Design Thinking for the Applied Sciences: Developing a Novel Approach to Encourage the Use of Synthetic Aperture Radar (SAR) and Open Source Tools for Forest Monitoring

Leah M. Kucera (1,2), Kelsey E. Herndon (1,2), Africa Ixmucane Flores Cordova (1,2), Emil A. Cherrington (1,2), Melvin Poplar III (1), Rajesh Bahadur Thapa (3) and Sylvia Wilson (4)

(1) University of Alabama in Huntsville, Huntsville, AL, United States, (2) NASA SERVIR, Science Coordination Office, Huntsville, AL, United States, (3) ICIMOD, Geospatial Solutions, Kathmandu, Nepal, (4) USGS, Reston, VA, United States

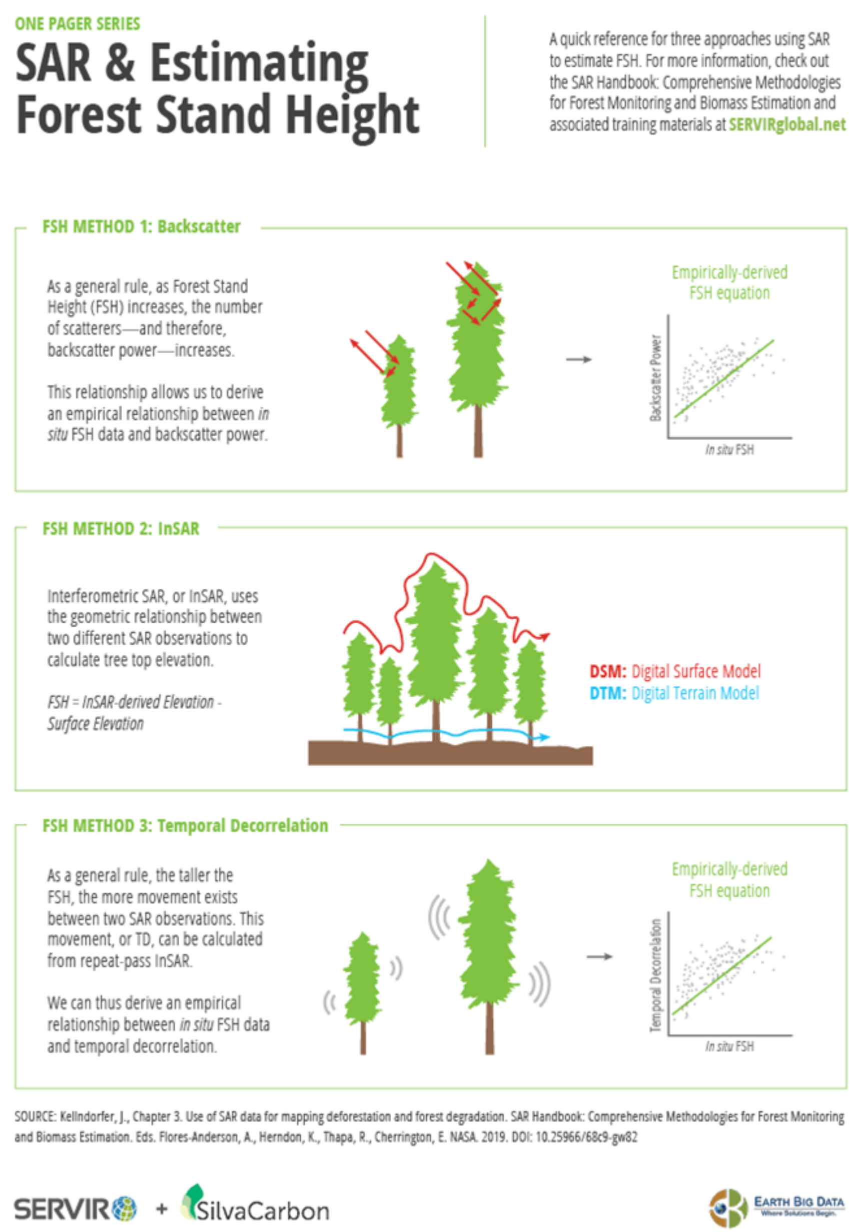
PRESENTED AT:

OBJECTIVES

- **BUILD GLOBAL CAPACITY** to process and use SAR for applied forestry topics from forest monitoring to biomass estimation
- **INCORPORATE** marketing and design principles (layout, illustration, content development) to increase uptake of the Handbook and associated training materials
- **DISTRIBUTE** print and digital optimized versions of content and trainings authored by SAR Subject Matter Experts (SMEs)
- **ITERATE** on materials to create "living documents," solicit feedback on strategies utilized

ONE PAGERS

Content from the SAR workshop series and Handbook chapters were used to create a series of one-pagers. Using a consistent template in line with the Handbook design ensures visual cohesion, with each covering topics from data acquisition to pre-processing.



One-pager on Forest Stand Height based on content in Chapter 3 of the SAR Handbook, authored by Josef Kellndorfer.

ONE PAGER SERIES

SAR Data Access & Availability

A quick reference to Synthetic Aperture Radar collecting-missions and where to obtain data. For more information, check out the SAR Handbook: Comprehensive Methodologies for Forest Monitoring and Biomass Estimation and associated training materials at **SERVIRglobal.net**

EXISTING DATA

SENSOR	LIFETIME	WAVELENGTH/ FREQUENCY	POLARIZATION	RESOLUTION	FRAME SIZE	REPEAT CYCLE	ACCESS
Seasat	1978	L-band λ = 24.6cm	HH	Az: 25m Rg: 25m	100km	-	Free & open
ERS-1	1991-2001	C-band λ = 05.6cm	W	AZ: 6-30m RG: 26m	100km	35 days	Restrained
JERS-1	1995-1998	L-band λ = 24.6cm	HH	Az: 18m Rg: 18m	75km	44 days	Restrained
ERS-2	1995-2011	C-band λ = 05.6cm	W	Az: 6-30m Rg: 26m	100km	35 days	Restrained
ENVISAT	2002-2012	C-band λ = 05.6cm	HH, W, W/HH, HH/HV, W/VH	Az: 28m Rg: 28m	100km	35 days	Restrained
ALOS-1	2006-2011	L-band λ = 24.6cm	FBS: HH, W FBD: HH/HV, HH/VH PLR: HH/HV /VH /W ScanSAR: HH, W	FBS: 10x10m FBD: 20x10m PLR: 30x10m ScanSAR: 100m	FBS: 70km FBD: 70km PLR: 30km ScanSAR: 250-350km	46 days	Free & open
Radarsat-1	1995-2013	C-band λ = 05.6cm	HH	Standard: 25x28m Fine: 9x9m Wide1: 35x28m Wide2: 35x28m ScanSAR: 50x50-100x100m	Standard: 100km Fine: 45km Wide1: 165km Wide2:150km ScarSAR: 305-510km	24 days	1995-2008: Restrained 2008-2013: Commercial
TerraSAR-X TanDEM-X	2007- 2010-	X-band λ = 03.5cm	Single: HH, W Dual: HH/W, HH/HV, W/VH Twin: HH/W, HH/VH, W/VH	Spotlight: 0.2x1.0-1.7x3.5m Stripmap: 3x3m ScanSAR: 18-40m	Spotlight: 3-10km Stripmap: 50x30km ScanSAR: 150x100- 200x200km	11 days	Application- dependent; restrained scientific, commercial
Radarsat-2	2007-	C-band λ = 05.6cm	Single: HH, W, HV, VH Dual: HH/HV, W/VH Quad: HH/HV/VH/W	Spotlight: ~1.5m Stripmap: ~3x3-25x25m ScanSAR: 35x35-100x100m	Spotlight: 18x8km Stripmap: 20-170m ScanSAR: 300x300- 500x500km	24 days	Commercial
COSMO- SkyMed	2007-	X-band λ = 03.5cm	Single: HH, W, HV, VH Dual: HH/HV, HH/W, W/VH	Spotlight: ≤1m Stripmap: 3-15m ScanSAR: 30-100m	Spotlight: 10x10km Stripmap: 40x40km ScanSAR: 100x100 - 200x200km	Satellite: 16 days Constellation: ~hrs	Commercial; limited proposal- based scientific
ALOS-2 PALSAR-2	2014-	L-band λ = 24.6cm	Single: HH, W, HV, VH Dual: HH/HV, W/VH Quad: HH/HV/VH/W	Spotlight: 1x3m Stripmap: 3-10m ScanSAR: 25-100m	Spotlight: 25x25km Stripmap: 55x70- 70x70km ScanSAR: 355x355km	14 days	Commercial; limited proposal- based scientific
Sentinel-1	2014-	C-band λ = 05.6cm	Single: HH, W Dual: HH/HV, W/VH	Stripmap: 5x5m Interferometric Wide Swath (IW): 5x20m Extra Wide Swath (EW): 20-40m	Stripmap: 375km IW: 250km EW: 400km	Satellite: 12 days Constellation: 6 days	Free & open
SAOCOM	2018-	L-band λ = 24.6cm	Single: HH, W Dual: HH/HV, W/VH Quad: HH/HV/VH/W	Stripmap: 10x10m TopSAR: 100x100m	Stripmap: >65km TopSAR: 320km	Satellite: 16 days Constellation: 8 days	TBD
PAZ SAR	2018-	X-band λ = 03.5cm	*See TerraSAR/ TanDEM-x	*See TerraSAR/ TanDEM-x	*See TerraSAR/ TanDEM-x	11 days	Commercial

One-pager on Forest Stand Height based on content in Chapter 2 of the SAR Handbook, authored by Franz Meyer. The interactive version of the PDF contains clickable links to download each available dataset.

ONE PAGER SERIES

SAR Data Pre-Processing Steps

A cheat sheet outling the workflow for pre-processing L1 Synthetic Aperture Radar data. For more information, check out the SAR Handbook: Comprehensive Methodologies for Forest Monitoring and Biomass Estimation and associated training materials at **SERVIRglobal.net**

Apply Orbit File
Defines the relationship between ground and image coordinates, improves accuracy of later orbit-based calibration steps.

Radiometric Calibration
Converts the image pixel values from digital number (DN) to a standard geophysical measurement unit of radar backscatter.

De-Bursting
SAR scenes can be made up of multiple swaths or sections. This step combines all swaths into a single image.

Multilooking
Uses spatial averaging to reduce image speckle noise and converts to ground range, producing an image with a standard pixel size. Reduces image resolution *(optional)*.

Speckle Filtering
Removes noise, or speckle, in an image. Many types of speckle filters can be applied, and different applications have specific filters that may work best. Unlike multilooking, this step does not reduce spatial resolution *(optional)*.

Terrain Correction: Radiometric Terrain Flattening (RTF) & Geocoding
RTF: Uses a DEM to remove geometry-dependent radiometric distortions; normalizes measured backscatter with respect to terrain slope.
Geocoding: Uses a DEM to remove geometric distortions such as foreshortening, layover, and shadow; connects the image to a geographic coordinate system.

Convert to dB
Linearly-scaled data is converted into decibels (dB) (optional).

SOURCE: Meyer, Franz. "Spaceborne Synthetic Aperture Radar – Principles, Data Access, and Basic Processing Techniques." SAR Handbook: Comprehensive Methodologies for Forest Monitoring and Biomass Estimation. Eds. Flores, A., Herndon, K., Thapa, R., Cherrington, E. NASA. DOI: 10.25966/ez4f-mg98

SERVIR + SilvaCarbon   UAF Alaska Satellite Facility

One-pager on SAR pre-processing steps based on content in the Chapter 2 training appendix of the SAR Handbook, authored by Franz Meyer. This handout provides at-a-glance steps for the process outlined in the training.

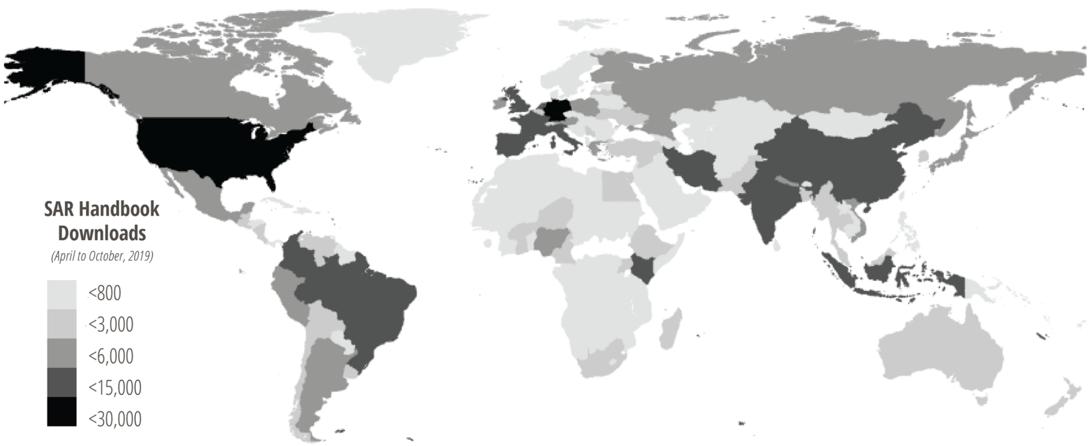
EXPLAINER VIDEOS

[VIDEO] https://www.youtube.com/embed/em41MxplcDc?feature=oembed&fs=1&modestbranding=1&rel=0&showinfo=0
Handbook content was also used to develop scripts for three animated explainer videos, outlining the basics of SAR properties such as polarization and scattering mechanisms for a general audience.

Storyboards created by Melvin Poplar, animation intern at the SERVIR Science Coordination Office.

IMPACT

Since the beta release at the UN FAO Global Forest Observation Initiative's plenary meeting in April 2019, Handbook materials have been accesed over 320,000 times from over 172 countries.



Global distribution of Handbook downloads.

ABSTRACT

Earth observations from Synthetic Aperture Radar, or SAR, have **yet to be fully leveraged for forest monitoring applications**. While SAR sensors are uniquely able to capture components of forest structure over optical imagery, especially in cloud-heavy regions, **there is a shortage of freely-available applied training materials and related case studies**. With the wealth of available datasets from Sentinel-1 and other missions, such as ALOS-Palsar open historical archive, and in preparation for upcoming open-data policy SAR missions (e.g. NISAR and BIOMASS), the applied forestry community would benefit from **increased access to relevant, understandable SAR training materials**.

This work documents lessons learned and best practices for creating EO capacity building/training materials gleaned from the SAR Handbook project. Strategies for increasing legibility for both print and online applications, illustration and editing guidelines for original and modified figures, and the development of quick-reference guides will be shared. Additionally, the conception and use of companion “explainer” videos, using cartoon characters and humor to outline relevant SAR concepts will be explored.

Preliminary results indicate the SAR Handbook and supplemental project materials are already having an impact in training sessions. Increased uptake of SAR technologies in SERVIR Hub regions, where Hubs are leading follow-on SAR trainings, has also been noted. In addition, a review of download statistics from the SERVIR global website indicates widespread worldwide access. We conclude similar holistic approaches integrating design concepts into future content development would help increase uptake of EO applications by the earth science community.

HANDBOOK MODULES

Handbook Modules:

http://bit.ly/SARhandbook (http://bit.ly/SARhandbook)

Funding Support: SilvaCarbon, NASA SERVIR, NASA Cooperative Agreement with the University of Alabama in Huntsville, NNM11AA01A.

Sorry but time is up!

ABSTRACT

Earth observations from Synthetic Aperture Radar, or SAR, have yet to be fully leveraged for forest monitoring applications. While SAR sensors are uniquely able to capture components of forest structure over optical imagery, especially in cloud-heavy regions, there is a shortage of freely-available applied training materials and related case studies. With the wealth of available datasets from Sentinel-1 and other missions, such as ALOS-Palsar open historical archive, and in preparation for upcoming open-data policy SAR missions (e.g. NISAR and BIOMASS), the applied forestry community would benefit from increased access to relevant, understandable SAR training materials.

This work documents lessons learned and best practices for creating EO capacity building/training materials gleaned from the SAR Handbook project. Strategies for increasing legibility for both print and online applications, illustration and editing guidelines for original and modified figures, and the development of quick-reference guides will be shared. Additionally, the conception and use of companion “explainer” videos, using cartoon characters and humor to outline relevant SAR concepts will be explored.

Preliminary results indicate the SAR Handbook and supplemental project materials are already having an impact in training sessions. Increased uptake of SAR technologies in SERVIR Hub regions, where Hubs are leading follow-on SAR trainings, has also been noted. In addition, a review of download statistics from the SERVIR global website indicates widespread worldwide access. We conclude similar holistic approaches integrating design concepts into future content development would help increase uptake of EO applications by the earth science community.

SWITCH TEMPLATE