

# Validation of modelled bottom shear stress under the influence of currents and waves, using long-term measurements

Van den Eynde Dries, Matthias Baeye, Michael Fettweis, Frederic Francken and Vera Van Lancker

Royal Belgian Institute for Natural Sciences  
Operational Directorate Natural Environment (OD Nature)  
Suspended Matter and Seabed Monitoring and Modelling Group  
Gulledelle 100, B-1200 Brussels, Belgium  
E-mail: [D.VandenEynde@mumm.ac.be](mailto:D.VandenEynde@mumm.ac.be)

## Abstract

More than 2800 days of currents measurements with a benthic tripod and almost 400 days with a bottom mounted ADCP have been collected in the Belgian part of the North Sea during the period 2005-2013. These data have been used to derive the bottom shear stress from the current profile and the high frequency currents and have been used to validate the modelled bottom stresses. The validated model allows to get insight in the spatial and temporal variability of the bottom roughness.

## Introduction

Bottom shear stress links the sea floor to the water column, and is a prime factor for the calculation of sediment transport, including erosion, resuspension and deposition, and bottom morphology. Bottom shear stress is influenced by a large number of factors, including the surface sediment texture, micro-bathymetry, benthic organisms, all influencing the bottom roughness.

In literature, many different methods are available for the calculation of the bottom shear stress, ranging from simple models, using a constant drag coefficient and depth-averaged currents, to complicated ones that take the different bottom boundary layers and the instantaneous bottom shear stresses in a wave cycle into account.

Comparison of the model results with measurements is not only important for validation of the model, but also to gain more insight in the variability of the bottom roughness, both in space and time. However, measuring bottom stresses is difficult and the (lack of) qualitative bottom stress measurements may hamper a sound validation of the model results.

## Bottom shear stress measurements

Since 2005 more than 70 deployments have been carried out using benthic tripods. The frame was equipped with (1) a SonTek ADV Ocean point current sensor and a downward looking SonTek 3MHz ADP current profiler for currents; (2) a Sequoia LISST-100X Laser In-Situ Scattering & Transmissometer for particle size distribution and the volumetric concentration of the material in suspension; (3) a Sea-Bird SBE37 thermosalinograph for temperature and salinity; (4) optical backscatter sensors for turbidity in the water column. Furthermore RDI bottom mounted Acoustic Doppler Current Profilers, type Sentinel 1200 kHz Workhorse, were deployed to measure the complete current profile.

Over the period 2005-2013 more than 2100 days of current measurements are available from the tripods and about 400 days from the ADCPs. Most of the data (68%) were collected in the nearshore in the vicinity of the port of Zeebrugge (MOW1) (see Figure 1), but also at some more offshore stations current data were collected.

The bottom shear stress was derived from the current measurements using three methods. The first one calculates the bottom shear stress and bottom roughness, and their associated error ranges, from a least-square regression of the current profile for the lower part of the water column using the data from the ADP and ADCP (Wilkinson, 1983). In the second method, the bottom shear stress is calculated from the high frequency ADV current measurements using the second moment (turbulent) statistics (Andersen *et al.*, 2007). Since the bottom shear stress is assumed to be linearly related to the turbulent kinetic energy, it can be calculated from the variance of the current fluctuations (Stapleton & Huntley, 1995). Finally, the inertial dissipation method was applied, including a correction for the advection of waves (Sherwood *et al.* 2006; Thowbridge & Elgar, 2001). In this method, the bottom shear stress is calculated as a function of the turbulent dissipation, derived from the energy spectrum of the currents.

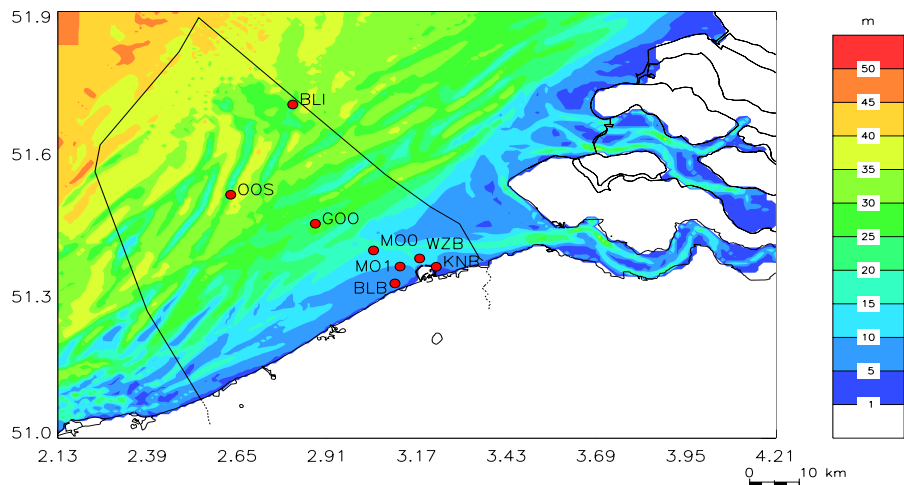


Fig. 1. Position of the measuring stations: OOS: Oosthinder, BLI: Bligh Bank, GOO: Gootebank, MOO: MOW0, BLB: Blankenberge, MO1: MOW1, WZB: WZ-Boei, KNB: Knokkebank.

#### Bottom shear stress calculations using a numerical model

The modules of Soulsby & Clarke (2005) and Malarkey & Davies (2012) have been used to calculate the bottom shear stress. Both modules parameterise the complex model results in an efficient way, so that they can be included in larger scale sediment transport models. Currents were calculated using a three-dimensional hydrodynamic model, based on the COHERENS software (Luyten, 2014), waves were calculated using an implementation of the WAM model (WAMDIG, 1988).

#### Acknowledgements

Data were acquired in several monitoring programmes (MOMO and MOZ4 (Flemish Government); ZAGRI and WinMON (private revenues)). RV Belgica shiptime was provided by RBINS, OD Nature and Belgian Science Policy Office. The commander and crew of the RV Belgica, and the Measuring Service Ostend (RBINS, OD Nature) are acknowledged for logistical support.

#### References

- Andersen T.J., J. Fredsoe and M. Pejrup (2007). In situ estimation of erosion and deposition thresholds by Acoustic Doppler Velocimeter (ADV). *Estuarine Coastal and Shelf Science*, 75: 327-336.
- Luyten P. (Editor) (2014). COHERENS – A Coupled Hydrodynamical-Ecological Model for Regional and Shelf Seas: User Documentation. Version 2.6. RBINS Report, Operational Directorate Natural Environment, Royal Belgian Institute of Natural Sciences, Brussels, Belgium, 1554p.
- Malarkey J. and A.G. Davies (2012). A simple procedure for calculating the mean and maximum bed stress under wave and current conditions for rough turbulent flow based on Soulsby and Clarke's (2005) method. *Computers & Geosciences*, 43: 101-107.
- Sherwood C.R., J.R. Lacy and G. Voulgaris (2006). Shear velocity estimates on the inner shelf off Grays Harbor, Washington, USA. *Continental Shelf Research*, 26: 1995-2018.
- Soulsby R.L. and S. Clarke (2005). Bed shear-stresses under combined waves and currents on smooth and rough beds. Report TR 137. HR Wallingford, Wallingford, United Kingdom, 42p.
- Stapleton K.R. and D.A. Huntley (1995). Seabed stress determinations using the inertial dissipation method and the turbulent kinetic energy method. *Earth Surface Processes and Landforms*, 20: 807-815.
- Trowbridge J. and S. Elgar (2001). Turbulence Measurements in the Surf Zone. *Journal of Physical Oceanography*, 31: 2403-2417.
- WAMDIG: The WAM Development and Implementation Group (1988). The WAM model: a third generation ocean wave prediction model. *Journal of Physical Oceanography*, 18: 1775-1810.
- Wilkinson R.H. (1983). A method for evaluating statistical errors associated with logarithmic velocity profiles. *Geo-Marine Letters*, 3: 49-52.