1. **Part 1: Scales of Turbulence** Estimate characteristic velocity and length scales of the turbulence. Can you use these scales to determine the dissipation rate? What is the Taylor microscale? Kolmogorov lengtscale? Does the model actually resolve the smallest turbulent scales? How do each of these scales vary with time? Is their variability consistent with your expectations? Can you also estimate a timescale for largest scale motions? And the smallest scale motions? Briefly explain how/whether/why these are consistent with your expectations.

   Ideas:

   - correlation to find length scale – or just use physical limits of problem $\ell = \int_0^\infty \rho(x)dx$
   - not sure on characteristic velocity scale – just square root tke, lol
   - $\frac{u^3}{\ell}$ for dissipation once I know the velocity and length
   - Kolmogorov scale is where Re=1; also $\eta = (\epsilon/\nu)^{1/2}$; $\eta = \left(\nu^3/\epsilon\right) \sim LRe^{-3/4}$
   - Taylor microscale relates characteristic velocity and dissipation $\frac{\lambda}{L} \sim Re_L^{-1/2}$ and $\epsilon = 15\nu u^2/\lambda^2$ for isotropic turbulence – Liburdy says to use correlation thing for Taylor microscale $1 + \frac{r^2}{2}\frac{\partial^2\rho}{\partial r^2} = 1 - \frac{r^2}{\lambda^2}$
   - compare characteristic time scale to time scale determined with frozen turbulence (ℓ/U and L/U); also $\frac{tke}{\epsilon} = \frac{u^2}{u^3/\ell} = \frac{u}{\ell}$

2. **Part 2: Eddy Viscosity** There are several ways that one can estimate an eddy viscosity. From the data, determine an "eddy viscosity" for this flow. Does your estimate evolve in time, and if so, how does it vary? Can you determine some average value for it? And then, is there a way in which you can determine/verify whether your estimate is approximately correct?

   Ideas:

   - $\overline{u_i u_j} = \nu_T \frac{\partial u_i}{\partial x_j}$
   - $\nu_T = (tke)^{1/2}\,\ell$ – this is what Liburdy said in class
   - $\nu_T \left(\frac{\partial U}{\partial z}\right)^2 = \epsilon$
   - $\frac{\partial U}{\partial t} = \nu_T \frac{\partial^2 U}{\partial z^2}$ – plugging back into momentum equation to check

3. **Part 3: Turbulent Spectra** Compute the turbulent energy spectrum that characterizes one component of the velocity fluctuations at a given timestep (it is usually useful to average a

number of spectra together in a quasi-homogeneous region to reduce noise/uncertainty). Does the spectrum look like you would expect it to? Do this for all the timesteps and plot on a single plot. Do the spectra vary in a way that is consistent with your expectations? Can you estimate the dissipation rate from those spectra, and is it consistent with your previous estimates?

Ideas:

- Dr. Nash said something about giving us a matlab file to calculate spectra?