The two primary mechanisms that generate turbulence are mean shear and buoyancy force, each of which act on covariances in underlying fluctuating velocity and temperature fields to alter turbulence structure. In the daytime atmospheric boundary layer, for example, shear generally dominates near the ground as convection dominates in the mixed layer above. Here we study the interaction between mean shear and the structure of fluctuating velocity and vorticity fields in homogeneous turbulent shear flow as a model for shear flows in general, by analyzing direct numerical simulations of the transition from initially isotropic to shear-dominated turbulence. I address two related issues: (1) the mechanisms that force the small-scale turbulent vorticity field from its initial tube/sheet-like structure in isotropic turbulence to one dominated by horseshoe/hairpin vortical structures in shear turbulence, and (2) the relationship in the velocity/vorticity fields between 3-D physical space and 3-D Fourier spectral space in the transition from unforced isotropic to shear-forced anisotropic turbulence. Study (1) evolves from a combined visual-quantitative analysis of individual turbulence “structures” algorithmically extracted from local concentrations of the fluctuating vorticity and strain-rate fields, while study (2) makes use of three-dimensional wavelet filtering to relate the evolving turbulence anisotropy of local physical space structure to global anisotropy in 3-D Fourier space. We conclude that the dynamics that generate hairpin vortical structures in shear flow lead to a global anisotropy in spectral space that is correlated to the average dimensions of the local streamwise-aligned vortices that pervade shear-dominated turbulence.

Thursday January 12
Foothills Laboratory 2
Room 1001
Lecture at 3:30pm