README for the PFL wave model

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1 Introduction

The PFL wave model is a Matlab code for the simulation of both regular and irregular wave fields in two horizontal dimensions. The code is based on the fully nonlinear potential flow description of the wave motion, and assumes the free surface to be single-valued. The method uses a volumetric approach to solve the Laplace problem inherent in the potential flow formalism, for which the horizontal dimensions are discretized using the Fourier collocation method and the vertical dimension is discretized using the Legendre collocation method. The spatial parts of the free surface boundary conditions are likewise discretized using the Fourier collocation method, and the time integration is performed with the classical fourth order Runge-Kutta method with a fixed time step. A full description of the numerical method and the validation of its stability, accuracy and efficiency can be found in the paper by Klahn et al. [4]. In the current release of the code, the following types of waves can be simulated:

- Steady nonlinear waves,
- Crescent waves,
- Broad banded focusing waves as studied experimentally by Johannessen & Swan [3],
- A Gaussian hump initially at rest,
- Multi-directional irregular wave fields described by JONSWAP spectra in both finite and inifinite water depth.

2 Name

The abbreviation "PFL" stands for "**P**seudospectral **F**ourier-**L**egendre" and refers to the discretization used in the wave model.

3 Requirements

The code is written in Matlab R2019a and contains only `.m`-files. In principle it should threfore run in any version of Matlab. The code, however, utilizes several built-in functions such as `gmres`, `fft2` and `sparse`, and as a consequence it may be that the code cannot be executed in older versions of Matlab.

4 Structure of the code and how to use it

The code is divided into two independent parts. One part deals with deterministic simulations for which the initial condition of the wave field is non-random, and comprises the simulations of steady nonlinear waves, the formation of crescent waves, the time evolution of a Gaussian hump initially at rest and the simulation of focusing events. The deterministic simulations can only be performed with a finite (but arbitrarily small or large) water depth. The other part deals with stochastic simulations for which the initial condition of the wave field depends on random numbers. In the current release of the code, the stochastic part may be used to study the time evolution of multi-directional irregular wave fields based on JONSWAP spectra in water of both finite and infinite depth. The specific structure of the two parts can be found in the documents "userManualDeterministic.pdf" and "userManualStochastic.pdf" in which it is also explained how the simulations can be set up and carried out.

5 Contributions and contact

The code has been developed by Mathias Klahn, Per A. Madsen and David R. Fuhrman at the Technical University of Denmark. Questions related to the code can be send to `mathias_klahn@hotmail.com`. The initial conditions for the simulations of steady nonlinear waves and crescent waves are generated using the freely available program `SSGW` developed by Clamond & Dutykh (see Clamond & Dutykh [1] for the code and Clamond & Dutykh [2] for a derivation of the method).

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References

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