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MULTISCALE COMPUTATIONS OF FLUID FLOWS USING AN ADAPTIVE WAVELET METHOD

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ABSTRACT

Adaptive algorithms are important for accurate and efficient numerical simulation of multi-dimensional physical problems whose solutions contains a wide range of spatial scales that may evolve with time. We present a wavelet-based adaptive multiresolution algorithm for the numerical solution of multiscale problems. The adaptive method takes advantage of an interpolating wavelet for the adaptive approximation in the design of a simple refinement strategy that reflects the local demands of the physical solution. The main features of the method include fast algorithms for the calculation of wavelet coefficients and approximation of derivatives on nonuniform stencils. The algorithm is based on the mathematically well-established wavelet theory. This allows us to provide error estimates of the solution resulting from the use of an appropriate threshold criteria. The algorithm is applied to inert as well as reacting multi-dimensional incompressible and compressible flows. The simulations show the striking ability of the algorithm to adapt to a solution having different scales at different spatial locations so as to produce accurate results at a relatively low computational cost. It is shown that the present algorithm, besides being significantly more efficient than other current methods, is free from many numerical difficulties associated with those schemes.