Temporal Decorrelation Studies Relevant for a Vegetation InSAR Mission

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For mapping vegetation 3-D information, there are currently two principal methods. One method is to use fast waveform ratio to map the canopy reflective properties as a function of range within the illuminated footprint. The second method is to use radar interferometry to collect the spatial frequencies which are used to estimate the 3-D structure of vegetation canopies over the radar range. A realistic scenario for implementing a spaceborne 3-D structure mapping mission will involve some combination of these two techniques, thus making best use of the high-resolution capability of the lidar measurements while benefiting from the all-weather and wide swath coverage of the SAR observations.

Because of the inherent and related constraints, the robustness of such systems would likely allow only a limited range of interferometric SAR missions. Interferometric SAR would be a promising technique for investigating the vegetation time series. However, the change of the target's geometry over time would be the principal error source in determining the vegetation 3-D structure.

In this paper we discuss early results from existing data and satellite data for assessing temporal decorrelation at I-band and P-band and present strategies which can be implemented in a spaceborne mission. By continuing this study of temporal decorrelation and quantifying its effect on 3-D structure estimation, we may be designing a mission to make these measurements from a spaceborne platform.

Airborne Studies of La Selva Biosstation, Costa Rica

La Selva biosatation is located north of the Cosa Rica, capital of San José. Ground cover extends from primary forest to tropical. This site was chosen for ISAR mission studies to demonstrate the existence of consistent target data as well as extensive studies of the forest's constituent tree species. This flight was designed to reduce the influence of volume scattering in the data.

Below are shown two examples of profiles through the data. The leftmost plots show estimated vegetation height. The center plots show expected correlation between 10 minute correlation (green line and red dots) and 2 day correlation (blue line and solid dots). The rightmost column shows the temporal decorrelation estimated from the difference between the expected and the observed correlations. Note that longer time periods lead to increased decorrelation, as expected. Also, temporal decorrelation surfaces is lower than noise vegetation.

Spaceborne Studies

Near the end of its brief lifetime in the fall (Aug-Oct) of 1999, SIR-C collected a variety of data, including data.

What A Vegetation InSAR Mission Might Look Like

There are a finite number of sun synchronous repeat area tracks. These are plotted below as a function of altitude and days between repeat cycles. Shouter repeat cycles dramatically lower resolving capability and increase the rate of decorrelation. It would be useful to acquire a repeat cycle to be used to change altitude by 50 km. Hence, repeat cycle should be able to accommodate various mission scenarios required for a realistic InSAR mission.

A near-polar satellite would require a slight offset from an exact repeat track. This offset would be used to provide the baseline necessary for achieving interferometric sensitivity to vegetation vertical details. The baseline was approximately a function of the altitude due to the crossover of the track point. A nominal L-band baseline separation at the equator for 500 km would be on the order of 6000 meters, and would be correlated with higher biomass levels present at the equator.

To date, we have just been performing a thorough analysis of the effects of temporal decorrelation. Potentially the largest source of error for a repeat pass InSAR mission for measuring vegetation vertical change is the effects of temporal decorrelation. The data to date has been collected by the JPL/UCSB/OSU, and AIRSAR. As more methods develop, we would like to expand the include consistent and independent optical data, as well as to increase the geographic and temporal extent of the observations.

In general, the studies thus far have revealed the following:

- Both L- and P-band repeat pass observation show signs of temporal decorrelation at even the shortest repeat pass periods (24 hours).
- Spatial decorrelation is significant for P-band observations, but not for L-band observations.
- The vegetation index is sensitive to changes in spatial decorrelation. It is useful at the moment to avoid excessive decorrelation that would be observed in the absence of precipitation.
- Quantitative results to date have been over relatively small geographic areas and under short repeat pass periods.
- More extensive studies to be made on the effect of temporal decorrelation for repeat pass observation would serve as a cornerstone for interpreting the observations presented in this paper.

"InSAR Sensitivity to Vegetation Profiles: Some Basics"

Collecting interferometric observations as a function of the baseline or temporal decorrelation will reveal the vertical profiles of the vegetation. Each line of sight through the vegetation forms a function which gives an estimate of the decorrelation at that position which would be equivalent to a single pass InSAR. One of the main sources of decorrelation would be the motion of the plant material that could be under a particular observing scenario.

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Other research shows that temporal decorrelation is the least problematic and therefore the most straightforward to achieve.

In the leftmost column, the decorrelation observed is due to the vegetation signature. Each of the lines of sight through the vegetation forms a function which gives an estimate of the decorrelation at that position which would be equivalent to a single pass InSAR. One of the main sources of decorrelation would be the motion of the plant material that could be under a particular observing scenario.

The presence of primary and secondary forest at different growth stages, as well as the variety of vegetation and collecting conditions, places severe challenges for analysis for some time to come.

"Airborne Studies of La Selva Biosstation, Costa Rica"

Repeat pass data for P- and L-band was processed over La Selva. Forested and non-forested regions were selected in close proximity to one another to gauge changes of the interferometric response.

Profile from selected areas can be used to determine changes of the correlation. Inputs to the model consist of the magnitude plot, a DEM plot, vegetation fraction, and zero baseline correlation. Measuring SNR decorrelation is very similar to the above, except the vegetation density was reduced to decrease the influence of volume scattering in the data.