EGU22-7004
https://doi.org/10.5194/egusphere-egu22-7004
EGU General Assembly 2022

Turbulent Energy Cascade in the Gulf of Mexico

Yinxiang Ma[1], Jianyu Hu[1,2], and Yongxiang Huang[1,2,3]
[1]State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China
[2]Southern Marine Science and Engineering Guangdong Laboratory (Zhuhai), Zhuhai 519000, China
[3]SJTU SMSE-Mingguang Joint Research Center for Advanced Palygorskite Materials, Mingguang 239400, China

Due to the extreme complexity of the oceanic dynamics, e.g., stratification, air-sea interaction, waves, current, tide, etc., the corresponding turbulent cascade remains unknown. The third-order longitudinal structure-function is often employed to diagnose the cascade direction and intensity, which is written as $S_{LLL}(r)=< \Delta u_L^3(r)>$, where Δu_L is the velocity increment along the distance vector **r**, and r is the modulus of **r**. In the case of three-dimension homogeneous and isotropic turbulence, $S_{LLL}(r)$ is scaled as $-4/5\varepsilon r$ in the inertial range, where ε is the energy dissipation rate per unit. In this work, $S_{LLL}(r)$ is estimated for two experimental velocities that obtained in the Gulf of Mexico, namely Grand LAgrangian Deployment (GLAD) and the LAgrangian Submesoscale ExpeRiment (LASER). The experimental $S_{LLL}(r)$ for both experiments shows a transition from negative values to a positive one roughly at r_T=10km, corresponding to a timescale around τ_T=12-hour (e.g., $\tau_T=r_T/u_{rms}$ with u_{rms} ≈0.24m/s. Power-law is evident for the scale on the range 0.01≤ r≤1km as $S_{LLL}(r) \propto -r^{1.45\pm0.10}$, and for the scale on the range 30≤ r≤300km as $S_{LLL}(r) \propto r^{1.45\pm0.10}$. Note that a weak stratification with depth of 10□15m has been reported for the GLAD experiment, indicating a quasi-2D flow topography. The scaling ranges are above this stratification depth. Hence, the famous Kraichnan's 2D turbulence theory or the geostrophic turbulence proposed by Charney are expected to be applicable. However, due to the complexity of real oceanic flows, hypotheses behind these theories cannot be verified either directly or indirectly. To simplify the situation, we still consider here the sign of $S_{LLL}(r)$ as an indicator of the energy cascade. It thus suggests a possible forward energy cascade below the spatial scale r_T, and an inverse one above the scale spatial r_T. While, the scaling exponents 1.45 are deserved more studied in the future if more data is available.

Ref.

Charney, J. G. (1971). Geostrophic turbulence. J. Atmos. Sci., 28(6), 1087-1095.

Frisch, U., & Kolmogorov, A. N. (1995). Turbulence: the legacy of AN Kolmogorov. Cambridge University Press.

Alexakis, A., & Biferale, L. (2018). Cascades and transitions in turbulent flows. Phys. Rep., 767,

1-101.

Dong, S., Huang, Y., Yuan, X., & Lozano-Durán, A. (2020). The coherent structure of the kinetic energy transfer in shear turbulence. J. Fluid Mech., 892, A22.

Poje, A. C., Özgökmen, T. M., Bogucki, D. J., & Kirwan, A. D. (2017). Evidence of a forward energy cascade and Kolmogorov self-similarity in submesoscale ocean surface drifter observations. Phys. Fluids, 29(2), 020701.