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Dynamic morphology of the Sittaung estuary, Myanmar: A detailed investigation and modeling of rapid bank erosion

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Keywords — Bank erosion, Numerical modelling, Sittaung estuary

Introduction

The Gulf of Mottama, located in the southwest of Myanmar, is home to morphologically interesting processes. The Sittaung estuary is subject to strong dynamic morphological activity, unique in the world, which is alleged to be driven by the large tidal energy and sediment inputs. Dynamics of the tidal channels in the Sittaung estuary result in severe bank erosion, at immense rates of up to 3 km/y, (see satellite imagery in Fig. 1). This is caused by an interplay of different processes and mechanisms, inherent to the estuary. The knowledge of these main processes and mechanisms enable in determining suitable and sustainable solutions to reduce erosion problems, but this knowledge is currently lacking. This research has made strides in demystifying the main contributors of the fundamental dynamic behaviour as well as clarifying the course towards sensible mitigation in the region. In the process, a grapple with the extent of application of numerical models in these particular dynamic contexts is evaluated till a certain extent.

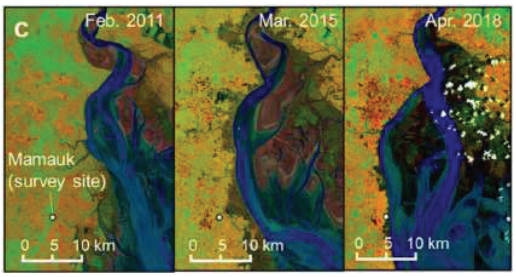

Figure 1: Rapid bank erosion of the last decade on west side and tidal channel evolution of Sittang estuary image from (Shimozono, 2019)

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Method

A combination of literature analysis, data analysis from several sources and numerical simulations is performed. Previous research has provided preliminary insights into the processes that are responsible for the rapid bank erosion in the estuary. Several questions have risen which initial analysis of the problem have deemed interesting avenues of inquiry. Aspects such as the tidal bore related phenomena and channel migration characteristics are investigated in their relation to the dynamic morphological activity.

A depth-averaged 2-dimensional model is used to investigate the mechanisms behind these dynamic characteristics. Multiple cases are evaluated with an elaboration on the case specific physical and numerical parameters in the respective sections. Various simulations with altering conditions are performed. With the evolving computational capabilities and the continuing development of modelling tools it becomes possible to evaluate ever more complex problems. Previous studies have been important for the model set-up of this thesis. The modeled situation is further applied to investigate certain hypotheses and discrepancies that might unfortunately develop.

With the help of a satellite analysis the interesting phenomena were further investigated and data has been gathered. A focus is applied to morphological (large-scale) processes concerning the formulated hypotheses and to retrieve relevant and necessary recent data supplementing the information. The modeled situation is applied to investigate certain hypotheses and discrepancies might unfortunately develop. In a sense, the model is applied with an engineering approach to serve a prospective goal.

Results

It seems as if the flow channels cannot reach much deeper either due to a erosion resistant layer in the subsoil or chocking of the channels due to an overload of sediment. A field measurement campaign is designed and initiated to clarify these claims but has not yet been performed.

It is evident is that the middle estuary region, where erosion is most rapid, experiences erosion at a similar rate throughout the year. This in contrast to the original hypothesis that the erosion would be related to the monsoon driven discharge increase. Which is a factor 10 difference with the dry season discharge. Furthermore, analysis of the recent cyclone arrival shows no additional implications to the morphological trends.

Simulations show that the large storm events, like cyclones, have a limited effect on the the dynamic morphology of the system, which is in accordance with the satellite analysis results. The investigated cross sections at different heights along the river and estuary show differentt profiles velocity profiles. According to these the expected erosion trend would be more severe in the upper parts, see Fig. 2. But the opposite is the case, indicating a stronger dependency on the tidal bore related phenomena. Zooming out and looking at the estuary wide sediment transport shows a discrepancy between the observed import behaviour of fines and the 2D modeled results. There is a strong indication that the 2D situation under represents large scale baroclinic sediment transport processes which are responsible for additional sediment streams.

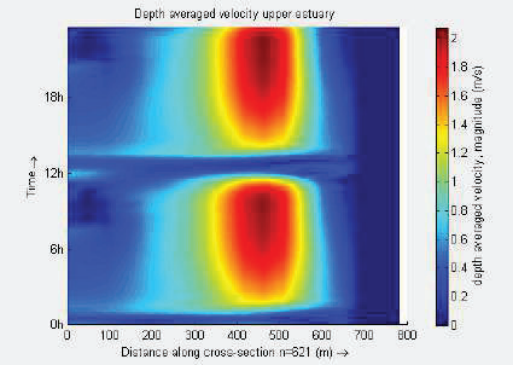

Figure 2: Upper estuary cross section plot of the velocity profile of the wet season discharge configuration.

Long term simulations with respect to the bank erosion result in several hindrances. The numerical difficulties with ascribing the bank erosion fluxes to the dry cells of the grid have shown to deserve extra attention. Channel incision occurs at levels which are much higher than observed or what would be expected, see Fig. 3. This is caused by a numerical instability of the advection scheme under certain conditions. Currently a workaround of increased transverse bed level factors is employed.

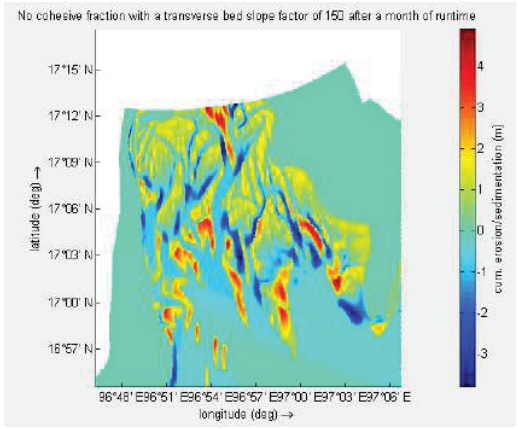

Figure 3: Plot of the high middle region of the estuary. Indicating the effect of a combination without cohesive sediment fractions but with a 100 times increased transverse bed slope factor.

Conclusion

- There is little to no correlation between the wet season and the bank erosion rates. This points to an added importance of the tidal bore specific induced erosion.
- Analysis of the recent cyclone arrival shows no additional implications to the dynamic morphology caused by large incidental storm events.
- Qualitative representations are not near the correct values and also the bank at wet/dry interface does not necessarily show an eroded behaviour. This is because the representation of bank erosion in the model is subject to some technical hindrances.
- The calculated residual transports point to large-scale and local redistribution of sediments. The presence of adjacent upstream and downstream directed zones in the estuary indicate sediment circulation at the scale of the entire estuary, resulting in redistribution of sediment along the entire estuary.

References

Shimozono, T. (2019), Large-scale Channel Migration in the sittang River estuary, in *Scientific reports*, edited by T. Shimozono and Y. Tajima and S. Akamatsu and Y. Matsuba and A. Kawasaki, Nature Publishing Group