Assignment 4

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1 Problem 1

In this assignment we recall the example of constant wind in the upper y-plane in x-direction on an unbounded infinitely large ocean. In the lecture we found the solutions (2.317-2.319):

$$v_n(x, y, t) \approx -\frac{\tau^x}{\rho_0} a_n \frac{\theta(t)}{2f} \Big[2\theta(y) - sig(y)e^{-|y|/R_n}\Big], \tag{1}$$

$$u_n(x, y, t) \approx \frac{\tau^x}{\rho_0} a_n \Big[\theta(t) t \frac{sig(y)e^{-|y|/R_n}}{2}\Big], \tag{2}$$

$$p_n(x, y, t) \approx \frac{\tau^x}{\rho_0} a_n \theta(t) t \frac{R_n f}{2} e^{-|y|/R_n}, \tag{3}$$

$$w_n = -\partial_t p_n, \tag{4}$$

with $R_n = \frac{1}{\lambda_n f}$ being the Rossby radius and

$$a_0 = \frac{1}{H}, \tag{5}$$

$$a_n = \frac{\sqrt{2}}{H}(-1)^n \frac{\sin\left(n\pi \frac{H_{mix}}{H}\right)}{n\pi \frac{H_{mix}}{H}}. \tag{6}$$

(a) Describe the problem and the meaning of each term from above, eq. (1)-(3).

(b) Reuse and extend the code from assignment 2 to calculate u, v, p and w by executing the summation:

$$(u, v, p) = \sum_n^N (u_n, v_n, p_n) F_n, \tag{7}$$

$$w = \sum_n^N w_n Z_n, \tag{8}$$

$$\tag{9}$$

with

$$Z_0 = -\frac{1}{g}\left(1 + \frac{z}{H}\right), \tag{10}$$

$$Z_n = -\sqrt{2}(-1)^n \frac{n\pi}{N_{BV}^2 H} \sin\left(n\pi \frac{z}{H}\right), \tag{11}$$

and plot u, v and p as a function of y and z (compare to figure 2.12 in the lecture script). Use the following numbers: $\tau^x = 1$Pa, $\rho_0 = 1000$g/kg, $H = 200$m, $N_{BV} = 10^{-2}$1/s, $f = 2\Omega\sin(\phi)$, $\phi = 54°$N, $t = 1/f$ and N = 100.

Hints: Recall that $\lambda_0 = \frac{1}{\sqrt{gH}}$ and $\lambda_n = \frac{n\pi}{HN_{BV}}$ with N_{BV}^2 the Brunt Väisälä frequency, do not confuse with the summation N! Write a function which calculates R_n. You can use `np.sign` and `np.heaviside` for computation. You can use `plt.pcolor` or `plt.contourf` for plotting, see matplotlib documentation for further information.

(c) Describe in your own words your plots from (b).