CENER | NATIONAL RENEWABLE ENERGY CENTRE

Meshing procedure for modelling of atmospheric wind flow

Pawel Gancarski

pgancarski@cener.com

SOWE 2014 Boulder

GOBIERNO DE ESPAÑA | MINISTERIO DE INDUSTRIA, ENERGÍA Y TURISMO | MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

Gobierno de Navarra

CENER | NATIONAL RENEWABLE ENERGY CENTRE

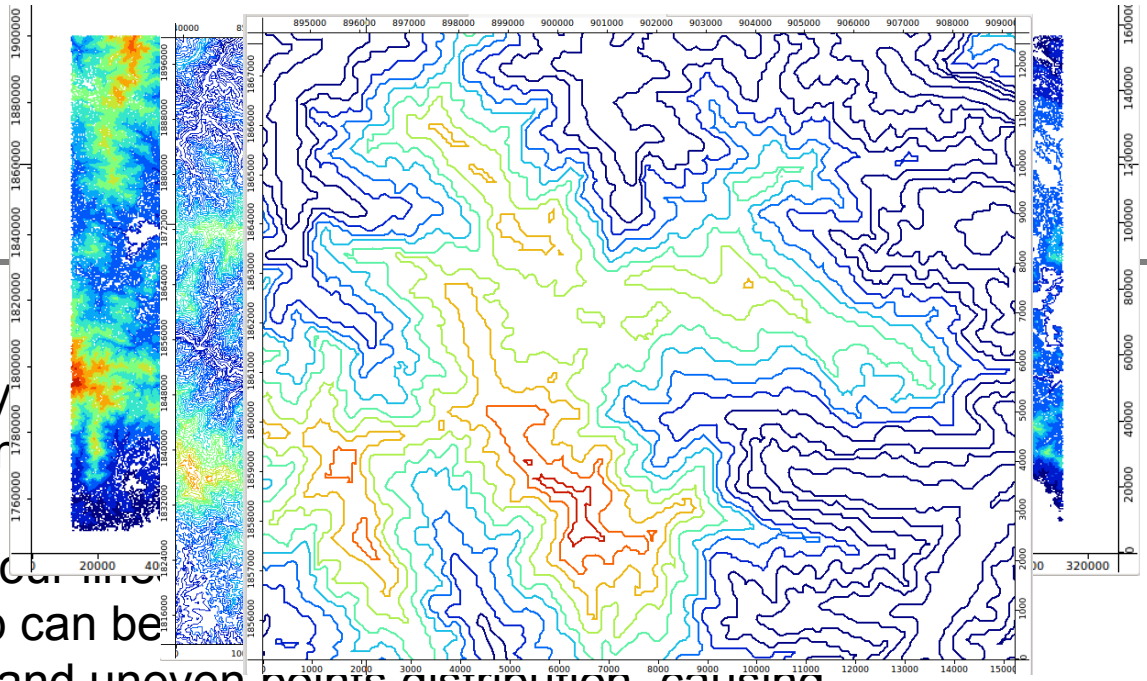
summary

1. Pre-processing inputs
2. Targets
3. Mesh construction
4. OpenFOAM tools

1. Pre-processing inputs

.map files

1. Pre-processing inputs



- .map files is an industry
  and for model validation
- Topography
  - Encoded with contour lines
  - Resolution of .map can be
  - Large white spots and uneven points distribution, causing problems with terrain approximation.
  - Near-shore topographies often come without the shore line being marked.

.map files

1. Pre-processing inputs

- .map files is an industry standard. It is used (and enforced) by clients and for model validation benchmarks.
- Topography
- Roughness
  - Encoded with regions (curve with inside and outside value of roughness).
  - Always broken and need manual editing.
    - Maps are often cropped (chopped) and sometimes nested.

.map files almost always need manual editing (WAsP editor + satellite pictures from Google Earth).

Terrain interpolation

1. Pre-processing inputs

- Delaunay triangulation
  - Very complex to implement
  - Always works, with good results
  - Very slow
- Shepard (distance weighted average of nearest neighbors)
  - Simple to implement and easy to speed up
  - Can perform smoothing
  - Have problems with bad .map files

1. Pre-processing inputs

- Complexity
  - For n=no_input_data, and m=points_to interpolate
    - Delaunay: triangulation - O(n logn), sampling – O(n*m)
    - Shepard: sampling O(m*n)
    - Improved Shepard: initialization - O(n), sampling – O(m*logn)
  - For a typical case where n=m=100 000
    - Delaunay: O(10^10)
    - Shepard: O(10^6) – faster about 10 000 times
  - In real case with a large input file the comparison is 2h (using well implemented SAGA module) to 1 min.

Solution:
WAsP editor (fix errors) -> SAGA (triangulation) -> Windmesh (Shepard)

2. Targets

2. Targets

- Structured mesh whenever possible
- Mesh “following” wind flow
- Neighboring cell size difference should not be larger than 20%
- Fully automatic
- Covering large domain, with fine resolution and with a mesh of few elements.

2. Targets

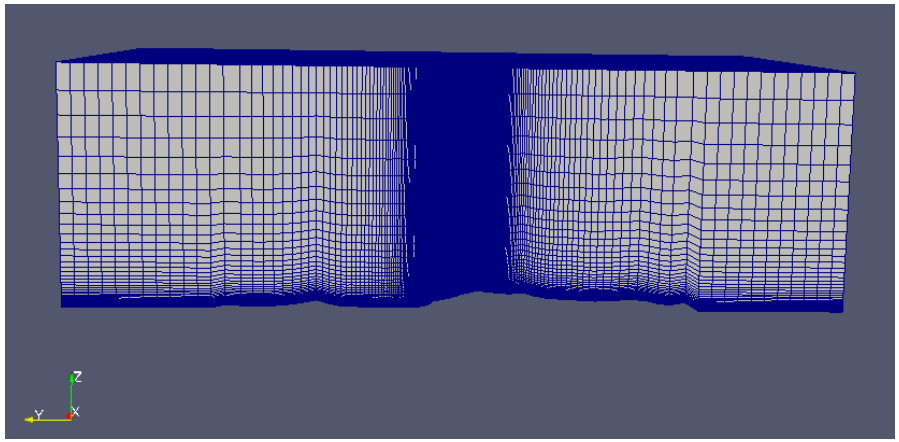
- Simple geometry
  - A box with one “wavy side”.
  - No objects in the middle
- Inlet profile is important, and has to be maintained
  - Vertical resolution can not change
- Very fine horizontal resolution close to the ground
  - At least 10 layers below a hub

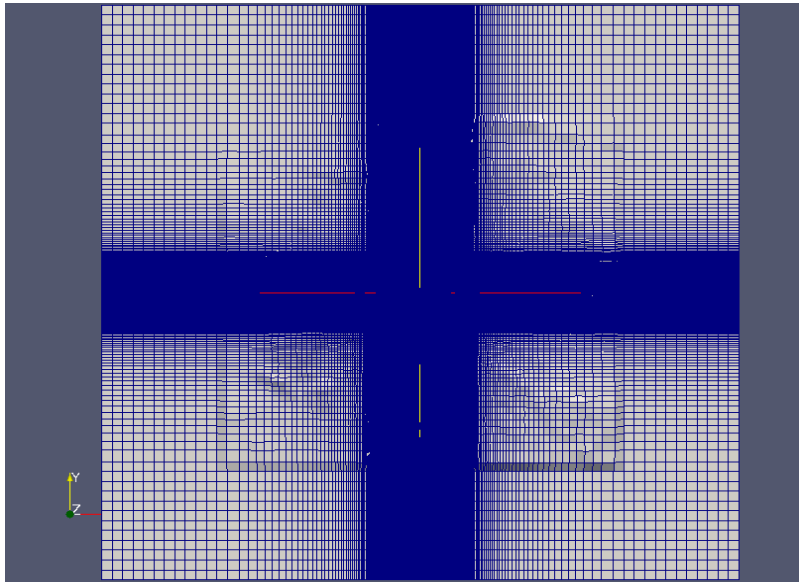
Very flat cells following terrain!

3. Mesh construction

3. Mesh construction

1. Create 2D mesh
2. Interpolate Z and Z0



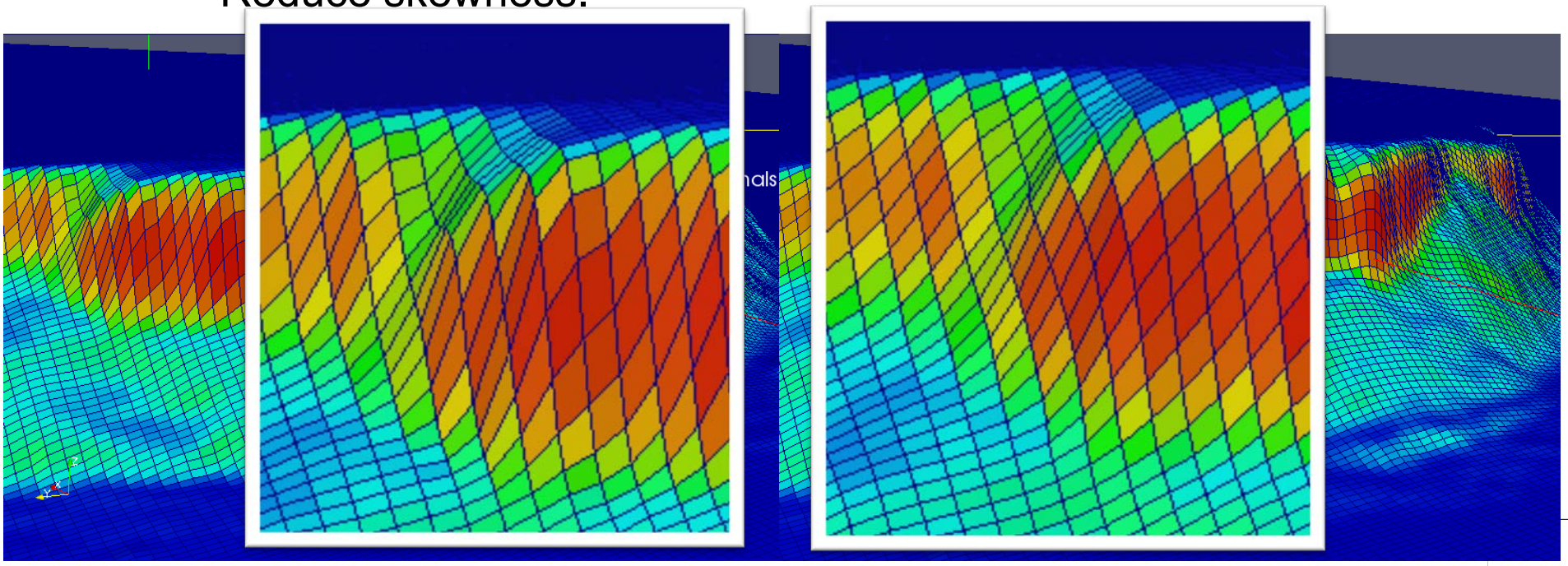


3. Create 3D mesh .

Improving 2D mesh

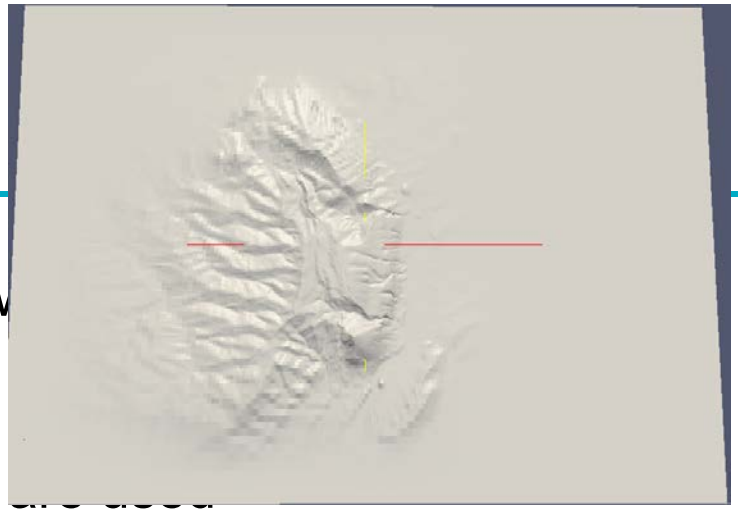
3. Mesh construction

- Rotating the mesh to face the wind flow
- Make the ground faces “more square”.
  - Reduces the size difference of neighbouring cells
  - Reduce skewness.

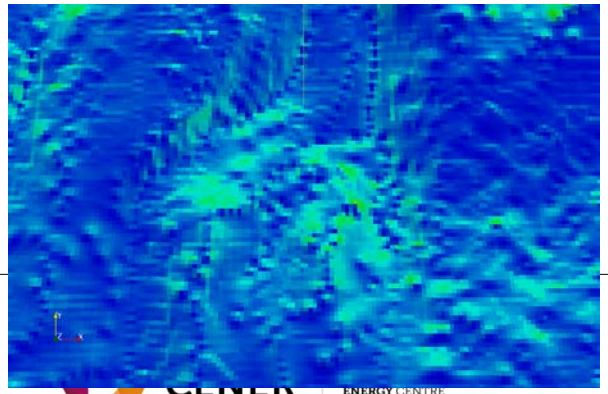


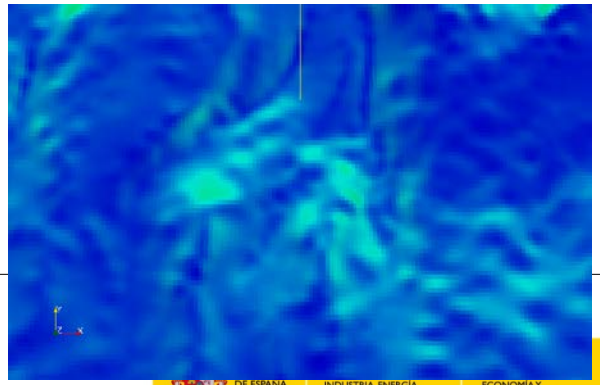
Improving 2D mesh

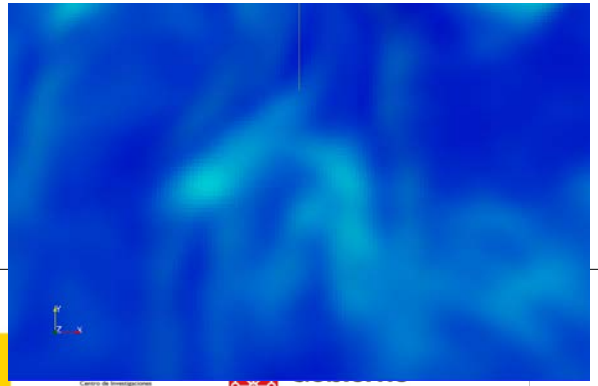
3. Mesh construction



- Rotating the mesh to face the wind flow
- Make the ground faces “more square”.
- Smoothing
  - Best results when two approaches are used
  - Buffer and transition zone: cells are very large but flat. In those regions strong smoothing of the mesh is necessary to avoid convergence problems.
  - Farm zone: cells are smaller, real terrain is priority, depending on the input file noise can be present.

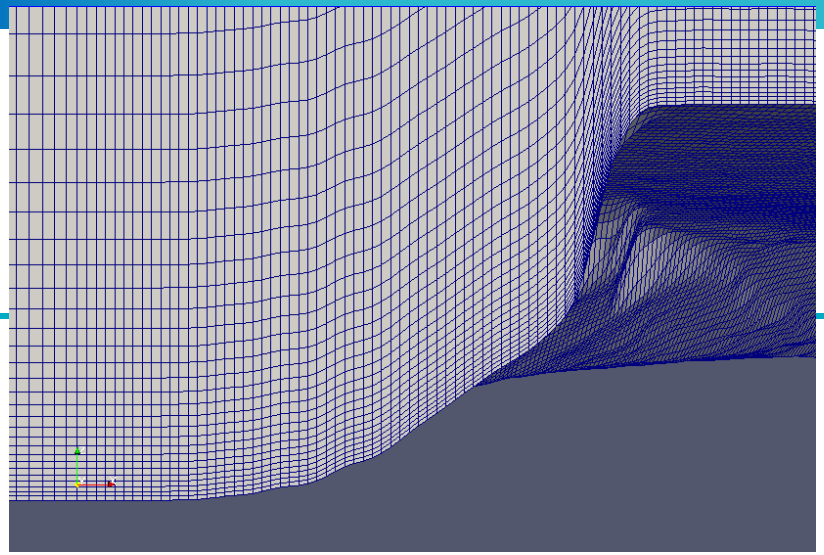




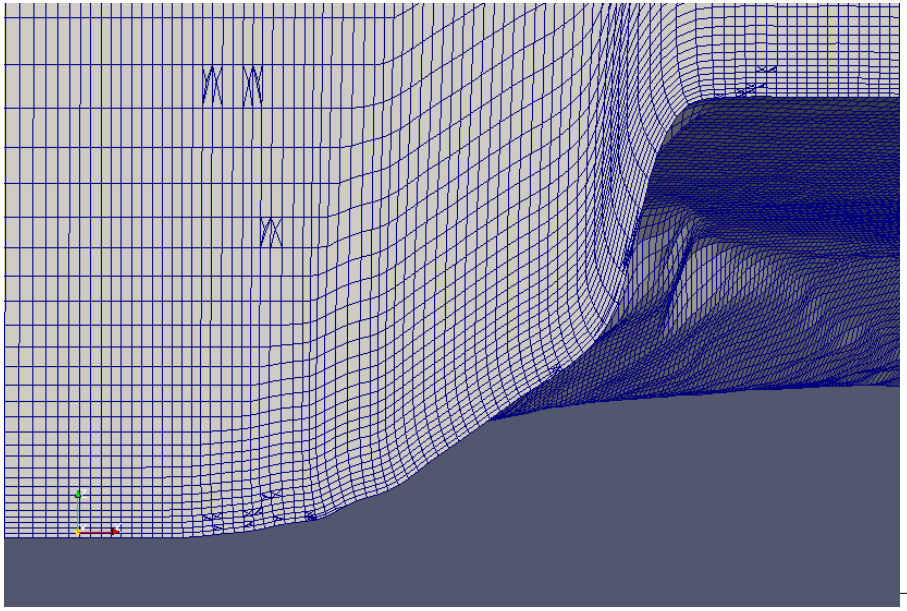


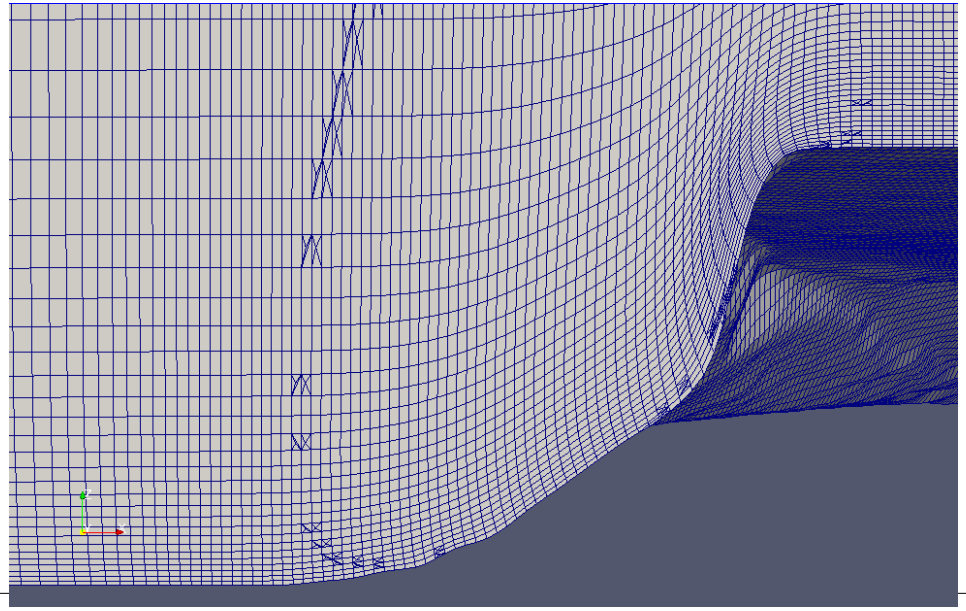
Improving 3D mesh

3. Mesh construction



- Cells should follow terrain.
- Cells above hills are flattened
- Elliptic smoothing
  - Improves mesh statistic but can not be used as a black box

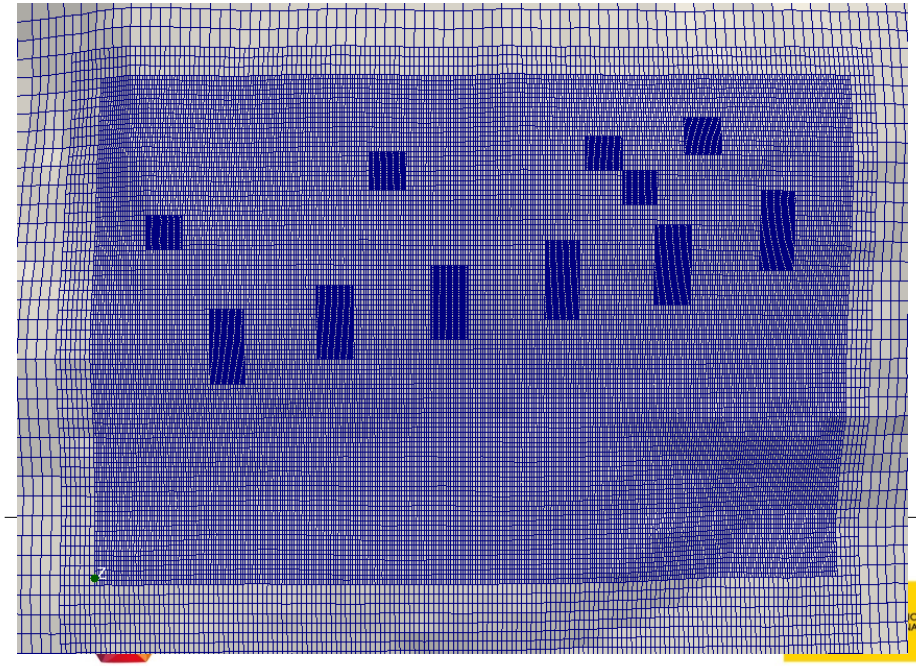


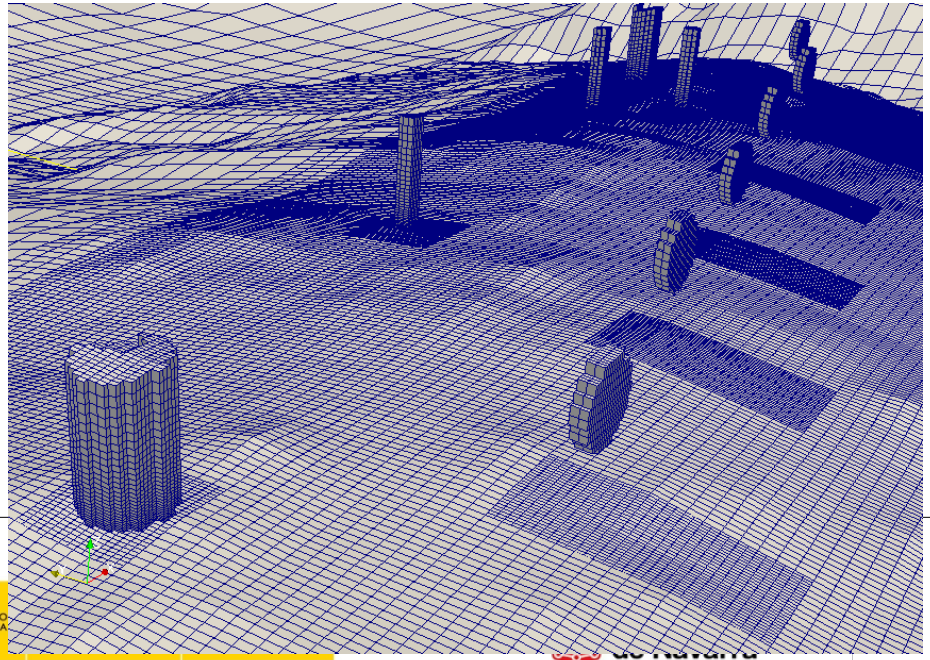


4. OpenFOAM tools

4. OpenFOAM tools

- `topoSet`
- `refineMesh`
  - Modelling wakes
- `mapFields`
  - Fine mesh can be initialised with results from a rougher one

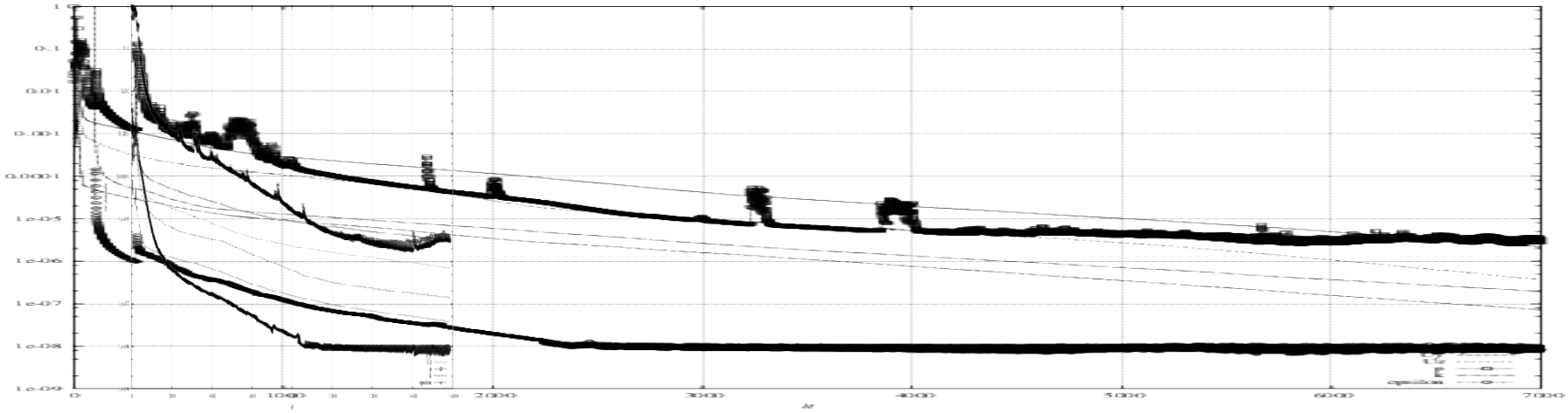




Improving 3D mesh

4. OpenFOAM tools

- `topoSet`
- `refineMesh`
  - Modelling wakes
- `mapFields`
  - Fine mesh can be initialised with results from a rougher one



Conclusions

- .map files are prone to errors, difficult to process and inaccurate. If possible, they should be avoided.
- Delaunay triangulation should be used for problematic input, in other cases Shepard is more efficient.
- OpenFOAM tools allows adapting the mesh for wake models and give promising results in initialisation with rough mesh results.
- While the new meshing software allows models convergence systematic test are necessary in order to
  - improve results
  - see how can the mesh size be reduced

CENER

NATIONAL **RENEWABLE**
ENERGY CENTRE