

Comparison between SPM concentration from satellite images and in situ measurements from the Belgian continental shelf (southern North Sea)

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Improving our understanding of suspended particulate matter (SPM) variability in nearshore areas, where the SPM concentration is high, is essential to assess the human footprint on this environment and to develop marine policies, matching international agreements aiming at the development of sustainable socio-economic activities in parallel with marine environmental protection. Measurements are necessary to obtain these goals and can be obtained from *in situ* measurements or from remote sensing (RS). Whereas long time series (several years) and large synoptic scenes of SPM concentrations on sea surface may be retrieved from RS, they represent only the cloud free data and miss higher SPM concentrations, occurring during storms. On the contrary, *in situ* measurements, which cover smaller spatial and time scales, are excellent witnesses of high turbidity under bad weather conditions and may catch SPM concentrations variability with a much finer scale and all over the water column. This study uses a large set of SPM concentrations gathered from different sources, i.e: from various ocean colour satellites and *in situ* measurement instruments. It evaluates the heterogeneity of this collection and proposes a method to merge these complementary data.

The study area is the Belgian coastal zone, which is of especial interest due to the occurrence of a high turbidity zone. It is characterised by depths between 5 and 35 m, a mean tidal range at Zeebrugge of 4.3 m (2.8 m) at spring (neap) tide and by maximum current velocities of more than 1 m/s. The winds are mainly from the southwest and the highest waves occur during north-westerly winds.

The SPM concentration data, which are discussed here, have been collected either from the *R/V Belgica*, with a tripod, or using SeaWiFS (Sea Wide Field of View instrument), MODIS (MODerate resolution Imaging Spectroradiometer) and MERIS (Medium resolution Imaging Spectrometer) images.

Since 1999 about 50 tidal cycle measurements have been carried out using a Sea-Bird SBE09 SCTD carousel sampling system, containing twelve 10 l Niskin bottles and an Optical Back Scatter (OBS) and a Seacat SBE19 SCTD system, with one OBS. Every 20 minutes a Niskin bottle was closed and every hour the carousel was taken on board of the vessel and the water samples were filtered, using pre-weighted GF/C filters, which were later dried and weighted to obtain SPM concentration. The SPM concentration from the filters has been used to calibrate the OBS. The tripod measuring system was developed to monitor SPM concentration and current velocity. It included a SonTek 3 MHz Acoustic Doppler Profiler, a SonTek 5 MHz Acoustic Doppler Velocimeter Ocean, a Sea-Bird SBE37 CT system and two OBS sensors (one at 0.2 and one at 2 m above the bottom). Since 2003 more than 200 days of tripod measurements have been collected. The RS data are time series of SPM concentrations obtained from SeaWiFS, MODIS and MERIS, respectively covering the periods 1997-2004, 2002-2008 and 2003-2008. SPM concentrations were derived from water-leaving reflectance after atmospheric correction of the signal measured at the top of the atmosphere by each satellite. Although the SeaWiFS and MODIS atmospheric correction and SPM retrieval

algorithm (one band algorithm) are different from the MERIS algorithm (Neural Network), they provide similar SPM concentrations. For the Belgian continental shelf about 60 (partially) cloud free images per year are available from each sensor. Satellites overpasses are between 9:30-11:30 UTC, 11:30-13:30 UTC and 12:40-13:40 UTC respectively for MERIS, SeaWiFS and MODIS.

In situ measurements falling within 1 hour of satellite overpass (also called matchups) are averaged and compared with satellite data. Seaborne and tripod measurements collected during satellites overpasses between 9:30 and 13:40UTC are averaged for each measurement station and their variability in time is compared with variability of the long term RS data at each station. The rest of *in situ* data are averaged each 2 hours and superimposed to RS time series to gauge the possible agreement between different data.

The comparison shows high correlation (0.83) between *in situ* matchups at surface (from 0 to 3 meters depth) and satellite data, with a difference about 30%. Remark that higher discrepancies are observed between the satellite data and the SPM, measured at the bottom and at 2 meters above the sea floor, following the tidal phase, especially in the turbidity maximum zone. The very high SPM concentrations identified by the tripod but never measured by the satellites, confirm the major importance of near bed processes. A slight agreement is found between the SPM measured at the bottom and RS data in locations outside the turbidity maximum area.

Based on comparison between *in situ* and satellite measurements, the Belgian coastal zone is divided into two areas: clear (case 1) waters and turbid (case 2) waters. A lookup table is constructed for each area, setting 3 classes of sea floor SPM concentrations. In case 1 waters, 3 ranges are used: less than 30mg/l, from 30mg/l to 100mg/l and above 100mg/l and in case 2 waters, less than 500mg/l, from 500mg/l to 1000mg/l and above 1000mg/l. Using the lookup tables, maps of classified bottom SPM concentrations are generated from satellite images and refined by integration of wind and currents data.