Breaking internal waves and ocean diapycnal diffusivity: A case study based upon dynamically downscaling of high-resolution global ocean model simulations into a regional domain

Kayhan Momeni[1]

Collaborators: *William R. Peltier*[1], *Yuchen Ma*[1], *Ritabrata Thakur*[2], *Yulin Pan*[3], *Dimitris Menemenlis*[4], *Brian K. Arbic*[2], *Joseph Skitka*[2]

1- Department of Physics, University of Toronto, Toronto, Ontario, Canada
2- Department of Earth and Environmental Science, University of Michigan, Ann Arbor, Michigan
3- Department of Naval Architecture and Marine Engineering, University of Michigan, Ann Arbor, Michigan
4- Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California

SWOT 2022 Science Team Meeting
Ocean Young Researcher Lightning Talks

VELUT ÆVO ARBOR

1. **Numerical Setup**
2. Theoretical Analysis
3. Shear-induced mixing

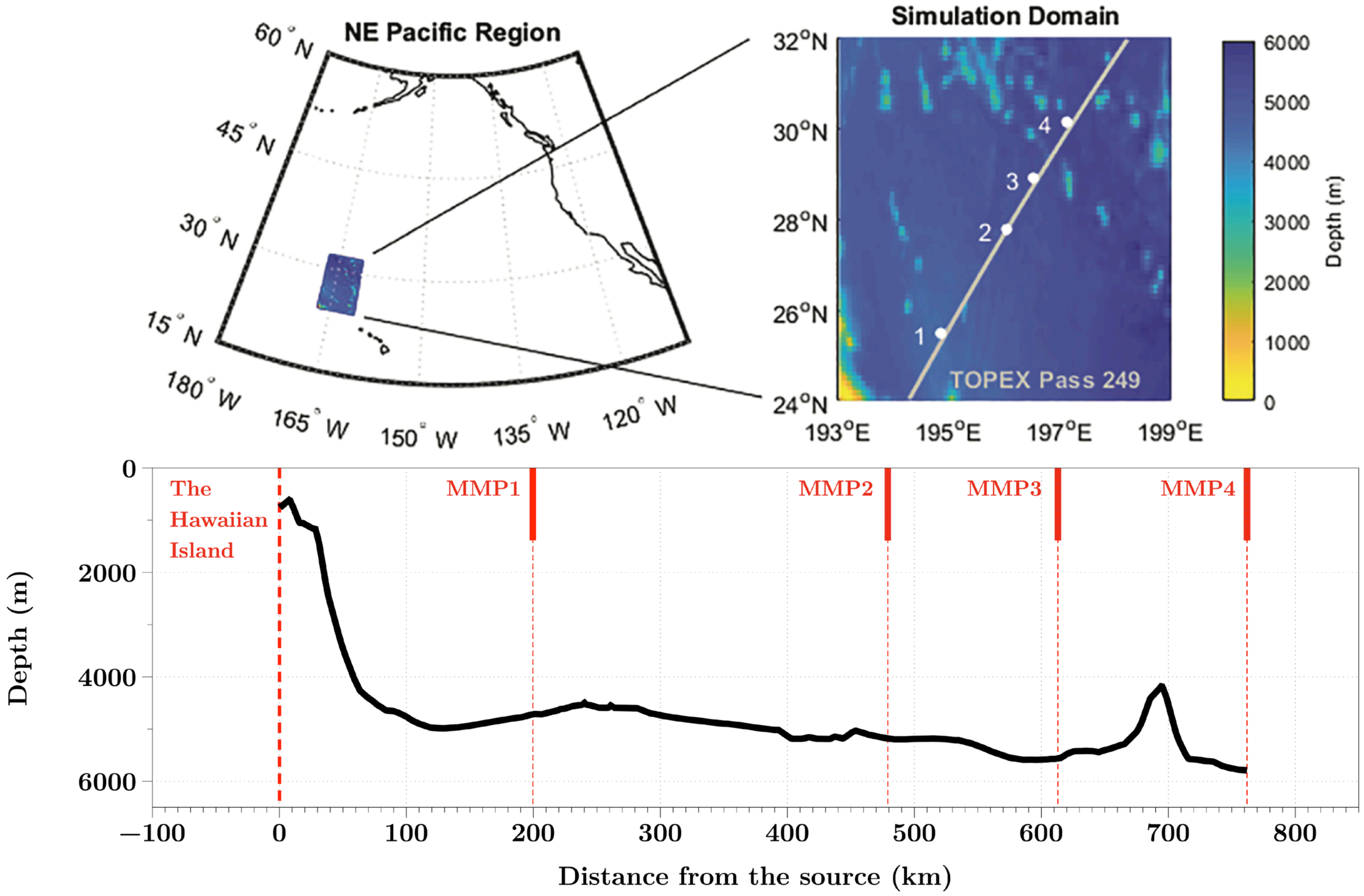


Image source (top): Nelson AD, Arbic BK, Menemenlis D, Peltier WR, Alford MH, Grisouard N, Klymak JM. Improved internal wave spectral continuum in a regional ocean model. Journal of Geophysical Research: Oceans. 2020 May;125(5):e2019JC015974.

1. **Numerical Setup**
2. Theoretical Analysis
3. Shear-induced mixing

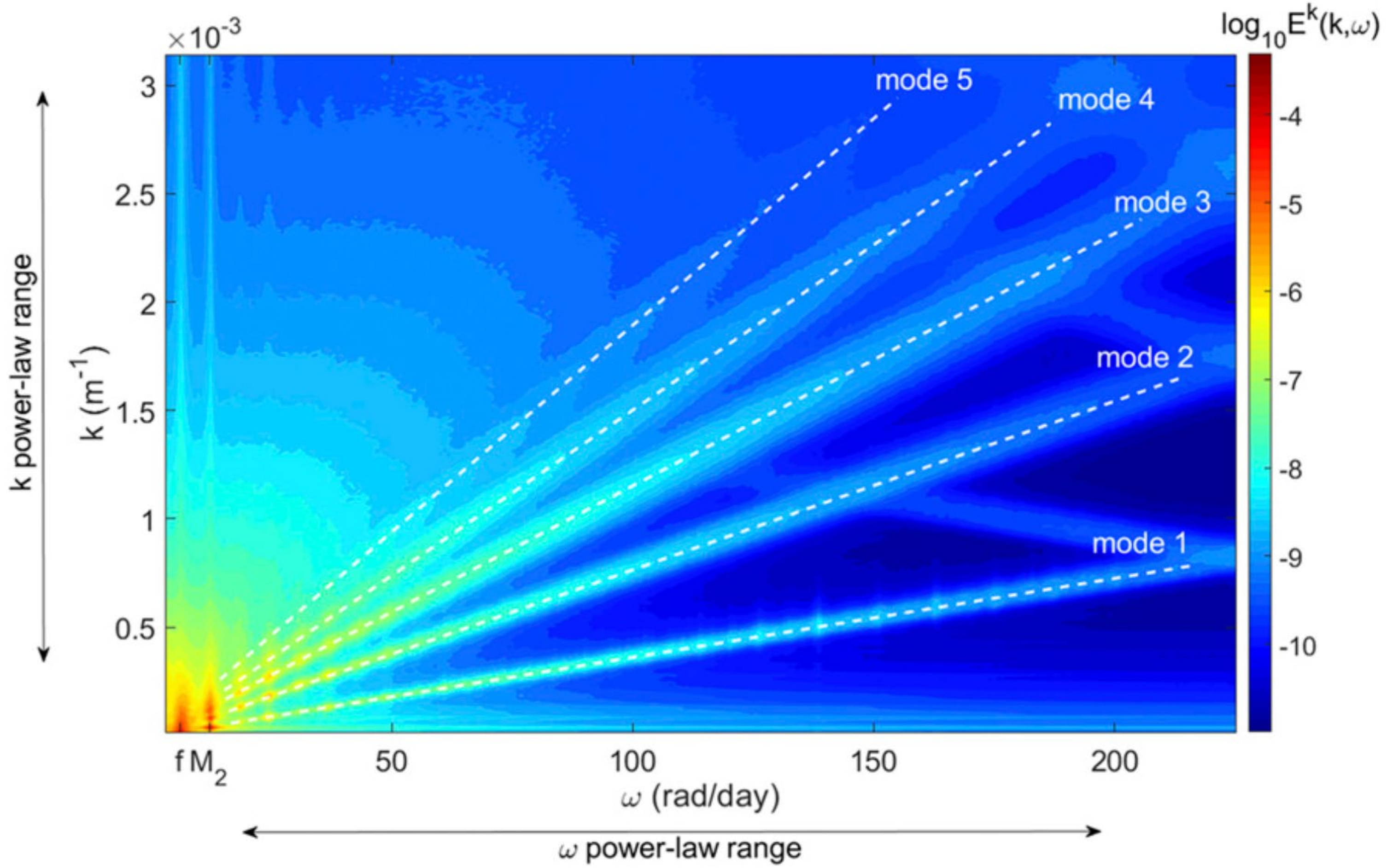


Image source: Pan Y, Arbic BK, Nelson AD, Menemenlis D, Peltier WR, Xu W, Li Y. Numerical investigation of mechanisms underlying oceanic internal gravity wave power-law spectra. Journal of Physical Oceanography. 2020 Sep 1;50(9):2713-33.

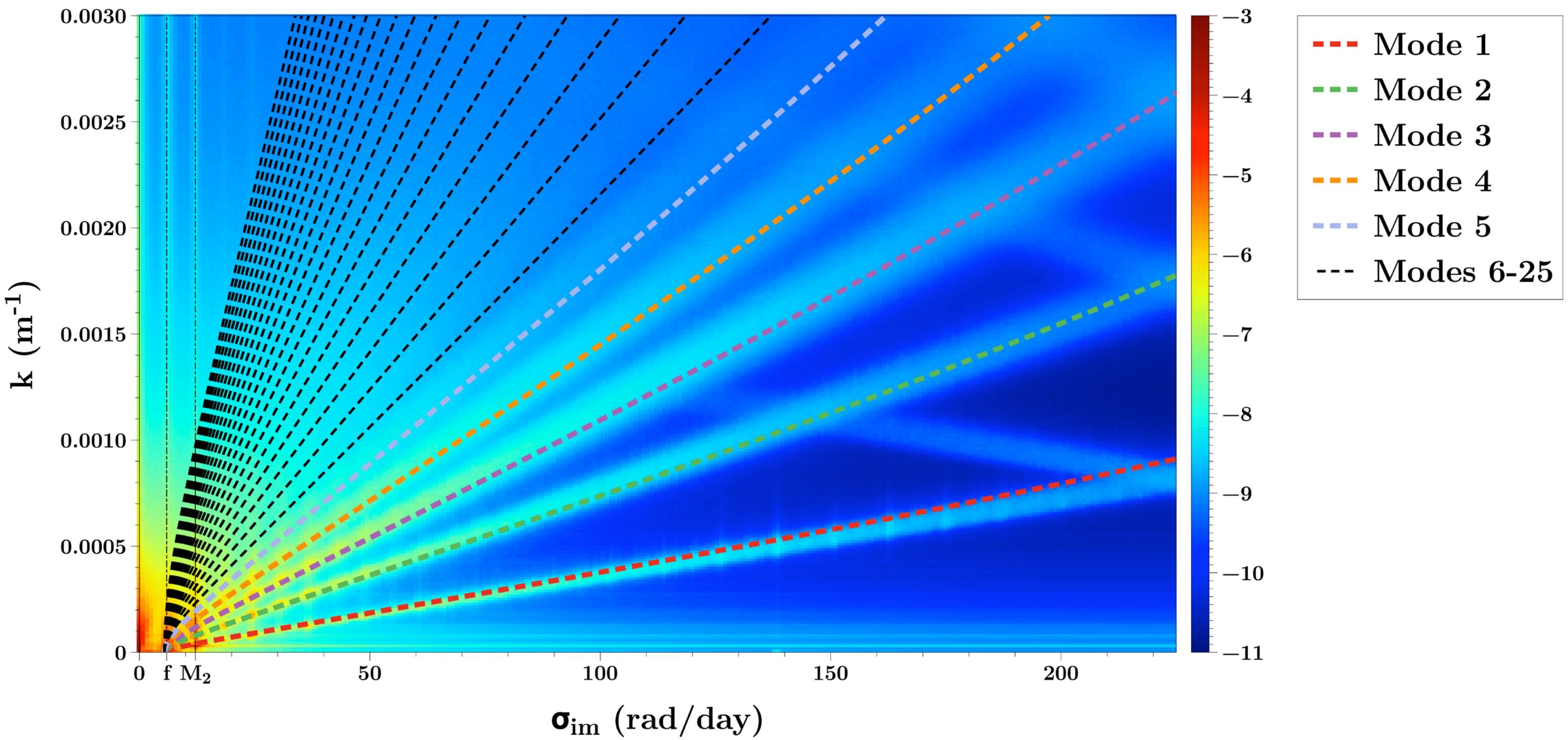
1. *Numerical Setup*
2. **Theoretical Analysis**
3. Shear-induced mixing

$$
\begin{cases}
U_x + V_y + W_z = 0 \\
U_t + UU_x + VU_y + WU_z = -\dfrac{P_x^{eff}}{\rho_0} + \nu^{eff}\nabla^2 U + \dfrac{\partial \nu^{eff}}{\partial z}(U_z + W_x) + fV \\
V_t + UV_x + VV_y + WV_z = -\dfrac{P_y^{eff}}{\rho_0} + \nu^{eff}\nabla^2 V + \dfrac{\partial \nu^{eff}}{\partial z}(V_z + W_y) - fU \\
W_t + UW_x + VW_y + WW_z = -\dfrac{P_z^{eff}}{\rho_0} + \nu^{eff}\nabla^2 W + 2\dfrac{\partial \nu^{eff}}{\partial z}W_z - g\dfrac{\rho}{\rho_0} \\
\rho_t + U\rho_x + V\rho_y + W\rho_z = \kappa^{eff}\nabla^2 \rho + \dfrac{\partial \kappa^{eff}}{\partial z}\rho_z
\end{cases}
$$

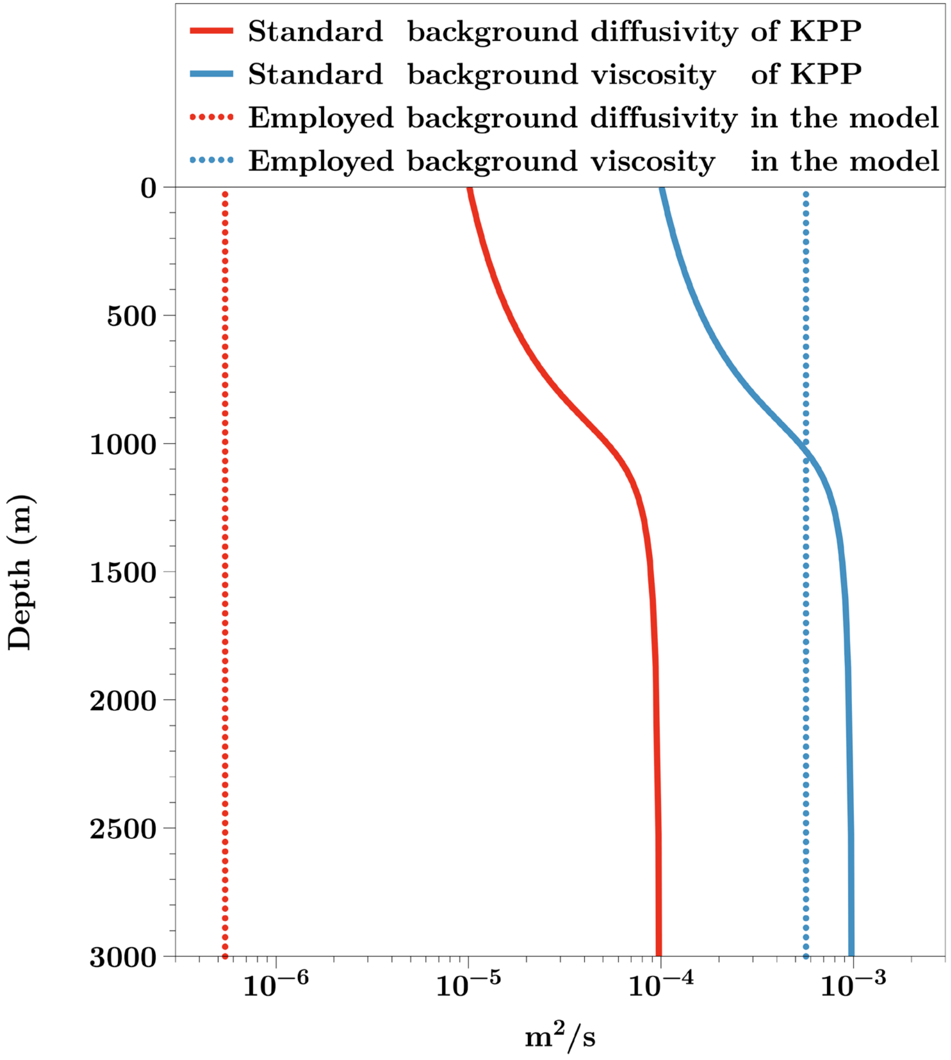
$$
\begin{cases}
\{U', V', P'\}(x,y,z,t) = \left[\displaystyle\sum_{j=1}^{J}\{U_j, V_j, P_j\}cos\left(\frac{j\pi z}{L}\right)\right]e^{\left(\sigma t - i(kx+ly)\right)}, \\
\{W', \rho'\}(x,y,z,t) = \left[\displaystyle\sum_{j=1}^{J}\{W_j, R_j\}sin\left(\frac{j\pi z}{L}\right)\right]e^{\left(\sigma t - i(kx+ly)\right)}.
\end{cases}
$$

$$
\begin{cases}
\sigma\Omega_j = -\nu_{mj}^{cc}k_m^2\Omega_m - \nu_{zmj}^{cs}\left(\dfrac{m\pi}{L}\right)\Omega_m - f\left(\dfrac{j\pi}{L}\right)W_j \\
\sigma k_j^2 W_j = \nu_{zmj}^{sc}k_m^2\left(\dfrac{m\pi}{L}\right)W_m - \nu_{mj}^{ss}k_m^2\left(\dfrac{m^2\pi^2}{L^2}\right)W_m + \nu_{zzmj}^{ss}\left(\dfrac{m^2\pi^2}{L^2}\right)W_m \\
\qquad + \nu_{zmj}^{sc}\left(\dfrac{m^3\pi^3}{L^3}\right)W_m - \nu_{zmj}^{sc}(k^2+l^2)\left(\dfrac{m\pi}{L}\right)W_m - \nu_{zzmj}^{ss}(k^2+l^2)W_m \\
\qquad - \nu_{mj}^{ss}k_m^2(k^2+l^2)W_m + 2\nu_{zmj}^{sc}(k^2+l^2)\left(\dfrac{m\pi}{L}\right)W_m - \dfrac{g}{\rho_0}(k^2+l^2)R_j \\
\qquad + f\left(\dfrac{j\pi}{L}\right) \\
\sigma R_j = -\rho_{zmj}^{ss}W_m - k_m^2\kappa_{mj}^{ss}R_m + \kappa_{zmj}^{sc}\left(\dfrac{m\pi}{L}\right)R_m
\end{cases}
$$

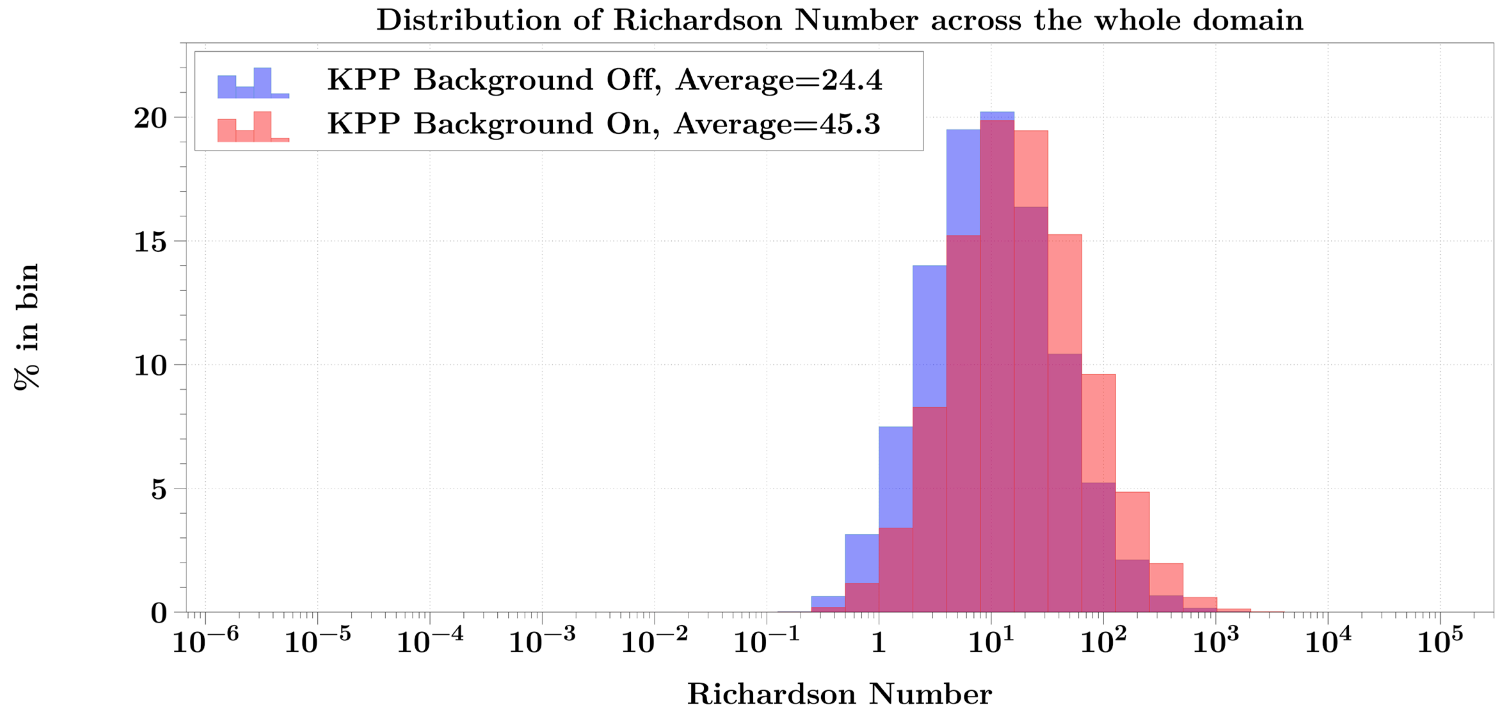
1. *Numerical Setup*
2. **Theoretical Analysis**
3. Shear-induced mixing



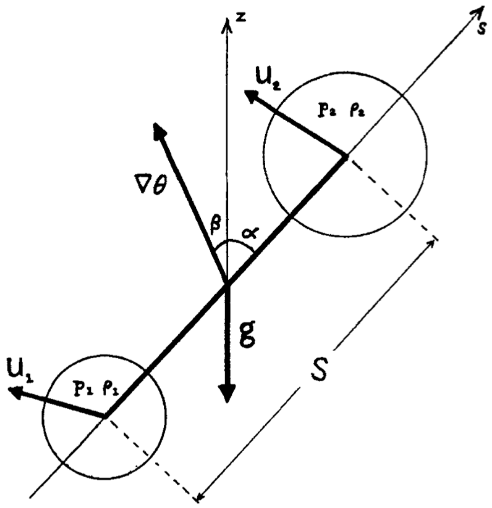
1. *Numerical Setup*
2. *Theoretical Analysis*
3. **Shear-induced mixing**

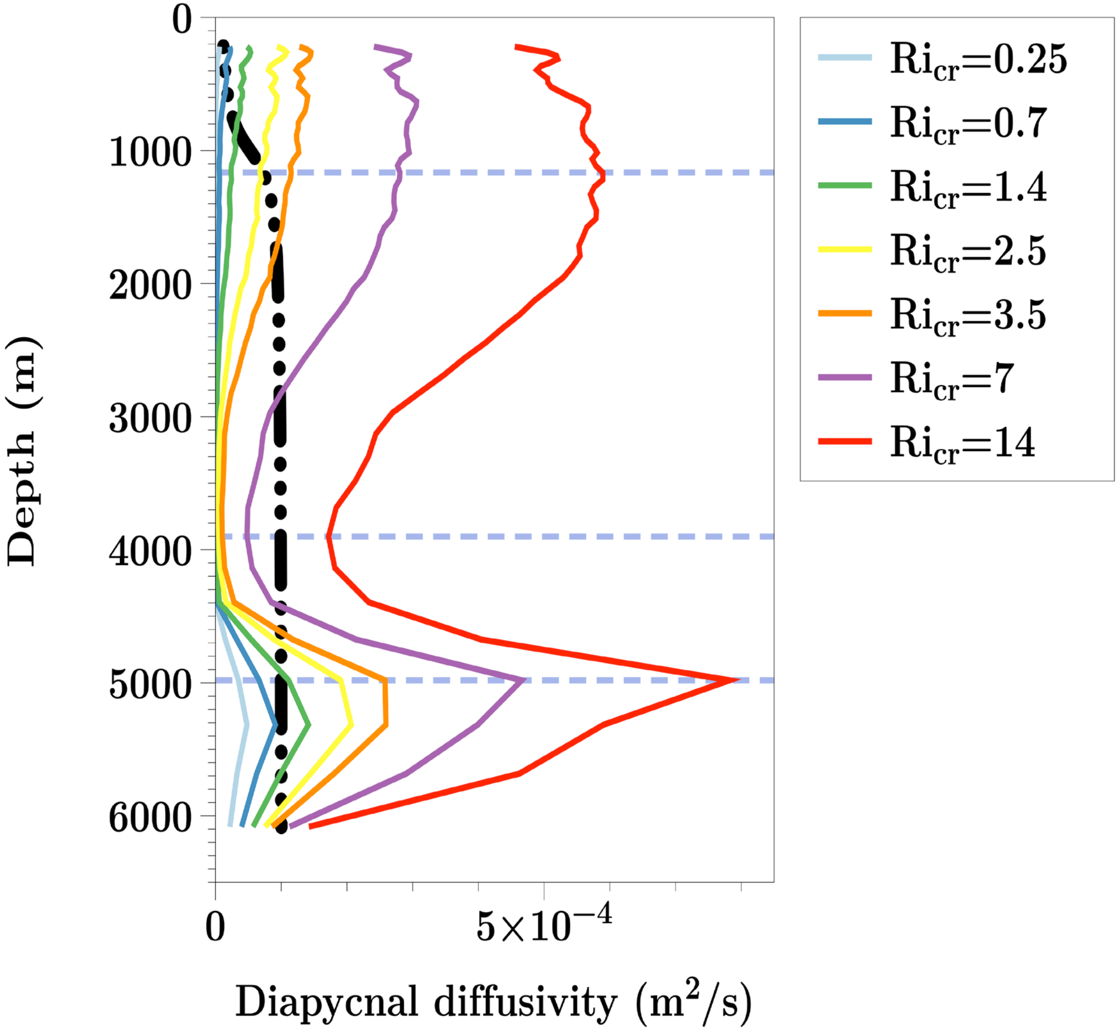


1. *Numerical Setup*
2. *Theoretical Analysis*
3. **Shear-induced mixing**



1. *Numerical Setup*
2. *Theoretical Analysis*
3. **Shear-induced mixing**





Left image source: Generalizations of the richardson criterion for the onset of atmospheric turbulence. Quarterly Journal of the Royal Meteorological Society, 97(414), 429–439.

Thanks to our sponsors!

NSERC
CRSNG

UNIVERSITY OF
TORONTO

SciNet

NASA

UNIVERSITY OF
MICHIGAN