Predictions for Small-Scale Turbulence

A statistical tool tests the long-held assumption that small-scale turbulence is isotropic.

By **Rachel Berkowitz**

Large-scale turbulence is causing new headaches for anxious aviators in a warming atmosphere, but it's small-scale turbulence that has always made physicists scratch their heads. The cascading process that transfers energy from the biggest eddies down to the tiniest ones causes a turbulent flow at the small scale to retain no memory of the large-scale flow structure. Because of this memory loss, researchers often assume that small-scale turbulence is isotropic. Subharthi Chowdhuri and Tirtha Banerjee of the University of California, Irvine, now introduce a framework for investigating turbulent flows and show that anisotropy persists even at the small scale [**1**].

If you measure the statistical properties of a turbulent flow on a large scale relative to the overall flow size, you'll get different values along different directions. Determining whether the same thing is true at the small scale, where the effect of viscosity becomes dominant, is difficult, because obtaining 3D information of the flow field at high enough resolution is impossible. Instead of trying to measure small-scale turbulence directly, Chowdhuri and Banerjee quantified its anisotropy by modeling how sudden, short-lived disturbances impart kinetic energy in different directions. They applied their model to previously obtained numerical and experimental datasets that cover a broad range of flow conditions. They found that, in every case, it could successfully identify small-scale anisotropy from sequences of measurements made at a single point in space—a more feasible task than capturing the full 3D picture.

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Chowdhuri says that their results imply a universal relationship between a turbulent flow's large-scale conditions and its small-scale anisotropy. Incorporating this relationship will help make next-generation models of turbulence more accurate.

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REFERENCES

1. S. Chowdhuri and T. Banerjee, "Quantifying small-scale anisotropy in turbulent flows," **Phys. Rev. Fluids 9, 074604 (2024).**