Mesh adaptation for unsteady flow and more

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Mesh adaptation strategy

Algorithm 1 Transient $\mathbf{L}^\infty(0,T;\mathbf{L}^p(\Omega))$ fixed-point mesh adaptation algorithm

//- Loop over time subintervals $i=1,n_{adap}$

For i=1,n_{adap}

//- Solve adaptively on time subinterval $S_i=[t_{i-1},t_i]$

//- Fixed point adaptation loop

For j=1,n_{nptfx}

- $\mathcal{W}_{0,i}^j$ = ConservativeSolutionTransfer($\mathcal{H}_{i-1}^j, \mathcal{W}_{i-1}^j, \mathcal{H}_i^j$)
- $\mathcal{W}_i^j$ = SolveStateForward($\mathcal{W}_{0,i}^j, \mathcal{H}_i^j$)
- $\mathcal{M}_i^j$ = ComputeFeatureOrientedMetric($\varepsilon, \mathcal{W}_i^j, \mathcal{H}_i^j$)
- $\mathcal{H}_i^{j+1}$ = GenerateAdaptedMeshe($\mathcal{H}_i^j, \mathcal{M}_i^j$)

End for j

End for i

- The subinterval S_i is chosen such that : $|S_i| \approx \frac{2}{f}$ (f the vortex emission frequency)
- Mesh adaptation on the Mach and $\frac{\partial^2 p}{\partial t^2}$

First test model : Cylinder at Re=3900

- Two computations, with a coarse mesh and a finer mesh

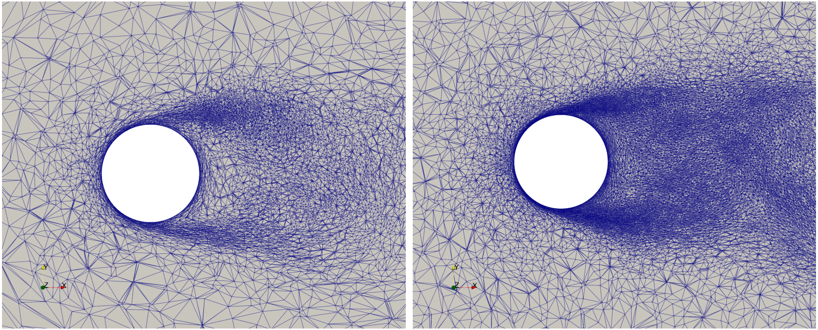


Figure – View of the 6th coarse and finer mesh of our adaptation in cross-section (right ~ $230K$ vertices, left ~ $2.1M$ vertices).

First test model : Cylinder at Re=3900

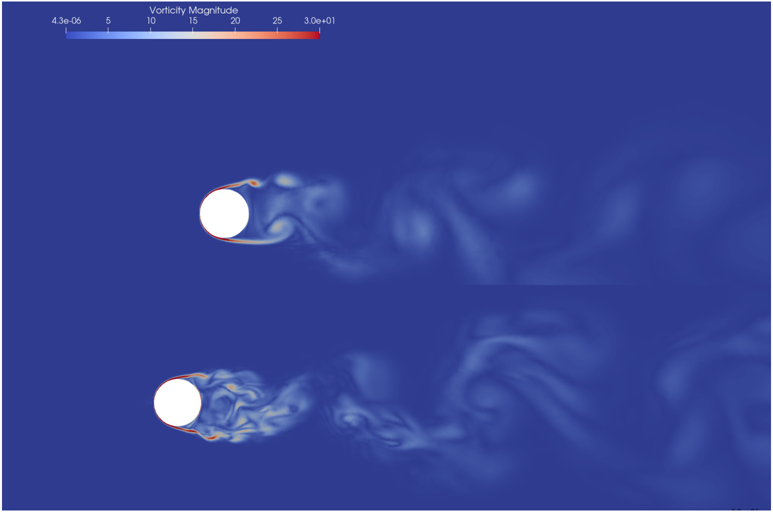


Figure – Vorticity result for our two meshes.

First test model : Cylinder at Re=3900

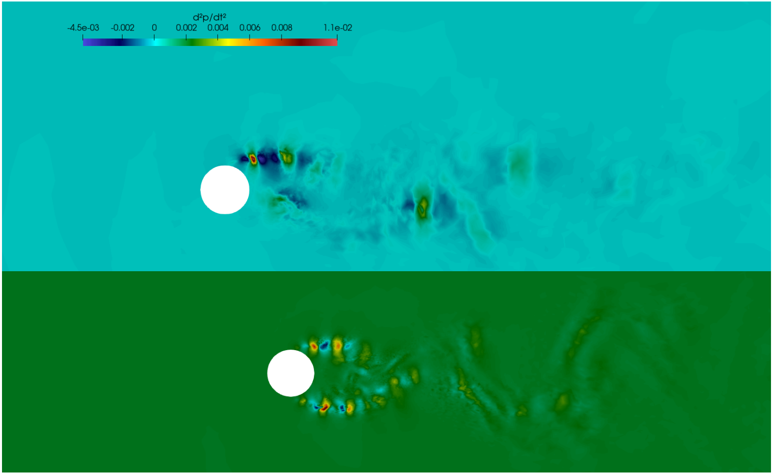
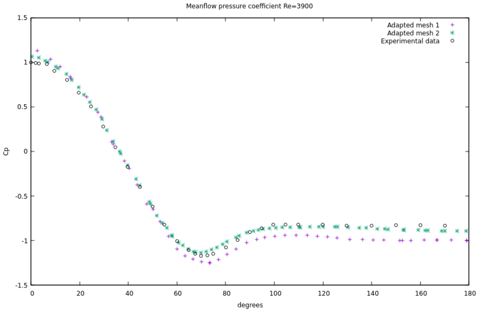


Figure – $\frac{\partial^2 p}{\partial t^2}$ view for our two meshes.

First test model : Cylinder at Re=3900

Name	Mesh	δ_w	$\overline{C}_d$	C_l'	$-C_{pb}$	$\overline{\theta}$	St
Present simulation							
$k-\varepsilon$ Goldberg	176K	0.002	0.96	0.11	0.85	111	0.20
$k-R$	176K	0.002	1.00	0.11	0.86	93	0.20
DVMS WALE	1.46M	0.004	0.94	-	0.85	-	0.22
VMS	2.6M		0.99	0.11	0.88	89	0.21
VMS Adapted	230K		1.14	0.27	1.1	88	0.20
VMS Adapted	2.1M		1.06	0.18	1.00	85	0.20
Measurements							
Norberg [7 8]	-	-	1.03	0.1	0.84	-	0.21
Kravchenko-Moin [9]	-	-	0.99	-	0.88	86	0.215

Table – Bulk coefficients of the flow around a circular cylinder at Reynolds number 3900, $\overline{C}_d$ holds for the mean drag coefficient, $\overline{C}_l'$ is the root mean square of lift time fluctuation, $\overline{C}_{P_b}$ is the pressure coefficient at cylinder basis, L_r is the mean recirculation length, $\overline{\theta}$ is the mean separation angle.



Problem with cylinder at Re=1M

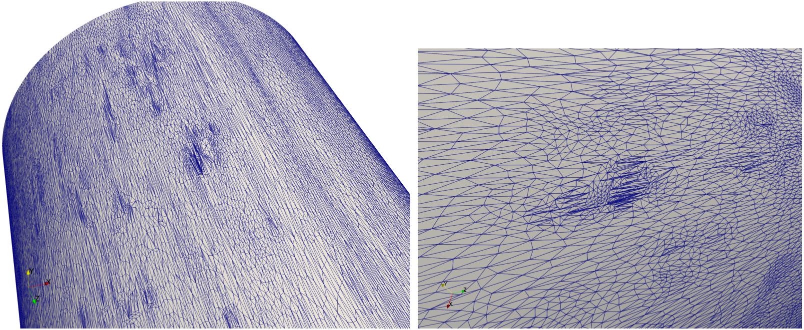


Figure – Mesh problem at the cylinder surface.

Problem with cylinder at Re=1M

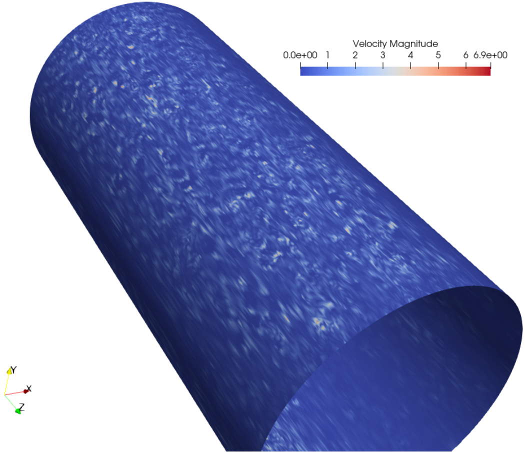


Figure – Velocity problem at the cylinder surface.

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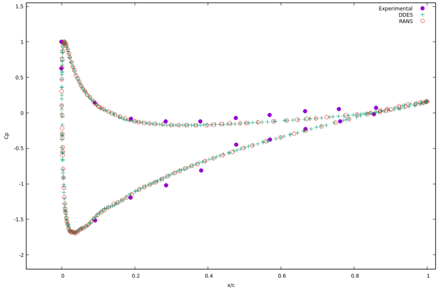

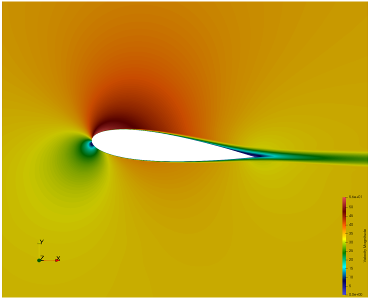

Figure – Distribution of mean pressure on left and velocity field in cross-section on right.

High order scheme test

- Gaussian advection test case to compare V4 and V6 schemes in NiceFlow (on regular mesh), with

$$\rho_0 = 1 + e^{-0.25((x-10)^2+y^2+z^2)},$$

an advection velocity of 0.5 m/s, explicit computation with $CFL = 0.2$.

⚠ Conclusion : The V6 gave bad results !

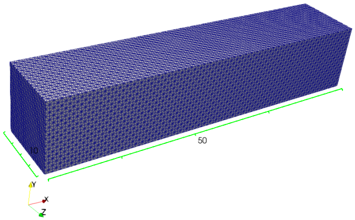

Figure – Computational domain for advection.

High order scheme test

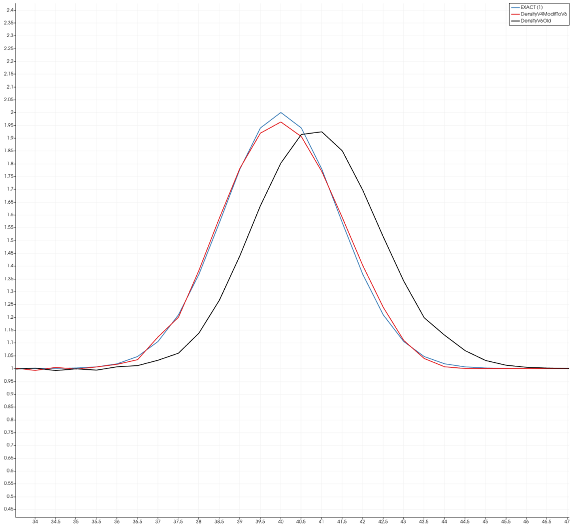

Figure – In black result with the old V6 and in red result with the corrected V6 at $T = 60s$.

New Caradonna-Tung computation

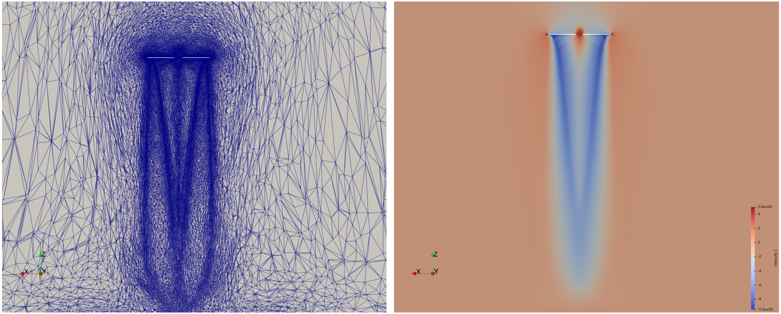

Figure – Caradonna-Tung DDES simulation results : mesh (left) and velocity field (right) incross-section.

Other ongoing and future work

- Space-time mesh adaptation
  - Finish the theory
  - Implementation in the WOLF code at Inria Saclay (several months' stay)
- Mesh convergence for LES
  - Write the theory
  - Check feasibility (for the implementation)