Mapping Landslide Susceptibility and Ground Displacement Assessment of Travis County, Texas, USA

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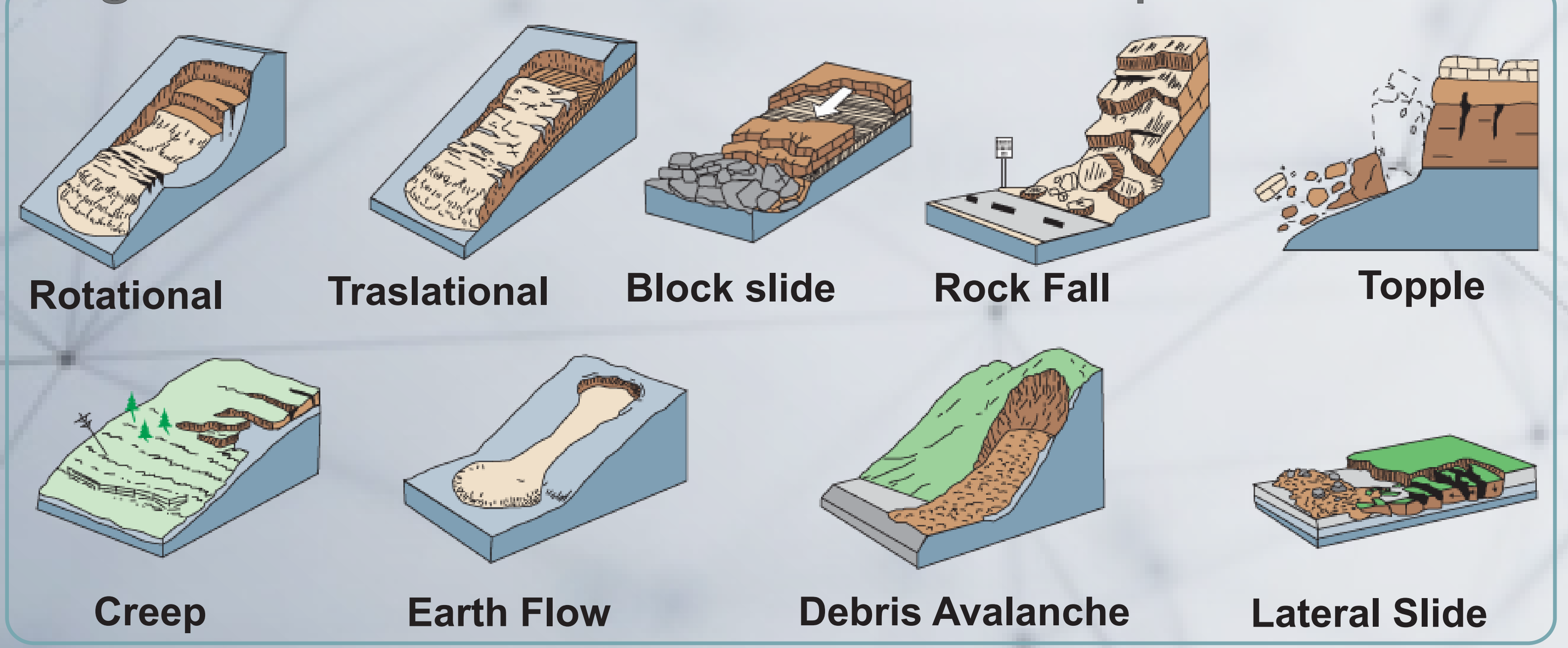
Abstract

Landslides may be caused naturally or triggered by human activities and have enormous societal and economic impacts. Detecting and mapping landslides through the generation of landslide susceptibility maps (LSM) and understanding the factors that trigger these processes will be helpful in land use planning and risk assessments. Moreover, it will also assist landslide mitigation efforts by controlling anthropogenic-led processes that induce landslides. This study deals with the analysis to identify slow-moving landslides in Travis County, Texas. It combines geographic information systems(GIS) and remote sensing datasets and techniques to generate an LSM of the study area and identify ground displacements. Remote sensing data provide key information about the topography and land uses, combined with controlling factors for a landslide occurrence such as slope, geology/soil and geological structures, and vegetation/land uses to perform an empirical approximation to map and assess landslide susceptibility. Once the susceptible areas are identified, analysis for ground displacement is applied using a Synthetic Aperture Radar Interferometric (InSAR) technique referred to as the Small Baseline Subset (SBAS) and field-based multitemporal Real-Time Kinematic (RTK) GPS measurements.

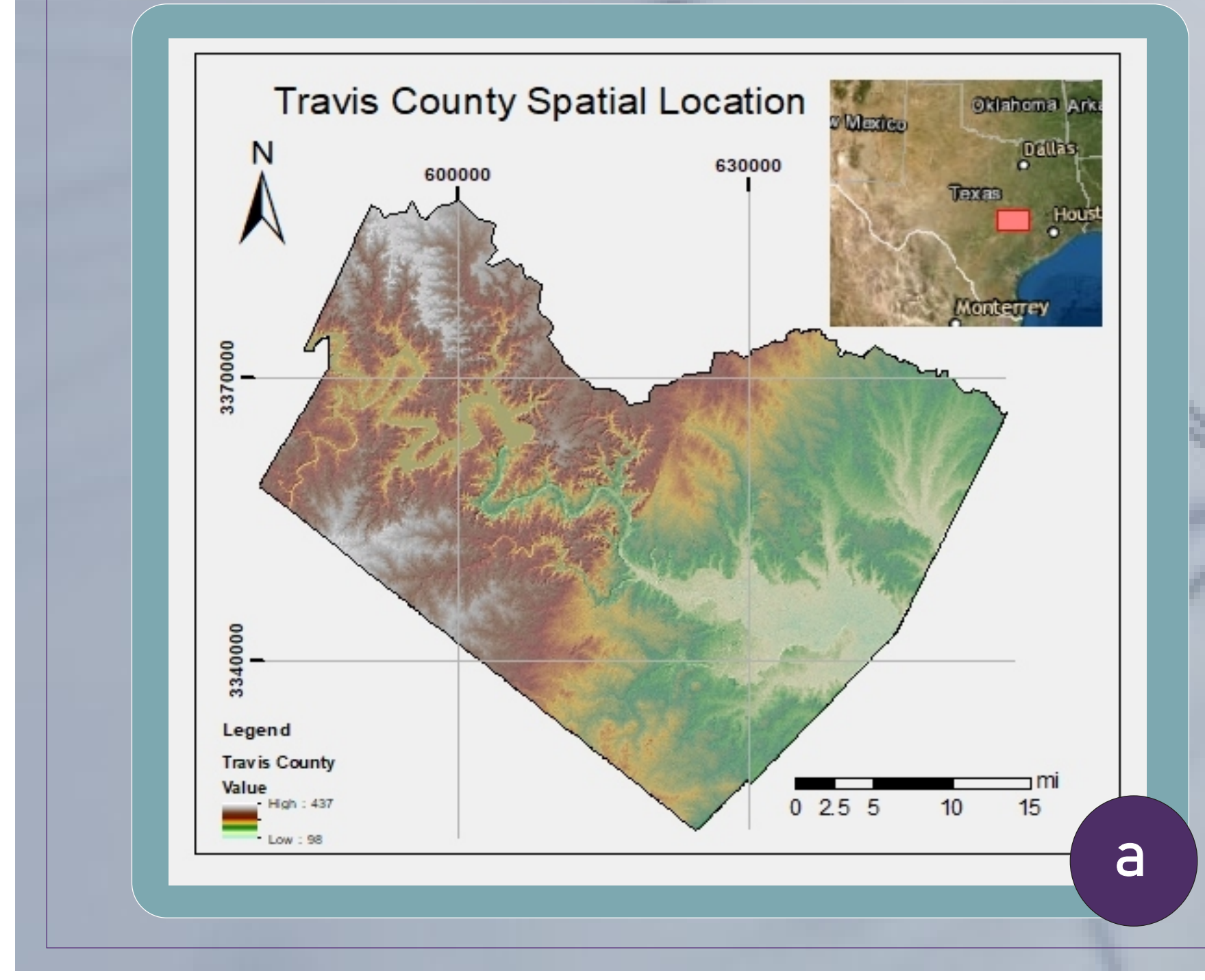
Background

Landslides can occur naturally or are triggered by human activity and cause massive damages and financial costs. Landslide susceptibility maps are essential for effective land use management that can support decision-makers for urban and infrastructural plans. As a definition, a landslide is the movement of a mass of rock, debris, or earth down a slope. Different landslide types depend largely on the manner and speed in which material moves down a slope (slide, fall, slip, topple, flow, creep, or avalanche). Such classifications are useful, although some landslides represent different combinations (Fig. 1). Rock falls, topples and debris avalanches are more common in mountainous harder rock areas. Earth flows and creeps are more common in steep topographical areas, especially in soft sedimentary rock. This study will deal with the analysis to identify areas susceptible to creep, being the informal name for slow earth flow landslides, characterized by slow displacement with a depth of a few meters and loosely defined limits. Once the susceptible areas are identified, analysis for ground displacement is applied. Using a InSAR technique referred to as the SBAS, field-based multitemporal RTK GPS measurements, and geology/soil sample.

Figure 1. Classification of subaerial slope movement



The area under study is Travis County (a) located in south-central Texas, USA. The area has experienced rapid growth of population in the past few decades, and development has encroached into unstable terrain that is vulnerable to landslides. A recent landslide has occurred (May 2018) on a cliff that overlooks Shoal Creek (b) causing significant damages to public and private properties. The natural geology of the area is prone to slide. Fractures limestone sits on top of a clay layer that weakens when it gets wet.



Objective

- + Identify and analyze areas susceptible to creep.
- + Quantify the rate of displacement occurring due to a landslide.
- + Identify the factors that trigger the hazard.

Data & Methods

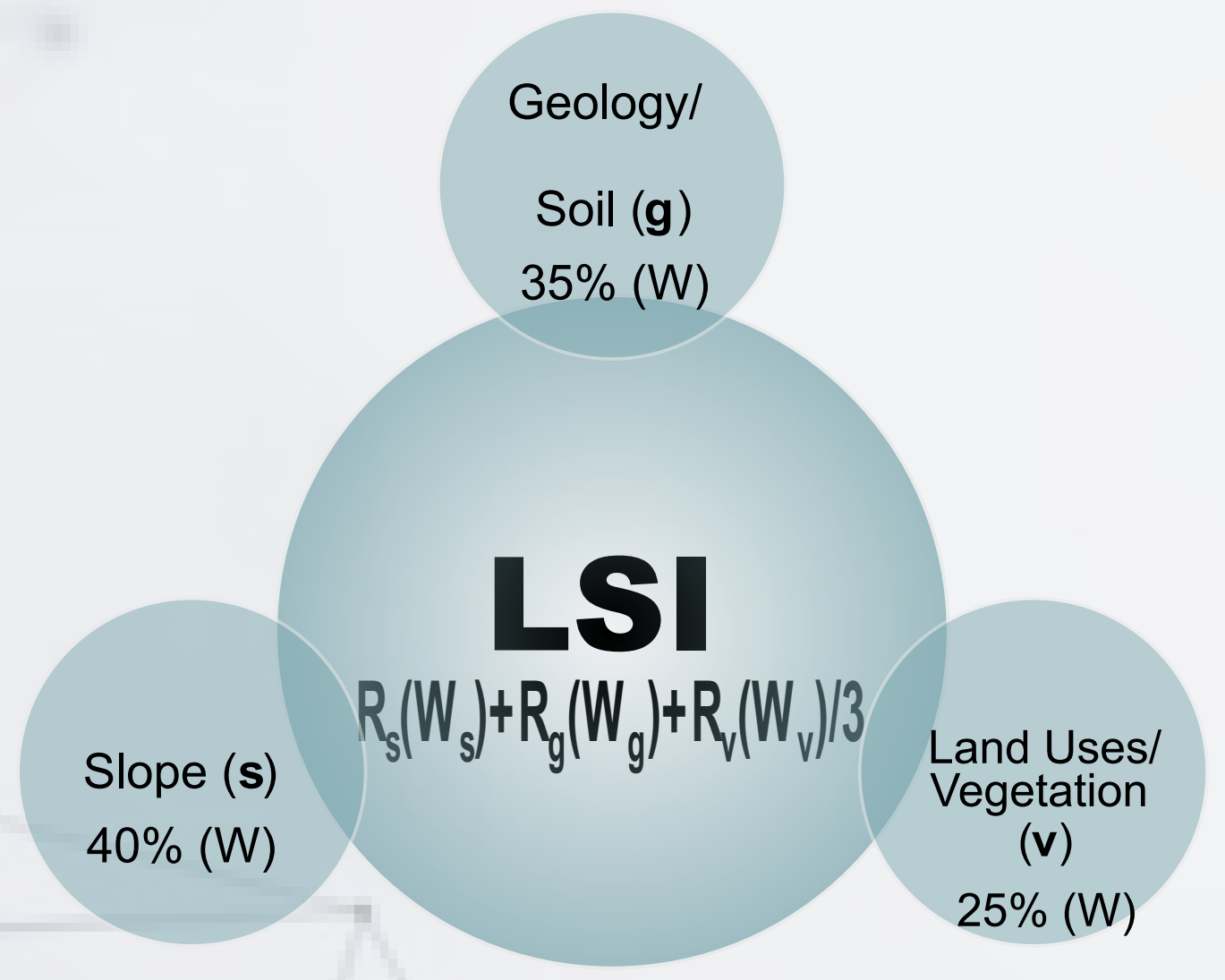
Data:

- + Geological map and Faults (scale 1:250,000), USGS.
- + Land cover map, Multi-Resolution Land Characteristics consortium.
- + DEM, 30 m of resolution from Earth Explore USGS.
- + Sentinel-1, SAR images.

Methodologies:

+GIS techniques

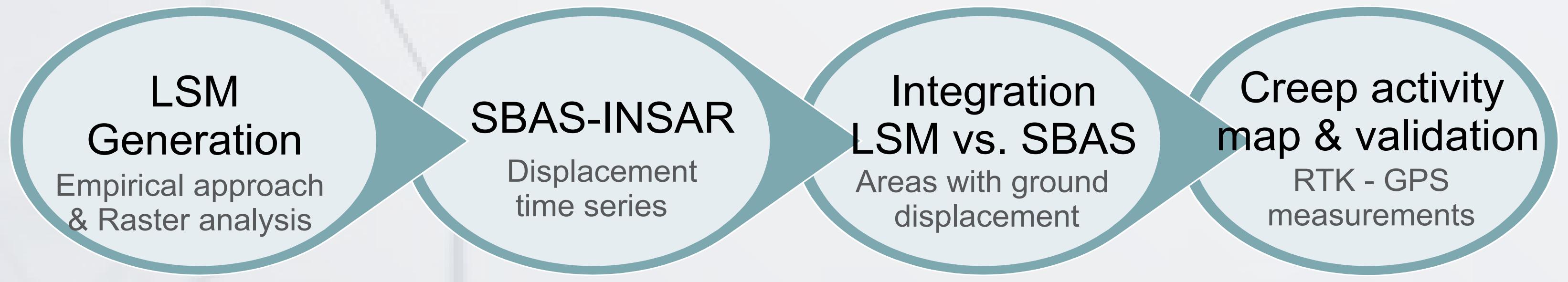
+Empirical approaching to get a Landslide susceptible index(LSI). It rates in four categories base on the weight(W) and factors [R] such as slope, geology/soil, and vegetation/land use, affecting slide occurrence.



LANDSLIDE SUSCEPTIBILITY INDEX

Low Susceptibility	1.00 - 1.50
Moderate Susceptibility	2.51 - 2.00
High Susceptibility	2.01 - 4.00

+The integration of LSI and InSAR - SBAS let to identify slow movement ground displacement that will be validated with the work field using RTK - GPS measurements and geology/soil sample.



LSM Generation
Empirical approach & Raster analysis

SBAS-INSAR
Displacement time series

Integration LSM vs. SBAS
Areas with ground displacement

Creep activity map & validation
RTK - GPS measurements

Results & Discussion

+ LSI values classify into three susceptible categories, low, moderate, and high.

+ Base on the LSI the areas with relatively high potential for a landslide are the combination of the three principal factors that contribute to slope instability.

+ Areas close to the south-central region of Travis county seem to concentrate moderately to high susceptibility to landslides.

+ The highest factors that trigger the hazard are a greater degree of slope and unconsolidated materials with clay content around urban areas.

+ Our analysis shows a good spatial correlation with the Shoal Creek landslide (see a black box, Fig. 2).

+ The interferogram analysis shows that are a strong displacement anomaly in the Shoal Creek area(See green box, Fig. 3)

+ Efforts are currently underway to quantify the displacement over five-year intervals using the InSAR-SBAS technique.

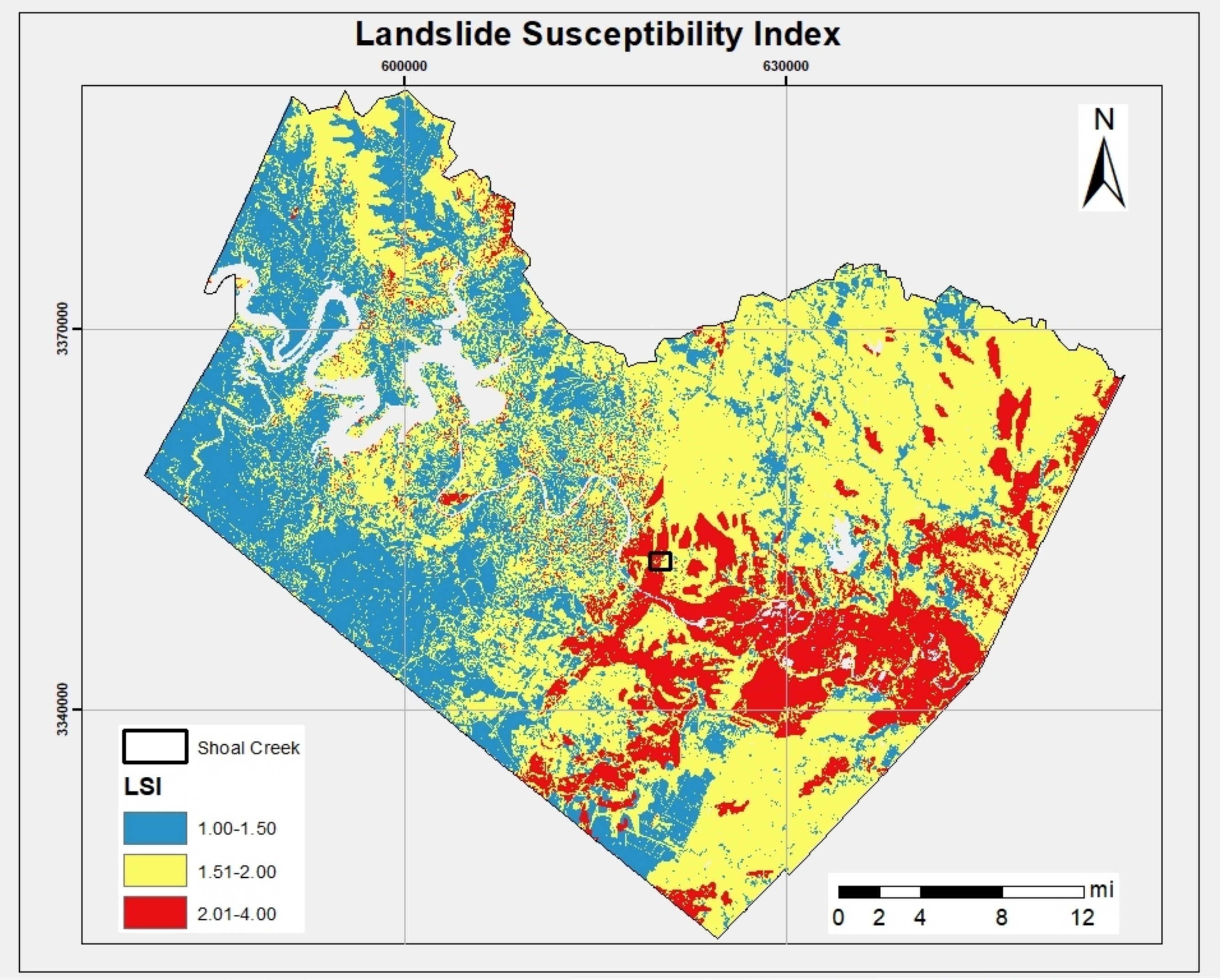


Figure 2. Lanslide susceptibility index and Shoal Creek location

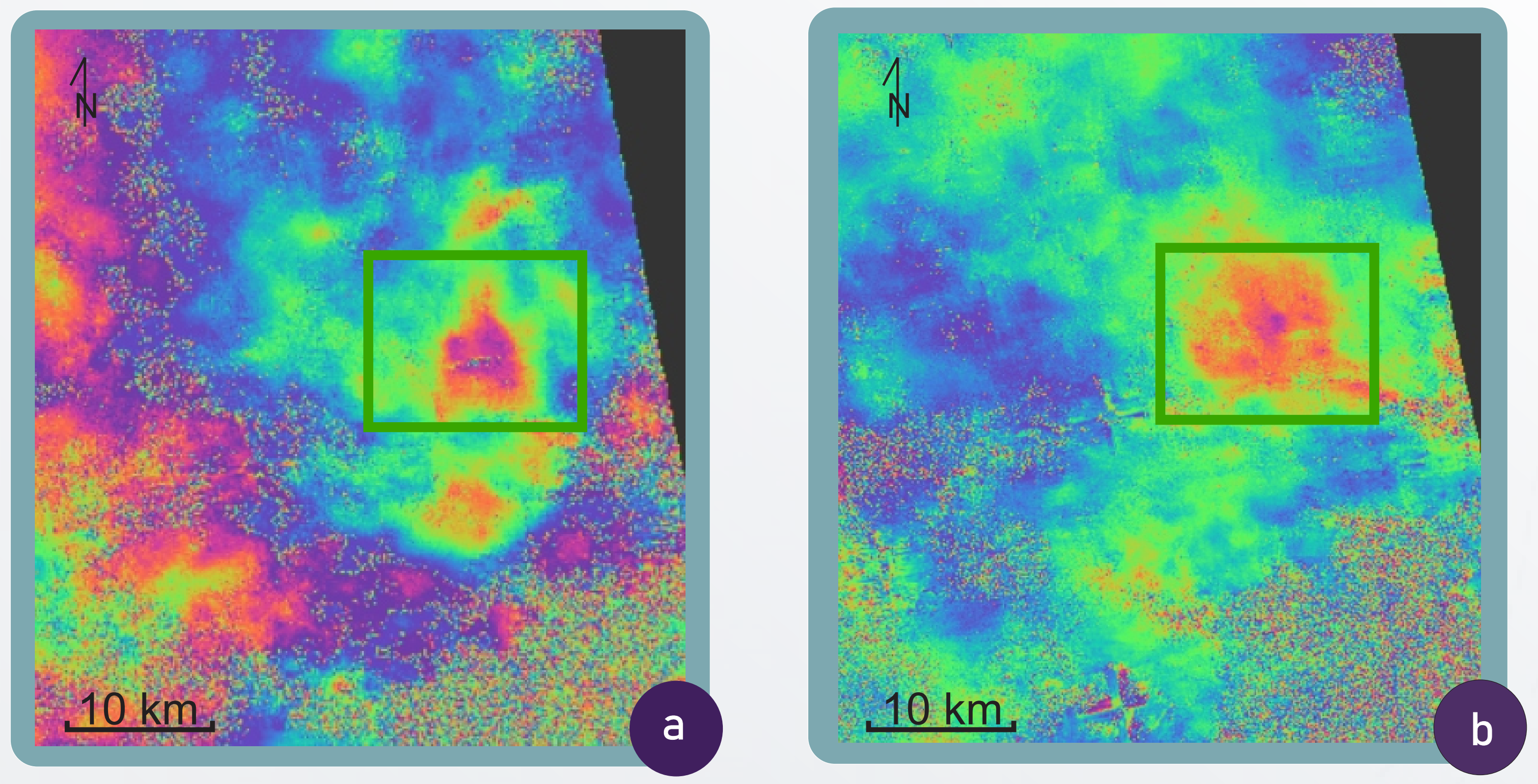


Figure 3. Interferograms shows ground displacement correlation in Shoal Creek area. (a. Temporal correlation between September 2017 and May 2018, b.Temporal correlation between November 2017 and May 2018)

Conclusion

+ The GIS approach on this research was able to assess potential slope instability in Travis County. This analysis delineated susceptible areas to LS by three levels, low, medium, and high, based on preliminary triggering factors as degree slope, rock/soil composition, and land uses/vegetation characteristics.

+ Preliminary interferogram results validate that Shoal Creek area had ground displacement that can be validated in further analysis with InSAR-SBAS technique and RTK-GPS measurements on field.

+ The identification of area susceptible to soil creep would be useful for effective land use management that can support decision makers for urban and infra structural plans.