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A Scale-by-Scale Linear Analysis of Convective Velocities and Taylor's Hypothesis in Turbulent Channel Flows ISMAIL HAMEDUDDIN, DENNICE GAYME, The Johns Hopkins University — We examine convective velocities in turbulent channel flows using a linear, stochastically forced model approximation of the Navier-Stokes equations. The resulting system is analytically tractable and includes the terms that are typically associated with the break-down of Taylor's hypothesis. We show that this approach leads to convective velocity predictions that are consistent with DNS. We demonstrate that our observed differences between the local mean and convective velocities can be attributed to the dependence of the phase velocities on both the streamwise and spanwise wavelengths. The convective velocity in the viscous sublayer is roughly constant and distinct from the mean velocity. Previous work suggests that this viscous sublayer convective velocity arises due to (a) buffer layer rolls and (b) large-scale outer layer structures that influence the near-wall region. We show that there is also a series of structures, self-similar in the cross-stream plane, that modify the convective velocity in the sublayer. The streamwise extent of these structures scales as the square of the cross-stream dimensions, which is similar to previously proposed scalings of near-wall spectra based on DNS. This work is supported by a Johns Hopkins University Catalyst Award.

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