Development of OpenFOAM - WRF Coupling Methodology for Wind Power Production Estimations

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1 Abstract
The objective of the this study is the development of a tool to predict daily wind energy production potential accurately for a region of interest. For that purpose, mesoscale weather prediction model WRF (Weather Research and Forecast) is coupled with the opensource CFD solver OpenFOAM via using low resolution WRF data as unsteady and spatially varying boundary conditions in the CFD solver OpenFOAM. For that purpose, a new boundary condition class (timevaryingmixed) in OpenFOAM was developed and utilized. 12 hour WRF coupled OpenFOAM solutions are performed in Mersin/Mut region in Turkey where a met-mast is located for validation purposes. Unlike other methodologies, capability of time resolved energy prediction is attained in this study and also, observation data is not a must. As time is of essence for predictions, paralleling the process is crucial. Studies for the parallelization of the process is ongoing.

2 Introduction and Methodology
In this study, mesoscale weather prediction model WRF (Weather Research and Forecast) will be coupled with the opensource CFD solver OpenFOAM via using low resolution WRF data as unsteady and spatially varying boundary conditions in the CFD solver OpenFOAM. Unstructured grids are used to discretize the complex terrain of interest. High resolution (1.5 arcsec) ASTER GDEM topographical data is used to create terrain following grids in order to capture the viscous effects which dominates the flow characteristics at the surface layer of the atmosphere where majority of the wind turbines reside. WRF solutions can be obtained using the real time weather prediction data ECMWF provides for a region of interest. Spatially and time varying boundary conditions are to be interpolated both in time and space from the WRF solutions and updated for each cell. A new boundary condition class (timevaryingmixed) in OpenFOAM was developed and utilized for this purpose. A schematic for the coupling procedure is given in Figure 1 along with the location of the OpenFOAM and WRF domains for case study done for Mut, Mersin region.

Unlike other methodologies, in this study, capability to answer the question how much energy can be extracted tomorrow? which is a valuable information for the energy market, is attained. Spatially varying boundary conditions taken from WRF can be defined in the CFD code, not only on one point like commercial tools but on whole of CFD domain boundaries. As the time requirement for prediction is steep (solutions must be faster than real-time), paralleling the process is crucial. Details about the methodology and parallelization of the process will be given in the final paper.

3 Preliminary Results
Unsteady OpenFOAM solutions coupled with WRF are performed using the methodology on high resolution stretching structured grids. The region of interest is chosen as Mersin Mut in Turkey where a wind farm and

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a met-mast is located. Trial runs are made for laminar flow. Preliminary unsteady WRF coupled flowfield solutions at 2 time instances are given in Figure 2.