Operational sediment transport modelling in the Western Mediterranean. System implementation and quality assessment

This poster participates in **OSP**

Outstanding Student Poster Contest

Juan Fernández[1,2], Gabriel Jordà[3], Vicente Gracia[1], Manuel Espino[1]

1.UPC, Laboratori d'Enginyeria Maritima, c/ Jordi Girona, 1-3, Campus Nord, 08034 Barcelona, Spain. juan.fernandez.sainz@upc.edu.

2.SIMO, Soluciones de Ingeniería Marítima Operacional, Edifici El Far, UPC-NT3, c/Escar 6-8, 08039 Barcelona, Spain.

3.Instituto Mediterráneo de Estudios Avanzados, C/ Miquel Marquès, 21, 07190 Esporles, Mallorca, Balearic Islands, Spain.

INTRODUCTION

Operational systems providing forecasts of different variables and at different scales are widely used in meteorology and, to a lesser extent, in oceanography. Few sediment transport operational models, are implemented worldwide and in particular, none of them has been developed for Mediterranean continental shelves. The implementation of such systems requires a careful set-up.

- Calibration and validation of the sediment transport module is a basic step.
- The assessment of different sources to provide wind, large scale currents and river run-off is also required. The suitability of the implementation of this forecasting system for a particular energetic event will be shown.

Regional Setting

- The Ebro Delta (Fig. 1) is located on the Spanish western Mediterranean coast.
- This continental shelf is located at a transition zone between a northern narrow shelf stretch and a wider southern one.
- The circulation in this microtidal region is dominated by a quasi-permanent slope current, the Northern Current (Millot 1999)
- The dynamics in the shelf are influenced by the wind forcing, watercourse inflow and by the slope current variability (Jordà et al. 2007).

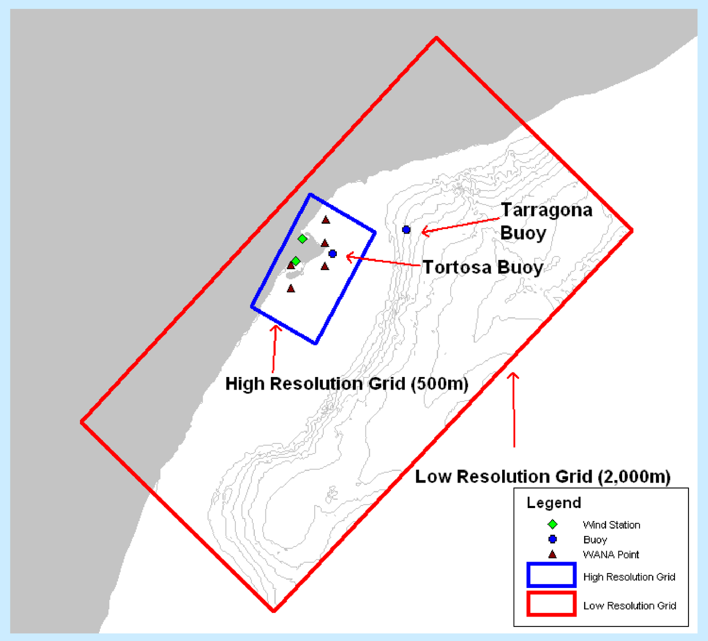

Fig. 1. Ebro Delta, data location and model configuration

Data

Observed data: Tarragona (Puertos del Estado): wind, waves, currents, T-S
Tortosa Buoy (XIOM): waves, currents and temperature (1 and 15m)
Ebro river at Tortosa (discharge) and Xerta (Turbidity and stage)
MERIS Satellite images

Predicted data: Wind: SMC, AEMET (WANA)
Waves: SMC, WANA
Currents, Temperature and Salinity: MFS, MERCATOR, (ESOMED).

Numerical model

The numerical model used (Symphonie (Marsaleix *et al.* 2008), was previously calibrated and validated in the area (Fernandez et al. 2009). The same model suite was used during a high energetic storm event.

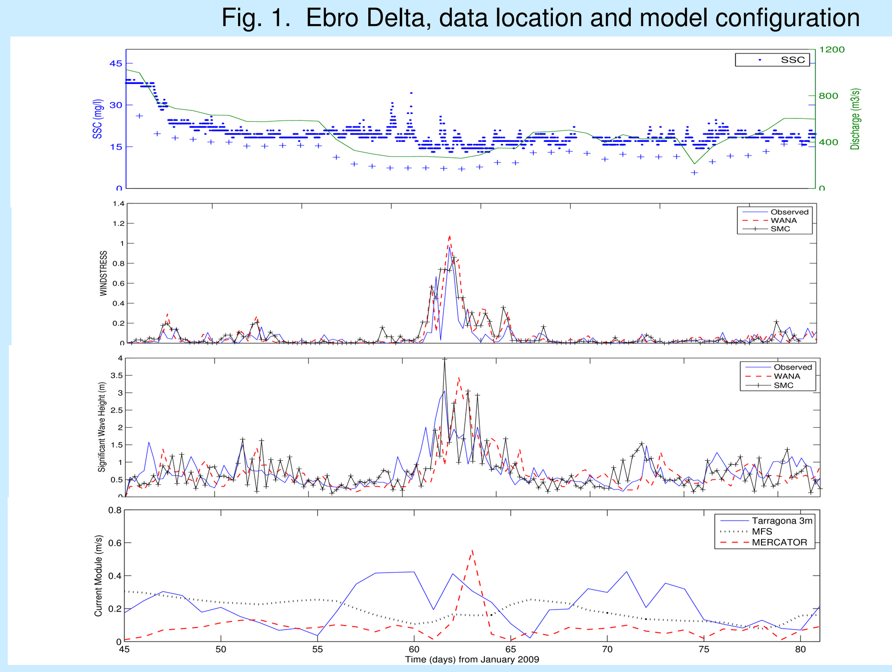

Fig. 2. Time series of (a) SSC and Discharge, (b) Wind Stress (c) Hs (d) Current intensity. Observations (in blue) are compared to different forecast sources

RESULTS

Results were analysed in both grids in order to find best boundary conditions for the pre-operational model set up.

RMS were obtained for the low and high resolution hydrodynamics grids and for the sediment transport one.

Results accuracy varied within the analysed period, and regarding the sediment transport module errors are higher at the beginning of the simulation.

The model reproduces areas with high concentration of sediment in suspension, whereas low concentration areas are not so well represented.

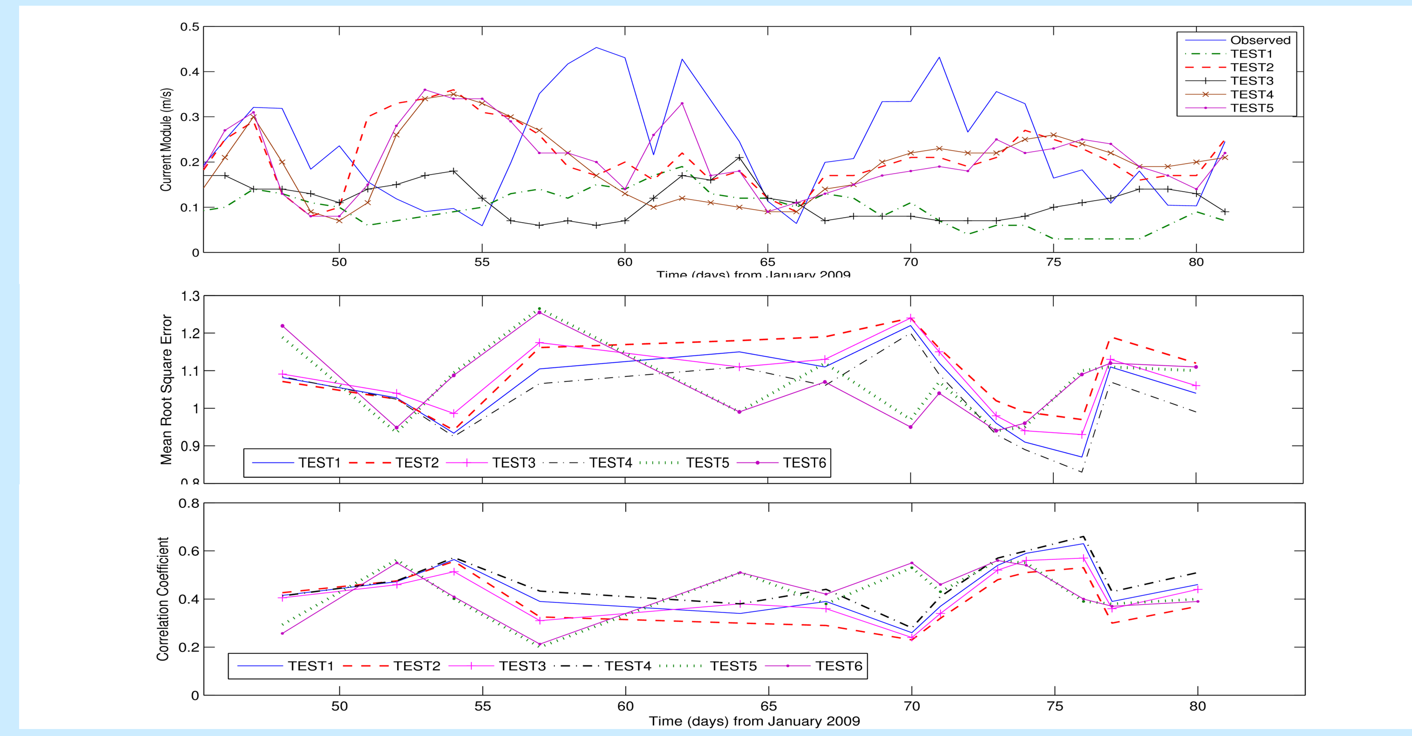

Fig. 3. Current module comparison for the high resolution hydrodynamic module (top) and time evolution of root mean square errors (middle) and correlation (bottom) for the sediment transport module for every test

Table 1 shows the different 'Test Scenarios' and RMS for both the hydrodynamic and the sediment transport modules. Current intensity RMS error (in m/s) is assessed at different locations. Coarse resolution quality is assessed at Tarragona buoy while high resolution model outputs are compared to Tortosa data. RMS error for the sediment transport module is yielded after comparison with satellite images derived data (Doerffer and Schiller, 2007)

	TEST	BC	Wind	Waves	SSC-River	RMS Tarragona	RMS Tortosa (1m)	RMS Tortosa (15m)
Hydrodynamics	TEST1	REAL	REAL			0.1755	0.2639	0.2992
	TEST2	MFS	REAL			0.1431	0.0921	0.0628
	TEST3	MERCATOR	REAL			0.1828	0.1581	0.0902
	TEST4	BEST FIT	WANA			0.1501	0.118	0.0764
	TEST5	BEST FIT	SMC			0.1422	0.0921	0.0702
	TEST	**BC**	**Wind**	**Waves**	**SSC-River**	**Satellite Images**		
Sediment transport	TEST1SED	REAL	REAL	REAL	XERTA	1.13		
	TEST2SED	REAL	REAL	REAL	RELATION	1.19		
	TEST3SED	REAL	REAL	SMC	XERTA	1.16		
	TEST4SED	REAL	REAL	WANA	XERTA	1.11		
	TEST5SED	BEST FIT	BEST FIT	REAL	XERTA	1.15		
	TEST6SED	BEST FIT	BEST FIT	BEST FIT	RELATION	1.15		

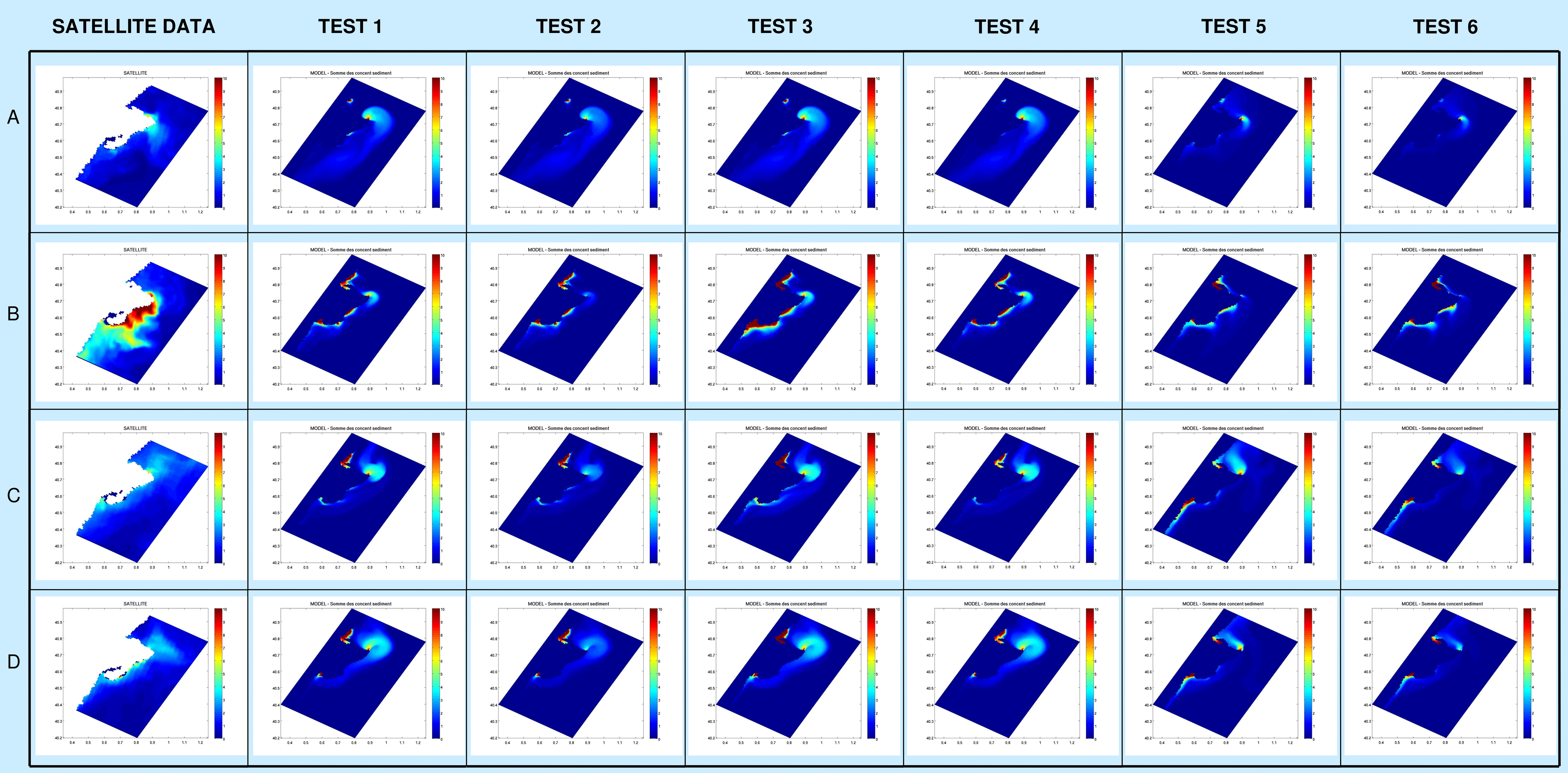

Fig.4. Satellite and test scenarios surface suspended sediment concentrations (mg/l) for 22/02/09 (A), 06/03/09 (B), 15/03/09 (c) and 18/03/09 (D)

SUMMARY AND CONCLUSIONS

HYDRODYNAMICS MODULE

MFS boundary conditions yielded the model outputs which were in best agreements with observed data for both low and high resolution grids.

Using any of the three different available wind fields (observed, SMC and WANA data) produced comparable results in the low resolution grid but different results in the high one due to direction differences in the wind fields. The interaction of winds with the river plume is critical. The wind direction modulates the shape of the river plume very quickly (few hours) which in turn changes the circulation pattern around the Ebro delta. In both grids, the SMC wind fields provided best results, probably because it provides a 2D distribution of the wind field.

SEDIMENT TRANSPORT MODULE

Results are acceptable provided the large number of parameters interacting. Different model forcing combinations have been tested.

The proper description of the SSC in the river is a key element to define the sediment concentration in the plume and is reflected in the RMS error and correlation values.

No qualitative difference in the plume extension is induced by the different formulations for the river SSC.

Current fields play a major role. Results using observed or MFS boundary conditions lead to some differences in the surface sediment dispersion. Influence of the wave input is significant.

The difference between the model output and the satellite derived data may be due to several reasons:

- Wave-resuspended material is predicted in higher quantity in the north Delta than in the south-east section, whereas observed data indicates the contrary, possibly due to the usage of a climatological sediment distribution.
- Model errors are higher immediately after energetic event, indicating that sediment settling may not be properly defined due to the lack of information regarding riverine sediment size and the percentage of every class in this input. Also, possible layer maladjustment between the upper and lower layer caused by the watercourse input may prevent sediment to easily fall into the seabed.

A pre-operational sediment transport forecasting system has been implemented in the Western Mediterranean. A two-level nesting has been implemented to forecast the time evolution of 3D circulation. Then, a sediment transport module has been linked to the high resolution circulation fields. The system has proven to be able to produce good quality forecasts of near-surface suspended sediment concentrations. However, result quality depends on the quality of the forcing fields. Currents are difficult to model due to the quality of the open boundary conditions. Nevertheless, they are not the most determining factor. Riverine input and wave and wind forcing seem to dominate suspended sediment dynamics.

References

Doerffer, R., Schiller, H. (2007). The MERIS Case 2 water algorithm. *International Journal of Remote Sensing*, Vol. 28, Nos. 3-4, pp 517-535.

Fernandez, J., Jordá, G., Gracia, V., Espino, M., Sanchez-Arcilla, A. Sediment transport in the Ebro Shelf, a modelling approach. *Proc. River, Coastal and Estuarine Morphodynamics: RCEM 2009 (2)*,346-355.

Jordà, G., Comerma, E., Bolaños, R. & Espino, M. (2007). Impact of forcing errors in the CAMCAT oil spill forecasting system. A sensitivity study.

Marsaleix P., Auclair F., Floor J. W., Herrmann M. J., Estournel C., Pairaud I., Ulses C., (). Energy conservation issues in sigma-coordinate free-surface ocean models. *Ocean Modelling*. 20, 61-89

Millot C. (1999). Circulation in the Western Mediterranean sea. *Journal Marine Systems* 20: 423-442.

Acknowledgements

This study has been undertaken under the framework of the ECOOP project (Project Reference GOCE-036355).Special thanks to all the data providers, the Spanish Port Authority, Mercator Ocean, the Italian Group of Operational Oceanography, the European Space Agency, the XIOM network, the Catalan Meteorological Service and the Ebro River Catchment Authority.