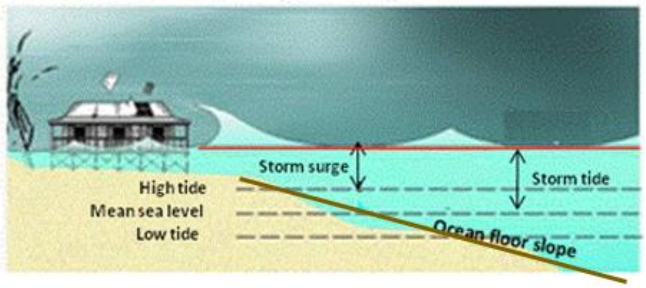
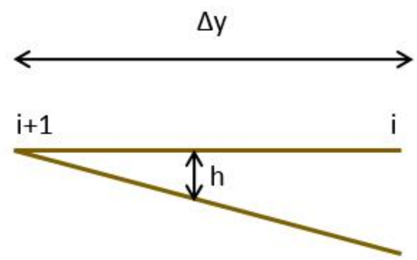
Class exercise, surge calculation using spreadsheet





All units below are metric. Assume hurricane is making landfall so that the wind is perpendicular to shoreline: Then, $|\overrightarrow{V}| = \sqrt{u^2 + v^2}$ becomes v. For easier notation, assume this is the eyewall's maximum winds, typically denoted as V_{max}

At landfall, also assume no accelerations in the zonal current ($\frac{\partial u_{water}}{\partial t} = 0$)

Assume the ocean floor has a linear slope represented as

$$h_i = h_{i+1} + m(y_i - y_{i+1})$$

If the constants are C_D=3.5X10^{-3}, g=9.8ms^{-2}, ρ_{water}=1000 kg m^{-3} , and ρ=1 kg m^{-3} , the wind setup becomes

$$\frac{\partial \eta}{\partial y} = \frac{(3.57X10^{-7})V_{max}^2}{(h + \eta)}$$

Which can be solved from south to north, approximated as:

$$\eta_{i+1} = \eta_i + \frac{\Delta y(3.57X10^{-7})V_{max}^2}{(h_{i+1} + \eta_i)}$$

Where the last i is on the coastline (surge on land).

The pressure setup at landfall location is simply:

$$\eta_{land} = \frac{(p_{env} - p_c)}{\rho_{water} g}$$

Note this is approximately 1 cm per mb pressure drop (or 4.0 inches per 10 mb drop). Make sure pressure is in Pascals (1 mb=100 Pa).

1) Vary the ocean slope *m* from 0.5 to 5.0 and wind speed V_{max} from 70 to 150 mph (cells D1 and G1). How does the wind setup change?
2) Convert wind setup (on land) to feet in cell K5. (1 meter=3.28 feet)
3) Central pressure can be roughly approximated by $p_c = p_{env} - 100(0.29V_{max})^{1.55}$ where $p_{env} = 101300$ Pa and V_{max} is in ms^{-1}. Add this equation to cell K1
4) Add pressure setup to cell E5.
5) Non spreadsheet exercise: show the pressure setup is 4 inches per 10-mb pressure drop.
6) Add the wind setup, pressure setup, and forerunner effect in cell I5 . This is the total surge (minus wave setup).
7) Convert the pressure setup, forerunner effect, and total surge to feet in cells M5, O5, and Q5.

Caveat: some solutions become nonsense due to numerical instability or a lack of grid resolution for very small or very large slopes. Numerical models contain diffusion terms and better approximations to derivatives to overcome this problem, and higher resolution also reduces these problems.