Effect of SDRWallFactor in Nalu-Wind

- Wall boundary condition of the omega in the SST turbulence model

$$\omega_{wall} = \boxed{10} \frac{6\nu}{\beta_1 (\Delta d_1)^2}$$

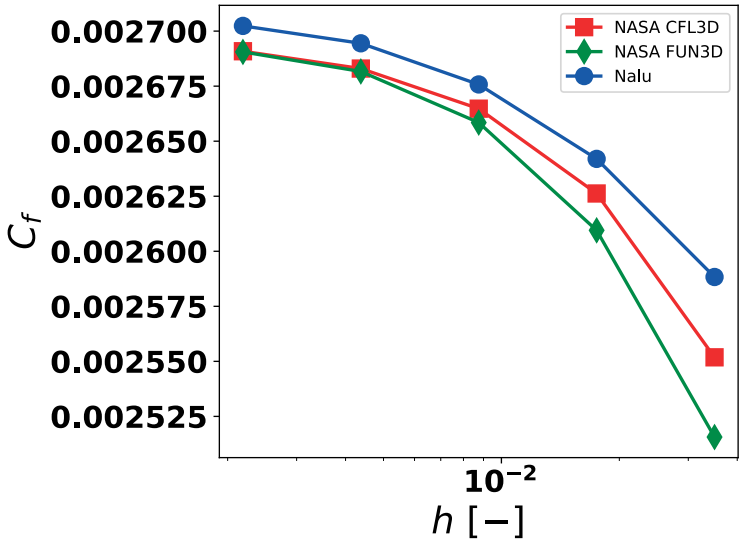
SDRWallFactor in Nalu-Wind

- Users can specify the SDRWallFactor in the input. The default value in Nalu-Wind is 1 if not explicitly specified. Many users run with the default value
- Marc performed the validation of the NASA's 2D Zero Pressure Gradient (ZPG) Flat Plate Verification Case with SDRWallFactor of 10
  - Marc's validation repository: https://github.com/marchdf/flatPlate
- Some reg test cases in the repository used 0.625
- This plays a crucial role in transition simulations because the transition model triggers laminar-turbulent transition based on flow quantities near the middle of the boundary layer.
- Tested NASA TMR's 2D ZPG flat plate and NACA 0012 airfoil cases with different values of SDRWallFactor
  - https://turbmodels.larc.nasa.gov/flatplate_val.html
  - https://turbmodels.larc.nasa.gov/naca0012_val.html

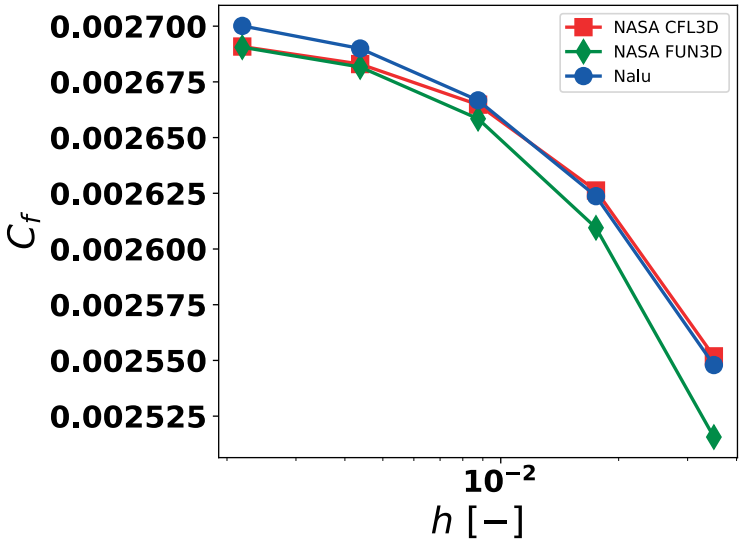
NASA's 2D Zero pressure gradient flat plate

- Convergence of skin friction coefficient at x = 0.97

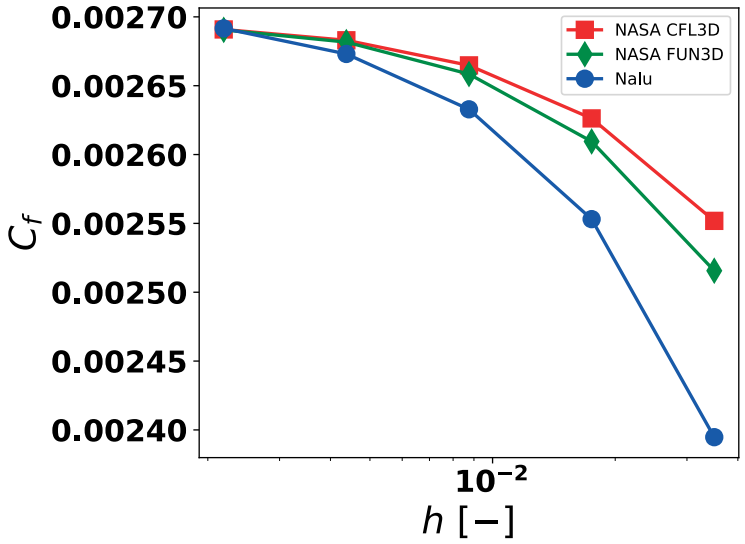
SDRWallFactor = 0.625



SDRWallFactor = 1 (default)



SDRWallFactor = 10

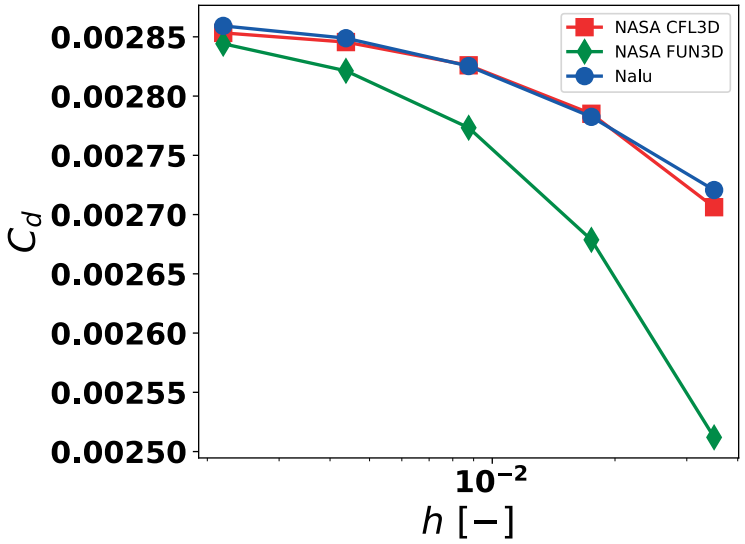


- Nalu-wind overpredicts the skin friction at the finest mesh level with SDRWallFactor of 0.625 or 1
- SDRWallFactor of 10 gives the best comparisons with CFL3D and FUN3D results at the finest mesh level

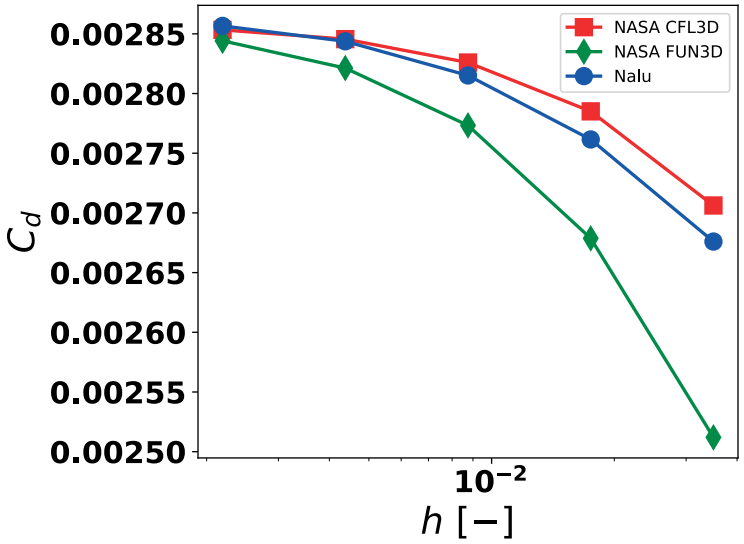
NASA's 2D Zero pressure gradient flat plate

- Convergence of drag coefficient

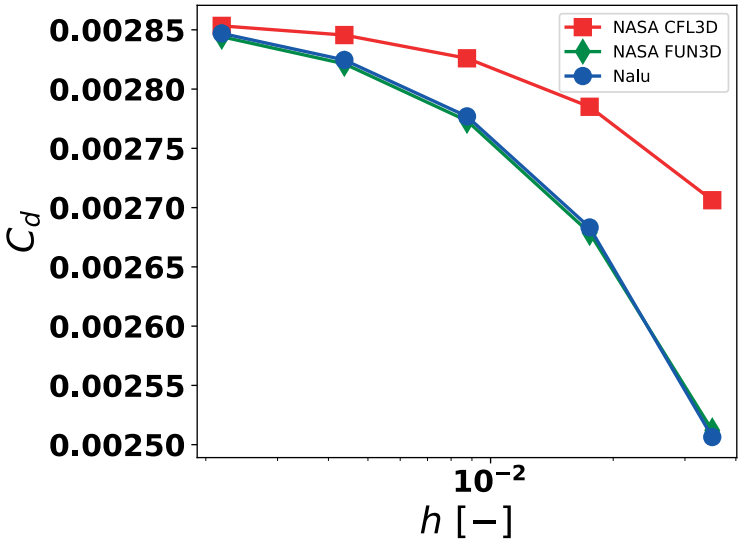
SDRWallFactor = 0.625



SDRWallFactor = 1 (default)



SDRWallFactor = 10

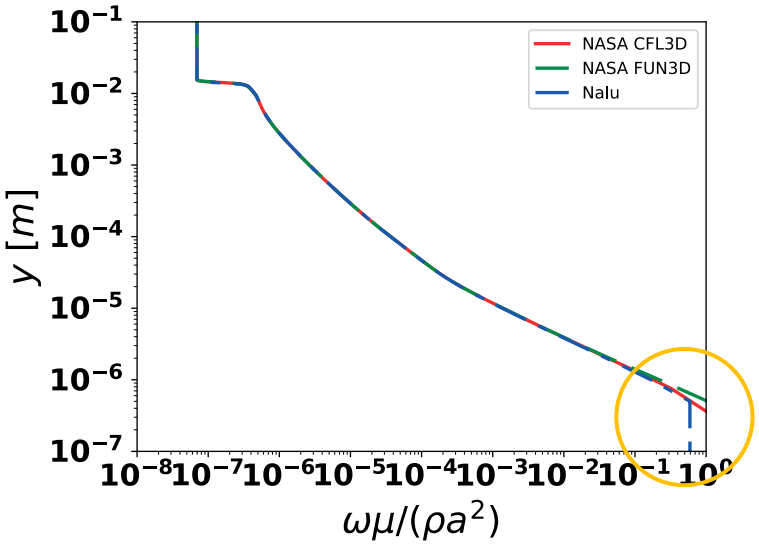


- Similarly, SDRWallFactor of 10 gives the best comparisons with FUN3D results.
- Considering both the FUN3D and Nalu-Wind are unstructured flow solver, the result with 10 more make senses than those with 0.625 or 1

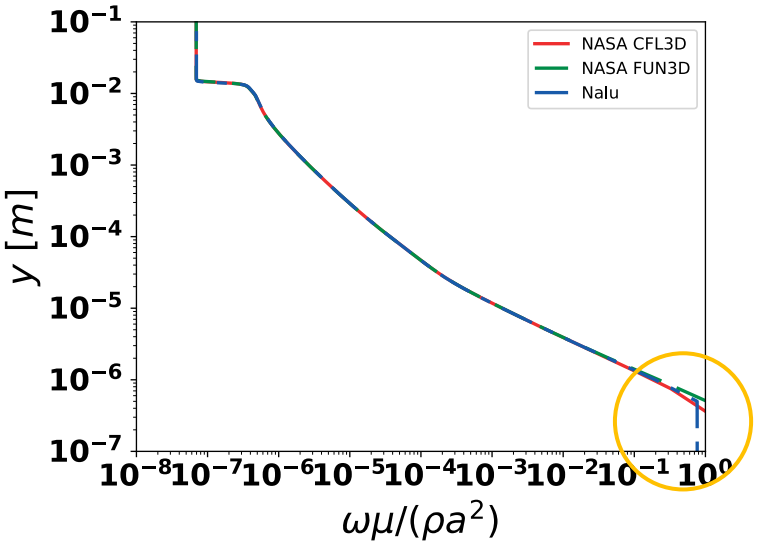
NASA's 2D Zero pressure gradient flat plate

- Nondimensional omega at x=0.97 (545x385 mesh)

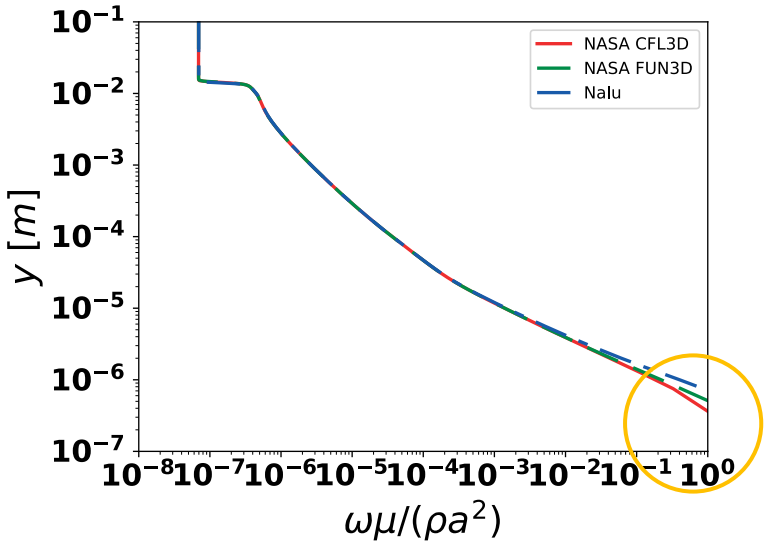
SDRWallFactor = 0.625



SDRWallFactor = 1 (default)



SDRWallFactor = 10

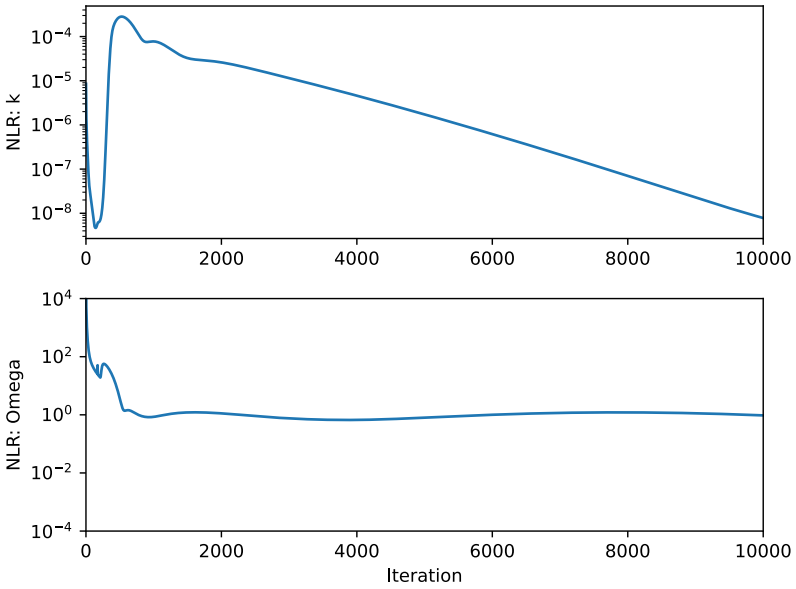


- CFL3D and FUN3D results show that the omega smoothly increases near the wall. The maximum omega at the wall.
- However, the results with SDRWallFactors of 0.625 or 1 don't increase near the wall
- The trend with SDRWallFactors of 10 has the best agreement with the trends of CFL3D or FUN3D results

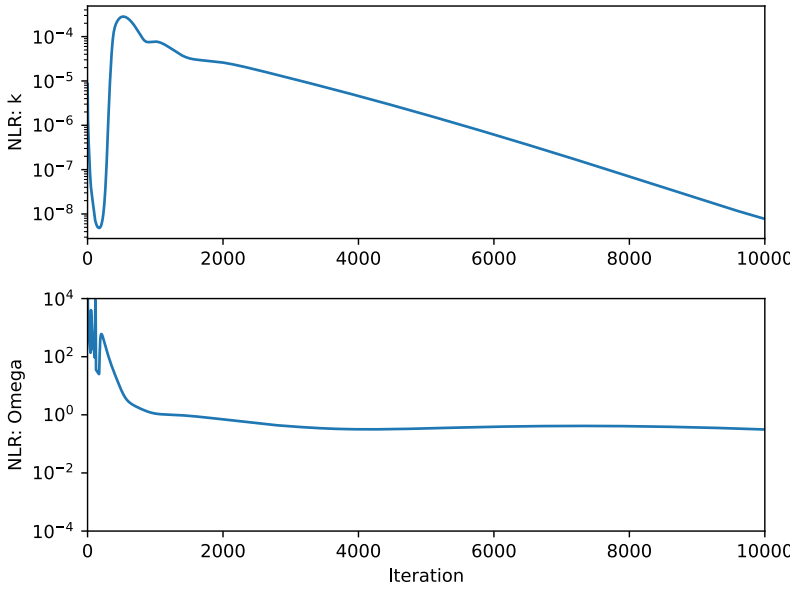
NASA's 2D Zero pressure gradient flat plate

- Convergence of the turbulence model: *k* and *omega*

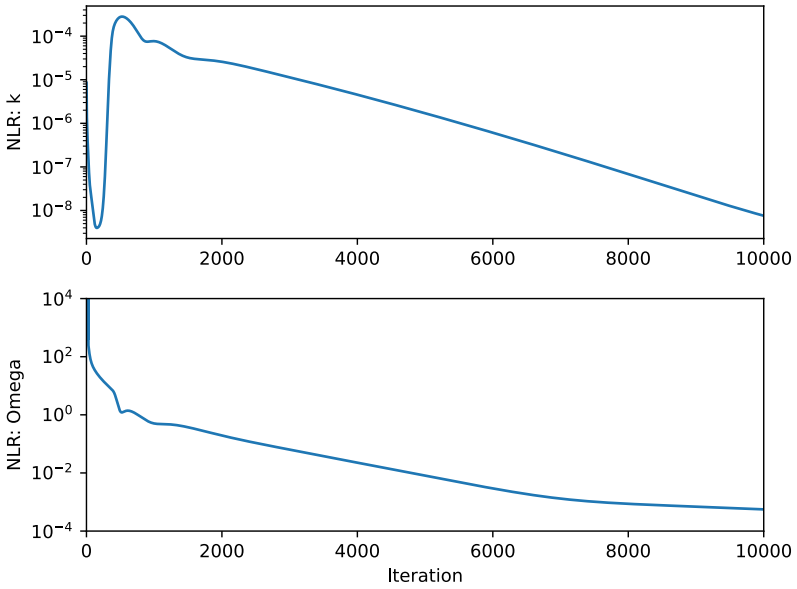
SDRWallFactor = 0.625



SDRWallFactor = 1 (default)



SDRWallFactor = 10

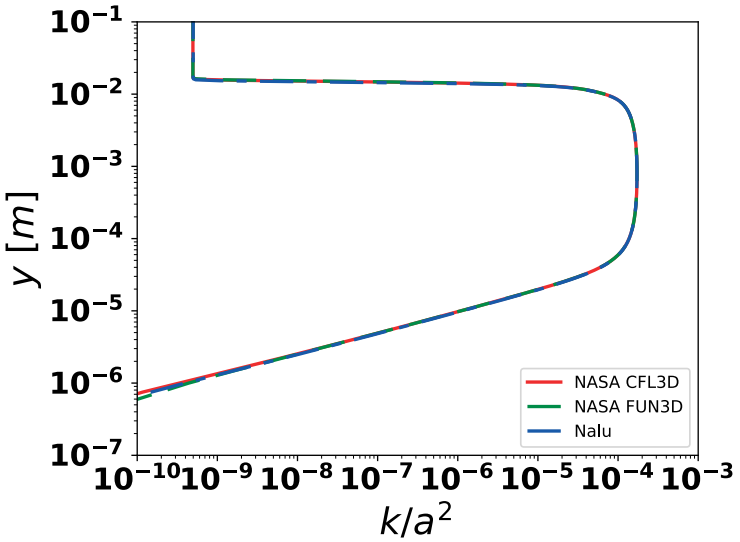


- Omega residual stalls with SDRWallFactors of 0.625 or 1

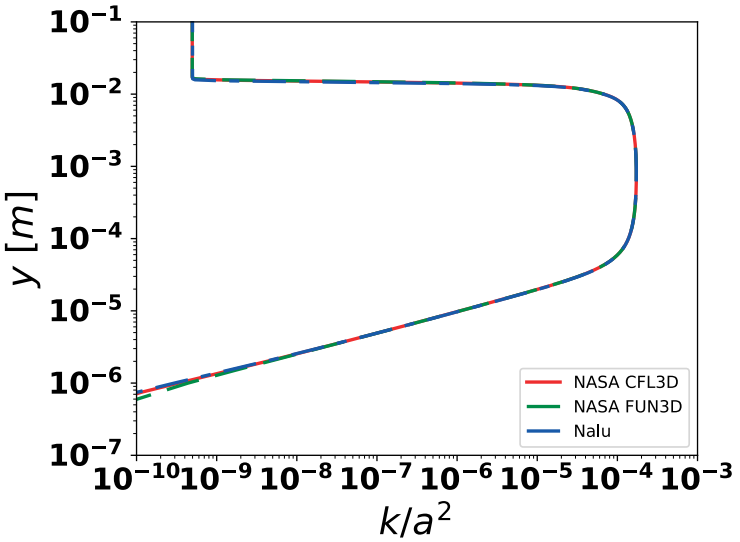
NASA's 2D Zero pressure gradient flat plate

- Nondimensional k at x=0.97 (545x385 mesh)

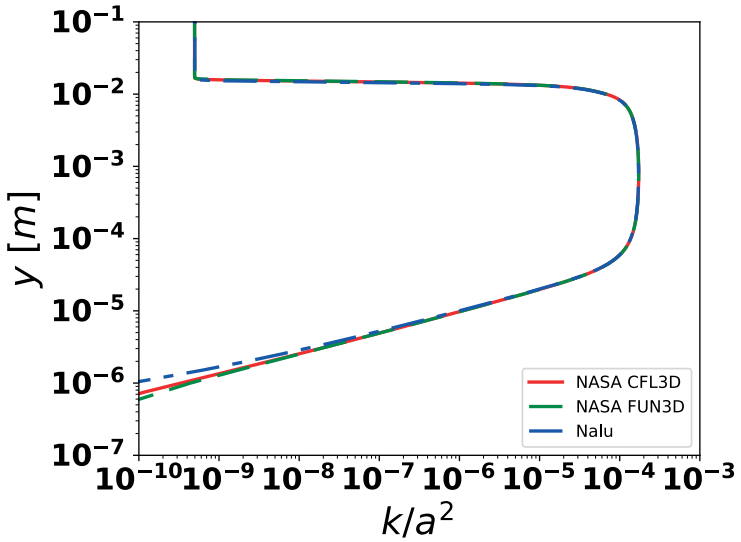
SDRWallFactor = 0.625



SDRWallFactor = 1 (default)



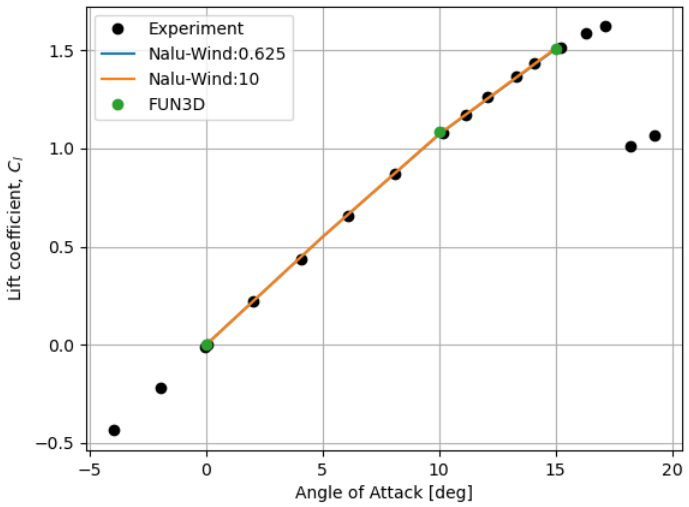
SDRWallFactor = 10



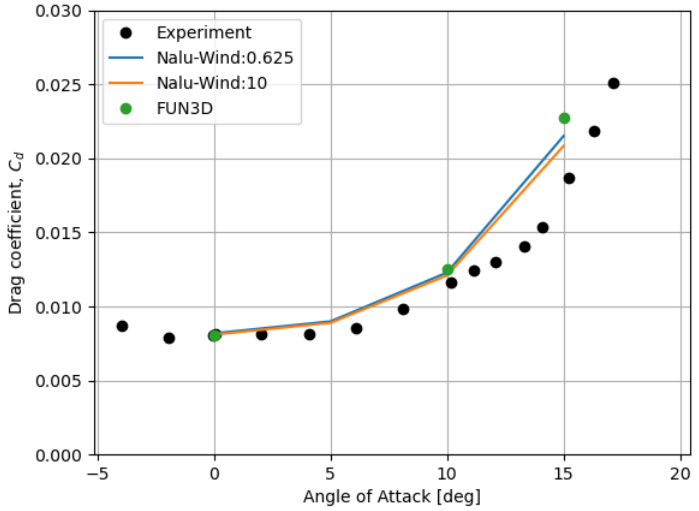
- *k* at the wall is 0 in the SST model. SDRWallFactor of 10 predicts smaller k than those from CFL3D and FUN3D near the wall.
- However, considering the previous results, SDRWallFactor of 10 seems to be correct.

NASA's 2D NACA 0012 Airfoil Validation Case

- Comparison of the lift and drag (897x257 mesh)



AoA Vs. Cl



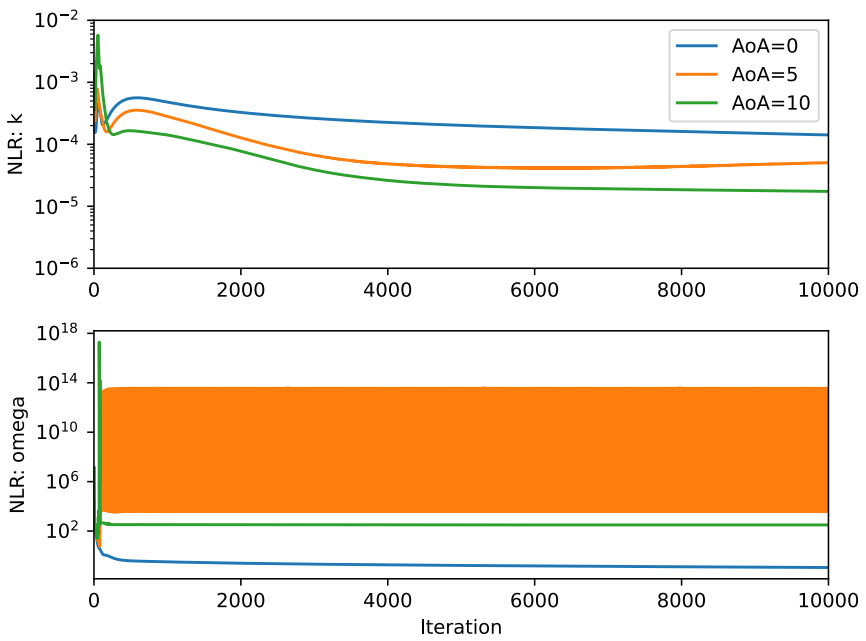
AoA Vs. Cd

- No significant differences in the attached flow region
- SST-SUST model doesn't show any noticeable differences

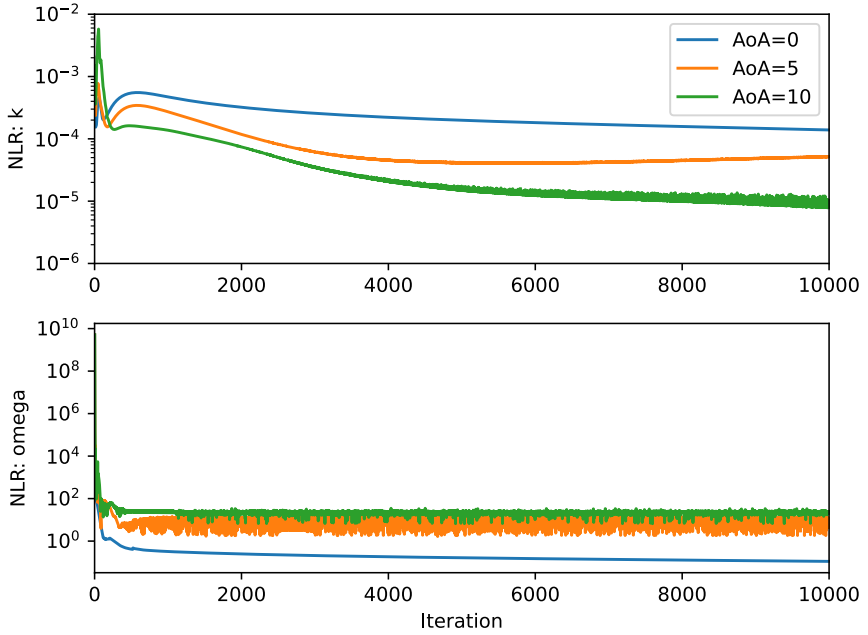
2D NACA 0012 Airfoil Validation Case

- Convergence of the turbulence model (897x257 mesh): *k* and *omega*

SDRWallFactor = 0.625



SDRWallFactor = 10



- Despite the minor differences in the predicted lift and drag coefficients, SDRWallFactor of 0.625 has convergence issues at AoA=5deg
- Based on the results of the canonical turbulent cases, the default value for SDRWallFactor should be 10, not 1 or 0.625