Ocean Convection Eddy-Diffusivity-Mass-flux (EDMF)

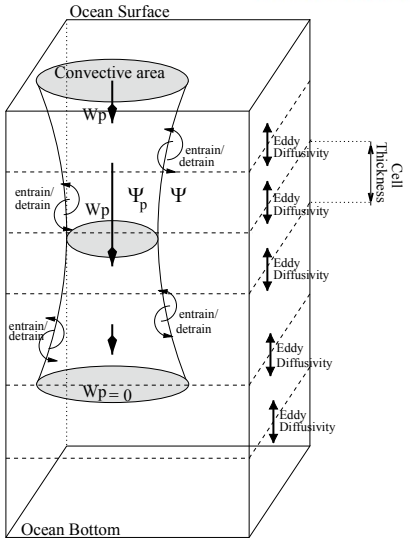
Hervé Giordani, Romain Bourdallé-Badie, Florent Gasparin

Parameterization of convective plumes in ocean models (Giordani et al., 2020)

Vertical Mixing: **ED+MF=EDMF**

- **local** (standard Eddy Diffusivity scheme)
- **non-local** (Mass Flux = Convection)

$$\overline{w'\psi'} = \overline{w'\psi'}_{\text{Diffusion}} + \overline{w'\psi'}_{\text{Convection}} = \underbrace{-K_z \frac{\partial \psi}{\partial z}}_{\text{Diffusion}} \underbrace{- F_M (\psi - \psi_p)}_{\text{Convection}}$$



Schematic representation of a convective plume in a single grid-cell

Mass-Flux Equations System

Prognostic variables : $\psi = \Theta, S$

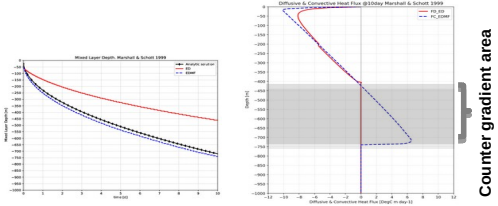
$$\begin{cases} \frac{\partial \psi_p}{\partial z} = \epsilon_t(\overline{\psi}_p - \psi_e) & \text{Entraining parcel of the plume} \\ \left(\frac{1}{2}+\alpha\right)\frac{\partial w_p^2}{\partial z} = a_1 F_b(z) - \alpha g \frac{\rho_p}{\rho_h} & \text{Vertical velocity} \\ \frac{1}{a_p}\frac{\partial a_p}{\partial z} = -\frac{1}{w_p}\frac{\partial w_p}{\partial z} + \epsilon_{ap} - \delta_{ap} & \text{Convective area} \\ F_M = -a_p\, w_p & \text{Mass Flux (MF)} \\ \frac{\partial \psi}{\partial t} = \frac{\partial F_M(\psi - \psi_p)}{\partial z} & \text{Convection Equation} \end{cases}$$

with $\epsilon_g = 0.01, a_1 = 1, \alpha = 10^{-2}, \beta_1 = \beta_2 = 0.9, C_{M0} = -0.065$

Academic Experiment : Strong Surface Buoyancy loss over a stratified Ocean

Marshall & Shott, (1999)

- 1D configuration of NEMO4
- Constant stratification
- Constant surface heat forcing
- No surface wind stress

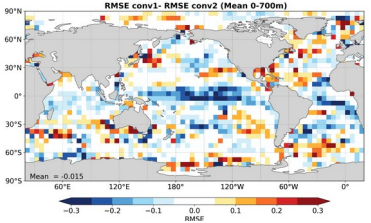


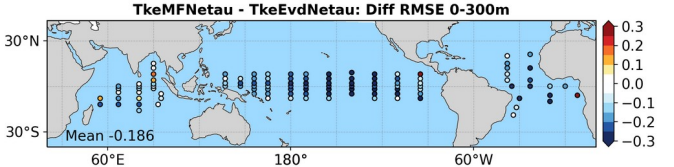
- **Diffusive fluxes vanish at the thermocline**
- **EDMF realistic because of realistic counter-gradient convective fluxes in the stratified zone**

- Two Global Experiments : **ED vs EDMF**
- NEMO3.6, iORCA025 grid, 75 lev, ERA5 forcing, IFS bulk formulation
- Simulated Period: 1993-2018

Global 1/4°: RMSE differences compare to EN4 (0-700m; over 1993-2018)

Blue = EDMF better





- Encouraging results with **EDMF**
- **EDMF** implemented in NEMO4.2
- Tune lateral entrain/detrain rates to LES. Global optimization versus reanalysis
- **EDMF** on momentum and TKE
- Sensitivity of BGC models to **EDMF**
- On-going evaluation at global scale