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Energy and enstrophy spectra of geostrophic turbulent flows derived from a maximum entropy principle

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The principle of maximum entropy is used to obtain energy and enstrophy spectra as well as average vorticity fields in the context of geostrophic turbulence on a rotating sphere. In the unforced-undamped (inviscid) case the maximization of entropy is constrained by the (constant) energy and enstrophy of the system, leading to the familiar results of absolute statistical equilibrium. In the damped (freely decaying) and forced-damped case the maximization of entropy is constrained by either the decay rates of energy and enstrophy or by the energy and enstrophy in combination with their decay rates. Integrations with a numerical spectral model are used to check the theoretical results for the different cases.

Maximizing the entropy, constrained by the energy and enstrophy, gives a very good description of the energy and enstrophy spectra in the inviscid case, in accordance with known results. Maximizing the entropy, constrained by the energy and enstrophy in combination with their decay rates, also leads to very good descriptions of the energy and enstrophy spectra in the freely decaying case, not too long after the damping has set in. In the forced-damped case, maximizing the entropy with the energy and enstrophy in combination with their (zero) decay rates as constraints, gives a reasonable description of the spectra although discrepancies remain.