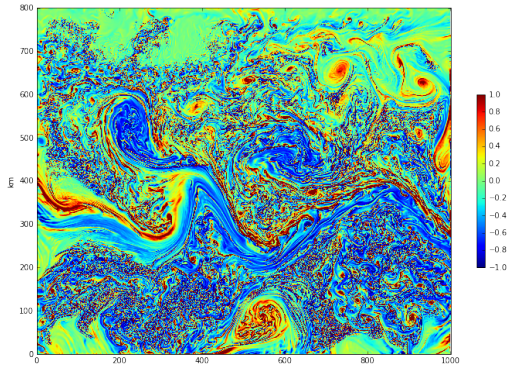
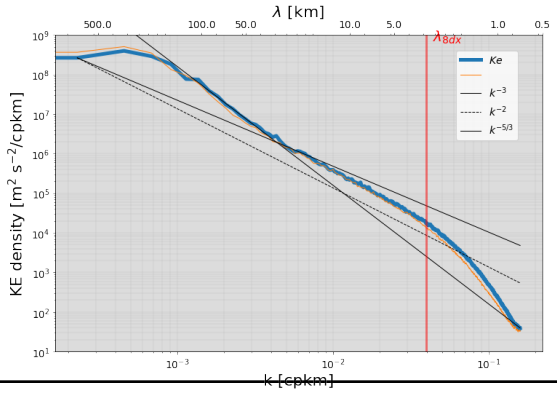
Homework - Ocean turbulence





Introduction

You need to provide a written report for this homework, which will be used for the evaluation of the Turbulence course. Due date is: **March 8, 2021**

1. Get the data

Two Files containing model outputs are available here: jgula.fr/Turb/

- **Atlantic_for_turb.nc** is a 5 km resolution simulation of the Atlantic ocean
- **GS_for_turb.nc** is a 500 m resolution simulation of the Gulf Stream after separation during winter.

Each file contains temperature (T), salinity (S), and horizontal velocities (u,v,) at different depths (surface, 200, 300, 500, 1000 m). For example (us,vs) are surface velocities, while (u300,v300) are velocities at 300 m depth.

An example notebook with 1d and 2d spectra is available here: https://github.com/Mesharou/mesharou.github.io/blob/master/Turb/turbulence2d_example.ipynb

▸ Dimensions: (eta_rho: 1602, eta_v: 1601, time: 1, xi_rho: 2002, xi_u: 2001)

▸ Coordinates: (0)

▾ Data variables:

zeta	(time, eta_rho, xi_rho)	float32	...
ocean_time	(time)	float32	...
us	(time, eta_rho, xi_u)	float32	...
vs	(time, eta_v, xi_rho)	float32	...
u200	(time, eta_rho, xi_u)	float32	...
v200	(time, eta_v, xi_rho)	float32	...
u300	(time, eta_rho, xi_u)	float32	...
v300	(time, eta_v, xi_rho)	float32	...
u500	(time, eta_rho, xi_u)	float32	...
v500	(time, eta_v, xi_rho)	float32	...
u1000	(time, eta_rho, xi_u)	float32	...
v1000	(time, eta_v, xi_rho)	float32	...
f	(time, eta_rho, xi_rho)	float32	...
h	(time, eta_rho, xi_rho)	float32	...
pm	(time, eta_rho, xi_rho)	float32	...
pn	(time, eta_rho, xi_rho)	float32	...
T	(time, eta_rho, xi_rho)	float32	...
S	(time, eta_rho, xi_rho)	float32	...
T300	(time, eta_rho, xi_rho)	float32	...
S300	(time, eta_rho, xi_rho)	float32	...
vrt	(time, eta_rho, xi_rho)	float32	...
vrt300	(time, eta_rho, xi_rho)	float32	...
lon	(time, eta_rho, xi_rho)	float32	...
lat	(time, eta_rho, xi_rho)	float32	...

Several scientific articles are available here: *http://mespages.univ-brest.fr/~gula/Turb/Articles/* to give you some context on the mesoscale and submesoscale turbulence in the ocean.

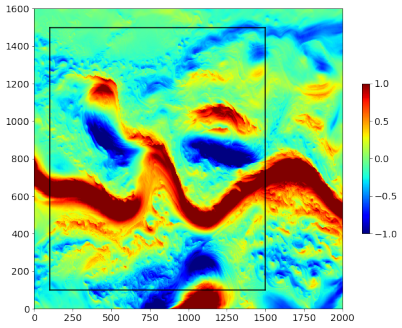
2.Ocean turbulence

1. Plot horizontal maps of Sea Surface Temperature and surface relative vorticity for the Atlantic domain.

2. Compute the power spectral density of kinetic energy at the surface over the Northern subtropical gyre. Comment the results. In particular describe the slopes of the curves. Are they consistent with turbulence theory and with observations?

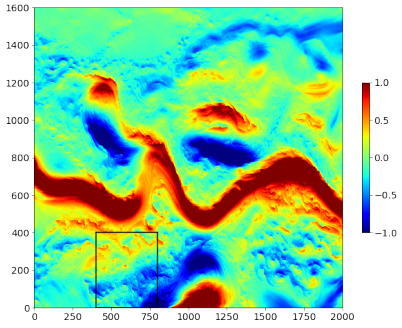
3. Compute the same spectra at 500 m depth. Is it different than at the surface?

4. Plot horizontal maps of Sea Surface Temperature and surface relative vorticity for the Gulf Stream zoom at higher resolution



5. Compute the power spectral density of kinetic energy over a large domain (corresponding approximately to the box on the right figure). Comment the results. In particular describe the slopes of the curves. Are they consistent with turbulence theory and with observations?

6. Compute the same spectra at 500 m depth. Is it different than at the surface? Can you explain why?



7. Compute the power spectral density of kinetic energy over a smaller domain south of the Gulf Stream (corresponding approximately to the box on the right figure). Comment the results. In particular describe the slopes of the curves. Are they consistent with turbulence theory and with observations?