How Earth's rotation affects vortices in nature

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What do smoke rings, tornadoes and the Great Red Spot of Jupiter have in common? They are all examples of vortices, regions within a fluid (liquid, gas or plasma) where the flow spins around an imaginary straight or curved axis. Understanding how geophysical (natural world) vortices behave can be critical for tasks such as weather forecasting and environmental pollution monitoring.

In a new paper in the journal *Physics of Fluids*, researchers Junho Park and Paul Billant of the CNRS Laboratoire d'Hydrodynamique in France describe their study of one such geophysical vortex behavior, radiative instability, and how it is affected by two factors, density stratification and background rotation.

Radiative instability is a phenomenon that alters the behavior of fluid flows and can deform a vortex. The "radiative" tag refers to the fact that it is an instability caused by the radiation of waves outward from a vortex.

"These waves can exist as soon as there is a density stratification—a variation of densities—throughout the vertical column of the vortex," Park said. "In this study, we have considered how background rotation—in this case, the rotation of the Earth—impacts them."

Examples of density stratification in nature, Park explained, include the decrease in air density as one moves higher in the atmosphere or the increase in water density due to salinity and temperature with increasing ocean depth. "So, the waves in our mathematical model are somewhat analogous to waves on the ocean surface," he said. "Likewise, the impact from background rotation on our modeled waves serves as an equal for the impact of the Coriolis force caused by the Earth's rotation."

"What we learned from our models is that strong background rotation suppresses the radiative instability, a characteristic that had been expected but whose dynamics had never been studied precisely," Park said. "We've now developed a sophisticated mathematical means to explain this phenomenon, and that's important to being better able to study and understand the behavior of geophysical vortices such as hurricanes and ocean currents."

Park said that he and Billant next plan to study instability behaviors in vortices with non-columnar shapes. "For example," he said, "there are pancake-shaped flows called Mediterranean eddies, or meddies, that would be worth studying since we know they affect the mixing of the components that make up the ocean ecosystem."

More information: The article, "Instabilities and waves on a columnar vortex in a strongly-stratified and rotating fluid" by Junho Park and Paul Billant appears in the journal *Physics of Fluids*.
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