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The scaling of wild events in stochastic models: The Fisher limit, the Mandelbrot limit, and FARIMA as a model of the intermediate cases

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Stochastic modelling is of increasing importance, both specifically in climate science and more broadly across the whole of nonlinear geophysics. Traditionally, the noise components of such models would be spectrally white (delta-correlated) and Gaussian in amplitude, and their variance (first named by Fisher in 1918) would well characterise the likely size of fluctuations. Integration, for example in autoregressive models like AR(1), would redden a noise spectrum, while multiplication in turbulent cascades could greatly increase the range of fluctuation amplitudes, but such processes would still inherit aspects of their finite variance building blocks.

In the 60s and 70s, however, Mandelbrot and others [see e.g. Watkins, GRL Frontiers, 2013] began to present evidence in nature for much stronger departures from Gaussianity (via very heavy tailed, infinite variance, distributions) and from white noise (through long range dependence (LRD) in time). He also observed intermittency, defined here as correlations between absolute magnitudes in some time series, in, for example, finance and turbulence. He proposed various models, including self-similar ones for heavy tails and LRD, and multifractal cascades for intermittency.

In this presentation we compare contrasting types of model by looking at the "wild" events that they produce. The notion of a "wild" event can be made more precise in many ways, including by its duration in time, peak amplitude, and spatial extent. Our chosen measure will be the "burst", defined as the area of a time series above a fixed threshold. We will compare burst scaling in a self-similar, LRD, heavy tailed model (LFSM, e.g. Watkins et al, PRE, 2009] with our newer results for multifractal random walks [with M. Rypdal and O. Lovsletten], and for the heavy tailed extended version of the FARIMA (1,d,0) process, which combines long range dependence with the high frequency structure familiar from AR(1). We will also discuss the physical meaning of FARIMA and its potential as a modelling tool.