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Technische Universität
Cottbus - Senftenberg

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TELEMAC 2D

EUROAQUAE+

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Overview

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- Developed by the R&D group of Electricite de France (EDF) as a freely available software since 2010.
- The software solves the Barre de Saint Venant equations (Shallow water equations) based on a two-dimensional grid.
- Uses finite volumes and finite elements schemes to solve the equations.
- It computes on each point of a mesh resolving for water height, averaged velocity in x and y direction.

Considers the following physical phenomena within the model calculations:

1. Large wave propagation with influence of non-linear effects.
2. Bottom friction.
3. Influence of Coriolis force.
4. Meteorological phenomena such as atmospheric pressure and wind effects.
5. Turbulence.
6. Sub and supercritical flows.
7. Influence of vertical gradients in temperature and salinity.
8. Dry areas in a computing domain such as dry banks and flood zones.
9. Allow for marker set up based on current transport and dispersion.

- Telemac 2D solves the following four hydrodynamic equations simultaneously at each mesh location

1. Continuity

$$\frac{\partial h}{\partial t} + u \cdot \vec{\nabla}(h) + h \cdot \mathrm{div}(\vec{u}) = S_h$$

2. Momentum on x-direction

$$\frac{\partial u}{\partial t} + u \cdot \vec{\nabla}(u) = -g\frac{\partial Z}{\partial x} + S_x + \frac{1}{h}\mathrm{div}\left(h \cdot v_t \cdot \vec{\nabla}\vec{u}\right)$$

3. Momentum on y-direction

$$\frac{\partial v}{\partial t} + u \cdot \vec{\nabla}(v) = -g\frac{\partial Z}{\partial y} + S_y + \frac{1}{h}\mathrm{div}\left(h \cdot v_t \cdot \vec{\nabla}v\right)$$

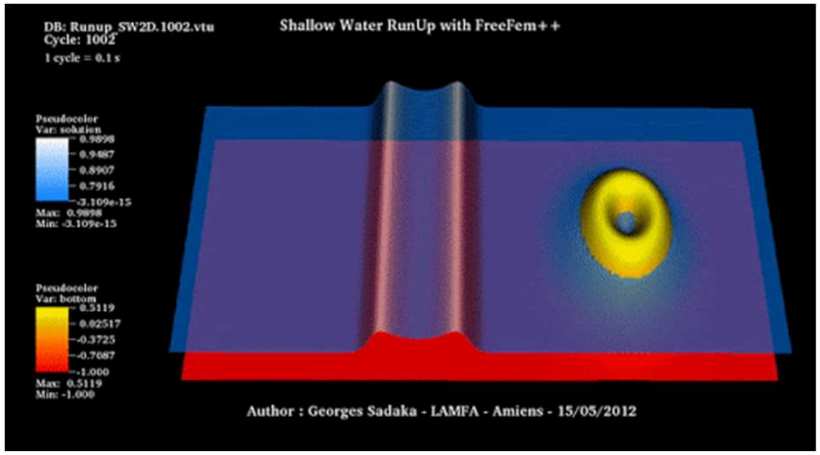
4. Tracer conservation

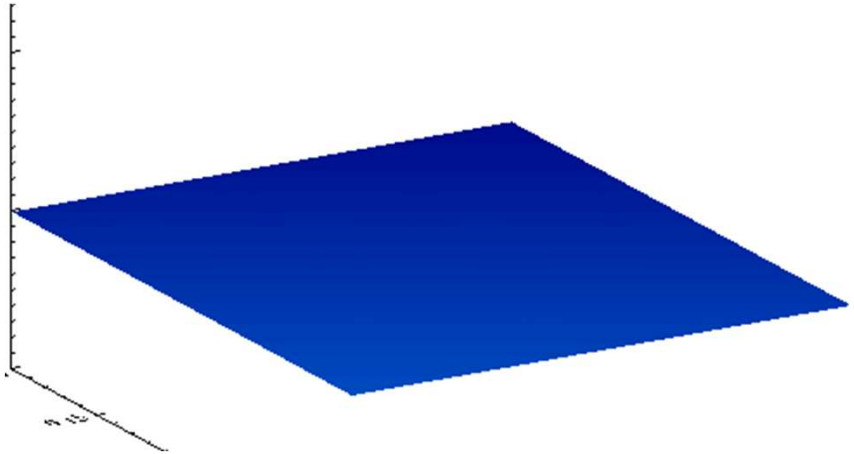
$$\frac{\partial T}{\partial t} + u \cdot \vec{\nabla}(T) = S_t + \frac{1}{h}\mathrm{div}\left(h \cdot v_T \cdot \vec{\nabla}T\right)$$

Theoretical Aspects

- The equations are given in Cartesian coordinates but can also be processed using spherical coordinates.
- The source terms represent wind, Coriolis effect, bottom friction, moment of source or sink within the domain.
- The latter terms are processed in one or more steps depending on the characteristics of the analysis in based on:

1. Advection of h,u,v and T.
2. Propagation, diffusion and source terms of dynamic equations.
3. Diffusion and source terms of tracer transport equation

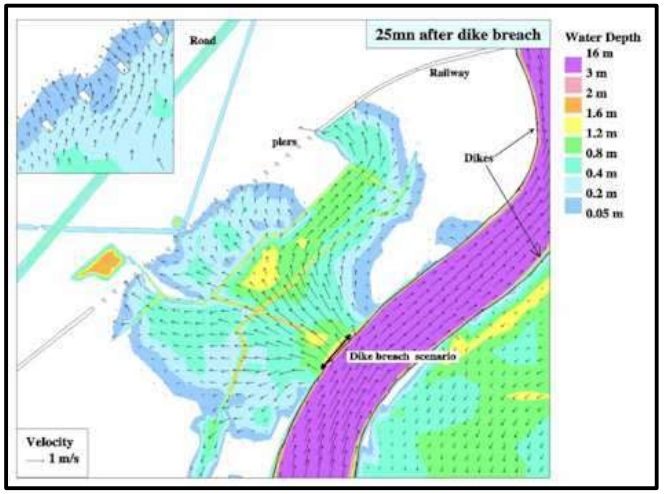


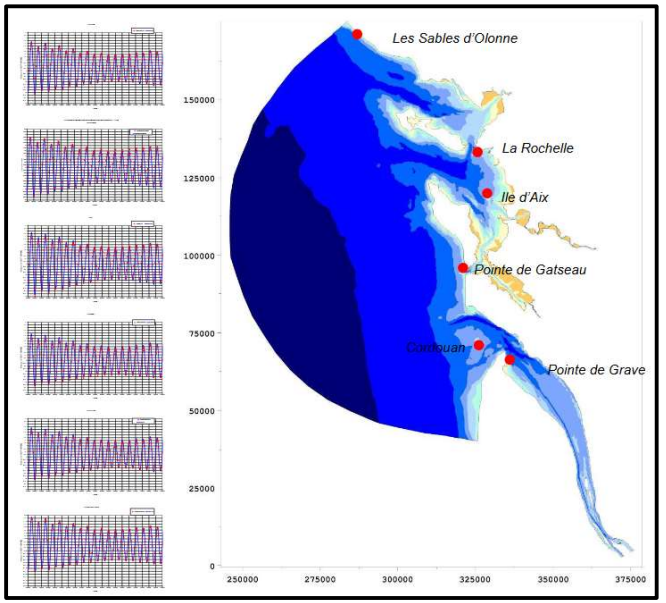


Applications

- The versatility of the software enables it for usage in a wide range of applications, including:

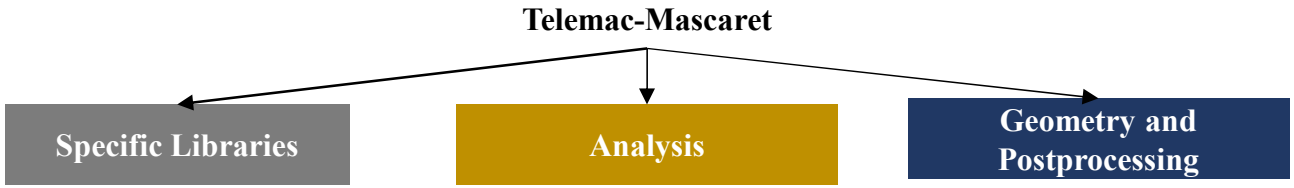
1. Sizing of port structures.
2. Study of effects of building submersible dikes or dredging.
3. Impact of waste discharged from coastal outfalls.
4. Impact of construction works including groynes, weirs, and bridges.
5. Dam breaks.
6. Flooding or transport of decaying or non-decaying tracers.





TELEMAC Ensemble

- Open software developed as a collaboration between the French and Canadian authorities.
- TELEMAC software was developed using FORTRAN, allowing the user to create sub-routines to meet specific requirements in each model.
- It is available for usage through Python 2.7 UI, called as a subroutine from the parent folder where the software is installed.
- It is integrated in a modelling system called TELEMAC-MASCARET that encompass software for analysis, pre- and post-processing of data.



Specific Libraries	Analysis	Geometry and Postprocessing
ARTEMIS Berkhoff Equations	**TELEMAC-2D** Shallow Water Equations	**MATISSE** Mesh Generator
MASCARET 1D Free-Surface Flow	**TELEMAC-3D** Navier-Stokes Equations	**RUBENS** Post-Processor
SISYPHE Sediment Transport	**TOMAWAC** Wave Generation by Wind	

Inputs and Outputs

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Using TELEMAC2D requires for a set of files that are used either as inputs or outputs. Some of the files are optional depending on the conditions of the simulation.

Inputs

1. Steering file: containing the configuration of the computation (mandatory).
2. Geometry file: containing mesh (mandatory).
3. Boundary condition file: containing description of each type of boundary (mandatory).
4. Previous computation file, given state of initial computation (optional).
5. Bottom topography file: containing elevation of bottom. The geometry file already contains the topographical information (optional).
6. Reference file: containing reference results and used when performing validation (optional).
7. Liquid boundary file: contains information about prescribed values in open boundaries (optional).
8. FORTRAN file: contains specific programming steps (optional).

Among others.

Outputs

1. The result file: containing the graphical results.
2. The listing printout: which is the “log file” of the computation.
3. The sections output file: containing results of control sections computation.

Mandatory Files

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Steering File

- Legacy from the 80's.
- It is a text file that is created by using a text editor or using the software FUDAA-PREPRO.
- It has an extension .cas or .txt
- Generally, it is based upon an already existing parameter file available in the TELEMAC structure.
- It represents the control panel of the computation, containing a number of keywords which have assigned values to them.
- The keywords define a "dictionary" which is specific to each simulation module.

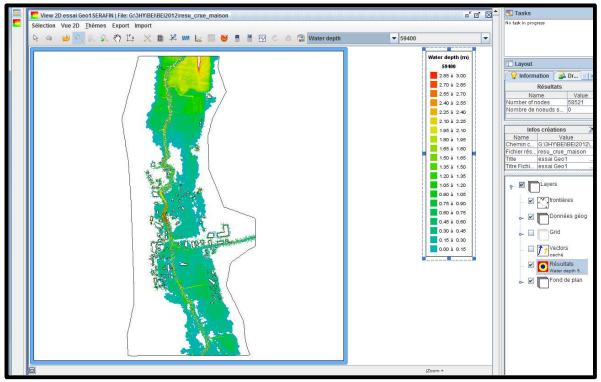
Geometry File

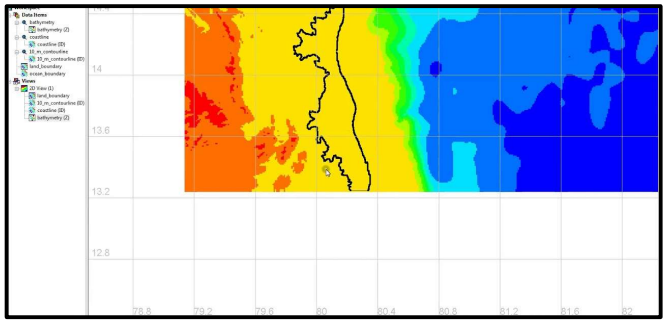
- This is a binary file created from BlueKenue.
- It is defined with name SELAFIN file with extension .sel
- The file contains all the information pertaining the mesh domain including number of mesh points, number of elements, number of nodes per elements and coordinates X and Y.
- The file can also contain information about the bottom topography and/or friction coefficient at each mesh point.

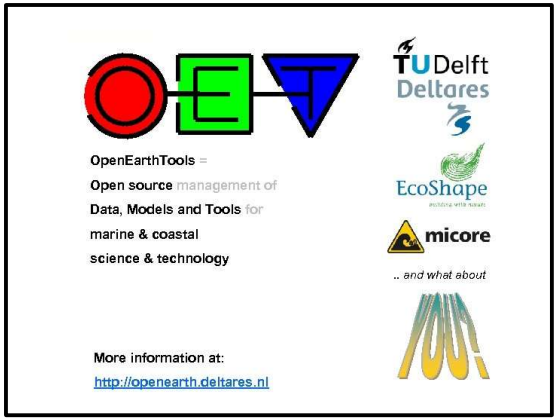
Boundary File

- File formatted using BlueKenue.
- It has extension .cli
- It can be modified with a standard text editor.
- The line of each file is dedicated to one specific point in the mesh boundary.
- It describes the contour of the domain trigonometrically starting from the bottom left-hand corner of the domain and going clockwise.

Pre and Post Processing







FUDAA PRE-PRO: provides tools for animations and reporting capabilities

BlueKenue
windows free software provide by CHC, used for mesh and boundary file generation and visualization purposes.

Openearthtools
Matlab, R and Python libraries that can be coupled for processing telemac results

- After all files are ready for the simulation, the telemac2d simulation can be called upon using the command line.
- Move to location in which the latter files are located
- Once in the folder, run the following command

Telemac2d.py nameofcasfile.cas

- The program is available globally through virtual box on the local machine

Description of mandatory and optional files in local folder

Specification of output files and variables

Setting initial conditions for the simulation

Physical parameters to include in the analysis

Specification for numerical and theoretical background

cas.txt - Notepad

File Edit Format View Help

```
/-------------------------------------------/
/ TELEMAC-2D /
/-------------------------------------------/
/-------------------------------------------------
/ COMPUTER INFORMATIONS
/-------------------------------------------------
/
STEERING FILE :cas.txt
BOUNDARY CONDITIONS FILE :Bathy_BC.cli
GEOMETRY FILE :River.slf
RESULTS FILE :res.slf
/
/-------------------------------------------------
/ GENERAL INFORMATIONS - OUTPUTS
/-------------------------------------------------
/
TITLE = 'Exercise 1'
VARIABLES FOR GRAPHIC PRINTOUTS = 'U,V,S,B,H,Q,M,F,L'
GRAPHIC PRINTOUT PERIOD = 750
LISTING PRINTOUT PERIOD = 750
TIME STEP = 0.04
DURATION : 120
MASS-BALANCE = YES
INFORMATION ABOUT SOLVER = YES
/-------------------------------------------------
/ INITIAL CONDITIONS
/-------------------------------------------------
/
INITIAL CONDITIONS : 'CONSTANT ELEVATION'
INITIAL ELEVATION : 2.60
/OUTPUT OF INITIAL CONDITIONS = YES
PRESCRIBED ELEVATIONS : 0.; 2.66
PRESCRIBED FLOWRATES : 30.0; 0.
/
/-------------------------------------------------
/ PHYSICAL PARAMETERS
/-------------------------------------------------
/
TURBULENCE MODEL = 1
/VELOCITY DIFFUSIVITY = 1.E-4
LAW OF BOTTOM FRICTION : 3
FRICTION COEFFICIENT : 40.0
/
/-------------------------------------------------
/ NUMERICAL PARAMETERS
/-------------------------------------------------
/
/EQUATIONS = 'SAINT-VENANT EF'
TIDAL FLATS = NO
/OPTION FOR THE TREATMENT OF TIDAL FLATS : 1
/TYPE OF ADVECTION = 1;5
/DISCRETIZATIONS IN SPACE = 11;11
/SOLVER = 3
```

Hydrodynamic Simulation

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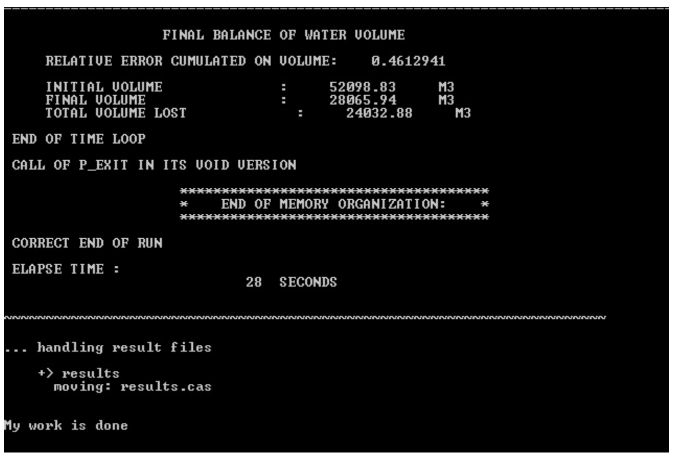

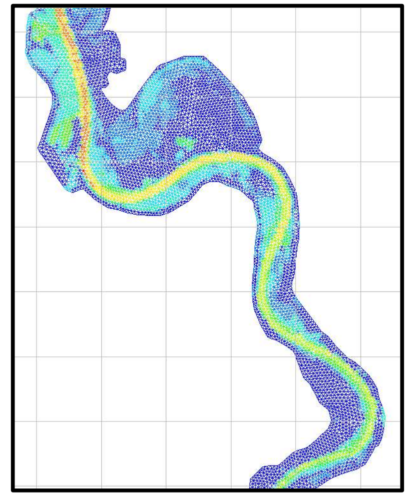

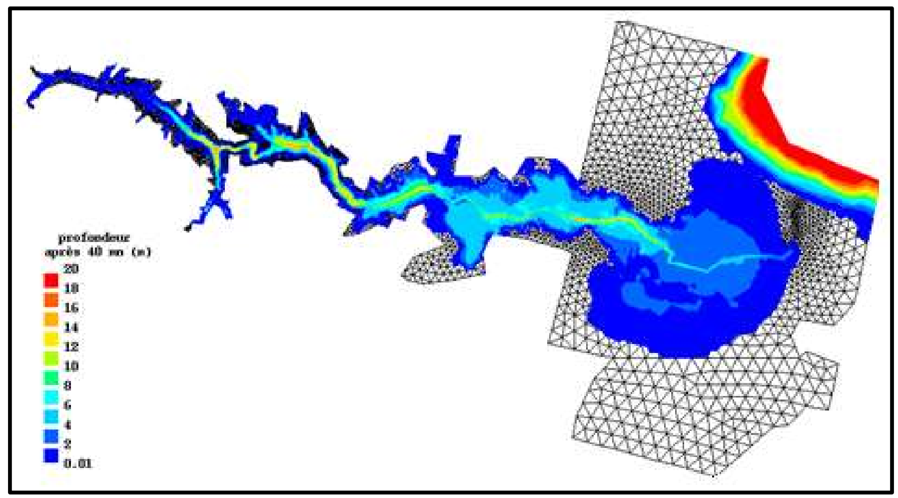

Comparative features

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Advantages

- Software code has been in public since its launch in 2010.
- It has been widely used throughout research and industry in a variety of applications.
- Free tools for both pre and post data processing.
- Training available through telemac consortium, third party organizations and online community support.
- Can be coupled with other software (i.e. Delwaq).
- Ability to be executed on a linux cluster.

Disadvantages

- Use of command line for running, lack of UI.
- Does not account of groundwater.
- Cannot be coupled with urban drainage flood systems.
- Requires at least three different programs for generating results.

Conclusions

- TELEMAC2D along with the TELEMAC-MASCARET software suite are designed for the simulation of hydrodynamic processes in 2D-and 3D using the Saint Venant equations by applying numerical solvers.
- It is widely used because of its wide range of applications, being open software with the possibility to add new features from outside developers.
- Requires 3 different software interfaces for obtaining results.
- Lacks a user interface, which might become counterintuitive and tedious.

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