National Aeronautics and Space Administration

Stereoimagery applications for improved UAVSAR processing and source characterization

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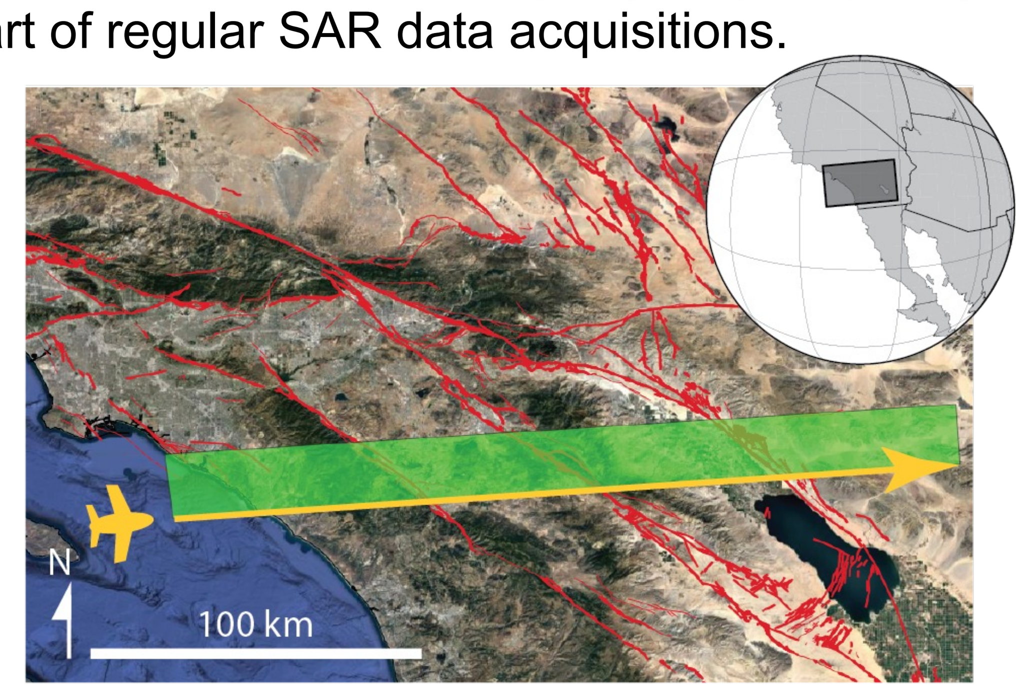
Program: FY22 R&TD Innovative Spontaneous Concepts

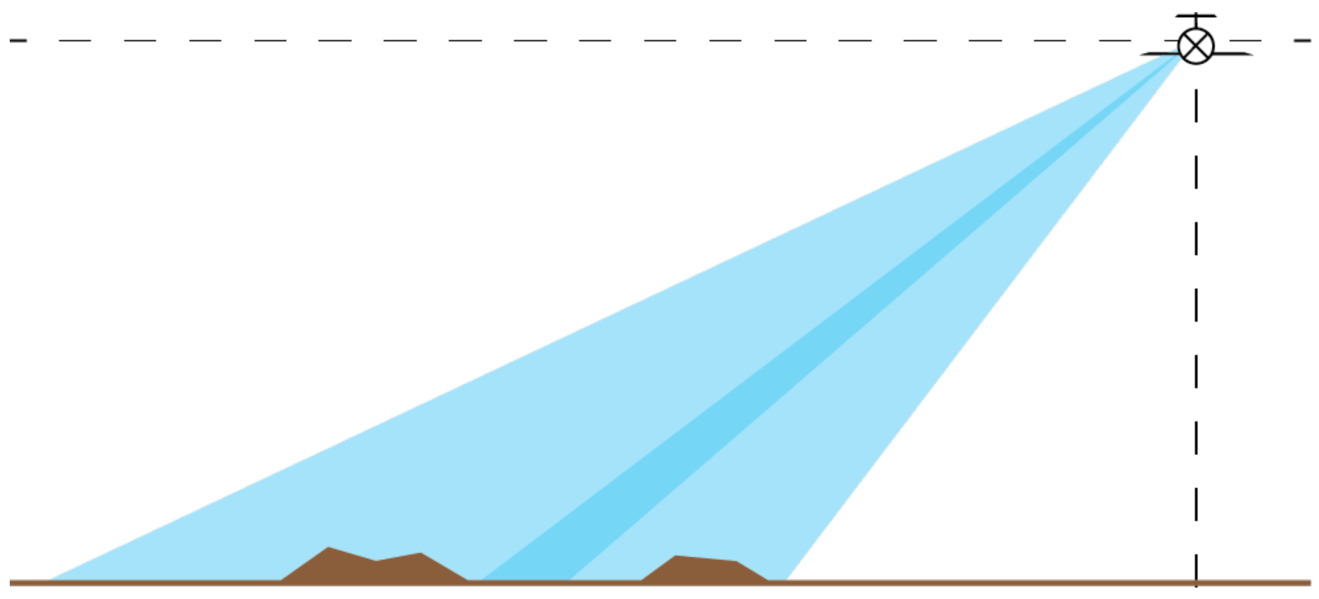
Objectives:

The aim of this project is to advance the application of optical imagery in the processing, analysis, and interpretation of radar data in Earth Science applications. Here, I use optical imagery collected by the Quantifying Uncertainty and Kinematics and Earth Systems (QUAKES) SAR Fusion imager to inform analysis of radar data from NASA's Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) in two ways: (1) I use the optical images to produce a digital elevation model (DEM) of the topography along the UAVSAR swath for improved processing of radar interferograms; and (2) I visually analyze the optical imagery to help characterize anomalies in the radar data. The end goal of this work is to demonstrate the utility of jointly acquiring optical imagery as part of regular SAR data acquisitions.



Background:

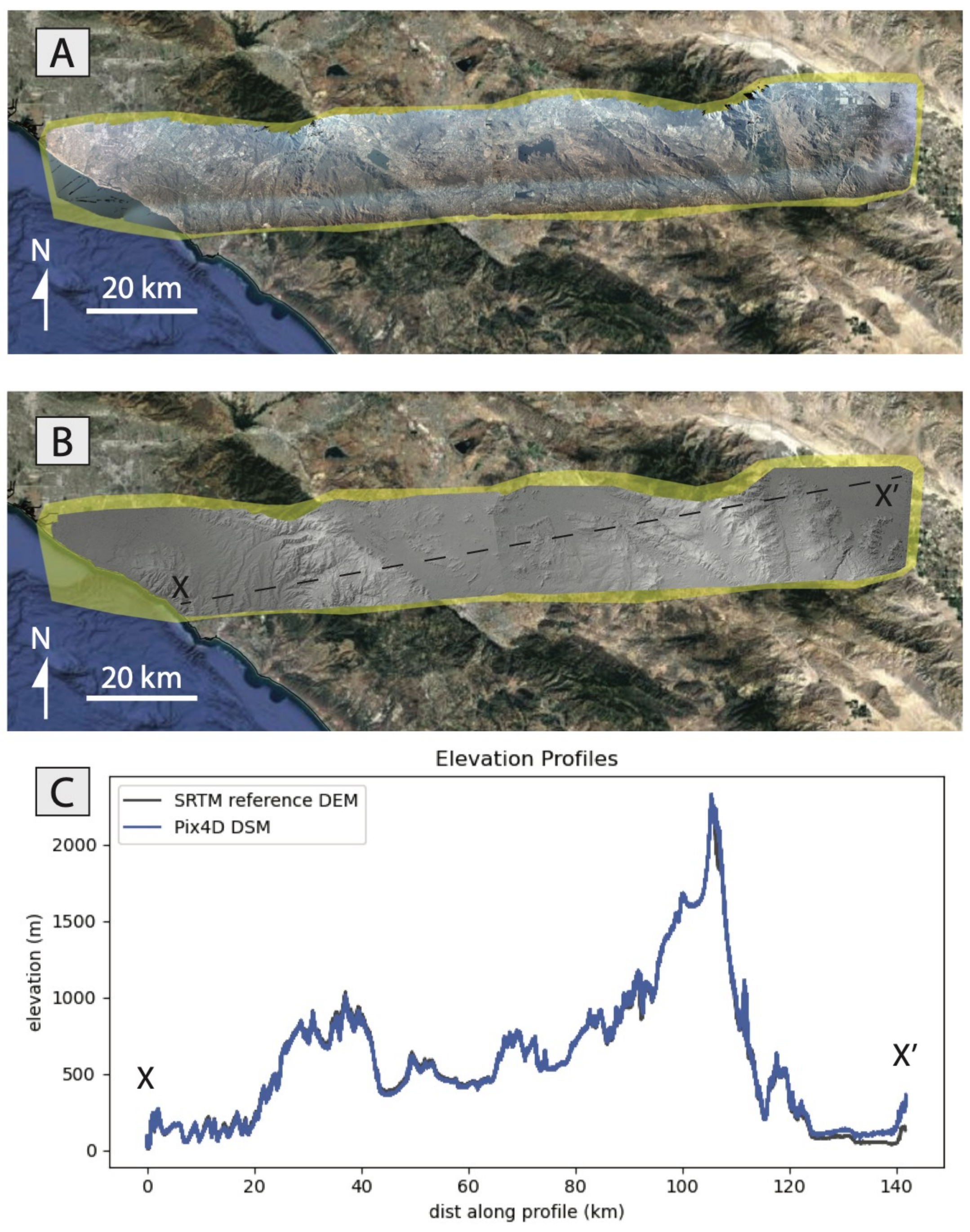
Synthetic aperture radar (SAR) can measure the line-of-sight position and radar attributes of points on the ground surface, and is key to NASA's Surface Topography and Vegetation (STV) observation goal. Determining ground deformation requires accurate knowledge of the gross 3D topography. Generic, coarse-resolution DEMs are typically used to approximate the topography, however higher-resolution, custom-made DEMs can potentially improve the result. Furthermore, radar images often capture more than one natural process, such as tectonic strain accumulation and changes in atmospheric moisture. When collected at the same time as the SAR data, optical imagery can help identify and distinguish the various natural processes manifest in the observed signal.



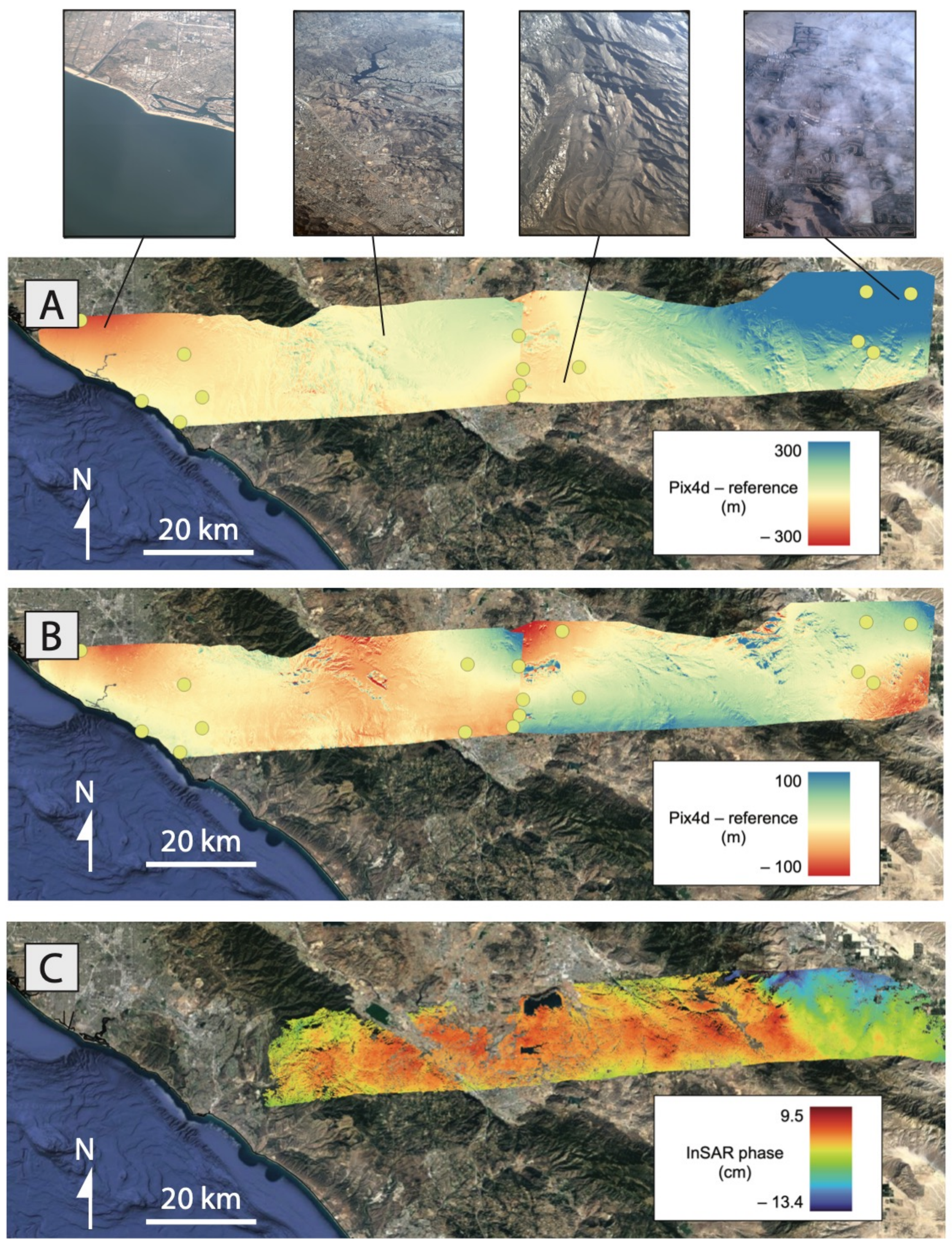
SAR Fusion coverage (coincides with UAVSAR)

Approach and Results:

To address the shortcomings of coarse-resolution DEMs and possible signal source ambiguities in the data, I used optical imagery acquired by the SAR Fusion component of the QUAKES-I imager suite. SAR Fusion is a two-camera rig designed to image the same ground area imaged by UAVSAR (see above). For this study, I analyzed data from UAVSAR flightline 08517 on 23 November 2021. I created an orthoimage and DEM from the SAR Fusion images (below, left) using the commercial Pix4Dmapper software. To align the stereo reconstructions in geographic space, I manually chose ground control points (GCPs) with known 3D coordinates in each batch (below, right).



The stereo-DEMs showed 10–100+ m-scale deviations from the NASA SRTM reference DEM (below, right). I sought to refine the stereo-DEMs by adding more GCPs, resulting in a significant reduction in the overall discrepancy (below, right). By jointly examining the optical orthophoto and the DEM deviation, I determined that areas with large deviations were associated with high atmospheric moisture. Comparison of the 2018–2021 UAVSAR interferogram to the SAR Fusion data shows phase anomalies might occur in areas of high water vapor.



Significance/Benefits to JPL and NASA:

Transient atmospheric water vapor presents a key challenge to meeting NASA's Surface Topography and Vegetation observation goals, as it can alter remote sensing measurements necessary for determining fine-scale topography and ground positional change as well as other characteristics (e.g., vegetation). Evaluating the data using a multi-sensor approach can help address these issues: By examining the optical imagery for clouds or other signs of atmospheric moisture, one may better determine what physical processes underlie anomalies in remotely sensed data such as radar phase delay; or guide the scientist to areas where stereoimage-based DEMs require more attention during processing. As such, future researchers could benefit from SAR Fusion data collection being made a routine part of future UAVSAR flights.

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