Uncertainty of *in situ* SPM concentration measurements

Fettweis Michael[1], Matthias Baeye[1] and Romaric Verney[2]

[1] Operational Directorate Natural Environment, Royal Belgian Institute of Natural Sciences, Gulledelle 100, B-1200 Brussels, Belgium
E-mail: m.fettweis@mumm.ac.be

[2] Laboratoire Dyneco/Physed, IFREMER, BP 70, F-29280 Plouzané, France

The aim of the study is to assess the state of our understanding, to evaluate the confidence with which SPM concentration can be measured, and to identify human impact in the data series. Direct or indirect measurements of parameters are inherently associated with uncertainties (errors) due to a lack of accuracy of the measuring instruments, inadequate precision of the observations, and the statistical nature of the parameters. When using observations, understanding of the uncertainties is needed, in order to avoid speculative statements. Uncertainty will become an important issue for scientists and decision-makers in the future as they will be used to evaluate GES of the European marine areas and to predict the impact of human activities. Uncertainty in measured data can originate from different sources (Winter, 2007). Those that can be reduced by further study of the system and improving our state of knowledge, and those that are considered unknowable such as variability in the system beyond the existing time series, the chaotic nature of the system, and the indeterminacy of human systems (Dessai and Hulme, 2003).

SPM concentration can be measured using optical or acoustic sensors. The voltage output of Optical Backscatter Sensors (OBS) is converted to Formazine Technical Unit using solutions of formazine and SPM concentration by calibration against filtered water samples. After conversion to decibels, the backscattered acoustic signal strength (from an Acoustic Doppler Profiler) is corrected for geometric spreading, water attenuation, sediment attenuation (Kim *et al.*, 2004) and is calibrated using the OBS-derived SPM concentration estimates (Fettweis, 2008). In general, acoustic backscattering is affected by sediment type, size and composition (Thorne *et al.*, 1991; Hamilton *et al.*, 1998; Bunt *et al.*, 1999; Fugate and Friedrichs, 2002; Voulgaris and Meyers, 2004). OBS signals have primarily been designed to be most sensitive to SPM concentration; size effects are an order of magnitude lower than those of concentration, and flocculation effects are even smaller (Downing, 2006). Compared to optical devices, acoustic devices are more sensitive to coarser grain sizes and thus produce better estimates of the mass concentration of the coarser granular fraction. Changes in colour, size and density of the suspended sediments have been reported to influence the OBS results by a factor 10 to 20 (Sutherland *et al.*, 2000). The latter is especially disturbing when using long-term time series of data of SPM concentration from OBS, as it is collected at a station near Zeebrugge and in the Seine Estuary, and where changes in sediment composition during e.g. a storm or fortnightly cycles have been reported (Baeye *et al.*, 2011; Fettweis *et al.*, 2012; Verney *et al.*, 2013). Therefore a careful analysis of existing calibration data, of LISST data, and of acoustic and optical sensor data, has been carried out. Calibration of sensors (OBS and ADCP) is carried out during 6 tidal cycle measurements in the Belgian nearshore area and the Seine Estuary using *in situ* water samples. The analysis allows to evaluate calibration procedures of sensor output as a function of e.g. seasonal changes in composition and thus on the uncertainty of long-term time series of SPM concentration derived from acoustic and optical measurements of turbidity.

References

Baeye M., M. Fettweis, G. Voulgaris and V. Van Lancker 2011. Sediment mobility in response to tidal and wind-driven tidal flows along the Belgian ineer shelf, southern North Sea. Ocean Dynamics 61(5): 611-622.

Bunt J.A.C, P. Larcombe and C.F. Jago 1999. Quantifying the response of optical backscatter devices and transmissometers to variations in suspended particulate matter. Continental Shelf Research 19:1199–1220.

Dessai S. and M. Hulme 2003. Does climate policy need probabilities? Tyndall Centre for Climate Change Research, Working Paper 34, 42p.

Downing J. 2006. Twenty-five years with OBS sensors: the good, the bad, and the ugly. Continental Shelf Research 26:2299–2318.

Fettweis M. 2008. Uncertainty of excess density and settling velocity of mud flocs derived from in situ measurements. Estuarine Coastal and Shelf Science 78:428-436.

Fettweis M., M. Baeye, B.J. Lee, P. Chen and J.C.R. Yu 2012. Hydro-meteorological influences and multimodal suspended particle size distributions in the Belgian nearshore area (southern North Sea). Geo-Marine Letters 32:123-137.

Fugate D.C. and C.T. Friedrichs 2002. Determining concentration and fall velocity of estuarine particle populations using ADV, OBS and LISST. Continental Shelf Research 22:1867–1886.

Hamilton L.J., Z. Shi and S.Y. Zhang. 1998. Acoustic backscatter measurements of estuarine suspended cohesive sediment concentration profiles. Journal of Coastal Research 14:1213–1224.

Sutherland T.F., P.M. Lane, C.L. Amos and J. Downing 2000. The calibration of optical backscatter sensors for suspended sediment of varying darkness levels. Marine Geology 162:587-597.

Thorne P.D., C.E. Vincent, P.J. Hardcastle, S. Rehman and N.D. Pearson 1991. Measuring suspended sediment concentrations using acoustic backscatter devices. Marine Geology 98:7–16.

Verney R., G. Voulgaris, A. Manning, J. Deloffre and P. Bassoullet 2013. Quantifying suspended particulate matter (SPM) dynamics in estuaries: Combining acoustic and optical approaches. Proc. of the 12th Int. Conf. on Cohesive Sediment Transport Processes (INTERCOH), Gainesville, Florida.

Voulgaris G. and S. Meyers 2004. Temporal variability of hydrodynamics, sediment concentration and sediment settling velocity in a tidal creek. Continental Shelf Research 24:1659–1683.

Winter C. 2007. Evaluation of Sediment Transport Models. Sedimentary Geology 202:562-571.