Observations of accreting systems often show significant variability (10–20 percent of accretion luminosity) on timescales much longer than expected for the disc regions releasing most of the luminosity. We propose an explicit physical model for disc variability, consistent with Lyubarskii’s (1997) general scheme for solving this problem. We suggest that local dynamo processes can affect the evolution of an accretion disc by driving angular momentum loss in the form of an outflow (a wind or jet). We model the dynamo as a small–scale stochastic phenomenon, operating on roughly the local dynamical timescale. We argue that large–scale outflow can only occur when the small–scale random processes in neighbouring disc annuli give rise by chance to a coherent large–scale magnetic field. This occurs on much longer timescales, and causes a bright large–amplitude flare as a wide range of disc radii evolve in a coherent fashion. Most of the time, dynamo action instead produces small–amplitude flickering. We reproduce power spectra similar to those observed, including a $1/f$ power spectrum below a break frequency given by the magnetic alignment timescale at the inner disc edge. However the relation between the black hole mass and the value of the break frequency is less straightforward than often assumed in the literature. The effect of an outer disc edge is to flatten the spectrum below the magnetic alignment frequency there. We also find a correlation between the variability amplitude and luminosity, similar to that found in some AGN.