Book: Dynamical Oceanography
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Chapter: 5, Exercise: 5.3: Ekman layer at the ocean-atmosphere interface
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Suppose we have a basin of dimensions $1000 \times 1000 \times 1$ *km at 45°N (domain* $[0,1] \times [-1,1] \times [-1,0]$*) with the flow forced by the wind stress* $\tau_*^x = \tau_0 y, \tau_*^y = 0$*; take* $\tau_0 = 10^{-1}$ *Pa and choose* $U = 10^{-2}$ ms^{-1}.

a. Write a computer program that calculates the dimensionless Ekman velocities for this wind stress field for different values of A_V*. Make a plot of the velocitities* $(\hat{u}^0, \hat{v}^0)$ *versus* $\chi \in [0,10]$ *for three different values of* $A_V = 0.1, 0.01$ *and* 0.0001 m^2s^{-1}.

The dimensionless velocities are given by

$$u_E = \frac{\alpha}{2} e^{-\chi}(-y \sin\chi + y \cos\chi)$$

$$v_E = \frac{\alpha}{2} e^{-\chi}(-y \cos\chi - y \sin\chi)$$

The factor α is given by

$$\alpha = \frac{2\tau_0}{\rho_0 f_0 \delta_E U} = \frac{2\tau_0}{\rho_0 U}\sqrt{\frac{1}{f_0 A_V}}$$

and hence it is proportional to $1/\sqrt{A_V}$. The profiles look like those in Fig. 5.9 for every y.

b. Calculate for each of the values of A_V *the dimensional Ekman transport* $\mathbf{M}_{E*}$.

For every value of A_V, the dimensional Ekman transport is given by

$$M_{E*} = \begin{pmatrix} \frac{\tau^y}{\rho_0 f_0} \\ -\frac{\tau^x}{\rho_0 f_0} \end{pmatrix}$$