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Multiscale analysis of ocean color turbulent heterogeneities: comparisons of SST and Chl-a multifractal properties using 2D structure functions

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Satellite remote sensing is a powerful tool for understanding many of oceanic processes synoptically. Renosh et al. [2015] proposed a methodology for analyzing the multiscaling properties of satellite images using tools borrowed from the field of turbulence and multifractal analysis. The present work addresses the practical application of this study into different oceanic regions.

For this purpose we have selected satellite ocean color images of Chlorophyll-a ($Chl-a$) and thermal infra-red Sea surface temperature (SST). For understanding the spatial scaling associated with turbulence, it is important to have a daily imagery of these products. As far as ocean color remote sensing is considered, it is very difficult to have cloud free images for the understanding of scaling behavior. We have identified seven contrasted regions of the global ocean, characterized by high spatial heterogeneity in $Chl-a$ and SST. Power spectral analysis has first been used for the present study. Here we use 2D Fourier power spectra to understand the spatial scaling of $Chl-a$ and SST. The 2D spectral slope β is derived from the 2D power spectrum using radial sum of the power spectrum.

The multi-scaling properties of these images are also studied using the 2D Structure Function (SF) method. Using a lognormal fit, we have derived the multifractal parameters (Hurst exponent H and intermittency parameter μ) of these images using SF method. The derived multifractal parameters show variability in their values depending upon the region. The scatter plot of μ versus H shows some clustering of these parameters. The SST is showing lower intermittency than $Chl-a$, indicating biological activities. This indicator of biological activity is weaker in oligotrophic regions.

This approach can be applied even for irregular images with missing data, and help to characterize the heterogeneities, and the scale dependence and intensity of physics-biology coupling at sub-mescales using ocean color satellite images.