Analysis of SGS Fluxes in Shear Driven Turbulence

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Analysis of high resolution simulations of Richtmyer-Meshkov turbulent mixing layers and homogeneous, compressible turbulence using the sPPM and PPM gas dynamics codes have led to a relationship between the forward transfer of energy and the determinant of the symmetric rate of strain of the filtered fields (Woodward et. al. 2000, and Cohen et. al. 2002). This relationship relates velocity gradients of filtered fields to transfer of energy across the filter in both homogeneous, compressible turbulence and shock driven turbulence in a manner that properly captures both the regions of large forward and large backward energy transfer.

Here we examine this relationship in the context of a compressible shear driven mixing layer. To the flow field of a slip surface a velocity perturbation is added which imposes a large variation in the determinant of the rate of strain, including a change of sign, across the span-wise direction of the shear layer. This new experiment is intended to clarify the role played by the determinant beyond the level that is observed in the previous work.

We are building the above ideas into a subgrid-scale (SGS) turbulence model for our PPM gas dynamics code. We regard our simulations on very fine grids of the three types of flows mentioned above as numerical experiments against which we test SGS model ideas. From these large simulations we are constructing data sets especially suited to such comparisons, and we plan to make these available to other investigators. In addition to complete simulation data from each run archived at a small number of times, we collect frequent dumps of filtered fields on coarser grids, such as 512^3, along with the averages of the interface fluxes and products of fluctuating quantities of interest. Our intent is to compare this data distilled from large direct simulations with the results of computations on coarser grids using SGS models.

References:

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The visualization, below, shows the vorticity in a perturbed shear layer.