GREEN-NAGHDI MODELLING OF WAVE TRANSFORMATION, BREAKING AND RUN-UP, USING A HIGH ORDER FINITE-VOLUME FINITE-DIFFERENCE SCHEME

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Fully Non-linear Boussinesq-type models are a very powerful tool to describe nearshore hydrodynamics. As they take into account both non-linear and dispersive aspects of wave propagation, they can accurately predict nonbreaking wave transformation from deep to shallow-water. However, these equations do not naturally include dissipation due to wave breaking, and then become invalid in the surf zone. Several attempts have been made to introduce wave breaking in Boussinesq models by the mean of ad hoc techniques (e.g. Kennedy et al. (2000), Cienfuegos et al. (2009)). FUNWAVE is a well-known exemple of this kind of models. It gives a good prediction of wave transformation, but each use of the model implies the prior tuning of several parameters, as the ones determining wave breaking and run-up (see Bruno et al. (2009)). On the other hand, Nonlinear Shallow-Water (NSW) models accuratly reproduce broken wave dissipation and swash oscillations without any ad hoc parametrisation (e.g. Brocchini and Dodd (2008)). However, since dispersive effects are not taken into account, these equations are restricted to the inner surf and swash zones, where nonlinearities predominate.

The model used in the present study is based on the Green-Naghdi (GN) equations, which are the basic fully nonlinear Boussinesq equations (Lannes and Bonneton (2009)). They can be written as an hyperbolic part, corresponding to the NSW equations, plus a dispersive term. We present here an hybrid finite-volume finite-difference method (Bonneton et al (2010)) which permits to naturally handle wave breaking. The model is an extension of the NSW model SURF_WB developed by Marche et al (2007). We decompose the solution operator S(T) associated to the equation at each time step dt by the following splitting scheme:

$$S(dt) = S1(dt/2)S2(dt)S1(dt/2),$$

where S1 and S2 are respectively associated to the hyperbolic and dispersive parts of the GN equations. The numerical schemes are respectively of 5th and 3rd order in space and time. The idea is to switch from one set of equations to the other, locally, by skipping the dispersive step S2(dt). To determine where to suppress the dispersive step at each time step, we use the first half-time step S1 as a predictor to assess the local energy dissipation. This dissipation is close to zero in regular wave regions, and forms a peak when shocks are appearing. We can then easily locate the eventual breaking wave fronts, and handle irregular waves breaking without any complex wave tracking. Figure 1 shows a good agreement between model predictions and laboratory data for a solitary wave breaking on a plane beach (Synolakis (1987)). It illustrates the ability of our model to reproduce shoaling, breaking and run-up as well as the breaking of the backwash bore. In this presentation, extensive 1DH validations will be shown, for both laboratory and in-situ data.

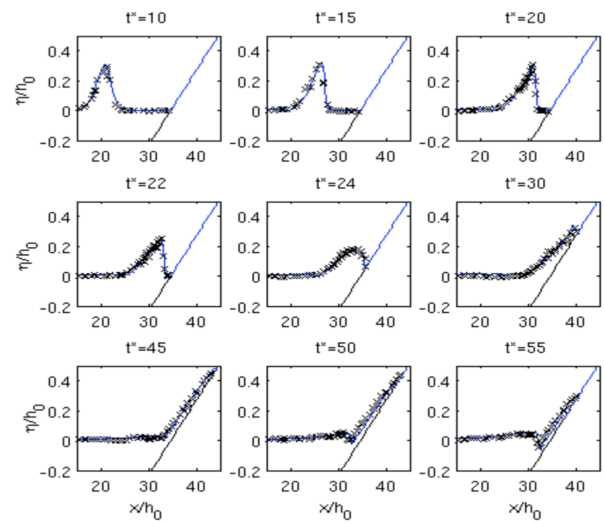

Figure 1 - Comparisons of model predictions (lines) and experimental data (+) from Synolakis (1987).

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