Note on the Spectral Analysis of the Comodo baroclinic Jet

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1 The Spectral Analysis

From the Kinetic Energy balance equation (see Capet 2008):

$$\frac{1}{2}\frac{\partial u_h^2}{\partial t} = -u_h \cdot (u_h.\nabla_h)u_h - u_h \cdot w\frac{\partial u_h}{\partial z} - \frac{1}{\rho_0}u_h \cdot \nabla_h p + u_h \cdot D_h + u_h \cdot \frac{\partial K_V \frac{\partial u_h}{\partial z}}{\partial z} \quad (1)$$

We do a spectral decomposition with respect to horizontal wave number, averaging in time(we take the last 3 months of the 2 years simulation) , between a level z_0 (around 200m depth at the moment) and the free surface ξ which gives (equation 2 of Capet 2008):

$$T = \frac{1}{\xi - z_0}\int_{z_0}^{\xi} \Re e\left[\overline{\underbrace{-\hat{u}_h^*.(\widehat{u_h.\nabla})u_h}_{A_H} - \underbrace{\hat{u}_h^*.w\widehat{\frac{\partial u_h}{\partial z}}}_{A_V} - \underbrace{\frac{1}{\rho_0}\hat{u}_h^* \cdot \widehat{\nabla_h p}}_{P_H} + \underbrace{\hat{u}_h^* \cdot \widehat{D_h}}_{D_H} + \underbrace{\hat{u}_h^* \cdot \frac{\widehat{\partial K_V \frac{\partial u_h}{\partial z}}}{\partial z}}_{D_V}}\right] \quad (2)$$

From Marchesiello 2011, dropping the integral notation for simplicity, terms are written as function of the wavenumber k:

$$T(k) = P(k) + I(k) + A_H(k) + A_V(k) + D_H(k) + D_V(k) \quad (3)$$

$$A(k) = A_H(k) + A_V(k) = \Re e\left[\overline{-\widehat{u_h^*}.(\widehat{u_h.\nabla})u_h - \widehat{u_h^*}.w\widehat{\frac{\partial u_h}{\partial z}}}\right] \quad (4)$$

$$D_V(k) = \Re e \left[\overline{\widehat{u_h^*} \cdot \frac{\partial \widehat{K_V \frac{\partial u_h}{\partial z}}}{\partial z}} \right] \quad (5)$$

$$P_H(k) = P(k) + I(k) \quad (6)$$

$$P(k) = \Re e \left[\overline{\frac{-1}{\rho_0} \widehat{u^*} . \widehat{\nabla p}} \right] \quad (7)$$

$$I(k) = \Re e \left[\overline{\widehat{w^*} \hat{b}} \right] \quad (8)$$

Where the hat $\hat{}$ notation represents the fourier transform of a variable, * its conjugate, $\Re e$ the real part of the complex number and the overbar an average in time. b is the buoyancy $\frac{-g\rho}{\rho_0}$

2 The tools

With a sourceforge account for romsagrif one can check out the svn branche containing the spectral analysis tools:

svn co https://scm.gforge.inria.fr/svn/romsagrif/branches/spectra_tools/Roms_tools/

No documentation so far and the sripts are rough but usable.

Everything happens in the DIAGS_spectra_online/diags_spectra_budget_online.py script. Using some utility functions from utilities.py

Reading the netcdf are done using 2 libraries: pycomodo for the comodo compliant files and pyroms for the other (diagnostic output file is not under COMODO norm in roms so far)

2.1 Online

All terms in **??** are read from an output file. Except for the vertical buoyancy flux term which is simply computed as in **??**, the spectral decomposition with respect to horizontal wave number is done by computing co-spectra bewteen these terms and the velocity:

i.e: The real part of the scalar product between the fourier transform of the horizontal velocity and the Fourier transform of each term of **??**

$$\Re e \left[\hat{u}^{*}.V\hat{a}r_{u} + \hat{v}^{*}.V\hat{a}r_{v} \right] \tag{9}$$

The 2D spectra obtained is then re-centered around larger wave number so that a circle integration can be performed to obtain a 1D spectra. Each

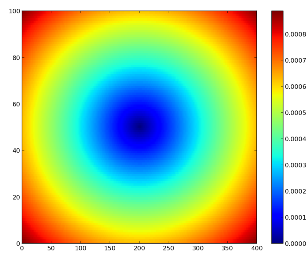


Figure 1: Frequency repartition after shift

spectra is integrated over circle $k-1<k<k+1$.

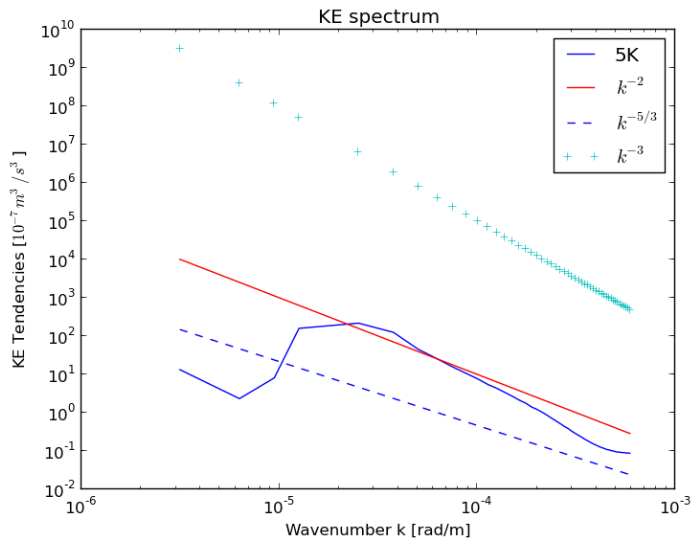
2.2 Offline

Each term from the momentum equation has to be computed manually the same way the model does (respecting the type of advection scheme for example).

3 Few results to illustrate what the routine does:

3.1 5K run

3.1.1 Kinetic energy spectra



3.1.2 Budget