TEXAS TECH UNIVERSITY
National Wind Institute™

Improving Wind Farm Efficiency Using Advanced Doppler Radar Technologies

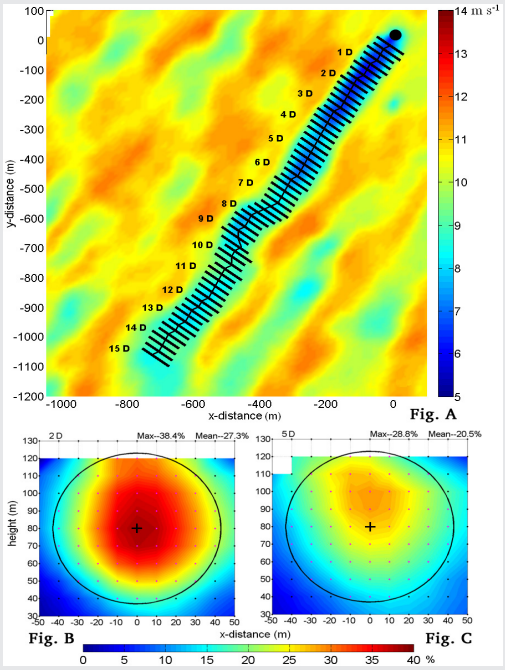
Doppler radar technologies and techniques developed at Texas Tech University have the potential to revolutionize the wind energy community by providing comprehensive information about the modulated flows within a wind farm. These technologies and techniques will enhance wind farm design, layout practices, and operation. Documenting the structure and evolution of complex flows within and surrounding wind farms will lead to increased efficiency as turbine wakes are fully characterized, turbine-to-turbine interactions are defined, transient wind events are proactively identified, the effects of local terrain are documented, and turbine inflows are adequately characterized allowing intelligent control of individual wind turbines and entire wind farms.

Texas Tech University is at the forefront of making full-scale wind farm observations. Using state-of-the-art Doppler radar technologies, Texas Tech University has successfully characterized the modulated wind flow near an individual wind turbine (image top right) and within a broader wind farm setting (image bottom right). Coordinated observations have been collected using two radar systems allowing dual-Doppler synthesis of the three-dimensional wind flow over a large footprint with exceptional spatial and temporal resolution.

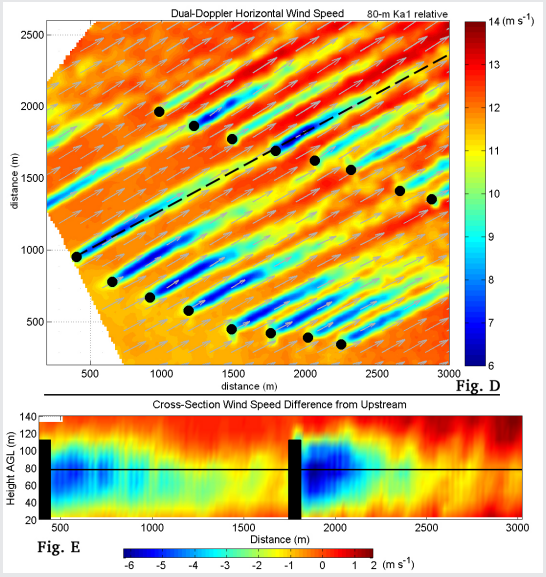
"What could you do with a three-dimensional map of the modulated flow field to enhance the performance of your wind farm?"

Utilizing adaptive scanning strategies, the variability of the flow surrounding a turbine can be observed and documented in real-time. Individual turbine wakes can be tracked at multiple downstream locations both in the horizontal and vertical dimensions. Inflow-relative wind speed reductions can be constructed across the rotor sweep, along with power output deficits for a hypothetical downstream turbine located within the wake. These same principles can also be expanded to multiple turbines in a wind farm setting where turbine-to-turbine interactions exist.

Integration of these technologies and techniques will lead to "smarter" wind farms by improving individual turbine and wind farm awareness and efficiency. The deployment of multiple Doppler radars can document the modulated wind field of an entire wind farm, leading to an advanced controls opportunity to optimize the wind farm for enhanced performance and loads mitigation, reducing the cost of energy.



(Top) Dual-Doppler synthesized horizontal wind speed at hub height with algorithm defined wake centerline and cross-section lines. Vertical cross-sections within the wake of horizontal wind speed reduction from the free-stream wind profile are shown at (bottom left) two rotor diameters (2D) and (bottom right) five rotor diameters (5D) down-wind. The black circle describes the projected rotor sweep.



(Top) Dual-Doppler synthesized horizontal wind speed near hub height within a wind farm. Black dots indicate turbine locations. (bottom) Vertical cross-section through two turbines showing wind speed differences from the free-stream wind profile. Black rectangles represent the turbines and the black horizontal line represents hub height.

John Schroeder, Ph.D., Director, National Wind Institute, john.schroeder@ttu.edu
Box 41023 | Lubbock, Texas 79409-1023 | T 806.834.5678 | F 806.742.3446 | www.nwi.ttu.edu