Better topographical data gives a better simulation of sediment transport: a step towards the refinement of terrain elevations

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1.0 Introduction

High-accuracy airborne digital elevation models (DEMs) are available in developed countries. But many regions of the world still rely on spaceborne DEMs. The accuracy of terrain elevation mapping has improved in recent years as a result of advances in remote sensing techniques. The Shuttle Radar Topography Mission (SRTM) measured land elevations using radar interferometry. More recently, higher spatial resolution global DEMs, such as ASTER GDEM (Advanced Spaceborne Thermal Emission and Reflection Radiometer-Global DEM) and AW3D-DEM (ALOS: Advanced Land Observing Satellite, World 3D-DEM), have been developed using stereo viewing of optical satellite images. However, spaceborne DEMs contain various observational errors like speckle, stripe noise, absolute, tree height bias etc. Methods for removing these errors from spaceborne DEMs have been developed by utilizing other satellite data sets and filtering techniques.

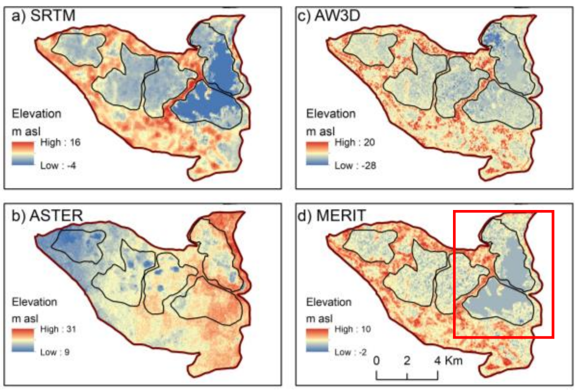

Figure 1: spaceborne DEMs [a. SRTM, b. ASTER, c. AW3D and d. MERIT] of Polder 24 in southwestern Bangladesh. Note: legend scales are different

Yamazaki et al., (2017) developed high accurate terrain elevations named as Multi-Error-Removed Improved-Terrain DEM (MERIT DEM) by eliminating multiple error components from existing spaceborne DEMs. AW3D and SRTM DEMs were used as the baseline DEMs and the unobserved areas were filled with the Viewfinder Panoramas DEM (VFP-DEM) and other sources [Please see (Yamazaki et al., 2017) for the detailed information]. ASTER GDEM was not used in their study due to the fact that height errors are larger than the SRTM and AW3D DEMs. Even though significant improvements were found, there are some observation gaps over water bodies. In the case of Polder 24 in southwestern Bangladesh, almost whole areas in two eastern beels (**Figure 1d**) are with same elevation values. This might be due to the limitation of SRTM observation over water bodies (**Figure 1a**) and importantly MERIT DEM is taking SRTM as base DEM. This study has attempted to consider the use of ASTER GDEM to fill the gaps of MERIT DEM.

2.0 Methodology

As the height errors of ASTER GDEM are relatively large, we attempted to utilize the variability of elevations of ASTER GDEM and use the magnitude of surrounding values of MERIT DEM to fill the data gap (shown in **Figure 2 a**).

$$X_{bad\,M} = \frac{(X_A - X_{A_{min}})}{(X_{A_{max}} - X_{A_{min}})} \times (X_{M_{max}} - X_{M_{min}})_{sur} + (X_{M_{min}})_{sur}$$

where, X is elevation value at the pixel.
A = ASTER, M = MERIT
sur = surrounding

The limited bathymetric data of March 2007 (**Figure 2b**) provided by Institute of Water Modelling is used to estimate the profile of the river channel and check the performance of spaceborne DEMs. We used improved DEM (**Figure 2c)** to generate the mesh for numerical simulation. The ground is divided by a non-structured mesh. The flood simulation model is a 2-D unsteady flow model based on a shallow water equation and a suspended sediment transport is used for transport of the sediment. Please refer Talchabhadel et al., (2018) for the detailed information. **Figure 2d** represents the estimated sediment deposition due to tidal river management (TRM). TRM is the process where the selected lowland (*beel*) is connected to the tidal river by opening the embankment and allowing the natural free tidal flow up and down. It is assumed TRM is operated for four years each one after another.

3.0 Results and Discussions

The flood extents and resulting sediment depositions of each spaceborne DEMs showed different patterns. The sample results in one of the *beel*s of Polder 24 are shown in **Figures 3** and **4**. In general, MERIT DEM had the highest applicability. But as mentioned, some inaccuracies exist in MERIT DEM esp. in two eastern beels (sample shown in **Figure 5**). Therefore, our improved terrain primarily based on MERIT and ASTER's variability produced superior and reliable results (**Figure 2d**).

Acknowledgements

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References:

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- Yamazaki D, Ikeshima D, Tawatari R, Yamaguchi T, O'Loughlin F, Neal JC, Sampson CC, Kanae S, Bates PD. 2017. A high-accuracy map of global terrain elevations. Geophysical Research Letters, 5844 - 5853.

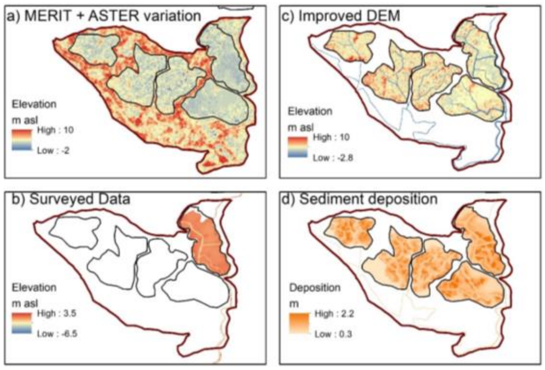

Figure 2: a-c) Processes involved during refinement of DEMs and d) Final sediment deposition after TRM

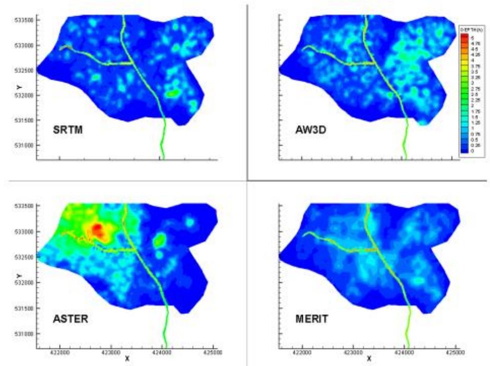

Figure 3: Water depth at high tide during TRM on a *beel* based on different spaceborne DEMs

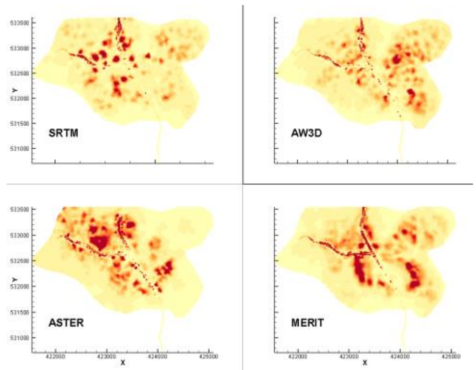

Figure 4: Sediment deposition after TRM on a beel based on different spaceborne DEMs

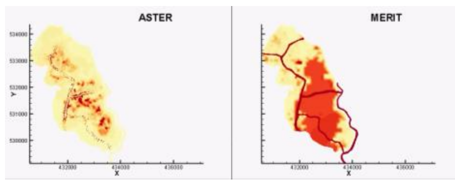

Figure 5: Sediment deposition after TRM on eastern beel based on ASTER and MERIT DEM