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MULTISCALE SPACE–TIME METHODS FOR THERMO-FLUID ANALYSIS OF A VEHICLE AND TIRES

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We present the core and special multiscale space–time (ST) methods [1] we developed for thermo-fluid analysis of a vehicle and tires. We also present application of these methods to thermo-fluid analysis of a freight truck and rear set of tires. The core multiscale ST method is the ST variational multiscale (ST-VMS) formulation [2] of the Navier–Stokes equations of incompressible flows with thermal coupling [3, 1], which is multiscale in the way the small-scale thermo-fluid behavior is represented in the computations. The special multiscale ST method is spatially multiscale, where the thermo-fluid computation over the global domain with a reasonable mesh refinement is followed by a higher-resolution computation over the local domain containing the rear set of tires, with the boundary and initial conditions coming from the data computed over the global domain. The large amount of time-history data from the global computation is stored using the ST computation technique with continuous representation in time (ST-C) [4], which serves as a data compression technique in this context. In our thermo-fluid analysis, we use a road-surface temperature higher than the free-stream temperature, and a tire-surface temperature that is even higher. We include in the analysis also the heat from the engine and exhaust system, with a reasonably realistic representation of the rate by which that heat transfer takes place as well as the surface geometry of the engine and exhaust system over which the heat transfer occurs. We take into account the heave motion of the truck body. We demonstrate how the spatially multiscale ST method, with higher-refinement mesh in the local domain, substantially increases the accuracy of the computed heat transfer rates from the tires.

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