Geophysical Research Abstracts
Vol. 12, EGU2010-3484, 2010
EGU General Assembly 2010

Numerical simulations of rogue waves in the presence of wind

Pauline ROBIN (1,2), Olivier KIMMOUN (1,2), Christian KHARIF (1,2)
(1) IRPHE, Technopôle de Château-Gombert, 13384 Marseille Cedex 13, France , (2) Ecole Centrale Marseille, 13451 Marseille cedex 20, France

, Freak wave formation due to the dispersive focusing mechanism is investigated numerically without wind and in the presence of wind. Here we use a Boussinesq-type model based on the method developed by Bingham *et al* [1]. This model deals with the fully nonlinear equations and can consider water waves propagation on a variable sea bottom from deep water to shallow water.
We introduce in this Boussinesq-type model a forcing term due to wind effect: the modified Jeffreys' sheltering mechanism. The numerical results are then compared with experiments in deep water.

We consider the flow of an incompressible inviscid fluid on a free surface to refer by a cartesian coordinate system. The horizontal axes x and y are located on the still-water plane and the z axis pointing vertically upwards. The fluid domain is bounded by the sea bed at $z = -h(x, y)$ and the free surface at $z = \eta(x, y, t)$. According to the hypothesis of irrotational flow, we can introduce the velocity potential ϕ: $u = \nabla\phi$ where u is the velocity and $\nabla = [\frac{\partial}{\partial x}, \frac{\partial}{\partial y}]$ is the horizontal gradient operator.
The Boussinesq hypothesis assumes that the velocity potential have a vertical variation in the form of polynomial. The free surface boundary conditions are written in terms of the velocity potential $\tilde{\phi} = (\phi)_{z=\eta}$ and the vertical velocity $\tilde{w} = (\phi_z)_{z=\eta}$ defined directly on free surface. The dynamics and kinematics conditions on the free surface are written allowing to advance in time

$$\eta_t + \nabla\eta.\nabla\tilde{\phi} - \tilde{w}(1 + \nabla\eta.\nabla\eta) = 0$$

$$\tilde{\phi}_t + g\eta + \frac{1}{2}\left(\nabla\tilde{\phi}\right)^2 - \frac{1}{2}\tilde{w}^2(1 + \nabla\eta.\nabla\eta) = 0$$

where g the gravitational acceleration.

The numerical integration is computed with a classical fourth-order runge-Kutta scheme.

The problem of modelling the interaction of wind and sea waves has been widely studied. Many papers have been written about the rogue phenomenon. We present briefly the modified Jeffreys' sheltering mechanism used by Touboul *et al* [2] and Kharif *et al* [3]. This mechanism, first introduced by Jeffreys (1925) [4], is based on the difference of pressure between the leeward and the windward faces of the waves induced by air flow separation over waves crest. Following Touboul *et al* [2], a critical value of the local slope η_{x_c}, above which an energy transfer from wind to the waves occurs is introduced. For each wave, the maximal local slope is computed and the pressure distribution on the surface of the wave is given by

$$p(x) = \begin{cases} 0 & if \quad \eta_{xmax} < \eta_{xc} \\ \rho_a s(U - c_\varphi)^2 \frac{\partial\eta}{\partial x}(x) & if \quad \eta_{xmax} \geq \eta_{xc} \end{cases}$$

where s is the Jeffreys' sheltering coefficient, ρ_a is the atmospheric density, U is the mean wind velocity, c_φ is the wave phase velocity. Wind effect is introduced in the dynamic boundary condition as the pressure term $p(x)$.
We have compared the present numerical results with experimental study developed by Kharif *et al* [3], in the large air/sea facility of IRPHE at Marseille Luminy.
Freak waves are generated by means of spatio-temporal focusing mechanism based upon the dispersive behaviour

of water waves. A linear approach of the problem was considered to calculate the variable frequency $\omega(x,t)$ imposed to the paddle for focusing all the waves in one point.
To examine how the wave elevation changes along the direction of the wave propagation, we compute the amplification factor A, defined as

$$A(x,U) = \frac{H_{max}(x,t)}{H_{ref}}$$

where $H_{max}(x,t)$ is the maximal height between two consecutive crest and through at different fetch x for a fixed wind speed and H_{ref} is the initial wave height.

Our numerical results are in good agreement with experimental results of Kharif *et al* [3] in deep water. We have shown the ability of the Bingham *et al* model to describe correctly the formation of extreme wave events. This Boussinesq model is really interesting because it will be possible to study freak wave occurrence in the presence of variable bathymetries.

References

[1] Bingham, H.B., Madsen, P.A Fuhrman, D.R., 2009. Velocity potential formulations of highly accurate Boussinesq-type models. Coastal Engineering, 56, 467-478
[2] Touboul, J., Giovanangeli, J.P., Kharif C. Pelinovsky E., 2006. Freak waves under the action of wind: experiments and simulations. Eur. J. Mech. B/Fluids, 25, 662-676
[3] Kharif, C., Giovanangeli, J.P., Touboul J., Grare L. Pelinovsky E., 2008. Influence of wind on extreme wave events: experimental and numerical approaches. J. Fluid Mech., 594, 209-247
[4] Jefferys H., 1925. On the formation of waves by wind. Proc. R. Soc. Lond., A 107, 189-206