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We consider scaling limits for the weakly driven Zhang and the Bak-Tang-Wiesenfeld (BTW) model for self-organized criticality. We show that the weakly driven Zhang model converges to an SPDE with singular-degenerate diffusion. In addition, the deterministic BTW model is proved to converge to a singular-degenerate PDE. Alternatively, the proof of convergence can be understood as a proof of convergence of a finite-difference discretization for singular-degenerate SPDE. This extends recent work on finite difference approximation of (deterministic) quasilinear diffusion equations to discontinuous diffusion coefficients and SPDE. In addition, we perform numerical simulations illustrating relevant features of the considered models and the convergence to stochastic PDEs in spatial dimension $d = 1, 2$.