THE APPLICATIONS AND BENEFITS OF SYNTHETIC APERTURE RADAR
Overview

- Introductions
- What is SAR?
- SAR benefits
- SAR in ENVI
- Applications

Agricultural Monitoring in the Mekong river delta 2014 – 2016 with Sentinel-1
An integrated software platform for operational processing of SAR data

- ENVI UI
- ENVI Workflows
- ENVI Modeler
- ArcGIS Pro
- Desktop-Enterprise-Cloud
The Applications and Benefits of Synthetic Aperture Radar Technology to Connect, Inform and Protect

Run SARscape where you are most comfortable.

ENVI UI
ENVI Workflows
ENVI Modeler
ArcGIS Pro
Desktop-Enterprise-Cloud
What is Synthetic Aperture Radar?

SAR antenna

Backscattered radar pulse

Ground targets
What is Synthetic Aperture Radar?

The SAR antenna transmits a radar pulse, which is backscattered by ground targets. The backscattered radar pulse can be specular or diffuse, and it can undergo double bounce.
Backscatter Results: Amplitude and Phase

Amplitude

Phase Change

Cycle

A

- A
### Amplitude and Phase

<table>
<thead>
<tr>
<th>Amplitude/Intensity ($A^2$)</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplitude shows visual characteristics based upon scattering returns, which can give us information on surface roughness and dielectric properties.</td>
<td>The phase of one scene may not be visually useful, but phase allows for powerful techniques such as polarimetry and interferometry over multiple scenes.</td>
</tr>
</tbody>
</table>
Why SAR?

Optical: Visible to Infrared

SAR: Active Microwave
Optical vs. SAR

TerraSAR-X - Indianapolis
07/01/2007

QuickBird - Indianapolis
07/01/2007
Camp Fire, California, USA

Optical imagery during Camp Fire vs SAR imagery of extent during the fire
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Synthetic Aperture Radar Applications

Landslides
Glaciers and permafrost
Oil spills
Subsidence
Earthquakes
Shipping

DEM generation
Biomass
Deforestation
Flooding
Volcano monitoring
Activity monitoring
# Radar frequency and applications

<table>
<thead>
<tr>
<th>Band</th>
<th>Frequency</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHF</td>
<td>300 kHz - 300 MHz</td>
<td>Foliage/ground penetration, biomass</td>
</tr>
<tr>
<td>P</td>
<td>300 MHz - 1 GHz</td>
<td>Biomass, soil moisture, ground penetration</td>
</tr>
<tr>
<td>L</td>
<td>1 - 2 GHz</td>
<td>Agriculture/forestry, soil moisture, ground penetration</td>
</tr>
<tr>
<td>S</td>
<td>3-4 GHz</td>
<td>Agriculture, biomass, ocean</td>
</tr>
<tr>
<td>C</td>
<td>4 - 8 GHz</td>
<td>Ocean, agriculture, general surface investigation</td>
</tr>
<tr>
<td>X</td>
<td>8 - 12 GHz</td>
<td>Ocean, agriculture, general surface investigation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(high resolution)</td>
</tr>
<tr>
<td>Ku</td>
<td>14 - 18 GHz</td>
<td>Glacial/ice, snow cover</td>
</tr>
<tr>
<td>Ka</td>
<td>27 - 47 GHz</td>
<td>Glacial/ice, very high resolution imagery</td>
</tr>
</tbody>
</table>
The Applications and Benefits of Synthetic Aperture Radar Technology to Connect, Inform and Protect

Synthetic Aperture Radar satellite missions

- **ERS-1** (1991 - 2000)
- **ERS-2** (1995 - 2011)
- **ALOS** (2006 - 2011)
- **ALOS-2** (2014)
- **SAOCOM** (2018)
- **NISAR** (2021)
- **RADARSAT-1** (1995 - 2013)
- **RADARSAT-2** (2007)
- **EnviSat-1** (2002 - 2012)
- **RISAT-1** (2012)
- **Sentinel-1A** (2014)
- **Sentinel-1B** (2015)
- **Gaofen-1** (2013)
- **COSMO-SkyMed** (2007)
- **TerraSAR-X** (2007)
- **TanDEM-X** (2010)
- **KOMPSAT-5** (2013)
- **COSMO-SkyMed 2nd generation**
- **CAPELLA SPACE constellation**
- **XpressSAR constellation**
- **ICEYE constellation**
- **PAZ**
- **UMBRA LAB**

Technology to Connect, Inform and Protect™
SARscape data processing in ENVI

Import
Multilooking
Coregistration
Filtering
Geocoding & Radiometric calibration
SARscape data processing in ENVI

The Applications and Benefits of Synthetic Aperture Radar
The Applications and Benefits of Synthetic Aperture Radar Technology to Connect, Inform and Protect

SARscape data processing in ENVI

Import
Multilooking
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Geocoding & Radiometric calibration
Data Import

Import

- Subset by ROI
- Choose polarization
- Mosaic same track
Multilooking

Import
- Subset by ROI
- Choose polarization
- Mosaic same track

Multilooking
- Choose grid size
- Removes speckle
- Convert to ground range
Coregistration

- Aligns pixel footprints when working with overlapping images
- Critical step for multitemporal analyses
The Applications and Benefits of Synthetic Aperture Radar Technology to Connect, Inform and Protect

Despeckling

Coregistration
- Aligns pixel footprints when working with overlapping images
- Critical step for multitemporal analyses

Filtering
Geocoding and Radiometric Calibration

- Apply projection
- Calibrate backscatter intensity to allow for direct comparison to other scenes
Automate and batch process your data in the ENVI modeler with SARscape tasks

Full preprocessing and fusion of Sentinel-1 (all bands) and Sentinel-2

Skaneateles Lake, NY
Red- Red (Sentinel-2)
Green- Green (Sentinel-2)
Blue- VV (Sentinel-1)
The Applications and Benefits of Synthetic Aperture Radar Technology to Connect, Inform and Protect

Synthetic Aperture Radar Applications

- Landslides
- Glaciers and permafrost
- Oil spills
- Subsidence
- Earthquakes
- Shipping
- DEM generation
- Biomass
- Deforestation
- Flooding
- Volcano monitoring
- Activity monitoring
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DEM Generation
Terrain and Infrastructure Monitoring

- Displacement
- DEM
- Multi-Temporal Analyses of the Displacement
- Identification of areas affected by catastrophic events
Deforestation

- Coefficient of variation
- Mean
- Gradient
Tracking Deforestation

The Applications and Benefits of Synthetic Aperture Radar

Technology to Connect, Inform and Protect™
Disaster Management: Flood Mapping

Hurricane Florence, September 2018
Disaster Management: Flood Mapping

Pre-storm SAR

Wilmington, NC

Goldsboro, NC
Disaster Management: Flood Mapping

Post-storm SAR

Wilmington, NC

Goldsboro, NC
Disaster Management: Flood Mapping

Flood map products

- **Wilmington, NC**
  - Dual-polarimetric RGB

- **Goldsboro, NC**
  - Threshold and ratio calculation

R: $V_{V}^{\text{post}}$
G: $V_{H}^{\text{post}}$
B: Average $V_{V}^{\text{pre}}$ and $V_{H}^{\text{pre}}$
Activity Monitoring: Change Detection

Coherent change detection over Burning Man Festival
Black Rock Desert, NV, USA

R: Coherence

G: Average backscatter

B: Difference in backscatter between pre (2018-06-08) and during (2018-08-31)
Questions?

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Upcoming events

**December 10 – 14, 2018:**
See ENVI and SARscape at the AGU fall meeting! (booth # 1359)
Washington DC

**January 17, 2019**
Webinar
Land & Sea Applications using SAR