New sisyphe features for v6p3 links from New version features

v6p3 Sisyphe

Internal coupling waves-currents and sediment transport

The internal coupling waves-currents and sediment transport is implemented in the Telemac-Mascaret system. The keyword (in the Telemac-2d steering file) COUPLING WITH = 'TOMAWAC, SISYPHE' is used to internally couple with Tomawac and Sisyphe.

The coupling period with Tomawac and Sisyphe can be controlled with the keywords 'COUPLING PERIOD FOR TOMAWAC' and 'COUPLING PERIOD FOR SISYPHE', respectively.

In the Telemac-2d cas file, the keyword 'WAVE DRIVEN CURRENTS = YES' allows to incorporate the effect of waves in the hydrodynamic simulation.

In the Sisyphe cas file, the keyword 'EFFECT OF WAVES = YES' is used to consider the effect of the waves on the solid transport formula. In Sisyphe, the implemented bedload transport formulae that consider the combined effect of currents and waves are BIJKER (=4), SOULSBY - VAN RIJN (=5), BAILARD (=8) and DIBAJNIA ET WATANABE (=9). Formulae 4, 5 and 8 consider bedload and suspended load transport. Formula 9 considers total transport.

The application of this keyword is showed in the test case 019_Littoral.

Settling lag (based on Miles' approximation)

According to the accepted theory of sediment suspension turbulence opposes gravity and ensures that the sediment is distributed vertically throughout the water column. The continuity of sediment concentration equation in one, vertical, dimension is:

$$\frac{\partial C}{\partial t} = W_s \frac{\partial C}{\partial z} + \frac{\partial}{\partial z}\left(D_z \frac{\partial C}{\partial z}\right)$$

where W_s is fall velocity. The vertical diffusivity D_z, which is approximated from the horizontal parabolic eddy viscosity assuming a logarithmic velocity profile, which describes the time rate of change of sediment in the vertical, z, direction for uniform flow conditions (Mei,1969): $D_z = 1/6\ \kappa u.h$, where U_* is the friction velocity and κ =0.4 is von Karman's constant. Solutions to this equation can be found by employing suitable boundary conditions. The free surface boundary is trivially defined as, at the free surface, there must be zero flux of sediment. At the bed there are a number of options and various assumptions have been made to describe the exchange of sediment between the water and the bed. Mei (1969) assumes that the concentration at the bed responds instantaneously to changes in the flow. This leads to

$$W_S(C_S - C)_{z=0} = W_S(C_S - C_0)_{z=0}$$

where C_0 is the initial near bed concentration. The bed exchange depends on the difference between the equilibrium concentrations scaled with the settling velocity of the sediment. Mei's assumption is, however, unrealistic as it requires that the rate of exchange of sediment is infinite at some initial time in the case of a rapid change in velocity. Lean (1980) argued that it is the sediment entrainment rate that responds most rapidly to changes in the flow leading to bottom boundary conditions that can be expressed mathematically as:

$$\left(D_z \frac{\partial C}{\partial z}\right)_{z=0} = \left(D_z \frac{\partial C_S}{\partial z}\right)_{z=0}$$

where the saturated concentration C_S is the concentration that is in equilibrium with the flow and fulfills:

$$W_S \frac{\partial C}{\partial z} + \frac{\partial}{\partial z}\left(D_z \frac{\partial C}{\partial z}\right) = 0$$

Boundary condition (4) is a more generic condition than that suggested by Mei (1969) but does include the boundary condition of Mei. Following the approach suggested by Mei (1969), Miles (1981) derived a similarity solution to equation (2) for the bottom boundary conditions given in equation (4). This solution provides an approximate explicit analytical solution for C. Using this solution Miles (1981) shows that the erosion deposition source term can be written as:

$$W_s(C_S - C)_{z=0} = W_s\left((1+2\tau^2)E(\tau) - 2\tau\pi^{-\frac{1}{2}}e^{-\tau^2}(C_S - C_0)_{z=0}\right.$$

(6)

where C_0 is the initial near bed concentration and:

$$\tau = (W_S/4D_z)^{\frac{1}{2}} t^{\frac{1}{2}}$$

(7)

is the non-dimensional time and $E(\tau)$ is the error function. This modified source term now incorporates a scaling factor that accounts for both the settling velocity and the lag time required for the saturation concentration profile to adjust to changes in the flow.

This keyword allows to compute the bed exchange factor beta based on Miles (1986), see also HR Wallingford report SR75. The application of this keyword is showed in the test case 017_foulness.

Dredgesim

Finally Dredgesim is integrated in the new version of the Telemac-Mascaret system. Further information can be found HERE (add link).

(simple) Bank erosion model

In the context of the Ph.D thesis of Andres Die-Moran, the simple bank erosion model has been improved and validated.

The thesis can be download from:
http://innovation.edf.com/fichiers/fckeditor/Commun/Innovation/theses/TheseDieMoran.pdf,

New test cases

017_foulness

SISYPHE 2D is tested against field data from the Thames estuary (UK). These measurements show a distinct hysteresis effect in the sediment transport rates and sediment concentrations. The goals is to reproduce the measured sediment transport rates during ebb and flood. The test case is explained in more detail in Knaapen and Kelly (2011).

SISYPHE 2D is tested against flume experiments of a trench infill performed at Delft hydraulics (van Rijn, 1986). The measurements show a migrating an infilling of a trench under a constant current and waves travelling with the flow. The goals is to reproduce this morphodynamic change. The test case is explained in more detail in Knaapen and Kelly (2011).

The numerical flume consists of a straight channel, 250 m wide and 5000 meter long. The mesh is very regular, with uniform node distances of 10 m along the boundaries. Boundary conditions at either end of the flume were provided by forcing saturated sediment concentrations there. Sediment composition.

The particle distribution of the sediment collected at FM1 consisted of silt and fine sand. The bed material was shown to consist of fine sand (median grain size 160 µm) with a long tail of fine material. The measured suspended material was finer (median grain size 100 µm). To cover both fine-sand and silt dynamics, the simulation employs a mixed sediment bed using 6 fractions (50 µm [5%], 100µm [20%], 120 µm [37%] 150 µm [34%], 200 µm [3%] and 300 µm [1%]).

The results from the model using the trunk version on the 18th of March 2013 show a fair agreement between the modelled suspended transport and the field measurements. The L2 error norm during flood was 0.148 and during ebb it was 0.082.

Knaapen, M.A.F. and Kelly, D.M. 2011. Modelling sediment transport with hysteresis effects. Procceding of the XVIIIth TELEMAC and MASCARET User Club, Chatou, France.

018_sandpit

SISYPHE 2D is tested against flume experiments of a trench infill performed at Delft hydraulics (van Rijn, 1986). The measurements show a migrating an infilling of a trench under a constant current and waves travelling with the flow. The goals is to reproduce this morphodynamic change. The test case is explained in more detail in Knaapen and Kelly (2011).

Description SISYPHE was run coupled with TELEMAC2D employing a simple numerical flume with a horizontal bed employing Soulsby-van Rijn for the sediment transport incorporating a settling lag following Miles (1981). A constant wave result is used to represent the waves. Using Soulsby-van Rijn at these scales is impossible, as this formula is invalid for water depths smaller than 1 m. This limitation is circumvented by scaling the experiment up to field dimensions, multiplying the domain lengths by 10 and the time by v10. Assuming the morphology is bed-load dominated, the sediment grain size has not been altered.

The numerical flume consists of a straight channel, 10 m wide and 160 meter long. Halfway the flume, a trench is created. The mesh is very regular, with uniform node distances of 1 m across the flume and 2 m along the wall of the flume. The elements are oriented symmetrical across the central axis of the flume. Boundary conditions at either end of the flume were provided as both a water level and a discharge at both sides. Although this leads to an over-defined problem, it results in an acceptable flow field. For the sediment, boundary conditions were provided by forcing saturated sediment concentrations there. The computations were done using a uniform sediment with 0.1 mm median diameter. This is in line with the assumption that the bedload processes dominate the morphodynamic development.

SISYPHE predicts the location of the trench accurately and reproduces both the slopes correctly. The hump in the measured bathymetry is probably related to a slope failure in the experiments (not confirmed). The differences are minor, the optimal L2 norm is 0.032 and the optimal Brier Skill score is 0.95.

019_Littoral

% Description of test case This is the classical test case of a rectilinear beach with sloping bed

The model allows to calculate the littoral transport.

This test case illustrates the effect of waves which is :

1. to generate the current induced littoral current parallel to the beach

2. to increase the sand transport rate using the Bijker sand transport formula.

% Geometry:

The beach is 1000 m long, 200 m wide

The beach slope (Y=200m) is 5% and defined in corfon.f

The water depth along the open boundary (Y=0) is h=10m

We use a trianglular regular grid

% Boundary conditions

–> Offshore (Y=0): Offshore wave imposed/no littoral current/no set up

Tomawac:

The wave height is imposed on the offshore boudary (5 4 4) (Hs=1m), for a wave period (Tp=8s).

Telemac:

The current and free surface are imposed to 0 along the offshore boundary (5 5 5).

–> Left and right hand side of the domain (X=0, X=1000m):recirculation condition

Tomawac:

The wave height is imposed on the offshore boudary (5 4 4), based on the model solution, calculated at the center line of the domain.

This is done in Limwac.f (princi_tom.f)

Telemac :

the model solution for the current (4 5 5) on the center line of the model domain are copied on both right and hand side. This is done in bord.f (princi_tel.f). **This test case does not work in parallel.**

% Model results Results (littoral current and transport rates) as well as wave set up/set down are in good agreement with expectations from theoretical classical results (Longuet Higgins).The model is able to reproduce the wave induced current, as well as the effect of set down/set up as the waves dissipate in the breaking zone. The sediment transport rate is located in the near shore breaking zone, where the longshore current is generated. Similar results for the littoral transport could be obtained by using an integrated formula (e.g. CERC formula).

020_Bar_formation_propagation

The capabilities for reproducing bar formation and propagation in channels are tested by performing a test based on the simulations by Defina (2003) Numerical experiments on bar growth, Water Resources Research, 39(0) and Lanzoni, S., 2000, Experiments on Bar formation in a straight flume. Part 1: Uniform sediment, Water Resources Research, 36(11).

For a fixed rectangular channel with initial bed configuration covered with a random perturbation of 0.005m of amplitude, bars appear and propagate downstream as observed in experiences.

301_KD09

This test case is included to assess the ability of Sisyphe to handle coupled hydro-morpho-dynamic evolution at high Froude numbers. The sediment transport is based on a pure bedload formulation where the sediment transport is a function of the velocity field only (i.e. q=q(u)). The test simulates a wet-dry dam break on a mobile bed and compares the numerical results against the analytical solution presented by Kelly & Dodd (Kelly, D.M. and Dodd, N., 2009. Floating grid characteristics method for unsteady flow over a mobile bed <http://dx.doi.org/10.1016/j.compfluid.2008.09.011>. Computers and Fluids. 38, 899-909). Note that this test should be run coupled (as it is impossible to divorce the hydro-morpho-dynamics in such energetic flow) and the Sisyphe princi.f file goes in the Telemac-2d cas file.

021_bifurcation_FSF_02

This is an example test on how to impose solid discharge at two inlets in a bifurcation.