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Formation of convection-driven banded zonal jets in the laboratory

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The atmospheres of Jupiter and Saturn have been know to posses remarkably stable banded zonal jets, visualised by the horizontal drift of the clouds. Meanwhile, state-of-the art numerical models and observations have started to reveal the presence of banded zonal jets in most part of Earth's oceans. An interesting common feature of these jets is their coexistence with eddies of various sizes.

We conducted a set of laboratory experiments to test the theory that the banded zonal jets are naturally generated from turbulent flow when there is a gradient in the effective Coriolis parameter. We used the world's largest rotating tank to reduce the unwanted viscosity effects so that multiple jets can emerge within the tank. The fluid were driven by nearly uniform buoyancy forcing alone, but apparently random, small-scale convections and larger-scale multiple jets were generated. The scale of the jet was comparable to the theoretical Rhines scale, and a strong anisotropy was observed in the kinetic energy spectrum. Further analyses show that the zonal jets are primarily barotropic and maintained by the energy transfer from the eddies.