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Optimad

AEROGUST Workshop

27th - 28th April 2017, University of Liverpool

Presented by Haysam Telib

Contribution to the AeroGust project

WP2

Cost efficient High-Fidelity Simulation tool

in collaboration with
S. Pirozzoli & D. Modesti, Sapienza Università di Roma

WP4

Zonal hybrid POD / CFD simulation tool

in collaboration with
INRIA

Introduction of gust

- MUSCLE type
  - not appropriate due to excessive numerical dissipation
  - fine background grids
  - ad-hoc numerical modelization of gust (e.g. Split Velocity Method)

- Low dissipation
  - direct introduction of the gust as an atmospheric disturbance (??)
  - high-order methods (>2)
  - recast MUSCLE type scheme to a low dissipation scheme??

Derivation of a FV second-order low dissipation scheme

based on Pirozzoli J Comput Phys 229 (2010)

$$\frac{d}{dt}\int_V \mathbf{u}\, dV + \sum_{i=1}^{3}\int_{\partial V}\left(\mathbf{f}_i - \mathbf{f}_i^v\right) n_i\, dS = 0,$$

$$\mathbf{u} = \begin{Bmatrix} \rho \\ \rho u_i \\ \rho E \end{Bmatrix}, \quad \mathbf{f}_i = \begin{Bmatrix} \rho u_i \\ \rho u_i u_j + p\delta_{ij} \\ \rho u_i H \end{Bmatrix}, \quad \mathbf{f}_i^v = \begin{Bmatrix} 0 \\ \sigma_{ij} \\ \sigma_{ik} u_k - q_i \end{Bmatrix},$$

$$\mathbf{f}_i = \mathbf{f}_i + \mathbf{p}_i = \begin{Bmatrix} \rho u_i \\ \rho u_i u_j \\ \rho u_i H \end{Bmatrix} + \begin{Bmatrix} 0 \\ p\delta_{ij} \\ 0 \end{Bmatrix},$$

$$\hat{\mathbf{f}}_{ON} = \hat{\mathbf{f}}_{ON}^C + \hat{\mathbf{f}}_{ON}^D, \quad \hat{\mathbf{p}}_{ON} = \hat{\mathbf{p}}_{ON}^C + \hat{\mathbf{p}}_{ON}^D$$

$$\hat{\mathbf{f}}_{ON}^C = 1/8\,(\rho_O + \rho_N)\,(u_{nO} + u_{nN})\,(\boldsymbol{\varphi}_O + \boldsymbol{\varphi}_N)$$

$$\hat{\mathbf{p}}_{ON}^C = 1/2\,(\mathbf{p}_O + \mathbf{p}_N)$$

+ some diffusive fluxes to be defined

Flow adaptive numerical dissipation

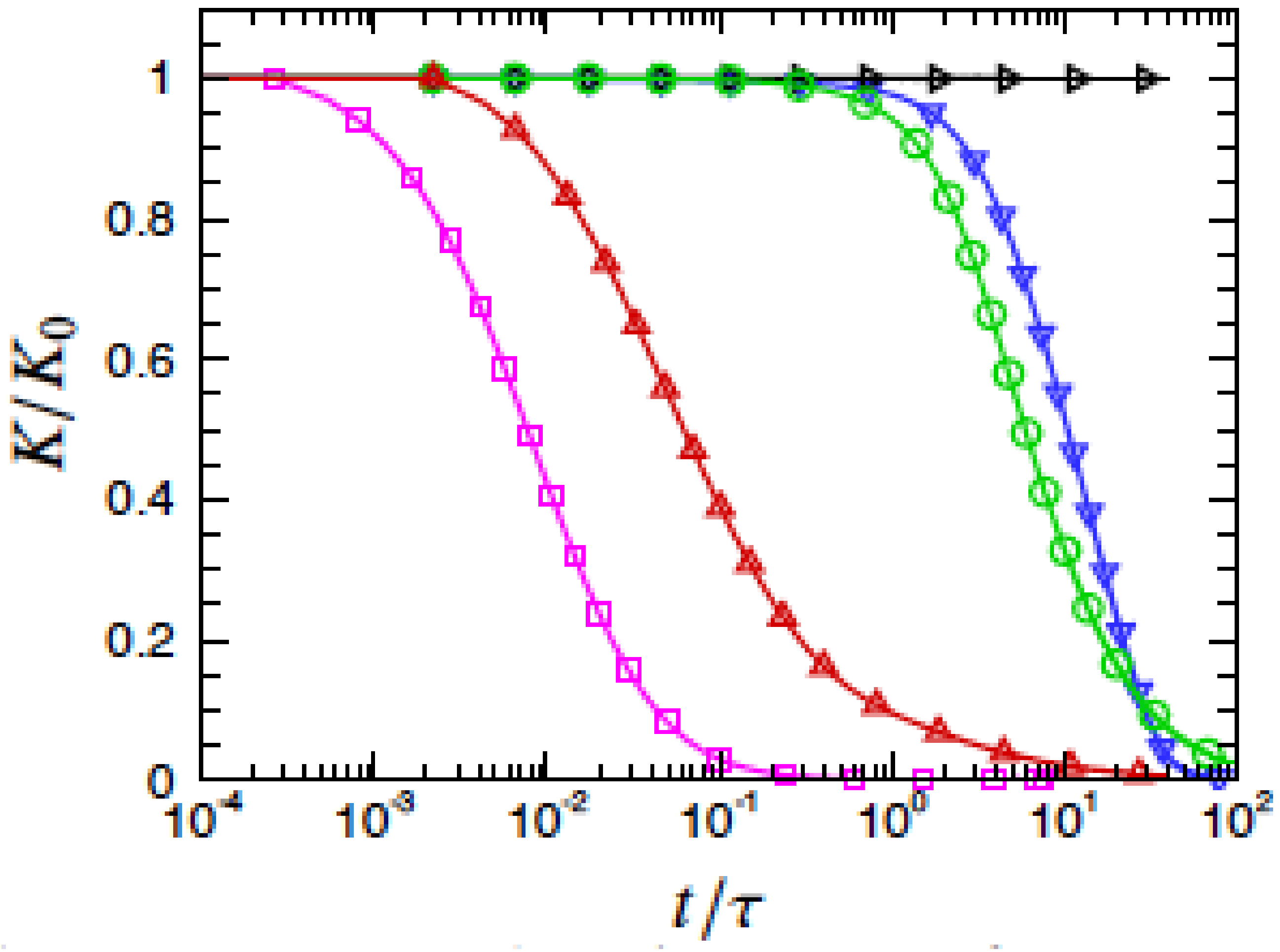
Ducros shock sensor

$$\theta = \max\left(\frac{-\nabla \cdot u}{\sqrt{\nabla \cdot u^2 + \nabla \times u^2 + u_0^2/L_0}}, 0\right) \in [0, 1],$$

g = heaviside($\boldsymbol{\theta}$ - $\boldsymbol{\theta}_{thres}$)

$f^D = g\, f^D_{ausmp+up}$ $p^D_{ON} = g\, \boldsymbol{\theta}\, p^D_{ausmp+up}$

Validation: Decaying homogenous turbulence @Re=10^8



Validation: reversibility of inviscid Taylor-Green Vortex

triple-periodic domain π^3, $Mach_0 = 0.01$, $k_0 = 1$

with initial conditions:

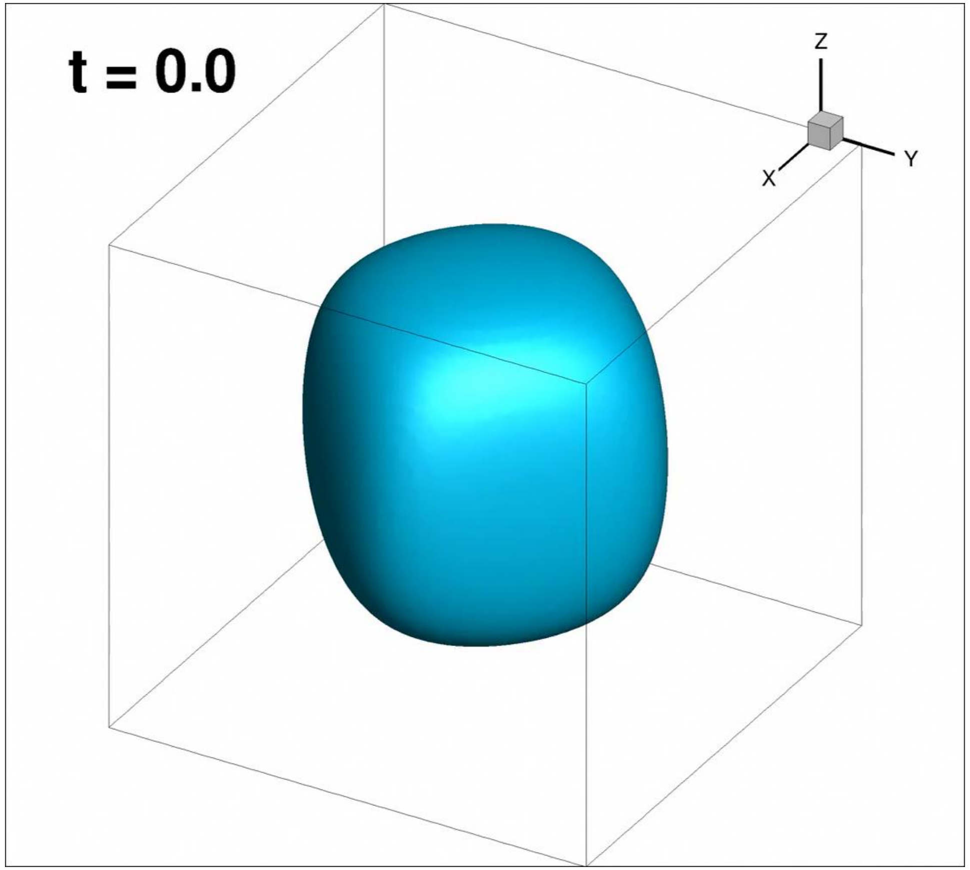
$$\rho = \rho_0,$$
$$u = u_0 \sin(k_0\, x) \cos(k_0\, y) \cos(k_0\, z),$$
$$v = u_0 \cos(k_0\, x) \sin(k_0\, y) \cos(k_0\, z),$$
$$w = 0,$$
$$p = p_0 + u_0^2/16[\cos(2\, k_0\, z) + 2(\cos(2\, k_0\, x) + \cos(2\, k_0\, y)) - 2].$$

Duponcheel et al *J Comput Phys* 227 (2008)

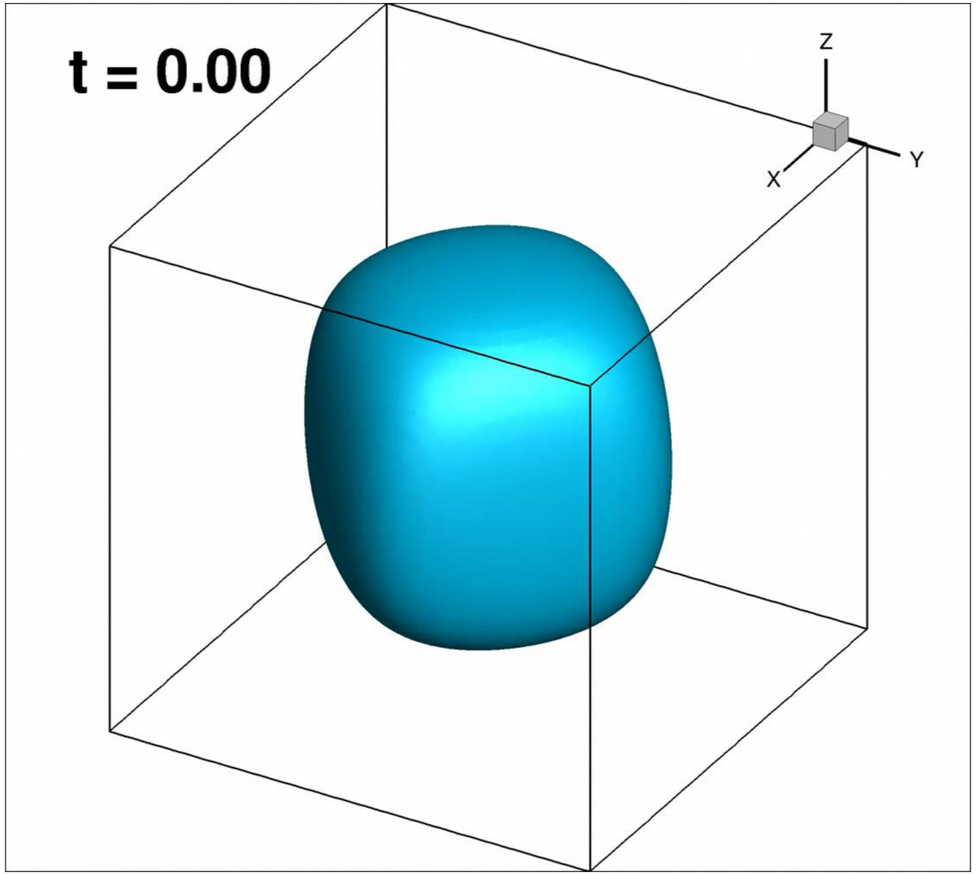
1. solution is advanced to $T' = 8\,/u_0k_0$
2. velocity is inverted
3. solution is advanced to $T'' = 16\,/u_0k_0$
4. recover initial solution

Validation: reversibility of inviscid Taylor-Green Vortex

Kurganov & Tadmor

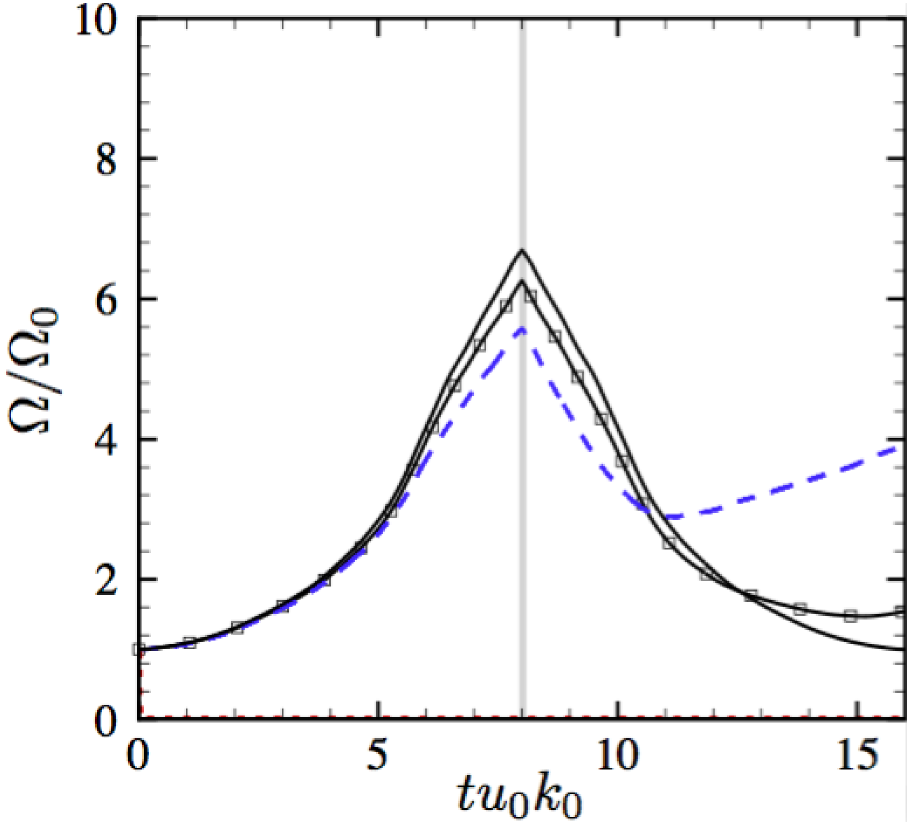


KEC

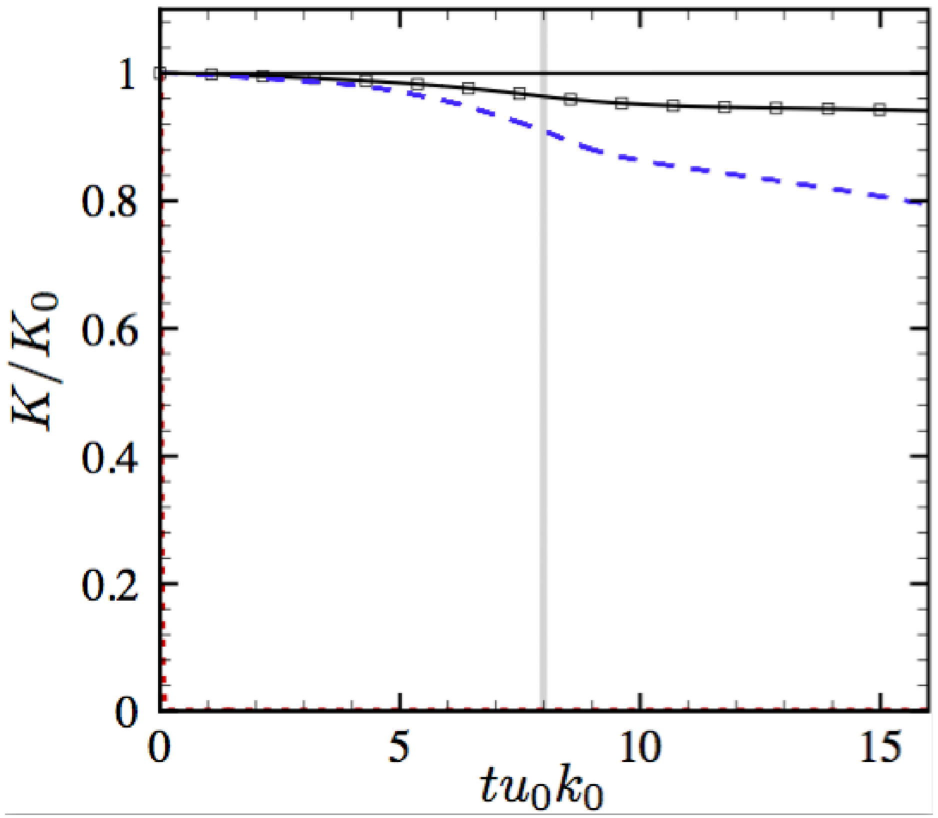


Validation: reversibility of inviscid Taylor-Green Vortex

Enstrophy

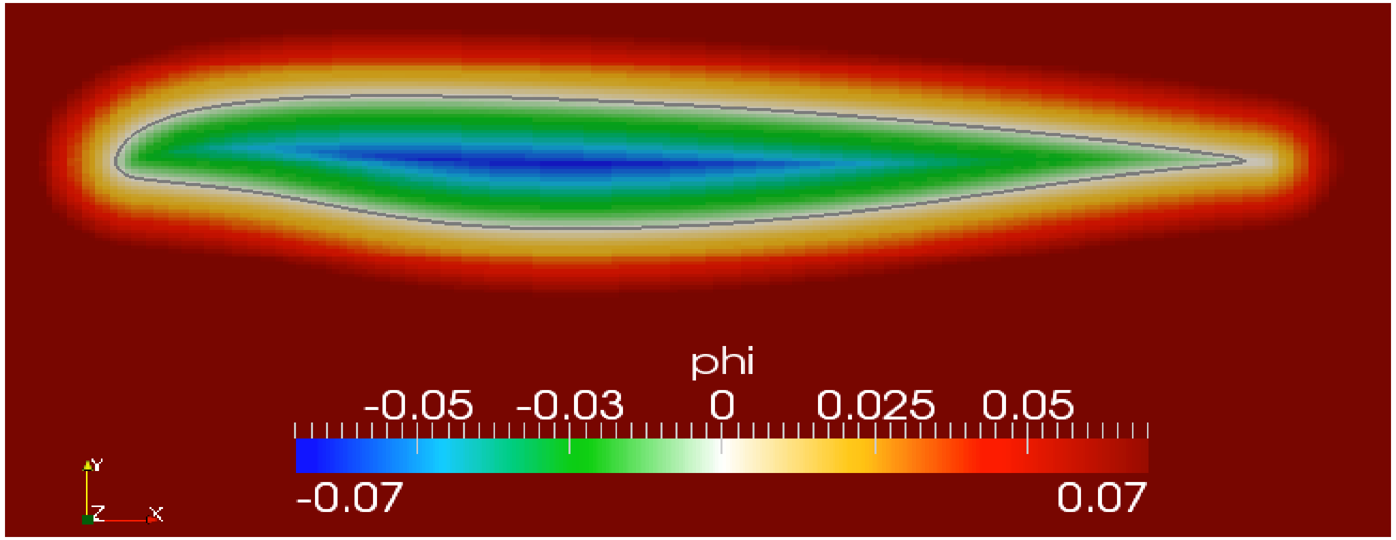


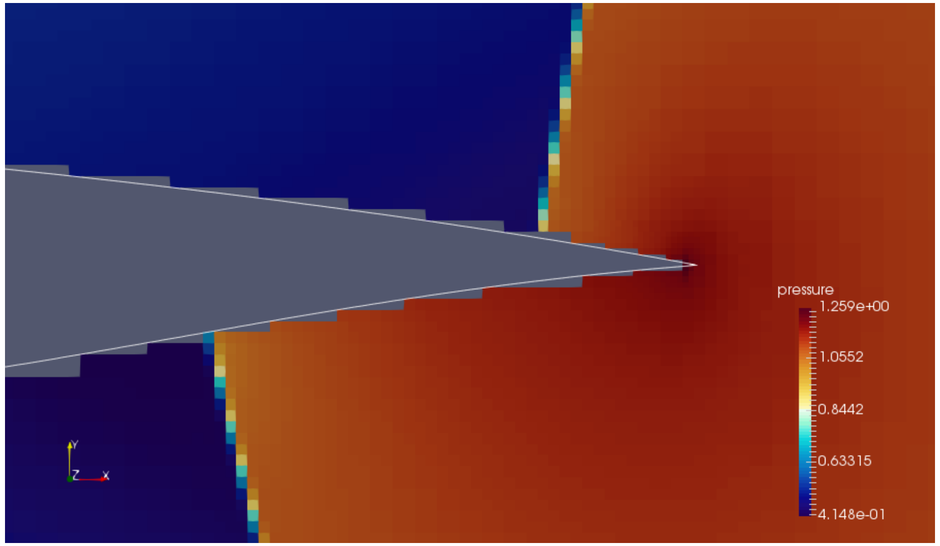
Kintetic Energy



Integration with immersed boundaries

- geometry represented as zero Level Set
- first cell resolved – not interpolated
- inviscid shock-wall inter-action
- wall-functions integrated in reconstruction step at all faces based on distances

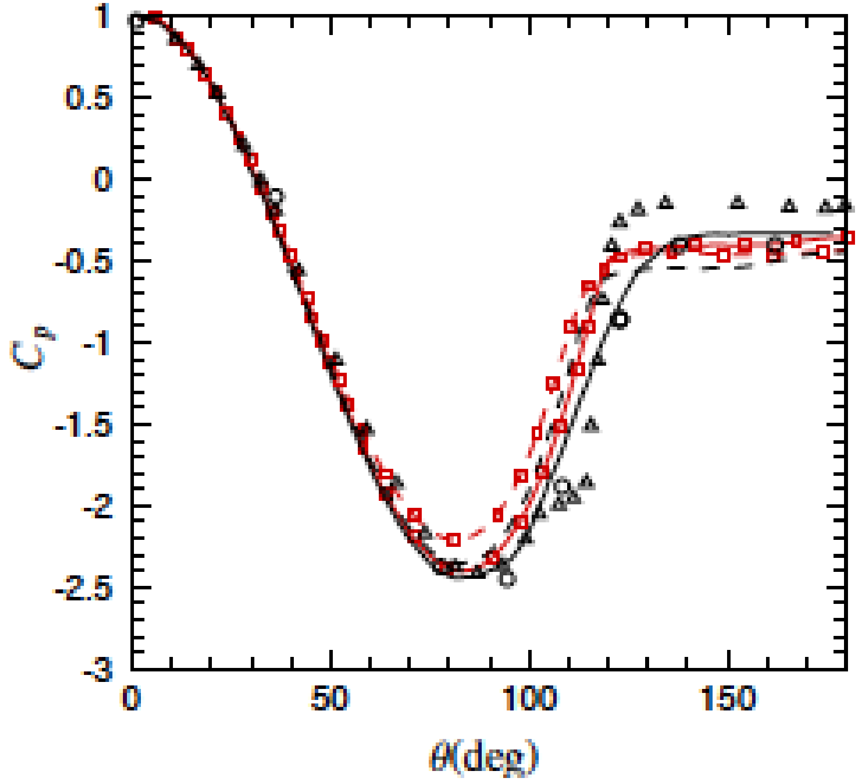




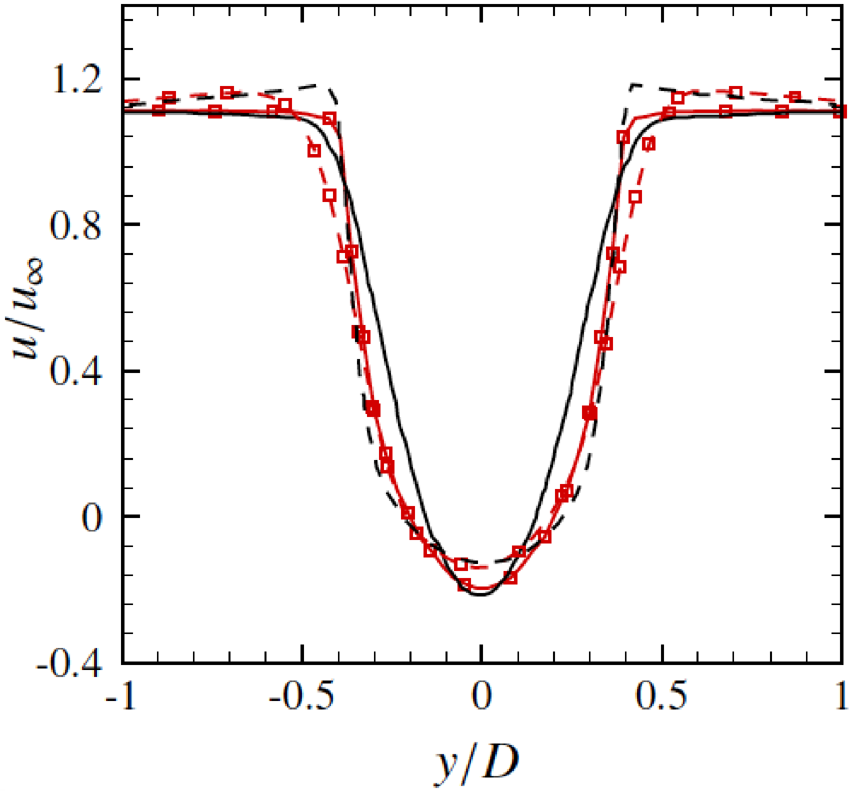
Validation: Integration with immersed boundaries

flow past cylinder, Mach=0.1, Re=10^6, DES = red solid, URANS = red dashed

pressure coefficient



velocity profile in wake



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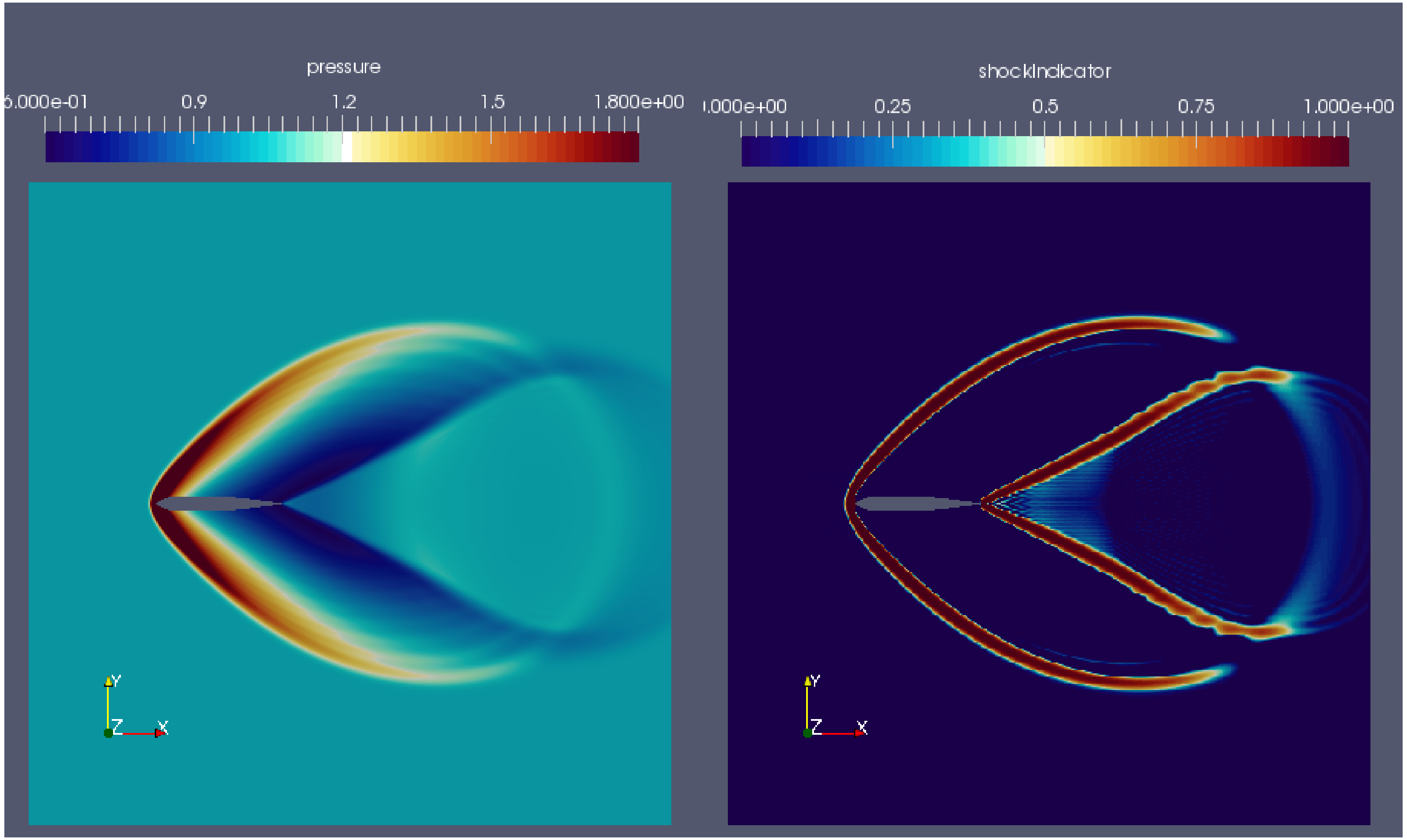
Validation: Mach=2 flow around Naca0012

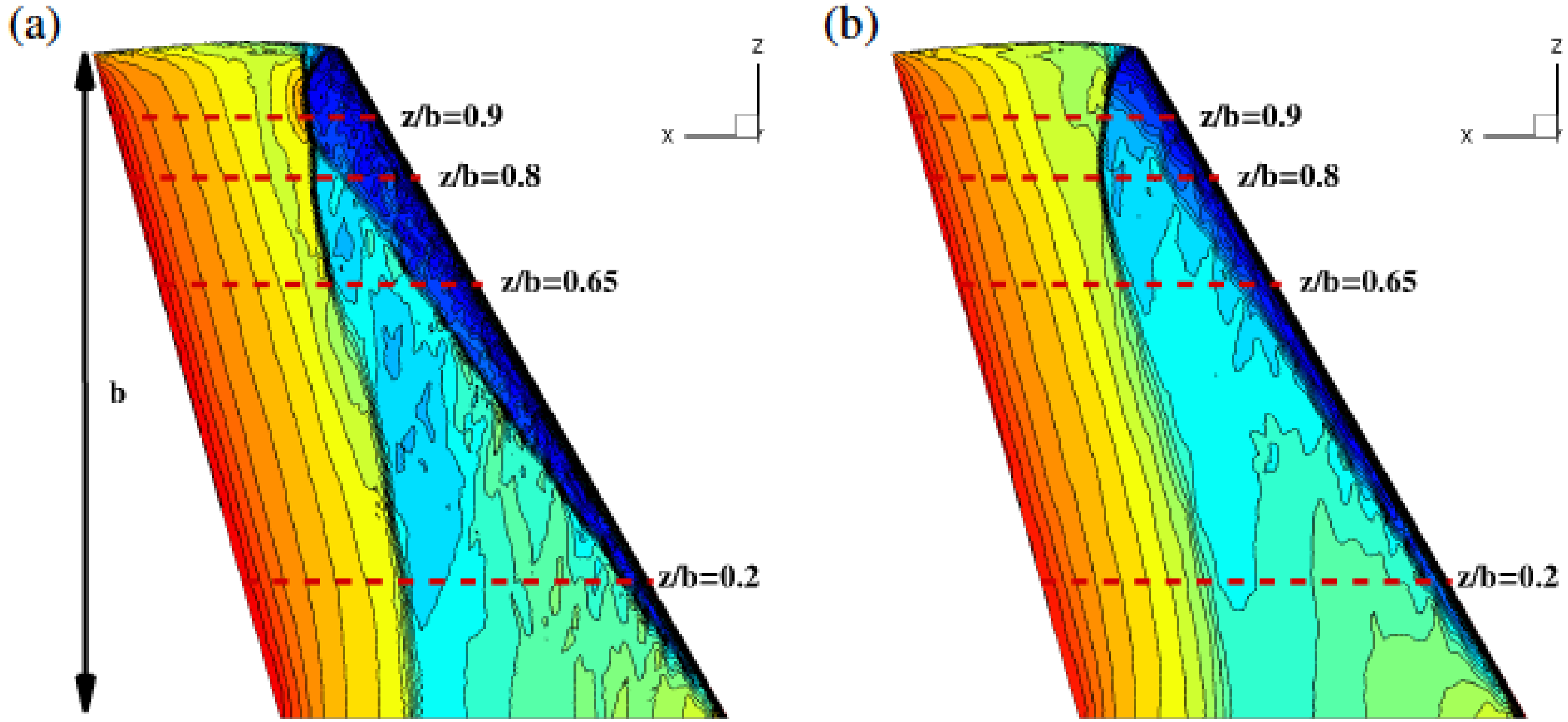


Validation: Integration with immersed boundaries

Onera M6, Mach=0.83, AoA=3.06

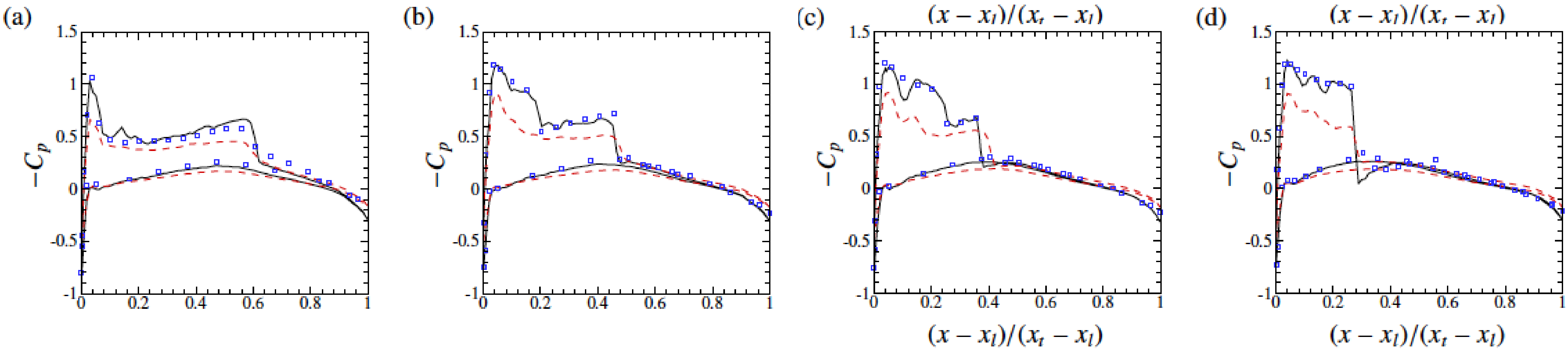
DKEC

Kurganov & Tadmor

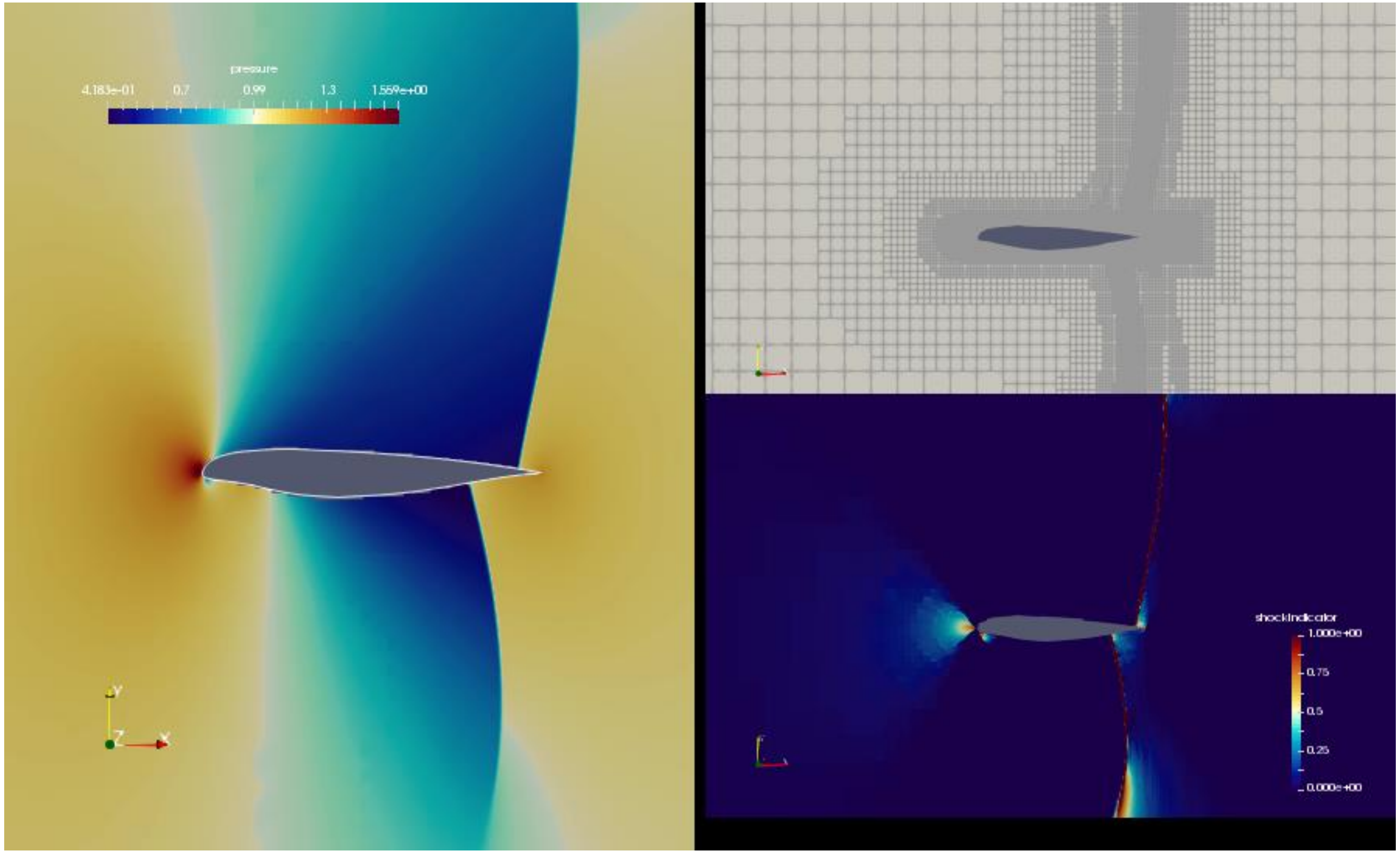


Validation: Integration with immersed boundaries

Onera M6, Mach=0.83, AoA=3.06



Crank base line flow + adaptive grid



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