EP33B-0921

Suspended sediment load in an Indonesian river draining a rainforested basin subject to land cover change: suspended sediment division at a tidal junction

Frans A. Buschman[1], M. van der Vegt[1], A.J.F. Hoitink[12] , S.M. de Jong[1] and P. Hoekstra[1]

[1]Institute for Marine and Atmospheric research Utrecht (IMAU), Department of Physical Geography, Utrecht University, The Netherlands.

[2]Hydrology and Quantitative Water Management Group, Wageningen University, The Netherlands.

Introduction

- The Berau river (Figure 1) is an example of a relatively pristine tropical river. It drains a catchment that is facing rapid development.
- The increasing sediment load in the Berau river is transported via a tidal channel network to the adjacent ocean, which is hosting coral reefs with a high biodiversity. The increasing sediment load poses a threat for the coral reefs in Figure 1.
- Since the northern channel mouth debouches into the ocean closest to most of the coral reefs, the distribution of suspended sediment over the tidal network partly determines the stress for the coral reefs,.
- Analysis of observations taken at a tidal junction in the network helps to understand how suspended sediment is distributed over a network.

Aims

1) Estimate suspended sediment load in the still relatively pristine Berau river
2) Identify key physical aspects that determine the suspended sediment division at a tidal junction from observations

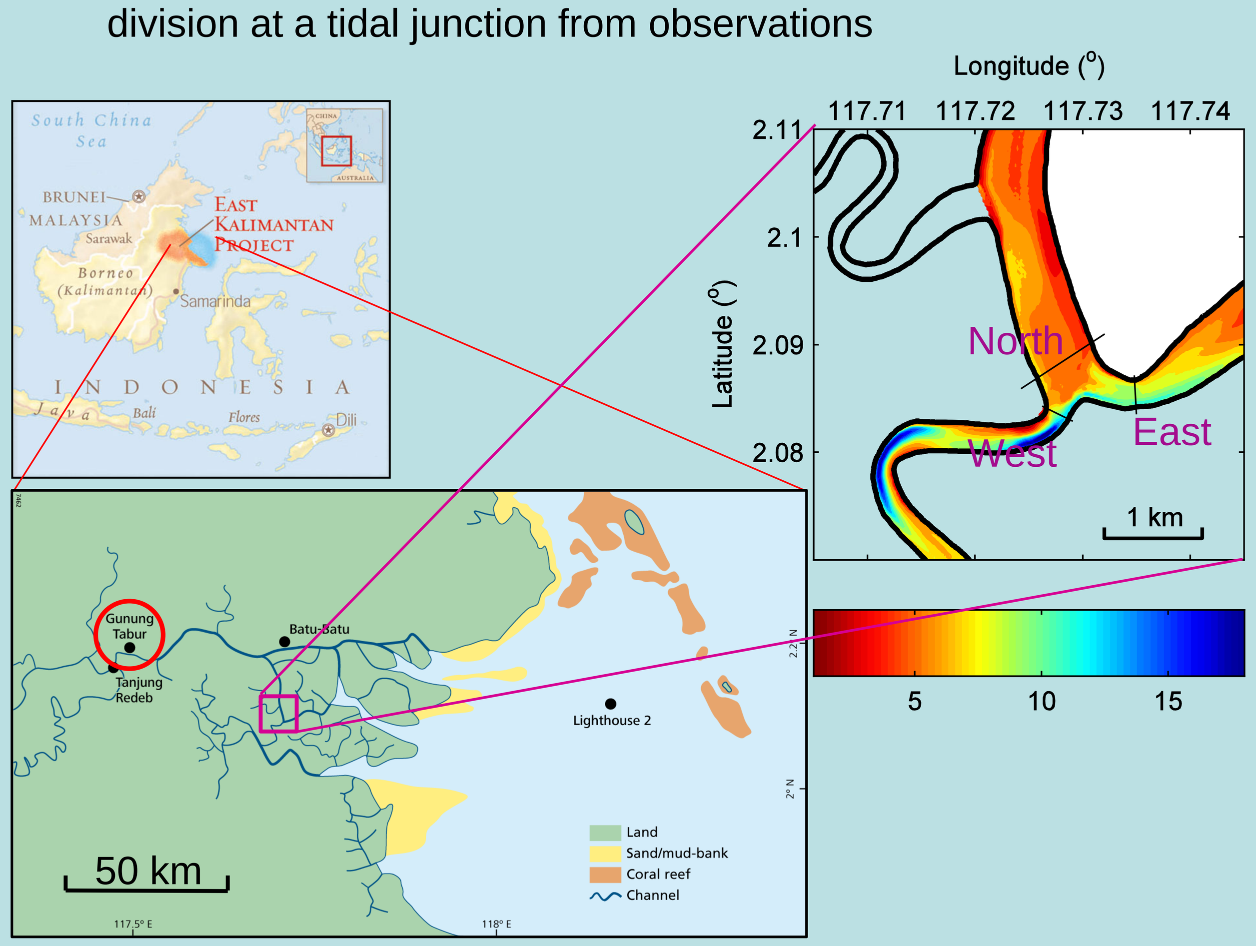

Figure 1 Topographical map of a part of Indonesia [top left], the Berau region [bottom] and morphology at a tidal junction with depth shown in m below mean sea level [right].

Methods

1) Sediment load was determined by multiplying discharge with optically observed suspended sediment concentration at Gunung Tabur (circle Figure 1). Discharge was observed continuously using a Horizontal Acoustic Doppler Current Profiler according Hoitink et al. (2009).
2) At the tidal junction in the channel network (right panel of Figure 1) flow velocity profiles were observed with a vessel mounted ADCP. Salinity and suspended sediment concentration were obtained in the three channels with a CTD-OBS. ADCP backscatter was used to obtain spatial variation in suspended sediment concentration across the channels. The flow velocities were projected on grids across the channels.

Results (1)

- The suspended sediment load in the Berau river was 2 Mton y^{-1} averaged over 6.5 weeks in 2007. Considering the relatively wet conditions in this period, this load can be considered as an upper limit of the yearly averaged load.
- Even this upper limit is lower than expected for an Indonesian river draining about 12,000 km^2 (e.g. Milliman and Farnsworth, 2011). This may be due to the old and erosion resistant rocks (Douglas, 1999).

Spring tide

Neap tide

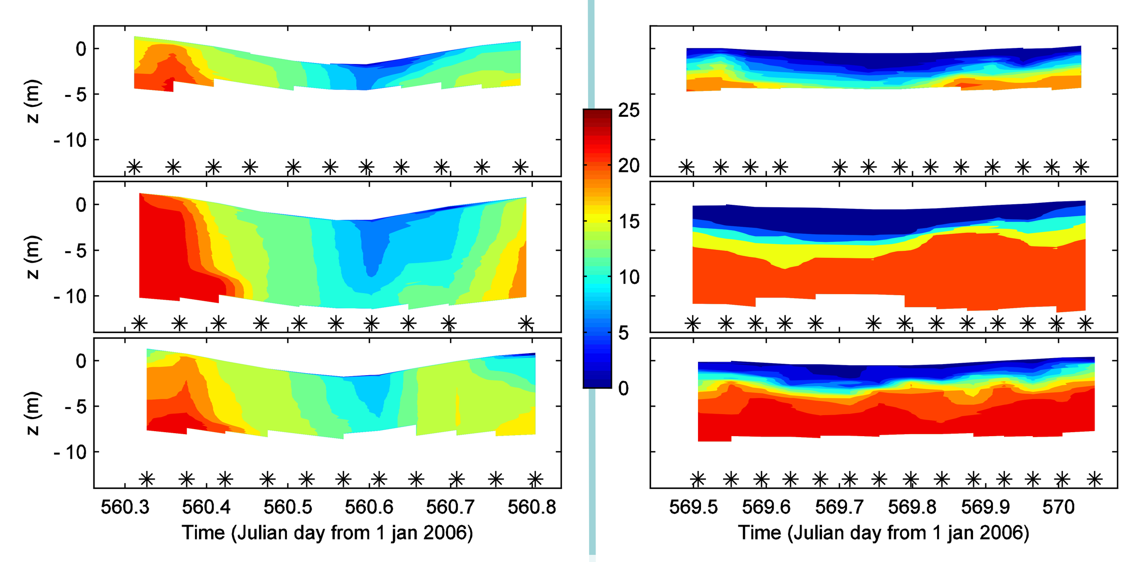

Figure 2 Salinity contours (psu) in the northern [top], western [middle] and eastern channel [bottom] around the tidal junction (right panel of Figure 1) for each of the 12.5 hour periods.

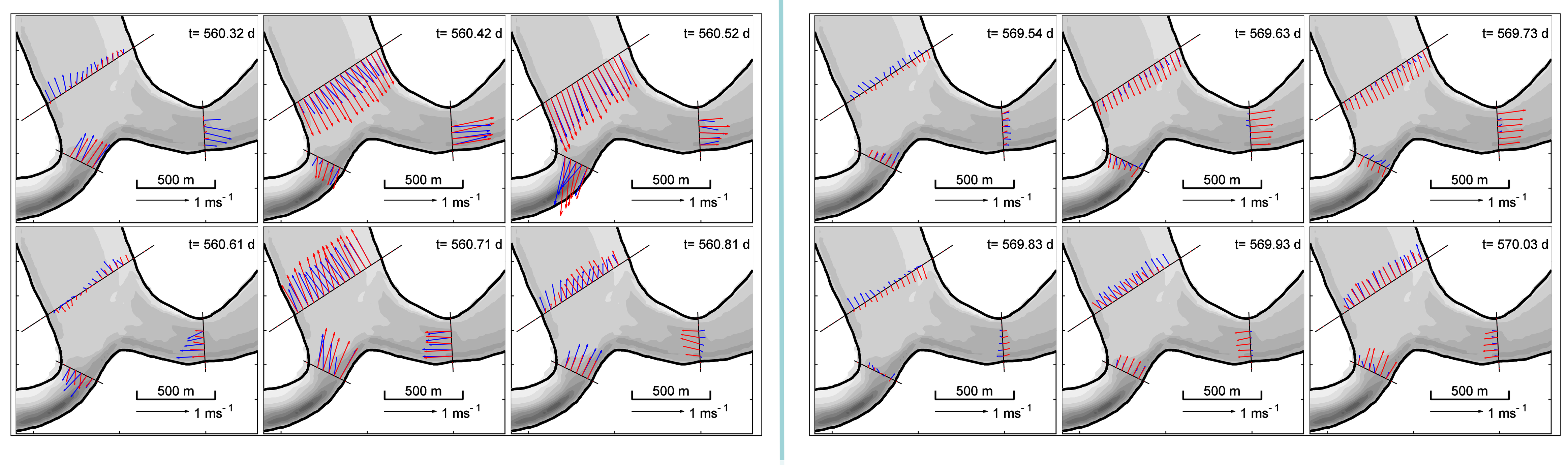

Figure 3 Flow velocities averaged over the top half (red) and bottom half of the water column (blue) for 6 moments of each 12.5 hours observation period.

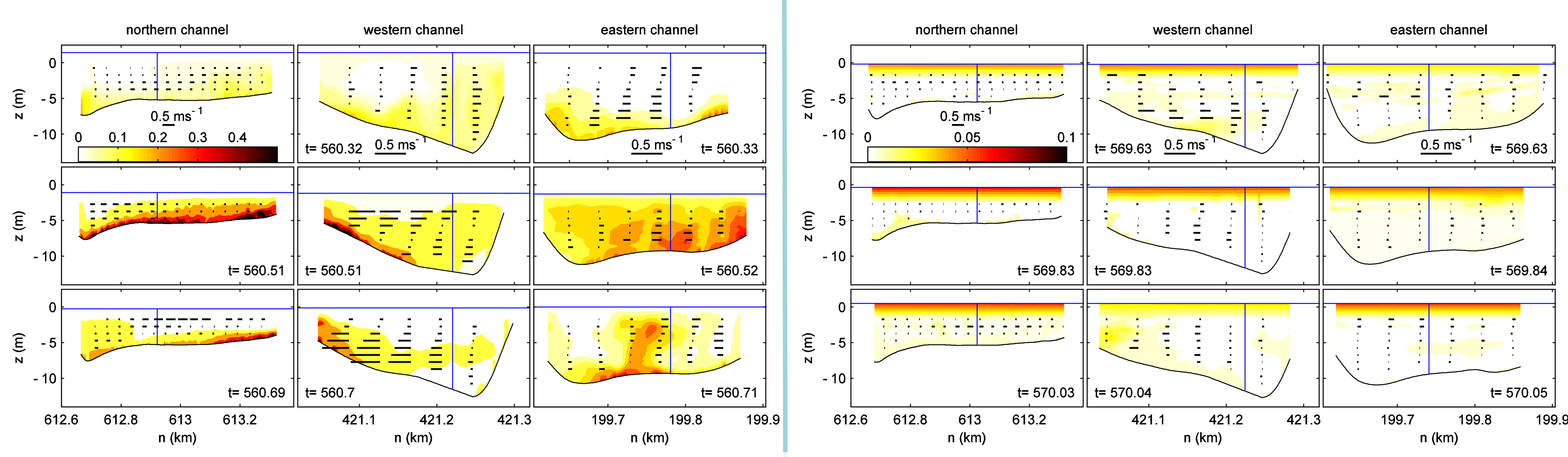

Figure 4. Suspended sediment concentration contours and flow velocity across the three channels for 3 moments of each 12.5 hours observation period, corresponding to moments in Figure 3. Note the difference in contour scaling between spring tide and neap tide.

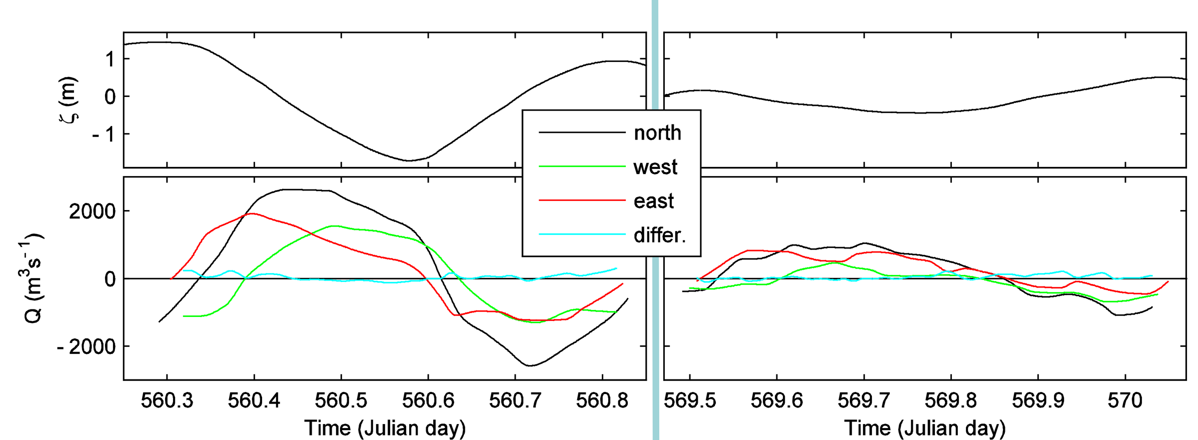

Figure 5. Water surface level (top) and discharge in the three channels north, west and east of the tidal junctionfor two 12.5 hour periods. Positive discharge means seaward directed flow.

Results (2)

- Figure 2 shows that the water columns in the channels around the tidal junction are stratified. During neap tide highly stratified.
- Figure 4 shows that during spring tide suspended sediment was concentrated near the bed and that the concentration was about an order of magnitude larger than during neap tide. During neap tide concentrations were highest in the top fresh water layer.
- The middle and bottom row of Figure 4 for spring tide show two moments with high flow velocity magnitudes (3rd and 5th moment of Figure 3). In the western channel, the pronounced secondary flow redistributed near-bed suspended sediment towards the inner bend.
- The 1st and 6th moment of spring tide in Figure 3 show that in the eastern channel vertical circulations occurred that have an opposite direction as the common estuarine circulation.
- Figure 5 shows that especially around spring tide considerable flow phase differences occur between the 3 channels around the junction, whereas the water level variation is the same.

Discussion

Three key physical aspects were identified that affect the suspended sediment division at a tidal junction:

1. The flow phase differences result in differences in Stokes transport per unit width, affecting the flow division (Buschman et al., 2010). The Stokes transport in a channel is larger when the phase difference between flow and water level variation is smaller.
2. The horizontal density gradients may be strong, resulting in vertical flow circulations that are uncommon in single channels.
3. Pronounced secondary flow may redistribute suspended sediment in the cross-section.

Conclusions

1) The suspended load in the Berau river is maximally 2 Mton y^{-1}, which is lower than expected.
2) The differences in Stokes transport per unit width, the potentially strong horizontal density gradients and the pronounced secondary flow that redistributes suspended sediment are key aspects in determining the suspended sediment division.

For more information or the PhD thesis of Frans Buschman: Frans.buschman@gmail.com

Literature

Buschman, F.A. , A.J.F. Hoitink, M. van der Vegt and P. Hoekstra *Subtidal flow division at a shallow tidal junction* WRR 46, 2010.

Douglas, I. *Hydrological investigations of forest disturbance and land cover impacts in south-east Asia: a review*, Phil. Trans. R. Soc. Lond. B 354, 1999.

Hoitink, A.J.F., F.A. Buschman and B. Vermeulen *Continuous measurements of discharge from a Horizontal ADCP in a tidal river*, WRR. 45, 2009.

Milliman, J.D. and K.L. Farnsworth *River discharge to the coastal ocean: a global synthesis*, 2011.