UNIVERSITY OF CALIFORNIA, DAVIS
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

COURSE: WATER RESOURCES SIMULATION (ECI 146)
CRN: 59900; 4 units

INSTRUCTOR: ***Fabián A. Bombardelli***
(fabianbombardelli2@gmail.com, bmbrdll@yahoo.com, fabombardelli@ucdavis.edu)
OFFICE: 3105, Ghausi Hall (former Engineering III building)

Class: Tuesdays and Thursdays-10:30 to 11:50 PM (Haring 1204)
Computer lab: Fridays-12:10 PM to 2:00 PM (Ghausi Hall 2030)
READER: Mr. Alex Yuen
TEACHING ASSISTANT: Mr. Kaveh Zamani (kzamani@ucdavis.edu)
http://cee.engr.ucdavis.edu/faculty/bombardelli/eci146/default_ECI_146.htm

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SPECIAL, FINAL PROJECT: Routing of a flood in a river

Due on: March 21, 2014

Note: This project is individual (although you are allowed to discuss the results with classmates)

1. Introduction

Floods are costly in property damages and, often, unfortunately, in human lives. Thus, it is necessary to develop tools to address the potential damages of a flood before it occurs.

In this project, we will assume that you have been hired by a consultant company from Davis, and that you have been assigned to determine the water depth and velocities in the Sacramento River when a flooding event occurs. Flood events with a large return period (usually 100 years) are studied. To that end, your supervisor has obtained an existing code for which you can access the source file (i.e., you can see the code lines and potentially edit the file). This code is available on the course website and was developed by Prof. Mustafa Altinakar, from the University of Mississippi, Oxford, Mississippi.

2. Analysis of the code

2.1 Numerical discretization

The code solves the Saint-Venant equations (mass and momentum equations) in the river using an explicit method, as follows:

$$y_i^{j+1} = y_i^j + \frac{\Delta t}{2\,\Delta x}\left[U_i^j\left(y_{i-1}^j - y_{i+1}^j\right) + y_i^j\left(U_{i-1}^j - U_{i+1}^j\right)\right] \quad (1)$$

$$U_i^{j+1} = \frac{1}{2}\left[-\Gamma + \left(\Gamma^2 + 4\,\Gamma\,\chi \right)^{1/2} \right] \qquad (2)$$

with $\chi = \left[U_i^j + \frac{\Delta t}{2\Delta x} U_i^j \left(U_{i-1}^j - U_{i+1}^j \right) + \frac{g\,\Delta t}{2\Delta x} \left(y_{i-1}^j - y_{i+1}^j \right) + g\,\Delta t\, J_f \right]$, and $\Gamma^{-1} = \frac{n^2\, g\, \Delta t}{\left(R_i^{j+1} \right)^{4/3}}$. The meaning of all variables can be found in the attached notes.

In order to obtain a stable solution, the Courant criterion has to be satisfied (see the chapter found in the book by Mays, uploaded in the course website).

2.2 Input variables

The code input variables are:

a) Width of the channel.
b) Lateral angles of the cross section.
c) Bottom slope of the channel.
d) Manning's n.
e) Depth of the initial uniform flow.
f) Length of the channel.

Details of the flood: The flood is assumed to be of triangular shape, and we need to specify:

g) the time to the peak;
h) the amount of the discharge at the peak; and
i) the remaining time till the end of the flood.

3. Project

The Project is composed by three parts. In the first part, you are asked to please answer some questions about the code. In the second part, you are asked to please check whether the code gives correct results. In the third part, you are asked to use the code to address the flow in another river.

3.1 Part I

1) Please present a plausible explicit scheme to solve the mass and momentum equations.
2) Discuss potential implicit schemes to solve those equations.

3.2 Part II

3) Develop the run stated in the attached pages. In order to do that, please follow exactly the set of steps explained in the pages. You will need to select a time step based on the Courant criterion, and will need to select stations where the results will be displayed. Check that the results of your run match the results found in the attached pages. (There may be differences in the third digit in the numerical result.)
4) Plot the results in terms of water levels, discharges and velocities in the three stations selected as a function of time (i.e., reproduce all plots of the attached pages).

3.3 Part III

5) Once you have checked that the numerical results are fine, please develop numerical simulations for the propagation of a flood in the Sacramento River. Please estimate the width of the Sacramento River (you can use 200 m as a start), use a slope of 0.001 and a Manning's n of 0.025. Select a flood with a peak of 2,500 m^3/s, which occurs after 18,000 seconds. Please simulate about 30 hours. Utilize a convenient time step based on what the program allows you to use.

6) Plot all results in terms of water levels, discharges and velocities in the three stations selected as a function of time, as in 4).

7) Perform other runs (three more) altering parameters of interest (for instance Manning's n, the time to the peak, etc.) and discuss your results.

Again and again, your grade will depend upon the depth of your discussion. Please ask me or the Teaching Assistant for help if you have doubts about the code.