A singularity-free model of the local velocity gradient and acceleration gradient structure of turbulent flow.

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Research on the fine scale motions in turbulence has led to a greatly improved understanding of the basic geometry of the local flow patterns associated with kinetic energy dissipation. One model of the local flow that has been considered by the author and others is based on a simplification of the transport equation for the velocity gradient tensor called the Restricted Euler equation. This equation is exactly solvable and, although the solution reproduces many of the geometrical features observed in direct numerical simulations of turbulence, the solution also exhibits a finite time singularity - it blows up! It is well known that the velocity and acceleration gradients in free turbulent flows actually decrease continuously with time when measured by a Lagrangian observer. The power law in time associated with this decay can generally be estimated using dimensional analysis together with classical balances relating turbulent kinetic energy production and dissipation. This paper will describe a procedure for removing the singularity in the Restricted Euler model while maintaining the convenience of an exact solution which is particularly useful for generating large ensembles for statistical modeling. The new model matches decay rates derived from dimensional analysis and accurately predicts many of the geometrical features of both the velocity and acceleration gradient tensor. Probability density functions for both gradient fields generated by the model will be compared with results from direct numerical simulation.