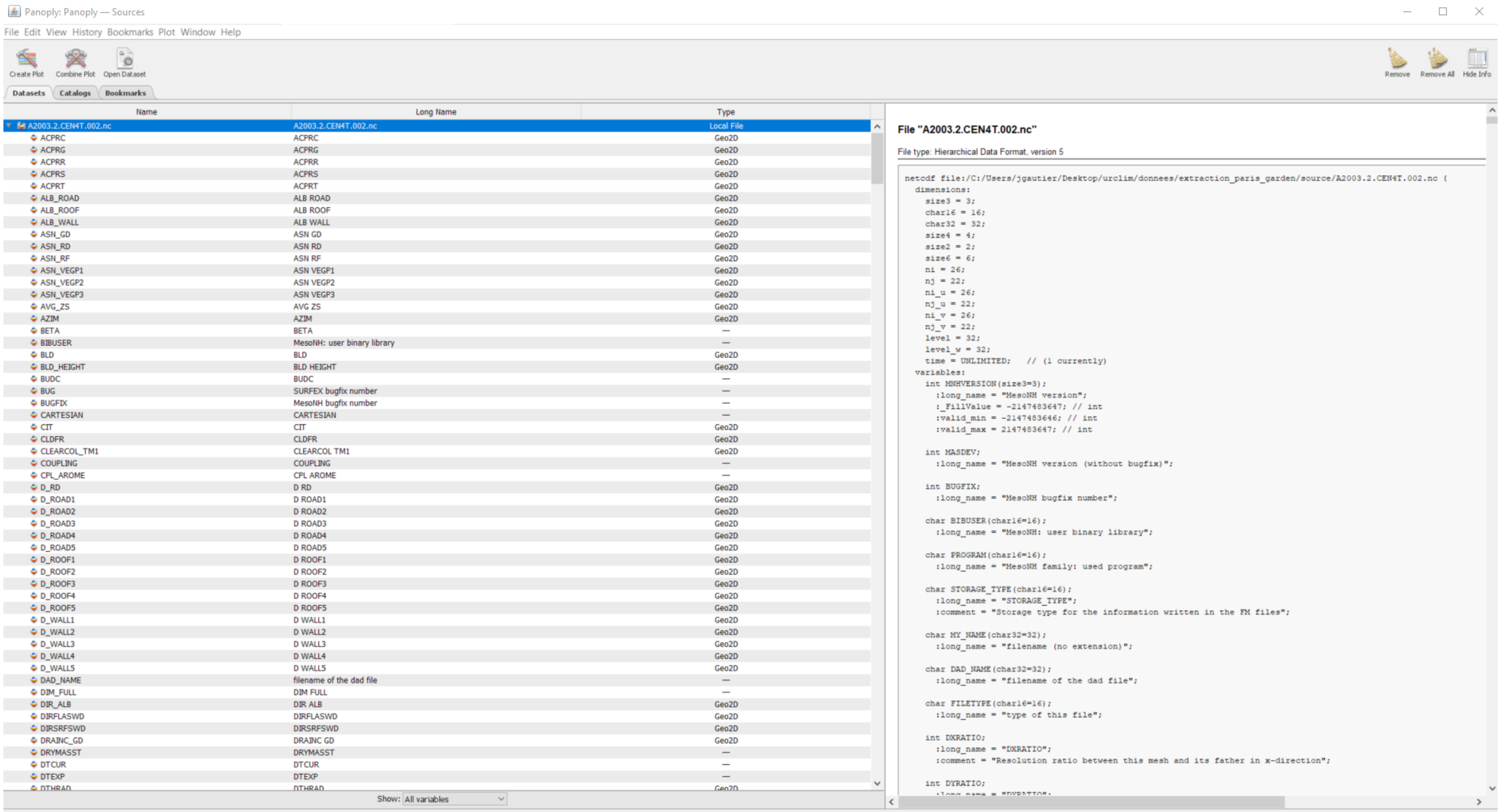
Climate data:
Centre national de recherches météorologiques (CNRM, Météo France)
NetCDF



Software: panoply

NetCDF

Multidimensional array file

CNRM NetCDF file

Containing:

- Climate simulated data, obtained with Meso-NH and TEB simulation models:
    - Temperature data
    - Pressure data
    - Wind data
- Input data for the simulation model:
    - Albedo
    - Surface elevation
    - …
- Simulation model information:
    - Climate data coordinates
    - …

```
netcdf file:/C:/Users/jgautier/Desktop/urclim/donnees/extraction_paris_garden/source/
  dimensions:
    size3 = 3;
    char16 = 16;
    char32 = 32;
    size4 = 4;
    size2 = 2;
    size6 = 6;
    ni = 26;
    nj = 22;
    ni_u = 26;
    nj_u = 22;
    ni_v = 26;
    nj_v = 22;
    level = 32;
    level_w = 32;
    time = UNLIMITED;   // (1 currently)
  variables:
    int MNHVERSION(size3=3);
      :long_name = "MesoNH version";
      :_FillValue = -2147483647; // int
      :valid_min = -2147483646; // int
      :valid_max = 2147483647; // int

    int MASDEV;
      :long_name = "MesoNH version (without bugfix)";

    int BUGFIX;
      :long_name = "MesoNH bugfix number";

    char BIBUSER(char16=16);
      :long_name = "MesoNH: user binary library";

    char PROGRAM(char16=16);
      :long_name = "MesoNH family: used program";

    char STORAGE_TYPE(char16=16);
      :long_name = "STORAGE_TYPE";
      :comment = "Storage type for the information written in the FM files";

    char MY_NAME(char32=32);
      :long_name = "filename (no extension)";

    char DAD_NAME(char32=32);
      :long_name = "filename of the dad file";
```

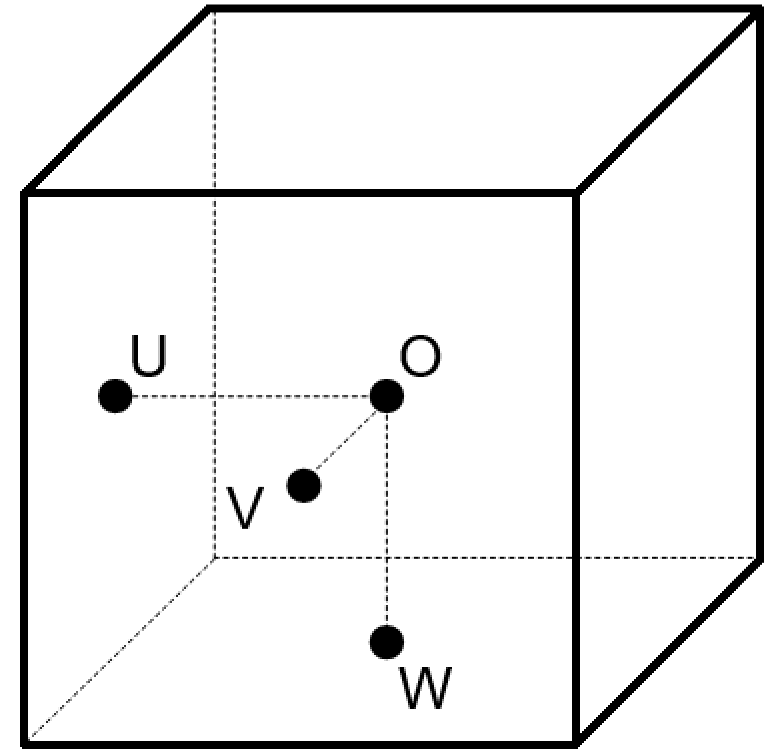
Meso-NH data

Correspond to climate data simulated above buildings rood

Climate data are simulated for a 3D grid

Each Meso-NH grid cell is formed by 4 points:

- O, for which temperature and pressure data are simulated
- U, for which wind speed in UO direction is simulated
- V, for which wind speed in VO direction is simulated
- W, for which wind speed in WO direction is simulated

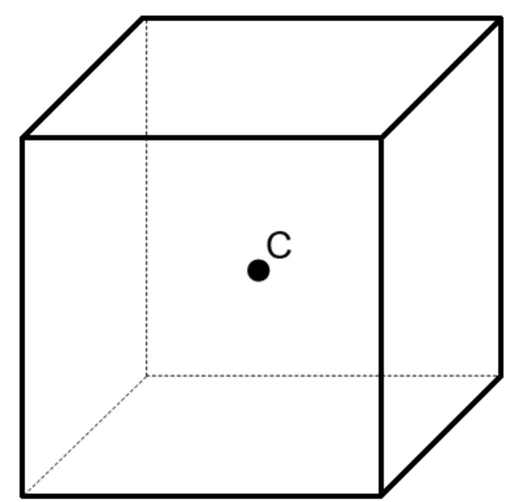


TEB data

Correspond to climate data simulated below the urban canopy

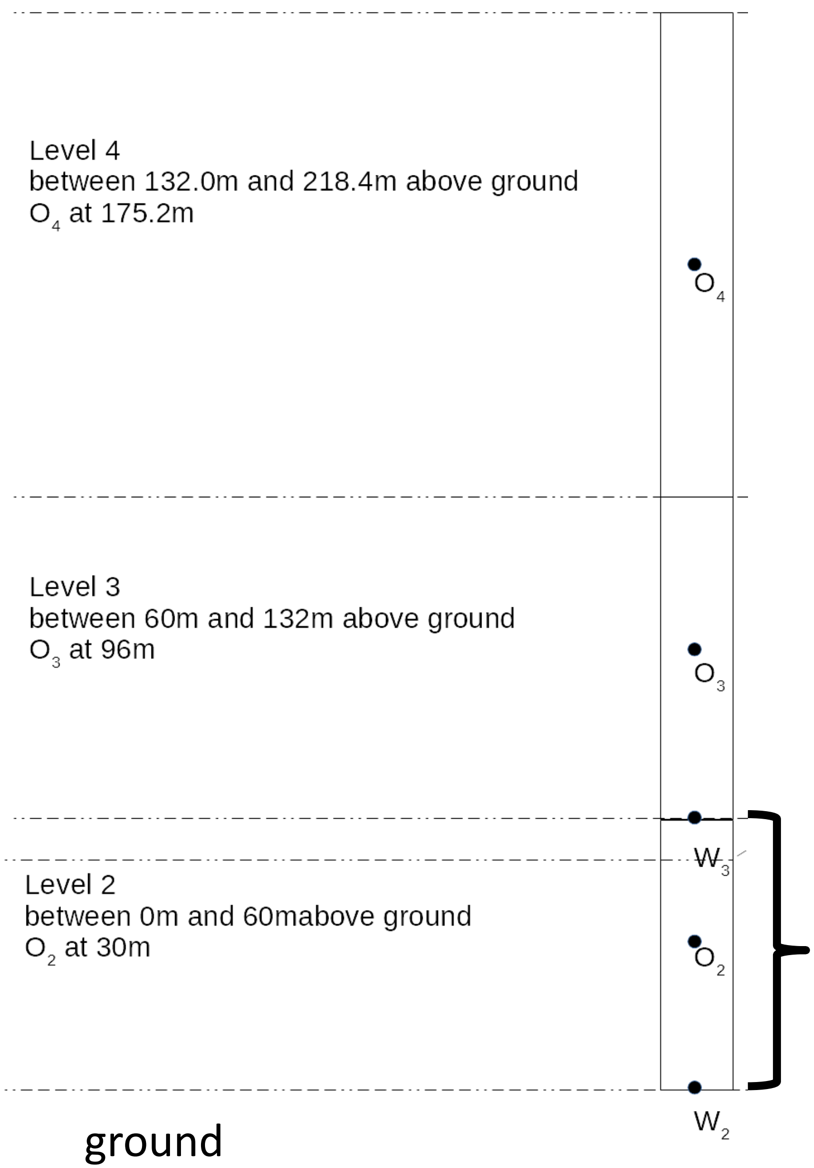
Climate data are simulated for a 3D grid
For each center of a TEB grid cell, following data are simulated:

- Temperature
- Pressure
- Wind data in any direction



TEB and Meso-NH grids share the same XY dimensions and coordinates (WGS84)

Meso-NH model : climate data above buildings roof



For Paris, grid size is:
26 cells East-West
22 cells North-South

Along vertical axis:
Meso-NH has 32 levels, whose thickness grows with elevation (60m -> 350m)

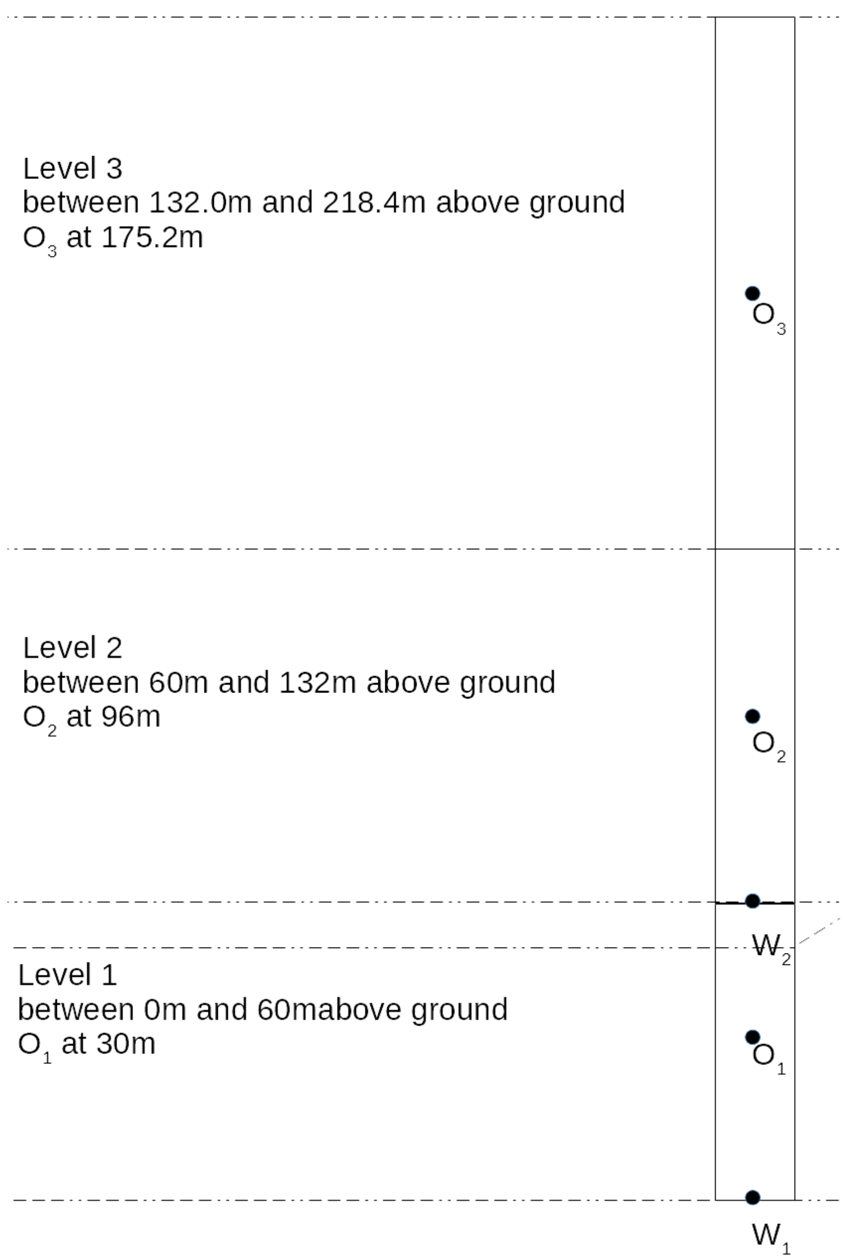
Meso-NH level 2: first Meso-NH level taken into account

Meso-NH level 1 is considered as below the ground (between -60m and 0m)

Level 2 is considered as above buildings roofs
Buildings are considered as below the ground surface

TEB and Meso-NH grids share the same XY dimensions and coordinates (WGS84)

Meso-NH model : climate data above buildings roof



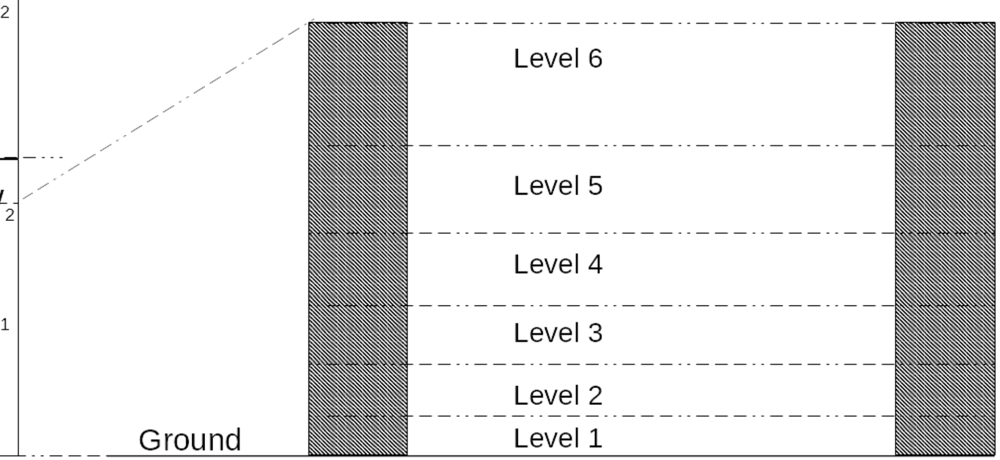
For Paris, grid size is:
26 cells East-West
22 cells North-South

Along vertical axis:

Meso-NH has 32 levels, whose thickness grows with elevation (60m -> 350m)

TEB grid has 6 levels, whose thickness grows with elevation (0.5m -> 29m)

TEB model : climate data below urban canopy



TEB and Meso-NH grids share the same XY dimensions and coordinates (WGS84)

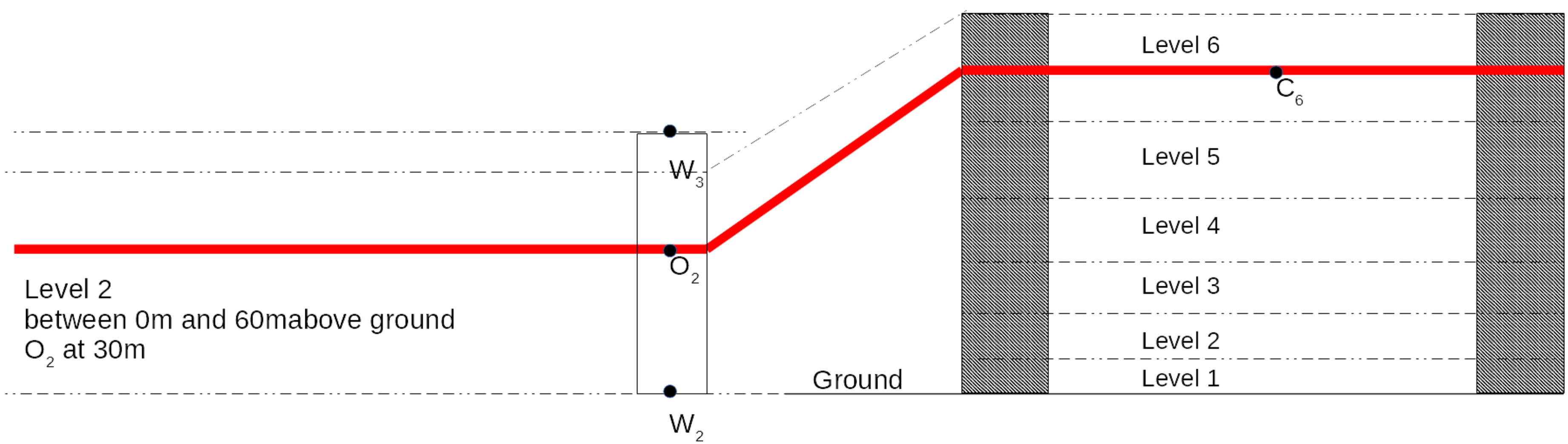
For Paris, grid size is:
26 cells East-West
22 cells North-South

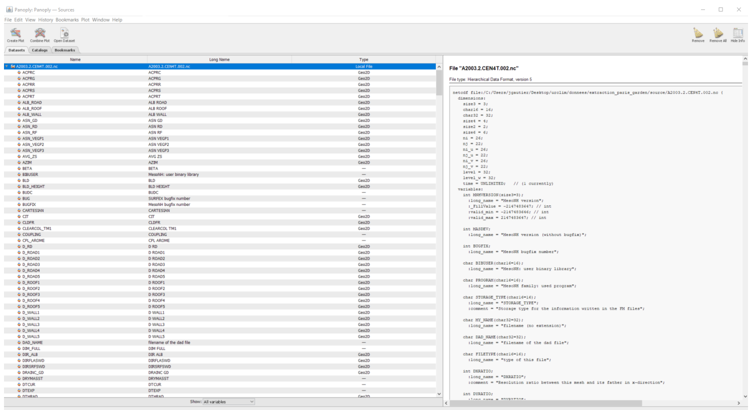
Along vertical axis:

Meso-NH has 32 levels, whose thickness grows with elevation (60m -> 350m)

TEB grid has 6 levels, whose thickness grows with elevation (0.5m -> 29m)

Center of TEB level 6 cells corresponds to center of MesoNH level 2 cells





10 dimensions :

- i_O (x), j_O (y),
- i_U (x), j_U (y),
- i_V (x), j_V (y),
- i_W (x), j_W (y),
- level (z)
- Level_W (z)

x variables

Latitude_O(i,j)
Longitude_O(i,j)

List of 2D points O

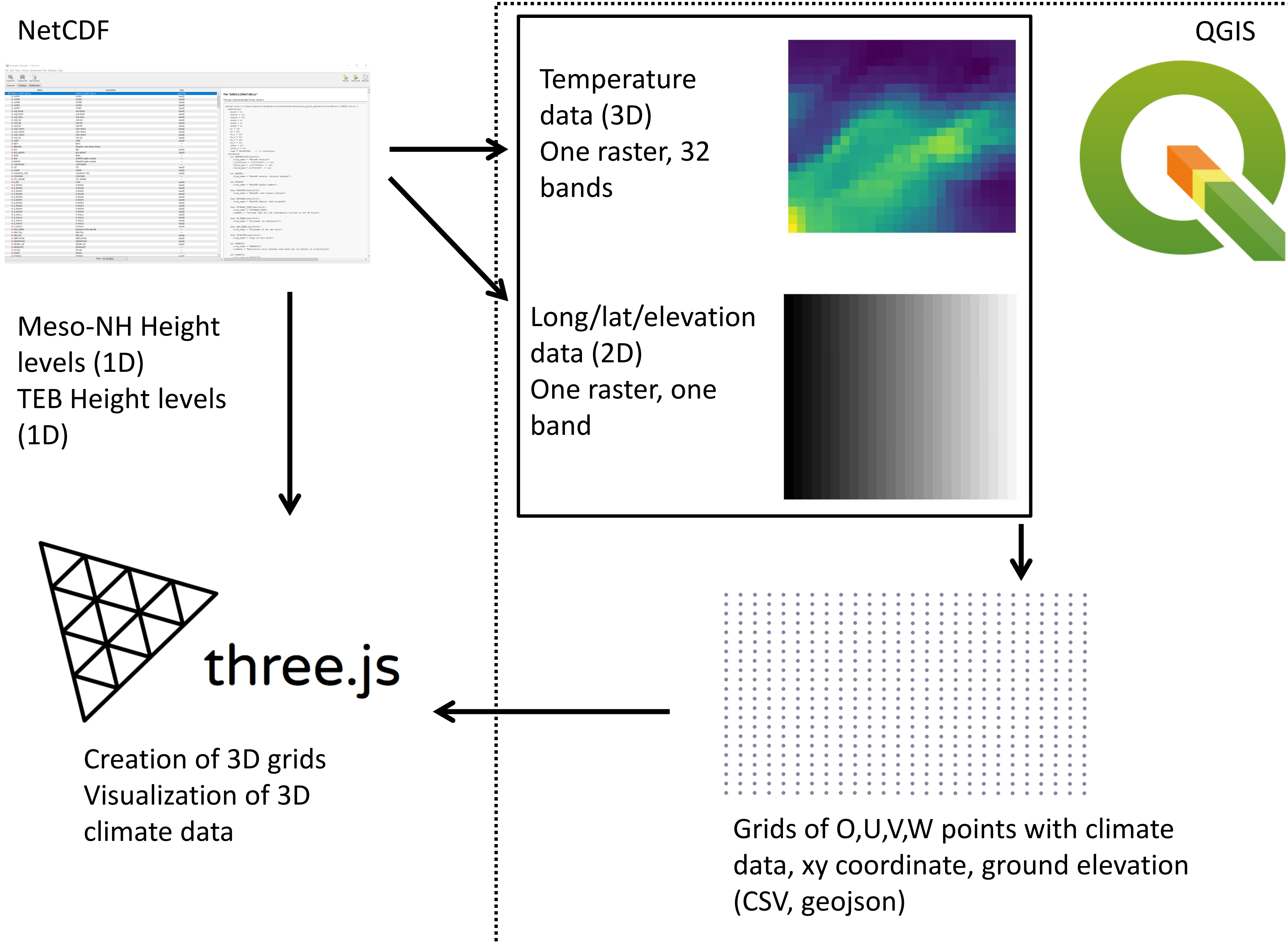
List of 3D points O

List of 3D points O with temp. values

zs(i,j) : surface altitude

height(level)

Temperature(i,j,level)


NetCDF
Meso-NH Height levels (1D)
TEB Height levels (1D)
QGIS
Temperature data (3D)
One raster, 32 bands
Long/lat/elevation data (2D)
One raster, one band
Grids of O,U,V,W points with climate data, xy coordinate, ground elevation (CSV, geojson)
three.js
Creation of 3D grids
Visualization of 3D climate data

Grids of O,U,V,W points with climate data, xy coordinate, ground elevation (CSV, geojson)

O points grid:

- Lat, long (WGS84); X,Y (Lambert93)
- ZS
- Building heights
- Pressure for 31 levels (PABST2 - PABST32)
- Potential temperature for 31 levels (THT2 - THT32)
- TEB temperature for 6 levels (TEB_CAN_T01 - TEB_CAN_T06)
- TEB pressure for 6 levels (TEB_CAN_P01 - TEB_CAN_P06)
- TEB wind data for 6 levels (SSO_CAN_U01 - SSO_CAN_U06)
- ISBA temperature for 6 levels (ISBA_CAN_T01 - ISBA_CAN_T06)

U points grid:

- Lat, long (WGS84); X,Y (Lambert93)
- ZS
- Wind for 31 levels (UT2 - UT32)

V points grid:

- Lat, long (WGS84); X,Y (Lambert93)
- ZS
- Wind for 31 levels (VT2 - VT32)

W points grid:

- Lat, long (WGS84); X,Y (Lambert93)
- ZS
- Wind for 31 levels (WT2 - WT32)

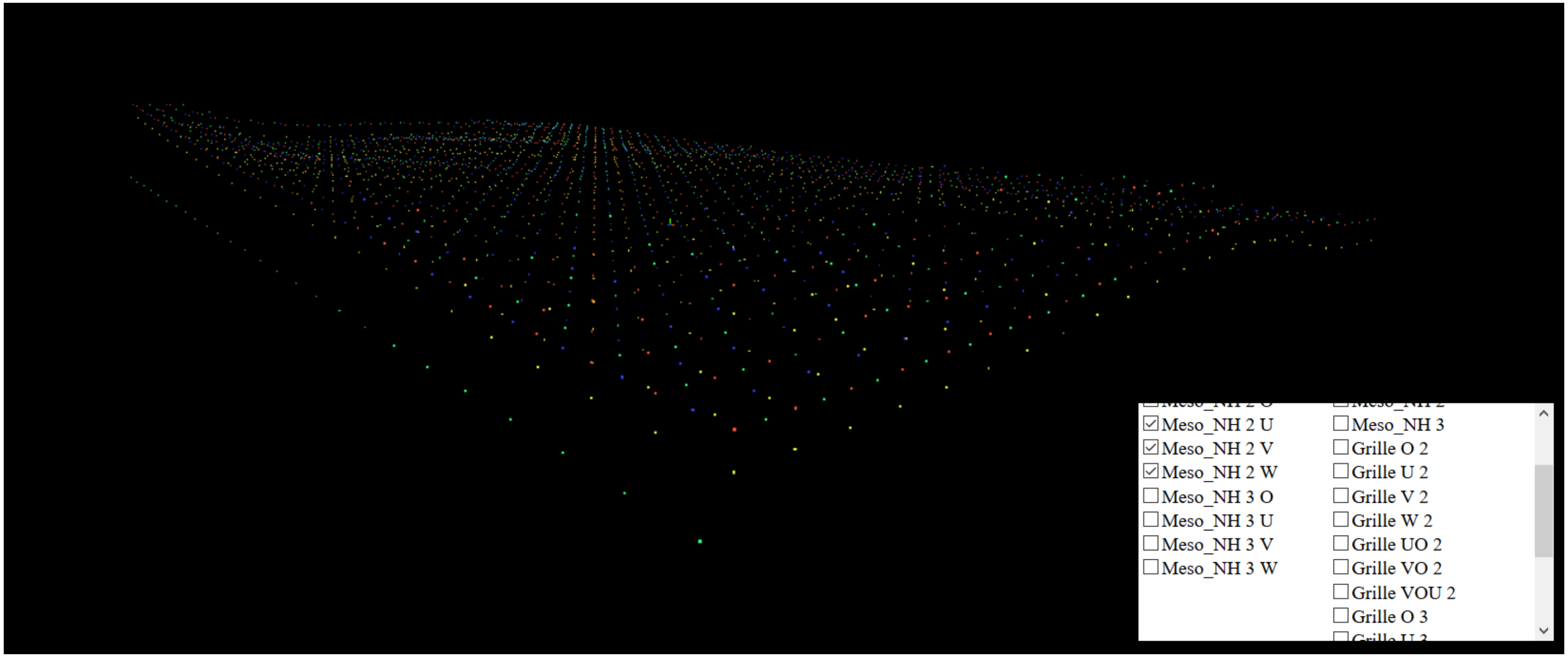
Meso-NH Height levels (1D)

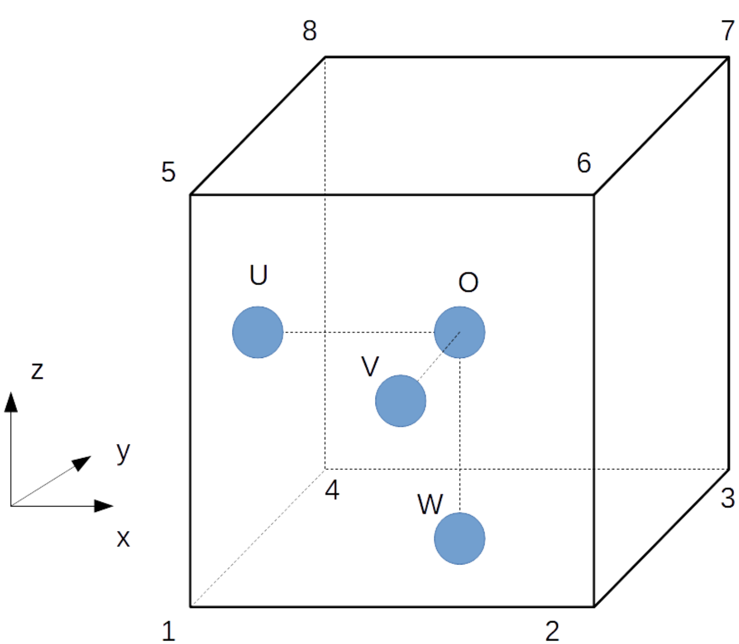
2 * 1D lists (O, W heights)

TEB Height levels (1D)

2 * 1D lists (C, cells bottom heights)

Visualization of TEB and Meso-NH points and grids





1 : $x = x_U$
$y = y_V$
$z = z_W$

2 : $x = x_O + (x_O - x_U)$
$y = y_V$
$z = z_W$

3 : $x = x_O + (x_O - x_U)$
$y = y_V + (y_O - y_V)$
$z = z_W$

4 : $x = x_U$
$y = y_V + (y_O - y_V)$
$z = z_W$

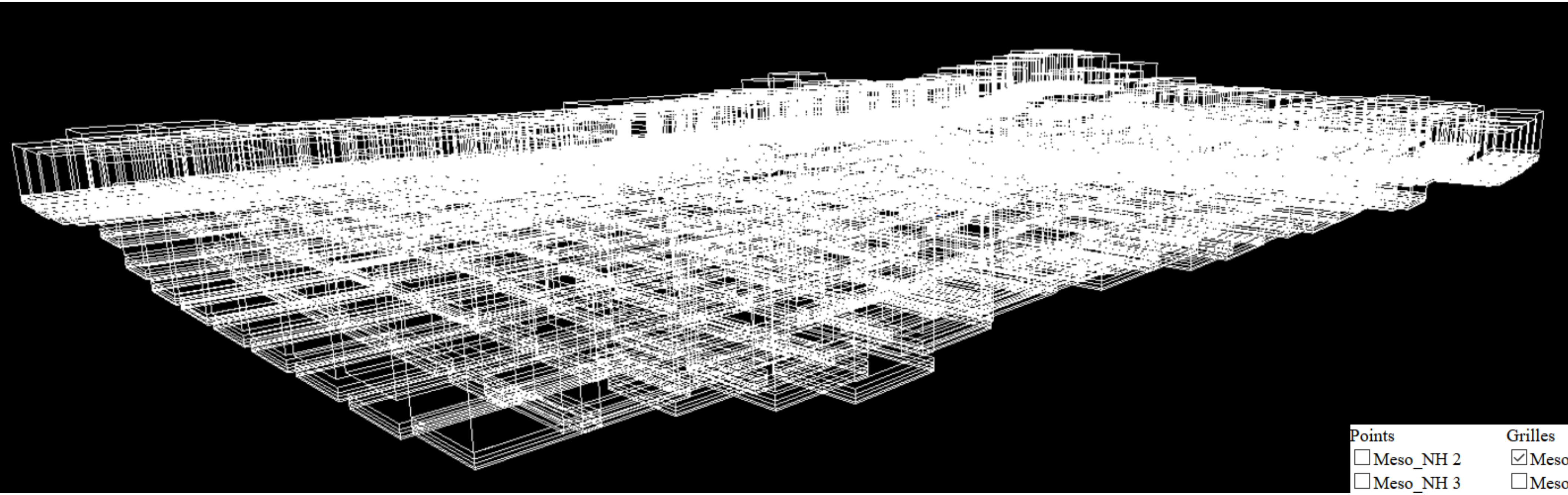
5 : $x = x_U$
$y = y_V$
$z = z_O + (z_O - z_W)$

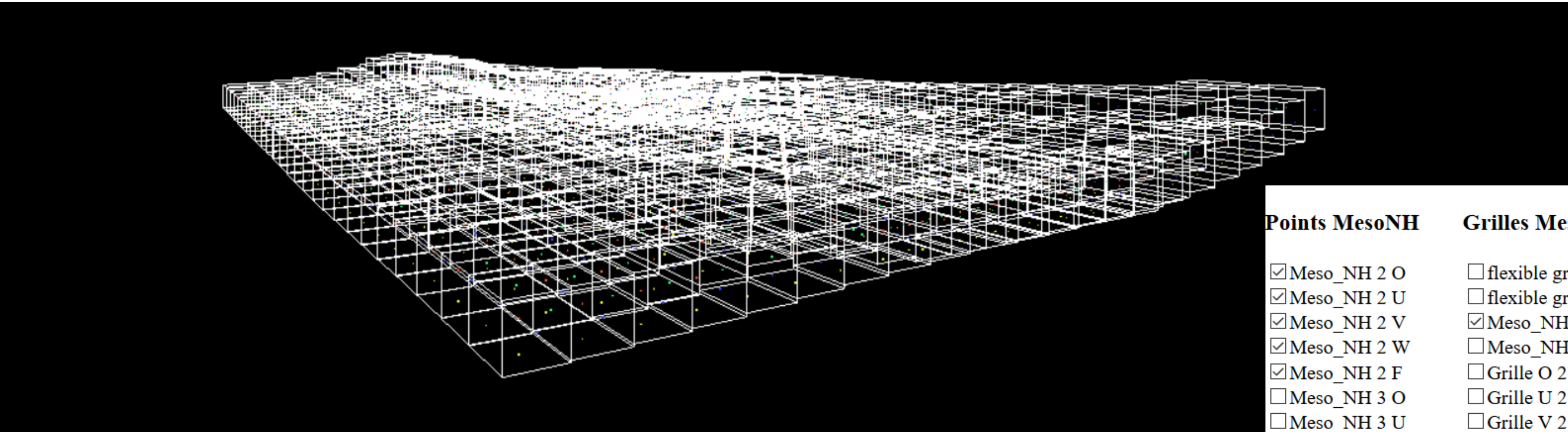
6 : $x = x_O + (x_O - x_U)$
$y = y_V$
$z = z_O + (z_O - z_W)$

7 : $x = x_O + (x_O - x_U)$
$y = y_V + (y_O - y_V)$
$z = z_O + (z_O - z_W)$

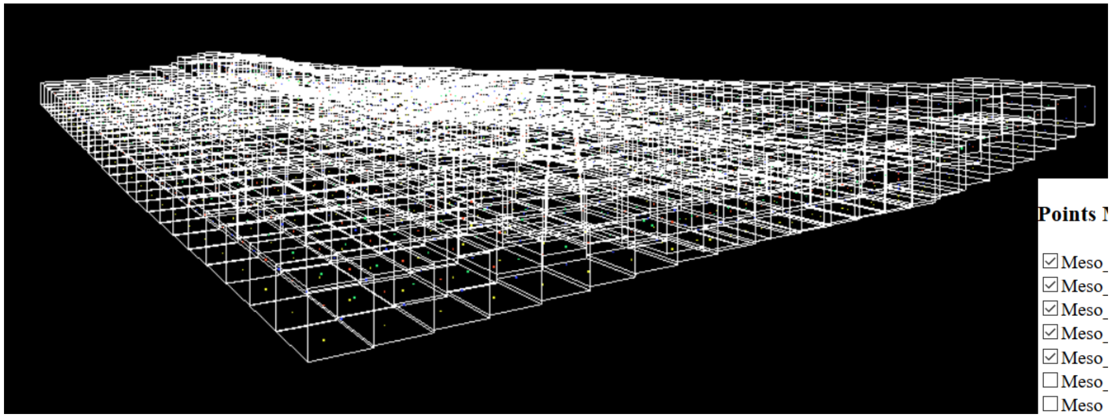
8 : $x = x_U$
$y = y_V + (y_O - y_V)$
$z = z_O + (z_O - z_W)$

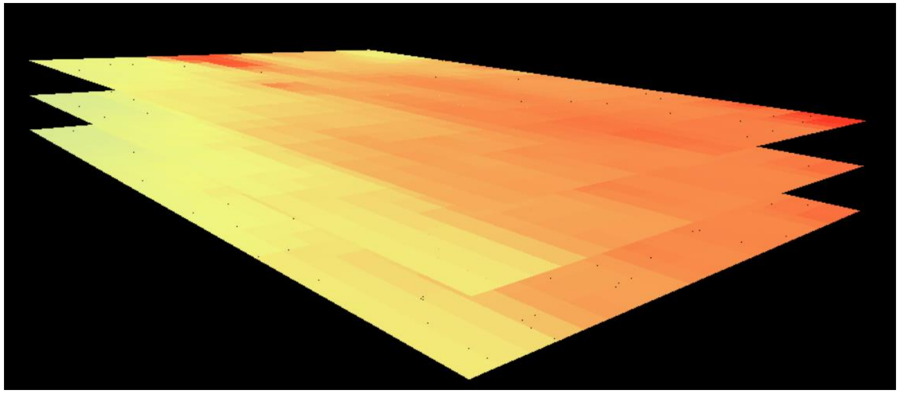
Visualization of TEB and Meso-NH grids

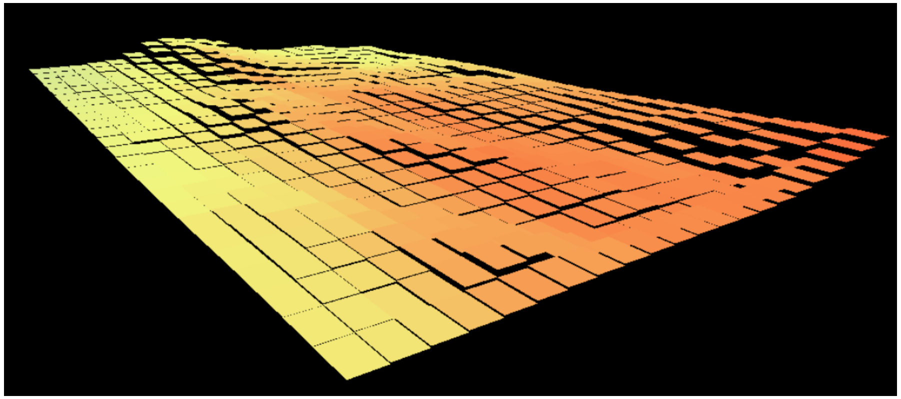


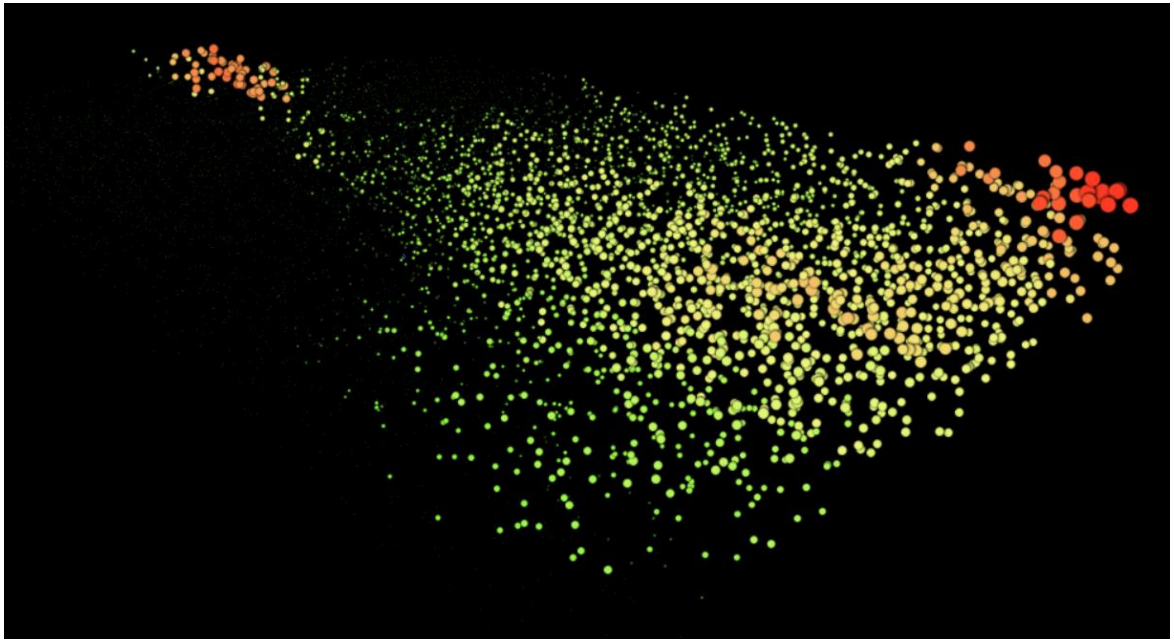


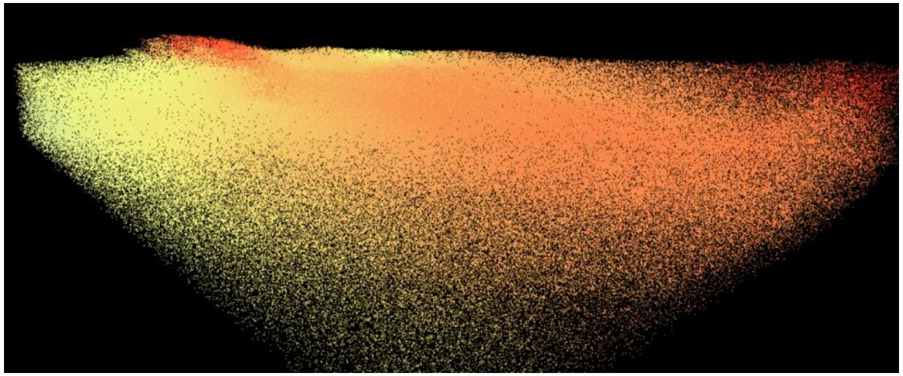
How visualize temperature data in 3 dimensions











Questions:

Vertical coordinates of points
Z Offset between ground and data z coordinates
ZS? MNT or MNE? (O point for beaubourg case study: ZS = 46.81231; MNT = 35)
Beaubourg case study: large offset between data z coordinate and buildings coordinates

Vertical coordinates

- Vertical coordinate of **Gal-Chen et Sommerville** :

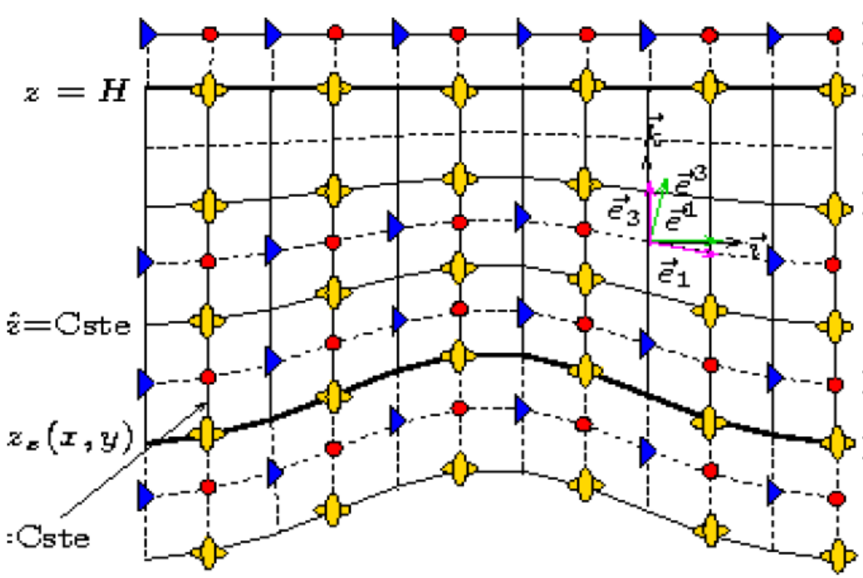
$$\hat{z}(k) = \frac{z(i,j,k) - z_s(i,j)}{H - z_s(i,j)} H$$

z = height of the model level, z_s = Orography

$$z = z_s \rightarrow \hat{z} = 0, \quad z = H \rightarrow \hat{z} = H$$

$$z(i,j,k) = \hat{z}(k) \frac{(H - ZS(i,j))}{H} + ZS(i,j)$$

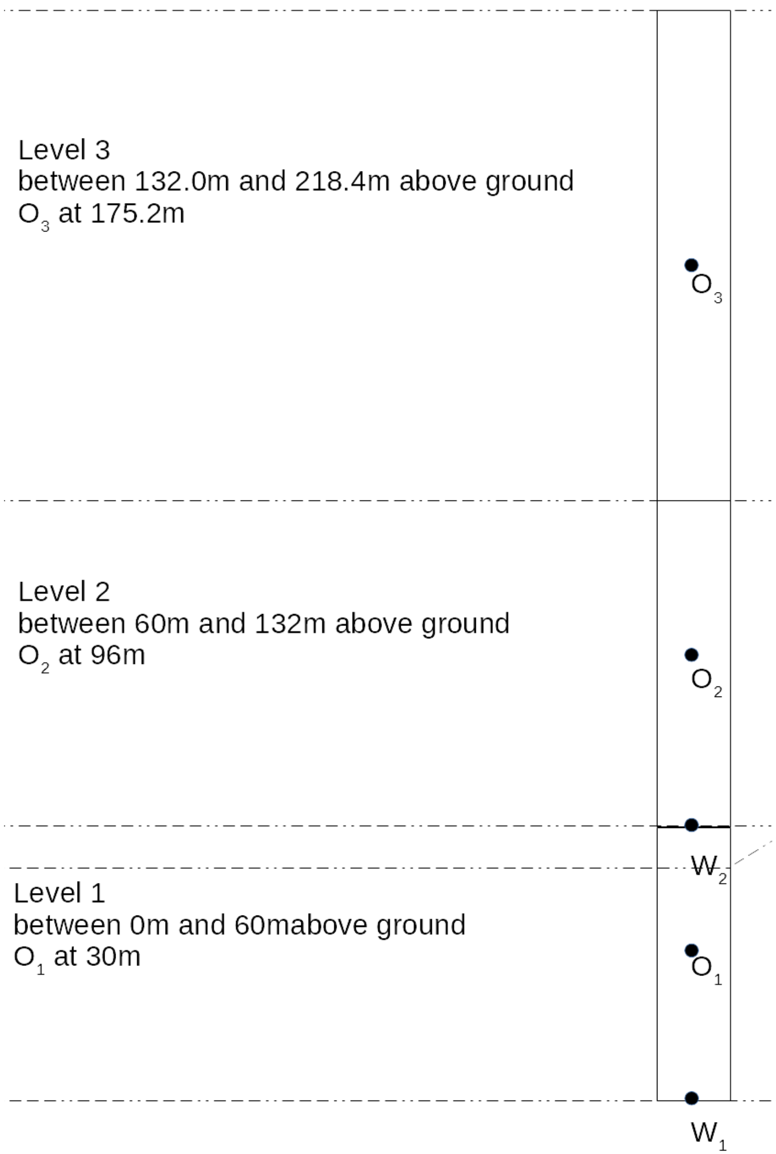
Linear decrease of the orography



$$z(i,j,k) = XZZ : flux \;\; pt$$
$$\hat{z}(k) = XZHAT : flux \;\; pt$$

Questions:

Meso-NH model : climate data above buildings roof



Models
Differences between Meso-NH and TEB
Between TEB and ISBA
SBL?

Good correspondence between Meso-NH and TEB

TEB model : climate data below urban canopy