DBSAR's First Multimode Flight Campaign

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Introduction

•The Digital Beamforming SAR (DBSAR) is an airborne imaging radar system that combines phased array technology, reconfigurable on-board processing and waveform generation, and advances in signal processing to enable techniques not possible with conventional SARs

•The system exploits the versatility inherently in phased-array technology with a state-of-the-art data acquisition and real-time processor in order to implement multi-mode measurement techniques in a single radar system.

• Operational modes include scatterometry over multiple antenna beams, Synthetic Aperture Radar (SAR) over several antenna beams, or Altimetry.

•The radar was flight tested in October 2008 on board of the NASA P3 aircraft over the Delmarva Peninsula, MD.

System Architecture

DBSAR Some of its main features include:

- 1-Dimensional scanning (across track in nominal configuration)
- polarimetric operation (HH,VV,VH,HV)
- software defined radar functions,
- in-phase and quadrature (I&Q) high data rate acquisition mode,
- real-time onboard processing,
- adjustable transmitter illumination (from narrow-beamwidth high-gain beam steering to wide-beamwidth illumination),
- reconfigurable waveform generation,
- noise source and closed loop calibration schemes,
- real-time data monitoring through a customized graphical interface unit.

System Architecture

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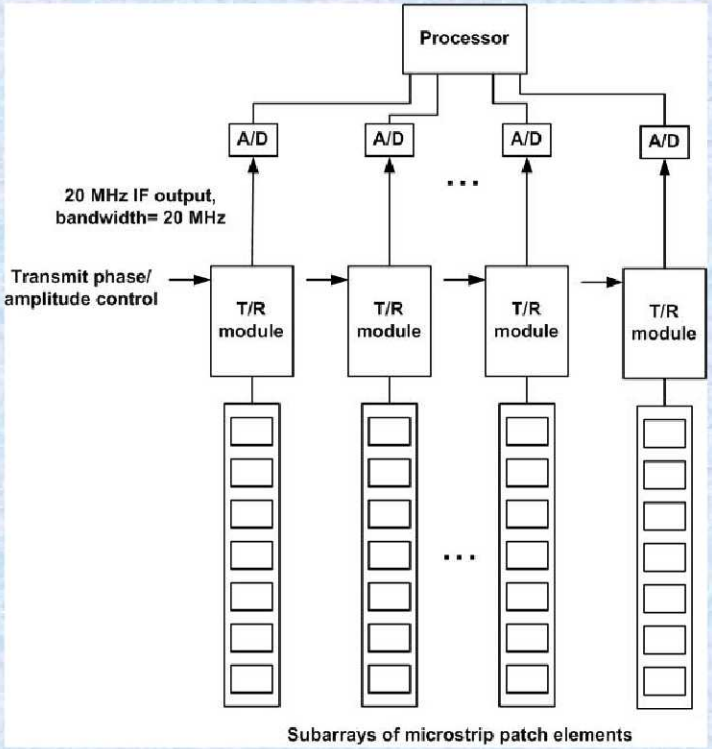
- Antenna is a microstrip phased array with 64 active elements
- 8 sub-arrays enable cross-track scanning over a wide range of angles
- Transmit modules perform digital phase steering and amplitude taper
- DBSAR was designed for operation on board of the NASA P3 aircraft

Radar and NASA P3 Aircraft

LIS Architecture



Radar Characteristics

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RF Specifications

Frequency	1.26 GHz
Bandwidth	20 MHz
PRF	40 Hz - 10 KHz
Pulse Width	1 – 100 μs
Number of Transmitters	8
Output Power	16 W
Beam Steering Angles	± 50 degrees

Antenna

Type	Microstrip Patch
Number of Patches	80
Bandwidth	20 MHz
Polarization	Dual
3 dB Beamwidth	12 Degrees
Two-Way Side Lobes	< – 26 dB
Subarray Gain	≥10.5 dB

Miscellaneous

Dimensions (m)	1.2 x 1 x 0.5
Power Draw (W)	350
Weight (kg)	106
Cooling System	Vortex Tubes/ Compressed N_2

Radar Calibration in Anechoic Chamber

The Real-time Processor

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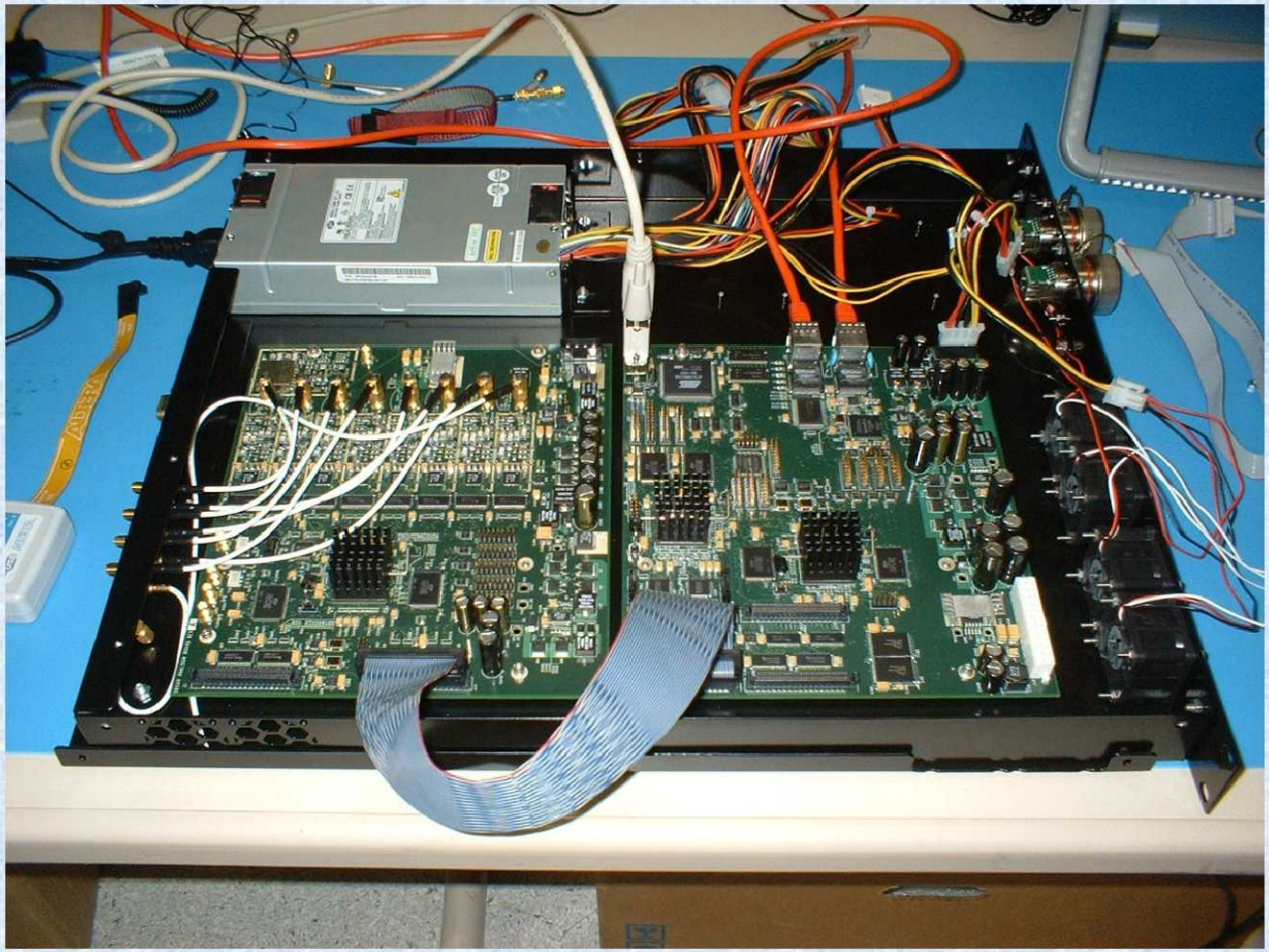
- Fully Reconfigurable
- Custom design
- Three Stratix II FPGAs
- Eight A/D converters
- Six SRAMs
- ARM microcontroller
- 1-Gb Ethernet interface
- Size (cm): 17 x 24 x 4
- Power: 94 W max



SMAP-VEX Airborne Campaign 2008

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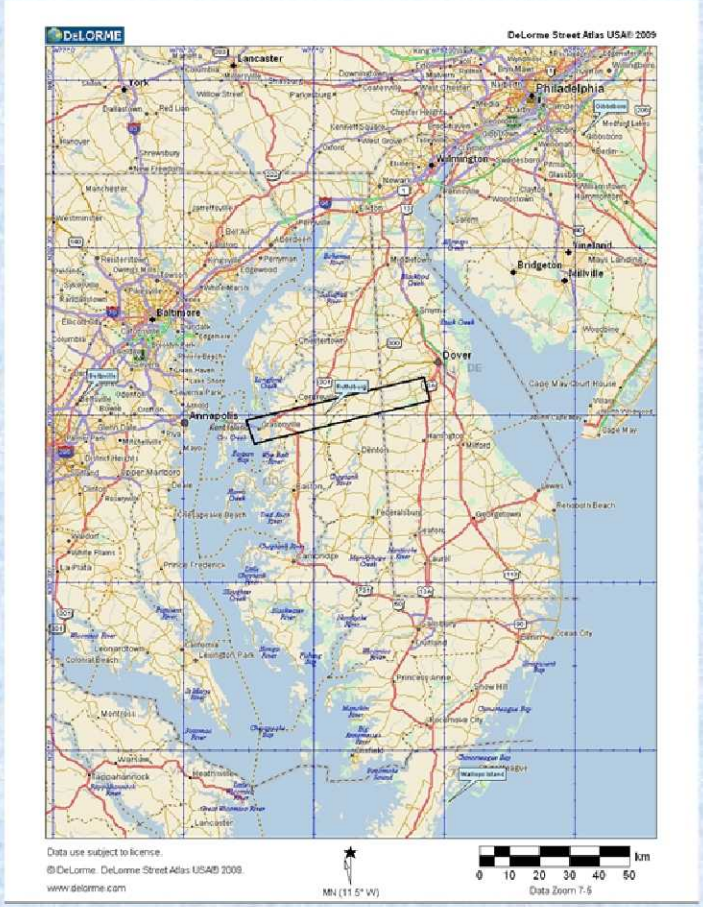
- The Soil Moisture Active Passive Mission (SMAP) is currently addressing numerous issues related to the soil moisture retrieval algorithms.
- 7 Flights where conducted on the NASA P3 at the beginning of October 2008 over the Choptank area, MD.

Radar Integrated to P3 aircraft



DBSAR Operational Modes

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- Scatterometry over multiple antenna beams
    1. Narrow Beam mode → simultaneous transmission and reception on all subarrays.
    2. Wide Beam mode → transmission on a single subarray, and simultaneous reception on all subarrays.

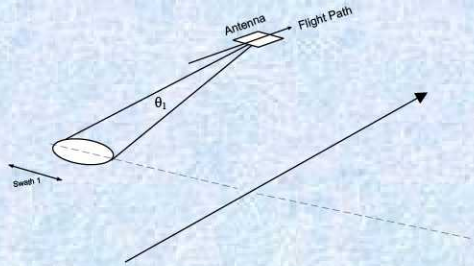
- Synthetic Aperture Radar (SAR) Imaging over several antenna beams
    1. Narrow Beam mode: Strip map Imaging
    2. Wide Beam mode: Left and right of the track imaging

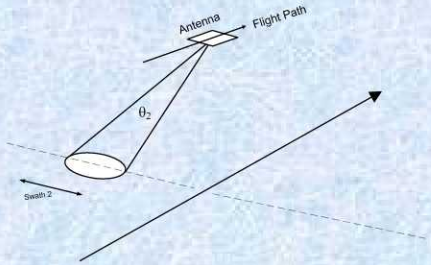
- Altimetry on Nadir beam of SAR mode

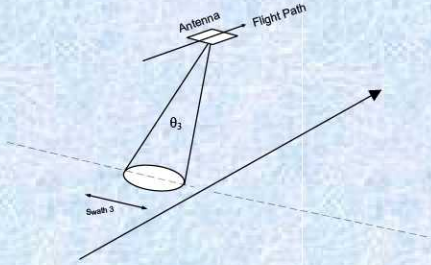
Scatterometer
Operational Mode 1

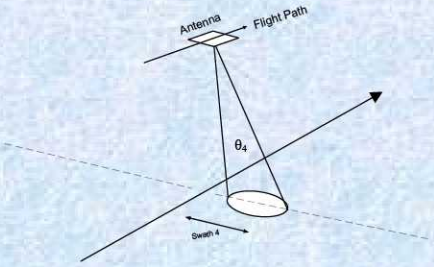
Scatterometer: Narrow beam on transmission

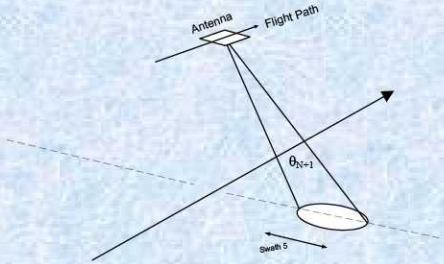
- A narrow beam is generated at a particular look angle by electronically steering the array
- Signal returns are collected with the full aperture
- A single beam is synthesized at the same look angle

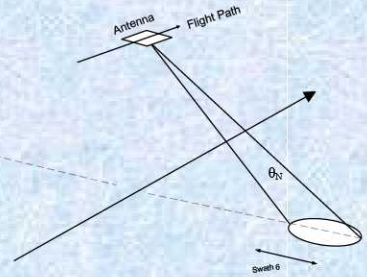












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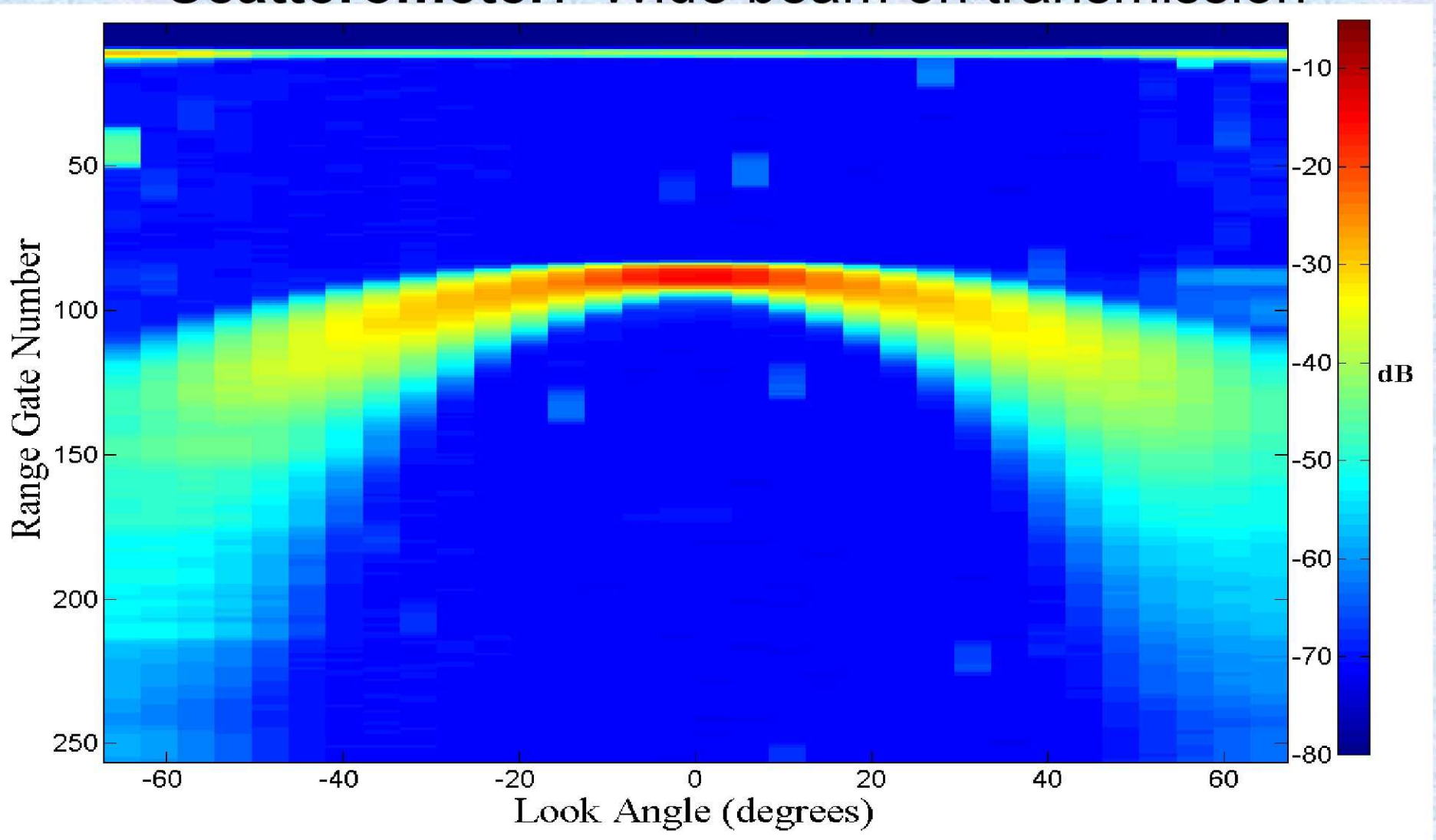
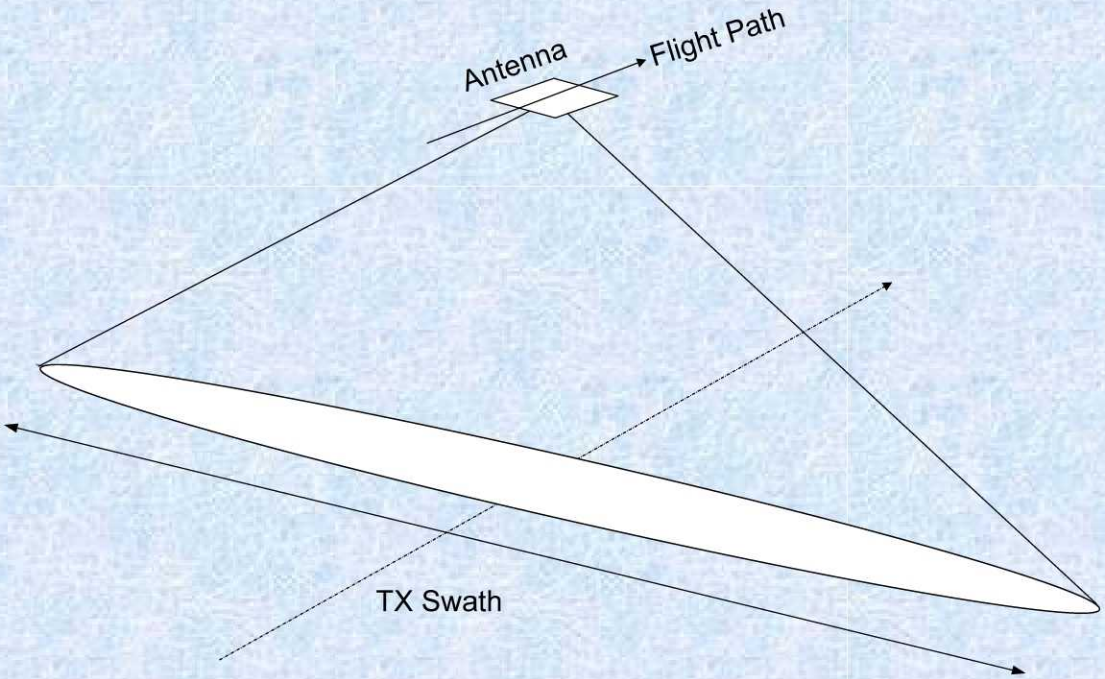
Scatterometer
Operational Mode 1
Scatterometer: Wide beam on transmission



Scatterometer
Operational Mode 2
Scatterometer: Wide beam on transmission

- A broad beam is generated by energizing a small section of the antenna
- The beam illuminates entire field of view
- Signal returns are collected with the full aperture



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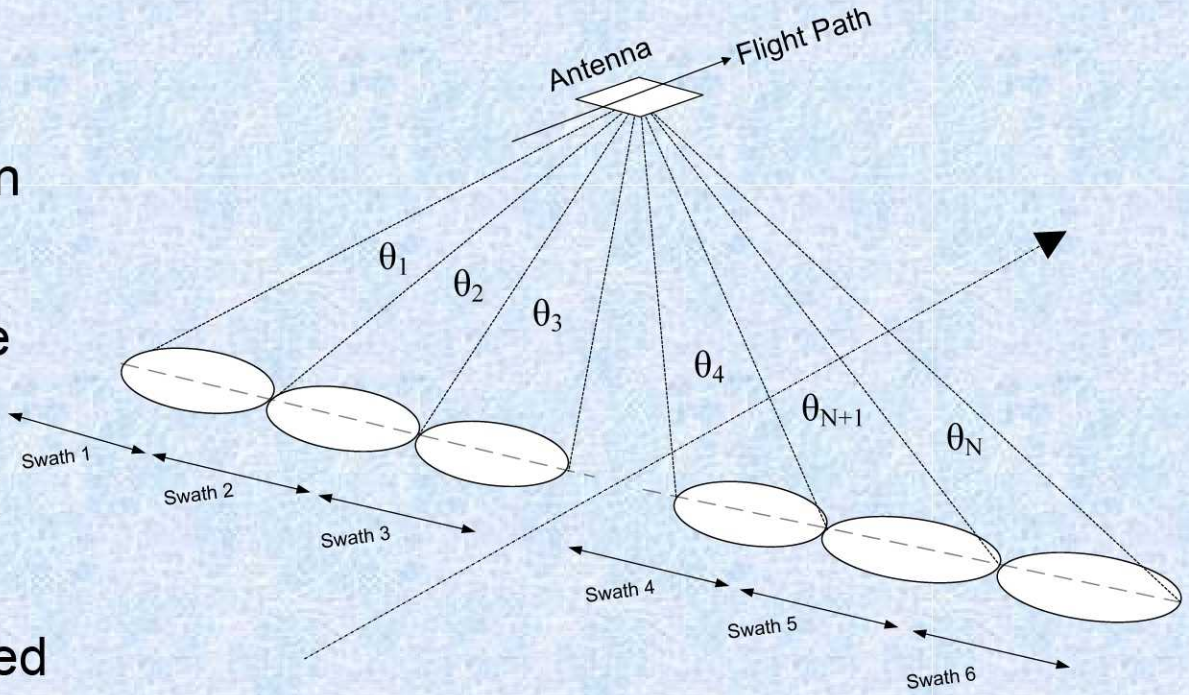
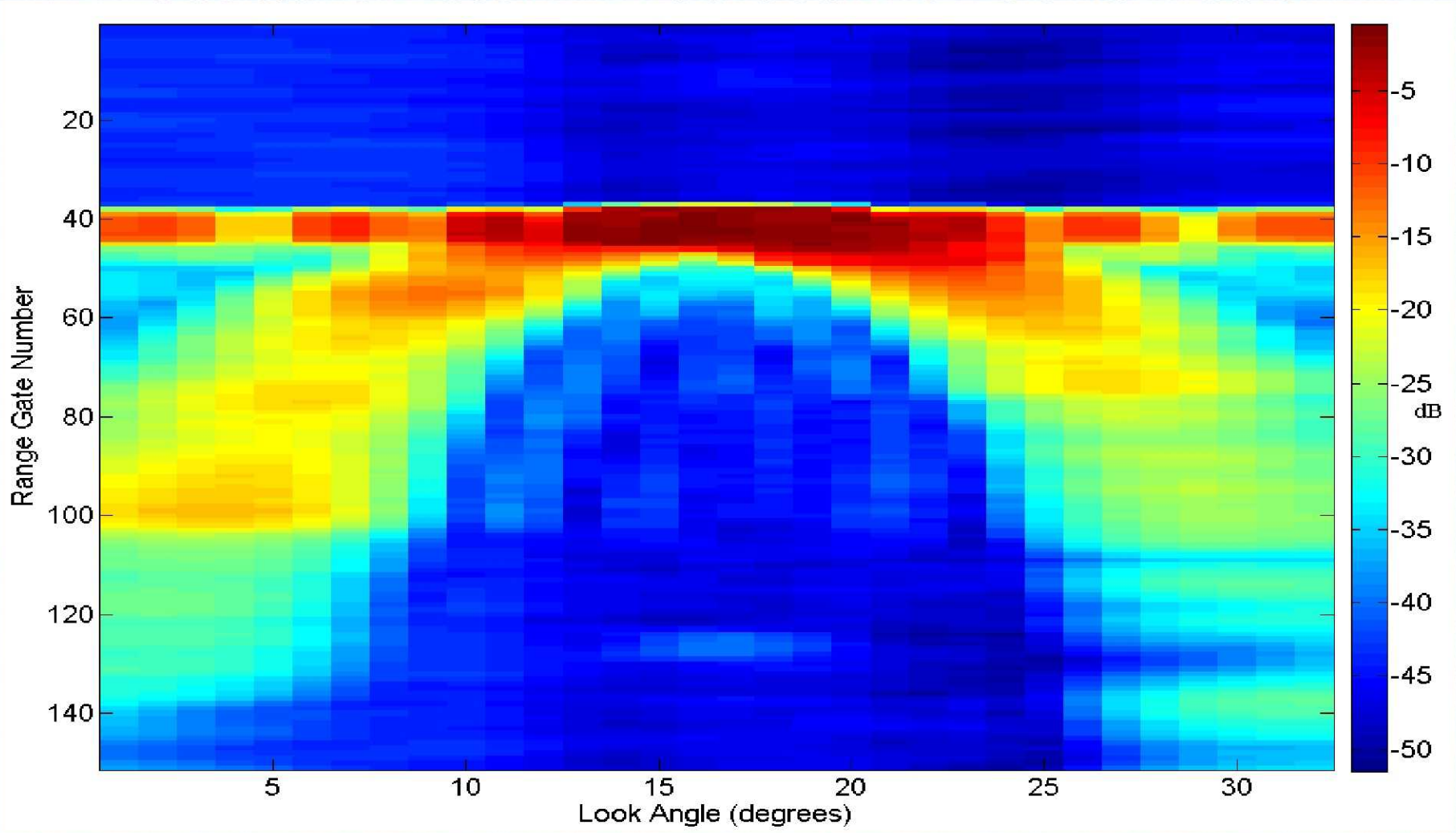
Scatterometer
Operational Mode 2
Scatterometer: Wide beam on transmission

- A broad beam is generated by energizing a small section of the antenna
- The beam illuminates entire field of view
- Signal returns are collected with the full aperture
- Many beams are synthesized simultaneously on receive

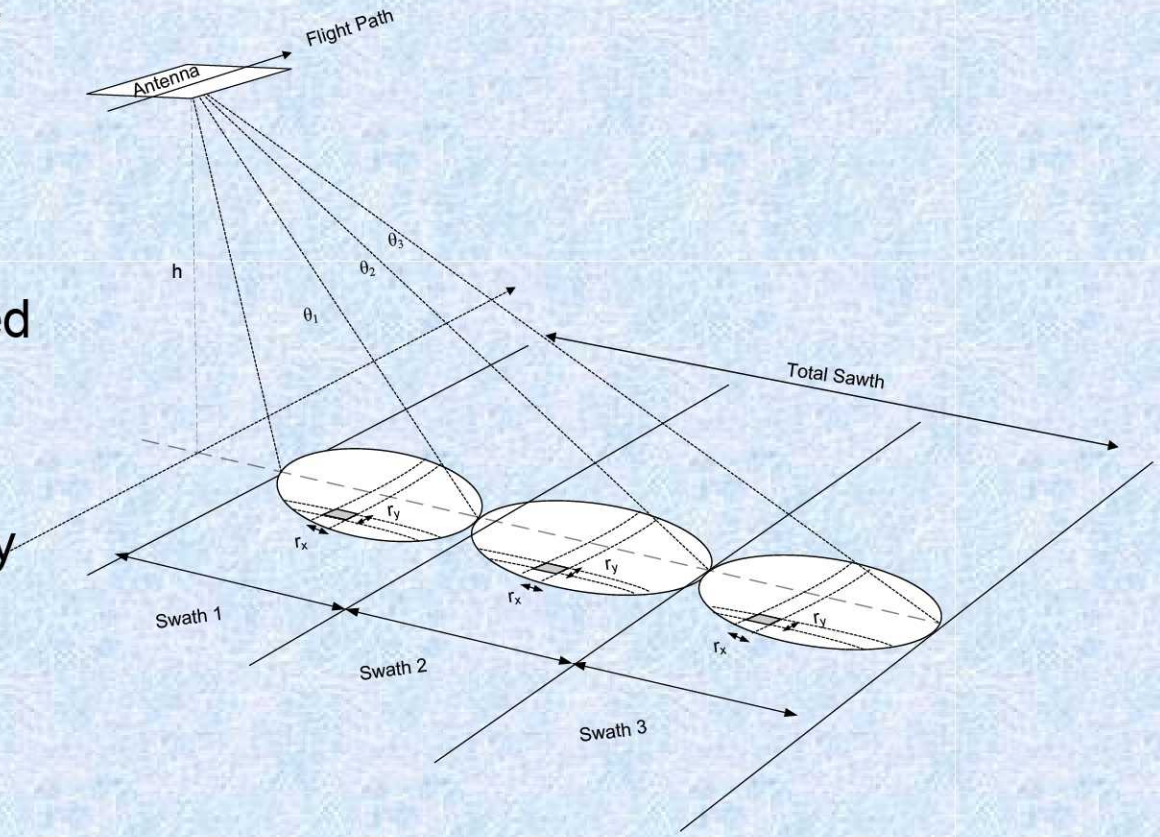


Scatterometer
Operational Mode 2
Scatterometer: Wide beam on transmission



SAR
Operational Mode 1
Narrow beam transmission

- One or several beams are generated by steering
- The beam illuminates a target area
- Signal returns are collected with the full aperture
- Selected beams are synthesized simultaneously
- SAR processing is performed on each beam



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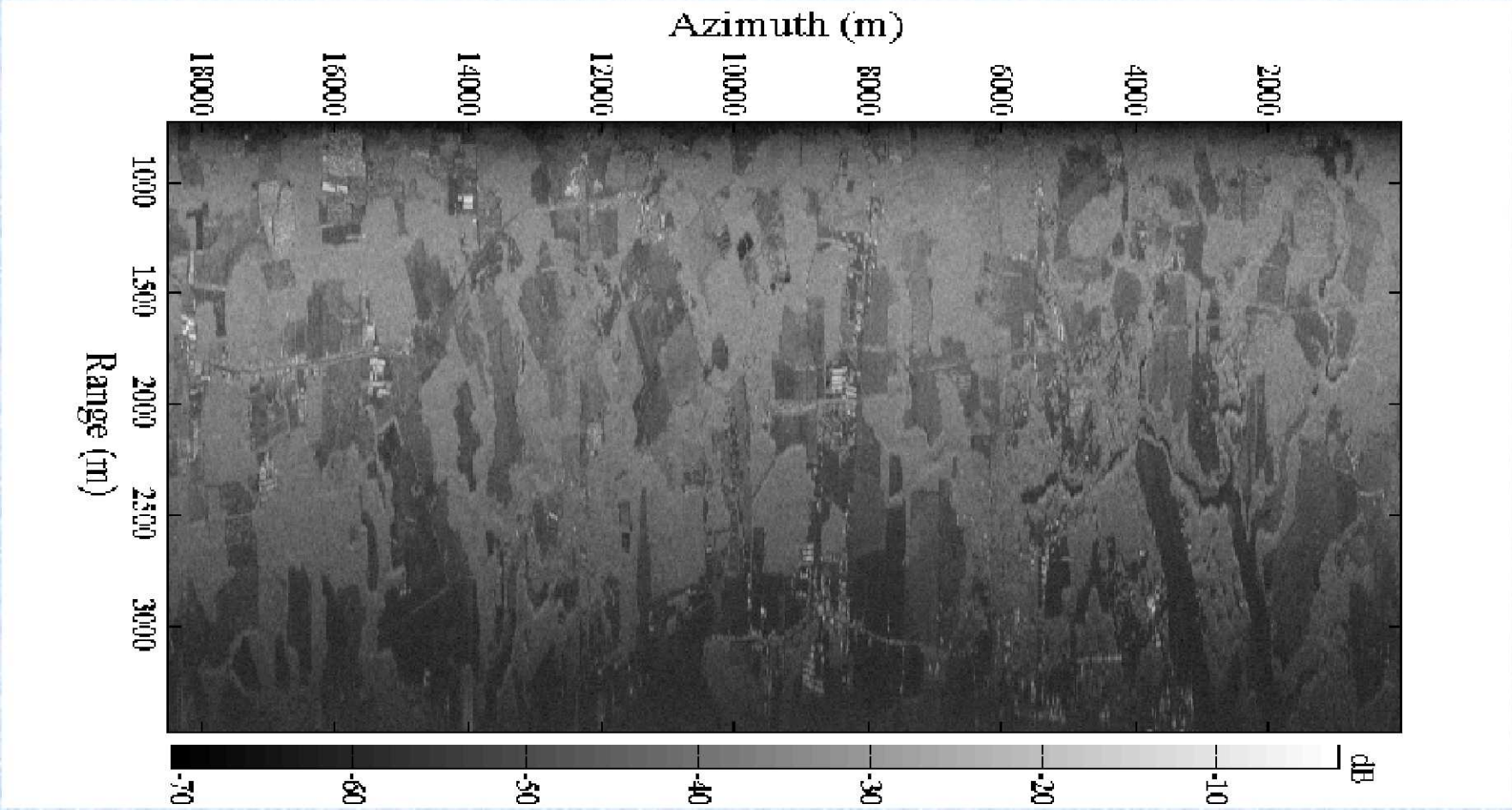
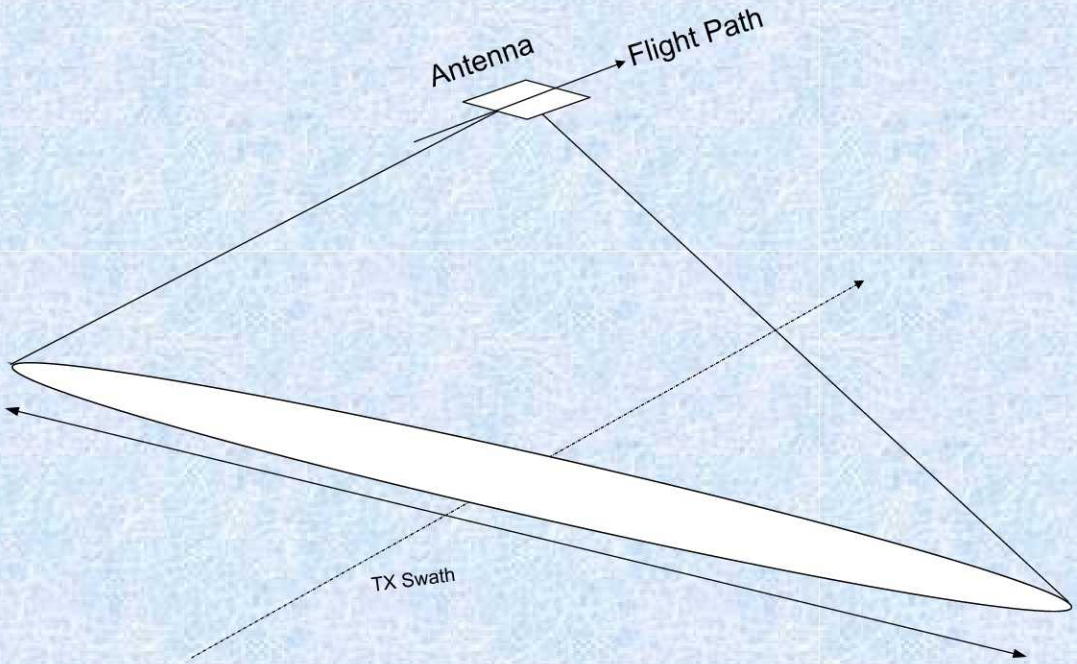
SAR
Operational Mode 1
Narrow beam transmission



SAR
Operational Mode 2
Wide beam TX, imaging on both sides of the track

- A broad beam is generated by energizing a small section of the antenna
- The beam illuminates entire field of view
- Signal returns are collected with the full aperture



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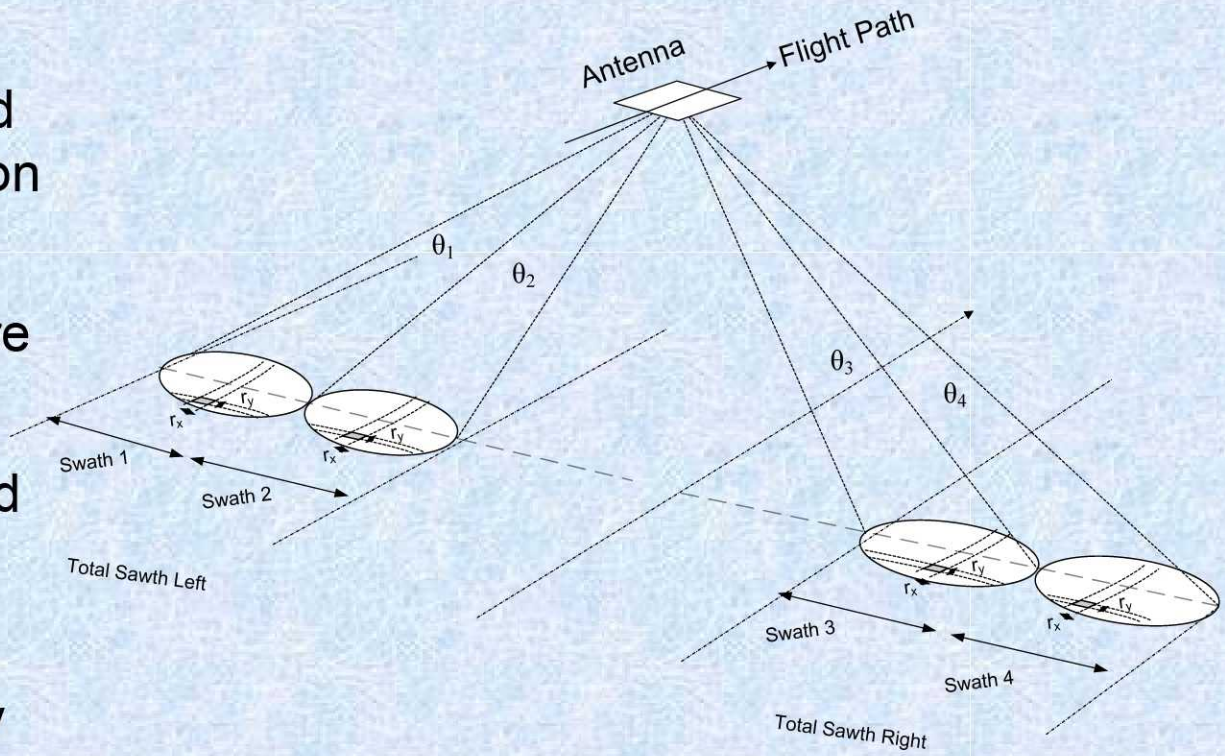
SAR
Operational Mode 2
Wide beam TX, imaging on both sides of the track

- A broad beam is generated by energizing a small section of the antenna
- The beam illuminates entire field of view
- Signal returns are collected with the full aperture
- Several beams are synthesized simultaneously
- SAR processing is performed on each beam



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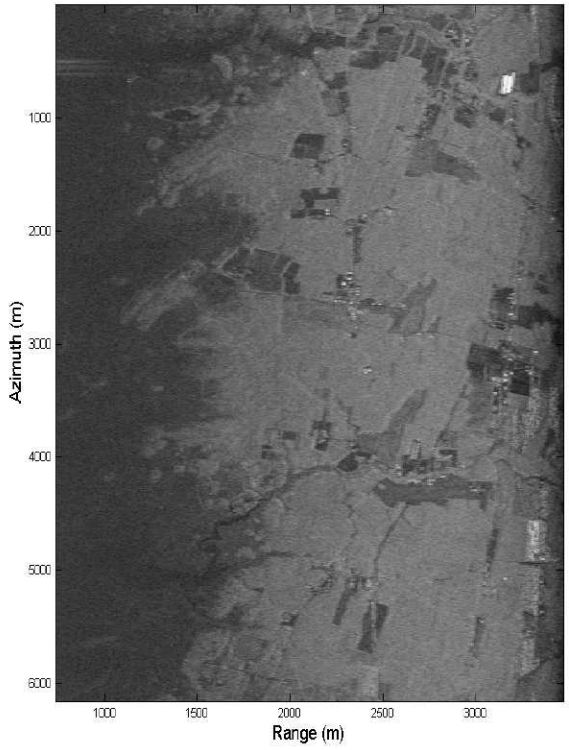
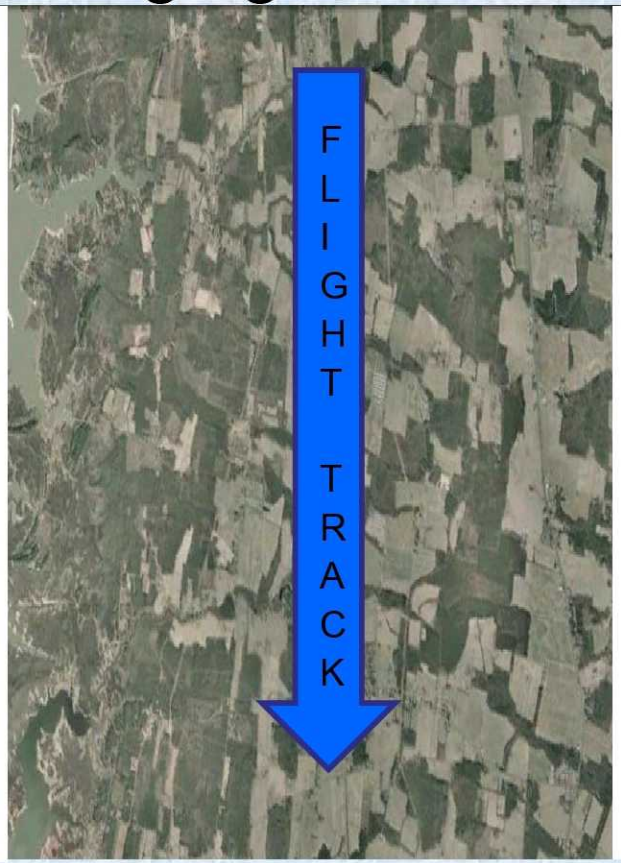
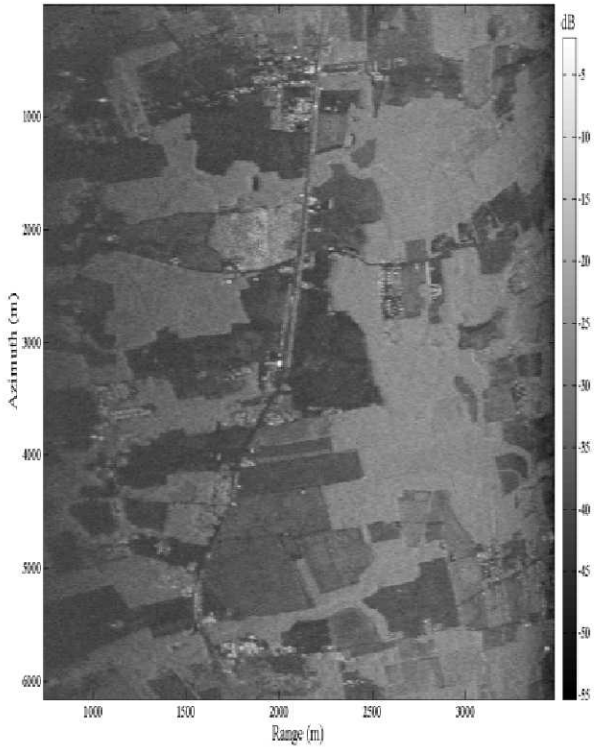
SAR
Operational Mode 2
Wide beam TX, imaging on both sides of the track







The DBSAR Modes

Simultaneous SAR and Altimetry

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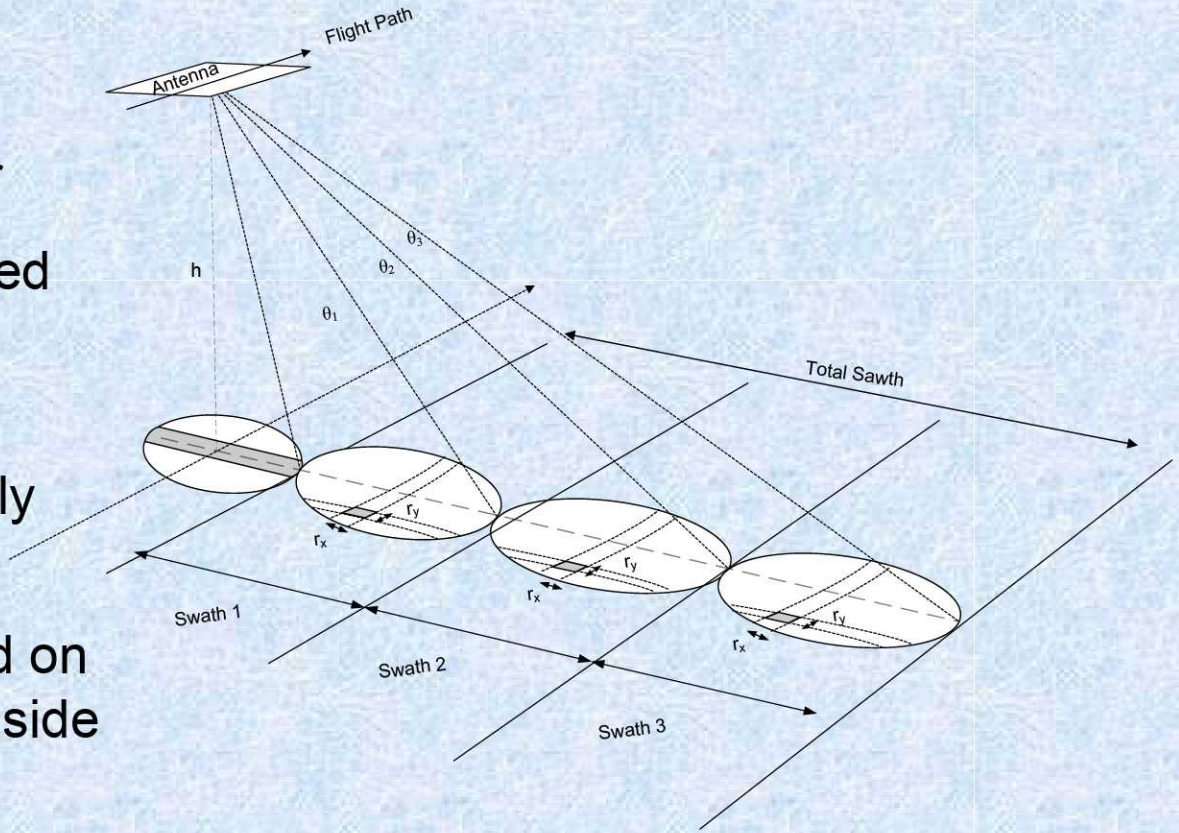
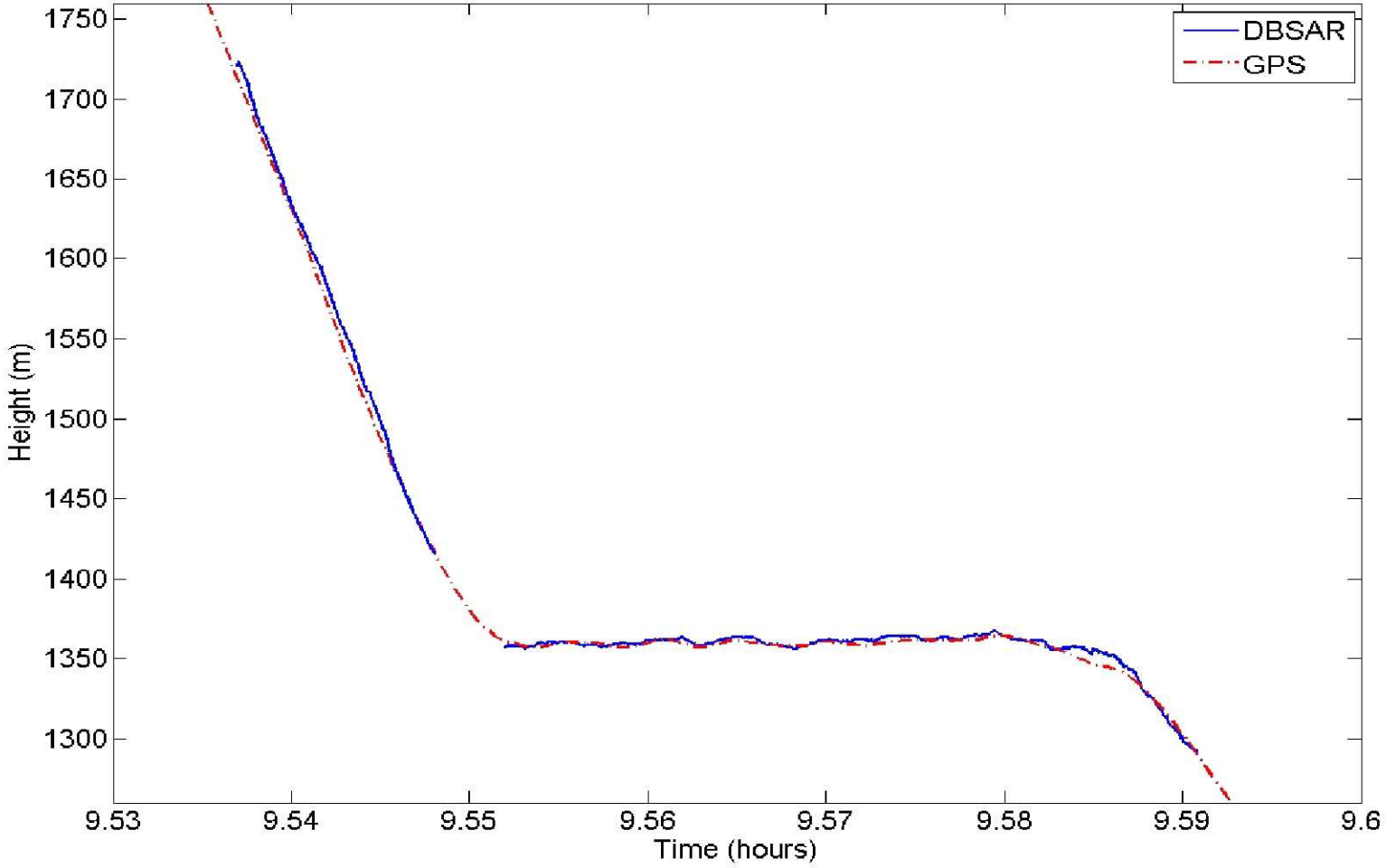
- One or several beams are generated by steering
- The beam illuminates a target area including nadir
- Signal returns are collected with the full aperture
- Selected beams are synthesized simultaneously
- Range and azimuth compression is performed on each of the beams on the side of the track
- Altimetry processing is performed on the nadir beam



Altimetry Mode

Nadir beam of SAR mode



Concluding Remarks

•Results from the first mulit-mode campaign indicated a very successful performance of the radar system.

• DBSAR was recently upgrade with polarimetric operation (hh,vv,hv,vh) which enhances the science capability of the system

• DBSAR's next flight campaign is schedule in August 2010 when the system will be used to retrieve biomass over forests on the US east coast.