IMPROVING FLOOD MONITORING IN THE LOWER MEKONG RIVER BASIN USING MULTI SENSOR METHODS [REQUESTED RESUBMISSION]

Project Description

Title of Project	Improving Flood Monitoring in the Lower Mekong River Basin using Multi Sensor Methods [Requested Resubmission]
Project Start Date	5/15/2020
Fieldwork Start Date	
Fieldwork End Date	
Project End Date	5/15/2021
Primary Fieldwork Location Country or Area	Thailand
Fieldwork Location Country or Area #2	Vietnam
Fieldwork Location Country or Area #3	Cambodia
Fieldwork Latitude	11.648
Fieldwork Longitude	104.910
The primary focus of your project is:	Technology
The secondary focus of your project (if applicable) is:	Research
What is the Discipline/Field of Study for the project?	Computer Science, Information Systems; Computer Science, Interdisciplinary Applications; Environmental Sciences; Geography, Physical; Geosciences, Multidisciplinary; Physics, Applied; Water Resources
If applicable discipline/s to your project are not on the list above, please enter them below:	
Brief Project Summary	Flood disasters in Southeast Asia result in significant loss of life and economic damage. Satellitebased information systems designed to monitor floods through space and time can help governments and international agencies formulate effective disaster response strategies during a flood, and can ultimately alleviate negative impacts to population, infrastructure, and agriculture. The goal of this project is to use unmanned aerial vehicle (UAVs) and drone based imagery to: (1) improve on existing satellite-

	based flood monitoring systems developed at NASA, and (2) calibrate algorithms for new satellites to accurately identify floods in real time. Results will include (1) A novel multisensor data fusion methodology (and peer reviewed publication) to rapidly identify flooding from a number of satellite sensors and (2) intuitive, easy to use, customizable webapp distributed to stakeholders (e.g. local and regional governments, international NGOs) and the general public.
Total Project Budget:	$10,000.00

Project Leader Information

Project Leader Name	Aakash Ahamed
Salutation	Mr.
How did you learn about the specific grant opportunity to which you are applying?	
***Please add specifics.**	
Country or Area of Primary Citizenship	United States
Country or Area of Citizenship #2	Canada
Country or Area of Citizenship #3	India
Country of Primary Residency	United States
If you are a citizen or resident of the United States, please indicate your race/ethnicity.	Asian American
Date of Birth	7/4/1990
Gender Identity	Male
Current Position or Job Title	PhD Student
Institution/Organization	Stanford University
Department	Geophysics
Primary Language	English
What other languages, if any, do you use for professional communication?	
Additional languages (if applicable):	

Highest Degree Awarded	M.Sc.
Department/Major	Earth and Environmental Sciences
Year Awarded	2014
School	Boston College
Degree Awarded #2	B.Sc.
Department/Major	Earth Sciences
Year Awarded	2012
School	Franklin & Marshall College
Degree Awarded #3	B.A.
Department/Major	Government
Year Awarded	2012
School	Franklin & Marshall College
If awarded, will you accept grant funds to your personal bank account (individual) or through an affiliated institution?	Individual
Describe the skills of your team members, and tell us why they are necessary to the success of your project. Please provide no more than two sentences per team member.	
Do you or your Team Members already have any media commitments or interest for this project? This includes media commitments already held by your home institution or other funding bodies.	No, but we are open to media coverage. If selected, our home institution may also elect to cover our work.
In one or two paragraphs, please describe what skills, attributes, and/or experiences make you uniquely qualified to implement this project. Please include any relevant information not in your CV that you wish to share.	Currently a PhD student at Stanford University's Geophysics Department, I formerly worked at NASA, a successful aerial imaging startup, and the World Wildlife Fund. Outcomes of my research projects include peer reviewed publications, international conference presentations, community engagement and capacity building workshops, and media features. I hold 2.5 citizenships (USA, Canada, Overseas Citizen of India), and have traveled to 21 countries across 5 continents. I am passionate about using technology to better our understanding of the world, and using research outcomes to benefit society. I hold a M.Sc. in Earth Sciences from Boston College and a B.Sc. with honors from Franklin & Marshall College.
In one or two paragraphs, please describe your career goals over the next 5 years and tell us how receiving a	My career goal is to be a technical and subject matter expert in the fields of remote sensing and hydrology. Through research and development, I aim to construct

grant from National Geographic will help you achieve them.

and refine techniques and tools that can be used to address problems in water resources including natural hazards, water management, agriculture, sanitation, hygiene, and other critical applications.

Project Details

Background

Southeast Asia is one of the most flood prone regions in the world. Intergovernmental Panel on Climate Change (IPCC, 2007) projections suggest that regional precipitation extremes and flood frequency are increasing. The region has already experienced intensified flood and drought as well as sea level rise in the last 30–50 years (IPCC, 2012). Floods are especially devastating due to lack of infrastructure and urban planning coupled with large portions of the population living on or near the floodplain (Jonkman, 2005; Long and Trong, 2001; Stromberg, 2007). Destructive floods occurred in 2000, 2011, 2013, 2016, and 2017 (Mekong River Commission, 2018), resulting in hundreds of deaths, thousands of displaced persons, and billions of USD in economic damages.

Due to the aforementioned factors, there is a pressing need for improved characterization of flood extent through space and time. This can be accomplished using satellite-based real-time flood monitoring systems. Recent advances in satellite imaging technology present an opportunity to map floods with unprecedented resolution, frequency, and coverage. Further, drones and unmanned aerial vehicles afford researchers a unique method to ground truth satellite measurements, which are lacking in most state of the art flood monitoring methods.

When combined with new methods in machine learning and statistics, the aforementioned tools are poised to become an essential asset to decision makers within the disaster response community, and have the potential to save lives, reduce economic damage, and guide relief and recovery efforts following a disaster.

Goals

The high level goal of this project is to save lives and limit damages caused by flooding in Southeast Asia. This will be accomplished by meeting scientific and technical milestones as well as conducting outreach and educational activities.

Scientifically, our team will develop new ways to combine satellite data and drone data at multiple scales and resolutions in order to build more accurate models for surface water classification. This will be done using state of the art cameras and equipment in conjunction with the most effective and useful satellite sensors for surface water mapping (e.g. Sentinel, MODIS, Landsat). Machine learning will be used to optimize classification algorithms, and accuracy assessments will be conducted for historic flood events.

Through long standing relationships with local NGOs, our team will also conduct outreach, education, and capacity building with local entities. Part of these activities will involve organizing workshops in which data, tools and

software created during this project are distributed to stakeholders (e.g. local governments, decision makers, and NGOs).

Methods

While a number of satellite-based flood monitoring systems exist (e.g. Brakenridge et al., 2003; Brakenridge and Anderson, 2006; Nigro et al., 2014; Ahamed and Bolten, 2017), a key limitation in these implementations is lack of ground truth data describing surface water. Using Unmanned Aerial Vehicles (UAVs) to identify surface water bodies while orbiting satellites are acquiring data from overhead, the algorithms and statistical methods underlying satellite classification of water bodies can be improved substantially.

Satellites to be considered in this analysis include but are not limited to (1) the Moderate Resolution Orbiting SpectroRadiometer (MODIS; two images per day at 250 meter resolution); (2) Sentinel (images and data every 3 days at 15-meter resolution), (3) Landsat (images every 16 days at 30-meter resolution), and (4) Soil Moisture Active Passive (SMAP; data every 3 days at 1-3 kilometer resolution). While the aforementioned satellites are overhead, UAVs will fly over the same areas, and acquire data using optical and thermal cameras encompassing similar wavelengths. This technique allows for inter-comparison between aerial drone data and satellite data. A number of flights will be conducted in order to encompass a range of water bodies (rivers, lakes, etc), sediment concentrations (suspended sediment vs. lack thereof), landscapes (forested, agricultural), geographies (rural, urban), and atmospheric conditions Flights will ideally take place during multiple seasons, so as to encapsulate seasonal variations in surface water optics and thermography. In situ sampling of the electromagnetic properties of water bodies, as well as suspended sediment, will also be considered.

Following acquisition, orthorectification, and processing of UAV imagery, water bodies will be manually traced and delineated. Machine learning methods, not currently used in most flood monitoring applications, will be employed to optimize the classification of water bodies from satellite data. Using the water bodies identified through drone flights, machine learning techniques can be applied to the satellite imagery in order to accurately characterize the spectral signatures of water bodies. Specific machine learning techniques to be used include but are not limited to (1) Convolutional Neural Networks, (2) Feed-Forward Neural Networks, (3) Support Vector Machines, (4) Naive Bayes multinomial event models, and (5) Statistical performance evaluation techniques such as Stochastic Montecarlo parameter optimization. A number of regularization, normalization, and training strategies will be considered in model development.

Another novel methodological contribution of this project will be the development of a data fusion approach to reconcile measurements from different satellites attained at different spatial resolutions. This is one of the challenges of modern satellite data science. A statistical downscaling method, similar to Gao et al, (2006) will be tested, among other random forest and decision-tree based methods.

Following training, optimization, and data fusion, flood detection models will be applied to historical satellite data with available ground truth information to ensure classification efficacy. Validation of the models will be carried out using a confusion matrix approach, similar to the validation described in Ahamed and Bolten (2017).

Communication and Engagement

Results will be disseminated through at least one peer reviewed publication describing the methods by which satellite-based flood water classification (described in the Methodology section) is calibrated using drone-based aerial imagery and fused with multi-resolution satellite sensors. Results will also be shared through workshops and training materials developed in tandem with the Asian Disaster Preparedness Center.

Outputs and Evaluation

In collaboration with local NGOs (e.g. Asian Disaster Preparedness Center), stakeholder and end-user workshops will be carried out to assess the usability of tools developed for this project. We expect to have at least one workshop in collaboration with the Asian Disaster Preparedness Center

Works Cited

Ahamed, A., & Bolten, J. D. (2017). A MODIS-based automated flood monitoring system for southeast asia. International Journal of Applied Earth Observation and Geoinformation, 61, 104-117.

Brakenridge, R., & Anderson, E. (2006). MODIS-based flood detection, mapping and measurement: the potential for operational hydrological applications. Transboundary floods: reducing risks through flood management, 1-12.

Brakenridge, G. R., Anderson, E., Nghiem, S. V., Caquard, S., & Shabaneh, T. B. (2003). Flood warnings, flood disaster assessments, and flood hazard reduction: The roles of orbital remote sensing.

IPCC, (2007). Climate Change The Physical Science Basis Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC, (2012). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change.

Gao, F., J. Masek, M. Schwaller and Hall, F. (2006). On the Blending of the Landsat and MODIS Surface Reflectance: Predict Daily Landsat Surface Reflectance, IEEE Transactions on Geoscience and Remote Sensing, 44, 8, 2207-2218.

Jonkman, S. N. (2005). Global perspectives on loss of human life caused by floods. Natural hazards, 34(2), 151-175.

Long, N. T., & Trong, B. D. (2001, November). Flood monitoring of Mekong River delta, Vietnam using ERS SAR data. In A paper presented at the 22nd Asian conference of remote sensing, Singapore (pp. 5-9).

Mekong River Commission (2018). http://ffw.mrcmekong.org/historical_rec.htm. Accessed 1/3/2018.

Nigro, J., Slayback, D., Policelli, F., & Brakenridge, G. R. (2014). NASA/DFO MODIS near real-time (NRT) global flood mapping product evaluation of flood and permanent water detection. Evaluation, Greenbelt, MD

Oddo, P. C., Ahamed, A., & Bolten, J. D. (2018). Socioeconomic Impact Evaluation for Near Real-Time Flood Detection in the Lower Mekong River Basin. Hydrology, 5(2), 23.

Strömberg, D. (2007). Natural disasters, economic development, and humanitarian aid. The Journal of Economic Perspectives, 21(3), 199-222.

Budget Details

Please enter the budget information you are requesting from NGS below, fitting items as closely as possible into the categories provided. To begin, click Generate Budget (the approximate start and end dates for your project are pre-filled). **Please visit HERE to read all Budget Restrictions & Guidelines before completing.** Utilize the comments field to elaborate on each entry, as requested per the guidelines. If you are not requesting funds for a particular budget category, please leave the field blank. Enter all amounts rounded to the nearest US dollar, with no punctuation or symbols (example: 5200).

Parent Category	Grantee Budget Category	2019	2020	2021	Total	Justification
Travel	**Airfare**	$2,500.00	$0.00	$2,500.00	$5000.00	Travel to Southeast Asia for multiple team members
Travel	**Vehicle Rental and Maintenance**	$0.00	$0.00	$0.00	$0.00	
Travel	**Other Transportation**	$0.00	$0.00	$0.00	$0.00	
Lodging/Food	**Lodging**	$0.00	$0.00	$0.00	$0.00	
Lodging/Food	**Food**	$0.00	$0.00	$0.00	$0.00	
Equipment/Lab	**Equipment & Supplies**	$1,000.00	$0.00	$0.00	$1000.00	DJI Phantom 4 Pro Quadcopter, custom built thermal and optical camera systems similar to FLIR duo thermal imaging system.
Equipment/Lab	**Laboratory Costs**	$0.00	$0.00	$0.00	$0.00	
Equipment/Lab	**Laboratory Tests**	$0.00	$0.00	$0.00	$0.00	
Compensation	**Applicant and Team Members Compensation**	$0.00	$0.00	$0.00	$0.00	

Parent Category	Grantee Budget Category	2019	2020	2021	Total	Justification
Compensation	**Assistants and Consultants Compensation**	$2,000.00	$2,000.00	$0.00	$4000.00	Local guides, technicians for drones and other systems, field assistants for navigating unfamiliar and wild terrain. Compensation will be determined by task. Consultants will be referred by local NGO Asian Disaster Preparedness Center.
Evaluation	**Measurement and Evaluation**	$0.00	$0.00	$0.00	$0.00	
Other	**Institutional Overhead**	$0.00	$0.00	$0.00	$0.00	
Other	**Miscellaneous**	$0.00	$0.00	$0.00	$0.00	
	SubTotal	**$5500.00**	**$2000.00**	**$2500.00**	**$10000.00**	

Other Funding Sources

Please list the amounts of support already received for this project from individuals or institutions other than the National Geographic Society (up to 3). If you have more than three additional sources please list the three main sources of funding. Please list each current funding source by clicking the "New" button and filling in pertinent information.

Funding Source	Category	Amount Received
Stanford University	Educational Institution	$10,000

Recommended Reviewer

Please enter the contact information of your advisor, supervisor, or mentor. This person should know you and your work well enough to provide a reference for you and your project. This person can be a Team Member on your grant application without a conflict of interest. Please be sure you discuss your project with this person in advance.

Last Name	First Name	Email

Last Name	First Name	Email
Bolten	John	john.bolten@nasa.gov

Expected Outputs

To assist National Geographic in better understanding the goals of your project, please individually add and categorize the results and outputs your project is setting out to achieve. These results should be summarized in the Project Details tab of your application and you will be expected to report back on these results at the time of your final report, if you receive funding.

Please select "New" below to create an expected result/output.

Category	Result	Description (Details)	#
Education, Training, and Capacity Building	Local Community Members (# of Individuals)	Workshops to be held in coordination with Asian Disaster Preparedness Center to engage stakeholders and disseminate tools and models.	1
Public Communications Products	Peer-reviewed academic publications	Development of an improved multi sensor satellite flood monitoring system calibrated with UAV based data.	1

Attachments

Please upload a C.V. or Resume (required).

No.	File Name	-
1	Resume-Ahamed_NatGeo_CV	

Image Upload 1

No.	File Name	-
No Attachments		

Image Upload 2

No.	File Name	-
No Attachments		

Ethical Certification

National Geographic Society has zero tolerance for bribery and corruption, and complies with all applicable laws prohibiting such conduct including the U.S. Foreign Corrupt Practices Act and the U.K. Bribery Act. Grantees may not: offer or give anything of value to a government official or any other person as an incentive to, or in exchange or as a reward for, obtaining an improper advantage for National Geographic; or give, offer, solicit or accept anything of value that is intended to induce the recipient to violate his/her duty of loyalty to his/her employer. All licenses, permits and other government permissions or approvals required to carry out a grant must be obtained through the lawful, legitimate process of the country where the grant activity occurs.	Yes
National Geographic Society complies with all embargos and sanctions established by the U.S. Department of Treasury Office of Foreign Asset Controls (OFAC). If any work under the proposed grant will be performed in countries including but not limited to Cuba, Iran, Sudan, Syria, North Korea and Crimea, you must consult your legal counsel to ensure that an appropriate general license is available, or a specific license has been obtained, allowing the grant activity to take place. Additionally, the U.S. Department of Commerce must be notified when certain items are exported (including encryption software standard on all computers). You must consult with your legal counsel and comply with all export requirements applicable to the grant work.	Yes
By submitting this application, I represent that I am in compliance with the ethical standards and codes of practice for my discipline, and specifically the requirements for projects relating to human or animal subjects. I further agree that I practice the National Geographic Society's internal values including honesty, fairness and transparency . Lastly, I agree that the National Geographic Society may share details about the project at the time of award.	Yes