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Energy Cascades in the Baroclinic Ocean Double Gyre Problem

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We consider the baroclinic double gyre problem over a range of forcing and dissipation parameters. Energy fluxes associated with various terms (beta, nonlinear, forcing, etc) are described in detail. As one would expect, barotropization removes baroclinic energy from a Rossby-radius-like scale. Less expected is that this energy is typically injected into somewhat larger scales –near the scale at which bottom drag removes energy from the system. Because of this, there is little net inverse cascade of barotropic energy. Instead, the nonlinear inverse energy cascade is nearly compensated by a forward energy cascade associated with the linear beta term. That is, there is a cycling of barotropic energy, with nonlinear effects driving it upscale and the beta term bringing it back. A similar "double cascade" is also evident in the baroclinic mode, although in this case the interpretation is less clear. We also note that zonal jet structures are seen in snapshots of the baroclinic streamfunction over a wide range of parameters; possible mechanisms for creating the jets are briefly discussed.