



EARTH SCIENCE  
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# 2019 ANNUAL SUMMARY

NASA Earth Science Applied Sciences Program

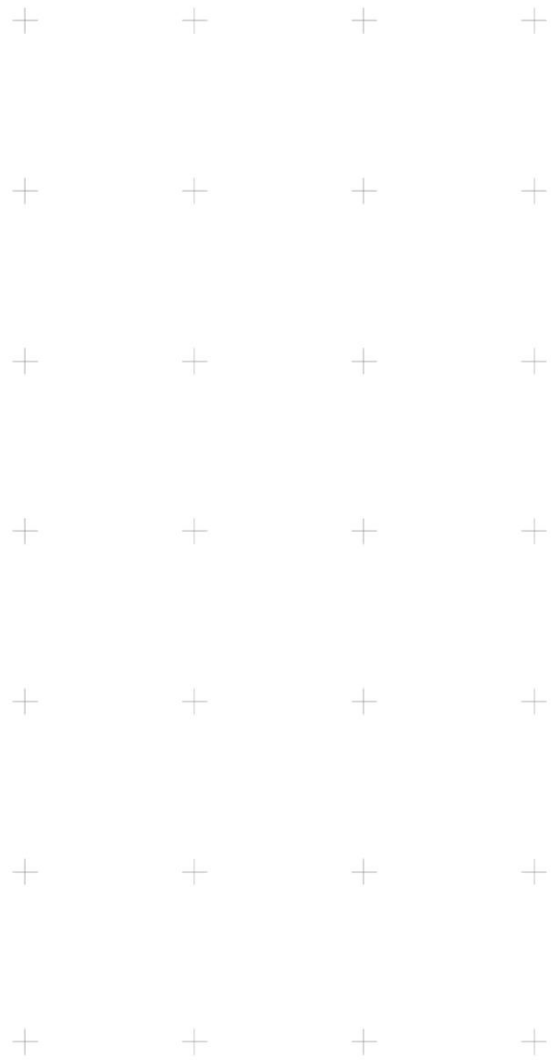
CAPACITY BUILDING

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# INTRODUCTION & 2019 OVERVIEW



# Welcome

We welcome you to the Capacity Building Program's 2019 Annual Report. It has been an exciting year for the program as we continue our pursuit to increase awareness and use of Earth observations. We broke our record in numbers of individuals and institutions engaged, countries reached, and trainings and projects conducted. It was also a year of significant milestones – ARSET celebrated its 10th anniversary, DEVELOP conducted eight projects in partnership with the Central American Integration System (SICA), and SERVIR's Amazonia hub began work. On behalf of the Capacity Building Program Team, I'd like to thank our many stakeholders that help us impact so many across the globe. We invite you to read on to learn about our 2019 highlights and accomplishments.

Dr. Nancy D. Searby  
Capacity Building Program Manager



## I. Introduction

The Earth Science Division's (ESD) [Applied Sciences Program](#) (AppSci) promotes efforts to discover and demonstrate innovative and practical applications of Earth observations. AppSci activities collaborate with organizations across all sectors to apply scientific findings and satellite data in their decision-making activities. The Program has three primary lines of business: Applications, Capacity Building, and Mission Planning. Program activities support our goals to deliver near-term uses of Earth observations, build capabilities to apply Earth science data, and contribute to satellite mission planning.

The Applied Sciences' [Capacity Building Program](#) (CBP) builds capacity around the globe to expand the Earth observations user base and increase awareness within non-traditional audiences of NASA Earth observations data and products. CBP engages across the AppSci Application Areas' portfolios of Water Resources, Disasters, Ecological Forecasting, Health & Air Quality, and Agriculture & Food Security, as well as other application areas including Energy, Urban Development, and Transportation & Infrastructure. The Capacity Building Program works through both program and element activities. Program activities include participating in domestic and international capacity building groups, such as the Group on Earth Observations (GEO) and the Committee on Earth Observation Satellites (CEOS), as well as identifying partnership opportunities to reach new end-users like the Indigenous Peoples Initiative. CBP includes three elements: the Applied Remote Sensing Training Program (ARSET), DEVELOP, and SERVIR.



## Element & Initiative Descriptions

ARSET empowers the global community through remote-sensing trainings. Through online and in-person trainings, participants learn how to use NASA Earth science data, applications, and models. Participants can then apply these free resources to environmental management and decision support. Trainings are intended for policymakers, non-governmental organizations (NGOs), and other applied science professionals. To access the training materials, join the listserv, and learn about upcoming activities, visit <http://arset.gsfc.nasa.gov/>.

DEVELOP addresses environmental and public policy issues by conducting interdisciplinary feasibility projects that apply the lens of NASA Earth observations to community concerns. Bridging the gap between NASA Earth Science and society, DEVELOP provides workforce development opportunities for both participants and partner organizations to prepare them to address challenges that face our society and future generations. To learn more about DEVELOP, view previous projects, and propose a project idea, visit <http://develop.larc.nasa.gov/>.

SERVIR, a joint development initiative between NASA and the U.S. Agency for International Development (USAID), works in partnership with leading regional organizations around the globe to work with developing countries to use information provided by Earth-observing satellites and geospatial technologies to increase resilience and manage environmental risks. SERVIR empowers decision makers with tools, products, and services to improve awareness and increase access to Earth observations and geospatial data in Eastern & Southern Africa, West Africa, Hindu Kush Himalaya, the Lower Mekong, and the Amazon Basin. For more information about SERVIR and its network of regional hubs, visit [www.servirglobal.net/](http://www.servirglobal.net/).

### Capacity Building Initiatives & Affiliated Activities:

- The Indigenous Peoples Pilot Project focuses on building relationships between NASA and indigenous communities through remote sensing training, community engagement, and project opportunities. This pilot project aims to increase the capacity for tribal communities to continue to use NASA resources alongside indigenous knowledge for continued sustainable resource management.
- The A.50 AmeriGEO and Human Planet projects are managed by CBP and are a subset of a broader portfolio, which represents a significant U.S. Group on Earth Observations (USGEO) contribution to the GEO Work Programme for 2017–2019 and 2020–2022. For more information about the larger initiatives to which these projects are contributing, visit: <https://www.amerigeoss.org> and <https://ghsl.jrc.ec.europa.eu/HPI.ph>. An overview and summary of these affiliated projects are included separately in Section IX.

## II. 2019 Overview

Throughout 2019, the Capacity Building Program continued to contribute to Applied Sciences’ goals with a broad reach across sectors, thematic areas, and geographies. Below you can see the program’s 2019 impact “by the numbers” and “by the map.”

### 2019 By the Numbers:

**14,445:** Individuals Engaged

**4,556:** Institutions Engaged

**478:** Products Developed

**56:** Feasibility Studies

**71:** Projects Conducted

**163:** Trainings Conducted

**50:** U.S. States Impacted

**158:** Countries Impacted

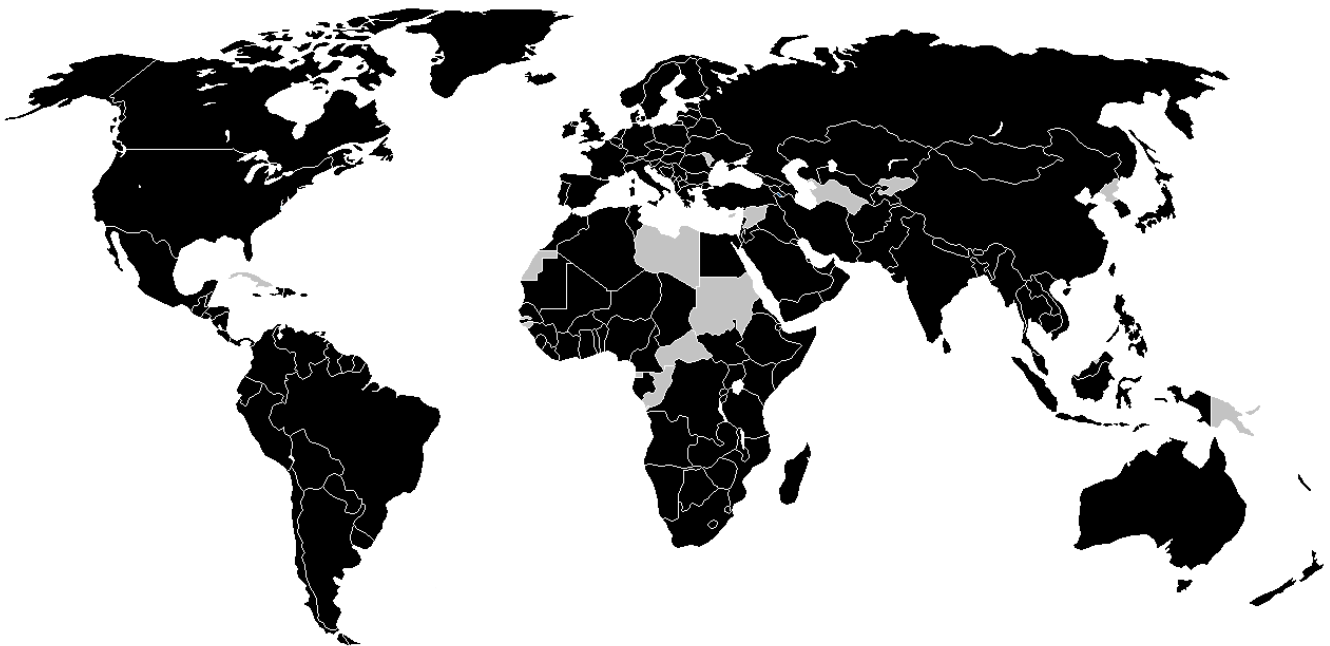
**31:** Peer-Reviewed Publications

**8:** Application Areas Addressed

**101:** Conferences & Exchanges Attended

**57:** Earth Observation Assets Applied

### 2019 By the Map:



*Black denotes the 158 countries reached by CBP activities; gray denotes countries not impacted.*

Throughout 2019, the program worked toward its own strategic goals to expand the networks of individuals and institutions aware of, able to access, and able to apply Earth observations. In support of these activities, the program continued to use a strategic framework focused around the needs of individuals and institutions.



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# ACCOMPLISHMENTS & HIGHLIGHTS



## III. Accomplishments & Highlights

### Programmatic Accomplishments

The Capacity Building Program broke records in 2019. It engaged 14,445 individuals (a 68% increase from 2018) and 4,556 institutions (a 55% increase from 2018). Geographic reach was mapped by including project study areas and locations of end-users and individuals engaged in CBP activities, and showed the program reached all 50 U.S. states and 158 countries. The program supported 163 trainings and 127 projects, developed 478 products, and published 31 peer-reviewed journal articles in 2019. CBP participated in a total of 101 conferences, meetings, and science exchanges, including 18 NASA events (science team meetings, panel reviews, Distributed Active Archive Centers (DAAC) user working group meetings, and AppSci events).

Program elements had a productive year in 2019. Summaries of accomplishments and highlights follow.

In 2019, **ARSET** recognized its 10th anniversary with multiple events, a journal article, and its highest reach yet. The program conducted one in-person training and 15 online trainings. Through the 16 trainer-led offerings, ARSET produced 187 training documents in English and Spanish. There were 12,370 instances of live participation in trainings. ARSET's recorded trainings on the NASA Video YouTube channel have had over 160,000 views. ARSET engaged 4,273 organizations in its trainings, and the program reached attendees that work in 151 countries. The most popular ARSET training in 2019 was the Advanced Webinar: SAR for Disaster & Hydrological Applications, with 1,288 participants, which offered one Spanish session and one English session.

**DEVELOP** had a dynamic year, engaging 269 participants and 135 partner organizations through 56 projects that took place at 12 office locations. These projects and the participants that conducted them impacted 48 U.S. states and 29 countries. The program presented project results and participated in 35 science and policy conferences and meetings, chaired/co-chaired sessions at three conferences [American Association of Geographers (AAG) Annual Meeting, Pecora 21/International Symposium on Remote Sensing of Environment (ISRSE-38), and the American Geophysical Union (AGU) Fall Meeting], and supported five NASA review panels. The program also had three peer-reviewed journal publications and created over 30 videos in 2019, hosted on the DEVELOP YouTube channel, highlighting the use of Earth observations in decision-making.

In 2019, **SERVIR** was active in 46 countries, with five regional hubs located at the Regional Center for Mapping of Resources for Development (RCMRD) in Nairobi, Kenya; the International Centre for Integrated Mountain Development (ICIMOD) in Kathmandu, Nepal; through a consortium led by the Asian Disaster Preparedness Center (ADPC) in Bangkok, Thailand; through a consortium led by Agriculture, Hydrology and Meteorology Regional Center (AGRHYMET), based in Niamey, Niger; through a consortium led by the International Center for Tropical Agriculture (CIAT) in Cali, Colombia; as well as the Science Coordination



Office (SCO) in Huntsville, Alabama, the SERVIR Support Team in Washington D.C., and the SERVIR Applied Sciences Team (AST) at NASA Centers and universities across the United States. The program had 36 custom services in development or delivery stages and conducted 83 trainings during the year with a total reach of 52 countries. Products and tools operate based on data from 33 different satellite instruments. A total of 1,771 people were trained in the use of SERVIR tools, technologies, data, and methodologies, with a total of 194 institutions engaged. Approximately 110 new institutions improved their capacity to address issues relating to changing environments through engagement with SERVIR activities.

In 2019, the **Indigenous Peoples (IP) Pilot** project conducted three in-person trainings and one webinar, attended eight workshops and conferences, and continued to foster relationships with indigenous groups through meetings and engagement activities. The first training was held in collaboration with the Western Water Applications Office (WWAO), to provide an overview of remote sensing and to beta test a drought-monitoring web tool for the Navajo Nation. The second training, held at the Tribal Leaders Summit in Bismarck, ND, focused on web-based climate tools at NASA and strengthened our relationship with tribal groups like the Great Plains Water Alliance. The training held at the Society for Conservation GIS (SCGIS) workshop focused on accessing land data and analysis through LP DAAC tools. The final training activity was an online webinar focused on NASA data and tools for disasters. The audience for this training included tribal liaisons for the USGS Climate Adaptation Centers, the Bureau of Indian Affairs Tribal Resilience Coordinator, and members of the Institute for Tribal Environmental Professionals. This training was held in collaboration with the AppSci Disasters program, and acted as a precursor to a 2020 in-person training. The IP team also attended multiple conferences to increase community engagement. The IP team was instrumental in the creation of the first indigenous-focused session in the history of the international Group on Earth Observations (GEO) ministerial summit.



## Highlight Events & Activities

The Capacity Building Program’s activities are best illustrated by highlighting events and activities that delivered Earth observations to decision makers. Top highlights for 2019 follow:

The **ARSET** program celebrated 10 years of remote sensing training in 2019, and its tenth year was best characterized by exponential growth. Starting in 2009 with only two staff members on hand, ARSET has steadily grown over the years with 19,495 participants engaging in trainings from 2009 to 2018. The year 2019 saw a massive jump to a total of 31,865 participants. In recognition of this milestone, ARSET hosted an



anniversary seminar and celebration in November, which highlighted the many achievements of the team. ARSET aims to continue this growth curve upward in the coming years, and their trainings will continue to evolve to meet the needs of the global remote sensing community.

ARSET has offered materials in Spanish for multiple years, and beginning in 2019, ARSET presented six webinars in Spanish. These trainings included Earth Observations for Indigenous-Led Land Management, Remote Sensing for Disasters Scenarios, A Q&A Session on Radar Remote Sensing, Remote Sensing for Monitoring Land Degradation and Sustainable Cities SDGs, SAR for Land Cover Applications, and SAR for Disasters and Hydrological Applications. As a result of these bilingual trainings, targeted outreach, and a long-term history of presenting high quality materials, ARSET reached attendees in every Latin American country in 2019.

**DEVELOP** had the opportunity in 2019 to support the Joint Statement signed in March 2019 between NASA and Sistema De La Integracion Centroamericana (Central America Integration System, SICA) to make Earth observations and remote sensing data and products more readily available in SICA member countries to help inform decision making. DEVELOP conducted eight projects over the summer and fall 2019 terms that engaged government decision-makers impacting all eight SICA member countries. These projects included mapping landslide susceptibility in the Dominican Republic, assessing water quality near Belize coral reefs, identifying particulate matter and aerosols, and detecting land change along the Mesoamerican Biological Corridor. The outcomes of these projects were successfully presented to SICA stakeholders and senior leaders from Central America attended the Applied Earth Science Applications Showcase in August, which featured many of these projects.



DEVELOPers authored three peer-reviewed journal articles and one article on the LPDAAC website. DEVELOP projects were highlighted in media venues such as Hakai Magazine, the Daily Press, and Energy News Network. Additionally, DEVELOP's people and projects were featured on NASA.gov including an International Astronautical Congress Spotlight, 'Building Results While Building the Workforce,' along with 14 highlight articles on the Applied Sciences Space for U.S. website. DEVELOP participants were recognized for their efforts through a series of awards including SSAI

scholarships and a grand prize at AGU's Data Visualization & Storytelling Competition. Science Advisor Paul Evangelista was awarded NASA's Outstanding Public Leadership Medal.

During 2019, projects from the SERVIR 2015 ASTs completed the major part of their activities. Significant progress was made in achieving their final milestones. Their results were highlighted in an AST Showcase and Celebration 'Celebrating the Successful Application of Satellite Data to Global Development Challenges,' in Washington, D.C., on June 27 and 28. Each of these ROSES projects

collaborated with a regional SERVIR hub – Eastern and Southern Africa (E&SA), West Africa, Hindu Kush Himalaya (HKH), and the Lower Mekong region of Southeast Asia (Mekong) – based on needs identified for that region. These projects included data products and tools such as AST PI Inbal Becker-Reshef's and Co-I Catherine Nakalembe's development of



a GIS-based sampling frame that enabled the expansion of the Kenyan Crop Insurance program; and Patrick Gatlin's development of the High Impact Weather Assessment Toolkit (HIWAT) to forecast extreme weather in the HKH region. Products described in this section and in brief summaries by region below. Catherine Nakalembe won the GEO award for individual excellence for her work with the crop monitor, and received it at the GEO Ministerial Summit in Canberra, Australia, November 4–9.

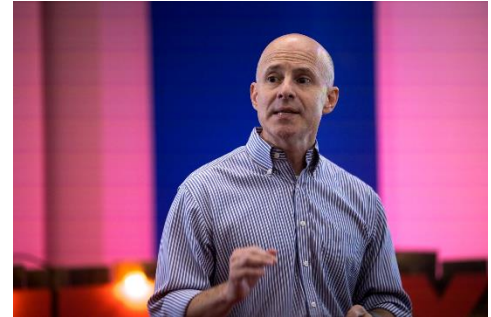
The AST projects achieved an average Application Readiness Level (ARL) of 7.2 by the end of calendar year 2019, increasing their ARL by an average of 1.1 over the calendar year, and with an average ARL increase of 4.4 since project start. Representing a needs-based portfolio in water and water-related disasters, food security and agriculture, weather and climate, and land use and ecosystems application areas, the projects continue to be well integrated with the hubs. One AST project by HKH AST Principal Investigator (PI) Dr. Jim Nelson's team developed the Tethys platform that has lowered the barrier for developing geospatial web applications and is being used across all hubs.

SERVIR continued to develop strategies for maturing its services and growing and strengthening existing partnerships. Collect Earth Online (CEO) was launched in 2018 as a global resource initiated in partnership with the United Nations Food and Agricultural Organization (FAO). CEO is being used by over 190 countries for the 2020 Forest Resource Assessment conducted by the FAO. Countries are also using CEO to support their Greenhouse Emissions reports. In 2019, SERVIR worked with the U.S. Forest Service (USFS) to enhance CEO and integrate TimeSync (beta), and the operational CEO version integrating TimeSync is expected for spring 2020.

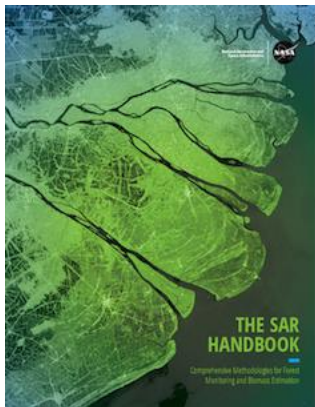


In the context of the March 2019 signing of the joint statement between NASA and SICA, the SERVIR SCO also supported the implementation of the joint statement’s objectives through multiple activities. Among those, SCO personnel contributed to the implementation of eight NASA DEVELOP projects done in collaboration with SICA. The SCO also organized and led a number of webinars with representatives from the SICA countries, involving reach back to other NASA centers and focusing on introducing the SICA country representatives to various NASA Earth observation datasets and technologies as well as GEO flagships and initiatives.

Dan Irwin highlighted the power of Earth observations and a selection of the global projects conducted over the past 15 years by SERVIR, at TEDxVoyagerWay 2019 on Saturday, September 7. The event was held in an updated venue on the campus of the University of Alabama in Huntsville. Irwin spoke to a packed audience, as one of two invited speakers for the well-attended event.

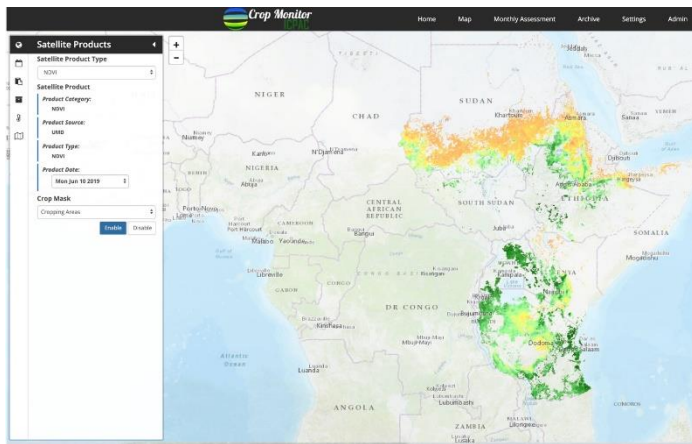


SERVIR, in a joint collaboration with SilvaCarbon, published *The SAR Handbook: Comprehensive Methodologies for Forest Monitoring and Biomass Estimation* in April 2019 and made it available to the public. The SAR Handbook is an actionable guide that focuses on the application of SAR data for forest monitoring and biomass estimation with step-by-step tutorials that include open-source scripts. From its launch in April to November 2019, the SAR Handbook has been downloaded over 300,000 times in over 170 countries. Several SAR workshops have been conducted by SERVIR hubs and the SCO since the SAR Handbook’s release. Also, SERVIR SCO has been working with SAR Subject Matter Experts to expand and keep strengthening SERVIR Global’s SAR capacity. A CEOS WGCapD technical training, Synthetic Aperture Radar Applied in Rice and Forest Monitoring, was supported by SERVIR-Mekong in Hanoi, Vietnam (February 20–22, 2019), while SERVIR-HKH led a training on SAR Applications for Afghanistan in New Delhi, India, April 15–21. A SAR Water & Disasters Training was led by Subject Matter Expert (SME) Bruce Chapman, in Bangkok, Thailand (June 10-14), and the SCO co-led a training with AmeriGEO PI Franz Meyer on Ecosystems Applications of SAR with the new SERVIR-Amazonia hub, in Bogota, Colombia (August 11–17). SERVIR provided a pre-conference training on SAR with CEOS WGCapD at the RCMRD International Conference (RIC) & 4th AfriGEO Symposium in Nairobi, Kenya, August 13–16. SERVIR SCO also created an animated explanatory video about SAR principles and how it works for forest monitoring, launched at the 2019 AGU Fall Meeting in San Francisco, California.



The SERVIR 2015 AST project, led by PI Inbal Becker-Reshef and Co-I Catherine Nakalembe (both of University of Maryland, College Park/NASA HARVEST) and the SERVIR-Eastern and Southern Africa Hub



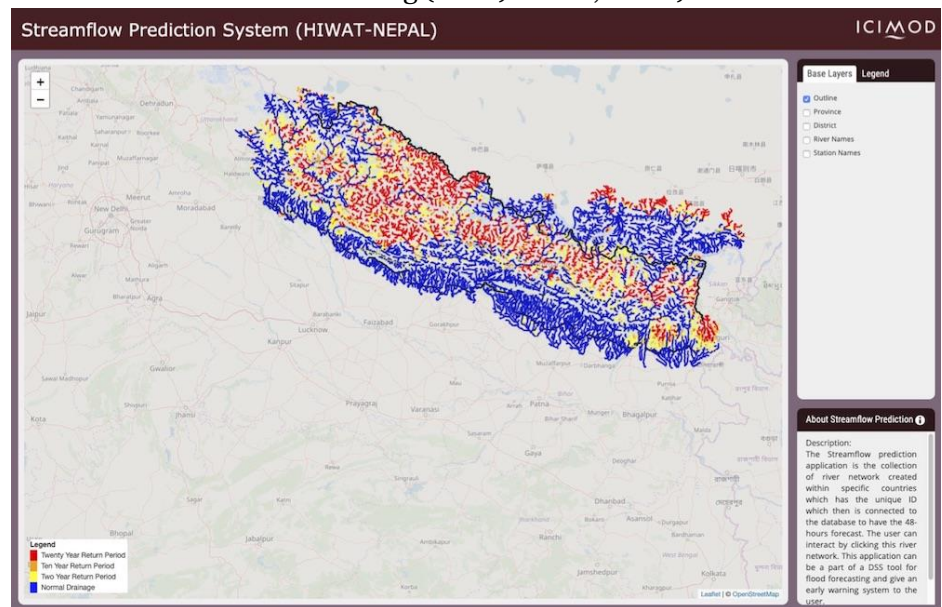


at RCMRD in Nairobi, Kenya, supported the production of regional crop monitors (seasonal) with the Intergovernmental Authority on Development (IGAD) Climate Prediction and Applications Centre (ICPAC) and co-developed ministerial agency/SERVIR national crop condition bulletins (monthly) for Kenya, Uganda, and Tanzania. These ministries are now responsible for the production of the bulletins and have allocated staff and time toward these processes. A learning exchange hosted by the AST

and RCMRD showcased the work with the crop monitors and has inspired continued support for crop monitor development by the governments of Rwanda and Ethiopia, which was led by RCMRD technical staff. An additional activity from the AST involved the creation of a GIS-based sampling frame, which enabled the Kenyan Crop Insurance program to expand coverage across the country, thereby allowing for a 70% cost reduction over previously used data collection methods and insuring hundreds of thousands of additional farmers.

To leverage the latest development in the SERVIR thematic area of Weather and Climate, the SERVIR 2015 AST project, entitled “Monitoring Intense Thunderstorms in the Hindu-Kush Himalayan Region,” led by Principal Investigator Patrick Gatlin, from NASA Marshall Space Flight Center, has co-developed a service with national hydro-meteorological ministries in the HKH that uses the High Impact Weather Assessment Toolkit (HIWAT). The HIWAT facilitates probabilistic forecasting and assessment of hazards associated with high-impact weather. It consists of 1) a real-time, convection-permitting ensemble numerical weather prediction system based on the Weather Research and Forecasting (WRF) model, and 2) a situational awareness tool for gauging thunderstorm intensity from satellite measurements.

Through the SERVIR AST, the Bangladesh Metrological Department (BMD) has been involved in evaluating the HIWAT results for Bangladesh. They were engaged from the beginning of the project and participated in the consultation and capacity-building events. Besides attending regional consultation and training



events, a customized training program was designed for BMD forecasters and conducted at BMD premises in Dhaka, Bangladesh. The HIWAT system was well received within BMD and has been endorsed by the chief weather forecaster and his team, and implementation of the system was recommended to the Director.

The **Indigenous Peoples Pilot** Project co-organized a session at the National Adaptation Forum in Madison, WI, focused on Cross-Cultural Scientific Investigation: Connecting Indigenous Knowledge with Satellites. This session was held in collaboration with NASA’s Minority University Research and Education Project (MUREP) for American Indian and Alaska Native Science, Technology, Engineering, and Mathematics (STEM) Engagement (MAIANSE), NOAA, and the Olohano Foundation. The session focused on how Earth observations can provide insight into the nature and characteristics of changing climate systems and benefit from in-situ knowledge from tribal groups. Discussions and outcomes included 1) addressing how to incorporate different knowledge systems into monitoring natural resources and developing adaptation strategies, 2) strategizing on how to build cross-cultural collaborations between sovereign tribal nations with a focus on indigenous empowerment, and 3) guidance on protocols for collaborations among indigenous groups and NASA. This session brought together scholars, Indigenous Knowledge Holders, and multiple government agencies.



The Indigenous Peoples Pilot Project co-organized a session at the International Group on Earth Observation (GEO) Ministerial Summit in Canberra, Australia, November 4–9, 2019. This session, “Earth observations and the world’s indigenous peoples,” was supported by CBP and colleagues from Conservation International, and was the first indigenous-focused session in the history of GEO. This session included indigenous panelists from Kenya, Ecuador, Australia, and the U.S. The goal of the session was to bring attention to the importance of indigenous peoples to participate in GEO as well as emphasize how Earth observations could benefit indigenous communities. In addition, the pilot project invited James Rattling



Leaf, a member of the Rosebud Sioux Tribe in South Dakota, to attend the Summit. He became the first Native American to be a member of the U.S. Delegation focused on the importance of Earth observations for U.S. tribal nations. These efforts have led to the creation of an indigenous community of practice within GEO.





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# COMMUNITY ENGAGEMENT



## IV. Community Engagement

### Community Leadership

Capacity Building participated, presented, and led sessions in many national conferences, interagency events, and international events in 2019. The CBP Program Manager, Dr. Nancy Searby, supports the interagency U.S. Group on Earth Observations (USGEO)'s International Activities Working Group, the U.S. participation in the regional AmeriGEO initiative, and the GEO Capacity Development Working Group. In June, she became the program scientist for NASA's Socioeconomic Data Center (SEDAC). In November, she began as Chair of the CEOS Working Group for Capacity Building and Data Democracy (WGCapD). Highlights of these broader activities included the 8th Annual WGCapD Meeting in Dehradun, India, in March 2019, AmeriGEO Week in August 2019, in Lima, Peru, and a peer-reviewed publication in Space Policy demonstrating a conceptual framework for a coordinated space capacity development advisory board (SCDAB).

CBP leadership chaired multiple sessions at the InterAction Forum in Washington, D.C., in April and the AGU Fall Meeting in San Francisco, California, in December. These sessions focused on expanding the capacity to use Earth observations to enhance environmental management decisions, actions, and policies and building the community of practice around capacity building efforts. These convenings brought together multiple sectors to discuss their best practices for improving workforce skills to use Earth observations in environmental management and policy decision-making.



The program supported the creation of the CEOS Training Calendar (<https://training.ceos.org/>), which collects Earth observation training opportunities and connects users through a calendar platform. A beta version was launched by the CEOS Systems Engineering Office (SEO) in September and provides a simple means for users to discover available training opportunities. Previously, upcoming trainings were shared through a CEOS WGCapD listserv but now are easily discoverable online. CBP provided guidance in the selection of fields and other calendars feeding this one, continues to promote the resource, collect feedback and suggestions for updates, and is working on a feed to incorporate CBP trainings automatically in 2020.

**ARSET**, in cooperation with remote sensing application community organizations, conducted one in-person training in 2019. This two-day training was held in conjunction with the TEMPO Health Applications



Conference: New Applications in the Use of Satellite Data Monitoring for Population Health. With community and stakeholder interests in mind, ARSET co-produced tailored agendas to provide attendees with the skills required to apply Earth observations to decision-making activities. Lectures and exercises highlighted applications related to air-quality monitoring, forecasting, smoke, fire, PM2.5 monitoring, image interpretation, and data access for modeling efforts.

**DEVELOP** led and joined the science and policy communities in a variety of activities in 2019. The program chaired sessions at the American Association of Geographers Annual Meeting, U.S. International Association for Landscape Ecology (US-IALE), Pecora 21/ISRSE-38, and co-chaired a session at the 2019 AGU Fall Meeting. DEVELOP engaged policy makers through informative visits to state legislators and participation in Virginia’s Aerospace Day in Richmond, Virginia, in February and at NASA Day at the Alabama State Capitol in April. For the second time, DEVELOP attended Groundwork USA’s Youth Summit and National Assembly, presenting on the recent collaborations, continuing engagement with local trusts across the U.S.



**SERVIR’s** SCO continued to promote and strengthen ongoing engagements with regional initiatives such as AfriGEO and AmeriGEO. In conjunction with the West Africa and Eastern & Southern Africa Hubs, the SCO participated in the RCMRD International Conference (RIC) & 4th AfriGEO Symposium in Nairobi, Kenya, August 13–16. Several hundred attendees participated in the conference events, and RCMRD Director General Dr. Emmanuel Nkurunziza expressed gratitude to the U.S. Government, particularly USAID and NASA, for their 10-year partnership with RCMRD through the SERVIR program. Members of the SCO and the SERVIR-Amazonia hub participated in the AmeriGEO Week Symposium in Lima, Peru, August 19–23, with SERVIR-Amazonia Project Director Carlos Gasco giving a presentation about the new hub. Dan Irwin gave a GEO Plenary Intervention at the GEO Ministerial Summit, part of GEO Week events in Canberra, Australia, November 4–9. He represented the U.S. Delegation in giving plenary remarks to over 100 countries about the value of SERVIR regional hubs in support of GEO.

Representatives from the SERVIR-Mekong hub presented at the 16th Annual Meeting of the Asia Oceania Geosciences Society (AOGS 2019) in Singapore, July 29 – August 2, while 13 participants from across the SERVIR global network attended Google’s Geo for Good (G4G) event, held September 16–19 in Sunnyvale, Calif. G4G brought together Earth Engine and Earth Outreach users for panels,





demonstrations, impact stories, and a “Build-A-Thon.” Kabir Uddin and Sudip Pradhan, representing ICIMOD/SERVIR-HKH and working on improving crop layers in the Nepal National Land Cover Monitoring System (NLCMS), received the Best User Interface Award during the Build-a-thon. Members of the SERVIR SCO introduced SERVIR to members of the scientific community participating in the 70th International Astronautical Congress in Washington, D.C., 21–25 October 2019 and Pecora 21/ISRSE-38, and SERVIR’s global activities were once again well-represented at the AGU 2019 Fall Meeting, held in San Francisco, California (December 9–12). In addition, Dan Irwin presented the keynote address at the first Africa Geospatial Data and Internet Conference (AGDIC), held in Accra, Ghana, October 21–25. SERVIR-West Africa hosted their Cloud Computing and Big Data Forum in conjunction with the AGDIC event.

The **Indigenous Peoples Pilot** supported multiple efforts to increase indigenous representation at national and international meetings focused on Earth systems, including at the GEO Week Ministerial Summit. The IP team also engaged with the indigenous community through conference sessions focused on collaborations between sovereign tribal nations, federal agencies, and academics, which allows for better understanding of the value of indigenous knowledge to understanding our complex Earth system. Themes of the National Adaption Forum (NAF) (Madison, Wisconsin, April 25, 2019), the Society for Conservation GIS Workshop (Pacific Grove, California, July 15–17), and the Tribal Leaders Summit (Bismarck, North Dakota, September 5), centered around connecting multiple paths of knowledge, the role of indigenous satellite-based projects at NASA, and finding indigenous leaders to engage with for future efforts.

## Enhancing Data Accessibility

To increase the capabilities of individuals and institutions to use and apply NASA Earth observations, CBP continues efforts to improve data discovery, access, and management through working with WGCapD to build awareness of new datasets and future data architectures and with NASA’s SEDAC on needed population and infrastructure data sets.

**ARSET** helps training attendees build skills to acquire and use Earth observations for decision support. Through its capacity-building activities, ARSET facilitated access to satellite data hosted by NASA and other organizations, including the NOAA, the U.S. Department of Agriculture (USDA), USFS, and non-profit organizations. The program is also deeply engaged with multiple NASA data centers, serving as a formal member on two user working groups, GES DISC, and LANCE. These relationships allow ARSET to share the perspectives and needs of the end-user community with NASA data centers.

**DEVELOP** continued efforts to expand access to tools and results created by its feasibility projects through its publicly available GitHub portal of data processing tools. In 2019, the program had NASA's Software Release Authority approve the release of two tools for public dissemination. Thirty-two projects used Google Earth Engine (57% of total projects) to harness cloud computing for running analyses, simplify data processing for project partners, and increase the utility of DEVELOP products. The LPDAAC conducted two webinars for DEVELOP participants to introduce them to the tools and products made available by the data center.

**SERVIR** and its network are highly involved in enhancing data accessibility in the developing world. SERVIR participated in quality assessment of the very high-resolution data from a commercial vendor under the NASA Data Augmentation plan. SERVIR SCO evaluated the Planet imagery for its radiometric and positional accuracies over West Africa. The data were further used to map out small ephemeral water bodies in West Africa, which was challenging earlier due to moderate spatial resolution data from Landsat and others.

SERVIR SCO continues to have a critical role in the development and continuous improvement of the Collect Earth Online (CEO) application that UN-FAO, USFS, SERVIR, and many other organizations throughout the globe are using to collect expert-interpreted land use/land cover samples using medium- to high-resolution Earth observation data. SERVIR's project was one of many that led to the open provision of the purchased high-resolution data; for more information visit: <https://earthdata.nasa.gov/esds/small-satellite-data-buy-program/commercial-datasets>.

The SOCRATES compute cluster has become an extremely important platform for development and prototyping of SERVIR services, particularly those requiring computing resources exceeding the current capacity of the regional hubs or the hubs' partners. HIWAT was run for Hindu-Kush Himalaya for the second consecutive year successfully and the outputs are being evaluated prior to deployment on stakeholder-owned infrastructure. SOCRATES is also used for running hydrological models and agricultural forecasts for Eastern and Southern Africa, and a visualization application (RHEAS Viewer) has been built to provide farmers with easy to use information derived from these sources.

For the Mekong region, the SCO is co-developing with ADPC an Air Quality Viewer application that incorporates information from multiple sources that will inform a diverse community of users (ranging from government organizations to individuals) about historical trends, real time observations, and machine-learning-based forecasts.

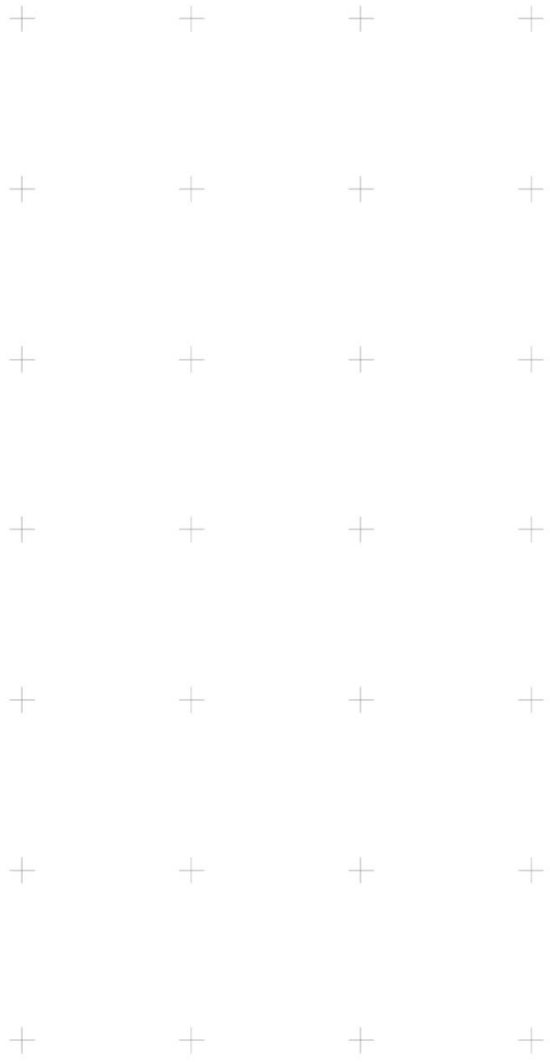
In-person training activities conducted by the **Indigenous Peoples Pilot** project have enhanced data access and use among tribal communities. The IP team trainings have continued to provide overviews of remote sensing, but have focused on highlighting user-friendly online tools that use NASA data in management decisions. The Satellite-based Drought Reporting on the Navajo Nation Training Workshop

(April 9–10, 2019, Flagstaff, Arizona), held in partnership with a Western Water Applications Office (WWAO) project, provided hands-on exercises for the use of Landsat, MODIS, and VIIRS data for land cover mapping and vegetation health, along with beta testing of the Drought Severity Evaluation Tool, a Google Earth Engine application tailored specifically to generate drought severity maps on the Navajo Nation. The IP team also provided a “NASA Tools and Resources for Disasters” webinar, in collaboration with the AppSci Disasters Program, that highlighted multiple NASA Earth observation satellites and tools, such as the NASA Disasters Mapping Portal. This training was provided to members of the Institute of Tribal Environmental Professionals (ITEP) and to tribal liaisons from other regional and federal agencies.





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# 2019 PORTFOLIO

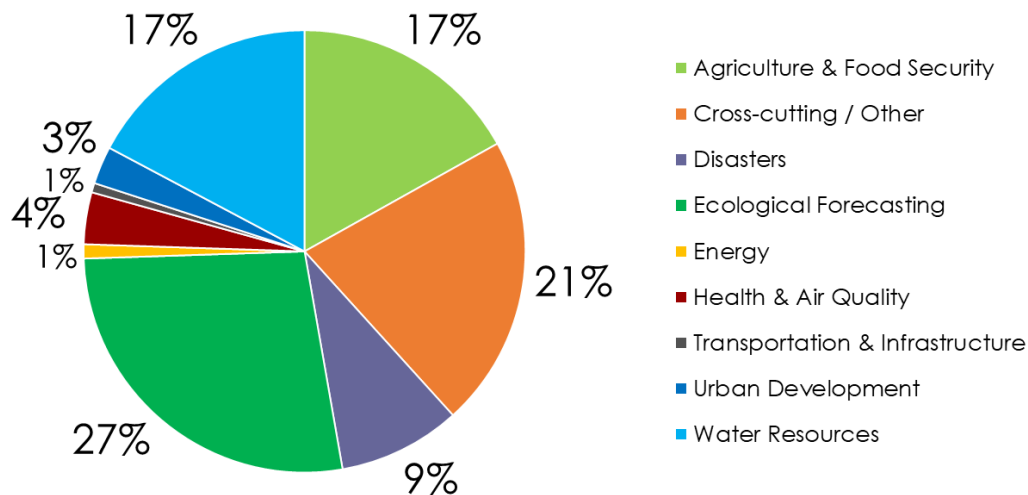


## V. 2019 CBP Portfolio

The Capacity Building Program engages individuals and institutions through a variety of methods for building capacity to use Earth observations: trainings, feasibility studies, and projects. In 2019, the program conducted 163 trainings, 56 feasibility studies, and 71 projects. More information about individual projects and trainings can be found on ARSET, DEVELOP, and SERVIR websites.

CBP activities addressed eight thematic topics in alignment with the Applied Sciences' Application Areas: Agriculture & Food Security, Disasters, Ecological Forecasting, Energy, Health & Air Quality, Transportation & Infrastructure, Urban Development, and Water Resources, as well as other cross-cutting topics such as remote sensing and GIS fundamentals, climate, and weather applications.

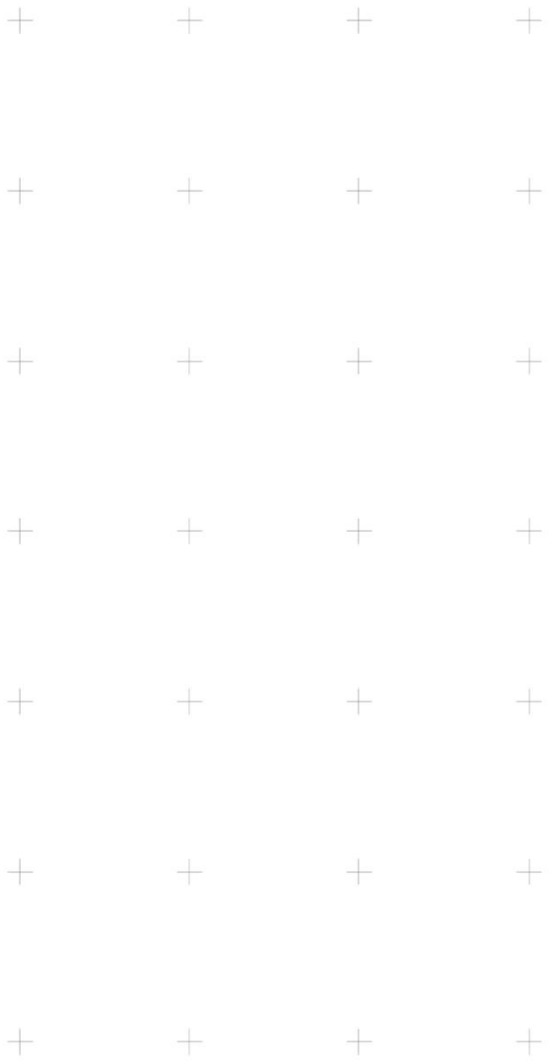
### Thematic Focus Areas of the Capacity Building Activities



Application Areas	Training Portfolio	Project Portfolio
<i>Agriculture &amp; Food Security</i>	14% (23 trainings)	20% (26 projects)
<i>Disasters</i>	11% (18 trainings)	7% (9 projects)
<i>Ecological Forecasting</i>	29% (47 trainings)	25% (32 projects)
<i>Energy</i>	0% (0 trainings)	2% (3 projects)
<i>Health &amp; Air Quality</i>	5% (8 trainings)	2% (3 projects)
<i>Transportation &amp; Infrastructure</i>	0% (0 trainings)	2% (2 projects)
<i>Urban Development</i>	0% (0 trainings)	6% (8 projects)
<i>Water Resources</i>	9% (14 trainings)	28% (36 projects)
<i>Cross-cutting / Other</i>	33% (53 trainings)	7% (9 projects)



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# GEOGRAPHIC REACH

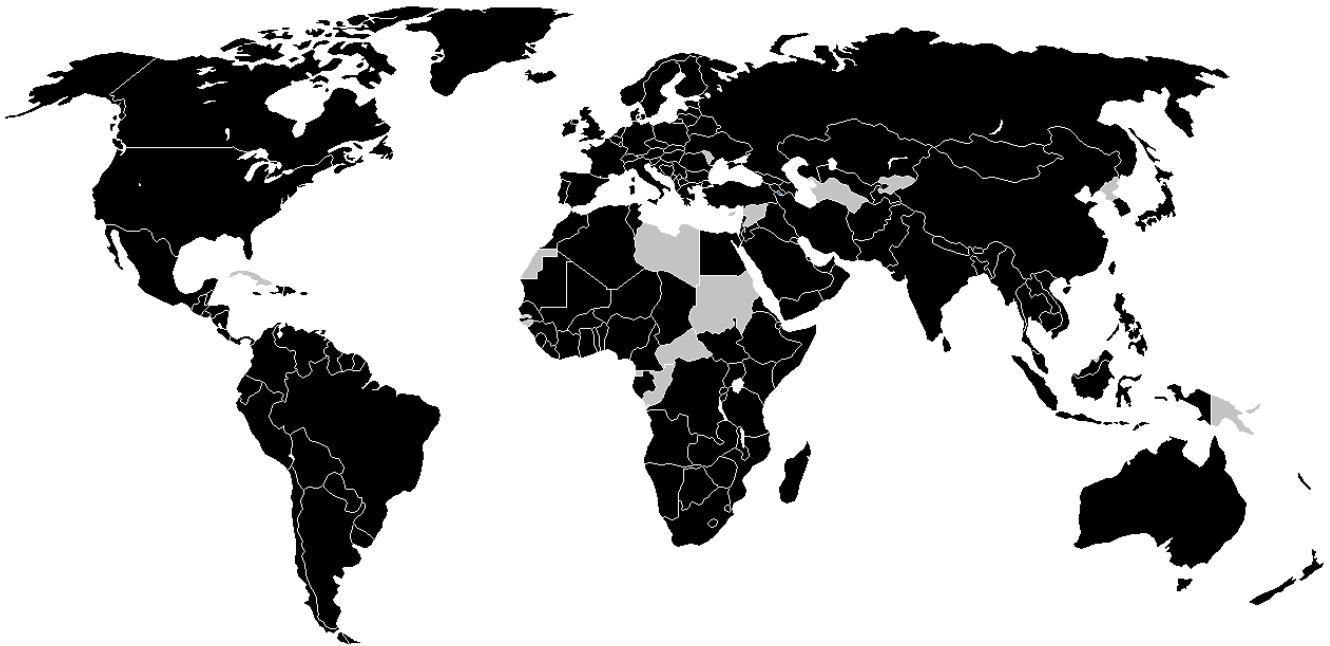


## VI. Geographic Reach

### Geographic Extent of Activities

The Capacity Building Program actively participated in U.S. and international Earth observations and capacity-building activities in 2019 through USGEO, GEO, CEOS, and program element activities.

### Combined CBP Reach



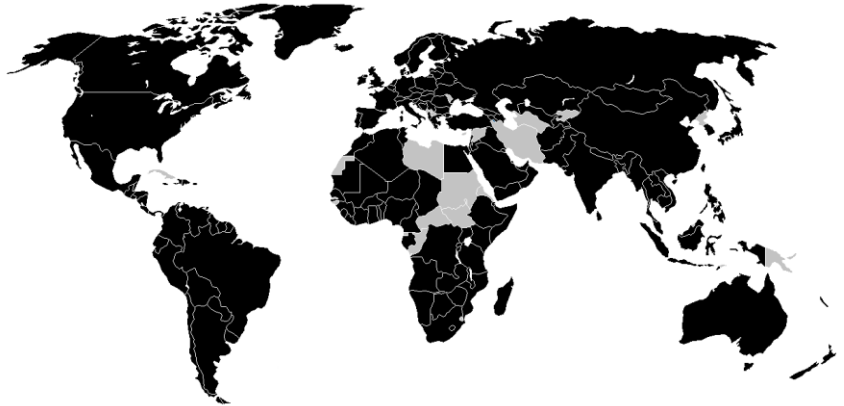
*Black denotes the 158 countries reached by CBP activities; gray denotes countries not impacted.*

### Element Reach

Each element has different geographical targets and focus. Through its online and in-person trainings, ARSET has a global reach, with approximately 18% of the training participants from the U.S. and 82% from outside the U.S. DEVELOP's primary focus is domestic capacity building, and in 2019 the project portfolio consisted of 71% of projects addressing domestic issues and 93% of participants were U.S. citizens. SERVIR is inherently international, working in partnership with leading regional organizations around the globe to help developing countries use information provided by Earth observing satellites and geospatial technologies for managing environmental risks and land use, but also engages domestically through its AST.

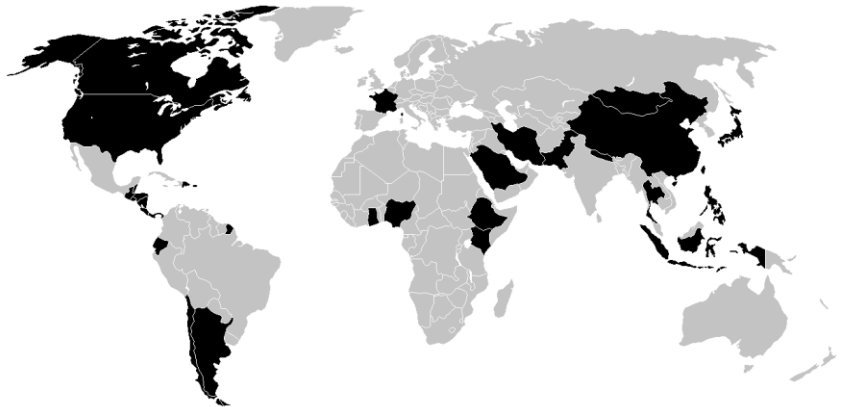


**ARSET** online and in-person trainings reached participants in 151 countries and all 50 U.S. states.



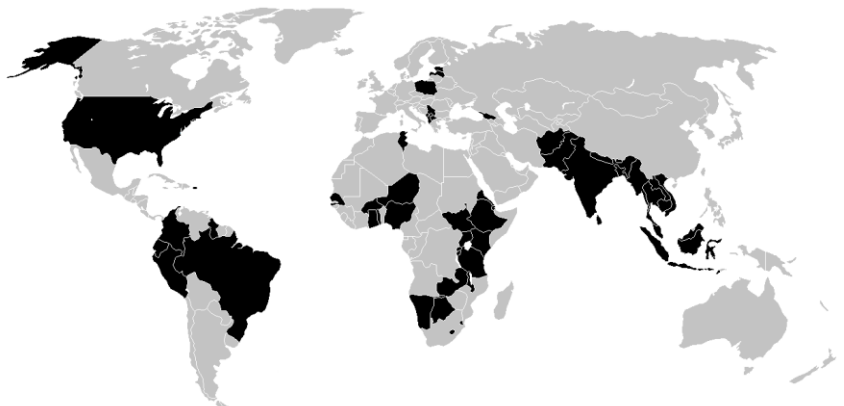
*Black denotes the 151 countries impacted by ARSET*

**DEVELOP** reached 48 U.S. states and 29 countries through its projects and participants.



*Black denotes the 29 countries impacted by DEVELOP*

**SERVIR** engaged in 52 countries and 21 U.S. states through its SCO, regional hubs, and AST.



*Black denotes the 52 countries impacted by SERVIR*

## Regional Reach

CBP organizes international activities by GEO Regional Caucus (Americas, Asia & Oceania, Europe, Africa, and CIS) to assess progress and identify regions that have benefited most from the Program’s capacity building. For each region, overall reach is summarized, and additional information from AST projects is included.

### Americas

CBP reached 7,098 individuals in 29 countries in the Americas caucus region through:

- ARSET – 6,619 individuals (trainees) through one in-person and 16 online trainings
- DEVELOP – 254 individuals (project participants) through 40 feasibility studies (projects with study area in region) and six trainings
- SERVIR – 190 individuals through 11 in-person trainings, and three workshops
- Indigenous Peoples – 35 individuals through three in-person trainings

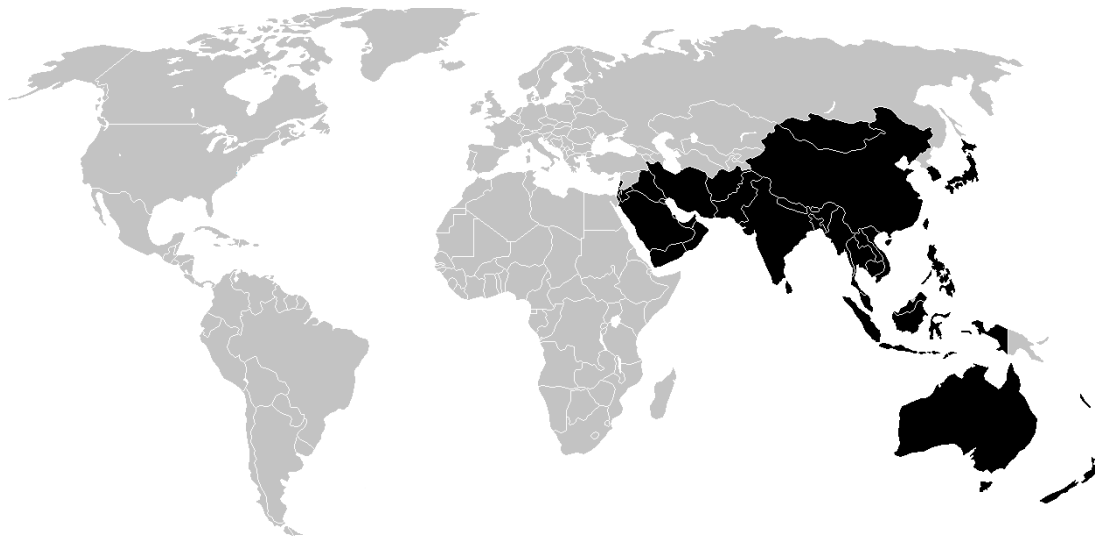


*Black denotes the 29 countries in the Americas impacted by CBP*

### Asia & Oceania

CBP reached 3,218 individuals in 39 countries in the Asia & Oceania caucus region through:

- ARSET – 2,422 individuals through 15 online trainings
- DEVELOP – 11 individuals (project participants) through two feasibility studies (projects with study area in region)
- SERVIR – 785 individuals and eight multi-year projects, 43 in-person trainings, and 25 workshops



*Black denotes the 39 countries in Asia & Oceania impacted by CBP*

*More information for the multi-year projects:*

**Monitoring and Forecasting Drought and Crop Yield for the Lower Mekong Basin (ROSES 2015 - SERVIR AST)**

Principal Investigator: Konstantinos Andreadis, NASA Jet Propulsion Laboratory (former PI was Stephanie Granger)

AppSci Application Area: Agriculture | Thematic Service Area: Agriculture and Food Security

Description: This project used NASA data, local ground observations, and forecasts in a modeling system to provide hydrologic data and drought assessments with associated agricultural yield for the Lower Mekong Basin. The drought-monitoring component of this project contributes significantly toward hub services related to the Agriculture Service Area. Konstantinos Andreadis and Narendra Das conducted technical meetings on the Regional Drought & Crop Yield Information System with co-development partners and stakeholders in Hanoi, Vietnam, on April 25–26, followed by a Hackathon on RHEAS Coding conducted by Das and Amor Ines at ADPC in Bangkok, Thailand, from April 29 – May 3rd. RHEAS was implemented and is operational at ADPC, for drought and rice yield nowcast and seasonal forecast, at <https://rdcylis-servir.adpc.net>. Goal ARL of 8 was achieved for this project, which completed on July 31, 2019.

**Improved Hydrologic Decision Support for the Lower Mekong River Basin through Integrated Remote Sensing and Modeling (ROSES 2015 - SERVIR AST)**

Principal Investigator: John Bolten, NASA Goddard Space Flight Center

AppSci Application Area: Water Resources | Thematic Service Area: Water Resources & Hydroclimatic Disasters

Description: This project aimed to complement and improve ADPC/SERVIR-Mekong’s hydrological modeling capabilities and access to state-of-the-art Earth observation satellite data to enhance water resource management decision-making, agricultural monitoring and forecasting capabilities. Leveraging a previous NASA Disasters Program project, an operational flood inundation and socio-economic impact system was transitioned and began testing, running on ADPC’s server in 2018. A training on the Advanced Soil and Water Assessment Tool (SWAT-CUP) and Soil Moisture Downscaling was held at ADPC in November 2018, followed by a seminar/training on Observing the Terrestrial Water Cycle from Space, provided by Dr. Venkat Lakshmi at ADPC on October 21, 2019.

PI Bolten attended the SWAT-SEA conference Oct. 21–26 in Siem Reap, Cambodia, presenting a keynote on ‘Mapping the Blue Marble: Using Space-Based Observations for Improved Global Water Security and Sustainability,’ and a joint AST-Hub-SCO publication on SWATOnline and NASAaccess was published in October 2019, in Environmental Modelling & Software, and a joint AST-Hub-SCO publication on SWATOnline and NASAaccess was published in October 2019 in Environmental Modelling & Software. Goal ARL of 8 was achieved for this project, which was completed on June 30, 2019.

### **Managing the Changing Water Resources South of the Himalayas (ROSES 2015 - SERVIR AST)**

Principal Investigator: Cédric David, NASA Jet Propulsion Laboratory

AppSci Application Area: Water Resources | Thematic Service Area: Water Resources & Hydroclimatic Disasters

Description: This project trains regional stakeholders and local water managers in the Hindu Kush Himalaya Region to combine remotely-sensed data from GRACE, MODIS, and AMSR2 with NASA modeling assets (GLDAS and RAPID) to provide actionable information on water resources and water-related disasters (floods and droughts), focusing on historical conditions and near real time estimates. The project held a Training of Trainers on “Estimation of Groundwater Storage Changes Using GRACE Satellites” at ICIMOD in Kathmandu, Nepal, April 22–24, 2019. PI David also held a UNESCO/NASA GRACE training in Iguacu Falls, Brazil, June 4–8. The project’s Satellite Hydrology Bits Analysis And Mapping (SHBAAM) application (using GRACE AND GLDAS), and Routing Application for Parallel computatIon of Discharge (RAPID) Flow (using GLDAS and RAPID) have reached an ARL of 6, while the SERVIR-Snow application (using MODIS and AMSR) reached its goal ARL of 5. RAPID is now running at ICIMOD. Current overall ARL for this ongoing project is 6, with a no-cost extension (NCE) through the end of February 2020.

### **Monitoring Intense Thunderstorms in the Hindu Kush-Himalayan Region (ROSES 2015 - SERVIR AST)**

Principal Investigator: Patrick Gatlin, NASA Marshall Space Flight Center

AppSci Application Area: Weather | Thematic Service Area: Weather and Climate

Description: This project integrated NASA Earth Observing System information to facilitate daily assessments of the hazards posed by thunderstorms in the Hindu-Kush Himalayan region. High Impact Weather Assessment Toolkit (HIWAT) components correctly depicted the fatal and damaging hail event in Bangladesh on March 30, 2018. During 2018, the project completed the major milestone of a spring forecast demonstration with the Toolkit. HIWAT weather forecasts were used by the Department of Hydrology and Meteorology (DHM)-Nepal in their decision-making process during the pre-monsoon and monsoon season for that year, and the project reached its goal ARL of 7. HIWAT successfully demonstrated the feasibility of enhancing weather forecasting services, in particular for high-impact weather hazards in the HKH region, and is being expanded for use in other SERVIR regions susceptible to extreme weather. PI Gatlin held a HIWAT Transitional Training for the ICIMOD GIT team from April 8–12, 2019, as well as an ‘Extreme Weather Warning Using HIWAT’ Training to the Bangladesh Meteorological Department on April 10–11. As part of a related Subject Matter Expert (SME) activity from October 28–29, PI Gatlin held a Technical Meeting on Supporting Developing HIWAT for SERVIR-Mekong, at ADPC in Bangkok, Thailand. HIWAT is running at ICIMOD at <https://tethys.servirglobal.net/apps/hiwat/>. The project was completed on October 31, 2019.

### **Building Lasting Capacity for Water Management in Vulnerable Deltas of Indochina (ROSES 2015 - SERVIR AST)**

Principal Investigator: Hyongki Lee, University of Houston

AppSci Application Area: Water Resources | Thematic Service Area: Water Resources & Hydroclimatic Disasters



Description: This project aimed to develop a comprehensive, satellite data-based system that can routinely map, provide early warning of, and enable decision-making on water-related vulnerability issues in low-lying deltas of Indochina. A seasonal water availability anomaly forecasting prototype with the Soil & Water Assessment Tool (SWAT) was developed during 2018. A training was provided to SERVIR-Mekong on June 3, 2019, followed by a training and ‘Technical Meeting on Supporting Flood Forecasting and Water Resource Management Services for the Viet Nam Meteorological and Hydrological Administration (VNMHA)’ on June 4. VIC-added altimetry-based daily river level forecasting for the Mekong was developed, particularly for downstream regions of Tonle Sap Lake and the Mekong Delta, and an operational virtual gauging system using Jason-2/3 altimetry was adopted by SERVIR-Mekong (<https://vrsg-server.adpc.net>) for regional applications and made available for global applications at <https://tethys.servirglobal.net/apps/altex>. An operational dam monitoring and outflow prediction system is now in service with NAWAPI of Vietnam (<http://forecasting.vaci.org.vn>). This project reached a final ARL of 6 and was completed on July 31, 2019.

### **Comprehensive Stream Flow Prediction and Visualization to Support Integrated Water Management (ROSES 2015 - SERVIR AST)**

Principal Investigator: Jim Nelson, Brigham Young University

AppSci Application Area: Water Resources | Thematic Service Areas: Water Resources & Hydroclimatic Disasters

Description: This project developed a cloud-based water resources applications portal and specific web applications to empower the International Centre for Integrated Mountain Development to help water resource managers and other decision-makers in the Hindu Kush Himalaya region access and use streamflow forecasts, flood mapping, and data. Access to these tools and information is enabling preparation for and public warnings of impending floods and related disasters, promoting resilience and recovery after flood events. Tools including HIWAT, GRACE, SALDAS Forecast Visualizer, Streamflow Prediction Tool (for Nepal and Bangladesh), Regional Drought Monitoring System (beta), Agricultural Drought Watch, and HydroViewer Nepal are now available through the SERVIR-HKH, SERVIR-Mekong, and SCO Tethys Apps, with hydroinformatics support provided for all four Applied Science Team (AST) projects for HKH. PI Nelson joined AST PI Ben Zaitchik at the ICIMOD-SERVIR Training Workshop on AST Forecasting Tools in Kathmandu, Nepal, May 13–14, 2019. Current ARL is 8 for this project, with a NCE through January 31, 2020.

### **Supporting satellite-based national land-cover and land-use change monitoring systems in South-East Asian countries (Burma, Cambodia, Laos, Thailand, and Vietnam) (ROSES 2015 - SERVIR AST)**

Principal Investigator: Peter Potapov, University of Maryland, College Park

AppSci Application Area: Ecological Forecasting | Thematic Service Area: Land Cover and Land Use Change & Ecosystems

Description: This tool employed annual Landsat time-series data to create regionally consistent annual tree canopy cover and height layers at 98-ft. (30m) spatial resolution for Southeast Asian Countries. The provided data and data analysis tools were designed to help develop regionally consistent annual forest extent and change maps and implement monitoring results in national and regional planning and management. The data layers are key contributors to SERVIR-Mekong’s Regional Land Cover Monitoring System (RLCMS). During 2019, the project completed development of a semi-automatic, operational algorithm for mapping and monitoring of woody vegetation canopy cover and height at a regional scale using Landsat ARD time-series. The 2000–2018 time-series of regional products were integrated into RLCMS and provided as a service to regional stakeholders through a dedicated data portal, and capacity has been transferred over to SERVIR-Mekong. A training on ‘Implementing the Global Land Cover and Analysis (GLAD) System for monitoring forest cover change in Cambodia’ was held in

Phnom Penh from April 22 – May 3, 2019, and an ‘Overview of SERVIR RLCMS and GLAD systems implementation for national forest monitoring in Myanmar’ training was held in Nay Pyi Taw, Myanmar, July 2–3. This project reached a final ARL of 8, and was completed July 17, 2019.

**Seasonal Prediction of HKH Hydrological Extremes with the South Asia Land Data Assimilation System (ROSES 2015 - SERVIR AST)**

Principal Investigator: Benjamin Zaitchik, Johns Hopkins University

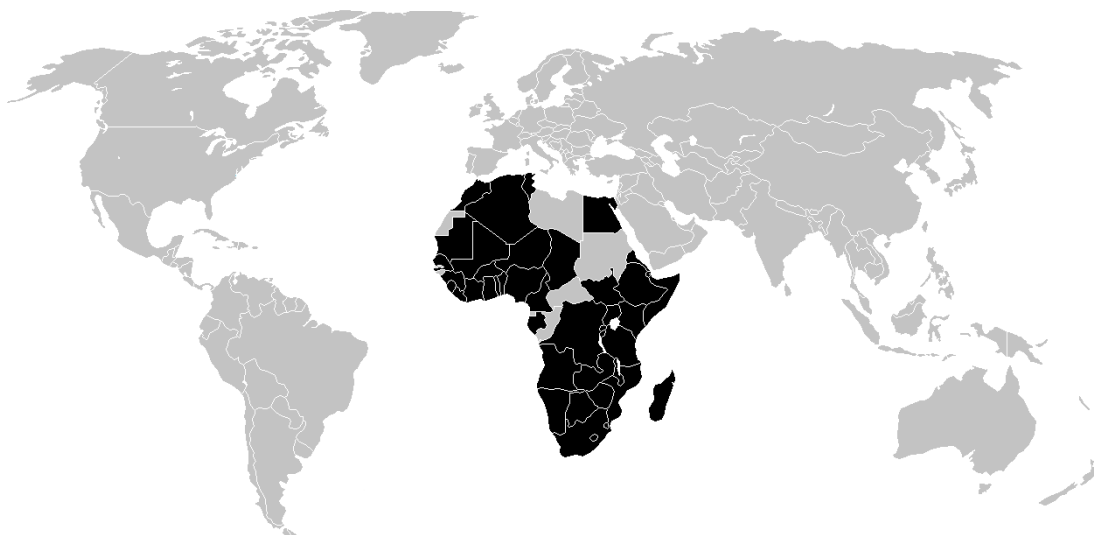
AppSci Application Area: Climate | Thematic Service Area: Weather and Climate

Description: This project generates sub-seasonal to seasonal (S2S) hydrological forecasts for the Hindu Kush Himalaya region, working with end users to produce forecast products that describe the risk of drought or floods on time horizons of weeks to months. This project is helping the SERVIR-Hindu Kush Himalaya Hub with better compilation of different data layers to analyze regional drought. The South Asia LDAS Subseasonal to Seasonal Forecast System (SALDAS) now includes preprocessing scripts to automate bias correction and downscale GEOS-S2S seasonal forecasts using the NCAR GARD tool, and forecast capabilities have been transferred to ICIMOD. PI Zaitchik joined AST PI Jim Nelson at the ICIMOD-SERVIR Training Workshop on AST Forecasting Tools in Kathmandu, Nepal, May 13–14, 2019. The 2019 monsoon season hydrological forecasts were presented to end users during the workshop, and are served through ICIMOD’s portal, and SALDAS has been integrated into ICIMOD’s Agricultural Drought Watch. The goal ARL of 8 was achieved for this project, with a NCE through July 17, 2020.

**Africa**

CBP reached 1,842 individuals in 44 countries in the Africa caucus region through:

- ARSET– 1,265 individuals through 15 online trainings
- DEVELOP – Three individuals (project participants) through one feasibility study (project with study area in region)
- SERVIR – 574 individuals and eight multi-year projects, 28 in-person trainings and eight workshops



*Black denotes the 44 countries in Africa impacted by CBP*

*More information for the multi-year projects:*

**Supporting National Agricultural Monitoring for Food Security (ROSES 2015 - SERVIR AST)**

Principal Investigator: Inbal Becker-Reshef, University of Maryland, College Park

AppSci Application Area: Agriculture | Thematic Service Area: Agriculture and Food Security

Description: This project builds capacity and develops remote-sensing, smart-phone, and collaborative internet technologies for the collection, analysis, and dissemination of data on the status of agricultural and crop conditions as a basis for decision-making, policy design, and agricultural development interventions in Eastern and Southern Africa. A joint UCSB-UMD Hydro-agrometeorology Training was led by Becker-Reshef and AST PI Shrad Shukla (University of California, Santa Barbara), February 27 – March 1 in Dar es Salaam, Tanzania; and a National Crop Monitor Training was led by Becker-Reshef and RCMRD staff in Kigali, Rwanda, March 4–8. Data from this project continues to serve as inputs to Intergovernmental Authority on Development (IGAD) Climate Prediction and Application Centre's (ICPAC's) Eastern Africa Crop Monitor report, delivered quarterly, as well as to the Kenya National Crop Monitor report, the National Crop Monitor Report for Uganda, and National Crop Monitor Report for Tanzania, each delivered monthly. A GIS-based sampling frame was developed and enabled the Kenyan Crop Insurance program to expand coverage across the country. This project reached a final ARL of 8 (exceeding the goal ARL of 7) and was completed on August 1, 2019.

**A West Africa LDAS for Forecasting Extreme Hydrological Events (WALFEHE) (ROSES 2015 - SERVIR AST)**

Principal Investigator: Augusto Getirana, NASA Goddard Space Flight Center

AppSci Application Area: Climate | Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project provides an improved land data assimilation system (LDAS) for integrated water management by Agriculture, Hydrology and Meteorology (AGRHYMET) Regional Center member nations, with a focus on hydrological modeling to provide meteorological, hydrological, and agricultural drought characterizations and forecasts, as well as flood modeling and forecasting. During 2019, Land surface Data Toolkit (LDT) and Land Information System (LIS) libraries were successfully implemented on SERVIR's SOCRATES server, capacity was transferred over to the hub, and AGRHYMET acquired a server (at their own cost) to install LIS to have it run operationally. The West Africa LIS Viewer was installed and is now running at AGRHYMET. The West Africa LDAS is fully based on the NASA's LIS, using state-of-the-art models, data assimilation schemes, and datasets for integrated water management in West Africa. Current ARL is 5 for this ongoing project, with a NCE through August 1, 2020.

**Desertification or "re-greening"? Adaptation lessons learned in coping with late 20th century drought in West Africa (ROSES 2015 - SERVIR AST)**

Principal Investigators: Alessandra Giannini, International Research Institute for Climate and Society (IRI), Columbia University – transitioned in April 2019 to Christopher Small, Lamont-Doherty Earth Observatory, Columbia University

AppSci Application Area: Climate | Thematic Service Area: Weather and Climate

Description: This project uses information from Earth observations and model simulations to develop climate information for decision-making in natural resources management, including water and landscapes, to improve understanding of historical trends in the character of precipitation, their relation to oceanic influence, and to expectation from warming, and to improve agriculture and food security outcomes in West Africa. The project's main results were shared at the SERVIR AST showcase event at NASA headquarters in June 2019. A paper

(Giannini & Kaplan, 2019) was published in Climatic Change, and research regarding the prediction of Sahelian rainfall was prepared for publication, as well as presented at the 2019 AGU fall meeting. Current ARL is 6 for this ongoing project, with a NCE through July 17, 2020.

### **Supporting Pastoralist Livelihoods in West Africa Through Remote Sensing of Rangeland Vegetation Structure, Forage Production and Long-Term Trend Analysis (ROSES 2015 - SERVIR AST)**

Principal Investigator: Niall Hanan, New Mexico State University

AppSci Application Area: Agriculture | Thematic Service Area: Agriculture and Food Security

Description: This project assists SERVIR-West Africa in developing remote sensing-based applications relevant to rangeland vegetation structure and forage production to improve the well-being and resilience of pastoralist and agropastoralist communities in West Africa. This project collaborates with West Africa Consortium partner CSE (based in Senegal), to improve rangeland monitoring in West Africa. CSE has been using the tools developed under this project (in GEE), and these tools will be integrated into the ephemeral water body monitoring service at CSE. Current ARL for this ongoing project is 7, with a goal ARL of 8 and an award end date of July 11, 2020.

### **Enabling Local Monitoring of Landscape Change Across Eastern Africa (ROSES 2015 - SERVIR AST)**

Principal Investigator: Sean Healey, U.S. Forest Service, Rocky Mountain Research Station

AppSci Application Area: Ecological Forecasting | Thematic Service Area: Land Cover and Land Use Change and Ecosystems

Description: This project enabled SERVIR-Eastern and Southern Africa/RCMRD to use cloud computing and the Landsat archive to deliver historical and continuously updated 98-ft. (30m) land cover maps across seven countries (Kenya, Malawi, Ethiopia, Zambia, Tanzania, Rwanda, and Uganda). This project built the capacity of the SERVIR hub to become the regional leader in Land Cover Monitoring, and is providing key annual updates to member countries. Annual Land Cover Change Maps are now operational, with the TimeSync tool used to visualize the Landsat archive. The project worked in collaboration with Spatial Informatics Group (SIG), and integration of the TimeSync tool with Collect Earth Online is nearly complete. This project reached a final ARL of 8 (exceeding the goal ARL of 7) and was completed on August 3, 2019.

### **Forecasting and Communicating Water-Related Disasters in Africa (ROSES 2015 - SERVIR AST)**

Principal Investigator: Yang Hong, University of Oklahoma, Norman

AppSci Application Area: Disasters | Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project uses the EF5 (the Ensemble Framework for Flash Flood Forecasting) hydrologic model to enhance decision-making for water and water-related disasters in Eastern and Southern Africa. Capacity has been strengthened at RCMRD and with stakeholders to use EF5 for flood monitoring and forecasting in the region. Advanced EF5 Training for Kenya was held at RCMRD on November 18–19, 2019, followed by an Advanced EF5 Training for Uganda (November 21–22, in Kampala, Uganda). Current ARL is 7 for this ongoing project, with a NCE through April 17, 2020.

### **Enhancing Eastern and Southern Africa Climate Services by Increasing Access to Remote Sensing and Model Datasets (ROSES 2015 - SERVIR AST)**

Principal investigator: Shraddhanand Shukla, University of California, Santa Barbara

AppSci Application Area: Agriculture, Climate | Thematic Service Area: Agriculture and Food Security



Description: This project enhances SERVIR-Eastern and Southern Africa/RCMRD's access to NASA and Famine Early Warning System Network (FEWS NET) Earth observations, datasets, models, forecasts, and web services to support agricultural and water resources decision-making by ministries and organizations in the region. The Early Warning Explorer (EWX) products, created as part of this project, are being used in several hub services, such as climate vulnerability assessments, and EWX has been fully transitioned to SERVIR-E&SA/RCMRD. Operational production of seasonal scale Evaporative Demand Drought Indication (EDDI) forecasts has been occurring since August 2018, and development and validation of CHIRTSmax was completed. For more information and access to the forecasts, visit <https://chc.ucsb.edu/data>. A joint UCSB-UMD Hydro-agrometeorology Training was led by Becker-Reshef and AST PI Shrad Shukla (University of California, Santa Barbara), February 27 – March 1 in Dar es Salaam, Tanzania. CHIRPS-GEFS and EWX are now being applied by the Zambia Meteorological Department (ZMD) for providing weather forecast maps in ZMD's crop weather bulletin, while the Tanzania Ministry of Agriculture is using CHIRPS and EWX to support early warning of crop yield and food security in the region. Goal ARL of 9 was achieved for this project, which completed July 12, 2019.

### **Monitoring and Projecting Environmental Change in Fragmented Tropical Forest Landscapes (ROSES 2015 - SERVIR AST)**

Principal Investigator: Michael Wimberly, GISc Center of Excellence, South Dakota State University

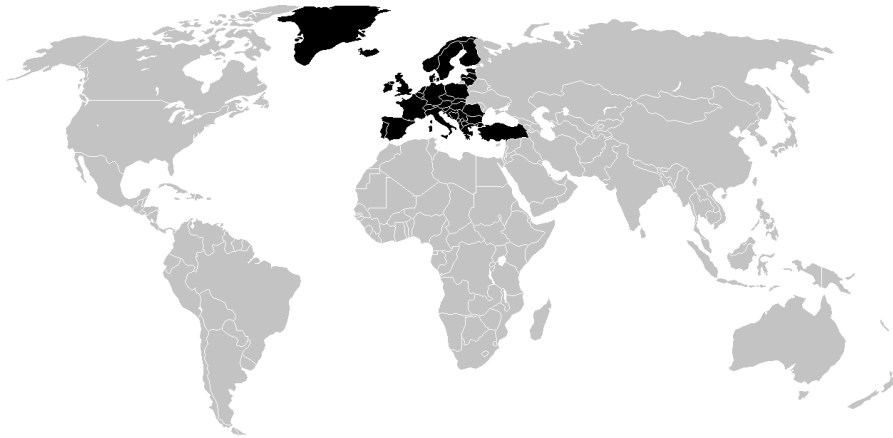
AppSci Application Area: Ecological Forecasting | Thematic Service Area: Land Cover and Land Use Change and Ecosystems

Description: This project integrates Landsat data and landscape simulation models to map historical forest degradation and project future impacts of climate and land-use change on West African forests. This project has generated annual estimates of forest degradation from 2004–2014 in response to a request from the Forestry Commission of Ghana (FC). A database of 7,750 training and validation plots interpreted with high-resolution imagery from 2010–2017 were developed for accuracy assessment, and field assessments were conducted. The project worked closely with the FC to adapt the West Africa Forest Degradation Dataset (WAFForDD) to their needs. Outputs of v1.0 are being used by the FC for their REDD+ reference emission baseline calculations. WAFForDD v2.0, combining multi-sensor predictions of forest canopy condition with temporal segmentation of degradation trends using the LandTrendr algorithm in GEE, is now complete. Stakeholders from the FC also provided feedback on several desired modifications that will be implemented before the end of the project period, with v2.1 coming soon. Goal ARL of 7 has been reached for this ongoing project, with a NCE through February 7, 2020.

## Europe

CBP reached 2,168 individuals in 38 countries in the Europe caucus region through:

- ARSET – 1,945 individuals through 15 online trainings
- DEVELOP – one individual (project participant)
- SERVIR – 222 individuals through two in-person trainings



*Black denotes the 38 countries in Europe impacted by CBP*

## Commonwealth of Independent States (CIS)

CBP reached 108 individuals in eight countries in the CIS caucus region through:

- ARSET – 108 individuals through 15 online trainings



*Black denotes the eight countries in CIS impacted by CBP*



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# PROGRAM MANAGEMENT



## VII. Program Management

### Management Team

Capacity Building is led by Dr. Nancy Searby at NASA Headquarters. In 2019, the program was supported by Christine Mataya and Lauren Childs-Gleason, who served as liaisons between the Elements and NASA Headquarters. Each Element was led by management teams at NASA Centers: ARSET – Dr. Ana Prados, UMD at GSFC; DEVELOP – Michael Ruiz, NASA LaRC; and SERVIR – Dan Irwin, NASA MSFC. The Indigenous Peoples Initiative is led by Dr. Cindy Schmidt, BAERI at ARC. Betzy Hernandez, UAH at MSFC, serves as Associate Program Manager for the AmeriGEO and Human Planet project portfolio.

### Strategic Planning

The Capacity Building Program continues to grow and strengthen through enhanced communication, coordination, and collaboration.

In 2019, the program established bi-annual strategic discussions with each of the Applied Sciences' program areas' teams in the areas of Water Resources, Disasters, Agriculture & Food Security, Ecological Forecasting, and Health & Air Quality. These exchanges allowed for increased coordination through shared discussions around programmatic activities and user engagement. Joint actions and increased awareness of each others' efforts have found efficiencies and new opportunities.

Also in 2019, the program facilitated four virtual retreats focused on tactical topics of priority to the program. Participants focused their discussions on: 1) creation of a GEO & CEOS engagement strategy, 2) indicators and tracking logistics, 3) streamlining reporting mechanisms, and 4) needs assessments, feedback collection, and sharing. Outcomes of the retreats were a strategic engagement planning process for activities related to CEOS and GEO, an updated and finalized set of indicators for the program that were collected in 2019 and are being reported in this document, a shared understanding of the various needs assessments and opportunities for collecting and sharing feedback, and identification of opportunities to simplify reporting requirements. Looking ahead to 2020, the program plans to build on these efforts and conduct an in-person retreat focused on revisiting the framework and re-envisioning our feedback collection and sharing.



On August 2, the program participated in a one-day strategic communications workshop at NASA Headquarters, which was focused on collecting inputs from the team to draft strategic goals for the program’s technical content strategy. This document will guide and support the program’s communications efforts and activities for 2020 and into the future.



In addition to programmatic strategic planning, elements also participated in strategic activities at the element level:

- ARSET’s strategic planning relies on feedback from program participants. These data are used by the program to help determine if program goals are being met and to make adjustments as needed. They are also used for end-user needs assessments and to determine future training topics. ARSET held an Annual Team meeting at the University of Maryland, Baltimore County in February 2019. Highlights included an overview of 2018 program accomplishments and a discussion of what went well and what did not. Survey results were also discussed in detail because these are always used for future planning. Results have been consistent over the past few years, with some changes in future topics of interest such as cloud computing. Future ARSET hires will reflect these changes, so that ARSET can continue to build skills that are consistent with user demand. The last day featured an interactive session on communications, including live practice of elevator speeches on what ARSET does and how NASA data can be used for societal benefit.
- DEVELOP hosted two leadership and strategic planning retreats in 2019. The April retreat’s primary focus was to evaluate the outcomes of the past three-year strategic plan and lay the groundwork for the next plan. Participants conducted a SWOT analysis, identifying areas of success and areas of improvement for the program, and brainstorming sessions for new and innovative approaches for DEVELOP’s consideration. The December retreat focused on refining elements of the draft strategic plan for completion in early 2020. During both retreats, participants benefited from sessions on professional development, meetings with NASA leadership, and learning about broader efforts of the Applied Sciences and Capacity Building programs.
- On May 23, 2019, NASA and U.S. Agency for International Development (USAID) officials convened at NASA Headquarters in Washington, D.C., for the sixth SERVIR Joint Working Group (JWG). The purpose of the meeting was to discuss progress since the last JWG, provide updates and accomplishments, and discuss plans moving forward. Support, commitment, and encouragement was expressed for the SERVIR Project by NASA and USAID leadership, including support for development of a 2020–2025 SERVIR Strategic Plan. An official NASA memo summarizing the event was released in June.

- Indigenous Peoples Pilot Project will primarily focus on establishing and strengthening the GEO indigenous community of practice. This includes attending tribal-led meetings to listen to community needs and discuss tools and resources available, collaborating and partnering with organizations (government, NGOs, private foundations) to work with indigenous communities, co-developing training materials for indigenous communities that include participatory mapping approaches specifically at the Indigenous Mapping Workshop in Regina, Canada, in May, and continuing to learn from indigenous communities about their needs and best ways to use Earth observations. We will also focus on increasing the engagement of indigenous peoples in U.S. GEO and AmeriGEO by co-developing an engagement plan, conducting workshops in U.S. Indian country, and developing an indigenous session at the AmeriGEO meeting in Mexico in September 2020.

## Program Assessment

The program collects outcomes through success stories, highlights, ARSET surveys, and DEVELOP participant surveys. Indicators are used to track intermediate results. Strategic targets are assessed annually, along with Application Readiness Level (ARL) and Project Strength Index (PSI) scores to track yearly progress.

## Strategic Targets & Growth

Each element addresses strategic goals and contributes to the objectives through specific targets and activities. Below shows tracking of targets and actuals over time.

### **ARSET**

Activity	Target	2014	2015	2016	2017	2018	2019
U.S. States Impacted	40+	44	50	50	50	50	50
Countries Impacted	90+	109	123	130	132	138	151
Total # of Individuals	1,500+	1,014	2,877	3,277	4,864	6,362	12,370
Total # of Institutions	500+	650	1,032	1,392	2,030	2,570	4,273
Application Areas	4	4	4	7	4	4	4
Trainings	Varies	11	11	15	18	17	16

### **DEVELOP**

Activity	Target	2014	2015	2016	2017	2018	2019
U.S. States Impacted	35+	46	50	42	49	46	48
U.S.: International	<1:4	N/A	1:4	1:4	1:6	1:5	2:7
Total # of Individuals	250+	379	393	359	342	308	269
Total # of Institutions	75+	160	157	125	128	121	135
Application Areas	All	All (9/9)	All (9/9)	8/9	All (9/9)	All (8/8)	All (8/8)
Feasibility Studies	60	83	93	77	70	65	56

### **SERVIR**

Activity	Target	2014	2015	2016	2017	2018	2019
Countries Impacted	38	44	43	40	40	41	52
Custom Services	42	N/A	47	38	37	42	36
Total # of PI Leads	16	N/A	11	27	25	16	36
Total # of Individuals	283	425	834	623	1202	1,907	1,771
Total # of Institutions	27	159	128	143	150	249	195

### ***Indigenous Peoples Pilot***

Activity	2017	2018	2019
US States Impacted	9	3	7
Total # of Participants	39	23	35
Total # of Organizations	19	12	11
Application Areas Covered	3	2	3

### **Indicator Tracking**

The programmatic performance tracking system was initiated in 2016 based on results frameworks that identify unique indicators for each program element, with a refined number of program-wide indicators collected across all elements. The collection process and indicators collected were refined at the end of 2018 with enhanced definitions of inputs feeding each indicator from each element and a new submission system and documentation. 2019 provided the first full year with the refined indicators, where inputs were collected on a quarterly basis.

#### ***2019 Aggregated Indicators:***

<b>IR-1: Improved Awareness of – and Access to – Earth Observation Data, Products, and Tools</b>	
<i>Sub-IR 1.1: Awareness Increased in New Geographic Regions &amp; Different Sectors</i>	
1.1.1 The Number of States & Countries Reached through CBP Trainings & Projects	50 states; 158 countries
1.1.2 The number of Institutions (by type) Reached through Trainings & Projects	<b>Total:</b> 4,556 – Academic Institution (38%); Consortium (<1%); Federal/ Central Government (19%); Intergovernmental Organization (2%); Local Government (3%); Private Sector (For-Profit) (16%); Private Sector (Non-Profit)/Voluntary or NGO (13%); Research Institute (<1%); State/ Provincial Government (5%); Tribal Entity (1%)
<i>Sub-IR 1.2: Individual &amp; Institution Needs Identified</i>	
1.2.1 The number of front end engagement activities	35,944
<i>Sub IR-1.3: Access to Data, Products, Tools &amp; Trainings Enhanced</i>	
1.3.1 The number of CBP trainings & projects by AppSci National Application Area	<b>Projects – 127 Total:</b> Agriculture (26); Disasters (8); Ecological Forecasting (32); Energy (3); Health & Air Quality (3); Transportation & Infrastructure (2); Urban Development (8); Water Resources (36) <b>Trainings – 163 Total:</b> Agriculture (23); Disasters (18); Ecological Forecasting (47); Energy (0); Health & Air Quality (8); Transportation & Infrastructure (0); Urban Development (0); Water Resources (14)
1.3.2 The number of CBP products posted online	384

1.3.3 The number of NASA Earth observation platforms & sensors utilized in projects & highlighted in trainings	57
<b>IR-2: Strengthened Capacity to Use Earth Observation Data, Products &amp; Tools</b>	
<i>Sub-IR 2.1: Individuals Engaged &amp; Trainings Delivered</i>	
2.1.1 The number of trainings & workshops given or facilitated by CBP Elements	163
2.1.2 The number of individuals engaged in CBP activities	14,445
2.1.3 The number of policy & science conferences attended	101
<i>Sub-IR 2.2: Tailored Products &amp; Tools Co-developed</i>	
2.2.1 The number of products developed by/with support from CBP	478
<i>Sub-IR 2.3: Number of Organizations Using NASA Earth Observations in Their Decision-Making Process</i>	
2.3.1 The number of individuals and/or institutions integrating Earth observations in their decision-making process	40
<b>IR-3: Improved Capacity Building Practices &amp; feedback to Earth Science Community</b>	
<i>Sub-IR 3.1: Best Practices &amp; Lessons Learned Collected &amp; Shared</i>	
3.1.1 The number of best practice documents produced and/or presented by CBP	3
3.1.2 The number of outreach events for CBP activities	24
<i>Sub-IR 3.2: Increased Capability to Monitor &amp; Evaluate Impact of CBP Activities and Collect Feedback</i>	
3.2.1 The percent of individuals who completed pre-training/project surveys & assessments	ARSET (100%); DEVELOP (Participants – 99%; Partners – 50%) SERVIR (N/A); IP (N/A)
3.2.2 The percent of individuals who completed post-training/project surveys & assessments	ARSET (33%); DEVELOP (Partners – 22%; Participants – 97%); SERVIR (N/A); IP (N/A)
3.2.3 The number of projects that achieved yearly ARL goal	8 out of 16
3.2.4 The annual average PSI score for feasibility projects	3.1
<i>Sub-IR 3.3: Feedback to Earth Science Community Delivered</i>	
3.3.1 The number of participation in Science Team Meetings	6
3.3.2 The number of DAAC engagement and feedback activities	7

## Project Process Tracking

Capacity Building tracks projects through two measurements: SERVIR AST’s long-term projects are tracked using the Application Readiness Level (ARL) scale, which begins at 1 (basic research) and continues to a 9 (sustained use of tool); and DEVELOP feasibility projects are tracked using the Project Strength Index (PSI).

### *Metrics for Multi-Year Projects in 2019:*

<b>Metric</b>	<b>ROSES 2015 Projects</b>
<b>SERVIR AST ARL Range</b>	5 - 9
<b>SERVIR AST ARL Mean</b>	7.2
<b>SERVIR AST ARL Mode</b>	8
<b># of Projects with ARL 1-3:</b>	0
<b># of Projects with ARL 4-6:</b>	5
<b># of Projects with ARL 7-9:</b>	11
<b>% of Projects Advanced 1+ ARL in past 12 months</b>	68.7% (11 of 16)



In terms of performance, out of the 2015 AST projects, 11 of 16 projects advanced one or more ARLs. Six projects advanced by two or more ARLs, one increased by at least three levels, and two projects exceeded their goal ARL. The initial mean ARL for these projects was 2.8, and the current mean is 7.2.

A new ROSES 2018 SERVIR AST was selected in fall 2019, resulting in 20 new AST projects. Each of these projects will address needs identified in the thematic service areas by the five regional hubs in Eastern and Southern Africa, Hindu Kush-Himalaya, Lower Mekong, West Africa, and Amazonia regions, and as with the previous round of AST projects will collaborate closely with their respective hubs. Preceded by a series of virtual kickoff meetings, along with informal engagements at the 2019 AGU Fall Meeting, the in-person kickoff for the new teams will be held at the 2020 SERVIR Annual Global Exchange (SAGE). As in previous years, sessions on the first day of SAGE will allow participants from the new AST team to engage with SCO and hub scientists to meet face-to-face and share insights on their regional activities and look forward to close collaborations over the next three years. The 2018 AST projects do not have ARLs to report at this time.

DEVELOP continued to track and assess its feasibility projects by means of its Project Strength Index (PSI). This scale takes into consideration both the scientific merit of the work and the project's applicability to decision making and partner capacity building. The PSI measures a project on scientific merit and the applicability to decision making for the project partners. The PSI tracks the progress of projects across a 5-point scale of 1) Basic Research, 2) Application Concept Complete, 3) Application Demonstration Successful, 4) Application Verified/End User Engaged, and 5) Transition to End User/Decision Enhanced. For the 56 feasibility projects conducted during 2019, the average PSI score was a 3.1.

## Analysis & Discussion

A review of the targets and actuals, as well as an analysis of the updated indicators' change from the previous year provide interesting takeaways. Areas with the biggest change are reviewed and discussed below:

- ***Individuals***: CBP saw a 68% increase from 2018, which was entirely driven by ARSET's increase in participants. This growth has been driven by an expansion of "room" size in the webinar platform used by the program and increased promotional activities.
- ***Institutions***: CBP saw a 55% increase in unique institutions engaged, which was driven by ARSET's growth in individuals trained. An interesting aspect of the institutions engaged is an increase seen in more private sector (both for-profit and non-profit), which saw for-profit engagement increase from 8% in 2018 to 16% in 2019, and non-profit engagement rose from 6% in 2018 to 13% in 2019. While the drivers behind this shift are not entirely evident, efforts in 2019 to present at conferences and meetings where there were more private sector institutions in attendance (e.g., the InterAction Forum, an annual meeting of non-profits) may have contributed.
- ***Projects***: CBP saw a 51% increase in the number of projects conducted in 2019. This growth was driven by SERVIR and its global network, which has expanded with the addition of a new hub in Amazonia in 2019 and temporarily includes both projects from the second SERVIR AST and third SERVIR AST, which began at the end of 2019. The most projects were conducted within the Water

Resources theme (28% in 2019), although this was down from 2018 when Water Resources made up 35% of the portfolio. Ecological Forecasting saw a 167% increase of projects, shifting from 14% of the portfolio in 2018 to 25% of the portfolio in 2019. While DEVELOP project numbers have shown steady decline since 2015 when the program had 16 nodes, the quality of projects has increased as shown by the increase in average annual PSI score. The decline in the number of projects conducted by DEVELOP is a product of a relatively uniform budget year-to-year combined with changes in employee classifications increasing per-participant costs, and other programmatic adjustments like standardization of project team size, fewer nodes to host projects, and the elimination of volunteer opportunities.

- ***Trainings:*** CBP saw a 92% increase in the number of trainings in 2019, which was driven by a major increase in the number of SERVIR trainings throughout its network and DEVELOP’s introduction of Software Carpentry Trainings. An interesting note within trainings was that 2019 saw Ecological Forecasting-related trainings make up the greatest part of the portfolio (29% in 2019, up from 21% in 2018), while Water Resources went from 28% of the portfolio in 2018 to only 8% in 2019. There was also a major increase in the number of cross-cutting trainings, which may be a product of improved reporting and not of an actual increase.
- ***Countries:*** CBP saw an 8% increase in countries reached through its activities, primarily through ARSET’s online trainings. A gap analysis shows that 37 countries were not impacted by CBP in 2019. In 2020, CBP will explore options for engaging the 37 countries in ARSET trainings, where possible.
- ***Front-end Activities:*** In 2019, CBP updated the definitions for inputs feeding indicators, and one product was a major increase in front-end activities counted (109 in 2018 to 35,944 in 2019). This was solely due to improved tracking and collection by the elements and additional items being included in the number, not a functional change in capacity building activities from 2018. The updated definition of the indicator includes all early engagements of individuals and institutions conducted by CBP, whereas in 2018 the input was primarily driven by DEVELOP inputs. 2019 saw a major addition of both ARSET and SERVIR inputs, meaning a more holistic view on front-end activities has been captured. Discussions in 2020 will focus around the inputs in this indicator, what the indicator is telling us, and if an adjustment is needed.

Looking ahead to 2020, the program will continue its monitoring and evaluation efforts with a focus on learning from these activities and how to better conduct these analyses. Updates to indicators will be discussed and course correction taken as appropriate.

## Internal Collaborative Activities

The Capacity Building Program integrates and efficiently leverages activities between program elements. In 2019, the program continued collaboration between the elements in the following ways:

- 14 DEVELOPers participated in ARSET online trainings.
- SERVIR and ARSET collaborated on the online training “A Q&A Session on Radar Remote Sensing,” a July 2019 ARSET training.

- ARSET and DEVELOP collaborated to represent CBP at the 2019 InterAction Forum to increase engagement of NGOs.
- SERVIR provided extensive support to the eight DEVELOP projects in support of the NASA-SICA Joint Statement.
- Representatives from ARSET, DEVELOP, and the Indigenous Peoples Pilot Project participated in and contributed capacity building insights to SERVIR’s Capacity Building Exchange, engaging with hub capacity building leads and SCO participants in Huntsville, Alabama, from Dec 4–6, 2019.
- DEVELOP and SERVIR collaborated on an international project ‘Utilizing NASA Earth Observations in the RHEAS Model to Enhance Drought Monitoring and Mitigation in Kenya.’



EARTH SCIENCE  
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# LOOKING AHEAD





## VIII. Looking Ahead

### What will 2020 bring?

In 2020, the Capacity Building Program will continue to address the CBP strategic goals to expand the networks of individuals and institutions to be aware of, able to access, and use Earth observations in their decision making. Through its elements and initiatives, the program will engage with interagency and international consortiums, boundary organizations, and the broader NASA Earth Sciences community to further increase the number of individuals and institutions benefiting from NASA's investment in Earth science. As Dr. Searby assumes the CEOS WGCapD Chair position, the program will identify strategic opportunities for new international capacity-building partnerships and activities. The program also intends to focus efforts on enhancing communications with an emphasis on “storytelling,” more strategic targeting of audiences, and increased common language.

ARSET plans to include thematic, asynchronous on-demand trainings into its platform. ARSET will also continue its focus on Latin America, providing several dual-language trainings and translating most online materials into Spanish. Topics for 2020 include webinars on Disaster Risk Management and SAR applications. In addition to the regular multi-week webinar series, there will also be a larger number of single ½-hour to 1-hour webinars.

DEVELOP will continue to engage the future workforce through its 11 nodes and use resources across the CBP Elements and at the DAACs to strengthen connections between DEVELOP participants, especially those at regional locations, and the broader NASA community. The program will continue implementation of Software Carpentry trainings throughout the program, increasing the number of locations that host these trainings. The program also aims to expand its outreach and recruiting efforts to underrepresented applicants, geographic areas, and partner sectors.

SERVIR will continue to strengthen the network through co-development of services across multiple Hubs and partners. SERVIR will mark its 15th year on February 3, 2020, celebrated at the 2020 SAGE held February 3–7 in Siem Reap, Cambodia, as well as through a series of articles and social media. 2020 will also mark the 10th year since the launch of SERVIR-HKH.

The Indigenous Peoples Pilot will pursue additional workshops and trainings with national and international partners, support the GEO indigenous community of practice activities, engage with CEOS activities in Canada and Australia for indigenous workshops, and continue to provide innovative tools/resources that meet the unique needs of indigenous communities.

On September 30, 2019, a new Interagency Agreement was signed between NASA Marshall Space Flight Center and the U.S. Department of State to support individual and collaborative SERVIR, DEVELOP, and GLOBE activities, focused on strengthening the capacity of Bhutanese scholars and institutional partners

from government, academia, and other non-governmental sectors to use NASA Earth observations to take better environmental decisions and actions. Activities will launch in early CY 2020.

All CBP elements will contribute to the CBP goal to build Earth sciences community capacity to define end-user needs, collect and share robust feedback, build capacity, and assess impact of capacity building activities. CBP will continue to collect, compile, and communicate lessons learned and best practices. The CBP will continue to grow the community of practice around Earth observation capacity building. This will be accomplished through participating in science conferences like the AGU Fall Meeting, building relationships with other program managers in AppSci and NASA's Research & Analysis, participating in DAAC User Working Groups and Science Team meetings, leading CEOS WGCapD and co-chair of GEO Capacity Development Working Group, and engaging with the broader community.

Focused on its five strategic goals and strategic framework, CBP will continue to evolve and strengthen as it further refines methods for tracking progress and impact. Capacity Building management will continue to work with the program element teams to ensure that they have the resources to address user needs for Earth observations skills and to integrate and benefit from each others' work as well as the work of the capacity-building networks acting through CEOS, GEO, and the Coordination Group for Meteorological Satellites (CGMS). Implementation of the SCDAB, envisioned to be a network of networks like CEOS, GEO, and CGMS capacity building networks, to coordinate capacity development to support the 2030 Agenda of Sustainable Development, the Sendai Framework for Disaster Risk Reduction, and the Paris Agreement, will be an important focus for 2020.



EARTH SCIENCE  
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# GEO PROJECTS



## IX. GEO Projects

### Overview

The AmeriGEO and Human Planet projects focus respectively on building and strengthening capacity in the use of Earth observations in the Americas, and strengthening the capacity to apply spatial data to understand human presence on the planet. Both sets of projects – seven altogether – are a subset of a broader group of NASA A.50 projects, which represent a significant USGEO contribution to the GEO Work Programme for 2017–2019 and 2020–2022. Specifically, the four AmeriGEO projects contribute to the work of the AmeriGEO regional initiative, while the three Human Planet projects operate in the context of the GEO Human Planet initiative. While the Human Planet projects are mainly global in scope, the AmeriGEO projects focus particularly on a number of the now 19 GEO member countries in the Americas. For more information about the larger initiatives to which these projects are contributing, visit:

<https://www.amerigeoss.org> and <https://ghsl.jrc.ec.europa.eu/HPI.php>.

In their second year of implementation, the GEO projects continued to have noteworthy contributions to and engagement with the broader Earth observation community. The AmeriGEO projects had active participation in the annual AmeriGEO Week Symposium in Lima, Peru, in August 2019, while the Human Planet projects were all highlighted at the second Human Planet Forum, in New York, in late September 2019. Both sets of projects were also highlighted at GEO Week 2019 in Canberra, Australia, in November 2019. At GEO Week, six of the seven projects submitted impact stories, which were in turn featured at the US GEO booth in Canberra. Updates on the AmeriGEO projects' progress have also been fixtures of the monthly AmeriGEO Coordination Working Group calls. At the end of 2019, there was also strong participation from the AmeriGEO and Human Planet project PIs and collaborators at the AGU Fall Meeting, where most of the projects were featured in oral or poster presentations. The AmeriGEO projects were also highlighted in an Americas-specific oral and poster session which emphasized the role of Earth observation in environmental monitoring in the Western Hemisphere.

The AmeriGEO and Human Planet projects are internationally focused, contributing to GEO Work Programme 2017–2019 and 2020–2022 activities in countries across the world. While the Human Planet projects have mainly been developing global-scale products (e.g., NASA Black Marble), some of the projects' activities have been focused on pilot countries, such as Colombia and Nigeria. In contrast, the AmeriGEO projects have engaged 19 countries in the Americas. The projects operate in close conjunction with the GEO initiatives to which they contribute. In the case of AmeriGEO projects, which seek to strengthen capacity particularly in GEO member countries in the Americas, the projects are largely being implemented along with specialized agencies of the governments where these projects are operating. In the case of the EO4IM project, which seeks to strengthen the capacity of indigenous communities in Ecuador and Peru to use Earth observations, the project is engaging the Achuar nation in Ecuador and the Regional Office for the Development of Indigenous Peoples of San Martin in Peru.



## Project Descriptions

### **SAR-CBC: A Capacity Building Center for the Use of SAR in Decision Making (ROSES 2017 - AmeriGEO)**

Principal Investigator: Franz Meyer, University of Alaska-Fairbanks

Thematic Service Area: Agriculture & Food Security, Biodiversity & Ecosystems, Water Resources and Hydroclimatic Disasters

Description: This project is developing targeted educational material, webinars, and on-site trainings that build capacity in the use of SAR-based Earth observation data in decision making. To sustain the use of SAR resources long term, the project is also developing innovative cloud-based data processing solutions that enable SAR data analysis without requiring expensive computing infrastructure. In 2018, the project conducted needs assessments with the four sets of stakeholders in Colombia (i.e., IDEAM), Ecuador (IIGE, UCE), and El Salvador (MARN), as well as developing the structure and curriculum for the capacity building center and activities which will be implemented in project years 2–4 (2019–2021). In 2019, the project carried out an in-person training in Colombia and a virtual training in Ecuador.

### **Laying the Foundations of the Pole-to-Pole Marine Biodiversity Observation Network (MBON) of the Americas (ROSES 2017 - AmeriGEO)**

Principal Investigator: Enrique Montes, University of South Florida

Thematic Service Area: Biodiversity & Ecosystems

Description: This project is building a community of practice at the continental scale that serves the information needs of multiple national and international stakeholders for the conservation of marine living resources. In 2019, the project has continued its collaborative development of seascape biogeographic datasets and maps for both coasts of the Americas. The project also hosted its second regional training workshop in April 2019, in Puerto Morelos, Mexico. Data from biodiversity surveys for various countries in the Americas have also been collected and used in the validation of the project's seascape outputs. Data from those surveys can be visualized via: <https://marinebon.github.io/p2p/>.

### **Harnessing Earth Observations to Support Indigenous-Led Land Management (ROSES 2017 - AmeriGEO)**

Principal Investigator: Karyn Tabor, Conservation International

Thematic Service Area: Biodiversity & Ecosystems

Description: This project is focused on strengthening the technical capacities of indigenous organizations in the Americas to harness the power of Earth observation data for enhanced sustainable land management across indigenous lands. Where this project focuses on strengthening the capacity of indigenous communities in Ecuador and Peru to utilize Earth observation data, in 2019, a variety of activities were accomplished. The project hosted a side session on the use of Earth observations for indigenous land management at the 2019 GEO Week in Canberra, Australia, which was also attended by representatives of stakeholder groups with whom the project is working. Also coming out of GEO Week 2019, there was a strong endorsement by indigenous communities for initiatives like the EO4IM project, via an official declaration by those communities.

### **Supporting the Vision for GEOSS in the Americas: Community Building and Capacity Development in Support of AmeriGEO's Food Security and Sustainable Agriculture Area (ROSES 2017 - AmeriGEO)**

Principal Investigator: Alyssa Whitcraft, University of Maryland

#### Thematic Service Area: Agriculture & Food Security

Description: This project seeks to: enhance national and regional capacity to monitor food supply using Earth observations; empower science-based decision making related to food security & agriculture; increase regional collaboration and cooperation around agriculture monitoring; create a sustainable model for within-region collaboration; guide future capacity development activities related to Earth observations; and enhance the adoption of NASA instruments' data. In 2019, the project has continued its coordination with stakeholder agencies in Argentina, Brazil, and Chile, toward improvement of the existing GLAM systems in the first two countries, and development of a GLAM system for Chile. In 2019, a resource hub for the Agricultural Monitoring in the Americas (AMA) community of practice was launched (<http://www.agamericas.org>). Cooperation with SICA was explored, in the context of the Joint Statement that had been entered into between NASA and SICA in early 2019.

#### **Population and Infrastructure on Our Human Planet: Supporting Sustainable Development Through Improved Spatial Data and Models for Human Settlements, Infrastructure, and Population Distribution Based on Earth Observations (ROSES 2017 - Human Planet)**

Principal Investigator: Robert Chen, Columbia University

Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project is being implemented in close collaboration with national statistical offices (NSOs) and related ministries and stakeholders in two countries, Nigeria and Colombia, to identify and address their needs for integrated settlement, infrastructure, and population data and models with respect to monitoring, planning, and decision making regarding the Sustainable Development Goals (SDGs) and associated targets and indicators. In 2019, a stakeholder consultation in Nigeria was held, also involving partners from the NASA- and USAID-supported SERVIR-West Africa initiative. PI Chen also convened the second Human Planet Forum, which was held on Columbia University's Lamont campus in New York, in late September 2019.

#### **Mapping the Missing Millions: Developing a Global Database of Informal Settlement Location, Schema, and SDGs Indicators Using Crowdsourced Data, Machine Learning, and Multi-Sensor Satellite Imagery (ROSES 2017 - Human Planet)**

Principal Investigator: Jamon Van Den Hoek, Oregon State University

Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project is developing open, global-scale geospatial data to locate, characterize, and assess SDG indicators at informal settlements belonging to refugees, internally displaced populations, and forcibly displaced and resettled people: the "missing millions." Using crowdsourced data, machine learning, and remotely sensed SDG indicator proxies, the project is developing a novel open, global-scale vector dataset representing "missing millions" informal settlements, attributed with information on schema, spatial typology, and enviro-climatic conditions to support sub-national SDGs assessment for the world's most vulnerable. In 2019, the project finalized development of typologies for informal settlements and continued development of the machine-learning algorithms for identifying such settlements, including validation. In the context of the NASA data buy for high spatial-resolution data, the project also evaluated the potential use of high temporal- and spatial-resolution data from Planet for settlement detection.

#### **A Framework for Validation of Global Nighttime Environment Products (ROSES 2017 - Human Planet)**

Principal Investigator: Virginia Kalb, NASA Goddard Space Flight Center (former PI was Miguel Roman)

Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project, focused on the Human Planet initiative's Nighttime Product Validation (NPV) Task, is dedicated to the uncertainty assessment of NASA's Black Marble product suite through validation – the process of comparing satellite-derived products to independent reference data. NPV seeks to facilitate international objective benchmarking and standardization techniques for satellite-derived nighttime lights products. In 2019, the project released the VNP46A (At-sensor TOA Nighttime Radiance) product via NASA's LAADS DAAC. Operational production of the VNP46A2 data set (Moonlight-adjusted Nighttime Lights) was also begun.

## 2019 GEO Project Peer-Reviewed Publications

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## Looking Ahead

Where the AmeriGEO and Human Planet projects are all slated to end between late 2020 and late 2021, it is expected that the projects' efforts will be sustained by the project partners via the capacity development work that has been done. The projects have been focusing on capacity and technology transfer to the in-country partners with which they have been working. Therefore, a future outlook for these projects will include the future outputs that the partner institutions are able to develop using the capacities that have been developed and strengthened. Engagement with the GEO Principals, as well as the leads for the relevant GEO flagships, initiatives, and community activities, will also be key to sustaining the impacts of these projects.





EARTH SCIENCE  
APPLIED SCIENCES



# APPENDIX



# X. Appendix

## A. Acronyms

ADPC: Asian Disaster Preparedness Center  
AGRHYMET: Agrometeorology, Hydrology and Meteorology (Regional Center)  
AGU: American Geophysical Union  
AmeriGEO: Americas Group on Earth Observations  
ARL: Application Readiness Level  
ARSET: Applied Remote Sensing Training  
ASDC: Atmospheric Science Data Center  
AppSci: Applied Sciences Program  
AST: Applied Sciences Team  
BIA: Bureau of Indian Affairs  
CGMS: Coordination Group for Meteorological Satellites  
CHIRPS: Climate Hazard Group InfraRed Precipitation with Stations  
CI: Conservation International  
CMIP5: Coupled Model Intercomparison Project Phase 5  
CY: Calendar Year  
DAAC: Distributed Active Archive Centers  
DSSAT: Decision Support System for Agro-technology Transfer  
EF5: Ensemble Framework for Flash Flood Forecasting  
EO: Earth Observations  
ESI: Evapotranspiration Stress Indices  
EWX: Early Warning eXplorer  
FEWS NET: Famine Early Warning System Network  
FY: Fiscal Year  
GEE: Google Earth Engine  
GEO: Group on Earth Observations  
GEOSS: Global Earth Observation System of Systems  
GES DISC: Goddard Earth Sciences (GES) Data and Information Services Center (DISC)  
GHACOF: Greater Horn of Africa Climate Outlook Forum  
GIS: Geographic Information Systems  
GLAM: Global Agricultural Monitoring  
GLDAS: Global Land Data Assimilation Systems  
GMAO: Global Modeling and Assimilation Office  
GRACE: Gravity Recovery and Climate Experiment  
HKH: Hindu Kush Himalaya  
ICIMOD: International Centre for Integrated Mountain Development  
ICPAC: IGAD's Climate Prediction and Applications Centre  
IGAD: Intergovernmental Authority on Development  
IISD: International Institute for Sustainable Development  
IITM: Indian Institute of Tropical Meteorology  
IP: Indigenous Peoples  
IRI: International Research Institute for Climate and Society  
ITC: Faculty of Geo-Information Science and Earth Observation  
JWG: Joint Working Group  
KMD: Kenya Meteorological Department  
LAADS DAAC: Level-1 and Atmosphere Archive and Distribution System Distributed Active Archive Center  
LANCE: Land, Atmosphere Near real-time Capability for EOS  
LDAS: Land Data Assimilation System  
LIDAR: Light Detection and Ranging  
LPDAAC: Land Processes Distributed Active Archive Center

MODIS: Moderate-resolution Imaging Spectroradiometer  
MoNRE: Ministry of Natural Resources and Environment  
NASA: National Aeronautics and Space Administration  
NGO: Non-Governmental Organization  
NOAA: National Oceanic and Atmospheric Administration  
OPM: Office of the Prime Minister  
ORNL DAAC: Oak Ridge National Laboratory Distributed Active Archive Center  
PI: Principal Investigator  
PSI: Project Strength Index  
RAPID: Routing Application for Parallel computation of Discharge  
RCMRD: Regional Centre for Mapping of Resources for Development  
REDD: Reduced Emissions from Deforestation and Forest Degradation  
RHEAS: Regional Hydrologic Extremes and Assessment System  
ROSES: Research Opportunities in Space and Earth Sciences  
S2S: Sub-seasonal to Seasonal  
SAGE: SERVIR Annual Global Exchange  
SAR: Synthetic Aperture Radar  
SCAQMD: South Coast Air Quality Monitoring District  
SCO: Science Coordination Office  
SOCRATES: SERVIR Operational Cluster Resource for Applications – Terabytes for Earth Science  
TEK: Traditional Ecological Knowledge  
TEX: Thriving Earth Exchange  
UNDP: UN Development Programme  
UNDP: United Nations Development Program  
UNESCO: United Nations Educational, Scientific and Cultural Organization  
USAID: United States Agency for International Development  
USDA: United States Department of Agriculture  
USFS: United States Forest Service  
VIC: Variable Infiltration Capacity  
WA: West Africa  
WALFEHE: West Africa LDAS for Forecasting Extreme Hydrological Event

## B. 2019 CBP-Authored/Co-Authored Peer-Reviewed Publications

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## C. Earth Observation Assets Employed by CBP

ALOS L-PALSAR	Aqua MODIS	ENVISAT
ALOS-2	Suomi NPP ATMS	ER-2 Jet AVIRIS
AMSR-2	Aura	GEDI LiDAR
AMSR-E	AVHRR	GeoEye
Aqua AMSR-E	CALIPSO CALIOP	GEOS-5
Aqua CERES	Digital Globe	GOES

GPM DPR  
GPM IMERG  
GPM LIS  
GPM TMPA  
GRACE  
GRACE-FO  
IKONOS  
ISS ECOSTRESS  
Jason-2  
Jason-3  
Landsat 4 TM  
Landsat 5 TM  
Landsat 7 ETM+  
Landsat 8 OLI

Landsat 8 TIRS  
NASA Gulfstream III -  
UAVSAR  
NISAR  
Peru-Sat-1  
PlanetScope  
RadarSat-1  
RadarSat-2  
RapidEye  
Sentinel-1A  
Sentinel-1B  
Sentinel-2 MSI  
Sentinel-3 OLI  
SMAP

SMOS  
SRTM  
Suomi NPP VIIRS  
SWOT  
TanDEM-X  
Terra ASTER  
Terra CERES  
Terra MISR  
Terra MODIS  
TerraSAR-X  
TRMM TMI  
Worldview