Effect of wind stress forcing on ocean dynamics at Air-Sea Interface

Joël Sudre, Hussein Yahia, Christophe Maes, Veronique Garçon

▶ To cite this version:

Joël Sudre, Hussein Yahia, Christophe Maes, Veronique Garçon. Effect of wind stress forcing on ocean dynamics at Air-Sea Interface. Frontiers in ocean-atmosphere exchange: Air sea interface and fluxes of mass and energy, May 2017, Cargèse, France. 2017. hal-01522024

HAL Id: hal-01522024

https://hal.inria.fr/hal-01522024

Submitted on 12 May 2017

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Effect of wind stress forcing on ocean dynamics at Air-Sea Interface

J. Sudre[1], H. Yahia[2], C. Maes[3], V. Garçon[1]
[1]LEGOS/CNRS, France
[2]INRIA Centre-Bordeaux Sud-Ouest, France
[3]LOPS/IRD, Plouzané France.

Abstract

Surface currents in air-sea interaction are of crucial importance because they transport heat from low to high latitudes. At first order, oceanic currents are generated by the balance of Coriolis and pressure gradient (**geostrophic current**) and the balance of Coriolis and the frictional force dominated by wind stress in the surface ocean (**Ekman current**). The GEKCO product [1] is a daily 1/4 degree resolution product which permits the computation of two kinds of vector fields: **geostrophy with and without wind stress forcing**.

We aim at studying the difference in term of turbulent hydrodynamics carried by the wind forcing at the air-sea interface.

We explore the statistical properties of singularity spectra computed from velocity norms and vorticity data, notably in relation with kurtosis information to underline differences in the turbulent regimes associated with both kinds of velocity fields. This study is conducted over 1 year of daily data and demonstrates the differences in terms of turbulent property of wind forcing.

1 Ocean dynamics product at the 1/4° resolution [1]

o The central hypothesis is to estimate the first order current as the sum of geostrophic and wind driven components

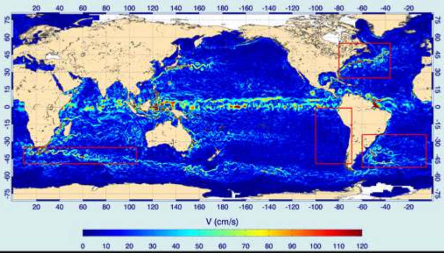
o Geostrophic current is determined from Absolute Dynamic Topography

o Equator singularity is solved with the semi-geostrophy approximation

o Ekman current is estimated by fitting a simple Ekman model based on the residual (U drifter – U geos)

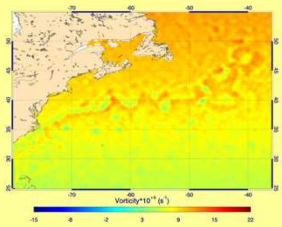
o Validation with shipboard ADCP, equatorial moorings, SVP drifters and Argo floats

o Calculate the norm of geostrophic current with and without Ekman currents and the associated vorticity on different study areas :

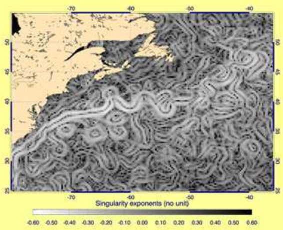


Norm of the geostrophic surface current for the 1st January 2010. The red rectangles represent the 4 study areas:
- Agulhas retroflection
- Gulf-Stream area
- Peru-Chile area
- Brazil-Malvinas area

2 Statistical tools to evaluate the turbulence

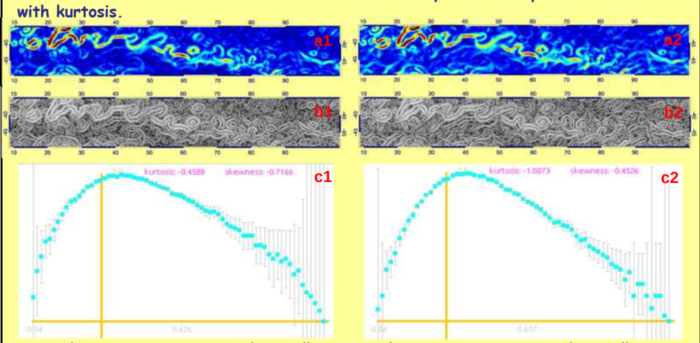


Absolute vorticity of geostrophic and Ekman currents for the 1st January 2010



Corresponding singularity exponents of the left image

o Singularity spectra: the mapping h → Dh of each scaling exponent to the Hausdorff dimension of the associated manifold [2,3]. Narrower spectra indicate different multifractal behavior. The statistical shape of the spectra is measured with kurtosis.



For the 1st January 2010 in the Agulhas area: a1) Norm of geostrophic currents, b1) Singularity exponents of a1), c1) Singularity spectra associated

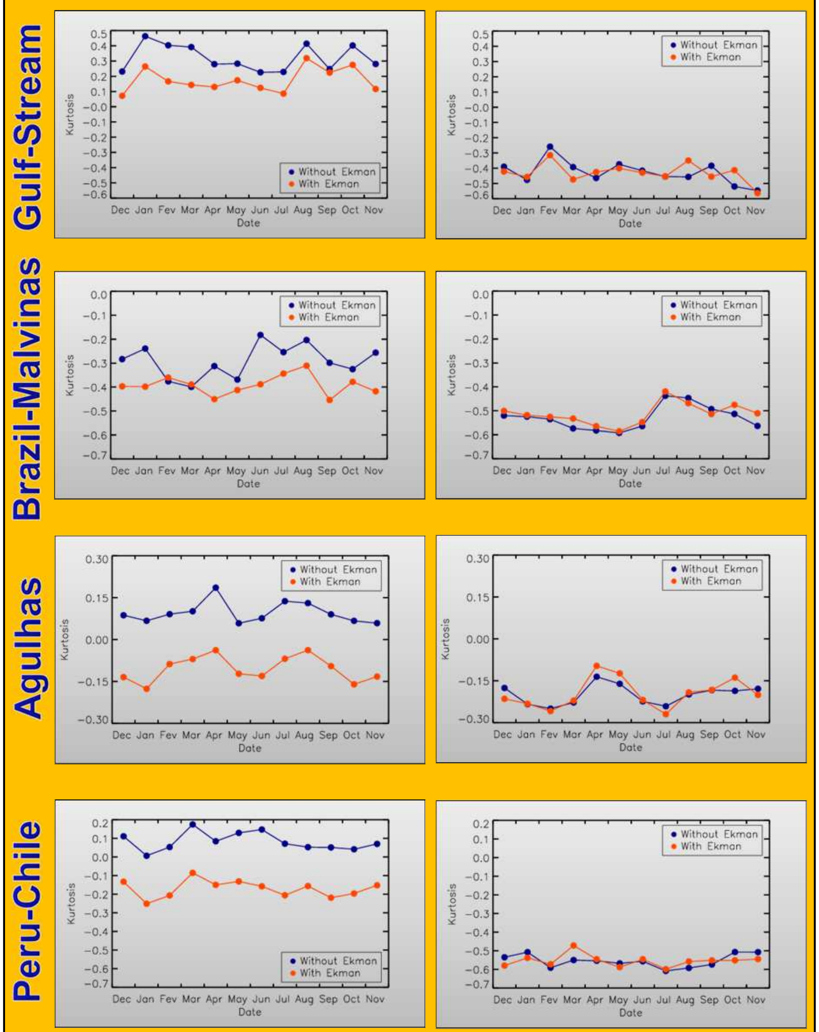
For the 1st January 2010 in the Agulhas area: a2) Norm of geostrophic and Ekman currents, b2) Singularity exponents of a2), c2) Singularity spectra associated

o Results

The standard normal distribution has a kurtosis of zero. In addition, positive kurtosis indicates a "heavy-tailed" distribution and negative kurtosis indicates a "light tailed" distribution. Consequently, neat differences in kurtosis (in particular, positive and negative) mean different organization of the multifractal hierarchy, and differences in turbulence regime.

3 Results

Monthly mean kurtosis of the singularity spectra of geostrophic norm | **Monthly mean kurtosis of the singularity spectra of geostrophic vorticity**



Conclusion and Future Work

➢ Differences in kurtosis (in particular positive and negative) are significant and indicate different spectra (a gaussian distribution has kurtosis 0). The norms of the velocity fields clearly show different turbulent properties.

➢ No significant difference in term of vorticity spectra.

➢ Determine a turbulent regime classification in the world ocean to adapt the turbulent cascade pathways for a better inference of super-resolution currents product developped in [2,3].

➢This will improve the description of the oceanic submesoscale turbulence

➢ Adapt this methodology to high resolution GHG fluxes [4]

➢ Construct a monthly climatology with the 1993 – 2016 period of GEKCO products for each province

References
- [1] J. Sudre, C. Maes, and V. Garçon, 2013, On the global estimates of geostrophic and Ekman surface currents, Limnology and Oceanography: Fluids and Environments, vol. 3, pp. 1–20, DOI 10.1215/21573689-2071927
- [2] H. Yahia, J. Sudre, C. Pottier and V. Garçon, 2010, Motion analysis in oceanographic satellite images using multiscale methods and the energy cascade, Pattern Recognition, DOI: 10.1016/J.patcog.2010.04.011
- [3] J. Sudre, H. Yahia, O. Pont, and V. Garçon, 2015, Ocean turbulent dynamics at superresolution from optimal multiresolution analysis and multiplicative cascade, IEEE TGRS, DOI: 10.1109/TGRS.2015.2436431
- [4] I. Hernández-Carrasco, J. Sudre, V. Garçon, H. Yahia et al., 2015, Reconstruction of super-resolution ocean pCO2 and air-sea fluxes of CO2 from satellite imagery in the southeastern Atlantic, Biogeosciences, DOI: 10.5194/bg-12-5229-2015