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New developments in geostrophic turbulence and its implications for climate modeling and weather predictability[1]

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One of the many areas in geophysical fluid dynamics that impacts how we model dissipation in the climate system is the theory of two-dimensional and quasi geostrophic turbulence and its impact on atmospheric flow. Upscale energy and and down scale enstrophy cascades have been observed in the atmosphere along with the -3 power law predicted in two-dimensional turbulence theory put forward by Batchelor and Kraichnan in the late 1960s. A consequence of this observational finding is the fact that, unlike three-dimensional turbulence in which the eddy turnover time decreases with eddy length scale, in two dimensional and quasi-geostrophic turbulence the eddy turnover time is constant independent of eddy length scale in the enstrophy cascading range. A further consequence of this is that the Rossby number is constant through the enstrophy cascade. This implies that instabilities which depend on ageostrophic processes are restricted because the scaling laws which imply balanced, quasi-geostrophic dynamics are valid at all length scales. Recent results show, however, even given that all of the above statements are true and maintained in the dynamics, there is a mechanism through which quasi-geostrophic turbulence becomes inconsistent and develops the seeds of its own destruction at small scales.

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