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Flocculation and resuspension of suspended matter in a tidal freshwater river

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Knowledge about the delivery of suspended sediments to the coastal zone is essential for land and water management in estuaries and river deltas. Sediment discharge estimates, that largely rely on in situ measurements and model efforts, can vary over relatively short time-spans by a countless number of processes whose underlying mechanisms are of somewhat different nature. We present observations in a large river system of two distinct processes of flocculation and resuspension, sharing common features. We discuss the implications for long-term suspended sediment monitoring and modeling.

An instrumented frame was deployed at the bottom of the River Mahakam (Indonesia) and located at the entrance of a mild bend, approximately at 50 m from the riverbank and at a mean depth of about 15 m. Observations took place during the wet and dry seasons, when typical mean river discharges exceeded the 5000 m^3 s^{-1} and remained well-below 1000 m^3 s^{-1}, respectively. In both seasons, salinity intrusion was negligible and the river reach under consideration remained a tidal freshwater river. The flow at this location is characterized by a streamwise velocity component strongly modulated by the semidiurnal tide and by moderate secondary circulation cells. Secondary circulations develop during ebb in the wet season and both during ebb and flood in the dry season. Slack flow is observed only during the dry season with flood flows of the same magnitude as ebb flows.

The distribution of volume concentration measured by a LISST instrument shows a clear co-evolution with the semidiurnal tide and a strong shift of the distribution towards the coarse size class when secondary circulation is absent. Spectra of size distribution per volume generally show two main modes with a peak at nearly $\phi = 3$ and $\phi = 1.5$, respectively. An objective classification analysis based on information theory yields two groups of spectra having distinct characteristics: group 1 is characterized by the same distribution in observations, both in the dry and the wet seasons, and group 2 exhibits two slightly different distributions among the surveys. Estimates of the flow strength confirm the spectral classification objectively splits the observations in periods corresponding with high and low shear stress, for both surveys. For high shear-stress observations (group 1), the median particle size remains nearly independent of the flow strength. For low shear-stress observations (group 2) a strong negative correlation between particle size and flow strength is observed in the wet season.

These observations suggest turbulence controls the processes of aggregation and disaggregation of suspended matter during the wet season (as mean particle size decreases with flow strength and vice versa) and the resuspension of coarse material from the bed during the dry season. These two seemingly unrelated physical processes share common features in time as they are bounded by the characteristic period of the semidiurnal tide, however, they differ significantly both in terms of spatial scales and transport characteristics. Our results may have consequences for the interpretation of long-term temporal analysis of suspended sediment transport based on observations and modeling.