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Fractal Dropsonde Trajectories and Anomalous Turbulence Exponents in the Vertical

Much of our knowledge about the structure of the atmosphere is obtained by *in situ* measurements: aircraft, radiosondes and more recently, dropsondes. However, turbulence, especially in the wind field affects these measurement platforms by altering the trajectories of measuring devices; they are no longer along straight horizontal or vertical sections. Indeed, a model of turbulence is required in order to interpret the measurements. For example, if the turbulence is isotropic in three dimensional space, then one expects (at least naïvely) that unique exponents will exist and— at least as far as the scaling exponents are concerned —that the nonrectilinear trajectories are unimportant. Similarly, in 2D isotropic turbulence, the vertical structure is too smooth to lead to biases. However, if the turbulence is anisotropic (neither 3D nor 2D)— and growing evidence shows that it is indeed in-between with $D \approx 2.55$ —then the trajectories can be perturbed over long ranges. Recently Lovejoy, *et al.* (2004) have shown that aircraft can have fractal trajectories and anomalous horizontal scaling exponents over hundreds of kilometers.

We have investigated the corresponding problem for state-of-the-art dropsondes and the implications for the vertical structure of the atmosphere. Dropsondes measure temperature, humidity and pressure as they fall through the troposphere. The velocity is estimated by accurately tracking their position using GPS and then applying a correction using a simple dynamical model of how the sonde responds to the wind. When averaged over all altitudes from 0 to 12 km, the scaling is generally excellent but yields a scaling exponent somewhat higher that the Bolgiano-Obukov value of 3/5. However, when "conditional" statistics are examined, it is found that, at least for altitudes below 6 km, Bolgiano-Obukov scaling holds as expected. The deviation from Bolgiano-Obukov statistics is apparently due to strong shear layers above 6 km.