C1.2 Flow over the NACA 0012 Airfoil, Inviscid and Viscous

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:

- A 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
- Adjoint-based error estimation and metric-based mesh adaption for drag and lift separately

The runs were performed on a 24-core desktop with Intel(R) Xeon(R) CPUs and 64GB shared memory. On one core of this machine, one TauBench unit is equivalent to 9.66 seconds of compute time.

3. Meshes

Triangular meshes with order $Q = 4$ curved elements near the boundary were generated using the bi-dimensional anisotropic mesh generator (BAMG). The initial mesh had 356 elements, and subsequent meshes were adapted using metric-based remeshing of the entire domain.

4. Results

The figures below present the results requested for the first two conditions in this test. Output errors were calculated relative to truth solutions computed from adjoint-based h-adaptive runs of the *ref0* mesh using $p = 5$ until more than 30,000 elements were obtained.

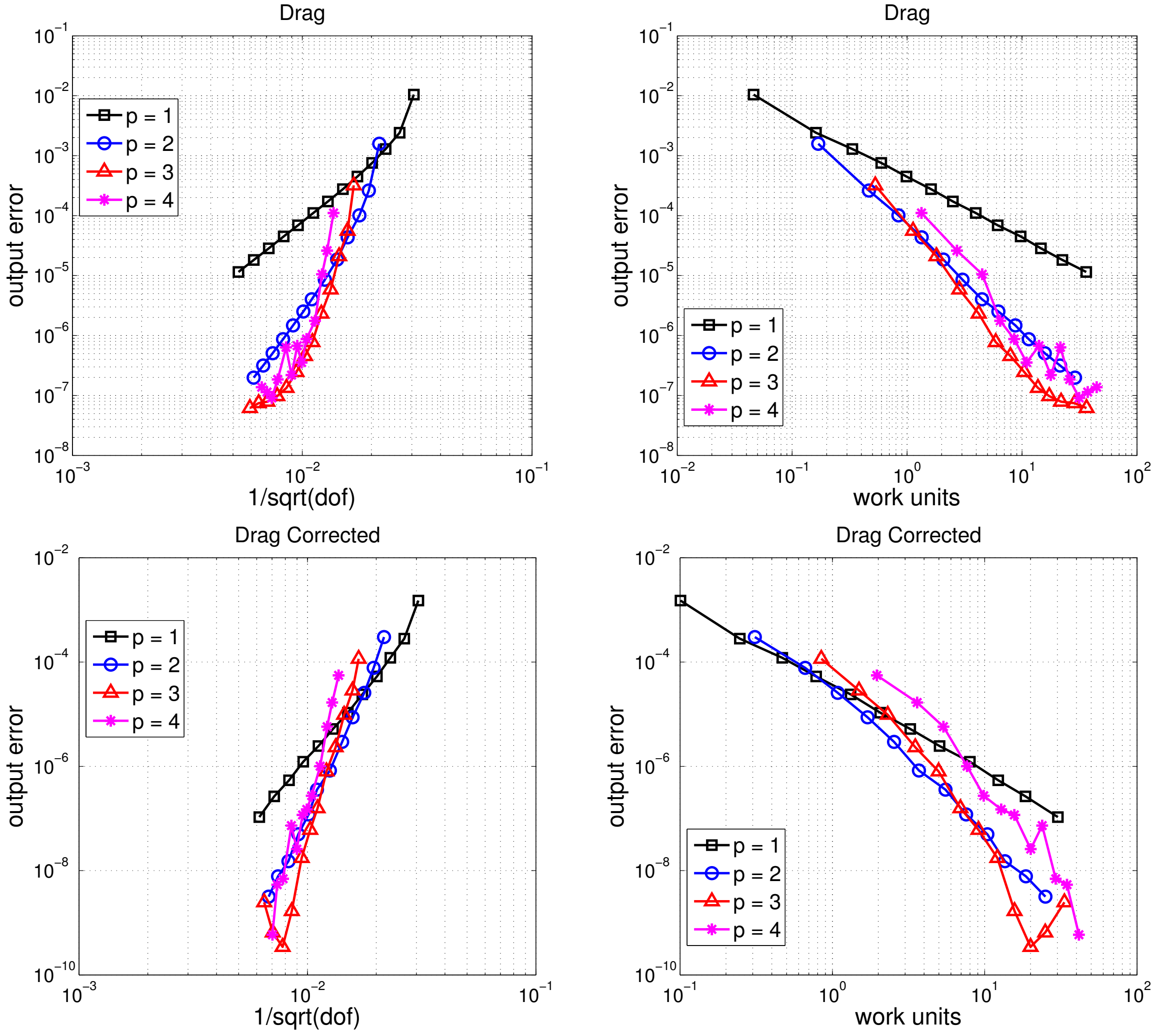

Figure 1: $M = 0.5, \alpha = 2^o$, inviscid: drag and corrected drag (adjoint-based) error convergence with mesh h refinement and work units

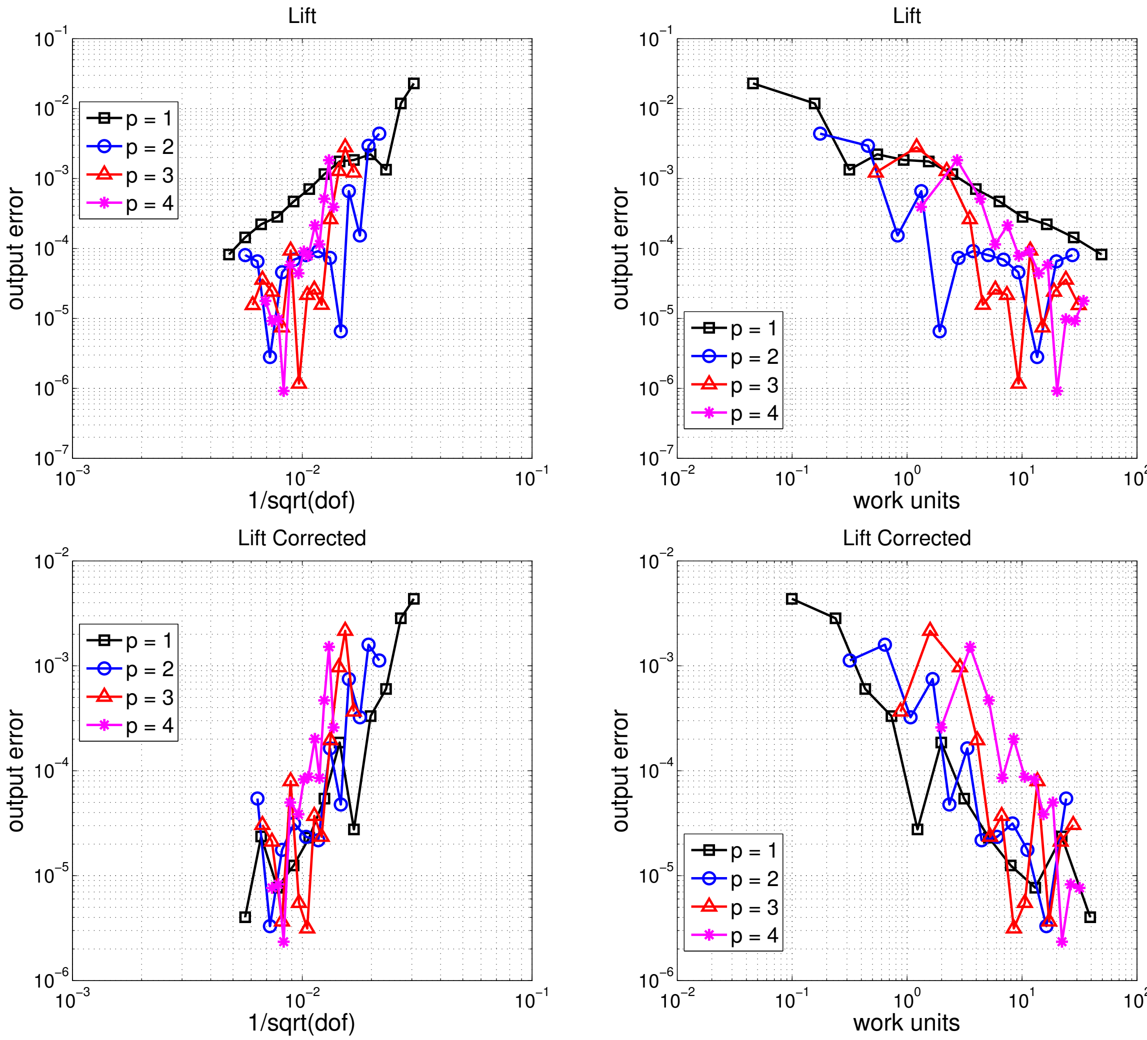

Figure 2: $M = 0.5, \alpha = 2^o$, inviscid: lift and corrected lift (adjoint-based) error convergence with mesh h refinement and work units

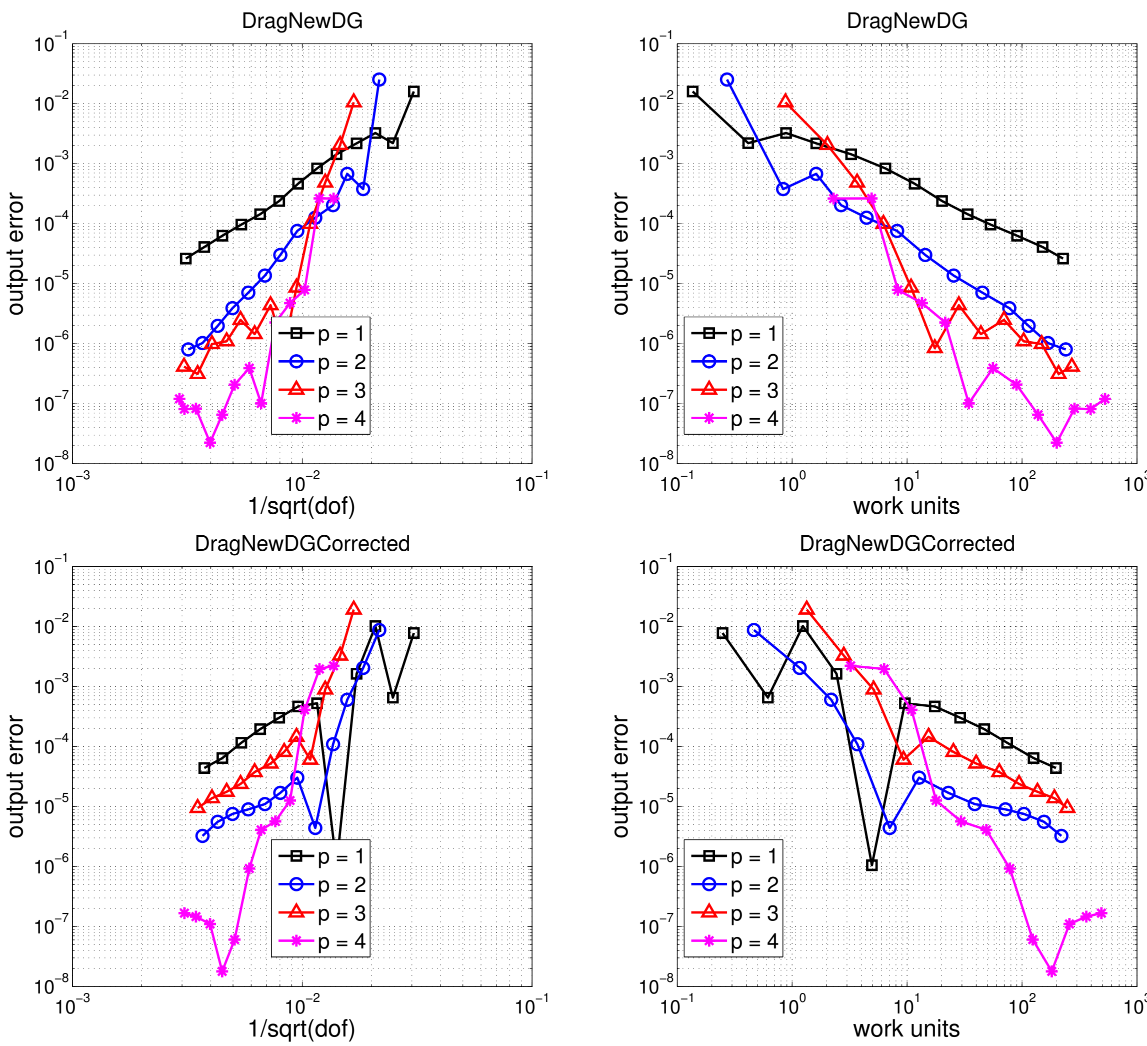

Figure 3: $M = 0.5, \alpha = 1^{\circ}, Re = 5000$: drag and corrected drag (adjoint-based) error convergence with mesh h refinement and work units

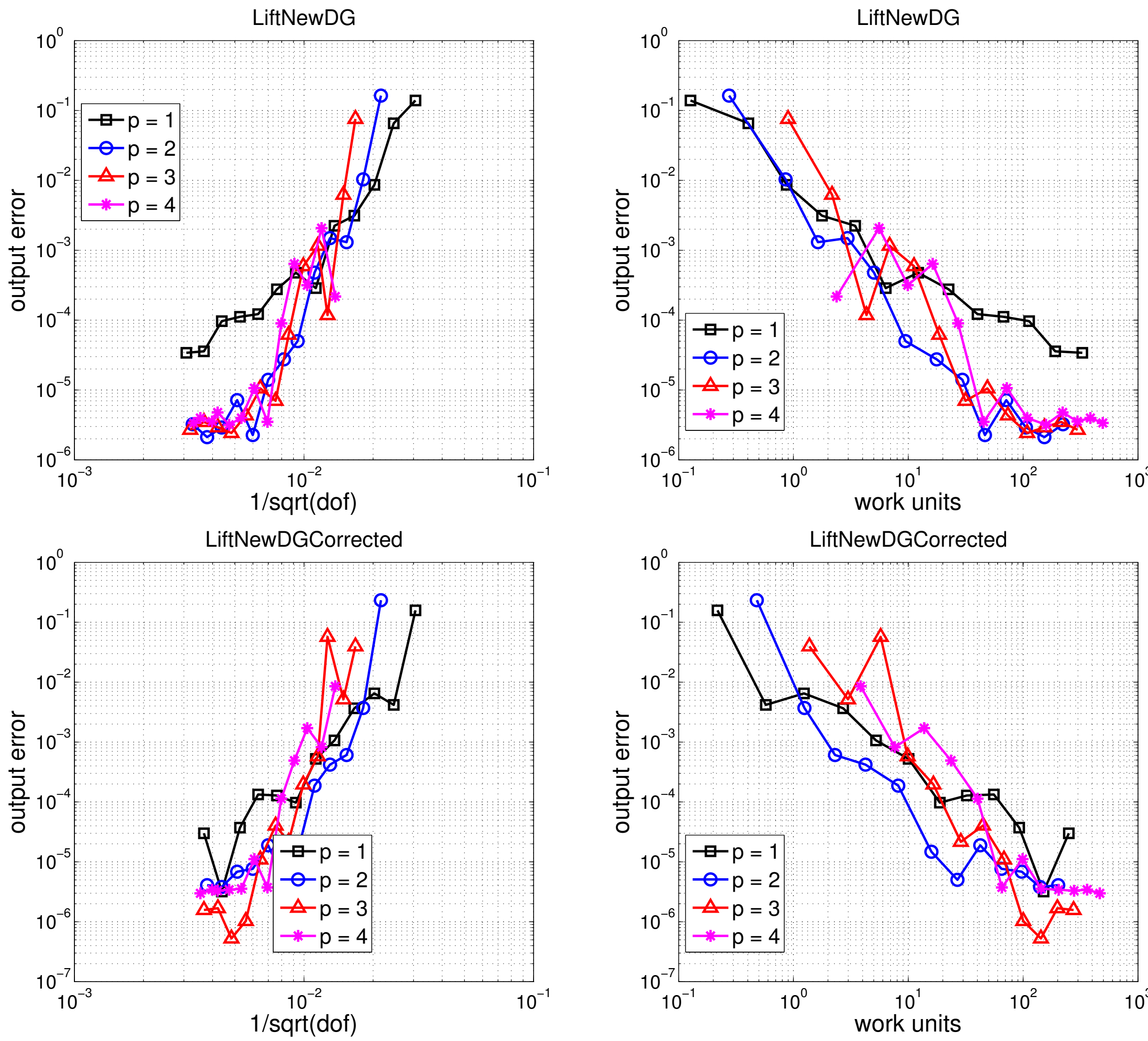

Figure 4: $M = 0.5, \alpha = 1^\circ, Re = 5000$: lift and corrected lift (adjoint-based) error convergence with mesh h refinement and work units