# STUDY OF ISOLATED WAKES AND THEIR SUPERPOSITION IN WIND FARMS, USING DIFFERENT TURBULENCE MODELS

**A. Crespo*, E. Migoya, A. Jiménez**

*Departamento de Ingeniería Energética y Fluidomecánica, ETSI Industriales
Universidad Politécnica de Madrid (UPM)
e-mail: crespo@etsii.upm.es

## ABSTRACT

Different models to simulate wakes in wind farms are reviewed [1], [2]. Special emphasis is put in those elaborated by the authors. First, kinematic models, based on self-similar velocity deficit profiles and global momentum conservation, are briefly revisited. Then, field models of a different degree of complexity, which solve numerically the flow equations with several types of simplifications and turbulence closure models, are analyzed and compared. Models like Ainslie´s that uses a simple algebraic expression for the eddy viscosity, and are still widely used, are compared to other more complete models like UPMWAKE, which uses a k-ε turbulence closure. Ground effect, simulation of atmospheric conditions, atmospheric stability, simulation of turbulence characteristics, wake superposition and computer time consumed, will be used as terms of comparison. Results of an algebraic Reynolds Stress Model will also be presented. Although a more detailed discussion on the appropriateness of the different turbulence closure models and their corrections will be made in another paper of this mini-symposium. Then a comparison will follow of elliptic and parabolic models, and how boundary conditions at the disk are imposed. A discussion on the displacement of the wake origin for parabolic models will be made. The simplicity and computer time consumed to simulate wake superposition in whole large wind farms of the elliptic and parabolic models will be analyzed and compared. Results of a large eddy simulation model will also be presented and compared to those of previously mentioned models [3]. Wake meandering, and its role in wake turbulence generation when using simpler eddy viscosity models will be analyzed, and compared with other mechanisms of turbulence generation. The possibility and convenience of introducing unsteady terms in parabolic field models of wind farms, like UPMPARK, and thus simulate wake meandering will be discussed. Results of UPMPARK with and without meandering will be compared with available experimental data.

[1] Crespo, J. Hernández and S. Frandsen (1999) "**A Survey of Modelling Methods for Wind-Turbine Wakes and Wind Farms"** Wind Energy. Volume 2, Issue 1, 1999. Pages: 1-24.

[2] L.J. Vermeer, J.N.Sørensen y A. Crespo (2003) **"Wind Turbine Wake Aerodynamics"** Progress in Aerospace Sciences. Vol. 39. Issues 6-7. Agosto-Octubre 2003. pp. 467-510.

[3] A Jimenez, A Crespo, E Migoya, J. García (2007) **"Advances in large-eddy simulation of a wind turbine wake"** Vol. 75 Journal of Physics (IOP):Conference series.