Evaluating dynamical quality of ocean prediction modeling and satellite observations

The upper ocean is crowded with fronts of varying intensities and extents, which significantly influence the dynamics of the ocean's upper layers and help determine properties such as the spectral slopes of Sea Surface Temperatures (SST), among others. Here, we show that the upper layers of the ocean can be modelled by the multifractal theory of turbulence. Then, we use this theory to provide insight about the functioning of the upper ocean and to assess de dynamical consistency of satellite SST observations. Similarly, the multifractal theory alsoprovides a guide to develop, and adjust, numerical models. Specifically, we demonstrate that the behaviour of thermal gradients at small enough scales can be characterized by the singularity exponents. We then use the singularity exponents of thermal gradients as a measure of the intensity of thermal fronts; and the fractal dimension of the set of points with the same singularity exponent, known as the singularity spectrum, as a measure of their extension. This approach enables us to link fronts with the structure functions of temperature through the multifractal formalism. Assuming that the turbulent cascade can be modelled by a log-Poisson model, we analytically shown that the anomalous scaling of the structure functions depends on the intensity of the strongest front, i.e. the smallest singularity exponent. This prediction is validated using the SST provided by numerical simulations of an upwelling system, simulations of the global ocean, and satellite observations. Moreover, we show that the predicted relationship also applies to other variables, such as velocities. Our results imply that numerical models need to correctly account for those processes generating the most intense fronts in order to properly reproduce some of the statistics of ocean temperatures.

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