Effect of Topography on Wake Steering In Wind Farms

A. Mishra[*,†], Nitish Arya[*], Amitabh Bhattacharya[*]

Wind farms typically consist of an array of wind turbines, and wake interference between the turbines can lead to significant losses in overall power output from the wind farm. Wake steering is a strategy where yaw is introduced with respect to the incoming flow field in the upstream turbines to reduce wake interference with downstream turbines. While wake steering is known to increase overall power output from a wind farm located on a flat terrain, its effectiveness is not understood for wind farms located on hilly terrain. We have utilized the open source solver SOWFA[1] to perform LES of a 15MW wind turbine with hub diameter $D = 200$m located at the base of a sinusoidal hill. The incoming flow field, generated from precursor simulations, corresponds to a neutral atmospheric boundary layer. The height of the hill is varied from 50m to 200m, whereas the length of the hill is kept fixed at 800m. The yaw of the turbine with respect to incoming flow is then systematically varied to characterize the effect of topography on wake steering. Analysis of the wake trajectory indicates that the height of the wake center increases after the hill, compared to the flat terrain (Figure 1), irrespective of the yaw angle. The presence of hill also leads to the appearance of several secondary flow structures below the wake (Figures 1(b)), at the leeward side of the hill. The trajectory of the wake center, projected on the $x - z$ plane does not get affected by the presence of the hill, even in the presence of yaw in the turbine. On the other hand, the effective radius of the wake gets diminished due to the presence of secondary flow structures behind the hill. Results from this study indicate that the presence of hill behind the turbine does not affect the trajectory of the wake behind yawed turbine, and may lead to quicker wake recovery.

Acknowledgement: This work has been supported by ReNew Centre of Excellence for Energy and Environment at I.I.T. Delhi (project no. MI02338). Authors also gratefully acknowledge direct support and guidance from ReNew Pvt. Ltd.

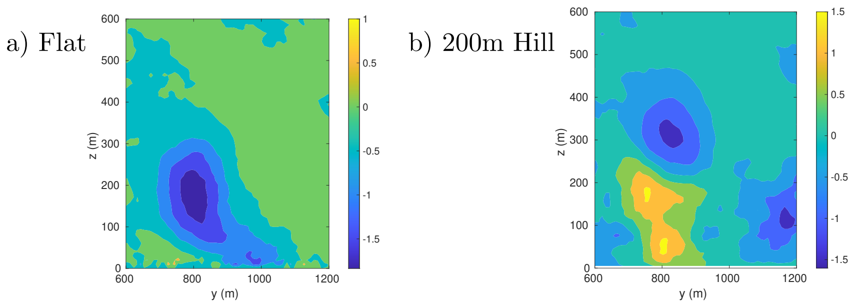

Figure 1: Cross section iso-contours of streamwise velocity deficit 1600m ($8D$) behind 20° yawed turbine (a) on flat surface and (b) in the presence of 200 m sinusoidal hill.

[*] Department of Applied Mechanics, I.I.T. Delhi
[†] ReNew Centre of Excellence for Energy and Environment, I.I.T. Delhi

[1] Churchfield et al., *National Renewable Energy Laboratory* (2012)