ME568 / OC674 Assignment #4

Data is provided on Canvas from Bill Smyth's direct numerical simulations of a 2-layer stratified shear flow. As previously described, the flow is initially uniform and susceptible to shear instability, so forms an unstable Kelvin-Helmholtz billow that evolves in time into a fully turbulent state. Hopefully you've already been able to look at the series of 2D cross-sections (spatial snapshots) of this low-Re turbulent flow at various times in this evolution (demo_dns.m demonstrates how to plot these data. Smyth et al (2001) paper provide more details of the simulations, and I also included a Smyth & Moum (2012) article that might also be of interest.

We are going to explore the turbulent properties of these data in stages. For part 1, ignore density / buoyancy effects; for part 3, calculate them.

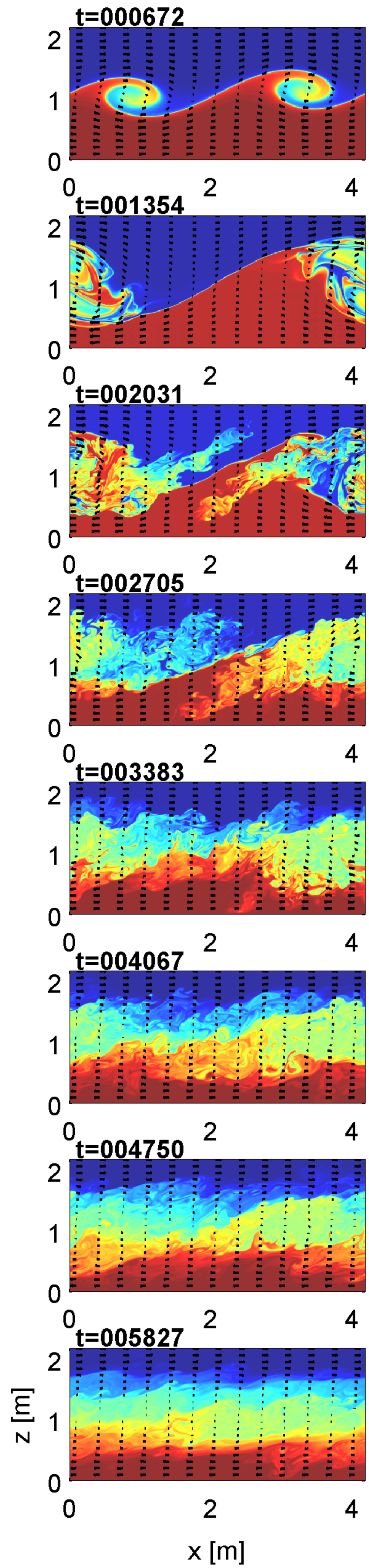
Part 1: Choose a time when the flow is strongly turbulent and evaluate the following:

(a) First perform a Reynolds decomposition by defining the mean and perturbation *u, v, w*. Because the background state varies in *z*, it may be appropriate for your means to also be a function of *z.* Discuss any challenges you might have in doing decomposition.

(b) Now that you have decomposed the velocity, compute the individual components of the turbulent kinetic energy and the Reynolds stresses. Discuss any significant features of the patterns or magnitudes.

(c) perform the same set of calculations for an earlier time in the flow (when the turbulence is perhaps less homogeneous). Discuss any differences in the character of the flow and/or the components of the tke and Reynolds stresses.

Part 2: For now neglect the buoyancy contributions and
(a) compute the shear production and dissipation throughout the domain at some point in time. Determine a horizontal and volume average of each. Does production balance dissipation?
(b) Once you are satisfied that you can compute production and dissipation (i.e., (a) above), compute the average of each for every timestep and plot a time series. Does production=dissipation at each time? Does production=dissipation on average? Write a paragraph describing the production and dissipation evolution.



Part 3: Now consider the buoyancy production term.
(a) Compute time-integrals of the spatially-integrated buoyancy production J_b and compare this to shear production and dissipation. Does this help to account for any mismatches above? If there are mismatches and you can't close the energy budget, explain what might be the problem.
(b) now try to compare these to the integrated TKE production and the total change in potential energy due to mixing within the simulation domain. Can you close an energy budget, and if not, what might be the problem? What is the mixing efficiency? Which measure of the total mixing is most robust?