En route wake vortex dynamics; a computational study

A.A. Wyszogrodzki, P.K. Smolarkiewicz and R. Sharman,
NCAR, Boulder, CO USA.

Commercial aircraft generate wake vortices that are shed from the wing tips and can persist downstream for a significant distance and time. The en route environment in which commercial aircraft spend most of their time is in the upper troposphere or lower stratosphere (UTLS), where the stability, wind shear, and turbulence levels are substantially different than in the terminal area, yet these parameters crucially influence the wake vortex characteristics.

We investigate the evolution of a realistic en route vortex pair in idealized stratified and sheared environments with the multi-scale multi-physics model EULAG [J.M. Prusa et al., Comput. Fluids 37, 1193 (2008)]. The initial vorticity distribution is based on the Lamb-Oseen theoretical vortex model. The results from two- and three-dimensional simulations document the significance of ambient stratification and turbulence on the vortex propagation and decay. The results are quantified in terms of temporal evolution of vortex pair strength, descent and separation. Nonlinear effects of the vortex meandering in the sheared environment and the onset of the Crow instability are evaluated using several model-grid resolutions.

In addition to the idealized canonical studies of fundamental fluid-dynamics sensitivities, we present the results of EULAG large-eddy simulations of vortex behavior in the UTLS for a realistic atmospheric and operational condition based on an actual wake vortex encounter that occurred over northern Washington State on 10 Jan 2008. The A319 aircraft was at FL350 (~10.7 km altitude) following a B747-400 at FL370 (~11.3 km). Due to the encounter, eight passengers and crew received minor injuries and three received serious injuries, and the flight was diverted. Comparisons to onboard flight recorder data taken during the encounter are used to evaluate the realism of the simulation. The results of simulations such as these are a necessary step in evaluating the en route wake vortex hazard in the Next Generation Air Transportation System (NextGen) air traffic environment.