2013-2016

GOAmazon Project Final Report
Submitted to
U.S. Department of Energy, Office of Science
Terrestrial Ecosystem Science Program
Dr. Daniel Stover, Program Manager
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Project Title:	Understanding the Response of Photosynthetic Metabolism in Tropical Forests to Seasonal Climate Variations
Lead Organization (Award 1 of 2):	U.S. Geological Survey, Western Geographic Science Center 345 Middlefield Road, MS531, Menlo Park, CA 94025
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Register #:	ER65592
SC #:	DE-SC0008383
Award Period:	Jan. 1, 2013 – December 31, 2016 (3 years)

Principal Investigators:

U.S. (DOE-TES Funding):	Award 1: USGS Western Geographic Science Center
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	Award 2: University of Michigan
	Valeriy Ivanov, University of Michigan
	Scott Saleska, University of Arizona
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Brazil (FAPESP Funding):	Luiz Aragao, INPE
Brazil (FAPEAM Funding):	Marciel J. Ferreira, UFAM

1. Summary

This U.S-Brazil collaboration for GOAmazon has investigated a deceptively simple question: what controls the response of photosynthesis in Amazon tropical forests to seasonal variations in climate? In the past this question has been difficult to answer with modern earth system process models. We hypothesized that observed dry season increases in photosynthetic capacity are controlled by the phenology of leaf flush and litter fall, from which the seasonal pattern of LAI emerges. Our results confirm this hypothesis (Wu et al., 2016).

Synthesis of data collected throughout the 3-year project period continues through December 31, 2017 under no-cost extensions granted to the project teams at University of Michigan and University of Arizona (Award 2). The USGS component (Award 1) ceased on the final date of the project performance period, December 31, 2016.

This report summarizes the overall activities and achievements of the project, and constitutes the final project report for the USGS component. The University of Michigan will submit a separate final report that includes additional results and deliverables achieved during the period of their and the University of Arizona's no-cost extension, which will end on December 31, 2017.

2. USGS Activities and Accomplishments

The USGS team deployed custom instruments for in situ monitoring at the Santarem (Tapajos km67) and Manaus (ZF2 km34) study sites (Dye and Bogle, 2016). The instruments consist of two high dynamic range sky imaging systems for monitoring of sky conditions and the sky radiance distribution of PAR (Fig. 1), and two multispectral imaging systems (phenocams) for monitoring of the forest canopy phenology (Fig. 2).

The USGS team maintained the phenocam and sky imager instruments and incorporated refinements to improve their reliability for sustained operation at the remote field sites. Additional software development was aimed at enabling efficient processing and analysis of the sensor datasets. The software development was approaching maturity in late 2016; however completion and implementation could not be achieved due to loss of critical programming staff.

An extensive observational dataset was gathered over intermittent periods through the 3-year project period. Data gaps occurred for each sensor as result of periodic system failures associated primarily with power outages, hardware failure, or software deficiencies. Field work planned for late 2016 was cancelled, and consequently, sensor data collected since the USGS team's prior field visit in 2015 was not retrieved. The data will be retrieved and compiled by the University of Arizona team in early 2017.

The reliability of the phenocam and sky imager instruments was improved during the course of the project. The first-generation sky imager was upgraded by replacing the original Canon 50D single lens reflex camera with a CMOS industrial vision camera. The industrial vision camera has an electronic shutter rather than a mechanical shutter, which substantially improved the system durability. Software enhancements were successfully incorporated to improve the reliability of both instruments for continuous operation, most importantly their ability to reinitiate observations after power failures.

At the time of this report, the USGS instruments and related equipment remain deployed at the Brazil study sites. Arrangements are in progress for the USGS to donate them to INPA, one of the collaborating Brazilian institutions on the GOAmazon project. Current plans are to investigate of tropical forest-climate relations over a longer time period by continuing to operate the existing USGS instruments and to establish additional monitoring sites in the Amazon region. This follow-on activity is being pursued outside of USGS under funding obtained from a new, 3-year, $1 million grant from NASA to the University of Arizona.

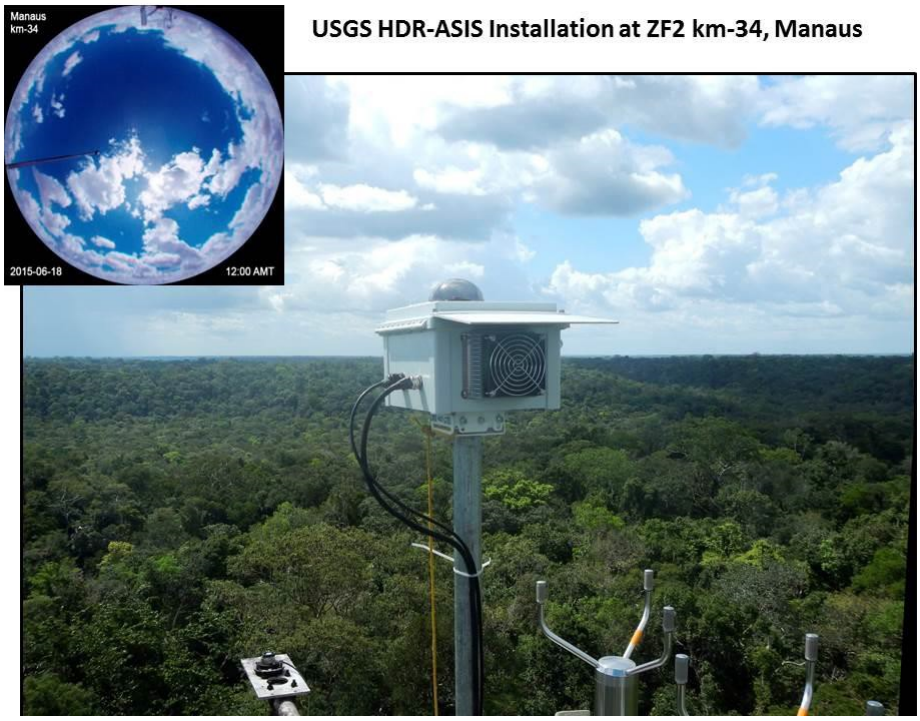

Figure 1. The high dynamic range sky imager installed at the top the tower at ZF2 km-34 near Manaus, Brazil. The inset image shows sky conditions near solar noon on June 18, 2015.

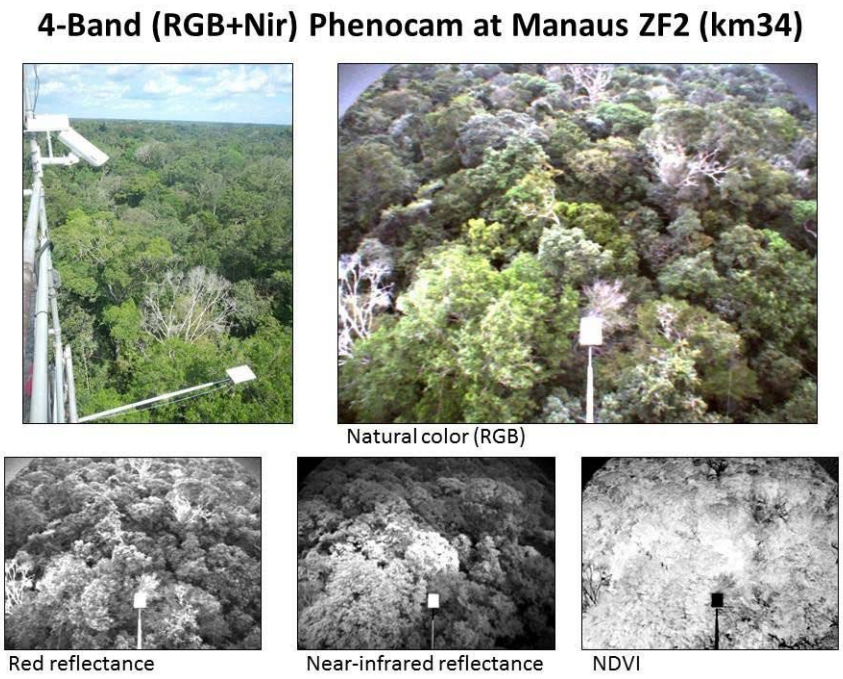

Figure 2. The phenocam system (upper left) at ZF2 km-34 near Manaus, Brazil. Sample images are shown for natural color, red reflectance, near-infrared reflectance, and NDVI.

3. Workshops and Special Sessions Organized

2014, U.S.-Brazil GOAmazon Joint Workshop, Manaus, Brazil, 14-18 Mar.

2014, U.S. GOAmazon Workshop, Tucson, AZ, 20-21 May

4. Publications

Dye, D.G., and Bogle, R.C., 2016, Improved ground-based remote-sensing systems help monitor plant response to climate and other changes: U.S. Geological Survey Fact Sheet 2016–3013, 2 p., available online at URL http://dx.doi.org/10.3133/fs20163013.

Wu, Jin, Lauren Albert, Aline Lopes, Natalia Restrepo-Coupe, Matthew Hayek, Kenia T. Wiedemann, Kaiyu Guan, Scott C. Stark, Bradley Christoffersen, Neill Prohaska, Julia V. Tavares, Suelen Marostica, Hideki Kobayashi, Maurocio L. Ferreira, Kleber Silva Campos, Rodrigo da Silva, Paulo M. Brando, Dennis G. Dye, Travis E. Huxman, Alfredo Huete, Bruce Nelson, and Scott Saleska, 2016. Leaf development and demography explain photosynthetic seasonality in Amazon evergreen forests, *Science*, 3521(6276):972-976, available online at URL https://pubs.er.usgs.gov/publication/70168734.

5. Presentations

Dye, D.G.,Saleska, S.R., Ivanov, V., Huete, A., 2015, Understanding the response of photosynthetic metabolism in tropical forests to seasonal climate variations, FAPESP-US Symposium on Collaborative Research in the Amazon, Wash., DC

Dye, D.G., Saleska, S.R., Ivanov, V., Huete, A., Wu, J., Albert, L., da Silva, R., Nelson, B., Aragao, L., and Ferreira, M., 2015, What Regulates the Seasonality of Photosynthetic Metabolism in Tropical Forests, US Department of Energy, Environmental System Science Principal Investigators Meeting, Potomac, MD

Garnello, A., Dye, D., Bogle, R., Vogel, J., Saleska, S.R., Crill, P.M., 2015, Using High-Dynamic Range Repeat Photography to Measure Plant Phenology in a Subarctic Mire, American Geophysical Union Fall Meeting, San Francisco, CA

Dye, D.G., Saleska, S., Ivanov, V., 2016, Understanding the Response of Photosynthetic Metabolism in Tropical Forests to Seasonal Climate Variations, US Department of Energy, Environmental System Science Principal Investigators Meeting, Potomac, MD.

6. Press Releases

Dye, D., Gordon, L., 2014. *Amazon Carbon Dynamics: Understanding the Photosynthesis-Climate Link.* Available online at URL https://www.usgs.gov/news/amazon-carbon-dynamics-understanding-photosynthesis-climate-link.