EGU22-6369, updated on 09 Aug 2022
https://doi.org/10.5194/egusphere-egu22-6369
EGU General Assembly 2022


# Temporal resolution of echosounding measurements for assessing bedload transport rates via dune tracking

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Assessment of bedload transport rates is of great importance for river morphology. Over the years, many efforts have been made to get a realistic estimate of the bedload transport rate in a river. Several researchers suggested that a reliable estimate of the bedload transport rate can be computed from migration of dunes based on the so-called dune tracking method. To apply this method, bed elevation profiles have to be measured using echosounding of the river bed to determine dune geometries (length (λ) and height (H)) and dune migration rate (C).
The migration rate of dunes (C = ΔX/ΔT) is calculated by cross-correlation based on dune migration distance (ΔX) and time interval (ΔT) between echosounded profiles of two successive measurements. Based on literature, the ΔT between successive echosoundings has to be small enough for the same dunes to be clearly detectable in both measurements. However, the parameter ΔT has not been yet quantified for different river conditions. The objective of the present study is to get an appropriate estimation of the ΔT in order for the cross-correlation to work properly and thus to get a reliable magnitude of bedload transport rate which is at the same time also a specification for the execution of the measurements.
To provide an accurate estimate of the ΔT, both the dune migration distance (can be related to the dune geometries) and the dune migration rate need to be known. Since both parameters (ΔX and C) are not available at the beginning of measurements in the field, they need to be estimated based on the existing predictors (e.g. Allen (1968), Tsuchiya & Ishizaki (1967), Van Rijn (1984), Wilbers (2004)) in the literature. The predictors' verification has been carried out by using the dune geometries and the dune migration rate obtained based on the echosounded profiles. The analysis has been conducted by using the echosounding data of the LiLaR campaign (November 2021) from the Rhine River around the German-Dutch border between km 858-859. For the verification, the dune tracking method has been used. The applied dune tracking method is based on a combination of the software RhenoBT (Frings et al. 2012) and Bedforms ATM (Gutierrez et al. 2018), which determine the dune geometries. Besides, the dune migration rate has been calculated by the cross-correlation using an R script.
This study shows that the dune migration distance can be related to the dune length (ΔX = p.λ). The p parameter depends on echosounding measurement uncertainties and dune geometries changes as they migrate downstream. Furthermore, the migration rate would be probably predicted best with Wilbers (2004) predictor in which dune migration rate is related to dune length. While large dunes migrations show high correlation (> 0.7) for time interval of more than

20 hours, small superimposed dunes only show high correlation for time interval lower than 2 hours. Knowing the required time interval can be a helpful factor during echosounding measurements which results in finding the dunes that are most active in transporting bedload material as they migrate downstream.