

# Monitoring of Landslides in Vermont Using Drone and Geologic Surveys

Kim, Jonathan<sup>1</sup> ; Springston, George<sup>2</sup> ; Klepeis, Keith<sup>3</sup> ; Boyles, Julia<sup>1</sup> ; and Robinson, Evan<sup>4</sup>  
<sup>1</sup>Vermont Geological Survey, <sup>2</sup>Norwich University, <sup>3</sup>University of Vermont, <sup>4</sup>Vermont Agency of Transportation



## Purpose

Landslides are a risk to human health and safety and property assets. Since 2019, geologists from the Vermont Geological Survey, Norwich University, and the University of Vermont have collaborated with the VTrans U.A.S Team on the monitoring of active landslide sites in north-central Vermont.



Figure 1. We are conducting annual monitoring surveys of the Cotton Brook landslide (Waterbury- left) and rockslides in Smugglers Notch (Cambridge-right).

## Annual Landslide Monitoring Methods

Intensive field surveys are necessary to understand the underlying geologic framework for a landslide and drone surveys give a critical aerial perspective. Game cameras can be used to view parts of a landslide area on an hourly basis. Each of these field methods is completed annually. All data sets are integrated using photogrammetry software to produce 3-D geologic maps (next section).



Figure 2. Field survey (left), drone takeoff (center), and game camera (right).

## Preliminary Land Surface Change Analysis

Quantitative changes to the landslide and different mechanisms of failure and erosion between 2019-2020 are shown below: (A) DEM of Difference (DOD) of the landslide surface was created by subtracting the 2020 photogrammetrically-derived model from the 2019 model. The raised areas (bumps) are shaded with cool colors and show material that was eroded between the 2019 and 2020 events. This map allows us to distinguish different mechanisms of mass wasting. (B) Interpretive geologic map showing the landslide's internal structures and the different mechanisms of erosion that created it. (C) Cotton Brook delta located downstream from the landslide in 2019 (post slide), with contours (black lines, 1 m interval) of the delta in 2020, representing the peak of sediment deposition. This image is used to quantify how much the delta grew after the 2019 failure. (D) DOD created by subtracting the 2020 model (peak state) of the delta from a 2021 model (erosive state). Topographic highs (blues and purples) show material that was eroded between 2020 and 2021. Contour lines (1 m interval) highlight domains and patterns of erosion.

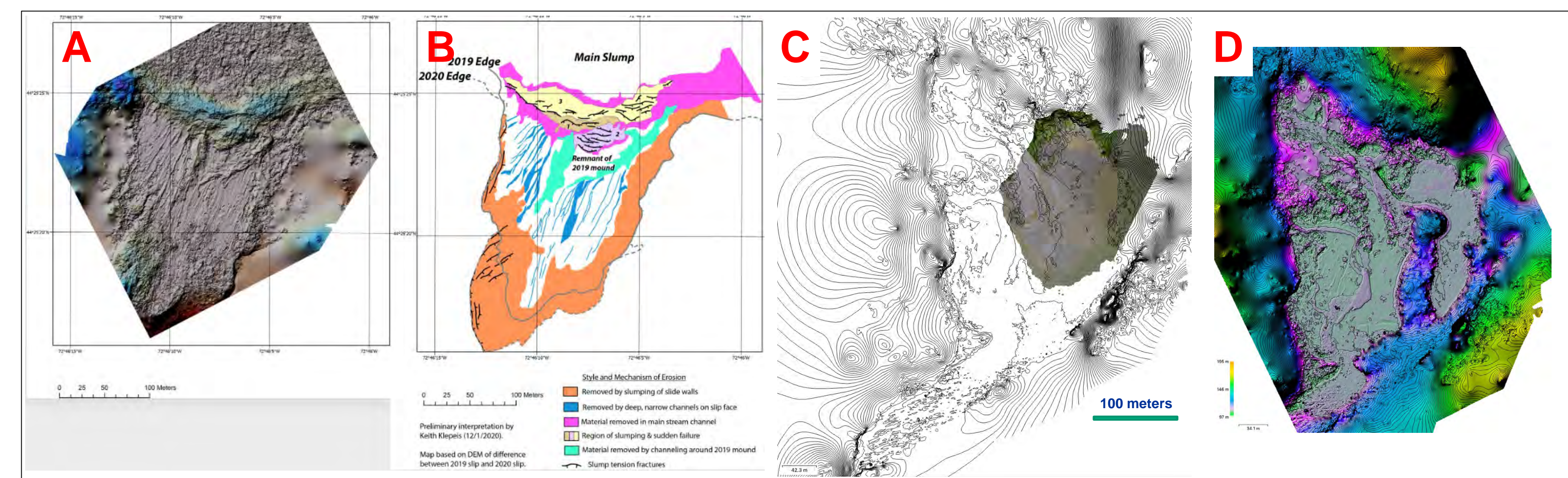


Figure 3. Quantifying land surface change from source to sinks (landslide to delta).

## Conclusions and Next Steps

Monitoring of active landslides using geologic and drone surveys and analysis with photogrammetric software, has detected subtle differences over a year at the Cotton Brook landslide and Smugglers Notch rockslides. Our landslide team plans to apply this methodology to other active landslide sites of interest to VTrans, including Westmore (Lake Willoughby) and Buels Gore.