N94-16743

INVESTIGATION OF AIRSAR SIGNATURES OF THE GULF STREAM

G.R. Valenzuela, J.S. Lee, D.L. Schuler,
G.O. Marmorino, F. Askari, K. Hoppel,
J.A.C. Kaiser, and W.C. Keller

Center for Advanced Space Sensing
Naval Research Laboratory
Washington, DC 20375-5000

1. INTRODUCTION

Extensive AIRSAR measurements were made on 20 July 1990 during the NRL Gulf Stream (GS) experiment which addressed a number of scientific questions relating to SAR imaging of the ocean surface in the presence of variable currents and the background thermohaline circulation (Valenzuela et al. 1991).

In this paper we concentrate on the nature of the electromagnetic (e.m.) backscatter from the North edge of the GS using polarimetric signatures and amplitude imagery from the AIRSAR data.

2. STUDY SITE

On 20 July 1990 the AIRSAR operated from 9 h 49 min to 15 h 45 min EDT. It provided extensive coverage from Norfolk, VA to 37°N, 72°W on the North edge of the GS and South across the GS towards the center of a cold ring (34°18'N, 71°20'W), and return back to Norfolk. For details on the tracks and specific patterns performed see Kobrick (1990).

During the AIRSAR data collection the R/V Cape Henlopen was stationed near the North edge of the GS and remained within 30 km of 36.75°N, 72°W the location of the main thermal front. The winds ranged from 6 to 10 m/s from the south-west (230°T) and waves were almost 1 m high.

3. POLARIMETRIC SIGNATURES

The AIRSAR imagery contained a strong linear feature about 20 km south of the North edge (thermal front) of the GS and weaker signatures were evident on the South edge (Valenzuela et al. 1991). These signatures in the amplitude imagery are strongly frequency and polarization dependent. Therefore, a full polarimetric study was done to obtain further insight on the nature of the e.m. backscatter for these features.

Van Zyl et al. (1987) discussed the theory and application of co-polarized polarimetric signatures to identify the scattering mechanisms from earth surfaces using the shape of the three-dimensional display (Intensity as a function of Orientation and Ellipticity angles) as derived from the transmit and receive polarization vectors operating on the Stokes matrix of the AIRSAR imagery.

In preliminary analysis of polarimetric co-polarized signatures for the North edge of the GS (using one frame from pass GS NS 135-1) (Figure 1) and comparisons with numerical simulations from a second order tilted-Bragg model (Schuler et al. 1992) we have been able to identify that P- and L-band backscatter for the background ocean were consistent with Bragg scattering, while for the linear feature and C band other contributions are present (Figure 2).

4. THERMAL FRONTS SIGNATURES

In addition to the strong linear feature discussed in the previous section, weaker signatures were present in the SAR imagery right on the North edge of the GS (the main thermal front) and another signature on a thermal front about 7 km north.

We have extensive sea truth on these fronts for a quantitative correlation with the SAR imagery (one frame from pass GS SS 360-1) (Figure 3), but here we investigate the frequency and polarization dependence of these signatures for the amplitude imagery. From study of the SAR imagery for these features at P, L and C bands and various polarizations, it is clear that the signatures are largest for HH and HV polarization, and nearly absent for VV polarization.

Furthermore, we note that the mean intensities for P and L bands do not change with azimuth in the image, while C band intensity increases by 2-3 dB towards the warm GS waters (Figure 4). The main thermal front is about pixel 800 in the azimuthal cut and the other front 7 km to the North is about pixel 200. This increase in mean intensity towards the GS is consistent with Ku band scatterometer data from the Henlopen and the NRL/P-3 aircraft.

5. SUMMARY AND CONCLUSIONS

In this work we have used polarimetric analysis and amplitude imagery to investigate the nature of the e.m. backscatter from AIRSAR data near the North edge of th GS during 20 July 1990. The e.m. backscatter for the background ocean is tilted-Bragg for P and L bands, while C band backscatter contains other mechanisms as well, probably specular scattering.

Acknowledgments

We are grateful to the AIRSAR team for collecting and providing the SAR images used in this study.

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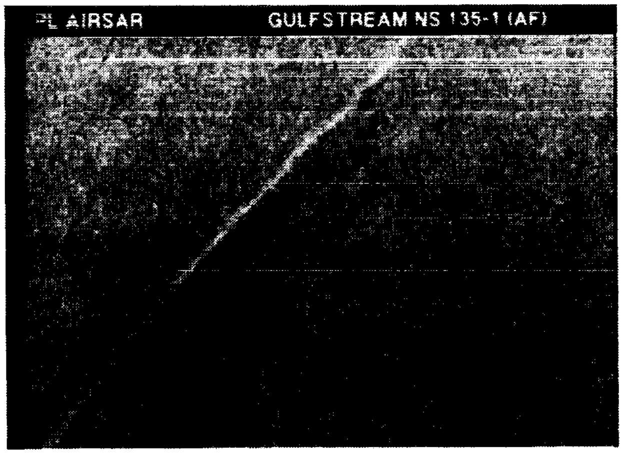

Figure 1. JPL AIRSAR total-power image for a strong linear ocean feature about 20 km south of the North edge of the GS seemingly related to a region of large current gradient.

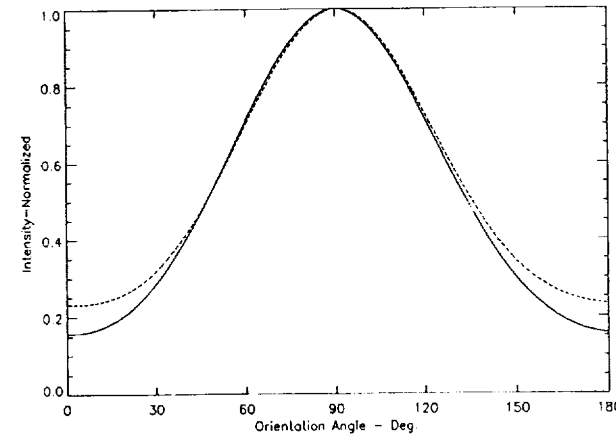

Figure 2. A (linear-pol) slice (40° incidence) of the 3-D polarimetric display of intensity for both the background ocean (solid line) and the strong linear feature (broken line) of Figure 1. Note the increase in horizontal polarization at 0° and 180° angles.

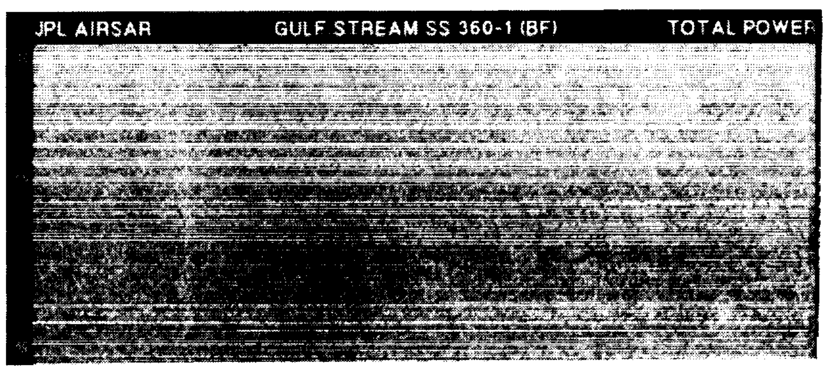

Figure 3. JPL AIRSAR total-power image for the North edge of the GS. The two signatures are associated with the temperature fronts, the one on the r.h.s. is the main front, the North edge of the GS. North is towards the left.

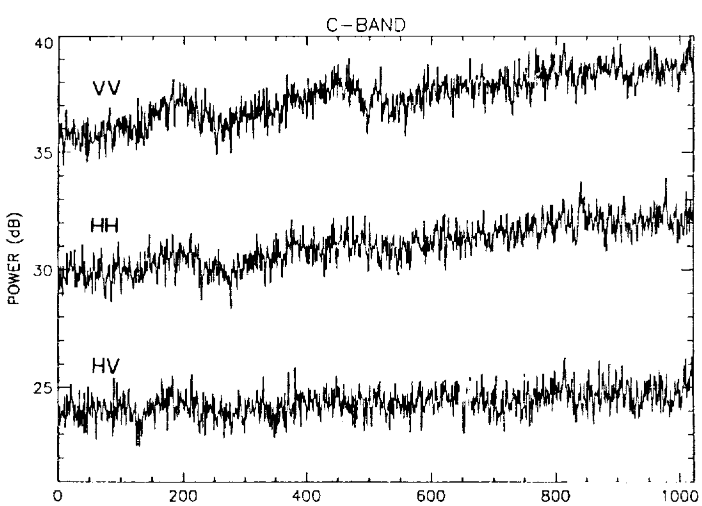

Figure 4. Azimuthal intensity cuts (averages of 50 pixels) of AIRSAR image of Figure 3 for C band and various polarizations at about 55° incidence. The North edge of the GS is about pixel 800, the other temperature front to the north is about pixel 200.