Available potential energy and its relatives

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In 1955 Ed Lorenz derived a diagnostic of atmospheric energetics based on the Available Potential Energy (APE). This diagnostic has been widely used to understand the circulation of the atmosphere. It turns out that the concept of APE arises naturally in geophysical fluid dynamics, and has numerous extensions. This all becomes clear when things are viewed within the context of Hamiltonian dynamics and pseudoenergy. The Hamiltonian formulation allows a general finite-amplitude definition of APE for arbitrary systems, and leads directly to finite-amplitude (Liapunov) stability conditions. For unstable states, the same formulation leads to bounds on nonlinear saturation of instabilities. For vorticity dynamics the concept of "available enstrophy" is a natural extension of APE, and is related to the Eliassen-Palm wave activity.