



**National Digital Orthophoto (NDOP) Meeting
October 7, 2008**

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Fugro EarthData



Fugro is an international geotechnical, survey, and geosciences services company that collects and interprets data about the earth's land surface and oceans.

Geotechnical Division

Investigation regarding the physical characteristics of the soil, foundation design, and construction materials.

Survey Division

Airborne mapping; topographic, hydrographic and geological surveying; geospatial data production and management; support services for offshore and onshore construction projects; precise positioning.

Geoscience Division

Acquisition, processing, and interpretation of seismic and geological data; reservoir modeling and estimation of oil gas, mineral, and water resources; optimization of resource exploration, development and production.





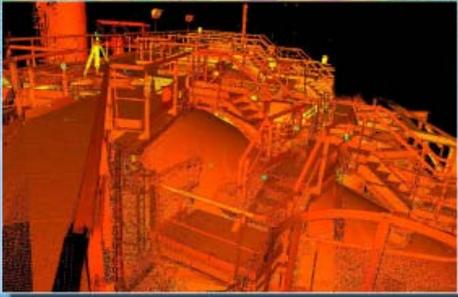
Fugro Global Network



12,400 employees in 280 offices in 60 countries
US\$2 Billion revenue in 2007



Fugro Geospatial Services



GEOSPATIAL SERVICES





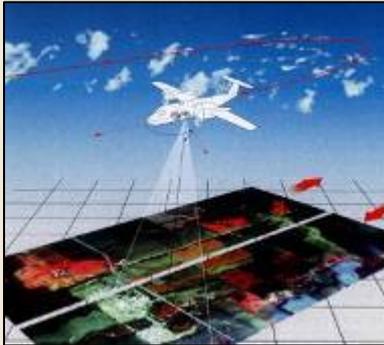
Fugro Geospatial Services

- Engineering company
- Fee for services business model
- **No licensing restrictions on geospatial data products**
- Major Business Lines:
 - Terrestrial Survey Services
 - Aerial Remote Sensing and Mapping Services
 - GNSS Augmentation Services
 - Geospatial Information Services

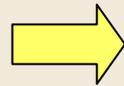


Multi-disciplinary end-to-end solutions

ACQUISITION



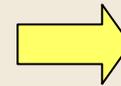
Advanced aerial data collection technologies using diverse sensor suite



PROCESSING



Sophisticated processing systems delivering high accuracy, quality, and fast turnaround



PRODUCT & APPLICATION DEVELOPMENT



Turnkey functionality to meet a multitude of needs

ISO 9001:2000-CERTIFIED SYSTEMS

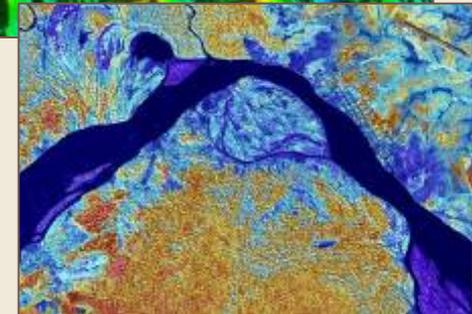
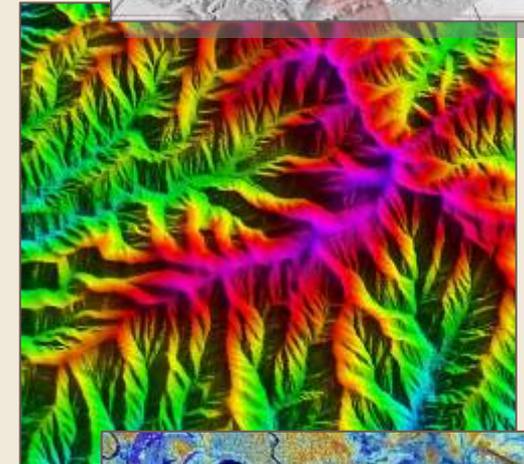


Fugro Geospatial Services – Aerial Mapping

Airborne imagery & photogrammetry: performing acquisition-to-production services for the creation of customized, high resolution mapping products from airborne imagery.

Topographic lidar mapping: acquiring high accuracy 3D elevation and surface feature data for efficient production of topographic mapping products.

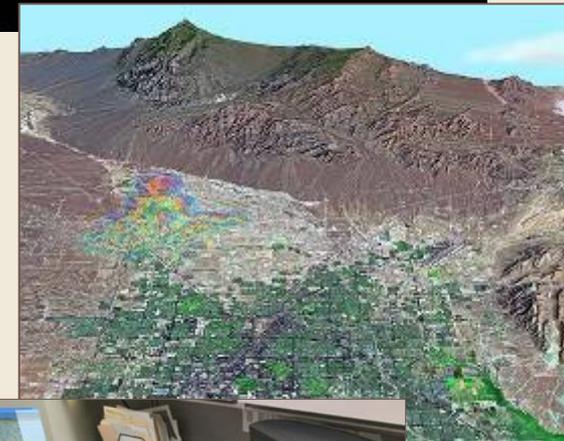
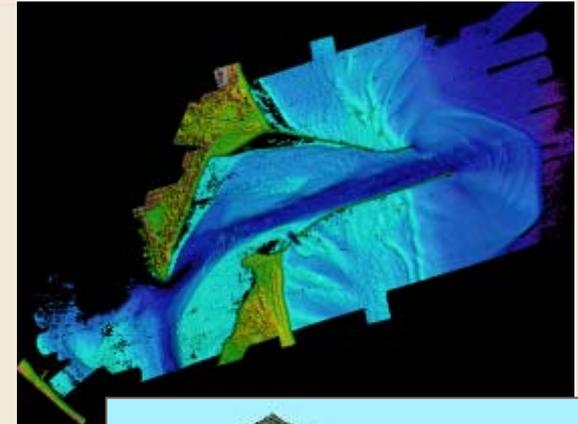
GeoSAR radar mapping: providing efficient large-area topographic mapping, through clouds and beneath foliage, at 1:50,000-1:25:000 map scales.





Other Fugro Survey Division Services

- **Hydrographic surveying:** airborne bathymetric lidar and vessel-based multibeam echo-sounding
- **Conventional/GPS land surveying**
- **OmniSTAR - GNSS augmentation:** high accuracy positioning services worldwide, 24 hours a day, 365 days a year
- **Satellite mapping:** image interpretation and DEM development (SPOT, Ikonos, QuickBird)
- **3D modeling & visualization**
- **Enterprise GIS:** designing and implementing enterprise systems that provide all users with common access to shared datasets and applications





Fugro Geospatial Airborne Acquisition Assets

Global Assets

- 21 geospatial aircraft
- 30 aircraft for airborne geophysics
- 7 large-frame digital cameras:
 - 5 Leica ADS40
 - 1 Zeiss DMC
 - 1 Vexcel UltraCam X
- 5 medium-frame digital cameras
- 10 large-frame film cameras
- 8 lidar systems:
 - 3 topographic lidar systems (ALS50/40)
 - 4 FLI-MAP high-density lidar systems
 - 1 bathymetric lidar system (SHOALS-1000T)
- 1 IFSAR system - GeoSAR





GeoSAR Mapping System

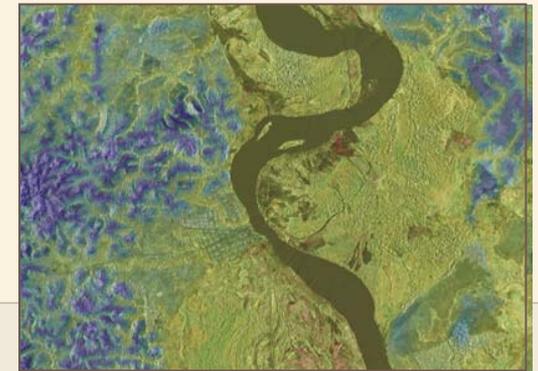
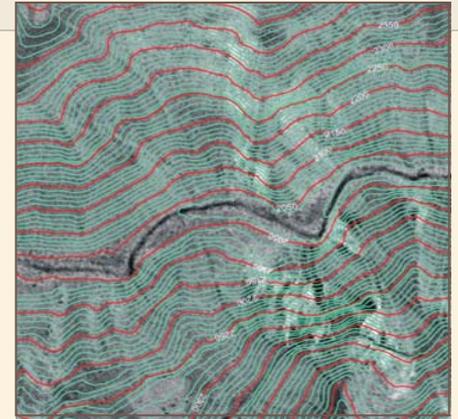




GeoSAR Mapping System

GeoSAR is the **only** dual-sided, dual-frequency, interferometric synthetic aperture radar (IFSAR) mapping system.

- GeoSAR is integrated onto a Gulfstream-II jet
- The IFSAR operates at 2 frequencies simultaneously
 - **X-Band**, First surface elevation models
 - **P-Band**, Foliage Penetration and Contour Generation
- The system produces accurate DEMs and SAR orthophoto mosaics





The GeoSAR System



Two X-band antennas: 9,630 to 9,790 MHz

Two P-band antennas: 270 to 430 MHz

Unique configuration allows simultaneous P and X-Band IFSAR collection



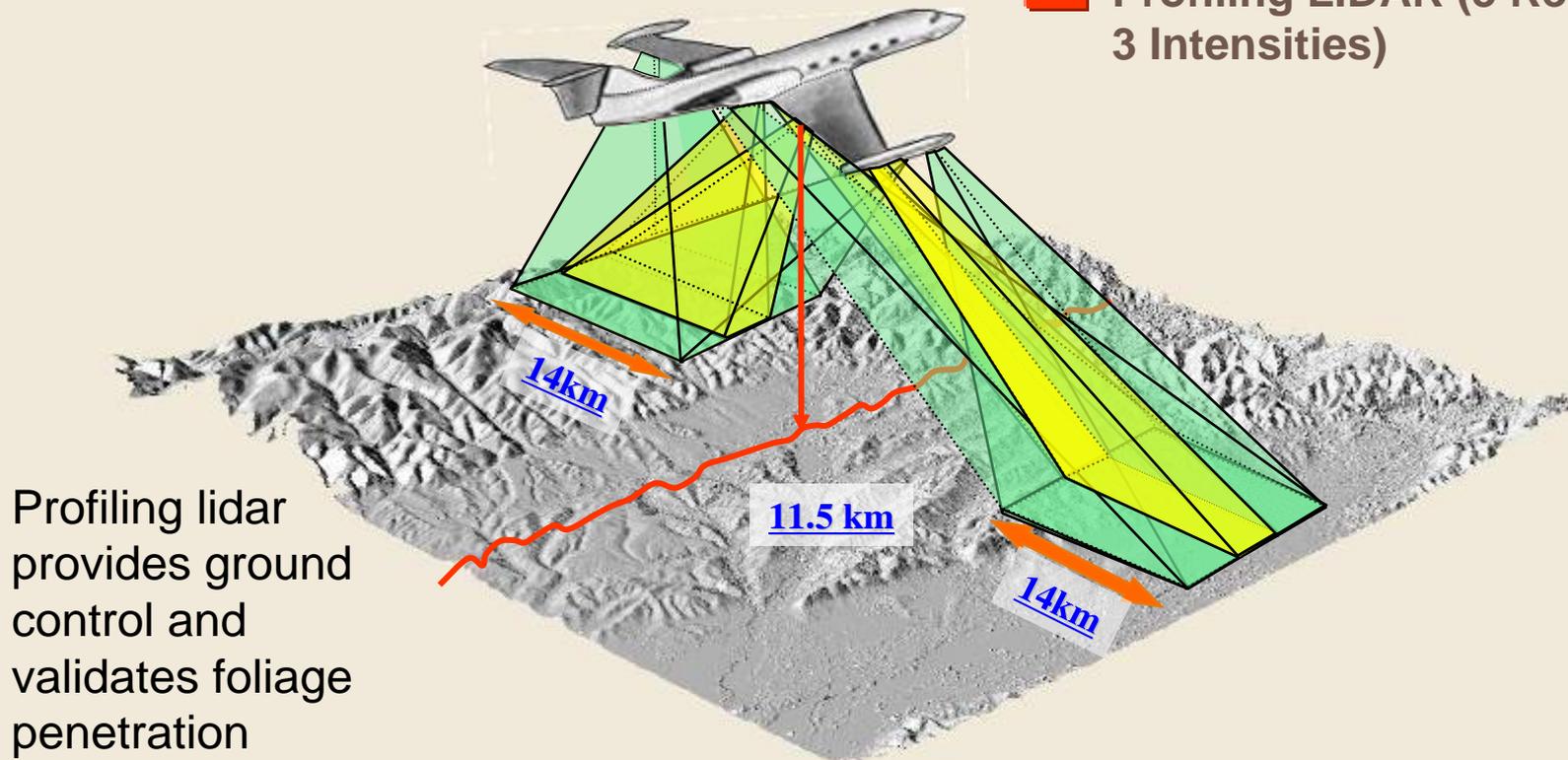
GeoSAR Collection Configuration

Collection Height:
10,000m to 12,000m MSL

 X-Band (3 cm wavelength)

 P-Band (85 cm wavelength)

 Profiling LIDAR (3 Returns, 3 Intensities)



Profiling lidar provides ground control and validates foliage penetration

- Collects 280 square km per minute
- Collects 1.2 GBytes of data per second



GeoSAR Collection Configuration

Integrated Lidar Profiler: GeoSAR incorporates a profiling lidar system for in-air ground control.

Characteristics:

- Variable pulse rate, 0 to 45 kilohertz (10,000 hertz at 10,000 meters AGL)
- 1064 nanometer wavelength
- 4-Watt laser transmitter, 0.15 mj max/pulse
- 8.5 nanosecond pulse width
- 3 ranges (first, second, true last) with 3 intensities (first, second, third)
- 3 m spot size at 10,000 meters AGL
- 2 cm post spacing at 180 m/s velocity

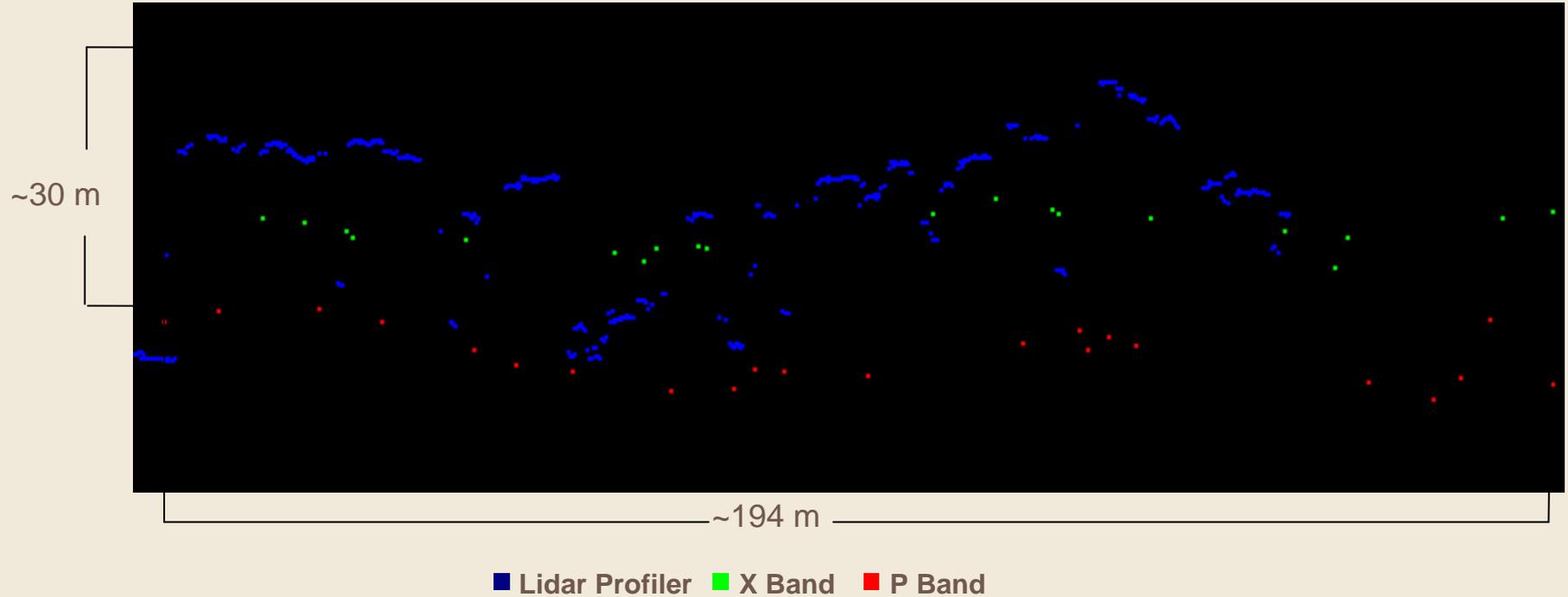
Advantages:

- Can provide an accurate measure of surface height
- Can serve as an excellent substitute to sending surveyors into difficult or dangerous areas for obtaining ground control points
- Can help to define the canopy structure of the foliage and help interpret P-band penetration



GeoSAR Collection Configuration

Example Lidar Profiler Data



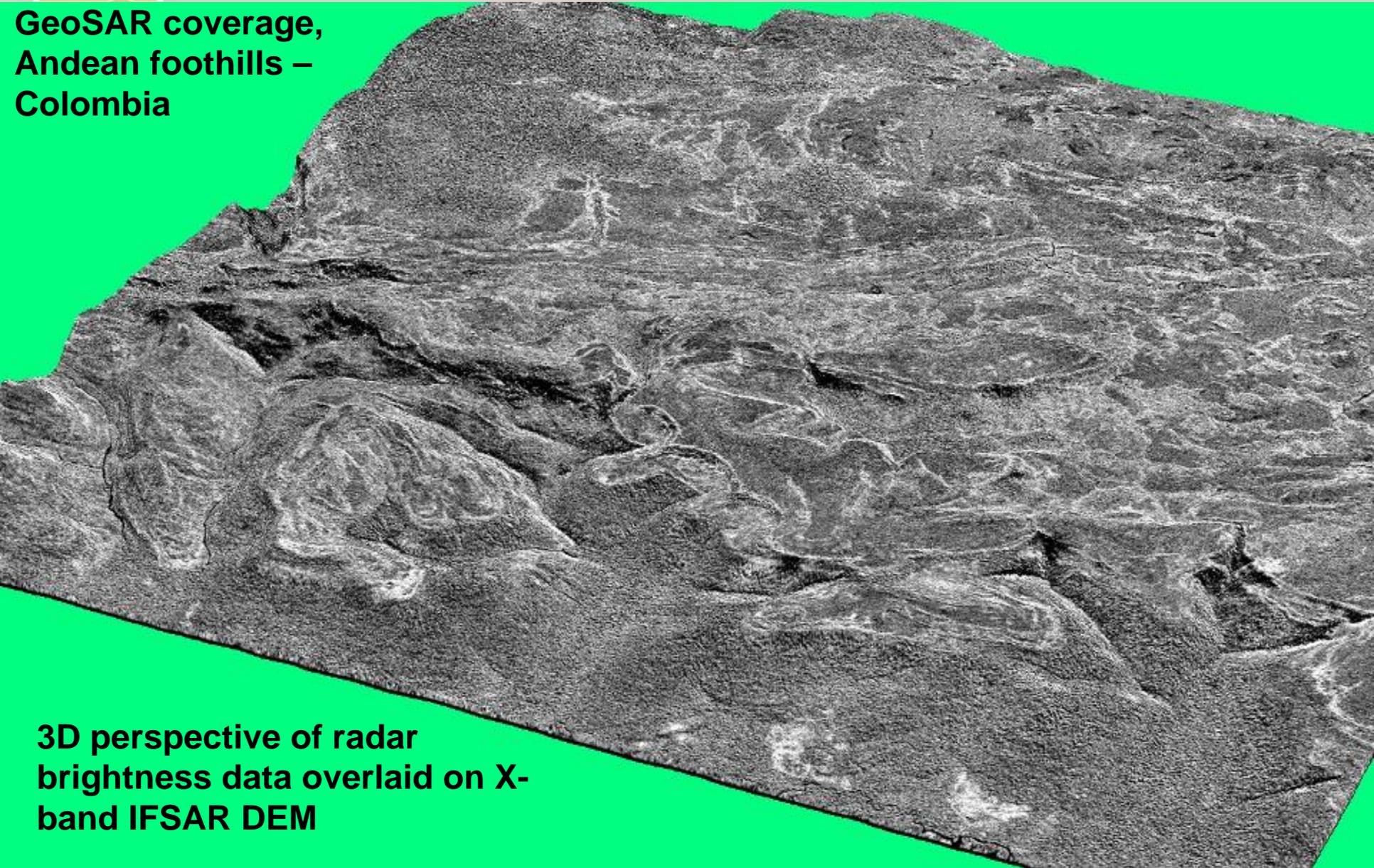


- The longer wavelength (85cm) of the P-Band SAR gives it foliage penetration or FOPEN capabilities.
 - Radar waves will propagate until they encounter an object with a radar cross-section as large as the wavelength.
 - For this reason, X-Band SAR, with a 3cm wavelength, will tend to scatter off tree tops, or have relatively shallow penetration.
 - P-Band will penetrate much deeper into the canopy, often all the way to the ground.



Foliage Penetration for Contour Generation

**GeoSAR coverage,
Andean foothills –
Colombia**

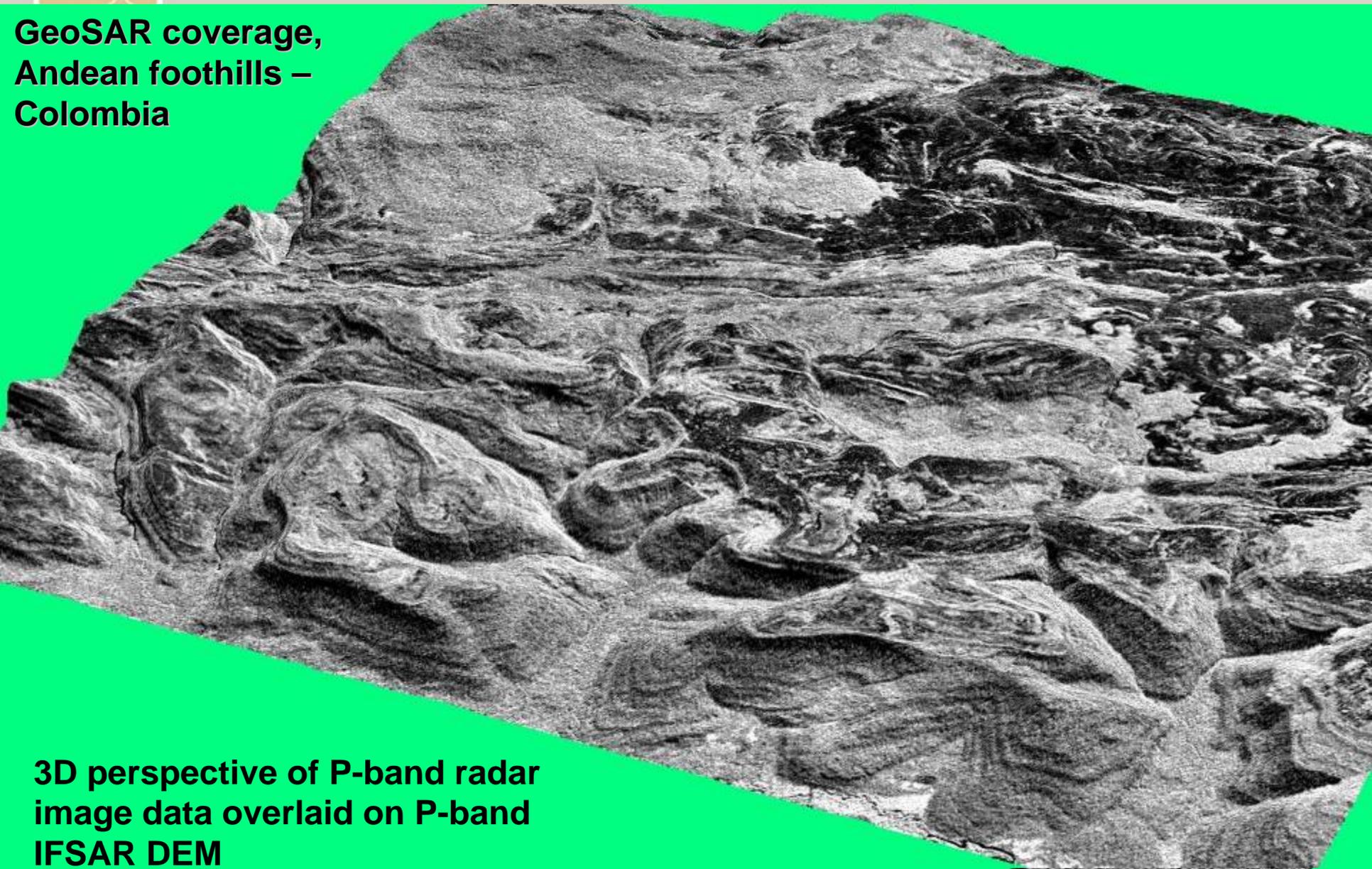


**3D perspective of radar
brightness data overlaid on X-
band IFSAR DEM**



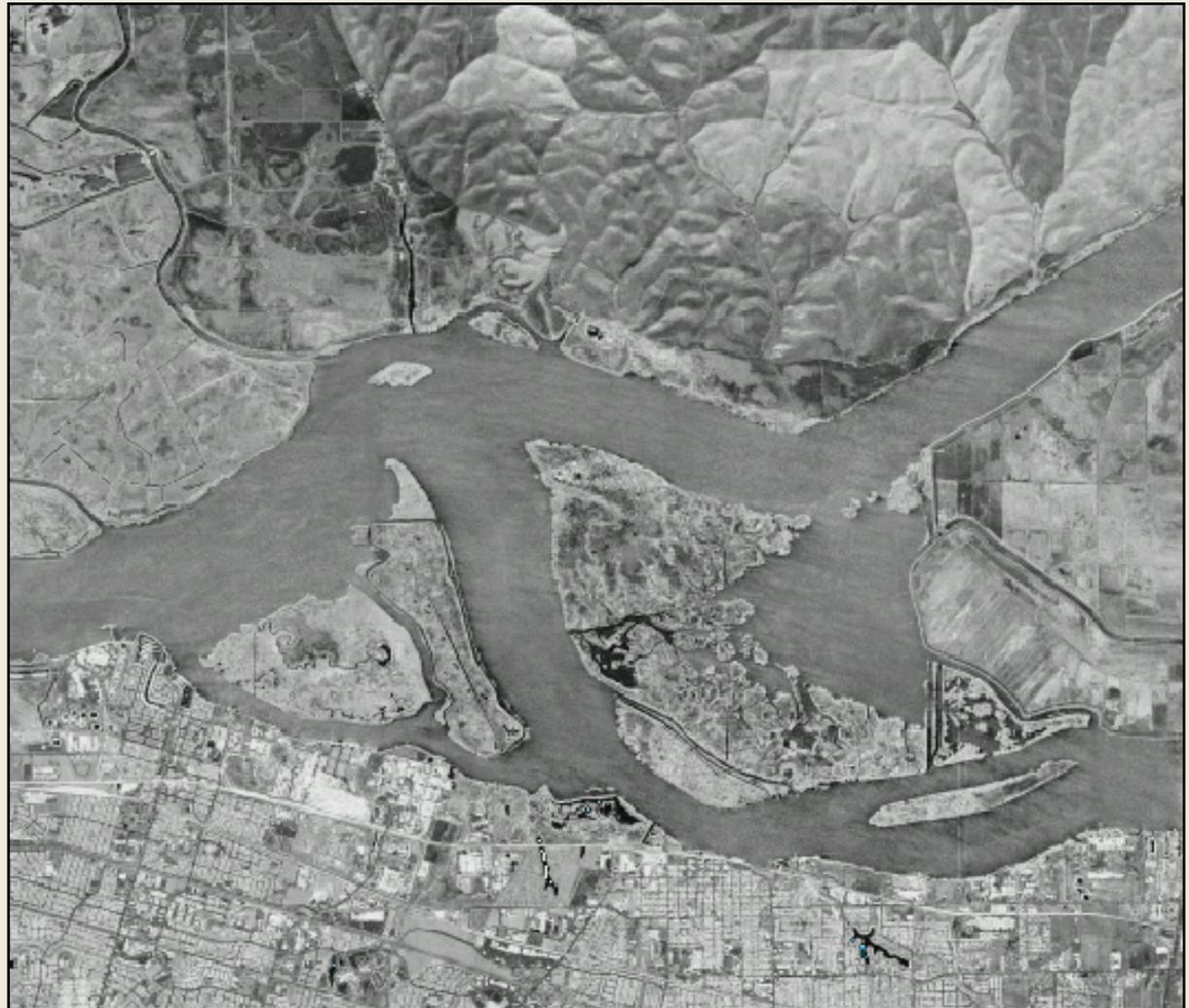
Foliage Penetration for Contour Generation

**GeoSAR coverage,
Andean foothills –
Colombia**



**3D perspective of P-band radar
image data overlaid on P-band
IFSAR DEM**

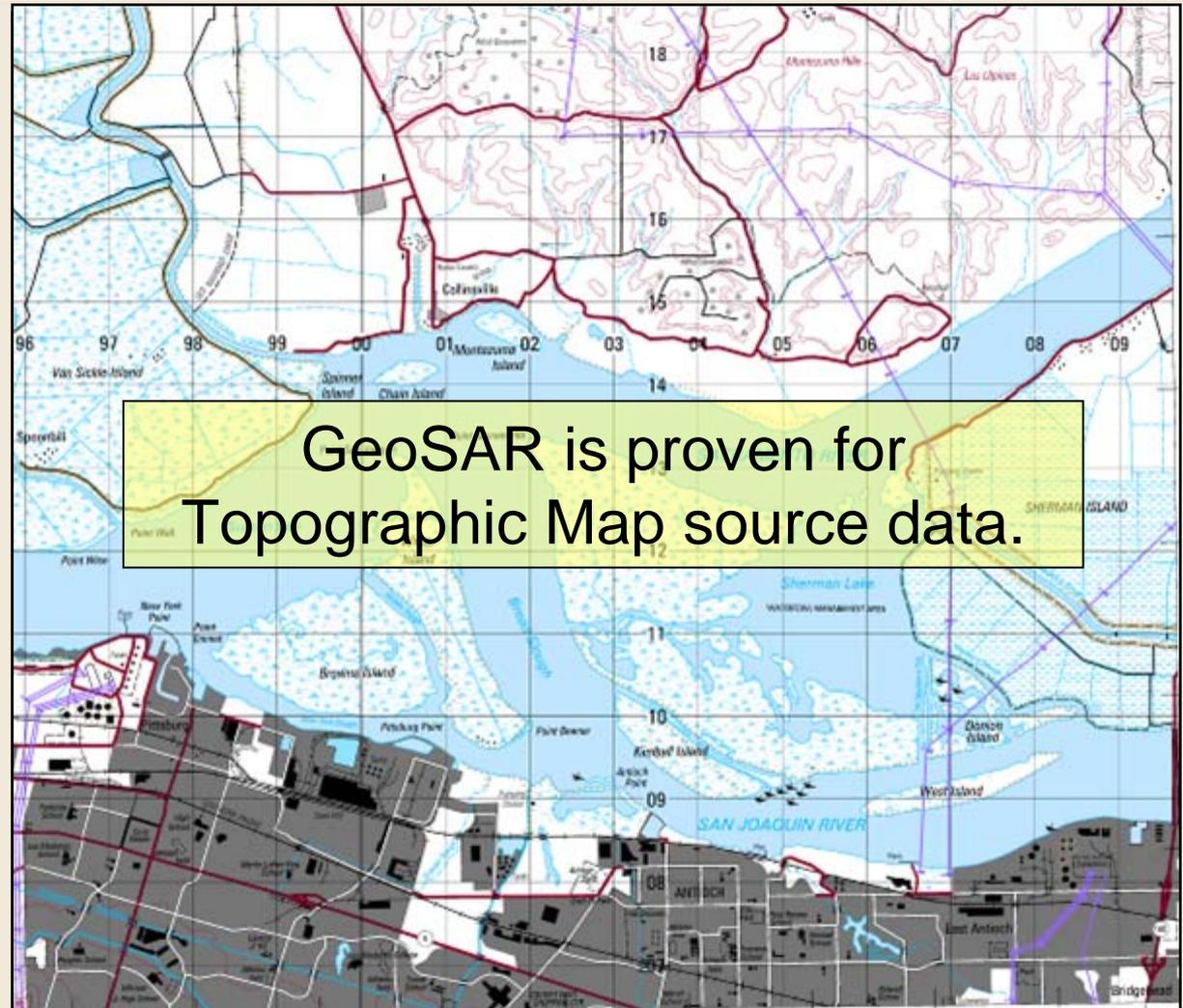
- GeoSAR data can be used to easily extract features for standard mapping products.
- The data can be used both in monoscopic and stereo extraction.



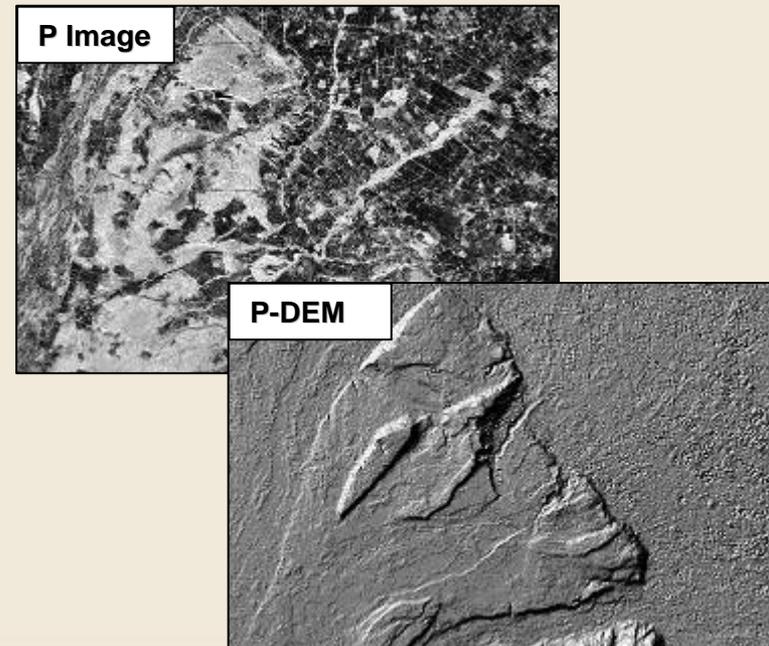
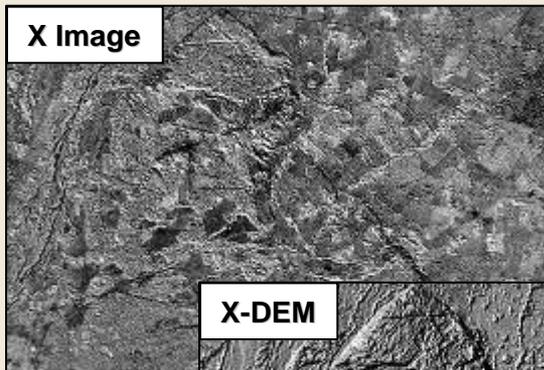


Topographic Mapping

- GeoSAR data can be used to easily extract features for standard mapping products.
- The data can be used both in monoscopic and stereo extraction.



- Orthorectified radar imagery
 - P-band imagery: 5 m pixel resolution data depicting ground features and structures hidden beneath foliage and very dry soils
 - X-band imagery: 3-5 m pixel resolution data depicting above ground features
- Digital elevation models
 - P-band DEM: 5 m post-spacing near bare-earth surface models with 5-10 m vertical accuracies (RMSE)
 - X-band DEM: 2.5-3 m post-spacing reflective surface models with 2-5 m vertical accuracies (RMSE)





GeoSAR Product Specifications

	X-band	P-band
<u>GeoSAR DEM</u>		
Height Accuracy	1.0 - 2.5 meters	2.0 - 5.0 meters
Planimetric Accuracy	1.0 - 2.5 meters	2.0 - 4.0 meters
Standard post-spacing	3.0 meters	5.0 meters
<u>GeoSAR Imagery</u>		
Planimetric Accuracy	3.0 meters	5.0 meters
Standard resolution	1.25 – 3 meters	3 – 5 meters
Polarization	VV	HH & HV or VV & VH



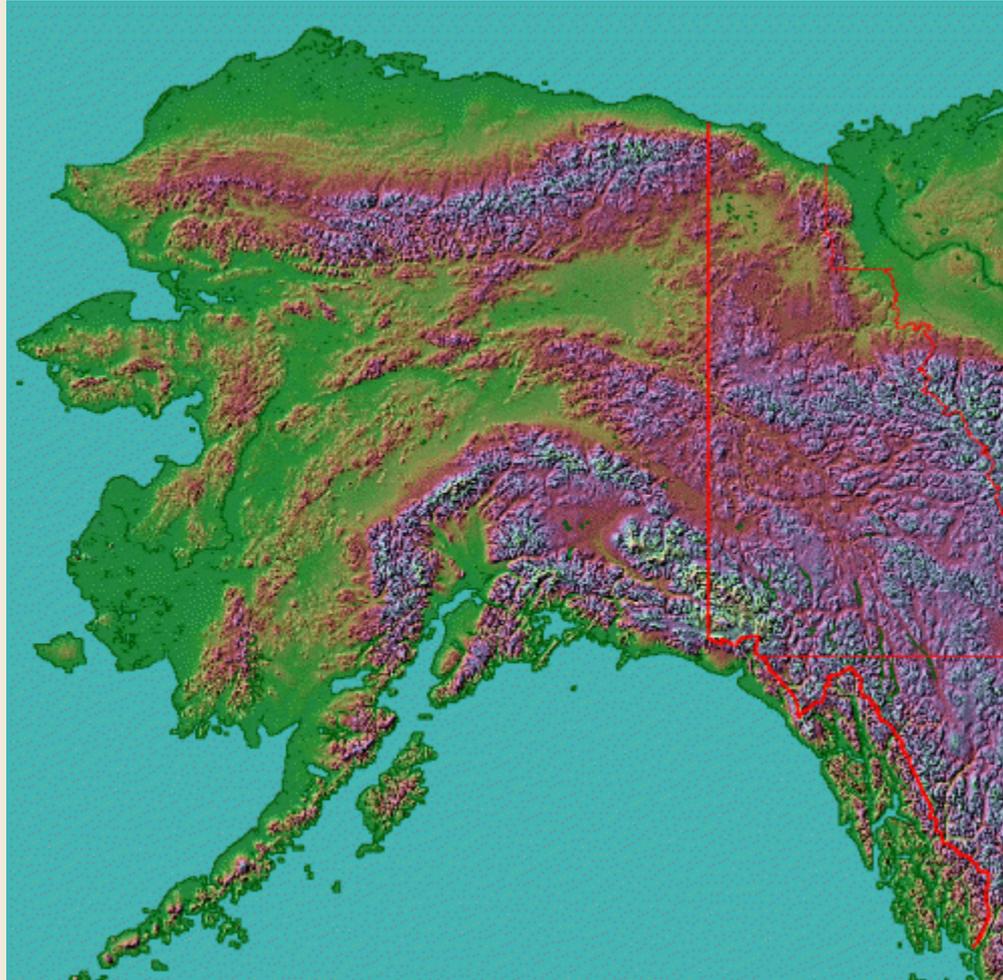
GeoSAR Value-added Products

- Image Products
 - Σ_0 image product which normalizes the backscatter return per unit area; useful in land-cover extraction and similar tasks
 - False-color images that are a combination of X- and P-band image data
 - Stereopairs created from SAR imagery and elevation models
- Digital Terrain Model (DTM)
 - Produced by a combination of the X-band DEM (for open terrain) and the P-band DEM for forested terrain
 - Requires some editing and filtering to produce bare-earth model
- Fugro EarthData can produce a wide variety of other value added products from GeoSAR data, including topographic and thematic mapping with extraction of specific data types, such as break-lines, contours, drainage, and road networks



Alaska Statewide Digital Mapping Initiative

- Fugro participated in the July 2008 Alaska DEM Workshop.





Alaska Experience

Fugro in Alaska: Since 1973, Fugro companies have been working in Alaska to support government, academia, and private-sector customers.

Services have included:

- Onshore airborne geophysical surveys
- Offshore geophysical surveys
- Offshore geotechnical programs
- Offshore cable route surveys
- Harbor surveys
- Hydrographic surveys by sea and air



Alaska contracts include work for mining and oil & gas companies, the U.S. Dept of Transportation, the U.S. Army Corps of Engineers, NOAA, the AK Dept of Fish and Game, and the University of Alaska



Alaska Statewide Digital Mapping Initiative

- The summary report of September 2008 related key user requirements:
 - **Elevation Surface**
 - Both Bare Earth and Reflective Surface models are required
 - Need ability to measure bare earth terrain in forests.
 - **Elevation Type**
 - Both Ellipsoidal and Orthometric Heights
 - Requires updated geoid model (GRAV-D Project)
 - **Vertical and Horizontal Accuracy**
 - **High Accuracy Requirements**
 - Mainly driven by NOAA Coastal Services Center
 - » Lidar to support 2' contour accuracy in coastal areas
 - » Differential IFSAR to measure mm scale subsidence and uplift
 - **Medium Accuracy Requirements**
 - Statewide requirements
 - Mainly supported by Airborne IFSAR



- FUGRO offers an integrated solution
- Fugro is a global company with a wide variety of technical and logistical experience.
- We are uniquely positioned to offer an integrated solution that will produce an accurate National Digital Elevation Model that can be accurately reduced to Mean Sea Level coordinates and be monitored in areas of rapid change.



Alaska Statewide Digital Mapping Initiative

- Digital Elevation Program:
 - **Fugro EarthData Incorporated** GeoSAR IFSAR aircraft, as well as lidar and digital camera technologies.
- GRAV-D Project:
 - The GeoSAR aircraft is capable of carrying the NOAA TAGS gravity sensor during the IFSAR operations.
 - Both aircraft environment and flight regime are compatible.
 - **Fugro Airborne Services** has long experience in gravity collection and modeling, and owns a TAGS sensor.
- Elevation Change Monitoring
 - **Fugro NPA** is a world leader in the use of differential Interferometry (DiFSAR) to monitor elevation changes due to tectonics, glacial rebound, and extraction activities.

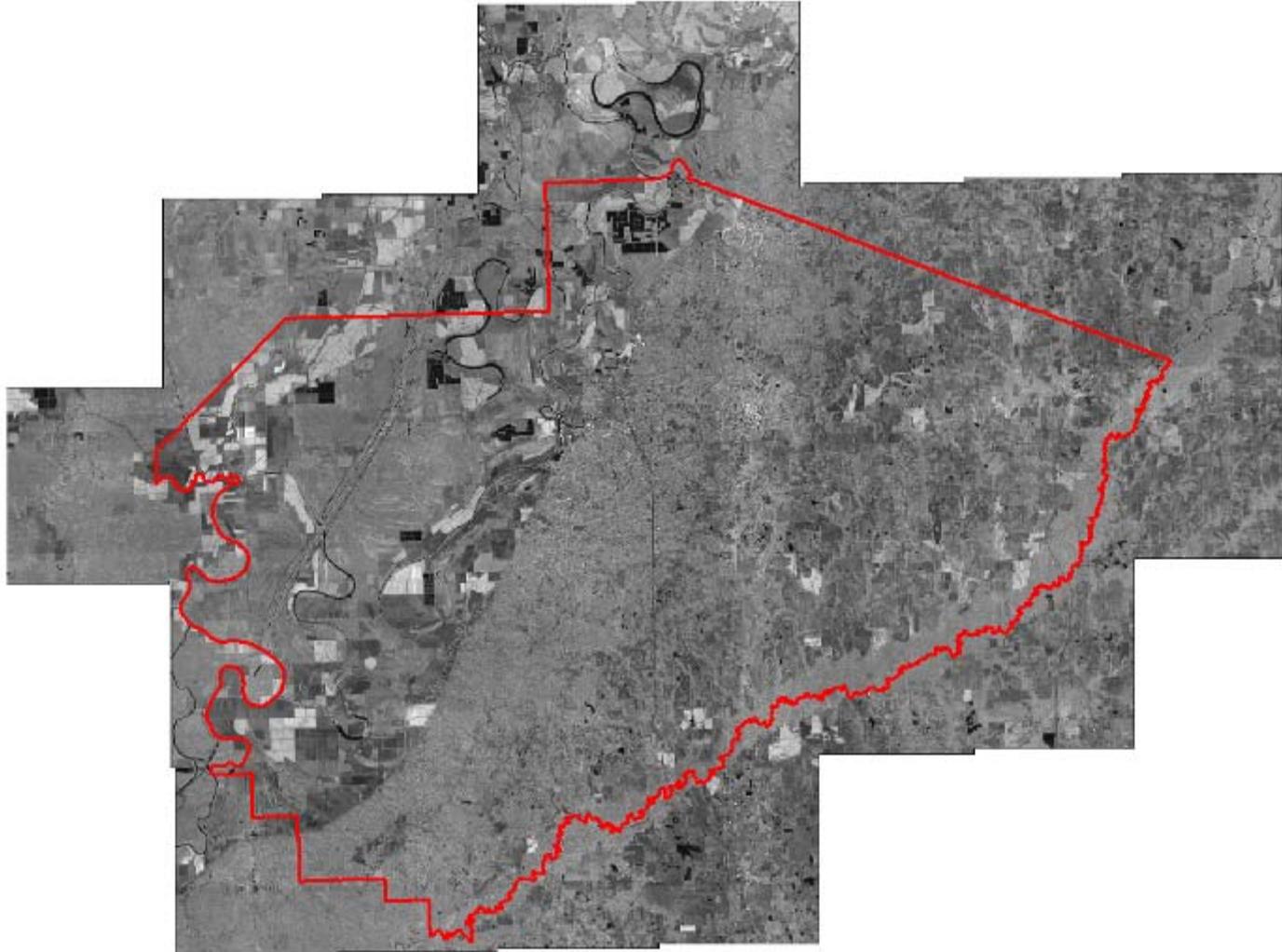


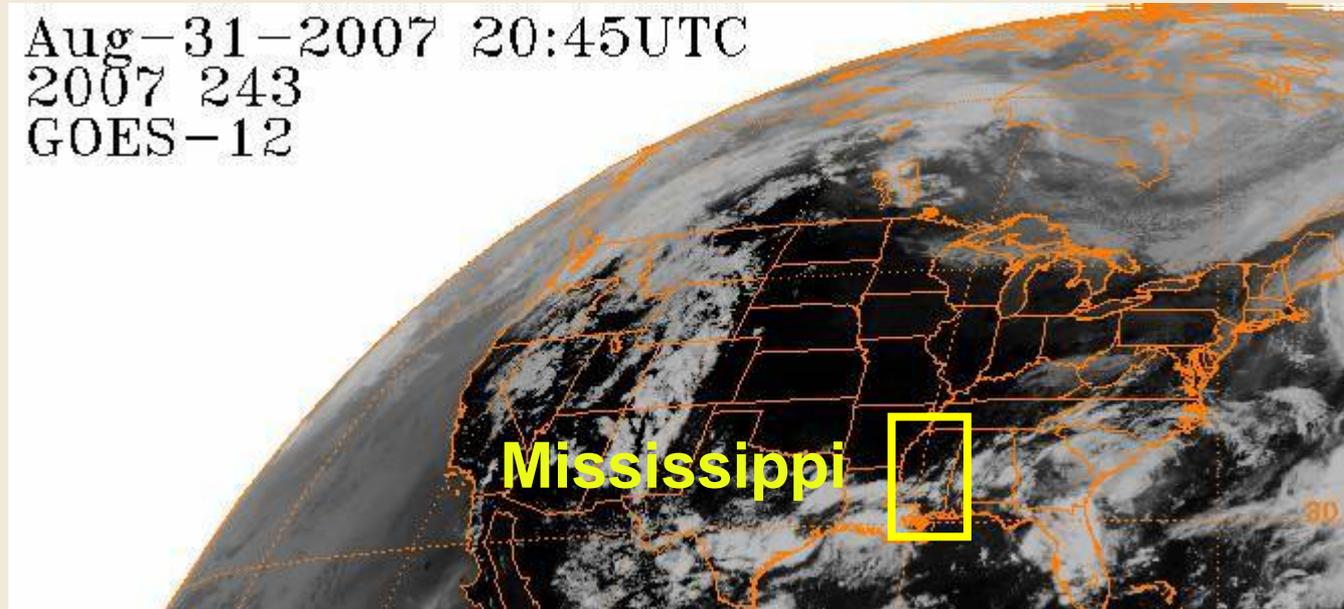
GeoSAR USDA Yazoo County Project

- Fugro EarthData Incorporated collected Yazoo, County Mississippi with GeoSAR in August, 2007.
- The main goals of the project was to:
 - Demonstrate the ability to augment or replace NAIP image data collection with radar imagery.
 - Collect imagery during NAIP collection window when normal optical sensors can't operate: eg. night, clouds.
 - Produce a high resolution digital elevation model over the county.
 - Register with Common Land Unit vectors.
 - Demonstrate the use of GeoSAR data to perform crop identification.
- 28 7.5 minute quads of X and P Band Digital Elevation Models and Orthophoto mosaics were produced.
- An object-oriented classification of the 3 main crop types (Corn, Cotton and Soy Beans) was performed.



GeoSAR USDA Yazoo County Mississippi Project

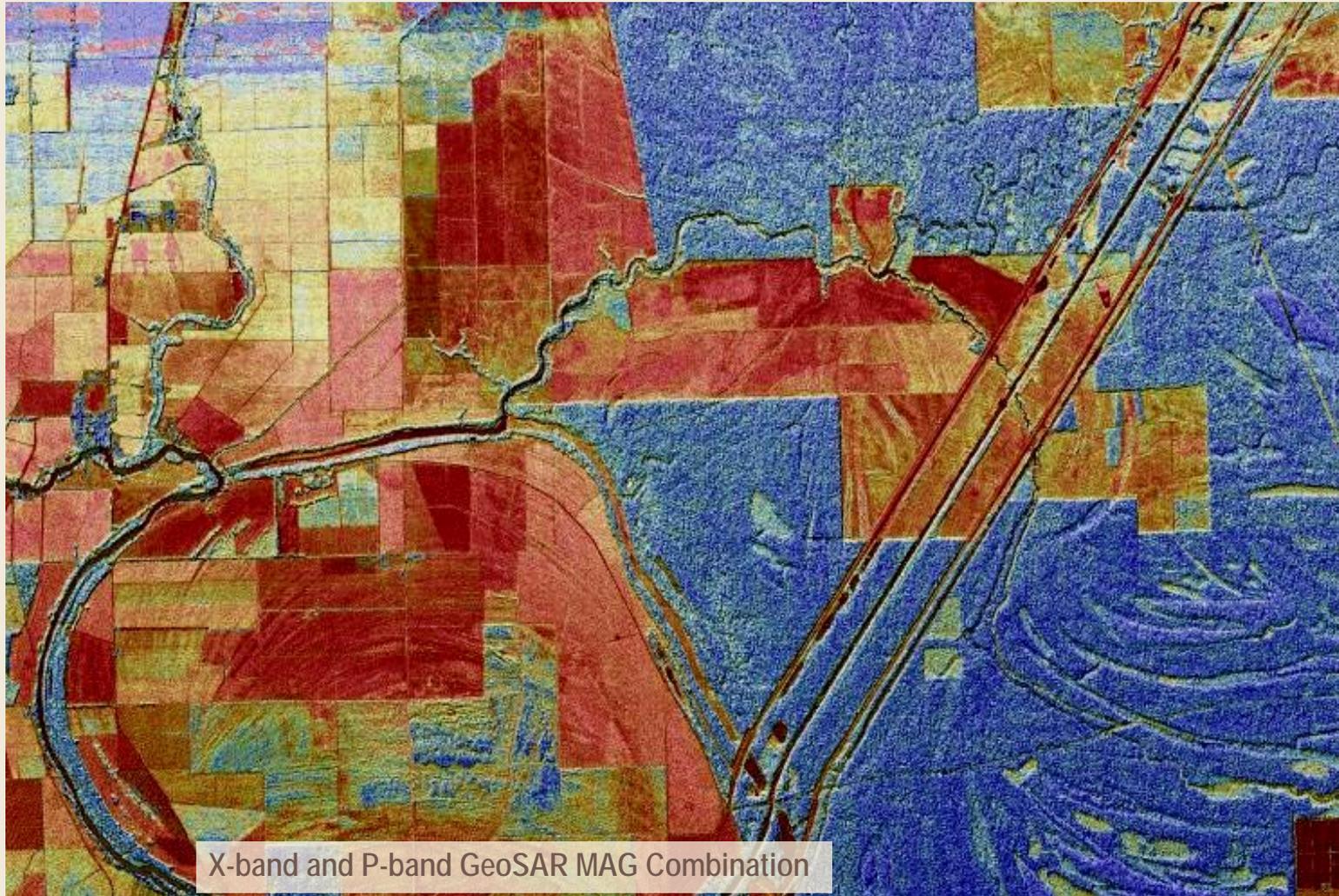




- GOES-12 IR Images of Eastern US from Aug 29-31 2007, about 09:00 AM to 03:00 PM (Typical Imaging window for optical images).
- Demonstrates ability to collect during cloudy weather.



Yazoo County GeoSAR Image



X-band and P-band GeoSAR MAG Combination



Yazoo County GeoSAR Image



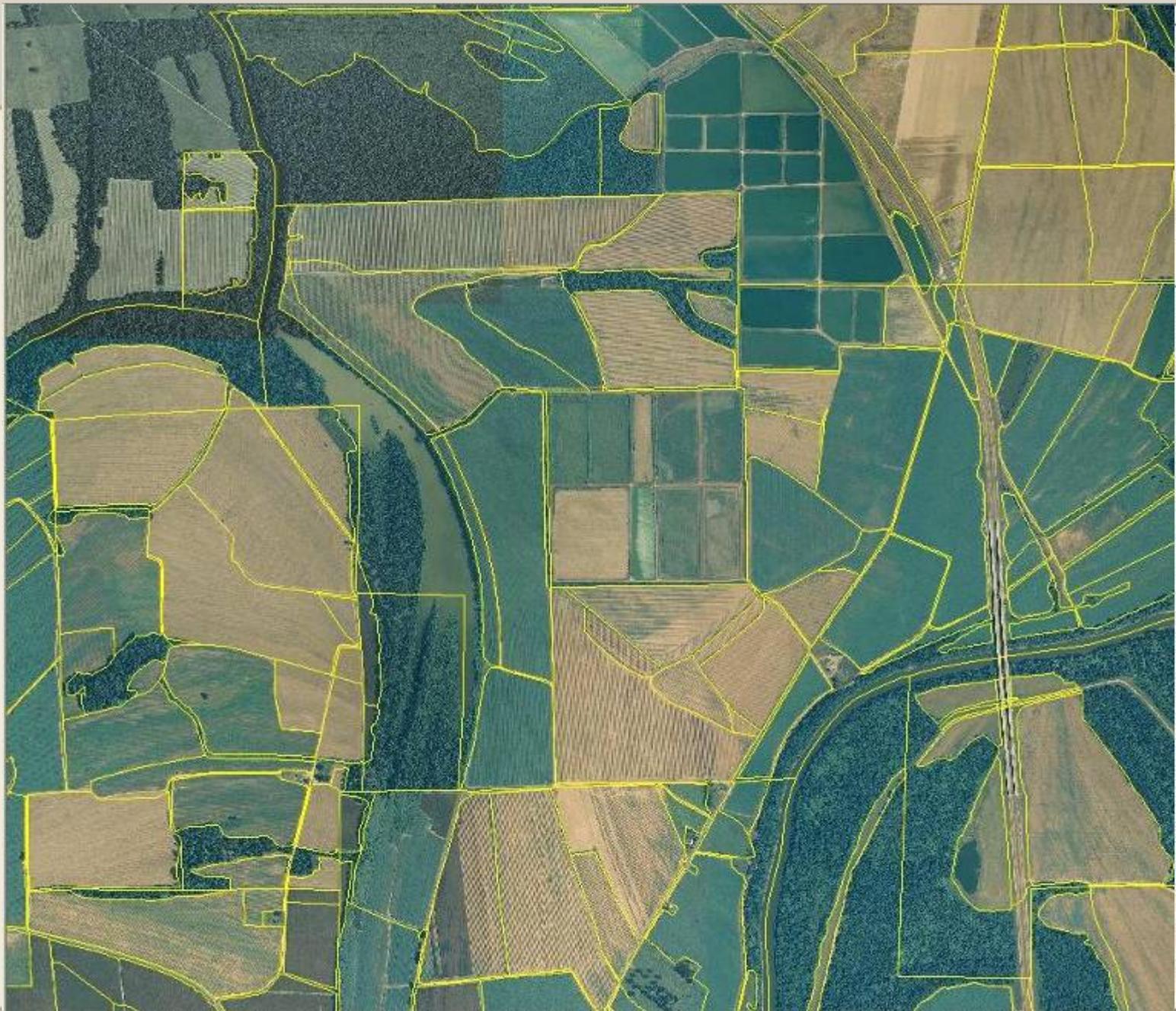
USDA NAIP IMAGE



GeoSAR IMAGE



NAIP Image With CLU





X Image
With CLU



GeoSAR Derived Crop Classification

Reference Data

	3 X 3	Corn	Cotton	Soybeans	Totals	User's Accuracy
Map Data	Corn	27		1	28	0.96
	Cotton		12	2	14	0.86
	Soybeans	1	2	8	11	0.73
	Totals	28	14	11	53	
	Producer's Accuracy	0.96	0.86	0.73		0.89

Used Definiens software and Classification and Regression Tree (CART) techniques to classify fields in the Common Land Unit data set.



I would be happy to entertain questions.

