Local Scaling of the Oceanic Flux of Energy Between Scales

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Abstract

The energy cascade is key to a good understanding of the dynamics of a turbulent flow like the ocean. In the recent years, the investigation of the energy cascade has been exploring the spatial properties of the flux of energy between scales, $\Pi_r(\vec{x})$ [1, 2, 3]. This article tackles the investigation of the local scaling of Π_r relaying on the multifractal theory of turbulence. This formalism is constructed around the assumption that, within an inertial range of scales, the turbulent flow obeys a local sense of scale invariance, and the scaling is quantified through the singularity exponents, $h(\vec{x}, t)$, which constitute a measure of the local singularity of the flow and define a multifractal decomposition into universality classes [8].

A month long numerical simulation of the circulation in the upper North Atlantic Ocean was generated with the Coastal and Regional Ocean COmmunity model (CROCO) with a 7.5 km spatial resolution and a one day temporal resolution. First, Π_r was computed from the velocity fields using a top-hat filter. Then, $h(\vec{x}, t)$ were extracted from the velocity gradients, rather than from the dissipation or the velocity differences as it has been historically done. Results show that the regions with more intense Π_r have a relevant correlation with those of higher singularity, that is, with stronger currents [5]. Besides, a theoretical analysis of the scaling properties of Π_r predicts a scaling of:

$$\Pi_r(\vec{x}, t) \sim r^{3h(\vec{x},t)+2}$$

(see [7] and references therein). However, Π_r was revealed to scale with $2h + 1$. This finding is supported by the computation of the critical exponent in the singularity spectrum, $h_\infty \approx -0.5$ with a numerical error of $\mathcal{O}(0.1)$. Such a scaling for Π_r implies that the Reynolds tensor scales as $h + 1$ rather than $2h + 2$.

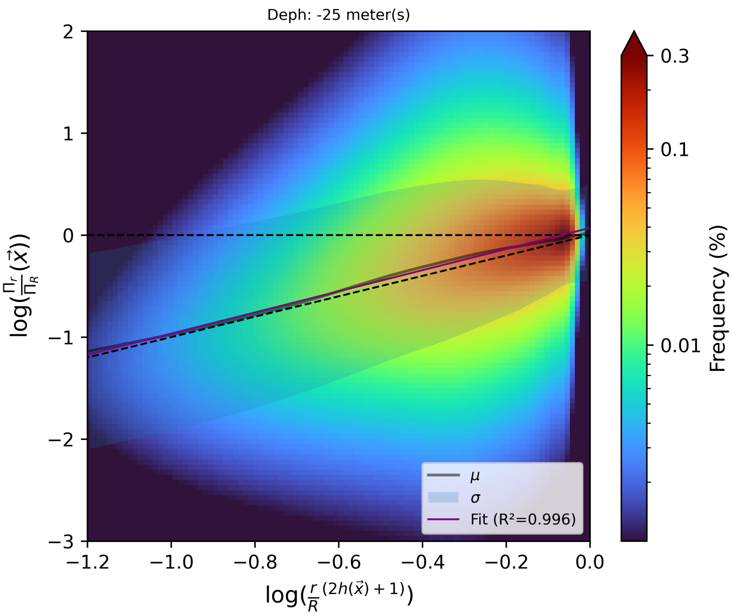

Figure 1: Temporally-averaged —over 30 days— two-channel histogram representing the correlation of the local scaling of the surface flux of energy across the mesoscale with a prediction arisen from the singularity exponents. The vertical means (μ) and standard deviations (σ) were fit to a correlation line which closely resembles the $x = y$ line.

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