a031curnt[001-004]: Following, Opposing and Slanting current

Purpose

The purpose of these tests is to validate wave propagation in the presence of currents (current-induced refraction and shoaling).

Situation

A deep water region of constant depth, 4000 m long and infinitely wide is considered (essentially a one-dimensional situation; Figure 1). For all cases monochromatic, uni-directional waves propagate in positive x-direction. The up-wave boundary is at x = 0. The incident wave height H_i and period T_i are 1 m and 10 s respectively.

For cases a031curnt001 and a031curnt002 the wave direction is parallel to the x-axis. For case a031curnt001 the current direction is in positive x-direction. The current velocity increases linearly from 0 to 2m/s (as in Figure 11, following current and Figure 2, opposing current). For case a031curnt002 the current direction is in negative x-direction (opposing current) and increases linearly from 0 to -2 m/s in positive x-direction.

For case a031curnt003 the wave direction at the up-wave boundary is 120^0. For a031curnt004 the wave direction at the up-wave boundary is 60^0. For these cases the current is parallel to the x-axis and in positive x-direction (as in Figure 1). The current velocity increases linearly from 0 to 2 m/s in positive x-direction.

For all four cases wind is absent. The water is infinitely deep.

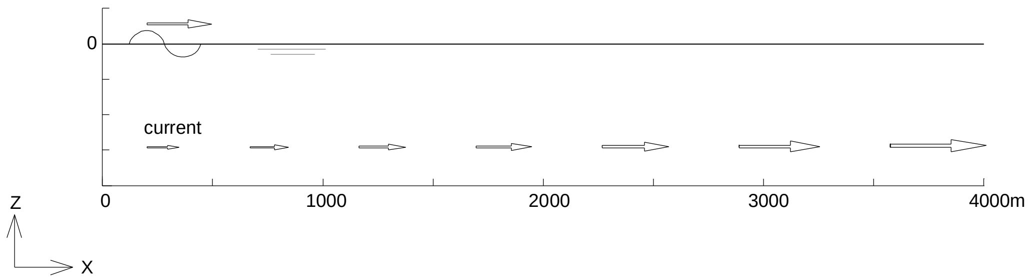

Figure 1 Following current condition

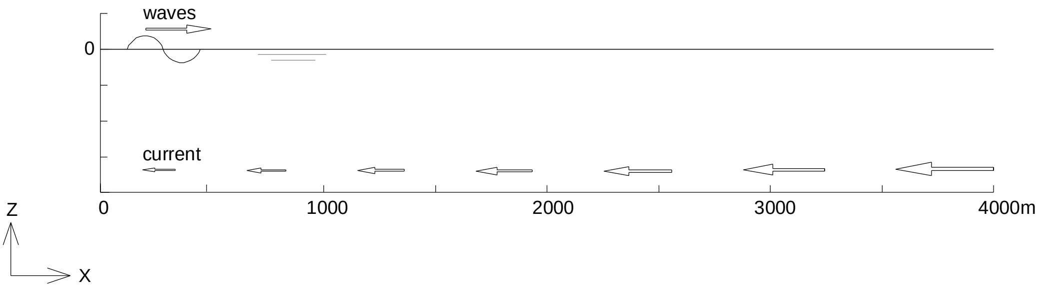

Figure 2 Opposing current condition

Comparison

Model results for the following current and the opposing current cases are compared with an analytical solution. The analytical solution is calculated with (Phillips, 1977; Jonsson, 1993):

$$\frac{H^2}{H_i^2} = \frac{c_i^2}{c(c+2U)} \qquad \text{where} \qquad \frac{c}{c_i} = \frac{1}{2} + \frac{1}{2}\left(1 + 4\frac{U}{c_i}\right)^{\frac{1}{2}} \qquad \text{(A3.1)}$$

For the slanting current cases, the analytical solutions for the wave direction and the wave height, using Snel's law: $\sin\theta / c$ = constant, are (see e.g., Hedges, 1987; Jonsson, 1993):

$$\begin{cases} \theta = \arccos\left(\dfrac{gk_i \cos(\theta_i)}{[\omega - Uk_i \cos(\theta_i)]^2}\right) \\ H = H_i\sqrt{\dfrac{\sin(2\theta_i)}{\sin(2\theta)}} \end{cases} \qquad \text{(A3.2)}$$

Comparison is made for wave height, wave period and wave direction.

Default model commands

	COMPUTATIONAL GRID					
	1D/2D	XPC	YPC	ALPC	XLENC	YLENC
	2D	0	0	0	16000	4000

	AX	AY	DIR1	DIR2	Δθ	FLOW	FHIGH	MSC
001	400	40	30°	150°	2°	0.05	0.25	40
002	400	40	30°	150°	2°	0.05	0.25	40
003	640	40	60°	140°	1°	0.05	0.25	40
004	640	40	10°	70°	1°	0.05	0.25	40

	PHYSICS								
	GEN	BREAK	FRIC	TRIADS	QUAD	WCAP	REFRAC	FSHIFT	SETUP
	off	off	off	off	off	on	on	on	off

	BOUNDARY CONDITIONS										
	TYPE	BOU	C/V	P/R	SHAPE	PE/ME	DSPR	HS	PER	PDIR	DD
001	side	S	con	par	Gauss 0.01	peak	power	1	10	90°	500
002	side	S	con	par	Gauss 0.01	peak	power	1	10	90°	500
003	side	S	con	par	Gauss 0.01	peak	power	1	10	120°	500
004	side	S	con	par	Gauss 0.01	peak	power	1	10	60°	500

	BOTTOM:	WIND:	CURRENT:	WATER LEVEL:
001	'a031curnt001.bot'	-	'a031curnt001.cur'	-
002	'a031curnt002.bot'	-	'a031curnt002.cur'	-
003	'a031curnt003.bot'	-	'a031curnt003.cur''	-
004	'a031curnt004.bot'	-	'a031curnt004.cur'	-

References

Phillips, O.M, 1977: The dynamics of the upper ocean, 2nd edition, Cambridge University Press, 336 p.

Jonsson, I.G., 1993: *The Sea,* Ocean Engineering Science, 9, Part A

Hedges, T.S., 1987: Combination of waves and currents: an introduction, *Proc. Instn. Civ. Engrs.*, Part 1, 82,567-585

Acknowledgements