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Reconciling deep convection with wide range statistical scaling

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Classical "two-scale" theories of convection (e.g. Malkus 1957) single out a "convective scale" somewhere in the meso-scale. Theoretically, they rely on the classical picture of atmospheric motions which postulates a three dimensional isotropic turbulence at small scales and a 2-D isotropic turbulence at large scales. This classical statistical picture itself relies empirically on observations taken by aircraft flying on isobaric trajectories which observed a break in wind spectra typically at around 40 km. However, by closely scrutinizing state-of-the art aircraft observations of pressure, (aircraft) altitude and wind using cross-correlation and other techniques, recent work shows that rather than being a physical scale separation between k**-5/3 and k**-3 (3-D and 2–D) regimes that the actual transition is between k**-5/3 and k**-2.4 spectra and is in fact a completely spurious consequence of the transition from the (different) isoheight (small scales) to isobaric (large scale) spectra. The actual isoheight spectra is found to be scaling over huge ranges. This reinterpretation is bolstered by other work using drop sondes, lidars and passive and active satellite radiances. This presentation focuses on the important consequences that this reinterpretation has for our views of convection. We describe an alternative model in which the underlying dynamical processes are anisotropic multiplicative cascades with different exponents in the horizontal and vertical directions. This has two consequences. First, that structures will systematically change shape/morphology with scale; in this case going from vertically oriented "cells" at small scales to flattened strata at large scales. Second, that the fields will have strong singularities (hence coherent structures) distributed over sparse fractal sets (multifractals). Basing ourselves on analyses of CloudSat reflectivities (convection surrogates) which show that the latter do indeed respect anisotropic cascades, we empirically calculate the relation between horizontal and vertical scales of structures showing that they are almost identical to those of aerosols but with sphero-scales about 1000 times larger readily accounting for structures $\approx$ 100 km wide and $\approx$ 10 km thick (although with large variability). The observed statistics are well described by anisotropic cascade extensions of classical turbulence.