Highly resolved Large-Eddy Simulation of wind turbine wakes

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BOOK OF ABSTRACTS

WESC2017 – Wind Energy Science Conference
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Preface

Wind Energy Science Conference 2017 (WESC-2017) is held at the Technical University of Denmark in Lyngby during June 26-29, 2017. This conference is the first of a series of bi-annual conferences launched by the European Academy of Wind Energy (EAWE). The purpose of the conference is to gather leading scientists and researchers in the field of wind energy to present their latest findings. The conference aims at covering all scientific topics in wind energy, comprising from most fundamental aspects to recent applications. It provides a world-wide forum for scientists to meet each other and exchange information of all aspects of wind energy, including aerodynamics, turbulence, wind resource assessment, wind farms and wakes, aero-serve-elasticity, loads, structural mechanics, control, operation and maintenance, generator technology, grid integration, structural design and materials, new concepts, as well as community acceptance, environmental aspects, and economics.

This volume of abstracts comprises all presentations of the conference, including two plenary lectures, and nearly 370 contributed papers, presented in either oral sessions or during 13 mini symposia. The abstracts are sorted chronologically after the day of presentation, corresponding to the way they appear in the conference programme. At the end of the book you will find a list of presenting authors, listed alphabetically, and the page number where their abstract appear.

I like to thank the scientific committee and the local organizing committee for their work with the evaluation and selection process. In particular, I thank Marianne Hjorthede Arbirk for her invaluable help in preparing the conference and this book of abstracts.

Jens N. Sørensen, chairman WESC-2017
Lyngby, June 2017

Keywords or mini-symposium identification: aerodynamics and noise, wind and turbulence

Highly resolved Large-Eddy Simulation of wind turbine wakes

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An horizontal axis wind turbine placed in a free stream develops a wake behind its rotor. Inside this wake, complex vortical instabilities are developing and can lead to turbulent structures generation[1]. In order to predict performances and loads of wind turbines in wind farms, it is essential to accurately characterize these wakes and their impact on the downstream turbines. Large-Eddy Simulation (LES) is well adapted to this problem as the considered flow is 3D, complex and strongly unsteady. The state-of-the-art approach for taking into account the effect of the turbine on the flow is the Actuator Line (AL) method[2,3]. This method enables the use of Cartesian grids, which brings numerous advantages but prevents space adaptivity and limits the shape of the flow domain.

In the present work, the AL approach was implemented in a massively parallel high-order finite-volume LES solver named YALES2[4]. This code offers good scalability and is able to handle unstructured meshes up to billions of elements. We propose here to assess this approach on the Tjaereborg wind turbine case[5]. In particular, the quality of the results obtained using Cartesian and fully unstructured tetrahedral meshes will be compared.

The strategy is then applied to an aerodynamically optimized 1MW wind turbine[6]. Fully unstructured grids with local refinement are used here. Figure 1 presents the simulated wakes by plotting iso-contours of Q-criterion Q=1 s^{-2} at three different Tip Speed Ratios (TSR). The figure shows that the tip blade vortices are faster destabilized as the TSR increases leading to a faster transition to fully developed turbulence. The analysis of wake break-up to turbulence is then performed thanks to the Dynamic Mode Decomposition method.

This work demonstrates the ability to perform massively parallel scale-resolving simulations where both near and far turbine wakes are accurately modeled. These simulations may be further exploited to get more insights into wind turbine wakes and to compare and validate design tools based on simpler models.

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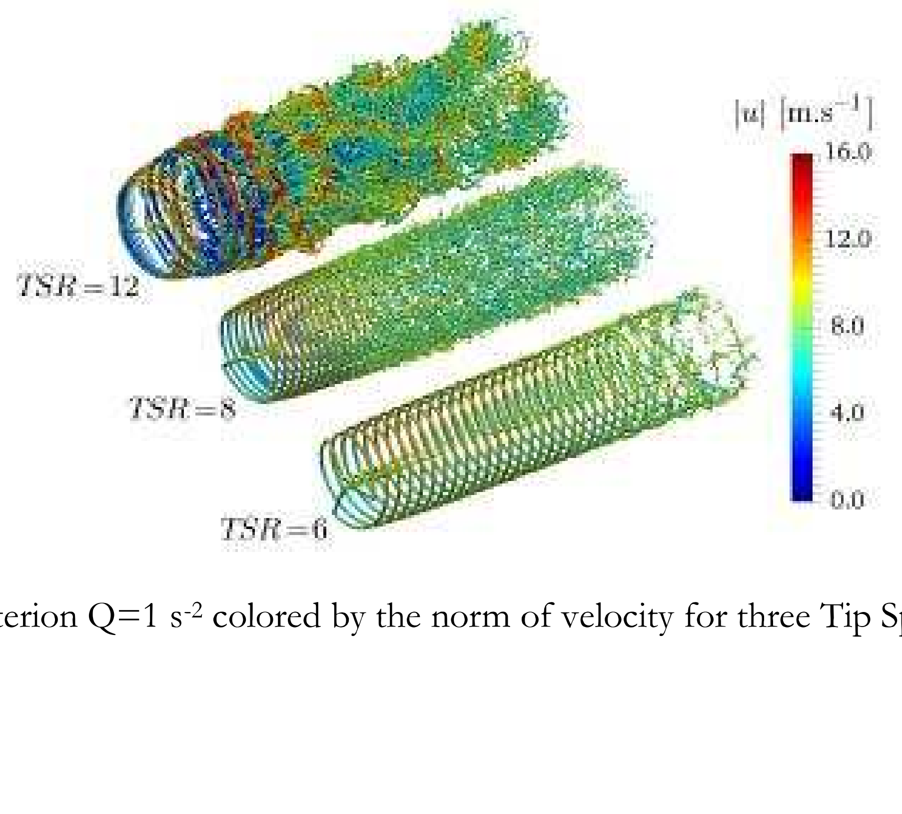

Figure 1: Iso-contour of Q-criterion Q=1 s^{-2} colored by the norm of velocity for three Tip Speed Ratios.