ATOM: the Almighty Topography Modifier

Tutorial

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Program overview

Why & when do i need ATOM?

ATOM is written in Python and was developed to prepare input files for the large-eddy simulation model PALM[1] in case of simulation of complex terrain sites using non-cyclic boundary conditions (BC).

The implementation of non-cyclic BC in PALM currently only allows for a mean flow from the left side to the right side of the model domain, which corresponds to the wind direction ”west”.
However in complex environments, the simulation of different wind direction is usually of particular interest to the modeler.

In these cases, the topography data needs to be rotated. Furthermore, additional modifications, which are required by the non-cyclic BC, are applied.

[1] see `https://palm.muk.uni-hannover.de`

What can ATOM do?

- Data I/O
  - Read/write topography in ASCII format[2]
  - Automated creation of the main PALM parameter file (`_p3d`) using user-defined templates
- Interpolate topography to gridspacing used in PALM
- Modify for non-cyclic BC
  - Rotate topography
  - Add flat inflow and outflow planes
  - Smooth transitions to real topography
  - Cyclic transition in direction perpendicular to mean flow
- Rotate coordinates of, e.g., wind turbines/met masts/...
- Already supports PALM's new nesting method

[2] No netCDF support yet. However, can be easily implemented if requested.

Installation

Installation

ATOM can be downloaded to a folder of your choice on your computer and can be used right away.

Get ATOM from:

```
https://github.com/boeske/atom
```

Clone branch master using git:

```
$ cd /home/username/some/folder
$ git clone https://github.com/boeske/atom.git
```

Execute ATOM inside this folder:

```
$ python3 atom.py
```

Required Python packages

Make sure the following Python packages are installed on your system and are available to `python3`:

- numpy
- scipy
- matplotlib
+ netCDF4 (for future releases)

These packages should appear in the output of

```
$ python3 -m pip list
```

Configuration

Required input files

If executed, ATOM will need the following input files (relative paths):

`atom.ini`

- Contains all steering parameters ATOM which can be set by the user

`input/some_topo_file.txt`

- ASCII table containing topography data on a regular grid
- Path can be set `atom.ini`

`templates/some_example_p3d`

- This is PALM's main parameter file
- Define a PALM simulation setup and let ATOM fill out the remaining parameters
- Path can be set in `atom.ini`

The `atom.ini` file

ATOM is configured via a standard INI file which has to be edited by the user.

Example `atom.ini` file (Part 1)

```
[Name]
case_name = example                          # Run-ID of PALM Simulation

[Plotting]
plotting = True                              # Create additional plots during the modification
dpi_value = 300                              # Resolution (DPI) of output PNG-graphic

[InputData]
inputfile = example/example_topo.txt         # Relative path to input file
dx_raw = 20.0                                # Specify spatial resolution of input data (m)
origin_x = 431410.                          # x-Coordinate of lower left corner of input
                                             #   topography map (UTM ED50)
origin_y = 4733200.                          # y-Coordinate of lower left corner of input
                                             #   topography map (UTM ED50)
p3d_template = example/example_template_p3d  # Relative path to PALM parameter file template

[Meteorology]
wdir = 240.                                  # Set wind direction (needed for rotation of
                                             #   topography data)
```

The atom.ini file

Example atom.ini file (Part 2)

```
   .
   .
   .

[ModelDomain]
dx = 5.0                  # Gridspacing used in PALM Simulation
Dx_left          = 4000.  # Unmodified topography upstream of turbines (m)
Dx_right         = 250.   # Unmodified topography downstream of turbines (m)
Dy               = 1000.  # Unmodified topography north/south of turbines (m)
Lx_inflow        = 5500.  # Length of the flat inflow plane (m)
Lx_outflow       = 2800.  # Length of the flat outflow plane (m)
Lx_smooth_left   =  250.  # Length of the smooth transition from flat inflow to real topography (m)
Lx_smooth_right  = 1000.  # Length of the smooth transition from real topography to flat outflow (m)
Ly_cyclic        =  500.  # Width of cyclic transition in y-direction (m)


   .
   .
   .
```

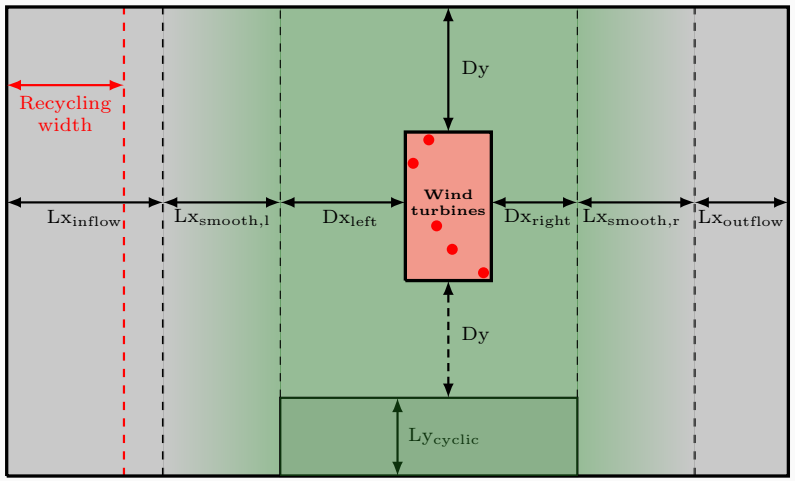


Fig.: Structure of PALM model domain in case of complex terrain simulations. The value (in meter) of each subdomain size parameter is defined in `atom.ini`.
Make sure that the recycling width in your PALM simulation is considerably smaller than `Lx_inflow`.

The `atom.ini` file

Example `atom.ini` file (Part 3)

```
   .
   .
   .

[ProcessorGrid]
ngp_x = 16       # Numbers of grid points per processor (x-direction) in PALM simulation
ngp_y = 16       # Numbers of grid points per processor (y-direction) in PALM simulation

[WindTurbines]
n_turbines = 15                       # Number of virtual wind turbines in PALM simulation
coordinates_1  = [441375, 4744262]    # Coordinates [x, y] of the turbines
coordinates_2  = [441612, 4743487]    #   (same format as origin_x/y !!)
coordinates_3  = [441811, 4742686]



  .
  .
  .

coordinates_14 = [441234, 4747357]
coordinates_15 = [449876, 4741325]
```

The p3d file

Example p3d file

```
&inipar

 !!! Numerical Grid
        nx = <nx>,
        ny = <ny>,
        nz = 336,

        dx = <dx>,
        dy = <dy>,
        dz = <dz>,

 !!! Initialization
        initializing_actions  = 'cyclic_fill',



  .
  .
  .

&userpar

        do_wind_turbines = .T.,
        n_turbines = <n_turbines>,

        wka_x = <wka_x>,
        wka_y = <wka_y>,
        /
```

All variables with angle brackets (e.g., <nx>) will be replaced with values by ATOM.

Example of usage

Example files

ATOM comes with a complete set of example files, which can be used to test ATOM on your system and to learn how to use it. The following files can be found in the `example`-folder:

- Artificial example topography file (`example_topo.txt`)
  - ASCII format
  - 1000×1000 grid points
  - $\Delta x = 20\,\text{m} \rightarrow 20\,\text{km} \times 20\,\text{km}$
- Example parameter file for PALM (`example_template_p3d`)
  - The variables **nx, ny, nz, dx, dy, dz, npex, npey, wka_x, wka_y** will be replaced by ATOM
- Example `atom.ini`

Test ATOM using the example files

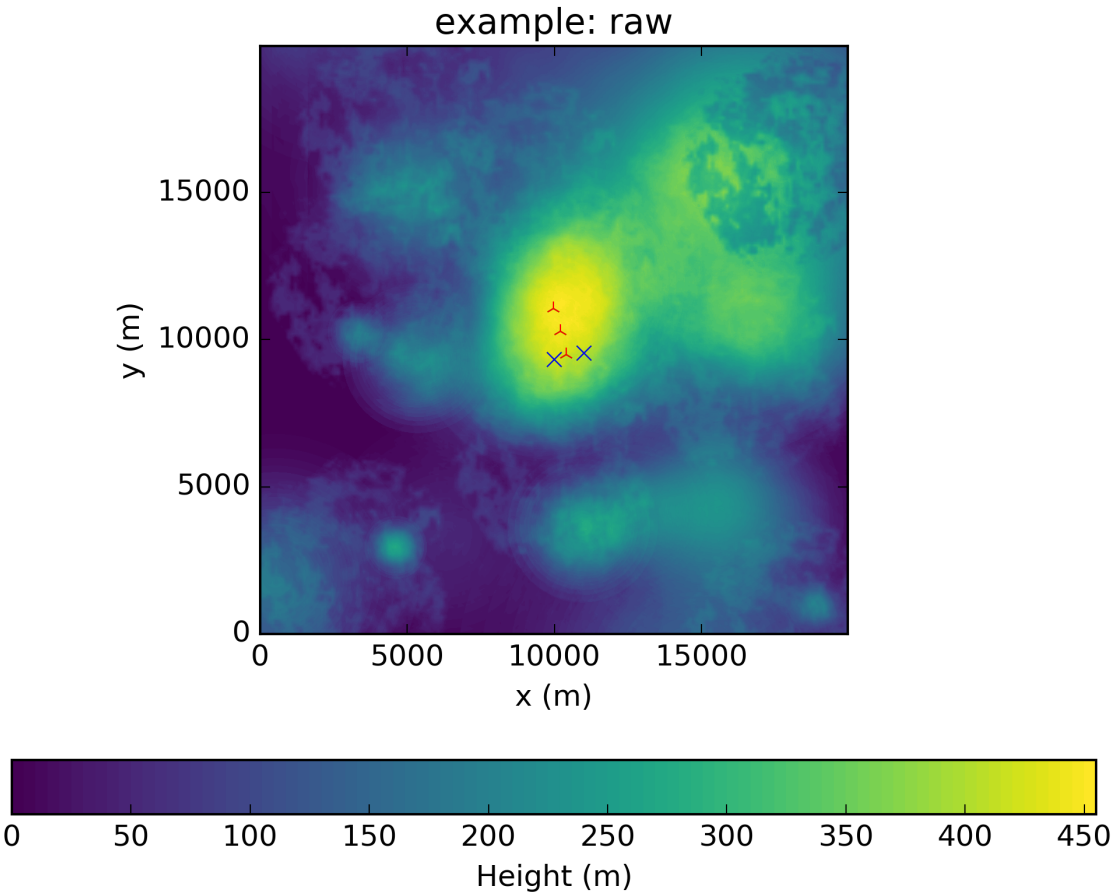
First, change into ATOM's base directory and open a terminal.

Copy the example ini-file into the base directory and run ATOM

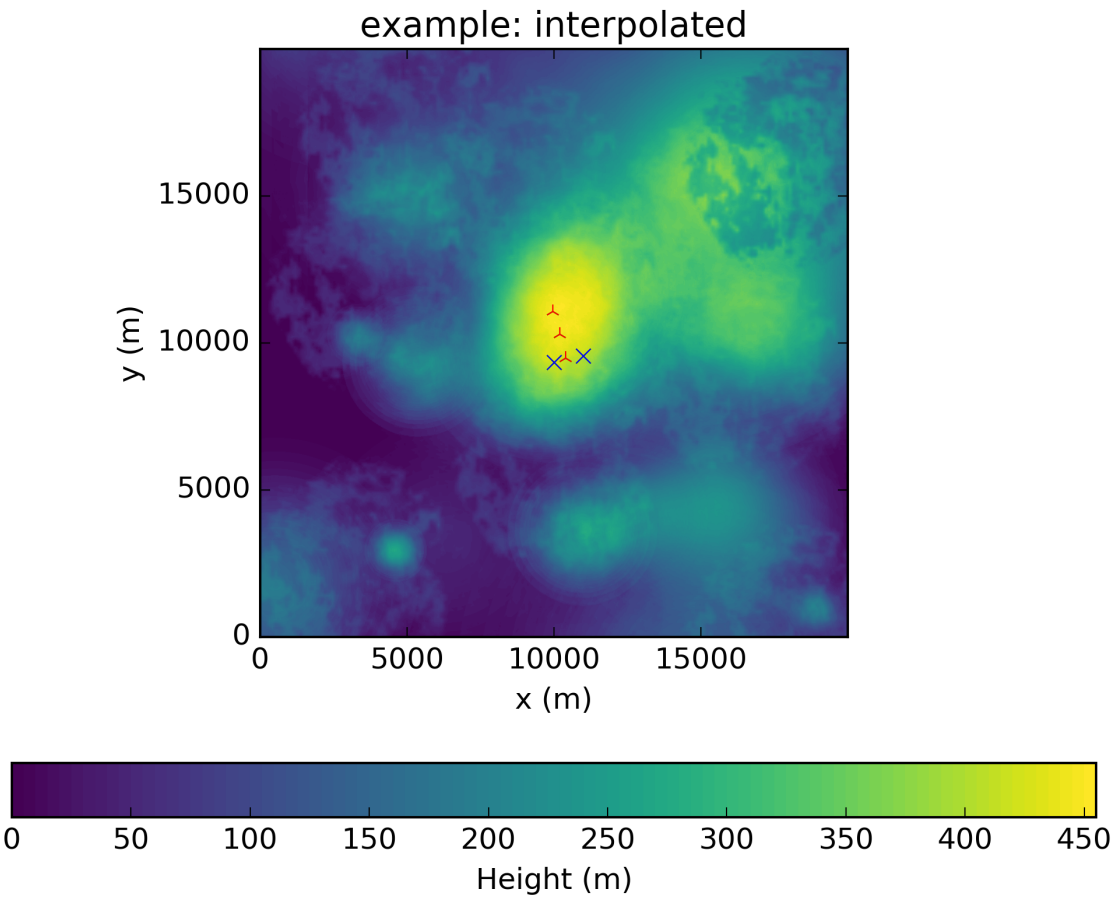
```
$ cp example/atom.ini .
$ python3 atom.py
```

If ATOM runs without error your output data will be saved in `output/example/`.

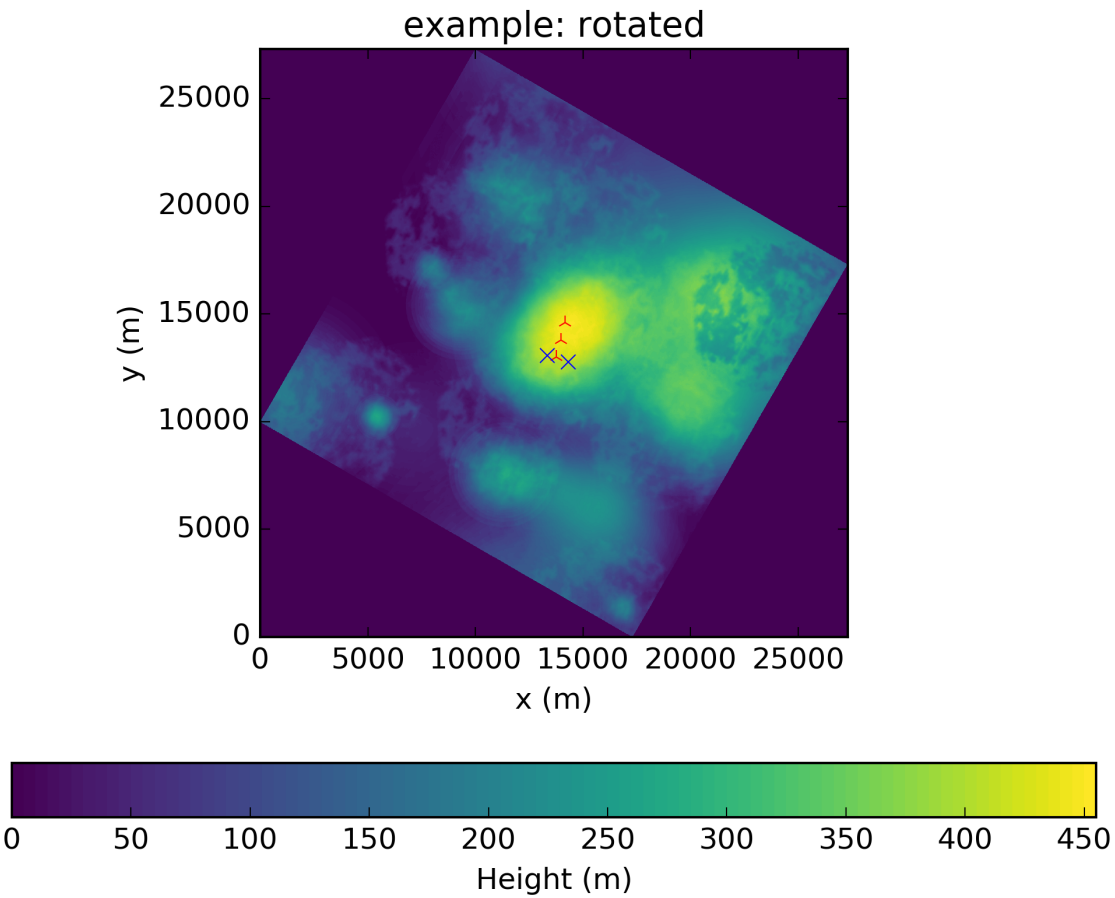
1) Raw input topography



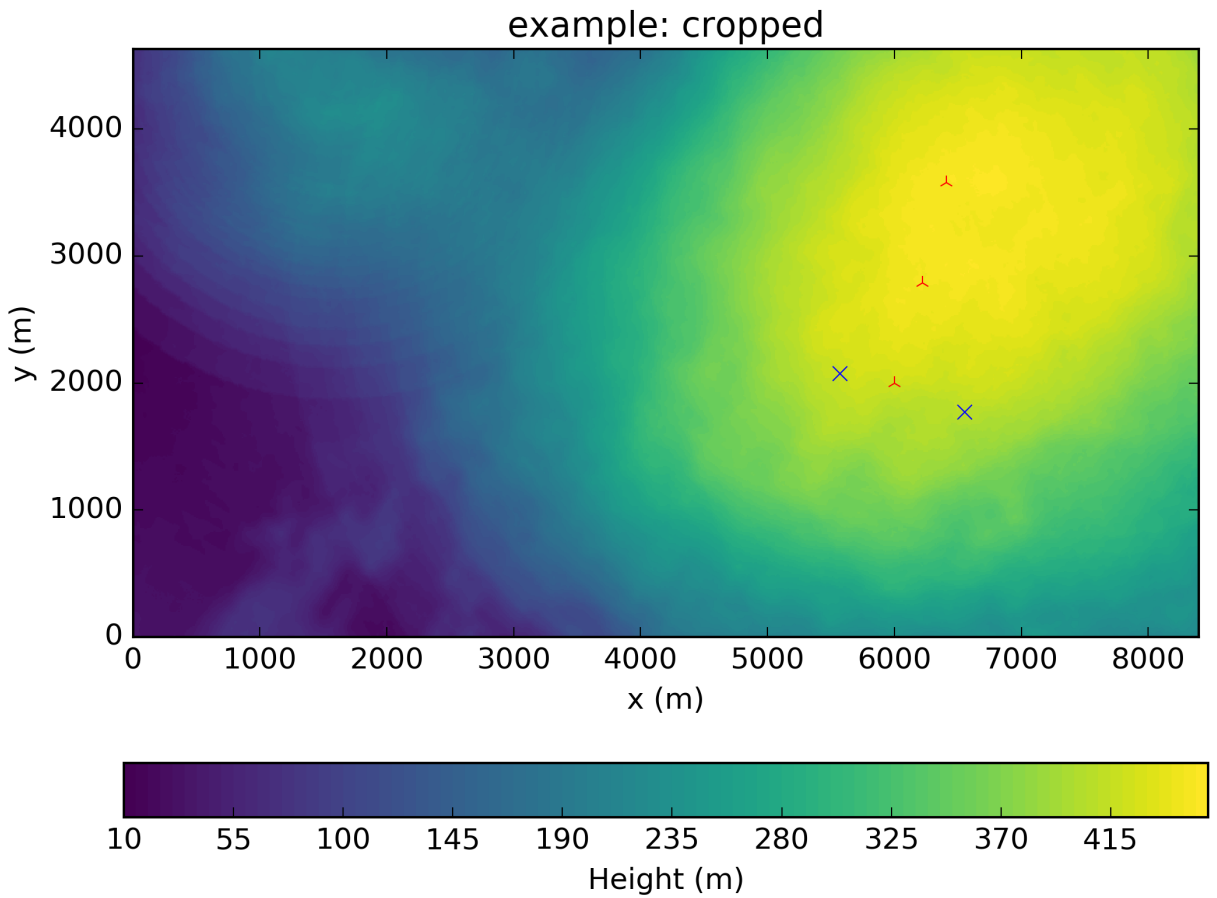
2) Interpolated topography



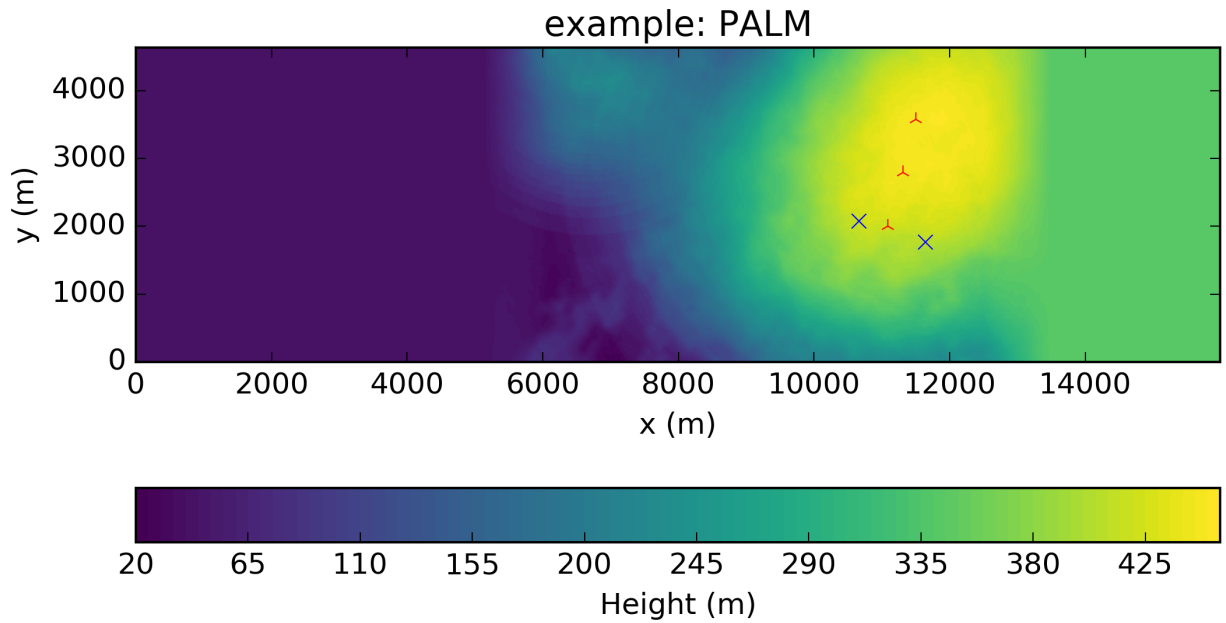
3) Rotated topography



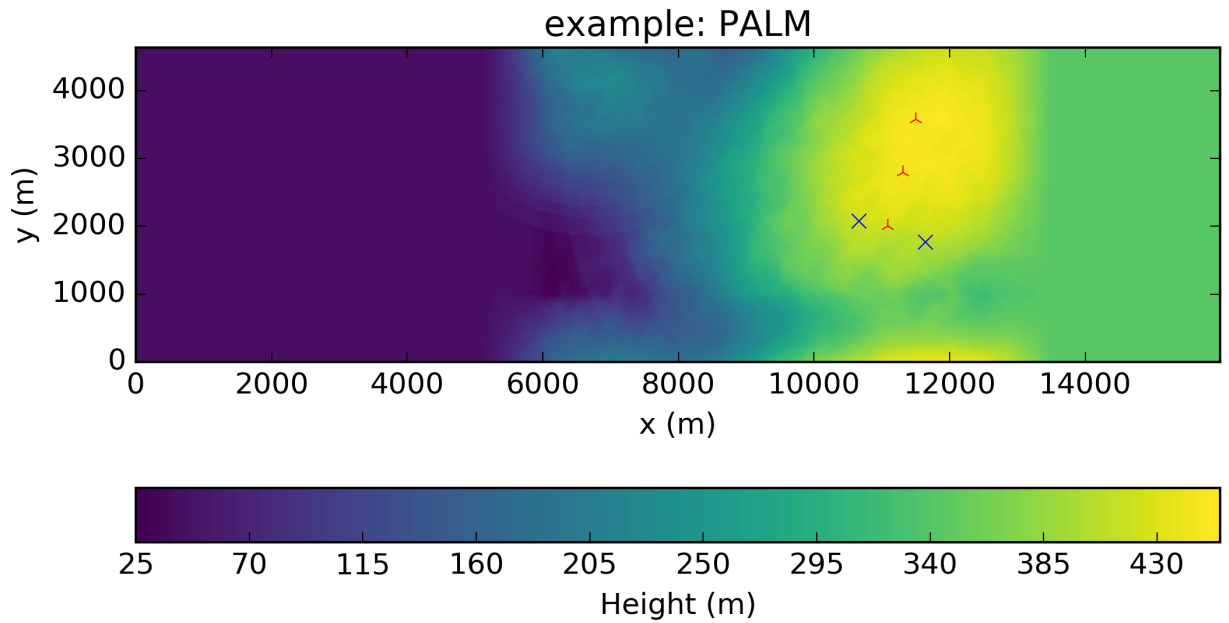
4) Cropped topography



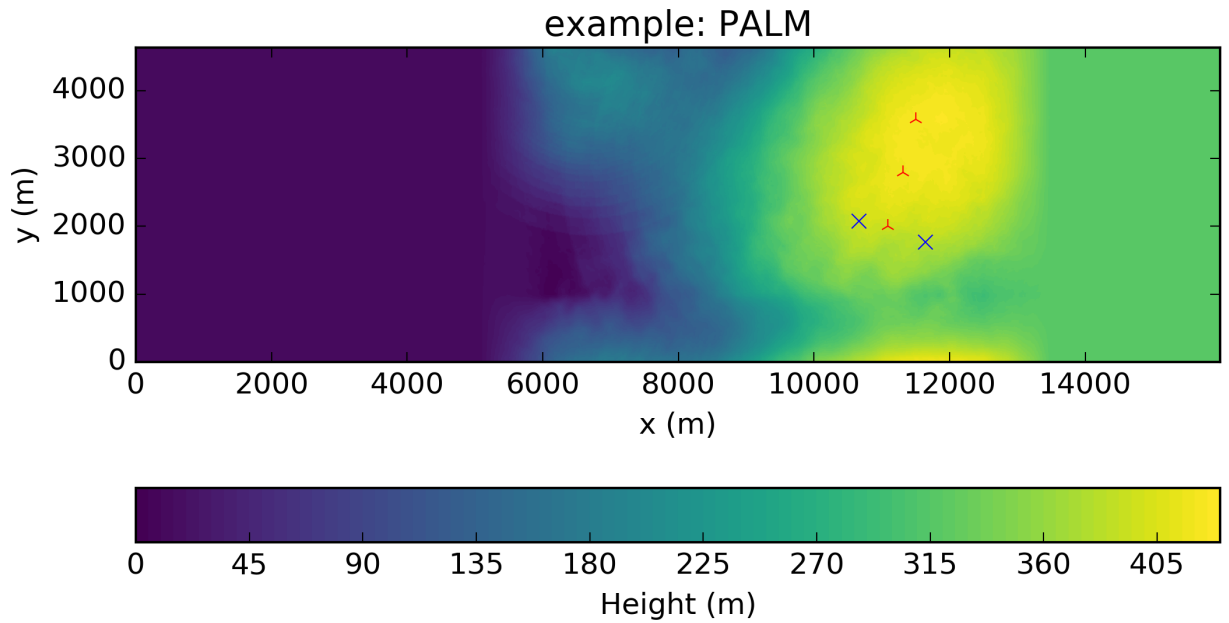
5) Added in- and outflow plane



6) Cyclic transition in y-direction



7) Final topography (set lowest point to $z = 0$)



Nesting-Mode

Nesting method

This section will follow soon.