How to obtain ocean turbulent dynamics at super resolution from optimal multiresolution analysis and multiplicative cascade?
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How to obtain ocean turbulent dynamics at super resolution from optimal multiresolution analysis and multiplicative cascade?

Abstract

A fundamental challenge in oceanography is the synoptic determination of ocean circulation using the data acquired from space, with a coherent depiction of its turbulent characteristics. This determination has the potential of revealing all aspects of the ocean dynamic variability on a wide range of spatio-temporal scales and will enhance our understanding of ocean-atmosphere exchanges at super resolution, as required in the present context of climate change.

- New method based on an approximation of the energy of Microcanonical Cascade (MC), expressed in a Multiscale Microcanonical Formulation (MMF), associated to turbulent signals provided by different Sea Surface Temperature (SST) or Ocean Color (Ch-a) products.
- The approach offers the opportunity to infer different oceanic turbulent signals from Low Resolution (LR) to HR. Basic idea: optimal cascading to decrease the spatial resolution of the HR signal (dimensional critical transition informations of SST), - use the signal available at LR (GEKCO product at 1/4° [1]), transmit that information along the scales back to higher spatial resolution using the cascade to obtain a new HR signal.
- The process has been successfully used to obtain oceanic currents at 1/24° [2] and 1/64°.

1 General concept of the MMF/MC method

HR Signal with FDT

Microcanonical Cascade with its Optimal Wavelet:

New HR inferred signal

- Obtain a relevant signal with SST and MMF to carry through the resolution (ascent) a new signal only known at LR

Replace the approximation of the signal by LR information to make the inference

2 To obtain Oceanic current at HR : Separation of Norm and Direction (See [1,2] for full description)

SST° (Fluid Exponent)

Singularity Exponent of SST°C

Microcanonical Cascade

Stream Function (seen-Fontaine et al. 2007)

Singularity Exponent of SST°C

Microcanonical Cascade

Stream Function

Microcanonical Cascade

\[ V(\text{Exp})_{\text{HR}} = \frac{1}{\text{HR}} \]

Direction Algorithm

Norm Algorithm

3 To validate oceanic current at HR (4 years period): Use drifters during the period January 1, 2006 to December 31, 2009. (more validation tests in [2])

Positions of the 373 drifters dropped at a 15 m depth coming from Global Drifter Program at the AOML (925712 points)

Computation of

- Recorded buoy and computed velocities

\[ u_i = \sum_{j=1}^{n} \frac{v_{ij}}{w_i} \]

\[ w_i = \sum_{j=1}^{n} v_{ij} \]

Comparison of

- SST & Chl-a or SSS & Chl-a inferred HR currents using Expt.

4 Examples of data obtained by the MMF/MC method

Maps of :

- a) absolute dynamic topography at 1/4° and the LR current (geostrophic and Ekman components) associated (02/08/2007)
- b) inferred HR current at 1/24° [2] with SST (02/08/2007)
- c) inferred HR current at 1/24° [2] with SST (02/08/2007)
- d) norm difference between b) and c)
- e) inferred HR current at 1/64° (only one per two calculated sectors is shown) with BLR SST (01/05/2015)

Conclusion and Future Work

- Evidencing multiscale geometric structures in synthetic ROMS data and satellite data through the Multiscale Microcanonical Formulation
- Validation of algorithms on synthetic ROMS data
- Application of the algorithms on satellite data
- Validation of the new HR satellite data with in-situ data
- Future Work: - Analyze the difference between SST and Chl-a inferred HR currents for the 4 years period - Process and validate SST HR currents at 1/64° on global area

References


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