C35E-0919 : Avalanches in L-band InSAR imagery during the 2020-21 SnowEx Mission

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Abstract

We investigate the impact of avalanches on L-band InSAR and the potential for detecting avalanches. In January 2024, NISAR will launch, providing global L-band InSAR data at 12 day intervals. We compare the impact of avalanches on the L-band InSAR signal for both 7-day and 14-day intervals, using airborne L-band InSAR imagery from UAVSAR, collected as part of the SnowEx 2020-21 time series campaign. To study temporal baselines shorter than one week, a car-based L-band InSAR was used. Future work will incorporate arrays of infrasound sensors to compare InSAR signatures to avalanche detections from the infrasound arrays. In the future, InSAR and infrasound could be combined to provide additional information about avalanche release for avalanche forecasters.

Figure 1: NISAR launches January 2024, providing 10-50m resolution InSAR globally every 12 days.

Figure 2: To test the capability of NISAR for measuring snow on the ground, the 2020-21 NASA SnowEx time series was performed with UAVSAR, an airborne L-band InSAR.

Introduction

- Dry snow is not expected to cause significant volume scattering at L-band frequencies (λ =24cm)
- If coherence is maintained, $\Delta\phi = f(H_s, SWE)$ (*Guneriussen et al.*, 2001; *Deeb et al.*, 2011; *Marshall et al.*, 2021)
- In ideal situations avalanches can cause measurable changes in phase (Fig. 3)

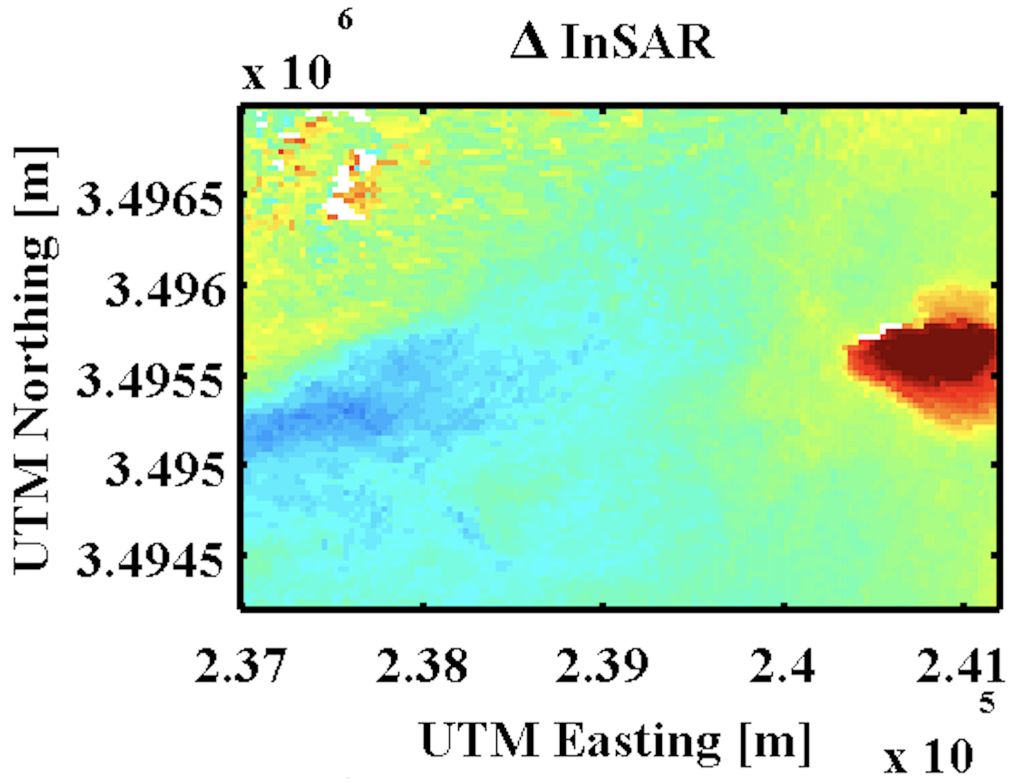

Figure 3: Example of a likely avalanche in satellite L-band InSAR data (PALSAR), over High Mountain Asia. Color shows phase change bracketing a storm, in steep mountain area with slope towards the east.

Avalanche detection

- Accurate avalanche observations are required to investigate the potential for avalanche signals in InSAR
- We leverage observations from avalanche forecasters, and arrays of infrasound sensors (*Havens et al.*, 2014; *Johnson et al.*, 2021)

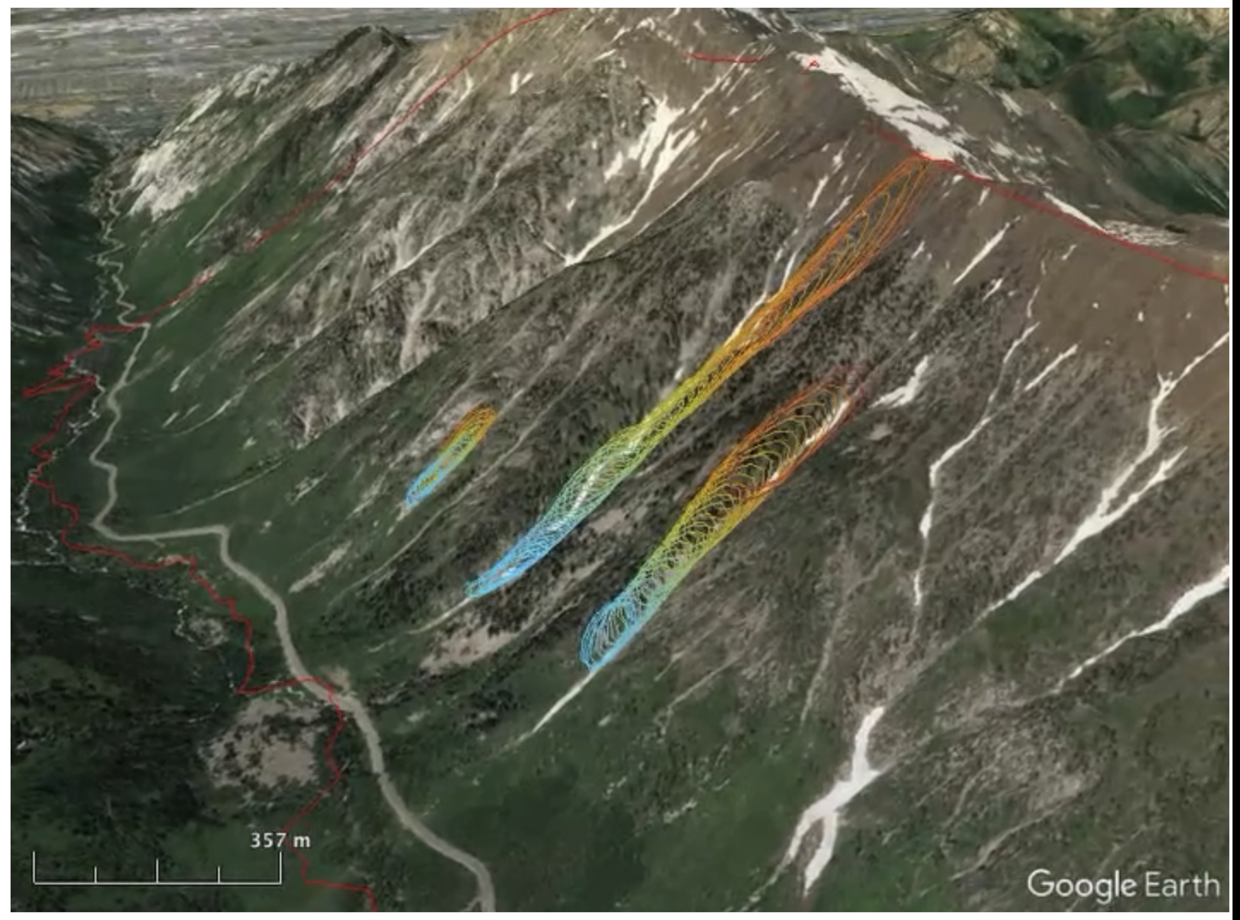

Figure 4: Infrasound avalanche detection, location, and tracking in LCC with multiple infrasound arrays. Colors indicate progression of time as the avalanche releases in the starting zone, and moves along the path (*Johnson et al.*, 2021)

Building from the ground up: CarSAR

- Mobile L-band InSAR allows control of temporal baseline, and enables short temporal baseline observations
- CarSAR deployed in Little Cottonwood Canyon during SnowEx 2021, coincident w/ UAVSAR overflights
- Changes in coherence correlated with locations where avalanche control was performed with small releases

Figure 5: Mobile L-band InSAR, built by GAMMA Remote Sensing, deployed on a car.

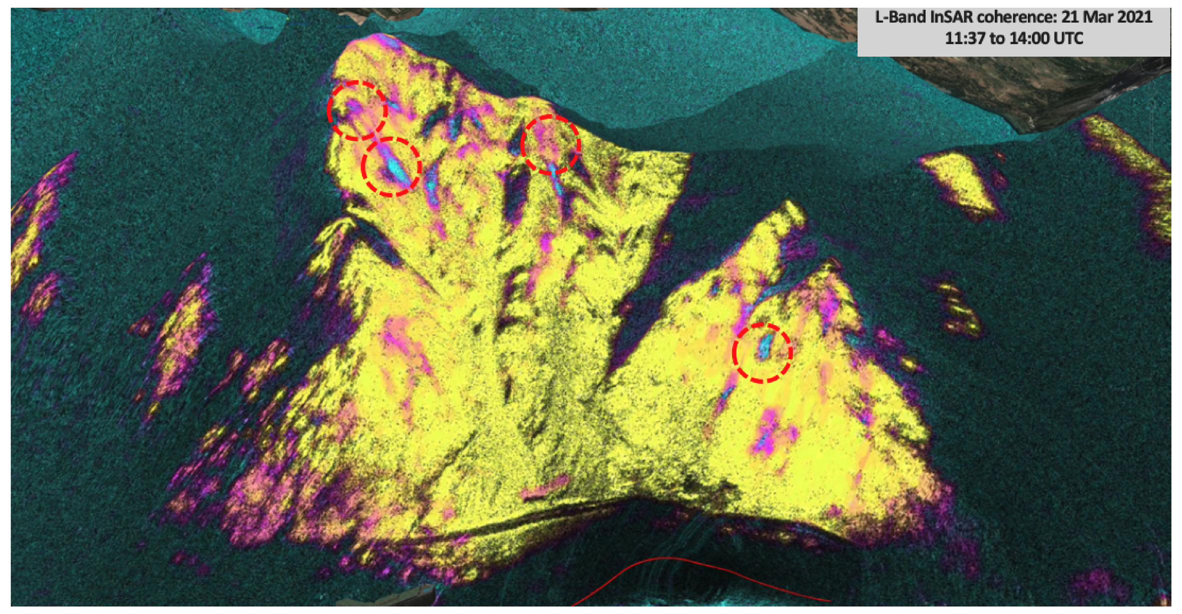

Figure 6: Changes in InSAR coherence indicate areas where avalanche control work was performed.

Airborne L-band InSAR during SnowEx

- Depth change inversion from InSAR: $-\Delta H_s$ in path, $+\Delta H_s$ in debris
- InSAR inversion shows signature of avalanches in dry snow conditions
- Previous SAR avalanche detection has focused on changes in amplitude, and allows detection of large (>D2) slides, but small avalanches are challenging
- InSAR phase and coherence in the right conditions may provide more sensitivity, in particular detection of smaller slides
- Our future work will combine phase, coherence, and amplitude for detection of a wide range of avalanche sizes, using infrasound arrays to precisely determine timing and location of events

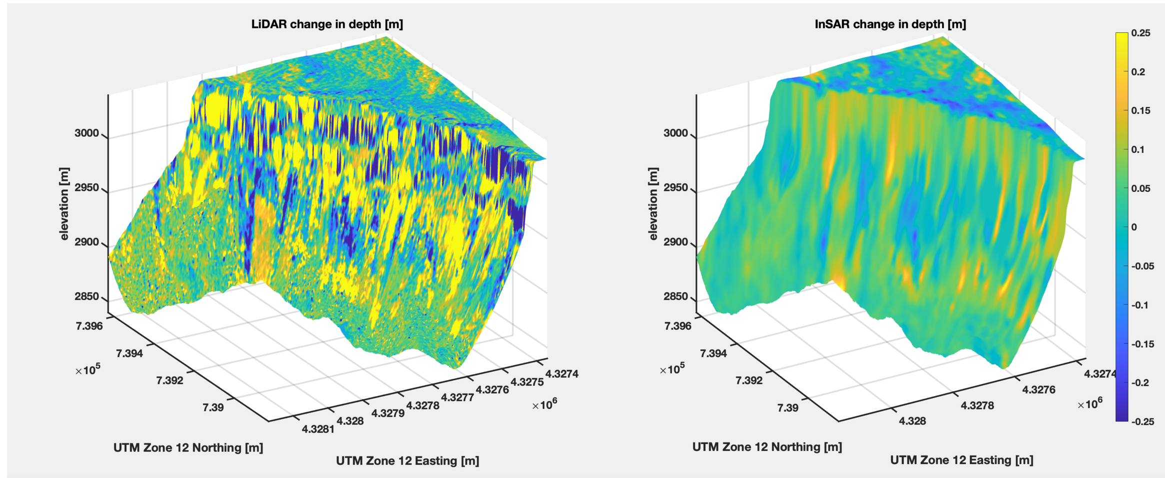

Figure 7: Dry snow avalanches on steep north-facing slopes, Grand Mesa, CO. Depth difference during 1st two weeks of Feb 2020, observed by LiDAR (left) and InSAR (right)

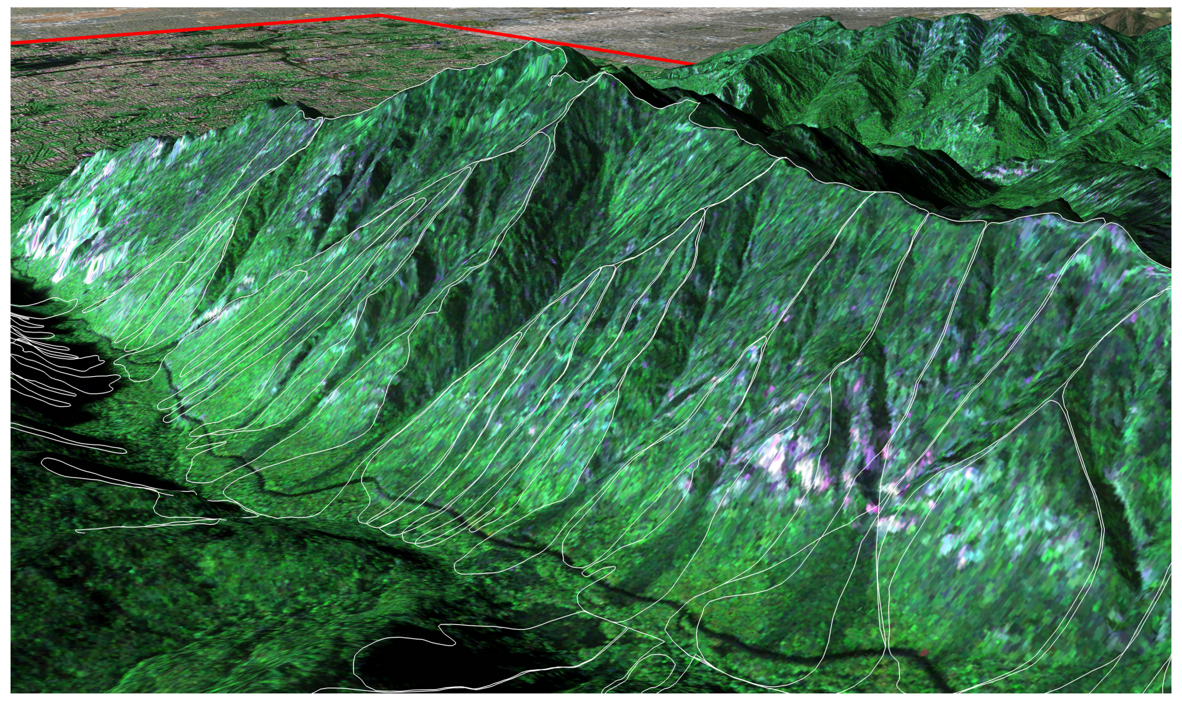

Figure 8: UAVSAR PolSAR image over LCC (red=HH,green=HV,blue=VV) for Feb 23, 2021, after a large avalanche cycle. Impact of avalanche debris can be seen as dark areas in runout zone.

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