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Modeling and satellite remote-sensing of near-surface non-algal suspended particulate matter in the English Channel

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Introduction

Concentration of near-surface suspended particulate matter (SPM) is a key parameter for the characterization of sediment dynamics and the quantification of light in the water column crucial for biological production in coastal seas. The respective influences of tides and wind-generated surface-gravity waves on non-algal near-surface SPM in the English Channel have recently been identified by Rivier et al. (2012) on the basis of statistical models applied to a large satellite database. The present study extends this analysis by comparing satellite images and numerical model predictions of non-algal near-surface SPM. Its spatio-temporal variability as well as the respective roles of tides and waves on it are investigated.

Materials and methods

Remote-sensing data

Satellite images are **MODIS** (NASA) and **MERIS** (ESA) remote-sensing reflectance processed by the **IFREMER semi-analytical algorithm** (Gohin et al., 2011), available daily at 1.2 km resolution since 2003. 3 satellite images gathered in 2008 with more than 90% of data free of clouds and **various tides and waves conditions** are selected for comparison with numerical predictions: 11 February 2008 (5 days after a spell of strong waves, strong tide), 6 May 2008 (median waves, strong tide) and 11 October 2008 (median waves, small tide).

Statistical model

In Rivier et al. (2012), statistical models were built on the basis of an analysis of a large database of satellite images by multiple regressions. The more sophisticated model involves the tide, waves and a seasonal indicator (Fig. 1). It highlights and identifies spatially the roles of neap-spring tidal cycle and waves on SPM dynamics. In addition, this model, integrating remote-sensing data and hydrodynamic forcing variables, avoids lack of data due to clouds.

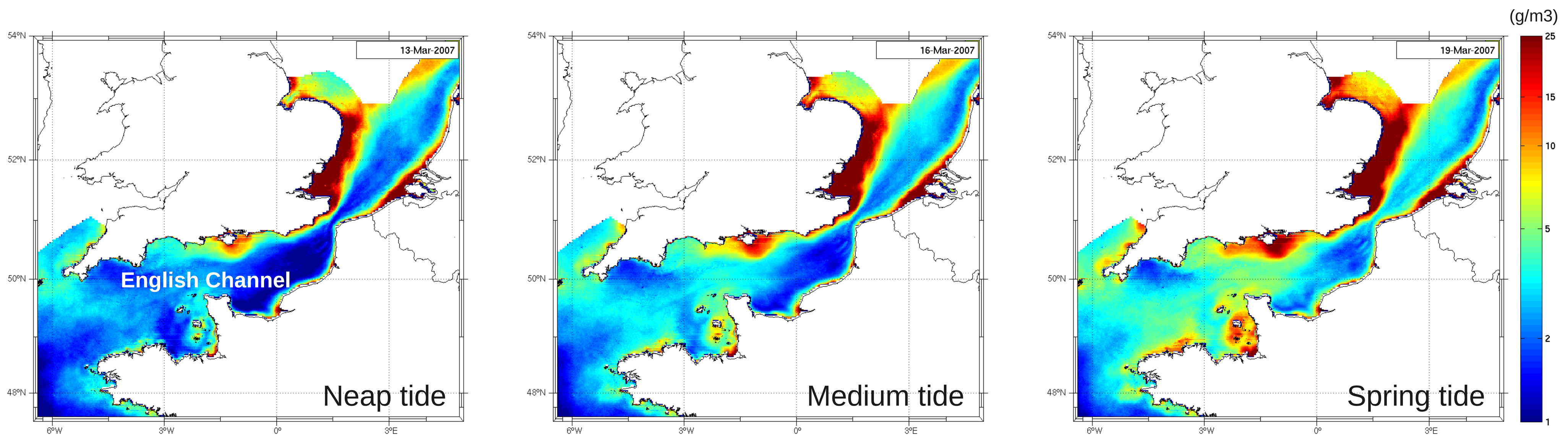

Figure 1 : Evolution of SPM estimated by statistical model along a neap-spring tidal cycle in March 2007

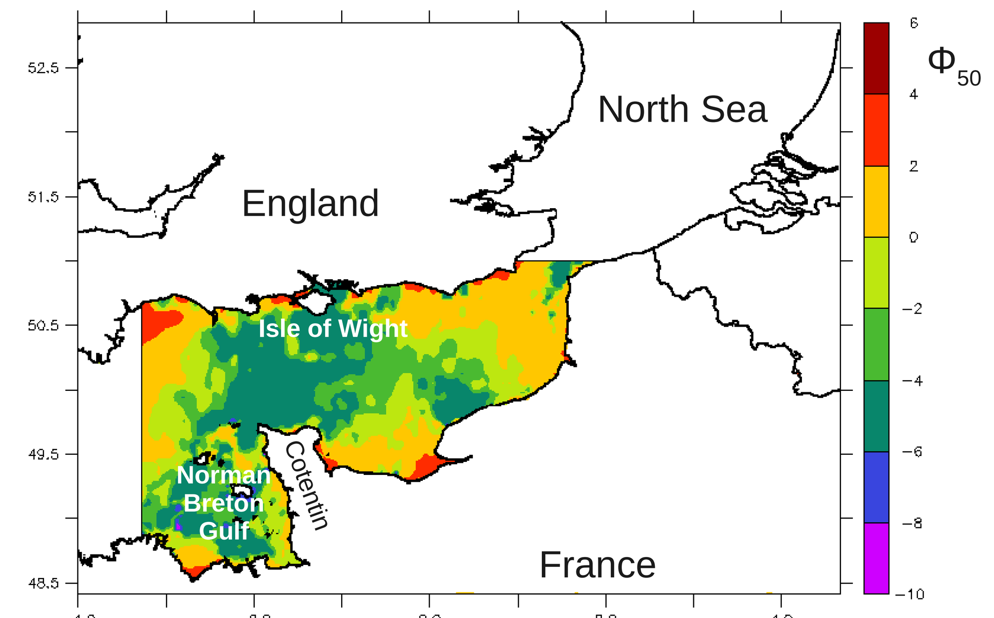

Figure2: Spatial repartition of median diameter Φ50 in the computational domain (Φ50=-log(d50)/log(2) with d50 in mm)

Numerical model

The three-dimensional hydro-sedimentary multi-class model **ROMS ("Regional Ocean Model System")** (e.g., Warner et al. 2008) is implemented on a regular grid covering the English Channel (Fig. 2) with a horizontal resolution of **3 km** and **10 uniform vertical sigma-grid cells**, following Guillou and Chapalain (2010) model setup. Baroclinic and barotropic time steps are 300 and 30 s, respectively.

Suspended sediment transport is computed for **5 non-cohesive and independent classes of particles** ranging from 25 to 750 µm. The **heterogeneous** availability of sedimentary particles as well as associated bottom roughness are determined applying a spatial interpolation method to an observed surficial sediment data-set (Fig. 2, Guillou et al., 2010). The computational domain is extended for hydrodynamic simulations to achieve more suitable open boundary conditions with a uniform bottom roughness z_0=3.5 mm. The model is driven by **tidal free-surface elevation** (TPXO.6) and integrates the effects of **winds** (Météo-France) at the surface and **waves** (IOWAGA and PREVIMER) in the bottom boundary layer. Rivers discharges are not considered. **Outputs of statistical model** are used for open boundary forcing of SPM concentration. Simulations are performed over the period **2007-2008**.

Results and discussion

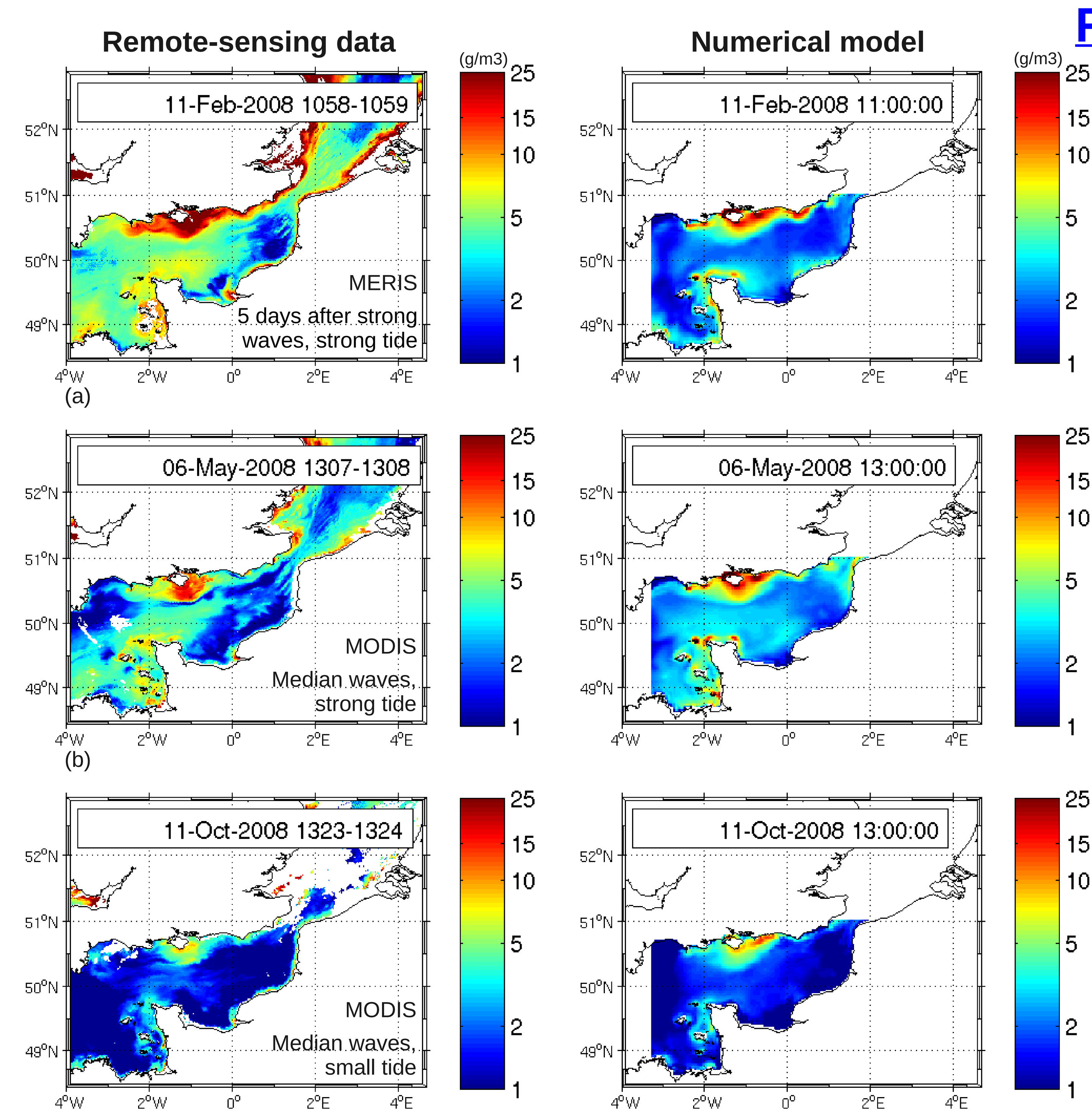

Figure 3: Comparison of SPM concentration observed by remote sensing and estimated by numerical model

The model reproduces globally the main patterns observed by remote-sensing (Fig. 3):

- Turbidity maximum zone around the Isle of Wight with larger stretching towards the East, composed by a majority of thin particles (<50 µm).
- High SPM concentration in Norman-Breton Gulf around isles and capes, composed by thin particles and sand locally.

Background SPM concentration in central English Channel is well estimated (lower than observed of a few g/m^3 in February and March) thanks to the use of statistical model outputs at open boundaries.

SPM concentration depends on hydrodynamical conditions of tides and waves (Fig. 3):

- Highest concentrations are observed in the central English Channel on 11 February after a spell of strong waves.
- SPM concentration varies depending on tidal intensity between 6 May (strong tide) and 11 October (small tide), keeping similar patterns.

Evolution of SPM concentration along a neap-spring tidal cycle estimated by the numerical model (Fig. 4) agrees fairly well with statistical model predictions (Fig. 2).

Modulation by the neap spring tidal cycle is noticed in Norman-Breton Gulf, around the Isle of Wight and the Cotentin Peninsula. SPM concentration increases in these zones following tidal intensity.

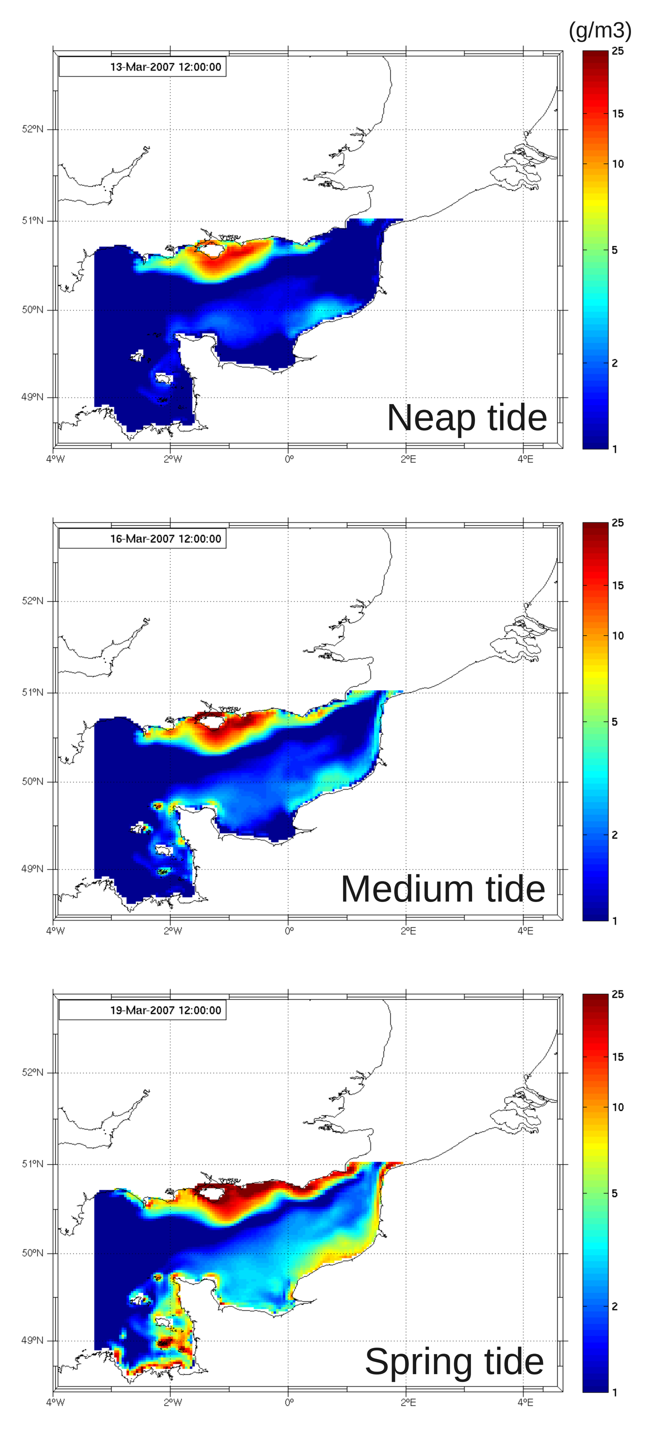

Figure 4: Evolution of SPM estimated by numerical model along a neap-spring tidal cycle in March 2007

Conclusions and perspectives

SPM dynamics in the English Channel are closely linked to waves and/or tides. Variability of SPM concentration is strongly influenced by tides in Norman-Breton Gulf and around the Isle of Wight.

Main patterns observed by remote sensing under various forcing conditions are reproduced by the numerical model. Use of statistical model outputs at open boundaries improves numerical predictions.

Implementation of aggregation/disaggregation processes and rivers discharges in the model will be the further developments under consideration.

Numerical modeling will allow a better understanding of SPM response to typical hydrodynamical forcing.

References:

GOHIN F. (2011). *Annual cycles of chlorophyll-a, non-algal suspended particulate matter and turbidity observed from space and in-situ in coastal waters.* Ocean Science, n°7, pp 705-732. doi:10.5194/os-7-705-2011

GUILLOU, N., CHAPALAIN, G., LEPRÊTRE, A. (2010). *Interpolation spatiale des distributions granulométriques des sédiments de fond - description théorique et applications en Manche orientale et en Mer d'Iroise.* Rapport de présentation des outils, CETMEF, LGCE, 44 p.

GUILLOU N., CHAPALAIN G. (2010). *Numerical simulation of tide-induced transport of heterogeneous sediments in the English Channel.* Continental Shelf Research, n°30(7), pp 806-819. doi:10.1016/j.c

RIVIER A., GOHIN F., BRYÈRE P., PETUS C., GUILLOU N., CHAPALAIN G. (2012). *Observed vs. predicted variability in non-algal suspended particulate matter concentration in the English Channel in relation to tides and waves.* Geo-marine Letters, n°32(2), pp 139-151. doi:10.1007/s00367-011-0271-x

WARNER J.C., SHERWOOD C.R., SIGNELL R.P., HARRIS C.K., ARANGO H.G. (2008). *Development of a three-dimensional, regional, coupled wave, current, and sediment-transport model.* Computers & Geosciences, n°34(10), pp 1284-1306. doi:10.1016/j.cageo.2008.02.012.