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How the fractal and gently sloping nature of aircraft trajectories can lead to spurious conclusions about atmospheric dynamics: results from TAMDAR and research aircraft

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Commercial aircraft are being increasingly used not only for obtaining operational data for GCM's, but also for creating vast data bases for statistical studies of the atmosphere, complementary to the much more modest data available from research aircraft. Before the current epoch of GPS altitude measurements and high resolution digital sensors, a simple model of the interaction of the aircraft and the atmosphere was adequate: it was assumed that – at least on "flat" isobaric legs - that the aircraft flew in a straight line at constant altitudes. When turbulence was studied it was presumed isotropic so that small deviations from linear trajectories were unimportant - at least for estimating supposedly unique turbulent exponents.

Today thanks to state of the art drop sondes, lidar and research aircraft, we have a new understanding of the atmosphere: we now know that it is on the contrary so highly anisotropic, so strongly stratified that even the statistical exponents are different in the horizontal and vertical directions. As a consequence, even small mean aircraft slopes can lead to spurious measurements of vertical rather than horizontal fluctuations. In addition, GPS altitude measurements have shown that over significant ranges, the trajectories are not linear but fractal, which has a significant effect on the intermittency. Consequently, it is now clear that we are in need of a model/theory of how the aircraft measuring platform interacts with the fields that they measure.

In this presentation we re-examine past aircraft campaigns including GASP and MOZAIC and show how they can be understood with the help of a simple model of anisotropic turbulence and gently sloping fractal trajectories. We then present results from analyses of data measured by commercial aircraft through the Tropospheric Airborne Meteorological Data Reporting (TAMDAR) system over CONUS during year 2009. The TAMDAR system allows us to calculate the statistical properties of the wind field not only on constant pressure but also (thanks to GPS) constant altitude levels (to within $\pm$3m) and hence to distinguish between isoheight and isobaric statistical properties and hence to avoid spuriously conflating the two.