Multi-block overset implementation of high-order Residual-Based Compact schemes for compressible aerodynamics

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Keywords: computational fluid dynamics, high-order, overset grids.

ABSTRACT

In the past ten years, a family of Residual-Based Compact (RBC) schemes - with orders of accuracy going from 2^{nd} to 7^{th} order - have been developped [1, 2, 3] for the simulation of the Euler and Navier-Stokes equations on structured meshes. The key concept is a compact approximation scheme that provides high accuracy not for each space derivative treated apart but for the complete residual r, i.e. the sum of all the terms in the governing equations. Recent work [4] has demonstrated the high-resolution capabilities of these schemes. In order to extend this work to complex geometries and target the simulation of industrial configurations, we investigate the use of RBC schemes in conjunction with an overset grid framework.

Overset methods were first introduced by Benek et al. [5, 6, 7] for aerodynamic computations. The method has been generalized by [8, 9] and used in conjunction with schemes of 3^{rd} and 5^{th} order accuracy for aerodynamics computations by [10] and with compact schemes by [11, 12]. It has also been used along with high-order interpolations optimized in Fourier's space for aeroacoustics simulations in [13].

In this work we extend RBC schemes of high order (order 3, 5 and 7) to geometrically complex configurations in aerodynamics. To this purpose, we develop an overlapping multi-block meshes strategy with high-order interpolations. The interest of overlapping grid strategies is that they may enable the use of Chimera type meshes, including Cartesian blocks, where high-order schemes can be efficiently implemented using the finite difference formulation while preserving their nominal accuracy. Because of the multidimensional stencil of RBC schemes, care must be taken to correctly interpolate grid points situated at the corners of mesh blocks. The computational domain is discretized by a set of overlapping meshes, each one equiped with one or more layers of ghost cells, according to the discretization stencil of the scheme in use. Such ghost cells are used to transfer information between connected meshes. The field variables are interpolated using high-order Lagrange polynomials, with the same order of accuracy as the internal scheme.

Preliminary results have been obtained for the 2-D advection of an isentropic vortex (see fig. 1). At the conference, detailed validations will be provided for this test case, as well as for a 3-D helicoidal advection problem. Applications to inviscid and viscous flows over airfoils will be finally shown.

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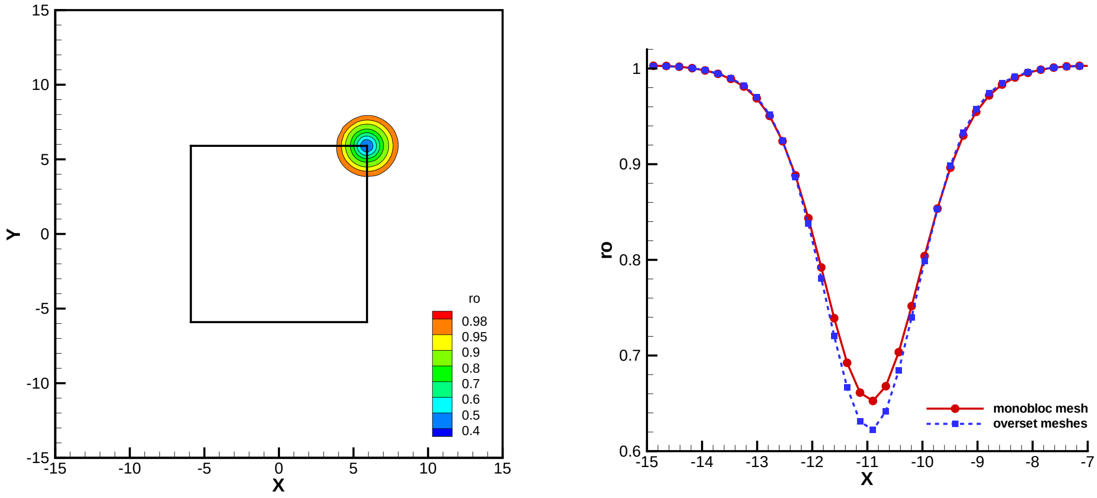

(a) (b)

Figure 1: Diagonal advection of an inviscid vortex initialized at $(x, y) = [-11, -11]$ using RBC3 with 3^{rd} order interpolations (a) View of the vortex on overset meshes (b) Comparison of the same computation on monobloc or overset mesh after traveling three times the area

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