Test Case for BBLM

This folder contains the neutral version of the Styles and Glenn Bottom Boundary Layer Model (BBLM). The code is written and must be run in MATLAB. The m-files contain the functions to compute the shear stresses, current, concentration, sediment transport and depth-integrated sediment transport. The variables referred to in this report are defined in a Technical Report referenced herein (Styles et al. 2017).

<u>Matlab script files</u>

Primary BBLM scripts

The following scripts (m-files) include the code and subroutines needed to compute the non-dimensional variables that define the shear stresses and other useful BBLM parameters.

bblm02.m – main driver program. This is a stand-alone program that reads in a time series of input parameters and saves the results in a mat file. The user must provide the input file with the correct format (provided in the bblm02.m header) and must name the output mat file.

pwave.m – called by bblm02.m computes the pure wave limit to provide upper bound on sigma

shldc.m – called by bblm02.m computes the critical shields parameter for initiation of sediment motion

bstress2.m – called by bblm02.m it contains the kernel of the model

phi2_1.m – called by bstress2.m it computes the Kelvin functions.

Model output scripts

In order to compute the variables required for analysis and plotting, the user must run CurSedPro.m after first running bblm02.m

CurSedPro.m – reads in the model_output_file2017.mat from bblm02.m and computes the current, concentration, and sediment transport profiles for plotting. It also calculates the shear velocities, hydraulic roughness, and other parameters for further analysis.

neutsedpro_fun.m – called by CurSedPro.m and produces the profiles.

Test Case

The model includes a test case, which predicts the BBLM parameters for a prescribed set of wave and current inputs.

Model Input

test2.mat is an input test case for the model. It uses three scenarios for the relative wave and current conditions. Table 1 shows the inputs required to run the model. The input data can be stored in an asci file or as a mat file. The format must be: 1st column (time), 2nd column (near-bed orbital velocity), 3rd column (near-bed excursion amplitude), 4th column (mean current), 5th column (height above the bed the mean current is calculated), and 6th column (angle between the wave and current [between 0 and 90 degrees]). In the following example, the first case represents strong current and strong wave conditions (SW-SC). The second case represents weak wave and strong current conditions (WW-SC). The third represents strong wave and weak current conditions (SW-WC). The default in bblm02.m is to read test2.mat.

Table 1 Input values for test case (saved as the variable DATA in test2.mat)

Parameter	Time series counter	Ub – wave orbital velocity	Ab – wave excursion amplitude	Ur – mean current	Zr – height above bed current is measured	Angle between the wave and current
Units	Year Day, etc.	(cm/s)	(cm)	(cm/s)	(cm)	(degrees)
SW-SC	1	40	50	60	100	0
WW-SC	1	10	15	100	100	0
SW-WC	1	100	140	5	100	0

Input sediment grain size distribution

The sediment grain size distribution and median grain diameter are specified by the user in bblm02.m.

bblm02.m default includes the following five grain size classes:

d = [0.009, 0.01, 0.02, 0.03, 0.04] in cm

median diameter:

d_median = 0.04 cm

Output

The program outputs several key non-dimensional variables as well as some input variables. Variable symbols are identified in the bblm02.m code. The mathematical formulas that define the variables can be found in Styles et al. (2017).

bblm02.m outputs the following MATLAB variables:

BBLMPRMS – includes the calculated parameters needed to compute the shear stresses

SKNPRMS – contains the calculated parameters needed to compute the skin friction shear stress

d – grain size distribution

d_median – median grain diameter

psicr – critical shear stress for the initiation of motion

wf – particle settling velocity

Calculating Sediment Concentration and Current Profiles

CurSedPro.m – reads the mat file, model_output_file2017.mat, from bblm02.m and computes the current, concentration, and sediment transport profiles.

CurSedPro.m produces mat files that contain arrays to compute vertical profiles of current, concentration, and sediment transport as well as the shear velocities. These arrays are not explicitly saved to a file, but MATLAB users can generate code to save any model output information needed for further analysis. The following variables are computed upon execution of this m-file.

ZZ.nsa – non-structured array that contains the vertical position where the current and concentration are calculated.

CUR.nsa – non-structured array that contains the current speed at different heights off of the bed (heights correspond with ZZ.nsa).

SED.nsa – non-structured array that contains the sediment concentration (for each size class) at different heights off of the bed (heights correspond with ZZ.nsa).

SEDTRANS.nsa – non-structured array that contains the sediment transport (for each size class) at different heights off of the bed (heights correspond with ZZ.nsa).

DTRANS.nsa – non-structured array that computes the depth-integrated sediment transport.

STRESS.xxx – non-structured array that computes the following parameters: combined wave and current shear velocity (ustarcw), time-average shear velocity (ustarc), maximum shear velocity for the wave (ustarwm), hydraulic roughness (znot), scale height of the wave boundary layer (z1), and the transition height (z2).

MATLAB users can generate time series plots and/or vertical profiles using these variables.

Test Output

Output derived from STRESS.xxx for the test case is listed in Table 2. The user should verify that for the test case (test2.mat) the model output matches the values in Table 2.

Table 2 Selected output variables for test case.

Parameter	ustarcw – maximum combined wave and current shear velocity	ustarwm – maximum shear velocity for the wave	ustarc – time average shear velocity	znot – Hydraulic roughness	z1 – wave boundary layer scale height
Units	(cm/s)	(cm/s)	(cm/s)	(cm)	(cm)
SW-SC	12.9	11.2	6.5	1.3	3.0
WW-SC	6.7	3.0	6.0	0.1	1.4
SW-WC	17.1	17.0	1.1	0.6	3.1

As a further test, the user can generate graphs of the current profile using the following MATLAB code:

semilogy(CUR(1).nsa(:,1), ZZ(1).nsa); grid;

xlabel('Current Velocity (cm/s)'); ylabel('Vertical Position (cm)');

The user can verify that the current should be 60 cm/s at 100 cm height. Similar code can be used to generate graphs of the concentration and sediment transport.

References:

Styles, R. and S. M. Glenn, 2000: Modeling stratified wave and current bottom boundary layers on the continental shelf. J. Geophys. Res., 101, 24,119-24,139.

Styles, R. and S. M. Glenn, 2002: Modeling bottom roughness in the presence of wave-generated ripples. J. Geophys. Res., 107, 24-1 to 24-15.

Styles, R., S. M. Glenn, and M. Brown, 2017: An optimized combined wave and current bottom boundary layer model for arbitrary bed roughness, U. S. Army Corps of Engineers, ERDC/CHL TR-17-11, 36 pp.