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Higher Order SSP Methods with Downwinding

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Strong stability preserving (SSP) time-stepping methods for initial value ODEs preserve the monotonicity properties in any norm, semi-norm, or convex functional of the Forward Euler method. All typical SSP methods, such as the Runge-Kutta or multistep method, and even implicit methods, require small step sizes and achieve only first order accuracy. However, when the ODE comes from a semi-discretization of a hyperbolic PDE we can obtain significantly more relaxed step size restrictions by using both upwind- and downwind-biased semi discretizations. We present an algorithm for finding optimal high order SSP time-stepping methods with downwinding and demonstrate their performance on test cases.

Classes of explicit SSP Runge-Kutta methods with downwinding have been found with a limited allowable effective time-step; however, the maximum downwind SSP coefficient for second order Runge-Kutta methods was shown to be unbounded. Currently, we are investigating the maximal downwind SSP coefficient for higher order implicit methods.