Compound Extremes and Bunched Black (or Grouped Grey) Swans

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Observed “wild” natural fluctuations may differ substantially in their character. Some events may be genuinely unforeseen (and unforeseeable), as with Taleb’s “black swans”. These may occur singly, or may have their impact further magnified by being ``bunched” in time, with accompanying issues about event identification.

Some others may, however, be rare extreme events taken from a light-tailed underlying distribution such as an exponential or Gaussian, that is either known a priori, or to be inferred. Studying their occurrence may then be tractable with the methods of extreme value theory [e.g. Coles, 2001], suitably adapted to cope with temporal dependence or spatial correlation if observed to be present.

This presentation, however, focuses on a third broad class [reviewed in Watkins, GRL Frontiers, 2013, doi: 10.1002/grl.50103]. Such “bursty” time series may show comparatively frequent high amplitude “wild” events, and/or “slow” long range correlations between successive values. The frequent large values due to the first of these effects, modelled in economics by Mandelbrot in 1963 using heavy- tailed probability distributions, can give rise to an “IPCC type I” burst composed of successive wild events. Conversely, long range dependence, even in a light-tailed Gaussian model like Mandelbrot and van Ness’ fractional Brownian motion, or Granger's FARIMA, can integrate ``mild” events into an extreme “IPCC type III” burst.

I will show how a standard statistical time series model, linear fractional stable motion (LFSM), which descends from the two special cases advocated by Mandelbrot, allows these two effects to be varied independently, and will present results from a preliminary study of such bursts in

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LFSM. The consequences for burst scaling when low frequency effects due to dissipation (FARIMA models), and multiplicative cascades (such as multifractals) are considered will also be discussed, as will be the physical assumptions and constraints associated with making a given choice of model.