Collaborative European Atlantic Water Quality Forecasting System

Final Report –Sept. 2012

Activity 2. Local Studies : The Adour model (UPPA-SIAME/IVS (LaSAGeC²))

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1 Introduction

The main purpose of this paper/report is to present works done by SIAME.IVS team from UPPA (University de Pau et des Pays de l'Adour) during the EASYCO project. First, the Adour Estuary problematic and the operational model organisation are presented, then the integrated design method for environmental modelling IDeASyCoM ® is described and at last operational model procedure is presented.

2 Presentation of the site and its specificities

The Adour River mouth is located in Anglet, on the South West of France (Fig. 1a) and gives access to the commercial harbour of Bayonne. In the past, the operation of the port and the economy of Bayonne suffered from the meandering of the Adour river estuary and from the bar which was formed at the mouth. Since the 16th century, numerous harbour works have been carried out to fix the Adour River mouth in its current location. Today the last ten kilometers of the Adour river are completely channeled. Nowadays the navigation channel located at the mouth of the Adour suffers from a recurring problem of silting and needs regular dredging to preserve the necessary depth for commercial navigation. So recently, in the last few decades, five breakwaters (called "jetties" on this site) were built to protect the port entrance (Fig. 1b). However, these constructions have not solved the silting problem and recently, a preventive trench was dug south of the navigation channel in order to decrease the rate of siltation, and reduce the frequency of maintenance dredging campaigns to twice a year. The cost of dredging is high and dredging activity can cause disruption to the normal port operations. Thus there is a need to plan dredging in order to contain costs while still removing sufficient material to maintain the navigation channel in operational condition.

Figure 1 : (a) Adour estuary located in Anglet, at the south east of the Bay of Biscay (b) Jetties at the Adour Mouth and along the beaches of Anglet

The Anglet coast lies on the southeastern edge of the Bay of Biscay and is particularly exposed to the broad swells which are formed over a fetch of 3000 km when meteorological depressions concentrate on Greenland or Iceland. This weather configuration is common in winter, creating very strong and very long swells, sometimes with periods between 17 to 25 s and heights from 8 to 12 m (Butel et al 2002, Abadie et al 2004, Abadie et al 2008). The typical winter swell has periods from

10 to 13 s and heights from 2 to 4 m, and occurs about 145 days a year, mainly from October to March. The 1 year return wave height (Hs) is estimated at 8 m and the 1 in 10 year swell height at 10 m. They are the strongest swells in France.

With regard to tidal characteristics the study site is mesotidal. Tides are semidiurnal and the maximum tidal range is 4.5 m (Landouer 1990).

The hydrodynamic processes responsible for the River mouth silting were characterized by (Brière 2005). Two complementary approaches were considered: field experiment and numerical modeling. The analysis of field campaign measurements and of numerical results obtained under representative forcings identified the influence of waves as the major forcing for sediment mobilization. The range of wave conditions that were able to lead to sediment deposition in the navigation channel were identified. Numerical simulations with Tomawac/Telemac 2D (EDF/DRD), (Hervouet 2003), were calibrated and used to simulate measurements obtained during the campaign. Different simulations were realized for mid range flow rates for the Adour and the analysis of the results has shown that under strong wave conditions (Hs > 3.3 m) a wave driven current is generated that flows from the extremity of the "South Jetty" to the Adour mouth. For less energetic waves (1.2 m < Hs < 3.3 m), this current is appreciable only during ebb flow tide. The Adour River flows along the "North Jetty". Moreover, the width of the Adour is reduced by half near the "little jetties", inducing a high velocity during ebb. Thus, with an average tide, the current speed increases from an upstream value of 0.7 $m.s^{-1}$ in the river to 2 $m.s^{-1}$ near the jetties and is maintained at this speed over a distance of about 500m (Landouer1990). This effect is increased by the Adour floods whose medium flow of 300 $m^3.s^-1$ can reach 1500 $m^3.s^{-1}$ under 1 in 10 year flood conditions and 2500 $m^3.s^{-1}$ under 1 in 100 year events. The ebb current velocity reaches 2.6 $m.s^{-1}$ in the 1 in 10 year flood and 4 $m.s^{-1}$ in the 100 year flood. In 2007, le SIAME/IVS team (ex. LaSAGeC) decided to leave TELEMAC which was a commercial model and use a free one. MOHID was chosen.

In a previous paper (Maron et al 2008), investigations on the medium term changes in seabed level in the region of the mouth of the Adour River, including the navigation channel and the preventive trench was done. The data comprised 40 bathymetric surveys collected by the Departmental Direction of Equipments of Bayonne (DDE) and SIAME/IVS team over a twenty six month period from 10/12/2001 to 13/02/2004. The survey data were analyzed using eigenfunction analysis; more often used for analyzing beach and near shore bathymetry over periods of tens of years (Winant et al 1975, Aubrey et al1980, Hsu et al 1986, Reeve et al 2001); the EOF method permitted to investigate the patterns of sediment movement. In particular, that wave driven long shore transport dominates transport by tidal currents in the river mouth. (Dubranna et al., 2008) proposed a method to predict the wave induced current in real time and to compute afterwards the associated sediment fluxes.

Therefore, this method was not accuracy enough and the development of a new model based on a free code as MOHID is necessary. Indeed, In harbor management, the understanding and prediction of navigation channel behavior is important. The effects of controlling parameters such as storms or river floods must be well-known in order to plan dredging campaigns effectively.

3 The Adour Hydrodynamic models

To modelised the Adour estuary, the problem is a great variability of the different phenomena caracteristic lengths to take in account. First the Adour plume extension with a characteristic length of about 30km, then the Anglet beaches erosion with a length of 4 km and at last the Adour mouth with a 150m width.

So the idea is to optimize calculation times with nesting grids covering only areas of interest. Square regular grids are used with nesting models.

3.1 The 3D and 2D Models

Main area of the new model (Plume_Adour) is grid 3D_L3. its influence is calculated for a spell of about 50 km wide and up to the level of the “Bassin d'Arcachon” to the North, an area that could be covered by the plume, particularly in cases of major flood. This model is mainly geared toward tracking the plume, but its influence also covers the coast south Aquitaine Basin of Arcachon and could therefore be used to examine other rivers that Adour (Nivelle; Bidasoa, Spanish rivers).

With the aim of monitoring the plume of the Adour, the 3D_L3 model will be forced by a father model 3D_L2 which will introduce the forcings parameters from MERCATOR (http://www.mercator-ocean.fr) (barotropic velocity U, Y barotropic velocity, salinity, temperature, velocity U, V velocity, velocity modulus, water level). The Mercator projection is a square grid mesh Δx = 0.06 ° and to limit the interpolation problems, we use a same grid width for this 3D_L2 level.

“Water Level" given by Mercator is the surge. The tidal wave is not integrated. It is therefore necessary to include this forcing phenomenon with a higher level, 3D_L1 . Raising the water level is imposed here by a network of gauges depending on the model produced by the FES2004 LEGOS (http://www.legos.obs-mip.fr). We will adopt the same size of meshes in the grid model 3D_L1, ie Δx = 0.06 ° as 3D_L2.

Regarding good practices in developing nesting models, and solving the problematic of a good representation of the tide, the final grids have the following properties.

This constraint sets the limits of model 3D_L1 to all Bay of Biscay ((4.74 ° W, 43 161 ° N) to (-0.90 ° W, 48.0810N), or 64 * 82 cells)

The 3D_L2 grid was included in 3D_L1. We also chose to have a single border because it did not involve an excessive increase in the number of cells ((3.84 ° W 43.22 ° N) to (-0.96 ° W, 47.84 ° N), or 48 * 77 cells)

The 3D_L3 model also respects all the nesting grids constraints ((-2.22 ° W, 43 281 ° N) to (-1.2 ° 0 44 601 ° N), or 85 * 110 cells). The spatial definition of each cell of 3D_L3 is about 1.3 km.

To obtain greater accuracy, especially for plumes of low amplitude, a lower level model was planned. Thus the model 3D_L4 has a width of 0.004 ° ((-1.80 ° W, 43 365 ° N) to (1404 ° W, 43 809 ° N) or 99 * 111 cells), and a definition of about 450m. A ratio of only three has been chosen to try to keep reasonable computing time.

3D_L3 and 3D_L4 are vertically refined in order to obtain a 150m definition at the vicinity of Adour River mouth which corresponds to the width of the river.

Figure 2 shows these four nested grids forming the “Adour_Plume” model.

Models 3D_L2, 3D_L3 and 3D_L4 are 3D models, while Model 3D_L1 is a 2D one. To obtain a good representation of the stratification phenomena of the Adour plume, we used the Lagrangian mesh identical to Mercator one until 8.68 m depth, and above a 7 levels Sigma mesh. Consequently, models 3D_L2, 3D_L3 and 3D_L4 respectively include 46, 38 and 34 levels.

Mercator data are interpolated and assimilated by the 3D_L2 model.

Models 3D_L2, 3D_L3 and 3D_L4 also receive meteorological forcing from the WRF model whose data were provided by MeteoGalicia (since February 2010) (air temperature, atmospheric pressure, Downward long wave radiation, latent heat, mean sea level pressure, precipitation, Relative Humidity, sea water temperature, sensible heat, solar radiation, ground, top outgoing shortwave radiation, wind stress, X, Y wind stress, wind velocity X, wind velocity Y). MeteoGalicia data are interpolated to each grid of these model.

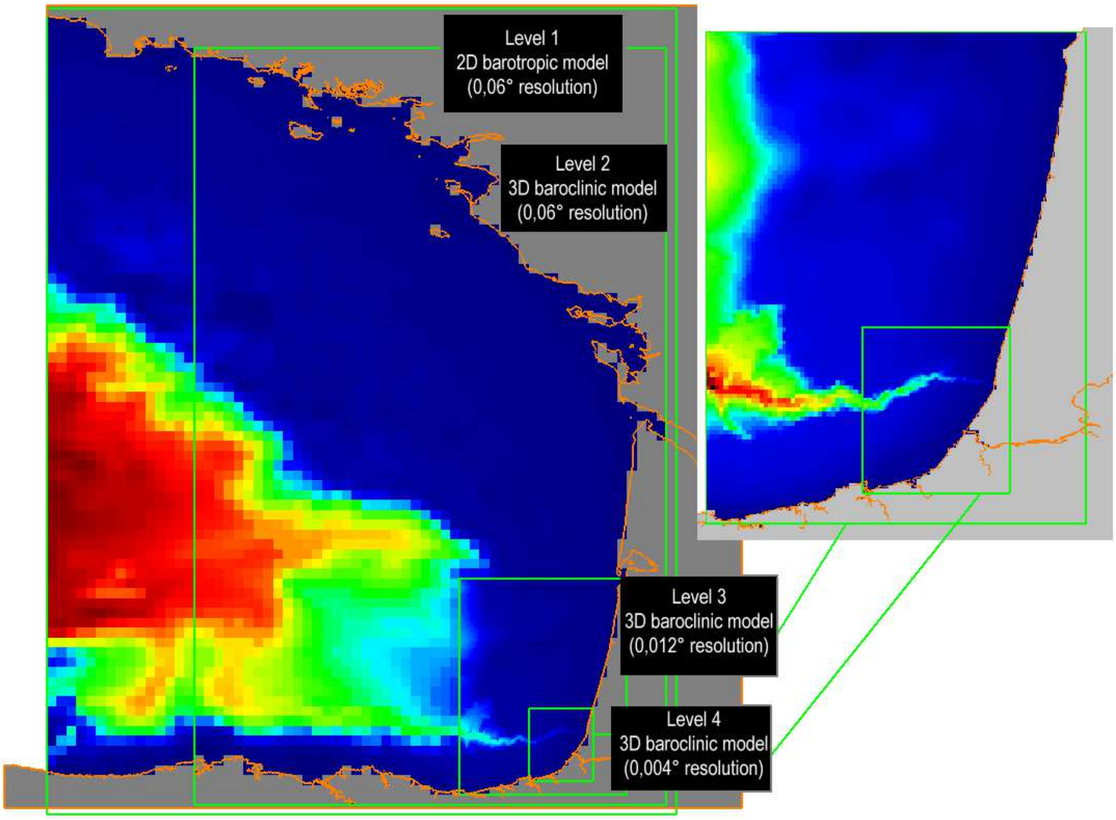

Figure 2 : Extent and mesh models 3D_L1, 3D_L2, 3D_L3 and 3D_L4

Table 1 summarizes the characteristics of different levels of the 3D model

Table 1: Characteristics of grids of 3D model

Model	***ΔL (°)***	***ΔL (m)***	***Longitudes***		***Latitudes***		***Number of Cells***		***2D/3D***	***Nb Levels***	***Forcing terms***
3D_L1	0.06°	6660,00	-4.74°	-0.90°	43.161°	48.081	64*82	5248	2D	1	WaterLevel
3D_L2	0.06° (Mercator)	6660,00	-3.84°	-0.96°	43,22	47,84	48*77	3696	3D	46	Mercator / MeteoGalicia
3D_L3	0.012°	1332,00	-2.22°	-1.2°	43.281°	44.601°	85*110	9350	3D	38	MeteoGalicia
3D_L4	0.004°	444,00	-1.80°	-1.404°	43.365°	43.809°	99*111	10989	3D	34	MeteoGalicia / Discharge

It remains to realize the flow forcing in the model. To do this, we must know the temporal variation of flow entering or leaving the mouth of the Adour. The first idea is to continue to refine the model but choosing a maximum ratio of 5 to get from 3D_L2 to 3D_L5 model, we obtain a mesh size of Δx = 0.0024 ° (≈ 266.4m) This is still very inadequate to model the Mouth of the Adour.

Going down again to a level 3D_L6, we obtain a mesh size of Δx = 0.00048 ° (≈ 53.3m). This level can be used to model the output of the Adour (It takes about 3 cells to model the output of the Adour and the width of the mouth is approximately 150 meters between the guide jetties). But it gets so that the minimum definition to obtain satisfactory results.

However, down by two additional levels compared to the level of 3D_L3 to model the mouth will cause a global model with 5 levels in 3D, which will likely leads to computing times incompatible with an operational model.

Consequently, the choice was to build a 2D model to construct time series of flows into and out of the Adour. This time series will then be introduced directly as forcing terms on the 3D_L4 model.

This model therefore reproduces 3D_L1(named here 2D_L1) level to achieve tidal forcing. The following grid 2D_L2 corresponds directly to the 3D_L3 grid geographic extension.

Then a 2D_L3 grid with mesh size Δx = 0.0024 ° ((-1.8 ° W, 43 365 ° N) to (1356 ° W, 43 809 ° N) or 185 * 185 cells) is constructed and at last a 2D_L4 grid with mesh size Δx = 0.00048 ° (-1.5552 ° W, 43.4826 ° N) to (1.3608 ° W, 43 545 ° N) is 405 * 130 cells).

Table 2 : Characteristics of different levels of the 2D model

Models	***ΔL (°)***	***ΔL (m)***	***Longitudes***		***Latitudes***		***Number of Cells***		***2D/3D***	***Nb Levels***	***Objectif Forçage***
2D_L1	0.06°	6660,00	-4.74°	-0.90°	43.161°	48.081	64*82	5248	2D	1	WaterLevel
2D_L2	0.012°	1332,00	-2.22°	-1.2°	43.281°	44.601°	85*110	9350	2D	1	Mercator /MeteoGalicia
2D_L3	0.0024°	266,40	-1.8°	-1.356°	43.365°	43.809°	185*185	34225	2D	1	MeteoGalicia
2D_L4	0.0048°	53,28	-1.603°	-1.361°	43.4826°	43.5546°	505*150	75750	2D	1	MeteoGalicia / Discharge

Figure 3 shows the nesting of these four models and Table 2 summarizes the characteristics of different levels of the 2D model.

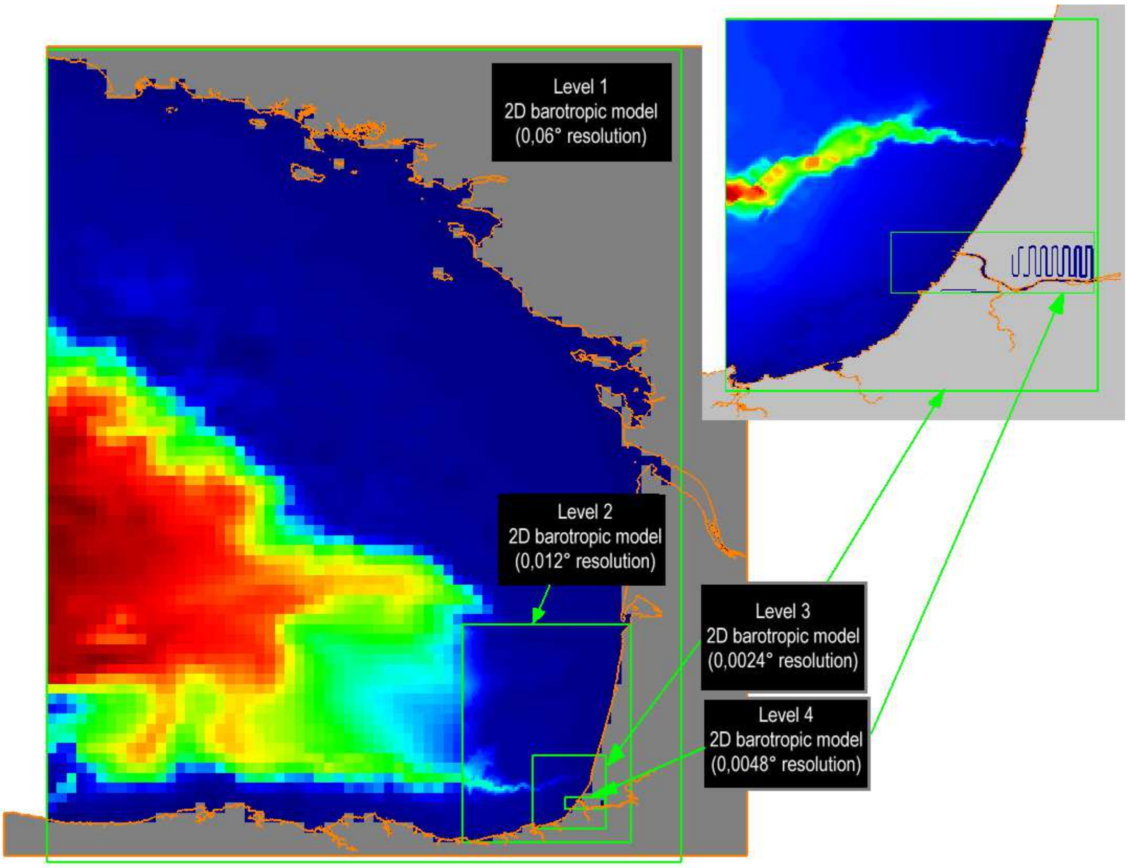

Figure 3 : Extent and mesh models from 2D_L1 to 2D_L4

First 2D model is running. Flows going down and up to a zone situated at the Adour mouth are recorded. Then this records are used to force the discharge in the 3D_L4 model. With this method, it is not necessary to modelised all the Adour estuary in 3D to study only the plume extension.

3.2 Calibration of the 2D model

Calibration of the model is obtained by comparison between model results and ADCP measurements.

3.2.1 Acquisition protocol of ADCP measures (bottom tracking mode):

The measurements were performed on several cross sections located in the estuary at the mouth of the Adour. Each profile has undergone three measurement days respectively during a spring tide to waters, an average tidal waters and tidal neap tides.

During each day, each profile was measured several times and every hour during a complete cycle of the tide.

We can thus reconstruct the profiles of each temporal velocity evolutions (U, V and W) (or flow rates) during three different tidal cycles.

3.2.2 Calibration of numerical model

Calibration of the numerical model is done after simulating the three measurement periods.

For the 2D model, the vertical averaged speeds (or flow rates) are compared between model results and measurement results. We can thus obtain twelve comparative values for each checkpoint (or cross sections). The quality of the correlation between measurements and simulation results is quantified through the ARMAE.

The Adjusted Relative Mean Absolute Error between observed and predicted values quantifies the model quality including all types of errors (Sutherland et al. 2004). The advantage of these criteria is that error measurements are taken in account.

The ARMAE is obtained by equation (1):

$$ARMAE = \frac{\langle |Y - X| - OE \rangle}{\langle |X| \rangle} \qquad (1)$$

With X, the observed values, Y the predicted values and OE the observed error e.g. the error on the observed values.

The measurement errors for velocity were estimated for different velocity ranges and combined to give an estimated value of observed error OE=0.05 m/s (Van Rijn et al., 2000).

Sutherland proposed a classification of the model quality based on the ARMAE as follows :

Table 3 : Error classification proposed by Sutherland

Classification	***Range of ARMAE***
Excellent	< 0.2
Good	0.2 – 0.4
Reasonable	0.4 – 0.7
Poor	0.7 – 1.0
Bad	> 1.0

The smaller the ARMAE is, the better the quality of the model is.

The observed velocity is from measurements on 4 profiles (Figure 4) on the 24th & 25th July 2008 (Average tide), 3rd & 4th August 2008 (Spring tide) and 11th & 12th August 2008 (Neap tide).

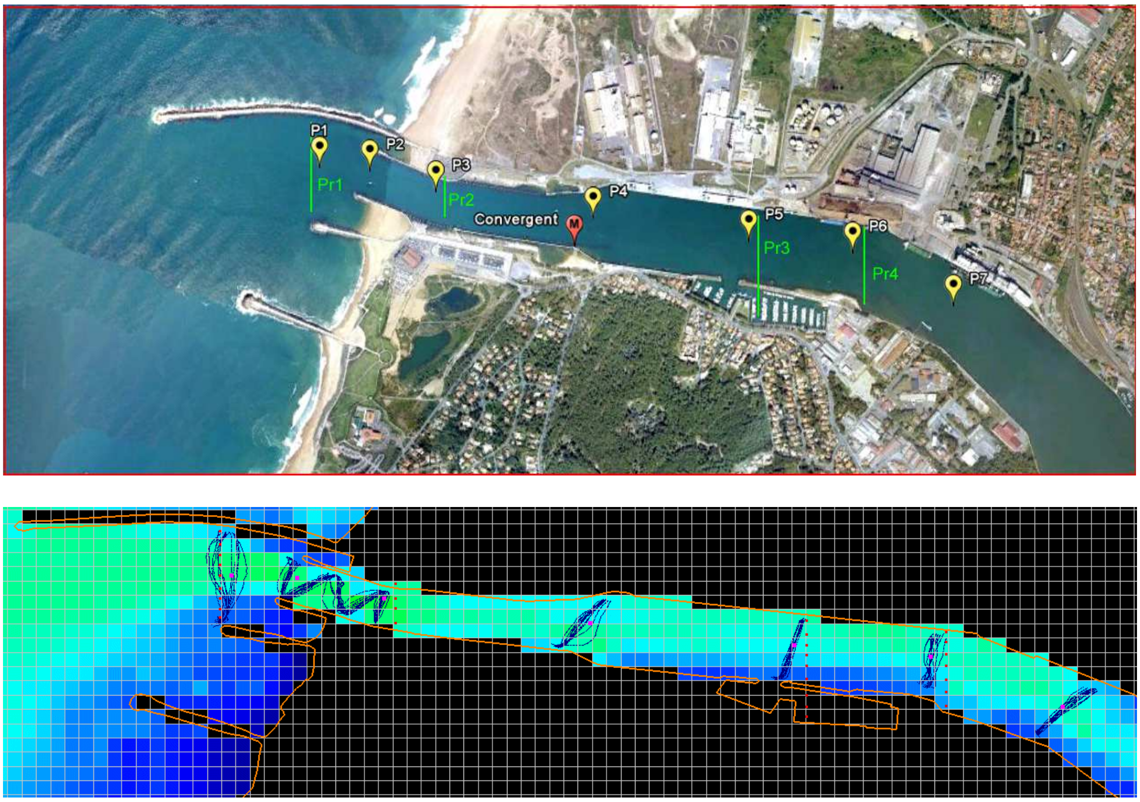

Figure 4 : a) Location of the different points and profiles used for comparison on mean velocities and flow rate b) view of location of the measurement of the ADCP campaign for average tide

The simulated velocity is the result from a 2DH model fed with data (tide, meteo, etc.) measured on the 24th & 25th July 2008 (Average tide), 3rd & 4th August2008 (Spring tide) and 11th & 12th August 2008 (Neap tide).

3.3 Obtain results with calibrated model

3.3.1 Water level

3.3.1.1 Average tide

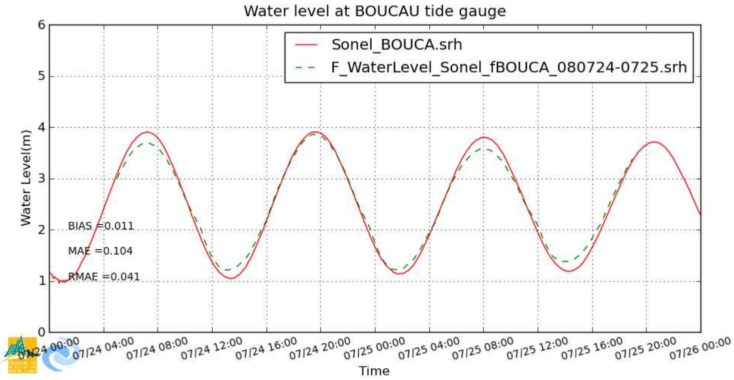

Figure 5 : Comparison of water levels between tides gauge at Boucau(Convergent) and the results of the model during a average tide

3.3.1.2 Spring tide

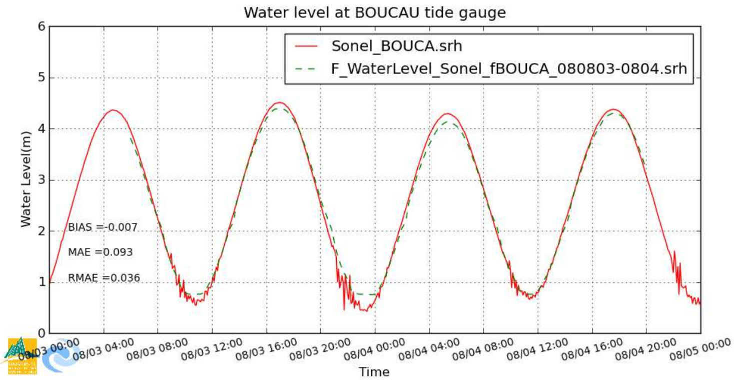

Figure 6 : Comparison of water levels between tides gauge at Boucau (Convergent) and the results of the model during a spring tide

3.3.1.3 Neap tide

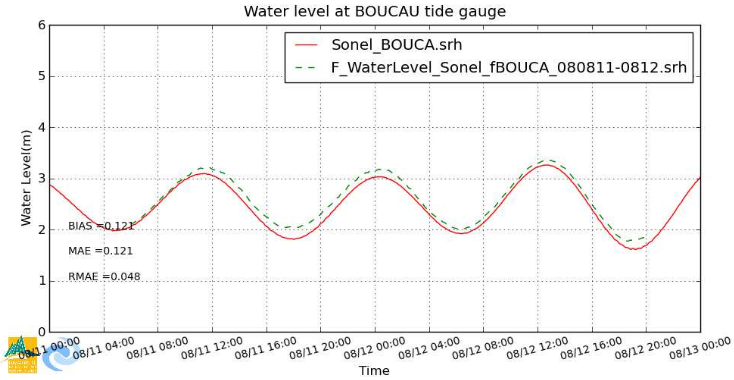

Figure 7 : Comparison of water levels between tides gauge at Boucau(Convergent) and the results of the model during a neap tide

In term of water level, we can see that the model tends to overestimate it for average and spring tide. on the contrary, for a neap tide, the model gives a good amplitude value, but the water level is lower than those measured.

The spring tide signal presents a noise at low water level that could be due to bathymetry at the point

3.3.2 Velocities

3.3.2.1 Average tide

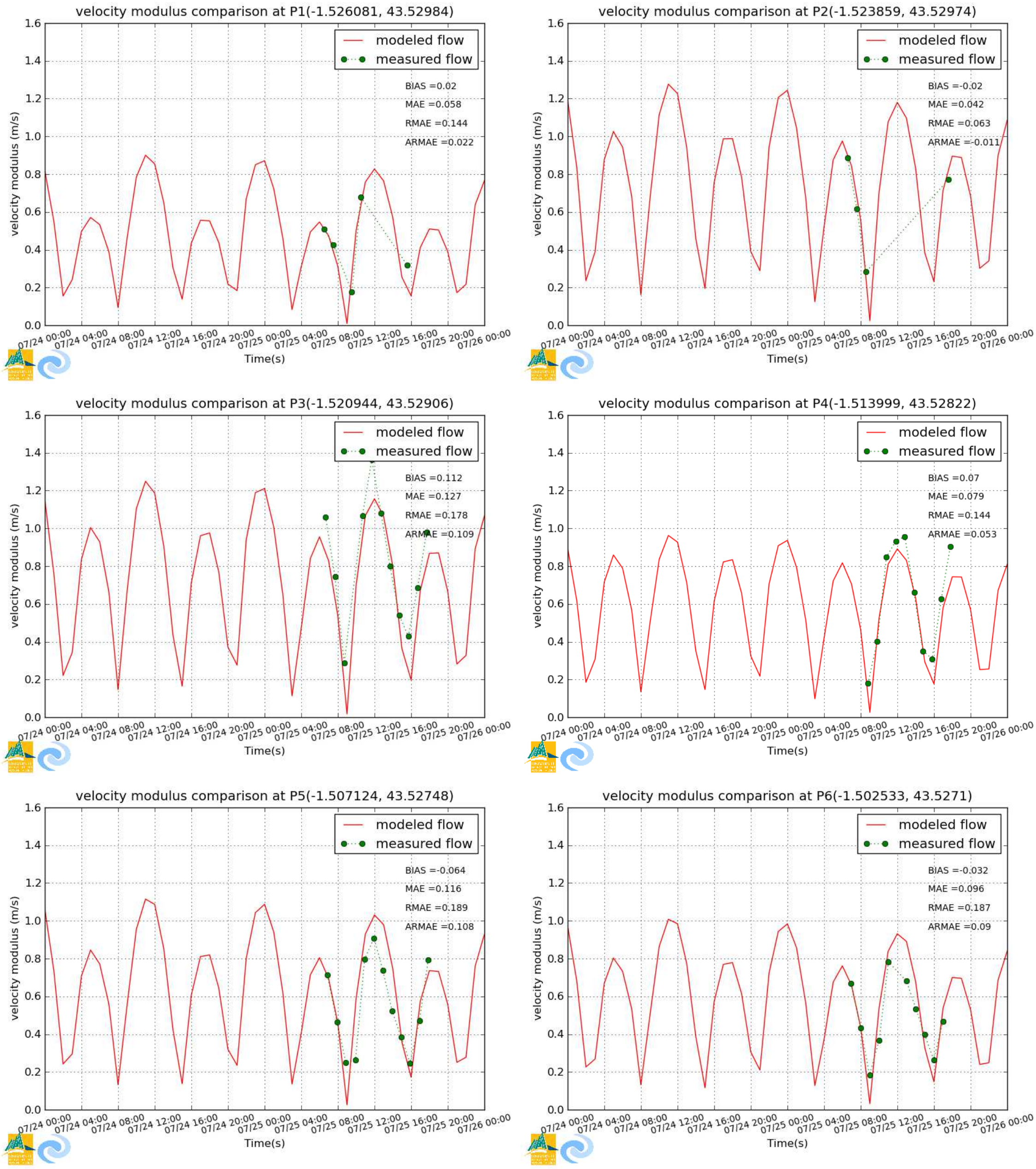

Figure 8 : Comparison of mean velocities at different points of the Adour mouth between measurement data and model results during an average tide

3.3.2.2 Spring tide

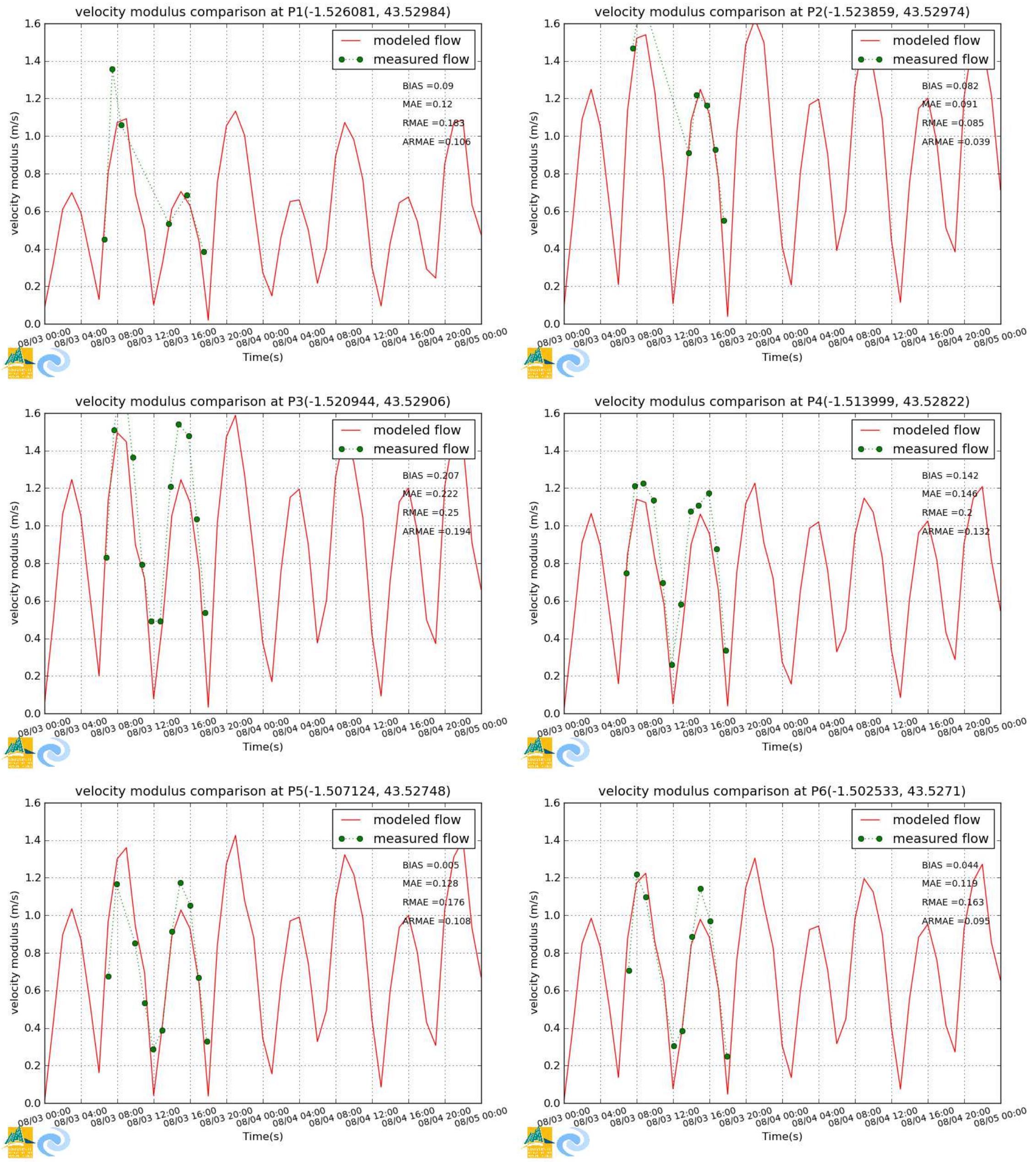

Figure 9 : Comparison of mean velocities at different points of the Adour mouth between measurement data and model results during a spring tide

3.3.2.3 Neap tide

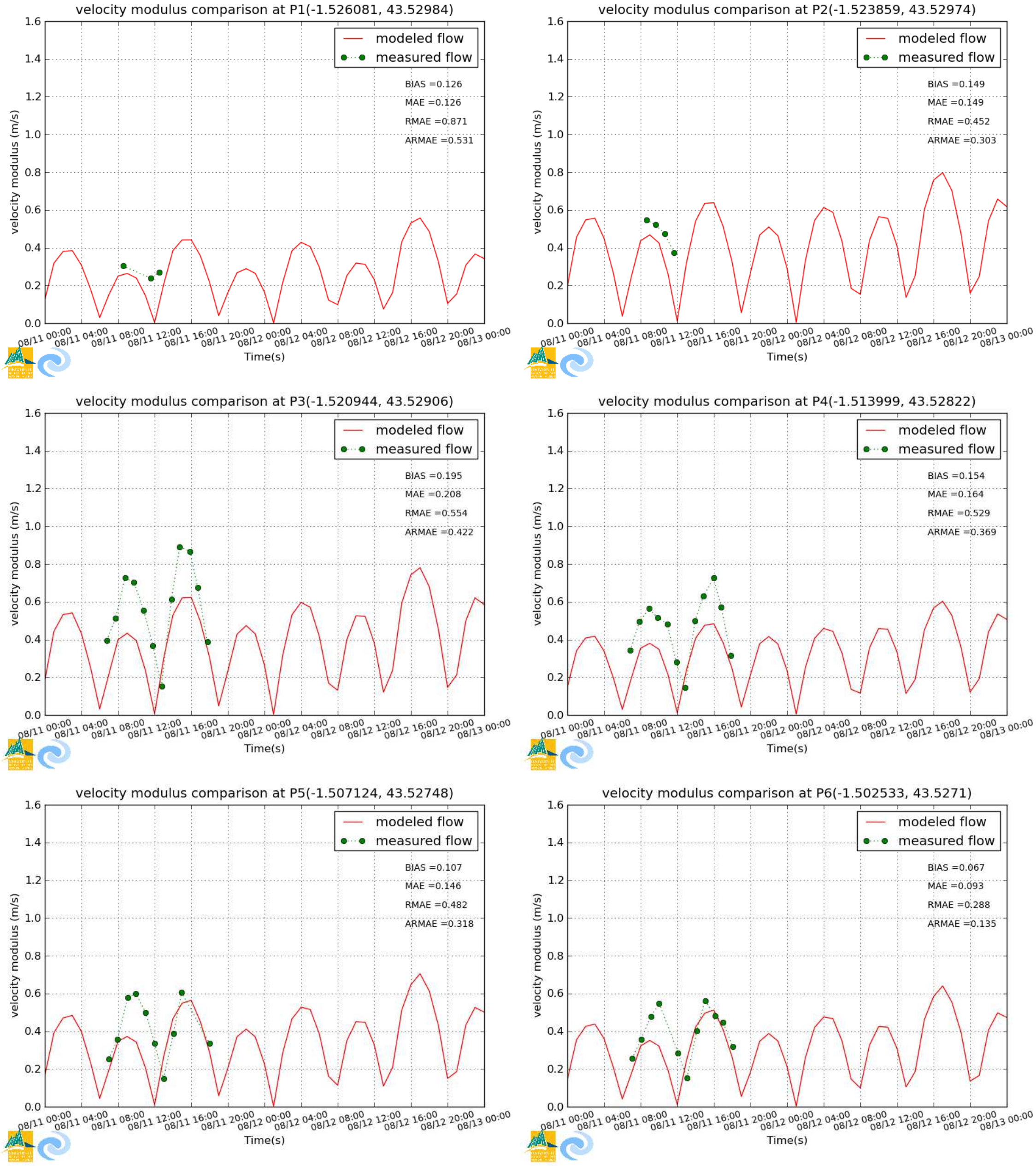

Figure 10 : Comparison of mean velocities at different points of the Adour mouth between measurement data and model results during a neap tide

3.3.3 Flow rates

3.3.3.1 Average tide

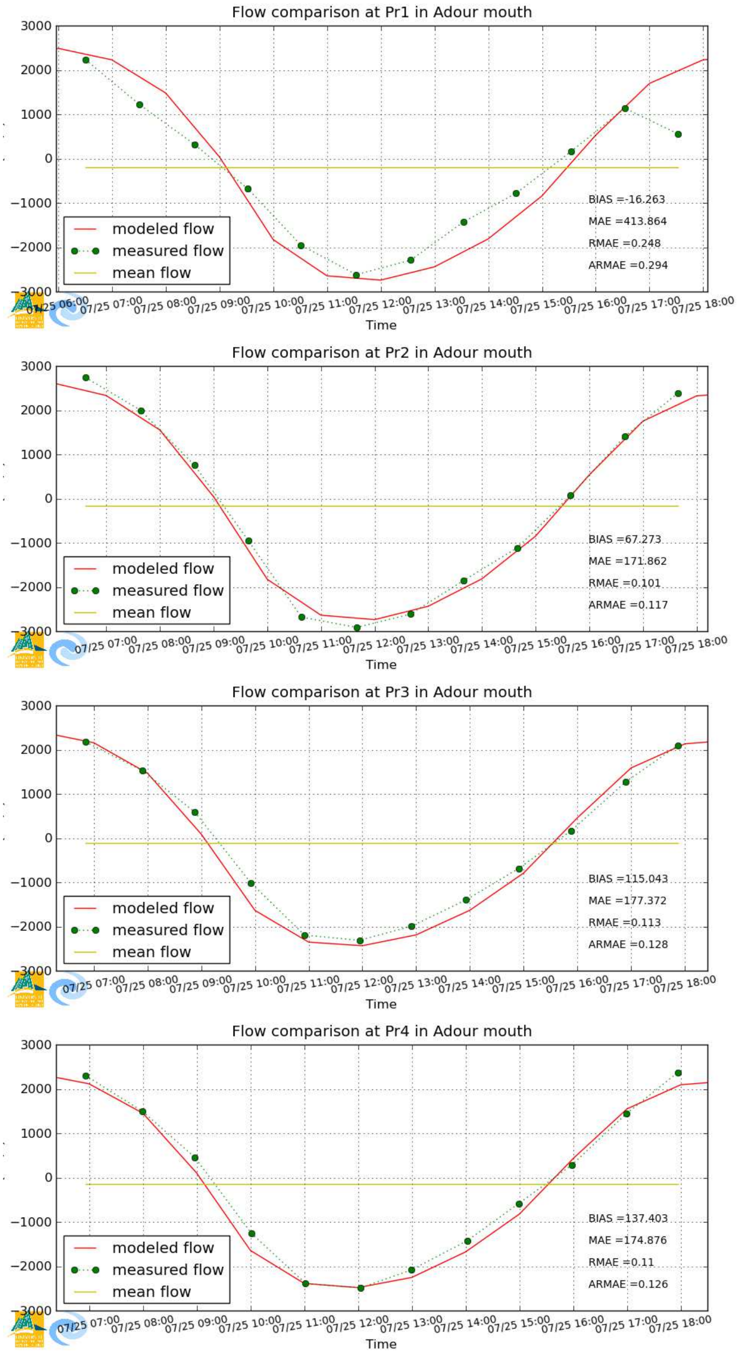

Figure 11 : Comparison of flow rate rate during an average tide

3.3.3.2 Spring tide

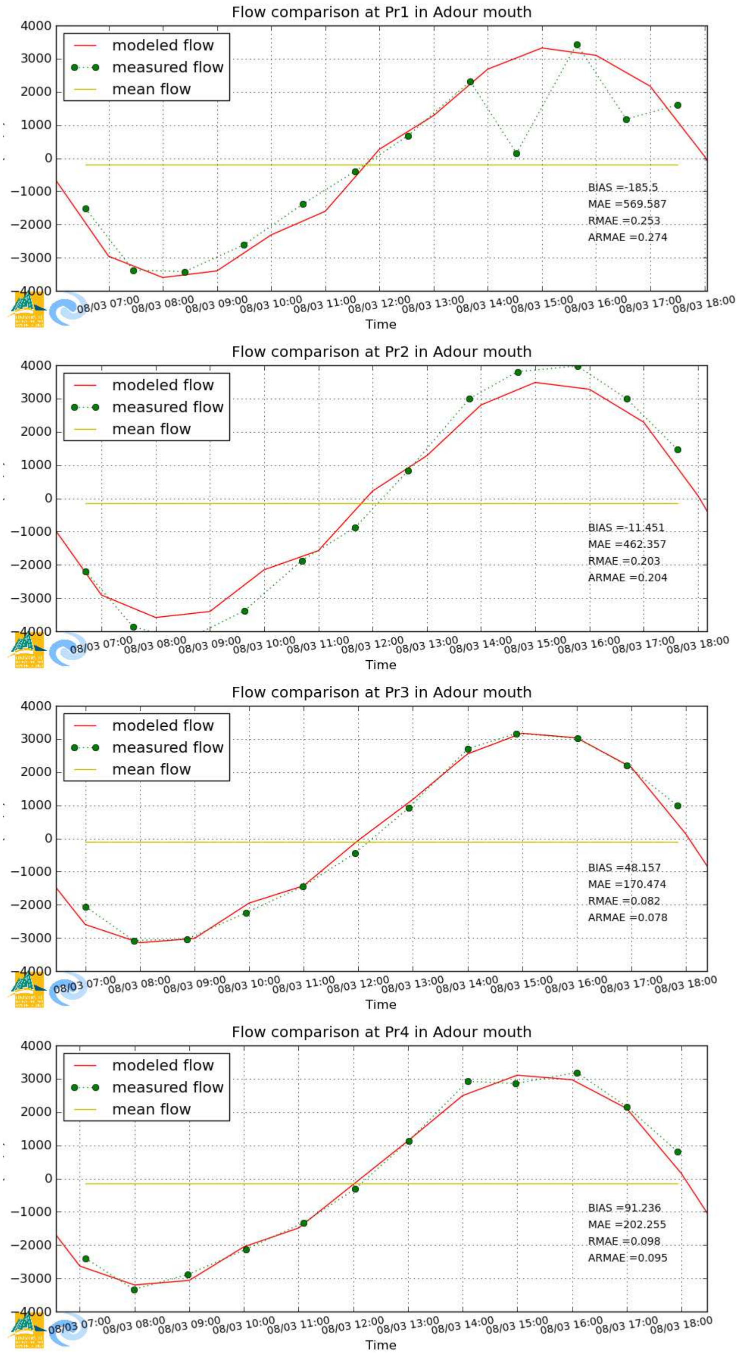

Figure 12 : Comparison of flow rate during a spring tide

3.3.3.3 Neap tide

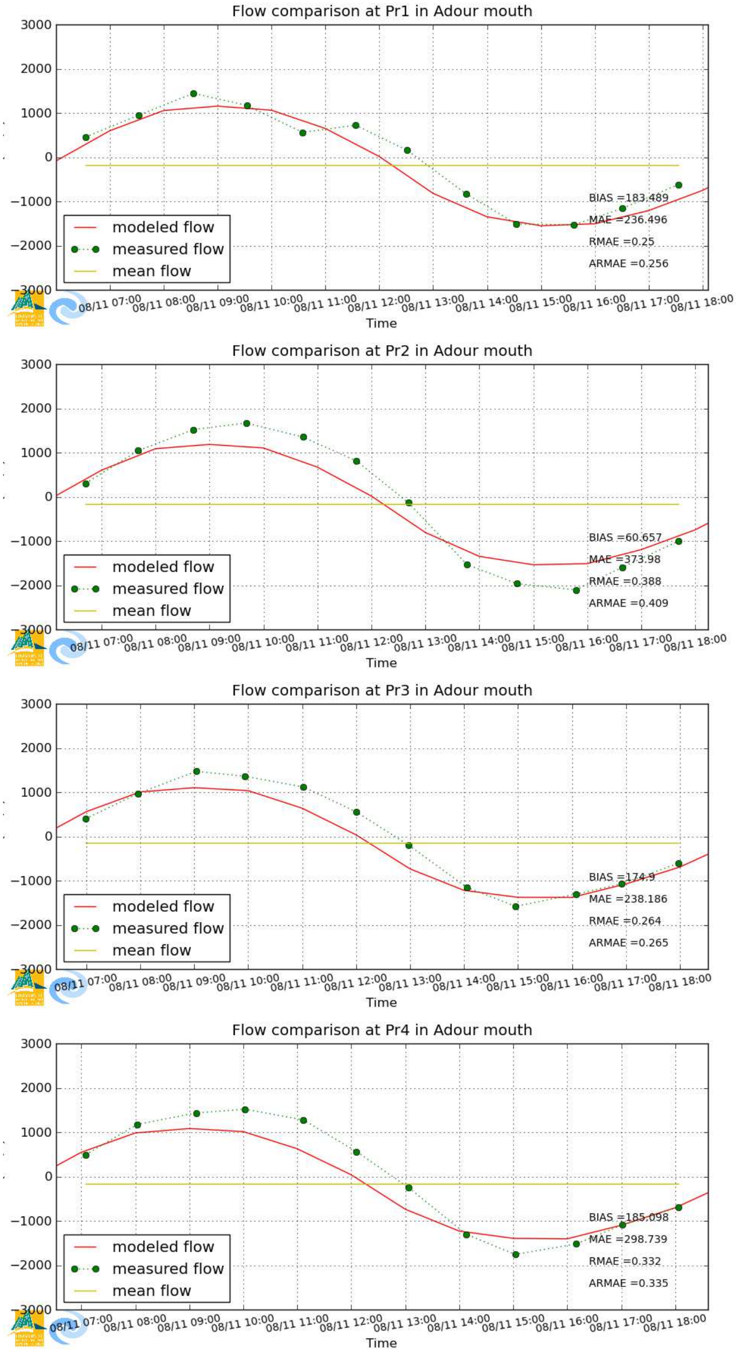

Figure 13 : Comparison of flow rate during a neap tide

3.3.4 Conclusion on quality of the model results

Statistics of different comparative tests are summarized in Table 4 for comparisons of velocities and Table 5 for comparisons of flow rates.

Table 4 : Statistic values for mean velocities

	Average tide				*Spring tide*				*Neap tide*			
	BIAS	***MAE***	***RMAE***	***ARMAE***	***BIAS***	***MAE***	***RMAE***	***ARMAE***	***BIAS***	***MAE***	***RMAE***	***ARMAE***
P1	0.020	0.058	0.144	0.022	0.090	0.120	0.183	0.106	0.126	0.126	0.871	0.531
P2	0.020	0.042	0.063	0.011	0.082	0.091	0.085	0.039	0.149	0.149	0.452	0.303
P3	0.112	0.127	0.178	0.109	0.207	0.222	0.250	0.194	0.195	0.208	0.554	0.422
P4	0.070	0.079	0.144	0.053	0.142	0.146	0.200	0.132	0.154	0.164	0.529	0.369
P5	0.064	0.116	0.189	0.108	0.005	0.128	0.176	0.108	0.170	0.146	0.482	0.318
P6	0.032	0.096	0.187	0.090	0.044	0.119	0.163	0.095	0.067	0.093	0.288	0.135

Based on the criteria of Sutherland summarized in Table 3, we find that the results for comparisons of mean velocities are :

excellent for an average tide and spring

good to reasonable for spring tide

Point P2 is just between the two little jetties at the Adour mouth. In the model 2D_L3, this area is not very detailed (the jetties are not present) which explains the poor results obtained for this point. Results with the model 2D_L4 should be more accurate.

Table 5 : Statistic values for flow rates

	Average tide				*Spring tide*				*Neap tide*			
	BIAS	***MAE***	***RMAE***	***ARMAE***	***BIAS***	***MAE***	***RMAE***	***ARMAE***	***BIAS***	***MAE***	***RMAE***	***ARMAE***
Pr1	-16.23	413.86	0.248	0.294	-185.5	569.58	0.253	0.274	183.48	236.49	0.250	0.256
Pr2	67.27	171.86	0.101	0.117	-11.45	462.35	0.203	0.204	60.65	373.98	0.388	0.409
Pr3	115.04	177.04	0.113	0.128	48.15	170.47	0.082	0.078	174.9	238.18	0.264	0.265
Pr4	137.40	174.87	0.110	0.126	91.23	202.25	0.098	0.095	185.09	298.73	0.332	0.335

Also according to Sutherland's criteria, we find that the results for comparisons of flow rates are excellent to good in all cases. The results are slightly degraded for a low tidal amplitude.

3.4 Current state : Mohid 3D Model

At the present time, 3D model runs every day and gives results for the d day and three days of forecast.

We simulated the period from 15/5/2010 to 20/5/2010 which corresponds to the METADOUR 3 field campaign carried out aboard the "Côte de la Manche" vessel in order to perform a series of water properties measurements near the Adour river mouth and in the river.

The numerical simulation begins on the 15/4/2010 in order to let enough time to stabilize the model.

We compared salinity and temperature profiles measured with a CTD probe 'Seabird' to the results of the model. Preliminary results of the comparisons between measurements and model results are presented in Fig. 14 and Fig.15.

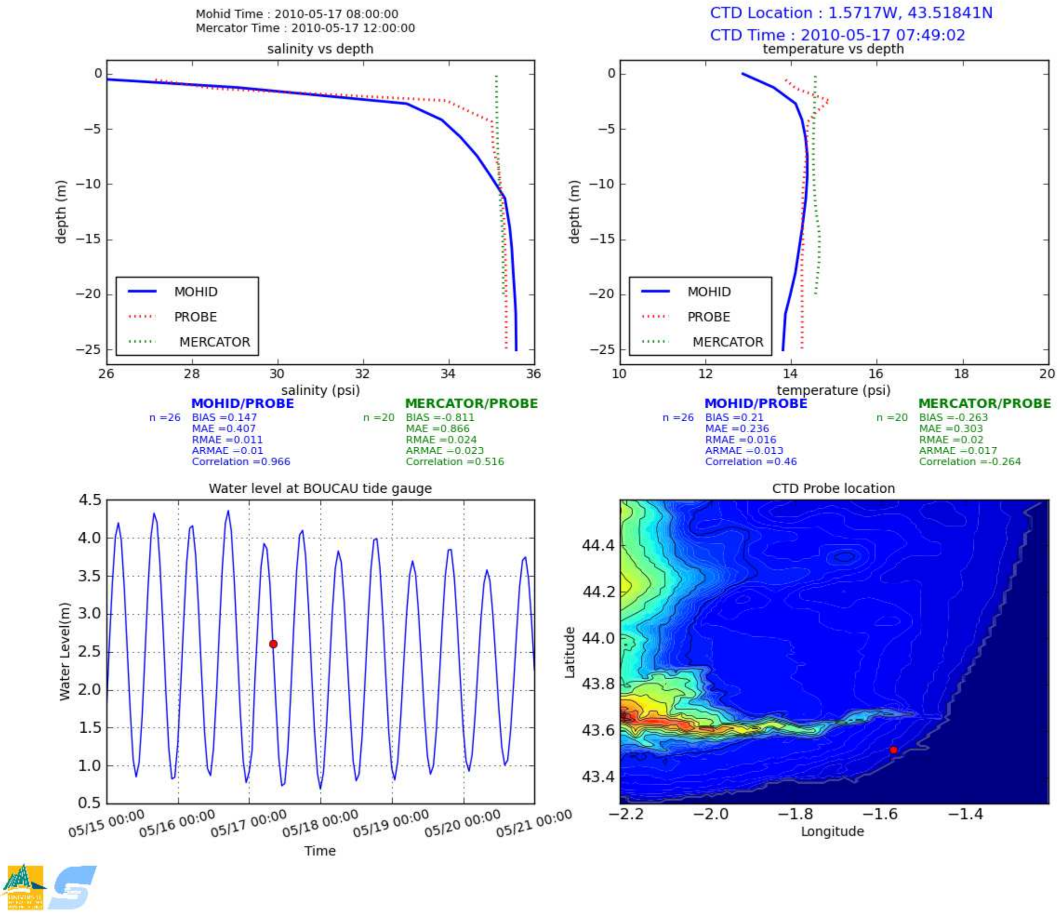

Fig. 14 : Comparison between model C3 results and CTD probe measurements on 17th May 2010 at 8h00

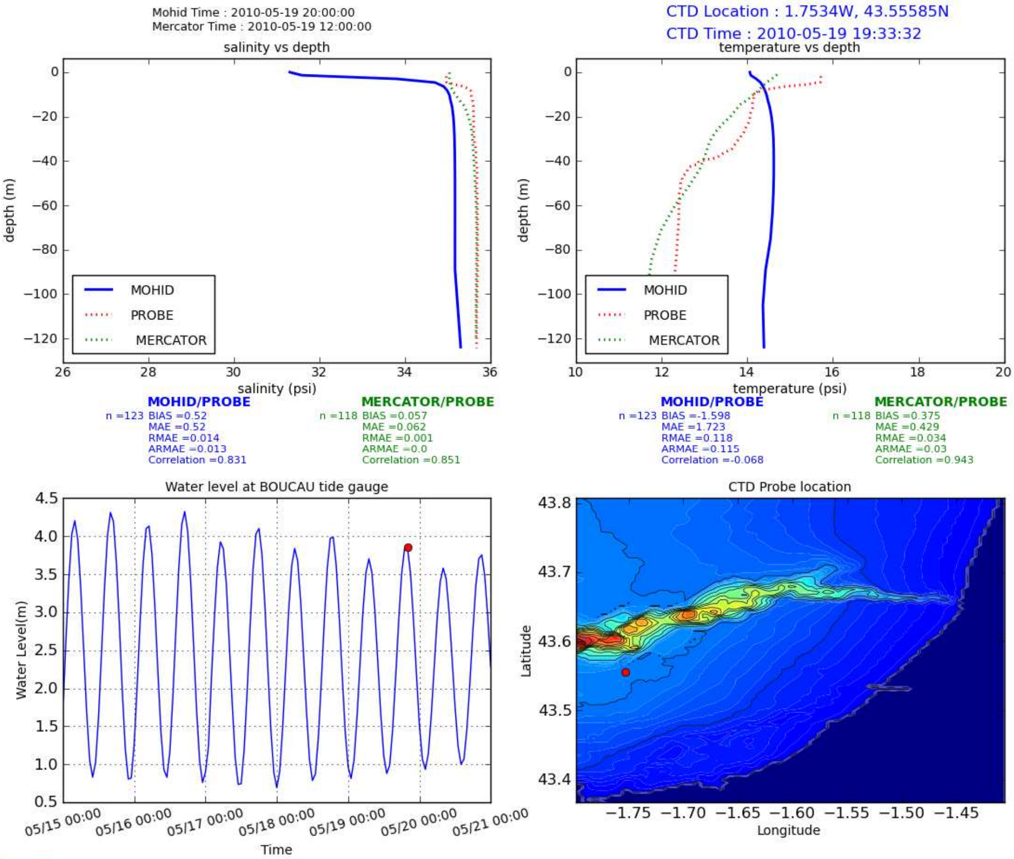

Fig. 15 : Comparison between model P4 results and CTD probe measurements on 19th May 2010 at 20h00

Although the results presented in these two figures seem correct, in fact, the model has problems at the boundaries. The fluxes doesn't go through the boundaries correctly, so differences in salinity, or temperature fields can be observed. The consequence of these differences are the advent of a velocity vortex which not physical.

Today, this problem is not solve yet and different solutions are being tested.

4 IdeASyCoM method

This part present a synthesis of the activities done by Raphaëlle Doré during the period from September 2009 to February 2011.

The main objective of this method is to work on the quality of the model all along its development instead of optimise it "a posteriori". This work is presented in detail in a paper accepted in Ocean & Coastal Management (Doré R., **Maron P.**, Neves R., "Toward a qualified process for coastal models: Integrated Development of Applied System to Coastal Management (IDeASyCoM)", *Ocean & Coastal Management,* Vol. 69, pp.307-315, 2012). A second paper presenting an example of use of this method is being written.

4.1 Numerical Models Optimization

4.1.1 Functionality of Numerical Models

Numerical models are used to reproduce a simplified representation of complex processes. Predictive model or operational models are used to anticipate events and situations, produce previsions on precise geographical areas and for determined variables (chemical, physical, biological, etc.). Descriptive models are used to gain a better understanding of phenomenon implied in coastal problems. Coastal questions and problems are characterized by a great space and time variability, so they can not be practicably studied by observations and measurements only [Hir09]. A model can be considered as a good alternative to field observations and can be used to :

- Study historical data (physical parameters monitoring over several years);
- Describe and understand real events
- Determine impacting scenarios in a coastal case study.

In the hydro – sedimentary field, numerical models are used to answer different types of questions : port silting, coastal erosion, etc. Despite its type (operational or descriptive), a model can only be functional if it answers the initial question and if it is calibrated and validated.

4.1.2 Functionality of hydro- sedimentary numerical models

A numerical model is developed to help answering a coastal matter. The efficiency of a model relies on a precise definition of the Need it is aimed to satisfy. The functionality of a model also relies on:

- Exhaustive list of physical, biological, chemical (etc.) phenomena that are implied in the coastal problem (bottom, horizontal and vertical scales);
- Choices of simplifying hypothesis in order to keep only pertinent phenomena from the defined problem.

Finally, the functionality of a model relies on modeling choices if they are made on the basis of:

- Exhaustive list of imposed constraints implied by the problem, the case study, the research context, etc. :
    - Case study typology;

    - Phenomena (physical, biological, chemical, etc.) that are pertinent from the problem point of view;
    - Systemic levels that are pertinent from the problem point of view;
    - Available field data (measurements, observations);
    - Available time;
    - Available resources (working people, numerical resources, etc.) ;
    - Available modeling System, etc.
- The research for the best compromises answering all the those constraints.

During the COAST3D project, Mulder (2001) has studied the numerical model development by asking the following questions:

1. What is the type of model that should be used and what area should be covered ?
2. What are the necessary information to develop and run the model ?
3. What are the desired date to calibrate the model as good as possible ?
4. What is the value-added for the model thanks to calibration data ?
5. What is the link between the value-added for the model after calibration and the added cost due to measurements and the implementation of calibration data in the model ?

But no systematical method has been proposed to solve and answer this list of questions.

4.1.3 Loops and numerical model development process

The figure 16 shows the classical numerical model development process.

The model development process implies many issues that demand efforts to reach compromise before taking any modeling decisions. One of the important issues is model calibration and validation. Calibration and validation phases are based on comparison between simulation results and field data. If the comparison due to calibration is not good, then some of the modeling decisions have to be modified, implying subsequent loops on modeling decisions and questions :

What is the minimum data set required for validating the model ?

Is the calibration / validation minimum data set available ?

If one considers several spatial grid refinements, loops on the modeling decisions can get numerous (Figure 16.a). So is it possible to reduce the number of loops and changes in the modeling decisions ?

Another issue is Optimization that classically implies loops between the results and the modeling decisions as shown on Figure 16. Is there a way to optimize the model as soon as the modeling decisions are taken ? Some other questions emanate from the global development process. How the time-consuming number of loops implied in the classical trial-and-error modeling process (Figure 16.a) could be reduced ? When a model is developed through this trial-and-error process how the final decisions could be qualified and fixed for some other coming model development ? Is it possible to guaranty proper results consistent with the initial problem, in advance ? How the coastal management problem could be defined to get the best model results with the available resources ? How the expertise acquired through case studies aggregation could be settled to save time ? Is there a way to argue the decisions, evaluate and guaranty model quality ?

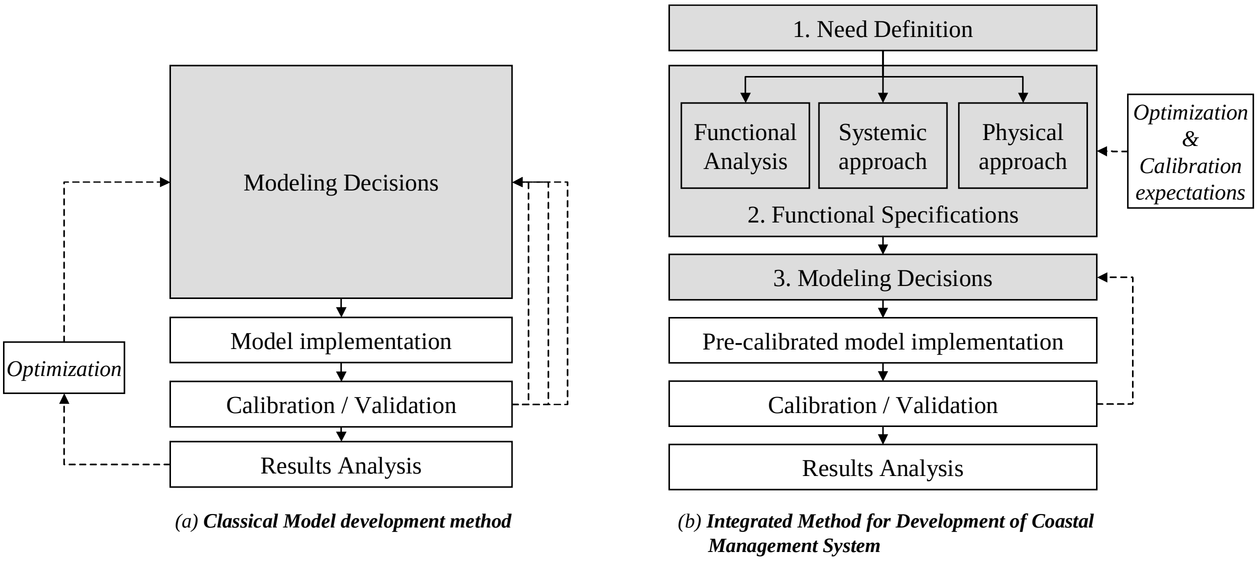

Figure 16. Comparison between classical development method (a) and the IDeASyCoM process (b).

4.1.4 Proposal : method for Integrated Development Applied to System for Coastal Management (IdeASyCoM method)

The Integrated Development of Applied System to Coastal Management (IDeASyCoM) method aims (1) to precisely define the Need, (2) to minimize the number of loops due to calibration, validation and optimization and (3) to develop a functional model based on the constraints and resources. The IDeASyCoM method assures results consistent with the Need using the minimum resources.

The IDeASyCoM is useful for every one in every systemic or hierarchical working level. For the modeler beginner the IDeASyCoM will facilitates its modeling choices and implementation options decisions. For the expert modeler, the IDeASyCoM will help decision fixing in a long modeling process. For a Task Group, the IDeASyCoM will be useful to reach compromise on different points of view into modeling decisions. For a larger working group, our method will be a strong support for knowledge, know-how and experience capitalization.

4.1.5 Working method

To build the IDeASyCoM method, the work has been divided into the following phases:

- Bibliographic study aimed to identify the optimization methods for hydrodynamic and hydro – sedimentary models,
- Adaptation of tools and methods coming from the Functional Analysis and the Specifications to different cases:
  - Adour estuary;
  - Nivelle estuary.
- Sensitive study of modeling choices:
  - Tide gauges space distribution,
  - Oceanic area considered in the model,

  - Length of the estuary queue,
  - Grid refinement,
  - Number of nesting, etc.
- Considerations of design of experiments in order to reduce the number of tested scenarios (Tagushi *et al*, 1987).
- Adaptation of the three steps method proposed by Scaravetti et al. (2004) and the TREFLE-ENSAM 'Energy systems and design' team [Sca04] and built on:
  - Functional Analysis,
  - Systemic and approach
  - Physical Approach
- Adaptation of TRIZ tools and methods for innovative and creative mechanical system design (Altshuller et al, 1997;Altshuller et al, 2007) to help typical contradictory situations to be solved (quick runs Vs precise results for example).
- Refinement of the technical solutions starting from the functional Specifications obtained.

4.2 IDeASyCoM method

4.2.1 IDeASyCoM value for EASYCO project

- Systematization of cognitive process implied in the modeling choices,
- Studies coordination especially in terms of sensitive study of modeling choices;
- Mutualization of know how and expertise;
- Time saving during the model development, etc.

4.2.2 Bibliography

- Qualification method for hydrodynamic models : NaN
- Optimization methods for hydrodynamic models : NaN
- Method for modelling choices in hydrodynamic models development (Mulder,2001)
- Adaptation of tools for decision support proposed by TREFLE-ENSAM 'Energy systems and design' team (Scaravetti *et al.*,2004).

4.2.3 Conclusions and Perspectives over IDeASyCoM method

For each specific case study, the Integrated Method for Development of Coastal Management System enables the development of an efficient and functional model. When the compromise between precision and numerical resources consumption is explicitly included in the model, the model itself can be used as a numerical experiment tool. If coupled with Design of experiments tools, the statistical analysis of the simulation results will provide an explicit qualitative law that facilitates the Need answering. Design of Experiment is a technical solution that has to be considered whenever the Need implies the definition of impacting scenarios for the definition of a conceptual model.

The Integrated Method for Development of Coastal Management System and enables time saving thanks to a reduction of loops on Modeling Decisions phase. The number of loops between Calibration / Validation and Modeling Choices is reduced thanks to :

- the integration of calibration expectations (affordable range of values for ARMAE) in the Functional Specifications as a Criterion Variable,
- the integration of in situ measured value ranges (flow velocity for example) as levels for Criterion Variables that influence the characterization of other Criterion Variable (horizontal turbulent viscosity for example). The number of loops between result analysis and Modeling Choices are also reduced since the model is developed through a systematic analysis and a systemic decomposition of the Need that include optimization expectations.

Along the whole model development, task groups gain time by minimizing the trial-and-error process because the objective is precisely defined as a Need. The trial-and-error process is also minimized because the general context is described (constraints and resources identified in the functional analysis) and explicitly taken into account in the model (constraints and resources quantified through the Criterion Variables characterization).

The special attention given to sufficiency and pertinence along the method facilitates the search for compromises. The functional hierarchization thanks to the K importance coefficient and the structuration of the Need decomposition through the Flexibility Class F also facilitates the Modeling Decisions. Sufficiency, pertinence, hierarchization and structuration lead to choices substantiation. A way to justify modeling Decisions could e really useful for a qualitative and standardized working process (ISO from International Organization for Standardization). We assume that it is the first step towards a qualification of Modeling Decisions.

The time profit coming from the Integrated Method for Development of Coastal Management System can be generalized to working process as it requires know-how formalization. Experiences, know-how, numerical habits and empirical knowledge can be formalized into qualitative rules, capitalized and re-used in other case studies. The capitalization also facilitates transfers, and expertise mutualization. Consequently every formalization effort made for each case study gives a set of transferable backgrounds and leads to more efficient working processes for working teams.

5 Operational model process

The operational model runs and provided the results of the day and three days of forecasting. The process in explained in the following figure :

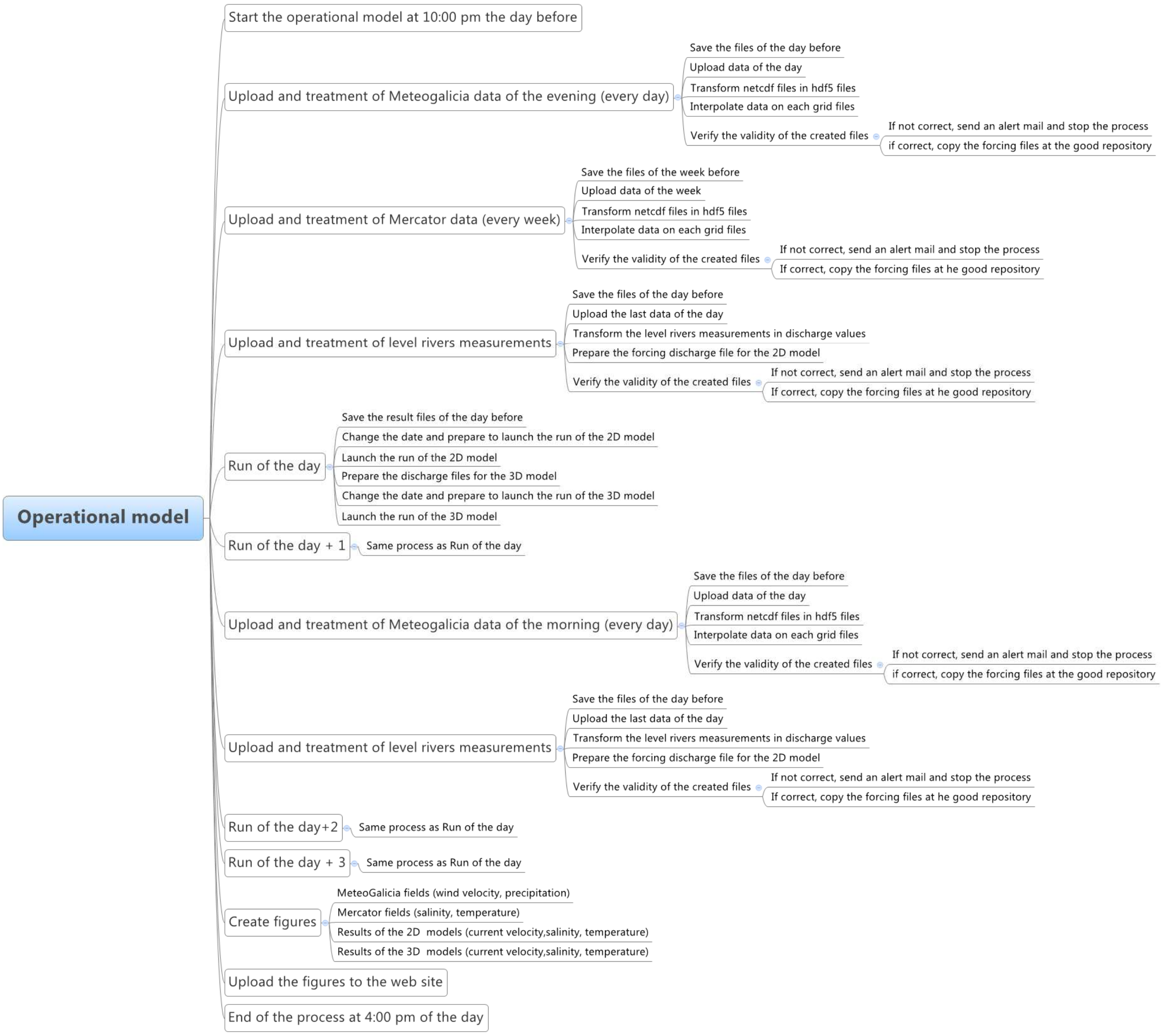

Figure 17 : Operational model process scheme

6 Review and Prospects

From the point of view of UPPA/SIAME, the EASYCO project has been extremely positive on several points of view.

From the standpoint partnership, it has allowed us to work closely with project partners and especially the Portuguese partners. Thus, four stays of one month were organized to destination IST Lisbon and/or the University of the Azores. We do not forget our Spanish partners of MeteoGalicia and French of Mercator who graciously put their data available.

The methodological point of view, we could through this project and through the hiring of 18 months Raphaëlle Doré consider the development methodology of the numerical model. IDeASyCoM method has been proposed and a paper is accepted in Ocean and Coastal Management. A second article is being written and we hope to submit by the end of the year. The recent disappearance of Raphaëlle does not help us in this task.

From a scientific perspective, this project has allowed us to develop an operational model of the Adour Plume. The results of this model are available on the website created for the occasion at the following address: http://web.univ-pau.fr/~maron/easyco/.

Although today the results of the 3D model are not satisfactory, everything is in place and fully operational as soon as we solved the problems at the boundaries. Resolution results from the site will be of great interest to public authorities, maritime, fishermen, surfers and also users of the Basque coast.

In the future, we hope to further improve the model of the Adour and include forcing waves that are not there now. Collaborative projects with chemist UPPA colleagues are already planned to integrate chemical transport models. The water quality is a concern here daily.

Finally, we hope in the near future to renew our partnership team that worked in EASYCO because the network exists today and now need to live.

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