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Planform deviations in river channel alignment due to active landsliding in the High Himalaya of Bhutan

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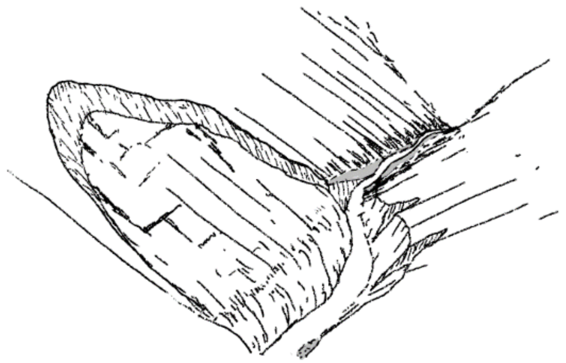
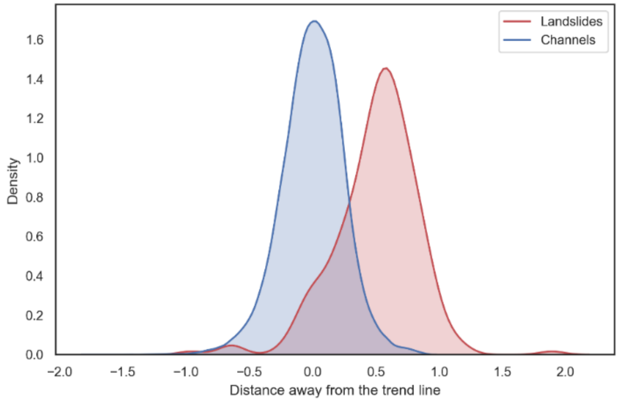
Key Findings

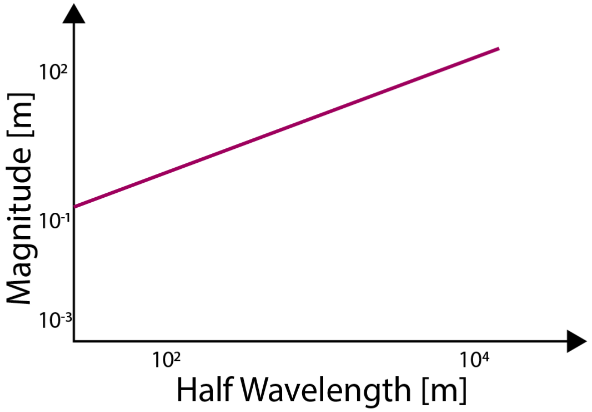
Active **landslides** influence the **planform alignment** of river channels that they are in interaction with.



Information regarding the **activity** of a landslide can be drawn from the magnitude of the **planform channel displacement** induced by the landslide.



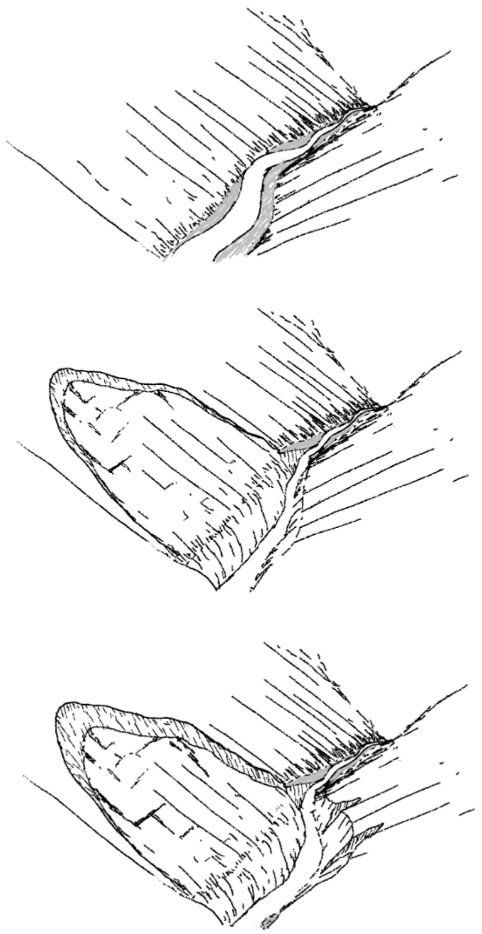
Rivers have a characteristic planform morphology, which follows a power law relationship between the **amplitude** of the river channel deviation and the deviation width (half-**wavelength**).



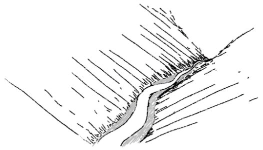
Planform Channel Displacements

Large rock slope instabilities affect river channels both due to catastrophic failures and long-term creep. The relationship between rock slop instabilities and processes in the adjacent river system are typically assessed in terms of channel profile perturbations (e.g. Perron and Royden, 2012) and cross-sectional morphology, e.g. excess topography (Blöthe et al., 2013). However, such relationships can also be evident in **planform changes of the channel alignment**, e.g. in landslide dams and long-term channel migration.

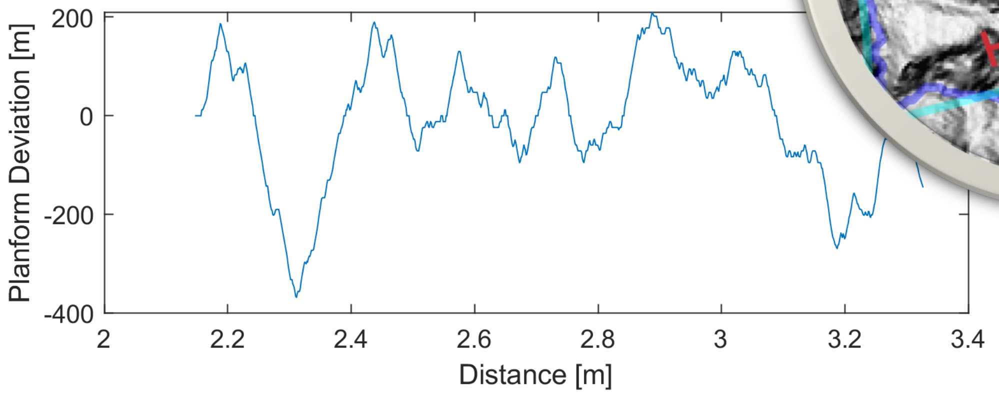
Large scale creeping rock slope instabilities can be considered **point sources** which introduce sediment laterally to a river channel. In cases in which sediment production from one side of the channel **exceeds that of the opposing side**, the course of the river can be **shifted** towards the less active hillslope. The deviation of the channel from its original course may therefore be used as a **proxy for relative sediment input** of the two opposing hillslopes.

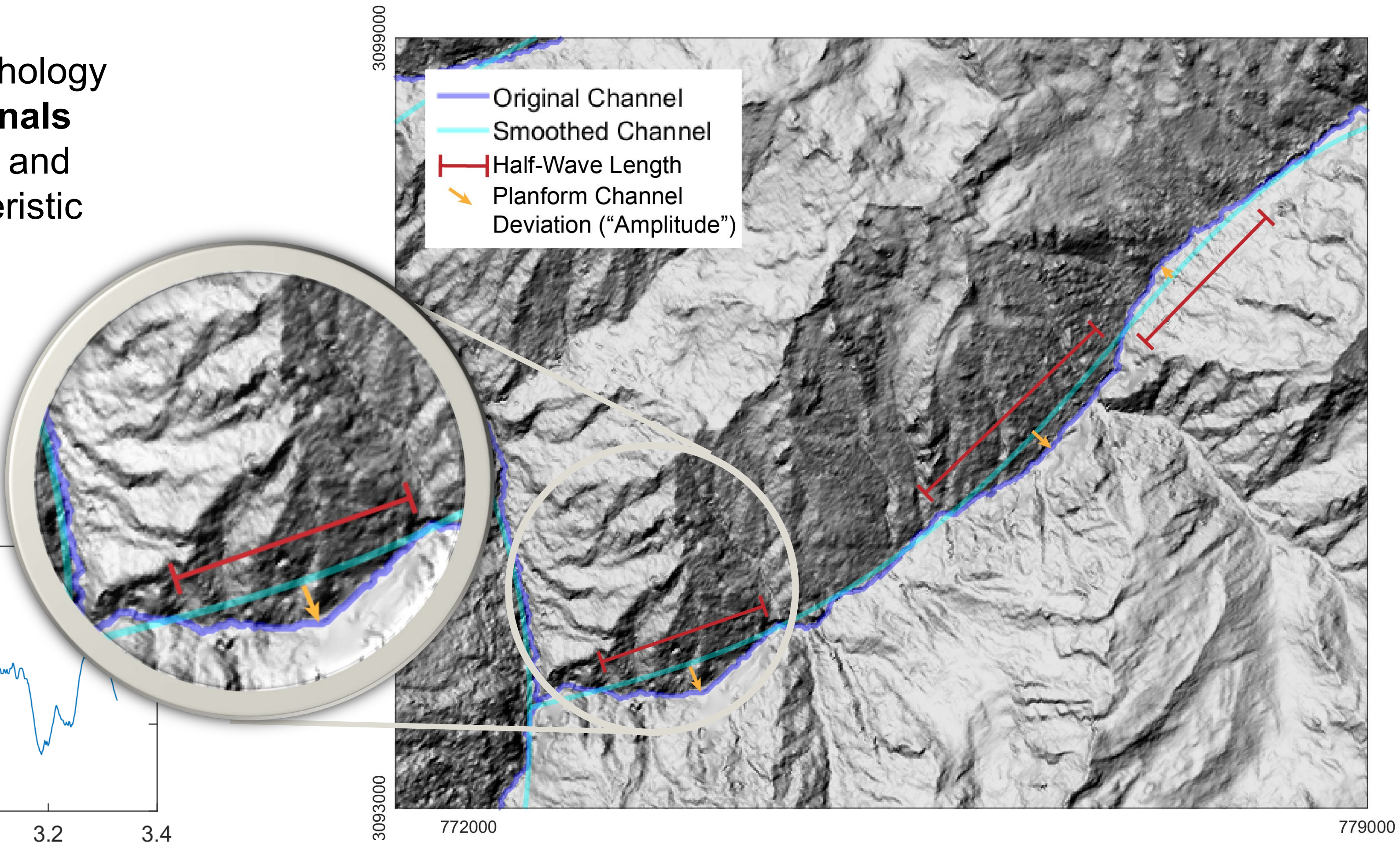


Planform River Alignment Analysis
Methods

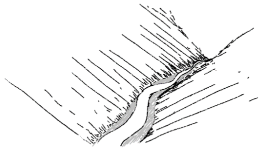


In order to characterize the planform morphology of the river channels, we treat them as **signals fluctuating around a smoothed channel** and use a Fourier transform to extract characteristic wavelengths and amplitudes of the stream network.



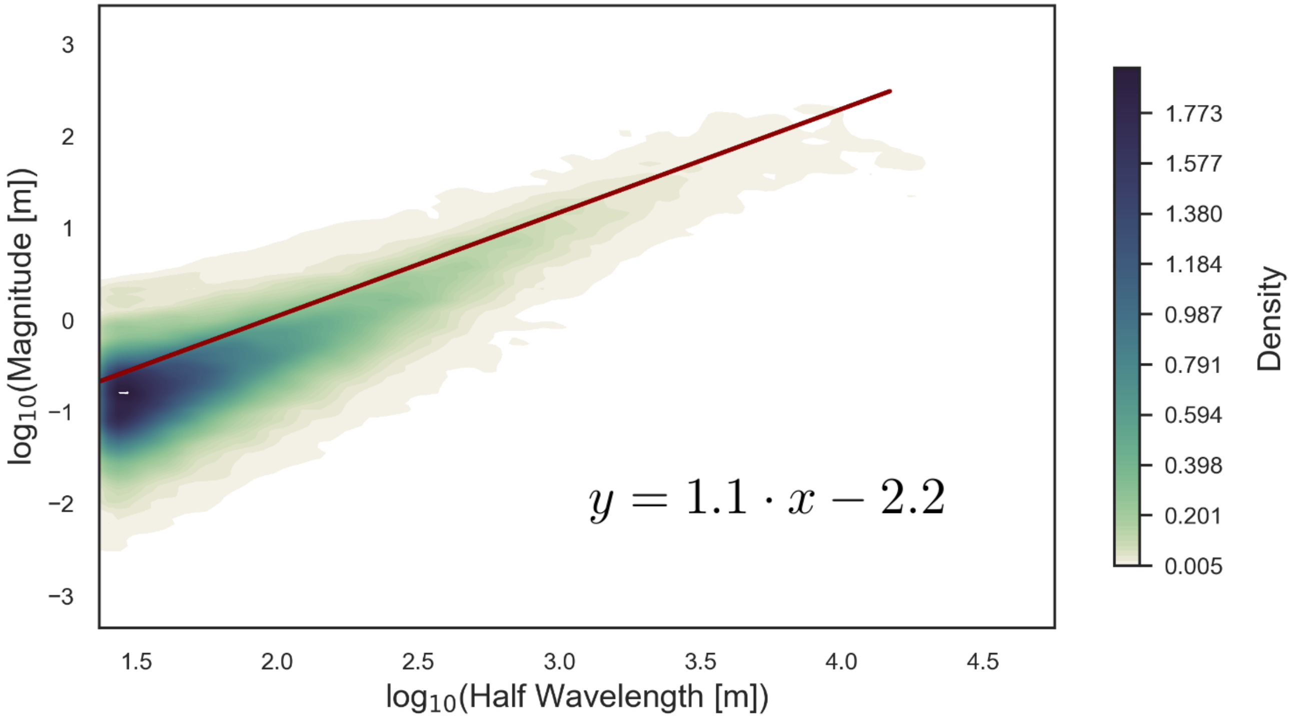


Planform River Alignment Analysis
Results

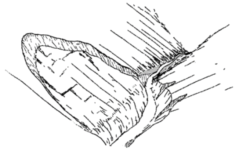


The highest density of channels plots at short wavelengths between $10^{1.5}$ and 10^{2} m.

The relationship between wavelength and magnitude follows a characteristic power law distribution. We observe a **consistent increase in amplitude of planform deviation with increasing wavelength** with the slope of the linear regression being just above 1.



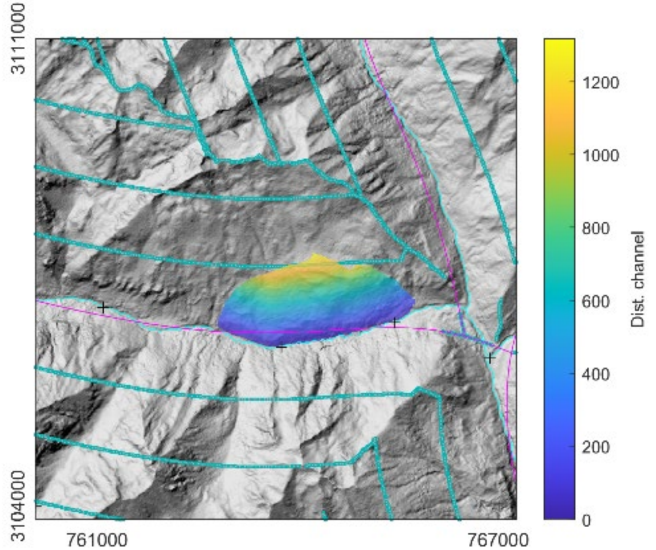
Planform Relative Channel Displacement due to Landsliding
Methods

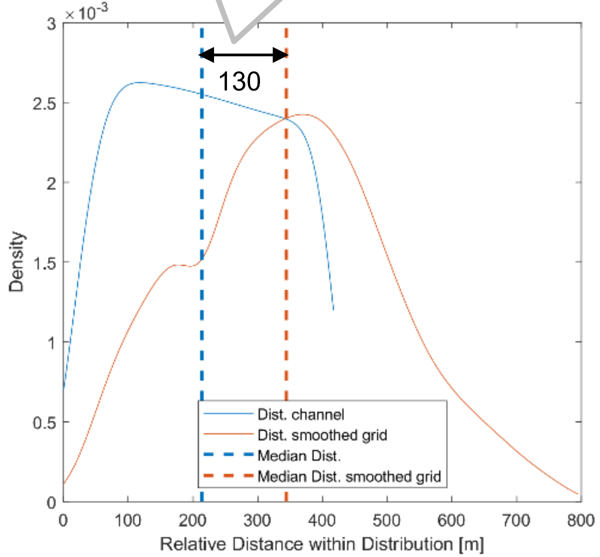


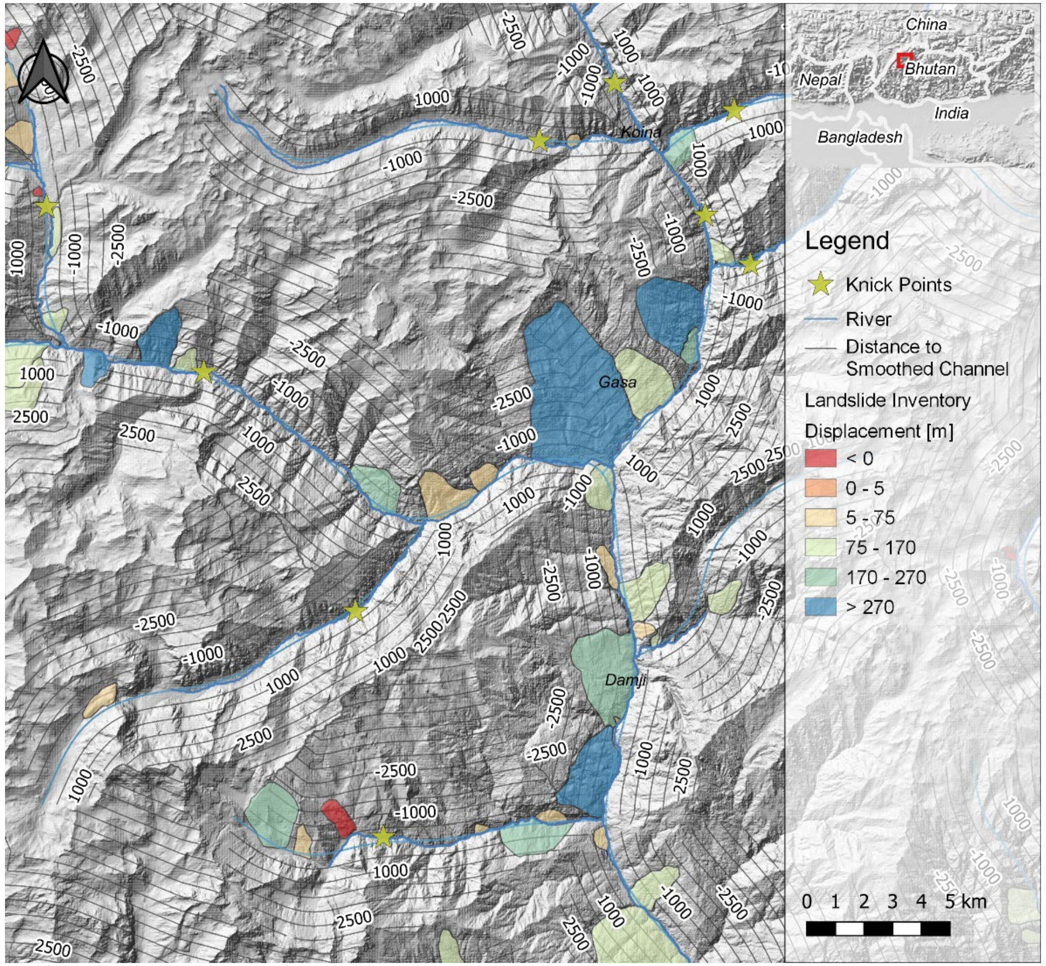
For our calculations, we use the landslide inventory by Dini et al. (2019). For each landslide we calculate the **distance distribution** within the polygon with respect to the

- original channel (pink line)
- an idealized channel (turquoise contour lines).

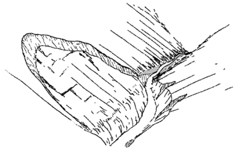
The difference between the medians of the two distance distributions serves as a proxy for the landslide displacement magnitude.



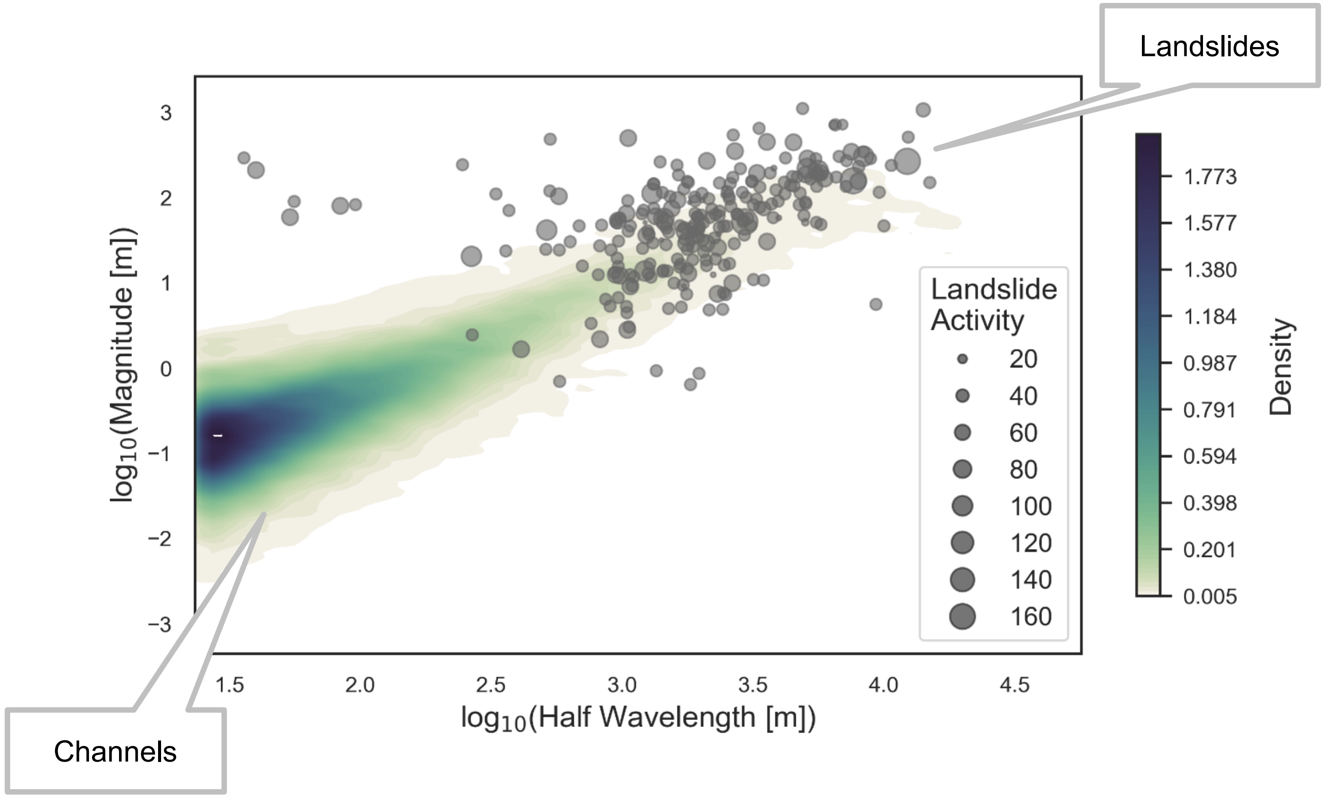


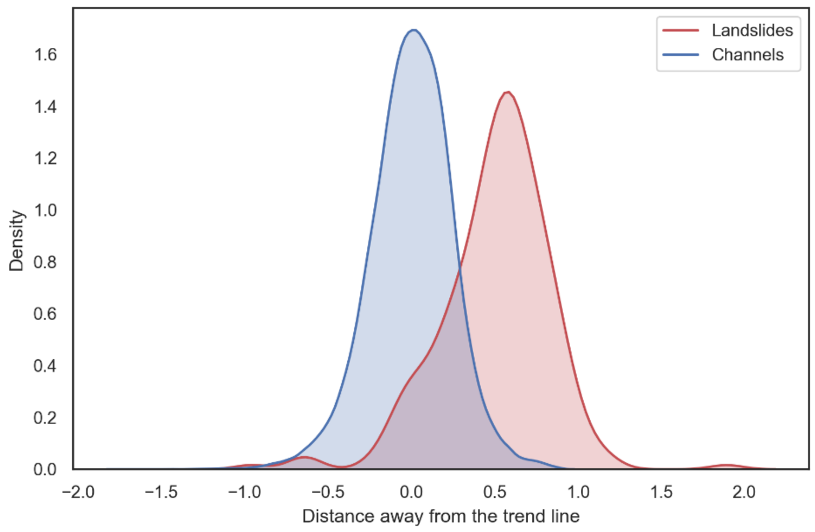


Planform Relative Channel Displacement due to Landsliding
Results

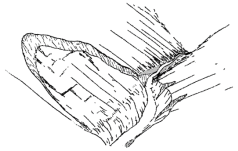


When comparing **characteristic channel morphologies** based on these analyses to the **deviation of channels** adjacent to mapped landslides, **the amplitude of the deviation appears higher than those naturally occurring in the river system at wavelengths similar to twice the landslide width**.

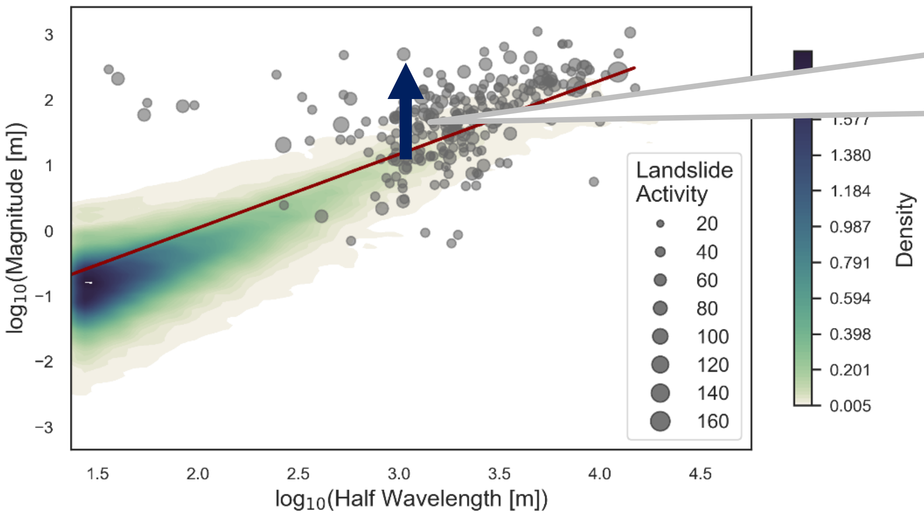




Planform Relative Channel Displacement due to Landsliding
Results

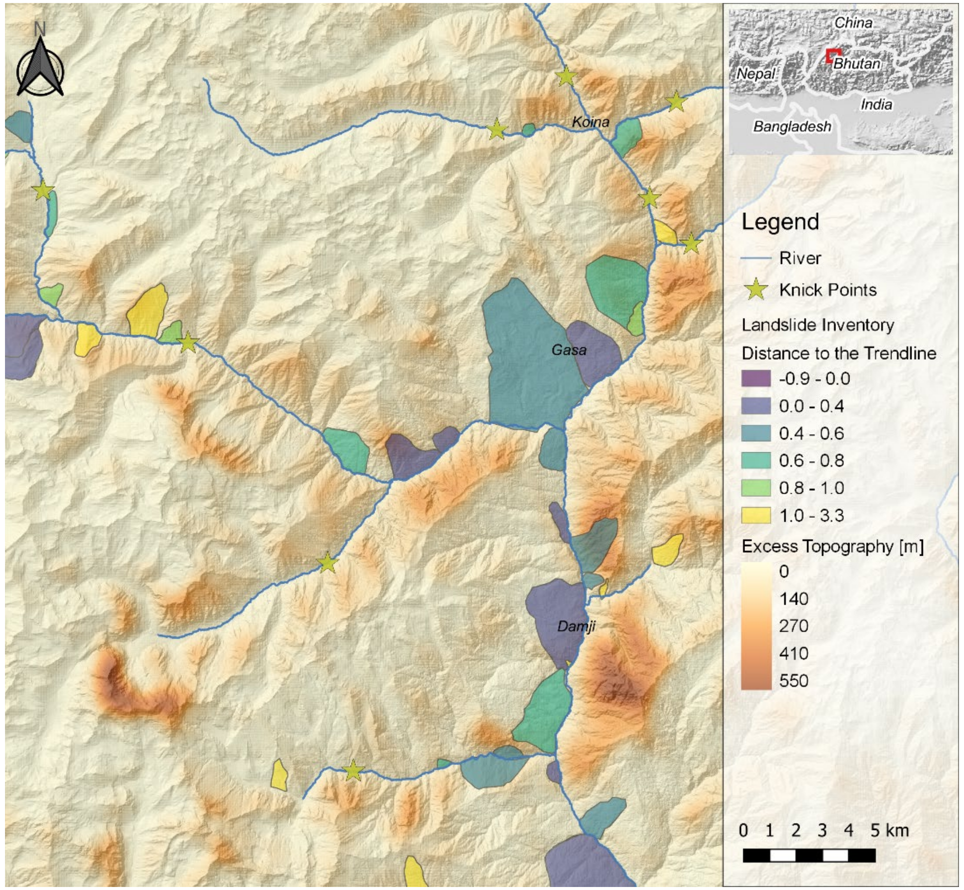


We can map out **landslide activity** via the proxy of the increased landslide channel displacement with respect to the baseline. The magnitude of the landslide displacements often exceeds that of the channels. Cases where the magnitude of the landslide is lower than what would be predicted based on the planform channel displacements are related to locations, where the landslide is not in direct interaction with the stream network.



The vertical distance of each landslide to the trendline (its expected value) is a proxy for landslide activity.

Stay tuned!
Paper coming up soon!



References

Blöthe, J. H., Korup, O., & Schwanghart, W. (2015). Large landslides lie low : Excess topography in the Himalaya- Karakoram ranges, *43*(6), 523–526.

Dini, B., Manconi, A., & Loew, S. (2019). Investigation of slope instabilities in NW Bhutan as derived from systematic DInSAR analyses. *Engineering Geology*, *259*(October 2018), 105111.

Perron, J. T., & Royden, L. (2012). An integral approach to bedrock river profile analysis. *Earth Surface Processes and Landforms*, *3302*.

Thank you for your attention!

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