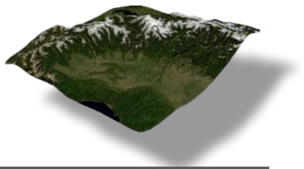
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Initial & Boundary Data

D. Rieger, F. Prill (DWD)

Overview

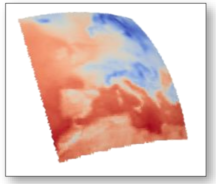
Computational Grids



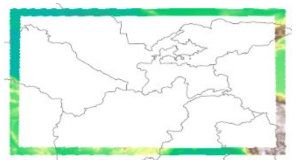
External Parameters

Zonda

Grid & Extpar Web Tool



Initial Data



Lateral Boundary Data

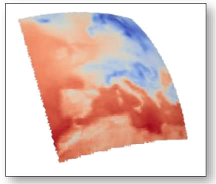
Computational Grids

Computational Grids

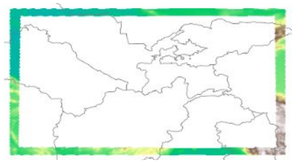
External Parameters

Zonda

Grid & Extpar Web Tool



Initial Data



Lateral Boundary Data

Spherical Geodesic Grids

Spherical geodesic grids derived from icosahedron.

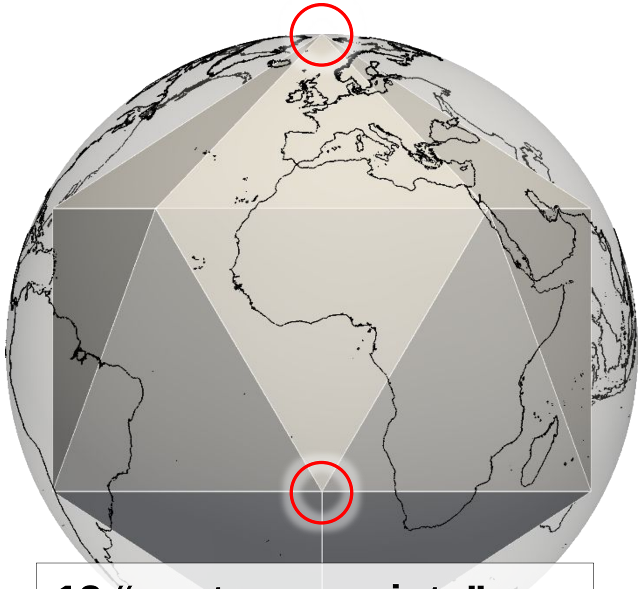
By **R**n**B**k we denote a grid that originates
from an icosahedron whose

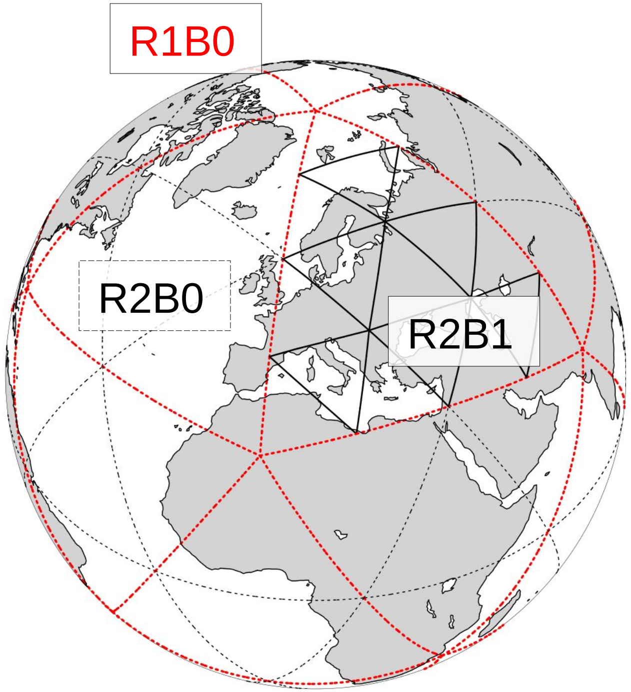
- edges have been initially divided into **n** parts,
- followed by **k** subsequent edge bisections.
- grid optimized by a so-called “spring dynamics step”.

The total number of cells in a global ICON grid is given by

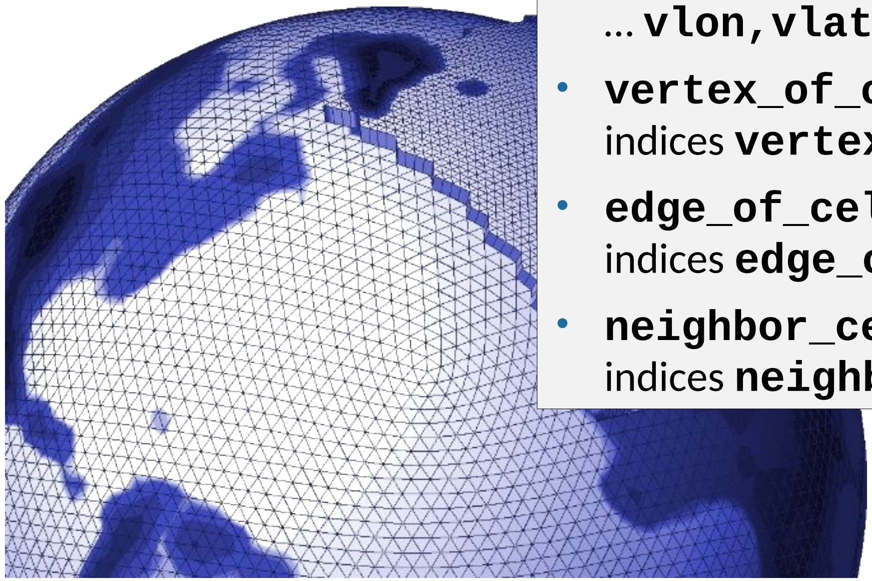
.

ICON namelist parameter
`grid_nml::dynamics_grid_filename`





NetCDF Format of Grid Files



The unstructured triangular ICON grid resulting from the grid generation process is represented in NetCDF following the CF metadata convention.

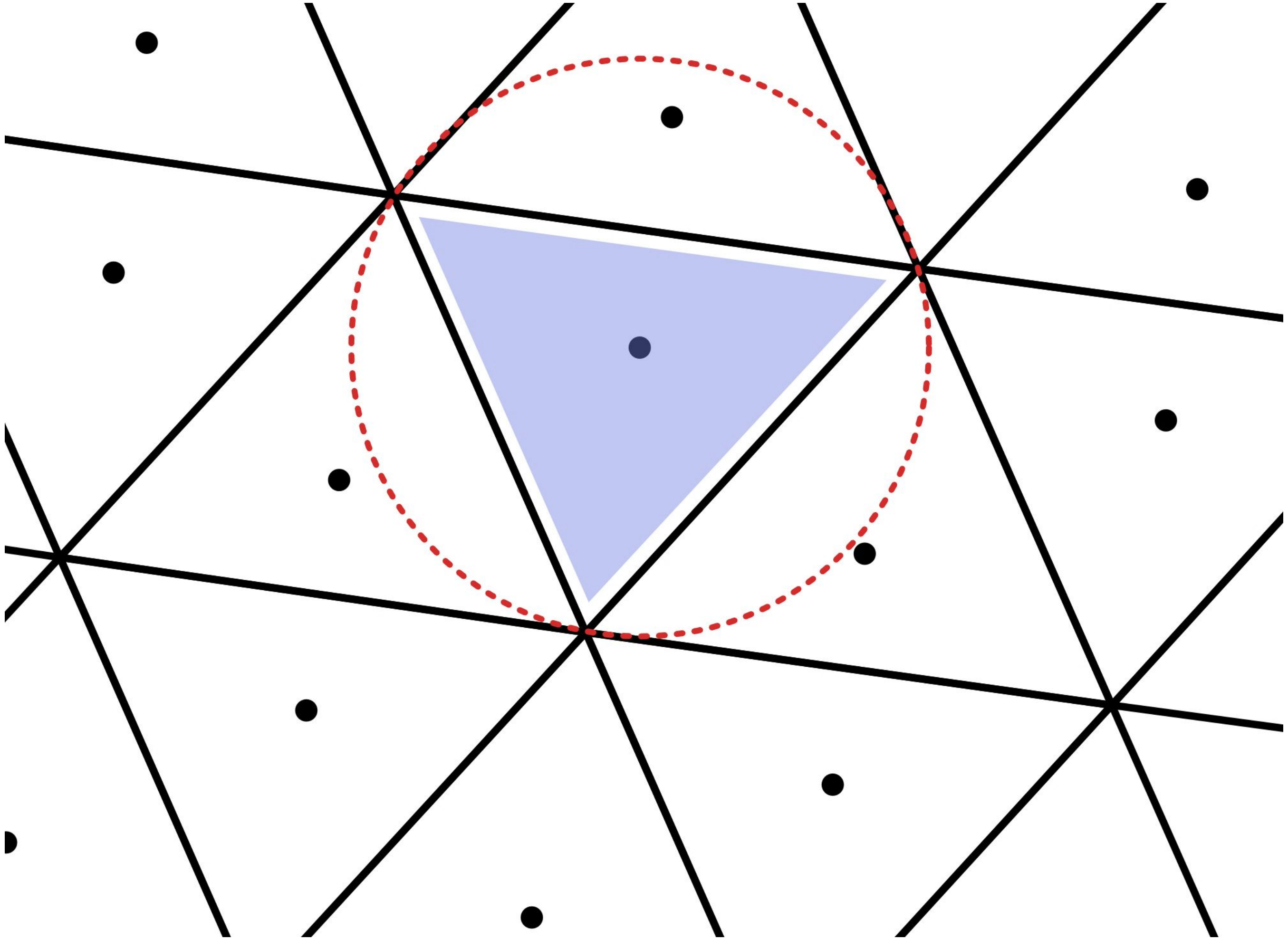
The most important data entries are

- edges have been initially divided into **`n`** parts,
- **`cell, vertex, edge`** (INTEGER dimension)
  number of triangle cells, vertices and edges
- **`clon, clat`** (double array, dimension: #triangles, given in radians)
  longitude/latitude of the midpoints of triangle circumcenters
  … **`vlon,vlat`** and **`elon, elat`** are defined accordingly.
- **`vertex_of_cell`** (INTEGER array, dimensions: [3, #triangles])
  indices **`vertex_of_cell(:,i)`** denote the triangle vertices that belong to the triangle **`i`**.
- **`edge_of_cell`** (INTEGER array, dimensions: [3, #triangles])
  indices **`edge_of_cell(:,i)`** denote the triangle edges that belong to the triangle **`i`**.
- **`neighbor_cell_index`** (INTEGER array, dimensions: [3, #triangles])
  indices **`neighbor_cell_index(:,i)`** denote the neighbor triangles for triangle **`i`**.

Geometry and Topology Data

C-staggering

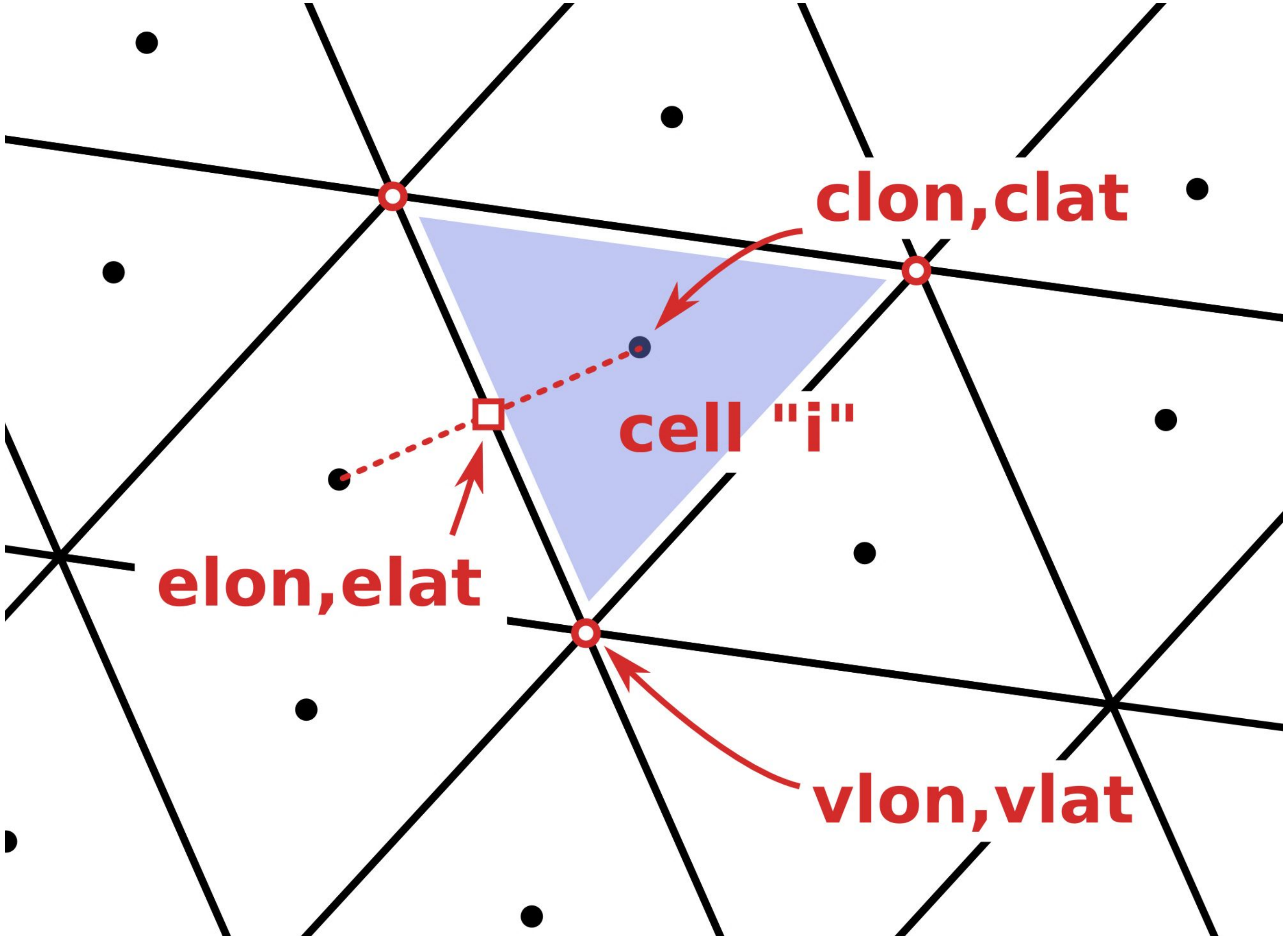
mass placed at triangle circumcenters



Geometry and Topology Data

The arc connecting two neighboring mass points (dual edge) is orthogonal to the shared triangle edge.

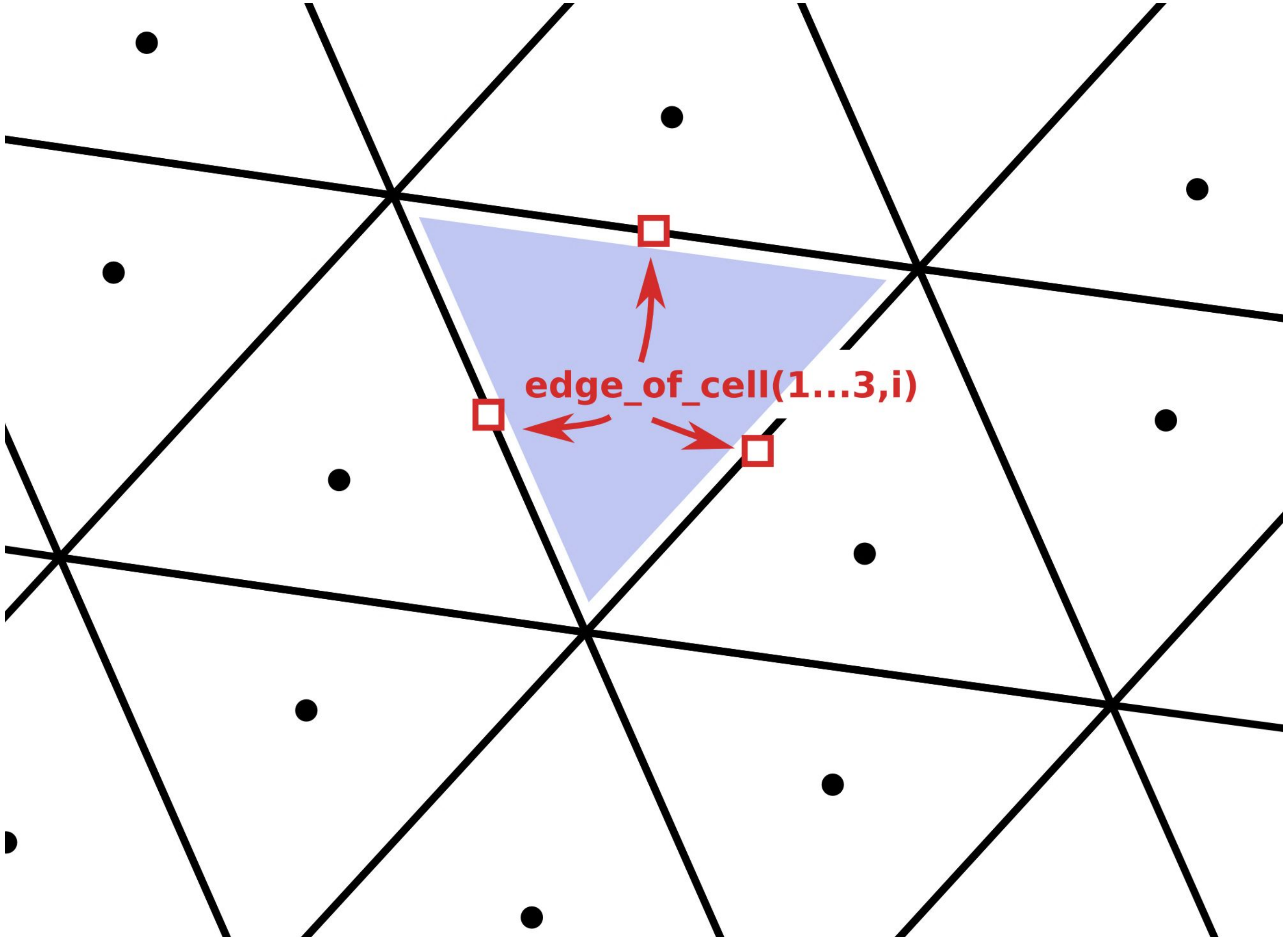
The bisection points are used as velocity points.



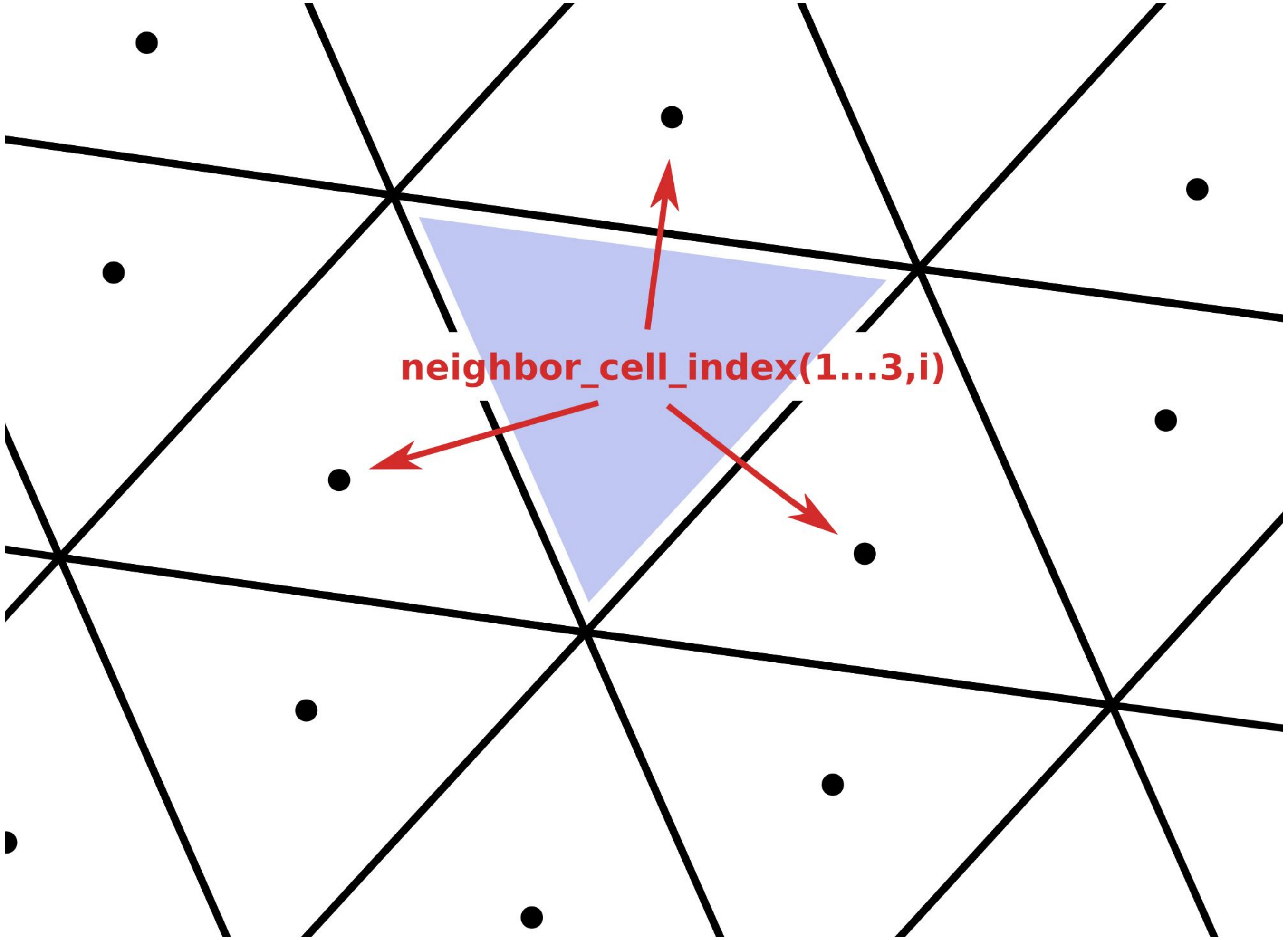
Geometry and Topology Data

Topologically, each triangular cell is defined by three edge indices, and each edge is given by its two vertex indices.

The cells' three edges are assumed to be oriented counter-clockwise.



Geometry and Topology Data



Other (redundant) topological and geometrical information is available.

Nested Grid Hierarchies

ICON has the capability for running

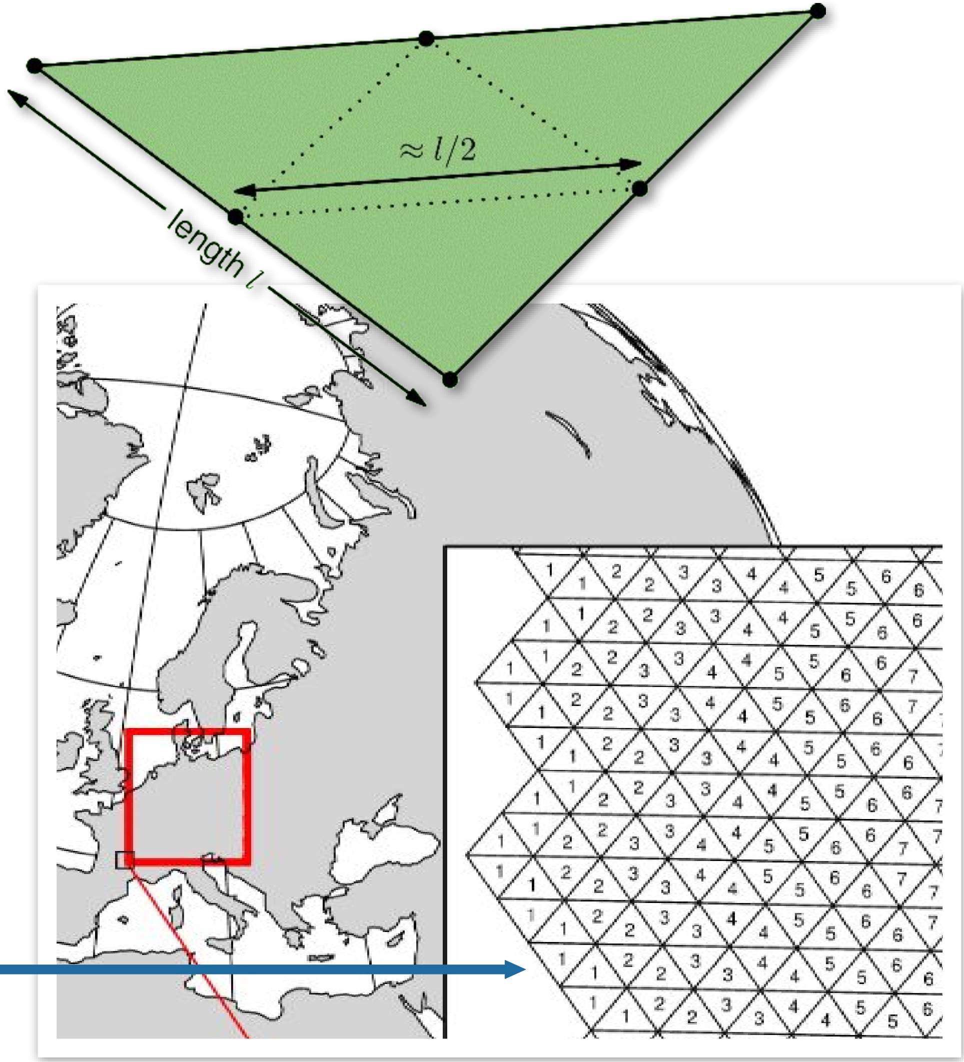
- **global** simulations on a single global grid
- global simulations with "**nests**" (= refined domains)
- regional simulations (**ICON-LAM**)

Due to the contained parent-child index data, a refined sub-grid can only be used with its original parent grid!

Legacy grids require the setting of

> **ICON namelist parameter**
> `grid_nml::dynamics_parent_grid_id`

Index Data for Grid Nesting and ICON-LAM



Refinement: **parent** triangle split into 4 **child** cells.

- only child-to-parent relations are stored:
  parent_cell_index(cell)
- even global grids have this information,
  used for **coarse radiation grids**.

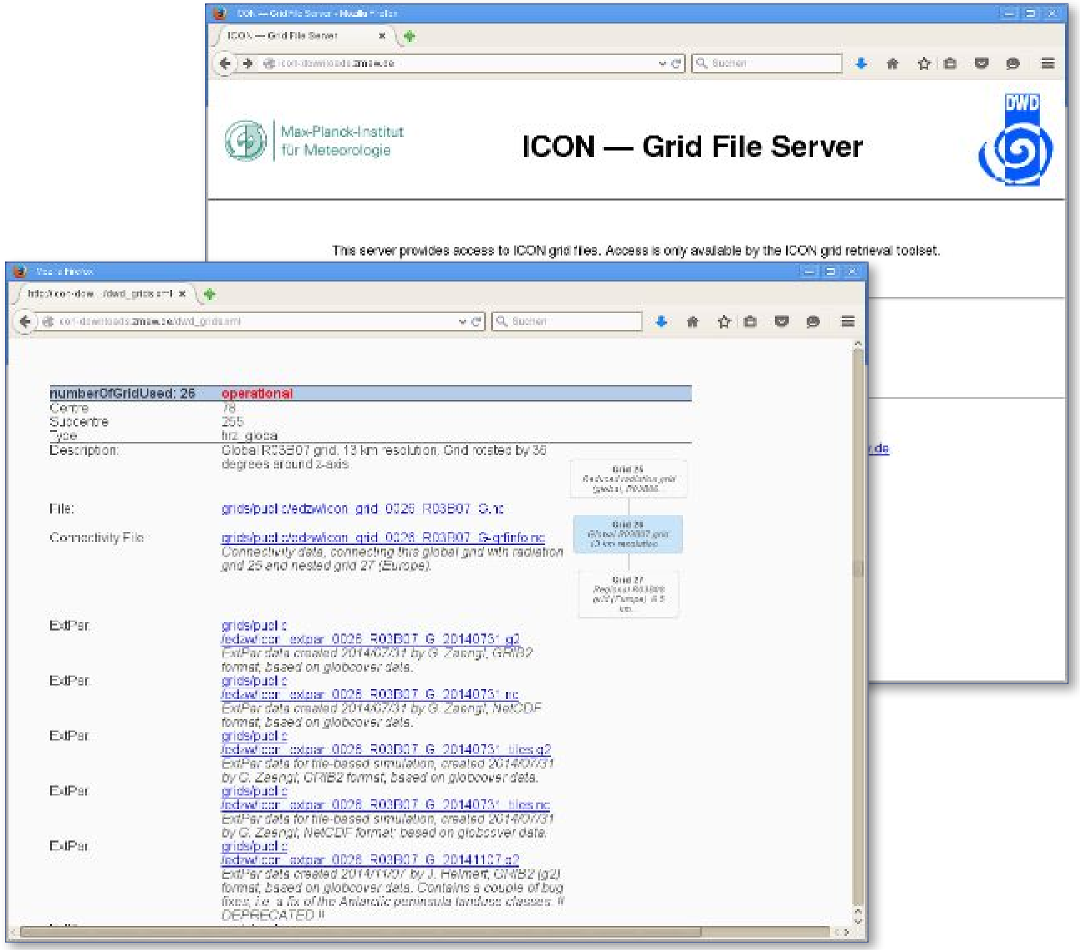
Regional grids can be used for nests and ICON-LAM.

(exception: local grids where **parent_cell_index** points to a regional radiation grid)

refin_c_ctrl(cell)

Used to identify the nest boundary zone: cell rows are numbered starting from the grid boundary

Public List of ICON Grids



For fixed domain sizes and mesh resolutions a list of grid files has been pre-built for the ICON model: http://icon-downloads.mpimet.mpg.de

- Grid list contains corresponding coarse radiation grids and the external parameters.

The pre-defined grids are identified by attributes:

- **`centre`** number (DWD/edzw: 78)
- **`subcentre`** number (DWD/edzw: 255)
- **`numberOfGridUsed`**
  `uuidOfHGrid`

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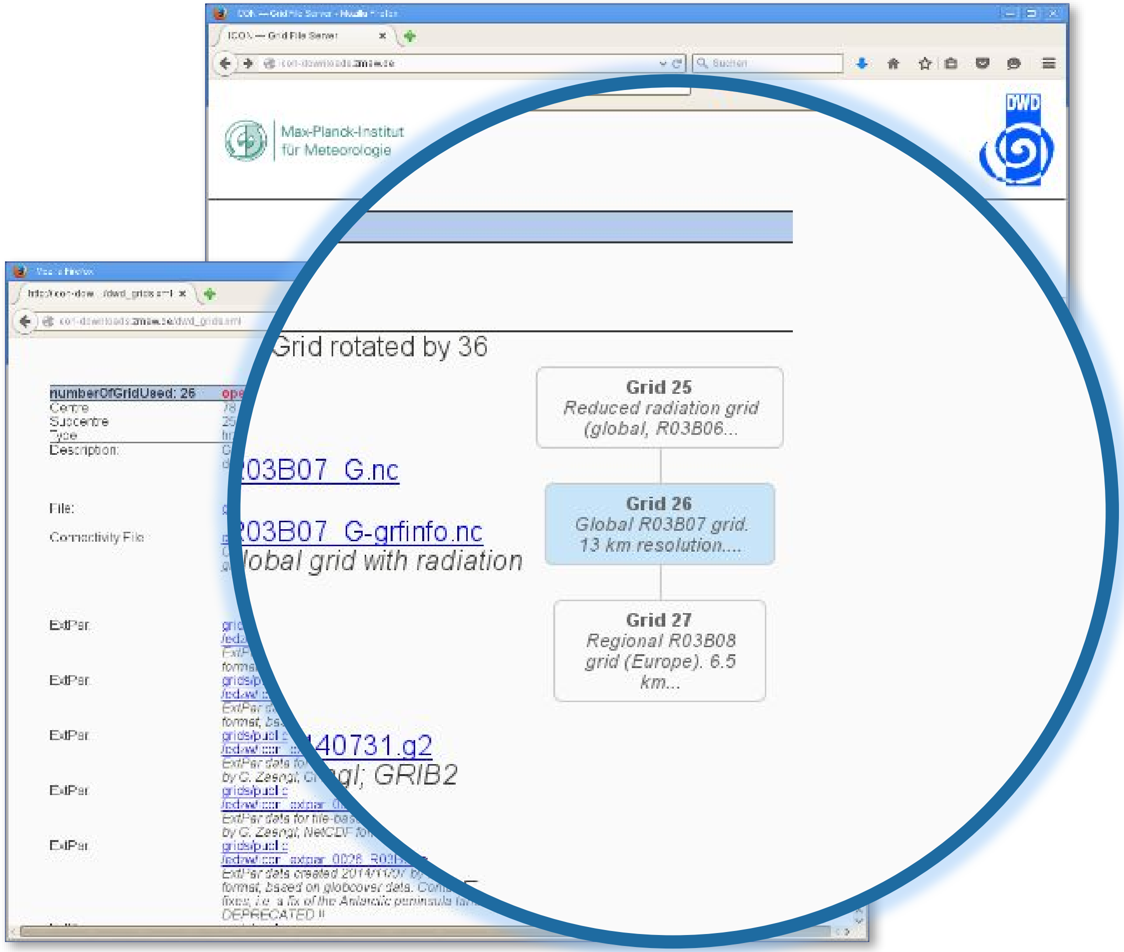

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Which Grid File is Related to my Data?

ICON data files do not (completely) contain the description of the underlying grid.

Input datasets and output files contain **reference to** the triangular **grid file**

These meta-data values allow to track the horizontal grid in all products and through all transformations of the scientific workflow.

- external parameter files
- analysis data for forecast input
- data files (diagnostic output)
- checkpoint files

`numberOfGridUsed`

- Integer number
- Reference number in list of published grids
- Mostly used internally (DWD)

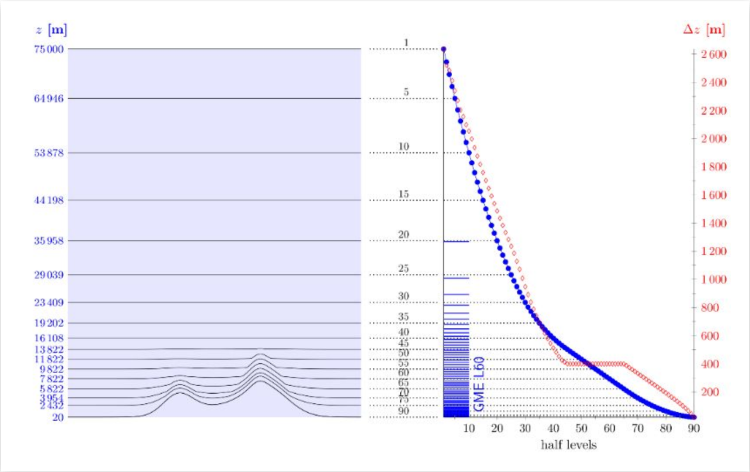
`uuidOfHGrid`

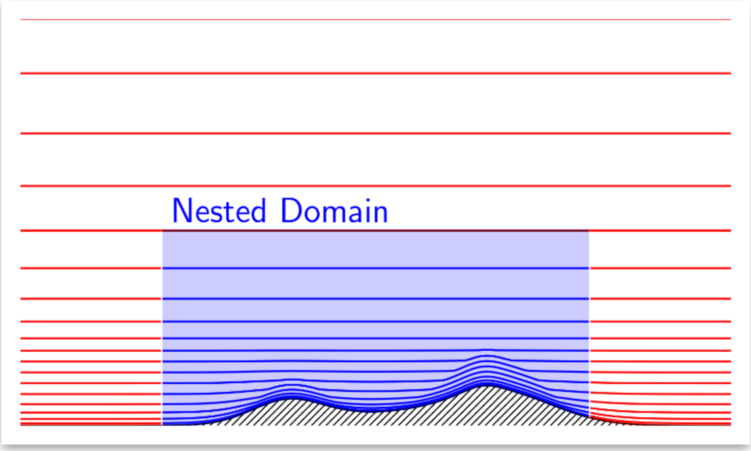
- Binary fingerprint
- Not human-readable
- Used for automatic consistency checks

Remark on Vertical Grids

ICON generates level heights during model setup, these are not read from file!

- Smooth Level Vertical (SLEVE) coordinate; level ordering: top-down
- topogaphy (external parameters) can be smoothed during model start-up





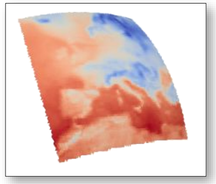
Note: the above graph shows ICON's older 90-level vertical setup (since 11/2022: 120 levels)

External Parameters

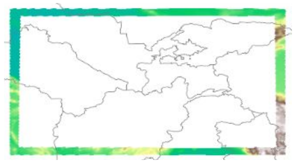
Computational Grids

External Parameters

Grid & Extpar Web Tool



Initial Data



Lateral Boundary Data

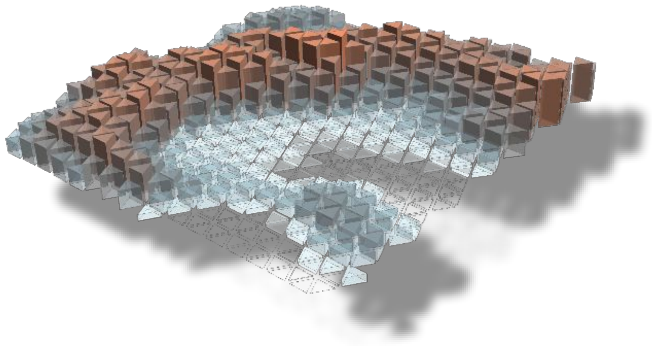
External Parameter Files

In addition to the grid, real-data ICON runs require **external parameter** files:

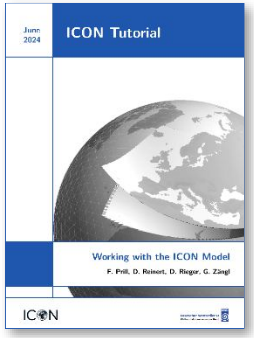
- land-sea mask, GLOBE/MERIT orography, soil type, surface albedo, angle of sub-grid scale orography and other geographical datasets (tutorial book Section 2.4)
- generated by the ExtPar software https://c2sm.github.io/extpar/

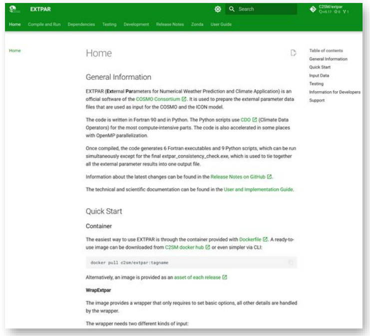
Remarks:

- Topography might be processed at ICON start-up external parameters!
- COSMO software, not part of the official release …
  … *use* Zonda *(see following slides)*



Raw Datasets





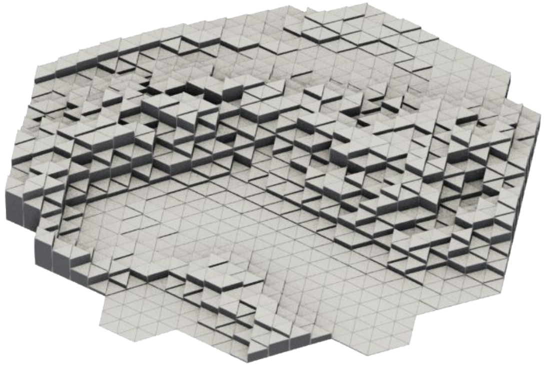
Raw datasets from which the ICON external parameter fields are derived: see the
ICON tutorial book, Section 2.4

… or the **ExtPar documentation**
https://c2sm.github.io/extpar/

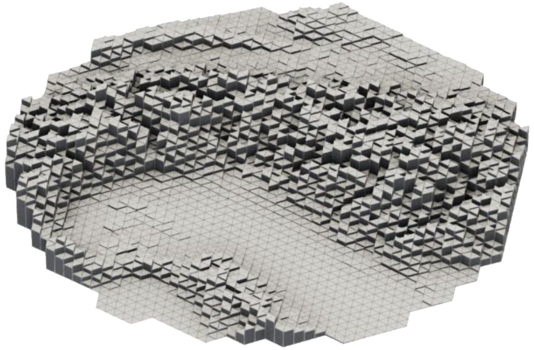
	irad_aero=6,9 (namelist radiation_nml)	
ALB_DIF12	Shortwave ($0.3 - 5.0\,\mu m$) albedo for diffuse radiation (monthly mean) albedo_type=2 (namelist radiation_nml)	MODIS
ALB_UV12	UV-visible ($0.3 - 0.7\,\mu m$) albedo for diffuse radiation (monthly mean) albedo_type=2 (namelist radiation_nml)	MODIS
ALB_NI12	Near infrared ($0.7 - 5.0\,\mu m$) albedo for diffuse radiation (monthly mean) albedo_type=2 (namelist radiation_nml)	MODIS
DEPTH_LK	Lake depth	GLDB
EMIS_RAD	Surface longwave (thermal) emissivity itype_lwemiss=1 (namelist extpar_nml)	GlobCover 2009
EMISS	Surface longwave (thermal) emissivity derived from satellite measurements (monthly mean) itype_lwemiss=2 (namelist extpar_nml)	CAMEL (combined ASTER and MODIS)
FOR_D	Fraction of deciduous forest ntiles=1 (namelist lnd_nml)	GlobCover 2009
FOR_E	Fraction of evergreen forest ntiles=1 (namelist lnd_nml)	GlobCover 2009
FR_ICE	Land glacier fraction Taken from FR_LUC, if missing	
FR_LAKE	Lake fraction (fresh water)	GLDB

Representation of Orography

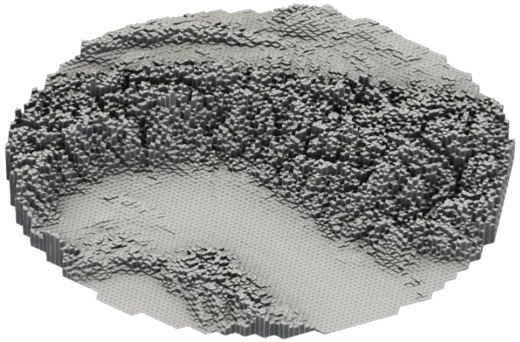
ICON-LAM
Alpine region
ASTER orography



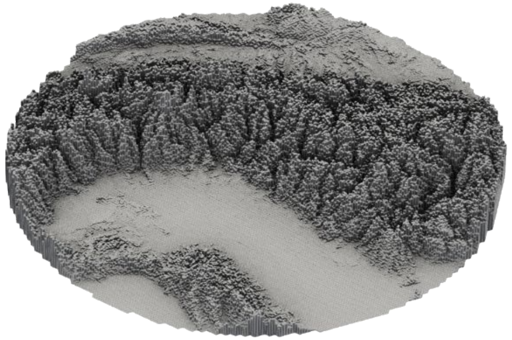
R03B07, 13 km grid size



R03B08, 6.5 km



R03B09, 3.28 km



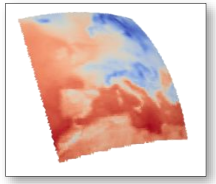
R03B10, 1.64 km

Grid & EXTPAR Web Tool

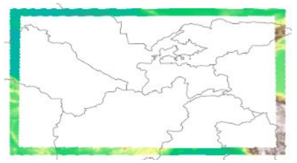
Computational Grids

External Parameters

Grid & Extpar Web Tool



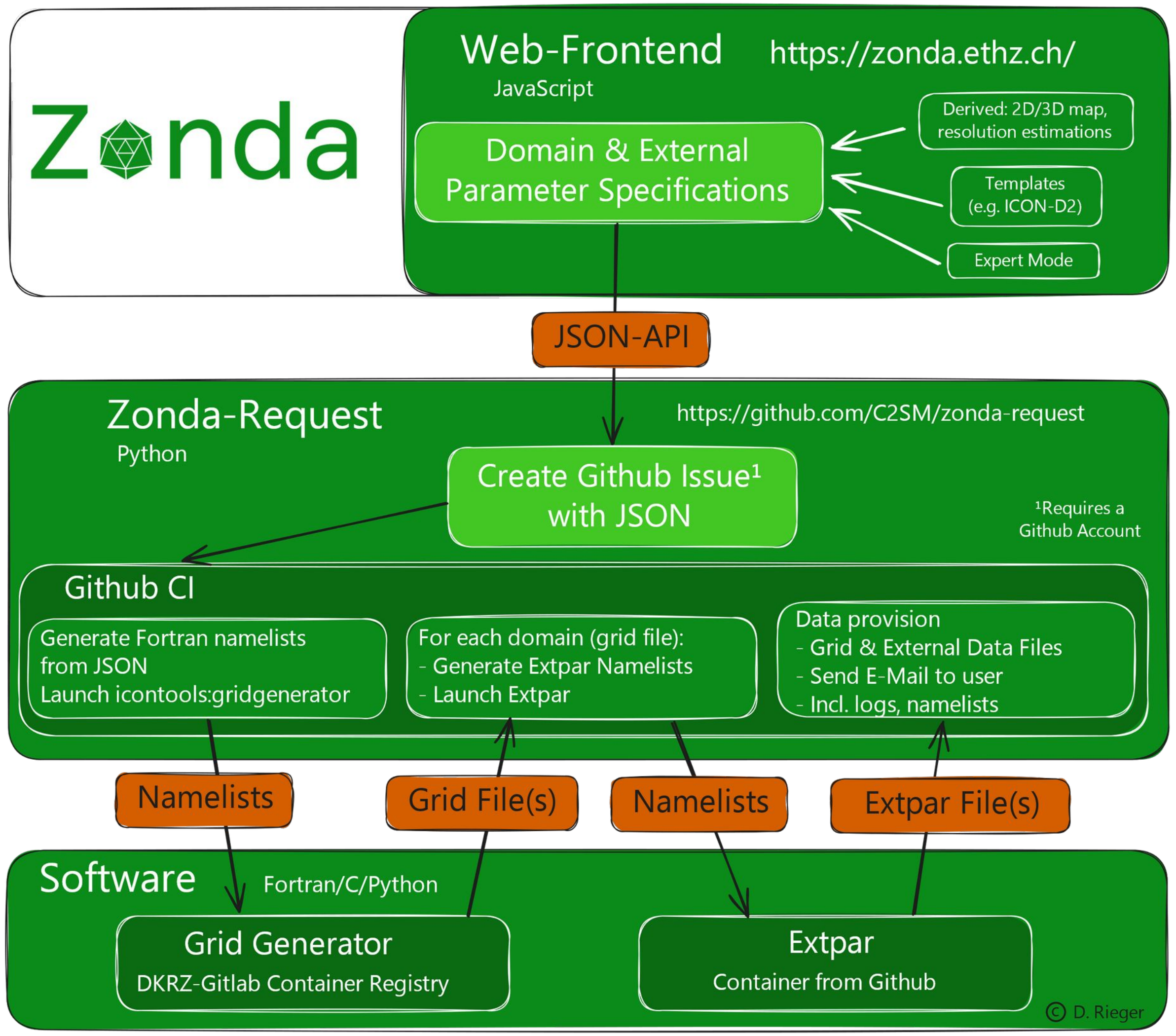
Initial Data



Lateral Boundary Data

M. Jaehn[1], J. Jucker[1], T. Kaspar[2], X. Lapillonne[2], D. Rieger[3], M. Stellio[1]
[1]C2SM, [2]MeteoSwiss, [3]DWD

ICON Grid & EXTPAR Web Tool: Zonda



Zonda is a web interface designed to facilitate the generation of

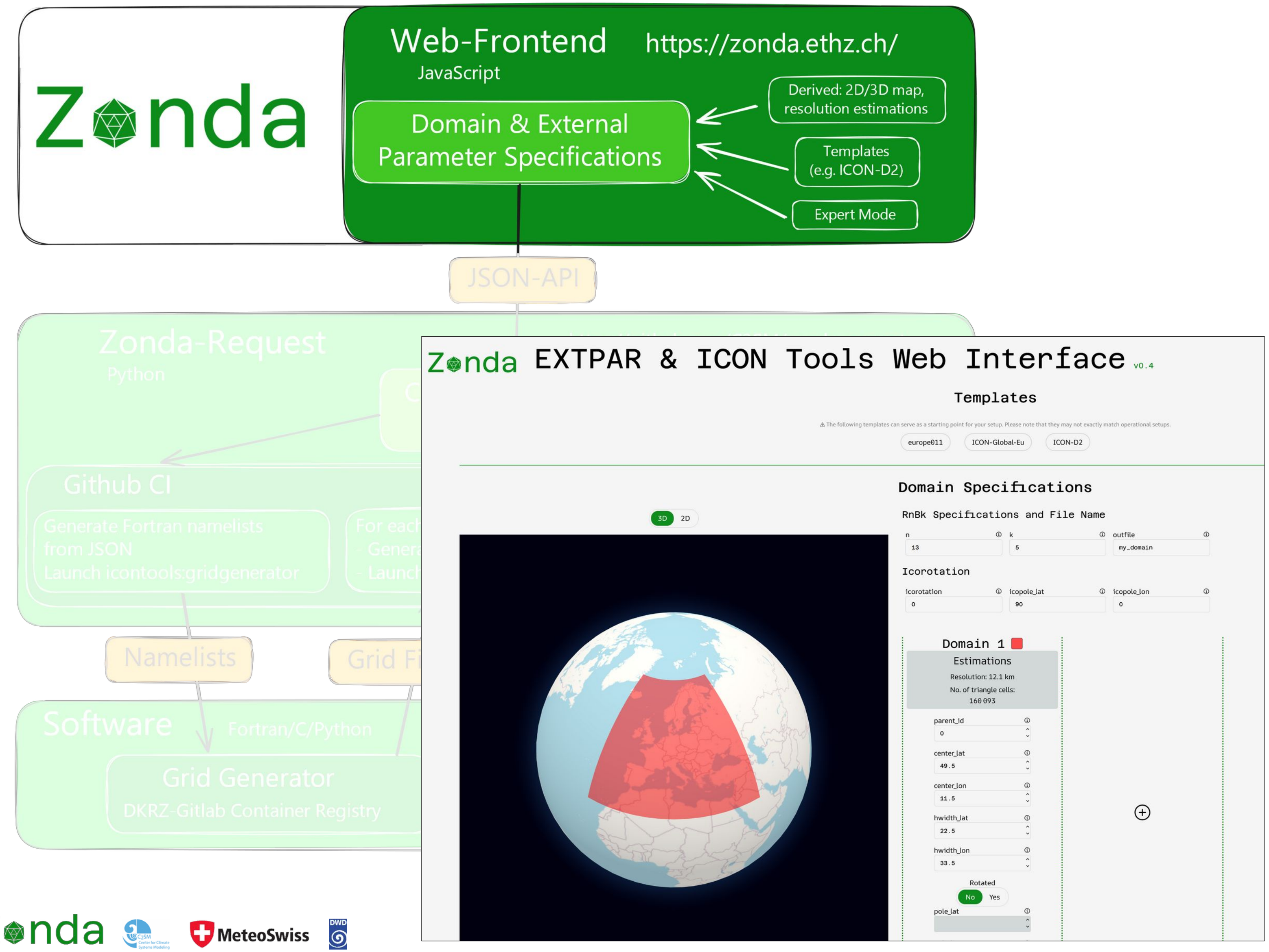
- **EXTPAR data**
- on **ICON triangular grids**

for research and on-demand simulations.

Joint project of C2SM (Centre for Climate Systems Modelling), MeteoSwiss and DWD led by **C2SM**.

Documentation is available at: https://zonda.ethz.ch/docs

Zonda Frontend

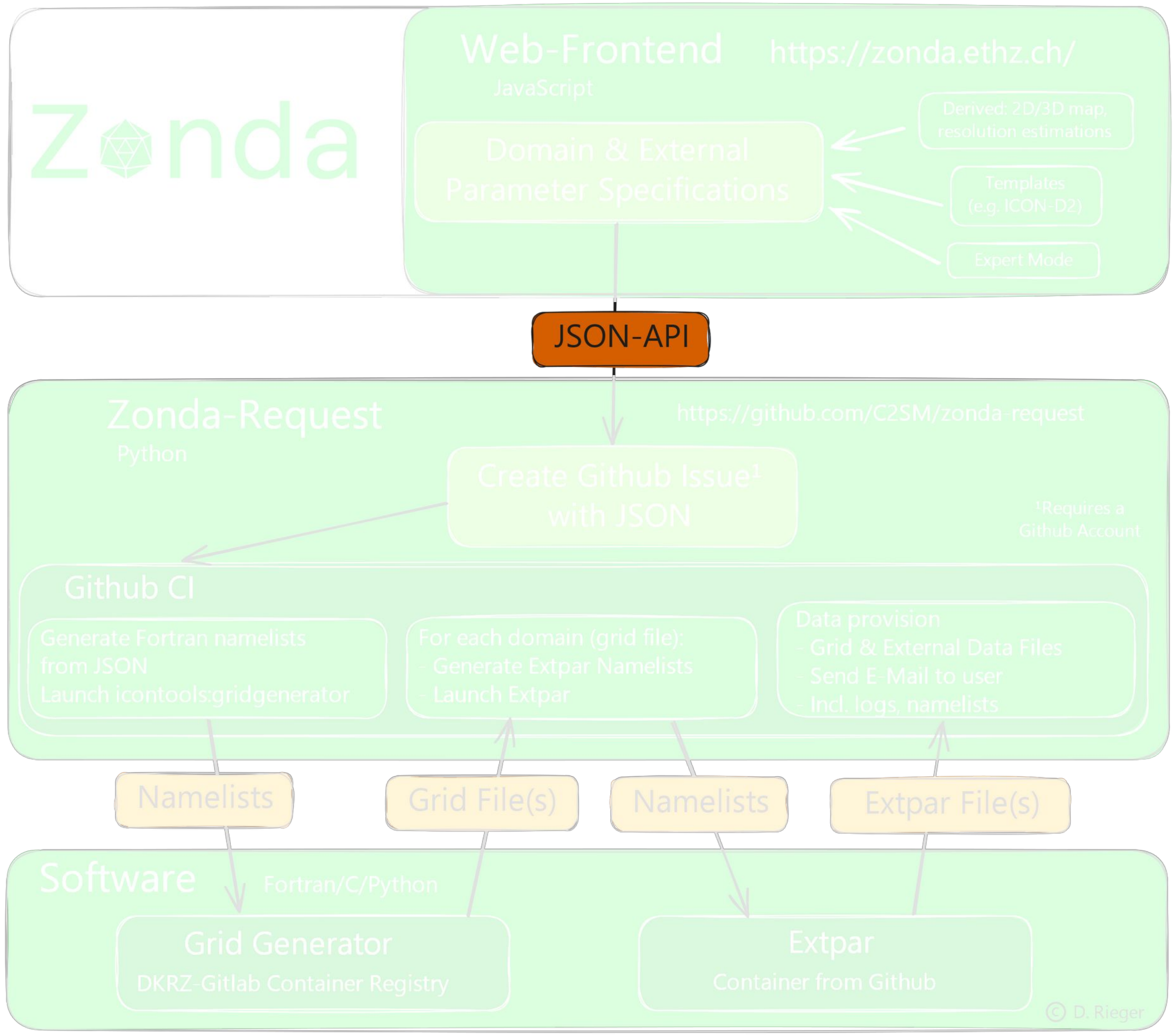


Zonda website https://zonda.ethz.ch

- Domain specifications (location, resolution, …)
- Additional domains (Nests)
- ExtPar settings
- Expert mode available

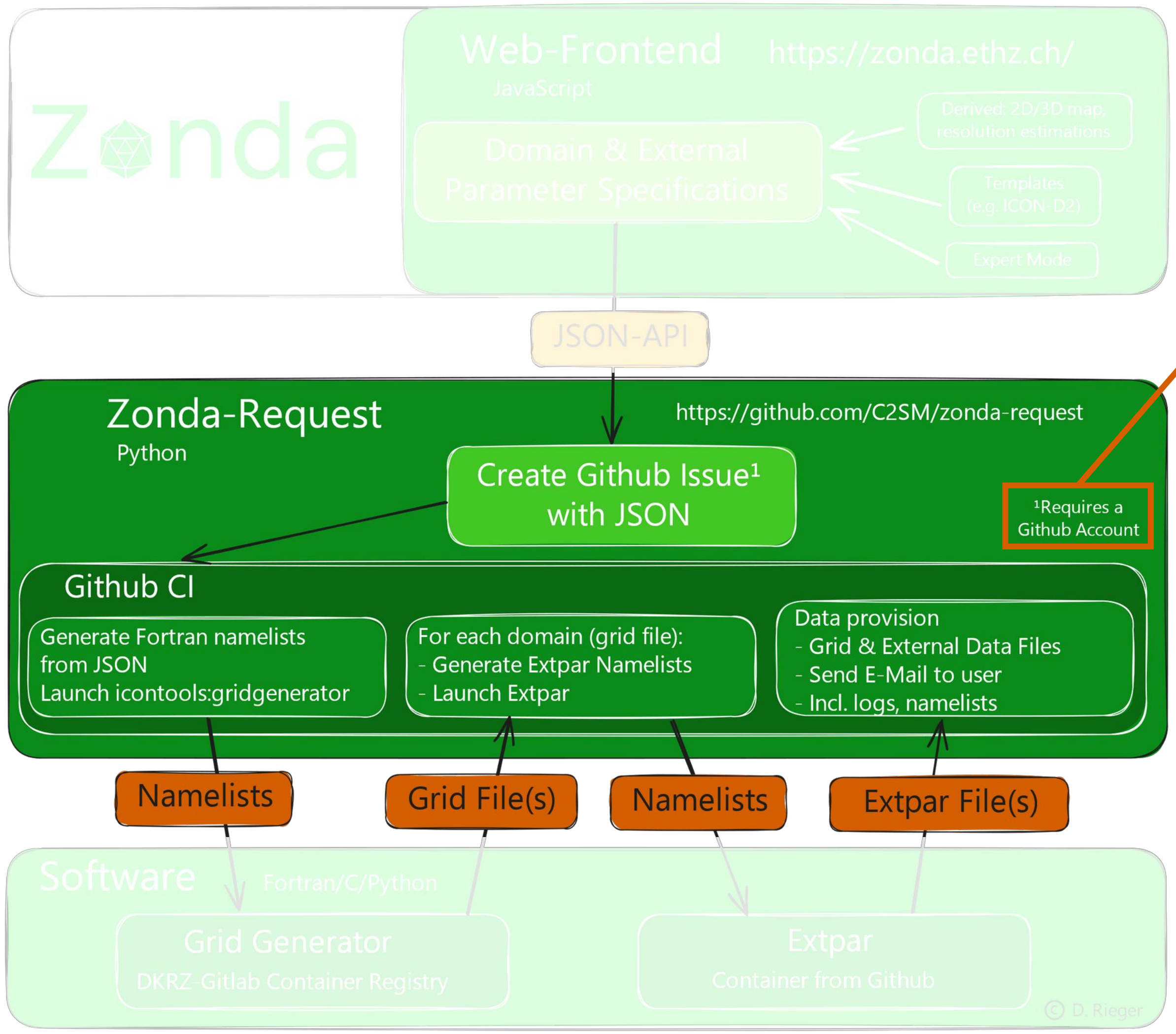
Result: JSON code containing the chosen settings which can be copied to clipboard.

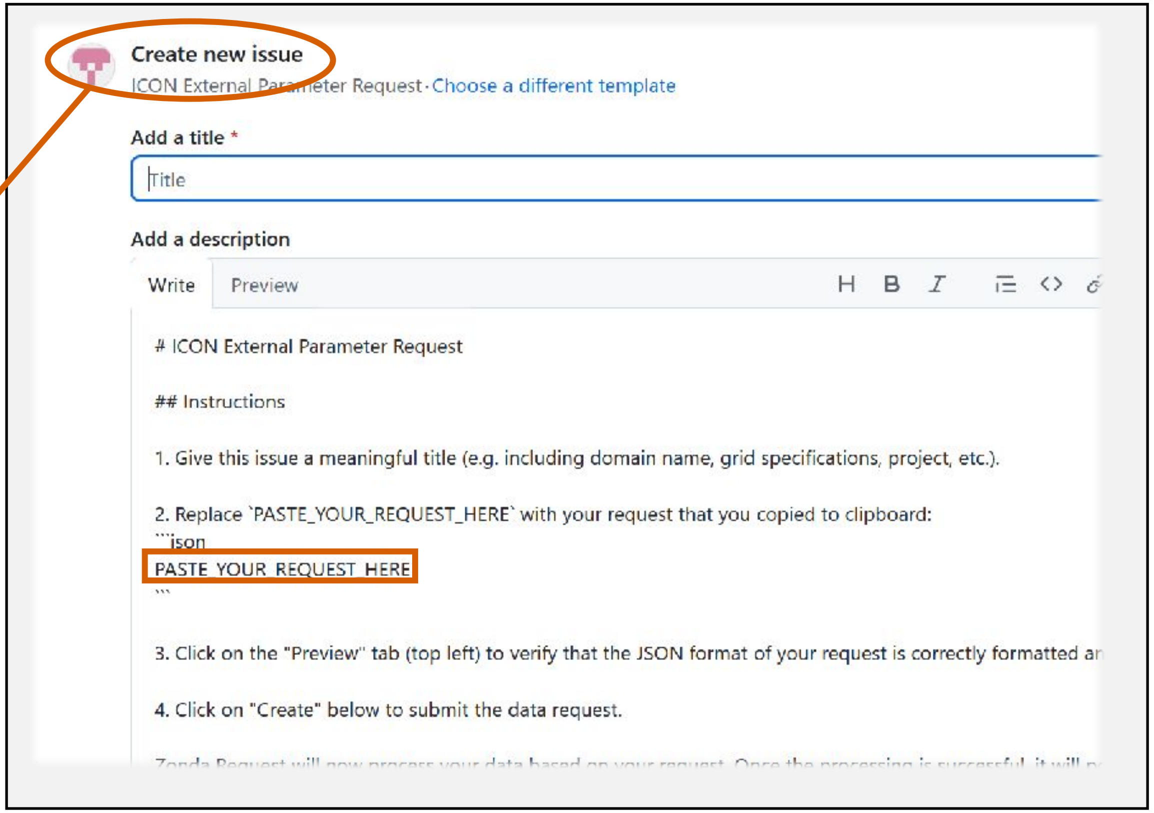
Zonda JSON API



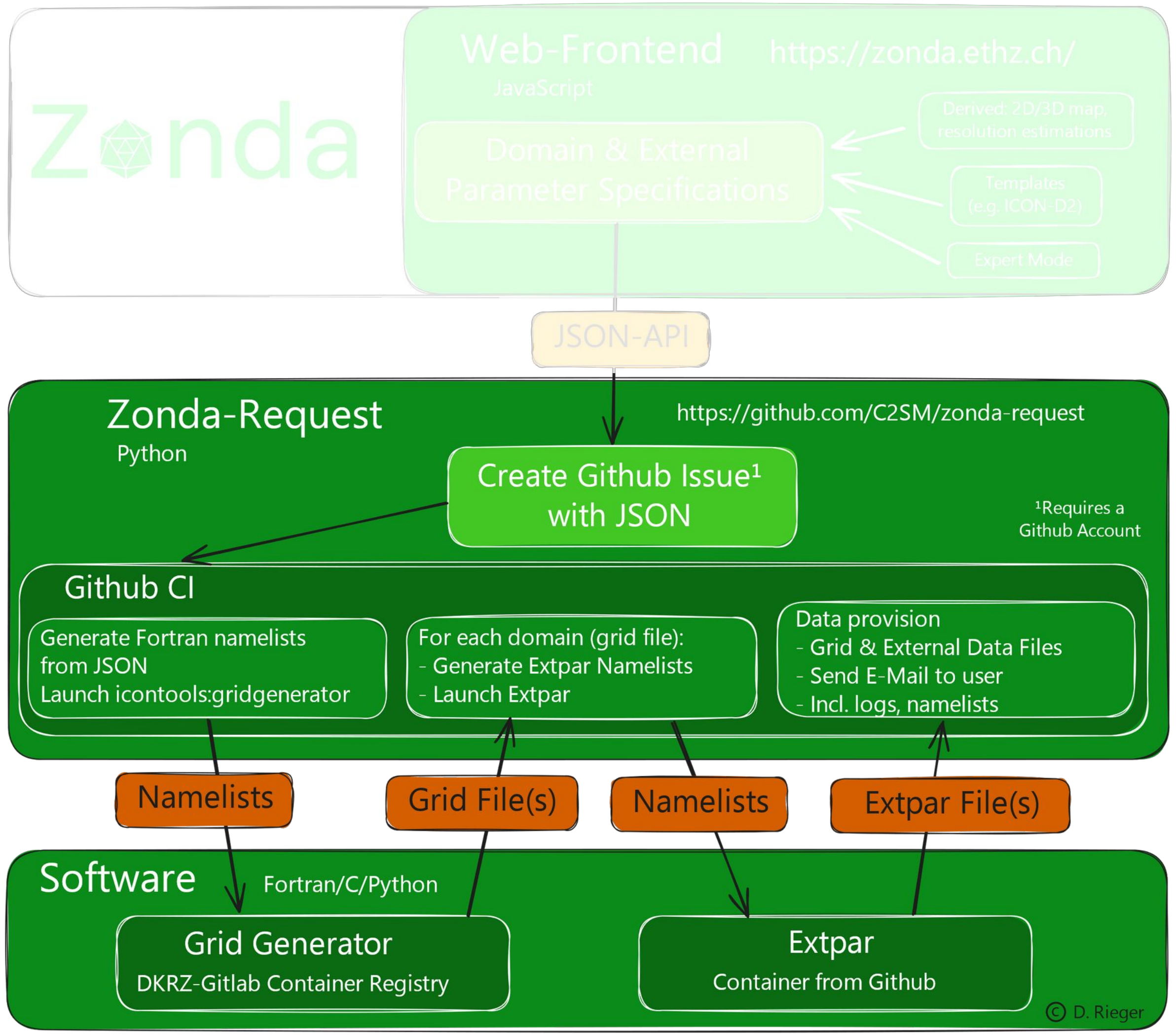

```json
{
  "zonda": {
    "extpar_tag": "v5.17"
  },
  "basegrid": {
    "keep_basegrid_files": false,
    "grid_root": 19,
    "grid_level": 6,
    "outfile": "ICON-D2",
    "icorotation": 36,
    "icopole_lat": 90,
    "icopole_lon": 0
  },
"domains": [
    {
      "domain_id": 1,
      "icontools": {
        "parent_id": 0,
        "region_type": 3,
        "lrotate": true,
        "pole_lat": 40,
        "pole_lon": -170,
        "center_lat": 0.85,
        "center_lon": -1,
        "hwidth_lat": 7.3,
        "hwidth_lon": 6.65
      },
"extpar": {
        "iaot_type": 1,
        "ilu_type": 1,
        "ialb_type": 1,
        "isoil_type": 1,
        "itopo_type": 2,
        "it_cl_type": 2,
        "iera_type": 2,
        "iemiss_type": 1,
        "lradtopo": false,
        "enable_cdnc": false,
        "enable_edgar": false,
        "radtopo_radius": 40000,
        "enable_art": false,
        "use_array_cache": false
      }
    }
  ]
}
```

Zonda Request Backend





Zonda Data Provision



After submitting the request

- Github CI takes over
- DWD ICONTOOLS & ExtPar

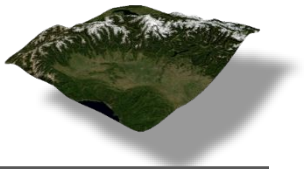
Upon completion

- E-Mail notification
- Notification in Github Issue
- Files available 7d for download

Zonda is a new tool!
https://zonda.ethz.ch/docs
Please provide feedback to:
c2sm.zonda@sympa.ethz.ch

Initital Data

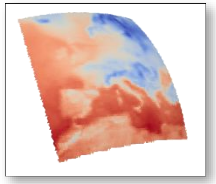
Computational Grids



External Parameters

Zonda

Grid & Extpar Web Tool



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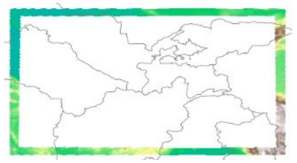


Lateral Boundary Data

Initial Datasets

DWD Uninitialized Analysis

- Start the model from the full analysis fields

Namelist `initicon_nml`:

`init_mode=1`

DWD Uninitialized Analysis for IAU

- Analysis with incremental analysis update (IAU)

`init_mode=5`

DWD Initialized Analysis

- Single file only, containing the analyzed state

list of fields: see tutorial book 11.3

`init_mode=7`

Other initial data

- E.g. IFS data from the ECMWF MARS database.

`init_mode=2`

remapping required if different grid (spacing)

ICON Model

Initial Datasets

For external users we strongly recommend to use the **initialized analysis** for model initialization.

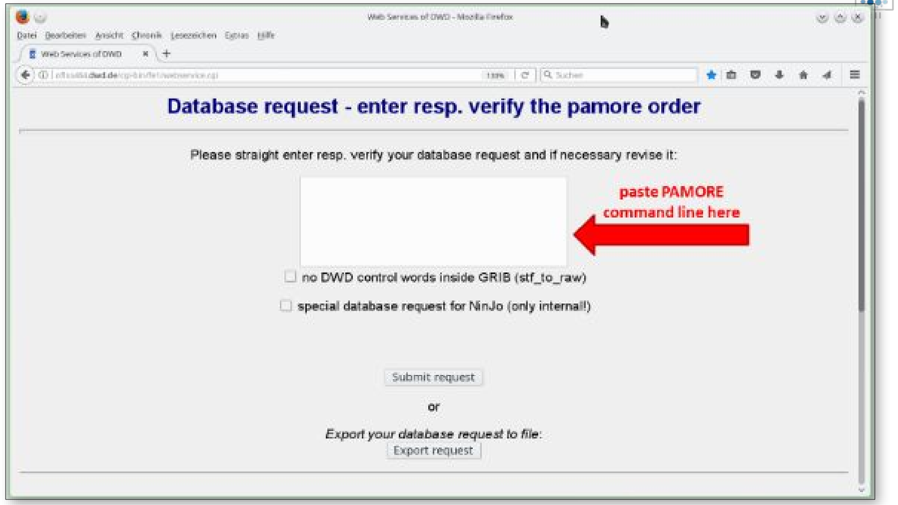
PAMORE[1] (**PA**rallel **MO**del data **RE**trieve from Oracle databases)

tool for retrieval of model data from DWD's meteorological database.

time range

```
pamore  -d date -hstart 0 -hstop 0
        -lt a -model ieu -iconlam_startdata_0
```

analysis   ICON-EU   initialized analysis



web service[1] requires registration

Pamore: Tutorial Book, Sections 2.2, 2.3
Examples for initial and boundary data, global and ICON EU/D2 nest

IFS Initial Data Set

Specifics of `init_mode=2`

- Supports only NetCDF format
- Includes vertical remapping

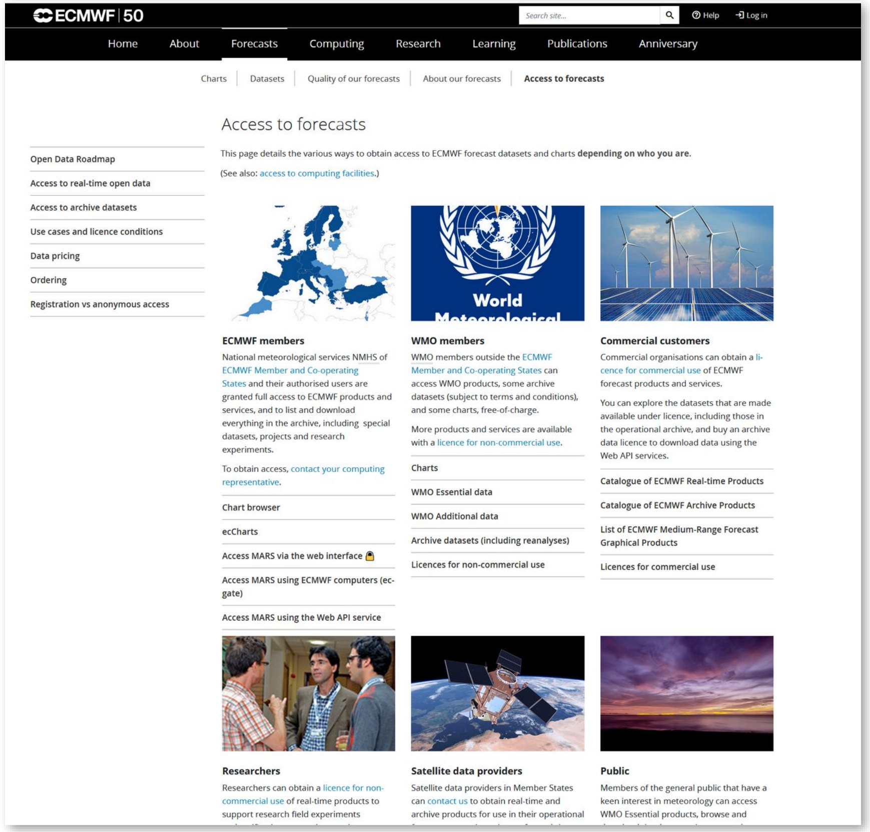
Example for Remapping

```
cdo -P 4 gencon,<targetgrid>:N1 <sourcedata> \
        weights.nc
cdo -f nc copy <sourcedata>.grb <sourcedata>.nc
cdo –s –r remap,<targetgrid>:N1,weights.nc \
        <sourcedata>.nc remapped.nc
```

Not shown: renaming of variables (alternative: dictionaries)

For older ICON grid files, the cell dimension needs a renaming:

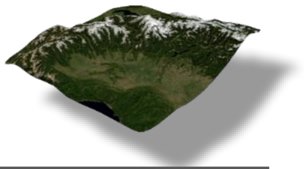
```
ncrename -d cell,ncells remapped.nc remapped_ncells.nc
```



https://www.ecmwf.int/en/forecasts/accessing-forecasts

Lateral Boundary Data

Computational Grids



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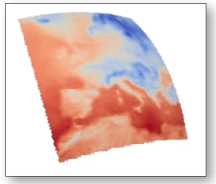
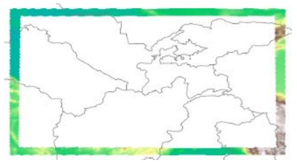
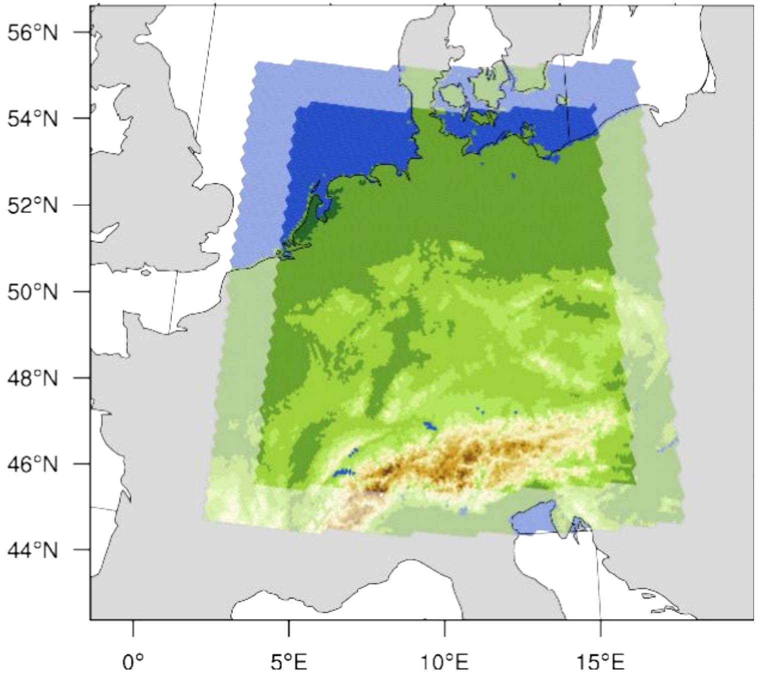


Initial Data



Lateral Boundary Data

Boundary datasets: Limited Area Mode (LAM)



Limited Area Run

- Main switch for limited area run:
  `l_limited_area=.TRUE. (grid_nml)`

ICON Namelist: `limarea_nml`

- Namelist setting specifying input frequency:
  `dtime_latbc`
- Input file names with „wildcards“: `latbc_filename`
- Enable prefetching of **boundary data**
  overlaps read-in with computation (mandatory):
  `num_prefetch_proc=1 (parallel_nml)`

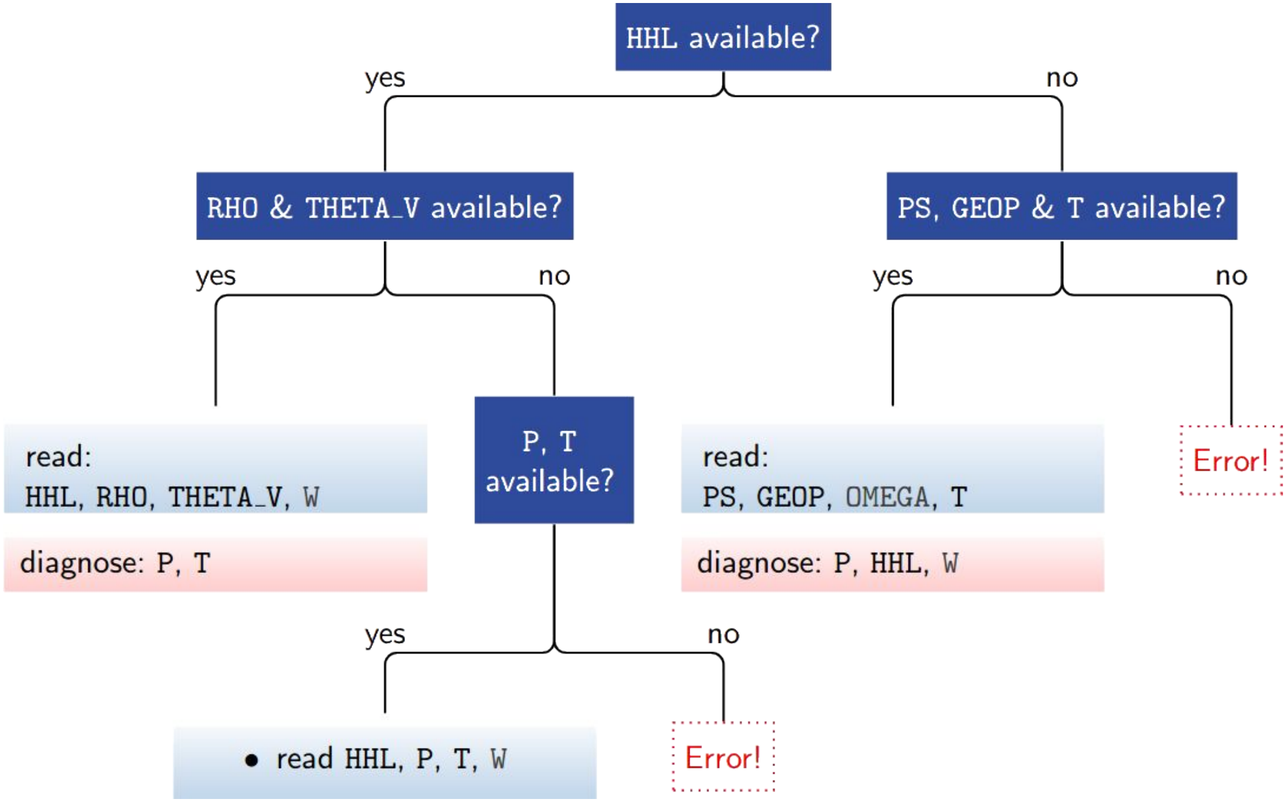
ICON-LAM **boundary data** can also be obtained via pamore requests.

```
pamore  -d date -hstart hh -hstop hh –hinc hh
        -model iglo -ilam_boundary
```

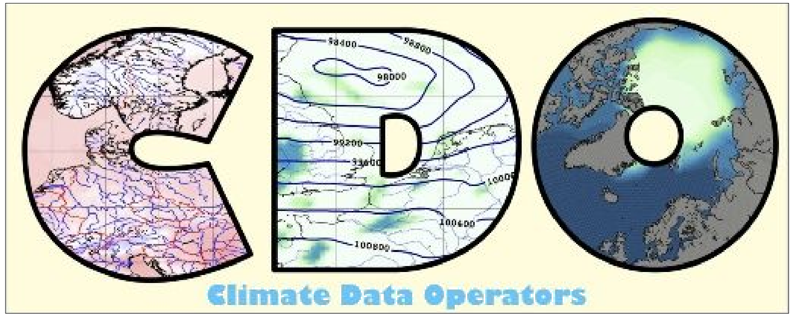
Boundary Dataset: Decision Tree

Read-in of boundary data is based on a **decision tree**.

- **Pro:** the user does not need to select a specific mode that fits the data.
- **Con:** when fields are missing (e.g. HHL), the model tries to interpret the remaining data and might abort with a non-intuitive error message.



ICON-LAM Data Pre-processing



After the successful download, the analysis/boundary data must be interpolated onto the ICON target grid. For example,

```
cdo remapcon,localgrid.nc:N1 –selname,FIELDS \
    –setgrid,ingrid.nc:N2 data-file.nc out-file.nc
```

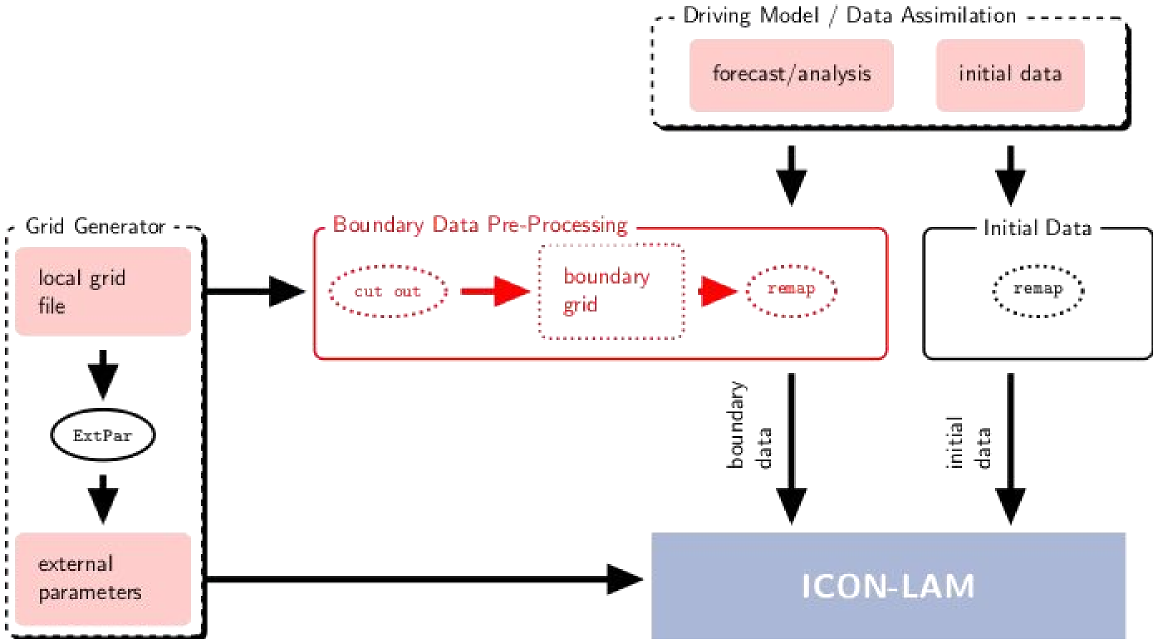
Vertical interpolation: no need for pre-processing; performed during read-in.

ICON-LAM accepts boundary data on the **full domain** or on a **sparse boundary** strip.

Pre-processing tools:

- Option 1: **CDO utilities**
- Option 2: **ICONREMAP** (DWD ICON Tools).

see the Tutorial Section 2.2.3



DWD OpenData

DWD forecasts available without retention time under

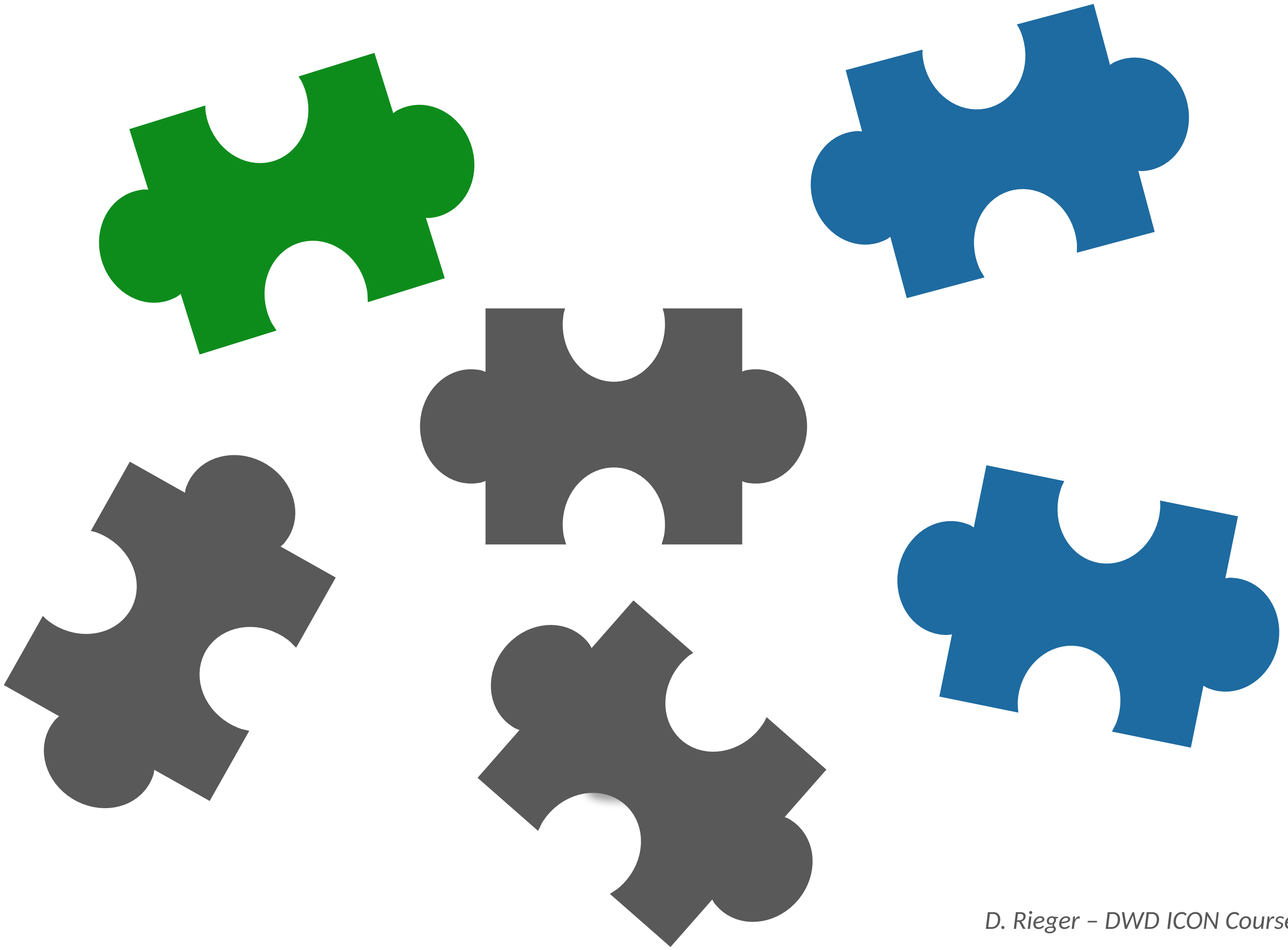
- https://dwd-geoportal.de/ (beta)
- http://opendata.dwd.de

A source for driving ICON-LAM? – Not yet, …

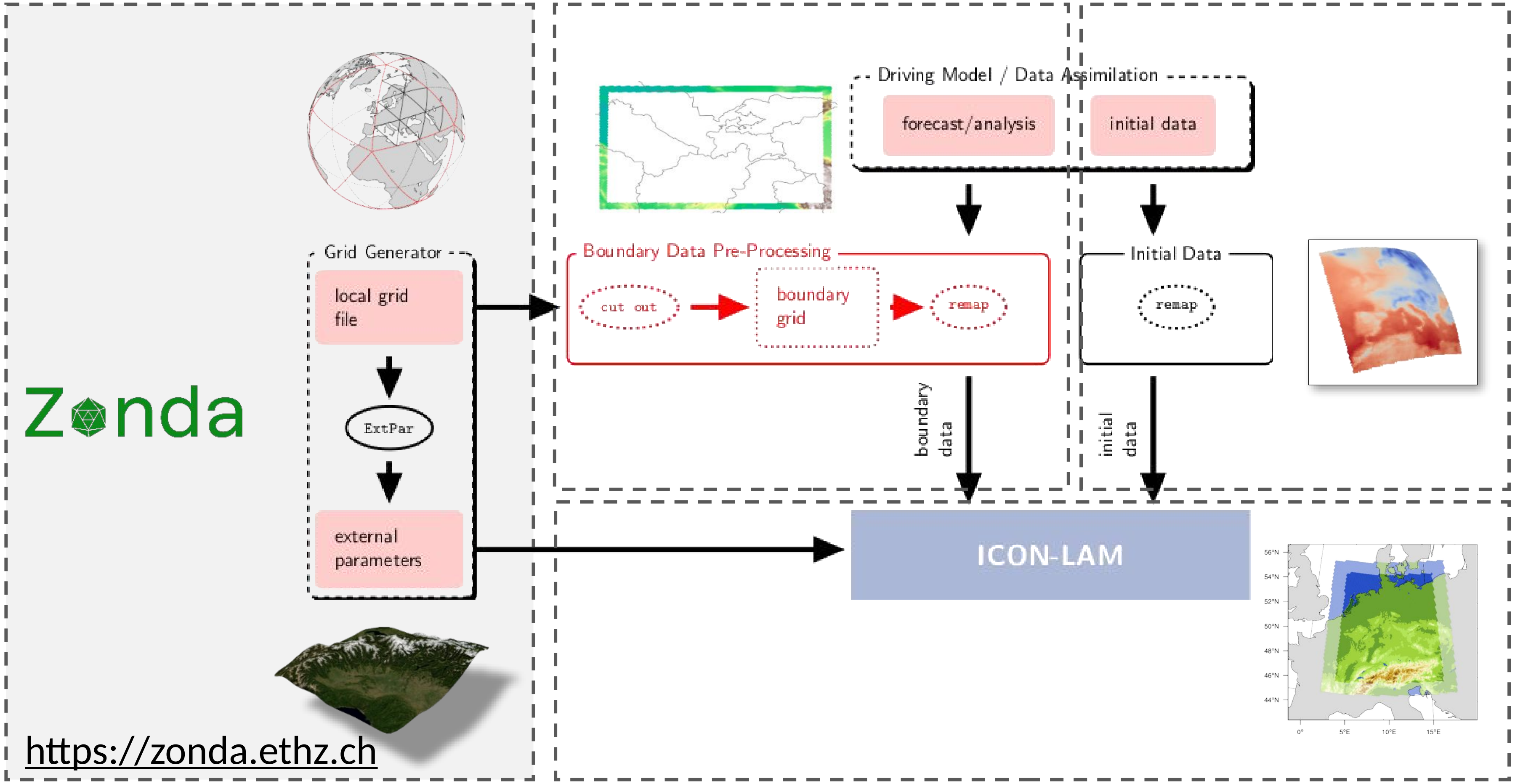
- the current datasets cover the boundary data fields required by the ICON model, but they do not contain all fields of the initial dataset (e.g. age of snow indicator “FRESHSNW”).
- OpenData data are forecasts, and not the so-called **initialized analysis** of the ICON model.

Set I (e.g. ICON)										
{U, V or VN},		W,	THETA_V,	DEN,	QV,	QC,	QI,	QR,	QS,	HHL
Set II (e.g. COSMO)										
U,	V,	W,	T,	P,	QV,	QC,	QI,	QR,	QS,	HHL
Set III (e.g. IFS)										
U,	V,	OMEGA,	T,	LNSP,	QV,	QC,	QI,	QR,	QS,	FI

Summary: Bringing the Pieces Together



Summary – Grid & External Parameters

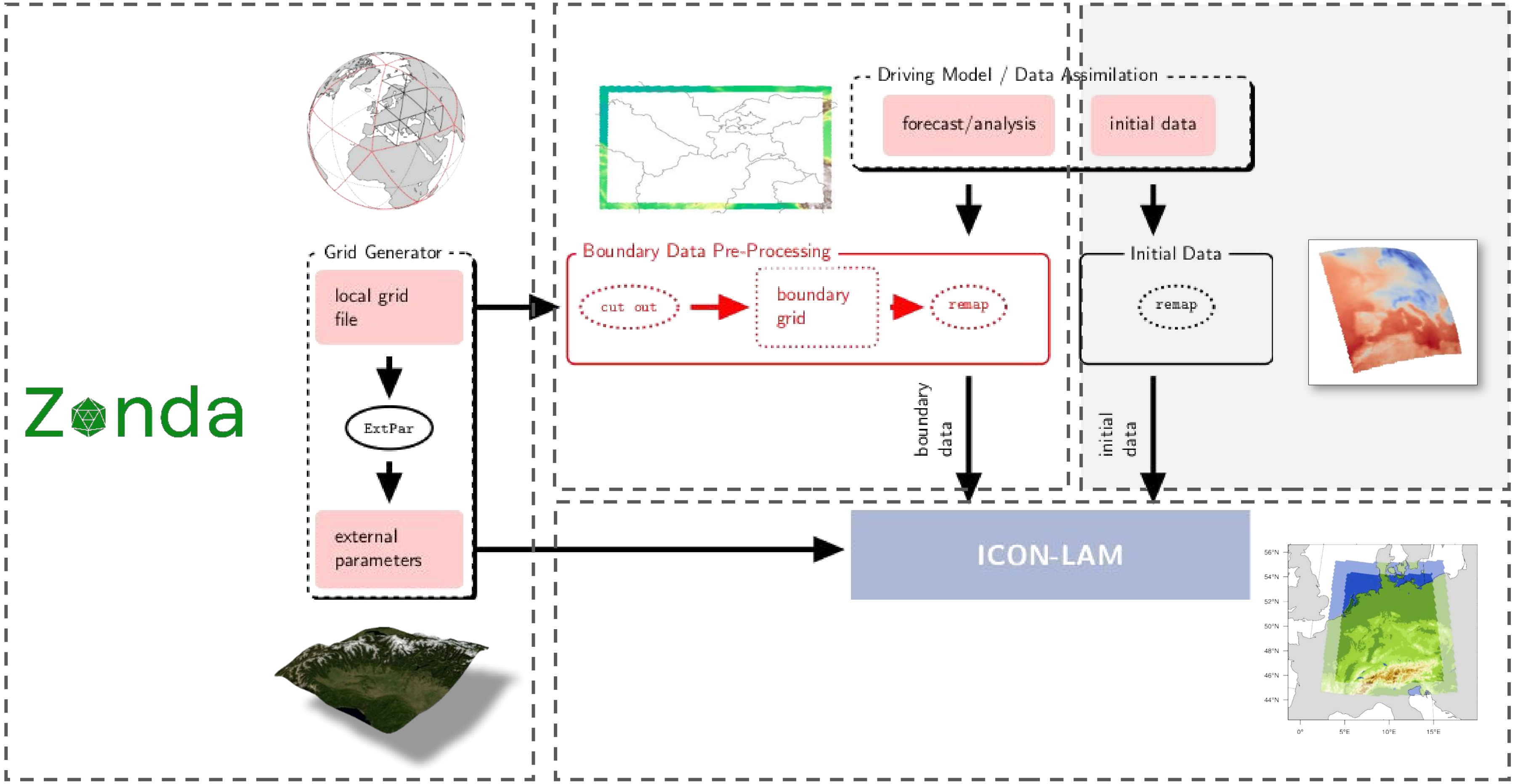


https://zonda.ethz.ch

Summary – Initial Data

https://www.dwd.de/EN/ourservices/pamore/pamore.html

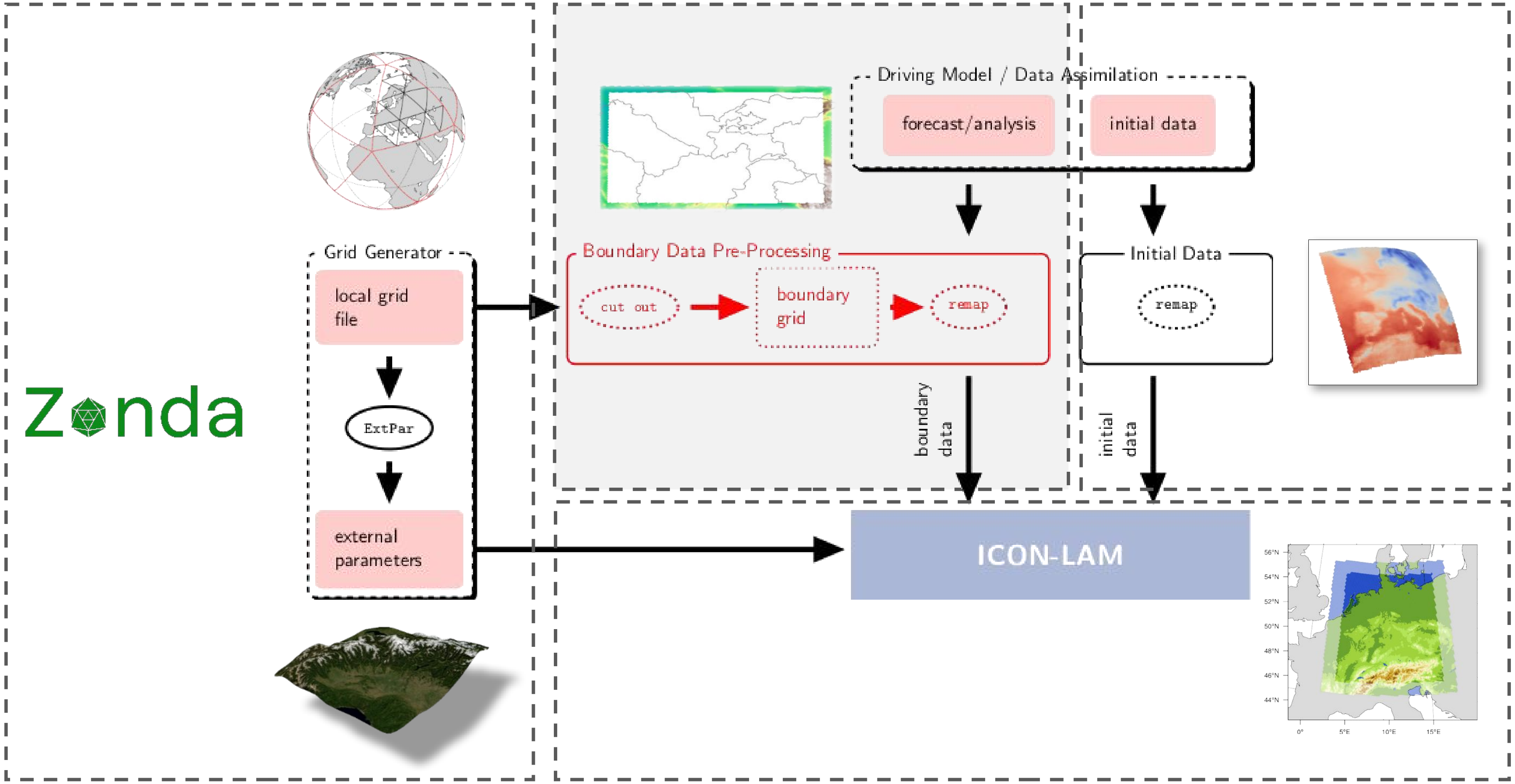
https://www.ecmwf.int/en/forecasts/accessing-forecasts



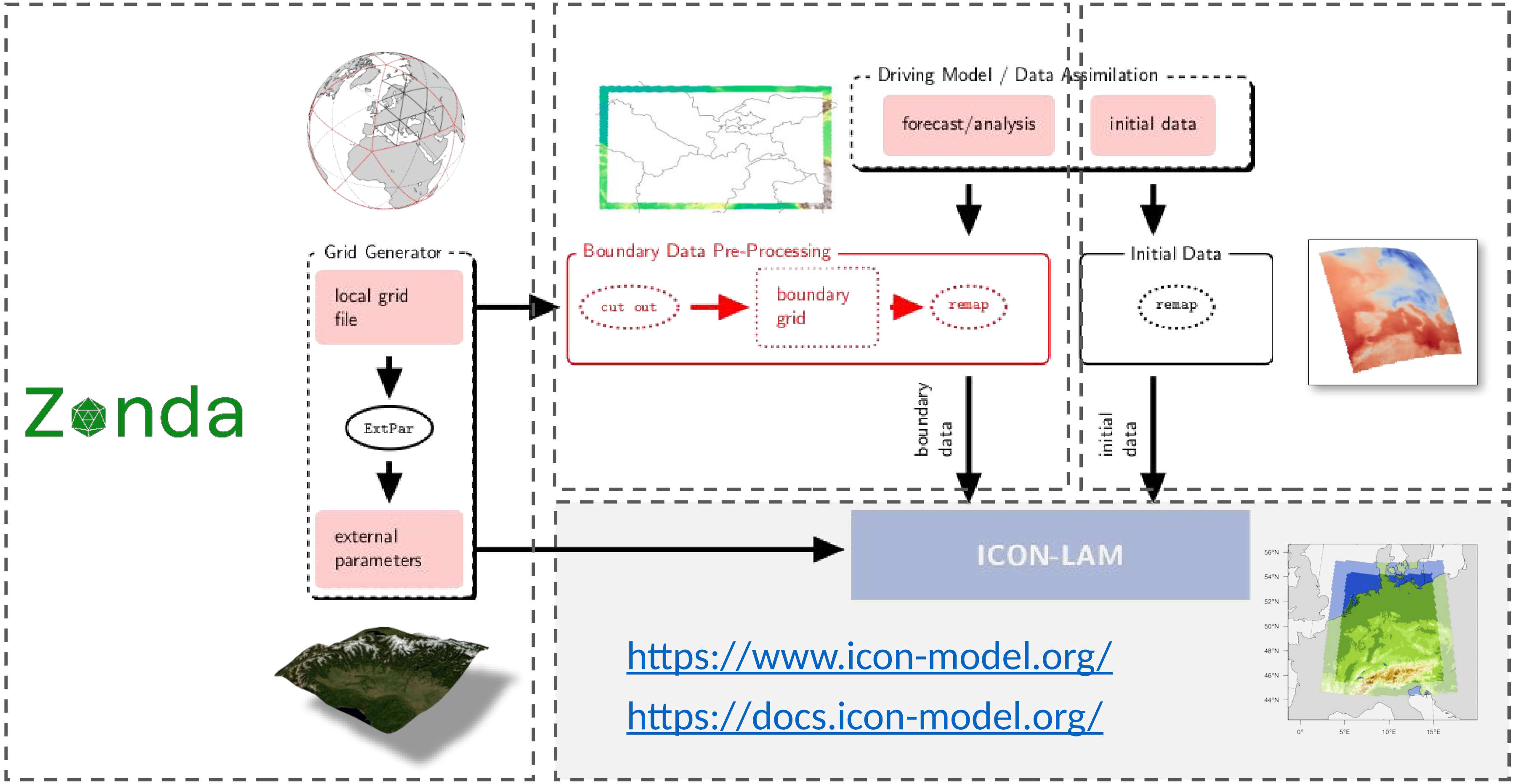
Summary – Lateral Boundary Data

https://www.dwd.de/EN/ourservices/pamore/pamore.html

https://www.ecmwf.int/en/forecasts/accessing-forecasts



Summary – Everything Ready for ICON(-LAM)



https://www.icon-model.org/

https://docs.icon-model.org/

Questions

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