Ordinary fluid flows involve such huge numbers of particles that rather than applying statistical mechanics, one typically exploits emergent macroscopic continuum properties and corresponding higher-level continuum and thermodynamic equations. In a similar way, one expects new higher-level laws to emerge from the chaos of sufficiently strong hydrodynamic turbulence. While the latter presumably continue to obey continuum mechanics, these become impractical and one searches for the emergence of even higher-level laws of “fully developed turbulence”; this was the quest of many of the pioneers of classical turbulence including L.F. Richardson, A. N. Kolmogorov, A. Obukhov, S. Corrsin, and R. Bolgiano.

These classical laws were based on scaling symmetries and were somewhat successful when applied to the usual variables of state. However, they could not handle turbulent intermittency and hence were impotent in dealing with the most intermittent atmospheric field of all: precipitation.

Intermittency motivated the development of explicit multiplicative cascades; these are the generic multifractal process and we argue that when suitably generalized to account for anisotropy, causality and waves, they provide us with the emergent higher level laws that the pioneers sought.

In this presentation we argue that such emergent laws can accurately explain the space-time statistics of precipitation and other atmospheric fields over scaling ranging from sub metric to planetary. We support this thesis with data analyses ranging from stereo-photography of drops, gauges, ground and satellite radar, satellite radiances and meteorological reanalyses. We discuss the consequences for the estimation of space-time rainfall and for quantifying the hydrological cycle.