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Direct evidence of an oceanic dual kinetic energy cascade and its seasonality from surface drifters

Jin-Han Xie[1], Dhruv Balwada[2], Raffaele Marino[3], and Fabio Feraco[3]
[1]Peking University, Department of Mechanics and Engineering Science, China (jinhanxie@pku.edu.cn)
[2]Lamont-Doherty Earth Observatory, Columbia University, New York, NY, USA.
[3]Laboratoire de Physique, ENS de Lyon, CNRS, Universit\'e de Lyon, Lyon, France.

Ocean turbulence causes flows to split into smaller whirls or merge to make larger whirls, cascading energy to small or large scales respectively. Conventional ocean dynamics dictates that the kinetic energy in the ocean will cascade primarily to larger scales, via the inverse energy cascade, and has raised the question of how the kinetic energy in the ocean dissipates, which would necessarily require the transfer towards the molecular scales. However, so far no clear observational quantification of the energy cascade at the scales where these mechanisms are potentially active has been made. By using forcing-scale resolving third-order structure-function theory, which captures bidirectional energy fluxes and is applicable beyond inertial ranges, we analyse data from surface drifters, released in dense arrays in the Gulf of Mexico, to obtain the kinetic energy flux magnitude and directions along with the energy injection scales. We provide the first direct observational verification that the surface kinetic energy cascades to both small and large scales, with the forward cascade dominating at scales smaller than approximately 1-10km. Our results also show that there is a seasonality in these cascades, with winter months having a stronger injection of energy into the surface flows and a more energetic cascade to smaller scales. This work provides exciting new opportunities for further probing the energetics of ocean turbulence using non-gridded sparse observations, such as from drifters, gliders, or satellites.