USE OF MICROWAVE POLARIMETRY TO ENHANCE SAR IMAGES OF THE OCEAN SURFACE

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Goals

The investigation of coherent backscatter of microwave signals from the ocean surface to better understand the effects of surface motion on synthetic aperture radar images.

Objective

To analyze the behavior of coherent electromagnetic backscatter from the ocean surface for a dual frequency dual polarization radar. Frequency and polarization diversity provides a picture of the mechanisms involved in the microwave backscatter. In this study, data was obtained from various UMass radar systems to obtain extensive radar observations of the ocean surface at the FPN research tower, in the North Sea, Germany. Some of the results were reported in the publications listed at the end of this report.

Approach

We have fabricated two radars for the FPN research: The first sensor operates at both C-band and X-band, and the second is a Ka-band Scatterometer. Both instruments obtain radar returns for all combinations of linear polarizations. While PolScat can measure the radar reflectivity of an ocean surface area for co- and cross-pol within 40 μs at two frequencies by using a specially designed switching matrix, the Ka-band Scatterometer must be mechanically re-configured for different polarization settings (e.g. VV, HH or HV). Both radars are capable of high speed sampling of the returned signal, PolScat at 50 μs and the Ka-band radar at 10 ms, so that the effects of surface motion may be oversampled. The radars are configured so that they may simultaneously look at the same footprint. This allows us to produce data covering a wide frequency range at all polarization combinations with common ocean surface parameters and ground truth measurements.

Research results obtained during the ONR-sponsored CLT experiment with a Stepped-Frequency ΔK (SFDK) radar system were also reported during this research effort. This frequency-agile C-Band system is capable of measuring ocean surface currents by use of the dual–frequency ΔK technique.

Another sensor, whose data are used to improve better understanding of the SAR imagery of the ocean, was also developed during this reporting period. The FOcused Phased Array Imaging Radar (FOPAIR) system was developed by Quadrant Engineering in cooperation with MIRSL. It uses a 128 element receiver array to resolve small pixels within the irradiated footprint of a single, broad-beam, transmitting antenna. FOPAIR is capable of rapidly imaging a surface with high ($1m^2$) spatial resolution and can, through repeated scans of the array, capture temporal changes of the surface that occur. These images are captured rapidly so that target or platform motion effects can be observed or eliminated. Furthermore, the focusing and calibration of FOPAIR is accomplished with software after the raw data has

been captured, thereby allowing array sidelobes to be controlled and for other advantages of digital beamforming to be exploited. FOPAIR development was supported by an AASERT (Augmentation Awards for Science and Engineering Research Training) fellowship provided to Mr. Stephen Frasier, which augmented the research support for the FPN project.

Tasks Completed

The Ka-band Scatterometer was refabricated and successfully tested in June, 1990 at the U.S. Army's Coastal Engineering Research Center's Field Research Facility in Duck, N.C.. Improvements were achieved both in the sensitivity and the measurement stability of this instrument. Also, the data acquisition system was redesigned to allow faster sampling (100 Hz) so that this sensor could be used for decorrelation studies of radar return signal at Ka-band. These upgrades are providing increased data quality during the SAXON-FPN experiment.

During the first half of 1990, PolScat was fully assembled, and preliminary field tests were performed. In August 1990, both sensors participated in the "dry-run" test for the SAXON-FPN experiment which was organized by the University of Massachusetts on the Amherst campus. Other participant included the University of Kansas, Johns Hopkins University and the Woods Hole Oceanographic Institute.

PolScat and Ka-band Scatterometer successfully participated in the SAXON-FPN in the fall and winter of 1990. Over 5.4 Gbytes of backscatter radar measurements were collected. During 1991 and 1992 a complete detailed data analysis was carried out at the laboratories at UMass. Data were thoroughly checked for quality using various testing algorithms (e.g. checking for power levels between different polarization channels, testing for the expected pdf, etc.). A careful calibration was performed before and after the SAXON-FPN which allowed for the absolute calibration of data. A large data base of normalized radar cross-section values was formed with data covering a wide range of weather and sea state conditions and

the data was entered onto the FPN data archives in December, 1991. This data base represent a valuable set of ocean radar cross section measurements specifically because it includes rear high quality simultaneous co- and cross- polarization measurements. The high-speed PolScat instrument also provided measurements of decorrelation times for the sea surface over a large number of sea surface conditions. The decorrelation time is an important parameter for the SAR processing of ocean images. UMass team participated in all four SAXON-FPN workshops where our progress results were presented. We have also presented these results on the several IGRASS conferences. Unfortunately, the UMass cross polarization measurements could not be compared to SAR measurements, which were to be provided by ERIM, because the SAR instrument was not sufficiently sensitive to make polarimetric measurements.

The FOPAIR system was completed during the summer of 1993, and it participated in engineering tests at N. Truro, MA in June, 1993. These tests were successful and we have obtained large amount of oversampled ocean images. Later experiments with K. Melville of Scripps Institute were performed in San Diego in August.

Publications from ONR sponsored work - FY 88/FY 93

PI: Robert E. McIntosh

Reviewed publications :

92-P , Popstefanija, I. and R.E. McIntosh, "Measurements of the Effects of Surface Winds on Ocean Currents With a Stepped-Frequency ΔK Radar System", JGR-Ocean, Vol 97, No.C4, Pages 5597-5605, April 15, 1992

93-P , Popstefanija, I., D.S. McQueen and R.E. McIntosh, "A Stepped-Frequency Delta-K Microwave Radar for Oceanographic Studies", IEEE Trans. On GRS, Vol. 31, No.3, May 1993

93-PS , McIntosh, R.E., Frasier, S., and Mead J., "A FOcused Phased Array Imaging Radar (FOPAIR) for high spatial and temporal imaging of the ocean surface", submitted to the IEEE Transactions on Antennas and Propagation, September, 1993

Conferences :

89-C , Popstefanija, I., "Microwave Measurements of Ocean Surface Currents for the SAXON Experiment", IGARSS '89, 1512, Vancouver, Canada

89-C , Popstefanija, I., et. al., "Simultaneous Ka-band scattering measurements and stereophotography", IGARSS '89, 1516, Vancouver, Canada

90-C , Popstefanija, I., McIntosh R.E., "Ka-band Backscattering Measurements of Ocean Surface During SAXON Experiment", Ocean Sciences Meeting, AGU, New Orleans

90-C , Popstefanija, I., McIntosh R.E., "Measurements of Ocean Surface Currents with Multifrequency Radars", Marine Science Technology Meeting, Washington DC.

91-C , Popstefanija, I., McIntosh R.E., "A Study of Signal-to-Clutter ratio for a Multifrequency Delta-K radar", IGARSS '91, 1625, Espoo, Finland

92-C , Popstefanija, I., Steve P. Lohmeier, Kazimierz Grzeslak and Robert E. McIntosh, "Simultaneous Polarimetric Measurements of Electromagnetic Backscatter at C- and X-Band During SAXON-FPN", IGARSS '92, Houston, TX