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Reynolds number dependency in equilibrium two-dimensional turbulence

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We use the Navier-Stokes equations for barotropic turbulence as a zero-order approximation of chaotic space-time patterns and equilibrium distributions that mimic turbulence in geophysical flows. In this overly-simplified set-up for which smooth-solutions exist, we investigate if is possible to bound the uncertainty associated with the numerical domain discretization, i.e. with the limitation imposed by the Reynolds number range we can explore. To do so we analyze a series of stationary barotropic turbulence simulations spanning a large range of Reynolds numbers and run over a three year period for over 300,000 CPU hours.

We find a persistent Reynolds number dependency in the energy power spectra and second order vorticity structure function, while distributions of dynamical quantities such as velocity, vorticity, dissipation rates and others are invariant in shape and have variances scaling with the viscosity coefficient according to simple power-laws.

The relevance to this work to the possibility of conceptually reducing uncertainties in climate models will be discussed.