

### Problem Set 3

September 19, 2016

## Tsunami

The open ocean propagation of tsunami waves is approximated by the long-wavelength, shallow-water equation:

$$\partial_t^2 P = \nabla \cdot (v^2 \nabla P) \quad (1)$$

$$= \partial_x v^2 \partial_x P + \partial_y v^2 \partial_y P + v^2 (\partial_x^2 P + \partial_y^2 P) \quad (2)$$

where  $P = P(x, y, t)$  is the height of tsunami waves above sea level,  $v = \sqrt{gH(x, y)}$  the wave speed,  $g$  the gravity acceleration,  $H$  the ocean depth.

When the term  $v^2$  is not changing rapidly, an approximation form of the governing equation that will accurately predict the speed, dispersion and focusing of the waves is:

$$\partial_t^2 P = v^2 \nabla^2 P \quad (3)$$

Equation (3) is called 'homogeneous', since it assumes that  $v^2$  is constant, i.e., a homogeneous medium. Extra terms in equation (2) are called 'inhomogeneous'.

**Problem:**

An example code is provided to you, which can solve the homogeneous equation to 2nd-order in space and time.

- (a) modify the code to (keep 2nd-order scheme in time) make it 4th-order in space
- (b) derive formula for the inhomogeneous terms, both in 2nd-order and 4th-order

**Additional information:**

1. The C-code can be compiled with:

`cc -o class_tsunami class_tsunami.c -lm` (use 'gcc' instead of 'cc' on linux)

2. Then the code is executed by simply typing:

`./class_tsunami`

3. The output is in the file 'slice.out', which can be viewed in Matlab with the script 'class\_movie.m'