

TRAINING WORKSHOP

“FLOW AND SEDIMENT TRANSPORT MODELING IN RIVER
BASINS USING TELEMAC 2D AND 3D NUMERICAL CODES”

February 26-28, 2022



3D hydrodynamics - TELEMAC-3D

Steering Telemac-3D: parameters and data files

Chen Peng-An



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Difficulty



✓ One-dimensional numerical model:

- HEC-RAS (Maskey & Ruther, 2019)
- SRH-1D
- MASCARET

✓ Two-dimensional numerical model:

- SRH-2D (Huang et al., 2019)
- RESED-2D (Hung et al., 2009)
- Anaysy CFX

✓ Three-dimensional numerical model:

- ANSYS-CFX (De Cesare et al., 2006)
- FLOW-3D (Janocko et al., 2013)
- SSIM-3D (Esmaeili et al., 2017; 2018)
- Telemac-3D (Pérez-Díaz et al., 2019)

Consider more complicated unsteady flow, backflow and sediment transportation.

Effectively grasp the complex flow regime and sediment migration behavior.



Computational time

Accuracy



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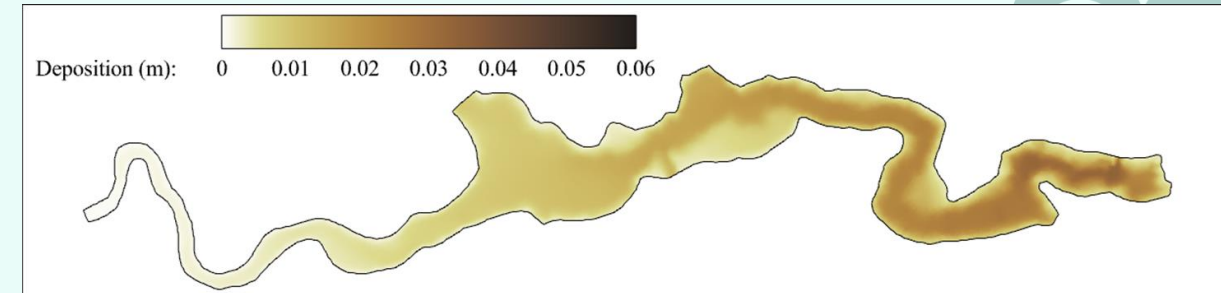


Output file

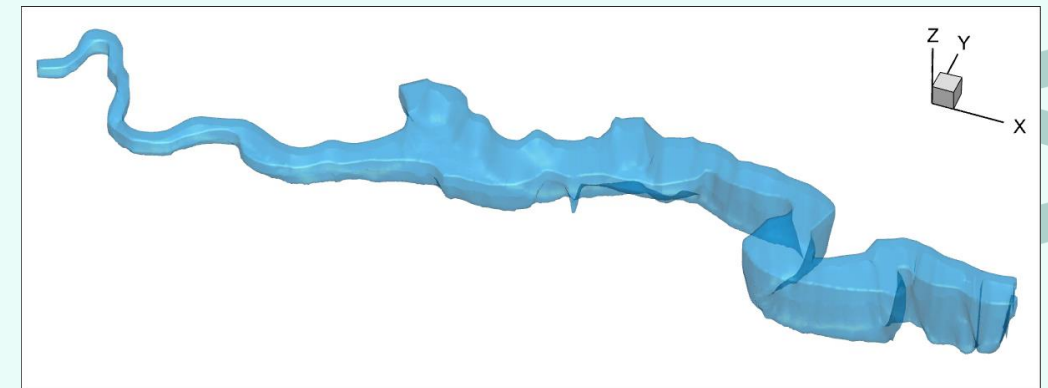


```
-----/
/  TELEMAC-3D      -  Shihmen_TC      /
/                   Chen              /
/-----/
/  COMPUTER INFORMATIONS
/-----/
/  GEOMETRY FILE           = Bottom_50m.slf
/  BOUNDARY CONDITIONS FILE = BOTTOM_BC.cli
/  3D RESULT FILE         = r3d_Shihmen.slf
/  2D RESULT FILE         = r2d_Shihmen.slf
/  LIQUID BOUNDARIES FILE  = Magat_Boundary.txt
/  COUPLING WITH          = 'GAIA'
/  GAIA STEERING FILE      = Gaia_Magat_2D.cas
/-----/
/  GENERAL INFORMATIONS - OUTPUTS
/-----/
/  TITLE                   = 'Magat3D'
/  VARIABLES FOR 2D GRAPHIC PRINTOUTS = H,S,B,F,TA*,W,HD,EF,DF,DZF,RB,QS
/  VARIABLES FOR 3D GRAPHIC PRINTOUTS = Z,U,V,W,RHO,TA*,RI
/  MASS-BALANCE            = YES
/  INITIAL TIME SET TO ZERO = YES
/  TIME STEP               = 60
/  NUMBER OF TIME STEPS    = 600
/  GRAPHIC PRINTOUT PERIOD = 1
/  LISTING PRINTOUT PERIOD = 10
/-----/
/  VERTICAL MESH
/-----/
/  NUMBER OF HORIZONTAL LEVELS : 15
/  MESH TRANSFORMATION         : 1
/-----/
/  TIDAL FLATS
/-----/
/  TIDAL FLATS : YES
/  OPTION FOR THE TREATMENT OF TIDAL FLATS : 1
/  TREATMENT OF NEGATIVE DEPTH : ^
```

2D: Deposition



3D: sediment transport



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Physical parameters: Layer



```

/-----/
/  TELEMAC-3D    -  Shihmen_TC      /
/                   Chen            /
/-----/

/  COMPUTER INFORMATIONS
/-----/

GEOMETRY FILE           = Bottom_50m.slf
BOUNDARY CONDITIONS FILE = BOTTOM_BC.cli
3D RESULT FILE          = r3d_Shihmen.slf
2D RESULT FILE          = r2d_Shihmen.slf
LIQUID BOUNDARIES FILE  = Magat_Boundary.txt
COUPLING WITH           = 'GAIA'
GAIA STEERING FILE      = Gaia_Magat_2D.cas
/-----/

/  GENERAL INFORMATIONS - OUTPUTS
/-----/

/
TITLE                   = 'Magat3D'
VARIABLES FOR 2D GRAPHIC PRINTOUTS = H,S,B,F,TA*,W,HD,EF,DF,DZF,RB,QS
VARIABLES FOR 3D GRAPHIC PRINTOUTS = Z,U,V,W,RHO,TA*,RI
MASS-BALANCE            = YES
INITIAL TIME SET TO ZERO = YES
TIME STEP               = 60
NUMBER OF TIME STEPS    = 600
GRAPHIC PRINTOUT PERIOD = 1
LISTING PRINTOUT PERIOD  = 10
/-----/

/  VERTICAL MESH
/-----/
NUMBER OF HORIZONTAL LEVELS : 15
MESH TRANSFORMATION         : 1
/-----/

/  TIDAL FLATS
/-----/
TIDAL FLATS                : YES
OPTION FOR THE TREATMENT OF TIDAL FLATS : 1
TREATMENT OF NEGATIVE BEDS : ^
    
```

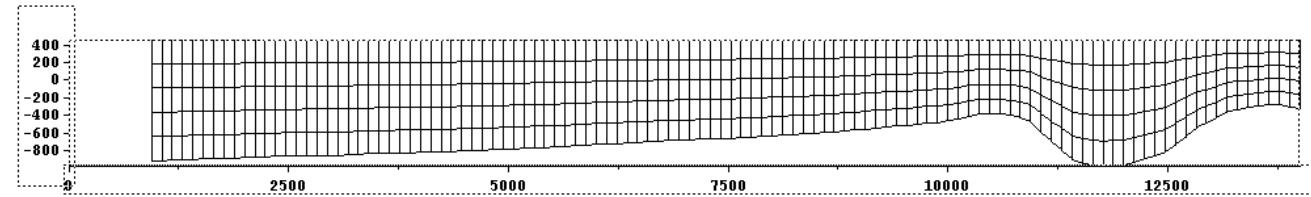
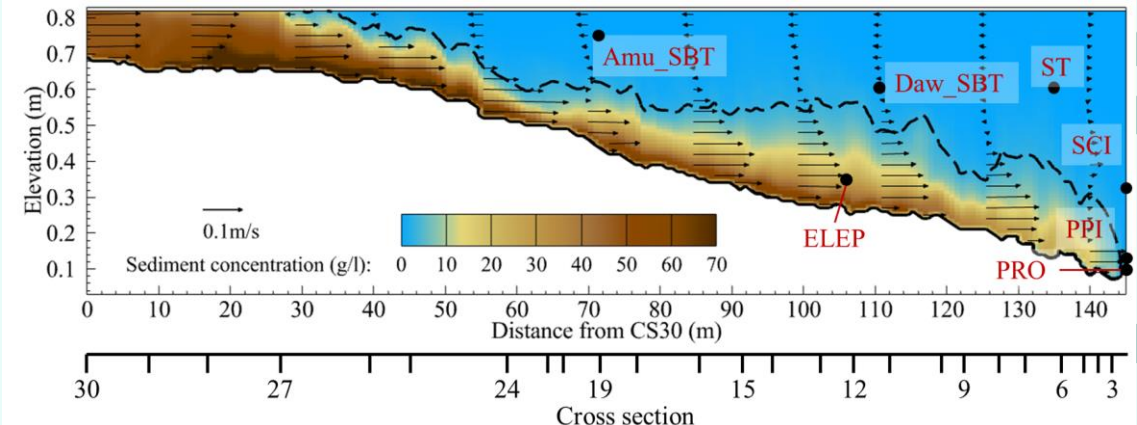


Figure 4.1: Effect of the MESH TRANSFORMATION keyword – Value 1: sigma.

Uniform layer is not suitable



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Physical parameters: Layer



```

/-----/
/  TELEMAC-3D    -  Shihmen_TC      /
/                   Chen            /
/-----/

/  COMPUTER INFORMATIONS
/-----/

GEOMETRY FILE           = Bottom_50m.slf
BOUNDARY CONDITIONS FILE = BOTTOM_BC.cli
3D RESULT FILE          = r3d_Shihmen.slf
2D RESULT FILE          = r2d_Shihmen.slf
LIQUID BOUNDARIES FILE  = Magat_Boundary.txt
COUPLING WITH           = 'GAIA'
GAIA STEERING FILE      = Gaia_Magat_2D.cas
/

/-----/
/  GENERAL INFORMATIONS - OUTPUTS
/-----/

TITLE                   = 'Magat3D'
VARIABLES FOR 2D GRAPHIC PRINTOUTS = H,S,B,F,TA*,W,HD,EF,DF,DZF,RB,QS
VARIABLES FOR 3D GRAPHIC PRINTOUTS = Z,U,V,W,RHO,TA*,RI
MASS-BALANCE            = YES
INITIAL TIME SET TO ZERO = YES
TIME STEP               = 60
NUMBER OF TIME STEPS    = 600
GRAPHIC PRINTOUT PERIOD = 1
LISTING PRINTOUT PERIOD = 10
/

/-----/
/  VERTICAL MESH
/-----/

NUMBER OF HORIZONTAL LEVELS : 15
MESH TRANSFORMATION         : 1
/

/  TIDAL FLATS
/-----/

TIDAL FLATS                : YES
OPTION FOR THE TREATMENT OF TIDAL FLATS : 1
TREATMENT OF NEGATIVE BEDS : ^
    
```

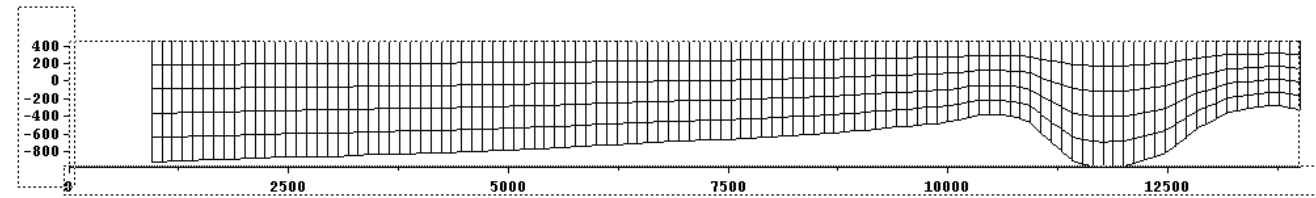


Figure 4.1: Effect of the MESH TRANSFORMATION keyword – Value 1: sigma.

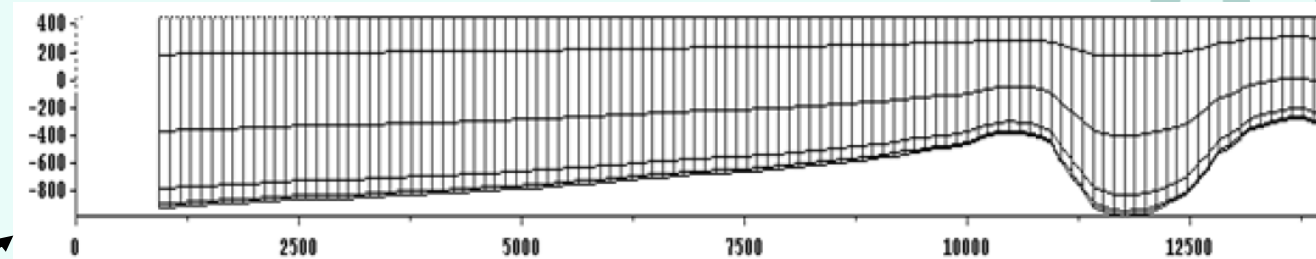


Figure 4.2: Effect of the MESH TRANSFORMATION keyword – Value 2: zstar.

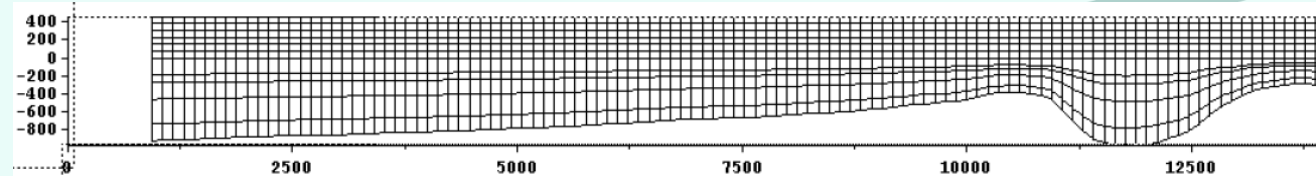


Figure 4.3: Effect of the MESH TRANSFORMATION keyword – Value 3: user defined.

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t3d_example_shihmen.cas - 記事本

檔案 編輯 檢視

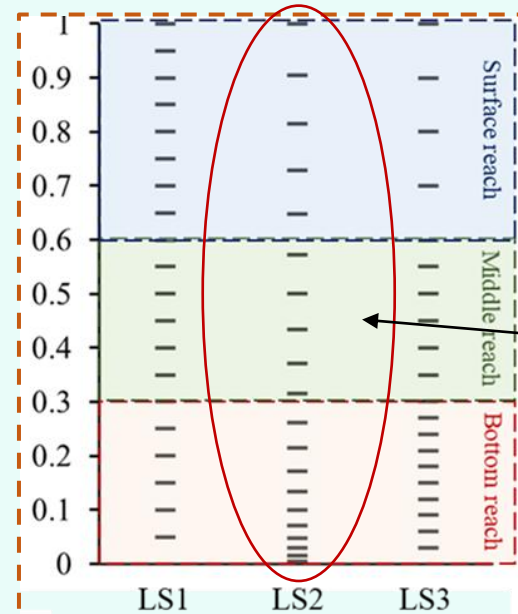
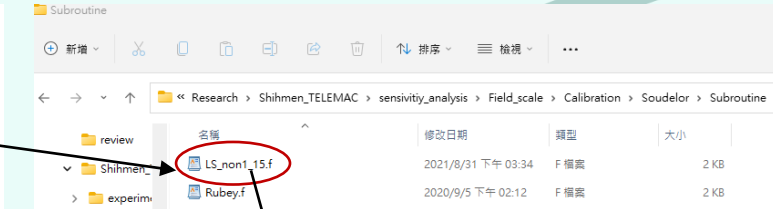
```

/-----/
/  TELEMAR-3D      - Shihmen_TC  /
/                   Chen        /
/-----/
/ COMPUTER INFORMATION /
/-----/
GEOMETRY FILE           = 2015_X240all2_mid.slf
BOUNDARY CONDITIONS FILE = 2015_X240all2_mid.cli
3D RESULT FILE          = r3d_Shihmen.slf
2D RESULT FILE          = r2d_Shihmen.slf
FORTRAN FILE            = 'Subroutine'
LIQUID BOUNDARIES FILE  = Shihmen_GAIA_Boundary.txt
/COMPUTATION CONTINUED  = YES
/PREVIOUS COMPUTATION FILE = wet_Shihmen.slf
INITIAL TIME SET TO ZERO = YES
GAIA STEERING FILE      = gia_example_shihmen.cas
/-----/
/ GENERAL INFORMATION - OUTPUTS /
/-----/
TITLE                   = 'Shihmen_TC_experiment'
VARIABLES FOR 2D GRAPHIC PRINTOUTS = H,S,B,F,TA*,W,HD,EF,DF,DZF,RB,QS
VARIABLES FOR 3D GRAPHIC PRINTOUTS = Z,U,V,W,RHO,TA*,RI
COUPLING WITH MASS-BALANCE = 'GAIA'
INITIAL TIME SET TO ZERO = YES
TIME STEP               = 4
NUMBER OF TIME STEPS    = 64800
GRAPHIC PRINTOUT PERIOD = 900
LISTING PRINTOUT PERIOD = 900
/-----/
/ VERTICAL MESH /
/-----/
NUMBER OF HORIZONTAL LEVELS : 15
MESH TRANSFORMATION         : 2
    
```

Physical parameters: Layer



extract_data	2021/10/16 下午 03:39	檔案資料夾
Subroutine	2021/10/16 上午 10:42	檔案資料夾
t3d_example_shihmen.cas_2021-10-16...	2021/10/16 下午 03:37	檔案資料夾
2015_X240all2_mid.cli	2021/10/7 下午 01:10	CLI 檔案 113 KB
2015_X240all2_mid.slf	2021/10/7 下午 01:08	SLF 檔案 625 KB
gai_shihmen.slf	2021/10/16 下午 03:26	SLF 檔案 56,702 KB
gia_example_shihmen.cas	2021/10/16 下午 12:29	CAS 檔案 2 KB
r2d_Shihmen.slf	2021/10/16 下午 03:25	SLF 檔案 33,310 KB
r3d_Shihmen.slf	2021/10/16 下午 03:26	SLF 檔案 434,191 KB
Shihmen_GAIA_Boundary.txt	2021/10/3 上午 11:11	文字文件 4 KB
src_shihmen - 複製.txt	2021/10/2 下午 05:24	文字文件 3 KB
src_shihmen.txt	2022/2/26 下午 12:32	文字文件 3 KB
t3d_example_shihmen.cas	2021/10/16 下午 12:29	CAS 檔案 7 KB
t3d_example_shihmen.cas_2021-10-16...	2021/10/16 下午 03:26	SORTIE 檔案 304 KB
t3d_example_shihmen.cas_2021-10-16...	2021/10/16 下午 03:26	WinRAR ZIP 壓縮檔 1,476 KB



```

*****
! TELEMAR3D
*****
! brief  DEFINES THE MESH TRANSFORMATION
! history C.-T. PHAM (LNHE)
!+ 24/03/2017
!+ V7P3
!+ Creation from not splitted CONDIM
!+ Called by CONDIM
!-----
! USE DECLARATIONS TELEMAR3D
! USE INTERFACE TELEMAR3D, EX_USER_MESH_TRANSF => USER_MESH_TRANSF
!
! IMPLICIT NONE
!
!-----
! INTEGER IPLAN
!
!-----
! DO IPLAN = 1,15
!   TRANSF_PLANE%(IPLAN)=2
! ENDDO
! ZSTAR%(1)=0.D0
! ZSTAR%(2)=0.025D0
! ZSTAR%(3)=0.05D0
! ZSTAR%(4)=0.0833D0
! ZSTAR%(5)=0.125D0
! ZSTAR%(6)=0.175D0
! ZSTAR%(7)=0.233D0
! ZSTAR%(8)=0.3D0
! ZSTAR%(9)=0.375D0
! ZSTAR%(10)=0.4583D0
! ZSTAR%(11)=0.55D0
! ZSTAR%(12)=0.65D0
! ZSTAR%(13)=0.7583D0
! ZSTAR%(14)=0.875D0
! ZSTAR%(15)=1.D0
!
!-----
! RETURN
! END
    
```

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Physical parameters: TURBULENCE MODEL



- The turbidity current transportation in the **horizontal** direction is **stable** and **complex interaction** in the **vertical** direction
- Therefore, it is reliable to adopt **Cst** for **horizontal** aspect and **$k-\omega$** for **vertical** aspect in the turbidity current simulation.

```
Magat_3D.cas - 記事本
-----
INITIAL TIME SET TO ZERO      = YES
TIME STEP                    = 60
NUMBER OF TIME STEPS         = 600
GRAPHIC PRINTOUT PERIOD      = 1
LISTING PRINTOUT PERIOD      = 10
/
/-----
/ VERTICAL MESH
/-----
NUMBER OF HORIZONTAL LEVELS  : 15
MESH TRANSFORMATION         : 1
/-----
/ TIDAL FLATS
/-----
TIDAL FLATS                  : YES
OPTION FOR THE TREATMENT OF TIDAL FLATS : 1
TREATMENT OF NEGATIVE DEPTHS : 2
THRESHOLD FOR SEDIMENT FLUX CORRECTION ON TIDAL FLATS : 0.0001 / Below this limiting depth, a
MINIMAL VALUE FOR DEPTH : 0.01 / !!!
/-----
/ SOURCE TERMS
/-----
LAW OF BOTTOM FRICTION       : 2
FRICTION COEFFICIENT FOR THE BOTTOM : 76.923
VERTICAL TURBULENCE MODEL    : 3 / 3kepsilon 2longueur me
COEFFICIENT FOR VERTICAL DIFFUSION OF VELOCITIES : 1.0-6
MIXING LENGTH MODEL         : 3
HORIZONTAL TURBULENCE MODEL  : 3 / 1viscosite cste
COEFFICIENT FOR HORIZONTAL DIFFUSION OF VELOCITIES : 1.0-6
AVERAGE WATER DENSITY      = 1000.
/-----
/ ADVECTION-DIFFUSION
/-----
SCHEME FOR ADVECTION OF VELOCITIES : 14
SCHEME FOR ADVECTION OF TRACERS   : 14
SCHEME FOR ADVECTION OF K-EPSILON : 14
SUPG OPTION                       : 0:0
NON-HYDROSTATIC VERSION           : YES
FREE SURFACE GRADIENT COMPATIBILITY : 0.5
TREATMENT OF FLUXES AT THE BOUNDARIES : 1:1
/-----
```

Cases	Horizontal aspect	Vertical aspect	CPU time (min)	RMSE (g/l)			
				Bottom reach	Cross section	Outlet	Mean
Same scheme for horizontal and vertical aspects							
1	Cst	Cst	27.82	29.50	23.51	20.71	22.11
2	$k-\varepsilon$	$k-\varepsilon$	34.82	28.27	22.71	23.08	22.89
3	$k-\omega$	$k-\omega$	38.83	26.61	21.82	22.31	22.07
4	Smag	Smag	30.28	112.82	82.53	84.97	83.75
Mixing scheme for horizontal and vertical aspects							
5	$k-\omega$	Cst	40.42	27.08	22.09	22.04	22.07
6	Cst	$k-\omega$	38.90	26.86	21.89	19.12	20.50
7	Cst	ML	28.20	129.76	95.05	94.67	94.86

- Similar to Smag, the ML is inappropriate for turbidity current simulation.

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Warning !!



```
Magat_2D.cas - 記事本
檔案 編輯 檢視

/-----/
/          FILE DEFINITION          /
/-----/
BOUNDARY CONDITIONS FILE      : 'BOTTOM_BC.cli'
GEOMETRY FILE                 : 'Bottom 50m.slf'
RESULTS FILE                  : 'Magat_V2.slf'
LIQUID BOUNDARIES FILE       = Magat_Boundary.txt /hydrograph B.C. file
/-----/
/          GENERAL OPTIONS          /
/-----/
TITLE : 'Magat'
VARIABLES FOR GRAPHIC PRINTOUTS : 'U,V,F,H,B,S,Q,W,L,T*'
TIME STEP                       : 25 /it should be determined by Courant Number
NUMBER OF TIME STEPS           : 20592
GRAPHIC PRINTOUT PERIOD        : 10
LISTING PRINTOUT PERIOD        : 10
TIDAL FLATS                    : YES
OPTION FOR THE TREATMENT OF TIDAL FLATS : 1
/-----/
/          COUPLING          /
/-----/
COUPLING WITH GAIA STEERING FILE : 'GAIA'
GAIA STEERING FILE               : 'Gaia_Magat_2D.cas' /steering file nar
/-----/
/          BOUNDARY CONDITIONS          /
/-----/
PRESCRIBED ELEVATIONS : 189.02; 0.0 /downstream boundary (water level)
PRESCRIBED FLOWRATES  : 0.0; 301 /upstream boundary (inflow discharge)
PRESCRIBED TRACERS VALUES : 0.0; 1.26 /upstream boundary (inflow sediment)
/-----/
/          INITIAL CONDITIONS          /
/-----/
INITIAL CONDITIONS : 'CONSTANT ELEVATION'
INITIAL ELEVATION  : 189.02 /initial water level
/-----/
```

```
Magat_3D.cas - 記事本
檔案 編輯 檢視

/-----/
/          TELEMAC-3D          /
/          - Shihmen_TC      /
/          - Chen            /
/-----/
/-----/
/          COMPUTER INFORMATIONS          /
/-----/
GEOMETRY FILE           = Bottom 50m.slf
BOUNDARY CONDITIONS FILE = BOTTOM_BC.cli
3D RESULT FILE          = r3d_Magat.slf
2D RESULT FILE          = r2d_Magat.slf
LIQUID BOUNDARIES FILE  = Magat_Boundary.txt
COUPLING WITH           = 'GAIA'
GAIA STEERING FILE      = Gaia_Magat_2D.cas
/-----/
/          GENERAL INFORMATIONS - OUTPUTS          /
/-----/
TITLE : 'Magat3D'
VARIABLES FOR 2D GRAPHIC PRINTOUTS : H,S,B,F,TA*,W,HD,EF,DF,DZF,RB,QS
VARIABLES FOR 3D GRAPHIC PRINTOUTS : Z,U,V,W,RHO,TA*,RI
MASS-BALANCE                       : YES
INITIAL TIME SET TO ZERO           : YES
TIME STEP                          : 25
NUMBER OF TIME STEPS               : 20592
GRAPHIC PRINTOUT PERIOD            : 50
LISTING PRINTOUT PERIOD            : 50
/-----/
/          VERTICAL MESH          /
/-----/
NUMBER OF HORIZONTAL LEVELS : 15
MESH TRANSFORMATION         : 1
/-----/
/          TIDAL FLATS          /
/-----/
TIDAL FLATS : YES
OPTION FOR THE TREATMENT OF TIDAL FLATS : 1
TREATMENT OF NEGATIVE DEPTHS : 2
THRESHOLD FOR SEDIMENT FLUX CORRECTION ON TIDAL FLATS : 0.0001 / Below this limiting depth, a
MINIMAL VALUE FOR DEPTH : 0.01 / !!!
/-----/
/          SOURCE TERMS          /
/-----/
```

```
v8p3r1.exe
+> root: C:\yopentelemac-mascaret\v8p3r1
+> module: ad / api / artemis / bief
          damocles / gaia / gretel / hermes
          identify_liq_bnd / khione / mascaret / nestor
          parallel / partel / postel3d / sisyphe
          special / stbtel / telemac2d / telemac3d
          tomawac / waqtel

.....

.. processing the steering file
..> Checking keyword/rubrique coherence
Traceback (most recent call last):
  File "C:\yopentelemac-mascaret\v8p3r1\scripts\python3\telemac3d.py", line 7, in <module>
    main('telemac3d')
  File "C:\yopentelemac-mascaret\v8p3r1\scripts\python3\runcode.py", line 279, in main
    run_study(cas_file, code_name, options)
  File "C:\yopentelemac-mascaret\v8p3r1\scripts\python3\execution\run_cas.py", line 163, in run_study
    mv_study = Study()
  File "C:\yopentelemac-mascaret\v8p3r1\scripts\python3\execution\study.py", line 130, in __init__
    self.cas = TelemacCas(self.steering_file, self.dico_file)
  File "C:\yopentelemac-mascaret\v8p3r1\scripts\python3\execution\telemac_cas.py", line 110, in __init__
    self._check_content()
  File "C:\yopentelemac-mascaret\v8p3r1\scripts\python3\execution\telemac_cas.py", line 216, in _check_content
    raise TelemacException(
utils.exceptions.telemacException: Unknown keyword RESULTS FILE in steering file Magat_3D.cas

C:\yopentelemac-mascaret\v8p3r1\examples\Magat_Sc4_3D_CorBC>
```


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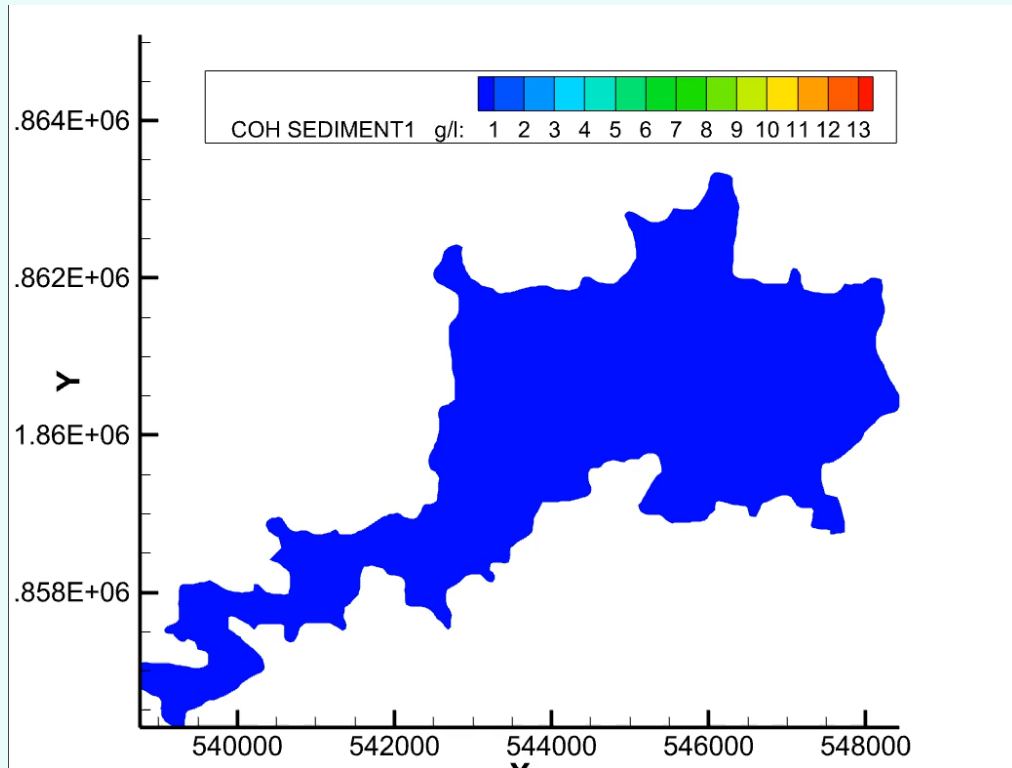
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2D vs. 3D



2D simulation



3D simulation

