CROCO

Coastal and Regional Ocean COmmunity model

Review of Some Sediment Test Cases

rachid.benshila@legos.obs-mip.fr
solene.le.gac@ifremer.fr
guillaume.morvan@legos.obs-mip.fr

https://croco-ocean.gitlabpages.inria.fr/croco_doc

Sediment test cases

WHY? >> Isolate specific sediment processes … with low computational resources

Initiate comparisons between sediment models

- See which processes are present within each model (different schemes, vertical grid, morphodynamic management ...)
- Establish the qualities and shortcomings for each

Sediment codes in Croco ?

Sediment USGS (U.S. Geological Survey model): native one, from the UCLA/ROMS Communauty / USGS , Blaas et al. (2007), Warner et al. (2008) and Shafiei et al. (2021)
(Contact in Croco team → P.Marchesiello, R.Benshila, G.Morvan)

Mustang model (MUd and Sand TrAnsport modelliNG) from Ifremer / Dhysed
(Contact in croco team → F. Dumas, M.Caillaud, S.Le Gac)

Sedim.Test cases	Cppkeys	Model used (to be tested)	Processes transport / scheme ?
Plannar Beach	SHOREFACE	Usgs	Wave current Interaction (WCI)
Sandbar	SANDBAR	Usgs	WCI / Bedload / Suspload / Morpho
Rip	RIP	Usgs	WCI
Dune	DUNE	Usgs/Mustang	Non cohesive sediments / Bedload / Morpho
Dune 3d	DUNE3D	Usgs/Mustang	Non cohesive sediments / Bedload / Morpho
Analytical Dune	ANA_DUNE	Usgs/Mustang	Non cohesive sediments / Bedload
Sed toy (Rouse)	SED_TOY_ROUSE	Usgs/Mustang	Cohesive sediments / Suspload
Sed toy (Double Resuspension)	SED_TOY_RESUSP	Usgs (Mustang)	Mixed bed / Double erosion and resuspension events / stratigraphy
Sed toy (consolidation)	SED_TOY_CONSOLID	Usgs (Mustang)	Mixed bed / Consolidation / Swelling
Sed toy (flocculation)	SED_TOY_FLOC	(Usgs / Mustang)	Mixed bed / Flocculation
Tidal Flat	TIDAL_FLAT	(Usgs)/Mustang	Mixed bed / effects from tidal cycles forcing
Estuary	ESTUARY	(Usgs)/Mustang	Tide and river flowrate effect on mixed sediment
Vilaine (Realistic case)	COASTAL + VILAINE	Mustang	Mixed Bed, realistic case

DUNE test cases

<u>Purpose ?</u>

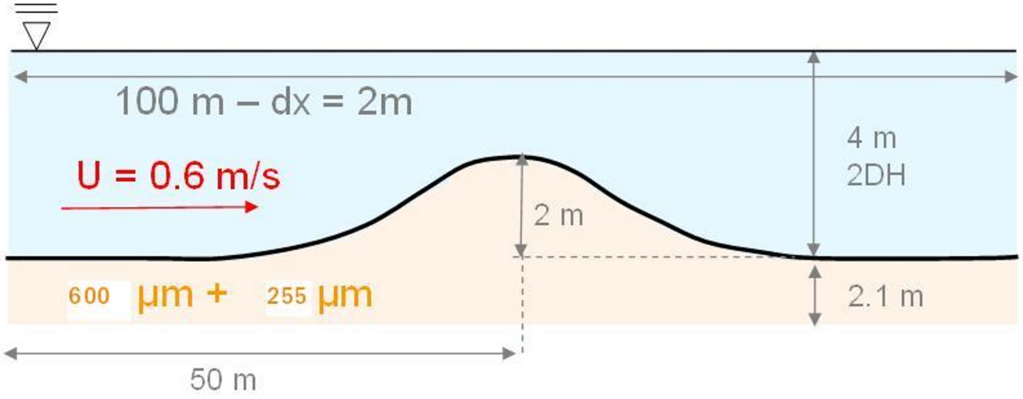
- test the capacity of the model to simulate the migration of an idealised gaussian shaped dune
- test bedload process only
- check if the dune is steepening downstream while propagating
- check how sands are sorted as long as the dune evolves

<u>Sub cases</u> :

- **DUNE3D** : the same than **DUNE** but in 3d
- **ANA_DUNE** : analytical case from Marieu & al 2007, Long et al 2008 (to compare the dune migration with analytical solution of the bedload transport equation)

```
#elif defined DUNE
/*
!                        Dune test case example
!                        ==== ==== ==== =======
!
*/
# undef  ANA_DUNE     /* Analytical test case (Marieu) */
# undef  DUNE3D       /* 3D example */

# undef  OPENMP
# undef  MPI
# define M2FILTER_NONE
# define UV_ADV
# define NEW_S_COORD
# undef  UV_COR
# define SOLVE3D
# define ANA_GRID
# define ANA_INITIAL
# define ANA_SSFLUX
# define ANA_SRFLUX
# define ANA_STFLUX
# define ANA_BSFLUX
# define ANA_BTFLUX
# define ANA_SMFLUX
# define OBC_WEST
# define OBC_EAST
# define ANA_SSH
# define ZCLIMATOLOGY
# define ANA_M2CLIMA
# define M2CLIMATOLOGY
# define SEDIMENT
# undef  MUSTANG
# define MORPHODYN
# ifdef SEDIMENT
#  undef  SUSPLOAD
#  define BEDLOAD
#  undef  BEDLOAD_WENO5
#  ifdef ANA_DUNE
#   define BEDLOAD_MARIEU
#  else
#   define BEDLOAD_WULIN
#   define TAU_CRIT_WULIN
#  endif
# endif
# ifdef MUSTANG
#  define key_MUSTANG_V2
#  define key_MUSTANG_bedload
#  define key_tenfon_upwind
# endif
# define GLS_MIXING
# define NO_FRCFILE
# undef  RVTK_DEBUG
```

DUNE (default)



<u>Grid</u> :

Length of the channel : 100m / Resolution : 2m
Analytical and gaussian centred at the middle (50m)
Amplitude dune : 2m

<u>Model discretization</u> :

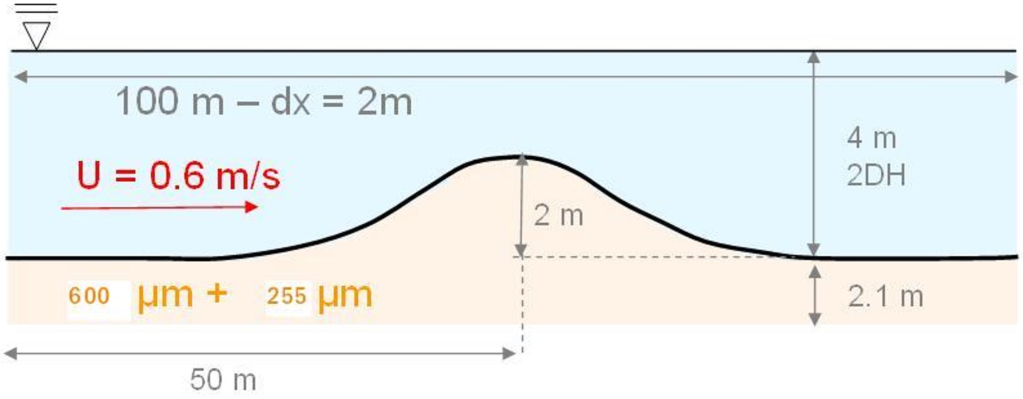
50 x-horizontal grid point (LLm0)
Seawater : 20 Layers (**N**)
Sediments : 10 Layers (**NLAY**)

first level on sediment is at bed
and then decrease at the bottom

NB : mustang model use a reverse index management on the sediment

```
!  * Seawater/sediment vertical level distribution:
!
!        W-level  RHO-level
!
!          N      __________
!                |          |
!                |    N     |
!        N-1     |__________|  S
!                |          |  E
!                |   N-1    |  A
!          2     |__________|  W
!                |          |  A
!                |    2     |  T
!          1     |__________|  E
!                |          |  R
!                |    1     |
!          0     |__________|______ bathymetry
!                |//////////|
!                |    1     |
!          1     |__________|  S
!                |          |  E
!                |    2     |  D
!          2     |__________|  I
!                |          |  M
!                |  NLAY-1  |  E
!       Nbed-1   |__________|  N
!                |          |  T
!                |   NLAY   |
!        Nbed    |__________|
!
```

DUNE (default)



Dynamics :

Periodic O-E barotropic flow (periodic case which generate a constant barotropic flow (0.6m/s)
Vertical Mixing Parameterization GLS (Generic Length Scale)
Morphodynamics (feedback to currents)

```
1  Stitle (a80)
ROMS - Dune Sediment - Test

2  Sd(1-NST), CSED, SRHO,  WSED,  ERATE,  TAU_CE, TAU_CD, BED_FRAC(1:NLAY)
     0.600     0.0  2650.   81     0.      0.29     0.1    10*0.5
     0.255     0.0  2650.   31     0.      0.17     0.1    10*0.5
```

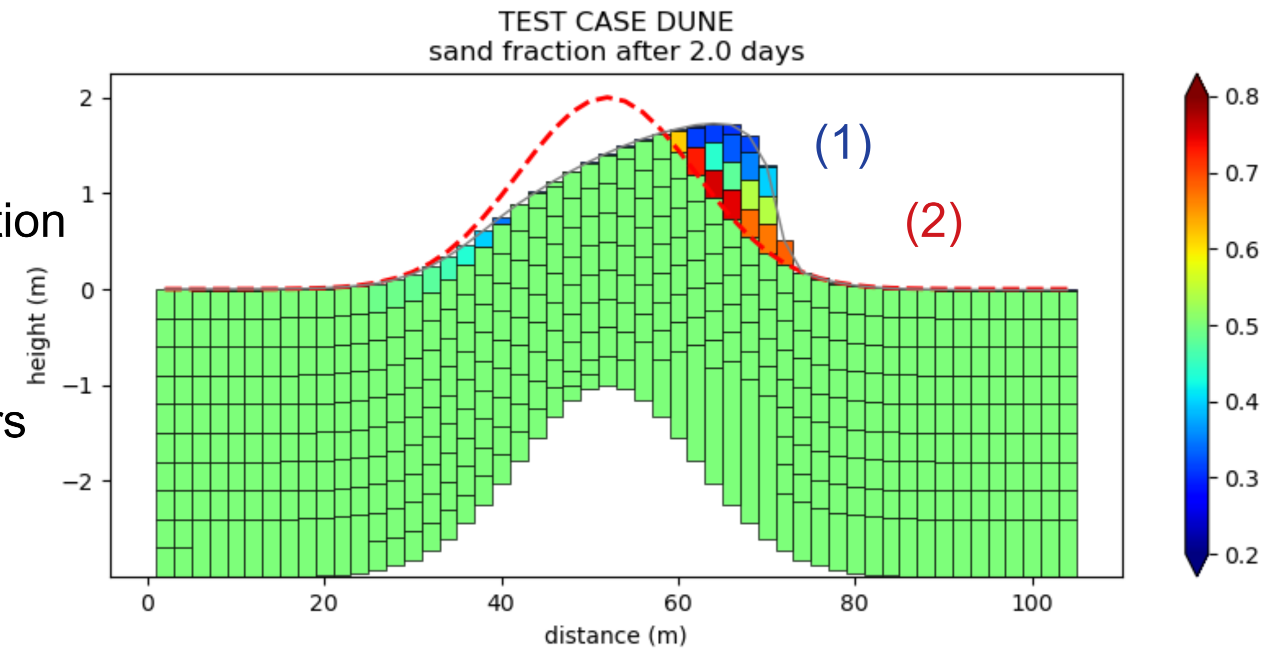
Sediments :

Non-cohesive sediment 2 classes (NST):
600 µm and 255 µm , density 2650 kg/m³ each
τ_c : critical shear stress for erosion (TAU_CE) i.e., the threshold for initiation of sediment motion (Pa)
3 meters of sediment (10 layers with layer thickness = 0.3 m for each)
Fraction of sediment for each grain size class 50% for each layers
No suspended load, bedload only (Wu et Lin, 2014 with slope effects (Lesser 2009))

DUNE (default - USGS)

Native position

10 layers



Finer sediment
(600 μm< 255 μm)

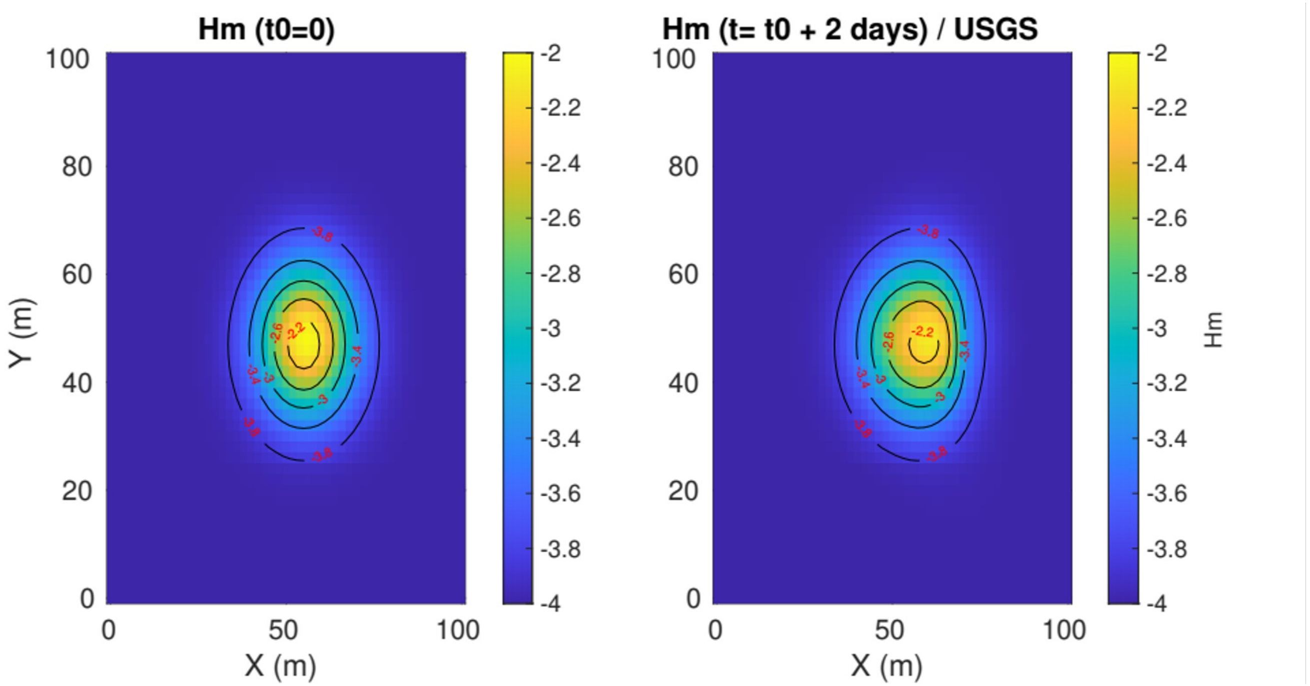
Coarser sediment
(600 μm> 255 μm)

Next to 2 days :

* the front moves forward ~10m
* coarser sand is in the majority on the top of bed (1)
* layer of finer sand just below it (2)

DUNE (3D)

```
#elif defined DUNE
/*
!                         Dune test case example
!                         ==== ==== ==== =======
!
*/
# undef  ANA_DUNE      /* Analytical test case (Marieu) */
# define  DUNE3D        /* 3D example */
```



→ Migration of a Sand bump forced by a barotropic constant flow
→ Evolution (Hm) Morphodynamics next 2 days

DUNE (Analytical)

```
#elif defined DUNE
/*
!                          Dune test case example
!                          ==== ==== ==== =======
!
*/
# define  ANA_DUNE      /* Analytical test case (Marieu) */
# undef  DUNE3D        /* 3D example */
```

Goal :

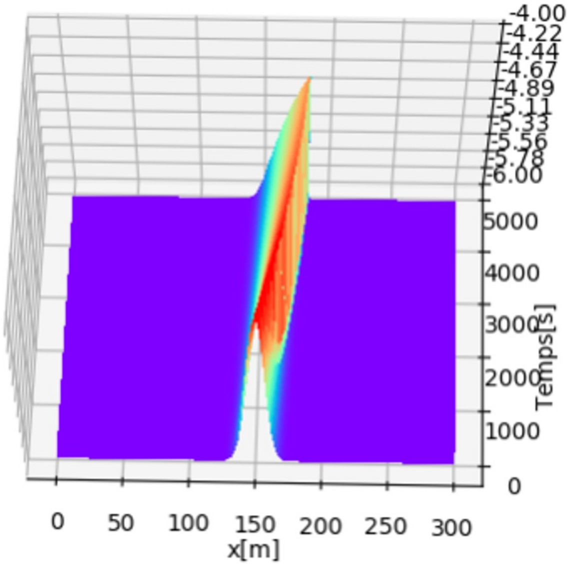
- Compare here, numerics (Croco) with analytical solutions (Marieu et al 2007)
- Test some flux interpolations methods when remain analytical steep slopes

Grid :

- Length of the channel : 300m / Resolution : 2m
- Analytical and gaussian centred at the middle (150m)
- Amplitude : 2m

Dynamics :

- Periodic O-E barotropic flow (u = 1.67 m.s^{-1})
- Morphodynamics (feedback to currents)
- Bottom roughness Length (Zob) : 1e^{-4} m



Marieu et al., 2007
Long et al, 2008

DUNE (Analytical)

sediment_ana_dune.in :

```
1  Stitle (a80)
ROMS - Dune Sediment - Test

2  Sd(1-NST), CSED, SRHO,  WSED,  ERATE,  TAU_CE, TAU_CD, BED_FRAC(1:NLAY)
      0.255    0.0  2650.   31     0.     0.17     0.1      11*1

3 BTHK(1:NLAY)
      11*0.3

4 BPOR(1:NLAY)
      11*0.4

5 Hrip
       0.

6 Lrip
       0.

7 bedload_coeff
      1.

8 morph_fac
      1.

99 END of sediment input data
```

Sediments :

- Non-cohesive sediment one class , Diameter (**Sd**) : 255 µm
- 3 meters of sediment (11 layers with layer thickness = 0.3 m for each

- **Bedload formulation:** Marieu et al 2007

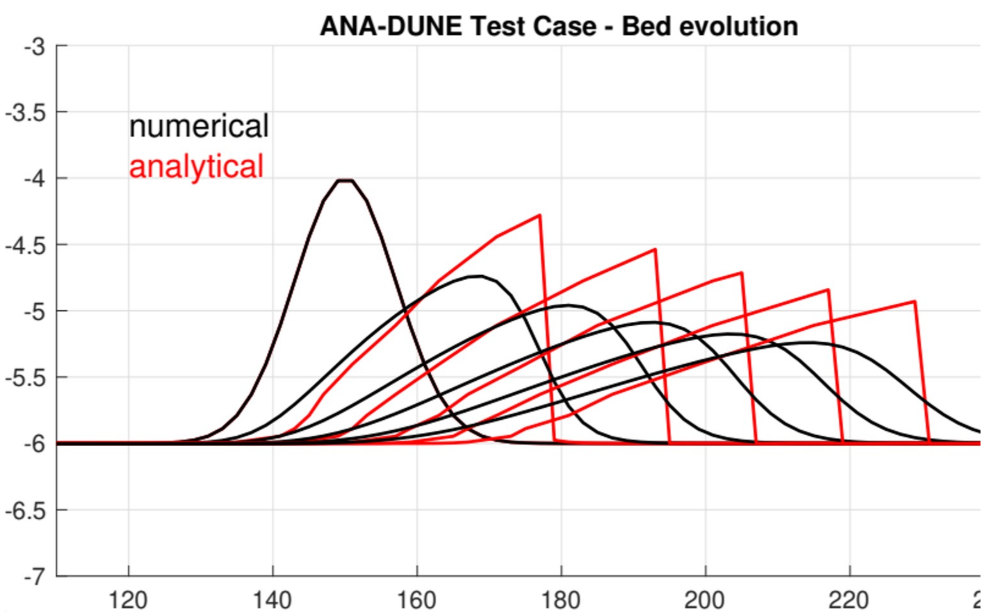
→ $q(x) = \alpha u(x)^{\beta}$ with $\alpha = 0.001 s^2/m$, $\beta = 3.0$

u(x) : barotropic u-current (m/s) **(for numerical solution)**

u(x) : Q/h (m/s) (channel flow=Q=10.m^2/s / h depth) (for analytical solution)

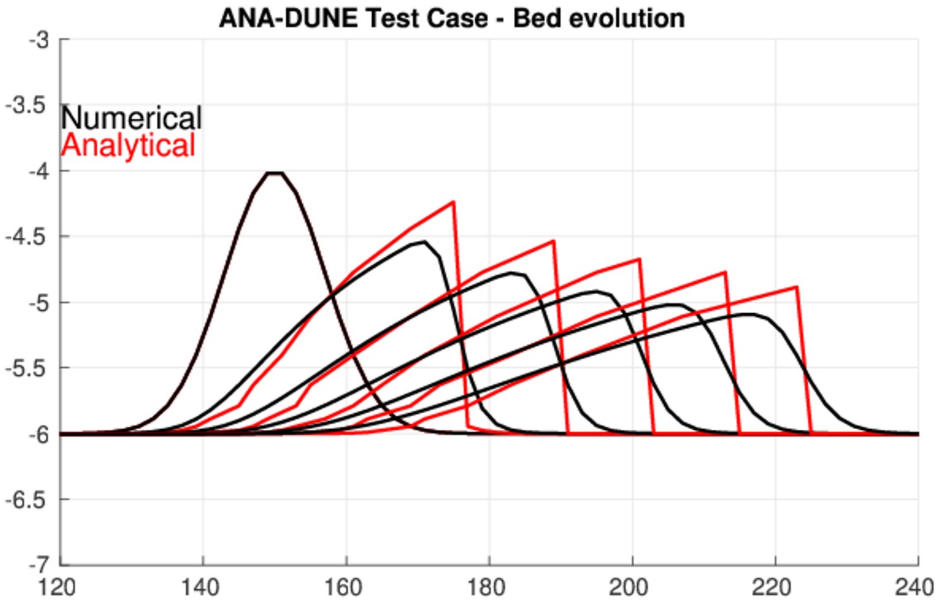
DUNE (Analytical)

Upwind first order interpolation flux **UP1**



Fifth order interpolation flux **WENO5**

```
# define BEDLOAD_WENO5
```



→ test some methods to interpolate flux
→ fifth order schemes allow to get closer to the steep slopes

Sed toy (1DV) test cases

Purpose ?

- cheap cases (one water column / flat bottom)
- periodic lateral boundary conditions on all sides
- suspended load only
- to isolate some processes with non-cohesive/cohesive sediments (erosion/ deposition/consolidation/flocculation)

Sub cases :

- SED_TOY_ROUSE : from Ifremer/Dhysed
- SED_TOY_RESUSP : from COAWST*
- SED_TOY_CONSOLID : from COAWST*

*(Coupled Ocean Atmosphere Wave Sediment System) , Sherwood & al, 2018

```
#elif defined SED_TOY
/*
!                       SED TOY (1D Single Column example)
!                       === === === ====== ====== ========
!
*/                            /* Choose an experiment :              */
# define SED_TOY_ROUSE        /*   Rouse                             */
# undef  SED_TOY_CONSOLID     /*   Consolidation                     */
# undef  SED_TOY_RESUSP       /*   Erosion and sediment resuspension */
# undef  SED_TOY_FLOC         /*   Flocculation                      */

# undef  OPENMP
# undef  MPI
# define NEW_S_COORD
# define SOLVE3D
# undef  NONLIN_EOS
# define SALINITY
# undef  UV_VIS2
# define ANA_GRID
# define ANA_INITIAL
# define ANA_SMFLUX
# define ANA_SRFLUX
# define ANA_STFLUX
# define ANA_SSFLUX
# define ANA_BTFLUX
# define ANA_BSFLUX
# define EW_PERIODIC
# define NS_PERIODIC

# ifdef SED_TOY_ROUSE
#  define ANA_VMIX
#  define BODYFORCE
# endif

# define SEDIMENT
# undef  MUSTANG
# ifdef SEDIMENT
#  define SUSPLOAD
#  undef  BEDLOAD
#  ifdef SED_TOY_ROUSE
#   define SED_TAU_CD_CONST
#  endif
#  if defined SED_TOY_FLOC || defined SED_TOY_CONSOLID || \
        defined SED_TOY_RESUSP
#   undef  BBL
#   define GLS_MIXING
#   define GLS_KOMEGA
#   define MIXED_BED
#   undef  COHESIVE_BED
#  endif
#  ifdef SED_TOY_FLOC
#   undef  FLOC_TURB_DISS
#   define FLOC_BBL_DISS
#   define SED_FLOCS
#   define SED_DEFLOC
#  endif
# endif

# undef  MORPHODYN
# define NO_FRCFILE
# undef  RVTK_DEBUG
```

Sed toy (Rouse)

```
#elif defined SED_TOY
/*
!                               SED TOY (1D Single Column example)
!                               === === === ====== ====== ========
!
*/                                    /* Choose an experiment :               */
# define SED_TOY_ROUSE              /*   Rouse                               */
# undef  SED_TOY_CONSOLID           /*   Consolidation                       */
# undef  SED_TOY_RESUSP             /*   Erosion and sediment resuspension   */
# undef  SED_TOY_FLOC               /*   Flocculation                        */

# undef  OPENMP
# undef  MPI
# define NEW_S_COORD
# define SOLVE3D
# undef  NONLIN_EOS
# define SALINITY
# undef  UV_VIS2
# define ANA_GRID
# define ANA_INITIAL
# define ANA_SMFLUX
# define ANA_SRFLUX
# define ANA_STFLUX
# define ANA_SSFLUX
```

sediment_sed_toy_rouse.in :

```
1  Stitle (a80)
CROCO - SED_TOY (rouse) - Test

2  Sd(1-NST), CSED,  SRHO,       WSED,       ERATE,  TAU_CE, TAU_CD, BED_FRAC(1:NLAY)
    1.E-03  0.02   2.600E+03  1           0.0005    0.1      0.1   0.1667
    1.E-03  0.02   2.600E+03  10          0.0005    0.1      0.1   0.1667
    1.E-03  0.02   2.600E+03  20          0.0005    0.1      0.1   0.1667
    1.E-03  0.02   2.600E+03  40          0.0005    0.1      0.1   0.1667
    1.E-03  0.02   2.600E+03  80          0.0005    0.1      0.1   0.1667
    1.E-03  0.02   2.600E+03  100         0.0005    0.1      0.1   0.1667

3 BTHK(1:NLAY)
      0.1

4 BPOR(1:NLAY)
      0.5

5 Hrip
      0.

6 Lrip
      0.

7 bedload_coeff
     1.

8 morph_fac
     1.

99 END of sediment input data
```

Model discretization :

Seawater : 100 Layers (**N**) / 5m depth (resolution : 5cm)
Sediments : 1 Layer (**NLAY**) / 10cm depth

Dynamics :

Logarithmic current profile
Parabolic vertical diffusion

Sediments :

cohesive sediment six classes (**NST**)
C_0 : 0,02Kg/m³ (**CSED**)
W_s : 0,001 / 0,01 / 0,02 / 0,04 / 0,08 / 0,1 m/s (**WSED**)

Sed toy (Rouse)

Criterion for suspension:

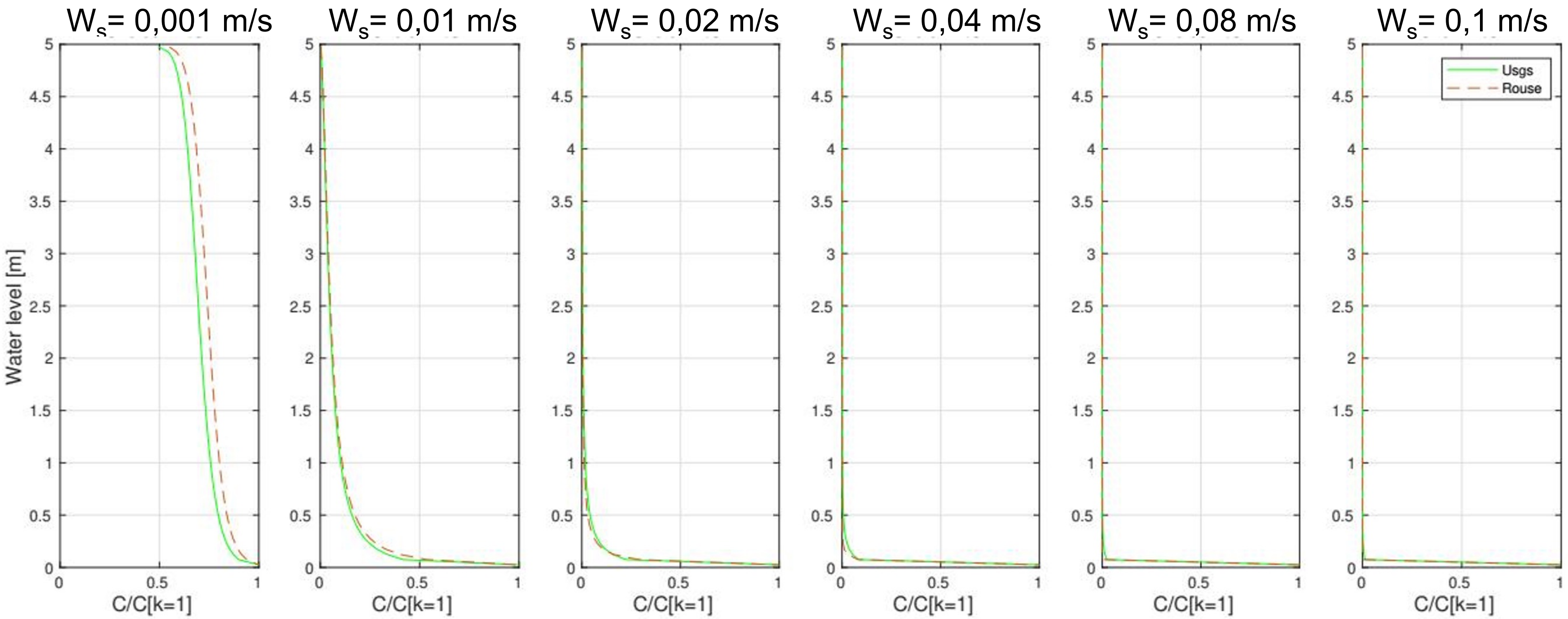
Suspended sediment behaves like tracers , and can be treated as diffusion problem, with higher concentration at bed, and lower concentration close to the surface.
Rouse theory : $C = C_0 (1 – z/h)$ linear in depth (C_0 : Concentration at bed / h : depth)
Rouse number : W_s/ku_* with W_s : settling velocity / u_* : shear stress velocity / k : von Karman (0,41)

Concentration at any depth z : $C_{rouse}(z) = C_0 [((h-z)/z) * (a/h-a)]^{Rouse\ number}$
with a= z_0 (at surface)

Goal :
To Know how my numerics experiment fitted the Rouse theory ⟶ $C_{usgs}(z)$ vs $C_{rouse}(z)$

$C_{usgs}(z)$ vs $C_{rouse}(z)$

Sed toy (Rouse)



* W_s < u*
* lower Rouse number

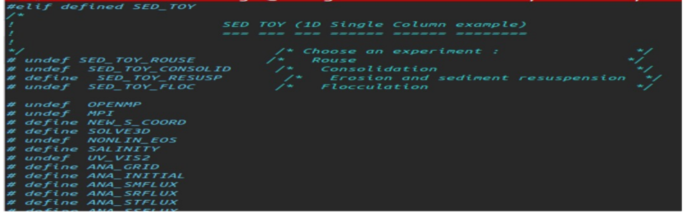
Higher suspended sediment concentration

W_s/ku_*

* W_s >> u*
* higher Rouse number

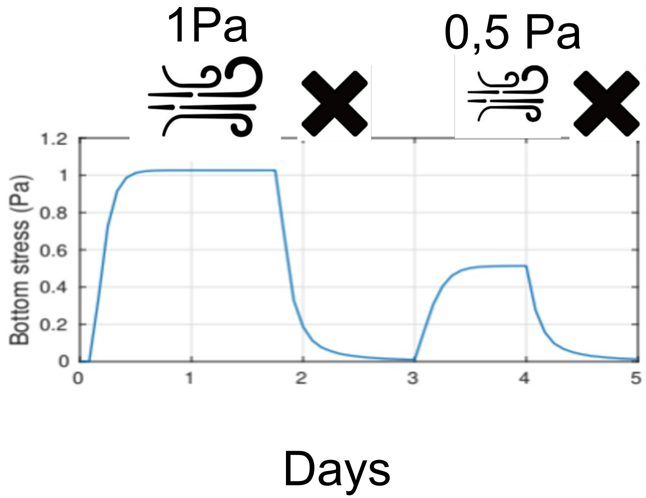
Lower suspended sediment concentration

Sed toy (resusp)



```
#elif defined SED_TOY
/*
!                         SED TOY (1D Single Column example)
!                         === === === ====== ====== ========
!
*/                                /* Choose an experiment :                  */
# undef SED_TOY_ROUSE            /*   Rouse                                 */
# undef  SED_TOY_CONSOLID        /*   Consolidation                         */
# define  SED_TOY_RESUSP          /*   Erosion and sediment resuspension    */
# undef  SED_TOY_FLOC            /*   Flocculation                          */

# undef  OPENMP
# undef  MPI
# define NEW_S_COORD
# define SOLVE3D
# undef  NONLIN_EOS
# define SALINITY
# undef  UV_VIS2
# define ANA_GRID
# define ANA_INITIAL
# define ANA_SMFLUX
# define ANA_SRFLUX
# define ANA_STFLUX
```

Goal :
Demonstrate the evolution of stratigraphy caused by resuspension and subsequent settling of sediment during time-dependent bottom shear stress event



Model discretization :

- Seawater : 20 Layers (**N**) / 20m depth (resolution : 1m)
- Sediments : 41 Layers (**NLAY**) / 4,1cm depth

Dynamics :

Time-varying surface wind stress applied that generated time-dependent horizontal velocities and bottom stress

Vertical mixing parametrization GLS

Sed toy (Resusp)

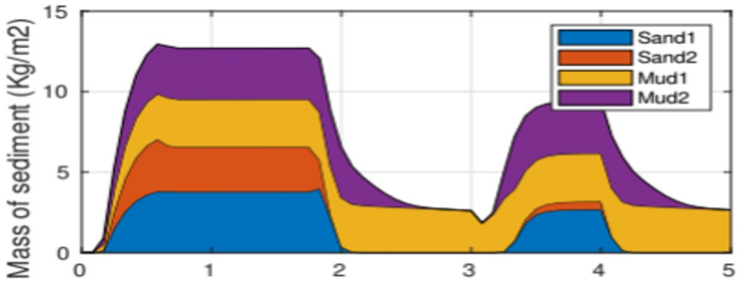
Sediments :

Non cohesive / cohesive sediment 4 classes (**NST**)
Sand : 140µm / 62,5µm   Mud : 30µm / 4µm (**Sd**)
W_s : 8 / 2 / 0,6 / 0,1 mm/s (**WSED**)
τ_c : 0,1 / 0,1 / 0,05 / 0,05 Pa (**TAU_CE**)

sediment_sed_toy_resusp.in :

```
1  Stitle (a80)
ROMS - SED_TOY (resuspension) - Test

2  Sd(1-NST), CSED,   SRHO,   WSED,    ERATE,  TAU_CE, TAU_CD, BED_FRAC(1:NLAY)
      0.0625     0.    2650.    2.     0.0015    0.1     0.1     41*0.25
      0.140      0.    2650.    8.     0.0015    0.1     0.1     41*0.25
      0.004      0.    2650.    0.1    0.0005    0.05    0.1     41*0.25
      0.030      0.    2650.    0.6    0.0005    0.05    0.1     41*0.25

3 BTHK(1:NLAY)
      41*0.001

4 BPOR(1:NLAY)
      41*0.6

5 Hrip
      0.01

6 Lrip
      0.1

7 bedload_coeff
      1.

8 morph_fac
      1.

9 transC
     0.03

10 transN
     0.1
```

Sed toy (resusp)

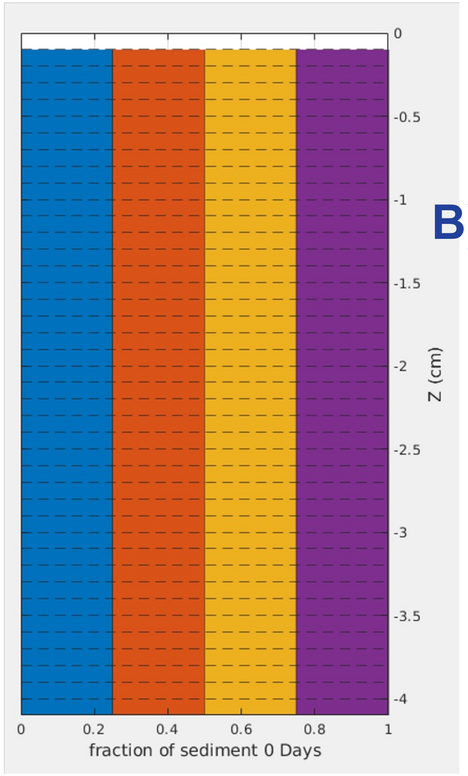


Sand1 140µm
Sand2 63µm
Mud1 30µm
Mud2 4µm

<u>0 days - 2days :</u>
first stress event → 1Pa
1,1 cm moves by erosion on the fluid **A)**
Mud classes more dominant than sand

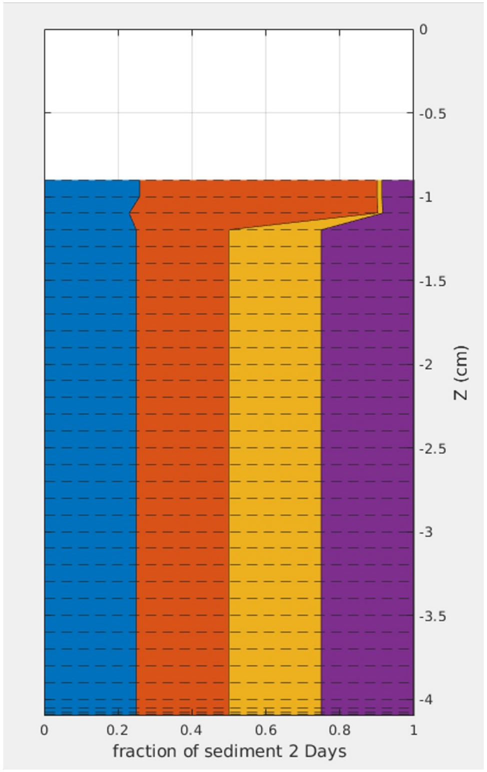
<u>At 2 days :</u>
B) When the stress subsided, coarser sediment deposited first (0,3 cm), while finer material remained suspended
C) Net erosion of 0,8 cm

A)



0 days

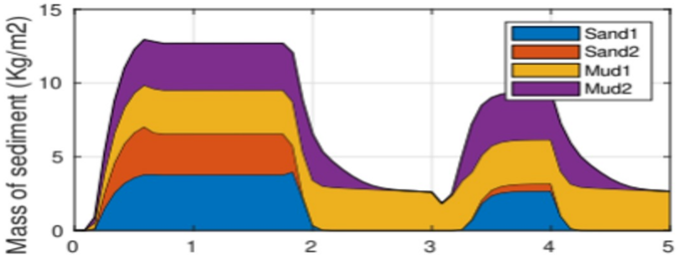
B)



C)

2 days

Sed toy (resusp)

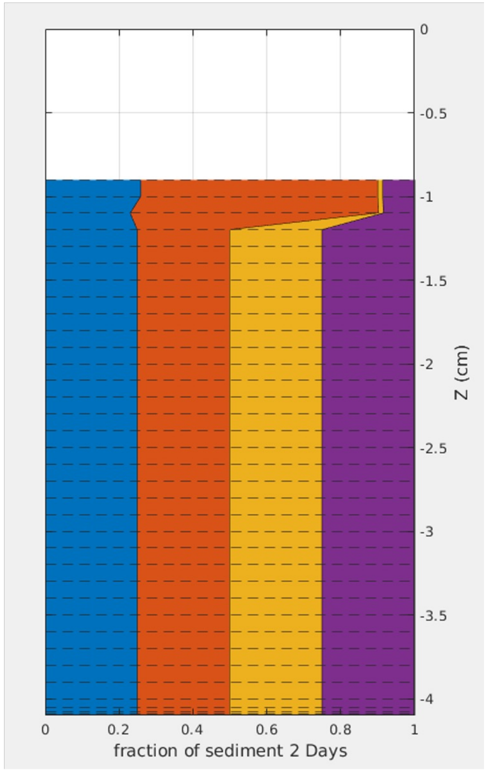


Sand1 140µm
Sand2 63µm
Mud1 30µm
Mud2 4µm

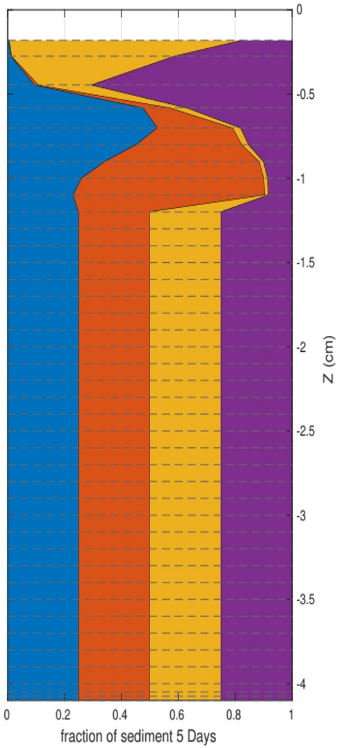
<u>3 days - 4days :</u>
2nd stress event → 0,5Pa

<u>At 5 days :</u>
Then, all sand classes are deposited, mud begin to deposit

Then some muds remains in the fluid (30µm dominant) and leave a net erosion 0,2cm **A)**



2 days



A)

5 days

Sed toy (consolidation)

→

```
#elif defined SED_TOY
/*
!                        SED TOY (1D Single Column example)
!                        === === === ====== ====== ========
!
*/                             /* Choose an experiment :             */
# undef SED_TOY_ROUSE         /*   Rouse                            */
# define  SED_TOY_CONSOLID     /*   Consolidation                      */
# undef  SED_TOY_RESUSP       /*   Erosion and sediment resuspension  */
# undef  SED_TOY_FLOC         /*   Flocculation                       */
```

Goal :

- Stratigraphic responses of cohesive behavior due to a single bottom-stress event
- Show the response of mixed bed with newer deposits
- Show consolidation / swelling processes on sediment layers

- Erodibility with Cohesive sediments :

- Sediments do not erode in the same way depending on whether they are cohesive or not
- Erodibility becomes a property of the bed layer and not only given for each sediment class
- You have a critical shear stress for the erosion for each layer, which is increasing with depth

- → It is managed by a cohesive bed module within Usgs

Sed toy (consolidation)

→

```
#elif defined SED_TOY
/*
!                        SED TOY (1D Single Column example)
!                        === === === ====== ====== ========
!
*/                              /* Choose an experiment :              */
# undef SED_TOY_ROUSE           /*   Rouse                             */
# define  SED_TOY_CONSOLID      /*   Consolidation                     */
# undef  SED_TOY_RESUSP         /*   Erosion and sediment resuspension */
# undef  SED_TOY_FLOC           /*   Flocculation                      */
```

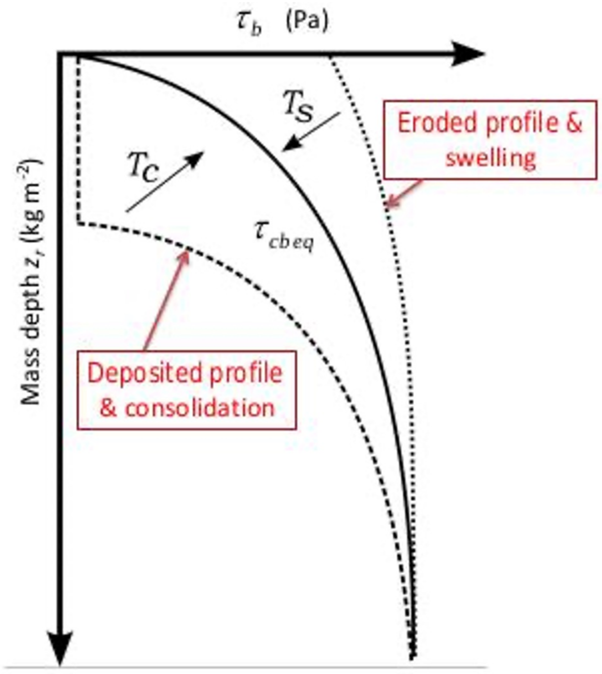
Initialization :

* Initialization of the cohesive bed module with a global critical shear stress profile at equilibrium for erosion (τ_{cbeq})
* You give some parameters like timescale (s) T_c : for consolidation / T_s : for swelling to accelerate or not each process

Run module :

* Applying a Bottom Stress event
* Then, differences appears, between τ_{cbeq} and the critical shear stress for the erosion profile (τ_b) in each layer
* τ_b profile is varying in time and then will be nudged by the model over timescale T_c or T_s toward the equilibrium profile during this period

Sediment



Sherwood & al 2018

Sed toy (consolidation)

sediment_sed_toy_consolid.in :

```
1  Stitle (a80)
ROMS - SED_TOY (consolidation) - Test

2  Sd(1-NST), CSED,  SRHO,   WSED,   ERATE,   TAU_CE, TAU_CD, BED_FRAC(1:NLAY)
      0.0625    0.    2650.    2.     0.0015     0.1     0.1    41*0.25
      0.140     0.    2650.    8.     0.0015     0.1     0.1    41*0.25
      0.004     0.    2650.    0.1    0.0005     0.05    0.1    41*0.25
      0.030     0.    2650.    0.6    0.0005     0.05    0.1    41*0.25

3 BTHK(1:NLAY)
      41*0.001

4 BPOR(1:NLAY)
      41*0.6

5 Hrip
      0.01

6 Lrip
      0.1

7 bedload_coeff
      1.

8 morph_fac
      1.

9 transC
      0.03

10 transN
      0.2

11  tcr_min
      0.030

12  tcr_max
      1.5

13  tcr_slp
      2

14  tcr_off
      3.4d0

15 tcr_tim
      28800.0d0

99 END of sediment input data
```

Model discretization :

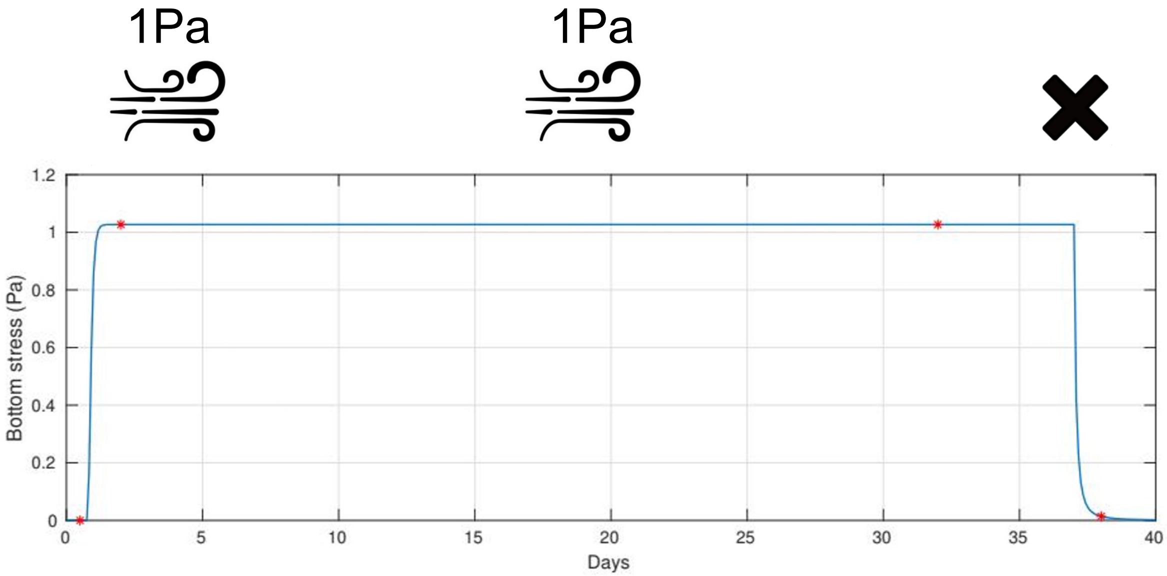
- Seawater : 20 Layers (**N**) / 20m depth (resolution : 1m)
- Sediments : 41 Layers (**NLAY**) / 4cm depth

Dynamics :

- one surface wind stress event applied that generated time-dependent horizontal velocities and bottom stress (1Pa) during 37 days
- Vertical mixing parameterization GLS

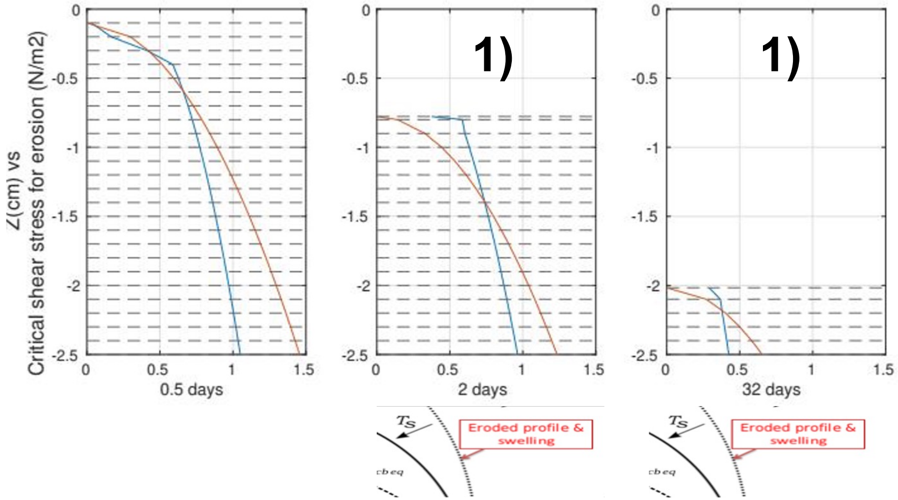
Sediments :

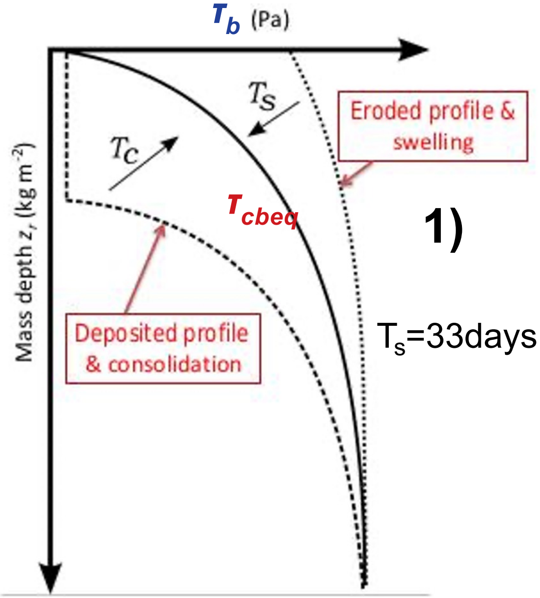
- Cohesive behaviour given by threshold value (**transN**)
- Parameters 13-14 (**tcr_slp**/**tcr_off**) : to compute τ_{cbeq}
- Consolidation rate T_c (**tcr_tim)** (8h in seconds)
- Swelling rate → $T_s = 100 * T_c = 33$ days

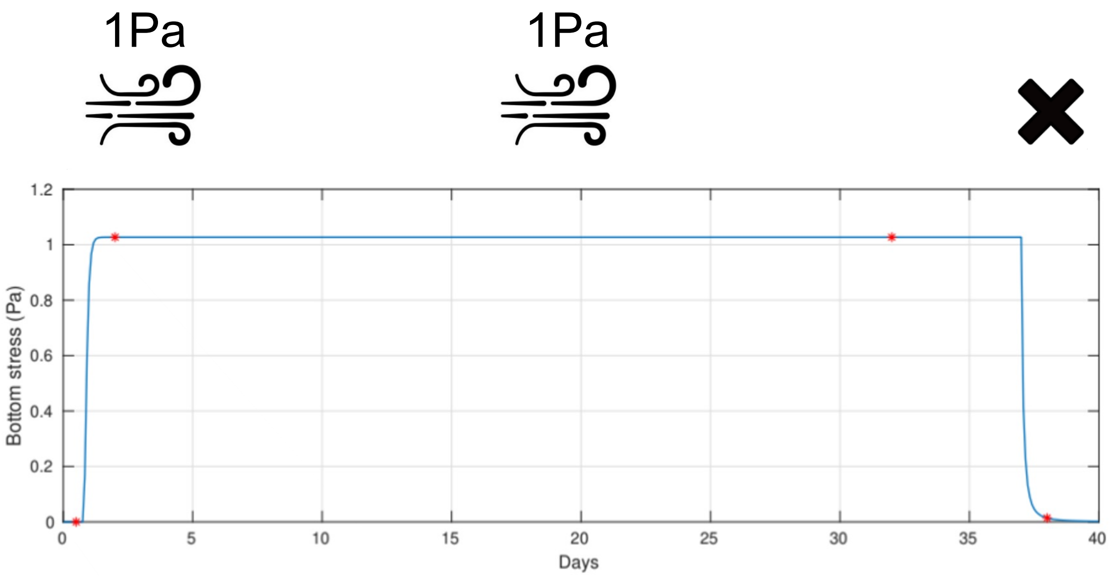


We Apply here a Bottom Stress event during a period of nearly 37 days :

1) cause erosion , resusp. of material process of swelling made more erodible layers and profile tend to τ_{cbeq}



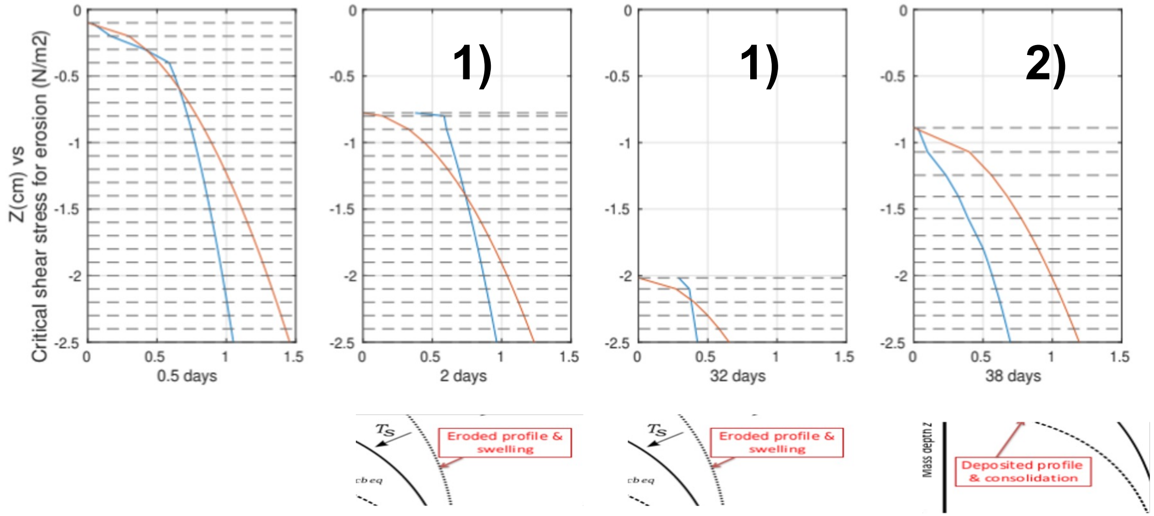




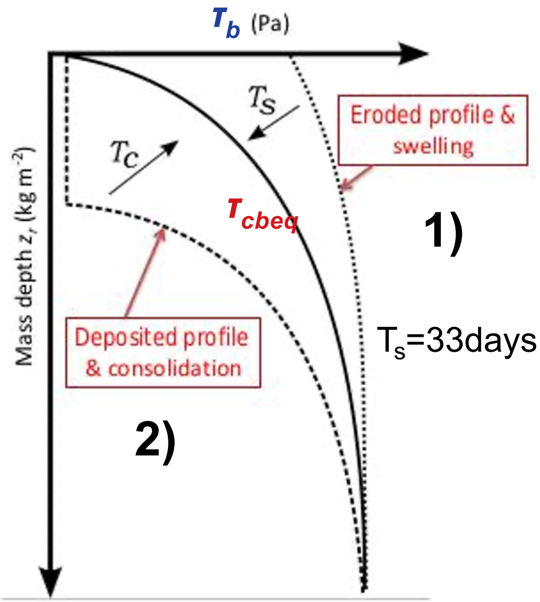
We Apply here a Bottom Stress event during a period of nearly 37 days :

1) cause erosion , resusp. of material
process of swelling made more erodible layers and profile tend to τ_{cbeq}

2) then happens new deposits
process of consolidation made less erodible



Layers consolidated next 38 days



Sandbar

Goal :

We initialize a linear beach slope → to see waves forcing effects on sediment bed
To predict onshore and offshore sandbar migrations

To Fit well with sandbar experiment data from European Large Installation Plan (LIP) :

* LIP-1B (characterizing erosion of sandbar) **SANDBAR_OFFSHORE**
* LIP-1C (accretion) **SANDBAR_ONSHORE**

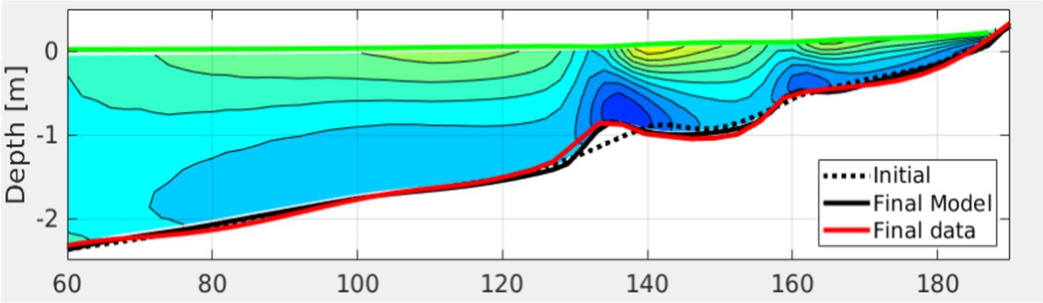
Different Wave Forcing methods :

Wave statistics from WKB wave model that will initialize a Bottom Boundary Layer and process then wave current interactions

Use of Wave maker for wave-resolving simulations in Non hydrostatic mode (NBQ) (need high resolution at the bottom)

```
#elif defined SANDBAR
/*
!                        SANDBAR Example
!                        ======= =======
!
!   Roelvink, J. A. and Reniers, A. (1995). Lip 11d delta flume experiments
!   - data report. Technical report, Delft, The Netherlands, Delft Hydraulics
*/
# define SANDBAR_OFFSHORE /* LIP-1B */
# undef  SANDBAR_ONSHORE  /* LIP-1C */
# undef  OPENMP
# undef  MPI
# define SOLVE3D
# define UV_ADV
# define NEW_S_COORD
# define ANA_GRID
# define ANA_INITIAL
# define ANA_SMFLUX
# define ANA_STFLUX
# define ANA_SSFLUX
# define ANA_SRFLUX
# define ANA_SST
# define ANA_BTFLUX
# define OBC_WEST
# define SPONGE
# define WET_DRY
# define MRL_WCI
# ifdef MRL_WCI
#   define WKB_WWAVE
#   define MRL_CEW
#   define WKB_OBC_WEST
#   define WAVE_ROLLER
#   define WAVE_FRICTION
#   define WAVE_BREAK_TG86
#   define WAVE_BREAK_SWASH
#   define WAVE_STREAMING
#   undef  WAVE_RAMP
# endif
# define GLS_MIXING
# define GLS_KOMEGA
# undef  LMD_MIXING
# ifdef LMD_MIXING
#   define LMD_SKPP
#   define LMD_BKPP
#   define LMD_VMIX_SWASH
# endif
# define BBL
# define SEDIMENT
# ifdef SEDIMENT
#  define SUSPLOAD
#  define BEDLOAD
#  define MORPHODYN
#  define TCLIMATOLOGY
#  define TNUDGING
#  define ANA_TCLIMA
# endif
# undef  STATIONS
# ifdef STATIONS
#  define ALL_SIGMA
# endif
# undef  DIAGNOSTICS_TS
# ifdef DIAGNOSTICS_TS
#  define DIAGNOSTICS_TS_ADV
# endif
# define NO_FRCFILE
# undef  RVTK_DEBUG
```

Sandbar



Model discretization :

- 720 x-horizontal grid point (LLm0) (200m)
- (resolution 0,25m)
- Seawater : 10 Layers (**N**) / 4,1m depth
- Sediments : 2 Layers (**NLAY**) / 10m depth

Dynamics :

- Morphodynamics
- Vertical mixing parameterization GLS

- WKB Wave propagation model (monochromatic): initialization
- WKB pass then his variables to *MRL_WCI*/*BBL* routines

- Interaction Wave Current (*MRL_WCI*)
- Bottom Boundary Layer (*BBL*) model compute his own bed roughness (depending of grain sediment and waves)

Croco.in.Sandbar_1B :

```
wkb_wwave:  amp [m], ang [deg], prd [s], tide [m], B_tg, gamma_tg
            0.45     0.0        5.       0.0       0.6   0.4
```

Waves parameters :
* amp : wave amplitude
* prd   : wave period

Sandbar

sediment_sandbar_(1B/1C).in :

```
1  Stitle (a80)
ROMS - Sediment - Test

2  Sd(1-NST), CSED, SRHO, WSED, ERATE, TAU_CE, TAU_CD, BED_FRAC(1:NLAY)
      0.220    0.0  2650.  25.0  1.e-3  0.18  1000    0.5 0.5
      0.220    0.0  2650.  25.0  1.e-3  0.18  1000    0.5 0.5

3 BTHK(1:NLAY)
      5 5

4 BPOR(1:NLAY)
      0.4 0.4

5 Hrip
       0.02

6 Lrip
       0.16

7 bedload_coeff
       0.5

8 morph_fac
      18.

99 END of sediment input data
```

Sediments :

- Non-cohesive sediment two classes (**NST**) : Diameters Sd : 220 µm Density (**SRHO**) 2650 kg/m³
- W_s : 25 mm/s (**WSED**)
- τ_c : 0,18 Pa (**TAU_CE**)
- E_0 : $1e^{-3}$ (**ERATE**)

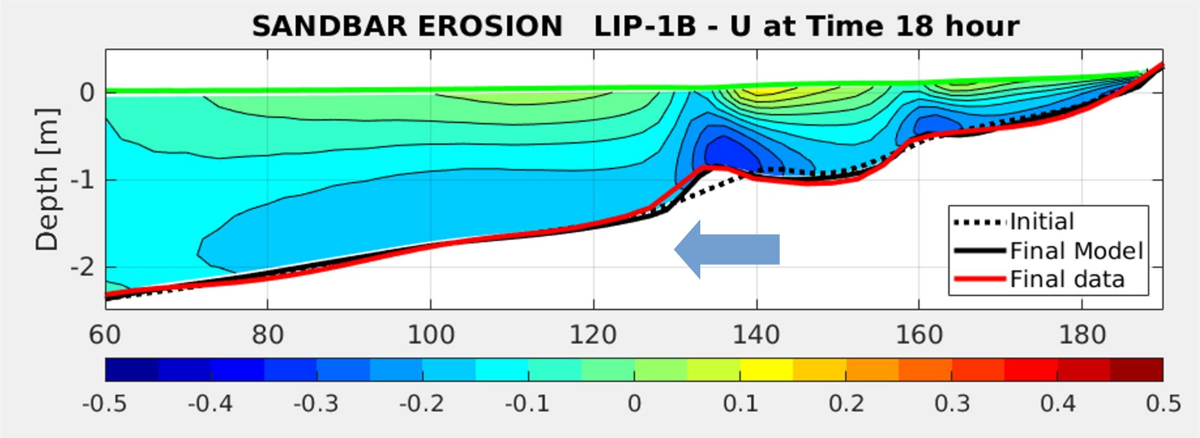
- Suspload and Bedload transport
- **Bedload formulation:** SANTOSS (Van der A, 2013) with bedload flux multiplied by factor 0,5 (**bedload_coeff**)
- Acceleration of bed response (**morph_fac**) : factor of 18 (13 for LIP-1C experiment) (with one hour simulation)

t_0

Initialize beach profile with linear slope

Dean number $De=H_s/T_pW_s$
(Erosion vs Accretion)
W_s=25mm/s

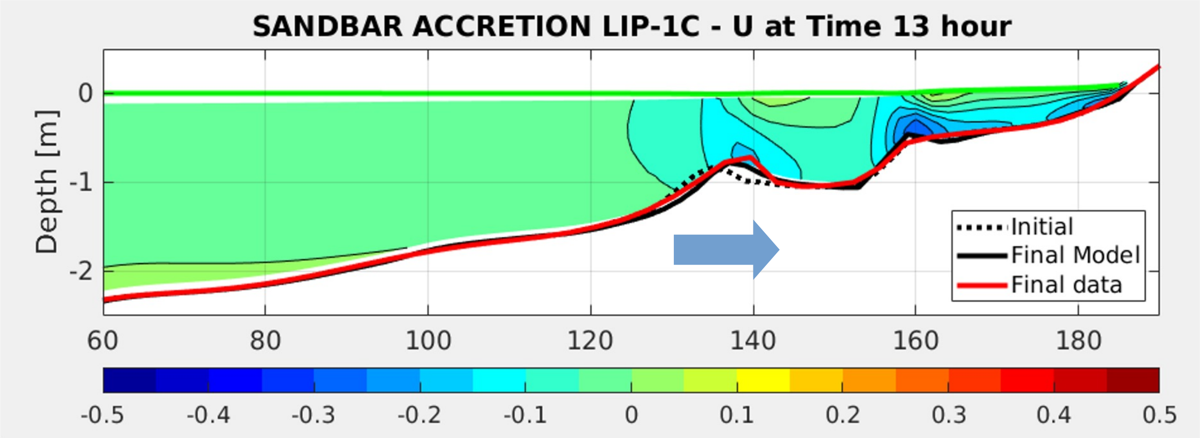
t_1



<u>Offshore Wave Forcing changes</u>

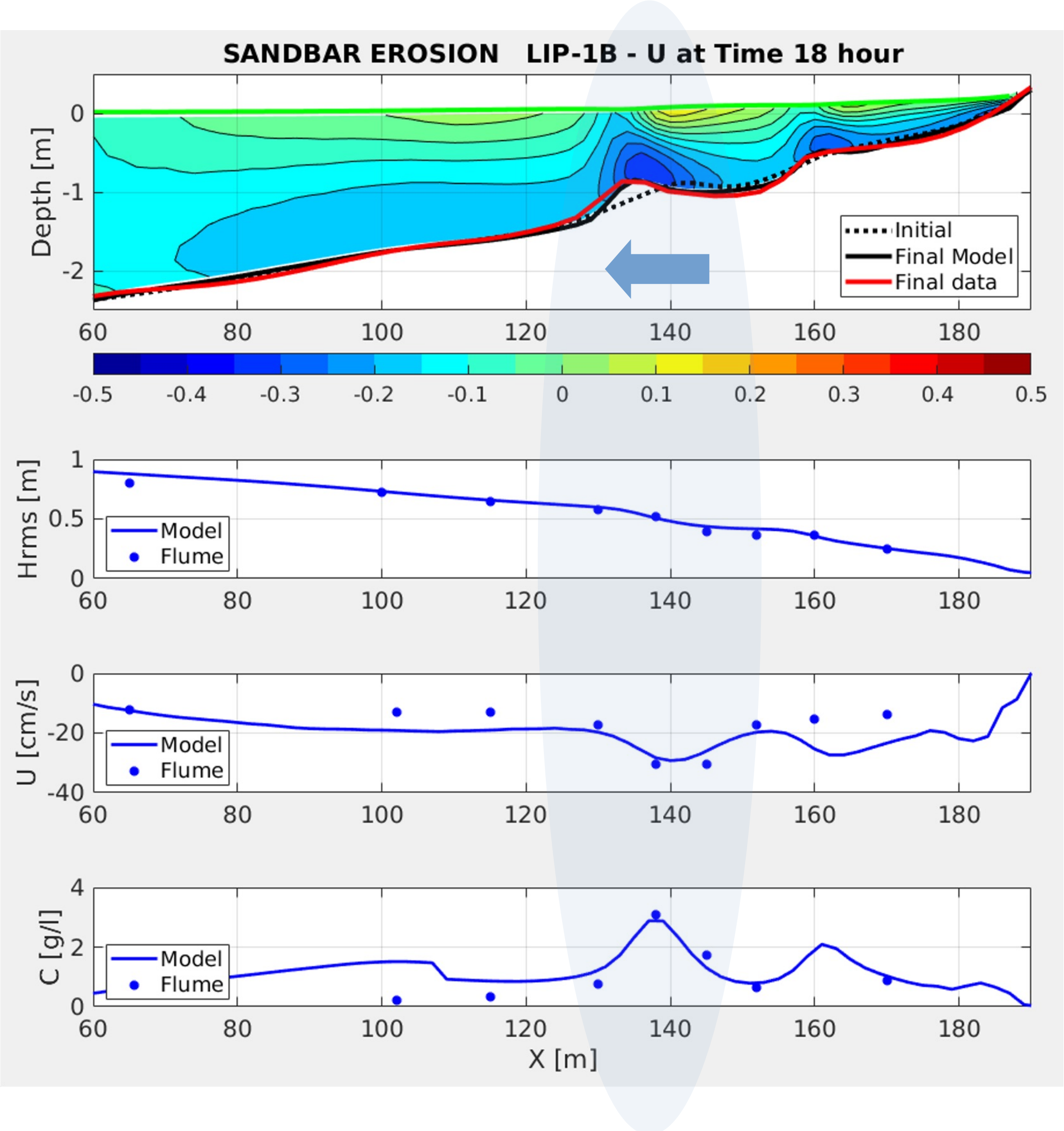
High energy waves :
H_s=0,45m / T_p=5s De =3,6

$t_2=t_1+18h$



Low energy waves :
H_s=0,18m / T_p=8s De=0,9

t_2+13h



*Transport increase onshore to offshore

* Hrms : root-mean-square wave height (fit well with flume data)

* Undertow

* Bottom Concentration is correlated with undertow Resuspended material greater

Tidal flat2DV

Goal :

Characterize bottom mud concentration evolution over several tidal cycles

Model discretization :

200 x-horizontal grid point (LLm0) (100km) (resolution 2km)
Seawater : 10 Layers / 16m depth
Sediments : 3 Layers / 15cm depth

Dynamics :

Flat bottom
At western boundary:
  SSH pulses : *zetabry_west(j)=2.*sin(2.*pi****time****/(12.0*3600.0))*

Bottom roughness Length (Zob) : $1e^{-4}$ m

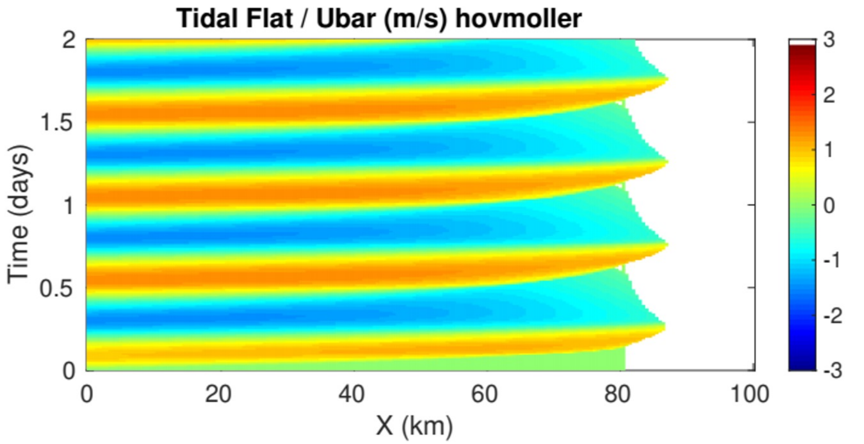
```
#elif defined TIDAL_FLAT
/*
!                       TIDAL_FLAT  Example
!                       ==========  =======
*/
# undef  OPENMP
# undef  MPI
# undef  NONLIN_EOS
# define NEW_S_COORD
# define SALINITY
# define UV_ADV
# define TS_HADV_WENO5
# define TS_VADV_WENO5
# define UV_HADV_WENO5
# define UV_VADV_WENO5
# define UV_COR
# define SOLVE3D
# define UV_VIS2
# define GLS_MIXING
# define ANA_INITIAL
# define WET_DRY
# define TS_DIF2
# define SPONGE
# define ANA_GRID
# define ANA_INITIAL
# define ANA_SMFLUX
# define ANA_SRFLUX
# define ANA_STFLUX
# define ANA_SSFLUX
# define ANA_BTFLUX
# define ANA_BSFLUX
# define OBC_WEST
# define FRC_BRY
# ifdef FRC_BRY
#  define ANA_BRY
#  define Z_FRC_BRY
#  define OBC_M2CHARACT
#  define OBC_REDUCED_PHYSICS
#  define M2_FRC_BRY
#  undef  M3_FRC_BRY
#  define T_FRC_BRY
# endif
# undef  SEDIMENT
# define MUSTANG
# ifdef SEDIMENT
#  define SUSPLOAD
#  undef  BEDLOAD
# endif
# ifdef MUSTANG
#  define key_sand2D
#  undef  key_MUSTANG_V2
# endif
# define NO_FRCFILE
# undef  ZETA_DRY_IO
# undef  RVTK_DEBUG
```

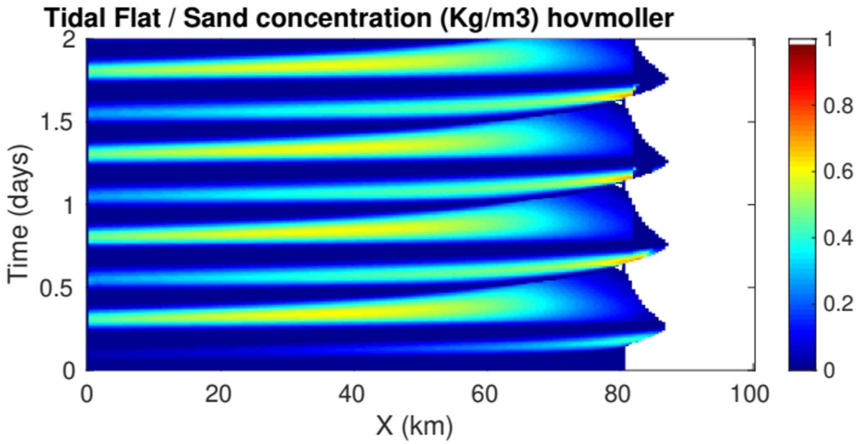
Tidal flat2DV

<u>Sediments</u> :

3 classes :
* 2 non cohesive sediment : 200µm (40% in each layer) / 100µm (40%)
* 1 cohesive sediment (20%) / W_s : 0,5 mm/s
* E_0 : $2e^{-4}$

Western Tide pulses give sequences of higher and lower concentrations of material on the fluid (anti-correlated with barotropic flow)





ESTUARY

From code MARS (casestuar.F90) 90 x 200 x 5 sigma layers ; dx = 600m dy = 100m

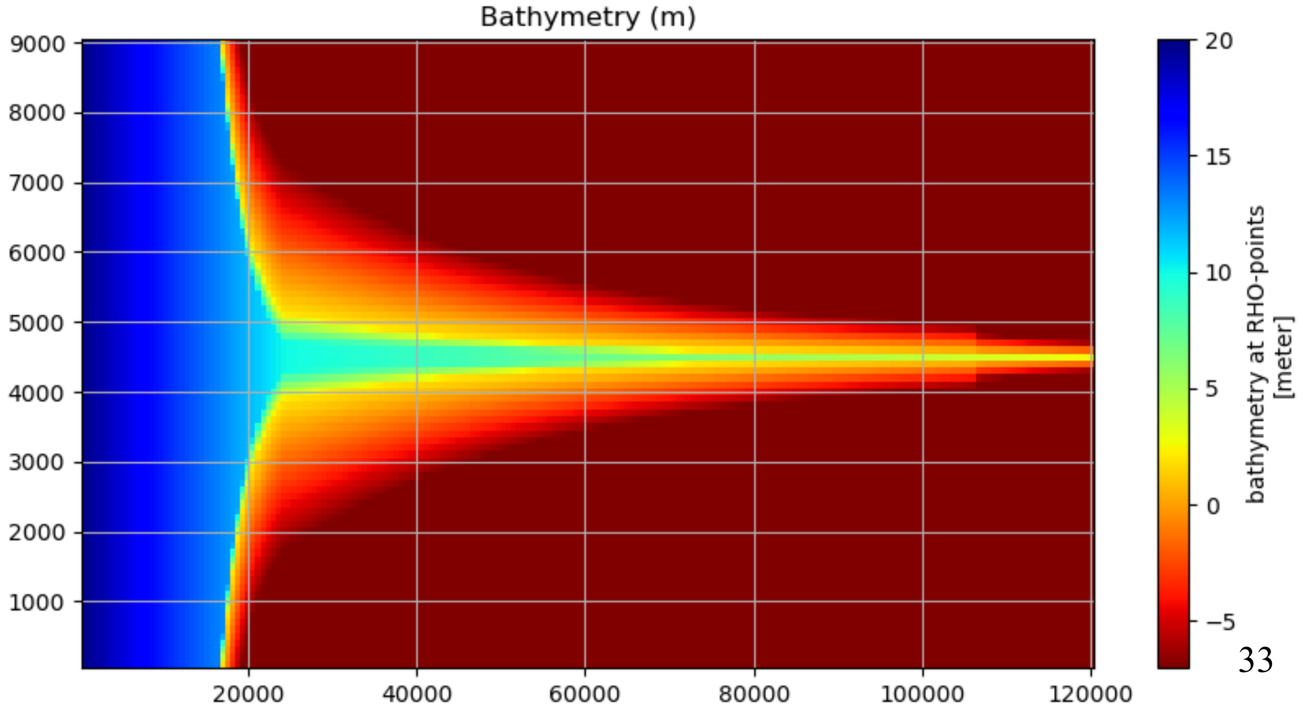
2 sediments : Sand (100μm; Ws = 7.2 mm/s), Mud (Ws = 0.5 mm/s)

PSOURCE : 400m3/s 50mg/L (mud)

OBC West : sinusoïdal tide

Initialization :

- No sediment in water
- In bed : 40% sand, 60% mud



How to build your own test case ?

* Most of test cases comes from literature

* Create your own cppkey « MYCONFIG »

 # define MYCONFIG

* Give various analytical fields / initial statement to the model when appropriate
Include it on files :

cppdefs.h / param.h
ana_grid.F / ana_initial.F / analytical.F

* Adapt namelists croco.in / sediment.in (USGS) / paraMUSTANG*.txt (Mustang)