HYDRODYNAMIC MODELING FOR EXPERIMENTAL LAGRANGIAN DRIFTER DATA

By Fernando Díaz Ledezma
Location: Stillwater, OK

Approximately 400 m long artificial canal.

The travel time down the channel was approximately 4 minutes.

The upstream boundary condition was fixed, 1.42 m$^3$/s.

Six GPS-tracking sensors.

Downstream boundary condition could be changed.
THEORETICAL BASIS
Saint – Venant Equations
(AKA the shallow waters equations)

Assumptions:

• The shallow water approximations apply → vertical accelerations are negligible and depth \( (y) \), is small compared to the wavelength so that the wave celerity is \( [gD]^{1/2} \).

• The channel bottom slope is small.

• The channel bed is stable

• The flow can be represented as one dimensional.
Saint – Venant Equations

• Continuity equation

\[ \frac{\partial y}{\partial t} + V \frac{\partial y}{\partial x} + D \frac{\partial V}{\partial x} = 0 \]

• Momentum equation

\[ \frac{\partial V}{\partial t} + V \frac{\partial V}{\partial x} + g \frac{\partial y}{\partial x} = g(S_0 - S_f) \]
Traslatory waves in channels

(a) Subcritical Flow

(b) Supercritical Flow

Raw data (the trajectories)
From 2D to 1D

• For the sake of simplicity the data is going to be analyzed as in a one dimensional case.
• Some modifications have to be done on the raw data of the drifters.
• It is necessary to translate the curved shape of the channel into a straight channel.
• Every single point in the 2D map will have its corresponding equivalent in 1D.
X–Y positions with respect to time

Determination of the initial and final x-y coordinates
Approximation of the center line of the channel

Trayectory of Drifter 1

Trayectory of Drifter 2

Trayectory of Drifter 3

Trayectory of Drifter 4

Trayectory of Drifter 5

Trayectory of Drifter 6
Is it acceptable?
1D Mapping: actual trajectory and polynomial trajectory
1D Mapping: projection on the polynomial curve
1D Mapping

- X position (length) [m]
- Y position

- Time [s]
- Velocity [m/s]

- Velocity vs Time
- Position Vs Time (channel-length based)
1D Mapping: channel-length based coordinates
1D Mapping: $x^*$ vs time

Position vs Time (channel-length based)
1D Mapping: velocity profile
The downstream end
(boundary condition)

Downstream boundary conditions were captured with an ad-hoc video system.
The stage (downstream end)

Perfectly clear, isn’t it?
Stage hydrographs for the downstream end

Height [m] (table 2-1)

Height [m] (1916)

Height [m] (tape 2-2)

Height [m] (1920)

Height [m] (1915)

Height [m] (1922)

Height [m] (tape 2-3)
MODELING
What is expected to find?

Traslatory wave

Velocity profile

What is expected to find?

I’m Batman!

Traslatory wave

Velocity profile

Points to cover in the remaining weeks

- Run a 1D model of the Saint – Venant equations considering some random initial conditions and using the boundary conditions for the upstream discharge and downstream stage.
- Compare the results of the simulation with the experimental data.
- Final analysis.
THANK YOU!
(Questions?)