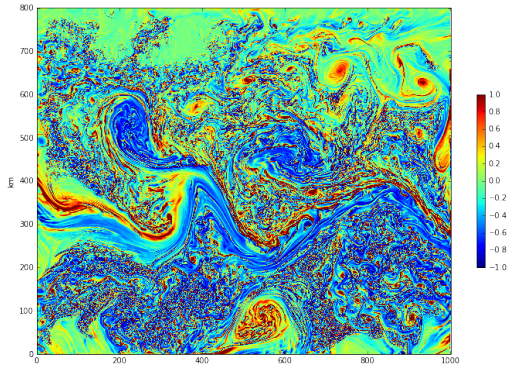
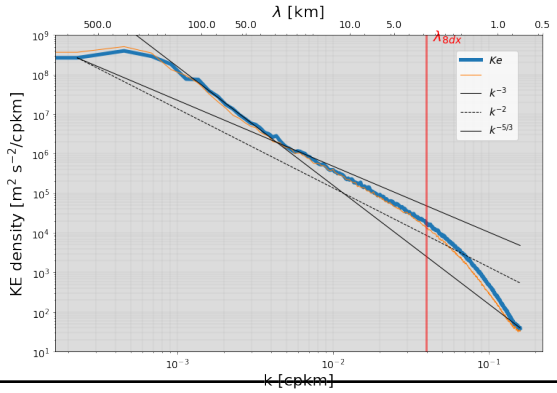
Homework - Ocean turbulence





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 25, 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.

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.

▸ 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	...

2.Ocean turbulence

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

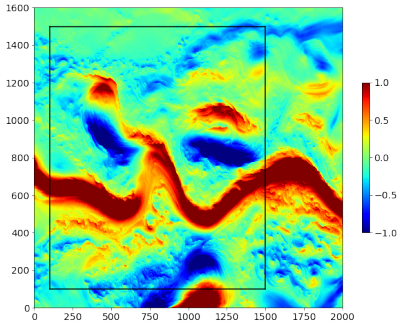
2. Compute the power spectral density of kinetic energy at the surface over the Northern subtropical gyre (pick a large domain at the center of the gyre). Comment on the results. In particular describe the slopes of the curves. Are they consistent with turbulence theory and with observations?

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

4. Compute the salinity and temperature variance spectra at the surface over the same domain. Are the results consistent with theoretical expectations (in particular the relation with kinetic energy spectra slopes)?

5. Compute the SSH variance spectra at the surface over the same domain. Is it also consistent with kinetic energy spectra slopes?

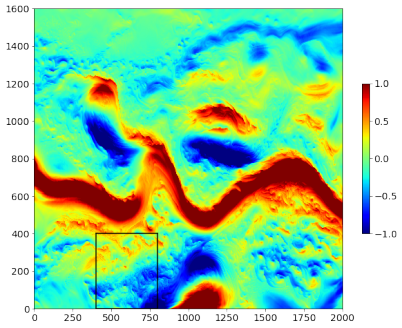
6. Plot horizontal maps of Sea Surface Temperature and surface relative vorticity for the Gulf Stream zoom at higher resolution



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

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

9. 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 on the results. In particular describe the slopes of the curves. Are they consistent with turbulence theory and with observations?



3. Summary of research articles

Choose two research articles available on this page: *http://mespages.univ-brest.fr/~gula/Turb/Articles/* **and summarise them (in french or english) using your own words. Each summary should be about one or two pages long and should:**

- State the question of the research and explain why it's important.
- State the hypotheses that were tested (if applicable)
- Explain the methods that were used
- State the different results and their interpretation
- State what the key implications were