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STABLE, ENTROPY-PRESSURE COMPATIBLE SUBSONIC RIEMANN BOUNDARY CONDITION FOR EMBEDDED DG COMPRESSIBLE FLOW SIMULATIONS

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Abstract. One approach to reducing the computational cost of simulating transitional compressible boundary layer flow is to adopt a near body reduced domain with boundary conditions enforced to be compatible with a computationally cheaper 3D RANS simulation. In such an approach it is desirable to enforce a consistent pressure distribution which is not typically the case when using the standard Riemann inflow boundary conditions. We therefore revisit the Riemann problem adopted in many DG based high fidelity formulations. Through analysis of the linearised DG approximation for one-dimensional Euler equations it is demonstrated that maintaining entropy compatibility with the RANS simulation is important for a stable solution. In the common practice the Riemann invariant is implicitly enforced at the outflow boundary condition (for the very upstream element) in a subsonic flow leaving one condition that can be imposed at the inflow boundary. Therefore the entropy-pressure enforcement is the only stable boundary condition to enforce a known pressure distribution. We further demonstrate that all the entropy compatible inflow Riemann boundary conditions are stable providing the invariant compatible Riemann outflow boundary condition is also respected. Although the entropy-pressure compatible Riemann inflow boundary condition is stable from the one-dimensional analysis, two-dimensional tests highlight divergence initiated from in the velocity fields in viscous simulations around the stagnation point. A two-dimensional analysis about a non-uniform baseflow assumption provide insight into this stability issue and motivate the use of a mix of inflow boundary conditions in this region of the flow. As a validation we apply the proposed boundary conditions to a reduced domain of a wing section normal to the leading-edge of the CRM-NLF model [1] taken out of a full 3D RANS simulation at Mach 0.86 and a Reynolds number of 8.5 million. The results show that the entropy-pressure compatible Riemann inflow leads to a good agreement in pressure distribution.

REFERENCES

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