Towards PIV assimilation of large-scale wake flows: study of several sub-grid models
Pranav Chandramouli, Dominique Heitz, Etienne Mémin, Sylvain Laizet

To cite this version:
Pranav Chandramouli, Dominique Heitz, Etienne Mémin, Sylvain Laizet. Towards PIV assimilation of large-scale wake flows: study of several sub-grid models. Workshop on CFD Processing Techniques for Particle Image and Tracking Velocimetry, Jul 2016, Lisbon, Portugal. <hal-01692195>

HAL Id: hal-01692195
https://hal.archives-ouvertes.fr/hal-01692195
Submitted on 24 Jan 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers. L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Towards PIV assimilation of large-scale wake flows: study of several sub-grid models

Pranav Chandramouli\textsuperscript{1}, Dominique Heitz\textsuperscript{2,1}, Etienne Mémin\textsuperscript{1}, and Sylvain Laizet\textsuperscript{3}

\textsuperscript{1} INRIA, Fluminance group, Campus universitaire de Beaulieu, F-35042 Rennes Cedex, France
pranav.chandramouli@inria.fr

\textsuperscript{2} Irstea, UR OPAALE, F-35044 Rennes Cedex, France

\textsuperscript{3} Department of Aeronautics, Imperial College London, London, United Kingdom

ABSTRACT

With the increasing attraction of data assimilation combined with improved computational power, the concept of using image based velocity measurements as a guiding mechanism for the numerical simulation of flow dynamics has gained a lot of interest. Previous PIV Data Assimilation study implemented on Incompact3d -a parallelised flow solver developed by [1]- has performed admirably in the case of a DNS of low Reynolds number wake flow [2]. However, performing such data assimilation on a Direct Numerical Simulation (DNS) basis remains computationally unachievable even for flows at moderate Reynolds number. Only, coarse Large Eddy Simulation (LES) is conceivable. This necessitates the identification of the best suited subgrid model for the flow under study, i.e. cylinder wake flow at a Reynolds number of 3900 corresponding to the turbulent Von-Karman vortex shedding regime (see figure 1 left). This is the focus of the present work.

Over the past decades, numerous LES sub-grid scale (SGS) models have been proposed each possessing some unique set of advantages. However, there exists no universal model providing statistically accurate results for all types of flows. Several SGS models have been compared. Models under scrutiny include the classical Smagorinsky model along with contemporary models under uncertainty developed by [2] namely Stochastic Smagorinsky (StSmag), Stochastic Spatial (StSp), and Stochastic Temporal (StTe) covariance models. The numerical simulation was performed on a very low-resolution mesh compared to a DNS as well as the LES simulations of [3]. The simulation statistics have been compared with the PIV data of [3] along with an under resolved DNS (URDNS) at the LES resolution mainly to identify the improvements in statistics (see figure 1 right). The statistics clearly show improved fit to the PIV data with the stochastic SGS models as compared to classic Smagorinsky model that over smoothens the velocity gradient— the directional dissipation associated with the stochastic models along with other factors can be attributed to this improvement. The next step will consist to perform a 4DVar PIV assimilation with such SGS models.

Figure 1 Cylinder wake flow LES simulations based on location uncertainty principle: (Left), Velocity norm for the LES with the StSp subgrid tensor; (Right), Streamwise velocity fluctuation profiles at 1.06D behind the cylinder axis, for different subgrid tensor models compared with PIV of [3] and an under resolved DNS.

REFERENCES


