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A maximum entropy approach to the problem of parameterization

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The uncertainty concerning the state of unresolved variables in models of geophysical fluid systems warrants a description in terms of a probability density function. Given a probability density function, one may either calculate the average effect on the resolved variables, leading to a deterministic parameterization, or perform random draws, leading to a stochastic parameterization. The central issue of any parameterization is the choice of the probability density function of the unresolved variables. It will be proposed here to address this issue by assuming that the unresolved variables are in a state of statistical equilibrium - on the time-scale of the resolved variables - that is characterized by a zero average time rate of change of the unresolved variables' energy. This in itself does not fix the probability density function, but by using this requirement as a constraint in applying the principle of maximum entropy, a unique probability density function is found. The approach is worked out for the system proposed by Lorenz in 1996. It is shown that, in the context of a deterministic parameterization, the resulting interaction is linear in the resolved variables. When, as in Lorenz' original system, the parameters are chosen in such a way that the full unforced/undamped system conserves energy, the interaction takes the form of a damping. The method is shown to have considerable predictive power by a confrontation with numerical simulations of the full system.