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Programme Area: Marine

Project: Tidal Modelling

Title: TELEMAC Installation Guide

Abstract:

The Continental Shelf Model is a sophisticated hydrodynamic model that is operated using the TELEMAC system. This document contains the supporting information required by an experienced modeller to operate the TELEMAC-2D solver in preparation to running the CSM model. In particular it describes the solver and provides instructions on how to download, install and run the available test cases.

Context:

Launched in October 2011 this project involved Black & Veatch, in collaboration with HR Wallingford and the University of Edinburgh to develop a model of the UK Continental Shelf and North European Waters, 100 times more accurate than existing marine data. This has been used to assess the tidal energy potential around the UK (tidal range and tidal streams), to inform the design of energy harnessing schemes, to assess their interactions, and to evaluate their impact on European coasts. It can also be used to renew and inform flood defences, coastal erosion and aggregate extraction. Now completed, the project has been launched to market under the brand of SMARTtide. This is available to the marine industry under licence from HR Wallingford.

Energy Technologies Institute

MA1009

Tidal Modelling

(Modelling Tidal Resource Interactions around the UK)

PM02.06 A

Technical Documentation for the UK Continental Shelf Model

Part A: The TELEMAC system: Installation Guide

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Version 2.0

Participant Lead – HR Wallingford

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CONTENTS

1 EXECUTIVE SUMMARY

The *Energy Technologies Institute* (ETI) is developing a *Continental Shelf Model* (CSM) of the UK waters to assess the tidal energy potential around the UK, to inform the design of energy harnessing schemes and to evaluate their impact on European coasts. *Black & Veatch* (B&V), in collaboration with *HR Wallingford* (HRW) and the *University of Edinburgh* (UoE), is providing support with regard to the development of this model and subsequent use by the tidal power industry. This report has been led by HRW and is part of the *Tidal Resource Modelling* (TRM) scope of work delivered by B&V as prime contractor.

B&V has been consulting on tidal energy since 1975 (B&V was previously Binnie & Partners in the UK until 1995). B&V has a very broad and in-depth experience of both tidal range and tidal current projects, including resource assessment and project development, technology development, due diligence, cost of energy and policy development. Through working on these projects, it has gained a deep technical and commercial understanding of tidal energy projects in addition to simply resource assessment.

HR Wallingford has vast experience of numerical modelling of free surface flows using the TELEMAC system and has been instrumental in its continued development. The TELEMAC system is a state-of-the-art free surface flow suite of solvers developed by a kernel of European organisations including HR Wallingford and other partners such as Electricité de France and the Federal Waterways Engineering and Research Institute of Germany (pertinent information related to the TELEMAC system and, in particular, to the 2D module used in this project is given in the D02 – CSM Requirements Specification document). HR Wallingford's expertise is acknowledged within the UK tidal modelling community as the only entity with an in-depth experience of TELEMAC and its tailoring to specific problems.

The UoE is one of the largest and most successful universities in the UK with an international reputation as a centre of academic and research excellence. The Institute for Energy Systems (IES) is one of five multi-disciplinary research groupings within the School of Engineering at the University. In the most recent UK-wide Research Assessment Exercise (RAE 2008), the School was ranked third in the UK for combined research quality and quantity.

The aim of the TRM scope of work is to address the following fundamental questions:

- How will the impacts of tidal range and tidal current energy schemes positioned around the UK combine to form an overall effect?
- Will the extraction of tidal energy resources in one area affect the tidal energy resources at distant sites around the UK and Europe?
- What constraints might these interactions place on the design, development and location of future systems?

This is achieved through a series of work packages and, ultimately, 10 deliverables outlined below.

D01 – Tidal resource characterisation
D02 – Continental Shelf Model (CSM) requirements specification document
D03 – Scenarios modelling
D04 – Cost of Energy Model and supporting documentation
D05 – Interface specification for detailed tidal current model with CSM
D06 – CSM (coarse and detailed versions) with supporting documentation
D07 – Interactions (analysis and conclusions report)
D08 – Interface specification for detailed tidal range model and the CSM
D09 – Tidal Range model and supporting documentation

D10 – Project dissemination

This report forms part of the D06 deliverables; specifically Part A. D06 is comprised of 3 parts:

- Part A – The TELEMAC system: Installation Guide,
- Part B – The CSM Functional and Testing Report,
- Part C – The CSM Web User Interface: User Guide.

It contains the supporting information required by an experienced modeller to get acquainted with the TELEMAC-2D solver, in particular a general description of the solver and instructions to download, install and run the available test cases.

This report remains a comprehensive source of references with respect to all practical, technical and theoretical aspects of TELEMAC-2D and will be referred to as such in subsequent publications of this project. The majority of the information presented can also be found on the TELEMAC official website hosted and managed by HR Wallingford: http://www.opentelemac.org/.

References to pre/post-processing and visualisation software are also provided at the end in this report.

HR Wallingford, as a primary distributor of the TELEMAC system for the last 20 years, strongly recommends that new users register for training courses. Interaction with an expert in the system is invaluable and is something that a technical report does not replace. Qualified and experienced users of TELEMAC are in a position to modify the programming of its operating rules or even re-build the CSM entirely from available supporting data.

However, it should be emphasised that because the CSM is not primarily intended for model developers, a web interface is also provided for users of the CSM that are not users of TELEMAC. A separate user manual, Part C of deliverable D06, describes how to set and upload a set of tidal current and tidal range energy schemes through that web interface, without having to understand the detail of the CSM modelling itself.

2 INTRODUCTION TO THE TELEMAC SYSTEM

The TELEMAC system is a state-of-the-art free surface flow suite of solvers developed by a kernel of European organisations including HR Wallingford and other partners such as Electricité de France and the Federal Waterways Engineering and Research Institute of Germany. The TELEMAC system is currently being used by more than 2,000 organisations worldwide; it has been developed under a quality assurance system including the application of a standard set of validation tests.

The caption opposite shows the cover of the latest book (dated April 2007) published on this solver. This reference includes in particular a full description of the latest theoretical and numerical developments.

The TELEMAC two-dimensional (2D) module, TELEMAC-2D, solves the 2D depth-integrated shallow water equations and is used to model various hydraulic phenomena such as tidal flows in estuaries, coastal flows, storm surges, floods in rivers including turbulence structures resulting from flow obstructions and transcritical flows, dam break simulations, cooling water dispersion and infill of navigation channels. The effect of a wind blowing on the water surface and causing a set-up or wind-induced current and the effect of an atmospheric pressure variation causing an inverted barometric effect can be included in the models. The bed friction can be specified with a Chezy, Strickler/Manning or linear coefficient, or a Nikuradse roughness length. It is possible to define a spatially varying friction coefficient over the model area. Viscosity can be set as a constant eddy viscosity value or computed through a k-epsilon model. Details of the equations solved by TELEMAC-2D and the numerical methods used to solve them can be found in the TELEMAC-2D Principle Note (see list of references).

TELEMAC-2D uses an unstructured mesh for the spatial domain discretisation. This allows the user to set a variable resolution across the model domain, with mesh refinements in areas of interest and a coarser resolution in areas affected by processes that have larger scales. It removes the need to couple models at different resolutions, and allows a more efficient use of computing facilities.

TELEMAC-2D can easily be converted to or dynamically coupled with the other modules of the system. Its three-dimensional (3D) module, TELEMAC-3D, solves the 3D Navier-Stokes equations either in hydrostatic or non-hydrostatic mode and is used to model hydraulic phenomena such as density currents, reservoir and estuary stratification and salt intrusion, lock exchanges and detailed assessment of tidal energy resources. Its wave transformation module, TOMAWAC, solves the temporal and spatial changes of the wave action density spectrum under the effects of the modelled processes. Its third generation mode splits the wave directional spectrum into a number of propagation frequencies and directions. The balance equation of wave action density is solved for each coupled component and does not require any parameterisation of the spectrum or any directional distribution of power (or action density).

TELEMAC-2D assumes that the flow is homogenous in the vertical, and hydrostatic. The assumptions and validity domains of the model are described in the TELEMAC-2D User Manual (see list of references), which also reports on a number of validation test cases.

3 INSTALLING THE TELEMAC SYSTEM

In this section, the following colour code was adopted, to assist the user in the installation of the TELEMAC system:

- Blue text in italic: comments specific to the CSM,
- Orange text: path, directory or file names; registration username and password,
- Green text: menus to follow on the website: http://www.opentelemac.org,
- Yellow background box: command lines in a DOS or Unix environment.

It is reminded that installation of the TELEMAC system is often included in training courses, which HR Wallingford strongly recommends for new users.

3.1 Particularities of the TELEMAC system

The TELEMAC system is platform independent and is implemented in the strictest standards of the programming languages it uses. It can be installed on Linux or Windows operating systems following the exact same procedure, whether the installation is for a desktop or a high performance computer. This flexibility, however, has slowed down the design of a graphical user interface that would be usable everywhere.

The TELEMAC system is therefore primarily intended for expert modellers knowledgeable in the use of either a DOS command or Shell terminal window. There are no icons to double-click on, just written commands to be executed manually. The information detailed in this section therefore assumes that the reader is familiar with either or both DOS command or Shell terminal windows as opposed to other graphical user interfaces and settings.

As a primary distributor of the TELEMAC system for 20 years, HR Wallingford strongly recommends that new users register for training courses. The TELEMAC system is an expert and advanced system, which requires care, experience and expertise in the set-up (especially for parallelisation) and interpretation of results. Interaction with an expert in the system is invaluable and is something that a technical report does not replace.

Since it is easier to list a set of commands than to explain a series of graphical mouse-driven actions each depending on the operating system , each subsection below will be concluded by a summary list of commands to execute in a Shell terminal window connected to the Internet (Ubuntu-Linux is here assumed as an example). Preference for a Linux operating system is not implied here as the reader should be able to find Windows equivalents. When possible, the equivalent DOS command window is also provided.

Particularities of the CSM:
A 64bit operating system with a minimum of 24-cores is necessary for using the DCSM (Detailed version of the CSM). The CCSM (Coarse version of the CSM) can be used either on a 32bit or 64bit standard multi-core desktop computer.

3.2 Access to binaries and source code

There are two methods of obtaining the TELEMAC-2D source code, both requiring users to create an account and login:

- Through the main website, it is possible to download the pre-compiled zip files with the source code directly: http://www.opentelemac.org/ (menu tab "Downloads / Compiled codes"). This

method does not require the source code to be re-compiled locally. However, it assumes a pre-defined configuration with options than may not be optimised for the user's computer and development environment. It is also less flexible for future updates of the system.

- Through the source code repository site: http://svn.opentelemac.org/svn/opentelemac/, also called the Subversion SVN site. It is possible to access and update to the latest version of the code with one click, having dealt with possible organisational firewall rules. This method requires the source code to be re-compiled locally, and therefore requires that a Fortran compiler be installed. There are a number of tools to access subversion systems (compatible with Subversion 1.7.4 or later), depending on your computer and development environment.

Access to the CSM:
While the first option is available to general users of the TELEMAC system, it is not recommended for the CSM. In order to better protect the source code and data associated to the CSM, only the second will be available and is here assumed in the rest of the document.

With regard to the second option, the following configuration settings should be used to access the most recent, stable and standard version of the TELEMAC system:

- Address: http://svn.opentelemac.org/svn/opentelemac/tags/v6p1/
- Source code repository path (latest stable version of the source code): **/tags/v6p1/**
- Validation repository path (latest stable version of the validation benchmark): **/validation/**
- Username: **ot-svn-public**
- Password: **telemac1***

A special and securely locked version of the system has been put in place on the same repository for authorised users of the CSM only. Usernames, passwords and address will be provided during authorisation process. The two versions of the TELEMAC system (standard and CSM) can be installed side by side without interferences.

Several tools exist for access to SVN repositories, whether they are integrated within the operating system, whether they are executed through a command line window or terminal or whether these are integrated within a source code development environment such as Netbeans or Eclipse. For reference, a few of the existing graphical tools are listed below:

- The default integration within Netbeans (http://netbeans.org/), which is cross platform
- Subclipse (http://subclipse.tigris.org/), for the Eclipse IDE, which is also cross platform
- TortoiseSVN (http://tortoisesvn.net/) integration within MS Windows operating system
- SCPlugin (http://scplugin.tigris.org/) integration within Mac Operating System
- KDESVN (http://kdesvn.alwins-world.de/), graphical tool for Linux operating system

For Windows users, it is here assumed that version 1.7.6 of TortoiseSVN is installed as it allows a DOS command window access to and management of Subversion SVN sites.

Summary commands on Linux for the download of the TELEMAC system:

terminal

```
$> cd ~
$> mkdir opentelemac
$> cd opentelemac
```

```
$> svn checkout http://svn.opentelemac.org/svn/opentelemac/tags/v6p1/ ./v6p1
```

Summary commands on Windows for the download of the TELEMAC system:

command

```
c:\> cd \
c:\> mkdir opentelemac
c:\> cd opentelemac
c:\> svn checkout http://svn.opentelemac.org/svn/opentelemac/tags/v6p1/ ./v6p1
```

3.3 Software requirements

Once the appropriate version of TELEMAC-2D has been downloaded, there are a number of software dependencies that need addressing on the local desktop or high performance computer before being able to use the system. Some are critical, others are optional but recommended.

First, it is critical that the modeller installs a Python interpreter (http://python.org/ version 2.7.2 and above, but not version 3.0 and above[1]), which is freely available in pre-compiled and self-install forms for various computer platforms, operating systems and development environments. The latest are known to be appropriate for both Windows and Linux operating systems. The TELEMAC system includes a series of Python scripts to compile the source code (see Section 3.4), prepare the input and output files and run the various modules (see Section 4.3). An older version of these scripts written in PERL (version 5) also exists and is available from the official website but is not recommended here as Python is compatible across many computer platforms, operating systems and development environments.

Second, it is recommended that the user tailors and optimises the TELEMAC system specifically for the target computer, i.e. that the user re-compiles all binaries of the TELEMAC system according to the available compiler and operating system. For this, a Fortran compiler is required as the core of the system is written in Fortran (standard Fortran 95). The latest commercially available Intel Fortran Compiler (http://software.intel.com/en-us/articles/intel-compilers/ version 10.0 or above) is known to be appropriate for both Windows and Linux operating systems. The latest open source gfortran Fortran compiler (http://gcc.gnu.org/fortran/ version 4.6.3 or above) is also known to be appropriate for both Windows and Linux operating systems. On Windows, the utility “make” is also necessary (version 3.82 or above) available for both 32bit and 64bit system. Because HR Wallingford is promoting a full open source distribution of the TELEMAC system, examples in the rest of this document will be illustrated based on the gfortran compiler. However, it should be noted that once a Fortran compiler has been selected, all external libraries introduced in the rest will also have to be compiled with that same compiler to avoid incompatibilities between binaries.

Finally, it is recommended that the user further tunes the TELEMAC system for use in parallel mode. Nowadays desktop computers default to the latest multi-core technology, each core being capable of accelerating computing time of the CSM. For this, three additional software packages are required as follows:

- Either the MPICH2 implementation of the Message Passing Interface standard (MPI-2) or the OpenMPI implementation of the same standard (MPI-2) need to be installed. Both are freely

[1] Python 3.0 is based on an entirely different concept from Python 2.7. They should not be considered as different releases but rather as different branches, which both evolve independently. The 2.7 branch was chosen for the TELEMAC system (as well as this project) since it is currently more stable. It is noted that migration of the support tools to Python 3.0 is envisaged, but can only be done in consultation with the rest of the TELEMAC Consortium.

available in pre-compiled and self-install forms for various computer platforms, operating systems and development environments. The latest MPICH2 binaries from the Argonne National Laboratories (http://www.mcs.anl.gov/research/projects/mpich2/) are known to be appropriate for both Windows and Linux operating systems. The latest OpenMPI binaries of the open source project hosted by the Indiana University (http://www.open-mpi.org/) are known to be appropriate for Linux operating systems but the authors claim testing on Windows operating systems.

- The Python interpreter referenced above needs to be expanded with the so-called "numpy" package (http://numpy.scipy.org/ version appropriate with the Python interpreter itself), which is the fundamental package for scientific computing with Python. This package is also freely available in pre-compiled and self-install forms for various computer platforms, operating systems and development environments, but should however match the core python version.

- A pre-compiled version of the METIS library, from the Karypis Laboratory of the University of Minnesota (http://glaros.dtc.umn.edu/gkhome/metis/metis/overview), version 4.0 and above, but not version 5.0 and above[2]. METIS is a set of serial programs for partitioning finite element meshes based on the multilevel recursive-bisection, multilevel k-way, and multi-constraint partitioning schemes.

Summary command on Linux for the installation of the METIS library, once downloaded:

terminal

```
$> mv metis-4.0.3.tar.gz ~/opentelemac/libs/
$> cd ~/opentelemac/libs/
$> tar zxvf metis-4.0.3.tar.gz
$> cd metis-4.0.3/
$> make
```

3.4 Configuration procedure

Once the required and recommended software have been installed on the target computer, users can carry out the rest of the TELEMAC installation procedure without administrative rights.

3.4.1 Configuration

First, it is recommended that the user **PATH** be modified or added to the user environment variables so that it also refers to the python scripts. This will help with the use of those scripts.

- On Windows operating systems, assuming the TELEMAC system is stored in the directory area **c:/opentelemac/v6p1/** then the **PATH** should also include **c:/opentelemac/v6p1/pytel**. ('**;**' are path separators on Windows)

- On Linux operating systems, assuming the TELEMAC system is stored in the directory area **\home\user\opentelemac\v6p1** then **\home\user\opentelemac\v6p1\pytel** should also be included in the user **PATH** ('**:**' are path separators on Linux).

Second, it is recommended to create or modify a text file named **systel.cfg**, or configuration file, based on a series of pre-defined examples for various platforms and Fortran compilers. The

[2] It is noted that maintenance and update of the CSM and associated software (in this case to the more recent version of the METIS library) will be organised through the Fee-For-Service arrangement.

TELEMAC system uses this file to find its way on the user desktop or high performance computer. The configuration file includes option defaults, compiler commands and references to external libraries such as for the MPI-2 implementation or the METIS library. It is located in the config subdirectory, under the root of the TELEMAC system:

- On Windows operating systems, assuming the TELEMAC system is stored in the directory area c:/opentelemac/v6p1/ then the configuration file systel.cfg should be found in c:/opentelemac/v6p1/config.

- On Linux operating systems, assuming the TELEMAC system is stored in the directory area \home\user\opentelemac\v6p1\ then the configuration file systel.cfg should be found in \home\user\opentelemac\v6p1\config.

Examples provided in the config subdirectory with the TELEMAC system download cover most common operating systems, such as Windows, Ubuntu-Linux, Fedora-Linux, OpenSUSE-Linux, and the most common Fortran compilers such as Intel Fortran Compiler and gfortran. Further information on the edition of the configuration file can be found on the website: http://www.opentelemac.org (menu tab "Documentations / Installations" following the "Installation Procedure with Python" and further "Configuring the TELEMAC system on your computer"). An example is reproduced below for Linux, where the commented lines are indicated in green.

Example of configuration file for Linux:

~/opentelemac/v6p1/config/systel.cfg

```
[Configurations]
configs:            ubuqfopenmpi
#
#
[ubuqfopenmpi]
#
root:               /home/telemac/opentelemac/v6p1
version:            v6p1
language:           2
modules:            update system
#
#par_cmdexec:        <config>/partel >> <partel.log>
par_cmdexec:        <config>/partel_prelim; python <root>/pytel/utils/partitioning.py >> <partel.log>
#mpi_hostfile: ..    /hostfile
mpi_hosts:          glc01 glc02 glc03 glc05 glc06 glc07 glc08 glc09 glc11
mpi_cmdexec:        /usr/bin/mpiexec <hostfile> <ncsize> <wdir> <exename>
#
cmd_obj:            qfortran -c -O3 -ffixed-line-length-132 -fconvert=big-endian -frecord-marker=4
                                                                    <mods> <incs> <f95name>
cmd_lib:            ar cru <libname> <objs>
cmd_exe:            /usr/bin/mpif90 -fconvert=big-endian -frecord-marker=4 -lpthread -v -lm -o
                                        <exename> <objs> -Xlinker --start-group <libs> --end-group
#
mods_all:           -I <config>
incs_parallel:      -I /usr/lib/openmpi/include/
#incs_parallel:      -I /usr/include/mpich2-x86_64
libs_parallel:      /home/ telemac/opentelemac /libs/metis-4.0.3/libmetis.a
libs_all     :      /usr/lib/openmpi/lib/libmpi.so
#libs_all     :       /usr/lib64/mpich2/lib/libmpich.a
#
```

3.4.2 Compilation

Once the desktop or high performance computer is configured, the installation procedure can be completed by the compilation of the entire TELEMAC source code. This is an optional but

recommended step for those users who downloaded the binaries of the TELEMAC system and necessary for those who downloaded the sources from the repository.

The compilation is achieved by executing the following Python script: **compileTELEMAC.py**. For instance:

- On Windows operating systems, in a DOS command windows the following command must be executed:

DOS window

```
c:\opentelemac> compileTELEMAC.py
```

- On Linux operating systems, in a Linux terminal the following command must be executed:

terminal

```
$~/opentelemac> compileTELEMAC.py
```

At the end of the compilation, the following message would demonstrate successful execution:

```
My work is done
```

Further information on the compilation of the TELEMAC system can be found on the website: http://www.opentelemac.org (menu tab "**Documentations / Installations**" following the "**Installation Procedure with Python**").

4 TESTING TELEMAC-2D OF THE TELEMAC SYSTEM

4.1 Running-a-simulation requirements

Running a TELEMAC-2D simulation requires a minimum of three user files:

- A steering file, commonly called the **CAS** file. It is a text file containing the list of numerical and physical parameters (keyword=values), and including the names and paths to any other input and output files needed for the simulation;

- A geometry file, commonly called the **GEO** file. It is a binary file containing the unstructured model mesh and the interpolated bathymetry. It is stored in SELAFIN format, which can be read/written by a number of pre- and post-processing tools and software such as BlueKenue (see Section 5);

- A boundary conditions file, commonly called the **CONLIM** file. It is a text file containing a description of each boundary segment in the model, distinguishing for example open boundary segments (node locations of open waters) from solid segments (node locations of islands and coastline).

Additional files may be required depending on the options chosen by the user. In particular, a Fortran file, commonly called the **PRINCI** file, can be specified, which allows users to re-write parts of the standard source code for various applications or new code developments. In this case the Fortran file is automatically re-compiled and combined with the rest of the TELEMAC system before the simulation starts.

More information about input files is given in the TELEMAC-2D User Manual. The steering file is based on a number of keywords, the list of which is given in the TELEMAC-2D Reference Manual (see list of references).

4.2 Available library of test cases

Hosted on the same repository as the TELEMAC source code is a series of test cases provided as examples of model setups covering a wide range of applications. Using the same methodology and credentials as provided above (see Section 3.2), the SVN address is:

- Address: http://svn.opentelemac.org/svn/opentelemac/validation/.

Because the validation dossier includes **GEO** files for dozens of test cases across all modules of the TELEMAC system, the download of that dossier may take some time.

4.3 Running a test case

Once the validation dossier has been downloaded, running TELEMAC-2D for one of the test cases is achieved by executing the following Python script: **telemac2d.py**, providing as argument the name of the **CAS** file. For instance:

- On Windows operating systems, in a DOS command windows the following command must be executed:

DOS window

```
c:\opentelemac > cd c:\opentelemac\validation\telemac2d\tel2d_v6p1\011_bumpflu
c:\...\telemac2d\tel2d_v6p1\011_bumpflu> telemac2d.py –s t2d_bumpflu_v1p0.cas
```

- On Linux operating systems, in a Linux terminal the following command must be executed:

terminal

```
$~/opentelemac>  cd  ~/opentelemac/validation/telemac2d/tel2d_v6p1/011_bumpflu
$~/.../telemac2d/tel2d_v6p1/011_bumpflu>  telemac2d.py –s t2d_bumpflu_v1p0.cas
```

At the end of the simulation, the following message would demonstrate successful execution:

```
My work is done
```

Additional information on the use of TELEMAC-2D can be found in the TELEMAC-2D User Manual. Additional information on the test cases can be found in the TELEMAC-2D Validation Document (see list of references).

Previous scripting conventions:
For users of version v6p1 or earlier, the Python script telemac2d.py does not exist (it was introduced with v6p2 and is available with the branch of the CSM). Instead, the user should use the full command of the script runcode.py telemac2d.

5 VISUALISATION AND ANALYSIS OF TELEMAC-2D RESULTS

For completeness, it is noted that results from TELEMAC-2D can be visualised using BlueKenue, developed by the Canadian Hydraulics Centre, National Research Council. The software and its documentation can be downloaded from the following link: http://www.nrc-cnrc.gc.ca/eng/ibp/chc/software/kenue/blue-kenue.html

For advanced users, the result files can also be handled using python tools included in the pytel subdirectory of the TELEMAC structure.

REFERENCES

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TELEMAC-2D Reference Manual. http://www.opentelemac.org/downloads/MANUALS/TELEMAC-2D/telemac2d_reference_manual_v6p0.pdf