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Zonal turbulence driven by baroclinic instabilities in the thermal quasigeostrophic equations[1] EMMA WARNEFORD, PAUL DELLAR, OCIAM, Mathematical Institute, University of Oxford — We present a mass- and momentum-conserving single layer model for the atmospheres of gas giant planets that produces both sub- and super-rotating equatorial jets. The thermal shallow water equations support horizontal temperature variations by treating the reduced gravity as an advected scalar. They were originally proposed for terrestrial lakes and tropical oceans. We add a radiative coupling term to create a model for the atmospheres of gas giant planets. Reducing the radiative relaxation time produces transitions from sub- to super-rotating equatorial jets. The radiative coupling also enhances the rate at which eddy kinetic energy supplied by small-scale random forcing is absorbed into the mean zonal flow. The quasigeostrophic limit of our model supports an instability whose dispersion relation coincides, up to an O(1) numerical factor, with the dispersion relation for baroclinic instability in continuously stratified fluids. This instability can drive sustained turbulence from imposed large-scale variations in the background temperature from pole to equator. Running our spectral numerical simulations on graphical processing units (GPUs) yields substantial (factors of ten) performance increases with little additional programming effort.

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