MITACS Seed project: Environment & Natural Resources

Modeling Atmospheric Boundary-Layer Flow for Wind Energy and other applications

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Our main focus has been on the modelling of winds blowing over complex terrain in the form of spatial variations in surface roughness and thermal properties and, so far separately, over hills and other topographic features.

For roughness changes Wensong Weng and Peter Taylor had previously developed a 2-D model of planetary boundary-layer flow over step changes in roughness (Weng et al, 2009) and, under the present project, we have been applying that model to situations appropriate to wind energy applications. This has included extending the model to include situations with non-neutral thermal stratification and step changes in thermal properties as well as roughness. Work on this was presented at the September 2009 CANWEA (Canadian Wind Energy Association) conference in Toronto, and we have submitted an abstract based on this work to the American Wind Energy Association, Windpower 2010 Conference, to be held in Dallas in May 2010.

Xiao (Frank) Yu, a PhD student in Applied Mathematics, is working on the project and focusing on improving the NLMSFD model (see Xu et al, 1994) of flow over topography. I particular we had been concerned by the fact that the model, which treats the non-linear terms via an iterative procedure, would only work for relatively low slopes and for steep slopes the iteration failed to converge. Once he became familiar with the model, Frank made various attempts to modify the iteration scheme but in the end we found that a simple relaxation method was the most satisfactory. This can increase the allowable topographic steepness from slopes of order 0.3 to 0.6 or even higher and is a significant advance in terms of applications for wind energy purposes. So far Frank's work has focused on 2D topographic features (2D ridges) and is run in a surface boundary-layer (or constant flux layer) scenario. A paper on this has been submitted to the Fifth International Symposium on Computational Wind Engineering (CWE2010) to be held in May 2010.

A current focus of our study is to use the models to predict the spatial variations in wind speed and turbulence over the island of Bolund in Denmark. This is part of a Blind Comparison of a range of modelling approaches in use within the wind energy community being run by the Risø laboratories. Thanks to MITACS and Zephyr North support Dr Weng and Mr Yu will be able to attend the workshop being held December 2009 in connection with this project. Details of three modelling approaches that we are using are on our MITACS project web site. Other Bolund details are at http://www.risoe.dtu.dk/en/Research/sustainable_energy/wind_energy/projects/VEA_Bolund.aspx.

Between now and March 2010, in addition to participation in the Bolund comparison study, we plan to extend both the roughness change and topography models from 2D Surface Layer to 3D Planetary Boundary Layer formulations allowing us to apply them more realistically to a wider range of terrain. For topography an important application will be comparison against field data from the Askervein study, (see Taylor and Teunissen, 1987).

References

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