Abstract Submitted
for the DFD09 Meeting of
The American Physical Society

Large Eddy Simulation of Persistent Contrails in Wind Shear and Atmospheric Turbulence ALEXANDER NAIMAN, FRANK HAM, SANJIVA LELE, JORDAN WILKERSON, MARK JACOBSON, Stanford University —

A study of contrail evolution was conducted using a three-dimensional Large Eddy Simulation (LES). The LES solves the incompressible Navier-Stokes equations with a Boussinesq approximation for buoyancy forces on an unstructured periodic grid. The numerical scheme uses a second-order finite volume spatial discretization and an implicit fractional-step method for time advancement. Lagrangian contrail particles grow according to a microphysical model of ice deposition and sublimation. The simulation is initialized with the wake of a commercial jet superimposed on a decaying turbulence field. The ambient atmosphere is stable and has a supersaturated relative humidity with respect to ice. Grid resolution is adjusted during the simulation, allowing higher resolution of flow structures than previous studies. We present results of a parametric study in which ambient turbulence levels, vertical wind shear, and aircraft type were varied. We find that higher levels of turbulence and shear promote mixing of aircraft exhaust with supersaturated ambient air, resulting in faster growth of ice and wider dispersion of the exhaust plume. These results provide sensitivity data that improves understanding of the development of persistent contrails into contrail cirrus, a poorly characterized aspect of the climate impact of aviation.

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Date submitted: 07 Aug 2009 Electronic form version 1.4