SCALING AND INTERMITTENCY IN OCEAN TURBULENCE: ANALYSIS OF COASTAL WATER OPTICAL PROPERTIES AND SEA SURFACE TEMPERATURE (SST).

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Abstract We consider here some scaling and intermittency properties of oceanic turbulence, with a general aim of considering the impact of turbulence on the bio-optical dynamics. For that purpose, we tried two different approaches, using in situ and satellite data. For the in situ study we adopted one dimensional and for the satellite two dimensional approaches. Different techniques such as Fourier power spectrum, Empirical mode of decomposition (EMD), Hilbert spectral analysis (HSA) have been used for analyzing the intermittency characteristics of the in situ data. For analyzing the multi-scale properties of the satellite images, we have considered Structure functions (SF) and Fourier power spectrum (1D and 2D). The general objective is to understand the multi-scale oceanic variability using scaling tools developed in the field of intermittent turbulence studies.

IN SITU MEASUREMENTS

In situ study, we measured the high frequency sampling of Particle size distribution along with the ocean current data from the turbulent coastal site of Eastern English channel. The instruments we used for the high frequency measurements are LISST-100X, ADV and ADCP. The LISST measures the volume concentration of particles having diameters ranging from 2.5 to 500 μm in 32 size classes in logarithmic scale. The Nortek Vector ADV current meter measured the North, East and up components of the local velocity components with an accuracy of $\pm$ 0.5% at 1 Hz.

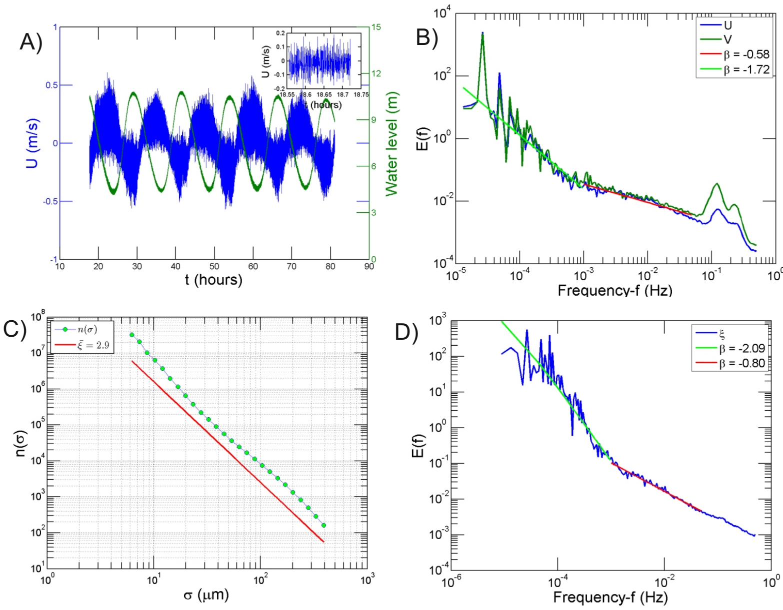

Figure 1. A) Time series of U. The insets represent a small portion of the time series to show the fluctuations. B) Power spectra of U (blue curve) and V (green curve). The two straight lines correspond to two different scales with slopes of -1.72 (near to -5/3 slope of Kolmogorov) in light green and -0.58 in red and the humps in the energy value at high frequency represent small scale forcing of high energy wave breaking. C) PSD slope of the entire particle dataset with a power-law fit of slope $\bar{\xi} = 2.9$.. D) Power spectrum of the slope $\xi(t)$ which shows 2 different scaling regimes.

Large temporal variability in the hydrodynamic fields, particle concentration and size distribution was observed during the in situ experiment. The hydrodynamic conditions, along with the high turbulence level encountered, provide favourable conditions for the re-suspension of particles. The present data set has shown that tidal current and waves have a significant role in the particle re-suspension and further water column turbidity [1]. Turbulence has been extracted from the along shore and cross shore components of the current velocity, which show periodic fluctuations in their magnitude. The power spectra of velocity components follow two different regimes depending on the scale. The first one, with typical inertial range, has a slope close to -5/3. The second one is characterized by a flatter slopeof -0.6 with a transition scale of 1000s [1]. At last, the energy spectra at high frequencies (3-10s) show a localized forcing attributed to waves forcing, similar to the previous results obtained in the same region [2]. We also consider the particle size distribution by estimating its PDF at each time step. This follow a powerlaw PDF with slope ξ (Fig. 1C). This exponent varies with time and Fig. 1D shows its dynamics, which can be velocity scaling regimes.

SATELLITE DATA

Satellite remote sensing is a powerful tool for understanding many of oceanic processes synoptically. Here we wish to understand the multi-scaling and multifractal properties of satellite images using typical turbulent tools. For this purpose we selected satellite ocean colour products like Remote sensing reflectance (R$_{rs}$-443 and R$_{rs}$-555) and Chlorophyll-a (Chl-a), and thermal infrared Sea Surface Temperature (SST).

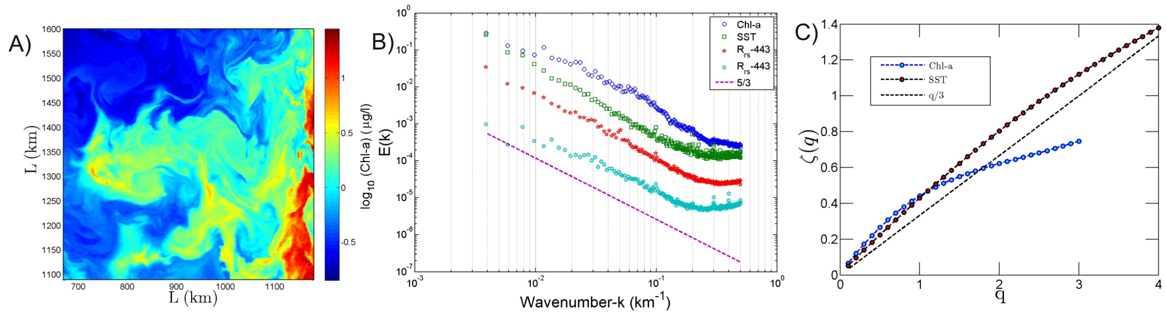

Figure 2. Chl-a sampled from Mauritanian coast 11-March-2003 A). 2D power spectra derived for Chl-a, SST, R$_{rs}$-443 and R$_{rs}$-555 in B) and scaling moment function of Chl-a and SST in C).

For that purpose, different contrasted regions of ocean, characterized by high spatial heterogeneity in Chl-a and SST have been selected. Spectral analysis is widely used technique in marine environment and marine ecology to assess the spatial variability of scalars, especially in connection with turbulence. Here we use 1D and 2D Fourier power spectra to understand the spatial scaling of R$_{rs}$, Chl-a and SST. The 2D powerspecral slope β is derived from the 2D power spectrum using a radial sum of the power spectrum. The β derived for 1D and 2D follow power law behaviour with specific slope values. The multi-scaling properties of these images are also studied using a 2D version of Structure Function (SF) method [3]. The nonlinear moment function $\zeta(q)$ is fitted using the lognormal model with 2 parameters, the Hurst index H and the intermittency μ. The values of H and μ are discussed for 4 different parameters (Chl-a, SST, R$_{rs}$-443 and R$_{rs}$-555) and for different locations.

References

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