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Multifractality in the Atmospheric Boundary Layer

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According to the Kolmogorov theory (K41), scaling exponents of the velocity structure functions, ζ_p, follow a linear relation with respect to the order, p, of these functions. However, experiments in fully developed turbulence show a deviation from this linear form; this phenomenon is known as intermittency of the turbulence. More precisely, in case of intermittency and in fully developed turbulence, ζ_p vs. p must describe a concave curve according to the Hölder inequality. However, from the analysis of the several stratification situations in the Atmospheric Boundary Layer, we have found out the possibility of a convex curvature. Indeed, unstable conditions of stratification present a concave curvature, but the convex one is showed in very stable situations, where the appearance of bursts of turbulence, due to the breaking up of internal waves, confers a sporadic and intermittent character to the turbulence, what prevent a fully developed turbulence.

The absence of intermittency can be explained from a monofractal point of view. However, in order to explain both types of deviation (concave and convex) of the scaling exponents from the linear form, the multifractal analysis should be used. According to this analysis, it is possible to relate the scaling exponents and the fractal dimension through the Legendre transformation. The representation of the dimensions corresponding to the different fractals of the system constitutes the multifractal spectrum or singularity spectrum, and the concave (convex) curvature of ζ_p vs. p is translated in a concave (convex) spectrum; moreover, the greater the deviation is, the wider the spectrum is, in a way that in the monofractal case, the spectrum is reduced to just a point. Therefore, the former mentioned relationship between type of stratification and type of curvature is showed in the singularity spectra.