Copla

REFERENCE MANUAL
COPLA 2.5 - ENGLISH

WHAT IS Copla-MC AND Copla-SP?

Copla-MC and Copla-SP solve the depth-average mean flow equation due to breaking waves from results of OLUCA-MC and OLUCA-SP models, respectively.

The routines of Copla-MC and Copla-SP models are integrated within the MOPLA model "Modelo Integral de Propagación de Oleaje, Corrientes y Morfodinámica en Playas". Thus, those numerical models are including into a real engineering project .

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

DESCRIPTION OF THE PROBLEM

The bottom configuration of natural beaches is in general complex, consisting of three-dimensional bars and troughs. Therefore, waves in the nearshore area propagate in a complicated way, and the nearshore current pattern is also complex. Nearshore currents seem to be influenced significantly by incident wave conditions as well as the bottom topography.

Numerical models of nearshore currents have been developed by Noda (1974), Birkemeier and Dalrympley (1975), Liu and Mei (1976), Ebersole and Dalremple (1980), Nishimura (1982), and Watanabe and Maruyama (1984), among others. In order to predict accurately the nearshore currents flowing over such a complicated bottom configuration, the characteristics of the waves must be accurately approximated. In the calculation of nearshore waves, we must account for the effects of shoaling, refraction, diffraction and breaking. The numerical models for the wave transformation including all these effects are OLUCA-MC and OLUCA-SP.

The current alters the wave field and, consequently, the current field itself, iterative computations are required to take into account this wave-current interactio. Moreover, if the sediment transport and the resulting bathymetric changes are considered, the bottom change will influence both waves and current, requiring an additional computational loop. (Horikawa, 88).

NEARSHORE CURRENT MODEL

The two-dimensional model of nearshore currents is computed with Navier-Stokes equation. This equations are depth-integrated and time-averaged within a reference system placed in the still water depth (x = cross-shore direction; y = longshore direction; z = vertical direction). The equations are:

Continuity:

$$\frac{\partial \eta}{\partial t}+\frac{\partial (UH)}{\partial x}+\frac{\partial (VH)}{\partial y}=0 \qquad (1)$$

Momentum:

Cross-shore direction (x)

$$\frac{\partial U}{\partial t}+U\frac{\partial U}{\partial x}+V\frac{\partial U}{\partial y}+g\frac{\partial \eta}{\partial x}+\frac{1}{\rho H}\frac{\partial}{\partial x}(S_{xx})+ \frac{1}{\rho H}\frac{\partial}{\partial y}(S_{xy})+\frac{gU}{C^2 H}(U^2+V^2)^{1/2}-\varepsilon\left[\left(\frac{\partial^2 U}{\partial x^2}\right)+\left(\frac{\partial^2 U}{\partial y^2}\right)\right]=0 \qquad (2)$$

Longshore-shore direction (x)

$$\frac{\partial V}{\partial t}+U\frac{\partial V}{\partial x}+V\frac{\partial V}{\partial y}+g\frac{\partial \eta}{\partial y}+\frac{1}{\rho H}\frac{\partial}{\partial x}(S_{xy})+ \frac{1}{\rho H}\frac{\partial}{\partial y}(S_{yy})+\frac{gV}{C^2 H}(U^2+V^2)^{1/2}-\varepsilon\left[\left(\frac{\partial^2 V}{\partial x^2}\right)+\left(\frac{\partial^2 V}{\partial y^2}\right)\right]=0 \qquad (3)$$

with,

$$H = \eta + h \tag{4}$$

$$S_{xx} = \frac{1}{T} \int_{t}^{t+T} \int_{-h}^{\eta} (\rho u^2 + p)\, dz\, dt - \frac{1}{T} \int_{t}^{t+T} \int_{-h}^{0} p_0\, dz\, dt \tag{5}$$

$$S_{yy} = \frac{1}{T} \int_{t}^{t+T} \int_{-h}^{\eta} (\rho v^2 + p)\, dz\, dt - \frac{1}{T} \int_{t}^{t+T} \int_{-h}^{0} p_0\, dz\, dt \tag{6}$$

$$S_{xy} = \frac{1}{T} \int_{t}^{t+T} \int_{-h}^{\eta} \rho uv\, dz\, dt \tag{8}$$

$$V = \frac{1}{T} \int_{t}^{t+T} \int_{-h}^{\eta} v(x, y, z, t)\, dzdt \tag{7}$$

$$\eta = \frac{1}{T} \int_{t}^{t+T} \eta(x, y, t')\, dt' \tag{9}$$

$$U = \frac{1}{T} \int_{t}^{t+T} \int_{-h}^{\eta} u(x, y, z, t)\, dzdt \tag{10}$$

Radiation stress terms (COPLA-MC)

$$S_{xx}(x,y) = E\left(n\cos^2\theta + n - \frac{1}{2}\right) \tag{11}$$

$$S_{yy}(x,y) = E\left(n\,sen^2\theta + n - \frac{1}{2}\right) \tag{12}$$

$$S_{xy}(x,y) = E\,sen\theta\cos\theta \tag{13}$$

where:

$$E = \frac{\rho g H_1^2}{8} \tag{14}$$

$$n = \frac{1}{2}\left[1 + \frac{2kh}{senh\,2kh}\right] \tag{15}$$

$$k = \frac{2\pi}{L} \tag{16}$$

Radiation stress terms (COPLA-SP)

$$S_{xx}(x,y)=\frac{1}{2}\rho g\sum_{j=1}^{N_f}\sum_{l=1}^{N_\theta}\left|A_{jl}\right|^2\left[n_j(1+\cos^2\theta_{jl})-\frac{1}{2}\right] \qquad (11a)$$

$$S_{yy}(x,y)=\frac{1}{2}\rho g\sum_{j=1}^{N_f}\sum_{l=1}^{N_\theta}\left|A_{jl}\right|^2\left[n_j\left(1+sen^2\theta_{jl}\right)-\frac{1}{2}\right] \qquad (12\ a)$$

$$S_{xy}(x,y)=\frac{1}{4}\rho g\sum_{j=1}^{N_f}\sum_{l=1}^{N_\theta}\left|A_{jl}\right|^2 n_j\,\mathrm{sen}(2\theta_{jl}) \qquad (13\ a)$$

$$n_j=\frac{1}{2}\left(1+\frac{2K_jh}{senh(2k_jh)}\right) \qquad (15\ a)$$

The variable of the problem, η, U, V are the surface elevation and current velocities averaged in depth.

The others variables are:

$A_{jl}(x, y)$	=	wave amplitude for a frequency component *j* and directional component *l*, in irregular waves
h	=	depth up to still water level
H	=	whole depth
j	=	frequency component for irregular waves
l	=	frequency component for irregular waves
n	=	relation between group velocity c_g and phase velocity c
n_j	=	relation between group velocity c_{gj} and phase velocity c_j from frequency component
t	=	time
T	=	wave period
S_{xx}	=	radiation stress on xx direction
S_{xy}	=	radiation stress on xy direction
S_{yy}	=	radiation stress on yy direction
$\eta(x,y,t)$	=	surface elevation from still water level
u	=	instantaneous velocity in x direction
v	=	instantaneous velocity in y direction
E	=	wave energy (monochromatic)
k	=	wave number
k_i	=	wave number for a frequency component
θ	=	wave number angle respect to x axis
θ_{jl}	=	wave number angle respect to x axis for a frequency component *j* and directional component *l*
c	=	Chezy coefficient
ε	=	Eddy viscosity
P	=	total pressure (dynamic and static)
P_0	=	static pressure from still water level
H_1	=	wave height
g	=	gravity
ρ	=	density

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