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INSTITUTO DE HIDRÁULICA AMBIENTAL

Oluca

REFERENCE MANUAL
OLUCA 2.5 - ENGLISH

FUNDACION INSTITUTO DE HIDRÁULICA AMBIENTAL DE CANTABRIA
UC UNIVERSIDAD DE CANTABRIA

WHAT IS Oluca-MC?

Oluca-MC, version 2.0, is a numerical wave model for monochromatic waves. Oluca-MC is a modified version of the model REF/DIF1 that was designed in the Center for Applied Coastal Research, Department of Civil Engineering, Newark, Delaware (USA), developed by James T. Kirby y Robert A. Dalrymple. The Ocean & Coastal Research Group of the University of Cantabria modified this model to use it in engineering real projects.

Oluca-MC has been included within the MOPLA model "Modelo Integral de Propagación de Oleaje, Corrientes y Morfodinámica en Playas".

For more details, please refer to the Spanish version of the Mopla and Oluca reference manuals.

DESCRIPTION OF THE PROBLEM

By applying the mild-slope equation to a large area in the coastal zone, one encounters the difficulty of specifying boundary conditions along the shoreline, which are essential for solving the elliptic-type mild-slope equation. The difficulty arises because the location of the breaking points cannot be determined a priori. To get over this problem, the **parabolic approximation** of the mild-slope equation (Kirby and Dalrymple 1983; Tsay and Liu 1982) can be used. For mainly forward propagation problems, the so-called parabolic approximation expands the validity of the ray theory by allowing the wave energy to "diffuse" across the wave "ray". Therefore the effects of diffraction have been approximately included in the parabolic approximation. For instance, in the mild-slope equation the free surface displacement η can be approximated as a wave propagating in the x-direction with an amplitude that varies in the two horizontal directions (Liu & Lodada, 93).

Modelling wave-current interaction

By using a Lagrangian approach, Booij (1981) developed a version of the mild-slope equation that includes current effects. A weak current hypothesis has been made and any product between currents velocities was despised. Kirby (1984) improved his model by considering the Booij (1981) work. The nonlinear term was added by Kirby and Dalrymple (1983b). In this paper, they present the modification of the waves by a jet stream. The mild-slope equation with the parabolic approximation is:

$$(c_g+U)\frac{\partial A}{\partial x}+V\frac{\partial A}{\partial y}+i(k_0-k)(c_g+U)A+\frac{\sigma}{2}\left[\frac{\partial}{\partial x}\left(\frac{c_g+U}{\sigma}\right)+\frac{\partial}{\partial y}\left(\frac{V}{\sigma}\right)\right]A-$$

$$-\frac{i}{2}\frac{\partial}{\partial y}\left[(cc_g-V^2)\frac{\partial}{\partial y}\left(\frac{A}{\sigma}\right)\right]+\frac{i}{2}\left\{\frac{\partial}{\partial x}\left[UV\frac{\partial}{\partial y}\left(\frac{A}{\sigma}\right)\right]+\frac{\partial}{\partial y}\left[UV\frac{\partial}{\partial x}\left(\frac{A}{\sigma}\right)\right]\right\}+$$

$$+\frac{1}{4k}\left\{\frac{\partial}{\partial x}\frac{\partial}{\partial y}\left[\left(cc_g-V^2\right)\frac{\partial}{\partial y}\left(\frac{A}{\sigma}\right)\right]+2i\frac{\partial}{\partial x}\left[\sigma V\frac{\partial}{\partial y}\left(\frac{A}{\sigma}\right)\right]\right\}-$$

$$-\frac{\beta}{4}\left\{2i\omega U\frac{\partial}{\partial x}\left(\frac{A}{\sigma}\right)+2i\sigma V\frac{\partial}{\partial y}\left(\frac{A}{\sigma}\right)-2UV\frac{\partial}{\partial y}\frac{\partial}{\partial x}\left(\frac{A}{\sigma}\right)\right\}-$$

$$-\frac{\beta}{4}\frac{\partial}{\partial y}\left[\left(cc_g-V^2\right)\frac{\partial}{\partial y}\left(\frac{A}{\sigma}\right)\right]+\frac{i}{4k}\left[\frac{\partial}{\partial y}(\omega V)+3\frac{\partial}{\partial x}(\omega U)\right]\frac{\partial}{\partial x}\left(\frac{A}{\sigma}\right)+$$

$$+\frac{\gamma A}{2}+\frac{i\sigma}{2}G(|A|,kh)A=0$$

where:

$$\beta=\frac{1}{k^2}\frac{\partial k}{\partial x}+\frac{1}{2k^2(cc_g-U^2)}\frac{\partial}{\partial x}\left[k\left(cc_g-U^2\right)\right]$$

This equation is solved in Oluca-MC model. For more details and mathematical derivations please read Kirby and Dalrymple (1985) and Kirby (1986a).

The function $G(|A|,kh)$ in the non-linear term is:

$$G(|A|,kh)=\begin{cases} 0 & \text{lineal theory} \\ k^2 D |A|^2 & \text{Stokes theory} \\ (1+f_1 K^2 |A|^2 D)\dfrac{\tanh(kh+f_2 k|A|)}{\tanh(kh)} - 1 & \text{combinded model} \end{cases}$$

with:

$$D=\frac{\cos h(4kh)+8-2\tan h^2(kh)}{8\sin h^4(kh)}$$

$$f_1(kh)=\tan h^5(kh)$$

$$f_2(kh)=\left[\frac{kh}{\sin h(kh)}\right]^4$$

The disipation term γ of the wave energy is:

$$\gamma = \begin{cases} \dfrac{2\sigma k \sqrt{\dfrac{\nu}{2\sigma}}(1+\cosh^2(kh))}{\sin h(2kh)}(1-i) & \text{para capa límite laminar} \\ \dfrac{2\sigma fk|A|}{3\pi \sinh(2kh)\sinh(kh)}(1-i) & \text{para capa límite turbulenta en el fondo} \\ \dfrac{gkC_p}{\cos h^2(kh)}(1-i) & \text{para fondo poroso} \\ \dfrac{Kc_g}{h}\left(1-\left(\dfrac{\Gamma h}{2|A|}\right)^2\right) & \text{para rotura} \end{cases}$$

with:

ν = $1.3 \cdot 10^{-6} \dfrac{m^2}{s}$ cinematic viscosity.

f = $4 f_\omega$ wave friction coefficients

f_ω = 0.01 Darcy-Weisbach coefficients

C_p = $4.5 \cdot 10^{-11}$ m^2 permeability coefficients

K = 0.15 parameter in the dissipation model

Γ = 0.40 parameter in the dissipation model

The variables in the equation are:

- $A = A(x, y)$, wave amplitude
- $h = h(x, y)$, depth

$\vec{U} = (U,V)$, current velocity

- T, wave period
- ω, absolute angular frequency
- σ, intrinsic angular frequency
- c, wave celerity
- c_g, wave group celerity
- k, local wave number
- k_0, mean wave number in y

Some relations between the variables:

$$\sigma = \sqrt{gk \tan h(kh)}$$

$$\sigma = \omega - kU$$

$$c = \frac{\sigma}{k}$$

$$c_g = \frac{\partial\sigma}{\partial k}$$

$$\omega = \frac{2\pi}{T}$$

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