PROJECT

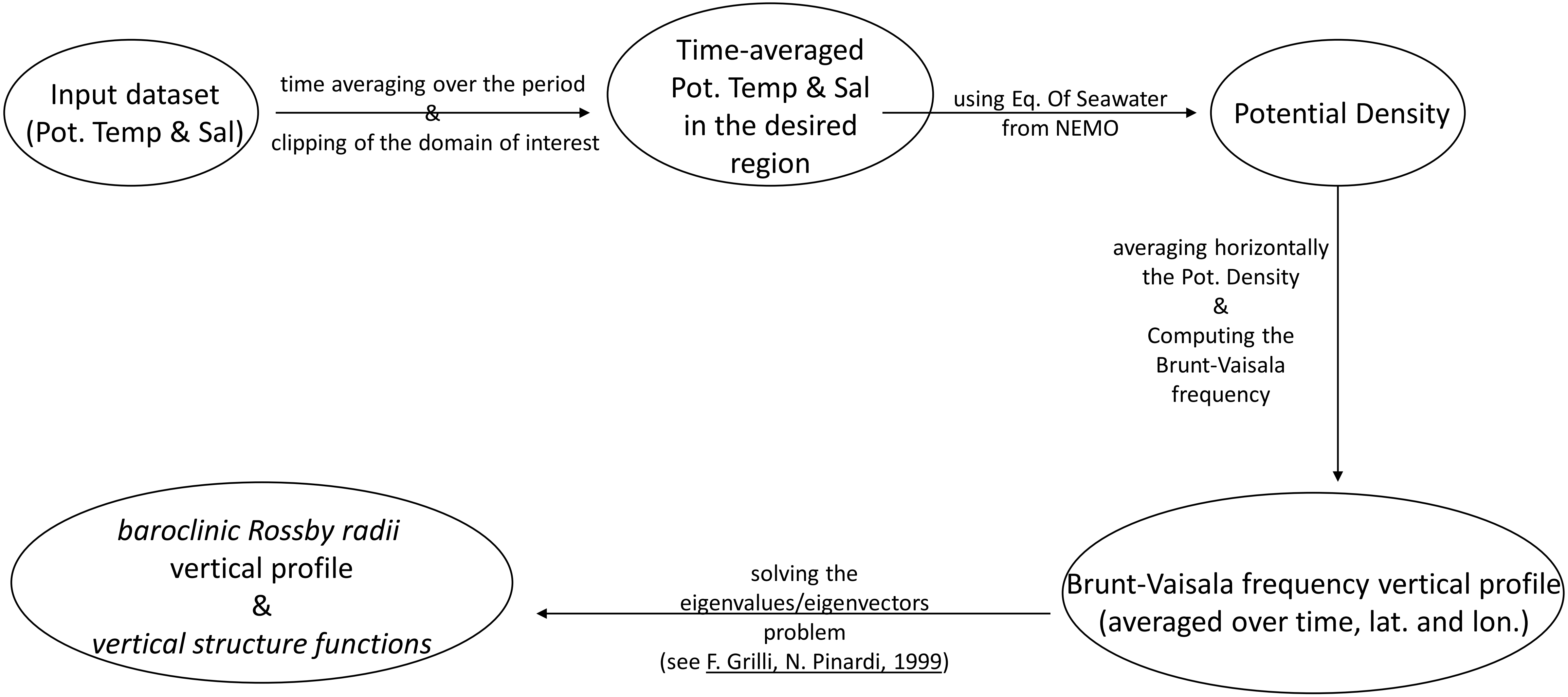
Ocean Baroclinic Modes 1.0 (OBM-1.0)

The Project: a downloadable repository on GitHub

- A «software» through which the user can compute time-averaged *baroclinic Rossby radius* vertical profile and *baroclinic vertical structure function* for each mode of motion, in a region of interest to him/her.
- How?
    1. Save the input dataset, containing **Potential Temperature** and **Salinity** variables, in a specific directory.
    2. Edit the configuration file.
    3. Run the «main.py» program.

    A directory is created, containing the results file and the vertical profiles plots.

Implementation Structure



Computing the baroclinic Rossby Radius & the vertical structure function [1]

- The Brunt-Vaisala frequency «N» is linearly interpolated on a new equally spaced depth grid with step equal to 1 m.
- The eigenvalues/eigenvectors problem is solved:

$$\frac{d^2w}{dz^2} = -\lambda S w \quad (1) \qquad \text{where } w = \frac{1}{S}\frac{d\Phi}{dz}, \quad S = \frac{N^2H^2}{f_0^2L^2}$$

(BCs: w = 0 at z = 0,1)

L = 100 km, H = maximum region depth (~ 5 km), $f_0 = 10^{-4}$ 1/s; «ϕ» vertical structure function.

A function from «scipy» is used for solving the discretized eigenvalues/eigenvectors problem:

$$\frac{1}{12dz^2}\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & \dots & 0 \\ 12 & -24 & 12 & 0 & \dots & 0 & \dots & 0 \\ -1 & 16 & -30 & 16 & -1 & 0 & \dots & 0 \\ 0 & -1 & 16 & -30 & 16 & \dots & \dots & 0 \\ \vdots & \ddots & \ddots & \ddots & \ddots & \dots & \dots & \vdots \\ 0 & \dots & \dots & 0 & 0 & 12 & -24 & 12 \\ 0 & \dots & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}\begin{bmatrix} w_0 \\ w_1 \\ w_2 \\ \vdots \\ \vdots \\ w_{n-1} \\ w_n \end{bmatrix} = -\lambda \begin{bmatrix} S_0 & 0 & 0 & 0 & \dots & \dots & 0 \\ 0 & S_1 & 0 & 0 & \dots & \dots & 0 \\ 0 & 0 & S_2 & 0 & \dots & \dots & 0 \\ 0 & 0 & 0 & S_3 & \dots & \dots & 0 \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \vdots \\ 0 & \dots & \dots & \dots & 0 & S_{n-1} & 0 \\ 0 & \dots & \dots & \dots & 0 & 0 & S_n \end{bmatrix}\begin{bmatrix} w_0 \\ w_1 \\ w_2 \\ \vdots \\ \vdots \\ w_{n-1} \\ w_n \end{bmatrix}$$

[1] F. Grilli, N. Pinardi (1999) "Le Cause Dinamiche Della Stratificazione Verticale Nel Mediterraneo"

- The *baroclinic rossby radius* is computed from the eigenvalues «λ» for a number of modes of motion set by the user, as

$$R_n = \frac{1}{\sqrt{\lambda_n}}$$

- The eigenvectors are computed integrating eq. (1) through Numerov's numerical method.

- The *vertical structure functions* are computed integrating the eigenvectors «w»:

$$\Phi_n(z) = \int_0^z S w_n dz + \Phi_0, \quad \text{with } \Phi_0 = \Phi(z=0)$$

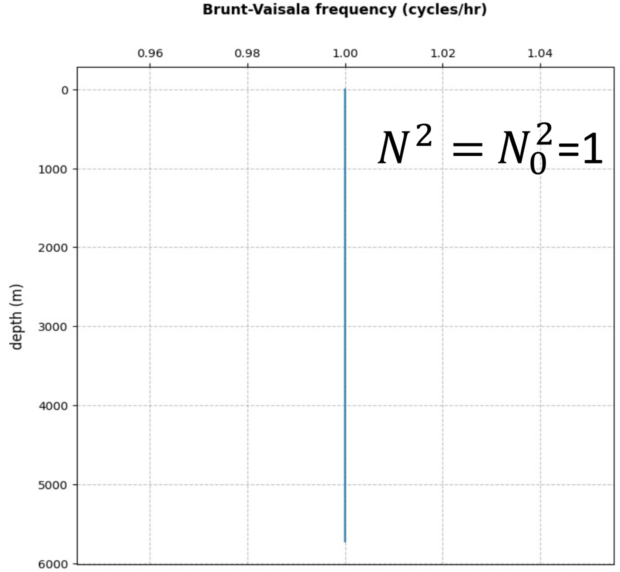
Here, $\phi_0 = 1$ is chose arbitrarily as modes of motion amplitude.

Results for particular cases

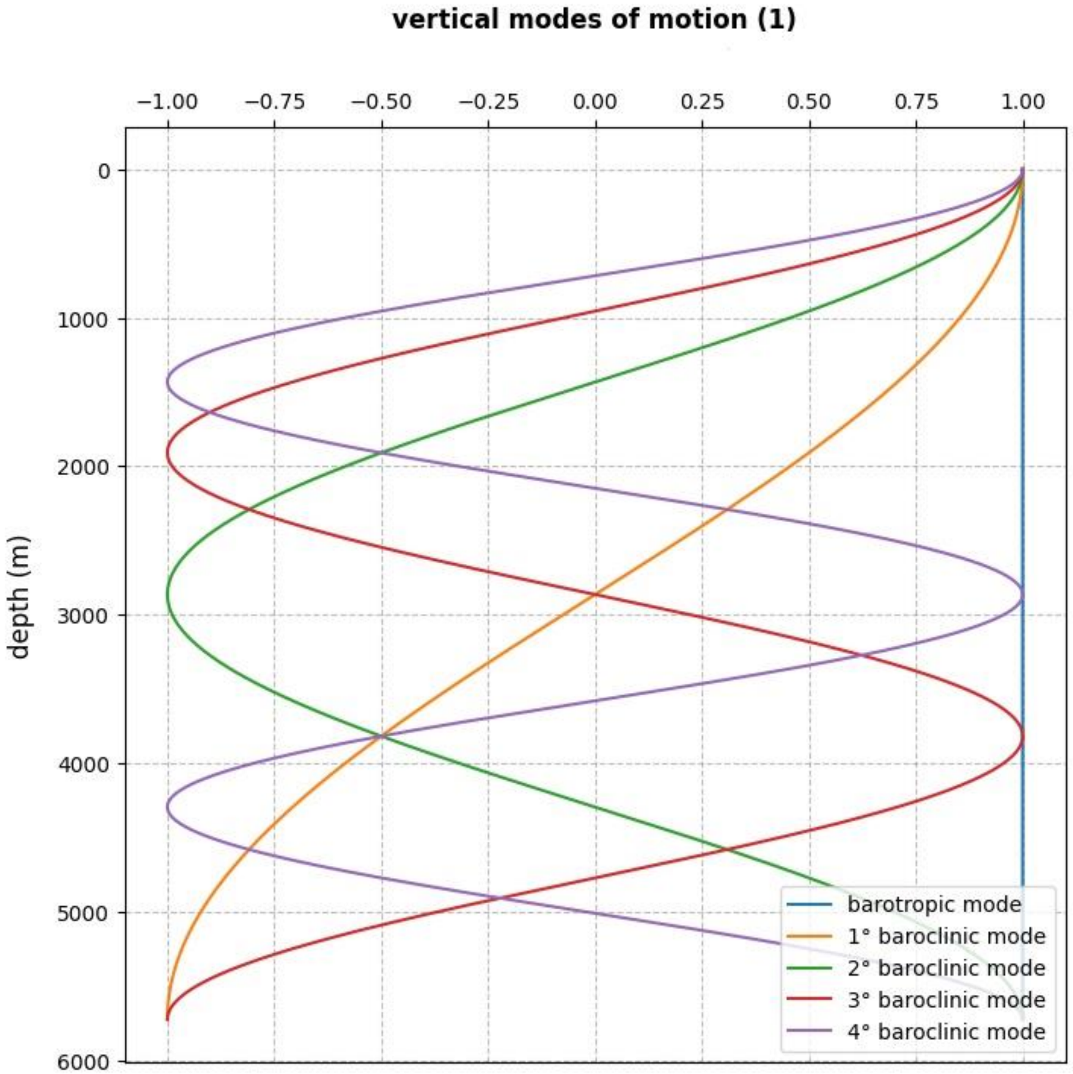
Comparison with analytical results from *J. H. LaCasce*

(«Surface Quasigeostrophic Solutions and Baroclinic Modes with Exponential Stratification*», 2012)*

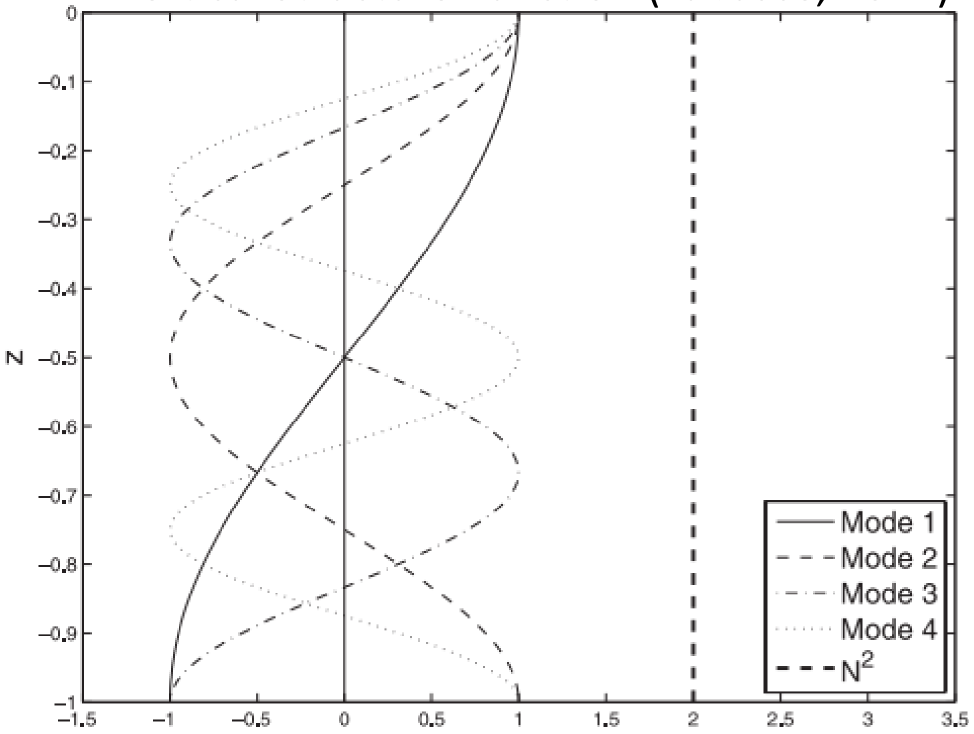
Constant Brunt-Vaisala Frequency



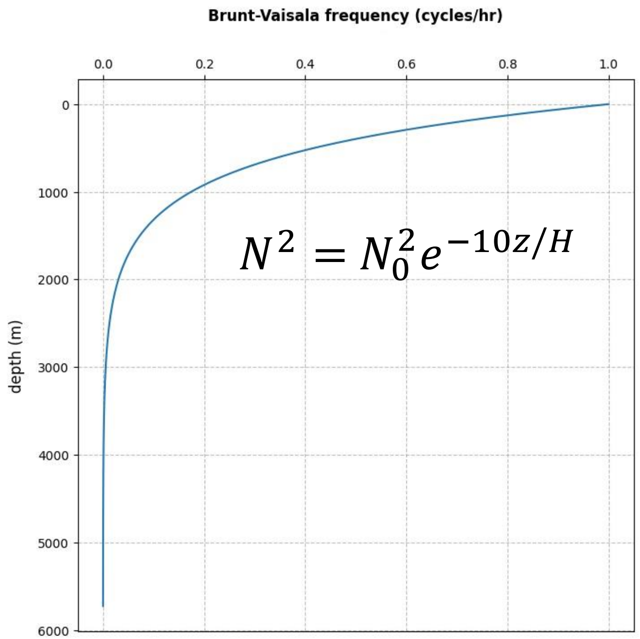
Numerical Result from OBM-1.0



Vertical Structure Function (LaCasce, 2012)

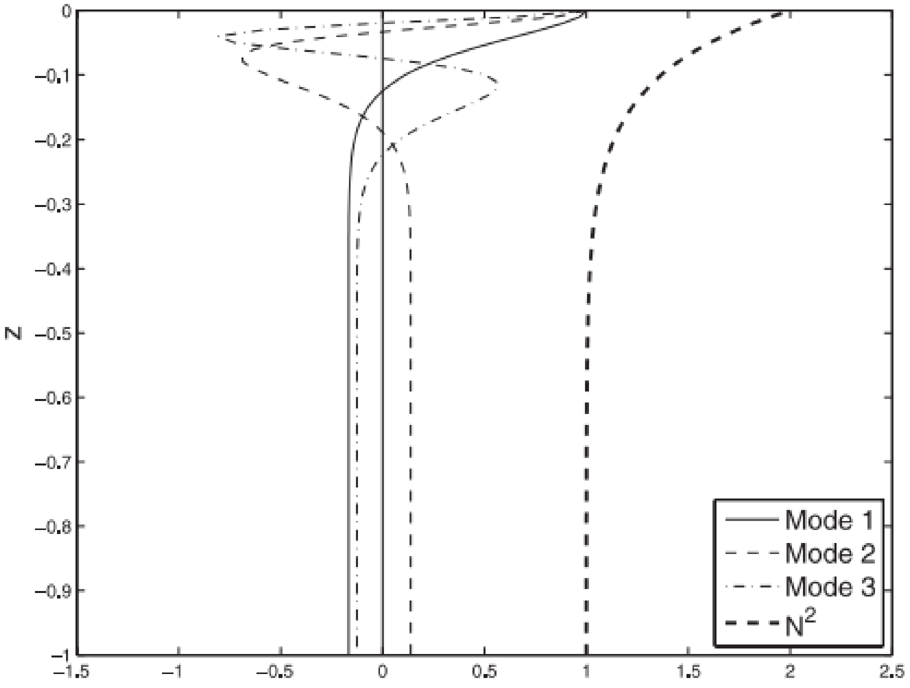


Exponential Brunt-Vaisala Frequency

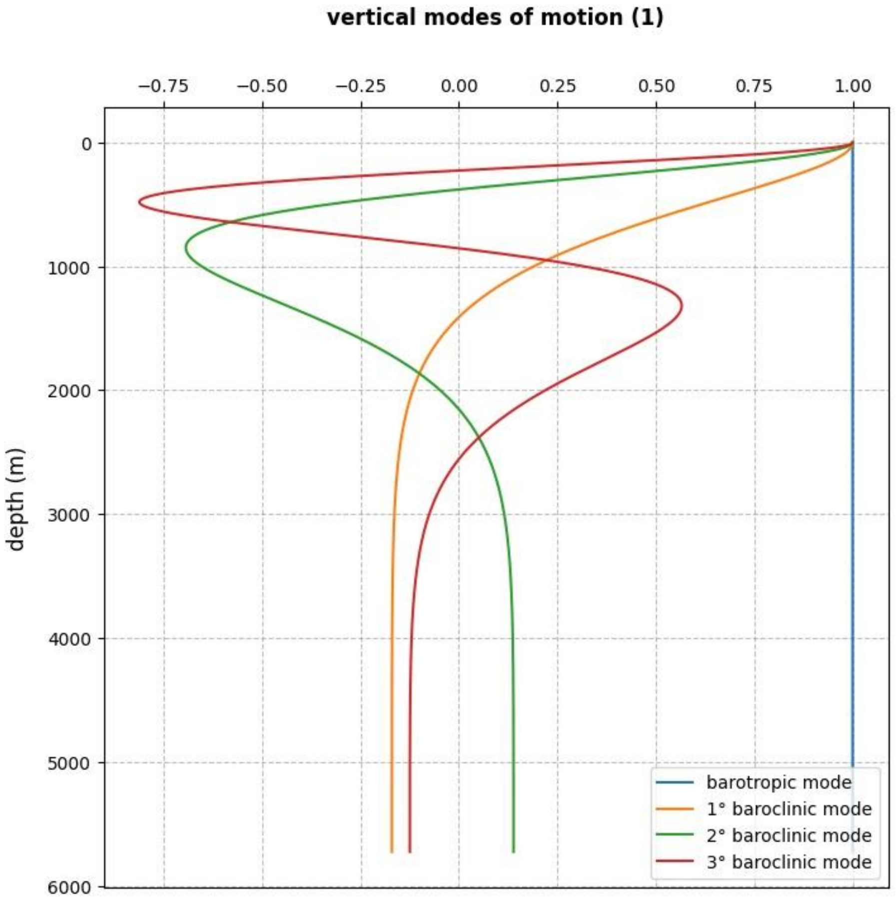


$$N^2 = N_0^2 e^{-10z/H}$$

Vertical Structure Function (LaCasce, 2012)



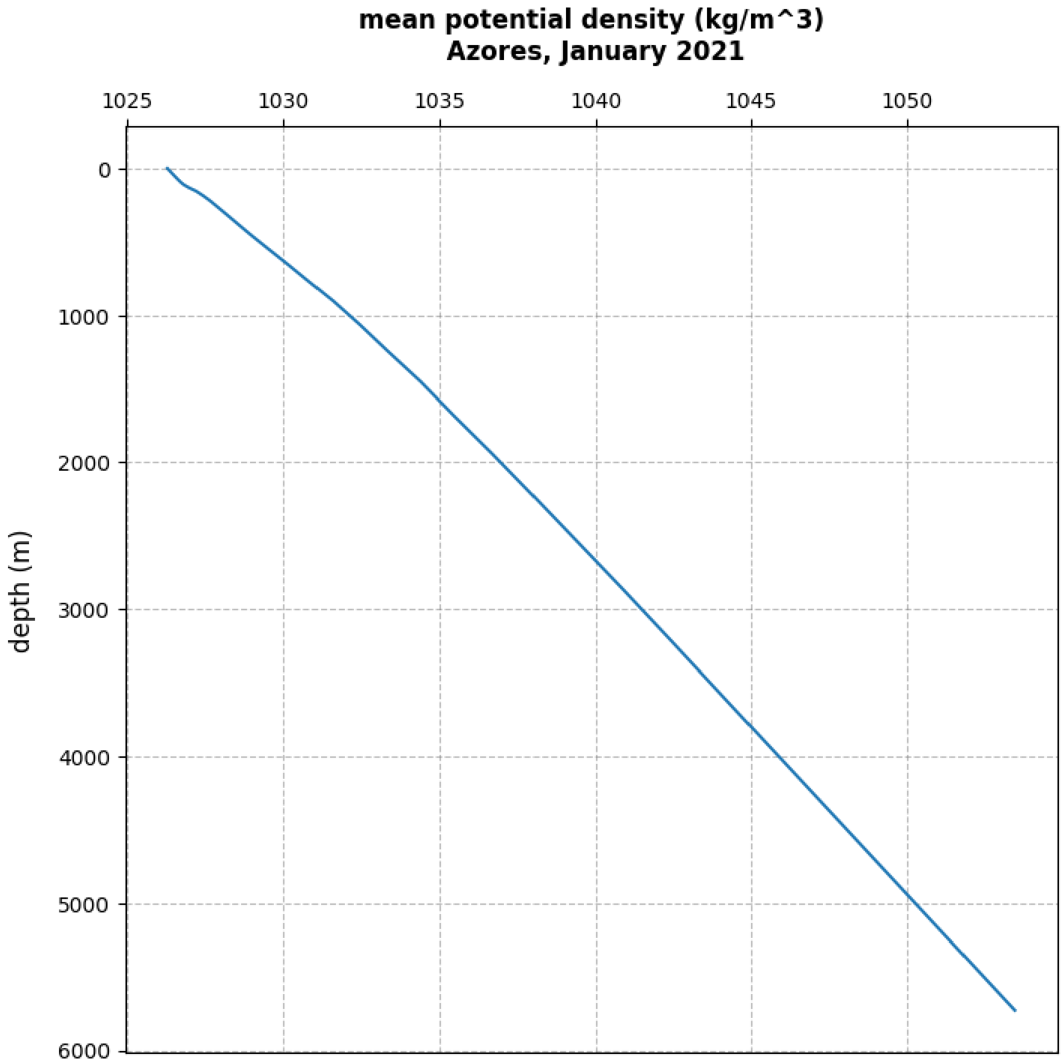
Numerical Result from OBM-1.0

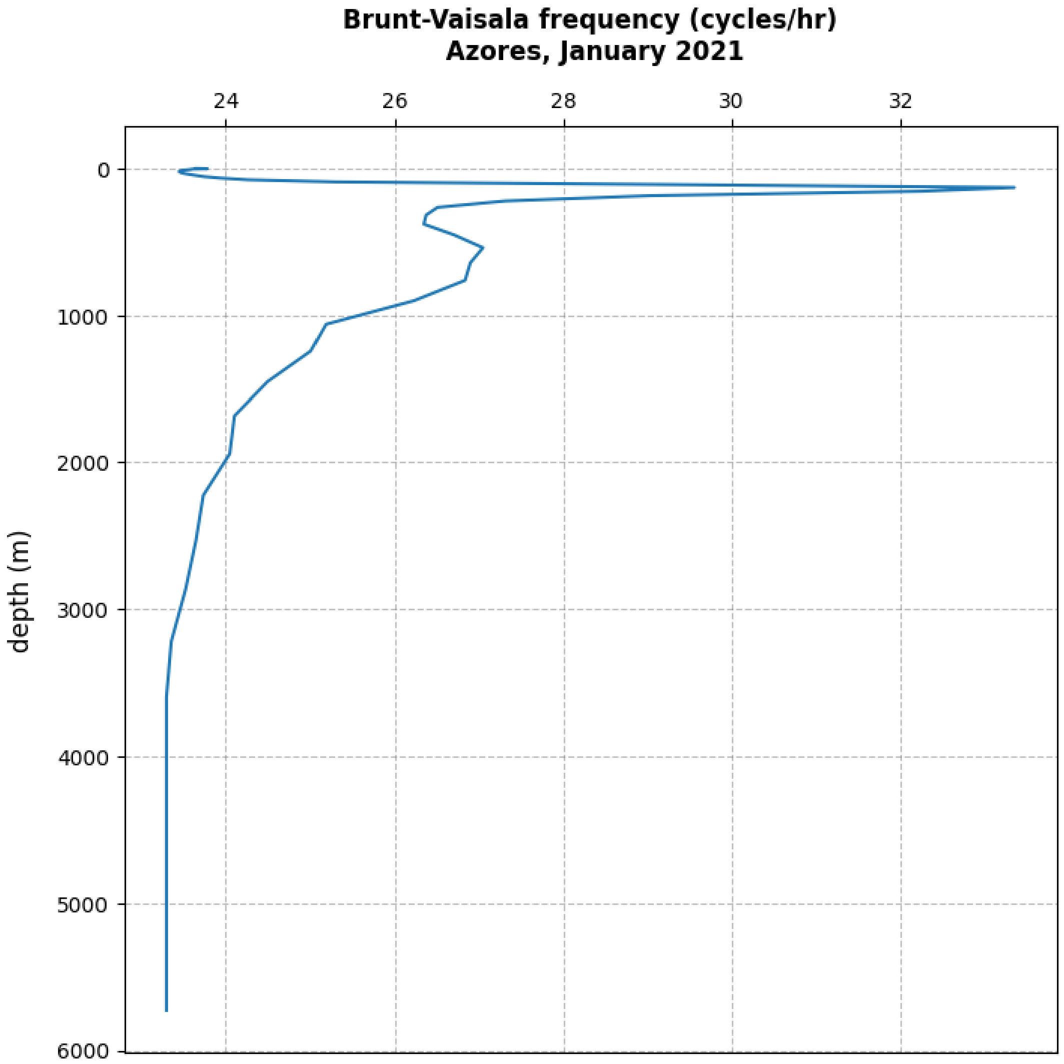


Test Case Results

(realistic Brunt-Vaisala frequency profile in the Azores region, Jan 2021)

Azores Region, January 2021
(latitude 35°N, longitude 28 ÷ 30°W)





Azores Region, January 2021
(latitude 35°N, longitude 28 ÷ 30°W)

	Baroclinic Rossby radius of deformation (km)
1° baroclinic mode	43.98
2° baroclinic mode	19.89
3° baroclinic mode	12.84
4° baroclinic mode	9.73