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Turbulence-inspired fusion methods for ocean remote sensing data

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New techniques for analyzing the structure of remote sensing maps of ocean variables have been developed during recent years [Turiel et al., 2008, and references therein]. These techniques have been designed in the framework of the Multifractal Microcanonical Formalism (MMF), and are appropriate for dealing with scalars submitted to the action of a turbulent flow (in this case, we are considering horizontal, quasi-geostrophic turbulence). Scalars submitted to the action of a turbulent flow develop a complex, intermittent structure: a multifractal hierarchy. The multifractal hierarchy can be evidenced by different means. The classical approach is to study global scaling properties by means of the scaling exponents of the structure functions. A different approach consists of calculating the scaling exponents at each point of the scalar. In the later case, the exponents are called singularity exponents and they are dimensionless measures of the regularity or irregularity of the function at each point.

Singularity exponents arise due to differential shear in the flow, and thus they are characteristic to the velocity field, but not to the advected scalar. Experiments with data from numerical simulations and from remote sensing sensors show that singularity exponents are almost independent of the scalar and related to the flow structure: singularity lines align with streamlines. This implies that a part of any scalar signal is common to all other scalars: the common part defines its multifractal structure.

Exploiting the redundancy (among different scalars) of the multifractal structure, we have derived a theoretical relation that can be used in data fusion without using any other information. We have applied this relation to fuse microwave SST data with SMOS SSS maps to produce enhanced SSS maps.

This technique can also be used to different goals as data assimilation in numerical models, filter noise in low-level remote sensing data, and in completing data series of Essential Climate Variables.