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Wünsche, Anna; Becker, Marius; Maushake, Christian; Winter, Christian Spring-neap variability of tidal current velocity in the Emder Fairway (Ems estuary) derived from moored ADCP

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Kiel University Christian-Albrechts-Universität zu Kiel

Spring-neap variability of tidal current velocity in the Emder Fairway (Ems estuary) derived from moored ADCP

Motivation

- Approaches which aim explaining upstream increase of sediment concentration, as observed in the Ems estuary, are among others based on the principle of tidal asymmetry. Residual flux of suspended sediment is often classified by the difference in maximum velocities (peak currents) of flood to ebb [1].
- Here, we evaluate velocity variability on spring-neap scales from measurements and **compare peak currents to durations**



of high velocities.

■47 ° N 3°W 2°E 7°E 12°E

diamond).

1 Data

- Moored ADCP from the Ems Dollard Measurement campaign (EDoM), located in the Emder Fairway (at EF, Fig. 1b)
- Coverage of 25 days in August 2018 (Fig. 2)
 - Select four consecutive days (8 tidal cycles) to represent each period: Spring A, Neap and Spring B



3 Results

- Variability is visible on period-internal (i.e. Neap) and period-toperiod scales (Spring A vs. Spring B) (Fig. 3).
 - Strongest at high magnitudes and at slack

Figure 3: Depthaveraged velocity magnitudes u_{av} (light blue line), their median $\langle u_{av} \rangle$ (dark blue, bold line) and maximum velocity magnitudes u_{max} (light red line), and their median $\langle u_{max} \rangle$ (dark red, bold line) (m/s) of the periods Spring A, Neap and Spring B. Labels at the x-axis indicate durations in minutes.



Figure 2: Velocity magnitude (m/s) from moored ADCP measured at EF for the period of the evaluated full spring-neap cycle and its subsequent spring period (upper panel) and a zoom into two tidal cycles, starting at 12 August, 20:06 (CET) (lower panel).

2 Methods

- Analyze time series for <u>each period</u> (Spring A, Neap and Spring B) of
 - Depth-averaged velocity magnitude u_{av} Note: In the
 - following methods Local maximum velocity magnitude u_{max} denoted as U
 - Compute respective median $\langle \cdot \rangle$
 - **Peak current** asymmetry (PCA): $max(U_{flood})/max(U_{ebb})$:
 - $PCA > 1: \max(U_{flood}) > \max(U_{ebb})$
 - $PCA < 1: \max(U_{flood}) < \max(U_{ebb})$

- Choice of depth-averaged or maximum velocity determines results of peak current ratio PCA (Fig. 4a).
- Durations of high velocities during ebb exceed those during flood $(t_{f,utr}/t_{e,utr} < 1)$ even when PCA suggests stronger flood than ebb currents (Fig. 4).



Figure 4: PCA (a) and ratio of duration of velocity magnitude exceeding critical value $(t_{f,utr}/t_{e,utr})$ (b) from depth-averaged velocity magnitudes u_{av} (blue) and maximum velocity magnitudes u_{max} (red) of the periods Spring A, Neap and Spring B.

4 Take home messages

- Ratio of duration of high velocities $t_{f,utr}/t_{e,utr}$:
 - Threshold velocity u_{tr} : median tidal current velocity -
 - Get $[U_{flood} \ U_{ebb}] > u_{tr}$
 - $t_{f,utr}/t_{e,utr} > 1$: high U_{flood} outlast high U_{ebb} -
 - $t_{f,utr}/t_{e,utr} < 1$: high U_{ebb} outlast high U_{flood}
- **Evaluate spring-neap variability**
- Compare peak current to duration of high velocity
- Variability of velocity magnitudes results in variability of derived peak currents and duration of high velocities.
- Classification of an estuary based on current velocity from short time series (e.g. one tidal cycle) is inapplicable.
- Peak currents may underestimate the impact of durations of high velocity magnitudes for possible sediment transport.

[1] Dronkers, J. (1986). Tidal asymmetry and estuarine morphology. *Netherlands Journal of Sea Research*, 20(2-3), 117-131. [2] Sievers, J., Rubel, M., Milbradt, P.: EasyGSH-DB: Themengebiet – Geomorphologie, Bundesanstalt für Wasserbau, https://doi.org/10.48437/02.2020.K2.7000.0001, 2020 [3] Bathymetry adapted from the EasyGSH-DB data collection [4] Made with Natural Earth.

September 2021 · Anna Wünsche, Marius Becker, Christian Maushake, Christian Winter | Phone: +49 40 81908-464 | Mail: anna.wuensche@baw.de

