RANDOM WAVE BREAKING MODELS: HISTORY AND DISCUSSION

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The complexity of breaker dynamics hampers a first-principle modeling approach of this process. Instead, a class of parametric models has been developed, which represent the loss of energy of the ordered wave motion by a sink term in spectral or lumped energy balance equations.

The development of these parametric wave breaker models started exactly thirty years ago, in Hamburg(!), at the 16th ICCE (Battjes and (Hans) Janssen, 1978, BJ1978 hereafter). Over the intervening three decades, the BJ1978 model has seen various modifications and revisions, the latest by (Tim) Janssen and Battjes (2007). In this contribution we present some historical notes concerning the development of BJ1978, and we discuss the background and implications of modifications proposed by various authors, so completing the thirty-year development from BJ1978 in Hamburg, via numerous authors including Janssen and Battjes (2007) to the present paper, Battjes and Janssen, 2008 (BJ2008), again in Hamburg at the ICCE.

The BJ1978 model rests on two basic, simple elements: a bore-type expression for the energy dissipation in an individual wave breaking in shallow water, and an idealized probability distribution of the heights of the breaking waves. Combining these two allows the calculation of the expected rate of energy dissipation due to depth-induced breaking in the random wave train from deep water to the shore.

Battjes and Stive (1985) presented an extensive validation of BJ1978 against lab and field data, and proposed an explicit parameterization of the ratio of the limiting wave height to the depth.

The simplicity of the BJ1978 model contrasts with the complexity of the underlying physics. Yet it has been found to be a very robust model that yields realistic estimates of the decay due to breaking in shoaling waves, with relative errors in rms or significant wave heights of the order of 10%. Although several refinements have been made to the original model through the years (Thornton and Guza, 1983; Lipmann et al., 1996; Baldock et al., 1998; Janssen, 2006; Janssen and Battjes, 2007; Alsina and Baldock, 2007), the predictive capability of the revised models is quite similar to that of BJ1978 for most conditions. In the Conference presentation and in the full paper we will describe these modifications and revisions in a systematic manner and discuss their implications for model behavior.

One element in these modifications stands out in the sense that it does in fact alter the model's unrealistic solution behavior near the waterline, an issue that has only recently been resolved in a satisfactory manner.

In BJ1978, the rate of shoaling surpasses that of the dissipation as the waterline is approached, so that the solution becomes singular at the shoreline, as in the classical WKB theory. To remedy this, BJ1978 introduced a cut-off of the wave height with an upper limit to the rms wave height as a fraction of the local mean depth, so that the wave height remains well behaved. The cross-shore range in which this occurs is almost negligible on gentle slopes but it can reach a substantial fraction of the breaker zone on steep slopes. In any case, the cut-off is only a means to an end, rather than a formulation resting on basic physics and as such is an aspect to be improved.

The modification by Thornton and Guza (1983) does not suffer from a shoreline singularity. It behaves uniformly all the way to the mean waterline. However, in the very nearshore on steep beaches, the fraction of breaking waves per wave height class exceeds unity (Janssen and Battjes, 2007), which is physically unrealizable.

Baldock et al. (1998) used another model adaptation, specifically aimed at removing the unwanted nearshore model behavior of BJ1978. However, as pointed out by Janssen (2006), their model too is internally inconsistent because the approximation that the breaking wave heights are of the order of the depth is incompatible with the assumed unlimited range of possible breaking wave heights, which is implied by the use of a Rayleigh distribution without cut-off, causing the model solution to diverge as the waterline is approached.

In order to remove the inconsistency noted above, Janssen (2006; see also Janssen and Battjes, 2007, and Alsina and Baldock, 2007) abandoned the approximation that the wave heights should be of the order of the water depth, while using the same probability model as Baldock et al. (1998). This adaptation removed the nearshore singularity, yielding a physically based solution that is internally consistent and uniformly valid from deep water to the waterline, thereby resolving this issue in a satisfactory manner.

Perhaps this latest revision is also the last, closing the progression of models for prediction of the bulk rate of energy dissipation in breaking random waves based on BJ1978. In the paper we will present an outlook on ongoing and future developments that may contribute to improving the skill of operational wave models in dissipative surf zones.