C1.2 Flow over the NACA0012 Airfoil, Inviscid and Viscous, Subsonic and Transonic

1. Code description

XFlow is a high-order discontinuous finite element library written in ANSI C, intended to be run on Linux-type platforms. XFlow supports DG and HDG discretizations and a variety of equation sets, including compressible Euler, Navier-Stokes, and RANS with the Spalart-Allmaras model. High-order is achieved compactly within elements using various high-order bases on triangles, tetrahedra, quadrilaterals, and hexahedra. Parallel runs are supported using domain partitioning and MPI communication. Visual post-processing is performed with an in-house plotter. Output-based adaptivity is available using discrete adjoints.

2. Case summary

The steady runs were performed using:

- DG discretization
- 8 orders of magnitude L_1 residual convergence of a conservative state vector of $\mathcal{O}(1)$ freestream density, velocity and pressure, and gas constant $R = 1.0$.
- Element-line preconditioned Newton-GMRES solver
- Mesh adaption for drag and lift depending on target output

The runs were performed in serial on the *flux* high performance computing cluster at the University of Michigan. On one core of this machine, one TauBench unit is equivalent to 6.61 seconds of compute time.

3. Meshes

For the abstract, the quadrilateral mesh *ref0* posted on the workshop site was used as the initial mesh for adjoint-based h-adaptive adaptive runs. Prior to the runs, conversion to an equivalent native format was performed without any loss of information.

4. Results

The figures below present the results requested for all three conditions in this test case. Output errors were obtained relative to truth solutions, which were computed from adjoint-based h-adaptive runs using $p = 5$ on the finest meshes of $p = 4$ results as respective starting points, except that the transonic case used our truth solutions for the 2nd High-order Workshop.

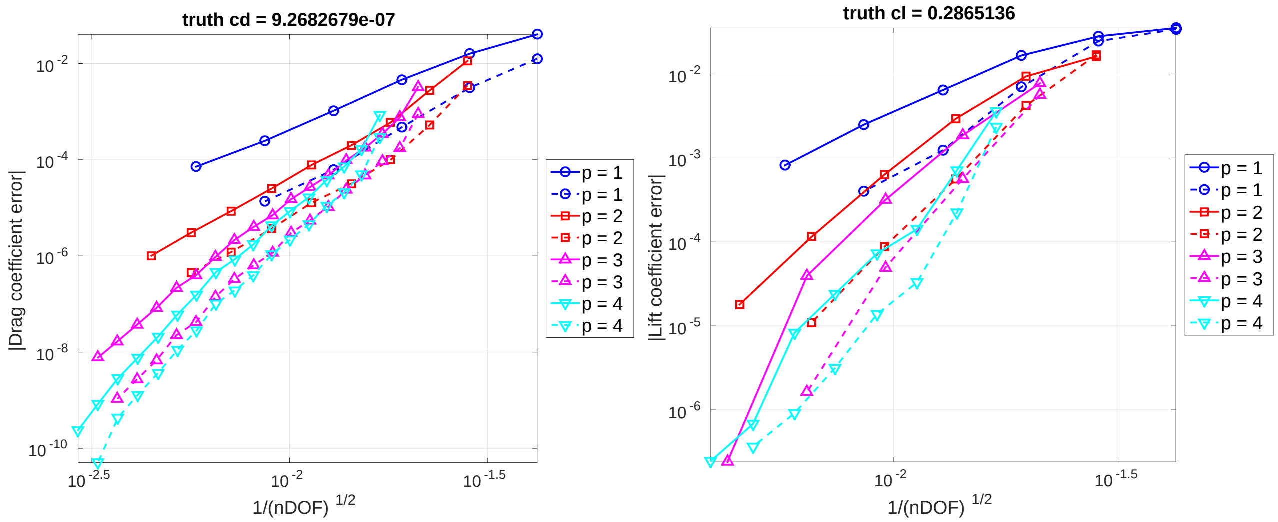

Figure 1: $M = 0.5, \alpha = 2^o$, inviscid: drag and lift error convergence with mesh h refinement (solid for raw error; dashed for corrected error)

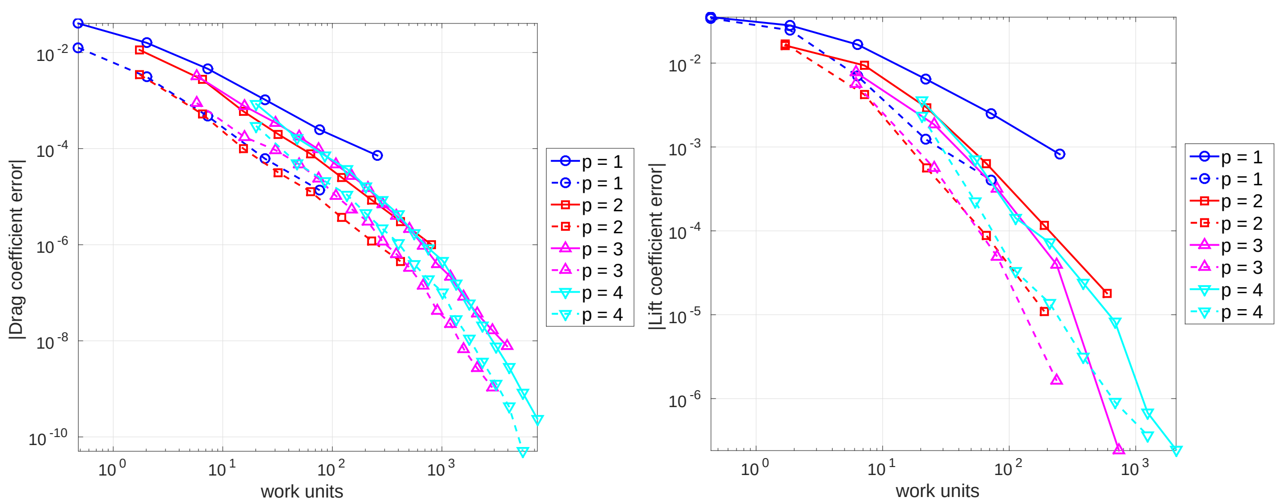

Figure 2: $M = 0.5, \alpha = 2^o$, inviscid: drag and lift error convergence with work units (solid for raw error; dashed for corrected error)

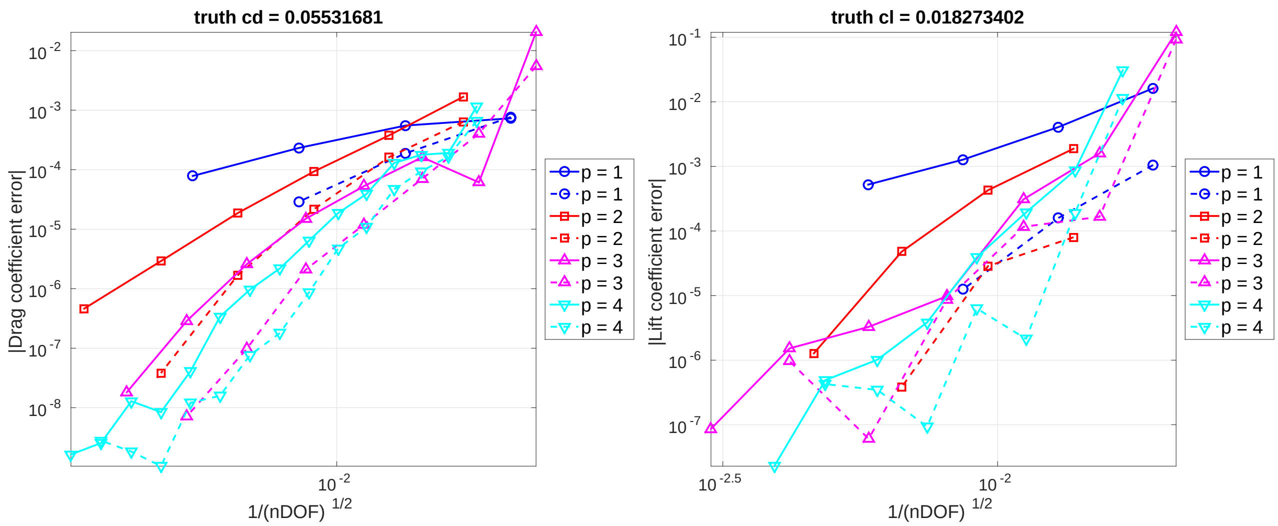

Figure 3: $M = 0.5, \alpha = 1^o, Re = 5000, Pr = 0.72$, viscous: drag and lift error convergence with mesh h refinement (solid for raw error; dashed for corrected error)

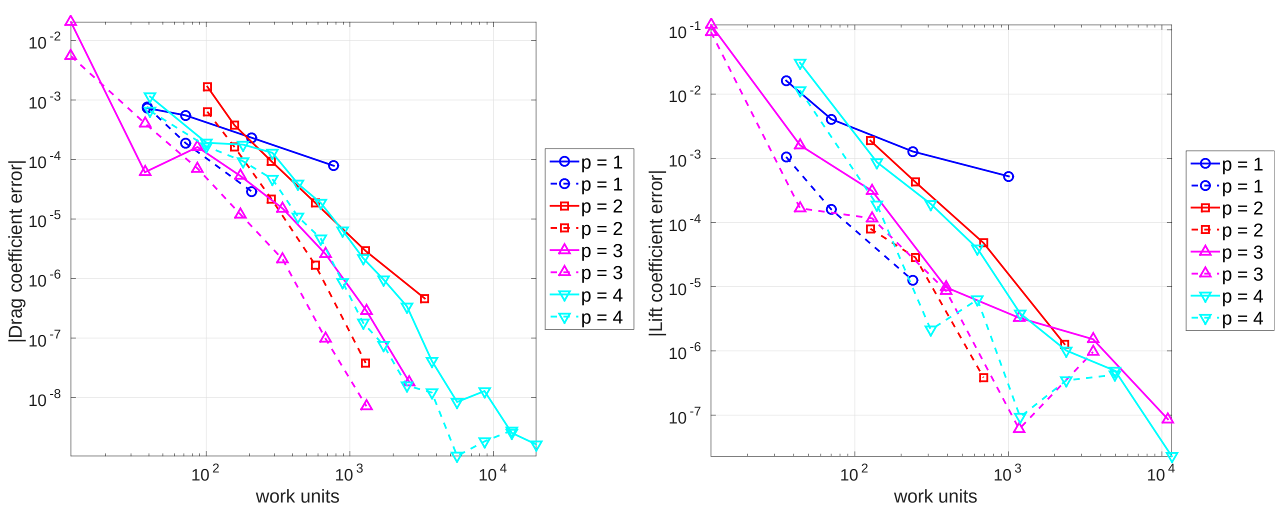

Figure 4: $M = 0.5, \alpha = 1^o, Re = 5000, Pr = 0.72$, viscous: drag and lift error convergence with work units (solid for raw error; dashed for corrected error)

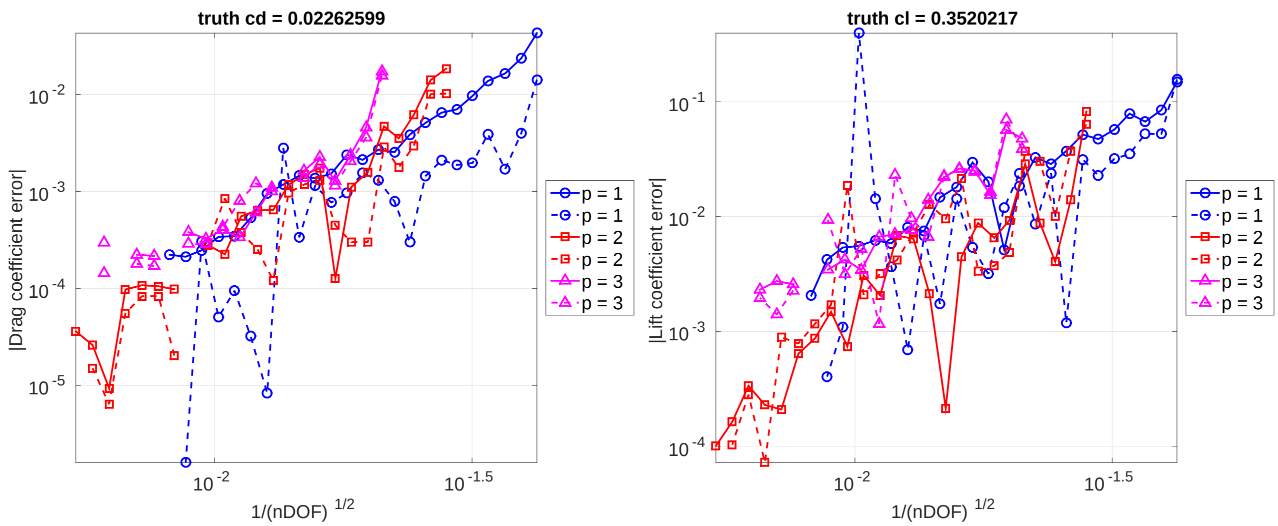

Figure 5: $M = 0.8, \alpha = 1.25^o$, transonic: drag and lift error convergence with mesh h refinement (solid for raw error; dashed for corrected error)

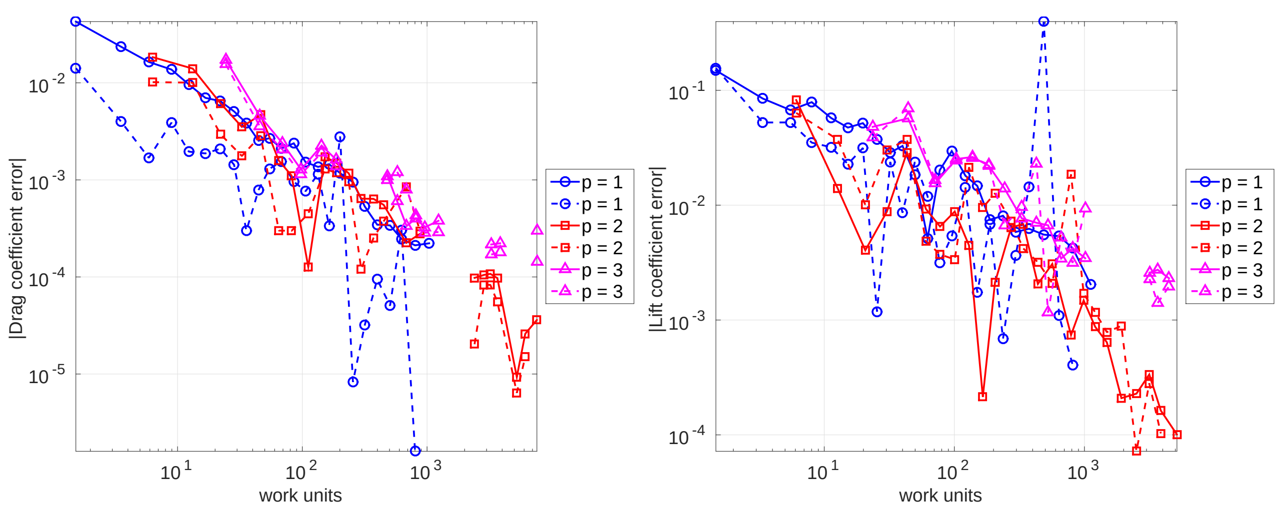

Figure 6: $M = 0.8, \alpha = 1.25^o$, transonic: drag and lift error convergence with work units (solid for raw error; dashed for corrected error)