Characterizing the temporal variability of L-band backscatter using dense UAVSAR time-series in preparation for the NISAR mission

Marco Lavalle, Gustavo X. H. Shiroma, Abby Lee and Paul Rosen

Jet Propulsion Laboratory, California Institute of Technology

BACKGROUND

The National Aeronautics and Space Administration (NASA) and the Indian Space Research Organisation (ISRO) are developing the NASA-ISRO SAR (NISAR), a synthetic aperture radar (SAR) mission, to be launched in 2021, to map Earth's surface every 12 days.

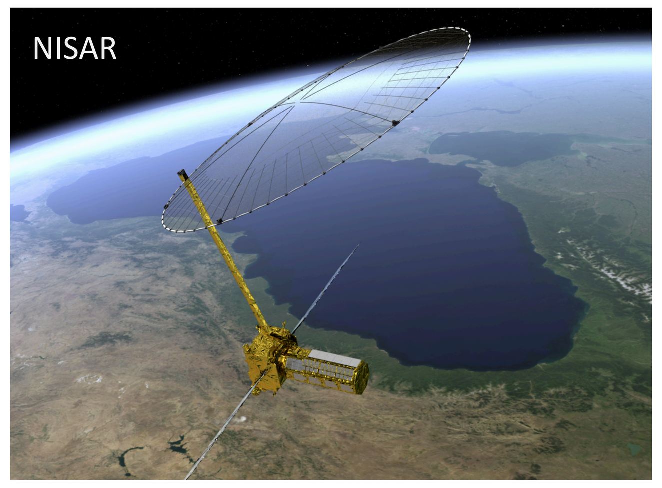
The default L-band (24 cm wavelength) radar mode of NISAR will collect approximately 60 dual-polarized (HH/HV) images per year globally with spatial resolution finer than 10 m, providing an unprecedented view of the Earth's surface from space. NISAR requirements include measuring above-ground woody biomass up to 100 Mg/ha with 20 Mg/ha accuracy from L-band backscatter

In preparation for the NISAR mission, we are using the NASA/JPL UAVSAR L-band airborne system as a testbed for the development and assessment of ecosystem algorithms. UAVSAR provides quad-polarimetric imagery with low noise (< 50 dB) and high resolution (1-2 m), and has the ability to fly repeated flight paths with great accuracy.

The objective of this study is to use dense time-series of UAVSAR imagery to characterize the temporal evolution of L-band backscatter

[1] The NASA-ISRO SAR Mission (NISAR), nisar.jpl.nasa.gov

[2] S. Hensley et al., "The UAVSAR instrument: Description and first results," in Proc. IEEE RADAR, May 2008, pp. 1–6.



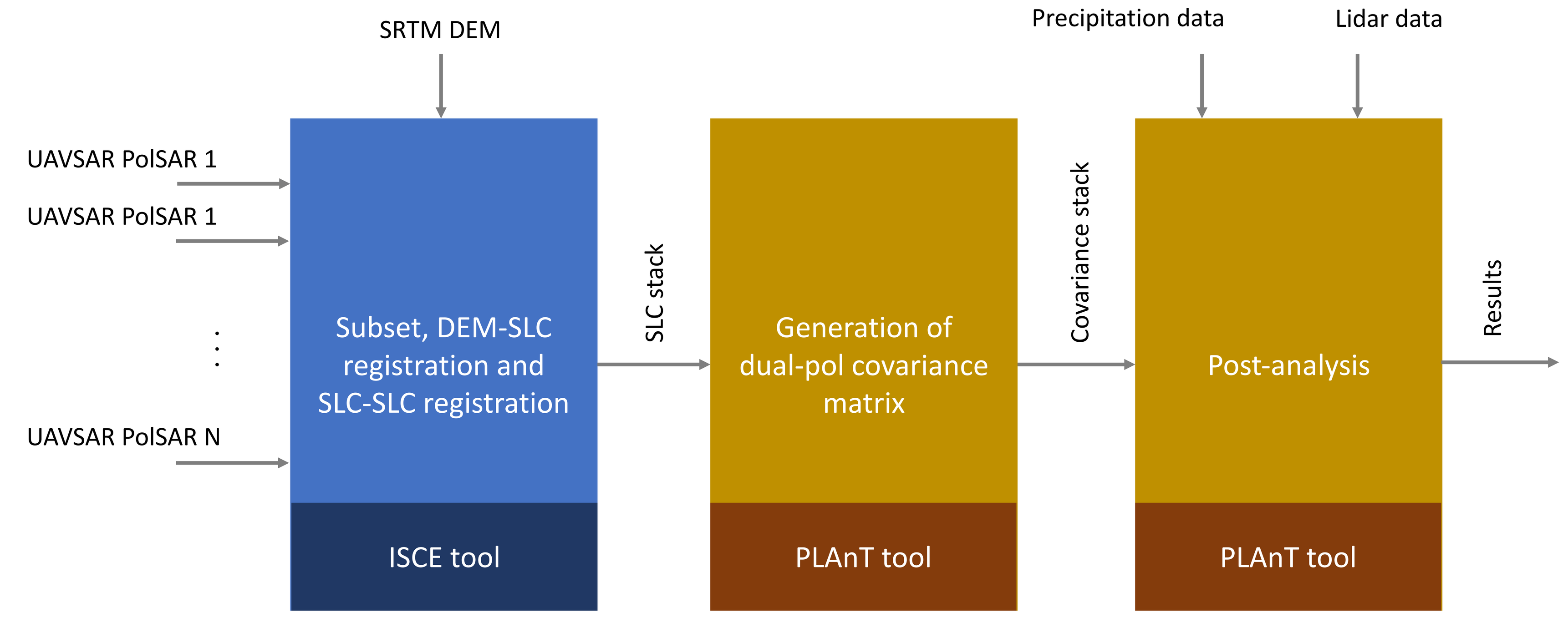
APPROACH

The set of 32 calibrated UAVSAR PolSAR acquisitions – focused to their natural track – is co-registered with the support of the SRTM DEM using the ISCE package to generate an accurate co-located stack of polarimetric complex images.

The polarimetric SLC stack is then ingested into the PLAnT (Polarimetric-Interferometric Lab and Analysis Tool) package to generate a stack of 2-by-2 complex multi-looked covariance matrices using < 100 independent looks.

Owing to precise DEM-SLC registration, the geographic coordinates of each covariance sample are used to locate and resample spaceborne lidar samples (and precipitation data) of radar imagery for subsequent post-analysis.

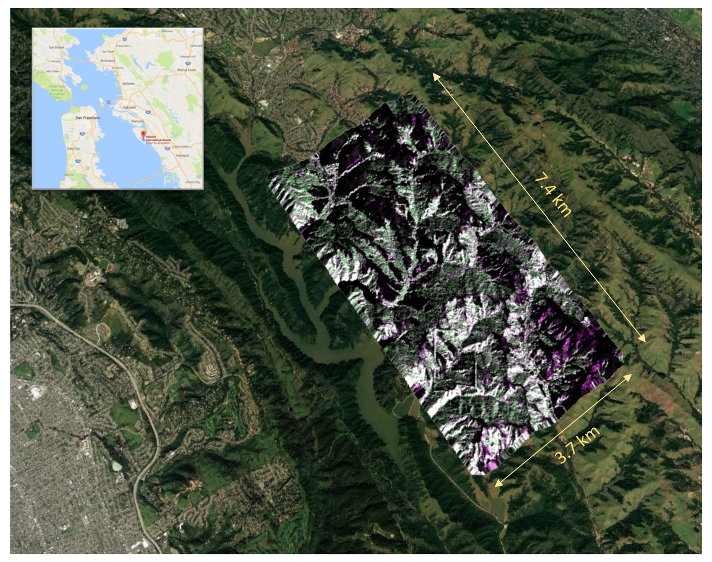
Post-analysis include estimation of mean and standard deviation over time of the UASAR time-series, segmentation of the temporal statistics by season and amount of precipitation, and analytical model fit.



[3] P. A. Rosen, E. Gurrola, G. Sacco, and H. Zebker. The InSAR Scientific Computing Environment. In Synthetic Aperture Radar, 2012. EUSAR. 9th European Conference on, pages 730–733, April 2012.

[4] M. Lavalle, G. H. X. Shiroma, P. Agram, E. Gurrola, G. F. Sacco, and P. Rosen. PLANT: Polarimetric-interferometric lab and analysis tools for ecosystem and land-cover science and applications. In 2016 IEEE IGARSS, pages 5354–5357, July 2016.

MATERIALS



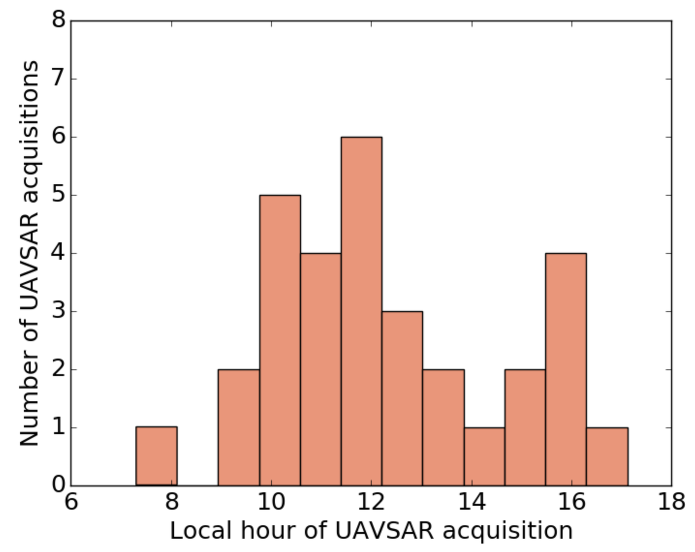
We considered a dense time series of 32 UAVSAR PolSAR images acquired between 10 am and 4 pm over 5 years near the Sacramento Delta in four seasons (mainly spring and winter).

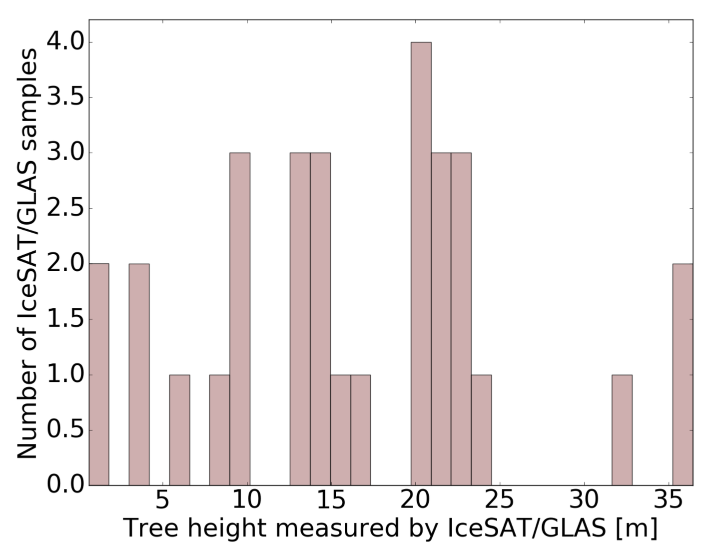
The full SLCs were cropped to a patch 3.7 km x 7.4 km on the ground (azimuth x range). The geometry-based DEM-SLC and SLC-SLC registration was applied only to the cropped patch.

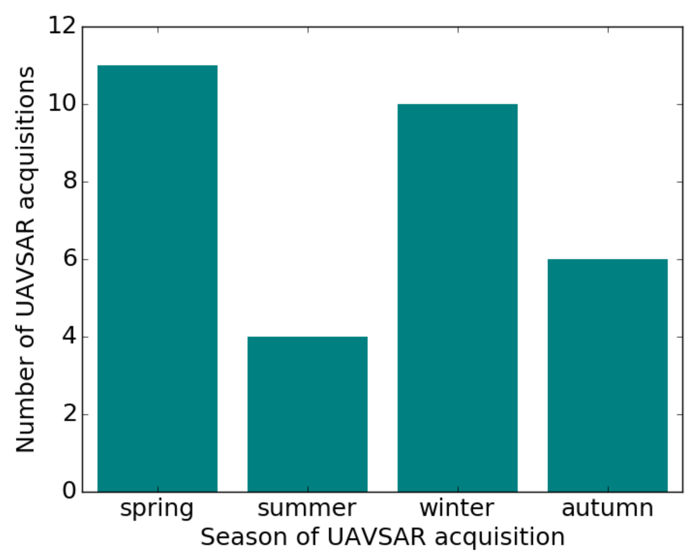
Precipitation data were obtained from the Oakland International Airport, 12.7km south-west of the UAVSAR dataset. Integrating precipitation over 4, 8 and 12 hours before the UAVSAR acquisition time shows that rain was present in the time-series in 3 dates.

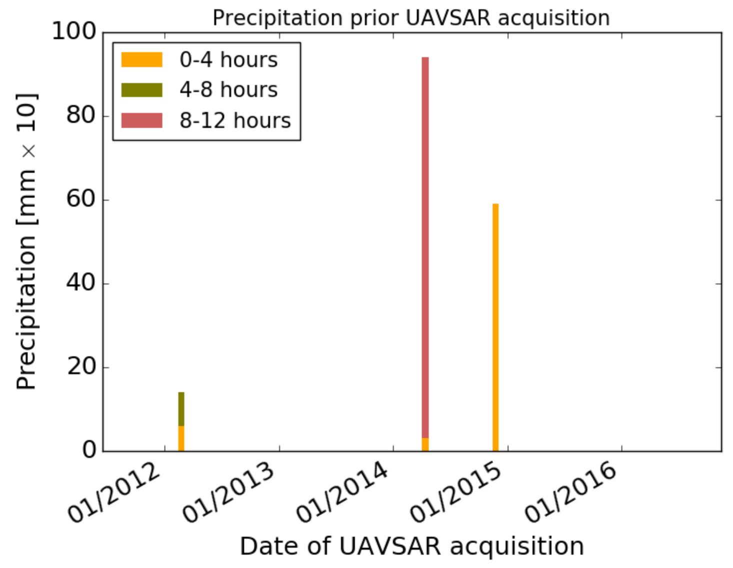
ICESat/GLAS lidar samples show that the distribution of tree height varies in the cropped path from 0 m (bare soil) to 35 m depending on the location within the patch.

[5] Smith, A., N. Lott, and R. Vose,: The Integrated Surface Database: Recent Developments and Partnerships. Bulletin of the American Meteorological Society, 92, 704–708, 2011

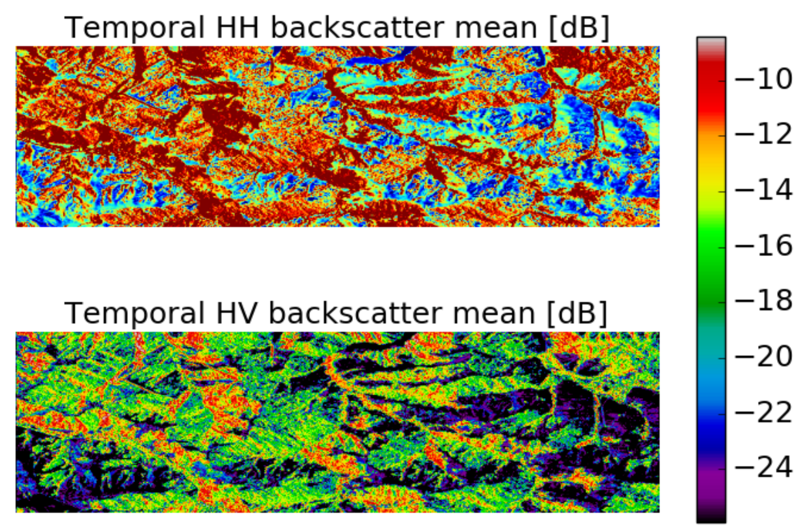


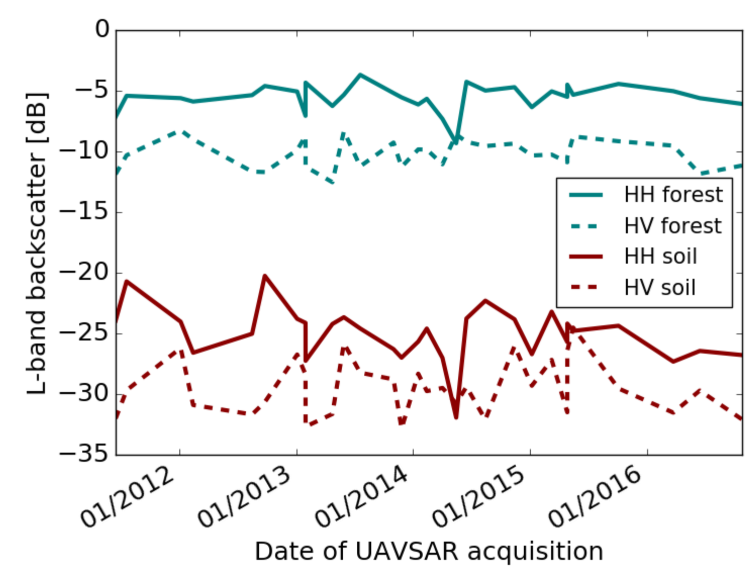






RESULTS





The temporal backscatter mean is the mean of the backscatter over time (32 samples) for the HH and HV polarization. Only radiometric slope correction to flat surface has been applied to UAVSAR PolSAR data.

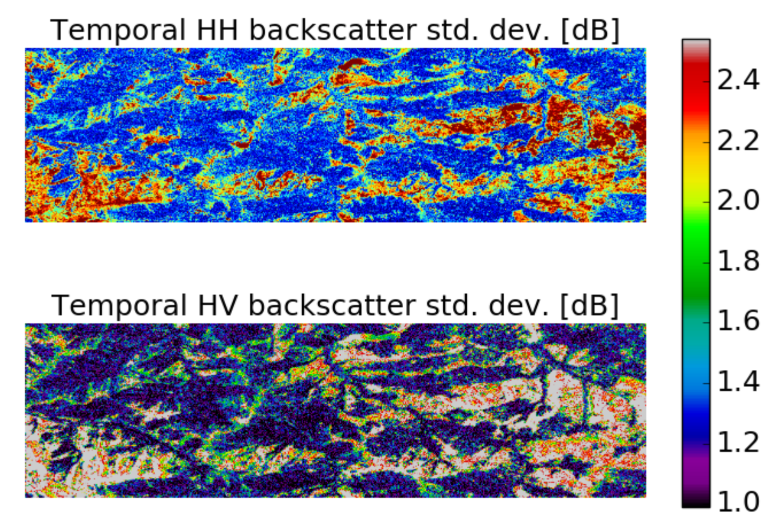
In forested areas, backscatter appears to be 15-20 dB higher than the backscatter over soil. Smaller forest/soil backscatter differences might be due to the presence of short vegetation or moisture.

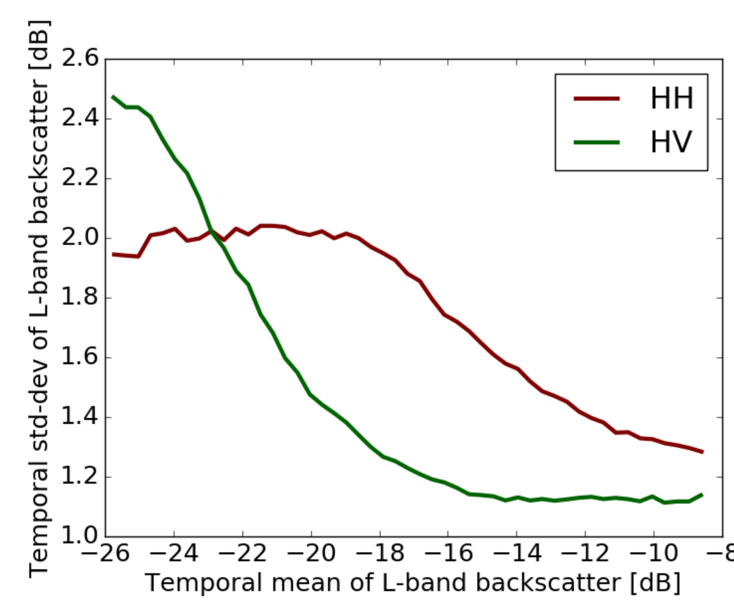
Backscatter in the polarimetric HV channels appears to be 5-8 dB lower than the HH backscatter. The HH/HV backscatter for forest and soil evolves over time with different mean and standard deviations due to the nature of L-band surface and volume scattering.

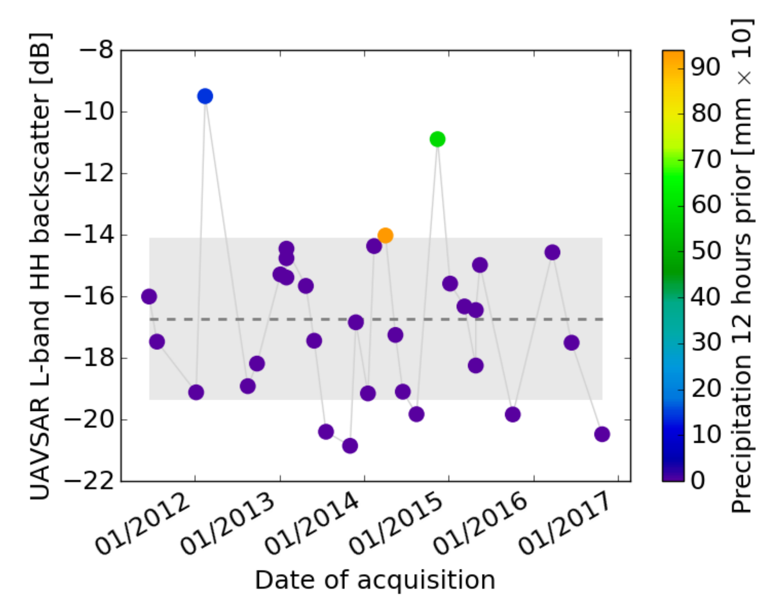
The standard deviation of the L-band UAVSAR backscatter calculated over time (32 images) shows distinct features depending on the land cover and the polarimetric channel (HH or HV). Note that these temporal variations correspond mainly to dry conditions.

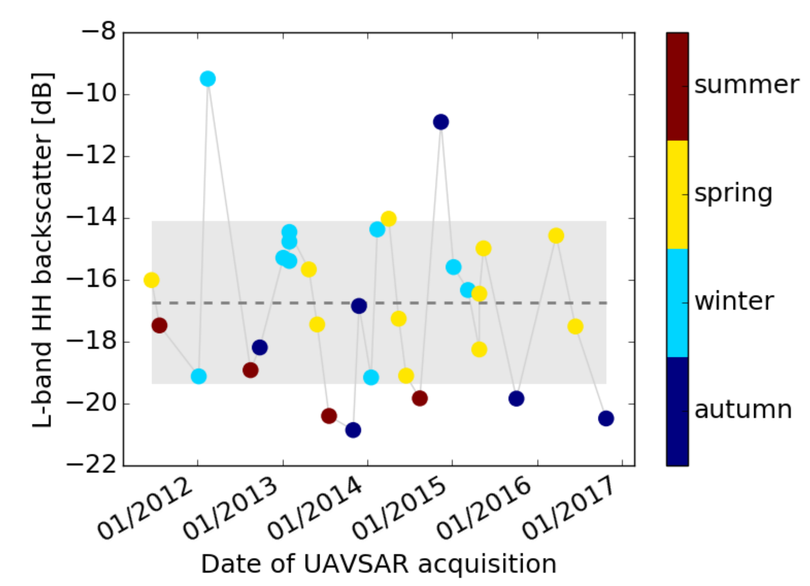
Interestingly, the relative HH/HV behavior of the temporal standard deviation changes between forest and soil. For low backscattering (surface scattering), the HV temporal variation is 2.5 dB, versus 2 dB temporal variation of the HH polarimetric channel.

For higher backscatter (volume scattering), the HH temporal standard deviation is larger (1.4 dB) than the HV standard deviation (1.2 dB). This is due primarily to vegetation phenomenology and nature of L-band volume and surface scattering.









The L-band backscatter for a single multi-looked sample over time appears to be correlated (i.e., increases) with the amount of precipitation (recorded a few km away from the sample).

The maximum deviation between HH backscatter in a rainy day and mean backscatter is about 7 dB. The maximum deviation of backscatter within the time-series for this selected sample is about 12 dB.

Seasonality affects the backscatter by a smaller extent and with less correlation with the season. HH backscatter in summer acquisitions appears to be 1-4 dB lower than the time-series average.

Acknowledgments: The authors would like to thank the UAVSAR team at JPL for acquiring, processing and calibrating the UAVSAR PolSAR data and Dr. Cathleen Jones for collecting the time-series dataset for deformation studies.

This work was supported by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.