Capacity Building Engagement for Estimating Forest Stand Height Utilizing the SAR Handbook

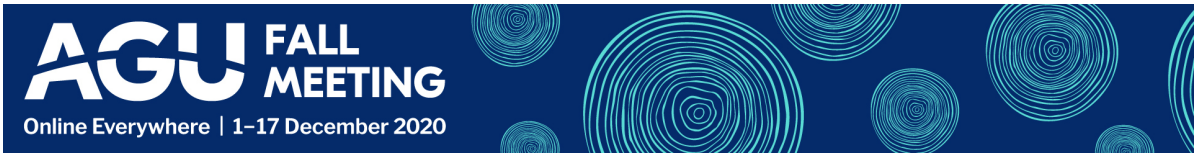


Tim Mayer[1], Helen Baldwin[1], Kelsey Herndon[1], Africa Flores[1], Thannarot Kunlamai [2], Quyen Nguyen [2], Peeranan Towashiraporn [2], Sylvia Wilson[3]

[1]NASA/SERVIR Science Coordination Office, Earth System Science Center, University of Alabama, Huntsville, United States, [2] SERVIR-Mekong, Asian Disaster Preparedness Center, Bangkok, Thailand,[3]United States Geological Survey, Reston, VA, United States



PRESENTED AT:



INTRODUCTION

SERVIR is a joint development initiative of National Aeronautics and Space Administration (**NASA**) and United States Agency for International Development (**USAID**), SERVIR works in partnership with leading regional organizations worldwide to help developing countries use information provided by Earth-observing satellites and geospatial technologies for managing climate risks and land use. We empower decision-makers with tools, products, and services to act locally on climate-sensitive issues.

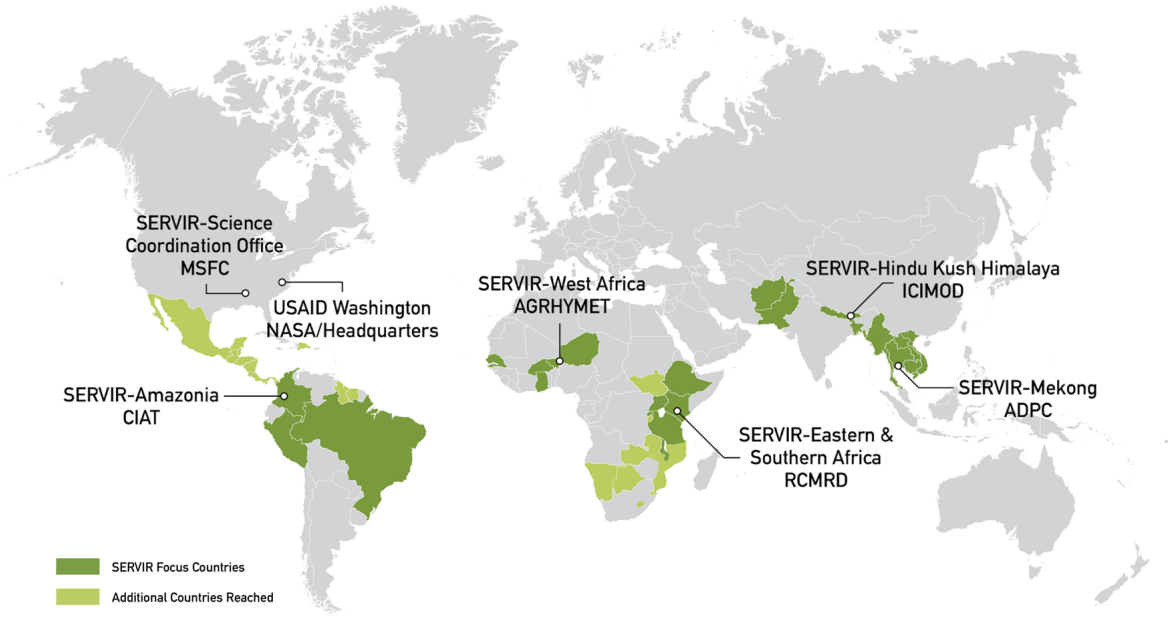


Figure 1. The SERVIR Global network

Credit: SERVIR-Global

SERVIR is improving awareness, increasing access to information, and supporting analysis to help people in West Africa, Eastern and Southern Africa, Hindu Kush-Himalaya, the Lower Mekong, South America, and Mesoamerica manage challenges surrounding four thematic areas. With activities in more than 45 countries and counting, SERVIR has already developed over 70 custom tools, collaborated with over 250 institutions, and trained more than 3,000 individuals, improving the capacity to develop local solutions.

Across SERVIR's global network there are four thematic service areas.

Weather and Climate


Land Use and Ecosystems


Water and Disasters


Agriculture and Food Security

For further background, with each SERVIR service, there are an array of service components these can include **data**, **products**, **tools**, **platforms**, and **capacity building**.

THE NEED

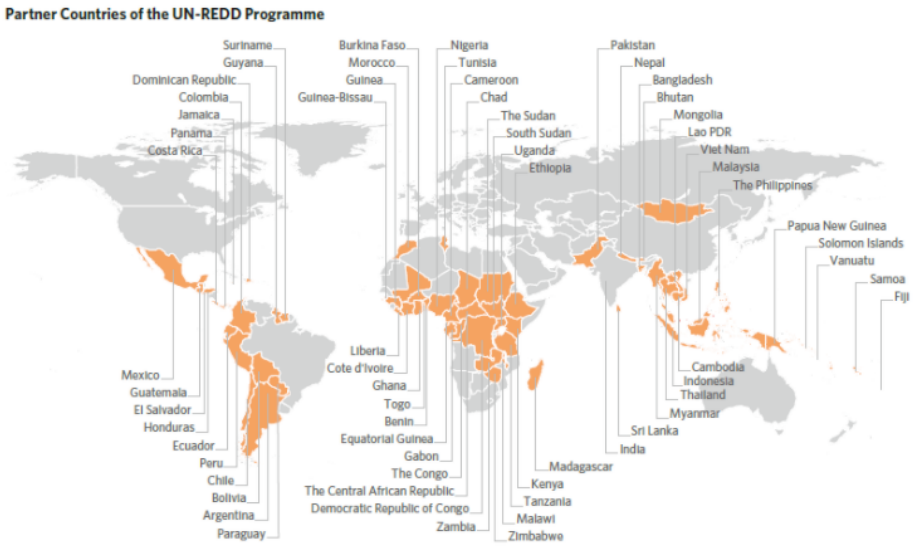


Figure 2. Partner countries of the UN-REDD program 2018

Credit: UN-REDD Annual Report 2018

The United Nations Program on Reducing Emissions from Deforestation and Forest Degradation (UN-REDD Program) continues to make efforts to reduce emissions from deforestation and degradation, sustainably manage forests, and conserve and enhance forest carbon stocks in developing countries. REDD+ requires robust and credible systems for measuring, reporting, and verification (MRV) of forest and more broadly land cover (Herold, et al 2019). With the 17 adopted Sustainable Development Goals (SDGs), in 2015, aimed at sustainably transforming our world an additional 232 targets, were established for effective monitoring (Swamy, et al. 2018; UN 2016; UN 2017).

Essential to the MRV process is establishing national level baselines through reporting mechanisms such as National Forest Inventories (NFIs), Forest Reference Emissions Level (FREL), Forest Reference Level (FRL), and Global Forest Resources Assessment (FRA) is key. Additionally, accounting and monitoring of Above Ground Biomass (AGB) is critical for meeting UNFCCC targets (UNFCCC 2015). To meet the need for large scale and sustainable monitoring leveraging remote sensing approaches is necessary (Duncanson, et al., 2019; Herold, et al 2019; Lucas, et al. 2015). However, focus countries across the SERVIR network are impeded by nearly constant cloud cover, thus limiting the application of optical sensors for effective forest monitoring.

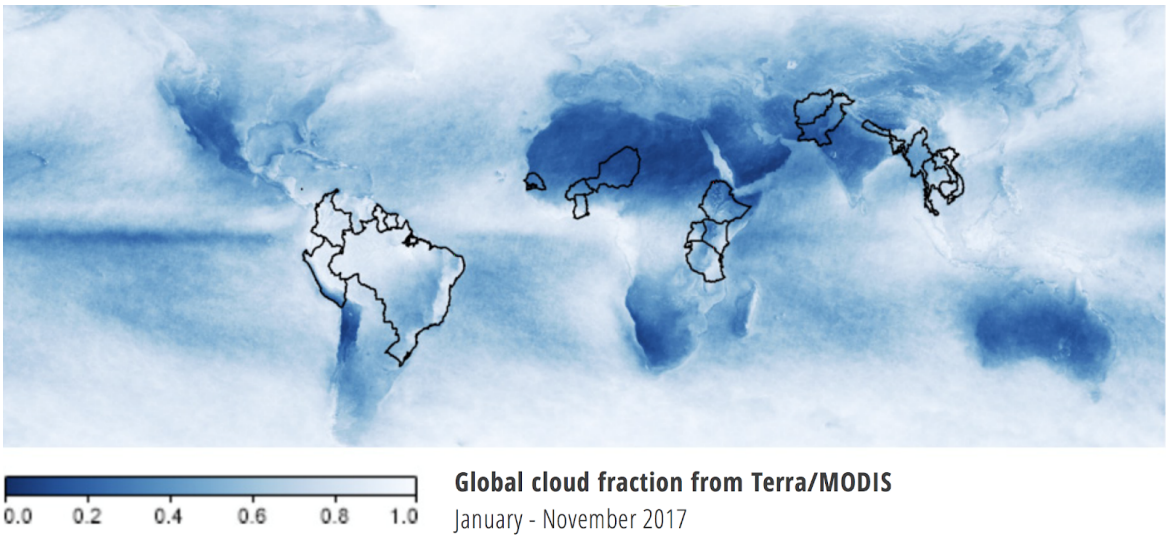


Figure 3. Global Cloud fraction with outlined countries are SERVIR focus countries, demonstrating the issue of data gaps.

Credit: SAR Handbook Chapter 1

To address the issue of cloud cover, there was a need to utilize Synthetic Aperture Radar (SAR) which penetrates clouds and is not limited by weather conditions and during the day or night. The comparison of optical and SAR data products captured at the same location and date illustrates the ability of SAR to provide significant information in areas with consistent data gaps.

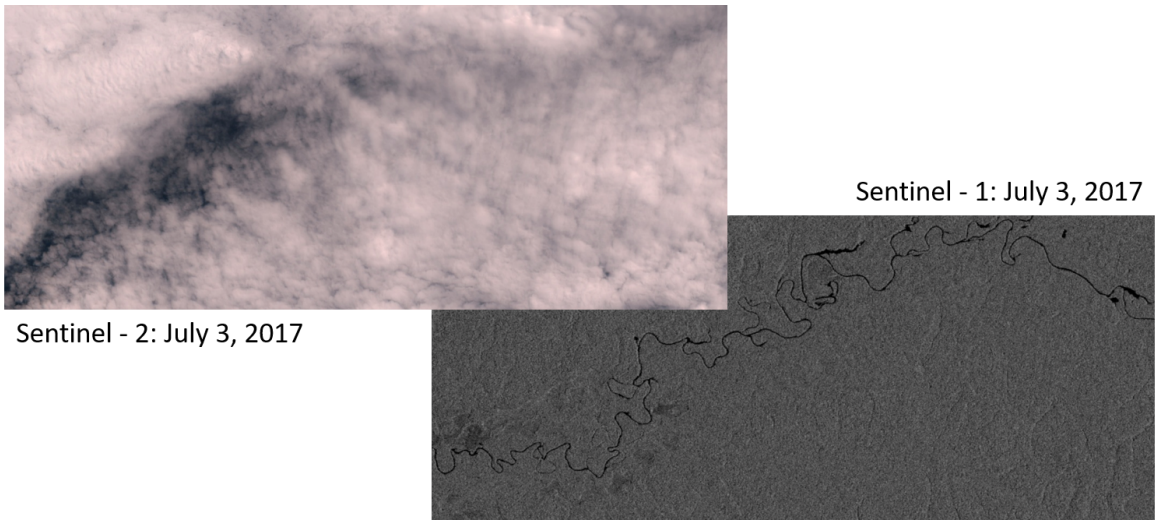


Figure 4. Comparison of optical and SAR over the Amazon rainforest (Sentinel-2 2017; Copernicus 2017)

Credit:Kelsey Herndon

THE SAR HANDBOOK: ESTIMATING FOREST STAND HEIGHT

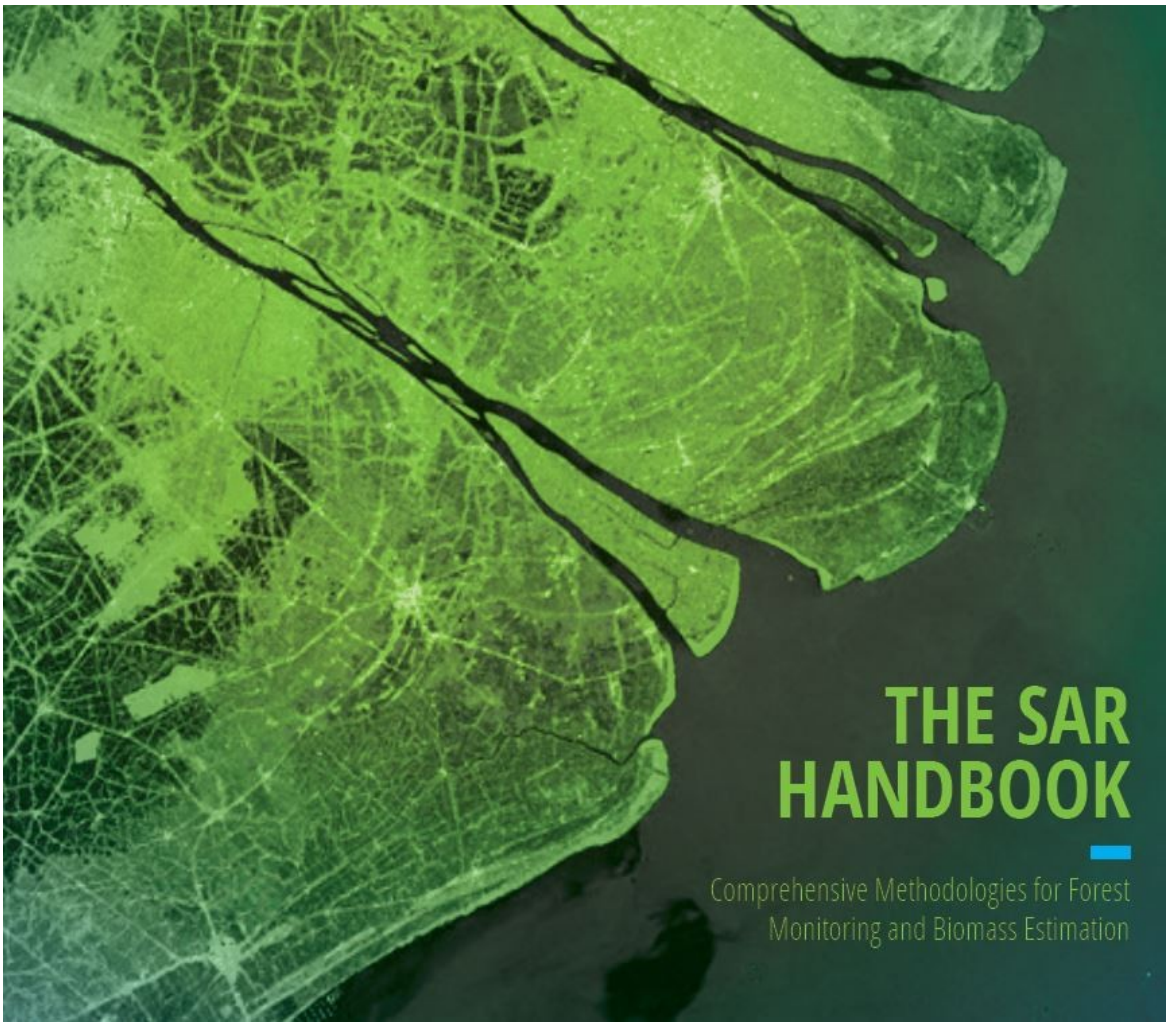


Figure 5. *The SAR Handbook: Comprehensive Methodologies for Forest Monitoring and Biomass Estimation*

Credit: SAR Handbook

From the specified need to effectively monitoring forests, and with the insight that an array of sensors including SAR must be utilized a global collaboration spanning two years was set forth by representatives from NASA SERVIR and SilvaCarbon. The culmination of those efforts resulted in *The SAR Handbook: Comprehensive Methodologies for Forest Monitoring and Biomass Estimation* (Flores-Anderson, et al., 2019). SERVIR which is part of NASA's Applied Science Program under the Capacity Building Program, set forth to disseminate the methodologies, techniques, and cutting-edge approaches to the applied researchers, resource and land managers, and national government officials in-region mandated with the reporting effort to meet the UN targets.

From this, five trainings, led by six SAR subject matter experts, were held at hubs throughout the SERVIR network. The topics of these training included SAR basics, SAR for forest change detection, forest stand height estimation, biomass estimation, mangrove monitoring, and sampling design.

The methodologies and application for estimating forest stand height (FSH) are outlined in chapter 4 of the SAR Handbook (Flores-Anderson, et al., 2019). Specifically, there are three methodologies for estimating FSH with SAR as depicted in figure 6. The capacity building training activity employed the temporal decorrelation approach utilizing the FSH algorithm developed by Paul Siqueira.and Yang Lei (Lei, et al. 2018).

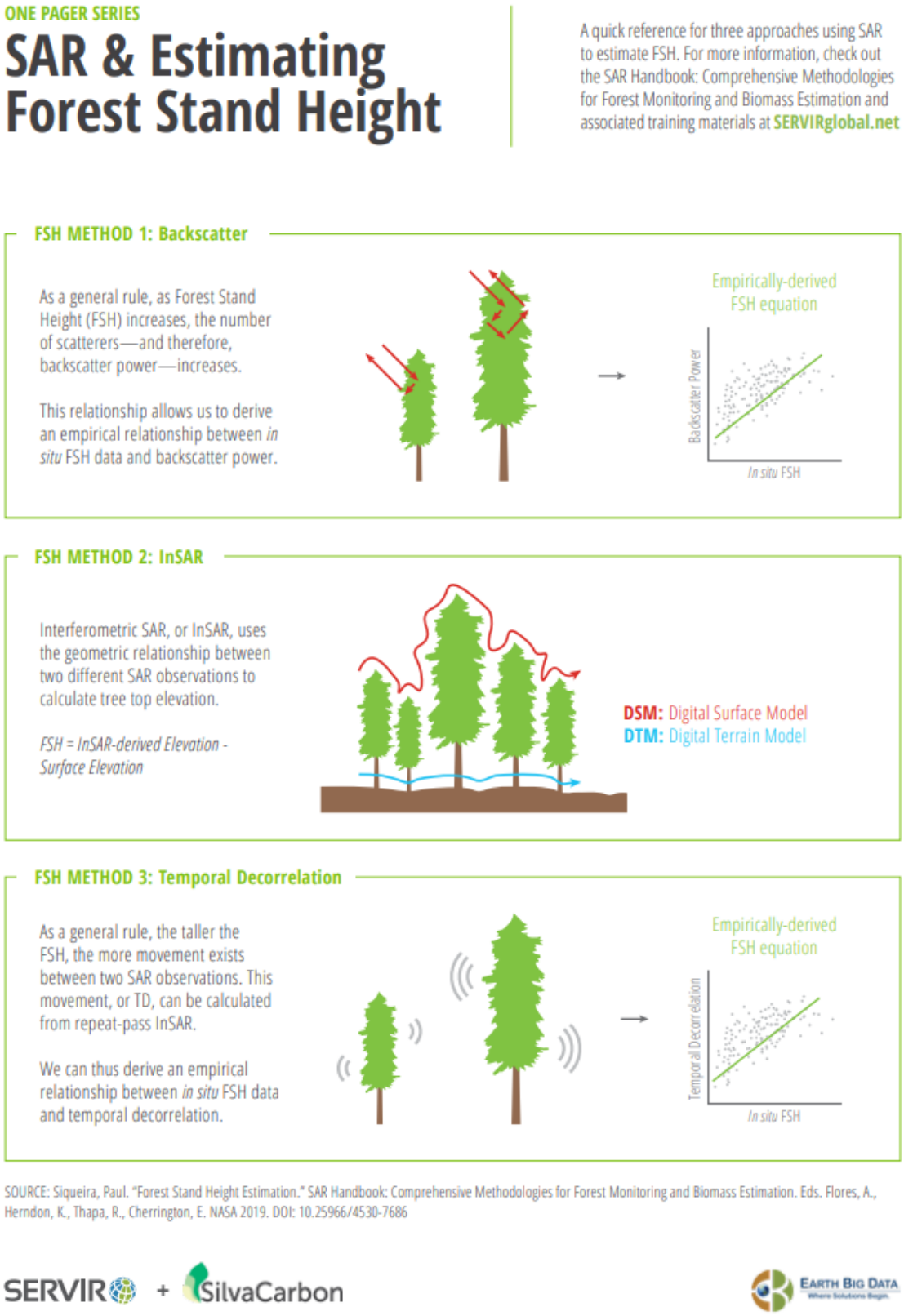


Figure 6. One page reference sheet for the methodologies employed in estimating Forest Stand Height

Credit: SAR Handbook

The development of the algorithm is based on a combination of empirical relationships between cross-polarized radar backscatter power and interferometric coherence (Flores-Anderson, et al., 2019; Lei & Siqueira 2014; Lei & Siqueira 2015; Lei, et al. 2017a; Lei, et al. 2017a) through leveraging L-Band ALOS (JAXA/METI 2007) and available LiDAR as ground truth to fit and produce an explicit estimate of Forest Stand Height.

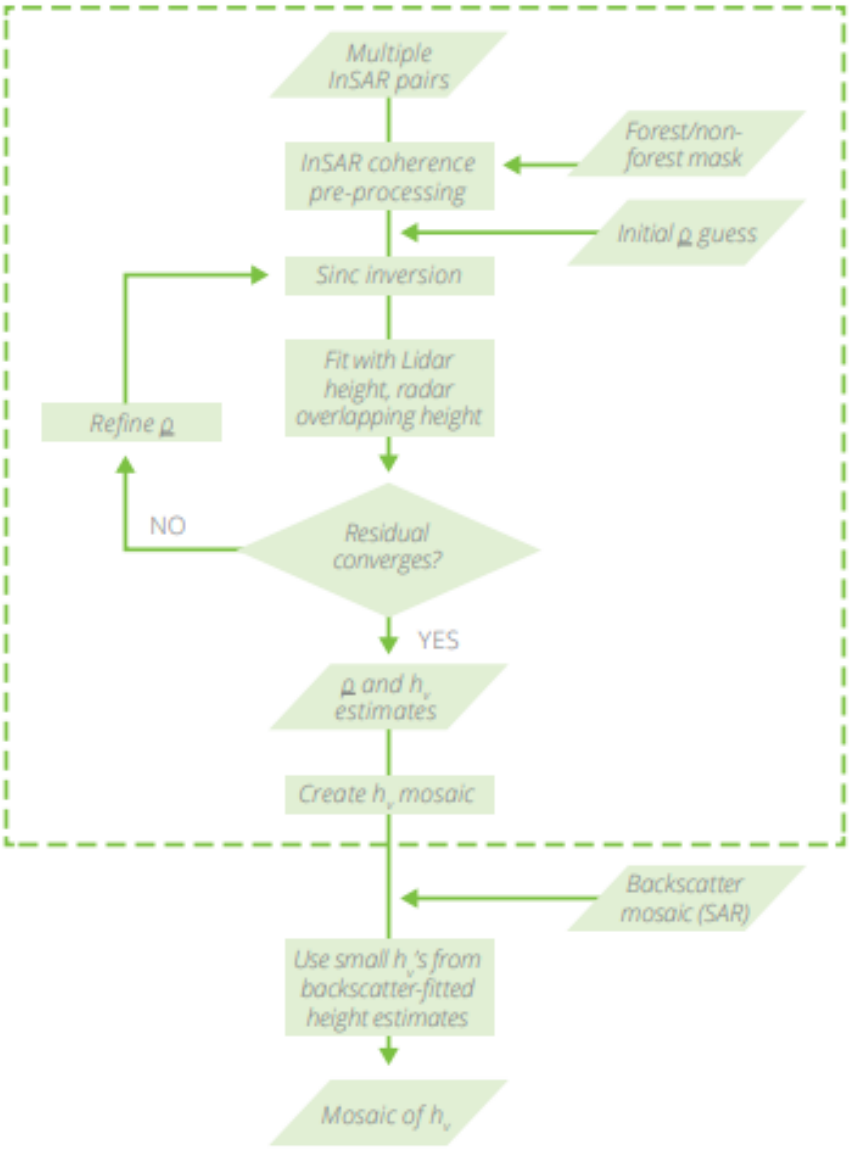


Figure 7. Describes the FSH algorithm workflow for producing an estimated Forest Stand Height data products

Credit: SAR Handbook Chapter 4

CAPACITY BUILDING



Figure 8. Photo from the Capacity Building Training

Credit: SERVIR-Mekong

Specifically, a team of NASA SERVIR researchers conducted a capacity building activity focused on disseminating and transferring knowledge for estimating FSH, in accordance with the SAR handbook initiative. This in-person training was focused on South and Southeast Asia and was hosted by SERVIR-Mekong at Asian Disaster Preparedness Center (ADPC) in Bangkok in January 2020. Representatives from SERVIR-Hindu Kush Himalaya as well as Thailand's Geo-Informatics and Space Technology Development Agency (GISTDA), Thailand Department of National Parks, Nepal Department of Forest Research and Survey (DFRS), Vietnam Forest Inventory and Planning Institute (FIPI), Vietnam National University (VNU), Myanmar Forest Department, and Lao PDR Forest Inventory Planning Department (FIPD) among others participated in the training.

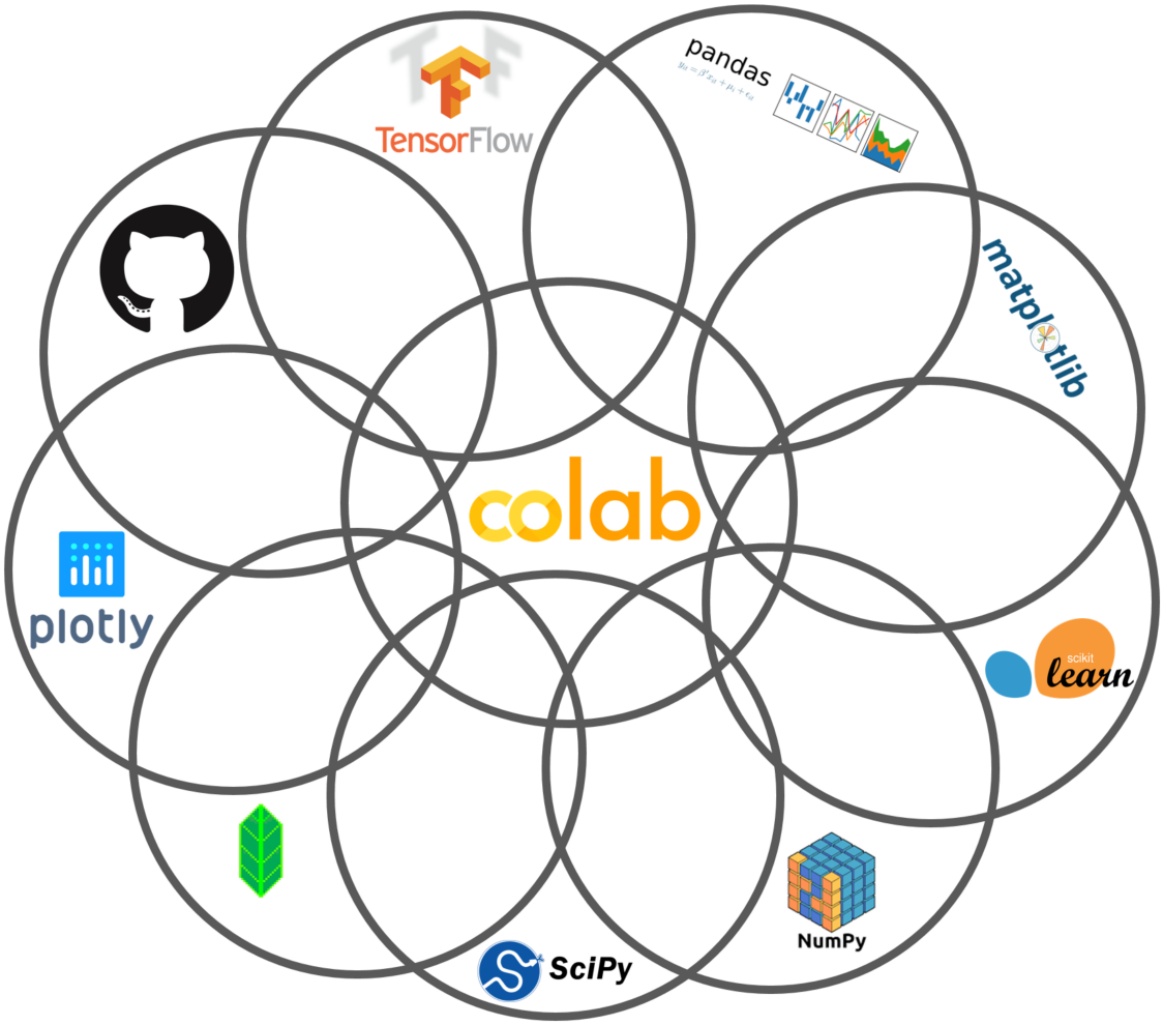


Figure 9. A component of the virtual notebook hands-on demonstration as part of the capacity building activity

Credit: Tim Mayer

To achieve the goal of effectively building capacity to leverage the FSH methodology our team of researchers employed a broad array of teaching techniques as well as emerging technology platforms. The training consisted of basic SAR knowledge, SAR retrieval, and pre-processing interferograms, theoretical discussion regarding the FSH algorithm, as well as exposure to virtual notebook platforms such as Google COLAB, GitHub, and command line, as well as python coding. The training consisted of hands-on demonstrations and the curriculum of the training was developed to accommodate technological limitations, such as low bandwidth and computing resources. The curriculum and material were also developed to be sharable and replicable using a virtual notebook format. Participants left the training with the tools to repeat the methodologies in their area of interest.

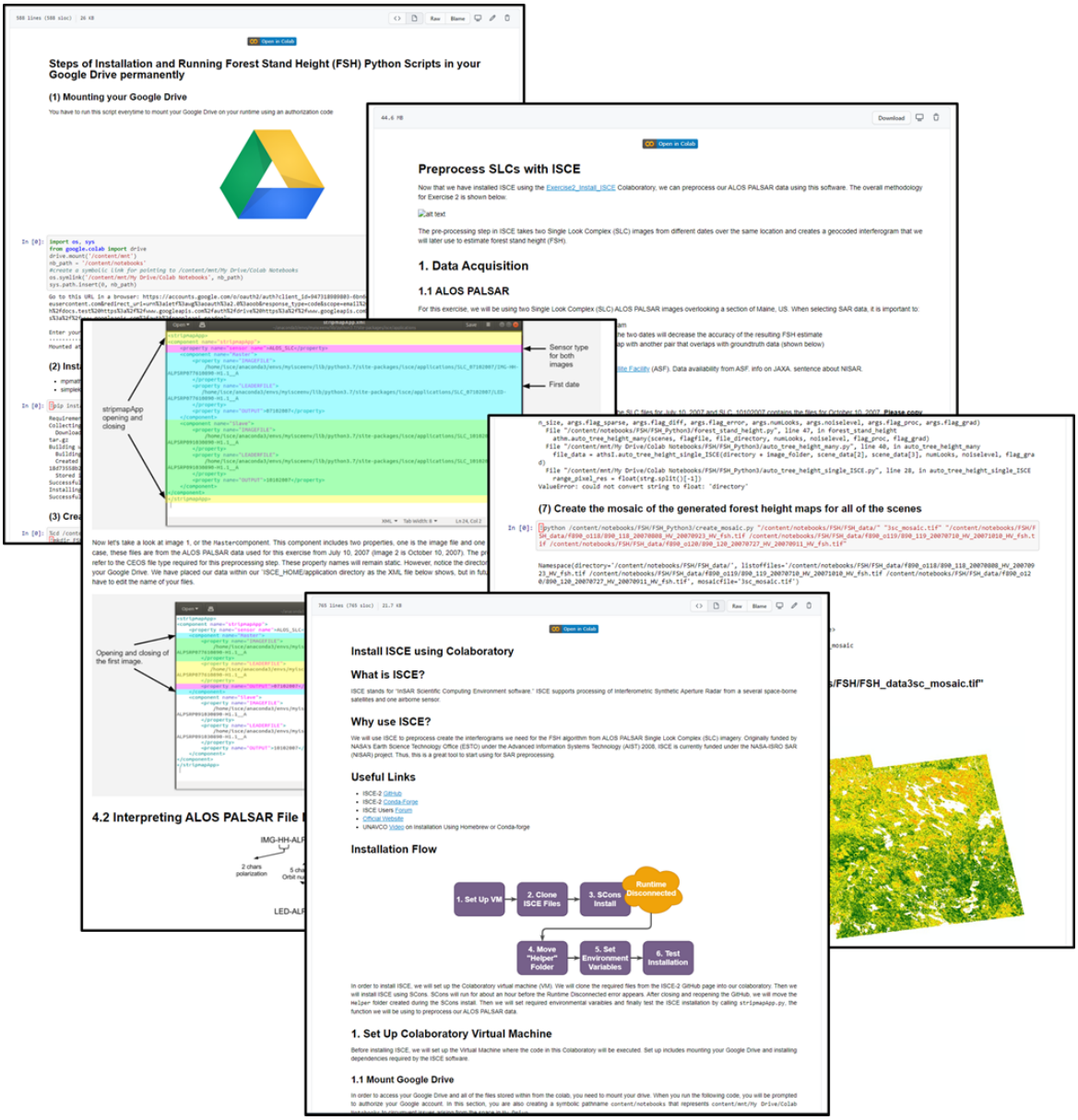


Figure 10. A snapshot of several virtual notebooks utilized during the training activity

Credit: NASA SERVIR

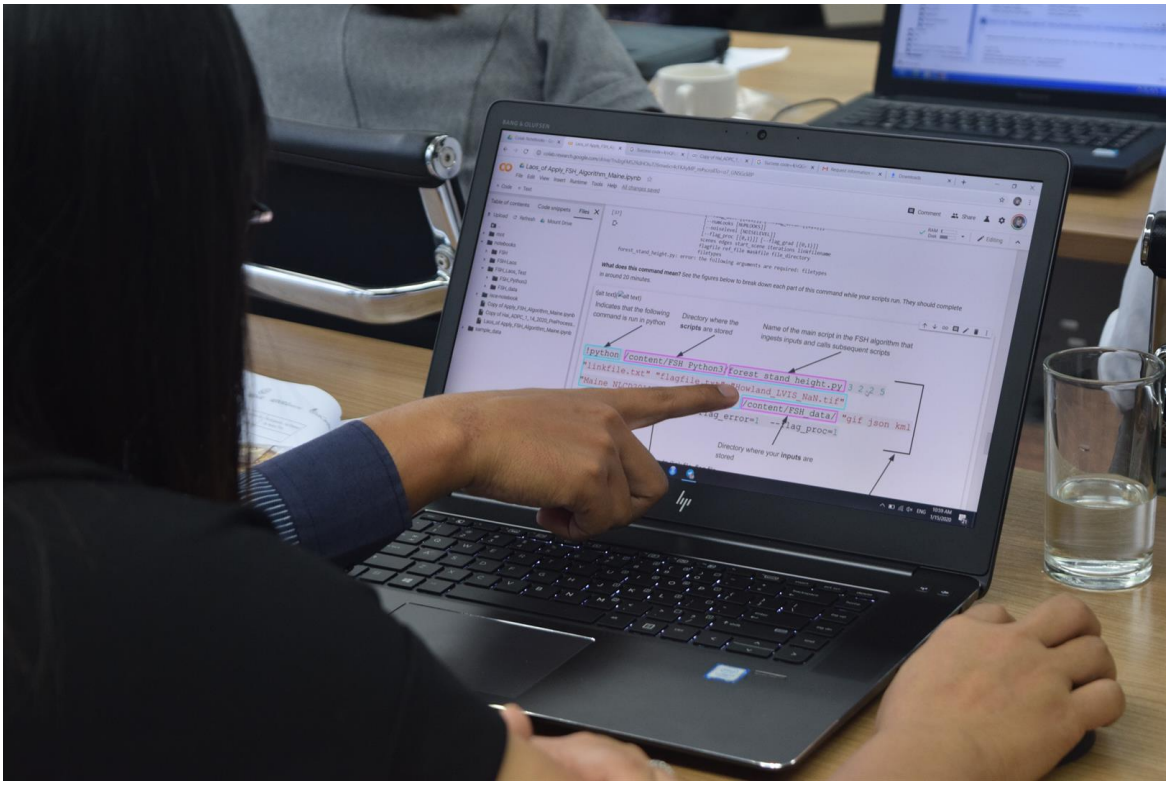


Figure 11. Hands-on demonstration utilizing the virtual notebooks

Credit: SERVIR-Mekong

CONCLUSIONS AND ACKNOWLEDGMENTS

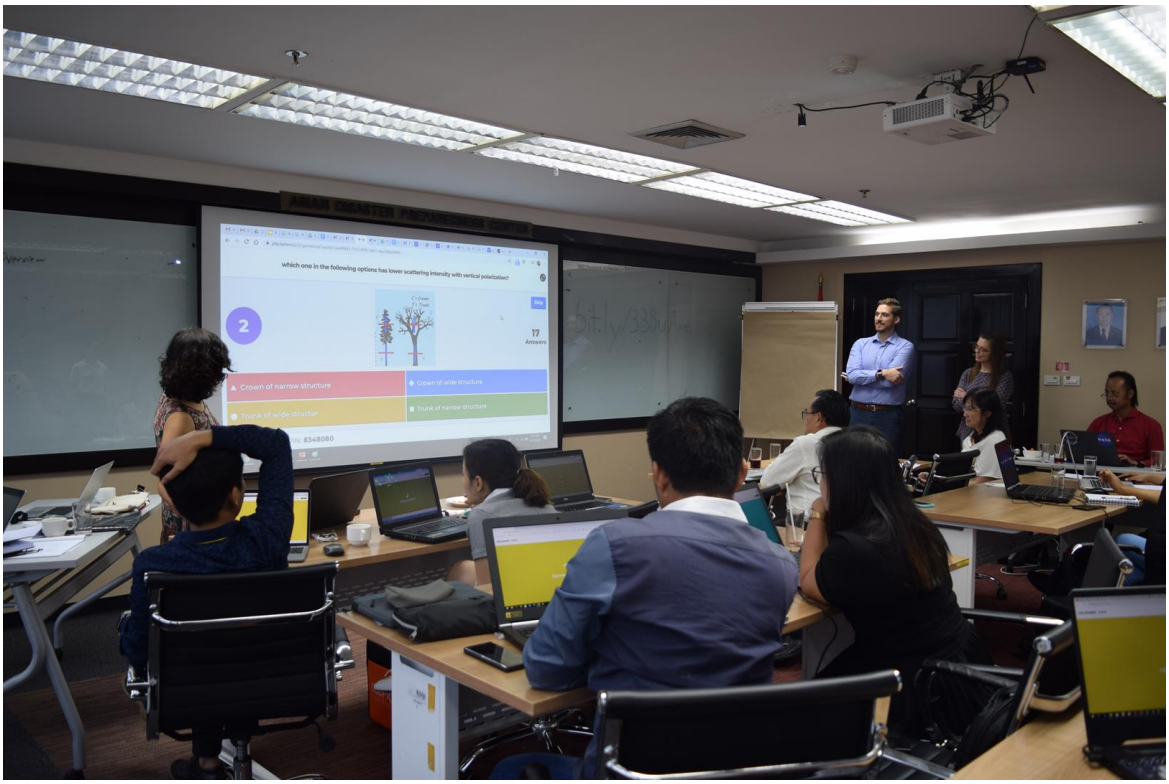


Figure 12. Photo from the Capacity Building Training

Credit: SERVIR-Mekong

Conclusions

The team of NASA researchers administered a pre and post self-reported wherein participants recorded their knowledge ascertained. Specifically, we observed a drastic increase in capacity regarding python coding, an increase of 19.36%, knowledge of applying SAR, an increase of 30.14%, ability to leverage ALOS PALSAR, an increase of 33.09%, as well as aptitude to leverage virtual notebooks such as COLAB, after the training with an increase of 33.50%.

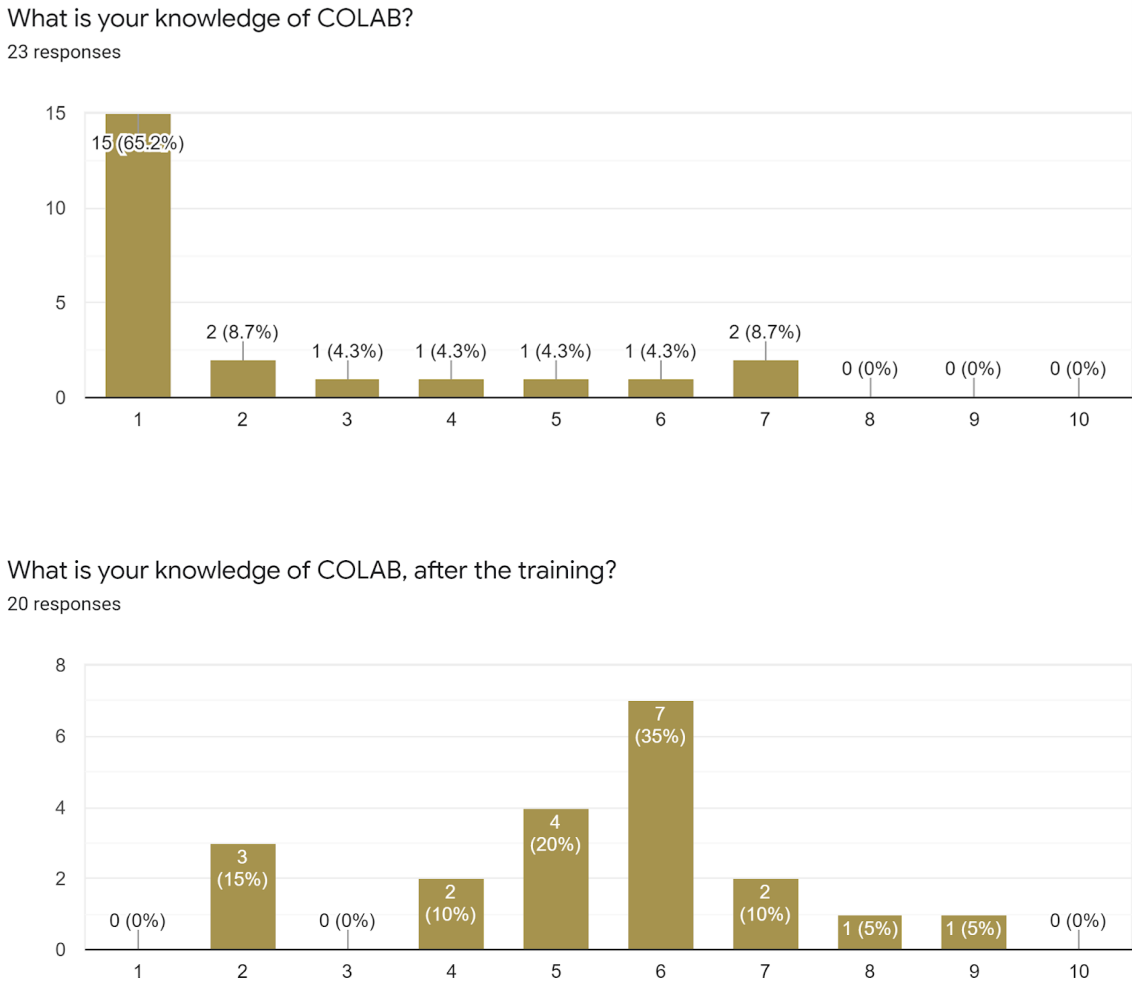


Figure 13. Sample of Self Reported Pre and Post Capacity Building Survey Results

Credit: NASA SERVIR

However, our training, and therefore sample size only included 24 individuals we believe the participants gain critical insight into meeting the needs for more effective forest monitoring. The training was successful in transferring cutting-edge methodologies, the capability to utilize Earth observation products, and virtual notebooks for future use by the participants.

Additionally, the SERVIR network made a commitment in 2018 to become more gender-responsive, inclusive, and equal and specifically empower women and girls in STEM fields in their countries. The demographics of the training included 13 women and 11 men, which is an initial step to continued support for localized STEM empowerment. Lastly, the SERVIR-Mekong and the SERVIR-Hindu Kush Himalaya hubs will continue to act as regional centers of excellence providing geospatial expertise directly associated with SAR and now guidance for effectively estimating Forest Stand Height to national organizations throughout the South and Southeast Asia regions.

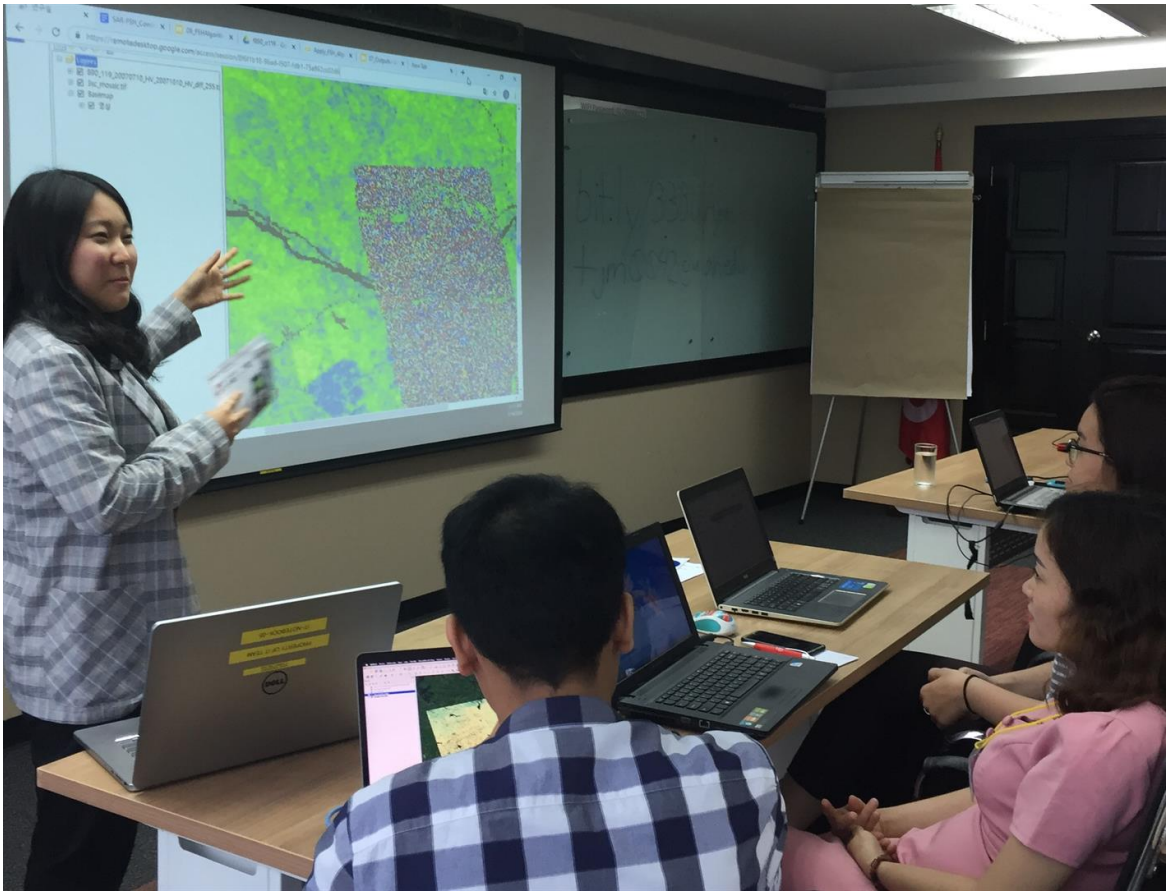


Figure 14. Participant providing an interpretation of the resulting estimated Forest Stand Height product

Credit: SERVIR-Mekong

Acknowledgments

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Aeronautics and Space Administration (NASA). Any mention of commercial product, service, or activity in this material does not constitute NASA endorsement. This material is based upon work supported by NASA through Co-operative agreement number: NNM11AA01A Task no.: 2.4.4

The authors would like to acknowledge the Earth System Science Center at the University of Alabama in Huntsville, the SERVIR Science Coordination Office, the NASA Applied Sciences Program, NASA Capacity Building Program, SERVIR-Mekong, Asian Disaster Preparedness Center (ADPC), SERVIR-Hindu Kush Himalaya, International Centre for Integrated Mountain Development (ICIMOD), Spatial Informatics Group (SIG), Deltares, and Stockholm Environment Institute (SEI). Additionally, information and photos were provided and used with their permission by the various SERVIR hub points of contact who are actively engaged in the partnership in their respective regions and countries.

AUTHOR INFORMATION

Tim Mayer, SERVIR Hindu Kush Himalaya Regional Science Coordination Lead

Tim Mayer[1], Helen Baldwin[1], Kelsey Herndon[1], Africa Flores[1], Thannarot Kunlamai[2], Quyen Nguyen[2], Peeranan Towashiraporn[2], Sylvia Wilson[3]

[1]NASA/SERVIR Science Coordination Office, Earth System Science Center, University of Alabama, Huntsville, United States

[2]SERVIR-Mekong, Asian Disaster Preparedness Center, Bangkok, Thailand

[3]United States Geological Survey, Reston, VA, United States

ABSTRACT

Utilizing Synthetic Aperture Radar (SAR) which provides information such as vegetation structure and moisture content, independently of weather conditions is a powerful tool that can be employed to more effectively monitor deforestation and estimate biomass which is of paramount concern, especially in South and Southeast Asia which contain nearly 15% of all tropical forests. SERVIR, a NASA-USAID initiative, works in partnership with regional hubs around the world building capacity through promoting the use of Earth observations and geospatial technologies. The SERVIR Global network and the SilvaCarbon program collaboratively developed the SAR Handbook: Comprehensive Methodologies for Forest Monitoring and Biomass Estimation which set out to reduce the barriers associated with leveraging SAR and increase the capacity of researchers and practitioners globally to use SAR for monitoring. In particular, utilizing SAR to estimate Forest Stand Height (FSH) is crucial for greenhouse gas emissions reporting and estimating carbon storage. Programs such as Reducing Emissions from Deforestation and Forest Degradation (REDD) rely on parameters such as these for their monitoring efforts. This talk will showcase the collaborative efforts, emergent geospatial technology leveraged, and capacity building approaches utilized by our team to conduct a South and Southeast Asia focused in-person training event located at SERVIR-Mekong, a SERVIR hub lead by the Asian Disaster Preparedness Center (ADPC) in Bangkok.

REFERENCES

Bloomfield, G., Bucht, K., Martínez-Hernández, J.C., Ramírez-Soto, A.F., Sheseña-Hernández, I., Lucio-Palacio, C.R. and Ruelas Inzunza, E., 2018. Capacity building to advance the United Nations sustainable development goals: An overview of tools and approaches related to sustainable land management. Journal of Sustainable Forestry, 37(2), pp.157-177.

Copernicus Sentinel data 2017. Retrieved from ASF DAAC 3rd July 2017, processed by ESA.

Duncanson, L., Armston, J., Disney, M., Avitabile, V., Barbier, N., Calders, K., Carter, S., Chave, J., Herold, M., Crowther, T.W. and Falkowski, M., 2019. The importance of consistent global forest aboveground biomass product validation. Surveys in geophysics, 40(4), pp.979-999.

Flores-Anderson, A.I., Herndon, K.E., Thapa, R.B. and Cherrington, E., 2019. The SAR Handbook: Comprehensive Methodologies for Forest Monitoring and Biomass Estimation.

Herold, M., Carter, S., Avitabile, V., Espejo, A.B., Jonckheere, I., Lucas, R., McRoberts, R.E., Næsset, E., Nightingale, J., Petersen, R. and Reiche, J., 2019. The role and need for space-based forest biomass-related measurements in environmental management and policy. Surveys in Geophysics, 40(4), pp.757-778.

Houghton, R.A., Hall, F. and Goetz, S.J., 2009. Importance of biomass in the global carbon cycle. Journal of Geophysical Research: Biogeosciences, 114(G2).

JAXA/METI ALOS PALSAR L1.0 2007. Accessed through ASF DAAC 11 June 2015.

Lei, Y. and Siqueira, P., 2015. An automatic mosaicking algorithm for the generation of a large-scale forest height map using spaceborne repeat-pass InSAR correlation magnitude. Remote Sensing, 7(5), pp.5639-5659.

Lei, Y. and Siqueira, P., 2014. Estimation of forest height using spaceborne repeat-pass L-band InSAR correlation magnitude over the US state of Maine. Remote Sensing, 6(11), pp.10252-10285.

Lei, Y., Lucas, R., Siqueira, P., Schmidt, M. and Treuhaft, R., 2017. Detection of forest disturbance with spaceborne repeat-pass SAR interferometry. IEEE Transactions on Geoscience and Remote Sensing, 56(4), pp.2424-2439.

Lei, Y., Siqueira, P. and Treuhaft, R., 2017. A physical scattering model of repeat-pass InSAR correlation for vegetation. Waves in Random and Complex Media, 27(1), pp.129-152.

Lei, Y., Siqueira, P., Torbick, N., Ducey, M., Chowdhury, D. and Salas, W., 2018. Generation of Large-Scale Moderate-Resolution Forest Height Mosaic With Spaceborne Repeat-Pass SAR Interferometry and Lidar. IEEE Transactions on Geoscience and Remote Sensing, 57(2), pp.770-787.

Lucas, R.M., Mitchell, A.L. and Armston, J., 2015. Measurement of forest above-ground biomass using active and passive remote sensing at large (subnational to global) scales. Current Forestry Reports, 1(3), pp.162-177.

Sentinel-2 2017 (ESA) image courtesy of the U.S. Geological Survey

Swamy, L., Drazen, E., Johnson, W.R. and Bukoski, J.J., 2018. The future of tropical forests under the United Nations Sustainable Development Goals. Journal of Sustainable Forestry, 37(2), pp.221-256.

United Nations (UN). (2015). Resolution adopted by the General Assembly on 25 September 2015. A/RES/70/1 Transforming our world: The 2030 Agenda for Sustainable Development.

UN (2016) UN sustainable development goals. https://sustainabledevelopment.un.org/?menu=1300. Accessed 22 Dec 2016

UN (2017) Revised list of global sustainable development goal indicators. Report of the inter-agency and expert group on sustainable development goal indicators (E/CN.3/2017/2), Annex III. 1–26

United Nations Framework Convention on Climate Change (UNFCCC). (2015). Adoption of the Paris Agreement (Report No. FCCC/CP/2015 /L.9/Rev.1). Retrieved from http://unfccc.int/ resource/docs/2015/cop21/eng/l09r01.pdf

United Nations Environment Programme (UNEP). (2002). Capacity building for sustainable development: An overview of UNEP environmental capacity development activities (p. 163). Nairobi, Kenya: UNEP

UN-REDD consolidated 2018 Annual Report

Yu, Y. and Saatchi, S., 2016. Sensitivity of L-band SAR backscatter to aboveground biomass of global forests. Remote sensing, 8(6), p.522.