Work on Improvements in Ocean Mixing

Armando M. Howard

With V.M. Canuto, Y. Cheng, M. Dubovikov and A. LeBoissetier
I. Improvements in Ocean Mixing Tested in a Stand Alone Ocean now to be implemented in the Coupled Model:

- Latitude dependence of interior background vertical mixing
- Double Diffusion: Salt Fingers and Diffusive Convection in same framework
- Geographically varying enhanced deep vertical mixing due to Internal Tides [2.0 TW] - Bottom Boundary Layer
- Geographically variable enhanced lateral bottom viscosity and vertical mixing due to Tidal Drag [1.5 TW]

II. Improvements to be Tested in a Stand Alone Ocean Model before being implemented in the Coupled Model:

- Vertical mixing up to infinite Richardson number including double diffusivity effects
- Parameterization of Mesoscale Eddy vertical and horizontal heat and salt fluxes in the Mixed Layer and Interior diabatic fluxes
Tidal flow hits topography

=> internal waves

=> dissipation of the energy carried by those waves

=> mixing

[Garrett, Nature 2003]
3.5 TW Tidal Dissipation
* Warm | Salty
---|---
| S | U
Cold | Fresh

Cold | * Fresh
---|---
| U | S
Warm | Salty

SF (Med.)

DC (water/ice)

\[ R_\rho = \frac{\alpha_S \frac{\partial S}{\partial z}}{\alpha_T \frac{\partial T}{\partial z}}, \quad \gamma = \frac{\alpha_T \frac{\partial \theta}{\partial z}}{\alpha_s w_s}, \quad \Gamma_{H,S} = \frac{K_{H,S} N^2}{\varepsilon} \]

SF: \( R_\rho < 1; \quad \gamma < 1 \)

DC: \( R_\rho > 1; \quad \gamma > 1 \)
GISS Model 2002:

\[ \Gamma_H \]
GISS Model 2008:

\[ \Gamma_H \]

\[ \begin{align*}
\text{a} & \quad R_i < 0.25 \\
\text{b} & \quad R_i < 0.5 \\
\text{c} & \quad R_i < 1 \\
\text{d} & \quad R_i > 1 \\
\text{e} & \quad R_i > 2 \\
\text{f} & \quad R_i > 5
\end{align*} \]
Small scale turbulence

Mesoscale non-adiabatic

Upwelling due to mixing across 27.96 kg/m³ neutral density surface m/yr