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Eect of wind stress forcing on ocean dynamics at air sea interface

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Eect of wind stress forcing on ocean dynamics at air-sea interface

Motivation

We study the variations in the statistics of ocean dynamics turbulence directly from the acquired data, with a focus on mesoscale oceanic data. Our goal is to provide quantitative evaluation of wind stress forcing effects on mesoscale ocean dynamics.

Data

We make use of the surface ocean dynamics product at the $1/4^o$ described in *Sudre 2013* and derived from altimetry. Our data covers one year of daily acquisitions from 2010. Using these datasets, the central hypothesis is to estimate the first order current as the sum of geostrophic and wind driven components:

- Geostrophic current is determined from the Absolute Dynamic Topography.
- Equator singularity is solved with the semi-geostrophy approximation.
- Ekman current is estimated by fitting a simple Ekman model based on the residual $\boldsymbol{v}_{\text{drifter}} - \boldsymbol{v}_{\text{geos}}$.
- Validation is performed with shipboard ADCP, equatorial moorings, SVP drifters, and surface displacement Argo floats.

Data

Using these data, we calculated the norm of geostrophic current with and without Ekman currents and the associated vorticity for the four following areas of study:

- Agulhas retroflection,
- Gulf-Stream area,
- Peru-Chile area,
- Brazil-Malvinas area.

For each daily acquisition from 2010, we get the norm of the oceanic velocity field with and without the Ekman currents. From these data we obtain the vorticity of the geostrophic velocity field, again with and without Ekman currents: $\omega = \nabla \wedge \boldsymbol{v}$.

Data

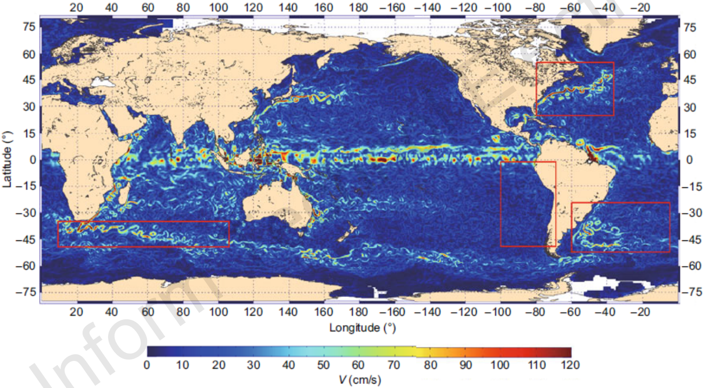

Fig. 1 Norm of the geostrophic surface current for the 1st January 2010. The red rectangles represent the four areas of study. References to color refer to the online version of this figure

Method

We use the multifractal formalism and the computation of **singularity spectra** over the datasets. These spectra encode turbulence properties directly in the shape of their graphs. Consequently, we compute statistics in order to discover differences in turbulence statistical properties.

Results

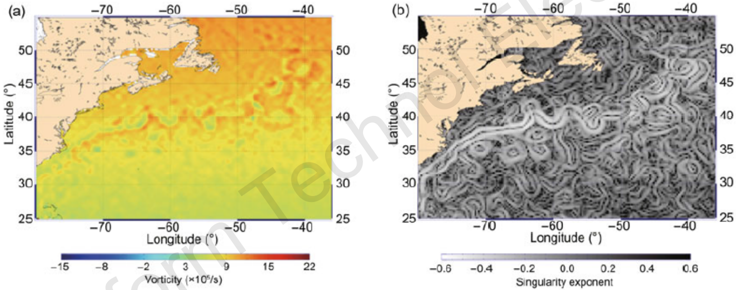

Fig. 3 Absolute vorticity of geostrophic and Ekman currents (a) and corresponding singularity exponents (b) for the 1st January 2010. References to color refer to the online version of this figure

Results

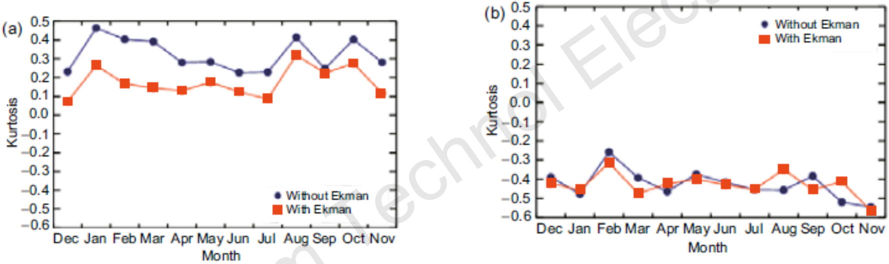

Fig. 5 Results of Gulf Stream area: monthly mean kurtosis of the spectra of geostrophic norm (a) and geostrophic vorticity (b)

Results

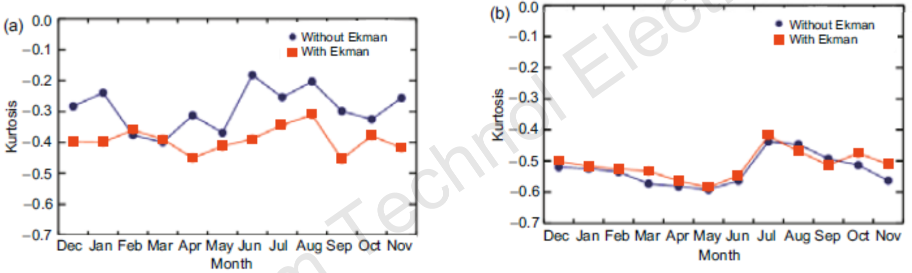

Fig. 6 Results of Brazil-Malvinas area: monthly mean kurtosis of the spectra of geostrophic norm (a) and geostrophic vorticity (b)

Results

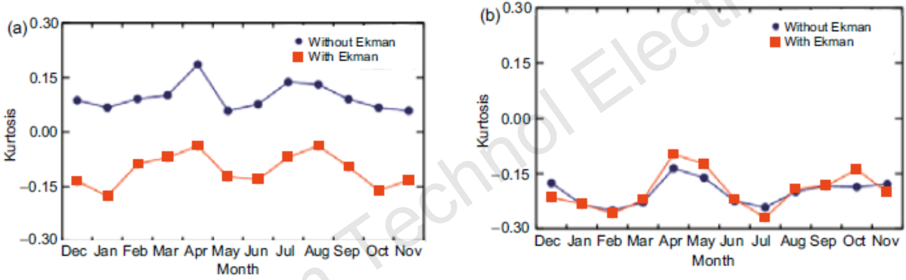

Fig. 7 Results of Agulhas area: monthly mean kurtosis of the spectra of geostrophic norm (a) and geostrophic vorticity (b)

Results

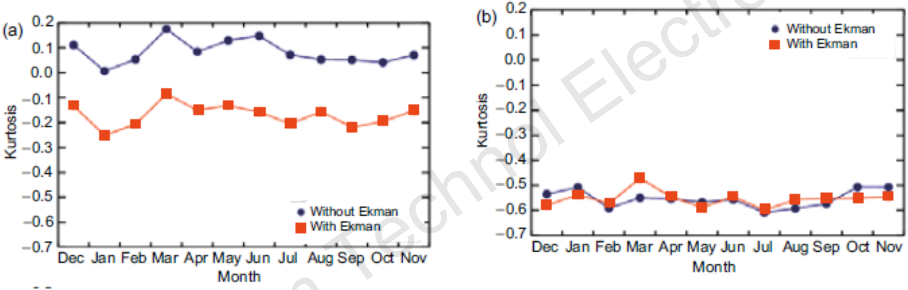

Fig. 8 Results of Peru-Chile area: monthly mean kurtosis of the spectra of geostrophic norm (a) and geostrophic vorticity (b)

Discussion

- Differences in kurtosis (in particular positive and negative) are significant and indicate different spectra. The norms of the velocity fields clearly show different turbulent properties between the norm of the oceanic velocity field with and without Ekman currents (*i.e.*, taking into account wind stress forcing).
- We note no significant difference in term of vorticity spectra.

Discussion

From these results we conclude that wind stress does affect oceanic turbulence geographically, notably w.r.t. latitude. On vorticity, it is likely that other tools than the ones presented in this work for the statistical study of turbulence have to be devised and tested.

Conclusion

Experiment using daily remotely sensed data acquired over one year to display different turbulence statistics of the oceanic system, with the goal of improving the description of the oceanic mesoscale (and sub-mesoscale) turbulence. Positive results put forward the differences in term of wind stress according to the area of study. The results also confirm the usefulness of the multifractal formalism for the study of natural complex and turbulent acquired data.