMO-7 and COSMO-2 setup 24 horizons are recommended. **Also the topographical corrected radiation can only be calculated, if the target grid is a COSMO grid**. If the switch is set to .TRUE. a border is added to the COSMO domain, as the computations need grid points beyond the edges of the normal domain.

Furthermore the variables of the namelist 'INPUT_ORO', which cover all the raw topographical data information, is fed into the program. In this namelist the path of the raw data is given as well as the names of the topography data files. An integer switch allows to choose between the highly resolved, non-global topography ASTER and the coarser and global data set GLOBE (1: GLOBE, 2: ASTER). Furthermore the logical switch to decide weather the SSO parameters are desired or not is read. In order to define the right number of raw data tiles the variables ntiles_column and ntiles_row must be available in the namelist. Additionally, the names for the buffer and output files are defined.

The topography data files must be manually changed in the run script, when switching from GLOBE to ASTER and vice versa.

Then, the number of tiles of the raw topography data is defined (this varies between the raw data sets: 16 tiles for GLOBE and 1 - 240 tiles for ASTER). This value is the product of the number of tiles in each column and each row. The variables concerning the raw topography are allocated and in a further step filled with the according values. These values are the edges of each raw topography tile, the number of gridpoints in x- and y-direction, as well as the resolution in both directions. These are directly deduced from the raw data netcdf files. Finally the boarders of the ASTER domain are defined, when ASTER is used.

After the definition of the target grid and the topography set, a check examines the compatibility of the user specified input with the target grid; as ASTER is not globally available at the moment it is checked that the user specified domain is contained in the current ASTER domain. And, if this is not the case, the *extpar_topo_to_buffer* is aborted with an information message.

Scale separation input

The namelist 'INPUT_SCALE_SEP' gives all the information needed to calculate the SSO parameters and roughness length based on a 3 km filtered topography. Thus the logical switch lscale_separation must be read to decide if a scale separation is deisred or not. Furthermore the raw data files and path must be provided. Note that the lscale_separation can only be set to .TRUE. if GLOBE is used as topogrphy, as there is no ASTER based 3 km filtered topography available yet. Additionally the user must decide if the computation of the SSO parameters make sense or not. Table 3 can give some assistance to come to the right decision.

Resolution	**Calculation of standard deviation**	**lscale_separation**
Model resolution is **smaller** than raw data resolution	SSOs: $\sigma = 0$ z0: $\sigma = 0$	.FALSE.
Model resolution is **greater** than the raw data resolution but **smaller** than 3 km	SSOs: $\sigma = 0$ z0: $\sigma = \sum (model - raw\, data)^2$	.FALSE. and lsso_param = .FALSE.
Model resolution is **greater** than 3 km	SSOs: $\sigma = \sum (model - 3km\, filt)^2$ z0: $\sigma = \sum (3km\, filt - raw\, data)^2$	.TRUE.

Table 3: Recommendations on the usage of the scale separation. Be aware that the actual model topography resolution is approximately twice as large as the model resolution. E.g. COSMO-2: The resolution of the topography is approximately 4 km.

Orographical smoothing input

The last namelist that must be read before allocating the orography is the namelist 'INPUT_ORO-SMOOTH', which defines all the variables needed to perform an orographical smoothing. The lfilter_oro logical switch, controls the computation of the smoothing in EXTPAR.

Aggregation of the raw topography to the target grid

The subroutine *det_topo_tiles_grid* defines the grid of each raw topography data tile. For this, the start and end latitude and longitude of each tile, the distance between two grid points in the latitudinal and longitudinal direction (dlat, dlon) as well as the number of grid points in both directions (nlat, nlon) are derived for each tile. Additionally, the grid for the whole GLOBE or ASTER domain is derived; This is done in the subroutine *det_topo_grid*.

Before the raw topography can be aggregated on the target grid, the target variables must be allocated. These variables include the land fraction (FR_LAND), the elevation of the surface (hh_target), the standard deviation of the elevation (stdh_topo), the roughness length of the topography (z0_topo), the sub-grid scale orography parameters (theta_topo, aniso_topo and slope_topo) ant the topographical corrected radiation parameters (slope_asp, slope_ang, horizon and skyview). For the ICON grid some additional parameters must also be allocated.

The following paragraphs describe computations on the raw data grid.

The subroutine *agg_topo_data_to_target_grid* does the actual work of aggregating the raw topography to the target grid. The whole topographical data set is divided in bands of 500 grid points in the latitudinal direction and the whole range of the raw data domain in the longitudinal direction (compare for this the black band in Fig. 3). This band is introduced to optimize memory usage, as it is not possible to read the whole raw data in one pass. In order to read the correct raw data the start and end index of each tile (green crosses in Fig. 3) is defined. These indices are additionally associated with a start and end index (red circles in Fig. 3) inside the band. The definition of the two kinds of indices is performed by the routine *get_topo_tile_block_indices*. With this band the whole raw data is read step by step as suggested in Fig. 3. If the scale separation is desired the same procedure is applied to the 3 km filtered topography.

After this step, a temporary variable of elevation values is filled. This variable consists of three rows, which comprises the whole longitude range of the raw topography data. This is used to deduce the gradients of the topography, which are calculated as averaged differences between one eastern and one western grid point (x-gradient) or with one northern and one southern grid point (y-gradient). From these gradients in x- and y- direction also the squared gradients and the $dx*dy$ are computed.

This is followed by a call of the subroutine *find_rotated_lonlat_grid_element_index*. This routine defines to which grid element of the target grid a certain grid element of the raw topography belongs. The allocation of the raw data points to the target grid element is performed as shown in Fig. 4 a). All raw data elements that are closer than half a grid point (green box) to the target point (red circle) are used to define the value at the corresponding target grid point. Only the green grid elements in Fig. 4 b) belong to a target grid element. The rest of the raw topography is unused.

The elevations of raw data pixels that belong to one target grid element are summed up, and the number of raw data pixels contributing to one target grid element is tracked. A summation of the raw data values for each target grid element is also performed for the squared elevation, which is later used for the standard deviation, and for the gradients calculated before, which are required for the computation of the subgrid scale orography parameters. The latter is only calculated if the SSO paramerers are desired. When making use of the scale separation the squared differences between the original and the 3 km filtered topography must be computed at every grid point. This is needed in order to calculate the roughness length specific standard deviation. After these calculations, the temporary rows are shifted to the north and the computation is repeated for the next center line. As soon as a band of 500 rows is finished a new one will be read in.

Now that all auxiliary variables are available, all loops over the raw topography data are closed and a new one over all the grid points of the target grid is opened.

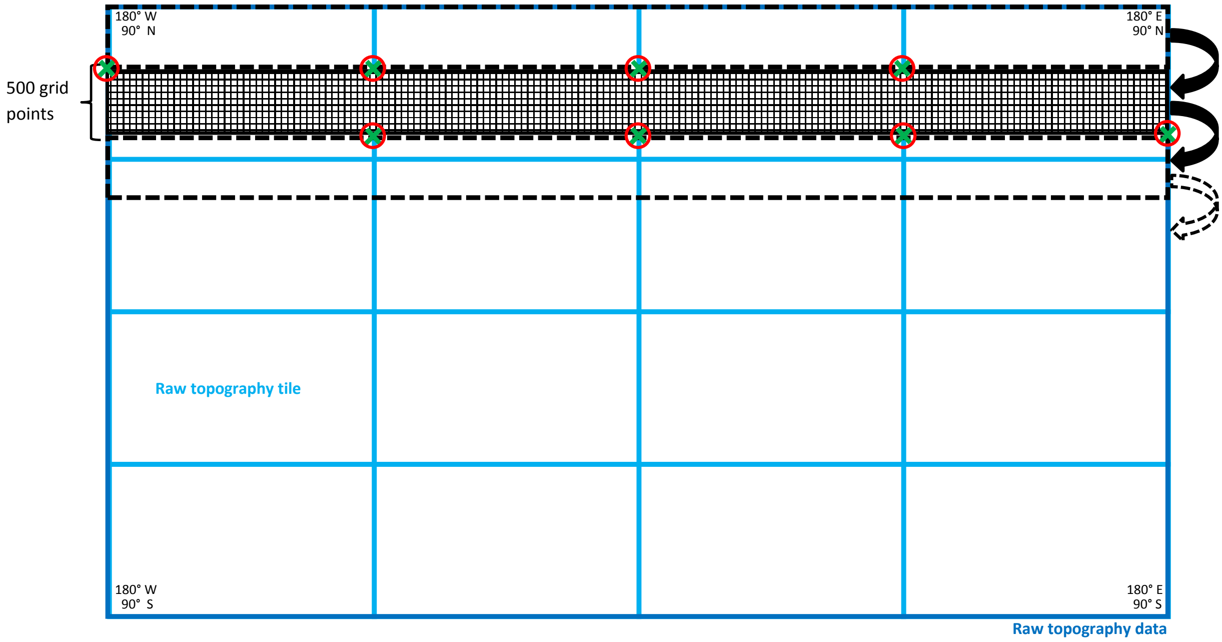

Figure 3: Schematic illustration of the filling of the raw data with a 500 grid points long band. The green crosses indicate the start end end latitudes and longitudes of each raw topography tile (light blue tiles), whereas the red circles show the indices inside the band, where the green indices of the tiles must be placed.

The following paragraphs describe computations on the target grid.

First of all the elevation is calculated as the mean of all the raw topography data points that are enclosed in one target grid point.

As soon as the topography is available on the target grid, the orographical smoothing is applied using the subroutine *do_orosmooth*.

In a next step the variance and the standard deviation of the elevation at each target grid point is estimated. Subsequently, the SSO parameters angle of principle axis, anisotropy factor and slope parameter are calculated according to Lott and Miller (1996). These SSOs are only calculated if the SSO switch is set to .TRUE. and if the standard deviation of the height is more than 10 meters, as the trivial case of the ocean is tried to be avoided. If the scale separation is switched on the SSOs are based on the 3 km filtered topography. Finally the orographical roughness length is calculated using the standard deviation, but only if at least one raw data pixel is present in the target grid element.

In case that no raw topography data pixel is available in a target grid, a weighted bilinear interpolation between neighboring raw data grid element is performed to obtain an elevation in all target grid points. This mainly happens if the raw topography has a similar resolution as the target grid. If the bilinear interpolation needs to be applied, all the SSO as well as z0 are set to zero for this grid element. With this step the end of the subroutine *agg_topo_data_to_target_grid* is reached.

In the program *extpar_topo_to_buffer* an additional check on SSOs and z0 is performed. If none of the elements of the target grid is associated with at least ten raw data pixels, or as soon as one single element is not associated with any raw data pixel, all the SSOs and z0 are set to zero.

As soon as there is a value for all the target grid elements, the calculation for the topographical corrected radiation parameters can start, if desired at all.

Finally netcdf files for the orography based external parameters are created, where different netcdf routines are used for each grid type, as different parameters are needed for each of them. If the lradtopo is set to .TRUE. the enlarged domain is cut back to the user specified domain, before writing it to the netcdf file.

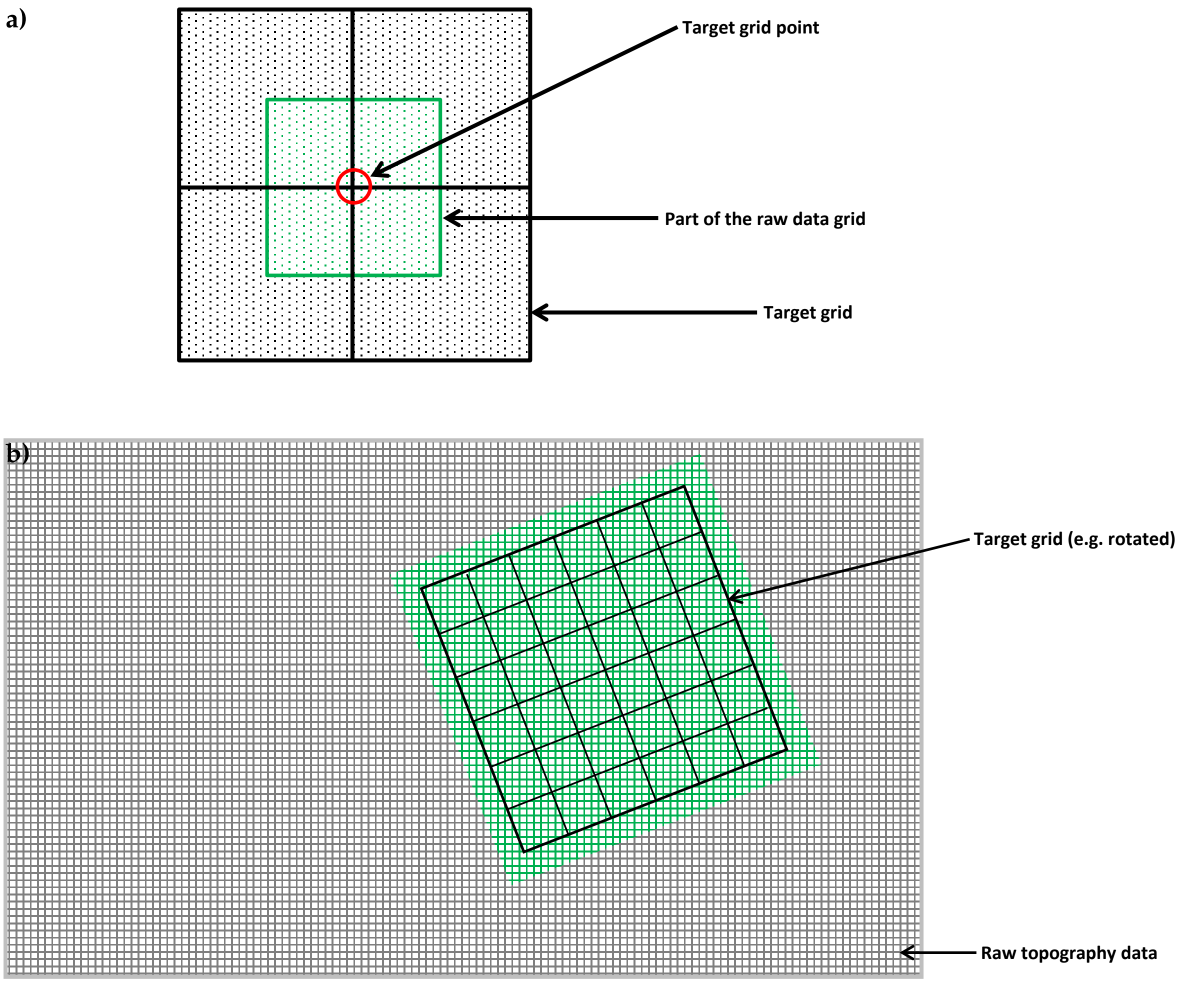

Figure 4: a) Illustration of the aggregation of the raw data to the target grid. The red circle indicates a target grid point, while the red green rectangle represents the part of the raw data that is aggregated on the target grid point. b) Showing the target grid on top of the raw data set, where only the green grid points of the raw data are used for the target grid.

2.1.2 Used namelist files and data in-/output:

- namelists files: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_ICON_GRID, INPUT_GME_GRID, INPUT_ORO, INPUT_OROSMOOTH
- data input (GLOBE): GLOBE_A10.nc, GLOBE_B10.nc, GLOBE_C10.nc, GLOBE_D10.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
- data input (ASTER): ASTER_T001.nc - ASTER_T240.nc
- data input (3 km filtered) GLOBE_A10_3km_filt.nc, GLOBE_B10_3km_filt.nc, GLOBE_C10_3km_filt.nc, GLOBE_D10_3km_filt.nc, GLOBE_E10_3km_filt.nc, GLOBE_F10_3km_filt.nc, GLOBE_G10_3km_filt.nc, GLOBE_H10_3km_filt.nc, GLOBE_I10_3km_filt.nc, GLOBE_J10_3km_filt.nc, GLOBE_K10_3km_filt.nc, GLOBE_L10_3km_filt.nc, GLOBE_M10_3km_filt.nc, GLOBE_N10_3km_filt.nc, GLOBE_O10_3km_filt.nc, GLOBE_P10_3km_filt.nc
- Output: GLOBE_buffer.nc

2.2 extpar_landuse_to_buffer

2.2.1 Short description of the subprogram *extpar_landuse_to_buffer*

The executable *extpar_landuse_to_buffer* aggregates the land use data to the target grid. Three different raw datasets can be processed: Globcover, GLC2000 and GLCC; as GLC2000 and Globcover do not include Antarctica, GLCC is taken for the missing areas.

Target grid definition

The definition of the target grid is done by reading the namelist 'INPUT_grid_org'. This namelist contains the information about the grid type, which can either be ICON, COSMO or GME. With the information about the grid type, the namelist containing the grid definition can be read. The name of the namelist must be changed manually by the user, according to the chosen grid type. The namelist must either be 'INPUT_ICON', 'INPUT_COSMO' or 'INPUT_GME'. For a more exact description of the target grid definition, read the subsection *'Target grid definition'* in section 2.1. After specifying the grid definition the southern band of the target grid is defined. This information is important, as the two raw data sets GLC2000 and Globcover do not cover the region below 60 degrees south. If this region is desired by the user, the third data must be considered for the domain below the southern band. Additionally the target fields for the land use data are allocated.

Raw landuse data

In a next step the namlist 'INPUT_LU' is read. It contains an integer switch (*i_landuse_data*) that gives the possibility to choose between the three different raw data sets e.g., 1 (Globcover), 2 (GLC2000) and 3 (GLCC). Furthermore the path and the filename of the desired raw data and of GLCC are specified there. The user must adjust the filename and path manually according to the chosen raw data in *i_landuse_data*. In addition the name of the desired lookup table is read, which again can be chosen by the user using an integer switch *ilookup_table_lu*. The lookup tables are described in more detail in table 5. Finally also the names of the buffer files for the target landuse fields and for the target GLCC fields are specified.

After having read the namelists, the number of tiles of the raw data set is defined. The number of tiles is set to 1 as default and must only be changed for the raw data Globcover. This data is composed of 6 tiles. The basic information of the Globcover tiles, such as the latitude and longitude edges and the resolution is allocated according to the number of tiles. Later these variables are filled with the respective information, read from the netcdf files directly.

For the remaining procedures the three different raw land use data have their seperate routines, which are constructed identically.

The allocation of the data is done using the number of grid points in the latitudinal and longitudinal direction. Furthermore the land-use target fields are allocated using the target grid for the dimension size and the number of land-use classes. The land-use classes differ for the three raw data sets and are described in more detail in table 4.

Data Set (Total number of Classes)	Number of Class	Name of Class
GLOBCOVER (23)		
	01	irrigated croplands
	02	rainfed croplands
	03	mosaic cropland (50-70%) - vegetation (20-50%)
	04	mosaic vegetation (50-70%) - cropland (20-50%)
	05	closed broadleaved evergreen forest
	06	closed broadleaved deciduous forest
	07	open broadleaved deciduous forest
	08	closed needleleaved evergreen forest
	09	open needleleaved decid. or evergr. forest

Data Set (Total number of Classes)	Number of Class	Name of Class
	10	mixed broadleaved and needleleaved forest
	11	mosaic shrubland (50-70%) - grassland (20-50%)
	12	mosaic grassland (50-70%) - shrubland (20-50%)
	13	closed to open shrubland
	14	closed to open herbaceous vegetation
	15	sparse vegetation
	16	closed to open forest regulary flooded
	17	closed forest or shrubland permanently flooded
	18	closed to open grassland regularly flooded
	19	artificial surfaces
	20	bare areas
	21	water bodies
	22	permanent snow and ice
	23	undefined
GLC2000 (23)		
	01	evergreen broadleaf tree
	02	deciduous broadleaf tree closed
	03	deciduous broadleaf tree open
	04	evergreen needleleaf tree
	05	deciduous needleleaf tree
	06	mixed leaf tree
	07	fresh water flooded tree
	08	saline water flooded tree
	09	mosaic tree / other natural vegetation
	10	burnt tree cover
	11	evergreen shrubs closed-open
	12	deciduous shrubs closed-open
	13	herbaceous cover closed-open
	14	sparse herbaceous or grass
	15	flooded shrub or herbaceous
	16	cultivated and managed areas
	17	mosaic crop/tree/natural vegetation
	18	mosaic crop/shrub or grass
	19	bare areas
	20	water bodies
	21	snow and ice
	22	artificial surfaces
	23	undefined
GLCC (24)		
	01	urban and built-up land
	02	dryland cropland and pasture
	03	irrigated cropland and pasture
	04	mixed dryland/irrigated
	05	cropland/grassland mosaic
	06	cropland/woodland mosaic
	07	grassland
	08	shrubland
	09	mixed shrubland/grassland
	10	savanna
	11	decidous broadleaf forest
	12	decidous needleleaf forest
	13	evergreen broadleaf forest
	14	evergreen needleleaf forest

Data Set (Total number of Classes)	Number of Class	Name of Class
	15	mixed forest
	16	water bodies
	17	herbaceous wetland
	18	wooded wetland
	19	barren or sparsely vegetated
	20	herbaceous tundra
	21	wooded tundra
	22	mixed tundra
	23	bare ground tundra
	24	snow or ice

Table 4: Land-use classes for the different raw data sets.

After the allocation of the data a check is performed to query, if the user desires a domain that goes beyond the southern bound of the raw data. If it is the case, the GLCC target fields are allocated as well.

In case that Globcover is used, the grid for the single tiles must be defined as well.

Aggregation of the raw land-use data to the target field.

The definition and allocation part is done and the most important part, the aggregation of the raw data to the target grid can be performed. In order to be able to aggregate the data, the lookup table must first be initialized. The initial values differ for the various settings listed in table 5. Also the name of the lookup table must be defined using the integer numbers specified in the namelist 'INPUT_LU'. The integer number are listed together with their associated lookup table names in table 5.

Raw Data	Integer	Setting	Name of the lookup table
GLOBCOVER	1	operational settings	Asensio, 2011
	2	experimental settings, analog to lookup tables of ECOCLIMAP	Asensio, 2010
GLC2000	1	operational settings of GME	Ritter, 2007
	2	operational settings of COSMO	Heise, 2005
	3	experimental settings, analog to lookup tables of ECOCLIMAP	Asensio, 2010
GLCC	1	operational settings of GME	Ritter, 2007
	2	operational settings of COSMO	Heise, 2005
	3	experimental settings, analog to lookup tables of ECOCLIMAP	Asensio, 2010

Table 5: Names of the lookup tables and the different possible settings for each raw land-use data set.

The following paragraphs describe computations on the raw data grid.

For GLC2000 and GLCC, the raw data is read in lines of a complete longitude going from 180 degrees east to 180 degrees west, trough a loop over the latitude. Before any calculation is performed, it is tested if the value of the latitude is contained inside the targed domain. In case it is not, the loop is cycled. Reading of the data line-wise can be done from the netcdf file directly.

Using the routine *find_nearest_target_grid_element* each raw data pixel is assigned to a target grid point. A more precise description and a figure that describes the procedure can be found in paragraph *'Aggregation of the raw topography to the target grid'* and in Fig. 4 in section 2.1.

As Globcover is composed of six tiles, the reading of the raw data must be performed in a different way than for the other two data sets. The reading of the data for Globcover is done in the same way as for the topography. Compare the paragraph *'Aggregation of the raw topography to the target grid'* in section 2.1. (As there is no need to calculate gradients for the land use, the corresponding variable, which contains three lines of raw data, is not used.

The lookup table is then fed with the land use class, which gives a value for all the target fields listed in table 6.

Variable long name	**Variable short name**
Fraction Land	FR_LAND
Ice fraction	FR_ICE
Plant cover maximum	PLCOV_MX
Plant cover minimum	PLCOV_MN
Leaf area index maximum	LAI_MX
Leaf area index minimum	LAI_MN
Minimal stomata resistence	RS_MIN
Urban area fraction	URBAN
Fraction of deciduous forest	FOR_D
Fraction of evergreen forest	FOR_E
Longwave surface emissivity	EMISS_RAD
Root depth	ROOTDP
Roughness length	Z0

Table 6: The variables that are computed using the raw land-use data.

The number of grid points that fall into the same target grid and land use class are summed up. The values of the target fields are weighted with the whole pixel area and summed up. Except for the emissivity, which is the only land-use parameter that also has valid values over water, only land pixels are considered. Values that depend on the plant cover, such as PLCOV_MX, PLCOV_MN, LAI_MN, LAI_MX, RS_MIN, FOR_E, FOR_D, ROOTDP and z0, are weighted **with the plant cover maximum** in addition to the pixel area.

The following paragraphs describe computations on the target grid.

The total area and the land area of each target grid point is first defined. Then the weighted sums of the target fields derived in the previous step are normalized to obtain the definite values. The emissivity and the number of land use classes are normalized by the total area to obtain the correct emissivity and area fraction of each land use class. The other parameters are only considered if the area_land is larger than zero: FR_LAND and FR_ICE are normalized with the total area, URBAN, FOR_D, FOR_E, PLCOV_MN and PLCOV_MX are normalized by the land area, the ROOTDP, LAI_MN, LAI_MX and RS_MIN are normalized by the area covered by plants. If only sea pixels are found, all the fields are undefined.

Finally land-use classes are defined for target grid points that do not contain any raw data pixel. In contrary to the topography, where a bilinear interpolation is performed, here the nearest neighbor is searched. The associated land use class is used with the lookup tables, and the target fields are defined.

The target fields are written to a netcdf buffer file, which can later be used for the consistency check. There is a file for the chosen land use data set, and one, if needed at all, for the GLCC land use data. Finally the allocated memory is deallocated again.

2.2.2 Used namelist files and data in-/output:

- namelists files: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_ICON_GRID, INPUT_GME_GRID, INPUT_LU

- data input: glc2000_byte.nc, glcc_usgs_class_byte.nc, GLOBCOVER_0_16bit.nc, GLOBCOVER_1_16bit.nc, GLOBCOVER_2_16bit.nc, GLOBCOVER_3_16bit.nc, GLOBCOVER_4_16bit.nc, GLOBCOVER_5_16bit.nc
- Output: extpar_landuse_buffer.nc, glcc_landuse_buffer.nc

2.3 extpar_aot_to_buffer

2.3.1 Short description of the subprogram *extpar_aot_to_buffer*

The executable *extpar_aot_to_buffer* aggregates aerosol optical thickness data to the target grid.

Target grid definition

The definition of the target grid is again done using the namelist 'INPUT_grid_oro'. As the subroutines are exactly the same as the ones used in *extpar_topo_to_buffer*, it is referred to the subsection *'Target grid definition'* in section 2.1, where the procedure is explained in more detail.

Raw aerosol optical depth data

The namelist 'INPUT_AOT' is kept very simple. It contains only the path and the name of the raw aerosol optical depth data. Additionally, also the filenames of the buffer and output files for the aggregated data is specified.

In order to allocate the variables used to read the raw data, the dimensions of the raw data is defined. These dimensions include the number of rows and columns of the netcdf raw data file, the number of months, which is equal to twelf, as a whole year cycle is described, and the number of types of aerosols contained in the raw data file. The number is 5, as the raw data file contains the aerosol optical thickness information of black carbon, dust, organic matter, sulfate and sea salt. [1]

In a next step, the complete raw data is read into a single variable; this is possible as the aerosol optical depth raw data has a very coarse resolution of 4×5 degrees. Also, the grid of the raw data is defined. Before the aggregation to the target grid can start, the target grid fields must be allocated, using the target grid, the number of months and aerosol types.

Aggregation of the aerosol optical depth to the target field

As the resolution of the raw data set is so coarse, there is no need to go through the whole raw data set and find the corresponding target grid element. Here there is only one loop over the target grid. For every target grid element four surrounding raw data points are searched for. With these four points, a weight for the bilinear interpolation is computed. As the raw data grids of the 5 different aerosols are equal, the four sourrounding points are the same for all months and aerosol types. Four new arrays (SW, SE, NE, NW) are then defined, which contain the four neighbor values, for each month and each type. These can now be used, together with the previously calculated weights, to calculate the bilinear interpolation.

Finally the data is saved in a netcdf buffer and an output file, and the allocated variables are deallocated.

2.3.2 Used namelist files and data in-/output:

- namelists files: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_ICON_GRID, INPUT_GME_GRID, INPUT_AOT
- data input: aerosol_optical_thickness.nc
- Output: extpar_buffer_aot.nc

[1] The describing paper to the data is: Tegen, I., P. Hollrigl, M. Chin, I. Fung, D. Jacob, and J. Penner 1997. Contribution of different aerosol species to the global aerosol extinction optical thickness: Estimates from model results. J. Geophys. Res., 102, 23895-23915. http://pubs.giss.nasa.gov/abstracts/1997/Tegen_etal.html

2.4 extpar_cru_to_buffer

2.4.1 Short description of the subprogram *extpar_cru_to_buffer*

The executable *extpar_cru_to_buffer* aggregates the temperature climatology of the Climate Research Unit (CRU) to the target grid.

Target grid definition

The definition of the target grid is again done using the namelist 'INPUT_grid_oro'. As the subroutines are exactly the same as the ones used in *extpar_topo_to_buffer*, it is referred to the subsection *'Target grid definition'* in section 2.1, where the procedure is explained in more detail.

Raw temperature climatology data

The namelist 'INPUT_TCLIM' gives the information of the path and the name of the raw temperature climatology data file. Additionally, the filenames for the buffer and output files are provided. There is also an integer switch (raw_data_t_id), which allows to choose between a newer higher resolved data set (1) and the older coarser raw data set (2). The dimensions, such as the number of grid points in latitudinal and longitudinal direction and the number of months, are read from the netcdf file directly. These dimensions can immediately be used to allocate the raw temperature climatology data. The grid is specified and defined from the netcdf file. The last step before the aggregation can take place is to allocate the target fields.

Aggregation of the temperature climatology to the target field

The following paragraphs describe computations on the raw data grid

The temperature climatology is treated pointwise and therefore a loop over the latitude and the longitude is started. The raw data set contains a two dimensional field for every months, but a yearly temperature climatology is required. Thus the CRU raw data is summed up and weighted with the days per month and then normalized by the days in a year. Also the temperature is transformed from Celsius to Kelvin as necessary. (This must be done only for the older version of the CRU temperature, as the new one is already provided in Kelvin.)

The following paragraphs describe computations on the target grid

As the resolution of the raw data set is so coarse, there is no need to go through the whole raw data set and find the corresponding target grid element. Here there is only one loop over the target grid. For every target grid element four surrounding raw data points are searched for. With these four points, a weight for the bilinear interpolation is computed. Four new arrays (SW, SE, NE, NW) are then defined, which contain the four neighbor values. These can now be used, together with the previously calculated weights, to calculate the bilinear interpolation. For the most recent CRU data set, an elevation parameter is also given. This parameter is aggregated in the same way as the temperature. The elevation is later needed in the consistency check to adjust the temperature to the height of the corresponding target grid element. The target values can now be written to a netcdf buffer and output file, and the allocated memory can be deallocated.

2.4.2 Used namelist files and data in-/output:

- namelists files: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_ICON_GRID, INPUT_GME_GRID, INPUT_TCLIM
- data input: absolute_hadcrut3.nc, CRU_T2M_SURF_clim.nc
- Output: crutemp_clim_extpar_buffer.nc

2.5 extpar_ndvi_to_buffer

2.5.1 Short description of the subprogram ***extpar_ndvi_to_buffer***

The executable *extpar_ndvi_to_buffer* aggregates NDVI data (Normalized Differential Vegetation Index) to the target grid.

Target grid definition

The definition of the target grid is again done using the namelist 'INPUT_grid_oro'. As the subroutines are exactly the same as the ones used in *extpar_topo_to_buffer*, it is referred to the subsection *'Target grid definition'* in section 2.1, where the procedure is explained in more detail.

Raw NDVI data

For the aggregation of the normalized differential vegetation index the namelist is quite simple again. It contains the path and the filename of the raw data set, as well as the names of the buffer and output files for the consistency check.

In order to be able to allocate the raw data, its dimensions must first be known. Therefore the number of grid points in x- and y-direction and the number of time in months are read from the netcdf file directly. Having these varibles the raw data fields can be allocated. Additionally, the target fields must be allocated, which is done using the target grid information and the number of months. The number of months is twelve, as a yearly cycle is calculated. Before the aggregation can start the grid of the raw data must be defined. Especially the start latitude and longitude as well as the resolution in both directions is needed.

Aggregation of the raw data to the target grid

The following paragraphs describe computations on the raw data grid

To aggregate the data three loops are necessary: The first one over the time index, the second over the latitudes, where the data is read from the netcdf file row-wise from 180 degrees west to 180 degrees east and finally over the longitude, which indicates a point-wise treatment of the raw data. For each raw data grid element a corresponding target grid element is defined. All the raw data pixels that are closer than half a grid point away from the target grid are aggregated to exactly this target grid element. This routine is described in more detail in the subsection *'Aggregation of the raw topography to the target grid'* in section 2.1 and in Fig. 4. Each time a raw data is associated with a target grid, the number of raw data points is increased by one and the ndvi field is summed up.

The following paragraphs describe computations on the target grid

If there is at least one raw data element in a target grid element, the summed up ndvi field is normalized by the number of available raw data points. If no raw data point is available, a weighted bilinear interpolation is performed using four neighbor raw data pixels. Additionally to the ndvi value, the monthly ratio with respect to the maximum ndvi are computed.

Finally the data is saved in a netcdf buffer and an output file and the allocated data is released again.

2.5.2 Used namelist files and data in-/output:

- namelists files: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_ICON_GRID, INPUT_GME_GRID, INPUT_NDVI
- data input: NDVI_1998_2003.nc
- Output: NDVI_buffer.nc

2.6 extpar_soil_to_buffer

2.6.1 Short description of the subprogram *extpar_soil_to_buffer*

The executable *extpar_soil_to_buffer* aggregates soil data of the FAO Digital Soil Map of the World or of the Harmonized World Soil Data (HWSD) to the target grid.

Target grid definition

The definition of the target grid is again done using the namelist 'INPUT_grid_oro'. As the subroutines are exactly the same as the ones used in *extpar_topo_to_buffer*, it is referred to the subsection *'Target grid definition'* in section 2.1, where the procedure is explained in more detail.

Raw soil data

The variables for the raw soil data are read from the namelist 'INPUT_SOIL'. These variables are the path and the names of the raw data files and two switches to decide whether the FAO or the HWSD data should be used and if the sub soil is desired or not. The switch to choose between the two raw data sets is an integer, 1 standing for FAO and 2 for the HWSD data.[2] The switch to chose the roduction of subsoil information is a logical. Additionally, the names of the buffer files are specified. Be aware that a change of the integer switch from FAO to HWSD requires also the manual replacement of the raw data file names in the namelist.

After reading the namelist, a check is made on the production of subsoil characteristics. This is only supported for HWSD data, and a warning is issued in case of bad usage.

The dimensions of the raw soil data are defined, which include the number of grid points in the latitudinal and longitudinal direction, as well as the number of soil data code of the raw data. These values are needed to allocate the soil data with the proper size.

The mapping between raw data sets specific codes and some standard soil types is defined; this concerns the soil types 'undefined', 'default', 'ice' and 'water'.

As the soil data is provided in one single file, all data can be read in one shot. The data that is read from the netcdf file are the texture and the slope of the soil data and the soil code. The aggregation of the data is done in a different way for the FAO and HWSD data, as these result in two completely different variables. Moreover, for HWSD data, to conserve memory, the topsoil data are allocated first and aggregated to the target grid, before the same is done for the subsoil.

Aggregation of the FAO data to the target grid

The following paragraphs describe computations on the raw data grid.

The soil data is read using a loop over the latitude and the longitude. This results in a point-wise reading of the raw data. As soon as the point is read, its corresponding target grid element is defined. If the regular latitude/longitude grid point is not contained in the target grid, a new point is read. If however the point is inside the target grid, the aggregation can begin.

The number of raw data pixels is increased by one, if a raw data point can be assigned to a target grid point. This number is later used to define the fraction land defined by the soil data. The corresponding soil unit is deduced from the raw data. If the soil unit is zero, this is an ocean pixel and the number of sea points is increased by one. If the soil code differs from zero, the number of land points is increased by one. The soil code is then associated to either a special or a normal soiltype. For all the special soiltypes such as ice, rock, salt, histosols, dunes and no data flags the respective texture (coarse, medium, fine) and the slope (flat, hilly, steep) are defined using a lookup table. All other soil units are

[2] Release 5.0 of COSMO and 2.0 of INT2LM do not support HWSD data, as the representation of te soil associated with this new data set has changed and is based on the use of pedotransfer functions and on fraction of soil components (e.g. clay, silt, ...)

described using the texture and slope available in the raw data. These values define the final texture variable 'texture'. Additionally, the slope is set to zero for sea points.

The following paragraphs describe computations on the target grid.

In the following a loop is opened over the target grid points. First of all the fraction land is defined using the number of land pixels minus the number of inland water pixels, which is then averaged by the number of raw data pixels that were available for the target grid element. Then the slope of the target grid element is defined. This is done by calculating the average of the summed up slope using the number of points that contribute to a slope. Slopes of water points and undefined soiltypes are set to 0 and 1 (slope of 100%), respectively. In a next step the texture for every target grid element is defined. For the special soiltypes (texture larger than 900) the corresponding number is associated. For the normal soiltypes (texture smaller than 900) the texture is calculated as average of the summed up texture. The resulting texture value is multiplied by 100 and converted into an integer number. This number is used to associate the final soiltype to every target grid element. The soiltypes are describe in more details in table 7. For target grid points that do not contain any raw data points, the nearest neighbor in the raw data is defined. If the target grid point is outside the raw data grid the slope is defined as zero and the texture as undefined.

TERRA Code	Soiltype	raw data code
1	**ice and glacier**[3]	9001
2	**rock, lithosols**	9002
3	sand	9003 (salt), 9005 (shifting sands and dunes) and coarse texture
4	sandy loam	coarse to medium texture
5	loam (default soiltype)	9009 (undefined), 9012 (dominant part undefined), medium texture
6	loamy clay	medium to fine texture
7	clay	fine texture
8	**histosols (peat)**	9004
9	**water**	9000 (undefined: inland water), -9 (undefined: ocean)

Table 7: TERRA soiltypes and their respective FAO raw data codes.

Aggregation of the HWSD data to the target grid

The aggregation starts again with a loop over the latitudes and longitudes. For each grid point a target grid element is looked for. If there is a target grid element, the aggregation can start. The soiltype is defined using the raw data value, if it is above zero, and zero otherwise. Additionally, all the ocean, land and lake points are counted in order to determine the land fraction which is calculated as the difference between the summed up land and lake points normalized by the number of raw data pixels available. For target grid points with no raw data, the nearest neighbor in the raw data is defined.

The resulting soiltype is not yet usable, as it contains numbers coded in a world code and not in TERRA soiltypes. This transformation is done in the consistency check, where the special soiltypes of the HWSD data, specified in table 8, are packed in the variable 'SOILTYP' the normal soiltypes are given in fractions of sand, silt, clay and organic carbon, and the bulk density is also given.

TERRA Code	Soiltype	TERRA Code	Soiltype
1	**ice and glacier**	8	**histosols (peat)**
2	**rock, lithosols**	9	**water**
3	sand	10	**alkali flat**
4	sandy loam	11	**shifting sand, dunes**
5	loam (default soiltype)	12	**Urban, human disturbed**
6	loamy clay	225	**Unknown**
7	clay		

Table 8: New TERRA soiltypes deduced from the HWSD data.

Output of the soil data

The soiltypes and the fraction land, together with the undefined value, the latitudes and longitudes are saved in a netcdf buffer file. This is later used to perform the consistency check, which is especially important for the HWSD data, as the main transformation of the data takes place there.

2.6.2 Used namelist files and data in-/output:

- namelists files: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_ICON_GRID, INPUT_GME_GRID, INPUT_SOIL

[3] Soiltypes written in bold indicate a special soiltype.

- data input: FAO_DSMW_DP.nc, HWSD0_30_texture_2.nc, HWSD30_100_texture_2.nc
- Lookup tables for HWSD: LU_TAB_HWSD_UF.data, HWSD_DATA_COSMO.data, HWSD_DATA_COSMO_S.data
- Output: FAO_DSMW_buffer.nc

2.7 extpar_flake_to_buffer

2.7.1 Short description of the subprogram *extpar_flake_to_buffer*

The executable *extpar_flake_to_buffer* aggregates lake depth data and lake fraction to the target grid.

Target grid definition

The definition of the target grid is again done using the namelist 'INPUT_grid_oro'. As the subroutines are exactly the same as the ones used in *extpar_topo_to_buffer*, it is referred to the subsection *'Target grid definition'* in section 2.1, where the procedure is explained in more detail.

Raw lake data

As only the target grid dimensions are needed to allocate the target fields, this is done right after the definition of the target grid. Then the namelist 'INPUT_FLAKE' is read to define the path and the filename of the raw lake data. Also the names of the buffer and the output file for the consistency check are given. Once more the dimensions of the raw data are needed to allocate the raw data correctly; these dimensions are deduced from the netcdf file directly and the raw data grid is defined.

Aggregation of the lake data to the target grid

The following paragraphs describe computations on the raw data grid.

The data is read row-wise, through a loop over the latitudes, shipping all latitudes not inside the user specified domain. If a row is kept, a new loop over the longitudes is started to treat the raw data point-wise. For each point, the corresponding target field element is defined. This is done in the same way described in the subsection *'Aggregation of the topography to the target grid'* in section 2.1 and Fig. 4. The number of raw data pixels that contribute to the target grid value are summed up as well as the lake depth, which is multiplied by a scale factor deduced from the area of each pixel that contributes to a lake fraction.

The following paragraphs describe computations on the raw data grid.

The lake fraction is derived and the lake depth is obtained by normalizing the weighted sum previously computed. Where no lake depth is available the value is set to undefined (-1). In case that no raw data pixel is available the nearest neighbor in the raw data is searched for.

The target fields are then written to a netcdf buffer and output file. Finally the allocated memory can be released.

2.7.2 Used namelist files and data in-/output:

- namelists files: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_ICON_GRID, INPUT_GME_GRID, INPUT_FLAKE
- data input: lakedepth.nc
- Output: flake_buffer.nc

2.8 extpar_albedo_to_buffer

2.8.1 Short description of the subprogram *extpar_albedo_to_buffer*

The executable *extpar_albedo_to_buffer* aggregates albedo data to the target grid.

Target grid definition

The definition of the target grid is again done using the namelist 'INPUT_grid_oro'. As the subroutines are exactly the same as the ones used in *extpar_topo_to_buffer*, it is referred to the subsection *'Target grid definition'* in section 2.1, where the procedure is explained in more detail.

Raw albedo data

The namelist 'INPUT_ALB' defines the filenames and paths for the normal albedo, the near infrared albedo and the ultra violet albedo. Also the names for the buffer and the output file are given. Additionally, the variable names to extract from each netcdf file are specified.

As the three data sets do all have the same grid, the dimension is only inquired once. This information allows to allocate all three raw albedo fields. The required information is read from one netcdf file (the start latitude and longitude and the resolution in both directions). All the target fields are also allocated at once, using the target grid and the number of months that need to be calculated, which is 12.

Aggregation of the albedo raw data to the target grid

The aggregation of the data is done in the exact same way for the three data sets albedo, near infrared albedo and ultra violet albedo. The data is read from the netcdf file row-wise and than treated point-wise, as each raw data grid point is assigned to a target grid point. The association of a raw data point and a target grid element is done only for the first time step, as it stays the same for all the others. The albedo values of each raw data point that contributes to a target grid element are summed up, and the number of these raw data pixels is added up. At target points that are associated with at least one raw data point, the albedo is obtained by normalizing the previously computed sum with the number of associated raw data pixels. If there is no raw data pixel available a weighted bilinear interpolation is performed.

As soon as the aggregation is done for all three data sets the target fields are written to the buffer and output netcdf file. The allocated memory is then deallocated.

2.8.2 Used namelist files and data in-/output:

- namelists files: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_ICON_GRID, INPUT_GME_GRID, INPUT_ALB
- data input: month_alb.nc, month_alnid.nc, month_aluvd.nc
- Output: month_alb_buffer.nc

2.9 extpar_consistency_check

2.9.1 Short description of the subprogram *extpar_consistency_check*

The *extpar_consistency_check* is performed after all raw data have been aggregated to the target grid to remove any inconsistencies that may appear among the different data and to derive additional information using multiple raw data sources.

Reading of namelists

Before the grid is defined, the namelists 'INPUT_RADTOPO', 'INPUT_ORO' and 'INPUT_SOIL' are read to obtain the settings of the different switches that are used (e.g. lradtopo, itopo_type, lsso_param, isoil_data, ldeep_soil). Then the namelist 'INPUT_grid_oro' is read to obtain the targed grid information and the grid type.

In a next step the 'INPUT_LU' is read by *extpar_consistency_check* to check if the GLCC data set is required, which is the case if the target grid domain reaches more to the south than the chosen raw land-use data set. (Globcover and GLC_2000 are not global.)

An additional namelist that is used, is the 'INPUT_CHECK', which defines all the buffer files. These files are read and all the variables needed for the final external parameters file are allocated.

The first task after reading the namelists is to derive the correct land sea mask from the land use data. If the GLCC data must be used, the land sea mask below the southern band is deduced from GLCC.

Then the total roughness length is computed as the sum of the roughness length deduced from the land-use and the topography.

Consistency check for water and ice pixels

The definition of a water grid element is based on the land-use data. The vegetation is set to zero for all water grid elements and FAO derived soil type is set to water. For non water pixels with undefined or invalid soil type, the FAO derived soil type is either set to default, which is loam, or to ice for regions that are below 60 degrees south (where only the Antarctica is located).

All the points that are classified as ice in the land-use data but not in the FAO derived soil type, are changed to ice in the latter; the vegetation of these pixels is set to zero.

The HWSD derived soiltype needs a transformation from the world code to the TERRA code, which is performed here. The world code is decoded with the TERRA HWSD lookup table, to define the regions that contain a special soiltype (see the special soiltypes in table 8). For each grid point the world code is associated to the single fractions of the soil composition, using an other lookup table. If there is a point that does not contain a bulk density it is calculated using the formula of the cultivated topsoil or the compact subsoil from Hollisa et al. (2012)[4] and Woesten et al. (1999)[5]. Furthermore there is a special treatment of peat with histosols. The whole procedure is also done for the subsoil, if it is desired at all.

Consistency check of lake data

Water grid points are either declared as lake or ocean, thus over land a fraction lake and over the ocean a fraction ocean is defined. Where the fraction land deduced from the topography is smaller than 0.99 the fraction ocean is defined. All the other points are used to determine the fraction lake. Both fractions are defined such that fr_lake or fr_ocean plus fr_land_lu (fraction land deduced from land-use) sum up to one. Some smaller seas must be defined manually, thus for the region of the Death Sea and the Caspian Sea not fraction lake but fraction ocean is calculated.

For fr_land [6] and fr_ocean [7] larger than a half, the lake depth is set to undefined. A default value for the lake depth is used for grid elements with a lake fraction [8] larger than a half and a negative lake depth. Additionally a maximum and minimum lake depth is defined. Included is also a manual correction of the depth of Lake Constance.

[4] J.M. Hollisa, J. Hannamb and P.H. Bellamyb, February 2012, Empirically-derived pedotransfer functions for predicting bulk density in European soils, European Journal of Soil Science, 63, 96109 doi: 10.1111/j.1365-2389.2011.01412.x

[5] J.H.M. Woesten, A. Lilly, A. Nemes and C. Le Bas, Development and use of a database of hydraulic properties of European soils, Geoderma, Volume 90, Issues 34, July 1999, Pages 169-185, doi: 10.1016/S0016-7061(98)00132-3.

[6] derived from the land use data

[7] derived from the land use data

[8] derived from the lake data set

Consistency check of albedo data

The consistency check of the albedo data concerns land pixels that have a albedo smaller than 0.07. For these pixels a weighted bilinear interpolation is performed. Only land points are used for the interpolation, if there is no surrounding land point a warning message is printed. Values that are still too small receive a soiltype dependant albedo. This is done for all three wavelengths.

Consistency check of NDVI data

The next consistency check is performed with the normalized difference vegetation index (NDVI). The NDVI values are set to undefined for water grid points. Additionally, values that are smaller than a predefined value are set to exactly this value.

Consistency check of the temperature climatology

The consistency check of the temperature climatology contains a height correction and is only performed for the finer resolved temperature climatology (e.g. raw_data_t_id = 1). The temperature is set to undefined for all the sea points. For land points that have a valid temperature, it is adjusted to the height. This is done by considering a constant temperature rate of 0.65 K per 100m ($\frac{dT}{dh} = -\frac{0.65K}{100m}$).

Target points that do not contain temperature values larger than zero are filled with surrounding values. First a valid point is looked for in the surrounding 3×3 grid box. If still no valid point can be found, it is searched along the longitude, and if nothing else helps the nearest neighbor is tried.

Definition of special points

Be aware that the definition of special points has only been tested for the COSMO grid and can only be used if the FAO raw soil type is used. At the moment there are three special points (1: Falkenberg, 2: Waldstation, 3: Lindenberg). At each of these points, values for soiltype_sp, z0_sp, rootdp_sp, plcovmn_sp, plcovmx_sp, laimn_sp, laimx_sp can be explicitly set by the user. The coordinates of the special point are also user specified. If no special treatment at these points is desired the number_special_points must be set to zero (see table 9). If no special treatment is desired at all, the integer switch i_lsm_treatment can be set to 1 instead of 2.

number_special_points	**Treatment of special points**
0	NO treatment of special points
1	special treatment of Falkenberg
2	special treatment of Falkenberg and Waldstation
3	special treatment of Falkenberg, Waldstation and Lindenberg

Table 9: Usage of the namelist parameter number_special_points.

Writing output

The final results are written into a GRIB and a netcdf file. The output file names can be specified in the namelist 'INPUT_CHECK'.

Used namelist files and data in-/output

- namelists files: INPUT_grid_org, INPUT_COSMO_GRID, INPUT_ICON_GRID, INPUT_GME_GRID, INPUT_CHECK
- data input: extpar_landuse_cosmo.nc, glcc_landuse_buffer.nc, topo_buffer.nc, extpar_buffer_aot.nc, crutemp_clim_extpar_buffer.nc, NDVI_buffer.nc, FAO_DSMW_buffer.nc, flake_buffer.nc, month_alb_buffer.nc

- data output: external_parameter.g1, external_parameter.nc

3 Current limitations

The EXTPAR software is subject to several limitations:

- The ASTER domain can only be used from 60°N to 60°S. Be aware that an additional border of several gridpoints is needed if the topographically corrected parameters are desired. If the ASTER domain is exceeded a warning message is printed and the program *extpar_topo_to_buffer* is aborted.
- The ASTER data shows some deficits, which are listed below:
  - Beyond 60 degrees north and south, the ASTER raw data set features several areas where no value is available e.g., over Finnland (private communication with HIRLAM).
  - Some bogus regions may appear in complex topography. One of these regions is located near Grindelwald in Switzerland.
  - The ASTER data are subject to artefacts of the satellite fly-over bands. Discontinuities can be spotted at the borders of such bands. In high latitudes these bands are better visible than in the low latitudes.
  - As the correction of these deficits are time consuming no effort has been expended to remove these.
  - The ASTER data might be subject to a shift of a half gridpoint (15 meters) in both directions.
- The topographically corrected radiation parameters (SLO_ASP, SLO_ANG, HORIZON and SKYVIEW) can only be used with the COSMO grid. If another grid is used the lradtopo switch is forced to be .FALSE.
- There is no 3 km filtered ASTER data set to derive the subgrid scale orography (SSO) parameters and the roughness length (z0) for ASTER.
- The HWSD raw data is in a test phase. Furthermore a new Version of Int2lm and TERRA is needed to make use of these data sets.
- The subsoil can only be used if the HWSD data is used for the topsoil. If the FAO and the HWSD data are combined a warning message is printed and the ldeep_soil parameter is set to .FALSE.
- The special points are only tested for the COSMO grid. Also it is not possible to use these corrections if the soil raw data set is HWSD.
- The GME output is not suppored anymore.
- The ICON output is not yet fully tested.
- The OpenMP implementation is not yet fully tested.

4 Namelist Input for Extpar

4.1 Namelist files

Namelist file	Purpose	Made by script	Used by program
INPUT_grid_org	define target grid type	runscript	extpar_consistency_check extpar_aot_to_buffer extpar_landuse_to_buffer extpar_topo_to_buffer extpar_cru_to_buffer extpar_ndvi_to_buffer extpar_soil_to_buffer extpar_flake_to_buffer
INPUT_COSMO_GRID	define target domain for COSMO grid	runscript	extpar_consistency_check extpar_aot_to_buffer extpar_landuse_to_buffer extpar_topo_to_buffer extpar_cru_to_buffer extpar_ndvi_to_buffer extpar_soil_to_buffer extpar_flake_to_buffer
INPUT_ICON_GRID	define target domain for ICON grid	runscript	extpar_consistency_check extpar_aot_to_buffer extpar_landuse_to_buffer extpar_topo_to_buffer extpar_cru_to_buffer extpar_ndvi_to_buffer extpar_soil_to_buffer extpar_flake_to_buffer
INPUT_GME_GRID	define target domain for GME grid	runscript	extpar_consistency_check extpar_aot_to_buffer extpar_landuse_to_buffer extpar_topo_to_buffer extpar_cru_to_buffer extpar_ndvi_to_buffer extpar_soil_to_buffer extpar_flake_to_buffer
INPUT_ORO	settings for orography data	runscript	extpar_topo_to_buffer
INPUT_OROSMOOTH	settings for orography smoothing	runscript	extpar_topo_to_buffer
INPUT_LU	settings for landuse data	runscript	extpar_landuse_to_buffer
INPUT_AOT	settings for aerosol data	runscript	extpar_aot_to_buffer
INPUT_TCLIM	settings for temperature data	runscript	extpar_cru_to_buffer
INPUT_NDVI	settings for NDVI data	runscript	extpar_ndvi_to_buffer
INPUT_SOIL	settings for soil data	runscript	extpar_soil_to_buffer
INPUT_FLAKE	settings for lake data	runscript	extpar_flake_to_buffer
INPUT_ALB	settings for albedo data	runscript	extpar_albedo_to_buffer
INPUT_CHECK	settings for the consistency check	runscript	extpar_consistency_check

4.2 Grid definition

The specification of the model type (COSMO, ICON or GME) is done in the namelist file INPUT_grid_org, the detailed target grid description for the model domain has to be provided in the namelists files INPUT_COSMO_GRID, INPUT_ICON_GRID, INPUT_GME_GRID.

4.2.1 general

NAMELIST /grid_def/ (INPUT_grid_org)

The namelist /grid_def/ defines the target grid type and the filenames with the namelists of the detailed target grid definition.

Parameter	Type	Default	Unit	Description
igrid_type	integer			target grid type, 1 for ICON, 2 for COSMO, 3 for GME grid
domain_def_namelist	character			namelist file with domain definition
domain_domain_refinement	character			namelist file with domain refinement definition (e.g. for the ICON grid)

4.2.2 Icon

NAMELIST /gridref_ini/ (INPUT_ICON_GRID)

Parameter	Type	Default	Unit	Description	Scope
grid_root	I	2		root subdivision of initial edges	
start_lev	I	4		number of edge bisections following the root subdivision	
n_dom	I	2		number of logical model domains, including the global one	
n_phys_dom	I	n_dom		number of physical model domains, may be larger than n_dom (in this case, domain merging is applied)	
parent_id	I(n_phys_dom-1)	i		ID of parent domain (first entry refers to first nested domain; needs to be specified only in case of more than one nested domain per grid level)	
logical_id	I(n_phys_dom-1)	i+1		logical grid ID of parent domain (first entry refers to first nested domain; needs to be specified only in case of domain merging, i.e. n_dom < n_phys_dom)	
l_plot	L	.FALSE.		produces GMT plots showing the locations of the nested domains	
l_circ	L	.TRUE.		Create circular (.T.) or rectangular (.F.) refined domains	

Parameter	Type	Default	Unit	Description	Scope
l_rotate	L	.FALSE.		Rotates center point into the equator in case of l_circ = .FALSE.	lcirc=.FALSE.
bdy_indexing_depth	I	max_rlcell (=8)		Number of cell rows along the lateral boundary of a model domain for which the refin_ctrl fields contain the distance from the lateral boundary; needs to be enlarged when lateral boundary nudging is required for one-way nesting	
radius	R(n_dom-1)	30.	deg	radius of nested domain (first entry refers to first nested domain; needs to be specified for each nested domain separately)	lcirc=.TRUE.
hwidth_lon	R(n_dom-1)	20.	deg	zonal half-width of refined domain (first entry refers to first nested domain; needs to be specified for each nested domain separately)	lcirc=.FALSE.
hwidth_lat	R(n_dom-1)	20.	deg	meridional half-width of refined domain (first entry refers to first nested domain; needs to be specified for each nested domain separately)	lcirc=.FALSE.
center_lon	R(n_dom-1)	90.	deg	center longitude of refined domain (first entry refers to first nested domain; needs to be specified for each nested domain separately)	
center_lat	R(n_dom-1)	30.	deg	center latitude of refined domain (first entry refers to first nested domain; needs to be specified for each nested domain separately)	

NAMELIST /icon_grid_ctl/ (INPUT_ICON_GRID)

The namelist /icon_grid_files/ specifies the filenames and the directory of the Icon grid files with the coordinates of the Icon grid.

Parameter	Type	Default	Unit	Description
icon_dom_nr	I			number of icon domain for target grid
grid_level	I			level of current grid
grid_id	I			domain id of current grid
i_cell_type	I	3		Cell shape. 3: triangluar grid, 4: quadrilateral grid, 6: hexagonal/pentagonal grid

NAMELIST /icon_grid_files/ (INPUT_ICON_GRID)

The namelist /icon_grid_files/ specifies the filenames and the directory of the Icon grid files with the coordinates of the Icon grid.

Parameter	Type	Default	Unit	Description
icon_grid_dir	character			path to directory which contains the ICON grid files with the coordinates
icon_grid_nc_files	character (max_dom)			filenames of the ICON grid files with the coordinates

4.2.3 COSMO

NAMELIST /lmgrid/ (INPUT_COSMO_GRID)

The COSMO grid is defined by a rotated latlon-grid.

Parameter	Type	Default	Unit	Description
pollon	real	-170.	deg	longitude of the rotated north pole (in degrees, $E > 0$)
pollat	real	32.5	deg	latitude of the rotated north pole (in degrees, $N > 0$)
polgam	real	0.	deg	longitude (in the rotated system) of the geographical north pole
dlon	real	0.08	deg	grid point distance in zonal direction (in degrees)
dlat	real	0.08	deg	grid point distance in meridional direction (in degrees)
startlon_tot	real	-1.252	deg	transformed longitude of the lower left grid point of the total domain (in degrees, $E > 0$)
startlat_tot	real	-7.972	deg	transformed latitude of the lower left grid point of the total domain (in degrees, $N > 0$)
ie_tot	integer	51		number of grid points in zonal direction
je_tot	integer	51		number of grid points in meridional direction

4.2.4 GME

NAMELIST /gme_grid_setup/ (INPUT_GME_GRID)

The parameter *ni* defines the resoultion of the GME grid.

Parameter	Type	Default	Unit	Description
ni	integer			number of intervals on a main triangle side

4.3 Orography

NAMELIST /orography_raw_data/ (INPUT_ORO)

Parameter	Type	Default	Unit	Description

Parameter	Type	Default	Unit	Description
itopo_type	integer			switch to choose an orography raw data set; 1 GLOBE, 2 ASTER
lsso_param	logical			switch to choose if SSO parameters should be generated or not
raw_data_orography_path	character			path to orography raw data
ntiles_column	integer	GLOBE: 4 ASTER: x		number of tile columns of desired region
ntiles_row	integer	GLOBE: 4 ASTER: x		number of tile rows of desired region
topo_files	character			filenames of GLOBE (16 tiles) / ASTER (240 tiles) raw data sets

NAMELIST /orography_io_extpar/ (INPUT_ORO)

Parameter	Type	Default	Unit	Description
orography_buffer_file	character			name for orography buffer file
orography_output_file	character			name for orography output file

NAMELIST /orography_smoothing/ (INPUT_OROSMOOTH)

Parameter	Type	Default	Unit	Description
lfilter_oro	logical	FALSE		switch for orogaphy smoothing
ilow_pass_oro	integer	0		type of orogaphy smoothing and stencil width
numfilt_oro	integer	1		number of filter applications
eps_filter	real	10		smoothing parameter ("strength" of the filtering)
ifill_valley	integer	1		fill valleys before or after oro smoothing (1: before, 2: after)
rfill_valley	real	0	m	mask for valley filling (threshold value)
ilow_pass_xso	integer	1		type of orogaphy eXtra SmOothing and stencil width (for steep orography)
numfilt_xso	integer	1		number of applications of the eXtra filter
lxso_first	logical	FALSE		eXtra SmOothing before or after orography smoothing (TRUE/FALSE)
rxso_mask	real	0	m	mask for eXtra SmOothing (threshold value)

NAMELIST /radtopo/ (INPUT_RADTOPO)

Parameter	Type	Default	Unit	Description
lradtopo	logical			Switch for radiation corrected topography parameters. Not recommended to use if orographical smoothing is false and smoothing is performed in Int2lm later, because of resulting inconsistencies.

Parameter	Type	Default	Unit	Description
nhori	integer	24		Number of horizon angles

NAMELIST /scale_sep/ (INPUT_SCALE_SEP)

Parameter	Type	Default	Unit	Description
lscale_separation	logical			Switch for scale separation. It can only be used in combination with GLOBE as raw data set.
raw_data_scale_sep_path	character			path to 3 km filtered topography
scale_sep_files	character			filename of 3 km filtered topography

4.4 Land Use data

NAMELIST /lu_raw_data/ (INPUT_LU)

Parameter	Type	Default	Unit	Description
raw_data_lu_path	character			path to landuse data
raw_data_lu_filename	character			filename of landuse raw data
i_landuse_data	integer			switch to choose a land use raw data set; 1 Globcover2009, 2 GLC2000, 3 GLCC
ilookup_table_lu	integer			switch to choose a lookup table GLC2000 and GLCC: 1: operational settings of GME (Ritter, 2007) 2: operational settings of COSMO (Heise, 2005) 3: experimental setting, analog to look-up tables of ECOCLIMAP (Asensio 2010) GLOBCOVER 2009: 1: operational settings (Asensio, 2011) 2: experimental settings, analog to look-up tables of ECOCLIMAP (Asensio 2010)

NAMELIST /glc2000_io_extpar/ (INPUT_LU)

Parameter	Type	Default	Unit	Description
glc2000_buffer_file	character			name for glc2000 buffer file
glc2000_output_file	character			name for glc2000 output file

NAMELIST /glcc_raw_data/ (INPUT_LU)

Parameter	Type	Default	Unit	Description
raw_data_glcc_path	character			path to glcc data
raw_data_glcc_filename	character			filename of glcc raw data
ilookup_table_glcc	integer			switch to choose a lookup table 1: operational settings of GME (Ritter, 2007)

Parameter	Type	Default	Unit	Description
				2: operational settings of COSMO (Heise, 2005) 3: experimental setting, analog to look-up tables of ECOCLIMAP (Asensio 2010)

NAMELIST /glcc_io_extpar/ (INPUT_LU)

Parameter	Type	Default	Unit	Description
glcc_buffer_file	character			name for glcc buffer file
glcc_output_file	character			name for glcc output file

4.5 Aerosol optical depth

NAMELIST /aerosol_raw_data/ (INPUT_AOT)

Parameter	Type	Default	Unit	Description
raw_data_aot_path	character			path to aerosol raw data
raw_data_aot_filename	character			filename of aerosol raw data

NAMELIST /aerosol_io_extpar/ (INPUT_AOT)

Parameter	Type	Default	Unit	Description
aot_buffer_file	character			name for aerosol buffer file
aot_output_file	character			name for aerosol output file

4.6 Climatological 2m temperature

NAMELIST /t_clim_raw_data/ (INPUT_TCLIM)

Parameter	Type	Default	Unit	Description
raw_data_t_clim_path	character			path to T2m climatology data
raw_data_aot_filename	character			filename of T2m climatology data
raw_data_t_id	integer			switch to choose between the new and fine (1) and the old and coarse (2) raw data set. Note that the fine data set (1) is topographically corrected.

NAMELIST /t_clim_io_extpar/ (INPUT_TCLIM)

Parameter	Type	Default	Unit	Description
t_clim_buffer_file	character			name for t_clim buffer file
t_clim_output_file	character			name for t_clim output file

4.7 NDVI data

NAMELIST /ndvi_raw_data/ (INPUT_NDVI)

Parameter	Type	Default	Unit	Description
raw_data_ndvi_path	character			path to ndvi raw data
raw_data_ndvi_filename	character			filename of ndvi raw data

NAMELIST /ndvi_io_extpar/ (INPUT_NDVI)

Parameter	Type	Default	Unit	Description
ndvi_buffer_file	character			name for ndvi buffer file
ndvi_output_file	character			name for ndvi output file

4.8 Soil data

NAMELIST /soil_raw_data/ (INPUT_SOIL)

Parameter	Type	Default	Unit	Description
isoil_data	integer			switch to choos between the raw soil data, 1: FAO, 2: HWSD
ldeep_soil	logical			switch for the deep soil, can only be set to .TRUE. if the top and sub soil are deduced from the HWSD data
raw_data_soil_path	character			path to soil raw data
raw_data_soil_filename	character			filename of soil raw data
raw_data_deep_soil_filename	character			filename of deep soil raw data

NAMELIST /soil_io_extpar/ (INPUT_SOIL)

Parameter	Type	Default	Unit	Description
soil_buffer_file	character			name for soil buffer file
soil_output_file	character			name for soil output file

NAMELIST /HWSD_index_files/ (INPUT_SOIL)

Parameter	Type	Default	Unit	Description
path_HWSD_index_files	character			path to HWSD lookup tables
landuse_table_HWSD	character			lookup table to convert soiltype index from global to TERRA soiltype
HWSD_data	character			lookup table to convert the global soiltype in fractions of sand, silt, clay and organic carbon and in bulk density for the topsoil
HWSD_data_deep	character			lookup table to convert the global soiltype in fractions of sand, silt, clay and organic carbon and in bulk density for the subsoil

4.9 Freshwater Lake data

NAMELIST /flake_raw_data/ (INPUT_FLAKE)

Parameter	Type	Default	Unit	Description
raw_data_flake_path	character			path to flake raw data
raw_data_flake_filename	character			filename of flake raw data

NAMELIST /flake_io_extpar/ (INPUT_FLAKE)

Parameter	Type	Default	Unit	Description
flake_buffer_file	character			name for flake buffer file
flake_output_file	character			name for flake output file

4.10 Albedo data

NAMELIST /alb_raw_data/ (INPUT_ALB)

Parameter	Type	Default	Unit	Description
raw_data_alb_path	character			path to raw albedo data
raw_data_alb_filename	character			filename of the raw albedo data

NAMELIST /alnid_raw_data/ (INPUT_ALB)

Parameter	Type	Default	Unit	Description
raw_data_alb_path	character			path to raw albedo data
raw_data_alnid_filename	character			filename of the raw near infrared albedo data

NAMELIST /aluvd_raw_data/ (INPUT_ALB)

Parameter	Type	Default	Unit	Description
raw_data_alb_path	character			path to raw albedo data
raw_data_aluvd_filename	character			filename of the raw ultra violet albedo data

NAMELIST /alb_io_extpar/ (INPUT_ALB)

Parameter	Type	Default	Unit	Description
alb_buffer_file	character			name for the albedo buffer file
alb_output_file	character			name for the albedo output file

NAMELIST /alb_source_file/ (INPUT_ALB)

Parameter	Type	Default	Unit	Description
alb_source	character	'al'		variable name of the albedo netcdf file
alnid_source	character	'alnid'		variable name of the near infrared albedo netcdf file
aluvd_source	character	'aluvd'		variable name of the ultra violet albedo netcdf file

4.11 Consistency check

NAMELIST /extpar_consistency_check_io/ (INPUT_CHECK)

Parameter	Type	Default	Unit	Description
grib_output_filename	character	external_parameters.grb		filename for grib output filename
grib_sample	character	GRIB2.tmpl		name for grib sample for grib_api (sample to be found in $GRIB_SAMPLES_PATH)
netcdf_output_filename	character			filename for netcdf output filename
orography_buffer_file	character			name for orography buffer file
soil_buffer_file	character			name for soil buffer file
glc2000_buffer_file	character			name for glc2000 buffer file
glcc_buffer_file	character			name for glcc buffer file
flake_buffer_file	character			name for flake buffer file
ndvi_buffer_file	character			name for ndvi buffer file
orography_buffer_file	character			name for orography buffer file
t_clim_buffer_file	character			name for t_clim buffer file
aot_buffer_file	character			name for aot buffer file
albedo_buffer_file	character			name for albedo buffer file
i_lsm_data	integer			integer switch to choose if an external land sea mask is desired or not. 0: no external land sea mask, 1: use external land sea mask
land_sea_mask_file	character			name of the file which can be used as the external land sea mask.
number_special_points	integer			number of points that should be treated specially (maximal value: 3, if no special treatment is desired choose 0).

NAMELIST /special_points/ (INPUT_SP_1)

Modifications for Falkenberg.

Parameter	Type	Default	Unit	Description
lon_geo_sp	real	14.115	deg east	longitude coordinate of the special point
lat_geo_sp	real	52.156	deg north	latitude coordinate of the special point
soiltype_sp	real	3.0	-	soiltype of the special point
z0_sp	real	0.03	m	roughness lenght of the special point
rootdp_sp	real	0.6	m	rooting depth of the special point

Parameter	Type	Default	Unit	Description
plcovmn_sp	real	0.55	1	plant cover minimum of the special point
plcovmx_sp	real	0.8	1	plant cover maximum of the special point
laimn_sp	real	0.5	1	leaf area index minimum of the special point
laimx_sp	real	2.5	1	leaf area index maximum of the special point

NAMELIST /special_points/ (INPUT_SP_2)

Modifications for Waldstation.

Parameter	Type	Default	Unit	Description
lon_geo_sp	real	13.954	deg east	longitude coordinate of the special point
lat_geo_sp	real	52.186	deg north	latitude coordinate of the special point
soiltype_sp	real	3.	-	soiltype of the special point
z0_sp	real	0.78	m	roughness lenght of the special point
rootdp_sp	real	0.6	m	rooting depth of the special point
plcovmn_sp	real	0.79	1	plant cover minimum of the special point
plcovmx_sp	real	0.81	1	plant cover maximum of the special point
laimn_sp	real	3.0	1	leaf area index minimum of the special point
laimx_sp	real	4.0	1	leaf area index maximum of the special point

NAMELIST /special_points/ (INPUT_SP_3)

Modifications for Lindenberg.

Parameter	Type	Default	Unit	Description
lon_geo_sp	real	14.119	deg east	longitude coordinate of the special point
lat_geo_sp	real	52.205	deg north	latitude coordinate of the special point
soiltype_sp	real	5.	-	soiltype of the special point
z0_sp	real	0.07	m	roughness lenght of the special point
rootdp_sp	real	0.6	m	rooting depth of the special point
plcovmn_sp	real	0.5	1	plant cover minimum of the special point
plcovmx_sp	real	0.9	1	plant cover maximum of the special point
laimn_sp	real	0.7	1	leaf area index minimum of the special point
laimx_sp	real	3.3	1	leaf area index maximum of the special point