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RECONSTRUCTION AND PHYSICAL INSIGHT OF COMPLEX UNSTEADY FLOWS THROUGH REDUCED ORDER MODELING

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Obtaining accurate CFD solutions of unsteady flows during the design process of an aircraft can be a really time-consuming task. Because of that, a common practice is the recourse to Reduced Order Methods (ROM), whose main peculiarity is to reduce the number of degrees of freedom in order to describe the physics of the fluid system in a fast yet fairly accurate manner.

Following this path, studies have been presented in the literature using the Proper Orthogonal Decomposition (POD) introduced by Lumley for the specific case of unsteady flows [1]. Alternatives to POD have also been proposed, such as Dynamic Mode Decomposition, Optimal Mode Decomposition and more recently, Spectral Proper Orthogonal Decomposition [3] in the attempt to overcome the recognized limit of POD for unsteady regimes in providing a sound physical interpretation of the modes and how to make them evolve in time in order to follow the coherent structures dynamics [2]. Nevertheless, to best of the authors knowledge, not much emphasis has been put on assessing the accuracy of methods relying on these alternative extraction techniques in reconstructing complete unsteady flow fields. At this time, POD still seems to be the most promising one, since it gives an optimal basis of functions that allows also using the minimum number of modes for a certain energy content representation.

The present work investigates the problem of the accuracy in reconstructing unsteady fluid flows by means of ROM methods, which is one of the key elements while performing for example, unsteady multi-point performance optimization. Namely, the classical snapshot POD and the SPOD will be compared in their capacity to reconstruct unsteady flow fields typical of aerospace applications. The cases studied are those of the impulsive start of a 2D three element airfoil and a 3D wing in high-lift configurations.

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