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A Simple Model for A Discharge-Recharge Cycle of a Convective System: Finite Departure from Convective Quasi-Equilibrium and Periodic Cycle

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A simple self-contained theory is proposed for describing life cycles of convective systems as a discharge-recharge process.

A closed description is derived for the dynamics of an ensemble of convective plumes based on an energy cycle. The system consists of prognostic equations for the cloud work function and the convective kinetic energy. The system can be closed by introducing a functional relationship between the convective kinetic energy and the cloud-base mass flux.

The behaviour of this system is considered under a bulk simplification. Previous cloud-resolving modelling as well as bulk statistical theories for ensemble convective systems suggest that a plausible relationship would be to assume that the convective kinetic energy is linearly proportional to the cloud-base mass flux.

As a result, the system reduces to a nonlinear dynamical system with two dependent variables, the cloud-base mass flux and the cloud work function. The fully nonlinear solution of this system always represents a periodic cycle regardless of the initial condition under constant large-scale forcing. Importantly, the inclusion of energy dissipation in this model does not in itself lead the system to an equilibrium.