

SUMMARY OF RESEARCH, pre-Warwick 2002

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Understanding turbulent and strongly nonlinear fluid dynamics presents many challenges to the mathematician and engineer. In the past, the emphasis has been on simplified equations or asymptotic analysis of the full equations. The primary emphasis of my research has been understanding fundamental and geophysical turbulent flows through direct three-dimensional simulations. My approach is to develop and run large numerical codes representing the full equations, then use several approaches to reach a new understanding about difficult problems. This includes extensive comparisons with experiments, observations, and mathematical theories and the use of sophisticated graphics. In reporting the results of several years work, I often prefer a single long paper so as to be able to relate the different approaches rather than a series of disconnected shorter papers. More recently I have been branching out in applying the new insight to a variety of geophysical and related problems using different codes and approaches.

Codes that I have developed study three-dimensional convective boundary layers, isotropic turbulence, and magnetohydrodynamics. The convection code has been used to study Rayleigh-Bénard convection, helicity effects in convection, zero Prandtl number convection, and salt fingering. Important results include being the first to show that there is a unique alignment of the strain that stretches vorticity that is important in parameterizing combustion, a signature of a singularity of the inviscid Euler equations consistent with rigorous mathematical requirements and confirmation of a transition to a non-classical heat flux law and large-scale flow that was found experimentally.

Recently I have begun working with two small-scale atmospheric dynamics codes, with the objective of applying my knowledge of turbulent processes to atmospheric phenomena. With a large team at NCAR and NOAA I introduced new analysis based on developments in vortex dynamics as a way to identify possible sources of clear-air turbulence. At the University of Arizona I am developing collaborations for simulations to study turbulence generated by thermal

convection and boundary layers With co-workers at NCAR and Los Alamos, we are developing new subgrid parameterizations for small-scale turbulence in these codes.