3D assimilation with PIV orthogonal-plane observations and a DNS dynamical model in a circular cylinder wake flow

Cordelia Robinson, Dominique Heitz, Alejandro Gronskis, Etienne Mémin

Workshop on CFD Processing Techniques for Particle Image and -Tracking Velocimetry
Lisbon, Portugal, July 3, 2016

3D assimilation with PIV orthogonal-plane observations and a DNS dynamical model in a circular cylinder wake flow

Cordelia Robinson[1,2], Dominique Heitz[1,2], Alejandro Gronskis[3] and Etienne Mémin[2]

[1] Irstea, UR OPAALE, 17 avenue de Cucillé, F-35044 Rennes Cedex, France
dominique.heitz@irstea.fr

[2] INRIA, Fluminance group, Campus universitaire de Beaulieu, F-35042 Rennes Cedex, France

[3] LFD, Facultad de Ingeniería, Universidad de Buenos Aires, Argentina

ABSTRACT

During the last decade, the fluid mechanics community witnessed the surge of techniques combining computational fluid dynamics and experimental fluid dynamics results in order to benefit from the assets and overcome the limitations of each approach. A first PIV data assimilation study had performed successfully in the two-dimensional case of a DNS of low Reynolds number wake flows [1]. The variational data assimilation technique (4DVar) was used to reconstruct the flow by modifying the initial and inflow conditions of the system. The ability of the technique to reconstruct the flow in gappy PIV data was also investigated [2].

The present study is an extension of the work of [1,2] to the reconstruction of a three-dimensional cylinder wake flow at Reynolds 300 by combining a highly accurate and parallelized code Incompact3d [3] with a sequence of two-dimensional stereo PIV observations. An important part of this application was focused on the construction and validation of the discrete adjoint parallelized code necessary to the implementation of the 4Dvar method [4]. We performed a first reconstruction of a purely synthetic flow generated by Incompact3d, using three-dimensional observations. We then performed the reconstruction of a fully three-dimensional flow from the alternated synthetic observations of orthogonal stereo PIV like observations (inflow and streamwise planes see figure 1). We investigate the possibilities of the reconstruction with the real observations obtained by orthogonal stereo PIV measurements.

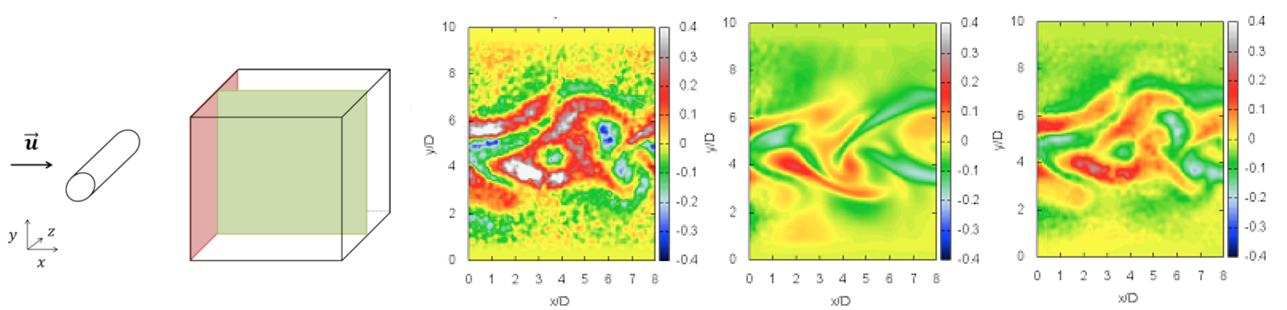

Figure 1 Data assimilation flow configuration (Lx . Ly . Lz = 8D . 10D . 6D) and snapshots of the spanwise velocity component at the beginning of the assimilation window in the streamwise plane z = 3D. From the left to the right: the PIV observation, the background and the analysis, respectively.

REFERENCES

[1] Gronskis A, Heitz D, Mémin E "Inflow and initial conditions for direct numerical simulation based on adjoint data assimilation." *Journal of Computational Physics* 242: 480-497 (2013).

[2] Gronskis A, Robinson C, Heitz D, & Mémin E "A 4DVar PIV-data assimilation for flow spatio-temporal reconstruction" 10TH INTERNATIONAL SYMPOSIUM ON PARTICLE IMAGE VELOCIMETRY - PIV13, July, Delft, Netherlands (2013).

[3] Laizet S & Lamballais E "High-order compact schemes for incompressible flows: a simple and efficient method with the quasi-spectral accuracy", J. Comp. Phys., vol 228-15, pp 5989-6015 (2009).

[4] Robinson, C "Image data assimilation with fluid dynamics models: Application to 3D flow reconstruction" Thèse de doctorat. Université de Rennes 1 (2015). English. <tel-01291532>