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ORIGINAL RESEARCH ARTICLE

The impact of tides and waves on near-surface suspended sediment concentrations in the English Channel

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Summary Numerous ecological problems of continental shelf ecosystems require a refined knowledge of the evolution of suspended sediment concentrations (SSC). The present investigation focuses on the spatial and temporal variabilities of near-surface SSC in coastal waters of the English Channel (western Europe) by exploiting numerical predictions from the Regional Ocean Modeling System ROMS. Extending previous investigations of ROMS performances in the Channel, this analysis refines, with increased spatial and temporal resolutions, the characterization of near-surface SSC patterns revealing areas where concentrations are highly correlated with evolutions of tides and waves. Significant tidal modulations of near-surface concentrations are thus found in the eastern English Channel and the French Dover Strait while a pronounced influence of waves is exhibited in the Channel Islands Gulf. Coastal waters present furthermore strong SSC temporal variations, particularly noticeable during storm events of autumn and winter, with maximum near-surface concentrations exceeding 40 mg l^{-1} and increase by a factor from 10 to 18 in comparison with time-averaged concentrations. This temporal variability strongly depends on the granulometric distribution of suspended sediments characterized by local bimodal contributions of silts and sands off coastal irregularities of the Isle of Wight, the Cotentin Peninsula and the southern Dover Strait.

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1. Introduction

An accurate knowledge of suspended sediment concentrations (SSC) is required for numerous ecological issues of continental shelf ecosystems. SSC influence thus water clarity, limiting the amount of light available to phytoplankton for photosynthesis and the biological primary production (Hoppe, 1984). Suspended particulates may also absorb and transport polluting substances such as heavy metals or radioactive materials with harmful consequences in terms of water quality (Haarich et al., 1993). A refined estimation of suspended sediment transport rates constitutes finally a prerequisite of coastal engineering applications dealing with maintenance dredging projects of estuaries or harbors.

Recognized as an important coastal ecosystem of northwestern European shelf seas, the English Channel (Fig. 1) has been the subject of numerous studies dedicated to suspended sediment transport. Initially based on in situ observations along transects in the Wight-Cotentin area and the Dover Strait (Dupont et al., 1993; Eisma and Kalf, 1979; Van Alphen, 1990; Velegrakis et al., 1997), first investigations exhibited a spatial "zonation" between (1) high turbid coastal waters with mean near-surface SSC of 10–35 mg l^{-1} and (2) central waters with low concentrations of 2–3 mg l^{-1}. Numerical modeling tools were then implemented to extend these local analyses focusing on effects of major hydrodynamic forcings of tides and waves (Gerritsen et al., 2000; Grochowski et al., 1993; Guillou and Chapalain, 2011; Guillou et al., 2009; Velegrakis et al., 1999). Three-dimensional (3D) predictions exhibited, in particular, remote advective and diffusive transport of silts ($d < 30$ μm) during spring tide with noticeable effects on grain-size variability of suspended sediments. Impacts of waves were furthermore quantified with SSC increase by a factor between 10 and 20 in exposed coastal areas during storm events.

Nevertheless, whereas these simulations provided interesting insights about temporal and spatial SSC variabilities in the English Channel complemented further local evaluations (Rahbani, 2015), numerical studies remained primary restricted to the vicinity of measurement sites. Broad-scale assessments of near-surface SSC have however been conducted relying on satellite monitoring of ocean color (Fettweis et al., 2007, 2012; Gohin et al., 2005; Gohin, 2011). Despite the reduced number of high-quality images fully covering the whole area over long time periods and the low accuracy of satellite observations (Wozniak, 2014), the refined analysis of remote-sensing images exhibited close correlations between observed SSC and hydrodynamic forcings of tides and waves (Rivier et al., 2012). Satellite-retrieved observations have thus been considered in numerous assessments of numerical simulations investigating regional variabilities of near-surface SSC at increased spatial and temporal resolutions in the English Channel (Guillou et al., 2015; Menesguen and Gohin, 2006; Souza et al., 2007; Sykes and Barcelia, 2012). Nevertheless, the attention was primary dedicated to approach of major SSC patterns and improvements of numerical predictions neglecting accurate evaluations about the roles of tides and waves on SSC variabilities.

The present study investigates the spatial and temporal variabilities of near-surface SSC under combined influences of tides and waves relying on numerical simulations established by Guillou et al. (2015) in the English Channel (Section 2). Predictions are first exploited to assess the global effects at the scale of the Channel identifying areas where concentrations are highly correlated with the evolutions of tides and waves (Section 3.1). Further investigation is then conducted about the temporal variabilities of nearshore SSC patterns quantifying effects of waves on near-surface concentrations in shallow waters (Section 3.2). The influence of

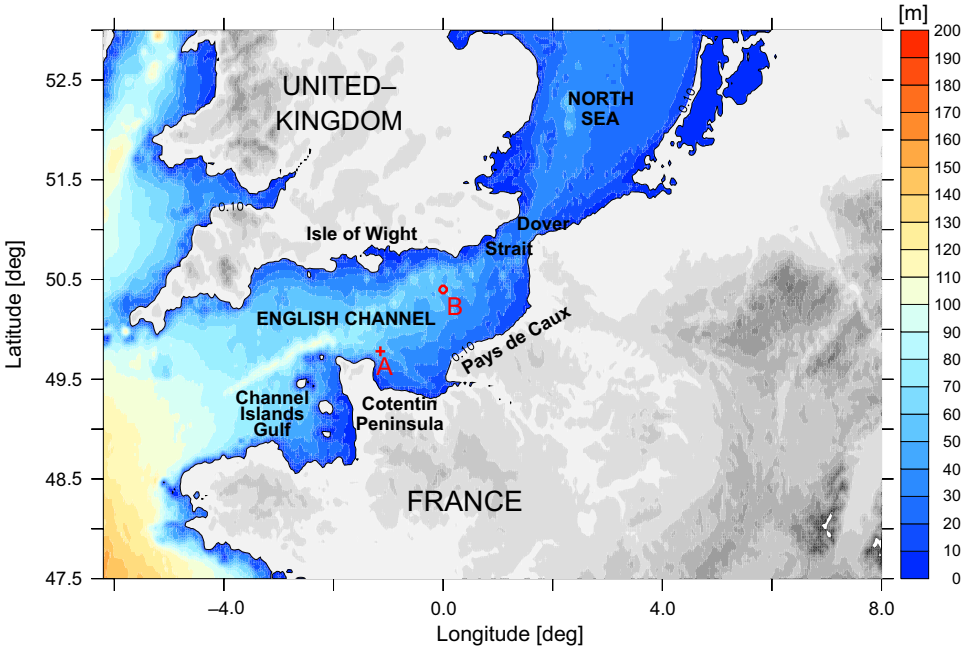

Figure 1 Bathymetry of the English Channel with locations of points A and B.