The Probability Distribution of Kinetic Energy Dissipation Rate in Ocean

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Ocean turbulence is highly intermittent in space and time with characteristic vertical scales of active turbulent zones (patches), varying from tens of centimeters up to several or sometimes tens of meters. The patches are separated by layers of relatively low turbulence activity, which is usually quantified in terms of the turbulent kinetic energy dissipation rate *eps* averaged over particular volumes or radius *r*. Such spatial inhomogeneity of dissipation has been specified as "mesoscale" or "external" intermittency in order to be distinguished from "internal" or genuine intermittency of *eps*, which is attributed to random distribution of vortex filaments within turbulent regions, where they stretch and dissipate energy in isolation. Internal intermittency of *eps* belongs to inertial-convective and diffusive subranges, between an outer turbulent scale L_o ˜ 1 m or less in stratified ocean and the dissipative Kolmogorov scale L_K of the order of less than 1 cm. The refined similarity hypothesis of Kolmogorov [1962] assumes random fluctuations of dissipation rate in the inertial-convective subrange and the probability distribution of the dissipation intermittency is lognormal. Although the lognormal model and its modifications has been successfully applied to various turbulent flows under high Reynolds numbers, it appears to be mathematically ill-posed. Yet, many researchers regard lognormal distribution as reasonably good practical approximation for *eps* that characterizes internal/genuine intermittency of turbulence generated continuously or by individual events/overturns.

The lognormal model has been applied to *eps* measured in well-mixed relatively deep turbulent boundary layers near the sea surface and near the ocean floor and in large turbulent overturns (˜10 m or more in diameter) that are observed in the ocean interior. However, conventional equidistant estimates of *eps*, which are usually calculated over relatively small vertical domains (typical averaging distance *l* = 1-2 m), represent a random field of the dissipation samples observed at various stages of turbulence evolution. The probability distributions of this dissipation field in a specific region can characterize external/mesoscale intermittency of turbulence influenced by larger scale dynamical processes, which depends on energy sources and ambient stratification. It has been recently shown that the probability distribution of the logarithm of the dissipation rate in a strongly stratified pycnocline can follow the generalized extreme value distribution due to rare random generation of energetic turbulence events, which form patches of high dissipation rate, while most of the background turbulence is confined to weakly dissipative regions at final stages of turbulence decay.

The notion that the probability distribution of the dissipation rate measured in stratified ocean by airfoil sensors substantially deviates from the classic lognormal approximation, often to follow the Burr probability distribution, is discussed here based on several field campaigns carried out by the authors during the last decade. The measurements have been taken in the East China Sea, Northern Bay of Bengal, to the south and to the east from Sri Lanka, and in the Gulf Stream region to the east from the North Carolina shelf. The background dynamics in the regions is characterized by distributions of the buoyancy frequency N^2 and buoyancy Reynolds number Re_b.

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