Go4Hybrid

Grey Area Mitigation for Hybrid RANS-LES Methods

DLR

DLR work plan in Go4Hybrid

Updated

- DLR contributes in WP 3.1, 3.2 (Embedded methods) and 4.2

- **Basic model development / implementation** in DLR-TAU / (THETA) Code:
  - generalized framework for synthetic turbulence methods, e.g. (DF-)SEM, ~~STG~~
  - insert synthetic turbulence at RANS/LES interface from ADDES
  - ~~combination with automatic grid adaptation in LES regions~~

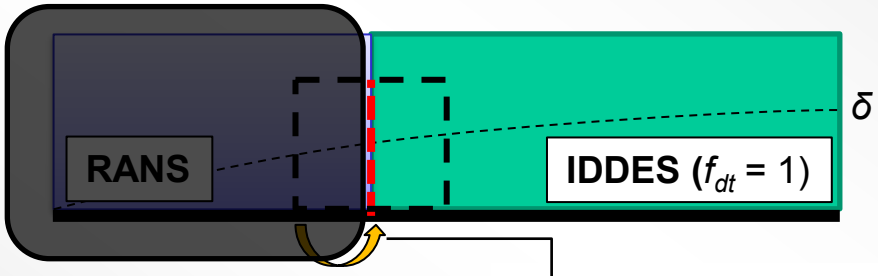
- **Test cases:**
  1. Flat plate (F.1)
     - basic tests of synthetic turbulence implementations in DLR-TAU
     - different turbulence generators and RANS „input“ models (up to RSM)
  2. 2D hump flow (I.4)
     - basic tests of ADDES + synthetic turbulence ~~+ grid adaptation~~
  3. 3-element high-lift airfoil (I.3, coordinated by DLR)
     - test full approach in consecutive steps: LES only on flap, LES only in slat cove, ~~final combined simulation (if time permits)~~

TC.F1: Flat plate flow

Basic development & assessment of SEM in DLR-TAU

(Preparatory) Work performed:

- implementation of (DF-)SEM in unstructured compressible DLR-TAU solver
  - 1st step: restriction to inflow boundary
- development & verification of (hybrid) low-dissipation/low-dispersion scheme (LD2)
  - ➢ essential for decent c_f-recovery in plane channel
- implementation & validation of RSM-IDDES (special DLR interest)
- all applied to mandatory flat-plate setup (SA-IDDES + SEM):



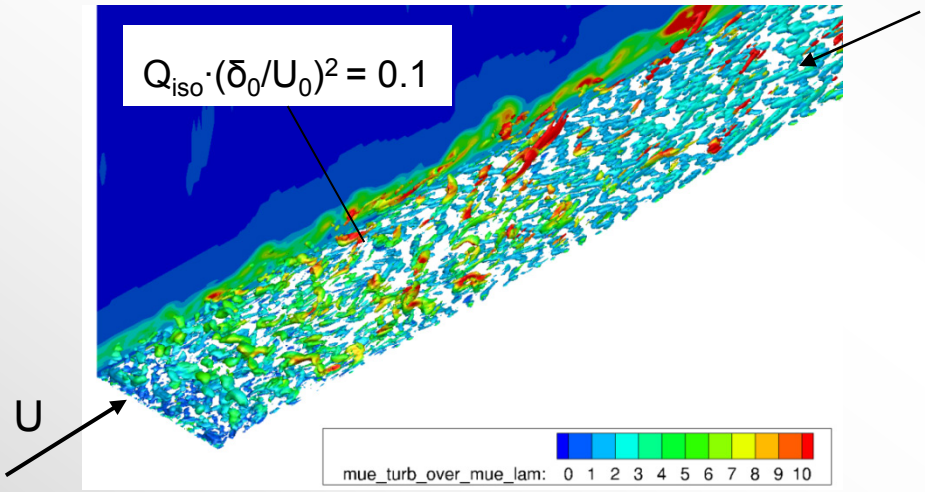
$$u_i' = \frac{1}{\sqrt{N}} \sum_{k=1}^{N} a_{ij} \varepsilon_j^{(k)} f_\sigma(\vec{x} - \vec{x}^{\,(k)})$$

- However, first results turned out <u>useless</u>
  - ➢ next slide

Go4Hybrid

TC.F1: Flat plate flow

"Bug tracking"



- strange development of Q-criterion
- no c_f-recovery!

➢ In-depth analysis performed:
- step-by-step verification of SEM in TAU
- tested alternative definition for σ_{SEM}
- used acoustic sponge layer to damp inlet-pressure disturbances
- checked underlying hybrid model (SA-IDDES) in plane channel

Finally:
- found rare TAU-bug: 2D-simplifications active despite 3D case!
- fix directly solved problems

➢ delay of 2-3 months, compensated by reduced work plan

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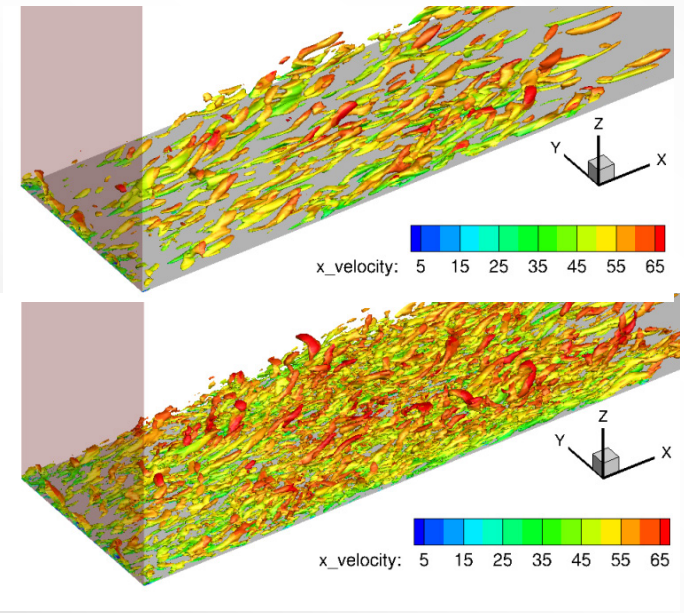
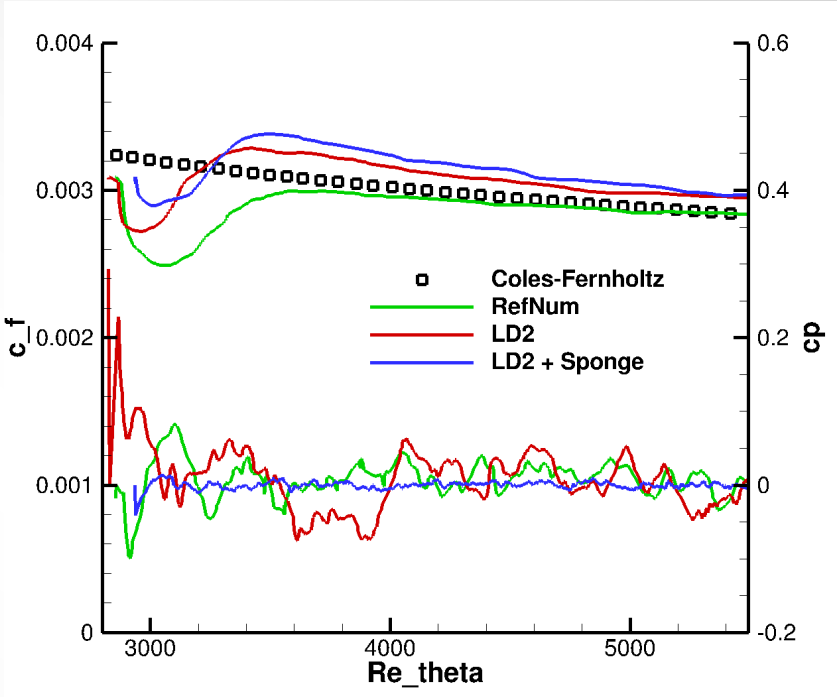
TC.F1: Flat plate flow

First results and further work

Ref.-scheme

LD2-scheme





Further work plan:

- DF-SEM (to be discussed with UniMAN) + SA-IDDES
- Finalizing running simulations:
  - SEM (with RSM-input data) + RSM-IDDES
  - SEM + SA-IDDES with hybrid LD2-scheme

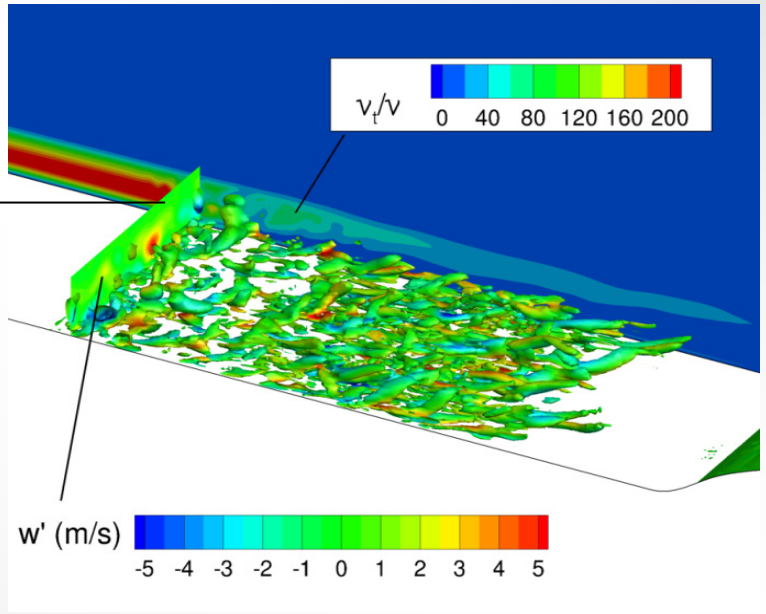
TC.I4: 2D hump flow

State of work

(Preparatory) Work performed:

- implementation of (DF-)SEM in unstructured compressible TAU solver
  - 2nd step: forcing inside flow domain via volume sources
  - coupling with AIDDES ("automatic" embedded-LES) ongoing
- reference simulation with mandatory settings, but global SST-IDDES (+ Δ_ω)

- embedded simulations running:
  - SEMorg (vol. sources) + SST-IDDES
  - first mandatory interface (x = -1)
  - 2 different time steps (mand. and half)
  - ~6 CTUs (of 30) finished

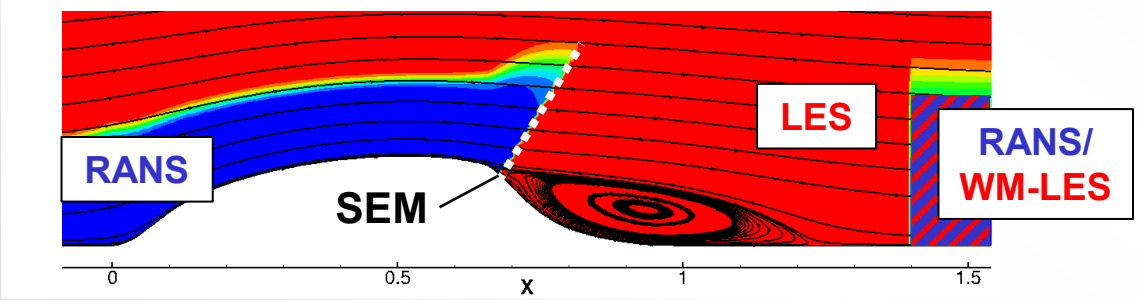


TC.I4: 2D hump flow

Further work plan

Further work plan:

- finalize SST-IDDES + SEM (x = -1) and evaluate results
- depending on observations:
  - consider DF-SEM (if promising according to TC.F1)
  - consider acoustic sponge layer around interface
  - consider damping source term for modelled turbulence behind interface
- probably skip:
  - second interface position (x = 0.5)
  - RSM-IDDES + SEM
- … in favor of demonstrating „automatic“ embedded approach:

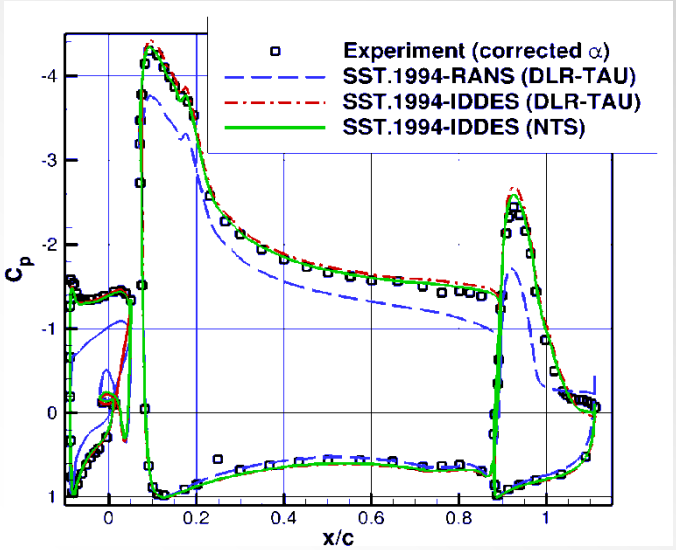


TC.I3: 3-element airfoil

Status and further work

(Preparatory) Work performed:

- SST-IDDES simulations with mandatory settings, but no synthetic turbulence
- comparison with equivalent NTS simulations:
  - overall good mean-flow agreement
  - improved aero-acoustic agreement with hybrid LD2-scheme in TAU



Further work:

- embedded simulation to be started:
  - SST-IDDES with fixed interface (volume sources)
  - orig. or DF-SEM depending on other TC's
  - probably only time for just one embedded setup