Digital Beamforming Scatterometer

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This paper discusses scatterometer measurements collected with multi-mode Digital Beamforming Synthetic Aperture Radar (DBSAR) during the SMAP-VEX 2008 campaign. The 2008 SMAP Validation Experiment was conducted to address a number of specific questions related to the soil moisture retrieval algorithms. SMAP-VEX 2008 consisted on a series of aircraft-based flights conducted on the Eastern Shore of Maryland and Delaware in the fall of 2008. Several other instruments participated in the campaign including the Passive Active L-Band System (PALS), the Marshall Airborne Polarimetric Imaging Radiometer (MAPIR), and the Global Positioning System Reflectometer (GPSR). This campaign was the first SMAP Validation Experiment.

DBSAR is a multimode radar system developed at NASA/Goddard Space Flight Center that combines state-of-the-art radar technologies, on-board processing, and advances in signal processing techniques in order to enable new remote sensing capabilities applicable to Earth science and planetary applications [1]. The instrument can be configured to operate in scatterometer, Synthetic Aperture Radar (SAR), or altimeter mode. The system builds upon the L-band Imaging Scatterometer (LIS) developed as part of the RadSTAR program [2] [3].

The radar is a phased array system designed to fly on the NASA P3 aircraft. The instrument consists of a programmable waveform generator, eight transmit/receive (T/R) channels, a micro-strip antenna, and a reconfigurable data acquisition and processor system. Each transmit channel incorporates a digital attenuator, and digital phase shifter that enables amplitude and phase modulation on transmit. The attenuators, phase shifters, and calibration switches are digitally controlled by the radar control card (RCC) on a pulse by pulse basis. The antenna is a corporate fed microstrip patch-array centered at 1.26 GHz with a 20 MHz bandwidth. Although only one feed is used with the present configuration, a provision was made for separate corporate feeds for vertical and horizontal polarization. System upgrades to dual polarization are currently under way.

The DBSAR processor is a reconfigurable data acquisition and processor system capable of real-time, high-speed data processing. DBSAR uses an FPGA-based architecture to implement digitally down-conversion, in-phase and quadrature (I/Q) demodulation, and subsequent radar specific algorithms. The core of the processor board consists of an analog-to-digital (A/D) section, three Altera Stratix field programmable gate arrays (FPGAs), an ARM microcontroller, several memory devices, and an Ethernet interface. The processor also interfaces with a navigation board consisting of a GPS and a MEMS gyro.

The processor has been configured to operate in scatterometer, Synthetic Aperture Radar (SAR), and altimeter modes. All the modes are based on digital beamforming which is a digital process that generates the far-field beam patterns at various scan angles from voltages sampled in the antenna array. This technique allows steering the received beam and controlling its beamwidth and sidelobe. Several beamforming techniques can be implemented each characterized by unique strengths and weaknesses, and each applicable to different measurement scenarios. In Scatterometer mode, the radar is capable to generate a wide beam or scan a narrow beam on

transmit, and to steer the received beam on processing while controlling its beamwidth and side-lobe level. Table I lists some important radar characteristics.

TABLE I

RADAR CHARACTERISTICS

Frequency	1.26 GHz
PRF	50 Hz to 10 KHz
Pulse Width	1 to 1000 μs
Total Output Power (Nominal)	16 W
Bandwidth (10 dB return loss)	20 MHz
Polarization	Horizontal
Total antenna Gain	> 20 dB
3 dB Beamwidth (Nadir, along track)	13.6 Degrees

In scatterometer mode, the processor generates 32 beams at a pulse repetition frequency as high as 10 KHz. The scatterometer mode was successfully flight tested in the fall 2008 on board of the NASA P3 aircraft over the Delmarva Peninsula, VA. The flight lines covered an area that included ocean, agricultural and forested land, coastal marshes, and the Chesapeake Bay. Figure 1 shows backscatter power vs. returned power for a scan range from – 65 to + 65 degrees.

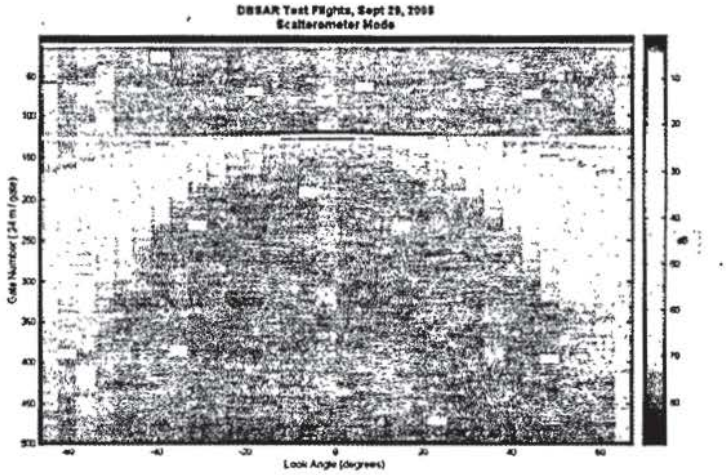

Figure 1 Plot of DBSAR's scatterometer mode showing backscatter power vs. look angle for a scan range from – 65 to + 65 degrees.

Upon completion of the test flights, the instrument participated in the SMAP-VEX camping collecting over ten hours of data at several altitudes. Data analysis and preliminary results for the scatterometer mode will be presented in the paper.

References

[1] Rincon, R, "Reconfigurable L-Band radar", presented at the European Radar Conference, Amsterdam, The Netherlands, October 2008.
[2] Rincon, R. et al., "NASA's L-Band Imaging Scatterometer, in IGARSS '04 Proceedings, 2004, Vol. 1, pp 686.
[3] Hildebrand, P., et al, "Science, measurement and technology goals for the RadSTAR FY2002 IR&D project". *NASA/GSFC internal report*, 2002.