XVIII SPANISH-FRENCH SCHOOL JACQUES-LOUIS LIONS ABOUT NUMERICAL SIMULATION IN PHYSICS AND ENGINEERING
Las Palmas de Gran Canaria, 25-29 June 2018

A proposed methodology of wind simulation over complex orography and applications on mountains of Aguimes, Gran Canaria, Spain - 21º

J.Abdelfatah[1], G.Winter[1], B.Gonzalez[1]

[1]Universidad de las Palmas de Gran Canaria,IUSIANI

Introduction

The numerical simulation of wind over irregular terrains is particularly useful to implement wind turbine plants. This work proposes the following methodology to develop a 3D wind field over irregular terrains. After many computational experiences carried out , the most practical conclusions to highlight are :

- In order to detect turbulence areas, the 3D transient Navier Stokes equations are solved by means of the numerical Chorin-Rannacher algorithm [7]. A wind field generated by a Consistent Mass Matrix (CMM) method [5] that absorbs available data, from meteorological stations and also stations defined from logarithmic profiles of variation of velocity with altitude, taking into account atmospheric stability, is used as initial solution (at time zero). This DNS algorithm is chosen to reduce the computational cost due to its low order (P1 for velocity and pressure). The results are obtained with a coarse grid to filter small eddies.
- In a few iterations, an improvement of the wind field quality is obtained since the average value of the wind field divergence decreases.

Modelization and discretization

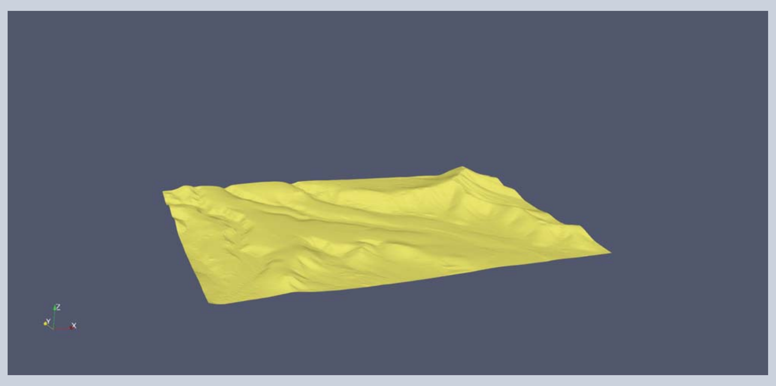

Figure 1: Ground model

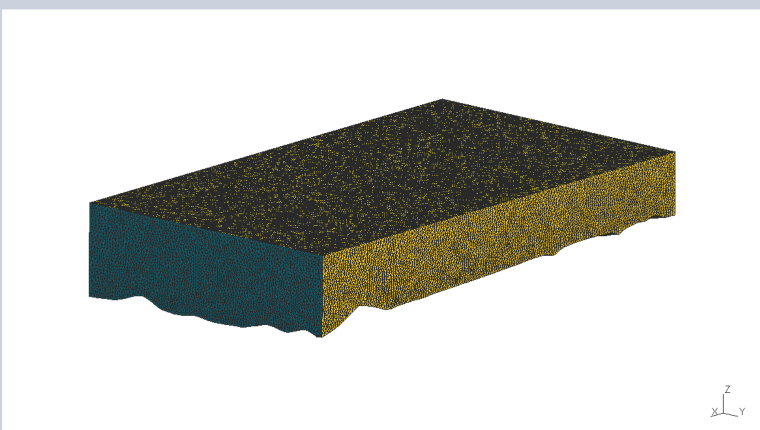

Figure 2: Domain mesh

Methodology

- The orography data are available from the National Geographic Institute (IGN) of Spain.
- Data are processed by using GIS software [1] to obtain a XYZ point cloud. The mesh of the terrain is defined from the point data, and the external surface of the air domain is defined by extruding the contours of the mesh and projecting the ground surface to a planar face. Afterwards, the mesh is imported into a mesh program [2] and a 3D anisotropic mesh is defined [3, 4].
- Wind data are oibtained from Meteorology Statal Agency(Aemet) of Spain. Data are interpolated using CMM method.
- CMM solution is used as initial condition in the Chorin-Rannacher Algorithm.
- Both models are implemented in FreeFem++.

Conclusions

- Both methods CMM and ChorinRannacher are complementary, because of from solution obtained with CMM in a few iterations an improvement of the wind field quality is obtained and helping to ChorinRannacher algorithm to converge.

Forthcoming Research

- Analyze the convergence in this application of the Chorin-Rannacher method by increasing the number of iterations.

Results

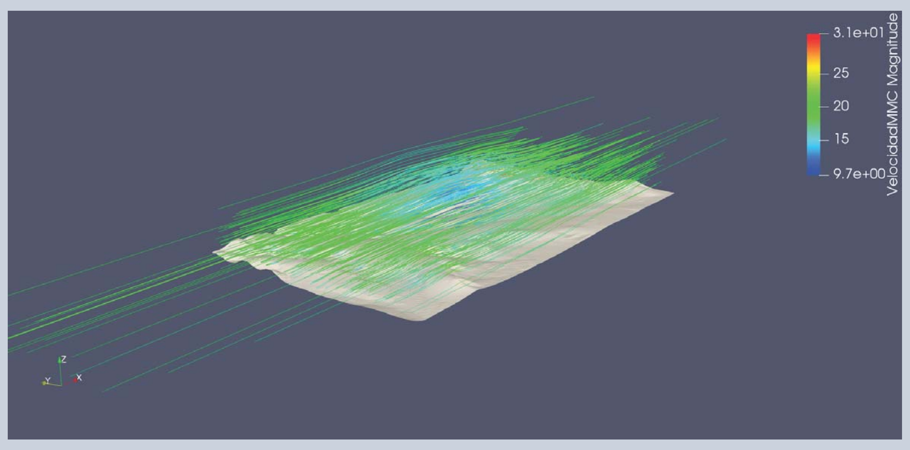

Figure 3: CMM velocity of the wind field

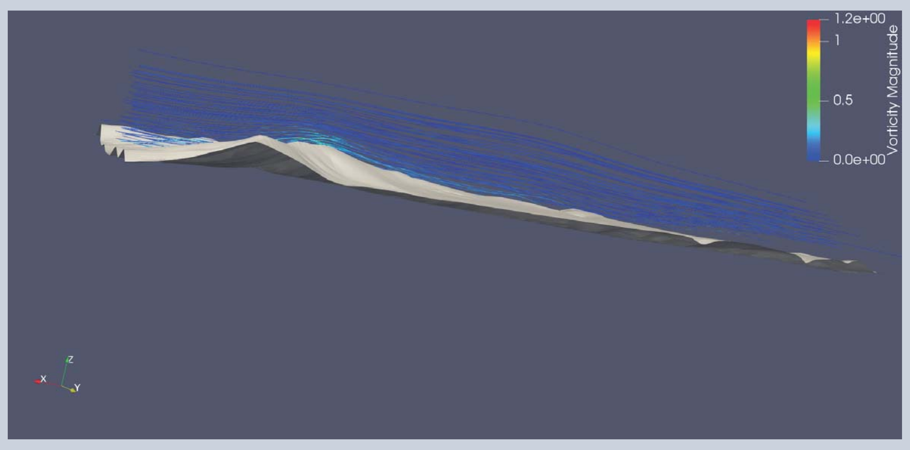

Figure 4: Vorticity of the wind field obtained from CMM ($t = 0$) Chorin-Rannacher

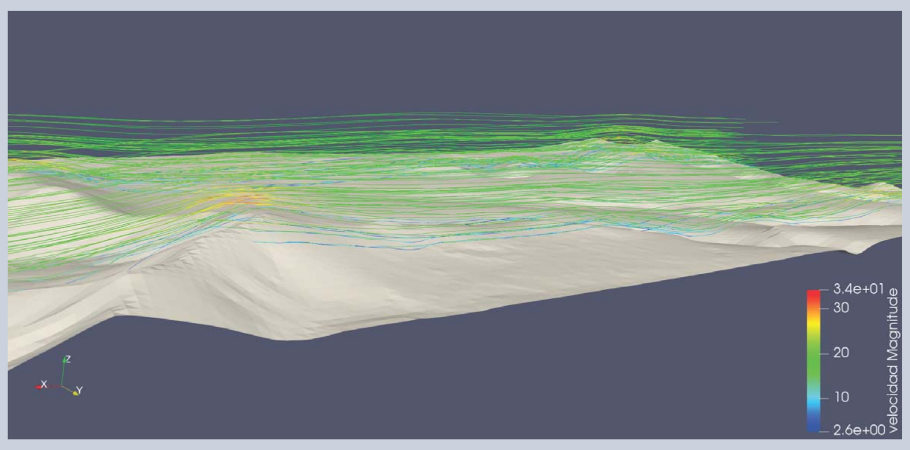

Figure 5: Velocity of the wind field obtained from CMM ($t = 0$) Chorin-Rannacher

References

1. QGIS Development Team (2016). QGIS Geographic Information System. Open Source Geospatial Foundation Project.
2. C. Geuzaine, J.-F. Remacle, Gmsh: a three-dimensional finite element mesh generator with built-in pre- and post-processing facilities. International Journal for Numerical Methods in Engineering 79(11), pp. 1309- 1331, 2009
3. C. Dobrzynski, P. Frey Anisotropic Delaunay mesh adaptation for unsteady simulations.Proceedings of the 17th international Meshing Roundtable.2008
4. C. Dapogny,C. Dobrzynski, P. Frey Three-dimensional adaptive domain remeshing, implicit domain meshing, and applications to free and moving boundary problems.April 1, 2014 - JCP
5. G. Winter,G. Montero,L. Ferragut,R. Montenegro, Adaptive strategies with standard and mixed finite element for wind fields adjustement. Solar energy 1995;54(49-56).
6. J. Abdelfatah , V. Henríquez, A. Ramos, G. Winter 3D Simulation with CFD of air speed and temperature evolution in a small commercial building. Application in Gran Canaria Island, Spain.July 2017.
7. R. Rannacher On chorin's projection method for the incompressible navier-stokes equations. Institutftir Angewandte Mathematik. Universitat Heidelberg.1992. The Navier-Stokes Equations II - Theory and Numerical Methods. Oberwolfach, Germany, August 18-24, 1991
8. S. Auliac, A. Le Hyaric, J. Morice, F. Hecht, K. Ohtsuka, O. Pironneau, FreeFem++. Third Edition, Version 3.31-2, 2014. http://www.freefem.org/ff++/ftp/freefem++doc. pdf
9. F. Hecht, New development in FreeFem++. J. Numer. Math. 20 (2012), no. 3-4, 251–265, 65Y15.

Contact information

- Mail address:jacoban90@outlook.es,gwinter@iusiani.ulpgc.es,bgonzalez@iusiani.ulpgc.es