Abstract for Case 1.3a and 1.3c

Flow over NACA0012 Airfoil

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1. Code description

- We employ the CPR-DG formulation [1-4] for space discretization
- A GMRES solver with a LU-SGS as a preconditioner [5]. Only the block diagonal matrices are stored.
- The standard p4 meshes are used in the simulation with p = 1 to 5
- The code was run in a serial mode

2. Case summary

- All simulations start from free stream
- 30 search directions employed in GMRES for inviscid flow, 90 for viscous flow.
- First time step dt=1.25E-5, after the residual achieves 1.0E-4, time step is changed to infinity (1.0E20).
- We were able to converge 10 orders for all the inviscid cases, and most viscous cases. We included the work units for both the 10 order and 8 order convergence.
- Taubench ran in 9.83s.

3. Meshes

- Standard posted p4 quadrilateral meshes were used
- The curved walls were p-4 represented with p-4 polynomials.

4. Results

For the inviscid flow, we used the “truth” C_l and C_d values from the University of Michigan, and for the viscous case, we used the “truth” values from MIT as our final values are quite close to the truth values obtained through adjoint based adaptations.

Inviscid flow results are shown in Figures 1 and 2.

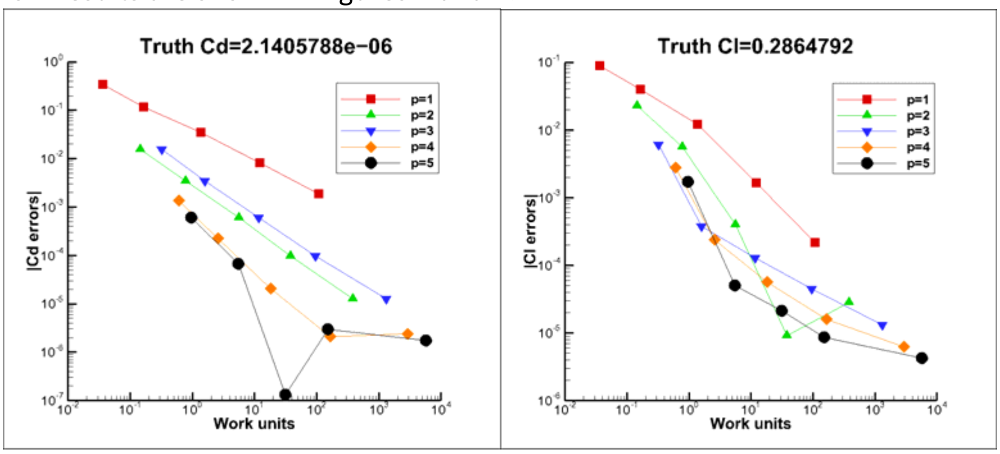

Figure 1. Plot of cl and cd errors vs. work units for different *h* and *p*. Inviscid flow

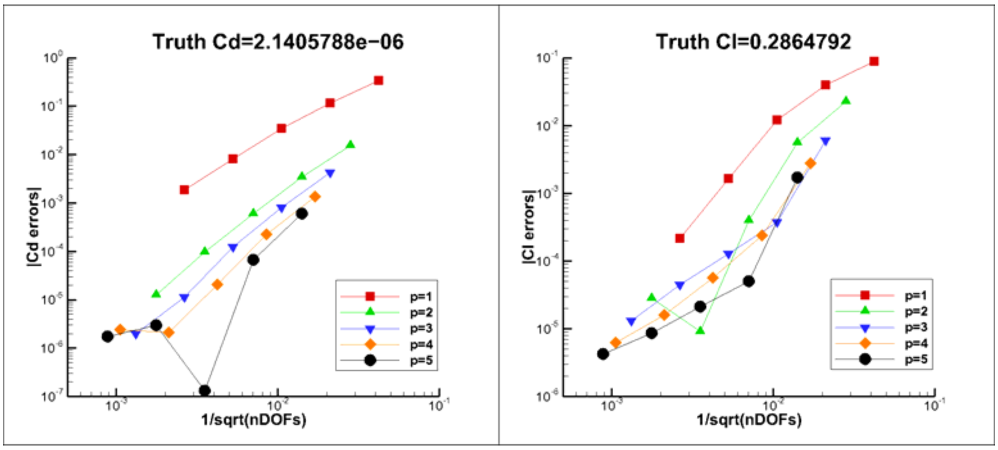

Figure 2. Plot of cl and cd errors vs $h = 1/\sqrt{nDOFs}$ for different h and p. Inviscid Flow

Viscous results are shown in Figures 3 and 4.

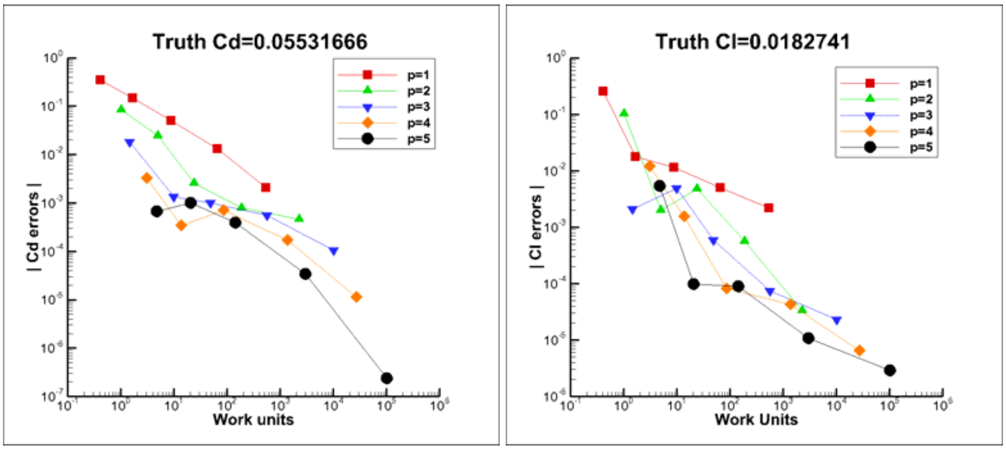

Figure 3. Plot of cl and cd errors vs. work units for different *h* and *p*. Viscous flow

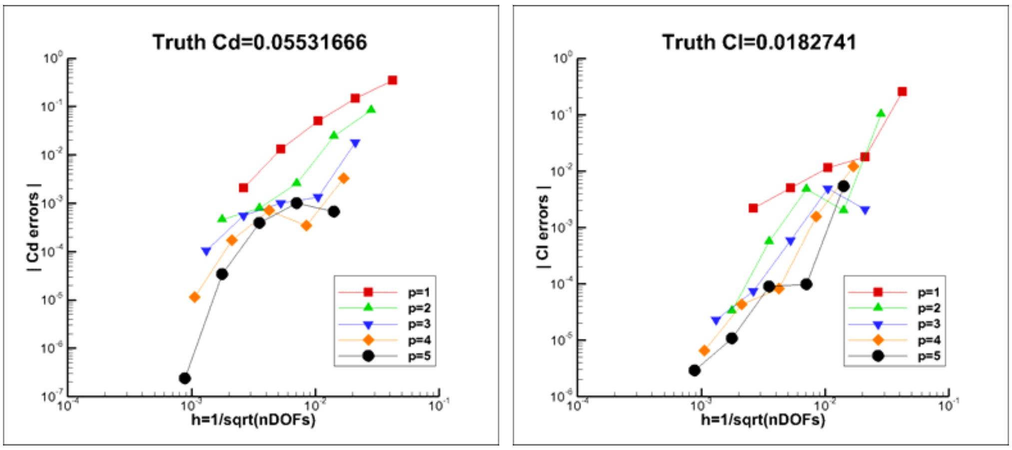

Figure 4. Plot of cl and cd errors vs $h = 1/\sqrt{nDOFs}$ for different h and p. Viscous Flow

5.References

[1] H.T. Huynh, A flux reconstruction approach to high-order schemes including discontinuous Galerkin methods, AIAA Paper 2007-4079.

[2] Z.J. Wang and Haiyang Gao, “A unifying lifting collocation penalty formulation including the discontinuous Galerkin, spectral volume/difference methods for conservation laws on mixed grids,” Journal of Computational Physics 228 (2009) 8161 – 8186.

[3] Z.J. Wang, H. Gao and T. Haga, “A Unifying Discontinuous Formulation for Hybrid Meshes,” Adaptive High-Order Methods in Computational Fluid Dynamics, Edited by Z.J. Wang, World Scientific Publishing, 2011.

[4] H. Gao, Z.J. Wang and H.T. Huynh, “Differential Formulation of Discontinuous Galerkin and Related Methods for the Navier-Stokes Equations”, Communications in Computational Physics, accepted.

[5] Y. Sun, Z.J. Wang and Y. Liu, “Efficient Implicit Non-linear LU-SGS Approach for Compressible Flow Computation Using High-Order Spectral Difference Method”, Communications in Computational Physics, Vol. 5, No. 2-4, pp. 760-778 (2009).