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Multiple remote-sensing assessment of the catastrophic collapse in Langtang Valley induced by the 2015 Gorkha earthquake

Hiroto Nagai et al.

Correspondence to: Hiroto Nagai (nagai.hiroto@jaxa.jp)

In order to calibrate the digital surface models (DSMs) of ALOS World 3D (AW3D) and WorldView-3 (WV-3), these data were compared and validated for two of the no-damage sites (Windows A and B) in the vicinity of the collapsed sediment surface (Fig. S1). For sites with no horizontal shift, the differences in values obtained from AW3D and WV-3 DSMs were extracted every 5 m (the pixel spacing for AW3D) in the rectangles of Windows A and B. The average difference between the values of altitude derived from WV-3 DSM and AW3D DSM was **27.4 m** (standard deviation of **1.7 m**) and **26.2 m** (standard deviation of **1.438 m**) at Windows A and B, respectively, where WV-3 yields the higher values.

Secondly, the AW3D DSM for Window A was horizontally shifted within Site A at 5 m steps to increase its consistency with the WV-3 DSM, and the standard deviation of the altitude difference from the WV-3 DSM in the original location was calculated for all such location shifts. The minimum standard deviation was calculated to be **1.5 m**, when the AW3D DSM is longitudinally shifted to −5 m (i.e., 5 m to the west) (Fig. S2a). In case of Site B, the minimum standard deviation was calculated to be **1.427 m**, when the AW3D DSM is longitudinally shifted to −5 m (Fig. S2b). These results suggest that the AW3D DSM should be shifted 5 m to the west (or that the WV-3 DSM should be shifted 5 m to the east) in order to obtain the most consistent outputs using both the DSMs.

In Window A, the values of altitude derived from WV-3 were, on an average, **28.2 m** higher than those derived from AW3D (with a standard deviation of **1.5 m**). In Window B, the values of altitude derived from WV-3 were, on an average, **25.9 m** higher than those derived from AW3D (with a standard deviation of **1.427 m**). To check any deviation of orientation, the horizontal profiles of the AW3D and WV-3 DSMs along the longitudinal and latitudinal ranges were plotted as shown in Fig. S3. Along the four example lines denoted in Fig. S1 (ax−ax', ay−ay', bx−bx', and by−by'), the values obtained from WV-3 are consistently higher than those obtained from AW3D by about **26** to **28** m. No anomaly trend was found along any direction.

Considering these results, we considered **27.0 m** to be the altitude difference between the shifted AW3D DSM and AW3D DSM in this study site. From the derived standard deviations of **1.427 m** and **1.5 m**, taking the greater one, we defined **1.5 m** as the possible error in altitude estimation to calculate the sediment volume (Chapters 3.4. and 4.2.).

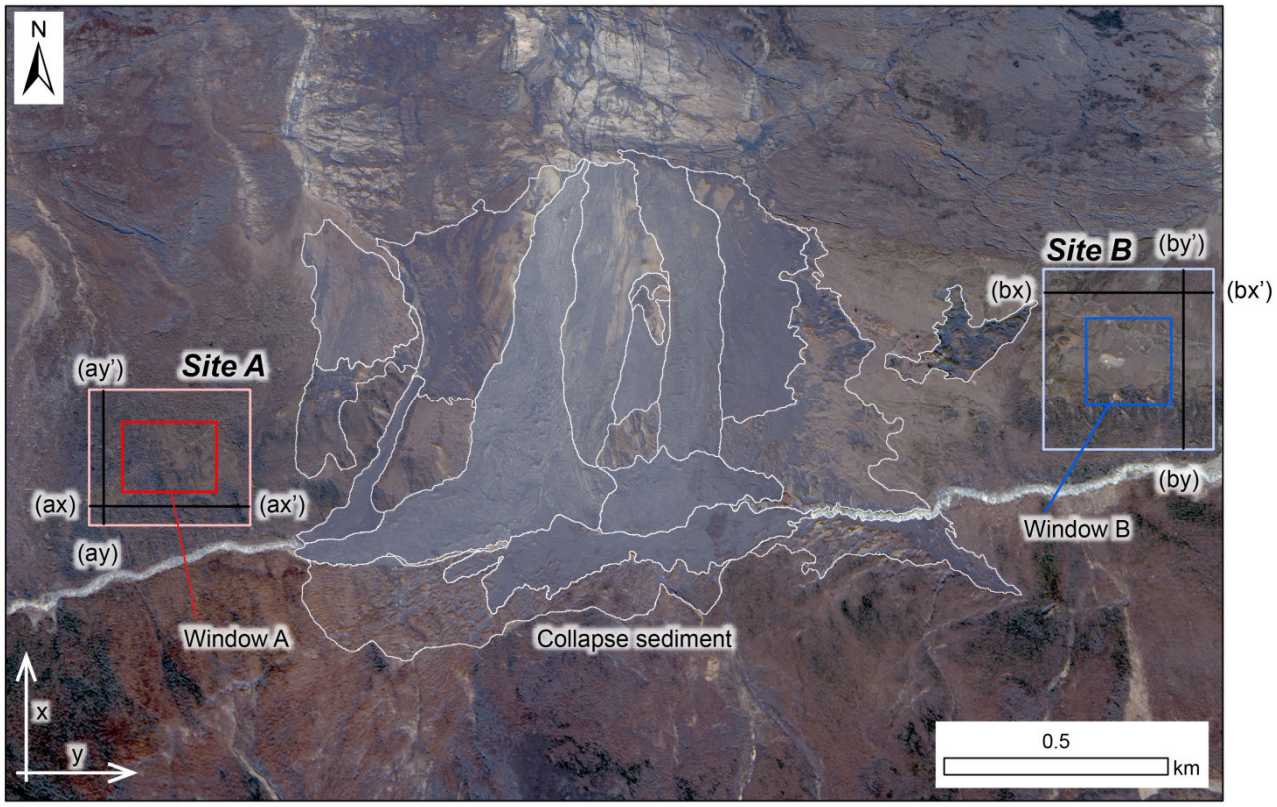

Fig. S1 Location of the two calibration sites (Site A and Site B) near the collapsed sediment surface. Locations of the related lines and rectangles used in Figs. S2 and S3 are also shown. The background is a WorldView-3 image acquired after the collapse (May 8, 2015).

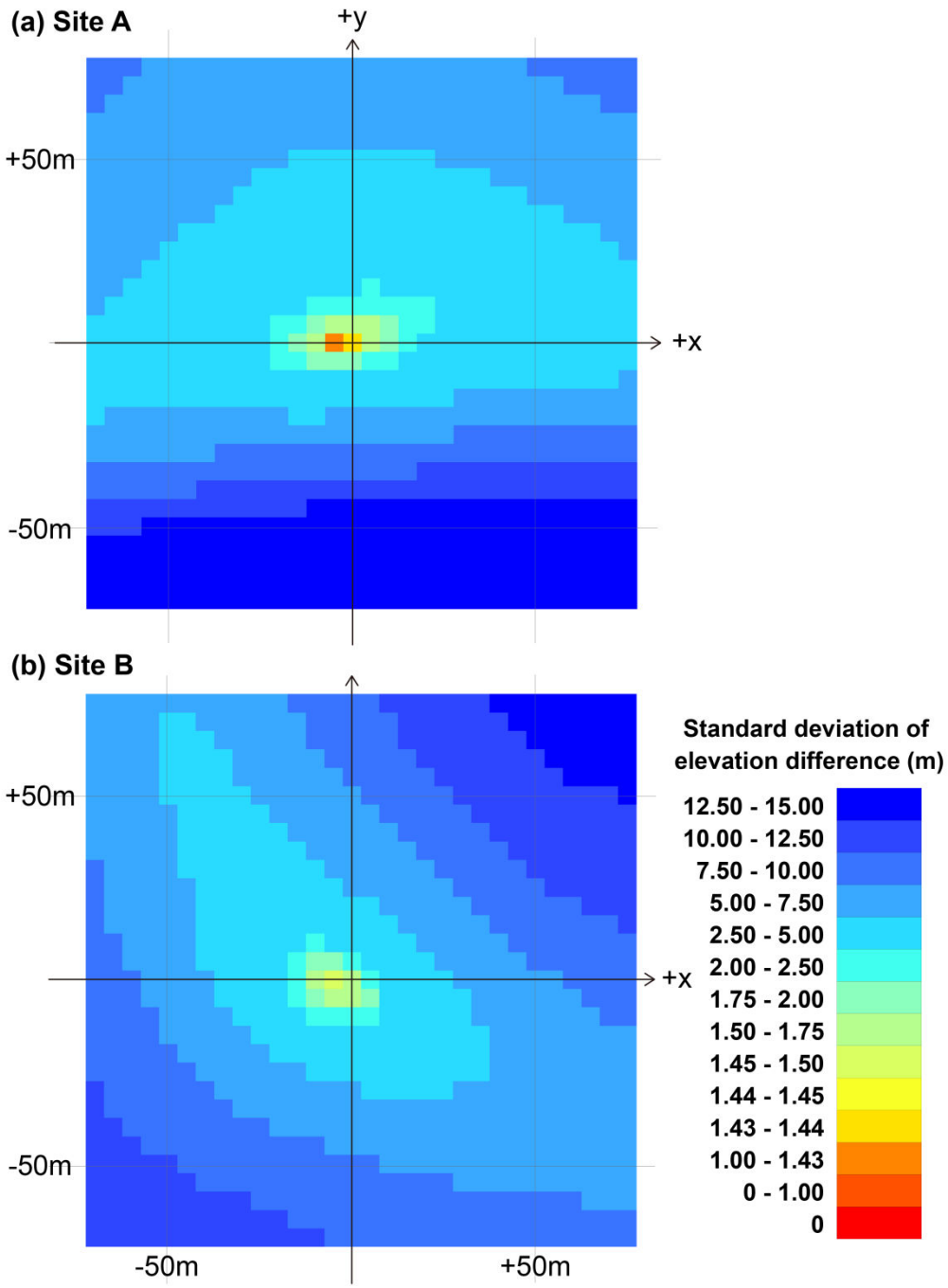

Fig. S2 Standard deviation of the elevation difference between AW3D and WV-3 DSMs. (a) AW3D DSM in Window A is shifted within Site A at 5 m steps, then the standard deviation is calculated with the WV-3 DSM at the original location in Site A. X-axis and Y-axis correspond to the distance from AW3D to the east and to the north, respectively. (b) Same calculation is done for the combination of the Window B in Site B.

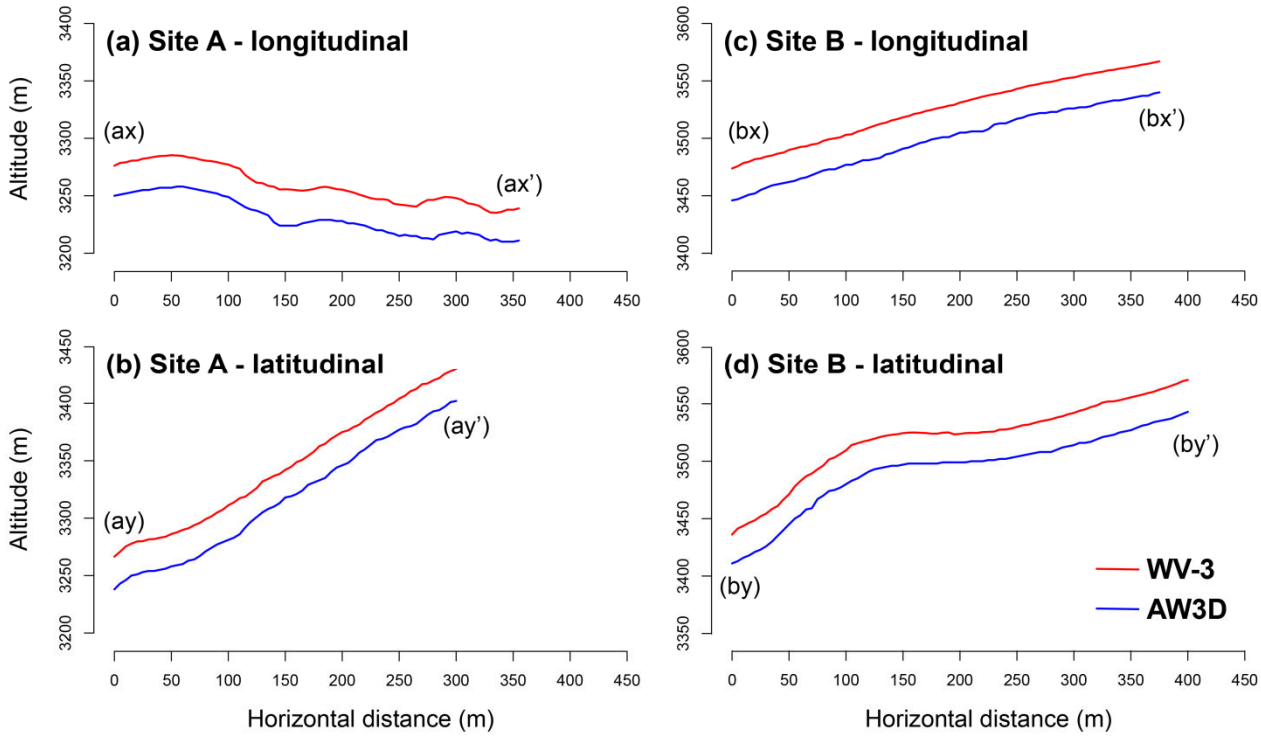

Fig. S3 Longitudinal and latitudinal profiles generated from the AW3D and WV-3 DSMs in Site A and Site B.