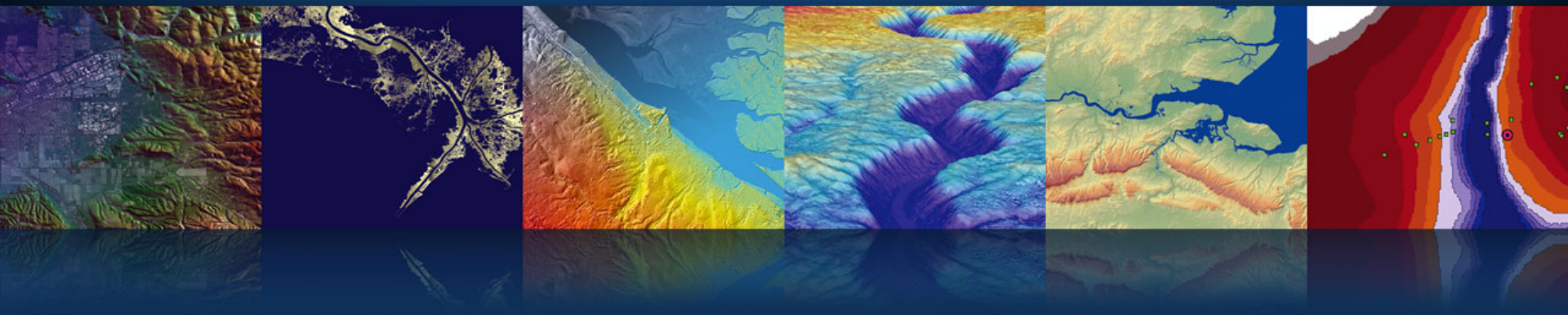

SAR Imagery: Airborne or Spaceborne?

Presenter: M. Lorraine Tighe PhD

Introduction

- The geospatial community has seen a plethora of spaceborne SAR imagery systems where there are now extensive archives for COSMO-SkyMed, ENVISAT, TerraSAR-X, and Tandem-X sensors.

- In addition, there are a handful of airborne SAR sensors from Intermap, Fugro, and Orbisat are also in operation collection high volumes of SAR data.

- But which platform air- or space is the most optimal system for a given application?

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Agenda

- Spaceborne Platforms (USGIF Group)
  - Specifications
  - Mapping Capabilities
- Airborne Platforms (USGIF Group)
  - Specifications
  - Mapping Capabilities
- Applications
  - Intelligence and Defense
  - Flood hazard and Risk Assessment
  - Mapping

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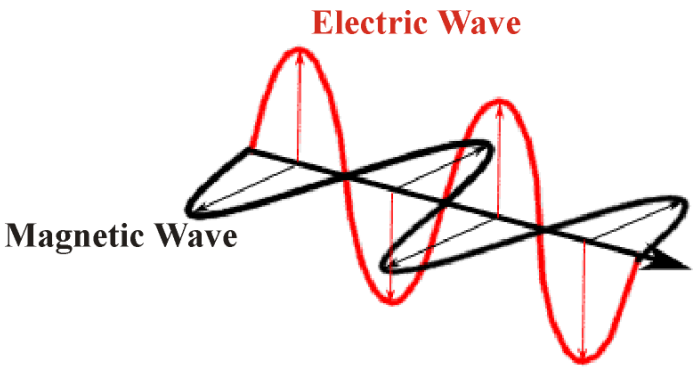
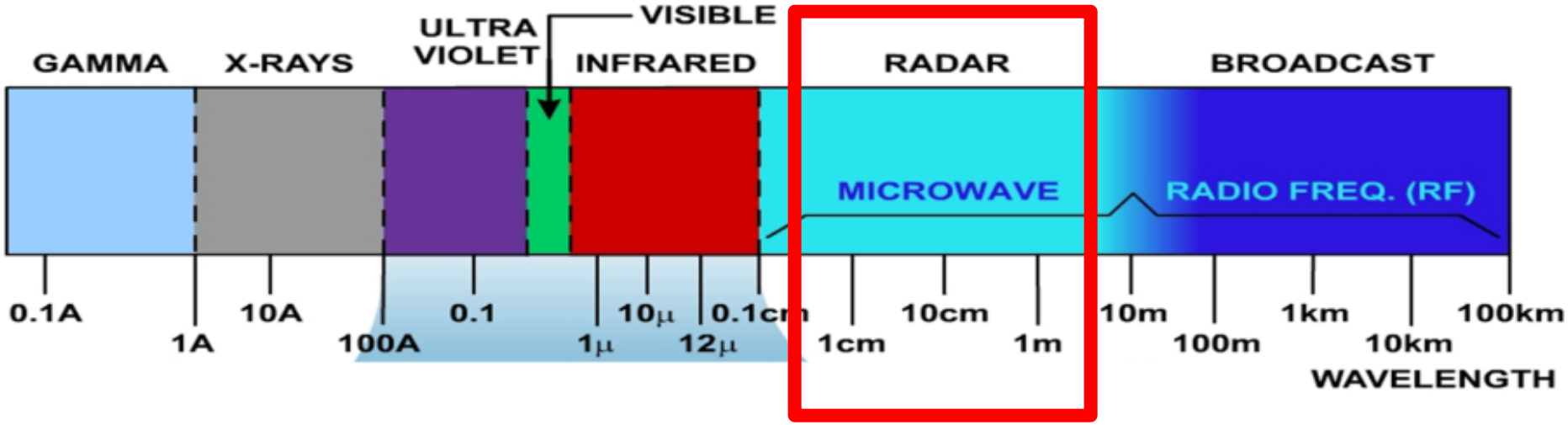
Basic SAR Operating Principles

- Electromagnetic (EM) wave is a changing electric field that produces a changing magnetic field.



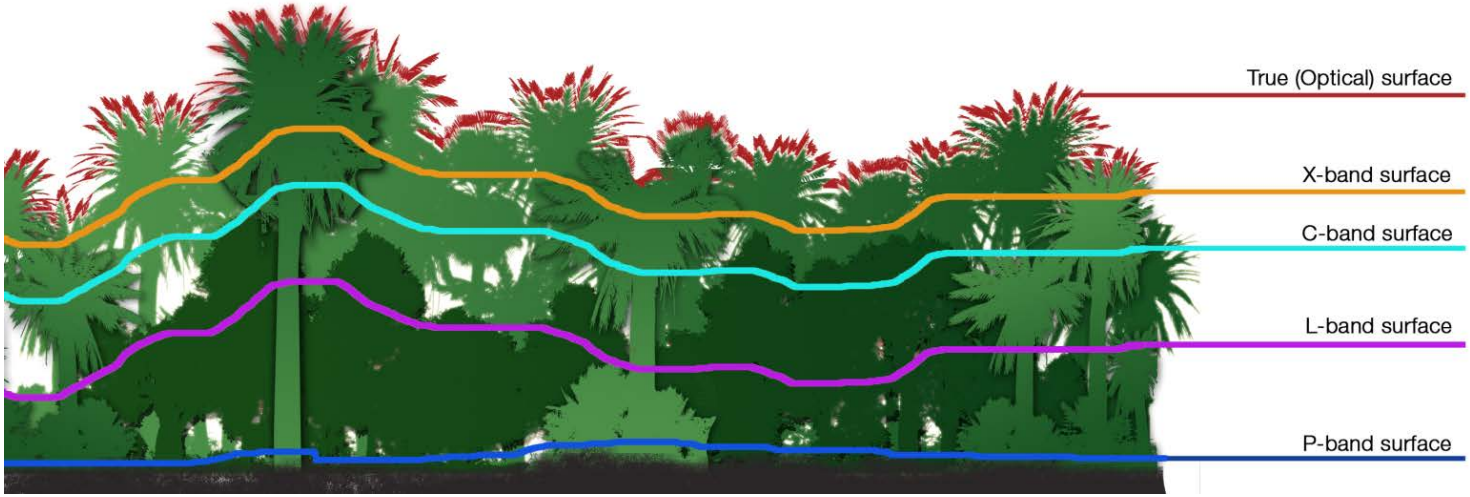
- EM is sensitive to moisture content and structure of the object being imaged.



SAR Signal Penetration

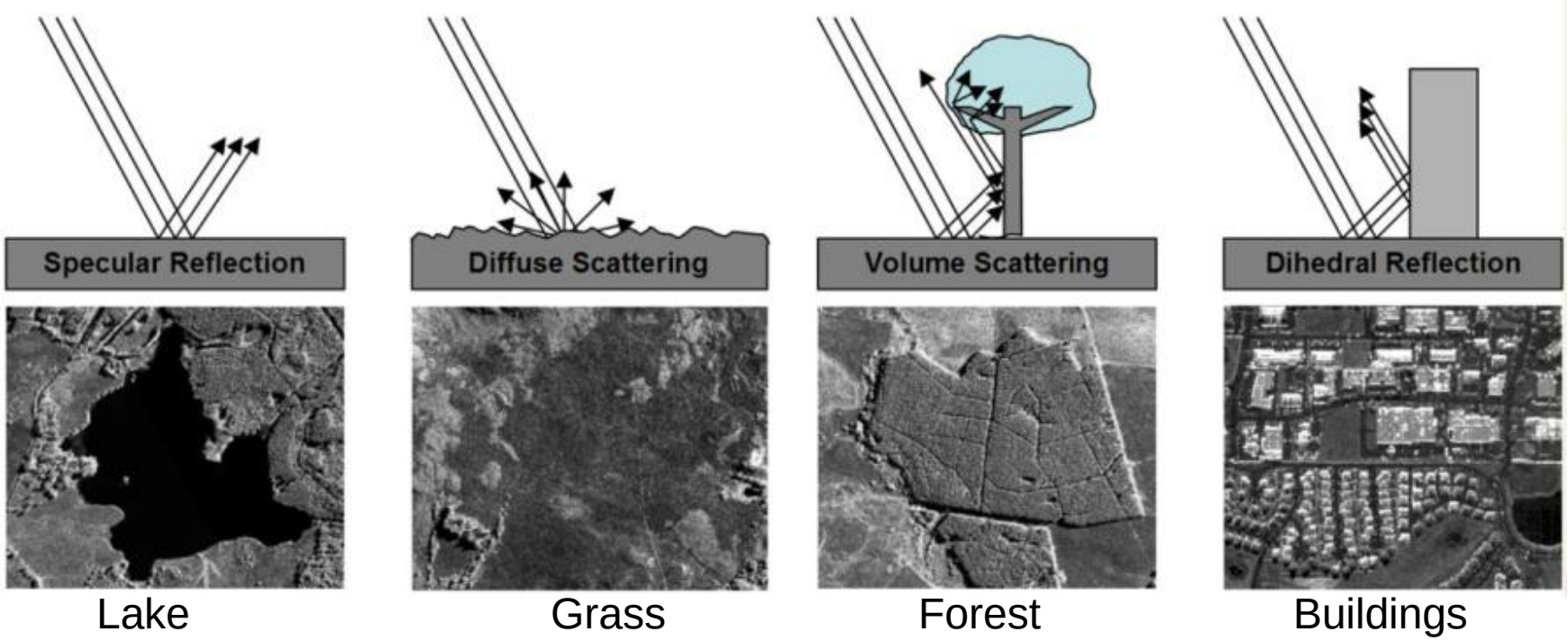
- Penetration at radar wavelengths is a function of many factors (moisture, structure, canopy density, land cover type, slope, incidence angle, position in swath, resolution, post processing).

- This illustration is often accepted to represent signal penetration into the canopy, but in reality – focusing on the X and P bands, penetration is deeper.



SAR Product: Orthorectified Image

- **SAR images** are formed by processing the amount of energy that is reflected or backscattered from a specific area of the terrain being imaged and recorded by the radar sensor. **Radar backscatter** is the portion of the outgoing radar signal that the target redirects directly towards the radar antenna.



Airborne

INTERMAP

	AIRBORNE - SAR		
Sensor	**NEXTMap**	**GeoSAR**	**GeoSAR**
Country	Canada	USA	USA
Wavelength	X	X	P
Polarization	HH	VV	HH/VV
InSAR Pass	Single	Single	Single
Ground Control Required	Minimum	Minimum	Minimum
DEM Type	DSM/DTM	DSM	DSM/DTM
DEM GSD	5m	3-5m	5m
Vertical Accuracy - RMSE	0.6m (2') - 9m (29.5')	1m (3.2') - 10m (32.8')	2m (6.4') - 7m (23')
Mapping Contour Interval	2m (6.6') - 29m (96')	3.3m (11') - 33m (107')	6.5m (21') - 29m (96')
Mapping Scale DTM Contours	5,000	5,000	5,000
Image Resolution	0.50m & 1.25m	1.5-3m	3m
Horizontal Accuracy - CE90	2m	3m	3m
Mapping Scale: Planimetric Feature Extraction	10,000	15,000	15,000
Data Availability Coverage	18M km^2 /For Hire	For Hire	For Hire
Data Availability in Cloud Belt	Yes	Yes	Yes

Spaceborne

INTERMAP

	SPACEBORNE - SAR			
Sensor	TerraSAR-X	Tandem-X	COSMO-SkyMed	RADARSAT
Country	Germany	Germany	Italy	Canada
Wavelength	X	X	X	C
Polarization	Quad	Quad	Quad	HH/VV
InSAR Pass	Repeat	Repeat	Single	Single
Image Resolution	2.5m	2.5m	3m	3m
Horizontal Accuracy - CE90	10m	10m	5m	3m
Mapping Scale: Planimetric Feature Extraction	25,000	25,000	50,000	50,000
DEM Type	DSM	DSM	DSM	DSM
DEM GSD	12m	12m	10m	10-20m
Vertical Accuracy - RMSE	10m (33') - 20m (66')	10m (33') - 20m (66')	10m (33') - 20m (66')	10m (33') - 20m (66')
Mapping Contour Interval	33m (108') - 65m (213')	33m (108') - 65m (213')	33m (108') - 65m (213')	33m (108') - 65m (213')
Mapping Scale DTM Contours	15,000	15,000	20,000	25,000
Data Availability in Cloud Belt	Yes	Yes	Yes	Yes

Airborne vs. Spaceborne SAR

INTERMAP

- **Resolution**
  - ORI Images – 0.5 m vs 3 m

    DEM Posting – 3 m vs 10 m
- **Vertical Accuracy**
  - 1 m RMSE vs 10 m RMSE; 2 m Contours vs 33 m Contours

NEXTMap ORI

Airborne vs. Spaceborne SAR

INTERMAP

- **Horizontal Accuracy**
  - 1:10,000 vs 1:25,000 - 1:50,000

Airborne vs. Spaceborne SAR

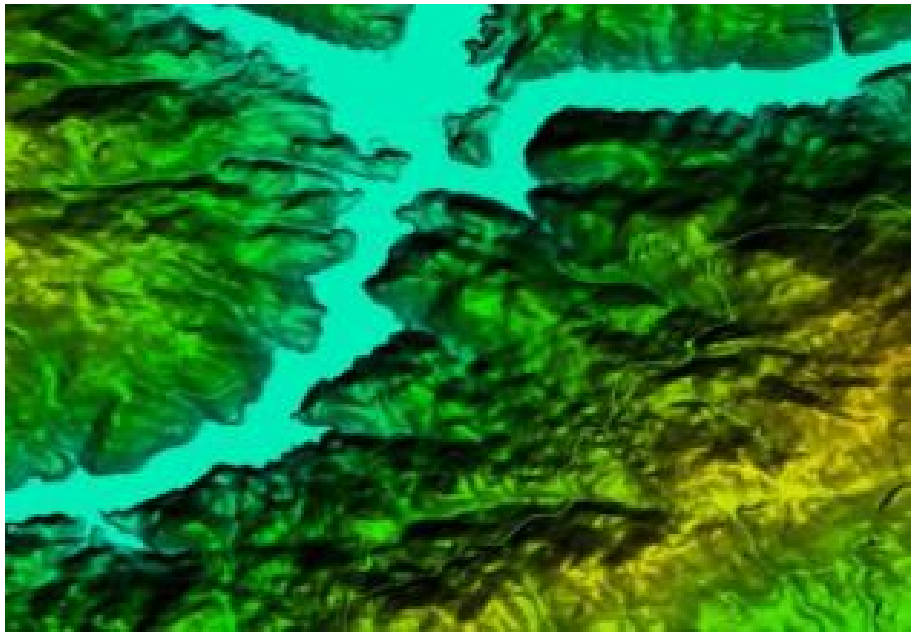
INTERMAP

- Acquisition
  - Airborne not constrained to polar orbit paths can fly at any orientation to reduce shadow and layover = less voids and interpolation

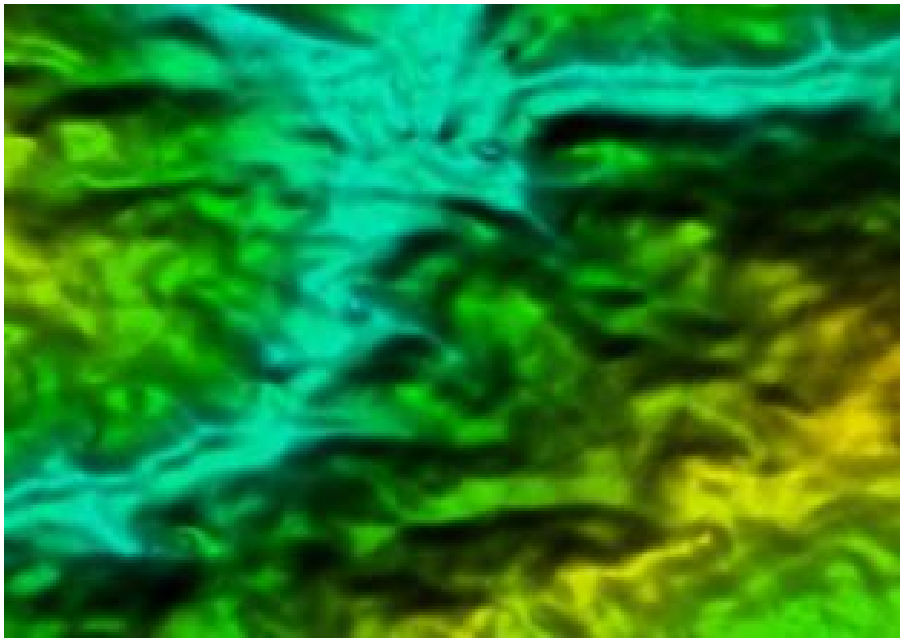
- Spaceborne
  - Short wavelength operation (X – L band)
  - Relatively larger size antenna required
  - Effects of ionosphere on image formation
  - Resultant difficulties involved in calibrating image products
  - Less signal to noise ration
  - Repeat-pass IFSAR collections

Airborne Vs Spaceborne DEMs

- Airborne SAR sensors to date still have higher accuracies compared to spaceborne platforms.
- 1:10k-15k scale base mapping in regions of the cloud belt that contain out dated and poor resolution maps.



5m DSM (air)



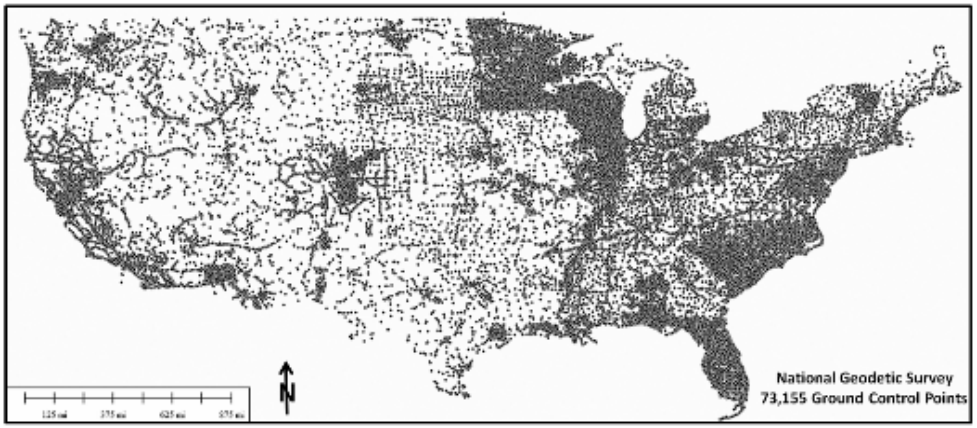
30m DSM (space)

Example Airborne SAR DTM in the Lower 48

INTERMAP

Area Size: 3,119,985 miles^2 (8,080,464.3 km^2)

7.5” Tiles 55,150



# NGS Samples	X-HH InSAR DTM	
	RMSE (m)	Mean Error (m)
73,155	1.08	0.31

SAR Sensor Applications Summary

INTERMAP

Application	Airborne	Spaceborne
Area Elevation Derivation		
Disaster Assessment		
Flood Mapping		
Hydrology Mapping		
Forestry Applications - Biomass		
Forestry Applications - Canopy Height		
Forestry Applications - DBH		
Mapping and Charting - Imagery for Reconnaissance		
Mapping and Charting - Imagery for Topographic Mapping		
Trail and Path Detection		
Structure Location and Identification		
Surveillance		
Area Features and Surface Type Identification		
Change Detection		

Thank You

INTERMAP

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The Commercial Airborne Working Group (CAWG) is pleased to offer this workshop on the capabilities of airborne acquired GEOINT data solutions and sensor phenomenology through several informative training modules.

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