Precipitation is the key input field into hydrological systems and models; it displays extreme variability with complex structures embedded within structures, from drop to planetary scales in space and from milliseconds to millennia in time. The natural theoretical framework is thus scale invariance which is a very general symmetry principle applicable even to highly anisotropic, stratified highly intermittent systems such as the atmosphere. Technology now permits observations of precipitation over wide ranges of scales including the extreme small drop scales (using stereophotography) and the extreme large planetary scales (using satellite borne radar) as well as meteorological reanalyses. We find that below scales of roughly 30 - 50 cm (depending on the rate) the rain decouples from the turbulence forming statistically homogeneous “patches”. At larger scales, on the contrary, the precipitation is strongly coupled with the turbulence so that in raining regions, the liquid water statistics are very nearly those of passive scalars. Using in situ rain gage networks, ground and satellite radar data and meteorological reanalyses, we show that the precipitation has a multiplicative cascade structure up to planetary scales in space and up to 30-50 days in time.

We conclude that Richardson’s old idea of scale by scale simplicity - today embodied in multiplicative cascades – can accurately explain the statistical properties of the atmosphere - including precipitation - and its models up to nearly planetary scales in space and over most of the meteorologically significant range of scales in time.