



2DH and Multi1DH morphological model for medium term evolution of large scale features and nourishment in the nearshore region: Application to Trucvert and corniche beach (france) and La barrosa beach (spain)

Philippe Larroudé, Benoît Camenen

► To cite this version:

Philippe Larroudé, Benoît Camenen. 2DH and Multi1DH morphological model for medium term evolution of large scale features and nourishment in the nearshore region: Application to Trucvert and corniche beach (france) and La barrosa beach (spain). 29th International Conference on Coastal Engineering (ICCE 2004), Sep 2004, Lisbonne, Portugal. hal-00259828

HAL Id: hal-00259828

<https://hal.science/hal-00259828v1>

Submitted on 8 Jan 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

2DH AND MULTI1DH MORPHOLOGICAL MODEL FOR MEDIUM TERM EVOLUTION OF LARGE SCALE FEATURES AND NOURISHMENT IN THE NEARSHORE REGION: APPLICATION TO TRUCVERT AND CORNICHE BEACH (FRANCE) AND LA BARROSA BEACH (SPAIN)

Philippe Larroudé¹

¹ Dr., LEGI BP 53 38041 Grenoble, France, larroude@hmg.inpg.fr

Benoît Camenen²

² Post-Doc Student, Lund University, Sweden, benoit@tvr1.lth.se

A modified 2DH morphodynamical model was employed to simulate the evolution of large-scale features with major implications for beach nourishment. The second part of the study is focused on modelling the evolution of material artificially placed in different parts of the profile, extracting or adding material to the natural bars, and quantifying how the profile responds to different wave climates and nourishment placements. The simulated results were compared with field data from a Mediterranean beach.

1. Introduction

Since few year the coastal management is oriented to the protection of the sand beaches and more to the protection trough an accurate nourishment of the beach. The aim of the study is to evaluate the level of wave energie and to parametrize it to be able to put the sand at the best location in front of the beach.

The morphological evolution of large scale features in the nearshore region has been investigated using a commercial 2DH model and a Multi1DH model (Camenen & Larroudé (2003b)). The simulation of the wave-driven and/or tidal currents is carried out using TELEMAC finite-volume elements. The SISYPHE sand transport module has been used to compute sediment transport and bed evolution. An undertow model has been added as the sediment transport in the surf zone is mainly controlled by the undertow.

During these last years, the survey of phenomena and process bound to the transport of sands on coasts took a fundamental importance in the management of the coastline. These studies show different aspects of the phenomenology circa as:

- the formation and the coastal sedimentary body evolution (onshore & offshore bars)
- the relative impact of processes of the sedimentary hydrodynamics on the evolution to large scale and long-term of a sandy inshore system, their interaction to different time scale.
- the suitable physical laws to represent the real sedimentary fluxes recorded in-situ (attributed to an alone surge or combination wave/current).

The understanding of these processes needs at this time the in situ data but also the development of models mathematics and numerical codes. Objectives of this thesis work will be therefore to modelise and to simulate processes of sedimentary transport on sandy beaches with varied weather conditions in the medium term time scale (from few days to few months).

2. The beaches

The first one is the TrucVert beach in the south west coast with a micro-tidal conditions and rhythmic features. The model are compared with data from a field experimentation on the Trucvert beach where rhythmic features were observed along the coastline (Camenen & Larroudé (2003) and Michel et al. (2000)). We will not show the some result of the beach in this paper.. The second is the Corniche beach close Sète on the mediterranean see with a climat dominated by the wind (Certain, 2002). On this beach we elaborate a wave energie map approach to determine the location of the sand nourishment and we compare with other nourishment in mediterranean environment (Boczar-Karakiewicz et al. 2001). We will show and discuss in this paper the comparaisn of a short time bed evolution between different location of the nourishment.. The third beach is in the south of spain and represent a single cell of the coast from Cadix to Gilbratar. The results are compared with data and integreted via the boundary condition of our model to other numrical tools.In the present paper we will show some wave and see bed evolution result on the La Barrosa beach more particulary.

3. The codes

The sedimentary evolution is modelling under the action of the oblique incident waves and is coupling with different numerical tools dedicated to the other process involved in the nearshore zone. We can mention the following modules:

- module of wave with hold in account of the energy dissipation by surge (hyperbolic equation of extended Berkhoff), LNHE, Artemis, 2002
- module that calculates currents induced means by the surge of the waves, from the concept of radiation constraints gotten according to the module of waves, LNHE, Telemac2d, 2002.
- sedimentary module integrating the combined actions of the waves and the current of waves (2D or 3D) on the transport of sediment, , LNHE, Sisyphe, 2002

- an hydrodynamic simplified model (called Multi1DH) use the following assumptions: a random wave approach, in a 1DH (cross-shore) direction. A offshore wave model (shoaling + bottom friction + wave asymetry) is used with the break point estimation. The waves in the surf zone are modeled with the classic model of Svendsen (1984) with an undertow model (roller effect, Svendsen, 1984, Dally et al. 1984). The longshore current model is the Longuet-Higgins's model (1970).

4. Results

4.1. On the Truc Vert beach

One of the principal objectives of our research is to improve the computation procedure aiming to a good representation of the reality. For instance, in collaboration with. A.Falquès et al. (Falquès et al. (1996)) on a linear instability model), we try to rebuild bars and "baïnes" of Trucvert beach, after a storm has flattened it. Hence, following the work of de Vriend et al. (1987), we try to improve the classic quasi-steady procedure.

Main difficulties are to estimate different time steps between hydrodynamic and morphodynamic modules. Then, for our tidal model, results are hydrodynamics field for a few time steps of the tide, then for a few water levels. So, for each of them, we have to compute the waves propagation, the littoral drift and undertow. Although it seems to be heavy to run, it is the only way to compute such a complex system.

4.2. On the La Barossa Beach

We will present in first the result that we obtain on the La Barrosa beach. We focus our simulation on three different energetic conditions, for 3 sea levels from Low Tide to High Tide. This simulation are conduct in the objective to use the different module of calculation. The interest of the result here is not to give a final result on the way to protect or nourish this beach but more to focus on the limitation of the phase averaged code and multi1dh code we used. The complete study could be find in the European project report Humor.

So, to evaluate our model on a concret cas we will test for the following wave condition on La Barrosa beach (see table 1).

Table 1 : Wave condition for simulation on La Barrosa beach

Hs (m)	Tp (s)	θ
3	12	W10S, W, W10N
5	14	W10S, W, W10N
7	16	W10S, W, W10N

The results with the wave module ARTEMIS are good in term of location on the beach of the principal wave break zone (see fig. 1,2). This allows us to have a

good representation of the radiation stress even if it is necessary to smooth their value in the swash zone to have a good field of current induced by the wave.

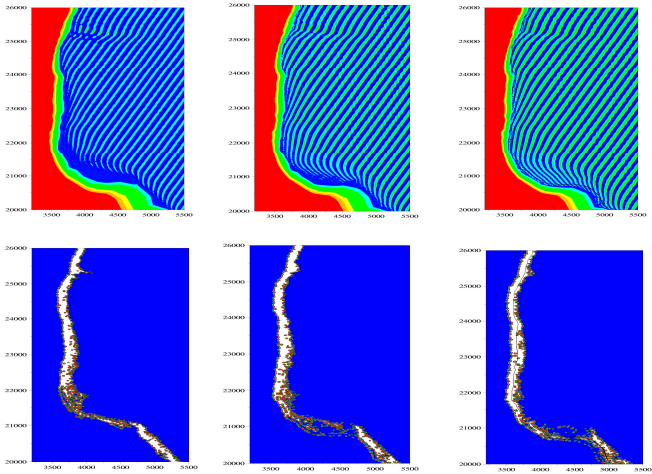


Figure 1: Waves and Break zone , with the condition : $\theta = W10S$, $H_s = 3$ m, $T_p = 12$ s for the three level of tide.

The module need also a minimum of 2 to 5 point in the wave length so need a lot of point in the mesh and forced us to reduce the domaine of interest. So with this module we calculate the wave and radiation stress on the La Barrosa beach but not on the all single cell from Cadix to Tarifa.

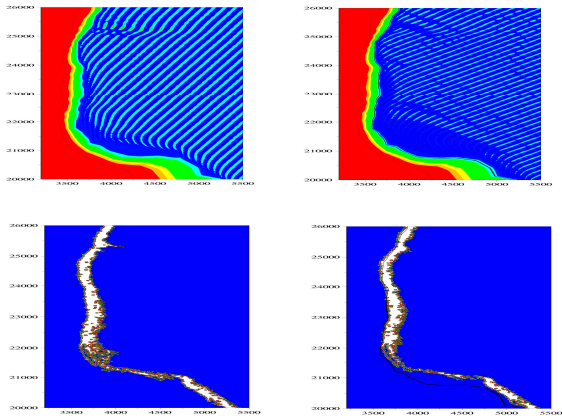


Figure 2: Waves and Break zone , with the condition: Low Tide, $H_s = 3$ m, $T_p = 12$ s, with two angle of incidence W10S on the left and W10N on the right.

As a numerical model this one need a good input in term of boundary condition.

To avoid the use a too huge numerical domaine, we did some specific development to avoid the numerical perturbation in domaine due to the boundary condition.

This need also a particular filtering in the radiation stress value in the very near shore region where there is a very small water level to avoid divergence in the simulation. (Cienfuegos 2002).

A numerical computation of the tidal effect is not so easy. Then, we modify the boundary conditions so that, we impose tidal water level on the offshore boundary, and velocities function of the water level on the both side of the domain but this simulation are not compute in the complete loop with the other module.

We completed this study with a Multi1DH model to be able to reproduce the undertow wich is an important current in the growth of our intertidal bars in term of reconstruction after a storm.

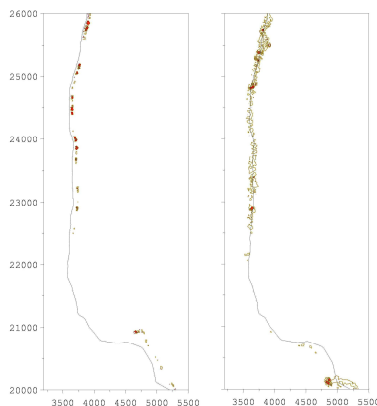


Figure 3: Sea bed evolution after 3 hours , with the condition : $\theta = W10S$, $H_s = 3$ m, $T_p = 12$ s (maximun of the evolution in term of erosion or deposition)

Having an hydrodynamic fields, it is now very important to choose the most adapted formulae to have more realistic results. On the figure 3 we show the erosion zone on La Barossa obtain after three hours. That is why we integrat several formulae which seem to be the most appropriate ones for a nearshore system. We compare all the results in Camenen & Larroudé, 2003. For the presente study we use the Bijker formulae principlaly because in tha actual version of the model the simulation of the sea bed evolution is quicker in term of cpu time with this formula.

4.3. On the Corniche beach (with a nourishment approach)

Firstly we set up a procedure to use the coupled codes Artemis-Telemac2d-Sisyphus and especially we improved the treatment of the boundary conditions in order to be able to work on fields of calculations close to the coastal zone and equivalents in dimension for the three codes. We also used the Multi1DH code for the medium term simulations. These models were used for monthly simulations taking of account the weather conditions. These weather conditions are drawn from the data of ground for the period of November 2000 and are simplified in terms of height of swell, period of swell and direction by dividing the month into 9 significant periods (see table 2). One can notice that the average height of the swells to broad during each period attenuated the weather events this November.

Table 2 : Simplified weather data: November 2000 (Θ angle in degree in the trigonometrical direction reverses compared to the normal with the beach)

time (s)	Hs (m)	Ts (s)	θ
162000.	0.244	7.45	25.475
302400.	1.703	7.92	27.861
680400.	0.351	7.13	28.094
896400.	1.787	6.76	6.065
1598400.	0.222	6.2	3.97
1738800.	1.358	6.78	14.9
2127600.	0.251	7.03	14.33
2386800.	1.259	6.27	-5.

We obtain a good adequacy between numerical bathymetries after one month and those raised on the ground (see fig. 4).

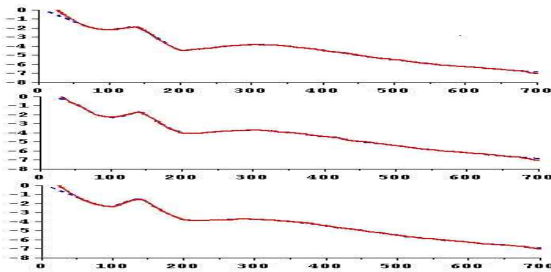


Figure 4: Sea bed for three location on the beach at the 25 november 2000, comparison between in situ data and numerical simulation after one month using the 2DH model with the meteorological model.

We began simulations with a fattening of the zone of study at the beginning of November 2000 and we can compare the results obtained with model 2DH (waves, hydrodynamics and transport) and the model simplified Multi-1DH. Secondly, we regarded as basic state a profile of the bathymetry of November 16, 2000, the P5 profile with $X = 200\text{m}$ (distance longshore compared to the beginning of the zone of study). This approach will enable us to more easily compare the models of calculation used by the various partners of the program. For these simulations we agreed to consider three cases of climatic conditions (see Table 3): Traditional Storm (TS), Falling from Storm (FS) and Exceptional Storm (ES). The whole of simulations was carried out with the model multi1DH and the results will be presented in the continuation. We also made some calculations with the chain of Artemis-Telemac2d-Sisyphe code.

Table 3 : Weather data simplified for the three cases of storm (Q angle in degree in the trigonometrical direction reverses compared to the normal with the beach).

	temps	Hs	Ts	θ
TS	24 h	1 m	6,5 s	0° et 20°
FS	24 h	2,5 m	7 s	0° et 20°
ES	24 h	4 m	10 s	0° et 20°

For case FS, the swells do not have effects on the internal and external bars. For simulations TS the swells erode the internal bar but does not seem to attack to a significant degree the beach and the external bar. Only one longer-term erosion of the internal bar can be prejudicial with maintains of beach.

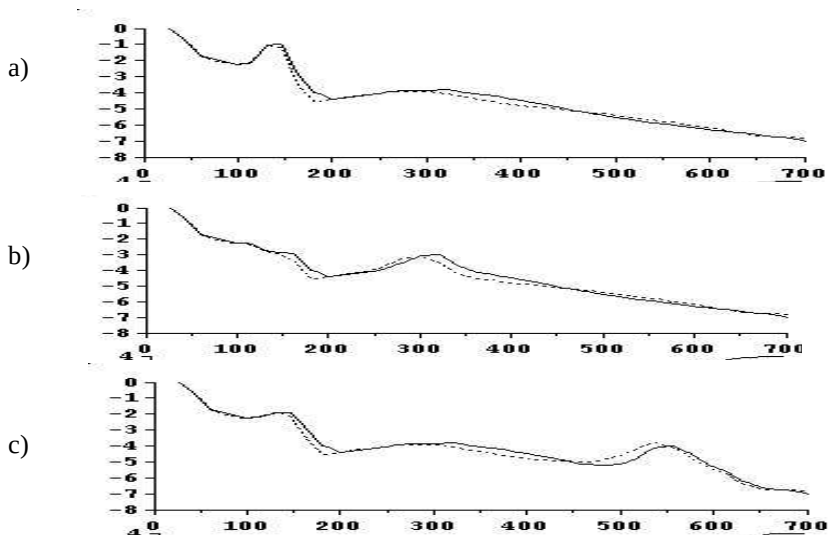


Figure 5: Sea bed evolution on 24 hours calculated with the multi1DH model for three location of nourishment: a) on the inner bar, b) on the offshore bar and c) with the cration of new bar offshore.

The case of the exceptional storms will be used to us as a basis to present the differences obtained with the model multi1DH between different the option from recharging. The case, on the basic profile of November 16, 2000, shows us an erosion of the bars internal and external with a transport of these bars towards the broad one and thus one can consider a weakening of the protection of the beach (see figure 5). The internal bar is eroded of approximately 10m and the external bar of 40m, the deposit with broad with a maximum of 25 m but is very spread out.

These values are indicative to be possibly compared with other simulations but cannot be used as quantitative values for real estimates of the quantities of sands put moving. We will further see they is values are still strongly dependent on the models and in particular on the formulas of sedimentary transport.

5. Conclusion

The interesting thing of this study is that we can compare our numerical results to an experimental approach. Then, it could be easier to modulate time steps to have the most realistic results. However, some modules like undertow module have to be improved, and the interaction between tidal currents and waves has to be performed to compare the influence of the interaction between the littoral drift and the waves. To decompose hydrodynamic system into four parts (waves, littoral drift, undertow and tidal currents) simplifies a lot the numerical computation but neglect some cases of interaction. Then, a great part of our future work is to reduce it.

This type of facilities corresponds to those that have be implanted effectively on the site of survey. It is therefore natural that this configuration is confronted to data in term of sedimentary transport. Our simulations with facilities will have for goal in a first time to compare modifications with the state of reference of the unbounded beach (single cell). These simulations will have to compared also with data on site recovered via the old campaign or the aerial photographs of follow-up of coast feature and via the present or future campaign on site.

Acknowledgements

The major part of the research is supported by the PNEC and LITEAU french programs and by CEE-HUMOR program.

References

- Boczar-Karakiewicz B., Romanczyk W. and Long B., Réhabilitation du littoral par rechargement : Nord-Est de Jerba, Tunisie. In : Proc., 2001 Canadian Coast. Conf. Pp 13-25, Québec, Canada. CCSEA
- Camenen B. and Larroudé Ph., 2003, *Comparison of sediment transport formulae for a coastal environment*, Journal of Coastal Engineering, 48, pp. 111-132.
- Camenen B. and Larroudé Ph., 2003b, *Un modèle morphologique côtier pour la création de barres rythmiques*, Revue française de génie civil, in Press.
- Certain, R., 2002 Morphodynamique d'une côte sableuse microtidale à barres : le golfe du Lion (Languedoc-Roussillon). PhD Thesis, University of Perpignan, 199 pp.
- Cienfuegos R. Rôle du rouleau de déferlement dans les courants littoraux engendrés par la houle, Master report, September 2002
- Christensen E.D., Deigaard R. and Fredsoe J. 1994, Sea bed stability on a long straight coast, 24th *Coastal Eng. Conf. Proc.*, ASCE, 1865-1879.
- Dally W.R., Dean R.G., and Dalrymple R.A. , 1984. A model for breaker decay on beaches. In 19th *Coastal Eng. Conf. Proc.*, pages 82-88. ASCE.
- De Vriend H.J., 2DH Mathematical Modelling of Morphological Evolutions in Shallow Water, 1987, Coastal Engineering ,11, pages 1-27
- De Vriend H.J. and Stive M.J.F., Quasi-3D Modelling of Nearshore Currents, 1987, Coastal Engineering ,11, pp. 565-601
- Falquès A., Montoto A. and Iranzo V. 1996, Bed-flow instability of the longshore current, *Cont. Shelf Res.*, 16, 1927-1964.
- LNHE-Chatou, Telemac2d - modelisation system of Telemac, version 5.2 – user-validation manual, 2002, Technical report, edf-gdf
- LNHE-Chatou, Sisyphe - modelisation system of Telemac, version 5.2 – user-validation manual, 2002, Technical report, edf-gdf
- LNHE-Chatou, Artemis - modelisation system of Telemac, version 5.2 – user-validation manual, 2002, Technical report, edf-gdf
- Michel D., Howa H., Thomas C., Chapalain G., Thais L. and Malengros D. 2000, Sediment dynamics and hydrodynamics on the inner part of the Aquitan shelf : preliminary results, *Sandwave Dynamics Workshop*, Lille, France, 123-125.
- Svendsen I.A. 1984, Mass flux and undertow in the surf zone, *Coastal . Eng.* ,8, 347-365.