The New Dual Frequency (C- And L-Band) Topsar Airborne Interferometric SAR

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ABSTRACT

This paper describes the implementation and initial results of the new NASA/JPL dual frequency C- and L-band interferometric SAR. The AIRSAR/TOPSAR system has been reconfigured to enable the simultaneous collection of C- and L-band interferometric radar data. This allows the quantitative study of penetration characteristics of various earth terrain types in addition to producing digital elevation data.

INTRODUCTION

For the past three years, the NASA/JPL AIRSAR system has collected simultaneous C-band cross-track interferometric and L- and P-band polarimetric SAR images. This mode has become known as the TOPSAR instrument [1] and several digital elevation models have been produced using this data. The height accuracy of the digital elevation models produced by this instrument has been shown to be on the order of 1 meter r.m.s. for flat bare surfaces, and a few meters r.m.s. for high relief terrain. This instrument has been developed as a proof of concept and a pre-cursor for a spaceborne interferometric SAR proposed under NASA's Global Topographic Mapping Mission.

One of the major unknowns in digital elevation models produced using the SAR interferometric technique, is what elevation is actually measured. For bare surfaces, one could assume this is the elevation of the actual surface, but for very dry, or vegetated, or snow and/or ice covered surfaces, the amount of penetration of the radar signals into the medium is not known. This effect is expected to be more pronounced at L-band, the frequency of choice for the proposed Global Topographic Mapping Mission SAR. To answer some of these questions, the current TOPSAR instrument was upgraded to collect simultaneous C- and L-band interferometric SAR images. These dual frequency images, and the associated digital elevation models derived from the dual frequency data, will allow us on a pixel by pixel basis to compare the differential penetration of the dual frequency radar waves. The differential penetration can directly be measured as the difference in the observed elevation for each pixel.

HARDWARE DESCRIPTION AND OPERATIONS

The TOPSAR instrument is a special mode of the AIRSAR system. This system consists of three radar transmitters (C-, L- and P-band) operated simultaneously, and six receivers (two at each frequency) which receive data simultaneously from six different antennas. In the normal TOPSAR mode, the two antennas forming the interferometer at C-band are physically separated by 2.4 meters, while the L- and P-band antennas are the horizontally and vertically polarized feeds of the AIRSAR antennas, respectively. To implement the new dual-frequency interferometric mode, we added another vertically polarized L-band microstrip antenna. The L-band interferometer is then formed using the new antenna and the vertical feed of the AIRSAR antenna. The new L-band antenna is physically mounted on the fuselage behind the current C-band top interferometric antenna. The physical size of the NASA DC-8 on which these antennas are mounted limits the L-band baseline to about 2 meters. Fig. 1 below shows schematically the relative positions of the different antennas of the AIRSAR/TOPSAR system.

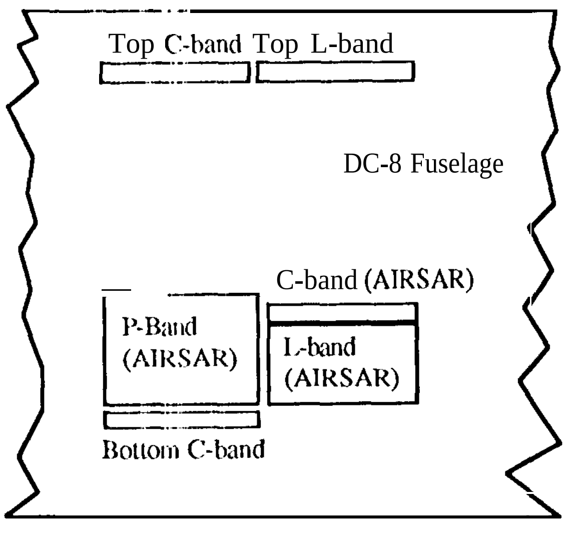

Figure 1. Schematic of the AIRSAR/TOPSAR system antennas on the DC-8 fuselage. The C-band interferometer utilizes the top- and bottom C-band antennas, while the new L-band interferometer is formed using the top L-band and the vertical feed of the AIRSAR L-band antenna,

The ncw microstrip antenna was designed and manufactured as a joint venture between JPL and the Institute for Microwave Techniques at the University of Karlsruhe in Germany. The antenna is an aperture coupled microstrip array [2] with ten patches and a boresite gain of about 17.5 dB, slightly lcss than the design value of 18.2 dB. The reduction in gain is mainly the result of changes to the feed network and connectors necessitated by manufacturing considerations. Actual flight tests showed this antenna to have a gain that is within a fcw percent of the current AIRSAR L-band array - a sixteen patch single-layer corporate feed microstrip antenna.

Since the AIRSAR system was designed to be a polarimetric radar, the transmitters arc equipped with a switch which allows alternate transmission out of either onc of two antenna. This feature allows us to operate the system in a dual baseline configuration. onc baseline is formed when transmitting out of the bottom (or top) antenna and receiving simultaneously through the top and the bottom antennas. This has been the standard mode in which the TOPSAR instrument was operated until this year. For a dual baseline operation, pulses arc transmitted alternately out of the top and bottom antennas, and signals arc received through both the top and bottom antennas simultaneously. This allows onc to form interferograms between the data files measured when transmitting and receiving through the top antenna and those measured when transmitting and receiving through the bottom antenna. This baseline is exactly twice the length of the onc formed when transmitting through the top (or bottom) antenna and receiving through both the top and bottom antennas simultaneously.

DATA PROCESSI NG

The data arc processed and delivered through the ncw AIRSAR Integrated Processor, This processor uscs a modification of the full motion compensation algorithm described by Madsen et al. [3] 10 process the multi-frequency data. For the TOPSAR mode, in addition to the radar images, digital elevation data arc produced from the interferometers, as well as local incidence angle maps, and maps of the correlation between the interferometric channels. All images arc automatically co-registered across frequencies. The C-band digital elevation information is used to geometrically resample the radar images to correct for the effects of topography on the radar imaging geometry. All radar images arc also radiometrically corrected, taking into account the effect of topography as described in van Zyl, et al. [4].

The same processor can also be used to process the standard three frequency fully polarimetric data acquired by the AIRSAR system. In this case, no geometric ‘correction is performed, and the images arc delivered in slant range format. Also, radiometric calibration is performed assuming a flat earth.

Images arc calibrate.d using data acquired over a corner reflec tor array deployed on Rosamond dry lake near Palmdale in California. Calibration images arc typically acquir cd two to three times pcr flight season. The calibration parameters derived from these calibration images arc used to automatically calibrate images produced operationally by the integrated processor,

Hardware is currently being procured for the operational integrated processor. In the interim, data arc produced using an Alliant super mini computer with a throughput of about three to five scenes pcr week. It is expected that the integrated processor will be fully operational by the end of June 1995. The expected throughput is 500-600 images pcr year.

INITIAL RESULTS

The first flights of this upgraded instrument took place in late March 1995. The initial results show the instrument to perform as prcdic.led, Wc will present the results of several flight campaigns planned for April - June 1995 at the conference. Several different type of terrains will be imaged ranging from arid deserts to volcanoes to the Greenland ice sheet and glaciers.

SUMMARY

‘J 'hc AIRSAR/TOPSAR system was upgraded to allow the simultaneous acquisition of C-band and L.-band interferometric data for topographic mapping. The differences between the topographic maps acquired at these two frequencies allows onc the estimate the differential penetration characteristics of different earth terrain types. This instrument is now ready to acquire science data and several flights arc planned for the rest of 1995.

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