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A fundamental probability distribution for heavy rainfall

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There is currently no physical understanding of the statistics of heavy precipitation. However, the statistics are central to diagnosing climate change and making accurate weather risk assessments. This work, for the first time, derives a fundamental rainfall distribution. A direct interpretation of the water balance equation for an atmospheric column gives a simple expression for daily precipitation as the product of specific humidity, vertical velocity and the precipitation efficiency. Statistical theory predicts that the tail of the distribution of the product of these three random variables will have a stretched exponential form with a shape parameter of 2/3. This is verified for a global data set of daily precipitation totals. The stretched exponential tail explains the apparent 'heavy' tailed behaviour of precipitation under standard assumptions used in extreme value theory. The novel implications for climate change are that the stretched exponential form of heavy rainfall distributions is unlikely to change and that the precipitation efficiency is an important variable in understanding future changes in heavy precipitation.